Molten Salt Coolants:

Transferring Heat From Reactors to H_2 Facilities

The Advanced High-Temperature Reactor for H_2 Production

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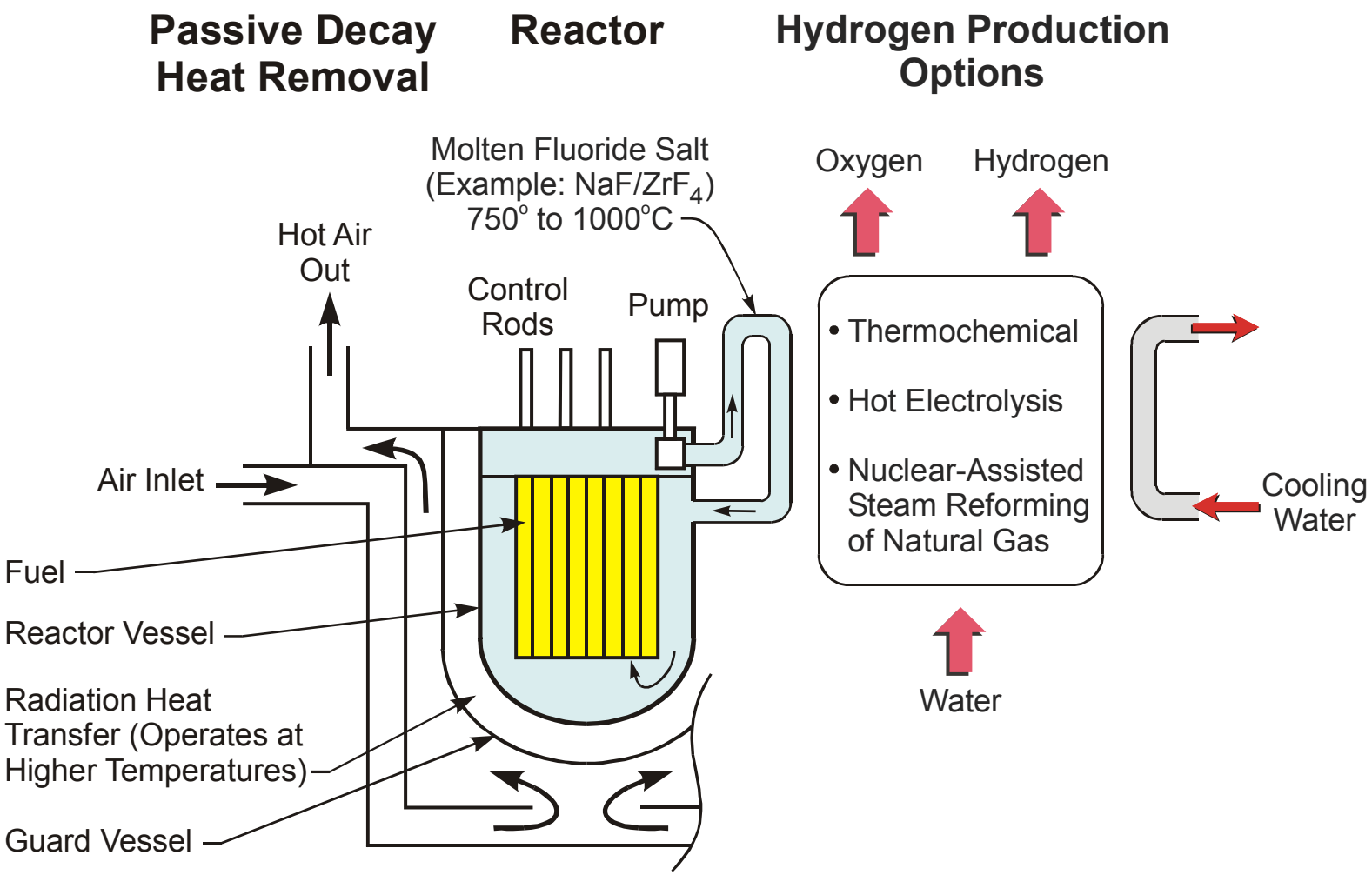
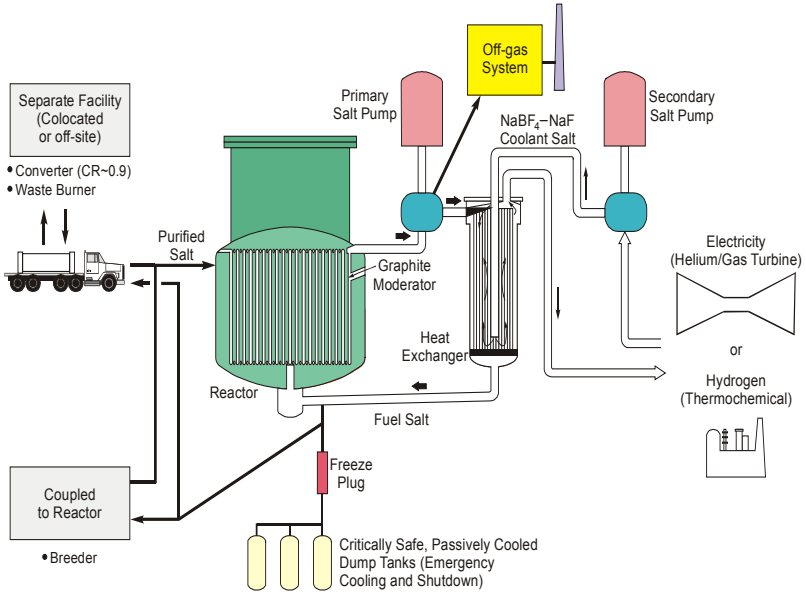
The Advanced High-Temperature Reactor for Hydrogen Production

