Attachment 2

Non-proprietary Calculations

Non - PROPRIETARY version

AREVA TRANSNUCLEAR INC.	Form 3.2-1 Calculation Cover Sheet TIP 3.2 (Revision 3)	Calculation No.:	13302-0600
		Revision No.:	1
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DCR NO (If applicable) : *13302-001*	PROJECT NAME: SMUD General Services
PROJECT NO: 13302	CLIENT: SMUD

CALCULATION TITLE:

Rancho Seco NUHOMS®-24P Criticality Analysis – Damaged Fuel Evaluation for As Loaded FO- and FC- DSCs

SUMMARY DESCRIPTION:

1) Calculation Summary

This calculation evaluates the effect on criticality of the Rancho Seco NUHOMS®-24P FO- / FC –DSCs due to loading of damaged fuel assemblies. A bounding configuration based on actual loaded fuel assemblies is utilized to determine the impact on criticality. The SCALE 4.4 computer code system is utilized to perform this evaluation. The design basis KENO models utilized in the previous calculations are re-evaluated using SCALE 4.4 in order to determine the effect on criticality. *This revision is an editorial correction to change the number of loaded DSCs (with fuel assemblies) from 24 to 20 in Section 1.0*

2) Storage Media Description

1 CD-ROM attached. *All Computer Cases from Revision 0 remain unchanged for Revision 1*

If original issue, is licensing review per TIP 3.5 required? *N/A since this is a revision*

Yes ☐ No ☒ (explain below)

This calculation is prepared in support of a submittal by SMUD that is subject to review by the NRC for a system that is governed by a site specific license. Therefore, a licensing review per TIP 3.5 by Transnuclear is not required.
See Page 2 for Licensing references.

Software Utilized: *NONE (For Rev. 1). Software used in Rev. 0 is listed below:*	Version:
SCALE 4.4 PC (CSAS25 Module)	C00545MNYCP00
Calculation is complete: Originator Name and Signature: George Jackson G M Jackson	Date: 9/19/08
Calculation has been checked for consistency, completeness and correctness: Checker Name and Signature: Prakash Narayanan A Prakash	Date: 09/19/2008
Calculation is approved for use: Project Engineer Name and Signature: Joginder Bindra for Ian McInnes	Date: 9/19/2008

REVISION SUMMARY

REV.	DATE	DESCRIPTION	AFFECTED PAGES	AFFECTED DISKS
0	*04/23/2008*	Initial Issue	ALL	1
1	9/17/08	*Revised to correct a typographical error. Changed pages shown by a Revision bars – Pages 1,2 and 5*	*ALL*	*None*

Licensing References:

- Rancho Seco Independent Spent Fuel Storage Installation Material License No. SNM-2510
- Appendix to the Material License No. SNM-2510: Technical Specifications
- Rancho Seco ISFSI Final Safety Analysis Report, Revision 3 (as updated in June 2006)

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1.0 PURPOSE

The purpose of this calculation package is to determine the effect of loading fuel assemblies with known or suspected cladding defects greater than a pinhole or hairline cracks on the criticality of the NUHOMS®-24P FO– / FC– DSCs. The NUHOMS®-24P FO– / FC– DSCs are designed to be loaded with intact B&W 15x15 fuel assemblies. The NUHOMS®-24P FF– DSC is designed to be loaded with failed B&W 15x15 fuel assemblies.

An evaluation performed by the Sacramento Municipal Utility District (SMUD) at the Rancho Seco Plant determined that some of the fuel assemblies that were loaded in the FO– / FC– DSCs contained cladding defects that were greater than a hairline crack or a pinhole. This evaluation, documented in, reference [2.9] that 5 DSCs out of the *20* loaded DSCs contained such damaged assemblies with one DSC being loaded with a maximum of 2 suspected damaged assemblies. The spent fuel parameters (initial enrichment, burnup and cooling time) of the loaded fuel assemblies and the position of these fuel assemblies within each DSC is described in reference [2.7] and [2.8] respectively. This information is utilized to perform a criticality evaluation with bounding representation of the damaged assemblies, as loaded within the FO– / FC– DSC.

The results of this calculation will demonstrate that the criticality safety of the NUHOMS®-24P FO– / FC– DSCs loaded with damaged fuel assemblies (one or two assemblies per DSC with limited damaged) in an as loaded configuration is not affected. These results will demonstrate that the k_{eff} values of such DSCs are bounded by the design basis k_{eff} of the NUHOMS®-24P FO– / FC– DSCs.

