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December 12, 2003

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant; Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
Independent Spent Fuel Storage Installation; Docket No. 72-8
License Amendment Request: Revision to the Technical Specifications to Support the ISFSI NUHOMS-32P® Upgrade

Pursuant to 10 CFR 72.56, the Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP) hereby requests an Amendment to Materials License No. SNM-2505 by incorporating the changes described below into the Technical Specifications (TS) for the Calvert Cliffs Independent Spent Fuel Storage Installation (ISFSI).

Calvert Cliffs Nuclear Power Plant, Inc. is in the process of optimizing its dry spent fuel storage capacity by upgrading portions of its ISFSI to use the Transnuclear NUHOMS-32P® Dry Shielded Canister. The proposed amendment would revise the ISFSI TS to incorporate changes required to support the NUHOMS-32P® upgrade and changes that support the operation of both the existing NUHOMS-24P® and the NUHOMS-32P® systems. The NUHOMS-32P® design will allow CCNPP to reduce the minimum number of canister loadings each year from four (using the 24P® design) to three (with the 32P® design). This should reduce the total annual radiological dose at CCNPP.

The environmental assessment and technical basis for this proposed change are provided in Attachment (1). Marked-up pages of the affected Technical Specifications are provided in Attachment (2). Attachments (4) through (13) contain calculations provided to support the technical basis described in Attachment (1).

The proposed amendment to the Calvert Cliffs ISFSI Updated Safety Analysis Report and Technical Specifications has been reviewed by our Plant Operations and Safety Review Committee and Nuclear Safety Review Board. They have concluded that implementing this amendment will not result in an undue risk to the health and safety of the public.

The Transnuclear, Inc. calculations that support our safety analyses in Attachment (1) contain information proprietary to Transnuclear, Inc. Therefore, they are accompanied by an affidavit signed by Transnuclear, Inc., 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 address with specificity the considerations listed in 10 CFR 2.790(b)(4). Accordingly, it is respectfully requested that

APO1

the information that is proprietary to Transnuclear, Inc. be withheld from public disclosure. The non-proprietary version of these evaluations are included in this transmittal for public disclosure.

We will be receiving the first NUHOMS-32P® Dry Shielded Canister for loading in August, 2004. To help us meet our internal schedule for our 2004 loading campaign, we request that you review and approve this request by July 1, 2004.

Should you have questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

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

I, George Vanderheyden, being duly sworn, state that I am Vice President - Calvert Cliffs Nuclear Power Plant, Inc. (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 12th day of December, 2003.

WITNESS my Hand and Notarial Seal:

Janet L. Scully
Notary Public

My Commission Expires:

March 25 2007
Date

GV/GT/bjd

Attachments:

(1) Technical Basis and Environmental Assessment

(2) Marked-Up Technical Specification Pages

(3) Transnuclear, Inc. Proprietary Affidavit

(4) CCNPP Engineering Evaluation, "Evaluation of the Shielding Source Terms for ISFSI-32P Phase I Design," Document No. ES200200585-0000, Revision No. 0

(5) Proprietary Transnuclear, Inc. Calculation, "NUHOMS-32P® Radiation Dose Rates for Loading and Transfer," Document No. 1095-49, Revision No. 0

(6) Non-Proprietary Transnuclear, Inc. Calculation, "NUHOMS-32P® Radiation Dose Rates for Loading and Transfer," Document No. 1095-49, Revision No. 0

(7) Proprietary Transnuclear, Inc. Calculation, "NUHOMS-32P® HSM Dose Rates for Calvert Cliffs ISFSI," Document No. 1095-50, Revision No. 0

(8) Non-Proprietary Transnuclear, Inc. Calculation, "NUHOMS-32P® HSM Dose Rates for Calvert Cliffs ISFSI," Document No. 1095-50, Revision No. 0

(9) CCNPP Calculation, "ISFSI 24P® Assembly Insertion Requirements," Document No. CA05803, Revision No. 0

(10) Proprietary Transnuclear, Inc. Calculation, "Criticality Analysis of the NUHOMS-32P® for Calvert Cliffs ISFSI," Document No. 1095-52, Revision No. 0

(11) Non-Proprietary Transnuclear, Inc. Calculation, "Criticality Analysis of the NUHOMS-32P® for Calvert Cliffs ISFSI," Document No. 1095-52, Revision No. 0

(12) Proprietary Transnuclear, Inc. Calculation, "Criticality Analysis of the NUHOMS-32P® for Calvert Cliffs ISFSI," Document No. 1095-59, Revision No. 0

(13) Non-Proprietary Transnuclear, Inc. Calculation, "Criticality Analysis of the NUHOMS-32P® for Calvert Cliffs ISFSI," Document No. 1095-59, Revision No. 0

cc: S. C. O'Connor, NRC

(Without Attachments)

J. Petro, Esquire
J. E. Silberg, Esquire
Director, Project Directorate I-1, NRC
G. S. Vissing, NRC

H. J. Miller, NRC
Resident Inspector, NRC
R. I. McLean, DNR

ATTACHMENT (1)

TECHNICAL BASIS AND

ENVIRONMENTAL ASSESSMENT

TABLE OF CONTENTS

1.0 DESCRIPTION

Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP) is in the process of optimizing its dry spent fuel storage capacity by upgrading portions of its Independent Spent Fuel Storage Installation (ISFSI) to use the Transnuclear NUHOMS-32P® Dry Shielded Canister (DSC). The proposed amendment would revise the ISFSI Technical Specifications (TS) to incorporate changes required to support the NUHOMS-32P® upgrade and changes that support the operation of both the existing NUHOMS-24P® and the NUHOMS-32P® systems. The NUHOMS-32P® system will safely store eight more assemblies than the current NUHOMS-24P® canister using the same external and internal shell dimensions. The NUHOMS-32P® storage capacity is optimized by removing the space between the locations of each fuel assembly and by slightly reducing the size of the storage locations. The NUHOMS-32P® design will allow CCNPP to reduce the minimum number of canister loadings each year from four (using the 24P® design) to three (with the 32P® design). This should reduce the total annual radiological dose at CCNPP.

The proposed changes to support the 32P® upgrade are: (1) TS 2.1 – adding a new neutron source per assembly value for 32P® canisters, (2) Limiting Condition for Operation (LCO) 3.1.1(4) – re-wording to indicate its applicability only to 24P® canisters, and (3) LCO 3.2.1.1 – increasing the required boron concentration from 1800 ppm to 2450 ppm. The proposed changes that support the operation of both the 24P® and the 32P® are: Surveillance Requirement (SR) 4.2.1.1 – increase time between taking boron sample and insertion of first assembly from 1 hour to 24 hours, (2) SR 4.2.1.2 – increase time between taking boron sample and flooding the DSC cavity for unloading from 1 hour to 24 hours, (3) LCO 3.1.1(5) and (6) – correction of an inaccurate statement, and (4) LCO 3.1.1(7) – increase the assembly weight that can be stored from 1,300 lbs to 1,450 lbs. The detailed descriptions and the safety analyses for the proposed revisions are provided below.

2.0 PROPOSED CHANGE

Change the Calvert Cliffs ISFSI TS 2.1, LCO 3.1.1, and TS 3/4.2.1 as shown on the marked-up pages in Attachment (2).

1. **Revision to Calvert Cliffs ISFSI TSs, "Fuel To Be Stored At ISFSI"**

   Functional and Operating Limits TS 2.1 and LCO 3.1.1 ensure that peak fuel rod temperatures, reactivity source, and fuel mass are below the design values. As discussed below, the proposed revisions to these specifications will add new design basis values, correct existing technical inaccuracies, and make administrative changes. Attachment (2) contains the marked-up TS pages.

   a. TS 2.1 - The proposed revision to TS 2.1 will add a new design basis neutron source value of 3.3E8 n/s for the NUHOMS-32P® canisters. Although this new value bounds all assemblies that meet the loading requirements in LCO 3.1.1, since we are not revising the design basis neutron dose rate calculation for the NUHOMS-24P® canisters, we are maintaining the existing 2.23E8 n/s source term. Additionally, for consistency with the latest revision of our Updated Safety Analysis Report (USAR), the referenced USAR table in this TS is changed from Table 10.3.1 to Table 9.4.1.

   b. LCO 3.1.1(4) - This specification is reworded to indicate its applicability only to NUHOMS-24P® canisters.

   c. LCO 3.1.1(5) - The inaccurate statement "This requirement is met if Requirements 2, 3, and 6 are met," is deleted from this TS.

d. LCO 3.1.1(6) – The incorrect reference to the ten-year minimum cooling time is deleted, and similar to TS 2.1 above, the referenced USAR table is changed from Table 10.3.1 to Table 9.4.1.

e. LCO 3.1.1(7) - The proposed change increases the assembly mass limit from 1,300 lbs (590 kg) to 1,450 lbs (658 kg). The current weight limit was acceptable for fuel assemblies used at Calvert Cliffs during the first 15 years of operation. Due to design improvements in the fuel assemblies and longer cycle lengths, the calculated weights of discharged fuel assemblies have increased. Some of the fuel assemblies that would otherwise be eligible for ISFSI storage do not meet the current weight limit of 1,300 lbs. While fuel to be loaded is only expected to marginally exceed the current limit, the proposed new limit will simplify the calculations necessary to verify that the weight limit has been met for fuel assemblies loaded into canisters for storage at the ISFSI facility.

