

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**Radiation protection instrumentation in nuclear facilities – Centralized systems for continuous monitoring of radiation and/or levels of radioactivity – Part 1: General requirements**

**Instrumentation pour la radioprotection dans les installations nucléaires – Ensembles centralisés pour la surveillance en continu des rayonnements et/ou des niveaux de radioactivité – Partie 1: Exigences générales**



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**Instrumentation pour la radioprotection dans les installations nucléaires – Ensembles centralisés pour la surveillance en continu des rayonnements et/ou des niveaux de radioactivité – Partie 1: Exigences générales**

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## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	9
2 Normative references .....	9
3 Terms, definitions and abbreviations .....	11
3.1 Terms and definitions .....	11
3.2 Test nomenclature.....	12
3.3 Abbreviated terms .....	12
4 Design requirements .....	12
4.1 General remarks.....	12
4.1.1 General .....	12
4.1.2 Safety classification.....	12
4.1.3 System configuration .....	13
4.1.4 Location of detector assemblies .....	14
4.2 Design requirements for the assemblies .....	14
4.2.1 Detector assembly.....	14
4.2.2 Processing assembly.....	14
4.2.3 Alarm assemblies .....	16
4.3 Central computer.....	17
4.3.1 General .....	17
4.3.2 Functional requirements of the central computer .....	17
4.3.3 Checking normal operation of the equipment .....	18
4.4 Electrical characteristics.....	18
4.4.1 General .....	18
4.4.2 Electromagnetic compatibility .....	19
5 General Test procedures .....	19
5.1 Test requirements .....	19
5.1.1 General .....	19
5.1.2 Test performed under standard test conditions .....	20
5.1.3 Test performed with variation of influence quantities .....	20
5.2 Test procedures for the detector assembly .....	20
5.3 Test procedures for the monitoring assembly .....	20
5.3.1 Alarm trip range.....	20
5.3.2 Equipment failure alarms .....	21
5.3.3 Alarm response time and stability .....	21
5.4 Test procedures for the central computer .....	21
5.4.1 Individual tests of access channels.....	21
5.4.2 Whole tests of access channels .....	21
5.4.3 Tests for functional validation and verification. ....	21
5.5 Test procedures for effects of power supply and environmental variations.....	22
5.5.1 Power supply variations.....	22
5.5.2 Power supply variations (interruptions and transients) .....	23
5.5.3 Surges and oscillatory waves .....	23
5.5.4 Ambient temperature and humidity .....	24
5.5.5 Electromagnetic compatibility .....	24
5.5.6 External electromagnetic immunity and electrostatic discharge.....	24

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5.5.7	Electromagnetic emission .....	24
6	Documentation .....	25
6.1	Report on type testing .....	25
6.2	Certificate .....	25
6.3	Operating and maintenance manual .....	25
Annex A (informative)	Selection of a measuring unit .....	31
Annex B (informative)	Guidance on location of detector assemblies .....	32
Bibliography	.....	34
Figure 1 – Monitoring assembly inside monitored area	.....	26
Figure 2 – Monitoring assembly outside monitored area	.....	26
Figure 3 – Centralized configuration	.....	27
Figure 4 – Centralized configuration	.....	28
Table 1 – Reference conditions and standard test conditions	.....	29
Table 2 – Tests performed under standard test conditions	.....	29
Table 3 – Tests performed with variations of influence quantities	.....	30

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## FOREWORD

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International Standard IEC 61559-1 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This standard cancels and replaces the first edition of IEC 61559 published in 1996. The document has been updated to take account of the requirements of IEC standards published since 1996. Specifically, to meet the functional safety lifecycle requirements of IEC 61508 and/or IEC 61513 have been introduced. Additionally, functional validation and verification tests have been added.

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

FDIS	Report on voting
45B/608/FDIS	45B/616/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.

A list of all parts of the IEC 61559 series can be found, under the general title *Radiation protection instrumentation in nuclear facilities – Centralized systems for continuous monitoring of radiation and/or levels of radioactivity*, on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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## INTRODUCTION

### a) Technical background, main issues and organisation of this standard

This IEC standard specifically applies to centralized systems intended for continuous monitoring of radiation and/or levels of radioactivity in nuclear facilities, primarily in support of radiological protection in the working areas. These centralized systems play an auxiliary or indirect role in the achievement or maintenance of a nuclear facility's safety. These are classified as category C in IEC 61226 since they include functions that have some safety significance.

This standard is intended for use by purchasers in developing specifications for their plant specific centralized systems radiation monitoring systems and by manufacturers to identify needed product characteristics when developing systems.

This standard is one associated with a series of standards which cover process and safety monitoring, and radiation protection and effluents monitoring in nuclear facilities. The full series is detailed in paragraph b) below.

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

IEC 60951 series of standards are at the third level in the hierarchy of SC 45A standards.

They provide guidance on the design and testing of radiation monitoring equipment used for accident and post accident conditions.

