Enclosure 8 to TN E-25820

Transnuclear, Inc. Calculation NUH06L-0504, "Shielding Analysis for On-Site Transfer Cask OS197L due to 32PT DSC Design Basis Fuel at selected transfer and loading operations," Revision 0 (without disks)

Proprietary

AREVA TRANSNUCLEAR INC.	Form 3.2-1 Calculation Cover Sheet TIP 3.2 (Revision 2)	Calculation No.:	NUH06L.0504
		Revision No.:	0
		Page: 1 of 42	

DCR NO : NUH06L-031	PROJECT NAME: NUHOMS® OS197L Light Onsite Transfer Cask
PROJECT NO: NUH06L	CLIENT: OPPD

CALCULATION TITLE: Shielding Analysis for On-Site Transfer Cask OS197L due to 32PT DSC Design Basis Fuel at selected transfer and loading operations

SUMMARY DESCRIPTION:

1) Calculation Summary

Calculate near and far field dose rates from On-Site Transfer Cask OS197L due to 32PT DSC Design Basis Fuel. Core shielding analysis of the cask was performed during design calculations in reference [1]. Shielding performance of the cask with temporary shield on top and on a trailer skid is analyzed in the current analysis.

2) Storage Media Description **1 CD**

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

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

This calculation is to provide support for off-site dose evaluation performed by the client. 10CFR72.48 review is not required.

Software Utilized:	**Version:**
MCNP 5 v. 1.40	C00730MNYCP00

Calculation is complete:

Originator Name and Signature: Yevgeniy Terekhin Yevgeniy Terekhin — Date: 12/20/07

Calculation has been checked for consistency, completeness and correctness:

Checker Name and Signature: Rick Migliore Rick Migliore — Date: 12/20/07

Calculation is approved for use:

Project Engineer Name and Signature: PETER SMITH P. Smith — Date: 12/20/07

REVISION SUMMARY

REV.	DATE	DESCRIPTION	AFFECTED PAGES	AFFECTED DISKS
0	12/20/2007	Initial Issue	1 - 42	1

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

1 Purpose

The purpose of this calculation is to determine neutron and gamma radiation dose rates at different distances from surface of onsite OS197L transfer cask due to 32PT [2] design basis fuel assembly source terms. Design calculations are performed in reference [1]. Current analysis is concentrated on shielding performance of select shielding configurations during cask loading on a trailer skid. Gamma and neutron radiation dose rate components at 0, 1, 2, 3, 4.57(15'), 10, 50.8(2000"), 100, 200, 300, 500 and 609.6(2000') meters from the cask and the transfer system will be determined and documented.

2 References

1. TN Calculation "Design of Integral Radiation Shield for On-Site Transfer Cask OS197L and Calculation of Occupational Exposure due to 32PT DSC Design Basis Fuel", NUH06L.0500 Revision 1.

2. TN Calculation "NUHOMS®-32PT Fuel Qualification and Source Term Calculation", NUH-32PT.0500, Revision 1." NUH32PT.0500, Revision 1.

3. TN Calculation "Near Field Dose Rates for HSM-H loaded with NUHOMS® -61B Canister Containing NUHOMS® -61B Design Basis Radiological Sources", 11301-0502, Revision 0.

4. TN Calculation "OS197L Occupational Exposure due to Remote Handling Device Failure", NUH06L.0503 Revision 1.

5. TN Drawing, "NUHOMS® 32PT Transportable Storage Canister for PWR Fuel" Main Assembly." Drawing No. NUH-32PT-1001-SAR, Revision 3

6. TN Drawing, "NUHOMS® OS197L-Light Onsite Transfer Cask Body Assembly." Drawing No.NUH06L-1001, Revision 1.

7. TN Drawing, "NUHOMS® OS197L-Light Onsite Transfer Cask Support Skid Assembly." Drawing No.NUH06L-1006, Revision 1.

8. TN Drawing, "NUHOMS® OS197L-Light Onsite Transfer Cask Additional Shielding." Drawing No.NUH06L-1007, Revision 1.

9. TN Drawing, "NUHOMS® OS197L-Light Onsite Transfer Cask Interim Top Cask Cover" Drawing No.NUH06L-1014, Revision 2.

10. "MCNP/MCNPX – Monte Carlo N-Particle Transport Code System Including MCNP5 1.40 and MCNPX 2.5.0 and Data Libraries," CCC-730, Oak Ridge National Laboratory, RSICC Computer Code Collection, January 2006.

11. A. Toor, A.A. Marchetti, "Monte Carlo Simulation for Mine Detection." U.S Department of Energy, Lawrence Livermore National Laboratory, March 14, 2000.

12. TN Technical Report, "NUHOMS® OS197L 75 Ton Design Report." NUH06L.0103 Revision 0

3 Methodology, Design Inputs and Assumptions

Core shielding analysis of the cask was performed during design calculations in reference [1]. Shielding performance of the cask with temporary shield on top and on a trailer skid is analyzed in the current calculation.

Current calculation relies on computational models, assumptions and design input data used in reference [1]. Assumptions made in Section 3 of reference [1], except item 2 and 8, are directly applicable. Information about the radiological source terms due to 32 Design Basis (DB) Fuel Assembly (FA), material densities, flux-to-dose rate conversion factor can be found in Section 4 of the reference. Composition and density of concrete and soil are taken from reference [3] and [11], respectively.

The three-dimensional, Monte Carlo particle transport computer code, MCNP5 [10], has been used to calculate dose rates. A transfer cask and a discrete basket MCNP model used in the current analysis has been prepared in calculation [1]. Fuel regions dimensions and the fuel regions material densities, axial burn-up profile, neutron source scaling factor to account for a subcritical multiplication and axial burn-up profile employed in reference [1] MCNP models are utilized in the current analysis.

4 Calculations

Shielding configurations studied during the original design of the cask are summarized in Table 16 of reference [1]. The bare cask corresponds to the shielding configuration designated in the reference as "Configuration B". The shielding configuration of the cask on the trailer skid resembles a configuration designated as "Configuration F" in the table. Because only dose rate on side and at different radial distances from side of OS-197L transfer cask and its modifications were the primary interest in reference [1] it was reasonable to assume that deviations in radial dimensions of shield plugs, cover plates at ends of the transfer cask from dimensions in reference drawings do not affect maximum dose rate values on side of the cask. Dose rates at different distances from TC side and top end are needed in the current analysis. Also shielding performance of the cask during loading on a trailer skid and on the trailer needs to be analyzed. To calculate the desired dose rates MCNP models from reference [1] calculation needed modifications.

