



**The Abdus Salam
International Centre for Theoretical Physics**



1944-19

**Joint ICTP-IAEA Workshop on Nuclear Reaction Data for Advanced
Reactor Technologies**

19 - 30 May 2008

**Gas-Cooled Reactors –Technology Options,
Operating Research Reactors and
Demonstration Plant Project Initiatives.**

J.M. Kendall
*Global Virtual LLC
Prescott
U S A*



IAEA-ICTP Workshop on Nuclear Reaction Data for Advanced Reactor Technologies

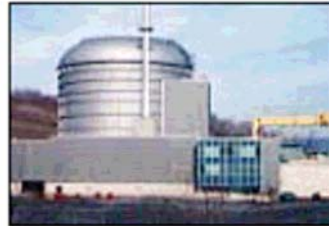
ICTP – Trieste, Italy, 18-30 May 2008

**Gas-Cooled Reactors –Technology Options,
Operating Research Reactors and
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**J. M. Kendall
Global Virtual LLC**



Gas Cooled Reactor Operating History



Dragon	Peach Bottom I	Fort St. Vrain	AVR	THTR
UK	USA	USA	Germany	Germany
Rods	Rods	Blocks	Pebbles	Pebbles
1964-1976	1966-1974	1977-1989	1966-1988	1985-1989
20 MWt	115 MWt	842 MWt	46 MWt	750 MWt
	40 MWe	330 MWe	15 MWe	296 MWe
350-750°C	344-728°C	406-785°C	275-950°C	250-750°C



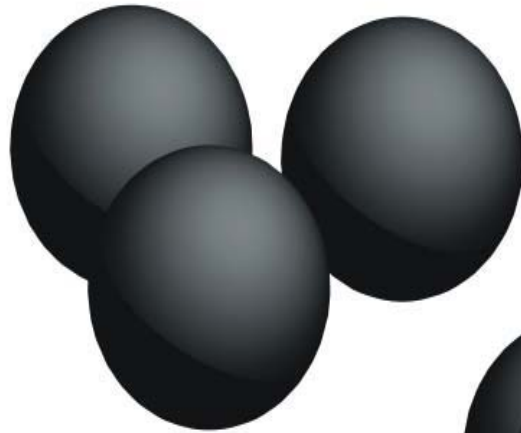
Major Technology Options

Pebble Bed

Prismatic Block



Technology Option Pebble Bed



Dia. 60 mm

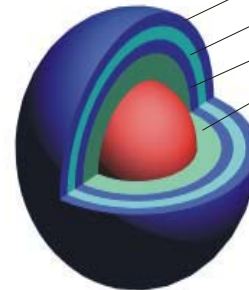
Fuel Sphere



5mm Graphite layer

Coated particles imbedded
in Graphite Matrix

Half Section



Pyrolytic Carbon
Silicon Carbide
Pyrolytic Carbon
Porous Carbon Buffer

Dia. 0,92 mm

Coated Particle



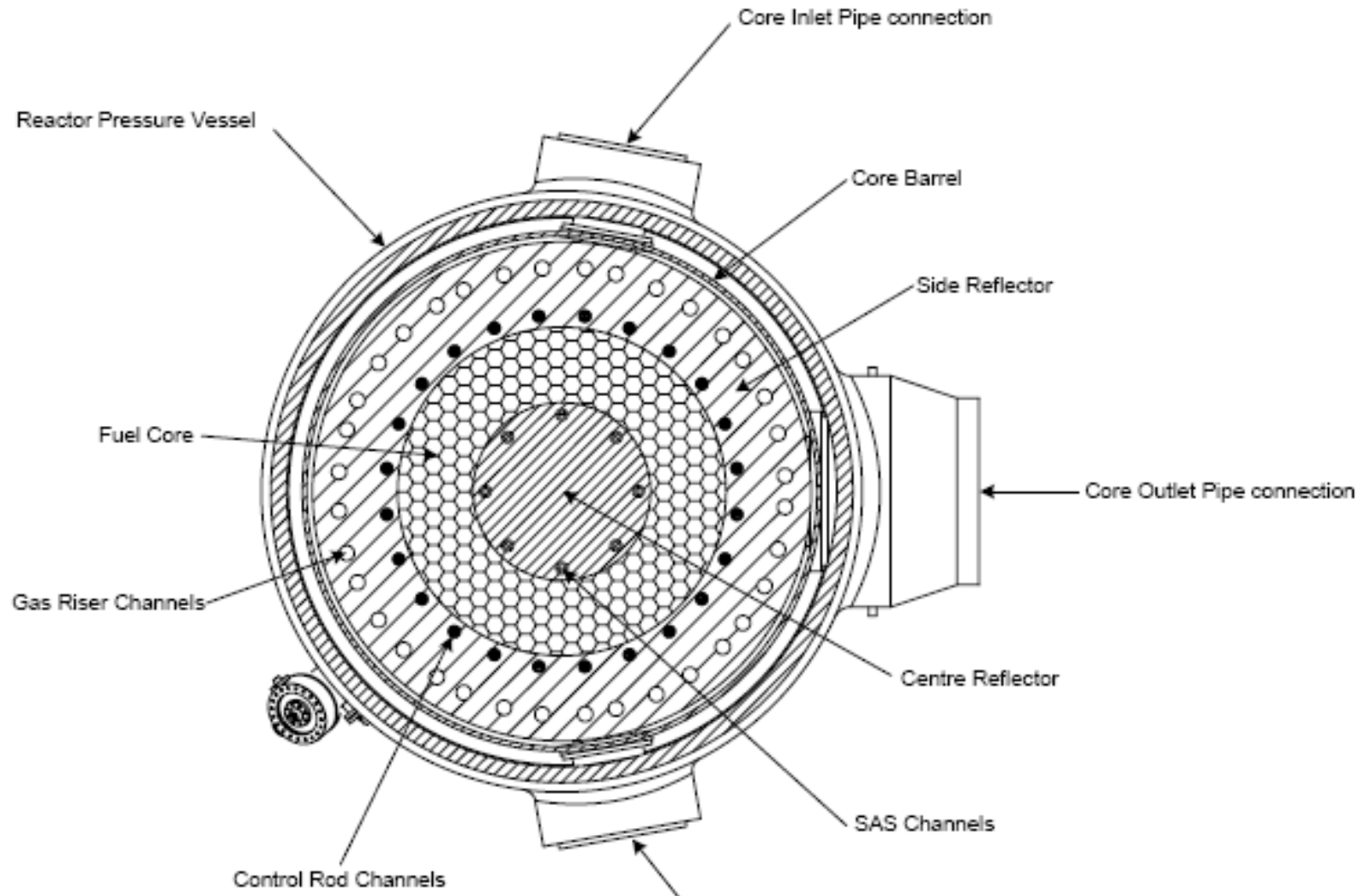
Dia. 0,5 mm

Uranium Dioxide

Fuel Kernel



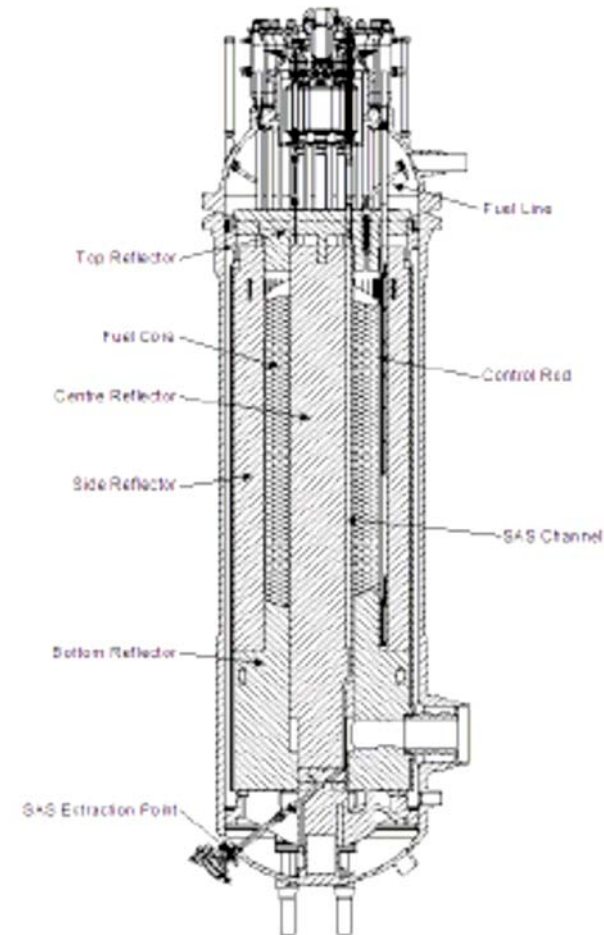
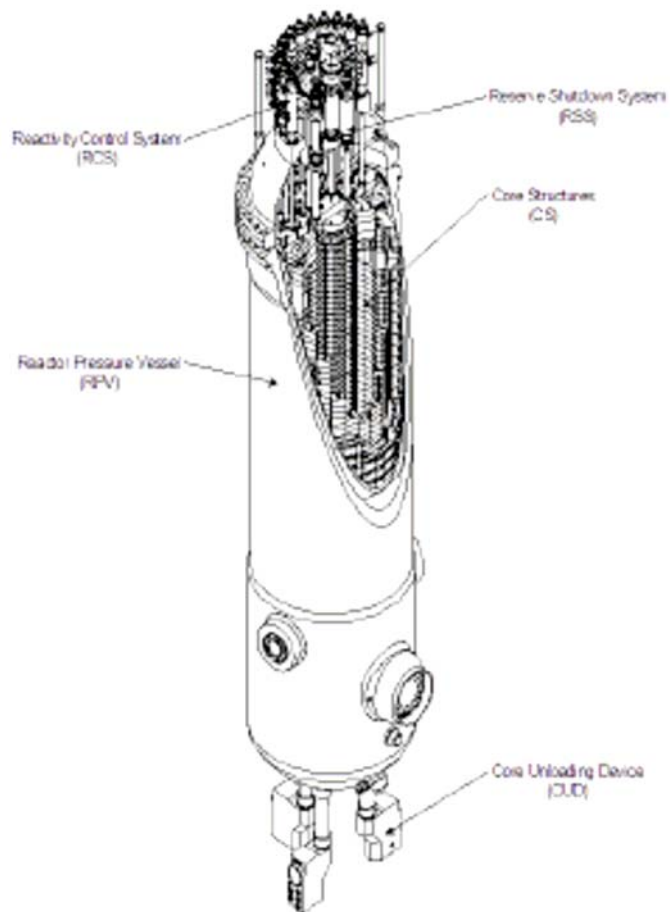
Technology Option Pebble Bed



PBMR Pty presentations to US Nuclear Regulatory Commission, Meeting on PBMR Safety and Design Familiarization, 28 February – 2 March 2006.

