TRANSNUCLEAR INC.

DOCKET NO. 72-1004

REQUEST FOR ADDITIONAL INFORMATION

RELATED TO AMENDMENT 10 TO THE

STANDARDIZED NUHOMS® SYSTEM

By application dated January 12, 2007, Transnuclear Inc. (TN) requested approval of an amendment to Certificate of Compliance (CoC) No. 1004. This amendment proposes to add several items to the CoC including:

- addition of two new dry shielded canisters (DSCs) designated the NUHOMS®-61BTH DSC and the NUHOMS®-32PTH1 DSC
- allow storage of Westinghouse 15x15 Partial Length Shield Assemblies in the NUHOMS®-24PTH DSC and Control Components in the NUHOMS®-32PT DSC
- add an alternate high-seismic option of the horizontal storage module for storing the 32PTH1 DSC

This request for additional information (RAI) identifies additional information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its review of the amendment. The requested information is listed by chapter number and title in the applicant's safety analysis report. NUREG -1536, "Standard Review Plan for Dry Cask Storage Systems," was used by the staff in its review of the amendment application.

Each individual RAI section describes information needed by the staff to complete its review of the application and the Safety Analysis Report (SAR) and to determine whether the applicant has demonstrated compliance with the regulatory requirements.

CHAPTER 3 Structural Evaluation

3-1: With respect to your response to RAI 3-4 (Round 1), please provide justification for the assumption that the mechanical properties of unirradiated Zircaloy with radial hydrides represent the behavior of high burn-up irradiated Zircaloy-2 with radial hydrides.

This information is required by the staff to verify the compliance with 10 CFR 72.236.

3-2: In response to RAI 3-12 (Round 1), the NRC staff noted that an "Axial Crack Fracture Mechanics Analysis" was added on pp T-3.6-28 and T.3.6-28A (Rev. 1). As shown on pages T.3.6-28 through T.3.6-31 and T.3.6-84 through T.3.6-85, Fracture Geometry #1 is a through-wall circumferential crack, and Fracture Geometry #2 is a crack emanating from a circular hole. Please clarify whether the axial crack model is a new Fracture Geometry #3.

Enclosure

Assuming that the axial crack analysis represents a third crack geometry, and not further analysis for Fracture Geometry #1 or #2, staff has a follow-on question. For Fracture Geometry #1 (for a 7 x 7 GE1, GE2, and GE3) the calculated value of K_I = 1.74 ksi-in$^{1/2}$ (page T.3.6-29). This value of K_I was computed based on a circumferential crack, with a crack length of 0.22 inches, and a nominal bending stress of 2.33ksi. However, for the new Rev. 1 analysis, the calculated value of K_I = 0.01 ksi-in$^{1/2}$ (page T.3.6-28 (new)). This value of K_I was computed based on an axial crack, with a crack length of 10 inches, and a nominal bending stress of 45 ksi.

Please explain how the axial crack analysis performed with approximately 45 times (10" vs. 0.22") longer crack length, and approximately 20 times (45ksi vs. 2.33ksi) more applied bending stress than the circumferential crack analysis, resulted in a demand stress intensity factor of K_I = 0.01 ksi-in$^{1/2}$, a value that is 174 times less (1.74 / 0.01) than the circumferential crack analysis (fracture geometry #1). Note that in both cases, the allowable stress intensity factor K_{IC} = 16.36 ksi-in$^{1/2}$ that was used, is acceptable to the staff.

This information is required by the staff to verify compliance with 10 CFR 72.236.

CHAPTER 4 Thermal Evaluation

Section U.4.8.3 32PTH1 DSC Basket Effective Thermal Properties

4-1: Correct the effective specific heat equation in Section U.4.8.3, Page U.4-44 of the SAR. Determine if the correction affects the analyses presented in the SAR, and if so, update those analyses.

Section U.4.8.3 of the SAR (page U.4-44), describes the homogenized DSC internals k-effective model. There appears to be a typographical error in the effective specific heat equation. A term appears to be missing or compressed in the equation for effective specific heat of the DSC. It appears that the equation term "weight of Al x C_p,fuel" should be "weight of Al x C_p,Al + weight of fuel x C_p,fuel" for the Type 2 basket.

