

Advanced Reactor Stakeholder Public Meeting

February 13, 2025

Bridge line: 301-576-2978

Conference ID: 969 566 695 #



Time	Agenda	Speaker
10:00-10:15 am	Opening Remarks	NRC
10:15-10:30	Trial Use RG 1.247 Update	NRC
10:30-11:00 am	Chemical Hazards of Licensed Material Under the Part 53 Regulatory Framework	NRC
11:00-11:30 am	Readiness Of the NRC's MACCS Consequence Analysis Computer Code	NRC
11:30 – 11:45 am	Planned Guidance on Comprehensive Risk Metrics and Associated Risk Performance Objectives	NRC
11:45 - 12:15 pm	Public Comment Period	Public
12:15 pm	Closing Remarks/Adjourn	NRC

Opening Remarks

Advanced Reactor Program Highlights

Recent Accomplishments:

- Publication of the [Prospective Applicant Landing Page](#) on the NRC's public website.

Updates:

- The Public Comment period for RG 1.87 Rev 3 (DG-1436) has been extended to February 26, 2025.

Upcoming Public Meetings:

- 2/20 1:00 pm: Microreactor workshop to discuss the draft activities integration plan.
- 3/11-13: Regulatory Information Conference.



AVAILABILITY OF CNSC – USNRC JOINT REPORT: CLASSIFICATION AND ASSIGNMENT OF ENGINEERING DESIGN RULES TO STRUCTURES, SYSTEMS, AND COMPONENTS

- Available in ADAMS document management system at: [ML25024A256](#)
- Also available under Joint Reports of the Canadian Nuclear Safety Commission (CNSC) and NRC at: <https://www.nrc.gov/reactors/new-reactors/advanced/who-were-working-with/international-cooperation/nrc-cnsc-moc/joint-reports.html>

Regulatory Guide 1.247

Status Update

Background

- RG 1.247 describes one acceptable approach for determining whether the acceptability of the probabilistic risk assessment (PRA) that is used to support an application is sufficient to provide confidence in the results, such that the PRA can be used in regulatory decision-making for non-light-water reactors.
 - It endorses with staff exceptions the ASME/ANS RA-S-1.4-2021, “Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants” and NEI 20-09, Revision 1, “Performance of PRA Peer Reviews Using the ASME/ANS Advanced Non-LWR PRA Standard”
- Trial Use RG 1.247 was published in May 2022 for a 2-year trial use period.
 - To help gain additional implementation experience to better inform draft and final staff positions.

Status

- Public Meeting- July 30th, 2024
 - NRC shared plan for finalizing RG (extended finalization period)
 - NEI provided feedback on Trial Use RG
- Internal workshop on EOCs on November 7, 2024.
 - NRC is developing a whitepaper to support staff position
- Working on revising pre-promulgation comments, addressing RG 1.200 inconsistencies and other open items.
- Planning to engage on opportunities for implementation experience (e.g., peer reviews)

Next Steps

- Addressing comments will delay the previous schedule; a new schedule is under development.
- Staff are also evaluating options to help ensure consistent and efficient determinations while maintaining flexibility across technology areas and regulatory frameworks for new license applications
- We plan to seek stakeholder input
- We continue our work to address the feedback we've received from the trial use reg guide and experience from use.

Draft Guidance to Support Meeting the Proposed 10 CFR 53.440(k)

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Treatment of Chemical Hazards of Licensed Material

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Part 53 Proposed Rule Language ([89 FR 86918](#))

10 CFR 53.440 Design requirements.

(k) Design features and related functional design criteria must be defined such that analyses demonstrate a low risk of permanent injury to the public due to the health effects of the chemical hazards of licensed material.

