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

May 10, 2001

NOTE TO: Isabelle Schoenfeld

FROM: Tom King, RES T. King

SUBJECT: BACKGROUND MATERIAL ON THE GAS TURBINE-MODULAR HELIUM REACTOR (GT-MHR) FOR THE CHAIRMAN'S MAY 22, 2001 MEETING WITH REPRESENTATIVES FROM GENERAL ATOMIC (GA)

Your e-mail of May 2, 1001, requested background information for the Chairman to support the subject meeting. Enclosed is a copy the GT-MHR handout GA representatives gave us at the Regulatory Information Conference in March 2001. It provides an overview of the design and the commercialization schedule. Based upon discussions with GA representatives, they would like to have pre-application interactions with NRC in 2002 and 2003 to support preparation of a safety analysis report on the design and application in 2004.

The GT-MHR design is based upon the GA work (funded by DOE) to develop a HTGR for plutonium disposition. It is a joint program with the Russians (Kurchatov Institute, Minatom and others) and the plant for plutonium disposition would be built in Russia. GA has decided to pursue commercialization of this design in the U.S., using a uranium fueled core in lieu of plutonium. The GT-MHR is an evolution from the GA designed modular HTGR (MHTGR) design that we reviewed (pre-application) beginning in the mid-1980s. This design was also sponsored by DOE.

A draft SER was issued in 1989 on the MHTGR design (NUREG-1338), but a final SER was never issued because the program was canceled. Key characteristics of the two designs are listed below:

	MHTGR	GT-MHR
• Size	350 Mwt 137 Mwe	600 Mwt 288 Mwe
• Fuel	TRISO coating UCO fuel Kernal prismatic fuel blocks 19.9% enrichment (blended with TRISO coated natural UCO)	TRISO coating UCO fuel Kernal prismatic fuel blocks 19% enrichment (blended with TRISO coated natural UCO)
• Core	annular	annular

O-1

TAB C12

•	Temperatures:		
	– core inlet	260°C	498°C
	– core outlet	690°C	858°C
•	Decay Heat Removal	passive air	passive air
•	Power Conversion	steam cycle	in line helium turbine

Attachment: GT-MHR Handout

cc: A.Thadani (w/o attachment)
R.Zimmerman " "
J. Flack " "

GAS TURBINE - MODULAR HELIUM REACTOR (GT-MHR)

COMMERCIALIZATION PROGRAM BRIEFING

March 2001

GENERAL ATOMICS

GAS TURBINE - MODULAR HELIUM REACTOR (GT-MHR)

COMMERCIALIZATION PROGRAM BRIEFING

- PLANT DESCRIPTION
- PROGRAM DESCRIPTION

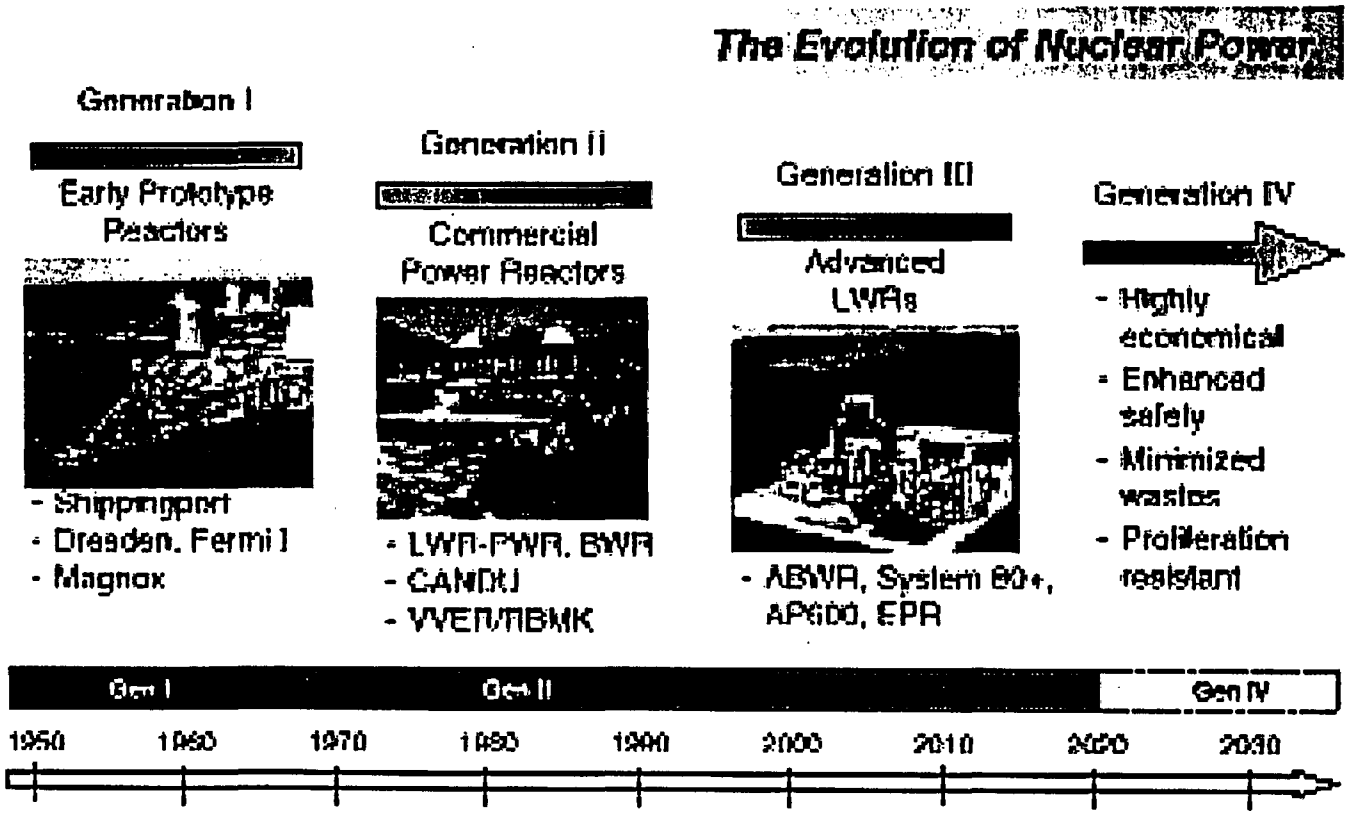
GENERAL ATOMICS

GT-MHR COMMERCIALIZATION PROGRAM

PLANT DESCRIPTION

GENERAL ATOMICS

Nuclear Power Generation IV Initiative

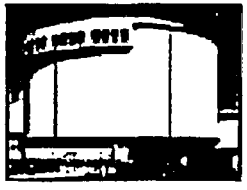


U.S. AND EUROPEAN TECHNOLOGY BASES FOR MODULAR HIGH TEMPERATURE REACTORS

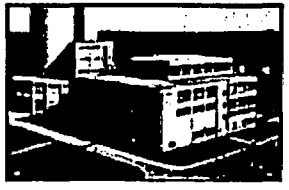
BROAD FOUNDATION OF HELIUM REACTOR TECHNOLOGY

