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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear power plants – Control rooms – Application of visual display units (VDUs)

Centrales nucléaires de puissance – Salles de commande – Utilisation des unités de visualisation

IEC 61772:2009

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CONTENTS

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NUCLEAR POWER PLANTS – CONTROL ROOMS – APPLICATION OF VISUAL DISPLAY UNITS (VDUs)

FOREWORD

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International Standard IEC 61772 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 1995 and constitutes a technical revision.

The main technical changes with respect to the previous edition are as follows:

– Expand the previous text to cover the use of Large Screen Displays (LSDs), to provide improved recommendations on the use of colour, and to improve the coverage of back-fit or upgrade applications.
– Provide references to relevant normative standards.
– Harmonise terminology according to SC 45A guidance.
– Cover experience of VDU systems design and use.
– Present examples of good practice, including methods of access to displays of current interest.

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

FDIS	Report on voting
45A/728/FDIS	45A/740/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- withdrawn,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 organisation of this Standard

During the work to create a standard for the design of control rooms of nuclear power plants, it became obvious that the volume of such a standard would become very large. Therefore the standard was split into one main standard (IEC 60964 with an annex) and some supplementary standards. This standard is one of the supplementary standards.

It is intended that the Standard be used by operators of NPPs (utilities), designers, systems evaluators and by licensors.

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

IEC 61772 is the third level IEC SC 45A document tackling the generic issue of use of VDUs in NPPs Main Control Room.

IEC 61772 is to be read in conjunction with IEC 60964 which is the appropriate IEC SC 45A document which provides general requirements concerning the design of Nuclear Power Plants main control rooms. IEC 61227, IEC 61771, IEC 62241 and IEC 61839 should also be read with this standard.

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 this Standard

It is important to note that this Standard establishes no additional functional requirements for safety systems.

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 – APPLICATION OF VISUAL DISPLAY UNITS (VDUs)

1 Scope and object

This International Standard supplements IEC 60964. It presents design requirements for the application of VDUs in main control rooms of nuclear power plants.

For the main control room of a nuclear power plant, IEC 60964 includes general requirements for layout, user needs and verification and validation methods and these aspects are not repeated in this standard. IEC 61227, IEC 61771, IEC 62241 and IEC 61839 should also be read with this standard.

This standard assists the designer in specifying VDU applications (including displays on individual workstations and larger displays for group-working or distant viewing) together with or instead of conventional (panel) displays by:

– stating principles to take advantage of VDU capability;
– giving examples of good practice and guiding the designer to avoid deficiencies of design.

This standard contains:

a) requirements for information needs:
   – according to information goals e.g. operation, maintenance, protection,
   – allowing for the necessary amount of space, e.g. location, arrangement,
   – using a hierarchy and/or relationships,
   – avoiding unnecessary information,
   – ensuring that information is relevant,

b) requirements for good presentation such as:
   – clear and flicker-free display with suitable updating frequency,
   – enough display space and an optimal arrangement,
   – adequate format and symbol sizes,
   – pictorial, symbolic display in addition to alpha-numeric capacity,
   – standardized, common symbols and names,
   – arrangements oriented to human factor needs, e.g. population stereotypes,
   – use of grouping and coding methods,
   – use of consistent flow directions,
   – appropriate abstraction levels according to the needs of the different presumed users,
c) methods for easy and quick access to the specific information of current interest:
   – by simple selection of single formats or format-sets according to information goals,
   – by using different kinds of menus (icons of neighbouring information) or other access techniques (last display, selection on screen, etc.) by soft keys on or off the VDU screens or cursors,
   – by using programmed presentation (triggered by any binary signal, such as an alarm),
d) design criteria to obtain appropriate reliability of all functions necessary to achieve the specified information goals.

This standard is intended for application to the design of new main control rooms in nuclear power plants designed to IEC 60964 and where this is initiated after the publication of this standard. If it is to be applied to existing control rooms or control areas designs, care should be taken as some assumptions made (such as automation level) may not apply.

