UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION CONTAINMENT LINER LEAK CHASE CHANNEL VENTING WISCONSIN ELECTRIC POWER COMPANY POINT BEACH NUCLEAR PLANT, UNIT NOS. 1 AND 2 DOCKET NOS. 50-266 AND 50-301

I. Background

The leak chase channels which cover the containment liner welds are welded to the liner plate. These channels were not specifically addressed in the original liner plate analysis, were not intended to be vented to the containment, and have not been vented during the containment integrated leakage rate tests (CILRT) conducted at Point Beach. The NRC position (Reference 1) is that the containment liner weld leak chase channels must be vented to the containment atmosphere during the Type A test or CILRT, unless the channels are designed and built to the same criteria as those used for the containment shell.

In a letter dated February 12, 1986 (Reference 2), Wisconsin Electric Power Company (WEPCO), the licensee for Point Beach Nuclear Plant, initiated a program to perform appropriate design reviews and tests to determine the qualification of the leak chase channel system as an integral part of the containment liner plate. By letter of July 24, 1986 (Reference 3), the licensee submitted a technical evaluation of containment liner plate leak chase channel system (Reference 4) and a test report on static load tests on liner plate leak chase channel assemblies (Reference 5). However, the staff believed that in order to redefine the pressure boundary of the containment, the licensee should compare the applicable portion of the ASME B&PV code, Section III, with what has been done in the program. Additional information was requested to demonstrate that the Point Beach leak chase channels and the associated welds meet the design acceptance criteria.

On December 1, 1988, a meeting was held between the licensee's representatives and the NRC staff to discuss the issue. (Reference 6) The licensee explained that since the Point Beach Plant was built before the ASME B&PV Code, Section III, was implemented, the containment liner plate leak chase channels cannot be compared with the code. Nevertheless, to qualify the leak chase channels as a structural unit, the staff requires that the leak chase channels, as built, meet the intent of the code. By letter of May 9, 1989, the licensee transmitted a summary report, "Containment Liner Plate Leak Chase Channel Pressure Boundary at Point Beach, Units 1 and 2," for staff information and review. (Reference 7)

II. Discussion

The staff has reviewed the licensee's submittals (References 2 through 7) and the justification for not venting the liner weld leak chase channels during a CILRT or Type A tests. It is the staff's position that the channels need not be vented if the licensee can demonstrate that:

(a) the channel welds are qualitatively equivalent to or better than those for the primary containment liner welds;

(b) the channels would maintain their integrity when subjected to the loading conditions of a postulated design basis accident as well as during normal operation; and

(c) the inspection and reporting of tests as required in 10 CFR Part 50, Appendix J has been implemented.

III. Evaluation

The containment structure is a right cylinder (105 ft. I.D., 110 ft. Ht.) with a flat base slab and a shallow (approximately 40 ft.) dome roof. The 3 ft.-6 in.-thick concrete cylindrical wall and 3-ft.-thick dome are prestressed and post-tensioned. The 9-ft.-thick concrete base slab is reinforced with high strength reinforcing steel. The ½-in.-thick liner plate is attached to the concrete by means of an angle grid system stitch welded to the liner plate and embedded in the concrete. The liner plate is fabricated with a leak chase channel system which covers all welded seams in the liner plate.

The original purpose of the leak chase channels was to have the ability to pressure-test the liner plate or penetration welds for leaks without pressurizing the full containment structure. Since these leak chase channels are not to be vented during subsequent Type A tests, they are considered as an integral part of the liner plate and therefore a part of the leak tight containment pressure boundary.

The licensee has conducted an investigation to assess the ability of the liner plate leak chase channel system to function as an integral part of the containment structure leaktight pressure boundary (References 3, 4 and 5). This investigation included the following:

a. Performance History

Forty-nine (49) plants in the United States with similar liner plate systems have been surveyed. No evidence of unacceptable leakage was found for leak chase channels or liner plate butt welds in these plants subsequent to the initial CILRT.

b. Quality Verification of Construction Records

Verification of existing construction records included reviewing documents such as fabrication drawings, bills of materials, welder qualification records, weld test and inspection records, certified material test reports, etc. A review of construction records for the Point Beach plants indicates that the liner plate system, including the leak chase channels, has been fabricated, constructed, and tested in accordance with specified requirements.

c. Structural Analysis

Structural analyses of typical containment liner plate sections were performed to evaluate the severity of loading on leak chase channels. These analyses included investigation of internal forces, stresses, strains and displacements of the leak chase channels in the liner plate system and the assessment of the effect of the presence of the leak chase channels on the structural behavior of the liner plate system. The results of these analyses indicate that some of the leak chase channel sections in the cylinder portion of the containment could sustain minor inelastic deformations when subjected to maximum design load conditions. The dome area leak chase channels, which are embedded in concrete, would also sustain some nonlinear deformation with a high factor of safety.

For analytical purposes, each leak chase channel section may be put in one of two categories. In the first category, which is typical of the dome sections, the leak chase channel projects outward and interacts with the containment structure concrete when relative displacement occurs between the liner plate and the concrete. In the second category, all leak chase channel sections project inward and do not directly interact with the concrete.

The general approach for the first category, i.e., embedded channels, included definition of loads in terms of induced strains, load-deformation characteristics in both linear and nonlinear response ranges, development of a mathematical model and a parametric analysis of the system. Conventional structural analysis techniques are utilized with evaluations based on lower bound physical material properties. The loads utilized in this investigation were derived from those contained in the plant FSAR. Because the loads in the liner plate leak chase channel system are predominantly a direct function of the relative strain between the liner plate and the containment structure concrete, the loads from the FSAR were redefined in terms of relative strain. The load combination includes dead load, differential pressure, accident pressure, seismic prestress, shrinkage, creep, operating thermal, and accident thermal loads.

Analytical results for embedded leak chase channels in concrete show that the lowest calculated safety factor of 11.3 is well above a lower bound acceptable value of 2. The presence of the leak chase channels increases safety margins for other critical elements of the liner plate system.

In the analyses of the second category, the interior leak chase channel sections receive direct containment internal pressure load in addition to forced displacements due to the strain in the structural elements to which the leak chase channel members are attached. The axial stresses and strains of the leak chase channels are comparable to those of the support element in the axial direction of the channels. The forced lateral displacements induce internal forces and moments into the leak chase channel member cross section which responds to these displacements and to direct pressure loading essentially as a rigid frame with flexural continuity at corners and support points. Conventional structural analysis procedures were utilized in solving the frame models. Most leak chase channels were found to remain elastic. In cases where inelastic response was predicted, ductility ratios based on strain levels and plastic section strengths were calculated. The resulting maximum ductility ratio was found to be 1.94 which is well within acceptable range.

d. Test Program

A test program was conducted to obtain the load-deformation characteristics of leak chase channels interacting with the liner plate and containment concrete and to verify the leak tight integrity of the leak chase channels under the severe load and deformation conditions imposed during testing.

It was required that the leak chase channels be soap bubble tested and pressure decay tested under a test pressure of 70 psig. Construction records showed that these requirements were met. The tests demonstrated that the leak chase channels and the 3/16-inch double pass fillet welds retained their leaktight integrity throughout the test loading which produced lateral deformations in the 2-inch channel sections in excess of 0.149 inch.

For the composite tests (channels embedded in concrete), the shear resistance capacity was controlled by compressive failure of the concrete engaged by the leak chase channels. For the liner plate leak chase channel (steel only) tests, the capacity was limited by the flexural resistance of the ¼-inch-thick liner plate. Although the sections sustained inelastic displacement in excess of 0.10 inch, no failures were observed in the channels or welds to the liner plate.

The licensee has concluded that, as a result of this investigation, the least factor of safety for the external leak chase channels (embedded in concrete) based on strain energy and test-defined capacities is greater than 11. The most severe conditions for the interior leak chase channels resulted in a ductility ratio of 1.94 and is comparable to a safety factor based on displacement of about 22. All tests, analyses, and quality control and historical records indicate that the liner plate leak chase channel systems will retain their structural and leaktight integrity under the most severe postulated loading conditions.

After reviewing the licensee's investigation, the staff wanted further assurance of structural integrity and requested comparisons of design analyses and tests of the containment liner plate leak chase channel system with the design criteria and requirements of the ASME Boiler and Pressure Vessel Code, Section III. On December 1, 1988, a meeting was held between the licensee and the NRC staff to discuss the problem and the nature of the additional information required. The licensee has adequately explained that the containment liner plate leak chase channels cannot be compared with the ASME B&PV Code, Section III, Division 1, Subsection MC requirements as requested because the Point Beach plants were designed and built before the ASME Code was implemented. Nevertheless, the staff required that the leak chase channels, as built, meet the intent of the code (Reference 6).

By letter of May 9, 1989, the licensee transmitted a summary report entitled, "Containment Liner Plate Leak Chase Channel Pressure Boundary at Point Beach, Units 1 and 2," which also addresses the staff's concern of meeting the intent of the ASME design code. Based on the review of this report and the additional information on comparison of design codes, the staff finds that:

(a) The channel welds are qualitatively equivalent to those for the primary containment liner welds as demonstrated by construction records, quality control measures, leak tests and inspection reports.

(b) The analyses and tests demonstrate that the leak chase channels, external or internal, are rugged components and will function as integral parts of the liner plate system. Comparison of FSAR specifications versus the present ASME code further confirms the strength of the leak chase channels.

IV. Conclusions

On the basis of the above evaluation, the staff concludes that:

(a) the channel welds at the redefined pressure boundary are qualitatively equivalent to those for the primary containment liner welds and are acceptable;

(b) the channels are capable to withstand the loading conditions of a postulated design basis accident as well as during normal operation and maintain their structural integrity at all times.

The staff therefore concurs with the licensee that it is not necessary for Point Beach plants to vent the containment liner weld leak chase channels during a CILRT, provided that the licensee commits to comply with the requirements of 10 CFR Part 50 Appendix J, including a visual inspection of readily accessible areas prior to each subsequent Type A test.

References:

1. Memorandum for K. V. Seyfrit from G. C. Lainas and W. R. Butler, dated December 15, 1977, on venting of containment liner weld channels.

2. Letter from C. W. Fay, WEPCO, to H. R. Denton, NRC, dated February 12, 1985.

3. Letter from C. W. Fay, WEPCO, to H. R. Denton, NRC, dated July 24, 1986, transmitting Bechtel's Evaluation Report (Reference 4) and University of Michigan's Test Report (Reference 5).

4. "Evaluation of Containment Liner Plate Leak Chase System for Point Beach Nuclear Plant Units 1 and 2," by Bechtel Associates Professional Corporation, June 1986.

5. "Test Report on Static Load Tests on Liner Plate Leak Chase Channel Assemblies," by University of Michigan, Department of Civil Engineering, December 1985.

6. Summary of December 1, 1988 meeting, including slides presented by WEPCO and Bechtel during the meeting.

7. Letter from C. W. Fay, WEPCO, to NRC, dated May 9, 1989 transmitting the summary report, "Containment Liner Plate Leak Chase Channel Pressure Boundary at Point Beach Nuclear Plant, Units 1 and 2," April 1989.

Principle Contributor: S. Chan

Dated: