INL/CON-24-76357-Revision-0

Out-of-Pile Testing and Instrumentation Transient Water Irradiation System

June 2024

Musa Abdennour Ahmed Moussaoui, Charles P Folsom, Colby B Jensen

Changing the World's Energy Future

Idaho National Laboratory

INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

INL/CON-24-76357-Revision-0

Out-of-Pile Testing and Instrumentation Transient Water Irradiation System

Musa Abdennour Ahmed Moussaoui, Charles P Folsom, Colby B Jensen

June 2024

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Out-of-Pile Testing and Instrumentation Transient Water Irradiation System

Musa Moussaoui[1], Charles Folsom[1], and Colby Jensen[1]

[1]*Nuclear Fuels and Materials, Idaho National Laboratory, 1955 Fremont Ave, Idaho Falls, ID 83415, musa.moussaoui@inl.gov*

[Placeholder for Digital Object Identifier (DOI) to be added by ANS]

Current initiatives to increase the burnup of conventional nuclear fuels past the approximate 62 GWd/t limit have been spurred on by direct savings to refueling and waste storage. The technical justification for a new license limit requires extensive qualification through experimental testing. Unlike beginning-of-life fuels, high-burnup fuels are more susceptible to fuel fragmentation, relocation, and dispersal (FFRD), therefore more data is needed to characterize fuels under key accident scenarios.

The Transient Reactor Test Facility (TREAT) located at the Idaho National Laboratory has developed a testing apparatus architecture to test fuels and claddings at prototypic conditions. The Transient Water Irradiation System (TWIST) is the latest iteration of a testing device capable of conducting loss of coolant accidents (LOCAs) in TREAT.

The Out-of-Pile Testing and Instrumentation TWIST (OPTI-TWIST) is an electrically heated device that is analogous to TWIST. OPTI-TWIST allows for detailed instrumentation and thermal-hydraulic characterization. TWIST ultimately aims to conduct the most advanced in-situ diagnostics to evaluate FFRD in a prototypic LOCA. Moreover, it will explore the phenomenological bifurcation of a decay-energy heat up driven LOCA and a stored-energy heat up driven LOCA. The instrumentation suite includes conventional thermocouples and pressure transducers in addition to an electro impedance sensor, an acoustic emission sensor, an optical pressure sensor, and an optical pyrometer. Characterizing these instruments in OPTI-TWIST eliminates complications of irradiation effects while preserving extreme thermal-hydraulic conditions. Finally, benchmarking both devices to a thermal-hydraulic code like the Reactor Excursion and Leak Analysis Program (RELAP)5-3D provides a unique opportunity for iteration. Pre-test predictions and post-test interpretations inform the physical designs, operational procedures, test conditions, and instrumentation types and positions.

Keywords: LOCA, TREAT, high-burnup