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

MSR International and Safety Activities

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Molten Salt Reactor PROGRAM

Molten Salt Reactor (MSR) Campaign Continues to Support International Safety Cooperation

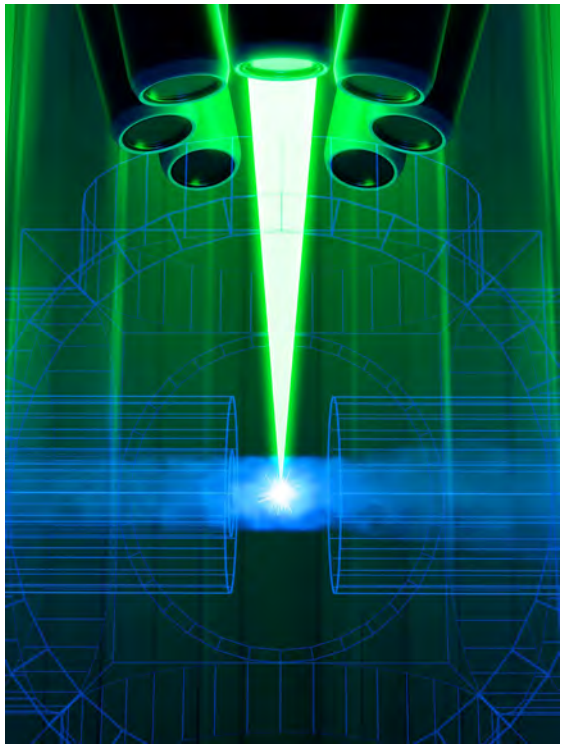
- **Generation IV International Forum (GIF) and International Atomic Energy Agency (IAEA) are the primary collaboration venues**
  - GIF MSR provisional system steering committee (pSSC)
    - Held ongoing discussions on differing approaches for establishing safety basis
    - MSR risk and safety task force remains under consideration
  - IAEA high-temperature gas reactor (HTGR) and MSR safety workshop (May 2022)
    - Supported evaluation of applicability of IAEA Specific Safety Requirements (SSR-2/1) to MSRs
  - IAEA Conference on Topical Issues in Nuclear Safety (October 2022)
    - Provided overview of MSR safety characteristics and US safety adequacy evaluation tools and methods
  - Joint IAEA-GIF Workshop on Safety of Non-Water-Cooled Reactors (May–June 2023)
    - Providing overview of potential domestic contributions to a collaborative safety assessment project
  - Develop materials for MSR safety training course (1-day) for *IAEA Interregional Training on Non-Water-Cooled Reactors and Small Modular Reactors* (2024)
    - Based on MSR overview course developed for the Nuclear Regulatory Committee (NRC) (updated December 2022)

GIF MSR pSSC Safety Collaboration

- **Limited to exchange of open/fundamental information**
- **Focus of collaboration is on developing and exchanging information suitable for providing technical basis for safety adequacy assessment**
  - Multiple alternative methods for safety adequacy assessment are possible
- **Technical basis derives from fundamental data**
  - Fuel salt thermophysical and thermochemical properties
  - Safety system, structures, and component (SSC) performance
  - Accident progression experiments and simulations
- **Employing open data for safety adequacy decisions can increase public acceptance of nuclear power**
  - Accident progression demonstrations have not yet been at sufficient scale to necessitate collaborative activities

Generation and Validation of Fundamental Data is a Key Element of GIF MSR Cooperation

- **Fuel salt thermochemical and thermophysical properties are central to understanding potential source term and accident progression**
  - Multiple independent measurements decrease property uncertainty
  - Fundamental scientific data is published openly
- **Multiple GIF participants independently contribute related information to safety-related topics**
  - United States demonstrating laser induced breakdown spectroscopy for monitoring aerosolized species and gases in headspace
  - European Union (EU) recently published thermodynamic evaluation of release kinetics of CsI into headspace
  - Canada has been experimentally evaluating fission product releases from halide salts



Laser-Induced Breakdown Spectroscopy (LIBS) application to off-gas.

Liquid-Fuel MSR Design Safety Standard Under Balloting at American Nuclear Society (ANS)

- **MSR campaign continues to support development of ANS 20.2 - *Nuclear Safety Design Criteria (DC) and Functional Performance Requirements for Liquid-Fuel Molten Salt Reactor Nuclear Power Plants***
  - Broad participation from national labs, industry, NRC, and universities
  - Canadian and EU participation
- **Draft standard provides MSR specific design criteria equivalent to the general design criteria of 10 Code of Federal Regulations (CFR) 50 Appendix A for light-water reactors (LWRs)**
  - Sodium-cooled fast reactor (SFR) and modular high-temperature gas-cooled reactor (mHTGR) specific design criteria developed in prior Department of Energy Office of Nuclear Energy (DOE-NE) projects
  - General advanced reactor design criteria (ARDC) as well as SFR and mHTGR DC endorsed by NRC in Regulatory Guide 1.232
- **Draft standard provides substantial background information on MSR safety characteristics–Appendix A**
- **Draft standard recommends the use of the non-LWR probabilistic risk assessment (PRA) standard for applicants employing PRA to develop principal design criteria–Appendix B**
- **Effort underway since 2015**

