Westinghouse Energy Systems Business Unit

ESBU

NUCLEAR SAFETY ADVISORY LETTER

THIS IS A NOTIFICATION OF A RECENTLY IDENTIFIED POTENTIAL SAFETY ISSUE PERTAINING TO BASIC COMPONENTS SUPPLIED BY WESTINGHOUSE. THIS INFORMATION IS BEING PROVIDED TO YOU SO THAT A REVIEW OF THIS ISSUE CAN BE CONDUCTED BY YOU TO DETERMINE IF ANY ACTION IS REQUIRED.

P.O. Box 355, Pittsburgh, PA 15230-0355

Subject: Reactor Coolant Pump (RCP) Support Column Tilt Issue	**Number:** NSAL-94-025
Basic Component: RCP Supports	**Date:** Nov. 10, 1994
Plants: See Page 2, Table 1	
Substantial Safety Hazard or Failure to Comply Pursuant to 10 CFR 21.21(a)	Yes ☐ No ☒
Transfer of Information Pursuant to 10 CFR 21.21(b)	Yes ☐
Advisory Information Pursuant to 10 CFR 21.21(c)(2)	Yes ☐
Reference:	

SUMMARY

The issue concerns a situation whereby certain reactor coolant pump (RCP) support columns may be tilted beyond design parameters. Specifically, some three and four loop plants have a loop piping layout in which the crossover leg piping interferes with the front inside support column of the RCP. The other two columns on the RCP are oriented to be vertical in the normal full power condition. This condition has been recognized by the support designer and changes have been made to the column layout to accommodate the interference between the column and the crossover leg. The change consists of moving the base of the one RCP column toward the reactor pressure vessel approximately 6-12 inches so that the tilted column no longer interferes with the crossover leg piping. The required tilt is from approximately 2 to 5 degrees depending on the column length and amount of movement. This condition was apparently reconciled during the design phase and was not considered a significant issue. Upon further review it has been determined that while the actual change in the value of the vertical stiffness is small, the potential impact on the thermal expansion of the system, and thus the loop loadings, may be significant.

Based upon the analyses performed, it has been determined that while some of the affected plants will have completely acceptable results from their specific RCP column tilt, other plants may have difficulty in meeting certain margin values for such specific evaluations as Leak-Before-Break. While such a situation may technically place a given plant outside its licensing basis, it has been determined that adequate margins remain such that this situation does not pose a challenge to the reactor coolant system (RCS) pressure boundary and therefore, does not represent a substantial safety hazard or failure to comply per the definitions provided in 10 CFR Part 21.21(a).

Additional information, if required, may be obtained from the originator. Telephone 412-374-5036.

Originator(s): J. S. Galembush

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TABLE 1 PLANT APPLICABILITY LIST

Based upon design information held by Westinghouse, the following plants are affected by the RCP Column Tilt issue:

J. M. Farley 1 & 2
V. C. Summer
Shearon Harris
Vogtle 1 & 2
Seabrook
Wolf Creek
Callaway
Comanche Peak 1 & 2
Sequoyah 1 & 2
Watts Bar 1 & 2
Sizewell B
Kori 3 & 4
Yonggwong 1 & 2
Ohi 1 & 2
Takahama 1
Mannheim 1 & 2

TECHNICAL DESCRIPTION

ISSUE DESCRIPTION

As described in the "Summary" section, the issue concerns a situation whereby certain reactor coolant pump (RCP) support columns may be tilted beyond design parameters. Specifically, some three and four loop plants have a loop piping layout in which the crossover leg piping interferes with the front inside support column of the RCP. The other two columns on the RCP are oriented to be vertical in the normal full power condition. This condition has been recognized by the support designer and changes have been made to the column layout to accommodate the interference between the column and the crossover leg. The change consists of moving the base of the one RCP column toward the reactor pressure vessel approximately 6-12 inches so that the tilted column no longer interferes with the crossover leg piping. The required tilt is from approximately 2 to 5 degrees depending on the column length and the amount of movement. This condition was apparently reconciled in an informal manner during the design phase and was not considered a significant issue. Upon further review it has been determined that while the actual change in the value of the vertical stiffness is small, the potential impact on the thermal expansion of the system, and thus the loop loadings, may be significant.

