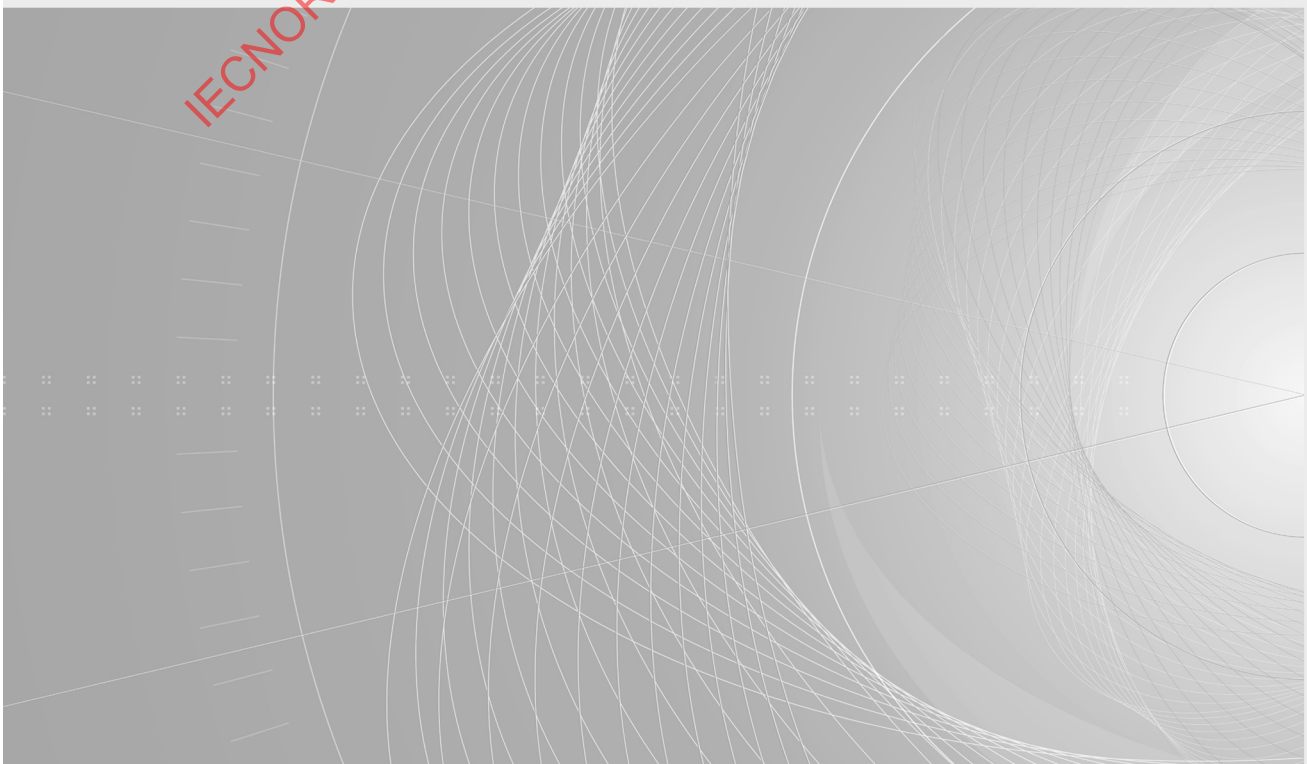
IEC 61031

Edition 2.0 2020-07

INTERNATIONAL STANDARD

Nuclear facilities – Instrumentation and control systems – Design, location and application criteria for installed area gamma radiation dose rate monitoring equipment for use during normal operation and anticipated operational occurrences



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Nuclear facilities – Instrumentation and control systems – Design, location and application criteria for installed area gamma radiation dose rate monitoring equipment for use during normal operation and anticipated operational occurrences

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CONTENTS

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NUCLEAR FACILITIES – INSTRUMENTATION AND CONTROL SYSTEMS – DESIGN, LOCATION AND APPLICATION CRITERIA FOR INSTALLED AREA GAMMA RADIATION DOSE RATE MONITORING EQUIPMENT FOR USE DURING NORMAL OPERATION AND ANTICIPATED OPERATIONAL OCCURRENCES

FOREWORD

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International Standard IEC 61031 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This document is to be used in conjunction with IEC 60532:2010.

