U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.

Nuclear Energy University Program (NEUP) Fiscal Year 2019 Annual Planning Webinar Molten Salt Reactor (Subtopic RC-7)

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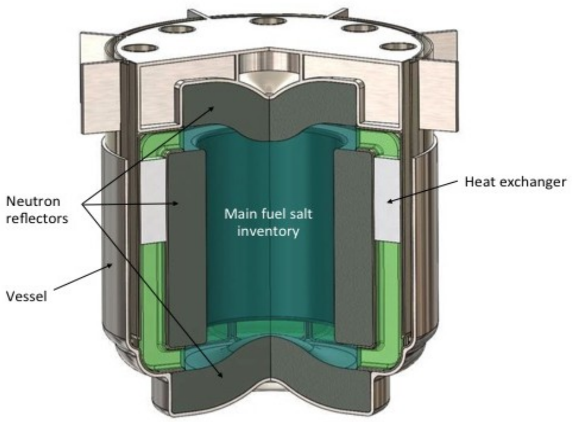
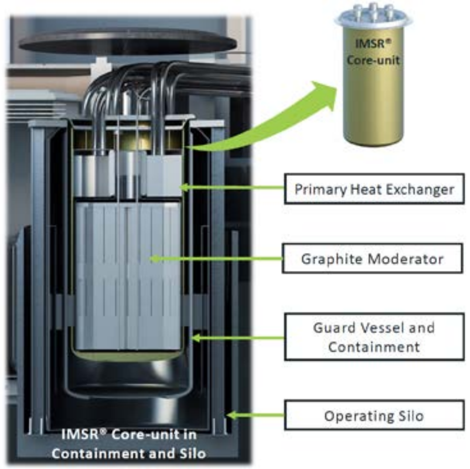
Molten Salt Reactor (MSR) Strategy

- Assist in the near-term deployment of molten salt reactors, both salt-cooled and salt-fueled concepts by establishing viability, developing needed research capability and enabling technology, reducing cost, and accelerating development to facilitate industry success.

Examples of MSR Designs being Developed by Industry

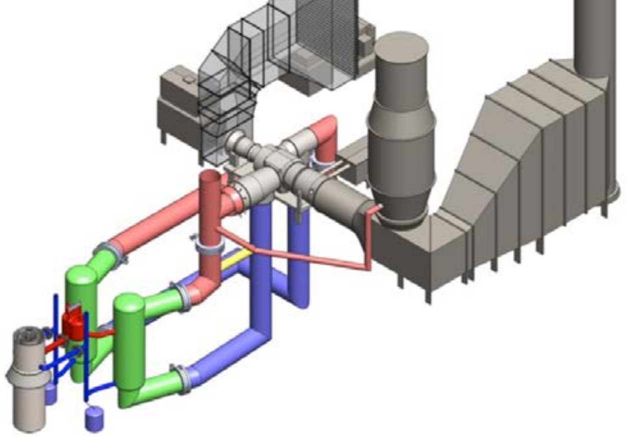


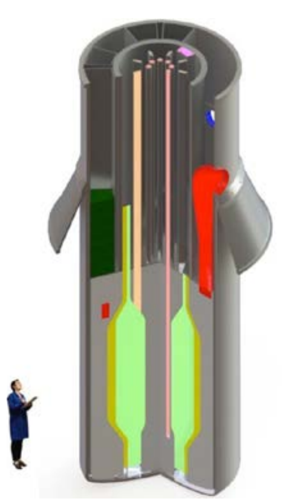
TerraPower
MCFR



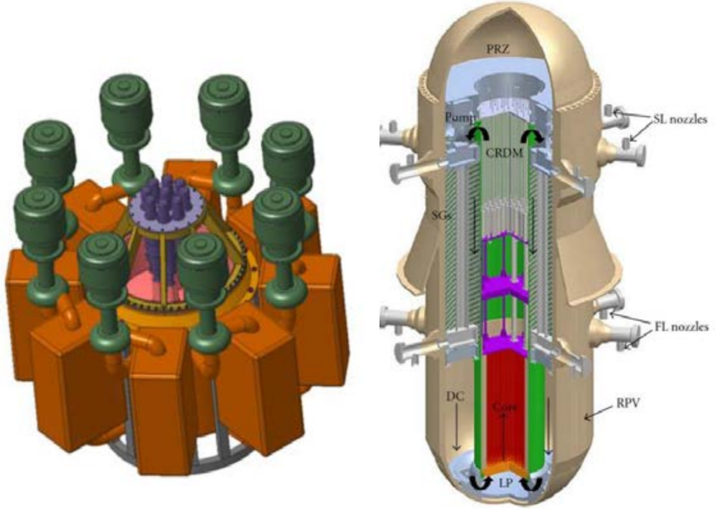
Terrestrial Energy
IMSR

Kairos Power
PB-FHR

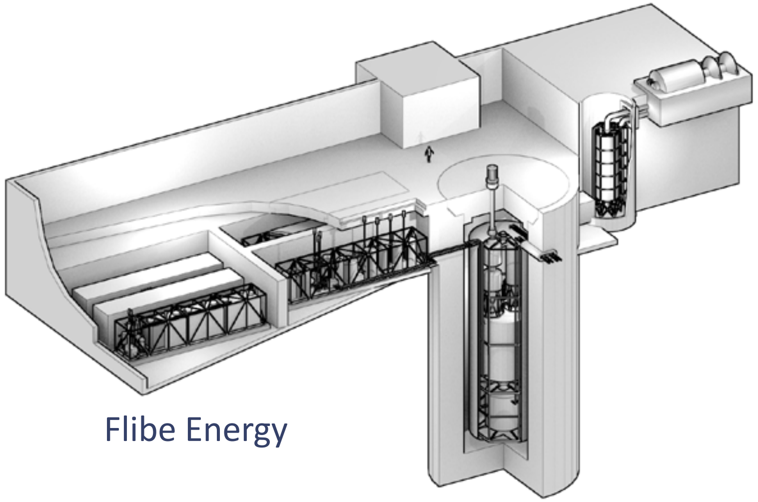




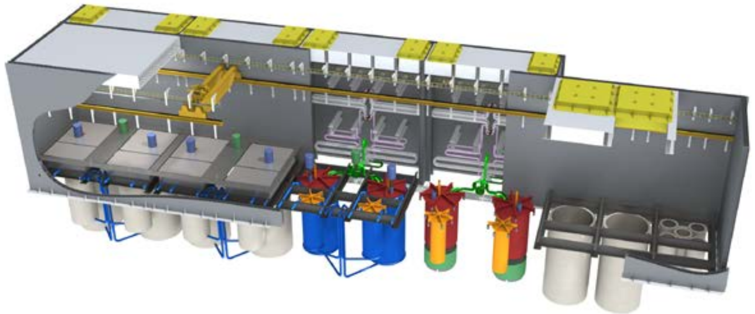
Reactor Vessel
Cross Section



Elysium USA, MCSFR



