U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

6.2.3 SECONDARY CONTAINMENT FUNCTIONAL DESIGN

REVIEW RESPONSIBILITIES

Primary - Containment Systems Branch (CSB)

Secondary - None

I. AREAS OF REVIEW

The CSB reviews the information in the applicant's safety analysis report (SAR) concerning the functional capability of the secondary containment system. The secondary containment system includes the outer containment structure of dual containment plants and the associated systems provided to mitigate the radiological consequences of postulated accidents. The secondary containment structure and supporting systems are provided to collect and process radioactive material that may leak from the primary containment following an accident. The supporting systems maintain a negative pressure within the secondary containment and process this leakage. Plant areas and systems contiguous to the secondary containment which also collect and process radioactive material that may leak from the primary containment following an accident are reviewed by the CSB in the same manner as the secondary containment.

The CSB review of the functional capability of the secondary containment system of dual containment designs includes the following points:

1. Analyses of the pressure and temperature response of the secondary containment to a loss-of-coolant accident within the primary containment.

2. Analyses of the effect of openings in the secondary containment on the capability of the depressurization and filtration system to accomplish its design objective of establishing a negative pressure in a prescribed time.

3. Analyses of the pressure and temperature response of the annular region between the primary and secondary containment to a high energy line rupture within the secondary containment.

4. The functional design criteria applied to guard pipes surrounding high energy lines within the secondary containment.

5. Analyses of any primary containment leakage paths that bypass the secondary containment.

6. The design provisions for periodic leakage testing of secondary containment bypass leakage paths.

7. Analyses of the pressure response of the secondary containment resulting from inadvertent depressurization of the primary containment when there is vacuum relief from the secondary containment.

8. The acceptability of the mass and energy release data used in the analysis of the secondary containment pressure response to postulated high energy line breaks.

The CSB will coordinate other branch evaluations that interface with the overall review of the secondary containment functional design, as follows: The Accident Evaluation Branch (AEB), as part of its primary review responsibility for SRP Section 6.5 and SRP Section 6.2.6 will evaluate the design requirements and the periodic inspection and operablity test program for the depressurization and filtration systems. The AEB also will evaluate the fission product removal capability of the secondary containment supporting systems. The Auxiliary Systems Branch (ASB), as part of its primary review responsibility for SRP Section 3.6.1, will evaluate the plant design for protection against postulated pipe ruptures in auxiliary areas outside primary containment that serve as the secondary containment. The Instrumentation and Control Systems Branch (ICSB) reviews and evaluates instrumentation necessary for the actuation and control features for the secondary containment function as part of its primary review responsibility for SRP Section 7.1 thru 7.5. The Mechanical Engineering Branch (MEB), as part of its primary review responsibility for SRP Section 3.6.2, will evaluate the break locations and dynamic effects associated with the postulated rupture of piping outside the primary containment. The Licensing Guidance Branch (LGB), at the operating licensing stage of review, will review the proposed technical specifications pertaining to the functional capability of the secondary containment system and the leakage testing of bypass leakage paths as part of its primary review responsibility for SRP Section 16.0.

For these areas of review identified above as being part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

CSB accepts the secondary containment functional design if the relevant requirements of General Design Criteria 4, 16, and 45 and Appendix J to 10 CFR Part 50 are complied with. The relevant requirements are as follows:

A. General Design Criterion 4 as it relates to structures, systems and components important to safety being designed to accommodate the effects of normal operation, maintenance, testing and postulated accidents, and being protected against dynamic effects (e.g., the effects of missiles, pipe whipping, and discharging fluids) that may result from equipment failures.

B. General Design Criterion 16 as it relates to reactor containment and associated systems being provided to establish an essentially leak-tight barriers against the uncontrolled release of radioactivity to the environment.

C. General Design Criterion 43 as it relates to atmosphere cleanup systems having the design capability to permit periodic functional testing to assure system integrity, the operability of active components, and the operability of the system as a whole and the performance of the operational sequence that brings the system into operation.

D. 10 CFR Part 50, Appendix J as it relates to the secondary containment being designed to permit preoperational and periodic leakage rate testing so that bypass leakage paths are identified.

