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Passive neutron dosimetry systems - Part 1: Performance and test requirements for personal dosimetry (ISO 21909-1:2021)

Systèmes dosimétriques passifs pour les neutrons -
Partie 1: Exigences de fonctionnement et d'essai pour
la dosimétrie individuelle (ISO 21909-1:2021)

This European Standard was approved by CEN on 16 July 2023.

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Contents	Page
European foreword.....	3

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European foreword

The text of ISO 21909-1:2021 has been prepared by Technical Committee ISO/TC 85 "Nuclear energy, nuclear technologies, and radiological protection" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 21909-1:2023 by Technical Committee CEN/TC 430 "Nuclear energy, nuclear technologies, and radiological protection" the secretariat of which is held by AFNOR.

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**Passive neutron dosimetry systems —
Part 1:
Performance and test requirements
for personal dosimetry**

Systèmes dosimétriques passifs pour les neutrons —

*Partie 1: Exigences de fonctionnement et d'essai pour la dosimétrie
individuelle*

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Contents

Page

Foreword.....	v
Introduction.....	vii
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	2
3.1 General terms and definitions.....	2
3.2 Quantities.....	3
3.3 Calibration and evaluation.....	5
3.4 List of symbols.....	7
4 General test conditions.....	9
4.1 Test conditions.....	9
4.2 Reference radiation.....	9
5 Test and performance requirements.....	10
6 Qualification for eliminating the use of the full neutron and photon package.....	11
6.1 Purpose of the test.....	11
6.2 Method of test.....	11
6.3 Interpretation of results.....	11
7 Performance tests for the intrinsic characteristics of the dosimetry systems.....	12
7.1 General.....	12
7.2 Irradiations.....	12
7.3 Coefficient of variation.....	16
7.3.1 General.....	16
7.3.2 Method of test.....	16
7.3.3 Interpretation of results.....	17
7.4 Linearity.....	17
7.4.1 General.....	17
7.4.2 Method of test.....	17
7.4.3 Interpretation of results.....	17
7.5 Energy and angle dependence of the response.....	18
7.5.1 General.....	18
7.5.2 Method of test.....	18
7.5.3 Interpretation of results.....	18
7.6 Specific test for thermal neutrons.....	18
7.6.1 General.....	18
7.6.2 Method of test.....	19
7.6.3 Interpretation of results.....	19
8 Performance tests for stability in the range of realistic conditions of use of the dosimeters.....	19
8.1 Fading.....	19
8.1.1 General.....	19
8.1.2 Method of test.....	19
8.1.3 Interpretation of results.....	20
8.2 Ageing.....	20
8.2.1 General.....	20
8.2.2 Method of test.....	20
8.2.3 Interpretation of results.....	20
8.3 Effect of storage for unexposed dosimeters.....	21
8.3.1 General.....	21
8.3.2 Method of test.....	21
8.3.3 Interpretation of results.....	21
8.4 Exposure to radiation other than neutrons.....	21

ISO 21909-1:2021(E)

8.4.1	General.....	21
8.4.2	Photon radiation.....	21
8.4.3	Radon.....	23
8.5	Stability under various climatic conditions.....	23
8.5.1	General.....	23
8.5.2	Effect on the dose equivalent response.....	23
8.5.3	Effect for unexposed dosimeters.....	24
8.6	Effect of light exposure (sensitivity to light).....	24
8.6.1	Effect on the dose response.....	24
8.6.2	Effect for unexposed dosimeters.....	25
8.7	Drop test.....	25
8.7.1	Effect on the dose response.....	25
8.7.2	Effect for unexposed dosimeters.....	26
8.8	Distance to the phantom.....	26
8.8.1	General.....	26
8.8.2	Method of test.....	26
8.8.3	Interpretation of results.....	27
8.9	Sealing.....	27
9	Identification and accompanying documentation.....	27
9.1	Individual marking.....	27
9.2	Collective marking.....	27
9.3	Accompanying documentation.....	27
	Annex A (informative) Links between this document and ISO 21909-2.....	29
	Annex B (normative) Performance requirements.....	30
	Annex C (informative) Dosimetry for the irradiation of the extremities.....	35
	Annex D (normative) Reference and standard test conditions.....	36
	Annex E (normative) Irradiation conditions.....	37
	Annex F (normative) Confidence limits.....	38
	Bibliography.....	42

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html. This document was prepared by technical committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

This second edition cancels and replaces ISO 21909:2015, which has been technically revised.

The main changes compared to the previous edition, based on feedbacks from laboratories applying ISO 21909-1, are as follows:

- link between ISO 21909-1 and ISO 21909-2 improved by the addition of a flow chart explaining the link between the two parts;
- irradiations qualities for the energy test modified:
 - fast energy range enlarged to a range between 10 MeV and 19 MeV;
 - modification of the possible relative contribution of the thermal field in the mixed field composed of ^{252}Cf or $^{241}\text{Am-Be}$ with a thermal one;
- modification in the tests and/or criteria for:
 - the test to potentially eliminate the use of the full neutron and photon package;
 - the test of the coefficient of variation: criteria given by a function;
 - the linearity test: modifications in the equation and associated criteria consequently;
 - the energy and angle dependence of the response test: modification of the performance limits using trumpet curves;
 - alignment of the criteria for the following 3 tests: Stability under various climatic conditions/ effect of light exposure (opacity to light) / effect of storage, all for unexposed dosimeters.

A list of all parts in the ISO 21909 series can be found on the ISO website.

ISO 21909-1:2021(E)

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Introduction

This document gives laboratory-based performance and test requirements for passive dosimetry systems to be used for the determination of personal dose equivalent, $H_p(10)$, in neutron fields with energies ranging from thermal to approximately 20 MeV.

