U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

12.2 RADIATION SOURCES

REVIEW RESPONSIBILITIES

Primary - ~~Radiological Assessment Branch (RAB)~~Emergency Preparedness and Radiation Protection Branch (PERB)[1]

Secondary - None

I. AREAS OF REVIEW

The following areas of the applicant's safety analysis report (SAR) are reviewed, as they relate to radiation sources in normal operations, anticipated operational occurrences, and accident conditions, affecting inplant radiation protection:

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 contains the description for 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 preliminary safety analysis report (PSAR), and update in the final safety analysis report (FSAR). The descriptions should include any required radiation sources containing byproduct, source, and special nuclear materials.

2. Airborne Radioactive Material Sources

The description of airborne radioactive material sources in the plant considered in the design of the ventilation systems, and used for 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, and should include models and parameters for the calculations (PSAR and update in FSAR).

For those areas of review identified as part of the primary responsibility of other branches, the acceptance criteria and methods of application are contained in the referenced SRP section.[2]

II. ACCEPTANCE CRITERIA

The information provided in the SAR is acceptable if it meets the requirements of 10 CFR Part 50, §50.34 and if it contains sufficient information identified in Section 12.2 of Regulatory Guide 1.70, so that the relevant requirements of the following regulations are met:

1. 10 CFR Part 20, ~~§20.101 - "Exposure of individuals to radiation in restricted areas,"~~§20.1201 - "Occupational dose limits for adults," 20.1202 - "Compliance with requirements for summation of external and internal doses," and §20.1206 - "Planned special exposures,"[3] as it relates to limiting radiation doses to protect individuals in restricted areas from whole or partial body exposures.

2. 10 CFR Part 20, ~~§20.103 - "Exposure of individuals to concentrations of radioactive materials in air, in restricted areas,"~~§20.1203 - "Determination of external dose from airborne radioactive material," and §20.1204 - "Determination of internal exposure,"[4] as it relates to limiting average concentrations of airborne radioactive materials to protect individuals in restricted areas, and addresses control of inhalation or absorption of such materials.

3. 10 CFR Part 20, ~~§20.104 - "Exposure of minors,"~~§20.1207 - "Occupational dose limits for minors,"[5] as it relates to limiting exposure to minors to one-tenth of limits for adults.

4. 10 CFR Part 20, ~~§20.106 - "Concentrations in effluents to unrestricted areas,"~~§20.1301 - "Dose limits for individual members of the public,"[6] as it relates to determination of radiation levels and radioactive materials concentrations within the components of waste treatment systems.

5. 10 CFR Part 20, ~~§20.207 - "Storage of licensed materials,"~~§20.1801 - "Security of stored material,"[7] as it relates to securing licensed materials against unauthorized removal.

6. 10 CFR Part 50, General Design Criterion 61 - "Fuel storage and handling and radioactivity control," as it relates to systems which may contain radioactive materials.

The following Regulatory Guides and NUREGs provide information, recommendations, and guidance, and in general describe a basis acceptable to the staff for implementing the requirements of 10 CFR Part 20, ~~§20.101, §20.103, §20.104, §20.106, and §20.207~~§20.1201, §20.1202, §20.1203, §20.1204, §20.1206, §20.1207, §20.1301, and §20.1801[8].

1. Regulatory Guide 1.3, "Assumption Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors," as it relates to assumptions used in evaluating gaseous concentrations of radionuclides in containment and plant systems, following a loss-of-coolant accident for BWRs.

2. Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors," as it relates to assumptions used in evaluating gaseous concentrations of radionuclides in containment and plant systems, following a loss-of-coolant accident for PWRs.

3. Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident," as it relates to methods for determining gaseous concentrations of radionuclides in containment following an accident.

4. Regulatory Guide 1.112 "Calculation of Releases of Radioactive Materials in Gaseous and Liquid effluents from Light-Water-Cooled Power Reactors," as it relates to complying with the Commission's regulations with regard to 10 CFR Part 20, ~~§20.106~~§20.1301[9], concerning the calculation of realistic radiation levels and radioactive materials source terms for the evaluation of waste treatment systems.

5. NUREG-0718 and NUREG-0737, Task Action Plan item II.B.2, as they relate to identification of specific post-TMI requirements which have been approved by the Commission for implementation at reactors.

6. ANSI N237-1976 "Source Term Specification,"[10] as it relates to the establishment of typical long-term concentrations of principal radionuclides in fluid streams of light-water-cooled nuclear power plants.

Specific acceptance criteria necessary to meet the relevant requirements of the regulations identified above are as follows:

All radiation sources which require

(1) shielding
(2) special ventilation systems
(3) special storage locations and conditions
(4) traffic or access control
(5) special plans or procedures
(6) monitoring equipment

shall be described. That source description shall include all pertinent information required for

(1) input to shielding codes used in the design process
(2) establishing related facility design features
(3) plans and procedures development
(4) assessment of occupational exposure.

For contained sources, the description should include plan scale drawings of each floor of the plant on which all sources are shown and identified in a manner that 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 are created by leakage, by opening formerly closed containers, by storage of leaking fuel elements, etc., shall be identified by location and magnitude, in a manner useful for designing appropriate ventilation systems and in specifying appropriate monitoring systems. Airborne radioactivity concentrations in frequently occupied areas will be a small fraction of 10 CFR Part 20, ~~§20.103~~§20.1203 and §20.1204[11], Appendix B concentrations. The assumptions made in arriving at quantitative values for these various sources should be specified, either in this section or by reference to Chapter 11 of the SAR.

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

(1) an offgas rate of 370 MBq/sec (100,000 µCi/sec)[12] after 30 minutes delay for BWRs.

(2) 0.25% fuel cladding defects for PWRs.

(3) Post-accident shielding for vital area access, including work in the area, source terms from Task Action Plan Item II.B.2 of NUREG-0718 and 0737.

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 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 Chapter 12 or referenced to 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 N237[13] and Regulatory Guide 1.112, for coolant and corrosion activation products source terms. For PWRs designed for 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 1.3×10^{14} Bq/gm (3.5 µCi/gm)[15].

~~Using the methods listed in Section II.B.2 of NUREG-0718, applicants with CP reviews already underway shall (1) perform radiation and shielding design reviews of spaces around systems that may contain highly radioactive fluids in the event of an accident and (2) implement plant designs or design modifications necessary to permit adequate access to vital areas. Applicants shall, to the extent possible, provide preliminary design information at a level consistent with that normally required at the construction permit stage of review. New applicants~~Applicants[16] for CPs shall provide a general discussion of their approach to meeting the requirements by specifying the design concept selected and the supporting design bases and criteria. Applicants shall also demonstrate that the design concept is technically feasible and within the state of the art, and that there exists reasonable assurance that the requirements will be implemented properly prior to the issuance of operating licenses.

Using the methods listed in Section II.B.2 of NUREG-0737, applicants for OLs shall (1) perform a radiation and shielding design review that identifies the location of vital areas and equipment in which personnel occupancy may be unduly limited during operations following an accident resulting in a degraded core, and (2) provide a description of the types of corrective actions needed to assure adequate access to vital areas and protection of safety equipment.

Technical Rationale[17]

The technical rationale for application of the above acceptance criteria is discussed in the following paragraphs.[18]

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, and maintain security of licensed radioactive materials that are stored in controlled or unrestricted areas.

   Collectively, the referenced sections of 10 CFR Part 20 set forth the limits on the amount of radioactive material that may be received by individuals in restricted areas as well as individual members of the public. The referenced sections direct the meeting of these limits by limiting the concentrations of radioactive materials, i.e., source terms, in restricted and unrestricted areas. Finally, the referenced sections address security of stored licensed radioactive materials.