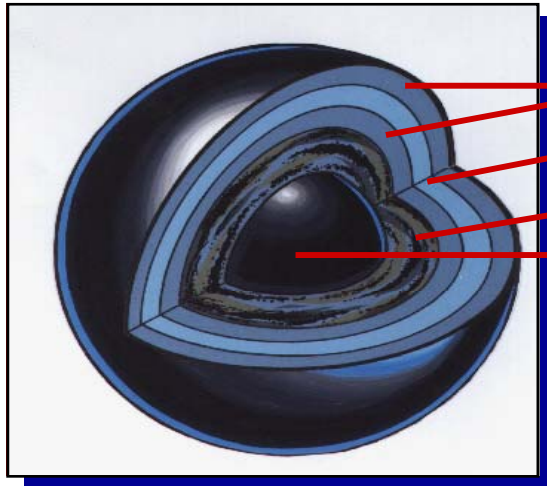


Technology Option Pebble Bed





Technology Option Prismatic Block



- Pyrolytic Carbon
- Silicon Carbide
- Porous Carbon Buffer
- Uranium Oxycarbide



PARTICLES



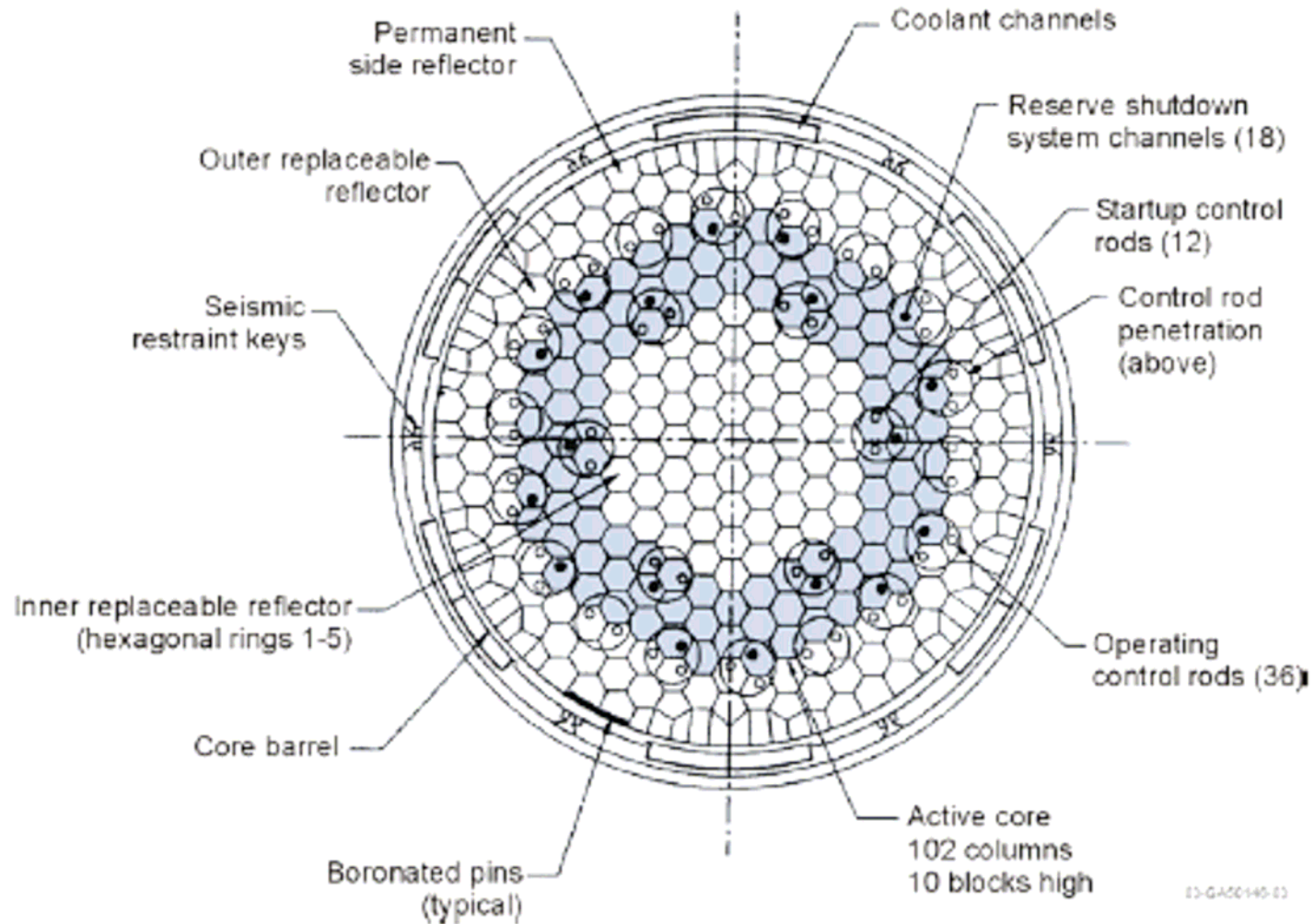
COMPACTS



FUEL ELEMENTS

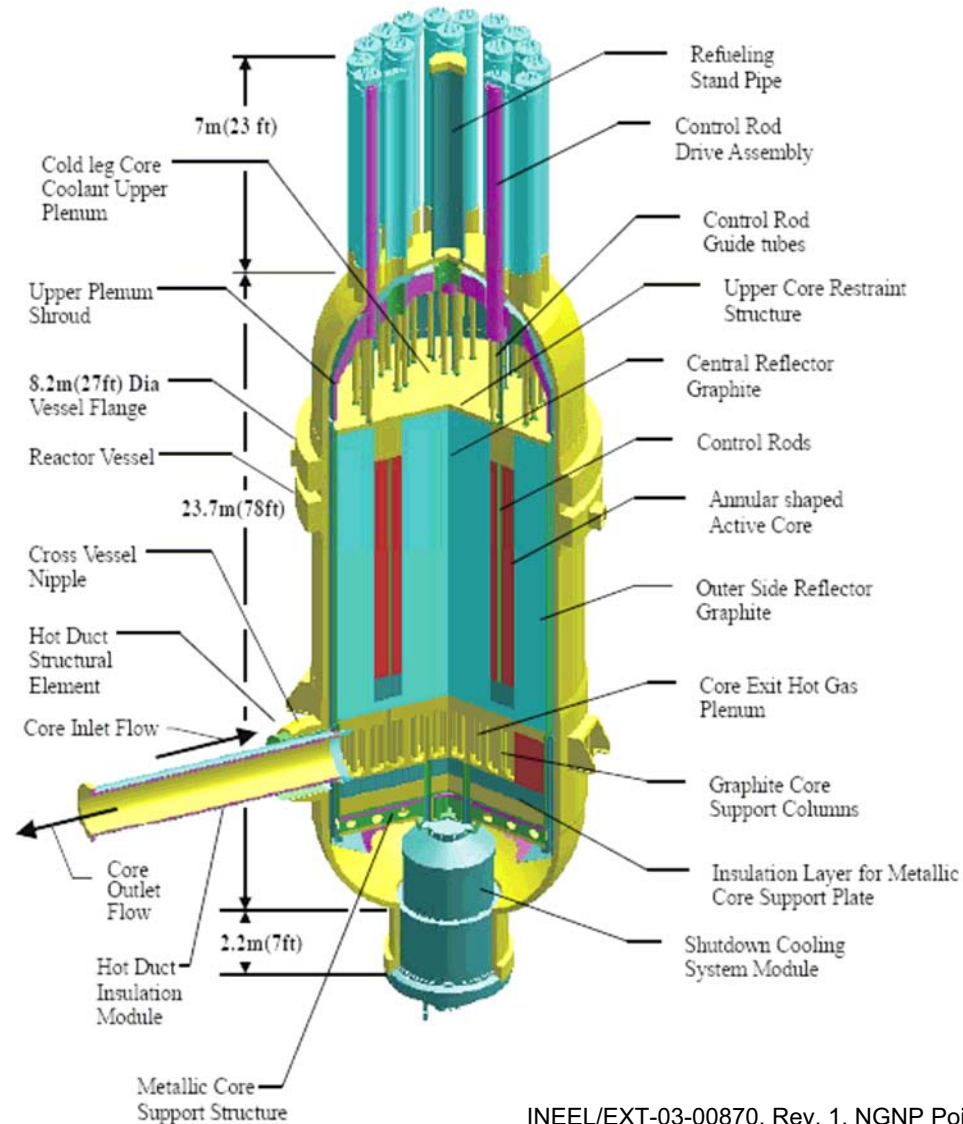


Technology Option Prismatic Block





Technology Option Prismatic Block



INEEL/EXT-03-00870, Rev. 1, NGNP Point Design – Results of the Initial Neutronics and Thermal-Hydraulic Assessments During FY-03, September, 2003.



