



U.S. NUCLEAR REGULATORY COMMISSION
**ENVIRONMENTAL STANDARD
 REVIEW PLAN**

7.2 SEVERE ACCIDENTS

REVIEW RESPONSIBILITIES

Primary— Organization responsible for Probabilistic Safety Assessment

Secondary— Organization responsible for the review of environmental consequences of severe accidents

I. AREAS OF REVIEW

This environmental standard review plan (ESRP) directs the staff's evaluation and input to the environmental impact statement (EIS) of the environmental risks of accidents involving radioactive material that can be postulated for the plant under review.

The scope of this review should include dose consequence analysis for severe accidents, including socioeconomic impacts. This includes coordination with the reviewers of safety analysis report (SAR) Chapter 19, Chapter 19 of the safety evaluation report (SER) for certified designs, and Chapter 19 of the Design Control Document (DCD), Tier 2 for reactor designs undergoing certification. The review directed by this plan includes consideration of a limited amount of plant specific data in sufficient detail to appropriately evaluate the dose consequences for severe accidents.

Review Interfaces

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

- ESRP 2.2.1 and 2.2.3. Obtain an evaluation of the land use information used in the severe accident consequence assessment.
- ESRP 2.3.1 and 2.3.2. Obtain input on aquifers and surface water users.

USNRC ENVIRONMENTAL STANDARD REVIEW PLAN

This Environmental Standard Review Plan has been prepared to establish guidance for the U.S. Nuclear Regulatory Commission staff responsible for environmental reviews for nuclear power plants. The Environmental Standard Review Plan is not a substitute for the NRC's regulations, and compliance with it is not required.

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. Individual sections of NUREG-1555 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 New Reactors, Washington, D.C. 20555-0001.

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- ESRP 2.5 and 2.5.1. Obtain an evaluation of the economic data used in the consequence assessment and the population data and distribution within an 80-km (50-mile) radius for a date 5 years from the time of the licensing action under consideration.
- ESRP 2.7. Obtain an evaluation of the meteorological data used in the consequence assessment.
- ESRP 5.4.3. Obtain the dose consequences and health effects associated with normal operational releases.
- ESRP 7.3. Provide a list of the major release categories, their respective frequencies, and dose consequences.

In addition, the reviewer of severe accidents should obtain input from reviewers of information covered in the following documents:

- SER Chapter 19. Coordinate with the responsible reviewer(s) (or review branch) of SAR Chapter 19 to ensure consistency with the severe-accident analyses given by the applicant in the environmental report (ER).
- SER Chapter 19 for Certified Designs and Design Control Document, Tier 2, Chapter 19. Coordinate with the responsible reviewer for the design certification to ensure consistency with the severe-accident analyses given by the applicant in the ER.

If the application references an early site permit, contact the reviewers listed above to determine if there is new and potentially significant information related to severe accident consequence assessments.

Data and Information Needs

The type of data and information needed will be affected by site- and station-specific factors, and whether the reactor design is certified or not. 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 release sequences (accident classes) for severe accidents with their associated core damage frequencies and source terms (from the ER and the design certification probable risk assessment submittal).
- a list of land uses and their locations in the vicinity and region of the site to a distance of 80 km (50 mi) (from ESRP 2.2.1 and 2.2.3).
- a list and characterization of aquifers in the vicinity to the site, and a list of public surface water users within 80 km (50 mi) of the site (from ESRPs 2.3.1 and 2.3.2).
- economic and projected demographic data within an 80-km (50-mile) radius from the plant for the 5 years from the time of the licensing action under consideration (from ESRP 2.5.1).

- meteorological data for a 1-year period that represents current conditions (from ESRP 2.7).
- radiological dose consequences and health effects associated with normal and anticipated operational releases (from ESRP 5.4.3).

II. ACCEPTANCE CRITERIA

Acceptance criteria for the review of environmental impacts of postulated accidents involving radioactive material and related to the plant are based on the relevant requirements of the following:

- 10 CFR 51.45 with respect to the requirement to address alternatives.
- 10 CFR 51.50(b) with respect to applications for early site permits.
- 10 CFR 51.50(c) with respect to applications for combined licenses.

Technical Rationale

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

The Commission has determined that the evaluation of events or accident sequences that lead to releases shall include, but not be limited to, those events or sequences that can reasonably be expected to occur. It has also stated that the environmental consequences of releases whose probability of occurrence has been estimated shall be discussed in probability terms. The consequences of the accidents that can reasonably be expected to occur are expressed in terms of potential exposure to individuals; the consequences of severe accidents referred to as probabilistic accidents in the policy statements (NRC 1985, 1986) are characterized in terms of exposure to population groups.

