George H. Gellrich
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CENG
a joint venture of Constellation Energy · eDF

CALVERT CLIFFS
NUCLEAR POWER PLANT

September 1, 2010

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Independent Spent Fuel Storage Installation; Docket No. 72-8
Second Request for Additional Information for License Amendment Request No. 9 to Materials License No. SNM-2505

REFERENCES:
(a) Letter from Mr. J. A. Spina (CCNPP) to Document Control Desk (NRC), dated June 15, 2009, License Amendment Request: Allow Increased Burnup Fuel to be Loaded into NUHOMS-32P Dry Shielded Canister

(b) Letter from Mr. J. Goshen (NRC) to Mr. G. H. Gellrich (CCNPP), dated August 6, 2010, Second Request for Additional Information for License Amendment Request No. 9 to Materials License No. SNM-2505, Calvert Cliffs Independent Spent Fuel Storage Installation (TAC No. L24350)

Calvert Cliffs submitted a license amendment request (Reference a) to allow the loading of increased burnup fuel into a NUHOMS-32P Dry Shielded Canister. The Nuclear Regulatory Commission has requested additional information concerning the supporting structural calculations (Reference b). The requested information is provided in Attachment (1).

Three of the calculations that are enclosed contain information that is proprietary to Transnuclear Inc. Therefore they are accompanied by affidavits (Attachment 2) signed by Transnuclear, Inc., the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission, and addresses, with specificity, the considerations listed in 10 CFR 2.390(b)(4). Accordingly, it is requested that the information proprietary to Transnuclear, Inc. be withheld from public disclosure. Non-proprietary versions of the calculations are also provided for public disclosure.

HMSS01

This additional information does not change the environmental assessment provided in Reference (a) and the categorical exclusion set forth in 10 CFR 51.22(c)(11) is still valid.

Should you have questions regarding this matter, please contact Mr. Douglas E. Lauver at (410) 495-5219.

Very truly yours,

STATE OF MARYLAND :
: **TO WIT:**
COUNTY OF CALVERT :

I, George H. Gellrich, being duly sworn, state that I am Vice President - Calvert Cliffs Nuclear Power Plant, LLC (CCNPP), and that I am duly authorized to execute and file this License Amendment Request on behalf of CCNPP. To the best of my knowledge and belief, the statements contained in this document are true and correct. To the extent that these statements are not based on my personal knowledge, they are based upon information provided by other CCNPP employees and/or consultants. Such information has been reviewed in accordance with company practice and I believe it to be reliable.

Subscribed and sworn before me, a Notary Public in and for the State of Maryland and County of St. Mary's, this 1 day of September, 2010.

WITNESS my Hand and Notarial Seal:

Notary Public

My Commission Expires: March 1, 2011

Date

GHG/PSF/bjd

Attachments: (1) Second Request for Additional Information for License Amendment Request No. 9

Enclosures:

(1) Proprietary Transnuclear Calculation 972-179, Revision 0, TN-68 High Burnup Cladding Mechanical Properties, November 2004
(2) Non-Proprietary Transnuclear Calculation 972-179, Revision 0, TN-68 High Burnup Cladding Mechanical Properties, November 2004
(3) Proprietary Transnuclear Calculation 1095-20, Revision 1, Maximum Operating Pressures, Storage and Transfer, May 2004
(4) Non-Proprietary Transnuclear Calculation 1095-20, Revision 1, Maximum Operating Pressures, Storage and Transfer, May 2004
(5) File Listing for 3 DVDs containing LS-DYNA Files for NUH32P+.0204
(6) Proprietary Transnuclear Calculation NUH32P+.0204, Revision 1, Fuel End Drop Analysis for NUH32P+ Using LS-DYNA, August 2010
(7) Non-Proprietary Transnuclear Calculation NUH32P+.0204, Revision 1, Fuel End Drop Analysis for NUH32P+ Using LS-DYNA, August 2010

(2) Proprietary Affidavits for Calculations 972-179, Revision 0, 1095-20, Revision 1, and NUH32P+.0204, Revision 1

cc: J. M. Goshen, NMSS (including DVDs with files as listed in Enclosure 5)

(Without Enclosures 1, 3, 6)
D. V. Pickett, NRC
M. L. Dapas, NRC
Resident Inspector, NRC
S. Gray, DNR
C. Haney, NMSS
V. L. Ordaz, NMSS

