

# U.S. NUCLEAR REGULATORY COMMISSION

## REGULATORY GUIDE 1.242, REVISION 0



Issue Date: May 2023  
Technical Lead: Charles Murray

# PERFORMANCE-BASED EMERGENCY PREPAREDNESS FOR SMALL MODULAR REACTORS, NON-LIGHT-WATER REACTORS, AND NON-POWER PRODUCTION OR UTILIZATION FACILITIES

## A. INTRODUCTION

### Purpose

This regulatory guide (RG) identifies methods and procedures the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use by applicants and licensees for small modular reactors (SMRs), non-light-water reactors (non-LWRs), and non-power production or utilization facilities (NPUFs) to demonstrate compliance with performance-based emergency preparedness (EP) requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, “Domestic Licensing of Production and Utilization Facilities” (Ref. <sup>1</sup>), specifically: 10 CFR 50.47, “Emergency Plans,” 10 CFR 50.160, “Emergency preparedness for small modular reactors, non-light-water reactors, and non-power production or utilization facilities” and 10 CFR 50 Appendix E, “Emergency Planning and Preparedness for Production and Utilization Facilities”

### Applicability

This RG applies to applicants for, and holders of construction permits, early site permits (ESPs), operating licenses (OLs), and combined licenses (COLs) for SMRs, non-LWRs, and NPUFs under the provisions of 10 CFR Part 50, and 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Reactors” (Ref. <sup>2</sup>), that choose to adopt the regulations for the performance-based EP framework under 10 CFR 50.160.

### Applicable Regulations

- 10 CFR Part 50 provides regulations for licensing production and utilization facilities.

---

Written suggestions regarding this guide or development of new guides may be submitted through the NRC’s public Web site in the NRC Library at <https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/>, under Document Collections, in Regulatory Guides, at <https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/contactus.html>.

Electronic copies of this RG, previous versions of RGs, and other recently issued guides are also available through the NRC’s public Web site in the NRC Library at <https://nrcweb.nrc.gov/reading-rm/doc-collections/reg-guides/>, under Document Collections, in Regulatory Guides. This RG is also available through the NRC’s Agencywide Documents Access and Management System (ADAMS) at <http://www.nrc.gov/reading-rm/adams.html>, under ADAMS Accession Number (No.) ML23226A036. The regulatory analysis may be found in ADAMS under Accession No. ML23226A027. The associated draft guide DG-1350, Revision 0, may be found in ADAMS under Accession No. ML18082A044, and the staff responses to the public comments on DG-1350 may be found under ADAMS Accession No. ML23229A227.

---

- o 10 CFR 50.2, “Definitions,” provides definitions for, among other terms, Non-Light-Water Reactor, Non-Power Production or Utilization Facility, and Small Modular Reactor.
- o 10 CFR 50.33, “Contents of applications; general information,” provides requirements for applications for an OL or construction permit under 10 CFR Part 50 or a COL or an ESP under 10 CFR Part 52, including emergency planning zone (EPZ) requirements for applicants complying with 10 CFR 50.160.
- o 10 CFR 50.47, “Emergency plans,” provides EP requirements for nuclear power reactors.
- o 10 CFR 50.54, “Conditions of licenses,” provides, in 10 CFR 50.54(q), requirements for changing emergency plans.
- o 10 CFR 50.160 provides alternative performance-based EP requirements for SMR, non-LWR, and NPUF applicant and licensee EP programs.
- 10 CFR Part 52 governs the issuance of ESPs, standard design certifications, COLs, standard design approvals, and manufacturing licenses for nuclear power facilities.
  - o 10 CFR 52.1, “Definitions,” provides a definition for the term “major feature of the emergency plans.”
  - o 10 CFR 52.17, “Contents of applications; technical information,” describes the required contents of the site safety analysis report for an ESP.
  - o 10 CFR 52.18, “Standards for review of applications,” describes the standards the staff will use to review ESP applications.
  - o 10 CFR 52.79, “Contents of applications; technical information in final safety analysis report,” describes the technical information that must be included in the final safety analysis report for a COL application.

## **Related Guidance**

The list of related guidance is provided to designers, applicants, and NRC staff to assist in the development, preparation, and review of applications. Although some guidance documents are written mainly for light-water nuclear power reactors, the designers and applicants may find the approaches described useful for developing accident consequence assessments and source terms for their given designs and applications. The staff may use the guidance, as appropriate, when reviewing the applicants’ approaches for the given subject areas. Appendix A, “General Methodology for Establishing Plume Exposure Pathway Emergency Planning Zone Size,” and Appendix B, “Development of Information on Source Terms,” of this RG contain further information concerning consequence assessments and source terms, respectively.

- RG 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis” (Ref. <sup>3</sup>), describes an integrated decisionmaking approach that the NRC has found acceptable.
- RG. 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors” (Ref. <sup>4</sup>), provides guidance on design-basis accident radiological consequence analyses for light-water nuclear power reactors, including the development of

design-basis accident radiological source terms used in siting and safety analyses.

- RG 1.200, “Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities” (Ref. <sup>5</sup>), provides guidance on determining whether the technical adequacy of the probabilistic risk assessment (PRA), in total or the parts that are used to support an application, is sufficient to provide confidence in the results, such that the PRA can be used in regulatory decisionmaking for light-water reactors (LWRs).
- RG 1.206, “Applications for Nuclear Power Plants” (Ref. <sup>6</sup>), provides guidance on the format of and content of a COL application for a nuclear power plant.
- RG 1.219, “Guidance on Making Changes to Emergency Plans for Nuclear Power Reactors” (Ref. <sup>7</sup>), provides guidance for nuclear power reactor licensees implementing the requirements in 10 CFR 50.54(q) for following, maintaining the effectiveness of, and evaluating and implementing changes to emergency plans.
- RG 1.233, “Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors” (Ref. <sup>8</sup>), provides guidance on using a technology-inclusive, risk-informed, and performance-based methodology to inform the licensing basis and content of applications for non-LWRs.
- RG 2.6, “Emergency Planning for Research and Test Reactors and Other Non-Power Production and Utilization Facilities” (Ref. <sup>9</sup>), provides applicants and licensees guidance on an acceptable method for complying with the regulations on the content of emergency plans for NPUFs.
- 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,” issued December 1978 (Ref. <sup>10</sup>), provides a planning basis for offsite EP efforts considered necessary and prudent for large power reactor facilities.
- NUREG-0654/Federal Emergency Management Agency (FEMA)-REP-1, Revisions 1 and 2, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,” issued November 1980 and December 2019, respectively (Refs. <sup>11</sup> and <sup>12</sup>), provide guidance and evaluation criteria for the development and evaluation of the radiological emergency response plans for operating power reactors.
- NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 13.3, “Emergency Planning” (Ref. <sup>13</sup>), provides guidance on the review and evaluation of a power reactor license applicant’s EP program as described in the safety analysis report.
- NUREG-0800, Chapter 15, “Transient and Accident Analysis” (Ref. <sup>14</sup>), provides guidance on the review and evaluation of safety analyses, including the evaluation of event categorization and design-basis accident radiological consequence analyses.
- NUREG-0800, Chapter 19, “Severe Accidents” (Ref. <sup>15</sup>), provides guidance on the review and evaluation of severe accident assessment, including severe accident releases and PRA.
- NUREG-1855, Revision 1, “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision Making,” issued March 2017 (Ref. <sup>16</sup>), provides further guidance on addressing uncertainties.

## **Purpose of Regulatory Guides**

The NRC issues RGs to describe methods that are acceptable to the staff for implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific issues or postulated events, and to describe information that the staff needs in its review of applications for permits and licenses. Regulatory guides are not NRC regulations and compliance with them is not required. Methods and solutions that differ from those set forth in RGs will be deemed acceptable if supported by a basis for the issuance or continuance of a permit or license by the Commission.

## **Paperwork Reduction Act**

This RG provides voluntary guidance for implementing the mandatory information collections in 10 CFR Parts 50 and 52 that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.). These information collections were approved by the Office of Management and Budget (OMB), under control numbers 3150-0011 and 3150-0151, respectively.

Send comments regarding this information collection to the FOIA, Library, and Information Collections Branch (T6-A10M), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by email to [Infocollects.Resource@nrc.gov](mailto:Infocollects.Resource@nrc.gov), and to the OMB reviewer at: OMB Office of Information and Regulatory Affairs, (3150-0011 and 3150-0151), Attn: Desk Officer for the Nuclear Regulatory Commission, 725 17th Street, NW, Washington, DC, 20503; e-mail: [oira\\_submissions@omb.eop.gov](mailto:oira_submissions@omb.eop.gov).

## **Public Protection Notification**

The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless the document requesting or requiring the collection displays a currently valid OMB control number.

