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Edition 2.0 2017-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear facilities – Instrumentation and control systems important to safety – Centralized systems for continuous monitoring of radiation and/or levels of radioactivity

Installations nucléaires – Systèmes d'instrumentation et de contrôle-commande importants pour la sûreté – Systèmes centralisés pour la surveillance en continu des rayonnements et/ou des niveaux de radioactivité

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NUCLEAR FACILITIES – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – CENTRALIZED SYSTEMS FOR CONTINUOUS MONITORING OF RADIATION AND/OR LEVELS OF RADIOACTIVITY

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61504 has been prepared by subcommittee 45A: Instrumentation, control and electrical systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition of IEC 61504, published in 2000, and the first edition of IEC 61559-2, published by subcommittee 45B in 2002, and constitutes a technical revision.

This standard is to be read in conjunction with IEC 61559-1.

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

a) It supplements IEC 61559-1 and integrates IEC 61559-2.

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b) It describes integration of functions including equipment such as those covered by IEC 60761-1, IEC 60761-2, IEC 60761-3, IEC 60761-4, IEC 60761-5, IEC 60768, IEC 60861, IEC 60910, IEC 60951-1 IEC 60951-2, IEC 60951-3, IEC 60951-4, IEC 60951-5, IEC 61031, IEC 61250, IEC 62302 and IEC 62303.

c) It establishes requirements for integration in centralized systems as defined by IEC 62705.

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

FDIS	Report on voting
45A/1135/FDIS	45A/1149/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.

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INTRODUCTION

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

Advances in distributed system technology have led to the introduction of centralized programmable digital systems for radiation monitoring into nuclear facilities.

IEC 61559 was introduced in 1996 to address centralized systems for radiation monitoring in non-reactor nuclear facilities. That standard primarily focused upon category C functions, such as area monitoring and excluded nuclear power plant applications. As IEC 61559 was being released, subcommittee 45A determined that it would be useful to develop a similar standard to address nuclear power plant application of plant-wide radiation monitoring systems, at that time. The intent was that IEC 61504 would parallel IEC 61559 would integrate or directly reference the other nuclear power standards that are relevant to plant-wide radiation monitoring. IEC 61504 was published on 2000-05.

As IEC 61559 was in the final release process, subcommittee 45B recognized the need to broaden the scope of that standard to include other applications of centralized radiation monitoring in nuclear facilities. These broader applications included, for example, monitoring of plant discharges, interlock of control functions, and environmental monitoring. IEC 61559-2 was developed to cover these broader functions, including category B functions, in non-reactor nuclear facilities and was published on 2002-06.

In 2004, the scope of subcommittee 45A standards was extended from “Reactor instrumentation” to “Instrumentation and control system of nuclear facilities”.

This Standard reflects this increased scope of application and merges the extant requirements of IEC 61504 with those in IEC 61559-2. Hence this Standard comes to cover not only nuclear power plants but also nuclear facilities other than nuclear power plants.

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

IEC 61504 is the third level in the hierarchy of SC 45A standards. This standard provides centralized systems for radiation monitoring for nuclear facilities. This standard is applicable to the centralized systems for radiation monitoring to be used for functions important to safety in nuclear facilities.

IEC 62705 provides the guidance for the radiation monitoring system (RMS) on the application of existing IEC/ISO standards covering design and qualification of system and equipment for RMS. IEC 62705 is the supplements of IEC 61513 and it is not intended that IEC 62705 limits the application of other IEC 61513 requirements to RMS lifecycle.

