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10 CFR 72.56

March 10, 2015

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Calvert Cliffs Nuclear Power Plant, Units Nos. 1 and 2
Renewed Facility Operating License Nos. DPR-53 and DPR-69
NRC Docket Nos. 50-317 and 50-318

Calvert Cliffs Nuclear Power Plant
Independent Spent Fuel Storage Installation, License No. SNM-2505
NRC Docket No. 72-8

Subject: Response to Amendment Request No. 1 to Renewed Materials License No. SNM-2505 for the Calvert Cliffs Specific ISFSI – First Request for Additional Information

References:
1. Letter from G. H. Gellrich (Exelon Generation) to Document Control Desk (NRC), dated March 26, 2014, License Amendment Request: High Burnup NUHOMS-32PHB Dry Shielded Canister
2. Letter from J. M. Goshen (NMSS) to G. H. Gellrich (Exelon Generation), dated December 5, 2014, Amendment Request No. 1 to Renewed Materials License No. SNM-2505 for the Calvert Cliffs Specific ISFSI – First Request for Additional Information

Reference 1 submitted a license amendment request for the Calvert Cliffs Nuclear Power Plant site-specific independent spent fuel storage installation. The amendment, if approved, would authorize the storage of Westinghouse and AREVA Combustion Engineering 14x14 fuel in the NUHOMS-32PHB Dry Shielded Canister system. As part of their review, the NRC staff has requested additional information (Reference 2). Responses to the requested additional information are provided in Attachment (1). A marked up Technical Specification page is included in Attachment (2). Enclosures 1, 2, 4, 6 and 7 contain information that is proprietary to AREVA Inc., therefore, they are accompanied by an affidavit signed by AREVA, the owner of the information (Attachment 3). The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission, and addresses, with specificity, the consideration listed in 10 CFR 2.390(b)(4). Accordingly, it is requested that the information that is proprietary to AREVA, Inc. be withheld from public disclosure. Non-proprietary versions of Enclosures 1, 2, 4, 6, and 7 are included as Enclosures 12-16.

NMSS26

The additional information provided does not change the environmental assessment provided in Reference 1 and the categorical exclusion set forth in 10 CFR 51.22(c)(11) is still valid. There are no regulatory commitments contained in this correspondence.

Should you have questions regarding this matter, please contact Mr. Michael J. Fick at (410) 495-6714.

I declare under penalty of perjury that the foregoing is true and correct. Executed on March 10, 2015.

Respectfully,

George H. Gellrich
Site Vice President

GHG/PSF/bjm

Attachments: (1) Response to Request for Additional Information

Enclosures:

1. PROPRIETARY NUH32PHB-0203, Revision 1, PWR Fuel Rod Accident Side Drop Loading Stress Analysis for NUHOMS 32 PHB System
2. PROPRIETARY NUH32PHB-0203, Revision 2, PWR Fuel Rod Accident Side Drop Loading Stress Analysis for NUHOMS 32 PHB System
3. Computation File List
4. PROPRIETARY 10955-TLAA01, Time Limited Aging Analysis (TLAA) of HSM-HB Concrete for Thermal Considerations
5. Calvert Cliffs Technical Procedure, ISFSI-03, Independent Spent Fuel Storage Installation (ISFSI) Loading NUHOMS-32P Dry Shielded Canister, Section 6.18, Revision 01500
6. PROPRIETARY NUH32PHB-0401, Revision 2, Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident conditions with Forced Cooling (Steady State)
7. PROPRIETARY NUH32PHB-0411, Revision 0, Grid Convergence Study for the ANSYS Model for the NUHOMS 32PHB DSC
8. NUH32PHB-0402, Revision 1, Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off-Normal, and Accident Conditions
9. NUH32PHB-0101, Revision 4, Design Criteria Document (DCD) for the NUHOMS 32PHB System for Storage
10. NUH32PHB-0400, Revision 2, Benchmarking of the ANSYS Model of the OS200FC Transfer Cask
11. NUH32PHB-0403, Revision 1, Thermal Evaluation of NUHOMS 32PHB DSC for Storage and Transfer Conditions

12. Non-Proprietary NUH32PHB-0203, Revision 1, PWR Fuel Rod Accident Side Drop Loading Stress Analysis for NUHOMS 32 PHB System
13. Non-Proprietary NUH32PHB-0203, Revision 2, PWR Fuel Rod Accident Side Drop Loading Stress Analysis for NUHOMS 32 PHB System
14. Non-Proprietary 10955-TLAA01, Time Limited Aging Analysis (TLAA) of HSM-HB Concrete for Thermal Considerations
15. Non-Proprietary NUH32PHB-0401, Revision 2, Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident conditions with Forced Cooling (Steady State)
16. Non-Proprietary NUH32PHB-0411, Revision 0, Grid Convergence Study for the ANSYS Model for the NUHOMS 32PHB DSC

(2) Marked Up Technical Specification Page

(3) AREVA TN Affidavit

cc: NRC ISFSI Project Manager, Calvert Cliffs

(Without Enclosures 1, 2, 4, 6, and 7)
NRC Project Manager, Calvert Cliffs
NRC Regional Administrator, Region I
NRC Resident Inspector, Calvert Cliffs
S. Gray, MD-DNR

ATTACHMENT (1)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

The Nuclear Regulatory Commission (NRC) staff has requested additional information concerning the March 26, 2014, License Amendment Request: High Burnup NUHOMS-32PHB Dry Shielded Canister (DSC). The request and the responses are provided below.

NRC RAI 5-1:

Explain rationale behind the 0.5 multiplication factor for the calculations involving the HSM-HB overturning due to flood load and the Horizontal Storage Module (HSM) HB sliding due to flood load in reference 13.10 of the Updated Safety Analysis Report (USAR).

Reference 13.10 is Transnuclear Calculation No. NUH32PHB-0208, HSM-HB Structural Analysis for NUHOMS®-32PHB System Design Calculation. The staff notes that in these calculations, the drag force used for the overturning moment and the sliding force is multiplied by a factor of 0.5. The explanation for this factor is, "50% of the drag force is assumed to act on one face of one module and 50% on opposite face of the adjacent module." Assumption number 6 states, "For stability analysis of the HSM-HB subjected to flood load a minimum of two modules adjacent to each other are required to prevent overturning and sliding." It is not clear how the interaction of the two modules reduces the drag force by 50%.

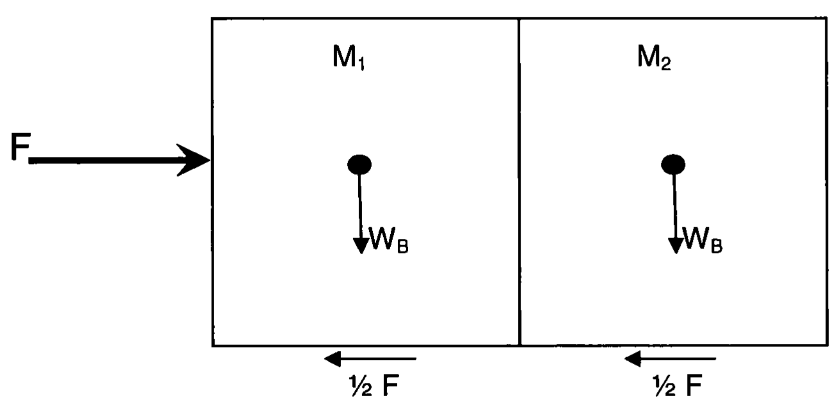
This information is needed to demonstrate compliance with 10 CFR 72.122.

CCNPP RESPONSE TO RAI 5-1:

The calculation NUH32PHB-208 considered two modules to be exposed to the total flood load. Since the modules in the pair are in contact, the total flood load is anticipated to be distributed equally to both modules. As discussed in Section 1.3.1.2 of the Calvert Cliffs ISFSI USAR, the ISFSI employs HSMs constructed in units of 12 configured in a 2x6 array. In an array of 6 HSMs with all the modules in contact, the total flood load is distributed among all the modules in the array. Therefore, the net force acting on a single module in the array direction, in reality, will be even lower than one half of total flood load.

