SAND2008-4252P

Annular Core Research Reactor (ACRR) and Supercritical CO_2 Brayton Cycle Experiments Overview

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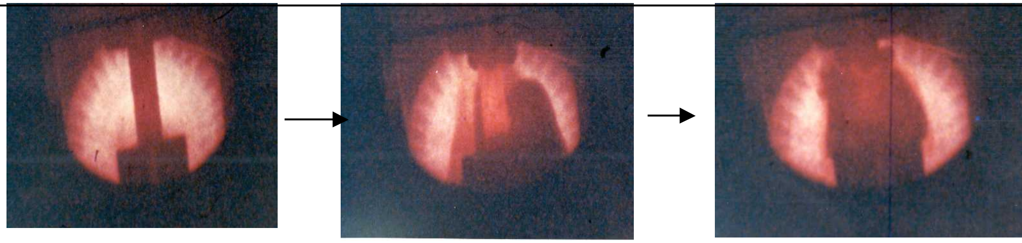
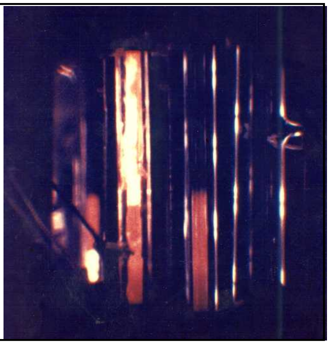
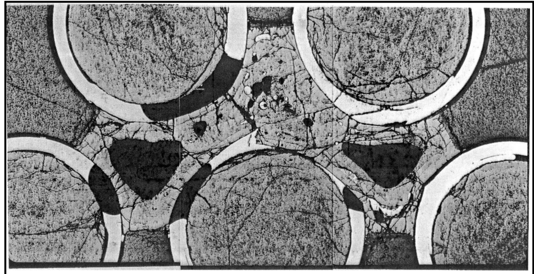
Reactor Safety Testing
(NRC tests of Oxide and Irradiated Mixed Oxide Fuels)



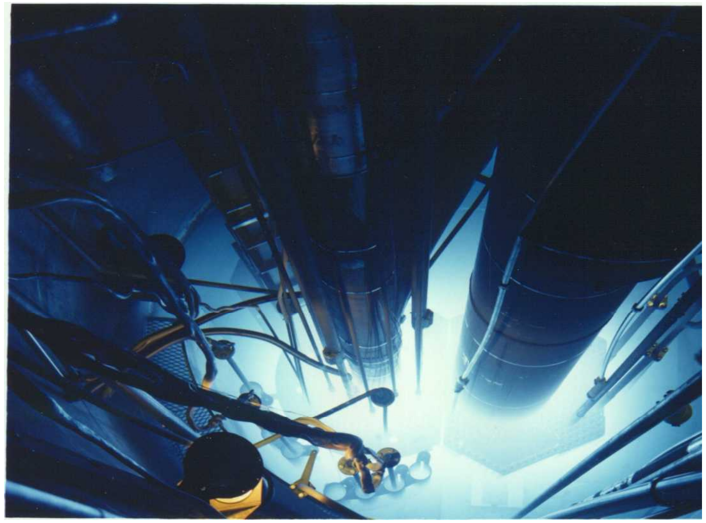
Pin heatup, clad melt and FP release, and fuel disruption sequence in LMFBR high burnup fuel pin (FD Program - JNC, UKAEA, KFK, NRC)

Axial clad and fuel relocation in LMFBR pin array (STAR Program - JNC, NRC)



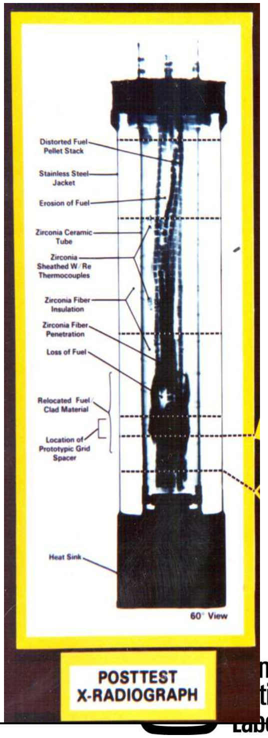


Transition phase studies in LMFBR pin arrays (TRAN Program - JNC, NRC)



ACRR has been used to simulate a wide range of transient fuel test conditions

Severe fuel damage and FP release tests on LWR fuel bundle (SFD Program)



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ACRR Description

ACRR w/ FREC-II

- 236 UO_2-BeO fueled elements (1.5 in dia. x 20 in) (3.8 cm dia. x 51 cm)
  – 100 g U-235 per element – 35% enriched
- Operating Power level
  - 4 MW_{th} Steady State Mode
  - 250 MJ Pulse Mode (6 ms FWHM)
  - 300 MJ Transient Mode (Programmable)
- Dry cavity 9 in (23 cm) diameter – extends full length of pool through core - Flux 4E13 n/cm^2-s at 2 MW, 56% > 10 keV, 45% > 100 keV
- Epithermal Spectrum – Flux in cavity can be tailored for desired energy spectrum – Poly, B4C
- Open-pool type reactor - Fuel elements cooled by natural convection – Pool cooled by HX and cooling tower
- FREC-II uses previous ACPR fuel – TRIGA type (UZrH) – 20 in (51 cm) dia. dry cavity
- Fuel burnup is minimal. Reactor used for short duration power runs, pulses, and transients

