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

SECTION 6.2.6 CONTAINMENT LEAKAGE TESTING

REVIEW RESPONSIBILITIES

Primary - Containment Systems Branch (CSB)

Secondary - Accident Analysis Branch (AAB)

I. AREAS OF REVIEW

Information describing the reactor containment leakage testing program is reviewed by the CSB. At the construction permit (CP) stage the preliminary safety analysis report (PSAR) will not usually contain a description of the program in detail but will contain commitments by the applicant to develop a program which will meet the intent of Appendix J to 10 CFR Part 50, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors."

The CSB review of the reactor containment leakage testing program at the operating license (OL) stage covers the following specific areas:

1. Containment integrated leakage rate tests (Type A tests as defined by Appendix J), including pretest requirements, general test methods, acceptance criteria for preoperational and periodic leakage rate tests, provisions for additional testing in the event of failure to meet acceptance criteria, and scheduling of tests.

2. Containment penetration leakage rate tests (Type B tests as defined by Appendix J), including identification of containment penetrations, general test methods, test pressures, acceptance criteria, and scheduling of tests.

3. Containment isolation valve leakage rate tests (Type C tests as defined by Appendix J), including identification of isolation valves, general test methods, test pressures, acceptance criteria, and scheduling of tests.

4. Technical specifications pertaining to containment leakage rate testing.

The Accident Analysis Branch analyzes the radiological consequences of loss-of-coolant accidents using the containment design leakage rate. The containment leakage testing program must verify that the containment leakage rate is less than the design limit.

In addition to the tests described above, CSB reviews the special leakage testing programs needed for subatmospheric-type containments, the secondary containments for plants using

the dual containment concept and the Mark III drywell-containment system. For subatmospheric containments, the leakage into the reactor containment must be monitored and limited such that the reactor containment pressure can be maintained below atmospheric for the duration of the post-accident period. A testing program should be described in the safety analysis report (SAR) and its adequacy is reviewed by CSB. Dual containments are proposed for some plants because of site limitations. The intent of the dual containment is to collect and process reactor containment leakage. Testing programs to ensure that leakage will be contained as proposed by applicants using this kind of containment are reviewed by CSB. CSB will also review the testing program for the Mark III type containment with regard to the integrity of the drywell and drywell bypass leakage paths.

II. ACCEPTANCE CRITERIA

The reactor containment leakage rate testing program, as described in the SAR, will be acceptable if it meets the requirements stated in Appendix J to 10 CFR Part 50. Appendix J provides the test requirements and acceptance criteria for preoperational and periodic leak testing of the reactor containment, and of systems and components which penetrate the containment. Appendix J also references ANSI N45.4-1972, which identifies acceptable methods for determining the leakage rate of containment structures. Exceptions to Appendix J requirements will be reviewed on a case-by-case basis.

The minimum acceptable design containment leakage rate shall not be less than 0.1% per day.

The inleakage rate to the reactor containment of subatmospheric containments will be acceptable if it is less than the inleakage rate used in the analysis of the containment response to loss-of-coolant accidents. Systems should be provided to measure the inleakage rate at periodic intervals.

The leakage limits of the secondary containments of dual-type containments are acceptable if they are based on the limits used in the analysis of the secondary containment depressurization time. These tests should be conducted at each refueling or at intervals not exceeding 18 months. Type B and C tests will be done on those penetrations and isolation valves that communicate directly with the atmosphere, where there is a possibility of uncollected leakage. The test limits should be consistent with the limits used for direct leakage in the analysis of the radiological consequences by AAB.

The leakage limit for Mark III drywells should be such that the measured leakage does not exceed 10% of the drywell bypass capability for small breaks. In terms of the leakage path area, this corresponds to a value of the parameter $A/\sqrt{k}$ of the order of one square foot.

III. REVIEW PROCEDURES

In the review of the PSAR, CSB confirms that the design leakage is stated and that the reactor containment leakage testing program, to be detailed at the OL stage, will be consistent with the requirements of Appendix J. In the review of the final safety analysis report (FSAR) at the OL stage, CSB reviews the reactor containment leakage testing program and the applicant's proposed technical specifications for completeness and for conformance to Appendix J.