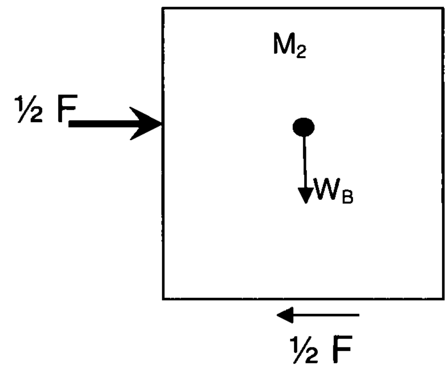
The rationale behind the use of 0.5 multiplication factor in NUH32PHB-208 for the calculations involving the HSM-HB overturning and sliding due to flood load is explained below.

Consider the following free-body diagram with the total flood force, F, acting on a pair of HSM modules, M_1 and M_2. The vertical reactions due to the buoyant weight are not shown in the free-body diagram.

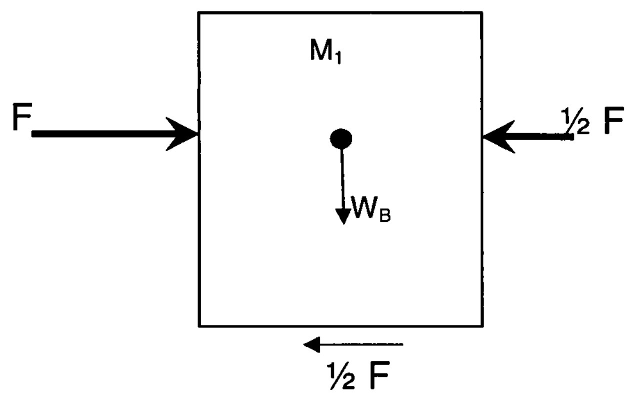


Let W_B be the buoyant weight of each module. The non-sliding friction forces due to the buoyant weight have not reached their sliding limit. Therefore, the sum of reactions at the base of each module equals the applied force (F). These reaction forces are developed due to the static friction at the base of each module. Due to similar weight, configuration and design, each module will have equal reaction force i.e., one half of the applied force.

The free body diagram of the module M_2 is:



The free body diagram of the module M_1 is:



Based on the above free body diagram of individual HSM module, the net force acting on each HSM module is ½F.

In addition, based on Section 3.2.2 of Calvert Cliffs ISFSI USAR, it is considered that the possibility of flooding the ISFSI is very rare due to higher elevation of the ISFSI location. This implies that the calculation addressing the effect of flood load is redundant.

Therefore, it is conservative and justified to use the multiplication factor of 0.5 in the calculations involving overturning and sliding of HSM-HB due to flood load.

<u>NRC RAI 5-2</u>:

Provide NUH32PHB-0203, Rev 1, "PWR Fuel Rod Accident Side Drop Loading Stress Analysis for NUHOMS®-32PHB System."

This reference is not included in Section 13.13 of the USAR, but is referenced in Reference 13.9, Transnuclear Calculation No. NUH32PHB-0207, "Fuel Rod End Drop Analysis *for NUHOMS®-32PHB System Design Calculation." This document contains the material properties of Zircaloy-4 and M-5 cladding at 750°F that establishes the scaling factor of 1.082 that was used to calculate the maximum principle strain in the M-5 cladding as a result of the end drop.*

This information is needed to demonstrate compliance with 10 CFR 72.122.

CCNPP RESPONSE TO RAI 5-2:

The requested calculation is provided in Enclosures 1 and 12. In addition, Revision 2 of the requested calculation is also provided (Enclosures 2 and 13). This revision increased the oxidation thickness microns to provide additional conservatism.

NRC RAI 5-3:

Provide ANSYS input and output files associated with the structural calculations of section 13.13 of the USAR.

The staff requested these calculations in the Request for Supplemental Information. Much of the structural analysis is completed through the use of finite element analysis with ANSYS and cannot be evaluated without the input and output files. The staff specifically prefers text based files (i.e. .inp) with an appropriate level of comments to allow for a timely technical review.

This information is needed to demonstrate compliance with 10 CFR 72.122.

CCNPP RESPONSE TO RAI 5-3:

The requested files are contained in Enclosure 3.

NRC RAI 5-4:

Provide a time-limited aging analysis (TLAA) or an aging management program (AMP) to address the aging effect of cracking due to thermal cycling fatigue in the HSM-HB concrete.

Fatigue is an age-related degradation mechanism caused by cyclic stressing of a component by either mechanical or thermal stresses, which becomes evident by cracking of the component. The license amendment request (LAR) does not address thermal cycling fatigue of the concrete of the HSM-HB. A fatigue analyses may be submitted as a TLAA if based on design thermal transients involving time-limited assumptions. Otherwise, the LAR should justify the adequacy of the AMP approved in the renewed license (ML14274A03B) or include a revised AMP to address this aging mechanism.

This information is needed to demonstrate compliance with 10 CFR 72.24(c), 72.122(b)(1) and (f), 10 CFR 72.162 and 10 CFR 72.172.

CCNPP RESPONSE TO RAI 5-4:

The time-limited aging analysis (TLAA) is prepared to address the effect of thermal cyclic fatigue and elevated temperature on the concrete components of HSM-HB. The TLAA is attached with this response (Enclosures 4 and 14). The TLAA explains why degradation due to elevated temperature and thermal cyclic fatigue are not an aging effect requiring management. The TLAA concludes that the concrete components of the HSM-HB will not be impaired by thermal cyclic fatigue or elevated temperature and the HSM-HB will be functionally adequate for a total service life of 60 years.

NRC RAI 6-1a:

Provide a technical basis for the revised maximum air temperature rise of 80°F for the HSM-HB currently provided in Technical Specification 3.4.1.1.

The applicant retains the current limit of 64°F for the maximum air temperature rise in a HSM containing a 24P or 32P DSC, but is requesting an increased limit of up to 80°F for the maximum air temperature rise in the HSM-HB storage module when loaded with a 32PHB DSC. The increase seems excessive in comparison to the magnitude of the changes in the limiting total decay heat loads for the 32 PHB in the HSM-HB.

It is expected that the HSM-HB storage modules would be somewhat more efficient than the older HSMs in the ISFSI. The 80°F temperature rise limit means that with high ambient temperatures (with peaks typically in the range of 90°F for sustained periods of time in the summer), the exit air temperature could approach 170°F or higher for the HSM-HB, if loaded with a 32PHB at design basis decay heat (29.6 kW). The applicant should provide the basis explaining why an increase of the maximum air temperature rise limit is needed for the inlet-to-exit of the storage module when loaded with 32PHB DSC.

CCNPP RESPONSE TO RAI 6-1a:

The HSM-HB storage module loaded with a 32PHB DSC operates on the same principles as the currently licensed HSM with 24P or 32P DSCs. A review of the maximum heat loads for the HSM (21.12 kW) and the HSM-HB (29.6 kW) shows that the maximum heat load increases by approximately 40% for the HSM-HB whereas the air temperature rise only increases by 25%. This shows that the overall increase in exit air temperature follows the increase in the heat load but by a lower magnitude. A direct comparison of the air temperature rise between the two models (HSM vs HSM-HB) is not performed due to the differences in the physical configuration of the two systems.

The HSM-HB proposed for use with the 32PHB DSC is identical in geometry and dimensions to the HSM-H described in the UFSARs for the Standardized NUHOMS® system (CoC 1004, Reference 2) and the NUHOMS® HD system (CoC 1030, Reference 3). The HSM-H model from these licenses is simply designated as HSM-HB in this application to differentiate between the general licenses and the site specific license for the CCNPP ISFSI. The following section provides a brief overview of the methodology that is used to evaluate the thermal performance of the HSM-H and associated conservatism as documented in the safety analysis report issued by NRC to aid in the discussion of the HSM-HB air temperature rise subsequently.

