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IAEA NEXSHARE TREAT Information

November 2023

Changing the World's Energy Future

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Idaho National Laboratory

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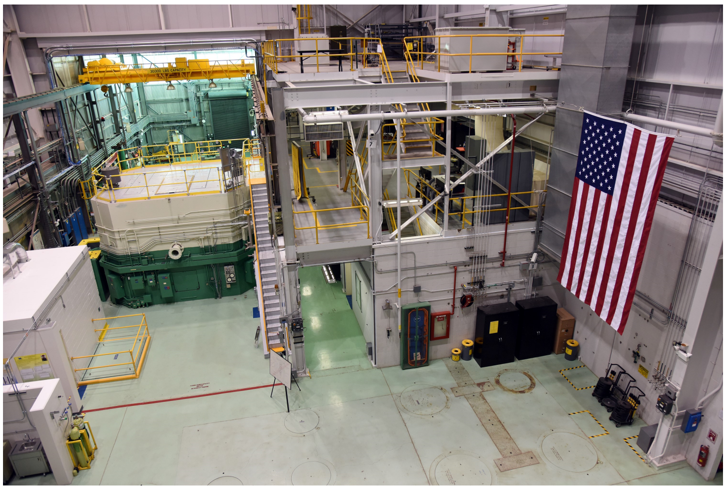
Transient Reactor Test Facility (TREAT)



GENERAL INFORMATION
Acronym: TREAT
Facility name: Transient Reactor Test Facility
Organization: Department of Energy
Country: United States
Operational since: 1959, Refurbished 2017
Reactor family: ☐ Water Cooled ☐ High Temperature Gas Cooled ☐ Molten Salt ☐ Liquid Metal Cooled Fast Spectrum Other: Air cooled graphite moderator reactor
Website/Contact email: inl.gov/Todd.pavey@inl.gov

TECHNICAL DESCRIPTION

Operating conditions modelled: ☐ Normal operation ☒ Accident conditions

please specify: TREAT can deposit over 2000 MJ of energy in transients power excursions of various shapes and durations, ranging from milliseconds to minutes, to perform safety research on nuclear fuel specimens.

Application:

☒ Thermal/hydraulics - separate effects	☒ Thermal/hydraulics - integral effects	☒ Neutronics
☒ Fuel LWR and SFR fuels	☒ Components/Feature	☒ Materials
☒ Containment	☒ Severe Accident	☐ Hazards (seismic)

Other:

Phenomena modelled:

Phenomena such as cladding failure, fuel specimen melting, two-phase heat transfer under extreme conditions, and fuel coolant interactions can be tested in TREAT. Specimens can range from rodlets to multi-rod bundles (e.g., 7 pin Sodium Fast Reactor (SFR) bundle, 9-rod Light Water Reactor (LWR) bundle). TREAT is able to perform testing on fresh fuel samples, plutonium-bearing fuels, and specimens which were previously irradiated to high burnup in other reactors.

Key facility parameters:

TREAT is a graphite based atmospheric pressure air environment reactor. The primary purpose of TREAT's air-cooling system is to cool the core down after transients and does not remove heat fast enough to be relevant during brief transients. Thus, TREAT behaves essentially as an adiabatic heat sink where graphite temperature increases yield negative reactivity feedback to enable extreme power maneuvers to be performed safely. Transients are automatically controlled to meet a desired power history by fast-moving transient control rods.

Dimensions/volume: Including graphite reflectors, TREAT's core is approximately ~2.5m cube. TREAT's active core fueled length is 1.2m.

