U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 15.6.3 RADIOLOGICAL CONSEQUENCES OF STEAM GENERATOR TUBE FAILURE (PWR)

REVIEW RESPONSIBILITIES

Primary - Accident Analysis Branch (AAB)

Secondary - Site Analysis Branch (SAB)
Reactor Systems Branch (RSB)

I. AREAS OF REVIEW

The AAB review covers the following areas:

1. The release of secondary coolant due to a steam generator tube failure, with and without a concurrent loss of offsite power, in a pressurized water reactor (PWR) plant.

2. The calculation of whole body and thyroid doses at the nearest exclusion area boundary due to the releases resulting from these accidents.

The purposes of the review are to assure that the plant procedures for recovery from a steam generator tube failure, with and without offsite power available, are properly taken into account in the computation of whole body and thyroid doses at the nearest exclusion area boundary, and to assure that releases from the failure are adequately limited by the coolant activity concentration technical specifications. The RSB will notify the AAB if this accident is predicted to cause fuel failures, with and without a control rod held in the fully withdrawn position. The SAB provides the reviewer with the accident condition wind speed at the nearest exclusion area boundary.

II. ACCEPTANCE CRITERIA

The plant is considered adequately designed against a steam generator tube failure, and the primary and secondary coolant activities adequately limited, if calculations show that the resulting doses at the nearest exclusion area boundary are small fractions of the 10 CFR Part 100 exposure guidelfines, and are within 10 CFR Part 100 guidelines for the case of a coincident iodine spike or for the case of one rod held out of the core.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects of the areas covered by this review plan as may be appropriate for a particular case. The judgment on the areas to be given attention and emphasis during the review is based on an inspection of the material presented to see whether

it is similar to that recently reviewed on other plants and whether items of special safety significance are involved.

The detailed review of the radiological consequences of a steam generator tube failure is done at the operating license (OL) stage when system parameters and accident analyses are fully developed. At the construction permit (CP) stage, the review is limited to a brief survey of the pertinent portions of the plant design and the applicant's discussion of this accident to determine that there are no unusual features that would prevent limitation of radiological consequences to acceptable levels by appropriate limits on coolant activity concentrations.

The AAB review of the steam generator tube failure accident at the OL stage consists of the following steps:

1. Review of the applicant's description of the tube failure accidents (with and without offsite power). This includes a review of the time steps used in the descriptions, the bases for their selection, and assurance of an adequate degree of conservatism.

2. Review of the signals available to the reactor operator that indicate the occurrence of the accident and the state of the system throughout the recovery procedure. Automatic and required manual operations by the operator as a function of time must also be determined.

3. Preparation of the input data required to run a digital computer code based on the preceding information. For this purpose the reviewer sets up a series of time intervals similar to those described by the applicant, or modified, if necessary, in order to obtain an adequate degree of conservatism (Ref. 2). The values of the parameters describing the primary and secondary system operating conditions are obtained from the summary table that the applicant provides in this section of the safety analysis report (SAR). These data may also be found elsewhere in the SAR, mainly in Chapters 4 and 10.

4. Determination of the values of the meteorological parameters for the dose calculations. The SAB provides the reviewer with the accident condition (5 percentile) wind speed at the nearest exclusion area boundary. The X/Q value for the calculation of the two-hour doses is obtained from Regulatory Guide 1.5 (Ref.3) and corrected for wind speeds differing from 1 m/sec (inverse ratio).

5. Determination of the parameters for the thyroid dose calculation. An appropriate value for the iodine decontamination factor is used in the calculation of the thyroid doses. A decontamination factor of 10 is currently being used between the water and steam phases for most plants unless the applicant presents reasonable evidence that the use of another value is justified. A breathing rate of 3.47×10^4 m^3/sec is used in the calculation of the thyroid doses.

6. Determination of the coolant activity concentrations. The reviewer assumes the primary and secondary coolant activity concentrations allowed by the technical specifications (SAR Chapter 16) as equilibrium conditions prior to the accident. Additional coolant activity may become available for release if fuel failures result from the accident. The RSB reviews, on a generic basis, the effect of a steam generator tube failure on core thermal margins. If this event is predicted to cause fuel failures, RSB notifies AAB so that the predicted magnitude and extent of fuel failures can be properly considered in the evaluation of the radiological consequences.