## TABLE OF CONTENTS

|   |     |
|---|-----|
| A. INTRODUCTION.....                                    | 1   |
| Purpose.....  | 1   |
| Applicability.....                                      | 1   |
| Applicable Regulations.....                             | 1   |
| Related Guidance.....                                   | 2   |
| Purpose of Regulatory Guides.....                       | 4   |
| Paperwork Reduction Act.....                            | 4   |
| Public Protection Notification.....                     | 4   |
| B. DISCUSSION.....                                      | 6   |
| Reason for Issuance.....                                | 6   |
| Background.....   | 6   |
| Consideration of EPA Protective Action Guides.....      | 6   |
| Consideration of International Standards.....           | 8   |
| C. STAFF REGULATORY GUIDANCE.....                       | 9   |
| General.....  | 9   |
| Performance-Based Framework.....                        | 10  |
| Onsite Planning Activities.....                         | 17  |
| Offsite Planning Activities.....                        | 19  |
| Hazard Analysis of Contiguous or Nearby Facilities..... | 23  |
| D. IMPLEMENTATION.....                                  | 24  |
| GLOSSARY.....   | 25  |
| REFERENCES.....   | 26  |
| APPENDIX A.....   | A-1 |
| APPENDIX B.....   | B-1 |

## B. DISCUSSION

### Reason for Issuance

This RG provides guidance on implementing a performance-based EP program to comply with 10 CFR 50.160 for SMRs, non-LWRs, and NPUFs. The requirements in 10 CFR 50.160 afford a performance-based, technology-inclusive, risk-informed, and consequence-oriented approach to EP as an alternative to the EP requirements under 10 CFR 50.47(b) and Appendix E to 10 CFR Part 50. Applicants and licensees choosing to comply with 10 CFR 50.160 also need to comply with the applicable provisions in 10 CFR 50.47.

### Background

This RG applies to applicants and licensees choosing the performance-based approach to EP. With the addition of 10 CFR 50.160, the NRC has addressed the differences in emergency planning and response between large LWRs and SMRs, non-LWRs, and NPUFs. In 10 CFR 50.160, the NRC establishes an approach to EP that focuses on performance and results, rather than control of emergency plans and procedures. Applicants and licensees for SMRs, non-LWRs, and NPUFs may choose to adopt either the requirements of 10 CFR 50.160, or those in Appendix E to 10 CFR Part 50 and, for nuclear power reactor licensees, the planning standards in 10 CFR 50.47(b). The EP requirements in 10 CFR 50.160 acknowledge technological advancements and other differences from large LWRs that are inherent in SMRs and other new technologies.<sup>1</sup>

Before the issuance of the EP requirements in 10 CFR 50.160, the NRC relied on EP regulations initially developed for large LWRs and currently operating nonpower reactors (also referred to as research and test reactors). Historically, small LWR and non-LWR applicants (e.g., La Crosse, Big Rock Point, Fort St. Vrain) requested exemptions from some of the emergency planning requirements in 10 CFR 50.47 and Appendix E to 10 CFR Part 50 or requested that their EPZ size be evaluated on a case-by-case basis, as described in 10 CFR 50.47(c)(2). Applicants and licensees for SMRs, non-LWRs, and NPUFs not adopting the requirements of 10 CFR 50.160 can use existing guidance in NUREG-0654/FEMA-REP-1 to address the implementation of EP programs under 10 CFR 50.47 and Appendix E to 10 CFR Part 50, or existing guidance in RG 2.6 to address the implementation of NPUF EP programs under Appendix E to 10 CFR Part 50.

### Consideration of EPA Protective Action Guides

A protective action guide (PAG), as defined in EPA-400/R-17/001, “PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents,” issued January 2017 (2017 EPA PAG Manual) (Ref. <sup>17</sup>), is 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. The performance-based approach to EP in 10 CFR 50.160 provides criteria for the plume exposure pathway EPZ, including the criterion that the EPZ is the area within which public dose is projected to exceed 10 millisieverts (1 rem) total effective dose equivalent (TEDE) over the first 96 hours from the release of radioactive materials from the facility, considering accident likelihood and source term, timing of the accident sequence, and meteorology. In addition, the plume exposure pathway EPZ is the area in which predetermined, prompt protective measures are necessary. This is consistent with the guidance in the 2017 EPA PAG Manual that the duration of early-phase protective actions would begin at the actual or projected start of a release and generally last up to 4 days (i.e., 96 hours). The 2017 EPA PAG Manual provides additional information on the timing for protective actions.

---

<sup>1</sup> The NRC uses the term “other new technologies” to refer to non-LWRs and certain NPUFs, such as medical radioisotope facilities.

## **Consideration of Ingestion Response Planning**

The requirements of 10 CFR 50.33(g) specify that nuclear power reactor applicants must describe in their emergency plans actions appropriate to protect the food ingestion pathway. For SMRs, non-LWRs, and NPUFs that choose the performance-based approach to EP, 10 CFR 50.160(b)(4) requires applicants and licensees to describe ingestion response planning in the emergency plan. Section C.3 of this RG provides additional guidance on ingestion response planning for SMRs, non-LWRs, and NPUFs choosing to comply with 10 CFR 50.160, including the need to describe in emergency plans the State and local resources available for protecting the food ingestion pathway in the event of a radiological emergency.

The concept of an ingestion pathway emergency planning zone (IPZ) was created in the 1970s when the infrastructure may not have been sufficient to support the identification and removal of radiologically contaminated goods from food chains. Of primary concern in the 1970s were the livestock and food products that could be contaminated from a radiological release at a large LWR. Since the 1970s, significant improvements have been made in the Nation's Federal and State capabilities to identify and remove from the food chain biologically and radiologically contaminated goods or produce. Federal resources developed since then that are available for radiological emergency response include the Federal Radiological Monitoring and Assessment Center (FRMAC) and the Advisory Team for Environment, Food and Health (Advisory Team), as well as sampling and testing laboratories.

The mission of the FRMAC is to coordinate and manage all Federal radiological environmental monitoring and assessment activities within the United States during a nuclear or radiological incident, in support of State, local, and Tribal governments; the U.S. Department of Homeland Security (DHS); and the Federal response coordinating agency. The FRMAC is a Federal asset for response to a nuclear or radiological incident that is available upon request by the DHS or State or Tribal agencies. The FRMAC is an interagency organization with representation from the National Nuclear Security Administration (NNSA), U.S. Department of Defense, U.S. Environmental Protection Agency (EPA), U.S. Department of Health and Human Services, Federal Bureau of Investigation, and other Federal agencies. The NNSA has the responsibility to maintain the operational readiness of the FRMAC and to deploy it upon request.

The Advisory Team is a radiological emergency response group whose mission is to provide coordinated advice and recommendations to Federal, State, local, and Tribal governments for radiological emergencies. The permanent membership includes representatives from the EPA, the U.S. Food and Drug Administration, the Centers for Disease Control and Prevention, and the U.S. Department of Agriculture. The permanent members may invite other agencies to participate in Advisory Team activities. The Advisory Team was incorporated into FEMA's National Response Framework's "Nuclear/Radiological Incident Annex," issued October 2016 (Ref. <sup>18</sup>).

Ingestion response is not required in the early phase of an emergency because the ingestion of contaminated foods and water is a longer-term concern. Federal and State resources developed since the 1970s are available for the intermediate and late phases of the response, whether or not actions are preplanned in a specific area. Therefore, SMRs, non-LWRs, and NPUFs that choose to comply with 10 CFR 50.160 do not need an IPZ because sufficient resources are available and the process and timing for identifying and removing radiologically contaminated goods from food chains are better understood than in the past. Nonetheless, State and local response organizations can issue precautionary actions to the public in the early phase, such as to wash all produce from gardens or to use stored feed for livestock for those areas in the downwind direction of a release. Furthermore, State and local response organizations do not need completed analyses to make a precautionary recommendation to interdict food or put livestock on stored feed. States and Federal agencies frequently issue such precautionary actions for foods with nonradiological contamination. None of these precautionary actions requires an IPZ.

## **Consideration of International Standards**

The International Atomic Energy Agency (IAEA) works with member states and other partners to promote the safe, secure, and peaceful use of nuclear technologies. The IAEA develops safety standards for protecting people and the environment from the harmful effects of ionizing radiation. These standards provide a system of safety fundamentals, safety requirements, and safety guides reflecting an international consensus on what constitutes a high level of safety. To inform its development of this RG, the NRC considered IAEA Safety Requirements and Safety Guides pursuant to the Commission's International Policy Statement (Ref. <sup>19</sup>) and Management Directive and Handbook 6.6, "Regulatory Guides" (Ref. <sup>20</sup>).

The following IAEA Safety Requirements and Guide was considered in the development of this RG:

- IAEA Safety Standard General Safety Requirements (GSR) Part 7, "Preparedness and Response for a Nuclear or Radiological Emergency," issued in 2015 (Ref. <sup>21</sup>). The NRC considers this RG to be consistent with the level of safety provided in IAEA GSR Part 7.



## C. STAFF REGULATORY GUIDANCE

This section provides the methods that the NRC staff considers acceptable for meeting the requirements of the regulations cited in the Introduction.