ATTACHMENT (1)

SECOND REQUEST FOR ADDITIONAL INFORMATION FOR LICENSE AMENDMENT REQUEST NO. 9

Calvert Cliffs Nuclear Power Plant, LLC
September 1, 2010

The only design basis accident where structural integrity of the fuel cladding is evaluated is the cask drop event. The Independent Spent Fuel Storage Installation (ISFSI) Updated Safety Analysis Report states that an actual drop event is not considered credible. However, consistent with the current licensing basis, the transfer cask with the dry shielded canister (DSC) inside is evaluated for an end or side drop from a maximum height of 80 inches. Therefore, the integrity of extended burnup fuel assemblies contained within a NUHOMS-32P DSC, following a postulated 80 inch side drop and a postulated 80 inch end drop, was analyzed.

The material property for the fuel pin cladding is dependent on the burnup level, and since the burnup of the fuel assembly is in the high burnup range, new analyses were submitted to structurally qualify the fuel pin. The high burnup material properties are based on information contained in a Pacific Northwest National Laboratory report and have been used in the analyses and reviewed by Nuclear Regulatory Commission (NRC). The NRC has generally accepted two approaches for structural analyses for the fuel pin, quasi-static, and dynamic. For both approaches the analysis should use the irradiated material properties and should include the weight of the fuel pellets. Typically, for end drop structural loadings, the fuel pin buckles in the range of a 13g static load. Therefore, dynamic analysis with strain criteria is used to structurally qualify the fuel pin during end drops. Fuel pin buckling is not a concern for the side drop analysis because of the orientation of the structural loadings, therefore quasi-static analyses are performed and compared with the yield strength of the fuel cladding to structurally qualify the fuel pin during side drops.

Side Drop Analysis

The methodology used in the updated side drop analysis (NUH32P+.0201) is based on that used in 72-1004, Amendment 10. A comparison between the parameters used in 72-1004, Amendment 10 and NUH32P+.0201 are provided below in the Calvert Cliffs Nuclear Power Plant (CCNPP) Response to Request for Additional Information (RAI) 3-1. The differences between the parameters are based on the differences in fuel design between the standard Westinghouse assembly used in 72-1004, Amendment 10 and the Calvert Cliffs fuel. These differences are minor. The analysis method is the same.

Questions 3-1 through 3-5 refer to the side drop analysis presented in Reference 1 (NUH32P+.0201). Responses are provided to those questions as they relate to NUH32P+.0201. Responses related to the original end drop analysis (NUH32P+.0202) were not provided because this analysis has been superseded as noted below.

End Drop Analysis

Following a January 2010 phone call with the NRC Staff, the end drop analysis was re-performed using a different methodology and submitted for review (Reference 2). The end drop analysis uses the LS-DYNA computer code (a finite element analysis). The analysis submitted in Reference 2 followed the methodology outlined in NUREG-1864. Based on recent discussions with the NRC staff, the methodology in the analysis was modified to address their concerns. Specifically, the methodology used in the attached analysis differs from the NUREG-1864 methodology as follows: the cask-to-ground spring was deleted; the unfiltered cask response was applied to the bottom of the pin-to-cask spring; and, damping is applied via the "DAMPING_PART_STIFFNESS" command with a Rayleigh damping coefficient of 0.05. Details are contained in the calculation.

Questions 3-8 through 3-11 refer to the end drop analysis presented in Reference 2 (NUH32P+.0204). Responses to those questions have resulted in a revision to NUH32P+.0204 as described in the CCNPP

Response to RAI 3-11. This revised analysis (NUH32P+.0204, Revision 1) supersedes the originally submitted end drop analysis (NUH32P+.0202).

The results of both the side drop analysis and the modified end drop analysis confirm that the fuel cladding integrity is maintained following these design basis events for fuel with a maximum assembly average burnup of 52,000 MWd/MTU.

	Factor of Safety
Side drop analysis	2.39 (S_y/S_{max})
End drop analysis	2.73 (Principal strain/yield)

Chapter 3.0 Structural Evaluation Part 1 (Referring to NUH32P+.0201, +.0202)

The information requested in all the following questions is needed to determine compliance with 10 CFR 72.122.