Specific criteria that pertain to design and functional capability of the secondary systems which are necessary to meet the relevant requirements of GDC 4, 16 and 43 and 10 CFR Part 50, Appendix J are as follows:

1. In meeting the requirements of GDC 16 regarding functional capability of the secondary containment, the analysis of the pressure and temperature response of the secondary containment to a loss-of-coolant accident occurring in the primary containment should be based on the following guidelines:

   a. Heat transfer from the primary to secondary containment should be considered.

      (1) Heat transfer from the primary containment atmosphere to the primary containment structure should be calculated using conservative heat transfer coefficients such as those provided in Branch Technical Position CSB 6-1 (Ref. 6).

      (2) Conductive heat transfer through the primary containment structure and convective heat transfer to the secondary containment atmosphere should be considered.

      (3) Radiant heat transfer to the secondary containment should be considered.

   b. Adiabatic boundary conditions should be assumed for the surface of the secondary containment structure exposed to the outside environment.

   c. The compressive effect of primary containment expansion on the secondary containment atmosphere should be considered.

   d. Secondary containment inleakage should be considered.

   e. No credit should be taken for secondary containment outleakage.

   f. Secondary containment response analyses should be based on the assumption of loss of offsite power and the most severe single active failure in the emergency power system (e.g., a diesel generator failure), in the primary containment heat removal systems, in the core cooling systems, or in the secondary containment depressurization and filtration system. Any delay, due to system design, in actuating the secondary containment depressurization and filtration system should be considered.

g. Heat loads generated within the secondary containment (e.g., equipment heat loads) should be considered.

h. Fan performance characteristics should be considered in evaluating the depressurization of the secondary containment.

2. In meeting the requirement of GDC 4 to project structures, systems and components important to safety against dynamic effects, high energy lines passing through the secondary containment should be provided with guard pipes. Design criteria for guard pipes are given in SRP Section 3.6.2. If guard pipes are not provided, analyses should be provided which demonstrate that both the primary containment structure and the secondary containment structure are capable of withstanding the effects of a high energy pipe rupture occurring inside the secondary containment without loss of integrity.

3. In meeting the requirements of GDC 16, regarding the functional capability of the secondary containment, the following criteria apply:

a. The secondary containment depressurization and filtration systems should meet the guidelines of Regulatory Guide 1.52 and be capable of maintaining a uniform negative pressure throughout the secondary containment, as well as other areas served by the systems.

b. The negative pressure differential to be maintained in the secondary containment and other contiguous plant areas should be no less than 0.25 inches (water) when compared with adjacent regions, under all wind conditions up to the wind speed at which diffusion becomes great enough to assure site boundary exposures less than those calculated for the design basis accident even if exfiltration occurs. If the leakage rate is in excess of 100% of the volume per day, a special exfiltration analysis should be performed.

c. All openings, such as personnel doors and equipment hatches, should be under administrative control. These openings should be provided with position indicators and alarms having readout and alarm capability in the main control room. The effect of open doors or hatches on the functional capability of the depressurization and filtration systems should be evaluated and confirmatory preoperational tests conducted.

d. Some plants may have only portions of the primary containment enclosed, rather than having a secondary containment structure or shield building that completely encloses the primary containment. These enclosed areas are areas into which the primary containment would most likely leak, and they may be equipped with air filtration systems. Quantitative credit cannot be given for the holdup effect of these enclosed areas or for the air filtration systems, to mitigate the radiological consequences of a postulated accident, unless the magnitude of unprocessed leakage can be adequately demonstrated. Quantitative credit for leakage collection in a partial-dual containment will be reviewed on a case-by-case basis.

e. The external design pressure of the secondary containment structure should provide an adequate margin above the maximum expected external pressure.

4. In meeting the requirements of GDC 43 and 10 CFR Part 50, Appendix J, regarding the inspection and testing of the secondary containment system, the following criteria apply:

   a. The fraction of primary containment leakage bypassing the secondary containment and escaping directly to the environment should be specified. Branch Technical Position (BTP) CSB 6-3 (Ref. 5) provides guidance for identifying the leakage paths to the environment which may bypass the secondary containment. The periodic leakage rate testing program for measuring the fraction of primary containment leakage that may directly bypass the secondary containment and other contiguous areas served by ventilation and filtration systems should be described.

   b. Provisions should be made in the design of the secondary containment system to permit inspections and monitoring of the functional capability. The determination of the depressurization time, the secondary containment in leakage rate, the uniformity of negative pressure throughout the secondary containment and other contiguous areas, and the potential for exfiltration should be included in the preoperational and periodic test programs.