This second edition cancels and replaces the first edition published in 1990. This edition constitutes a technical revision.

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

a) The scope of the standard is extended from nuclear power plants to nuclear facilities and the title is accordingly aligned.
b) The relevant standards published by IEC SC 45A since the publication of the first edition are taken into account and refered to when relevant.

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

FDIS	Report on voting
45A/1328/FDIS	45A/1341/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.

INTRODUCTION

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

This IEC standard specifically focuses on radiation monitoring systems used for normal operation and anticipated operational occurrences in nuclear facilities such as nuclear power plants.

This document is intended for use by purchasers in developing specifications for their plant specific radiation monitoring systems and by manufacturers to identify needed product characteristics when developing systems for normal operation and anticipated operational occurrences. Some specific instrument characteristics such as measurement range, required energy response, and ambient environment requirements will depend upon the specific application. In such cases guidance is provided on determining the specific requirements, but specific requirements themselves are not stated.

This document is intended to be used in conjunction with IEC 60532:2010.

For area gamma radiation dose rate monitoring equipment for accident and post-accident conditions refer to IEC 60951-1 and IEC 60951-3 (not within the scope of this document).

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

IEC 61031 is at the third level in the hierarchy of SC 45A standards.

This document provides requirements for equipment for area radiation monitoring in normal conditions in conjunction with IEC 60532. Other standards developed by SC 45A and SC 45B provide guidance on instruments used for monitoring radiation as part of normal operations.

The IEC 60761 series provides requirements for equipment for continuous off-line monitoring of radioactivity in gaseous effluents in normal conditions. IEC 60861 provides requirements for equipment for continuous off-line monitoring of radioactivity in liquid effluents in normal conditions. IEC 60768 provides requirements for equipment for continuous in-line and on-line monitoring of radioactivity in process stream in normal and incident conditions. Finally, ISO 2889 gives guidance on gas and particulate sampling. In addition, IEC 62705 was issued on July 2014. IEC 62705 provides guidance on the application of existing IEC/ISO standards covering design and qualification of system and equipment for RMS, and the overviews of the standards covering the radiation monitoring in nuclear facilities are listed in Table 1 below.

Table 1 – Overview of the standards covering the domain of radiation monitoring in nuclear facilities

Developer	ISO		IEC		
			SC 45A		SC 45B
Scope	Sampling	Calibration	Accident and post accident conditions	Normal conditions	
Radioactive noble gas off-line monitoring	ISO 2889	ISO 4037-1, ISO 4037-3	IEC 60951-1, IEC 60951-2	N/A	IEC 62302, IEC 60761-1, IEC 60761-3
Radioactive aerosol off-line monitoring	ISO 2889	ISO 4037-1, ISO 4037-3	IEC 60951-1, IEC 60951-2	N/A	IEC 60761-1, IEC 60761-2
Radioactive iodine off-line monitoring	ISO 2889	ISO 4037-1, ISO 4037-3	IEC 60951-1, IEC 60951-2	N/A	IEC 60761-1, IEC 60761-4
Liquid off-line monitoring	N/A	N/A	N/A	N/A	IEC 60861
Tritium off-line monitoring	N/A	N/A	N/A	N/A	IEC 62303 / IEC 60761-1, IEC 60761-5
On-line or in-line monitoring	N/A	ISO 4037-1, ISO 4037-3	IEC 60951-1, IEC 60951-4	IEC 60768	N/A
Area monitoring	N/A	ISO 4037-1, ISO 4037-3	IEC 60951-1, IEC 60951-3	IEC 61031	IEC 60532
Centralized system	N/A	N/A	IEC 61504, IEC 60960		IEC 61559-1
Classification/basic requirements	N/A	N/A	IEC 61513, IEC 60880, IEC 60987, IEC 61226, IEC 62138, IEC 62566, IEC 62645, IEC 61250 IEC 61500, IEC 61504		N/A
Qualification	N/A	N/A	IEC 60980, IEC 62003, IEC/IEEE 60780-323		IEC 62706

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 document establishes no additional functional requirements for safety systems.

