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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Warning equipment for criticality accidents

Instrumentation pour la radioprotection – Equipement de signalisation des accidents de criticité

IEC 60860:2014-06(en-fr)

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FOREWORD

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International Standard IEC 60860 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition issued in 1987. It constitutes a technical revision.

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

– reference to IEC 61508 concerning the safety classification;
– introducing requirement for the alarm sound level (90 dBA and 115 dBA at a distance of 1 m from the alarm source);
– energy response requirement changes from (–35 %, +35 %) to (–35 %, +50 %);
– time period of 1 min is specified for the overload requirement (1 kGy·h^{-1} during a period of at least 1 min);
– updated EMC, mechanical and environmental requirements according to IEC 62706.

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

FDIS	Report on voting
45B/791/FDIS	45B/794/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 stability 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- withdrawn,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.

RADIATION PROTECTION INSTRUMENTATION – WARNING EQUIPMENT FOR CRITICALITY ACCIDENTS

1 Scope and object

This International Standard applies to equipment intended to provide warning of a criticality accident by the detection of gamma radiation, neutrons or both from such an event.

This standard is primarily intended to apply to equipment design and, therefore, does not address the need for placement of such equipment. The need for criticality alarm systems and the utilisation procedures are described in ISO 7753 and ISO 11320.

The primary purpose of the criticality alarm system is to detect radiation from criticality accidents and warn personnel. Suitable alarms shall be provided so that personnel present in the area involved and in adjacent effected areas (often the complete facility) can be warned in the event of a criticality accident occurring. These alarms are intended to activate an evacuation alarm to reduce the probability of serious exposure to personnel.

Such systems may also have secondary functions, such as providing a follow-up measurement of the radiation level during the accident. The systems should only be used for these secondary functions, provided that the secondary functions have no adverse effect on the criticality alarms and their essential characteristics (for example, reliability) described in this standard.

The object of this standard is to prescribe general, radiation detection, environmental, mechanical, electromagnetic and documentation requirements and to specify acceptance criteria for criticality accident warning equipment.

This standard is not applicable to photon or neutron dose equivalent (rate) meters or monitors covered by IEC 60532, IEC 60846 (all parts), IEC 61017 (all parts), and IEC 61005. This standard is not applicable either to equipment or assemblies used in control and safety systems of nuclear reactors.

2 Normative references

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.

IEC 60050 (all parts): *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 62706, *Radiation protection instrumentation – Environmental, electromagnetic and mechanical performance requirements*

ISO 7753:1987, *Nuclear energy – Performance and testing requirements for criticality detection and alarm systems*

International Bureau of Weights and Measures: *The International System of Units, 8th edition, 2006*

3 Terms and definitions, quantities and units

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in IEC 60050-395 apply.

3.1.1
acceptance test
contractual test to prove to the customer that the device fulfils certain specifications

3.1.2
alarm
method for notification of a criticality accident

3.1.3
alarm set point
minimum radiation dose and/or dose rate that will activate the alarm

3.1.4
conventional quantity value (dose)
quantity value attributed by agreement to a quantity for a given purpose

Note 1 to entry: The term “conventional true quantity value” is sometimes used for this concept, but its use is discouraged.

Note 2 to entry: Sometimes a conventional quantity value is an estimate of a true quantity value.

Note 3 to entry: A conventional quantity value is generally accepted as being associated with a suitably small measurement uncertainty, which might be zero.

Note 4 to entry: In this standard the quantity is the dose.

[SOURCE: VIM:2007, 2.12]

3.1.5
criticality accident
release of energy as a result of an accidentally produced self-sustained or divergent neutron chain reaction

3.1.6
criticality alarm system
all parts of the assembly, subassemblies, functional units and components that together make a workable system, including all circuitry, alarms, connections, cables, detectors, and auxiliary subassemblies. The criticality alarm system comprises at least the following subassemblies:

– detection subassembly, including associated electronics;
– warning subassembly including the logic unit and alarm unit

3.1.7
false alarm
activation of the alarm signal in the absence of a criticality accident

3.1.8
type test
conformity test made on one or more items representative of the production

3.2 Quantities and units

In the present standard, units of the International System (SI) are used[1]. The definitions of radiation quantities are given in IEC 60050-395. The corresponding old units (non-SI) are indicated in brackets.

Nevertheless, the following units may also be used:

– for energy: electron-volt (symbol: eV), 1 eV = 1,602 × 10^{-19} J;

– for time: hour (symbol: h) or minute (symbol: min).

4 General requirements

4.1 General characteristics

Criticality alarm systems are designed for the automatic and prompt detection of gamma radiation or neutrons from a criticality accident and to actuate immediate evacuation and warning alarms. The primary functions of the criticality alarm system shall be to:

– detect a criticality accident as soon as it occurs within the monitoring zone of the detector(s);

– actuate an alarm with minimal delay;

– achieve a high degree of reliability required by its safety classification and low probability of false alarm;

– fail safe by design and reveal failures (single failure shall be indicated but shall not disable the system and result in a potential non-detection of a criticality accident);

– be secured against unauthorised adjustment.

Secondary functions of the criticality alarm system should be established by agreement between the manufacturer and user. A recommended secondary function should include the ability to measure radiation levels during and following a criticality accident.

