U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

15.0.3 DESIGN BASIS ACCIDENT RADIOLOGICAL CONSEQUENCE ANALYSES FOR ADVANCED LIGHT WATER REACTORS

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of design basis accident radiological consequence analyses

Secondary - Organization responsible for the review of meteorology

I. AREAS OF REVIEW

Chapter 15 of the SRP discusses the analysis of postulated accidents that could affect the safe design and siting of an advanced light-water reactor (LWR). The staff reviews information presented by the applicant for a construction permit (CP), operating license (OL), standard design certification (DC), early site permit (ESP), or combined operating license (COL) concerning radiological consequence analyses for postulated design basis accidents. This SRP section applies to reviews performed for each of these types of applications. The review covers the following specific areas:

1. CP, OL, DC or COL Applications. For a CP, OL, DC or COL application, the staff reviews the radiological consequences of potential design basis accidents (DBAs) in six parts: (1) review of selected bounding design basis accidents, (2) review of accident source terms, (3) review of the major structures, systems, and components of the facility that are intended to mitigate the radiological consequences of a DBA, (4) review of the

characteristics of fission product releases from the proposed site (for CP, OL and COL reviews) or reference site (for the DC review) to the environment, (5) review of the meteorological characteristics of the proposed site for the CP, OL or COL review (reference site for DC review), and (6) review of the total calculated radiological consequence dose at the exclusion area boundary (EAB), low population zone (LPZ) and control room from the bounding DBAs. In support of the SRP Section 13.3 emergency planning review, the staff also reviews the dose analysis performed to demonstrate technical support center (TSC) habitability.

The application must contain sufficient nuclear plant design information for the staff to review in making a determination regarding the acceptability of the proposed site using the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and General Design Criterion (GDC) 19.

2. ESP Applications that Reference Standard Reactor Designs Certified by NRC. Standard reactor designs are certified with a postulated set of short-term atmospheric relative concentration (χ/Q) values at an EAB and LPZ in lieu of site-specific meteorological data and actual distances to the EAB and LPZ. The NRC has determined, for purposes of the ESP review, that the certified standard reactor designs meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1), provided that the site parameters fall within those postulated in the design certification.

3. ESP Applications that Use the Plant Parameter Envelope (PPE) Approach. A PPE is a set of plant design parameters that are expected to bound the characteristics of a reactor or reactors that may be constructed at a site, and it serves as a surrogate for actual reactor design information. The PPE values are selected by the applicant to bound a range of possible current and future reactor designs. The PPE values and associated information in the ESP application must contain sufficient information for the staff to make a determination regarding the acceptability of the proposed site using the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1).

4. ESP Applications that Neither Reference the Standard Reactor Designs Certified by NRC Nor Use the PPE Approach. Applications may be received that neither reference a certified design nor use the PPE approach. For example, an application may reference a “standard” design that is not yet certified, or a custom design. In such cases, the staff reviews the radiological consequences of potential DBAs in six parts: (1) review of selected bounding design basis accidents, (2) review of accident source terms, (3) review of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site for mitigating the radiological consequences of a DBA under the radiological consequence evaluation, (4) review of the characteristics of fission product release from the site to the environment, (5) review of the meteorological characteristics of the proposed site, and (6) review of the total calculated radiological consequence dose at the EAB and LPZ from the bounding DBAs.

   The application must contain sufficient nuclear plant design information for the staff to review in making a determination regarding the acceptability of the proposed site using the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1).

5. COL Applications that Reference Standard Reactor Designs Certified by NRC and ESP Issued by NRC. Should the site characteristic short-term χ/Q values specified in the

ESP fall within the postulated short-term χ/Qs for the chosen certified design, the staff concludes that the COL applicant has satisfied the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1). However, the application must contain sufficient information regarding control room habitability for the staff to make a determination regarding the acceptability of the proposed control room design using the radiological dose acceptance criteria specified in GDC 19.

6. COL Applications that Reference an ESP Issued by NRC but not a Certified Standard Reactor Design by NRC. The staff reviews the radiological consequences of potential DBAs in five parts: (1) review of selected bounding design basis accidents, (2) review of accident source terms, (3) review of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site for mitigating the radiological consequences of a DBA under the radiological consequence evaluation, (4) review of the characteristics of fission product release from the site to the environment, and (5) review of the total calculated radiological consequence dose at the EAB and LPZ from the bounding DBAs to determine whether the applicable regulations in 10 CFR 50.34(a)(1) and GDC 19 regarding dose consequence evaluation factors have been met.

7. COL Applications that Reference a Certified Standard Reactor Design by NRC but not an ESP Issued by NRC. The staff evaluates the site-specific short-term χ/Qs for the selected site and uses the site-specific χ/Qs and the source term determined in the certified design to determine whether the applicable regulations in 10 CFR 50.34(a)(1) regarding dose consequence evaluation factors have been met. The application must contain sufficient information regarding control room habitability for the staff to make a determination regarding the acceptability of the proposed control room design using the radiological dose acceptance criteria specified in GDC 19.

