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10 CFR 72.7

RS-15-162

June 8, 2015

ATTN: Document Control Desk
Director, Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dresden Nuclear Power Station, Units 1, 2, and 3
Facility Operating License No. DPR-2
Renewed Facility Operating License Nos. DPR-19 and DPR-25
NRC Docket Nos. 50-010, 50-237, 50-249, and 72-37

Subject: Supplemental Information Concerning Exemption Request to Load and Store Thoria Rod Canister in a Holtec 68M Multi-Purpose Canister

References:
1. Letter from P. R Simpson (Exelon Generation Company, LLC) to U. S. NRC, "Exemption Request to Load and Store Thoria Rod Canister in a Holtec 68M Multi-Purpose Canister," dated January 29, 2015

2. Letter from Dr. P. Longmire (U. S. NRC) to P. R. Simpson, "Request for Additional Information for the Dresden ISFSI – Exemption Request (Docket No. 72-37, TAC No. L24989)," dated May 8, 2015

In Reference 1, Exelon Generation Company, LLC (EGC) requested a one-time exemption for the Dresden Nuclear Power Station (DNPS) Independent Spent Fuel Storage Installation (ISFSI) from the requirements of 10 CFR 72.212(b)(3) and (b)(11).

Specifically, EGC requested authorization to load and store the DNPS Unit 1 Thoria Rod Canister containing 18 DNPS Unit 1 thoria rods (Thoria Rods) in a Holtec International, Inc. (Holtec) Multi-purpose Canister (MPC)-68M, which is not currently permitted under Certificate of Compliance (CoC) Number (No.) 1014, Amendment 8, Appendix B, "Approved Contents and Design Features." The regulations require, in part, compliance to the terms and conditions of CoC No. 1014.

In Reference 2, the NRC forwarded request(s) for additional information (RAIs) concerning the Reference 1 exemption request. The Attachment to this letter provides EGC's response to the RAIs.

There are no regulatory commitments contained within this letter.

If you have any questions or require additional information, please contact Mr. John L. Schrage at (630) 657-2821.

Respectfully,

Patrick R. Simpson
Manager - Licensing

cc: NRC Regional Administrator - Region III

Attachment: EGC Response to Request for Additional Information, Exemption Request to Load and Store the DNPS Unit 1 Thoria Rod Canister in an MPC-68M Canister

Request for Additional Information (RAI)

"By application dated January 29, 2015, Exelon Generation Company, LLC (EGC) submitted an exemption request to the U.S. Nuclear Regulatory Commission (NRC) in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 72.7. EGC requests approval of a one-time exemption from the requirements of 10 CFR 72.212(b)(3) and (b)(11) for the Dresden Nuclear Power Station (DNPS) independent spent fuel storage installation (ISFSI). Specifically, EGC requests authorization to load and store the DNPS Unit 1 Thoria Rod Canister containing 18 DNPS Unit 1 Thoria Rods in a Holtec International, Inc. (Holtec) Multi-purpose Canister (MPC)-68M, which is not currently permitted under Certificate of Compliance (CoC) Number (No.) 1014, Amendment 8, Appendix B, 'Approved Contents and Design Features.' The regulations require, in part, compliance to the terms and conditions of CoC No. 1014.

The NRC staff reviewed the exemption request using the following guidance documents:

- NUREG-1536 Revision 1, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility" Final Report, dated July 2010, and
- NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," dated August 2003.

RAI-1: Clarify that the request is to store:

a. one or multiple DNPS Unit 1 Thoria rod canisters within,
b. one or multiple MPC-68M canisters,
c. for support of one loading campaign or multiple loading campaigns.

Section 3 a, "Authorized by Law," of the exemption request states, "This exemption would allow EGC to load and store a DNPS Unit 1 Thoria Rod Canister containing 18 DNPS Unit 1 Thoria Rods in a Multi-purpose Canister that is not currently approved for storage of this type of spent fuel rods (i.e., the Holtec MPC-68M)." It is not clear from this description in the exemption request how many DNPS Unit 1 Thoria rod canister(s) is/are being requested to be stored in how many MPC-68M canisters. The criticality and shielding safety analysis within Section 4, "Safety Analysis," of the exemption request indicates a single DNPS Unit 1 Thoria rod canister will be stored, this is not described in the structural, thermal, and confinement section of the exemption request. Section 1, "Background," of the exemption request describes a 2016 DNPS spent fuel loading campaign, it is not clear from the exemption request if the exemption is for one or multiple MPC-68M canister(s) in the specified loading campaign, and potentially additional loading campaigns.

