RS-002, "PROCESSING APPLICATIONS FOR EARLY SITE PERMITS"

ATTACHMENT 2

15.0 RADIOLOGICAL CONSEQUENCES OF DESIGN BASIS ACCIDENTS

REVIEW RESPONSIBILITIES

Primary - Probabilistic Safety Assessment Branch (SPSB)

Secondary - None

I. AREAS OF REVIEW

The NRC regulations in 10 CFR Part 100, "Reactor Site Criteria," present a framework that guides the staff in its evaluation of the suitability of proposed sites for stationary power and testing reactors. Under 10 CFR 52.17(a)(1), "Contents of Applications," early site permit (ESP) applications must contain an analysis and evaluation of the major structures, systems, and 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). This review standard applies to postulated design basis accident (DBA) radiological consequences for the exclusion area boundary (EAB) and low population zone (LPZ). Radiological consequences related to control room personnel will be evaluated as part of the combined license (COL) review.

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

The standard reactor designs are certified with a reference set of short-term atmospheric relative concentration (χ/Q) values at an EAB and LPZ in lieu of site-specific meteorological data and specific 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 are consistent with the assumptions made in the design certification. The staff reviews meteorological data, inputs, assumptions, and the dispersion model used to estimate the site-specific χ/Q values in the ESP application using the guidance of Section 2.3.4 of this review standard. The staff then compares the site-specific χ/Q values in the ESP application with the referenced χ/Q values in the design certification to verify that the site-specific values are within the bounds of the values specified in the design certification.

2. 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).

The staff reviews the proposed PPE values and associated information in the ESP application 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 not be unreasonable for consideration in the staff findings regarding compliance with Subpart A of 10 CFR Part 52 (Ref. 2). The staff evaluation of radiological consequences at the EAB and LPZ will be made using the site-specific χ/Q values in ESP applications in conjunction with the PPE values and associated information in the ESP application.

3. 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).

II. ACCEPTANCE CRITERIA

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).

The distances to the EAB and to the 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):

1. 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

2. an individual who is located at any point on the boundary of the LPZ and 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 ESP applications that neither reference the standard reactor designs certified by NRC nor use the PPE approach, the staff may establish exposure 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, "Accident Dose Criteria" of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 15.0.1,

"Radiological Consequence Analyses Using Alternative Source Terms." For ESP applications using the PPE approach, these acceptance criteria may be applied at the COL stage.

For ESP applications that do not reference a standard reactor design certified by the NRC, particularly those ESP applications that reference a PPE value, applicants bear the burden of ensuring sufficient margin is provided in the design parameters (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.

III. REVIEW PROCEDURES

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

   a. Using the guidance in Section 2.3.4 of this review standard, the staff reviews the applicant's meteorological data, inputs, assumptions, and dispersion model used to estimate the site-specific χ/Q values in the ESP application.

   b. The staff compares the site-specific χ/Q values in the ESP application with χ/Q values specified in the reactor design certification.

   c. If the site-specific χ/Q values are within the bounds of those specified in the design certification, no further radiological consequence evaluation is needed.

   d. If the site-specific χ/Q values exceed the bounds of those specified 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 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 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 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.

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 not be unreasonable for consideration in the staff's findings regarding compliance with Subpart A of 10 CFR Part 52.

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

(1) The isotopic quantities of fission products released in curies to the environment from the site.

(2) 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 times and rates 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 appearance rates should be fractions of fission product inventory in the reactor core at the ultimate maximum power level.

d. In accordance with the guidance in Section 2.3.4 of this review standard, the staff reviews the site-specific 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 χ/Q values provided in ESP applications 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 consequence, 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" (Ref. 3), and NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (Ref. 4), Section 15.0.1, "Radiological Consequence Analyses Using Alternative Source Terms."

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 χ/Q values specified in the ESP to confirm that the site-specific χ/Q values are bounded by those χ/Q values provided in the reactor design certification based on the proposed plant design, the plant location on the site, and the fission product release points.

NOTE: At the COL stage, in the event that the site-specific χ/Q values exceed the bounds of those specified 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).

3. ESP applications that neither reference the standard reactor designs 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 the 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 applicants 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:

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

(2) Times and rates of fission product release from the fuel following selected DBAs. The fission product appearance rates should be fractions of fission product inventory in the reactor core based on the maximum full power operation.

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

(4) Rates of fission product release to the environment from the site during the entire period of the DBAs as a function of time.

d. The staff reviews the fission product transport and removal models 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.

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

f. In accordance with the guidelines provided in Section 2.3.4 of this review standard, the staff reviews the site-specific χ/Q values determined by the applicant and provided in the applicant's ESP site safety assessment, and the staff performs an independent evaluation.

g. The staff performs an independent confirmatory radiological consequence analysis using pertinent information in the applicant's site safety assessment to determine whether the proposed site meets the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1).

h. 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 site safety assessment.

i. 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," and NUREG-800, Section 15.0.1, "Radiological Consequence Analyses Using Alternative Source Terms."

IV. EVALUATION FINDINGS

A conclusion of the following type for the radiological consequence analyses will be included in Section 15 of the site 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 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 design reference set of χ/Q values specified in the [name of certified reactor design] design control document.

[or:] As set forth above, the staff has reviewed the site-specific 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 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).

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 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 where deemed necessary, 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 consequence of such accidents meets 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 its 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 [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).

V. IMPLEMENTATION

The following provides guidance to applicants regarding the staff's plans for using this review standard section.

This review standard will be used by the staff when performing site safety evaluation of early site permit applications submitted by the applicants pursuant to 10 CFR Part 52.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulation, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

VI. REFERENCES

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

2. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

3. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors" (July 2000).

4. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 15.0.1, "Radiological Consequence Analyses Using Alternative Source Terms" (July 2000).