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Nuclear grade isostatic graphite for high temperature gas-cooled reactor internals

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Foreword

This document was drafted in accordance with the rules given in GB/T 1.1-2020 "Directives for standardization - Part 1: Rules for the structure and drafting of standardizing documents".

This document was proposed by China Iron and Steel Association.

This document shall be under the jurisdiction of National Technical Committee on Steel of Standardization Administration of China (SAC/TC 183).

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Nuclear grade isostatic graphite for high temperature gas-cooled reactor internals

1 Scope

This document specifies the classification, technical requirements, test methods, inspection rules, packaging, marking, storage, transportation and quality instructions of nuclear grade isostatic graphite used for reflector components of high temperature gas-cooled reactors.

This document applies to nuclear grade isostatic graphite for high temperature gas-cooled reactor internals.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 1431, *The test method for compressive strength of carbon materials*

GB/T 3074.1, *The test method for flexural strength of carbon materials*

GB/T 3074.2, *Method for the determination of the elastic modulus of graphite electrodes*

GB/T 3074.4, *Method for the determination of the coefficient of thermal expansion of graphite electrodes*

GB/T 8719, *General rule for packing, marking, storage, transport and quality certificates of carbonaceous material and products*

GB/T 8721, *The test method for tensile strength of carbon materials*

GB/T 8722, *Test method for thermal conductivity of carbon materials*

GB/T 24528, *Carbon materials - Determination method of the bulk density*

GB/T 38338, *Test method for fracture toughness of carbon materials*

JY/T 0567, *General rules of inductively coupled plasma emission spectroscopy analysis methods*

YB/T 5146, *Determination of ash for high pure graphite products*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 nuclear grade isostatic graphite

Graphite for nuclear industry that is manufactured from raw materials such as carbon aggregate and asphalt through grinding, kneading, isostatic pressing, roasting, impregnation, graphitization, purification and other process steps.

NOTE: In the case of fast neutron ($E_n \geq 0.1MeV$) irradiation, this kind of graphite needs to consider the influence of size and material property changes on the design. It is mainly used for high temperature gas-cooled reactor reflector components. These components also perform the function of the core support structure.

3.2 isotropy; α

The ratio of the thermal expansion coefficient in the molding gravity direction to the thermal expansion coefficient in the vertical molding gravity direction.

4 Classification

According to the index of isotropy, nuclear grade isostatic graphite is divided into isotropic nuclear grade isostatic pressing graphite, nearly isotropic nuclear grade isostatic pressing graphite and anisotropic nuclear grade isostatic pressing graphite.

5 Technical requirements

5.1 Unirradiated basic indicators

See Table 1 for the basic technical indicator requirements of nuclear grade isostatic graphite that are not irradiated.

6 Test methods

6.1 Bulk density

According to the provisions of GB/T 24528.

6.2 Thermal conductivity

According to the provisions of GB/T 8722.

6.3 Thermal expansion coefficient

According to the provisions of GB/T 3074.4.

6.4 Isotropy

Calculate according to $CTE_{\perp}/CTE_{/\!/}$. If $CTE_{\perp}<CTE_{/\!/}$, then calculate according to $CTE_{/\!/}/CTE_{\perp}$.

6.5 Tensile strength

According to the provisions of GB/T 8721.

6.6 Compressive strength

According to the provisions of GB/T 1431.

6.7 Flexural strength

According to the provisions of GB/T 3074.1.

6.8 Fracture toughness

According to the provisions of GB/T 38338.

6.9 Elastic modulus

According to the provisions of GB/T 3074.2.

6.10 Ash

According to the provisions of YB/T 5146.

6.11 Boron equivalent

According to the provisions of JY/T 0567, the impurity content of at least six elements Gd, B, Sm, Eu, Cd and Li shall be tested. The boron equivalent is calculated according

to formula (1):

$$A = 4.400 \times C_{Gd} + 1 \times C_B + 0.534 \times C_{Sm} + 0.425 \times C_{Eu} + 0.317 \times C_{Cd} + 0.144 \times C_{Li} \quad \cdots (1)$$

Where,

A - The boron equivalent;

C_{Gd} - The content of Gd gadolinium element in the sample;

C_B - The content of B boron element in the sample;

C_{Sm} - The content of Sm samarium element in the sample;

C_{Eu} - The content of Eu europium element in the sample;

C_{Cd} - The content of Cd cadmium element in the sample;

C_{Li} - The content of Li lithium element in the sample.

NOTE: The coefficient before each content in the formula is the boron equivalent factor of the corresponding impurity element.

6.12 Test method for graphite irradiation

Refer to Annex A for the test method for graphite irradiation.

NOTE: Annex A is for reference only.

7 Inspection rules

7.1 Batching

Each graphite block shall have a unique traceability number. The same designation of graphite in the same graphitization furnace is a batch.

7.2 Sampling

When sampling for testing of tensile strength and compressive strength of graphite, the sampling quantity A specified in Table 2 shall be carried out. When sampling for testing of graphite thermal conductivity, thermal expansion coefficient, isotropy, graphite flexural strength, fracture toughness, graphite composition, it shall be carried out according to the sampling quantity B specified in Table 2. When sampling for testing of other characteristics, it shall be carried out according to the sampling quantity C specified in Table 2.

When the testing sample is extracted, different positions of the graphite block shall be

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