Experimental Setup for Direct Electron Irradiation of the Uranyl Sulfate Solution: Bubble Formation and Thermal Hydraulics Studies.

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ABSTRACT

Argonne is assisted SHINE Medical Technologies in developing SHINE, a system for producing fissionproduct ⁹⁹Mo using a D/T-accelerator to produce fission in a non-critical target solution of aqueous uranyl sulfate. We have developed an experimental setup for studying thermal-hydraulics and bubble formation in the uranyl sulfate solution to simulate conditions expected in the SHINE target solution during irradiation. A direct electron beam from the linac accelerator will be used to irradiate 20L solution volume (sector of the solution vessel). Because the solution will undergo radiolytic decomposition, we will be able to study bubble formation and dynamics and effects of convection and temperature on bubble behavior. These experiments will serve as a verification/validation tool for the thermal-hydraulic model. Utilization of the direct electron beam for irradiation allows homogenous heating of a large solution volume and simplifies observation of the bubble dynamics simultaneously with thermal-hydraulic data collection which will compliment data collected during operation of the mini-SHINE experiment. Irradiation will be conducted using a 30-40 MeV electron beam from the high-power linac accelerator. The total electron-beam power will be 20 kW, which will yield a power density on the order of 1 kW/L. The solution volume will be cooled by the front and back surfaces and by a central tube to mimic the geometry of the proposed SHINE solution vessel. Also, multiple thermocouples will be inserted into solution to map its thermal profiles.