U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

15.6.5 Appendix A RADIOLOGICAL CONSEQUENCES OF A DESIGN BASIS LOSS-OF-COOLANT ACCIDENT INCLUDING CONTAINMENT LEAKAGE CONTRIBUTION

REVIEW RESPONSIBILITIES

Primary - Accident Evaluation Branch (AEB)

Secondary - Effluent Treatment Systems Branch (ETSB)

I. AREAS OF REVIEW

The review under SRP Section 15.6.5, Appendix A, consists of two parts, a summary review of the total calculated doses from the hypothetical design basis loss-of-coolant accident (LOCA) and the specific review of the containment leakage doses that contribute to the total LOCA doses as described below.

1. The calculated doses from all postulated release paths from the containment to the atmosphere are combined and the calculated doses are compared with appropriate exposure guidelines to confirm the acceptability of the nearest exclusion area boundary (EAB) and low population zone (LPZ) outer boundary and to confirm the adequacy of the engineered safety features (ESF) provided for the purpose of mitigating potential accident doses.

   The individual contributions to the total radiological consequences from a hypothetical LOCA from the various release paths to the atmosphere are treated in separate appendices to this SRP Section 15.6.5, as follows:

   Appendix A: Containment leakage, including the contribution from containment purge valves during closure.

   Appendix B: Post-LOCA leakage from ESF systems outside containment.

   Appendix C: Post-LOCA hydrogen purge from containment. This appendix has been deleted.

   Appendix D: MSIV Leakage (for BWR plants only).

2. The review encompasses the applicant's methodology and results of calculations of the radiological consequences resulting from containment leakage following a hypothetical LOCA as contributing to the total radiological consequences of the LOCA. The review includes an assessment of the containment with respect to the assumptions and the input parameters for the dose calculations.

3. The staff performs an independent analysis of the radiological consequences, including the modelling of the containment system. The analysis is based on pertinent information in the SAR and considers the staff's evaluation of dose mitigating engineered safety features, for example, the effectiveness of the containment spray system as evaluated in SRP Section 6.5.2.

A secondary review is performed by the Effluent Treatment Systems Branch (ETSB) and the results are used by AEB in the overall evaluation of the radiological consequences of the LOCA accident. ETSB reviews the ESF atmosphere filtration system to determine the iodine removal efficiency of the system and the results are transmitted to AEB for use in the independent analysis.

The review of the primary containment leakage rate, the secondary containment bypass leakage rate, and the containment vent/purge system release rate during the closure of the system following a LOCA is coordinated with the Containment Systems Branch (CSB) under SRP Sections 6.2.6, 6.2.3, and 6.2.4, respectively. The acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

The acceptance criteria are based on the requirements of 10 CFR Part 100 as related to mitigating the radiological consequences of an accident. Specific acceptance criteria for the total calculated doses and for the containment leakage contribution are as follows:

1. The distances to the exclusion area boundary and to the low population zone outer boundary are acceptable if the total calculated radiological consequences (i.e., thyroid and whole body doses) for the hypothetical LOCA fall within the appropriate exposure guideline values specified in 10 CFR Part 100, §100.11 (Ref. 1). The total dose is the combined dose from all release paths from the containment to the atmosphere. At the construction permit (CP) review stage, the staff applies exposure guideline values of 150 rem to the thyroid and 20 rem to the whole body in accordance with Regulatory Guides 1.3 and 1.4. This is to allow for uncertainties in meteorology and other site-related data and to allow for system design changes that might influence the final design of engineered safety features or the dose reduction factors of these features. These lower values are applied at the CP stage to provide reasonable assurance that the 10 CFR Part 100 guideline values can be met at the operating license (OL) review stage.

2. The model for and the calculation of the post-LOCA leakage contribution to the total whole body and thyroid doses of a hypothetical LOCA are acceptable if they incorporate the appropriate conservative design basis assumptions outlined in the regulatory positions of Regulatory Guide 1.3 (Ref. 2) for a BWR facility and of Regulatory Guide 1.4 (Ref. 3) for a

PWR facility with the exception of the guidelines for the atmospheric dispersion fusion factors (X/Q values). The acceptability of the X/Q values is determined under SRP Section 2.3.4.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects of the areas covered by this appendix as may be appropriate for a particular case. The decision as to which areas need to be given attention and emphasis in the review is based on a determination of whether the material presented is similar to that recently reviewed on other plants and whether items of special safety significance are involved. Review steps (1) through (8) below apply to the containment leakage contribution and step (9) applies to the total radiological consequences.

1. The design (stretch) power level of the core is taken from the applicant's safety analysis report (SAR). The core is assumed to have operated at this power level for a sufficiently extended period (typically about 3 years) such that the maximum equilibrium fission product inventory is present. At the time of the accident, 25% of all the equilibrium iodine fission products and 100% of the noble gas fission products are assumed available for release from the containment within a very short time (effectively instantaneously) after the accident. The iodine is assumed to be composed of 91% elemental iodine, 4% organic iodides, and 5% particulate iodine.

2. The reviewer ascertains the type of containment system used based on information in SAR Sections 6.2.1 and 6.2.3. The primary containment leakage rate for the LOCA dose analysis is obtained from SAR Section 6.2.6 which is reviewed by the CSB. If the leakage rate is revised as a result of CSB review, the CSB will inform AEB of the change. A check is made of the LOCA assumptions listed in Chapter 15 of the SAR to verify that the primary containment leakage rate has been assumed to remain constant over the course of the accident for a BWR and to remain constant at one half of the initial leak rate after 24 hours for a PWR. Leak rates of less than 0.1% per day have not been accepted by the staff because of integrated containment leakage test sensitivity limitations. The leakage rate used should correspond to that given in the technical specifications.

3. Where credit for a dual containment system is claimed, the reviewer verifies, based on SRP Sections 6.2.3 and 6.5.3, that the system meets requirements such as existence of separate primary and secondary containments, adequate separation of the two, and ability to test the negative pressure capability of the secondary containment. Where dilution credit for a secondary containment with recirculation is claimed, adequate mixing in the secondary containment volume should be demonstrated in addition to meeting the above requirements for a dual containment system. For dual containment systems, the bypass leakage is evaluated. This leakage, usually expressed as a fraction or percentage of the primary containment leak rate, is assumed to pass from the primary containment directly to the environment, bypassing the secondary containment. The secondary containment bypass leakage rate and any positive pressure characteristics in the secondary containment are obtained from SAR Section 6.2.3 which is reviewed by CSB.

If the bypass leakage rate or secondary containment positive pressure characteristics are revised as a result of CSB review, CSB will inform AEB of the change.

4. The operation of the normal containment vent/purge system is reviewed by CSB under SRP Section 6.2.4. If the proposed system operation does not meet the CSB positions, the CSB will request the AEB to perform an analysis of the radiological consequences using this release path as an additional contributor to the total LOCA doses.

5. Credit for any engineered safety features such as atmosphere filtration systems, spray systems, or ice condenser is deterined in the review of Section 6.5 of the SAR. These features operate during the LOCA to mitigate the consequences by reducing the amount of iodine fission products released to the environment. Noble gas releases to the environment are unaffected by the presence of filters or sprays. Typically, single containments employ spray systems with a chemical additive (e.g., sodium hydroxide, sodium tetraborate) to scavenge iodine from the containment atmosphere. The iodine removal rates of an ice condenser or a chemical additive spray system are determined. For atmosphere filtration systems verification of acceptability of design and efficiencies is provided by the ETSB under SRP Section 6.5.1. In dual containment systems, a determination must be made by the AEB of the operational modes of the ESF with respect to the accident sequence in order for proper credit to be given.

6. The distances to the exclusion area boundary and to the LPZ outer boundary are determined from Sections 2.1.2 and 2.1.3 of the applicant's SAR and are verified by the reviewer with the Siting Analysis Branch (SAB).

7. The appropriate X/Q values to be used in calculating the consequences of the accident are provided by the assigned meteorologist in accordance with SRP Section 2.3.4.

8. A dose computation model appropriate for the containment system and ESF systems is selected which conservatively represents the transfer of radioactivity from the containment to the environment. The reviewer may find it convenient to sketch a schematic arrangement to illustrate the compartments where radioactivity is located, with arrows drawn from one compartment to another indicating transport paths. The leak rates, spray removal rates, ice condenser efficiencies, atmosphere filtration system efficiencies, and flow rates are used to indicate the rates at which the activity moves from one compartment to another. Digital computer codes have been written to perform the actual dose calculation. The analyst selects the code with capabilities that most closely fit the schematic model obtained above. The codes contain a basic library of data which enter into the dose calculation, such as isotopic fission yields, half-lives, energies, and dose conversion factors.

