ENCLOSURE 10

Non-Proprietary TN Calculation NUH32PHB-0401, Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident Conditions with Forced Cooling (Steady State)

NON-PROPRIETARY VERSION

AREVA TRANSNUCLEAR INC.	Form 3.2-1 Calculation Cover Sheet TIP 3.2 (Revision 6)	Calculation No.: NUH32PHB-0401 Revision No.: 1 Page: 1 of 31

DCR NO (if applicable): NUH32PHB-010	**PROJECT NAME:** NUHOMS® 32PHB System
PROJECT NO: 10955	**CLIENT:** CENG - Calvert Cliff Nuclear Power Plant (CCNPP)

CALCULATION TITLE:

Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident Conditions with Forced Cooling (Steady State)

SUMMARY DESCRIPTION:

1) Calculation Summary

This calculation determines the maximum component temperatures of the Calvert Cliff Nuclear Power Plant Onsite Transfer Cask (CCNPP-FC TC) loaded with 32PHB DSC at 29.6 kW with forced cooling and also determines the peak fuel cladding temperatures in the 32PHB DSC.

2) Storage Media Description

Secure network server initially, then redundant tape backup

If original issue, is licensing review per TIP 3.5 required?

Yes ☐ **No** ☒ **(explain below)** **Licensing Review No.:**____________________

This calculation is prepared to support a Site Specific License Application by CCNPP that will be reviewed and approved by the NRC. Therefore, a 10CFR72.48 licensing review per TIP 3.5 is not applicable.

Software Utilized (subject to test requirements of TIP 3.3):	**Version:**
ANSYS	10.0
Calculation is complete: Originator Name and Signature: Venkata Venigalla *(signature)*	Date: 8/9/2011
Calculation has been checked for consistency, completeness and correctness: Checker Name and Signature: Davy Qi *(signature)*	Date: 8/9/2011
Calculation is approved for use: Project Engineer Name and Signature: Kamran Tavassoli *(signature)*	Date: 8/17/11

REVISION SUMMARY

REV.	DESCRIPTION	AFFECTED PAGES	AFFECTED Computational I/O
0	Initial Issue	All	All
1	To update and clarify the loss of forced cooling condition based on the maximum fuel cladding temperature limit used for this condition.	1-3, 6, 8, 17 and 21	None

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1.0 PURPOSE

The Calvert Cliff Nuclear Power Plant Onsite Transfer Cask (CCNPP-FC TC) loaded with 32PHB DSC at 29.6 kW utilizes forced cooling as a possible recovery mode to improve the thermal performance of the system if the transfer operations exceed the operational time limits (such as 20 hours for 29.6 kW heat load) determined for off-normal hot horizontal transfer conditions in Reference [6].

This calculation determines the maximum component temperatures of the CCNPP-FC TC loaded with 32PHB DSC at 29.6 kW with forced air cooling under steady-state conditions and also determines the peak fuel cladding temperature within the 32PHB DSC with the forced air cooling. There are no time limits associated for horizontal transfer operations once the forced air circulation is initiated.

It also establishes a time limit to restore the forced air circulation or to complete the transfer of the 32PHB DSC at 29.6 kW in CCNPP-FC TC to the HSM-HB in case of system failure to ensure that the peak fuel cladding temperature remains below the temperature limit of 752°F [8].

To determine the maximum component temperatures of the Calvert Cliff CCNPP-FC TC loaded with 32PHB DSC at 29.6 kW with forced air cooling under steady-state conditions, this calculation utilizes the methodology described in [7] and the ANSYS thermal model of CCNPP-FC TC described in [6]. The peak fuel cladding and the basket component temperatures for 32PHB DSC are determined using the ANSYS thermal model and methodology described in [5].

2.0 REFERENCES

1 Rohsenow, Hartnett, Cho, "Handbook of Heat Transfer", 3rd Edition, 1998.

2 Rohsenow, Hartnett, Ganic, "Handbook of Heat Transfer Fundamentals", 2rd Edition, 1985.

3 ANSYS computer code and On-Line User's Manuals, Version 10.0.

4 Design Criteria Document, "Design Criteria Document (DCD) for the NUHOMS® 32PHB System for Storage", Transnuclear, Inc., NUH32PHB.0101 Rev. 2.

5 Calculation, "Thermal Evaluation of NUHOMS 32PHB Canister for Storage and Transfer Conditions", Transnuclear, Inc., NUH32PHB-0403, Rev. 0.

6 Calculation, "Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident Conditions", Transnuclear, Inc., NUH32PHB-0402, Rev. 0.

7 Calculation, "Benchmarking of the ANSYS Model of the OS200FC Transfer Cask", Transnuclear, Inc., NUH32PHB-0400, Rev. 1.

8 NRC Spent Fuel Project Office, Interim Staff Guidance, ISG-11, Rev 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel".

9 GESC, NAC International, Atlanta Corporate Headquarters, 655 Engineering Drive, Norcross, Georgia (Engineering Report # NS3-020, Effects of 1300°F on Unfilled NS-3, while Bisco Products, Inc., 11/84).

10 Calvert Cliffs Independent Spent Fuel Storage Installation Updated Safety Analysis Report, Rev.17.

11 I.E. Idelchik, Handbook of Hydraulic Resistance, 3rd Edition, 1994.

12 ASHRAE Handbook Fundamentals, 1997.

13 Perry & Chilton, Chemical Engineering Handbook, 5th Edition,1973.

3.0 ASSUMPTIONS AND CONSERVATISM

The following assumptions and conservatism are considered in the calculation.

3.1 CCNPP-FC TC Mass Flow Rate Model

All the assumption and conservatism considered in this calculation for the CCNPP-FC TC Mass Flow Rate Model are the same as those described in [7] and are summarized below.

The annulus between the DSC shell and the TC inner liner are divided into parallel, individual segments along the DSC axis. No circumferential air flow is considered between the parallel segments. Since the presence of circumferential flow will tend to exchange hotter air in the narrower segments of the annulus with cooler air in the wider segments of the annulus, ignoring the potential for circumferential flow will yield conservative temperature estimates for the peak temperatures on the DSC shell and TC inner liner

An air flow rate of 450 cfm is considered for forced air cooling. To evaluate the air flow rate in each of the parallel segments, a constant pressure boundary condition is applied at the inlet such that the total mass flow rate at the outlet is equal to the total airflow rate of 450 cfm. Since the pressure drop through the annulus between the DSC shell and TC inner shell is the major factor controlling the amount of air flow rate in each segment, the mass flow rate model considers only the annulus over the length of the DSC to determine the mass flow rate through each segment.

3.2 CCNPP-FC TC Model

All the assumptions and conservatisms described in Section 3.1of [6] are applicable for this calculation.

The methodology to analyze the CCNPP-FC TC with forced cooling is presented in [7] and is used in this calculation.

3.3 32PHB DSC Model

The assumptions and conservatism considered for 32PHB DSC model are the same as those described in [5], Section 3.0.

4.0 DESIGN INPUT

4.1 Design Load Cases

The following design cases in Table 4-1 are analyzed in this calculation to determine the thermal performance of CCNPP-FC TC with 32PHB DSC at 29.6 kW and with forced cooling (FC). The load cases are based on requirements in [4].

Table 4-1 Design Load Cases for 32PHB DSC in CCNPP-FC TC with FC

Case	Operation Condition	Description	Notes	Ambient Temperature(3)	Insolation	Airflow
				[°F]	[Btu/hr-ft^2]	[cfm]
1	Normal	Normal Hot, FC	(1)	104	82	450
2	Normal	Normal Cold, FC	(1)	-8	0	450
3	Off-Normal	Off-Normal Hot, FC	--	104	127	450
4	Off-Normal	Off-Normal Cold, FC	(1)	-8	0	450
5	Off-Normal(4)	Loss of Forced Airflow, Transient	(2)	104	127	0

Notes:

1) Load cases # 1, 2 and 4 are bounded by the Load Case # 3 (See Section 6.0 for justification).
2) Initial temperatures taken from steady-state results of Load Case # 3. At time t=0, the forced air circulation is assumed to be lost.
3) Ambient air temperatures ranging from -8 to 104°F are conservative compared to the ambient air temperature range from -3 to 103°F in [10], Section 12.3.6.
4) The temperature limits of off-normal transfer conditions are considered to evaluate this load case.

4.2 Thermal Properties of Materials

Materials used in CCNPP-FC TC ANSYS thermal model are listed in Table 4-3, Section 4.3 of [6]. The material numbers associated with elements simulating the forced air cooling are listed in Table 4-2.

The heat transfer coefficients for the forced air flow over the DSC/TC annulus are calculated using the same correlations described in [7],Section 5.2 and are presented in MassFlow_ConvCoeff_32PHB_29.6kW.xls for the 29.6 kW heat load as noted in Table 8-2.

Thermal properties used in CCNPP-FC TC model are listed in Section 4.3 of [6].

Materials and Thermal properties used in the 32PHB DSC models are listed in Section 4.1 of [5].

Table 4-2 List of Materials in the CCNPP-FC TC Model (1)

Component	Mat # in ANSYS Model
TC FLUID116 Flow Elements	90
TC LINK34 Convection Elements	451-466
TC LINK34 Convection Elements (At Entrance through spacer disc)	470
TC LINK34 Convection Elements (At Exit thought Top Cask Lid)	471

(1) See Table 4-3, Section 4.3 of [6] for complete material listing of the CCNPP-FC TC components in addition to those listed above.

4.3 *Surface Properties of Materials*

The emissivity value of 0.587 is considered for both the DSC shell (stainless steel) and the transfer cask inner shell (stainless steel) in calculation of thermal radiation exchange between these shells [1].

It is assumed that the absorptivity and the emissivity of stainless steel are equal. Solar absorptivity and emissivity of 0.587 are used for the TC outer surfaces [1].