Draft Regulatory Guide (DG) Development

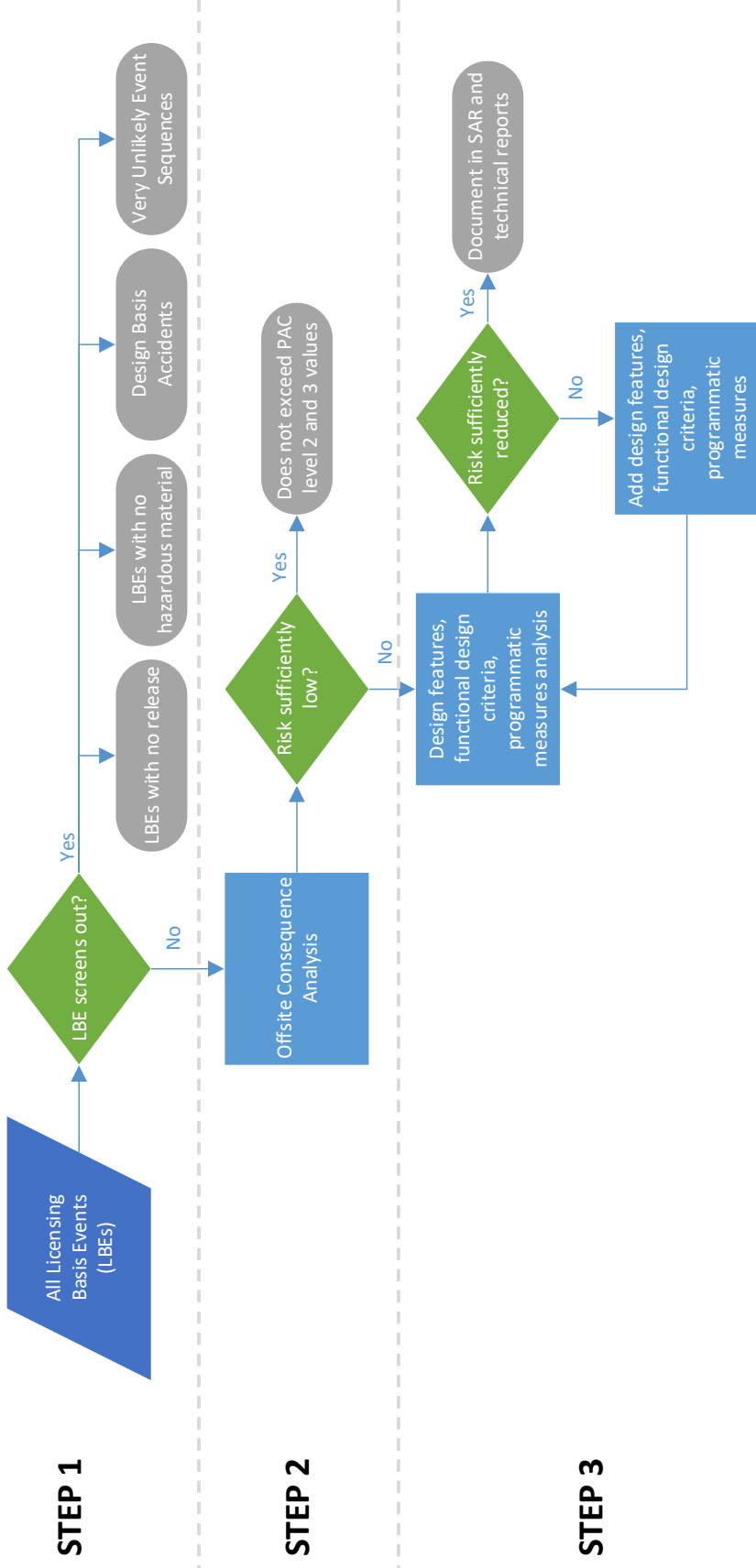
Assessing Public Health Risk Associated with Chemical Hazards of Licensed Material Under 10 CFR Part 53

- Would provide an approach for meeting § 53.440(k) and related requirements under §§ 53.400, 53.420, and 53.440, including guidance on appropriate levels of analysis

Method Overview

1. Identify licensing basis events (LBEs) with the potential for releasing hazardous chemicals associated with licensed material
 2. When appropriate, conduct an offsite hazard analysis to determine if the release of those materials pose a potential chemical hazard risk of permanent injury to the public
 3. Verify design features and related functional design criteria, programmatic measures, or combinations thereof sufficiently reduce the risk of permanent injury to the public from the postulated hazardous chemical release with licensed material
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Method Process Diagram



Method – Step 1

Identify the following types of LBEs other than design-basis accidents with hazardous chemical release(s)

- anticipated event sequence or an unlikely event sequence
- Result in a release of licensed material
- The release contains chemically hazardous licensed material

Use the Department of Energy Protective Action Criteria (PAC) database* to assess the associated chemical hazard:

- PAC level 2 ➔ irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape
- PAC level 3 ➔ life-threatening health effects or death

*<https://edms3.energy.gov/pac#/>

Method – Step 2

Conduct an offsite hazard analysis for each chemical release identified in Step 1 to determine whether it is a potential chemical hazard risk of permanent injury to the public

- An offsite consequence analysis is used to determine if the chemical concentrations exceed the PAC level 2 or 3 values, and thus would need to be addressed to reduce the risk to the public from a postulated release
- Simplified conservative analysis or more detailed analysis of chemical concentrations from release

Method – Step 3

Verify design features and related functional design criteria, programmatic measures, or combinations thereof sufficiently reduce the risk of permanent injury to the public from the postulated hazardous chemical release with licensed material

Next Steps

- Finish development of and publish DG for public comment
- Conduct public comment period
- Resolve public comments
- Brief Advisory Committee on Reactor Safeguards (ACRS)
- Proposed regulatory guide (RG) is provided to the Commission to support the Part 53 draft final rulemaking package

Thank you!

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Abbreviations and Initialisms

ACRS	Advisory Committee on Reactor Safeguards
AES	anticipated event sequences
CFR	<i>Code of Federal Regulations</i>
DBA	design-basis accident
DG	draft regulatory guide
DOE	U.S. Department of Energy
LBE	licensing basis event
NRC	U.S. Nuclear Regulatory Commission
PAC	Protective Action Criteria
RG	regulatory guide
SAR	safety analysis report
UES	unlikely event sequence

MACCS Code Development Activities for Advanced Reactors

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MACCS Code Development Activities for Advanced Reactors - Summary

RES

- In January 2020, the NRC issued the report titled, “NRC Non-LWR Vision and Strategy, Volume 3 – Computer Code Development Plans for Severe Accident Progression, Source Term, and Consequence Analysis Revision 1”
- The plan provided 7 topical areas of consideration pertaining to consequence analysis for the MACCS computer code.
- In FY24, staff completed the MACCS code development plan. Staff completed most of these tasks with the use of code updates or by identifying and adopting state-of-practice methods commonly used in the relevant topical areas.
- Currently, staff is evaluating future candidate research activities to further enhance the code readiness of MACCS for advanced reactors.

MACCS Code Development Activities

Status

RES

Phenomenological Areas	Fiscal Year					Reports	Notes
	2019	2020	2021	2022	2023	2024	
Nearfield Modeling	X	X	X			SAND2020-2609 SAND2021-6924	MACCS 4.1 has implemented upgraded nearfield models.
Radionuclide Release Screening			X	X		SAND2021-11703 SAND2022-12018	MACCS 4.2 has increased the radionuclide limit to 999. Report provided methodology for creating a list of radionuclides for MACCS dosimetry.
Radionuclide Size, Shape, and Chemical Form				X		SAND2022-12766	MACCS deposition and dosimetry capabilities are state-of-practice. Report identified use of resistance model as potential enhancement. Report also identified use of multiple radiochemical forms as a potential enhancement.
Tritium Modeling				X	X	SAND2022-12016 SAND2023-10896	MACCS provides tritium inhalation dose coefficients assuming tritiated water vapor. In MACCS v5.0, staff adjusted these values by x1.5 to account for intake through skin absorption. Modeling of tritium ingestion requires alternative codes.
Radionuclide Evolution in Atmosphere					X	SAND2024-12069	State-of-practice models for generic reactive atmospheric transport are limited in availability.
Decontamination Modeling						None	MACCS decontamination modeling shows no specific nexus to non-LWR technologies.
Chemical Hazards						None	Chemical hazards may be out of scope for severe accident probabilistic consequence analysis.

MACCS Code Development Activities

Path Forward (1/2)

RES

- MACCS-MELCOR interface: New source terms may necessitate MACCS model enhancements
 - Reactor designs with reactivity accident scenarios may require updates to MACCS to account for fission products being produced during the accident.
 - Source terms from reactor designs with new MELCOR radionuclide classes may require special attention in how they are imported into MACCS.
 - Designs with significant gaseous releases may benefit from a state-of-practice resistance model for deposition.
 - Designs that have the potential for large releases of tritium as HT gas or for releases of tritium leading to significant ingestion doses may require updates to MACCS or alternative codes.

