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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear power plants – Control rooms – Design

Centrales nucléaires de puissance – Salles de commande – Conception

IEC 60964:2009

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

NUCLEAR POWER PLANTS – CONTROL ROOMS – DESIGN

FOREWORD

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International Standard IEC 60964 has been prepared by subcommittee 45A: Instrumentation and control of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition published in 1989.

The revision of the standard is intended to accomplish the following:

– to take into account the fact that software engineering techniques advanced significantly in the intervening years;
– to align the Standard with the new revisions of IAEA documents NS-R-1 and NS-G-1.3, which includes as far as possible adaptation of the definitions;
– to replace, where relevant, the previous requirements in the standard, where these are now given by references to Standards published since the first edition, especially IEC 60709, IEC 60780, IEC 60980, IEC 61225, IEC 61226, IEC 61227, IEC 61513, IEC 61771, IEC 61772, IEC 61839, IEC 62241 and ISO 11064;
– to review the existing requirements and to update the terminology and definitions.

The text of this standard is based on the following documents:

FDIS	Report on voting
45A/724/FDIS	45A/731/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

INTRODUCTION

a) Technical background, main issues and organization of the standard

IEC 60964:1989 was developed to supply requirements relevant to the design of the main control room of NPPs. The first edition of IEC 60964 has been used extensively within the nuclear industry. It was however recognized that recent technical developments especially those which are based on software technology should be incorporated. It was also recognized that the relationships with derivative standards (i.e. IEC 61227, IEC 61771, IEC 61772, IEC 61839, and IEC 62241) should be clarified and conditioned.

This IEC standard specifically focuses on the functional designing of the main control room of NPPs. It is intended that the Standard be used by NPP vendors, utilities, and by licensors.

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

IEC 60964 is the second level IEC SC 45A document tackling the generic issue of control room design.

IEC 60964 is to be read in association with the derivative standards mentioned above which are the appropriate IEC SC 45A documents which provide guidance on operator controls, verification and validations of design, application of visual display units, functional analysis and assignment, and alarm functions and presentation.

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 is intended for application to new control rooms whose conceptual design is initiated after the publication of this standard. The recommendations of the standard may be used for refits, upgrades and modifications.

The primary purpose of this standard is to provide functional design requirements to be used in the design of the main control room of a nuclear power plant to meet operational and safety requirements.

This standard also provides functional interface requirements which relate to control room staffing, operating procedures and the training programme which are, together with the human-machine interface, constituents of the control room system.

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

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 document of the IEC SC 45A standard series is IEC 61513. It provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 61513 structures the IEC SC 45A standard series.

IEC 61513 refers directly to other IEC SC 45A standards for general topics related to categorization of functions and classification of systems, qualification, separation of systems, defence against common cause failure, software aspects of computer-based systems, hardware aspects of computer-based systems, and control room design. The standards referenced directly at this second level should be considered together with IEC 61513 as a consistent document set.

At a third level, IEC SC 45A standards not directly referenced by IEC 61513 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.

IEC 61513 has adopted a presentation format similar to the basic safety publication IEC 61508 with an overall safety life-cycle framework and a system life-cycle framework and provides an interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. Compliance with IEC 61513 will facilitate consistency with the requirements of IEC 61508 as they have been interpreted for the nuclear industry. In this framework IEC 60880 and IEC 62138 correspond to IEC 61508-3 for the nuclear application sector.

IEC 61513 refers to ISO as well as to IAEA 50-C-QA (now replaced by IAEA GS-R-3) for topics related to quality assurance (QA).

The IEC SC 45A standards series consistently implements and details the principles and basic safety aspects provided in the IAEA code on the safety of NPPs and in the IAEA safety series, in particular the Requirements NS-R-1, establishing safety requirements related to the design of Nuclear Power Plants, and the Safety Guide NS-G-1.3 dealing with instrumentation and control systems important to safety in Nuclear Power Plants. The terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

NUCLEAR POWER PLANTS – CONTROL ROOMS – DESIGN

1 Scope and object

This International Standard establishes requirements for the human-machine interface in the main control rooms of nuclear power plants. The standard also establishes requirements for the selection of functions, design consideration and organization of the human-machine interface and procedures which shall be used systematically to verify and validate the functional design. These requirements reflect the application of human factors engineering principles as they apply to the human-machine interface during normal and abnormal plant conditions. This standard does not cover special purpose or normally unattended control points, such as those provided for shutdown operations from outside the main control room or for radioactive waste handling, or emergency response facilities. Detailed equipment design is outside the scope of this standard.