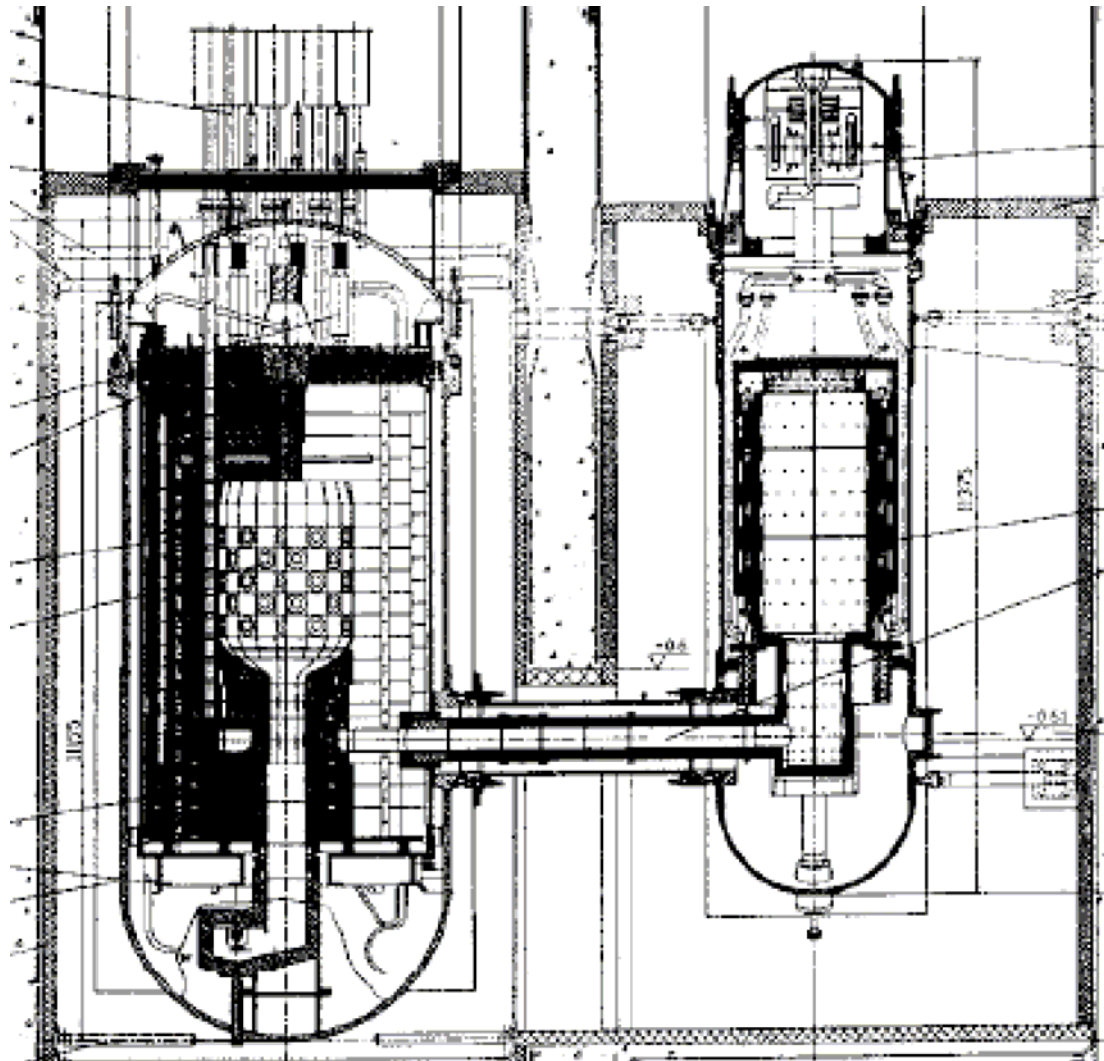
Operating Research Reactors

HTR-10
Pebble Bed
China

HTTR
Prismatic Block
Japan



Operating Research Reactors HTR-10 (China)





Operating Research Reactors HTR-10 (China)

10 MWt

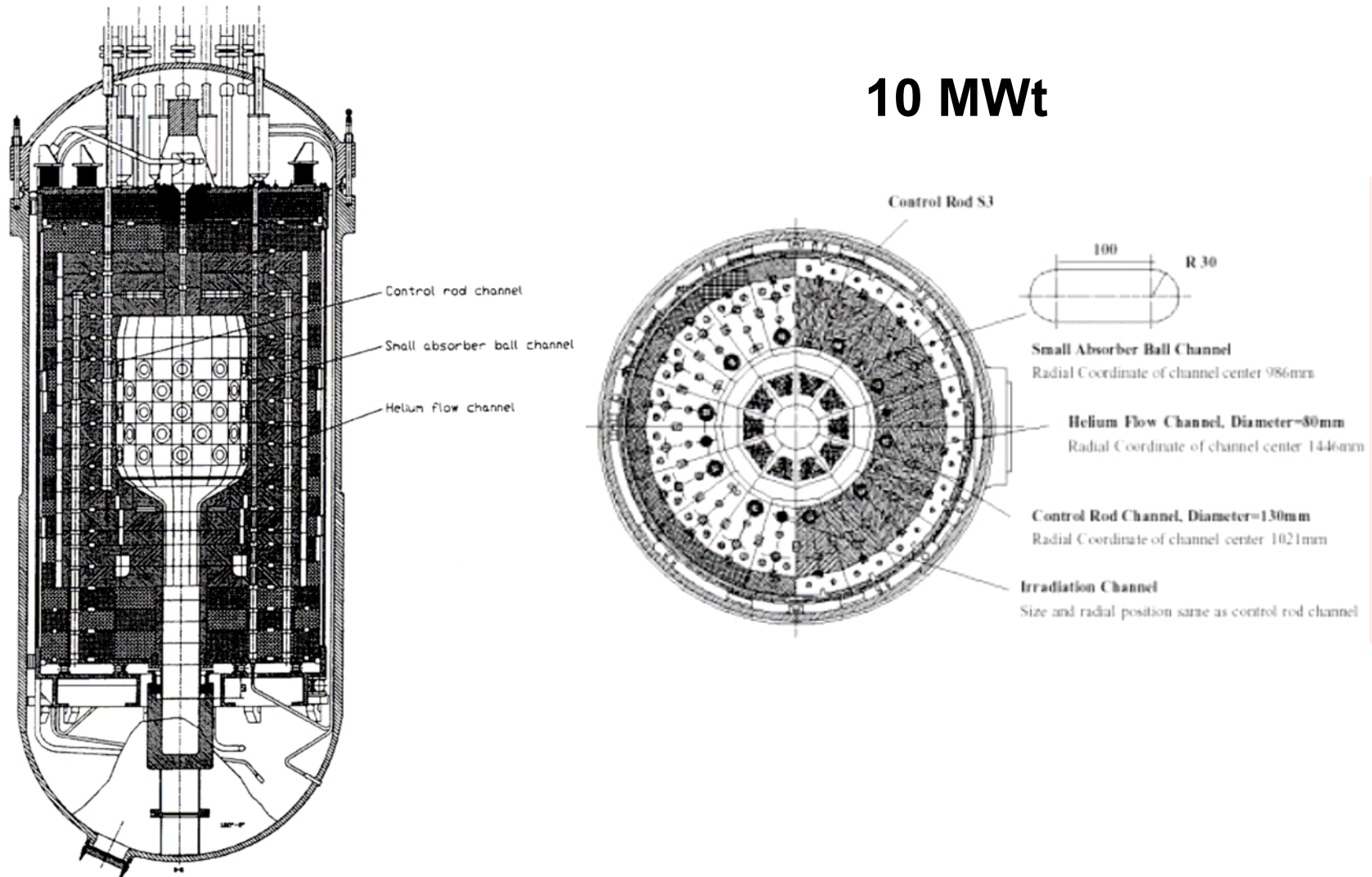
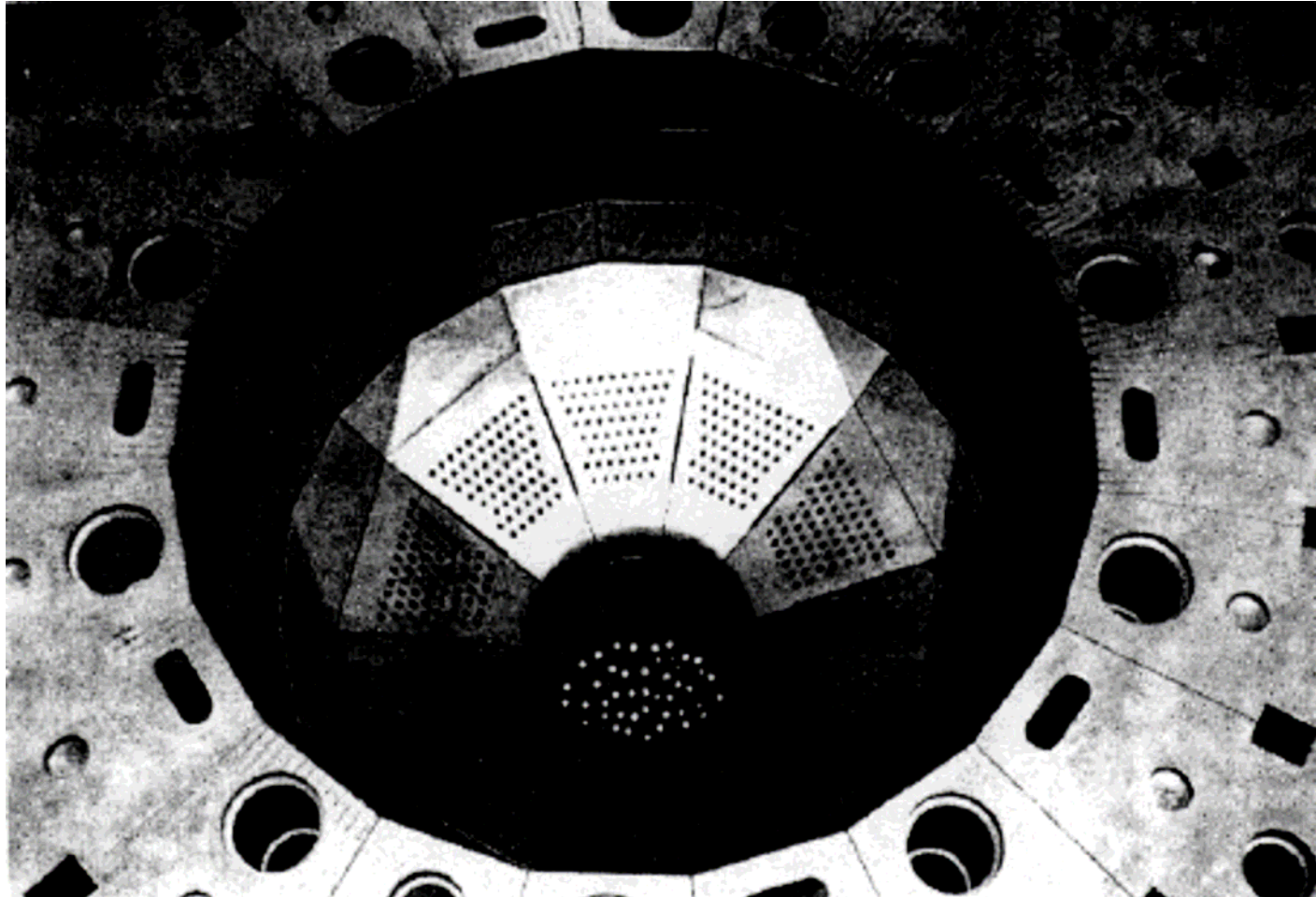


FIG. 4.6. HTR-10 reactor vertical cross-section.

