AREVA

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Response to U.S. EPR Design Certification Application RAI No. 380, Supplement 3

Ref. 1: E-mail, Getachew Tesfaye (NRC) to ZZ-DL-A-USEPR-DL (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. (4506), FSAR Ch 9," April 8, 2010.

Ref. 2: E-mail, Martin Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. (4506), FSAR Ch. 9," May 7, 2010.

Ref. 3: E-mail, Martin Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. , FSAR Ch. 9, Supplement 1," June 15, 2010.

Ref. 4: E-mail, Martin Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), " PROPRIETARY DRAFT Response to U.S. EPR Design Certification Application RAI No. , FSAR Ch. 9, Supplement 2," June 18, 2010.

Ref. 5: E-mail, Martin Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. , FSAR Ch. 9, Supplement 2," July 14, 2010.

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR design certification application (i.e., RAI No. 380). A schedule for responding to this RAI was provided in Reference 2. A revised schedule for responding to this RAI was provided in Reference 3. A draft response to this RAI was provided in Reference 4. To provide additional time for interaction between AREVA and the NRC staff, a revised schedule was provided in Reference 5. Technically correct and complete responses to all questions in RAI No. 380 are provided in Enclosure 1 to this letter.

The following table indicates the respective pages in the response document that contain AREVA NP's response to the subject questions.

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NRO

AREVA NP INC.
An AREVA and Siemens company
3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Tel.: (434) 832-3000 - Fax: (434) 832-3840

This concludes the formal AREVA NP response to RAI 380, and there are no questions from this RAI for which AREVA NP has not provided responses.

AREVA TN considers portions of the material contained in Enclosure 1 to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed (Enclosure 2) to support the withholding of the information from public disclosure. Proprietary and non-proprietary versions of Enclosure 1 to this letter are provided.

If you have any questions related to this submittal, please contact me by telephone at 434-832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Sandra M. Sloan, Manager
New Plants Regulatory Affairs
AREVA NP Inc.

Enclosures (2)

cc: G. Tesfaye
Docket No. 52-020

AFFIDAVIT PURSUANT
TO 10 CFR 2.390

Transnuclear, Inc.)
State of Maryland) SS.
County of Howard)

I, Robert Grubb, depose and say that I am Chief Operating Officer of Transnuclear, Inc., duly authorized to execute this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and referenced in the paragraph immediately below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.390 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is listed below:

1) Portions of Transnuclear, Inc. document TN-Rack.0101, "U.S. EPR New and Spent Fuel Storage Rack Technical Report," Revision 1
2) Portions of Transnuclear, Inc. responses to Request for Additional Information No. 380(4506), Revision 0, dated April 8, 2010

These documents have been appropriately designated as proprietary.

I have personal knowledge of the criteria and procedures utilized by Transnuclear, Inc. in designating information as a trade secret, privileged or as confidential commercial or financial information.

Pursuant to the provisions of paragraph (b) (4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

1) The information sought to be withheld from public disclosure involves details and analyses related to Transnuclear, Inc.'s design for new and spent fuel storage racks, which are owned and have been held in confidence by Transnuclear, Inc.

2) The information is of a type customarily held in confidence by Transnuclear, Inc. and not customarily disclosed to the public. Transnuclear, Inc. has a rational basis for determining the types of information customarily held in confidence by it.

3) Public disclosure of the information is likely to cause substantial harm to the competitive position of Transnuclear, Inc. because the information consists of details and analyses related to Transnuclear, Inc.'s design for new and spent fuel storage racks, the application of which provide a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with Transnuclear, Inc., take marketing or other actions to improve their product's position or impair the position of Transnuclear, Inc.'s product, and avoid developing similar data and analyses in support of their processes, methods or apparatus.

Further the deponent sayeth not.

Robert Grubb
Chief Operating Officer, Transnuclear, Inc.

Subscribed and sworn to me before this 10th day of June, 2010.

Notary Public

My Commission Expires 10/14/2012

ARLEASTRICE M. TAYLOR
NOTARY PUBLIC
HOWARD COUNTY, MD

Response to

Request for Additional Information No. 380(4506), Supplement 3, Revision 0

4/08/2010

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 09.01.02 - New and Spent Fuel Storage
Application Section: 9.1.2

QUESTIONS for Component Integrity, Performance, and Testing Branch 1 (AP1000/EPR Projects) (CIB1)

Question 09.01.02-33:

Background

In order to assure compliance with GDC 61, the Standard Review Plan (SRP), NUREG-0800 Section 9.1.2, recommends that the staff verify the compatibility and stability of neutron absorbing materials in the SFP environment, to ensure no unacceptable reduction in the neutron absorbing properties of these materials. Preventing degradation of the neutron absorbing materials also supports compliance with GDC 62, which requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes.

Proprietary Report TN-Rack.0101, Rev 0 in Section 2.2.1 paragraph 10 it states that "The neutron absorber material used in the construction of the fuel storage rack modules provides a minimum service life ...". The staff requests clarification of the service life of the MMC.

