



COMMISSION MEETING WITH THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

June 3, 2022



Agenda

- Joy Rempe, Chairman, ACRS
 - Overview
 - NRC Safety Research Program
- Vicki Bier, Member, ACRS
 - 10 CFR Parts 50 and 52 Alignment and Lessons Learned Rulemaking
- Greg Halnon, Member, ACRS
 - Rulemaking Activities to Support Small Modular Reactors (SMRs) and Other New Technologies (ONTs)
- David Petti, Member-at-Large, ACRS
 - Non-Light Water Reactor (Non-LWR) Source Term

Issued 19 Letter Reports since October 2021 Meeting

- SMR and ONT Rulemaking and Guidance
 - 10 CFR Part 53 Subpart F – Staffing, Personnel Qualifications, Training, and Human Factors
 - Draft Final Rule, "Emergency Preparedness for SMR and ONTs"
 - RG 1.247, "Acceptability of PRA Results for Advanced Non-LWR Risk-Informed Activities"
 - Integration of Source Term Activities for Advanced Reactors
 - NUREG-2246, Fuel Qualification for Advanced Reactors Draft Report
- Technology and Design-Specific SMRs
 - Fuel Qualification for Molten Salt Reactors Draft Report
 - Safety Evaluation of Kairos Mechanistic Source Term Methodology Topical Report (TR)
 - NuScale SC - TR on Building Design and Analysis for SR Structures
 - BWRX-300 TR on Containment Evaluation
 - BWRX-300 TR on Advanced Civil Construction and Design Approach

Issued 19 Letter Reports since October 2021 Meeting (Cont'd)

- LWR Plant- and Vendor-Specific Applications
 - North Anna Subsequent License Renewal
 - Point Beach Subsequent License Renewal
 - Holtec TR on Spent Fuel Pool Heat Up Calculation Methodology
 - Framatome TR on Galileo Implementation in LOCA Methods
- Other Topics
 - RG 5.71, Rev 1 - Cyber Security Programs for Nuclear Power Reactors
 - Research Information Letter (RIL) 2021-13 on Interpretation of Research on Fuel Fragmentation, Relocation, and Dispersal at High Burnup
 - Rulemaking Plan for the Revision of Embrittlement and Surveillance Requirements for High-fluence Nuclear Power Plants in Long-term Operation
 - Proposed Draft 10 CFR Parts 50 and 52 Alignment and Lessons Learned Rulemaking
 - Biennial Research Review

Other ACRS Activities

- Processes improvements
 - Benefit/impact of optional ACRS letters evaluated
 - Requests for formal presentations reduced (as appropriate)
- Safety-significant beneficial activities continuation / resumption
 - Focused reviews of selected activities
 - Plant and fuel fabrication facility visits
- Future submittals preparations
 - Subcommittee structure reorganization
 - Membership succession considerations

NRC Safety Research Program

- The Office of Nuclear Regulatory Research (RES) provides technical advice, tools, and information for meeting NRC's mission, including:
 - Resolving safety and security issues
 - Making regulatory decisions
 - Promulgating regulations and guidance
- Since 1974, ACRS has conducted formal NRC research reviews. Currently, this activity includes:
 - Reviews of research conducted in support of specific regulatory activities
 - Periodic reviews of important ongoing research
 - Our Biennial Review of the NRC safety research program

ACRS Biennial Review

- Review process continues to emphasize 1997 Commission direction to evaluate:
 - Need, scope, and balance of reactor safety research program
 - Progress of ongoing activities
 - How well RES anticipates research needs and is positioned for changing environment
- FY2022 Biennial Review also emphasizes:
 - Prioritization and identification of user needs
 - Long-term planning
 - Follow-up on prior ACRS recommendations

ACRS Biennial Review (continued)

- Integrated insights from:
 - Initial meeting with Director of RES to obtain overview of program, plans, priorities, and areas of interest
 - Three briefings to discuss research conducted by each RES division: Division of Risk Analysis, Division of Systems Analysis, and Division of Engineering
 - Other ACRS activities (e.g., focused reviews of important ongoing projects, etc.)