IEC 61513 is the first level standard of SC 45A standards, and provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 61226 provides the criteria for classification of instrumentation and control functions. Most modern RMSs contain programmable digital equipment. Hence RMS should often be treated as programmable digital system. So the following standards required for programmable digital system are generally applicable to RMS. IEC 60880 provides the software requirements for category A functions and IEC 62138 provides the software requirements for Category B or C functions. IEC 60987 provides hardware design requirements for programmable digital systems. IEC 62566 provides the requirements for HDL-Programmed Device (HPD) for systems performing category A functions. For the qualification testing, the following SC 45A standards are applicable. IEC/IEEE 60780-323 provides the guide for the environmental qualification and IEC 60980 provides the guidance for seismic qualification for equipment performing category A or B functions.IEC 62003 provides the requirements for electromagnetic compatibility testing. In addition, IEC 61250 specifies the leak detection requirements by using RMS.

For radiation monitoring specific requirements, the following standards provide requirements and guidance for RMS. The IEC 60951 series provides guidance on the design and testing of radiation monitoring equipment used for accident and post-accident conditions. The IEC 60761 series provide requirements for equipment for continuous off-line monitoring of radioactivity in gaseous effluent in normal conditions. Some of the SC 45B standards (e.g. Gas offline: IEC 62302, Tritium: IEC 62303) are now replacing the IEC 60761 series. IEC 60861 provides requirements for equipment continuous off-line monitoring of radioactivity in liquid effluent in normal conditions. IEC 60768 provides

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requirements for equipment for continuous in-line and on-line monitoring of radioactivity in process stream in normal and incident conditions. IEC 61031 provides requirements for equipment for area radiation monitor in normal conditions in conjunction with IEC 60532. IEC 61504 provides requirements for centralized system for plant-wide radiation monitoring in conjunction with the IEC 61559 series which specifies the requirements for centralized system. If the centralized system is a part of the safety parameter display system, IEC 60960 provides the functional design criteria. ISO 2889 gives guidance on gas and particulate sampling. The ISO 4037 series provides calibration methodology for radiation monitors.

The relationship among these various standards is given in Table 1.

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

Where requirements are given in this standard, they refer generally to the need to apply other IEC and ISO Standards and specific functional and technical requirements contained in these Standards.

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 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 NPP; it covers power supply systems including the supply

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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 (NPP), 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 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 requirement 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 be published this NOTE 2 of the introduction of IEC SC 45A standards will be suppressed.

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NUCLEAR FACILITIES – INSTRUMENTATION AND CONTROL SYSTEMS IMPORTANT TO SAFETY – CENTRALIZED SYSTEMS FOR CONTINUOUS MONITORING OF RADIATION AND/OR LEVELS OF RADIOACTIVITY

1 Scope

This document supplements IEC 61559-1 to include radiation monitoring functions important to safety that are not within the scope of IEC 61559-1. It applies to centralized systems having a direct role in the achievement or maintenance of radiation protection in nuclear facilities. These systems perform functions such as:

- radiation protection of plant discharge;
- interlock of control functions to prevent or to mitigate accidental release of radioactive material;
- radiation and environmental monitoring functions to support monitoring of and response to accidents;
- provide information to process control or safety systems for use in control or interlock functions.

This document defines the communication criteria to link distributed radiation monitoring equipment in the facility, integrates data processing, storage, optimization, and correlation of data flow and displays, and provides criteria for the interface between monitors of different safety classes.

It will not directly apply to the design and testing of detection and measurement assemblies except as necessary to define the interface with the central computer. Requirements for these assemblies are contained in existing standards.

This document describes the integration of functions including equipment such as those described in IEC 60761-1, IEC 60761-2, IEC 60761-3, IEC 60761-4, IEC 60761-5, IEC 60768, IEC 60861, IEC 60910, IEC 60951-1 IEC 60951-2, IEC 60951-3, IEC 60951-4, IEC 60951-5, IEC 61031, IEC 61250, IEC 62302 and IEC 62303, into a centralized system. The requirements of system-level components (central computer, subsystem computers, operator consoles, and interconnections) are discussed. For detector assemblies, processing assemblies and alarm assemblies, this document contains only the requirements needed to allow connection into the central computer. The standards referenced above contain the specific requirements for these components.

