UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

OF THE CORE SHROUD SEISMIC ANALYSIS DISCREPANCY

FOR THE QUAD CITIES, UNITS 1 AND 2

COMMONWEALTH EDISON COMPANY AND

MIDAMERICAN ENERGY COMPANY

DOCKET NOS. 50-254 AND 50-265

1.0 INTRODUCTION

The original General Electric (GE) design basis seismic analyses of reactor pressure vessel (RPV) internals at Quad Cities, Units 1 and 2, were performed in early 1970 (Reference 1). The seismic models which were used in the recent design and analysis of the core shroud repair hardware, were based on the data in the 1970 GE report. During the review by the licensee of the seismic analyses for the Quad Cities, Units 1 and 2, shroud repair hardware design, a discrepancy was discovered in the original 1970 GE seismic report that was used to reconstruct the primary structure seismic models utilized in those analyses. In the 1970 report, the mass corresponding to the top guide node was incorrectly listed as 1.73E3 slugs as opposed to the correct value of 17.3E3 slugs. Consequently, a new analysis was performed to reconfirm the seismic design adequacy of the existing shroud repair hardware design as well as other RPV internals (e.g., fuel, guide tubes, CRDs, etc.) and the major vessel supports. The seismic analysis discrepancy also affected the safety evaluations (SEs) issued by the staff relating to the flaw evaluations of the core shroud cracking at Quad Cities, Unit 1 (References 2 and 3).

In the revised seismic analysis to confirm the adequacy of the existing shroud with the correct nodal mass, the licensee refined the analytical techniques which resulted in higher safety margins. The refinements included a more realistic representation of the load sharing between the cracked shroud and the tie rod assembly.

A preliminary assessment of the nodal mass discrepancy in the seismic analysis for Quad Cities, Units 1 and 2, was submitted to the staff on September 5, 1995 (Reference 4). The completed core shroud repair seismic analysis was submitted to the staff on October 2, 1995 (Reference 5). In its submittal of October 31, 1995 (Reference 6), the licensee specifically addressed the impact on the flaw evaluation of the core shroud at Quad Cities, Unit 1, and summarized the various evaluations performed earlier.

The staff has reviewed these submittals, and based on its review has determined that the revised seismic analyses with the corrected mass in the seismic model will not change the conclusions of the staff's previous safety evaluations relative to the core shroud repair hardware for Quad Cities, Units 1 and 2 (Reference 7) and flaw evaluation of the core shroud cracking at Quad Cities, Unit 1 (Reference 3).

2.0 EVALUATION

The licensee used a new methodology for representing the shroud weld cracks in the revised seismic analysis. The "pinned" and "roller" weld crack conditions utilized in the initial shroud repair design were replaced with a pinned node in conjunction with a rotational spring at each weld crack location in the shroud. The representation also results in significant reductions in the shroud repair hardware design loads for the same seismic excitation. Thus, significantly higher seismic design margins can be demonstrated for the existing hardware design. A detailed description of the revised modeling methods is provided in Reference 5. The revised analyses incorporated the correction in the hydrodynamic mass as well as the revised modeling of the postulated circumferential weld cracks. A summary of the revised seismic analyses is provided in the licensee's submittal of October 31, 1995 (Reference 6).

The configuration in the revised seismic analyses is considered by the licensee to be more representative of the actual three-dimensional cracked shroud response in combination with the repair hardware. The staff finds this analytical approach reasonable and acceptable. The improved representation of the weld-crack interface connection is based on the fact that the three-dimensional geometry of the cracked shroud has a significant capacity to transmit moment across each weld-crack interface plane. This inherent capability was conservatively ignored in the "pinned" and "roller" weld-crack shroud connectivity conditions assumed in the previous analysis.

