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Standard Specification for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Spent Fuel Storage Racks[1]

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1. Scope

1.1 This specification defines criteria for boron-based neutron absorbing material systems used in racks for storage of nuclear light water reactor (LWR) spent-fuel assemblies or disassembled components in a pool environment, or both.

1.2 The materials systems described herein shall be functional for their service life in the operating environment of a nuclear reactor spent-fuel pool.

1.3 A number of acceptable boron-based absorbing materials combinations are currently available while others are being developed for use in the future. This specification defines criteria essential and applicable to all materials combinations and identifies parameters a buyer should specify to satisfy a unique or particular requirement.

1.4 Compliance with this specification does not relieve the seller or the buyer from obligation to conform to applicable federal regulations governing the storage of nuclear fuel.

2. Referenced Documents

2.1 *ASTM Standards:*

A 240 Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels[2]

B 209 Specification for Aluminum and Aluminum Alloy Sheet and Plate[3]

C 750 Specification for Nuclear-Grade Boron Carbide Powder[4]

C 859 Terminology Relating to Nuclear Materials[4]

E 105 Practice for Probability Sampling of Materials[5]

2.2 *ANSI Standards:*[6]

ANSI 45.2.2 Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants

ANSI-ASME NQA-1 Quality Assurance Program Requirements for Nuclear Facilities

2.3 *U. S. Government Documents:*[7]

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

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

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 Terms shall be defined in accordance with Terminology C 859 except as defined as follows:

3.1.2 *buyer*—the organization issuing the purchase order.

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

3.1.4 *irradiation*—the neutron, beta and gamma fluxes, from spent-fuel assemblies in a water-filled spent fuel pool.

3.1.5 *production batch*—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.

3.1.6 *seller*—the neutron absorbing system manufacturer.

3.1.7 *service life*—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 chemical and physical integrity.

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

4. Ordering Information

4.1 The buyer should specify the following environmental conditions to which the neutron absorbing material system shall be exposed:

4.1.1 Total service life of the neutron absorbing material system (considered forty years unless otherwise specified),

4.1.2 Dose rate and maximum integrated irradiation over the total service life of the neutron absorbing material system, and

4.1.3 Chemical and thermal environment of the water in the spent fuel pool in which the neutron absorbing material system will be located.

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[1] This specification is under the jurisdiction of ASTM Committee C-26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.03 on Neutron Absorber Materials Specifications.

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[2] *Annual Book of ASTM Standards*, Vol 01.03.

[3] *Annual Book of ASTM Standards*, Vol 02.02.

[4] *Annual Book of ASTM Standards*, Vol 12.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] Available from the American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[7] Available from Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

4.2 The buyer shall specify the following physical and chemical properties of the neutron absorbing material system, including retained samples or in-use sampling coupons:

4.2.1 Total quantity of individual pieces required,

4.2.2 Physical dimensions of each individual piece required, and physical form limitations including flatness, camber, bow, etc.,

4.2.3 Boron content of the neutron absorbing material system expressed in terms of grams of isotopic B-10 per cm^2 of surface area or by weight percent, and

4.2.4 Applicable tolerances for each dimension or property.

4.2.5 Material specifications for the components of the neutron absorbing material system shall be in accordance with Specifications A 240, B 209, and C 750, if applicable.

4.3 In addition to the properties of 4.2, the buyer shall specify the following system properties as required by the specific spent fuel storage rack design:

4.3.1 Structural properties for the neutron absorbing material system, if required, and

4.3.2 Limitations on gas evolution, product cleanliness, or other physical characteristics required for a sealed container design for the neutron absorbing material systems if applicable.

5. Material System Properties

5.1 The boron must be uniformly distributed throughout the neutron absorbing material system when evaluated on an areal basis.

5.1.1 To show uniform distribution of the boron, the seller shall demonstrate that the average boron areal concentration throughout any one piece of neutron absorber shall not be less than the concentration shown in the specification. The seller shall also show that the boron concentration in any randomly selected area of a size to be specified by the buyer shall not be less than that shown in the specification.

5.1.2 The boron quantity and uniformity may be determined by chemical analysis, physical measurement, or neutron attenuation measurement providing the seller can demonstrate to the satisfaction of the buyer the validity of the measurement method.

