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Measurements for Flattop-HEU Benchmark Reevaluation

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In June 2022, high-fidelity measurements of the Flattop critical assembly were taken at the National Criticality Experiments Research Center (NCERC) at the Nevada National Security Site by a team from Los Alamos National Laboratory, Figure 1. Flattop-HEU is composed of a sphere of highly enriched uranium (HEU) surrounded by a thick spherical natural uranium (NU) reflector as shown in Figure 2 and Figure 3. These measurements were taken as part of the reevaluation of the Flattop-HEU benchmark evaluation for the International Criticality Safety Benchmark Evaluation Program (ICSBEP) Handbook. This reevaluation is being completed to update the benchmark to modern standards with significantly improved fidelity and uncertainty analysis. [1] The measurements address the largest identified uncertainties determined during a preliminary reevaluation in 2015. [2]

Figure 1. LANL Team with CMM and Flattop.

Figure 2. Close-up of Flattop, in Closed Position, with Fullcap, HEU Core, and Pedestal Adapter (L-R) Arranged on the Tabletop.

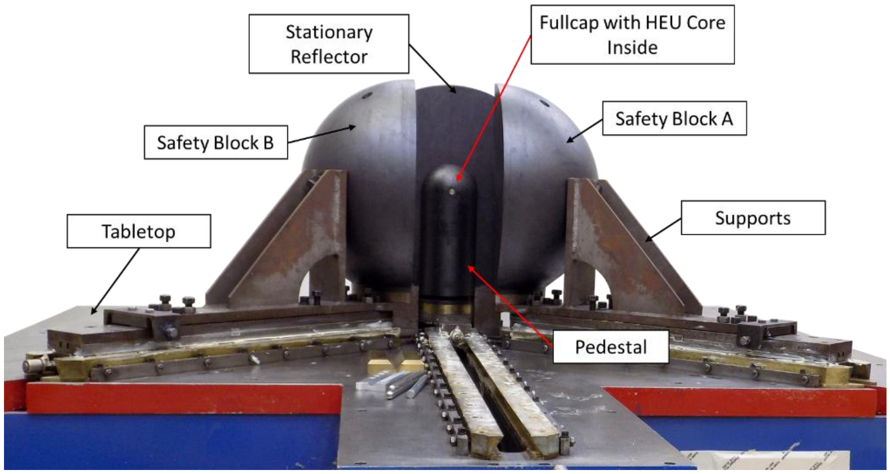

Figure 3. Expanded View of Flattop showing Locations of Core and Reflector Components.

The preliminary reevaluation identified that the largest uncertainties were associated with the mass and dimensions of the NU and HEU components.[2] To reduce the uncertainties associated with these categories, four different high-fidelity, calibrated measurement tools were used: a high-precision balance to weigh the glory hole pieces, a coordinate measuring machine (CMM) to determine the true diameter of the reflector components and HEU core, a set of high-precision calipers, and a pycnometer to measure the volume of the smaller pieces through gas displacement. The CMM and pycnometer were ordered specifically for this measurement campaign but will be useful for many other experiments in the future.

The CMM was used in two separate modes. The first mode was a scanning mode, which creates a 3D information-rich rendering of the scanned components. Figure 4 shows two of these scans being completed, and Figure 5 shows the digital results of the second scan. The second mode used with the CMM was point measurements made with a "ruby tip" probe at the end of the arm which inferred the diameter of the reflector piece from the locations of the touches.

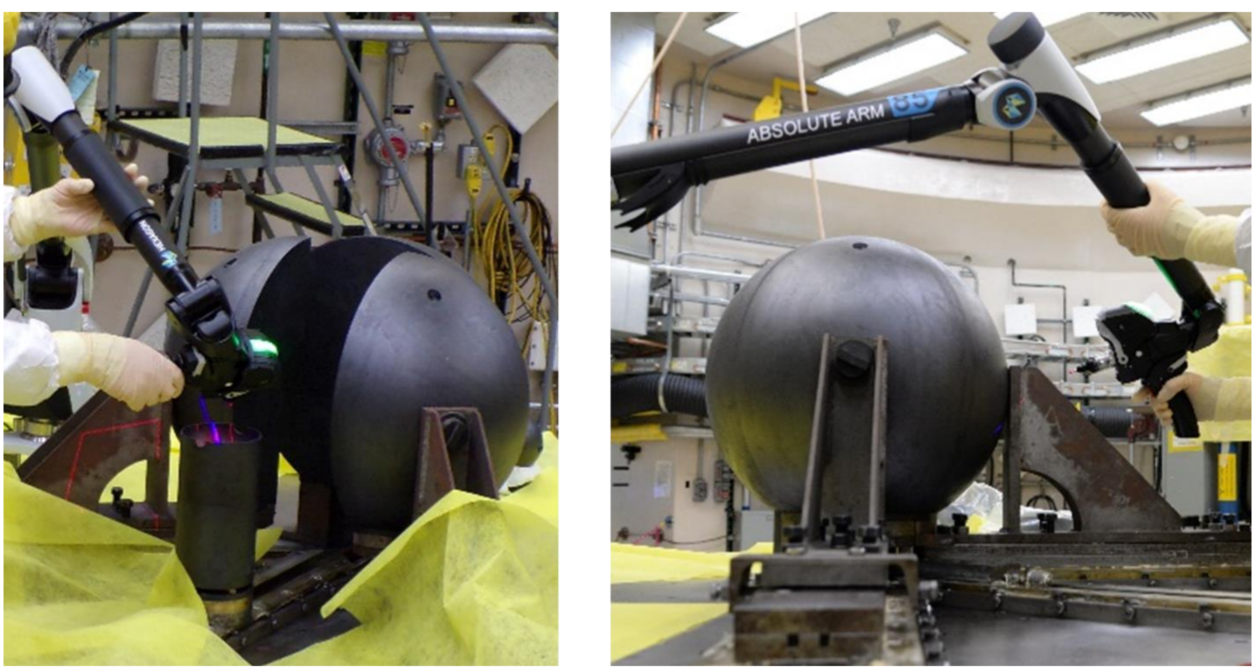

Figure 4. CMM Scans being Completed on Flattop.

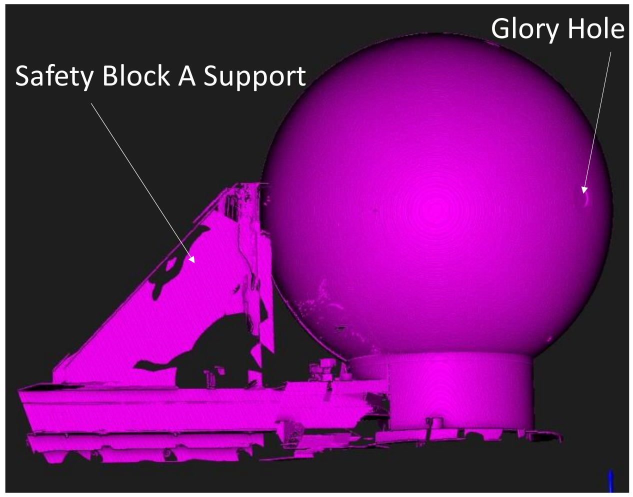

Figure 5. Digital Rendering of CMM Scan for Closed Flattop Configuration Showing Support for Safety Block A and Glory Hole.

Work has begun on the uncertainty analysis and Section 1 for the benchmark reevaluation. The preliminary results for the total mass-based uncertainty and largest individual uncertainties will be discussed at the upcoming American Nuclear Society winter meeting. [5] These preliminary results show that a marked improvement over the results of the original evaluation can be achieved. Upon completion of the reevaluation, the benchmark evaluation will be submitted for inclusion as a revision to the original Flattop-HEU evaluation, HEU-MET-FAST-028, in the ICSBEP Handbook. [3,4] This work may also necessitate the reevaluation of other benchmarks in the handbook that use Flattop, such as PU-MET-FAST-006; U233-MET-FAST-006; MIX-MET-FAST-002; and SPEC-MET-FAST-003. Future experiments such as a study of reactivity changes due to plutonium aging (IER 301) and an Americium worth experiment (IER 515) will benefit greatly from these measurements and revised benchmark.

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