EMERGENCY PLANNING

Emergency Planning Zone Sizing for Small Modular Reactors – Regulatory History & Policy Considerations

Listed below (in chronological order) are the key documents that provide the regulatory history associated with NRC's consideration of establishing a scalable, dose-based and consequence-oriented plume exposure pathway (PEP) emergency planning zone (EPZ) for small modular reactors (SMRs). Following this list are excerpts from each document (including some minor staff edits and clarifications), which provide detailed technical guidance and policy considerations that apply to EPZs for SMRs.

- NUREG-0396 (EPA 520/1-78-016), Task Force Report, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," December 1978 (ADAMS Accession No. ML051390356).

- NUREG-0654/FEMA-REP-1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," Revision 1, November 1980 (ADAMS Accession No. ML040420012).

- SECY-93-092, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements," April 8, 1993 (ADAMS Accession No. ML040210725); and Staff Requirements Memorandum (SRM), "SECY-93-092 – Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements," July 30, 1993 (ADAMS Accession No. ML003760774).

- SECY-97-020, "Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors," January 27, 1997 (ADAMS Accession No. ML992920024).

- SECY-02-0139, "Plan for Resolving Policy Issues Related to Licensing Non-Light Water Reactor Designs," July 22, 2002 (ADAMS Accession No. ML021790610),

- SECY-03-0047, "Policy Issues Related to Licensing Non-Light-Water Reactor Designs," March 28, 2003 (ADAMS Accession No. ML030160002); and Staff Requirements Memorandum (SRM), "Staff Requirements – SECY-03-0047 – Policy Issues Related to Licensing Non-Light-Water Reactor Designs," June 26, 2003 (ADAMS Accession No. ML031770124).

- SECY-10-0034, "Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs," March 28, 2010 (ADAMS Accession No. ML093290245).

- SECY-11-0152, "Development of an Emergency Planning and Preparedness Framework for Small Modular Reactors," October 28, 2011 (ADAMS Accession No. ML112570439).

- EPA "PAG Manual – Protective Action Guides And Planning Guidance For Radiological Incidents," Draft for Interim Use and Public Comment, March 2013.

- Commission Memorandum, "Current Status of the Source Term and Emergency Preparedness Policy Issues for Small Modular Reactors," May 30, 2013 (ADAMS Accession No. ML13107A052).

- SECY-15-0077, "Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies," May 29, 2015 (ADAMS Accession No. ML15037A176); and SRM, "Staff Requirement – SECY-15-0077 – Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies," August 4, 2015 (ADAMS Accession No. ML15216A492).

- SECY-16-0012, "Accident Source Terms and Siting for Small Modular Reactors and Non-Light Water Reactors," February 7, 2016 (ADAMS Accession No. ML15309A319).

NUREG-0396

NUREG-0396 introduced the concept of generic EPZs as the basis for pre-planned response actions that would result in dose savings in the environs of a nuclear facilities in the event of a serious power reactor accident. EPZs are designated as the areas for which planning is recommended to assure that prompt and effective actions can be taken to protect the public in the event of an accident.

Section III, "Recommended Planning Basis," states in Subsection A. "Emergency Planning Zone," that EPZs are designated as the areas for which planning is recommended to assure that prompt and effective actions can be taken to protect the public in the event of an accident. The EPZ guidance does not change the requirements for emergency planning, it only sets bounds on the planning problem.

Section III.B. "Size of the Emergency Planning Zone," states that several possible rationales were considered for establishing the size of the EPZs. These included risk, probability, cost effectiveness and accident consequence spectrum. The [NRC and EPA (NUREG-0396) task force on emergency planning] agreed that emergency response plans should be useful for responding to any accident that would produce offsite doses in excess of the protective action guides (PAGs). This would include the more severe design basis accidents (DBAs) and the accident spectrum analyzed in [NUREG-75/014 (WASH-1400), "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975]. For these types of accidents, it was the consensus of the task force that emergency plans could be based upon a generic distance out to which predetermined actions would provide dose savings for any such accidents. Beyond this generic distance it was concluded that actions could be taken on an ad hoc basis using the same considerations that went into the initial action determinations.

The task force judgment on the extent of the EPZ is derived from the characteristics of design basis and Class 9 accident consequences.[1] The EPZ recommended is of sufficient size to provide

[1] Appendix I, "Rationale for the Planning Basis," of NUREG-0396, states, in part, in Section B.2, "Class 9 Accidents," that '"Class 9" accidents cover a full spectrum of releases which range from those accidents which are of the same order as the DBA-LOCA [loss of coolant accident] type of releases; i.e., doses on the order of PAGs within 10 miles (mi); to those accidents which release significant fractions of the available radioactive materials in the reactor to the

dose savings to the population in areas where the projected dose from DBAs could be expected to exceed the applicable PAGs under unfavorable atmospheric conditions. In Section IV, "Conclusions," the task force provided the following conclusion:

- A spectrum of accidents (not the same source term from a single accident sequence) should be considered in developing a basis for emergency planning.

- The establishment of Emergency Planning Zones of about 10 mi for the plume exposure pathway and about 50 mi for the ingestion pathway is sufficient to scope the areas in which planning for the initiation of predetermined protective action is warranted for any given nuclear power plant.

- The establishment of time frames and radiological characteristics of releases provides supporting information for planning and preparedness.