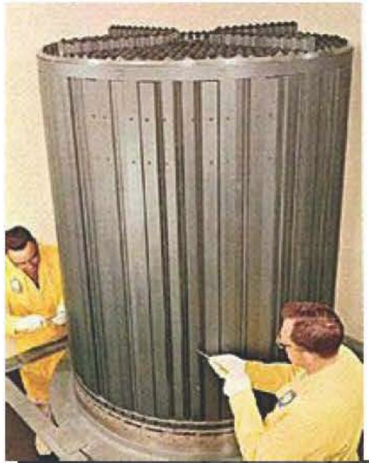
Flibe Energy

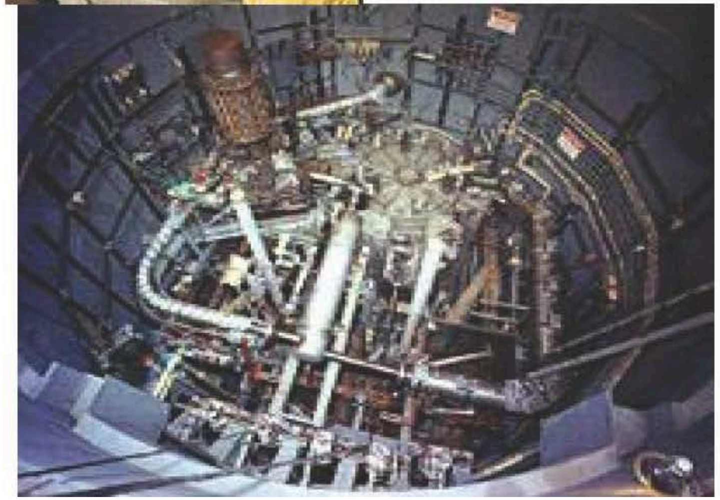


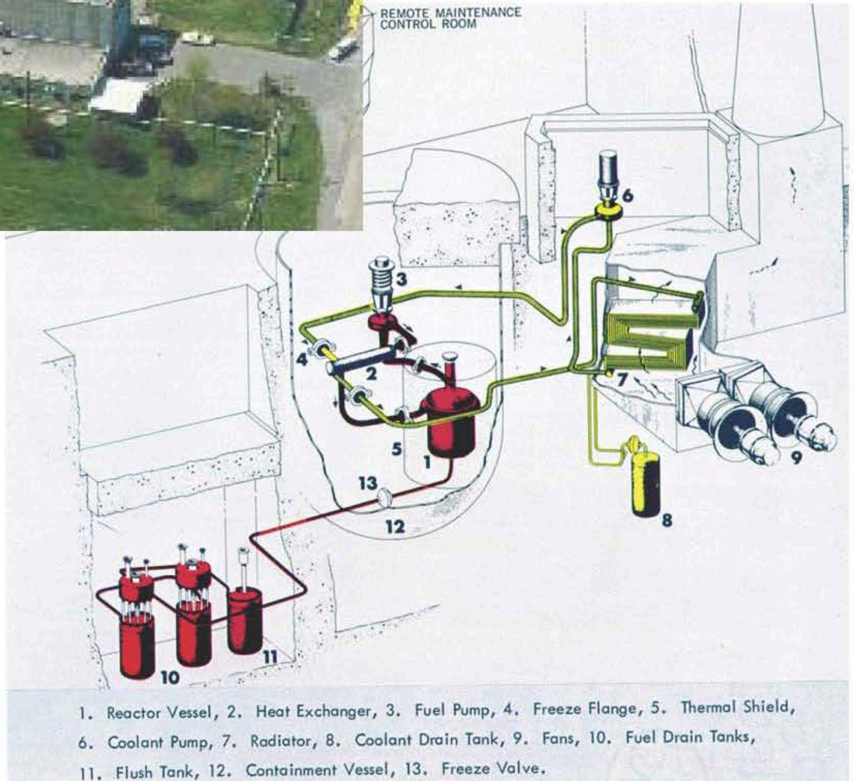
ThorCon Power

Molten Salt Reactor Experiment (MSRE)

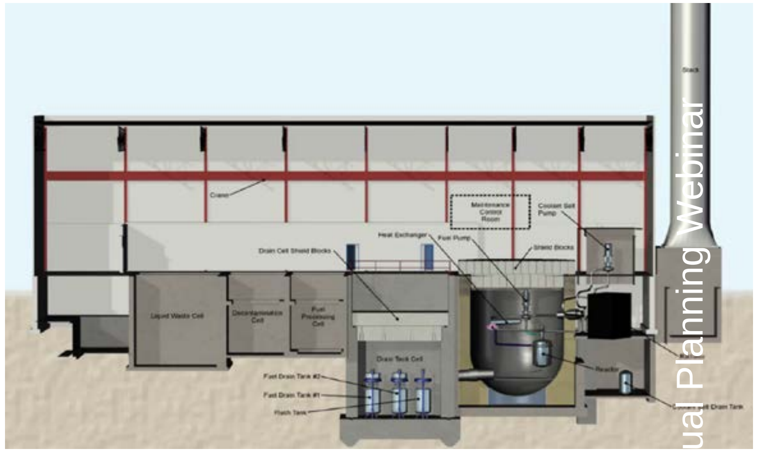
Operated at Oak Ridge National Laboratory from 1965 to 1969, is the Primary Reactor-Based Experience with Molten Salts







Molten Salt Reactor Experiment (MSRE)



