Designation: ~~D7219 – 08 (Reapproved 2014)~~ D7219 – 19

An American National Standard

Standard Specification for Isotropic and Near-isotropic Nuclear Graphites[1]

This standard is issued under the fixed designation D7219; 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~~ Scope*

1.1 This specification covers the classification, processing, and typical properties of as-manufactured 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~~may be suitable for reactor core applications where ~~neutron irradiation induced dimensional changes are a significant design consideration.~~dimensional change due to fast neutron irradiation has a significant impact on design, provided they meet the requirements of the ASME code.

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

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]

C559 Test Method for Bulk Density by Physical Measurements of Manufactured Carbon and Graphite Articles

~~C709 Terminology Relating to Manufactured Carbon and Graphite (Withdrawn 2017)~~[3]

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

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~~Facilities, Sec III Div 5 Sub Sect HH sub-part A: Graphite Materials (HHA)[3]

3. Terminology

3.1 *Definitions*—Definitions relating to this specification are given in Terminology ~~C709~~D4175.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *baking/re-baking ~~charge~~—charge, n—in carbon and graphite technology,* number of billets in a baking/re-baking furnace run.

[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, ~~Three~~Two Park Ave., New York, NY 10016-5990.

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

3.2.2 *bulk ~~density—~~density, n—in carbon and graphite technology,* mass of a unit volume of material including both permeable and impermeable voids.

3.2.3 *extrusion forming ~~lot—~~lot, n—in carbon and graphite technology,* number of billets of the same size extruded in an uninterrupted sequence.

3.2.4 *grain, n—in manufactured carbon and graphite*, particle of filler material (usually coke or graphite) in the starting mix formulation; also referred to as granular material, filler particle, or aggregate material; the term is also used to describe the general texture of a carbon or graphite body, as in the descriptions listed below:

3.2.4.1 *coarse grained, adj*—containing grains in the starting mix that are substantially greater than 4 mm in size.

3.2.4.2 *medium coarse grained, adj*—containing grains in the starting mix that are generally less than 4 mm in size.

3.2.4.3 *medium grained, adj*—containing grains in the starting mix that are generally less than 2 mm in size.

3.2.4.4 *medium fine grained, adj*—containing grains in the starting mix that are generally less than 1 mm in size.

3.2.4.5 *fine grained, adj*—containing grains in the starting mix that are less than 100 µm in size.

3.2.4.6 *superfine grained, adj*—containing grains in the starting mix that are less than 50 µm in size.

3.2.4.7 *ultrafine grained, adj*—containing grains in the starting mix that are less than 10 µm in size.

3.2.4.8 *microfine grained, adj*—containing grains in the starting mix that are less than 2 µm in size.

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

3.2.6 *green ~~mix—~~mix, n—in carbon and graphite technology,* 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—~~billet, n—in carbon and graphite technology,* extruded, molded, or iso-molded graphite artifact with dimensions sufficient to meet the designer's requirements for reactor components.

3.2.8 *graphite ~~grade—~~grade, n—in carbon and graphite technology,* 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 *graphitization ~~charge—~~charge, n—in carbon and graphite technology,* number of billets of the same grade in a graphitizing furnace run.

3.2.10 *graphitizing furnace ~~run—~~run, n—in carbon and graphite technology,* total number of billets graphitized together in one graphitization furnace.

3.2.11 *high purity nuclear ~~graphite—~~graphite, n—in carbon and graphite technology,* nuclear graphite with an Equivalent Boron Content less than 2 ppm.

3.2.12 *impregnation ~~charge—~~charge, n—in carbon and graphite technology,* number of billets in an autoclave cycle.

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

3.2.14 *low purity nuclear ~~graphite—~~graphite, n—in carbon and graphite technology,* nuclear graphite with an Equivalent Boron Content greater than 2 ppm but less than 10 ppm.

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

3.2.16 *molding forming ~~lot—~~lot, n—in carbon and graphite technology,* number of billets molded from a molding powder lot.

3.2.17 *molding powder ~~lot—~~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.

3.2.18 *near isotropic nuclear ~~graphite—~~graphite, n—~~graphite~~ in carbon and graphite technology,* graphite in which the isotropy ratio based on the coefficient of thermal expansion is 1.10 to 1.15.

3.2.19 *nuclear graphite ~~class—~~class, n—in carbon and graphite technology,* designation of a nuclear graphite based upon its forming method, isotropy, purity and density (see Table 1).

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

3.2.21 *purification ~~charge—~~charge, n—in carbon and graphite technology,* number of billets in a purification run.

3.2.22 *recycle green ~~mix—~~mix, n—in carbon and graphite technology,* ground non-baked billets or non used green mix manufactured in compliance with the mix formulation specified here.