	Min	**Max**
Facility power [kW]:	*<120kW Steady State*	*~20 GW peak in pulse mode*
Neutron flux level [n/cm^2/s]:		

Last update:

	8.0E11 n/cm²MJ	*8.6E12 n/cm²MJ (2.0E16 n/cm² max fluence per transient)*
Pressure [MPa]:	*1 atm air*	*1 atm air*
Temperature [°C]:	*N/A*	*TREAT's driver fuel is limited to 600C temperature*
Flow Rate [kg/s]:	*N/A*	*N/A*

Key characteristics for integral effect test facilities:

Cartridge-type experiment capsules/loops enable TREAT to currently support pressurized water, liquid metal, inert gas, and hydrogen gas environment tests with real time diagnostics to monitor test conditions and fuel temperature, pressure, and motion. Additional testing environments can also be developed for particular needs.

Most TREAT experiments are irradiated in a test cavity 25 cm in diameter.

	Min	**Max**
Facility power [kW]:	*<120kW Steady State*	*~20 GW peak in pulse mode*
Neutron flux level [n/cm²/s]:	*8.0E11 n/cm²MJ*	*8.6E12 n/cm²MJ (2.0E16 n/cm² max fluence per transient)*
Pressure [MPa]:	*Vacuum, 1 atm, depending on experiment capsule/loop*	*Up to ~35 MPa depending on experiment capsule/loop*
Temperature [°C]:	*Cryogenic using specialized capsule designs*	*Gross melting of UO_2 test specimens is possible in TREAT*
Flow Rate [kg/s]:	*Static environment (capsule)*	*Prototypic flow rates for water, liquid metal, and gas cooled reactors, depending on experiment loop*

Records of Experiments:

Inert gas heat sink capsules on LWR rods and Tri-structural Isotropic particle (TRISO) fuels

Pressurized water capsules on LWR rods

Liquid sodium heat sink capsules on SFR rods

Partial hydrogen-gas on space nuclear propulsion fuels

Loss of Coolant Accident (LOCA) testing in water blowdown capsule

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Planned Experiments:

SFR overpower testing in recirculating sodium loop (2025)

Space nuclear propulsion testing in flowing hydrogen (2026)

Pressurized Water Reactor (PWR) condition testing in recirculating water loop (2026+)

QUALITY ASSURANCE, INTELLECTUAL PROPERTY AND DATA SHARING

standards followed by the Facility: NQA-1

QA certifications received by an independent organization(s): None

Confidentiality and Intellectual Property (IP):

Experimenters can interact with TREAT personnel under non-disclosure agreements and IP can be protected under Department of Energy's (DOE's) Cooperative Research and Development Agreement (CRADA) rules.

Potential for data sharing:

Information which can legally be published can be shared with interested parties. Many of TREAT's DOE-funded experiments have been or will be published openly.

DETAILED DESCRIPTION

[**Optional section** - *please provide a more detailed description of the facility, along with an image(s), diagram(s) and references*]

TREAT is an air-cooled reactor driven by a core of graphite blocks having a small concentration of dispersed uranium dioxide shown graphically in Figure 1. Experiment assemblies are typically removed from or placed into the core, Figure 2 is the TREAT core map, through a slot in the reactor's upper rotating shield plug. Pulse type transients designed to simulate virtually any power history possible within 2500 MJ maximum core transient energy and are initiated in TREAT by bringing the reactor to a low steady state power of 50 watts and then rapidly removing transient control rods, resulting in a step insertion of excess reactivity. TREAT pulses initially have a nominally Gaussian shape followed by a decaying exponential tail. Larger step reactivity insertions result in transient pulses that have higher peak powers, higher overall energy releases, and shorter pulse widths. TREAT has the ability to re insert the transient control rods and shorten the natural transient. These maneuvers are referred to as "transient clipping". The clipping system has the ability to reduce both the pulse width (FWHM), total energy released, and almost completely eliminating the energy in the tail. As an example, for a 4.5% Δk/k reactivity insertion, clipping capabilities could decrease the maximum energy released from the reactor from ~2800 MJ to ~630 MJ and shorten the pulse width from 103ms to 95ms. This approach gives the ability to tailor transients to a desired duration and energy release, see Figure 3 for Transient Shapes. Tailoring is currently limited by the speed of the rod drive system (~355 cm/s). For TREAT's ~1m reactor length, it takes ~280ms for the control rods to fully insert themselves. However, pulses with FWHM of 89 ms have been demonstrated, and planned plant modifications involving a

He-3 clipping system are predicted to be able to achieve pulse FWHM as low as 50 ms.