This document identifies requirements pertinent to the integration of the above functions into a centralized system. Requirements for general and design characteristics, electrical performance requirements and tests, mechanical performance and tests, software performance requirements and tests, environmental characteristics performance requirements and tests and documentation are considered by referring to IEC 62705.

Certain complete centralized systems for radiation monitoring may be entirely implemented with direct-connected analogue/relay technology. This document does not apply to such systems.

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.

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

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

IEC 60761-1, *Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 1: General requirements*

IEC 60761-2, *Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 2: Specific requirements for radioactive aerosol monitors including transuranic aerosols*

IEC 60761-3, *Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 3: Specific requirements for radioactive noble gas monitors*

IEC 60761-4, *Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 4: Specific requirements for radioactive iodine monitors*

IEC 60761-5, *Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 5: Specific requirements for tritium monitors*

IEC 60768, *Nuclear power plants – Instrumentation important to safety – Equipment for continuous in-line or on-line monitoring of radioactivity in process streams for normal and incident conditions*

IEC 60861, *Equipment for monitoring of radionuclides in liquid effluents and surface waters*

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

IEC 60910, *Containment monitoring instrumentation for early detection of developing deviations from normal operation in light water reactors*

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

IEC 60951-2, *Nuclear power plants – Instrumentation important to safety – Radiation monitoring for accident and post-accident conditions – Part 2: Equipment for continuous off-line monitoring of radioactivity in gaseous effluents and ventilation air*

IEC 60951-3, *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 60951-4, *Nuclear power plants – Instrumentation important to safety – Radiation monitoring for accident and post-accident conditions – Part 4: Equipment for continuous in-line or on-line monitoring of radioactivity in process streams*

IEC 60960, *Functional design criteria for a safety parameter display system for nuclear power stations*

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

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IEC 61031, *Design, location and application criteria for installed area gamma radiation dose rate monitoring equipment for use in nuclear power plants during normal operation and anticipated operational occurrences*

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

IEC 61250, *Nuclear reactors – Instrumentation and control systems important for safety – Detection of leakage in coolant systems*

IEC 61497, *Nuclear power plants – Electrical interlocks for functions important to safety – Recommendations for design and implementation*

IEC 61500:2009, *Nuclear power plants – Instrumentation and control important to safety – Data communication in systems performing category A functions*

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

IEC 61559-1:2009, *Radiation protection instrumentation in nuclear facilities – Centralized systems for continuous monitoring of radiation and/or levels of radioactivity – Part 1: General requirements*

IEC 61771, *Nuclear power plants – Main control-room – Verification and validation of design*

IEC 61772, *Nuclear power plants – Control rooms – Application of visual display units (VDUs)*

IEC 62003, *Nuclear power plants – Instrumentation and control important to safety – Requirements for electromagnetic compatibility testing*

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

IEC 62302, *Radiation protection instrumentation – Equipment for sampling and monitoring radioactive noble gases*

IEC 62303, *Radiation protection instrumentation – Equipment for monitoring airborne tritium*

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

IEC 62645, *Nuclear power plants – Instrumentation and control systems – Requirements for security programmes for computer-based systems*

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

IAEA Safety Guide SSG-39:2015, *Design of Instrumentation and Control Systems for Nuclear Power Plants*

3 Terms and definitions

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

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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 RMS is given in IEC 62705 and specific terminology for the centralized system for continuous monitoring of radiation is given in IEC 61559-1. The following additional term is defined in this document.

3.1
operator console
OC
console that displays system or subsystem data to plant operators and is the operator control interface through which operators request information, and perform control functions

Note 1 to entry: Operator consoles typically incorporate a video display unit (VDU) as indicated in IEC 61559-1.

Note 2 to entry: This document uses the more general term "operator console" to make clear the intent that other types of user interfaces are allowed. A centralized system for radiation monitoring will have at least one OC. RMS OC functions may incorporate into the OC functions of a more general purpose display.

4 Design requirements

4.1 General

4.1.1 Background

Nuclear facility instrumentation and control systems such as the safety system, integrated control system, post accident monitoring system, and radiation monitoring system (RMS) are designed to provide the plant operator with timely information as well as control functions to be used during various conditions in facility including normal, anticipated operational occurrence, and accident conditions.