4.4 Design Criteria

The design criteria and evaluation of 32PHB DSC basket are presented in Reference [5] and design criteria for the TC are presented in Reference [6] and are listed below.

- Maximum fuel cladding temperature limits of 752°F (400°C) for normal/off-normal load cases listed in Table 4-1 and 1,058°F (570°C) for accident conditions listed in Table 4-1 are considered for the FAs with an inert cover gas as concluded in ISG-11 [8].
- The ASTM B29 lead used in the gamma shield has a melting point of approximately 620°F [13].
- For design purposes of this application, the long-term, bulk average temperature of the NS-3 material is set to 280 °F [10] or less, and short-term limits for accident conditions should be 1,300 °F or less [9].

5.0 METHODOLOGY

The CCNPP-FC TC contains design provisions for the use of forced air cooling to improve its thermal performance. The system will consist of redundant, industrial grade pressure blowers and power systems, ducting, etc. When operating, the fan system is expected to generate a flow rate of 450 cfm or greater, which will be ducted to the location of the ram access cover at the bottom of the cask.

The following are the steps to determine the maximum steady state temperatures of the DSC/TC components with the forced convection using ANSYS:

1. Assume a ΔT_{air} for initial runs, Calculate T_{exit} and T_{avg} based on the initial guess and the air properties based on T_{avg}.

   Where,

   $$T_{exit} = T_{amb} + \Delta T_{air}$$
   $$T_{avg} = (T_{amb} + T_{exit}) / 2$$
   $$T_{amb} = 104°F$$

2. Run Flow Rate Model described in Section 5.1 iteratively based on average properties of air calculated in previous step to compute the air mass flow rate in each DSC/TC annulus segment. (Run ID: "FlowRate_32PHB_29kW" for 29.6 kW load case listed in Table 8-1)

3. Determine the heat transfer coefficients within the annulus based on the mass flow rates computed in Step 2 (see worksheet "Hc_data" for mass flow rate in lbm/hr and Hc_calc for convection coefficients in "MassFlow_ConvCoeff_32PHB_29.6kW.xls" for the 29.6 kW heat load as noted in Table 8-2)

4. Run Thermal Model (Run ID: "TR_32PHB_29kW" for 29.6 kW heat load as listed in Table 8-1) described in Section 5.2 based on mass flow rates and heat transfer coefficients calculated in Step 2 and Step 3.

5. Calculate T_{exit}, T_{avg}, and ΔT_{air} based on results from Thermal Model in Step 4.

6. If difference between assumed ΔT_{air} in Step 1 and calculated ΔT_{air} in Step 5 is less than $1^{o}F$, stop iterations, otherwise proceed to Step 7.

7. Rerun the Flow Rate Model described in Section 5.1 and Step 2 with air properties based on T_{avg} from Step 5.

8. If differences between air mass flow rates in each DSC/TC annulus segment from Step 7 and Step 2 are less than 0.1 lbm/hr, stop iterations, otherwise proceed to Step 9.

9. Repeat Steps 4 to 9 until the solution converges.

The above methodology is validated versus a NRC accepted methodology using SINDA/FLUINT as documented in [7].

5.1 Flow Rate Model

The forced air enters the TC from the ram access opening and the airflow turns and enters the ten (10) flow paths formed by the 0.25" thick cutouts in the spacer disc attached to the TC's bottom. After the forced air exits from the flow paths formed by the cutouts in the spacer disc, the airflow turns and flows in the annulus between the DSC and the TC's inner liner. Given the gap between the DSC and TC varies with circumferential position, plus variances in the heating of the air, the airflow will distribute itself around the circumference of the DSC/TC inner liner, until an equal pressure drop is achieved everywhere.

For the purposes of this calculation, each half of the annulus is divided into 19 angular segments as shown in Table 5-1 with 0° at the top of the normally horizontal TC and 180° at the bottom. The mass flow rate along each of the 19 angular segments is calculated using the Flow Rate Model. The mass flow rates obtained from this model are used as input to the thermal model of the DSC/TC described in Section 5.2.

The 19 annular segments for forced air flow are modeled using FLUID116 elements with their length equal to the length of the DSC. The potential for circumferential airflow is conservatively ignored as discussed in Section 3.1. The flow area and hydraulic diameter for each annular segment are calculated based on the position of the DSC within the TC cavity. The determination of the gap between the DSC and the TC inner liner as a function of circumferential position was made considering a DSC shell outer diameter of 67.25 inches, a TC inner liner inner diameter of 68 inches, and a 0.120-inches thick slide rail that is located 18.5° from the centerline of the TC. Table 5-1 presents the calculation basis for the gap between the TC and DSC and the associated hydraulic diameter and air flow area.

Table 5-1 TC/DSC Annulus Hydraulic Diameter and Flow Area Calculation

Section	Angle Segment		Angle (degrees)	Cask "X" Location (in)	Cask "Y" Location (in)	DSC "X" Location (in)	DSC "Y" Location (in)	Hydraulic Diameter (m)	Flow Area (m^2)
1	-5	5	0	0.000	34.000	0.000	33.355	0.0328	2.423E-03
2	5	15	10	5.904	33.483	5.793	32.852	0.0326	2.407E-03
3	15	25	20	11.629	31.950	11.414	31.359	0.0319	2.363E-03
4	25	35	30	17.000	29.445	16.696	28.918	0.0309	2.289E-03
5	35	45	40	21.855	26.046	21.481	25.600	0.0296	2.189E-03
6	45	55	50	26.046	21.855	25.625	21.502	0.0279	2.066E-03
7	55	65	60	29.445	17.000	29.003	16.745	0.0259	1.923E-03
8	65	75	70	31.950	11.629	31.510	11.469	0.0237	1.765E-03
9	75	85	80	33.483	5.904	33.068	5.831	0.0214	1.595E-03
10	85	95	90	34.000	0.000	33.625	0.000	0.0191	1.420E-03
11	95	105	100	33.483	-5.904	33.160	-5.847	0.0167	1.244E-03
12	105	115	110	31.950	-11.629	31.684	-11.532	0.0144	1.073E-03
13	115	125	120	29.445	-17.000	29.237	-16.880	0.0122	9.123E-04
14	125	135	130	26.046	-21.855	25.891	-21.725	0.0102	7.667E-04
15	135	145	140	21.855	-26.046	21.747	-25.917	0.0085	6.406E-04
16	145	155	150	17.000	-29.445	16.929	-29.323	0.0072	5.382E-04
17	155	165	160	11.629	-31.950	11.587	-31.836	0.0062	4.627E-04
18	165	175	170	5.904	-33.483	5.885	-33.376	0.0055	4.164E-04
19	175	185	180	0.000	-34.000	0.000	-33.895	0.0053	4.007E-04

The friction factor along the length of the DSC/cask annulus is calculated as:

$f = (1.58 * \ln \mathrm{Re} - 3.28)^{-2}$ [Eq. 7 of Reference 2 / Section 5.1 of 7]

Table 5-2 lists the friction factors as a function of Reynolds numbers.

Table 5-2 List of the Friction Factors in the Mass Flow Model

Re	f	4*f	Re	f	4*f
1	0.093	0.372	1500	0.015	0.058
100	0.063	0.250	1750	0.014	0.055
200	0.039	0.154	2000	0.013	0.052
300	0.030	0.122	3000	0.011	0.046
400	0.026	0.105	4000	0.010	0.041
500	0.023	0.094	5000	0.010	0.039
600	0.021	0.086	6000	0.009	0.037
800	0.019	0.075	8000	0.008	0.034
1000	0.017	0.069	12500	0.007	0.030
1250	0.016	0.063	22500	0.006	0.025

The areas, hydraulic diameters, and friction factors calculated for the 19 annular segments are applied as real constants to the FLUID116 elements. The friction factors are applied using the TB,FCON command as function of temperature and Reynolds number.

The total mass flow rate based on 450 cfm discharge from the fan for the 29.6 kW load case is calculated as follows:

$$\dot{m} = 450\, cfm * \rho_{air,average\ temp}$$
$$= 450 * \frac{(0.3048)^3}{60} * 0.973 \frac{kg}{s}$$
$$= 0.2067\ kg/s$$

Where,

$\dot{m}$ = Total Mass Flow Rate, (kg/s)

$\rho_{air,average\ temp}$ = Density of air based on Average Air Temperature = 0.973 kg/m^3

The air density in the above equation is calculated based on a pressure drop of 6 inches water gauge based on the calculations presented in Appendix A and an initial air exit temperature of 292°F for the 29.6 kW heat load case. The final air exit temperature is determined iteratively through the steps shown in Section 5.0.

The forced air introduced in the annular gap between the DSC and the cask distributes itself based upon the flow area and hydraulic diameter. The Flow Rate Model computes the air flow rate in each annular segment based on achieving an equal pressure drop over any segments of the annulus. The Flow Rate Model for determining the mass flow rates is shown in Figure 5-1.

A constant volumetric airflow rate of 450 cfm is assumed to evaluate the air mass flow rate in each of the parallel segments. A constant pressure is applied at the inlet of the air flow into the DSC/TC annulus and the mass flow at the outlet is computed for the flow along the 19 annular segments. The pressure at the inlet is iteratively changed until the total mass flow rate at outlet of the 19 annular segments is equal to total mass flow rate of 0.2067kg/s for the 29.6 kW heat load.

The mass flow rates obtained for each of the 19 angular segments for use in the CCNPP-FC TC thermal model along with the hydraulic diameters and flow areas are presented in the Table 5-3 29.6 kW heat load cases.