MACCS Code Development Activities

Path Forward (2/2)

RES

- Several tasks identified potential follow-on work that may benefit both non-LWR and LWR technologies
- Tasks will be pursued in active code maintenance, documentation, and state-of-practice development activities. Candidate research activities include:
 - Benchmarking and stress-testing MACCS wake effect and downwash models
 - Incorporate EPA PRIME model plume rise/downwash algorithms
 - Examine sensitivity of dose coefficients to alternate chemical forms
 - Benchmark MACCS regression-based deposition model against AERMOD/HYSPLIT resistance-based model
 - Upgrade MACCS dose coefficient file to allow user-specified chemical forms
 - Upgrade MACCS deposition model to incorporate state-of-practice resistance model for deposition
 - Update guidance for modeling consequences of tritium releases when using MACCS
 - Examine methods to analyze or conservatively bound accidents with simultaneous release and fission.
 - Continue evaluating radionuclide importance to dose for non-LWR inventories and expand these evaluations to include ingestion doses

Conclusions

RES

- MACCS was originally designed with flexibilities to accommodate various types of facilities.
- Staff considers MACCS code readiness adequate for assessing consequences associated with non-LWR technologies.
- Staff is currently planning activities to further enhance our MACCS code readiness.
- Staff is open to other ideas to enhance MACCS from the advanced reactor stakeholder community.

Contact Information

RES

MACCS Advanced Reactor Tasks

- NRC Lead: AJ Nosek, AJ.Nosek@nrc.gov
- Sandia National Lab Lead: Kyle Clavier, kaclavi@sandia.gov

MACCS Resources

- Homepage: <https://maccs.sandia.gov/>
- Request MACCS code: <https://maccs.sandia.gov/getcode.aspx>
- Code suggestions and bugs: <https://maccs.sandia.gov/fogbugz.aspx>

Backup Slides

RES

MACCS Non-LWR Code Demonstration Project

RES

■ Purpose:

- Provide practical test of the capabilities of the MACCS code to analyze a selected conceptual advanced reactor design under a postulated accident scenario (ADAMS Accession No. [ML23045A044](#))

■ Conclusions:

- Staff confirmed that, despite some limitations, analysts can use the flexibility of the MACCS code to analyze the offsite consequences of an advanced reactor design under a postulated accident scenario
- The evaluation exercise provided valuable practical experience in implementing new ORIGEN inventories and MELCOR source terms in MACCS

■ Candidates for future research activities:

- Examine methods to analyze or conservatively bound accidents with simultaneous release and fission.
- Continue evaluating radionuclide importance to dose for non-LWR inventories and expand these evaluations to include ingestion doses
- Use core radionuclide inventory and atmospheric release from example SCALE and MELCOR demonstration calculations for further MACCS code demonstrations to facilitate NLWR knowledge management for NLWR consequence assessments

Near-Field Transport

RES

Improve MACCS near-field atmospheric transport and dispersion capability to better treat building wake effects in the near field (<500 meters from a containment or reactor building) given the need for probabilistic dose calculations closer to non-LWRs relative to large LWRs.

- Status: Complete
 - The assessment concluded that MACCS 4.0 can be used conservatively at distances significantly shorter than 500 meters downwind from a containment or reactor building.
 - MACCS v4.1 includes additional capabilities to better account for the nearfield wake and meander effects using the Ramsdell and Fosmire wake/meander model or the Regulatory Guide 1.145 wake/meander model.
- Next Steps: None
- Source Term Monitoring and Coordination: No
- Potential Future Work:
 - Consider benchmarking and stress-testing MACCS wake effect and downwash models. This task may be considered part of standard MACCS code validation and verification activities.
 - Consider incorporating the U.S. Environmental Protection Agency PRIME model plume rise/downwash algorithms. This task may be considered part of normal MACCS code development activities.

Radionuclide Screening

RES

Perform a screening analysis to identify which subset of radionuclides to include in MACCS calculations for each non-LWR type given the different mix of radionuclides that may be released in accidents from each type.

- Status: Complete
 - Staff developed a quantitative method for identifying radionuclides of potential interest for advanced reactors. The method, which is consistent with the approaches used to identify radionuclides for consideration for LWR consequence analyses, accounts for half-life, biological hazard, and relative abundance of radionuclides in the core.
 - In MACCS v4.2, the number of radionuclides that can be modeled was increased from 150 to 999. This enhancement enables the modeling of all 825 nuclides for which dose coefficients are available from Federal Guidance Report (FGR)-13.
- Next Steps: None
- Source Term Monitoring and Coordination: No, releases of radioactivity in chemical forms different from those assumed in the MACCS DCF file (typically 1 μm AMAD oxides and hydroxides) may require the application of a suitable dose coefficient inhalation clearance class for the expected chemical/physical form in the environment.
- Potential Future Work:
 - Consider providing guidance to model all nuclides for which dose coefficients are available. This task may be considered as part of standard MACCS code documentation activities to update NUREG/CR-7270 (ML22294A091).
 - Recommend coordinating inventory file processing with MELCOR inventory file processing.
 - Consider quantitative screening of additional advanced reactor inventories and ingestion pathway radionuclide screening.

Radionuclide Size, Shape, and Chemical Form

RES

Evaluate potential differences in radionuclide releases from non-LWRs relative to LWRs including different aerosol size distributions, shape factors, and chemical forms. Based on the evaluation, improve MACCS capabilities for atmospheric transport and dosimetry to appropriately capture these issues for probabilistic consequence analysis. If necessary, consider a state-of-practice resistance model for dry deposition.

- Status: Complete
 - Current MACCS capabilities for deposition modeling appear to be consistent with the state of practice for particulate wet and dry deposition.
 - The dosimetry model in MACCS aligns with the state of practice. MACCS's code capabilities for dosimetry can accommodate variable chemical forms by employing alternative dose coefficients derived from FGR-13.
- Next Steps: None.
- Source Term Monitoring and Coordination: Yes, releases of radioactivity in chemical forms other than those assumed in the MACCS DCF file (typically 1 μm AMAD oxides and hydroxides) may require modification of the MACCS DCF file by either the MACCS code developer or by the MACCS code user.
- Potential Future Work:
 - Consider improving documentation of physical and chemical forms assumed for developing DC file.
 - Consider examining sensitivity of FGR13 DCs to alternate chemical forms.
 - Consider modifying MACCS/MACCS DC file to allow user specified FGR13 chemical forms.
 - Consider benchmarking MACCS regression-based deposition model against AERMOD/HYSPLIT resistance-based model.
 - Consider upgrading MACCS deposition model to incorporate state-of-practice resistance model.

Tritium Modeling

RES

Develop MACCS model and/or dosimetry updates to better account for the unique behavior of tritium which is very mobile and can enter biological systems as part of water and organic molecules.

- Status: Complete
 - MACCS is capable of modeling inhalation doses resulting from tritium released as water vapor (HTO), but it may overestimate inhalation doses (compared to UFOTRI and ETMOD) from tritium released as hydrogen gas (HT) by approximately two orders of magnitude. Doses from inhalation of HT or HTO releases may remain low unless large amounts of tritium are released.
 - MACCS is not currently suited to modeling ingestion doses arising from tritium releases, but doses from ingestion of tritium incorporated into foodstuffs may also be low unless large quantities of tritium are released.
- Next Steps: Staff recommends updating the tritium inhalation dose coefficient in the MACCS DCF file to include the standard 50% supplement for uptake via skin absorption during air immersion.
- Source Term Monitoring and Coordination: Yes. Designs with the potential for large tritium releases as HT gas or releases leading to significant ingestion doses may require either an update to MACCS or a tritium-specific consequence code such as UFOTRI or ETMOD.
- Potential Future Work:
 - Consider updating guidance for modeling consequences of tritium releases when using MACCS and ingestion doses from large releases using codes such as UFOTRI or ETMOD. This task may be considered as part of the standard MACCS code documentation activities to update NUREG/CR-7270 (ML22294A091).
 - Staff will rely on the results of source term monitoring and coordination and input from program office staff to determine whether the resources needed to upgrade the MACCS food model are justified in the future. It may be noted that integration of a tritium-specific food model may be a major effort.