IEC 61559-1 discusses the types of monitoring provided by the centralized system for continuous monitoring of radiation in nuclear facilities. The scope of this document includes the following RMS functions:

- The initiation of control and protection functions to support normal operation of systems, to respond to anticipated operational occurrences, and to prevent or mitigate releases during and following accidents.
- The provision of information to control and protection systems for interlock or activation functions.
- The storage of relevant data for the analysis of normal, abnormal, or accident conditions, their initiation and their sequence.
- The provision of information to the station data processing and display system on essential alarms and information for use in the control room, and possibly in the ERC (emergency response centre).
- The provision of information during accident conditions, the RMS provides information to the operator to assist in the evaluation of potential releases to the environment, impact on personnel, or equipment performance.
- The provision of information during and following an accident, the RMS provides information to assist the operator in determining the type of accident, evaluate the potential releases to the environment, and initiate appropriate emergency procedures.
- The provision of information during and following an accident, the RMS provides release information to emergency response personnel. In some cases, this may include meteorological data to support prediction of release transport or calculation of estimates of activity cloud dispersion.

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For ease of purchasing and fabricating the equipment, the RMS is usually divided into subsystems such as area gamma monitors, airborne effluent monitors, liquid effluent monitors, and process monitors.

All of the above functions are performed by monitors with diverse types of detectors and electronic equipment, leaving to the operator the difficult task of integrating the information presented. It is important to note that, for many anticipated operational occurrences or accidents, no single radiation monitor can provide the definitive picture of the condition of the plant. An operator uses the indications of an array of monitors to assist in the decision process.

Digital technology, using network communication connections and protocols, provides the opportunity to design the centralized system for radiation monitoring to integrate the information provided by the diverse types of monitors and enhance the display capabilities of the RMS.

Below are the design requirements in the order they are listed in IEC 61559-1 as far as possible. For some design topics, this document imposes no additional design requirements beyond those stated in IEC 61559-1. For other design topics, additional requirements are described below. In this clause, the subclause of IEC 61559-1 is indicated in each subclause header, if an equivalent subclause exists.

4.1.2 General characteristics and lifecycle (IEC 61559-1:2009, 4.1.1)

The centralized systems for radiation monitoring performing functions that are important to safety shall comply with the requirements relating to the characteristics and lifecycle of RMS defined in IEC 62705 and the standards referred in IEC 62705 (e.g. IEC 61226).

4.1.3 Safety classification and applicable standards (IEC 61559-1:2009, 4.1.2)

The centralized system for radiation monitoring 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 6.2.3 of IEC 61513:2011.

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 RMS performing category A functions shall be designed and maintained in accordance with IEC 60880. Any HDL-Programmed Device (HPD) in the equipment of RMS performing category A functions shall be designed and maintained in accordance with IEC 62566. Any hardware in RMS performing category A functions 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 RMS performing category B or C functions shall be designed and maintained in accordance with IEC 62138. Any hardware in RMS performing category B function and including software shall be designed and maintained in accordance with IEC 60987. Hardware in the RMS performing category C function shall be designed, selected and maintained according to the supplier's requirements.

4.1.4 System architecture and configuration (IEC 61559-1:2009, 4.1.3)

System architecture is the structured relationship between the components of the system. Figure 1 illustrates one example of a typical architecture for a centralized system for radiation monitoring and shows the relationship of this document to other radiation monitoring standards. A number of configurations are acceptable and the figure is not intended to require a specific arrangement of components, communication busses, or interconnections.

