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Restarting the Transient Reactor Test (TREAT) Facility Reactor for Nuclear Transient Testing Science: A Special Issue of *Nuclear Technology*

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Transient testing of nuclear fuel and crash testing of cars have a lot in common: The goal is to design and test for high safety standards, and then we are prepared if the worst does occur. Transient testing of nuclear fuel involves placing the fuel into an experiment vehicle and then placing the vehicle into a reactor that is purpose-built for simulating nuclear accidents. This testing approach allows the nuclear fuel to be tested to the design limits, or to destruction, depending on the purpose of the test being conducted. The transient reactor is not harmed, but the nuclear fuel being tested can be tested to destruction.

Transient testing.

TREAT south view.

About 12 months after breaking ground in 1958, the Transient Reactor Test (TREAT) facility achieved first critical on February 23, 1959. TREAT was the first of a specialized subset of test reactors that was wholly dedicated to ensuring that a nuclear energy system could be operated safely. The fact that it has outlived nearly all of the 54 experimental, demonstration, or test reactors constructed on the Idaho National Laboratory site is a testament to its brilliant design and innovative user community. The experimental work done at TREAT over the following 35 years laid a foundation that would subsequently support the nuclear reactor technology widely distributed across the globe.

TREAT is a unique reactor, having around 350 4-inch by 4-inch by 8-foot Zircaloy fuel assemblies that contain 1 part of high-enriched uranium to 10,000 parts of graphite. The reactor is capable of up to 20 gigawatts thermal for a transient pulse that lasts around 100 milliseconds, and it is capable of variable-power, computer-controlled transients up to a minute or more, which provides sufficient power and control for an exceptionally flexible testing capability.

From 1959 to 1994, TREAT had 6604 reactor startups and conducted more than 2800 nuclear fuel transient tests. TREAT historically was used to study fuel meltdown, metal-water reactions, interactions between overheated fuel and coolant, and the transient behavior of fuels for high-temperature systems. Virtually every nuclear reactor technology today has benefitted from the historical experiment programs conducted at TREAT.

The plant was extensively upgraded from November 1987 and restarted in August of 1989, running for an additional 5 years before being shut down in 1994 because of a near stoppage of nuclear development during that time. But by 2010, the U.S. Department of Energy (DOE) Office of Nuclear Energy determined that restoration of transient testing capability was needed in the United States to support efforts to improve reactor sustainability and performance. The need for transient testing capability then became critical to support the new accident-tolerant fuel development that

TREAT fuel inspections.

was mandated by Congress following the events at Fukushima. It became apparent that testing fuel behavior in a prototypic neutron environment and obtaining time-resolved data was essential for guiding the development and validation of time-dependent computer models of fuel and core behavior across multiple time and length scales. Transient testing coupled with complete post-irradiation examination was needed to develop the knowledge basis for the next generation of nuclear reactor fuels.

In February of 2014, the DOE–Idaho site manager approved the National Environmental Policy Act documentation selecting TREAT as the preferred option for performing transient testing in the United States, and the restart effort immediately began. Along with restarting the reactor, efforts were performed in parallel to restore the scientific and enabling infrastructure required for preparing experiments for irradiation, vehicles for irradiation, and capability for post-irradiation examination.

The TREAT restart effort completed in February of 2018, 1 year ahead of schedule and $20 million less than the baseline. The strategy for restarting TREAT was to hire the operating organization and to use the operating organization to restart the reactor. This was very successful and resulted in a staff that knows the TREAT facility very well, and the operating record following restart has been exemplary.

It was a privilege and pleasure to lead the TREAT restart team, and it gives us great pleasure to provide the introduction to this special issue of *Nuclear Technology*, especially since the papers presented here have been authored primarily by members of the team that restarted the reactor and prepared for experiment performance. These papers are just the start and represent the dawn of a new era in transient testing.

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TREAT: The dawn of a new era of transient testing.