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3. N. Woolstenhulme, "The Transient Reactor Test Facility." Nuclear Reactors, ed. Chad Pope, Intech Open, 2022.

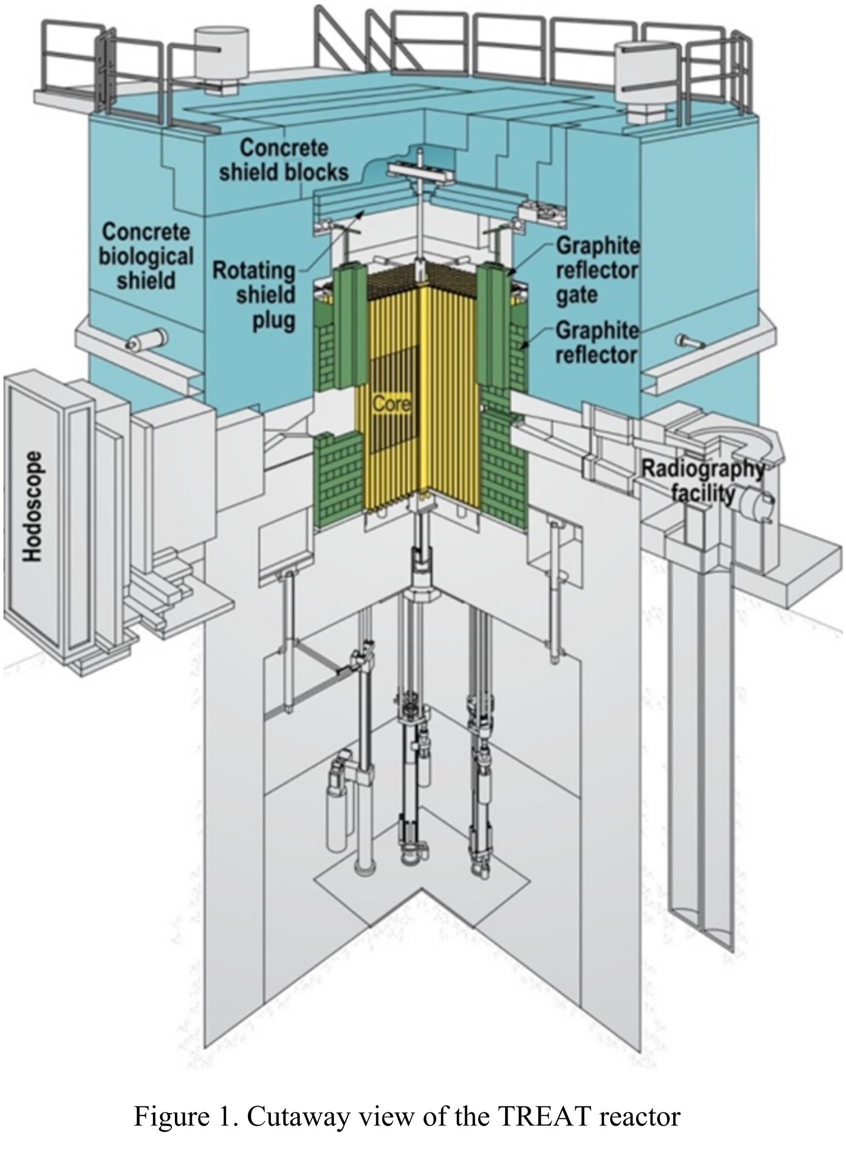

Figure 1. Cutaway view of the TREAT reactor

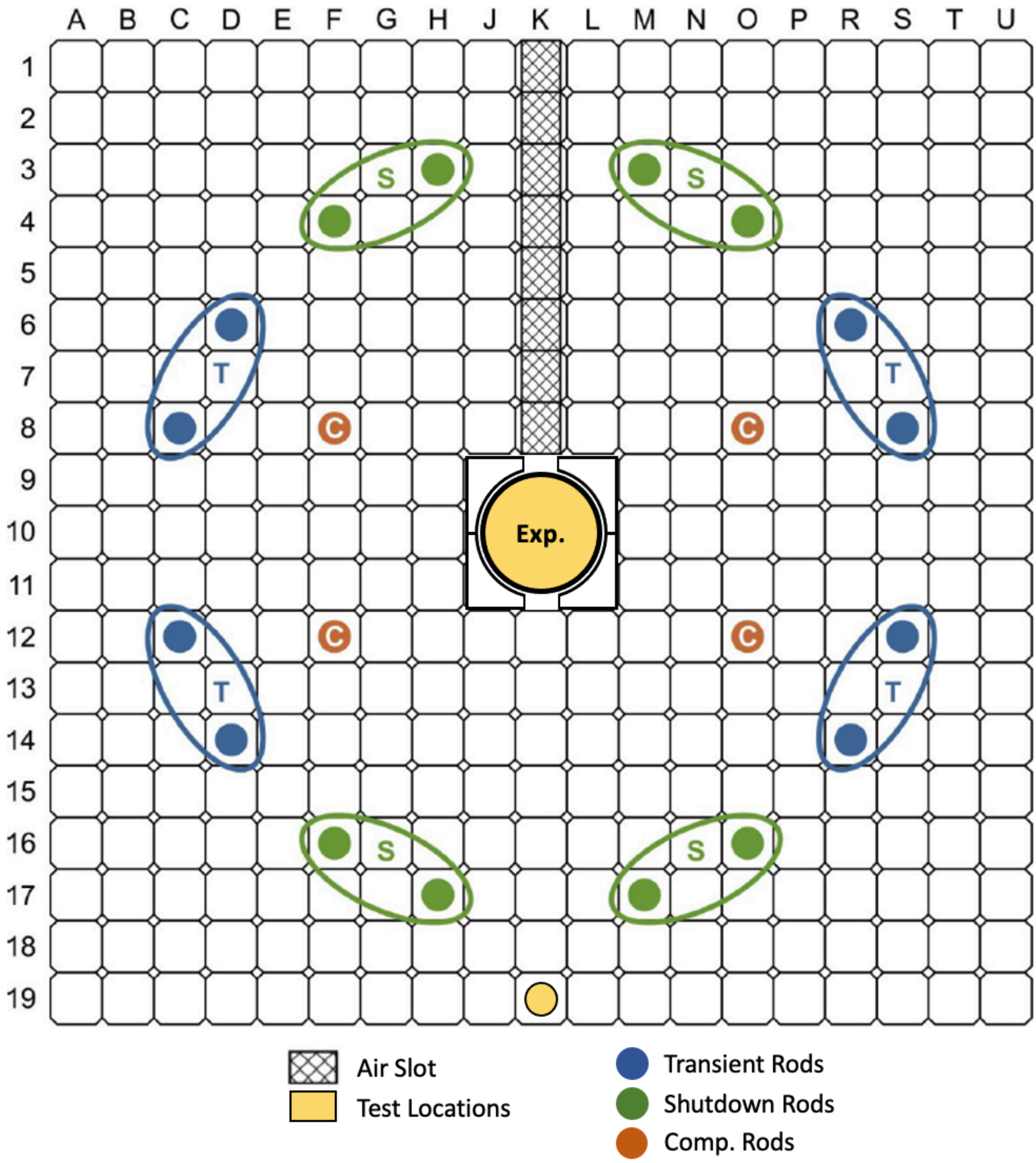

