

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear power plants – Control rooms – Design

Centrales nucléaires de puissance – Salles de commande – Conception

[IEC 60964:2018](#)

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	10
4 Abbreviated terms	15
5 Standard use	15
6 Design principles for the main control room	18
6.1 Main objectives	18
6.2 Functional design objectives	18
6.3 Safety principles	18
6.4 Availability principles	19
6.5 Human factors engineering principles	19
6.6 Utility operating principles.....	19
6.7 Relationship with other control and management centres.....	19
6.8 Operational experience	20
7 Functional design of the main control room.....	20
7.1 General.....	20
7.2 Functional analysis	20
7.2.1 General	20
7.2.2 Identification of functions	20
7.2.3 Information flow and processing requirements	21
7.3 Assignment of functions	21
7.3.1 General	21
7.3.2 Operator capabilities.....	22
7.3.3 I&C system processing capabilities.....	22
7.4 Verification of function assignment.....	23
7.4.1 General	23
7.4.2 Process	23
7.5 Validation of function assignment.....	23
7.5.1 General	23
7.5.2 Process	23
7.5.3 General evaluation criteria for validation.....	24
7.6 Job analysis.....	24
8 Functional design specification	24
8.1 General.....	24
8.2 Provision of data base on human capabilities and characteristics	25
8.3 Location, environment and protection.....	25
8.3.1 Location	25
8.3.2 Environment	25
8.3.3 Protection.....	26
8.4 Space and configuration	26
8.4.1 Space	26
8.4.2 Configuration.....	27
8.5 Panel layout.....	27

8.5.1	Priority.....	27
8.5.2	Positioning on control desks and panels	28
8.5.3	Mirror image layout.....	28
8.6	Location aids	28
8.6.1	Grouping of display information and controls	28
8.6.2	Nomenclature	29
8.6.3	Coding.....	29
8.6.4	Labelling.....	30
8.7	Information and control systems	30
8.7.1	General	30
8.7.2	Information functions	30
8.7.3	Control functions	34
8.8	Control-display integration	35
8.9	Communication systems	35
8.9.1	General	35
8.9.2	Verbal communication systems.....	35
8.9.3	Non-verbal communication systems.....	37
8.10	Other requirements.....	37
8.10.1	Power supplies	37
8.10.2	Qualification	37
8.10.3	Maintainability	37
8.10.4	Repairs.....	37
8.10.5	Testability.....	37
9	Verification and validation of the integrated control room system.....	38
9.1	General.....	38
9.2	Control room system verification.....	38
9.2.1	General	38
9.2.2	Process	38
9.2.3	General evaluation criteria for integrated system verification	38
9.3	Control room system validation	38
9.3.1	General	38
9.3.2	Process	38
9.3.3	General evaluation criteria for integrated system validation	39
Annex A (informative)	Explanation of concepts	40
A.1	Control room system.....	40
A.2	“Human” and “machine”	40
Bibliography	42
Figure 1	– Overview of control room system	16
Figure 2	– Overall design process and the relationship to clauses and subclauses of this document	17
Table A.1	– Human and machine in functional domain and physical domain	41

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NUCLEAR POWER PLANTS – CONTROL ROOMS – DESIGN

FOREWORD

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

This third edition cancels and replaces the second edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) to review the usage of the term "task" ensuring consistency between IEC 60964 and IEC 61839;
- b) to clarify the role, functional capability, robustness and integrity of supporting services for the MCR to promote its continued use at the time of a severe accident or extreme external hazard;
- c) to review the relevance of the standard to the IAEA safety guides and IEC SC 45A standards that have been published since IEC 60964:2009 was developed;
- d) to clarify the role and meaning of "task analysis",

- e) to further delineate the relationships with derivative standards (i.e. IEC 61227, IEC 61771, IEC 61772, IEC 61839, IEC 62241 and others of relevance to the control room design);
- f) to consider its alignment with the Human Factors Engineering principles, specifically with the ones of IAEA safety guide on Human Factors (DS-492) to be issued.

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

FDIS	Report on voting
45A/1214/FDIS	45A/1224/RVD

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

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

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 organization of the standard

IEC 60964:1989 was developed to supply requirements relevant to the design of the main control room of NPPs and reviewed in 2009. The first two editions of IEC 60964 were used extensively within the nuclear industry. It was however recognized that there was a need to develop an amendment for the 2009 edition to address:

- The usage of the term "task" needed to be examined.
- The role, functional capability, integrity of supporting services and robustness for the MCR should be clarified to promote its continued use at the time of a severe accident or extreme external hazard.
- The relevance of the standard to the IAEA safety guides and SC 45A standards published since 2009.

Given the size of the proposal amendment, it was decided that a new edition of IEC 60964 should be issued instead of an amendment. During the preparation of this third edition, it was agreed that the following points have to be covered:

- to clarify the role and meaning of "task analysis",
- to further delineate the relationships with derivative standards (i.e. IEC 61227, IEC 61771, IEC 61772, IEC 61839, IEC 62241 and others of relevance to the control room design);
- to consider its alignment with the Human Factors Engineering principles, specifically with the ones of IAEA safety guide on Human Factors (DS-492) to be issued.