### General

1. Each SMR, non-LWR, or NPUF applicant or licensee that chooses to adopt the emergency planning standards located in Appendix E to 10 CFR Part 50 and in 10 CFR 50.47(b), as applicable, should use the existing guidance found in NUREG-0654/FEMA-REP-1 or RG 2.6, as appropriate to the design and use of the facility, to implement the EP program.
2. Each SMR, non-LWR, or NPUF applicant or licensee that chooses to adopt the EP regulations in 10 CFR 50.160 should use the guidance found in Regulatory Guidance C.6 through C.9 of this RG, as applicable, to establish an EP program. Appendix A to this RG provides a sample methodology acceptable to the NRC for the analysis to establish EPZ size, as required under 10 CFR 50.33(g)(2).
  - a. All such SMR, non-LWR, or NPUF applicants and licensees should address the requirements in 10 CFR 50.160(b)(1)(i)–(iv)(A) and 10 CFR 50.160(b)(2)–(4) as described in Regulatory Guidance C.6, C.7, and C.9.
  - b. All such SMR, non-LWR, or NPUF applicants and licensees proposing a plume exposure pathway EPZ that extends beyond the site boundary should address the requirements in 10 CFR 50.160(b)(1)–(4) as described in Regulatory Guidance C.6 through C.9.
  - c. The analysis of the EPZ size required in 10 CFR 50.33(g)(2) may be preliminary for construction permits consistent with the preliminary design of the facility as described in the preliminary safety analysis report. The applicant should describe its EPZ sizing analysis methodology and the preliminary analysis results, including the radius of the plume exposure pathway EPZ.
  - d. 10 CFR 50.33(g) requires applicants referencing an early site permit must meet the terms of the permit, including the radius of the plume exposure pathway EPZ if that is determined in the early site permit, or request a variance under 10 CFR 52.39(d).
3. Each SMR, non-LWR, or NPUF applicant or licensee that chooses to adopt the EP regulations in 10 CFR 50.160, 10 CFR 50.33(g)(1) requires that an applicant must describe in the emergency plan the Federal, State, and local resources for protection of the ingestion pathway in the event of a radiological emergency. Even if the facility's plume exposure pathway EPZ is bounded by the site boundary, 10 CFR.160(b)(4) requires that the applicant and licensee must reference the capabilities of Federal, State, and local authorities that provide actions to prevent contaminated food and water from entering the ingestion pathway. The capabilities described in the emergency plan need to address major exposure pathways associated with the ingestion of contaminated food and water.
  - a. For ingestion response planning, the licensee or applicant should describe the Federal, State, local, or licensee capabilities that support intermediate and long-term monitoring, analysis, and interdiction or embargo, when warranted, for the products identified as a part of the site's food and water ingestion pathway.

- b. In order to interdict food pathways effectively, the contamination would need to be located, sampled, and identified. Federal, State, and local officials would need to notify food producers to stop harvesting, using, and distributing from those identified locations to limit contaminated foods and water from entering the ingestion pathway. Therefore, the applicant's and licensee's emergency plan should describe the Federal, State, or local capabilities to assess, sample, and notify to interdict foods and waters in a timely manner sufficient to avoid exceeding ingestion PAG doses.
- 4. Each SMR, non-LWR, or NPUF applicant or licensee that chooses to adopt the EP regulations in 10 CFR 50.160 must include in the emergency plan an analysis of any credible hazard from a contiguous or nearby facility that would adversely impact the implementation of emergency plans. Regulatory Guidance C.9 provides additional guidance on the required hazard analysis.
  - 5. Each SMR, non-LWR, or NPUF applicant or licensee that chooses to adopt the EP regulations in 10 CFR 50.160 should determine the need to contact State agencies or the NRC or another Federal agency, as applicable, to coordinate with Tribes to obtain information to meet the NRC's application requirements for emergency planning.

### **Performance-Based Framework**

- 6. The regulations in 10 CFR 50.160 require applicants and licensees to demonstrate effective response in drills and exercises for emergency and accident conditions.

Because of the performance-based nature of 10 CFR 50.160, this section of the RG provides general guidance on the content of emergency plans but does not give specific methods for compliance. The methods needed to demonstrate preparedness will vary based on design- and site-specific considerations. If the NRC or industry develops design-specific guidance at a future date, applicants may reference those documents within their applications. Applicants should begin interacting with the NRC early in the application development process to ensure that significant issues and content to support the application are identified and resolved early.

The NRC will review each application to determine whether an applicant has described how the performance-based framework in 10 CFR 50.160 will be met. The NRC staff will evaluate applications using a graded approach based on site-specific consequence analyses. Program elements that may be implemented and evaluated according to a graded approach include frequency between inspections, drills, exercises, number of performance objectives, and staffing.

- a. Maintenance of Performance (10 CFR 50.160(b)(1)(i))
  - (1) The emergency plan should include a general description of the facility; any site-specific definitions; and any relevant appendices, drawings, diagrams, and other information needed to demonstrate compliance with this section.
  - (2) The emergency plan should describe the process for maintaining and making changes to the emergency plan and associated procedures, including methods to account for facility changes and the methods used to conduct independent reviews of the EP program. Licensees may make changes to capabilities described in the emergency plan without creating a reduction in effectiveness, consistent with the requirements in 10 CFR 50.54(q).
- b. Performance Objectives (10 CFR 50.160(b)(1)(ii))

The emergency plan should describe a performance monitoring program to include the following topics:

- (1) the process used to develop performance metrics and objectives for each emergency response function in 10 CFR 50.160(b)(1)(iii), including the methodology applied to develop the objectives, the basis for relying on the objectives, and how acceptability or successful achievement is determined; for example, the methodology used to develop performance objectives and metrics could be as follows:

$$\text{performance objective metric}(\%) = \frac{\text{Number of correct opportunities}}{\text{Number of opportunities}} \times 100$$

- (2) performance measures used during drills and exercises to determine acceptable performance, including the means for determining quality and timeliness;
  - (3) reference levels to benchmark performance of each emergency response function in 10 CFR 50.160(b)(1)(iii);
  - (4) quarterly update of performance objective and metric data and maintenance of these objectives and data for previous eight calendar quarters, or other frequency as applicable;
  - (5) performance objective data format and method; and
  - (6) correction of previous performance objective data.
- c. Event Classification and Mitigation (10 CFR 50.160(b)(1)(iii)(A))

The emergency plan should describe the following:

- (1) capabilities to perform event classification and mitigation, including the methods, processes, equipment, specific instruments, parameters, facilities, and personnel;
- (2) how the emergency response team will accurately and in a timely manner assess facility conditions and classify events that would warrant an emergency declaration (e.g., the emergency response team would use emergency plan implementing procedures to assess malfunctions and the impact on safety; classify the event; monitor, plan, and repair facility malfunctions in a timely manner; and return the facility to safe conditions, which includes termination of accident progression and return of the facility to within safety limits or technical specifications); and
- (3) the emergency classification scheme and the associated emergency action levels (EALs), as applicable for the design of the facility, and the technical basis and methodology for determining the thresholds corresponding to each of the EALs, including consideration of the following:
  - (a) those standard classes (i.e., notification of unusual event, alert, site area emergency, general emergency) appropriate for dealing with accident consequences for the specific facility;
  - (b) the use of guidance provided or endorsed by the NRC that is applicable to the facility design;

- (c) any hazards or initiating conditions associated with a contiguous or nearby facility where a hazard would adversely impact the implementation of emergency plans; and
- (d) the EALs associated with each class of emergency and the particular immediate actions to provide an appropriate graded response (see Table 1 as one example of generic EALs to be considered during the development of site-specific EALs).

The NRC approves the initial emergency classification and action level scheme as part of the agency's approval of the emergency plan.

**Table 1. Sample EAL Description**

| <b>AREA</b>                           | <b>INITIATING CONDITION</b>   | <b>EMERGENCY ACTION LEVELS</b> | <b>THRESHOLD</b> | <b>BASIS</b> |
|---------------------------------------|---|--------------------------------|------------------|--------------|
| Abnormal Radiological Conditions      | High radiological effluents   | Gaseous                        |                  |              |
|                                       |   | Liquid                         |                  |              |
|                                       |   | Unmonitored                    |                  |              |
|                                       |   | Areas                          |                  |              |
|                                       | Processes   |                                |                  |              |
|                                       | Inadvertent criticality   |                                |                  |              |
| External Hazards or Natural Phenomena | Natural phenomena (high wind speeds, high/low ultimate heat sink, seismic, other) |                                |                  |              |
|                                       | Technical hazards (hazardous gases, hostile action based, fire, other industrial) |                                |                  |              |
|                                       | Hazardous chemical releases incident to the processing of licensed material       |                                |                  |              |
| System Malfunctions                   | At power  |                                |                  |              |
|                                       | Hot shutdown  |                                |                  |              |
|                                       | Cold shutdown   |                                |                  |              |
|                                       | Refueling/reloading   |                                |                  |              |
|                                       | Startup   |                                |                  |              |
| Fission Product Barriers              | Fuel (or target) matrix and cladding  |                                |                  |              |
|                                       | Coolant   |                                |                  |              |
|                                       | Containment or confinement function   |                                |                  |              |
| Judgment                              |   |                                |                  |              |

d. Protective Actions (10 CFR 50.160(b)(1)(iii)(B))

The emergency plan should describe capabilities to determine, implement, and recommend appropriate protective actions for a variety of hazards, to include the methods, processes,

equipment, facilities, and personnel. Capabilities to determine, implement, and recommend protective actions that may be considered include but are not limited to the following:

- (1) protect workers from ionizing radiation, toxic chemicals, or other industrial hazards using a spectrum of predetermined, available protective actions;
- (2) issue respiratory protection;
- (3) issue protective clothing and equipment as necessary;
- (4) removal of nonessential individuals and members of the public from the facility, to include evacuation, accountability, and search and rescue as deemed necessary; and
- (5) recommend protective actions to offsite authorities as conditions warrant.

e. Communications (10 CFR 50.160(b)(1)(iii)(C))

The emergency plan should describe the following:

- (1) capabilities to establish and maintain communications among the response facilities, as applicable, and with organizations that may have emergency response responsibilities, to include the methods, processes, equipment, facilities, and personnel;
- (2) information that will be provided when alerting site personnel (e.g., nature of the emergency classification and releases, location of the emergency, protective actions that are implemented on site);
- (3) activation and notification of the emergency response team and response organization based on the nature of the emergency condition;
- (4) procedures for notifying response personnel and organizations that may have responsibilities during emergencies;
- (5) procedures for notifying response personnel and organizations that may have onsite responsibilities or agreements (e.g., local law enforcement, medical and hospital services, fire response services);
- (6) methods used to provide periodic updates on emergency conditions containing pertinent information to response teams, facility staff, and offsite organizations; and
- (7) methods used to maintain continuous communications when requested.

f. Command and Control (10 CFR 50.160(b)(1)(iii)(D))

The emergency plan should describe the following:

- (1) the capabilities to perform adequate command and control, to include the methods, processes, equipment, facilities, and personnel;
- (2) the supporting organizational structure with defined roles, responsibilities, and authorities for directing and performing emergency response functions; and
- (3) qualitative criteria to assess command and control, such as how the emergency response team leader would use emergency plan implementing procedures to demonstrate the ability to do the following:

- (a) lead and direct the team to perform emergency response functions;
  - (b) maintain awareness of the emergency conditions;
  - (c) make timely and accurate unilateral decisions based on facility conditions to protect the public and environment;
  - (d) maintain emergency response functions continuously and indefinitely through the termination of the emergency;
  - (e) transition to resumption of normal operations or shutdown conditions; and
  - (f) coordinate emergency response functions with other organizations.
- g. Staffing and Operations (10 CFR 50.160(b)(1)(iii)(E))

The emergency plan should describe the following:

- (1) the capabilities to adequately staff the emergency response functions within an appropriate timeframe, to include the methods, processes, equipment, facilities, and personnel.
  - (a) The emergency plan should describe the staffing of the response centers and the training for the personnel. It may reference facility training procedures or other documents as needed. A complete roster of trained and qualified individuals should be maintained and updated on a set frequency and as personnel are added or removed from positional assignments.
  - (b) The plan should describe the on-shift emergency response staff augmentation process, including maintenance of staffing and succession of leadership for the duration of the emergency response or expansion of the response as needed.
  - (c) The plan should describe the analysis used to determine the minimum positions and the corresponding responsibilities to perform the emergency response functions described in the emergency plan, including consideration of the emergency response team leader; authorization for emergency declaration, termination, and transition to recovery; recovery operations; authorization for emergency radiation worker exposure; and authorization for media and news releases.
- (2) the process used to complete training before assigning roles and responsibilities to the emergency response team.
  - (a) Drills are a vehicle to use to train and retrain facility personnel in emergency responsibilities. The emergency plan should describe the drills and include references to a complete list of drill objectives and frequencies for various drill types:
    - integrated drills—drills incorporating multiple facilities or with any offsite organization that may be used for training and instruction;
    - communication drills—activities that drill the use of communication equipment and procedures to communicate facility status and emergency

conditions and that may be used to verify contact information, protocols, and reliability;

- fire drills—activities that drill the use of fire suppression technology;<sup>1</sup>
- medical emergency drills—activities that drill the use of first aid and emergency medical response for contaminated individuals or other industrial accidents; and
- radiological monitoring drills—activities that drill the use of equipment and procedures to determine the adequacy of equipment, training, and procedures for radiological monitoring of processes, effluents, releases, samples, contamination, and dose assessments.

- (b) Drills should allow sufficient free play to determine the adequacy of other emergency response functions with a minimum number of controller intrusions.
- (c) Evaluated exercises are used to demonstrate proficiency in the major portions of the emergency plan and, as such, cannot be used for training and instruction. Participation in an evaluated exercise is not required before assignment to an emergency response role.

h. Radiological Assessment (10 CFR 50.160(b)(1)(iii)(F))

(1) Radiological Conditions (10 CFR 50.160(b)(1)(iii)(F)(1))

The emergency plan should describe the capabilities to assess, monitor, and report to applicable response personnel the radiological conditions in and around the facility and onsite locations, such as abnormally high radiological area and process conditions and inadvertent criticality accident conditions as applicable, to include the methods, processes, equipment, facilities, data, and personnel.

(2) Protective Equipment (10 CFR 50.160(b)(1)(iii)(F)(2))

The emergency plan should describe the following:

- (a) capabilities to issue and use protective equipment and expand mitigation and protective action strategies, to include the methods, processes, equipment, facilities, and personnel; and
- (b) how the emergency response team will use emergency plan implementing procedures to demonstrate the issuance and correct use of protective equipment.

(3) Core or Vessel Damage (10 CFR 50.160(b)(1)(iii)(F)(3))

The emergency plan should describe the following:

- (a) capabilities to assess, monitor, and report to the applicable response personnel the extent of any core (or other vessel containing irradiated special nuclear

---

<sup>1</sup> If the facility has a separate program to address fires, the emergency plan only needs to reference that program. That program will be evaluated outside the EP program.

material, such as fuel or targets<sup>2</sup>) damage, to include the methods, processes, equipment, facilities, and personnel; and

- (b) how the applicable response personnel will use emergency plan implementing procedures to demonstrate assessing, monitoring, and reporting core or other vessel damage.

(4) Releases (10 CFR 50.160(b)(1)(iii)(F)(4))

The emergency plan should describe the following:

- (a) capabilities to assess, monitor, and report to the applicable response personnel the extent of any radiological release, including the releases of hazardous chemicals produced from licensed material,<sup>3</sup> to include the methods, processes, equipment, facilities, and personnel; and
- (b) how the emergency response team will use emergency plan implementing procedures to demonstrate assessing, monitoring, and reporting all radiological releases, and releases of hazardous chemicals produced from licensed material.

i. Reentry (10 CFR 50.160(b)(1)(iii)(G))

The emergency plan should describe the following:

- (1) capabilities to develop and implement reentry plans for access to the facility after radiological emergencies, including the methods, processes, equipment, facilities, and personnel;
- (2) capabilities to develop and implement reentry plans for access to the facility following hostile action-based emergencies, including the methods, processes, equipment, facilities, and personnel in coordination with site security and the Incident Command Post (ICP), if applicable;
- (3) how the emergency response team will use emergency plan implementing procedures to demonstrate the development and implementation of reentry plans.

j. Critique and Corrective Actions (10 CFR 50.160(b)(1)(iii)(H))

The emergency plan should describe the following:

- (1) capabilities to critique emergency response functions and implement effective corrective actions, to include the methods, processes, equipment, facilities, and personnel; and

---

<sup>2</sup> For the purposes of this guidance, a “target” is special nuclear material irradiated or processed within a utilization facility or production facility, respectively, as defined in 10 CFR 50.2, for the purposes of producing or extracting fission products for research, development, or commercial sale.

<sup>3</sup> For the purposes of this guidance, “hazardous chemicals produced from licensed materials” means substances having licensed material as precursor compound(s) or substances that physically or chemically interact with licensed materials and that are toxic, explosive, flammable, corrosive, or reactive to the extent that they can endanger life or health if not adequately controlled. These include substances commingled with licensed material and include substances such as hydrogen fluoride that is produced by the reaction of uranium hexafluoride and water, but do not include substances prior to process addition to licensed material or after process separation from licensed material.



- (2) how the emergency response team will use emergency plan implementing procedures to critique emergency response functions and implement timely corrective actions.

### **Onsite Planning Activities**

7. The emergency plan should address the following planning activities:

a. Public Information (10 CFR 50.160(b)(1)(iv)(A)(1))

The emergency plan should describe the capabilities and processes to manage and coordinate the licensee's media information during an emergency and support the public information functions of the Federal, State, and local authorities.

b. Coordination with Safeguards Contingency Plan (10 CFR 50.160(b)(1)(iv)(A)(2))

The emergency plan should describe the capabilities and processes or procedures to support implementation of the emergency plan in conjunction with the licensee Safeguards Contingency Plan, including the following:

- (1) initial notifications to law enforcement and other first responder agencies;
- (2) communication of threat-related information to the NRC;
- (3) coordination of response actions within the licensee organization, and with the Incident Commander<sup>4</sup> and local law enforcement agency personnel;
- (4) coordination with the Incident Commander for the deployment of onsite and offsite first responders;
- (5) support for the operations of an ICP;
- (6) coordination of onsite radiation protection measures for offsite first responders with the ICP;
- (7) mobilization of the site's emergency staff with security and the ICP, including during reentry; and
- (8) development and release of public information.

c. Communications with the NRC (10 CFR 50.160(b)(1)(iv)(A)(3))

The emergency plan should describe the planning activities, capabilities, and processes or procedures to support, including but not limited to the following:

- (1) emergency notifications to the NRC and the briefing of offsite authorities and the NRC on facility and emergency response status; and

---

<sup>4</sup> FEMA defines "Incident Commander" in "Program Manual, Radiological Emergency Preparedness," FEMA P-1028, December 2019, Appendix B, "Glossary of REP Terms," as the individual responsible for on-scene incident activities, including developing incident objectives and ordering and releasing resources. The Incident Commander has overall authority and responsibility for conducting incident operations. More information on the National Incident Management System appears on FEMA's Web site at <https://www.fema.gov>.