Hazards Evaluation of Non-Reactor Portion of MSR Fuel Cycle *RD-22OR070401*

- **Develop technical basis and regulatory mapping for integrated MSR reactor and fuel cycle facility safety adequacy evaluation reflective of the multiple regulatory aspects arising from the additional fuel cycle activities possible at liquid-fueled MSR sites**
  - Evaluation includes multiple examples of different reactor configurations emphasizing the diversity of potential MSR configurations (e.g., fast, thermal, fluoride, chloride, U/Pu, Th/U)
  - Focus is on emerging technologies and their resultant safety impacts
  - Regulatory mapping documents multiple sets of regulations that pertain to all aspects of integrated plant operation throughout its lifecycle
- **Existing licensing process is not structured to address front-end, back-end, and reactor regulatory issues in an integrated manner**
  - Existing licensing pathway includes multiple regulations that derive from characteristics of solid-fueled reactors
  - Licenses would currently involve multiple exceptions and approval by different NRC offices
- **Project provides the technical basis and regulatory map necessary for development of an efficient and effective regulatory pathway that is reflective of the technical issues of liquid-fueled MSRs to integrate additional portions of the fuel cycle**
- **Findings documented in Oak Ridge National Laboratory (ORNL)/TM-2022/2671**

Central Project Effort Was Technical Analysis and Regulatory Mapping of Hazards of Co-located MSR Fuel Cycle Facilities

- **Provides multiple examples of representative MSR fuel cycle facilities, their hazards, and potential deployment scenarios**
  - Describes technical issues arising from selecting particular technologies from a facility hazards and regulatory compliance perspective
  - Includes examples of recently proposed MSR fuel cycle technologies in addition to historic molten salt breeder reactor technologies
- **Maps the regulatory compliance aspects of MSR fuel cycle facilities to existing and developing regulations**
  - Includes regulations throughout site and facility lifecycle from
    - initial fuel synthesis through construction
    - operations (including waste processing and storage)
    - accident progression
    - facility decommissioning

MSRs Integration Into Nuclear Fuel Cycles In Diverse Scenarios Likely

- **Safety principals underlying the existing regulatory base remain relevant**
- **MSRs may be deployed with other nuclear power facilities on existing sites**
- **Multiple MSRs may share common facilities**
  - Fuel salt preparation or waste stabilization and storage
- **Providing robust barriers and adequate separation between facilities and processes enables separate facility licensing**
  - Existing rules about adequate separation of reactor systems are applicable
- **Even nominally independent facilities without shared services can be commonly impacted by large scale external events such as fire, flooding, or severe storms**
- **Performance-based, site-level regulations would be necessary to enable integrating risks from multiple, separately-licensed facilities on a single site**
  - Issue for all complex nuclear sites (not just MSRs) under beyond-design-basis events

Continuing COVID Outbreak in Fiscal Year 2022 Limited Stakeholder Outreach

- **Resulted in larger amount of carryover than intended**
  - Additional outreach planned for Fiscal Year 2023
- **New FY-23 task planned to initiate evaluation of safety and regulatory issues associated with developing a Part 50 equivalent to Framework B of Part 53**
  - Recognizes technical similarities to the existing non-power reactor licensing process described in NUREG 1537
  - Technology independent methodology
    - Intended to be useful to multiple different sizes and configurations of MSRs including designs that include additional elements of the fuel cycle at the reactor site
  - Employs a maximum credible accident as a bounding concept
- **New task will accelerate development of technical basis to support regulatory development as Part 53 becomes finalized (2-year horizon)**

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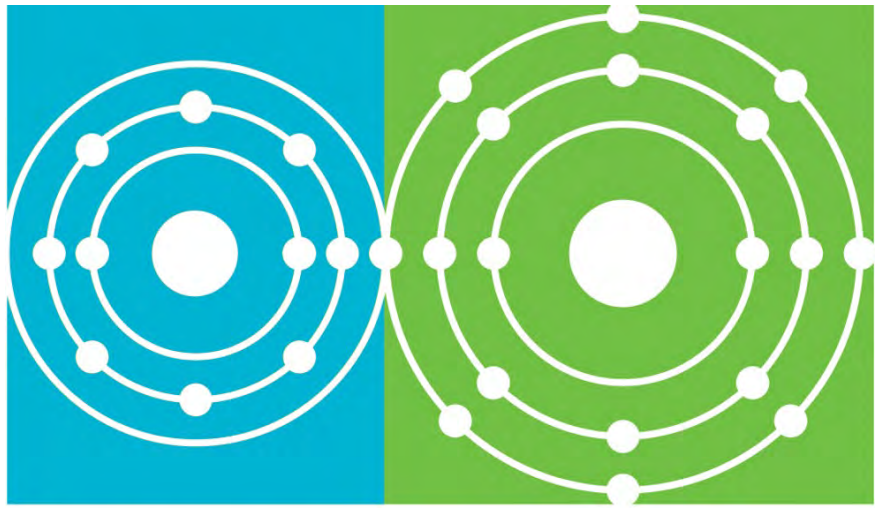

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Thank you