RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**364-8421**
SRP Section:	**09.01.01 – Criticality Safety of Fresh and Spent Fuel Storage and handling**
Application Section:	**09.01.01**
Date of RAI Issue:	**01/11/2016**

Question No. 09.01.01-28

Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix A, General Design Criteria 62 requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes.

Technical Report APR1400-Z-A-NR-14011 "Criticality Analysis of New and Spent Fuel Storage Racks" describes the criticality calculations used to evaluate the adequacy of the new and spent fuel storage racks.

The "Bias and Uncertainty" calculations in this document includes tolerance for the thickness of several components. The applicant provides the thickness of the materials used in construction in Tables 2.1-1, 3.1-1, and 3.1-2. The majority of material used in the design has been specified as ASTM/ASME SA-240, Type 304 or 304L material.

Material specification (S)A-240 references specification (S)A-480. (S)A-480 contains the material processing requirements that are applicable to a wide range of materials in the Stainless Steel family including Type 304/304L. Annex A2 and A3 contains tables that specify normal tolerances for as purchased material; this includes material thickness tolerances which are specific to the manufacturing method (e.g. hot rolled Quarto Plate, cold rolled material processed from a coil, etc.).

The staff notes that the thickness tolerance stated in APR1400-Z-A-NR-14011 may or may not be in conformance with (S)A-480 based upon the method of manufacturing. In the event that (S)A-480 tolerance on material thickness is greater than the technical report, the applicant can order custom material meeting the thickness requirements in the technical report.

As such, state if any Type 304/304L material in the new or spent fuel racks will have custom requirements on thickness tolerances.

Response

Stainless steel plates are purchased in accordance with ASTM A-480 and there is no custom requirement for the thickness tolerance. Thickness tolerance is decided on the finish requirement and width of the purchased plate.
For new & spent fuel storage rack projects, usually finish requirement - 1 or 2B – is applied, and the width per each thickness - 1000mm or 1219mm – is applied.

For the APR1400 DC project, '2B' for spent fuel storage rack (Region I & II) and '1' for new fuel storage rack are applied, and the width of 1000mm or 1219mm with coil type is applied. Therefore, the tolerance per each thickness is as follows,

1. In the case of a stainless steel plate with a thickness of 0.6mm (Spent fuel pool Region I & II),
   1) Type of finish available on sheet products : 2B Finish – Cold rolled, bright finish
   2) Tolerance in thickness applies TABLE A2.5,
      - For width w $\leq$ 40in [1000mm], tolerance is ±0.002in [0.05mm]
      - For width 40in [1000mm] < w $\leq$ 50in [1300mm], tolerance is ±0.002in [0.05mm]

2. In the case of a stainless steel plate with a thickness of 2.5mm (Spent fuel pool Region I & II),
   1) Type of finish available on sheet products : 2B Finish – Cold rolled, bright finish
   2) Tolerance in thickness applies TABLE A2.5,
      - For width w $\leq$ 40in [1000mm], tolerance is ±0.004in [0.1mm]
      - For width 40in [1000mm] < w $\leq$ 50in [1300mm], tolerance is ±0.004in [0.1mm]

3. In the case of a stainless steel plate with a thickness of 6.0mm (New fuel storage rack),
   1) Type of finish available on plate products : 1 – Hot rolled, annealed, and descaled
   2) Tolerance in thickness applies TABLE A2.13
      - Plate width w $\leq$ 60in [1525mm], tolerance is -0.010in [0.25mm], +0.020 [0.50mm]

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

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Question No. 09.01.01-30

Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix A, General Design Criteria 62 requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes.

This question was provided to the applicant prior to the July 29th, public meeting as Issue #6 (AI 9.24-6). Because no response has been docketed the issue has been turned into an RAI.

In FSAR Section 9.1.2.2.2, on page 9.1-13, the applicant states:

“Stainless steel plate for sheath is welded to each side of the fuel storage cell with the neutron absorbing material installed in the sheath cavity.”

The staff interprets this sentence to specify that the neutron absorber to be installed prior to welding.

The heat produced by welding the sides of the sheath may affect the Metamic material. Provide the staff with a discussion on how the heat from welding will impact the neutron attenuation uniformity, mechanical properties, thermal properties, and possible production of reactive products.

Response

According to EPRI report “Qualification of METAMIC® for Spent Fuel Stoage Application” (Doc No.1003137), Metamic was subjected to an extensive array of tests sponsored by EPRI that evaluated the functional performance of the material at elevated temperatures (up to 900ºF) and radiation levels (1E+11 rads gamma). In accordance with the above-referenced EPRI

report, the physical and neutronic properties of Metamic are essentially unaltered under exposure to elevated temperatures (up to 900ºF).