Overview of the HSM-H Thermal Evaluation Methodology

The methodology to calculate the exit air temperature (airflow calculation) is described in more detail in Section 4.13, "Thermal-Hydraulic Equations for the HSM-H" of Reference 3.

The exit air temperature is then used in the 3D ANSYS model to determine the DSC shell temperature profile. This 3D ANSYS model does not include the DSC internals such as the basket assembly. Rather, the 3D ANSYS model includes only the DSC shell and the HSM-H storage module. Appendix B of Reference 4 presents the exit air temperature calculation and Appendix C of Reference 4 presents the 3D ANSYS model of the HSM-H with 61BTH DSC. The 3D ANSYS model provides the maximum temperatures for the HSM-H components and the DSC shell temperature profile for use in the detailed DSC basket assembly model.

The combination of the airflow calculation and the 3D ANSYS model constitutes the methodology for the evaluation of the thermal performance of the HSM-H, which has also been used to evaluate the HSM-HB as noted in Reference 4. This methodology was reviewed by NRC in Amendment 8 to CoC 1004 (Reference 5, certificate issued on 12/05/2005), Amendment 10 to CoC 1004 (Reference 6, certificate issued on 08/24/2009), Amendment 13 to CoC 1004 (Reference 7, certificate issued on 05/24/2014) and in Amendment 0 to CoC 1030 (Reference 8, certificate issued on 01/10/2007).

The evaluation methodology was validated using a series of tests on a full scale mockup of the HSM-H. As described in Section 4.9 of Reference 8, the test protocols were reviewed by NRC with a conclusion that the methodology predicts conservative temperatures for the system components.

In addition, a comprehensive confirmatory analysis was performed by NRC in review of CoC 1004, Amendment 10 for a 32PTH1 DSC in an HSM-H as documented in the corresponding SER (Reference 6) in Section 4.6.3.2. The results of the confirmatory analysis show that:

"...the modeling approach used in the SAR is conservative, in that it tends to over-estimate the DSC shell temperatures, and predicts a greater area of the DSC surface to be at the higher temperatures. The component temperatures reported in the SAR for the HSM-H have a similar conservative bias"

and

"...the temperature results obtained with the StarCD model tend to confirm that the ANSYS model used in the thermal analysis of the HSM-H is conservative. The comparison for the most limiting case (DSC with Type 1 basket, HLZC #1, 40.8 kW) indicates that the HSM-H peak temperatures and the DSC shell temperatures are conservative with respect to a CFD model that represents the HSM-H and DSC as an integrated system. The total air flow rate is also conservative for the SAR model, compared to the flow rate predicted with the detailed CFD solution in StarCD."

Since the methodology to evaluate the HSM-H or HSM-HB, including the airflow calculation, has been reviewed multiple times by NRC in previous applications and found to be conservative, this response refers only to the previous application to facilitate the review.

HSM-HB Air Temperature Rise

The HSM-HB thermal evaluation is documented in Reference 4. As noted in this calculation, the thermal evaluation of the HSM-HB including the air temperature rise is based on a previously evaluated DSC, i.e., 61BTH in HSM-H. The maximum exit air temperature rise of 80°F is based on the evaluation presented in Appendix B of Reference 4.

Based on the methodology presented in the UFSAR for the NUHOMS® HD system (Reference 3, CoC 1030) in Section 4.13 "Thermal-Hydraulic Equations for the HSM-H," the exit air temperature is dependent on the:

a. Heat load of the DSC.
b. Ambient temperature of the inlet air.
c. Dimensions of the HSM-H.

d. Dimensions of the DSC. Only the outer dimensions of the DSC, i.e., the diameter and length impact this evaluation.

From the discussion titled "Reconciliation of HSM-H airflow temperatures" in Section 6.0 of Reference 4, the air temperature rise determined for the HSM-H with 61BTH DSC is conservative to use for the 32PHB DSC since:

a. The maximum heat load for 61BTH DSC is 31.2 kW and is higher than the maximum allowable heat load of 29.6 kW for the 32PHB DSC.
b. A higher ambient temperature of 105°F is used for the 61BTH DSC in HSM-H compared to the maximum ambient temperature of 104°F considered for the 32PHB DSC in HSM-HB.
c. There are no changes in the dimensions of the HSM-H compared to the HSM-HB.
d. The outer diameter of the 61BTH DSC is identical to the outer diameter of the 32PHB DSC whereas the length of the 61BTH DSC is longer than the length of the 32PHB DSC. A longer DSC provides more flow resistance to the air flow and results in a higher dynamic loss coefficient compared to a shorter DSC. As discussed in Section 4.13 (Reference 3), the exit air temperature rise is proportional to the total dynamic loss coefficients. Therefore, the exit air temperature rise determined for the HSM-H with the 61BTH DSC remains bounding for the HSM-HB with 32PHB DSC.

Based on this discussion, the exit air temperature rise of 80°F determined for the HSM-H with 61BTH DSC is acceptable for the HSM-HB with 32PHB DSC.

<u>NRC RAI 6-1b</u>:

Explain the methodology that is used to determine the inlet-to-exit temperature rise in the storage module (HSM and HSM-HB.) How is the measured temperature data processed and evaluated to determine the overall temperature rise through the module?

The staff is seeking to understand how compliance is evaluated with respect to the limit defined in Technical Specification 3.4.1.1.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

<u>CCNPP RESPONSE TO RAI 6-1b</u>:

An overview of the methodology to determine the exit air temperature rise for the HSM-HB is presented in the response to RAI 6-1a. The air temperature rise measurements (air temperature rise = exit air temperature – ambient temperature) serve as positive evidence that the system is within the bounds of the thermal evaluations documented in the ISFSI USAR after each loading. The procedure to measure and process the air temperature rise to comply with the requirement of ISFSI Technical Specification 3.4.1.1 is presented in Section 6.18 of Reference 9. This section of the procedure is provided as Enclosure 5.

<u>NRC RAI 6-2a</u>:

Provide the technical basis for allowing up to 8 hours to initiate corrective action when these time limits are exceeded, and show that the peak temperatures within the DSC, including the peak cladding temperature, do not exceed the specified limits.

The proposed new Technical Specification (TS) 3.4.3.2 "Time Limit for Completion of NUHOMS®-32PHB DSC Transfer Operation", defines specific time limits for operations from initiation of draining water from the DSC/TC annulus to completion of insertion of the DSC into the HSM-HB (72 hours for decay heat loads up to 23.04 kW, 48 hours for decay heat loads up to 25.6 kW, or 20 hours for decay heat loads up to 29.6 kW). If the specified time limit is exceeded, the "required ACTION" section states that the operators have 8 hours to INITIATE the corrective action, one of which is "complete the transfer of the DSC to the HSM." This in effect adds 8 hours to the stated time limits defined in 3.3.2.1. Therefore the operators actually have up to 80 hours, 56 hours, or 28 hours, respectively, as the corresponding limiting decay heat loads for completion of transfer operations. The thermal analyses presented in the Calculation Packages provided in support of this review include analyses only to the specified limits of 72 hours, 48 hours and 20 hours.

<u>CCNPP RESPONSE TO RAI 6-2a</u>:

The time limits presented to complete the transfer operations in calculation NUH32PHB-0402 (Reference 10) are necessary to prevent the fuel cladding temperature from exceeding its normal temperature limit of 752°F. Therefore, any recovery actions must be initiated prior to exceeding the time limits specified in Reference 10.

Based on a review of the similar NUHOMS systems certified under CoC 1004, duration of two hours is considered sufficient to initiate the recovery action. Based on this, the proposed Technical Specification (TS) 3.4.3.2 is revised as shown in the attached markup (Attachment 2) to ensure that the time limit for transfer operations, including the time allowed to initiate the recovery operation, do not exceed the time limits determined in Reference 10. This attached markup replaces the same page markup provided in Reference 11.

<u>NRC RAI 6-2b</u>:

Provide additional analysis, justifying that the 8-hour time limit is conservative for this bounding configuration, as well as for the more benign failure from steady-state with forced cooling (FC).