A dosimetry system may consist of the following elements:

- a) a passive device, referred to here as a detector, which, after the exposure to radiation, stores information (signal) for use in measuring one or more quantities of the incident radiation field;
- b) a dosimeter, made up of one or more detector(s) incorporated together and with some means of identification;
- c) a reader which is used to read out the stored signal from the detector, and the associated algorithm, if applicable, aiming to determine the personal dose equivalent.

A treatment to prepare the dosimeter before irradiation and/or before reading is also part of the process and is considered in the document.

This document does not focus on any technique in particular, but intends to be general, including new techniques as they emerge. When distinctions are necessary, they are defined as generically as possible, e.g., disposable/reusable dosimeters and photon-sensitive dosimeters. In conclusion, no performance tests are dedicated to one particular technique, unless it is absolutely necessary. Consequently, this document aims to define performance tests leading to similar results, independently of the techniques used.

The main objective of this document is to achieve correspondence between performance tests and conditions of use at workplaces. Dosimetry systems complying with this document exhibit consistent annual dosimetry results in workplace environments. Reaching such an objective means that this document accounts for the various situations of exposure in terms of dose levels and neutron energy distributions.

Annual exposures of many workers comprise the sum of several low doses close to the minimum recording value. The dosimeter needs therefore to be well characterized, not only for use in relatively high dose situations but also for use in low dose situations, to ensure that the annual dose is determined with an adequate uncertainty. In this document, false positive events when there is not any irradiation, are considered but there is no test of the detection threshold by measuring the background signal of the dosimeter when it is not irradiated. However, all the tests aimed at characterizing the dosimetric performance of the system (coefficient of variation and linearity, energy and angle dependence of the responses) are required at two levels of dose: around 1 mSv and close to the minimum recording value. The criteria applied at these two levels of dose could differ. This choice is made to ensure that dosimetric systems are adapted to the range of doses usually encountered at workplaces.

The main goal of this document is to ensure that a dosimeter is reliable enough to use in most workplaces. Reference neutron radiation characteristics and methodologies for the proper calibration of the dosimeters are reported in ISO 8529 (all parts), ISO 12789-1 and ISO 29661. The dose equivalent distributions of the most common reference radiation sources (e.g. $^{241}\text{Am-Be}$ or ^{252}Cf) as used for calibration are generally higher in energy (where the fluence-to-dose-equivalent conversion coefficients are greater) than the ones encountered in workplaces. The performance of the dosimeters for neutron energies between a few tens and a few hundreds of keV specifically needs to be determined to ensure good response in most of the workplaces. To address this need, some performance tests with monoenergetic neutrons fields at low energies are required in this document.

One well-characterized neutron field (e.g., $^{241}\text{Am-Be}$ or ^{252}Cf) is sufficient to test the stability of dosimetric performances for influencing factors (e.g., fading, ageing, the impact of non-neutron radiation on the neutron signal, harsh climatic conditions, light exposure, physical damage, and sealing).

ISO 21909-1:2021(E)

This document does not present performance tests for characterizing any type of potential degradation (see Scope). However, to ensure the stability of the dosimetry system, it is necessary for the laboratory to evaluate the potential degradation and/or set adapted controls on processing.

For the case that a dosimetry system does not comply with the full range of requirements of this document with regard to the dependence of the response on the energy and direction distributions of the neutron fluence, it is necessary to evaluate the performance for the conditions of the selected workplace. This is addressed in ISO 21909-2 which gives methodologies and criteria to qualify the dosimetry system at the workplace. Even when the dosimetry system fulfils the requirements of this document, it may still be desirable to make a similar study at the workplace.

This document may be extended in the future to another part for the ambient dose equivalent $H^*(10)$ for ambient and environmental dosimetry.

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Passive neutron dosimetry systems —

Part 1: Performance and test requirements for personal dosimetry

1 Scope

This document provides performance and test requirements for determining the acceptability of neutron dosimetry systems to be used for the measurement of personal dose equivalent, $H_p(10)$, for neutrons ranging in energy from thermal to 20 MeV¹⁾.

This document applies to all passive neutron detectors that can be used within a personal dosimeter in part or in all of the above-mentioned neutron energy range. No distinction between the different techniques available in the marketplace is made in the description of the tests. Only generic distinctions, for instance, as disposable or reusable dosimeters, are considered.

This document describes type tests only. Type tests are made to assess the basic characteristics of the dosimetry systems and are often ensured by recognized national laboratories

This document does not present performance tests for characterizing the degradation induced by the following:

- intrinsic temporal variability of the quality of the dosimeter supplied by the manufacturer;
- intrinsic temporal variability of preparation treatments (before irradiation and/or before reading), if existing;
- intrinsic temporal variability of reading process;
- degradation due to environmental effects on the preparation treatments, if existing;
- degradation due to environmental effects on the reading process.

This document gives information for extremity dosimetry in the [Annex C](#), based on recommendations given by ICRU Report 66. This document addresses only neutron personal monitoring and not criticality accident conditions.

The links between this document and ISO 21909-2 are given in [Annex A](#).

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.

ISO 29661, *Reference radiation fields for radiation protection — Definitions and fundamental concepts*

1) This maximal limit of the energy range is only an order of magnitude. The reference radiation fields used for the performance tests are those defined in ISO 8529-1. This means that the maximal energies could only be 14,8 MeV or 19 MeV. This document gives performance requirements to 14,8 MeV which is the typical neutron energy encountered for fusion. For fission spectra, the highest energies are around 20 MeV but the contribution to dose equivalent coming from neutrons with energy higher than 14,8 MeV is negligible.