71-9302

TRANSNUCLEAR, INC.

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E-19512

Mr. Chris Regan, Project Manager
Spent Fuel Project Office
Division of Industrial and Medical Nuclear Safety
Office of Nuclear Material Safety and Safeguards
Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Subject: Docket No. 71-9302 (TAC No. L23328), Additional Clarification for the NUHOMS®-MP197 Transport Package Application dated October 24, 2001

Dear Mr. Regan:

Enclosed for your review is additional clarification to our RAI response submittal on January 31, 2002. They consist of the following attachments:

a. Attachment 1-Response questions on the thermal Chapter for the NUHOMS MP197 SAR (8 copies)
b. Appendix 3.7.5 (8 copies)
c. CD (1 copy)

If you have any questions or comments, please call me.

Sincerely,

P. Shih

Peter Shih
Project Manager

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Additional questions on the Thermal Chapter for the NUHOMS - MP197 SAR

1. Provide a sensitivity study on the ANSYS models supplied to the staff to show the effects of: 1) reduced stainless steel emissivity values and 2) including gaseous conduction and radiation in the helium filled gap at the top of the 61-BT canister on the overall package temperature values. Perform this study for both Normal and Accident Conditions and provide results to the staff for all cask components.

The thermal emissivity of Type 304/304L stainless steel varies with temperature and surface finish. In the credible references familiar to the staff, values given for emmissivity of stainless steel are between 0.3 and 0.5. The applicant uses an emmissivity value of 0.8 for weathered stainless steel. Given the loading procedures for the cask and DSC, it is unlikely that the stainless steel surface of the cask will become weathered. Therefore, the value used by the applicant does not have adequate justification, and should be revised.
The lack of conduction medium and radiation interaction in the top portion of the 61 BT canister model presents a conservative case with respect to fuel, cask, and canister components in the mid-section region, however; this modeling approach reduces the canister lid, and consequently, the cask lid and seal normal condition temperatures.
Since these components rise in temperature during the hypothetical accident conditions (HAC) event, cask lid components should be analyzed using the maximum possible normal condition temperatures.

A sensitivity analysis is performed on the ANSYS model of the MP-197 transport cask to investigate the effect of the stainless steel emissivity on the temperature distribution. In this investigation the stainless steel emissivity is decreased from 0.8 to 0.5. It is assumed that the absorptivity and the emissivity have the same values for practical purposes. The result of this analysis is provided in Appendix 3.7.5.

2. Provide a basis for the assumption that there is only a single gap between the lead shield and cask outer shell.

Depending on the vendor's fabrication process, it is possible that a gap may also exist between the inner cask shell and lead as well. The applicant should confirm that the cask configuration assumed in the SAR is representative of the fabricated cask body.

Response: To fabricate the lead shield, molten lead will be poured into the gap between the inner and outer shell of the cask. The cask will be heated for this procedure. After the cool down air gaps might be created on each side of the lead shield. Since the thermal expansion coefficient of the lead is higher than that of the stainless steel, the larger gap will be between the lead shield and the outer shell. To maximize the lead temperature and to simplify the model the maximum possible gap (sum of the both gap sizes) is considered to be located between the lead shield and the outer cask shell. Since the total thermal resistance is not changed, considering one gap between the lead shell and the cask outer shell does not change the temperature distribution in the basket. This method is conservative according to the

maximum lead temperature and does not have any effect on the maximum temperatures of the other components.

APPENDIX 3.7.5

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APPENDIX 3.7.5

SENSITIVITY ANALYSIS REGARDING THE SURFACE EMISSIVITY OF STAINLESS STEEL FOR THE CASK RADIAL SURFACE

3.7.5.1 Discussion

In Chapter 3 an emissivity value of 0.8 was assumed for the weathered stainless steel. This emissivity value was used to calculate the total heat transfer coefficient from the radial surface of the cask to the ambient as described in detail in Section 3.4.1.1. A sensitivity analysis is performed to investigate the effect of a lower emisivity value for the cask surface on the component temperatures within the transport cask. This investigation is focused on the normal conditions of transport. The emissivity value of the weathered stainless steel is only used for cask surface to calculate the pre-fire conditions in the evaluation of the hypothetical fire accident case. Therefore, the impact of using a lower emisivity on the fire accident analysis is close to its impact on the normal condition case.

3.7.5.2 Thermal Models

The two thermal models described in Chapter 3 are the bases for this sensitivity analysis. Only the basket model is modified to add conduction paths at the top and bottom of the basket towards the shield plugs of the canister. The length of the fuel assembly is extended from the active length (144") to the full assembly length of 176" (Reference 3). All the elements representing the fuel assembly are given the effective fuel conductivity calculated in Appendix 3.7.1. The decay heat load profile is unchanged and it is applied over the active fuel length of 144".

The top surface of the fuel assembly is considered to be oxidized. An emissivity value of 0.9 is considered for this oxidized surface to maximize the axial heat transfer. The inner surface of the canister front plug is made of carbon steel. An emissivity value of 0.8 is considered for the carbon steel from References 1 and 2. To simplify the model, an effective radiation conductivity is calculated for the helium elements between the top of fuel assembly and the front shield plug based on the following equation.

$$k_r = \frac{\sigma L}{\left(\dfrac{1-\varepsilon_f}{\varepsilon_f} + \dfrac{1}{F_{12}} + \dfrac{1-\varepsilon_p}{\varepsilon_p}\right)} \frac{\left(T_f^{\,4} - T_p^{\,4}\right)}{\left(T_f - T_p\right)}$$

Where,

k_r = effective radiation coductivity	(Btu/hr-in-F)
σ = Stefan-Boltzmann coefficient = 0.119×10^{-10}	(Btu/hr-in^2-R^4)
L = distance between the top of fuel assembly to the inner surface of the shield plug = 3.375	(in)
ε_f = emissivity of the fuel assembly top plate = 0.9	

ε_p = emiisivity of the shield plug inner surface = 0.8
F_{12} = view factor from top plate fuel assembly to the inner surface shield plug =1.0
T_f = average temperature of the fuel assembly top plate (R)
T_p = average temperature of the shield plug inner surface (R)

The effective conductivity values ($k_{eff} = k_r + k_{cond}$) are listed below.

