Hydrogen Production With The Advanced High-Temperature Reactor

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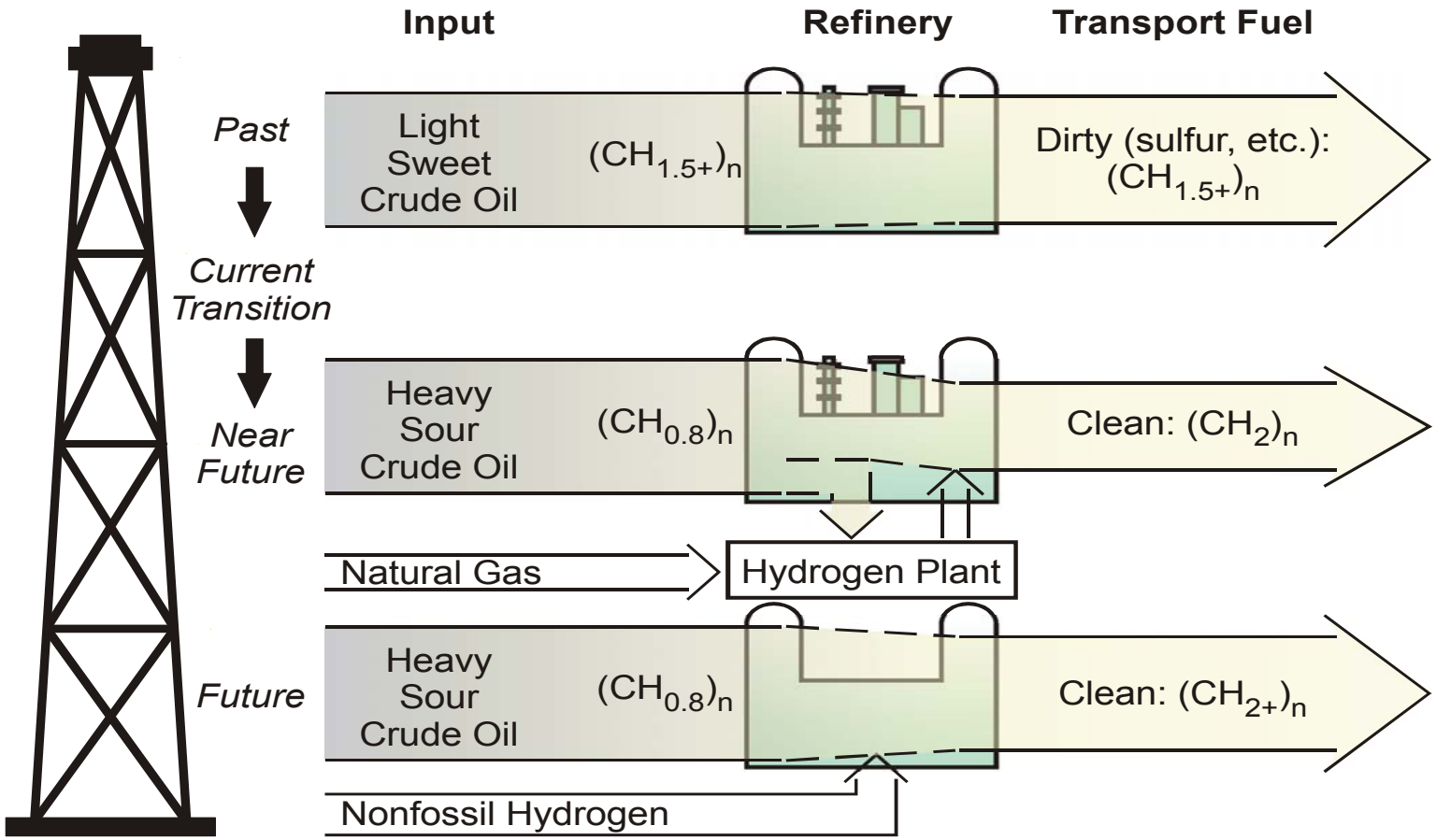
Hydrogen Production Requirements

Large Scale
Physical Separation

Massive Quantities of Hydrogen Are Use Today

Worldwide Production: 50 Million Tons/Year

Largest H_2 Plant: Equivalent to 2,400 MW(t) Nuclear Reactor

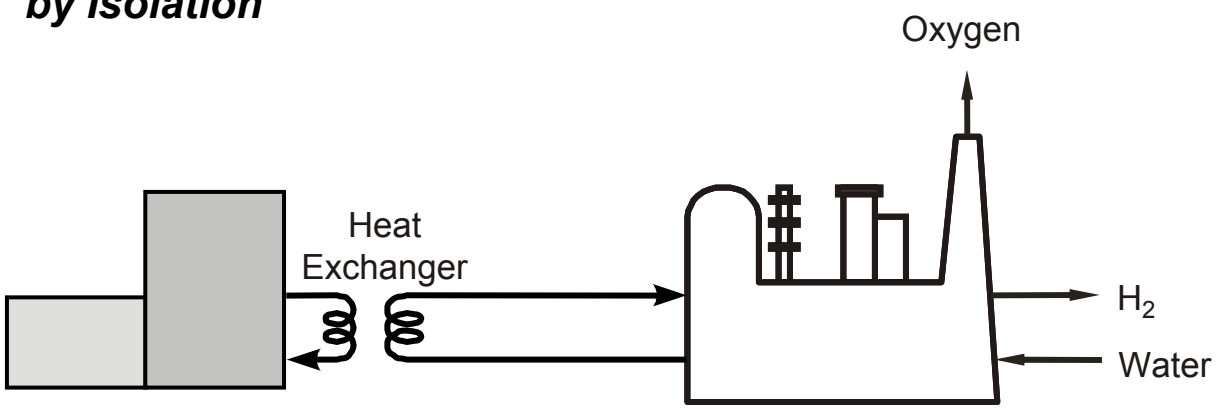


Thermochemical Hydrogen Facilities May Require Physical Separation From the Nuclear Reactor