It shall be possible to test the response and performance of the criticality alarm system without causing personnel evacuation.

4.2 Detection criterion

The following detection criterion definition described in ISO 7753 is used. Criticality alarm systems shall be designed to detect promptly the minimum accident of concern. For this purpose, in typical unshielded process areas, the minimum accident may be assumed to deliver an equivalent absorbed neutron and gamma dose in free air of 0,2 Gy at a distance of 2 m from the reacting material within 60 s. Very slowly increasing excursions, while unlikely to occur, may not attain this value. Furthermore, excursions in unmoderated systems will probably occur much more rapidly.

In the design of radiation detectors, it may be assumed that the minimum duration of the radiation transient is 1 ms FWHM (Full Width Half Maximum). The criticality alarm system shall be designed so that instrument response and latched alarm occur as a result of transients of such duration.

4.3 Safety classification

The equipment covered in this standard may be installed in facilities such as nuclear fuel storages and processing sites.

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1 International Bureau of Weights and Measures: The International System of Units, 8th edition, 2006.

The basic safety standard IEC 61508 applies. The SIL (Safety Integrity Level) specification for equipment shall be SIL1 as a minimum. The requirement for higher SIL specification (SIL2-4) shall be agreed between manufacturer and purchaser. Compliance with IEC 61513 will facilitate consistency with the requirements of IEC 61508 as they have been interpreted for the nuclear industry.

4.4 False alarms

Particular consideration shall be given, during the design of the criticality alarm system, to minimize false alarms.

A redundant system, requiring response from at least two detector channels out of three (2OO3) is one of the methods used in minimising false alarms. If a redundant system is used, alarm or failure of any single channel shall not activate the alarm or render the criticality alarm system inoperative. A warning signal of a detected malfunction shall be provided in this case and the system shall continue to operate as a one out of two (1OO2) redundant system using the remaining healthy channels.

The maintenance requirements shall be kept to the minimum practicable and the equipment shall be designed to facilitate maintenance without causing false alarms.

4.5 Failure of components

For all criticality alarm systems, it is recommended that a failure modes and effects analysis (FMEA) in accordance with IEC 60812 is carried out to identify any potential failure modes, their causes and the effects on system performance. This will assist in the development of the design, and identify areas requiring modification or design improvement for mitigation against failure modes.

Failure of components which would directly affect the detection and warning capability of the criticality alarm system shall be designed to fail safe and reveal failures by visual and/or audible indication.

A revealed failure shall result in corrective action being immediately taken to return the system to full operational state. To avoid loss of confidence and disruption of work, warnings of instrument failure should be distinguishable, whenever possible, from warnings due to genuine radiological hazards.

4.6 Ease of decontamination

The assemblies shall be designed in such a manner as to facilitate decontamination.

4.7 Multiple function systems

If the system is to be used for secondary functions in addition to criticality accident detection, it shall be designed in such a manner as not to compromise its primary purpose of criticality accident detection and warning.

4.8 Interconnection cables and connectors

4.8.1 Interconnecting cables

The criticality alarm system shall include a device for self-verification to determine complete operability with its installed interconnecting cables. These cables shall be protected from spurious signals which could activate the warning subassembly or render the assembly inoperative.

4.8.2 Connectors

Cable connectors shall be mechanically secured.

4.9 Reliability

All assemblies shall be designed to the standard of reliability defined by the specified SIL (Safety Integrity Level), i.e. the Probability of Failure on Demand (PFD). The manufacturer shall specify the period between proof tests, when operational in the facility which is required to meet the specified SIL(PFD). The manufacturer shall specify the periods between the necessary maintenance operations, and provide full maintenance procedures. The maintenance requirements shall be kept to the minimum practicable.

4.10 Functional testing

It is recommended that individual subassemblies and units are capable of being functionally tested without being removed from the criticality alarm system.

4.11 Interchangeability

It is recommended that all subassemblies and units of similar function such as detectors, readout and display units, and power supplies be of modular construction enabling easy replacement of these items.

4.12 Detection subassembly

A detection subassembly refers to the equipment by which the radiation from a criticality accident is detected, and may consist of more than one radiation detector and auxiliary circuits. A detection subassembly shall:

– have suitable response to gamma radiation, neutrons or both produced by a criticality accident (see Clause 6);
– not be inhibited by gamma and/or neutron overload dose (see overload characteristics, 6.6).

4.13 Logic unit for signal treatment

This unit processes the information originating from the detection assemblies concerning gamma and/or neutron radiation. Failure of any one detector or any one component of the logic unit shall not result in the failure of the criticality alarm system.

A means shall be provided to check the proper functioning of each detector channel at any time without compromising the criticality alarm system or causing an evacuation.

4.14 Alarm signals unit

4.14.1 Alarm signals

Audible alarm signals shall be of distinctive tone, the acceptable level shall be established between the manufacturer and user, and shall give a clear warning above background noise. The sound level shall be between 90 dBA and 115 dBA at a distance of 1 m from the alarm source. The audible and visual alarms shall be continuous until manually reset. Manual activation means may also be provided, but with limited access. Manual reset should be external to the area to be evacuated. Automatic reset after a pre-defined period could be possible if this does not decrease the reliability of the system.

In areas with high background noise or required hearing protection, visual alarm signals or other alarm means should be considered in addition to those stated above.