- If previous consideration has been given to the basic planning elements put forth in existing guidance documents,[2] the establishment of Emergency Planning Zones should not result in large incremental increases in required planning and preparedness resources.

NUREG-0396 established the technical basis for the 10-mi PEP EPZ and 50-mi ingestion pathway EPZs, based upon the EPA PAGs. Subsequent Nuclear Regulatory Commission (NRC) and Federal Emergency Management Agency (FEMA) regulations and guidance have reflected this technical basis; requiring the 10-mi and 50-mi EPZs for licensing large commercial light water reactors (LWRs). Over many years, numerous licensing actions for small commercial LWRs, research and test reactors, decommissioned reactor sites, and independent spent fuel storage facilities (ISFSIs) have allowed smaller EPZs or removed the need for an EPZ beyond the site boundary, based upon the same EPA PAGs.

NUREG-0654

The guidance in NUREG-0654 provides a basis for NRC licensees, and State and local governments, to develop radiological emergency plans and improve emergency preparedness, and is used by reviewers to determine the adequacy of those plans and preparedness. Section I.D.1, "Background," states that the NRC/EPA Task Force Report on Emergency Planning (i.e., NUREG-0396) provides a planning basis for offsite emergency preparedness efforts considered necessary and prudent for large power reactor facilities, and that the NRC's policy statement of October 23, 1979 (44 FR 61123), directs the NRC staff to incorporate the guidance in the report into emergency preparedness documents. Additionally, the guidance in NUREG-0396 is reflected in NRC's emergency planning (EP) rule, and FEMA has also concluded that it should be used as the planning basis for emergency preparedness around nuclear power facilities.

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atmosphere, thus having potential for life-threatening doses.

[2] Existing guidance documents referenced include (1) NUREG-75/111 (WASH-1293), "Guide and Check List for the Development and Evaluation of State and Local Government Radiological Emergency Response Plans in Support of Fixed Nuclear Facilities," December 1, 1974 (ADAMS Accession No. ML080180304); (2) EPA "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," EPA-520/1-75-001, September 1975; and (3) NRC Regulatory Guide 1.101, "Emergency Planning for Nuclear Power Plants," Revision 1, March 1977 (ADAMS Accession No. ML12305A226).

Section I.D.2, "Emergency Planning Zones," states that EPZs are defined as the areas for which planning is needed to assure that prompt and effective actions can be taken to protect the public in the event of an accident, and that the choice of the EPZ size represents a judgment on the extent of detailed planning which must be performed to assure an adequate response base. In addition, the criteria in NUREG-0396 are to be applied by the response organizations in these zones, as applicable. For large LWRs, the NUREG-0396 task force selected a radius of about 10 mi for the PEP EPZ, and a radius of about 50 mi for the ingestion pathway EPZ. The size of the PEP EPZ was based primarily on the following considerations:

- projected doses from the traditional DBAs and most core melt sequences would not exceed EPA PAG levels outside the zone;
- for the worst core melt sequences, immediate life threatening doses would generally not occur outside the zone; and
- detailed planning within the zone would provide a substantial base for expansion of response efforts in the event that this proved necessary.

The NUREG-0396 task force concluded that it would be unlikely that any protective actions for the PEP would be required beyond the zone. Also, the PEP EPZ was of sufficient size for actions within this zone to provide for substantial reduction in early severe health effects (i.e., injuries or deaths), in the event of a worst case core melt accident.

The joint FEMA/NRC Steering Committee that developed NUREG-0654 concluded that small water-cooled power reactors (less than 250 MWt) and the Fort St. Vrain gas-cooled reactor may use a PEP EPZ of about 5 mi in radius and an ingestion pathway EPZ of about 30 mi in radius. This conclusion was based on the lower potential hazard from these facilities, consisting of a lower radionuclide inventory and longer times to release significant amounts of activity for many accident scenarios. In addition, the Steering Committee concluded that the radionuclides considered in planning should be the same as recommended in NUREG-0396.

SECY-93-092

The purpose of SECY-93-092 is to request Commission guidance for those areas where the staff is proposing to depart from current regulatory requirements in the pre-application review of the advanced reactor and CANDU 3 designs. In SECY 93-092, the staff raised the issue, "Should advanced reactors with passive design safety features be able to reduce emergency planning zones and requirements?" The staff proposed no changes to the existing regulations governing EP for advanced reactor licensees.

In a July 30, 1993, SRM, the Commission stated that it is premature to reach a conclusion on emergency planning for advanced reactors, but requested that the staff remain open to suggestions to simplify EP requirements for reactors that are designed with greater safety margins. Additionally, the staff was requested to submit to the Commission recommendations for proposed technical criteria and methods to use to justify simplification of existing EP requirements. In response to that SRM, the staff stated in a memorandum to the Commission, dated December 22, 1993,[3] that it would be reexamining the technical basis for EP, and would be

[3] Memorandum, "SECY-03-092 – Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements," December 22, 1993 (ADAMS Legacy Accession

developing recommendations for possible simplification of EP requirements for reactors with greater safety margins.

SECY-97-020

The purpose of SECY-97-020 is to inform the Commission of the results of the staff's effort to develop recommendations for technical criteria and methods to use to justify simplification of existing emergency planning requirements for evolutionary and advanced reactor designs.

