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# INTERNATIONAL STANDARD

**Nuclear power plants – Instrumentation systems – Measurements for monitoring adequate cooling within the core of pressurized light water reactors**

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# CONTENTS

FOREWORD ..... 5
INTRODUCTION ..... 7
1 Scope ..... 9
2 Normative references ..... 9
3 Terms and definitions ..... 10
4 Abbreviated terms ..... 13
5 Operational conditions ..... 13
5.1 General ..... 13
5.2 Cooling state with steam generator ..... 14
5.2.1 General ..... 14
5.2.2 Coolant subcooled state ..... 14
5.2.3 Coolant saturated state ..... 14
5.2.4 Coolant superheated state ..... 15
5.3 Cooling state with RHRS ..... 15
5.3.1 General situation under RHRS operation ..... 15
5.3.2 Cold shutdown maintenance operations ..... 16
5.3.3 Cold shutdown refuelling operation ..... 16
5.3.4 PRHRS operation ..... 16
5.4 Cooling state with primary loop feed and bleed ..... 17
5.5 Cooling state with CIS ..... 17
6 Measurement methods ..... 17
6.1 General ..... 17
6.2 Water level measuring devices ..... 17
6.2.1 General ..... 17
6.2.2 RPV water level measuring devices ..... 17
6.2.3 RPV outlet pipe water level measuring devices ..... 19
6.2.4 Differential pressure measurement ..... 19
6.2.5 Ultrasonic liquid level monitoring ..... 19
6.2.6 Pressurizer level ..... 19
6.2.7 Reactor cavity level ..... 19
6.2.8 Containment flood-up level ..... 19
6.3 Temperature measuring devices ..... 19
6.3.1 General ..... 19
6.3.2 Core exit temperature ..... 20
6.3.3 RPV outlet and inlet pipe temperature ..... 20
6.3.4 RHRS temperature ..... 20
6.3.5 PRHRS temperature ..... 20
6.3.6 RPV and cavity temperature ..... 20
6.4 Flow measuring device ..... 20
6.4.1 RPV outlet pipe flow ..... 20
6.4.2 RHRS flow ..... 20
6.4.3 RSIS flow ..... 20
6.4.4 CIS flow ..... 21
6.5 Pressure measuring device ..... 21
7 Instrumentation requirements ..... 21
7.1 General requirements ..... 21

7.1.1 Overview ..... 21
7.1.2 Safety classification ..... 21
7.1.3 Accuracy and response time ..... 21
7.1.4 Reliability ..... 21
7.1.5 Single failure considerations ..... 21
7.2 Differential pressure measurement ..... 22
7.2.1 Differential pressure transmitters ..... 22
7.2.2 Reference columns ..... 22
7.2.3 Differential pressure tap locations ..... 22
7.2.4 Hydraulic instrument line installations ..... 23
7.2.5 Hydraulic instrument line temperature ..... 23
7.2.6 Type and quality of the fluid in the instrument lines ..... 24
7.3 Heated sensor measurement ..... 24
7.4 Ultrasonic liquid level measurement ..... 24
7.4.1 Application ..... 24
7.4.2 Accuracy and response time ..... 24
7.4.3 Installation considerations ..... 24
7.4.4 Special human machine considerations ..... 24
7.5 Temperature sensing devices ..... 24
7.6 Magnetic float sensing devices ..... 25
8 Operator displays ..... 25
9 Calibration ..... 26
10 In-service testing and maintenance ..... 26
11 Qualification ..... 26
12 Documentation ..... 26
Annex A (informative) Thermodynamic analysis of the reactor coolant system ..... 39
A.1 General ..... 39
A.2 Assessment of thermodynamic conditions ..... 39
A.2.1 General ..... 39
A.2.2 Momentum and mass behaviour ..... 39
A.2.3 Energy behaviour ..... 40
A.3 Display parameters ..... 40
A.4 Example of displays ..... 41
A.4.1 General ..... 41
A.4.2 Pressure-temperature deviation display ..... 41
A.4.3 Subcooling history display ..... 44
A.4.4 Temperature-pressure display ..... 44
Bibliography ..... 45

Figure 1 – Different void distributions with equivalent liquid levels ..... 11
Figure 2 – PWR configuration 1: Cooling state with steam generator ..... 27
Figure 3 – PWR configuration 2: Cooling state with RHRS ..... 28
Figure 4 – PWR configuration 3: Cooling state with PRHRS (primary side) ..... 29
Figure 5 – PWR configuration 4: Cooling state with PRHRS (secondary side) ..... 30
Figure 6 – PWR configuration 5: Cooling state with primary loop feed and bleed (RSIS) ..... 31
Figure 7 – PWR configuration 6: Cooling state with primary loop feed and bleed (recirculated in containment) ..... 32

Figure 8 – PWR configuration 7: Cooling state after core melting ..... 33
Figure 9 – Water level measurement by differential pressure method ..... 34
Figure 10 – Heated temperature sensor measurement ..... 35
Figure 11 – Magnetic float actuated reed switches for water level measurements ..... 36
Figure 12 – Flow measurement by differential pressure method ..... 37
Figure 13 – Thermal-hydraulic considerations affecting water level measurements ..... 38
Figure A.1 – Pressure-temperature deviation display ..... 42
Figure A.2 – Subcooling history display ..... 43
Figure A.3 – Temperature-pressure display ..... 43

Table A.1 – Thirteen different cases of changing pressure, temperature and subcooling ..... 41

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# NUCLEAR POWER PLANTS – INSTRUMENTATION SYSTEMS – MEASUREMENTS FOR MONITORING ADEQUATE COOLING WITHIN THE CORE OF PRESSURIZED LIGHT WATER REACTORS

## FOREWORD

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IEC 60911 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 second edition cancels and replaces the first edition published in 1987. This edition constitutes a technical revision.

