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March 26, 2009

U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852-2738

Attn: Document Control Desk

Subject: Submittal of a Request to Amend the U.S. Nuclear Regulatory Commission Certificate of Compliance No. 1031 for the NAC International MAGNASTOR® Cask System

Docket No. 72-1031

References:
1. U.S. Nuclear Regulatory Commission (NRC) Certificate of Compliance (CoC) No. 1031 for the NAC International MAGNASTOR Cask System, Amendment No. 0, February 4, 2009
2. MAGNASTOR Cask System Final Safety Analysis Report (FSAR), Revision 0, NAC International, February 2009

NAC International (NAC) hereby submits a request to amend Reference 1 defining and clarifying the requirements for qualification and testing of BORAL neutron absorber material.

The proposed changes to References 1 and 2 were presented to and discussed with the NRC Spent Fuel Storage and Transportation staff during a February 12, 2009, teleconference.

This submittal includes eight copies of this transmittal letter and Revision 09A changed pages to the Reference 2 FSAR. The changed pages incorporate the requested amendment. Attachment 1 contains a brief summary of the changes to the FSAR for the amendment. Consistent with NAC administrative practice, this proposed FSAR revision is numbered to uniquely identify the applicable changed pages. Revision bars mark the FSAR text changes on the Revision 09A pages. The included List of Effective Pages identifies the current revision level of all pages in the Reference 2 FSAR.

In order to better facilitate the review process, NAC is providing the Revision 09A change pages as a complete section of the FSAR. Consequently, a number of Revision 09A pages with no revision bars are included. In accordance with NAC's administrative practices, upon final acceptance of this application, the Revision 09A changed pages will be reformatted and incorporated into the next revision of the NAC-MAGNASTOR FSAR.

This amendment request affects only Chapter 10, Acceptance Criteria and Maintenance Program, of the Reference 2 FSAR and Appendix A of Reference 1.

NMSS01
NMSS

Approval of this amendment to Reference 1 and the issuance of the draft CoC/Safety Evaluation Report are requested by November 30, 2009, to support fabrication and equipment delivery schedules planned for 2010. Applying the Direct Final Rulemaking process, the estimated/ desired Direct Final Rule effective date is May 31, 2010.

If you have any comments or questions, please contact me on my direct line at 678-328-1274.

Sincerely,

Anthony L. Patko

Anthony L. Patko
Director, Licensing
Engineering

Attachment 1: List of Changes, MAGNASTOR FSAR, Revision 09A and Technical Specifications, Appendix A

Enclosure

Attachment 1

LIST OF CHANGES

MAGNASTOR® FINAL SAFETY ANALYSIS REPORT

REVISION 09A

AND

TECHNICAL SPECIFICATIONS

APPENDIX A

NAC International

March 2009

List of Changes, Amendment 09A to MAGNASTOR® FSAR, Rev. 0

Proposed Technical Specifications, Appendix A, Changes

- Page A4-1, Section 4.1.1, Criticality Control, item b) – Revise to read as follows (changes are in italics and bolded):

    b) Acceptance and qualification testing of ***borated aluminum alloy and borated MMC*** neutron absorber material shall be in accordance with Sections 10.1.6.4.5, 10.1.6.4.6 and 10.1.6.4.7. ***Acceptance testing of Boral shall be in accordance with Section 10.1.6.4.8.*** These sections of the FSAR are hereby incorporated into the MAGNASTOR CoC.

MAGNASTOR FSAR Changes

Note: The List of Effective Pages and the Chapter 10 Table of Contents were revised as needed to incorporate the following changes.

Chapter 10

- Page 10.1-7, Section 10.1.6, Note in box – added "10.1.6.4.8"; changed "three sections" to "four sections"
- Page 10.1-8, 1st paragraph, 2nd sentence – deleted "Neutron attenuation"
- Page 10.1-10 – added new last paragraph to address procurement and qualification of all neutron absorber materials
- Page 10.1-11, Section 10.1.6.4.1, 1st paragraph, last sentence – deleted "acceptance and qualification" and changed "Sections 10.1.6.4.4, 10.1.6.4.5 and 10.1.6.4.6" to "Section 10.1.6.4.8"
- Page 10.1-12, Section 10.1.6.4.4 – added "Metal Matrix and Borated Aluminum" to title; Thermal Conductivity Testing, 1st paragraph, 2nd sentence – deleted "at room temperature"
- Page 10.1-13, 1st paragraph, 1st sentence – deleted all parenthetical information; 1st paragraph below table – deleted 1st sentence; Yield Strength Testing, 1st paragraph – deleted 2nd and 3rd sentences
- Page 10.1-14, Section 10.1.6.4.5 – added "Borated Aluminum Alloy and Borated MMC" to title
- Page 10.1-15, 1st bullet – deleted "75% for Boral and"
- Page 10.1-17, Section 10.1.6.4.6 – added "Metal Matrix and Borated Aluminum" to title
- Pages 10.1-19 through 10.1-21 – added new section titled "Boral Neutron Absorber Tests" to describe the manufacturing process for Boral, the neutron absorber sampling plan, the neutron absorber wet chemistry testing, the acceptance criteria for the wet chemistry test results, and yield strength testing

Proposed MAGNASTOR® CoC Change
Technical Specifications, Appendix A

4.0 DESIGN FEATURES

4.1 Design Features Significant to Safety

4.1.1 Criticality Control

a) Minimum ^{10}B loading in the neutron absorber material:

Neutron Absorber Type	Required Minimum Effective Areal Density (^{10}B g/cm^2)		% Credit Used in Criticality Analyses	Required Minimum Actual Areal Density (^{10}B g/cm^2)	
	PWR Fuel	BWR Fuel		PWR Fuel	BWR Fuel
Borated Aluminum Alloy	0.036	0.027	90	0.04	0.03
Borated MMC	0.036	0.027	90	0.04	0.03
Boral	0.036	0.027	75	0.048	0.036

b) Acceptance and qualification testing of borated aluminum alloy and borated MMC neutron absorber material shall be in accordance with Sections 10.1.6.4.5, 10.1.6.4.6 and 10.1.6.4.7. Acceptance testing of Boral shall be in accordance with Section 10.1.6.4.8. These sections of the FSAR are hereby incorporated into the MAGNASTOR CoC.

c) *Soluble boron concentration in the PWR fuel pool and water in the TSC shall* be in accordance with LCO 3.2.1, with a minimum water temperature 5-10°F higher than the minimum needed to ensure solubility.

d) Minimum fuel tube orthogonal (x, y) pitch

PWR basket — 9.249 inches
BWR basket — 6.166 inches

4.1.2 Fuel Cladding Integrity

The licensee shall ensure that fuel oxidation and the resultant consequences are precluded during canister loading and unloading operations.

