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INTRODUCTION

An extensive series of delayed critical experiments were performed at the Oak Ridge Critical Experiments Facility using enriched uranium metal during the 1960s and 1970s in support of criticality safety operations at the Y-12 Plant. These experiments were designed to evaluate the storage, casting, and handling limits of the Y-12 Plant and to provide data for the verification of cross sections and calculation methods utilized in nuclear criticality safety applications. Many of these experiments have already been evaluated and included in the International Handbook of Evaluated Criticality Safety Benchmark Experiments (ICSBEP Handbook): unreflected (HEU-MET-FAST-051), graphite-reflected (HEU-MET-FAST-071), and polyethylene-reflected (HEU-MET-FAST-076).[1]

Three of the experiments consisted of highly-enriched uranium (HEU, ~93.2% ^{235}U) metal parts reflected by beryllium metal discs. The first evaluated experiment was constructed from a stack of 7-in.-diameter, 4-1/8-in.-high HEU discs top-reflected by a 7-in.-diameter, 5-9/16-in.-high stack of beryllium discs.[2] The other two experiments were formed from stacks of concentric HEU metal annular rings surrounding a 7-in.diameter beryllium core. The nominal outer diameters were 13 and 15 in. with a nominal stack height of 5 and 4 in., respectively.[3] These experiments have been evaluated for inclusion in the ICSBEP Handbook.

DESCRIPTION OF THE ACTUAL WORK

Both detailed and simple benchmark models were developed for all three experimental configurations. The detailed models included the exact diameters, heights, and masses of each individual uranium and beryllium component. The simple models each consisted of two homogenized regions representing the stack of beryllium discs and the stack of uranium metal parts. Components from the experimental assembly and associated facility were not included in the models.

The benchmark models were evaluated using ENDF/B-VII.0 neutron cross section data[4] with Monte Carlo N-Particle (MCNP) version 5.1.51.[5] The evaluated uncertainties included the dimensions and material properties of the individual components, as well as assembly alignment, separation gaps, assembly worth, delayed neutron fraction, and impurities. The statistical uncertainty in the MCNP calculations was negligible.

RESULTS

A comparison of the benchmark and calculated eigenvalues are provided in Table I. The total uncertainty (1σ) in these benchmark experiments is very small due to the precision to which measurements were performed. The largest contributors are due to vertical separation of the components, impurities in the beryllium discs, and reactivity worth measurements of the experiment support structure. The difference between the eigenvalues is significantly greater than the uncertainty in the benchmark experiment.

The evaluation of these benchmark experiments are being prepared for publication in the ICSBEP Handbook: top-reflected (HEU-MET-FAST-069) and annuli (HEU-MET-FAST-059).

Table I. Results from HEU-Be Evaluation.

	Benchmark	Calculated	Δk/k
Detailed Model			
Top-Reflected	0.9998 ± 0.0002	0.9980	-0.18%
13-in. Annulus	1.0005 ± 0.0002	0.9970	-0.35%
15-in. Annulus	0.9994 ± 0.0002	0.9966	-0.29%
Simple Model			
Top-Reflected	0.9995 ± 0.0002	0.9978	-0.17%
13-in. Annulus	0.9930 ± 0.0003	0.9895	-0.35%
15-in. Annulus	0.9954 ± 0.0002	0.9926	-0.28%

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