BENCHMARK EVALUATION OF DISTRIBUTION MEASUREMENTS FOR A BERYLLIUM-REFLECTED SPACE REACTOR MOCKUP. M. A. Marshall[1,2] and J. D. Bess[2], [1]Center for Space Nuclear Research, PO Box 1625, MS 3860, Idaho Falls, ID 83415-3860, Margaret.Marshall@inl.gov. [2]Idaho National Laboratory, PO Box 1625, MS 3855, Idaho Falls, ID 83415-3855, John.Bess@inl.gov.

Introduction: The critical configuration of the small, compact critical assembly (SCCA) experiments performed at the Oak Ridge Critical Experiments Facility (ORCEF) in 1962-1965 have been evaluated as acceptable benchmark experiments. [1] The initial intent of these experiments was to support the design of the Medium Power Reactor Experiment (MPRE). [2] The third configuration in this series of experiments was a beryllium-reflected assembly of stainless-steel-clad, highly enriched uranium (HEU)-O_2 fuel mockup of a potassium-cooled space power reactor. [3]

Documentation of the evaluated SCCA critical configurations benchmarks can be found in the *International Handbook of Evaluated Criticality Safety Benchmark Experiments* (ICSBEP Handbook). [4] Additional measurements such as reactivity effects for the addition or removal of materials, spectral characteristics such as cadmium ratio distributions, and reaction-rate distributions were also performed as part of the SCCA analyses. Evaluation of these additional reactor physics measurements are found in the *International Handbook of Evaluated Reactor Physics Benchmark Experiments* (IRPhEP Handbook) [5] for the graphite-reflected SCCA experiments.

Recent benchmark activities include the evaluation of cadmium ratio and reaction-rate distribution measurements performed with the beryllium-reflected configuration. These measurements have been determined to represent acceptable benchmark experiment data and will be included in the March 2014 edition of the IRPhEP Handbook. These measurements serve to provide further validation to support the next Fission Surface Power (FSP) reactor design. [6]

Summary of Benchmark Evaluation: Figure 1 provides a schematic overview of the detailed benchmark model developed to represent the beryllium-reflected SCCA experiment configuration. The experimenter utilized 93.15 % ^{235}U-enriched metal foils (0.75-cm-diameter × 0.010-cm-thick) with and without 0.051-cm-thick cadmium covers at various locations in the core and the top reflector. Results from the foil activation measurements provided both reaction-rate axial and radial distributions and cadmium ratio axial distributions. Reaction-rate measurements along the center core position range from approximately the core mid-plane up through the upper axial beryllium reflector; cadmium ratio measurements were only performed in the upper axial reflector. Radial activation measurements were performed in-core along the core mid-plane from the core center to the core boundary. The fission rate distribution was relatively flat until within 2.54 cm of the radial beryllium reflector, and then increased by almost a factor of four at the core boundary. Simulations of modern FSP demonstrate a similar increase in power deposition in pins adjacent to the radial reflectors. [7]

Uncertainties were evaluated for each measurement. Calculations were performed using Monte Carlo n-Particle (MCNP5-1.60) [8] and ENDF/B-VII.0 nuclear data library [9] to simulate perturbations in foil parameters to estimate an effective uncertainty in the reported foil activations. Evaluated uncertainties include measurement of the foil activities, composition and density of the uranium foils and cadmium covers, foil and cover dimensions, and the physical position of each foil. Computational results for the cadmium ratios are within 8 % of the benchmark values and also within 3σ of the benchmark uncertainties. Axial foil activation calculations are within 5 % of the benchmark values and within 3σ of the benchmark uncertainties. Radial foil activation calculations performed similar to the axial rates except near the core/reflector interface where calculated values are up to 15 % greater than the benchmark values, which is greater by approximately eight times the benchmark uncertainties. This difference is possibly due to beryllium cross section data and should be further investigated.

Conclusion: Benchmark evaluation of the SCCA beryllium-reflected experiment data is useful in validating our current and future computational tools and nuclear data for the design and development of future FSP systems. Further improvement of our nuclear analysis methods will enhance our confidence in future systems design and reduce uncertainties incorporated into our design margins.