1970s German Studies Indicated Molten Salts Preferred For Heat Transfer

Nuclear Safety by Isolation

Hydrogen Safety by Dilution



Loop Heat Transfer Comparison
[50 MW(t)]

Characteristic	Salt	Helium
Pressure (bar)	1	70
Velocity (m/s)	4	40
Temperature Drop (°C)	200	200
Pipe Diameter (m)	0.25	1.2
Relative Pumping Power	1	45

The Advance High-Temperature Reactor

A Large, Passively Safe, High-Temperature Reactor for Hydrogen Production

- Large reactor (>2000 MW(t))
- New reactor concept
  - Combines existing technologies in a new way
  - Developed during the DOE GenIV roadmap activity

High-Temperature Reactors

Characteristic	*AHTR*	*MHTGR (He)*
Fuel	Coated Particle	Coated Particle
Neutronics	Epithermal	Epithermal
Safety System	Passive	Passive
Coolant	*Molten Salt*	*Helium*
Pressure	Atmospheric	High Pressure
Power Level	2400 MW(t)	600 MW(t)

Key Reactor Characteristics

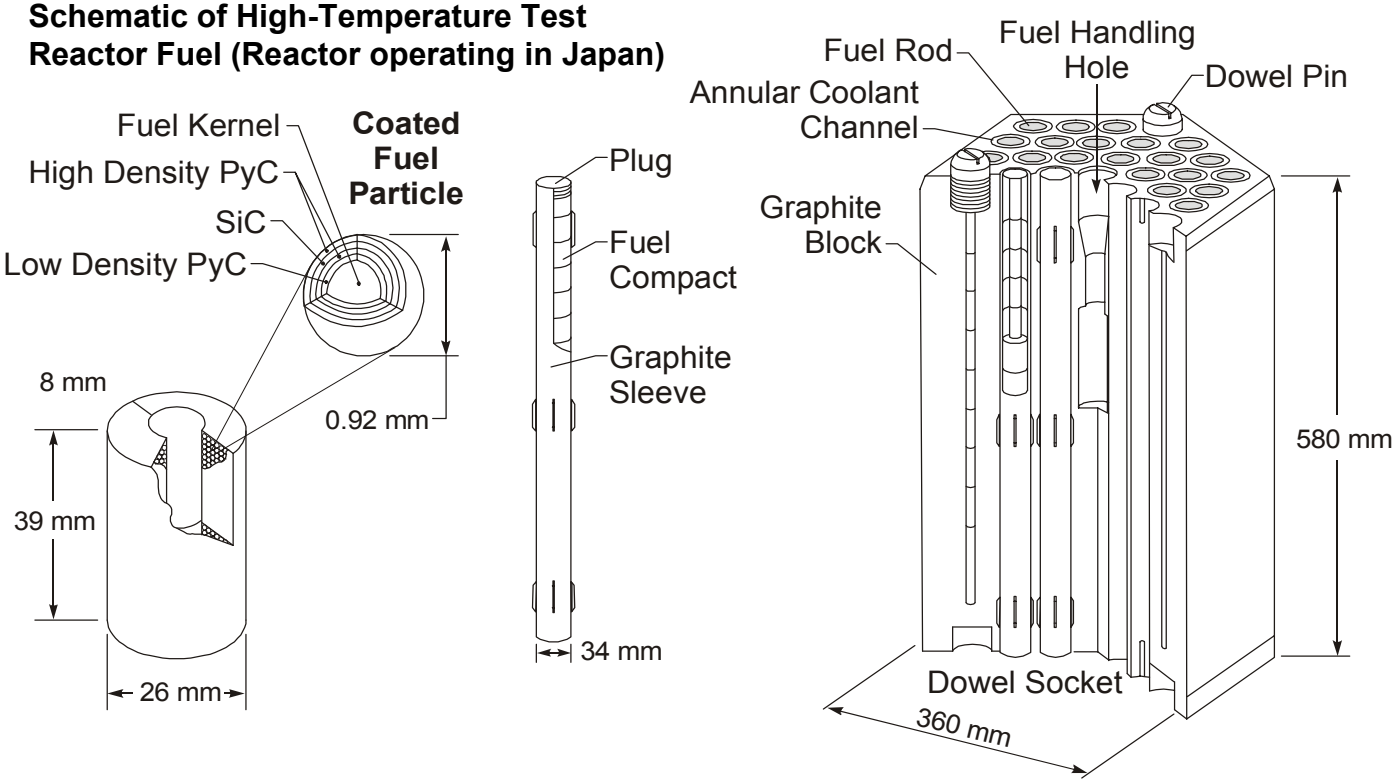
Reactor fuel

Reactor coolant

The AHTR Uses Coated-Particle Graphite Fuels

(Similar to Helium-Cooled Reactors; Failure Temperature >1600ºC)

Schematic of High-Temperature Test Reactor Fuel (Reactor operating in Japan)

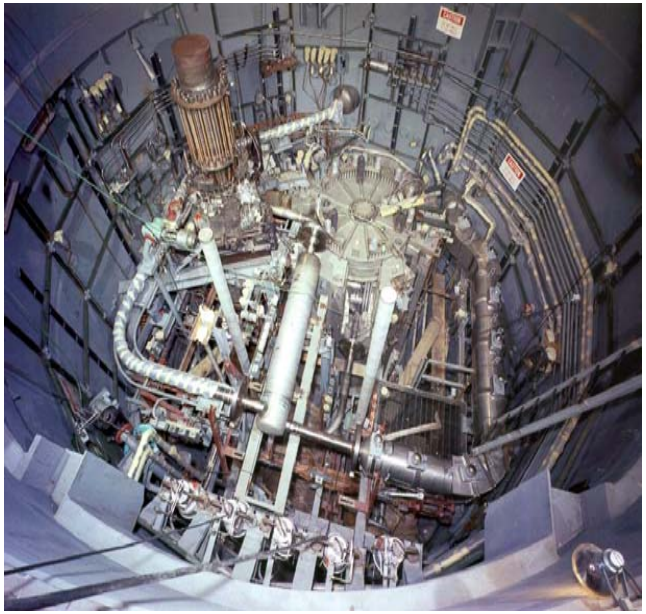


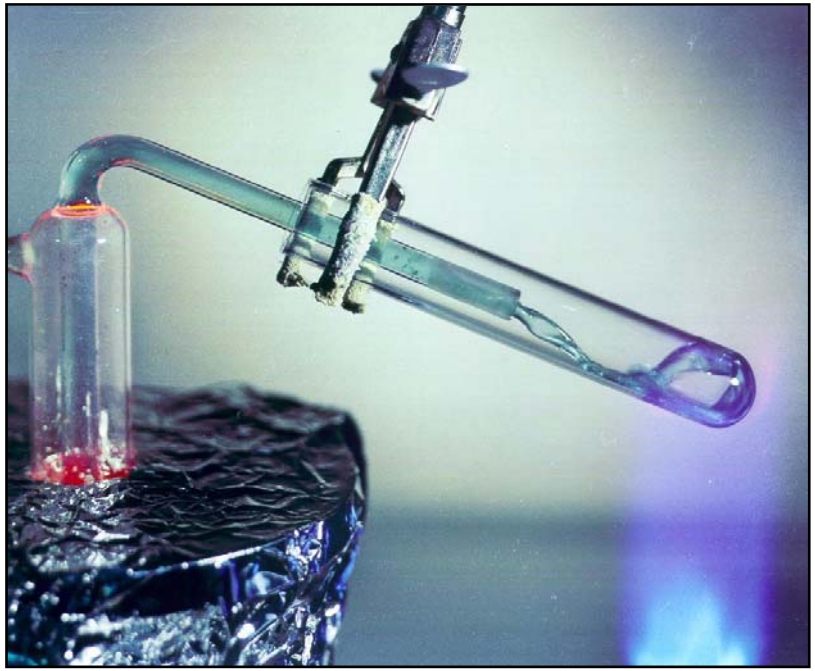
Fuel Compact **Fuel Rod** **Fuel Block**