This information is needed to determine compliance with 10 CFR 72.11.

EGC Response to RAI-1:

During a single Spent Fuel Loading Campaign (SFLC), currently scheduled for Spring 2016, EGC will load and store a single DNPS Unit 1 Thoria Rod Canister in a single MPC-68M canister, along with 67 other fuel assemblies. This is the only DNPS Unit 1 Thoria Rod Canister. The DNPS Unit 1 Thoria Rod Canister will contain 18 DNPS Unit 1 Thoria Rods. By Safety Evaluation Report (SER) dated July 18, 2002 (ADAMS Accession No. ML022000249), the NRC approved the storage of the single DNPS Unit 1 Thoria Rod Canister in the MPC-68 and MPC-68F.

RAI-2: Describe in the structural, thermal, and confinement section within Section 4, "Safety Analysis," of the exemption request how the previous steady state and transient thermal analyses for normal, off-normal, and accident conditions are bounding for the inclusion of the DNPS Unit 1 Thoria rod canister, as well as per thoria rod. Alternatively, provide steady state and transient thermal analyses for normal, off-normal, and accident conditions that consider the cask decay heat distribution with the inclusion of the DNPS Unit 1 Thoria rod canister.

The relatively lower decay heat of the DNPS Unit 1 Thoria rod canister (less than or equal to 115 watts) may allow relatively higher decay heat fuel assemblies to be loaded in the cask. This could change the cask decay heat distribution and may result in higher predicted fuel and component temperatures. The application has not clearly described the thermal analysis of any potential changes in cask decay heat distribution, or how the previous analysis bounds any potential changes in cask decay heat distribution due to the relatively lower decay heat DNPS Unit 1 Thoria rod canister. In addition, it has not been addressed if the predicted fuel or component temperatures are bounding for the decay heat per thoria rod.

This information is needed to determine compliance with 10 CFR 72.122(h)1).

EGC Response to RAI-2:

By letter dated August 31, 2000, Holtec submitted an amendment application to modify the HI-STORM 100 Cask System (i.e., proposed Amendment 1 to CoC No. 1014, ADAMS Accession No. ML003748006). This amendment request included proposed Revision 11 of the Topical Safety Analysis Report (TSAR). TSAR Revision 11, Chapter 4, "Thermal Evaluation," (i.e., ADAMS Accession No. ML003747975) describes the steady state and transient thermal analyses for normal, off-normal, and accident conditions for storage of intact and damaged fuel in an MPC-68 or MPC-68F.

Specific to the thermal analysis for storage of the Thoria Rod Canister, TSAR Chapter 4 states (emphasis added):

"A thoria rod canister designed for holding a maximum of twenty fuel rods arrayed in a 5x4 configuration is currently stored at the Dresden-1 spent fuel pool. The fuel rods were originally constituted as part of an 8x8 fuel assembly and used in the second and third cycle of Dresden-1 operation. The maximum fuel burnup of these rods is quite low (~14,400 MWD/MTU). The thoria rod canister internal design is a honeycomb structure formed from 12-gage stainless steel plates. The rods are loaded in individual square cells. This long cooled, part assembly (18 fuel rods) and very low fuel burnup thoria rod canister renders it a miniscule source of decay heat. The canister all-metal internal honeycomb construction serves as an additional means of heat dissipation in the fuel cell space. In accordance with fuel loading stipulation in the Technical Specifications, long cooled fuel is loaded toward the basket periphery (i.e., away from the hot central core of the fuel basket). All these considerations

> *provide ample assurance that these fuel rods will be stored in a benign thermal environment and, therefore, remain protected during long-term storage."*