The thermal analysis in the calculation package NUH32PHB-0401 is presented to show that an 8-hour time limit for initiating corrective action in response to loss of the forced air in the DSC/TC annulus during transfer operations is sufficient to assure that temperature limits, including peak cladding temperature, are not exceeded. This analysis assumes that loss of FC occurs from a steady-state condition with FC, which has no time limit for completion of transfer operations. (The calculation package reports a steady-state PCT of 689°F for the maximum permitted decay heat load case of 29.6 kW.)

The staff has noted that the failure of FC from a steady-state condition is not bounding and may not be conservative. The bounding case for failure of FC would be at the point where the time limit applicable to the DSC (depending on its decay heat load), as defined in TS 3.3.3.1, has been exceeded, and FC has just been initiated as a corrective action. The PCT at this point in the transient would be expected to be much higher than the steady-state PCT with FC active.

The staff has noted that the failure of FC from a steady-state condition with FC is not bounding and may not be conservative. The applicant should provide additional analysis for determining the time period to complete the transfer operation without exceeding peak temperature limits, as a function of the period of time that FC was in operation before failure.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-2b:

The time limits specified in proposed Technical Specification 3.3.2.1 ensure that the normal fuel cladding temperature limit of 752°F is not exceeded during transfer operations whereas the time limits specified in Technical Specification 3.3.3.1 ensure that the normal fuel cladding temperature limit of 752°F is not exceeded during vacuum drying operations. Since, forced air circulation is not a permitted during vacuum drying operation, proposed Technical Specification 3.3.2.1 is considered in this response.

If the transfer operations cannot be completed within time limits specified in proposed Technical Specification 3.3.2.1, one of the recovery actions is to initiate forced air circulation. If forced air circulation is initiated as a recovery operation during transfer, the forced air circulation needs to be turned off before inserting the 32PHB DSC into the HSM-HB storage module.

Further, with the forced air circulation turned on, another postulated scenario considered is evaluation of the system performance for the case wherein steady-state conditions are established with the forced air circulation in operation and, subsequently the forced air circulation is lost. To minimize the occurrence of this condition, the CCNPP-forced air circulation (FC) Transfer Cask (TC) skid is equipped with redundant industrial grade blowers and each one of these blowers is capable of supplying the required minimum air flow rate. These blowers are also powered with a redundant power supply. Due to this redundant arrangement, the loss of forced air circulation is not considered as a credible accident.

In both the above scenarios, i.e., turning off forced air circulation to insert the 32PHB DSC into the HSM-HB or failure of the forced air circulation, will result in a decreased rate of heat dissipation and a gradual increase of the maximum temperatures of the TC/DSC components.

Due to the large thermal mass of the system, the time to complete the transfer operations or to restore the forced air circulation once the forced air circulation is turned off to insert the DSC into the storage module depends on the duration the forced air circulation was in operation before becoming unavailable. A time limit of 8 hours is specified to complete the transfer operation once the forced air circulation is unavailable as determined per calculation NUH32PHB-0401, Rev. 1 (Reference 12). This calculation assumes that the system is at a steady-state condition.

Therefore, an additional evaluation is performed to determine the time to operate the blowers to reach steady-state conditions. Based on the evaluation presented in Appendix B of calculation NUH32PHB-0401, Rev. 2 (Reference 13), the forced air circulation needs to be operated for a minimum of 20 hours to ensure that the system reaches steady-state conditions.

In addition to determining the time limit to complete the transfer operations when the forced air circulation is unavailable from a steady-state condition, an evaluation is performed wherein it is considered that the forced air circulation is operated for 8 hours. After 8 hours, the forced air circulation is turned off and the system begins to heat up. To determine the time limit to complete the transfer operations once the forced air circulation is turned off after 8 hours, the maximum fuel cladding temperatures at 4 hours and 6 hours (after the forced air circulation is turned off) are determined in Appendix B of Reference 13. Based on this evaluation, the maximum fuel cladding temperature is 726°F and 735°F at 4 hours and 6 hours, respectively after the forced air circulation is turned off. Based on this discussion, if the forced air circulation is operated for 8 hours and then becomes unavailable, a maximum duration of 6 hours is available to complete the transfer to the HSM-HB or re-establish the forced air circulation.

Therefore, if the transfer operations cannot be completed within time limits specified in proposed Technical Specification 3.3.2.1 and forced air circulation is initiated, additional operational controls are proposed as shown in the attached Technical Specification markup (Attachment 2).

Reference 13 (Enclosures 6 and 15) along with the computational files generated for Appendix B of that calculation (Enclosure 3) are submitted as part of the response to facilitate review by the NRC.

NRC RAI 6-3:

Explain why a temperature of 280°F is considered in the thermal evaluation for the NS-3 neutron shield.

The applicant stated in calculation package NUH32PHB-0101 that a maximum bulk temperature of 280°F is considered in the thermal evaluation for the NS-3 neutron shield to limit the off-gas pressure and to limit the hydrogen loss to less than 10% within the NS-3 neutron shield.

The applicant should provide more information to explain why a maximum temperature of 280°F is considered for the NS-3 neutron shield and how this temperature considered in the thermal analysis will limit the off-gas pressure and the hydrogen loss (to less than 10%) in the NS-3 neutron shield.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-3:

Response provided in Reference 1.

NRC RAI 6-4:

Provide more information to support the bounding correlation of the DSC shell temperatures, comparing the HSM-H model with 61BTH DSC and HSM-HB model with 32PHB DSC.

The applicant provided the summary of boundary conditions in Section 5.1.2 of calculation package NUH32PHB-0403 as (a) the 32PHB DSC length of 176.5 inches is shorter than the 61BTH DSC length of 195.8 inches, (b) the 32PHB DSC heat load of 29.6 kW is less than the 61BTH DSC heat load of 31.2 kW, and (c) the shorter 32PHB DSC in HSM-HB has a lower hydraulic resistance than the 61BTH DSC in HSM-H. Therefore based on these assumptions the applicant assumed the DSC shell temperatures from the HSM-H model with 61BTH DSC are bounding for the 32PHB, and can be used as the DSC shell temperatures for the thermal analysis of HSM-HB model with 32PHB DSC.

There are significant configuration differences between the HSM-H (containing the 61BTH DSC) and the HSM-HB (containing the 32PHB DSC). Therefore, the DSC shell temperatures of 61BTH DSC in HSM-H may not bound the DSC shell temperatures of 32PHB DSC in HSM-HB. The applicant should provide more information to support the bounding correlation for the DSC shell temperatures between HSM-H model with 61BTH DSC and HSM-HB model with 32PHB DSC.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-4:

As discussed in response to RAI 6-1a, the HSM-HB is essentially a renamed version of the HSM-H with flat stainless steel heat shields. Therefore the thermal model of the HSM-H is applicable to HSM-HB. Based on the discussion in the response to RAI 6-1a, section "Overview of the HSM-H Thermal Evaluation Methodology," two steps are considered in the thermal evaluation of the HSM-H storage module with the 61BTH DSC:

1. Determine the exit air temperature of the HSM-H.
2. Using the exit air temperature from Step 1, a 3D ANSYS model is used to determine the DSC shell temperature profile and the HSM-H component temperatures.

The 3D ANSYS model noted in Step 2 is described in Appendix C of Reference 4. This model includes the HSM-H with the 61BTH DSC at 31.2 kW heat load. As shown in Figure 7-1, Appendix C of Reference 4, the ANSYS model of the HSM-H with 61BTH DSC does not include the explicit details of the basket assembly. Therefore, the differences between the 61BTH DSC basket assembly and the 32PHB DSC basket assembly do not impact the thermal evaluation.

Further, as seen from Figure 7-1 and described in Appendix C, Section 4.2 of Reference 4, the 3D ANSYS model only includes the DSC shell and the HSM-H components for normal/off-normal condition (steady-state evaluations). The heat generated from the fuel assemblies is applied as heat flux over the inner surface of the 61BTH DSC shell in this model. The DSC shell is similar between the 61BTH DSC and 32PHB DSC with the key difference being the length. The justification to use the 61BTH DSC shell as boundary conditions for steady-state evaluations of 32PHB is presented in Item A of this response.