NRC Question 3-1:

In its June 15, 2009, amendment application (LAR [License Amendment Request] No. 9) Constellation Energy cited the approved NUHOMS® 32PTH Dry Storage Canister (DSC) design, Docket 72-1030, as a precedent for the Calvert Cliffs NUHOMS -32P DSC. The NRC reviewed and approved the NUHOMS® HD Storage System for Combustion Engineering 14x14 fuel for storage of fuel up to 60,000 MWd/MTU. However, it appears that the NUHOMS® 32PTH1 system approved as part of the Standardized NUHOMS® Horizontal Modular Storage System, Docket No. 72-1004, Amendment No. 10, may be a more appropriate precedent for LAR No. 9. Constellation Energy should clarify the specific system it is using as a precedent and provide a difference evaluation between the analyses used to support the previously approved systems, and TN calculations NUH32P+.0201 and NUH32P+.0202.

CCNPP Response 3-1:

Side Drop Analysis

The fuel side drop analysis for the extended burnup NUHOMS-32P DSC design is documented in the calculation NUH32P+.0201 submitted in Reference 1.

The fuel side drop analyses performed for the Standardized NUHOMS® Horizontal Modular System, Docket No. 72-1004, Amendment 10 license and NUH32P+.0201 are essentially identical. The only difference is the geometry of the fuel cladding. Critical dimensions for the fuel cladding are summarized below.

For the 72-1004, Amendment 10 evaluations, a bounding fuel cladding was selected for the 14x14 class, which was the Westinghouse 14x14 standard fuel assembly. In the NUH32P+.0201 calculation, the bounding fuel assembly is the CE 14x14 standard fuel assembly. The table below summarizes the differences in the analysis for the two applications.

Location of the Analysis	**72-1004, Amendment 10, Section U.3.5.2**	**NUH32P+.0201**
Geometry	Bounding 14x14 Fuel Assembly (WE 14x14)	CE 14x14
Original Fuel Cladding OD (in)	0.422	0.44
Fuel Cladding Thickness (in)	0.0198	0.0252
No. of Spacers	7	9
Maximum Span Length (in)	24.69	17.36
Material Property	$E = 9.93 \times 10^6$ psi $S_y = 92{,}000$ psi	$E = 9.93 \times 10^6$ psi $S_y = 92{,}000$ psi
Software	ANSYS, Rev. 10	ANSYS, Rev. 10
Analysis Type	Quasi-Static	Quasi-Static
Element Type	PIPE16	PIPE16
G-load used in the Analysis	75g	75g

End Drop Analysis

The fuel end drop analysis for the extended burnup NUHOMS-32P DSC design is documented in calculations NUH32P+.0203 and NUH32P+.0204 submitted in Reference 2. Responses to questions concerning those calculations are contained in Responses to RAIs 3-8 through 3-11.

NRC Question 3-2:

Provide a copy of Transnuclear Calculation No. 972-179, Rev. 0, "TN-68 High Burnup Cladding Mechanical Properties." Transnuclear has taken substantial data from this calculation to support the two structural calculations. The staff requires this reference to verify the design information used in the analyses.

CCNPP Response 3-2:

A proprietary and a non-proprietary version of Transnuclear Calculation 972-179, Revision 0 is provided as Enclosures 1 and 2. It should also be noted that material properties calculated and used from this calculation are identical to the material properties used in analyses performed for 72-1004, Amendment 10.

NRC Question 3-3:

Provide a copy of TN Calculation No. 1095-20, Rev. 1, "Maximum Operating Pressures, Storage and Transfer." TN has taken substantial data from this calculation to support the two structural calculations. The staff requires this reference to check the design information used in the analyses.

CCNPP Response 3-3:

A proprietary and non-proprietary version of Transnuclear Calculation 1095-20, Revision 1 is provided as Enclosures 3 and 4.

NRC Question 3-4:

In LAR No. 9 Constellation Energy provided new calculations to support the request to load fuel with up to 52,000 MWd/MTU burnup. It is not clear that these calculations are meant to supersede the design basis for 47,000 MWd/MTU fuel previously supplied as part of the original licensing basis. Constellation Energy needs to provide this clarification.