In the July 18, 2002 SER that approved Amendment 1 to CoC No. 1014, the NRC concluded (emphasis added):

> *"The storage of this material will be limited to one Thoria Rod Canister in combination with other intact and damaged fuel and damaged fuel debris as delineated in Appendix B to the CoC 1014. Thoria Rod canisters contain 18 fuel rods of long cooled very low fuel burnup which constitute a very small source of decay heat. The staff agrees that their contribution to heat load is small and that thermal implications of casks loaded with Thoria Rod Canisters are bounded. Thoria rod loading, due to the length of cooling time for this material, is stipulated by Technical Specifications, to be positioned toward the basket periphery. The staff concurs that this provides assurance that these fuel rods will be stored in a benign thermal environment, and therefore remain protected during long term storage."*

This conclusion indicates that the thermal analyses for the Thoria Rod Canister in an MPC-68 or MPC-68F are bounded by the existing thermal analyses for the design basis heat load, and therefore no new thermal analyses have been performed. The same logic applies to storage of the Thoria Rod Canister in an MPC-68M.

The thermal implications of an MPC-68M cask loaded with the DNPS Unit 1 Thoria Rod Canister are bounded by the already existing cask thermal analyses. This conclusion is supported by the May 10, 2012 SER that approved Amendment 8 to CoC No. 1014 (ADAMS Accession No. ML12132A081). In Section 4.2.7 of the SER, the NRC states (emphasis added):

> *"The staff checked the allowable limits in the FSAR and the calculated data in Supplement III, and confirmed that 1) the MPC-68M has lower maximum temperatures of fuel cladding, basket, and MPC shell. Therefore, MPC-68M provides higher temperature margins than MPC-68, and 2) all the cask components are maintained within their temperature limits and MPC internal pressure is below the criteria of 100 psig for the long-term normal storage conditions. The staff confirmed that the calculated temperatures of the cask components comply with the design criteria and meet the requirements of 10 CFR 72.122(h)(1), and 10 CFR 72.236(f) to ensure adequate heat removal is provided."*

There is no change to the cask decay heat distribution for storage of the Thoria Rod Canister in an MPC-68M, and therefore no change to the bounding thermal analyses. Amendment 8 to CoC No. 1014, Appendix B, "Approved Contents and Design Features," Table 2.4-1 provides the maximum allowable decay heat per fuel storage location for ZR-clad fuel in uniform fuel loading for each MPC model. As described in the HI-STORM 100 FSAR, with uniform fuel loading, every basket cell is assumed to be occupied with fuel producing heat at the maximum rate. This maximum decay heat applies to standard fuel assemblies as well as damaged fuel and fuel debris. The maximum allowable decay heat limit for damaged fuel and fuel debris stored in an MPC-68M, as well as the MPC-68 or MPC-68F is 3930 Watts.

Conversely, the maximum decay heat for the Thoria Rod Canister is 115 Watts, as stated in CoC No. 1014, Amendment 8, Appendix B, Table 2.1-1 (i.e., Items II.A.d and III.A.d). This limitation is significantly below the maximum allowable limit of 3930 Watts for damaged fuel and fuel debris stored in an MPC-68M. Therefore, the predicted fuel and component temperatures for a uniformly loaded MPC-68M that includes the Thoria Rod Canister are bounded by the previously calculated values, and no new analyses are necessary.

RAI-3: Provide experimental data or calculations that demonstrates the best estimate hoop stress that the thoria rod fuel cladding experiences during vacuum drying is bounded by the stresses expected in UO_2 rods for the fuel that is being loaded into the MPC-68M at the maximum temperature calculated in the HI-STORM 100 FSAR.

> The HI-STORM 100 FSAR, Table 4.III.5, "Maximum MPC-68M Temperatures Under Vacuum Drying Scenarios," shows that the maximum temperature calculated during vacuum drying is 754°F which exceeds the limit of 752°F in ISG-11, Rev. 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel." The 752°F limit was based on the stresses expected to be experienced in UO_2 based fuel. It is not clear to the NRC staff if the cladding stresses expected to be experienced in the thoria rods is bounded by that in the UO_2 rods. If the stress is greater in the thoria rods compared to the UO_2 rods, the temperature limit may be lower than 752°F. A higher short-term temperature limit may be used for low burnup thoria rod fuel if it is shown that the best estimate hoop stress that the thoria rod fuel cladding experiences is bounded by the stresses expected in UO_2 rods at the maximum temperature calculated in the HI-STORM 100 FSAR.
>
> This information is needed to determine compliance with 10 CFR 72.122(h)(1) and 72.122(l).

