Molten Salt Reactors and Molten-Salt-Cooled Reactors

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Molten-Salt-Cooled Reactors (MSCRs) Were a Result of the Aircraft Nuclear Propulsion Program

- **Heat had to be transferred from the solid-fueled reactor to the heat exchanger in the aircraft jet engine**
- **Ultra high temperatures were required for efficient propulsion**
- **After extensive investigation, molten salts were chosen based on physical and nuclear property considerations**

Molten Salt Coolants Can Transport Heat at Higher Temperatures than Other Coolants

- **Very low vapor pressures, and thus, lower requirements for high-temperature materials strength**
- **Excellent heat transfer**
  - **Maximum coolant temperature for a given maximum fuel temperature**
  - **Efficient heat dump to electric or hydrogen production systems**
- **Temperatures that can exceed those of helium systems**

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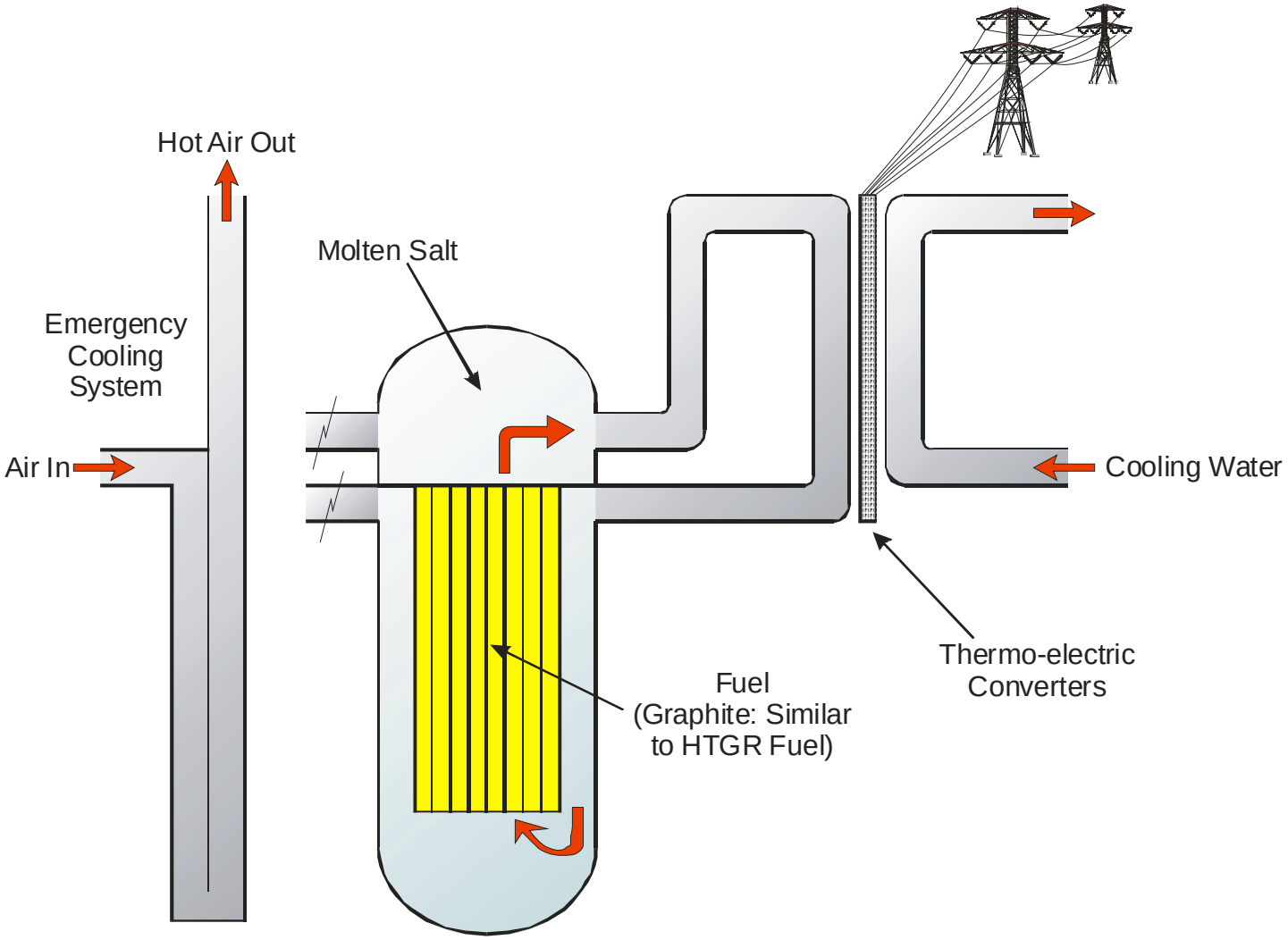


Molten Salt Cooled Reactor

MSCR Characteristics

- **High temperatures create unique options**
  - **Direct thermoelectric power production**
  - **Direct thermal-hydrogen production**
- **Graphite HTGR-type fuels preferred**
  - **High-temperature capability**
  - **Demonstrated fuel**
  - **Fully compatible with molten salts (good experience base)**