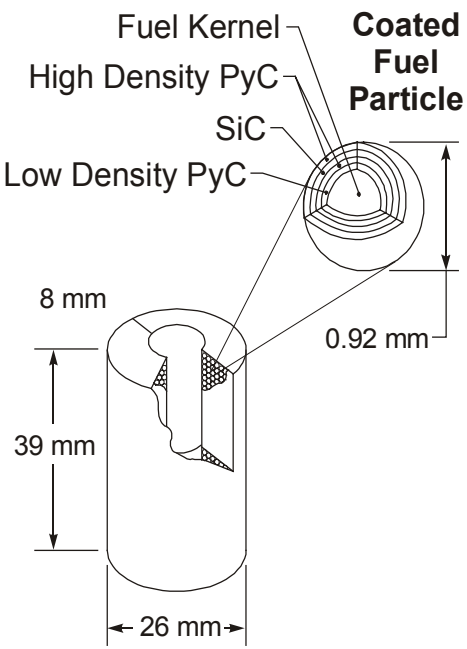


The AHTR Is NOT a Molten Salt Reactor (MSR)

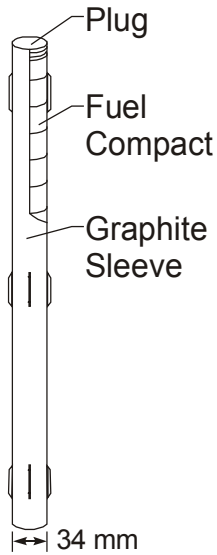


- **MSR**
  - **Fuel dissolved in the molten salt**
  - **Aircraft Reactor Experiment operated at 815 °C**
- **AHTR**
  - **Solid fuel**
  - **Molten salt coolant**
  - **Uses MSR experience**

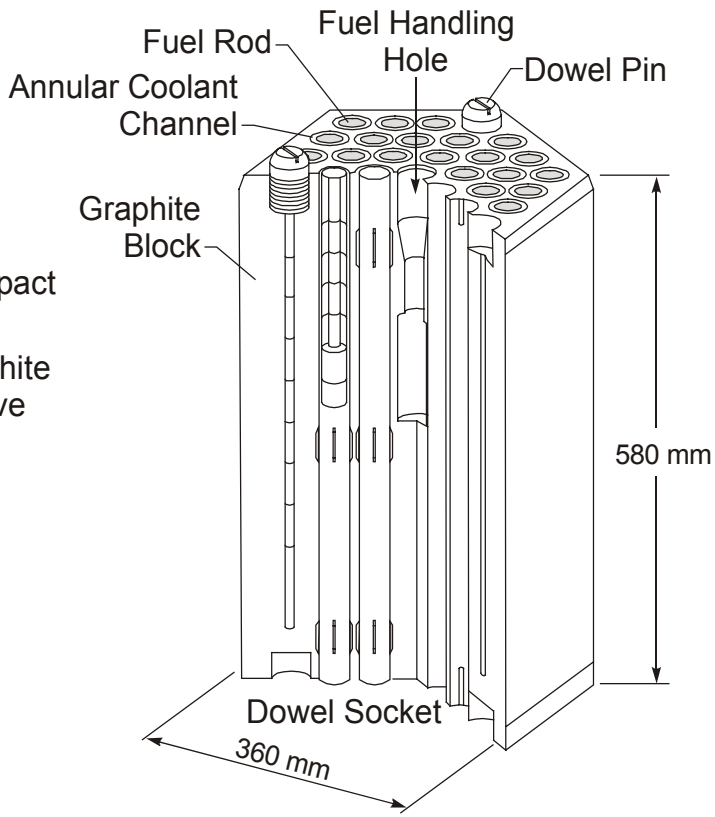
The AHTR and VHTR Use the Same Coated-Particle Fuel



