Liquid-Fuel Molten Salt Reactor Design Safety Standard (ANS 20.2) Overview

ORNL-GAIN MSR Workshop

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Draft Standard Increases Safety Adequacy Design and Evaluation Efficiency and Predictability

- Existing body of regulations and safety evaluation methods are based upon the characteristics of the existing fleet of LWRs
  - MSRs represent a substantial technological departure from LWRs
  - Cumbersome to evaluate the safety of each new MSR design based upon customized exceptions to existing practice
- Safety principles are the same for any nuclear plant
- MSR focused design safety standard
  - Preserves and translates existing safety principles to MSRs
  - Addresses MSR specific issues

Draft Standard Was Developed By A Broad Team Representing Developers, National Laboratory Staff, Universities, and Regulators

- American Nuclear Society working group organized in 2015
- Early draft developed by 2018
  - Hiatus while NRC developed Regulatory Guides 1.232 and 1.233
- Development resumed in 2020
  - Two-hours per week virtual team writing meetings
- Initial draft submitted for balloting in August 2021
- Subcommittee votes and comments due in October 2021

Standard Applicable to Both Traditional and Probabilistic Safety Adequacy Evaluation Processes

- Technical information organized into three main sections

1. Background on MSR safety and accident progression concepts that highlight differences from LWRs
2. MSR specific design criteria translating the safety elements of the General Design Criteria (GDC) or Advanced Reactor Design Criteria (ARDC) to MSRs
   - Augmented by additional MSR specific design criteria
3. Risk-informed design process guidance that describes MSR specific considerations for probabilistic plant safety evaluation

Background Section Highlights the Shifts in the Safety Basis Relative to LWRs

- Section serves as in information resource on issues to be considered during the design and evaluation of MSRs
- Example content
  1. Design options enabled by multi-layer radionuclide retention embodied in functional containment
  2. Concept of applying specified acceptable radionuclide release design limits (SARRDLs) instead of specified acceptable fuel design limits (SAFDLs)
  3. Safety issues arising from employing a common inner containment layer and the potential to leak a large fraction of radionuclides into the next containment volume as a result of a breach

MSR Specific Design Criteria Derive from General Design Criteria of 10 CFR 50 Appendix A

- Principal design criteria establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety

> General Design Criteria are also considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the principal design criteria for such other units. – 10 CFR 50 Appendix A

- NRC has provided guidance for developing principal design criteria for non-light-water reactors in Regulatory Guide 1.232
  - RG 1.232 provides advanced reactor design criteria and class specific design criteria for sodium fast reactors and modular high temperature gas reactors

ANS 20.2 Provides MSR Class Specific Design Criteria That Embody the Safety Objective of Each of the GDCs

- Each GDC sequentially evaluated for applicability to MSRs
  - GDC directly adopted when fully relevant (e.g., quality assurance)
  - ARDC adopted in cases where it provides better match to MSR characteristics
  - SFR or MHTGR design criteria adopted where they more closely match MSR characteristics
- Additional criteria reflective of the distinctive characteristics of MSRs added to set of criteria
  - For example – criterion added to address safety issue of coolant activation due to proximity to the neutron field
- Each MSR-DC provides rationale for adaption to GDC – for example

> *Rationale for Adaption to GDC: Derived from ARDC. "Coolant boundary" has been relabeled "fuel salt boundary" to reflect the difference between MSRs and other advanced reactors.*

Risk-Informed MSR Design Process Section Introduces MSR Specific Considerations into Probabilistic Risk Formulation

- Describes MSR considerations for implementing the risk-informed methods endorsed in Regulatory Guide 1.233
  - Provides MSR specific information useful for developing a PRA following ANS/ASME-RA-S-1.4 “Probabilistic Risk Assessment Standard for Advanced Non-LWR Power Plants”
- Based upon associating systems and phenomena for achieving the fundamental safety functions and potential failure modes
- Discusses MSR characteristics useful for performing reliability assessments
  - For example – passive heat transfer systems tend to be larger than active systems, which can impact system performance during external events
- Recognizes that much of the implementation of a risk-informed design process is independent of the reactor class

10 CFR Part 53 May Substantially Change the Preferred MSR Safety Adequacy Evaluation Method

- ANS 20.2 describes an acceptable, current process for risk-informing MSR designs and safety-evaluations
- Acceptable nuclear plant safety adequacy methods continue to evolve rapidly
  - Rate of change is more rapid than has been the case for the past several decades
  - Substantial changes to the acceptable methods for risk informing designs in draft 10 CFR Part 53 language over the past few months
- Standard will need to be updated as additional MSR safety evaluation methods are approved
  - All ANS standards require updates every 5 years