U.S. Nuclear Industry Council Perspectives on Risk Metrics for Public Workshop on Technology Inclusive Risk Metrics for Advanced Reactors

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Understanding of NRC Approach (based on Commissioner's Part 53 SRM)

- Part 53 requires a risk metric
 - Appropriate for a risk-informed, performance-based regulation
- The risk metric will be part of a demonstration of adequate protection, but not a substitute for other components of that demonstration of compliance
 - Appropriate for a regulation that is risk-informed but not risk-based
- The risk metric is not a real-time requirement that is continuously monitored by licensees, but an input to the NRC's initial licensing decision and other decision-making
 - Appropriate for a risk-informed regulation
- Include innovative concepts such as alternative evaluation for risk insights (AERI)
- Open to novel approaches to comprehensive plant risk



Perspectives on Risk Metrics

- **Industry is responsible for the bulk of the risk-informed technical approaches**, which are being tested in the 2020's by near-term applicants. We are finding where there are gaps or limitations that developers can address themselves.
- Developer community is learning as they develop their safety cases, unpacking possible implications of any given approach, learning what it means in their use-cases and applications. PRA practitioners will have good technical opinions about specific metrics and techniques, and developers have opinions about how risk insights affect licensing-- but there are a variety of perspectives.
- Reactor designs are different. There are good reasons that surrogate measures are needed, especially early in design. In principle, a metric should have an objective that clarifies why we develop it and what we use it for, and that considers the lifecycle of product development.
- Undue focus on risk-metrics carries the danger of crossing the line into risk-based, instead of risk-informed, regulation.
- Want to develop positions on specific risk metrics and techniques applicable across the range of licensing actions available to the community (not just for implementation in Part 53). We want efforts to be **supportive of many licensing strategies/approaches** (and importantly, not cause) unintended harm to any given approach).



Quantitative Health Objectives (QHOs) - Background

QHOs were established by the Nuclear Regulatory Commission in 1986, as part of the NRC Safety Goals for the Operations of Nuclear Power Plants Policy Statement. The objective of the policy statement was to establish goals that broadly define an acceptable level of radiological risk. The qualitative safety goals are:

- Individual members of the public should be provided a level of protection from the consequences of nuclear power • plant operation such that individuals bear no significant additional risk to life and health.
- Societal risks to life and health from nuclear power plant operation 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.

The associated quantitative objectives, also known as QHOs, are

- The risk to an average individual in the vicinity of a nuclear power plant¹ of prompt fatalities that might result from • reactor accidents should not exceed one-tenth of one percent (0.1 percent) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed.²
- The risk to the population in the area near a nuclear power plant³ of cancer fatalities that might result from nuclear • power plant operation should not exceed one-tenth of one percent (0.1 percent) of the sum of cancer fatality risks resulting from all other causes.⁴

QHOs were never implemented as a regulatory acceptance criterion for U.S. nuclear power plants, but have been used to guide **regulatory decision making**. For large light water reactors, the risk surrogates of core damage frequency (CDF) and large early release frequency (LERF) are often used to avoid the need to perform a full Level III PRA calculation to assess risk. Those risk surrogates are not technology inclusive and cannot be used directly for the range of advanced reactor designs.

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Defined as within 1 mile of the nuclear power plant site boundary. In the proposed 10 CFR Part 53, this is five in 10 million years or 5x10⁻⁷ per year. Defined as within 10 miles of the nuclear power plant site.

^{1.} 23. 4.

In the proposed 10 CFR Part 53, this is two in one million years or 2×10^{-6} per year.

Quantitative Health Objectives (QHOs) - SRM

The NRC staff proposed including QHOs in 10 CFR Part 53, its draft risk-informed, performance-based regulation for licensing advanced reactors. In the March 4, 2024 Staff Requirements Memorandum (SRM) for SECY-23-0021, the Commission rejected the codification of the QHOs in the proposed 10 CFR Part 53 and instead directed

- NRC staff should revise draft 10 C.F.R. 53.220 to specify that applicants must propose a comprehensive plant risk metric (or set of metrics) and a description of the associated methodology used to demonstrate that the proposed design meets said metric(s). The methodology must explain the initial and boundary conditions and key assumptions used to develop and calculate the risk metric(s).
- Term "cumulative" as used in the preamble to the proposed rule or "comprehensive" means that the risk metric(s) should approximate the total overall risk from the facility (i.e., all modes, all hazards) to the extent practicable. Screening tools and bounding or simplified methods may be used for any mode or hazard, provided that the applicant provides an acceptable technical basis. As with all risk-informed methodologies, treatment of uncertainties should be addressed.
- The Commission indicated no specific concern with the QHOs as comprehensive plant risk metrics, but elected to give applicants the flexibility to propose their own metrics, with appropriate justification.