8. 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. For DC applications and COL applications referencing a DC rule or DC application, review of the site parameters in the Design Control Document (DCD) Tier 1 and Chapter 2 of the DCD Tier 2[1] submitted by the applicant is performed under SRP Section 2.0, "Site Characteristics and Site Parameters."

[1]Additional supporting information of prior DC rules may be found in DCD Tier 2 Section 14.3.

2. Review of the short-term χ/Q values for use in the DBA radiological consequences analyses is performed under SRP Section 2.3.4, "Short-Term Dispersion Estimates for Accidental Atmospheric Releases."

3. Review of the coolant radioactivity source terms for non-LOCA accidents is performed under SRP Section 11.1, "Source Terms."

4. Review of the provisions for protection of the control room from radiation and habitability during an emergency is performed under SRP Section 6.4, "Control Room Habitability System." A similar review of TSC habitability is performed in support of SRP Section 13.3, "Emergency Planning."

5. Review of the emergency safety features (ESFs) ventilation and filtration systems that are designed to remove fission products is performed under SRP Section 6.5.1, "ESF Atmosphere Cleanup Systems."

6. Review of the fission product removal capability of containment spray systems is performed under SRP Section 6.5.2, "Containment Spray as a Fission Product Cleanup System."

7. Review of the analysis modeling of fission product removal capability for plant systems and structures is performed under SRP Section 6.5.3, "Fission Product Control Systems and Structures."

8. If a plant design includes an ice condenser in the containment, the review of the fission product removal capability of the ice condenser is performed under SRP Section 6.5.4, "Ice Condenser as a Fission Product Cleanup System."

9. The review of the fission product removal capability of a BWR pressure suppression pool is performed under SRP Section 6.5.5, "Pressure Suppression Pool as a Fission Product Cleanup System."

10. For review of DC applications, CPs and OLs, and COLs or ESPs referencing an advanced light-water reactor design, this SRP section supersedes the radiological analyses, assumptions, acceptance criteria, and methodologies identified in the SRP sections (with appendices) listed below. Provisions related to the nonradiological analysis aspects of these SRP sections remain applicable.

    A. Section 15.1.5, "Steam System Piping Failures Inside and Outside of Containment (PWR)"

    B. Sections 15.3.3-15.3.4, "Reactor Coolant Pump Rotor Seizure and Reactor Coolant Pump Shaft Break"

    C. Section 15.4.8, "Spectrum of Rod Ejection Accidents (PWR)"

    D. Section 15.4.9, "Spectrum of Rod Drop Accidents (BWR)"

    E. Section 15.6.2, "Radiological Consequences of the Failure of Small Lines Carrying Primary Coolant Outside Containment"

F. Section 15.6.3, “Radiological Consequences of Steam Generator Tube Failure (PWR)”

G. Section 15.6.4, “Radiological Consequences of Main Steam Line Failure Outside Containment (BWR)”

H. Section 15.6.5, “Loss-of-Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant System Pressure Boundary”

I. Section 15.7.4, “Radiological Consequences of Fuel Handling Accidents”

J. Section 15.7.5, “Spent Fuel Cask Drop Accidents”

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

II. ACCEPTANCE CRITERIA

Requirements

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

1. Section 50.34(a)(1) of 10 CFR Part 50, “Contents of applications; technical information,” as it relates to the evaluation and analysis of the offsite radiological consequences of postulated accidents with fission product release.

2. General Design Criterion (GDC) 19 of Appendix A to 10 CFR Part 50, “Control room,” as it relates to maintaining the control room in a safe condition under accident conditions by providing adequate protection against radiation.

3. Section 100.21 of 10 CFR Part 100, “Non-seismic siting criteria,” as it relates to the evaluation and analysis of the radiological consequences of postulated accidents for the type of facility to be located at the site in support of evaluating the site atmospheric dispersion characteristics.

4. Paragraph IV.E.8 of Appendix E, to 10 CFR Part 50, “Emergency Planning and Preparedness for Production and Utilization Facilities,” as it relates to adequate provisions for an onsite technical support center (TSC) from which effective direction can be given and effective control can be exercised during an emergency.

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.

1. Offsite Radiological Consequences of Postulated Design Basis Accidents. The acceptance criteria are based on the requirements of 10 CFR 50.34(a)(1) as related to mitigating the radiological consequences of an accident in accordance with 10 CFR 52.17(a)(1) [early site permits], 10 CFR 52.47(a)(1) [standard design certifications] and 10 CFR 52.79(b) [combined licenses].

   The plant design features intended to mitigate the radiological consequences of accidents, site atmospheric dispersion characteristics and the distances to the exclusion area boundary (EAB) and to the low population zone (LPZ) outer boundary are acceptable if the total calculated radiological consequences for the postulated fission product release fall within the following exposure acceptance criteria specified in 10 CFR 50.34(a)(1)(ii)(D):

   A. An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, would not receive a radiation dose in excess of 25 rem total effective dose equivalent (TEDE), and

   B. An individual located at any point on the outer boundary of the LPZ, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage), would not receive a radiation dose in excess of 25 rem TEDE.

