U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

12.2 RADIATION SOURCES

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of health physics issues

Secondary - None

I. AREAS OF REVIEW

The staff will review the applicant's preliminary safety analysis report (PSAR) for a construction permit (CP) or final safety analysis report (FSAR) for an operating license (OL), design certification (DC), or combined license (COL) as it relates to radiation sources in normal operations, anticipated operational occurrences, and accident conditions affecting inplant radiation protection.

The specific areas of review are as follows:

1. Contained Sources. The description of radiation sources, during normal operations and accident conditions in the plant, is used as the basis for designing the radiation protection program and for shield design calculations. (SAR Chapter 11 describes the sources contained in equipment of the radioactive waste management systems.) This description should include isotopic composition, location in the plant, source strength and source geometry, and the basis for the values (in the CP PSAR and updated in the OL FSAR, DC FSAR, or COL FSAR or, for sources not described in a referenced certified design, the COL FSAR). The descriptions should include any required radiation sources containing byproduct, source, and special nuclear materials.

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.

Requests for single copies of SRP sections (which may be reproduced) should be made to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Reproduction and Distribution Services Section, or by fax to (301) 415-2289; or by email to DISTRIBUTION@nrc.gov. Electronic copies of this section are available through the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/, or in the NRC's Agencywide Documents Access and Management System (ADAMS), at http://www.nrc.gov/reading-rm/adams.html, under Accession # MLxxxxxxxxx.

2. Airborne Radioactive Material Sources. The staff will review the description of airborne radioactive material sources in the plant considered in the design of the ventilation systems and used for the design of personnel protective measures and for dose assessment. (SAR Chapter 11 contains the description for airborne sources to be considered for their contribution to the plant effluent releases, through equipment of the radioactive waste management systems or the plant ventilation system.) This description should include a tabulation of the calculated concentrations of radioactive material, by nuclide, expected during normal operation, anticipated operational occurrences, and accident conditions for equipment cubicles, corridors, and operating areas normally occupied by operating personnel. It should also include models and parameters for the calculations (PSAR and updated in the OL FSAR, DC FSAR, or COL FSAR or, for sources not described in a referenced certified design, the COL FSAR).

3. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

4. 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

None

II. ACCEPTANCE CRITERIA

Requirements

The information provided in the SAR is acceptable if it meets the requirements of 10 CFR 50.34 and if it contains sufficient information identified in Section 12.2 of Regulatory Guide 1.70 (or RG 1.206 for COLs).

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

1. 10 CFR 20.1201, 10 CFR 20.1202, and 10 CFR 20.1206, as they relate to limiting occupational radiation doses

2. 10 CFR 20.1203 and 10 CFR 20.1204, as they relate to limiting average concentrations of airborne radioactive materials to protect individuals and control the intake (inhalation or absorption) of such materials

3. 10 CFR 20.1207, as it relates to limiting exposure to minors to one-tenth of limits for adults

4. 10 CFR 20.1301, as it relates to the determination of radiation levels and radioactive materials concentrations within the components of waste treatment systems

5. 10 CFR 20.1801, as it relates to securing licensed materials against unauthorized removal

6. General Design Criterion 61 found in Appendix A to 10 CFR Part 50, as it relates to systems that may contain radioactive materials

7. 10 CFR 50.34(f)(2)(vii) and General Design Criterion 19, as they relate to the acceptable radiation conditions in the plant under accident conditions, and the source term release assumptions used to estimate calculate those conditions[1].

   10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;

   10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

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.

The following regulatory guides, standards, and NUREGs provide information, recommendations, and guidance and in general describe a basis acceptable to the staff for

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[1]For Part 50 applicants not listed in 10 CFR 50.34(f), the provisions of 50.34(f) will be made a requirement during the licensing process.

implementing the requirements of 10 CFR 20.1201, 10 CFR 20.1202, 10 CFR 20.1203, 10 CFR 20.1204, 10 CFR 20.1206, 10 CFR 20.1207, 10 CFR 20.1301, and 10 CFR 20.1801:

1. Regulatory Guide 1.3[1], as it relates to assumptions used in evaluating gaseous concentrations of radionuclides in containment and plant systems following a loss-of-coolant accident, for boiling-water reactors (BWRs)

2. Regulatory Guide 1.4[1], as it relates to assumptions used in evaluating gaseous concentrations of radionuclides in containment and plant systems following a loss-of-coolant accident, for pressurized-water reactors (PWRs).