Similarly, as seen from Figure 7-1 and described in Appendix C, Section 4.3 of Reference 4, the 3D ANSYS model includes the DSC shell, a homogenized basket and the HSM-H components for blocked vent accident condition (transient evaluations). The heat generated from the fuel assemblies is applied as volumetric heat generation over the homogenized basket of the 61BTH DSC in this model. The justification to use the 61BTH DSC shell as boundary conditions for transient evaluations of 32PHB DSC is presented in Item B of this response.

The DSC shell temperature profiles from both the steady-state and transient evaluations are applied as boundary conditions on the detailed 32PHB DSC basket assembly model to determine the maximum fuel cladding and DSC component temperatures.

<u>A) Reconciliation of DSC Shell Temperatures for Steady-State Evaluations</u>

As described in Appendix C, Section 4.2 of Reference 4, steady-state thermal analysis is performed for normal/off-normal storage conditions. For these evaluations, the heat load is considered to be distributed evenly on the radial inner surface of the DSC shell with a length equivalent to the basket length.

Decay heat flux, $q = \dfrac{Q}{\pi D_i L_B}$

where,
Q = decay heat load,
D_i = inner DSC diameter (ID),
L_B = DSC basket length.

The decay heat flux applied in the steady-state thermal analysis of the HSM-H depends only on DSC inner diameter, basket length and decay heat load. It does not depend on the explicit differences between the 61BTH DSC basket assembly and the 32PHB DSC basket assembly. Table 1 presents a comparison of the heat flux between the 61BTH DSC with 31.2 kW heat load and the 32PHB DSC with 29.6 kW heat load. As seen from Table 1, the heat flux for the 61BTH DSC is larger compared to the 32PHB DSC. Therefore, the DSC shell temperature profile and the maximum HSM-H component temperatures from the thermal evaluation of 61BTH DSC in HSM-H are bounding for the 32PHB DSC in HSM-HB.

Table 1 - Comparison of Heat Flux and Heat Generation for HSM-H/61BTH DSC and HSM-HB/32PHB DSC Models [Table 6-1 of Reference 4]

DSC	**61BTH**	**32PHB**
Total DSC Axial Length, in	195.8	172.75
Basket length, in	164	158
Outer diameter, in	67.25	67.25
Inner diameter, in	66.25	66
Heat load Q, kW	31.2	29.6
Heat load Q, Btu/hr	106464	101004
Heat flux q, Btu/hr-in²	*3.119*	*3.083*
Heat generation rate $\dot{q}$, Btu/hr-in³	0.188	0.187

B) Reconciliation of DSC Shell Temperatures for Transient Evaluations

As described in Appendix C, Section 4.3 of Reference 4, a transient thermal evaluation is performed to evaluate the blocked vent accident condition of 61BTH DSC in HSM-H. For this evaluation, the DSC internal contents including basket, fuel assemblies and the top grid are modeled as homogenized materials with effective properties to represent the thermal mass of the basket assembly. The total heat load of the DSC, 31.2 kW, is applied uniformly as volumetric heat generation rate on all of the elements representing the homogenized basket. The amount of generated heat per unit volume of the homogenized basket is:

Heat generation rate, $$\dot{q} = \frac{Q}{(\pi/4\ D_i^2 L_B)}$$

As shown in Table 1, the heat generation rate applied in thermal analysis of the HSM-HB with 32PHB DSC is bounded by the heat generation rate used in the thermal analysis of the HSM-H with 61BTH DSC.

A comparison of the effective properties between 32PHB basket assembly and 61BTH basket assembly is listed in Table 2. The effective density and specific heat for 32PHB basket and 61BTH basket are listed in Table D-1 of Reference 10 and Appendix C, Section 3.1.1 of Reference 4, respectively. The low value of effective specific heat at 200°F is chosen for comparison.

Table 2 - Comparison of Heat Capacity for Homogenized Basket Assembly of 61BTH DSC and 32PHB DSC

Basket Type	$\rho_{eff,basket}$ (lbm/in^3)	$Cp_{eff,basket}$ (Btu/lbm-°F)	$(\rho \times Cp)_{basket}$ (Btu/in^3-°F)	$\frac{(\rho \times Cp)_{61BTH}}{(\rho \times Cp)_{32PHB}}$
61BTH	0.1145	0.0959	0.01098	0.88
32PHB	0.126	0.099	0.01247	

As shown in Table 2, the overall heat capacity for the 61BTH basket assembly (density × specific heat) is about 12% lower than that for the 32PHB basket assembly. Therefore, the heat up rate for the 32PHB DSC is lower than that for the 61BTH DSC for the same heat load.

As described in Appendix C, Section 4.3 of Reference 4, the initial conditions for the blocked vent accident case are based on the steady-state evaluations discussed in Item A of this response. Based on the discussion in Item A, the initial conditions determined for the 61BTH DSC in the HSM-H are bounding for the 32PHB DSC in the HSM-HB.

Based on the comparison of the heat generation rate, heat capacity and initial conditions in Item A and Item B of this response, the DSC shell temperature profile and the maximum HSM-H component temperatures from the thermal evaluation of the 61BTH DSC in the HSM-H is bounding for the 32PHB DSC in the HSM-HB.

A similar approach of using the DSC shell temperature profiles from the 32PTH1 DSC in the HSM-H with 31.2 kW to evaluate the thermal performance of the 37PTH DSC in the HSM-H with 30.0 kW is discussed in Reference 2, Appendix Z, Section Z.4.4.2 as part of Amendment 13 to CoC 1004 (certificate issued on 05/24/2014).

NRC RAI 6-5:

Justify why an ambient temperature of 0°F is selected as the design basis DSC shell temperatures under normal storage for 32PHB DSC storage conditions.

The applicant stated in Section 5.1.2 of calculation package NUH32PHB-0403 that the DSC shell temperatures for the 31.2 kW heat load in the HSM-H model are used to map the surface temperatures for 32PHB DSC shell surface temperatures. The DSC shell temperatures based on normal ambient 0°F, off-normal ambient 117°F and accident 40-hour blocked vent from the HSM-H model are the design basis DSC shell temperatures for 32PHB DSC storage conditions.

The staff questions the description of an ambient temperature of 0°F as "normal". This temperature is in some cases used as "cold, normal", but a more appropriate mapping of the DSC shell temperatures would be at "hot, normal" ambient, which is more typically 100°F, and is usually selected as the design basis ambient temperature for normal storage conditions. A lower ambient temperature of 0°F would be less conservative in thermal calculations under normal storage. The applicant is required to clarify use of 0°F ambient to define normal storage conditions in the evaluations in calculation package NUH32PHB- 0403.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-5:

Response provided in Reference 1.

NRC RAI 6-6:

Justify the application of the solar heat load to only the top half of the horizontal package during outdoor transfer operations. Perform sensitivity studies of the effect of this assumption by applying the solar heat load to the full circumference of the cask when in the horizontal orientation.

The applicant assumes that only the "top half" of the cask sees the solar heat load when in the horizontal orientation. However, the heat load values specified in 10 CFR 71.71 are based on a circumferential average, calculated from detailed studies of specular solar radiation on exposed surfaces of various shapes, taking into account the fact that the lower half of a horizontal cylinder still sees some solar radiation, due to reflection from the ground, and the changing angle of the sun throughout the day. The averaged values specified in 10 CFR 71.71 should therefore be applied to the full circumference of the cask. The applicant should explain in detail (including analyses of specular radiation on horizontal cylinders, if appropriate) why it might be appropriate to apply the 10 CFR 71.71 solar heat load value to only the top half of the cask when in the horizontal orientation.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-6:

A sensitivity study to evaluate the effect of the solar heat on the full circumference of the transfer cask is presented in Appendix E of Reference 10. Appendix E of Reference 10 also presents a discussion on the solar heat load values used in the design basis evaluations in comparison to the solar heat load values from 10 CFR 71.71.

