**TN Calculation 1121-0504, Revision 1, OS197L 75 Ton Transfer Cask Dose Rates Calculation to be used with OPPD Exemption Request**

| TRANSNUCLEAR<br>AN AREVA COMPANY | Form 3.2-1<br>Calculation Cover Sheet | Calculation No.: 1121-0504 |
|---|---|---|
| | | Revision No.: 1 |
| **CALCULATION TITLE:**<br>**OS197L 75 Ton Transfer Cask Dose Rate Calculation to be Used With OPPD Exemption Request** | | Page: 1 of 12 |
| | | Project No.: 1121 |
| | | DCR No.: 1121-012 |

**PROJECT NAME:**

**Fort Calhoun Station Spent Fuel Storage Project**

**Number of CDs attached: 1**

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

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

This calculation determines the radiation dose rates around the OS197L TC in support of an exemption request by OPPD to be submitted to the NRC. OPPD is planning to load the NUHOMS® -32PT DSC using the OS197L Transfer Cask. These configurations are NOT the design basis for the NUHOMS® -32PT System. Therefore, a 72.48 licensing review per TIP 3.5 is not required.

| **Software Utilized:** | **Version:** |
|---|---|
| MCNP5 | 1.2 |
| MCNP5 (Limited Use Software) | 1.4 |
| No new MCNP5 calculations are performed in this revision | |

| | |
|---|---|
| **Calculation is complete:**<br>**Shane Gardner**<br>Originator Signature: Shane R. Gardner | Date: 06/07/2006 |
| **Calculation has been checked for consistency, completeness and correctness:**<br>**Douglas Kinsman**<br>Checker Signature: Douglas Kinsman | Date: 06/07/2006 |
| **Calculation is approved for use:**<br>**James Axline**<br>Project Engineer Signature: James W. Axline | Date: 6/7/06 |

## REVISION SUMMARY

| REV. | DATE | DESCRIPTION | AFFECTED PAGES | AFFECTED DISKS |
|---|---|---|---|---|
| 0 | 06/01/06 | Initial issue<br><br>Summary Description: The OS197L-75 is a general purpose, light weight (75 Tons) on-site Transfer Cask (TC). A detailed shielding evaluation of the OS197L TC with various configurations is performed in Calculation NUH06L-0500 at normal and accident conditions. This calculation is prepared to document radiation dose rate calculations in support of an exemption request by OPPD to be submitted to the NRC for review and approval. OPPD is planning to load the NUHOMS® -32PT DSC using the OS197L Transfer Cask.<br><br>Above all, this calculation is NOT a design basis or a licensing basis calculation for either the OS197L TC or the NUHOMS® 32PT DSC. | 12 | 1 |
| 1 | 6/7/06 | This revision deletes all information pertaining to the bare TC with 18.4 kW/DSC evaluation. The design basis axial dose rate is added. Other minor editorial corrections are made. | All | |
| | | | | |

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## 1. PURPOSE

The purpose of this summary calculation is to calculate the radiation dose rates around the OS197L Transfer Cask (TC) with a fully loaded NUHOMS® 32PT DSC containing 32 design basis B&W 15x15 PWR fuel assemblies. A comprehensive shielding evaluation for the OS197L TC with a variety of shielding configurations is documented in reference [2]. This calculation provides the radiation dose rates as a function of distance from the TC surface for a specific configuration not described in reference [2].

The evaluation is based on the OS197L cask under normal conditions, when the OS197L cask is inside the decon sleeve, with shield bell, with the neutron shield full and water in the DSC/TC annulus. The radiation dose rates (radial) as a function of distance for the NUHOMS® 32PT with design basis (24 kW/DSC) fuel assemblies are determined in this evaluation. The axial dose rate applicable to technical specification limits is also determined. This calculation is NOT a design basis or licensing basis calculation for either the OS197L TC or the NUHOMS® 32PT DSC.