EGC Response to RAI-3:

The DNPS Thoria Rod Canister contains 18 thoria rods which have obtained a relatively low burnup of less than 16,000 MWD/MTU. These rods were removed from two DNPS Unit 1 8x8 fuel assemblies (i.e., nine rods from each assembly). As stated in CoC No. 1014, Amendment 8, Appendix B, Table 2.1-1, "Fuel Assembly Limits," the cladding on the thoria rods is zirconium-based. EGC has concluded that the thoria rods, within the Thoria Rod Canister, will experience similar stresses as the UO_2 rods that would be stored with the Thoria Rod Canister in a single MPC-68M. EGC does not plan to load any high burnup fuel in the MPC-68M that contains the Thoria Rod Canister. As such, the heat load of the MPC-68M which contains the Thoria Rod Canister will be well below the design basis heat load of 36.9 kW.

Given that the expected heat load will be much lower than the design basis value, fuel and component temperatures are also expected to be well below the values specified in Table 4.III.5 of the HI-STORM 100 FSAR, Revision 11 during vacuum drying operations, and thus below the 400°C limit specified in ISG-11, "Cladding Considerations for the Transportation and Storage of Spent Fuel," Revision 3.

Therefore, the NRC's conclusions in the May 10, 2012 SER that approved CoC No. 1014, Amendment 8 concerning hoop stress and hydride reorientation bounds the storage of the Thoria Rod Canister in an MPC-68M (emphasis added):

> *However, based on the staff's evaluation, it is expected that the <u>fuel assemblies with the moderate burnup, as described in scenario (A), are not likely to have a significant</u>*

amount of hydride reorientation due to limited hydride content. Furthermore, most of the low or moderate burnup fuel has hoop stresses below 90 MPa. Even if hydride reorientation occurred during storage, the network of reoriented hydrides is not expected to be extensive enough in moderate burnup fuel to cause fuel rod failures. Given the conditions of hydride reorientation and hoop stress described above and the fact that the calculated temperature is just 1°C (2°F) over the allowable limit, the staff finds the cladding temperature of 401° in scenario A is acceptable for this application. This is based on the applicant's use of other conservative assumptions (e.g., the water in the HI-TRAC annulus is conservatively assumed to be boiling with a water temperature of 111°C (232°F) in the calculation. Additionally, the hydrostatic head of water at the annulus with the MPC bottom surface insulation causes boiling at higher than 100°C (212°F) used in the model analyses, and that the fuel rods in MPC-68M should not fail during the moisture removal operations in Scenario (A). In scenario (B), the calculated cladding temperature of 389°C (732°F) is well below the allowable limit of 400°C (752°F) as identified in ISG-11.

The staff found the evaluations of scenarios of (A) and (B) acceptable based on two conservative assumptions: (1) the water in the HI-TRAC annulus is assumed to be boiling 111°C (232°F) under the hydrostatic head of water at the annulus bottom and (2) the bottom surface of the MPC is insulated. The staff finds that the maximum cladding temperatures under scenarios (A) and (B) are in compliance with thermal limits review guidance provided in ISG-11, Rev 3.

RAI-4: Provide evaluation with details of the design characteristics of the thoria rods, including dimensions, weights, materials, and verify that the weight(s) is bounded by those used in the qualified canisters.

The NRC staff reviewed Section 4, "Safety Analysis," contained in the EGC exemption request letter, RS-15-013. The design characteristics of the thoria rods such as: dimensions, weights, materials, etc., are not included in the exemption request.

This information is needed to determine compliance with 10 CFR 72.11.