Fuel Compact



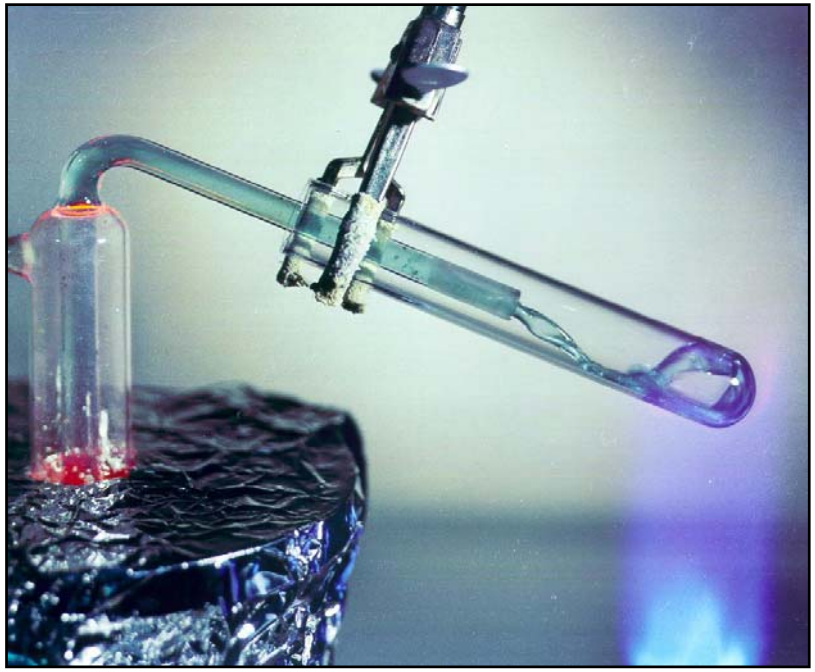
Fuel Rod



Fuel Block

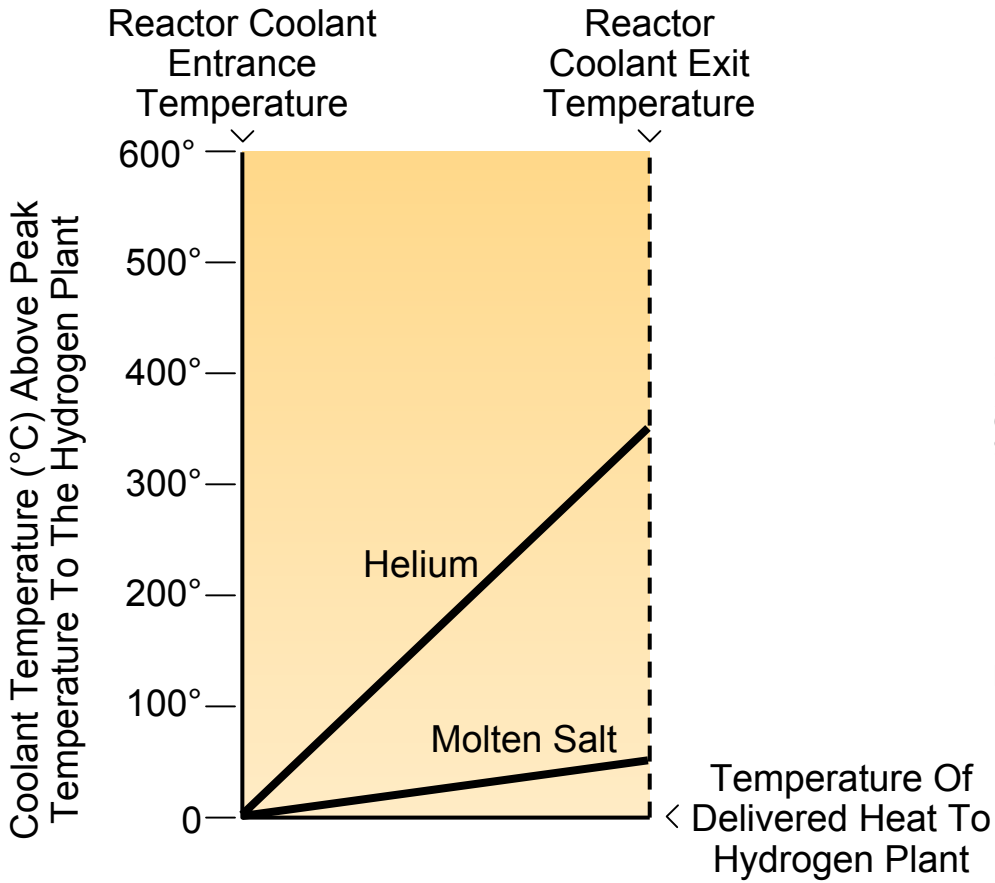
AHTR Molten Salt Reactor Technology Was Developed in the Aircraft Nuclear Propulsion Program with Test Reactor Operations to 860°C

(Requirements: Low Pressure and Efficient Heat Transfer)

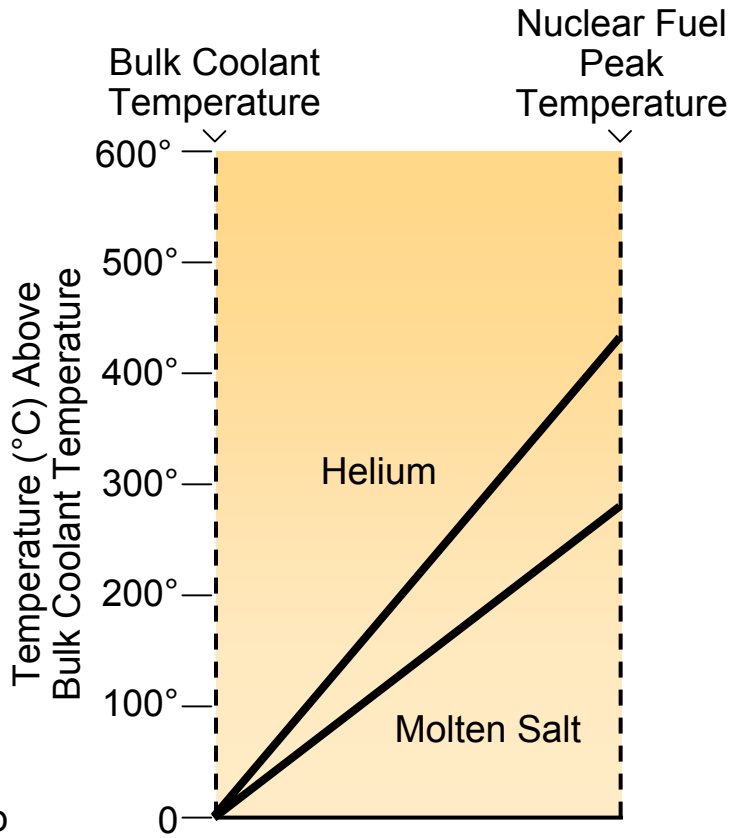


A Molten-Salt-Cooled Reactor Reduces Reactor Temperatures Compared to Gas-Cooled Reactors

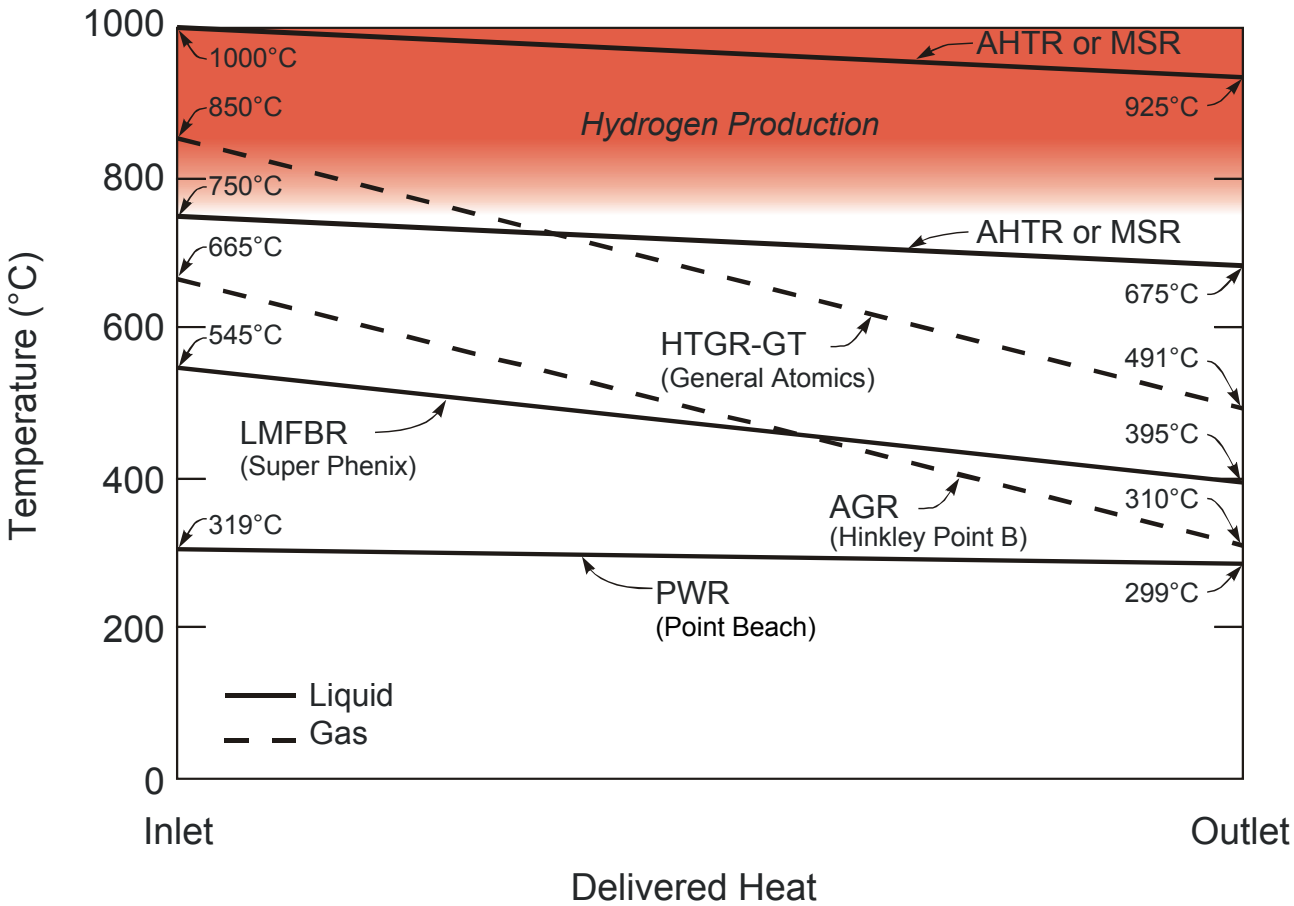
Bulk Coolant Temperature Rise Across Reactor



