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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 6.2.1.1.B ICE CONDENSER CONTAINMENTS

REVIEW RESPONSIBILITIES

Primary - Containment Systems Branch (CSB)

Secondary - Core Performance Branch (CPB)
Electrical, Instrumentation and Control Systems Branch (EICSB)
Accident Analysis Branch (AAB)
Structural Engineering Branch (SEB)
Mechanical Engineering Branch (MEB)

I. AREAS OF REVIEW

The CSB review of ice condenser containments includes the following areas:

1. The pressure and temperature conditions in the containment due to a spectrum (including break size and location) of loss-of-coolant accidents; i.e., reactor coolant system pipe breaks and steam and feedwater line breaks.

2. The maximum expected external pressure to which the containment may be subjected.

3. The design and qualification testing of ice condenser components.

4. The pressure conditions within containment internal structures and acting on system components and supports due to high energy line breaks.

5. The maximum allowable operating deck steam bypass area for a full spectrum of reactor coolant system pipe breaks.

6. The design provisions and proposed surveillance program to assure that the ice condenser will remain operable for all plant power operations.

7. The design and qualification testing of the return air fan systems and system components.

8. The effectiveness of static and active heat removal mechanisms.

9. The minimum containment pressure used in the analyses of emergency core cooling system capability.

10. The instrumentation provided to monitor and record containment atmosphere pressure and temperature and sump water temperature under post-accident conditions.

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11. The proposed technical specifications, at the operating license stage of review, pertaining to the surveillance requirements for steam bypass area, return air fan system operability, ice condenser operability, and vacuum relief devices.

The CSB will also review analyses of anticipated transients without scram (ATWS) which discharge fluid to the containment to assure that containment pressure and temperature design conditions are not exceeded.

The fission product removal capability of the ice condenser is evaluated by AAB under Standard Review Plan 6.5.4.

II. ACCEPTANCE CRITERIA

The following acceptance criteria apply to the design and functional capability of ice condenser containments:

1. The ice condenser components should be designed, fabricated, erected, and tested in accordance with Group B quality standards, as recommended by Regulatory Guide 1.26.

   The ice condenser components should be designated Category I (seismic); i.e., designed to withstand the effects of the safe shutdown earthquake without loss of function, as recommended by Regulatory Guide 1.29.

   Analyses or qualification tests should be performed for all ice condenser components that are changed in design from that reported in Appendices M and N to the D.C. Cook FSAR (Ref. 27) to assure that the ice condenser will remain operable in the accident environment for as long as accident conditions require. If a component was originally qualified by analytical methods, confirmation of the new design by reanalysis or a test program will be acceptable. For components that were originally qualified by a test program, the redesigned component should be requalified by a test program.

2. The containment accident pressure and temperature response should be calculated using the LOTIC (or an equivalent) computer code (Ref. 27). Conservative assumptions which maximize the energy release to the containment should also be used (See Standard Review Plan 6.2.1.3, "Mass and Energy Release Analysis for Postulated Loss-of-Coolant Accidents").

   For plants being reviewed for construction permits, the containment design pressure should provide at least a 20% margin above the highest calculated accident pressure. For plants being reviewed for operating licenses, the highest calculated accident pressure should not exceed the design pressure of the containment.

3. Ice condenser subcompartment or control volume differential (internal) pressures should be calculated using the Transient Mass Distribution (TMD) computer code (Ref. 28), without the augmented critical flow correlation. Mass and energy releases from postulated pipe breaks should be determined using the SATAN-VI computer code (Ref. 24) and used as input to the TMD code.

For plants being reviewed for construction permits, the design differential pressures for all ice condenser control volumes or subcompartments, and system components (e.g., reactor vessel, pressurizer, steam generators) and supports, should provide at least a 40% margin above the highest calculated differential pressures. For plants being reviewed for operating licenses, the highest calculated differential pressures for all ice condenser control volumes or subcompartments should not exceed the corresponding design differential pressures.

The operating deck should be designed to withstand the maximum calculated differential pressure between the upper and lower compartments. To account for uncertainties in the analysis of reverse differential pressures, an adequate margin should be provided above the maximum calculated reverse differential pressure.

4. The maximum allowable area for steam bypass of the ice condenser should be greater than the identifiable bypass area for the plant (e.g., the drainage provisions to allow containment spray water to return from the upper compartment to the sumps in the lower compartment). The bypass area capability of the plant should be based on analyses of the spectrum of postulated reactor coolant system pipe breaks, and should be about 35 square feet or greater.

5. The design of the ice condenser system should incorporate provisions for periodic inservice inspection and testing of essential system components; e.g., the ice baskets and doors, the ice condenser temperature monitoring system, and the available mass of ice. The inspection and test program should assure the integrity and operability of the ic- ndenser system and should satisfy the requirements of General Design Criteria 3. d 40.

6. The return air fan system components should be designed, fabricated, erected, and tested in accordance with Group B quality standards, as recommended by Regulatory Guide 1.26. The system should be designated Category I (seismic) as recommended by Regulatory Guide 1.29.