The tie rods are attached to the shroud head support ring at the upper end and to the shroud support plate at the lower end. The tie rods act as axial members and can transmit only vertical loads. Consequently, in the seismic horizontal beam element model, the only elastic coupling between the plane of the shroud head support ring and that of the shroud support plate is rotational. Due to differential elongation, the tie rods give rise to a restoring moment between the shroud flange plane and that of the shroud support plate - if there is relative rotation between the two planes.

The tensile loads which develop in the vertical tie rods, as a result of rotation of the shroud, are applied to calculate equivalent rotational stiffness at the circumferential weld crack in the horizontal seismic model. The equivalent rotational stiffnesses impede opening of the weld crack and enable the shroud to transfer horizontal shear loads.

The initial preload in the tie rod (mechanical plus thermal) and the restoring moment due to dead weight are conservatively neglected in the calculation of the rotational stiffness. These effects, however, are included when calculating the tie rod maximum loads.

The core shroud repair hardware seismic design loads obtained from the previous seismic analyses (References 8 and 9) are larger than those obtained from the revised seismic analyses (Reference 5) and, thus, the existing shroud repair hardware stress analysis represents an evaluation of the bounding repair hardware loads.

The bounding seismic loads on the RPV and Internals are summarized in Reference 5. The revised analyses resulted in some load increases for several components under a DBE loading case with an uncracked core shroud. These results are consistent with the load increases that were previously noted for the analysis of an uncracked core shroud without the shroud repair hardware. The staff has reviewed the revised analyses and finds them reasonable and acceptable. The evaluation of the identified load increases on the RPV internals was performed by comparing the new design loads to those used for the previously completed stress analyses. The previous stress analyses were performed for the bounding emergency loading case (DBE with normal operating pressure) and, thus, still represents a qualification for the bounding conditions. Based on its review, the staff finds that the increases in the revised loads for all loading conditions are less than the previously qualified loads with the single exception of the shear load at the shroud support plate. An increase in the bounding design shear load of 961 Kips to 1190 Kips occurred for the emergency case with an uncracked shroud model. However, it has been shown that this load increase can be accommodated by the design margins that exist in the shroud support. The staff, therefore, concludes that the design loads for the core shroud hardware are acceptable.

Flaw Evaluation Loads -- Quad Cities, Unit 1

This unit does not have the core shroud repair hardware installed but was inspected during the last refueling outages in 1994 (Q1R13). The previous core shroud weld flaw evaluations were performed using the original GE design basis seismic analysis (Reference 1). The staff approved 15 months of hot operation on July 21, 1994 (Reference 2) based on these flaw evaluations. The unit is currently operating and is scheduled to install core shroud repair hardware during the next refueling outage. Updated flaw evaluations were completed and submitted to the NRC on December 14, 1994 (Reference 10). These updated flaw evaluations incorporated all of the results of the ComEd efforts to more clearly define the loadings, flaw size, and crack growth parameters and, thus, serve as the basis for this revised flaw evaluation.

A new seismic analysis has been performed using the revised seismic models for Quad Cities, Unit 1, with the correct nodal mass at the top guide location. The licensee has provided the results of the new analysis in its submittal of October 31, 1995 (Reference 6). The model includes the stiffness properties of a partially degraded core shroud. The effect of the corrected mass is most pronounced in the localized response of the core shroud. The results of these new analyses for a partially degraded core shroud were used to perform a reassessment of the previously identified core shroud circumferential weld flaws.

The revised analysis for a partially degraded core shroud shows that the primary impact in the seismic response is limited to the elements representing the core shroud. A review of the total mass modeled for the core shroud elements versus the other structural elements shows that though the change is significant at the core plate location, the magnitude of the change is small in comparison to the total mass of the RPV internals (17 percent) and is insignificant in comparison to the mass of the rest of the RPV and building structures (0.1 percent). A comparison of the modal frequencies and participation factors for the seismic analysis (with the incorrect mass) versus the revised analysis results (with the corrected mass) has been provided in Reference 6 for the east-west and north-south seismic models. The results indicate that the effect of this localized mass discrepancy is minimal with respect to the overall seismic response.