In response to a Commission request, the staff performed an evaluation to develop technical criteria and methods for EP for evolutionary and advanced reactor designs. The evaluation focused on the evolutionary and passive advanced LWR designs because of the availability of design and risk assessment data and because applicants were pursuing certification of these designs. The staff determined that the rationale upon which EP for current reactor designs is based, that is, potential consequences from a spectrum of accidents, is appropriate for use as the basis for EP for evolutionary and passive advanced LWR designs and is consistent with the Commission's defense-in-depth safety philosophy. Rigid application of the technical criteria derived from this rationale against the evolutionary and passive advanced LWR designs indicates that no changes to EP requirements are warranted because the potential consequences of severe accidents associated with evolutionary and passive advanced LWRs are similar to those for current reactors. The staff recognizes the industry's significant effort to make evolutionary and passive advanced LWRs safer than current designs. The staff also recognizes that changes to EP requirements may be warranted if the technical criteria for the EP requirements were modified to account for the lower probability of severe accidents or the longer time period between accident initiation and release of radioactive material for most severe accidents associated with evolutionary and passive advanced LWRs.

In order to justify these types of changes to the EP basis, the staff believes that several issues, which would require significant expenditure of staff resources, need to be addressed: (1) the probability level, if any, below which accidents will not be considered for EP, (2) the use of increased safety in one level of the defense-in-depth framework to justify reducing requirements in another level, and (3) the acceptance of such changes by Federal, State, and local emergency response agencies. Because industry has not petitioned for changes to EP requirements for evolutionary and passive advanced LWRs, the staff did not dedicate the resources to fully evaluate these issues. The staff remains receptive to industry petitions for changes to EP requirements for evolutionary and passive advanced LWRs, but it does not intend to dedicate further staff resources until such a petition is received.

In order to gain perspective on potential technical criteria and methods for EP for evolutionary and passive advanced LWR designs and to ascertain whether simplification of the EP requirements may be warranted for these designs, the staff examined the technical basis of EP requirements for current plants and analyzed design-basis and severe-accident data for revolutionary and passive advanced LWRs. The staff's evaluation consists of two part. Part 1 is a review of the rationale, criteria, and methods that form the basis for EP for currently licensed reactor designs as discussed in NUREG-0396. Part 2 is an evaluation of whether improved safety features of evolutionary and passive advanced LWR designs may warrant changes in the technical criteria or methods used as the basis for the EP regulations, and whether application of these criteria for the evolutionary and passive advanced LWRs indicates that changes to EP requirements are

No. 9312300304).

warranted.

In support of its evaluation, the staff reviewed challenges made to EP regulations for current plants (petitions for rulemaking and requests for a waiver and an exemption), new source-term and severe-accident analyses, and industry submittals concerning EP for advanced reactors. The staff recognizes that an extensive research effort has been conducted to understand accident phenomena, including fission product release and transport. The staff's review of these areas is summarized in an appendix to this paper, and the staff is developing a NUREG report documenting the details of the evaluation discussed in this paper.

SECY-02-0139

The purpose of SECY-02-0139 is to provide the Commission a status report on issues with potential policy implications related to licensing non-LWR designs and the staff's plans for seeking Commission guidance and resolving these issues. This information paper provides the Commission with an early indication of the scope and nature of the technical related policy issues, and is to be followed later with a policy paper containing recommendations for Commission action (see SECY-03-0047, below). In an attachment to this paper, the staff addressed the following specific EP policy issue (see also, Issue 7 in SECY-03-0047, below), with emphasis on the underlying considerations and previous Commission work.

Emergency Preparedness

Issue: Under what conditions, if any, can emergency planning zones be reduced, including a reduction to the site exclusion area boundary?

It has been proposed by Exelon that the pebble bed modular reactor (PBMR) design has sufficient fission product retention capability that the EPZ can be reduced from 10 mi (typical for LWRs) to the exclusion area boundary for the site (assumed to be 400 meters for analysis purposes). The proposed licensing basis events for the PBMR include a set of emergency planning basis events that are to be used to test the fission product retention capability of the plant for emergency planning purposes. As defined by Exelon, these events are in the frequency range of 10^{-4}/plant-year to 5×10^{-7}/plant-year and are to be evaluated using mean values of frequency and consequences so that the dose to an individual at the exclusion area boundary is less than the EPA PAGs. The foundation for this approach has not been fully developed, reviewed or accepted; however, the issues it raises are clear. In effect, the PBMR proposal would eliminate the need for offsite emergency notification and drills, although there would be guidance kept onsite that could be used to facilitate ad hoc protective measures, if deemed necessary. The PBMR proposal seeks to establish a probabilistic cutoff (using the safety goal fatality quantitative health objective) for events that need to be considered for emergency planning purposes. This differs from the basis used to establish the current 10-mi EPZ for LWRs, in that the full range of accidents were considered, and a 10-mi distance chosen as the point where doses to the public large enough to cause early fatalities rapidly diminish. To arrive at a recommendation on the policy issue, the staff will consider the following:

- Should there be minimum requirements for emergency evacuation as part of the defense-in-depth philosophy, regardless of plant design or projected risk, and if so, what should they be?

- To what extent should probabilistic criteria be used to define the events to be considered for emergency planning, and if so, what should they be?