   The inservice inspection and testing program for the return air fan system should satisfy the requirements of General Design Criteria 39 and 40.

   Analyses or tests should be performed for the return air fan system components to demonstrate that the system will remain operable in the accident environment for as long as accident conditions require.

7. Inadvertent operation of engineered safety features (e.g., the return air fan system or the containment spray system) should not cause the external design pressure of the primary containment to be exceeded. This may be accomplished through conservative containment design, use of vacuum relief devices, or electrical interlocks that preclude inadvertent operation of the spray and fan systems. Vacuum relief devices should be provided in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NE (Ref. 3) and should meet applicable requirements of General Design Criteria 54 and 56.

8. Instrumentation capable of operating in the post-accident environment should be provided to monitor the containment atmosphere pressure and temperature, and the sump water temperature following an accident. The instrumentation should have adequate range, accuracy, and response to assure that the above parameters can be tracked throughout the course of an accident. Recording equipment capable of following the transient should be provided.

9. The minimum calculated containment pressure should not be less than that used in the analysis of the emergency core cooling system capability (See Standard Review Plan 6.2.1.5, "Minimum Containment Pressure Analysis for Emergency Core Cooling System Performance Capability Studies").

III. REVIEW PROCEDURES

The procedures described below are followed for the review of ice condenser containments. The reviewer selects and emphasizes material from these procedures as may be appropriate for a particular case. Portions of the review may be carried out on a generic basis for aspects of functional design common to a class of ice condenser containments or by adopting the results of previous reviews of plants with essentially the same containment functional design.

1. The CSB evaluates the design of the ice condenser type containment by comparing it to the design information presented in Appendices M and N to the D.C. Cook FSAR, and discussed in the staff's safety evaluation report on the plant (Ref. 27). The CSB has reviewed the design of the Cook ice condenser as reported in these documents and has found that it satisfies the acceptance criteria stated in Section II. Any differences from the design reported in the Cook documents are evaluated. The CSB determines that all design changes have been justified, and the components have been requalified for use in the ice condenser by the same methods originally used to qualify them, i.e., for simple structures which were qualified by analytical methods, a reanalysis will be accepted; and for components qualified by test programs, the tests should be repeated on the revised design.

   The CSB compares the quality standards applied to the ice condenser to Regulatory Guide 1.26.

   The CSB compares the seismic design classification of the ice condenser to Regulatory Guide 1.29.

2. The CSB reviews the analysis of the containment pressure and temperature response. The CSB and CPB determine that the mass and energy release to the containment for the duration of the accident has been maximized (See Standard Review Plan 6.2.1.3, "Mass and Energy Release Analysis for Postulated Loss of Coolant Accidents"). The CSB has reviewed the LOTIC code which is used to determine the containment pressure and temperature response, and has determined that the code is acceptable for containment analysis. The CSB assures that the LOTIC code has been used and that the input assumptions to the code are conservative. Code revisions and improvements will also be considered.

CSB determines from the results of analyses that the peak calculated containment pressure does not exceed the design pressure of the containment, for plants at the operating license stage of review. For plants at the construction permit stage of review, the CSB will ascertain from the results of analyses reported in the safety analysis report that the design pressure provides a margin of at least 20% above the maximum calculated pressure.

Modifications to the CONTEMPT-LT code which will provide improved capability to analyze the response of an ice condenser containment to a loss-of-coolant accident are being made. When the COMTEMPT-LT modifications have been completed, CSB will perform confirmatory analyses using the modified code.

3. The TMD code is used to evaluate the transient pressure responses (internal) of the ice condenser containment subcompartments. The code is described in the proprietary report WCAP-8077 (Ref. 28). The TMD code utilizes ice condenser heat transfer and flow data obtained from full-scale section tests of the ice condenser. As stated in the D.C. Cook Safety Evaluation Report, the CSB has reviewed the assumptions and equations used in the TMD code and with the exception of the critical flow model used to predict subcompartment vent mass flow rates, has concluded that the TMD code conservatively calculates transient pressure response.

   The TMD code calculates the critical flow of a two-component, two-phase fluid (air, steam, and water) assuming a thermal equilibrium condition. However, a correction factor is then applied to the calculated critical flow. The CSB has not accepted the use of this corrected critical flow, referred to as "augmented flow," and has required that the short-term transient responses of subcompartments be determined using the TMD code without applying a correction factor to the critical flow; i.e., without the "augmented flow" correlation.

   Before accepting the containment transient responses calculated by the TMD code, the CSB reviews the mass and energy data input to the TMD code and the modeling of the containment subcompartments, the size and area of assumed vents between nodes, volumes of nodes, the flow loss coefficients for each vent modeled, and the heat transfer coefficients within the ice condenser.

   The CSB will determine from the safety analysis report that the TMD code, without the "augmented flow" correlation, has been utilized to determine the transient pressure response in each subcompartment that contains a high energy line, and in adjoining subcompartments.