7. Determination of the iodine spiking effects. The effect of iodine spiking following the accident (Ref. 4) can be accounted for by increasing the iodine source term in the primary system upon depressurization. At the present time, the I-131 equivalent source term (release rate from fuel) is increased by a factor of 500 at the time of reactor trip. A case with an iodine spike which already exists (due to a previous power transient) is also considered, assuming the I-131 equivalent coolant concentration technical specification limit for an iodine spike.

8. Determination of the leakage into the unaffected steam generators. Normal operating primary-to-secondary leakage is assumed to exist in the unaffected steam generators. The leakage rate should be the maximum allowed by the technical specifications (SAR Chapter 16). Currently this value is about 1 gpm but may be lower because of fuel densification, rod ejection accident consequences, or anticipated transient without scram (ATWS) consequences.

9. Determination of the coolant flow through the failed tube. The computer code is run for different values of the primary-to-secondary leakage through the failed tube. The flow rate resulting in the highest offsite dose is used as representative of the accident if it is smaller than the value calculated for a complete double-ended break.

10. Calculation of the exclusion area boundary doses. The reviewer uses a digital computer code with the input data and assumptions developed in the preceding steps, to determine the nearest exclusion area boundary doses for the steam generator tube failure accident. Doses are calculated with and without coincident iodine spiking.

11. Review of the results of the dose calculations. The reviewer compares the doses at the nearest exclusion area boundary, calculated without coincident iodine spiking, to the 10 CFR Part 100 guidelines. If the doses are a small fraction of the guideline values, the design is accepted. If not, the technical specification limits on the radioactivity concentrations in the coolant should be reduced accordingly. The doses calculated with coincident iodine spiking are also compared to the 10 CFR Part 100 guidelines. If they are within the guidelines, the design is accepted; if not, appropriate reductions of the technical specification limits on coolant activity concentrations are made.

12. Review of the effects of possible fuel damage in the accident on exclusion area boundary doses. The reviewer assumes that the applicant's calculations of fuel damage are correct for the case of a control rod held at the fully withdrawn position unless informed otherwise by RSB. If fuel damage does occur, calculations should be performed in order to assure that 10 CFR Part 100 guidelines are not exceeded (without a coincident iodine spike).

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that the review and calculations support conclusions of the following type, to be included in the staff's safety evaluation report at the operating license stage:

"The steam generator tube failure accident has been evaluated with and without a concurrent loss of offsite power. The design of the plant has been found to assure an expeditious recovery from these accidents with acceptably limited activity releases.

"A decontamination factor of ____ between the water and steam phases and a X/Q value of ____ sec/m^3 has been used in our evaluation of the radiological consequences. The calculated doses are presented in Table ____. Technical specification limits on primary and secondary coolant activities will limit potential doses to small fractions of the 10 CFR Part 100 exposure guidelines. The potential doses are within the 10 CFR Part 100 exposure guidelines even if the accident were to occur coincident with an iodine spike."

The following paragraph is added if fuel damage is found to be a possible consequence of the accident:

"The evaluation of the steam generator tube failure accident has also been evaluated with ____% fuel damage in the core (as a result of the most reactive control rod remaining fully withdrawn). The resulting doses are within the guidelines of 10 CFR Part 100."

At the construction permit stage the following paragraph is included in the staff's safety evaluation report:

"On the basis of our experience with the evaluation of steam generator tube failure accidents for pressurized water reactor plants of similar design, we have concluded that the consequences of these accidents can be controlled by limiting the permissible primary and secondary coolant system radioactivity concentrations so that potential offsite doses are small. We will include appropriate limits on primary and secondary coolant activity concentrations in the technical specifications."

V. REFERENCES

1. 10 CFR Part 100, "Reactor Site Criteria."

2. H. M. Fontecilla, "Analysis of Accidental Iodine Releases from the Secondary Coolant System," Trans. Am. Nucl. Soc., 17, 336 (1973).

3. Regulatory Guide 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors."

4. W. F. Pasedag, "Effects of Iodine Spiking on Light-Water Reactor Accident Analysis," Trans. Am. Nucl. Soc., 17, 336 (1973).

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