



**NSAI**  
Standards

Irish Standard  
I.S. EN ISO 19226:2020

Nuclear energy - Determination of neutron fluence and displacement per atom (dpa) in reactor vessel and internals (ISO 19226:2017)

**I.S. EN ISO 19226:2020**

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NSAI  
1 Swift Square,  
Northwood, Santry  
Dublin 9

T +353 1 807 3800  
F +353 1 807 3838  
E standards@nsai.ie  
W NSAI.ie

Sales:  
T +353 1 857 6730  
F +353 1 857 6729  
W standards.ie

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## National Foreword

I.S. EN ISO 19226:2020 is the adopted Irish version of the European Document EN ISO 19226:2020, Nuclear energy - Determination of neutron fluence and displacement per atom (dpa) in reactor vessel and internals (ISO 19226:2017)

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EUROPEAN STANDARD

**EN ISO 19226**

NORME EUROPÉENNE

EUROPÄISCHE NORM

February 2020

ICS 27.120.10

English Version

## Nuclear energy - Determination of neutron fluence and displacement per atom (dpa) in reactor vessel and internals (ISO 19226:2017)

Énergie nucléaire - Détermination de la fluence neutronique et des déplacements par atome (dpa) dans la cuve et les internes du réacteur (ISO 19226:2017)

Kernenergie - Bestimmung der Neutronenfluenz und Verschiebungen pro Atom (dpa) im Reaktorbehälter und Einbauten (ISO 19226:2017)

This European Standard was approved by CEN on 6 January 2020.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



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**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

**EN ISO 19226:2020 (E)**

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## **European foreword**

The text of ISO 19226:2017 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 19226:2020 by Technical Committee CEN/TC 430 "Nuclear energy, nuclear technologies, and radiological protection" the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2020, and conflicting national standards shall be withdrawn at the latest by August 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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## **Endorsement notice**

The text of ISO 19226:2017 has been approved by CEN as EN ISO 19226:2020 without any modification.

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# INTERNATIONAL STANDARD

**ISO**  
**19226**

First edition  
2017-11

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## **Nuclear energy — Determination of neutron fluence and displacement per atom (dpa) in reactor vessel and internals**

*Énergie nucléaire — Détermination de la fluence neutronique et du  
déplacement par atome (dpa) dans la cuve et les internes du réacteur*



Reference number  
ISO 19226:2017(E)

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**ISO 19226:2017(E)**



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ISO copyright office  
Ch. de Blandonnet 8 • CP 401  
CH-1214 Vernier, Geneva, Switzerland  
Tel. +41 22 749 01 11  
Fax +41 22 749 09 47  
copyright@iso.org  
www.iso.org

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## ISO 19226:2017(E)

### 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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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](http://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 6, *Reactor Technology*.

This document is based on the ANSI/ANS 19.10-2009 but extends to cover the evaluation of irradiation damage due to neutron fluence.

## **Introduction**

This document is intended for use by

- a) those involved in the determination of exposure parameters for the prediction of irradiation damage to the vessel and to the internals of a nuclear reactor, where the exposure parameters can be neutron fluence and/or displacements per atom (dpa),
- b) those involved in the determination of material properties of irradiated reactor vessel and reactor internals,
- c) regulatory agencies in licensing actions such as the writing of Regulatory Guides, analysis of reports concerning the integrity and material properties of irradiated pressure vessels and reactor internals.



# Nuclear energy — Determination of neutron fluence and displacement per atom (dpa) in reactor vessel and internals

## 1 Scope

This document provides a procedure for the evaluation of irradiation data in the region between the reactor core and the inside surface of the containment vessel, through the pressure vessel and the reactor cavity, between the ends of active fuel assemblies, given the neutron source in the core.

NOTE These irradiation data could be neutron fluence or displacements per atom (dpa), and Helium production.

The evaluation employs both neutron flux computations and measurement data from in-vessel and cavity dosimetry, as appropriate. This document applies to pressurized water reactors (PWRs), boiling water reactors (BWRs), and pressurized heavy water reactors (PHWRs).

This document also provides a procedure for evaluating neutron damage properties at the reactor pressure vessel and internal components of PWRs, BWRs, and PHWRs. Damage properties are focused on atomic displacement damage caused by direct displacements of atoms due to collisions with neutrons and indirect damage caused by gas production, both of which are strongly dependent on the neutron energy spectrum. Therefore, for a given neutron fluence and neutron energy spectrum, calculations of the total accumulated number of atomic displacements are important data to be used for reactor life management.

## 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.

ANSI/ANS 19.10, *Methods for determining neutron fluence in BWR and PWR pressure vessel and reactor internals*

ASTM E170-16a, *Standard Terminology Relating to Radiation Measurements and Dosimetry*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ANSI/ANS 19.10, ASTM E170-16a and the following apply.

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

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

### 3.1

#### accuracy of a measured/calculated value

difference between the “real” and the measured/calculated value, typically due to systematic errors in the measurement/calculation procedure

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