A Graded Approach to Emergency Preparedness for Nuclear Power Reactors

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Protecting People and the Environment

What is Risk-Informed Regulation?

- The NRC is moving toward a risk-informed, performance-based regulatory framework
- Many past regulations contained deterministic and prescriptive requirements
- Risk-informed regulation considers the safety significance or relative risk of regulation in protecting the public
- Advances in knowledge and experience with probabilistic risk assessment (PRA) provide the ability to examine the frequency and consequences of various scenarios, giving a measure of risk

What's Changing?

Technology is Advancing

- Advanced light water reactors and small modular reactors with passive safety features, microreactors, accident tolerant fuels
- Technology important to Emergency Preparedness (e.g., IPAWS)

Knowledge is Increasing

- Better understanding of actual (not hypothetical) consequences
- Research to inform protective action decision-making
- Lessons learned from real world events

Regulations and Guidance are Evolving

- Nuclear Energy Innovation and Modernization Act (NEIMA)
- EP for SMR & ONT Rulemaking/EP for Decommissioning Rulemaking
- NUREG-0654/FEMA-REP-1, Revision 2

2008 Commission Policy Statement on Advanced Reactors

Commission Policy Statement on Advanced Reactors

"the Commission expects, as a minimum, at least the same degree of protection of the environment and public health and safety and the common defense and security that is required for current generation light-water reactors (LWRs)…

the Commission expects that advanced reactors will provide **enhanced** margins of safety and/or use **simplified, inherent, passive, or other innovative means** to accomplish their safety and security functions." (emphasis added)[1]

Modernizing Advanced Reactor Licensing

Nuclear Energy Innovation and Modernization Act (NEIMA)

- Defined an *advanced nuclear reactor* to mean a nuclear fission or fusion reactor with significant improvements compared to commercial nuclear reactors that include improvements such as additional inherent safety features, greater fuel utilization, enhanced reliability, increased thermal efficiency, and ability to integrate into electric and nonelectric applications.

NRC'S Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Rector Mission Readiness (ML16356A670)

- Readiness for non-light water reactors to include policy issue resolution on EP requirements for high-safety, low-consequence designs.
- Licensing Modernization Project provides endorsed guidance (RG-1.233) that focuses on evaluating defense in depth for *advanced reactor* designs.

NRC is modernizing its approach to licensing advanced reactors

- transparent manner with participation of all stakeholders as outlined in its webpage at https://www.nrc.gov/reactors/new-reactors/advanced.html

NRC Safety Policy and Reasonable Assurance

- NRC safety policy expresses the Commission's views on acceptable level of risks to public health and safety and on safety-cost tradeoffs in regulatory decision making
- Reasonable assurance of adequate protection of public health and safety is defined by the totality of Commission's health and safety regulations

  "Adequate protection does not mean absolute protection…
  Safe is not the equivalent of risk-free"[1]

- When applicant/licensee demonstrates compliance with NRC regulations, it follows that there is reasonable assurance of adequate protection of public health and safety
- Once adequate protection is achieved, NRC is not empowered to drive risk even lower—that would be unnecessary regulatory burden
- NRC has the sole authority to make determinations regarding requirements for emergency preparedness, both onsite and offsite

1. Union of Concerned Scientists vs NRC 824F.2.d 114, 118 D.C. Cir 1987

Objective of Radiological Emergency Preparedness and Response

- The objective of emergency preparedness (EP) at NRC is to ensure that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency
  - —Reasonable Assurance finding is made before a nuclear facility is licensed
  - —Inspected over the lifetime of that facility
- EP provides for dose savings for a spectrum of accidents that could produce doses in excess of the Environment Protection Agency (EPA) protective action guides (PAG)

Graded Approach to EP

- A risk-informed process in which the safety requirements and criteria are set commensurate to the risk of the facility
- Existing NRC regulations employ EP graded approach
  - Power reactors (low-power testing, power operations, decommissioning)
  - Research and test reactors
  - Fuel Fabrication Facilities
  - Independent Spent Fuel Storage Installations
  - Monitored Retrievable Storage
- Same level of protection afforded to public health and safety

NUREG-0396 EP Planning Basis

A spectrum of accidents should be considered to scope the planning efforts for:[2]

- *The **distance** to which planning for predetermined protective actions is warranted*
- *The **time** dependent characteristics of a potential release*
- *The type of radioactive **materials***

2. NUREG-0396 "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," December 1978 (ML051390356)

Emergency Planning Zones (EPZ)

"The EPZ guidance does not change the requirements for emergency planning, it only sets bounds on the planning problem. The Task Force does not recommend that massive emergency preparedness programs be established around all nuclear power stations."

So how do you set the boundary?

Scalable EPZ

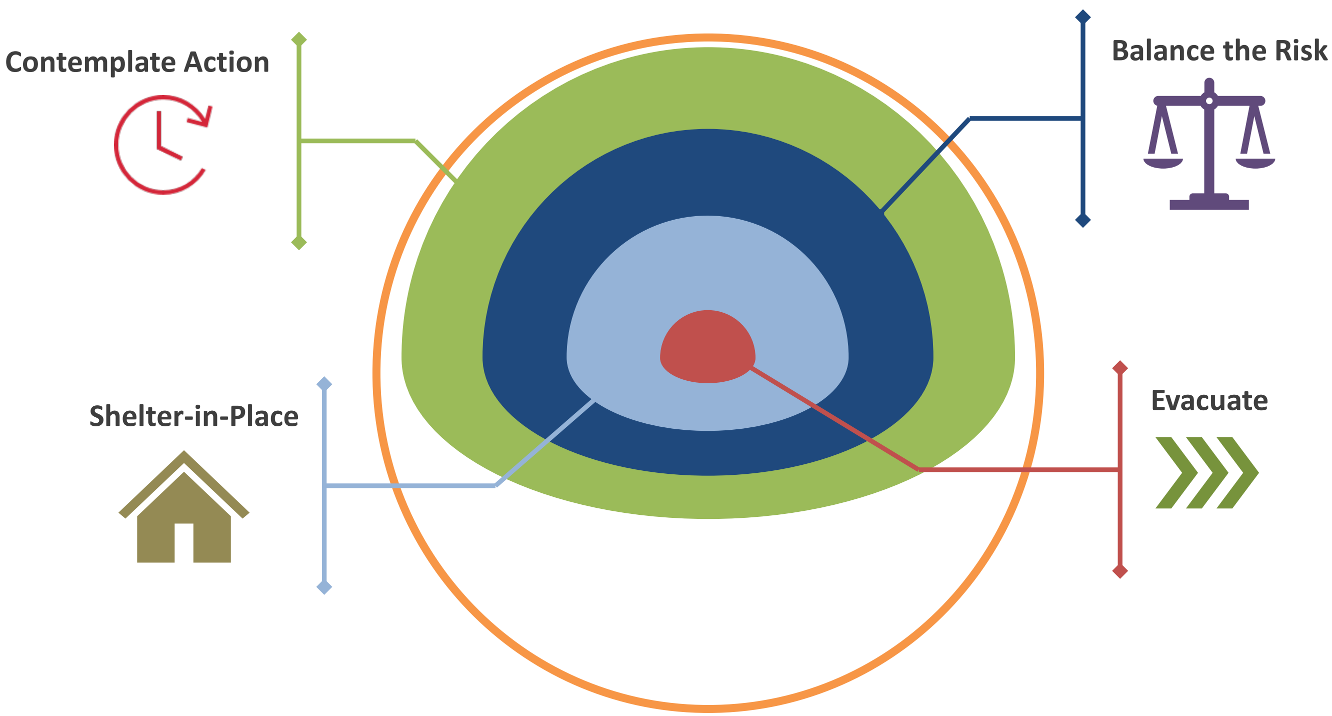
- EPZ size based on the consequences from a spectrum of accidents, tempered by probability considerations.
- NRC regulations provide for scalable EPZs
  - —Large light-water reactors have been approved for a 5 mile EPZ in the past.
  - —Non-power reactors (e.g., research reactors) have scalable EPZs[3]
  - —Depending on facility type, there may be no EPZ.
- Considerable number of studies since the 1980s on sizing EPZs for passive and advanced reactor designs all based on NUREG-0396 methodology.

3. NUREG-0849, "Standard Review Plan for the Review and Evaluation of Emergency Plans for Research and Test Reactors," October 1983 (ML062190191)

Graded Approach to EP Rulemakings

- NRC rulemaking applies the EP planning basis in a graded approach commensurate to the risk of the facility involved
  - **EP for SMRs & ONT Rulemaking** (85 FR 44025; regulations.gov Docket ID: NRC-2015-0225)
  - **EP for Decommissioning Proposed Rule** (ADAMS package ML18012A019)
  - **10 CFR Part 53: Risk-Informed, Technology Inclusive Regulatory Framework for Advanced Reactors** (85 FR 71002; regulations.gov Docket ID: NRC-2019-0062)
  - **Petition for Rulemaking PRM-50-123 Public Protective Actions During a General Emergency** (85 FR 53690; regulations.gov Docket ID: NRC-2020-0155)

Risk-Informed Protective Action Strategies



What Have We Learned?

- Compelling evidence from Chernobyl and Fukushima of a broad range of deterministic nonradiological consequences
  - psycho-social and mental health impact following relocation, ruptured social links, disconnected family ties and stigmatization (World Health Organization).
- Similar nonradiological health consequences observed as a result of evacuations and relocations from other hazards
- Stochastic radiological health consequences not well predicted by LNT at low dose
- Deterministic health consequences of protective actions can outweigh the stochastic risk of radiation exposure

Leading Research to Support Risk-Informed EP

- Protective Action Decision-Making in the Intermediate Phase (NUREG/CR-7248)
- Evacuation Time Estimate Study (NUREG/CR-7269)
- Emergency Planning Zone (EPZ) Size Methodology
- Sensitivity of Dose Projections to Weather
- Analysis of the Effectiveness of Sheltering-in-Place[4]
- Dose Reduction Effectiveness of Masks
- Nonradiological Health Impacts of Evacuations and Relocations (NUREG/CR)
- MACCS Consequence Model Improvements
- Technical Basis for Protective Action Recommendations (PARs)
- Sequoyah State-of-the-Art Reactor Consequence Analysis (SOARCA) – earthquake impacts (NUREG/CR-7245)
- Level 3 Probabilistic Risk Assessment (PRA) – Full offsite consequence analyses

4. "Design of a Novel Decision-Making Tool for the Analysis of Protective Actions During a Radiological Release," *Transactions of the American Nuclear Society*, Vol. 123, 2020 ANS Virtual Winter Meeting, November 16-19, 2020.

**Reactor technology is advancing,
EP is evolving,
but the NRC’s mission to protect the health and safety of the public remains unchanged**

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