



## U.S. NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

### 11.1 SOURCE TERMS

#### REVIEW RESPONSIBILITIES

**Primary** - Organization responsible for review of source term associated with normal operations.

**Secondary** - None.

#### I. AREAS OF REVIEW

At the early site permit (ESP), construction permit (CP) or standard design certification stage of review, the staff reviews the information in the applicant's safety analysis report (SAR) on the sources of radioactivity that are input to the radioactive waste management systems for treatment of liquid and gaseous wastes. At the operating license (OL) or combined license (COL) stage of review, the staff confirms the information accepted at the CP or standard design certification stage.

1. The staff's review of the radioactive source terms includes consideration of parameters used to determine the concentration of each isotope in the reactor coolant; fraction of fission product activity released to the reactor coolant; and concentrations of all nonfission product radioactive isotopes in the reactor coolant. The following sources are considered in the evaluation of effluent releases:
  - a. Boiling water reactor (BWR) gaseous wastes (noble gases, radio iodine, particulates, carbon-14 and tritium), consisting of offgases from the main condenser evacuation and turbine gland sealing systems, steam and liquid leakage to containment, radwaste, turbine, fuel handling and auxiliary buildings,

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### USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of Regulatory Guide 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to [NRR\\_SRP@nrc.gov](mailto:NRR_SRP@nrc.gov).

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and ventilation system exhausts from buildings having the potential for containing radioactive materials.

- b. BWR liquid wastes, consisting of leakage of equipment and floor drains from buildings housing equipment and components that may contain radioactive fluids; contaminated liquids produced by plant operations, such as demineralizer regenerants and resin sluice water, filter backwashes, ultrasonic resin cleaning rinses, decontamination solutions, and laboratory samples and rinses; and detergent wastes.
  - c. Pressurized water reactor (PWR) gaseous wastes (noble gases, radio iodine, particulates, carbon-14 and tritium), consisting of offgases from the steam generator blowdown flash tank; offgases from the main condenser evacuation system; leakage to containment, fuel handling, auxiliary, and turbine buildings; noble gases stripped from the primary coolant during normal operation and at shutdown; and cover and vent gases from tanks and equipment containing radioactive material.
  - d. PWR liquid wastes, consisting of primary coolant processed to control boron concentration (shim bleed); leakage collected in equipment and floor drains from buildings housing equipment and components that may contain radioactive fluids; steam generator blowdown; condensate demineralizer regenerant solutions; contaminated liquids from anticipated plant operations such as resin sluices, filter backwashes, decontamination solutions, and sample station drains; and detergent wastes.
2. Additional Information for 10 CFR Part 52 Applications: Additional information will be presented dependent on the type of application. For a COL application, the additional information is dependent on whether the application references an ESP, a DC, both or neither. Information requirements are prescribed within the "Contents of Application" sections of the applicable Subparts to 10 CFR Part 52.
  3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

### Review Interfaces

Other SRP sections interface with this section as follows:

1. The reviewer responsible for review of effectiveness of the radwaste systems will use the coolant concentrations calculated above as inputs for evaluation of the liquid waste system, under SRP Section 11.2, and the gaseous waste systems, under SRP Section 11.3, to determine if these systems meet the dose design objectives of Appendix I to 10 CFR Part 50.

2. The reviewer responsible for review of effectiveness of the radwaste systems - monitoring instrumentation will review under SRP Section 11.5, "Process and Effluent Radiological Monitoring and Sampling Systems," the monitoring and control provisions for all the applicable effluent release points identified in Subsection I.1, above.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

## II. ACCEPTANCE CRITERIA

### Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. 10 CFR Part 20, as it relates to determining the operational source term that is used in calculations associated with potential radioactivity in effluents to unrestricted areas. Part 20 is not applicable to an ESP application.
2. 10 CFR Part 50, Appendix I, as it relates to determining the operational source term that is used in calculations associated with potential radioactivity in effluents considered in the context of numerical guides for design objectives and limiting conditions for operation to meet the criterion "as low as is reasonably achievable" (ALARA) for radioactive material in LWR effluents.
3. General Design Criterion 60 (GDC) as it relates to determining the operational source term that is used in calculations associated with potential radioactivity in effluents to unrestricted areas, such that a nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents provided during normal reactor operation, including anticipated operational occurrences. GDC 60 is not applicable to an ESP application.

### SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

In general, the source terms used as the design basis for expected releases have been found acceptable if these values are determined using models and parameters that are consistent with NUREG-0016 (BWR-GALE code) or NUREG-0017 (PWR-GALE code) and the guidance provided in ANSI/ANS 18.1-1999.

Applicable regulatory guides are as follows:

- Regulatory Guide 1.110, as it relates to the cost-benefit analysis for radioactive waste management systems and equipment.
- Regulatory Guide 1.112, as it relates to the method of calculating release of radioactive materials in effluents from nuclear power plants.
- Regulatory Guide 1.140, as it relates to the design, testing, and maintenance of normal ventilation exhaust system air filtration and adsorption units at nuclear power plants.

Specific SRP criteria are as follows:

1. All normal and potential sources of radioactive effluent delineated above in Subsection I will be considered.
2. For each source of liquid and gaseous waste considered above in Subsection I.1, the volumes and concentrations of radioactive material given for normal operation and anticipated operational occurrences should be consistent with those given in NUREG-0016 or NUREG-0017.
3. Decontamination factors for inplant control measures used to reduce gaseous effluent releases to the environment, such as iodine removal systems and high-efficiency particulate air (HEPA) filters for building ventilation exhaust systems and containment internal cleanup systems should be consistent with those given in Regulatory Guide 1.140. The building mixing efficiency for containment internal cleanup should be consistent with NUREG-0017.
4. Decontamination factors for inplant control measures used to reduce liquid effluent releases to the environment, such as filters, demineralizers and evaporators, should be consistent with those given in NUREG-0016 or NUREG-0017.
5. Radwaste augments used in the calculation of effluent releases to the environment are consistent with the findings of a cost-benefit analysis, which may be performed using the guidance of Regulatory Guide 1.110. The provisions that require a cost-benefit analysis are stated in Section II.D of Appendix I to 10 CFR Part 50.
6. Effluent concentration limits at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B to 10 CFR Part 20.
7. The source terms result in meeting the design objectives for doses in unrestricted areas as set forth in Appendix I to 10 CFR Part 50.
8. For evaluating the source terms, the applicant should provide the relevant information in the SAR as required by 10 CFR 50.34, and 10 CFR 50.34a. This technical information should include all the basic data listed in Appendix A (BWRs) and Appendix B (PWRs) to Regulatory Guide 1.112 in order to calculate the releases of radioactive material in liquid and gaseous effluents (the source terms). An acceptable method for satisfying the criteria given in items 1 through 5 consists of using the Gaseous and Liquid Effluent

(GALE) Computer Code and the source term parameters given in NUREG-0016 or NUREG-0017 for BWRs and PWRs, respectively. Complete listings of the GALE Computer Codes for BWRs and PWRs are given in NUREG-0016 and NUREG-0017, respectively.

9. If the applicant's calculational technique or any source term parameter differs from that given in ANSI/ANS 18.1-1999, NUREG-0016, or NUREG-0017, they should be described in detail and the bases for the methods and/or parameters used should be provided.

### Technical Rationale

The technical rationale for application of these acceptance criteria is to determine the coolant source term as a precursor to calculating radioactivity in effluents. In addition, the technical rationale for application of the acceptance criteria for reviewing the radwaste treatment system is discussed in the following paragraphs:

1. 10 CFR Part 50, Appendix I, provides numerical guidance on offsite individual doses and air doses due to effluents. It also provides an acceptance criterion for cost-benefit analysis as it relates to population doses due to liquid and gaseous effluents (Section II.D of Appendix I). Conformance with Section II.D of Appendix I demonstrates that the plant design includes all items of established modern technology for reducing the cumulative population dose due to releases of radioactive materials from the reactor to ALARA levels of Appendix I.