4.1.3 Transfer Cask Shielding

The nominal configuration transfer cask radial bulk shielding (i.e., shielding integral to the transfer cask; excludes supplemental shielding) must provide a minimum radiation shield equivalent to 2 inches of steel and 3.25 inches of lead gamma shielding and 2.25 inches of NS-4-FR (with 0.6 wt % B_4C and 6.0 wt % H) neutron shielding. Material and dimensions of the individual shield layers may vary provided maximum calculated radial dose rates of 1100 mrem/hr (PWR system) and 1600 mrem/hr (BWR system) are maintained on the vertical surface.

(continued)

March 2009

Revision 09A

MAGNASTOR®

(Modular Advanced Generation
Nuclear All-purpose STORage)

FINAL SAFETY ANALYSIS REPORT

Docket No. 72-1031

NAC INTERNATIONAL

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16 drawings (see Section 1.8)

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Chapter 10

Chapter 10
Acceptance Criteria and Maintenance Program

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10.1 Acceptance Criteria

This section provides the workmanship and acceptance tests to be performed on the MAGNASTOR components and systems during their fabrication, as well as prior to and during loading of the system. These tests and inspections provide assurance that the components and systems have been procured, fabricated, assembled, inspected, tested, and accepted for use under the conditions and controls specified in this document and the Certificate of Compliance.

10.1.1 Visual Inspection and Nondestructive Examination

Fabrication, inspection, and testing are performed in accordance with the applicable design criteria, codes and standards specified in Chapter 2 and on the license drawings.

The following fabrication controls and inspections shall be performed to assure compliance with this document and the license drawings:

a) Materials of construction for the MAGNASTOR are identified on the license drawings and shall be procured with certification and supporting documentation as required by the ASME Code, Section II [1], when applicable; and the requirements of ASME Code, Section III, Subsection NB [2] and Subsection NG [3], when applicable.

b) Materials and components shall be receipt inspected for visual and dimensional acceptability, material conformance to the applicable Code specification and traceability markings, as applicable. Materials for the TSC confinement boundary (e.g., TSC shell plates, base plate, closure lid, and port covers) shall also be inspected per the requirements of ASME Code, Section III, Subsection NB-2500.

c) The confinement boundary shall be fabricated and inspected in accordance with ASME Code, Section III, Subsection NB, with the code alternatives as listed in Chapter 2, Table 2.1-2. The TSC fuel basket and basket supports shall be fabricated and inspected in accordance with the ASME Code, Section III, Subsection NG, with the alternatives listed in Table 2.1-2.

d) The steel components of the transfer cask shall be in accordance with ASTM specifications and fabricated in accordance with ANSI N14.6 [11]. Inspections and NDE of the transfer cask shall be in accordance with ASME Code, Section III, Subsection NF.

e) The steel components of the concrete cask shall be in accordance with ASTM specifications and fabricated in accordance with ASME Code, Section VIII [6] (or fabrication may be in accordance with ANSI/AWS D1.1). Inspections of the welded steel components of the concrete cask shall be in accordance with ASME Code, Section VIII or ANSI/AWS D1.1.

f) ASME Code welding shall be performed using welders and weld procedures qualified in accordance with ASME Code, Section IX [7] and the ASME Code, Section III subsection applicable to the component (e.g., NB, NG or NF). ANSI/AWS code welding may be performed using welders and procedures qualified in accordance with the applicable AWS requirements or in accordance with ASME Code, Section IX.

g) Construction and inspections of the concrete component of the concrete cask shall be performed in accordance with the applicable sections and requirements of ACI-318 [8].

h) Visual examinations of the welds of the confinement boundary shall be performed in accordance with ASME Code, Section V, Articles 1 and 9 [9], with acceptance per Section III, Subsection NF, Article NF-5360. The final surface of TSC shell welds shall be dye penetrant examined (PT) in accordance with ASME Code, Section V, Articles 1 and 6, with acceptance per Section III, Subsection NB, Article NB-5350. The TSC shell longitudinal and circumferential welds shall be radiographic examined (RT) in accordance with ASME Code, Section V, Articles 1 and 2, with acceptance per Section III, Subsection NB, Article NB-5320. The weld of the TSC baseplate to the TSC shell shall be ultrasonic examined (UT) in accordance with ASME Code, Section V, Articles 1 and 5, with acceptance per Section III, Subsection NB, Article NB-5330. In accordance with ISG-15 [14], the TSC closure lid to shell weld, performed following fuel loading, shall be dye penetrant (PT) examined at the root, mid-plane and final surface in accordance with ASME Code, Section V, Articles 1 and 6, with acceptance per Section III, Subsection NB, Article NB-5350. The closure ring to TSC shell and the closure ring to closure lid welds shall be PT examined in accordance with the same code and acceptance criteria as the closure lid to TSC shell weld, except that only the weld final surface will be examined. The inner and outer (redundant) port covers to closure lid welds shall be PT examined at the final surface in accordance with the same code and acceptance criteria as for the closure lid to shell weld. Repairs to TSC vessel welds shall be performed in accordance with ASME Code, Section III, Subsection NB, Article NB-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

i) Visual examinations of the welds of the fuel basket and basket supports shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, with acceptance per Section III, Subsection NG, Article NG-5360. The fuel tube welds shall be magnetic particle examined (MT) in accordance with ASME Code, Section V, Articles 1 and 7, with acceptance criteria per Section III, Subsection NG, Article NG-5340. Repairs to fuel basket welds shall be performed in accordance with ASME Code, Section III, Subsection NG, Article NG-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

j) Visual examinations of the concrete cask structural steel weldments shall be performed in accordance with the ASME Code, Section V, Articles 1 and 9, or ANS/AWS D1.1, Section 6.9, with acceptance per Section VIII, Division 1, Part UW, Articles UW-35 and UW-36, or Table 6.1 of ANSI/AWS D1.1, respectively. Repairs to concrete cask structural weldment welds shall be performed in accordance with ANSI/AWS D1.1, and the welds reinspected per the original acceptance criteria.

