# IEC 60951-1

Edition 3.0 2022-11
REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside

## Nuclear ~~power plants~~ facilities – Instrumentation systems important to safety – Radiation monitoring for accident and post-accident conditions – Part 1: General requirements



IEC 60951-1:2022-11 RLV(en)



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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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## Nuclear ~~power plants~~ facilities – Instrumentation systems important to safety – Radiation monitoring for accident and post-accident conditions – Part 1: General requirements

INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# NUCLEAR ~~POWER PLANTS~~ FACILITIES – INSTRUMENTATION SYSTEMS IMPORTANT TO SAFETY – RADIATION MONITORING FOR ACCIDENT AND POST-ACCIDENT CONDITIONS –

## Part 1: General requirements

## FOREWORD

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**This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60951-1:2009. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.**

IEC 60951-1 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2009. This edition constitutes a technical revision.

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

- Title modified.
- To be consistent with the categorization of the accident condition.
- To update the references to new standards published since the second edition.
- To update the terms and definitions.

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

| Draft | Report on voting |
|---|---|
| 45A/1440/FDIS | 45A/1449/RVD |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

A list of all parts of IEC 60951 series, under the general title *Nuclear facilities – Instrumentation systems important to safety – Radiation monitoring for accident and post-accident conditions,* can be found on the IEC website.

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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

This IEC standard specifically focuses on radiation monitoring systems (RMSs) used for ~~accident and post-~~accident operations.

According to the lessons learned from the Fukushima-Daiichi accident, it re-acknowledges a need to provide operators with reliable radiation monitoring data to allow them to understand the plant state during and after the accident conditions. To support the design of such instrumentation, it is necessary to provide general guidance on the design principles and performance criteria for radiation monitoring instrumentation applied during and after the accident conditions. In addition, the scope of IEC 63147 which provides criteria for accident monitoring instrumentation for nuclear power generating stations has evolved to include severe accident (SA) to accident conditions.

Thus, to address the specific lessons learned from the Fukushima-Daiichi accident, this standard categorizes accident condition into design basis accidents (DBA) and design extension conditions (DEC), including severe accident (SA).

This standard is intended for use by purchasers in developing specifications for their plant-specific radiation monitoring systems and by manufacturers to identify needed ~~product~~ equipment characteristics when developing systems for accident monitoring conditions. Some specific instrument characteristics such as measurement range, ~~required~~ energy response, and ~~ambient environment requirements~~ environmental withstanding conditions will depend on the specific application. In such cases, guidance is provided on determining the specific requirements, but specific requirements themselves are not stated.

This standard is one in a series of standards ~~covering post-accident radiation monitors important to safety~~ applicable to equipment for continuous monitoring of radiation level important to safety intended for use during design basis accidents (DBA) and design extension conditions (DEC) including severe accident (SA), and post-accident conditions. The full series is comprised of the following standards.

– 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 streams.

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

The IEC 60951 series of standards are at the third level in the hierarchy of SC 45A standards. They provide guidance on specification, design and testing of radiation monitoring equipment used for accident and post-accident conditions.

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 streams in normal and incident conditions. Finally, ISO 2889 gives guidance on gas and particulate sampling. ~~The relationship between these various radiation monitoring standards is given in Table 1.~~ In addition, IEC 62705 provides guidance on the application of existing IEC/ISO standards covering design and qualification of RMS. An overview of the standards covering the radiation monitoring in nuclear facilities is given in Table 1.

IEC 63147/IEEE Std 497™ provides general guidance for accident monitoring instrumentation. IEEE Std 497™ was directly adopted as a joint logo standard and a technical report, IEC TR 63123, was prepared to discuss the application of the joint standard within the IEC context.

The structure of this standard is adapted from the structure of IEC 63147/IEEE Std 497™, and the technical requirements of this standard are consistent with the requirements given in IEC 63147/IEEE Std 497™ together with the application guidance given in IEC TR 63123.