IAEA-TECDOC-1382, Evaluation of high temperature gas cooled reactor performance: Benchmark analysis related to initial testing of the HTTR and HTR-10, November 2003.



Operating Research Reactors HTR-10 (China)



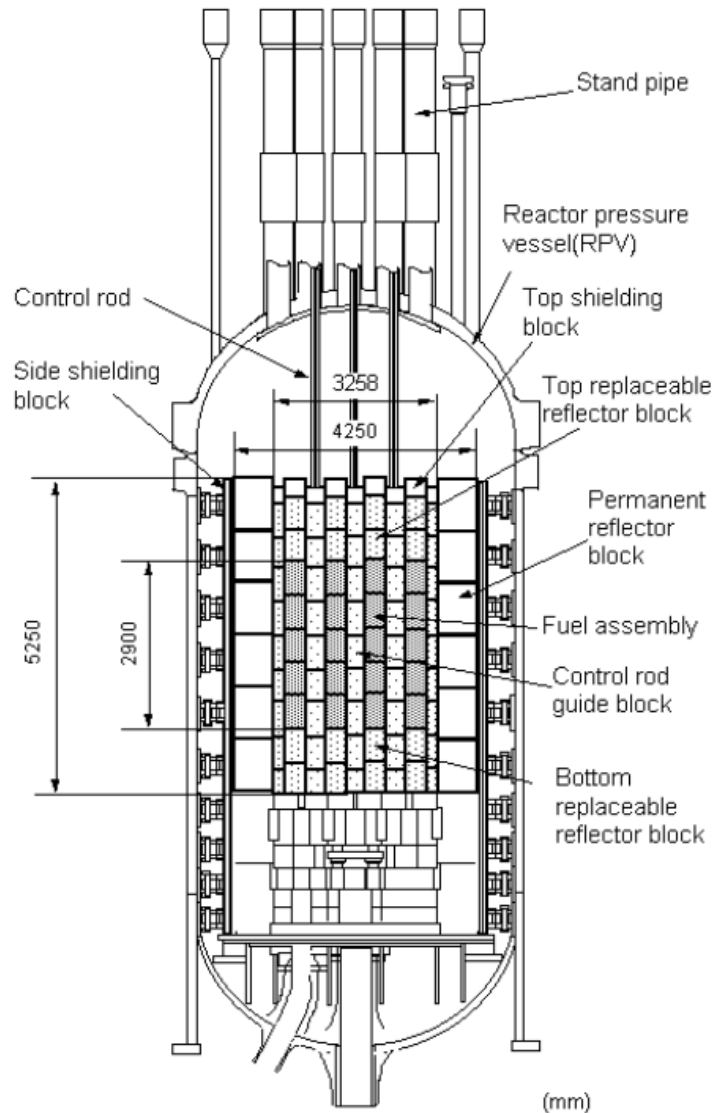


Operating Research Reactors HTR-10 (China)

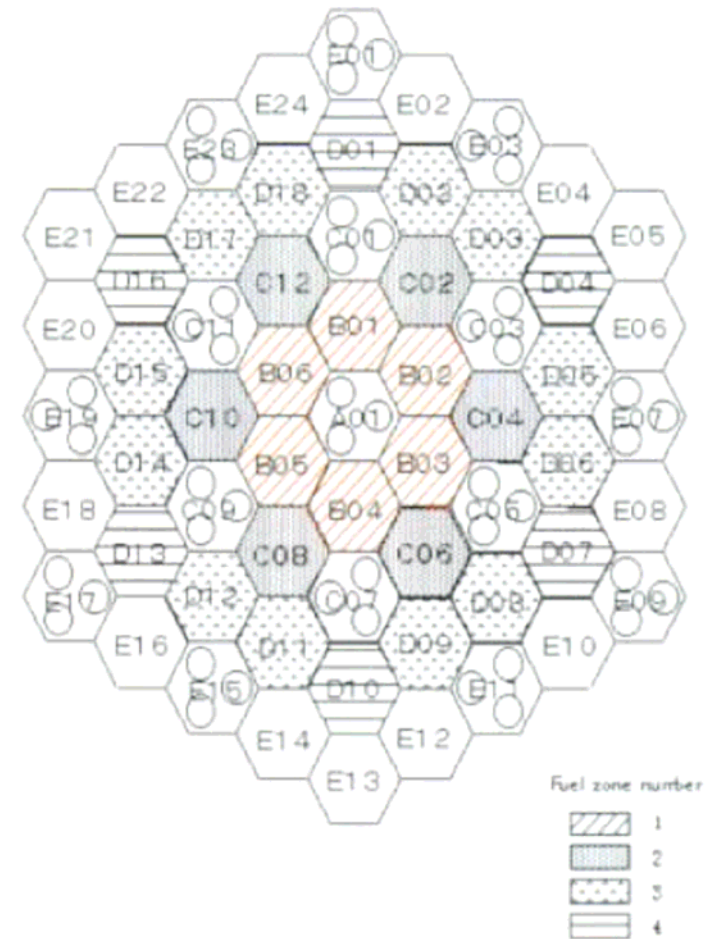




Operating Research Reactors HTTR (Japan)

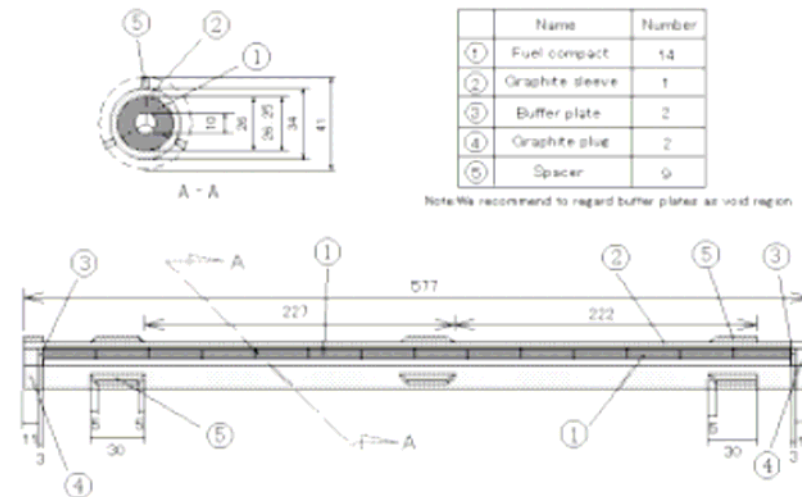
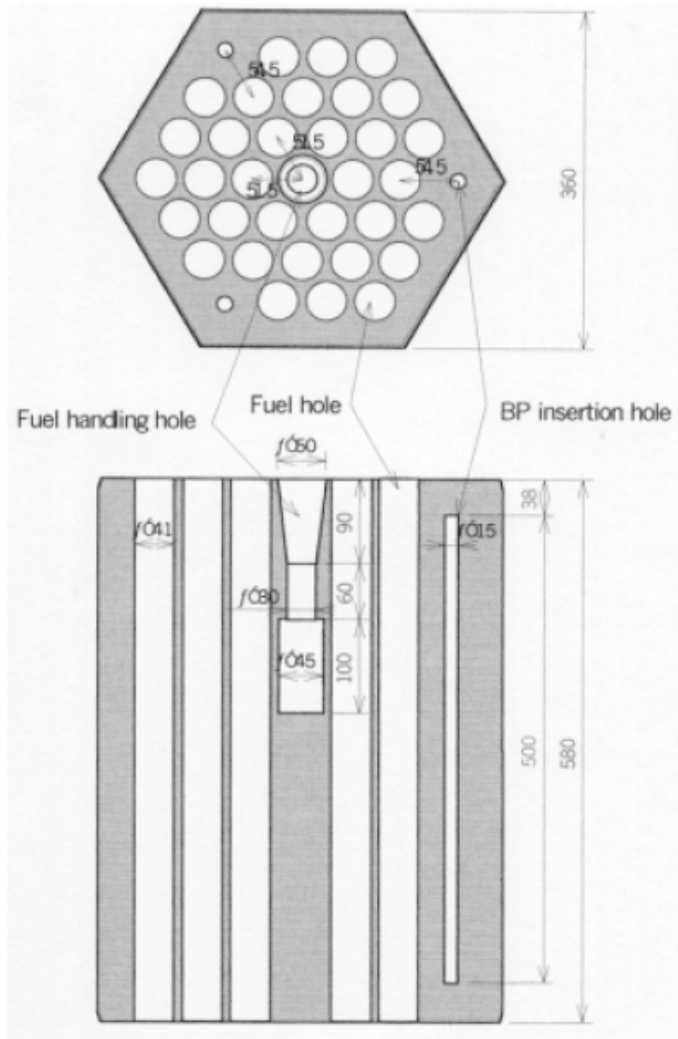