As per the EPRI report, The applicant performs the mock-up to simulate the temperature affecting the Metamic by welding the side of sheath. The details of mock-up is as follows:

TS

TS

TS

TS

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

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Question No. 09.01.01-31

Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix A, General Design Criteria 62 requires preventing criticality in the fuel storage and handling system through the use of physical systems or processes.

These topics were provided to the applicant prior to the July 29th, public meeting in Issue #9 (AI 9.24-9). Because no responses have been docketed the issues have been turned into an RAI.

Issue 9

In FSAR Section 9.1.2.4, on page 9.1-18, the applicant states:

“Qualification Program for the METAMIC Neutron Absorbing Material

The potential environmental deterioration mechanism is corrosion. Corrosion testing is performed, and the results are evaluated. The neutron absorbing material has sufficient strength and ductility for handling and fabrication and supporting its own weight in the rack.”

The staff seeks further information on the qualification program for Metamic:

1. Reynolds Metal Company in cooperation with EPRI has conducted accelerated corrosion testing as part of the qualification program of Metamic (“Qualification of METAMIC for Spent-Fuel Storage Application,” EPRI 1003137, available on EPRI’s website and “Use of Metamic in Fuel Pool Applications,” ML022280353). Is the proposed corrosion testing different than the EPRI and Holtec qualification tests? If so, provide a description of tests to be performed and the acceptance criteria.

2. The applicant does not describe the qualification program for the manufacturing of the Metamic material. Will critical characteristics (such as areal density, dimensions, thermal conductivity) be verified? Revise FSAR Section 9.1.2.4 to list all characteristics to be verified and the acceptance criteria.

3. Metamic is not a standardized material. Revise FSAR Section 9.1.2.4 to describe the quality assurance program that will be used to manufacture the material. The program should be sufficient to give confidence that the Metamic product will meet all the design functions.

Response

Question 1

As per “Qualification of METAMIC for Spent-Fuel Storage Application” (Doc No. EPRI 1003137), TS

Question 2

According to “Sourcebook for Metamic Performance Assessment” (Doc No. HI-2043215, Holtec proprietary document), the principal manufacturing parameters of Metamic are 1) B_4C wt% in the mixture, 2) Panel thickness, 3) Material density. From these principal parameters, the areal ^{10}B density and tolerance may be derived.

Additional details on the principle manufacturing parameters for Metamic are as follows:

TS

TS

FSAR 9.1.2.4 will be revised to include each principle manufacturing parameter for Metamic. But details of the parameter cannot be cannot be included in the ARP1400 FSAR, because these are the proprietary information of Holtec.

Question 3
FSAR 9.1.2.4 will be revised, the following description will be added:

“Holtec International's Quality Assurance Program ensures that Metamic™ is manufactured under the control and surveillance of a quality assurance/quality control program that conforms to the requirements of 1OCFR50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants."

Impact on DCD

FSAR 9.1.2.4 will be revised as indicated on the attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

Qualification Program for the METAMIC™ Neutron Absorbing Material

The potential environmental deterioration mechanism is corrosion. Corrosion testing is performed, and the results are evaluated. The neutron absorbing material has sufficient strength and ductility for handling and fabrication and supporting its own weight in the rack.

[INSERT]
Holtec International's Quality Assurance Program ensures that Metamic™ is manufactured under the control and surveillance of a quality assurance/quality control program that conforms to the requirements of 1OCFR50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants." The principal manufacturing parameters of the neutron absorbing material are : (1) B_4C wt% in the mixture, (2) panel thickness, (3) material density, and (4) areal ^{10}B density.

9.1.3.1 Design Bases

Specific design bases for the SFPCCS are as follows:

a. The SFP chemistry parameters for cleanliness during normal operation are shown in Table 9.1.3-1. The SFPCCS is designed to clean and purify the water in the SFP, refueling pool, cask loading pit, fuel transfer canal, and refueling canal without causing any interruption in the refueling operation. The filters and demineralizers of the SFP cleanup system are designed to provide adequate purification to maintain the maximum radiation dose to 0.025 mSv per hour for personnel.

b. The SFP cooling system consists of two redundant divisions that are independent with each other. The SFP cooling system, during normal and accident conditions, is designed to remove the decay heat that is produced by the spent fuel assemblies of the newest batch just offloaded from the core and the accumulated assemblies resulting from previous refueling. Each of the two cooling divisions is capable of maintaining the SFP water temperature below 60 °C (140 °F) with the SFP heat exchanger through the component cooling water system (CCWS) at the design flow and temperature. The system is designed to maintain an SFP temperature below 60 °C (140 °F) in an SFPCCS single active failure.

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Question No. 09.01.01-33

On November 13th 2015 the applicant provided docketed responses to eight of the ten items of concern that were sent as part of a request for a July 29th, 2015 public meeting on DCD Tier 2, FSAR Section 9.1.1 (ML15317A525).

