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NUCLEAR REGULATORY COMMISSION  
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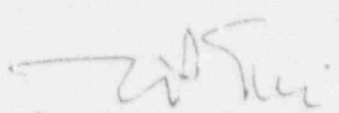
JAN 17 1992

MEMORANDUM FOR: Warren Minners, Director  
Division of Safety Issue Resolution  
Office of Nuclear Regulatory Research

FROM: Eric S. Beckjord, Director  
Office of Nuclear Regulatory Research

SUBJECT: GENERIC ISSUE NO. 118, "TENDON ANCHOR HEAD FAILURE"

The prioritization of Generic Issue No. 118, "Tendon Anchor Head Failure," shows that the issue has been resolved. The enclosed evaluation will be incorporated into NUREG-0933, "A Prioritization of Generic Safety Issues," and is being sent to the regions, other offices, the ACRS, and the PDR, by copy of this memorandum, to allow others the opportunity to comment on the evaluation. All comments should be sent to the Reactor and Plant Safety Issues Branch, DSIR, RES (Mail Stop NL/S-314). Should you have any questions pertaining to the contents of this memorandum, please contact Ronald Emrit (492-3731).

  
Eric S. Beckjord, Director  
Office of Nuclear Regulatory Research

Enclosure:  
Prioritization Evaluation

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ENCLOSURE

PRIORITIZATION EVALUATION

Issue 118: Tendon Anchor Head Failure

ISSUE 118: TENDON ANCHOR HEAD FAILURE

DESCRIPTION

Historical Background

On January 27, 1985, a dented and leaking tendon grease cap was found during inspections at Farley Unit 2 prior to the integrated leak rate test of the prestressed concrete containment structure. Subsequent detailed inspection revealed that three lower vertical tendon anchor heads were broken. Several anchor heads were then removed from the vertical tendons and magnetic particle testing revealed cracks in the ligaments between the holes in the back of the anchor heads. Metallurgical analysis of the anchor head material indicated that the failures had been caused by hydrogen stress-cracking (HSC). There was evidence of corrosion caused by hydrogen generation from the anodic reaction of zinc and steel in the presence of water since quantities of water ranging from a few ounces to about 1.5 gallons were found in the grease caps; most of the water was found in the vertical tendon lower anchor grease caps. Concerns for the generic implications of the tendon anchor failure at Farley Unit 2 resulted in the identification of this issue by NRR/DL.<sup>1354</sup>

A Task Force was assembled by the NRC to evaluate the anchor failures, including their failure mechanism and the safety significance on Farley and other plants with tendons supplied by the same vendor (INRYCO). The Task Force was to propose corrective action, determine the need for long-term generic action, prepare generic correspondence, and study the potential changes in Regulatory Guide 1.35.<sup>481</sup> At the time the anchor head cracks were found, Regulatory Guide 1.35 was undergoing revision and the supplemental Regulatory Guide 1.35.1<sup>1360</sup> was being developed. Work on these guides was suspended until review of the Farley tendon anchor head failure was completed.

By August 1985, the Farley anchor head failure was also studied by: (1) Inland Steel Laboratory/INRYCO, manufacturer of the Farley post-tension system; (2) Battelle Columbus Laboratories, consultant to INRYCO; and (3) BNL. In November 1985, the Task Force completed its review of the studies by these three laboratories and concluded that cracking of the anchor heads occurred in areas of high stress, was hydrogen-induced, and initiated because of the presence of water, zinc, and sulfur.

Although the Farley Unit 2 problem was concluded to be plant-specific because of the moisture-traveling path to the anchor heads, further study of the contributing factors continued. These factors, in conjunction with the incidence of HSC of anchor heads at Bellefonte and of stress corrosion cracking of anchor bolt material at Midland, prompted the staff to investigate the potential generic implications and an action plan was developed for resolution of the issue.<sup>1358,1359</sup> This resolution also addressed the concerns of Issue 156.2.3, "Containment Design and Inspection."

### Safety Significance

The failed tendon anchor heads were found to be losing the capability of carrying tendon design force. Tests on cracked anchor heads showed them to be capable of taking the original design force. However, the mechanism of crack initiation and propagation is time-dependent and eventually these anchor heads would not be able to carry the loads. