Integral Experimental Investigation of Radioisotope Retention in Stagnant and Flowing Lead for the Mechanistic Source Term Evaluation of Lead Cooled Fast Reactor

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ABSTRACT:
The goal of this NEUP is to experimentally investigate the integral effects of radioisotope interactions with liquid lead to support the following technical goals: (1) evaluating the mechanistic source term of the Lead-cooled Fast Reactor (LFR), (2) developing a universal integral effect test methodology for liquid metal source term evaluations, and (3) establishing a basis for the comparison of radioisotope retention between lead and sodium. This research will advance the LFR licensing pathway by establishing the phenomenological foundation of the interaction between fission products and liquid lead. We will conduct integral and separate effect testing on radioisotope retention in lead with a focus on the chemical behavior of the coolant, including solubility, and the thermodynamic equilibrium of compound formation, as well as the radioisotope transportation mechanisms from the coolant to the cover gas by bubble transport and free surface vaporization. The major objectives of the proposed research are to: (1) conduct stagnant lead testing to collect solubility and compound formation data of key isotopes, (2) investigate bubble transport and scrubbing in flowing lead, (3) assess the vaporization of radio isotopes from the coolant, (4) develop physics-based empirical correlations for the integral effects of the aforementioned phenomena, and (5) evaluate its impacts on the licensing strategies of LFR and implications on SFR mechanistic source term evaluations. A new scientific understanding of the triad: 'chemistry – bubble transport – surface vaporization', in the context of the integral mechanistic source term evaluation in liquid metal, will be attained. These new insights will lay a foundation upon which future licensing strategies and a detailed path forward can be established.