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Development of Versatile Liquid Metal Testing Facility for Lead-cooled Fast Reactor Technology

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Program: RC-3: Liquid Metal-cooled Fast Reactor Technology Development and Demonstration to Support Deployment

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ABSTRACT:

Lead-cooled fast reactor (LFR) technology offers technical benefits such as high temperature operation, virtually no loss of coolant accidents and operation at atmospheric pressure. Liquid lead is non-reactive with air and water, has a high boiling point, poor neutron absorption and excellent heat transfer properties. Regardless of substantial advantages, the corrosive nature of liquid lead is a critical challenge in implementing LFR technology. The solubility of common alloying elements, especially nickel, is high in liquid lead, causing dissolution and attack of steels and nickel-base alloys to occur. This problem is especially pronounced at higher temperatures (>550°C). While some promising candidate materials have been identified, very little testing has been carried out at high temperatures under oxygen controlled conditions (dissolved oxygen in the liquid lead has a large impact on the corrosion behavior of materials). Furthermore, nearly all such studies are conducted in stagnant conditions. Therefore, the capability to test the corrosion of materials at high temperatures, with controlled oxygen content, and under dynamic conditions is needed to provide better representation of the service conditions that will be experienced by components in an industrial scale facility using liquid lead.

The objective of this project is to 1) develop a unique, versatile high temperature liquid lead testing facility, 2) experimentally test material corrosion behavior, and 3) develop ultrasound imaging technology in liquid lead. The results of these experiments will be combined with high-fidelity computational fluid dynamics (CFD) modelling to allow prediction of corrosion behavior under a wide variety potential liquid lead flow conditions. This project will overall tackle the issue of materials integrity in the LFR environment in three ways: (1) understanding of erosion/corrosion behavior of materials in liquid lead, (2) minimizing such corrosion by controlling the chemistry (dissolved oxygen content) of the liquid lead (3) demonstrating the ability to monitor the condition of components with under-lead viewing technology. This project will support deployment of the LFR technology, which is being pursued by Westinghouse due to its favorable attributes in areas such as safety, economic performance and sustainability. It is complementary to the ongoing effort on LFR in the U.S. and in the world. The planned collaboration with Italian and UK partners allows the project to leverage both domestic and international expertise in liquid lead technology, CFD, and materials science and corrosion.