EXPERIMENTAL REACTORS

DEMONSTRATION OF BASIC HTGR TECHNOLOGY



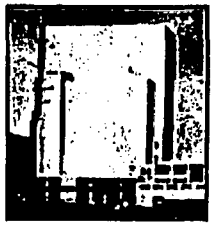
DRAGON
(U.K.)
1963 - 76



AVR
(FRG)
1967 - 1988

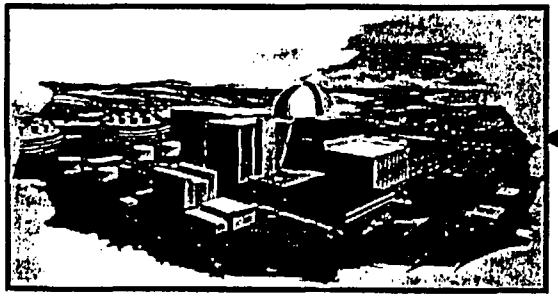
PEACH BOTTOM 1
(U.S.A.)
1967 - 1974

FORT ST. VRAIN
(U.S.A.)
1976 - 1989



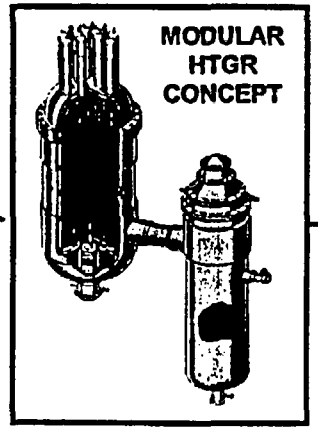
THTR
(FRG)
1986 - 1989

LARGE HTGR PLANTS

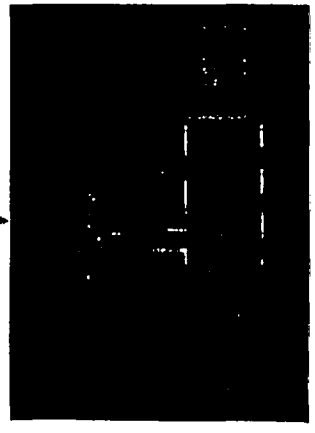


HTGR TECHNOLOGY PROGRAM

- MATERIALS
- COMPONENTS
- FUEL
- CORE
- PLANT TECHNOLOGY

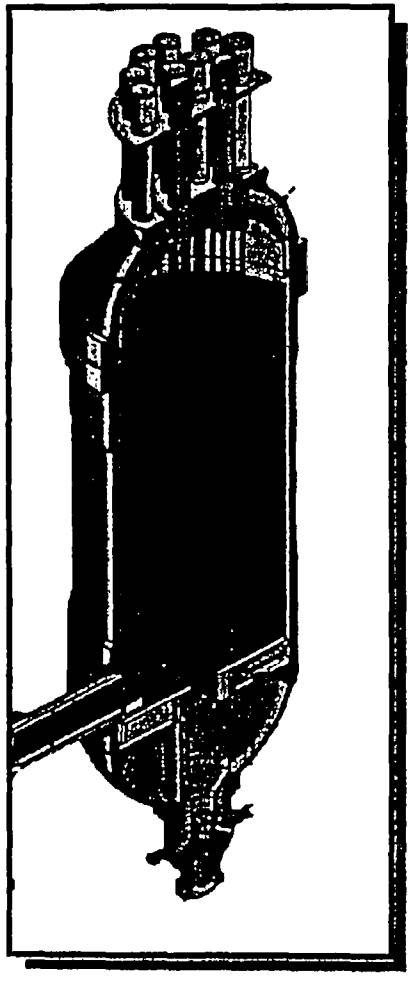


GT-MHR



GENERAL ATOMICS

MODULAR HELIUM REACTOR CHARACTERISTICS ATTRACTIVE FOR GEN IV GOALS



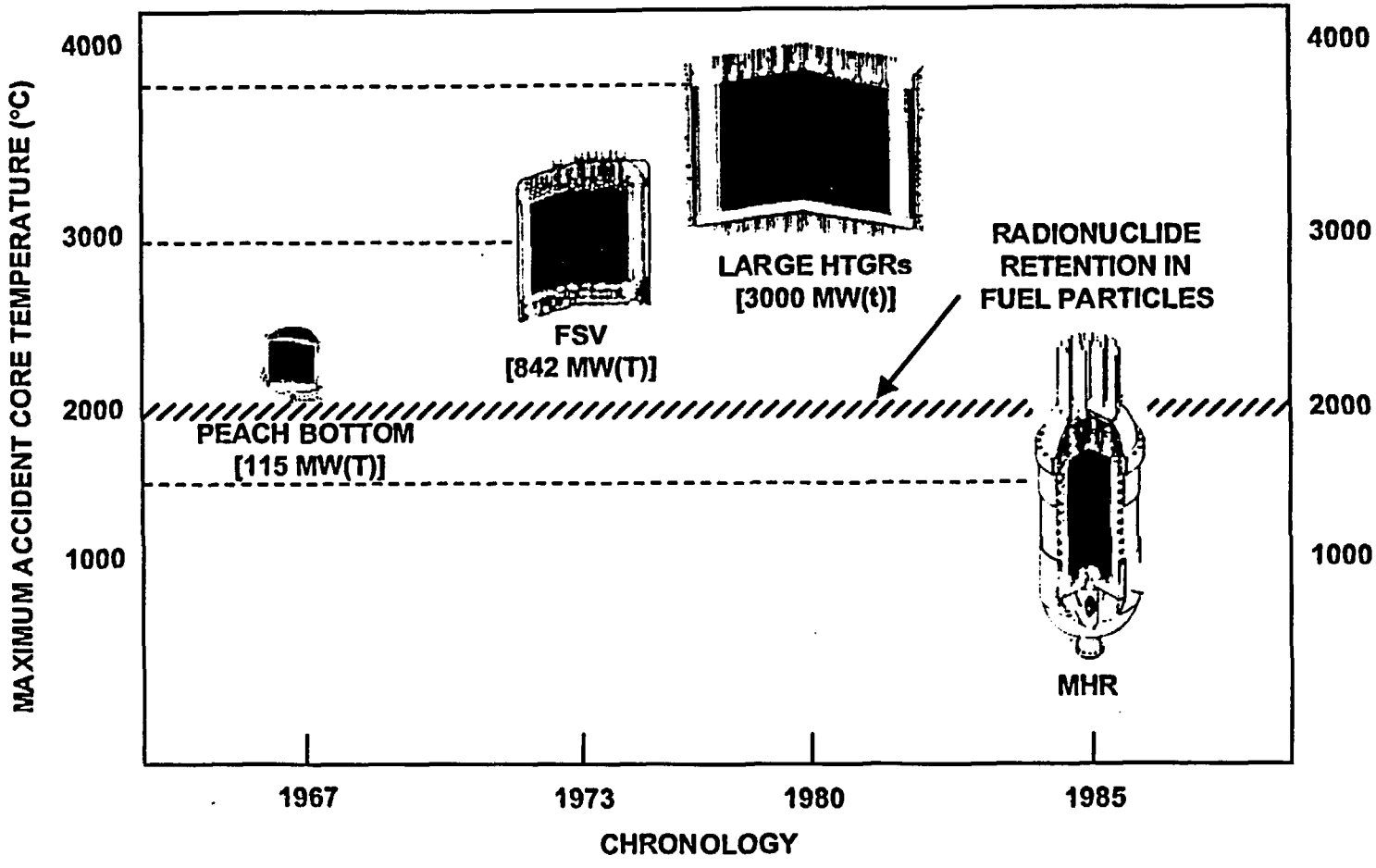
- Helium gas coolant (inert)
- Refractory fuel
  (high temperature capability)
- Graphite reactor core
  (high temperature stability)
- Low power density (order of magnitude lower than LWRs)
- Demonstrated technologies

. . . EFFICIENT, RELIABLE PERFORMANCE WITH INHERENT SAFETY

GENERAL ATOMICS

L-271(3)
6-6-95

MODULAR HELIUM REACTOR REPRESENTS A FUNDAMENTAL CHANGE IN REACTOR DESIGN AND SAFETY PHILOSOPHY

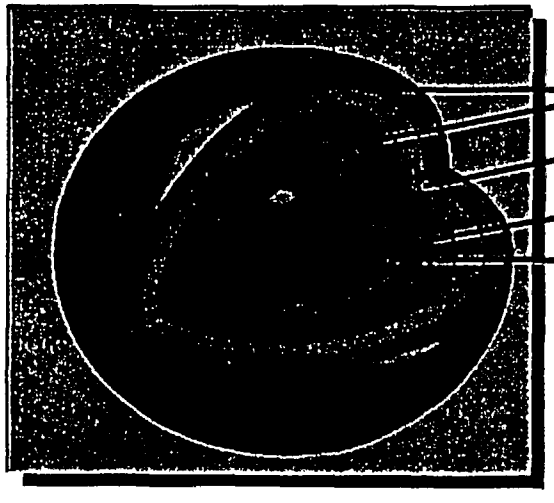


...SIZED AND CONFIGURED TO TOLERATE EVEN A SEVERE ACCIDENT

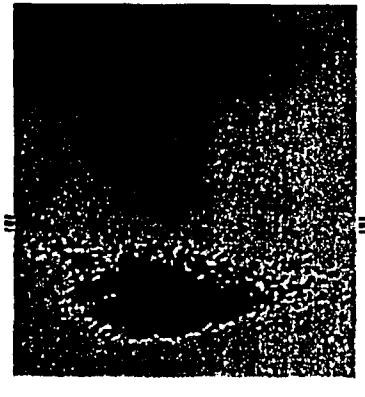
GENERAL ATOMICS

I-222(1)
1-12-96

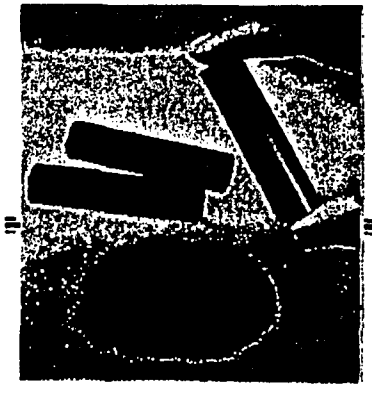
CERAMIC FUEL RETAINS ITS INTEGRITY UNDER SEVERE ACCIDENT CONDITIONS



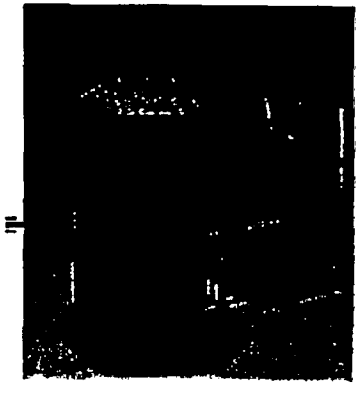
TRISO Coated fuel particles (left) are formed into fuel rods (center) and inserted into graphite fuel elements (right).



PARTICLES



COMPACTS

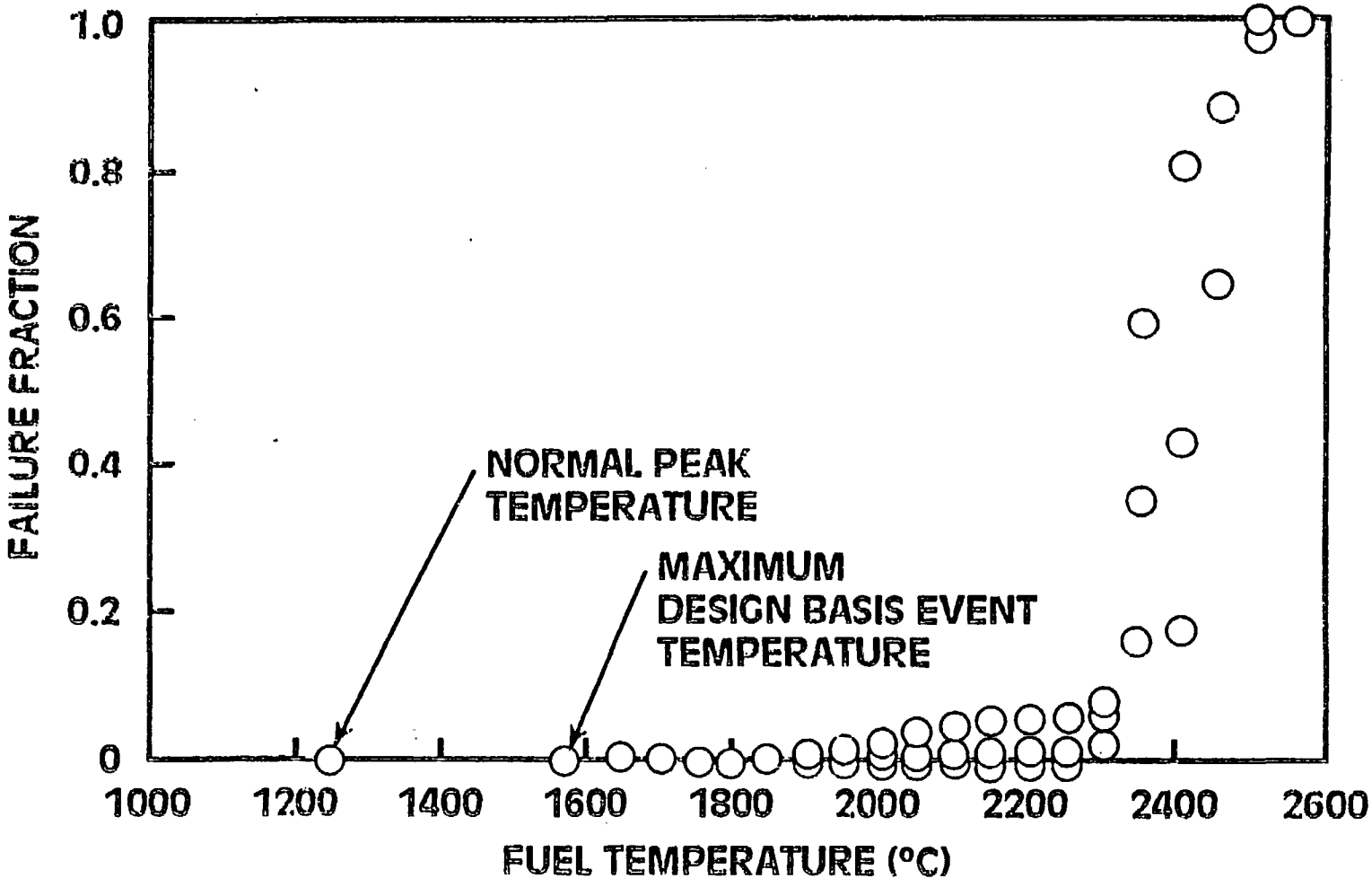


FUEL ELEMENTS

GENERAL ATOMICS

L-029(5)
4-14-94

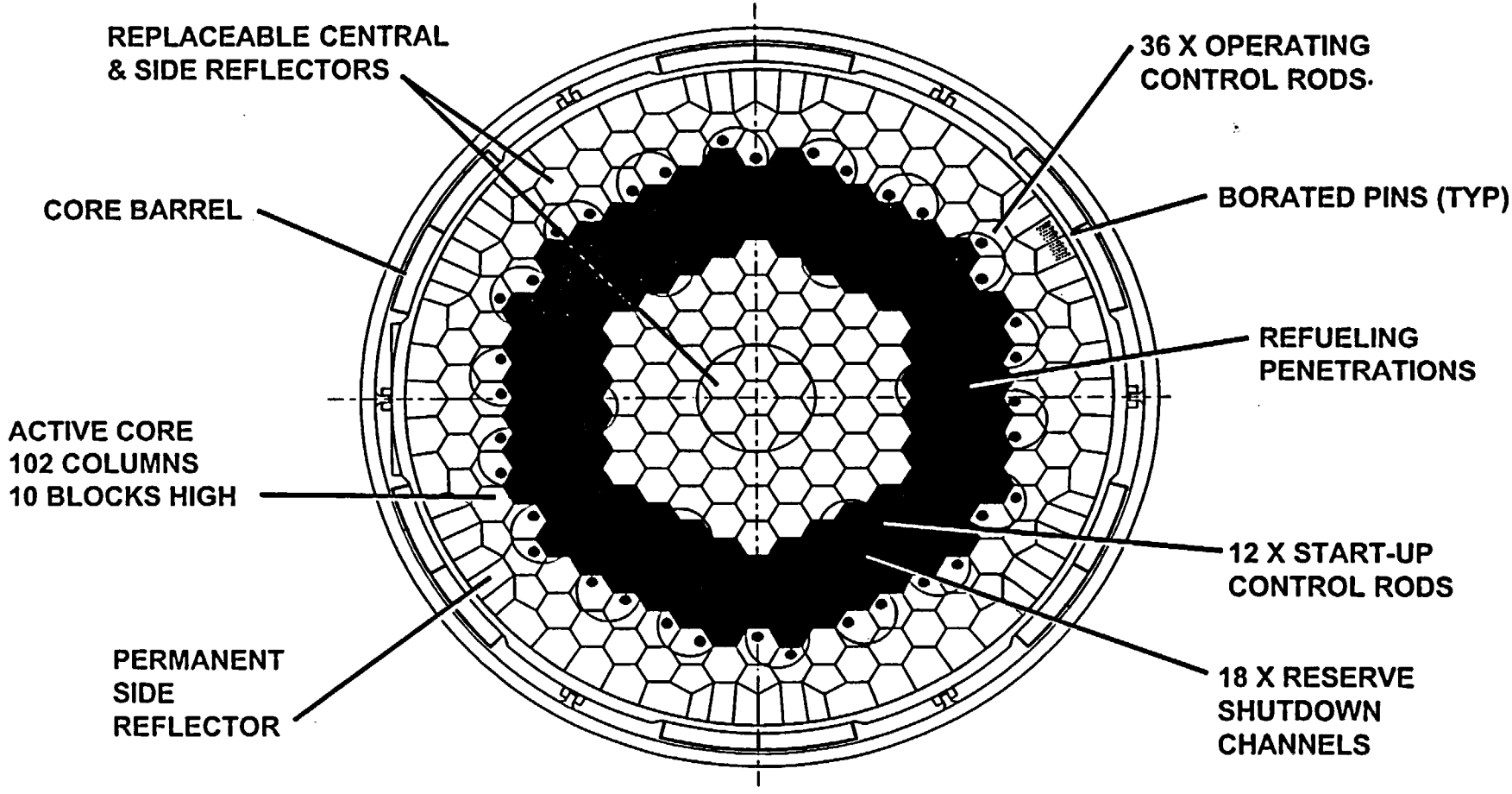
COATED PARTICLES STABLE TO BEYOND MAXIMUM ACCIDENT TEMPERATURES



GENERAL ATOMICS

L-266(1)
7-28-94
W-9

ANNULAR REACTOR CORE LIMITS FUEL TEMPERATURE DURING ACCIDENTS

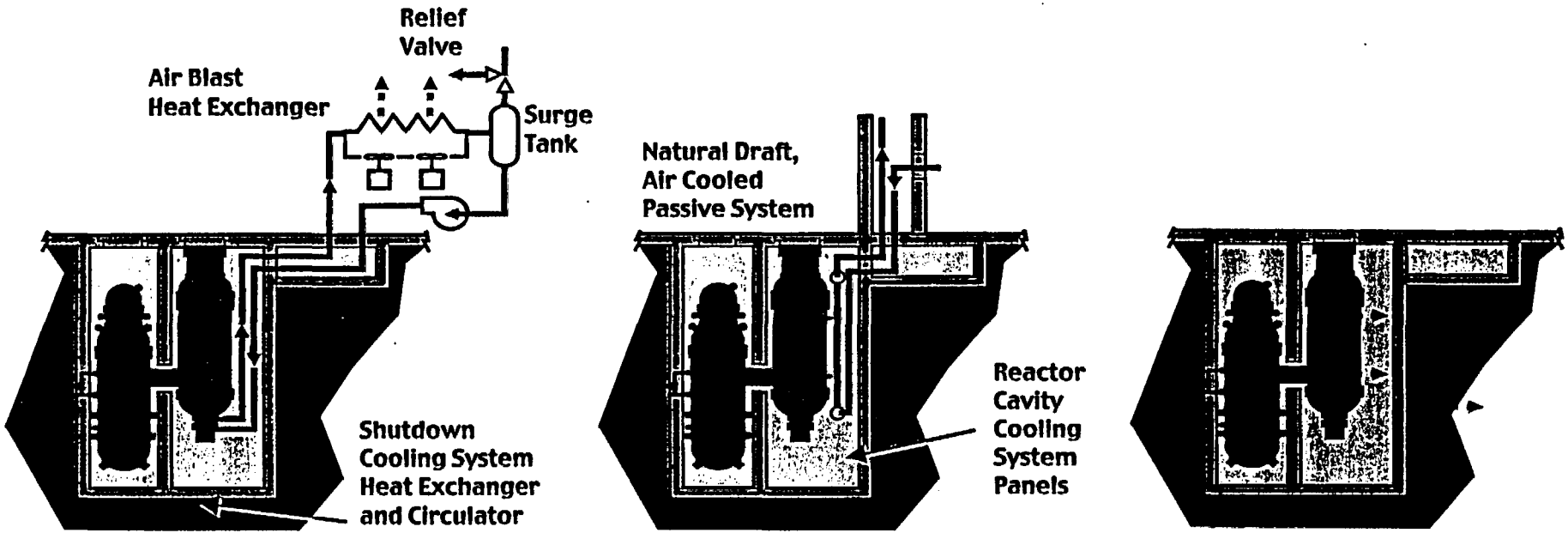


. . . ANNULAR CORE USES EXISTING TECHNOLOGY

GENERAL ATOMICS

L-199(10)
6-9-95

POSSIBLE DECAY HEAT REMOVAL PATHS WHEN NORMAL POWER CONVERSION SYSTEM IS UNAVAILABLE



A) Active Shutdown Cooling System

B) Passive Reactor Cavity Cooling System

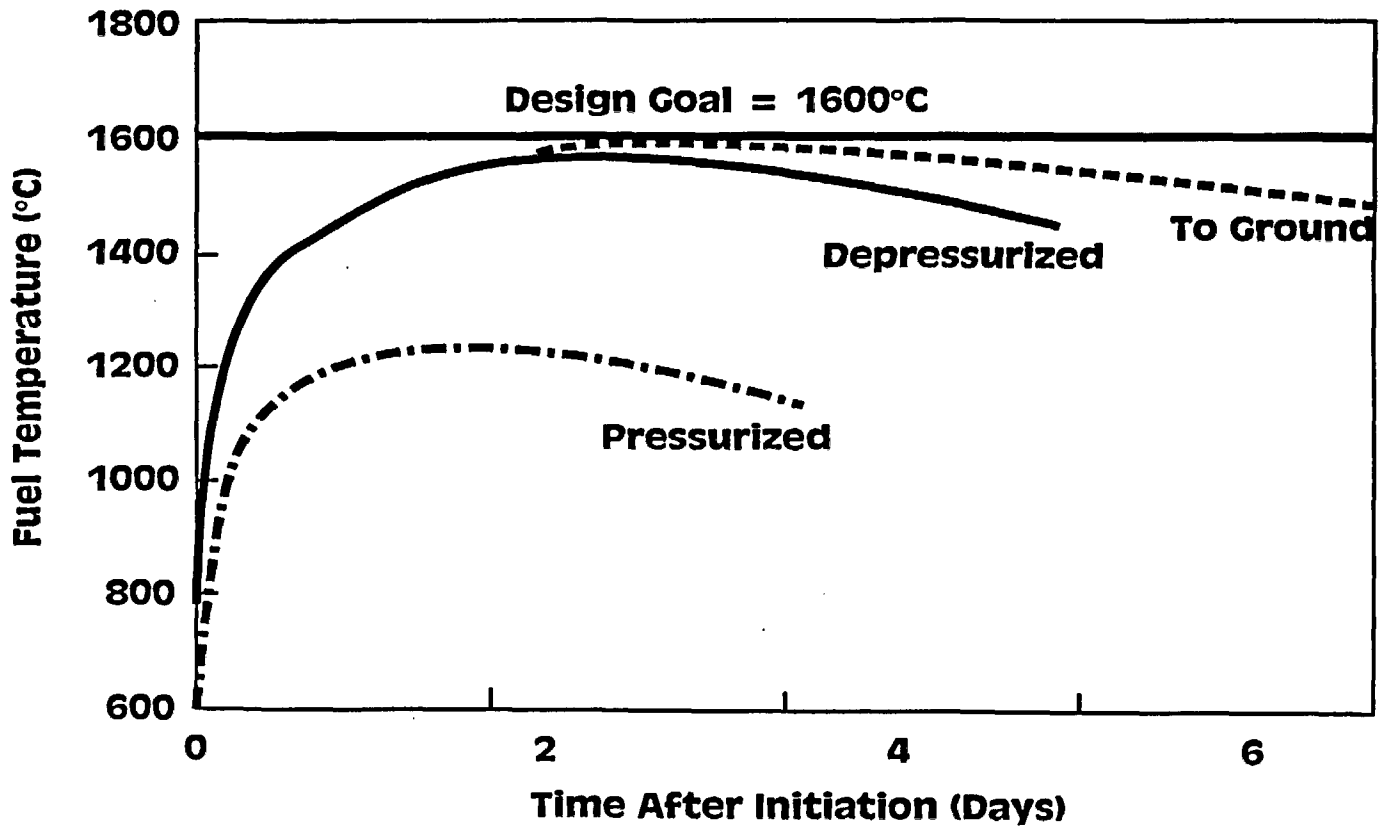
C) Passive Radiation and Conduction of Afterheat to Silo Containment (Beyond Design Basis Event)

. . . DEFENSE-IN-DEPTH BUTTRESSED BY INHERENT CHARACTERISTICS

GENERAL ATOMICS

L-266(2)
7-28-94

FUEL TEMPERATURES REMAIN BELOW DESIGN LIMITS DURING LOSS OF COOLING EVENTS



. . . PASSIVE DESIGN FEATURES ENSURE FUEL REMAINS BELOW 1600°C

GENERAL ATOMICS

L-340(3)
11-16-94

PASSIVE SAFETY BY DESIGN

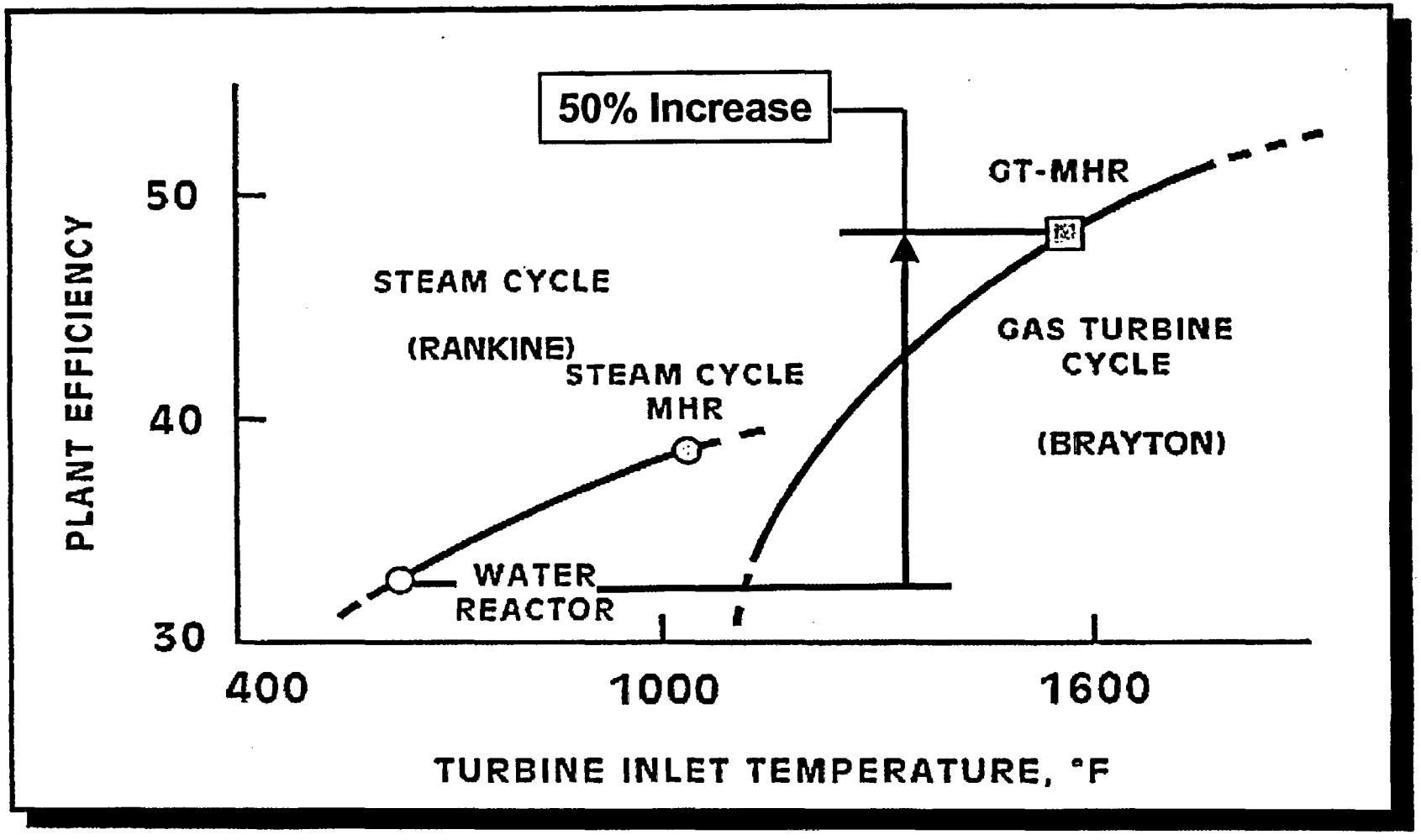
- **Fission Products Retained in Coated Particles**
  - *High temperature stability materials*
  - *Refractory coated fuel*
  - *Graphite moderator*

- **Worst case fuel temperature limited by design features**
  - *Low power density* 4.7 w/cc Nat'l U + 19% enriched U
  - *Low thermal rating per module*
  - *Annular Core*
  - *Passive heat removal* ***....CORE CAN'T MELT***

- **Core Shuts Down Without Rod Motion**

GENERAL ATOMICS

HIGH TEMPERATURE GAS REACTORS HAVE UNIQUE ABILITY TO USE BRAYTON CYCLE



GENERAL ATOMICS

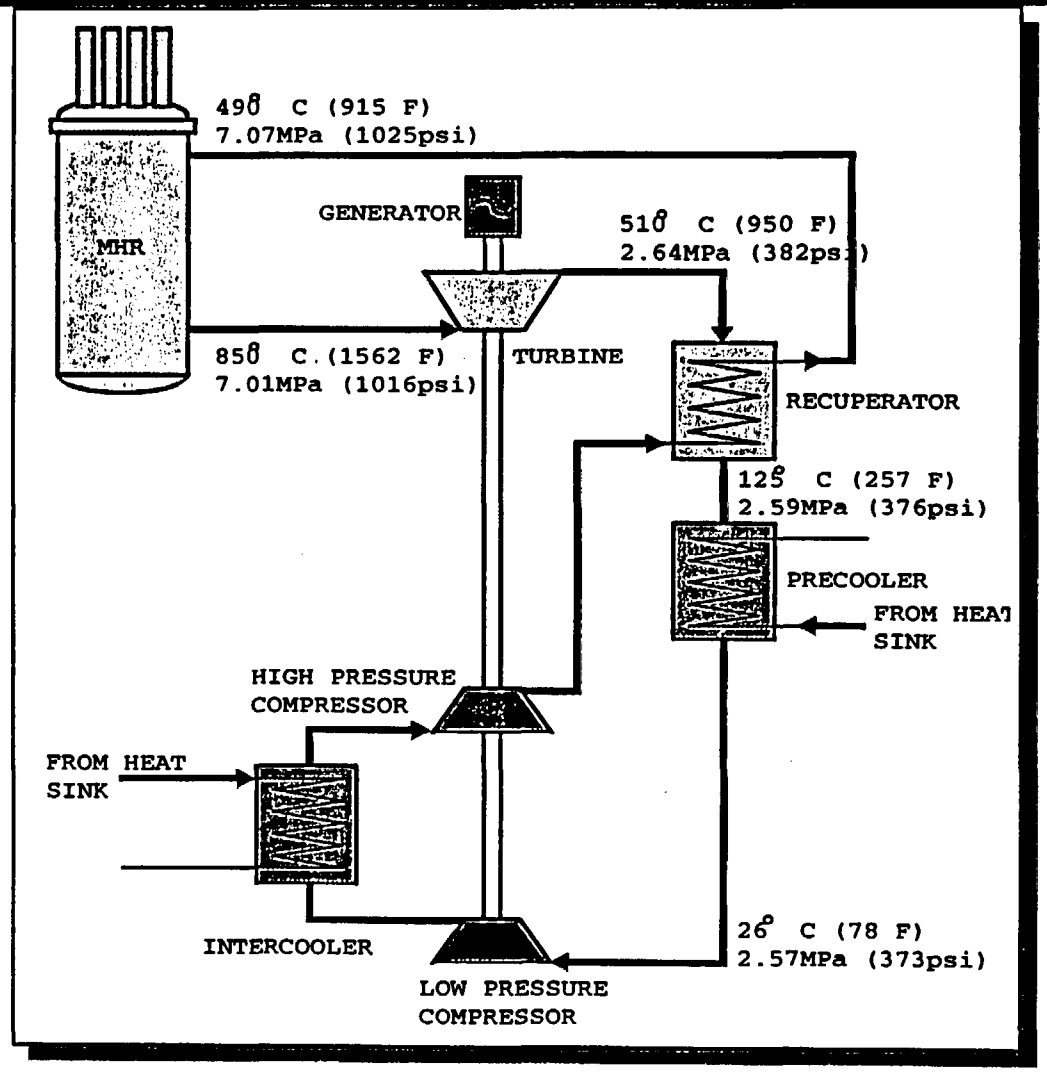
L-029(4)
6-9-94

TECHNOLOGY ADVANCEMENTS HAVE ENABLED THE GT-MHR

- Small Passively Safe Modular Helium Reactor
  - *turbine size requirements reduced*
  - *insensitive to turbine failure accidents*
- Large Gas Turbine Engines
  - *significant increase in industrial applications*
  - *size now match modular reactor size*
- Magnetic Bearings
  - *eliminates oil ingress concerns*
  - *improves performance and reliability*
  - *rapidly increasing industrial experience; larger sizes*
- Compact Heat Exchangers
  - *dramatically improves efficiency*
  - *size improves design integration*
  - *extensive fossil operating experience*

GENERAL ATOMICS

GT-MHR FLOW SCHEMATIC



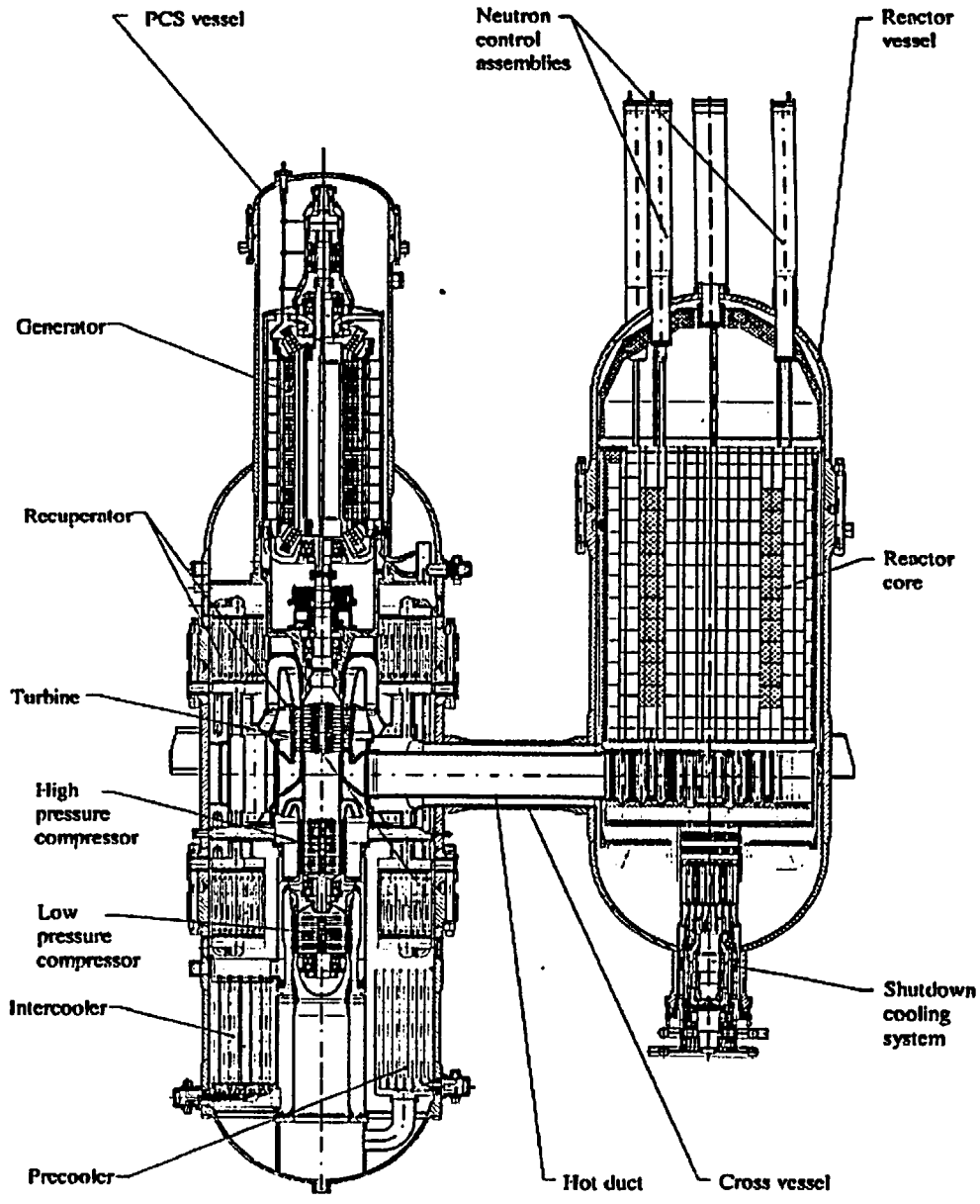
GENERAL ATOMICS

L-271(12a)
8-14-94
A-36

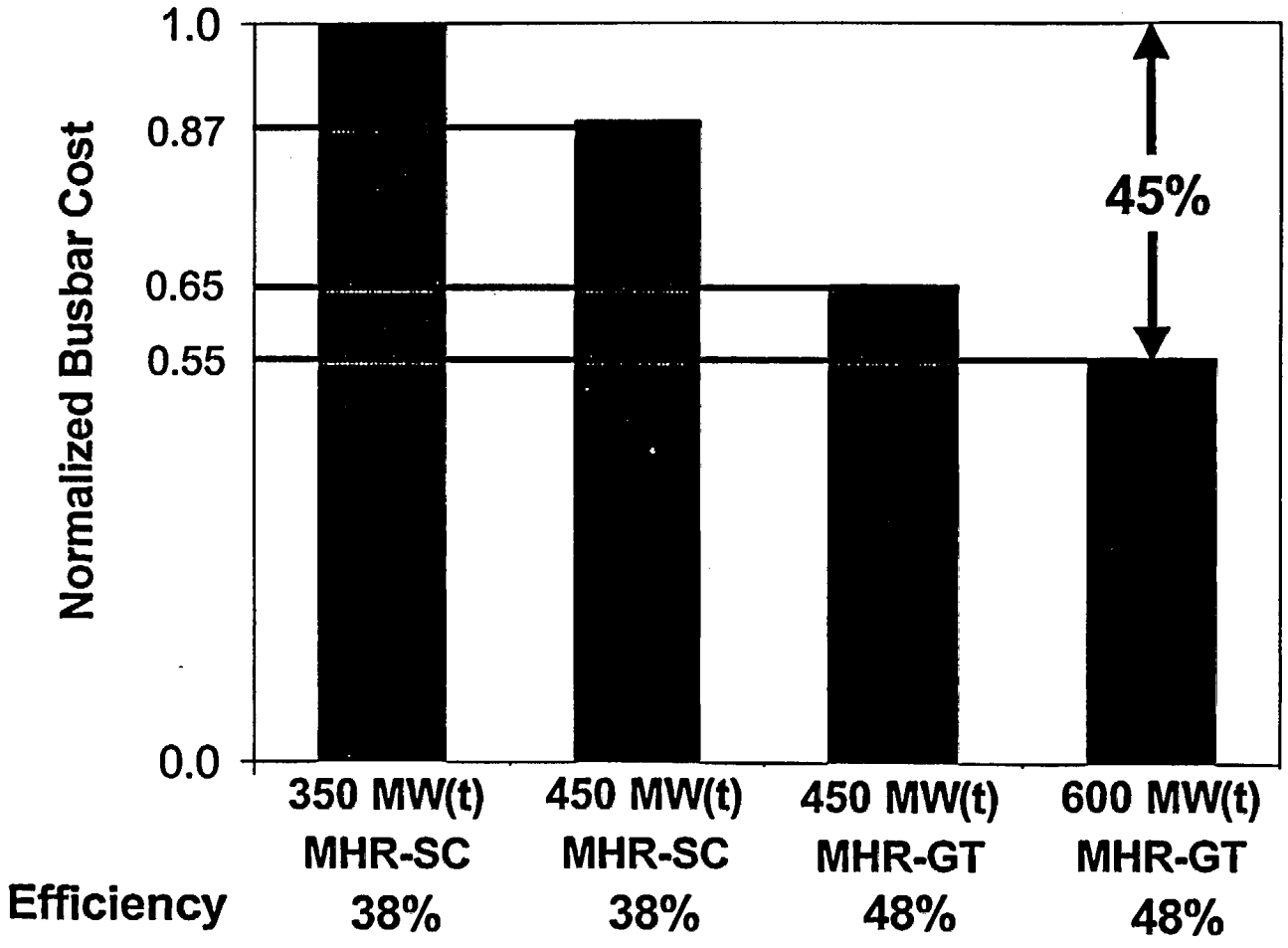
GT-MHR COMBINES MELTDOWN-PROOF ADVANCED REACTOR AND GAS TURBINE

POWER LEVEL 600 MWt

GENERAL ATOMICS



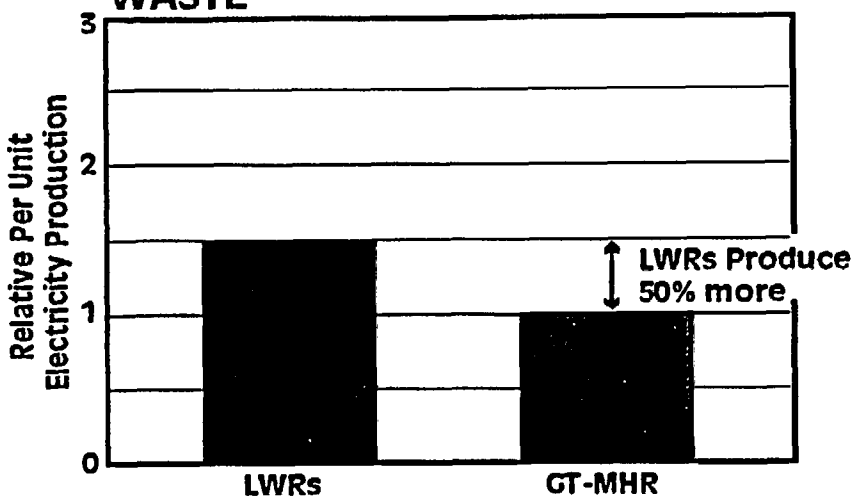
600 MW(t) GT-MHR REDUCES POWER COST BY 45% COMPARED TO 350 MW(t) STEAM CYCLE



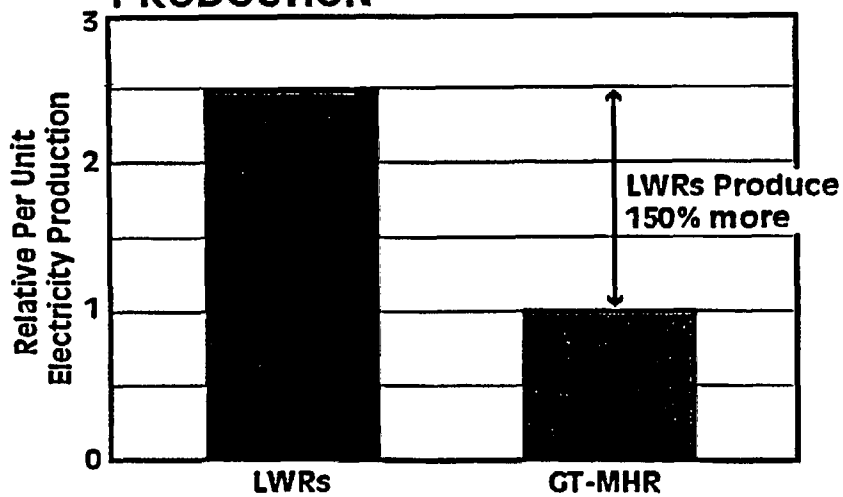
GENERAL ATOMICS

GT-MHR OFFERS MAJOR ENVIRONMENTAL BENEFITS

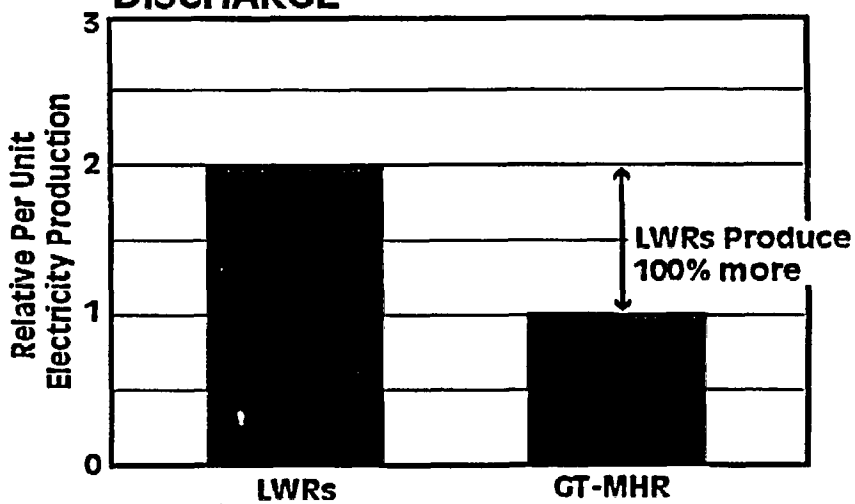
HIGH LEVEL WASTE



ACTINIDE PRODUCTION



THERMAL DISCHARGE



GENERAL ATOMICS

L-592(2)
11-14-95

IN SUMMARY, GT-MHR IS A GENERATION IV SYSTEM

- Inherent safety Features- No core melt
- High thermal efficiency resulting Lower Cost
- Significantly reduced environmental impact
- Superior radio-nuclide retention for long-term spent disposal

GENERAL ATOMICS

GT-MHR COMMERCIALIZATION PROGRAM

PROGRAM DESCRIPTION

GENERAL ATOMICS

GT-MHR NOW BEING DEVELOPED IN INTERNATIONAL PROGRAM

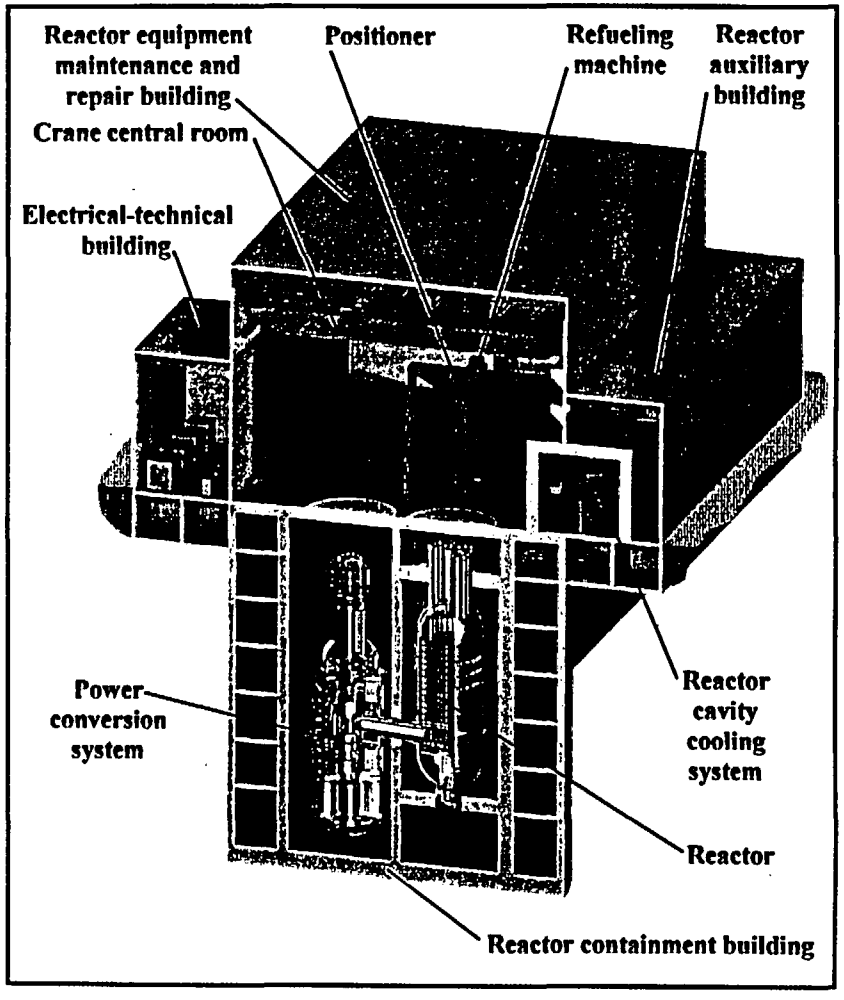
- In Russia under joint US/RF agreement for management of surplus weapons Pu
- Sponsored jointly by US (DOE) and RF (Minatom); supported by Japan and EU
- Conceptual design completed; preliminary design complete early 2002

GENERAL ATOMICS

INTERNATIONAL GT-MHR PROGRAM

- Design, construct and operate a prototype GT-MHR module by 2009 at Tomsk, Russia
- Design, construct, and license a GT-MHR Pu fuel fabrication facility in Russia
- Operate first 4-module GT-MHR by 2015 with a 250 kg plutonium/ year/module disposition rate

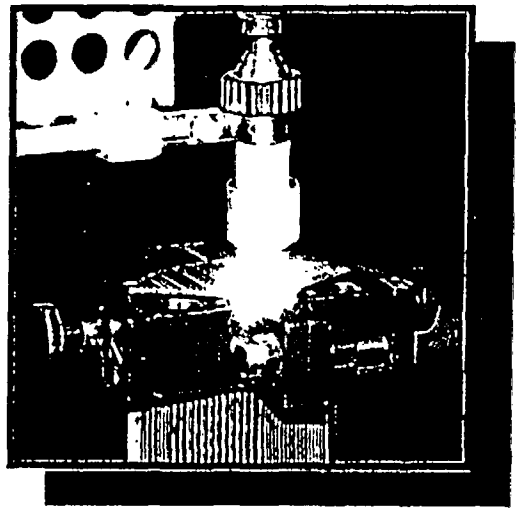
....Fuel contains Pu only
.....No fertile component



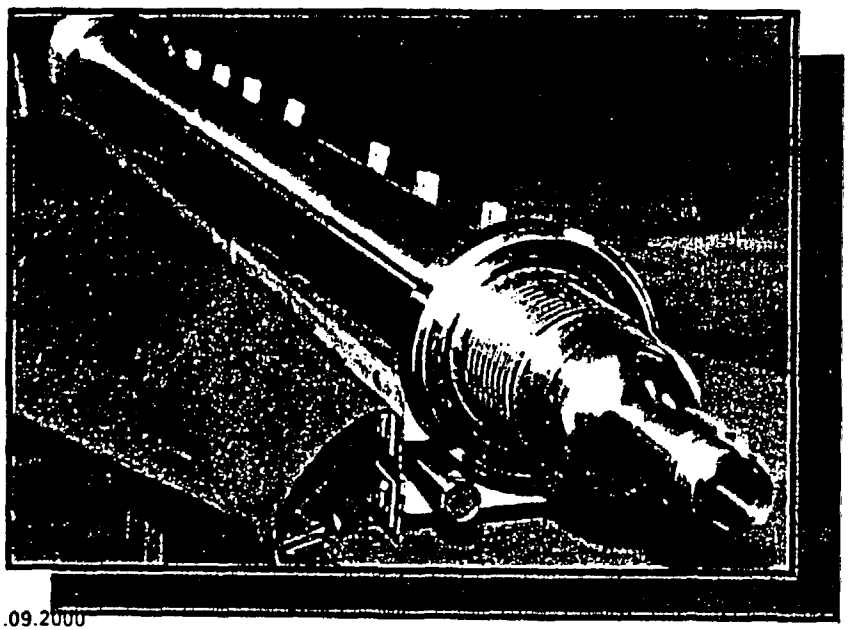
GENERAL ATOMICS

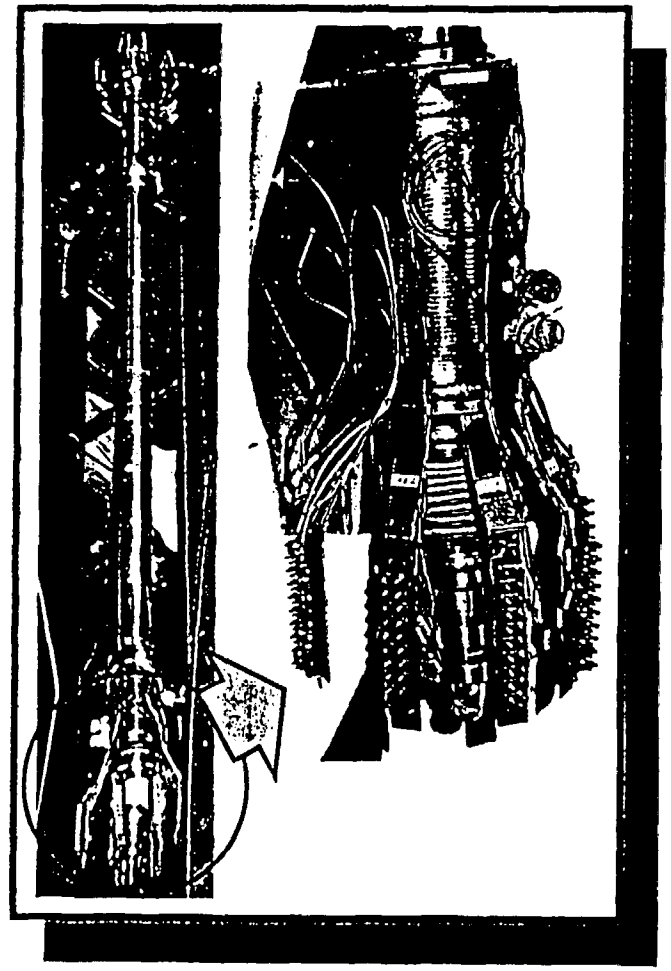
Russian Technological Developments. Recuperator

