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ARCS Replacement at TREAT for TRTR 2020 - Abstract

September 2020

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Changing the World's Energy Future

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The Automatic Reactor Control System (ARCS) Replacement at the TREAT reactor

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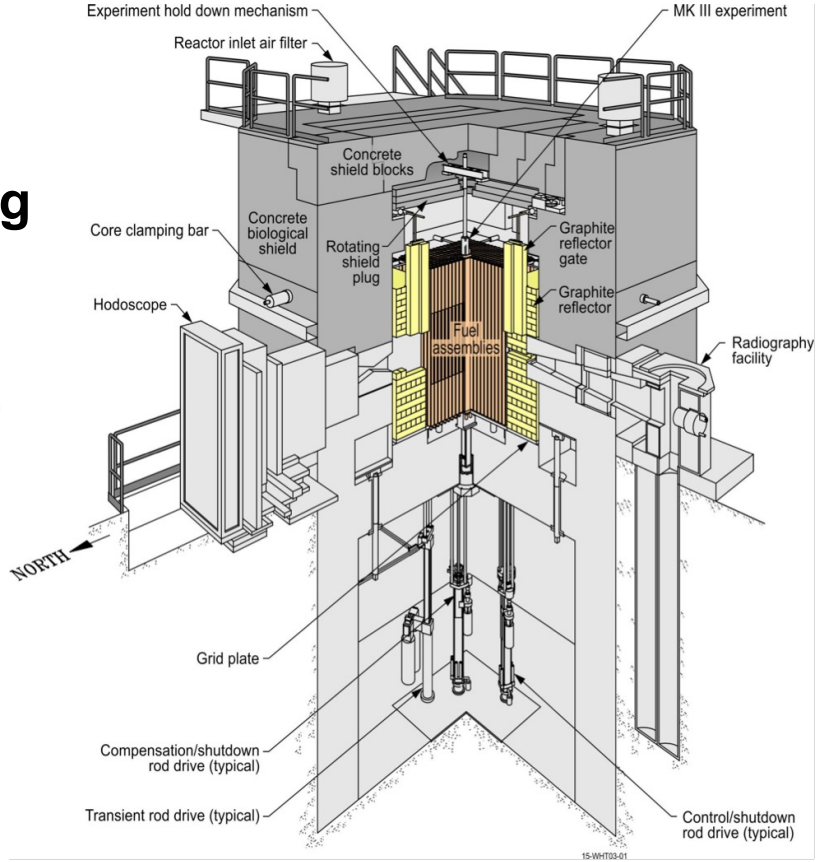
September 2020

