Advanced Test Reactor (ATR) and Materials Testing

Sean O’Kelly
Associate Laboratory Director
ATR Complex

APS Workshop, April 3, 2017
ATR Specifications

Reactor Type
- Pressurized, light-water moderated and cooled, beryllium reflector

Reactor Vessel
- 12 ft diameter cylinder, 36 ft high
- Stainless steel

Reactor Core
- 4 ft (diameter & height)
- 40 fuel elements, highly enriched U-235

Coolant Temperatures and Pressure
- <52ºC (125ºF) Inlet
- 71ºC (160ºF) Outlet
- 2.7 Mpa (390 psig)
ATR Characteristics

• Highest-power research reactor operating in the world (250MW)
• Provides high neutron fluxes while being operated in a radially unbalanced condition
• Serpentine fuel arrangement affords experimental versatility while ensuring maximum efficiency of core reactivity-control components
• Numerous Test Positions (77) and Large Test Volumes
• Four different experiment types (Capsule, Hydraulic Shuttles, Lead Outs, and Pressurized Water Loop Experiments)
• Individual Experiment Temperature, Pressure, Flow, and Chemistry Control in Six Pressurized Water Test Loops with a Capacity for Up to Nine Experiment Loops
• Constant Axial Power (neutron flux) Profile
• Operates in short-duration cycles (50-60 day) with ~30 day refueling and maintenance outages
ATR Fuel & Experiment Layout
ATR Cross Section

ATR Fuel element

Nominal Dimensions

- 0.073
- 0.077 water gap - channels 11-19
- 0.078 water gap - channels 2-10
- 0.050 (plates 2 to 18)
- 0.100 (plate 19)

Detail of inner plate

0.015 aluminum clad
In-Pile Tube Experiments

2A Water Loop
NSUF Water Loop Experiment

0.4 CT Specimens, X-750 and XM-19
Test Train Arrangement

TEM discs
Accident Tolerant Fuel Water Loop Experiment

ATF-2 Water Loop

ATF Water Loop Configuration for Safety Analysis Purposes

Upper "Out of Core" Portion

"In Core" Portion

Top of Core

Tier 5, Instrumented
6" pins

Tier 5 (Stationary)

Tier 4
6" pins

Tier 3
12" pins

Tier 2
6" pins

Tier 1
6" pins

Tiers 1-4 (Removable)

Instrumented Lead Sensors are located above the core region in Tier 5 to reduce potential irradiation damage.

Tiers 1-4 may contain in-rod ferritic cores that allow measurements between irradiation cycles.

All tiers will have a 2x3 configuration as shown.
Advanced Reactor Technology Lead Out Experiment

Capsule 5
<900 °C

Capsule 4
900 °C – 1050 °C

Capsule 3
1350 °C – 1500 °C

Capsule 2
900 °C – 1050 °C

Capsule 1
900 °C – 1350 °C

NE Flux Trap

Test train

Outer shell (SST)

Hafnium

Inner shell (SST)

Flux wire guide tube

Water

Flux trap baffle

1/2" THRU-TUBE

GRAPHITE FUEL HOLDER

FUEL COMPACTS

Capsule
Capsule Experiments (Accident Tolerant Fuels)

Conceptual capsule, rodlet /basket configuration

TREAT Pulsing Test Reactor
Open Capsule Experiments

KJRR
Programs Currently Supporting

- Nuclear Science User Facilities – NSUF
  - GE-Hitachi
  - EPRI
  - Universities

- Advanced Reactor Technologies - ART
- Light Water Reactor Sustainability – LWRS
- Materials Management and Minimization (LEU Conversion)
- Tritium Technology Program – TTP
- DOE Isotope Business Office
- Work For Others and Cooperative Research and Development Agreements
- Fuel Cycle Research and Development
- Naval Reactors
User Conversion Requirements

- ATR functional requirements for ATR LEU conversion should limit impact to future experiment needs and assure that experimental programs that may cross the conversion date do not lose experimental progress
  - A. Greater than $4.8 \times 10^{14}$ fissions per second per gram of U-235
  - B. Fast to thermal neutron flux ratio within +/-5% of current values
  - C. Gamma to neutron flux ratio with +10%/-0% of current values
  - D. Constant cycle power
  - E. 3/1 south-north lobe power split
  - F. Operational cycle length of 56 days
  - G. Operational availability of at least 70%
  - H. Maintain current core geometry
  - I. Lobe power must be capable of 70 MW during high power tests
Requirement B – Fast Flux % change
Requirement C

• Gamma to neutron flux ratio within +10% -0% of current value
  – **Description:** The ratio of gamma to neutron flux is an important parameter in the testing of some specimens. A change greater than +10% -0% would limit the relation of new data to the existing databases.
  – One specific requirement: gamma to neutron flux ratio within +10%/-0% at gamma and neutron energies greater than 1 MeV
  – HELIOS showed -15% for flux traps inside the fuel serpentine and -18% for flux traps outside the fuel serpentine.
Requirement C

Gamma flux in fuel meat of plate 10

\[
\text{flux } [\gamma/\text{cm}^2\text{s}] = 10^{10} - 10^{15}
\]

\[
\text{energy [eV]} = 10^4 - 10^8
\]

- HEU $\phi_\gamma$
- LEU $\phi_\gamma$