Irradiation Testing of LWR Additively Manufactured Materials

PI: Dr. Ronald Horn, GE Hitachi Nuclear Energy

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ABSTRACT:

The purpose of this proposed work is to perform full irradiation / PIE on structural materials produced by Direct Metal Laser Melting (DMLM) fabrication. The proposed project, designed similarly to a current EPRI/NSUF pilot project for irradiation and PIE, would evaluate two structural materials that are key alloys used in LWRs. The specimens will be configured for microscopy, tensile, fracture toughness, and SCC tests and provided to NSUF by GE Hitachi for neutron irradiation to approximately 3.5 X 1020 n/cm2 (E>1.0 MeV) at Boiling Water Reactor (BWR) temperatures and for subsequent PIE. The irradiated test data will complement un-irradiated testing and evaluation that will be performed by GEH.

The program will evaluate two key structural materials, Type 316L and Alloy 718, processed using DMLM. The processing methods will employ previous developed techniques and heat treatments to build test specimens. GEH, in collaboration with its Global Research Center (GRC), will assess the un-irradiated microstructure and properties. Unique NSUF capabilities will be used to irradiate and then characterize and test companion specimens to those tested by GEH. The summary of the resulting tests and examinations are as follows:

1. Processing history summary, microstructural characterization, mechanical properties, stress corrosion crack growth data for un-irradiated Type 316L prepared using the DMLM additive manufacturing process (performed by GEH and GE GRC)

2. Processing history summary, microstructural characterization, mechanical properties, stress corrosion crack growth data for un-irradiated Alloy 718 prepared using the DMLM additive manufacturing process (performed by GEH and GE GRC)

3. Irradiation history, microstructural characterization, mechanical properties, corrosion crack growth data and fracture properties for DMLM AM Type 316L (performed by NSUF)

4. Irradiation history, microstructural characterization, mechanical properties, corrosion crack growth data and fracture properties for DMLM AM Alloy 718 (performed by NSUF)

The program will develop key irradiated data and the understanding of the effects of irradiation on material property changes that will support the use of DMLM/AM structural materials in LWRs and SMRs. The data will be used to gain ASME approval of this innovative manufacturing technology. It is desirable to test material fabricated in this manner because there are significant opportunities for implementation as reactor internal repair parts, fuel debris resistant filters, and fuel spacers in existing Light Water Reactors (LWRs), complex parts in Advanced LWRs and in Small Modular Reactors (SMR). Implementation of materials produced using this and similar processes offer a potential step change in efficiency for complex parts production and hence a potential for large cost savings for repair and production components in the future.