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The various types of nuclear facilities existing today have different radiation monitoring requirements. RMS functions are therefore plant-specific. A study of the specific RMS functions and design basis shall be performed for each plant and documented accordingly. IAEA safety guide SSG-39 and IEC 61226 should be used as applicable to guide the development of the design basis. Each RMS function shall be classified according to the guidance of IEC 61226 and the study for the system configuration shall consider the following conditions:

- Regulations and limits that the RMS shall detect.
- Plant conditions, both normal and other than normal conditions, postulated for the plant (see IEC 60910 and IEC 60951).
- Effluent monitoring requirements (see IEC 60761, IEC 60861, IEC 62302 and IEC 62303).
- Area gamma monitoring requirements (see IEC 61031 and IEC 60532).
- Process monitoring requirements (see IEC 60768, IEC 60951-4).
- Coolant leakage monitoring requirements (see IEC 61250).
- Display, recording, and alarm requirements to be provided in the control room, locally in the detector areas, and in remote locations such as, health physics offices, technical support centre and emergency operations facility.
- Human factor requirements for user display, recording, and alarms.
- The control room operator interface(s) (IEC 61772).
- Data communications (IEC 61500).
- Radiation units to be used, range, trending requirements, etc.
- Monitor grouping requirements.
- Safety-related functions of the RMS.
- Safety functions of the RMS.
- Requirements for interface with other plant instrument and control systems.
- Actuation requirements.
- Display, recording, and calculation requirements to be provided for use by radiation protection organizations.
- Maintenance and troubleshooting provisions needed to support maintenance and engineering personnel.
- Plant environmental conditions (e.g. temperature, humidity, seismic) in which RMS will operate.
- Data archiving needs.
- Future needs to add functions and equipment to the installed RMS.

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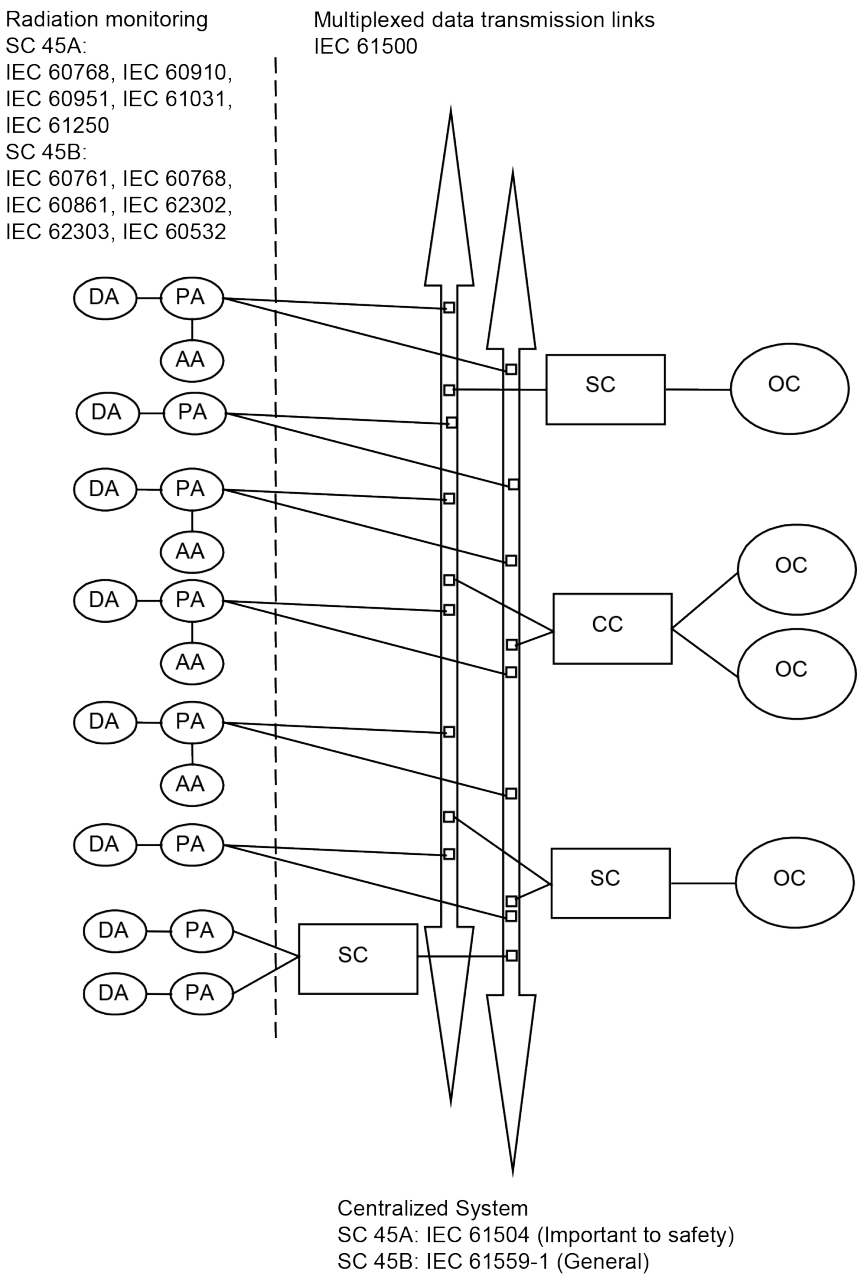

