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**Uranium dioxide powder —  
Determination of apparent density  
and tap density**

*Poudre de dioxyde d'uranium — Détermination de la masse  
volumique apparente et de la masse volumique après tassement*

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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.

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 of 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 [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 5, *Nuclear installations, processes and technologies*.

This second edition cancels and replaces the first edition (ISO 9161:2004), which has been technically revised.

The main changes compared to the previous edition are as follows:

- an introduction has been added;
- definitions in [Clause 3](#) have been updated;
- safety precautions have been updated.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

Uranium dioxide (UO<sub>2</sub>) powder is the source material for the manufacture of nuclear fuel as pellets, and is produced for use in nuclear reactors by a variety of processes. Specifications for UO<sub>2</sub> powder used in the production of sintered pellets as a nuclear fuel are given in standards such as ASTM C753<sup>[5]</sup> or specifications supplied by the user. These specifications can include requirements for apparent (or bulk) density, tap density, or both.

This document specifies a method for determination of the apparent density and tap density of free-flowing UO<sub>2</sub> powder, and can be used for a variety of powder types. The method can also be applied to other fuel powders, and to powder mixtures, to demonstrate compliance with appropriate specifications for those powders.

It has been assumed in the preparation of this document that the execution of its provisions and the interpretation of the results obtained are entrusted to appropriately qualified and experienced people.

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# Uranium dioxide powder — Determination of apparent density and tap density

## 1 Scope

This document specifies a method of determining the apparent density and tap density of free-flowing uranium dioxide (UO<sub>2</sub>) powder which will be used for pelleting and sintering of UO<sub>2</sub> pellets as a nuclear fuel.

This method can be used for different UO<sub>2</sub> powder types including grains, granules, spheres or other kinds of particles. The method can also be applied to other fuel powders as PuO<sub>2</sub>, ThO<sub>2</sub> and powder mixtures as UO<sub>2</sub>-PuO<sub>2</sub> and UO<sub>2</sub>-Gd<sub>2</sub>O<sub>3</sub>.

This document is based on the principle of using a flowmeter funnel (see 4.1). Other measurement apparatus, such as a Scott volumeter, can also be used.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions (standards.iteh.ai)

For the purposes of this document, the following terms and definitions 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

#### apparent density

loose bulk density

dry mass per unit volume of a powder obtained by free pouring under specified conditions

### 3.2

#### tap density

dry mass per unit volume of a powder in a container that has been tapped under specified conditions

## 4 Principle

### 4.1 Apparent density

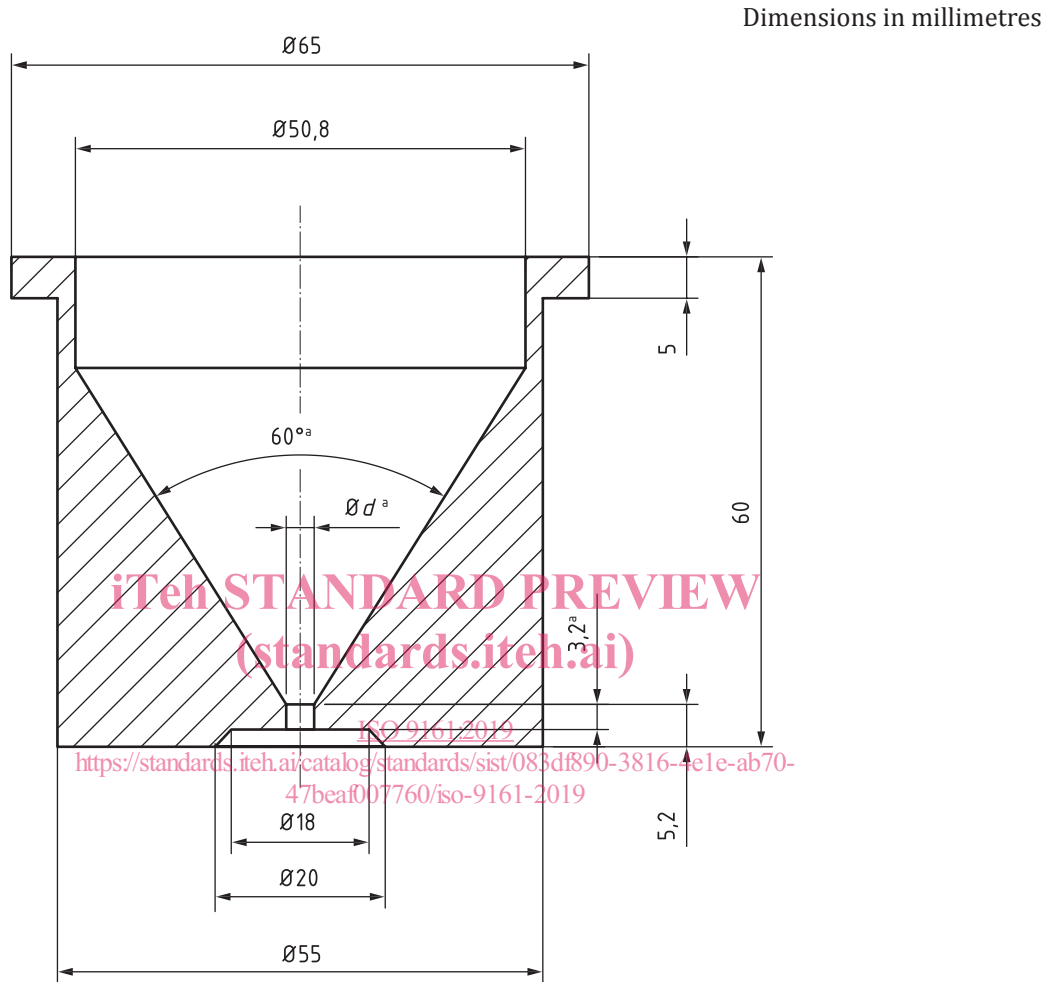
A portion of sample is allowed to fall through a funnel of standard dimensions into a tared density cup filled up to a mark which defines a distinct volume. The cup and contents are weighed to determine the mass of the material in the known volume. The apparent density is calculated from the mass and volume of the powder.