CCNPP Response 3-4:

Calvert Cliffs intended that the information supplied in support of License Amendment Request No. 9 would become the analysis of record for the NUHOMS-32P canisters in the ISFSI licensing basis, and the Technical Specification burnup and source term limits for the NUHOMS-32P canister would be increased as indicated in Reference 1. However, Calvert Cliffs has no intention of reloading previously loaded NUHOMS-32P canisters with fuel exceeding the 47,000 MWd/MTU limit, or recertifying the loaded canisters to the higher burnup limit since they do not contain fuel in excess of the limit to which they were previously certified. Only the nine unloaded NUHOMS-32P canisters Calvert Cliffs currently possesses, and any future purchases of that canister design, would be certified to the higher burnup and source term limits.

NRC Question 3-5:

Justify the deviation from the SFST-Interim Staff Guide (ISG)-11, Rev. 3 regarding the following structural evaluations of 14X14 fuel assemblies subjected to side and end drop cases:

Referring to Section 4.0 of NUH32P+.0201, Rev. 1 and +.0202, Rev. 1, both of these reports state that the "reduction in outside diameter (OD) and thickness of cladding is based on the formation of oxides" as consistent with the ISG-11, Rev 3. However, it appears that in the ANSYS analyses, a nominal OD of 0.4334 inch and a nominal thickness of 0.0252 inch were considered for pipe elements (PIPE16 and PIPE20).

Based on the oxide layer of 125 microns, the nominal OD and nominal thickness of cladding should have been reduced by 0.00281 inch. The absorbed oxide thickness in the cladding OD should be considered as "wastage" adding no capability of load-bearing.

If the applicant is committing to using the guidance provided in ISG-11, Rev. 3, then it is incumbent on the applicant to apply the guidance correctly when calculating the stress in the cladding by using the "effective cross sectional properties of cladding," as stated in ISG-11, Rev. 3.

CCNPP Response 3-5:

The outer diameter and the nominal thickness of the CE 14x14 standard fuel cladding are 0.44 inches and 0.028 inches, respectively (see Table A-1 in NUH32P+.0201 submitted in Reference 1). Considering an oxidization thickness of 0.00281 inches, the reduced outer diameter and nominal thickness are 0.4344 inches and 0.0252 inches, respectively. The reduced outer diameter and nominal thicknesses are considered in the analyses.

NRC Question 3-6:

Model sensitivity analyses are requested for NUH32P +.0202, Rev. 1. The single pin evaluation methodology includes some assumptions that are not necessarily conservative. Provide a direct comparison between the final NUH32P +.0202 results and the following three sensitivity analysis cases.

a.) Zero Damping: Eliminate all damping from the model. Section 4.0 of NUH32P+.0202, Rev. 1 states the 5% damping assumption is conservative for various reasons. However, it is standard engineering practice to include the mass of fuel in cladding but to ignore any mechanical benefits the spent fuel might offer. Excessive damping can artificially reduce peak cladding stress and strain.

Compare the damped results to the undamped results to demonstrate that damping is not a significant factor in the calculations.

b.) Internal Pressure: Calculate the fuel pin impact response assuming both pressurized and unpressurized conditions. Ignoring internal pressure is not always a conservative assumption. While internal pressure can stabilize a fuel pin against lateral deflections it can also exacerbate plastic strains when they occur. ANSYS pipe elements (PIPE16, PIPE20) cannot capture this type of nonlinear effect so a different choice of element type will be needed to represent the cladding. Compare the pressurized results to the unpressurized results to confirm that the most conservative case is being considered.

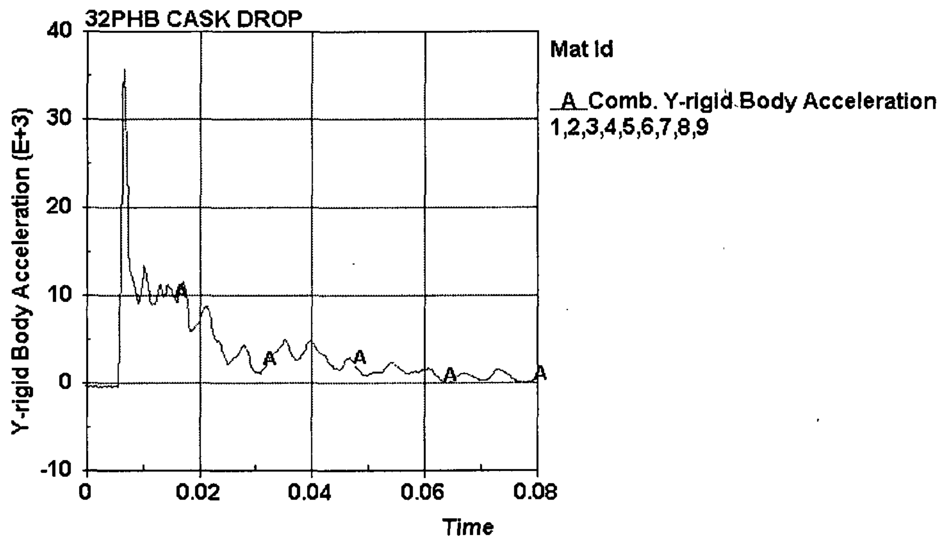
c.) Realistic Grid Spacer Lateral Motion: Apply grid spacer springs to the fuel pin model (similar to what was done in reference 2.15 of NUH32P +.0202). Applying zero lateral deflection constraints at the spacer grids does not match the reality of the fuel assembly structure. Some amount of lateral deflection is possible at the spacer grids, either through gross relative motion of the spacer grids within the basket compartment or through deflection against the leaf springs. Compare the results of realistic grid spacer representation to the constrained lateral motion results to ensure that the most conservative case is being considered.

CCNPP Response 3-6:

Calculation NUH32P+.0202 from Reference 1 is no longer used to evaluate the effects of a fuel end drop. Calculations NUH32P+.0203 and NUH32P+.0204 submitted in Reference 2 evaluate the effects of a fuel end drop. Requests for Additional Information concerning the NHU32P+.0203 and NUH32P+.0204 calculations are contained in Questions 3-8 through 3-11 below.

NRC Question 3-7

The forcing functions applied to the cladding in NUH32P+.0202, Rev. 1, Figure 3, do not appear to be a reasonable approximation of the load history a fuel assembly or fuel pins would experience in a realistic cask drop. The results of NUH32P+.0203 suggest a far different acceleration history can be expected on the fuel. For example, the rigid body acceleration history of the combined Center of Gravity (CG) of the cask and all its subcomponents shows a 92g peak acceleration, with a positive acceleration beyond 60 ms (see the figure attached below, units are in/s^2.). As another example, the velocity of the cask's combined CG does not reverse sign until after 40 ms. These indicators from the 3 dimensional cask impact model suggest that the family of forcing function curves in NUH32P+.0202, Rev. 1, Figure 3, are not realistic, and because of the differences in magnitude and duration may not form conservatively bounding loading conditions for the fuel cladding evaluation. Realistic loading is required, which may include dynamic effects associated with end plate flexibility, because end plate to fuel assembly interaction is expected to be significant to load history.



CCNPP Response 3-7:

Calculation NUH32P+.0202 from Reference 1 is no longer used to evaluate the effects of a fuel end drop. Calculations NUH32P+.0203 and NUH32P+.0204 submitted in Reference 2 evaluate the effects of a fuel end drop. Requests for Additional Information concerning the NHU32P+.0203 and NUH32P+.0204 calculations are contained in Questions 3-8 through 3-11 below.

Chapter 3.0 Structural Evaluation Part 2 (Referring to NUH32P+.0203, +.0204)

The information requested in all the following questions is needed to determine compliance with 10 CFR 72.122.

NRC Question 3-8:

Compare the impact target (concrete and soil) modeled in NUH32P+.0203 to the actual potential impact sites at Calvert Cliffs and justify the as-modeled geometry and materials. The range of potential impact surfaces at Calvert Cliffs is expected to include a large concrete pad with variable thickness and an asphalt roadway. The concern is that the as-modeled concrete and soil may not adequately represent the actual conditions at the site.

CCNPP Response 3-8:

The existing road pavement structure along the heavy haul path is bounded by 2 inch asphalt concrete surface on top of a 6 inch asphalt treated base course. The concrete approach slab on the ISFSI pad consists of a 14 inch thick slab of concrete with a 28-day compressive strength ranging from 3,000 to 5,000 psi. Impact of an object as massive and stiff as the transfer cask will tend to punch through the lightly reinforced, thin concrete along the heavy haul path resulting in lower decelerations than a drop on the concrete approach slab at the ISFSI pad. Therefore, the cask decelerations for a cask end drop accident on the concrete approach slab bound the decelerations for a cask end drop accident along the heavy haul path.