Requested Information

1. Provide the means of measuring minimum service life in addition to the neutron capture capability of the MMC™.
2. Provide a more complete description of the definition of "minimum service life" that is used here so that there is a quantitative measure of the determination of the service life.
3. Identify other parts of the racks that:
    a. Have shorter "service lives".
    b. If so provide the shorter service lives.
    c. Provide a description of the testing program of the service life of the other parts.
    d. Describe the monitoring of the service life of these other parts of the assembly during operation.
4. Provide the basis for the acceptance criteria for the thickness increase limit and the edge corrosion limit of the coupons

Response to Question 09.01.02-33:

In responding to this RAI, AREVA has performed an extensive review of the technical literature concerning the neutron absorbers Boraflex® and BORAL®, the use of aluminum as a component in spent fuel racks, the wet storage of aluminum-clad MTR fuel, and the testing of the metal matrix composites Boralyn®, Metamic®, Bortec®, and Alcan MMC. The major observations of this review, which are described in greater detail in the responses below, are as follows:

a) The deterioration of Boraflex® is entirely due to the fact that it is a polymer-based composite in a radiation environment.

b) The blistering of BORAL® is entirely due to its porous core. Water could enter the core either through the edges or through a pit in the clad face. The exit route for the water could then become blocked by corrosion products, and then the formation of hydrogen, either by corrosion or by radiolytic decomposition, resulting in increased internal pressure causing blistering, that is, local delamination of the clad face.

c) MMCs from two different suppliers have been immersed in water and subjected to gamma irradiation equivalent to a 60-year exposure in a spent fuel storage rack and neutron irradiation about eight orders of magnitude higher. In neither case was there any damage due to irradiation. Similar results were obtained during dry irradiation of an MMC from the third supplier to slightly lower levels (see Response 3 to Question 09.01.02-35 for further detail on these tests).

d) Testing of MMCs indicates behavior that is essentially the same as that of aluminum – general corrosion that is limited by the formation of a protective passive layer along with pitting, sometimes associated with iron impurities in the MMC surface.

e) The IAEA and Savannah River reports on aluminum and aluminum-clad fuel in wet storage indicate that the single most significant mechanism of damage is pitting corrosion, sometimes enhanced by galvanic or crevice conditions, and always associated with chlorides or heavy ions (iron or copper).

f) There is no evidence in the literature that there is any direct or indirect radiation damage to aluminum in spent fuel pools –the fact that aluminum was used as a cladding on MTR fuel further provides support to that.

g) There is no mention of damage to aluminum in spent fuel pools from the absorption of hydrogen, whether generated radiolytically or by corrosion, other than the generation of hydrogen *internally* in BORAL®.

From these observations, AREVA draws three major conclusions:

- There has been sufficient irradiation testing of MMCs and sufficient experience with aluminum in spent fuel pools to indicate that further irradiation testing of MMCs is unnecessary (see Reference 6).
- Elimination of internally connected porosity in the material is essential. AREVA's proposed qualification testing program for MMCs includes quantitative acceptance criteria for density and for interconnected porosity.
- Given the U.S. EPR controls over pool water chemistry, and the limitation on porosity, the most significant potential for damage to the MMCs would be pitting due to impurities from manufacturing, or due to crevice or galvanic conditions in the rack. To address these, Areva's proposed qualification testing and surveillance programs include pitting criteria, and key process controls over factors that could affect pitting are imposed on the manufacturing process, following the guidance of ASTM C1671 (Ref 18). By these measures, AREVA has focused on the most significant damage mechanisms that could affect the performance of any aluminum based boron carbide materials like MMCs. The process controls provide verification that as-supplied materials correspond to materials as qualified. To AREVA's knowledge, these pitting criteria and key process controls are unique in the industry.

Response to Question 09.01.02-33, Part 1:

[ ]

[ ]

Response to Question 09.01.02-33, Part 2:

For consistency with the U.S. EPR FSAR, the term “minimum service life” will be replaced with “design life”. Technical Report TN-Rack.0101, Revision 0, Sections 2.2.1 and 7.1 will be revised to reflect this change in terminology. The ability of the rack to perform its design functions for the 60 year design life is dictated by corrosion resistance of all materials, including welds, and maintenance of the neutron attenuation capability of the neutron absorber.

Response to Question 09.01.02-33, Part 3:

There are only two other materials in the rack design: [ ] The corrosion resistance of these materials is addressed in Technical Report TN-Rack.0101, Revision 0, Chapter 7.

Response to Question 09.01.02-33, Part 4:

The nominal cell pitch in the region 2 racks is 9.5 inches (241 mm), and the outside dimension of the tubes is [ ] The remaining nominal space between the tubes in the region 2 racks is [ ] The maximum thickness of the neutron absorber at the time of manufacturing is [ ] The thickness increase limit of [ ] inch provides sufficient time for evaluation before the buildup of corrosion products causes distortion of the fuel compartment tubes.

[ ]

FSAR Impact:

AREVA Technical Report TN-Rack.0101, Revision 0, Sections 2.2.1 and 7.1 will be revised as described in the response and indicated on the enclosed markup.

The U.S. EPR FSAR will not be changed as a result of this question.

Question 09.01.02-34:

Background

The Standard Review Plan (SRP), NUREG-0800, Section 9.1.2 recommends that licensees have a program for monitoring the effectiveness of neutron poison present in the neutron absorbing panels. Additionally, to meet GDC 61, SRP 9.1.2 also recommends that provision for testing to detect degradation of any strong fixed neutron absorbers.

The coupon removal and testing frequency is stated in Section 6.2.2 of Report TN-Rack.0101 Rev. 0. The frequency intervals are stated to start with the *commissioning* of the fuel storage racks.

The timed of removal of coupons should start with the first fuel offload. The commissioning of the racks will likely be 18 months to two years prior to seeing the first spent fuel.

Requested Information

As the with the MMC material in the spent fuel racks will probably not be exposed to irradiated fuel until 18-24 months after the plant is commercially operable, justify not commencing the coupon removal cycle 2 years after the first irradiated fuel is inserted.