4. Significance and Use

4.1 *Purpose*—The purpose of this specification is to document the ~~minimum acceptable properties~~ typical properties of as-manufactured nuclear graphite and levels of quality assurance and traceability for isotropic and near-isotropic nuclear grade

TABLE 1 ASTM Standard Classes of Nuclear Graphite

Class[A]	CTE Isotropy Ratio[B] (α_{AG}/α_{WG})	Purity: ~~Ash Content,[B] ppm (max)~~	Bulk Density,[C] g/cm^3 (min)	Class Designation	Boron Equiv ppm (ma
~~Isomolded, isotropic—High Purity~~	~~1.0-1.1~~	~~300~~	~~2~~	~~1.7~~	~~IIHP~~
Isomolded, isotropic—High Purity	1.0-1.1	2	1.7	IIHP	
~~Isomolded, isotropic—Low Purity~~	~~1.0-1.1~~	~~1000~~	~~10~~	~~1.7~~	~~IILP~~
Isomolded, isotropic—Low Purity	1.0-1.1	10	1.7	IILP	
~~Isomolded, near-isotropic—High Purity~~	~~1.1-1.15~~	~~300~~	~~2~~	~~1.7~~	~~INHP~~
Isomolded, near-isotropic—High Purity	1.1-1.15	2	1.7	INHP	
~~Isomolded, near-isotropic—Low Purity~~	~~1.1-1.15~~	~~1000~~	~~10~~	~~1.7~~	~~INLP~~
Isomolded, near-isotropic—Low Purity	1.1-1.15	10	1.7	INLP	
~~Extruded, isotropic—High Purity~~	~~1.0-1.1~~	~~300~~	~~2~~	~~1.7~~	~~EIHP~~
Extruded, isotropic—High Purity	1.0-1.1	2	1.7	EIHP	
~~Extruded, isotropic—Low Purity~~	~~1.0-1.1~~	~~1000~~	~~10~~	~~1.7~~	~~EILP~~
Extruded, isotropic—Low Purity	1.0-1.1	10	1.7	EILP	
~~Extruded, near-isotropic—High Purity~~	~~1.1-1.15~~	~~300~~	~~2~~	~~1.7~~	~~ENHP~~
Extruded, near-isotropic—High Purity	1.1-1.15	2	1.7	ENHP	
~~Extruded, near-isotropic—Low Purity~~	~~1.1-1.15~~	~~1000~~	~~10~~	~~1.7~~	~~ENLP~~
Extruded, near-isotropic—Low Purity	1.1-1.15	10	1.7	ENLP	
~~Molded, isotropic—High Purity~~	~~1.0-1.1~~	~~300~~	~~2~~	~~1.7~~	~~MIHP~~
Molded, isotropic—High Purity	1.0-1.1	2	1.7	MIHP	
~~Molded, isotropic—Low Purity~~	~~1.0-1.1~~	~~1000~~	~~10~~	~~1.7~~	~~MILP~~
Molded, isotropic—Low Purity	1.0-1.1	10	1.7	MILP	
~~Molded, near-isotropic—High Purity~~	~~1.1-1.15~~	~~300~~	~~2~~	~~1.7~~	~~MNHP~~
Molded, near-isotropic—High Purity	1.1-1.15	2	1.7	MNHP	
~~Molded, near-isotropic—Low Purity~~	~~1.1-1.15~~	~~1000~~	~~10~~	~~1.7~~	~~MNLP~~
Molded, near-isotropic—Low Purity	1.1-1.15	10	1.7	MNLP	

[A] These classes may be further modified by the grain ~~size as defined in Terminology~~ size.~~C709 (see Table 2).~~
[B] Determined in accordance with Practice C781.
[C] Determined in accordance with Test Method C559.
[D] Determined in accordance with Practice C1233.

graphites. The properties which are considered suitable for the application will depend on the design requirements and on the range of materials that can be available from the manufacturer.

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~~25 °C to ~~500°C,~~500 °C, of between 3.5×10^{-6} °C^{-1} and 5.5×10^{-6} °C^{-1}.

5.2.1.3 The coke shall be sampled and distributed as described in Table ~~3~~2.

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.

5.4 *Impregnant*—The impregnant(s) shall consist of a petroleum or coal tar pitch of the same grade from the same manufacturer. The specific impregnant used shall be identified to the purchaser and be traceable through the impregnation steps.

5.5 *Manufacturing or Processing Additives*—Additives (for example, extrusion aids) may be used to improve the processing, quality and properties of the product, but only with the consent and approval of the purchaser, and they must be traceable through the forming lot.

5.6 *Manufacture:*

5.6.1 *Formulation*—The mix formulation (as defined in ~~3.2.14~~3.2.15) and recycle green mix fraction (as defined in ~~3.2.21~~3.2.22) in the filler shall be recorded. This information shall be reported to the purchaser if requested.

5.6.2 *Forming*—The green mix may be formed by extrusion, molding (including vibrationally molding), or iso-molding.