Table 5-3 Mass Flow Rates Along Each Annular Segment

	29.6 kW		
Section	Massflow (lbm/hr)	Hydraulic Diameter (in)	Flow Area (in^2)
1	100.53	1.29	3.75
2	99.46	1.28	3.73
3	96.26	1.26	3.66
4	91.33	1.22	3.55
5	84.26	1.16	3.39
6	75.78	1.10	3.20
7	66.59	1.02	2.98
8	57.09	0.93	2.74
9	47.89	0.84	2.47
10	39.32	0.75	2.20
11	30.98	0.66	1.93
12	23.67	0.57	1.66
13	17.61	0.48	1.41
14	12.81	0.40	1.19
15	9.17	0.34	0.99
16	6.66	0.28	0.83
17	5.01	0.24	0.72
18	4.07	0.22	0.65
19	3.77	0.21	0.62

5.2 CCNPP-FC TC Model

ANSYS model and the thermal analysis methodology for the CCNPP-FC TC are described in Section 5.0 of reference [6]. This calculation utilizes the thermal model of CCNPP-FC TC from reference [6] by adding the FLUID116 and LINK34 elements to simulate the forced convection. Figure 5-2 shows the CCNPP-FC TC finite element model with the LINK34 and FLUID116 elements added.

Forced air circulation through the annulus of the DSC/TC is modeled using the FLUID116 and LINK34 elements. The FLUID116 element models the forced air flow along the axial length of the DSC/cask annulus by conducting heat and transmitting the fluid between its nodes, whereas the LINK34 elements model the convection from the DSC/TC surfaces due to the forced air flow. The FLUID116 elements are modeled such that they are connected to the LINK34 convection elements.

The mass flow rates obtained from the Flow Rate Model described in Section 5.1 for each of the annular segments from 0° to 150° are applied to the FLUID116 elements using the "SFE,,,hflux" command.

Based on the mass flow rates obtained for each of the annular segments from 0° to 150°, the convection heat transfer coefficients for the DSC/TC annulus are computed using the correlations for flow within ducts and pipes. The convection heat transfer coefficients are computed as a function of the local hydraulic diameter, the Reynolds number, and the thermophysical properties of air. These convection heat transfer coefficients are applied to the LINK34 elements using the mpdata,hf / mp,hf commands.

The correlations for the convection coefficients are identical to those in [7] and are taken from equations 7, 43, 44, 45, 57, and 57a from Chapter 7 of [2] as follows:

For $0.5 < Pr < 2000$ and $10^4 < Re < 5x10^6$:

$$Nu = \frac{h_c D_h}{k} = \frac{Re \times Pr \times f/2}{1.07 + 12.7(Pr^{2/3} - 1)(f/2)^{0.5}}$$

$$Re = \frac{V \times \rho \times D_h}{\mu}$$

$$f = (1.58 \times \ln Re - 3.28)^{-2}$$

For $0.5 < Pr < 2000$ and $3000 < Re \leq 10^4$:

$$Nu = \frac{h_c D_h}{k} = \frac{(Re - 1000) \times Pr \times f/2}{1.0 + 12.7(Pr^{2/3} - 1)(f/2)^{0.5}}$$

For $0.5 < Pr < 2000$ and $0 < Re \leq 3000$:

$$Nu = \frac{h_c D_h}{k} = 2.035 \times (x^*)^{-(1/3)} - 0.7, \quad \text{for } x^* \leq 0.01$$

$$Nu = 2.035 \times (x^*)^{-(1/3)} - 0.2, \quad \text{for } 0.01 < x^* < 0.06$$

$$Nu = 3.657 + 0.0998/x^*, \quad \text{for } x^* \geq 0.06$$

Where:

Nu = Nusselt number
h_c = convection coefficient
D_h = hydraulic diameter
k = thermal conductivity of fluid at film temperature
V = flow velocity
ρ = density of fluid at the film temperature
μ = dynamic viscosity
Pr = Prandtl number
f = friction factor
Re = Reynolds number
x^* = entry length factor = $x/Re/D_h/Pr$
x = length of duct/pipe

Forced convection is omitted conservatively and conduction is assumed in the region between the canister support rails (i.e., approximately 150° to 180°) due to the narrowness of the gap between the DSC and the TC inner liner. Based on the above correlations and the mass flow rates from Section 5.1 the heat transfer coefficients for the annular segments from 0° to 150° are calculated and are presented in Table 5-4 for the DSC/TC annulus with a 29.6 kW heat load.

The material properties used in the CCNPP-FC TC model are listed in Section 4.3 of [6] as noted in Section 4.0.

The geometry of the CCNPP-FC TC Model is shown in Figure 5-1 to Figure 5-5 of Reference [6] and in Figure 5-2 with the LINK34 and FLUID116 elements.

Typical boundary conditions for the Thermal Model of CCNPP-FC TC are shown in Figure 5-6 through Figure 5-7 of Reference [6].

Steady state calculations were performed to determine the maximum component temperatures for the CCNPP-FC TC with 32PHB DSC at 29.6 kW and forced convection.

Table 5-4 Heat Transfer Coefficients in the DSC/TC Annulus for Forced Air Flow

	Heat Transfer Coefficients (Btu/hr-in²-°F)								
Temp (°F)	Entry at Spacer(1)	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8
110	0.015	0.028	0.028	0.028	0.027	0.027	0.026	0.025	0.024
210		0.029	0.029	0.028	0.028	0.027	0.026	0.025	0.024
310		0.029	0.029	0.029	0.029	0.028	0.027	0.026	0.024
410		0.030	0.030	0.030	0.029	0.029	0.028	0.026	0.025
510		0.031	0.031	0.030	0.030	0.029	0.028	0.027	0.025
	Heat Transfer Coefficients (Btu/hr-in²-°F)								
Temp (°F)	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14	Section 15	Section 16	Exit at Top Lid(1)
110	0.022	0.020	0.009	0.010	0.011	0.012	0.015	0.017	0.016
210	0.022	0.020	0.010	0.011	0.012	0.014	0.017	0.020	
310	0.023	0.010	0.011	0.012	0.014	0.016	0.019	0.022	
410	0.023	0.011	0.012	0.013	0.015	0.017	0.021	0.024	
510	0.011	0.012	0.013	0.014	0.016	0.019	0.022	0.026	

Notes:

(1) The lowest heat transfer coefficient is used for the Entry at spacer disc and Exit at Top lid for conservatism

5.3 Loss of Forced Airflow during Transfer Operations

The postulated loss of forced airflow condition considers an evaluation of the system performance for the case wherein steady-state conditions are established with the fan in operation and, subsequently the fan airflow is lost. To minimize the occurrence of this postulated condition, the CCNPP-FC TC skid is equipped with redundant industrial grade blowers, each one of these blowers capable of supplying the required minimum air flow rate. These blowers are also powered with a redundant power supply. The analysis assumes that the transient begins with DSC/TC at steady-state conditions from load case# 3. At time = 0, the fan airflow is lost and the system starts to heat up.

This analysis presents a time limit to restore the forced airflow or to complete the transfer of the 32PHB DSC with 29.6 kW heat load to the HSM-HB concrete module. The time limit is selected such that the peak fuel cladding temperature will remain below the normal/off-normal cladding temperature limit of 752°F for transfer operations as recommended in [8]. The selected time limit is bounding for NUHOMS 32PHB system with heat loads at or less than 29.6 kW. The results of the calculated thermal response of the DSC and TC for this transient analysis are presented in Section 6.0.

It should be noted that this condition also covers the normal/off-normal conditions in the transfer operations when the fans are removed and the ram is prepared to insert the DSC into the HSM-HB.

5.4 32PHB DSC/Basket Analysis

The DSC shell temperature profiles from steady state analysis in Section 5.2 for load case # 3 and from the transient analysis described in Section 5.3 for load case # 5 are used to determine the maximum basket component temperatures including the maximum fuel cladding temperature based on the 32PHB DSC/basket model described in Reference [5]. No changes are considered to the thermal model of the 32PHB DSC and the methodology presented in Reference [5].