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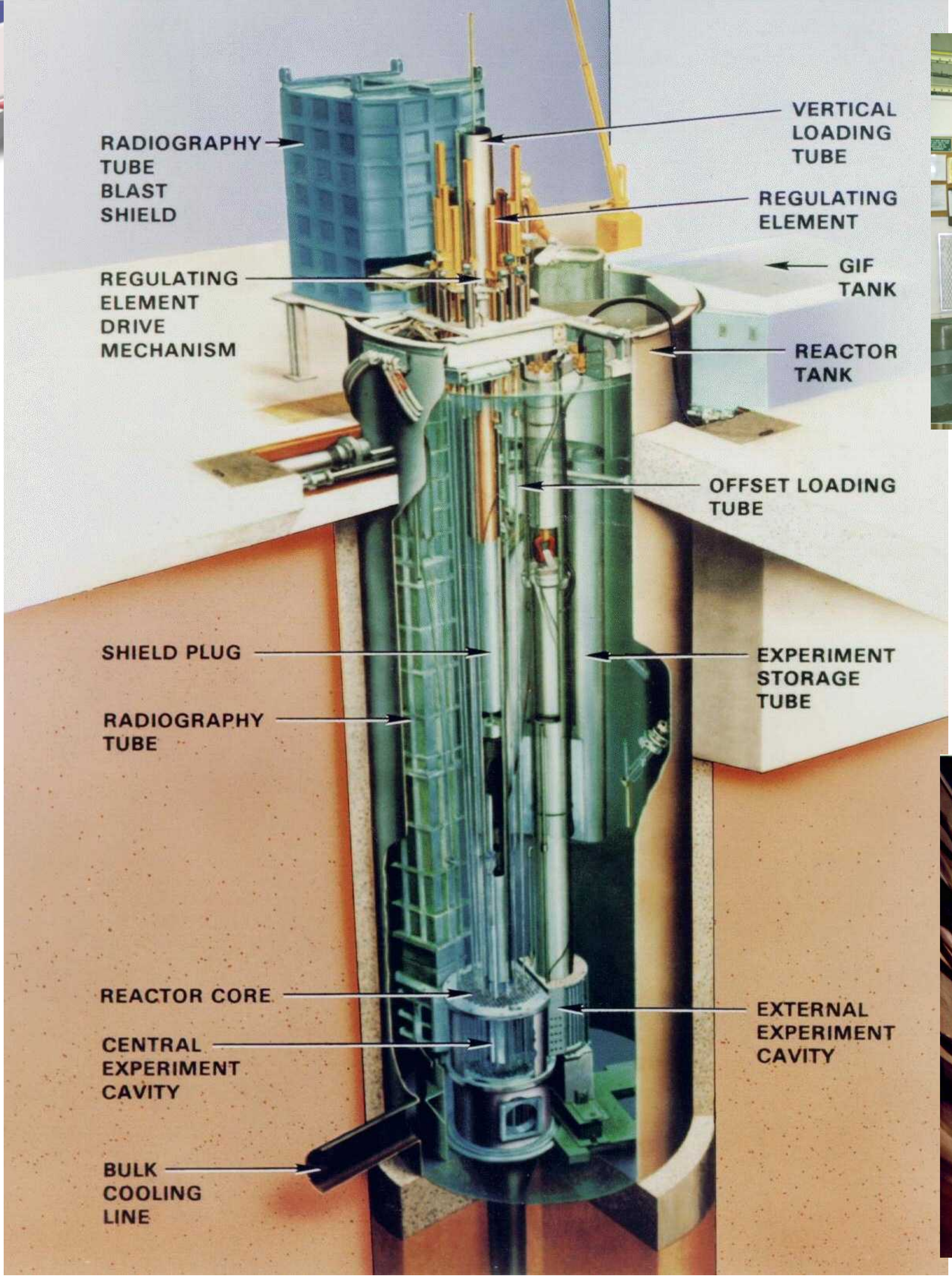
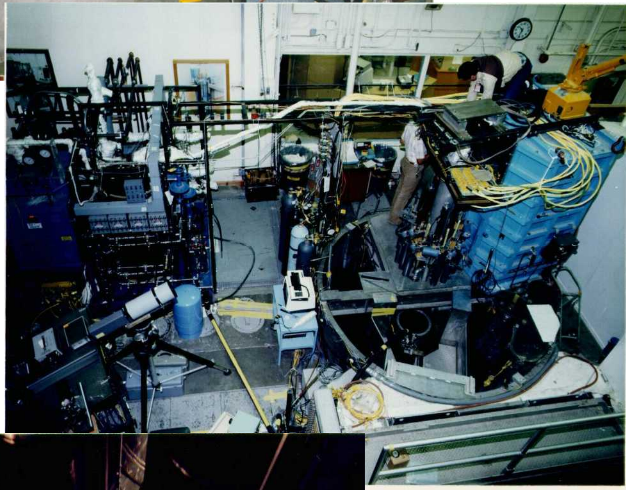
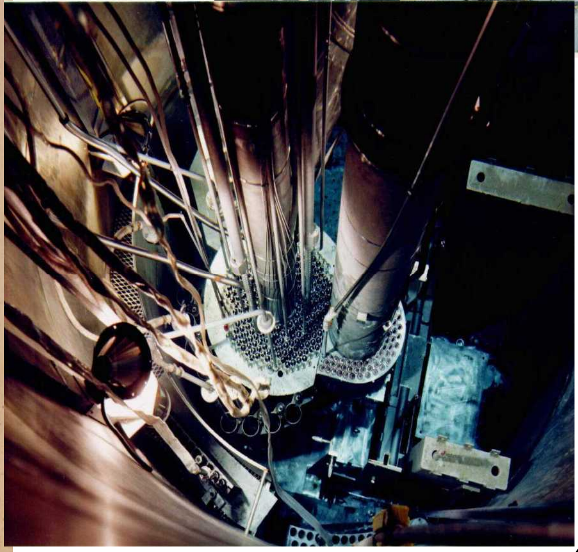