Temperature Rise From Coolant To Fuel Centerline

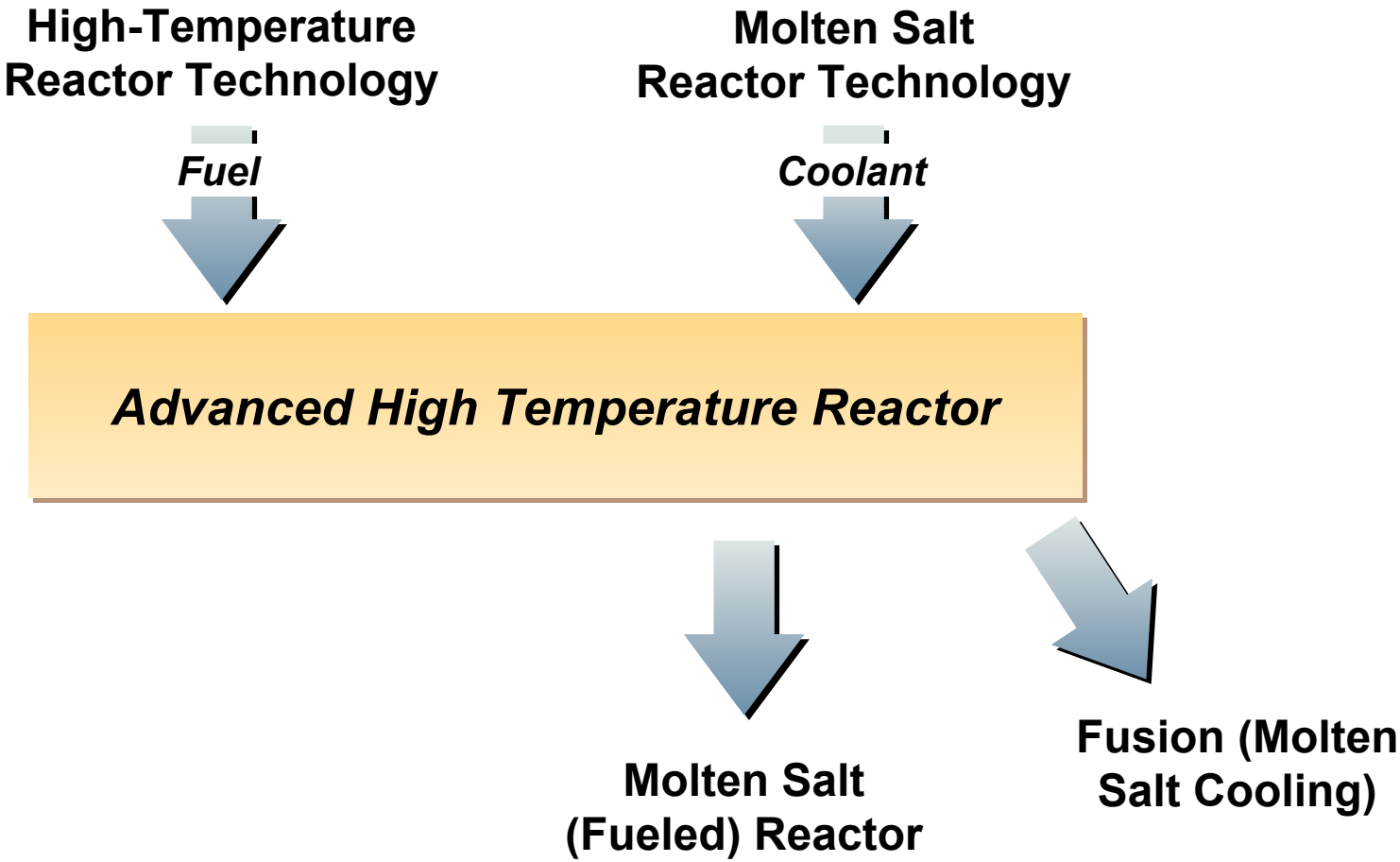


Power Reactor Experience Shows That Liquid Coolants Minimize Peak Reactor Temperatures