In addition, the C_p,fuel value appears to be an order of magnitude too large. It should be on the order of 0.06-0.07 Btu/lbm-°F, but is reported as 0.677 Btu/lbm-°F. If the reported value was actually used in the calculation for the blocked vent transient, as described in the SAR, it would result in overestimating the thermal capacity of the DSC. This would tend to reduce the rate of increase in the DSC outer shell temperatures during the transient, which would in turn lead to a lower estimated peak clad temperature, using the decoupled methodology employed in the accident analysis presented in the SAR.

The application should provide reasonable assurance that all analyses are realistic and conservative, and that analysis methods used to evaluate thermal performance of systems are applied properly and appropriately for the designs evaluated.

This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

Section U.4.4.3 HSM-H Air Flow Analysis (Stack Effect Calculations)

4-2: Review the NUHOMS cask system SAR and provide corrections to the systems affected by the potential error in the ‘dead zone’ angle of 4.4° behind the I-beam support rail for the DSC in the HSM. Demonstrate that all NUHOMS system DSC/HSM storage configurations maintain system components below applicable temperature limits.

In a response to the first RAI, (see Enclosure 3 to RN E-25506) the applicant corrected an error in the analysis model related to the convective ‘dead zone’ that existed in the vicinity of the rail for the 32PTH1 DSC in the HSM-H. The NUHOMS system SAR references Appendix P (from an earlier NUHOMS system amendment for the 24PTH in the HSM-H) for details on the methodology used in the thermal analysis presented in Appendix U. In Appendix P, Figure P.4-2 (page P.4-115) shows a diagram of the convection regions around the 24PTH DSC in the HSM-H. This diagram identifies a ‘dead zone’ of 4.4° behind the I-beam support rail (between Region 1-T1 and Region 2-T2). Appendix U shows a ‘dead zone’ angle of 18.9° (see Figure U.4-4, page U.4-89) for the 32PTH1 DSC in the HSM-H, but reports a value of 4° in the Calculation Package NUH32PTH1-0421, "Thermal Analysis of HSM-H Loaded with 32PTH1 DSC," Revision 0, (see Figure 5.5, page 27).

The geometry in Figure 5.5 of TN Calculation Package NUH32PTH1-0421 appears to be erroneous in the analysis of the 32PTH1 DSC in the HSM-H. Since the ‘dead zone’ region is due to the presence of the I-beam support rail, it appears that an angle of only 4.4° may not be valid in the Appendix P analyses for the 24PTH DSC, or for any other DSC within the HSM-H. If a ‘dead zone’ angle 4.0-4.4° has been used in other analyses for a DSC within the HSM-H, this could adversely impact reported peak clad temperatures for these configurations. The application should provide reasonable assurance that all analyses are realistic and conservative, and that analysis methods used to evaluate thermal performance of systems are applied properly and appropriately for the designs evaluated. This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

Calculation Package NUH32PTH1-0421 “Thermal Analysis of HSM-H Loaded with 32PTH1 DSC,” Revision 0

4-3: Clarify the statements presented in Section 3 (page 7) and Section 4.2 of Calculation Package NUH32PTH1-0421, which appear to indicate that effective thermal properties from the DSC using the Type 2 basket are used in the analysis for a heat load that is not applicable (40.8 kW) to the Type 2 basket configuration.

Section 3 of NUH32PTH1-0421 (page 7) lists assumptions and conservatisms "applied in this analysis." One item states that "Effective thermal properties of 32PTH1 DSC alternate 2 basket are conservatively used in this thermal analysis for 31.2 kW and 40.8 kW heat loads." In Section 4.2 (page 10) of NUH32PTH1-0421, the k-effective properties for the Type 2 basket are reported in tabular form and the text states that these calculated thermal conductivity values are "conservatively applied to HSM-H DSC thermal analysis." These statements are not clear, in that they seem to imply that this conservatism is generally applied to all calculations reported for the DSC within the HSM-H.

In Section 5 (page 13) of NUH32PTH1-0421 it states that temperature distributions in the HSM-H are determined "using a steady-state model without contents of the DSC," and that "for the accident blocked vent case," a "homogenized DSC with basket effective properties is used." The statements do not fully counterbalance the effect of the statements in Sections 3 and 4.2. The description of conservatisms or assumptions that apply only to specific calculations in an analysis should clearly identify the limited range of their application.

This information is needed to satisfy the provisions of 10 CFR 72.236(f), and10 CFR 72.11.