The AHTR Uses A Molten Salt Coolant

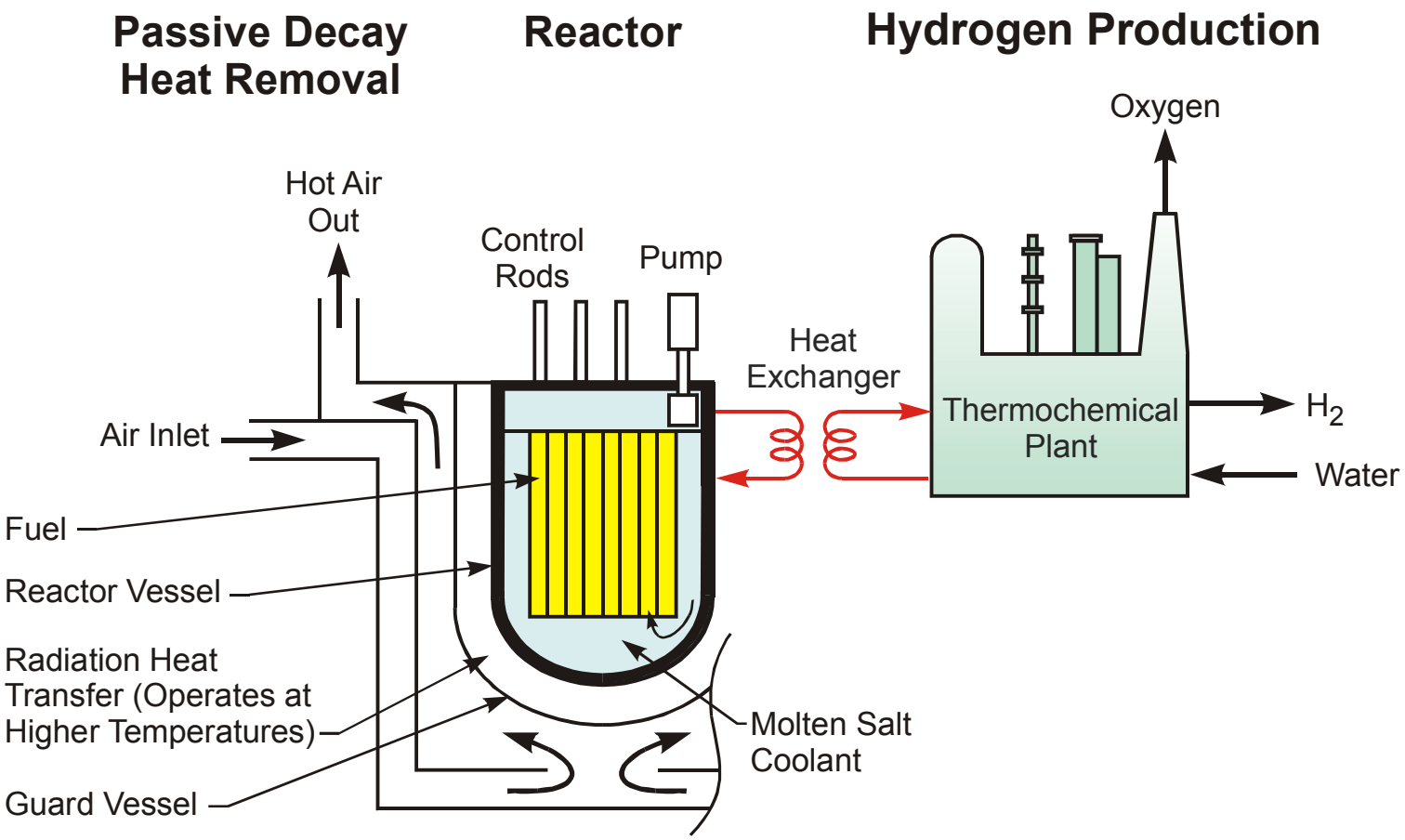
Good Heat Transfer, Low Pressure Operation, In-Service Inspection, and Boiling Point ~1400ºC