2. **Revision to Calvert Cliffs ISFSI TS 3/4.2.1, "Dissolved Boron Concentration"**

This specification ensures subcriticality during wet fuel loading and unloading operation. As discussed below, the proposed changes support NUHOMS-32P® canister operation and provide operational flexibility. Attachment (2) contains the marked-up TS pages.

a. LCO 3.2.1.1 - The existing specification requires the DSC cavity to be moderated by water with a boron concentration of greater than or equal to 1,800 ppm. We are proposing to increase the required boron concentration to 2,450 ppm to accommodate NUHOMS-32P® canister operation. The proposed limit bounds the operation of the NUHOMS-24P® canister.

b. SR 4.2.1.1 - The existing specification requires verification of boron concentration in the spent fuel pool within one hour prior to insertion of the first spent fuel assembly into a DSC. We propose increasing the initial verification from "within one hour" to "within 24 hours" prior to insertion of the first spent fuel assembly into a DSC. This change will result in greater operational flexibility without any significant impact on safety.

c. SR 4.2.1.2 - The existing specification requires verification of boron concentration in the spent fuel pool within one hour prior to flooding the DSC cavity for unloading the fuel assemblies. We propose increasing the initial verification from "within one hour" to "within 24 hours" prior to flooding the DSC cavity for unloading the fuel assemblies. This change will result in greater operational flexibility without any significant impact on safety.

3.0 BACKGROUND

The existing Calvert Cliffs ISFSI is a NUHOMS-24P® dry storage system designed by Transnuclear, Inc. (formerly known as VECTRA Technologies, Inc.; Pacific Nuclear Fuel Services, Inc.; and Nutech Engineers, Inc.). Calvert Cliffs Nuclear Power Plant, Inc. operates its ISFSI under a site-specific material license. The NUHOMS-24P® system uses a reinforced concrete horizontal storage module (HSM) to store spent fuel that is sealed in a stainless steel DSC. Each DSC holds 24 spent fuel assemblies. The HSM provides radiological shielding and physical protection for the DSC and has internal air flow passages to provide natural circulation cooling for decay heat removal. The Calvert Cliffs ISFSI is licensed for 120 HSMs; 72 HSMs have already been built. A total of 48 HSMs will be loaded with the NUHOMS-24P® DSC.

To optimize the storage of spent fuel assemblies at Calvert Cliffs, a new higher capacity DSC design called the NUHOMS-32P® DSC was developed. The NUHOMS-32P® system will safely store eight more assemblies than our current NUHOMS-24P® canister using the same external and internal shell dimensions. The NUHOMS-32P® storage capacity is optimized by removing the space between the locations of each fuel assembly and by slightly reducing the size of the storage locations. The NUHOMS-32P® design will allow CCNPP to reduce the minimum number of canister loadings each year from four (using the 24P® design) to three (with the 32P® design). This should reduce the total annual radiological dose at CCNPP. We expect to load a total of 72 HSMs with the NUHOMS-32P® canister at CCNPP.

The DSC is a vessel for the confinement of spent nuclear fuel and provides an inert environment to ensure the long-term integrity of the spent fuel. Each DSC contains an outer leak-tight shell and an internal basket assembly. The outer shell provides the structural strength, shielding, and a leak-tight chamber for containing helium. The major difference between the NUHOMS-32P® and 24P® DSC is the internal basket assembly. The NUHOMS-24P® design includes 24 stainless steel guide sleeves (one for each spent fuel assembly), 9 perforated carbon or stainless steel spacer discs, and 4 stainless steel or carbon steel support rods. The nine spacer discs are spaced out along the length of the DSC at locations that approximately coincide with the spent fuel assemblies' eight spacer grids and the single lower retention grid. The spacer discs are not structurally attached to the DSC shell walls or inner cover plates. The guide sleeves traverse the length of the DSC cavity through openings in the nine spacer discs. Four support rods are used to maintain the spacer disc locations. The support rods traverse the length of the DSC cavity through the spacer discs, and are structurally welded to the spacer discs.

The NUHOMS-32P® DSC increases the number of stainless steel guide sleeves to 32 (one for each spent fuel assembly) and uses an egg-crate design made of stainless steel and aluminum (borated and unborated plates) to support the guide sleeves. This egg-crate design is similar to the Transnuclear TN-68 basket assembly currently in use at a number of nuclear plants. Both the guide sleeves and the egg-crate components run the full length of the DSC cavity. This allows the guide sleeves to be in contact with the egg-crate components over the whole length of the DSC cavity verses only at spacer discs in the NUHOMS-24P® design. As with the 24P® design, the basket assembly is not attached to the DSC shell walls or cover plates.

One additional difference is in the location of the vent and siphon ports. They have been moved from the DSC shell wall (24P® location) to the DSC shield plug (32P® location). This change was to improve the welding operation of the shield plug to the DSC shell.

All the major steps for loading and unloading a DSC (welding, vacuum drying, etc.) are the same for the NUHOMS-24P® and 32P® systems. The DSC is loaded into a transfer cask for transporting to and from the HSM.

4.0 <u>TECHNICAL ANALYSIS</u>

1. Revision to Calvert Cliffs ISFSI TSs, "Fuel To Be Stored At ISFSI"

a. Revision to TS 2.1

<u>*Addition of Design Basis New Neutron Source Term*</u>

Limiting Condition for Operation 3.1.1 currently limits the fuel to be loaded in the ISFSI to CE 14x14 assemblies with ^{235}U enrichment ≤ 4.5%, burnup ≤ 47 GWD/MTU, heat output ≤ 660 W, and a minimum cooling time of ten years. Technical Specification 2.1 permits fuel not specifically meeting the requirements of Section 3.1 for maximum burnup and post irradiation time to be stored if it meets the minimum cooling time listed in the Calvert Cliffs ISFSI USAR and the neutron and gamma source requirements. However, it is possible for an assembly that meets the LCO 3.1.1 criteria listed above to have an assembly neutron source term that will exceed the existing TS 2.1 design basis neutron source value of 2.23E8 n/s. This value was used for the NUHOMS-24P® shielding calculations. For NUHOMS-24P®, the ISFSI USAR *radiological source term limit curve* (Figure 7.2-1, Reference 1) *is currently used to identify* assemblies that are bounded by the 2.23E8 n/s source term (refer to Section 1.c below and Attachment (9) for more information). Updated Safety Analysis Report Figure 7.2-1 will be revised to include the radiological source term limit applicable to 32P. We performed an engineering evaluation (Attachment 4) that determined that an assembly neutron source strength of 3.3E8 n/s would bound all assemblies in the pool that are within the LCO 3.1.1 loading limits. Since ^{244}Cm spontaneous fission remains the dominant neutron source at the time when the heat limit of 660 watts is reached, the original neutron source energy spectrum was retained. This higher assembly neutron source was utilized in the NUHOMS-32P® neutron dose rate calculations.