RADIOGRAPHY TUBE BLAST SHIELD
VERTICAL LOADING TUBE
REGULATING ELEMENT
REGULATING ELEMENT DRIVE MECHANISM
GIF TANK
REACTOR TANK
OFFSET LOADING TUBE
SHIELD PLUG
EXPERIMENT STORAGE TUBE
RADIOGRAPHY TUBE
REACTOR CORE
EXTERNAL EXPERIMENT CAVITY
CENTRAL EXPERIMENT CAVITY
BULK COOLING LINE

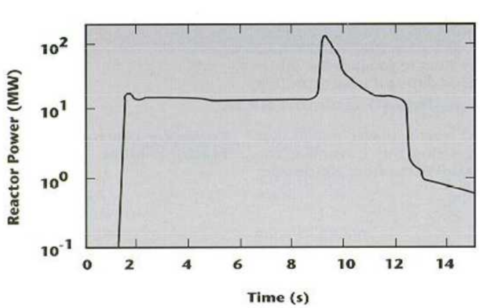




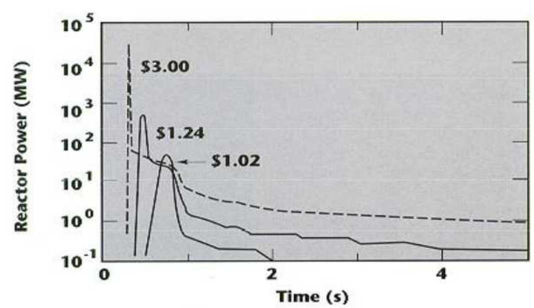
Reactor Simulation of Postulated Accident Scenario
Sandia Annular Core Research Reactor (ACRR)