k) Visual examination of the welds of the transfer cask shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, or ANSI/AWS D1.1, Section 6.9, with acceptance per Section III, Subsection NF, Article NF-5360. Following structural load testing of the transfer cask, the final surface of all critical load-bearing welds shall be either dye penetrant (PT) or magnetic particle (MT) examined in accordance with ASME Code, Section V, Articles 1 and 6 for PT and Articles 1 and 7 for MT. The acceptance criteria for the weld examinations shall be in accordance with Section III, Subsection NF, Article NF-5350 for PT and NF-5340 for MT. Repairs to the transfer cask vertical load-bearing welds shall be performed in accordance with ASME Code, Section III, Subsection NF, Article NF-4450 or ANSI/AWS D1.1. Repaired welds shall be reinspected per the original acceptance criteria applicable to the examination method.

l) Dimensional inspections of components shall be performed in accordance with written and approved procedures to verify compliance to the license drawings and fit-up of individual components. All dimensional inspections and functional fit-up tests shall be documented.

m) All components shall be inspected for cleanliness and proper packaging for shipping in accordance with written and approved procedures. All components will be free of any foreign material, oil, grease, and solvents.

n) Inspection and nondestructive examination personnel shall be qualified in accordance with the requirements of SNT-TC-1A [10].

10.1.2 Structural and Pressure Tests

10.1.2.1 Load Testing of Transfer Casks

The transfer cask is designed, fabricated, and tested to the requirements of ANSI N14.6 [11]. The transfer cask is provided with two lifting trunnions near the top of the cask for lifting and handling. The trunnion pair is designed for a maximum design lift load of 230,000 pounds. The transfer cask shield doors and supporting door rails are designed to retain and support the maximum TSC loaded weight of 118,000 pounds.

Following completion of fabrication, the load-bearing components of the transfer cask, including the lifting trunnions, shield doors, and rails, are load tested to verify their structural integrity to lift and retain the applicable loads.

The lifting and handling of the transfer cask and loaded TSC are defined as critical lifting loads per NUREG-0612 [12] at a number of nuclear facilities. In accordance with ANSI N14.6, special lifting devices for critical loads shall be provided with redundant lifting paths, or be designed and tested to higher safety factors. The transfer cask lifting trunnions, shield doors, and rails are designed to higher safety factors and are load tested to 300% of the maximum service load for each type of component.

The lifting trunnion pair shall have a load equal to three times their maximum service load applied for a minimum of 10 minutes. Likewise, the transfer cask shield doors and rails shall have a load equal to three times their maximum service load applied for a minimum of 10 minutes. After release of the test loads, the accessible portions of the trunnions and the adjacent areas, and the shield doors and rails and adjacent areas shall be visually examined to verify no deformation, distortion, or cracking occurred. The critical load-bearing welds of the transfer cask shall be examined by the methods and acceptance criteria defined in Section 10.1.1, Item k).

Any evidence of deformation, distortion, or cracking of the loaded components, critical load-bearing welds or adjacent areas shall be cause for failure of the load test, and repair and/or replacement of the component. Following repair or replacement, the applicable portions of the load test shall be performed again and the components reexamined in accordance with the original procedure and acceptance criteria.

Load testing of the transfer cask shall be performed in accordance with written and approved procedures, and the test results shall be documented.

10.1.2.2 Load Testing of Concrete Cask Lifting Lugs and Anchors

The concrete cask is designed to be lifted and transported using two lifting anchors imbedded in the reinforced concrete of the shell. Lifting lugs are bolted to the anchors and provide a pin connection to a lifting system. The concrete lifting anchors, lifting lugs and attachment bolting are designed, fabricated, and tested in accordance with the requirements of ANSI N14.6 for lifts not made over safety-related equipment (noncritical lifts).

The concrete cask lifting lug load test shall be performed on the lugs independently of the concrete cask and will consist of applying a vertical load that is equal to 150% of the maximum concrete cask weight, plus a 10% dynamic load factor. The test load shall be applied for a minimum of 10 minutes. After the release of the test load, the accessible portions of the lifting anchors shall be visually examined to verify no deformation, distortion, or cracking occurred. Critical load-bearing welds of the lifting anchors shall be magnetic particle (MT) examined in accordance with ASME Code, Section V, Articles 1 and 7, with acceptance criteria per Section III, Subsection NF, Article NF-5340.

Any evidence of deformation, distortion, or cracking of the loaded components, critical load-bearing welds or adjacent areas shall be cause for failure of the load test, and repair and/or replacement of the affected component(s). Following repair or replacement, the applicable portions of the load test shall be reperformed and the components reexamined in accordance with the original procedure and acceptance criteria.

Load testing of the concrete cask lifting lugs shall be performed in accordance with written and approved procedures, and the test results shall be documented.

10.1.2.3 Pressure Testing of the TSC

Following completion of the closure lid-to-TSC shell weld during the TSC preparation operations after fuel loading, the TSC shall be hydrostatically pressure tested in accordance with ASME Code, Section III, Subsection NB, NB-6000 requirements as described in Section 9.1.1. The minimum test pressure of 130 psig shall be applied to the drain port connection for a minimum of 10 minutes. The minimum test pressure is 125% of the normal operating pressure of 104 psig. There shall be no loss in pressure or visible water leakage from the closure lid weld during the 10-minute test period. The normal operating pressure and minimum test pressure are identical for both PWR and BWR TSCs.

10.1.3 Leakage Tests

The confinement boundary is defined as the TSC shell weldment, closure lid, and vent and drain port covers. As described in Section 10.1.1, the confinement boundary is designed, fabricated, examined, and tested in accordance with the requirements of the ASME Code, Section III, Subsection NB, except for the code alternatives listed in Table 2.1-2.

Following welding, the TSC shell weldment shall be leakage tested using the evacuated envelope method as described in ASME Code, Section V, Article 10, and ANSI N14.5 to confirm the total leakage rate is less than or equal to 1×10^{-7} ref. cm^3/s at an upstream pressure of 1 atmosphere absolute and a downstream pressure of 0.01 atmosphere absolute, or less. Under these test conditions, this corresponds to a test leakage rate of 2×10^{-7} cm^3/s, helium at standard conditions.

The TSC shell weldment will be closed using a test lid installed over the top of the shell and the cavity evacuated with a vacuum pump to a vacuum of two torr or less. A test envelope will be installed around the TSC enclosing all of the TSC shell confinement welds, evacuated and backfilled to approximately 1 atmosphere absolute with 99.995% (minimum) pure helium. The percentage of helium gas in the test envelope will be accounted for in the determination of the test sensitivity. A mass spectrometer leak detector (MSLD) is attached to the test lid and samples the evacuated volume for helium. The minimum sensitivity of the helium MSLD and test system shall be less than or equal to 1×10^{-7} cm^3/s, helium, which is one-half of the allowable leakage criteria for leaktight.

If helium leakage is detected, the area of leakage shall be identified and repaired in accordance with the ASME Code, Section III, Subsection NB, NB-4450. The complete helium leakage test shall be performed again to the original test acceptance criteria.

Leakage testing of the TSC shell weldment shall be performed in accordance with written and approved procedures, and the test results documented.

Based on the confinement system materials, welding requirements and inspection methods, leakage testing of the closure lid is not required. In order to ensure the integrity of the vent and drain inner port cover welds, a helium leakage test of each weld is performed using the evacuated envelope method, as described in ASME Code, Section V, Article 10, and ANSI N14.5. The leakage test is to confirm that the leakage rate for each port cover is $\leq 1\times10^{-7}$ ref. cm^3/s, which corresponds to a helium test leakage rate of $\leq 2\times10^{-7}$ ref. cm^3/s. Following inner port cover welding, a test bell is installed over the top of the port cover and the test bell volume is evacuated to a low pressure by a helium Mass Spectrometer Leak Detector (MSLD) system. The minimum sensitivity of the helium MSLD shall be $\leq 1\times10^{-7}$ ref. cm^3/s, helium, which is one-half of the allowable leakage criteria for leaktight.

If leakage is detected, the area of leakage shall be identified and repaired in accordance with ASME Code, Section III, Subsection NB, NB-4450. The helium leak test shall be reperformed to the original test acceptance criteria.

10.1.4 Component Tests

10.1.4.1 Valves, Rupture Discs, and Fluid Transport Devices

The MAGNASTOR system design does not include any rupture discs or fluid transport devices. The closure lid vent and drain openings are each closed by valved quick-disconnect nipples. These nipples are recessed into the closure lid and are used during TSC preparation activities to drain, dry, and helium fill the TSC cavity. No credit is taken for the ability of the valved nipples to confine radioactive material. After completion of final helium backfill pressure adjustment, the port covers are welded in the vent and drain openings enclosing the valved nipples. The port covers provide the confinement boundary for the vent and drain openings.

10.1.4.2 Gaskets

The confinement boundary provided by the welded TSC has no mechanical seals or gaskets. The concrete cask includes weather seals at the concrete cask lid to cask interface. These gaskets do not provide a safety function and loss of the gaskets during operation would have no effect on the safe operation of the concrete cask. The gaskets are provided to facilitate concrete cask maintenance by minimizing water intrusion into the gasketed area.

10.1.5 Shielding Tests

The MAGNASTOR system design is analyzed based on the materials of fabrication and their thickness, using conservative shielding codes to evaluate system dose rates at the system's surface and at selected distances from the surface. The system shield design does not require performance of a shield test.

Following the loading of each MAGNASTOR and its movement to the ISFSI pad, radiological surveys are performed by the system user to establish area access requirements and to confirm that evaluated offsite doses will meet the applicable regulations. These tests are sufficient to identify any significant defect in the shielding effectiveness of the concrete cask.

10.1.6 Neutron Absorber Tests

NOTE

Sections 10.1.6.4.5, 10.1.6.4.6, 10.1.6.4.7 and 10.1.6.4.8 are incorporated into the MAGNASTOR CoC Technical Specification by reference, Paragraph 4.1.1, and may not be deleted or altered in any way without a CoC amendment approval from the NRC. The text in these four sections is shown in bold to distinguish it from other sections.

Neutron absorber materials are included in the design and fabrication of the MAGNASTOR fuel basket assemblies to assist in the control of reactivity, as described in Chapter 6. Criticality safety is dependent upon the neutron absorber material remaining fixed in position on the fuel tubes and containing the required amount of uniformly distributed boron. A neutron absorber material can be a composite of fine particles in a metal matrix or an alloy of boron compounds with aluminum. Fine particles of boron or boron-carbide that are uniformly distributed are required to obtain the best neutron absorption. Three types of neutron absorber materials are commonly used in spent fuel storage and transport cask fuel baskets: Boral (registered trademark), borated metal matrix composites (MMC), and borated aluminum alloy. The fabrication of the neutron absorber material is controlled to provide a uniform boron carbide distribution and the specified ^{10}B areal density.

10.1.6.1 Design/Performance Requirements

The MAGNASTOR system utilizes sheets of neutron absorber material that are attached to the sides of the spent fuel storage locations in the fuel baskets. The materials and dimensions of the neutron absorber sheets are defined on license drawings 71160-571 and 71160-572. The material is called out as a metallic composite (includes borated aluminum alloy, borated MMC, and Boral, which are available under various commercial trade names). Incorporating optional neutron absorber materials in the design provides fabrication flexibility for the use of the most economical and available neutron absorber material that meets the critical characteristics necessary to assure criticality safety. The critical design characteristics of the neutron absorber material are:

- A minimum "effective" areal density of 0.036 g/cm^2 ^{10}B for the PWR basket and 0.027 g/cm^2 ^{10}B for the BWR basket; and
- A uniform distribution of boron carbide; and
- A yield strength greater than or equal to that used in Section 10.1.6.4.4; and
- An effective thermal conductivity greater than or equal to that used in Section 10.1.6.4.4.

The required minimum actual ^{10}B loading in a neutron absorber sheet is determined based on the effectiveness of the material, i.e., 75% for Boral and 90% for borated aluminum alloys and for borated metal matrix composites. Testing will be used to verify the areal density and the uniform distribution of ^{10}B in the neutron absorber materials. Table 8.8-1 presents a tabulation of the types of neutron absorber materials, the required minimum effective areal density of ^{10}B, and the required minimum as-fabricated areal density of ^{10}B.

The positions of the neutron absorber sheets with their attachments and retainers to the fuel tubes are shown on license drawings 71160-551 and 71160-591. The attachments and retainers ensure that the neutron absorber remains in place for all loading conditions for the lifetime of the canister.