3. Regulatory Guide 1.183[2], as it relates to the assumptions used in evaluating the concentrations of radionuclides in containment and plant systems following a loss-of-coolant accident

4. Regulatory Guide 1.7, as it relates to methods for determining gaseous concentrations of radionuclides in containment following an accident

5. Regulatory Guide 1.112, as it relates to complying with the Commission's regulations under 10 CFR 20.1301 concerning the calculation of realistic radiation levels and radioactive materials source terms for the evaluation of waste treatment systems

6. NUREG-0737, Task Action Plan Item II.B.2, as it relates to the identification of specific postaccident sources of radiation in the facility

7. American National Standards Institute/American Nuclear Society (ANSI/ANS) Standard 18.1, as it relates to the establishment of typical long-term concentrations of principal radionuclides in fluid streams of light-water-cooled nuclear power plants

Compliance with the following specific acceptance criteria is necessary to meet the relevant requirements of the regulations identified above.

Descriptions should be provided for all radiation sources that require (1) shielding, (2) special ventilation systems, (3) special storage locations and conditions, (4) traffic or access control, (5) special plans or procedures, or (6) monitoring equipment. The source descriptions should include all pertinent information required for (1) input to shielding codes used in the design process, (2) establishment of related facility design features, (3) development of plans and procedures, and (4) assessment of occupational exposure.

For contained sources, the description should include plan scale drawings of each floor of the plant that show all sources identified so that they can easily be related to tables containing the pertinent and necessary quantitative source parameters. Their position should be located accurately, indicating the approximate size and shape. Neutron and gamma streaming into containment from the annulus between the reactor pressure vessel and the biological shield should be analyzed to determine the radiation fields that could occur in areas that may require occupancy. Relevant experience from operating reactors may be used. Airborne sources that

1: Regulatory Guides 1.3 and 1.4 provide guidance related to Technical Information Document (TID) 14844, "Calculation of Distance Factors for Power and Test Reactor Sites." This guidance is applicable to a holder of an operating license issued prior to January 10, 1997 or a holder of a renewed license under 10 CFR Part 54 whose initial operating license was issued prior to January 10, 1997. These license holders may voluntarily revise the accident source term.

2: Regulatory Guide1.183 is applicable to applicants or license holders issued after January 10, 1997.

are created by leakage, opening formerly closed containers, storage of leaking fuel elements, and other mechanisms should be identified by location and magnitude so that they can be used for designing appropriate ventilation systems and in specifying appropriate monitoring systems. Airborne radioactivity concentrations in frequently occupied areas should be a small fraction of the concentrations related to 10 CFR 20.1203, 10 CFR 20.1204, and Appendix B to 10 CFR Part 20. The assumptions made in arriving at quantitative values for these various sources should be specified, either in this section or by reference to SAR Chapter 11.

Shielding and ventilation design fission product source terms will be acceptable if developed using these bases:

- An offgas rate of 370 MBq/s (100,000 µCi/s) after a 30-minute delay for BWRs
- 0.25-percent fuel cladding defects for PWRs
- Postaccident shielding (for vital area access, including work in the area) source terms from NUREG-0737, Item II.B.2, or Regulatory Guide 1.183

Coolant and corrosion activation products source terms should be based on applicable reactor operating experience. The buildup of activated corrosion products in various components and systems should be addressed. Any allowances made in design source terms for the buildup of activated corrosion products should be explained. Neutron and prompt gamma source terms should be based on reactor core physics calculations and applicable reactor operating experience.

The tables of source parameters, which can be placed in SAR Chapter 12 or referenced to SAR Chapter 11, will be acceptable if the accompanying text either in this section or other referenced sections makes it clear how the values are used in a shield design calculation or in a ventilation system design. In addition, the quantities will be acceptable if the specific values given in the tables are consistent with ANSI/ANS Standard 18.1 and Regulatory Guide 1.112 for coolant and corrosion activation products source terms. For PWRs designed for the recycling of tritiated water, tritium concentrations in contained sources and airborne concentrations in the regions specified in item I.2 above should be based on a primary coolant concentration of 1.3x10 Bq/gm (3.5 µCi/gm).

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. Compliance with the referenced sections of 10 CFR Part 20 requires that the licensee control both occupational dose limits and dose limits to individual members of the public from radioactivity that may be received from both internal and external sources. The licensee must also maintain the security of licensed radioactive materials that are stored in controlled or unrestricted areas.

   Collectively, meeting these acceptance criteria ensures that all of the sources of radiation exposure to workers and members of the public resulting from the licensed activities (normal operations and anticipated operational occurrences) and to workers under accident conditions are identified, characterized, and considered in the design

and operation of the facility, consistent with the relevant requirements of 10 CFR Part 20 and 10 CFR Part 50.

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.

The reviewer will consider whether source strengths, concentrations of airborne radioactivity, and quantitative source descriptions are consistent with the assumptions made and the methods used by the applicant. The reviewer will examine locations of the contained sources relative to shield walls, occupied areas, traffic pathways, inservice inspection points, sampling stations, controls, and other parameters for special situations requiring additional action to ensure that occupational radiation exposure (ORE) will be as low as is reasonably achievable (ALARA). Based on the review, the staff may request additional information or ask the applicant to reevaluate the analysis and modify those areas that do not meet the acceptance criteria given in Subsection II of this SRP section.