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-3 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, regarding control rooms, IEC 60964 is the entry document for the IEC/SC 45A control rooms standards and IEC 62342 is the entry document for the IEC/SC 45A 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 The 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.

NUCLEAR FACILITIES – INSTRUMENTATION AND CONTROL SYSTEMS – DESIGN, LOCATION AND APPLICATION CRITERIA FOR INSTALLED AREA GAMMA RADIATION DOSE RATE MONITORING EQUIPMENT FOR USE DURING NORMAL OPERATION AND ANTICIPATED OPERATIONAL OCCURRENCES

1 Scope

This document applies to the design, location and application of installed equipment for monitoring local gamma radiation dose rates within nuclear facilities during normal operation and anticipated operational occurrences. High range area gamma radiation dose rate monitoring equipment for accident conditions currently addressed by IEC 60951-1 and IEC 60951-3 is not within the scope of this document.

This document does not apply to the measurement of neutron dose rate. Additional equipment for neutron monitoring may be required, depending on the plant design, if the neutron dose rate makes a substantial contribution to the total dose equivalent to personnel.

This document provides guidelines for the design principles, the location, the application, the calibration, the operation, and the testing of installed equipment for continuously monitoring local gamma radiation dose rates in nuclear facilities under normal operation conditions and anticipated operational occurrences. These instruments are normally referred to as area radiation monitors. Portable instruments are also used for this purpose but are not covered by this document.

Radiation monitors utilized in area radiation monitoring equipment are addressed in IEC 60532. As discussed in IEC 60532, measurement of gamma radiation may be expressed by a number of alternative quantities depending on national regulations. However, for this type of instrument, the most likely quantity to be measured is the air kerma (Gy), or the ambient dose equivalent H*(10)(Sv).

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 60050-395:2014, *International Electrotechnical Vocabulary – Part 395: Nuclear instrumentation: Physical phenomena, basic concepts, instruments, systems, equipment and detectors*

IEC 60532:2010, *Radiation protection instrumentation – Installed dose rate meters, warning assemblies and monitors – X and gamma radiation of energy between 50 keV and 7 MeV*

IEC 60880:2006, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category A functions*

IEC 60951-1:2009, *Nuclear power plants – Instrumentation important to safety – Radiation monitoring for accident and post-accident conditions – Part 1: General requirements*

IEC 60951-3:2009, *Nuclear power plants – Instrumentation important to safety – Radiation monitoring for accident and post-accident conditions – Part 3: Equipment for continuous high range area gamma monitoring*

IEC 60980:1989, *Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generating stations*

IEC 60987:2007, *Nuclear power plants – Instrumentation and control important to safety – Hardware design requirements for computer-based systems*

IEC 61226:2009, *Nuclear power plants – Instrumentation and control important to safety – Classification of instrumentation and control functions*

IEC 61513:2011, *Nuclear power plants – Instrumentation and control important to safety – General requirements for systems*

IEC 62003:2020, *Nuclear power plants – Instrumentation, control and electrical power systems – Requirements for electromagnetic compatibility testing*

IEC 62138:2018, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category B or C functions*

IEC 62566:2012, *Nuclear power plants – Instrumentation and control important to safety – Development of HDL-programmed integrated circuits for systems performing category A functions*

IEC 62705:2014, *Nuclear power plants – Instrumentation and control important to safety – Radiation monitoring systems (RMS): Characteristics and lifecycle*

IEC/IEEE 60780-323:2016, *Nuclear facilities – Electrical equipment important to safety – Qualification*

3 Terms and definitions

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

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

NOTE Specific terminology for the radiation monitoring system is given in IEC 62705 and specific terminology for the area radiation monitor is given in IEC 60532

3.1
anticipated operational occurrence
deviation of an operational process from normal operation that is expected to occur at least once during the operating lifetime of a facility but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions

[SOURCE: IAEA Safety Glossary, 2018 edition]

3.2
area radiation monitor
equipment designed for continuously monitoring local gamma radiation dose rates in a fixed position in a nuclear facility

Note 1 to entry: The equipment usually consists of a gamma radiation sensitive detector, a signal processing unit, interconnecting cables for signal transmission and a power supply. It is used to measure and display, locally and/or at some remote location, the radiation dose rate present at the detector location.

