Maine Yankee
RELIABLE ELECTRICITY SINCE 1972

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January 28, 1997
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UNITED STATES NUCLEAR REGULATORY COMMISSION
Attention: Document Control Desk
Washington, DC 20555

Reference: (a) License No. DPR-36 (Docket No. 50-309)

Subject: Generic Letter 96-06

Gentlemen:

Generic Letter 96-06 requested that licensees determine: (1) if containment air coolers cooling water systems are susceptible to either water hammer or two phase flow conditions during postulated accident conditions, and (2) if piping systems that penetrate the containment are susceptible to thermal expansion of fluid so that over pressurization of piping could occur.

A. Within 120 days of the date of the Generic Letter (Sept. 30, 1996) addressees are requested to submit a written summary stating actions taken in response to the requested information noted above, conclusions that were reached relative to susceptibility for water hammer and two phase flow in the containment air cooling water system and over pressurization of piping that penetrates the containment, the basis for continued operability of the affected systems and components as applicable, and corrective actions that were implemented or are planned to be implemented. If systems are found to be susceptible to the conditions that are discussed in the generic letter, identify the systems affected and describe the specific circumstances involved.

Maine Yankee has completed the actions requested in the generic letter. The evaluations, results and conclusions reached, relative to the requested actions, are described in the attached report. In summary we have concluded that:

1. The containment recirculation air coolers at Maine Yankee are isolated under design basis accident conditions and do not perform a post accident heat removal function. The potential for water hammer was evaluated for a loss of off site power case where an interruption and subsequent resumption in pumped flow occurs in conjunction with single failure of the cooling water containment isolation valve to close. Plant specific calculations have shown that the containment air cooler cooling water system is not susceptible to either water hammer or two phase flow conditions during postulated LOCA accident conditions. The water trapped in the coolers remains subcooled throughout the LOCA transient. Similar calculations, using the Main Steam Line Rupture (MSLR) containment temperature response, showed a small amount of voiding. This voiding is not expected to create a potential for water hammer, and the system integrity will not be adversely affected. Supporting calculations have been prepared and are expected to be finalized by March 1, 1997.

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2. Of the 107 liquid filled containment penetrations at Maine Yankee, a total of 16 have been identified as being susceptible to thermal expansion of fluid so that over pressurization of piping could occur. Note that this does not include the 12 penetrations for which relief valves were installed in July 1996 as discussed in the Generic Letter. Maine Yankee plans to install the necessary over pressure protection features on the affected penetration piping to limit piping stresses to within code allowable values. These modifications will be completed during the next scheduled refueling outage. We have also completed operability reviews on all affected penetrations for which the over pressurization potential exists, and have concluded that reasonable assurance exists that the penetration piping will continue to function as intended in Maine Yankee's licensing bases. This assurance is based on original licensing bases reviews, as well as the use of strain based evaluation criteria.

   Although not related directly to the penetration integrity review discussed above, we have identified a condition similar to that described in the Generic Letter for Beaver Valley where a valve located inside containment would not open due to thermal expansion of trapped fluid. At Maine Yankee, Emergency Operating Procedures call for initiating hot leg recirculation after several hours following a postulated large cold leg break to prevent boron precipitation in the core. This is accomplished, in part, by opening the loop fill motor operated valves located inside containment. We have concluded that these valves may be subjected to a substantial pressure transient caused by expansion of trapped fluid at the onset of the accident and this pressure transient may render these valves inoperable. For this reason, the plant will operate with one of the three hot leg injection valves open until the permanent modification is installed. This will preclude the postulated over pressure condition noted above. The modifications required to preclude this potential over pressure condition with the hot leg valves closed will be implemented during the next scheduled refueling outage.

We trust this information is satisfactory. Please contact us should you have any questions in the matter.

Very truly yours,

James R. Hebert

James R. Hebert, Manager
Licensing & Engineering Support Department

JRH/mwf

Enclosure

c: Mr. Hubert Miller
Mr. J. T. Yerokun
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(1) if containment air cooler cooling water system are susceptible to either water hammer or two phase flow conditions during postulated accident conditions.

System Design

The containment recirculation air coolers at Maine Yankee are isolated under accident conditions, and do not perform a post accident heat removal function. Therefore, the potential for water hammer was evaluated for the loss of off site power case where an interruption and subsequent resumption in pumped flow occurs in conjunction with single failure of the cooling water containment isolation valve to close.

Evaluation

The potential for a water hammer event in the containment cooler piping is dependent on the occurrence and the extent of voiding in the fan cooler tubing. If the fan cooler tubes experience significant voiding, the dynamics of the pump restart (restoration of flow in the system) will affect the magnitude of the hydrodynamic loads due to the voiding collapse.

Two events were analyzed separately to assess the impact on the fan cooler tubing, a large break LOCA and a Main Steam Line Rupture (MSLR) coincident with a loss of offsite power (LOOP).