9. The containment leakage doses are combined with the calculated dose contributions from all other appropriate post-LOCA transport paths and the total thyroid and whole body LOCA doses are compared with the exposure guideline values of 10 CFR Part 100, §100.11, as discussed in item II.2 of this appendix. If the calculated total doses exceed these guidelines, alternatives which would reduce the doses to an acceptable level are

explored with the applicant. Such alternatives may include increased distance, a different containment type, and more efficient atmosphere filtration or spray systems.

IV. EVALUATION FINDINGS

The reviewer prepares a table for inclusion into the evaluation findings that lists the 2-hour and 30-day thyroid and whole body doses from the various fission product release paths to the atmosphere as calculated by the staff under SRP Section 15.6.5, Appendices A, B, and D. The table also lists the total doses calculated by the staff. A conclusion of the following type for the total doses will be included in the section "LOCA Radiological Consequences" of the SER:

> The applicant has selected and analyzed a hypothetical design basis loss-of-coolant accident (LOCA) and has determined that the total radiological consequences of such an accident meet the exposure guidelines of 10 CFR Part 100, §100.11 with respect to the adequacy of the distances to the exclusion area boundary and the low population zone outer boundary. The analysis included the following sources and radioactivity transport paths from the containment to the atmosphere (note: cite each of the following as applicable):
>
> (1) contribution from containment leakage,
>
> (2) contribution through containment purge/vent valves during closure,
>
> (3) contribution from post-LOCA leakage from ESF sytems outside containment,
>
> (4) contribution from main steam isolation valve leakage.

The staff has reviewed the applicant's analysis and has performed an independent analysis of the radiological consequences from each of these transport paths. Details of the staff's analyses are presented in Sections 15.____ to 15.____ of this report and the results are listed in Table 15.____. The total calculated thyroid and whole body doses from the hypothetical LOCA are also listed in the table.

In the SER for an application for an operating license (OL), the following paragraph shall be added:

> The staff concludes that the distances to the exclusion area boundary and to the low population zone boundary of the (Name) site, in conjunction with the engineered safety features of the (Name) plant, are sufficient to provide reasonable assurance that the total radiological consequences of such an accident will be within the exposure guidelines set forth at 10 CFR Part 100, §100.11. This conclusion is based on the staff review of the applicant's analysis and on the independent analysis by the staff which confirms that the calculated total doses are within these guidelines.

In the SER for an application for a construction permit (CP), the following paragraph shall be added:

The staff concludes that the distances to the exclusion are boundary and to the low population zone boundary of the (Name) site, in conjunction with the proposed engineered safety features of the (Name) plant, are sufficient to provide reasonable assurance that the total radiological consequences of such an accident will be within the guidelines set forth at 10 CFR Part 100, §100.11. This conclusion is based on the staff review of the applicant's analysis and on the independent analysis by the staff which confirms that the calculated total doses meet the exposure guidelines set forth in Regulatory Guide 1.____. (Use Regulatory Guide 1.3 for a BWR plant, and Regulatory Guide 1.4 for a PWR plant.)

Following the conclusion on the total radiological consequences, there will be separate sections discussing the plant specific fission product release paths from the containment to the atmosphere and the corresponding doses in accordance with SRP Section 15.6.5, Appendices A, B, and D. Each section will include an Evaluation Finding regarding the staff's independent analysis of the dose contribution and a reference to the table for all the LOCA doses calculated by the staff.

The first section will be for the dose contribution from containment leakage in accordance with Appendix A of SRP Section 15.6.5. An Evaluation Finding of the following type should be included in the section:

The radiological consequences from containment leakage following a hypothetical design basis loss-of-coolant accident were evaluated. The staff reviewed the applicant's analysis and performed an independent calculation. The staff's calculation incorporates the appropriate conservative assumptions of the regulatory positions in Regulatory Guide 1.____ (use Regulatory Guide 1.3 for a BWR facility, Regulatory Guide 1.4 for a PWR facility). The atmospheric dispersion characteristics (X/Q values) stated in Section 2.3 of this report were used in the calculations. The results of the staff's calculation are presented in Table 15.____, and the contribution to the total radiological consequences is evaluated in Section 15.____.

V. IMPLEMENTATION

The following provides guidance to applicants and licensees regarding the staff's plans for using this SRP section.

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.

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

VI. REFERENCES

1. 10 CFR Part 100, §100.11, "Determination of Exclusion Area, Low Population Zone, and Population Center Distance."

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

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