Designation: C992 – 20

Standard Specification for Boron-based Neutron Absorbing Material Systems for Use in Nuclear Fuel Storage Racks in Pool Environment[1]

This standard is issued under the fixed designation C992; 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 defines criteria for boron-based neutron absorbing material systems used in racks in a pool environment for storage of nuclear light water reactor (LWR) spent-fuel assemblies or disassembled components to maintain sub-criticality in the storage rack system.

1.2 Boron-based neutron absorbing material systems normally consist of metallic boron or a chemical compound containing boron (for example, boron carbide, B_4C) supported by a matrix of aluminum, steel, or other materials.

1.3 In a boron-based absorber, neutron absorption occurs primarily by the boron-10 isotope that is present in natural boron to the extent of 18.3 ± 0.2 % by weight (depending upon the geological origin of the boron). Boron enriched in boron-10 could also be used.

1.4 The materials systems described herein shall be functional (that is, always be capable to maintain a boron-10 areal density such that subcriticality is maintained depending on the design specification for the service life in the operating environment of a nuclear spent fuel pool).

1.5 Observance of this specification does not relieve the user of the obligation to conform to all applicable international, national, and local regulations.

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

1.7 *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]

C859 Terminology Relating to Nuclear Materials

C1187 Guide for Establishing Surveillance Test Program for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Fuel Storage Racks In a Pool Environment

E105 Practice for Probability Sampling of Materials

E2971 Test Method for Determination of Effective Boron-10 Areal Density in Aluminum Neutron Absorbers using Neutron Attenuation Measurements

ASTM Dictionary of Engineering Science and Technology

2.2 *ANSI Standard:*[3]

ANSI N45.2.2 Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants

2.3 *ASME Standard:*[4]

ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Application

2.4 *U. S. Government Documents:*[5]

10CFR50 Title 10, CFR, Energy Part 50—Licensing of Production and Utilization Facilities

10CFR72 Title 10, CFR, Energy Part 72—Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this specification, refer to Terminology C859 or the ASTM Dictionary of Engineering Science and Technology.

3.2 *Definitions of Terms Specific to This Standard:*

[1] This specification is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.03 on Neutron Absorber Materials Specifications.

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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 National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

[5] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

3.2.1 *accelerated testing, n*—a procedure for investigating the potential for long-term changes in physical properties or chemical composition of a material important to safety, caused by a system operating parameter such as temperature, chemical environment, or radiation.

3.2.1.1 *Discussion*—The procedure uses a value of the identified parameter that is outside the normal bound of the operating parameter being investigated, in order to (*1*) increase the rate of degradation, if any, (*2*) identify the operating limit for acceptable limit of the parameter, and (*3*) to provide information that might assist in interpreting the degradation mechanism(s) involved. In this manner, the long-term behavior of a material may be simulated in an appreciably shorter period of time.

3.2.2 *areal density, n—for neutron absorber materials with flat parallel surfaces*, the boron-10 per unit area of a sheet, which is equivalent to the mass per unit volume of boron-10 in the material multiplied by the thickness of the material in which that isotope is contained.

3.2.3 *buyer, n*—the organization issuing the purchase order.

3.2.4 *degradation, n*—a change in a material property that lessens the original design functionality.

3.2.5 *individual piece, n*—a discrete section of neutron absorber material whose individual dimensions conform to those in the purchase specification.

3.2.6 *irradiation, n*—the incidence of neutron, gamma, and beta radiation from spent fuel assemblies on materials in a water-filled spent fuel pool.

3.2.7 *production batch, n*—a group of neutron absorbing material pieces produced in a continuous production period, all of which can be shown to have the same chemical composition, physical, and nuclear properties within specification limits.

3.2.8 *seller, n*—the neutron absorbing system manufacturer.

3.2.9 *service life, n*—the period of time for which properties of the neutron absorbing material system are expected to remain in compliance with the contract requirements which relate to material functionality.

3.2.10 *supplier, n*—any outside source of raw materials and services used by the seller.

4. Ordering Information

4.1 The buyer should specify a material for which there is documented evidence that the neutron absorbing material system is capable of acceptable performance in the following environmental conditions to which the material is expected to be exposed:

4.1.1 Total service life of the neutron absorbing material system,

4.1.2 Maximum integrated irradiation over the total service life of the neutron absorbing material system, and

4.1.3 Environment of the fuel pool in which the neutron absorbing material system will be located, including consideration of normal operation and effects of anticipated operational occurrences.

4.2 The buyer shall specify the following material properties and applicable tolerances of the neutron absorbing material system (this may include archive or in-service surveillance coupons):

4.2.1 Total quantity of individual pieces required,

4.2.2 Physical dimensions of each individual piece required, and may also include physical form limitations including flatness, camber, bow, and so forth,

4.2.3 Boron-10 isotopic content of the neutron absorbing material system expressed in terms of areal density. Alternatively, the boron-10 content may be specified by material density, the weight percent boron, minimum thickness, and the minimum acceptable weight fraction of boron-10 in the boron,

4.2.4 Material for the components of the neutron absorbing material system shall be in accordance with applicable specifications or standards,

4.2.5 Mechanical properties of the neutron absorbing material system for structural requirements, as required, and

4.2.6 Acceptance criteria for gas evolution, product cleanliness, or other physical characteristics, if applicable.

5. Material System Properties

5.1 The boron-10 shall be uniformly distributed throughout the neutron absorbing material as defined in 7.3 and 8.1.4.

5.2 The neutron absorbing material system may contain, in addition to the boron or boron compound, any matrix materials necessary to maintain that boron in the state of specified uniformity and boron-10 areal density throughout the stipulated service life of the spent fuel storage system.

5.2.1 The seller shall provide to the buyer a chemical analysis of the neutron absorbing material system, so that the buyer may determine the compatibility of the neutron absorbing material with the spent fuel storage rack and the pool environment.

5.3 The seller shall provide the buyer with the elemental and boron isotopic composition of the neutron absorbing material system and the particle size distribution when necessary of the boron compound so that the buyer may determine the neutron attenuating and absorbing properties of the material and its suitability for the buyer's application.

5.4 Material system's neutron absorbing capability shall not be reduced below the allowable limit within the stated service life (see 6.1.1) including geometric changes, loss of boron, or other degradation.

5.5 In-service surveillance tests shall be performed to monitor the material system properties (for example, see Guide C1187).

6. Test Documentation

6.1 The seller shall provide to the buyer documentation of tests performed to characterize the neutron absorbing material system performance and mechanical properties.

6.1.1 When appropriate, accelerated test may be performed to demonstrate compliance to 5.4. The test reports shall include both a description of procedures and a review of results.