10.1.6.2 Terminology

Applicable terminology definitions for the neutron absorber materials:

acceptance – tests conducted to determine whether a specific production lot meets selected material properties and characteristics, or both, so that the lot can be accepted for commercial use.

areal density – for sheets with flat parallel surfaces, the density of the neutron absorber times the thickness of the material.

designer – the organization responsible for the design or the license holder for the dry cask storage system or transport packaging. The designer is usually the purchaser of the neutron absorber material, either directly or indirectly (through a fabrication subcontractor).

lot – a quantity of a product or material accumulated under conditions that are considered uniform for sampling purposes.

neutron absorber – a nuclide that has a large thermal or epithermal neutron absorption cross-section, or both.

neutron absorber material –	a compound, alloy, composite or other material that contains a neutron absorber.
neutron attenuation test –	a process in which a material is placed in a thermal neutron beam, and the number of neutrons transmitted through the material in a specified period of time is counted. The observed neutron counting rate may be converted to areal density by performing the same test on a series of calibration standards.
neutron cross-section –	a measure of the probability that a neutron will interact with a nucleus; a function of the neutron energy and the structure of the interacting nucleus.
packaging –	in transport of radioactive material, the assembly of components necessary to enclose the radioactive contents completely.
qualification –	the process of evaluating and testing, or both, a material produced by a specific manufacturing process to demonstrate uniformity and durability for a specific application.

10.1.6.3 Inspections

After manufacturing, each sheet of neutron absorber material will be visually and dimensionally inspected for damage, embedded foreign material, and dimensional compliance. The neutron absorber sheets are intended to be defect/damage free, but limited defects/damages are acceptable. Allowed defects are discussed in each material specification section that follows. Standard industrial inspections will be performed on the neutron absorber sheets to verify the acceptability of physical characteristics such as dimensions, flatness, straightness, tensile properties (if structural considerations are applicable) or other mechanical properties as appropriate, surface quality and finish. Inspection and testing of the neutron absorber materials will be performed in accordance with written procedures, by appropriately certified personnel, and the inspection and test results will be documented.

10.1.6.4 Specification

Three types of neutron absorber materials are permitted to augment criticality control in the MAGNASTOR fuel baskets – (1) Boral, a clad composite of aluminum and boron carbide, as specified in Section 10.1.6.4.1; (2) borated metal matrix composites (MMC), as specified in

Section 10.1.6.4.2; and (3) borated aluminum alloy, as specified in Section 10.1.6.4.3. The required minimum "effective" areal density of ^{10}B in a neutron absorber is defined on license drawings 71160-571 and 71160-572, in Section 1.8, and is based on the fuel basket geometry and on the fuel assembly type and reactivity. The analyses of the fuel baskets do not consider the tensile strength of the neutron absorber material other than that it be sufficient to maintain its form, i.e., at least equivalent to the properties listed in Table 8.3-16. Environmental conditions encountered by the neutron absorber material may include:

- Immersion in water with the associated chemical, temperature and pressure concerns
- Dissimilar materials
- Gamma and neutron radiation fluence
- Dry heat-up rates
- Maximum temperatures

Except for materials for which validation has been completed, the durability of the neutron absorber materials is validated to demonstrate the following results:

- Neutron absorber materials will not incur significant damage due to the pressure, temperature, radiation, or corrosion environments that may be present in the loading and storage of spent fuel;
- Aluminum and boron carbide do not react with each other in the range of the maximum temperatures present in the fuel baskets;
- There are no significant changes in mechanical properties of the neutron absorber materials due to the fast neutron fluences experienced in spent fuel storage;
- General corrosion does not have time to affect the integrity of the neutron absorber material due to the very short time of immersion in spent fuel pool water.

Individual material types and process lots are tested to verify the presence, uniform distribution and minimum areal density (effectiveness) of ^{10}B specific to each type of neutron absorber material.

All neutron absorber materials are procured and qualified under a Quality Assurance/Quality Control program in conformance with the requirements of 10 CFR 72, Subpart G.

10.1.6.4.1 Boral

Boral is a composite core of blended boron carbide and aluminum powders between outer layers of aluminum. The core is slightly porous. Sheets of Boral are formed and mechanically bonded by hot-rolling ingots of the core material between aluminum sheets. Boral is credited with an effectiveness of 75% of the specified minimum areal density of ^{10}B in Boral based on testing of the material as described in Section 10.1.6.4.8.

Visual inspections of the Boral sheets will verify the presence of a full core and will identify any cladding damage, cracks or discontinuities, embedded foreign material, or peeled cladding. Evidence of less than a full core, embedded foreign material, cracks or sharp burrs in the cladding shall be identified as nonconforming. Nonconforming items are segregated and evaluated within the NAC International Quality Assurance Program, and assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted. Embedded pieces of B_4C matrix material are not considered foreign material, but such material shall be removed from the surface of the Boral. Scratches, creases or other surface indications are acceptable on the cladding of the Boral, but exposure of the core through the cladding surface of the sheet is not acceptable.

10.1.6.4.2 Borated Metal Matrix Composites - MMC

Borated metal matrix composite (MMC) material can be produced by powder metallurgy, casting or thermal spray methods and consists of fine boron carbide particles in a matrix of aluminum. Borated MMC material is a metallurgically bonded matrix, low porosity product. Borated metal matrix composites rely on a fine (average 10-40 micron) boron carbide particle size to achieve a uniform boron distribution. Specifications on the boron carbide particle size in MMCs are included in Section 10.1.6.4.7. MMCs are credited with an effectiveness of 90% of the specified minimum areal density of ^{10}B in the borated MMC material based on acceptance and qualification testing of the material as described in the Sections 10.1.6.4.4, 10.1.6.4.5 and 10.1.6.4.6. Visual inspections of the sheets of borated MMC material will be based on Aluminum Association recommendations, as applicable—i.e., blisters and/or widespread rough surface conditions such as die chatter or porosity shall be identified as nonconforming. Nonconforming items are segregated and evaluated within the NAC International Quality Assurance Program, and assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores or discoloration are acceptable based on material neutron attenuation and thermal performance not being impacted by minor fabrication anomalies.