This evaluation is based on a detailed assessment of the H5 circumferential weld location, as it was the location where the most significant amount of cracking was discovered during the Q1R13 refueling outage inspections. The same structural margin assessments as previously reported (Reference 10) have been performed in the governing loading cases. The required ligaments and operating time until the allowable depth is reached were calculated using the same limit load approach as was used for the previous evaluation. These results provide a direct comparison between the bounding results of the December 14, 1994, flaw evaluation and the revised results with the correction of the mass discrepancy. The allowable ligament depth is reached in 20.4 months in the revised calculations as compared to 20.7 months in the previous calculations. Based on its review of these results, the staff finds that adequate safety margins continue to exist with the revised seismic loads and the previous approval for 15 months of operation remains valid.

3.0 CONCLUSION

The evaluation of the revised seismic analysis for Quad Cities, Unit 1, indicates that the effect of the incorrect nodal mass on the shroud seismic response will not invalidate the conclusions of the existing flaw evaluations (Reference 10). The revised loads at the critical H5 weld location have been shown to be within the existing safety margins in the seismic analysis and the licensee has demonstrated that adequate margins continue to exist to operate this unit. Based on a review of the results presented in Reference 6 in conjunction with the original safety assessment for a fully cracked core shroud, the staff finds that the nodal mass discrepancy will not change the conclusions of the previous safety evaluations related to the adequacy of the flaw size at critical weld locations (References 2 and 3).

The evaluation of the Quad Cities, Unit 2, core shroud repair hardware shows that the existing core shroud repair design is adequate with the correction of the nodal mass. The results of these new seismic analyses indicate that the loads previously used for the qualification of the core shroud repair hardware

are larger and, thus, bound the new results. While all of the design loads for the core shroud repair hardware were bounded by the previous analysis, the loads on some of the RPV internals increased slightly. The effect of these load increases was evaluated and found to be within the existing design margin. The staff, therefore, concludes that the effect of the identified discrepancy in the nodal mass will not change the conclusions of the previous staff Safety Evaluation of the Quad Cities, Units 1 and 2, Core Shroud Repair (Reference 7).

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REFERENCES

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3. Letter, John F. Stang (NRC) to D. L. Farrar, (ComEd), Subject - "Resolution of Generic Letter 94-03, Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors at Dresden, Units 2 and 3, and Quad Cities Units 1 and 2 (TAC Nos. M90088, M90089, M90109 and M90110)," dated January 31, 1995.

4. Letter, J. Schrage (ComEd) to the U.S. NRC Document Control Desk, Subject - "Dresden Station Units 2 and 3, Quad Cities Station Units 1 and 2, Design Basis Discrepancy Related to Core Shroud Seismic Calculations," dated September 5, 1995.

5. Letter, P. Piet (ComEd) to the U.S. NRC Document Control Desk, Subject - "Dresden Station Units 2 and 3, Transmittal of the Dresden Design Documents for the Core Shroud Repair," dated October 2, 1995.

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7. Letter, Robert M. Pulsifer (NRC) to D. L. Farrar (ComEd), Subject - "Quad Cities Nuclear Power Station, Units 1 and 2, Safety Evaluation Regarding Core Shroud Repair (TAC Nos. M91301 and M91301)," dated June 8, 1995.

8. GENE 771-71-1094, Revision 1, "Quad Cities Units 1 and 2 - Shroud Repair Seismic Analysis," January 5, 1995.

9. GENE 771-72-1091, Revision 1, "Quad Cities Units 1 & 2 - Shroud Repair Seismic Analysis Backup Calculations," January 5, 1995.

10. Letter, P. Piet (ComEd) to the U.S. NRC Document Control Desk, Subject - "Response to NRC for Request for Additional Information Concerning Generic Letter 94-03, dated December 14, 1994, Attachment E, 'Final Evaluation of the Core Shroud Flaws at the H5 Horizontal Weld for Quad Cities Unit 1.'"