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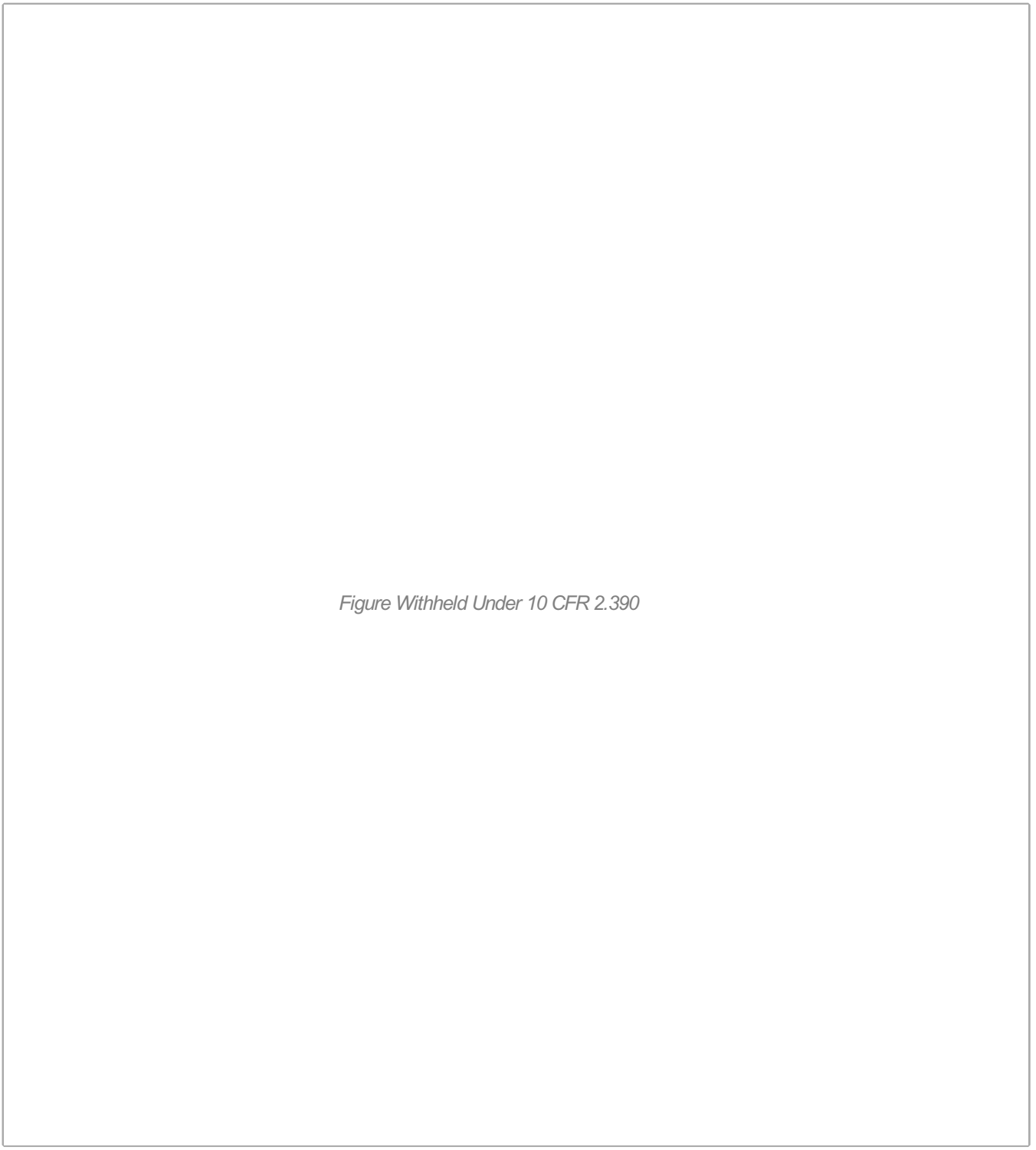

Figure 4-1 OS197L Transfer Equipment Schematic

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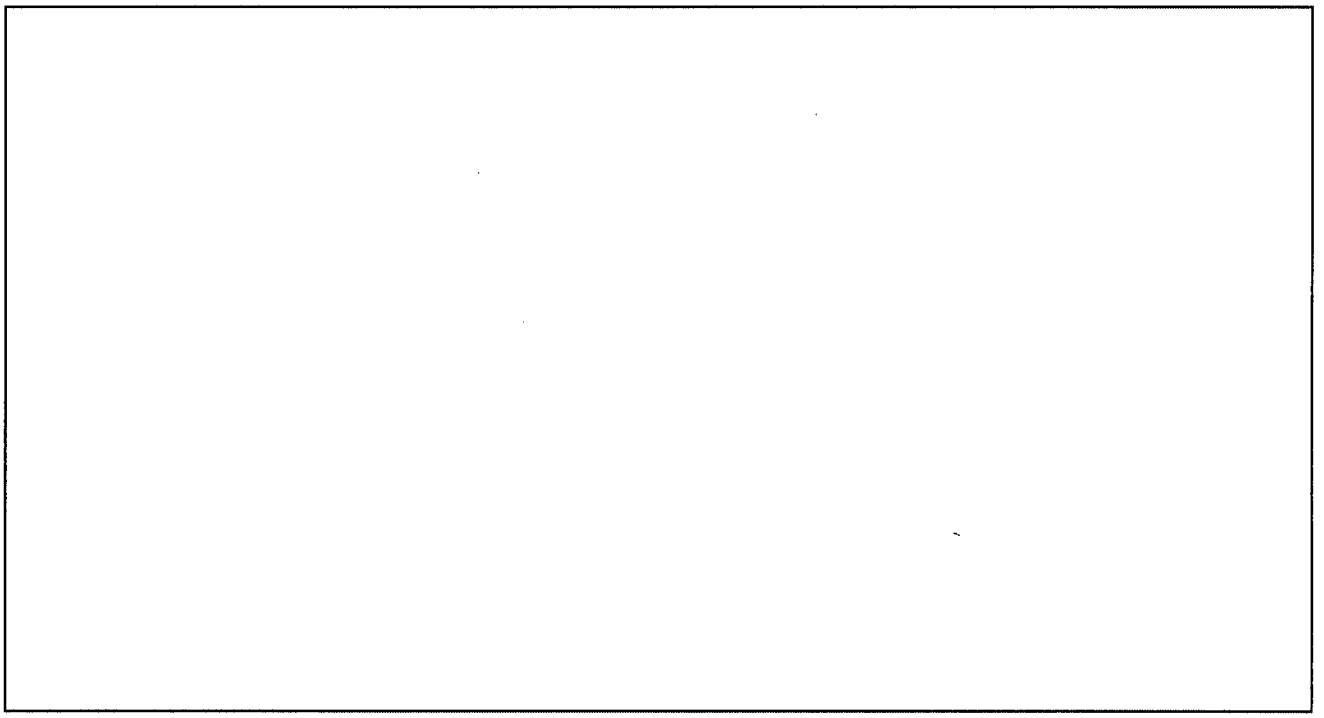
PROJECT NO:	NUH06L	REVISION:	0
CALCULATION NO:	NUH06L.0504	PAGE: 15	Of 42