10.1.6.4.3 Borated Aluminum

Borated aluminum material is a direct chill cast metallurgy product with a uniform fine dispersion of discrete boron particles in a matrix of aluminum. Borated aluminum material is a metallurgically bonded matrix, low porosity product. Borated aluminum is credited with an effectiveness of 90% of the specified minimum areal density of ^{10}B in the borated aluminum material based on acceptance and qualification testing of the material as described in Sections 10.1.6.4.4, 10.1.6.4.5 and 10.1.6.4.6. Visual inspections of the sheets of borated aluminum material will be based on Aluminum Association recommendations, as applicable—i.e., blisters and/or widespread rough surface conditions such as die chatter or porosity shall be identified as nonconforming. Nonconforming items are segregated and evaluated within the NAC International Quality Assurance Program, and assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores or discoloration are acceptable based on material neutron attenuation and thermal performance not being impacted by minor fabrication anomalies.

10.1.6.4.4 Thermal Conductivity and Yield Strength Testing of Metal Matrix and Borated Aluminum Neutron Absorber Material

Thermal Conductivity Testing

Thermal conductivity qualification testing of the neutron absorber materials shall conform to ASTM E1225 [15], ASTM E1461 [16], or an equivalent method. The testing shall be performed on test coupons taken from production material. Note that thermal conductivity increases slightly with temperature increases.

- Sampling will initially be one test per lot and may be reduced if the first five tests meet the specified minimum thermal conductivity. Additional tests may be performed on the material from a lot whose test result does not meet the required minimum value, but the lot will be rejected if the mean value of the tests does not meet the required minimum value.
- Upon completion of 25 tests of a single type of neutron absorber material having the same aluminum alloy matrix and boron content (in the same compound), further testing may be terminated if the mean value of all of the test results minus two standard deviations meets the specified minimum thermal conductivity. Similarly, testing may be terminated if the matrix of the material changes to an alloy with a larger coefficient of thermal conductivity, or if the boron compound remains the same, but the boron content is reduced.

In the Chapter 4 thermal analyses, the neutron absorber is conservatively evaluated as a 0.125-in nominal thickness sheet for the PWR fuel basket and a 0.10-in nominal thickness sheet for the BWR fuel basket. The required minimum thermal conductivities for the MAGNASTOR absorbers are as follows.

Minimum Effective Thermal Conductivity - BTU/(hr-in-ºF)

Fuel Basket Type	Radial		Axial	
	100°F	500°F	100°F	500°F
PWR	4.565	4.191	4.870	4.754
BWR	4.687	4.335	5.054	5.017

The neutron absorber thermal acceptance criterion will be based on the nominal sheet thickness. Surface anomalies increase radiation heat transfer and have insignificant influence on thermal conductivity, permitting acceptance of minor surface defects without additional material testing.

Additional thermal conductivity qualification testing of neutron absorber material is not required if certified quality-controlled test results (from an NAC approved supplier) that meet the specified minimum thermal conductivity are available as referenced documentation.

Yield Strength Testing

Yield strength qualification testing of the neutron absorber shall conform to ASTM Test Method B 557/B 557M, E 8 or E 21 [17, 18, 19].

Neutron absorber material yield strength must be equal to or greater than 1.6 ksi at 700°F. Per Table 8.3-16, a yield strength of 1.6 ksi is the material strength of the neutron absorber at 700°F and is applied as a temperature-independent value in the structural evaluations of the absorber. This yield strength assures that the material will maintain its form when subjected to normal, off-normal and accident condition loads.

The neutron absorber yield strength acceptance criterion will be based on the absorber meeting the specified nominal sheet thickness. Control and limitations on the neutron absorber boron content (primary driver to material structural performance) permits acceptance without additional material yield strength acceptance testing.

Additional yield strength qualification testing of neutron absorber material is not required if certified quality-controlled test results (from an NAC approved supplier) that meet the specified minimum yield strength are available as referenced documentation.

10.1.6.4.5 Acceptance Testing of Borated Aluminum Alloy and Borated MMC Neutron Absorber Material by Neutron Attenuation

NOTE
Section 10.1.6.4.5 is incorporated into the MAGNASTOR CoC Technical Specification by reference, Paragraph 4.1.1, and may not be deleted or altered in any way without a CoC amendment approval from the NRC. The text in this section is shown in bold to distinguish it from other sections.

Acceptance testing shall be performed to ensure that neutron absorber material properties for sheets in a given production run are in compliance with the materials requirements for the MAGNASTOR fuel baskets and that the process is operating in a satisfactory manner.

Statistical tests will be run to augment findings relating to isotopic content, impurity content or uniformity of the ^{10}B distribution.

- **Determination of neutron absorber material acceptance shall be performed by neutron attenuation testing. Neutron attenuation testing of the final product or the coupons shall compare the results with those for calibrated standards composed of a homogeneous ^{10}B compound. Other calibrated standards may be used, but those standards must be shown to be equivalent to a homogeneous standard. These tests shall include a statistical sample of finished product or test coupons taken from each lot of material to verify the presence, uniform distribution and the minimum areal density of ^{10}B.**
- **Alternative test methods for neutron attenuation may include chemical analysis or radiography, or a combination of these two methods, provided the alternate methods have been benchmarked (validated or calibrated) to neutron attenuation testing results and have adequate precision to confirm absorber efficacy.**
- **The ^{10}B areal density is measured using a collimated thermal neutron beam of up to 1.2 cm diameter. A beam size greater than 1.2 cm diameter, but no larger than 1.7 cm diameter, may be used if computations are performed to demonstrate that the calculated k_{eff} of the system is still below the calculated Upper Subcritical Limit (USL) of the system, assuming defect areas the same area as the beam. Following are the required computations for using a neutron beam size greater than 1.2 cm diameter.**

    1. **Defects of the same area as the proposed neutron beam or larger have an areal density significantly below the specified minimum areal density.**

2. These defects are distributed randomly or systematically over the material, or in a manner that is conservative for the design analysis.
3. The total of such defective areas amounts to (100-x) percent of the neutron absorber material area, where x is the probability level used for determining the lower tolerance limit.

Alternately, apply more rigorous statistical criteria for lot acceptance, i.e., increase the factor K in the following expression.

Lower tolerance limit = average of sample – K * standard deviation of sample ≥ Technical Specification areal density acceptance criterion,

where, K is the one-sided tolerance limit factor for a normal distribution with a specified sample size, probability and confidence.