30 MWt



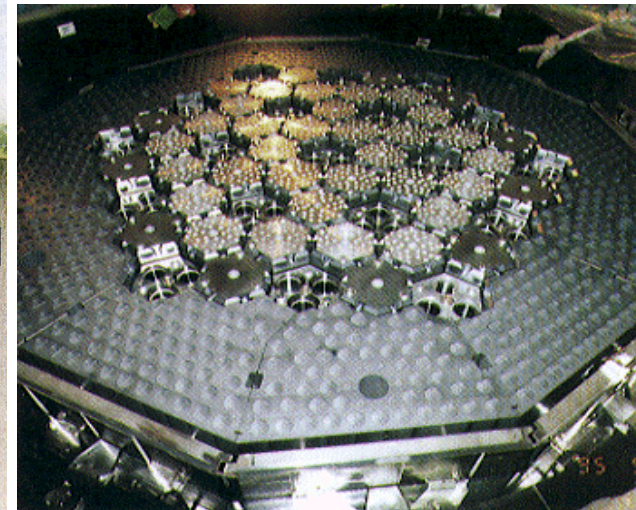
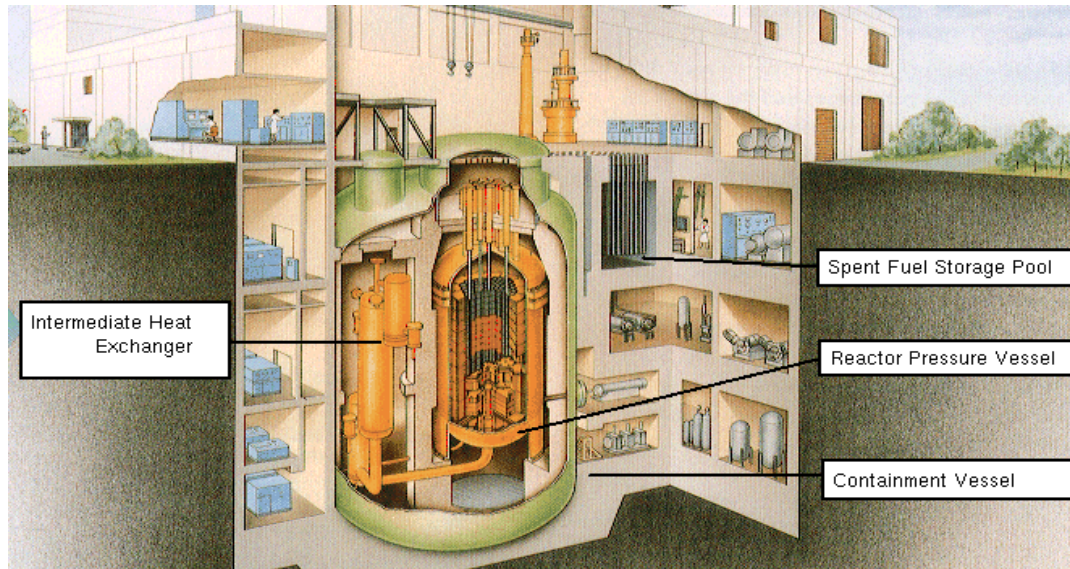
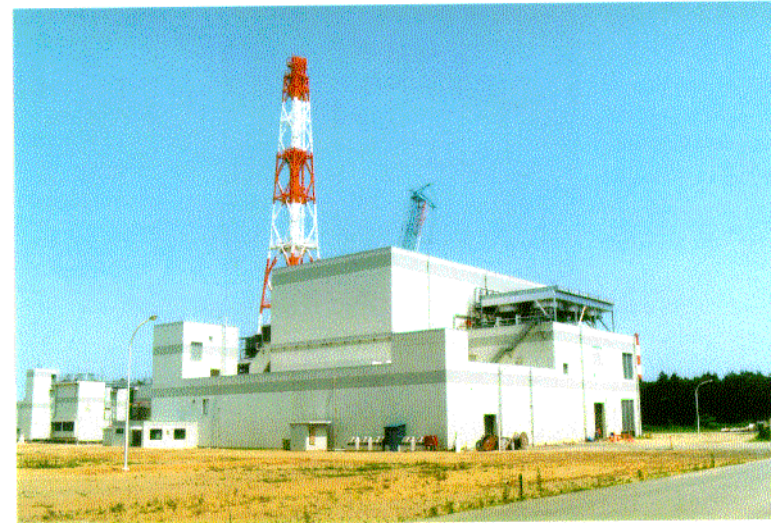
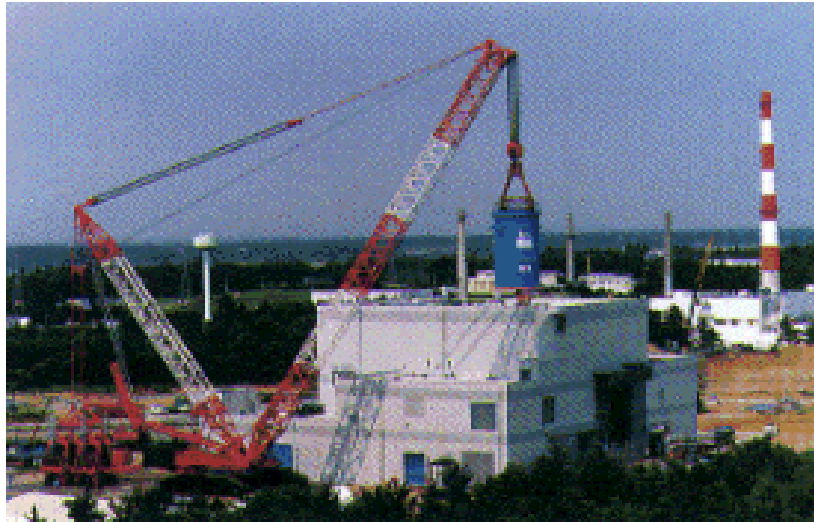


Operating Research Reactors HTTR (Japan)





Operating Research Reactors HTTR (Japan)





Operating Research Reactors HTTR (Japan)



Initial Criticality November 1998



Demonstration Projects Pebble Bed and Prismatic Block

Ongoing Projects

- **Pebble Bed**
 - **China – HTR-PM**
 - **South Africa – PBMR**
- **Prismatic Block or Pebble Bed**
 - **USA - NGNP**

Initiatives (Prismatic Block)

- **US/Russia – GT-MHR Pu**
- **Japan – GTHTR 300**

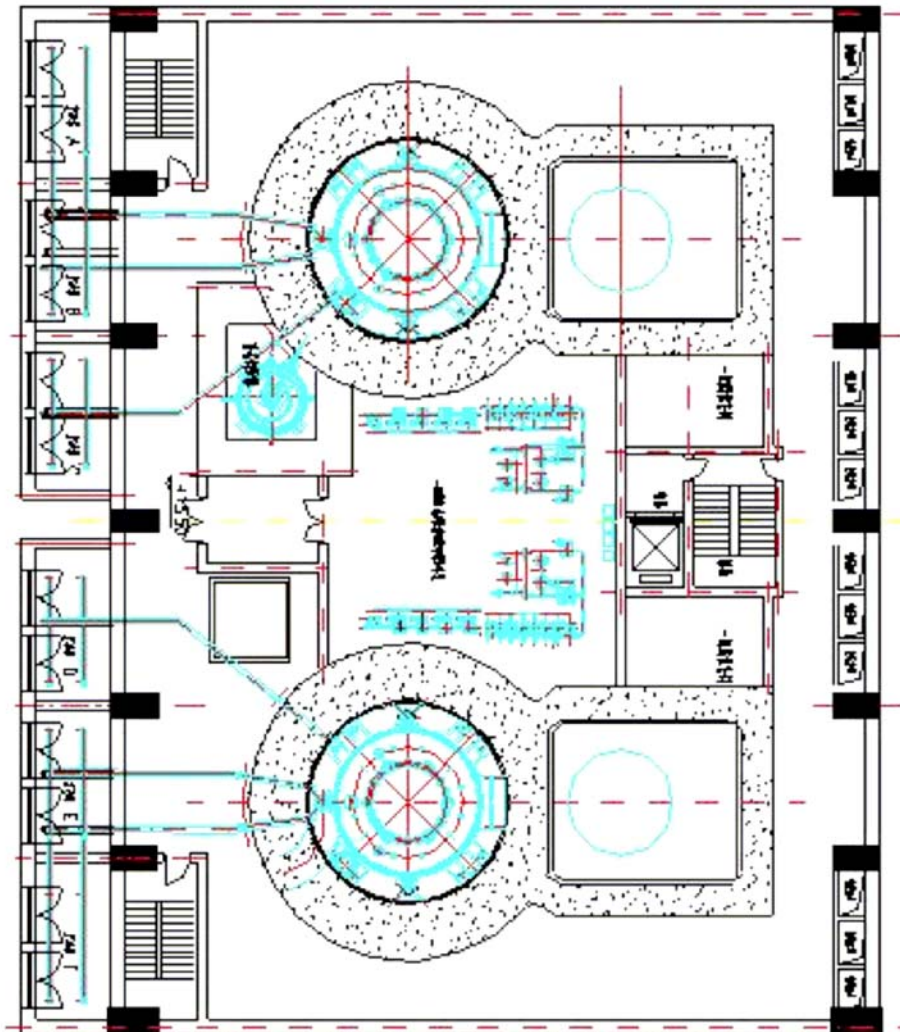


Demonstration Projects HTR-PM (China)





Demonstration Projects HTR-PM (China)

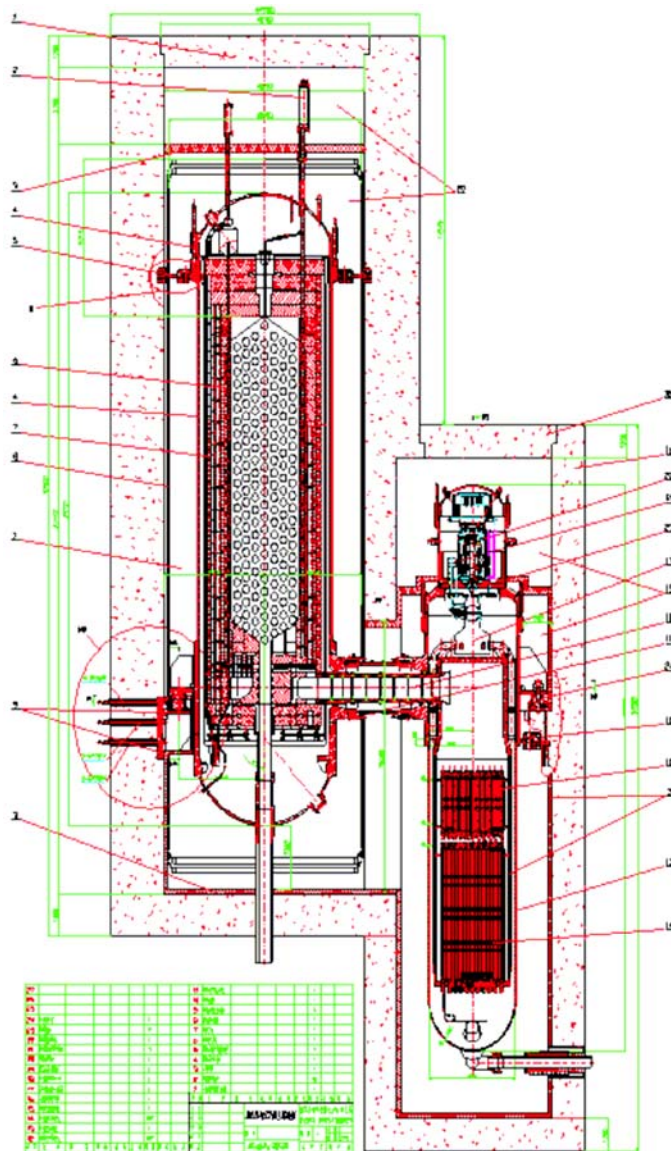


- Pebble Bed
- 2 Reactor/Steam Generator units at 250 MWt each
- Steam Turbine-Generator output 200 Mwe
- Scheduled Completion ~2013