3.3
calibration check
calibration procedure which is followed periodically on each area radiation monitor to ensure that the response of the equipment remains within specified limits

3.4
local dose rate
dose rate at the detector location measured in whatever radiation dose rate quantity approved under national regulations and displayed on the instrument in appropriate units

Note 1 to entry: See also IEC 60532.

3.5
normal operation
operation within specified operational limits and conditions

[SOURCE: IAEA Safety Glossary, 2018 edition]

4 Abbreviated terms

EMC	Electromagnetic Compatibility
HPD	HDL (hardware description language) – Programmed Device
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KERMA	Kinetic Energy Released per unit MAss
NPP	Nuclear Power Plant
NSLR	National Standardizing Laboratory of a country for Radioactivity measurement
RMS	Radiation Monitoring System

5 Design principles

5.1 Function and application criteria

The primary purpose of area radiation monitors is to protect personnel by alerting them to significant changes in radiation levels. To this end, the monitors measure continuously the gamma radiation dose rate in defined areas of a nuclear facility, and inform plant personnel by audible and/or visual alarms when predetermined dose rate levels are exceeded. Items such as meters, displays and alarm indicators, etc., shall be designed so that plant personnel in the vicinity of the local indication devices can quickly and easily determine the conditions in the areas monitored.

Area radiation monitors serve to protect plant personnel against radiation hazards and to inform them immediately when predetermined radiation levels are exceeded within the plant.

NOTE Area radiation monitors are not normally used for personnel dosimetry purposes, except as a source of backup information, nor are they normally used for the determination of the length of time which personnel are permitted to remain within radiation fields. They complement rather than replace operational health physics measurements and procedures including use of portable equipment. Nevertheless, they can also provide information on the effectiveness of such procedures.

Because of their location, area radiation monitors may also be capable of indicating changes in plant parameters which are of interest to the plant operator. Where this is the case, monitor output functions shall be available at a remote location, usually the plant control room or an associated area.

Area radiation monitors may also be used for interlocks and/or for initiating protective actions. In some cases, they may even be considered as inputs to reactor safety systems, although this would not normally be regarded as good practice.

Area radiation monitors may also be used under accident conditions if the range of measurement is appropriate to the defined purpose and all sub-assemblies are qualified for the accident environmental conditions at their locations. This application is covered in more detail in IEC 60951-1 and IEC 60951-3.

5.2 General requirements

5.2.1 General characteristics and lifecycle

The design of the area radiation monitor shall meet the requirements of IEC 60532. Furthermore, the additional specific requirements given in IEC 61031 shall be met.

If signals from area radiation monitors are used as inputs to interlock systems or plant and/or reactor safety systems, the design of such monitors shall also meet the appropriate requirements of such systems (for example, in respect to interface requirements, classification, reliability, qualification, etc.).

In the selection of the area radiation monitor, consideration shall be given to the range of measurement, temperature, pressure, humidity, electromagnetic interference, vibration, expected total integrated dose and seismic qualification in the areas where the equipment and in particular the detector will be located. Any requirements to extend the normal environmental specifications shall be identified (see IEC 60532).

The area radiation monitor performing functions that are important to safety shall comply with the requirements relating to the characteristics and lifecycle of RMSs defined in IEC 62705 and the standards referenced in IEC 62705 (e.g. IEC 61226).

5.2.2 Safety classification and applicable standards

The area radiation monitor shall be classified according to its suitability to implement I&C functions up to a defined category during the system specification phase as shown in IEC 61513:2011, 6.2.3.

According to the category of the function implemented, the following standards shall be applied:

a) System and equipment performing category A functions

Any software in the area radiation monitor performing category A function shall be designed and maintained in accordance with IEC 60880. Any HDL-Programmed Device (HPD) in the equipment of the area radiation monitor performing category A function shall be designed and maintained in accordance with IEC 62566. Any hardware in the area radiation monitor performing category A function and including software or HPD shall be designed and maintained in accordance with IEC 60987.

b) System and equipment performing category B or C functions

Any software in the area radiation monitor performing category B or C function shall be designed and maintained in accordance with IEC 62138. Any hardware in the area radiation monitor performing category B function and including software shall be designed and maintained in accordance with IEC 60987. Hardware performing category C function in the area radiation monitor shall be designed, selected and maintained according to the supplier's requirements.

5.3 Range of measurements

The required area radiation monitoring range shall be specified as agreed between manufacturer and purchaser. These ranges shall take into account the radiation environment of the plant design on the basis of:

– the expected minimum gamma radiation dose rate and whether it is desirable to monitor that rate,

– the expected dose rate in normal operating conditions, and

– the expected peak dose rate under anticipated operational occurrences.

The measuring range shall normally be high enough to assure an on-scale reading for radiation dose rates up to the expected peak dose rate under anticipated operational occurrences. However, when high transient dose rates occur in areas during periods when personnel access is prevented, it may not be necessary to meet this requirement. In order to avoid false dose rate indication in this situation, the radiation monitoring system shall comply with the overload testing specified in IEC 60532.

In the event of a high transient dose rate, the instrument shall maintain on over-range indication and alarm status. It is necessary to avoid "foldback" of the detector. "Foldback" is shown in Annex B.

Unless otherwise specified, the area radiation monitor shall at least cover the measuring range of 10^{-5} Gy/h or Sv/h to 10^{-2} Gy/h or Sv/h. It is expected that, in most applications, a measuring range of four or five decades will be used (see Annex A). Six or more decades may be required for some special applications.

Examples of ranges of measurement of area radiation monitors in boiling and pressurized light water reactors, gas cooled reactors and sodium cooled fast reactors are given in Annex A.

5.4 Location criteria

5.4.1 General

Location criteria and safety requirements for area radiation monitors shall be appropriate to the plant design.

Generally, they will be required at those locations which can be routinely entered by plant personnel and where one or more of the following plant conditions are identified:

a) where the dose rates are significant and may increase rapidly and without other indication;

b) where the radiation dose rate can increase sufficiently to require evacuation of personnel;

c) where occasional high radiation dose rates might preclude access at certain times;

d) where the dose rate data is required prior to personnel access;

e) where the dose rate can rapidly increase due to external operation of the controls by others.

In addition, area radiation monitors may be required at locations such as access routes and plant areas where access is essential under accident conditions.

Examples of locations of area radiation monitors in different types of nuclear facilities are given in Annex A.

Area radiation monitors will normally be required to monitor the local radiation dose rate inside a containment building where personnel access is possible. The detector location will normally be immediately inside all entrances (personnel and equipment locks) and other locations, where regular access is required.

Because periodic calibration and maintenance of area radiation monitors generally require access to the detector assembly in order to expose it to an appropriate radiation field, care shall be taken in choosing the location of this assembly so as to facilitate introduction of a suitable radiation source or field generator and to minimize radiation scatter as well as access problems to the equipment to be calibrated.

The detector location shall be chosen, as far as is consistent with the required monitor function, in order to avoid adverse environmental conditions and significant levels of electromagnetic interference.

Depending on the technical solution chosen (i.e. ionization chamber detectors, scintillation detector) one important location criteria should also be (to the extent possible) to minimize the required cabling length between the detector assembly and the processing assembly.

5.4.2 Detector assembly

The radiation detector assembly shall be located so that the radiation dose rate which is measured is representative of the radiation dose rate to personnel in the monitored area (e.g. the location of the detector assembly shall be such that inadvertent shielding by structural material is minimized). Mounting of the detector assembly shall be realized such, that the preferential direction of the detector is oriented to the area to be monitored.

5.4.3 Processing assembly

The location of the processing assembly shall be chosen to be compatible with its maximum withstand total integrated dose without failure.

5.4.4 Alarm assembly

The alarm assembly location shall be chosen to provide as far as possible warning to operators before they enter a high radiation area (e.g. outside the entrance to the containment building or enclosed areas). Audible and visible alarm assemblies shall be located to warn personnel who may be in areas of high radiation dose rate and personnel who may be approaching such areas.

In some circumstances, it may be appropriate to use either audible or visible alarms alone.