Releases refer to radiation or radioactive materials or both entering environmental exposure pathways, including air, water, and groundwater. In-plant accident sequences that can lead to a spectrum of releases shall be discussed and shall include sequences that can result in inadequate cooling of reactor fuel and melting of the reactor core. The events arising from causes external to the plant that are considered possible contributors to the risk associated with the plant should be discussed. Socioeconomic impacts associated with emergency measures during or following an accident should also be discussed, and the environmental risks compared to and contrasted with radiological risks should be associated with normal and anticipated operational releases.

The Commission also takes the position that detailed quantitative considerations that form the basis of probabilistic estimates of releases do not need to be incorporated into the EIS, but may be referenced, including references to safety evaluation reports.

III. REVIEW PROCEDURES

Severe accidents are those involving multiple failures of equipment or function and, therefore, the likelihood of occurrence is 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 (such as the MACCS2 code package; Chanin and Young [1997]). 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.

This ESRP section is designed to provide a methodology for reviewing the applicant's probabilistic assessment of the dose consequences of severe accidents. The reviewer should be familiar with the basic concepts of probabilistic risk assessment, the guidance set forth in SRP Sections 19 and 19.1 (NRC 2002 and 2006), and with relevant Commission Policy Statements (NRC 1985, 1986).

When analyzing doses calculated to result from severe accidents, the reviewer should do the following:

- (1) Obtain copies of Chapter 19 of the SER for the reactor design and/or of Chapter 19 of the Design Control Document, Tier 2 (DCD), if the application references a certified design or design undergoing certification.
- (2) If the application references a certified reactor design or a design undergoing certification,
 - (a) Consult with the reviewer for Chapter 19 of the SER and/or Design Control Document to determine if the information given in the ER on which the applicant's analysis is based is appropriate (release sequences, core damage frequencies, and source terms). Determine if the ER includes release sequences for both internally-initiated and externally-initiated events. Estimates of the core damage frequencies of externally-initiated events are typically provided in the design certification probabilistic risk assessment documentation and should be considered within the severe accident assessment. NUREG-1742 (NRC 2001) provides insights on externally-initiated events for current generation reactors.

Otherwise
 - (b) Consult with the reviewer for Chapter 19 of the SAR to determine if the information given in the ER on which the applicant's analysis is based is appropriate (release sequences, core damage frequencies, and source terms). Determine if the ER includes release sequences for both internally-initiated and externally-initiated events. It may be necessary to review other information related to potential releases including core inventory estimates (e.g., from the ORIGEN-ARP code [Bowman and Leal 1998]) and estimates of release fractions (e.g; from the RADTRAD code [Humphreys et al. 1998; Bixler and Erickson 1999]), which are used as input to the severe accident consequence assessment.
- (3) In consultation with the reviewer of the SER and/or DCD, determine if the method (computer code) used to evaluate the environmental consequences is appropriate and that it evaluates

consequences to a distance of 80 km (50 mi). If the method used for the consequence assessment is not currently approved or endorsed by NRC, then the method should be evaluated in detail, or the consequences of severe accidents should be evaluated using a method approved or endorsed by the NRC and the results should be compared with the results of the consequence assessment calculated by the applicant.

- (4) Consult with the reviewers of ESRPs 2.2.1 and 2.2.3 to determine if land fraction and land-use characterization (farm land, etc) used as input to the consequence assessment methodology used to support the ER severe accident analysis are appropriate and consistent with land-use information used elsewhere in the ER.
- (5) Consult with the reviewer of ESRP 2.3.1 to determine if proposed site is over or near a sole source aquifer.
- (6) Consult with the reviewer of ESRP 2.3.2 to determine if water-use input to the consequence assessment methodology used to support the ER severe accident analysis is appropriate and consistent with water-use information used elsewhere in the ER (e.g., does the ER include a list of public surface water users within 80 km (50 mi) of the site?)
- (7) Consult with the reviewer of ESRP 2.5 to determine if economic input (land values, relocation costs, cleanup costs, etc) to the consequence assessment methodology used to support the ER severe accident analysis is appropriate.
- (8) Consult with the reviewer of ESRP 2.5.1 to determine if demographic input to the consequence assessment methodology used to support the ER severe accident analysis is appropriate and consistent with demographic information presented elsewhere in the ER.
- (9) Consult with the reviewer of ESRP 2.7 to determine if meteorological data input to the consequence assessment methodology used to support the ER severe accident analysis is appropriate and consistent with meteorological information used elsewhere in the ER. (Check to see that the same meteorological data were used for to develop input to evaluation of radiological impacts of normal operations, design-basis accidents, and severe accidents.)
- (10) Evaluate the protective actions considered by the applicant in its consequence assessment. Were protective actions properly considered?
- (11) Evaluate the applicant's analysis of consequences associated with the groundwater pathway. Compare the applicant's analysis with the analysis for generic sites presented in NUREG-0440 (NRC 1978) and the analyses for actual sites presented in NUREG-1437 (NRC 1996).
- (12) Compare severe accident dose risks with the Commission's Safety Goals (NRC 1986) and with the doses estimated for normal operations.