Where a deviation from this standard is necessary in a back-fitting application the reasons should be documented.

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 60964:2009, *Nuclear power plants – Control rooms - Design*

IEC 61226:2005, *Nuclear power plants – Instrumentation and control systems important to safety – Classification of instrumentation and control functions*

IEC 61227:2008, *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 61839:2000, *Nuclear power plants – Design of control rooms – Functional analysis and assignment*

IEC 62241:2004, *Nuclear power plants – Main control room – Alarm functions and presentation*

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

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

3 Terms, definitions and abbreviations

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

3.1
associated information
additional, or helpful information complementary to the main display content of a single format or a format-set. The existence of this additional capability of display may be indicated by certain icons (navigation targets, as integrated parts of the displayed information) and their selection will lead to the display of single formats or pictorial menus or, where suitable, alpha-numeric menus

3.2
Large Screen Display (LSD)
any form of larger display intended for group viewing, shared tasks, monitoring at a distance, etc.

3.3
navigation targets
areas on the display screens that provide access to other displays, when a cursor or pointer is placed on the area and a suitable control action is taken

3.4
primary display
VDU display intended as the main (or one of the main) displays to facilitate the operator's main monitoring and control tasks. Primary displays need to be located more restrictively so that the operator is able to use them effectively from the working position

3.5
secondary display
VDU display filling a supportive role, such as to promote general situation awareness, group cooperation, casual monitoring when moving around the MCR, overall monitoring when not occupied with more specific tasks

3.6
touch panel
soft control which uses a position detector to detect the operator's finger pointing at the label on the VDU. Alternatively, a light pen may be used or a cursor may be moved over the VDU format to identify a label. The label may describe an item of plant or a control action.

3.7
Visual Display Unit (VDU)
type of display incorporating a screen for presenting computer-driven images

[IEC 60964]

3.8 Abbreviations

CRT: cathode ray tube

DLP: digital light processing

LCD: liquid crystal display

LSD: large-screen display

MCR: main control room

NPP: nuclear power plant

V&V: verification and validation

VDU: visual display unit

4 Design requirements

4.1 Intended purpose and application

4.1.1 General

The design process of the VDU system shall reflect the requirements of IEC 60964.

The design process shall identify the goals of the display system, e.g. safety, availability, operability.

Where a system is back-fitted to an existing plant, the extent of application of the requirements of IEC 60964 and of this standard shall be identified.

The availability requirements shall be determined from the classification of the system in accordance with IEC 61226 and IEC 61513.

The VDU system shall be designed so that operators can perform their tasks correctly and promptly. Account should be taken of the relationship between the information to be presented and any associated controls.

Consideration shall be given to control/display integration and the type of operating procedure (event based, symptom-based or state-based).

The presentation of the relevant information shall be taken into account in the choice of the kind of display to be used.

The design shall be based on ergonomic principles to ensure ease of operation and to minimize operator errors, both of intention and execution.

As the information displayed on VDUs is a major information source and contributes to the total operator workload, the display design shall minimize the workload contribution from monitoring, operation and problem solving to avoid information overload.

The design of the VDU system shall develop and document a clear definition of the intended purpose of the displays, their safety role and their basic performance requirements.

The following factors have great influence on the necessary extent, structure and capabilities of the entire system:

– new design or back-fitting application,
– safety, non-safety or legal licensing relevance,
– extent of plant automation,
– capabilities and needs of the main users,
– display only, or integrated soft controls.

The system may be provided in one step or in several steps according to funding, time limits, increased experience or changes in the state of the art of hardware and software, and changes in philosophies which might affect the role of the operators.

Some aspects of enhanced VDU-based displays are given in Annex A of this standard.

This standard offers broad guidance, but when the project needs to go into more detail, a set of specific design and style guides shall be established. To do so, this standard also provides directions to ensure that the project specific guidance can provide a consistent design across displays, systems and old/new equipment.