Dose calculations for NUHOMS-32P® transfer cask drop accident (Attachments 5, 6, 7, and 8), where it is assumed that the neutron shielding is lost, indicate that the doses are 1517.6 mrem/hr on contact, and 127.6 mrem/hr at 15 feet, using the proposed neutron source term. The later yields an eight-hour recovery time dose of 1021 mrem at 15 feet. The ISFSI USAR, Section 4.7.3.3, indicates a contact dose rate limit of 5000 mrem/hr for this accident, and 10 CFR 72.106 establishes an accident dose limit of 5 rem at the site boundary. The ISFSI USAR, Section 8.2.5.3, indicates that the NUHOMS-24P® contact dose rate is 1126 mrem/hr, and the dose to an on-site worker at 15 feet will be 776 mrem in the eight hours required to mitigate the accident. Since total dose at 15 feet is less than 5 rem, the 10 CFR 72.106 limit is also met. Both the dose rate and the accident dose for the NUHOMS-32P® with the proposed neutron source term meet the limits, and the 15 feet worker/site-boundary dose increase (1021-776=245 mrem) is a "minimal increase in the consequences of an accident" as defined by 10 CFR 72.48 [i.e., less than 10% of the delta from the old dose to the limit; 10%x(5000– 776) = 422 mrem]. The shielding calculations also show that the egg-crate basket design of the NUHOMS-32P® actually results in a decrease in dose for the transfer cask drop accident compared to the NUHOMS-24P® when the same assembly source term is used for both cases. This reduction in dose is due to the presence of additional steel in the 32P basket design. Therefore, the proposed assembly neutron source term for use with the NUHOMS-32P® basket design results in no significant increase in the potential for, or consequences from radiological accidents.

Changing of the referenced USAR table in this TS from Table 10.3.1 to Table 9.4.1

This is an administrative change and has no safety impact. The Table number was changed in the USAR when information was reorganized. The technical content of the Table remains appropriate for these TSs.

b. Revision to LCO 3.1.1(4)

Spent fuel assemblies for the NUHOMS-24P® design have to meet a minimum burnup verses initial enrichment curve, because there is no requirement for fixed neutron absorbers in the canister basket assembly. This curve is not needed for the NUHOMS-32P® DSC due to the presence of fixed neutron absorbers in the basket assembly. Therefore, this specification is reworded to indicate its applicability only to NUHOMS-24P® canisters.

c. Revision to LCOs 3.1.1(5) and 3.1.1(6)

Deletion of Inaccurate Statements

Limiting Condition for Operation 3.1.1(5) states that the maximum heat generation rate shall not exceed 0.66 kilowatt per fuel assembly. It also states that the maximum heat generation rate requirement is met if LCO 3.1.1(2) [which requires that the maximum enrichment is less than 4.5 w/o U-235], LCO 3.1.1(3) [which requires that maximum assembly average burn-up is less than 47 GWD/MTU], and LCO 3.1.1(6) [which requires that fuel shall have cooled a minimum of ten years after reactor discharge] are met. Based on calculations performed for assembly insertion requirements (Attachment 9), the ten-year minimum cooling time is non-conservative with respect to thermal and radiological considerations for some burnup and enrichment combinations.

The inaccurate parenthetical statement in LCO 3.1.1 that states "This requirement is met if Requirements 2, 3, and 6 are met," and the reference to the ten-year minimum cooling time in LCO 3.1.1(6) are deleted. Calvert Cliffs ISFSI USAR Table 9.4-1 (Reference 1) was updated to generically cover current fuel assembly designs and provides the "Post Discharge Cooling Time To Meet 0.66 kW Decay Heat Limit," as a function of fuel assembly enrichment and burnup. As shown in USAR Table 9.4.1, for some enrichment and burnup combinations ten years is not a sufficient amount of decay time to ensure that the fuel assembly is less than 0.66 kW. Thus, the parenthetical LCO 3.1.1(5) statement is not always true in that just meeting LCO 3.1.1(2), (3), and (6) does not guarantee (by themselves) that the fuel assembly decay heat will be less than 0.66 kW. The time required to meet the 0.66 kW limit is now determined from ISFSI USAR Table 9.4-1. All fuel assemblies currently loaded in the Calvert Cliffs ISFSI met the 0.66 kW limit prior to loading.

Changing of the referenced USAR Table LCO 3.1.1(6) from Table 10.3.1 to Table 9.4.1

Similar to TS 2.1, this is an administrative change and has no safety impact.

d. Revision LCO 3.1.1(7)

The proposed increase in the assembly weight limit from 1,300 lbs to 1,450 lbs is supported by calculations done during the CCNPP ISFSI NUHOMS-24P® design basis reconstitution project in 2001. During this project, all of the applicable ISFSI calculations were validated or revised using a 1,450 lbs per assembly weight limit. The revised fuel integrity analysis that was the subject of our 2001 license amendment request (Reference 2) is based on 1,450 lbs assembly weight. The 1,450 lbs per assembly weight is also used in all the design basis calculations for the NUHOMS-32P® canisters.

The calculations for the 24P® and 32P® canisters show that the increased fuel assembly weight does not change the results of the applicable analyses. The structural integrity of the canisters is evaluated for all normal operations, off-normal operations and accident analysis, and the accident dose exposure is unchanged as a result of the fuel assembly weight increase. The stresses imposed on the transfer cask, transfer equipment, and HSM's as a result of this change are evaluated to be within the required structural limits. Therefore, the intent of this TS, which is to ensure that the fuel assembly mass stays below the design basis values is unaffected for both the NUHOMS-24P® and 32P® canisters. It is also worth noting that Transnuclear's General License for its NUHOMS-24P® system that is similar to CCNPP's NUHOMS-24P® system assumes a maximum assembly weight of 1,682 lbs.

2. **Revision to Calvert Cliffs ISFSI TS 3/4.2.1, "Dissolved Boron Concentration"**

   a. ***Limiting Condition for Operation 3.2.1.1***

The criticality calculations performed for the NUHOMS-32P® upgrade resulted in the need for an increased boron concentration in the moderator water during wet operation. The required increment is from 1,800 ppm to 2,450 ppm. Attachments (10), (11), (12), and (13) are the calculations which were performed that covered all normal, off-normal, and hypothetical accident conditions.

Attachment (10) [and (11)] is a new criticality analysis performed to determine a worst-case bounding K_{eff} value for the NUHOMS-32P® system loaded with CE 14X14 non-Value Added Pellet (VAP) fuel assemblies containing UO_2 fuel enriched up to 4.50 wt% U-235. This calculation is the design basis K_{eff} criticality calculation for the NUHOMS-32P® system for normal and off-normal conditions. Criticality is controlled by taking credit for the 2,450 ppm soluble boron poison present in the spent fuel pool and fixed neutron absorbers present in the NUHOMS-32P® basket. Our current canister system, NUHOMS-24P®, also takes credit for soluble boron in the spent fuel pool (1,800 ppm) but does not require fixed neutron absorbers in the canister basket assembly. Spent fuel assemblies for the NUHOMS-24P® design have to meet a minimum burnup verses initial enrichment curve. This curve is not needed for the NUHOMS-32P® DSC due to the presence of fixed neutron absorbers that are credited in the basket assembly design.

The poison loading requirements for these fixed neutron absorbers are also determined in this calculation package. Fuel assemblies were modeled as unirradiated fuel with a uniform enrichment. The fuel assemblies are conservatively modeled as being infinitely long with periodic boundary conditions at the axial boundaries. Erbia rods and axial or radial enrichment zones are modeled as fully enriched Uranium. All fuel rods are modeled with 100% pure water in the fuel/cladding gap. The fixed poison inside the basket is based on a borated aluminum alloy material design. Credit for 90% of the absorber material (B-10) is assumed in the analysis. This results in a very large margin of conservatism in the calculated K_{eff}.

To support a demonstration of compliance with storage regulations, parametric studies were performed to maximize reactivity for the normal and off-normal storage conditions. These conditions include optimal internal and external moderation, fuel geometry based on the arrangement of fuel assemblies (centered or inward) relative to the center of the basket, geometrical tolerances, poison plate thickness, steel and aluminum rail thicknesses, and temperature. Internal moderator refers to the borated moderator inside the basket structure, while the external moderator refers to the unborated moderator outside the basket, including basket/canister annulus, canister/transfer cask annulus, neutron shield, and outside of the cask.

A series of 121 benchmark criticality calculations were performed by Transnuclear. These calculations assumed unirradiated fuel in the criticality analysis and used the SCALE4.4 computer code package. The Upper Safety Limit (USL) as described in Section 4 of NUREG/CR-6361 was determined using the results of these 121 benchmark calculations. The benchmark problems used to perform this verification are representative of benchmark arrays of commercial light water reactor fuels with the following characteristics: water moderation, boron neutron absorbers, unirradiated light water reactor type fuel, close reflection, and uranium oxide fuel. The 121 uranium oxide experiments were chosen to model a wide range of uranium enrichments, fuel pin pitches, assembly separation, concentration of soluble boron and control elements in order to test the code's ability to accurately calculate K_{eff}. The minimum value of the USL over the parameter range (in this case, the assembly separation distance) is 0.9422. This USL value (0.9422) is based on a methodology bias and an administrative 5% margin on criticality.