- Are projected doses to individuals that are less than the EPA PAGs sufficient to use as criteria to establish the EPZ?

- What demonstration of plant performance, if any, would be necessary to find such a proposal acceptable?

It is recognized that the resolution of this issue is related to the issues associated with event selection as well as predicted plant performance, including fuel performance and fuel quality over the life of the plant, projected fission product source terms for various accident scenarios, and how to account for the uncertainties due to the lack of operating experience as compared to current LWRs.

Previously, in SECY-93-092, the staff had assessed the issue of emergency planning and did not recommend any generic policy or regulation changes. Rather, EP for each advanced design would be reviewed on a case-by-case basis. The Commission, in a July 30, 2003, SRM, stated that it was premature to reach a conclusion on emergency planning for advanced reactors, but requested the staff remain open to suggestions to simplify EP requirements for reactors designed with greater safety margins. Additionally, the staff was requested to submit to the Commission recommendations for proposed technical criteria and methods to use to justify simplification of existing EP requirements.

In SECY-97-020, the staff provided the results of the evaluation of emergency planning for evolutionary and advanced reactors. That evaluation focused on the evolutionary and passive advanced LWR designs because of the availability of design and risk assessment data and because applicants were pursuing certification of these designs. The staff concluded that the rationale upon which EP for current reactor designs is based, that is, potential consequences from a spectrum of accidents, is appropriate for use as the basis for EP for evolutionary and passive advanced LWR designs and is consistent with Commission's defense-in-depth philosophy. In order to justify change to the EP basis, the staff believes that several issues would need to be addressed:

(1) The probability level, if any, below which accidents will not be considered for EP;

(2) The use of increased safety in one level of the defense-in-depth framework to justify reducing requirements in another level; and

(3) The acceptance of such changes by the Federal, State, and local agencies responsible for emergency planning, as well as other stakeholders.

The staff still considers EP an essential part of the NRC "defense-in-depth" philosophy; even for new plants that are designed to reduce the risk from severe accidents. Notwithstanding the need to consider potential consequences from a spectrum of accidents, a design's ability to prevent the significant release of radioactive material, or to provide a long delay time preceding a release for all but the most unlikely events, should be reflected in any decision on relaxing emergency planning requirements. In addition, the public perception of risk from nuclear power plant accidents may be a factor. Therefore, the projected dose should not be the only factor considered as the basis for relaxing emergency planning.

SECY-03-0047

The purpose of SECY-03-0047 is to provide for Commission consideration options and recommended positions for resolving the seven policy issues associated with the design and licensing of future non-LWR designs discussed in SECY-02-0139, and to highlight any implications for licensing future LWRs. In SECY-02-0139, the staff identified seven technical issues with policy implications resulting from the pre-application activities to date on non-LWR designs, including an EP issue related to the reduction of the EPZs. With regard to determining the EPZs, the following addresses the staff's recommendation that no change to current EP requirements are needed.

Emergency Preparedness

Issue 7: Under what conditions can the EPZ be reduced, including a reduction to the site exclusion area boundary?

EP is considered by many to be the last line of defense in the defense-in-depth philosophy. Its requirements have been established in consideration of the potential for accidents that could lead to severe core damage and the subsequent release of large amounts of radioactive material. For LWRs, this release could occur in a matter of hours after the initiating event, and a 10-mi PEP EPZ has been chosen to envelope the distance beyond which it is very unlikely doses large enough to cause early fatalities would occur. In considering whether or not to modify the EPZ, similar considerations would need to be taken into account. These would include:

- What is the potential for a severe core damage accident?
- What is the potential for a large offsite release of radioactive material?
- Should the assumption of a large offsite release be a fundamental part of defense-in-depth?
- How should the characteristics of the release be used to set the EPZ (e.g., potential for early fatalities, timing of release)?
- How should uncertainties and experience with the design and technology be taken into account?

The options considered by the staff in addressing this issue are: (Option a) No change for current requirements, and (Option b) Allow a reduction in the EPZ based upon the extent and timing of predicted core damage and fission product release. Consistent with the Commission's July 30, 1993, SRM to SECY-93-092, the staff recommends the Commission not modify EP requirements at this time, which is consistent with Option a, and is based upon the following two considerations:

- Provision already exists in 10 CFR 50.47 for accommodating the unique aspects of high temperature gas reactors (HTGRs).
- In the near term, new plants are likely to be built on an existing site, which conforms to current requirements.

If approved by the Commission, the role of EP in defense-in-depth would be addressed as part of the development of a policy or description of defense-in-depth (addressed elsewhere in this

document). In the June 26, 2003, SRM, the Commission approved the staff's recommendation.

SECY-10-0034

In SECY-10-0034, the staff identified a number of potential policy and licensing issues associated with SMRs, including offsite emergency planning requirements. The paper provides a summary description of the key issues for Commission information, and the discussions are consistent with information provided in previous Commission papers and other related agency documents. The paper addresses only those potential policy and licensing issues for which resolutions may require Commission consideration. While approaches to potential resolutions of issues are described, the paper does not include proposed resolutions for any of the issues.

