

Nuclear power plants — Main control room — Alarm functions and presentation

ICS 27.120.20

National foreword

This British Standard is the UK implementation of EN 62241:2015. It is identical to IEC 62241:2004. It supersedes BS IEC 62241:2004, which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee NCE/8, Reactor instrumentation.

A list of organizations represented on this committee can be obtained on request to its secretary.

The publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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31 March 2015	This corrigendum renumbers BS IEC 62241:2004 as BS EN 62241:2015

English Version

**Nuclear power plants - Main control room - Alarm functions and presentation
(IEC 62241:2004)**

Centrales nucléaires de puissance - Salle de commande principale - Fonctions et présentation des alarmes
(IEC 62241:2004)

Kernkraftwerke - Warte - Alarmfunktionen und ihre Darstellung
(IEC 62241:2004)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This document (EN 62241:2015) consists of the text of IEC 62241:2004 prepared by SC 45A "Instrumentation, control and electrical systems of nuclear facilities" of IEC/TC 45 "Nuclear instrumentation".

The following dates are fixed:

- latest date by which the document has to be implemented (dop) 2016-02-16
at national level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2018-02-16

As stated in the nuclear safety directive 2009/71/EURATOM, Chapter 1, Article 2, item 2, Member States are not prevented from taking more stringent safety measures in the subject-matter covered by the Directive, in compliance with Community law. In a similar manner, this European standard does not prevent Member States from taking more stringent nuclear safety measures in the subject-matter covered by this standard.

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The text of the International Standard IEC 62241:2004 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)**Normative references to international publications
with their corresponding European publications**

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60964	1989 ¹⁾	Design for control rooms of nuclear power plants	-	-
IEC 61226	-	Nuclear power plants - Instrumentation and control important to safety - Classification of instrumentation and control functions	EN 61226	-
IEC 61771	-	Nuclear power plants - Main control-room - - Verification and validation of design		-
IEC 61772	-	Nuclear power plants - Control rooms - Application of visual display units (VDUs)	EN 61772	-
IEC 61839	-	Nuclear power plants - Design of control rooms - Functional analysis and assignment	EN 61839	-

¹⁾ Superseded by IEC 60964:2009.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

NUCLEAR POWER PLANTS – MAIN CONTROL ROOM – ALARM FUNCTIONS AND PRESENTATION

FOREWORD

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International Standard IEC 62241 has been prepared by subcommittee 45A: Instrumentation and control of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

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

FDIS	Report on voting
45A/540/FDIS	45A/546/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.

This International Standard supplements 4.6.4 of IEC 60964:1989 and therefore supersedes the guidance given in A.4.6.4 of Annex A of IEC 60964.

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

Technical background, main issues and organisation of the standard

IEC 60964:1989 was developed to supply requirements relevant for the design of Control Rooms (CR) of nuclear power plants. In this first edition of IEC 60964 which has been used extensively within the nuclear industry, the subject of alarm systems was tackled in a one page clause. Considering the return of experience gathered worldwide on the subject, it appeared that a comprehensive standard on alarm systems was needed.

This standard is for application to the design of new main control rooms of nuclear power plants conforming to IEC 60964, where work is initiated after the publication of this standard. It serves as a reference for upgrading and modernizing existing control rooms. If it is desired to apply it to supplementary and local control rooms, special attention should be given to identifying the areas affected.

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

IEC 62241 will be directly referenced by the second edition of IEC 60964 (under consideration) and is the third level document specifically tackling the topic of alarm systems.

For more details on the structure of the IEC SC 45A series of standards, see below the "Description of the structure of the IEC SC 45A series of standards".

Recommendations and limitations regarding the application of this standard

This Standard supplements Subclause 4.6.4 of IEC 60964:1989 and therefore supersedes the guidance given in A.4.6.4 of Annex A of IEC 60964 Ed.1.0.

For the categorization of alarm systems, the safety classification of IEC 61226 should be taken into account.

Description of the structure of the IEC SC 45A series of standards and relationships with other IEC documents and other bodies documents (IAEA, ISO)

The top level document of the IEC SC 45A series of standards is IEC 61513. It provides general requirements for instrumentation and control systems and equipment (I&C systems) that are used to perform functions important to safety in nuclear power plants (NPPs). IEC 61513 structures the IEC SC 45A series of standards.

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 45A series of standards corresponds to the Technical Reports which are not normative.

IEC 61513 has adopted a presentation format similar to the basic safety series 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, parts 1, 2 and 4, for the nuclear application sector. Compliance with this standard 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 for topics related to quality assurance.

The IEC SC 45A series of standards consistently implements and details the principles and basic safety aspects provided in the IAEA code on the safety of nuclear power plants and in the IAEA safety series, in particular the Requirements NS-R-1 and the Safety Guide NS-G-1.3¹. The terminology and definitions used by IEC SC 45A standards are consistent with those used by the IAEA.

¹ Requirements NS-R-1: *Safety of Nuclear Power Plants: Design*

Safety Guide NS-G-1.3: *Instrumentation and Control Systems Important to Safety in Nuclear Power Plants*

NUCLEAR POWER PLANTS – MAIN CONTROL ROOM – ALARM FUNCTIONS AND PRESENTATION

1 Scope and object

This International Standard provides the functional requirements for the alarm systems in the main control room of nuclear power plants. It gives definitions of the terms used for alarm functions. It also establishes the human factors requirements and the design guidelines for alarm presentation for the main control room of nuclear power plants.

NOTE The alarm functions can be implemented in a dedicated system (alarm system) or preferably be an integrated part of the main control room HMI (Human-Machine Interface) system.

It specifies the alarm functions including those for the selection and definition of original alarm signals, alarm signal processing (e.g., event sequence processing, static and dynamic prioritisation), alarm display processing (e.g., alarm suppression) and the use of associated display devices (e.g., Visual Display Unit (VDU), conventional alarm fascia, mural display), with acknowledge and reset sequences, and other related matters.

Under abnormal conditions or plant transient conditions in the nuclear power plant, many alarms occur simultaneously. For this reason, the alarm functions of the main control room of nuclear power plants require special considerations for human factors engineering and system configuration, to avoid operator misunderstandings and to provide the operator with adequate information. Therefore, the scope includes special alarm functions based on human factors for monitoring and operation of nuclear power plants. It does not cover specific alarm systems, such as the fire alarm and security alarm systems.

The object of this Standard is to establish a common international understanding of the underlying functional design basis of alarm systems for control rooms, covering the corresponding functional requirements, the human factors requirements and design guidelines for the alarm functions and alarm presentation for the main control room of nuclear power plants.

This Standard therefore aims to give guidance to reduce problems which have been experienced in the past: omission of important alarms, delay in detecting important alarms, increased workload that may affect the performance of other operational activities, inattention to frequently activated alarms known as 'nuisance alarms,' and confusion associated with the misunderstanding of the relationships among alarms and of the importance of alarms.

2 Normative references

The following referenced documents are necessary 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 60964:1989, *Design for control rooms of nuclear power plants*

IEC 61226, *Nuclear power plants – Instrumentation and control systems important for safety – Classification*

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60964, as well as the following definitions, apply.

NOTE When the same term is defined in IEC 60964 and in this standard, the definition given in this standard applies.

3.1 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 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.

3.2 alarm acknowledgement

action, which operators are required to carry out to show that they have recognized an alarm presented to them

3.3 alarm avalanche

condition where a large number of alarms appear within a short time at a rate exceeding the operator's capacity to take them into account

3.4 alarm coding

method of highlighting an object of concern visually or audibly, with the intention of drawing the operator's attention to the object

3.5 alarm control

set of alarm presentation control functions, which support the operators in recognizing alarm status correctly and in a timely manner

NOTE Alarm acknowledgement, silence, and reset are typical examples of alarm control.

3.6

alarm display processing

alarm signal processing functions or mechanisms, which are used in controlling or enhancing alarm presentation, for example, grouped alarms, alarm suppression

NOTE The alarm display processing operates on the alarms identified by the alarm signal processing (q.v.) logic.

3.7

alarm fascia

alarm display consisting of a set of alarm tiles

3.8

alarm reduction or filtering

alarm signal processing function or mechanism which has the aim of reducing the number of alarms for operator attention

NOTE Filtering or reduction are generic terms.

3.9

alarm generation

alarm signal processing function or mechanism, which is used to generate an alarm based on a logical combination of pre-defined alarm signals and non-alarm binary signals (e.g., component status signals)

NOTE See also under alarm signal processing logic.

3.10

alarm legend

caption identifying an alarm

3.11

alarm message

alarm phrase identifying an alarm, which is used typically in VDU-based alarm displays

NOTE It may be associated with supplemental information such as the time of alarm activation, the threshold, and the trend of a corresponding process. It is also used to mean a string of speech-based audible announcements, representing an alarm, which may be associated with guidance or other supplemental information.

3.12

alarm prioritisation

alarm signal processing function or mechanism, which categorizes alarms into groups of different priorities of importance

NOTE The priority may be defined beforehand or determined dynamically from plant conditions. See also under alarm signal processing (q.v.) logic.

3.13

alarm recording

method ensuring that the identity and time of appearance and clearing of each alarm and alarm signal can be available for off-line study and analysis, using a permanent record such as printout or long-term magnetic or optical recording

3.14

alarm signal

binary signal taken into the alarm system, which is processed to provide an alarm. These signals may be raw signals from the plant or from the I&C systems

3.15

alarm signal processing

logic or mechanisms which operate on the alarm signals (q.v.), before alarms are identified and passed to alarm display processing (q.v.) to be displayed to operators

NOTE Alarm signal processing may be used to validate alarm signals, generate alarms, reduce alarms, or prioritise alarms.

