

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Nuclear power plants – Instrumentation important to safety – Temperature sensors (in-core and primary coolant circuit) – Characteristics and test methods

Centrales nucléaires de puissance – Instrumentation importante pour la sûreté – Capteurs de température (dans le cœur et le circuit primaire) – Caractéristiques et méthodes d'essai



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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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Fax: +41 22 919 03 00

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	9
4 General considerations.....	11
4.1 Requirements for temperature measurements	11
4.2 Safety applications	12
4.3 Nuclear conditions.....	12
5 Temperature sensors.....	12
5.1 Resistance temperature detector.....	12
5.2 Thermocouple	14
5.3 Other temperature sensors.....	15
5.4 Comparison between RTD and thermocouples	15
6 Characteristics of a temperature sensor	16
6.1 General.....	16
6.2 Installation	16
6.2.1 Thermowell.....	16
6.2.2 Cables.....	16
6.3 Functional characteristics.....	16
6.3.1 Sensitivity.....	16
6.3.2 Response time	16
6.3.3 Linearity	17
6.4 Accuracy in temperature measurements.....	17
6.5 Mechanical characteristics	17
7 Temperature measurement system design	18
7.1 General requirements.....	18
7.1.1 General	18
7.1.2 Environmental conditions.....	19
7.1.3 Classification.....	19
7.1.4 Performance.....	19
7.2 Site implementation.....	19
7.2.1 Environmental conditions and operation	19
7.2.2 Operating mode.....	20
7.2.3 Calibration.....	20
7.2.4 Measuring range and accuracy.....	21
7.2.5 Electrical conditions.....	21
8 Requirements for tests	22
8.1 General.....	22
8.2 Pre-production testing	22
8.3 Production processes and testing.....	22
8.3.1 General	22
8.3.2 Factors for sheathed thermocouples	23
8.3.3 Factors for RTD.....	23
8.4 Tests on site	23
9 Qualification tests.....	23

9.1	Principles	23
9.2	Test sequence on a sensor	24
9.3	Test for environmental conditions	24
9.3.1	Temperature test	24
9.3.2	Pressure test	24
9.3.3	Other tests	24
9.4	Seismic tests	24
	Bibliography	25
	Table 1 – RTD and thermocouple characteristic comparison	15

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**NUCLEAR POWER PLANTS –
INSTRUMENTATION IMPORTANT TO SAFETY –
TEMPERATURE SENSORS (IN-CORE
AND PRIMARY COOLANT CIRCUIT) –
CHARACTERISTICS AND TEST METHODS**

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 60737 has been prepared by subcommittee 45A: Instrumentation and control of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition published in 1982. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

- to up-date the references to standards published or revised since the issue of the first edition of the current standard, including IEC 61513 and IEC 61226;
- to include descriptions of the comparative performance of thermocouples and resistance temperature detectors;
- to include a discussion of the temperature measuring system requirements for reactors;
- to adapt the definitions;

- to update the format to align with the current ISO/IEC Directives on style of standards.

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

FDIS	Report on voting
45A/800/FDIS	45A/806/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has 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.

INTRODUCTION

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

This International Standard addresses the issues specific to temperature detectors used mainly for in-core and primary coolant circuit instrumentation systems. It describes the principles, the characteristics and the test methods for temperature detectors including: RTDs and thermocouples.

It is organized into clauses giving:

- the definitions;
- description of the different types of temperature sensors;
- system design;
- analysis of the factors of influence;
- the operational conditions for sensors;
- the factory tests;
- the qualification tests.

It is intended that the Standard be used by operators of NPPs (utilities), nuclear plant designers and constructors, systems evaluators and by licensors.

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

IEC 60737 is the third level IEC SC 45A document tackling the specific issue of characteristics and test methods related to temperature detectors used in power reactors.

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

c) Recommendations and limitations regarding the application of the Standard

There are no special recommendations or limitations regarding the application of this standard.

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 as well as to 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.

NUCLEAR POWER PLANTS – INSTRUMENTATION IMPORTANT TO SAFETY – TEMPERATURE SENSORS (IN-CORE AND PRIMARY COOLANT CIRCUIT) – CHARACTERISTICS AND TEST METHODS

1 Scope

This International Standard is applicable to general aspects of system and component design, manufacturing and test methods for temperature sensors used in-core and for the primary coolant circuit in nuclear power reactors.

These sensors include thermocouples and RTDs (Resistance Temperature Detector–RTD). Emphasis is placed on the features specific to the nuclear application and recommendations concerning components and sensors are made only when they relate to the containment of such components within the reactor primary envelope and/or in high radiation fields.

The conditions imposed by reactor use are often different from those which occur in non-nuclear applications. Parts of the in-core system may be located in very severe environments.

Exposure to high neutron and gamma radiations is liable to cause error due to nuclear transformations, heating and structural changes, and to affect the mechanical and electrical properties of the equipment so that extra care has to be taken in the standards adopted for installations and in the choice of materials.

Furthermore, design consideration needs to be given to the effects of high environmental pressure, high temperature, temperature gradients and temperature cycling as well as to the way in which the temperature measuring system could influence the safety or economic performance of the reactor.

The consequences of nuclear conditions for temperature sensors lead to strong requirements regarding qualification.

This standard deals with specific requirements for nuclear applications of temperature sensors. It has two purposes:

- a) to provide a guide which will help to ensure that the reactor conditions do not damage the temperature sensors;
- b) to ensure that the in-core temperature measuring system and the sensor installation do not prejudice the safe operation and the availability of the reactor.

Statements of general applicability are made but detailed consideration is restricted to thermocouples and RTDs.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60584-1, *Thermocouples – Part 1: Reference tables*

IEC 60584-2, *Thermocouples – Part 2: Tolerances*

IEC 60584-3, *Thermocouples – Part 3: Extension and compensating cables – Tolerances and identification system*

IEC 60709, *Nuclear power plants – Instrumentation and control systems important to safety – Separation*

IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*

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

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

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

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

IEC 61515, *Mineral insulated thermocouple cables and thermocouples*

IEC 62342, *Nuclear power plants – Instrumentation and control systems important to safety – Management of ageing*

IEC 62385, *Nuclear power plants – Instrumentation and control important to safety – Methods for assessing the performance of safety system instrument channels*

IEC 62397, *Nuclear power plants – Instrumentation and control important to safety – Resistance temperature detectors*

IEC 62460, *Temperature – Electromotive force (EMF) tables for pure-element thermocouple combinations*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IAEA Safety Glossary edition 2007, IEC 60050-393 and IEC 60050-394 apply as well as the following:

3.1

accuracy of measurement

closeness of the agreement between the result of a measurement and the conventionally true value of the measurand

[IEV 394-40-35]

NOTE 1 “Accuracy” is a qualitative concept.

NOTE 2 The term “precision” should not be used for “accuracy”.

3.2

electrical shunting

effect of the shunting of the source impedance of the sensing device by the input impedance of the measuring device and the earth leakage impedance of the sensor