

NE-18-16115, Characterization of the Radiation Stability of Molten Nitrate/Nitrite Salts for use as Heat Transfer Fluids in Nuclear Reactor Power Plants

Yellowstone Energy is developing an advanced modular nuclear reactor with integrated thermal energy storage that maximizes use of existing supply chains to enable near-term deployment of a cost effective, economic, and passively safe clean energy source. The Yellowstone Energy Molten Nitrate Salt Reactor (MNSR) power plant is unique among advanced reactor designs in using a molten nitrate salt primary coolant, a high-temperature, ambient-pressure liquid heat transfer fluid commercially deployed in MW-scale chemical and concentrated solar power systems. The technical readiness and manufacturability of this MNSR design coupled with the cost reductions and revenue enhancements relative to current reactors makes the MNSR an ideal candidate to replace the aging U.S. nuclear capacity to be retired in 2030s.

Molten nitrate salts are mature heat transfer fluids used in the petrochemical and concentrated solar power industries. While the thermophysical properties of these salts have been studied extensively and long-term high-temperature operation has been commercially demonstrated, a primary barrier to qualification of nitrate salts as a primary or intermediate coolant for nuclear reactors is their behavior in high radiation environments. Through an ongoing Cooperative Research and Development Agreement (CRADA) between Yellowstone Energy and Oak Ridge National Laboratory, lab scientists identified nitrate salt radiation degradation as a potential technical barrier for the MNSR concept and recommend performing irradiation studies of molten nitrate salt to qualify radiation stability similar to an MNSR environment.

Coupled neutron and photon transport simulations of the MNSR indicate that coolant energy deposition is dominated by photons. Therefore, it is most desirable to have a high-intensity photon ionizing radiation source to test the simulation. This project will pair Yellowstone Energy with Sandia National Laboratory to complete the necessary irradiation testing required and accelerate the retirement of risk related to qualification of nuclear environment nitrate salts. It is expected that the results of this project will significantly advance the MNSR design by qualifying the radiation stability of nitrate salt coolants in a nuclear environment. The results will also be used to develop detailed design requirements for chemistry control systems in the MNSR to mitigate any deviation from optimum coolant chemistry that is induced by radiolytic decomposition.