MSRE Intermediate Heat Transfer Loop Used Clean Salt

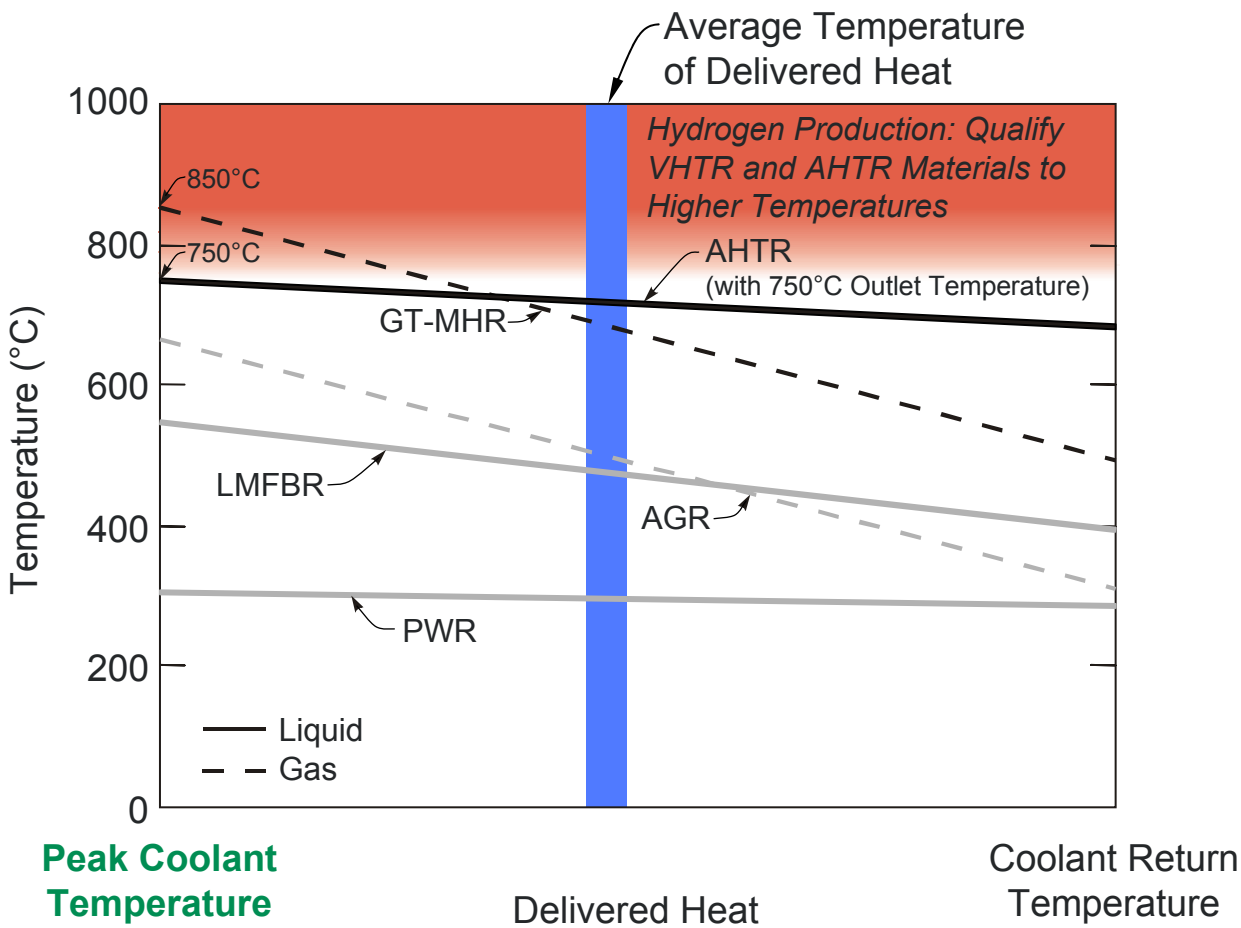




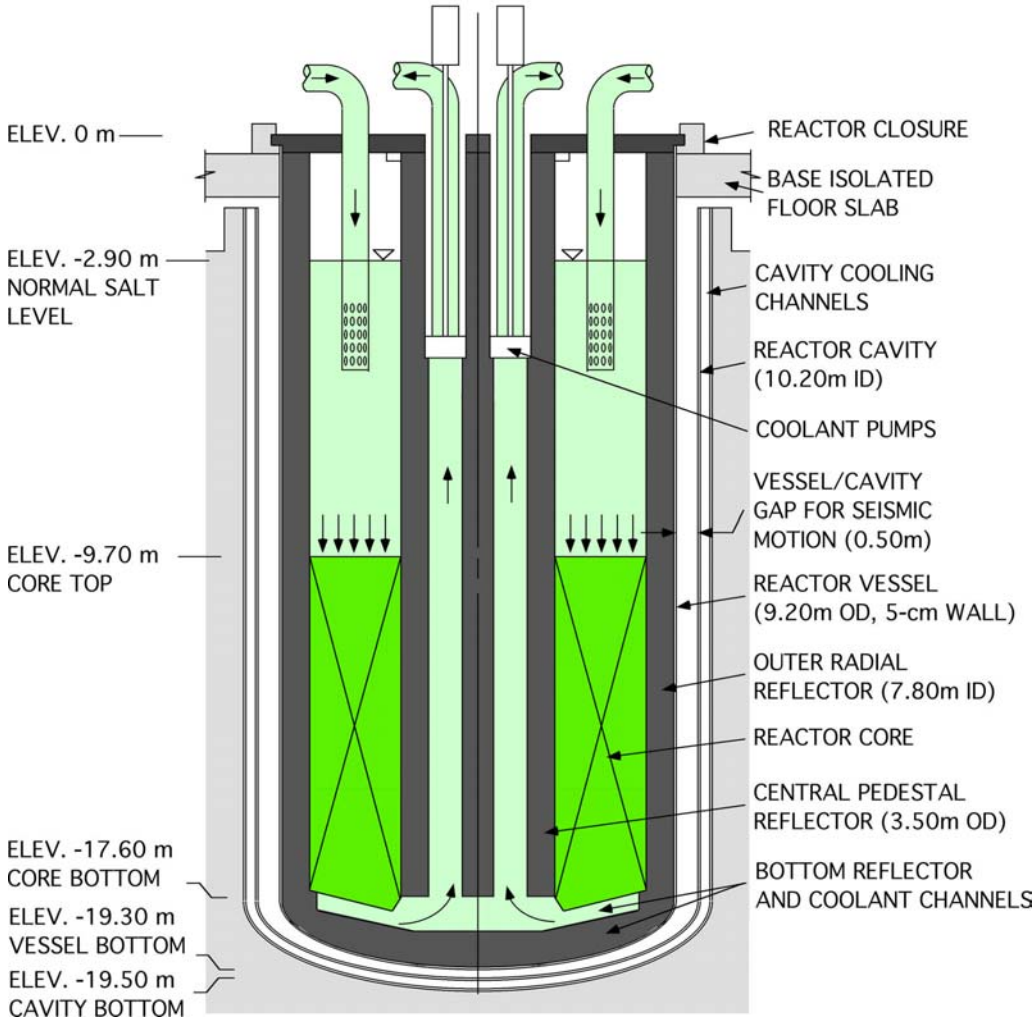
Advanced High-Temperature Reactor



AHTR Lowers Peak Coolant Temperatures



Conceptual 2400 MW(t) AHTR Design



- **Transportable vessel**
  - **Same size as S-PRISM 1000 MW(t) vessel**
  - **Similar size to 600 MW(t) GT-MHR reactor vessel**
- **Down-flow molten salt**
- **MHTGR annular core**