The value of K should be increased to compensate for the decreased standard deviation that results from using a larger neutron beam to examine a material that has defect areas with a characteristic dimension of 1.2 cm.

- Based on the MAGNASTOR required minimum effective areal density of ^{10}B – 0.036 g/cm^2 for the PWR basket and 0.027 g/cm^2 for the BWR basket – and the credit taken for the ^{10}B for the criticality analyses, i.e., 90% for borated aluminum alloys and for borated metal matrix composites, a required minimum areal density for the as-manufactured neutron absorber sheets is established.
- Test locations/coupons shall be well distributed throughout the lot of material, particularly in the areas most likely to contain variances in thickness, and shall not contain unacceptable defects that could inhibit accurate physical and test measurements.
- The sampling plan shall require that each of the first 50 sheets of neutron absorber material from a lot, or a coupon taken therefrom, be tested. Thereafter, coupons shall be taken from 10 randomly selected sheets from each set of 50 sheets. This 1 in 5 sampling plan shall continue until there is a change in lot or batch of constituent materials of the sheet (i.e., boron carbide powder or aluminum powder) or a process change. A measured value less than the required minimum areal density of ^{10}B during the reduced inspection is defined as nonconforming, along with other contiguous sheets, and mandates a return to 100% inspection for the next 50 sheets. The coupons are indelibly marked and recorded for identification. This identification will be used to document the neutron absorber material test results, which become part of the quality record documentation package.

- The minimum areal density specified shall be verified for each lot at the 95% probability, 95% confidence level (also expressed as 95/95 level) or better. The following illustrates one acceptable method.

  The acceptance criterion for individual plates is determined from a statistical analysis of the test results for that lot. The minimum ^{10}B areal densities determined by neutron attenuation are converted to volume density, i.e., the minimum ^{10}B areal density is divided by the thickness at the location of the neutron attenuation measurement or the maximum thickness of the coupon. The lower tolerance limit of ^{10}B volume density is then determined—defined as the mean value of ^{10}B volume density for the sample, less K times the standard deviation, where K is the one-sided tolerance limit factor for a normal distribution with 95% probability and 95% confidence.

  Finally, the minimum specified value of ^{10}B areal density is divided by the lower tolerance limit of ^{10}B volume density to arrive at the minimum plate thickness that provides the specified ^{10}B areal density.

  Any plate that is thinner than this minimum or the minimum design thickness, whichever is greater, shall be treated as nonconforming, with the following exception. Local depressions are acceptable, as long as they total no more than 0.5% of the area on any given plate and the thickness at their location is not less than 90% of the minimum design thickness.

- All neutron absorber material acceptance verification will be conducted in accordance with the NAC International Quality Assurance Program. The neutron absorber material supplier shall control manufacturing in accordance with the key process controls via a documented quality assurance system (approved by NAC or NAC's approved fabricator), and the designer shall verify conformance by reviewing the manufacturing records.

- Nonconforming material shall be evaluated within the NAC International Quality Assurance Program and shall be assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted.

10.1.6.4.6 Qualification Testing of Metal Matrix and Borated Aluminum Neutron Absorber Material

> NOTE
>
> Section 10.1.6.4.6 is incorporated into the MAGNASTOR CoC Technical Specification by reference, Paragraph 4.1.1, and may not be deleted or altered in any way without a CoC amendment approval from the NRC. The text in this section is shown in bold to distinguish it from other sections.

Qualification tests for each MAGNASTOR System neutron absorber material and its set of manufacturing processes shall be performed at least once to demonstrate acceptability and durability based on the critical design characteristics, previously defined in this section.

The licensed service life will include a range of environmental conditions associated with short-term transfer operations, normal storage conditions, as well as off-normal and accident storage events. Additional qualification testing is not required for a neutron absorber material previously qualified, i.e., reference can be provided to prior testing with the same, or similar, materials for similar design functions and service conditions.

- **Qualification testing is required for: (1) neutron absorber material specifications not previously qualified; (2) neutron absorber material specifications previously qualified, but manufactured by a new supplier; and (3) neutron absorber material specifications previously qualified, but with changes in key process controls. Key process controls for producing the neutron absorber material used for qualification testing shall be the same as those to be used for commercial production.**
- **Qualification testing shall demonstrate consistency between lots (2 minimum).**
- **Environmental conditions qualification will be verified by direct testing or by validation by data on the same, or similar, material, i.e., the neutron absorber material is shown to not undergo physical changes that would preclude the performance of its design functions. Conditions encountered by the neutron absorber material may include: short-term immersion in water, exposure to chemical, temperature, pressure, and gamma and neutron radiation environments. Suppliers' testing will document the durability of neutron absorber materials that may be used in the MAGNASTOR system by demonstrating that the neutron absorber materials will not incur significant damage due to the pressure, temperature, radiation, or corrosion environments or the short-term water immersion that may occur in the loading and storage of spent fuel.**

- **Thermal conductivity and yield strength qualification testing shall be as previously described in Section 10.1.6.4.4.**
- **The uniformity of the boron carbide distribution in the material shall be verified by neutron attenuation testing of a statistically significant number of measurements of the areal density at locations distributed throughout the test material production run, i.e., at a minimum from the ends and the middle of the run. The sampling plan must be designed to demonstrate 95/95 compliance with the absorber content requirements. Details on acceptable neutron attenuation testing are previously provided in this section for Acceptance Testing. Alternate test methods may be employed provided they are validated (benchmarked) to neutron attenuation tests.**
- **One standard deviation of the neutron attenuation test sampling results shall be less than 10% of the sample mean. This requirement provides additional assurance that a consistent product is achieved by the manufacturing process.**
- **A material qualification report verifying that all design requirements are satisfied shall be prepared.**
- **Key manufacturing process controls in the form of a complete specification for materials and process controls shall be developed for the neutron absorber material by the supplier and approved by NAC to ensure that the product delivered for use is consistent with the qualified material in all respects that are important to the material's design function.**
- **Major changes in key manufacturing processes for neutron absorber material shall be controlled by mutually agreed-upon process controls established by the certificate holder/purchaser and the neutron absorber supplier. These process controls will ensure that the neutron absorber delivered will always be consistent with the qualification test material in any and all respects that are important to the neutron absorber's safety characteristics. Changes in the agreed-upon process controls may require requalification of those parts of the qualification that could be affected by the process changes. Typical changes covered by the agreed-upon process controls may include:**
  - **Changes that could adversely affect mechanical properties (e.g., change in thermal conductivity, porosity, material strength, change of matrix alloy, boron carbide content, increase in the B_4C content above that used in previously qualified material, etc.);**
  - **Changes that could affect the uniformity of boron (e.g., change to mixing process for aluminum and boron carbide powders, change in stirring of melt, change in boron precipitate phase, etc.).**

