POLICY ISSUE
(INFORMATION)

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FOR: The Commissioners

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SUBJECT: DEVELOPMENT OF AN EMERGENCY PLANNING AND PREPAREDNESS FRAMEWORK FOR SMALL MODULAR REACTORS

PURPOSE:

To inform the Commission of staff actions to develop an emergency planning and preparedness framework for small modular reactor (SMR) sites.

SUMMARY:

This paper discusses the staff's intent to develop a technology-neutral, dose-based, consequence-oriented emergency preparedness (EP) framework for SMR sites that takes into account the various designs, modularity and collocation, as well as the size of the emergency planning zone (EPZ). Work dating to 1978 established the basis for the current plume exposure pathway EPZ (of about 10 miles) and an ingestion exposure pathway EPZ (of about 50 miles) for large light-water reactors (LWRs). As the U.S. Nuclear Regulatory Commission (NRC) codified these EPZ definitions, a clarification was included noting that the size of the EPZ could also be determined on a case-by-case basis for gas cooled nuclear reactors and for reactors with an authorized power level less than 250 megawatts thermal (MWt). Several advanced reactor designs have

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been proposed in the United States where the designers are seeking to introduce an alternative to large LWRs. EP is a significant policy issue for these designers because prospective applicants assert that these designs have a significantly reduced potential for accident-related offsite releases.

The staff has reviewed the existing EP requirements associated with various nuclear facilities and has identified that all of the existing types of NRC-licensed nuclear facilities use a dose/distance approach to establish the boundary of their EPZ (or other planning area) based on the Environmental Protection Agency Protective Action Guidelines. The staff concluded that a similar technology-neutral dose/distance rationale would also be appropriate for the advanced designs.

The approach the staff is developing is based on the concept that EP requirements could be scaled to be commensurate with the accident source term, fission product release, and associated dose characteristics for the designs. As the staff is developing the approach, issues related to modularity of the designs and the potential for collocating the reactors near industrial facilities are also being explored.

The methodology for calculating the dose is also being considered. The staff will work with stakeholders to develop general guidance on calculating the offsite dose, and is anticipating that the industry will develop and implement the detailed calculation method for review and approval by the staff.

The staff has planned a number of outreach activities to improve the development of the NRC's Advanced Reactor Program. Communication and coordination with these stakeholders will continue as the EP approach is developed.

BACKGROUND:

In 1978, NUREG-0396 (EPA 520/1-78-016), "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," established the basis for the current plume exposure pathway EPZ (of about 10 miles) and an ingestion exposure pathway EPZ (of about 50 miles) for large LWRs. The NRC incorporated these EPZ definitions into Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." Of particular relevance is the clarification on EPZs in footnote 1 of Appendix E, which states the following:

> The size of the EPZs also may be determined on a case-by-case basis for gas cooled nuclear reactors and for reactors with an authorized power level less than 250 MW thermal.

Since the publication of Appendix E, several advanced reactor designs in the United States have been proposed, including the U.S. Department of Energy's (DOE's) Generation IV, Next Generation Nuclear Plant (NGNP), and SMR programs, and those by private sector companies seeking to introduce an alternative to large LWRs. The staff has conducted public meetings with DOE and SMR designers to discuss potential policy, licensing, and technical issues associated with their designs. EP is a significant policy issue for SMR designers because

prospective applicants assert that SMR designs have a significantly reduced potential for accident-related offsite releases. As such, consequences from an accident involving an SMR may have a limited impact on public health and safety, thereby forming the basis for smaller EPZs.

DISCUSSION:

NUREG-0396 introduced the concept of generic EPZs as the basis for preplanned response actions that would result in dose savings in the environs of a nuclear facility in the event of a reactor accident. The task force that developed NUREG-0396 considered several possible rationales for establishing the size of the EPZs, including risk, cost effectiveness, and the accident consequence spectrum. After reviewing these alternatives, the task force concluded that the objective of emergency response plans should be to provide dose savings for a spectrum of accidents that could produce offsite doses in excess of the U.S. Environmental Protection Agency (EPA) Protective Action Guidelines (PAGs) (EPA-400, "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents"). This rationale established bounds on the planning effort and identified the necessary planning elements. It also resulted in a planning basis that is easily stated and understood in terms of areas (or distances), timeframes, and radiological characteristics that correspond to the consequences of a wide range of possible accidents. This dose-based, consequence-oriented guidance also provided consistency and uniformity in the planning recommendations made to State and local governments.

Section 50.47(b)(11) of 10 CFR states, in part, that the onsite and offsite emergency response plans for nuclear power reactors shall include exposure guidelines consistent with EPA Emergency Worker and Lifesaving Activity Protective Action Guides. NUREG-0396 established a plume exposure pathway EPZ of about 10 miles for large LWRs. For the worst core melt sequences, the authors determined that immediate life threatening doses would generally not occur outside the 10-mile zone and that detailed planning for the 10-mile zone could be expanded if deemed necessary. NUREG-0396 and EPA-400 identified the PAG dose guidelines (1–5 rem) as doses at which public protective actions should be considered and undertaken. The revised EPA PAG guidance (issued in 1992 as EPA-400-R-92-001) provides that licensed facilities that can demonstrate that accident doses at the site boundary would not exceed the PAGs should not be required to have either defined EPZs or comprehensive offsite emergency planning.

Although the guidance in NUREG-0396 and EPA-400 was written for large LWRs, the principle of using dose savings to determine EPZ size can also be applied to SMRs. In fact, the NRC has licensed several small reactors with a reduced EPZ size of 5 miles. These reactors include the Fort St. Vrain high-temperature gas-cooled reactor (HTGR) (842 MWt), the Big Rock Point boiling-water reactor (BWR) (240 MWt), and the La Crosse BWR (165 MWt). With the expected safety enhancements in SMR designs and the potential for reduced accident source terms and fission product releases, the staff believes that it may be appropriate for SMRs to develop similarly reduced EPZ sizes, commensurate with their accident source terms, fission product releases, and accident dose characteristics.

In November 2010, the staff reviewed the existing EP requirements associated with various nuclear facilities, including large and small reactors, material facilities, fuel facilities, independent spent fuel storage installations, and research and test reactors. This review

identified that all of the existing types of NRC-licensed nuclear facilities use a dose/distance approach to establish the boundary of their EPZ (or other planning area) based on the EPA PAGs. The staff concluded that a similar technology-neutral dose/distance rationale would also be appropriate for SMR designs.

Emergency Preparedness Framework Considerations for Small Modular Reactors

The staff have identified three primary technology groups that represent the anticipated future SMR work for the NRC: HTGRs (which is the reactor technology selected for the NGNP); integral pressurized-water reactors, which include designs by Babcock & Wilcox, NuScale Power, Westinghouse, and Holtec International; and sodium cooled fast reactors, such as the Toshiba 4S and General Electric PRISM designs. The design information currently available to the staff for SMRs is not yet sufficient to support a comprehensive evaluation of source terms and accidents and resultant offsite dose consequences. Nonetheless, the staff has identified a broad SMR EP framework, described below.

The staff considers it appropriate to be open to applicant requests for establishing SMR technology-neutral, variable distance, plume exposure EPZs. However, the staff recognizes that the burden would be on the applicant to provide a well-justified basis for this section. A number of challenges are associated with establishing the size of the EPZs for SMRs the staff is currently reviewing, including determining the SMR accident source term, fission product release and associated dose characteristics, and the effects of “modularity” and “collocation” (described in detail later in this paper). The staff plans to provide implementation details of the SMR EP framework as it is further developed, as well as likely policy issues in future Commission papers. In addition, the staff plans to detail the changes necessary to both EP requirements and related guidance documents to support an associated rulemaking, if warranted. Lastly, the staff recognizes the need to reflect in the anticipated framework, the lessons learned at the conclusion of agency task force reviews from the accident at the Fukushima Dai-ichi nuclear power plant in Japan.