The criticality analysis for the NUHOMS-32P® DSC system demonstrates that the maximum K_{eff} value is below the USL of 0.9422 for a variety of loading configurations under normal and off-normal conditions. The maximum K_{eff} value (0.9412) is based on an "inward" loading of all the 32 CE 14x14 fuel assemblies at the maximum enrichment of 4.5 wt% U-235. This configuration includes the minimum compartment tube dimension of 8.47", an internal moderator (soluble boron at 2,450 ppm) density of 70% and an external moderator (pure water) density of 10%. It also conservatively includes allowances for uncertainties due to fuel positioning, basket rail modeling, compartment tube dimensions, poison plate thickness, etc.

Attachment (12) [and (13)] addresses fuel misloads of 5.00 wt% VAP assemblies and the cask drop accident. Even though VAP fuel is not scheduled for storage in NUHOMS-32P® canisters, it resides in the spent fuel pool and could be misloaded into a canister. For fuel misloads, the stack density of the non-VAP fuel assembly is 93.10% full density, which is based on utilizing the maximum density of fuel pellets present in the Calvert Cliffs spent fuel pool. Criticality calculations are carried out to determine the worst case K_{eff} due to a misload of up to 2 VAP fuel assemblies with varying internal moderator density. Subsequently, calculations are also carried out to determine the K_{eff} due to a misload of up to 8 fuel assemblies at full moderator density. The higher misloadings are evaluated at full moderator density because of the fact that, while the assembly misload is expected to be unlikely, the DSC loading verification process would catch any misloadings prior to transfer back to the cask washdown pit and draindown. The maximum K_{eff} for a two-fuel-assembly accident misload is 0.9373 and it occurs at a moderator density of 70%. The maximum K_{eff} for a misload accident at full moderator density with eight fuel assemblies is 0.9385. Both values are less than the USL.

The cask drop accidents are analyzed by assuming that the consequences of a drop result in grid collapse. This enables the fuel pins to re-arrange within a 14x14 lattice with a different pitch. The minimum value of the pitch, 0.4400", is restricted by the size of the clad while the maximum value, 0.6176", is restricted by the compartment size. While it is not credible to assume that the pin pitch would increase following a cask drop accident, it is still evaluated. These cases are analyzed assuming two different moderating materials, helium and 2,450 ppm borated water. For the borated water moderated system with a boron concentration of at least 2,450 ppm, the maximum K_{eff} is 0.9413, which is below the USL of 0.9422. The maximum K_{eff} with helium moderation (K_{eff} less than 0.60) is also well within the USL.

Therefore, with the proposed increase in the boron concentration, the NUHOMS-32P® meets the requirements of 10 CFR 72.124 for normal, off-normal, and hypothetical accident conditions.

b. Surveillance Requirement 4.2.1.1

The existing SR requires verification of boron concentration in the spent fuel pool within one hour prior to insertion of the first spent fuel assembly into a DSC. It also requires reconfirmation at intervals not to exceed 48 hours until such time as the DSC is removed from the spent fuel pool. We propose increasing the initial verification from "within one hour" to "within 24 hours" prior to insertion of the first spent fuel assembly into a DSC. This proposed change is consistent with the provision for verification of boron concentration approved for the NUHOMS-32P® general license. This proposed change will result in greater operational flexibility without any significant impact on safety as determined by the inclusion of this provision in the NUHOMS-32P® general license. This proposed change is still more conservative than the 72-hour frequency required for verifying boron concentration during reactor core alteration. The 72-hour frequency is based on operating experience (Reference 3).

c. *Surveillance Requirement 4.2.1.2*

The existing specification requires verification of boron concentration in the spent fuel pool within one hour prior to flooding the DSC cavity for unloading the fuel assemblies. It also requires reconfirmation at intervals not to exceed 48 hours until such time as the DSC is removed from the spent fuel pool. We propose increasing the initial verification from "within one hour" to "within 24 hours" prior to flooding the DSC cavity for unloading the fuel assemblies. This proposed change is consistent with the provision for verification of boron concentration approved for the NUHOMS-32P® general license. As in the case of the requirement for loading the DSC discussed above, this change will result in greater operational flexibility without any significant impact on safety as determined by the inclusion of this provision in the NUHOMS-32P® general license.

Conclusion

The proposed amendment supports the NUHOMS-32P® upgrade, corrects existing TS deficiencies, and provides operational flexibility without impacting safety. We have demonstrated that as a result of the proposed amendment there is no significant change in the type or significant increase in the amounts of any effluents that may be released offsite, there is no significant increase in individual or cumulative occupational radiation exposure, nor there is a significant increase in the potential for or consequences of radiological accidents. Therefore, the proposed amendment has no impact on the long-term safe storage of spent fuel at the Calvert Cliffs ISFSI, and will not result in an undue risk to the health and safety of the public.

5.0 ENVIRONMENTAL ASSESSMENT

Pursuant to 10 CFR 51.41, Calvert Cliffs Nuclear Power Plant, Inc. has reviewed the environmental impact of the proposed amendment and has determined that it meets the criteria for categorical exclusion set forth in 10 CFR 51.22(c)(11). Therefore, we have not provided a separate document entitled "Supplement to the Applicant's Environmental Report," as would be otherwise required by 10 CFR 51.60. Our determination for categorical exclusion is based on the following evaluation of the proposed amendment against the standards in 10 CFR 51.22(c)(11):

1. *There is no significant change in the type or significant increase in the amounts of any effluents that may be released offsite.*

Revision to Calvert Cliffs Independent Spent Fuel Storage Installation (ISFSI) Technical Specifications (TS), "Fuel To Be Stored At ISFSI"

Technical Specification 2.1 and Limiting Condition for Operation (LCO) 3.1.1 ensure that peak fuel rod temperatures, reactivity, and fuel mass are below the design values. The proposed revisions to these specifications adds new design basis values, correct an existing technical inaccuracy, and make administrative changes. No effluents are released from the ISFSI during operation and the proposed changes have no impact to dry shielded canister (DSC) loading activities. Therefore, there is no significant change in the type or significant increase in the amounts of any effluents that may be released offsite.

Revision to Calvert Cliffs ISFSI TS 3/4.2.1, "Dissolved Boron Concentration"

The proposed increase in the required boron concentration from 1,800 ppm to 2,450 ppm is to accommodate NUHOMS-32P® canister operation, and also bounds the 24P® canister operation. This specification adds additional safety margin for subcriticality during wet fuel loading and unloading operation. The primary control methods for prevention of criticality under wet conditions consist of the physical properties and irradiation history of the fuel, mechanical control of fuel assemblies' location by the DSC basket, neutron absorption in the DSC basket structural materials (in the case of NUHOMS-32P® additional poison neutron absorbers), and administrative controls for fuel identification, verification, and handling. The criticality analyses performed using the proposed boron concentration of 2,450 ppm for the NUHOMS-32P® demonstrated that the maximum K_{eff} value is below the upper safety limit of 0.9422 for a variety of loading configurations under normal, off-normal, and hypothetical accident conditions. The upper safety limit of 0.9422 is based on a methodology bias and an administrative 5% margin for criticality, which is the same as used for the NUHOMS-24P®. The DSC loading and unloading process for NUHOMS-32P® remains unchanged from the NUHOMS-24P® process. The proposed revision to the surveillance requirement has no impact on the effluents release. Therefore, there is no significant change in the type or significant increase in the amounts of any effluents that may be released offsite.

2. *There is no significant increase in individual or cumulative occupational radiation exposure.*

Revision to Calvert Cliffs ISFSI TSs, "Fuel To Be Stored At ISFSI"

The proposed increase in the assembly neutron source term results in some increase in dose rates for some loading and transfer activities and horizontal storage module (HSM) dose locations. However, this increase is generally less than the percent increase in the assembly neutron source term, due to the additional self-shielding provided by the NUHOMS-32P® basket design. In many cases the egg-crate basket design of the NUHOMS-32P® actually results in decreased dose rates for many loading activities, and HSM locations compared to the NUHOMS-24P® when the same assembly source term is used for both designs. This occurs because the inclusion of peripheral steel rails and elimination of space between assemblies for the 32P basket design provides additional shielding that was not present in the tube-and-disk basket of the 24P® design.

With regard to fuel assembly mass increase, the calculations for the 24P® and 32P® canisters show that the increased fuel assembly mass does not change the results of the applicable analyses. The structural integrity of the canisters has been evaluated for all normal operations, off-normal operations, and accident analysis and is shown to be maintained, thus the accident dose exposure is unchanged as a result of the fuel assembly weight increase. All the other proposed changes have no impact on radiation exposure. Therefore, there is no significant increase in individual or cumulative occupational radiation exposure from the proposed revisions to TS 2.1 and LCO 3.1.1.