The response to Issue #8 (AI 9.24-8) the applicant provided the staff with acceptance criteria for the coupon monitoring program:

Acceptance criteria for these measurements are as follows:

- A decrease of no more than 5% in Boron-10 content, as determined by neutron attenuation, is acceptable.
- An increase in thickness at any point should not exceed 25% of the initial thickness at that point.

Changes in excess of either of these two criteria requires investigation and engineering evaluation which may include early retrieval and measurement of one or more of the remaining coupons to provide corroborative evidence that the indicated change(s) is real. If the deviation is determined to be real, an engineering evaluation shall be performed to identify further testing or any corrective action that may be necessary.

The remaining measurement parameters serve a supporting role and should be examined for early indications of the potential onset of neutron absorbing material degradation, if any, that would suggest a need for further attention and possibly a change in the measurement schedule. These include (1) visual or photographic evidence of unusual surface pitting, corrosion or edge deterioration, or (2) unaccountable weight loss in excess of the measurement accuracy.”

Part 1:
Provide additional clarification:
The Metamic product has a requirement of “decrease of no more than 5%” of B-10.”

What will the measured neutron attenuation of the coupon be compared to? Will it be compared to the 95% probability 95% confidence minimum areal density of the heat of the Metamic material? Or compared to a pre-operation neutron attenuation measurement done on each coupon? Or something else?

Part 2:
Provide additional clarification:
The Metamic product has a requirement of “not exceed 25% of the initial thickness at that point.”

Will all points of the Metamic coupons be measured prior to installation in the spent fuel racks? Or will the “initial thickness” be the thickness of the Metamic coupons on the periphery of the coupon where blistering is unlikely to occur?

Part 3:
The second to last paragraph is not sufficient. If the coupon monitoring program determines that Boron-10 is being lost or blistering of the material is occurring, a licensee must immediately evaluate implications to GDC 62. Revise the last paragraph as follows:

“Changes in excess of either of these two criteria requires investigation and engineering evaluation which may include early retrieval and measurement of one or more of the remaining coupons to provide corroborative evidence that the indicated change(s) is real. If the deviation is determined to be real, an evaluation shall be performed to determine if the spent fuel system complies with the licensing basis.”

Part 4:
The final paragraph (which relates to visual examination and weighing of coupons) states that if signs of degradation are found, then a licensee, “would suggest a need for further attention and possibly a change in the measurement schedule.”

This requirement is insufficient. Corrosion of the neutron absorber could be initiated by several different events (e.g. foreign material introduced to the pool, failure of the spent fuel pool cleanup system, contamination of the neutron absorber during fabrication, etc.) which could impact the safety of the spent fuel pool or other shared systems.

If indications of material degradation are found, then the degradation should be evaluated, the causes should be identified, and the necessary corrective actions should be implemented.

Revise the acceptance criteria. An acceptable change would be:

The remaining measurement parameters serve a supporting role and should be examined for early indications of the potential onset of neutron absorbing material degradation. These include: (1) visual or photographic evidence of unusual surface pitting, corrosion, or edge

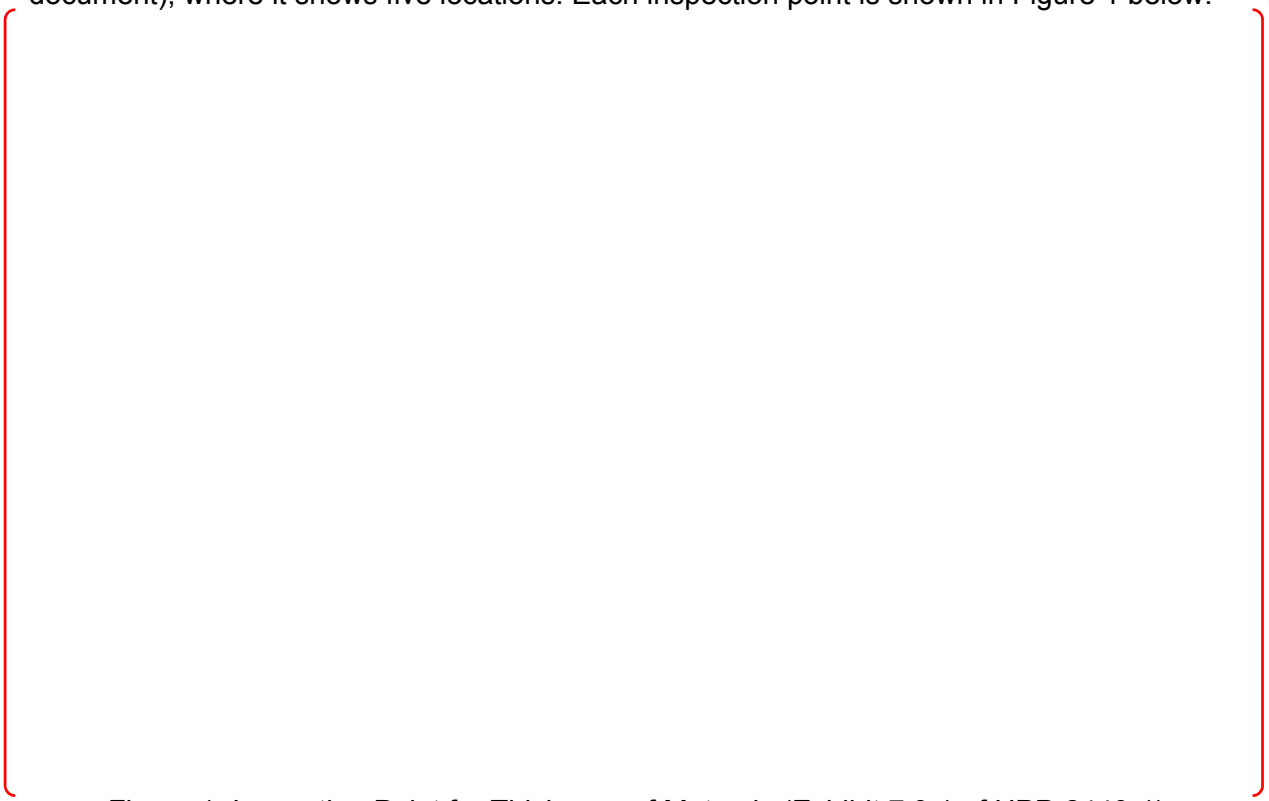
deterioration; or (2) unaccountable weight loss in excess of the measurement accuracy. If indications of material degradation are found (other than normally expected oxidation), then the degradation shall be evaluated, causes shall be identified, and corrective actions, as necessary, shall be implemented.

