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CALCULATION SUMMARY SHEET (CSS)

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Document Identifier 32 - 5035847 - 02

Title ISOTOPIC GENERATION AND CONFIRMATION OF THE BWR APPLICATION. MODEL

PREPARED BY:	REVIEWED BY:
METHOD: ☒ DETAILED CHECK ☐ INDEPENDENT CALCULATION	
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TITLE PRIN. ENGR. DATE 12/8/04	TITLE Engineer DATE 12/8/04
COST CENTER 212020 REF. PAGE(S) 110	TM STATEMENT: REVIEWER INDEPENDENCE WJH

PURPOSE AND SUMMARY OF RESULTS:

The objective of this calculation is to establish an isotopic database to represent commercial spent nuclear fuel (CSNF) from boiling water reactors (BWRs) in criticality analyses performed for the proposed Monitored Geologic Repository at Yucca Mountain, Nevada. Confirmation of the conservatism with respect to criticality in the isotopic concentration values represented by this isotopic database is performed as described in Section 3.5.3.1.2 of the *Disposal Criticality Analysis Methodology Topical Report* (Reference 7.1).

Section 2 of this report presents two requirements imposed in the Disposal Criticality Analysis Methodology Topical Report (Reference 7.1, pp. 3-38 and 3-39) to ensure that the isotopic concentrations used for burnup credit are conservative with respect to criticality. The calculations presented in this calculation demonstrate that the isotopic database presented here meets these requirements. However, additional confirmation should be performed using additional assemblies that may be bounding, but are not currently included in the CRC database. Also, it would be advisable to investigate the relative affect of the bounding model in a waste package, similar to the RCA confirmation calculations. This may be accomplished by calculating k_{eff} values for the each assembly listed in Table 10 in a 44 BWR waste package. All 44 locations in the waste package could be filled with the same assembly using the best-estimate isotopic concentrations present in the CRC calculations. The calculations would then be repeated using the isotopic database isotopic concentrations. These "best-estimate" k_{eff} values could be compared to the "Isotopic Database" k_{eff} values to determine the level of relative conservatism.

This revision affects references only. Calculation results are not affected in any way by this revision.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:		THE DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK
CODE/VERSION/REV	CODE/VERSION/REV	
SAS2H OF SCALE,	MCNP VERSION 4.B2L	
VERSION 4.4A.1	MCNP VERSION 4.B2L2	☐ YES ☒ NO

RECORD OF REVISIONS

Revision Number		Date
00 (Initial)		June 2004
01	Corrected the title in the header	June 2004
02		December 2004

- Revised Calculation Summary Sheet to note that this revision does not affect calculation results in any way.
- Revised title for Reference 7.3, page 7 of 143.
- Revised date for Reference 7.2, page 110 of 143.
- Revised title for Reference 7.3, page 110 of 143.
- Completed Design Verification Checklist to reflect revisions.

1. PURPOSE

The objective of this calculation is to establish an isotopic database to represent commercial spent nuclear fuel (CSNF) from boiling water reactors (BWRs) in criticality analyses performed for the proposed Monitored Geologic Repository at Yucca Mountain, Nevada. Confirmation of the conservatism with respect to criticality in the isotopic concentration values represented by this isotopic database is performed as described in Section 3.5.3.1.2 of the *Disposal Criticality Analysis Methodology Topical Report* (Reference 7.1). The isotopic database consists of the set of 14 actinides and 15 fission products presented in Section 3.5.2.1.1 of Reference 7.1 for use in CSNF burnup credit. This set of 29 isotopes is referred to as the principal isotopes and are provided in Table 1 of this document. The oxygen isotope from the UO_2 fuel is also included in the database but is not included in the 29 principal isotopes.

The isotopic database covers enrichments of ^{235}U ranging from 1.5 to 5.5 weight percent (wt %) and burnups ranging from approximately zero (.001) to 75 GWd per metric ton of uranium (MTU). The burnup and fuel enrichment range covered by the isotopic database is presented in Table 3. The choice of fuel assembly and operating history values that are used in generating the isotopic database, are provided in Section 5. The tables of isotopic concentrations for the 29 principal isotopes (Table 1) are provided in Sections 6.1 and 6.2. Results of the confirmation of the conservatism with respect to criticality in the isotopic concentration values are provided in Section 6.3.

This report is an engineering calculation supporting the burnup credit methodology of YMP (Reference 7.1) and was performed under Framatome ANP Administrative Procedure 0402-01, Preparing and Processing FANP Calculations (Reference 7.2) and Framatome Fuel Sector Quality Management Manual (Reference 7.3).

2. METHOD

The burnup credit methodology for CSNF applications requires the use of isotopic concentrations that are bounding with respect to criticality. The isotopic concentrations are calculated using the SAS2H sequence of SCALE 4.4a with the 44-group, ENDF/B-V cross section library (Reference 7.4) and conservative input values for fuel assembly and operating history parameters. These concentrations are calculated as a function of initial fuel enrichment and fuel assembly burnup. The method to confirm the conservatism in the isotopic concentrations consists of using MCNP 4B2 (Reference 7.5) to calculate effective neutron multiplication factor (k_{eff}) values based on measured radiochemical assay (RCA), best-estimate, and bounding isotopic concentration values. The best-estimate values are from fuel depletion calculations for the RCA samples that approximate the physical characteristics and depletion history of the sample based on the best information available.

The following two requirements are imposed in the *Disposal Criticality Analysis Methodology Topical Report* (Reference 7.1, pp 3-38 and 3-39) to ensure that the isotopic concentrations used for burnup credit of CSNF are conservative with respect to criticality.