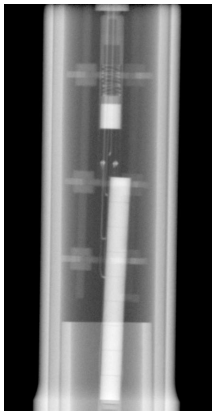


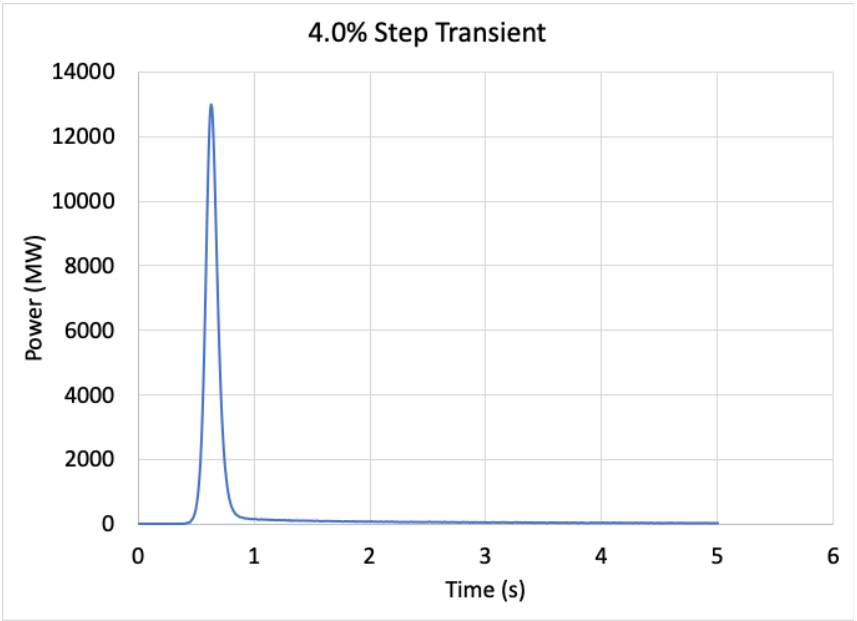
TREAT Reactor Overview

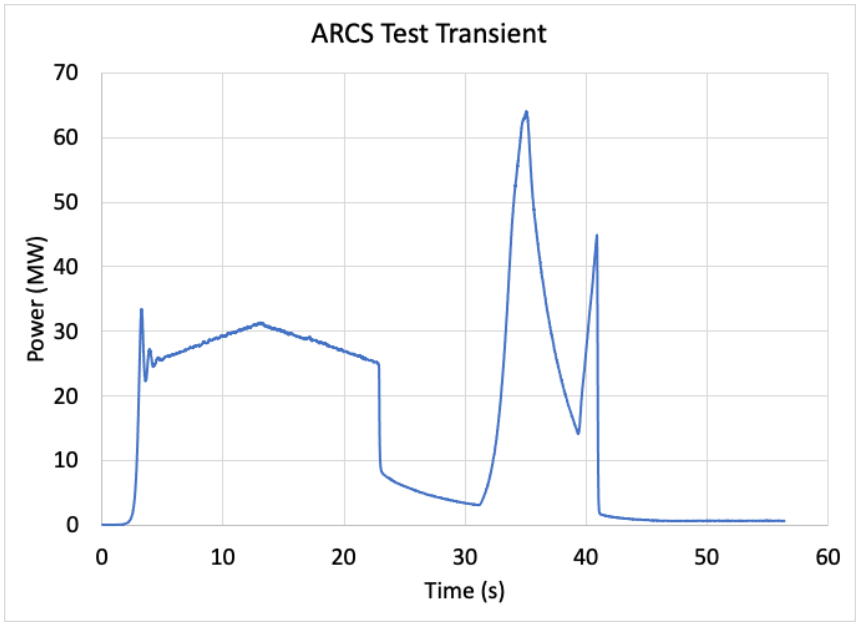
- Built in 1959 (11 months construction)
- Graphite Moderator & Reflector
  - Used for Transient Testing of Fuels
- 19x19 Element Array (Elements 4 inch x 4 inch (10.16cm))
  - Experiment in the Center
  - Other assemblies (slotted, dummies, TC, Control Rod, …)
  - Rod Banks (C/S, Comp, Transient)
    - 20 Control Rods (12 rod drives)
    - Only Transient Rods are computer controlled
    - Transient ~140 in/sec (355.6cm/sec)
- Highest recorded power > 19 GW
- Shutdown in 1994
- Restarted in 2017

TREAT Reactor Overview

- TREAT is a transient reactor for fuels testing
  - Able to test fuels to failure
  - https://www.youtube.com/watch?v=h0o4P_F4s9s
- https://www.youtube.com/watch?v=Og7XlWKsAnM
- TREAT is capable of high-power pulses
- Treat can also shape power transients as desired by the experimenter