5.5 Energy response

The radiation area monitor shall measure the dose rate due to gamma rays of the energy range of at least 80 keV to 1,5 MeV according to IEC 60532.

If more than 20 % of the local gamma radiation dose rate to be measured is due to gamma radiation having an energy less than 80 keV or more than 1,5 MeV (e.g. gamma radiation of the isotopes ^{16}N and/or ^{88}Kr), the effective response of the monitor shall be extended to cover the appropriate photon energy.

5.6 Signal processing and display

Area radiation monitors inform and warn personnel in working areas and in the control room or other locations about the gamma radiation level (and its variation) within the plant. Therefore, appropriate output signals for remote display, data processing, recording and alarm annunciation shall be provided and agreed between manufacturer and purchaser.

5.7 Power supply

Area radiation monitors are generally powered from high integrity (battery backed) power supply systems which may be subject to short transient breaks of supply covered by the monitor specification in IEC 60532. Those requirements are not necessarily applicable to additional alarms and displays for which the requirements shall be agreed.

6 Functional test

Except where otherwise specified, all the function tests specified in IEC 60532:2010, Clause 5 and Clause 6, shall be carried out. Tests described in Clause 6 are to be considered as type test, although any or all may be considered as acceptance tests by agreement between manufacturer and purchaser. Other tests (e.g. environmental, seismic, or EMC) shall be performed according to the requirements shown in Clause 7.

Area radiation monitors shall be designed and installed so that it is possible to check prior to use and at regular intervals that they are functioning in accordance with their specified performance. Design features shall be incorporated to facilitate the required calibration (8.2.3) and routine functional tests (8.2.4) and any other testing to meet requirements defined to ensure the safety function of the monitors.

7 Qualification

7.1 General

The qualification envelope of the equipment of the radiation area monitor shall comply with the environmental requirements of the installed location in the nuclear facility. The justification shall be done to show the compliance between the qualification envelope of the equipment of the area radiation monitor and the environmental requirements of the installed location in the nuclear facility. The following qualification requirements supersede the qualification requirements defined in IEC 60532.

7.2 Environmental qualification

The area radiation monitor shall maintain the specified accuracy and performance for the range of the environmental conditions at the equipment locations during normal plant operations. The environmental qualification for the area radiation monitor shall be performed in accordance with IEC/IEEE 60780-323 for the equipment performing category A or B functions.

The equipment of the radiation area monitor performing category C functions only shall be qualified based on the characteristics requirements IEC 60532:2010, 7.4. Where claims are made for operation in abnormal environmental conditions to the requirements of IEC 60532:2010, 7.4, the qualification results shall be justified by documentary evidence. Where significant ageing factors exist, and when qualified life cannot be demonstrated in accordance with the definition given in IEC/IEEE 60780-323, an on-going qualification program shall be proposed and justified compliant with IEC/IEEE 60780-323.

7.3 Seismic qualification

The area radiation monitor shall maintain the specified accuracy and performance features either during and after the seismic event, or after the seismic event in agreement between manufacturer and purchaser. The seismic qualification shall be performed in accordance with IEC 60980 for the equipment performing category A or B functions.

The equipment performing category C functions only shall be qualified based on the characteristics requirements of IEC 60532:2010, 7.3.

7.4 Electromagnetic interference

Precautions shall be taken against the effects of electromagnetic interference either received or emitted by the equipment. Electromagnetic interference shall be evaluated in accordance with IEC 62003 in conjunction with the performance criteria of IEC 60532:2010, 7.2.

8 Calibration

8.1 General

Calibration of the radiation area monitor is performed as a part of the maintenance activities in accordance with Clause 8. The overall operation and maintenance activities for the radiation area monitor which are not specified in Clause 8 shall be performed in accordance with IEC 62705 and IEC 61513.

8.2 Calibration and functional check

8.2.1 General

The radiation area monitor shall maintain the specified accuracy and performance features during the operating period. For this purpose, calibration checks and functional checks shall be performed periodically.