### 4.2 Tap density

A calibrated density cup containing a weighed portion of sample is tapped by means of a special apparatus. The tapping conditions are fixed. The tap density is determined from the mass and volume of the powder after the treatment.

## 5 Apparatus

**5.1 Powder flowmeter funnel**, having an orifice diameter,  $d$ , of 2,5 mm, 5,0 mm, 10 mm or 15 mm, depending on the powder type, having a conical angle of  $60^\circ$  and some means of closing the orifice (see [Figure 1](#)).



### Key

$d = 2,5^{+0,2}_0, 5,0^{+0,2}_0, 10,0^{+0,2}_0$  or  $15,0^{+0,2}_0$

<sup>a</sup> These dimensions are mandatory.

**Figure 1 — Powder flowmeter funnel (according to Reference [1])**

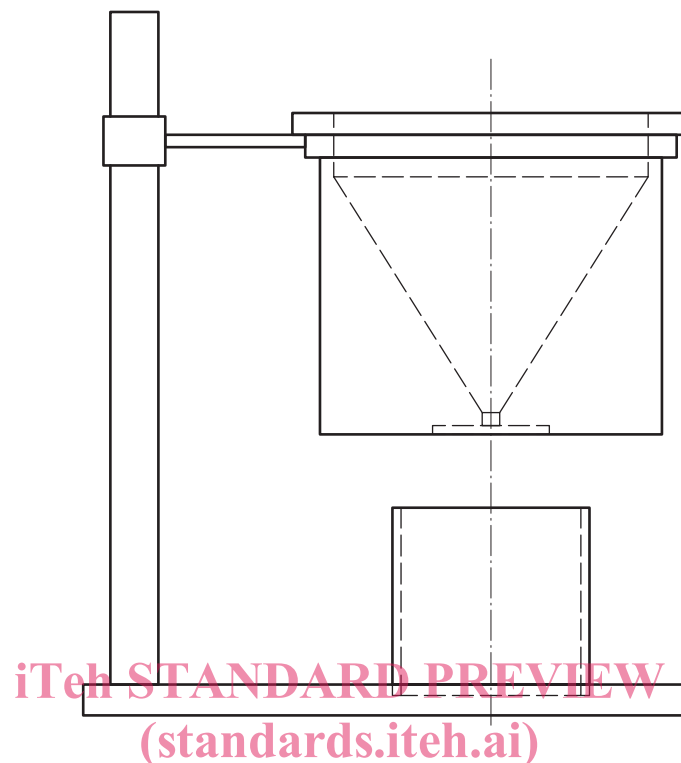
**5.2 Density cup**, a graduated cylindrical cup having a capacity of  $10 \text{ cm}^3$ ,  $25 \text{ cm}^3$ ,  $50 \text{ cm}^3$  or  $100 \text{ cm}^3$ , depending on the powder type.

**5.3 Tapping device**, consisting, for example, of a baseplate which is tapped by a motor with worm drive and a cam shaft speed of  $(250 \pm 15) \text{ min}^{-1}$  and enabling a tapping stroke travel of about 2 mm to 3 mm.

**5.4 Adjustable counter**, which can be preset to deliver a number of taps between 1 and 9 999.



**5.5 Stand**, to support the powder flowmeter concentric with the density cup so that the bottom of the powder flowmeter orifice is 50 mm above the mark of the density cup when the apparatus is assembled as shown in [Figure 2](#).



**Figure 2 — Stand with powder flowmeter funnel and density cup (without tapping device)**

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**5.6 Balance**, having a capacity which is suitable for the chosen density cup and a sensitivity of 0,01 g or better.

## 6 Sampling and samples

A representative laboratory test portion shall be taken from the UO<sub>2</sub> powder production batch to be characterized.

Measures shall be undertaken, if necessary, to prevent separation of the powder particle fractions or any change of properties during the transport of the powder.

The test portion size shall be sufficient to exceed the volume of the graduated density cup (approximately twice the volume of the density cup).

Additional guidance on uranium dioxide sample collection can be found in ASTM C753[5].

## 7 Procedure

### 7.1 Safety precautions

Standard precautions, including appropriate containment and personal protective equipment (PPE), shall be observed when handling samples.