The calculations using the Gaseous and Liquid Effluent (GALE) Computer Code and the source term parameters given in NUREG-0016 and NUREG-0017 for BWRs and PWRs, respectively, take into account modern technology and the availability of equipment based on that technology to reduce the liquid and gaseous waste management system source terms. The assumptions used in the calculations that are based on the performance of modern equipment have a driving influence on the design parameters used for the radwaste management systems reviewed in SRP Section 11.2, "Liquid Waste Systems," and in Section 11.3, "Gaseous Waste Systems."

Meeting the source term calculation criteria of SRP Section 11.1 provides reasonable assurance that the system designs reviewed in SRP Sections 11.2 and 11.3 will meet the effluent concentration limits in unrestricted areas specified in 10 CFR Part 20, the requirements and ALARA objectives of 10 CFR 50.34a as they relate to the adequacy of design information for radwaste management systems; GDC 60 and 61 of 10 CFR Part 50, Appendix A; and the public dose limitations of 10 CFR Part 50, Appendix I.

2. GDC 60 requires, in part, that the nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents produced during normal reactor operation, including anticipated operational occurrences.

GDC 60 specifies that sufficient holdup capacity shall be provided for retention of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual

operational limitations on the release of such effluents to the environment. The holdup capacity also provides time to allow the shorter lived isotopes a chance to decay before they are further processed or released to the atmosphere. Acceptable holdup times are used in the source term calculations provided in NUREG-0016 and NUREG-0017.

Meeting the requirements of GDC 60 provides reasonable assurance that releases of radioactive materials during normal operation of the radwaste processing systems and during anticipated transients will not result in offsite radiation doses exceeding the limits specified in 10 CFR Part 50, Appendix I, and the effluent concentration limits in unrestricted areas exceeding the limits specified in 10 CFR Part 20.

### III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. In the review of the mathematical models and parameters given in the SAR to calculate primary coolant concentrations, the reviewer compares parameters and calculations given in the SAR with the models and parameters given in ANSI/ANS 18.1-1999, NUREG-0016, or NUREG-0017. If the SAR includes models or parameters to estimate reactor coolant concentrations that differ from these reports, the parameters and calculations used should be substantiated. The preferred method of substantiation is by presentation of operating data from similar reactors.
2. The reviewer performs an independent calculation of the primary and secondary (PWR) coolant concentrations using the guidance provided in ANSI/ANS 18.1-1999.
3. In the calculation, the reviewer will use the applicant's values as given in the SAR for the following parameters: design core thermal power level, steam flow rate, coolant mass, and coolant purification rates. Note: The source terms referenced in the section are used for both the review of the SAR and for the staff's environmental impact statement.
4. Review Procedures Specific to 10 CFR Part 52 Application Type
  - a. Early Site Permit Reviews

Subpart A to 10 CFR Part 52 specifies the requirements applicable to the Commission's review of an ESP application. Information required in an ESP application includes a description of the site characteristics and design parameters of the proposed site. The scope and level of detail of review of data parallel that used for a CP review.

For review of an ESP application, staff will evaluate the postulated design parameter associated with the normal operational source term.

In the absence of certain circumstances, such as a compliance or adequate protection issue, 10 CFR 52.39 precludes the staff from imposing new site characteristics, design parameters, or terms and conditions on the early site permit at the COL stage. Accordingly, the reviewer should ensure that all physical attributes of the site that could affect the design basis of SSCs important to safety are reflected in the site characteristics, design parameters, or terms and conditions on the early site permit.

b. Standard Design Certification Reviews

For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

c. Combined License Reviews

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

#### IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

Sufficient information has been provided by the applicant so that the requirements of 10 CFR Part 50, Sections 50.34 and 50.34a have been met. The reviewer responsible for review of effectiveness of radwaste systems will provide a summary statement on the acceptability of source terms used as design parameters for the waste management systems will be made under SAR Sections 11.2, "Liquid Waste Systems," and 11.3, "Gaseous Waste Systems."