References: [1] Marshall M. A. and Bess J. D. (2013) *NETS 2013*. [2] Frass A. P. (1967) ORNL-4048. [3] Mihalczo J. T. (1963) ORNL-TM-655. [4] *International Handbook of Evaluated Criticality Safety Benchmark Experiments* (2013) OECD-NEA. [5] *International Handbook of Evaluated Reactor Physics Benchmark Experiments* (2014) OECD-NEA. [6] Parry J. R. et al. (2008) INL/EXT-08-14678. [7] Poston D. I. et al. (2009) *NETS 2009*. [8] Brown F. B. et al. (2002) LA-UR-02-3935. [9] Chadwick M. B. et al. (2006) *Nucl. Data Sheets*, 107, 2931-3060.

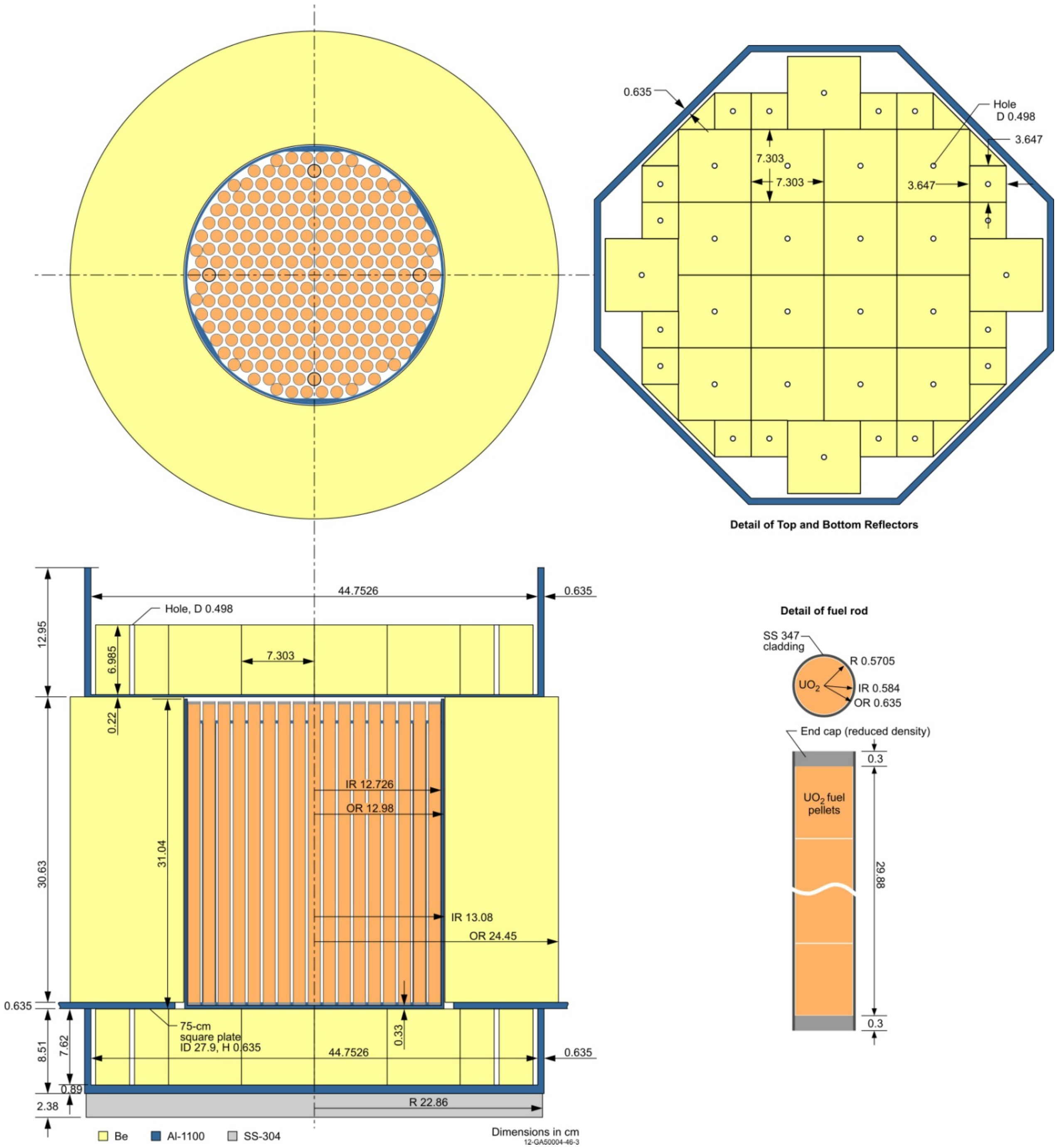

Figure 1. Detailed Benchmark Model of Beryllium-Reflected SCCA Experiment Configuration.