UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 16, 2000

APPLICANT: General Atomics

FACILITY: Gas Turbine - Modular Helium Reactor (GT-MHR)

SUBJECT: MEETING SUMMARY ON STATUS OF GT-MHR

The subject meeting was held on March 7, 2000, in the Rockville, Maryland, office of the U.S. Nuclear Regulatory Commission (NRC) between representatives of General Atomics, the Department of Energy (DOE), and NRC. Enclosure 1 is a list of meeting attendees. Enclosures 2 and 3 are copies of vu-graphs that were used during the meeting.

General Atomics (GA) requested this meeting to inform the NRC staff of the status of the development of their GT-MHR design. Dr. Shenoy made the presentation on behalf of GA and used the vu-graphs in Enclosure 2. When support for the GT-MHR design was canceled by the U.S. Congress in 1995, GA and Russia's Ministry of Atomic Energy (MINATOM) began a joint program to design and develop a GT-MHR in Russia for destruction of weapons-grade plutonium. Since December 1995, GA, MINATOM, Framatome, and Fuji Electric have been working together on the design of a plutonium-consuming GT-MHR. Their goal is to:

- build and operate a prototype plutonium-fueled GT-MHR module in Russia by 2009,
- build and operate several four-module GT-MHR plants to burn weapons-grade plutonium, and
- use the GT-MHR design and technology for commercial application using uranium fuel.

GA stated that they have just started discussions on licensing the GT-MHR with the regulatory authorities in Russia, but they are not ready to begin a licensing review in the U.S. However, GA may request an NRC review of the GT-MHR design in the future. GA also stated that the plutonium-consuming GT-MHR design will have a containment, but the uranium-fueled version will use a vented confinement, similar to GA's Modular High-Temperature Gas-Cooled Reactor (MHTGR) design.

Mr. Matthews (NRC) stated that there are no resources currently planned for in NRR's budget for reviewing advanced reactor designs and, if GA wants some type of NRC review, they need to send the NRC a letter of intent. I presented a summary of the different types of design reviews that the NRC has performed in the past (Enclosure 3). Mr. King stated that pre-application reviews were traditionally done by the Office of Research and, if GA requested another pre-application review under the Commission's Advanced Reactor Policy Statement, the Commission would have to decide on whether a fee would be charged for the review based on budget considerations.

Ms. Feltus (DOE) asked if the NRC staff could provide their views on whether further research or testing was needed for the GT-MHR design. The staff stated that we had already made recommendations for further research and testing in our previous review of the MHTGR design (refer to NUREG-1338, "Draft Preapplication Safety Evaluation Report for the Modular High-Temperature Gas-Cooled Reactor") and the preparation of any further recommendations would have to be paid for by DOE or GA.

Jerry N. Wilson, Senior Policy Analyst
License Renewal and Standardization Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Project No. 672

Enclosures: As stated

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/RA/

Jerry N. Wilson, Senior Policy Analyst
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Office of Nuclear Reactor Regulation

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Enclosures: As stated

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GAS-COOLED REACTOR LICENSING
ATTENDANCE LIST
MARCH 7, 2000

NAME	ORGANIZATION
JERRY WILSON	NRC\NRR\DRIP\RLSB
TOM KING	NRC\RES
JACK DONOHEW	NRC\NRR\PDIV-1
DAVID MATTHEWS	NRC\NRR\DRIP
JARED WERMIEL	NRC\NRR\DSSA\SRXB
PETER KARCZ	DOE
WALT SIMON	GA
ARVAL SHENOY	GA
MARK HAYNES	GA
SIDNEY CRAWFORD	CONSULTANT
ALAN LEVIN	NRC\OCM\RAM
HOWARD FAULKNER	NRC\OIP
FRANK GOLDNER	DOE
TOM CLEMENTS	NUCLEAR CONTROL INSTITUTE
BRAIN MCINTYRE	WESTINGHOUSE
HERBERT BERKOW	NRC\NRR
JANICE D. LEE	NRC\OIP
MADELINE ANNE FELTUS	DOE
FAROUK ELTAWILA	NRC\RES

Enclosure 1

International GT-MHR Program

Presented at
Visit to U.S. Nuclear Regulatory Commission

Arkal Shenoy
Director, Modular Helium Reactors
General Atomics

March 07, 2000

Enclosure 2

Outline

- Modular Helium Reactor History at GA
- GA/Minatom Private Program
- Conceptual Design Summary
- Design Reviews
- US Government Participation
- Where do we go from Here

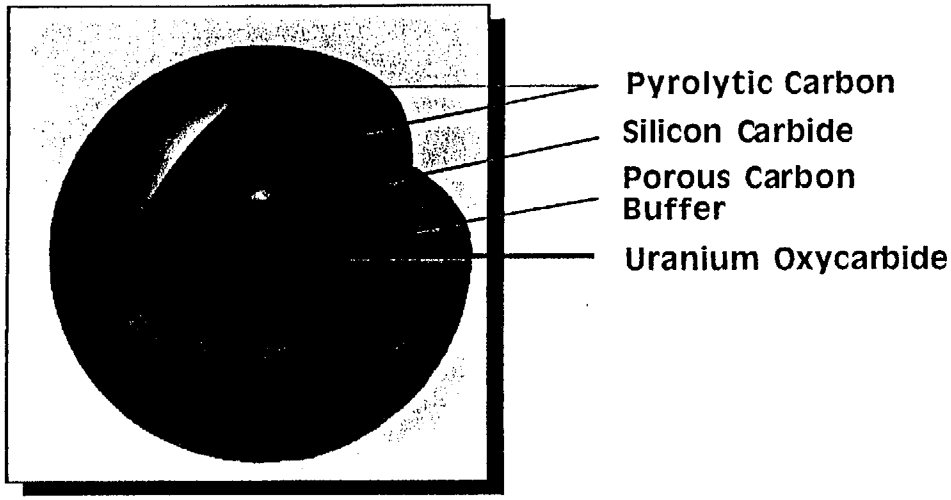
Modular Helium Reactor History at GA

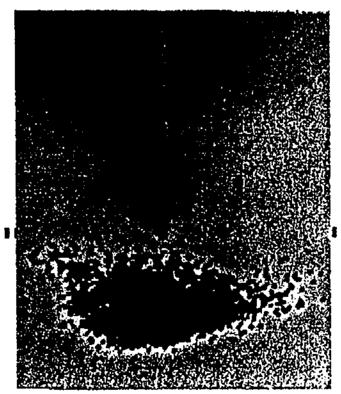
- 1984: 200 MW(t) Modular Design with Pebble Selected
- 1985: 350 MW(t) MHTGR Steam Cycle
- 1988: DOE Selects MHTGR as One of Two NPR Designs
- 1990: 450 MW(t) MHTGR Steam cycle
- 1992: Pu Consumption MHR Study
- 1993: Gas Turbine Chosen as Reference Design
- 1994: 600 MW(t) Power Level Recommended
- 1995: US Congress Cancels GT-MHR Support

Basic GT-MHR Design Selections

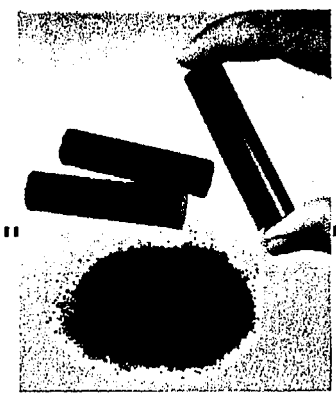
- Coated Particle Fuel
- Graphite Core Configuration
- Low Power Density
- Helium Coolant
- Brayton Cycle

