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Nuclear facilities – Instrumentation important to safety – Spent fuel pool instrumentation

Installations nucléaires – Instrumentation importante pour la sûreté – Instrumentation des piscines de refroidissement et de stockage du combustible

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CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 9
1.1 General 9
1.2 Purpose 9
1.3 Application 9
2 Normative references 9
3 Terms and definitions 10
4 Symbols and abbreviated terms 12
5 Functional requirements 12
6 Performance criteria 14
6.1 Range 14
6.2 Accuracy 15
6.2.1 General 15
6.2.2 Additional criteria for DEC spent fuel pool monitoring instrumentation 15
6.3 Response time 15
6.4 Required accident operating time 15
6.5 Reliability 15
6.6 Documentation of performance criteria 15
6.6.1 General 15
6.6.2 Additional criteria for DEC spent fuel pool monitoring instrumentation 15
7 Design criteria 16
7.1 Redundancy 16
7.2 Common cause failure 16
7.3 Physical independence and separation 16
7.4 Electrical isolation 17
7.5 Information ambiguity 17
7.6 Power supply 17
7.6.1 General 17
7.6.2 Additional criteria for DEC spent fuel pool monitoring instrumentation 18
7.7 Calibration 18
7.7.1 General 18
7.7.2 Additional criteria for DEC spent fuel pool monitoring instrumentation 18
7.8 Testability 18
7.8.1 General 18
7.8.2 Additional criteria for DEC spent fuel pool monitoring instrumentation 18
7.9 Direct measurement 18
7.10 Control of access 19
7.11 Maintenance and repair 19
7.12 Supporting features 19
8 Qualification criteria 19
8.1 General 19
8.2 Seismic qualification 19
8.3 Environmental qualification 19
8.4 Shock and vibration qualification 20
9 Display criteria 20

9.1 Human factors 20
9.2 Trend or rate information 20
9.3 Continuous versus on-demand displays 20
9.3.1 General 20
9.3.2 Additional criteria for DEC spent fuel pool monitoring instrumentation 20
9.4 Display identification 20
9.5 Display location 20
9.5.1 General 20
9.5.2 Additional criteria for DEC spent fuel pool monitoring instrumentation 21
10 Quality assurance 21
Annex A (informative) Typical bases for identifying spent fuel pool conditions to be detected 22
Bibliography 25

Figure A.1 – Spent fuel pool monitoring instrumentation 22

Table 1 – Relationship of functional groups used in this document 14

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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NUCLEAR FACILITIES – INSTRUMENTATION IMPORTANT TO SAFETY – SPENT FUEL POOL INSTRUMENTATION

FOREWORD

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International Standard IEC/IEEE 63113 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation, in cooperation with Nuclear Power Engineering Committee of the IEEE, under the IEC/IEEE Dual Logo Agreement.

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

FDIS	Report on voting
45A/1373/FDIS	45A/1382/RVD

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

International standards are drafted in accordance with the rules given in the International Organization for Standardization (ISO) / IEC Directives, Part 2.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

a) Technical background, main issues and organization of the Standard

This IEC/IEEE standard sets out the requirements for instrumentation to monitor spent fuel pool water level and temperature in nuclear facilities as well as radiation monitoring in the vicinity of the pool.

Prior to the accident at Fukushima Daiichi, spent fuel pool monitoring in nuclear power plants was provided mainly to enable operators to monitor pool temperature at a location near the top of the pool. It was also used to determine that the water level remained below the point where flooding of operational areas would be a concern and above the level assumed in safety analyses that evaluated the release of fission products from the pool in the event of a fuel handling accident.

In general, robust spent fuel pools protect the fuel from physical damage and use highly reliable coolant systems that ensure continuous decay heat removal. Monitoring of the pool cooling system and drain taps at the bottom of the pool were considered sufficient to confirm pool cooling under operational states and design basis accidents. Because these are straightforward measurements, neither IEC SC 45A nor IEEE NPEC considered that a standard on this topic was necessary.

During the accident at Fukushima Daiichi, explosions occurred in the reactor buildings of units 1, 3, and 4. Hydrogen release from fuel in the spent fuel pool, due to loss of water inventory, had to be considered as a possible cause of the explosions. Instrumentation suitable for checking this hypothesis was not installed and operators could not directly check pool conditions because of radiation dose rates and other hazards in the reactor buildings. Consequently, plant operators had to take action on the assumption that the spent fuel was no longer fully covered by water.

Eventually, it was confirmed that the many extraordinary actions taken by site personnel succeeded in averting a greater release of radioactive material from the spent fuel pools. Nevertheless, the lack of real time information about pool conditions created significant difficulties in responding to the accidents, increased public anxiety, and diverted resources away from activities to restore core cooling.

