Designation: C1233 – 15 (Reapproved 2021)

Standard Practice for Determining Equivalent Boron Contents of Nuclear Materials[1]

This standard is issued under the fixed designation C1233; 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) 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 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.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C696 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets

C698 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Mixed Oxides ($(U, Pu)O_2$)

C761 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride

C799 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Nuclear-Grade Uranyl Nitrate Solutions

C859 Terminology Relating to Nuclear Materials

3. Terminology

3.1 Terminology used in this practice is in accordance with Terminology C859.

4. Significance and Use

4.1 Use of this standard practice yields an equivalent boron content (EBC) that can be used to characterize the neutron-absorbing properties of a nuclear material. The elements included in the calculation are typically chosen so that the EBC represents either the entire material (for example, for a moderator) or the impurities in the material (for example, for a nuclear fuel). This practice is typically used for materials in which thermal neutron absorption is undesirable. The EBC is not intended for use as an input to any neutronic calculation. The EBC factors in Table 1 were selected to represent neutron absorption in water reactors under normal operating conditions. It is the responsibility of the user to evaluate their suitability for other purposes.

5. Procedures for EBC Determination

5.1 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, C698, C761, and C799 as applicable or as otherwise agreed upon between buyer and seller.

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

$$EBC\ of\ constituent = (EBC\ factor\ of\ constituent)(\mu g\ of\ constituent\ /\ g\ of\ material)$$

where:

[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.

Current edition approved Oct. 1, 2021. Published October 2021. Originally approved in 1993. Last previous approved in 2015 as C1233 – 15. DOI: 10.1520/C1233-15R21.

[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* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Equivalent Boron Content Factors

Element	Neutron Absorption Cross Section[A] (Barns) at 2200 m/s	Atomic Mass[B]	EBC Factor
Aluminium[C]	0.231	26.98	1.21E-04
Antimony	5.1[D]	121.75	5.93E-04
Argon	0.68	39.95	2.41E-04
Arsenic	4.5	74.92	8.50E-04
Barium[C]	1.2[D]	137.33	1.24E-04
Beryllium[C]	0.0076[D]	9.01	1.19E-05
Bismuth[C]	0.0338	208.98	2.29E-06
Boron	764[E]	10.81	1.00E+00
Bromine	6.9	79.91	1.22E-03
Cadmium	2520	112.41	3.17E-01
Calcium[C]	0.43	40.08	1.52E-04
Carbon[C]	0.0035	12.01	4.12E-06
Cerium[C]	0.63[D]	140.12	6.36E-05
Cesium	29	132.91	3.09E-03
Chlorine	33.5	35.45	1.34E-02
Chromium	3.07	52.00	8.35E-04
Cobalt	37.2	58.93	8.93E-03
Copper	3.78	63.54	8.42E-04
Dysprosium	940	162.50	8.18E-02
Erbium	159.2	167.26	1.35E-02
Europium	4565	151.97	4.25E-01
Fluorine[C]	0.0096[D]	19.00	7.15E-06
Gadolinium	48890	157.25	4.40E+00
Gallium	2.9	69.72	5.89E-04
Germanium	2.3[D]	72.59	4.48E-04
Gold	98.65	196.97	7.09E-03
Hafnium	104.1	178.49	8.25E-03
Helium[C]	0.0073	4.00	2.58E-05
Holmium	64.7	164.93	5.55E-03
Hydrogen	0.33	1.01	4.62E-03
Indium	193.8[D]	114.82	2.39E-02
Iodine	6.2	126.90	6.91E-04
Iridium	425.30	192.22	3.13E-02
Iron	2.56[D]	55.85	6.49E-04
Krypton	25.00	83.80	4.22E-03
Lanthanum	8.97[D]	138.91	9.14E-04
Lead[C]	0.171	207.2	1.17E-05
Lithium	70.6[F]	6.94	1.44E-01
Lutetium	76.4	174.97	6.18E-03
Magnesium[C]	0.063	24.31	3.67E-05
Manganese	13.3	54.94	3.43E-03
Mercury	372.3	200.59	2.63E-02
Molybdenum	2.55[D]	95.94	3.76E-04
Neodymium	50.5[D]	144.24	4.95E-03
Neon[C]	0.039	20.18	2.73E-05
Nickel	4.49[D]	58.69	1.08E-03
Niobium[C]	1.15	92.91	1.75E-04
Nitrogen	1.90	14.01	1.92E-03
Osmium	16.00	190.20	1.19E-03
Oxygen[C]	0.00019[D]	16.00	1.68E-07
Palladium	6.90	106.42	9.17E-04
Phosphorus[C]	0.172	30.97	7.86E-05
Platinum	10.30	195.08	7.47E-04
Potassium	2.1[D]	39.10	7.60E-04
Praseodymium	11.5	140.91	1.15E-03
Rhenium	89.70	186.21	6.82E-03
Rhodium	145.20	102.91	2.00E-02
Rubidium[C]	0.38[D]	85.47	6.29E-05
Ruthenium	2.56[D]	101.07	3.58E-04
Samarium	5670	150.36	5.34E-01
Scandium	27.20	44.96	8.56E-03
Selenium	11.70	78.96	2.10E-03
Silicon[C]	0.171	28.09	8.61E-05
Silver	63.3	107.87	8.30E-03
Sodium	0.53	22.99	3.26E-04
Strontium	1.28[D]	87.62	2.07E-04
Sulfur	0.52	32.06	2.29E-04
Tantalum	20.6	180.95	1.61E-03
Tellurium	4.70	127.60	5.21E-04
Terbium	23.4	158.92	2.08E-03
Thallium	3.43	204.37	2.37E-04
Thorium	7.37	232.04	4.49E-04
Thulium	105	168.93	8.79E-03
Tin[C]	0.626[D]	118.71	7.46E-05