CERAMIC FUEL RETAINS ITS INTEGRITY UNDER SEVERE ACCIDENT CONDITIONS

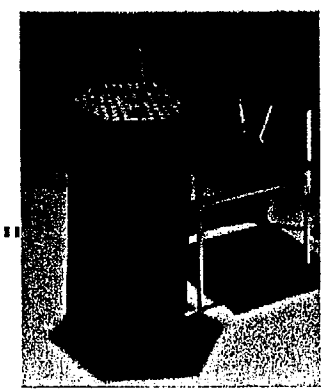




PARTICLES



COMPACTS



FUEL ELEMENTS

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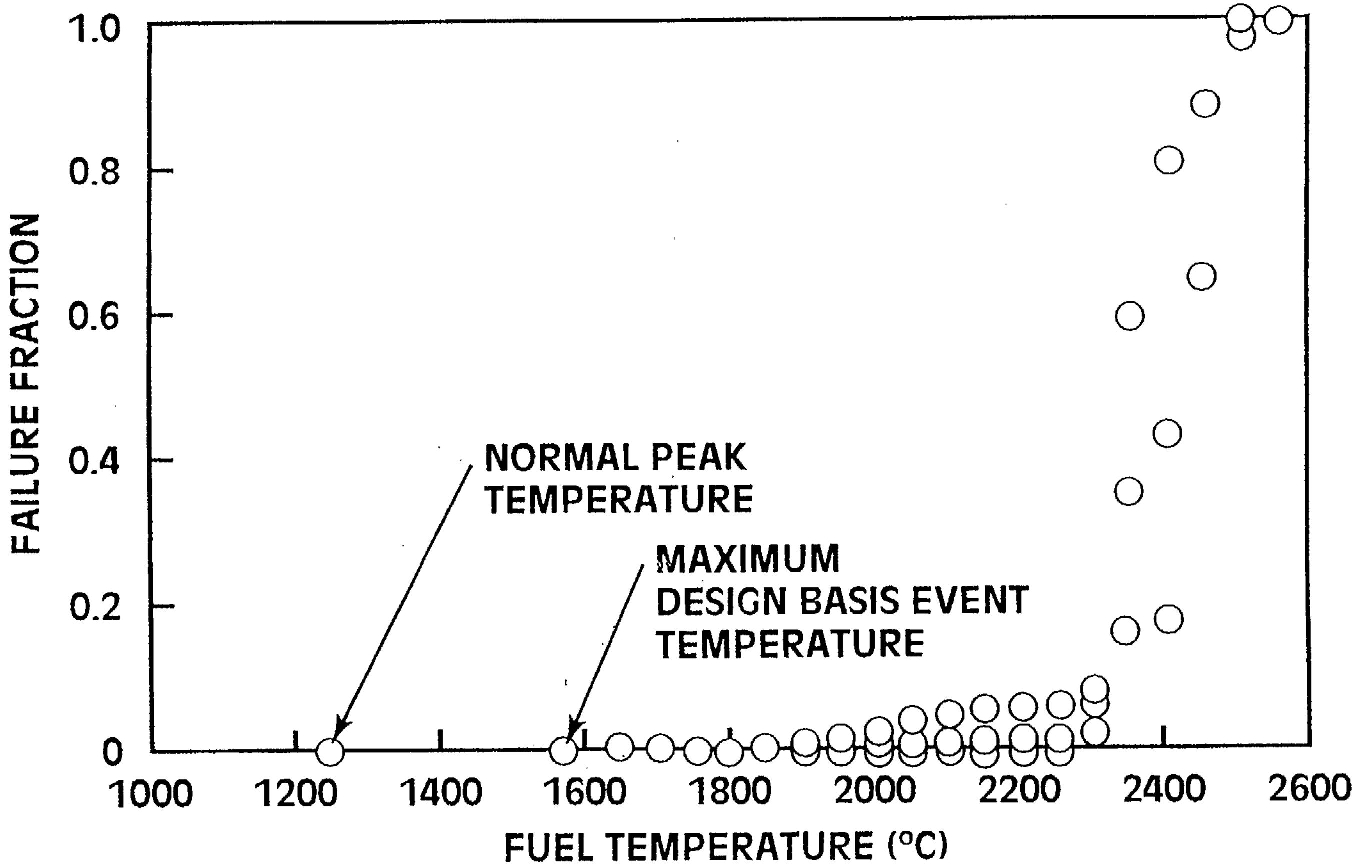
GENERAL ATOMICS

COATED PARTICLES STABLE TO BEYOND MAXIMUM ACCIDENT TEMPERATURES



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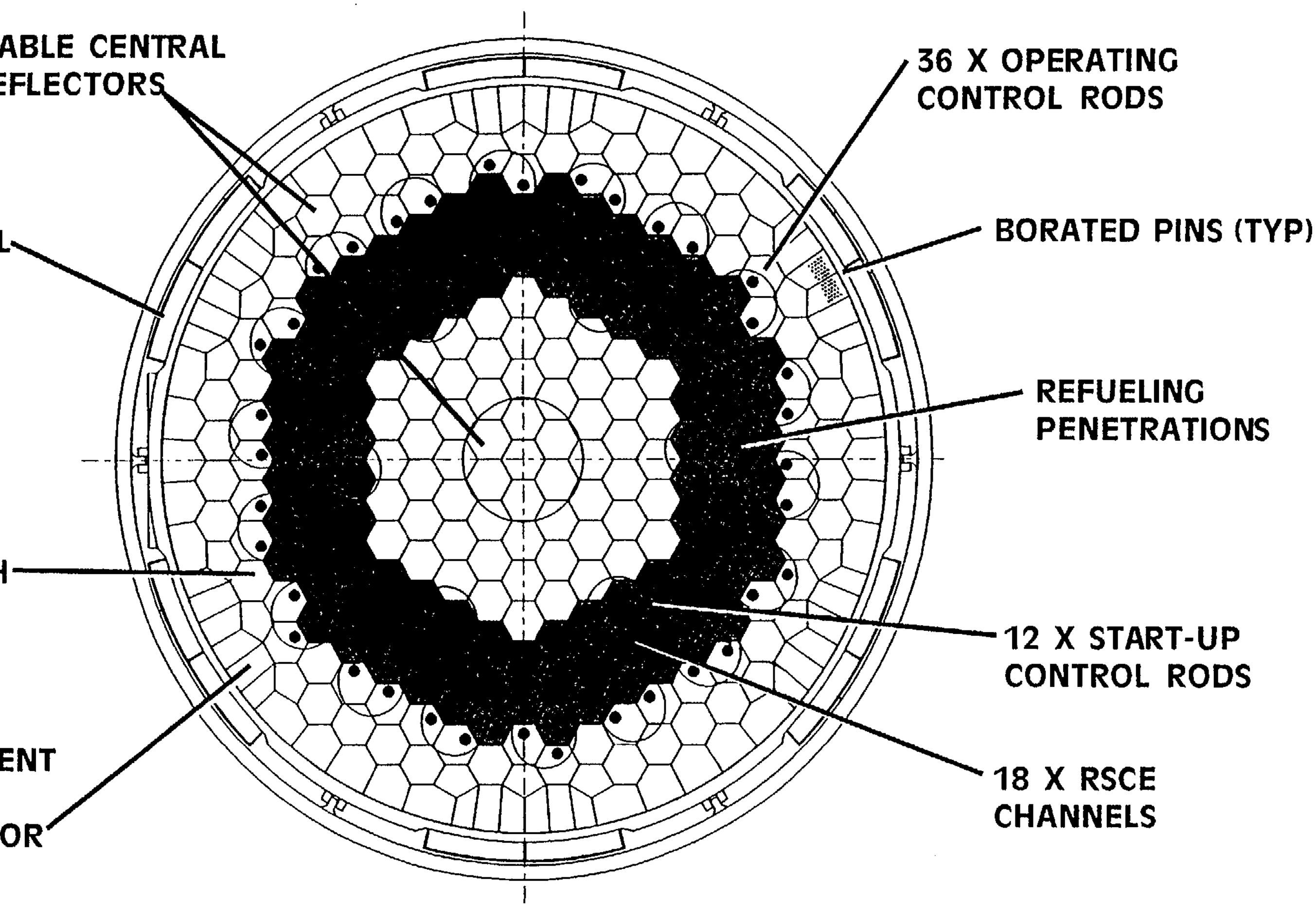
GENERAL ATOMICS

ANNULAR REACTOR CORE LIMITS FUEL TEMPERATURE DURING ACCIDENTS



. . . ANNULAR CORE USES EXISTING TECHNOLOGY

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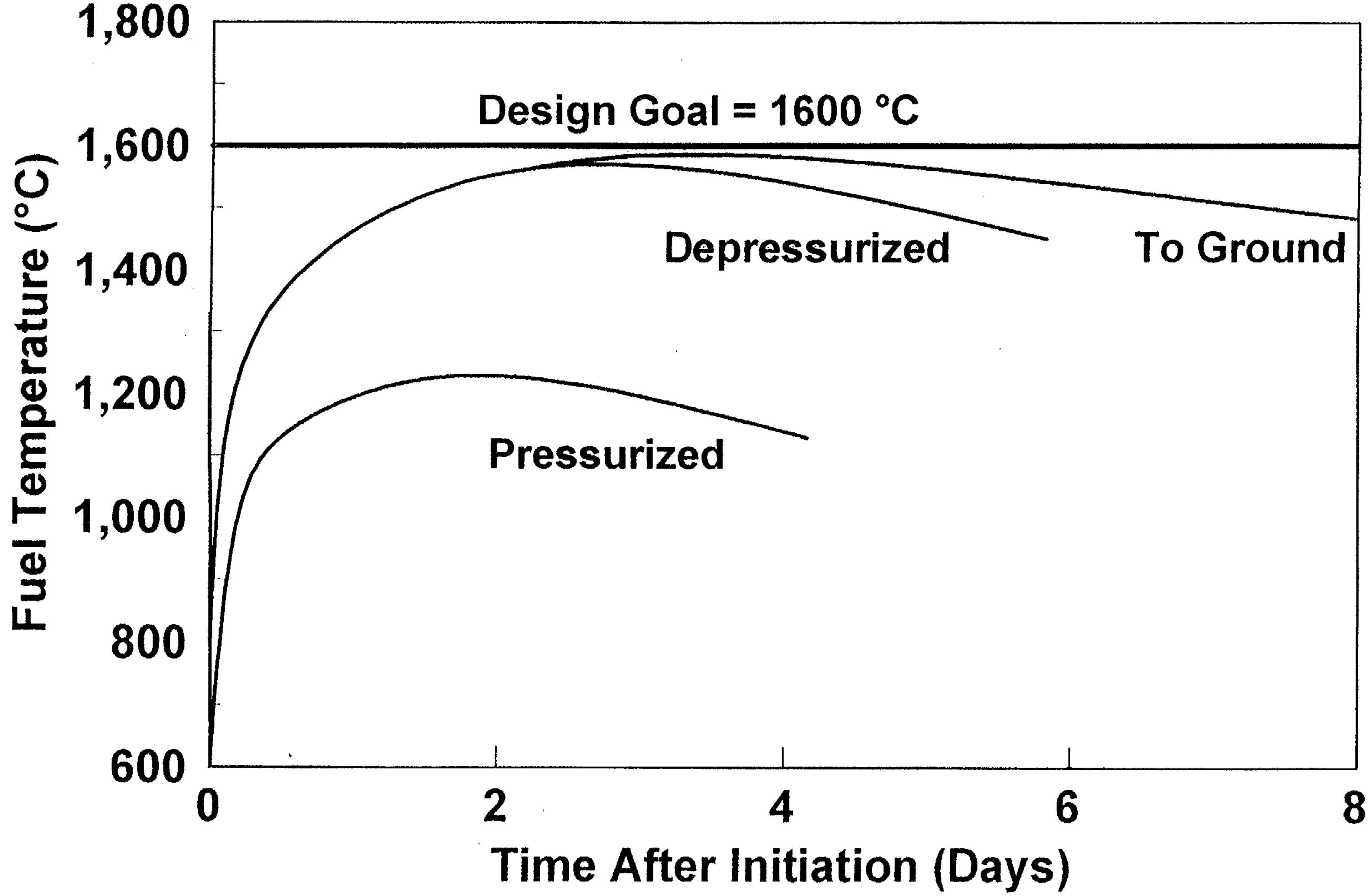
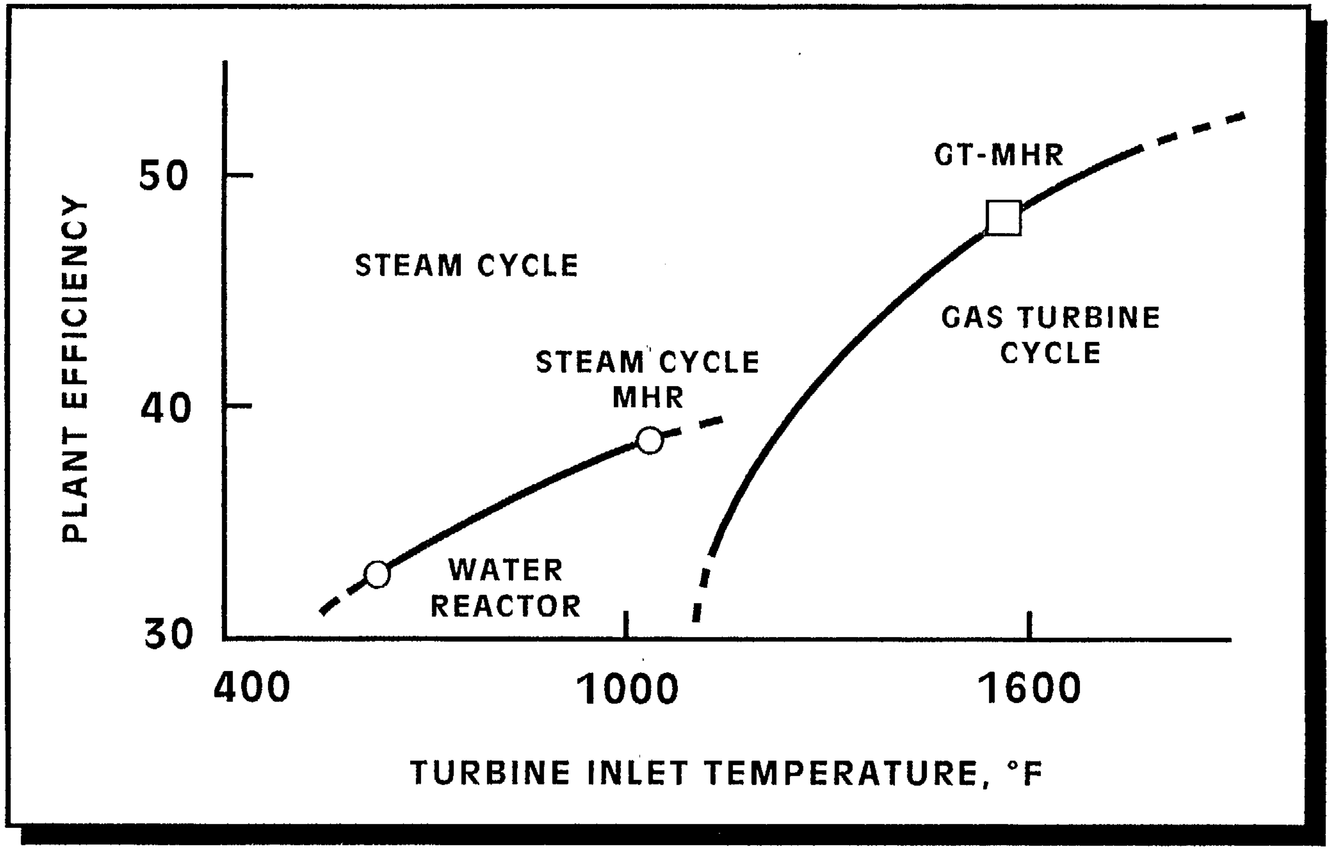
GENERAL ATOMICS

GT-MHR Fuel Temperatures Remain Below Design Limits During Conduction Cooldown Events



...Passive Design Features Ensure Fuel Remains Below 1600 °C

GAS REACTORS HAVE UNIQUE ABILITY TO USE BRAYTON CYCLE



...high temperatures mean high efficiency

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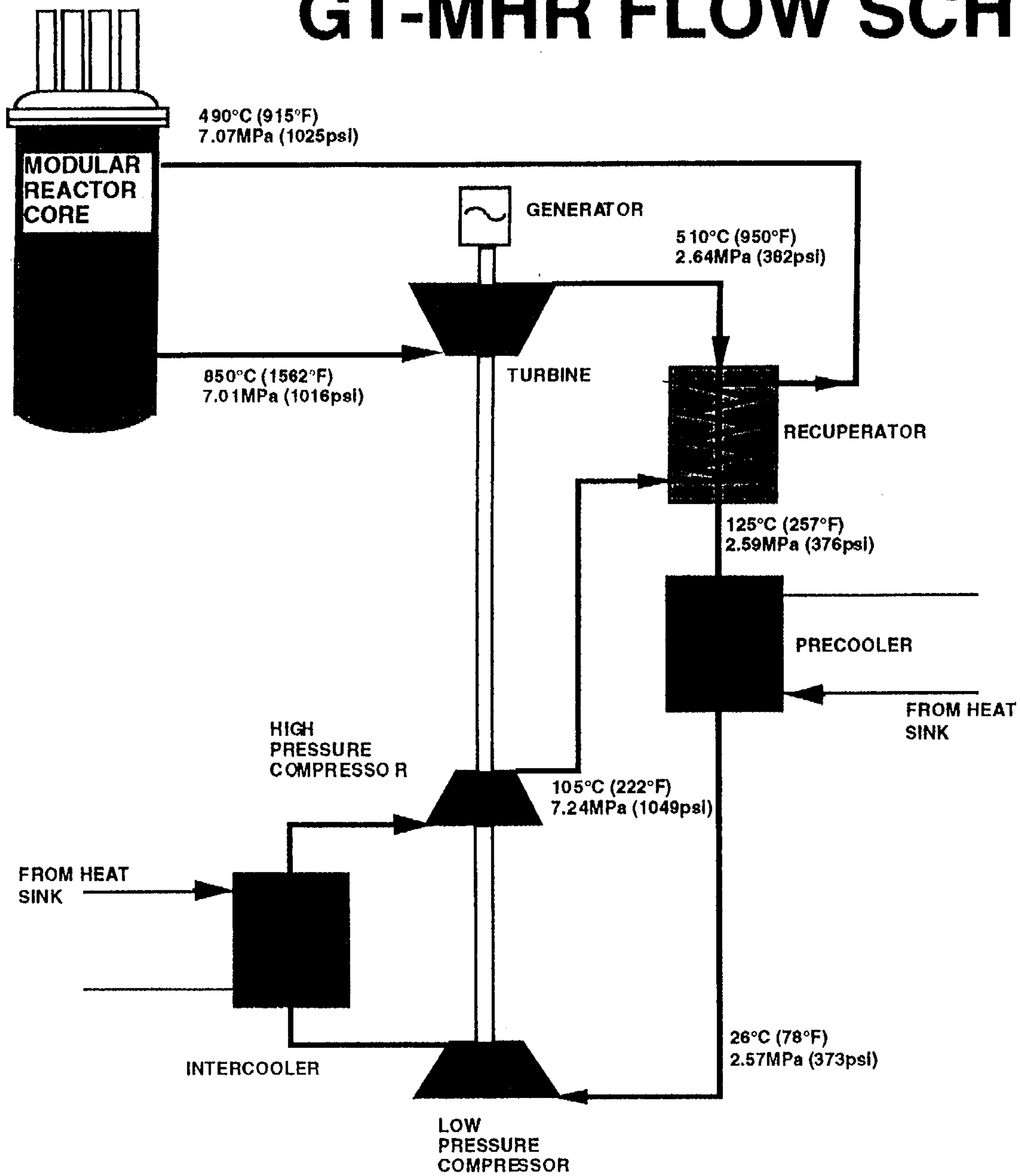
GENERAL ATOMICS

GT-MHR FLOW SCHEMATIC



GENERAL ATOMICS

AJN 8/2/94
HIRSCH

GA/Minatom Private GT-MHR Program

- April 1993: Minatom/GA MOU on joint GT-MHR development
- June 1994: Russia proposes to build GT-MHR at Seversk to burn Russian weapons grade plutonium
- July 1994: GA and Minatom each pledge $1M
- Feb. 1995: GA/Minatom Agreement - start of work
- Jan. 1996: Framatome joins GT-MHR program ($200K)
- Jan. 1997: Fuji Electric joins GT-MHR program ($200K)
- Dec. 1997: Team completes Conceptual Design
- Oct. 1998: GT-MHR becomes an option within the US/RF Pu Disposition Strategy

Participating Russian Organizations

ОКБМ

Experimental Machine Building Design Bureau (OKBM)

- Leading design organization

РНЦ "Курчатовский институт"

Kurchatov Institute (RRC-KI)

- Coordinate fuel and graphite related tasks

ВНИИНМ имени А.А.Бочвара

All-Russian Scientific Institute of Inorganic Materials (VNIINM)

- Design and develop plutonium kernel

Scientific Industrial Organization (SIA-Lutch)

- Design and develop fuel coating and fuel compacts

Siberian Chemical Complex (SCC)

- Provide site for GT-MHR, fuel fabrication and handling facility, and plan for spent fuel storage/disposal

Conceptual Design Sponsoring Organizations

Ministry of Atomic Energy, Russia

General Atomics, United States

Framatome, France

Fuji Electric, Japan

Why GT-MHR in Russia

- Superior Level of Reactor Safety
- High Plant Efficiency, Low Environmental Impact
- Used for both Heat and Electricity
- High Plutonium Destruction Without Recycle- Effective Use of Plutonium Energy Content
- Diversion and Proliferation Resistance
- Commercial Deployment Potential

GT-MHR Mission

- Design and deploy standard GT-MHR
- To burn weapon grade plutonium and generate electricity
- To provide replacement power at Seversk
- To ensure the highest level of safety and protection of the environment
- To be competitive on world-wide market for commercial electricity production with low enriched uranium

GT-MHR Conceptual Design Summary

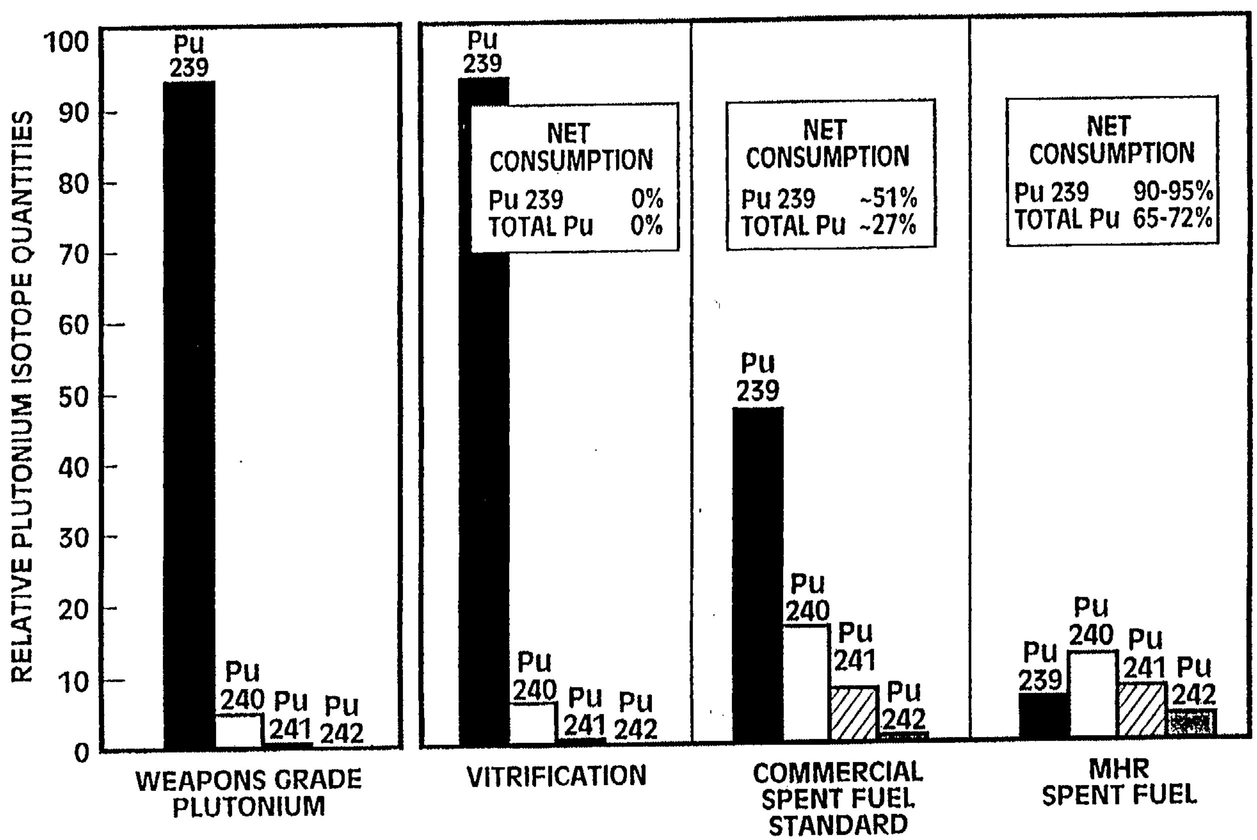
Accomplishments

- Established Design Requirements based on U.S., Russian and other International Requirements
- Transferred relevant technology to Russia
- Completed Conceptual Design of major plant systems
- Developed detail drawings of components
- Established Plant and Fuel Technology Development plans
- Developed design, development, construction and operation costs and schedule
- Initiated Key Development Tasks in Plant and Fuel Areas
- Documented Conceptual Design

GT-MHR MAIN TECHNICAL CHARACTERISTICS

- Thermal power, MW ____ 600
- Electricity generation efficiency, % ____ up to 48
- Helium temperature (inlet/outlet), °C ____ 490/850
- Core configuration ____ annular core consisting of prismatic graphite blocks
- Fuel ____ plutonium oxide
- Fuel type ____ coated fuel particles
- Initial plutonium load, kg ____ 750
- Pu-239 destruction level, % ____ ~90
- Annual plutonium consumption, kg/yr. ____ 250
- Quantity of weapons grade plutonium processed for reactor lifetime (60 years), t ____ 15
- Electricity output from 50 t. of weapons grade plutonium, GW(e).yr. ____ 46

THE GT-MHR ACHIEVES HIGH PU DESTRUCTION WITHOUT RECYCLE



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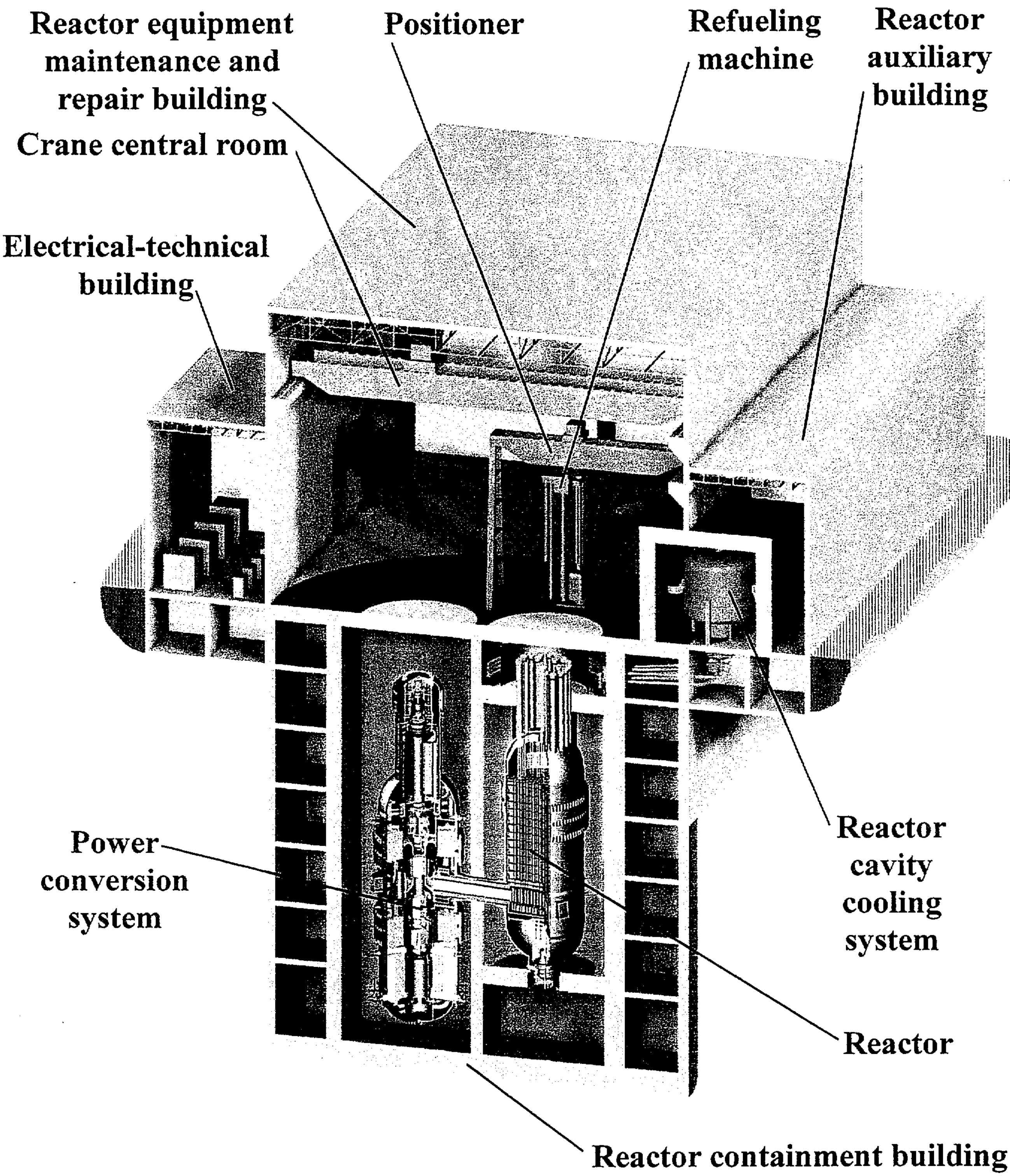
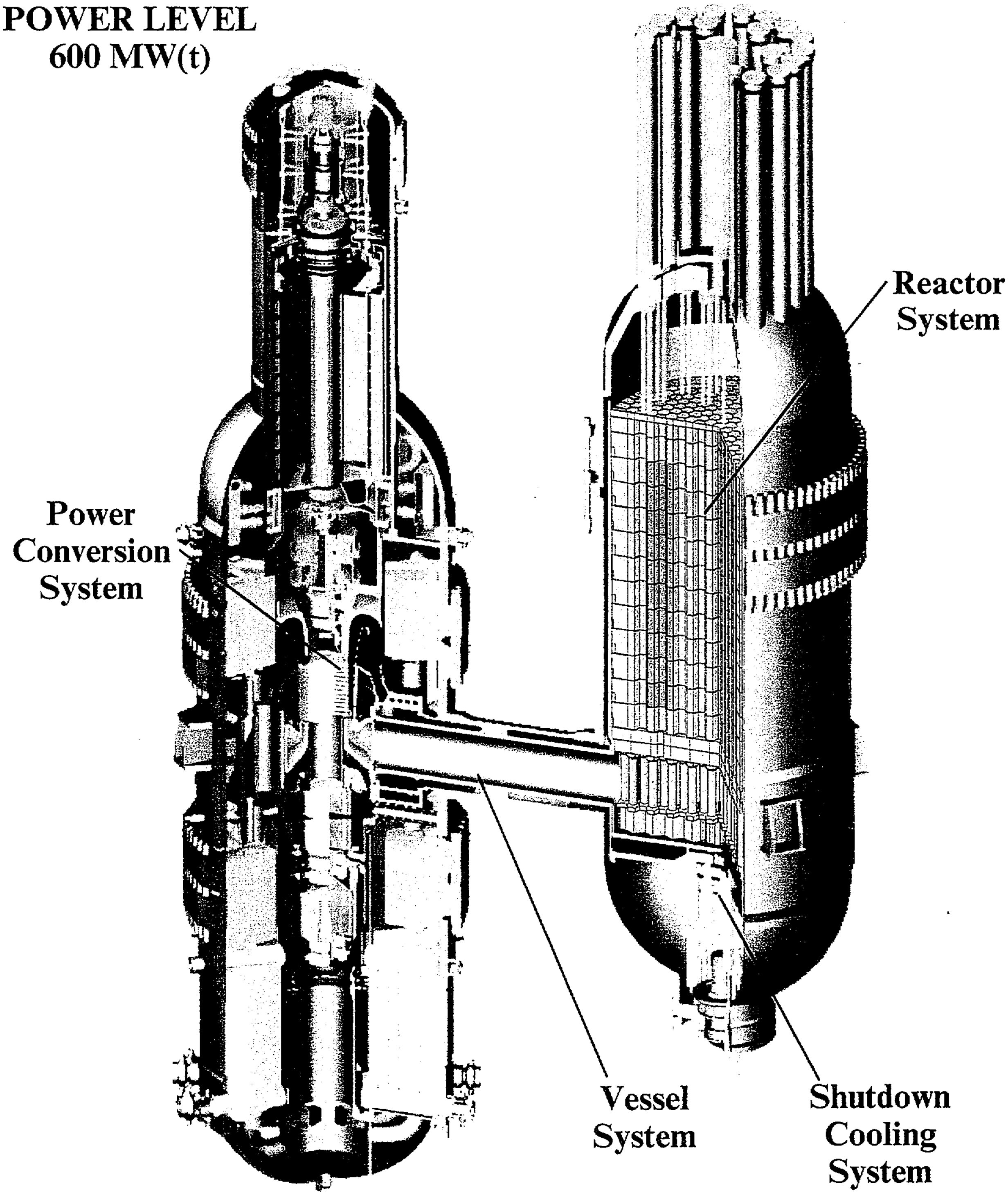
GENERAL ATOMICS

GT-MHR MODULE GENERAL ARRANGEMENT



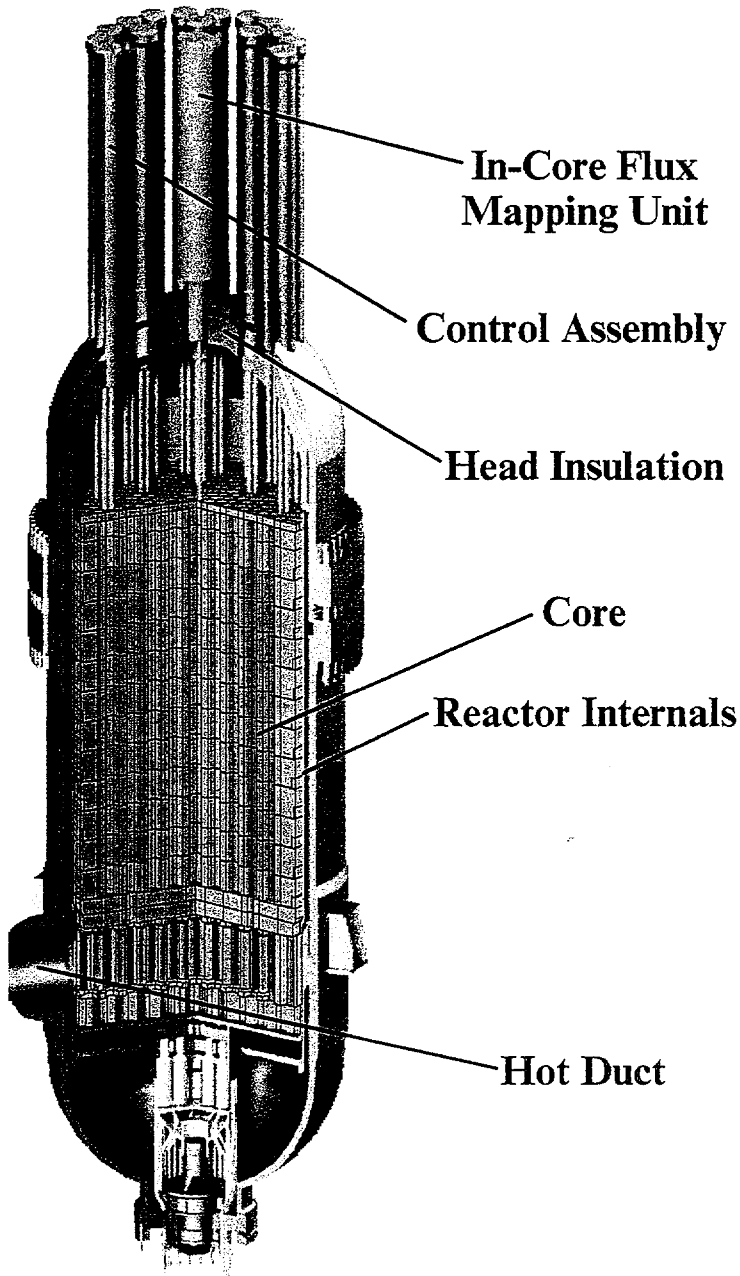
GT-MHR COMBINES MELTDOWN-PROOF ADVANCED REACTOR AND GAS TURBINE

- POWER LEVEL
  600 MW(t)



REACTOR SYSTEM

- Power Output 600 MW(t)
- Core Dimensions:
  - Equivalent Diameter Inner / Outer 2,96 m / 4,84 m
  - Height 8,0 m
- Average Power Density 6,5 MW/m^3
- Fuel-weapons Grade Plutonium
- Fuel Loading 701 kg of Plutonium



- Helium Gas Coolant (Inert)
- Refractory Fuel (High Temperature Capability)
- Graphite Reactor Core (High Temperature Stability)
- Inherent and Passive Safety Features
- Demonstrated Technologies
- Multiple Module Installations

...EFFICIENT, RELIABLE PERFORMANCE WITH INHERENT SAFETY

GT-MHR Conceptual Design Summary (Cont)

Fuel Development

- Developed uranium and plutonium fuel kernel fabrication technology at VNIINM 'Bochvar'. Produced 200g PuO_2 and 5kg UO_2 kernels within specifications
- Established TRISO coating capability at SIA-Lutch
- Developed compact fabrication technology and produced GT-MHR fuel compacts using graphite-filler and resin binder
- Designed bench-scale fuel fabrication line for remote fabrication of PuO_2 TRISO fuel particles and compacts
- Developed conceptual design of Fuel Fabrication Facility at SCC-Seversk to produce PuO_2 fuel
- Initiated laboratory work at SCC-Seversk to develop Fuel Fabrication Pilot Line for GT-MHR

Pu Fuel Irradiation Tests

Dragon Test Elements: (1965 - 1967)

• Test Elements ID	FE-434 and FE-437
• Kernel Diameter	300 microns
• Max. Irradiation Temp.	900 -1275 C
• Max. Burnup	747,000 MWd/MT
• Peak Fast Fluence	1.3 to 1.7 x 10^{25}n/m^2
• Irradiation Time	224 EFPD
• Gaseous Release	1.6 to 4.5 x 10^{-5}

Pu Fuel Irradiation Tests

Peach Bottom Test Elements: (1972 - 1974)

• Test Elements ID	FTE-13
• Kernel Diameter	110 to 220 microns
• Particle Diameter	338 to 573 microns
• Max. Irradiation Temp.	1440 C
• Max. Burnup	709,000 to 737,000 MWd/MT
• Peak Fast Fluence	$2.3 \times 10^{25} n/m^2$
• Irradiation Time	512 EFP

POWER CONVERSION SYSTEM

FUNCTIONS

- Convert termal energy to electrical one with high efficiency
- Provide GT-MHR startup, shutdown and its cooldown during normal operation and most accidents

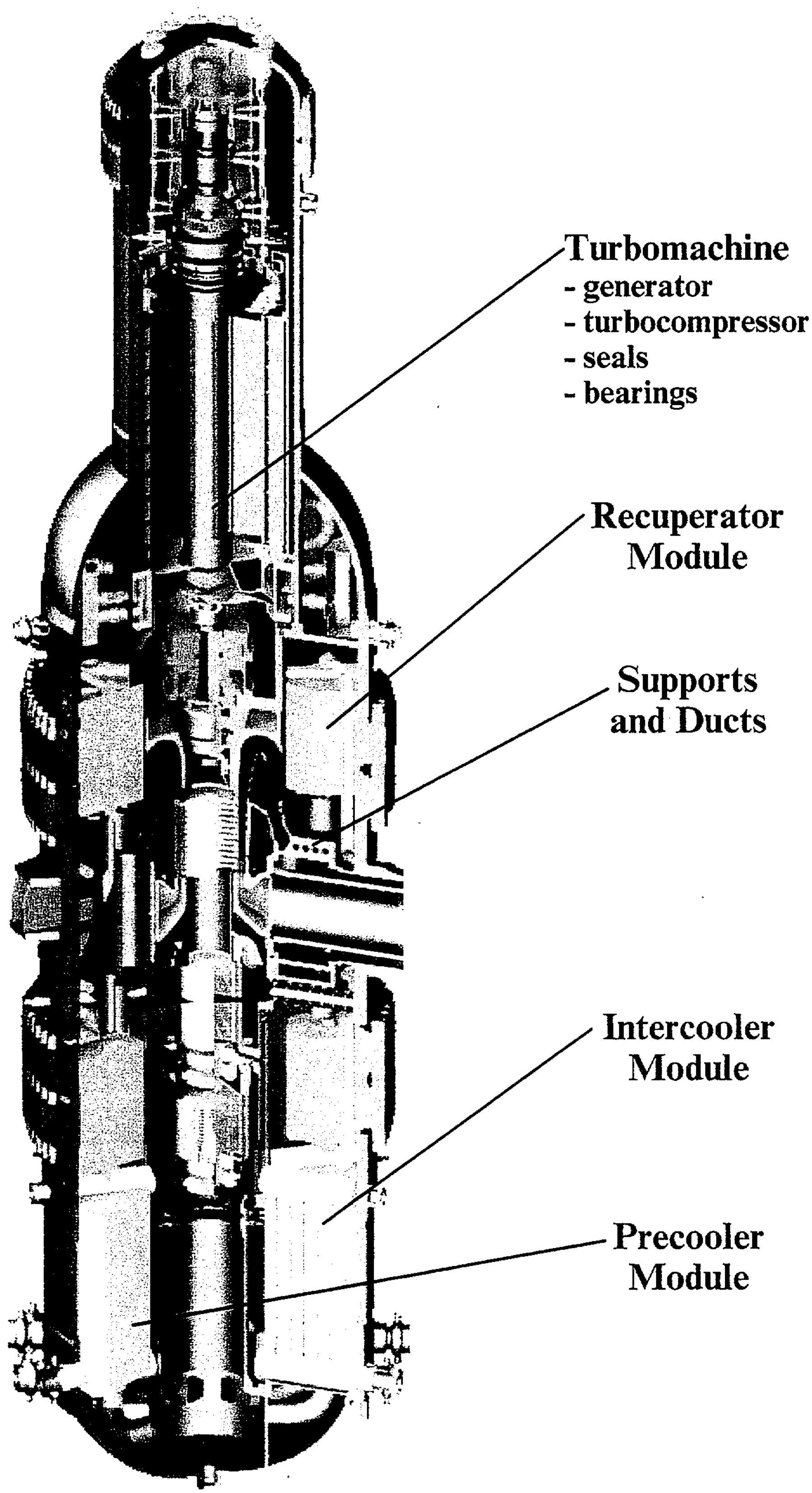
COMPOSITION

- Turbomachine
- Recuperator
- Intercooler and precooler
- Supports and ducts

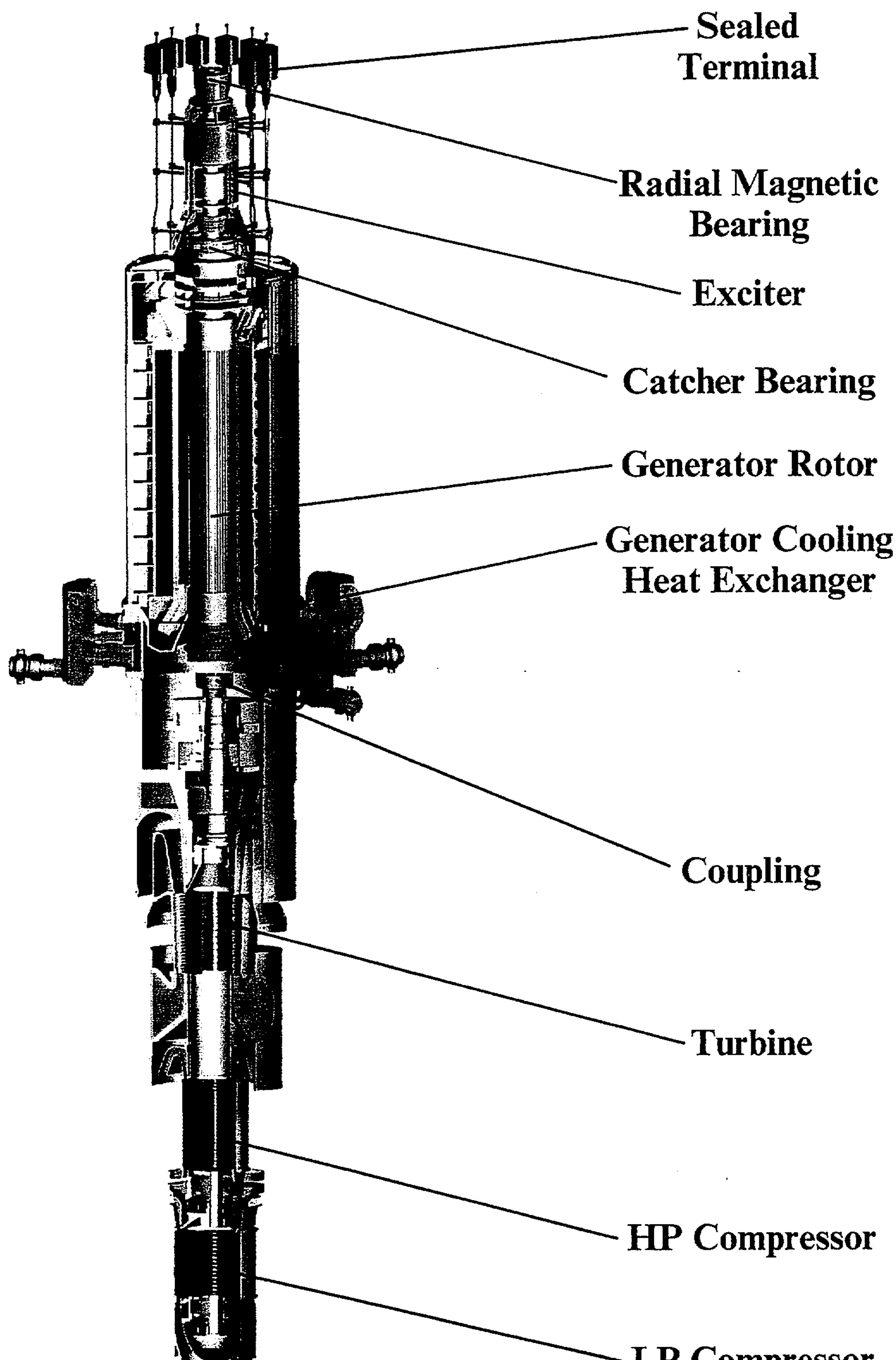
MAIN PCS CHARACTERISTICS

- Thermal power supplied to PCS, MW _______ 594,92
- Electric power at the generator terminals, MW _______ 285,24
- Power production efficiency, % _______ 47,54
- Current frequency, Hz _______ 50
- Voltage, kV _______ 20
- PCS inlet helium temperature, °C _______ 848,4
- PCS outlet helium temperature, °C _______ 487,9
- PCS inlet helium pressure, MPa _______ 7,07
- PCS outlet helium pressure, MPa _______ 7,16
- Helium flow rate through PCS, kg/s _______ 317,0
- Number of modules: recuperator / precooler / intercooler ____ 20 / 10 / 10