III. REVIEW PROCEDURES

The procedures described below provide guidance on the review of the secondary containment system. The reviewer selects and emphasizes material from the review procedures as may be appropriate for a particular case. Portions of the review may be done on a generic basis for aspects of secondary containment functional design common to a class of plants, or by adopting the results of previous reviews of similar plants.

Upon request from the CSB primary reviewer, other branches will provide input for the areas of review stated in subsection I of this SRP section. The CSB reviewer obtains and uses such input as required to assure that this review procedure is complete.

CSB reviews the analytical models used and the assumptions made in the analyses of the pressure and temperature response of the secondary containment to loss-of-coolant accidents in the primary containment. In general, CSB determines that the analyses conservatively predict the secondary containment pressure response. In so doing, CSB compares the analyses to the guidelines in subsection II of this SRP section.

If considered necessary, CSB performs confirmatory analyses of the pressure and temperature response of the secondary containment for loss-of-coolant accidents within the primary containment and for high energy line (e.g., steam line and feedwater line) ruptures occurring within the annular region formed by the secondary containment. The analyses are done using the CONTEMPT-LT computer code (Ref. 4). It should be noted that, for the analysis of the pressure and temperature response in the secondary containment for loss-of-coolant accidents within the primary containment, the present version of the CONTEMPT-LT only has the capability of calculating the pressure in the secondary containment up to the time the depressurization systems are actuated. The code is being improved to permit the calculation of the pressure response for the entire course of an accident.

The analysis will be based on the guidelines given in subsection II of this SRP section, and code input data obtained from the SAR. CSB determines that the secondary containment design pressure is not exceeded and that the depressurization time is consistent with that assumed in the AEB analysis of the radiological consequences of the accident. In addition, CSB determines that the primary containment external design pressure is not exceeded.

CSB determines that all direct leakage paths have been properly identified, and from a review of the proposed leakage testing program that provisions have been made in the design of the plant to measure the fraction of total primary containment leakage that bypasses the secondary containment. CSB advises AEB of any inadequacies in the applicant's direct leakage assumptions used in the radiological analysis. At the operating license stage of review, LGB reviews technical specifications which specify the surveillance requirements for leakage testing of the secondary containment bypass leakage paths.

CSB reviews analyses of the capability of the secondary containment system to resist exfiltration under post-accident conditions. If the secondary containment leakage rate is in excess of 100% of the volume per day, CSB advises AEB in order that they may perform a special exfiltration analysis. CSB reviews the preoperational and periodic inservice testing programs to assure that testing will be done to verify the extent of exfiltration.

CSB reviews the proposed secondary containment system testing program and the surveillance requirements to assure that tests will be periodically conducted to verify that the prescribed negative pressure can be uniformly maintained throughout the secondary containment. CSB also reviews the testing program and surveillance requirements to assure that tests will be periodically conducted to verify the secondary containment design inleakage rate and to verify the analysis of the depressurization of the secondary containment.

LGB reviews the proposed technical specifications to assure that adequate administrative control will be exercised over the secondary containment openings, such as personnel access doors and equipment hatches. CSB determines from the descriptive information in the SAR that all doors and hatches are provided with position indicators having readout and alarm capability in the main control room. The CSB will ascertain that normally open doors were considered in the analyses of the functional capability of the secondary containment system.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that his evaluation supports conclusions of the following type, to be included in the staff's safety evaluation report:

> The scope of review of the functional design of the secondary containment system for the (Plant name) has included plan and elevation drawings, system drawings, and descriptive information. This system is provided to control the atmosphere within the secondary containment and contiguous

areas. The review has included the applicant's proposed design bases and analyses of the functional capability of the secondary containment system.

The staff concludes that the containment functional design is acceptable and meets the requirements of Genera Design Criteria 4, 16 and 43. The conclusion is based on the following: [The reviewer should discuss each item of the regulations or related set of regulations as indicated.]

1. The applicant has met the requirements of (cite regulation) with respect to (state limits of review in relation to regulation) by (for each item that is applicable to the review state how it was met and why acceptable with respect to regulation being discussed):

   a. meeting the regulatory positions in Regulatory Guide ___ or Guides;

   b. providing and meeting an alternative method to regulatory positions in Regulatory Guide ___, that the staff has reviewed and found to be acceptable;

   c. meeting the regulatory position in BTP ___;

   d. usin calculational methods for (state what was evaluated) that has been previously reviewed by the staff and found acceptable; the staff has reviewed the impact parameters in this case and found them to be suitably conservative or performed independent calculations to verify acceptability of their analysis; and/or

   e. meeting the provisions of (industry standard number and title) that has been reviewed by the staff and determined to be appropriate for this application.

2. Repeat discussion for each regulation cited above.

V. IMPLEMENTATION

The following is intended to provided guidance to applicants and licensees regarding the NRC 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 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."

2. 10 CFR Part 50, Appendix A, General Design Criterion 16, "Containment Design."

3. 10 CFR Part 50, Appendix A, General Design Criterion 43, "Testing of Containment Atmosphere Cleanup Systems."

4. R. J. Wagner and L. L. West, "CONTEMPT-LT Users Manual," Interim Report I-214-74-12.1, Aerojet Nuclear Company, August 1973.

5. Branch Technical Position CSB 6-3, "Determination of Bypass Leakage Paths in Dual Containment Plants," attached to this SRP section.

6. Branch Technical Position CSB 6-1, "Minimum Containment Pressure Model for PWR ECCS Performance Evaluation," attached to SRP Section 6.2.1.5.

BRANCH TECHNICAL POSITION CSB 6-3

DETERMINATION OF BYPASS LEAKAGE PATHS IN DUAL CONTAINMENT PLANTS

A. BACKGROUND

The purpose of this branch position is to provide guidance in the determination of that portion of the primary containment leakage that will not be collected and processed by the secondary containment. Bypass leakage is defined as that leakage from the primary containment which can circumvent the secondary containment boundary and escape directly to the environment, i.e., bypasses the leakage collection and filtration systems of the secondary containment. This leakage component must be considered in the radiological analysis of a loss-of-coolant accident.

The secondary containment consists of a structure which completely encloses the primary containment and can be maintained at a pressure lower than atmospheric so that primary containment leakage can be collected or processed before release to the environment. The secondary containment may include an enclosure building which forms an annular volume around the primary containment, the auxiliary building where it completely encloses the primary containment, and other regions of the plant that are provided with leakage collection and filtration systems. Depressurization systems are provided as part of the secondary containment to decrease or maintain the secondary containment volume at a negative pressure.

All primary containment leakage may not be collected because (1) direct primary containment leakage can occur while the secondary containment is being depressurized and (2) primary containment leakage can bypass the secondary containment through containment penetrations and seals which do not terminate in the secondary containment.

Direct leakage from the secondary containment to the environment can occur whenever an outward positive differential pressure exists across the secondary containment boundary. The secondary containment can experience a positive pressure transient following a postulated loss-of-coolant accident in the primary containment as a result of thermal loading and infiltration from the environment and the primary containment that will occur until the depressurization systems become effective. An outward positive differential on the secondary containment wall can also be created by wind loads. In this regard, a "positive" pressure is defined as any pressure greater than -0.25 in. w.g. (water gauge), to account for wind loads and the uncertainty in the pressure measurements. Whenever the pressure in the secondary containment volume exceeds -0.25 in. w.g., the leakage-prevention function of the secondary containment is assumed to be negated. Since leakage from the secondary containment during positive pressure periods cannot be determined, the conservative assumption is made that, all primary containment leakage is released directly to the environment during these time periods. Therefore, it becomes necessary to determine the time periods during which these threshold conditions exist.

The existence and duration of periods of positive pressure within the secondary containment should be based on analyses of the secondary containment pressure response to postulated loss-of-coolant accidents within the primary containment and the effectiveness of the depressurization systems.