- (2) communication and data transmission utilizing technology systems that are compatible with NRC communication and data technology systems. The data that is to be provided should be determined on a case-by-case basis.

d. Emergency Facility or Facilities (10 CFR 50.160(b)(1)(iv)(A)(4))

The emergency plan should describe each emergency response facility, including, as applicable, descriptions of location, capabilities, size, equipment, and backup locations to transfer the functions if the facility is not habitable or accessible. The emergency plan should also describe the processes, systems, and equipment for collecting and processing data for decisionmaking in an emergency.

e. Site Familiarization Training (10 CFR 50.160(b)(1)(iv)(A)(5))

The emergency plan should describe the following:

- (1) site familiarization training to be provided, the expected participants, and the frequency of training; and
- (2) any coordination to ensure that the local law enforcement, medical, and fire services are familiar with the site environs and hazards associated with the site.

Service-specific information concerning the site's capabilities should be shared with the responding service. For example, the locations of important fire mains, hydrants, and suppression systems should be provided to the fire response services if needed to respond to the facility and assist in fire suppression and investigation. Likewise, local law enforcement and medical services should be aware of the relevant capabilities the site has and the locations of key resources.

f. Emergency Plan Maintenance (10 CFR 50.160(b)(1)(iv)(A)(6))

The emergency plan should do the following:

- (1) describe the process by which the emergency plan, implementing procedures, forms, and other programmatic documents are maintained at a high quality (references to the quality assurance program and to existing regulatory guidance may be used);
- (2) identify the individual(s) and organizations responsible for ensuring the documents are up to date; and
- (3) describe the frequency and the process for the review of emergency plan-related documentation and for the coordination of reviews (including an annual review of the EAL scheme, if applicable) with any offsite organization that may have emergency response responsibilities.

Established NRC guidance for power reactors (e.g., NUREG-0654/FEMA-REP-1) or for NPUFs (e.g., RG 2.6) may be referenced for approaches to implementing the planning activities.

### **Offsite Planning Activities**

8. The following planning activities are required for only those SMR, non-LWR, and NPUF applicants and licensees that propose a plume exposure pathway EPZ that extends beyond the site boundary:

a. Contacts and Arrangements with Federal, State, Local, and Tribal Governmental Agencies (10 CFR 50.160(b)(1)(iv)(B)(1))

The emergency plan must describe contacts and arrangements made with Federal, State, local, and Tribal governmental agencies, including the principal coordinating agencies. This can include medical service providers, local law enforcement, fire departments, emergency management agencies, and other emergency response organizations. The emergency plan should also document the relevant emergency planning and preparations and roles and responsibilities for each agency, including the following:

- (1) agency or organization name;
- (2) responsibilities for each agency or organization;
- (3) capabilities to be planned and prepared;
- (4) periodic review of contacts and arrangements; and
- (5) references to or attachment of agreements maintained (e.g., describing the services needed, activation of the service, and how to modify or periodically renew the agreements).

b. Notification of Offsite Organizations (10 CFR 50.160(b)(1)(iv)(B)(2))

For the persons assigned to the organizations listed in Regulatory Guidance C.8.a, the emergency plan must describe the following:

- (1) means of notification;
- (2) validation of the notification;
- (3) time within which notifications should be completed; and
- (4) the primary and secondary notification methods.

c. Protective Measures<sup>5</sup> (10 CFR 50.160(b)(1)(iv)(B)(3))

The emergency plan should describe the nature of protective measures to be taken to protect the public, including the following:

- (1) preplanned protective measure strategies, to include consideration of evacuation time estimates;
- (2) organization responsible for notifying the public;
- (3) range of protective measures (e.g., evacuation and sheltering);

---

<sup>5</sup> The 2017 EPA PAG Manual contains planning guidance and PAGs for considering and implementing protective actions for the public.

- (4) use of relocation centers;
- (5) methods to sustain the protective measures and periodic bulletins of ongoing efforts; and
- (6) methods to initiate, expand, relax, suspend, or terminate the protective actions.

d. Evacuation Time Estimate Study (10 CFR 50.160(b)(1)(iv)(B)(4))

The emergency plan must include an evacuation time estimate for the plume exposure pathway EPZ. Reasonable adaptation of NRC-issued or -endorsed evacuation time estimate guidance (e.g., NUREG/CR-7002, Revision 1, "Criteria for Development of Evacuation Time Estimate Studies," issued February 2021 (Ref. <sup>22</sup>)), may be used.

e. Emergency Response Facilities (10 CFR 50.160(b)(1)(iv)(B)(5))

The emergency plan should describe the following:

- (1) the offsite facility, alternative facility, and backup facility, as applicable, from which the licensee coordinates offsite response; and
- (2) for one of the offsite facilities, the facility's media and press capabilities, including the methods for disseminating information.

f. Offsite Dose Projections (10 CFR 50.160(b)(1)(iv)(B)(6))

The emergency plan should describe the following:

- (1) the capabilities for making offsite dose projections; and
- (2) the means of communicating offsite dose projections to offsite coordinating agencies, to include the methods, processes, equipment, facilities, and personnel.

g. Dissemination of Public Information (10 CFR 50.160(b)(1)(iv)(B)(7))

The emergency plan should describe the following:

- (1) the capabilities by which information is provided to members of the public concerning emergency planning;
- (2) the public alert and notification system; and
- (3) any prompt actions that need to be taken by the public, to include the methods, processes, equipment, facilities, and personnel.

h. Reentry (10 CFR 50.160(b)(1)(iv)(B)(8))

The emergency plan should describe the following:

- (1) the process to establish reentry into the affected parts of the EPZ during and after termination of an emergency and transition to recovery; and

- (2) criteria and processes to authorize emergency dose for volunteers who have been briefed on the health effects of receiving emergency doses.

Capabilities should exist so that specific plans can be developed during an emergency to allow for timely reentry into the affected parts of the EPZ as conditions warrant.

i. Drills and Exercises (10 CFR 50.160(b)(1)(iv)(B)(9))

The emergency plan should do the following:

- (1) describe the drill and exercise program, with references to the process for testing and implementing major portions of the planning, preparations, capabilities, and coordination with offsite organizations to maintain the key skills of emergency responders;
- (2) list the major drills and their specific frequencies, as well as the organization and position with which the licensee coordinates response;
- (3) describe arrangements and contacts to facilitate joint planning by all responding organizations for specific drills; and
- (4) describe the drill and exercise critique program and process for the correction of identified weaknesses.

The applicant or licensee should ensure that offsite plans include the above capabilities in Section C.8. A crosswalk at the end of the emergency plan should reference the offsite plans that describe the capabilities. Table 2 provides a sample format for such a crosswalk.

**Table 2. Emergency Preparedness and Planning Crosswalk Requirements to Locations**

| <b>RULE (10 CFR 50.160)</b> | <b>EMERGENCY PLAN LOCATION</b> | <b>EMERGENCY PLAN IMPLEMENTING PROCEDURE OR FACILITY PROCESS PROCEDURE</b> | <b>LOCATION IN OFFSITE PLANS</b> |
|-----------------------------|--------------------------------|--|----------------------------------|
| 50.160(b)(1)(i)             |                                |  |                                  |
| 50.160(b)(1)(ii)(A)         |                                |  |                                  |
| 50.160(b)(1)(ii)(B)         |                                |  |                                  |
| 50.160(b)(1)(iii)           |                                |  |                                  |
| 50.160(b)(1)(iii)(A)        |                                |  |                                  |
| 50.160(b)(1)(iii)(B)        |                                |  |                                  |
| 50.160(b)(1)(iii)(C)        |                                |  |                                  |
| 50.160(b)(1)(iii)(D)        |                                |  |                                  |
| 50.160(b)(1)(iii)(E)        |                                |  |                                  |
| 50.160(b)(1)(iii)(F)(1)     |                                |  |                                  |
| 50.160(b)(1)(iii)(F)(2)     |                                |  |                                  |

| <b>RULE (10 CFR 50.160)</b> | <b>EMERGENCY PLAN LOCATION</b> | <b>EMERGENCY PLAN IMPLEMENTING PROCEDURE OR FACILITY PROCESS PROCEDURE</b> | <b>LOCATION IN OFFSITE PLANS</b> |
|-----------------------------|--------------------------------|--|----------------------------------|
| 50.160(b)(1)(iii)(F)(3)     |                                |  |                                  |
| 50.160(b)(1)(iii)(F)(4)     |                                |  |                                  |
| 50.160(b)(1)(iii)(G)        |                                |  |                                  |
| 50.160(b)(1)(iii)(H)        |                                |  |                                  |
| 50.160(b)(1)(iv)(A)(1)      |                                |  |                                  |
| 50.160(b)(1)(iv)(A)(2)      |                                |  |                                  |
| 50.160(b)(1)(iv)(A)(3)      |                                |  |                                  |
| 50.160(b)(1)(iv)(A)(4)      |                                |  |                                  |
| 50.160(b)(1)(iv)(A)(5)      |                                |  |                                  |
| 50.160(b)(1)(iv)(A)(6)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(1)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(2)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(3)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(4)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(5)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(6)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(7)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(8)      |                                |  |                                  |
| 50.160(b)(1)(iv)(B)(9)      |                                |  |                                  |
| 50.160(b)(2)                |                                |  |                                  |
| 50.160(b)(3)                |                                |  |                                  |
| 50.160(b)(4)                |                                |  |                                  |

**Hazard Analysis of Contiguous or Nearby Facilities**

- The emergency plan should describe the results of a hazard analysis of any contiguous or nearby facility in which a credible hazard has been identified that would adversely impact the implementation of the emergency plans. The emergency plan should describe planning activities or emergency response functions that will address any credible hazard that would adversely impact the implementation of emergency plans. The analysis should do the following:

- a. identify and characterize the site-specific hazards posed by multimodular and nuclear units and contiguous or nearby facilities that could complicate the SMR, non-LWR, or NPUF's emergency response (e.g., nature of the challenge in terms of timing, severity, and persistence);
- b. evaluate the impacts of the identified hazards (e.g., realistic response timeline, functional threats caused by the hazard, strategies needed to address the hazard); and
- c. describe the planning activities or emergency response functions that will mitigate the impacts of the identified hazards (see Regulatory Guidance C.6.c.(3)(c)).