T_{fuel}	T_{plug}	T_{avg}	k_r	k_{cond}*	k_{eff}
°F	°F	°F	Btu/hr-in-°F	Btu/hr-in-°F	Btu/hr-in-°F
350	150	250	0.0381	0.0086	0.0467
375	160	268	0.0410	0.0087	0.0498
400	185	293	0.0454	0.0089	0.0543
425	200	313	0.0491	0.0091	0.0582
450	215	333	0.0531	0.0093	0.0623
475	240	358	0.0582	0.0095	0.0676
500	250	375	0.0621	0.0096	0.0717

After solving the thermal models, the average temperatures at the inner surface of the front shield and the upper surface of the fuel assemblies are checked to verify the values in the above table.

A solar absorptivity of 0.5 is considered for the cask surface for the practical purposes (Reference1). All other boundary conditions and material properties are the same as those described in Chapter 3.

3.7.5.3 Maximum Temperatures

The maximum component temperatures resulted from the steady state runs of the thermal models with the cask surface emissivity of 0.5 are summarized in Table 3.7.4-1. This table also shows the maximum temperatures calculated with an emissivity value of 0.8 for the weathered stainless steel.

3.7.5.4 Effect of the Lower Emisivity on the Maximum Temperatures

A comparison of the maximum temperatures in Table 3.7.5-1 shows a maximum increase of 14°F for the component of the transport cask. This increase is due to a decrease of the cask surface emisivity value from 0.8 to 0.5.

The mechanical properties of cask component are evaluated at higher temperatures than those resulted from this analysis. Therefore, a temperature increase of maximum 14°F does not have any adverse effect on the structural analysis. The average maximum temperatures resulted from this analysis are compared to the temperatures used for structural analysis in Table 3.7.5-2.

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* Interpolated and converted from Helium conductivity values in Chapter 3.

Adding the axial conduction and radiation paths in the basket model causes a reduction in the maximum temperatures at the hottest cross section of basket. The temperatures of the shield plugs, seals and impact limiters are increased due to the higher axial heat transfer in the modified model. The maximum temperatures of these components remain below their corresponding thermal limits (see Table 3.5.7-1).

Since all the maximum temperatures are well below their limits, the temperature increase resulted from this analysis is not significant, and does not have any adverse effect on the component performances.

3.7.5.5 References

1. *Principles of Heat Transfer, Fourth Edition,* Kreith et. al., Harper & Row, Publishers, New York, 1986.

2. *Standard Handbook for Mechanical Engineers, Seventh Edition,* Baumeister & Marks, McGraw-Hill Book Co., New York, 1969

3. *Domestic Light water Reactor Fuel Design Evolution, Vol. III, J. M. Viebrock, 1981*

4. ANSYS Engineering Analysis System, *User's Manual for ANSYS Revision 6.0*, ANSYS, Inc., Houston, PA.

TABLE 3.7.5-1

Maximum Temperatures Normal Conditions of Transport (Comparison of the modified and original models)

Component	Maximum Temperature Modified model with conduction and radiation in DSC, ε =0.5	Maximum Temperature Original model, ε =0.8	Temperature Difference (Modified – Original)	Thermal Limits
(---)	(°F)	(°F)	(°F)	(°F)
Shield Shell	241	227	+14	---
Resin	263	249	+14	300
Lead	312	299	+13	---
Cask Body	315	302	+13	---
Outer Surface of Outer Shell	272	258	+14	
Impact Limiters	198	195	+3	---
Cask Lid	201	199	+2	---
Thermal Shield	192	186	+6	---
Flourocarbon Seals, Lid	206	204	+2	400
Flourocarbon Seals, Ram Plate	231	217	+14	400
Canister	392	388	+4	---
Peripheral Inserts	477	482	-5	---
Basket	568	578	-10	---
Fuel Cladding	588	598	-10	1058

TABLE 3.7.5-2

Maximum Average Temperatures Compared to the Temperatures used in the Structural Analysis

Component	Maximum Temperature Modified model with conduction and radiation in DSC, $\varepsilon = 0.5$	Maximum Temperature Original model, $\varepsilon = 0.8$	Temperature used for Structural Analysis Limits
---	(°F)	(°F)	(°F)
Cask Body, $T_{avg,max}$ *	294	280	300
Peripheral Insetrs, $T_{avg,max}$	434	435	500
Canister Shell, $T_{avg,max}$	379	372	500
Basket, $T_{avg,max}$	523	530	600
Front Shield Plug, $T_{avg,surf}$ **	222	203	400
Rear Shield Plug, $T_{avg,surf}$	255	221	400

* $T_{avg,max}$ is the average temperature at the hottest cross section for the Cask body, Peripheral Inserts, Canister Shell, and Basket.

** For the shield plugs, $T_{avg,surf}$ is the average surface temperature.