



U.S. NUCLEAR REGULATORY COMMISSION
**ENVIRONMENTAL
STANDARD
REVIEW PLAN**
OFFICE OF NUCLEAR REACTOR REGULATION

7.3 SEVERE ACCIDENT MITIGATION ALTERNATIVES

REVIEW RESPONSIBILITIES

Primary—Appendix B

Secondary—Appendix B

I. AREAS OF REVIEW

This environmental standard review plan (ESRP) directs the staff's evaluation of the severe accident mitigation alternatives (SAMAs), referred to as severe accident mitigation design alternatives (SAMDAs) in some references. The scope includes the identification and evaluation of design alternatives and procedural modifications that reduce the radiological risk from a severe accident by preventing substantial core damage (i.e., preventing a severe accident) or by limiting releases from containment in the event that substantial core damage occurs (i.e., mitigating the impacts of a severe accident). The intent is to identify additional cases that might warrant either additional features or other actions that would prevent or mitigate the consequences of serious accidents.

Review Interfaces

The reviewer for this ESRP should provide input to or obtain input from the reviewers for the following ESRP sources, as indicated:

- ESRP 7.2. Obtain information that characterizes the risk profile of the plant. This includes a list showing leading contributors to (1) core damage frequency (e.g., from dominant severe accident sequences or initiating events), (2) large release frequency (e.g., from containment failure mode or accident-progression bin), and (3) dose consequences with and without interdiction (e.g., from each release class and associated source term).

October 1999

7.3-1

NUREG-1555

USNRC ENVIRONMENTAL STANDARD REVIEW PLAN

Environmental standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for environmental reviews for nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Environmental standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The environmental standard review plans are keyed to Preparation of Environmental Reports for Nuclear Power Stations.

Published environmental standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555-0001.

- 10 CFR 50.34(f)(1)(I). Obtain input from the responsible 10 CFR 50.34(f)(1)(I) reviewer to ensure consistency of the SAMA and the 10 CFR 50.34(f)(1)(I) reviews.
- Internal Plant Examination (IPE). Obtain input from the responsible reviewer for the IPE to ensure consistency of the SAMA analysis with the findings of the IPE.
- Internal Plant Examination of External Events (IPEEE). Obtain input from the responsible reviewer of the IPEEE to ensure consistency of the SAMA analysis with the results of the IPEEE.
- Safety Analysis Report (SAR), Chapter 19 Review. Obtain input from the responsible reviewer of Chapter 19 of the SAR to assure consistency of the SAMA analysis with the results of the SAR Chapter 19 review.

Data and Information Needs

The type of data and information needed will be affected by site- and station-specific factors, and the degree of detail should be modified according to the anticipated magnitude of the potential impacts. The following data or information should be obtained:

- a list of leading contributors to (1) core damage frequency (e.g., from dominant severe accident sequences or initiating events), (2) large release frequency (e.g., from containment failure mode or accident progression bin), and (3) dose consequences with and without interdiction (e.g., from each release class and associated source term) (from ESRP 7.1)
- the methodology, process, and rationale used by the applicant to identify, screen, and select design alternatives and procedural modifications (from the environmental report [ER])
- the estimated cost, risk reduction, and value impact ratios for the selected SAMAs and the assumptions used to make these estimates (from the ER)
- a description and list of any alternatives that have been or will be implemented to prevent or mitigate severe accidents or reduce the risk of a severe accident (from the ER).

II. ACCEPTANCE CRITERIA

Acceptance criteria for the analysis and evaluation of severe accident mitigation alternatives are based on the relevant requirements of the following:

- the U.S. Court of Appeals decision in *Limerick Ecology Action v. NRC* 869 F.2d 719 (3rd Cir. 1989) with respect to the requirement that the NRC include consideration of certain SAMAs in environmental impact reviews performed under Section 102(2)(c) of NEPA as part of operating-license applications

- 10 CFR 50.34(f)(1)(I) with respect to requirements for the applicant to perform a plant/site-specific probabilistic risk assessment, the aim of which is to seek such improvements in the reliability of core and containment heat removal systems that are significant and practical and do not impact excessively on the plant
- 10 CFR 52.17 with respect to requirements in 10 CFR 50.34(f) for the applicant to perform a plant/site-specific probabilistic risk assessment, the aim of which is to seek such improvements in the reliability of core and containment heat removal systems that are significant and practical and do not impact excessively on the plant
- 10 CFR 52.79 with respect to requirements to contain the technically relevant information required of applicants for an operating license in 10 CFR 50.34

Regulatory positions and specific criteria necessary to meet the regulations identified above are provided in the following:

- Interim Policy Statement, “Power Plants—Nuclear Power Plant Accident Considerations under NEPA” (1980) with respect to the early consideration of either additional features or other actions that would prevent or mitigate the consequences of serious accidents
- SECY-91-229 (NRC 1991a), which presents alternative courses of action and the staff’s recommendations concerning the treatment of the SAMA issues to be considered under NEPA as they relate to the certification of standard plant designs, including evolutionary, passive, and advanced reactors
- NUREG/BR-0058, Rev. 2 (NRC 1997a), which states the policy for the preparation and the contents of regulatory analyses, including estimation of values and impacts for design alternatives and the “dollars per person-rem” conversion factors
- NUREG/BR-0184 (NRC 1997b) with respect to the value impact methodology
- NUREG/CR-6349 (Mubayi et al. 1995) with respect to dollars per person-rem conversion factor for offsite damage costs
- Generic Letter 88-20 (NRC 1988) with respect to the performance of an IPE at operating plants for severe-accident vulnerabilities
- Generic Letter 88-20, Supplement 3 (NRC 1990), with respect to accident prevention and mitigation features identified in the Containment Performance Improvement Program that may be valid for consideration in the review of SAMA
- Generic Letter 88-20, Supplement 4 (NRC 1991b), with respect to conducting an individual plant examination for externally initiated events.

In addition, the following acceptance criterion is used:

- Completeness and reasonableness, also with respect to the following: (1) the identification of SAMAs applicable to the plant or design under consideration, (2) the estimation of core damage frequency reduction and averted person-rem for each SAMA, (3) the estimation of cost for each SAMA, (4) the ranking of value-impact screening criteria to identify SAMAs for further consideration, and (5) the final disposition of promising SAMAs.

Technical Rationale

The technical rationale for evaluation of the applicant's severe accident mitigation alternatives is discussed in the following paragraphs:

An evaluation of SAMAs is required to be performed as part of the certification of new designs for nuclear power plants (as well as licensing custom plants) and for site approval applications. The purpose of SAMAs is to review and evaluate plant-design alternatives that could significantly reduce the radiological risk from a severe accident by preventing substantial core damage (i.e., preventing a severe accident) or by limiting releases from containment in the event that substantial core damage occurs (i.e., mitigating the impacts of a severe accident).

In 1980, the NRC published an interim policy statement (Interim Policy Statement, "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969" [NRC 1980]) that stated that it was the intent of the Commission for the staff to take steps to identify additional cases that might warrant early consideration of either additional features or other actions that would prevent or mitigate the consequences of serious accidents.

In 1985, the NRC published a policy statement ("Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants," August 9, 1985 [NRC 1985a]). It concluded that existing plants posed no undue risk to public health and safety and no present basis for immediate action on a generic rulemaking or other regulatory changes for these plants because of severe accident risk. However, the policy statement indicated that "the Commission plans to formulate an approach for a systematic safety examination of existing plants to determine whether particular accident vulnerabilities are present and what cost-effective changes are desirable to ensure that there is no undue risk to public health and safety."

A 1989 court decision (*Limerick Ecology Action vs. NRC*, 869 F.2d 719 [3rd Cir. 1989]) stated that the "Action of NRC in addressing severe accident mitigation design alternatives through policy statement, not rule making, did not satisfy NEPA, where policy statement did not represent requisite careful consideration of environmental consequences, excluded consideration of design alternatives without making any conclusions about effectiveness of any particular alternative, and issues were not generic in that impact of severe accident mitigation design alternatives on environment would differ with particular plant's design, construction and locations."

Currently, NRC considers the evaluation of SAMAs in the environmental impact review that is now performed as part of every application for a construction permit, an early site permit, an operating license, and a combined license. In addition, the Commission has endorsed staff consideration of SAMAs in conjunction with the design certification application. The purpose of this consideration is to ensure that plant design changes with the potential for improving severe accident performance are identified and evaluated.

III. REVIEW PROCEDURES

This procedure applies to the review of applications for construction permits, operating licenses, combined licenses, standard design certifications, and early site permits.

When evaluating SAMAs, the reviewer should do the following:

- (1) Be familiar with analyses previously performed and with the potential process and design alternatives, if any, in previous studies, including the following:
 - Limerick (NRC 1989)
 - Watts Bar (NRC 1995)
 - 10 CFR 50.34(f)(1)(I) reviews of the System 80+ (NRC 1997c)
 - the Advanced Boiling Water Reactor (ABWR) (NRC 1997d)
 - the GESSAR II (NRC 1985b)
 - the Containment Improvement Program
 - Generic Environmental Impact Statement for License Renewal (NRC 1996).
- (2) Evaluate the applicant's methods for identifying the potential mitigation alternatives. If the applicant used an alternative methodology to a probabilistic risk assessment approach to assess potential SAMAs (e.g., a margins-based approach to evaluate external events initiated by fires or seismic activity), the staff evaluation should be appropriately modified. For example, the synergistic effects of mitigation alternatives that reduce risks for internally initiated events that also provide a benefit for mitigation of externally initiated events should be considered. Alternative benefit-cost approaches are appropriate when a margins method has been used to screen external events.
 - (a) Determine if this set of potential design alternatives and procedural modifications represents a reasonable range of preventive and mitigative alternatives.