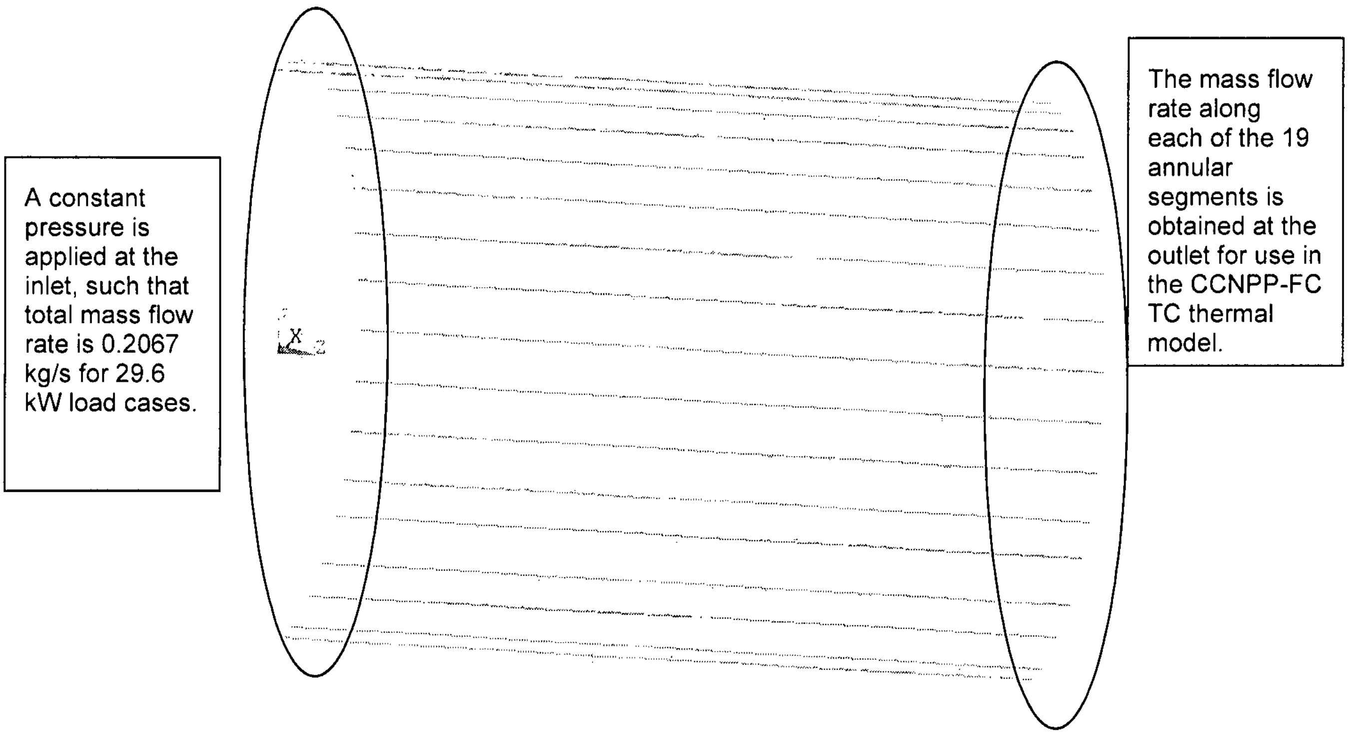


Figure 5-1 Finite Element Mesh of Flow Rate Model with FLUID116 Elements

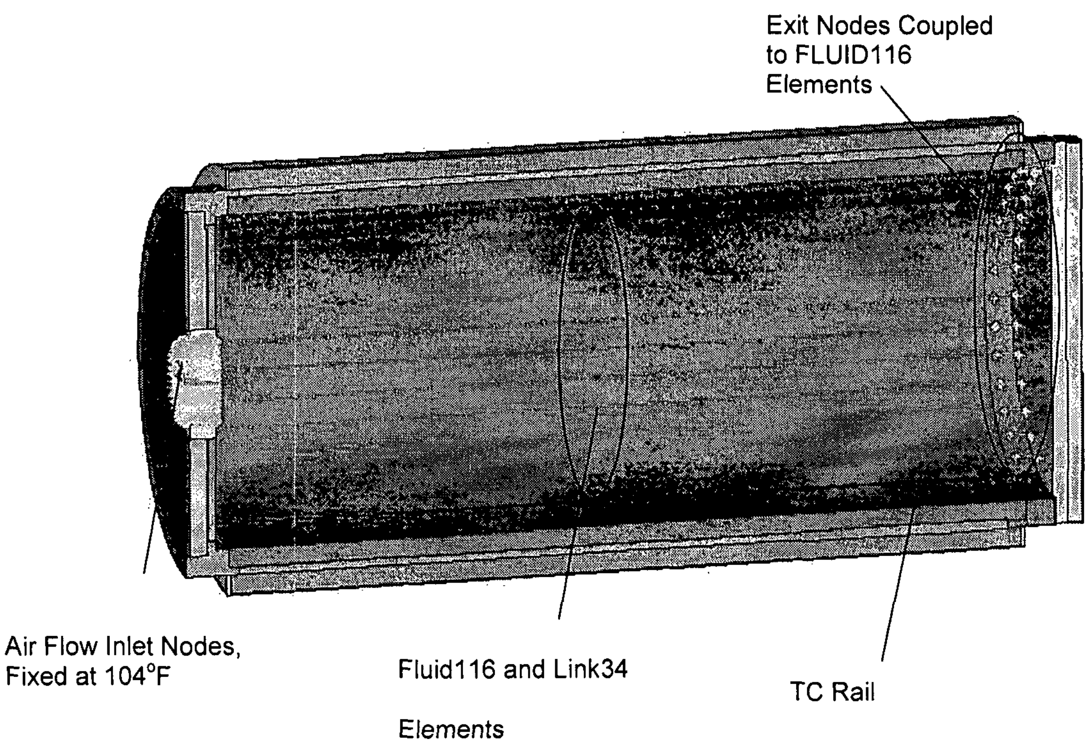


Figure 5-2 Finite Element Model of CCNPP-FC TC

6.0 RESULTS AND DISCUSSION

Based on the ambient conditions for normal/off-normal operations presented in Table 4-1, off-normal hot ambient conditions (load case # 3) presents the bounding case for the thermal analysis due to the higher ambient temperature/insolation. Therefore, the maximum temperatures of the CCNPP-FC TC with 32PHB DSC at 29.6 kW and forced convection for off-normal hot ambient conditions (load case # 3) bounds the maximum temperatures for normal hot/cold and off-normal cold conditions (load cases # 1, 2 and 4).

Steady state thermal analysis is performed for the CCNPP-FC TC with 32PHB DSC at 29.6 kW and forced convection for off-normal hot ambient conditions listed in Table 4-1 to determine the DSC shell temperature profile and the maximum TC component temperatures. The DSC shell temperature profiles is used to determine the peak fuel cladding and basket component temperatures based on the 32PHB DSC/Basket thermal model steady state analysis.

Table 6-1 summarizes the maximum temperatures for the CCNPP-FC TC components / 32PHB DSC components and shows that the maximum component temperatures are below the allowable limits. Figure 6-1 and Figure 6-2 present the temperature profiles for the off-normal hot condition with forced convection for the CCNPP-FC TC and 32PHB DSC.

In addition, the maximum difference between the exit air temperature of 292°F assumed in Section 5.1 and exit air temperature of 291.6 obtained from the thermal model as presented in Table 6-1 for the 29.6 kW heat load is -0.4°F. Therefore, no further iterations are required.

Table 6-1 Maximum Temperatures of CCNPP-FC TC @ 29.6 kW, Forced Air Cooling

Component	Temperature [°F]	
	Off-Normal Hot (Load Case # 3)	Max. Allowable
Fuel Cladding	689	752 [4, 8]
Basket (Guide Sleeve)	667	
Al/Poison Plate	666	
Basket Rails	451	
Top Shield Plug	366	
Bottom Shield Plug	247	
Max. DSC Shell (1)	410	---
Inner Shell	362	---
Gamma Shield	356	620
Structural Shell	310	---
Bulk Avg. Temp of Radial Neutron Shield	203	280 [10]
Bulk Avg. Temp of Top Neutron Shield	223	280 [10]
Bulk Avg. Temp of Bottom Neutron Shield	151	280 [10]
Cask Lid	256	---
Cask Outer Shell	279	---
Forced Air, Inlet / Exit	104 / 291.6	

(1) The maximum DSC shell temperature is the temperature along the "DSC Shell" as shown in Figure 5-3 of [6] and does not include the top and bottom end plates.

Transient thermal analysis is performed for the CCNPP-FC TC with 32PHB DSC at 29.6 kW and without forced convection to analyze the loss of forced air circulation condition listed in Table 4-1 to determine the DSC shell temperature profile and the maximum TC component temperatures. This analysis assumes that the transient begins with DSC/TC at steady-state conditions from load case# 3. At time = 0, the fan airflow is lost and the system starts to heat up.

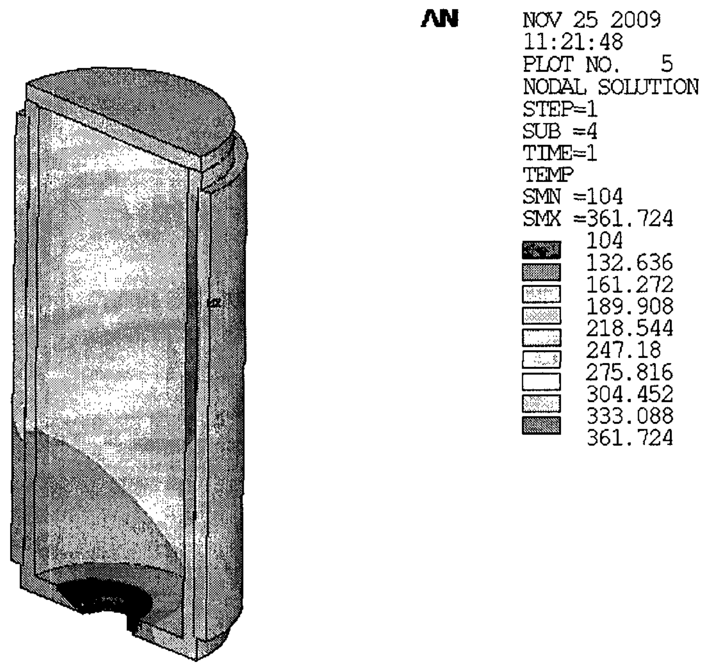
Based on the transient thermal analysis a maximum duration of 8 hours is available to complete the transfer to the HSM-HB or re-establish the fan airflow. The DSC shell temperature profiles at 8 hours from the time the fan airflow is lost is used to determine the peak fuel cladding and basket component temperatures based on the 32PHB DSC/Basket thermal model steady state analysis. Table 6-2 summarizes the maximum temperatures for the CCNPP-FC TC components / 32PHB DSC components and shows that the maximum component temperatures are below the allowable limits.

Table 6-2 Maximum Temperatures of CCNPP-FC TC @ 29.6 kW, Loss of Forced Air Transient

Component	Temperature [°F]	
	Loss of Forced Air Flow (Load Case # 5)	Max. Allowable
	Time = 8 hrs	
Fuel Cladding	734	752 [4, 8]
Basket (Guide Sleeve)	716	
Al/Poison Plate	715	
Basket Rails	478	
Top Shield Plug	377	
Bottom Shield Plug	316	
Max. DSC Shell (1)	422	---
Inner Shell	364	---
Gamma Shield	358	620
Structural Shell	310	---
Bulk Avg. Temp of Radial Neutron Shield	216	280 [10]
Bulk Avg. Temp of Top Neutron Shield	202	280 [10]
Bulk Avg. Temp of Bottom Neutron Shield	174	280 [10]
Cask Lid	253	---
Cask Outer Shell	276	---

(1) The maximum DSC shell temperature is the temperature along the "DSC Shell" as shown in Figure 5-3 of [6] and does not include the top and bottom end plates.

Figure 6-3 and Figure 6-4 present the temperature profiles for the loss of forced air flow transient analysis at 8 hrs for the CCNPP-FC TC and 32PHB DSC.



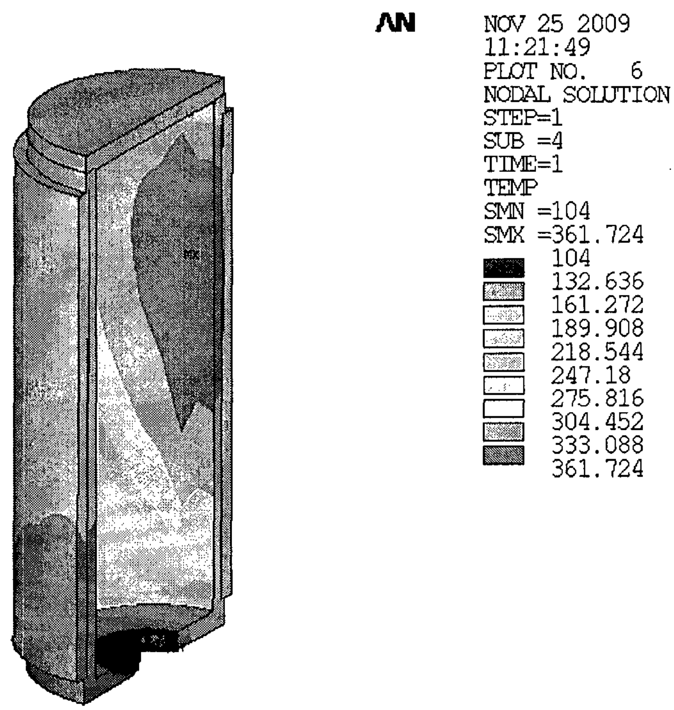
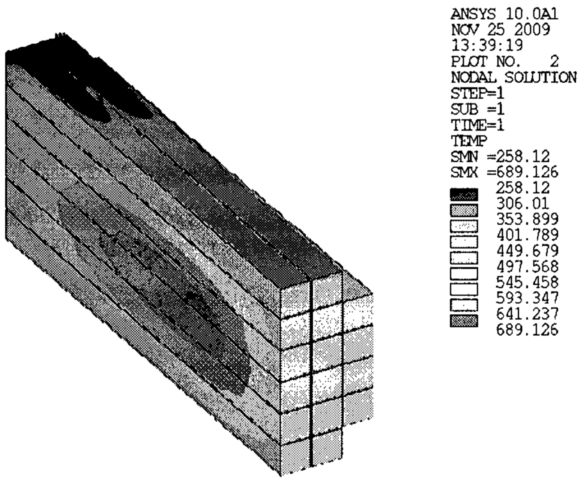
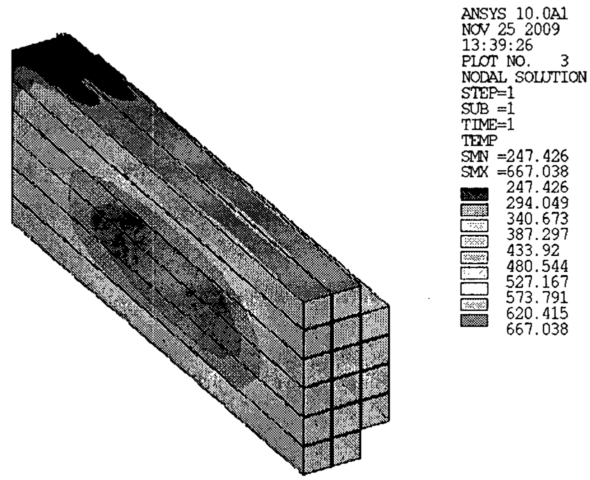


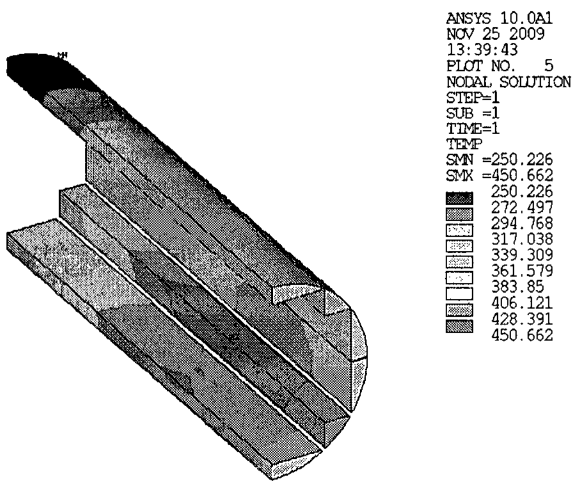
Figure 6-1 TC Temperature Distribution – Off-Normal Hot with Forced Convection, @ 29.6 kW, 127 Btu/hr-ft^2 Insolation, 104°F Ambient (load case # 3)



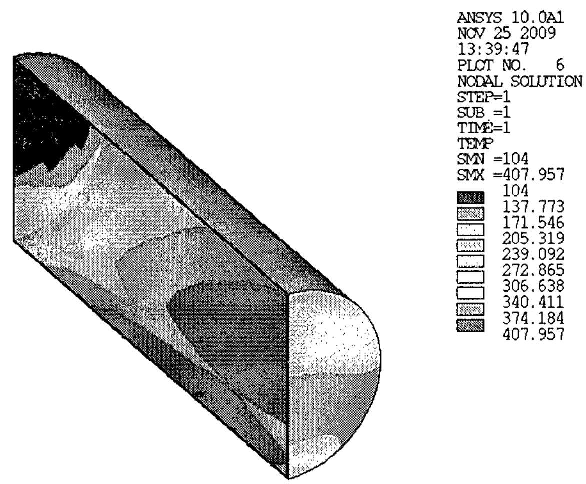
Fuel Cladding



Guide Sleeve

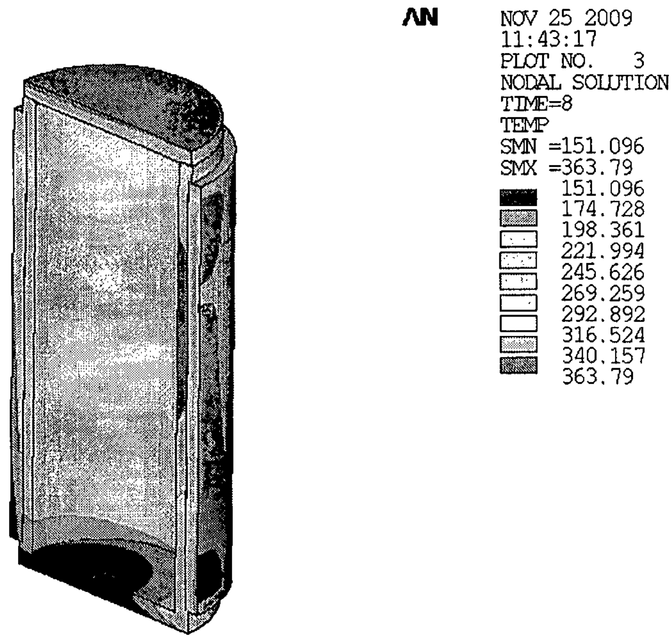


Basket Rail

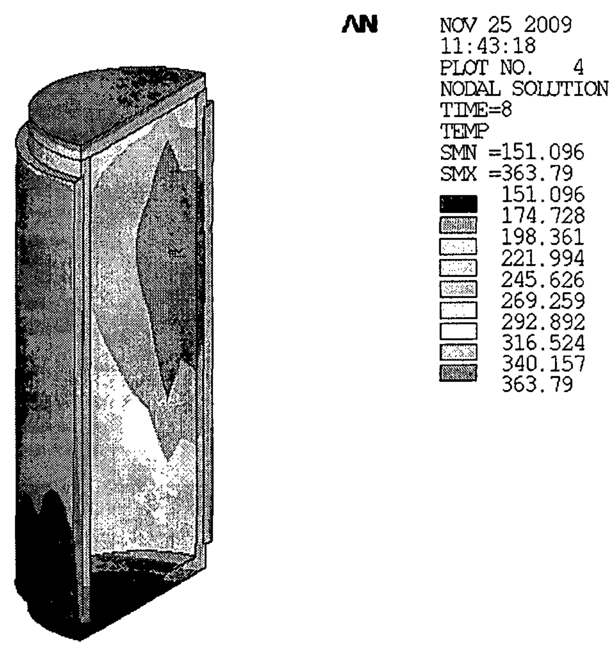


DSC Shell

Figure 6-2 32PHB DSC Temperature Distribution – Off-Normal Hot with Forced Convection, @ 29.6 kW, 127 Btu/hr-ft^2 Insolation, 104°F Ambient (load case # 3)