The review of the reactor containment leakage rate test program at the OL stage includes the following:

1. Containment Integrated Leakage Rate Test (Type A Test)

   a. Pretest requirements are reviewed to ensure that a general inspection for containment structural deterioration is included and procedures for corrective action are available. The reviewer confirms that an inspection of the accessible interior and exterior surfaces of the containment structures and components will be performed prior to any Type A tests. The purpose of this inspection is to identify any structural deterioration which may affect the containment structural integrity or leak tightness. The reviewer confirms that procedures for corrective action, if necessary, are specified in the test program. The reviewer also confirms that the test program includes a provision that, in the event that structural deterioration is discovered, a Type A test will not be performed until corrective action is taken in accordance with procedures specified in the test program. In addition, these corrective actions will be reported to the staff in the test report.

   The program should require that the containment isolation valves be closed by normal operating procedures, with no accompanying adjustments.

   The reviewer should confirm that the test program includes stabilization of containment conditions (temperature, pressure, humidity) for a period of at least four hours as a pretest requirement.

   The pretest requirements should identify those portions of fluid systems which will be opened or vented to atmosphere and drained of fluids, to assure that isolation valves are exposed to the containment test air pressure.

   Those systems not vented or drained should be identified and the reason for not venting or draining should be stated. Piping and instrumentation diagrams and process flow drawings are used by the reviewer to confirm that in the vented and drained condition, the isolation valves of those portions of fluid systems that are part of the reactor coolant pressure boundary and are opened directly to the containment atmosphere during a LOCA, are exposed to the test air pressure. Those systems required to maintain the plant in a safe condition or normally filled with water and needed post-LOCA (i.e., heat removal systems) need not be vented. By reference to the drawings, the reviewer assures himself that leakage to the environment cannot occur for those systems not vented and drained.

   b. Test methods described in the program are reviewed to assure that they are consistent with the methods stated in ANSI N45.4-1972. The accuracy of the Type A leak test must be confirmed by a supplemental test. The supplemental test is prescribed by Appendix J.

The proposed supplemental test is acceptable if the difference in leakage rate between the Type A test and the supplemental test is specified to be within 25 percent of the maximum allowable leakage rate of the Type A test.

c. Acceptance criteria for preoperational and periodic leakage rate tests should be included in the test program and in the technical specifications. The reviewer confirms that the acceptable measured containment leakage rate will not exceed 75% of the maximum allowable leakage rate during either preoperational or periodic leakage rate tests.

d. Provisions for additional testing in the event of failure to meet acceptance criteria should be stated in the program. The reviewer assures that the test program specifies that if two consecutive Type A tests fail the acceptance criteria, a Type A test shall be performed at each refueling shutdown or every 18 months until two Type A tests meet the acceptance criteria. Also, it should be stated that if any periodic Type A test fails the acceptance criteria, the test schedule for subsequent Type A tests will be submitted to the staff for review.

2. Containment Penetration Leakage Rate Test (Type B Test)

a. All containment penetrations should be listed in the test program. By reference to piping and instrumentation diagrams, the reviewer confirms that all penetrations have been listed. The program should identify any penetration not requiring leakage testing and the reason for not requiring a test should be stated. The reviewer confirms that those penetrations not requiring testing cannot result in leakage to the atmosphere during normal operation or a LOCA. An example of such penetrations is a seal-welded equipment hatch.

b. Test methods for determining penetration leakage rates are accepted by the reviewer if they include any of the following methods: examination by the halide leak detection method of a pressurized test chamber constructed as part of the penetration; measurement of the rate of pressure loss of the pressurized test chamber of the penetration; and leakage surveillance by means of a permanently installed system for continuous or intermittent pressurization of individual or groups of penetrations, and measurement of pressure loss.

c. Test pressures for containment penetrations should be stated in the test program and in the technical specifications. The test pressure is acceptable if it is the maximum calculated containment accident pressure.

d. Acceptance criteria for penetration leakage rate testing should be included in the test program and the technical specifications. The reviewer confirms that the combined leakage rate of all penetrations and valves subject to Type B and

Type C tests is specified in the SAR to be less than 60 percent of the maximum allowable containment leakage rate. Leakage measurements obtained through leakage surveillance systems that maintain a pressure not less than the calculated containment accident pressure at penetrations during normal reactor operation are acceptable in lieu of Type B tests.