Subsequent analysis, however, determined that if the water in the reactor well and dryer-separator pits in Unit 4 had not leaked into the spent fuel pool as water in the pool evaporated, the spent fuel in Unit 4 may have become uncovered. [6], [8] [1]

This experience points to a need to provide plant operators with instrumentation to enable them to understand the state of spent fuel cooling under design extension conditions (DEC). To support the design of such instrumentation, the expected pool conditions must be defined and the instruments should be designed considering any special characteristics needed to ensure their high reliability and operability in the presence of hazards that might exist during design extension conditions.

It is also necessary to monitor spent fuel pools during normal operations in order to: detect a potential loss of heat removal from the pool, detect high pool levels that risk pool overflow, confirm the pool contains sufficient water to shield operators from the radiation from fission products contained in the spent fuel, and ensure safety analysis assumptions are met concerning pool water hold-up of fission products in the event of a fuel handling accident.

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[1] Numbers in square brackets refer to the Bibliography.

To address the specific lessons learned from the Fukushima Daiichi accident and to give an overall view of the requirements for spent fuel pool monitoring, this document establishes criteria for the performance, design, qualification, display, and quality assurance of instruments for monitoring spent fuel pool conditions during both operational states and accident conditions (including design extension conditions) at nuclear facilities.

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

IEC 63113 is at the third level in the hierarchy of SC 45A standards.

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 Nuclear Power Plants (NPPs). IEC/IEEE 60780-323 provides the standard for environmental qualification. IEC 62003 provides the requirements for electromagnetic compatibility testing.

IEC 63147/IEEE Std 497™ provides criteria 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. This standard deals with instrumentation intended to help plant operators avoid severe accidents in spent fuel pools. The introduction to IEEE Std 497™ notes that design extension conditions that are not severe accidents are not covered by that standard. 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 the Standard

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

This standard is directed at facilities in which loss of spent fuel pool inventory makes possible a significant fission product release to the environment. Thus, the standard applies only to spent fuel pools at which the water fill is necessary to prevent a release of fission products that exceeds allowed operational limits.

d) Description of the structure of the IEC SC 45A standard series and relationships with other IEC documents and other bodies' documents (e.g., 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 covers power supply systems including the supply systems of the I&C systems. IEC 61513 and IEC 63046 are to be considered in conjunction and at the same level. IEC 61513 and IEC 63046 structure the IEC SC 45A standard series and shape a complete framework establishing general requirements for instrumentation, control and electrical systems for nuclear power plants.

IEC 61513 and IEC 63046 refer directly to other IEC SC 45A standards for general topics related to categorization of functions and classification of systems, qualification, separation, defence against common cause failure, control room design, electromagnetic compatibility, cybersecurity, software and hardware aspects for programmable digital systems, coordination of safety and security requirements and management of aging. 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 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 NPPs, the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPPs, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPPs, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPPs and the implementing guide NSS17 for computer security at nuclear facilities. The safety and security terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

IEC 61513 and IEC 63046 have adopted a presentation format similar to the basic safety publication IEC 61508 with an overall life-cycle framework and a system life-cycle framework. Regarding nuclear safety, IEC 61513 and IEC 63046 provide the interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. In this framework IEC 60880, IEC 62138 and IEC 62566 correspond to IEC 61508-3 for the nuclear application sector. IEC 61513 and IEC 63046 refer to ISO as well as to IAEA GS-R 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 and IEC 62342 is the entry document for the aging management standards.

NOTE 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.

NUCLEAR FACILITIES – INSTRUMENTATION IMPORTANT TO SAFETY – SPENT FUEL POOL INSTRUMENTATION

1 Scope

1.1 General

This document provides criteria for spent fuel pool instrumentation for nuclear power generating stations and other nuclear facilities. The document applies to water filled spent fuel pools where the water volume is necessary to prevent a release of fission products that exceeds allowed operational limits.

1.2 Purpose

The purpose of this document is to establish design, performance, qualification, and display criteria for spent fuel pool instrumentation for normal operation, anticipated operational occurrences, design basis events, and design extension conditions (including severe accident conditions).

1.3 Application

This document applies only to instrumentation for monitoring the condition of the spent fuel pool, i.e., pool level, pool temperature, and area radiation. It does not apply to control systems that are related to the spent fuel pool such as: the pool cooling systems, isolation valve control, crane instrumentation and control, or refuelling machine instrumentation and control.

In some plant designs some of the instruments covered by this document also provide inputs to protection system functions. Such instruments must also comply with requirements for protection systems that are given elsewhere.

The requirements applied to the systems and components performing these functions depend on how they contribute to the safety of the spent fuel pool.

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 60709:2018, *Nuclear power plants – Instrumentation, control and electrical power systems important to safety – Separation*

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

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

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

NOTE 1 The use of IEC 61226 should take account of the discussion given in IEC TR 63123 [19].

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

IEC 63046, *Nuclear power plants – Electrical power system – General requirements*

IEEE 384™, 2018, *IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits*

NOTE 2 This document can be used with either IEEE and/or IEC normative references, but one coherent and consistent set of references shall be defined at the beginning of the project and used as a whole as the basis for the design and for all the project.