- (b) Verify that the applicant's list of potential SAMAs includes a reasonable range of applicable SAMAs derived from consideration of previous analyses and based on insights from the Level 1 and Level 2 portions of the applicant's probabilistic risk assessment (PRA) or IPE/IPEEE.
- (3) Evaluate the applicant's basis for estimating the degree to which various alternatives would reduce risk (expressed as a reduction in core damage frequency or in terms of person-rem averted). In performing its independent assessment, the staff may make bounding assumptions to determine the magnitude of the potential risk reduction for each SAMA.
- (4) Evaluate whether the applicant's cost estimates for each SAMA are reasonable and compare the cost estimates with estimates developed elsewhere (e.g., using previous SAMA evaluations or using accepted cost-estimation tools).
- (5) Evaluate the benefit-cost comparison to determine if it is consistent with the benefit-cost balance criteria and methodology given in NUREG/BR-0058, Rev. 2 (NRC 1997a), and further analyze any SAMAs that are within a decade of the NUREG/BR-0058, Rev. 2, or NUREG/CR-6349 (Mubayi et al. 1995) benefit-cost criteria to ensure that a sufficient margin is present to account for uncertainties in assumptions used to determine the cost and benefit estimates. The benefit-cost criterion in NUREG/BR-0058 is \$200,000 per person-sievert averted (\$2000 per person-rem averted) for health effects. In addition, a criterion of \$300,000 per person-sievert averted (\$3000 per person-rem averted) is given in NUREG/CR-6349 (Mubayi et al. 1995) for offsite damage and other related costs for severe accidents.
- (6) Subject any SAMAs that remain following the screening given above to further probabilistic and deterministic considerations, including a qualitative assessment of the following:
- the impact of additional benefits that could accrue for the SAMA if it would be effective in reducing risk from certain external events, as well as internal events
 - the effects of improvements already made at the plant
 - any operational disadvantage associated with the potential SAMA.

IV. EVALUATION FINDINGS

The input to the environmental impact statement (EIS) should describe the applicant's analysis and detail the staff's review process. Any design mitigation or procedural modification should be described along with the estimated benefit-cost ratio. The risk reduction for the facility should be provided.

A concluding statement similar to the following should be made in the EIS:

The staff concludes that the applicant completed a comprehensive, systematic effort to identify and evaluate the potential plant enhancements to mitigate the consequences of severe accidents. The

staff considered the robustness of this conclusion relative to critical assumptions in the analysis—specifically the impact of uncertainties in the risk and cost estimates and the use of alternative benefit-cost screening criteria. The staff concludes that the findings of the analysis would be unchanged even considering these factors. Therefore the staff concludes that the mitigation alternatives committed to by the applicant are appropriate and no further mitigation measures are warranted.

V. IMPLEMENTATION

The method described herein will be used by the staff in evaluating conformance with the Commission's regulations, except in those cases in which the applicant proposes an acceptable alternative for complying with specified portions of the regulations.

VI. REFERENCES

10 CFR 50.34, "Contents of application; technical information."

10 CFR 51.53, "Postconstruction environmental reports."

10 CFR 52.17, "Contents of application."

10 CFR 52.79, "Contents of applications; technical information."

Limerick Ecology Action vs. NRC. 869 F.2d 719 [3rd Cir. 1989].

Mubayi, V., V. Sailor, and G. Anandalingam. 1995. *Cost-Benefit Considerations in Regulatory Analysis*. NUREG/CR-6349, U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1980. "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969." 45 FR 40101, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1985a. "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants." 50 FR 32138, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1985b. *Safety Evaluation Report Related to the Final Design Approval of the GESSAR II BWR/6 Nuclear Island Design*. NUREG-0979, Supplement 4, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1988. Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities." November 23, 1988, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1989. Letter from U.S. NRC to G. A. Hunger, Jr. Philadelphia Electric Company. Subject: Supplement to the Final Environmental Statement—Limerick Generating Station, Units 1 and 2. Supplement to NUREG-0974.

U.S. Nuclear Regulatory Commission (NRC). 1990. Generic Letter 88-20, Supplement 3, “Completion of Containment Performance Improvement Program and Forwarding Insights for Use in the Individual Plant Examination for Severe Accident Vulnerabilities.” July 6, 1990, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1991a. “Severe Accident Mitigation Design Alternatives for Certified Standard Designs.” SECY-91-229, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1991b. Generic Letter 88-20, Supplement 4, “Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10 CFR 50.54(f).” June 28, 1991, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). April 1995. *Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2*. NUREG-0498, Suppl. 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1997a. *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission. Final Report*. NUREG/BR-0058, Rev. 2, Washington, D.C.

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

U.S. Nuclear Regulatory Commission (NRC). 1997c. *Final Environmental Assessment by the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Relating to the Certification of the System 80+ Standard Nuclear Plant Design*. NUREG-1462, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1997d. *Final Environmental Assessment by the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Relating to the Certification of the U.S. Advanced Boiling Water Reactor Design*. NUREG-1503, Washington, D.C.