72-1004

**TRANSNUCLEAR WEST**

August 28, 2001
NUH03-01-1722

Ms. Mary Jane Ross-Lee
Spent Fuel Project Office, NMSS
U. S. Nuclear Regulatory Commission
11555 Rockville Pike M/S O13-D-13
Rockville, MD 20852

Subject: Supplemental Thermal Calculations and Supporting ANSYS Input Files for Amendment No.5 of NUHOMS® Certificate of Compliance No. 1004 for Dry Spent Fuel Storage Casks

Reference: Verbal Request for Supplemental Information to Support Staff's Thermal Review of Amendment No.5 of NUHOMS® Certificate of Compliance No. 1004 for Dry Spent Fuel Storage Casks.

Dear Ms. Ross-Lee:

Transnuclear West Inc. (TN West) herewith submits the supplemental thermal calculations and supporting ANSYS input files you requested to support your staff's thermal review of Amendment No.5 of NUHOMS® Certificate of Compliance No. 1004.

This submittal includes proprietary information which may not be used for any purpose other to support your staff's review of the application. In accordance with 10 CFR 2.790, I am providing an affidavit (Enclosure 1) specifically requesting that you withhold this proprietary information from public disclosure.

Should you or your staff require additional information to support review of this application, please do not hesitate to contact me at 510-744-6053.

Sincerely,

UB Chopra

U. B. Chopra
Licensing Manager

Docket 72-1004

Enclosures:
1. Affidavit for withholding proprietary information.
2. Supplemental Thermal Calculations.
3. CD containing electronic files (Proprietary Information).



NMSS01 Prop

# AFFIDAVIT PURSUANT TO 10 CFR 2.790

Transnuclear West Inc. )
State of California ) SS.
County of Alameda )

I, Robert M. Grenier, depose and say that I am President and Chief Operating Officer of Transnuclear West Inc., duly authorized to make this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and referenced in the paragraph immediately below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.790 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is contained in the ANSYS input files and spread sheet included in Enclosure 3 (CD) of this submittal and as listed below:

1. 32p_Blk_Vent_Conv.xls
2. BL_Vent_Conv_32PT.txt
3. sd32_blk_alt_it2.txt
4. sd32pt_vac.txt
5. sd32_stor1r.txt

These input files and spreadsheet have been appropriately designated as proprietary.

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

Pursuant to the provisions of paragraph (b) (4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

1) The information sought to be withheld from public disclosure is design drawings and calculations of NUHOMS® Cask, which is owned and has been held in confidence by Transnuclear West Inc.

2) The information is of a type customarily held in confidence by Transnuclear West Inc. and not customarily disclosed to the public. Transnuclear West Inc. has a rational basis for determining the types of information customarily held in confidence by it.

3) The information is being transmitted to the Commission in confidence under the provisions of 10 CFR 2.790 with the understanding that it is to be received in confidence by the Commission.

4) The information, to the best of my knowledge and belief, is not available in public sources, and any disclosure to third parties has been made pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence.

5) Public disclosure of the information is likely to cause substantial harm to the competitive position of Transnuclear West Inc. because:

a) A similar product is manufactured and sold by competitors of Transnuclear West Inc.

b) Development of this information by Transnuclear West Inc. required thousands of man-hours and hundreds of thousands of dollars. To the best of my knowledge and belief, a competitor would have to undergo similar expense in generating equivalent information.

c) In order to acquire such information, a competitor would also require considerable time and inconvenience related to the development of a design and analysis of a dry spent fuel storage system.

d) The information required significant effort and expense to obtain the licensing approvals necessary for application of the information. Avoidance of this expense would decrease a competitor's cost in applying the information and marketing the product to which the information is applicable.

e) The information consists of description of the design and analysis of a dry spent fuel storage and transportation system, the application of which provides a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with Transnuclear West Inc., take marketing or other actions to improve their product's position or impair the position of Transnuclear West's product, and avoid developing similar data and analyses in support of their processes, methods or apparatus.

f) In pricing Transnuclear West's products and services, significant research, development, engineering, analytical, licensing, quality assurance and other costs and expenses must be included. The ability of Transnuclear West's competitors to utilize such information without similar expenditure of resources may enable them to sell at prices reflecting significantly lower costs.

Further the deponent sayeth not.

SHANNON L. CHRISTENSEN
COMM. # 1264196
NOTARY PUBLIC-CALIFORNIA
ALAMEDA COUNTY
COMM. EXP. MAY 18, 2004

Robert M. Grenier
President and Chief Operating Officer
Transnuclear West Inc.