1. 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.

   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).

2. For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

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.

1. The staff's review should verify that the SAR and its amendments contain sufficient information, in accordance with the provisions of Section 12.2 of Regulatory Guide 1.70 (RG 1.206 for COLs) and 10 CFR 50.34 to arrive at conclusions of the following type, which are to be included in the staff's safety evaluation report (SER). The report will include a summary of the applicant's submittal, the staff's basis for review and

acceptance criteria, and the findings of the review. The following is a brief representation of the evaluation findings:

A. The staff concludes that the information provided by the applicant with respect to radiation sources is acceptable and meets the requirements of 10 CFR Part 20 and General Design Criterion 61 in Appendix A to 10 CFR Part 50. This conclusion is based or the following rationale.

B. The applicant has described a facility that can meet the requirements of 10 CFR 20.1201, 10 CFR 20.1202, 10 CFR 20.1203, 10 CFR 20.1204, 10 CFR 20.1206, 10 CFR 20.1207, 10 CFR 20.1301, and 10 CFR 20.1801, as they relate to the evaluation of source terms and the related provisions of General Design Criterion 61 in Appendix A to 10 CFR Part 50 and supplemented by the guidance of Regulatory Guide 1.112, Regulatory Guide 1.183, NUREG-0737, and ANSI/ANS Standard 18.1.

C. The applicant has provided a description of contained and airborne radioactivity sources used as inputs for the dose assessment and for shielding and ventilation designs. The applicant also included its assumptions in arriving at quantitative values for these contained and airborne source terms, based on ANSI N237, Regulatory Guide 1.112, General Design Criterion 61, 10 CFR 20.1201, 10 CFR 20.1202, 10 CFR 20.1203, 10 CFR 20.1204, 10 CFR 20.1206, and 10 CFR 20.1207. For postaccident shielding for vital area access, the applicant used the source terms in NUREG-0737 and Regulatory Guide 1.183.

During power operation, the greatest potential for personnel dose is inside the containment from nitrogen-16, noble gases, and neutrons. Outside the containment, and after shutdown inside the containment, the primary sources of personnel exposure are fission products from fuel clad defects, and activation products, including activated corrosion products. The coolant and corrosion activation product source terms are based on operating experience from reactors of similar design; allowances are included for the buildup of activated corrosion products. Neutron and prompt gamma source terms are based on reactor core physics calculations and operating experience from reactors of similar design. Chapter 11 contains other parameters used, as well as a complete description of the routine operation source term development. The accident source terms are based on the NRC short-term lessons learned recommendation in NUREG-0737 and the alternate accident source term in Regulatory Guide 1.183. The source terms presented are comparable to estimates by other applicants with similar designs.

Almost all of the airborne radioactivity within the plant results from equipment leakage. The applicant has provided a tabulation of the maximum expected routine radioactive airborne concentrations in equipment cubicles, corridors, and operating areas because of equipment leakage. The bases for these leakage calculations are in accordance with Regulatory Guide 1.112.

The source terms used to develop these airborne concentration values are comparable to estimates by other applicants with similar designs, and are acceptable.

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.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

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.

The referenced regulatory guides contain the implementation schedules for conformance to parts of the method discussed herein.

VI. REFERENCES

1. 10 CFR Part 20, "Standards for Protection Against Radiation."

2. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

3. 10 CFR Part 52

4. General Design Criterion 61, "Fuel Storage and Handling and Radioactivity Control."

5. Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors."

6. Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors."

7. Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."

8. Regulatory Guide 1.112, "Calculations of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors."

9. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors."

10. ANSI/ANS Standard 18.1, "Source Term Specification," American National Standards Institute/American Nuclear Society.

11. NUREG-0737, "Clarifications of TMI Action Plan Requirements."

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.

SRP Section 12.2
Description of Changes

This SRP section updates Revision 2, dated July 1981 of this SRP. See ADAMS accession number ML052350047.

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 technical changes are incorporated in Revision 3, dated [Month] 2007:

1. Updated references to 10 CFR 20 to reflect current paragraph numbering. The entire 10 Part 20 was re-numbered in 1993 revision.

2. Revised text to reflect current 10 CFR 20 requirements. Examples include; added references to a) occupational dose limits for minors, b) dose limits for members of the public, and c) the determination of dose from internally deposited radionuclides.

3. Added wording to make SRP section applicable to Design Certifications (DC) and Combined Operating License (COL) reviews.

4. Deleted references to specific (outdated) NRR organizational units.

5. Updated references to the TMI Lessons Learned Action Items, and included reference to the corresponding requirements in 10 CFR 50.34(f).

6. Added references to current 10 CFR 20 requirements applicable to the control or radioactive sources (i.e., 20.1601, 1602, 1701, and 1802) to the list in the "Evaluation Findings" section.

7. Removed redundant text in the "Evaluation Findings" section.