Based upon the analyses performed for this evaluation, it has been determined that while some of the affected plants will have completely acceptable results with their specific RCP column tilt, other plants may have difficulty in meeting certain margin values for such specific evaluations as Leak-Before-Break (LBB). While such a situation may technically place a given plant outside its licensing basis, it has been determined that adequate margins remain, such that this situation does not pose a challenge to the reactor coolant system (RCS) pressure boundary.

TECHNICAL EVALUATION

Analyses have been performed to evaluate the impact of the RCP column tilt on the plant with the most severe tilt. A plant with a column tilt associated with a 12 inch movement of the column base from the front inside pump column was chosen for this evaluation.

The additional loadings associated with column tilt originate from the use of a support stiffness that has been rotated from vertical by a few degrees. This rotated stiffness at one of the three column locations acts to restrain and rotate the RCP. For a loop piping system thermal expansion of approximately 1.8 inches, the vertical displacement associated with the rotation of an RCP column will vary from about 10 mils for a nearly vertical column to about 130 mils for an upper bound tilted column. This difference in displacements at the three RCP columns is what causes a rotation in the pump not previously accounted for. This source of additional loading varies from plant to plant based on the primary equipment support design. There are plants without pin-ended columns that will not have this type of additional loading. There are a number of plants that have support details not of Westinghouse design. Many of the Westinghouse designed supports have a tilt that is approximately half of the that analyzed as a part of this evaluation.

When this enhancement was made to the thermal analysis, different system loadings resulted. The bending moment at the RCP outlet nozzle for the test case increased by more than 100%. The RCP column loads also changed. The tilted column went from a compression load to a tension load. The change in column loading met applicable Code allowable limits. The loop LBB evaluation was of particular concern for system load changes. The LBB evaluation is performed with the goal of achieving certain margins required by the

NRC. The new loadings were reviewed for all 12 weld locations in the primary loop for the test plant, and acceptable margins were maintained.

The test case loop evaluation for column tilt loads was successful. The column tilt for the test plant is approximately twice (12 inches versus 6 or 6.5 inches) that of most other plants. Unfortunately, it has been determined that due to the overwhelming plant specific nature of both RCS loops and the RCP column design, the test case configuration is not generic nor necessarily enveloping, but it is representative of a typical Westinghouse configuration. Every one of the plants affected by the RCP column tilt issue has a plant-specific loop analysis that has a unique set of margins. Because loadings local to the RCP can be quite different due to the inclusion of column tilt, those plants that have small margins in this area may be unable to meet NRC mandated LBB margins. Those plants with small LBB margins in the cold leg may require additional analysis. As mentioned, there are conservative NRC mandated margins that are part of the licensing associated with LBB. Even if the licensing margins are not satisfied, one can argue that the LBB conclusions are still valid with smaller margins and that the LBB design basis continues to apply.

A second test plant was reviewed, which has an LBB critical point (location of lowest margin) at the RCP outlet nozzle weld. This test plant also has a significant column tilt (approximately 10 inches out-of-plumb). Using an estimated increase in bending moment, based on the first test case results, the critical location for the second case does not meet NRC required LBB margins. This evaluation is preliminary because the increase in loading was estimated. This second case is unusual because the critical location is at the RCP outlet nozzle. It is possible that more refined modeling and analysis could be performed that would change the loading and the location of the critical weld for the second test case plant.

The inclusion of RCP column tilt has been shown to change loop loadings by large percentages in the area of the RCP. A review of the increased loadings on our first test plant yielded acceptable results in all areas reviewed. For the first test case evaluation, there were significant margins available in the areas where loadings increased. Good margins in the RCP area are fairly typical for Westinghouse plants, but there may be plants where margins are slim. If specific modeling techniques are the cause of low margins, additional analysis may reduce some of the potential conservatism that led to the low margins. For those plants with low margin around the RCP, structural analysis may need to be revisited to assure compliance with the licensing basis, but as has already been mentioned, there is not a pressure boundary integrity concern due to the RCP column tilt issue.

