Molten Salt Reactor Workshop

DOE’s Enhanced R&D Focus on MSRs

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Advanced Reactor Technologies Program Overview, Mission & Structure

• **Program Mission:**
  • Identify and resolve the technical challenges to enable transition of advanced non-LWR reactor technologies and systems to support detailed design, regulatory review and deployment by the early 2030’s.

• **POC’s**
  • Director – Alice Caponiti (DOE-HQ)
  • MSR Program Manager – Brian K. Robinson (DOE-HQ)
  • National Technical Director – Lou Qualls (ORNL)
R&D programs are working to address several high level questions related to advanced reactor development and deployment, including:

- How can we improve the affordability of nuclear power?
- How can we improve the inherent safety of advanced nuclear reactors?
- How can we improve on the proliferation resistance of advanced reactors?
- How can we expand nuclear technologies into non-traditional nuclear energy markets?
- How can we increase the performance and efficiency of advanced nuclear plants through new materials, advanced systems or components?
The previous MSR Workshop (2016) identified two initiatives:

- “Develop multiscale models to understand the chemistry of fission products in operating reactors (high performance computing, integration with neutronics and thermohydraulics)”
- “Develop databases and computational methods for phase diagram development”

The following resulting activities being considered for future R&D activities:

- Salt property data collection and salt property database development
- Salt property predictive modeling (fundamental salt chemistry)
- Salt and materials interface behavior
- Salt constituent evolution due to exposures under reactor conditions
- Salt processing during reactor operations (fission product management)
- Salt monitoring and processing during reactor operation (salt corrosion chemistry)
Advanced Reactor Technology MSR Activities

- **Nuclear Energy University Program (NEUP), 2011-2017**
  - $800K (FHR)
    - Design of a Commercial-Scale, Fluoride-Salt-Cooled, High-Temperature Reactor, Investigation of Overcooling Transients that include Freezing,
    - In Fluoride-Salt Cooled High-Temperature Reactors (FHRs)
  - $4.6M (MSR) NuSTEM, Methods to Predict Thermal Radiation and to Design Scaled Separate and Integral Effects Testing
  - $800K (Materials) Bimetallic Composite (Incoloy 800H/Ni-201) Development and Compatibility in Flowing FLiBe

- **Integrated Research Projects (IRP)**
  - $7.5M (FY11) MIT, Wisconsin, UC Berkeley; High-Temperature Salt-Cooled Reactor for Power and Process Heat
  - $10M (FY14) MIT, Georgia Tech, Integrated Approach to FHR Technology and Design Challenges
  - $3M (FY17) TAMU, UC-Berkeley, SAMOFAR, Grand Challenge Problem for Nuclear Energy
Advanced Reactor Technology MSR Interfaces 1/2

• Gateway for Acceleration Innovation in Nuclear (GAIN)
  • FY16 - 2 salt related awards in FY16 ($0.4M)
  • FY17 - 7 salt related awards in FY17 ($2.1M)

• Industry Engagements

<table>
<thead>
<tr>
<th>Company</th>
<th>Concept Type</th>
<th>DOE Supported Work</th>
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<tr>
<td>TerraPower (MCFR)</td>
<td>MCFR</td>
<td>ARC 15 (partnered with Southern Co. Services)</td>
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<td>Elysium</td>
<td>MCFR</td>
<td>GAIN Voucher (FY17)</td>
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<td>Kairos</td>
<td>MSR solid fueled</td>
<td>GAIN Voucher (FY17)</td>
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<td>Terrestrial Energy</td>
<td>MSR liquid fueled</td>
<td>GAIN Voucher (FY16 and FY17)</td>
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<tr>
<td>Transatomic Power</td>
<td>MSR liquid fueled</td>
<td>GAIN Voucher (FY16 and FY17)</td>
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<tr>
<td>Southern Company Services</td>
<td>MCFR</td>
<td>ARC 15 (Molten chloride fast reactor development)</td>
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<tr>
<th>Topics</th>
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<tr>
<td>IMSR® Fuel Salt Property Confirmation: Thermal Conductivity and Viscosity</td>
<td>ANL</td>
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<tr>
<td>Evaluation of Power Fluidic Pumping Technology for Molten Salt Reactor Applications</td>
<td>ORNL</td>
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<td>Fuel Salt Characterization</td>
<td>ANL</td>
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<td>Synthesis of Molten Chloride Salt Fast Reactor (MCSFR) Fuel Salt from Spent Nuclear Fuel (SNF)</td>
<td>INL</td>
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<tr>
<td>NEAMS Thermal-Fluids (T/F) Test Sand (T/F-TS) for Fluoride-Salt-Cooled, High-Temperature Reactor (FHR) Development</td>
<td>ANL</td>
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<tr>
<td>Conversion of LWR SNF to Fluoride Salt Fuel</td>
<td>ORNL</td>
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<tr>
<td>Development of the Micro-scale Nuclear Battery Reactor System</td>
<td>INL</td>
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Advanced Reactor Technology MSR Interfaces 2/2

- Advanced Reactor Working Group (NEI)
  - Quarterly meetings
  - January 2017 - Presentations available on GAIN website Includes overview of current U.S. MSR modeling and simulation tools

- MSR Technology Working Group (TWG)
  - Quarterly meetings
  - December 2016 Letter outlining Separate Effects Test Program for MSRs

- Molten Salt Chemistry Workshop
  - April 2017 Emphasized identifying fundamental knowledge gaps

- Office of Science - Basic Energy Science (BES)
  - August 2017 – Establish the science base to realize molten salt coolants and liquid fuels

- Small Business Innovation Research (SBIR)
Potential MSR FY18 R&D Activities

- **Technology Development and Demonstration**
  - Hardware and instrumentation needs are evaluated to ensure enabling capabilities exist for chemistry monitoring, corrosion testing, instrumentation and control, and component development

- **Methods, Modeling and Validation**
  - Ensure neutronic and thermal-hydraulic models are readily adaptable for MSRs; predictive chemistry models related to salt property evolution, salt and material interactions, and salt constituent inventory tracking

- **Fuel Qualification**
  - Develop and understand fuel salt chemistry and associated regulatory challenges

- **Advanced Materials Development**
  - Develop and qualify of advanced structural materials by leveraging international collaborations (DOE, KAERI, EU, JAEA, PBMR) to ensure compliance with ASME Section III Division 5 for High Temperature Reactors

- **Coolant Chemistry**
  - Establish a DOE database and develop predictive modeling frameworks
American Nuclear Society Standards

• Currently there are four standards under development supporting MSRs.
  • ANS-30.1, “ Integrating Risk and Performance Objectives into New Reactor Nuclear Safety Designs” (in development-first draft)
  • ANS-30.2, “Categorization and Classification of Structures, Systems, and Components for New Nuclear Power Plants” (in development)
ANS Standards for Research Reactors: NUREG 1537

- In NUREG 1537 eleven ANS standards for research reactors are referenced.
- All will need to be examined to determine applicability for use in licensing a MSR test reactor.
Summary

• Over the past few years DOE has Enhanced R&D Focus on MSRs

• While there are many MSR challenges, most can be overcome through collaborative efforts of industry, national laboratories and universities.

• Thank you for your support and we look forward to working with you.