Single Pulse Mode

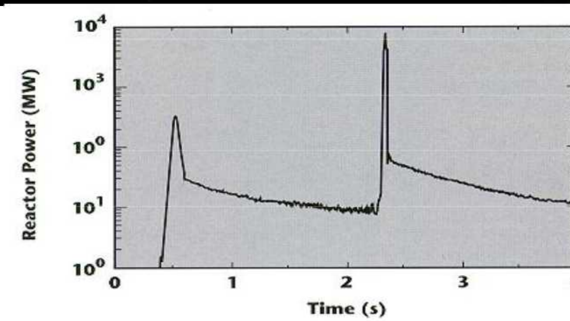
Programmed Transient Mode



Programmed Transient Mode

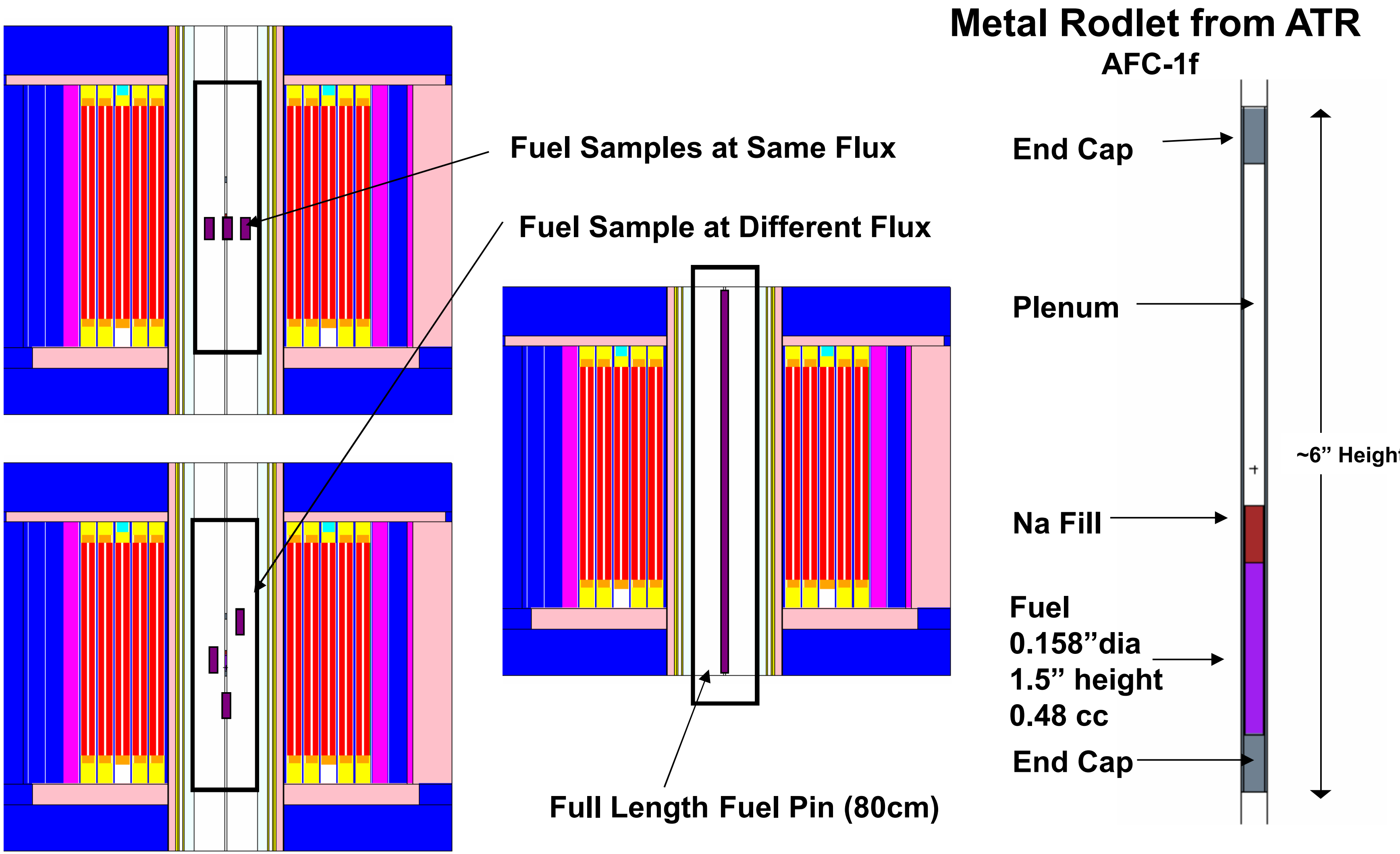


Single Pulse Mode

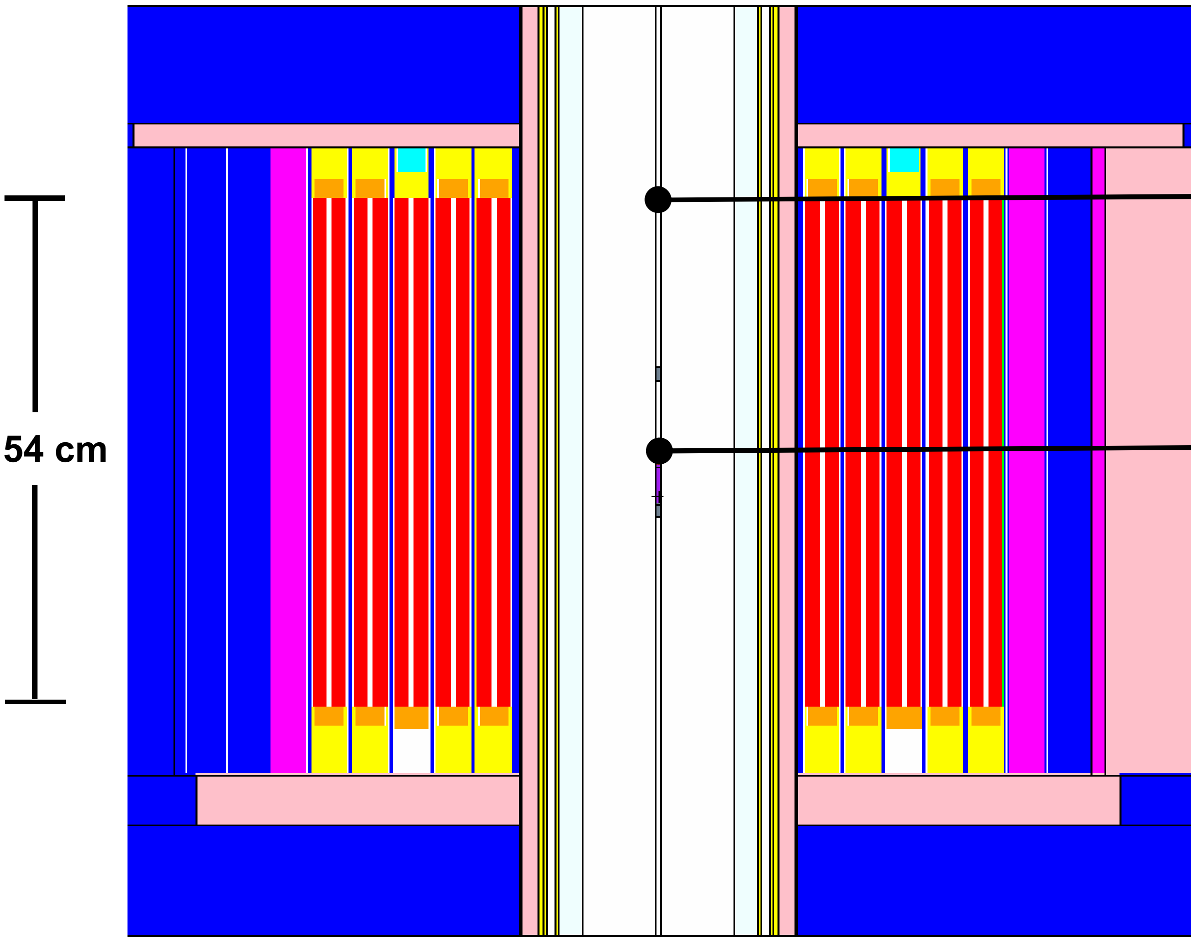


Double Pulse Mode

Experiment Configuration



Neutron Flux in ACRR Central Cavity Unmoderated



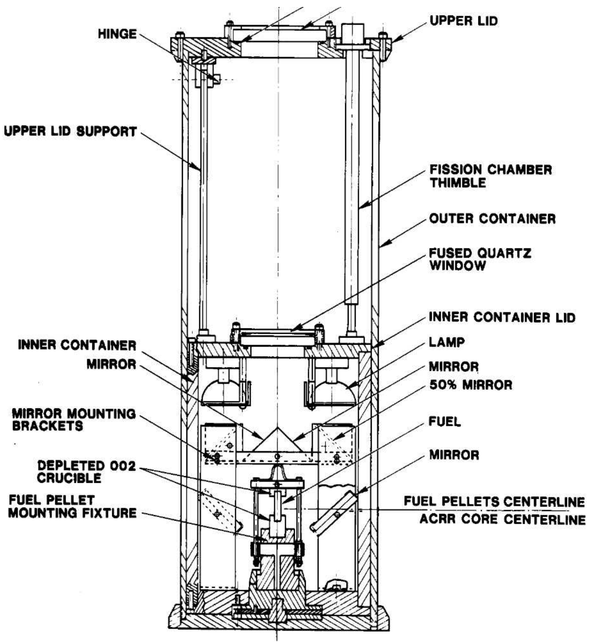
1.0 x 10^{13} n/cm^2 /MJ total

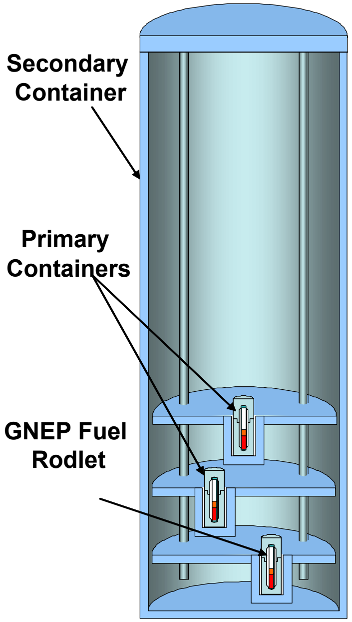
1.9 x 10^{13} n/cm^2 /MJ total
> 100 keV = 45%
> 10 keV = 56%