   For CP, OL, DC and COL reviews, the application is acceptable with regard to the radiological consequences of analyzed DBAs if the calculated TEDEs at the EAB and the LPZ outer boundary do not exceed the dose acceptance criteria listed in Table 1 below.

   For ESP applications that neither reference the standard reactor designs certified by NRC nor use the PPE approach, the staff may establish dose acceptance criteria lower than those stated above for certain DBAs based on the probability of occurrence. Examples of such criteria are illustrated in Table 1.

   For COL applications using an ESP with a PPE approach, these acceptance criteria may be applied at that time. Such applicants bear the burden of ensuring sufficient margin is provided in the design parameters (for example, PPE values) in the ESP application to compensate for uncertainty in those parameters. The margin should be large enough such that the actual design submitted at the COL stage, coupled with the site characteristics as described in the ESP, will comply with NRC regulations.

2. Control Room Radiological Habitability. The acceptance criterion is based on the requirements of GDC 19 that mandate a control room design providing adequate radiation protection to permit access and occupancy of the control room under accident conditions for the duration of the accident, without personnel receiving radiation exposures in excess of 5 rem whole body, or its equivalent to any part of the body, for the duration of the accident. These requirements are incorporated by reference in 10 CFR 52.47(a)(1) [standard design certifications] and 10 CFR 52.79(b) [combined licenses].

   The radiation protection design of the control room is acceptable if the total calculated radiological consequences for the postulated fission product release fall within the

exposure acceptance criteria specified in GDC 19 of 5 rem TEDE for the duration of the accident.

3. Technical Support Center Radiological Habitability. This acceptance criterion is based on the requirement of Paragraph IV.E.8 of Appendix E to 10 CFR Part 50 to provide an onsite TSC from which effective direction can be given and effective control can be exercised during an emergency. The radiation protection design of the TSC is acceptable if the total calculated radiological consequences for the postulated fission product release fall within the exposure acceptance criteria specified for the control room of 5 rem TEDE for the duration of the accident.

Table 1
Accident Dose Criteria

Accident or Case	EAB and LPZ Dose Criteria	Analysis Release Duration
LOCA	25 rem TEDE	30 days for all leakage pathways
BWR Main Steam Line Break		Instantaneous puff, until MSIV isolation
Fuel Damage or Pre-incident Spike	25 rem TEDE	
Equilibrium Iodine Activity	2.5 rem TEDE	
BWR Rod Drop Accident	6.3 rem TEDE	24 hours
Small Line Break Accident	2.5 rem TEDE	Until isolation, if capable, or until cold shutdown is established
PWR Steam Generator Tube Rupture		Affected SG: time to isolate; Unaffected SG(s): until cold shutdown is established
Fuel Damage or Pre-incident Spike	25 rem TEDE	
Coincident Iodine Spike	2.5 rem TEDE	
PWR Main Steam Line Break		Until cold shutdown is established
Fuel Damage or Pre-incident Spike	25 rem TEDE	
Coincident Iodine Spike	2.5 rem TEDE	
PWR Locked Rotor Accident	2.5 rem TEDE	Until cold shutdown is established
PWR Rod Ejection Accident	6.3 rem TEDE	30 days for containment leakage pathway; Until cold shutdown is established for secondary pathway
Fuel Handling Accident or Cask Drop	6.3 rem TEDE	2 hours

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 10 CFR 50.34(a)(1) ensures that the safety analysis report (SAR) includes a description and safety assessment of the standard design, custom design

and/or site on which the facility is to be located. The review performed under this SRP section ensures that the SAR contains a sufficient description of the design basis accident radiological consequences analyses that will enable the staff to evaluate the planned site and provide reasonable assurance that plant design and operation will reflect site considerations in a manner adequate to minimize the consequences of an accident.

The dose acceptance criteria in Table 1 of this SRP section are fractions of the 10 CFR 50.34(a)(1) dose reference values for accidents other than the LOCA, as has been done historically. For events having a moderate frequency of occurrence, any release of radioactive material must be such that the calculated offsite doses are a small fraction of the 10 CFR 50.34(a)(1) reference values. A small fraction is defined as less than 10% of the 10 CFR 50.34(a)(1) reference values, or 2.5 rem TEDE. The plant site and dose mitigating engineered safety features are acceptable with respect to the radiological consequences of a postulated control rod drop accident (BWR), control rod ejection accident (PWR), fuel handling accident or cask drop accident if the calculated offsite doses are well within the dose reference values in 10 CFR 50.34(a)(1). "Well within" is defined as 25% of the 10 CFR 50.34(a)(1) reference values, or 6.3 rem TEDE.

2. Compliance with the radiological provision of GDC 19 provides assurance that control of the plant is maintained during emergency operation. The applicant is required to maintain the control room in a safe condition under accident conditions, including loss-of-coolant accidents, and provide adequate radiation protection to permit access and occupancy of the control room under accident conditions for the duration of the accident. The review performed under this SRP section for CPs, OLs, DCs and COLs determines if the design of the control room is acceptable with respect to the radiological consequences of design basis accidents.