Subscribed and sworn to me before this 27th day of August, 2001, by Robert M. Grenier.

Notary Public

 08/27/01

# Supplemental Thermal Calculations

**Item 1:Provide quench analysis and discussion of thermal shock as it applies to reflood activities specific to the 32PT DSC design.**

As discussed with the thermal reviewer in the conference call, Section M.4.7.1.2 of Amendment No. 5 discusses reflood operations of the 32PT DSC.

**Item 2: Provide methodology and calculations for determining various internal free volume configurations used in pressure calculations**

There are four design configurations for the NUHOMS® 32PT DSC, two 100-ton configurations, one long and one short canister; and two 125-ton configurations, one long and one short canister. The long 100-ton configuration is designated the 32PT-L100 and the short 100-ton configuration is designated the 32PT-S100. Likewise the long 125-ton configuration is designated the 32PT-L125 and the short 125-ton configuration the 32PT-S125. The basket has two transition rail configurations: welded steel plates and solid aluminum sections. This translates into eight different cavity volume configurations.

The maximum DSC length dimension is 186.55 inches for the "standard cavity" DSC and 192.55 inches for the "long cavity" DSC. The corresponding cavity length for each configuration is based on the maximum DSC lengths minus the combined nominal thickness of the top and bottom cover plates and shield plugs. These dimensions are shown in the Table 1 below for each 32PT DSC configuration.

The DSC cavity volume for each configuration is calculated based on the cavity length dimensions and an inner diameter of 66.19 inches. For example, for the Standard DSC, ≤ 100 ton, with steel plate transition rails configuration, the DSC cavity volume is calculated as follows:

$$V_{DSC} = \frac{D_i^2 \pi}{4}\left(L_{DSC} - L_{end\ plates/plugs}\right) = \frac{66.19^2 \pi}{4}(186.55 - 16.50) = 585{,}129\, in^3$$

The basket volume is based on the calculated weight of the basket components divided by the density of their respective materials. The fuel volume used corresponds to the controlling B&W 15x15 with and without control components for the long and short DSCs respectively.

The free volume is calculated as:

$$V_{free} = V_{DSC\ cavity} - V_{basket} - V_{fuel}$$

The DSC Cavity, basket, fuel assembly and total free volumes for the eight configurations are presented in Table 1. Note that the fuel assemblies for the Long Cavity DSC may include control components, and therefore displace more volume.

Table 1 summarizes the free volume calculation for all the 32PT DSC configurations.

**Table 1 32PT DSC Cavity Free Volume Calculation Summary**

| DSC Type 32PT- | 32PT-S100 | 32PT-S100 | 32PT-S125 | 32PT-S125 | 32PT-L100 | 32PT-L100 | 32PT-L125 | 32PT-L125 |
|---|---|---|---|---|---|---|---|---|
| Rail Type | Steel Plates | Aluminum | Steel Plates | Aluminum | Steel Plates | Aluminum | Steel Plates | Aluminum |
| Maximum DSC Length, $L_{DSC}$ (in) | 186.55 | 186.55 | 186.55 | 186.55 | 192.55 | 192.55 | 192.55 | 192.55 |
| Total top and bottom cover plates and shield plugs, $L_{end\ plates/plugs}$ (in) | 16.50 | 16.50 | 19.00 | 19.00 | 16.50 | 16.50 | 19.00 | 19.00 |
| DSC Cavity Volume ($in^3$) | 585,129 | 585,129 | 576,526 | 576,526 | 605,774 | 605,774 | 597,172 | 597,172 |
| Basket Volume ($in^3$) | 107,513 | 163,508 | 105,859 | 161,105 | 111,484 | 169,353 | 109,829 | 166,951 |
| Fuel Volume ($in^3$) | 177,619 | 177,619 | 177,619 | 177,619 | 189,760 | 189,760 | 189,760 | 189,760 |
| Free Volume ($in^3$) | 299,997 | 244,002 | 293,048 | 237,802 | 304,530 | 246,661 | 297,583 | 240,461 |

**Item 3: Provide calculations for quantity of gas release from BPRA's**

The Long Cavity configuration of the 32PT DSC may include up to 16 Burnable Poison Rod Assemblies (BPRA). However, the amount of helium released from 24 BPRAs are conservatively used in DSC internal pressure calculation.

The following assumptions are made in calculating the contribution to pressure from the B&W BPRAs.