4.1.2 Number and location of displays

Typically, one of the first design decisions is the overall control-room configuration, i.e.:

– number and location of computer workstations and their hardware such as VDUs, keyboards,
– number and location of other hardware items such as alarms and controls.

In order to minimize late changes of the design, an early analysis of operator tasks should include the following tasks:

– analysing the information to be presented to the operators,
– obtaining input from operating crews.

For new plant designs the following should be included in the design team:

– staff with operating experience from previous plants,
– staff with operating experience from similar designs,
– representative future operators.

Determining the appropriate amount of display area should include consideration of:

– the information that will be needed at one time by the operators,
– the arrangement of information within display pages,
– the arrangement of pages within the display network,
– the means used to access the information.

The coordination of activities among crew members should be taken into account.

4.1.3 Placement to avoid daylight and lighting problems

The overall requirements and guidance given in the general control room design basis are relevant.

The major lighting problem is to supply enough light to illuminate printed and written material without illuminating the display screens (and LSDs) and undesirably reducing screen contrast.

In general, the overall lighting in the control room should be indirect and somewhat diffuse.

The room décor and colours of furnishing are important in determining the overall appearance of the workspace.

Architectural-surface reflectance should support diffuse lighting while not creating too much reduction of contrast on VDUs and LSDs.

The lighting scheme and choice of luminaires should be integrated with the rest of the design process.

The lighting scheme and choice of luminaires should not be handled piecemeal or in isolation.

Each new light-source or bright surface that is added into a control-room can potentially cause a variety of problems. For example:

– unplanned supplementary illumination can cause glare or reflections from VDU screens;
– unplanned general lighting can cast “waste light” or scattered light onto LSDs, reducing:
  – contrast,
  – colour-saturation,
  – readability.

Note that projection-screens with lower gain are more prone to cause the above problems than screens with higher gain.

Windows that admit daylight are especially problematic for LSDs.

Light distribution may need to be carefully controlled.

Front-projectors should be positioned so that they do not cause glare or reflections on operator workstation displays.

Care should be taken with colours in relation to room lighting conditions. Note that:

– unsaturated colours are difficult to discriminate in bright room light,
– similar colours are hard to distinguish in dim room-lighting.

Luminaires should have neutral colour rendering.

Coloured ambient illumination should not be used if colour-coding is used in the control-room.

Lamp-types with poor colour-rendering should not be used.

If the control-room has emergency lighting that may be used while operators continue to use displays, then this also should have good colour-rendering

4.2 Principal users

The principal users of each group of VDUs shall be identified as part of the definition of design requirements. These may be the reactor or other plant operators, the operation supervisor, maintenance staff or management. In the case of LSDs, there may be different users or groups of users situated in different areas of the MCR.

The level of understanding of the displayed information shall be primarily related to main control room operators' mental capabilities and the formats shall be produced with their fullest co-operation from the outset. This is because operators in the main control room normally are the principal users of the information system at NPPs in normal, disturbed and accident situations. They are the only personnel always present and in charge.

In addition to the basic information, a more concentrated and abstract display of information shall be given to shift leaders, safety engineers and, according to utility practice, other on-site and off-site advisors to the control room staff. These may be concerned with the analysis and strategic decision-making in longer lasting, complex situations. Such a display format is also a suitable candidate for LSD when one of its identified functions is to maintain situation awareness and promote group cooperation.

The design targets should be to enhance the operators' role towards that of a safety and performance optimizer, by exploiting and supporting the mental capacity and expert knowledge of the operator.

Experience of display use on nuclear plants shows that operating and maintenance staff need access to all plant information, both direct and derived, within the workstation's VDU display system, and that this should include specific facilities to allow display of information on:

– logic control algorithms,
– trip setpoints,
– alarm thresholds,
– signal scale factors,
– input assignment,

and other characteristics of the system used to define the performance of the display application. This facility is of specific value during plant commissioning and for the confirmation of modifications.