IEC 60951-1 – General requirements

IEC 60951-2 – Equipment for continuous off-line monitoring of radioactivity in gaseous effluents and ventilation air

IEC 60951-3 – Equipment for continuous high range area gamma monitoring

IEC 60951-4 – Equipment for continuous in-line or on-line monitoring of radioactivity in process stream

Other standards developed by SC 45A and SC 45B provide guidance on instruments used for monitoring radiation as part of normal operations. IEC 60761 series provide 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 requirement for equipment for continuous in-line and on-line monitoring of radioactivity in process stream in normal and incident conditions. ISO standard 2889 gives guidance on gas and particulate sampling. The relationship between these various radiation monitoring standards is given in the table below:

Developer	ISO	SC 45A – process and safety monitoring		SC 45B – radiation protection and effluents monitoring
Scope	Sampling circuits and methods	Accident and post accident conditions	Normal and incident conditions	
Gas, particulate and iodine with sampling (OFF LINE)	ISO 2889	IEC 60951-1 and -2	IEC 60761 series	
Liquid with sampling	N/A	N/A	IEC 60861	



(OFF LINE)				
Process stream (gaseous effluents, steam or liquid) without sampling (ON or IN-LINE)	N/A	IEC 60951-1 and -4	IEC 60768	N/A
Area monitoring	N/A	IEC 60951-1 and -3	IEC 60532	
Central system	N/A	IEC 61504		IEC 61559

### c) Recommendations and limitations regarding the application of this standard

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

### d) Description of the structure of the IEC SC 45A/SC 45B standard series and relationships with other IEC documents and other bodies' documents (IAEA, ISO)

The basic safety publication is IEC 61508-7, *Functional safety of electrical/electronic/programmable electronic safety-related systems*. It defines the requirements for an overall safety life-cycle framework and a system life-cycle framework. IEC 61508 should be complied with when developing instruments with safety functions for centralized systems of radiation monitoring outside the nuclear power plant sector whilst complying with the requirements defined in this standard.

#### IEC 61559-1:2009

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 nuclear power plants. 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/SC 45B 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/SC 45B 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 power plant 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 50-C/SG-Q) 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.

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# RADIATION PROTECTION INSTRUMENTATION IN NUCLEAR FACILITIES – CENTRALIZED SYSTEMS FOR CONTINUOUS MONITORING OF RADIATION AND/OR LEVELS OF RADIOACTIVITY –

## Part 1: General requirements

### 1 Scope

This part of IEC 61559 series applies to centralized systems intended for continuous monitoring of radiation and/or levels of radioactivity installed in nuclear facilities, primarily in support of radiological protection in the working areas. This standard specifies general characteristics, general test procedures, radiation, electrical, safety, and environmental characteristics and the identification certificate for the systems addressed by this standard.

More specifically, it applies to centralized data processing systems, data links, and equipment siting and layout. It also applies to indications displayed locally and centrally. It gives general guidance to the specification, operation, and testing of computers for the centralized monitoring function.

Typically these centralized systems play an auxiliary or indirect role in the achievement or maintenance of nuclear facility's safety. These are classified as category C in IEC 61226 since they include functions that have some safety significance.

It does not directly apply to the design and testing of detection and measurement assemblies. These should, wherever practical, conform to relevant IEC specifications.

This standard applies to normal monitoring functions. IEC 61559-2 applies to Requirements for Discharge, Environmental, Accident, or Post-Accident Monitoring Functions.

For Radiation monitoring equipment for accident and post-accident conditions in nuclear power plants see IEC 60951.

This standard does not apply to criticality alarm systems. These shall conform to IEC 60860.

### 2 Normative references

The following referenced documents are relevant to 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).

IEC 60038:2002, *IEC standard voltages*

IEC 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

IEC 60532:1992, *Radiation protection instrumentation – Installed dose ratemeters, warning assemblies and monitors – X and gamma radiation of energy between 50 keV and 7 MeV*

IEC 60860:1987, *Warning equipment for criticality accidents*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-12:2006, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC/TR 61000-5-1:1996, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 1: General considerations*

IEC 61000-6-4:2006, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61005:2003, *Radiation protection instrumentation – Neutron ambient dose equivalent (rate) meters*

IEC 61187:1993, *Electrical and electronic measuring equipment – Documentation*

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

IEC 61322:1994, *Radiation protection instrumentation – Installed dose equivalent rate meters, warning assemblies and monitors for neutron radiation of energy from thermal to 15 MeV*

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

IEC 61513:2001, *Nuclear power plants – Instrumentation and control for systems important to safety – General requirements for systems*

### 3 Terms, definitions and abbreviations

#### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

The general terminology concerning detection and measurement of ionizing radiation and nuclear instrumentation is given in IEC 60050-393, IEC 60050-394, and IEC 60050-151.

##### 3.1.1 Manufacturer and purchaser

###### 3.1.1.1

###### **manufacturer**

designer and seller of the equipment

###### 3.1.1.2

###### **purchaser**

user (operator) of the equipment

##### 3.1.2

###### **category C classification**

category that denotes functions that play an auxiliary or indirect role in the achievement or maintenance of NPP safety; it includes functions that have some safety significance, but are not category A or B

[IEC 61226]

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NOTE Category C denotes systems that have:

- a) functions used to prevent or mitigate a minor radioactive release, or minor degradation of fuel, within the NPP design basis,
- b) functions to warn personnel or to ensure its safety during or following events that involve or result in release of radioactivity in the NPP, or risk of radiation exposure.