PROJECT NO:	NUH06L	REVISION:	0
CALCULATION NO:	NUH06L.0504	PAGE: 16	Of 42

6 Summary

Dose rates presented in the current section correspond to transfer cask shielding configurations designated as B, K and L. Descriptions of the configurations are presented in Section 4.1. Configuration B and L dose rates are determined for accident and normal conditions, respectively. Configuration K dose rates are for both, accident and normal. The dose rates are summarized in Table 6-1 through Table 6-6. Dose rates vs. distance behavior for selected shielding configurations are displayed on Figure 6-1 and Figure 6-2. Dose rates in the tables can be traced back to corresponding MCNP input decks using cross reference matrix in Table 5-3. Description of MCNP tallies is provided in Table 4-1. Detailed discussion of the results is provided in Section 5.

Note that maximum of gamma and neutron radiation dose rates may occur at different locations. Therefore maximum of total dose rate is not necessarily equal to the sum of gamma maximum and neutron maximum.

Dose rates in Table 5-1 and on Figure 10-3 through Figure 10-6 are calculated for the case when only 2" thk temporary shielding is in place of the TC top. According to reference drawing NUH06L-1014 [9] (see sheet 1 and 2) however the nominal thickness of aluminum in the temporary shielding is 1". Dose rates in Table 6-1 and Table 6-2 are adjusted to 1" thick temporary aluminum plate on top of the cask. Details are provided in Section 9.

Table 6-1 Axial Neutron Radiation Dose Rates for Shielding Configuration B with Temporary Cask Lid on Top, Accident Conditions

Radial Position, r, from TC Axis	Absolute Maximum if r< 18 ft		On TC Axis, r=0		Maximum at r<= TC Radius	
Distance from TC Top Lid, m	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error
0	205.2	0.16	68.8	0.03	102.2	0.005
1	99.6	0.02	31.2	0.02	35.0	0.01
2	61.8	0.02	17.5	0.03	20.0	0.02
3	43.5	0.02	11.6	0.04	13.0	0.02
4.57(15')	27.2	0.03	7.3	0.05	8.1	0.03
10	7.9	0.03	2.6	0.08	3.1	0.02
50.8 (2000")	0.66	0.009	0.66	0.02	0.66	0.01
100	0.24	0.01	0.24	0.02	0.24	0.01
200	0.06	0.01	0.06	0.02	0.06	0.01
300	0.02	0.01	0.02	0.02	0.02	0.01
500	3.32E-03	0.01	3.32E-03	0.03	3.32E-03	0.01
609.6 (2000')	1.05E-03	0.02	1.05E-03	0.06	1.05E-03	0.02

Table 6-2 Axial Gamma Radiation Dose Rates for Shielding Configuration B with Temporary Cask Lid on Top, Accident Conditions

Radial Position, r, from TC Axis	Absolute Maximum if r< 18 ft		On TC Axis, r=0		Maximum at r<= TC Radius	
Distance from TC Top Lid, m	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error
0	5364.9	0.01	116.4	0.08	718.6	0.02
1	2336.2	0.02	135.9	0.04	226.4	0.02
2	1348.1	0.01	87.4	0.05	152.5	0.01
3	791.6	0.01	70.1	0.05	122.1	0.02
4.57(15')	399.9	0.01	52.8	0.07	91.4	0.02
10	84.9	0.01	26.9	0.07	49.3	0.05
50.8 (2000")	4.4	0.01	4.4	0.01	4.4	0.01
100	1.7	0.01	1.7	0.01	1.7	0.01
200	0.50	0.03	0.50	0.03	0.50	0.03
300	0.17	0.01	0.17	0.01	0.17	0.01
500	1.99E-02	0.03	1.99E-02	0.03	1.99E-02	0.03
609.6 (2000')	9.66E-03	0.29	9.66E-03	0.29	9.66E-03	0.29

Table 6-3 Maximum of Radial Dose Rates for Shielding Configuration K, Normal Conditions

Distance from TC Side, m	Neutron Radiation		Gamma Radiation		Total Radiation	
	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error
0	54.6	0.02	1956.6	0.01	2008.5	0.01
1	18.9	0.01	860.6	0.01	879.4	0.006
2	9.7	0.01	493.2	0.01	502.5	0.006
3	5.7	0.01	315.1	0.01	320.7	0.007
4.57(15')	3.0	0.02	177.7	0.01	180.7	0.01
10	0.8	0.02	47.7	0.01	48.4	0.01
50.8 (2000")	0.03	0.02	1.7	0.01	1.7	0.01
100	0.01	0.02	0.4	0.01	0.4	0.01
200	0.001	0.04	0.1	0.01	0.1	0.02
300	3.08E-04	0.06	0.01	0.02	0.01	0.02
500	5.07E-05	0.15	1.73E-03	0.07	1.77E-03	0.06
609.6 (2000')	1.55E-05	0.30	5.88E-04	0.11	5.94E-04	0.10

Table 6-4 Maximum of Radial Dose Rates for Shielding Configuration K, Accident Conditions

