U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

15.6.2 RADIOLOGICAL CONSEQUENCES OF THE FAILURE OF SMALL LINES CARRYING PRIMARY COOLANT OUTSIDE CONTAINMENT

REVIEW RESPONSIBILITIES

Primary - Accident Evaluation Branch (AEB)

Secondary - None

I. AREAS OF REVIEW

This SRP section covers the radiological consequences of failures outside the containment of small lines connected to the primary coolant pressure boundary, such as instrument lines and sample lines. The review includes the following:

1. The identification of small lines postulated to fail and the isolation provisions for these lines, including the applicability of General Design Criterion 55 (Ref. 1), which requires isolation capability of the line inside and outside containment, and Regulatory Guide 1.11 (Ref. 2), which requires isolation capability outside containment for those lines that are exempt from GDC 55. The implementation of these regulatory positions and guidelines is reviewed by the Containment Systems Branch (CSB) under SRP Section 6.2.4.

2. The failure scenario, as described by the applicant, to assure that the most severe radioactive releases have been considered.

3. The models ad assumptions used by the applicant for the calculation of the thyroid and whole-body doses for the postulated failure.

4. An evaluation of the primary coolant iodine activity, including the effects of a concurrent iodine spike, and the technical specifications for the reactor coolant iodine activity.

5. An independent calculation by the staff of the thyroid and whole-body doses for the small line failure, including an evaluation of the isolation times and maximum leak rates of the isolation valves.

USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

6. A comparison of the doses calculated by the applicant and by the staff with appropriate exposure guidelines of 10 CFR Part 100, §100.11 (Ref. 3), as stated in subsection II below.

In addition, AEB will coordinate its review with other branches that interface in the overall review of the break analysis. The Reactor Systems Branch (RSB) upon request by the AEB will confirm the value used by the applicant for the mass of coolant released in the accident and to determine if this accident will cause fuel failures. The Containment Systems Branch (CSB) upon request by the AEB, will verify that secondary containment integrity and leaktightness are maintained during the course of the accident.

II. ACCEPTANCE CRITERIA

The acceptance criteria for this SRP section are based on the relevant requirements of the following regulations:

1. General Design Criterion 55 (Ref. 1) as it relates to the identification of small diameter lines connected to the primary system that are exempted from the isolation requirements of GDC 55 and that are acceptable on the basis of meeting item (2) below,

2. 10 CFR Part 100, §100.11 (Ref. 3) as it relates to the radiological consequences of a small line break carrying primary coolant outside containment.

The plant site and the dose mitigating engineered safety feature (ESF) systems are acceptable with respect to the radiological consequences of a postulated failure outside the containment of a small line carrying reactor coolant if the calculated whole-body and thyroid doses at the exclusion area and the low population zone outer boundaries do not exceed a small fraction of the exposure guideline values of 10 CFR Part 100, §100.11 (Ref. 3) as stated in position C.1.b of Regulatory Guide 1.11 (Ref. 2). A "small fraction" of 10 CFR Part 100 means 10 percent of these exposure guideline values, that is, 2.5 rem and 30 rem for the whole-body and thyroid doses, respectively.

A plant-specific technical specification is required for the iodine activity in the primary coolant system. The specification is acceptable with respect to the postulated failure if the calculated doses resulting from the failure are within the above exposure guidelines.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes specific aspects of this SRP section as are appropriate for a particular plant. The areas to be given attention and emphasis are determined by the similarity of the information provided in the applicant's Safety Analysis Report (SAR) to that recently reviewed on other plants and whether items of special safety significance are involved. The review consists of the following steps:

1. Review of the applicant's description of the small line failures to determine the appropriateness and conservatism of the assumptions used in the analysis.

2. Identification of the small lines connected to the primary reactor coolant system and penetrating the containment. The isolation provisions are

identified with respect to the applicability of GDC 55 (i.e., isolation capability inside and outside containment) and Regulatory Guide 1.11 (i.e., isolation capability outside containment for lines exempt from GDC 55). The implementation of these guidelines is reviewed by the Containment Systems Branch under SRP Section 6.2.4. The AEB reviewer will coordinate his review with CSB if additional clarification is needed.

3. Performance of an independent analysis by the staff. The reviewer selects for a failure analysis those small lines that most likely will result in the highest offsite radiological consequences. The selection is largely based on the analysis performed on recently reviewed plants but should include, if appropriate, the letdown line of the chemical volume and control system (CVCS) and the largest instrument and sample line. The following conservative assumptions are made for the analysis:

   a. For small lines that meet GDC 55, such as the CVCS letdown line, the failure is assumed to occur downstream of the outboard containment isolation valve in conjunction with a single failure of one of the two containment isolation valves. The amount of primary coolant released outside the containment is determined by considering the method, capability and time required to detect such failure and the time required to isolate the failure (i.e., time to close the operable isolation valve).