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

| ~~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 IEC 60951-2~~ | ~~IEC 60761 series and IEC 62302 (noble gases only)~~ | |
| ~~Liquid with sampling (OFF-LINE)~~ | ~~N/A~~ | ~~N/A~~ | ~~IEC 60861~~ | |
| ~~Process streams (gaseous effluents, steam or liquid) without sampling (ON or IN-LINE)~~ | ~~N/A~~ | ~~IEC 60951-1 and IEC 60951-4~~ | ~~IEC 60768~~ | ~~N/A~~ |
| ~~Area monitoring~~ | ~~N/A~~ | ~~IEC 60951-1 and IEC 60951-3~~ | ~~IEC 60532~~ | |
| ~~Central system~~ | ~~N/A~~ | ~~IEC 61504~~ | | ~~IEC 61559 series~~ |

| Developer | ISO | | IEC | | | |
|---|---|---|---|---|---|---|
| | | | SC45A | | | SC45B |
| Scope | Sampling (Normal operation) | Calibration (Normal operation) | Normal operation, AOO | DBA | DEC | Normal operation |
| Radioactive noble gas off-line monitoring | ISO 2889 | ISO 4037-1, ISO 4037-3 | N/A | 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 | N/A | 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 | N/A | 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 | N/A | IEC 60861 |
| Tritium off-line monitoring | N/A | 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 60768 | IEC 60951-1, IEC 60951-4 | N/A | N/A |
| Area monitoring | N/A | ISO 4037-1, ISO 4037-3 | IEC 61031 | IEC 60951-1, IEC 60951-3 | | IEC 60532 |
| Centralized system | N/A | N/A | IEC 61504, IEC 60960 | | N/A | IEC 61559-1 |
| Classification/basic requirements | N/A | N/A | IEC 61513, IEC 60880, IEC 60987, IEC 61226, IEC 62138, IEC 62566, IEC 62566-2, IEC 62645, IEC 61250 | | N/A | N/A |
| Qualification | N/A | N/A | IEC/IEEE 60780-323, IEC/IEEE 60980-344, IEC 62003 | | N/A | IEC 62706 |

For more details on the structure of the IEC SC 45A standard series, see the item d) of this introduction.

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

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

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

~~The top-level document of the IEC SC 45A standard series is IEC 61513. It provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 61513 structures the IEC SC 45A standard series.~~

~~IEC 61513 refers directly to other IEC SC 45A standards for general topics related to categorization of functions and classification of systems, qualification, separation of systems, defence against common cause failure, software aspects of computer-based systems, hardware aspects of computer-based systems, and control room design. The standards referenced directly at this second level should be considered together with IEC 61513 as a consistent document set.~~

~~At a third level, IEC SC 45A standards not directly referenced by IEC 61513 are standards related to specific equipment, technical methods, or specific activities. Usually these documents, which make reference to second-level documents for general topics, can be used on their own.~~

~~A fourth level extending the IEC SC 45A standard series, corresponds to the Technical Reports which are not normative.~~

~~IEC 61513 has adopted a presentation format similar to the basic safety publication IEC 61508 with an overall safety life-cycle framework and a system life-cycle framework and provides an interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. Compliance with IEC 61513 will facilitate consistency with the requirements of IEC 61508 as they have been interpreted for the nuclear industry. In this framework IEC 60880 and IEC 62138 correspond to IEC 61508-3 for the nuclear application sector.~~

~~IEC 61513 refers to ISO standards as well as to IAEA 50-C-QA (now replaced by IAEA GS-R-3) for topics related to quality assurance (QA).~~

~~The IEC SC 45A standards series consistently implements and details the principles and basic safety aspects provided in the IAEA code on the safety of NPPs and in the IAEA safety series, in particular the Requirements NS-R-1, establishing safety requirements related to the design of Nuclear Power Plants, and the Safety Guide NS-G-1.3 dealing with instrumentation and control systems important to safety in Nuclear Power Plants. The terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.~~

The IEC SC 45A standard series comprises a hierarchy of four levels. The top-level documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046.

IEC 61513 provides general requirements for instrumentation and control (I&C) systems and equipment that are used to perform functions important to safety in nuclear power plants (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 power systems for nuclear power plants.

IEC 61513 and IEC 63046 refer directly to other IEC SC 45A standards for general requirements for specific topics, such as categorization of functions and classification of systems, qualification, separation, defence against common cause failure, control room design, electromagnetic compatibility, human factors engineering, 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 requirements for specific equipment, technical methods, or activities. Usually these documents, which make reference to second-level documents for general requirements, can be used on their own.

A fourth level extending the IEC SC 45 standard series, corresponds to the Technical Reports which are not normative.

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, the IAEA safety guide SSG-51 dealing with human factors engineering in the design of NPPs and the implementing guide NSS17 for computer security at nuclear facilities. The safety and security terminology and definitions used by the 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 9001 as well as to IAEA GSR part 2 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, IEC 60964 is the entry document for the IEC/SC 45A control rooms standards, IEC 63351 is the entry document for the human factors engineering standards and IEC 62342 is the entry document for the 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 TR 64000 provides a more comprehensive description of the overall structure of the IEC SC 45A standards series and of its relationship with other standards bodies and standards.