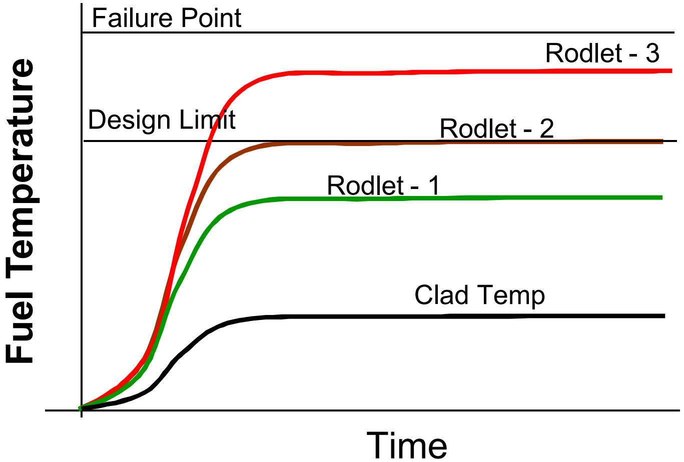
300 MJ shot = 6 x 10^{15} n/cm^2 total

Coupling Factor for U-235
~18 J/$g_{U\text{-}235}$-MJ_{ACRR} Unmoderated
~90 J/$g_{U\text{-}235}$-MJ_{ACRR} Moderated

