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SUBMERSION CRITICALITY SAFETY ANALYSIS OF A TUNGSTEN-BASED FUEL FOR NUCLEAR POWER AND PROPULSION APPLICATIONS

Abstract

Nuclear thermal rockets are the preferred propulsion technology for a manned mission to Mars. Tungsten-uranium oxide fuel could provide significant performance and cost advantages over many other fuel types for nuclear thermal rockets. A nuclear reactor for use in space remains subcritical before and during launch. Additionally, the reactor is designed to remain sufficiently subcritical in launch abort scenarios where the reactor falls back to Earth and becomes submerged in terrestrial materials, including seawater, wet sand, and dry sand. Submersion increases reflection of neutrons and also thermalizes the neutron spectrum, which typically increases the reactivity of the core. This effect is typically very significant for compact fast-spectrum reactors. This paper provides a submersion criticality safety analysis for a representative nuclear rocket-style reactor fueled with various tungsten-based fuel compositions. Both rhenium content and uranium oxide volume fraction in the cermet are analyzed for each submersion case. The inclusion of rhenium significantly improves submersion criticality safety behavior. While increased uranium oxide content increases the reactivity of the core, it does not significantly affect the submersion behavior of the reactor.