Heat Exchange Element Fabrication



Recuperator Heat Exchange Element





Tests of full scale heat exchange element in helium test facility

COMMERCIALIZATION PROGRAM

COMMERCIAL PROGRAM = INTERNATIONAL PROGRAM TECHNOLOGY + URANIUM FUEL RATHER THAN Pu FUEL

Plant construction can start in 5 years

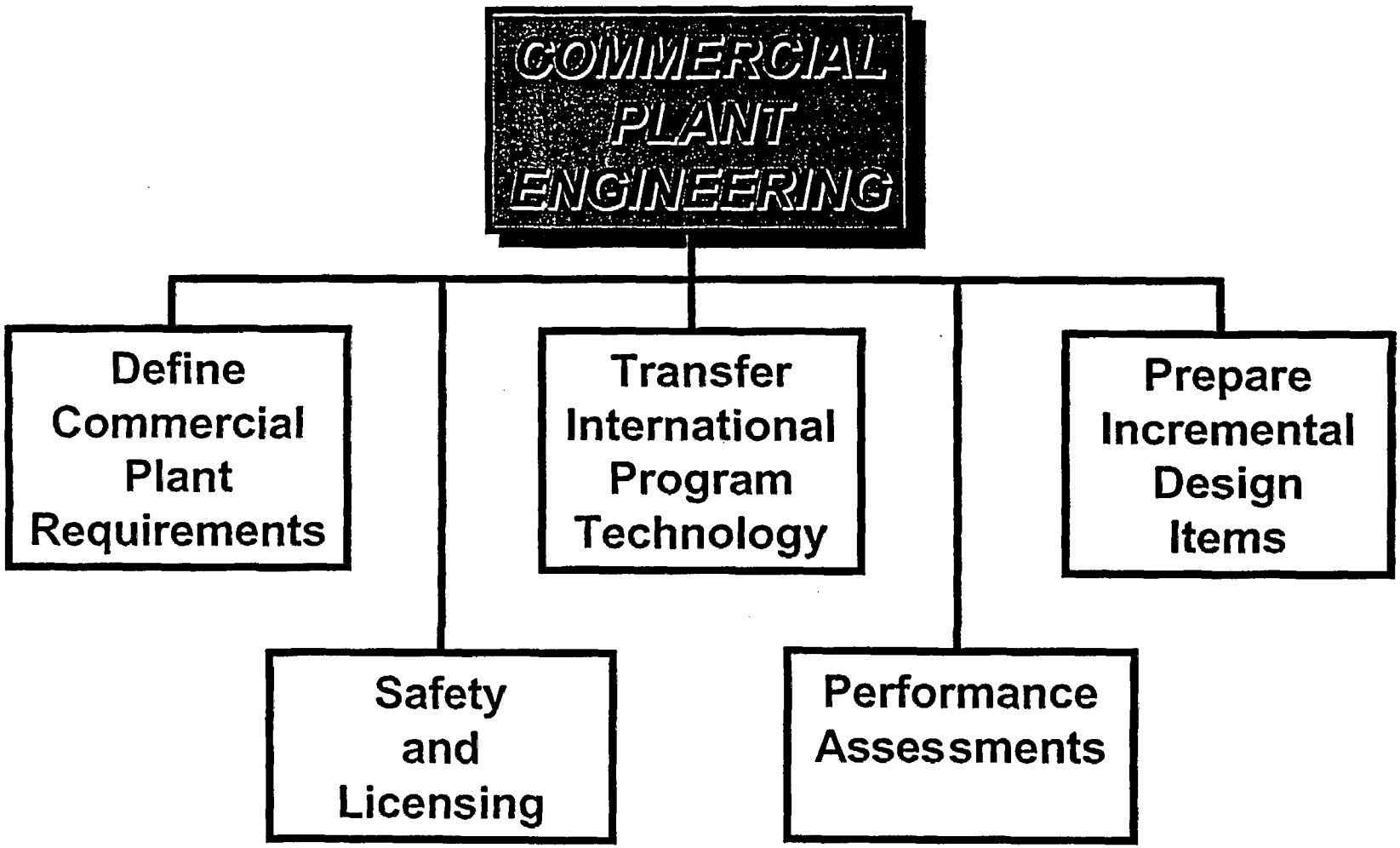
GENERAL ATOMICS

COMMERCIAL PROGRAM FOLLOWS INTERNATIONAL PROGRAM

	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15
INTERNATIONAL PROGRAM														
Design and Devel				Complete Design & Development										
Prototype Licensing					Construction License									
Prototype constr									Complete Proto Constr					
Prototype Startup										Complete Proto Demo				
Full Power Operation										Start Full Power Ops				
GT-MHR COMMERCIAL PROGRAM														
Prel Design			Complete Plant Preliminary Design											
SAR			Complete SAR											
SER					Complete SER									
Final Design						Complete Final Design								
Fuel														
- Automated FF Plt					Complete Automated Fuel Fab Plant Pilot Plant									
- Qualified Fuel										CompleteTests				
First Comm Plt														
- First Order			Ltr of Intent			Order for First Comm Plant								
- Constr						Start Plant Construction								
- Operation Mod 1										Startup of Module 1				
- Operation Mod 2											Mod 2			
- Operation Mod 3												Mod 3		
- Operation Mod 4													Mod 4	

GENERAL ATOMICS

LIMITED ENGINEERING WORK REQUIRED



GENERAL ATOMICS

PLANT REQUIREMENTS PLANNED FROM SEVERAL SOURCES

Externally Imposed Requirements
- US regulatory requirements
- US codes and standards

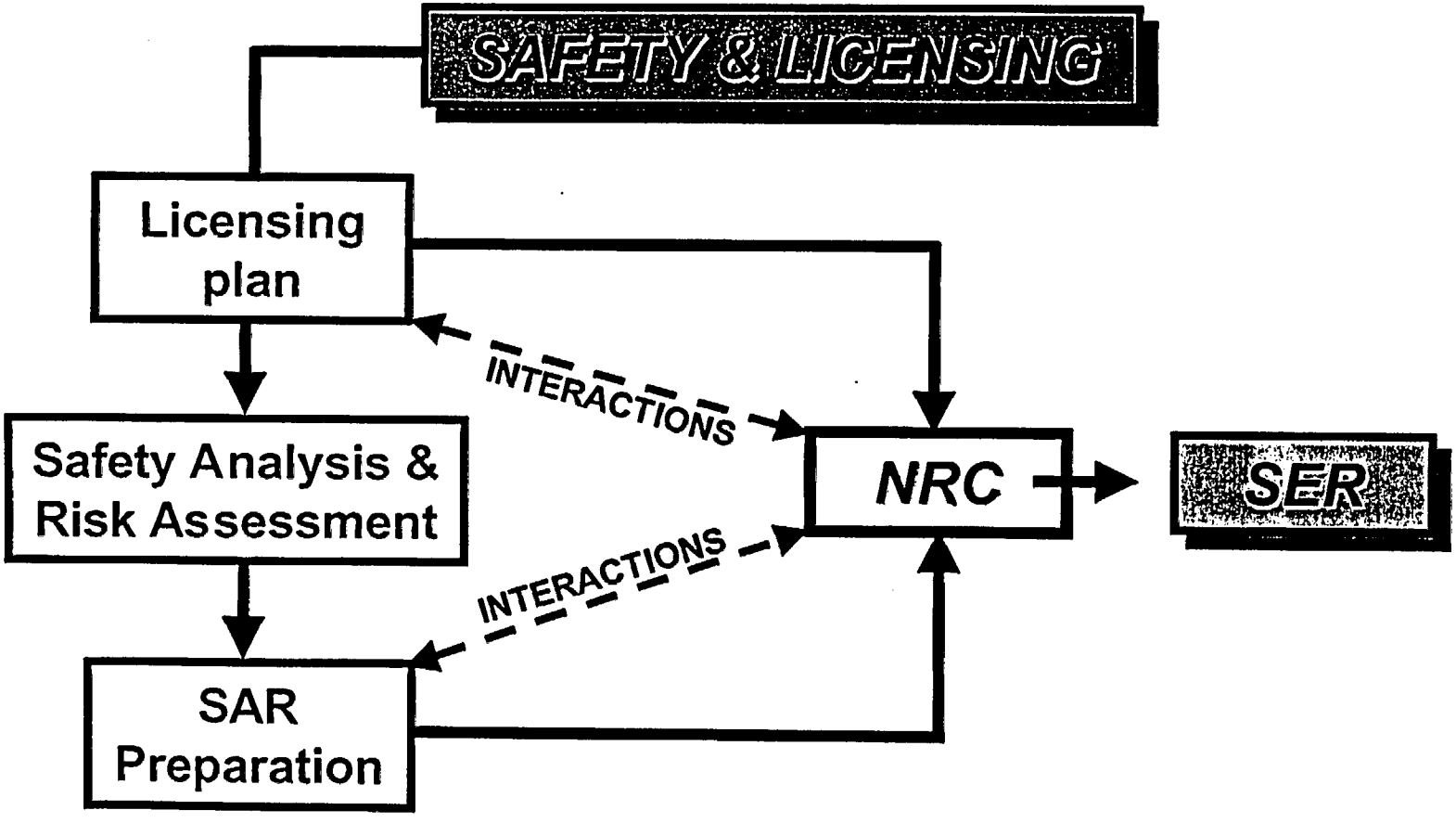
Utility/User Requirements
(safety, economics, etc)