Section U.4.4.2 Thermal Analysis of HSM-H with 32PTH1 DSC

4-4: Address the inconsistencies related to the correlation approach to analysis of heart transfer in the HSM-H with the 32 PTH1 DSC, or other applicable DSCs and contents requested for modification in this amendment request. Provide revised analyses that utilize the appropriate updated correlations from the most current revisions of the references cited in the Amendment 10 SAR.

The reference for all of the correlations in Amendment 10 is given as Rohsenow and Hartnett, “Handbook of Heat Transfer Fundamentals,” 2nd edition, 1985. Some of the coefficients for turbulent forms of a particular correlation are referenced to Kreith, “CRC Handbook of Thermal Engineering,” 2000. It appears, however, that some of these correlations have been updated in the latest edition of the Rohsenow and Hartnett reference, which is the “Handbook of Heat Transfer,” 3rd edition, McGraw-Hill, 1998. The current correlations should be justified, or the application should be updated to correct the following editorials, updated correlations, and potential errors in used correlations.

This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

(a) For the general form of the correlation for natural convection from a horizontal cylinder (used for DSC shell, except for top region, bottom region, and area of contact with I-beam support rail); a coefficient of m = 3.3 is used; the updated reference has m = 10. The source of the original coefficient m=3.3 could not be determined.

(b) For the correlation for natural convection from vertical flat surfaces (used for side heat shields, interior concrete walls, and vertical face of DSC end plugs), Nu for fully laminar heat transfer; a coefficient of 2.0 is used; the updated reference has 2.8.
(c) For the correlation for convection from inclined surfaces (used for flanges and center web of I-beam support rail), Nu for fully laminar heat transfer uses a coefficient of 2.0; the updated reference has 2.8.

(d) For the correlation for convection from inclined surfaces (used for flanges and center web of I-beam support rail), the definition of Rayleigh number (Ra) is not consistent with updated reference. A multiplier cos(φ) is included, where φ is the angle of inclination of the plate from the vertical. Ra in the updated reference does not include this term, using cos or sin of φ only in the definition of the leading coefficient for the Nusselt number for fully turbulent heat transfer.

(e) The definition of term Nu^T is omitted from documentation of correlation for natural convection from a horizontal cylinder.

(f) The definition of component "f" in Nusselt number for fully laminar heat transfer is omitted from documentation of the correlation for natural convection from a horizontal cylinder.

(g) The documentation for the correlation for natural convection from a horizontal surface facing downwards (used for concrete ceiling and lower surface of top heat shield in HSM-H) erroneously defines the equation for Nu^T as the Nusselt number for fully laminar heat transfer, and omits the actual formula for the Nusselt number for fully laminar heat transfer.

Section U.4.5 Thermal Analysis of OS200 Transfer Casks with 32PTH1 DSCs

4-5: Provide a discussion of how a circumferentially varying Nusselt number in the liquid neutron shield annulus would effect the temperature distribution of the DSC within the OS-200 TC. Include a discussion of the effects of the stagnation zone at the bottom of the liquid neutron shield annulus. A discussion of the limitations associated with the constant Nusselt number approach, as presented in Section U.4.5.2 and U.4.2 of the SAR, should also be included.

The staff believes that the Nusselt number values applied in the applicant's analyses may artificially shift and/or incorrectly predict the component temperature distributions within the DSC. The staff has performed independent CFD analyses that have yielded results indicating that the Nusselt number varies around the circumference of the liquid neutron shield of the OS-200 transfer cask, and indicates that a stagnation zone exists in the bottom of the liquid neutron shield annulus. As a result, heat transfer rates vary significantly around the circumference of the OS-200 TC annulus.

The applicant has used a constant Nusselt number about the circumference of the liquid neutron shield, which appears to have yielded conservative temperatures for this specific design configuration and the decay heats requested in this amendment; however, the applicant's approach does not account for the actual physics of the flow in the liquid neutron shield. Rather than constrain the thermal design dimensions and loading operations in the CoC, the staff seeks to document the limitations and associated uncertainties of the applicant's constant Nusselt number approach with correlations to be described as part of the SAR methodology.

The staff has also reviewed the Sandia report (SANDIA report SAND2002-3132, "CFD Calculation of Internal Natural Convection in the Annulus Between Horizontal Concentric Cylinders") provided as a reference in support of the method and approach for the analysis of the OS200 liquid neutron shield, and does not believe it applies specifically to this analysis, as it is presented in the SAR. For example the SANDIA study focuses on large gap widths (0.5 meter or greater (19.6 inches or greater) and large radius ratios (approx. 3.5), with air as the working fluid. The OS200 TC has a gap of approx. 12 cm (4.93 inches) and a radius ratio of approximately 1.1, with water as the working fluid.

This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

4-6: Demonstrate that extrapolated k-effective values taken from Tables 4-14 and 4-17 of the NUHOMS® HD SAR and applied in the thermal analysis of the OS200 transfer cask for DSC heat loads of 24 kW, 31.2 kW, and 40.8 kW are appropriate. Justify that the extrapolation of a heat transfer correlation developed to provide an average Nusselt number for the annulus between two concentric cylinders at uniform temperatures to conditions where the cylinders have large circumferential temperature gradients, and non-uniform boundary conditions on the exterior surface facing the ambient is appropriate.

The values of the neutron shield effective thermal conductivity reported in Appendix U (page U.4-10) are taken directly from Chapter 4 of the Safety Analysis Report for the NUHOMS® HD Horizontal Modular Storage System for Irradiated Fuel, NRC Docket No. 72-1030, Revision 4 (specifically, Table 4-14 and Table 4-17.) This is justified on the grounds that the neutron shield for the OS187 transfer cask is identical to that of the OS200. The methodology described in Chapter 4 of the SAR for the NUHOMS® HD shows that the Nusselt number for free convection within each neutron shield segment is determined using a heat transfer correlation for free convection between concentric cylinders. This correlation was developed and validated using heat transfer data obtained in test sections small enough to ensure a uniform temperature distribution on the inner and outer cylinder surfaces.

In addition, the k-effective values listed in Tables 4-14 and 4-17 were calculated using a total decay heat load of 34.8 kW, but the OS200 transfer cask will be carrying DSCs with maximum heat load capacities of 24 kW, 31.2 kW, and 40.8 kW. Instead of directly applying the heat transfer correlation for this methodology to calculate the Nusselt number and k-effective values as part of the energy solution for the OS200 neutron shield, the tabulated values of k-effective for the OS187 were used for the OS200. This approach decouples the k-effective values from the decay heat load of 34.8 kW which was used to derive these specific values.

This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

Section T.8 Procedures for Loading Cask, T.8.1.2 DSC Fuel Loading

4-7: Remove permissive language from the Technical Specifications (TS) that could potentially allow operators to deviate from the actions stated in the TSs related to cask handling, drying, and sealing.

Appendix T, Section T.8, “Procedures for Loading Cask, T.8.1.2 DSC Fuel Loading,” (page T.8-5) has a revised Step 16 which adds that “provision should be made to assure that air will not enter the DSC cavity. This may be achieved by replenishing the helium in the DSC cavity during cask movement from fuel pool to the decon area in case of malfunction of equipment used for cask movement.” This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

4-8: Clarify what quantities of water may be drained from NUHOMS system DSCs prior to removal from the spent fuel pool.

Appendix T, Section T.8, “Procedures for Loading Cask, T.8.1.2 DSC Fuel Loading,” (page T.8-5) adds a new Step 17A, to refill the partially drained cask once it is in the decon area, “If option of draining approximately 1100 gallons of water in Step 15 was selected… then slowly refill the DSC cavity” with about same amount of water that was drained.

This guidance appears to offer only one option as to the quantity drained from the DSC, specifically, 1100 gallons, in the case of the 61BTH. This also applies to the 32PTH1, in Section U.8.1.2 of Appendix U.

This information is needed to satisfy the provisions of 10 CFR 72.236(f).

Section U.4.5.4 OS200 TC Thermal Model Results

4-9: Insert revised page U.4-23

It appears that Page U.4-23 should show revisions, if only because of shifted text, as a result of additions to page U.4-22. Otherwise, some text will be deleted from the document. This information is needed to satisfy the provisions of 10 CFR 72.11.

Section U.4.6.5.3 Maximum Temperatures

4-10: Provide clarification in the SAR text to state precisely what the footnote to Table U.4-16 means.

In Appendix U, Chapter U.4, new tables U.4-15 (Fuel cladding peak temperatures for normal conditions of transfer and storage; Type 1 and Type 2 basket) and U.4-16 (DSC component temperatures for Type 1 configuration only) have been added. A footnote stating “Temperatures adjusted based on effect of correction to “Dead Zone”/No correction DSC shell-support structure interface.”