Key

DA	Detector assembly
PA	Processing assembly
CC	Central computer
SC	Subsystem computer
OC	Operator console
AA	Alarm assembly

Figure 1 – Example of a typical centralized system configuration

4.1.5 Location of detector assemblies (IEC 61559-1:2009, 4.1.4)

Location of the area radiation dose rate monitor in nuclear power plants shall be designed in accordance with IEC 61031.

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4.1.6 Failure mode

The system shall be designed such that no individual system component failure adversely affects RMS functions that do not directly use the failed component. For example:

- Failure of any detector assembly shall not affect the operability of other detector assemblies.
- Operator console failures shall not affect the operability of the central computer, local alarm assemblies, subsystem computers, or other operator consoles.
- Failure of any combination of central computer inputs and/or outputs shall not affect the ability of the central computer to perform functions unrelated to the failed inputs and outputs.
- Central computer failures shall not affect the operability of subsystem computers, or local alarm assemblies. Subsystem computer failures shall not affect the operability of local alarm assemblies or the operability of the central computer with other non-failed components of the RMS.

Programmable digital systems shall initialize to a safe state on power-up or reset.

IEC 60987 and IEC 61500 provide additional guidance regarding reliability requirements and the identification of the types of failures that should be considered in the design.

4.1.7 Interlock functions

Interlock functions provided by the RMS shall meet the requirements of IEC 61497.

4.1.8 Control functions

Control of process equipment by the RMS is outside of the scope of this standard; however, the central computer may provide control signals to RMS equipment such as detector assemblies (e.g., to operate check sources, or to align valves in sample lines). The central computer shall not allow simultaneous, uncoordinated, and/or conflicting control of system components by multiple operator consoles.

The control functions should include facilities to start and stop scans, to read and display data from specific groups of instruments, to initiate calculations, to initiate special and routine logs and recordings, and to initiate transfer of information units or blocks to archive and to other computer systems.

Transfer of any control function from one operator console to any other operator console, including those of a subsystem computer, should normally require operator acknowledgement from the currently controlling operator console. The capability to override this feature may need to be supplied to allow for abnormal operating conditions.

4.1.9 Control of access

The design shall permit the administrative control of access to system equipment, system controls, software, and set points. It should also provide protection against accidental or unauthorized deletion or modification of stored data. IEC 62645 provides the guidance for the security programme.

4.1.10 Testability

The RMS shall have arrangements that permit test and calibration at intervals based upon the equipment function, expected calibration drift rate, and reliability requirements. As far as is practicable, these tests shall be overall checks (from the measured variable where appropriate), capable of being performed in situ and with a minimum of effort. It is acceptable for the testing to consist of overlapping tests which together test the whole channel. All the

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output functions of the system shall be testable, for example, alarms, control actions, and operation of actuation devices.

Periodic self-test and diagnostics should be automatically performed to detect component failures.