Passive Safety

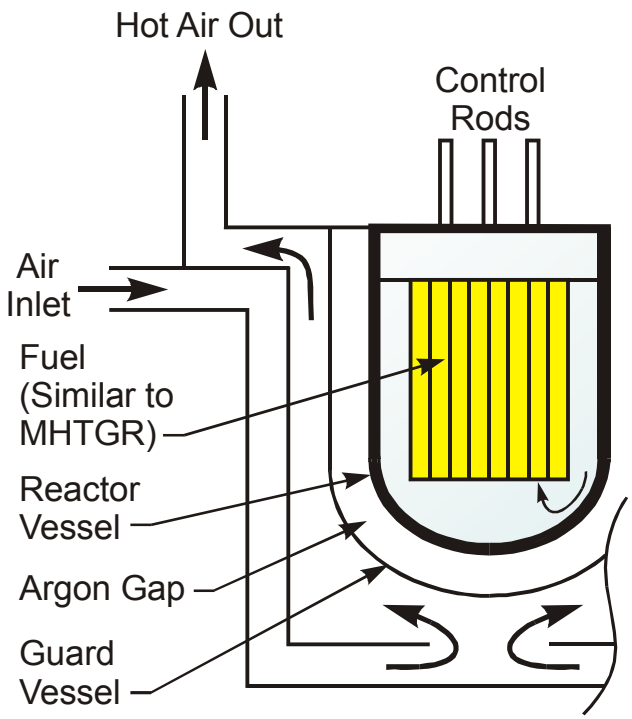
Decay Heat to the Reactor Vessel Wall With Silo Cooling

Same approach as Modular High-Temperature Gas-Cooled Reactors and the General Electric Sodium-Cooled Modular S-PRISM

In an Emergency, Decay Heat is Transferred to the Reactor Vessel and Then to the Environment

Passive Decay Heat Removal

Reactor

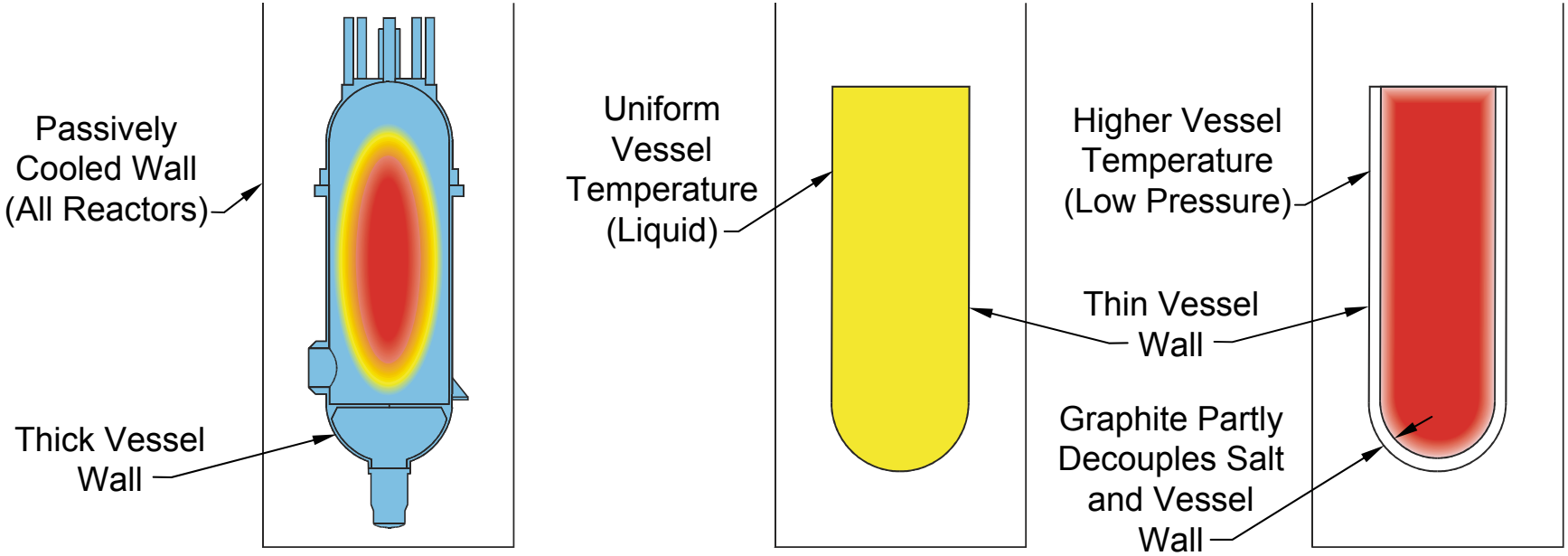


Decay-Heat Cooling System Characteristics

- Similar to GE S-PRISM (LMR)
- Argon Gap
  - Heat Transfer ~T^4
  - Thermal Switch Mechanism
- Heat Rejection: Temperature Dependent
  - LMR: 500-550°C [~1000 Mw(t)]
  - AHTR: 750-1000°C [>2000 Mw(t)]
- High Heat Capacity
  - Molten Salt and Graphite
  - High Temperature (Limited-Insulation of Vessel from Hot Salt)

Evolution of Passive Decay Heat Removal Systems in Similar Size Vessels Enables Design of Larger Reactors

Reactor	MHTGR	S-Prism	AHTR
Coolant	Helium	Sodium	Molten Salt
Power	600 MW(t)	1000 MW(t)	>2000 MW(t)
Limitation	Conduction	Sodium Boiling Point	Vessel

