Evaluation of Oak Ridge National Laboratory Health Physics Research Reactor Operation Data for Critical Benchmark Creation

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ABSTRACT

The Oak Ridge National Laboratory (ORNL) Health Physics Research Reactor (HPRR) was a research reactor designed and built at ORNL in 1961. The critical assembly was using a highly enriched uranium and molybdenum alloy as the fuel, and it could be operated in steady-state or burst modes. The reactor was used for about 25 years to produce a lot of publications related to dosimetry, radiobiology and radiation detectors testing before its decommissioning in 1987. In recent years, the idea of using legacy operation data from the to create a valuable critical accident alarm system shielding benchmark arose. Such a benchmark has been submitted to the International Criticality Safety Benchmark Experiment Project (ICSBEP) Technical Review Group for a potential inclusion in the 2022 version of the handbook. Another way to use the valuable data from the operation of the HPRR is to evaluate the feasibility of the creation of a subcritical or prompt supercritical benchmark for inclusion in the ICSBEP or the International Reactor Physics Experiments Evaluation Project (IRPhEP) handbooks. To initiate a burst, the HPRR had to be operated in a slightly subcritical state for a few minutes. Then, the insertion of the burst control rod would greatly increase the reactivity of the system and start the burst. No critical configuration of the HPRR critical assembly could be located. The only information available concerns stable subcritical and prompt supercritical states, found in a burst experiments' logbook. In the recovered logbook pages, information about 8 different bursts is available. The information includes the rods positions before and during a burst, the recorded subcritical reactor period and reactivity, and the burst fission yield derived from the temperature elevation sulfur pellet irradiation analysis. By using the HPRR logbook information and the as-built drawings of the critical assembly, a highly detailed model of the HPRR was created with SCALE 6.2.4/KENO-VI. Eight KENO-VI models were created to replicate the sub-critical assembly configurations described in the eight bursts from the recovered logbook pages. KENO-VI calculates k_{eff} and it can be linked to a reactivity value in cents by using the delayed neutron fraction B_{eff}, also calculated by KENO-VI. KENO-VI can also be used to model the prompt super-critical configurations of the HPRR and to assess the similarity with the burst measurements by comparing the calculated k_{eff} and the measured fission yields between each burst. Unfortunately, high uncertainty exist and the obtained discrepancies between experiments and calculation results are high, compromising the creation of a valuable critical benchmark from HPRR operation data. The reasons of the discrepancies and potential ways to solve them are explored.

Key Words: **subcritical, prompt supercritical, HPRR, data evaluation, benchmark creation.**