3. 10 CFR 100.21 requires that radiological dose consequences of postulated accidents meet the requirements of 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site. Compliance with 10 CFR Part 100 provides assurance that the consequences of an accident on the proposed site will be within acceptable levels. The review performed under this SRP section for CPs, OLs, COLs and ESPs determines if the site is acceptable with respect to the radiological consequences of design basis accidents.

4. Paragraph IV.E.8 of Appendix E, to 10 CFR Part 50, requires that onsite emergency facilities be provided, from which effective direction can be given and effective control can be exercised during an emergency. NUREG-0737 III.A.1.2, Emergency Response Facilities, describes requirements for maintaining emergency facilities in a safe, habitable condition under accident conditions by providing adequate protection against radiation and toxic gases. In particular, the TSC should provide the same level of protection against radiation that the control room provides, for the duration of the event. The radiological consequences analysis for the TSC is performed under this section to support the Section 13.3 review for acceptability of the TSC.

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.

For reviews of OL applications, these procedures are used to verify that the data and analyses remain valid and that the facility's design specifications are consistent with these data. As applicable, reviews of OLs and COLs include a determination that the content and intent of technical specifications related to the plant features intended to mitigate the radiological consequences of postulated design basis accidents are acceptable and consider any identified unique conditions.

1. ESP applications that reference standard reactor designs certified by NRC

   A. In the evaluation using Section 2.3.4 of this standard review plan, the staff reviews the applicant's meteorological data, inputs, assumptions, and dispersion model used to estimate the site-specific short-term atmospheric dispersion estimate (χ/Q) values in the ESP application.

   B. The staff compares the site-specific short-term χ/Q values in the ESP application with short-term χ/Q values postulated in the reactor design certification.

   C. If the site-specific short-term χ/Q values fall within those postulated in the design certification, no further radiological consequence evaluation is needed.

   D. If the site-specific short-term χ/Q values exceed those postulated in the design certification, the staff verifies that the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using the applicant's site-specific short-term χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1).

   NOTE: At the COL stage, the staff verifies that no changes from the site-specific short-term χ/Q values specified in the ESP application have occurred due to changes in plant design, plant location on the site, building orientation, or fission product release points. The staff performs independent confirmatory radiological consequence dose calculations using the site-specific short-term χ/Q values and the source term provided in the certified reactor design control document to determine the resulting radiological consequences at the EAB and LPZ for public information and to supplement the design basis.

   NOTE: Also the COL stage, the staff determines that the radiation protection design of the control room is acceptable if the total calculated radiological consequences for the postulated fission product release fall within the exposure acceptance criteria specified in GDC 19 of 5 rem TEDE for the duration of the accident.

2. ESP applications that use the PPE approach

   A. The staff reviews the proposed PPE values to determine whether the set of PPE values is sufficient to enable the staff to conduct its evaluation of the radiological consequences. The PPE values should be found not unreasonable for

consideration in the staff's findings regarding compliance with Subpart A of 10 CFR Part 52.

B. To enable the staff to perform its independent radiological consequence analyses, the PPE values should include, but are not limited to, the following design basis accident source term parameters:

   i. The isotopic quantities of fission products released in curies to the environment from the site.

   ii. Rates of fission product release to the environment from the site as a function of time.

C. The staff reviews the following information if available: (1) the timing and rate of fission product release from the fuel and (2) the isotopic quantities and the chemical forms of fission products released from the fuel, following selected bounding DBAs. This information will help the staff determine whether the proposed PPE values are not unreasonable. The fission product release rates should be fractions of fission product inventory in the reactor core at the ultimate maximum power level.

D. In the evaluation using Section 2.3.4 of this standard review plan, the staff reviews the site-specific short-term χ/Q values determined by the applicant and performs an independent evaluation of atmospheric dispersion.

E. The staff performs independent confirmatory radiological consequence analyses using the docketed PPE values and the site-specific short-term χ/Q values provided in the ESP application to determine whether the proposed site meets the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) at the nearest EAB and LPZ outer boundary as described in Chapter 2 of the site safety assessment.

F. For the methodology and assumptions for calculating the radiological consequences of postulated accidents, the staff will use, where applicable, the regulatory positions stated in Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors".

NOTE: If a COL application references a certified design and an ESP that referenced a PPE, the staff reviews (at the COL stage) the site-specific short-term χ/Q values specified in the ESP to confirm that the site-specific short-term χ/Q values are bounded by those short-term χ/Q values postulated in the reactor design certification based on the proposed plant design, the plant location on the site, and the fission product release points.

In the event that the site-specific short-term χ/Q values exceed the bounds of those postulated in the referenced design certification, the staff verifies that the COL applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site-specific χ/Q values continue to meet the radiological consequence evaluation factors of 10 CFR 50.34(a)(1). In addition, the staff determines that the radiation protection design of the control room is acceptable if the total calculated

radiological consequences for the postulated fission product release fall within the exposure acceptance criteria specified in GDC 19 of 5 rem TEDE for the duration of the accident.