Conclusions and Recommendations

- RES program meets Agency's near-term needs.
The program:
 - enables staff to maintain core competencies
 - prepares for reviews of anticipated submittals
 - emphasizes “enterprise risk” in project selection, evaluation, and termination

Conclusions and Recommendations (cont'd)

- RES program and initiatives enabling Agency to 'be ready' for emerging needs and future submittals. Examples include:
 - Future Focused Research (FFR) Program
 - Non-LWR Integrated Action Plans (IAPs)
 - Agency-wide strategies and initiatives
 - Reorganizations and expanded applications of new capabilities

Conclusions and Recommendations (cont'd)

- Appendices to main report provide detailed insights and comments, such as:
 - Continue using collaborations and virtual capabilities to leverage resources and maintain core competencies
 - Use reference plant evaluation results to prioritize data needs for SMRs and ONTs
 - Continue emphasizing 'enterprise risk' for project selection, evaluation, and termination; consider fixed end-dates for user need requests

Conclusions and Recommendations (cont'd)

- The interval between our formal reviews should increase from two to three years.
 - RES research portfolio healthy
 - Rate at which research results obtained
 - ACRS has more frequent briefings on research topics of special interest and provides reports as necessary

10 CFR Parts 50 and 52 Alignment and Lessons Learned Rulemaking

Vicki Bier, Chair

Regulatory Rulemaking, Policies, and Practices
Subcommittee

Background (1/2)

- Two licensing pathways are currently available:
 - 10 CFR Part 50 (construction permit then operating license)
 - 10 CFR Part 52 (combined license)
- Both pathways were designed for light water reactors
- 10 CFR Part 53 may provide more flexible pathway:
 - Until 10 CFR Part 53 becomes available, 10 CFR Parts 50/52 may need modification for near-term non-LWR applications

Background (2/2)

- Both pathways (Parts 50/52) provide reasonable assurance of public health and safety
- Recent activities primarily focused on Part 52
- Part 50 not aligned with some Part 52 requirements:
 - Application of the severe accident policy statement
 - Three Mile Island (TMI) requirements
 - Usage of probabilistic risk assessment (PRA)
 - Fire protection design features and plan documentation
- Therefore, these two pathways may not provide equivalent protection, and do not fully reflect lessons learned from recent licensing activities

Objectives of Rulemaking

- Objectives of this current rulemaking process are to:
 - Align the licensing requirements in 10 CFR Parts 50 and 52
 - Incorporate lessons learned from recent power-reactor licensing reviews
 - Improve clarity
 - Reduce unnecessary burden
- Rulemaking objectives being accomplished through development of several draft rulemaking documents:
 - Changes to 10 CFR Parts 50 and 52
 - Changes to associated documents (e.g., regulatory guides, Standard Review Plan)
- This has been an extensive staff effort

Alignment of Parts 50 and 52

- The proposed changes will require all applicants to address the four alignment issues discussed earlier
- These changes offer several safety and regulatory-efficiency benefits
- ACRS identified several points that could benefit from additional clarification:
 - The required level of detail for an “essentially complete conceptual design” (or preliminary design) for construction-permit applications under Part 50
 - Inconsistent or vague words and phrases—e.g., “credible” and “substantial” (which could lead to inconsistent application of regulatory requirements)

Process Improvements

- Changes to 10 CFR Part 52 are designed to increase flexibility, reduce unnecessary regulatory burden, and provide clarity
- We have two observations in this regard:
 - We concur with the staff decision to preclude use of a 10 CFR 50.59-like process for changes to Tier 1 and Tier 2* information
 - Reduced reporting requirements for evolutionary designs based on well-established engineering models may not be suitable for first-of-a-kind designs using unique new engineering models

Other Considerations

- The process under 10 CFR Part 52 does not provide a step prior to fuel load where the PRA must be inspected:
 - This may reflect a missed opportunity to confirm that there are no outstanding risk issues
- Also, more attention may need to be paid to licensing of reactors being transported to and from a site with a loaded core:
 - Existing regulations were not intended for fueled transportable microreactors
 - We support staff's holistic look at these regulations
 - A roadmap or additional guidance may be beneficial in this area

Conclusions and Recommendations

- The proposed changes to the regulation and guidance documents address the stated rulemaking objectives:
 - Align the licensing requirements in 10 CFR Parts 50 and 52
 - Incorporate lessons learned from recent power-reactor licensing reviews
 - Improve clarity
 - Reduce unnecessary burden
- Staff should proceed with this rulemaking package
- We offered several comments for staff consideration as they proceed with this package

Rulemaking Activities to Support Small Modular Reactors and Other New Technologies

Greg Halnon, Member
ACRS

Emergency Preparedness for SMRS and ONTS

- The staff worked through some difficult concepts and numerous comments
- Connectivity with the other advanced reactor activities
- Review focused on four major categories:
 - EPZ boundary selection and offsite planning and response
 - Hazards from non-nuclear, co-located facilities
 - Performance-based regulatory oversight of emergency response function
 - Event selection for sizing EPZ