##### 3.1.3

###### **detector assembly (DA)**

component of the installed radiation monitor that contains detector and may contain associated electronics (amplifier, discriminator, output pulse shaper), and may also include programmable electronic circuits

##### 3.1.4

###### **processing assembly (PA)**

assembly which converts the output signals of one or more detector assemblies into a form, generally digital, suitable for transmission down a data link to the central computer; central computer, and/or which generates alarm outputs to the alarm units at present signal levels

##### 3.1.5

###### **alarm assembly (AA)**

assembly which is initiated by the PA. It provides audible and/or visual alarms, in the event of an alarm threshold being breached or in the case of an equipment fault. It is normally sited local to the DA

##### 3.1.6

###### **central computer (CC)**

central processing and control system for the calculation, display, and storage of data from the processing units

##### 3.1.7

###### **monitoring assembly (MA)**

integrated assembly consisting of combinations of processing, alarm, and detector assemblies

### 3.2 Test nomenclature

#### 3.2.1

##### **type test**

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

[IEV 394-40-02]

#### 3.2.2

##### **acceptance test**

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

[IEV 394-40-05]

### 3.3 Abbreviated terms

ALI	Annual Limit on Intake
DAC	Derived Air Concentration
DWL	Derived Working Limit
PES	programmable electronic system
SIL	safety integrity level
VDUs	visual display units

## 4 Design requirements

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### 4.1 General remarks

#### 4.1.1 General

IEC 61559-1:2009

A centralized system for continuous monitoring of the radiation levels in nuclear facilities is composed of appropriate devices for measurement, acquisition, processing, display and storage of data. The data is mainly related to detection or measurement of ionizing radiation and, more generally, to the radiological safety of facilities, premises, and their surrounding environment.

By monitoring the status of the nuclear facility, the centralized system provides confirmatory information on the maintenance of a satisfactory working environment, and provides a display of any developing long-term trends.

This type of monitoring is intended to provide:

- continuous monitoring of all parameters defining the radiological status and especially those related to the work place (radiation fields, volumetric radioactive contamination in air) and other associated parameters (e.g. ventilation);
- activation of audible and visual indicators when predetermined thresholds are exceeded;
- storage of data for subsequent processing. For example, this may be used to review longterm changes in the radiological status of the facility, or to perform historic reviews of the radiological conditions.

#### 4.1.2 Safety classification

The equipment covered in this standard is installed in facilities such as nuclear power plants, nuclear fuel storage and processing sites.

The equipment is intended primarily for the purpose of radiological protection and is thus category C classification as defined in 5.4.3 of IEC 61226 since it may play an auxiliary or indirect role in the achievement or maintenance of nuclear power plants safety.

If a safety classification applies, appropriate requirements shall apply concerning specification, design, manufacturing, installation and operation of the equipment with respect to the necessary quality of computer hardware and software. The requirements shall be agreed between manufacturer and purchaser. In particular the purchaser (operator) shall decide the appropriate safety standard applicable to the site in which the system will function. The basic safety standards IEC 61508 series apply.

When IEC 61508 is selected, then the requirements of that standard shall apply as appropriate to the required safety integrity level specified for the system.

Compliance with IEC 61513 facilitates consistency with the requirements of IEC 61508 series as they have been interpreted for the nuclear industry.

#### 4.1.3 System configuration

The type of equipment defined in this standard generally comprises up to four types of assemblies, which may be interconnected in a number of configurations and to the central computer (CC) (see Figures 1 to 4).

These assemblies are:

- detector assembly (DA);
- processing assembly (PA);
- alarm assembly (AA);
- monitoring assembly (MA).

The monitoring assembly is an integrated assembly consisting of combinations of processing, alarm, and detector assemblies. These assemblies may be located in a single package (instrument), or as individual assemblies.

Each installation is unique; some typical examples are illustrated.

Figure 1 shows a monitoring assembly located within the monitoring area.

Figure 2 shows an example where the detector assembly is located within the monitored area, whilst the processing assembly is located in an area of lower radiation or volumetric radioactive contamination in air. In this example, the alarm assembly must be located within the monitoring area to warn personnel. The detector assembly measuring volumetric radioactive contamination in air may be located outside the monitoring area, but the air sample must be drawn from within the area. The need to position a second alarm unit at the entry point to prevent access, should be considered. Further alarm assemblies triggered by the processing assembly may be required to adequately cover the geographical area.

The links from detector assembly to processing assembly and processing assembly to alarm assembly shall be standardized and ideally independent of assembly type.

The elements forming a monitoring assembly shall have the ability to be grouped, and to operate in autonomous mode. The monitoring assembly to CC link shall be standardized.

The central computer has to collect the data transmitted from the various monitor units data links. Additionally diverse digital alarm status inputs may also be accepted.

All data links shall be a good quality, commercially available protocol. Additionally the installation of the detector assembly to processor unit link and processing unit to alarm unit link and links to the central computer, shall follow the electromagnetic compatibility requirements of IEC 61000–5-1.