Response to Question 09.01.02-34:

Technical Report TN-Rack.0101, Revision 0, Section 6.2.2 will be revised to clarify that the initiation of the surveillance program begins when irradiated fuel is first inserted into the racks.

In addition, U.S. EPR FSAR Tier 2, Section 9.1.2.4 will be revised to state that the coupons are removed and examined at given frequencies "from the first insertion of irradiated fuel into the racks."

FSAR Impact:

AREVA Technical Report TN-Rack.0101, Revision 0, Section 6.2.2 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Section 9.1.2.4 will be revised as described in the response and indicated on the enclosed markup. Note that AREVA NP is currently processing Revision 2 of the U.S. EPR FSAR for submittal. The work to process some of the associated U.S. EPR FSAR Section(s) has already been accepted and completed prior to formal submittal of this response. As a result, a portion of the U.S. EPR FSAR changes associated with this response have already been processed for inclusion in Revision 2. These changes are not denoted by "redline-strikeout" on the enclosed markup of U.S. EPR FSAR Interim Revision 3.

Question 09.01.02-35:

In order to assure compliance with GDC 61, the Standard Review Plan (SRP), NUREG-0800 Section 9.1.2, recommends that the staff verify the compatibility and stability of neutron absorbing materials in the SFP environment, to ensure no unacceptable reduction in the neutron absorbing properties of these materials. Preventing degradation of the neutron absorbing materials also supports compliance with GDC 62, which requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes.

The proposed corrosion coupon testing from TN-Rack.0101, Rev. 0 and the environment used in EPRI 1003137, "Qualification of METAMIC for Spent-Fuel Application" (2001) which contains < 10 ppb of chloride, no fluoride, no sulfate and no peroxide does not match realistic chemistry conditions encountered in the spent fuel pool.

Experience with water chemistry at US PWR SFPs shows that the nominal contaminant levels will be chloride (20-50 ppb), fluoride (5-10 ppb) and sulfate 20-150 ppb), as well as hydrogen peroxide (5-10 ppb).

The proposed testing of MMC cited represents a short term test at a range of temperatures only nominally above the temperature in the SFP (100-120 ^{0}F), and using a boric acid solution with no contaminants present.

<u>Requested Information</u>

1. Provide a calculation or other technical justification demonstrating that the test temperature and time of testing (less than one-half year) is equivalent to a 40 year exposure period at the expected normal operating temperature of the SFP.
2. Provide a technical justification that the corrosion rate of the MMC determined in the tests will provide a bounding limit for the existing operating conditions in the spent fuel pool when it contains the maximum allowable contaminant levels of chloride, sulfate and fluoride, plus hydrogen peroxide up to 5 ppm.
3. Given that the MMC specimens were not exposed to radiation during the corrosion testing, justify not assuring that there are no synergistic effects between the radiation field and the chemical environment in the SFP on corrosion or other degradation mechanisms of the MMC.

Response to Question 09.01.02-35:

Response to Question 09.01.02-35, Part 1:

[ ]

Response to Question 09.01.02-35, Part 2:

[ ]

Response to Question 09.01.02-35, Part 3:

Table 09.01.02-35-1—Summary of Radiation Tests Involving MMCs

[ ]

Notes:

1. The Boralyn® specimens were not immersed in water during irradiation. Post-irradiation examination of the Boralyn® material by transmission electron microscopy found some decomposition of ferro-aluminum impurities at grain boundaries, with no clear detrimental effect. Limitation of iron impurities is necessary for pitting prevention in any event, as addressed in the response to Question 09.01.02-36.
2. The Bortec® and Metamic® coupons were immersed in the reactor water for three to six months for irradiation, and had some pitting. The Bortec® report also notes slight densification of the specimens after irradiation, which may have been thermally induced.

FSAR Impact:

AREVA Technical Report TN-Rack.0101, Revision 0, Sections 6.2.2 and 6.4.2.1.2 will be revised as described in the response and indicated on the enclosed markup.

The U.S. EPR FSAR will not be changed as a result of this question.

Figure 09.01.02-35-1—Range of Aluminum Alloy Corrosion Rates Versus Storage Time in Spent Fuel Pool Environments

Notes:

1. Reference 10, Figure 5.

Question 09.01.02-36:

Background

In order to assure compliance with GDC 61, the Standard Review Plan (SRP), NUREG-0800 Section 9.1.2, recommends that the staff verify the compatibility and stability of neutron absorbing materials in the SFP environment, to ensure no unacceptable reduction in the neutron absorbing properties of these materials. Preventing degradation of the neutron absorbing materials also supports compliance with GDC 62, which requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes.

Trace contaminants, such as iron or iron-containing particles, either on the material surface or included in second-phase particles within the material, has been linked to pitting corrosion observed in aluminum-based neutron absorbing materials including both Boral and Metamic. Additionally, testing for other localized corrosion mechanisms, specifically crevice and galvanic corrosion, has been performed as part of qualification of other aluminum-based neutron absorbing materials for spent fuel pool service (Reference 1, 2). Section 6.4.1 of TN-Rack.0101, Rev 0 identifies material specifications for MMC™.

Requested Information

1. Discuss the minimization of the potential for localized corrosion, particularly pitting, of the MMC due to trace contaminants or contaminant particles (either on the surface or in the bulk of the material) in the MMC material. Discuss the control of contaminant particles through the design specification.
2. Described the testing program for the crevice corrosion testing and galvanic corrosion (as has been done with other materials for this service), or provide technical justification to demonstrate that crevice and galvanic corrosion will not occur.