EGC Response to RAI-4:

The August 31, 2000 application for CoC No. 1014, Amendment 1 included proposed Revision 11 to the HI-STORM 100 Topical Safety Analysis Report (TSAR). TSAR Table 2.1.12, "Design Characteristics for Thoria Rods in D1 Thoria Rod Canisters" (i.e., ADAMS Accession No. ML003748010) provides the following physical design characteristics (i.e., limits), as well as the calculated values for the thoria rods and the Thoria Rod Canister.

Physical Characteristic	**Design Limit**	**Calculated Value**
# of Fuel Rods	≤18	18
Clad Material	Zircaloy (Zr)	Zr
Clad OD (inches)	≥ 0.412	0.412
Clad ID (inches)	≤ 0.362	0.362
Pellet OD (inches)	≤ 0.358	0.358
Rod Active Length (inches)	≤ 111	105.719
Rod Length - Total (inches)	n/a	111.938
Weight of 18 Thoria Rods (lb.)	n/a	99.84
Weight of Canister including Thoria Rods (lb)	≤ 550	408.311

TSAR Revision 11, Appendix 3.AR, "Analysis of Transnuclear Damaged Fuel Canister and Thoria Rod Canister," provides the structural analysis, given these physical design characteristics, to demonstrate that the Thoria Rod Canister is structurally adequate to support the loads that develop during normal lifting operations and during postulated accident conditions, when loaded into the MPC-68 or MPC-68F. In the July 18, 2002 SER that approved Amendment 1 to CoC No. 1014, the NRC stated:

> *Detailed specifications for the approved fuel assemblies, as modified by this amendment, are given in Section 2.1 of the FSAR. These include the maximum enrichment, maximum decay heat, maximum average burnup, minimum cooling time, maximum initial uranium mass, and detailed physical fuel assembly parameters. The limiting fuel specifications are based on the fuel parameters considered in the structural, thermal, shielding, criticality, and confinement analyses.*

With respect to the physical design characteristics of the HI-STORM 100 system, including storage of the DNPS Unit 1 Thoria Rod Canister in an MPC-68 or MPC-68F, the NRC established the following evaluation findings in the July 18, 2002 SER.

F2.1 The staff concludes that the principal design criteria for the HI-STORM 100 Cask System are acceptable with regard to demonstrating compliance with the regulatory requirements of 10 CFR Part 72. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. More detailed evaluations of design criteria and assessments of compliance with those criteria are presented in Chapters 3 through 14 of this SER.

F3.6 The staff concludes that the structural design of the HI-STORM 100 Cask System is in compliance with 10 CFR Part 72 and that the applicable design and acceptance criteria have been satisfied. The structural evaluation provides reasonable assurance that the HI-STORM 100 Cask System will enable safe storage of spent nuclear fuel. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable industry codes and standards, accepted practices and confirmatory analysis.

These NRC evaluation findings, the underlying Holtec analyses, and the physical design characteristics of the Thoria Rod Canister approved in CoC No. 1014, Amendment 1 bound the proposed storage of the Thoria Rod Canister in an MPC-68M. Specifically In Section 3.1 of the May 10, 2012 SER that approved CoC No. 1014, Amendment 8 (i.e., the use of an MPC-68M), the NRC stated (emphasis added):

> *Because of the lighter weight of the MPC-68M, as well as the load bearing capacity of the unchanged overpack, <u>most of the load cases analyzed previously bound the applicable loadings with the MPC-68M</u>. The worst load conditions for the MPC-68M basket are the tipover and end drop case.*
>
> *For the tipover event, the applicant performed an analysis based on a ratio of mass and geometry of the MPC-68M to the previously analyzed HI-STORM 100 configuration to establish the maximum rigid-body deceleration. <u>The applicant determined, based on this revised analysis, that the maximum deceleration for the tipover event with the MPC-68M would be 43.42g, and this is less than the design-basis limit of 45g identified in Table 3.1.2 of the FSAR.</u>*
>
> *In order to ensure compliance with the dimensionless deformation limit (defined as the maximum total deflection sustained by the basket panels under the loading event over the nominal inside (width) dimension of the storage cell) of 0.005 set forth in the FSAR (Table 2.III.4) the applicant performed a finite element analysis applying a 70 g deceleration on the basket. <u>The calculated results show only small plastic strains that do not significantly alter the basket structure. This demonstrates a significant margin between available basket strength and the design basis loads.</u>*
>
> *For the end drop event, the applicant established a proportion by weight to the deceleration of the previously analyzed configuration. <u>The resultant maximum deceleration for the end drop for the system using an MPC-68M is 44.39g, which is below the design basis limit of 45g stated in Table 3.1.2 of the FSAR. The applicable maximum lift height of 11 in (28 cm), previously established, still applies.</u>*