3. COL applications that reference both an ESP and a standard reactor design certified by NRC

   A. The staff verifies that no changes from the site-specific short-term χ/Q values specified in the ESP application have occurred due to changes in plant design, plant location on the site, building orientation, or fission product release points.

   B. Should the site-specific characteristic short-term χ/Q values specified in the ESP fall within the postulated short-term χ/Qs for the chosen certified design, the staff concludes that the COL applicant has satisfied the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1).

   C. If the site-specific short-term χ/Q values do not fall within the postulated short-term χ/Q values for the chosen certified design, the staff reviews the applicant's radiological dose calculations and performs independent confirmatory radiological consequence dose calculations using the site-specific short-term χ/Q values and the source term provided in the certified reactor design control document.

   D. For each postulated accident, the calculated doses from all postulated fission product release pathways from the facility are combined and are compared with the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) at the nearest EAB and LPZ outer boundary stated in the applicant's site safety assessment.

   E. For each postulated accident, the calculated doses from all postulated fission product release pathways from the facility, including all sources of radiation exposure to the control room personnel, are combined, and the calculated dose in the control room is compared with the radiological consequence evaluation factors identified in GDC 19.

   F. For each postulated accident, the calculated doses from all postulated fission product release pathways from the facility, including all sources of radiation exposure to the personnel in the technical support center, are combined, and the calculated dose in the TSC is compared with the radiological consequence evaluation factors identified for the control room of 5 rem TEDE for the duration of the accident.

4. CP, OL, DC and COL and ESP applications that neither reference a standard reactor design certified by NRC nor use the PPE approach

   A. The staff reviews the sequences of DBA events as described by the applicant to ensure that the spectrum of DBAs includes the bounding DBA with respect to calculated fission product releases. The spectrum of DBAs has generally been assumed to reflect a substantial meltdown of the reactor core (a major reactor accident) with subsequent release of appreciable quantities of fission products to

the environment. Although the loss-of-coolant (LOCA) is typically the maximum credible accident associated with the light-water reactor design, the applicant should consider other accident sequences of greater radiological consequence for the specific reactor designs selected by the applicants or for reasonably foreseeable future reactor designs if the applicant has not selected the specific reactor designs at the time of ESP application.

B. The staff reviews a spectrum of representative DBAs selected and evaluated by the applicant for determining the bounding DBA radiological consequences. The selected DBA should cover a spectrum of reactor transients and accidents.

C. The applicant's proposed accident source terms are reviewed in the following areas:

i. Fission product inventory in the reactor core operated at the ultimate maximum proposed power level with the limiting condition which maximizes fission product releases.

ii. Timing and rate of fission product release from the fuel following selected DBAs. The fission product release rates should be fractions of fission product inventory in the reactor core based on the maximum full power operation.

iii. The coolant activity concentration is reviewed under SRP Section 11.1. The non-LOCA DBA coolant source terms are calculated based on the coolant activity concentration and include iodine spiking, using the guidance in RG 1.183.

iv. The isotopic quantities in curies and the chemical forms of fission products released to the containment and to the environment. The staff reviews the modeling of changes in chemical form as the releases are processed by mitigating systems.

v. Rates of fission product release to the environment from the site during the entire period of the DBA as a function of time.

D. The staff reviews the fission product distribution, transport, removal, and release models within and between the major structures and systems, as well as the engineered safety feature (ESF) components of the facility, that bear significantly on the acceptability of the site with respect to the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1). The staff reviews the efficiencies of fission product removal by the ESF systems and components. Conditions for credit for fission product removal by ESF systems are discussed in SRP Sections 6.5.1 - 6.5.5 and control room habitability systems are discussed in SRP Section 6.4. The review under this SRP section should be coordinated with the primary review organization for each of the aforementioned sections.

E. Advanced reactor designs may include unique design features and passive safety systems. The design basis accident radiological consequences analyses may consider credit for the mitigation capability of the design through natural fission product removal processes such as diffusiophoresis, thermophoresis and gravitational settling. The staff's review of removal through natural fission product removal processes or for unique features of the design will require additional information from the applicant to fully explain the process being credited, the amount of removal being credited (specifically decontamination factors or coefficients and timing), basis for the proposed values and inputs to the dose analysis calculation, and the justification for assuming the removal process is applicable to the design of the plant for the duration of the event. The staff should determine if a technical assistance contract to assist the NRC staff should be placed to verify the applicant's proposed fission product removal credit.

F. The staff reviews the points of fission product release from the major structures and systems, and from the ESF components of the facility.

G. Using Section 2.3.4 of this standard review plan, the staff reviews the site-specific short-term χ/Q values determined by the applicant, and performs an independent evaluation as described therein.

H. The staff performs an independent confirmatory radiological consequence analysis using pertinent information in the applicant's SAR to determine whether the proposed site meets the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1). For applications other than an ESP, the staff also determines if the requirements of GDC 19 for maintaining the control room in a safe condition are met. By performing an independent confirmatory calculation, the staff will evaluate the reasonableness of the licensee's analysis model and results.