References

1. Safety Evaluation By The Office Of Nuclear Reactor Regulation Related To Holtec International Report HI-2022871 Regarding Use Of Metamic® In Fuel Pool Applications Facility Operating License Nos. DPR-51 And NPF-6 Entergy Operations, Inc. Arkansas Nuclear One, Unit Nos. 1 and 2 Docket Nos. 50-313 and 50-368; Transmitted Via Letter From Thomas W. Alexion To Mr. Craig T. Anderson (ANO) Dated June 17, 2003, Subject: Arkansas Nuclear One, Units 1 And 2 - Review Of Holtec Report Re: Use Of Metamic® In Fuel Pool Applications (TAC Nos. MB5862 and MB5863). Agencywide Documents Access and Management System (ADAMS) Accession No. ML031681432
2. Qualification of METAMIC® for Spent Fuel Storage Application, EPRI report 1003137,prepared by Northeast Technology Corp, Oct 2001, cosponsor Reynolds Metals Company

Response to Question 09.01.02-36:

Response to Question 09.01.02-36, Part 1:

[ ]

Response to Question 09.01.02-36, Part 2:

FSAR Impact:

AREVA Technical Report TN-Rack.0101, Revision 0, Sections 6.2.2, 6.4.1, 6.4.2.1.2, 6.4.2.1.4, and 6.4.4 will be revised as described in the response and indicated on the enclosed markup. AREVA Technical Report TN-Rack.0101, Revision 0, Figure 6-1 will be added as described in the response and indicated on the enclosed markup.

The U.S. EPR FSAR will not be changed as a result of this question.

Question 09.01.02-37:

Background

In order to assure compliance with GDC 61, the Standard Review Plan (SRP), NUREG-0800 Section 9.1.2, recommends that the staff verify the compatibility and stability of neutron absorbing materials in the SFP environment, to ensure no unacceptable reduction in the neutron absorbing properties of these materials. Preventing degradation of the neutron absorbing materials also supports compliance with GDC 62, which requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes.

Evidence presented in "Resolution of Generic Safety Issue 196: Boral Degradation" shows that exposure of Boral to SFP chemistry and gamma radiation causes blistering of the Boral. One potential cause is from "gamma ray heating" of the Boral. Gamma ray heating is caused by the energy of the spent fuel gamma rays being trapped by the Boral casing causing temperature to increase above 212 ^{0}F in localized areas. This specific condition is not tested for using the coupon test program cited in the EPRI document. From GSI 196:

As stated in GSI 196:

> "The Boral sheets were sandwiched (clad) within seal-welded stainless steel cover plates, apparently to keep water from contacting the Boral. Nevertheless, there were several instances (dating back to 1983) where the stainless steel cover plates experienced bulging, to the point where mechanical interference with the fuel assemblies became a problem. It was discovered upon investigation that there had been water ingress into the stainless steel sandwich, and the aluminum in the Boral had reacted chemically with the water to produce hydrogen gas and aluminum oxide. The hydrogen gas pressure had built up to the point where the stainless steel cladding bulged."

From the same GSI the NRC stated:,

> "Possible Solution:
>
> The proposed solution for this generic issue is in two steps. The first step would be to test samples of Boral under conditions duplicating the environmental conditions that would be experienced in these MPC units. This experiment can be done quite readily, and at a modest cost. If there is no evidence for crumbling or relocation of the B_4C-Al composite material, the issue would be considered resolved."

Requested Information

1. The description in the Technical Report and the accompanying drawings are not clear as to how or if the MMC material will be encased in aluminum or stainless steel. Provide more detailed drawings or figures showing the details of the materials in these racks, specifically the MMC and any sheathing material surrounding it.
2. If the MMC will be sheathed in stainless steel, provide test data such as that recommended by the NRC in GSI-196 that shows that the integrity of the MMC™ will be maintained under duplicate environmental conditions to those experienced in the SFP [i.e., the test conditions had the MMC™ sheathed in stainless steel as it will be in the SFP].

Response to Question 09.01.02-37:

The metal matrix composite (MMC) is not sheathed. MMC sheets are [ ] in the region 2 (high density) rack modules. Horizontal stainless steel bars around the perimeter of each rack module retain the MMC sheets within the array of square tubes. In the region 1 (flux trap) rack modules, [ ] and retained in place by the [ ] tubes. In both cases, the MMC is open to the pool water without any encapsulation.

Figures that clarify the construction details of the fuel racks are available for audit/inspection.

FSAR Impact:

Neither the U.S. EPR FSAR nor AREVA Technical Report TN-Rack.0101 will be changed as a result of this question.

Question 09.01.02-38:

Background

In order to assure compliance with GDC 61, the Standard Review Plan (SRP), NUREG-0800 Section 9.1.2, recommends that the staff verify the compatibility and stability of neutron absorbing materials in the SFP environment, to ensure no unacceptable reduction in the neutron absorbing properties of these materials. Preventing degradation of the neutron absorbing materials also supports compliance with GDC 62, which requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes. Further, the Standard Review Plan (SRP), NUREG-0800, Section 9.1.2 recommends that licensees have a program for monitoring the effectiveness of neutron poison present in the neutron absorbing panels. Additionally, to meet GDC 61, SRP 9.1.2 also recommends that provision for testing to detect degradation of any strong fixed neutron absorbers.

Although Technical Report TN-Rack-0101 contains a full description of the material properties, proposed qualification testing program , production material acceptance testing program, and coupon surveillance program for the for the metal matrix composite (MMC) neutron absorbing material, none of this information is included in the current revision of the FSAR.

