



# Standard Specification for Isotropic and Near-isotropic Nuclear Graphites<sup>1</sup>

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## 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 fuel elements, moderator or reflector blocks, 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 a significant design consideration.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard. (See [IEEE/ASTM SI 10](#).)

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

[C559 Test Method for Bulk Density by Physical Measurements of Manufactured Carbon and Graphite Articles](#)

[C709 Terminology Relating to Manufactured Carbon and Graphite](#)

[C781 Practice for Testing Graphite and Boronated Graphite Materials for High-Temperature 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](#)

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

2.2 *ASME Standard:*

[NQA-1 Quality Assurance Program Requirements for Nuclear Facilities](#)<sup>3</sup>

## 3. Terminology

3.1 *Definitions*—Definitions relating to this specification are given in Terminology [C709](#).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *baking/re-baking charge*—number of billets in a baking/re-baking furnace run.

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

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

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

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

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

3.2.7 *graphite grade*—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.

3.2.8 *graphitization charge*—number of billets of the same grade in a graphitizing furnace run.

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

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

<sup>1</sup> 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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<sup>2</sup> 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.

<sup>3</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

**TABLE 1 ASTM Standard Classes of Nuclear Graphite**

Class <sup>A</sup>	CTE Isotropy Ratio <sup>B</sup> ( $\alpha_{AG}/\alpha_{WG}$ )	Purity		Bulk Density, <sup>C</sup> g/cm <sup>3</sup> (min)	Class Designation
		Ash Content, <sup>B</sup> ppm (max)	Boron Equivalent, <sup>D</sup> ppm (max)		
Isomolded, isotropic—High Purity	1.0-1.1	300	2	1.7	IIHP
Isomolded, isotropic—Low Purity	1.0-1.1	1000	10	1.7	IILP
Isomolded, near-isotropic—High Purity	1.1-1.15	300	2	1.7	INHP
Isomolded, near-isotropic—Low Purity	1.1-1.15	1000	10	1.7	INLP
Extruded, isotropic—High Purity	1.0-1.1	300	2	1.7	EIHP
Extruded, isotropic—Low Purity	1.0-1.1	1000	10	1.7	EILP
Extruded, near-isotropic—High Purity	1.1-1.15	300	2	1.7	ENHP
Extruded, near-isotropic—Low Purity	1.1-1.15	1000	10	1.7	ENLP
Molded, isotropic—High Purity	1.0-1.1	300	2	1.7	MIHP
Molded, isotropic—Low Purity	1.0-1.1	1000	10	1.7	MILP
Molded, near-isotropic—High Purity	1.1-1.15	300	2	1.7	MNHP
Molded, near-isotropic—Low Purity	1.1-1.15	1000	10	1.7	MNLP

<sup>A</sup> These classes may be further modified by the grain size as defined in Terminology C709 (see Table 2).

<sup>B</sup> Determined in accordance with Practice C781.

<sup>C</sup> Determined in accordance with Test Method C559.

<sup>D</sup> Determined in accordance with Practice C1233.

3.2.11 *impregnation charge*—number of billets in an auto-clave cycle.

3.2.12 *isotropic nuclear graphite*—graphite in which the isotropy ratio based on the coefficient of thermal expansion is 1.00 to 1.10.

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

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

3.2.15 *molding forming lot*—number of billets molded from a molding powder lot.

3.2.16 *molding powder lot*—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.

3.2.17 *near isotropic nuclear graphite*—graphite in which the isotropy ratio based on the coefficient of thermal expansion is 1.10 to 1.15.

3.2.18 *nuclear graphite class*—designation of a nuclear graphite based upon its forming method, isotropy, purity and density (see Table 1).

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

3.2.20 *purification charge*—number of billets in a purification run.

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

#### 4. Significance and Use

4.1 The purpose of this specification is to document the minimum acceptable properties and levels of quality assurance and traceability for isotropic and near-isotropic nuclear grade graphites.

**TABLE 2 ASTM Graphite Grain Size Definitions from Terminology C709**

Graphite Designation	Definition of Grains in the Starting Mix that are: <sup>A</sup>
Medium Grained	Generally < 4 mm <sup>B</sup>
Fine Grained	Generally < 100 μm
Superfine Grained	Generally < 50 μm
Ultrafine Grained	Generally < 10 μm
Microfine Grained	Generally < 2 μm

<sup>A</sup> Grain size as defined in Terminology C709.

<sup>B</sup> For nuclear graphite, the maximum grain size is 1.68 mm in accordance with 5.2.1.6.

#### 5. Materials and Manufacture

5.1 *Nuclear Graphite Classes*—See Table 1.

5.2 *Raw Materials*:

5.2.1 *Fillers*:

5.2.1.1 The filler shall consist of a near-isotropic or isotropic coke derived from a petroleum oil or coal tar.

5.2.1.2 The coke shall have a coefficient of linear thermal expansion (CTE), determined in accordance with Practice C781 and measured over the temperature range 25 to 500°C, of between  $3.5 \times 10^{-6}$  and  $5.5 \times 10^{-6} \text{ }^\circ\text{C}^{-1}$ .

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

5.2.1.4 Graphite manufactured in compliance with this specification but failing to meet the property requirements of Sections 6 and 7 may be used as recycle material in the mix formulation.

5.2.1.5 Recycle green mix manufactured from raw materials in compliance with this specification may be used in the mix formulation.

5.2.1.6 The maximum filler particle size used in the mix formulation shall be 1.68 mm.

5.3 *Binder*—The binder(s) shall consist of coal tar pitch of the same grade from the same manufacturer. The specific binder(s) used shall be identified to the purchaser and be traceable through the forming lot.