   Meeting the requirements of the referenced sections of 10 CFR Part 20 will provide a level of assurance that exposure to radioactivity will be controlled such that individual workers and members of the public will not be receive radiation levels exceeding the limits specified in 10 CFR Part 20.[19]

2. Compliance with GDC 61 requires that systems which may contain radioactivity shall be designed to assure adequate safety under normal and postulated accident conditions. This criterion specifies that such systems be designed with appropriate containment, confinement, and filtering systems.

The requirements of this GDC apply to this SRP because systems and components that contain radioactive material are a potential source of exposures to individual workers and members of the public both as a consequence of normal operation and accidents.

Meeting the requirement of GDC 61 provides a level of assurance that releases of radioactive materials during normal operation and during anticipated operational occurrences will not result in radiation doses that exceed the limits specified in 10 CFR Part 20. In addition, meeting the requirement will help assure that the system will continue to perform its safety function(s) under postulated accident conditions.[20]

III. REVIEW PROCEDURES

The reviewer determines whether the source term design bases are consistent with the acceptance criteria, and whether source strengths, concentrations of airborne radioactivity, and quantitative source descriptions are consistent with the assumptions made and the methods used by the applicant. Locations of the contained sources relative to shield walls, occupied areas, traffic pathways, inservice inspection points, sampling stations, controls, etc., are examined for special situations requiring additional action to assure that occupational radiation exposures (ORE) will be as low as is reasonably achievable (ALARA). Based on the review, ~~RAB~~PERB[21] may request additional information or request the applicant to reevaluate the analysis for the purpose of modifying those areas which do not meet the acceptance criteria given in subsection II of this SRP section.

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[22]

IV. EVALUATION FINDINGS

The staff's review should verify that sufficient information is contained in the SAR and amendments, in accordance with the provisions of Section 12.2 of Regulatory Guide 1.70 and 10 CFR Part 50, §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.

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 10 CFR Part 50, General Design Criterion 61. This conclusion is based or the following:

The applicant has described a facility that can meet the requirements of 10 CFR Part 20, ~~§20.101, §20.103, §20.104, §20.106, and §20.207~~§20.1201, §20.1202, §20.1203, §20.1204, §20.1206, §20.1207, §20.1301, and §20.1801[23] as they relate to evaluation of

source terms and the related provisions of 10 CFR Part 50, GDC 61, and supplemented by the guidance of Regulatory Guide 1.112, NUREG-0718, NUREG-0737, and ANSI Standard N237-1976.

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. Also included are the applicant's 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, and 10 CFR Part 20, ~~§20.101, §20.103 and §20.104~~§20.1201, §20.1202, §20.1203, §20.1204, §20.1206, §20.1207[24]. For post-accident shielding for vital area access, the source terms in NUREG-0737 were used.

During power operation, the greatest potential for personnel dose during operation is inside the containment due to 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. Other parameters used, as well as a complete description of the routine operation source term development, are contained in Chapter 11. The accident source terms are based on NRC Short-Term Lessons Learned recommendation in NUREG-0737. The source terms presented are comparable to estimates by other applicants with similar designs.

Almost all of the airborne radioactivity within the plant is due to equipment leakage. The applicant has provided a tabulation of the maximum expected routine radioactive airborne concentrations in equipment cubicles, corridors, and operating areas, due to 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 design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[25]

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[26] Except in those cases in which the applicant proposes an acceptable alternative method for complying with

specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[27]