## **D. IMPLEMENTATION**

The NRC staff may use this regulatory guide as a reference in its regulatory processes, such as licensing, inspection, or enforcement. However, the NRC staff does not intend to use the guidance in this regulatory guide to support NRC staff actions in a manner that would constitute backfitting as that term is defined in 10 CFR 50.109, "Backfitting," and as described in NRC Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests," (Ref. <sup>23</sup>), nor does the NRC staff intend to use the guidance to affect the issue finality of an approval issued under 10 CFR Part 52. The staff also does not intend to use the guidance to support NRC staff actions in a manner that constitutes forward fitting as that term is defined and described in Management Directive 8.4. If a licensee believes that the NRC is using this regulatory guide in a manner inconsistent with the discussion in this implementation section, then the licensee may file a backfitting or forward fitting appeal with the NRC in accordance with the process in Management Directive 8.4.



## GLOSSARY

|   |  |
|---|--|
| <b>consequence oriented</b>                         | The principal rationale used to scope the planning efforts, which is understood in terms of the areas or distances, time frames, and radiological characteristics that correspond to a range of potential consequences from a spectrum of accidents, including those that could result in an offsite radiological release.   |
| <b>hostile action</b>                               | As defined in Section IV.A.7 of Appendix E to 10 CFR Part 50, an act directed toward a nuclear power plant or its personnel that includes the use of violent force to destroy equipment, take hostages, or otherwise intimidate the licensee to achieve an end. This includes attack by air, land, or water using guns, explosives, projectiles, vehicles, or other devices used to deliver destructive force. |
| <b>non-light-water reactor</b>                      | As defined in 10 CFR 50.2, a nuclear power reactor using a coolant other than light water.   |
| <b>non-power production or utilization facility</b> | As defined in 10 CFR 50.2, a production or utilization facility, licensed under 10 CFR 50.21(a), 10 CFR 50.21(c), or 10 CFR 50.22, "Class 103 licenses; for commercial and industrial facilities," that is not a nuclear power reactor or production facility as defined under paragraphs (1) and (2) of the definition of "Production facility" in 10 CFR 50.2.   |
| <b>performance based</b>                            | A regulatory approach that focuses on desired, measurable outcomes rather than prescriptive processes, techniques, or procedures. For EP, the performance-based approach focuses on licensee demonstration of required emergency response functions.   |
| <b>safe conditions</b>                              | The point at which the facility has been restored to a radiologically safe and stable condition following an event.  |
| <b>small modular reactor</b>                        | As defined in 10 CFR 50.2, a power reactor, which may be of modular design as defined in 10 CFR 52.1, licensed under 10 CFR 50.21, "Class 104 licenses; for medical therapy and research and development facilities," or 10 CFR 50.22 to produce heat energy up to 1,000 megawatts-thermal per module.   |
| <b>site boundary</b>                                | As defined in 10 CFR 20.1003, "Definitions" (Ref. <sup>24</sup> ), that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.  |
| <b>technology inclusive</b>                         | The principle of establishing performance requirements developed using methods of evaluation that are flexible and practicable for application to a variety of power reactor and NPUF technologies.  |

## APPENDIX A

# GENERAL METHODOLOGY FOR ESTABLISHING PLUME EXPOSURE PATHWAY EMERGENCY PLANNING ZONE SIZE

### A-1. Introduction

This appendix describes an acceptable approach for determining a plume exposure pathway emergency planning zone (EPZ) size based on the area within which public dose, as defined in Title 10 of the *Code of Federal Regulations* (10 CFR) 20.1003, "Definitions," is projected to exceed 10 mSv (1 rem) total effective dose equivalent (TEDE) over 96 hours from the release of radioactive materials from the facility, considering accident likelihood and source term, timing of the accident sequence, and meteorology. In addition, the plume exposure pathway EPZ is the area in which predetermined, prompt protective measures are necessary. This approach has been generalized from the dose assessment methodologies that informed EPZ size determinations in 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," issued December 1978. For the plume exposure pathway EPZ determination, the applicant and licensee should demonstrate the following in the technical analysis:

- a. The size of the EPZ should encompass an area where it may be expected that predetermined, prompt protective measures, such as evacuation and sheltering, may be needed to minimize the exposure to individuals.
- b. If predetermined, prompt protective measures are not required because sufficient time is available after the accident occurs but before the release is expected to occur, or after the release is expected to occur but before protective measures are necessary, for Offsite Response Organizations (OROs) to initiate appropriate response actions to adequately protect public health and safety, then such accidents may be excluded from consideration in determining the size of the plume exposure pathway EPZ based on the dose criterion.
- c. If the proposed plume exposure pathway EPZ extends beyond the site boundary and if the application is for an operating license, a combined license, an early site permit that contains plans for coping with emergencies under 10 CFR 52.17(b)(2)(ii), or an early site permit that proposes major features of the emergency plans and describes the EPZ, then 10 CFR 50.33(g)(2) requires the exact shape of the plume exposure pathway EPZ must be determined in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries.
- d. If no plume exposure pathway EPZ is defined, then that position must be supported by an analysis that shows that one or both of the criteria in 10 CFR 50.33(g)(2)(i) are not met.

### A-2. Methodology Basis/Assumptions

The staff has developed the following generalized methodology to be consistent with the approaches used in the NUREG-0396 quantitative analyses, to the extent that the details of those analyses could be discerned. The following key assumptions informed development of the generalized methodology:

- a. Adequate information on licensing basis events,<sup>0</sup> radiological source terms, and, as appropriate, probabilistic risk assessment (PRA) is assumed to be available. Appendix B to this regulatory guide contains more information on the development of radiological source terms and the use of PRA.
- b. The atmospheric release pathway is assumed to be the risk-dominant contributor to offsite doses (i.e., no consideration of direct exposures or releases to liquid pathways).
- c. The U.S. Nuclear Regulatory Commission developed the guidance in this methodology under the assumption that the atmospheric release may be modeled as a neutral density plume that does not undergo chemical or physical transformations after release to the atmosphere, with corrections for radioactive decay and ingrowth, wet or dry deposition (or both), and plume rise due to buoyancy or momentum (or both), as appropriate. If the chemical or physical form of the atmospheric release requires more complex atmospheric transport modeling, then additional analyses may be needed.
- d. Use of a straight-line Gaussian plume segment-type atmospheric dispersion model (with modifications as needed to account for near-field dispersion phenomena) to estimate atmospheric concentrations is assumed to be appropriate. If a more advanced method for dispersion modeling is used, then the details of the methodology described in this document may need to be adapted to account for the use of such models.
- e. An exposure duration of 96 hours from the onset of a release is assumed, and no credit for protective actions such as evacuation, relocation, or sheltering in place should be assumed over this 96-hour period.

### **A-3. Generalized Methodology**

The following guidance describes a generalized methodology for the analyses that provide a technical basis for a plume exposure pathway EPZ. Figure A-1 is a visual representation of the steps in the generalized methodology.

#### **A-3.1 Event Selection**

The applicant should determine the radiological releases from the facility that are evaluated in the radiological dose assessment to aid in the determination of the plume exposure pathway EPZ. In its safety analysis report, the applicant describes the licensing basis events relevant to the facility. The applicant should consider these licensing basis events as candidates for the development of the radiological releases. These licensing basis events may include both design-basis accidents and beyond-design basis events. Event likelihood may be used to determine whether the accident should be included in the range of accidents used in this analysis. For light-water reactor (LWR) power reactors, the licensing basis events should include the design-basis events, design-basis accidents, and beyond-design-basis events evaluated in Chapter 15, “Transient and Accident Analysis,” and Chapter 19, “Severe Accidents,” of NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition.” For non-LWRs, the applicant may opt to use the technology-inclusive, risk-informed, and performance-based methodology endorsed by Regulatory Guide 1.233, “Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors,” to determine their licensing basis events. Facilities that use a

<sup>0</sup> 1 For the purposes of this discussion, licensing basis events are the entire collection of event sequences considered in the design and licensing basis of the facility.

maximum hypothetical accident should ensure that the estimated release is bounding for any event at the facility (see, for example, Chapter 13, “Accident Analyses,” of NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors,” issued February 1996).

To ensure that radiological releases with large potential consequences that may affect the size of the EPZ are not inappropriately scoped out of the consequence assessment based on low likelihood, the applicant should consider the uncertainty of the accident likelihood. In other words, if the mean frequency of a scenario is below a screening threshold, but the upper end of the frequency uncertainty range lies above that threshold, then the scenario should be considered for inclusion in the analysis. If accident or release frequency values from a PRA are used to determine whether to exclude the accident from the EPZ size determination analysis, then the applicant should ensure that the PRA is acceptable for this use in a risk-informed application and the uncertainty of the frequency estimate should be quantified.