The LS-DYNA analysis models a 36 inch thick concrete slab (thicker than the actual 14 inch slab) with the material model developed by LLNL for a compressive strength of 4200 psi. The soil was modeled with elastic material model of E=6,000 psi.

Several sensitivity studies were performed in NUREG/CR-6608 and NUREG-1864 to determine the effect on cask deceleration due to variation in soil properties; it was shown that the cask deceleration is insensitive to the variation in soil properties.

Even though the compressive strength for concrete used in the analysis is lower than the maximum compressive strength of the Calvert Cliffs approach slab, the thickness of the concrete used in the analysis is 2.5 times more than the thickness of the Calvert Cliffs approach slab. Therefore, the analysis is equal to or bounds the range of potential impact surfaces at Calvert Cliffs during the transfer to and from the horizontal storage module. However a sensitivity study was performed to determine the effect of the cask impact response to the maximum principal strain in the fuel pin (see CCNPP Response 3-11).

NRC Question 3-9:

The LS-DYNA model of the cask bottom plate in NUH32P+.0203 has a slight incline on the impact face. Specifically, node #75584 has a y coordinate value of 0.1, when a value of 0.0 would define a flat surface. This feature of the model geometry is expected to affect the cask impact response by altering the concrete crushing footprint. Justify or remove this feature of the cask model.

CCNPP Response 3-9:

This feature is not present in the final model and is not included in the results provided in calculations NUH32P+.0203 and NUH32P+.0204, submitted in Reference 2. However, the input/output files provided in Reference 2 were from an earlier version of the calculation and contained this feature. The input/output files containing corrected information are listed in Enclosure 5 of this submittal.

NRC Question 3-10:

Include the DSC shell assembly bottom end geometry in the cask impact model (NUH32P+.0203) to ensure realistic dynamic interaction between the DSC and the transfer cask is captured. Refer to drawing #84-003-E, near the Shell Assembly Bottom End, Detail 2; these components will be referred to in these RAIs as the "end plate". DSC end plate dynamic (flexibility) effects are expected to have some influence on the fuel pin response. The fuel assemblies interact directly with the DSC end plate during impact, but that is not currently modeled.

CCNPP Response 3-10:

The cask impact analysis was used to determine the response of the cask at the concrete soil interface. The dynamic interaction between the DSC and the transfer cask is captured in the fuel pin analysis (NUH32P+.0204). A sensitivity study was performed to determine the effect of the end plate interaction on the maximum principal strain in the fuel pin, see CCNPP Response 3-11.

NRC Question 3-11:

Implement a physically realistic method of loading the single pin model. The current methodology of NUH32P+.0204 involving the nonlinear spring definition was developed for transportation cask impact limiter behavior and is not appropriate for a hard drop onto concrete (see Ref. 2.1 of NUH32P+.0204). The concern is that the fuel pin must be loaded with a deceleration history that is comparable to the local response of the DSC end plate, because this is the realistic load path. The fuel assemblies contact the

DSC, and through that contact the reaction forces are transferred. Even the flexure of the end plate must be considered to calculate realistic fuel cladding stress and strain results.

CCNPP Response 3-11:

The response to this question discusses both the sensitivity studies mentioned in the response to question 3-8 and 3-10, and a revision to the NUH32P+.0204 fuel end drop calculation. Two different models are used in the responses below. The first model (Model I) is used to determine the effects of different parameters on the maximum principal strain in a series of sensitivity studies. The second model (Model II) is used to calculate the maximum principal strain using an unfiltered cask response. The models are described in NUH32P+.0204, Revision 1. The proprietary and non-proprietary versions of this calculation are attached as Enclosures 6 and 7.