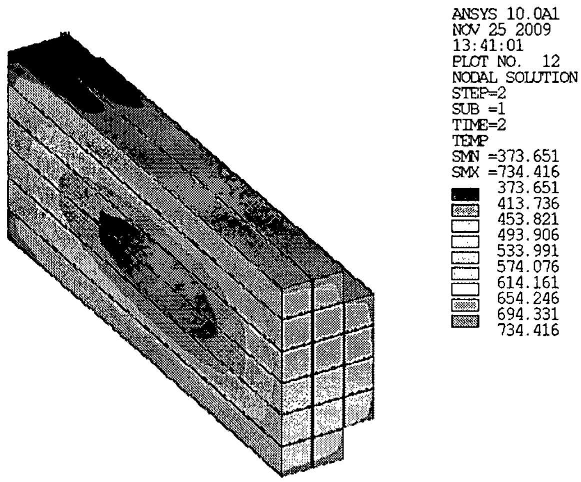


CCNPP-FC-TC with 32PHB, 29.6 kW - Off-Normal Loss of FC Transient

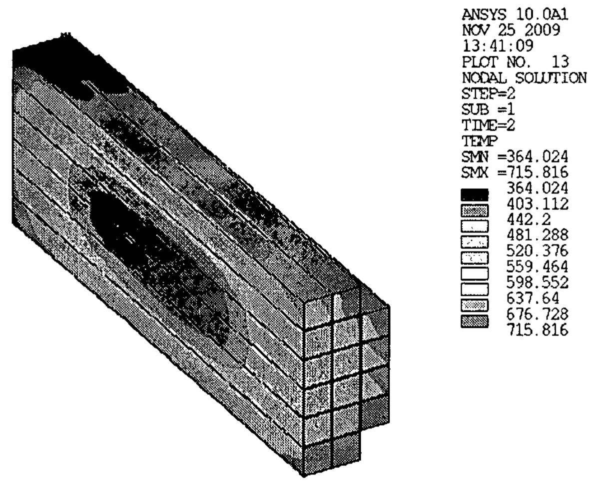


CCNPP-FC-TC with 32PHB, 29.6 kW - Off-Normal Loss of FC Transient

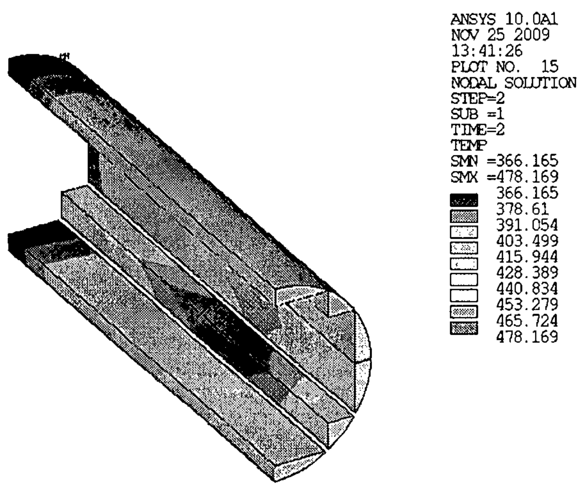
Figure 6-3 TC Temperature Distribution – Loss of Forced Air Transient, t = 8 hr @ 29.6 kW, 127 Btu/hr-ft^2 Insolation, 104°F Ambient (load case # 5)



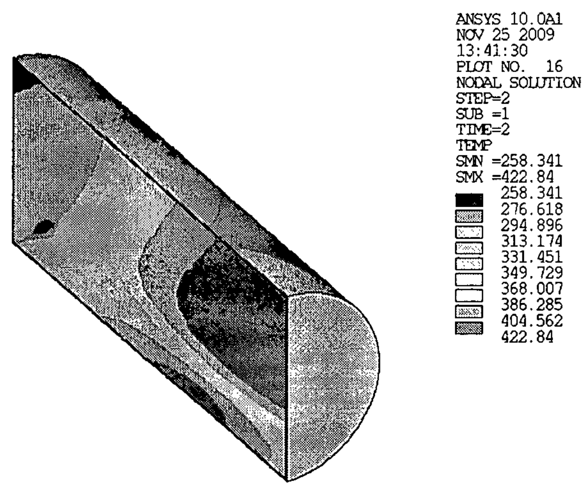
Fuel Cladding



Guide Sleeve



Basket Rail



DSC Shell

Figure 6-4 32PHB DSC Temperature Distribution – Loss of Forced Air Transient, t = 8 hr @ 29.6 kW, 127 Btu/hr-ft^2 Insolation, 104^{o}F Ambient (load case # 5)

7.0 CONCLUSION

Table 7-1 summarizes the maximum temperatures of the TC components and the 32PHB DSC for the off-normal hot horizontal transfer condition with forced cooling and at 8 hours transient after the loss of forced cooling.

Table 7-1 Maximum Temperatures of CCNPP-FC TC @ 29.6 kW, Forced Air Circulation

	Temperature [°F]		
Component	Off-Normal Hot (Load Case # 3)	Loss of Forced Cooling time = 8 hrs (Load Case # 5)	Max. Allowable
Fuel Cladding	689	734	752 [4, 8]
Basket (Guide Sleeve)	667	716	
Al/Poison Plate	666	715	
Basket Rails	451	478	
Top Shield Plug	366	377	
Bottom Shield Plug	247	316	
Max. DSC Shell (1)	410	422	---
Inner Shell	362	364	---
Gamma Shield	356	358	620
Structural Shell	310	310	---
Bulk Avg. Temp of Radial Neutron Shield	203	216	280 [10]
Bulk Avg. Temp of Top Neutron Shield	223	202	280 [10]
Bulk Avg. Temp of Bottom Neutron Shield	151	174	280 [10]
Cask Lid	256	253	---
Cask Outer Shell	279	276	---
Forced Air, Inlet / Exit	104 / 291.6	--	--

Notes:

(1) The maximum DSC shell temperature is the temperature along the "DSC Shell" as shown in Figure 5-3 of [6] and does not include the top and bottom end plates.

Also based on the discussion presented in Section 6.0, in the event of loss of forced air flow a maximum duration of 8 hours is available to complete the transfer to the HSM-HB or re-establish the fan airflow.

As seen the above table, all design criteria specified in Section 4.4 are herein satisfied.

8.0 LISTING OF COMPUTER FILES

All the runs are performed using ANSYS version 10.0 [3] with operating system "Linux RedHat ES 5.1", and CPU "Opteron 275 DC 2.2 GHz" / "Xeon 5160 DC 3.0 GHz".

A summary of ANSYS runs is shown in Table 8-1.

Table 8-1 Summary of ANSYS Runs

Run Name	Description	Date / Time for Output File
FlowRate_32PHB_29kW	Flow Rate Model to determine the mass flow rates for 29.6 kW Heat Load.	11/25/2009 11:04 AM
TR_32PHB_29kW	CCNPP-FC TC with 32PHB DSC and Forced Convection- 29.6 kW	11/25/2009 11:21 AM
TR_32PHB_29kW-Map	Run for Mapping the 32PHB DSC Shell Temperature Profiles for off-normal hot load case	11/25/2009 11:33 AM
TR_32PHB_29kW-TC-Map	Run for Mapping the CCNPP-FC TC Temperature Profiles for Loss of Forced Airflow load case	11/25/2009 11:33 AM
32PHB_LOSSFC_OFN_TRANS	CCNPP-FC TC with 32PHB DSC and Loss of Forced Airflow- 29.6 kW	11/25/2009 11:43 AM
32PHB_LOSSFC_OFN_TRANS_Map	Run for Mapping the 32PHB DSC Shell Temperature Profiles for Loss of Forced Airflow load case at 8 hrs	11/25/2009 11:48 AM
32PHB_TC4M	Load 1: 32PHB DSC Basket for Off-Normal Hot Transfer with Forced Convection Load 2: 32PHB DSC Basket for Loss of Forced airflow @ 8 hrs	11/25/2009 1:42 PM

ANSYS macros, and associated files used in this calculation are shown in Table 8-2.

Table 8-2 Associated Files and Macros

File Name	Description	Date / Time
HTOT_HCL.MAC [6]	Total heat transfer coefficients for horizontal cylindrical surface	2/19/2009 12:37 PM
HTOT_VPL.MAC [6]	Total heat transfer coefficients for vertical flat surface	2/19/2009 12:37 PM
32PHBTC_Mat.inp [6]	Material properties for CCNPP-FC Cask	10/21/2009 6:07 PM
32PHB_TC_RAD_Horizontal.inp [6]	Macro for Creating Radiation Exchange between the DSC/TC when the TC is in Horizontal Orientation	10/21/2009 4:46 PM
32PHB_Mat1.inp [5]	Material properties for 32PHB DSC with Helium	09/09/09 09:54 AM
32PHB_HLZC2.MAC [5]	Heat generation for 32PHB DSC, 29.6 kW	09/03/09 08:56 AM
Macro [5]	Macro to get Maximum/Minimum temperatures	05/20/05 12:03 PM
Results.mac [5]	Macro to list maximum and average 32PHB DSC component temperatures	07/22/09 11:52 AM
CCNPP-FC-TC.db [6]	ANSYS thermal model for CCNPP-FC TC	08/28/09 2:41 PM
32PHB_Model.db [5]	ANSYS thermal model for 32PHB DSC	07/10/09 7:49 PM
32PHB_TC_PP_LFC.inp	Macros for Post-Processing Transient Runs	11/11/2009 5:07 PM
MassFlow_ConvCoeff_32PHB_29.6kW.xls	Spreadsheet for calculating the hydraulic diameters, friction factors, mass flow rates and heat transfer coefficients	11/25/2009 4:01 PM
Pressure Drop-CCNPP-FC-TC.xls	Spreadsheet for Pressure Drop Calculation	11/25/2009 4:00 PM

APPENDIX A FORCED AIR PRESSURE DROP

The pressure drop experienced by the forced air from the fan discharge, through the DSC and cask annulus, and its subsequent exhausting back into the ambient is computed assuming 1-D flow pipe flow relationships. Table A-1 presents the build up of the 'fittings' assumed along the flow path, the effective hydraulic diameter, the assumed loss coefficients from [11] and [12], and the resultant pressure drop. A pressure drop of approximately 5.64 inches water gauge is expected. For conservatism and to account for operational modifications, a design fan rating of 8 inches water gauge is recommended.

