

## **Environmental and NUREG-0800 Standard Review Plan**

### **Chapter 19 Analyses**

#### **Purpose and Regulatory Requirements**

##### *Safety Review*

In a new nuclear power reactor design certification (DC) application, the applicant provides an evaluation of potential design improvements to show compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) 52.47(a)(8), which refers to the Three Mile Island (TMI)-related requirements in 10 CFR 50.34(f) with exceptions. The applicant performs a cost-benefit analysis of potential design improvements based on the probabilistic risk assessment (PRA) of the facility and considers severe accident consequences, including estimates of the economic consequences of offsite property damage. As required by 10 CFR 52.47(a)(23), a light-water reactor DC application must include a description and analysis of design features for prevention and mitigation of severe accidents. Furthermore, 10 CFR 52.47(a)(27) requires that the DC application include a description of the design-specific PRA and its results.

Similarly, a combined license (COL) application must include a description of the plant-specific PRA and its results, in accordance with 10 CFR 52.79(a)(46); a light-water reactor design-related severe accident features analysis, in accordance with 10 CFR 52.79(a)(38); and an evaluation of potential design improvements, in accordance with 10 CFR 52.79(a)(17). The COL application that refers to the standard DC must use the PRA information for the DC, updated to account for site-specific design information and any design changes or departures.

##### *Environmental Review*

The National Environmental Policy Act of 1969, as amended (NEPA), requires that a Federal agency complete an assessment of the impact to the environment resulting from any major Federal action which significantly affects the quality of the human environment. In this case, the Federal agency is the U.S. Nuclear Regulatory Commission (NRC), and the pertinent Federal actions are issuances of permits, certifications, or licenses, or changes thereof. The NRC's NEPA implementing regulations are contained in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." The provisions of 10 CFR 51.20(b) requires the NRC staff to issue an environmental impact statement (EIS) for the following actions:

- issuance of a limited work authorization or construction permit for a nuclear power reactor, testing facility, or fuel reprocessing plant under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," or an early site permit (ESP) under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants"
- issuance or renewal of a full-power or design capacity operating license for a nuclear power reactor, testing facility, or fuel reprocessing plant under 10 CFR Part 50 or a COL under 10 CFR Part 52 (renewal requirements fall under 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants")
- issuance of permit to construct or a design capacity license to operate an isotopic enrichment plant under 10 CFR Part 50

- conversion of a provisional operating license to a full-term or design capacity license for a nuclear power reactor, testing facility, or fuel reprocessing plant under 10 CFR Part 50, if a final EIS covering full-term or design capacity operation was not previously prepared
- issuance of a license to possess and use special nuclear material for processing and fuel fabrication, scrap recovery, or conversion of uranium hexafluoride under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material"
- issuance of a license to possess and use source material for uranium milling or production of uranium hexafluoride under 10 CFR Part 40, "Domestic Licensing of Source Material"
- issuance of a license for an independent spent fuel storage installation at a site not occupied by a nuclear power reactor or for a monitored retrievable storage installation under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste"
- issuance of a license for a uranium enrichment facility
- issuance of renewal of a license authorizing receipt and disposal of radioactive waste under 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste"
- issuance of a license amendment under 10 CFR Part 61 authorizing closure of land disposal facility, transfer, or termination of the license
- issuance of a construction authorization and license under 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," or 10 CFR Part 63, "Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada"
- any other action which the Commission determines is a major Commission action significantly affecting the quality of the human environment

In addition, 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," also requires applicants for the above actions to submit an environmental report with pertinent information to support the NRC staff's development of its EIS for the major Federal action. The review of environmental impacts of postulated accidents involving radioactive material and related to the nuclear power plant is based on the relevant requirements of the following:

- 10 CFR 51.45, "Environmental Report," with respect to the requirement to address alternatives to the proposed action
- 10 CFR 51.50(b), with respect to applications for ESPs
- 10 CFR 51.50(c), with respect to applications for COLs

- 10 CFR 51.53(c)(3)(ii)(L) with respect to license renewals

Issuance of a certification for a standard design does not require an EIS, but instead receives an environmental assessment, in accordance with 10 CFR 51.21, “Criteria for and Identification of Licensing and Regulatory Actions Requiring Environmental Assessments.”