Revision to Calvert Cliffs ISFSI TS 3/4.2.1, "Dissolved Boron Concentration"

The occupational dose calculations for the 32P® design for the wet configurations assume an 1,800 ppm boron concentration, and are therefore bounded by the proposed 2,450 ppm required boron concentration. The proposed revision to the surveillance requirements has no impact on radiation exposure. Therefore, there is no significant increase in individual or cumulative occupational radiation exposure from the proposed revisions to TS 3/4.2.1.

3. *There is no significant construction impact.*

   The proposed changes do not involve construction of any kind. Therefore, there is no significant construction impact associated with the proposed amendment.

4. *There is no significant increase in the potential for or consequences from radiological accidents.*

   Revision to Calvert Cliffs ISFSI TSs, "Fuel To Be Stored At ISFSI"

   The accident dose for the NUHOMS-32P® with the proposed neutron source term meet the 10 CFR 72.106 regulatory limit. The shielding calculations also show that the egg-crate basket design of the NUHOMS-32P® actually results in a decrease in dose for the transfer cask drop accident compared to the NUHOMS-24P® when the same assembly source term is used for both cases. Therefore, the proposed assembly neutron source term for use with the NUHOMS-32P® basket design results in no significant increase in the potential for, or consequences from radiological accidents.

   As discussed in Item 2 above, the calculations for the 24P® and 32P® canisters show that the increased fuel assembly weight does not change the results of the applicable analysis. The structural integrity of the canisters has been evaluated for all normal operations, off-normal operations, and accident analysis. The stresses imposed on the transfer cask, transfer equipment, and HSM's as a result of this change are evaluated to be within the required structural limits. All the other proposed changes have no impact on radiation exposure. Therefore, there is no significant increase in the potential for or consequences from radiological accidents from the proposed revisions to TSs 2.1 and LCO 3.1.1.

   Revision to Calvert Cliffs ISFSI TS 3/4.2.1, "Dissolved Boron Concentration"

   As discussed in Items 1 and 2 above, the proposed increase in the required dissolved boron concentration from 1,800 ppm to 2,450 ppm for the NUHOMS-32P® design maintains the fuel in a subcritical configuration for all normal, off-normal, and accident conditions, and increases the margin to criticality for the NUHOMS-24P® design. There are no design basis accidents involving a wet canister. The proposed revision to the surveillance requirements has no impact on design basis accidents. Therefore, there is no significant increase in the potential for or consequences from radiological accidents from the proposed revisions to TS 3/4.2.1.

6.0 PRECEDENCE

The NUHOMS-24P® design has been approved as part of the general license granted to Transnuclear, Inc.

Certificate of Conformance 72-1004

7.0 REFERENCES

1. CCNPP ISFSI USAR, Revision 12
2. Letter from C. H. Cruse (CCNPP) to Document Control Desk (NRC), dated July 26, 2001, License Amendment Request: Revision to Fuel Assembly Integrity Analyses Requiring NRC Prior Approval Pursuant to 10 CFR 72.48, and Revision to Technical Specifications 2.3 and 6.3
3. CCNPP TS Bases Surveillance Requirement 3.9.1.1, Revision 10

ATTACHMENT (2)

MARKED-UP TECHNICAL SPECIFICATION PAGES

2.0 FUNCTIONAL AND OPERATING LIMITS

2.1 FUEL TO BE STORED AT ISFSI

9.4.1

SPECIFICATION: Any fuel not specifically filling the requirements of Section 3.1 for maximum burnup and post irradiation time may be stored if it meets the minimum cooling time listed in the Calvert Cliffs ISFSI SAR Table ~~10.3.1~~ 9.4.1 and all the following requirements are met:

Neutron Source Per Assembly (NUHOMS-24P)	$\leq 2.23 \times 10^8$ n/sec/assembly, with spectrum bounded by Table 3.1-4 of the Calvert Cliffs ISFSI SAR
Neutron Source Per Assembly (NUHOMS-32P)	$\leq 3.3 \times 10^8$ n/sec/assembly, with spectrum bounded by Table 3.1-4 of the Calvert Cliffs ISFSI SAR
Gamma Source Per Assembly	$\leq 1.53 \times 10^{15}$ MeV/sec/assembly with spectrum bounded by that shown in Table 3.1-4 of the Calvert Cliffs ISFSI SAR

APPLICABILITY: This specification is applicable to all spent fuel to be stored in the Calvert Cliffs ISFSI.

ACTION: If the requirements of the above specification are not met, do not load the fuel assembly into a DSC for storage.

3/4.1 FUEL TO BE STORED AT ISFSI

LIMITING CONDITION FOR OPERATION

3.1.1 The spent nuclear fuel to be received and stored at the Calvert Cliffs ISFSI shall meet the following requirements:

(1) Only fuel irradiated at the Calvert Cliffs Units 1 or 2 may be used. (14 x 14 CE type PWR Fuel)

(2) Maximum initial enrichment shall not exceed 4.5 weight percent U-235.

(3) Maximum assembly average burnup shall not exceed 47,000 megawatt-days per metric ton uranium.

(Applicable only to NUHOMS-24P)

(4) Minimum burnup shall exceed the minimum specified in SAR Figure 3.3-1.

(5) Maximum heat generation rate shall not exceed 0.66 kilowatt per fuel assembly. ~~*(This requirement is met, if Requirements 2, 3 and 6 are met.)~~

(6) Fuel shall have cooled ~~a minimum of ten years after reactor discharge prior to storage in the Calvert Cliffs ISFSI, or~~ as specified in ISFSI SAR Table ~~10.3-1~~ 9.4.1,

(7) Maximum assembly mass including control components shall not exceed ~~1300~~ 1450 lb.(~~590~~ 658 kg).

(8) Fuel shall be intact unconsolidated fuel.

(9) Fuel assemblies known or suspected to have structural defects (other then a pinhole leaks) sufficiently severe to adversely affect fuel handling and transfer capability shall not be loaded into the DSC for storage.

APPLICABILITY: This specification is applicable to all spent fuel to be stored in Calvert Cliffs ISFSI.

ACTION: If any fuel does not specifically meet the requirements for maximum burnup and post irradiation time (items 3 & 6 above), confirm to see if the requirements of Section 2.1 are satisfied. If any other requirements of the above specification are not satisfied, do not load the fuel assembly into a DSC for storage.

~~* This number may be determined analytically.~~

3/4.2 DRY SHIELDED CANISTER (DSC)

3/4.2.1 DISSOLVED BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.2.1.1 The DSC cavity shall be moderated only by water with a boron concentration greater than or equal to ~~1,800~~ 2,450 ppm ppm.

APPLICABILITY: Applicable to all DSCs.

ACTION:

1. With the measured boron concentration less than the specification prior to the beginning of DSC loading and unloading operations, suspend all activities involving DSC loading and unloading.

2. With the measured boron concentration less than the specification during DSC loading and unloading operations, take action to increase boron concentration while unloading fuel from the DSC.

SURVEILLANCE REQUIREMENTS

4.2.1.1 Within ~~one hour~~ 24 hours prior to insertion of the first spent fuel assembly into a DSC, the dissolved boron concentration in water in the spent fuel pool and introduced into the DSC cavity shall be independently determined by chemical analysis (two samples analyzed by two different individuals). The boron concentration in the water shall be reconfirmed at intervals not to exceed 48 hours until such time as the DSC is removed from the spent fuel pool. All boron concentration measurement shall be documented.

4.2.1.2 Within ~~one hour~~ 24 hours prior to flooding the DSC cavity for unloading the fuel assemblies, the dissolved boron concentration in water in the spent fuel pool and introduced into the DSC cavity shall be independently determined by chemical analysis (two samples analyzed by two different individuals). The boron concentration in the water shall be reconfirmed at intervals not to exceed 48 hours until such time as the fuel has been removed from the DSC. All boron concentration measurements shall be documented.

ATTACHMENT (3)

TRANSNUCLEAR, INC. PROPRIETARY AFFIDAVIT

December 1, 2003

AFFIDAVIT

STATE OF NEW YORK }
}
}
}
COUNTY OF WESTCHESTER }

Before me, the undersigned authority, personally appeared Alan Hanson who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Transnuclear, Inc. and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

Alan S. Hanson

ALAN HANSON

Sworn to and subscribed
Before me this 2 day
of December 2003.

