Restart of the Transient Reactor Test Facility (TREAT) and Resumption of Transient Testing

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Facility Location
TREAT Reactor

- Designed to conduct transient testing of fuels and structural materials
- Operated from 1959 to 1994 (construction completed in November, 1958)
- Several major bldg. and system upgrades, most recently in 1988
- Reactor has performed 6604 reactor startups, 2884 transient irradiations

- 19 GW Peak Transient Power (120 kW Steady-state power)
- Core: 4 ft. high x roughly 6 ft. dia.; surrounded by 2 ft. graphite reflector
- 19 x 19 array of 4 in. X 4 in. fuel and reflector assemblies
- Fuel: 0.2 wt.% HE UO$_2$ dispersed in graphite, LEU conversion work initiated
- Nearly instantaneous & large negative temperature coefficient due to unique fuel design
Nuclear Fuels development is a high U.S. priority for multiple reasons

- Fukushima: Resulted in Congressional mandate for more accident tolerant nuclear fuels.

- World Health: Over 1 Million people die per year worldwide from air pollution related to coal fueled electricity generation; a cleaner option is required including new design nuclear plants.

- Greenhouse Gas Minimization: Wind and solar are not stable base loads; nuclear power plants must qualify fuel for load follow operation to allow better utilization of these alternative power sources.
Nuclear Fuels development requires transient testing for design development and qualification

Nuclear fuel tends to fracture during use or when exposed to a power burst, it is important for the fuel to retain reasonable structural integrity.

During a transient test, fuel is exposed to a much higher than normal neutron flux, driving the fuel to high power levels.

Transient testing fuel and crash testing cars have a lot in common: Design and test for high safety standards.
TREAT Cooling Air is needed to cool reactor for next cycle – is not safety related
Reactor Control

- Automatic Reactor Control System – Intel Multibus
- Early form of distributed control, 1.4 ms response time
- Parts available
- Power supplies replaced, DMT computer restarted

- Control panels are located in 724 Building – ½ mile from TREAT Reactor
- Has remained energized
Reactor Trip System

- Replaced ~1988
- Paint is not even scratched...
- Age related degradation issues will be resolved – capacitors, power supplies, pots
- Calibrate, retest...
Cartridge Experiment Concept

- A variety of test vehicle designs are available (including both static and recirculating coolant systems)
- Experiment is isolated from the reactor by a pressure vessel system, allowing for use of any coolant of interest (water, Na, He, etc.)
- Test packages are fully assembled at the Hot Fuel Examination Facility and delivered to TREAT ready for testing
- The test vehicle typically replaces either one or two standard TREAT fuel elements (~10 cm x 20 cm cross-section w/ 1.2 m active length)

Example: Dry Capsule

Example: Wet Capsule

Example: Na Loop
Real-time Fuel Motion Monitoring: Fast Neutron Hodoscope
Neutron Radiography and Tomography

2D and 3D images reconstructed from neutron radiographs allows for detailed investigation of complex interactions between components without extensive destructive examinations.
Restart Progress

- The DOE has authorized and funded activities required to resume transient testing operations at TREAT.

- Facility is being restarted from an extended outage using standard outage management processes, with a focus on time related degradation and changing standards, **start-up prior to 2018**

- No major modifications have been identified,
  - Digital Automatic Reactor Control System has parts commercially available, testing is in progress
  - Most reactor systems have low operating hours since upgrade in the 1980’s, for example, cooling fans <2,500 run hours

- Efficient organization
  - Minimal operations staff, certified operator and supervisor role provided by other orgs such as engineering, maintenance, training
  - Utilizing other partners such as AREVA for industry expertise, personnel from within INL in a variety of roles, and other national laboratories
  - Organization is assembled, personnel training is underway, and corrective maintenance is being performed
  - Organization will restart plant then immediately support science mission

- Procedures and documentation such as drawings exist, and are being updated
Long lead general maintenance or procurement items are under way and progressing well

- PHP Enclosure has been removed
- Roofing replacement has been completed
- Component testing of the Automatic Reactor Control System is under way: hard drives have been repaired, power supplies have been replaced, and some software has been operated
- Dedicated Microprocessor Tester computer has been energized and successfully started
- Component testing of the control rod drive systems is under way: hydraulic oil has been sampled, general cleaning of mechanical parts has started, and the magnetic latch mechanism is acceptable for use
- Replacement uninterruptible power supplies and new air compressors have been received and are being installed
- Standby and redundant diesel generators were evaluated. Operational modes and procedures will be established changed to allow continued use for restart and test operations.
## Transient Testing Roadmap

**Maturity Curve**

<table>
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<tr>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>End State</th>
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| FACILITY AVAILABILITY  
- Re-establish basic TREAT complex infrastructure (i.e. fire water system, roof, office space, etc.) required to support reactor restart activities | Complete TREAT fuel inspections  
Complete development of updated TREAT reactor physics models  
Complete TREAT facility health assessments | Complete all TREAT maintenance, modifications, and renewal activities  
Complete modifications to HFET to support remote TREAT test handling and assembly station | Complete TREAT readiness review  
Complete TREAT physics testing  
Conduct first TREAT transient tests (late CY2017, FY2018) | TREAT is recognized as the international center of excellence for performing transient testing of nuclear fuels and materials |
| RESEARCH CAPABILITY  
- Develop specific research needs for the future  
- Establish a vision and strategy for world class in-reactor instrumentation suite and sample environment | Prepare multi-purpose drop-in capsule TREAT irradiation vehicle  
Complete design of first TREAT drop-in irradiation test including test vehicle hardware, experiment operating conditions, and experiment safety basis | Standard suite of experiment condition monitoring instruments available for use in TREAT transient tests  
Complete reactivation of partial view hodoscope for rodlet test  
Complete design of TREAT flowing water loop (to prepare for installation by 2019) | Complete design of TREAT flowing Na loop (to support fast reactor testing by 2020)  
Concepts for next generation hodoscope developed and fundamental technology demonstrations complete  
Reactivate TREAT experiment and loop handling cask | TREAT and MFC are recognized as having a world leading range of transient testing experiment environments, real-time instrumentation, sample preparation, and PIE capabilities. |
| RESOURCES  
Establish transient testing advisory committee to assist in prioritization of scientific capability development and identify opportunities | TREAT operating staff fully established for resumption of operations | Rx Operator and Rx Supervisor Certification complete  
Establish multi-year industry supported program for transient testing (comparable to Studsvik or Halden projects) | Design of system to support remote remanufacturing and instrumentation of irradiated fuel complete | Transient Irradiation National Scientific User Facility is recognized as leading the innovative use of transient irradiation in the scientific investigation of nuclear fuel behavior |