Table 1 presents the maximum temperatures of fuel cladding, TC and DSC components for sensitivity analysis with solar heat load applied to the full circumference of the TC in comparison to the design basis values listed in Table 7-1 of Reference 10 and Table 6-1 and Table 6-2 of Reference 14.

Table 1 - Sensitivity of Maximum Temperatures of Fuel Cladding, TC and DSC Components to Solar Heat Load Boundary Conditions

	Temperature [°F]		
	Off-Normal Hot @ 20 hr (Load Case # 6)		
	Sensitivity Run	**Design Basis Run**	
Solar Heat Load	Full Circumference	Top Half	Difference
TC Component	**Table E-3 of Ref. 10**	**Table 7-1 of Ref. 10**	$T_{Sensitivity} - T_{Design\ Basis}$
Inner Shell	318	313	+5
Gamma Shield	312	308	+4
Structural Shell	270	263	+7
Bulk Avg. Temp of Radial Neutron Shield	212	214	-2
Bulk Avg. Temp of Top Neutron Shield	170	186	-16
Bulk Avg. Temp of Bottom Neutron Shield	186	201	-15
Cask Lid (Top Cover Plate)	217	216	+1
Cask Outer Shell (Neutron Shield Panel)	236	233	+3
DSC Component	**Table E-3 of Ref. 10**	**Table 6-1/Table 6-2 of Ref. 14**	$T_{Sensitivity} - T_{Design\ Basis}$
Fuel Cladding	728	728	0
Basket Plates	709	709	0
Al/Poison Plate	708	708	0
Basket Rail	470	472	-2
Top Shield Plug	343	346	-3
Bottom Shield Plug	354	358	-4
Cavity Gas (Average)	515	516	-1
Fuel Cladding (Average)	566	566	0
Max. DSC Shell	405	408	-3

As seen from Table 1, for the various TC components the maximum temperatures retrieved from the sensitivity analysis (solar insolation from 10 CFR 71.71 applied over the full circumference) vary slightly compared to the design basis temperatures determined with a solar heat load 127 Btu/hr-ft^2 (applied over the upper half of the curved surfaces and on all vertical surfaces). However, all temperatures remain below their allowable limits and there is no adverse impact by the application of solar heat load over the entire circumference of the TC outer surfaces.

Further, as described in Section 5.1.2 of Reference 15, the thermal stress evaluation of the TC loaded with the 32PHB DSC is based on the design basis thermal stress evaluation of the TC loaded with the 32P DSC, which is documented in Reference 16. As discussed in Section 3.4.1 of Appendix 1 in Reference 16, the thermal stress analysis is based on a design temperature of 400°F for the TC, which is higher than all the temperatures for the TC components reported in

Table 1. Therefore, there is no impact of small temperature increases observed for some of the TC components on the structural analysis.

In addition, as seen from Table 1, there is no impact on the maximum temperature of the fuel cladding due to the change in the solar heat load boundary conditions. Further, the maximum temperatures for the various DSC components are either reduced or not impacted due to the change in the solar heat load boundary conditions. This shows that the fuel cladding and the DSC components are not impacted due to the change in the application of the solar heat load.

Therefore, the application of the conservative solar heat load of 127°Btu/hr-ft^2 only to the top half of the transfer cask during outdoor transfer operation is adequate to evaluate the thermal performance of the 32PHB DSC in the CCNPP-forced air circulation TC.

Computer files for the sensitivity study listed for Appendix E of Reference 10 are enclosed (Enclosure 3) as part of this response to facilitate NRC review.

NRC RAI 6-7:

Analyze meshing sensitivity and spatial discretization error with the GCI method and provide the calculations for review.

The applicant performed the thermal calculations of 32PHB DSC using 3-D ANSYS finite element model. The sensitivity of meshing on temperature distribution was investigated for 32P DSC (not 32PHB DSC) and the results show the maximum fuel cladding temperature change is within 1°F for 14x14 meshing when compared to the coarse meshing. The applicant stated in calculation package NUH32PHB-0403 that the results from the model meshing sensitivity analysis of 32P DSC can be applied to 32PHB DSC model with a meshing of 14x14.

Given that the application is aimed for 32PHB DSC and the 32PHB DSC model is available, the applicant should analyze the spatial discretization error directly using the 32PHB DSC model with the grid convergence index (GCI) method which is described in NUREG-2152 "Computational Fluid Dynamics Best Practice Guidelines for Dry Cask Applications".

When using the GCI method to estimate the discretization error, the following criteria should be met:

- *The solution from the different grids used display monotonic convergence.*
- *The solution from the different grids used should be in the asymptotic range.*

The applicant should provide the calculations for review.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-7:

Meshing sensitivity and spatial discretization error with the GCI method and calculations have been analyzed. Analysis included executing an additional calculation (Reference 17, provided as Enclosures 7 and 16) performing a grid convergence study of the ANSYS finite element model used for the thermal evaluation of the NUHOMS® 32PHB DSC in Reference 14 and determining the discretization error of the solution. The grid convergence index (GCI) and discretization error are determined using the five-step procedure for uncertainty estimation specified in Section 2-4.1 of ASME V&V 20-2009 (Reference 18).

As seen from Table 6-1 of Reference 14, the thermal evaluation for the DSC in Vertical TC at 20 hrs. within the fuel building has the lowest margin to the fuel cladding temperature limit of 752°F. Therefore, this load case is evaluated using four levels of meshes generated with systematic grid refinement as follows:

Mesh	Total Number of Elements	Mesh Refinement Factor
Baseline Mesh (Grid # 1)	935,820	
Fine Mesh 1 (Grid # 2)	2,295,000	1.35
Fine Mesh 2 (Grid # 3)	4,369,000	1.24
Fine Mesh 3 (Grid # 4)	8,263,578	1.24

Using the four meshes, two sets of calculations are performed to determine the discretization error. Each set comprises of three grids based on the guidelines noted in Step 2, Section 2-4.1 of Reference 18. In Set # 1, Grids # 1, 2, and 3 are considered. In Set # 2, Grids # 2, 3, and 4 are considered.

As seen from Table 3 in Reference 17, the GCIs are 0.097% and 0.002% for Set # 1 and # 2, respectively. The dimensional discretization errors are 0.72°F and 0.01°F for Set # 1 and # 2, respectively. These small values of GCI and discretization errors indicate that the computed maximum fuel cladding temperature is close to the asymptotic value, and therefore, the computed results are within the asymptotic range.

Figure 1 in Reference 17 shows that the maximum fuel cladding temperatures resulting from the various grids display asymptotic behavior. The maximum fuel cladding temperature increases monotonically as the total number of elements increases, but then approaches the asymptotic range as the mesh is further refined.

For all vertical transfer conditions reported in Reference 14, the bounding maximum fuel cladding temperature is 733°F for Grid # 1. The maximum fuel cladding temperature based on the fine Grid # 3 with an uncertainty estimate is 740.5°F, which has a margin of 11.5°F to the fuel cladding temperature limit of 752°F in NUREG-1536. The variation of the maximum fuel cladding temperature between the coarsest to the finest grids is as small as 0.86%. Therefore, the thermal evaluations performed using Grid # 1 in Reference 14 remain valid and acceptable.

For the GCI study, the computational files for Grid # 1 from Reference 14 and Grids # 2, 3, and 4 from Reference 17 are enclosed (Enclosure 3) to facilitate review by the NRC.

NRC RAI 6-8:

Explain how the 1.3% increase of the loss coefficient due to the dose reduction inserts is determined when calculating the maximum air temperature rise limit in the cask annulus.

The applicant stated in Section M of Calvert Cliffs ISFSI USAR that the dose reduction inserts for inlet vents of HSM-HB are included in the models developed for the thermal analysis to determine the maximum air temperature rise limit in the storage module. The dose reduction inserts introduce a flow resistance to the air flow through the HSM-HB and will have an effect on the air temperature used for evaluating the NUHOMSO-32PHB DSC in HSM-HB. The increase of the loss coefficient due to the dose reduction inserts constitutes approximately 1.3% of the overall loss coefficient in the HSM-H-B.