7. REFERENCES

7.1 AREVA/FANP Document Number 38-5032055-01, 2003. YMP. *Disposal Criticality Analysis Methodology Topical Report*, YMP/TR-004Q, Rev. 02, Las Vegas, Nevada: Yucca Mountain Site Characterization Office. DOC.20031110.0005.

7.2 AREVA/FANP, Administrative Procedure, Number: 0402-01, Preparing and Processing FANP Calculations, November 2003, Framatome ANP, Lynchburg, VA

7.3 AREVA/FANP Document Number FQM Rev 01, July 2003. Framatome ANP, Inc. Fuel Sector Quality Management Manual (US Version).

7.4 *SAS2H: A Coupled One-Dimensional Depletion and Shielding Analysis Module*, NUREG/CR-200, Revision 6, Volume 1, Section S2, ORNL/NUREG/CSD-2/V2/R6, March 2000. Distributed by the Computational Physics and Engineering Division, Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee

7.5 Briesmeister, J. F., Ed., "MCNP™ – A General Monte Carlo N-Particle Transport Code, Version 4B" LA-12625-M, Los Alamos National Laboratory (LANL), March 1997

7.6 AREVA/FANP Document Number 38-5028974-00, 2001. *Summary Report of Commercial Reactor Criticality Data for Grand Gulf Unit 1,* TDR-UDC-NU-000002 REV 00, Las Vegas, Nevada: Yucca Mountain Site Characterization Office

7.7 AREVA/FANP Document Number 38-5035940-00, 1999. *Summary Report of Commercial Reactor Criticality Data for LaSalle Unit 1,* B-00000000-01717-5705-00138 Rev 00, Las Vegas, Nevada: Yucca Mountain Site Characterization Office

7.8 AREVA/FANP Document Number 38-5036356-00, 1999. *Summary Report of Commercial Reactor Criticality Data for Quad Cities Unit 2,* B-00000000-01717-5705-00096 Rev 01, Las Vegas, Nevada: Yucca Mountain Site Characterization Office

7.9 AREVA/FANP Document Number 32-5037984-01, 2004. *Critical Limit Development for PWR and BWR SNF Waste Package*, May 2004, Framatome ANP, Lynchburg, VA

7.10 AREVA/FANP Document Number 38-5040793-00, 2003. *Limerick Unit 1 Radiochemical Assay Comparisons to SAS2H Calculations*, CAL-DSU-NU-000002 REV 00A, Las Vegas, Nevada: Yucca Mountain Site Characterization Office. MOL.20031002.0139

7.11 AREVA/FANP Document Number 38-5040775-00, 2003. *Calculation of Isotopic Bias and Uncertainty for BWR SNF*, CAL-DSU-NU-000003 REV A, Las Vegas, Nevada: Yucca Mountain Site Characterization Office

7.12 DOE (U.S. Department of Energy) 1992, *Characteristics of Potential Repository Wastes*, DOE/RW-0184-R1, Volume 1, U.S. DOE OCRWM, July, 1992

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DESIGN VERIFICATION CHECKLIST

Document Identifier 32 - 5035847 - 02

Title Isotopic Generation and Confirmation of the BWR Application Model

1.	Were the inputs correctly selected and incorporated into design or analysis?	☐ Y	☐ N	☒ N/A
2.	Are assumptions necessary to perform the design or analysis activity adequately described and reasonable? Where necessary, are the assumptions identified for subsequent re-verifications when the detailed design activities are completed?	☐ Y	☐ N	☒ N/A
3.	Are the appropriate quality and quality assurance requirements specified? Or, for documents prepared per FANP procedures, have the procedural requirements been met?	☒ Y	☐ N	☐ N/A
4.	If the design or analysis cites or is required to cite requirements or criteria based upon applicable codes, standards, specific regulatory requirements, including issue and addenda, are these properly identified, and are the requirements/criteria for design or analysis met?	☒ Y	☐ N	☐ N/A
5.	Have applicable construction and operating experience been considered?	☐ Y	☐ N	☒ N/A
6.	Have the design interface requirements been satisfied?	☐ Y	☐ N	☒ N/A
7.	Was an appropriate design or analytical method used?	☐ Y	☐ N	☒ N/A
8.	Is the output reasonable compared to inputs?	☐ Y	☐ N	☒ N/A
9.	Are the specified parts, equipment and processes suitable for the required application?	☐ Y	☐ N	☒ N/A
10.	Are the specified materials compatible with each other and the design environmental conditions to which the material will be exposed?	☐ Y	☐ N	☒ N/A
11.	Have adequate maintenance features and requirements been specified?	☐ Y	☐ N	☒ N/A
12.	Are accessibility and other design provisions adequate for performance of needed maintenance and repair?	☐ Y	☐ N	☒ N/A
13.	Has adequate accessibility been provided to perform the in-service inspection expected to be required during the plant life?	☐ Y	☐ N	☒ N/A
14.	Has the design properly considered radiation exposure to the public and plant personnel?	☐ Y	☐ N	☒ N/A
15.	Are the acceptance criteria incorporated in the design documents sufficient to allow verification that design requirements have been satisfactorily accomplished?	☐ Y	☐ N	☒ N/A
16.	Have adequate pre-operational and subsequent periodic test requirements been appropriately specified?	☐ Y	☐ N	☒ N/A
17.	Are adequate handling, storage, cleaning and shipping requirements specified?	☐ Y	☐ N	☒ N/A
18.	Are adequate identification requirements specified?	☐ Y	☐ N	☒ N/A
19.	Is the document prepared and being released under the FANP Quality Assurance Program? If not, are requirements for record preparation review, approval, retention, etc., adequately specified?	☒ Y	☐ N	☐ N/A

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Comments:

See Record of Revisions page for changes to Reference. No other parts were affected.

Verified By:	Mehmet Saglam	M. Saglam	12/8/04
(First, MI, Last)	Printed / Typed Name	Signature	Date