Sample Fuel Rodlet Tests



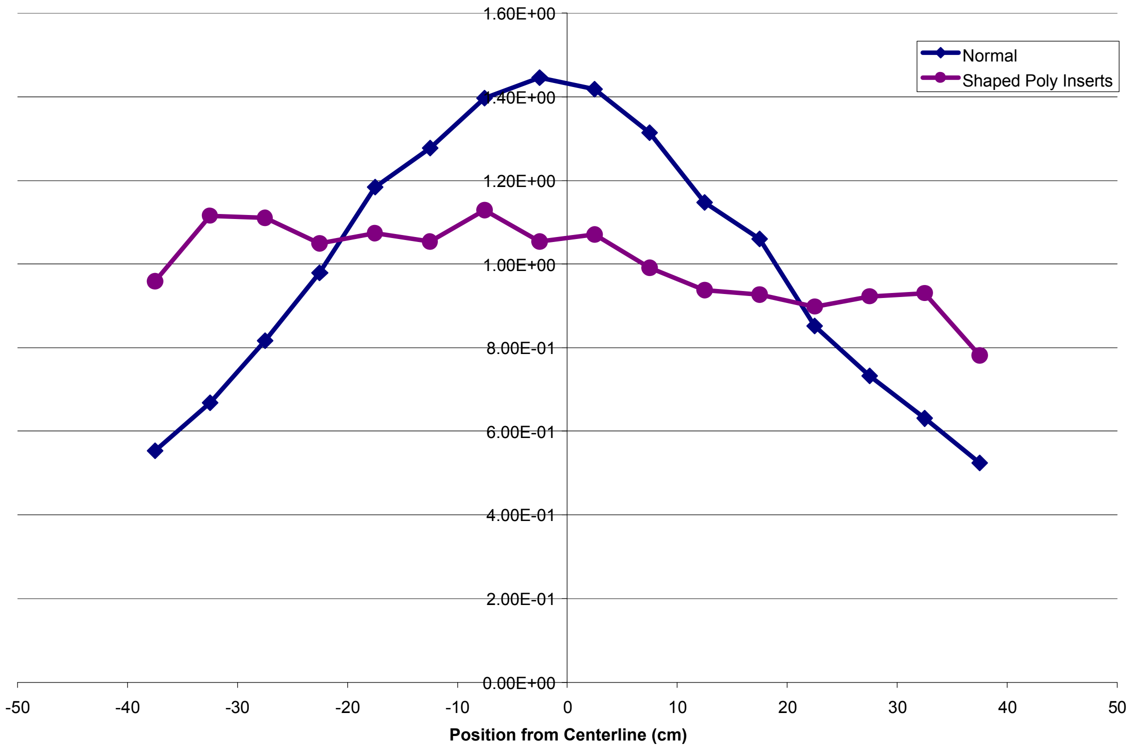


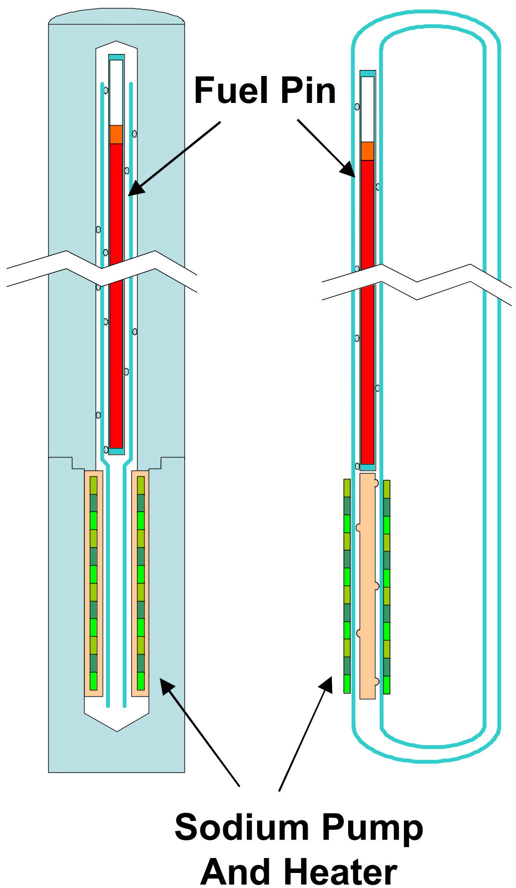


Full Length Fuel Pin Test With Sodium Cooling

Annular or Loop Configuration

Axial Power Shaping Options





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Possible Transient

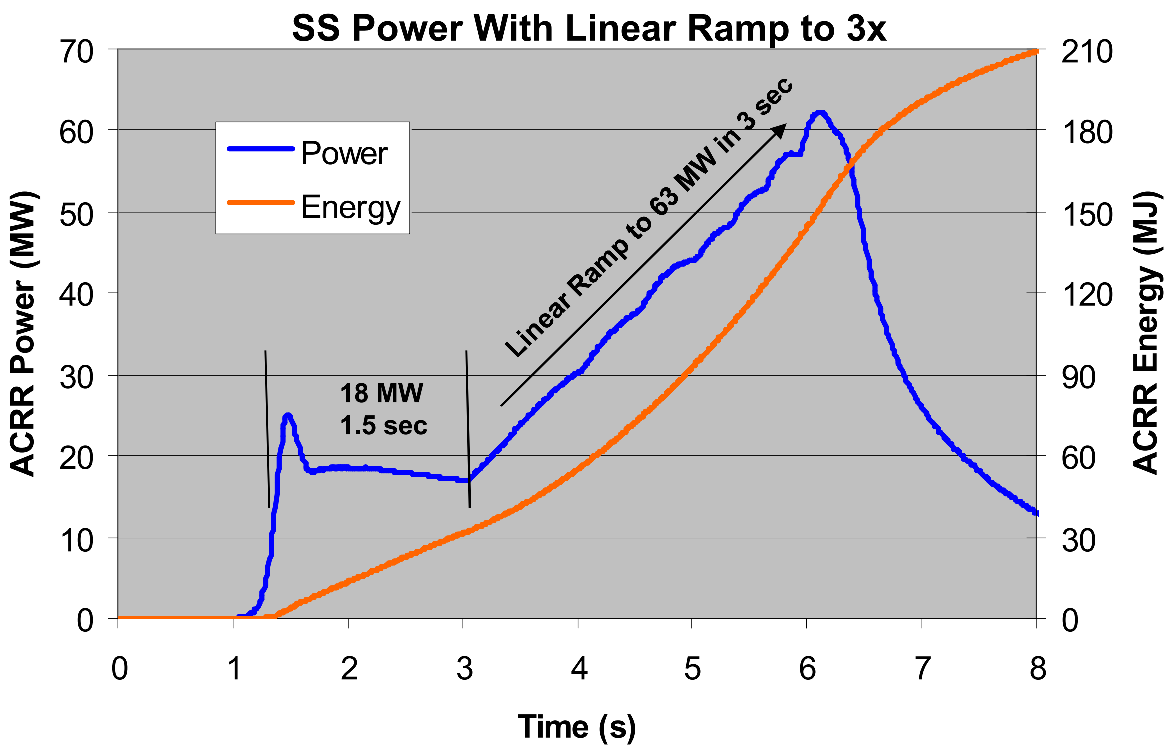
Coupling factor (typical fast reactor fuel samples)