In Section 4.7, "Offsite Emergency Planning Requirements for SMRs," the staff discussed SECY-93-0092 and the related July 30, 1993, Staff Requirements Memorandum (SRM). With regard to EPZ size, the staff stated the following:

In SECY-93-0092, the NRC staff questioned whether applicants for licenses referencing advanced reactors with passive design safety features should be able to adjust EPZs and requirements. In its SRM dated July 30, 1993, the Commission stated that it was premature to reach a conclusion on emergency planning for advanced reactors and directed the staff to use existing regulatory requirements. However, it instructed the staff to remain open to suggestions to simplify the emergency planning requirements for reactors that are designed with greater safety margins. The smaller size, lower power densities, lower probability of severe accidents, slower accident progression, and smaller offsite consequences per module that characterize SMR designs have led the U.S. Department of Energy (DOE), SMR designers, and potential SMR operators to raise questions regarding the appropriate size of the EPZ, the extent of onsite and offsite emergency planning, and the number of response staff needed. Should the applicants propose deviation from NRC requirements, Commission input may be needed to determine whether the proposals are in keeping with Commission policy on this issue.

This issue is applicable to license applications for new, first-of-a-kind SMR designs. A change in the requirements for protective actions and the size of an EPZ is a policy issue that will be of interest to all stakeholders, including FEMA and the public. Any changes to current policies would necessitate appropriate changes to the regulatory requirements and associated guidance documents. This effort would be needed in preparation for combined license (COL) application reviews. The staff will consider white papers or topical reports proposing to deviate from emergency preparedness requirements that it receives from DOE and potential SMR applicants. During its review of COL applications, the staff will discuss site-specific justifications to support proposed deviations, review site-specific proposed emergency preparedness plans, coordinate the reviews with the FEMA, and review similar activities with other nuclear facilities.

SECY-10-0034 also addresses SMR accident source terms (including site boundary dose acceptance criteria and associated dose calculations), which are used for the assessment of the effectiveness of the containment and plant mitigation features, site suitability, and emergency planning. Potential policy, licensing, and key technical issues for SMR designs is not addressed in this report; as such, issues are more appropriately addressed at the COL application stage, when the SMR technology (including number of modules) has been identified.

SECY-11-0152

SECY-11-0152 discusses the staff's intent to develop a technology-neutral, dose-based, consequence-oriented EP framework for SMR sites that takes into account the various designs, modularity, and collocation,[4] as well as the size of the EPZs. The staff has reviewed the existing NRC 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 EPA PAGs. 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. 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.

SECY-11-0152 also provides an overview of three policy issues associated with EP for SMRs, consisting of (1) Scalable Emergency Planning Zone, (2) Modularity and Collocation, and (3) Considerations for Establishing the Size of EPZs for SMRs.

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-mi, 5-mi, and 10-mi EPZs.

If projected accident offsite doses are less than 1 roentgen equivalent man (rem) 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 mi, then the requirements for the EPZ would be limited to the 2-mi zone. Similarly, if projected offsite dose is greater than 1 rem at 2 mi, but less than 1 rem at 5 mi, the size of the EPZ would be 5 mi. If the expected offsite dose is greater than 1 rem at 5 mi, the size of the EPZ would default to the current 10-mi EPZ.[5]

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[4] *Modularity* means two or more reactor modules that have some common or shared systems. *Collocation* means SMRs being collocated with large reactors, industrial facilities, different SMR types, or any combination of these. (See SECY-11-0152, section entitled "*Modularity and Collocation*.")

[5] SECY-11-0152 Table 1, "Example of a Scalable EPZ," indicates that for a site boundary EPZ, the offsite EP plan would be an 'all-hazards' plan, subject to a license condition. The associated footnote states that "[t]he NRC would issue a license condition that will require the licensee to ensure that a certified offsite all-hazards plan exists (which provides

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-mi 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.

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.

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 and the public. The staff will more fully address the above described policy issues in a future Commission paper (see May 30, 2013, Commission Memorandum, below).

<u>2013 EPA PAG Manual</u>

The EPA developed the PAG Manual to assist public officials in planning for emergency response to radiological incidents. The manual provides radiological protection criteria for application to all incidents that would require consideration of protective actions, with the exception of nuclear war. These include recommended numerical PAGs for the principal protective actions available to public officials during a radiological incident. A PAG is defined for purposes of this document as the projected dose to an individual from a release of radioactive material at which a specific protective action to reduce or avoid that dose is recommended. PAGs are guides to help public officials select protective actions under emergency conditions, during which exposures would occur for relatively short time periods. They are not meant to be applied as strict numeric criteria, but rather as guidelines to be considered in the context of incident-specific factors. PAGs do not establish an acceptable level of risk for normal, non-emergency conditions, nor do they represent the boundary between safe and unsafe conditions. The PAGs are not legally binding regulations or standards, and do not supersede any environmental laws.

the basic framework for responding to a wide variety of disasters)."

Background[6]

In September 1975, EPA published the first edition of the "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," EPA-520/1-75-001, which established protective actions for whole body and thyroid exposure. That was followed in December 1978 by NUREG-0396 (discussed below) – a report prepared by an NRC and EPA task force on EP – which introduced the concept of generic EPZs as a basis for the planning of response actions. The EPZ sizes were based on the PAG guidance in the 1975 PAG Manual.