3.16

alarm signal validation

alarm signal processing function or mechanism, which determines whether an alarm signal is correctly representing a corresponding process or system status

3.17

alarm silence

action, which is made to stop an audible cue or warning associated with an alarm

3.18

alarm suppression

alarm presentation function, which switches off the illumination or prevents display of the messages of alarms with no current operational significance

NOTE The state of suppressed alarms can still be determined by other means.

3.19

alarm system

system designed to alert the operators to the existence of an anomaly (i.e., a system or process deviation), for which corrective action might be needed

NOTE Normally, an alarm system is an integral part of I&C systems, especially computerized I&C systems, but it may also be a separate set of equipment as found in hardwired I&C systems.

3.20

alarm threshold

process value or system state, which is used as a reference for activating an alarm signal

NOTE Also called alarm limit or alarm setpoint.

3.21

alarm tile

alarm display unit which consists of an engraved legend shown on a tile and lit from behind when its alarm condition is present

3.22

alerting

act of warning by means of visual and audible signals, which is intended to draw the operators' attention

3.23

dark-board

for alarm display, a design goal that, for normal healthy plant conditions, no alarms are shown

3.24

discrepancy indicator

display in which an indicator switch or a switch controlling an equipment item shows an illumination when the state is different from the last state ordered by that switch or shown by that switch

3.25

dynamic alarm coding

alarm display processing function or mechanism, which is used to dynamically change alarm coding (e.g. alarm presentation colour)

NOTE Lighting an alarm window with different colours in accordance with dynamically determined priorities is an example of dynamic display coding.

3.26

first-up alarm

alarm which indicates the first initiation triggering an associated set of alarms

NOTE Often used for the first signal causing the actuation of the reactor protection system or safety systems. Also known as 'first-out' alarm.

3.27

grouped alarm

alarm, which is defined as a logical combination of several alarms

NOTE Usually simple 'OR' logic is used to generate a grouped alarm. Sometimes called a 'shared alarm.'

3.28

grouping

group of alarms in terms of physical or functional properties

NOTE Laying out a group of alarms in a certain place in a distinctive manner is an example of physical grouping.

3.29

navigation

function, which supports the operators in locating the position of desired information in a VDU-based information system, and also in guiding the selection of displays

3.30

nuisance alarm

alarm which repeatedly cycles between the alarmed and cleared states and leads to control room distraction or annoyance

NOTE Also called a 'repeating alarm.'

3.31

reflash

action of flashing an alarm legend or of presenting it again with a flashing symbol on a VDU, when it has been activated again after it has cleared, or to indicate that a grouped alarm is reactivated by a new alarm

3.32

reset

alarm control function, which is used to return the alarm system to a pre-defined state by removing cleared alarms from display

3.33

ringback

alarm presentation function, which is used to indicate that an alarm condition has been cleared

3.34

standing alarm

alarm which is present and has been acknowledged

3.35

telop

short message or a symbol, often with a numerical content, presented at the foot or heading line of a VDU display to direct the user to another display or to inform the user of some information such as the number of outstanding alarms

4 Background explanations

4.1 Problems of alarm systems

Poor alarm system design is known to sometimes cause human factor problems, which may be critical to plant availability and safety. Typical human factor problems involve the following:

- omission of important alarms;
- delay in detecting important alarms;
- increased workload that may affect the performance of other operational activities;
- inattention to frequently activated alarms;
- confusion associated with the misunderstanding of the relationships between alarms and of the importance of each alarm;
- delay in presentation of alarms when the operators know a plant change has occurred, causing loss of operator belief in the integrity of the alarms.

It is known that the following are the major causes of these human factor problems:

- A large number of alarms are activated in a transient, and operators cannot acknowledge them immediately. This problem is known as ‘alarm avalanche’. In addition, many of these alarms do not necessarily possess operational value but are dependent on other alarms of higher significance.
- Nuisance alarms and standing alarms.
- Alarms activated as a direct result of normal operating conditions.
- Large numbers of alarms activated during a plant outage or due to maintenance work, or to periodic testing.
- Operating styles. In order to cope with human factors difficulties, operators tend to create their own operating styles. For instance, some operators do not try to acknowledge alarms soon after a transient. This alleviates the problem of increased workload, but may cause delay in detecting important alarms.
- Limitations of existing alarm system designs for alarm signal processing and alarm display processing.

More fundamentally, these problems can be diminished if all system designers attend to the following:

- the operational value of each alarm at a given condition is clearly defined;
- the dynamic relationships among alarms;
- the implementation of suitable alarm signal processing logic and alarm display processing methods.

A primary intention of this standard is to alleviate these human factors problems through the clear identification of the functional requirements and the recommendations on their implementation given by this standard.

Annex A shows supplementary information.