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

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

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

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

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

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

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

7. ANSI-N237, Final Draft by Working Groups 18.1, "Source Term Specification," American National Standards Institute.

8. NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License."

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

SRP Draft Section 12.2
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB name and abbreviation	Editorial change made to reflect current PRB name, Emergency Preparedness and Radiation Protection Branch, and abbreviation, PERB.
2.	Editorial	Added standard paragraph noting the location of acceptance criteria and description of methods of application for those areas of review identified as the primary responsibility of other branches.
3.	Integrated Impact No. 1419	Replaced reference to 10 CFR Part 20, 20.101 with 10 CFR Part 20, 20.1201, 20.1202, and 20.1206.
4.	Integrated Impact No. 1419	Replaced reference to 10 CFR Part 20, 20.103 with 10 CFR Part 20, 20.1203 and 20.1204.
5.	Integrated Impact No. 1419	Replaced reference to 10 CFR Part 20, 20.104 with 10 CFR Part 20, 20.1207.
6.	Integrated Impact No. 1419	Replaced reference to 10 CFR Part 20, 20.106 with 10 CFR Part 20, 20.1301.
7.	Integrated Impact No. 1419	Replaced reference to 10 CFR Part 20, 20.207 with 10 CFR Part 20, 20.1801.
8.	Integrated Impact No. 1419	Replaced references to sections of 10 CFR Part 20 with revised references.
9.	Integrated Impact No. 1419	Replaced reference to 10 CFR Part 20, 20.106 with 10 CFR Part 20, 20.1301.
10.	Integrated Impact No. 525	The reference to ANSI N237-1976 needs to be updated to ANS 18.1, provided that comparison of the two versions supports the update of the citation.
11.	Integrated Impact No. 1419	Replaced reference to 10 CFR Part 20, 20.103 with 10 CFR Part 20, 20.1203 and 20.1204.
12.	SRP-UDP format item	Added SI units for µCi/sec.
13.	Integrated Impact No. 525	The reference to ANSI N237-1976 needs to be updated to ANS 18.1, provided that comparison of the two versions supports the update of the citation.
14.	SRP-UDP format item	Added SI units for µCi/gm.
15.	Editorial	Deleted sentences referencing active CP reviews because none are currently in that status.
16.	SRP-UDP format item	"Technical Rationale" added to "ACCEPTANCE CRITERIA" subsection to describe the bases for referencing 10 CFR Part 19, 19.12 and 10 CFR Part 20, 20.1101.

Item	Source	Description
17.	SRP-UDP format item	Added lead-in sentence for "Technical Rationale."
18.	SRP-UDP format item	Added Technical Rationale for 10 CFR Part 20.
19.	SRP-UDP format item	Added Technical Rationale for GDC 61.
20.	Current PRB abbreviation	Editorial change made to reflect current PRB abbreviation, PERB.
21.	SRP-UDP format item	Added reference to design certification reviews.
22.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
23.	Integrated Impact No. 1419	Replaced references to sections of 10 CFR Part 20 with revised references.
24.	SRP-UDP format item	Added reference to design certification reviews.
25.	SRP-UDP Format Item, Implement 10 CFR 52 Related Changes	To address design certification reviews a new paragraph was added to the end of the Evaluation Findings. This paragraph addresses design certification specific items including ITAAC, DAC, site interface requirements, and combined license action items.
26.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
27.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.

Integrated Impact No.	Issue	SRP Subsections Affected
525	Revise SRP Subsections to replace citations of superseded sections of 10 CFR Part 20.	Subsection II, ACCEPTANCE CRITERIA, first paragraph, subitem 1. Subsection II, ACCEPTANCE CRITERIA, first paragraph, subitem 2. Subsection II, ACCEPTANCE CRITERIA, first paragraph, subitem 3. Subsection II, ACCEPTANCE CRITERIA, first paragraph, subitem 4. Subsection II, ACCEPTANCE CRITERIA, first paragraph, subitem 5. Subsection II, ACCEPTANCE CRITERIA, second paragraph. Subsection II, ACCEPTANCE CRITERIA, second paragraph, subitem 4. Subsection II, ACCEPTANCE CRITERIA, fourth paragraph. Subsection IV, EVALUATION FINDINGS, first paragraph. Subsection IV, EVALUATION FINDINGS, second paragraph.