I. For each postulated accident, the calculated doses from all postulated fission product release pathways from the site are combined, and the calculated doses are compared with the radiological consequence evaluation factors identified in 10 CFR Part 50.34(a)(1) at the nearest EAB and LPZ outer boundary stated in the applicant's SAR.

J. For each postulated accident, the calculated doses from all postulated fission product release pathways from the site, including all sources of radiation exposure to the control room personnel, are combined, and the calculated dose in the control room is compared with the radiological consequence evaluation factors identified in GDC 19.

K. For each postulated accident, the calculated doses from all postulated fission product release pathways from the site, including all sources of radiation exposure to the personnel in the technical support center, are combined, and the calculated dose in the TSC is compared with the radiological consequence evaluation factors identified for the control room of 5 rem TEDE for the duration of the accident.

L. For the methodology and assumptions for calculating the radiological consequences, the staff will use the regulatory positions stated in Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," as applicable to the plant design. Additional information on the progression and assumptions for the failure of small lines carrying coolant outside containment can be found in SRP Section 15.6.2.

5. 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 and procedures applicable to the Commission's review of an ESP application for approval of a proposed site. 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.

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 ESP 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 of the early site permit.

B. Standard Design Certification Reviews: DC applications do not contain general descriptions of site characteristics because this information is site-specific and will be addressed by the COL applicant. However, pursuant to 10 CFR 52.47(a)(1), a DC applicant must provide site parameters postulated for the design. Site parameters associated with this SRP section are reviewed, as applicable, to verify that:

a. The postulated site parameters are representative of a reasonable number of sites that have been or may be considered for a COL application;

ii. The appropriate site parameters are included as Tier 1 information. This convention has been used by previous DC applicants. Additional guidance on site parameters is provided in SRP Section 2.0;

iii. Pertinent parameters are stated in a site parameters summary table; and

iv. The applicant has provided a basis for each of the site parameters.

C. Combined License Reviews: For a COL application referencing a certified standard design, the NRC staff reviews that application to ensure that sufficient information is presented to demonstrate that the characteristics of the site fall within the site parameters specified in the DC rule. Should the actual site characteristics not fall within the certified standard design site parameters, the COL applicant will need to demonstrate by some other means that the proposed

facility is acceptable at the proposed site. This might be done by re-analyzing or redesigning the proposed facility.

For a COL application referencing an ESP, NRC staff reviews the application to ensure the applicant provides sufficient information to demonstrate that the design of the facility falls within the site characteristics and design parameters specified in the early site permit as applicable to this SRP section. In accordance with 10 CFR 52.79(b)(2), should the design of the facility not fall within the site characteristics and design parameters, the application shall include a request for a variance from the ESP that complies with the requirements of 10 CFR 52.39 and 10 CFR 52.93.

In addition, long-term environmental changes and changes to the region resulting from human or natural causes may have introduced changes to the site characteristics that could be relevant to the design basis. 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. Consequently, a COL application referencing an ESP need not include a re-investigation of the site characteristics that have previously been accepted in the referenced ESP. However, in accordance with 10 CFR 52.6, "Completeness and Accuracy of Information," the applicant or licensee is responsible for identifying changes of which it is aware, that would satisfy the criteria specified in 10 CFR 52.39. Information provided by the applicant in accordance with 10 CFR 52.6(b) will be addressed by the staff during the review of a COL application referencing an ESP or a DC.

For a COL application referencing either an ESP or DC or both, the staff should review the corresponding sections of the ESP and DC FSER to ensure that any early site permit conditions, restrictions to the DC, or COL action items identified in the FSERs are appropriately handled in the COL application.

IV. EVALUATION FINDINGS

The review should document the staff's evaluation of the applicant's design basis accident radiological consequences analyses against the relevant regulatory criteria. The evaluation should support the staff's conclusions as to whether the regulations are met. The reviewer should state what was done to evaluate the applicant's submittal. The staff's evaluation may include verification that the applicant followed applicable regulatory guidance, performance of independent calculations, and/or validation that the appropriate assumptions were made. The reviewer may state that certain information provided by the applicant was not considered essential to the staff's review and was not reviewed by the staff. While the reviewer may summarize or quote the information offered by the applicant in support of its application, the reviewer should clearly articulate the bases for the staff's acceptance and conclusions.

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.

A conclusion of the following type for the radiological consequence analyses will be included in Section 15 of the site safety evaluation, standard design safety evaluation, or combined license safety evaluation:

1. ESP application that references a standard reactor design certified by NRC.
   As set forth above, the staff has reviewed the site-specific short-term atmospheric dispersion (χ/Q) values at the exclusion area boundary (EAB) and at the boundary of the low population zone (LPZ) for the proposed site in the early site permit (ESP) application and has verified that they are within the postulated design basis χ/Q values specified in the [name of certified reactor design] design control document.

   Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [name] site, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1).

   [or:]

   As set forth above, the staff has reviewed the site-specific short-term χ/Q values at the EAB and at the boundary of the LPZ for the proposed site in the ESP application and found that they exceed the postulated design basis χ/Q values specified in the [name of certified reactor design] design control document. However, the staff has verified that the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site-specific χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1).

   Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [name] site, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1).

2. ESP application that uses the PPE approach. As set forth above, the applicant submitted its radiological consequence analyses using the site-specific short-term χ/Q values and the plant parameter envelope (PPE) source term values and concluded that the proposed site meets the radiological consequence evaluation factors identified in Section 50.34(a)(1). The results of the applicant's radiological consequence dose calculation are provided in Table [ ], and the PPE values and the site-specific χ/Q values used by the applicant and the staff are listed in Tables [ ] through [ ].

   The staff reviewed the radiological consequence analyses submitted by the applicant and finds that the PPE values that are inputs to these analyses are not unreasonable based on information provided by the applicant, on the staff's experience in evaluating similar parameters, and on the staff's confirmatory investigation and evaluation.

   To verify the applicant's radiological consequence analyses, the staff performed its confirmatory radiological consequence dose calculation using the site-specific χ/Q

values and the PPE source term values provided by the applicant, and the staff finds that its results are within the radiological consequence evaluation factors identified in Section 50.34(a)(1). Although the staff performed its independent radiological consequence dose calculation as a means of confirming the applicant's results, the staff's approval of the ESP is based on the applicant's analyses.

Therefore, the staff concludes that the distances to the EAB and the LPZ outer boundary of the [name] site, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1). This conclusion is subject to confirmation at the combined license (COL) stage that the relevant design parameters specified by the applicant in the COL application are bounded by the applicant's PPE submitted with the ESP application.

3. ESP application that neither references a standard reactor design certified by NRC nor uses the PPE approach. As set forth above, the applicant has selected and analyzed the bounding design basis accidents and has determined that the total radiological consequences of such accidents meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1). The results of the applicant's radiological consequence dose calculation are provided in Table [ ].

   The staff reviewed the radiological consequence analyses provided by the applicant and has performed an independent analysis of the radiological consequences of each design basis accident considered in the application using the site-specific χ/Q values at the EAB and LPZ proposed in the ESP application. The staff finds that its results are also within the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1). Although the staff performed an independent radiological consequence dose calculation as a means of confirming the licensee's results, the staff's approval of the ESP is based on the applicant's analyses. Details of the staff's analyses are presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

   Therefore, the staff concludes that the distances to the EAB and the LPZ outer boundary of the [site name] site, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1). This conclusion is based on the staff review of the applicant's analysis and on the staff's independent analysis, which confirms that the calculated total doses are within the dose evaluation factors set forth at 10 CFR 50.34(a)(1).

4. Standard reactor design certification application. As set forth above, the applicant has selected and analyzed the bounding design basis accidents and has determined that the total radiological consequences of such accidents meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19 for the standard reactor design, considering a reference site. The results of the applicant's radiological consequence dose calculation are provided in Table [ ].

The staff reviewed the radiological consequence analyses provided by the applicant and has performed an independent analysis of the radiological consequences of each design basis accident considered in the application using the design reference χ/Q values at the EAB, LPZ, and control room proposed in the application. The staff finds that its results are also within the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19. Although the staff performed an independent radiological consequence dose calculation as a means of confirming the licensee's results, the staff's approval of the standard design is based on the applicant's analyses. Details of the staff's analyses are presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

The staff performed a similar review of the applicant's evaluation of the design basis accident radiological consequences in the technical support center in support of the emergency planning review. The staff has reasonable assurance that the dose in the TSC will be within 5 rem TEDE. The details of the staff's analysis is presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

Therefore, the staff concludes that the plant features intended to mitigate the radiological consequences of postulated design basis accidents, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1) and GDC 19. This conclusion is based on the staff review of the applicant's analysis and on the staff's independent analysis, which confirms that the calculated total doses are within the dose evaluation factors set forth at 10 CFR 50.34(a)(1) and GDC 19.

5. Combined license application without ESP or certified standard reactor design. As set forth above, the applicant has selected and analyzed the bounding design basis accidents and has determined that the total radiological consequences of such accidents meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19. The results of the applicant's radiological consequence dose calculation are provided in Table [ ].

The staff reviewed the radiological consequence analyses provided by the applicant and has performed an independent analysis of the radiological consequences of each design basis accident considered in the application using the site-specific χ/Q values at the EAB, LPZ and control room proposed in the COL application. The staff finds that its results are also within the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19. Although the staff performed an independent radiological consequence dose calculation as a means of confirming the licensee's results, the staff's approval of the COL is based on the applicant's analyses. Details of the staff's analyses are presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

The staff performed a similar review of the applicant's evaluation of the design basis accident radiological consequences in the technical support center in support of the emergency planning review. The staff has reasonable assurance that the dose in the TSC will be within 5 rem TEDE. The details of the staff's analysis is presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

Therefore, the staff concludes that the distances to the EAB and the LPZ outer boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated design basis accidents, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1) and GDC 19. This conclusion is based on the staff review of the applicant's analysis and on the staff's independent analysis, which confirms that the calculated total doses are within the dose evaluation factors set forth at 10 CFR 50.34(a)(1) and GDC 19.