- **Fuel (^{235}U, ^{233}U and ^{239}Pu) dissolved in a fluoride salt**
  - **Liquid-fuel reactor**
  - **Thermal-spectrum limited breeder reactor**
  - **7.34 MW**
  - **1225^{o}F (662 C) outlet temperature**
  - **Fuel salt was 65% Li7F - 29.1% BeF2 - 5% ZrF4 - 0.9% UF4**
  - **Program cancelled when the liquid metal fast breeder reactor chosen**
- **New interest in MSR**
  - **Fast spectrum or thermal spectrum**
  - **Liquid fuel or solid fuel**
  - **Target diverse markets – base load electricity generation, process heat applications, desalination, water purification, remote locations**

RC-7.1: Fuel Salt Sampling Technology Development - Project Scope

- **Proposals are requested to develop and demonstrate, in a non-radioactive environment, a modern equivalent to MSRE's sampler-enricher with improved reliability and potential to serve as a technology model to guide deployment in future MSRs**
- **Key parameters such as;**
  - **progress of corrosion**
  - **fissile material consumption and isotope distribution**
  - **fuel salt redox condition**
  - **in-leakage of coolant salt by measuring fuel salt composition**

RC-7.2: Evaluation of 316SS Lifetime in MSRs - Project Scope

- **Experimental projects are sought to evaluate the combined corrosion and mechanical stress impact on SS316 component service lifetimes and design limits**
- **Current R&D has shown;**
  - **High salt temperature, neutron damage, and mechanical service requirements will cause the material properties to degrade over time**
  - **Generalized and grain boundary corrosion are expected to weaken the surface making it more vulnerable to erosion**
  - **A key design for a molten salt heat transport system is the maximum allowable fluid velocity**
  - **Understanding material aging under service conditions will support establishing an evidence-based flow specification**

RC-7.3: Radiation Hardened Vision Systems - Project Scope

- **Demonstration of a multi-camera, radiation hardened 3D vision system to continuously update the in-containment model status is requested. In addition, demonstration of techniques to repair and/or replace vision system components within containment is also requested.**
- **A key elements to consider;**
  - **Enabling the automation system or the operator to perform tasks is to provide real-time 3D visual updates of the positioning of the tooling, components, and surround structures**
  - **Depending on the local shielding employed, the MSR containment environment may have very high radiation dose rates**
  - **Radiation hardened remote tooling and operations have been developed in support of O&M in multiple prior high-radiation environments**

RC-7.4: Molten Salt Mechanical Filters- Project Scope

- Experimental projects are sought that demonstrate fuel salt mechanical filter performance and operational issues using non or low radioactivity materials
- MSR R&D has shown;
  - Plating out corrosion resistant materials onto surfaces would be considered a positive/protective effect
  - It is anticipated that mechanically filters will be used to remove fission products out of the salt
  - Under certain conditions, fissile materials may also plate out onto filters
  - Sintered nickel is the leading candidate structure to serve as a mechanical filter
  - Filtering out radionuclides has a number of complex interrelated issues such as;
    - monitoring filter condition and performance
    - introducing and removing the highly-radioactive filter
    - cooling and shielding the filter once removed
    - surveying the filter for fissile material control and accountability

RC-7.5: Shutoff Valve Technology Development - Project Scope

- **On a molten salt flow loop, design and demonstrate MSR coolant salt shutoff valves whose component technologies would be suitable for qualification under a 10CFR50 Appendix B quality assurance program**
- **Information to consider;**
  - **The primary coolant salt will be operated at a somewhat higher pressure than the fuel salt to cause in-leakage in the event of heat exchanger tube failure**
  - **Primary coolant salt lines penetrate radionuclide containment layers providing a potential barrier bypass route**
  - **Ability to provide high reliability closure to the primary coolant salt lines on-demand decreases the risk of radionuclide release**
  - **Valves may be a safety-related item as they could be relied upon to mitigate the impact of postulated accidents**
  - **Valves should remain operable even under beyond design basis event conditions**
  - **High-reliability, molten salt, safety-related shutoff valves with local activation energy storage have not previously been developed or demonstrated**

Points of Contact for RC-7 Molten Salt Reactor

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