4.1.11 Maintainability

The equipment shall be designed so that it facilitates surveillance and maintenance and, in the case of failure, easy diagnosis and repair or replacement.

To facilitate maintenance, the RMS equipment shall, where practicable, be located so as to minimize risks to operating personnel. Ample room should be left surrounding the equipment to ensure that the maintenance staff can fulfil their tasks under normal working conditions. Where practicable, equipment should not be placed where there is a risk of high radiation level, or where conditions of extreme temperature, high humidity, or other safety hazards normally exist.

4.1.12 Operator interface

The control room operator interface(s) shall comply with IEC 61772.

4.1.13 Data communication

The design of data communication systems that are part of, or support the centralized system for radiation monitoring shall provide for detection of errors in the information transmitted that are due to faults in the common data transmission equipment. Means shall be provided to check for calibration drift in the analogue-to-digital converters. Means shall be provided to check data communication equipment one input at a time. If error detection features are provided to improve signal transmission so as to meet reliability goals, it shall be possible to verify the operation of these detection features.

The performance of the data communication system shall enable the transmission of data within the measurement resolution and display update requirements. The design of the cable system should provide the maximum amount of noise immunity to the network while minimizing signal distortion and attenuation.

4.2 Design requirements for the subassemblies

4.2.1 Detector assembly (IEC 61559-1:2009, 4.2.1)

No requirement beyond IEC 61559-1 is necessary.

4.2.2 Processing assembly (IEC 61559-1:2009, 4.2.2)

4.2.2.1 General

Processing assembly may provide interlock or protection function in addition to those discussed in IEC 61559-1.

4.2.2.2 Main characteristics

No requirement beyond IEC 61559-1 is necessary.

4.2.2.3 Processing assembly alarm specification

No requirement beyond IEC 61559-1 is necessary.

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4.2.2.4 Processing assembly outputs

No requirement beyond IEC 61559-1 is necessary.

4.2.2.5 Historical records

Provisions shall be made to maintain historical records consistent with national legal requirements.

4.2.3 Alarm assembly (IEC 61559-1:2009, 4.2.3)

No requirement beyond IEC 61559-1 is necessary.

4.2.4 Subsystem computer

Subsystem computers may also be included in the RMS as necessary. Typically, they will be incorporated where unique design requirements apply to a subset of RMS functions (e.g., a safety-related subsystem), or where there is a need for recording, display, or control capabilities remote to the central computer location.

Subsystem computers receive data from a functional grouping of control and measurement assemblies and provide for various functions such as data recording, data validation, data display, and control for the associated group of parameters. Subsystem computers may send information to the central computer or may receive information in parallel with the central computer.

4.2.5 Operator console

Operator consoles display system or subsystem data to plant operators and are the operator control interface through which operators request information, input information, and perform control functions. A centralized system for radiation monitoring will have at least one operator console. RMS operator console functions may be incorporated into the operator console functions of a more general purpose display.

4.2.6 Interconnections

Interconnections provide for the transmission of data and power between subassemblies. Interconnections include direct-analogue connections, data busses, communication protocols, and any data communication equipment that are distinct from the processing assembly, subsystem computer, central computer, or operator console. All interconnections between system components shall be made using non-proprietary, standardized connection methods, and communication protocols.

4.3 Central computer

4.3.1 General (IEC 61559-1:2009, 4.3.1)

IEC 61559-1 describes the function of a central computer. This description is not intended to preclude the distribution of the central computer functions over a number of computers or over an interconnected set of processing assemblies.

If the central computer is a part of the safety parameter display system, the design shall meet the requirements of IEC 60960.

4.3.2 Functional requirements of the central computer (IEC 61559-1:2009, 4.3.2)

In systems containing multiple operator consoles, the central computer shall not allow simultaneous, uncoordinated, and/or conflicting control of system components by multiple operator consoles. The provisions to prevent uncoordinated and/or conflicting control may be a function of the central computer or processing assembly.

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