The applicant should consider internal and external initiating events, multi-module and multiunit accidents and interactions, and all sources of radioactive material whose release may result in the need to take prompt protective actions.

Timing of the radiological release to the environment, as justified, may be used to determine whether an accident scenario should be included in the consequence assessment to determine the size of the plume exposure pathway EPZ. As an example of an analysis of timing considerations, the Low-Power Rule (“Emergency Planning and Preparedness Requirements for Nuclear Power Plant Fuel Loading and Low-Power Testing – Final Rule,” 53 FR 36955; September 23, 1988) included an analysis on the need for predetermined, prompt protective measures. Due to the substantial reduction in the likelihood of an accident and potential accident consequences for low power testing as compared to continuous full power operation, the analysis for this example identified a time period of 10 hours (from the start time of the initiating event to the start time of a potential major release) as a reasonable amount of time for OROs to take appropriate response actions that provide for public health and safety without the need for predetermined, prompt protective measures.

### **A-3.2 Source Terms**

For each release scenario for which doses are assessed, a quantitative radiological source term would be developed by specifying atmospheric release characteristics such as the time-dependent isotopic release rates to the atmosphere, release durations, release locations, physical/chemical form, and plume buoyancy. The accident radiological source terms can be referenced from the safety analysis for the facility.

### **A-3.3 Meteorological Input**

An analysis to develop meteorological data may be needed to evaluate a range of meteorological conditions in a probabilistic fashion. Alternately, conservative transport and dispersion conditions may be assumed, although the conservatism of the selected conditions should be evaluated to ensure that the combination of parameters selected for transport and dispersion modeling was in fact conservative. The selection of meteorological data should consider the data needs of the selected atmospheric transport model (see Section A-3.4). The selection of a source of meteorological data would include evaluation of data on parameters such as wind speeds, wind directions, atmospheric stability, precipitation, and mixing height for temporal and geographical representativeness. The quality and completeness of the meteorological data should be assessed. It should be noted that meteorological data are site specific. However, some applications could involve assessments that are not site specific. An explanation of the appropriateness of the meteorological data used for such assessments would be needed to evaluate the analysis.

#### **A-3.4 Atmospheric Transport Modeling**

An atmospheric transport model appropriate for the range of distances under consideration should be identified. NUREG-0396 used Gaussian-type models for atmospheric transport. For these types of models, dispersion parameters appropriate to the characteristics of the area and distance ranges under consideration should be identified, and conceptual approaches for the treatment of wind shifts during the release and near-field effects such as elevated releases, building wake effects, plume meander, and plume rise should also be identified. The selection of an atmospheric transport model should also involve selection of a conceptual approach for the treatment of wet and dry deposition. Any assumptions made in the atmospheric transport model should be identified so that the analyst can evaluate the suitability of the model for their particular application.

#### **A-3.5 Exposure Parameters**

The relevant exposure pathways should be identified. For example, exposure to both airborne and deposited radioactivity from atmospheric releases would involve both external (groundshine and cloudshine) and internal (inhalation of airborne material during cloud passage or as a result of resuspension) exposure.

Assumptions about the geographic distribution of the receptor population, if any, should be identified. The estimation of peak centerline doses as a function of distance only implicitly assumes that no credit is being taken for the distribution of population around the site.

In order to assess the dose, the exposure parameters (e.g., shielding factors, breathing rates, exposure durations) would need to be characterized. The development of factors such as the exposure durations and shielding factors should not assume any credit for preplanned protective actions such as evacuation or sheltering.

#### **A-3.6 Dose Estimation for Pathway Contributors**

The dose estimation is carried out by combining the results of the release, transport, and exposure assessment with a recognized source of dose conversion factors to estimate dose-distance curves for comparison to the 10 mSv (1 rem) TEDE criterion. The distance at which the doses are evaluated should be identified and explained. For example, the dose may simply be estimated at the site boundary to demonstrate that it is sufficiently low, or it may be evaluated over a range of distances from the site boundary.

#### **A-3.7 Probabilistic Dose Aggregation**

The method for aggregating doses from different source terms, given consideration of their frequencies, should be identified. For example, analyses with design-basis accident source terms may simply present dose-distance curves conditional upon the occurrence of the source term without consideration of frequency. For beyond-design-basis events, dose-distance results may be aggregated using frequency information developed as described in Appendix B to evaluate the likelihood of exceeding a TEDE of 10 mSv (1 rem) as a function of distance.

The likelihood of exceeding a TEDE of 10 mSv (1 rem) due to the combined effect of accident frequency and variability in meteorological conditions should be discussed. For this purpose, dose assessment results are to be characterized by a distribution of exceedance distances reflecting the combined effect of accident frequency and variability in meteorological conditions. Methods used to

compare the dose assessment results to the dosimetric criteria (which is a single dose value per comparison) should be identified.

The likelihood of exceeding a TEDE of 10 mSv (1 rem) at the proposed EPZ boundary should be consistent with the evaluation in Appendix I to NUREG-0396, which provides relative probabilities of exceeding certain critical doses as a function of distance from the facility for a spectrum of severe accidents. For example, NUREG-0396 examined the conditional probability of exceeding a variety of dose levels of interest, given a core melt accident with a stated frequency of  $5 \times 10^{-5}$  per reactor year. The conditional probability was examined down to a level of 0.1 percent ( $1 \times 10^{-3}$ ) to identify the distance at which the likelihood of exceeding the dose level of interest dropped substantially.

The probabilistic dose aggregation in NUREG-0396 demonstrated that the plume exposure pathway EPZ was of sufficient size such that all of the following conditions were met:

- a. Projected doses from the traditional design-basis accidents would not exceed Protective Action Guide levels outside the EPZ.
- b. Projected doses from most core melt sequences would not exceed Protective Action Guide levels outside the EPZ.
- c. For the worst core melt sequences, immediate life-threatening doses would generally not occur outside the EPZ.

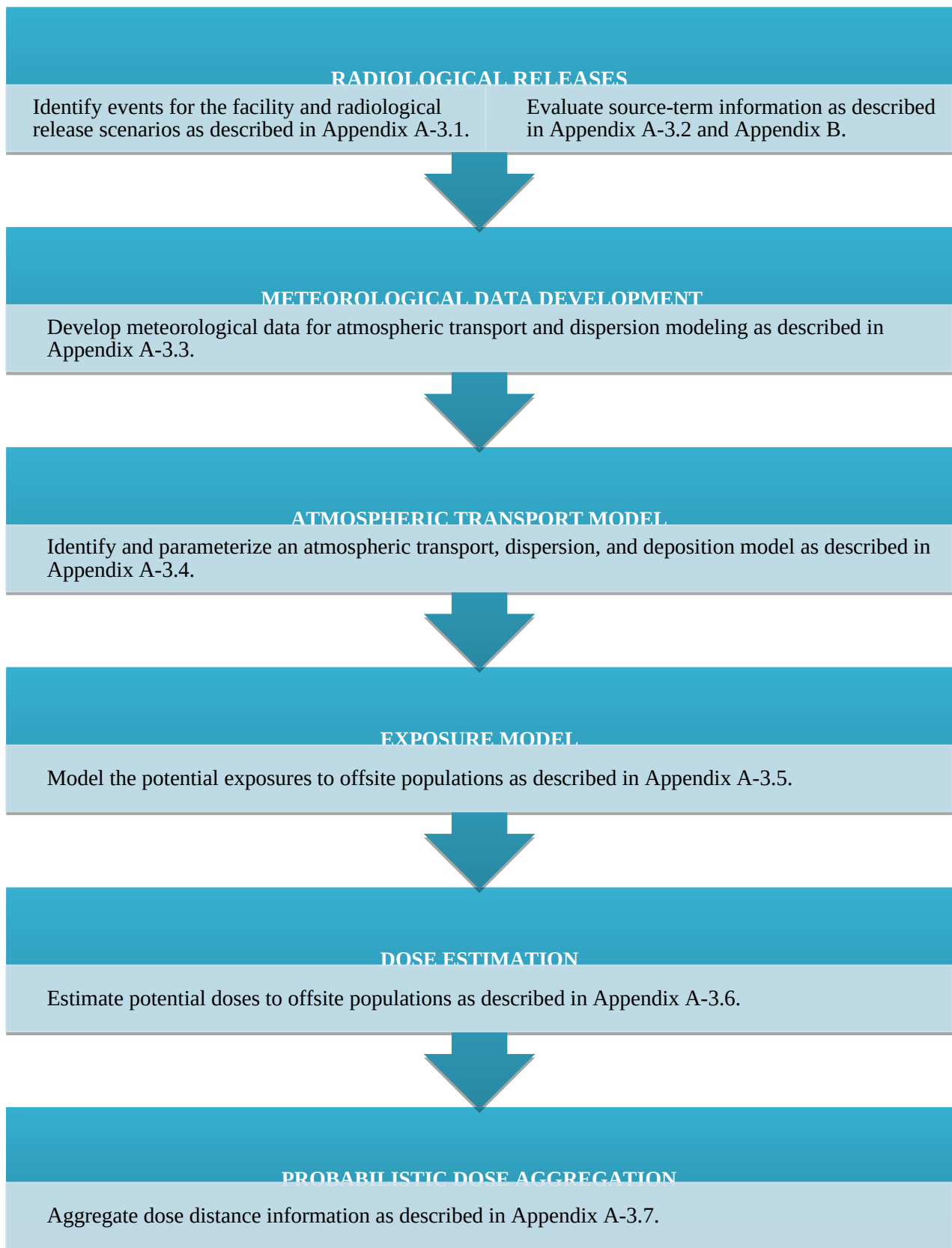
The methodologies used for event selection, identification of source terms, modeling of releases, and aggregation of potential offsite doses should provide similar confidence that appropriate offsite planning will be identified for small modular reactors, non-light-water reactors, and non-power production or utilization facilities.