Radionuclide Evolution in the Atmosphere

Identify whether non-LWR accident releases may be more subject to evolution in the atmosphere relative to LWR releases based on differences in hygroscopic properties or potential for chemical reactions during transport

- Status: In progress
 - Staff completed a literature review to comprehend the potential chemical and physical transformations and their modeling approaches in other state-of-the-art codes for atmospheric transport, diffusion, and deposition. Notable codes encompassing these transformations are HYSPLIT, CMAQ, WRF-CHEM, SORAMI, and RATCHET.
 - Staff is evaluating the feasibility and methodology for MACCS to simulate these potential atmospheric transformations. Additionally, staff is planning a model intercomparison exercise against codes that simulate the transformation of iodine to assess the dosimetry significance of chemical and physical atmospheric evolution.
- Next Steps: Staff expects that transformation kinetics may vary significantly for individual chemical forms, such as UF₆, to the extent that generic code updates may not adequately address highly reactive species.
- Source Term Monitoring and Coordination: Yes, releases of radioactivity in chemically reactive forms may require chemical-form specific transport and dispersion modeling.
- Potential Future Work: Source term monitoring and coordination efforts will continue to identify design-specific chemical and physical forms requiring code updates via the normal MACCS code development cycle.

Decontamination Modeling

RES

Based on the potential for non-LWRs to be sited closer to developed/urban lands, develop updated decontamination costs, durations, and dose reduction factors to account for the differences in decontaminating more urban areas relative to the generally rural areas where most large LWRs are sited.

- Status: Not started.
- Next Steps: No additional work is scheduled for non-LWR code development in this area due to the specific nexus to non-LWR technologies and the availability of a method to address variations in decontamination between urban and rural areas.
- Source Term Monitoring and Coordination: No.
- Potential Future Work: Conduct sensitivity analyses using existing MACCS decontamination cost model to examine sensitivity to differences in land use (e.g., population density). This task may be considered as part of the standard MACCS code documentation and development activities.

Chemical Hazards

RES

Identify whether non-LWRs themselves, or because of their potential collocation with industrial processing plants, create greater likelihood of chemical releases to the environment. If appropriate, update MACCS to integrate CHEM_MACCS for probabilistic calculations of offsite consequences of chemical releases.

- Status: Not started.
- Next Steps: No additional work is scheduled for non-LWR code development in this area due to the specific nexus to non-LWR technologies. Furthermore, any chemical hazard would be design- and source term specific.
- Source Term Monitoring and Coordination: Yes, if chemical hazards are found to be within scope for severe accident consequence analysis.
- Potential Future Work: None. However, staff could leverage methods and lessons learned from the development of CHEM_MACCS to identify necessary MACCS model updates for probabilistic calculations of offsite consequences of chemical releases. This task may be considered as part of the standard MACCS code development activities.

10 CFR PART 53 Rulemaking

Planned Guidance on Comprehensive Risk Metrics and Associated Risk Performance Objectives

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U.S. Nuclear Regulatory Commission (NRC)

Advanced Reactor Stakeholders Meeting

February 13, 2025

Proposed Rule

89 FR 86918; October 31, 2024

§ 53.220 Safety criteria for licensing-basis events other than design-basis accidents.

Design features and programmatic controls must be provided for each commercial nuclear plant such that identification and analysis of licensing-basis events (LBEs) other than DBAs [design basis accidents] in accordance with § 53.240 demonstrate the following:

(a) Plant SSCs, personnel, and programs provide the necessary capabilities and maintain the necessary reliability to address LBEs other than DBAs in accordance with §§ 53.240 and 53.450(e), and provide measures for defense in depth in accordance with § 53.250; and

(b) ~~The analysis of risks to public health and safety resulting from LBEs other than DBAs under § 53.450(e) includes comprehensive risk metrics that satisfy associated risk performance objectives that are acceptable to the NRC and provide an appropriate level of safety.~~

Relevant Commission Policies

Advanced Reactor Policy

- Expects same degree of protection that is required for current LWRs
- Expects advanced reactors “will comply”* with safety goal policy

* Policy statements are not legally binding.

73 FR 60612; October 14, 2008

Qualitative Safety Goals

- Individuals should bear no significant additional risk
- Societal risk should be comparable to or less than the risks of generating electricity by viable competing technologies and should not be a significant addition to other societal risks