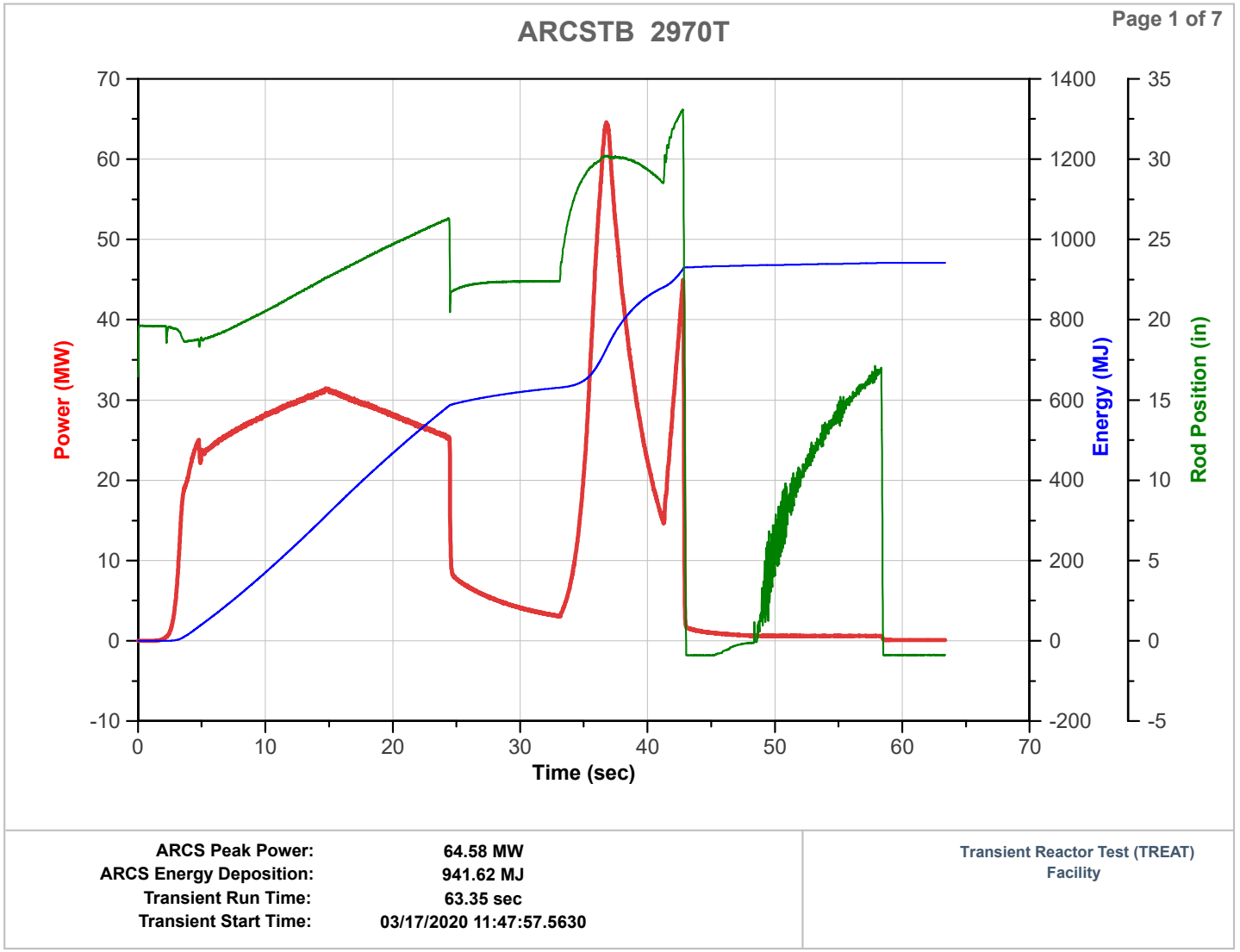
Automatic Reactor Control System

- Controls reactor power during a transient
- Based on Intel Multibus and 8086 CPUs
- Distributed architecture for performance
  - Utility node (1 CPU)
  - Control node (2 CPUs)
  - Monitor node (3 CPUs)
  - Simulator node (3 CPUs)
- Transient prescription Fortran programs
  - Generates a series of configuration and transient parameter files off-line
- Transient execution assembly code
  - Uses transient parameter file to perform transient
  - Executes real-time 2 milliseconds

ARCS Control Segment Types and Terminators

- Control:
  - Rod Step
  - Rise or Fall on a period
  - Rise or Fall on a ramp
  - Clip
  - Rod Stop
- Termination
  - Segment Time
  - Segment Energy
  - Power approached from below
  - Power approached from above
  - Extrapolation to peak energy