Table A-1 Forced Air Pressure Drop

Proprietary Information Withheld Pursuant to 10 CFR 2.390

ATTACHMENT (2)

MARKED UP TECHNICAL SPECIFICATION PAGES

Calvert Cliffs Nuclear Power Plant, LLC
December 8, 2011

Insert A

for the NUHOMS-24P and NUHOMS-32P DSCs. The double closure seal welds at the bottom of the DSC shall satisfy the Liquid Penetrant Acceptance Standards of ASME B&PV Code Section III, Division 1, Subsection NB-5350 (1998 with addenda up to and including 1999) for the NUHOMS 32-PHB DSCs.

Insert 3.1.1(2)

(a) 4.5 weight percent U-235 for the NUHOMS-24P DSC and NUHOMS-32P DSC
(b) 4.75 weight percent U-235 for NUHOMS-32PHB DSC for basket type A
(c) 5.0 weight percent U-235 for NUHOMS-32PHB DSC for basket type B

Insert 3.1.1(3)

(a) 47,000 MWd/MTU for NUHOMS-24P DSCs
(b) 52,000 MWd/MTU for NUHOMS-32P DSCs
(c) 62,000 MWd/MTU for NUHOMS-32PHB DSCs

Insert 3.1.1(5)

(a) 0.66 kilowatts per fuel assembly for the NUHOMS-24P DSC and NUHOMS-32P DSCs
(b) 0.8 kilowatts per fuel assembly for the NUHOMS-32PHB DSC basket zones 1 and 4
(c) 1.0 kilowatts per fuel assembly for the NUHOMS-32PHB DSC basket zones 2 and 3

Insert 3.1.1(7)

(a) 1450 lbs (658 kg) for the NUHOMS-24P and NUHOMS-32P DSCs
(b) 1375 lbs (625 kg) for the NUHOMS-32PHB DSCs

Insert 3.2.2.1

for the NUHOMS-24P and NUHOMS-32P DSCs. The top shield plug closure weld, the siphon and vent port cover welds, and the top cover plate weld shall satisfy the Liquid Penetrant Acceptance Standards of ASME B&PV Code Section III, Division 1, Subsection NB-5350 (1998 with addenda up to and including 1999) for the NUHOMS 32-PHB DSCs.

LICENSE FOR INDEPENDENT STORAGE OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter 1, Part 72, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, and possess the power reactor spent fuel and other radioactive materials associated with spent fuel storage designated below; to use such material for the purpose(s) and at the place(s) designated below; and to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified herein.

Licensee 1. Calvert Cliffs Nuclear Power Plant, LLC	3. License No. SNM-2505 Amendment No. 9
2. 100 Constellation Way Baltimore, MD 21202	4. Expiration Date November 30, 2012 5. Docket or Reference No. 72-8

6. Byproduct, Source, and/or Special Nuclear Material	7. Chemical or Physical Form	8. Maximum Amount That Licensee May Possess at Any One Time Under This License
Spent fuel assemblies from Calvert Cliffs Nuclear Station Units 1 and 2 reactor using natural water for cooling and enriched not greater than ~~4.5~~ 5.0 percent U-235 and associated radioactive materials related to receipt, storage, and transfer of fuel assemblies.	A. As UO_2 clad with zirconium or zirconium alloys.	A. ~~1,111.68~~ 1558.27 TeU of spent fuel assemblies.

9. Authorized Use: For use in accordance with the conditions in this license and the attached Technical Specifications. The basis for this license was submitted in the Safety Analysis Report (SAR) application dated December 21, 1989, and supplemented April 26, June 29, November 1, and December 20, 1990; February 1, February 12, September 30, October 18, December 19, and December 27, 1991; August 18 and September 4, 1992; July 29 and October 20, 1994; March 31, 1995; November 22, 1999; May 19, June 20, October 4, November 10 and 16, 2000; May 18, and July 26, 2001; December 12, 2003, May 12, 2004 and June 7, 2005; May 16, September 29, October 28, 2005, January 22, February 26, April 8, June 25, July 27, October 15, October 19, October 25 (2 letters), October 26, October 28, 2009; June 15, 2009, February 18, March 31, May 6, and September 1, 2010.

   The material identified in 6.A and 7.A above is authorized for receipt, possession, storage, and transfer.

10. Authorized Place of Use: The licensed material is to be received, possessed, transferred, and stored at the Calvert Cliffs ISFSI located on the Calvert Cliffs Nuclear Power Plant site in Calvert County, Maryland. This site is described in Chapter 2 of the licensee's SAR for the Calvert Cliffs ISFSI.

11. The Technical Specifications contained in Appendix A attached hereto are incorporated into the license. The licensee shall operate the installation in accordance with the Technical Specifications in Appendix A.

B The Calvert Cliffs Nuclear Power Plant Emergency Plan shall be reviewed and modified as required to include the ISFSI.

C A training module shall be developed for the Calvert Cliffs Nuclear Power Plant Training Program establishing an ISFSI Training and Certification Program which will include the following:

1. DSC, TC, and HSM Design (overview)
2. ISFSI Facility Design (overview)
3. ISFSI Safety Analysis (overview)
4. Fuel loading and DSC and TC handling procedures and abnormal procedures
5. ISFSI License (overview).

D The Calvert Cliffs Nuclear Power Plant health physics procedures shall be reviewed and modified as required to include the ISFSI.

E The Calvert Cliffs Nuclear Power Plant Administrative Procedures shall be reviewed and modified as required to include the ISFSI.

F A procedure shall be developed and implemented for the documentation of the characterizations performed to select spent fuel to be stored in the canisters and modules. Such procedure shall include independent verification of fuel assembly selection by an individual other than the original individual making the selection.

G A procedure shall be developed and implemented for two independent determinations (two samples analyzed by different individuals) of the boron concentration in the water used to fill the DSC cavity for fuel loading and unloading activities.

H Written procedures shall be implemented to describe actions to be taken during operation and abnormal/emergency conditions.

15. The design, construction, and operation of the ISFSI shall be accomplished in accordance with the NRC regulations specified in Title 10 of the U.S. Code of Federal Regulations. All commitments to the applicable NRC Regulatory Guides and to engineering and construction codes shall be carried out.

16. The double closure seal welds at the bottom end of the DSC shall satisfy the Liquid Penetrant Acceptance Standards of ASME B&PV Code Section III, Division 1, Subsection NB-5350 (1983). [Insert A] Additionally, these seal welds at the bottom of the DSC shall be leak tested in accordance with ANSI N14.5 (1987).

Fuel and TC movement and handling activities which are to be performed in the Calvert Cliffs Nuclear Power Plant Auxiliary Building will be governed by the requirements of the Calvert Cliffs Nuclear Power Plant Facility Operating Licenses (DRP-53 and -69) and associated Technical Specifications.

18. Pursuant to 10 CFR 72.7, the licensee is hereby exempted from the provisions of 10 CFR 72.122(i) with respect to providing instrumentation and control systems for the DSC and HSM during storage

2.0 FUNCTIONAL AND OPERATING LIMITS

2.1 FUEL TO BE STORED AT ISFSI

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 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)	$\leq 4.175 \times 10^{8}$ n/sec/assembly, with spectrum bounded by Table 3.1-4 of the Calvert Cliffs ISFSI SAR
Gamma Source Per Assembly (NUHOMS-24P)	$\leq 1.53 \times 10^{15}$ MeV/sec/assembly with spectrum bounded by that shown in Table 3.1-4 of the Calvert Cliffs ISFSI SAR
Gamma Source Per Assembly (NUHOMS-32P)	$\leq 1.61 \times 10^{15}$ 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.

Neutron Source Per Assembly (NUHOMS-32PHB)	$\leq 6.66 \times 10^{8}$ n/sec/assembly, with spectrum bounded by Table 3.1-4 of the Calvert Cliffs ISFSI SAR
Gamma Source Per Assembly (NUHOMS-32PHB)	$\leq 2.56 \times 10^{15}$ MeV/sec/assembly with spectrum bounded by that shown in Table 3.1-4 of the Calvert Cliffs ISFSI SAR

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~~ Insert 3.1.1 (2)

(3) Maximum assembly average burnup shall not exceed: ~~47,000 megawatt-days per metric ton uranium (NUHOMS-24P) or 52,000 megawatt-days per metric ton uranium (NUHOMS-32P).~~ Insert 3.1.1 (3)

(4) Minimum burnup shall exceed the minimum specified in SAR Figure 3.3-1. (Applicable only to NUHOMS-24P.)

(5) Maximum heat generation rate shall not exceed: ~~0.66 kilowatt per fuel assembly.~~ Insert 3.1.1 (5)

(6) Fuel shall have cooled as specified in ISFSI SAR Table 9.4.1.

(7) Maximum assembly mass including control components shall not exceed: ~~1450 lb. (658 kg).~~ Insert 3.1.1 (7)

(8) Fuel shall be undamaged.

(9) Fuel shall be intact (NUHOMS-32P), only if air is the blowdown medium for DSC drying.

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.

3/4.2 DRY SHIELDED CANISTER (DSC)

3/4.2.2 DSC CLOSURE WELDS

LIMITING CONDITION FOR OPERATION

3.2.2.1 The top shield plug closure weld, the siphon and vent port cover welds, and the top cover plate weld shall satisfy the Liquid Penetrant Acceptance Standards of ASME B&PV Code Section III, Division 1, Subsection NB-5350 (1983). (Insert 3.2.2.1)

3.2.2.2 The standard helium leak rate for the top shield plug closure weld, and the siphon and vent port cover welds shall not exceed 10^{-4}atm-cc/s. ((NUHOMS 24P and NUHOMS 32P) or 10^{-7} ref.-cc/s (NUHOMS 32PHB))

APPLICABILITY: Applicable to all DSCs.