Requested Information

The staff therefore requests the applicant revise the FSAR to incorporate the critical aspects of TN-Rack-0101 related to:

a. The coupon surveillance program for the MMC. The description of the surveillance program description should provide the types and numbers of coupons, withdrawal schedule, tests to be performed, and acceptance criteria
b. The MMC material properties.
c. The quality assurance program for the MMC, including the design specification, qualification test program, and acceptance testing program.

Response to Question 09.01.02-38:

a) A general discussion of the coupon surveillance program is included in U.S. EPR FSAR Tier 2, Section 9.1.2.4. This includes a description of the types and number of coupons, withdrawal schedule, and a high-level description of the testing performed. The testing description in U.S. EPR FSAR Tier 2, Section 9.1.2.4 will be revised to state that the B-10 areal density will also be measured.

   For consistency with Technical Report TN-Rack.0101, Revision 0, U.S. EPR FSAR Tier 2, Section 9.1.2.4 will be revised for clarification as follows:

   1) "The size of each coupon will be large enough to obtain a tensile test specimen (approximately 1 x 8 inches) and a specimen for B-10 areal density testing (approximately 2 inches square)."
   2) The description of the coupon locations in U.S. EPR FSAR Tier 2, Section 9.1.2.4 will be clarified to state that they are located in an empty fuel compartment in Region 2 adjacent to freshly discharged irradiated fuel.

3) The axial depth of the coupons will be clarified to state that they are in the region of the center of the active zone of the fuel assembly, "plus or minus five feet."

Details of the acceptance criteria for the coupon surveillance tests are proprietary and are described in Technical Report TN-Rack.0101, Revision 0.

b) The following information on the metal matrix composite (MMC) material properties will be added to U.S. EPR FSAR Tier 2, Section 9.1.2.2.3:

"Materials and the material properties to be used in the design of the neutron absorber plates are as follows: borated stainless steel ASTM A887, Type 304B to 304B7; or boron carbide/aluminum metal matrix composite supported by corrosion, mechanical, and neutronic testing for the proposed service. The neutron absorber used in the spent fuel racks is a metal matrix composite (MMC) consisting of aluminum alloy and boron carbide with no polymer or organic components. The minimum B-10 areal density is 28 mg/cm^2. The manufacturer shall specify the chemical composition of the matrix and the boron carbide."

c) Most of the information regarding the quality assurance program for the MMC neutron absorber in the fuel racks documented in Technical Report TN-Rack-0101, Revision 0, is proprietary and cannot be included in the U.S. EPR FSAR. The following general discussion of the quality assurance program for the MMC will be added to U.S. EPR FSAR Tier 2, Section 9.1.2.4:

"Qualification Program for the MMC Neutron Absorber

Any differences between the manufacturing of qualification test materials and the full scale manufacturing methods will be evaluated to verify that there is no non-conservative effect on the applicability of the test results to production material. The potential environmental deterioration mechanism is corrosion. Corrosion testing will be performed and evaluated. The neutron absorber material must have sufficient strength and ductility for handling and fabrication and to support its own weight in the rack."

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 9.1.2.2.3 and 9.1.2.4 will be revised as described in the response and indicated on the enclosed markup. Note that AREVA NP is currently processing Revision 2 of the U.S. EPR FSAR for submittal. The work to process some of the associated U.S. EPR FSAR Section(s) has already been accepted and completed prior to formal submittal of this response. As a result, a portion of the U.S. EPR FSAR changes associated with this response have already been processed for inclusion in Revision 2. These changes are not denoted by "redline-strikeout" on the enclosed markup of U.S. EPR FSAR Interim Revision 3.

In the responses, section, figure, and chapter references are related to Technical Report TN-Rack.0101, Revision 0, "U.S. EPR New and Spent Fuel Storage Rack Technical Report," unless otherwise noted.

References for RAI 380, Supplement 1:

17. ASTM Standard G46, 1994 (2005), "Standard Guide for Examination and Evaluation of Pitting Corrosion," ASTM International, West Conshohocken, PA, 2005, DOI: 10.1520/G0046-94R05, www.astm.org.

18. ASTM Standard C1671, 2007, "Standard Practice for Qualification and Acceptance of Boron Based Metallic Neutron Absorbers for Nuclear Criticality Control for Dry Cask Storage Systems and Transportation Packaging," ASTM International, West Conshohocken, PA, 2007, DOI: 10.1520/C1671-07, www.astm.org.

Endnote to Responses:

In addition to the changes in the Technical Report cited in the responses to the RAIs, the following changes are made. Pages from Chapters 2, 6 and 7 of Interim Revision 1 of the Technical Report are transmitted with the responses.

6.2.2 Change:

From:

> The location of the coupons in the spent fuel pool shall be either an empty fuel compartment in Region 2 or a space between rack modules...

To:

> The location of the coupons in the spent fuel pool shall be an empty fuel compartment...

Reason: The placement of coupons between racks may affect interactions between racks in an earthquake in a way that has not been analyzed.

6.4.1(c) Change:

From:

> The boron carbide particles shall have an average size from 5 to 40 microns.

To

> The boron carbide particles shall have an average size of 40 microns or less.

Reason: smaller particle size is better for the purpose of neutron attenuation, so there is no design reason to establish a minimum.

U.S. EPR Final Safety Analysis Report Markups

09.01.02-38

Materials and the material properties to be used in the design of the neutron absorber plates are as follows: borated stainless steel ASTM A887, Type 304B to 304B7; or boron carbide/aluminum metal matrix composite supported by corrosion, mechanical, and neutronic testing for the proposed service. The neutron absorber used in the spent fuel racks is a metal matrix composite (MMC) consisting of aluminum alloy and boron carbide with no polymer or organic components. The minimum B-10 areal density is 28 mg/cm^2. The manufacturer shall specify the chemical composition of the matrix and the boron carbide.