Based on the information described in Section 3.1 of the SER for CoC No. 1014, Amendment 8, the NRC made the following evaluation findings:

> *F3.1 The SSCs important to safety are designed to accommodate the combined loads of normal, off-normal, accident, and natural phenomena events with an adequate margin of safety. Stresses at various locations of the cask for various design loads are determined by analysis. Total stresses for the combined loads of normal, off normal, accident, and natural phenomena events are acceptable and are found to be within limits of applicable codes, standards, and specifications.*
>
> *F3.2 The structural design and fabrication includes acceptable structural margins of safety for those SSC important to nuclear criticality safety. The applicant has demonstrated acceptable structural safety for the handling, packaging, transfer, and storage under the normal, off-normal, and accident conditions that are identified in the FSAR.*

RAI-5: Provide analysis showing that criticality safety for the 68M with a thoria rod canister remains unchanged or is bounded.

Previous analyses approved by the staff and referenced by this exemption do not include a criticality safety analysis of thoria fuel rods in a basket with Metamic as the neutron absorber material. Those analyses involved other types of neutron absorber materials. An analysis of thoria fuel rods in a 68 BWR fuel assembly basket with Metamic neutron absorber is needed.

This information is necessary to determine compliance with 10 CFR 72.124.

EGC Response to RAI-5:

TSAR Revision 11, Chapter 6, "Criticality Evaluation," (i.e., ADAMS Accession No. ML003747975) documents the criticality evaluation of the HI-STORM 100 System. This evaluation demonstrates that the effective multiplication factor (k_{eff}) of the HI-STORM 100 System, including all biases and uncertainties evaluated with a 95% probability at the 95% confidence level, does not exceed 0.95 under all credible normal, off-normal, and accident conditions.

Section 6.4.6 of TSAR Revision 11 states that the Thoria Rod Canister is similar to a Damaged Fuel Canister with an internal separator assembly containing 18 intact fuel rods. The k_{eff} value for an MPC-68F filled with Thoria Rod Canisters is calculated to be 0.1813. This low reactivity is attributed to the relatively low content in ^{235}U (equivalent to UO_2 fuel with an enrichment of approximately 1.7 wt% ^{235}U), the large spacing between the rods (the pitch is approximately 1", the cladding OD is 0.412") and the absorption in the separator assembly. Together with the maximum k_{eff} values for fuel assemblies, 6.1.8 this result demonstrates that the k_{eff} for a Thoria Rod Canister loaded into the MPC-68 or the MPC-68F together with other approved fuel assemblies or DFCs will remain well below the regulatory requirement of k_{eff} < 0. 95.

In the July 18, 2002 SER that approved Amendment 1 to CoC No. 1014, the NRC stated the following (emphasis added):

> *The applicant requested approval to store one thoria rod canister within the MPC-68 or MPC-68F only. A sketch of the thoria rod canister is given in figure 2.1.2.A. The thoria rod contents are described in Section 6.4.6 of the amendment request. The applicant modeled the thoria rod canister explicitly and performed an analysis for a cask filled with 68 of these canisters. The applicant calculated a k_{eff} of 0.18.*
>
> <u>*The staff previously reviewed and approved this canister and its contents for the MPC-68 and MPC-68F during review of the HI-STAR Amendment #1* [i.e., ADAMS Accession No.ML003780760] *and further review is not necessary.*</u> *The MPC-68 and MPC-68F design features important to criticality safety have not been changed. The transfer cask used with HI-STORM, the HI-STORM overpack, and the HI-STAR overpack are constructed of different materials. Thus, the effectiveness of these materials to reflect neutrons was explicitly evaluated during the staff's initial review and licensing of the HI-STORM 100 to determine the effect on the system reactivity. The staff's analysis showed that the difference in the overpack materials and transfer cask materials do not significantly affect the system reactivity.*