Technology from International Program

COMMERCIAL PLANT REQUIREMENTS

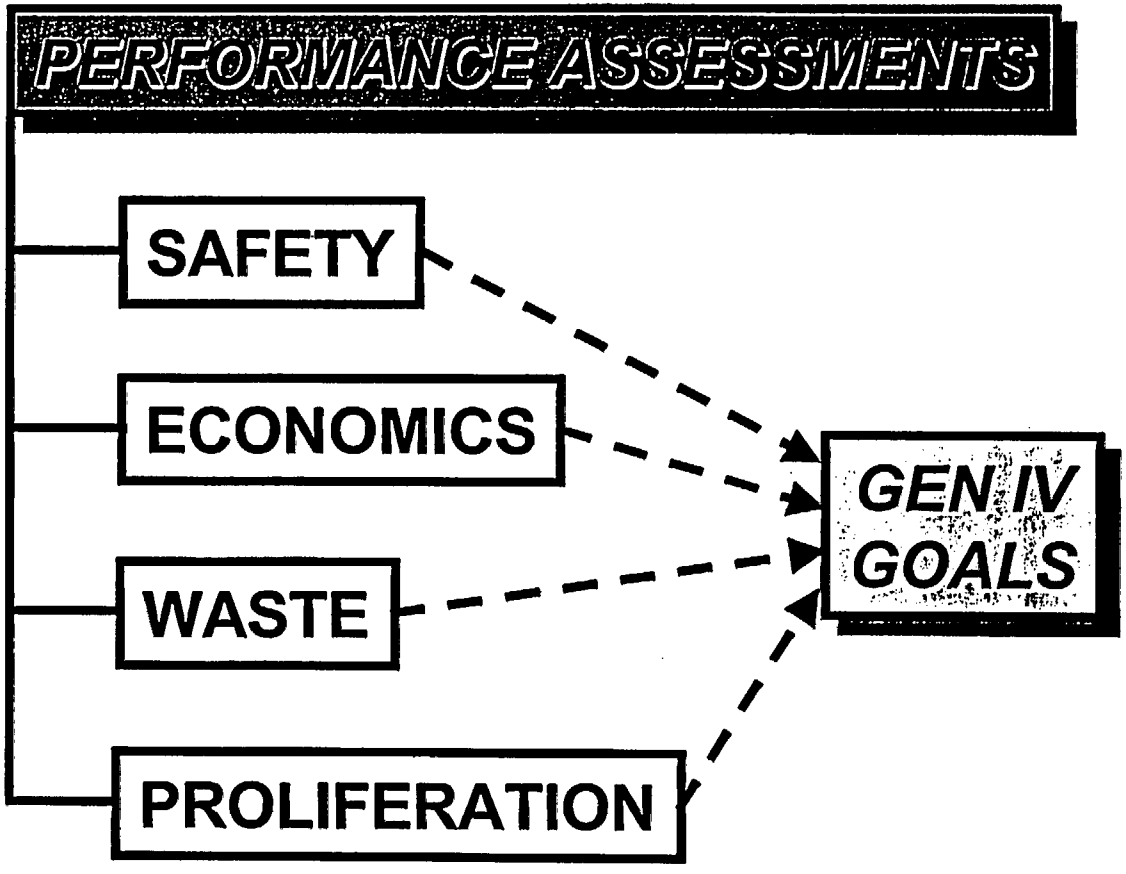
GENERAL ATOMICS

SAFETY & LICENSING ACTIVITIES



GENERAL ATOMICS

PERFORMANCE ASSESSMENT ACTIVITIES PLANNED



GENERAL ATOMICS

COMMERCIAL PROGRAM SUMMARY

- GEN IV PLANT
- COST EFFECTIVE
- NEAR TERM

GENERAL ATOMICS

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

April 16, 2001

Mr. Walter A. Simon
Sr. Vice President
Nuclear Projects
General Atomics
Building 1-240
3550 General Atomics Court
San Diego, CA 92121-1122

Dear Mr. Simon:

Thank you for your letter of March 22, 2001, on the potential commercialization of the Gas Turbine - Modular Helium Reactor (GT-MHR) which is being designed and developed under the sponsorship of the Department of Energy and others. In your letter you request that the NRC staff engage in exploratory discussions with General Atomics on how to proceed with a licensing review of the GT-MHR. Your letter indicates that these discussions are intended to address a licensing plan that you will be developing later this fiscal year.

In response to your letter, I have requested the Office of Nuclear Regulatory Research, in cooperation with the Office of Nuclear Reactor Regulation and the Office of Nuclear Material Safety and Safeguards, to take the lead for early interactions with you. The purpose of such early interactions would be to become familiar with the GT-MHR design, its supporting technology, and related safety issues with a goal of seeking early resolution of issues fundamental to the GT-MHR design. In this regard, the staff plans to build upon its previous advanced reactor review work, including its earlier experience with a pre-application review of a DOE-sponsored modular high-temperature gas-cooled reactor.

We look forward to the opportunity to hear about the GT-MHR and to discuss plans for further interactions. If you have any questions please do not hesitate to contact Mr. Ashok C. Thadani, Director, Office of Nuclear Regulatory Research (301-415-6641).

Sincerely,

William D. Travers
Executive Director
for Operations

Project: 30058
GA/NRC-125-01

GENERAL ATOMICS

March 22, 2001

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 2055-0001

Attn: Mr. William Travelers

Subject: Gas Turbine – Modular Helium Reactor (GT-MHR) Review

Dear Mr. Travers

Since the mid-1990s, the design of a Gas Turbine – Modular Helium Reactor (GT-MHR) has been advancing under the sponsorship of the DOE, private moneys, and foreign sources. While this effort has been largely aimed at dispositioning surplus weapons plutonium, current conditions in the energy sector and proposed DOE budgets indicate that the time and markets may ready for introduction of advanced nuclear systems. Accordingly, General Atomics, with the DOE, is considering a plan at the commercialization of the GT-MHR.

The NRC's statement of Policy for Regulation of Advanced Nuclear Power Plants" (8 July 1986) encourages early interaction between the agency and applicants to provide licensing guidance. Consistent with this policy, General Atomics is requesting to engage in exploratory discussions on how to proceed with the licensing of the GT-MHR. We expect these discussions to address a Licensing Plan we will be developing later this fiscal year and preapplication issues such as:

- Importation of technology from the Russian Federation where the majority of design development is centered, and

- The degree to which an application could build on the approach to licensing bases and Preliminary Safety Information Document (PSID) of the steam cycle MHTGR submitted to and reviewed by the NRC during the 1980s.

In addition, we would anticipate identifying any unique policy issues, and establish an estimate of cost and schedule for subsequent interactions.

If you have any questions, please do not hesitate to contact me or Dr. Arkal Shenoy at (858) 455-2552.

Sincerely yours,

Walter A. Simon
Sr. Vice President

Rg-FYI
T. King

Project: 30058
GA/DOE-123-01

GENERAL ATOMICS

March 22, 2001

Mr. William Magwood
Director
U.S. Department of Energy
Office of Nuclear Energy, Science and Technology
1000 Independence Ave, SW
Washington, D.C. 20585

Dear Bill:

As you are aware, General Atomics is proceeding with plans for commercialization and deployment of the GA direct cycle Gas Turbine-Modular Helium Reactor (GT-MHR), following in the footsteps of the current DOE sponsored program for construction of a prototype GT-MHR for plutonium disposition in Russia. We have a commercialization plan including assembly of a Utility Advisory Board, pre-application review with NRC of generic gas reactor design and licensing issues in close coordination with Exelon, and participation in DOE, NRC, NEI and industry programs and forums for advanced nuclear plant deployment in the U.S. We would like to expand our dialogue with your staff in coordinating GA participation in DOE programs for near term deployment, gas reactor training, early plant siting, and other key issues in expanding the infrastructure for new nuclear deployment in the U.S.

This is a very important and exciting time in this industry and we look forward to using this design to help meet expanding U.S. and international energy needs in the coming years. We intend to meet with your people to address assumptions, policy issues, scheduling, generic approached to modularization, optimized licensing, education and training and standardized costing methods.

Please advise if you have any questions or require additional information. We look forward to our participation in DOE sponsored programs in meeting the energy needs for the U.S. with a clean and reliable energy source.

If you have any questions, please call me or Dr. Arkal Shenoy at (858) 455-2552.

Sincerely yours,

Walt

Walter A. Simon
Sr. Vice President

CC: Senator Ted Stevens
Senator Pete V. Domenici
Congressman Joe Barton
Congressman Joe Knollenberg
Congressman John M. Spratt, Jr.

Ark. K

Project: 30058
GA/NEI-122-01

FYI

T. King

GENERAL ATOMICS

March 22, 2001

Mr. Joe Colvin
President and Chief Executive Officer
Nuclear Energy Institute
1776 I Street, NW
Washington, D.C. 20006-2708

Dear Joe:

As you are aware, we are proceeding with plans for commercialization and deployment of the GA direct cycle Gas Turbine - Modular Helium Reactor (GT-MHR), following in the footsteps of the current DOE sponsored program for construction of a prototype GT-MHR for plutonium disposition in Russia. We have a commercialization plan including assembly of a Utility Advisory Board, pre-application review with NRC of generic gas reactor design issues in concert with Exelon, and participation in DOE, NRC, NEI and industry forums for advanced nuclear plant deployment in the U.S. We would like to expand our dialogue with your staff in coordinating NRC review of generic issues and inclusion of the GT-MHR footprint in the early plant siting program and other key goals of the "Strategic Plan for New Nuclear Generating Plants." We would also like to have full participation in NEI's near term deployment group.

This is a very important and exciting time in this industry and we look forward to using this design to help meet U.S and international energy goals in the coming years. We intend to meet with your people to address assumptions, policy issues, scheduling and generic approaches to modularization, optimized licensing, education and training and standardized cost and scheduling methods.

Please advise if you have any questions or require additional information. We look forward to our participation as an NEI member in meeting energy needs for the U.S. with a clean and reliable energy source.

If you have any questions, please call me or Dr. Arkal Shenoy at (858) 455-2552.

Sincerely yours,

Walt

Walter A. Simon
Sr. Vice President

CC: Senator Ted Stevens
Senator Pete V. Domenici
Congressman Joe Barton
Congressman Joe Knollenberg
Congressman John M. Spratt, Jr.