The staff requires additional clarification as to what is meant by the footnote. This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

Sections U.4.4.6 Description of Cases Evaluated for the HSM-H and U.4.4.7.1 Normal and Off-Normal Operating Condition Results

4-11: Revise the appropriate analyses to account for the potential rise in mean air temperature and total air mass flow rates based on the new DSC shell and HSM-H surface temperatures provided in the response to the first RAI (RAI 4-10, Round #1).

New DSC shell surface temperatures and HSM-H surface temperatures (corresponding to new peak values reported in Rev. 1, for Table U.4-2) should also result in new values for mean air temperature, the T_n air temperatures for the eight ‘levels’ within the DSC, and the air exit temperature. The SAR changes for Revision 1 should also include a new Table U.4-1 (Air Flow Calculation Results Summary), and new total air mass flow rate values for the limiting cases with Type 1 and Type 2 baskets. This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

Section U.4.4.5 – Description of HSM-H Model for the Blocked Vent Transient

4-12: Clarify the phrase: “7.9° No Convection Zone,” which appears in Figures U.4-11 and U.4-13 for the Blocked Vent accident condition transient.

Captions for Figures U.4-11 thru U.4-13 include the added phrase “7.9° No Convection Zone.” Given that the blocked vents accident neglects convection (i.e., conduction only to cavity air) within HSM-H, according to SAR text (see Section U.4.4.5 – Description of HSM-H Model for the Blocked Vent Transient, page U.4-16), this caption does not appear to apply to the Blocked Vent Transient.

This information is needed to satisfy the provisions of 10 CFR 72.236(f), and 10 CFR 72.11.

CHAPTER 7 Confinement Evaluation

7-1: Modify the Operating Procedure T.8.1.3 (and the corresponding section for the other designs) to reflect that the vacuum pump needs to be shut off, or its isolated suction open to the atmosphere, when complying with Technical Specification 1.2.2 requirements for maintaining a stable vacuum pressure for 30 minutes to ensure that the water has been removed from the DSC

Steps 21 and 27 of T.8.1.4 “DSC Drying and Backfilling” just isolate the vacuum pump when performing the pressure rise test as required by the TS. However, a leaking isolation valve (single failure) would negate the results. To prevent this possibility and to perform a valid test, the vacuum pump needs to be shut off or the isolation valve closed and the suction of the vacuum pump exposed to atmospheric pressure.

10CFR 72.162 requires that, in part, that a test program is established to ensure that the system will perform satisfactorily in service.

CHAPTER 8 Operating Systems

Note: RAI 8-1 is related to the materials review of the application.

8-1: Provide a TS section and wording to incorporate SAR section 8.1.3 into the TS by reference.

10 CFR 72.122(h) requires: “The spent fuel cladding to be protected during storage against degradation that leads to gross rupture. . . .” The staff has identified, through the guidance in ISG-22 (Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel), that the loading/unloading process risks gross rupture of the cladding if precautions are not made to prevent or limit air exposure. SAR section 8.1.3 provides appropriate measures in accordance with the staff guidance of ISG-22. However, these measures need to be incorporated into the TS to ensure compliance with 10 CFR 72.122(h).

This information is required for compliance with 10 CFR 72.122(h).

CHAPTER 9 Materials Evaluation (and Technical Specifications)

9-1: Clarify TN's position regarding helium leak rate testing for the vent and siphon port cover welds of the 24P and 52B DSC's.

TS 1.2.4 (Amendment 10, SAR page A-117) specifies a helium leakage rate test of the inner top cover seal weld. However, this TS wording is silent with respect to helium leakage rate testing of the vent and siphon port cover welds.

In the previous RAI, (RAI 9-1, Round #1) this question was posed somewhat differently. However, in that RAI question, the staff misunderstood the design intent, thinking the acceptable leak rate should be 10E-7 instead of 10E-4 as stated in the SAR. The TN response correctly stated that TS 1.2.4 applies only to the 24P and 52B, which have a design leak rate limit of 10E-4. However, the response did not address helium leakage rate testing of the vent and siphon port covers.

TS 1.2.4a (Amendment 10, SAR page A-118) has been amended by way of another response to the first Amendment 10 RAI to include helium leakage rate testing of these cover plates for all the other designs covered by amendment 10. Thus, there is an apparent oversight.

This information is required for compliance with 10 CFR 72.236(j).