Emergency Preparedness for SMRS and ONTS (cont'd)

- Hazards from non-nuclear, co-located facilities
 - Impact of non-nuclear hazards
 - Response actions for events, radiological and non-radiological
 - FEMA jurisdiction
- Performance-based regulatory oversight of emergency response function
 - Performance measures
 - Framework for inspections being developed
- Event selection for sizing EPZ
 - Appendix B of RG 1.242 added
 - Staff is continuing to interact with industry

EPZ Boundary Selection, Offsite and Onsite Plans

- Risk-informed plume exposure EPZ generally supported
- Offsite planning commensurate with reduced hazards of smaller reactors
- Ingestion pathway EPZ changes to ad-hoc response
- Plume exposure EPZ within site boundary
 - FEMA excluded from review
 - Radiological offsite planning solely through All-Hazards planning process

Plume Exposure EPZ Rule

Planning Requirements

- Onsite and Offsite Planning Activities All Applicants

- Maintain capability to:
 - Public information
 - Safeguards Contingency
 - Communicate with NRC
 - Establish emergency facilities
 - Site familiarization training for OROs
 - Maintain E-plan

NRC Review

- Offsite Planning Activities (EPZ>Site Boundary)

- E-plan must describe:
 - Contacts and arrangements with Fed, State, Tribal, Local
 - Communications with OROs
 - Protective measures in EPZ to protect public
 - Evacuation Time Estimates
 - Offsite facilities and backups
 - Means for offsite dose projections
 - Public information, alert notification
 - Re-entry plans
 - Drill and exercise program

NRC Review
FEMA Review

Plume Exposure EPZ Rule

Planning Requirements

NOT REQUIRED if EPZ is \leq Site Boundary

Only functions completely eliminated

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NRC Review

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NRC Review

FEI/MA Review

Summary – Emergency Preparedness

- Overall, rule and guidance are well developed
- Staff addressed many comments
- Source term efforts are a continuing topic for our meetings
- Inspection guidance being developed
- FEMA should remain informed of new reactor siting
- We look forward to continuing dialogue on our comments and recommendations

Operator Licensing Requirements

- Balance of flexibility and predictability
- Largely follows Part 55 for licensing of Reactor Operators and Senior Reactor Operators
- Staffing Plan submittal has value
 - Shift Technical Advisor (STA) initially eliminated
 - Blanket elimination not appropriate
 - Single management position for decision-making
- Scope of simulators appropriate for intended use
- Some guidance documents are dated and need updating

Certified Operator Proposal

- Operator Action not required to maintain safety of plant
- Licensees essentially “license” or certify their own operators
- Certification process largely follows the NRC licensing process
- Certified operators perform all functions of a licensed operator
- Certified or NRC Licensed operators not at same facility

Certified Operator Proposal (cont'd)

- Sole licensing authority of NRC
 - Importance of federal license
 - Potential conflict-of-interest in safety decisions
- Limited operating experience of new technologies
- Current operating licensing process can recognize relevant and inherent passive features
 - Operating training time
 - Examination focus
 - Reduce time spent on non-significant features of new technology

Summary - Part 53 - Operations

- Provides a reasonable performance-based, technology inclusive framework for operator staffing
- Licensed operators will be equivalent to present Part 55
- Submittal of Staffing Plan will be of value in establishing operating strategy
- STA position should be required unless elimination is justified
- Certified Operator program should not be pursued and staff resources should focus on adapting existing licensing processes

Non-Light Water Reactor Source Term

Dave Petti, Member-at-large
ACRS

Outline

Source Term: release of radioactive and chemical species during postulated accidents from the fuel, through barriers in the facility, to the environment

- Source Term as part of Fuel Qualification
 - Qualification of solid fuel systems
 - Qualification of fuel dissolved in coolant (molten salt)
- Kairos Mechanistic Source Term Topical Report
- Integration of Source Term Activities in Support of Advanced Reactor Initiatives

Fuel Qualification Reports

NUREG – 2246 DRAFT REPORT FUEL QUALIFICATION FOR ADVANCED REACTORS

- The draft NUREG provides a logical approach to fuel qualification
 - The top-down approach is methodical and provides some assurance of completeness when a claim is made that a nuclear fuel is qualified.
 - Key parts of the approach are identifying relevant experimental data and assessing associated safety margins.
- NUREG document discusses need for developing source term data as part of fuel qualification process

Fuel Qualification Reports (continued)

NUREG/CR – XXXX, “FUEL QUALIFICATION FOR MOLTEN SALT REACTORS,” DRAFT REPORT FOR COMMENT

Nuclear fuel behavior is a key part of the overall safety case. For molten salt fueled reactor concepts, the fuel is dissolved in the molten salt coolant. This different configuration requires a new approach to fuel qualification for molten salt fueled reactors.