Because each of the analyses supporting the evaluation can contain uncertainties, any significant uncertainties that could affect this comparison should be identified and characterized.

### **A-3.8 Considerations on Whether Predetermined Prompt Protective Measures are Necessary**

In addition to the consequence analysis to determine EPZ size, the analysis should consider whether predetermined prompt protective measures are necessary. Considerations include timing from the initiation of the event to the start of radiological release to the environment for all accident scenarios evaluated in the radiological dose assessment to aid in the determination of the plume exposure pathway EPZ and the capability to protect the public without needing to develop predetermined prompt protective measures.

There may be a case where an application does not define a plume exposure pathway EPZ based on not meeting the criterion in 10 CFR 50.33(g)(2)(i) that the plume exposure pathway EPZ is the area where predetermined, prompt protective measures are necessary. In such a case, the application should include an analysis with a discussion and justification for the determination that there is no area where predetermined prompt protective measures are necessary.



**Figure A-1. Analyses to Support Radiological Dose Assessment for EPZ Size Evaluation**

## APPENDIX B

### DEVELOPMENT OF INFORMATION ON SOURCE TERMS

This appendix provides guidance for establishing source terms that are acceptable to the staff and associated with a technology-inclusive, risk-informed approach to support radiological dose assessment. Such source terms may be used in the radiological assessment supporting the determination of the size of the plume exposure pathway emergency planning zone (EPZ).

- B-1.** Each applicant should develop potential source terms from licensing basis events for its facility. For the source-term evaluation, the applicant should identify in the analysis the release scenarios for which doses would be assessed for the purposes of the analysis (e.g., plume exposure pathway EPZ size determination). For beyond-design-basis-event scenarios, the applicant should evaluate the frequencies to allow quantitative consideration of the relative likelihood of a range of accidents. In developing information on release scenarios and their frequencies, the applicant should consider information developed in the safety analysis report, as well as information in the environmental report on the consequences of severe accidents, as applicable.
- B-2.** If the applicant intends to use a probabilistic risk assessment (PRA) to define the accidents used in the radiological dose assessment, the applicant should apply a risk-informed integrated decisionmaking process.<sup>0</sup> The integrated decisionmaking process should consider the defense-in-depth philosophy, maintain sufficient safety margins, and include treatment of uncertainties. In addition, the applicant should justify that the PRA is acceptable for this use, and that it considers internal and external hazards, all modes of operation, and all significant radionuclide sources. The PRA should also include event sequences involving single or multiple modules/units, if applicable, to provide useful risk insights into the source-term selection process. The treatment of uncertainties in the PRA should quantify the impacts of uncertainties using quantitative uncertainty analyses supported by sensitivity analyses.<sup>0</sup>
- B-3.** A technical basis for the screening of any identified release scenarios from quantitative consideration (for example, on the basis of low likelihood or very long accident progression times) would need to be provided. The categorization of accidents, including any category bounds based on frequency (including consideration of uncertainty), should be explained. If based on PRA, the use of a low-frequency “cutoff” should consider uncertainty. The PRA results should retain event sequences with frequencies below the “cutoff,” and analysts should use them to confirm that there are no cliff edge effects and that there is adequate defense in depth.
- B-4.** The accident radiological source terms should be estimated for the specific facility using accepted analysis methods and codes, such as the MELCOR or MAAP codes. The source-term calculations should reflect the performance of the facility under normal and off-normal conditions, include sufficient data on facility performance, and model the transport of fission products<sup>0</sup> across all barriers and pathways to the environs. Evaluations of design-basis accidents

---

<sup>0</sup> Regulatory Guide 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” describes an integrated decisionmaking approach that the U.S. Nuclear Regulatory Commission has found acceptable.

<sup>0</sup>

2 NUREG-1855, Revision 1, “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decisionmaking,” issued March 2017, provides further guidance on addressing uncertainties.

<sup>0</sup> The term “transport of fission products” refers to the physical movement of radionuclides through the facility and across fission product retention barriers, including radionuclide retention and holdup by engineered features, as well as natural processes of radionuclide depletion. Radionuclide depletion processes may include, but are not limited to,



should assume only safety-related structures, systems, and components are available to mitigate the accident. The operation of structures, systems, and components according to their capability under the plant conditions for the event may be modeled in the evaluation of beyond-design-basis events. Applicants that use a bounding source term from a maximum hypothetical accident may reference the description in the safety analysis report as an alternative to detailed calculation of radiological source terms.

- B-5.** The PRA and source-term models should be as realistic as possible so that the values and limitations of any mechanism or barrier are not obscure.

---

gravitational settling, diffusiophoresis, thermophoresis, spray depletion, and chemical reactions, as justified for the facility. Retention or holdup in natural features (e.g., soil) may be considered on a case-by-case basis as justified.

## REFERENCES <sup>0</sup>

---

<sup>0</sup> Publicly available NRC published documents are available electronically through the NRC Library on the NRC's public Web site at <http://www.nrc.gov/reading-rm/doc-collections/> and through the NRC's Agencywide Documents Access and Management System (ADAMS) at <http://www.nrc.gov/reading-rm/adams.html>. The documents can also be viewed online or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD. For problems with ADAMS, contact the PDR staff at 301-415-4737 or (800) 397-4209; fax (301) 415-3548; or e-mail [pdr.resource@nrc.gov](mailto:pdr.resource@nrc.gov).

Copies of EPA documents may be obtained from the EPA's Web site <https://www.epa.gov>; this document is also available directly at [https://www.epa.gov/sites/production/files/2017-01/documents/epa\\_pag\\_manual\\_final\\_revisions\\_01-11-2017\\_cover\\_disclaimer\\_8.pdf](https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf).

Copies of International Atomic Energy Agency (IAEA) documents may be obtained through their Web site: [WWW.IAEA.Org/](http://WWW.IAEA.Org/) or by writing the International Atomic Energy Agency, P.O. Box 100 Wagramer Strasse 5, A-1400 Vienna, Austria.

1 *U.S. Code of Federal Regulations (CFR), “Domestic Licensing of Production and Utilization Facilities,” Part 50, Chapter I, Title 10, “Energy.”*

2 CFR, “Licenses, Certifications, and Approvals for Nuclear Power Plants,” Part 52, Chapter I, Title 10, “Energy.”

3 U.S. Nuclear Regulatory Commission (NRC), Regulatory Guide (RG) 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” Washington, DC.

4 NRC, RG. 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors,” Washington, DC.

5 NRC, RG 1.200, “Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities,” Washington, DC.

6 NRC, RG 1.206, “Applications for Nuclear Power Plants,” Washington, DC.

7 NRC, RG 1.219, “Guidance on Making Changes to Emergency Plans for Nuclear Power Reactors,” Washington, DC.

8 NRC, RG 1.233, “Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors,” Washington, DC.

9 NRC, RG 2.6, “Emergency Planning for Research and Test Reactors and Other Non-Power Production and Utilization Facilities,” Washington, DC.

10 NRC and U.S. Environmental Protection Agency (EPA) Task Force on Emergency Planning, 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,” Washington, DC, December 1978.

11 NRC and Federal Emergency Management Agency (FEMA), NUREG-0654/FEMA-REP-1, Revision 1, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,” Washington, DC, November 1980.

12 NRC and FEMA, NUREG-0654/FEMA-REP-1, Revision 2, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,” Washington, DC, December 2019.

13 NRC, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 13.3, “Emergency Planning,” Washington, DC.

14 NRC, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition, Chapter 15, “Transient and Accident Analysis,” Washington, DC.

15 NRC, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Chapter 19, “Severe Accidents,” Washington, DC.

16 NRC, NUREG-1855, Revision 1, “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decisionmaking,” Washington, DC, March 2017.

17 FEMA, “Nuclear/Radiological Incident Annex,” National Response Framework Final, Washington, DC, October 2016.

18 EPA, EPA-400/R-17/001, “PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents,” Washington, DC, January 2017.

19 NRC, “Nuclear Regulatory Commission International Policy Statement,” Federal Register, Vol. 79, No. 132, July 10, 2014, pp. 39415-39418.

- <sup>20</sup> NRC, Management Directive (MD) 6.6, “Regulatory Guides,” Washington, DC.
- <sup>21</sup> International Atomic Energy Agency (IAEA), General Safety Requirements Part 7, “Preparedness and Response for a Nuclear or Radiological Emergency,” IAEA Safety Standards, Vienna, Austria, 2015,
- <sup>22</sup> NRC, NUREG/CR-7002, Revision 1, “Criteria for Development of Evacuation Time Estimate Studies,” Washington, DC, February 2021.
- <sup>23</sup> NRC, MD 8.4, “Management Backfitting, Forward Fitting, Issue Finality, and Information Requests,” Washington, DC.
- <sup>24</sup> CFR, “Standards for Protection Against Radiation,” Part 20, Chapter I, Title 10, “Energy.”