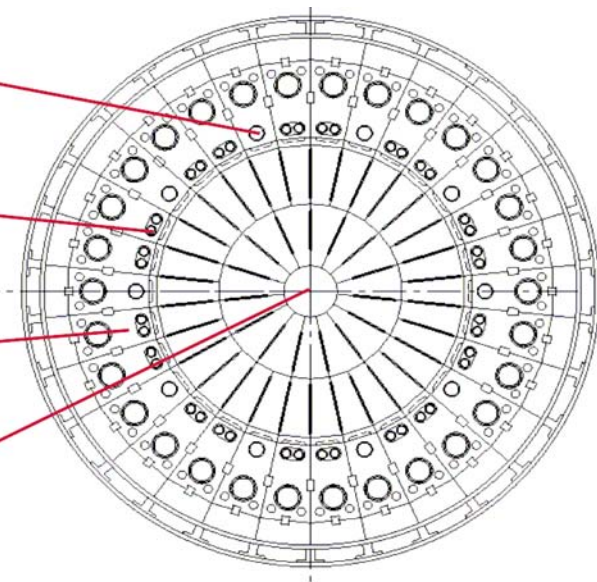


Demonstration Projects

HTR-PM (China)



- control rod channels*
- absorb ball channels*
- Side reflector graphite blocks*
- Fuel discharge hole*





Demonstration Projects

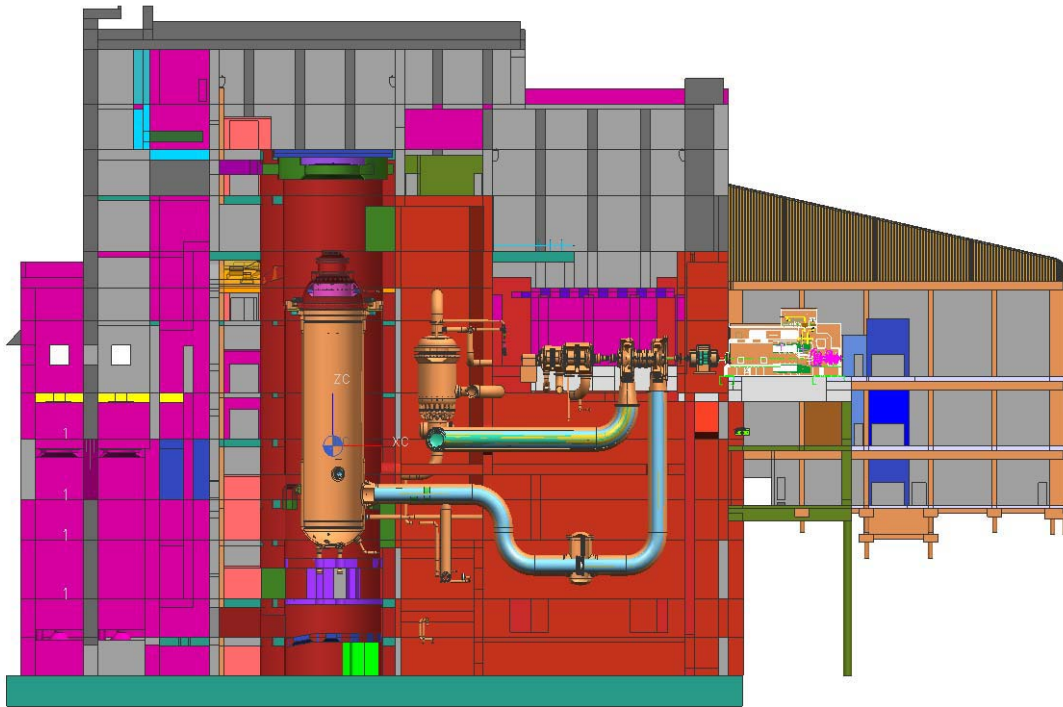
PBMR DPP (South Africa)





Demonstration Projects

PBMR DPP (South Africa)

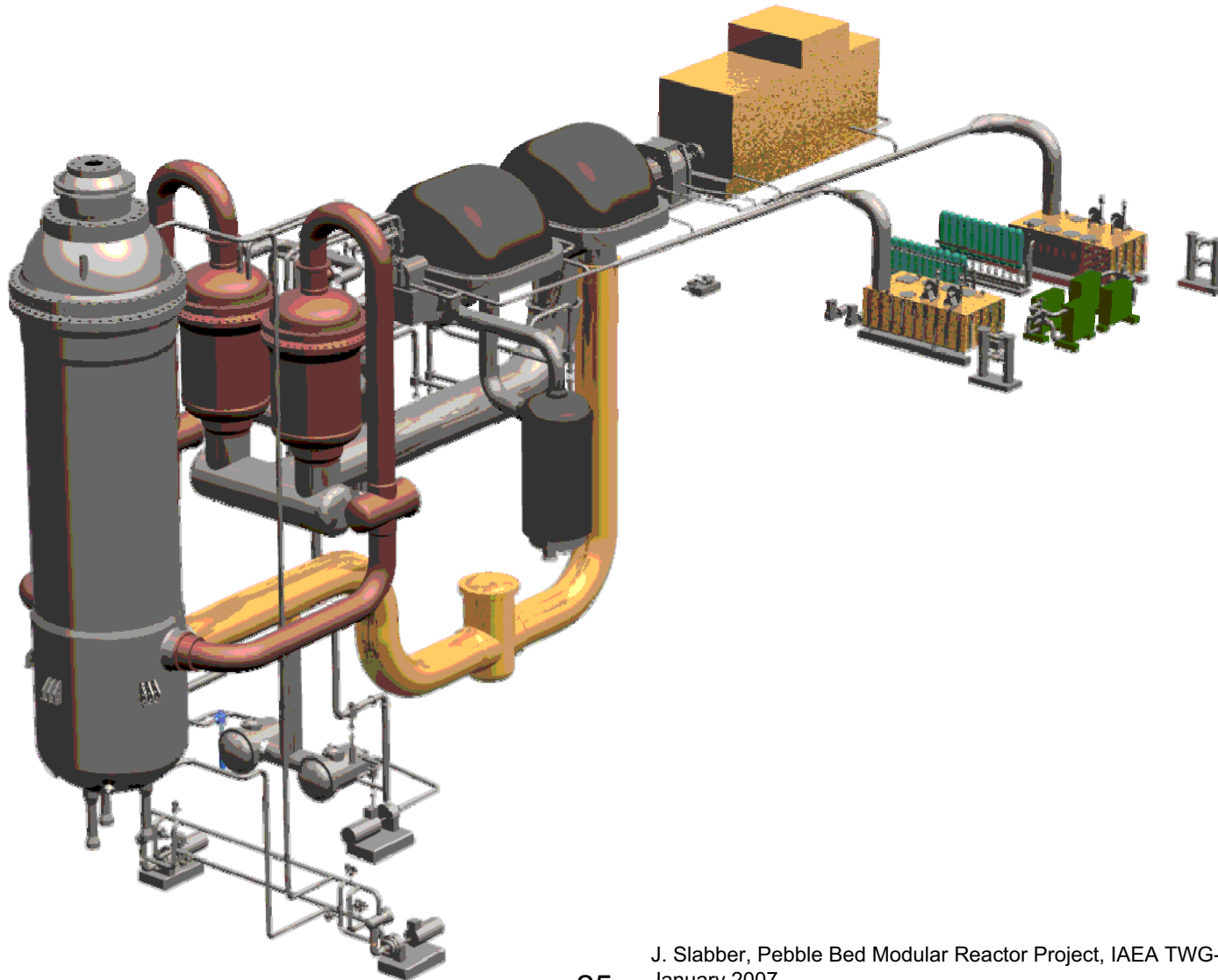


- Pebble Bed
- Annular reactor core 400 MWt
- Direct cycle gas turbine ~175 MWe
- Scheduled Completion ~2013