Distance from TC Side, m	Neutron Radiation		Gamma Radiation		Total Radiation	
	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error
0	860.2	0.003	3090.1	0.01	3938.9	0.01
1	304.7	0.002	1365.5	0.004	1670.3	0.004
2	154.7	0.002	779.5	0.005	933.5	0.004
3	91.6	0.003	499.3	0.01	590.8	0.005
4.57(15')	49.1	0.003	280.4	0.01	329.3	0.01
10	13.0	0.004	75.7	0.01	88.6	0.01
50.8 (2000")	0.53	0.003	2.7	0.01	3.2	0.01
100	0.11	0.003	0.6	0.01	0.7	0.01
200	0.01	0.01	0.1	0.01	0.1	0.01
300	3.47E-03	0.01	0.02	0.01	0.03	0.01
500	3.43E-04	0.02	2.60E-03	0.02	2.93E-03	0.02
609.6 (2000')	7.97E-05	0.04	8.47E-04	0.03	9.22E-04	0.03

Table 6-5 Maximum of Radial Dose Rates for Shielding Configuration L (below Top of Trailer Platform), Normal Conditions

Distance from TC Side, m	Neutron Radiation		Gamma Radiation		Total Radiation	
	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error
0	50.4	0.02	9436.9	0.01	9487.3	0.01
1	17.1	0.02	2287.1	0.01	2304.2	0.01
2	7.3	0.02	325.0	0.01	332.0	0.01
3	4.8	0.02	127.4	0.01	131.9	0.01
4.57(15')	2.8	0.02	63.1	0.01	65.9	0.01
10	0.9	0.04	20.5	0.07	21.4	0.06
50.8 (2000")	0.04	0.02	1.0	0.01	1.1	0.01
100	0.01	0.04	0.24	0.02	0.26	0.02
200	0.002	0.07	0.04	0.02	0.04	0.02
300	0.001	0.28	0.01	0.03	0.01	0.04
500	7.36E-05	0.29	1.46E-03	0.15	1.53E-03	0.14
609.6 (2000')	2.51E-05	0.56	3.23E-04	0.08	3.48E-04	0.09

Table 6-6 Maximum of Radial Dose Rates for Shielding Configuration L (between Cask Support Skid and Trunnions Level), Normal Conditions

Distance from TC Side, m	Neutron Radiation		Gamma Radiation		Total Radiation	
	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error	Dose Rate, mrem/hr	Relative Error
0	24.8	0.02	183.7	0.01	202.2	0.01
1	14.7	0.01	361.6	0.01	374.7	0.01
2	8.9	0.01	227.6	0.01	236.4	0.01
3	5.8	0.02	171.9	0.01	177.8	0.01
4.57(15')	3.4	0.02	105.9	0.01	109.3	0.01
10	1.0	0.05	30.3	0.03	31.1	0.03
50.8 (2000")	0.05	0.02	1.1	0.01	1.1	0.01
100	0.01	0.03	0.24	0.01	0.26	0.01
200	0.002	0.07	0.04	0.04	0.05	0.04
300	0.001	0.10	0.01	0.07	0.01	0.07
500	7.84E-05	0.31	1.38E-03	0.16	1.45E-03	0.15
609.6 (2000')	1.34E-05	0.50	3.27E-04	0.07	3.41E-04	0.07

Dose rates for configurations analyzed in the current calculation are plotted on Figure 6-1 and Figure 6-2. "Bare Cask" legends on the figures correspond to Configuration B dose rates in Table 23 of reference [1]. "Below Cask Support Skid" and "Cask with Inner Trailer Shielding" correspond to dose rates in Table 6-5 and Table 6-6 of the current calculation, respectively. Finally "Cask with Inner and Outer Trailer Shielding" is for Configuration F data in Table 25 of reference [1].

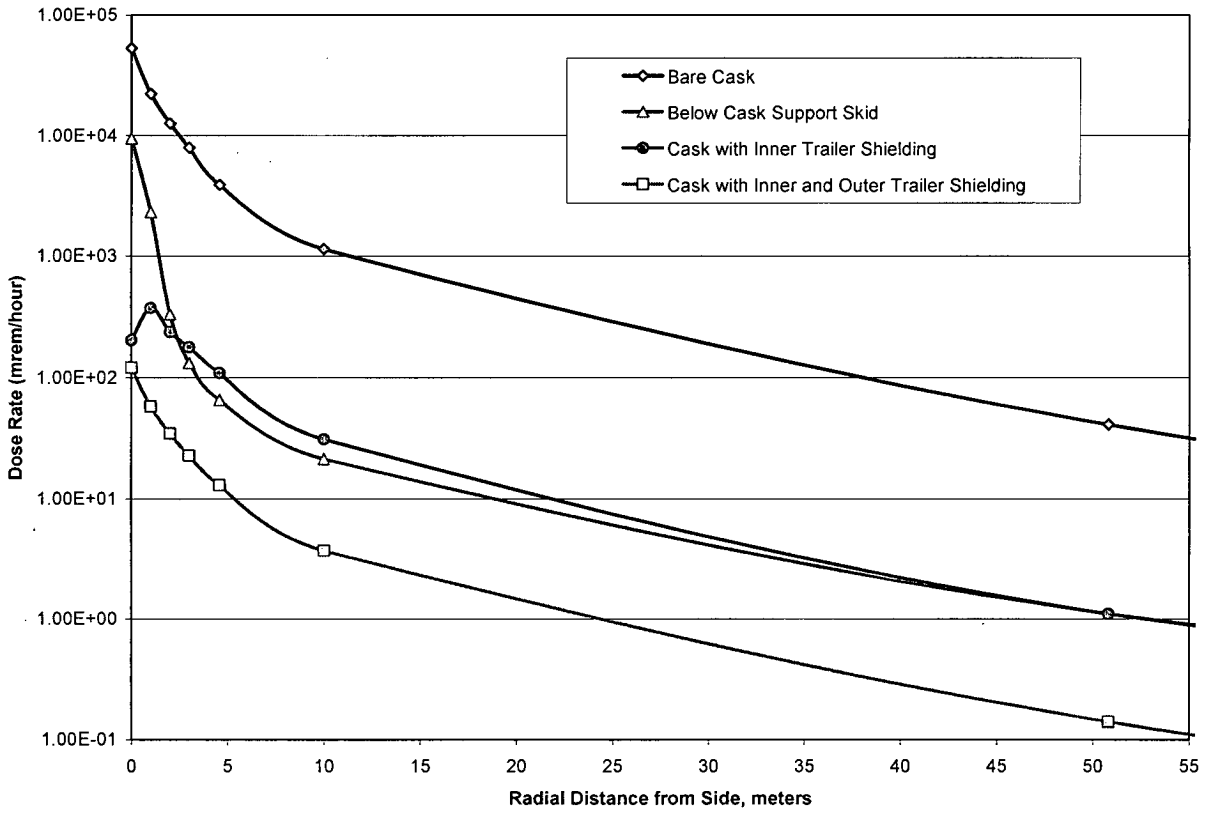


Figure 6-1 Dose Rate as a Function of Distance for Various Shielding Configurations (Short Range Distances)