POWER CONVERSION SYSTEM

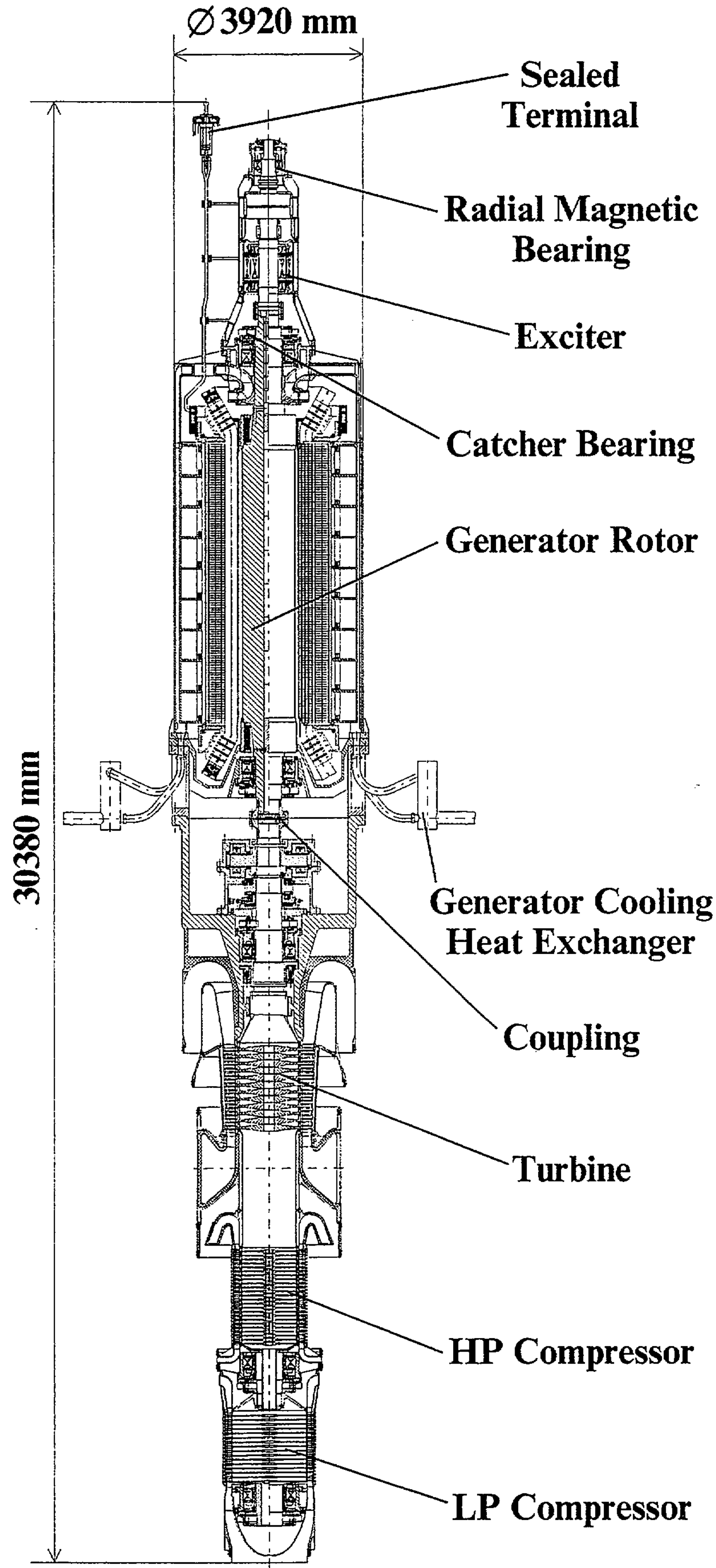


TURBOMACHINE

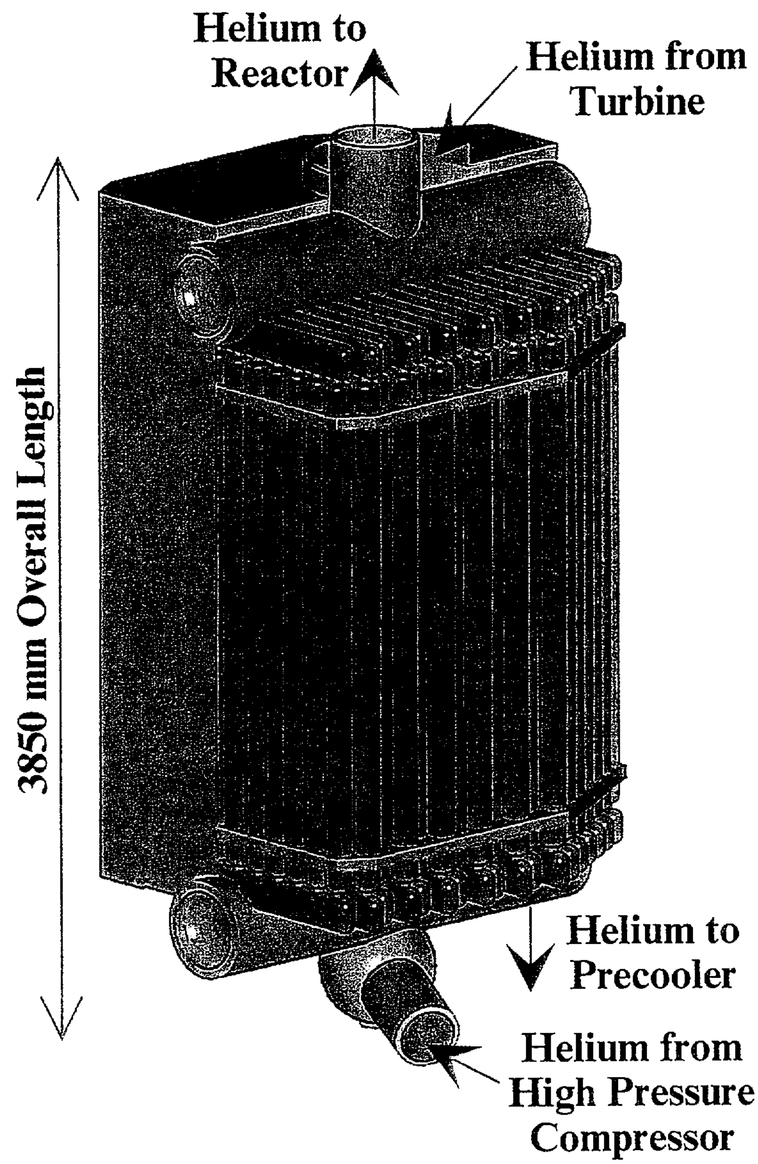


TURBOMACHINE

- Rotational Speed
  3000 rpm
- Number of Stades:
  - Turbine 12
  - HP Compressor 24
  - LP Compressor 16
- Mass 620 tons