In January 1980, EPA updated this manual[7] to include methods for estimating population dose from plume exposure, and to provide guidance for decision-making on comparing projected dose with PAGs. In May 1992, EPA substantially revised the manual[8] to include recommendations that feature lower dose values, and broadened the range of radiological and nuclear incidents to include events at other than nuclear power plants (i.e., nuclear fuel cycle facilities, defense and research facilities, transportation accidents, radioisotope manufacturing facilities, and any other event except nuclear war). In early January 2009, EPA published a revised manual, as a draft for public comment, which was subsequently withdrawn in late January 2009. In March 2013, EPA revised this manual,[9] which was issued as a draft for interim use and public comment, followed in 2016 with another update,[10] and a final PAG Manual revision in January 2017.[11]

Applicability

Protective actions may be recommended for a wide range of incidents, but generally apply to incidents involving relatively significant releases of radionuclides. Each type of incident would pose a unique threat to public health and should be planned for and managed accordingly. The decision to advise members of the public to take a protective action during a radiological incident involves a complex judgment in which the radiological risk must be weighed against the action's inherent risks. This decision may have to be made under emergency conditions, with limited information and little time to analyze options. Advance planning reduces the complexity of the decision-making process during an incident.

The planning process can identify the viability of responses to various incidents, the courses of action that can be set in motion in advance and the decisions that can only be made during an actual emergency. While many aspects of protective actions can be considered well in advance of an emergency, the situation and conditions that exist at the time of emergency must be considered if the most effective action is to be selected.

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[6] Background information provided from SECY-11-0078, "U.S. Environmental Protection Agency Revisions to the Protective Action Guidance Manual," June 9, 2011 (ADAMS Accession No. ML111430863).
[7] "Manual of Protective Actions for Nuclear Incidents," EPA-520/1-75-001-A, January 1980.
[8] "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," EPA 400-R-92-001, May 1992.
[9] EPA "PAG Manual – Protective Action Guides And Planning Guidance For Radiological Incidents," Draft for Interim Use and Public Comment, March 2013.
[10] EPA "PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents," Draft for Interim Use and Public Comment, EPA-400/R-16/001, November 2016.
[11] EPA "PAG Manual – Protective Action Guides and Planning Guidance for Radiological Incidents," EPA-400/R-17/001, January 2017, www.epa.gov/radiation/protective-action-guides-pags.

PAGs and Nuclear Facilities Emergency Planning Zones (Section 2.3.5)

Under NRC regulations, before a nuclear power reactor may be issued a license, the NRC must find that licensee, state and local emergency plans are adequate, and that they can be implemented. For [large light water] nuclear power reactors, there is a plume exposure EPZ within a 10 mi (16.1 kilometer (km)) radius of the plant, and for a separate ingestion pathway EPZ within a 50 mi (80.5 km) radius. The sizes of these EPZs were developed by the NRC/EPA Task Force Report on Emergency Planning (i.e., NUREG-0396), and are based, in part, on the numerical values of the PAGs for the plume exposure and ingestion pathway EPZs. The licensee develops and maintains a detailed emergency plan for its facility, while state and local authorities within the EPZ develop and maintain detailed emergency response plans for their respective jurisdictions. Guidance to these licensees, states and local agencies for developing these emergency response plans, including guidance on arrangements for implementing immediate protective actions, is primarily contained in NUREG-0654, and supplemented with other guidance issued by NRC (for licensees) and FEMA (for off-site response organizations).

Planning for incidents at other types of nuclear facilities should be developed using similar considerations. Emergency preparedness requirements for non-power reactors (e.g., test and research facilities) are provided in 10 CFR Part 50 Appendix E, with supporting guidance in NRC Regulatory Guide 2.6, "Emergency Planning for Research and Test Reactors." Emergency preparedness requirements for fuel cycle and materials facilities are provided in 10 CFR Parts 30, 40, and 70, with supporting guidance in NRC Regulatory Guide 3.67, "Standard Format and Content for Emergency Plans for Fuel Cycle and Materials Facilities." Because of the relatively limited number and diverse natures of these facilities, the size of the EPZ is determined, if needed, on a case-by-case basis for reactors with an authorized power level less than 250 megawatt thermal.

Within an EPZ, an area should be pre-designated for immediate response based on specified plant conditions prior to a release, or, given a release, prior to the availability of information on quantities of radioactive materials released. The shape of this area will depend on local topography, as well as political and other boundaries. Additional areas of the EPZ, particularly in the downwind direction, may require evacuation or sheltering-in-place, as determined by dose projections. The size of these areas will be based on the potential magnitude of the release and on an angular spread determined by meteorological conditions and any other relevant factors.

The EPZs should be large enough to cover affected urban and rural areas, and accommodate the various organizations needed for emergency response.[12] Although the size of the EPZ is based on the maximum distance at which a PAG might be exceeded, the actual boundary of an EPZ shall be demarcated by features readily identifiable by people within this area. Such boundaries generally include major topographical features (e.g., rivers, roads, transmission line corridors, rail rights of way) and political boundaries. The EPZ should be further subdivided, using similarly identifiable features, to facilitate implementing protective actions when the entire EPZ is not affected. Maps, showing the boundaries of the EPZ and the sub-areas and evacuation routes should be provided to the public within the EPZ on a periodic basis in a format that will likely be available if the emergency occurs (e.g., inserted sections in local phone directories, wall calendars, etc.). EPZs are not necessary at those facilities where it is not possible for PAGs to be exceeded off-site.