## 2. REFERENCES

### 2.1 Referenced Documents, Calculations, Publications etc.

1. UFSAR "Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel", NUH-003 Rev. 9.
2. Transnuclear Calculation NUH06L-0500, Revision 1, "Design of Integral Radiation Shield for On-Site Transfer Cask OS197-L and Calculation of Occupational Exposure due to 32PT DSC Design Basis Fuel."
3. Transnuclear Calculation 1121-0500, Revision 3, "OPPD ISFSI Phase I through Phase IV Dose Rates and Annual Exposure Calculation."
4. MCNP – A General Monte Carlo N-Particle Transport Code, Version 5, Volume II: User's Guide, LA-CP-03-0245, 2003.
5. MCNP5 v1.20 Computer Code Verification Record. Test Plan: TN File No. QA 040.230.0001, Test Report: TN File No. QA 040.230.0002.
6. "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.
7. Transnuclear Calculation NUH32PT.0501, Revision 0, "NUHOMS® -32PT Surface Dose Rates and Occupation Exposures."
8. Transnuclear Calculation NUH06L.0502, Revision 0, "OS197/OS197L Transfer Cask Shielding Evaluation for a Hypothetical Single Fuel Assembly Misload Event."

### 2.2 List of Acronyms and Conventions

| | |
|---|---|
| DSC | Dry Shielded Canister |
| UFSAR | Updated Final Safety Analysis Report |
| TC | Transfer Cask, refers to OS-197 cask in general and its modifications unless specified otherwise |
| TN | Transnuclear Inc. |

## 3. METHODOLOGY AND DESIGN INPUTS

### 3.1 Methodology

The evaluation pertains to the calculation of radiation dose rates (radial) as a function of distance for the NUHOMS® 32PT DSC using design basis fuel (24 kW/DSC) loading. The shielding configuration for this evaluation is based on a drained DSC cavity with the DSC/TC annulus filled with water. The decontamination shield shell (6″ steel) and the shield bell are also included in this evaluation. The configuration "F" MCNP models (reference [2]) are modified to include the defined shielding configuration. These models are then utilized to determine the radial dose rates.

The 3-D Monte Carlo particle transport computer code, MCNP5 (reference [4]), is utilized to determine the dose rates. MCNP5 is a state of the art computer code and has been utilized by TN for shielding evaluations in NRC approved applications, including the calculations documented in the UFSAR, reference [1]. MCNP5 has also been utilized in the reference [2] calculations.

The reference design calculations [7, 1] are relied upon for the axial dose rate.

3.2 Design Inputs

The design basis radiation source terms (24 kW/DSC) for the NUHOMS® 32PT DSC are utilized per Reference [1,2].

The axial DSC inner cover plate welding neutron dose rate 1 meter (3 ft) from the welding shield top [1, 7, 1] is taken from page 124 of Reference [7] and Figure M.5-27 of Reference [1].

The axial DSC inner cover plate welding gamma dose rate 1 meter (3 ft) from the welding shield top is taken from Table 3 of Reference [8].

## 4. ASSUMPTIONS AND CONSERVATISMS

All assumptions and conservatisms applicable to the calculational methodology employed in the reference [2] calculations to generate the MCNP5 models are also assumed to be valid in this calculation. In addition, the following assumptions and conservatisms are employed in this calculation.

1. The decontamination area shield thickness is assumed to be a nominal 6.0 inches in the evaluation described in Section 3.1. This assumption is an input to the MCNP5 models.

# 5. CALCULATIONS

## 5.1 Use of MCNP5 Software

A newer version of the MCNP5 computer code, version 1.4 [6], has been utilized to determine the radial dose rates. As part of the calculation/project specific verification, a single MCNP5, version 1.2 [5], computer case from reference [2] calculation is re-evaluated with this version of MCNP5. The acceptance criterion for this verification is that the differences between the results of interest from the two versions of MCNP5 be within statistical uncertainty. This acceptance criterion that the two versions produce statistically similar results is adequate for the purpose of this calculation since these results are utilized to calculate the nearfield dose rates. The MCNP5 file listing for the benchmark cases is provided in Section 8.1 of this calculation. A comparison of the differences of the MCNP5 results/tallies indicates that the two versions of MCNP5 produce statistically similar results consistent with the acceptance criterion. Therefore, version 1.4 of the MCNP5 code as documented in reference [6] is acceptable for use as "limited use" software for this calculation.

