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Deflection of Plates by Flow Channel Disparities in Research Reactor Fuel

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ABSTRACT

LEU fuel element designs of the U.S. high performance research reactors LEU conversion cores have been optimized by each reactor facility to allow the reactors to meet mission, operational, and safety basis requirements using monolithic LEU fuel. As a part of work supporting the Preliminary Safety Analysis Report (PSAR) submitted to the NRC this year by the University of Missouri Research Reactor (MURR), the impact of thinner 44 mil LEU fuel plates, compared to the HEU thickness of 50 mil HEU plates, has been assessed. Plate deflection due to differences coolant channel thickness can arise from velocity, and hence pressure, differentials. Thus, a combined numerical modeling and experimental effort has been undertaken in order to better understand and characterize the potential for plate deflections. Experiments at the University of Missouri (MU) involving both flat and curved plates were conducted in a water flow test loop at conditions and geometries that can be related to the MURR LEU fuel element. The deflections of the plate were measured at several locations along the plate using laser displacement sensors. High-fidelity 3D simulations of the experiments were performed at Argonne National Laboratory (ANL) using STAR-CCM+ and COMSOL, and at MU using STAR-CCM+ fluid dynamics, coupled with ABAQUS for structural mechanics. When the as-built geometry of the plates is used in simulations the computed plate deflections were predicted with good agreement to measured deflections. Application of the validated computational methodology to the prototypic MURR LEU plate predicts a small plate deflection under nominal flow conditions in the order of 0.2 mils which is far less than allowances in the PSAR for change in coolant channel thickness.