Sensitivity Analyses

Model I is used for the sensitivity analyses described below. The model is consistent with the model developed in Reference 2.1 of NUH32P+.0204, which utilizes a nonlinear spring representing the mechanical response for the concrete impacted by the loaded cask. This model is the same as the model in NUH32P+.0204, Revision 0 (Reference 2), except the fuel pin axial pressure is taken into consideration. As mentioned in the cover letter of Reference 2, the fuel pin analysis took into account the fuel pin internal pressure only in the radial direction. The axial pressure which helps stabilize the fuel pin was not included in the model. Analyses are performed with and without fuel pin internal pressure, Cases 1 and 2 respectively, to determine the bounding condition. The maximum principal strains in the fuel pin are 0.189% and 0.094% for the cases with and without internal pressure, respectively.

There are two springs in the fuel drop analysis which accounts for the load path between the fuel pin and ground; pin-to-cask spring and cask-to-ground spring. Sensitivity analyses are performed on each spring to determine the effect of variation on the maximum principal strain.

Cask-to-Ground Spring

The cask-to-ground spring represents the mechanical response for the concrete impacted by the loaded cask. The spring is characterized by a constant force deflection curve where the magnitude of the constant force is determined through an iterative process to approximately match the deformation characteristics of the transfer cask. A sensitivity study is performed to determine the effect of the spring on the maximum principal strain in the fuel pin. The magnitude of the constant force is varied ±25%, Cases 3 and 4. The 25% used in the sensitivity analysis bounds the difference in the compressive strength used in the analysis vs. the maximum compressive strength of the ISFSI approach slab concrete. The maximum principal strains are 0.207% and 0.187% for plus 25% and minus 25%, respectively.

Pin-to-Cask Spring

A compression-only spring (1E5 lb/in) is used to model the flexure behavior of the fuel end plate and the DSC end plate. The stiffness of the fuel end plate was estimated as 1E5 lb/in in Reference 2.1 of NUH32P+.0204. For the DSC end plate, the equivalent stiffness of a simply supported circular plate is 7.7E5 lb/in. For two springs in series, the combined stiffness is $1/K_T = 1/K_1 + 1/K_2$, thus the combined stiffness of the fuel end plate and DSC end plate is 0.85E5 lb/in. It is seen that the combined stiffness is insensitive to the DSC end plate stiffness. However, sensitivity analyses are performed where the stiffness of the pin-to-cask spring is varied ±25%, Cases 5 and 6. The 25% used in the sensitivity analysis bounds the effect of the DSC end plate on the combined stiffness of the pin-to-cask spring. The maximum principal strains are 0.194% and 0.199% for plus 25% and minus 25%, respectively.

From these sensitivity studies, summarized in the table below, it is concluded that the maximum principal strains are insensitive to the small variation in the inputs and that the maximum principal strain is well below the yield strain of 0.93%.

Case Number	Description	Max Principal Strain (%)	Yield Strain (%)
1	Baseline Case with Internal Pressure	0.189	0.93
2	Baseline Case without Internal Pressure	0.094	0.93
3	Baseline Case with Internal Pressure and plus 25% of the cask-to-ground spring	0.207	0.93
4	Baseline Case with Internal Pressure and minus 25% of the cask-to-ground spring	0.187	0.93
5	Baseline Case with Internal Pressure and plus 25% of the pin-to-cask spring	0.194	0.93
6	Baseline Case with Internal Pressure and minus 25% of the pin-to-cask spring	0.199	0.93

Unfiltered Cask Response

Model II was developed to calculate the maximum principal strain in the fuel pin using an unfiltered cask response. Model I was modified to apply the actual unfiltered (raw) cask deceleration time history to the fuel pin. The following modifications were made to Model I to create Model II:

- The cask-to-ground spring was deleted from the model.
- A large mass is added at the bottom of the pin-to-cask spring and is used to apply the acceleration at the bottom of the pin-to-cask spring via a force time history. The force time history is calculated by multiplying the mass by the cask deceleration time history.

The maximum principal strain calculated in the fuel cladding is 0.34%, which is well below the yield strain of 0.93%. Details of the analysis are contained in Enclosures 6 and 7.

References

1. Letter from Mr. J. A. Spina (CCNPP) to Document Control Desk (NRC), dated June 15, 2009, License Amendment Request: Allow Increased Burnup Fuel to be Loaded into NUHOMS-32P Dry Shielded Canister
2. Letter from G. H. Gellrich (CCNPP) to Document Control Desk (NRC), dated March 31, 2010, Supplemental Information Related License Amendment Request No. 9 (TAC No. L24350)