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BSI Standards Publication

**Nuclear energy - Evaluation of homogeneity of Gd distribution within gadolinium fuel blends and determination of  $Gd_2O_3$  content in gadolinium fuel pellets by measurements of uranium and gadolinium elements**

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## National foreword

This British Standard is the UK implementation of EN ISO 16424:2017. It is identical to ISO 16424:2012. It supersedes BS ISO 16424:2012, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee NCE/9, Nuclear Installations, Processes & Technologies.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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**Compliance with a British Standard cannot confer immunity from legal obligations.**

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| Date             | Text affected  |
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| 30 November 2018 | This corrigendum renumbers BS ISO 16424:2012 as BS EN ISO 16424:2017 |

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English Version

**Nuclear energy - Evaluation of homogeneity of Gd  
distribution within gadolinium fuel blends and  
determination of Gd<sub>2</sub>O<sub>3</sub> content in gadolinium fuel pellets  
by measurements of uranium and gadolinium elements  
(ISO 16424:2012)**

Énergie nucléaire - Évaluation de l'homogénéité de la  
distribution du Gd dans les mélanges de combustibles  
au gadolinium et détermination de la teneur en Gd<sub>2</sub>O<sub>3</sub>  
dans les pastilles combustibles au gadolinium par  
mesurage des éléments uranium et gadolinium (ISO  
16424:2012)

Kernenergie - Bewertung der Homogenität der Gd-  
Verteilung in Gadolinium-Brennstoffgemischen und  
Bestimmung des Gd<sub>2</sub>O<sub>3</sub>-Gehaltes in Gadolinium-  
Brennstofftabletten durch Messung der Uran- und  
Gadolinium-Bestandteile (ISO 16424:2012)

This European Standard was approved by CEN on 13 September 2017.

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.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**

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## European foreword

The text of ISO 16424:2012 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 16424:2017 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 April 2018, and conflicting national standards shall be withdrawn at the latest by April 2018.

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.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## Endorsement notice

The text of ISO 16424:2012 has been approved by CEN as EN ISO 16424:2017 without any modification.

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## 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 16424 was prepared by Technical Committee ISO/TC 85, *Nuclear Energy, Nuclear Technologies, and Radiological Protection*, Subcommittee SC 5, *Nuclear Fuel Cycle*.

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# Nuclear energy — Evaluation of homogeneity of Gd distribution within gadolinium fuel blends and determination of Gd<sub>2</sub>O<sub>3</sub> content in gadolinium fuel pellets by measurements of uranium and gadolinium elements

## 1 Scope

This International Standard is applicable to the evaluation of the homogeneity of Gd distribution within gadolinium fuel blends, and the determination of the Gd<sub>2</sub>O<sub>3</sub> content in sintered fuel pellets of Gd<sub>2</sub>O<sub>3</sub>+UO<sub>2</sub> from 1 % to 10 %, by measurements of gadolinium (Gd) and uranium (U) elements using ICP-AES.

After performing measurements of Gd and U elements using ICP-AES, if statistical methodology is additionally applied, homogeneity of Gd distribution within a Gd fuel pellet lot can also be evaluated. However, this International Standard covers the statistical methodology only on a limited basis.

NOTE 1 ISO 16796 also provides a method for Gd<sub>2</sub>O<sub>3</sub> content determination by atomic emission spectrometry using an inductively coupled plasma source (ICP-AES). The methodology of ISO 16796 is different from the one of this International Standard.

NOTE 2 In this International Standard, gadolinium fuel blend represents a mixture of uranium dioxide (UO<sub>2</sub>) powder and gadolinium oxide (Gd<sub>2</sub>O<sub>3</sub>) powder. The physically blended and homogenized powder may additionally contain in it rather large quantities of uranium oxide (U<sub>3</sub>O<sub>8</sub>) powder particles and/or the M<sub>3</sub>O<sub>8</sub> powder particles obtained by oxidation of Gd pellets. In this International Standard, the symbol "M" in the chemical formula "M<sub>3</sub>O<sub>8</sub>" and in the terminology "O/M ratio" represents metallic elements U and Gd.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including amendments) applies.

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*

## 3 Principle

If the Gd and U element contents and the oxygen to metal atomic ratio (commonly referred to as O/M ratio) in a gadolinium fuel pellet are measured or determined, the Gd<sub>2</sub>O<sub>3</sub> content of that pellet can be determined by calculation based on the stoichiometry of the pellet. The stoichiometric compositions for Gd and U will depend upon pellet manufacturing specification. If the specification requires that the Gd<sub>2</sub>O<sub>3</sub> content in the pellet be 6 % as mass fraction, after manufacturing, the ratio of total Gd mass to total U mass in that pellet will be close to 0,063.

The Gd and U element content values measured from a powder blend can make it possible to evaluate whether Gd distribution in the powder is sufficiently homogeneous. Moreover, the two values make it possible to estimate accurately the actual Gd<sub>2</sub>O<sub>3</sub> content of the pellet after sintering. The estimated Gd<sub>2</sub>O<sub>3</sub> content can be used to anticipate whether the Gd pellets to be produced will meet Gd<sub>2</sub>O<sub>3</sub> content specifications or not.