The simulation using a large break LOCA containment temperature response did not predict any voiding in the fan cooler tubes at the beginning of system repressurization and flow restoration. The temperature attained by the liquid in the tubing was approximately 229F, while the saturation temperature of the fluid is about 250F (@ 30 psia). Therefore, the cooling water remains subcooled during the transient, there is no voiding predicted, and there will be no water hammer transient.

A similar calculation using the MSLR containment temperature response was analyzed. Using a bounding heat transfer representation, voiding within the tubes was predicted. However, it is expected that when the simulation is run using a more realistic heat transfer across the cooler tubes, little or no voiding will be predicted. Therefore, pump restart and subsequent system refill is not expected to result in significant water hammer loads. The conservatisms in the heat transfer modeling are currently being quantified.

It should be noted that containment integrity is not essential for a MSLR inside containment as the radiological consequences of the accident are not significant.

Conclusion

The Maine Yankee containment air cooler cooling water system is not susceptible to water hammer during postulated LOCA conditions. A small amount of voiding may occur during postulated MSLR conditions. However, this voiding is not expected to have an adverse impact on the system integrity during subsequent system refill (pump restart). The calculations supporting these conclusions are currently being finalized.

(2) if piping systems that penetrate the containment are susceptible to thermal expansion of fluid so that over pressurization of piping could occur.

Background

In July of 1996, Maine Yankee made a conservative decision to shut down as a result of the condition reported in the Generic Letter concerning design inadequacies of Primary Component Cooling (PCC) piping. Should the condition described in the Generic Letter occur, the PCC system could be disabled and together with a single active failure in the redundant cooling water train, result in a complete loss of component cooling water. This condition was not in conformance with the Maine Yankee licensing bases, and was corrected by providing relief capability for the containment air coolers and associated piping, which prevent the postulated condition from occurring.

Evaluation

We have examined the Maine Yankee licensing bases, and its implementation with regard to other systems that could be exposed to post-accident containment temperatures, to determine whether the bases could be challenged elsewhere. The Maine Yankee design bases does not include consideration of the effect of the post-accident temperature inside containment on piping. The piping code of record is USAS B31.1 -1967. Industry implementation of this code at the time Maine Yankee was designed did not include the post-accident containment ambient temperature transient as a design condition.

The piping layout geometry at Maine Yankee is much more flexible than later vintage plants. Given this flexibility, the ductility of the piping and support materials, and the one-time accident temperature loading condition, there is reasonable assurance that the system integrity would be maintained. All penetrations are anchored into the reinforced concrete containment wall. The anchor strength of the subject piping penetrations equals or exceeds the full plastic strength of the pipe with regard to torsion, bending and shear. The resulting distortions of the reinforced concrete containment wall are minor in intensity; therefore, significant loads will not be imposed on the liner, thereby preserving its integrity.

Assuming the isolated piping remains leak tight, the postulated expansion of the trapped fluid, when subjected to the post accident ambient temperature transient, would result in high internal pressures. At these pressures, it is likely that one of the valves isolating the volume would allow a small amount of fluid to escape and thus prevent pressure boundary failure. Even if a failure of the boundary is postulated, the second isolation barrier would remain intact. Two simultaneous barrier failures are not credible since the boundaries are not of perfectly uniform strength. Likewise, subsequent failure of the remaining containment isolation boundary would not occur as pressure is relieved from the first barrier failure and neither valve is subject to active failure consideration since the required safety function has already occurred.

As discussed above, the post accident environment will cause a thermally induced pressure transient in the constrained piping segment between two closed containment isolation valves since the coefficient of thermal expansion of the water is greater than that of the piping. For information, strains required to completely relieve the differential volume expansion are provided, as follows.

A simplified plastic analysis has been performed for several of the containment penetrations which are representative of the penetration population that are susceptible to over-pressurization due to post-LOCA containment environmental conditions. The discussion below outlines the methodology used to develop the plastic strains and presents the maximum resulting strain from this bounding analysis.

The first step of the simplified analysis process was to determine the volumetric expansion that the entrapped fluid would undergo, due to heating, from an initial 70°F temperature to the maximum post-LOCA temperature of 300°F. No attempt was made to determine a lower temperature for the entrapped fluid even though the majority of the penetrations have a substantial amount of piping between the containment penetration and the out-board isolation valve. This long length of piping will not only make heating of the entrapped fluid to the maximum post-LOCA temperature unlikely, it will also serve as a radiator for the heated fluid. Considering the entrapped fluid to be at the same temperature as the maximum post-LOCA containment environment is conservative. This total volume was determined to be 108.5% of the original volume or an 8.5% increase in volume.

A new inside pipe diameter (D_t) was calculated based in the radial thermal expansion of the pipe wall. Second, the inside pipe diameter (D_r) required to accommodate the volumetric expansion of the fluid was calculated. The plastic deformation (e_r) required to accommodate volumetric expansion is the difference between the diameters D_r and D_t. Expressed as a percent:

$$e_r = [(D_r - D_t)/D_t]*100$$

Using this approach, a radial deformation(i.e., plastic strain) of 4.7% for carbon steel material and 4.6% for stainless steel material was determined.