Response

Each response about the NRC staff's question for Metamic surveillance program is as follows:

Part 1:
The percent change of Boron-10 content is to be determined by comparing the attenuation testing of the post-irradiated coupons with the attenuation testing results of the pre-irradiated coupons. Often, the pre-irradiated testing is handled as a step in the fabrication process when Holtec supplies Metamic.

Part 2:
The inspection points for thickness of the Metamic coupons are described in Exhibit 7.3.1 of HPP-2449-1, "In-Situ Neutron Absorbing Surveillance Program" (Holtec proprietary document), where it shows five locations. Each inspection point is shown in Figure 1 below: **TS**



<Figure 1. Inspection Point for Thickness of Metamic (Exhibit 7.3.1 of HPP-2449-1)>

This ensures that the measurements are not limited to a section of the coupon.

Part 3 & 4:
FSAR 9.1.2.4 will be revised as recommended by the NRC.

Impact on DCD

FSAR 9.1.2.4 will be revised as indicated on the attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

Coupons that are not destroyed may be returned to the pool for continued use in the surveillance program.

[Insert]
Changes in excess of either of these two criteria requires investigation and engineering evaluation which may include early retrieval and measurement of one or more of the remaining coupons to provide corroborative evidence that the indicated change(s) is real. If the deviation is determined to be real, an evaluation shall be performed to determine if the spent fuel system complies with the licensing basis.

The remaining measurement parameters serve a supporting role and should be examined for early indications of the potential onset of neutron absorbing material degradation. These include: (1) visual or photographic evidence of unusual surface pitting, corrosion, or edge deterioration; or (2) unaccountable weight loss in excess of the measurement accuracy. If indications of material degradation are found (other than normally expected oxidation), then the degradation shall be evaluated, causes shall be identified, and corrective actions, as necessary, shall be implemented."

A_9-24.8R

Of the measurements to be performed on the neutron absorbing material surveillance coupons, the most important are (1) the neutron attenuation measurements (to verify the continued presence of the boron) and (2) the thickness measurement (as a monitor of potential swelling). Acceptance criteria for these measurements are as follows:

- A decrease of no more than 5% in Boron-10 content, as determined by neutron attenuation, is acceptable. This is tantamount to a requirement for no loss in boron within the accuracy of the measurement.

- An increase in thickness at any point should not exceed 25% of the initial thickness at that point. ~~Changes in excess of either of these two criteria requires investigation and engineering evaluation which may include early retrieval and measurement of one or more of the remaining coupons to provide corroborative evidence that the indicated change(s) is real. If the deviation is determined to be real, an engineering evaluation shall be performed to identify further testing or any corrective action that may be necessary.~~

~~The remaining measurement parameters serve a supporting role and should be examined for early indications of the potential onset of neutron absorbing material degradation, if any, that would suggest a need for further attention and possibly a change in measurement schedule.~~

~~These include (1) visual or photographic evidence of unusual surface pitting, corrosion or edge deterioration, or (2) unaccountable weight loss in excess of the measurement accuracy.~~