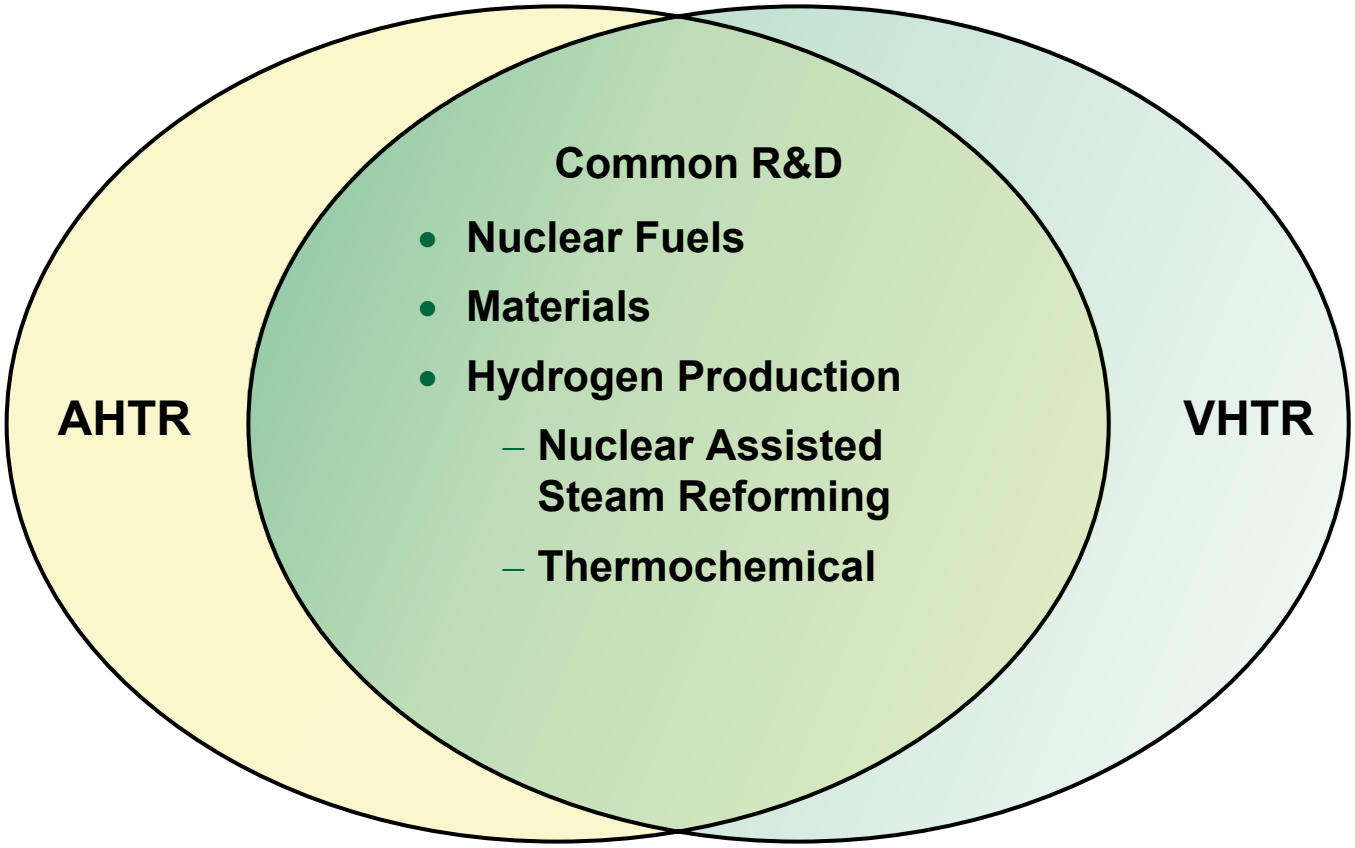


The AHTR Is the Child of GenIV:

It Was Developed in the GenIV Process and Combines GenIV Technologies



There Is a Massive R&D Overlap Between the AHTR and VHTR

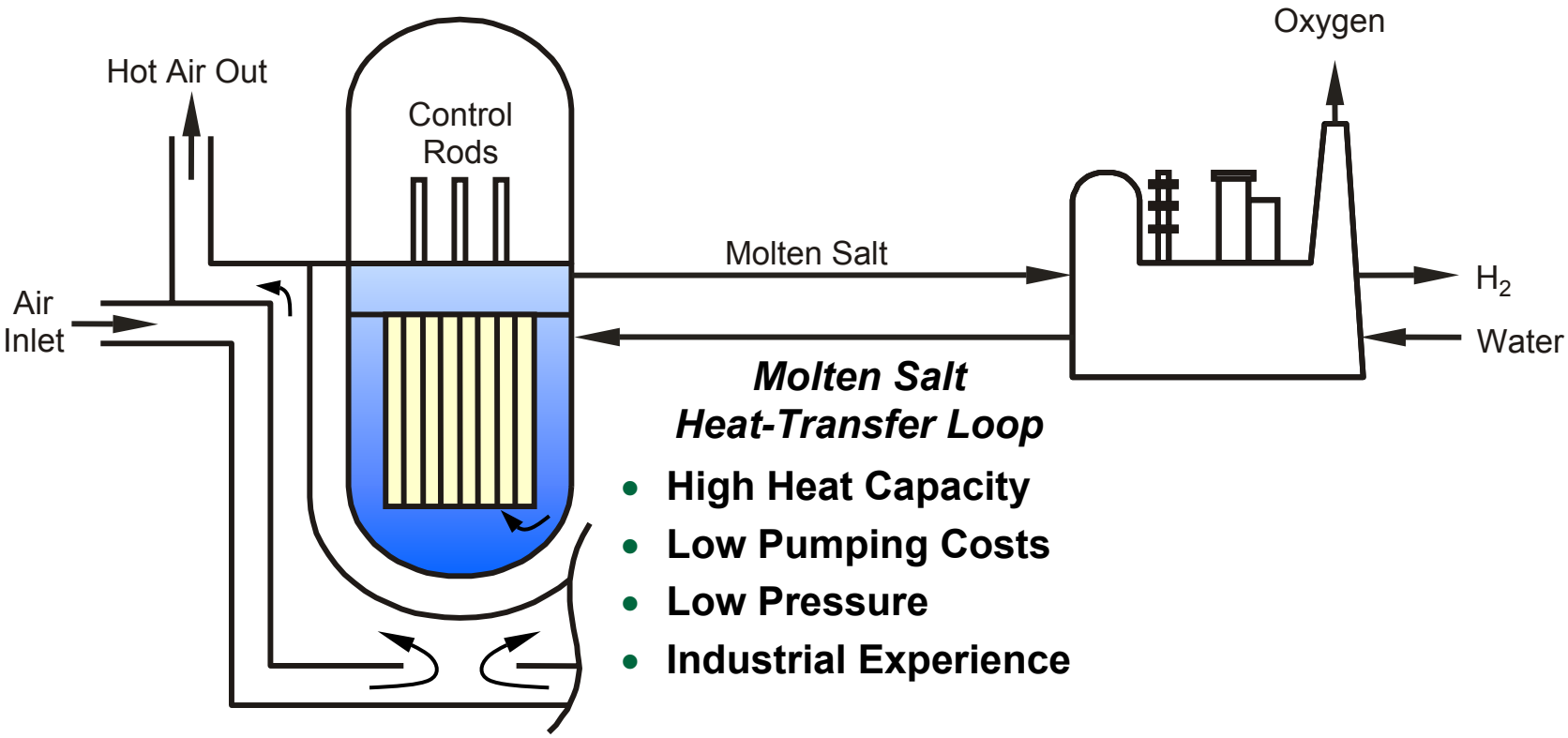


Molten-Salt Heat Transfer Loops May Be Preferred To Transfer Heat From a Reactor to the H_2 Facilities

(German Studies Supported Molten Salt Coolant Between Gas-Cooled Reactors and H_2 Facilities; Molten Salts Used in the Chemical Industry)

Nuclear Safety by Isolation

Hydrogen Safety by Dilution

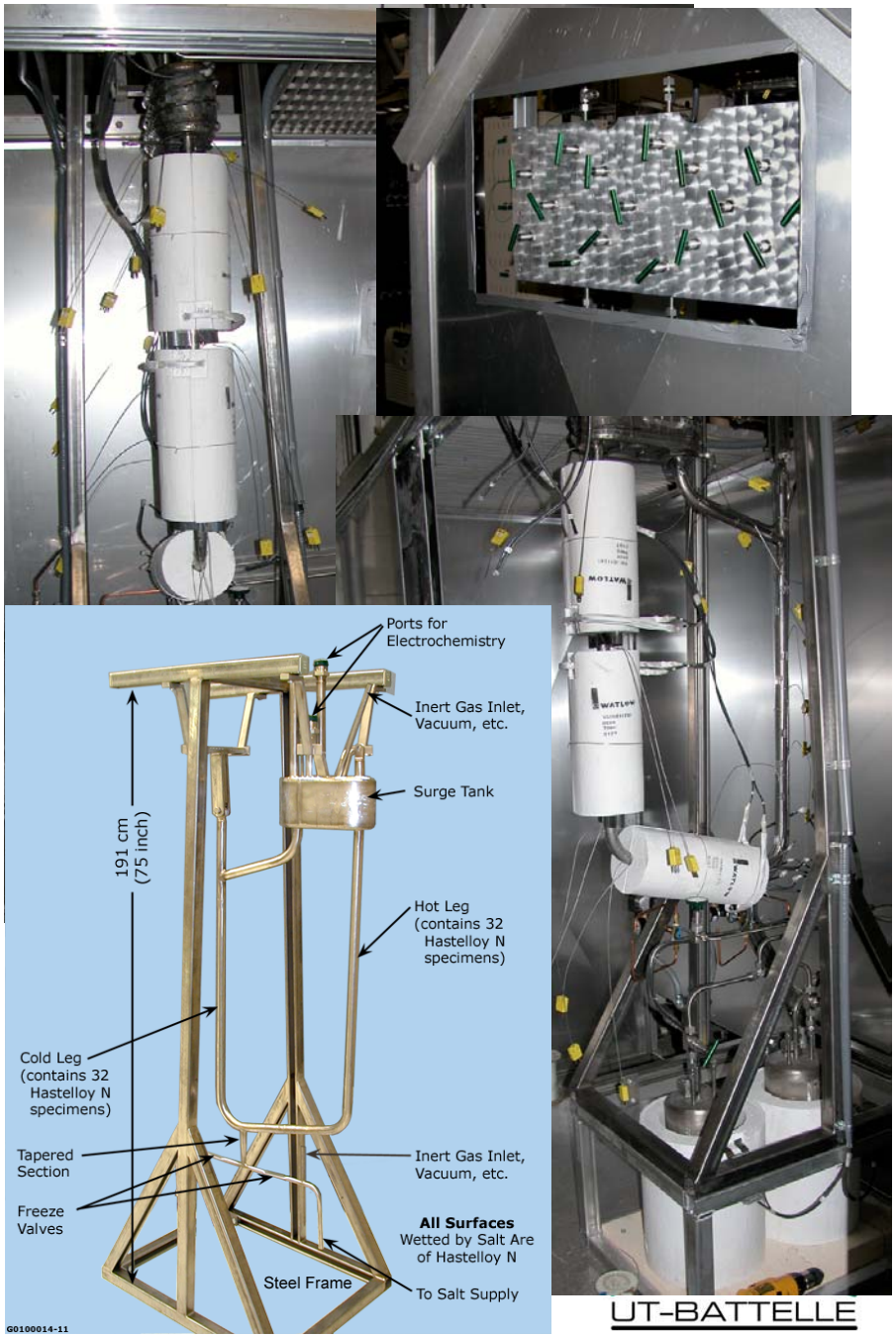


Molten Salt Heat-Transfer Loop

- **High Heat Capacity**
- **Low Pumping Costs**
- **Low Pressure**
- **Industrial Experience**

ORNL LDRD Hastelloy-N Molten-Salt Corrosion Test Loop Will Be Operational March 2003

- **Hastelloy-N Specimens**
  - 32 in hot section
  - 32 in cold section
- **4 kg Molten Salt**
  - FLiNaK
- **Thermal Gradient**
  - 800ºC — 700ºC
- **Initial Test Duration**
  - At least 1000 h



Conclusions

- Molten-salt-coolant technology is a critical technology for hydrogen production
- Several applications
  - Intermediate heat transfer loop between any reactor and a hydrogen production plant
  - Advanced High-Temperature Reactor
    - Lower reactor temperatures for high-temperature heat
    - Larger reactor
- R&D is required
  - Very high-temperature operation
  - Production systems require long lifetimes