- **Minor neutron absorber material processing changes may be determined to be acceptable on the basis of engineering review without additional qualification testing, if such changes do not adversely affect the particle bonding microstructure, i.e., the durability or the uniformity of the boron carbide particle distribution, which is the neutron absorber effectiveness.**
- **Nonconforming material shall be evaluated within the NAC International Quality Assurance Program and shall be assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted.**

10.1.6.4.7 Additional Material Specifications

NOTE

Section 10.1.6.4.7 is incorporated into the MAGNASTOR CoC Technical Specification by reference, Paragraph 4.1.1, and may not be deleted or altered in any way without a CoC amendment approval from the NRC. The text in this section is shown in bold to distinguish it from other sections.

Boron carbide particles for MMCs shall have an average size in the range 10-40 microns and no more than 10% of the particles shall be over 60 microns. The material shall have negligible interconnected porosity exposed at the surface or edges.

10.1.6.4.8 Boral Neutron Absorber Tests

NOTE

Section 10.1.6.4.8 is incorporated into the MAGNASTOR CoC Technical Specification by reference, Paragraph 4.1.1, and may not be deleted or altered in any way without a CoC amendment approval from the NRC. The text in this section is shown in bold to distinguish it from other sections.

The Boral neutron absorbing material is an aluminum matrix material formed from aluminum and boron-carbide. The mixing of the aluminum and boron-carbide powder forming the neutron absorber material is controlled to assure the required ^{10}B areal density. The constituents of the neutron absorber material shall be verified by chemical testing and by physical property measurement to ensure the quality of the finished plate or sheet. The results of all neutron absorber material tests and inspections, including the

results of wet chemistry coupon testing, are documented and become part of the quality records documentation package for the fuel tube and basket assembly.

The manufacturing process of Boral consists of several steps. The initial step is the mixing of the aluminum and boron carbide powders that form the core of the finished material. The amount of each powder is a function of the desired ^{10}B areal density. The methods used to control the weight and blend the powders are proprietary processes of the manufacturer.

After manufacturing, test samples from each Boral batch of neutron absorber sheets shall be tested using wet chemistry techniques to verify the presence and minimum weight percent of ^{10}B. The tests shall be performed in accordance with approved written procedures.

The neutron absorber sampling plan is selected to demonstrate a 95/95 statistical confidence level in the neutron absorber sheet material in compliance with the specification. In addition to the specified sampling plan, each sheet of material is visually and dimensionally inspected using at least six measurements on each sheet. The sampling plan is supported by written and approved procedures.

The sampling plan requires that a coupon sample be taken from each of the first 100 sheets of absorber material. Thereafter, coupon samples are taken from 20 randomly selected sheets from each set of 100 sheets. This 1 in 5 sampling plan continues until there is a change in lot or batch of constituent materials of the sheet (i.e., boron carbide powder, aluminum powder, or aluminum extrusion) or a process change. If either of these circumstances occurs, the sampling plan reverts back to a coupon sample being taken from each of the first 100 sheets of absorber material, followed by the 20 randomly selected sheets from each set of 100 sheets. The sheet samples are indelibly marked and recorded for identification. This identification is used to document neutron absorber test results, which become part of the quality record documentation package.

Neutron Absorber Wet Chemistry Testing

Wet chemistry testing of the test coupons obtained from the sampling plan is used to verify the ^{10}B content of the neutron absorber material. Wet chemistry testing is applied because it provides an accurate and practical direct measurement of the boron and B_4C content of metal materials.

An approved facility with chemical analysis capability, which could include the neutron absorber vendor's facility, shall be selected to perform the wet chemistry tests. Personnel

performing the testing shall be trained and qualified in the process and in the test procedure.

Wet chemistry testing is performed by dissolving the aluminum in the matrix, including the powder and cladding, in a strong acid, leaving the B_4C material. A comparison of the amount of B_4C material remaining to the amount required to meet the ^{10}B content specification is made using a mass-balance calculation based on sample size.

A statistical conclusion about the neutron absorber sheet from which the sample was taken and that batch of neutron absorber sheets may then be drawn based on the test results and the controlled manufacturing processes.

The adequacy of the wet chemistry method is based on its use to qualify the standards employed in neutron blackness testing. The neutron absorption performance of a test material is validated based on its performance compared to a standard. The material properties of the standard are demonstrated by wet chemistry testing. Consequently, the specified test regimen provides adequate assurance that the neutron absorber sheet thus qualified is acceptable.

Acceptance Criteria

The wet chemistry test results shall be considered acceptable if the ^{10}B areal density is determined to be equal to, or greater than, that specified on the fuel tube License Drawings. Failure of any coupon wet chemistry test shall result in 100% sampling, as described in the sampling plan, until compliance with the acceptance criteria is demonstrated.

Yield Strength Testing

Yield strength qualification testing of the neutron absorber shall conform to ASTM Test Method B 557/B 557M, E 8 or E 21 [17, 18, 19]. For Boral, a laminated absorber, yield strength credited in the structural analysis was limited to the outer aluminum cover sheets. Therefore, only the cover sheet must be shown to meet the required strength.

10.1.7 Thermal Tests

Thermal acceptance testing of the MAGNASTOR system following fabrication and construction is not required. Continued effectiveness of the heat-rejection capabilities of the system may be monitored during system operation using a remote temperature-monitoring system.

The heat-rejection system consists of convection air cooling where air flow is established and maintained by a chimney effect, with air moving from the lower inlets to the upper outlets.

Since this system is passive, and air flow is established by the decay heat of the contents of the TSC, it is sufficient to ensure by inspection that the inlet and outlet screens are clear and free of debris that could impede air flow. Because of the passive design of the heat-rejection system, no thermal testing is required.

10.1.8 Cask Identification

Each TSC and concrete cask shall be marked with a model number and an identification number. Each concrete cask will additionally be marked for empty weight and date of loading. Specific marking instructions are provided on the license drawings for these system components.