10 J/g/MJ_{ACRR} = ~11 kW/m-MW_{ACRR} (with moderation => 5x)

Fast reactor peak linear power density ~40 kW/m

36 MW_{ACRR} would result in 40 kW/m linear power density

7 MW_{ACRR} with moderation



Supercritical CO_2 Brayton Cycle Experiments Overview

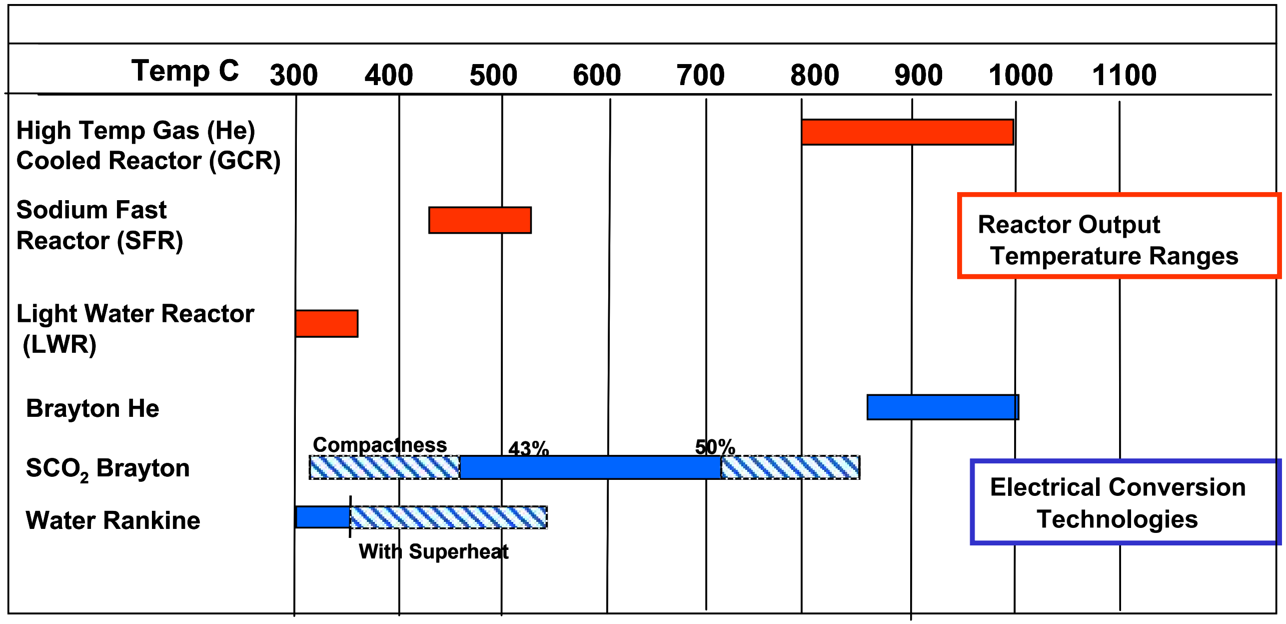
Advanced Brayton Cycles

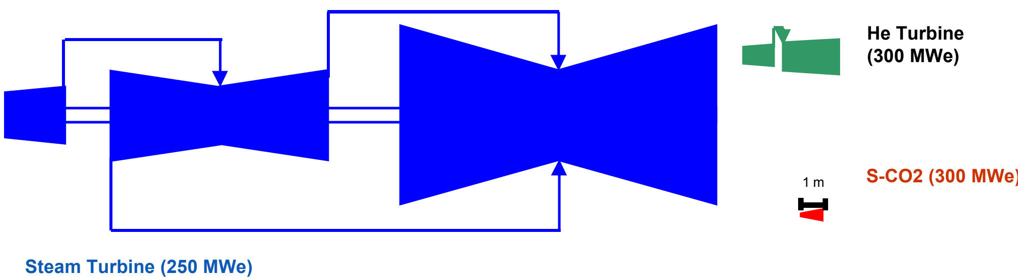
- **Advanced Brayton Cycles can improve efficiencies to nearly 50%**
- **Supercritical CO_2 Brayton Cycles**
  - **Very Good Efficiency 43-50% (500C & 800C)**
  - **Less Corrosive than Steam**
  - **Stainless Steels and Inconels (Allows for Intermediate HX with Current Technology)**
  - **Inherent Safety Capabilities (for decay heat removal)**
  - **Very High Power Density (Small)**
    - **Fewer Components**
    - **Less Material Mass**
    - **Lower Costs**
    - **Modular**
    - **Transportable**
  - **Works with LWR, SFR, and Gas Cooled Reactor + Fossil Fuels**

Sandia's Leading Role

- Sandia is leading the development of the S-CO_2 Brayton cycle through DOE Gen IV and other DOE programs
  - Phased Development approach
  - Low Pressure/ ~ 10kW_e closed Brayton Cycle developed and demonstrated
  - S-CO2 test loop fabricated at Barber Nichols
  - MW system operating in the 2010 timeframe at Sandia
  - Scaled up ~10 MWe Demonstration through partnerships

Supercritical CO_2 Brayton Cycle





Supercritical CO_2 Compressor

(50kWe = 70 hp)

Sandia Closed Brayton Cycle Test Loop

60 kW_{th}/10kW_e

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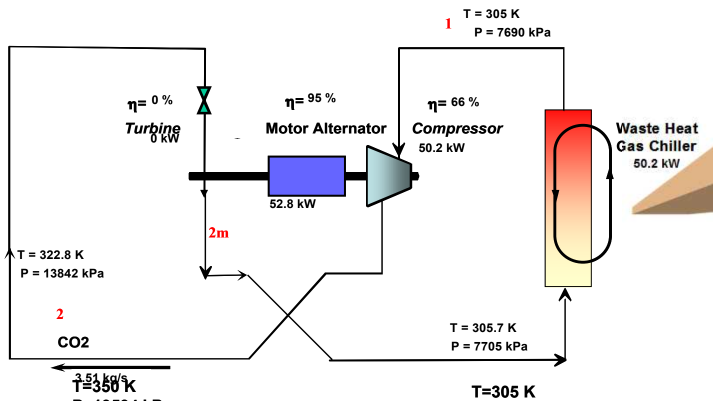
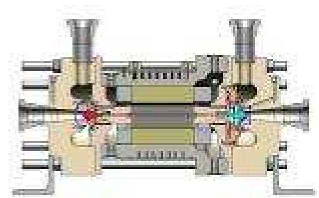
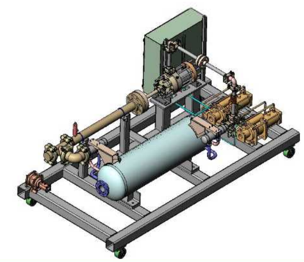
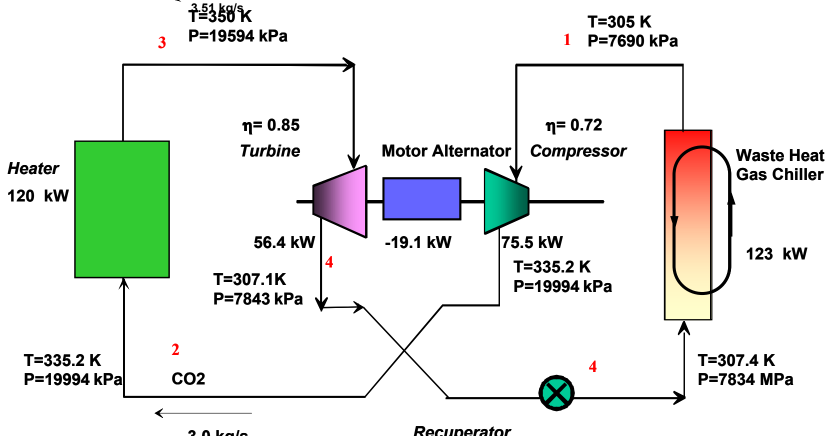
Sandia S-CO_2 Single Shaft Brayton Configurations



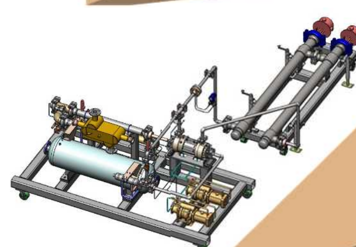
Motor Driven Supercritical CO_2 Test Loop Heater
May-June 2008 at BNI