### **Historical Perspective**

Prior to the time of the Three Mile Island accident, the Commission had relied on the draft accident classification scale, set forth in a December 1, 1971 proposed rulemaking, to determine that severe accidents were essentially remote and speculative (36 FR 22848, 22851).<sup>1</sup> In 1980, the Commission issued a policy statement on the consideration of severe accidents in EISs for new reactor applications submitted after July 1, 1980 (volume 45, page 40101, of the *Federal Register* (45 FR 40101) dated June 13, 1980). This policy statement states that it is “the intent of the Commission that the staff take steps to identify additional cases that might warrant early consideration of either additional features or other actions which could prevent or mitigate the consequences of severe accidents.” These features became known as severe accident mitigation alternatives (SAMAs), which include severe accident mitigation design alternatives (SAMDAs) (particularly important for DC), as well as changes in operating procedures and training. In 1985, the Commission issued in the *Federal Register* a notice titled, “Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants” (50 FR 32138; August 8, 1985), concluding “that existing plants pose no undue risk to public health and safety and that there was no present basis for immediate action on generic rulemaking or other regulatory changes for those plants because of severe accident risk.” This policy statement also called for each licensee to perform an analysis to discover instances of particular vulnerability to core melt or poor containment performance given a core melt accident. The NRC believed that this policy statement was a sufficient basis for not requiring SAMDAs to be considered at the operating license review stage for previously constructed plants. However, a 1989 court decision ruled that such a policy statement was not sufficient under NEPA to preclude consideration of SAMDAs and that such a consideration is required for plant operation (*Limerick Ecology Action v. NRC*, 869 F.2d 719 (3<sup>rd</sup> Cir. 1989)). This is known as the “Limerick decision.”<sup>2</sup>

For new nuclear power reactor licensing, SECY-90-016, “Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements,” dated January 12, 1990, and SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs,” dated April 2, 1993, which the Commission approved in related staff requirements memoranda (SRMs) dated June 26, 1990, and July 21, 1993, respectively, laid out expectations for evolutionary and advanced light-water reactor design with respect to severe accident prevention and mitigation capabilities.

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<sup>1</sup> Although never published as a final rule, the agency relied on the proposed rule containing the accident classification scale to address severe accidents under NEPA, and appellate courts have upheld this practice. *Limerick Ecology Action v. NRC*, 869 F.2d 719, 725-26 (3d Cir. 1989) (citing *Carolina Environmental Study Group v. United States*, 510 F.2d 796, 798-800 (D.C. Cir. 1975)).

<sup>2</sup> This paragraph quotes extensively from NUREG-1437, “Generic Environmental Impact Statement for License Renewal of Nuclear Plants,” issued in 1996 (referred to as the GEIS).

For materials, waste, and fuel cycle facility licensing, there are no comparable analyses for treating accidents and offsite consequences. NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," which provides general procedures for the environmental review of licensing actions regulated by NMSS and FSME, contains no guidance that specifically addresses the impact of accidents and offsite consequences.

## **Process**

Severe nuclear accidents are those in which substantial damage is done to the reactor core whether or not there are serious offsite consequences (50 FR 32138). Severe accidents are expected to involve multiple failures of equipment or function. Therefore, the likelihood of occurrence is much lower for severe accidents than for design-basis accidents, but the consequences of such accidents may be higher. The environmental consequences of severe accidents are estimated using acceptable methodology (PRA analysis and NRC regulatory techniques). The MELCOR Accident Consequence Code System, Version 2, (MACCS2) software package is used to estimate the consequences of severe accidents for NEPA reviews. The risks for specific accident types are defined as the product of the probability of that type of accident occurring multiplied by the estimated consequences for that type of accident.

Consideration of the environmental impacts of operating a nuclear power plant in the EIS includes an evaluation of the environmental risk (or probability weighted consequences) of accidents involving radioactive material. The scope of the NRC staff's evaluation of the environmental risks of accidents includes severe accident consequence analysis, which includes health impacts from radiological dose and the socioeconomic impacts, including offsite property damage. As discussed above, there are two principal actions for which the environmental risks of accidents from nuclear power plants are evaluated—license renewal for operational reactors and new reactor applications (e.g., DCs, COLs, and ESPs under 10 CFR Part 52 or construction permits and operating licenses under 10 CFR Part 50).

The NRC staff's evaluation of severe accidents for new reactor licensing is coordinated between the safety review of the PRA and severe accident evaluation and the development of the EIS section concerning the postulated accidents presented in the applicant's environmental report. Chapter 19.0 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Plants: LWR Edition," provides guidance for the PRA and severe accident review. Sections 7.2 and 7.3 of the latest revision of NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan (with Supplement 1 for Operating Reactor License Renewal), provides guidance on severe accident consequence assessment and SAMAs. Regulatory Guide (RG) 4.2, "Preparation of Environmental Reports for Nuclear Power Stations," gives guidance to applicants on preparing their environmental report.

The NRC considers the evaluation of SAMAs/SAMDAs in the environmental review of applications for construction permits or operating licenses under 10 CFR Part 50, and of DC, ESP, or COL applications under 10 CFR Part 52. For license renewals, 10 CFR 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs or SAMDAs for the

applicant's plant in an EIS or related supplement or in an environmental assessment.<sup>3</sup> The purpose of a SAMA/SAMDA is to ensure that plant design changes with the potential for improving severe accident performance (i.e., reducing the risk, or probability-weighted consequences) are identified and evaluated. These reactor licensing actions include offsite property damage as an averted cost component of the SAMDA/SAMA evaluation. While new reactor ESPs consider severe accident consequences, thus disclosing offsite property damage impacts as necessitated by NEPA, SAMDAs/SAMAs are not addressed under ESPs; thus, the expected subsequent COL application should include a complete averted offsite property damage cost assessment.

Section 7.2, "Severe Accidents," of NUREG-1555 instructs that environmental reviewers should evaluate the environmental impacts of severe accidents using an accepted methodology. Section 7.3, "Severe Accident Mitigation Alternatives," of the Environmental Standard Review Plan instructs that environmental reviewers should evaluate the applicant's SAMA analysis in the environmental report to identify cases that might warrant either additional features or other actions that would prevent or mitigate the consequences of severe accidents. The NRC staff and industry uses the NRC-sponsored MACCS2 code package<sup>4</sup> as the accepted methodology to estimate the radiological and economic consequences of the airborne releases from severe accidents.

Under the SRP Chapter 19.0 safety review, there are two aspects of the NRC staff's review. The first aspect is the use of the PRA and severe accident evaluation to identify and assess preventive and mitigative features, including consideration of operator actions, such that the plant's operation will reflect a reduction in risk compared to existing operating plants. The second aspect is the use and application of the PRA results and insights to support other programs. The NRC staff reviews the applicant's description and analysis of the design features to prevent and mitigate severe accidents, in accordance with the requirements in 10 CFR 52.47(a)(23) or 10 CFR 52.79(a)(38), for a DC or a COL application, respectively. This review specifically addresses the issues identified in SECY-90-016 and SECY-93-087, and their related SRMs, for severe accident prevention (e.g., anticipated transients without scram, midloop operation, station blackout, fire protection, and intersystem loss-of-coolant accident) and mitigation (e.g., hydrogen generation and control, core debris coolability, high-pressure core melt ejection, containment performance, dedicated containment vent penetration, equipment survivability). In addition, the SRP Chapter 19.0 safety review addresses the information provided by the applicant to satisfy the technically relevant TMI-related requirements. In particular, the invoked requirement in 10 CFR 50.34(f)(1)(i) to specify that a design-specific or plant-specific PRA should be performed to seek improvements in core heat removal system reliability and containment heat removal system reliability that are significant and practical and do not excessively impact the plant.

Excluding ESPs, which are not required to include the SAMDA/SAMA evaluation, the applicant's analysis should identify potential SAMDAs/SAMAs and provide an estimate of the cost of implementing them. This requires that the potential benefits (monetized) of the SAMDA/SAMA are estimated. Potential benefits of a SAMDA/SAMA include averted public exposure; averted

<sup>3</sup> Table B-1 of Appendix B, Subpart A, 10 CFR Part 51, provides a generic finding that the probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants.

