ATR Transient Testing Capabilities

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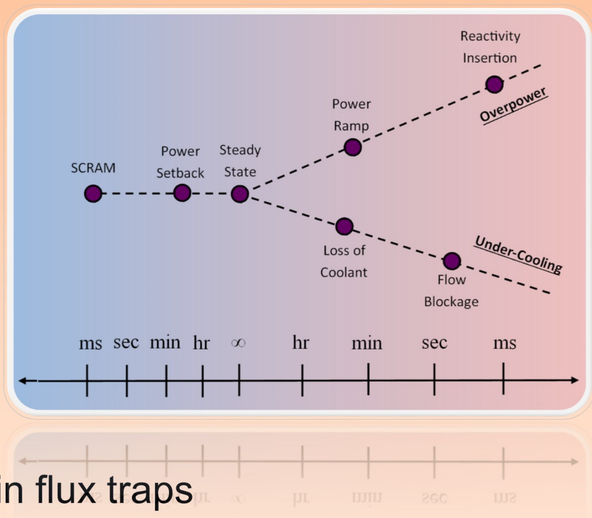
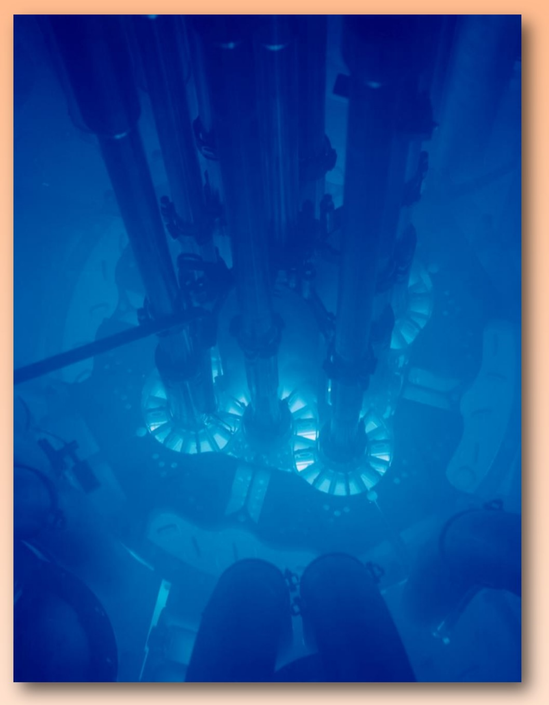
Overview

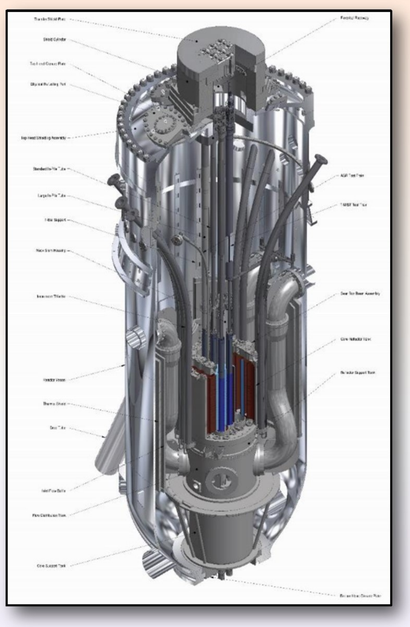
-Nuclear transient testing often requires purpose-built transient test reactors
-But depending on event duration, steady state reactors can be better suited to some transient scenarios
-The Advanced Test Reactor (ATR) has a rich history of transient testing, particularly for power cycling
-ATR's unique design would also allow accident simulations
1) Transient overpower
2) Loss of flow
3) Loss of coolant





Intro to ATR

-Constructed in 1967 and still considered advanced in 2017
-Unique serpentine shape creates nine high intensity flux traps
-Up to nine (currently five) in-pile tubes for pressurized water loops in flux traps
1) Discrete control over flowrate, chemistry, and inlet temperature
-Other positions (flux trap and reflector) for drop-in or instrumented lead-out tests