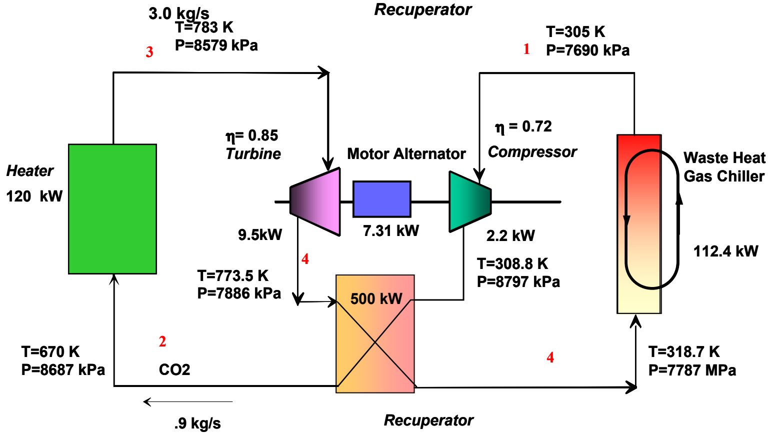






Simple Un-recuperated Brayton Cycle
Up to 260 kWe for Heater
July-Sept 2008





Recuperated Brayton Cycle
Up to 260 kWe for Heater
Possibly with SF6 as Alternative Fluid
May-June 2009 at SNL

Makes Electricity

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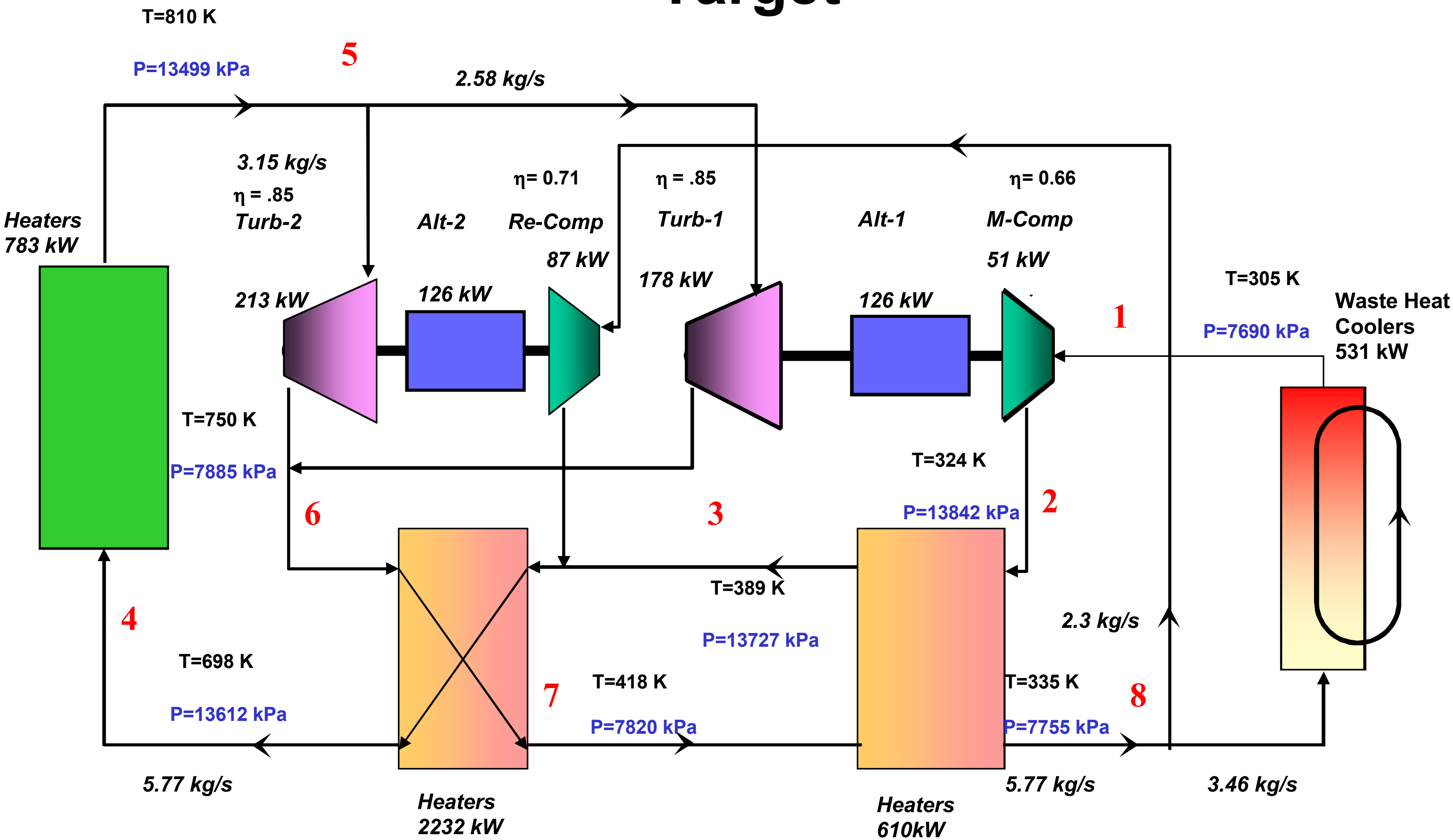
Gen IV Recompression SCO_2 Brayton Cycle Target



Key Technology Development Focus

- Compression near the critical point
- System control
- Design Tool Development and Validation for supercritical fluids
- Turbo-Alternator-Compressor Design Details
  - High speed/high power density motor/alternator
  - Bearing and Seals
  - Single versus dual shaft
    - Control
    - Model Validation