9.1.2.3 Safety Evaluation

The safety evaluation that follows corresponds to the requirements associated with the GDCs in Section 9.1.2.1:

1. The NFSF and SFSF are located within the Fuel Building, a Seismic Category I structure. The Fuel Building is designed to withstand shipping, handling and normal operating loads, as well as the effects of external hazards such as earthquakes, tornadoes, hurricanes, floods, and external missiles. Section 3.3, Section 3.4, Section 3.5, Section 3.7, and Section 3.8 provide the bases for the adequacy of the structural design of the building.

2. The NFSF and SFSF are designed to remain functional after an SSE. Section 3.7 and Section 3.9 provide the design loads that were applied. The results of the hazards analyses are presented in Section 9.5.1 (fire), Section 3.5, and Section 3.6 and show that the NFSF and SFSF can perform their intended function following postulated internal hazards.

3. The NFSF and SFSF are capable of storing the required number of fuel assemblies, in accordance with the design basis. Structures, systems and components (SSC) are not shared with other units.

4. The NFSF does not require any shielding and is accessible for periodic inspections. Access to the SFSF is provided for periodic inspection as shown in Figure 3.8-42 through Figure 3.8-46 and Figure 3.8-50 through Figure 3.8-52.

5. A minimum of 23 feet of water above the tops of the spent fuel pool assemblies in the spent fuel racks provides sufficient shielding to limit radiation doses to personnel in the spent fuel pool area to minimal values in keeping with the ALARA approach described in Section 12.1.

6. Containment and confinement are provided in the SFSF by the spent fuel pool liner and by the ventilation system for the Fuel Building (see Section 9.4.2). The joint welds that require initial testing and subsequent monitoring of weld integrity are provided with a leak chase system. A monitoring system is provided for the leak chase system. Any water collected is directed to the floor and equipment drain system and transferred to the liquid radwaste system for processing. Filtering of the spent fuel pool water is provided by the FPCPS (see Section 9.1.3). For the NFSF, appropriate confinement of the new fuel assemblies is provided by

A minimum of 12 coupons are immersed in the storage racks into the spent fuel pool. Additional coupons may be used to address potential license extensions and post-shutdown fuel storage. 09.01.02-38 The size of each coupon will be large enough to obtain a tensile test specimen (approximately 1 x 8 inches) and a specimen for B-10 areal density testing (approximately 2 inches square). The coupons are located adjacent to freshly discharged irradiated fuel in an empty fuel compartment in Region 2. The coupons are placed at a depth in the region of the center of the active zone of a fuel assembly, plus or minus five feet.

09.01.02-34 The recommended schedule for coupon monitoring is to remove and examine one coupon at approximately 2, 4, 6, 8, 10, 15, 20, 25, 30, 40, 50, and 60 years from the ~~time the spent fuel pool is permanently filled with water~~first insertion of irradiated fuel into the racks. Coupons are measured and visually examined to monitor changes in the physical properties of the MMC material. B-10 areal density will also be measured. Coupons that are not destroyed may be returned to the pool for continued use in the surveillance program. 09.01.02-38

Qualification Program for the MMC Neutron Absorber

Any differences between the manufacturing of qualification test materials and the full scale manufacturing methods will be evaluated to verify that there is no non-conservative effect on the applicability of the test results to production material. The potential environmental deterioration mechanism is corrosion. Corrosion testing will be performed and evaluated. The neutron absorber material must have sufficient strength and ductility for handling and fabrication and to support its own weight in the rack.

9.1.2.5 Instrumentation Requirements

Instrumentation is provided to monitor the pool water level and water temperature (see Section 9.1.3) to provide indication of the loss of water and degradation of the decay heat capability. As described in Section 12.3.4, area radiation monitors are placed near the NFSF and the SFSF which provide a clear audible and visual alarm to alert personnel in the vicinity of abnormal radiation levels and the need to evacuate the area.

9.1.2.6 References

1. ANSI/ANS-57.3-1983: “Design Requirements for New Fuel Storage Facilities at Light Water Reactor Plants,” American National Standards Institute/American Nuclear Society, 1983.

2. ANSI/ANS-57.2-1983: “Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants,” American National Standards Institute/American Nuclear Society, 1983.

