LIFETIME ANALYSIS OF IRRADIATED

BERYLLIUM IN RESEARCH REACTORS

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ABSTRACT

The objective of this study is to develop a technique to predict onset of cracking and ultimately failure of materials exposed to neutronic bombardment. Beryllium is commonly used in research reactors as a reflector material and is capable of reducing the neutron energy and multiplies the neutrons so the compact reactor core keeps running at an appropriate level. Thus, the importance of knowing when a beryllium structural material will fail in the nuclear community is of utmost importance.

There is a need to predict cracks for beryllium material scaled on energy partitioning and not just an empirical fluence scaling. Since there is limited literature on beryllium failures, the research here will use beryllium as a surrogate material upon which to apply the new technique. Its unique molecular structure moderates high energy neutrons while allowing thermal neutrons to pass through more easily. However, high energy neutron interactions cause atomic lattice changes and transmutations. Those atomic changes give rise to macroscopic material property changes. A result of changing properties is that field parameters like temperature and stress can increase and lead to potential material failure. Being able to predict the time when a likely failure will occur can help ensure that the reflector be replaced in a timely manner. An observed

failure determined the lifetime of a previous reflector design with beam port holes that is no longer utilized.

To demonstrate the validity of the technique, one case studies was used to match a known failure location and time. Additionally, two additional case studies with unobserved failure times are included and the goal is to analyze the detailed thermal/structural behavior of the beryllium reflectors at MURR in order to determine lifespan of irradiated beryllium, and possibly other materials. The study will use Monte Carlo N-Particle (MCNP) models of each reactor to capture localized gamma heating and the tritium and helium gas distribution within the beryllium due to its transmutation.

Using the historical failure as a reference point, other failure modes were ruled outed, leading the hypothesis that cracks forming caused by manufacturing flaws and material transmutation are the likely failure mechanism. The research relies on material degradation and fracture mechanics to explain why and how a material exposed to radiation in a pool breaks down and ultimately fails. The research helps support reactors by finding a scientific manner in which to estimate failure in irradiated materials. Many methods used currently rely on empirical correlations, different modes of fractures, or observed failures. The new technique allows projections of lifetime based on the irradiation energy distribution and partitioning. New lifetime projections for MURR are suggested.