ANNE MARIE CLEARY
Notary Public, State of New York
No. 01CL6001814
Qualified in Westchester County
Commission Expires Jan. 26, 2010

(1) I am President of Transnuclear, Inc. and my responsibilities include reviewing the proprietary information sought to be withheld from public disclosure in connection with the licensing of spent fuel transport cask systems or spent fuel storage cask systems. I am authorized to apply for its withholding on behalf of Transnuclear, Inc.

(2) I am making this Affidavit in conformance with the provisions of 10CFR Section 2.790 of the commission's regulations and in conjunction with the Transnuclear application for withholding accompanying this Affidavit.

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

(4) The following information is furnished pursuant to the provisions of paragraph 10CFR 2.790(b)(4) to determine whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Transnuclear.

(ii) The information is of a type customarily held in confidence by Transnuclear, is not customarily disclosed to the public and is transmitted to the commission in confidence.

(iii) The information sought to be protected is not now available in public sources to the best of our knowledge and belief and the release of such information might result in a loss of competitive advantage as follows:

(a) It reveals the distinguishing aspects of a storage system where prevention of its use by any of Transnuclear's competitors without license from Transnuclear constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a component or material, the application of which secures a competitive economic or technical advantage.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(5) The information is being transmitted to the commission in confidence and, under the provision of 10CFR Section 2.790, it is to be received in confidence by the Commission.

(6) The information sought to be protected is not available in public sources to the best of our knowledge and belief.

(7) The proprietary information sought to be withheld in this submittal is that which is contained in the proprietary version of:

Transnuclear Calculation 1095-49, Revision 0
Transnuclear Calculation 1095-50, Revision 0
Transnuclear Calculation 1095-52, Revision 0
Transnuclear Calculation 1095-59, Revision 0

(8) This information should be held in confidence because it provides details of materials qualification programs that were developed at significant expense. This information has substantial commercial value to Transnuclear in connecting with competition with other vendors for contracts.

The subject information could only be duplicated by competitors if they were to invest time and effort equivalent to that invested by Transnuclear provided they have the requisite talent and experience.

Public disclosure of this information is likely to cause substantial harm to the competitive position of Transnuclear, because it would simplify design and evaluation tasks without requiring a commensurate investment of time and effort.

ATTACHMENT (4)

CCNPP ENGINEERING EVALUATION, "EVALUATION OF THE SHIELDING SOURCE TERMS FOR ISFSI-32P PHASE I DESIGN," DOCUMENT NO. ES200200585-0000, REVISION NO. 0

ESP No.:	ES200200585	Supp No.	000	Rev. No.	0000	Page 1 of 2

FORM 1, ENGINEERING SERVICE PACKAGE COVER SHEET (ESP)
(Page 1 of 2)

INITIATION (Control Doc Type: ESP)

ORIGINATOR/EXT/DATE: J. R. Massari x3707 7/23/2002
PRINTED NAME

REQUESTED DUE DATE: 7/24/02 ☐ UNIT 1 ☐ UNIT 2 ☐ COMMON ☒ ISFSI

NUCLEIS PRIORITY: QSS WINDOW: SYS NO.: 068

MECH NO./NUCLEIS EQUIP. ID:

IR/MO NO.:

ACCOUNT NO.:

REASONS FOR ENGINEERING SERVICES REQUEST/PROPOSED CHANGES:

Evaluation of the Shielding Source Terms for the ISFSI 32P Phase I Design

☐ Check if additional sheets are attached (mark sheets with ESP No., Supplement and Rev. No., as applicable)

PLANT ENGINEERING REVIEW/APPROVAL ☒ N/A

SERVICE REQUESTED

☐ Engineering Assistance Request* ☐ Like-for-Like Evaluation ☐ Equivalent Change Evaluation**
☐ Configuration Document Change ☐ Modification**
☐ Engineering Evaluation ☐ Product Only

*Does not require any further Design assistance. No ESP number required. Attach disposition, obtain System Engineer and System Manager signature, return to initiator

System Engineer: ____________________
System Manager: ____________________

**New Modifications and Equivalent Change Evaluations (5.7.A.2) require Plant Engineering approval
Existing modification scope changes, supplements, and revisions require only Project Manager signature.

System Engineer
(New Mod Only): ____________________ Approved / Disapproved (Circle One)
(Printed Name/Signature)

System Engineer Supervisor
(New Mod Only): ____________________ Approved / Disapproved (Circle One)
(Printed Name/Signature)

Project Manager ____________________ Approved / Disapproved (Circle One)
(Printed Name/Signature)
(Scope Changes/Supplements/ Revisions Only):

Recommended Assignment for Modifications:

Project Manager: Responsible Engineer: Unit:

ESP No.:	ES200200585	Supp No.	000	Rev. No.	0000	Page 2 of 2

FORM 1, ENGINEERING SERVICE PACKAGE COVERSHEET (ESP)
(Page 2 of 2)

FINAL SERVICE

SERVICE PERFORMED (check one)

- ☐ Configuration Document Change
  - ☐ Design Related ☐ Non-Design Related
- ☐ Engineering Evaluation
- ☐ Equivalent Change Evaluation
- ☐ Like-for-Like Evaluation
- ☐ Modification Evaluation
- ☒ Product Only

SERVICE CLASSIFICATION: ☒ SR ☐ NSR ☐ AQ

ENGINEERING REVIEW/APPROVALS (Printed Name and Signature)

RESPONSIBLE INDIVIDUAL/ENGINEER: J. R. Massari Date: 7/23/02

INDEPENDENT REVIEWER: G. E. Gryczkowski Date: 7/24/02

APPROVAL: M. T. Finley Date: 7/30/02

Comments:

IMPLEMENTATION REVIEW/APPROVALS ☐ N/A

POSRC Meeting No.: Date:

POSRC Chairman: ☐ Approved ☐ Disapproved

Plant General Manager: ☐ Approved ☐ Disapproved
(or designee if POSRC review is not required)

CLOSE-OUT (Required for Modifications Only) ☐ N/A [B-36]

Responsible Engineer: ☐ Approved ☐ Disapproved

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FORM 24, ENGINEERING EVALUATION

REASONS FOR ENGINEERING EVALUATION:

An engineering evaluation is required for the changes described below.

DESCRIPTION OF CHANGES:

Evaluation of the Shielding Source Terms for the ISFSI -32P Phase I Design

DETAILED EVALUATION OF CHANGE(S):

REFERENCE:

1. ES200100633 (CA05803), "ISFSI 24P ASSEMBLY INSERTION REQUIREMENTS," 12/31/2001.
2. UCR00317, "ISFSI SAR Table 9.4-1 Update," 12/31/01
3. DES Calculation CCNPP-DES-003, "Calvert Cliffs ISFSI/NUHOMS-24P HSM Dose Rates," Rev. 0.

IR199901540 identified the issue that an assembly could theoretically have a thermal output ≤660 watts and yet still have a neutron and gamma source term that exceeded the design basis. This issue was resolved for the 24P by changing Table 9.4-1 in the ISFSI USAR (Ref. 2). The purpose of this memo is to suggest a revision to the design basis shielding source term to be used for the 32P such that an assembly will be bounded by the design basis source term at the time when it meets the 660 watt limit.

Based on the results of Reference 1, the time required for the neutron source term to fall below the design basis value of 2.23E8 n/sec was the primary contributor to additional decay time beyond what was required to reach 660 watts. Figure 1 provides a general overview of the decay times required for an assembly to reach 660 watts as a function of initial enrichment and burnup (based on Reference 1), and the percentage of the current spent fuel pool inventory that is bounded by each cooling time. Figure 2 show the total neutron source strength at the time that the assembly has a decay heat of 660 watts as a function of initial enrichment and burnup, and also indicates the percentage of the current spent fuel pool inventory that is bounded by each source strength. These curves were developed by fitting data from the ORIGEN 2.1 cases in Reference 1 to the following equation using the Excel97 regression tool:

$$\text{Ln } N660(e,b)= C_0+C_1e+C_2b+C_3e^2+C_4b^2+C_5e^3+C_6b^3+C_7eb$$

Variable	*Coefficients*
C_0	1.4084E+01
C_1	-1.3936E+00
C_2	3.7215E-04
C_3	3.5562E-02
C_4	-6.1017E-09
C_5	-7.2675E-03
C_6	3.0982E-14
C_7	1.8237E-05

