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NCS Calculation Note Title:

PWR Fuel Assemblies

Objective:

Explicitly model the Final Assembly to investigate potential assembly interaction and determine requirements for maintaining 95/95 $k_{EFF} \leq 0.95$ of Pressurized Water Reactor (PWR) fuel assemblies.

Results:

For assemblies in the
analyses are presented that demonstrate the following:

- With one bounding PWR assembly in each , at their closest possible approach, the 95/95 k_{EFF} is below the abnormal condition acceptance criterion of 0.98

Additional conclusions are summarized in Section 2.0.

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Revision Log

Rev	Date	Revision Description/Reason
0	02/07	Original Issue
1	N/A	Added new fuel types:

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1.0 INTRODUCTION

1.1 Background/Purpose

This calculation note documents analyses of PWR assemblies in the , to investigate potential interactions between assemblies and to derive the conditions necessary to maintain 95/95 $k_{EFF} \leq 0.95$.

The results herein cover all PWR fuel assembly types that are currently authorized to be fabricated, stored, or handled at the CFFF, with respect to approved Criticality Safety Evaluations (CSEs). Although fuel assemblies are constructed for many customers at the CFFF,

1.2 Limits of Applicability

The results herein apply to the following PWR assembly types, as described in References 2 and 10:

These assembly types bound the various customer-specific variants currently fabricated at the CFFF, as well as fuel variants credibly expected to be fabricated at the CFFF in the near future. Fuel assembly types not listed above are not necessarily bound by the calculations presented herein.

2.0 CONCLUSIONS

For assemblies

analyses are presented that demonstrate the following:

With one bounding PWR assembly

With one bounding PWR assembly

- The 95/95 k_{EFF} of the following PWR assembly types will not exceed 0.95 during washing:

For the remaining types of PWR assemblies currently authorized to be fabricated, stored, or handled at the CFFF, the 95/95 k_{EFF} will exceed 0.95 only if the following conditions occur:

3.0 ASSUMPTIONS & OPEN ITEMS

3.1 Assumptions

The analyses documented herein are based on the following assumptions:

5 wt% maximum ^{235}U enrichment modeled in all pellets (unless otherwise noted): This is the maximum enrichment allowed by the CFFF license

3.2 Open Items

There are no open items.

4.0 ACCEPTANCE CRITERIA

Per the CFFF license, calculated k_{EFF}s must be adjusted to account for statistical uncertainty and any applicable code bias and bias uncertainty. The final adjusted k_{EFF} is referred to as the 95/95 k_{EFF}.

The CFFF license further requires that the 95/95 k_{EFF} be demonstrated to be less than or equal to 0.98 for credible abnormal conditions.

5.0 COMPUTER CODES USED IN CALCULATION

The results documented herein are derived using the MCNP 5 code running on the WEC LINUX cluster [6] and using the default cross-section libraries [15]. For this combination of code and computational platform, Reference 1 provides a validation analysis for heterogeneous low-enriched UO_2 systems, which results in . Table 1 lists the areas of applicability (AOAs) for the validation analysis and the calculations performed herein.

Table 1: Areas of Applicability

Parameter	Reference 1 Validation	Current Calculations
Fissile Material	UO_2	UO_2
Fissile Material Form	Solid	Solid

Based on the table above, the calculations documented herein are well within the validation AOA, with one minor exception.

Note that specific parameter limits to protect double contingency and the 0.98 acceptance criterion are not derived herein. Instead, bounding credible configurations are modeled to demonstrate that the 0.98 criterion is not exceeded,

necessary to maintain 95/95 $k_{EFF} \leq 0.95$ are derived. Therefore, no sensitivity calculations as described in Reference 3 are performed herein.

6.0 REFERENCES

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6. Christian, W. R., *MCNP 5 Version 1.40 Installation Verification Report*, CE-06-452, December 7, 2006.

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7.0 CALCULATIONS

7.1 Method Discussion

The basic geometries of the fuel assembly are described in Section 7.1.1, while material compositions employed in the analyses are described in Section 7.1.2.

7.1.1 Model Geometry

With the exception of the , all of the fuel assembly types modeled herein have

Figure 1 depicts an example model of a PWR fuel assembly.

Figure 1: Example PWR Fuel Assembly Model

[a] Equivalent to 19.9 at% [5].