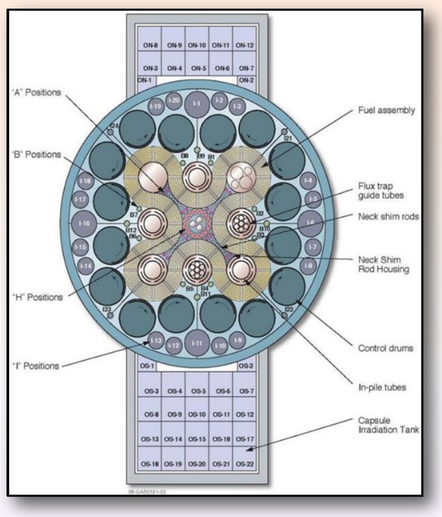


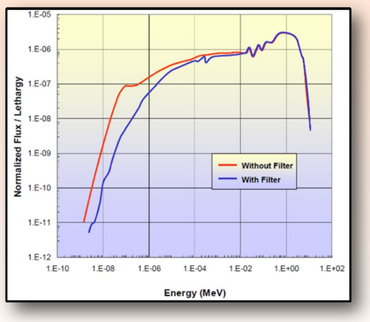
Table 1. ATR general characteristics

Reactor	
Thermal Power	250 MW_{th}[a]
Power Density	1.0 MW/L
Maximum Thermal Neutron Flux	1.0×10^{15} n/cm^2-sec[b]
Maximum Fast Flux	5.0×10^{14} n/cm^2-sec[b]
Number of Flux Traps	9
Number of Experiment Positions	68[c]
Core	
Number of fuel assemblies	40
Active length of Assemblies	1.2 m (4 ft)
Number of fuel plates per assembly	19
Uranium-235 content of an assembly	1,075 g
Total core load	43 kg[d]
Coolant	
Design Pressure	2.7 MPa (390 psig)
Design Temperature	115°C (240°F)
Reactor coolant	Light water
Maximum Coolant Flow Rate	3.09 m^3/s (49,000 gpm)
Coolant Temperature (Operating)	<52°C (125°F) inlet, 71°C (160°F) outlet

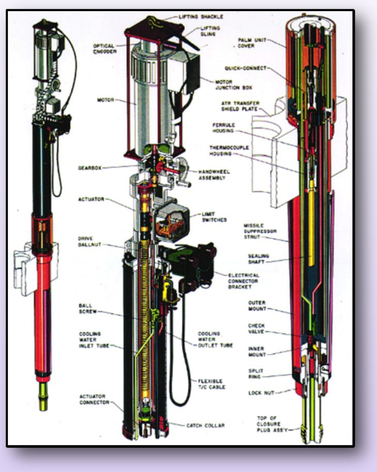
a. Maximum design power. ATR is seldom operated above 110 MW_{th}
b. These parameters are based on the full 250 MWth power level and will be proportionally reduced for lower reactor power levels.
c. Only 66 of these are available for irradiations.
d. Total U-235 always less because of burn-up.

Table A-6. Approximate peak flux values for various ATR capsule positions for a reactor power of 110 MWth.

Position	Diameter (cm [in])[a]	Thermal Flux (n/cm^2-s)[b]	Fast Flux (E>1 MeV) (n/cm^2-s)	Typical Gamma Heating W/g (SS)[c]
Northeast and Northwest Flux Traps	13.3 [5.250]	4.4×10^{14}	2.2×10^{14}	
Other Flux Traps	7.62 [3.000][d]	4.4×10^{14}	9.7×10^{13}	
A-Positions				
(A-1 - A-8)	1.59 [0.625]	1.9×10^{14}	1.7×10^{14}	8.8
(A-9 - A-16)	1.59 [0.625]	2.0×10^{14}	2.3×10^{14}	
B-Positions				
(B-1 - B-8)	2.22 [0.875]	1.2×10^{14}	8.1×10^{13}	6.4
(B-9 - B-12)	3.81 [1.500]	1.1×10^{14}	1.6×10^{13}	5.5
H-Positions (14)	1.59 [0.625]	1.9×10^{14}	1.7×10^{14}	8.4
I-Positions				
Large (4)	12.7 [5.000]	1.7×10^{13}	1.3×10^{12}	0.66
Medium (16)	8.26 [3.500]	3.4×10^{13}	1.3×10^{12}	
Small (4)	3.81 [1.500]	8.4×10^{13}	3.2×10^{12}	