The primary purpose of this standard is to provide functional design requirements to be used in the design of the main control room of a nuclear power plant to meet operational and safety requirements. This standard also provides functional interface requirements which relate to control room staffing, operating procedures, and the training programmes which, together with the human-machine interface, constitute the control room system.

This standard is intended for application to new control rooms whose conceptual design is initiated after the publication of this standard. If it is desired to apply it to an existing control room, special caution must be exercised so that the design basis is kept consistent.

2 Normative references

The following referenced documents are indispensable for the application 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 60709, *Nuclear power plants – Instrumentation and control systems important to safety – Separation*

IEC 60780, *Nuclear power plants – Electrical equipment of the safety system – Qualification*

IEC 60960, *Functional design criteria for a safety parameter display system for nuclear power stations*

IEC 60965, *Supplementary control points for reactor shutdown without access to the main control room*

IEC 60980, *Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generating stations*

IEC 61225, *Nuclear power plants – Instrumentation and control systems important for safety – Requirements for electrical supplies*

IEC 61226, *Nuclear power plants – Instrumentation and control important to safety – Classification of instrumentation and control functions*

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

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

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 (VDU)*

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

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

ISO 11064 (all parts), *Ergonomic design of control centres*

IAEA NS-G-1.3, *Instrumentation and control systems important to safety in Nuclear Power Plants, 2002*

IAEA NS-G-1.9, *Design of the reactor coolant system and associated systems in nuclear power plants*

IAEA, NS-G-1.11, *Protection against internal hazards other than fires and explosions in the design of nuclear power plants*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. For other terms, refer to the general terminology defined in IEC 61513 and in the IAEA NUSS programme, such as Safety Guide NS-G-1.3.

3.1
alarms
an item of diagnostic, prognostic, or guidance information, which is used to alert the operator and to draw his or her attention to a process or system deviation.

NOTE Specific information provided by alarms includes the existence of an anomaly for which corrective action might be needed, the cause and potential consequences of the anomaly, the overall plant status, corrective action to the anomaly, and feedback of corrective actions.

Two types of deviation may be recognised:

– Unplanned - Undesirable process deviations and equipment faults;

– Planned - Deviations in process conditions or equipment status that are the expected response to but could be indicative of undesirable plant conditions.

[IEC 62241]

3.2
auxiliary control (operating) systems
operating systems that are installed outside the control room such as local-to-plant control points and local-to-plant shutdown systems

3.3
control room staff
a group of plant personnel stationed in the control room, who are responsible for achieving the plant operational goals by controlling the plant through the human-machine interface.

Typically, the control room staff consists of supervisory operators, and operators who actually manipulate controls but may also include those staff members and experts who are authorized to be present in the control room, e.g. during long lasting event sequences

3.4
control room system
an integration of the human-machine interface, the control room staff, operating procedures, training programme, and associated facilities or equipment which together sustain the proper functioning of the control room

3.5
controls
devices which the operator uses to send demand signals to control systems and plant items

NOTE Controls as defined in this standard (i.e. devices used for control actions) hold a different meaning from the one defined in the IAEA safety Glossary and are not replaceable.