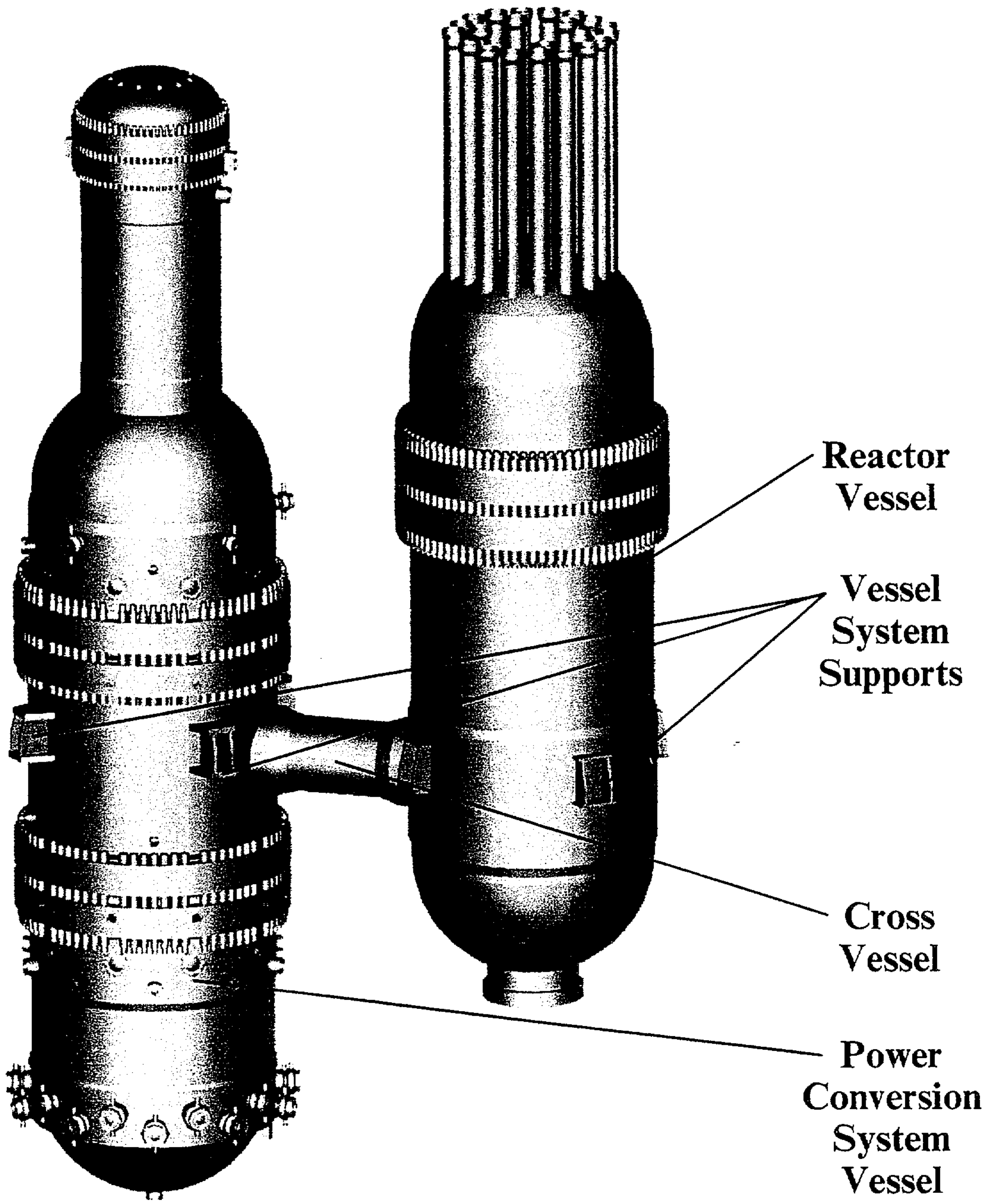


RECUPERATOR MODULE



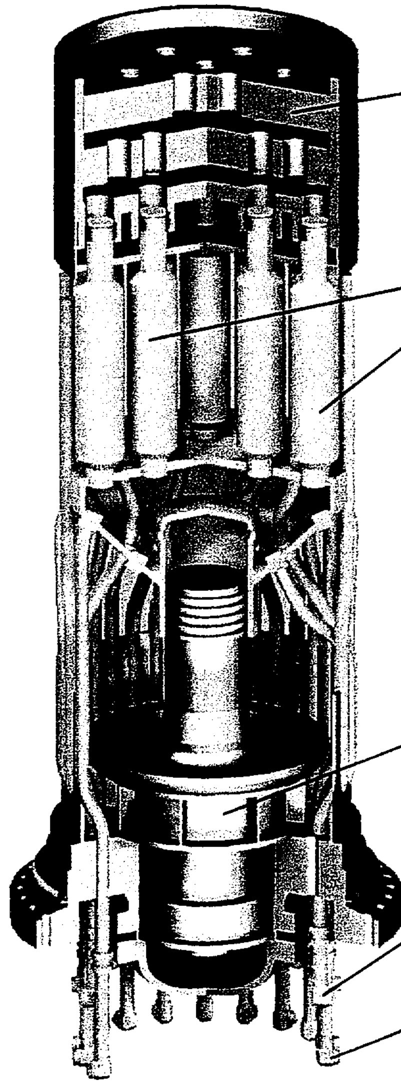
- Thermal Capacity 31,4 MW(t)
- Helium Parameters for Low / High Pressure Side:
  - Inlet 507,5 °C; 2,63 MPa / 108,1 °C; 7,22 MPa
  - Outlet 127,3 °C; 2,60 MPa / 487,5 °C; 7,15 MPa
  - Flow Rate 15,90 kg/s / 16,15 kg/s
- Design Heat Exchange Surface 3288 m^2
- Mass 17,9 tons

VESSEL SYSTEM



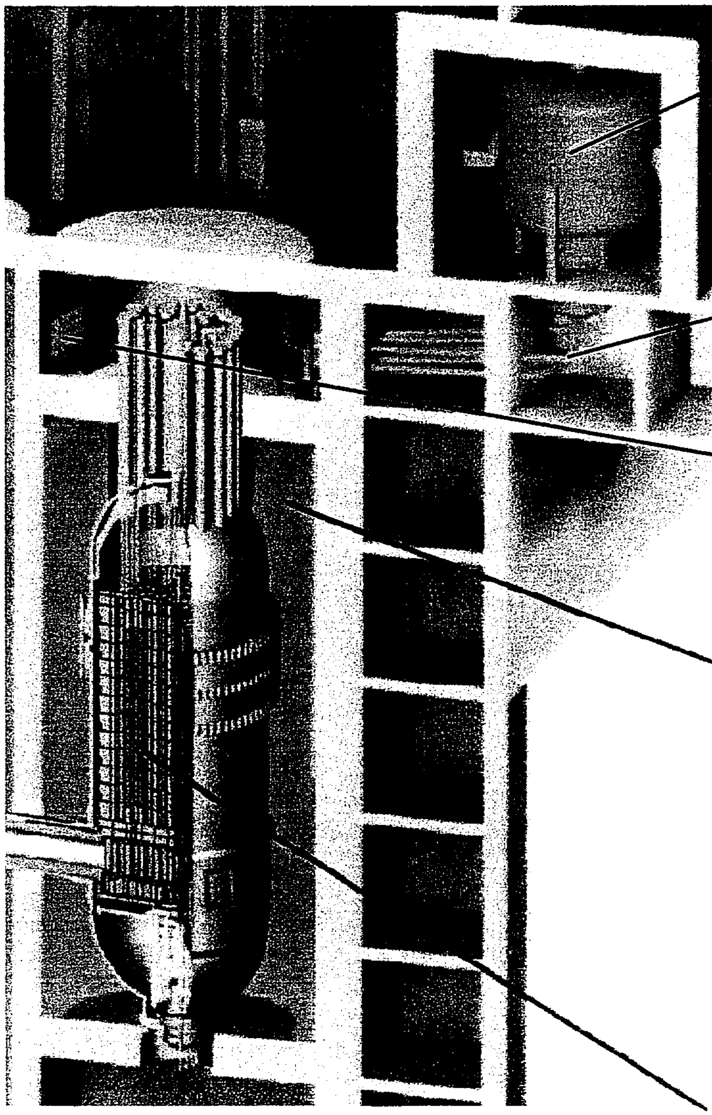
- Design Pressure 8,0 MPa
- Pressure of the Vessel System:
  - Hydraulic Test at the Site 12,6 MPa
  - Pneumatic Test During Operation 11,6 MPa
- Mass 3218 tons

SHUTDOWN COOLING SYSTEM



- Thermal Capacity 29,1 MW
- Helium / Cooling Water Parameters:
  - Inlet 666,2 °C; 5,52 MPa / 24,7 °C; 3,5 MPa
  - Outlet 106,2 °C; 5,519 MPa / 140,3 °C; 3,2 MPa
  - Flow Rate 10 kg/s / 60 kg/s
- Design Heat Exchange Surface 150 m^2
- Mass 40 tons

REACTOR CAVITY COOLING SYSTEM



- Number of RCCS Channels 2
- Thermal Power Removed by RCCS 4 MW
- Water Temperature at the Surface Cooler:
  - Inlet 27°C
  - Outlet not more than 90°C
- Pressure in Heat Exchanger-Evaporators 0,1 MPa
- Mass 240 tons

GT-MHR Design Reviews

• Internal Design Review	Dec. 1997	Program Participants
• Independent Design Review	Jan. 1998	OKBM Independent experts
• External Design Review	April 1998	Institute of Power Engineering
• RF Design Review	Sept. 1998	Russian Academy of Sciences, Moscow
• Minatom Review	Oct. 1999	Minatom Council
• International Design Review	June 1999	Independent International Reviewers

International GT-MHR Design Review Conclusions

- Bold and innovative nuclear power concept
- No readily apparent technical show stoppers
- Willing "Customer" with good site for Demo.
- Builds on cumulative international experience
- Pools limited international resources
- Supports "Swords to Plowshares" goals
- Much lower cost for RD & E and Demo.

Current Sponsoring Organizations

МИНАТОМ
РОССИЯ

Ministry of Atomic Energy, Russia

Department of Energy, USA

US-DOE GT-MHR Requirements

Plutonium Disposition

- Prototype in operation by 2009

- Capable of having first 4-module GT-MHR plant in operation by 2012 - 2015

- Disposition capacity up to 2MT/yr (250kg Pu/yr per module)

Start of Preliminary Design

U.S. Government Support for GT-MHR

- Congress authorized $5M each for FY 1999 and FY 2000
  - $3M for work in Russia
  - $2M for work in U.S. (GA, ORNL)

- Russian matching funds or in-kind contributions required

- Future support contingent on
  - U.S./Russian agreement on WPu disposition
  - Cost sharing from other countries and/or private sources

GT-MHR Overall Strategy

- Use existing world-wide Gas-Cooled Reactor Technology to the maximum extent possible
- Design and develop remaining GT-MHR Technology in Russia
- Construct/demonstrate GT-MHR by building and operating Prototype Module at SCC
- Build and operate several four-module GT-MHR plants to burn weapons grade plutonium
- Use GT-MHR Design and Technology for commercial applications using uranium fuel

United States
Nuclear Regulatory Commission

ADVANCED REACTOR DESIGN REVIEWS

- **Pre-application Design Reviews under NRC's Advanced Reactor Policy Statement [51 *FR* 24643]**

- **Preliminary or Final Design Reviews under Appendix O of 10 CFR Part 52**

- **Standard Design Certification Reviews under Subpart B of 10 CFR Part 52**

Enclosure 3