ARCS Test Transient with All Control Types



ARCS Simulation Capability

- ARCS can also simulate transients without going critical
  - Confirms transient will perform as expected
  - Allows tuning of transients without running
- Full simulation mode simulates every aspect of the reactor and sends signals to instruments
- Partial simulation mode simulates the core, but the transient rods respond to the simulated signals
  - Control shutdown rods and compensation rods remain in the core to stay sub-critical
- Another tool was required to allow reactor engineers to initially define the transient on their desktops without using reactor time

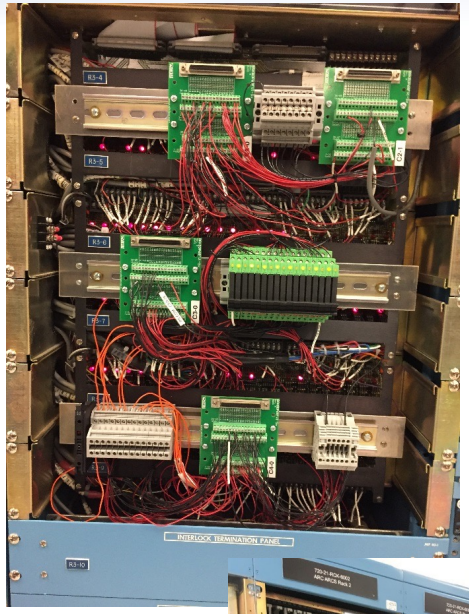
ARCS Replacement

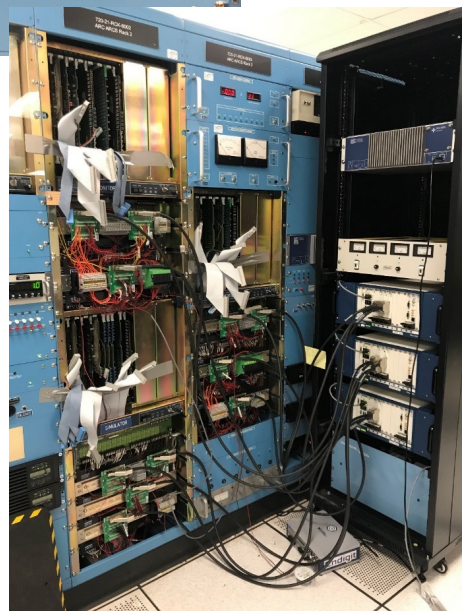
- ARCS Replacement started in Early 2018
  - Requirement for the same functionality
- Contracted with Endigit to
  - Translate the Assembly and Fortran code into LabVIEW
  - Create a prototype system to prove feasibility (became the development system for future upgrades)
- Decision to proceed:
  - LabVIEW™
  - PXI chassis
  - Real time OS Phar Lap

Endigit

ARCS Testing

- Created a system to connect the new ARCS system to the plant without removing the old system
- 2 week grooming outages to perform functional testing and problem solving
  - Temporary Disconnect old System (2 days)
  - Hook up new system (Effective 4-6 days)
  - Take down new system and Re-connect old System (2 days)
- September 2019 grooming outage identified circuit/hookup problems
- October 2019 outage finished circuit/hookup troubleshooting and performed full and partial transient simulations