- 100% of the Boron-10 atoms in the BPRA rod are assumed to undergo reaction during reactor operation and generate Helium gas, and 30% of this Helium gas is assumed to be released into the void volume. This is conservative because only 10% of Helium is expected to be released into the cavity.
- The initial fill pressure in the BPRA is 1 atmosphere (14.7 psia) .
- The BPRA assembly initially contains 22.3 lbs. $Al_2O_3$, which has 4 wt. % Boron. The Boron has 18.16 wt. % Boron-10.
- There are 10 grams per gm-mole of B-10.
- The dimensions of the BPRA are as follows: 147.25" long rod with 0.43" diameter, with wall thickness 0.035" containing a 126" long absorber with diameter 0.34" and 16 rods per BPRA.

  The amount of moles of B-10 per assembly is calculated as follows;

$$n_{B-10} = 22.3\,lbs \cdot 453.6\frac{g}{lbs} \cdot 0.04 \cdot 0.1816 \cdot \frac{1\,gmole}{10\,g} \cdot = 7.35\,gmoles$$

  With a conservative 30% release fraction of Helium into the void volume, 100% consumption of the B-10 atoms, and 24 BPRA assemblies per DSC the amount of Helium from BPRA assemblies per DSC is 0.3*24*7.35 = 52.9 gmoles.

The number of Helium fill gas moles is calculated based on an initial fill gas pressure of 14.7 psia and the dimensions listed above. The free volume in the BPRA rod is then,

$$V = \pi/4 \cdot \left[(0.43 - 2 \cdot 0.035)^2 \cdot 147.25 - 0.34^2 \cdot 126\right] = 3.55\,in^3$$

Assuming the Helium gas is filled at room temperature (20°C), the amount of moles of Helium released from BPRAs is:

$$n_{He} = \frac{(14.7\,\text{psia})(6894.8\,\text{Pa/psi})(24 \cdot 16 \cdot 3.55\,\text{in}^3)(1.6387 \times 10^{-5}\,\text{m}^3/\text{in}^3)}{(8.314\,\text{J/mol} \cdot \text{K})(293.15\,\text{K})}$$

$$= 0.93\,\text{moles}$$

The total gas moles available for release in the DSC cavity from all BPRA rods from all BPRAs is then 52.9 + 0.9 = 53.8 gmoles.

The percentage of BPRA rods ruptured during normal, off-normal and accident conditions is assumed to be 1%, 10% and 100% respectively, similar to the assumption made for fuel rod rupturing. The maximum amount of gas released to DSC cavity from the BPRAs for normal, off-normal and accident conditions is given in Table 2 below.

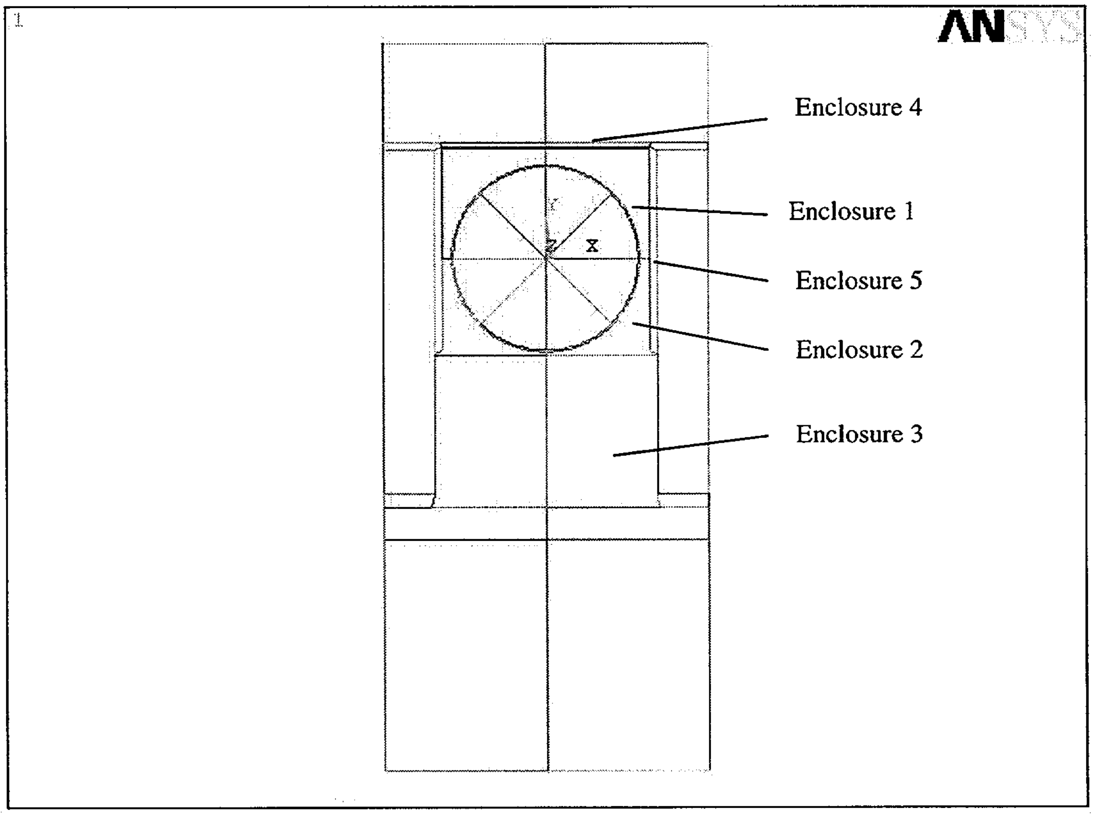
**Table 2 24P DSC BPRA Helium Gas Quantities**

