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Understanding of ATF Cladding Performance under Radiation using MITR

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Program: IRP Fuel Cycle-1

ABSTRACT:

The objective of this proposed integrated research project (IRP) is to utilize the Massachusetts Institute of Technology Reactor (MITR) to study ATF (Accident Tolerant Fuel) Cladding performance under radiation in collaboration with leading institutions and all major US ATF vendors. MITR is a 6 MWth reactor that provides similar neutron and gamma flux levels and water flow rates as a commercial light water reactor (LWR). MITR features an existing in-pile high temperature (up to ~300ºC) and high flow water loop with full chemistry control including oxygen, hydrogen and boron-levels. Since Pressurized Water Reactor (PWR) claddings are exposed to temperatures of up to 350ºC, for this project, in-kind cost share from the proposing team is provided to procure a higher pressure and temperature autoclave that can provide a more prototypic hydrothermal corrosion environment. The existing autoclave will then be used for Boiling Water Reactor (BWR) irradiations as it meets the target cladding temperature range. Given that both autoclaves extend from bottom of the active core to well outside of the core (and radiation field), MITR provides capability to test cladding performance under *(1) simultaneous Neutron and Gamma flux (in-core) (2) Mainly Gamma flux and its impact on radiolysis and electro-chemical potential (in upper reflector) (3) no radiation environment (above the reflector),* in a single 10-week cycle. This capability will be leveraged for all the planned 7 cycles in the water loop under this IRP.

For the comprehensive assessment of ATF performance, additional testing will be performed: (1) 2 MITR cycles where electrical heating is applied to the cladding will also be performed to study impact of heat flux on hydrothermal corrosion (2) the identical out-of-pile high flow heated cycle testing with and without presence of CRUD (3) low flow high temperature out-of-pile testing with and without loading (4) Insertion of pre-treated out-of-pile samples (e.g. with different CRUD loading or noble chemistry) for in-pile testing. The proposed sample matrix will be combined with state-of-art post-testing/irradiation examination by the core team, namely, Idaho National Laboratory (INL), MIT, University of Michigan (UM) and Pennsylvania State University (PSU) and will meet the overarching objective of understanding ATF cladding performance under radiation. The proposed PIE includes microscopy, thermal and mechanical

characterization and corrosion (oxygen and hydrogen) measurements. Specifically, the following original technical contribution to the nuclear field are proposed:

- ✓ Study of BWR Coating Survivability under Prototypic Hydrothermal Corrosion
- ✓ Study Impact of Defective Coating on Hydrothermal Corrosion
- ✓ Impact of Chemistry, Boiling and CRUD on Hydrothermal Corrosion for Zircaloy and ATFs
- ✓ Impact of Heat Flux/Temperature Gradients on SiC/SiC Composite Cladding Thermo-Mechanical Performance

In order to meet the above objectives and perform the proposed testing with high quality (.i.e. industry relevant) samples, the IRP core team is partnered with GE-Hitachi (and Global Nuclear Fuels), Framatome, Westinghouse, General Atomics and Ceramic Tubular Products. Additional samples will be provided through past DOE funded activities as well as in-kind from Czech Technical University (CTU) were coated samples had been fabricated to support international and US ATF activities in the past. Such collaborations will ensure meeting DOE AFC's ATF programmatic goals for this IRP. To further ensure the testing conditions are relevant to broader ATF community and avoid duplication of work, an advisory board made up representatives from Nuclear Regulatory Commission (NRC), Oakridge National Laboratory (ORNL) and Electric Power Research Institute (EPRI) has been formulated. The phenomenological understanding enabled by the utilized unique infrastructures (e.g., MITR, IMCL in INL) based on decades of investment by DOE will provide the unique hands-on training for the next generation of nuclear engineers on nuclear fuel R&D, which is at the heart of nuclear energy technology development.