# NUCLEAR ~~POWER PLANTS~~ FACILITIES – INSTRUMENTATION SYSTEMS IMPORTANT TO SAFETY – RADIATION MONITORING FOR ACCIDENT AND POST-ACCIDENT CONDITIONS –

## Part 1: General requirements

## 1 Scope

This part of IEC 60951 provides general guidance on the design principles and performance criteria for equipment to measure radiation and fluid (gaseous effluents or liquids) radioactivity levels at nuclear ~~power plants~~ facilities during and after ~~an accident~~ design basis accidents (DBA) and design extension conditions (DEC), including severe accident (SA). This document is limited to equipment for continuous monitoring of radioactivity in design basis accidents (DBA), design extension conditions (DEC), including severe accident (SA) and post-accident conditions.

The purpose of this document is to lay down ~~mandatory~~ general requirements and give examples of acceptable methods for equipment for continuous monitoring of radioactivity within the ~~plant~~ facility during and after ~~accident conditions in nuclear power plants using light water reactors~~ design basis accidents (DBA), design extension conditions (DEC), including severe accident (SA) in nuclear facilities.

It specifies, for the equipment described above, the general characteristics, general test procedures, radiation, electrical, safety and environmental characteristics and the identification and certification of the equipment. If this equipment is part of a centralized system for continuous radiation monitoring in a nuclear facility, there may be additional requirements from other standards related to this system.

Sample extraction and laboratory analysis, which are essential to a complete programme of effluent monitoring, are not within the scope of this document.

## 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 60038:~~2002~~2009, *IEC standard voltages*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-78:~~2001~~2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60529, *Degrees of protections provided by enclosures (IP code)*

~~IEC 60780, *Nuclear power plants – Electrical equipment of the safety system – Qualification*~~

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

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

~~IEC 60980, *Recommended practices for Seismic qualification of electrical equipment of the safety system for nuclear generating stations*~~

IEC/IEEE 60980-344, *Nuclear facilities – Equipment important to safety – Seismic qualification*

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

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

IEC 61000-4-3:~~2006~~2020, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:~~2004~~2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:~~2005~~2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:~~2008~~2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:~~2001~~2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-12:~~2006~~2017, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC 61000-4-18:2019, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*

IEC 61000-6-4:~~2006~~2018, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61069-1:~~1991~~2016, *Industrial-process measurement, control and automation – Evaluation of system properties for the purpose of system assessment – Part 1: ~~General considerations and methodology~~ Terminology and basic concepts*

IEC 61226, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – ~~Classification of instrumentation and control functions~~ Categorization of functions and classification of systems*

IEC 61504:~~2000~~2017, *Nuclear ~~power plants~~ facilities – Instrumentation and control systems important to safety – ~~Plant-wide radiation monitoring~~ Centralized systems for continuous monitoring of radiation and/or levels of radioactivity*

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

~~IEC 61559-2:2002, *Radiation in nuclear facilities – Centralized systems for continuous monitoring of radiation and/or levels of radioactivity – Part 2: Requirements for discharge, environmental, accident, or post-accident monitoring functions*~~

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

IEC 62262:2002, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

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 62566-2:2020, *Nuclear power plants – Instrumentation and control important to safety – Development of HDL-programmed integrated circuits – Part 2: HDL-programmed integrated circuits for systems performing category B or C functions*

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

ISO 2889:~~2009~~2015, *Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities*

## 3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

**3.1**
**absolute error of measurement**
difference between the measured value and the conventional quantity value of the measurand

**3.2**
**acceptance test**
contractual test to prove to the customer that the device fulfils certain specifications

~~[IEV 394-40-05]~~

~~**3.2**~~
~~**accident conditions**~~
~~deviations from normal operation more severe than anticipated operational occurrences, including design basis accidents and severe accidents~~

~~[IAEA Safety Glossary, 2007 edition]~~

**3.3**
**aerodynamic equivalent diameter**
diameter of unit-density sphere having the same gravitational settling velocity as the particle ~~in question~~ of concern

Note 1 to entry: The aerodynamic equivalent diameter concerns particles with a diameter from 0,1 µm to 2 mm.