3.6
displays
devices used for monitoring plant conditions and status, e.g. process status, equipment status

3.7
format (display format)
a pictorial display of information on a visual display unit (VDU) such as message text, digital presentation, symbols, mimics, bar-charts, trend graphs, pointers, multi-angular presentation

3.8
function
specific purpose or objective to be accomplished, that can be specified or described without reference to the physical means of achieving it

[IEC 61226]

3.9
functional analysis
the examination of the functional goals of a system with respect to available manpower, technology, and other resources, to provide the basis for determining how the function may be assigned and executed

3.10
functional goal
the performance objectives that shall be satisfied to achieve the corresponding function

3.11
hierarchical goal structure
relationship between a functional goal and sub-functional goals structured in a hierarchical order

3.12
high-level mental processing
human act to process and/or interpret information to obtain reduced abstract information

3.13
human-machine interface
the interface between operating staff and I&C system and computer systems linked with the plant. The interface includes displays, controls, and the Operator Support System interface

3.14
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. The different functions within a system may use dedicated or shared resources.

NOTE 1 The elements included in a specific I&C system are defined in the specification of the boundaries of the system.

NOTE 2 According to their typical functionality, IAEA distinguishes between automation and control systems, HMI systems, interlock systems and protection systems.

[IEC 61513]

3.15
job
a set of tasks which are operationally related. The tasks within a job should be coherent with regard to required skill, knowledge and responsibility

3.16
job analysis
an analysis identifying basic requirements which a job imposes on the control room staff structure, the operating procedures and training programme

3.17
local control points (or facilities)
points (or facilities) located outside the control room where local operators perform control activities

3.18
local operators
the operating staff that perform tasks outside the control room

3.19
operating procedures
a set of documents specifying operational tasks it is necessary to perform to achieve functional goals

3.20
operating staff
plant personnel working on shift to operate the plant. The operating staff includes the control room staff, maintenance engineers, etc.

3.21
operator interaction
interrelation between operator and the I&C system. Specifically, display of plant status by the I&C system and corresponding operator action

3.22
Operator Support System (OSS)
a system or systems supporting the high-level mental information processing tasks assigned to the control room staff

3.23
performance requirements
quantitative requirements specifying performance of tasks which ensure the achievement of functional goals

3.24
plant operational goals
ultimate purposes of plant design, i.e. controlled generation of electricity and limitation of release of radioactivity to the environment

3.25
population stereotype
the tendency for most persons in a group or population to give the same response to a particular stimulus, even when there are alternative responses. The population stereotype depends on the customs and habits of the population sampled

3.26
task analysis
a detailed description of an operator's task, in terms of its components, to specify the detailed human activities involved, and their functional and temporal relationships

3.27
tasks
actions performed by either human or machine for the accomplishment of a functional goal

3.28
training programme
a programme which is designed to train the control room staff so that they can acquire the skills and knowledge necessary for operational activities

3.29
validation
the 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.

[IAEA Safety Glossary, 2007 edition]

3.30
verification
the process of determining whether the quality or performance of a product or service is as stated, as intended or as required

[IAEA Safety Glossary, 2007 edition]

3.31
Visual Display Unit (VDU)
a type of display incorporating a screen for presenting computer-driven images

4 Standard use

This clause is provided to orient the user to the organization and focus of this standard. Figure 1 shows an overview of a control room system. The goal of a control room design team is the successful completion of an integrated control room system. The control system is an integration of the human-machine interface, control room staff, operating procedures, training

programme and the associated equipment and facilities. Annex A provides a supplemental explanation concerning the concept of the control room system.

The focus of this standard is the establishment of the human-machine interface in the control room design. The standard also establishes a means for developing staffing requirements, operating procedures and a training programme but does not provide detailed methodology for such development. The various clauses and subclauses of this standard are developed.

After the scope, statements and specifications of design principles, the design process is shown in Figure 2 to include functional analysis, function assignment, function assignment verification, function assignment validation and job analysis. Then, the functional design specifications are developed as shown in Figure 2.

From these specifications, the detailed design, operating procedures and training programme are developed. Finally, the resultant system constituents are verified and the integrated control room system validated.

This standard is addressed to the control room designer. This refers not necessarily to a single person; typically it is implemented by a design team which comprises a variety of competencies and disciplines. This includes at least the following areas:

- nuclear engineering;
- architectural design and civil engineering;
- systems engineering;
- I&C systems;
- information and computer systems;
- human factors engineering;
- plant operations;
- training.

These competencies may be provided by permanent or temporary team members, or even by consultants.