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 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 isotopic composition of the neutron absorbing material system and the particle size 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 *Boron Loss*—The loss of boron through any degradation mechanisms such as leaching, neutron capture, out-gassing, chemical interaction, radiation, etc., shall not lower the boron content below the allowable limits within the stated service life (see Section 6.1.1).

5.5 It is recommended that in-service surveillance tests be performed to monitor maintenance of the boron areal density. It is further recommended that these tests determine both physical and performance characteristics. The physical tests should determine at least the size, weight, density, and surface appearances. The performance tests should determine at least the strength and neutron attenuation capabilities. The test samples should be positioned to maximize the irradiation doses the samples will receive during each exposure period. The before and after exposure test results must be compared for any unfavorable changes in the physical or performance characteristics.

6. Test Documentation

6.1 The seller shall provide to the buyer documentation of tests performed on the neutron absorbing material system demonstrating compliance with the specifications.

6.1.1 The tests to demonstrate compliance to 5.4 shall be accelerated tests to be performed whenever possible by testing organizations not affiliated with the seller, and the test reports shall include both a description of procedures and a review of results.

6.2 The buyer shall determine the suitability of the neutron absorbing material system for the buyer's application on the basis of accelerated test documentation and other evidence offered by the seller and by additional testing and evaluation performed by the buyer.

7. Sampling

7.1 Sampling plans to meet acceptance criteria and inspection and measurement procedures that describe the method of compliance with this specification shall be established by the seller and submitted to the buyer for approval prior to manufacture of the required product. The degree of sampling shall be specified by the purchase order. Recommended Practice E 105 is referenced as a guide.

7.2 Each sample taken shall be sufficient to perform the following in the event they are necessary or desired by the buyer:

7.2.1 Quality control tests at the seller's plant,

7.2.2 Acceptance tests at the buyer's plant,

7.2.3 Referee tests in the event these become necessary, and

7.2.4 Archive sample for retention by the seller.

7.3 Archive samples shall be retained by the seller for a period of time specified by the buyer and delivered to the buyer upon request.

8. Inspection

8.1 Inspection of the neutron absorbing material shall be by production batch and by individual piece.

8.1.1 Evaluation of chemical composition, density, boron content, and uniformity may be made on a production batch basis.

8.1.2 Inspection of dimensions and physical form shall be made by individual piece.

9. Rejection

9.1 Items that fail to conform to the requirements of the

specification may be rejected by the buyer. The seller may petition to the buyer to waive the specifications for specific out-of-specification items. Decision to grant such waiver belongs to the buyer. The seller may also effect any remedy to bring rejected items into specification providing he can demonstrate to the buyer that such remedy does not impair the function or preclude the certification of the neutron absorbing material system.

10. Certification

10.1 When specified in the purchase order or contract, the seller shall prepare a certification that the neutron absorbing material system was manufactured, sampled, tested, and inspected in accordance with the specifications and has been found to meet the requirements. When specifically required, testing results of the material shall accompany the certification. Each certification furnished shall be signed by an authorized agent of the seller.

11. Marking, Packaging, and Shipping

11.1 For marking, packaging, and shipping, ANSI N45.2.2 is referenced as a guide. Each individual piece of neutron absorbing material system shall be marked on one face in a location agreed upon by the buyer and seller with a serial identification traceable to the test analysis, production batch, and certification. The characters of the markings shall be of such size as to be clearly legible. The markings shall be sufficiently durable to withstand normal handling. The method of marking shall be approved by the buyer.

11.2 The neutron-absorbing material shall be packaged for shipment in a suitable manner to assure that the material will normally arrive in an undamaged condition.

11.2.1 The buyer shall indicate to the seller unusual conditions of handling or storage and specify additional protective packaging as necessary.

11.2.2 Each package of neutron-absorbing material shall be identified as to buyer, seller, contents, and quantity as a minimum and any other information specified by the seller.

11.3 Method of shipping shall be specified by the buyer. The selected method shall be suitable to protect the neutron absorbing material system from direct weather exposure and mechanical damage.

12. Quality Assurance

12.1 Quality assurance requirements shall be as agreed upon between the buyer and the seller when specified in the purchase order. CFR Title 10, Part 50, Appendix B, CFR Title 10, Part 72, and ANSI-ASME NQA-1 are referenced as guides.