TN-Rack.0101 Markups

2.2.1 Fuel Storage Rack Modules

1. The underwater fuel storage rack modules are free standing structures [ ] to provide additional seismic restraint. The rack modules are not mechanically connected to the fuel pool floor or walls in the spent fuel pool.
2. The dry new fuel storage racks (NFSR) in the new fuel storage vault area are [ ] so there is no amplification of the seismic response.
3. The storage capacity of the underwater fuel storage racks provides a minimum of 382 accessible fuel storage spaces in Region 1 and 865 accessible fuel storage spaces in Region 2 of the spent fuel pool as shown in Figure 1-2 of Chapter 1.
4. The fuel storage rack modules will maintain the capability to remove and insert fuel assemblies for the design lifetime of the rack modules.
5. The fuel storage rack modules are designed to prevent physical damage to the stored fuel assemblies.
6. The fuel storage rack modules are capable of maintaining the stored fuel assemblies in a subcritical configuration.
7. The Region 1 and 2 rack modules have been designed so that they can be disassembled and removed from the new fuel storage vault area or spent fuel pool for servicing and replacement, if necessary, so that maintenance time and dose to personnel is ALARA.
8. Modules have been designed and fabricated so that periodic inspections of the rack components are not required.
9. The affect of fuel handling tools or other foreign objects that are vulnerable to being dropped into the pool were evaluated to ensure they cannot degrade the performance of the fuel storage racks.
10. The neutron absorber material used in the construction of the fuel storage rack modules provides a minimum *design* life of [ ]
11. Fuel storage rack modules have been designed to minimize pockets which could trap air bubbles. 09.01.02-33(2)
12. Each fuel storage rack module includes [ ] support pads (feet) on the bottom. The support feet are vertically adjustable and sized so that each foot does not exert more than 2,175 psi (15 MPa) pressure on the fuel pool bottom liner for normal operating loads. Bearing pressures for the postulated free drop of a fuel assembly meet the requirements of ACI 349-97 [1] [ ] compressive strength concrete. The feet are circular with the edges rounded to avoid sharp edge loads that could jeopardize the fuel pool floor liner from any rack rotation during a seismic event.
13. The empty weight of the fuel storage rack modules is limited to 22 ton (20 tonne) including the lifting rig to meet the available crane capacity.

Chapter 6
Acceptance Tests and Maintenance Program

CONTENTS

LIST OF FIGURES

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Chapter 6
Acceptance Tests and Maintenance Program

NOTE: References in this Chapter are shown as [1], [2]. Reference list is presented in Section 6.5.

6.1 Acceptance Criteria

The US EPR fuel storage racks are accepted based on dimensional inspections, dummy fuel assembly insertion, material certifications, and weld inspections. Material acceptance criteria shall be in accordance with the governing material specifications, including the specification for neutron absorbing materials, Section 6.4.3 below. Acceptance criteria for weld NDE are in accordance with ASME Code Subsection NF-5000.

6.2 Maintenance Program

No routine maintenance is required for the US EPR fuel storage racks. A surveillance program shall be established to verify continued satisfactory performance of the neutron absorbing material.

6.2.1 Neutron Absorber Description

The neutron absorber used in the US EPR spent fuel racks is a metal matrix composite (MMC) consisting only of aluminum alloy and boron carbide, with no polymer or organic components. The material as specified in Section 6.4 has essentially no interconnected porosity.

MMCs have been used for criticality control since their approval for the TN-68 dry storage cask in the year 2000 [1]. These materials are distinguished from earlier boron carbide – aluminum composites by their lack of interconnected porosity and their use of finer boron carbide particles. MMCs produced by several different suppliers, using both 1000 and 6000 series aluminum matrix alloys, have been subjected to radiation and corrosion testing [2, 3, 4, 15]. The testing has demonstrated that neither gamma nor neutron radiation has any effect on MMCs, and that because of their lack of interconnected porosity, MMCs are not subject to blistering, swelling, or delamination as a result of corrosion. Testing also demonstrates that relative to pure water, boric acid solutions either have no effect on the corrosion of aluminum and MMCs, or actually inhibit the rate of corrosion.

6.2.2 Neutron Absorber Coupon Monitoring Program

The MMC shall be qualified per Section 6.4.2 below. As an additional measure to verify the continued performance of the neutron absorber over its lifetime in spent fuel storage racks, a surveillance program shall be established in accordance with ASTM C1187 [5]. At least twelve coupons shall be immersed in storage racks in the spent fuel pool. The size of each coupon shall be large enough to obtain a tensile test specimen (approximately 1 x 8 inches) and a specimen for ^{10}B areal density testing (approximately 2 inch square). All coupons shall be permanently marked to maintain traceability to production lots of MMC used in the racks. [

]

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[

]

]

End note to responses.

The location of the coupons in the spent fuel pool shall be an empty fuel compartment, at a depth corresponding to the center of the active zone of a fuel assembly plus or minus five feet, and adjacent fuel compartments shall be loaded with freshly discharged irradiated fuel as much as possible.

first insertion of irradiated fuel into the racks

At approximately 2, 4, 6, 8, 10, 15, 20, 25, 30, 40, 50 and 60 years from *the* ~~time the spent fuel~~ ~~*pool is permanently filled with water*~~ at least one coupon shall be removed. The coupon shall be measured and visually examined, and ^{10}B areal ~~density~~ shall be measured, with the following acceptance criteria:

09.01.02-34

a) [
]

b) [
]

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c) [ ]

d) [ ]

[

] See Section 6.4.3.3.4 below. Furthermore, the criticality calculations use only 90% of the minimum specified ^{10}B areal density.

If any of the acceptance criteria are not satisfied, an engineering evaluation shall be performed to determine if there is any effect on the performance of the rack's safety-related functions, and if any corrective action is required. Coupons that are not destroyed may be returned to the pool for continued use in the surveillance program.

6.3 Pre-Operational Testing, Inspection and Training Exercise

Pre-operational inspection and training shall consist of insertion of a dummy fuel assembly into a sample of fuel compartments using the plant fuel handling bridge, and a demonstration of the retrieval and replacement of the surveillance coupons.