| Case | Percentage of BPRA Rods Ruptured, % | Helium Released Per DSC from BPRAs (moles) |
|---|---|---|
| Normal | 1 | 0.538 |
| Off-Normal | 10 | 5.38 |
| Accident | 100 | 53.8 |

**Item 4: Provide additional description of "Closed Cavity Convection" modeling technique to include graphical representation of the zones used for the model and electronic files of any computer models used.**

In order to evaluate the thermal effect of closed cavity convection of air within the HSM on DSC shell temperatures, the HSM cavity surrounding the DSC is divided into 5 enclosures as shown in Figure 1 below.

**Figure 1 Closed cavity convection model**




The bottom border of the bottom inclined enclosure 2 - the free surface - can be considered as solid for mean temperature evaluation. Interference of flows in enclosures 1 and 2 is expected to be negligible, since enclosure 1 is heated from below and enclosure 2 from the top.

Convection within enclosure 3 is conservatively neglected, since the rectangular annulus heated from the top does not experience noticeable free thermal convection. Convection and conduction in the air are combined into an effective thermal conductivity value for each enclosure, based on temperature difference, geometry and flow regime. The analysis considered the geometry and thermal convection conditions for each particular enclosure. Irregular enclosures 1 and 2 were represented by inclined (45° and -45°, respectively) flat rectangular annuluses. Inclination correction coefficients were applied.

Effective thermal conductivity of the air within closed cavity convection enclosures is evaluated by hand calculations. Excel spreadsheet (32p_Blk_Vent_Conv.xls) and copies of ANSYS HSM and DSC input files (BL_Vent_Conv_32PT.txt, sd32_blk_alt_it2.txt) are provided in the attached CD.

**Item 5: Provide numerical values for Figure M.4-14**

Table 3 below provides the NUHOMS-32PT DSC and TC Temperature Response to 15 Minute Fire Accident Conditions