<sup>4</sup> The NRC staff uses a version of MACCS2 known as WinMACCS, which has a graphical user interface for input deck development, running the code, and output reviews for PC-based computers.

offsite property damage; averted onsite occupational exposure; and averted onsite costs, such as decontamination and replacement power. Finally, the costs and benefits of the SAMDA/SAMAs are compared to see whether any SAMDA/SAMA is cost beneficial. The NRC staff evaluates the applicant's benefit-cost comparison to determine whether it is consistent with the benefit-cost balance criteria and methodology given in NUREG/BR-0184 and NUREG/BR-0058. The staff further analyzes any SAMAs that are within a factor of 10 of the benefit-cost criteria given in NUREG/BR-0058 or NUREG/CR-6349, "Cost-Benefit Considerations in Regulatory Analysis," issued October 1995, to ensure that a sufficient margin is present to account for uncertainties in assumptions used to determine the cost and benefit estimates. For new reactor COL applications, the DC SAMDA evaluation for the reactor design being proposed by the application forms the basis for the site-specific SAMA included as part of the COL application's environmental report. Thus, the Office of New Reactor's environmental review staff confirms that the COL applicant reexamined the SAMDA analyses from the selected reactor DC and includes site-specific population, land use, and meteorology data in the severe accident consequence calculations performed using the MACCS2 computer code.

The process for the review of SAMAs as part of the NEPA review for license renewal is similar to that used in the new reactor licensing reviews. Section 5.4 of the GEIS provides background information on the genesis of the SAMA regulatory requirement. The severe accident review for license renewal uses guidance in NUREG-1555, Supplement 1, to prepare site-specific EIS supplements to the GEIS. RG 4.2, Supplement 1, gives guidance to applicants on preparing the environmental report for nuclear power plant operating license renewal. Additionally, the NRC staff has recommended that applicants for license renewal follow the guidance provided in the Nuclear Energy Institute's report, NEI-05-01, Revision A (NEI-05-01A), in the staff's license renewal interim staff guidance, LR-ISG-2006-03. NEI-05-01A provides a template for completing the SAMA analysis in support of license renewal. The method described relies upon NUREG/BR-0184 regulatory analysis techniques. As described above, NUREG/BR-0184 includes estimates of the economic consequences of offsite property damage. Relative to the evaluation of potential improvements for existing reactors in the United States, the NRC gained considerable experience during the 1980s and 1990s by means of (1) staff assessments of SAMDAs for the Limerick, Comanche Peak, and Watts Bar plants performed as a result of the aforementioned Limerick decision, (2) the containment performance improvement program, (3) the individual plant examination and individual plant examination of external events programs, and (4) the implementation of severe accident management programs at all nuclear power plants as part of an industry initiative. These regulatory programs and initiatives provide assurance that any major vulnerabilities to severe accidents have been identified and addressed and that the residual level of risk is low. As a result, major plant modifications would not be expected as a result of a SAMA analysis. As stated in the GEIS, "the NRC expects that a site-specific consideration of severe accident mitigation for license renewal will only identify procedural and programmatic improvements (and perhaps minor hardware changes) as being cost-beneficial in reducing severe accident risk or consequence." This expectation has generally been met.

### **Reference/Guidance Material**

36 FR 22851, December 1, 1971, "Consideration of Accidents in Implementation of the National Environmental Policy Act of 1969," Federal Register, Atomic Energy Commission.

45 FR 40101, June 13, 1980. "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969." Federal Register. U.S. Nuclear Regulatory Commission.

50 FR 32138, August 8, 1985. "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants." Federal Register. U.S. Nuclear Regulatory Commission

51 FR 30028. August 21, 1986. "Safety Goals for the Operation of Nuclear Power Plants; Policy Statement; Correction and Republication." Federal Register. U.S. Nuclear Regulatory Commission.

SECY-90-016, "Evolutionary Light-Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," ADAMS Accession No. ML003707849, January 12, 1990, and the related staff requirements memorandum (SRM), ADAMS Accession No. ML003707885, June 26, 1990.

SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor Designs," ADAMS Accession No. ML003708021, April 2, 1993, and the related SRM, ADAMS Accession No. ML003708056, July 21, 1993.

U.S. Nuclear Regulatory Commission (NRC). 1976. *Preparation of Environmental Reports for Nuclear Power Stations*. Regulatory Guide 4.2, Rev. 2, Washington, D.C.

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U.S. Nuclear Regulatory Commission (NRC). 1997. *Regulatory Analysis Technical Evaluation Handbook*. NUREG/BR-0184, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Environmental Standard Review Plan — Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*. NUREG-1555, Supplement 1. Washington, D.C.

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U.S. Nuclear Regulatory Commission (NRC). 2004. *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*. NUREG/BR-0058, Rev. 4, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2007. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition*. NUREG-0800, Washington, D.C.