The applicant should explain how the loss coefficient increase of 1.3% due to the dose reduction inserts was determined. The applicant should provide the estimate or calculations for staff's review and evaluation.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-8:

Response provided in Reference 1.

NRC RAI 6-9

Evaluate the impact to thermal performance of the poison plate when adding the required minimum areal densities for basket types A and B of 32PHB DSC.

The applicant stated in Calvert Cliffs ISFSI USAR that the proposed amendment will add the required minimum areal density for 32PHB DSC poison plates. The 32PHB DSC poison plate shall have a minimum B^{10} areal density of 0.019 g/cm^2 for basket type A and 0.027 g/cm^2 for basket type B. Given that the change in the properties of the poison plate may affect the heat removal capability, the applicant should evaluate the impact to the thermal performance of the poison plate when adding the required minimum areal densities for basket types A and B of the 32PH DSC.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-9:

Response provided in Reference 1.

NRC RAI 6-10:

Justify the removal of the additional conservatism included in 32P thermal analysis.

The applicant noted in calculation package NUH32PHB-0407 that the radial effective thermal conductivity for the 32PHB DSC are provided up to 1100°F (Figure 8-3) by removing additional conservatism included in the 32P DSC thermal analysis, due to limiting of the temperature scale to 614°F.

The staff needs to understand what additional conservatism is removed from 32P DSC thermal analysis and assure the removal of conservatism from 32P DSC is reasonable and will not affect the thermal evaluation of 32PHB DSC.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-10:

Response provided in Reference 1.

NRC RAI 6-11:

Check the equations of air and helium thermal properties and assure that correct values are used in the actual model calculations.

For air thermal properties (Table 4-8, page 16) and helium thermal properties (Table 4-9, page 17) shown in calculation package NUH32PHB-0402, the equations reported on these two pages for polynomial fits of thermal conductivity, specific heat, and viscosity for air and helium appear to be in error. The equations are given as (for example, with thermal conductivity):

$$k = \sum C_i T_i$$

To be actual polynomial fits, the formula should be

$$k = \sum C_i T_i^t$$

Using the formula as documented (without exponents) yields erroneous values for thermal conductivity, specific heat, and viscosity. (The staff verified this by checking reported gas thermal properties in standard heat transfer textbooks). Using the formula as corrected, with exponents, yields correct and consistent values for these properties over the range reported for Table 4-8.

The applicant should check whether this is documentation error. The applicant should verify that the incorrect values, generated from incorrect equations which are "directly" setup in the model, were not used in the actual calculations. The applicant should verify the modeling input, and provide revised documentation, if appropriate. If modeling input errors are found, the applicant should provide revised calculations, and provide revised results for the thermal analyses.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-11:

The equations used to generate the air and helium properties in the ANSYS models were reviewed and have been found to have correct values. The temperature term for the polynomial is listed incorrectly only in the documentation and does not impact the ANSYS thermal models. The temperature term T_i is corrected to T^i in Tables 4-8 and 4-9 of calculation package NUH32PHB-0402 Rev. 0, and the revised calculation (Reference 10) is enclosed (Enclosure 8) as part of this response.

Further, a review of additional thermal calculations along with their ANSYS models has found that the temperature term has been incorrectly documented in the Design Criteria Document NUH32PHB-0101 Rev. 3, Calculation NUH32PHB-0400 Rev. 1 and Calculation NUH32PHB-0403 Rev. 0. The ANSYS models used the correct values and are not impacted by these documentation errors. The documents were revised and are enclosed (Enclosures 9-11) as part of this response.

NRC RAI 6-12:

Provide derivation of the effective thermal conductivity of nitrogen in the 0.02 Al/Poison contact gap and DSC-rail gap.

The applicant listed the effective thermal conductivity of nitrogen (N_2) for 0.02 Al/Poison contact gap in Table 5-3 and for DSC-rail gap in Table 5-8 of calculation package NUH32PHB-0403.

Explain how the "effective" thermal conductivity (both parallel and across effective thermal conductivities) was derived. The applicant should provide calculations (e.g., Excel spread sheets) to show how the effective thermal conductivity is derived for the 32PHB DSC which has different configuration from other DSCs.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-12:

Response provided in Reference 1.

NRC RAI 6-13:

Provide derivation of the radial effective thermal conductivity of CE 14x14 fuel assembly for nitrogen backfill/blowdown during vacuum drying.

The applicant listed the "radial" effective thermal conductivity of CE 14x14 fuel assembly in 32PHB DSC for nitrogen backfill/blowdown during vacuum drying, in Table 8-2 of the calculation package NUH32PHB-0407.

Explain how the "radial effective" thermal conductivity is derived and provide the calculations (e.g., Excel spread sheets) to show how these radial effective thermal conductivity is derived for the 32PHB DSC which has different configuration from other DSCs.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-13:

Response provided in Reference 1.

NRC RAI 6-14:

Provide derivation of the effective thermal properties of basket stainless steel plate and basket Al1100 plate used in the thermal evaluations of 32PHB DSC.

The applicant listed the "effective" thermal properties for basket stainless steel plate in Table 5-5 and for basket Al1100 plate in Table 5-7 for 32PHB DSC in the calculation package NUH32PHB-0403.

Explain how these "effective" thermal properties are derived and provide the calculations (e.g., Excel spread sheets) to show how these effective thermal properties are derived for the 32PHB DSC which has different configuration from other DSCs.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-14:

Response provided in Reference 1.

NRC RAI 6-15:

Provide References 6 and 7 cited in the calculation package NUH32PHB-0406.

The applicant set the short-term temperature limit of 1300°F for accident conditions per Reference 6 (Engineering Report # NS3-020) in calculation package NUH32PHB-0406. The applicant is required to provide this report for review, so the staff can assure the limit of 1300°F is acceptable.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-15:

Response provided in Reference 1.

NRC RAI 6-16:

Clarify the Action 4 under TS 3.3.2.1 to assure the specification is applicable to 32PHB DSC.

The applicant added new TS 3.3.2.1 in this amendment application, and stated, under Action 4 of TS 3.3.2.1 (see Attachment 2 of Enclosure 5, Marked Up Technical Specification Pages), "Return the transfer cask to the cask to the cask handling area and fill the transfer cask/DSC annulus with clean water, or initiate appropriate external cooling of the transfer cask outer surface by other means to limit the surface temperature increase."

Clarify (a) whether the transfer cask is in vertical orientation or horizontal orientation under Action 4, and (b) what can be the "other means" for limiting the surface temperatures? The clarification of actual activities allowed in Action 4 will help assure that the 32PHB DSC within the TC is maintained within acceptable thermal limits when transfer time limits are exceeded and FC is not available.

This information is required by the staff to determine compliance with 10 CFR 72.128(a)(4).

CCNPP RESPONSE TO RAI 6-16:

The actions specified in proposed Technical Specification 3.3.2.1 are provided to ensure that the maximum fuel cladding and cask components temperatures remain below their allowable limits if the transfer operations cannot be completed within the time limits specified.

Action 4 of the proposed Technical Specification 3.3.2.1 provides additional guidance to return the TC to the cask handling area if it is deemed necessary. In the cask handling area the TC is staged in a vertical orientation. Since the TC is in the vertical orientation, the TC/DSC annulus can be filled with water to ensure that the maximum fuel cladding and cask component temperature do not exceed the allowable limits. To be consistent with the other NUHOMS systems from the general licenses such as CoC 1004 and CoC 1029, the portion of the statement regarding "appropriate external cooling" is removed as shown in the attached Technical Specification markup (Attachment 2) to ensure that all recovery actions are appropriately evaluated in the CCNPP USAR.