**Table 3 32PT DSC and TC Temperature Response to Fire Accident**

| Time (min.) | Cask Neutron Shield (°F) | Cask Structural Shell (°F) | Cask l Lead Shielding (°F) | DSC Shell (°F) | Inside of Cask Lid (°F) |
|---|---|---|---|---|---|
| 0 | 225 | 165 | 194 | 392 | 197 |
| 2 | 225 | 165 | 194 | 392 | 197 |
| 6 | 425 | 989 | 217 | 392 | 198 |
| 9 | 519 | 1260 | 253 | 392 | 204 |
| 12 | 587 | 1362 | 291 | 392 | 216 |
| 15 | 642 | 1402 | 331 | 392 | 234 |
| 18 | 688 | 1421 | 369 | 392 | 256 |
| 25 | 502 | 781 | 369 | 393 | 308 |
| 50 | 268 | 394 | 331 | 399 | 329 |
| 100 | 219 | 263 | 310 | 407 | 313 |
| 150 | 217 | 239 | 297 | 412 | 300 |
| 200 | 218 | 230 | 288 | 416 | 291 |
| 250 | 219 | 224 | 281 | 419 | 284 |
| 300 | 220 | 220 | 275 | 421 | 278 |
| 350 | 221 | 217 | 271 | 424 | 274 |
| 400 | 222 | 215 | 267 | 426 | 271 |
| 450 | 223 | 213 | 265 | 429 | 268 |
| 500 | 224 | 211 | 263 | 431 | 266 |
| 550 | 225 | 210 | 261 | 433 | 264 |
| 600 | 226 | 209 | 260 | 435 | 263 |
| 700 | 227 | 208 | 258 | 438 | 261 |
| 800 | 229 | 207 | 257 | 442 | 260 |
| 900 | 231 | 206 | 256 | 445 | 260 |
| 1000 | 232 | 206 | 256 | 448 | 259 |
| 1200 | 234 | 206 | 256 | 453 | 260 |
| 1400 | 236 | 206 | 257 | 458 | 261 |
| 1600 | 237 | 206 | 258 | 462 | 262 |
| 1800 | 239 | 207 | 259 | 466 | 263 |
| 2000 | 240 | 207 | 260 | 469 | 264 |
| 2400 | 242 | 208 | 262 | 475 | 266 |
| 4000 | 247 | 210 | 268 | 488 | 272 |
| 5600 | 250 | 212 | 271 | 495 | 276 |
| 7200 | 251 | 213 | 273 | 498 | 277 |
| 8000 | 251 | 213 | 274 | 499 | 278 |

**Item 6:Provide calculation for vacuum drying analyses referred to in M.4.7.1**

*Vacuum Drying Transient Analysis*

A transient analysis of the vacuum drying operation is performed based on a two-dimensional cross section model of the DSC using ANSYS with the transient properties (density and specific heat).

The boundary temperature of the DSC shell during vacuum drying operation is derived as follows: The total nominal length of the DSC is assumed to be 186". The maximum basket temperature is expected near the axial center of the active fuel. If one half of the DSC length is assumed, then the pressure of the water at a depth of 93" would represent the axial midpoint. The saturation temperature of water is needed to provide a boundary condition for the DSC shell temperature during vacuum drying operations. Since water is required to be in the annulus between the DSC shell and the cask, the temperature of the DSC shell is controlled by the saturation temperature of water. In order to find the saturation temperature of the water at that depth, a simple pressure equation is used together with steam tables.

$$P = 101{,}353\,Pa + \rho \cdot g \cdot h$$

$$P = 101{,}353\,Pa + 958\frac{kg}{m^3} \cdot 9.81\frac{m}{s^2} \cdot 93in \cdot \frac{0.0254m}{in}$$

$$P = 123{,}554\,Pa$$

$$P = 17.92\ psia$$

The corresponding temperature from steam tables is $T_{sat}$ = 222°F. However, local boiling and the growth and collapse of steam bubbles cause a very large heat transfer coefficient that will tend to keep the canister shell temperature close to the water temperature. Evaporation from the surface of the annulus, together with the radiation and convection from the cask surface, tend to maintain the water temperature constant. These mechanisms dissipate all of the heat load to the environment. Therefore, a constant temperature of 215°F (near boiling) on the DSC shell during loading operations is a reasonable assumption in the vacuum drying transient calculation.

The initial temperature of all the basket components including the fuel is taken to be 215°F. For the transient analysis, a complete vacuum is assumed between the basket transition rails and the DSC and within the fuel. The thermal conductivities for vacuum conditions were derived assuming a complete vacuum within the fuel. The transient was run from 0 to 100 hours.

A routine to model radiation between the transition rail and the DSC shell was added to this model. The routine determines the length associated with each node along the periphery of the transition rails and stores this length as a real constant. These real constants are then applied to radiation link elements, which connect the nodes along the periphery of the transition rails and the corresponding nodes along inner surface of the DSC shell.

ANSYS input file sd32PT_vac.txt is provided in the attached CD.

**Item 7: Provide Electronic files (ANSYS, etc) for models used to determine maximum temperatures and temperature limits**

An input file for long term storage case ($T_{amb}$=70°F, $T_{fuel\ max}$=617°F ), sd32pt_stor1r.txt, and input file for vacuum drying case ($T_{fuel\ max}$ = 810°F), sd32pt_vac.txt, that bound maximum temperatures are provided in the attached CD.

**List of ANSYS input files (ANSYS V. 5.6.2) and spreadsheet in attached CD:**

1. 32p_Blk_Vent_Conv.xls
2. BL_Vent_Conv_32PT.txt
3. sd32_blk_alt_it2.txt
4. sd32pt_vac.txt
5. sd32_stor1r.txt