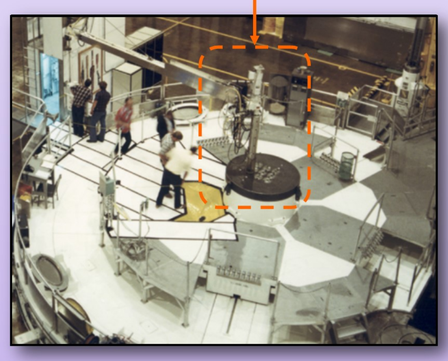


Transient Testing in ATR

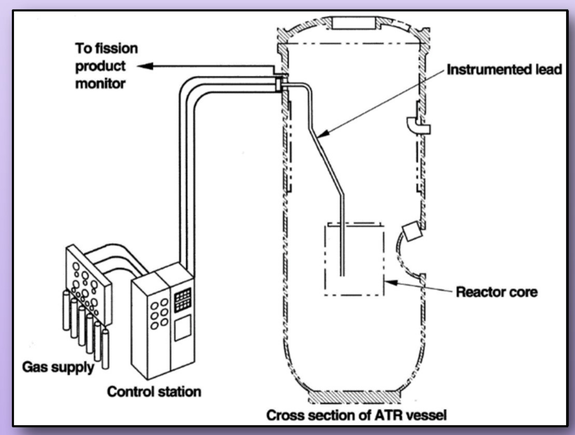


PALM Device

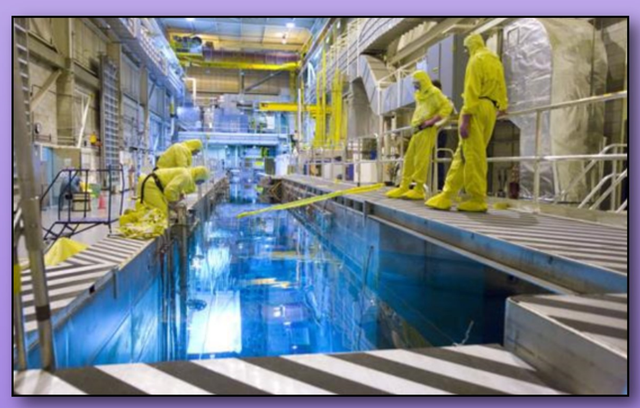
-ATR could be used for slower transient overpower testing
1) Control drums allow ~3:1 power tilt in corner lobe powers
2) ~30 sec minimum "comfortable" period in manual mode
-Leadout tests enable temperature adjustment via cover gas blend (Ar:He blend)
1) Could be used for temperature transients (with or without varying reactor power)
-Leadout and loop type tests can monitor real time for fission product release
-Powered Axial Locater Mechanism (PALM) drives experiments into and out of core
1) Max PALM speed 0.15 m/s (6 in/s)
2) Ideal for simulating load following, power demand cycles, etc.

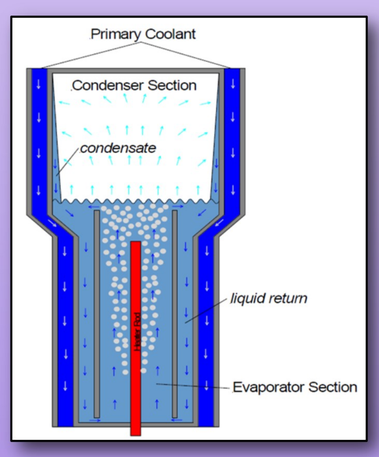


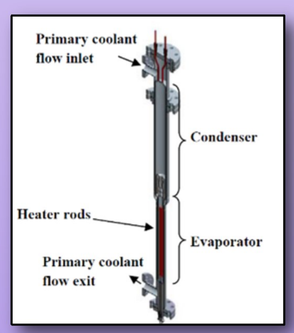
-ATR will trip on low flow signal from loops
1) Could simulate SCRAM-protected loss of flow
-Safety constraints prevent intentional loop blowdown
-Depressurization via blow down of thermosiphon in reflector
-Sync with planned SCRAM for a decay-heat driven LOCA test



-Experiments discharged to storage during outage can undergo non-destructive exams
1) Project underway to expand in-canal exam capabilities
-Experiment can be returned to reactor for further testing







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