2.0 REFERENCES

2.1 Transnuclear Calculation NUH005.0650, "Rancho Seco NUHOMS®-24P Criticality Analysis –FF– DSCs (for intact and failed fuel), Revision 5.

2.2 Transnuclear Calculation NUH005.0651, "Rancho Seco NUHOMS®-24P Criticality Analysis –FO– and FC– DSCs, Revision 3.

2.3 Transnuclear Calculation NUH005.0652, "Rancho Seco NUHOMS®-24P Criticality Analysis –Atom Density Calculations, Revision 3.

2.4 Transnuclear Calculation NUH005.0655, "Rancho Seco NUHOMS®-24P Criticality Analysis –Calculation of k_{eff}, Revision 3.

2.5 Transnuclear Calculation NUH32PTH1-0602, "KENO V.a Benchmarks for Criticality Analysis," Revision 0.

2.6 Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.

2.7 Design Input Document - Transnuclear file No. DI-13302-01, "DSC Loading Data," listing the parameters of the Spent Fuel as loaded for each DSC.

2.8 Design Input Document - Transnuclear file No. DI-13302-02, "Location of Fuel Assemblies in Loaded DSCs," identifying the fuel assembly and its position within each of the loaded DSCs.

2.9 Design Input Document - Transnuclear file No. DI-13302-03, "Evaluation of Damaged Assemblies," providing details of the extent of damage.

2.10 U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.

2.11 U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.

3.0 NOMENCLATURE

DSC **Dry Shielded Canister**

A double seal-welded stainless steel vessel which has integral shielded end plugs and an aluminum flame-sprayed carbon steel basket assembly. The basket is designed to maintain subcriticality by fixed neutron absorber panels and geometry control. There are three types of DSCs at Rancho Seco:

FO-DSC **Fuel-Only DSC**

A short-cavity DSC for storing 24 fuel assemblies without any associated non-fuel hardware. The basket has borated neutron absorbing panels. The DSC end plugs are solid carbon steel.

FC-DSC **Fuel-With-Control-Component DSC**

A long-cavity DSC for storing 24 fuel assemblies with their associated non-fuel hardware. The basket has borated neutron absorbing panels. The DSC end plugs are composite lead/stainless steel.

FF-DSC **Failed Fuel DSC**

A long-cavity DSC for storing 13 fuel assemblies without any associated non-fuel hardware. Fuel with damaged cladding or minor structural damage may be stored in the FF-DSC. The basket has thick unborated stainless steel guide tubes. The DSC end plugs are composite lead/stainless steel.

HSM **Horizontal Storage Module**

A passive concrete bunker which provides biological shielding and missile protection for the DSC during onsite storage.

MP187 Cask **NUHOMS® MultiPurpose-187 Cask**

A dual-purpose cask for off-site transportation (10CFR71). The MP187 also serves a function as the transfer cask to carry loaded, sealed DSCs from the Fuel Building to the HSM.

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7.3 Summary and Conclusions

Criticality calculations were performed to determine the effect of loading of fuel assemblies with postulated damage on the criticality of the NUHOMS®-24P FO– / FC– DSCs. The design basis criticality cases from reference [2.2] were modified to be compatible with the CSAS25 calculational module. Criticality benchmarks were performed to determine a USL for the NUHOMS®-24P FO– / FC– DSC with the SCALE4.4 code package. The results of the criticality calculations for the design basis intact assemblies show that the maximum calculated k_{eff} is below the USL of 0.9425 with a large margin.

Criticality calculations are also performed on a conservative representation of an "as loaded" DSC with two damaged assemblies. The conservatism in the modeling of the DSC was quantified to be approximately 0.005 Δk_{eff}. The evaluated damaged configurations ranged from modeling a row of de-cladded fuel rods within the guide-sleeves to modeling a 2" - 40x40 array of fuel pellets at the bottom of the DSC. These configurations conservatively cover all postulated damage ranging from cracking of the cladding to complete cladding damage of several fuel rods.

The maximum k_{eff} for the NUHOMS®-24P FO– / FC– DSC in an as loaded configuration with two damaged assemblies is calculated to be 0.9151. This value is well below the design basis maximum k_{eff} of 0.9298 for the FO– / FC– DSC. These results demonstrate that the loading of damaged fuel assemblies with damage greater than pinhole or hairline crack does not result in any significant impact on the criticality of the system.