TOP WORK



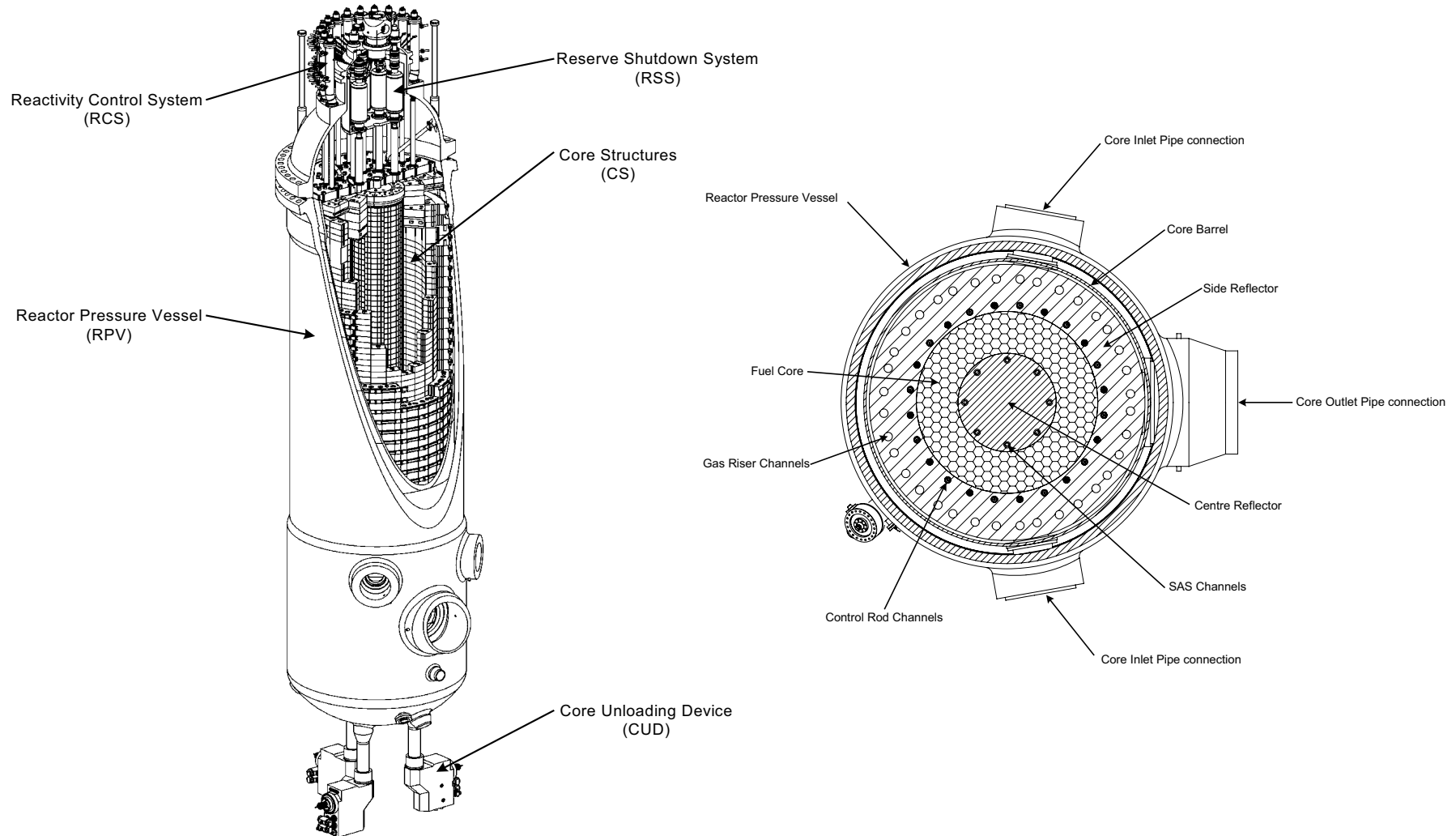
Demonstration Projects PBMR DPP (South Africa)



J. Slabber, Pebble Bed Modular Reactor Project, IAEA TWG-GCR 20, Vienna, January 2007.



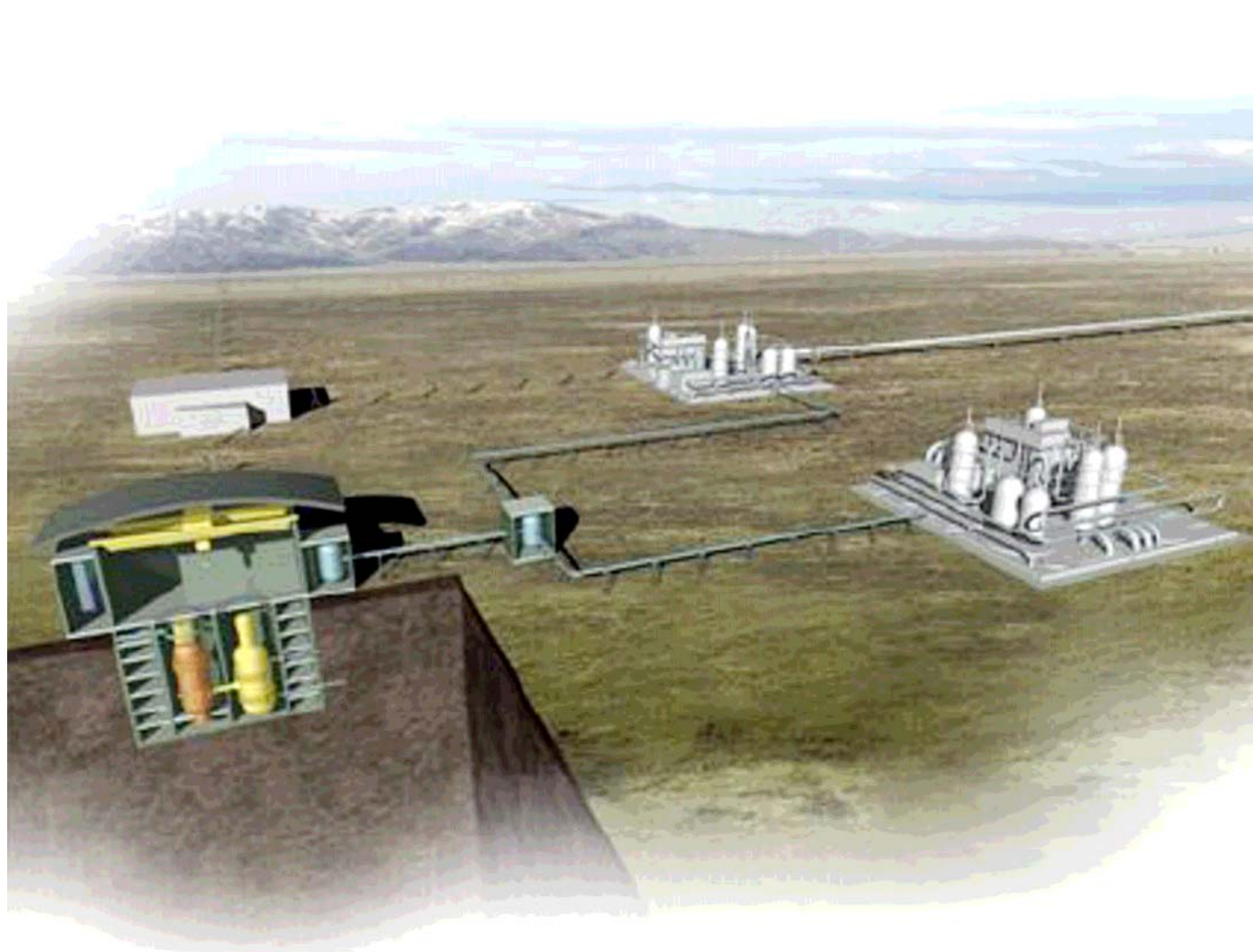
Demonstration Projects PBMR DPP (South Africa)



J. Slabber, Pebble Bed Modular Reactor Project, IAEA TWG-GCR 20, Vienna, January 2007.



Demonstration Projects NGNP (USA)



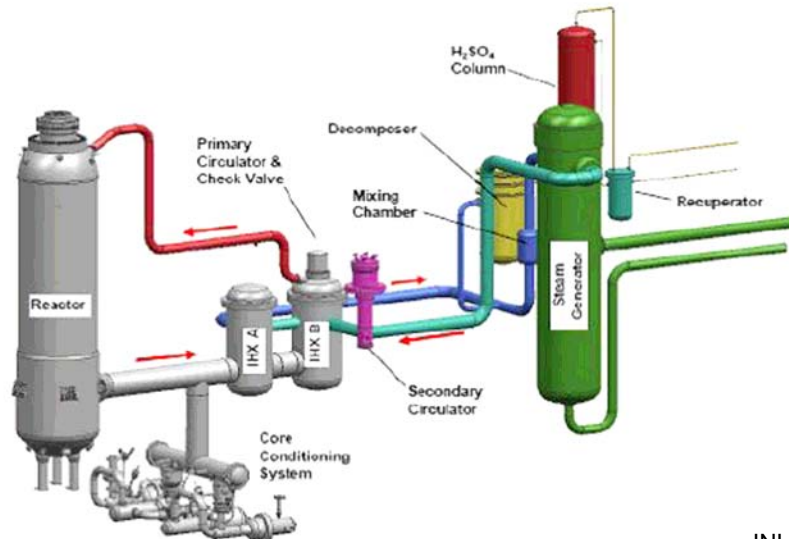
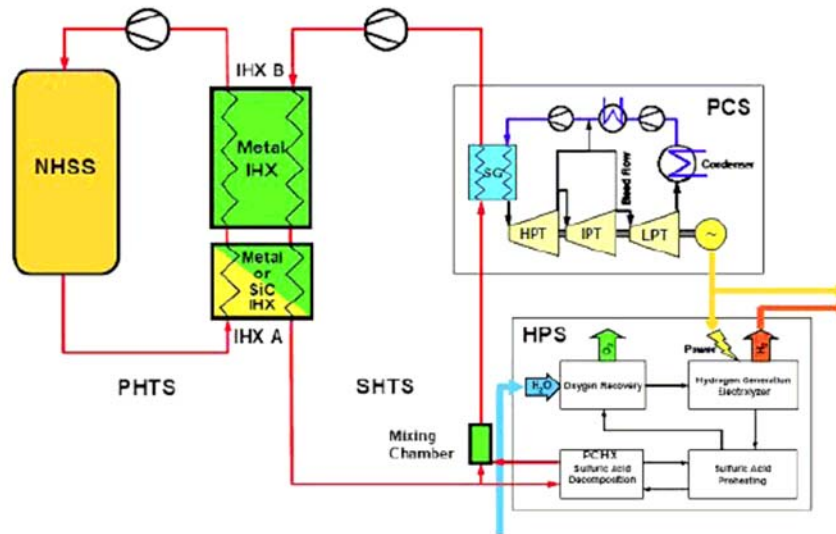


Demonstration Projects NGNP (USA)

- **Three competing design organizations**
 - **Westinghouse**
 - **AREVA**
 - **General Atomics**
- **Pebble Bed or Prismatic**
- **500-600 MWt**
- **Combined Electricity and Hydrogen Production**
- **Scheduled Completion ~2018**