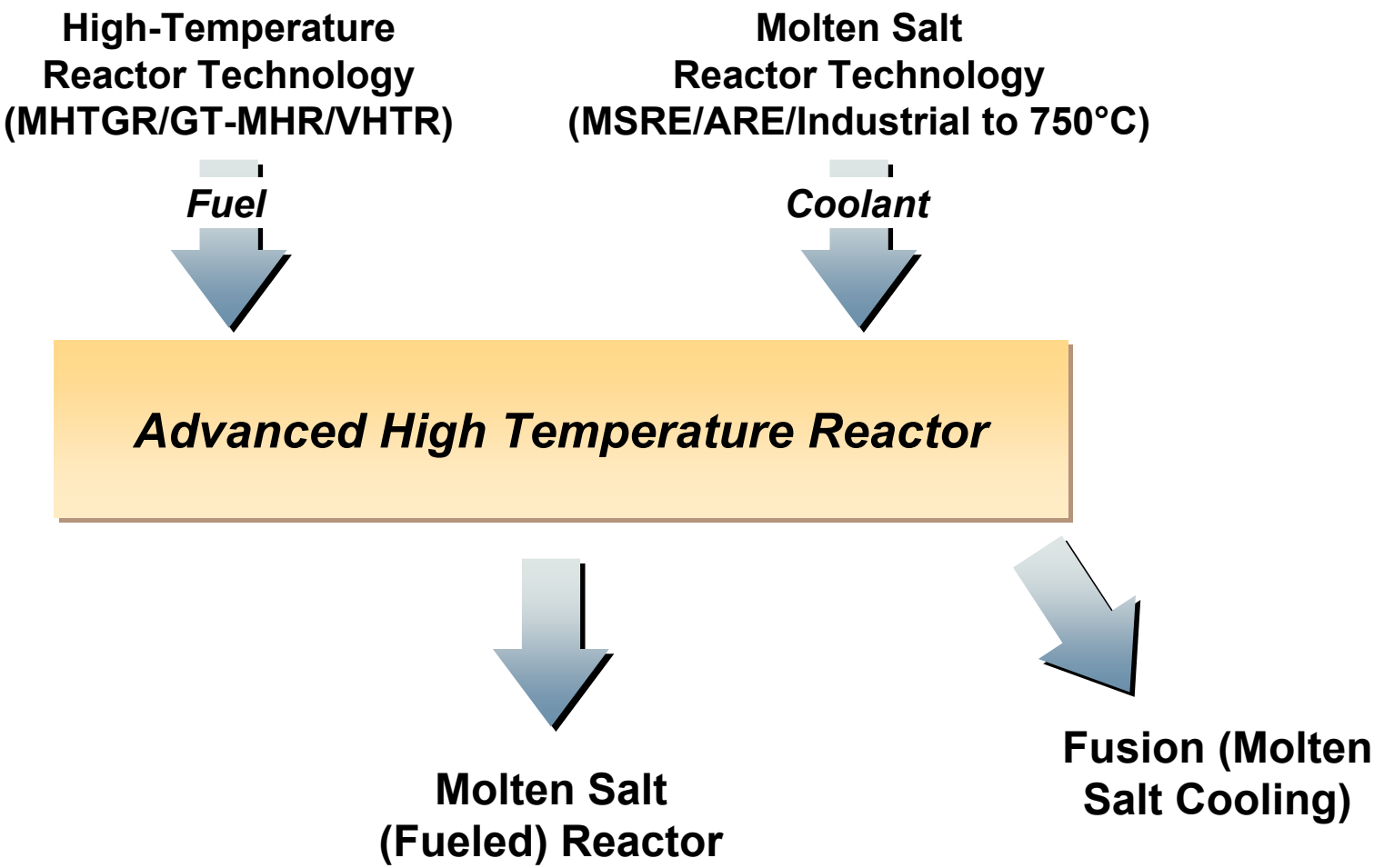


Conclusions

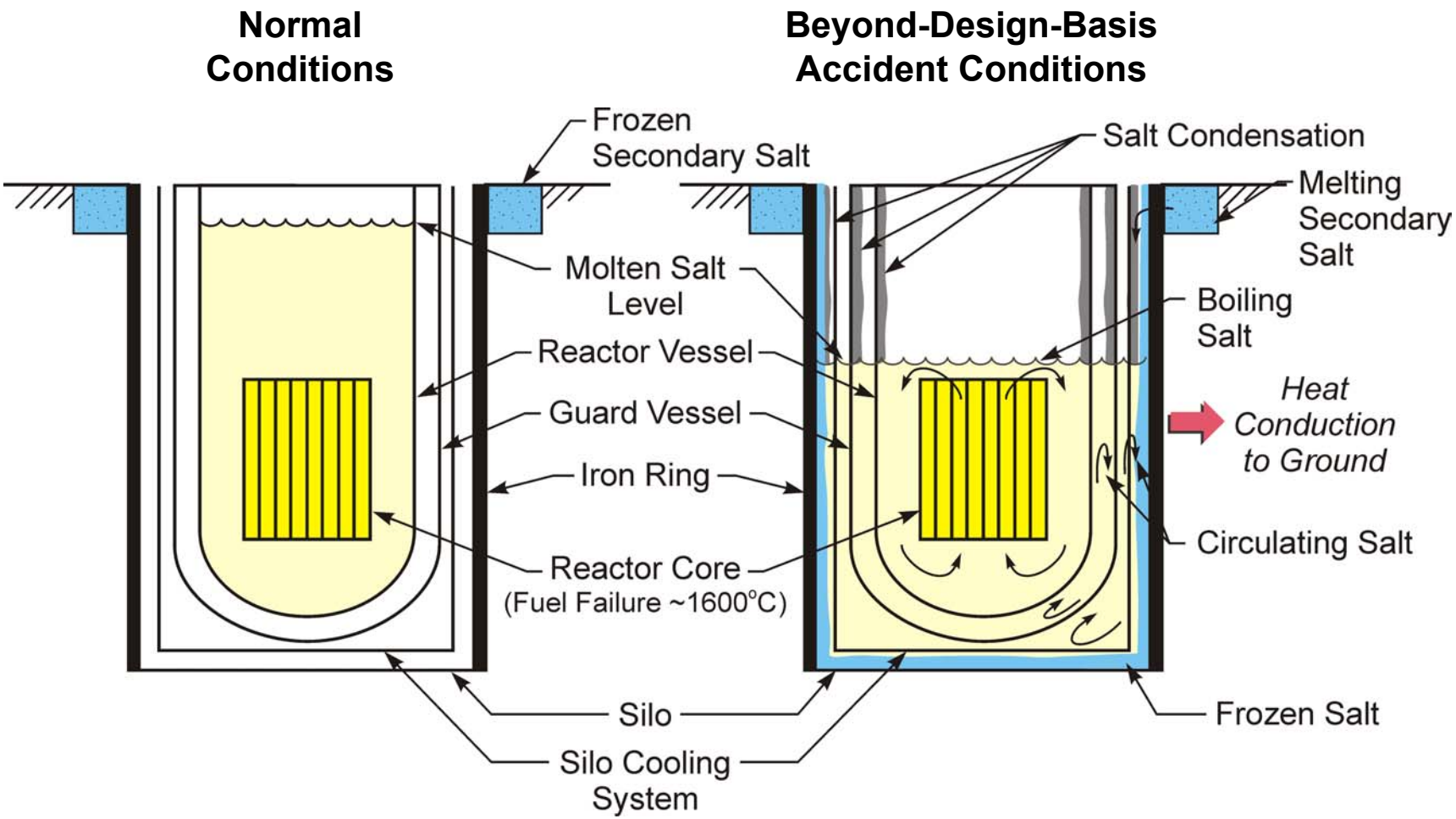
- AHTR goals
  - Match requirements for hydrogen production
  - Same passive safety basis as modular reactors
  - Improved economics
- Technology foundation based on
  - Modular high-temperature gas-cooled reactors
  - Molten salt experience (Industrial and reactor)
- New reactor concept
  - Combines old technologies in a new way
  - ~2 years old
