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Neutron Irradiation Testing of Structural Components in Support of an Accelerator Driven Subcritical Assembly for the Production of Mo-99

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ABSTRACT

The SHINE Medical Technologies subcritical hybrid fusion-fission device for the production of medical and diagnostic isotopes offers unique materials challenges that include environmental contact with uranyl sulfate solutions and a relatively intense radiation environment. Zircaloy-4 has been used extensively in chemically challenging and high radiation environments and has been selected as the primary structural material for the assembly based on its exceptional historic behavior under irradiation and corrosion tolerance. However, much of the irradiation and corrosion database available is for power reactor applications with conditions not necessarily observed in the SHINE assembly.

Our work outlines these environmental factors, the materials selection of the structural components involved in the target solution vessel (TSV) and periphery components and the developed test plan being implemented to evaluate the structural materials for a 30-year operation. Comparative work between alpha-annealed and beta-quenched forms of Zircaloy-4 and a Zr-2.5Nb alloy have been examined in the as-fabricated form, similar metal electron-beam and tungsten inert gas welds, and hydrogen charged conditions both before and after neutron irradiation exposure through mechanical property and microstructural characterizations. Testing has also involved 316L stainless steel, the primary material for support components to the TSV, and a duplex (ferritic/austenitic) 2304 grade steel as a potential candidate for consideration. This report will summarize the results to date of this testing.

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