## 5.2 MCNP5 Models

For the evaluation the shielding configuration includes the 6" of shielding provided by the decontamination area sleeve and the shield bell. In addition, the DSC cavity is drained and the DSC/TC annulus and the neutron shield are filled with water. This evaluation is performed with design basis fuel (24 kW/DSC) assemblies. The reference [2] MCNP models, Fg.mi and Fn.mi are utilized as starting models for neutron and gamma input files respectively. The MCNP5 version 1.4 is used to perform these calculations.

## 6. RESULTS

The MCNP5 results are discussed in this section. The maximum radial dose rates (maximum of both axial and angular) are calculated based on the discussion provided in Section 6.3.3.2 (Table 12) of reference [2]. All the MCNP input and output files are included in the attached CD.

### 6.1 Axial Dose Rates for the Design Basis Fuel Loading

Design basis axial dose rates for the NUHOMS® -32PT DSC loaded in the OS197 transfer cask are calculated in Reference [7]. Reference [7] is the basis for the UFSAR [1].

Dose rates over the cask 3 ft. from the cask top are shown in Table 6-1. The neutron dose rate is calculated for a partially filled DSC/Cask annulus and a drained DSC [7], which is conservative. The peak gamma dose rate is calculated for a dry DSC under welding conditions in [1].

**Table 6-1 Axial DSC Top Welding Dose Rates for OS197L**

| Location | [7] Neutron(1) (mrem/hr) | [1] Gamma (mrem/hr) | Total (mrem/hr) |
|---|---|---|---|
| 3-Feet from Welding Shield Top | 14 | 114 | 128 |

1. Maximum dose rate 1-meter from cask top [7].

### 6.2 Radial Dose Rates for the Design Basis Fuel Loading

The radial dose rates as a function of distance for the design basis fuel loading when inside the decontamination sleeve with water in the neutron shield and DSC/TC annulus are presented in Table 6-2. The maximum radial surface dose rate for this configuration is shown to be 67.5 mrem/hour. Note that the surface dose rate is on the surface of the decontamination area shielding sleeve.

**Table 6-2 Maximum of Total, Gamma +Neutron, Radiation Dose Rates (Averaged over angular Coordinate) at Different Radial Distances from Side of Decon Shield Sleeve**

| Radial Segment # | Radial Distance from Side, meters | Dose Rate, mrem/hr | Relative Error |
|---|---|---|---|
| 2 | 0 | 67.49 | 0.02 |
| 4 | 1 | 32.27 | <0.01 |
| 6 | 2 | 19.34 | <0.01 |
| 8 | 3 | 12.68 | 0.01 |
| 10 | 4.57 (15') | 6.72 | 0.03 |
| 12 | 10 | 2.07 | 0.01 |
| 14 | 50.8 (2000") | 0.08 | 0.02 |
| 16 | 100 | 0.01 | 0.02 |
| 18 | 200 | 0.001 | 0.04 |
| 20 | 300 | 2.76e-4 | 0.05 |
| 22 | 609.6 | 1.17e-5 | 0.15 |

## 7. SUMMARY AND CONCLUSIONS

Dose rates around the OS197L on-site transfer cask containing the NUHOMS®-32PT 32 PWR fuel assemblies for normal welding conditions have been determined. This calculation is NOT a design basis or a licensing basis calculation for either the OS197L TC or the NUHOMS® 32PT DSC.

The dose rates around the OS197L TC when it is within the decontamination area sleeve with the shield bell and water in the neutron shielding and the DSC / TC annulus for welding conditions are found to be:

Radial: 68 mrem/hr on surface on the decon shield sleeve.

Axial: 128 mrem/hr 3 ft. from the top of the welding shield.