6. Combined license application with certified standard reactor design. As set forth above, the staff has reviewed the site-specific short-term atmospheric dispersion (χ/Q) values at the exclusion area boundary (EAB), at the boundary of the low population zone (LPZ), in the technical support center (TSC) and in the control room for the proposed site in the combined operating license (COL) application and has verified that they are within the design reference set of χ/Q values specified in the [name of certified reactor design] design control document.

Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [name] site and plant features intended to mitigate the radiological consequences of postulated design basis accidents, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1) and GDC 19.

[or :]

As set forth above, the staff has reviewed the site-specific short-term χ/Q values at the EAB, at the boundary of the LPZ, in the TSC and in the control room for the proposed site in the COL application and found that [name the χ/Q receptors that are not within the DCD] exceed the design reference set of χ/Q values specified in the [name of certified reactor design] design control document. However, the staff has verified that the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site-specific χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19.

Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated design basis accidents, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1) and GDC 19.

7. Combined license application with both ESP and certified standard reactor design. As set forth above, the staff has verified that the site-specific short-term atmospheric dispersion (χ/Q) values at the exclusion area boundary (EAB) and at the boundary of the low population zone (LPZ) for the proposed site in the early site permit (ESP) and that the site-specific short-term χ/Q values for the control room and technical support center (TSC) are within the design reference set of χ/Q values specified in the [name of certified reactor design] design control document. Therefore, the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site-specific χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19.

   Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated design basis accidents, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1) and GDC 19.

   [or:]

   As set forth above, the staff has reviewed the site-specific short-term χ/Q values at the EAB and at the boundary of the LPZ for the proposed site in the ESP and the site-specific short-term χ/Q values for the control room and the technical support center (TSC) and has found that [name the χ/Q receptors that are not within the DCD] exceed the design reference set of χ/Q values specified in the [name of certified reactor design] design control document. However, the staff has verified that the applicant has demonstrated that the radiological consequences associated with the bounding DBAs using its site-specific χ/Q values meet the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19.

   Therefore, the staff concludes that the distance to the EAB and to the LPZ boundary of the [name] site, in conjunction with the engineered safety features as described in the [name] certified standard design, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents considered in the [name] certified design will be within the radiological consequence evaluation factors of 10 CFR 50.34(a)(1) and GDC 19.

8. Combined license application with ESP only. As set forth above, the applicant has selected and analyzed the bounding design basis accidents using the site-specific short-term atmospheric dispersion (χ/Q) values at the exclusion area boundary (EAB) and at the boundary of the low population zone (LPZ) for the proposed site in the early site permit (ESP), as well as site-specific short-term χ/Q values for the control room and technical support center (TSC), and has determined that the total radiological consequence of such accidents meets the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19. The results of the applicant's radiological consequence dose calculation are provided in Table [ ].

The staff reviewed the radiological consequence analyses provided by the applicant and has performed an independent analysis of the radiological consequences of each design basis accident considered in the application using the EAB and LPZ χ/Q values from the ESP and site-specific χ/Q values at the control room proposed in the COL application. The staff finds that its results are also within the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and GDC 19. Although the staff performed its independent radiological consequence dose calculation as a means of confirming the licensee's results, the staff's approval of the COL is based on the applicant's analyses. Details of the staff's analyses are presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

The staff performed a similar review of the applicant's evaluation of the design basis accident radiological consequences in the technical support center in support of the emergency planning review. The staff has reasonable assurance that the dose in the TSC will be within 5 rem TEDE. The details of the staff's analysis is presented in Section [ ] of this safety evaluation report, and the results are listed in Table [ ].

Therefore, the staff concludes that the distances to the EAB and the LPZ outer boundary of the [site name] site and plant features intended to mitigate the radiological consequences of postulated design basis accidents, in conjunction with the source term and the fission product release rates from the site to the environment provided by the applicant, are sufficient to provide reasonable assurance that the total radiological consequences of the design basis accidents will be within the dose evaluation factors set forth at 10 CFR 50.34(a)(1) and GDC 19. This conclusion is based on the staff review of the applicant's analysis and on the staff's independent analysis, which confirms that the calculated total doses are within the dose evaluation factors set forth at 10 CFR 50.34(a)(1) and GDC 19.

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

2. 10 CFR 50.34, "Contents of applications; technical information"

3. 10 CFR 50, Appendix A, “General Design Criteria for Nuclear Power Plants”

4. 10 CFR 50, Appendix E, “Emergency Planning and Preparedness for Production and Utilization Facilities”

5. 10 CR Part 52, “Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants”

6. 10 CFR Part 100, “Reactor Site Criteria”

7. Regulatory Guide RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition),” 2007.

8. Regulatory Guide 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors,” July 2000

9. NUREG-1793, “Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design,” September 2004

10. NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants,” February 1995

11. NRR Review Standard RS-002, “Processing Applications for Early Site Permits,” May 3, 2004 (ADAMS Accession No. ML040700094

12. SECY-98-154, “Results of the Revised (NUREG-1465) Source Term Re-Baselining for Operating Reactors,” June 1998