Figure 2. TREAT Core Map

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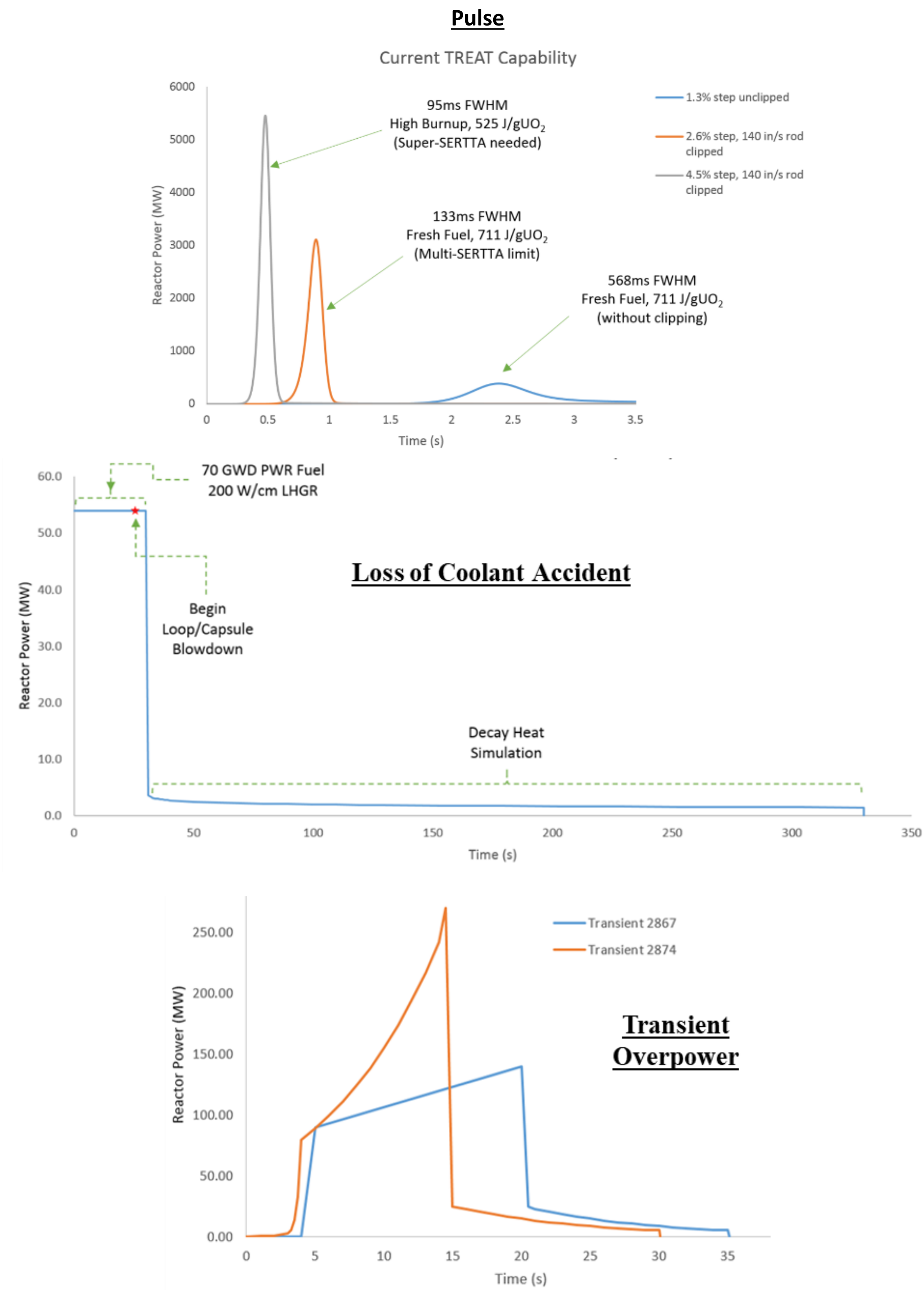

Figure 3 TREAT Transient Shaping

Last update: