Project Title

Experimental Determination and Modeling of Used Fuel Drying by Vacuum and Gas Circulation for Dry Cask Storage

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Program: NEUP-IRP-FC-2 – Forced Helium Dehydration/Vacuum Drying of Used Nuclear Fuel

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ABSTRACT:

A three year investigation involving multiple universities and an industry partner is proposed to investigate drying of used fuel canisters for dry cask storage. This proposed effort is led by a Carnegie One research university with partners including a minority serving institution and an industrial partner with experience in nuclear fuel and dry cask storage. This investigation will address questions surrounding the amount, form, and location of water remaining in dry casks. An experimental effort involving a full length mock used fuel assembly with multiple heater rods will be employed in these full scale experiments. Combined and separate effects tests will be conducted involving intact rods, failed rods, a BWR water rod, a PWR guide thimble, porous neutron absorber materials, spacer disks, etc. Smaller scale tests including short rodlets will be utilized to illicit a detailed and scientific understanding of the effects of rod surface condition on drying. A multipronged modeling effort will be conducted to provide a mechanistic understanding of drying for each of the scenarios for intact rod surfaces, failed waterlogged rods, trapped water, and ice crystal formation. Correlations will be developed for inclusion in multiphysics codes such as COMSOL or OpenFOAM and industry/regulatory codes such as TRACE and COBRA-SFS. These correlations and system models will be validated with experimental data collected in this effort.

AREVA provides a service for loading used nuclear fuel storage systems, based out of its facility in Aiken, SC. AREVA will provide the university with plans for construction of a vacuum drying system, as well as detailed vacuum drying procedures as they are currently implemented by AREVA for NUHOMS® canister loading services. This, together with the use of full size mockups supplied by AREVA Fuels, will enable the university team to evaluate the fuel drying performance while duplicating field conditions as closely as feasible in a laboratory environment. Subject matter experts will support the startup of the testing effort and review test results and assist in their interpretation. The dollar value of AREVA's participation is $800,000.

University of Florida (UF) will collaborate on the design of the testing program. With expertise in nuclear fuel and fuel performance, UF will also evaluate the design of the mock assembly and chamber to help ensure it is representative of the design features required for testing. In particular, UF will work with USC and vendor to ensure that the fuel assembly will physically represent breached and waterlogged fuel rods, PWR guide tube rods and BWR water rods. UF is able to manufacture Ceria (CeO_2) pellets for the

defected rod, if deemed necessary. Ceria is a well-known surrogate for UO_2. The dollar value of University of Florida participation is $320,000.

Faculty from SCSU and USC will collaborate on the thermal analysis of the experimental chamber containing the single mock fuel assembly (similar to a used fuel canister). USC will assist in establishing the computer software and modeling tools needed to collaborate on these analyses including assistance in obtaining license for the NRC code TRACE. COBRA-SFS license will be obtained from RSICC. This collaboration will include onsite faculty visits and sharing of video tutorials produced by USC graduate students related to these computer codes. SCSU faculty brings expertise in heat transfer and thermal analysis and will incorporate these computer codes into the SCSU capstone design course. This will have the benefit of providing real-world, hands on experience with these state-of-the-art tools to SCSU students. This collaboration will also provide additional funds for scholarships especially, as a recruitment tool for the Nuclear Engineering Program (NEP). The dollar value of SCSU participation is $250,000.