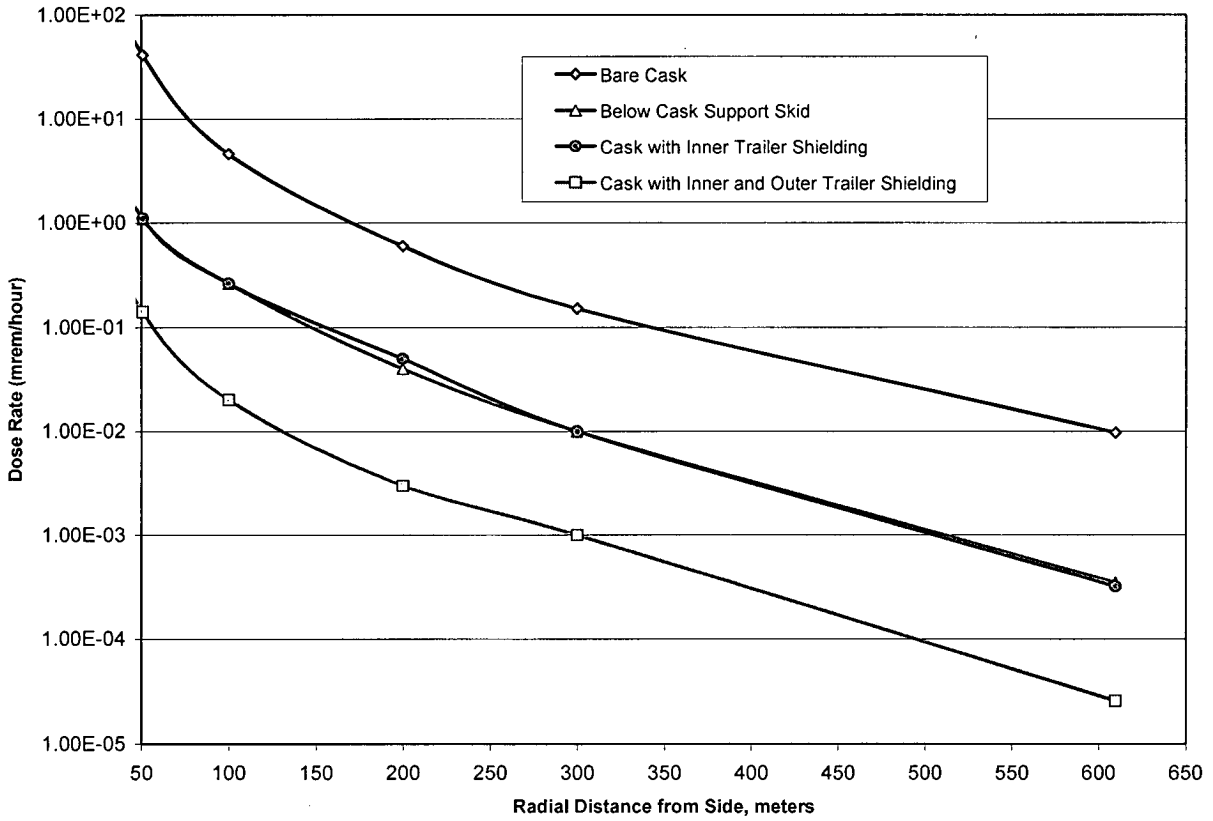


Figure 6-2 Dose Rate as a Function of Distance for Various Shielding Configurations (Large Range Distances)

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8 APPENDIX B: Sketches of MCNP Model of OS-197L System on Transfer Trailer with Shielding.

Sketches presented in the section are related to Shielding Configuration L (Model 3) described in Section 4.1.

Figure 8-1 Configuration L MCNP Model: Cross Section View in Vertical Elevation (DSC Internals are Not Shown).

Note: Configuration L MCNP model materials callouts on the drawings and nomenclature are shown on Figure 8-6.

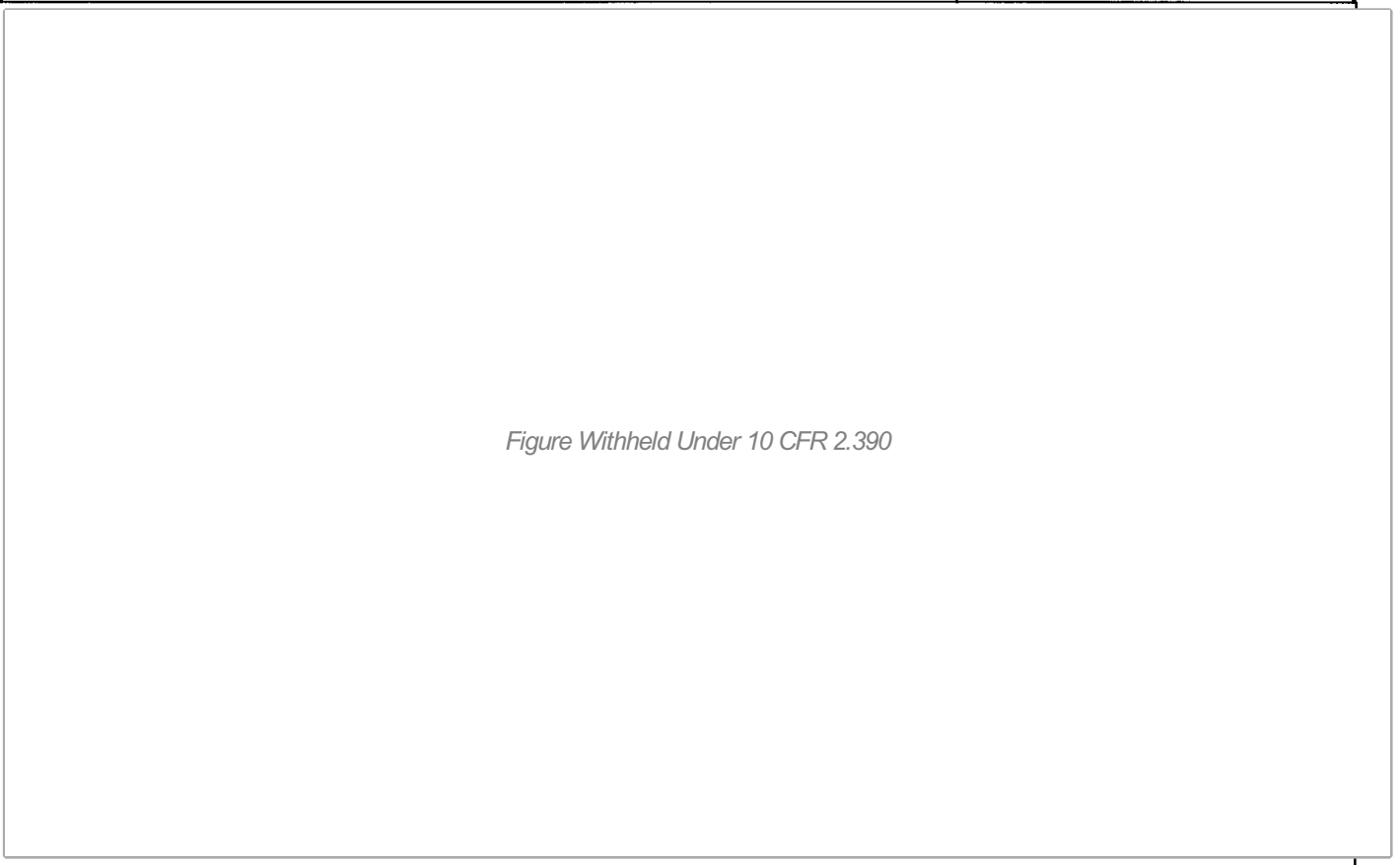


Figure 8-2 Configuration L MCNP Model: Detail I (DSC Internals are Not Shown).

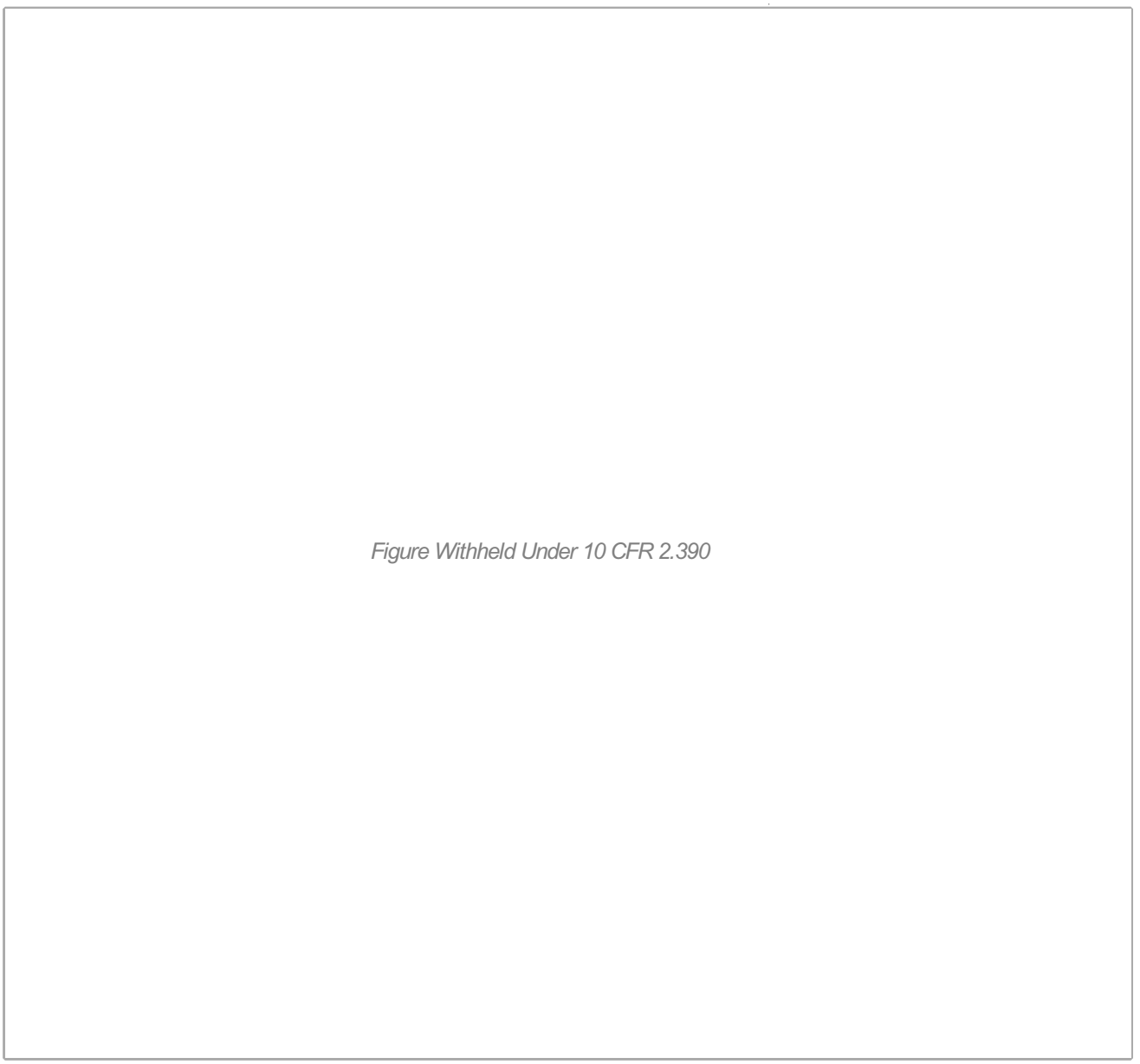
Note: Configuration L MCNP model materials callouts on the drawings and nomenclature are shown on Figure 8-6.

Figure 8-3 Configuration L MCNP Model: Axial Section View in Vertical Elevation (DSC Internals are Not Shown).

Note: Configuration L MCNP model materials callouts on the drawings and nomenclature are shown on Figure 8-6.

Figure 8-4 Configuration L MCNP Model: Detail II (DSC Internals are Not Shown).

Note: Configuration L MCNP model materials callouts on the drawings and nomenclature are shown on Figure 8-6.



SECTION B–B

Figure 8-5 Configuration L MCNP Model: Section B-B View (DSC Internals are Not Shown).

Note: Configuration L MCNP model materials callouts on the drawings and nomenclature are shown on Figure 8-6.

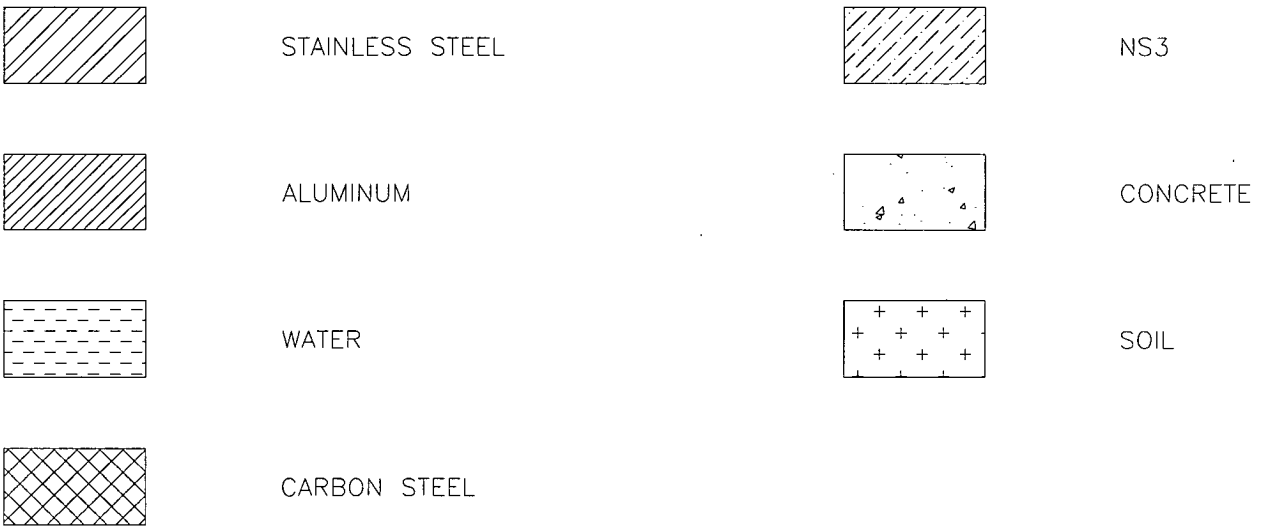


Figure 8-6 Configuration L MCNP Model: Materials Callouts on Drawings and Nomenclature

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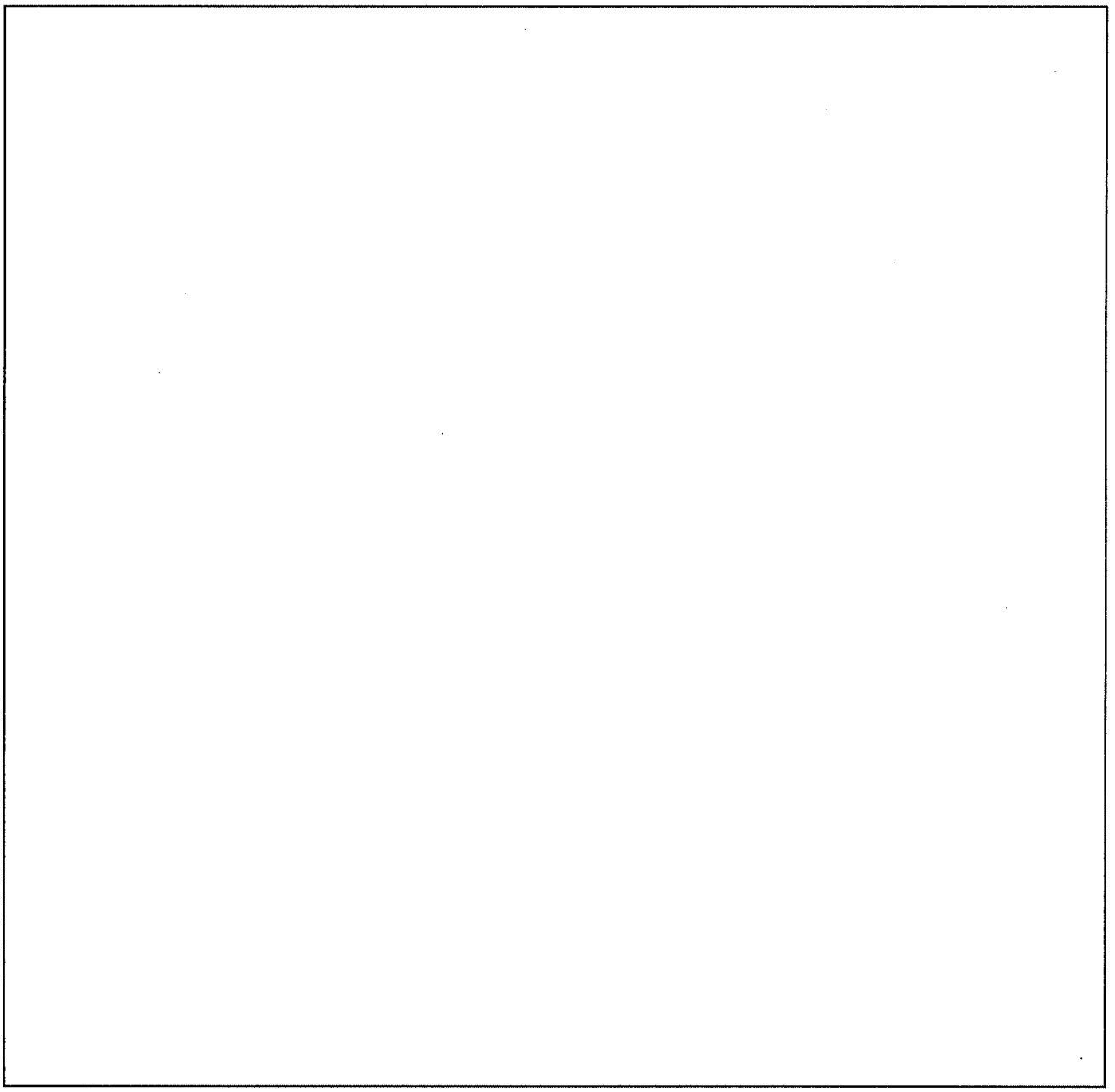

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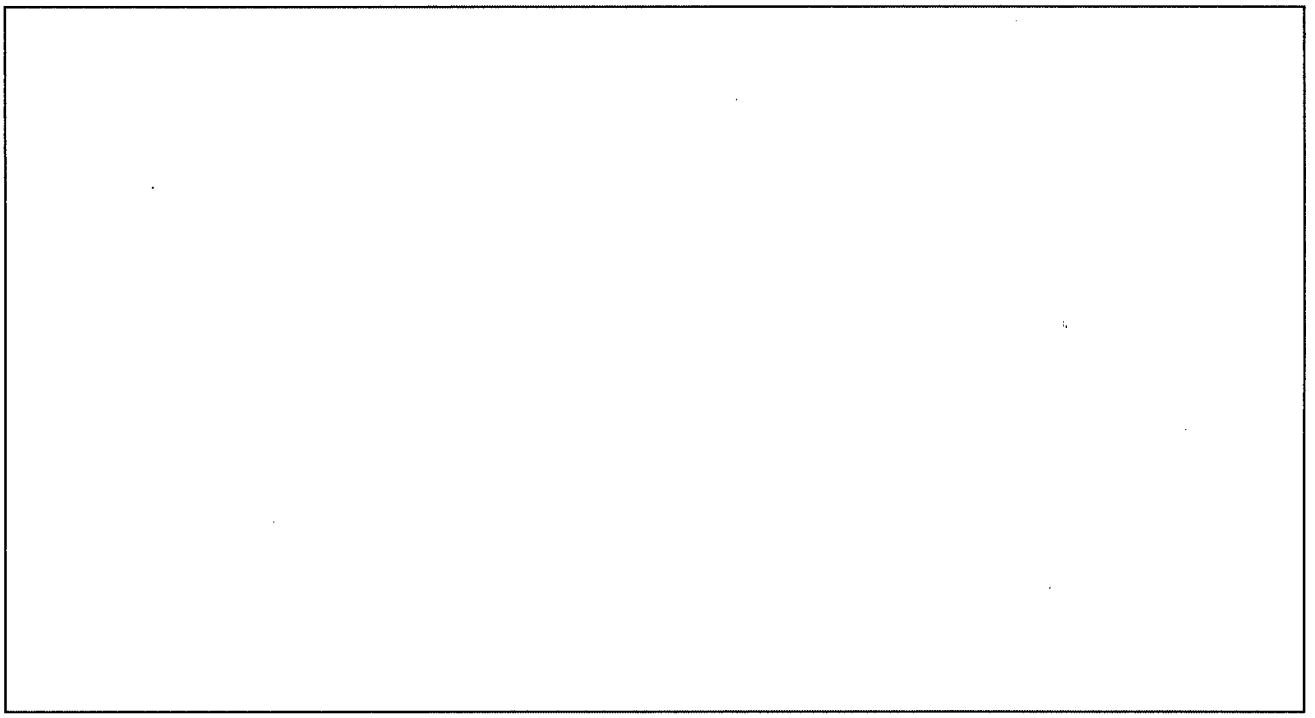
PROJECT NO:	NUH06L	REVISION:	0
CALCULATION NO:	NUH06L.0504	PAGE: 42	Of 42



Enclosure 10 to TN E-25820

Listing of Proprietary Computer Files Enclosed

Index	Listing	Description
0	000-ReadMe_Nuclear.pdf, proprietary	A short description of the MCNP Inputs and Mesh Files for NUH06L.0504
1	001-aBgt.mi, 41,590 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration B, no neutron shielding on side, dose rates above TC top due to gamma radiation source.
2	002-aBgt_mes, 572,756 bytes, proprietary	Mesh tallies calculated with "aBgt.mi".
3	003-aBnt.mi, 50,110 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration B, no neutron shielding on side, dose rates above TC top due to neutron radiation source.
4	004-aBnt_mes, 1,145,304 bytes, proprietary	Mesh tallies calculated with "aBnt.mi".
5	005-Kgr.mi, 43,657 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration K, normal conditions, dose rates due to gamma radiation source.
6	006-Kgr_mes, 572,756 bytes, proprietary	Mesh tallies calculated with "Kgr.mi".
7	007-Kn.mi, 54,851 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration K, normal conditions, dose rates due to neutron radiation source.
8	008-Kn_mes, 1,145,304 bytes, proprietary	Mesh tallies calculated with "Kn.mi".
9	009-aKgr.mi, 43,662 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration K, no neutron shielding on side, dose rates due to gamma radiation source.
10	010-aKgr_mes, 572,756 bytes, proprietary	Mesh tallies calculated with "aKgr.mi".
11	011-aKn.mi, 54,857 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration K, no neutron shielding on side, dose rates due to neutron radiation source.
12	012-aKn_mes, 1,145,304 bytes, proprietary	Mesh tallies calculated with "aKn.mi".
13	013-Lg.mi, 67,583 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration L, normal conditions, dose rates due to gamma radiation source.
14	014-Lg_mes, 883,744 bytes, proprietary	Mesh tallies calculated with "Lg.mi".
15	015-Ln.mi, 76,564 bytes, proprietary	NUH06L.0504: MCNP Model for shielding Configuration L, normal conditions, dose rates due to neutron radiation source.
16	016-Ln_mes, 1,767,284 bytes, proprietary	Mesh tallies calculated with "Ln.mi".
17	017-aBgt2.mi, 41,589 bytes, proprietary	NUH06L.0504: MCNP scoping analysis model for shielding Configuration B, no neutron shielding on side, dose rates due to gamma radiation source.
18	018-aBgt2_mes, 572,756 bytes, proprietary	Mesh tallies calculated with "aBgt2.mi".
19	019-Kn2.mi, 54,957 bytes, proprietary	NUH06L.0504: MCNP scoping analysis model for shielding Configuration K, normal conditions, dose rates due to neutron radiation source.
20	020-Kn2_mes, 1,145,304 bytes, proprietary	Mesh tallies calculated with "Kn2.mi".
Nothing follows		