[SOURCE: ~~IEV 393-11-41~~ IEC 60050-395:2014, 395-02-34]

~~**3.4**~~
~~**anticipated operational occurrence**~~
~~operational process deviating from normal operation which is expected to occur at least once during the operational lifetime of a nuclear power plant but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions~~

~~[IAEA Safety Glossary, 2007 edition]~~

**3.4**
**coefficient of variation**
ratio of the standard deviation $s$ to the arithmetic mean $\bar{x}$ of a set of $n$ measurements $x_i$ given by the following formula:

$$V = \frac{s}{\bar{x}} = \frac{1}{\bar{x}} \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

~~[IEV 394-40-14]~~

**3.5**
**collection efficiency**
percentage retained by the filter of the total amount of particles initially in a known volume of air passed through the filter

~~[ISO 2889]~~

~~**3.7**~~
~~**conventionally true value**~~
~~value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose~~

~~[IEV 394-40-10]~~

~~NOTE For example, a value and its uncertainty determined from a primary or a secondary standard, or by a reference instrument which has been calibrated against a primary or secondary standard, may be taken as the conventionally true value.~~

**3.6**
**conventional quantity value**
quantity value attributed by agreement to a quantity for a given purpose

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

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

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

~~**3.8**~~
~~**decision threshold**~~
~~fixed value of the activity which allows a decision to be made for each measurement with a given probability of error as whether the registered measurement includes a contribution from the physical effect~~

~~[IEC 60761-1,3.9]~~

~~NOTE The statistical test shall be designed such that the probability of wrongly rejecting the hypothesis (error of the first kind) is equal to a given value α. In the case of this standard, α equals 5 %.~~

~~**3.9**~~
~~**Design Basis Accident (DBA)**~~
~~accident conditions against which a facility is designed according to established design criteria, and for which the damage to the fuel and the release of radioactive material are kept within authorized limits~~

~~[IAEA Safety Glossary, 2007 edition]~~

~~**3.10**~~
~~**detection limit**~~
~~smallest true value of the measurand which is detectable by the measuring method~~

~~[IEC 60761-1,3.10]~~

~~NOTE The detection limit is the smallest true value of the measurand which is associated with the statistical test and hypotheses by the following characteristics: if in reality the true value is equal to or exceeds the detection limit, the probability of wrongly not rejecting the hypothesis (error of the second kind) shall be at most equal to a given value β. For this standard, β equals 5 %.~~

**3.7**
**effective range of measurement**
absolute value of the difference between the two limits of a nominal range

Note 1 to entry: In the nominal range the performance of a piece of equipment or an assembly meets the requirements of its specifications.

~~[IEV 394-40-16]~~

**3.8**
**electron beam**
electron flux emitted from one source and moving along the exactly determined tracks with very great velocities

Note 1 to entry: Such beam routed to a detector causes extremely high dose rates.

[SOURCE: IEC 60050-841:2004, 841-30-01]

**3.9**
**experimental standard deviation**
for a series of $n$ measurements of the same measurand, the quantity $s$ characterizes the dispersion of the results and is given by the formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}}$$

$x_i$ being the result of the $i$th measurement and $\bar{x}$ being the arithmetic mean of the $n$ results considered

Note 1 to entry: The expression $s/\sqrt{n}$ is an estimate of the standard deviation of the distribution of $x$ and is called the experimental standard deviation of the mean.

Note 2 to entry: Experimental standard deviation of the mean is sometimes incorrectly called standard error of the mean.

~~[IEV 394-40-40]~~

**3.10**
**measuring assembly**
assembly designed to measure a quantity

Note 1 to entry: In this document, the quantity is volumetric activity or dose rate, although the value may be expressed in other units.

**3.11**
**minimum detectable (measurable) activity**
~~quantity of radioactivity giving a count which, in the presence of a specified background noise, has a 95 % probability not to be caused by that of background noise alone~~

~~[IEV 394-40-25]~~

radioactivity which, if present in a sample, produces a counting rate that will be detected (i.e. considered to be above background) with a certain level of confidence

Note 1 to entry: The 'certain level of confidence' is normally set at 95 %; that is, a sample containing exactly the minimum detectable activity will, as a result of random fluctuations, be taken to be free of radioactivity 5 % of the time.

Note 2 to entry: The minimum detectable activity is sometimes referred to as the detection limit or lower limit of detection.

Note 3 to entry: The counting rate from a sample containing the minimum detectable activity is termed the determination level.

