



Designation: ~~C1233-03~~ Designation: C 1233 – 09

Standard Practice for Determining Equivalent Boron Contents of Nuclear Materials¹

This standard is issued under the fixed designation C 1233; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

~~1.1 This standard details a recommended practice for the calculation of the Equivalent Boron Content (EBC) values for elements that are of potential significance as thermal neutron poisons. The values are determined from a knowledge of the atomic weight of elements and the thermal neutron absorption cross section in barns. This practice is illustrated by using the EBC factors of Table 1 which are based on thermal neutron (2200 m/s) absorption cross sections. Other EBC factors may be used depending upon the actual neutron energy characteristics of the applicable reactor system.~~

~~1.2 The following elements do not require to be included in the EBC calculations, as their EBC factors are less than or equal to 0.0001:~~

| | | |
|-----------|------------|-----------|
| aluminum | fluorine | rubidium |
| barium | lead | silicon |
| beryllium | neon | tin |
| bismuth | oxygen | zirconium |
| carbon | magnesium | |
| cerium | phosphorus | |

~~Their contribution to the total poison effect is not considered significant.~~

1.1 This standard details a recommended practice for the calculation of the Equivalent Boron Content (EBC) for nuclear materials. The EBC is used to provide a measure of the macroscopic neutron absorption cross section of a nuclear material. EBC factors for the natural elements are determined from their atomic their masses and thermal neutron absorption cross sections. This practice is illustrated by using EBC factors that are based on thermal neutron (2200 m/s) absorption cross sections. Other EBC factors may be used depending upon the actual neutron energy spectrum.

1.2 The EBC is a characteristic of a homogeneous material. Characterization of inhomogeneous materials and calculation of neutron multiplication factors require techniques that are beyond the scope of this practice.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

ASTM C1233-09

~~2.1 ASTM Standards:² <http://www.astm.org/standards/sist/a3a7c9ae-ab8d-40fb-ae67-8aa343016f62/astm-c1233-09>~~

~~C 696 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets~~

~~C 698 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Mixed Oxides ((U, Pu)O₂)~~

~~C699 Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of, and Physical Tests on, Beryllium Oxide Powder²~~

~~C 761 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride~~

~~C 799 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Nuclear-Grade Uranyl Nitrate Solutions²~~

~~C859 Terminology Relating to Nuclear Materials² Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Nuclear-Grade Uranyl Nitrate Solutions~~

¹ This practice is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.02 on Fuel and Fertile Material Specifications.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards*, Vol 12.01, volume information, refer to the standard's Document Summary page on the ASTM website.

3. Terminology

3.1 Terms shall be defined in accordance with Terminology C859.

4. Methods For EBC Determination

4.1 Agreement shall be reached between the buyer and seller as to which elements shall be analyzed for calculation of their EBC. It is recommended that B, Cd, Dy, Eu, Sm, and Gd be included in this calculation. Analytical methods for such elements shall be those given in Test Methods C696, C699, and C799 C 696, C 698, C 761, and Test Methods C698 and C761 C 799 as applicable or as otherwise agreed upon between buyer and seller.

4.2 The individual EBC values are calculated using the EBC factors from Table 1 as follows:

EBC of impurity = (EBC factor)(μg of impurity/g base material) as follows:

$$EBC \text{ of constituent} = \frac{(\text{EBC factor of constituent})(\mu\text{g of constituent} / \text{g of material})}{\text{atomic neutron absorption cross section in barns}}$$

=
atomic neutron absorption cross section in barns.

The values given in Table 1 have been calculated using a value of 764 Barns for the neutron absorption cross section (σ_a) where:

$EBC \text{ factor of constituent} = \frac{(\text{atomic mass of boron})(\sigma_a \text{ of constituent})}{(\text{atomic mass of constituent})(\sigma_a \text{ of boron})}$, and
 $\sigma_a = \text{atomic neutron absorption cross section in barns}$.

The EBC factors been calculated using a value of 764 barns for the neutron absorption cross section (σ_a) of boron. This value may vary in nature according to the isotopic composition of the elements. If an alternative value is chosen the EBC factors must be recalculated using the chosen value.

4.3 If the concentration of any of the elements used in the calculation is reported as “less than” values, these values shall be used in calculating the EBC.

4.4 A total EBC value, if required, is determined by the summation of individual EBC values.

4.5 Plutonium, thorium and uranium have not been included, as they are fissionable elements.

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3.6 Table 1 includes elements that may provide a negligible contribution to the total EBC. In particular, elements with both small concentrations and very small EBC factors (less than $2\text{E-}4$) will generally provide a negligible contribution to the EBC of the material as a whole. Such elements should be excluded from determinations of the total EBC.

4. Keywords

5-4.1 boron; neutron absorption; nuclear materials; nuclear poisons