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.

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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 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 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 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 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 SC 45A domain was extended in 2013 to cover electrical systems. In 2014 and 2015 discussions were held in IEC SC 45A to decide how and where general requirements for the design of electrical systems were to be considered. IEC SC 45A experts recommended that an independent standard be developed at the same level as IEC 61513 to establish general requirements for electrical systems. Project IEC 63046 is now launched to cover this objective. When IEC 63046 is published this NOTE 2 of the introduction of IEC SC 45A standards will be suppressed.

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NUCLEAR POWER PLANTS – CONTROL ROOMS – DESIGN

1 Scope

This document establishes requirements for the human-machine interface in the main control rooms of nuclear power plants. The document also establishes requirements for the selection of functions, design consideration and organization of the human-machine interface and procedures which are 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 plant operational states and accident conditions (including design basis and design extension conditions), as defined in IAEA SSR-2/1 and IAEA NP-T-3.16. This document 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 document.

The primary purpose of this document 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 document 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 document is intended for application to new control rooms whose conceptual design is initiated after the publication of this document. 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.

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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 60671, *Nuclear power plants – Instrumentation and control systems important to safety – Surveillance testing*

IEC 60709, *Nuclear power plants – Instrumentation and control systems important to safety – Separation*

IEC/IEEE 60780-323, *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, *Nuclear power plants – Control rooms – Supplementary control room 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 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 (VDUs)*

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

IEC 62003, *Nuclear power plants – Instrumentation and control important to safety – Requirements for electromagnetic compatibility testing*

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

IEC 62645, *Nuclear power plants – Instrumentation and control systems – Requirements for security programmes for computer-based systems*

IEC 62646, *Nuclear power plants – Control rooms – Computer based procedures*

IEC 62859, *Nuclear power plants – Instrumentation and control systems – Requirements for coordinating safety and cybersecurity*

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

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*

IAEA NP-T-3.16, *Accident Monitoring Systems for 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 Safety Glossary.

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

accident conditions

deviations from normal operation that are less frequent and more severe than anticipated operational occurrences

Note 1 to entry: Accident conditions comprise design basis accidents and design extension conditions.

[SOURCE: IAEA Safety Glossary, 2016]

3.2

alarm

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 1 to entry: 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.

[SOURCE: IEC 62241:2004, 3.1]

3.3

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

3.4

control room staff

group of plant personnel stationed in the control room, which is responsible for achieving the plant operational goals by controlling plant through human machine interfaces

Note 1 to entry: Typically, the control room staff consists of supervisory operators, and operators who actually monitor plant and plant conditions and manipulate controls but also may include those staff members and experts who are authorized to be present in the control room, e.g. during long lasting event sequences.

3.5

control room system

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

3.6

controls

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

Note 1 to entry: Controls as defined in this document (i.e. devices used for control actions) hold a different meaning from the one defined in the IAEA safety Glossary and are not replaceable.

3.7

design basis accident

postulated accident leading to accident conditions for which a facility is designed in accordance with established design criteria and conservative methodology, and for which releases of radioactive material are kept within acceptable limits

[SOURCE: IAEA Safety Glossary, 2016]

3.8

design extension conditions

postulated accident conditions that are not considered for design basis accidents, but that are considered in the design process of the facility in accordance with best estimate methodology, and for which releases of radioactive material are kept within acceptable limits. Design extension conditions include conditions in events without significant fuel degradation and conditions with core melting

[SOURCE: IAEA Safety Glossary, 2016]

3.9

displays

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

3.10

format

display format

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

3.11

function

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

[SOURCE: IEC 61226:2009, 3.7]

3.12

functional analysis

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

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3.13

functional goal

performance objectives that shall be satisfied to achieve the corresponding function

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3.14

hierarchical goal structure

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

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3.15

high-level mental processing

human act to process and/or interpret information to obtain reduced abstract information

3.16

human-machine interface

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

3.17

I&C system

system, based on E/E/PE items, performing plant I&C functions as well as service and monitoring functions related to the operation of the system itself

Note 1 to entry: 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 2 to entry: The elements included in a specific I&C system are defined in the specification of the boundaries of the system.

Note 3 to entry: According to their typical functionality, IAEA distinguishes between automation and control systems, HMI systems, interlock systems and protection systems.

[SOURCE: IEC 62138:2018, 3.26]

3.18**job**

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

3.19**job analysis**

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

3.20**local control points****local control facilities**

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

3.21**local operators**

operating staff that perform tasks outside the control room

3.22**operating procedures**

set of documents specifying operational tasks it is necessary to perform to achieve functional goals

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3.23**operating staff**

plant personnel working on shift to operate the plant

IEC 60964:2018

Note 1 to entry: The operating staff includes the control room staff, maintenance engineers, etc.

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3.24**operator interaction**

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

3.25**Operator Support System****OSS**

system or systems supporting the high-level mental information processing tasks assigned to the control room staff

3.26**performance requirements**

quantitative requirements specifying performance which ensure the achievement of functional goals

3.27**plant operational goals**

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

3.28**population stereotype**

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