[12] The development of EPZs for nuclear power facilities is discussed in NUREG-0396 (NRC 1978).

Commission Memorandum (May 30, 2013)

The purpose of this memorandum is to inform the Commission of recent activities and the current status of the source term and EP issues for SMRs, which the NRC staff first described in SECY-10-0034 and SECY-11-0152.

Emergency Preparedness

SECY-10-0034 also discussed possible deviations from EP requirements for SMRs. In SECY-11-0152, the staff indicated a willingness to consider alternative EP requirements and frameworks for SMRs and described a dose-distance scalable approach that could be implemented for determining an emergency planning zone (EPZ). The staff has continued its engagement with industry stakeholders on these areas, as described below.

In October 2010, the DOE /Idaho National Lab's (INL's) Next Generation Nuclear Plant (NGNP) Project submitted a white paper, "Determining the Appropriate Emergency Planning Zone Size and Emergency Planning Attributes for an HTGR," which summarized an approach for establishing plume exposure and ingestion pathway EPZs for the high temperature gas-cooled reactor (ADAMS Accession No. ML103050268). In March 2013, the staff issued an assessment document that discussed a number of NGNP issues, including EP (ADAMS Accession No. ML13002A157). The assessment document, in response to DOE/INL requests to propose or revise regulations and guidance, restates the message in SECY-11-0152 that the staff is willing to consider alternatives, but it will not propose or revise regulations absent a specific proposal. The staff briefed the Advisory Committee on Reactor Safeguards (ACRS) sub-committee on Future Plant Designs on NGNP EP issues on April 9, 2013, and the full ACRS committee on the same topic on May 9, 2013.

At the December 13, 2012 public meeting with the Nuclear Energy Institute (NEI), NEI also gave a presentation on a proposed methodology and criteria for establishing a technical basis for SMR EPZ sizing.[13] During its presentation, NEI stated its intention to submit a position paper on this topic in the near future.[14] NEI plans to incorporate elements from its source-term position paper in the EPZ sizing paper.

Although no applicants have formally indicated to the staff that they plan to use an alternative EP approach, the NRC staff will continue to work with external stakeholders to address these issues further, as resources allow, but it will not go further in proposing new policy or revising guidance for specific changes to EP requirements absent specific proposals from an applicant or nuclear-industry group. The staff will continue to engage interested stakeholders in activities related to source term. The staff will update the Commission, as appropriate, when it receives new and significant information on these topics. The staff will also notify the Commission if any policy issues are identified that may warrant Commission review.

[13] See April 8, 2013, Summary of December 13, 2012, public meeting at ADAMS Accession No. ML13079A205.

[14] On December 23, 2013, NEI submitted a White Paper, entitled "Proposed Methodology and Criteria for Establishing the Technical Basis for Small Modular Reactor Emergency Planning Zone" (ADAMS Accession No. ML13364A345). On July 8, 2015, NEI submitted a White Paper, entitled "Proposed Emergency Preparedness Regulations and Guidance for Small Modular Reactor Facilities" (ADAMS Accession Nos. ML15194A275 and ML15194A276).

SECY-15-0077

The purpose of SECY-15-0077 is to seek Commission approval of the staff's recommendation to initiate a rulemaking to revise regulations and guidance for EP for SMRs and other new technologies (ONTs), such as non-LWRs and medical isotope production facilities. Specifically, the staff is requesting Commission direction on whether the staff should consider smaller EPZs – as described in SECY-11-0152, including a [PEP] EPZ distance effectively at the site boundary – and other possible changes in EP requirements associated with technologies such as SMRs and non-LWRs.

This paper proposes a consequence-based approach to establishing requirements, as necessary, for offsite EP, and initiate a rulemaking effort to establish EP requirements for SMRs and ONTs that are commensurate with the potential consequences to public health and safety, and the common defense and security at these facilities. The need for EP is based upon projected offsite dose in the unlikely occurrence of a severe accident. The current EP framework for large LWRs governing EPZs is based on EPA PAG dose guidelines for early phase protective actions in the unlikely event of a severe accident, at which point public protective actions should be considered and undertaken. The NRC staff can establish an EP framework for SMRs and ONTs based on PAG guidelines.

The staff proposes revising NRC regulations and guidance through rulemaking to require SMR license applications to demonstrate how their proposed facilities achieve EPA PAG dose limits at specified EPZ distances, which may include the site boundary. This framework can be established generically without site- or design-specific information regarding source term, fission products, or projected offsite dose. The staff anticipates that the technical basis for this EP framework would be developed also as part of rulemaking. This would include quantitative guidelines and criteria for accident selection and evaluation specific to SMRs and ONTs. The NRC technical staff will rigorously review design and licensing information to ensure that the information applicants provide on the offsite dose consequences is commensurate with the requested EPZ size, and that the applicable requirements ensure adequate protection of public health and safety, and the environment. Commission direction regarding EP for SMRs and other new technologies, including EPZ sizes, will enable the NRC staff to develop regulations and guidance to provide for regulatory stability, predictability, and clarity in the licensing process, and would minimize or eliminate the uncertainty for applicants and inefficient use of agency resources caused by reliance on serial EPZ exemption requests.