Backup Slides

Molten Salt Loop Technical Details

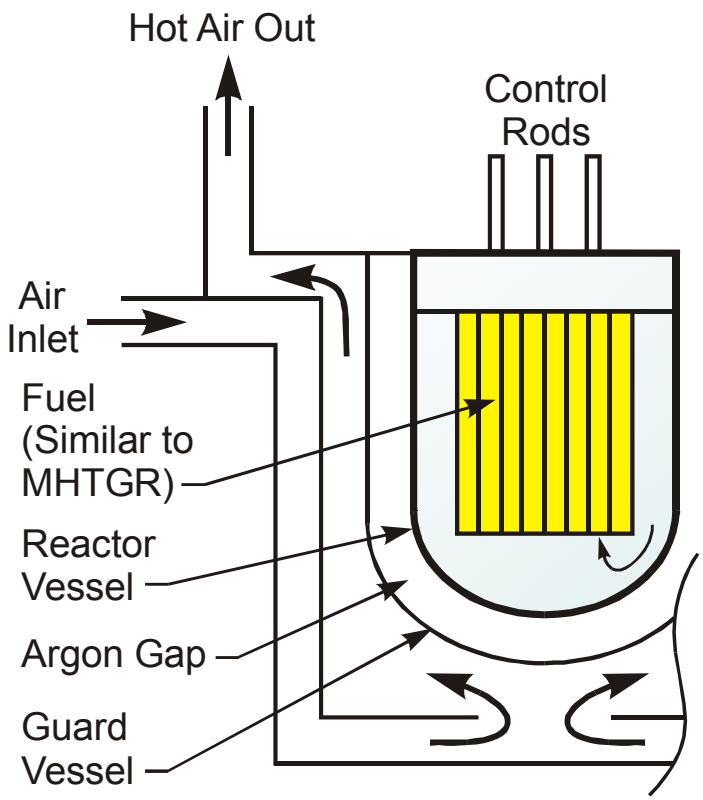
- Temperatures
  - Hot temperature: 800°C
  - Cold temperature: 700°C
- FLiNaK molten salt (mole %)
  - LiF: 46.5%
  - NaF: 11.5%
  - KF: 42%
- Hastelloy-N
  - 72% Ni
  - 16% Mo (Improve yield and tensile strength)
  - 7.25% Cr (Oxidation protection)
  - 3.7% Fe

The High-Temperature, Low-Pressure Liquid Coolant Enables Passive Decay Heat Removal in Large Reactors

(One Example: Several Other Decay-Heat Cooling Options Exist)