3. Containment Isolation Valve Leakage Rate Test (Type C Test)

   a. All containment isolation valves requiring a Type C test should be listed in the test program. By reference to the piping and instrumentation diagrams, the reviewer confirms that all isolation valves to be tested have been listed. The basis for determination that an isolation valve requires Type C testing is: a direct connection is provided between the inside and outside of the reactor containment and the valve forms a part of the containment boundary; the valve is required to close automatically upon receipt of a containment isolation signal; the valve is required to operate intermittently under post-accident conditions; or the valve is in main steam or feedwater piping or other systems which penetrate containment of boiling water reactors.

   b. Test methods for isolation valve Type C tests should be included in the test program. The method of testing is acceptable if the following is stated in the test program: Type C test pressure shall be applied in the same direction as that existing when the valve is required to perform its safety function; each valve to be tested will be closed by normal operating procedures with no preliminary adjustment or exercising; and test methods similar to those methods used for leak testing containment penetrations will be used.

   c. Test pressures for isolation valve Type C tests should be included in the test program and technical specifications. The reviewer should confirm that the test pressure specified is the maximum calculated containment accident pressure and that the test pressure for valves sealed with fluid from a seal system is 110% of the maximum calculated accident pressure.

   d. Acceptance criteria for isolation valve leak testing should be included in the test program and technical specifications. The reviewer confirms that the combined leakage rate of all penetrations and valves subject to Type B and C tests is specified in the SAR to be less than 60 percent of the maximum allowable containment leakage rate.

4. The scheduling and reporting of periodic tests should be included in the test program and technical specifications. The reviewer accepts test schedules if they are in accordance with the following:

   a. Type A periodic tests should be performed at three equal intervals during each ten-year service period. The third test should be scheduled for the ten-year shutdown inspection.

b. Type B periodic tests should be performed during each shutdown for refueling but no longer than two years (except air locks). Air locks should be tested at six month intervals or after each opening.

Penetrations using continuous monitoring should be tested with every other reactor shutdown for refueling but no longer than three years (except air locks).

c. Type C periodic tests should be performed during each reactor shutdown for refueling but no longer than two years.

Test reports should be discussed in the test program and the reviewer should confirm that it is stated in the program that preoperational and periodic tests shall be the subject of a summary report submitted to the Commission approximately three months after each test. It should be stated in the program that the following will be included in the preoperational test report: schematic of leak measuring system; instrumentation used; supplemental test method; test program; and analysis and interpretation of leakage rate test data for the Type A test.

It should be stated that test results that fail to meet acceptance criteria will be reported in a separate summary report, including analysis and interpretation of test data.

5. Special testing requirements should be included in the test program. Special testing procedures for subatmospheric and dual-type containments should be identified.

CSB assures that the applicant has provided a leakage testing program and has specified the maximum leakage which may occur from inleakage for subatmospheric type containments and bypass (or dilution) leakage for dual-type containments. Potential leakage paths which bypass the annulus or the auxiliary building areas or may leak directly to atmosphere must be identified. The total amount of containment bypass leakage to the environment must be specified and included in the technical specifications. The reviewer determines that the test provisions are adequate to confirm the bypass leakage specified.

6. Preoperational and post-operation test reports are not reviewed by CSB on a routine basis. Audits of tests may be conducted at the discretion of CSB or special reviews may be conducted at the request of other staff organizations.

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 proposed reactor containment leakage testing program complies with the requirements of Appendix J to 10 CFR Part 50. Such compliance provides assurance that containment leak-tight integrity can be verified throughout service lifetime and that the leakage rates will be periodically checked during service on a timely basis to maintain such leakages within the specified limits.

"Maintaining containment leakage rates within such limits provides assurance that, in the event of any radioactivity releases within the containment, the loss of the containment atmosphere through leak paths will not be in excess of acceptable limits specified for the site. Compliance with the requirements of Appendix J constitutes an acceptable basis for satisfying the requirements of General Design Criteria 52, 53, and 54 of Appendix A to 10 CFR Part 50."

V. REFERENCES

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

2. 10 CFR Part 50, Appendix A, General Design Criterion 52, "Capability for Containment Leakage Rate Testing."

3. 10 CFR Part 50, Appendix A, General Design Criterion 53, "Provisions for Containment Testing and Inspection."

4. 10 CFR Part 50, Appendix A, General Design Criterion 54, "Systems Penetrating Containment."

5. ANSI N45.4-1972, "Leakage-Rate Testing of Containment Structures for Nuclear Reactors," American National Standards Institute (1972).

6. A. K. Postma and B. M. Johnson, "Containment System Experiment Final Program Summary," BNWL-1592, Battelle Pacific Northwest Laboratories, July 1971.

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