- The report discusses volatility of fission products in salt, a key input to source term.
- The report identifies challenges to barriers to prevent fission product release and mitigation options.
- The NUREG/CR draft report provides a reasonable and practical approach to developing a licensing basis for fuel qualification for molten salt fueled reactors.

Kairos Mechanistic Source Term Topical Report

The KP-FHR is a molten salt cooled pebble bed reactor. The salt is Flibe, a eutectic mixture of beryllium fluoride and lithium fluoride.

The KP-FHR is the first implementation of functional containment.

TRISO fuel and a molten salt coolant, Flibe, both function as strong inherent barriers to fission product release.

- The topical report presents the methodology used by Kairos to calculate the mechanistic source term of fission products, activation products, and corrosion products produced in the KP-FHR core.
- The approach is consistent with existing high-level regulatory guidance on source terms for advanced reactors.

Kairos Mechanistic Source Term Topical Report (continued)

- Staff review of an application that employs this methodology will need to ensure that the experimental limitations related to tritium behavior in Flibe, and diffusion and trapping effects in graphitic components are adequately considered in conservative safety analyses and/or relevant sensitivity studies.
- The staff SE does not require experimental validation of vaporization of fission products from Flibe. This has an important effect on the overall source term and experimental validation data are needed to confirm the approach used by the applicant. The SE should not be issued until this shortcoming is addressed.
 - The staff agreed with our recommendations and updated the final SE appropriately

Integration of Source Term Activities in Support of Advanced Reactor Initiatives

- Staff provided excellent presentations on relevant aspects of the source term for advanced reactors.
- The NRC's dedicated web page for source term related documents is commendable and should keep potential applicants up to date on latest developments in this area.
- The staff should provide an overview section on the web page explaining how an applicant can best use the available information in concert with pre-application consultations with the staff to be better prepared to develop high quality submittals.

Integration of Source Term Activities in Support of Advanced Reactor Initiatives (continued)

- NRC staff has expended significant effort related to computer code model development and application for non-light-water reactor (LWR) technologies.
 - Calculations from accident initiation through to source term for numerous technologies
- Although design specific evaluations are needed, application of these codes as part of the NRC staff reference plant evaluations has identified key phenomena, data gaps, and accident system response features that impact source terms.
 - Staff insights from these evaluations should be documented.
- This activity should substantially increase the readiness of the staff and promote expeditious reviews of current and future non-LWR applications.

Integration of Source Term Activities in Support of Advanced Reactor Initiatives (continued)

- Clear and consistent guidance that aligns the use of the terms “maximum hypothetical accident” and “maximum credible accident” should be developed to assist potential applicants that would use this concept in their licensing strategy.
- Source terms should consider both radioactive and chemically hazardous materials in advanced reactor designs.

Summary (1/2)

- Focus of fuel qualification efforts is to assure fuel performs its relevant safety functions in the context of a specific design
- Source term aspects of the fuel need to be considered in the overall fuel qualification effort
- Staff's efforts to date on preparing for advanced reactor applications are commendable.
 - This activity should substantially increase the readiness of the staff and promote expeditious reviews of current and future non-LWR applications

Summary (2/2)

- ACRS comments are focused on:
 - Ensuring key components of the source term are identified
 - Ensuring all key assumptions related to source term are based upon experimental data or else conservative assumptions in the absence of data
 - Improving technical completeness and clarity of the documents given their broad range of applicability across advanced technologies and associated reactor designs

Acronyms

- ACRS – Advisory Committee on Reactor Safeguards
- CFR – Code of Federal Regulations
- DCA – Design Certification Application
- E-plan – Emergency Plan
- EPZ – Emergency Planning Zone
- FEMA – Federal Emergency Management Agency
- Flibe - a eutectic mixture of lithium fluoride (LiF) and beryllium fluoride (BeF₂), with a nominal chemical composition of 2LiF:BeF₂
- KP-FHR – Kairos Power Fluoride Salt-cooled High Temperature Reactor
- LBE – Licensing Basis Event
- LWR – Light Water Reactor
- ONT – Other New Technology
- ORO - Other Responsible Organization
- NRC – U.S. Nuclear Regulatory Commission
- PRA – Probabilistic Risk Assessment
- RES – Office of Nuclear Regulatory Research
- SE – Safety Evaluation
- SMR – Small Modular Reactor
- STA – Shift Technical Advisor