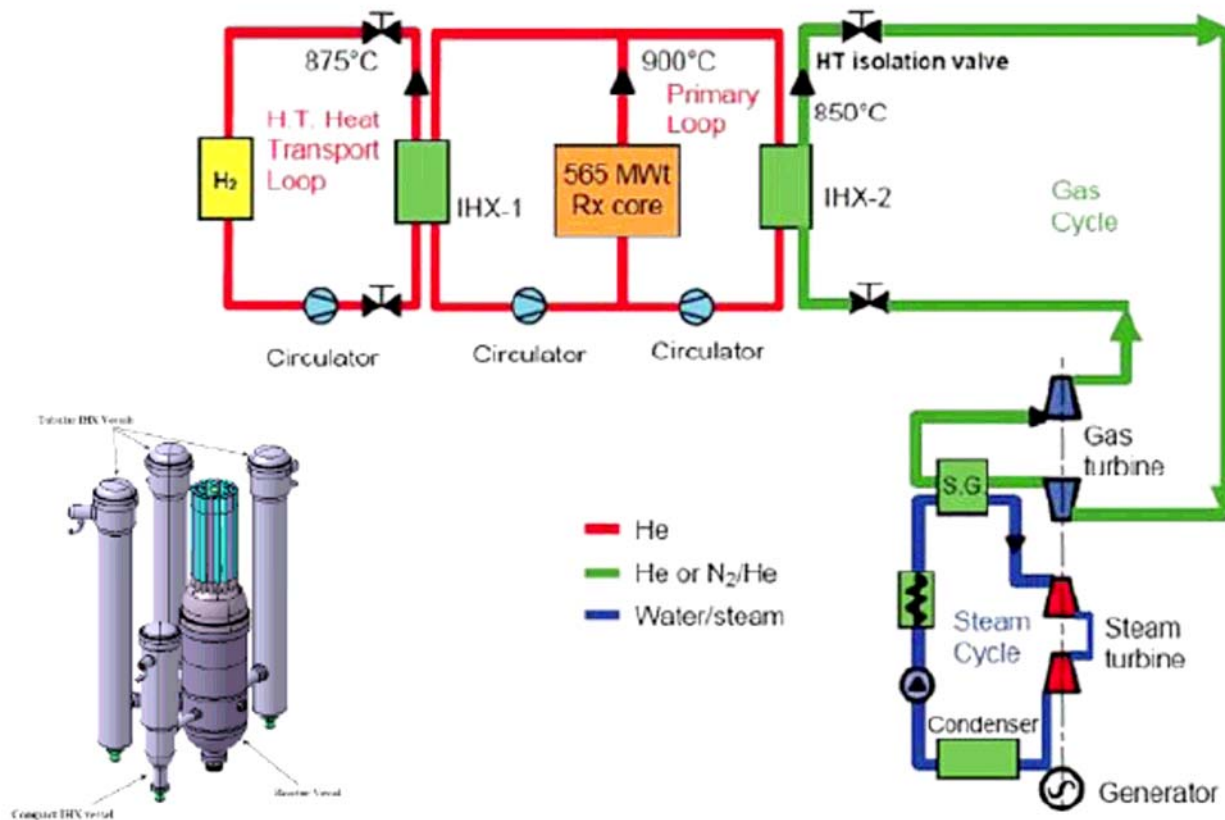
Demonstration Projects NGNP (USA)



- **Westinghouse**
- Pebble Bed
- Hydrogen production topping cycle
- Steam turbine bottoming cycle



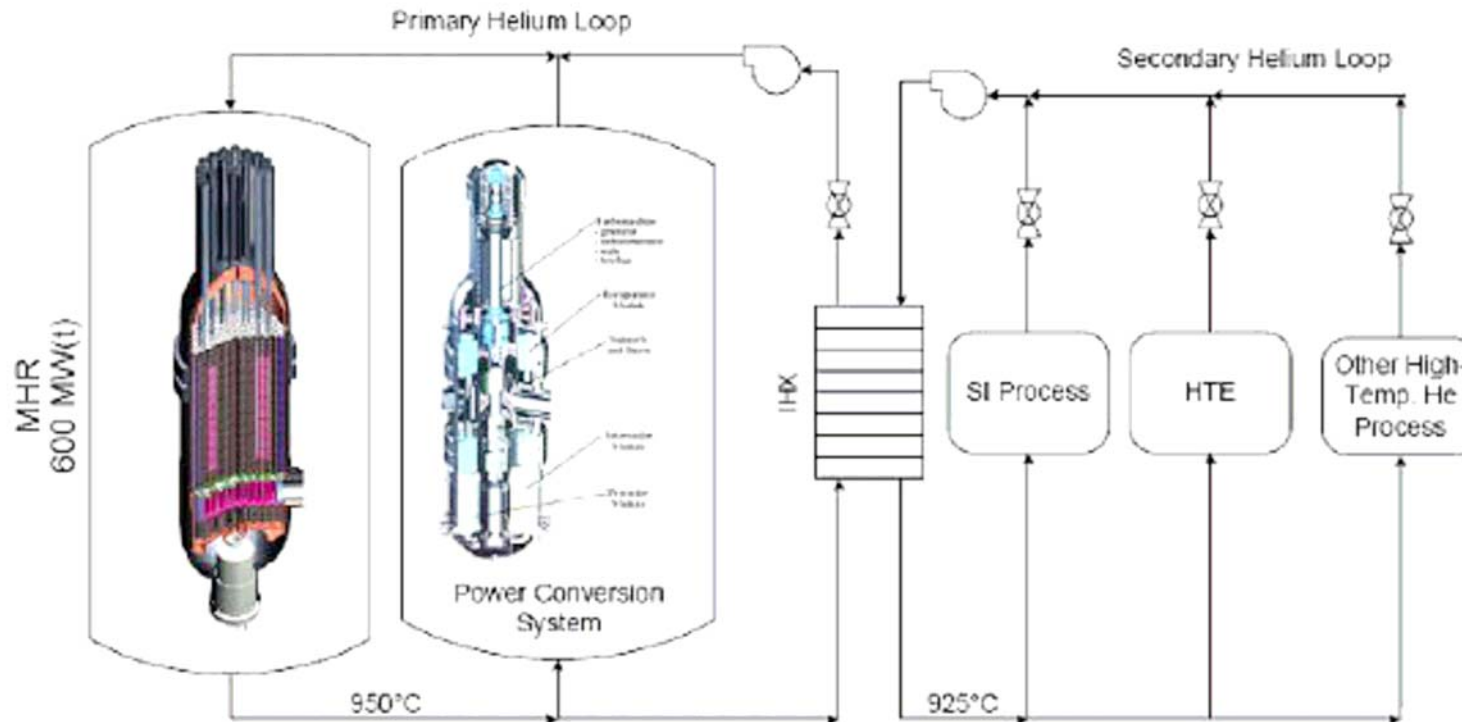
Demonstration Projects NGNP (USA)



- AREVA
- Prismatic
- Parallel Hydrogen production cycle
- Parallel gas turbine with steam turbine bottoming cycle



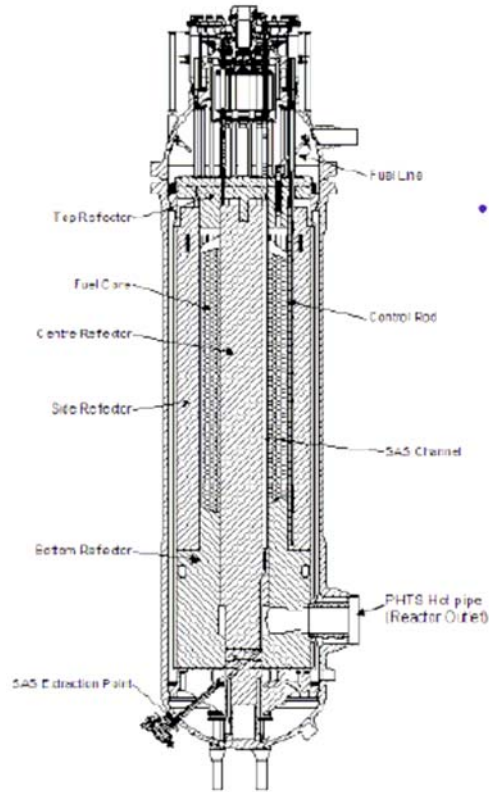
Demonstration Projects NGNP (USA)



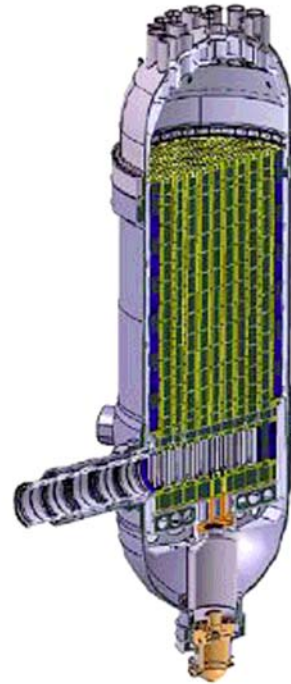
- **General Atomics - Prismatic**
- Direct cycle gas turbine
- Parallel Hydrogen production cycle



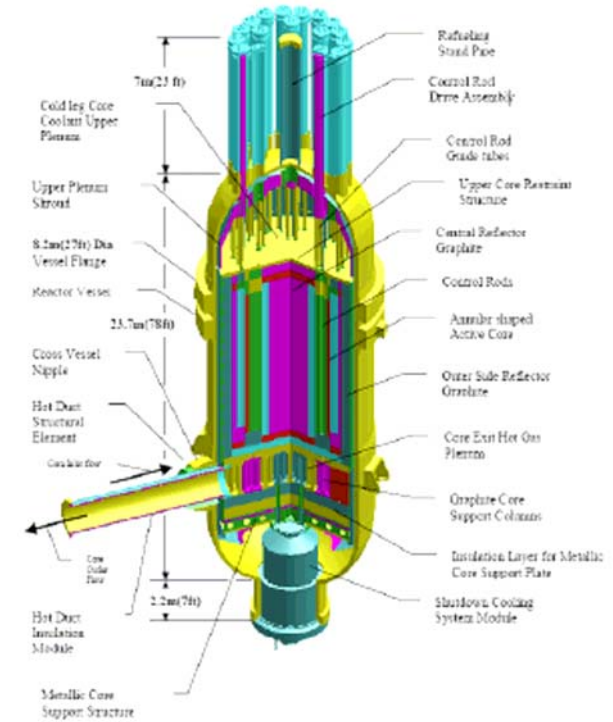
Demonstration Projects NGNP (USA)



**Westinghouse
Pebble Bed**



**AREVA
Prismatic**



**General Atomics
Prismatic**