As stated in the May 10, 2012 SER that approved Amendment 8 to CoC No. 1014, the MPC-68M is distinguished from the other HI-STORM 100 BWR fuel baskets (MPC-68, MPC-68F and MPC-68FF) in that the basket is made of METAMIC-HT material. This material acts as the structural material as well as the neutron absorber material.

The MPC-68M basket consists of homogeneously dispersed boron carbide (10% minimum by weight). The Boron (B)-10 areal density of the METAMIC-HT panels, which make up the basket, is consistent with the areal density of the METAMIC classic neutron poison panels in the MPC-68. The incorporation of METAMIC-HT in the MPC-68M fuel basket results in a much greater B-10 concentration than is available in fuel baskets designs with "attached" neutron absorber (i.e., the MPC-68, MPC-68F, and MPC-68FF). This accrues three major safety and reliability advantages:

- The BWR basket may store high enrichment fuel (i.e., fuel with up to 4.8 wt.% $_{235}$U initial planar enrichment) without reliance on gadolinium or burn-up credit.
- The neutron absorber cannot detach from the basket or displace within it.
- Axial movement of the fuel with respect to the basket due to internal clearances has no reactivity consequence because the entire length of the basket contains the same concentration of the B-10 isotope.

These design benefits ensure that the MPC-68M has equal or better criticality performance than the MPC-68 or MPC-68F, due to the basket itself being made from the METAMIC-HT, and thus the criticality evaluation for the MPC-68M is bounded by the original criticality analyses. In Section 7.1.3.2 of the Amendment 8 SER, the NRC validated this conclusion:

> *The applicant calculated a "representative value" of k_{eff} for the storage cask (overpack) and presented the results in Table 6.III.1.2 of the FSAR. The staff notes that this result is for the 10x10A array. Although, the applicant made no effort to determine the most reactive assembly class for this configuration, the analysis results provide a large margin to criticality. Therefore, any other assembly class would also show a large margin to criticality based on the similar characteristics and calculated keff values for other assembly classes identified in Tables 6.III.1.1, 6.III.1.2, and 6.III.1.3 of the FSAR. Light Water Reactor fuels require water as the moderating medium to become critical, and since storage conditions are dry (i.e. without water) the staff finds that this is conservative for all assembly classes. Therefore the staff finds this result acceptable and finds that it provides adequate assurance that the MPC-68M within the HI-STORM 100 overpack is subcritical.*
>
> *All of the calculated k_{eff} values meet the sub-criticality criterion of $k_{eff}<0.95$ and therefore the staff finds them acceptable.*

Therefore, the storage of the Thoria Rod Canister in an MPC-68M is bounded by the original criticality analyses.

RAI-6: Provide shielding analyses that demonstrate the proposed changes to the fuel composition and neutron absorber are bounded by the design basis analyses. Provide the calculations necessary to show the increase in average thoria composition will have a negligible effect on the subsequent gamma and neutron spectrum and the effects of neutron shielding due to the inclusion of Metamic absorber panels in the canister.

This information is necessary to determine compliance with 10 CFR 72.104 and 72.106.

EGC Response to RAI-6:

The radiological analysis of the DNPS Unit 1 Thoria Rod Canister in an MPC-68 or MPC-68F is described in the HI-STORM 100 FSAR, Revision 1. Specifically, the DNPS Unit 1 Thoria Rod Canister was analyzed to determine if it was bounded by the design basis 6x6 source terms for DNPS Unit 1 fuel. The results indicate that the design basis source terms bounded the Thoria Rod source terms in all neutron groups and in all gamma groups except the 2.5 to 3.0 MeV group (i.e., due to a high energy gamma from the decay of $_{208}$Tl, a daughter nuclide in the $_{233}$U decay chain).