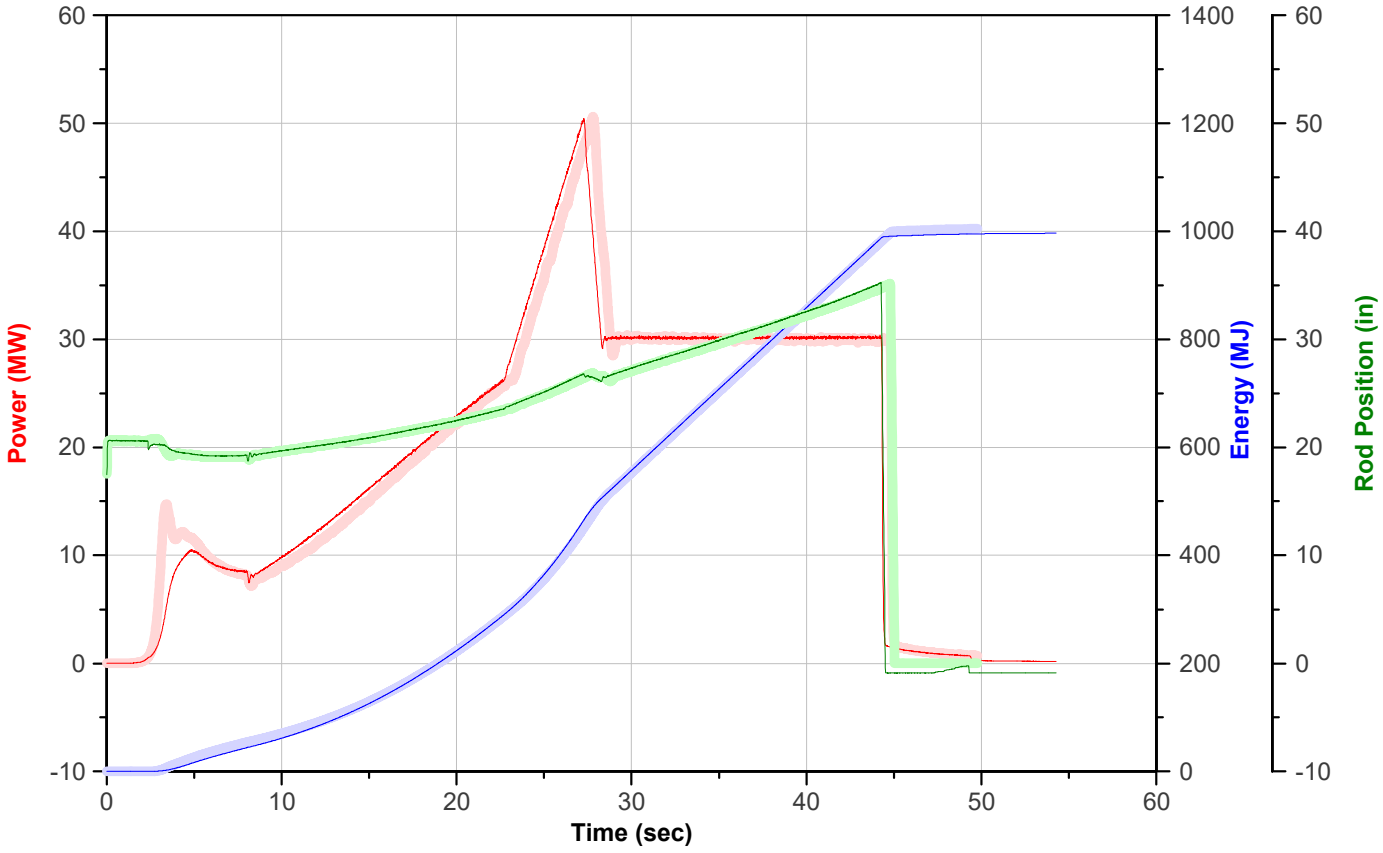




ARCS Installation and Commisioning

- Final permanent installation started the second week of January 2020.
  - Functional test plan to confirm proper hardware setup
  - System Operability (SO) test plan to confirm the integrated system operated as required.
  - Final part of SO test executed actual transient prescriptions that had been previously run on the old ARCS system.

Comparison of New to Old



	Legacy ARCS	New ARCS
ARCS Peak Power:	50.51 MW	50.44 MW
ARCS Energy Deposition:	1004.54 MJ	995.95 MJ
Transient Run Time:	49.78 sec	54.26 sec
Transient Start Time:	Unavailable	03/11/2020 12:04:22

Transient Reactor Test (TREAT) Facility

Resumed Unrestricted Reactor Operations

- ARCS turned over for unrestricted operations first week of June 2020 (includes 1 month lost to COVID)

Questions?