# 8. APPENDIX A, FILE LISTING

## 8.1 MCNP Runs

TC shielding configuration which includes temporal (removable) 6" cask shield and water in the DSC/TC annulus is also analyzed. It is essentially TC shielding Configuration F from reference [2] with a modified removable cask shield (increased the thickness from 5.5" to 6") and DSC/TC annulus filled with water. This evaluation is performed with design basis fuel assemblies, the reference [2] MCNP models, ***"Fg.mi"*** and ***"Fn.mi"*** are utilized as starting models for neutron and gamma input files respectively. The modified models are named as ***"Fg2.mi"*** and ***"Fn2.mi"***.

```
 37k Thu May 25 14:54:00 2006 Fg2.mi
712k Thu May 25 21:46:00 2006 Fg2.mo
 71k Thu May 25 21:46:00 2006 Fg2_mesh
2.9k Thu May 25 21:46:00 2006 Fg2_tal
 13M Thu May 25 21:46:00 2006 Fg2_tpe

 44k Thu May 25 14:53:00 2006 Fn2.mi
630k Fri May 26 07:47:00 2006 Fn2.mo
142k Fri May 26 07:47:00 2006 Fn2_mesh
6.9k Fri May 26 07:47:00 2006 Fn2_tal
 33M Fri May 26 07:47:00 2006 Fn2_tpe
```

The MCNP runs for OPPD specific fuel loading described in Section 5.2 were performed using MCNP 5 v.1.20 under Windows XP. The MCNP runs for the design basis fuel loading described in Section 5.2 were done using MCNP 5 v.1.40 under RedHat Enterprise Linux 4.0. To make sure that both versions give statistically the same results comparative run was done with v.1.40 under Red Hat Linux using ***"Fgl"*** model. It is essentially the same as ***"Fg"*** input from reference [2]. To make it consistent with the reference model the same **nps** as in ***"Fg.mo"*** file in reference [2] was set in ***"Fgl.mi"*** file.

```
 38k Wed Apr 26 10:45:00 2006 Fgl.mi
721k Wed Apr 26 13:00:00 2006 Fgl.mo
 71k Wed Apr 26 13:00:00 2006 Fgl_mesh
3.2k Wed Apr 26 13:00:00 2006 Fgl_tal
 11M Wed Apr 26 13:00:00 2006 Fgl_tpe
```

Next files contain line-by-line comparison of output files and mesh tallies from ***"Fg"*** and ***"Fgl"*** models. ***"Fg__vs__Fgl_outputs.prn"*** and ***"Fg_mesh__vs__Fgl_mesh.prn"*** is a summary for output files and mesh tally results, respectively. Mesh tally 64, 84 and 144(even R bins) represent a special interest since they were used to generate dose rates near Configuration F side in reference [2]. File comparisons were visually inspected to satisfy the acceptance criterion. It can be seen from ***"Fg_mesh__vs__Fgl_mesh.prn"*** file that dose rates for those tallies are statistically the same for both models, i.e. (dose rates)+\-(error) values lie within overlapping ranges.

```
903k Wed Apr 26 15:20:32 2006 Fg__vs__Fgl_outputs.prn
 55k Wed Apr 26 15:24:51 2006 Fg_mesh__vs__Fgl_mesh.prn
```

## 8.2 Miscellaneous Spreadsheets

All the results can be reproduced from the sets of MCNP runs listed above. However preprocessing the results is required. This section lists all the supplementary spreadsheets. The spreadsheets are not the vital part of the current calculation but can save substantial amount of time and efforts if the current calculation being used as a basis for future analysis or adjustment\estimates of results needed due to changes in source term, shielding configuration or properties, etc. The spreadsheets are in "***MCNP\Proccessed\Excel***" directory of the attached CD. Note that listed spreadsheets also contain results for the mesh tallies produced during MCNP 5 runs. Mesh tallies are in "***_mes***" or "***_mesh***" files.

The following spreadsheets contain the results for Table 6-2.

```
 88k Fri May 26 15:07:06 2006 Configuration_F2.xls
283k Fri May 26 15:29:40 2006 Configuration_F2_Normal.xls

183k Fri May 26 15:29:14 2006 144_174_transposed__Fg(n)2_mesh.xls
```