Passive Decay Heat Removal

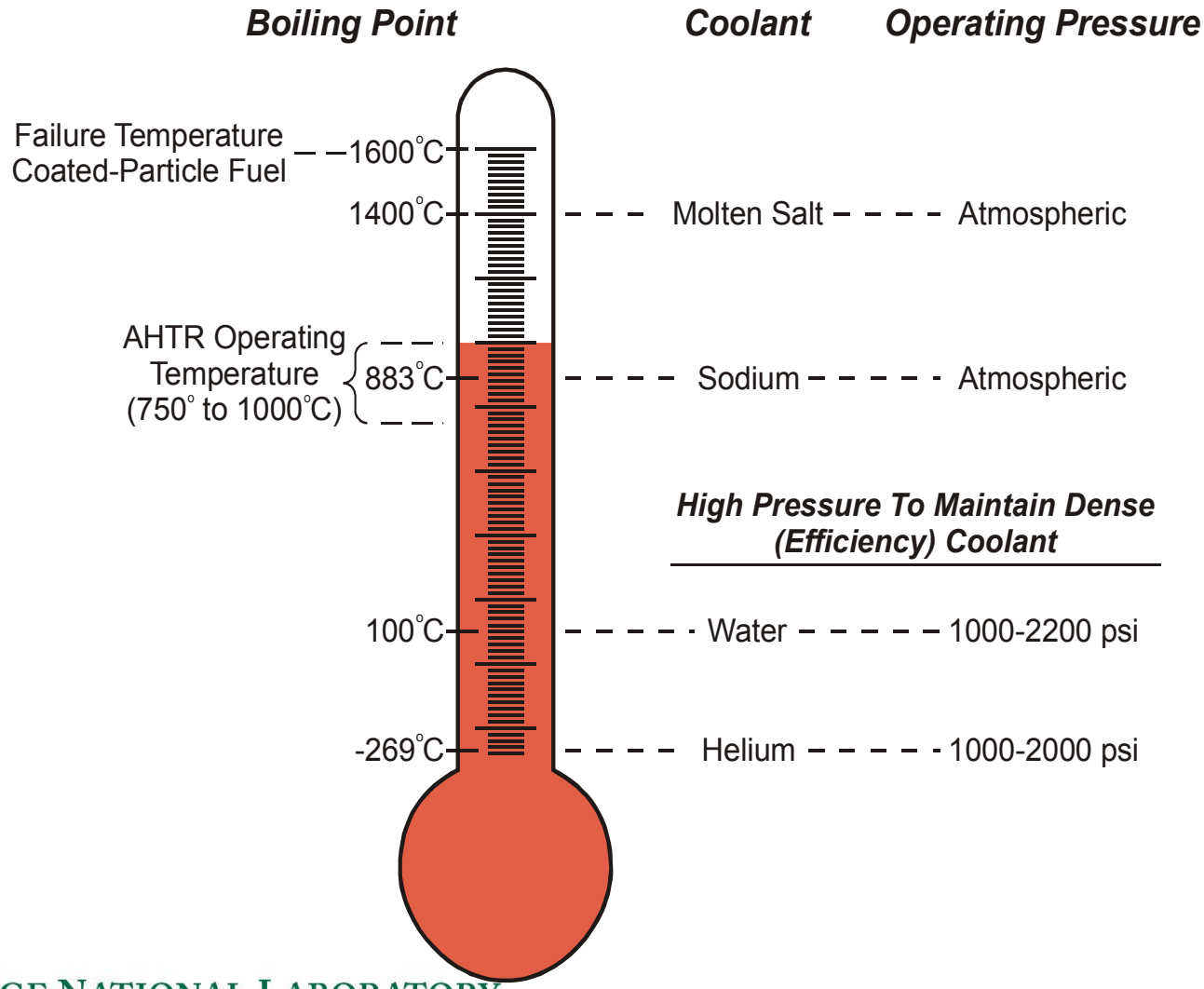
Reactor



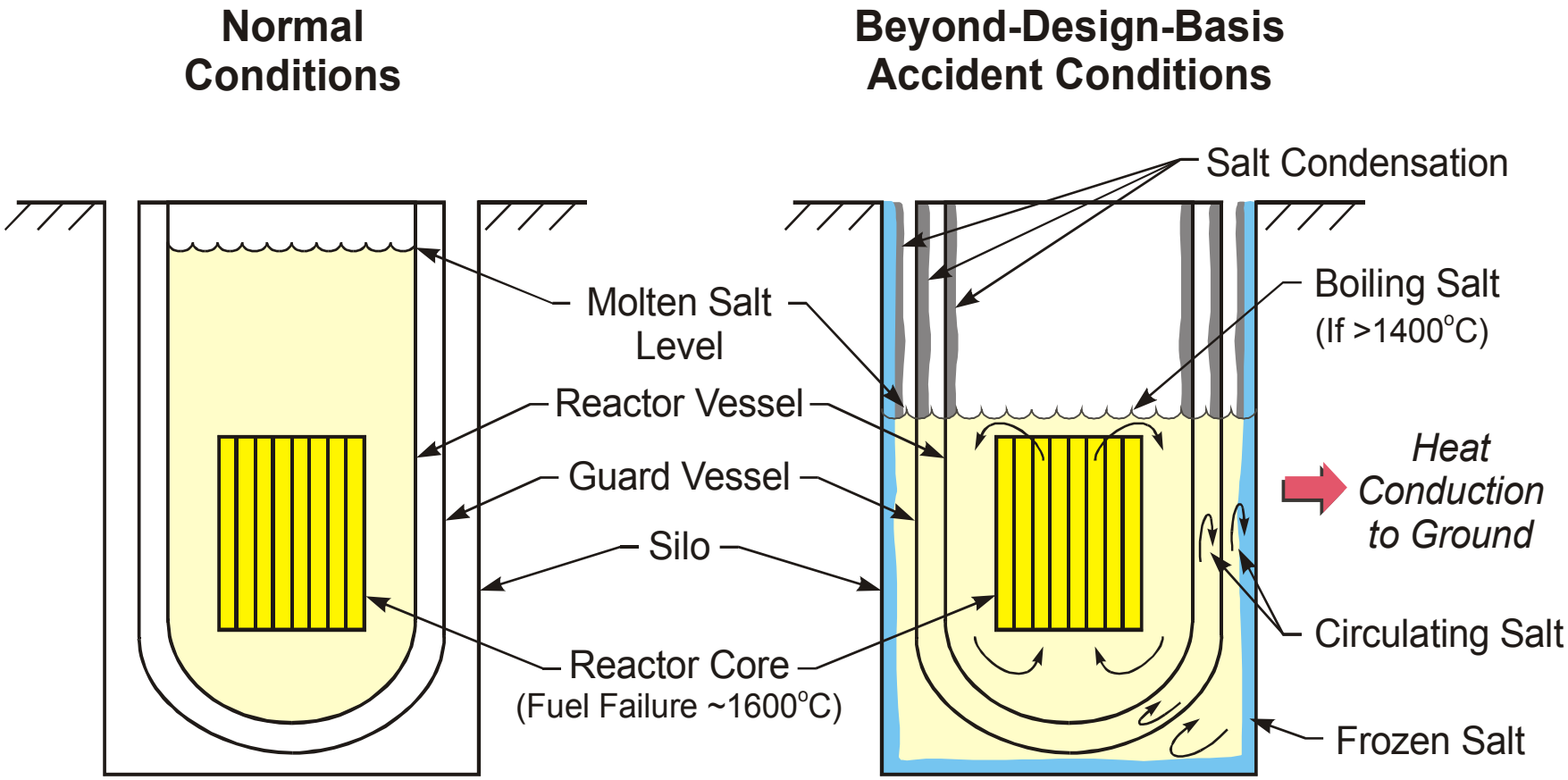
Decay-Heat Cooling System Characteristics

- 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)]

Molten Salts Have Large Margins to the Boiling Point and Boil-Off Before Major Fuel Failure

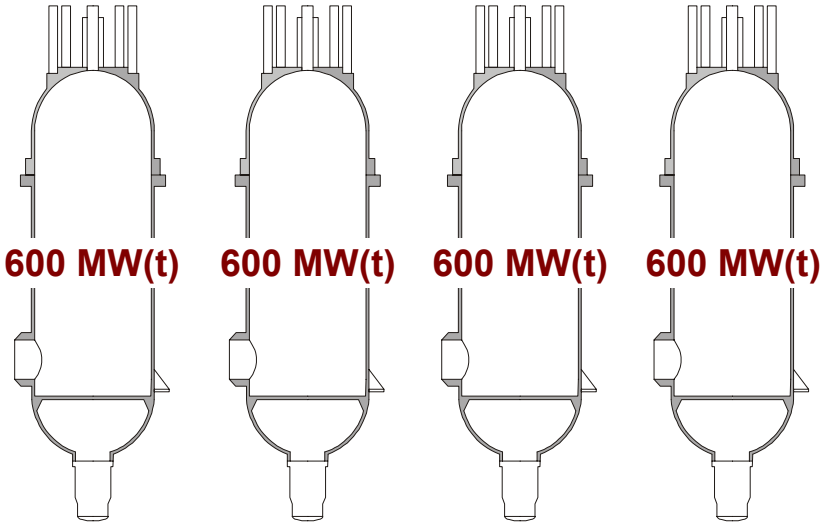
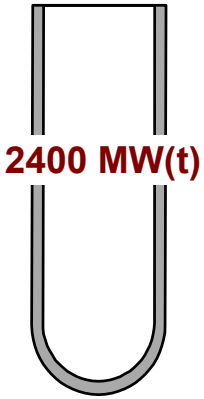


Beyond-Design-Basis Accident Avoids Radionuclide Release By Decay Heat Conduction-To-Ground (Liquid Circulation Moves Heat From Reactor Core)



The Economics of High-Temperature Liquid-Cooled Reactors may be Superior to Gas-Cooled Reactors for Systems with the Same Safety Goals

Pressure Vessels For 2400 MW(t) of HTGRs



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