

Molten salt reactors

Molten salt reactor designers claim inter alia the following benefits:

- Ease of fuel production (no need to convert UF_6 to UO_2)
- No risk of core melt (albeit the core is actually molten during normal operation)
- Strongly negative reactivity coefficients.
- Passive shutdown by melting of freeze plug
- Retention of iodine and caesium
- Successful operation of MSRE in Oak Ridge
- Competitive costs
- Proliferation tolerance (by use of Th-cycle)
- Ease of Pu and MA recycle using pyroprocessing

Issues related to MSR technology

Selected dis-advantages related to use of molten salts:

- **Zero solubility of oxygen in molten salts:**
 - No path to rely on corrosion protection by formation of oxide film on steel surfaces. All reactor walls will dissolve (possibly slowly) into fuel salt. Critical issue for thin walled tubes, such as steam generators.
- **Very high melting temperature: 460°C, combined with poor thermal conductivity**
 - Operation above 500°C
 - No suitable pump materials
 - Vessel creep limits operational life (graphite moderator deterioration apparently worse)
- **Strong negative temperature coefficient**
 - Difficult to shut down. Propensity for power oscillations
- **Molten fuel:**
 - Elimination of two barriers for fission product (Xe) release. Requires second containment
 - Poor understanding of where your delayed neutron precursors may be
- **Formation of tritium fluoride:**
 - Additional radio-toxic corrosion agent

Historical experience

Four reactors were operated

- ARE (Aircraft reactor experiment). 2.5 MWth reactor, operated nine days in 1954
- PWAR-1, zero power reactor, operated few weeks in 1957.
- MSRE experiment in Oak Ridge: 8 MWth reactor with U-Li-Be-Zr-F fuel.
 - 18 months of operation between 1965 - 1969. 10 months at full power.
- Molten salt reactor in China operated in 70's. Little information in open literature.



Incidents and accidents

Issues encountered during operation of Molten Salt Reactors

- Severe storage accident in Oak Ridge:
- Fluorination of UF_4 due to radiolysis of fluoride salt in storage canisters lead to evaporation of 4.4 kg of highly enriched (87% ^{235}U) UF_6 .
- 2.6 kg of UF_6 (1/3rd of critical core inventory) precipitated in off-gas char-coal filters.
- Fully un-controlled criticality accident barely avoided.
- Chinese reactor experiment abandoned due to material problems



New MSR projects

One MSR under construction

- 2 MW molten salt reactor under construction in Wuwei China.
- Permission to operate granted by the Chinese regulator
- A number of concept studies (thermal, fast, uranium, thorium, plutonium, fluorides, chlorides, hydroxides) developed by private start-up companies.
- Very little new technology available that would address known issues.
- Hastelloy-N still the reference structural material
- Reactor life-time: 7 years (Terrestrial) - 12 years (Seaborg)