Quantitative Health Objectives - Advantages

USNIC supports the direction of the Commissioners– we did not recommend QHOs being required in the Part 53 rule, but believe QHOs can be used by applicants to support their safety case

QHO Advantages

- QHOs are technology-inclusive; they may be applied to any reactor design. Risk calculations enable comparisons among very different technologies, including nuclear and non-nuclear.
- QHOs are achievable by the current generation of light water reactors; it is expected that advanced reactors employing inherent safety features will be able to demonstrate substantial margin to the QHOs.
- QHOs trace back directly to the NRC Safety Goal Policy Statement, which has been, for almost 40 years, the NRC answer to the question "how safe is safe enough?" Any other metric would have to answer that question anew, an inevitably contentious process.
- NRC has approved the use of QHOs as overall risk targets for advanced non-light water reactors using the NEI 18-04 methodology for identification of licensing basis events; safety categorization of structures, systems, and components; and demonstration of defense in depth.
- Due to advancements in probabilistic risk assessment (PRA) and computer capabilities, QHO results can be calculated once the plant PRA model has been developed. There are consensus standards available on the development and use of PRA for light water reactors and non-light water reactors.

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Quantitative Health Objectives - Issues/Use

QHO Issues

Perceived difficulty of calculating QHOs, or potential controversy justifying the results. QHOs are not directly measurable, but PRA is a mature technology that can be used to calculate risk, which is compared to the QHOs. Calculation of cancer incidence and mortality is population-specific, and takes a long time to properly assess. There is uncertainty associated with the actual level of risk at low doses of radiation, but there are standard techniques for performing such calculations consistent with national and international standards, and the same uncertainty issue can affect other possible metrics.

Considerations for Use of QHOs as a Comprehensive Risk Metric

- Applicants will need robust Level III PRA, but need to clarify how robust an analysis is sufficient for evaluating Commission goal
- Definition of the vicinity of the plant is implementation detail to be addressed¹

¹ The current definition for light water reactors is one mile for prompt fatalities and 10 miles for latent cancer fatalities. There is an argument for keeping those same values for advanced reactors, but the approach will have to be developed and agreed upon between applicant and regulator.



Issue on Choosing and Applying a Risk Metric

- Concern with what the "metric" is going to be
 – and how much information and
 effort will be required for evaluating the metric?
 - Especially if source term is small and risks are fundamentally less consequential (in terms of dose) than existing technologies that are licensed and operating



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Reference: 2021 and 2022 input on initial versions of Part 53

• August 21, 2022 USNIC/NEI letter to NRC

- Remove the QHOs from the rule language, and recognize that the dose criteria provides sufficient performancemetrics. Conformance with the QHOs can be confirmed consistent with the current Commission Policy Statement. NRC should rely on the existing safety standards which have a long history of interpretation and understanding.
- Remove the prescriptive details for the specific uses of the PRA, rather relying on risk-informed approaches that can be described in guidance. This would be consistent with other risk informed regulations such as the Maintenance Rule (50.65) and risk-informed special treatments (50.69).
- November 5, 2021 USNIC/NEI letter to NRC
 - As discussed in the Unified Industry Position letter, it is imperative that Part 53 not exclude any risk-informed approach that can demonstrate that the design meets the safety criteria. Parts 50 and 52 provide flexibility for applicants to use a wide range of risk-informed approaches, including the approach mandated in Part 53, and so Part 53 should also afford this same flexibility. To be clear, we are not against a requirement that the applicant incorporate risk insights from a PRA into the design, and in fact we propose a requirement for PRAs that is more extensive than the requirement Parts 50 and 52. However, we do believe the NRC's preliminary requirement for PRA goes beyond what is reasonable and results in the exclusion of all but one risk-informed approach.