The plastic strain values stated above are appropriate for those sections of the pipe wall remote from the juncture of the penetration and the reactor containment wall. Here, the piping is not allowed to radially expand under the influence of the volumetric expansion of the fluid. As previously stated, the piping designs at Maine Yankee have either relatively long runs of piping inside or outside of the containment, or both. This ensures that the total volume of piping available to radially deform is large compared to that constrained within the containment wall. The containment wall does, however, represent a point at which radial deformation is restrained. At this location there will also be additional axial strains induced as the pipe wall transitions from no radial displacement to that associated with the plastic radial deformation stated above. Using closed-formed solutions for elastic shells, the displacement profile for a pressurized cylinder with end constraints, consistent with the boundary conditions imposed by the containment penetration, was calculated. These displacement profiles were scaled-up to represent the plastic deformations and the axial strains were approximated. These approximated axial strains were combined with those radial plastic strains and the maximum resulting combined strains were approximately 5.6%.

The calculated plastic strains for the post-LOCA conditions are approximately 12% higher than those permitted in plastic design by ASME Code Case N-195. Further, these strain levels represent about 30% of the maximum load carrying capability for carbon steel while representing approximately 22% for stainless steel piping material. This indicates that there is significant additional strength in the pipe wall, beyond the current loading to ensure that gross failure will not result due to other concurrent loadings. Based on a margin of 70% before reaching the maximum plastic strength point of the material, it can be concluded that:

- Failure of the pipe wall due to the volumetric expansion of the trapped fluid is unlikely.
- Sufficient reserve capacity exists in the pipe wall to accommodate other concurrent loadings not included in the strain evaluation.

Not withstanding the above discussion, Maine Yankee has reviewed all containment penetrations for possible overpressure under accident conditions. Detailed guidelines and evaluation criteria were developed to determine the need for thermal relief protection for containment isolation boundary piping and components. All penetrations not meeting the approved acceptance criteria were identified as candidates for modification to provide appropriate over pressure protection.
Penetrations meeting the following acceptance criteria do not require thermal relief protection:

- Those with high fluid temperature during steady state mode of operation.
- Those containing air, steam or gas.
- Those which are normally drained during plant operation.
- Those within systems that remain operational during high temperature accident conditions.
- Small bore penetration piping that has an outside containment length to inside containment length ratio of 20 or greater.

Each penetration at Maine Yankee was reviewed against the above criteria using flow diagrams, piping drawings and isometric drawings . The results of each penetration review were independently reviewed and compiled into a final report. Of the 107 liquid filled containment penetrations at Maine Yankee, a total of 16 have been identified as being susceptible to thermal expansion of fluid so that over pressurization of piping could occur. The affected systems / penetrations are described below:

Penetration No.	***Description***
3 &6	Primary Component Cooling Water To And From the Reactor Coolant Pumps.
4 &5	Primary Component Cooling Water To And From Miscellaneous Heat Exchangers inside the Containment.
36	Reactor Coolant System Loop Fill / Alternate Charging
37 & 39	Primary Water To And From the Pressurizer Quench tank
45	Steam Generator Drain piping
62A &62C	Reactor Coolant Sample Lines
68	Safety Injection Accumulator Tank liquid sample Line
81A &81B	Primary Component Cooling Water To And From Containment Penetration Coolers
86 & 89	Primary Component Cooling Water To And From CEDM Air Coolers
92	Containment Sump Discharge

The penetrations listed above will be modified during the next scheduled refueling outage to provide appropriate over pressure protection features. These features will be designed to ensure that all piping and associated components will operate within code allowable parameters during all plant conditions including postulated design basis accidents.

Although not related directly to the penetration integrity review discussed above, Maine Yankee has identified a condition similar to that described in the Generic Letter for Beaver Valley where a valve located inside containment would not open due to thermal expansion of trapped fluid. At Maine Yankee, Emergency Operating Procedures call for initiating hot leg recirculation after several hours following a postulated large cold leg break to prevent boron precipitation in the core. This is accomplished, in part, by opening the loop fill motor operated valves which are located inside containment. Maine Yankee has concluded that these valves may be subjected to a substantial pressure transient caused by expansion of trapped fluid at the onset of the accident, and this pressure transient may render these valves inoperable. For this reason, the plant will operate with one of the three hot leg injection valves open. This will preclude the postulated over pressure condition noted above. The necessary modifications required to preclude this potential over pressure condition with the hot leg valves closed will be implemented during the next scheduled refueling outage.

Conclusion

There are several piping systems that penetrate containment that are susceptible to thermal expansion of fluid resulting in pressures in excess of code allowable design values. However, there is also adequate assurance that these piping systems will remain intact, and will continue to perform their containment isolation function.

During the next refueling outage, Maine Yankee will install over pressure protection features for 16 penetrations to ensure that the associated piping system operate within code allowable stress levels under all conditions including postulated accidents.