The CSB reviews the maximum calculated differential pressures and pressure profiles for each subcompartment. For plants at the construction permit state of review, the CSB will ascertain that it is the applicant's intent to design all internal structures with a margin of 40% between the maximum calculated differential pressure and the design differential pressure of the structure or component. At the operating license stage of review, the CSB will ascertain that an appropriate margin exists. However, changes in technology and calculational methods may affect the margin. The CSB will then determine that the maximum calculated differential pressures do not exceed the design differential pressures for the internal structures. The loads on components or their supports installed within the compartment due to possible pressure gradients will be evaluated by MEB and SEB.

Modifications to the RELAP4 code to include two-phase, two-component mixtures are being made. This will improve the capability of the code so that it may be used for subcompartment analysis of ice condenser plants. When the modifications to the RELAP4 code have been completed, the CSB will use the code to conduct confirmatory analyses.

4. The CSB reviews the methods, input assumptions, and results of the applicant's steam bypass analysis. The applicant's analysis should show considerable margin between the maximum tolerable bypass leakage area and the identifiable bypass area required to allow spray water drainage back to the containment sump. The CSB determines the adequacy of the margins provided for the full spectrum of reactor coolant pipe ruptures. Factors affecting the determination include the proposed inspections and tests to determine bypass leakage area and whether the design of the plant will permit access to seals between the upper and lower compartments for inspection. At the operating license stage, the CSB reviews the proposed technical specifications to assure that adequate surveillance will be maintained for the steam bypass area.

5. The CSB reviews the initial programs for ice loading and subsequent verification of individual ice basket and total ice loads. In addition, it reviews design provisions for monitoring the status of the ice condenser during plant operation to assure that the ice condenser retains its full capability. The CSB also reviews the aspects of the ice condenser design which will allow inspection and functional testing of ice condenser components during various modes of plant operation. Specific areas to be evaluated are the ice condenser temperature instrumentation system, lower inlet door position monitoring system, proposed ice basket inspection programs to determine total ice weight, proposed inspection and testing programs for intermediate and top deck doors, floor drains, lower inlet doors, ice condenser flow passages, divider barrier seals, and access hatches. The CSB determines that the proposed surveillance programs and attendant design provisions fulfill the intent of General Design Criteria 39 and 40. At the operating license stage, the CSB also evaluates the proposed technical specifications that have been established to assure ice condenser operability.

6. The CSB reviews the environmental conditions used in the qualification testing of the return air fan system components. The CSB determines whether the test conditions are representative of post-accident conditions to which the equipment may be subjected. The CSB will ascertain that the equipment can operate in the accident environment for as long as accident conditions require. The CSB reviews analyses demonstrating that where required, the return air fan system and its components are designed to withstand the transient differential pressures to which the system would be subjected following a loss-of-coolant accident.

The CSB reviews the provisions made in the design of the return air fan system and the proposed program for periodic inspection and functional testing of the system and components for compliance with the intent of General Design Criteria 39 and 40. The CSB determines the acceptability of the proposed periodic surveillance program for the return air fan system, taking into account the extent and frequency of testing proposed and the practices established for previous ice condenser plants. At the operating license stage, the CSB also evaluates the technical specifications for the return air fan system that have been proposed to assure system operability.

7. The CSB reviews the analysis of the maximum depressurization transient due to inadvertent operation of the containment sprays or return air fans. The CSB reviews the assumed containment initial conditions, methods of calculation, and spray system efficiency to determine whether the containment depressurization analysis is conservative. If the external design pressure of the containment is shown to be exceeded, the CSB will ascertain that containment vacuum relief devices to mitigate the consequences of inadvertent operation of the sprays or fans have been provided, or administrative controls have been established and interlocks provided to prevent inadvertent operation of the sprays or fans. If containment vacuum relief devices are used, the CSB reviews the analysis provided to demonstrate that the response time of the relief devices is short enough to prevent depressurization of the containment below the external design pressure. The CSB determines that the vacuum relief devices comply with the requirements of Subsection NE of Section III of the ASME Boiler and Pressure Vessel Code. CSB reviews the design of the vacuum relief devices and proposed inspection and testing programs to ensure that the intent of General Design Criteria 54 and 56 is fulfilled. If administrative controls are established and electrical interlocks provided to preclude inadvertent operation of the sprays or fans, the CSB in conjunction with the EICSB reviews the acceptability of these provisions from a functional standpoint. At the operating license stage of review, CSB also reviews the proposed technical specifications to assure that adequate surveillance and administrative control will be maintained over the vacuum relief devices.

8. The CSB determines whether instrumentation capable of withstanding post-accident environments, and recording equipment, has been provided to monitor and record the course of an accident within the containment. The CSB also determines that the instrumentation and recording equipment can accomplish the objectives stated in Section II. This review effort is coordinated with the EICSB. The EICSB, in Standard Review Plan 7.3, has review responsibility for the acceptability of, and the qualification test program for the sensing and actuation instrumentation of the plant protection system, the ice condenser temperature monitoring system, and the post-accident monitoring instrumentation and recording equipment.

IV. EVALUATION FINDINGS

The conclusions reached on completion of the review of this section are presented in Standard Review Plan 6.2.1.

V. REFERENCES

The references for this plan are listed in Standard Review Plan 6.2.1.

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SRP 6.2.1.1.C