The concept of an EPZ size commensurate with offsite radiological risk is not new to the NRC. The staff recently reviewed exemption requests from specific EP requirements from certain reactor licensees that have permanently ceased operations. . . . The staff considered the status of permanently shut down and defueled facilities, and the low likelihood of any credible accident resulting in radiological releases requiring offsite protective measures, and based its evaluation of the requests for exemptions from EP requirements on site-specific analyses. The staff verified that conclusions based on these analyses and calculations provided reasonable assurance that in granting the requested exemptions: (1) an offsite radiological release would not exceed the EPA PAGs at the site boundary; and (2) in the unlikely event of an accident resulting in a loss of all spent fuel pool cooling, there would be sufficient time to initiate appropriate mitigating actions. Also, if a release was projected to occur, there would be sufficient time for offsite agencies to take protective actions using an existing local Comprehensive Emergency Management Plan (CEMP)[15]

[15] The CEMP is part of FEMA's Comprehensive Preparedness Guide (CPG)-101, "Developing and Maintaining

to protect public health and safety.

In SRM-SECY-15-0077, the Commission approved the staff's recommendation to initiate a rulemaking to revise regulations and guidance for EP for SMRs and ONTs. The Commission directed the staff to be vigilant in continuing to assess the NRC's EP program, and should not rule out the possibility of moving to a performance-based framework in the future. The Commission also stated that for any SMR reviews conducted prior to the establishment of a rule, the staff should be prepared to adapt an approach to EPZ for SMRs under existing exemption processes, in parallel with its rulemaking efforts.

SECY-16-0012

SECY-16-0012 informs the Commission of the status of staff activities related to accident source terms for SMRs and non-light water reactors (non-LWRs), and the staff's current assessment of potential policy issues associated with use of mechanistic source terms (MSTs) in DBA dose analyses and siting.

As a result of pre-application activities over recent years and earlier work by the NRC staff and the Commission, the NRC staff previously identified a number of potential policy and licensing issues for SMRs and non-LWRs. One issue is associated with the determination of source terms, and the resulting dose calculations and siting evaluations. Current regulations and guidance, while maintaining the requirement to assume substantial meltdown of the core and substantial release into containment, permit the use of MSTs to account for the design-specific accident scenarios and accident progression in developing DBA radiological source terms. These same source terms are then used as a basis for evaluating equipment qualification, vital area access, some shielding calculations, and as part of the site suitability determination.

Use of MSTs for DBAs for SMRs, given the expected smaller amount of fuel and unique and passive nature of these designs, is expected to result in reduced source terms when compared to large LWRs. These reduced source terms could form the basis for an applicant request to establish EPZs that are smaller than what is currently required by 10 CFR 50.47(c)(2). In the SECY-16-0012 enclosure, "Background Information Regarding Accident Source Terms and Siting," the staff provided more information on the specific NRC reactor siting and safety analysis requirements, including the following discussion on EPZ size evaluations:

MST Relationship to the Basis for EPZ Size Evaluations

In SECY-11-0152, the staff discussed possible consideration of potential changes to the emergency planning and preparedness framework for SMRs. Among the considerations for establishing the size of EPZs for SMRs, the staff stated its expectation that the dose assessments that provide the basis for the EPZ distances would evaluate a spectrum of accidents, using the plant design probabilistic risk assessment (PRA), as well as including current insights on severe accident progression.

Emergency Operations Plans" (https:/www.fema.gov/media-library-data/20130726-1828-25045-0014/cpg_101_comprehensive_preparedness_guide_ developing_and_maintaininig_emergency_operations_plans_2010.pdf, visited December 22, 2017). It helps planners at all levels of government in their efforts to develop and maintain viable, all-hazards, all-threats emergency plans. A CEMP is often referred to as "all hazards planning." See www.tnema.org/ema/response/plans.html, visited December 28, 2017.

Subsequently, in SECY-15-0077, the staff proposed a consequence-based approach to establishing requirements for offsite emergency planning, as determined to be necessary for SMRs and other new technologies. In the related SRM dated August 4, 2015, the Commission approved the staff's proposal to revise NRC regulations and guidance through rulemaking to demonstrate how their proposed facilities achieve EPA PAG dose limits at specified EPZ distances, which may include the site boundary. During the upcoming rulemaking process, the technical basis for the emergency planning framework for SMRs and non-LWRs will be developed, including guidance and criteria for radiological consequence analyses performed by the applicant to justify an EPZ size commensurate with the potential offsite radiological risk posed by the facility.

The DBA dose analyses performed by an applicant to show compliance with the siting safety analysis regulations and their related radiological releases to the environment are expected to be included in the spectrum of analyses that form the technical basis for the EPZ distance. However, the EPZ size basis dose analysis would be done for the appropriate exposure period for comparison to the EPA PAG dose criterion of 1 rem total effective dose equivalent (TEDE), which is comparably less than the siting dose criterion of 25 rem [0.25 sievert (Sv)] TEDE. In this case, exclusion area boundaries (EABs) and low population zone (LPZ) boundaries, which are located at shorter distances, may coincide with the plume exposure EPZ. Satisfying a 1 rem TEDE dose criterion for an EPZ of the same size as the EAB and LPZ would likely also demonstrate compliance by a large margin if compared with the 25 rem TEDE siting requirement in 10 CFR 50.34(a)(1)(ii)(D). Additionally, the technical basis for both emergency plans and EPZs needs to include consideration of beyond design basis accidents.

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