Designation: D7301 – 21

Standard Specification for Nuclear Graphite Suitable for Components Subjected to Low Neutron Irradiation Dose[1]

This standard is issued under the fixed designation D7301; 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 specification covers the classification, processing, and properties of nuclear grade graphite billets with dimensions sufficient to meet the designer's requirements for reflector blocks and core support structures, in a high temperature gas cooled reactor. The graphite classes specified here would be suitable for reactor core applications where neutron irradiation induced dimensional changes are not a significant design consideration.

1.2 The purpose of this specification is to document the minimum acceptable properties and levels of quality assurance and traceability for nuclear grade graphite suitable for components subjected to low irradiation dose. Nuclear graphites meeting the requirements of Specification D7219 are also suitable for components subjected to low neutron irradiation dose.

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]

C561 Test Method for Ash in a Graphite Sample

C781 Practice for Testing Graphite Materials for Gas-Cooled Nuclear Reactor Components

C838 Test Method for Bulk Density of As-Manufactured Carbon and Graphite Shapes

C1233 Practice for Determining Equivalent Boron Contents of Nuclear Materials

D346 Practice for Collection and Preparation of Coke Samples for Laboratory Analysis

D2638 Test Method for Real Density of Calcined Petroleum Coke by Helium Pycnometer

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D7219 Specification for Isotropic and Near-isotropic Nuclear Graphites

D8186 Test Method for Measurement of Impurities in Graphite by Electrothermal Vaporization Inductively Coupled Plasma Optical Emission Spectrometry (ETV-ICP OES)

IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

2.2 *ASME Standards:*[3]

NQA-1 Quality Assurance Program Requirements for Nuclear Facilities

3. Terminology

3.1 *Definitions*—Definitions relating to this specification are given in Terminology D4175. See Table 1.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anistropic nuclear graphite, n*—graphite in which the isotropy ratio based on the coefficient of thermal expansion is greater than 1.15.

3.2.2 *baking/re-baking charge, n*—number of billets in a baking/re-baking furnace run.

3.2.3 *bulk density, n*—mass of a unit volume of material including both permeable and impermeable voids.

3.2.4 *extrusion forming lot, n*—number of billets of the same size extruded in an uninterrupted sequence.

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.F0 on Manufactured Carbon and Graphite Products.

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

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

***A Summary of Changes section appears at the end of this standard**

TABLE 1 ASTM Graphite Grain Size Definitions from Terminology D4175

Graphite Designation	Definition of Grains in the Starting Mix that are:[A]
Coarse Grained	Generally > 4 mm
Medium-Coarse Grained	2 mm < grain size < 4 mm
Medium Grained	1 mm < grain size < 2 mm
Medium-Fine Grained	100 µm < grain size < 1 mm
Fine Grained	50 µm < grain size < 100 µm
Superfine Grained	10 µm < grain size < 50 µm
Ultrafine Grained	2 µm < grain size < 10 µm
Microfine Grained	Generally < 2 µm

[A] Grain size as defined in Terminology D4175.

3.2.5 *green batch, n*—mass of coke, recycle green mix, recycle graphite, and pitch that is required to produce a forming lot.

3.2.6 *green mix, n*—percentage of mix formulation, pitch and additives required for the forming lot, which is processed and ready to be formed.

3.2.7 *graphite billet, n*—extruded, molded, or iso-molded graphite artifact with dimensions sufficient to meet the designer's requirements for reactor components.

3.2.8 *graphite grade, n*—designation given to a material by a manufacturer such that it is always reproduced to the same specification and from the same raw materials and mix formulation.

3.2.9 *graphitizing furnace run, n*—total number of billets graphitized together in one graphitization furnace.

3.2.10 *graphitization charge, n*—total number of billets graphitized together in one graphitization furnace.

3.2.11 *high purity nuclear graphite, n*—nuclear graphite with an Equivalent Boron Content less than 2 ppm.

3.2.12 *impregnation charge, n*—number of billets in an autoclave cycle.

3.2.13 *isotropic, adj—in carbon and graphite technology*, having an isotropy ratio of 0.9 to 1.1 for a specific property of interest.

3.2.14 *isotropic nuclear graphite, n*—graphite in which the isotropy ratio based on the coefficient of thermal expansion (25 °C to 500 °C) is 1.00 – 1.10.

3.2.15 *isotropy ratio, n—in carbon and graphite technology*, ratio of a given property value in the against grain direction to its corresponding value in the with grain direction (for example, the ratio of coefficients of thermal expansion).

3.2.16 *low purity nuclear graphite, n*—nuclear graphite with an Equivalent Boron Content greater than 2 ppm but less than 10 ppm.

3.2.17 *mix formulation, n*—percentages of each specifically sized filler used to manufacture a graphite grade.

3.2.18 *molding forming lot, n*—number of billets molded from a molding powder lot.

3.2.19 *molding powder lot, n*—sufficient quantity of re-milled and blended green batch produced from an uninterrupted flow of raw materials, or produced in a sequence of identical materials batches, to produce a molding forming lot.

3.2.20 *nuclear graphite class, n*—designation of a nuclear graphite based upon its forming method, isotropy, purity and density (see Table 2).

3.2.21 *production lot, n*—specified number of billets made in accordance with this specification and additional requirements determined by the purchaser.

3.2.22 *purification charge, n*—number of billets in a purification run.

3.2.23 *recycle green mix, n*—ground non-baked billets or non-used green mix manufactured in compliance with the mix formulation specified here.

4. Materials and Manufacture

4.1 *Nuclear Graphite Classes*—See Table 2.

4.2 *Raw Materials:*

4.2.1 *Fillers:*

4.2.1.1 The filler shall consist of a coke derived from a petroleum oil or coal tar.

4.2.1.2 The coke shall have a coefficient of linear thermal expansion (CTE), determined in accordance with Practice C781 and measured over the temperature range 25 °C to 500 °C, less than 5.5×10^{-6} °C^{-1}.

4.2.1.3 The coke shall be sampled and distributed as described in Table 3.

TABLE 2 ASTM Standard Classes of Nuclear Graphite

		Purity			
Class[A]	CTE Isotropy Ratio (α_{AG}/α_{AG})	Ash Content,[B] ppm (max)	Boron Equivalent,[C] ppm (max)	Density, g/cm^3 (min)	Class Designation
Isomolded, anisotropic-HP	>1.15	300	2	1.7	IAHP
Isomolded, anisotropic-LP	>1.15	1000	10	1.7	IALP
Extruded, anisotropic-HP	>1.15	300	2	1.7	EAHP
Extruded, anisotropic-LP	>1.15	1000	10	1.7	EALP
Molded, anisotropic-HP	>1.15	300	2	1.7	MAHP
Molded, anisotropic-LP	>1.15	1000	10	1.7	MALP

[A] These classes may be further modified by the grain size as defined in Terminology D4175.
[B] Determined in accordance with Test Method C561.
[C] Determined in accordance with Practice C1233.