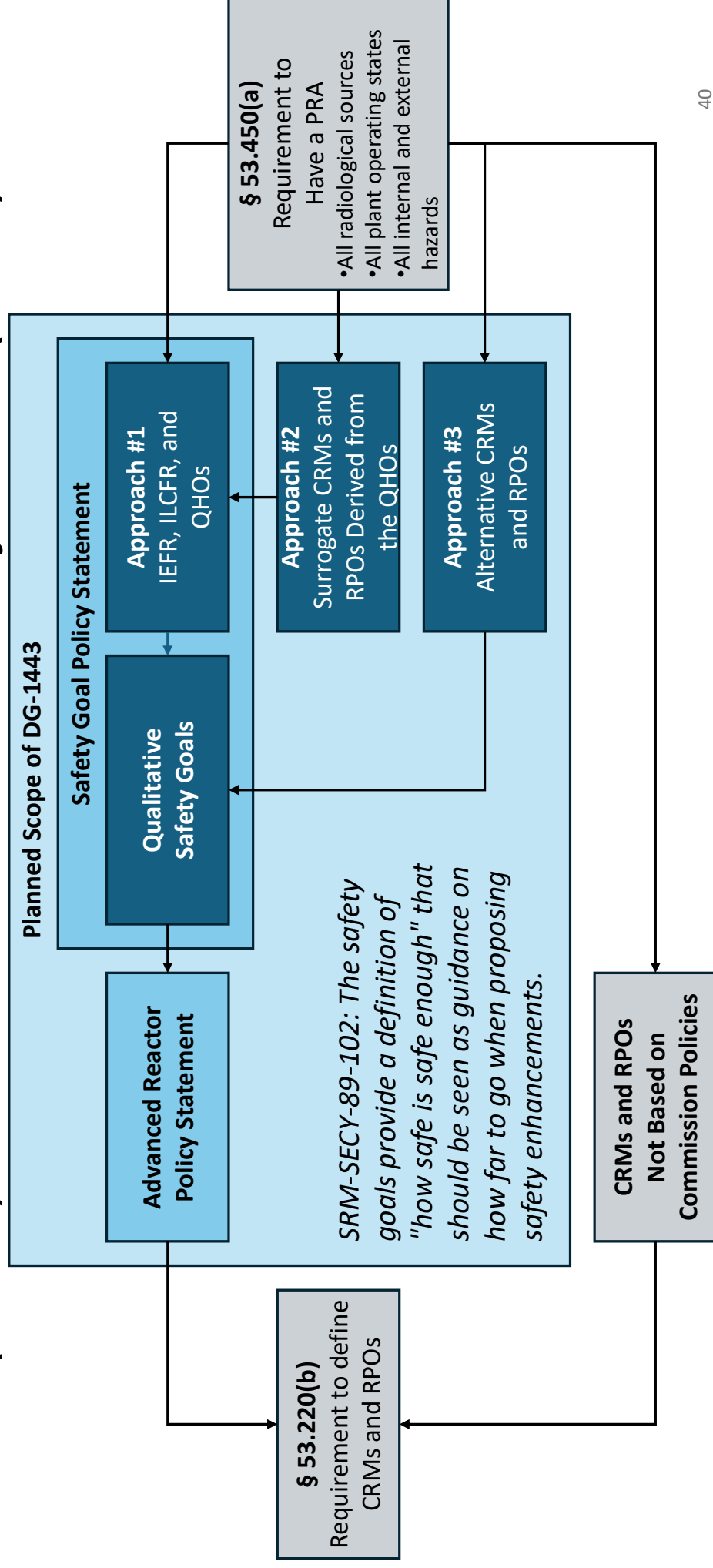
51 FR 28044; August 4, 1986 as corrected and republished at
51 FR 30028; August 21, 1986

Quantitative Health Objectives (QHOs)**

- Individual early fatality risk (IEFR) $\leq 5 \times 10^{-7}$ per plant-year
- Individual latent cancer fatality risk (ILCFR) $\leq 2 \times 10^{-6}$ per plant-year

** NUREG-0880 provides the rationale;
RG 1.247 provides definitions for IEFR and ILCFR

Approaches for Defining Comprehensive Risk Metrics (CRMs) and Risk Performance Objectives (RPOs)



Organization of Planned Guidance

Original Licensing Applications

1. May use IEFER, ILCFR, and the QHOs; or
2. May derive surrogate CRMs and RPOs from the QHOs; or
3. May develop alternative CRMs and RPOs to demonstrate that the qualitative safety goals are achieved

Subsequent Licensing Applications

1. May use CRMs and RPOs in referenced DCs, SDAs, MLs, COLs, CPs, and OLs; or
2. Seek a departure under Subpart H; may justify by using the guidance for original licensing applications

Operating Plants

1. Request a license amendment; may justify by using the guidance for original licensing applications

PUBLIC COMMENT PERIOD

PUBLIC COMMENTS

CLOSING REMARKS

CLOSING REMARKS