8.0 APPENDIX

8.1 File Listing

Computer Software: SCALE 4.4 PC (CSAS25 Module)
Software Version: C00545MNYCP00
Computer Type: PC Workstation with Windows-XP

CSAS25 Input and Output Files

Date	Size (Bytes)	File name
2/14/2008	38,425	csas25-FOHXF000.inp
2/14/2008	631,475	csas25-FOHXF000.out
2/14/2008	38,425	csas25-FOHXF005.inp
2/14/2008	631,619	csas25-FOHXF005.out
2/14/2008	38,425	csas25-FOHXF010.inp
2/14/2008	631,734	csas25-FOHXF010.out
2/14/2008	38,425	csas25-FOHXF020.inp
2/14/2008	631,782	csas25-FOHXF020.out
2/14/2008	38,425	csas25-FOHXF030.inp
2/14/2008	631,291	csas25-FOHXF030.out
2/14/2008	38,425	csas25-FOHXF040.inp
2/14/2008	631,577	csas25-FOHXF040.out
2/14/2008	38,425	csas25-FOHXF050.inp
2/14/2008	631,485	csas25-FOHXF050.out
2/14/2008	38,425	csas25-FOHXF060.inp
2/14/2008	631,906	csas25-FOHXF060.out
2/14/2008	38,425	csas25-FOHXF070.inp
2/14/2008	631,644	csas25-fohxf070.out
2/14/2008	38,425	csas25-FOHXF080.inp
2/14/2008	631,465	csas25-FOHXF080.out
2/14/2008	38,425	csas25-FOHXF090.inp
2/14/2008	631,483	csas25-FOHXF090.out
2/14/2008	38,425	csas25-FOHXF100.inp
2/14/2008	631,577	csas25-FOHXF100.out
4/1/2008	61,660	fo343-000-24ass-e000.inp
4/1/2008	757,942	fo343-000-24ass-e000.out
4/1/2008	61,655	fodsc10-001-24ass-e000.inp
4/1/2008	768,721	fodsc10-001-24ass-e000.out
4/1/2008	63,447	fodsc10-002-24ass-e000.inp
4/1/2008	785,179	fodsc10-002-24ass-e000.out
4/1/2008	63,447	fodsc10-003-24ass-e000.inp
4/1/2008	784,992	fodsc10-003-24ass-e000.out

Date	Size (Bytes)	File name
4/1/2008	63,447	fodsc10-004-24ass-e000.inp
4/1/2008	784,922	fodsc10-004-24ass-e000.out
4/1/2008	64,879	fodsc10-011-24ass-e000.inp
4/1/2008	780,304	fodsc10-011-24ass-e000.out
4/2/2008	64,348	fodsc10-021-24ass-e000.inp
4/2/2008	782,194	fodsc10-021-24ass-e000.out
4/2/2008	64,193	fodsc10-022-24ass-e000.inp
4/2/2008	785,972	fodsc10-022-24ass-e000.out
4/2/2008	65,203	fodsc10-031-24ass-e000.inp
4/2/2008	795,331	fodsc10-031-24ass-e000.out
4/2/2008	65,207	fodsc10-041-24ass-e000.inp
4/2/2008	795,269	fodsc10-041-24ass-e000.out
4/2/2008	65,216	fodsc10-041-24ass-e005.inp
4/2/2008	791,900	fodsc10-041-24ass-e005.out
4/2/2008	65,216	fodsc10-041-24ass-e010.inp
4/2/2008	792,075	fodsc10-041-24ass-e010.out
4/2/2008	65,216	fodsc10-041-24ass-e020.inp
4/2/2008	792,105	fodsc10-041-24ass-e020.out
4/2/2008	65,216	fodsc10-041-24ass-e030.inp
4/2/2008	791,918	fodsc10-041-24ass-e030.out
4/2/2008	65,216	fodsc10-041-24ass-e040.inp
4/2/2008	792,092	fodsc10-041-24ass-e040.out
4/2/2008	65,216	fodsc10-041-24ass-e050.inp
4/2/2008	791,880	fodsc10-041-24ass-e050.out
4/2/2008	65,216	fodsc10-041-24ass-e060.inp
4/2/2008	791,848	fodsc10-041-24ass-e060.out
4/2/2008	65,216	fodsc10-041-24ass-e070.inp
4/2/2008	791,918	fodsc10-041-24ass-e070.out
4/2/2008	65,216	fodsc10-041-24ass-e080.inp
4/2/2008	791,858	fodsc10-041-24ass-e080.out
4/2/2008	65,216	fodsc10-041-24ass-e090.inp
4/2/2008	792,598	fodsc10-041-24ass-e090.out
4/2/2008	65,216	fodsc10-041-24ass-e100.inp
4/2/2008	791,746	fodsc10-041-24ass-e100.out
4/2/2008	65,200	fodsc10-051-24ass-e000.inp
4/2/2008	794,356	fodsc10-051-24ass-e000.out