   b. For small lines exempt from GDC 55, such as instrument lines, but which meet the isolation guidelines of Regulatory Guide 1.11 (i.e., containment isolation valve outside containment), the failure is postulated to occur downstream of the valve in conjunction with a single failure (i.e., valve does not close). Unless other isolation or flow reduction capabilities are provided (e.g., orifice in line) which will be evaluated on a case-by-case basis, it is assumed that this line failure cannot be isolated and the primary coolant release will continue until the primary system is depressurized.

   c. The amount of primary coolant released is conservatively estimated by assuming critical flow at the small line break location with the reactor coolant fluid enthalpy corresponding to normal reactor operating conditions. The reviewer evaluates the reactor coolant release rates provided by the applicant, taking into consideration similar information for plants recently reviewed. The reviewer should verify the release rates and the total amount of coolant released with the RSB in a coordinating review effort.

   d. The initial fission product concentrations in the primary coolant are assumed to be the maximum equilibrium values permitted by the standard technical specification for the NSSS vendor or those provided by the applicant. In addition, it is assumed that an iodine spike occurs as a result of the reactor shutdown or depressurization of the primary system. The spike is modelled by increasing the equilibrium fission product activity release rate from the fuel by a factor of 500.

      The reviewer consults with the RSB regarding the potential for and extent of damage to the fuel as a result of the line failure. If appropriate, the additional fission product activity in the primary coolant activity will be included in the analysis.

The fraction of the iodine assumed to become airborne and available for release to the atmosphere, without credit for plateout, is equal to the fraction of the coolant flashing into steam in the depressurization process. The flash fraction is determined by assuming the discharge to be a constant enthalpy process.

e. For a plant with a dual containment system, it is assumed that the small line failure occurs outside the secondary containment if the line penetrates or bypasses the secondary containment. The release is assumed to occur within the secondary containment if the line terminates inside the secondary containment. The reviewer verifies, in a coordinating review effort with the CSB the integrity and leak-tightness of the secondary containment during the pressure transient associated with the postulated small line failure within its boundaries. An approximate mixing volume is determined from the location of the assumed failure location and the proximity to the secondary containment ventilation system assumed to be operating (if any).

   The release of the airborne radioactivity from the secondary containment to the outside atmosphere is evaluated in accordance with the assumption of SRP Section 15.6.5, Appendix A, subsection III.3.

f. The operation and effectiveness of an ESF-grade filtration system for removal of airborne radioiodine will be reviewed on a case-by-case basis. The reviewer verifies that all potential locations for a small line break are within ventilation zone of the system.

   Depending on the type of air treatment system credited in the analysis, a ground-level or elevated (stack) release is assumed. The appropriate atmospheric dispersion factors (X/Q values) are provided by the assigned meteorologist in accordance with SRP Section 2.3.4.

4. Review of dose calculations. The whole-body and thyroid doses calculated by the staff and by the applicant are compared with the acceptance criteria stated in subsection II of this SRP section. If the doses calculated by the staff are not within the exposure guidelines (i.e., they are not less than 10 percent of 10 CFR Part 100, §100.11), then the staff will pursue alternatives with the applicant to reduce the doses to within the guideline values.

IV. EVALUATION FINDINGS

The reviewer verifies in the Safety Evaluaton Report (SER) that sufficient information has been provided in the SAR. The applicant's analysis and the staff's independent calculations are summarized.

The SER should identify the specific small line failure that was analyzed by the staff and the calculated doses, including the assumptions and unique system and operation provisions. The evaluation should support conclusions of the following type to be included in the SER:

> The staff concludes that the distances to the exclusion area and to the low population zone outer boundaries for the (insert PLANT NAME) site, in conjunction with the operation of the dose mitigating ESF

systems, are sufficient to provide reasonable assurance that the calculated radiological consequences of a postulated small line failure outside the containment, assuming the primary coolant equilibrium iodine concentrations permitted by the standard technical specifications, in combination with an accident generated iodine spike, do not exceed a small fraction of the exposure guidelines as set forth in 10 CFR Part 100, §100.11. The results of the staff's calculations are listed in Table 15.___.

The staff's conclusion is based on (1) the staff review of the applicant's classification and identification of small lines in accordance with General Design Criterion 55, "Reactor Coolant Pressure Boundary Penetrating Containment," and Regulatory Guide 1.11, "Instrument Lines Penetrating Containment," (2) the staff review of the applicant's analysis of radiological consequences, (3) the independent dose calculation by the staff using regulatory position C.1.b of Regulatory Guide 1.11 and conservative atmospheric dispersion factors as discussed in Chapter 2 of this report, and (4) the (insert NSSS VENDOR) standard technical specifications for the equilibrium iodine concentrations in the primary coolant system. The staff will review the (PLANT NAME) specific technical specifications to assure that the dose guidelines stated above are not exceeded.

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 guide.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 55, "Reactor Coolant Pressure Boundary Penetrating Containment."

2. Regulatory Guide 1.11, "Instrument Lines Penetrating Primary Containment."

3. 10 CFR Part 100, §100.11, "Determination of Exclusion Area, Low Population Zone and Population Center Distance."