In the above equation, e is initial enrichment, and b is burnup in MWd/MTU. The regression has an R^2 of 0.9999, indicating a very good fit. Note however that for burnups > 47 GWd/MTU, the curves in Figures 1 and 2 represent extrapolations based on the Reference 1 ORIGEN 2.1 output. A neutron source term of 5.1E8 n/sec would bound every assembly currently in the spent fuel pool when it has cooled to 660 watts. However, like the 24P, the 32P will also have an assembly burnup limit of 47 GWd/MTU. Table 1 lists the assemblies currently in the spent fuel pool with the highest neutron source strength, as dermined using the above regression. Assembly 1BT07 had the highest n/sec at 660W of any assembly in the pool with a burnup ≤ 47 GWd/MTU, but has now been cooling for over 20 years, and has a neutron source that is ~3E8 n/sec. The next highest neutron source at 660 watts for an assembly ≤ 47 GWd/MTU is assembly 2J107 at 3.21E8 n/sec (3.4% enrichment, 46,575 MWd/MTU, 10.82 years decay). Since this is a recently discharged assembly, it has not yet cooled to 660 watts. Therefore, an assembly neutron source term of 3.3E8 n/sec should conservatively bound 100% of the current spent fuel pool inventory that is ≤ 47 GWd/MTU, at the cooling time required to reach 660 watts. This corresponds to an assembly with a 3.4% enrichment, 47,000 MWd/MTU, and an 11.11 year cooling time. The table below gives other burnup/enrichment/cooling time combinations below 47 GWd/MTU that have a thermal output of 660W and a neutron source of 3.3E8 n/sec. As can be seen from Figure 2, all assemblies with enrichments < 3.4% have burnups well below these values, and it is not anticipated that any of them will be reinserted into the core. However, if an assembly with an enrichment < 3.4% receives a burnup higher than indicated below, a specific analysis should be performed to determine the cooling time when the neutron source will be below 3.3E8 neutrons/sec.

Enrichment (Wt% U235)	Burnup (MWd/MTU)	Cooling Time (years) to 660W & 3.3E8 n/sec
2.05	36218	7.93
2.45	39305	8.39
2.73	41525	8.96
2.99	43627	9.66
3.03	43954	9.78
3.40	47000	11.11

Since ^{244}Cm spontaneous fission remains the dominant neutron source at the time when 660 watts is reached, the original neutron source spectrum should be retained.

Based on the results in Reference 1, the assembly photon source term used for the 24P (3.4% encrichment, 42 GWd/MTU, 8 yr cooling time) bounds all assemblies that have cooled for 10 years or more. Furthermore, Figure 3 compares the cooling times required for the various burnup/enrichment combinations in Reference 1 to fall below both the 660 watt limit and the 24P assembly photon source term (both 4.31E15 photons/sec and 1.53E15 MeV/sec) to the revised ISFSI USAR table 9.4-1 in Reference 2. The results show that the current 24P assembly source term (Ref. 1 for active fuel and Ref. 3 for end-regions) also bounds the cooling times defined in Reference 2, and thus does not require change.

SUMMARY

The tables below summarize the recommended neutron and photon source terms for the 32P phase I design shielding analyses.

Assembly Fuel Region Photon Source Term for 32P Shielding Analyses

Lower MEV	Upper MeV	Neutrons/ sec - assy	energy probability
0.00335	0.11	4.437E+06	0.01344
0.11	0.55	4.377E+07	0.13265
0.55	1.11	6.342E+07	0.19218
1.11	1.83	6.891E+07	0.20881
1.83	3.01	7.407E+07	0.22446
3.01	6.36	6.636E+07	0.20110
6.36	20.00	9.024E+06	0.02735
	total	3.300E+08	1.000000

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Assembly Fuel Region Photon Source Term for 32P Shielding Analyses

Photon Energy (MeV)	Photons/ Sec-assy	Energy Probability
0.0100	9.926E+14	2.299E-01
0.0250	2.228E+14	5.161E-02
0.0375	2.699E+14	6.252E-02
0.0575	1.980E+14	4.587E-02
0.0850	1.215E+14	2.815E-02
0.1250	1.258E+14	2.914E-02
0.2250	9.919E+13	2.298E-02
0.3750	5.282E+13	1.224E-02
0.5750	1.861E+15	4.311E-01
0.8500	2.618E+14	6.065E-02
1.2500	1.090E+14	2.525E-02
1.7500	2.239E+12	5.187E-04
2.2500	1.566E+11	3.628E-05
2.7500	8.750E+09	2.027E-06
3.5000	1.123E+09	2.601E-07
5.0000	9.698E+06	2.247E-09
7.0000	1.118E+06	2.590E-10
9.5000	1.285E+05	2.977E-11
total	4.317E+15	1.000

Assembly End-Region Photon Source Terms for 32P Shielding Analyses

Axial End Regions	Co-60 photons/sec-assy
bottom end fitting	1.1312E+13
top plenum	4.7760E+12
top flowplate	3.1880E+11
top above flowplate	6.1310E+11

Prepared By:

2-25-02

J. R. Massari
Nuclear Engineering Unit

Reviewed By:

2-25-02

G. E. Gryczkowski
Nuclear Engineering Unit

2/25/02

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Figure 1

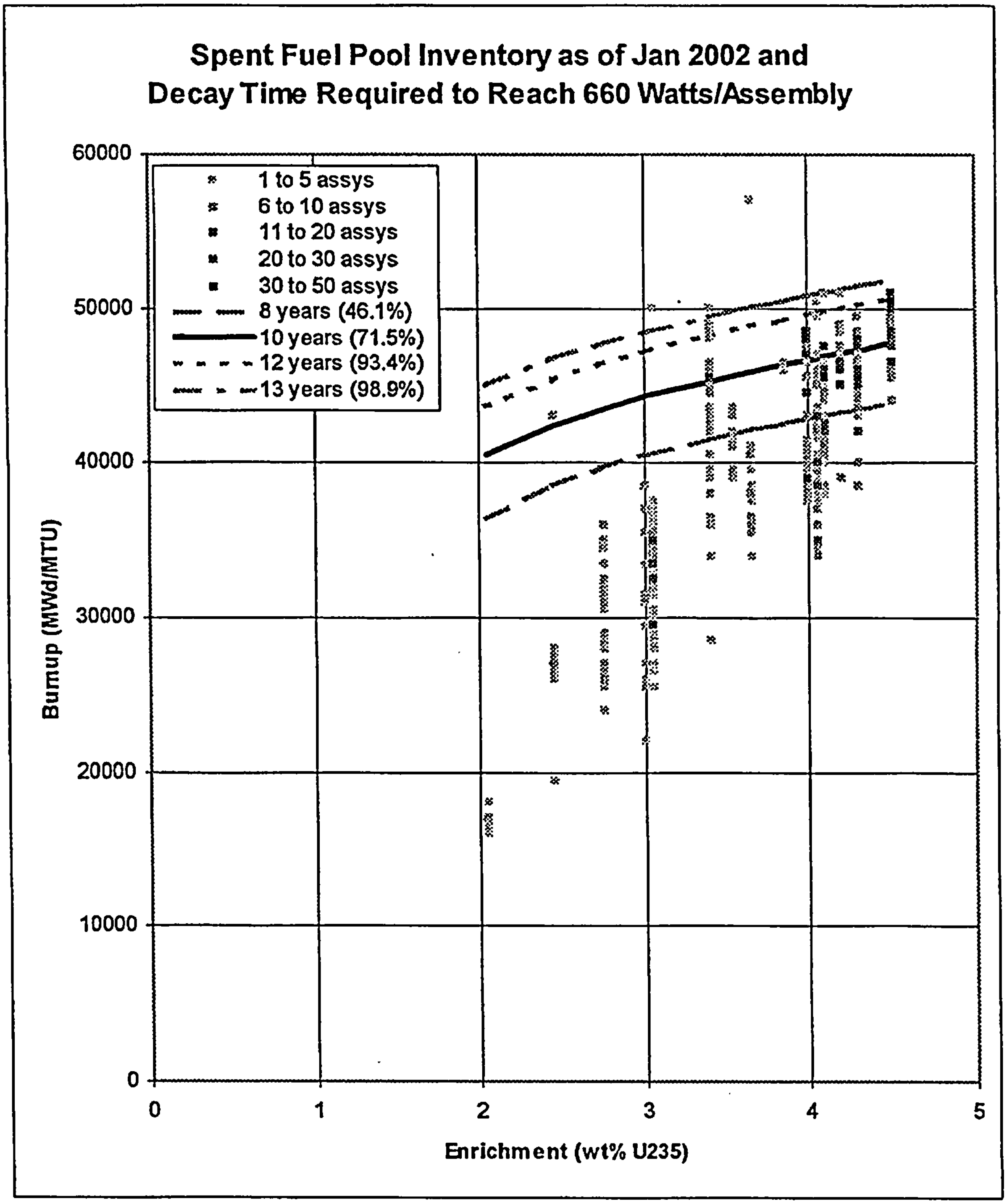

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Figure 2

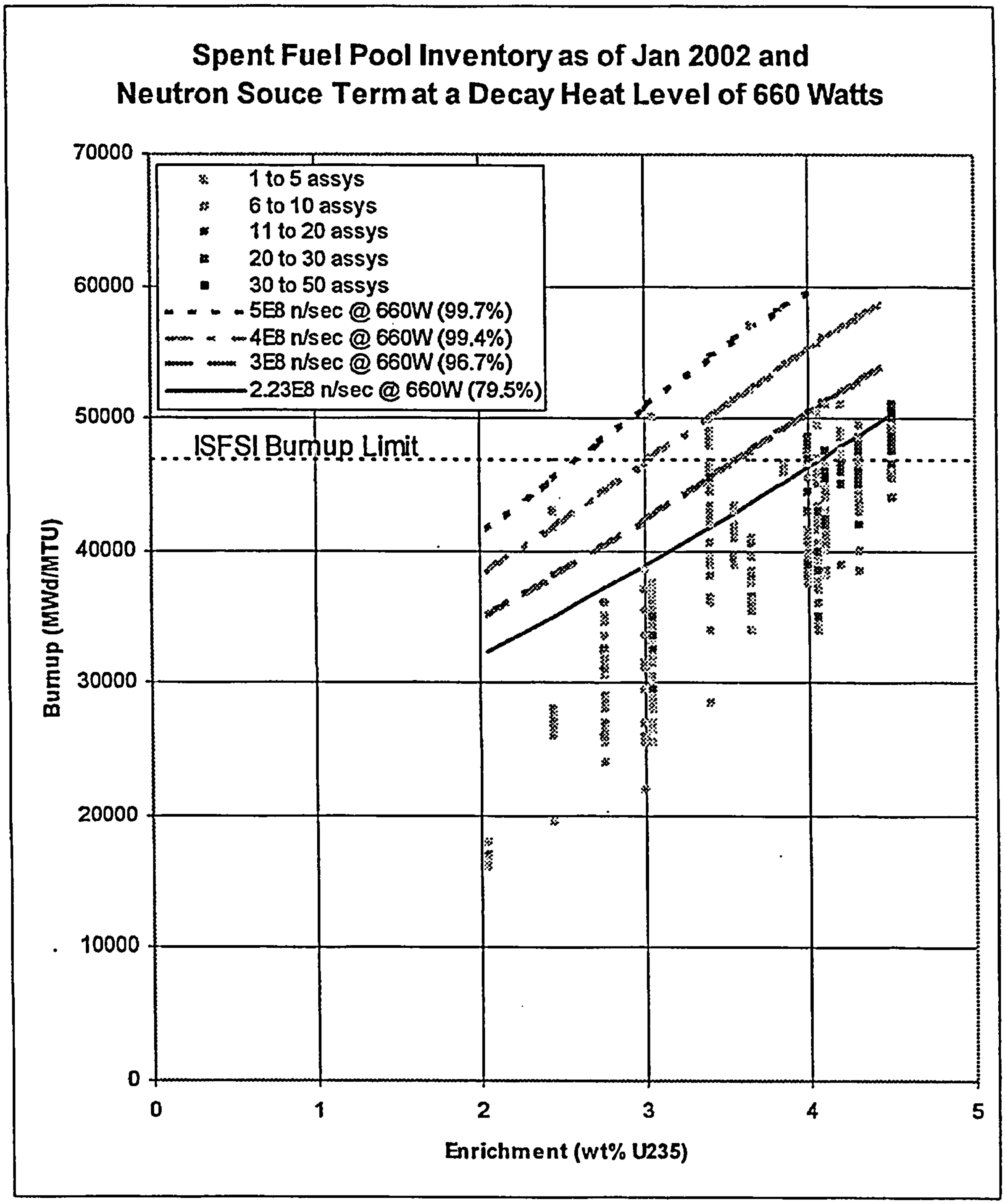

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Table 1

Assemblies with Highest Neutron Source Term at a Decay Heat Level of 660W

ASSEMBLY	Enrich.	BURNUP	NPS@660W	DISC_CYC	DATE
1G003	3.65	57162	5.07E+08	U1C9	08-Apr-88
1G006	3.65	57133	5.07E+08	U1C9	08-Apr-88
1G004	3.65	57113	5.06E+08	U1C9	08-Apr-88
1G008	3.65	57113	5.06E+08	U1C9	08-Apr-88
1F048	3.03	50365	4.81E+08	U1C8	24-Oct-86
1BT07	2.45	49239	4.37E+08	U1C4	17-Oct-80
2J111	3.40	50397	4.05E+08	U2C13	16-Mar-01
2J105	3.40	50223	4.01E+08	U2C11	15-Mar-97
2J106	3.40	49186	3.78E+08	U2C10	18-Mar-95
2J114	3.40	49186	3.78E+08	U2C10	18-Mar-95
2J117	3.40	49186	3.78E+08	U2C10	18-Mar-95
2J120	3.40	49186	3.78E+08	U2C10	18-Mar-95
2J118	3.40	48748	3.68E+08	U1C13	03-Apr-98
2J108	3.40	48497	3.63E+08	U1C14	10-Mar-00
2J102	3.40	48495	3.63E+08	U1C14	10-Mar-00
2J119	3.40	48486	3.63E+08	U1C14	10-Mar-00
2J116	3.40	48485	3.63E+08	U1C14	10-Mar-00
2J107	3.40	46575	3.21E+08	U1C14	10-Mar-00
2H110	3.40	46058	3.10E+08	U2C8	17-Mar-89
2H112	3.40	46058	3.10E+08	U2C8	17-Mar-89
2H113	3.40	46058	3.10E+08	U2C8	17-Mar-89
2H120	3.40	46058	3.10E+08	U2C8	17-Mar-89
1M003	4.08	51370	3.05E+08	U1C12	30-Mar-96
1M005	4.08	51370	3.05E+08	U1C12	30-Mar-96
1M006	4.08	51370	3.05E+08	U1C12	30-Mar-96
1M009	4.08	51362	3.04E+08	U1C12	30-Mar-96
1M002	4.08	51347	3.04E+08	U1C12	30-Mar-96
1M004	4.08	51347	3.04E+08	U1C12	30-Mar-96
1M008	4.08	51347	3.04E+08	U1C12	30-Mar-96
1M010	4.08	51347	3.04E+08	U1C12	30-Mar-96
2H103	3.40	45766	3.03E+08	U2C8	17-Mar-89
2H104	3.40	45766	3.03E+08	U2C8	17-Mar-89
2H105	3.40	45766	3.03E+08	U2C8	17-Mar-89
2H123	3.40	45766	3.03E+08	U2C8	17-Mar-89
2H116	3.40	45750	3.03E+08	U2C8	17-Mar-89
2H117	3.40	45750	3.03E+08	U2C8	17-Mar-89
2H118	3.40	45750	3.03E+08	U2C8	17-Mar-89

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Figure 3 – Cooling Times Required for Assemblies to Have a Thermal Output < 660W and a Photon Source Term < 24P Design Basis (4.27E15 p/sec and 1.53E15 MeV/sec)

Sum of Tinsert	E															
B	2.05	2.45	2.73	2.99	3.03	3.4	3.55	3.65	3.81	3.85	4	4.05	4.08	4.2	4.3	4.48
16000	4															
18000		4														
20000	5															
22000		5		5												
24000	5		5													
25974					5											
26000		5		5	5											
27000	6															
28000		6	6			6		6								
30000		6		6	6											
32000			6			6		6								
34000				7								7				
35000		7														
36000						7		7								
37000			8								7					
37500					8											
37732					8											
38000													7		7	
39000				8			8							8		
41199								8								
42000						9										
42174					9											
42433						9										
42500					9											
42718						9										
43239		10														
43361						9										
43451							9									
43499							9									
43505							9									
43640						9										
43879						9										
43884						9										
44000		11														
44649						10										
44688						10										
44690						10										
45000																10
45143						10										
45429						10										
45704						10										
45750						10					10					
45766						10										
46058						11										
46275									10							
46500												10				
46575						11										
46603										11						
46796											10					
47000	15	14	[illegible]	[illegible]	12	11	11	11	[illegible]		10	10	10	10	10	10

Table 9.4-1	
15	
13	
12	
11	
10	
9	
8	