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

a) Modification of the title.
b) Integration and merging with the content of IEC 62117:1999 relative to the monitoring of core cooling during cold shutdown.
c) Integration of feedback following the 2011 Fukushima accident.

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

| Draft | Report on voting |
|---|---|
| 45A/1580/FDIS | 45A/1602/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.

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.

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- reconfirmed,
- withdrawn, or
- revised.

# INTRODUCTION

**a) Technical background, main issues and organisation of the document**

This document focuses on the methods and requirements relating to the measurement of adequate cooling within the core of pressurised water reactors.

Adequate core cooling can be achieved only by providing sufficient coolant flow to the core to remove the heat. Under normal power operation, cooling of the core is adequately monitored by the normal reactor protection measurement. Normally, the coolant is forced circulation to facilitate the heat transfer. However, during certain abnormal shutdown conditions, the coolant might circulate naturally, or the coolant might even become stationary.

The coolant can be in one phase or two phases:

1) one phase: either liquid, or steam, or a mixture of steam and gas;
2) two phases: a mixture of liquid and steam or gas.

To monitor that adequate cooling is being achieved under those abnormal conditions for which operator action can be necessary or for which confirmation of coolant inventory status is of value, sufficient measurements of the coolant inventory shall be provided, including the level measurement.

Measurement of the subcooling and its time history shall also be provided to assist the operator in avoiding those abnormal conditions.

It is intended that this document be used by operators of NPPs (utilities), systems evaluators and by licensors.

**b) Situation of the current document in the structure of the IEC SC45A standard series**

IEC 60911 is a level 3 IEC SC 45A document covering the methods and requirements for the monitoring of cooling within the core of pressurised water reactors.

For more details on the structure of the IEC SC45A standard series, see item d) of this introduction.

**c) Recommendations and limitations regarding the application of the document**

To ensure that this document 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 SC45A standard series and relationships with other IEC documents and other bodies documents (IAEA, ISO)**

The IEC SC 45A standard series comprises a consistent set of documents organised in a hierarchy of four levels. The top-level documents of the IEC SC 45A standard series are IEC 61513 and IEC 63046, covering respectively general requirements for instrumentation and control (I&C) systems and general requirements for electrical power systems of NPPs. IEC 61513 and IEC 63046 adopt an overall system life-cycle framework and constitute, along with the relevant second-level standards, the nuclear implementation of the basic safety series IEC 61508.

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.

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 refer to second-level documents for general requirements and can be used on their own.

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

The IEC SC 45A standards series consistently implements and details the safety and security principles and basic aspects provided in the relevant IAEA safety standards and in the relevant documents of the IAEA nuclear security series (NSS). In particular this includes the IAEA requirements SSR-2/1 , establishing safety requirements related to the design of nuclear power plants (NPPs), the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPPs, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPPs, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPPs, the IAEA safety guide SSG-51 dealing with human factors engineering in the design of NPPs and the implementing guide NSS42-G 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 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 IEC TR 63400 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 – INSTRUMENTATION SYSTEMS – MEASUREMENTS FOR MONITORING ADEQUATE COOLING WITHIN THE CORE OF PRESSURIZED LIGHT WATER REACTORS

## 1 Scope

This document applies to pressurized water reactors (PWRs) and presents requirements for the monitoring of adequate cooling within the core in all operations, including normal and abnormal operations. Requirements for core cooling monitoring during conditions beyond a design basis accident, i.e. a design extension condition of type A or type B, are also covered in this document.

This document defines requirements for instrumentation to measure coolant parameters, which are of interest when abnormal conditions arise with either one or two phases of coolant or with gas included in the reactor pressure vessel (RPV).

PWR users can acquire this instrumentation to present information on coolant conditions, to assist the operator to decide on actions necessary to maintain adequate core cooling.

Typical applications in operating nuclear power plants are also presented in 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 60880, *Nuclear power plants – Instrumentation and control systems important to safety – Software aspects for computer-based systems performing category A functions*

IEC 60964, *Nuclear power plants – Control rooms – Design*

IEC 61225, *Nuclear power plants – Instrumentation, control and electrical power systems – Requirements for static uninterruptible DC and AC power supply systems*

IEC 61226, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Categorization of functions and classifications of systems*

IEC 61227, *Nuclear power plants – Control rooms – Operator controls*

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

IEC 62828-2, *Reference conditions and procedures for testing industrial and process measurement transmitters – Part 2: Specific procedures for pressure transmitters*

IEC 63147, *Criteria for accident monitoring instrumentation for nuclear power generating stations*

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

IEC/IEEE 60980-344:2020, *Nuclear facilities – Equipment important to safety – Seismic qualification*