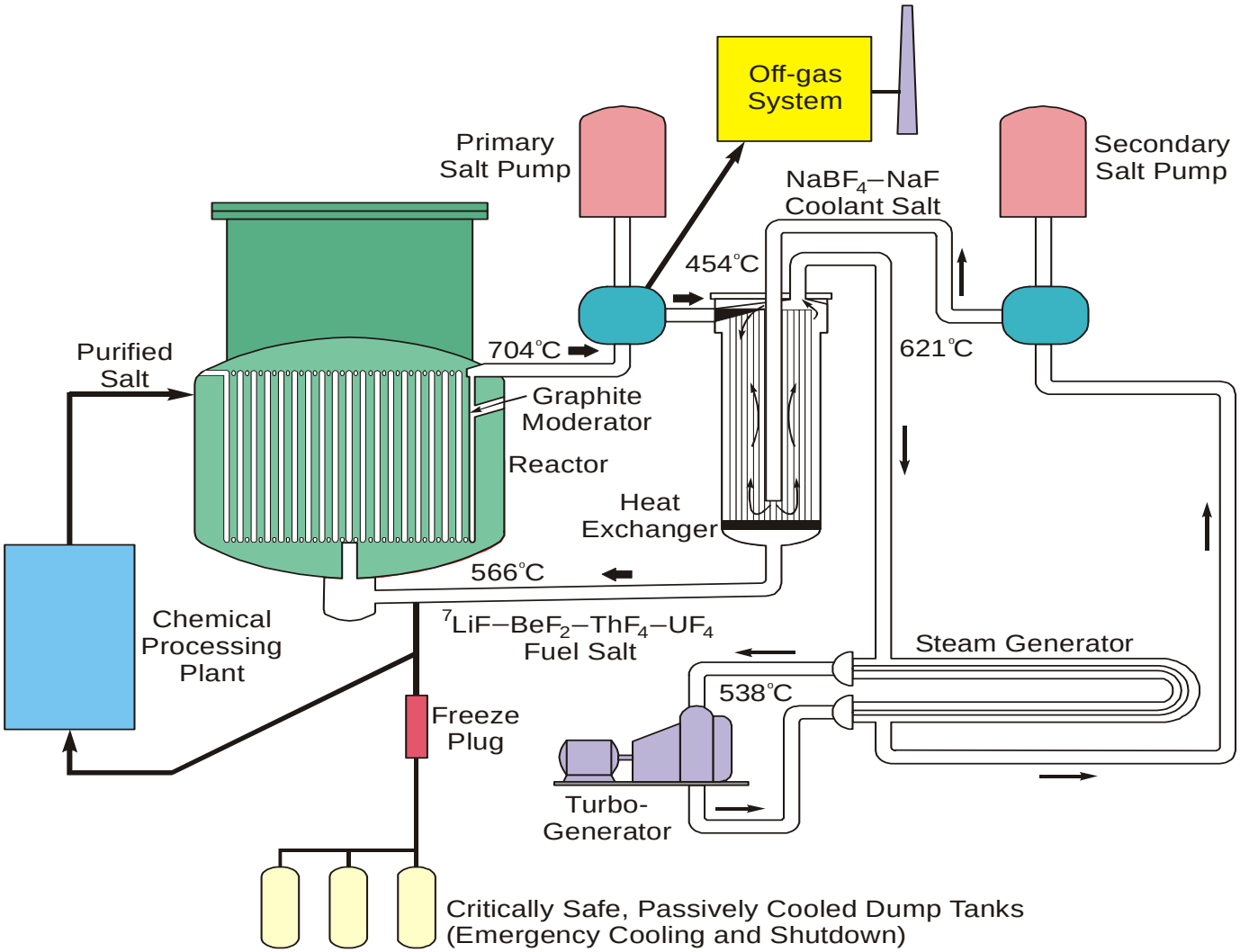
Two Critical Technical Challenges Exist for an MSCR

- **Materials of construction**
  - **Molybdenum alloys may be suitable (under development)**
  - **The same alloys are being considered for space reactors, cladding for lead-cooled fast reactors, and other applications**
- **Efficient thermoelectric conversion systems**
  - **Efficiency strongly dependent upon temperature**
  - **Several options available: all in development**

Molten Salt Reactors (MSRs) Use a Molten Salt Coolant Containing Dissolved Fuel

- **Concept was demonstrated by the Molten Salt Reactor Experiment [8 MW(t) reactor]**
- **The molten Salt Breeder Reactor (MSBR) was the backup for the LMFBR**
- **On-line processing removes selected fission products**
- **Fissile materials are never removed from the reactor**
- **No reactor size limit exists (low-pressure system)**

Molten Salt Reactor



Potential Advantages of the MSR

- **Passive safety in large reactors**
  - **In an emergency, fuel salt dumped to passively cooled drain tanks (freeze valves)**
  - **Fission products continually removed (reduced accident source term)**
- **Thorium-^{233}U thermal-neutron fuel cycle**
  - **Breeder reactor**
  - **Low actinide production; burns actinides**
  - **Potential nonproliferation benefits**
    - **Low total fissile inventory**
    - **With added ^{238}U, ^{233}U made non-weapons usable**
    - **Very poor plutonium isotopics (primarily ^{242}Pu)**

A Proliferation-Resistant MSR Is a "Breeder" Reactor

- **The refueling strategies of solid and liquid fuel reactors are different**
  - **Solid fuel: add fissile material and remove ^{238}U**
  - **Liquid fuel: add fissile material to molten salt and mix all fissile materials in the molten salt**
- **No method exists to extract excess ^{238}U except by isotopic separation**
- **Two fueling strategies**
  - **Breeder reactor: add thorium**
  - **Non-breeder reactor: requires HEU makeup**

The Technology Appears Viable, but Its Status Is Uncertain

- **The demonstration reactor worked well**
- **Questions on materials of construction**
  - **The biggest technical issue in the 1970s was the choice of materials of construction**
  - **A metallurgical R&D program continued after the main program ended**
  - **Program developed an alloy that appears to meet all requirements**
- **New technologies (over 30 years) may simplify reactor but are unanalyzed**