6.4 Specification for Neutron Absorbers

6.4.1 Material Specification

The MMC used for the US EPR fuel storage racks shall have the following characteristics:

a) The minimum specified areal density shall be 28 mg $^{10}B/cm^2$.

b) The material shall consist of boron carbide particles in a matrix of aluminum or an

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End note to responses.

aluminum alloy *not including 2000 or 7000 series alloys.*

c) The boron carbide particles shall have an average size *of* [ ] No more than [ ] of the particles shall be larger than [ ] microns.

d) The MMC shall have density greater than [ ] of theoretical, with no more than [ ] volume % interconnected porosity.

e) The MMC billets shall be produced by either direct chill casting, permanent mold casting, powder metallurgy, or thermal spray techniques.

f) The material may be supplied either mill finish or anodized, consistent with the material qualification testing.

g) The manufacturer shall specify the chemical composition of the matrix and the boron carbide.

h) Thickness shall be [ ]

i) Prior to first use in the US EPR fuel rack, MMCs shall be qualified as specified in Section 6.4.2, and shall subsequently be subject to the manufacturing process controls specified in Section 6.4.4.

j) Material manufactured for use in the US EPR fuel storage rack shall pass the acceptance tests and inspections specified in Section 6.4.3.

The criticality calculations assume an areal density of 25 mg $^{10}B/cm^2$, 90% of the minimum specified. The specified acceptance testing assures that at any location in the final product, the minimum specified areal density of ^{10}B will be found with 95% probability and 95% confidence. To achieve an areal density of 28 mg $^{10}B/cm^2$ at [ ] thickness requires approximately [ ] wt % boron carbide. The manufacturer typically supplies the material at [ ] of the minimum required boron carbide in order to pass the statistical analysis of areal density inspections (Section 6.4.3.3.4).

The following qualification and acceptance programs are developed according to ASTM C1671 [7], adapted as necessary for wet storage. Where ASTM test methods are cited, alternate equivalent test methods may be used.

6.4.2 Qualification

Any differences between the manufacturing of qualification test materials and the full scale manufacturing methods shall be evaluated to verify that there is no non-conservative effect on the applicability of the test results to production material.

[

]

6.4.2.1 Environmental Qualification

The two potential environmental deterioration mechanisms are corrosion and radiation damage.

6.4.2.1.1 Corrosion damage is related to the interconnected porosity of the neutron absorber material. [

]

6.4.2.1.2 Corrosion testing shall be performed and evaluated using the [

]

[

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]

[

]

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6.4.2.1.3 Because the neutron absorber material contains no polymers or organic material, and because it has [

]

6.4.2.1.4 [

]

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[

]

[

]

[

]

6.4.4 Manufacturing Process Controls

[

]

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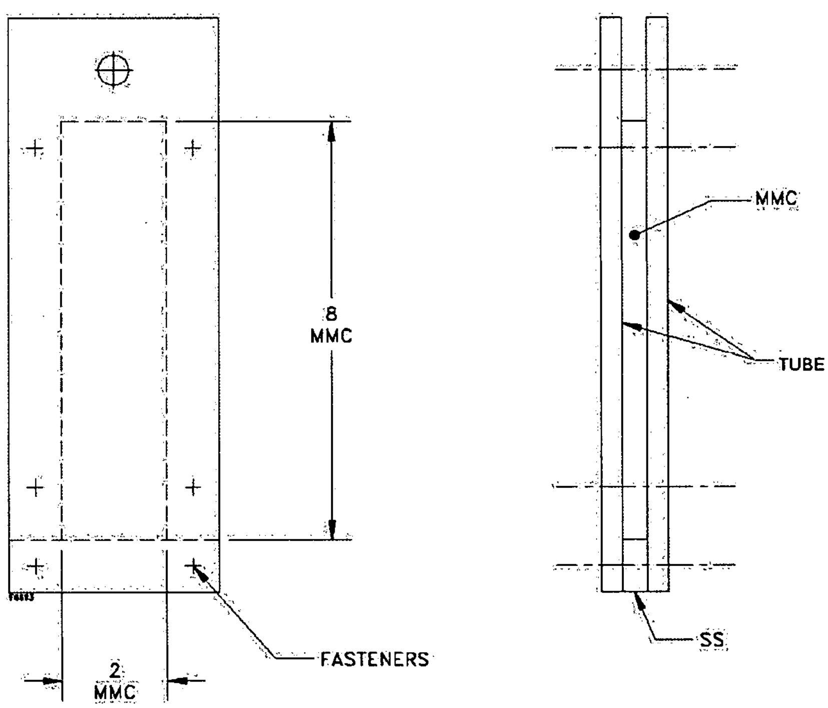

Figure 6-1

Typical MMC Surveillance Coupon Assembly

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Chapter 7
Material Selection and Compatibility

NOTE: References in this Chapter are shown as [1], [2]. Reference list is presented in Section 7.6.

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7.1 Introduction

The materials for the U.S. EPR fuel storage racks were selected to be compatible with the spent fuel and spent fuel water environment for a minimum *design life* of [ ]years. The materials specified to be utilized in the racks have been reviewed to ensure credited design strength is not affected and to determine whether chemical, galvanic or other reactions among the materials, contents and spent fuel pool water environment might occur during spent fuel storage over the [ ]year life of the racks.

The racks and contents are exposed to a borated water environment for PWR applications with strictly controlled water chemistry as shown below.

Attribute	Range/Limit
pH at 25 °C (77 °F)	[ ]
Chloride, max	[ ]
Fluoride, max	[ ]
Sulfate, max	[ ]
Reactive Silica, max	[ ]
Dissolved Air, max	[ ]
Lithium, max	[ ]
Boric Acid	[ ]
Conductivity, max	[ ]
Turbidity, max	[ ]
Bulk Water Temperature	[ ]

[ ]

7.2 Material Selection

The materials selected for the racks include Type 304/[ ] stainless steel for the rack structure, [ ] for the fuel storage tubes, and Metal Matrix Composite (MMC) material for the neutron absorber plates consisting of fine B4C powder dispersed in an aluminum matrix.