Overview of the Likely Policy Issues

Scalable Emergency Planning Zone

EP programs for SMR sites should address implications of a smaller source term and passive design features associated with SMRs. One approach could be to have the offsite EP requirements scaled to be commensurate with the SMR accident source term, fission product release, and associated dose characteristics, which are all a function of the licensed reactor power level. These factors are technology neutral, based on offsite dose, and use the EPA PAG values as the principal basis to establish standard EPZ distances. Under such an approach, different EPZ boundaries can be established for different dose limits. For example, in considering four discrete zone boundaries or categories: Site boundary, 2-mile, 5-mile, and 10-mile EPZs.

If projected accident offsite doses are less than 1 rem[1] at the site boundary, then no EPZ beyond the site boundary would be required and the offsite emergency planning requirements would be limited. If the expected offsite dose is greater than 1 rem off site but less than 1 rem at 2 miles, then the requirements for the EPZ would be limited to the 2-mile zone. Similarly, if projected offsite dose is greater than 1 rem at 2 miles, but less than 1 rem at 5 miles, the size of the EPZ would be 5 miles. If the expected offsite dose is greater than 1 rem at 5 miles, the size of the EPZ would default to the current 10-mile EPZ.

Table 1 describes an example of using a scalable EPZ.

Table 1 Example of a Scalable EPZ

EPZ Category	Dose Limits	Plume Exposure EPZ	Ingestion Exposure EPZ	EP Plan Required	Offsite EP Plan
I	Projected dose at site boundary <1 rem	Site boundary	No; however, EPZ can expand based on event, if determined to be necessary	Yes	All hazards—license condition*
II	Dose at site boundary ≥1 rem, <1 rem at 2 miles	2 miles**	Yes; dosed-based distance, ad hoc basis***—Food and Drug Administration (FDA) food PAGs	Yes	Yes
III	Dose at 2 miles ≥1 rem, <1 rem at 5 miles	5 miles**	Yes; dosed-based distance, ad hoc basis***—FDA food PAGs	Yes	Yes
IV	Dose at 5 miles ≥1 rem	10 miles**	Yes; per current regulations, ad hoc basis***	Yes	Yes

* The NRC would issue a license condition that will require the licensee to ensure that a certified offsite all-hazards plan exists (which provides the basic framework for responding to a wide variety of disasters).
** The staff will also consider the area needed to ensure an adequate planning basis for local response functions and the area in which acute health effects could occur.
*** Per NUREG-0396, actions that would provide dose savings for any such accident can be taken on an ad hoc basis using the same considerations that went into the initial action determinations.

Specific EP requirements would be commensurate with the size of the EPZ. Although the size of the EPZ would be based on offsite dose, specific EP requirements would consider such factors as event transient time and source term. For example, while the offsite dose may require a 2-mile EPZ, the timeline for this event leading to an offsite dose may be in excess of several hours. In addition, the current requirement for a licensee to notify responsible State and local governmental agencies within 15 minutes after declaring an emergency may need to be reexamined to be commensurate with the event transient time.

[1] A study of design-basis accidents (detailed in Appendix I, "Rationale for the Planning Basis," of NUREG-0396), concluded in part that the PAG plume exposure of 5 rem (whole body) would not be exceeded beyond 10 miles for any site analyzed. The study also concluded that even under the most restrictive PAG, a plume exposure value of 1 rem (whole body) would not require any consideration of emergency responses beyond 10 miles.

A scalable EPZ scheme would allow for regulatory predictability for SMR applicants and for State and local officials. This approach would ensure the consistent application of NRC regulations and requirements in the review of EP plans prepared for SMRs. This approach is consistent with current EP requirements and would not result in a reduction in the protection of public health and safety. The staff recognizes that a licensing path exists for SMRs via the exemption process; however, the exemption process is not an efficient method for licensing SMRs of potentially several different designs that are intended for a variety of uses. Therefore, by eliminating the need for a specific rulemaking for each SMR reactor technology, licensing activities would be able to proceed with minimal delays.