The NRC documented these analytical results, and approved the storage of the Thoria Rod Canister in the July 18, 2002 SER that approved Amendment 1 to CoC No. 1014. This approval was based on the bounding source terms and the conservatisms that were built into the shielding analysis to compensate for the high energy gamma from the decay of $_{208}$Tl (emphasis added):

> *The applicant requested the addition of the Dresden Unit 1 Thoria Rod Canister to the HI-STORM approved contents. The Dresden Unit 1 Thoria Rod Canister was requested for storage in the MPC-68 and the MPC-68F. The canister contains up to 18 thoria rods which have a maximum burnup of 16,000 MWD/MTIHM and a minimum cooling time of 18 years. The applicant used the SCALE 4.3, Revision 5, SAS2H module, with ORIGEN-S, to calculate the source terms. The thoria rod source terms, listed in FSAR Tables 5.2.37 and 5.2.38, are bounded by the source terms for the design basis BWR fuel in all neutron groups and in all gamma groups except in the 2.5-3.0 MeV group. To demonstrate that the gamma dose rate from the thoria rods is bounded by the design basis fuel, the applicant calculated the gamma dose rate on the radial surface of a 100 ton HI-TRAC and HI-STORM cask completely filled with the thoria rods. The results were compared to the gamma dose rate of a cask filled with design basis BWR fuel. The gamma dose of the design basis BWR fuel bounded that of the 100 ton HI-TRAC completely filled with thoria rods. However, the HI-STORM cask completely filled with thoria rods had a gamma dose rate 17 percent higher than the design basis BWR fuel.*
>
> *The staff review found the applicant's analyses acceptable, since there are sufficient conservatisms built into the analysis. Licensees will only be permitted to store one Thoria Rod Canister per MPC-68 or MPC-68F, rather than an entire cask load, as was analyzed. Based upon the review of the applicant's analysis, the staff agrees that the Thoria Rod Canister, with up to 18 thoria rods per canister and the burnup and cooling time limits given above, is acceptable for storage in the MPC-68 or MPC-68F.*

No additional shielding analyses were performed for the MPC-68M. The existing shielding analyses for the MPC-68 with the aluminum basket bound the improved MPC-68M METAMIC-HT basket. Therefore, the original NRC approval for storage of the Thoria Rod Canister in the MPC-68 or MPC-68F bounds storage in the MPC-68M. The NRC validated this conclusion in the May 10, 2012 SER that approved Amendment 8 to CoC No. 1014 (emphasis added):

> *The applicant supplied a series of qualitative analyses to show the bounding shielding evaluation is still applicable to the MPC-68M. <u>The applicant references the previously reviewed shielding analysis which states that the inner 32 assemblies, comprising 47% of the spent fuel, contribute 2% of the gamma dose and 27% of the neutron dose due to the shielding by the outer assemblies. This effect minimizes the impact that the basket material has on external dose rates.</u> Neither the MPC-68 nor the overpack are changed in amendment request 1014-8, and the 10x10F and 10x10G source term is bounded by the B&W 7x7 fuel class previously evaluated by the staff. Additional shims in the annulus surrounding the basket are provided in the MPC-68M, and the applicant has shown that the total shielding provided by the MPC-68M has not significantly changed from the MPC-68 previously evaluated acceptably by the staff. <u>Thus, the staff finds the MPC-68M acceptable.</u>*

As discussed in the January 29, 2015 Exemption Request, during a review of DNPS fuel characterization data, EGC identified that the weight percentage of ThO_2 in nine of the 18 Thoria Rods was slightly higher than the maximum approved ThO_2 value, while the weight percentage of UO_2 in these nine Thoria Rods was slightly lower than the maximum approved UO_2 value.

Specifically, these nine Thoria Rods have a composition of 98.8 wt.% ThO_2 and 1.2 wt.% UO_2. When combined with the nine Thoria Rods that comply with the CoC-authorized composition (i.e., 98.2 wt.% ThO_2 and 1.8 wt.% UO_2), the average composition in the DNPS Unit 1 Thoria Rod Canister would be 98.5 wt.% ThO_2 and 1.5 wt.% UO_2.