ASSESSMENT OF SAFETY SIGNIFICANCE

From information available to date, plants that incorporate an RCP column tilt in their design may be operating in an unanalyzed condition in that the actual tilt at hot conditions may be greater than the tilt called out in the design drawings thereby potentially affecting the structural reliability of the RCP supports. More importantly, regardless of any tilt condition described in the design drawings, there may be no analysis available to substantiate the acceptability of such an "as built" tilt in any affected plant design. At hot conditions the plant thermal analysis may be impacted in the following areas:

- Primary equipment support evaluation
- Primary piping fatigue evaluation
- Primary piping leak-before-break (LBB) evaluation
- Auxiliary line thermal anchor movement analysis

The above list is tied to any change to the plant thermal analysis. The seismic and LOCA analyses are expected to be less significantly impacted by a tilted column stiffness, but must also be included in the above

to determine exactly what magnitude of column tilt is indeed significant. It is noteworthy that the RCP column design is determined by the seismic and LOCA loads, therefore, even though the thermal portion of the load is changing, the total load the column may be experiencing represents a much smaller percent change.

The various loadings performed in a system evaluation have been reviewed and qualitatively assessed for the RCP column tilt situation. Due to the small angle of tilt associated with the RCP column tilt issue, the loadings for deadweight, OBE seismic, SSE seismic, and LOCA will change very little from the design basis analysis numbers that assumed no column tilt. This judgement is based on the fact that a stiffness matrix rotated by a few degrees is expected to offer the same kind of restraint to a deadweight or a dynamic loading as the original stiffness. The deadweight loading will load the column with an additional small shear load because there is no lateral movement. The seismic and LOCA loading conditions will involve some small lateral movement, but the additional lateral restraint is likely to generate a somewhat smaller seismic response and potentially, slightly higher LOCA loadings.

The thermal condition represents the loading condition most likely to be impacted by the column tilt. Because a normal plant heat-up and cooldown moves an RCP by more than 1.5 inches in a lateral direction, there is a more significant restraining load generated by the rotated stiffness as well as a heretofore unaccounted for rotation of the RCP centerline due to the 1.5 inch deflection. Both of these effects will likely increase the column loadings and the adjacent piping and pump nozzle loadings.

The thermal loadings factor into the ASME Section III Code fatigue analysis and into the leak-before-break (LBB) evaluation. The fatigue analysis has a stress limit for which there is usually good margin and a usage factor which, for the crossover and cold leg, there is good margin. The LBB evaluation is performed to satisfy certain NRC mandated margins. Even though the mandated margins may not be satisfied, it is the Westinghouse position that the LBB conclusions will still be valid with smaller margins such that the LBB design basis continues to apply. However, such a situation may technically place a given plant outside its licensing basis.

Primary equipment nozzle loads for the various loading conditions are compared to a set of allowable nozzle loads. This comparison is made for both a load case, such as thermal, as well as for a load combination like normal or upset. There is typically sufficient margin in the nozzles to accommodate a large increase in the thermal case loading. There is also margin between the Code limit and pressure boundary failure. There are not expected to be load magnitudes large enough to challenge pressure boundary or shutdown requirements.

In summary, the effects of RCP support column tilt have the potential to change the loadings on the loop piping, the primary equipment nozzles, and the primary equipment supports and embedments. Even with the loading changes it is judged that pressure boundary integrity will be maintained thus allowing continued safe plant operation.

NRC AWARENESS/REPORTING CONSIDERATIONS

Westinghouse submitted to the NRC an Interim Report of an Evaluation of a Deviation or Failure to Comply Pursuant to 10CFR21.21(a)(2) on September 19, 1994. This action was required since the Westinghouse evaluation of this issue would exceed the initial 60 day evaluation period allowed in 10 CFR part 21. Based upon our analyses and evaluations, this issue does not represent a substantial safety hazard or failure to comply pursuant to 10 CFR 21.21(a).

RECOMMENDED ACTIONS

While it has been determined that a substantial safety hazard does not exist, it is prudent that utilities review their plant specific drawings to verify the status of the RCP columns.