- Creates large high-temperature-reactor option

BACKUP

Evolution of AHTR and Other Technologies

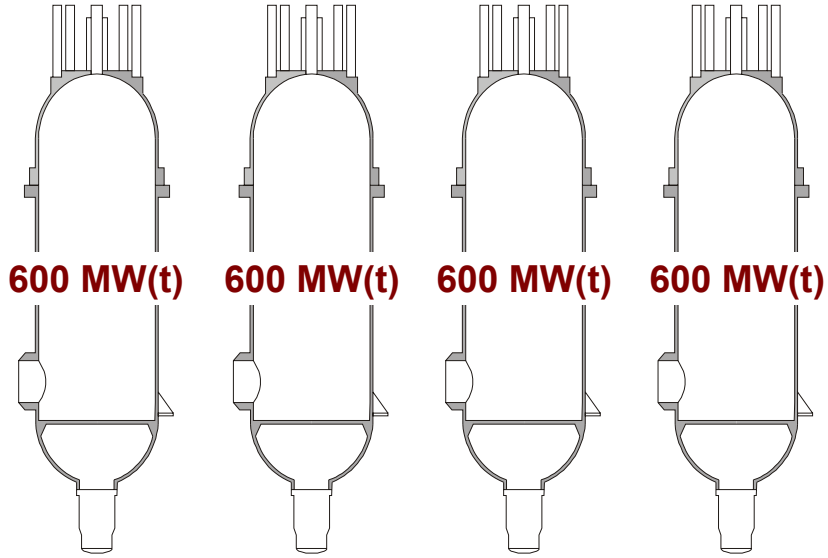
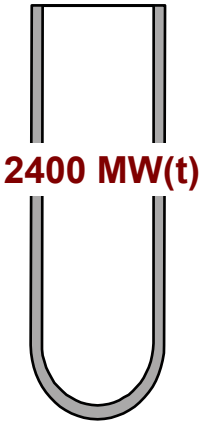


Beyond-Design-Basis Accident Avoids Radionuclide Release By Decay Heat Conduction To Ground



Equipment Comparisons Suggest AHTR Capital Cost Per MW(t) Is Less Than a Modular Reactor

Pressure Vessels For 2400 MW(t) of HTGRs



Low-Pressure Vessel For 2400 MW(t) of ATGR