IV. EVALUATION FINDINGS

The depth and extent of input to the EIS will be governed by the nature of the plant accidents and their impacts on the proposed project. The following information should be included:

- a summary of atmospheric releases in severe-accident sequences (this includes the accident sequence or sequence group and the probability of the accident sequence per reactor year).
- a summary of the environmental impacts and probabilities of severe accidents (including the probability of impact per reactor-year, the population exposure, the early and latent cancer fatalities, and the cost of offsite mitigating actions).
- the average values of environmental risks resulting from accidents per reactor-year (see NUREG-0921 [NRC 1983], Tables 5.8 through 5.13 for examples).
- a comparison of the environmental risk of severe accidents with (and contrasted to) the radiological risks associated with normal and anticipated operational releases. If appropriate, the following concluding statement may be used:

The environmental impacts that have been considered include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe, but the likelihood of their occurrence is judged to be small. This conclusion is based on (1) considerable experience gained with the operation of similar facilities without significant degradation of the environment, (2) compliance with applicable Commission regulations and requirements, and (3) a previously analyzed assessment of the risk of design-basis and severe accidents. The overall assessment of environmental risk of accidents, assuming protective action, shows that it is roughly comparable with the risk from normal operation, although accidents have a potential for early fatalities and economic costs that cannot arise from normal operations. The risks of an early fatality from potential accidents at the site are small in comparison with the risks of an early fatality from other human activities.

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 51.45, "Environmental Report."

10 CFR 51.50, “Environmental report—construction permit, early site permit, or combined license stage.”

Bixler, N. E., and C. M. Erickson. 1999. *RADTRAD: A Simplified Model for RADionuclide Transport and Removal And Dose Estimation*. NUREG/CR-6604, Supp. 1, (SAND98-0272/1), U. S. Nuclear Regulatory Commission, Washington, D.C.

Bowman, S. M., and L. C. Leal. 1998. *ORIGEN-ARP: Automatic Rapid Process for Spent Fuel Depletion, Decay, and Source Term Analysis*. NUREG/CR-0200, Rev. 6, Vol. 1. (ORNL/NUREG/CSD-2/V1/R6), U.S. Nuclear Regulatory Commission, Washington, D.C.

Chanin, D. L. and M. L. Young. 1997. *Code Manual for MACCS2: Volume 1, User's Guide*. SAND97-0594, Sandia National Laboratories, Albuquerque, New Mexico (Also published as NUREG/CR-6613 in 1998).

Humphreys, S. L., T. J. Heames, L. A. Miller, and D. K. Monroe. 1998. *RADTRAD: A Simplified Model for RADionuclide Transport and Removal And Dose Estimation*. NUREG/CR-6604,(SAND98-0272), U. S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1978. *Liquid Pathway Generic Study: Impacts of Accidental Radioactive Releases to the Hydrosphere from Floating and Land-Based Nuclear Power Plants*. NUREG-0440, Washington D.C.

U.S. Nuclear Regulatory Commission (NRC). 1983. *Final Environmental Statement Related to the Operation of Catawba Nuclear Station, Units 1 and 2*. NUREG-0921, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1985. “Policy Statement of Severe Reactor Accidents Regarding Future Designs and Existing Plants.” 50 FR 32138.

U.S. Nuclear Regulatory Commission (NRC). 1986. “Safety Goals for the Operations of Nuclear Power Plants: Policy Statement; Replication”. 51 FR 30028.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437, Volumes 1 and 2, Washington, D. C.

U.S. Nuclear Regulatory Commission (NRC). 2001. *Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program*. NUREG-1742, Volumes 1 and 2, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2007. “Standard Review Plan 19 -Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors.” *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants LWR Edition*. NUREG-0800, Washington, D. C.

U.S. Nuclear Regulatory Commission (NRC). 2007. "Standard Review Plan 19.1 Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities." *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants—LWR Edition*. NUREG-0800, Washington, D. C.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Environmental Standard Review Plan are covered by the requirements of 10 CFR Part 51, and were approved by the Office of Management and Budget, approval number 3150-0021.

PUBLIC PROTECTION NOTIFICATION

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