The evaluation of bypass leakage involves both the identification of bypass leakage paths and the determination of leakage rates. Potential bypass leakage paths are formed by penetrations which pass through both the primary and secondary containment boundaries. Penetrations that pass through both the primary and secondary containment may include a number of barriers to leakage (e.g., isolation valves, seals, gaskets, and welded joints). While each of these barriers aid in the reduction of leakage, they do not necessarily eliminate leakage. Therefore, in identifying potential leakage paths, each of these penetrations should be considered, together with the capability to test them for leakage in a manner similar to the containment leakage tests required by Appendix J to 10 CFR Part 50.

B. BRANCH TECHNICAL POSITION

1. A secondary containment structure should completely enclose the primary containment structure, with the exception of those parts of the primary containment that are imbedded in the soil, such as the base mat of the containment structure. For partial dual containment concepts, leak rates less than the design leak rate of the primary containment should not be used in the calculation of the radiological consequences of a loss-of-coolant accident, unless the magnitude of unprocessed leakage can be adequately demonstrated. Quantitative credit for leakage collection in a partial-dual containment will be reviewed on a case-by-case basis.

2. Direct leakage from the primary containment to the environment, equivalent to the design leak rate of the primary containment, should be assumed to occur following a postulated loss-of-coolant accident whenever the secondary containment volume is at a "positive" pressure; i.e., a pressure greater than -0.25 in. w.g. Positive pressure periods should be determined by a pressure response analysis of the secondary containment volume that includes thermal loads from the primary containment and infiltration leakage.

3. The secondary containment depressurization and filtration systems should be designed in accordance with Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water Cooled Nuclear Power Plants." Preoperational and periodic inservice inspection and test programs should be proposed for these systems and should include means for determining the secondary containment infiltration rate, and the capability of the systems to draw down the secondary containment to the prescribed negative pressure in a prescribed time.

4. For secondary containments with design leakage rates greater than 100 volume percent per day, an exfiltration analysis should be provided.

5. The following leakage barriers in paths which do not terminate within the secondary containment should be considered potential bypass leakage paths around the leakage collection and filtration systems of the secondary containment:

    a. Isolation valves in piping which penetrates both the primary and secondary containment barriers.

b. Seals and gaskets on penetrations which pass through both the primary and secondary containment barriers.

c. Welded joints on penetrations (e.g., guard pipes) which pass through both the primary and secondary containment barriers.

6. The total leakage rate for all potential bypass leakage paths, as identified in item 5 above, should be determined in a realistic manner, considering equipment design limitations and test sensitivities. This value should be used in calculating the offsite radiological consequences of postulated loss-of-coolant accidents and in setting technical specification limits with margin for bypass leakage.

7. Provisions should be made to permit preoperational and periodic leakage rate testing in a manner similar to the Type B or C tests of Appendix J to 10 CFR Part 50 for each bypass leakage path listed in item 5 above. An acceptable alternative for local leakage rate testing for welded joints would be to conduct a soap bubble test of the welds concurrently with the integrated (Type A) leakage test of the primary containment required by Appendix J. Any detectable leakage determined in this manner would require repair of the joint.

8. If air or water sealing systems or leakage control systems are proposed to process or eliminate leakage through valves, these systems should be designed, to the extent practical, using the guidelines for leakage control systems given in Regulatory Guide 1.96 (Ref. 4).

9. If a closed system is proposed as a leakage boundary to preclude bypass leakage, then the system should:

a. Either (1) not directly communicate with the containment atmosphere, of (2) not directly communicate with the environment, following a loss-of-coolant accident.

b. Be designed in accordance with Quality Group B standards, as defined by Regulatory Guide 1.26. (Systems designed to Quality Group C or D standards that qualify as closed systems to preclude bypass leakage will be considered on a case-by-case basis.)

c. Meet seismic Category I design requirements.

d. Be designed to at least the primary containment pressure and temperature design conditions.

e. Be designed for protection against pipe whip, missiles, and jet forces in a manner similar to that for engineered safety features.

f. Be tested for leakage, unless it can be shown that during normal plant operations the system integrity is maintained.

C. REFERENCES

1. 10 CFR Part 50, Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors."

2. Regulatory Guide 1.26, "Quality Group Classification and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

3. Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."

4. Regulatory Guide 1.96, "Design of Main Steam Isolation Valve Leakage Control Systems for Boiling Water Reactor Nuclear Power Plants."