The staff has reviewed the applicant's source term and has determined that the values are consistent with the guidance provided in ANSI/ANS-18.1-1999. The staff concludes that the source term is acceptable and that its use in calculating liquid and gaseous effluents will meet the regulatory requirements with respect to offsite radiation dose limits and effluent concentration limits.

For an ESP application, the finding to be made in SRP Sections 11.2 and 11.3 should be made such that Appendix I limits can be met.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

## V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

## VI. REFERENCES

1. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs)," current revision.
2. NUREG-0016, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWRs)," current revision.
3. Regulatory Guide 1.140, "Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."
4. Regulatory Guide 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors."
5. 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents."
6. 10 CFR Part 20, "Standards for Protection Against Radiation."
7. 10 CFR Part 50, Section 50.34, "Domestic Licensing of Production and Utilization Facilities - Contents of Applications; Technical Information."
8. 10 CFR Part 50, Section 50.34a, "Domestic Licensing of Production and Utilization Facilities - Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents - Nuclear Power Reactors."
9. Regulatory Guide 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluent from Light-Water-Cooled Power Reactors."
10. 10 CFR Part 50, Appendix A, General Design Criterion 60, "Control of Releases of Radioactive Materials to the Environment."

11. 10 CFR Part 50, Appendix A, General Design Criterion 61, "Fuel Storage and Handling and Radioactivity Control."
12. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combine Licenses for Nuclear Power Plants."
13. ANSI/ANS-18.1-1999, "American National Standard Radioactive Source Term for Normal Operation of Light Water Reactors."

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**PAPERWORK REDUCTION ACT STATEMENT**

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

**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.

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## **SRP Section 11.1**

### Description of Changes

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in (Draft) Revision 3, dated April 1996 of this SRP. See ADAMS accession number ML061520072.

In addition this SRP section was administratively updated in accordance with NRR Office Instruction, LIC-200, Revision 1, "Standard Review Plan (SRP) Process." The revision also adds standard paragraphs to extend application of the updated SRP section to prospective submittals by applicants pursuant to 10 CFR Part 52.

The following summarizes the changes in Revision 4, dated [Month] 2007.

1. Accepted the changes proposed by the April 1996 Draft Revision.
2. Updated review responsibilities throughout the document.
3. Incorporated generic paragraphs relating to ITAACs, certified designs, ESPs, and COLs.
4. Narrowed the scope of review to just the source term.

REVIEW RESPONSIBILITIES - Reflects changes in review branches resulting from reorganization and branch consolidation. Change is reflected throughout the SRP.

#### I. AREAS OF REVIEW

Incorporated the Review Interfaces section from draft Revision 3 - April 1996, changed to reflect current branches. Incorporated generic 10 CFR Part 52 paragraphs from template. Narrowed scope of review to source term only.

#### II. ACCEPTANCE CRITERIA

Incorporated Technical Rational section from draft Revision 3 - April 1996. Added additional information on acceptance criteria for the source term. Described the expected releases calculated from the source term must meet Commission regulations described in the SRP. Stated technical rational for the source term, separate from the source term for the radwaste treatment system.

Identified that for an Early Site Permit application, only Appendix I to 10 CFR Part 50 is applicable.

#### III. REVIEW PROCEDURES

Incorporated generic paragraphs relating to certified designs, ESPs, and COLs. Split the review procedures into those specifically for the source term and left the others that relate to the calculation of effluents as notes.

IV. EVALUATION FINDINGS

Incorporated generic paragraphs relating to 10 CFR Part 52. Also added specific references to SRP Sections 11.2 and 11.3. Added a boilerplate statement to be used in the safety evaluation.

V. IMPLEMENTATION

Incorporated reference to 10 CFR Part 52 from LIC-200.

VI. REFERENCES

Added 10 CFR 50.52 and ANSI/ANS-18.1-1999.