Modularity and Collocation

SMRs have other features that the NRC should consider in the development of EP regulations and guidance. As described in SECY-10-0034, "Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs," dated March 28, 2010, these include the potential for an SMR site to employ multiple reactors (i.e., modularity) and the potential for SMRs to be collocated near industrial facilities.

Regarding modularity, the staff will need to address a range of complex considerations, including shift staffing changes if the site increases the number of reactor modules from two to four or six or more and the impact on reactor modules that have some common or shared systems. The staff will also need to determine whether EP requirements should be based on the maximum number of reactor modules licensed for the site or whether the requirements should vary as reactor modules are added. This is an issue that the staff will continue to develop.

Regarding collocation, the staff recognizes that an EP framework will need to consider the impacts of SMRs of the same type being collocated with large reactors, industrial facilities, different SMR types, or any combination of these. In the responses to NRC Regulatory Issue Summary 2011-02, "Licensing Submittal Information and Design Development Activities for Small Modular Reactor Designs," dated February 2, 2011, no potential applicant indicated that it intends to submit a license application for an SMR facility to be collocated in such a manner. Although the Energy Policy Act of 2005 specifies that the NGNP shall be used to generate electricity, produce hydrogen, or generate electricity and produce hydrogen, the staff does not have sufficient information at this time to determine how the proposed EP framework might need to be adjusted. The staff does not intend to consider collocation outside of the staff's continuing work related to the NGNP.

Considerations for Establishing the size of EPZs for SMRs

The scalable method for determining the EPZ for SMRs is based on offsite dose considerations. The staff anticipates drawing on the substantial improvements over the last several years in understanding and modeling of severe accident phenomena. The staff anticipates that an appropriate method for use in this application would involve (1) using a probabilistic risk assessment (PRA) that includes dose assessment that is based on current insights in severe accident progression to calculate the probability of exceeding PAG as function of distance from the exclusion area boundary for a spectrum of accidents, (2) establishing criteria for determining the point at which the probability of exceeding the PAG is acceptably low, and (3) concluding that the events provide an acceptable spectrum of consequences. Although a more rigorous

design and site-specific approach, the staff anticipates that this approach will be generally analogous to that discussed in NUREG-0396. While the staff will work with stakeholders to develop general guidance on calculating the offsite dose and the criteria, it is anticipated that the industry will develop and implement the detailed calculation method for review and approval by the staff. The staff acknowledges a number of challenges in implementing the approach, such as developing a suitable SMR design-specific PRA and accounting for the uncertainties in the state of knowledge of SMR designs. The staff will continue to work with stakeholders on this issue.

Outreach

The staff has planned a number of outreach activities to improve the development of the NRC's Advanced Reactor Program, including interactions with the Nuclear Energy Institute (NEI), American Nuclear Society (ANS), DOE, U.S. Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), EPA, U.S. Department of State (DOS), U.S. Department of Commerce (DOC), and the public. The staff will use these coordination efforts to help organize its activities related to the development of regulatory criteria for specific SMR technologies and designs. Communication and coordination with these stakeholders will continue as the SMR EP framework is developed.

CONCLUSION:

The staff intends to continue developing a technology-neutral, dose-based, consequence-oriented EP framework for SMR sites that takes into account the various designs, modularity and collocation, as well as the size of the EPZ. The staff will continue appropriate and timely communications and coordination with SMR stakeholders such as NEI, ANS, DOE, DHS, FEMA, EPA, DOS, DOC, and the public. The staff will more fully address the above described policy issues in a future Commission paper.

RESOURCES:

No additional resources are required in support of this paper. Nevertheless, the staff is cognizant that task force and other staff-generated reports on the Fukushima Dai-ichi accident may impact resources to support the potential future policy issues paper(s) addressing the development of an emergency planning and preparedness framework for SRMs.

COORDINATION:

The Office of the General Counsel reviewed this paper and has no legal objection.

/RA/

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