REFERENCES

1. Letter from G. H. Gellrich (Exelon Generation) to Document Control Desk (NRC), dated February 3, 2015, Response to Amendment Request No. 1 to Renewed Materials License No. SNM-2505 for the Calvert Cliffs Specific ISFSI – First Request for Additional Information
2. Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NUH-003, Revision. 14, USNRC Docket No. 72-1004, AREVA Inc.
3. Updated Final Safety Analysis Report for NUHOMS® HD, Horizontal Modular Storage System for Irradiated Nuclear Fuel, Revision 4, USNRC Docket No. 72-1030, AREVA Inc.
4. NUH32PHB-0410, Rev. 1, "Reconciliation of Thermal Analyses Results for 32PHB DSC Storage in HSM-HB Module," Transnuclear, Inc.
5. USNRC, "Safety Evaluation Report Transnuclear Inc., Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Docket No. 72-1004 NUHOMS®-24PTH System Amendment No. 8 (ADAMS Accession No. ML053390318)

6. USNRC, "Final Safety Evaluation Report Transnuclear, Inc. Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Docket No. 72-1004 Amendment No. 10 (ADAMS Accession No. ML092290329)
7. USNRC, "Final Safety Evaluation Report Transnuclear Inc., Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Docket No. 72-1004 Amendment No. 13 (ADAMS Accession No. ML14153A579)
8. USNRC, "Safety Evaluation Report for the Transnuclear Inc., NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel," Docket No. 72-1030 (ADAMS Accession No. ML070160089)
9. Calvert Cliffs Nuclear Power Plant, Technical Procedure, ISFSI-03, Revision 01500, Independent Spent Fuel Storage Installation (ISFSI) Loading NUHOMS-32P Dry Shielded Canister
10. NUH32PHB-0402, Rev. 1, "Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off-Normal, and Accident Conditions," Transnuclear, Inc.
11. Letter from G. H. Gellrich (Exelon Generation) to Document Control Desk (NRC), dated March 26, 2014, License Amendment Request: High Burnup NUHOMS-32PHB Dry Shielded Canister
12. NUH32PHB-0401, Rev. 1, "Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident Conditions with Forced Cooling (Steady State)," Transnuclear, Inc.
13. NUH32PHB-0401, Rev. 2, "Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident Conditions with Forced Cooling (Steady State)," Transnuclear, Inc.
14. NUH32PHB-0403, Rev. 1, "Thermal Evaluation of NUHOMS 32PHB DSC for Storage and Transfer Conditions," Transnuclear, Inc.
15. NUH32PHB-0211, Rev. 1, "Reconciliation for Transfer Cask CCNPP-FC Structural Evaluation," Transnuclear, Inc.
16. 1095-35, Rev. 2, "NUHOMS 32P – Transfer Cask Structural Analysis," Transnuclear, Inc.
17. NUH32PHB-0411, Rev. 0, "Grid Convergence Study for the ANSYS Model for the NUHOMS® 32PHB DSC," Transnuclear, Inc.
18. ASME V&V 20-2009, American Society of Mechanical Engineers, "Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer," November 30th, 2009

ENCLOSURE 3

Computation File List

The hard drive containing these files has been provided to J. M. Goshen (NRC, NMSS). The files on the hard drive are PROPRIETARY and covered by the accompanying affidavit because they are contained in the listed calculations. The following list of file names is not proprietary.

RAI-5-3-Structural

NUH32PHB-0204
Appendix A
Appendix B
T_map
Thermal_Stress
Thermal_stress_gap_element.db

NUH32PHB-0205
0-deg
45-deg
60-deg
180-deg
Storage-Transfer-Thermal

NUH32PHB-0208
NUH24PTH-0220

NUH32PHB-0210
0deg
30deg
45deg
Create_Couples

NUH32PHB-0213
fig A-Shell_EnlargedNUH32PHB_LUG_Stress
Fig B_Support Plate Enlarge NUH32PHB_LUG
NUH32PHB_LUG.inp
nuh32phb_lug_model.db
nuh32phb_lug_model.out
nuh32phb_lug_model_4-check-cysm.db
nuh32phb_lug_model_4-check-cysm.out
nuh32phb_lug_model_4-check-cysm.rst
NUH32PHB_LUG_STRESS.db
NUH32PHB_LUG_STRESS.out
NUH32PHB_LUG_STRESS.rst
Plate_weld_forces.txt
plate_weld_nodal_forces.txt
Ring_weld_forces.txt
ring_shell_weld_forces.txt

32PHB Analysis IO summary-f.pptx

-RAI-Thermal-Files

Computational-Files-RAI-6-2b
32PHB_DSC_FC_TRANS
32PHB_DSC_TC_TRANS-8HR
TR_32PHB_29kW_TRANS
TR_32PHB_29kW_TRANS_8HR

Computational-Files-RAI-6-6
32PHB_OFN1
32PHB_TC_OFN1_TRANS

Computational-Files-RAI-6-7
Grid#1
Grid#2
Grid#3
Grid#4

MacDriver

Instruction.pdf
Tuxera NTFS for Mac.dmg

NTI

Setup.exe
User's Manual.pdf

Pogoplug PC

OpenSourceSoftwareInfo
Online Manual
Pogoplug PC for Mac.dmg
Pogoplug PC for Windows Setup.exe

Quick Reference Guide.pdf
Setup.exe
Warrenty.pdf

ENCLOSURE 5

Calvert Cliffs Technical Procedure, ISFSI-03,

Independent Spent Fuel Storage Installation (ISFSI) Loading

NUHOMS-32P Dry Shielded Canister, Section 6.18, Revision 01500

Calvert Cliffs Nuclear Power Plant
TECHNICAL PROCEDURE

ISFSI-03

INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI) LOADING NUHOMS-32P DRY SHIELDED CANISTER

Revision 01500

Safety Related

REFERENCE USE

Approval Authority:
General Supervisor-Mechanical Maintenance

6.18. HSM or HSM-HB Temperature Surveillance

NOTE

- Maximum air temperature rise should be checked a minimum of three times as follows:
- 1 hour after the HSM or HSM-HB door is installed **[B1562]**
- 24 hours after initial temperature surveillance **[B1562]**
- 7 days after initial temperature surveillance to ensure the heat removal capability of the HSM/HSM-HB is within the limits set forth in the ISFSI USAR. **[B1562]**

CAUTION

- Temperature differential between inlet and either outlet shall not exceed 64° F. **(ISFSI TS 3/4.4.1)**
- Measurements shall be obtained using a Type K thermocouple, Range 0-300° F (minimum).

6.18.1. **PERFORM** 1 hour temperature surveillance as follows:

- **RECORD** Thermocouple No: ____________ ________
- **RECORD** Cal Due Date: ________ ________
- **RECORD** Surveillance Date: __________ ________
- **RECORD** Time: ________ ________

NOTE

- Inlet and outlet screens are identified as looking at the HSM-HB Door.
- Optimal temperature measurement location is located in center of each screen.

1. **MEASURE AND RECORD** the following: ________

   - Left Air inlet screen temperature: _________ ________
   - Right Air inlet screen temperature: ________ ________
   - Left air outlet screen temperature: _______ ________
   - Right air outlet screen temperature: _______ ________

6.18 (Continued)

NOTE

Maximum air temperature differential is calculated by comparing the two air inlet screen temperatures, with the front air outlet screen, and rear air outlet screen temperatures on the HSM/HSM-HB.

2. **RECORD** maximum air temperature differential: _____ ________

6.18.1 (Continued)

3. **IF** temperature differential is <u>less than or equal to</u> 64° F,
THEN SIGN below **AND**
PROCEED to Step 6.18.2. ________

Initial Temperature Surveillance Results are acceptable.

Performer	Date/Time
Concurrent Verifier	Date

4. **IF** temperature differential <u>exceeds</u> 64° F,
THEN PERFORM the following:

   a. **NOTIFY** FNF. ________

   b. **PREPARE** to implement Attachment 3, Response to An ISFSI Abnormal Situation. ________

   c. **SIGN** below:

1 hour Temperature Surveillance Results are unacceptable.

Performer	Date/Time
Concurrent Verifier	Date

6.18.2. **INFORM** Control Room Supervisor HSM/HSM-HB Loading is complete. ________

6.18.3. **INFORM** Security HSM/HSM-HB Loading is complete. ________

6.18.4. **INFORM** FNF HSM/HSM-HB Loading is complete. ________

Performer	Date