PETALE Benchmark for Neutron Transmission and Activation in Heavy Reflector Materials at CROCUS

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Abstract

The PETALE experimental campaign at the CROCUS zero-power reactor was designed to validate nuclear data for heavy reflector and cladding materials (SS-304, Fe, Ni, Cr) in a well characterized thermal reactor environment. High purity metal slabs and activation foils (Al, Fe, Ni, In, Au) were placed in a stainless steel reflector box located near the core, which consists of 336 uranium dioxide (UO_2) rods with a ^{235}U enrichment of 1.8060 ± 0.0007 wt.% and 174 uranium metal (U_{met}) rods enriched to 0.9470 ± 0.0007 wt.%. This unique configuration produces a peak neutron flux of 2.5×10^9 cm^{-2} s^{-1}, starting from a single PuBe neutron source.

This work presents measurements of neutron transmission and foil activation obtained in several low power irradiation campaigns, together with a detailed three dimensional MCNP6.3 model of the experiment. The model is used to determine k_{eff}, reaction rates, and neutron fluxes at the foil positions, which are then compared to the measured activities in order to assess nuclear data and modeling biases for reactions such as ^{197}Au(n,γ), ^{115}In(n,γ) and (n, n'), ^{58}Ni(n,p), ^{54,56}Fe(n,p), and ^{27}Al(n,α), key isotopes that control neutron attenuation and spectral shaping. The PETALE results provides a tightly coupled set of integral (criticality) and semi differential (activation and transmission) observables that constitute a stringent test of evaluated nuclear data libraries and transport methods for light water reactor analyses involving stainless steel and related alloys in reflector regions.