ACTION: With the requirements of the above specifications not satisfied, the weld shall be repaired in accordance with approved procedures and re-examined in accordance with these specifications.

SURVEILLANCE REQUIREMENT

4.2.2.1 During DSC loading operations, the top shield plug closure and the siphon and vent port cover welds shall be tested using a helium leak detector to ensure that, for each weld, leak tightness is less than or equal to 10^{-4} atm-cc/s (NUHOMS 24P and NUHOMS 32P) or 10^{-7} ref-cc/s (NUHOMS 32PHB). These welds and the DSC top cover plate weld shall be dye penetrant tested.

New Technical Specification

3/4.3 TRANSFER CASK

3/4.3.2 TIME LIMIT FOR COMPLETION OF NUHOMS 32 PHB DSC TRANSFER OPERATION

LIMITING CONDITION FOR OPERATION

3.3.2.1 The time limit for completion of transfer of a loaded and welded NUHOMS 32 PHB DSC from the cask handling area to the HSM is as follows:

a. No time limit for a DSC with a total heat load of ≤ 21.12 kW

b. 72 hours for a DSC with a total heat load > 21.12 kW and ≤ 23.04 kW

c. 48 hours for a DSC with a total heat load > 23.04 kW and ≤ 25.6 kW

d. 20 hours for a DSC with a total heat load > 25.6 kW and ≤ 29.6 kW

APPLICABILITY: This specification is applicable to NUHOMS 32 PHB DSCs only. The time limit is defined as the time elapsed after the initiation of draining the transfer cask/DSC annulus water until completion of insertion of the DSC into the HSM.

ACTION: Initiate one of the following actions within eight hours if the specified time limit is exceeded. The chosen action may be temporarily suspended under administrative controls to change from one action to another.

1. Complete the transfer of the DSC to the HSM or,

2. If the transfer cask is in the cask handling area in a vertical orientation fill the transfer cask/DSC annulus with clean water or,

3. If the transfer cask is in a horizontal orientation, initiate air circulation by starting one of the blowers provided on the transfer skid or,

4. Return the transfer cask to the cask handling area and fill the transfer cask/DSC annulus with clean water, or initiate appropriate external cooling of the transfer cask outer surface by other means to limit the surface temperature increase.

SURVEILLANCE REQUIREMENTS

4.3.2.1 Monitor the time duration following initiation of draining of the transfer cask/DSC annulus until completion of the insertion of the NUHOMS 32 PHB DSC into the HSM.

New Technical Specification

3/4.3.3 <u>TIME LIMIT FOR COMPLETION OF NUHOMS 32 PHB DSC VACUUM DRYING OPERATION</u>

LIMITING CONDITION FOR OPERATION

3.3.3.1 The time limit for completion of vacuum drying of a loaded NUHOMS 32 PHB DSC following blow down with nitrogen is as follows:

a. 56 hours for a DSC with a total heat load ≤ 23.04 kW

b. 40 hours for a DSC with a total heat load > 23.04 kW and ≤ 25.6 kW

c. 32 hours for a DSC with a total heat load > 25.6 kW and ≤ 29.6 kW

<u>APPLICABILITY</u>: This specification is only applicable to vacuum drying of a NUHOMS 32 PHB DSC following blow down with nitrogen. The time limit is defined as the time elapsed after the initiation of the DSC blow down operation with the intent to uncover the active fuel region until the initiation of helium backfill. This specification is not applicable, and there are no time limits imposed on vacuum drying, when helium is used for blow down of the NUHOMS 32 PHB DSC.

<u>ACTION</u>: If vacuum drying cannot be completed within the specified time limit, backfill the DSC with helium and continue with the vacuum drying operation.

<u>SURVEILLANCE REQUIREMENTS</u>

4.3.3.1 Monitor the time duration following initiation of DSC blow down using nitrogen until the initiation of helium backfill.

3/4.4 HORIZONTAL STORAGE MODULE (HSM)

3/4.4.1 MAXIMUM AIR TEMPERATURE RISE

LIMITING CONDITION FOR OPERATION

3.4.1.1 The air temperature rise from the HSM inlet to the HSM outlets shall not exceed 64°F ~~(35.6°C)~~.

APPLICABILITY: Applicable to all HSMs.

ACTION: If the temperature rise is greater than 64°F (or 80°F, as appropriate,) ~~(35.6°C)~~ the air inlet and outlets should be checked for blockage. If any blockage is cleared and the temperature rise is still greater than 64°F ~~(35.6°C)~~ the DSC and HSM cavity shall be inspected, using video equipment or other suitable means. Analysis of the existing conditions shall be performed to confirm that conditions adversely affecting the fuel cladding integrity do not exist. Subsequent actions to return to acceptable conditions such as, providing temporary forced ventilation and/or retrieval of the DSC and verification that an assembly fuel with no more than 0.66 kW (or 0.8 kW or 1.0 kW, as appropriate) was loaded shall be performed.

SURVEILLANCE REQUIREMENTS

4.4.1.1. The maximum air temperature rise from the HSM inlet to outlets shall be checked at the time the DSC is stored in the HSM, again 24 hours later, and again after 7 days.

4.4.1.2 The HSM shall be visually inspected to verify that the air inlet and outlets are free from obstructions when there is fuel in the HSM. The visual inspection frequency shall be every 24 hours.

The air temperature rise from the HSM-HB inlet to the HSM-HB outlets shall not exceed 80°F.

5.0 DESIGN FEATURES

5.1 GENERAL

The Calvert Cliffs ISFSI design approval was based upon review of specific design drawings, some of which have been deemed appropriate for inclusion in the Calvert Cliffs ISFSI Safety Evaluation Report (SER). Drawings listed in Section 1.5 of the Calvert Cliffs ISFSI SER have been reviewed and approved by the NRC. These drawings may be revised under the provisions of 10 CFR 72.48 as appropriate.

(AND NUHOMS-32PHB)

5.2 NUHOMS-32P DRY SHIELDED CANISTER (DSC)

The NUHOMS-32P DSC poison plates shall have a minimum B10 areal density of 0.0100g/cm^2.

The NUHOMS-32PHB DSC poison plates shall have a minimum B10 areal density of 0.019 g/cm^2 for basket type A and 0.0270 g/cm^2 for basket type B.

5.3 COMBUSTIBLE GAS MONITORING DURING TOP SHIELD PLUG LID WELDING AND CUTTING

During top shield plug lid-to-shell welding and cutting operations, combustible gas monitoring of the space under the top shield plug lid is required, to ensure that there is no combustible mixture present.

6.0 ADMINISTRATIVE CONTROLS

6.1 GENERAL

The Calvert Cliffs ISFSI is located on the Calvert Cliffs Nuclear Power Plant site and will be managed and operated by the Calvert Cliffs Nuclear Power Plant, LLC, staff. The administrative controls shall be in accordance with the requirements of the Calvert Cliffs Nuclear Power Plant Facility Operating Licenses (DPR-53, and -69) and associated Technical Specifications as appropriate.

6.2 ENVIRONMENTAL MONITORING PROGRAM

The licensee shall include the Calvert Cliffs ISFSI in the environmental monitoring for Calvert Cliffs Nuclear Power Plant. An environmental monitoring program is required pursuant to 10 CFR 72.44(d)(2).

6.3 ANNUAL ENVIRONMENTAL REPORT

The annual radioactive effluent release reports under 10 CFR 50.36(a)(2) license requirements for the Calvert Cliffs Nuclear Power Plant shall also specify the quantity, if any, of each of the principal radionuclides released to the environment in liquid and gaseous effluents during the ISFSI operation and such other information as may be required by the Commission to estimate maximum potential radiation dose commitment to the public resulting from effluent releases. Copies of these reports shall be submitted to the NRC Region I office and to the Director, Office of Nuclear Material Safety and Safeguards. The report under this specification is required pursuant to 10 CFR 72.44(d)(3).

ATTACHMENT (3)

TRANSNUCLEAR, INC. PROPRIETARY AFFIDAVIT

AFFIDAVIT PURSUANT
TO 10 CFR 2.390

Transnuclear, Inc.)
State of Maryland) SS.
County of Howard)

I, Jayant Bondre, depose and say that I am a Vice President of Transnuclear, Inc., duly authorized to execute 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 2.390 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is contained in following documents as listed below:

1. TN Calculation NUH32PHB-0401, "Thermal Evaluation of NUHOMS 32PHB Transfer Cask for Normal, Off Normal, and Accident Conditions with Forced Cooling (Steady State)," Revision 1.

2. TN Calculation NUH32PHB-0503, "HSM-HB Shielding Analysis for NUHOMS 32PHB System," Revision 1.

These documents have been appropriately designated as proprietary.

I have personal knowledge of the criteria and procedures utilized by Transnuclear, 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 2.390 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 are certain portions of thermal evaluation and radiation dose rate analyses for NUHOMS® 32PHB dry storage system which are owned and have been held in confidence by Transnuclear, Inc.

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

3) Public disclosure of the information is likely to cause substantial harm to the competitive position of Transnuclear, Inc. because the information consists of descriptions of the design and analysis of dry spent fuel storage systems, the application of which provide a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with Transnuclear, Inc., take marketing or other actions to improve their product's position or impair the position of Transnuclear, Inc.'s product, and avoid developing similar data and analyses in support of their processes, methods or apparatus.

Further the deponent sayeth not.

Jayant Bondre
Vice President, Transnuclear, Inc.

Subscribed and sworn to me before this 15th day of November, 2011.

Notary Public

My Commission Expires

ZORA M. DOUGHERTY
NOTARY PUBLIC
HOWARD COUNTY, MD
My Commission Expires 10-17-2015