8.2.2 Initial calibration

Before each area radiation monitor is installed, the initial calibration shall be carried out on the equipment of the area radiation monitor equipment according to IEC 60532:2010, Clause 5 and Clause 6. For a primary calibration, the following aspects are important:

– traceability of all results to national standard (as written in 8.3);
– testing in clearly defined, documented and repeatable geometry (to compare test results);
– test on representative sample.

8.2.3 Calibration check after installation

After the installation, calibration checks shall be performed periodically. If the radiation area monitor equipment, especially the detector assembly, cannot be removed from the installed location for the duration of the calibration period, then measures for the calibration checks shall be provided without the need to remove equipment of the radiation area monitor from the installed location.

8.2.4 Functional check

The functions of the radiation area monitor shall be checked periodically. Except where otherwise specified, the procedure of the functional check shall be established by selecting from the functional requirements in IEC 60532:2010, Clause 5 and Clause 6.

8.2.5 Countermeasures to loss of monitoring during calibration or functional check

If the loss of monitoring functions during the calibration or functional check period is not permitted, additional measures, such as alternative monitoring, shall be provided.

8.3 Radiation calibration

Radiation calibration shall be performed in accordance with IEC 60532:2010, 6.3. The quantity of radiation should be traceable to the National Standardizing Laboratory for Radioactivity measurements (NSLR) in the country in which the radiation area monitor is installed.

Radiation calibration may comprise the following procedures:

– Primary calibration: All calibration tests performed during type testing in an official and traceable National Standardizing Laboratory testing all monitor characteristics.

– Secondary calibration verification: All calibration tests realized on the series monitors using manufacturer sources, but assuring traceability to the primary calibration with all measurements achieved.

– Tertiary calibration verification: Calibrations done on site using customer sources, but assuring traceability to the primary calibration (via the secondary calibration) with all measurements achieved.

Annex A
(informative)

Examples of locations and measuring ranges of area radiation monitors

Locations and measuring ranges are dependent on the plant design and shall be reviewed for each design. The following Table A.1, Table A.2 and Table A.3 contain areas to be considered in the review of potential locations for installed gamma area radiation dose rate monitoring equipment. The corresponding ranges of measurement represent typical values of current plants, but will vary with specific plant designs and national regulations.

Table A.1 – Light water cooled reactor plants

Location	Range of measurement Gy/h or Sv/h
Refuelling platform	10^{-5} – 10^{-1}
Access lock area (inside containment)	10^{-5} – 10^{-1}
Radwaste drumming station control panel area	10^{-5} – 10^{-2}
Radioactive workshop	10^{-5} – 10^{-2}
Radiochemistry laboratory	10^{-5} – 10^{-2}
Primary sample station area	10^{-5} – 10^{-2}
Equipment decontamination area	10^{-5} – 10^{-2}
Turbine deck (for BWR only)	10^{-5} – 10^{-2}
Main access routes	10^{-5} – 10^{-2}
Irradiated fuel pools	10^{-5} – 10^{-2}
Rooms containing equipment through which primary coolant is passed	10^{-5} – 10^{-2}
Ventilation filter rooms, where these are associated with areas subject to significant primary coolant leakage	10^{-5} – 10^{-2}
Rooms or areas which may require to be occupied in incident or accident conditions	10^{-5} – 10^{-2}
Areas where radioactive waste is processed and/or handled	10^{-5} – 10^{-2}

Table A.2 – Gas cooled reactor plants

Location	Range of measurement Gy/h or Sv/h
New fuel (stringer assembly) cell	10^{-5} – 10^{-1}
Fuelling machine (outside shield)	10^{-5} – 10^{-1}
Fuelling machine maintenance area	10^{-5} – 10^{-1}
Irradiated fuel (stringer) – Dismantling cells	10^{-5} – 10^{-1} *
Fuel storage pond	10^{-5} – 10^{-1}
Fuel transport flask area	10^{-5} – 10^{-1}
Fuel stringer and control rod mechanism maintenance cells	10^{-5} – 10^{-1} [a]
Reactor pile cap (refuelling area)	10^{-5} – 10^{-1}
Radioactive source store and instrument calibration room	10^{-5} – 10^{-1}
Material test laboratory (X-ray machine area)	10^{-5} – 10^{-1}
[a] Instruments in these areas may require ranges up to 1 Gy/h.	