Note 4 to entry: An example formulation for minimum detectable activity is calculated as follows.

$$MDA = \frac{k_1^2 + 2k_1\sqrt{R_b t_s\left(1 + \frac{t_s}{t_b}\right)}}{(t_s)(E)(C)}$$

where:

$k_1$ is the one-sided coverage factor = 1,645 at 95 % confidence

$R_b$ is the background count rate in $s^{-1}$

$t_s$ is the sample count time in min

$t_b$ is the background count time in min

$E$ is the detector efficiency in counts per disintegration

$C$ is the conversion factor from dpm to other desired activity unit, if applicable

[SOURCE: IAEA Safety Glossary, 2018 edition]

**3.12**
**particle**
aggregate of molecules, forming a solid or liquid ~~of size ranging from a few molecular diameters to some tenths of a milimeter (several hundred micrometers)~~, ranging in size from a few molecular diameters to several millimetres

[SOURCE: ISO 2889:2015, 3.55]

**3.13**
**process streams**
fluid which flows through a system intended to provide a useful purpose

Note 1 to entry: Examples of process streams are: primary coolant system, spent fuel cooling system, component cooling system, etc.

Note 2 to entry: The process streams within the scope of this document are those streams in which the level of radioactivity may significantly increase as a result of accident or post-accident conditions.

Note 3 to entry: Monitoring of these process streams for radioactivity provides information on the quality or integrity of the barrier and potential release to the environment.

**3.14**
**reference response**
response of the assembly under reference conditions to unit reference dose rate, expressed as:

$$R_{\text{ref}} = \frac{\nu - \nu_{\text{B}}}{\nu_{\text{c}}}$$

where:

$\nu$ is the value measured by the equipment or assembly under test

$\nu_{\text{B}}$ is the background value of the equipment without external influence

$\nu_{\text{c}}$ is the conventional quantity value of the reference source

Note 1 to entry: The background value may be automatically taken into account by an algorithm included in the measurement systems.

~~[IEV 394-40-22]~~

**3.15**
**relative error**
error of measurement divided by a true value of the measurand

~~[IEV 394-40-11]~~

Note 1 to entry: Since a true value cannot be determined, in practice, a ~~conventionally true~~ conventional quantity value is used. For this standard, relative error is calculated as follows.

$$E = \frac{(\nu - \nu_{\text{B}}) - \nu_{\text{c}}}{\nu_{\text{c}}}$$

where:

$\nu$ is the value measured by the equipment or assembly under test,

$\nu_{\text{c}}$ is the ~~conventionally true~~ conventional quantity value of the reference source,

$\nu_{\text{B}}$ is the background value of the equipment without external influence.

Note 2 to entry: The background value may be automatically taken into account by an algorithm included in the measurement system.

**3.16**
**relative response**
value calculated during type testing equal to the ratio between the reference response of the equipment and the sensitivity of the same equipment to the solid source of interest

Note 1 to entry: The relative response allows determination of the reference response of identical equipment that has been type tested from the measurement of the sensitivity of the solid source.

**3.17**
**response time**
period of time necessary for a component to achieve a specified output state from the time that it receives a signal requiring it to assume that output state

Note 1 to entry: For the purposes of the tests described in this document, the input signal is assumed to be a step variation and the ending output state is the point at which the output signal variation reaches 90 % of its final value for the first time.

[SOURCE: IAEA Safety Glossary, 2018 edition]

**3.18**
**routine test**
conformity test made on each individual item during or after manufacture

~~[IEV 394-40-03]~~

~~**3.23**~~
~~**sampling assembly**~~
~~set of interconnected devices for collecting a representative sample~~

**3.19**
**sampling collection efficiency**
for a given quantity of radioactive material, ratio of the collected activity to the supplied activity, for a specified time interval

~~[IEV 394-39-45]~~

**3.20**
**sensitivity <of a measuring assembly>**
~~for a given value of the measured quantity,~~ ratio of the variation of the observed variable to the corresponding variation of the measured quantity for a given value of the measured quantity

[SOURCE: ~~IEV 394-39-07~~ IEC 60050-395:2014, 395-03-105]

~~**3.26**~~
~~**volumetric activity**~~
~~quotient of the activity by the total volume of the sample~~

~~[IEV 393-14-16]~~

~~NOTE 1 For a gas, it is necessary to indicate the temperature and pressure conditions for which the volumic activity is measured, for example standard temperature and pressure (STP).~~

~~NOTE 2 This quantity is expressed in Becquerels per cubic meter ($Bq/m^3$).~~

## 4 Design principles

### 4.1 General

The radiation monitor classified for functions important to safety shall comply with the requirements relating to the characteristics and lifecycle of RMS defined in IEC 62705 and the standards referenced in IEC 62705 (e.g. IEC 61226).

In the case where different radiation monitoring systems for design basis accidents (DBA) and that for design extension conditions (DEC) including severe accident (SA) are required, they should be independent of each other as far as reasonably practicable.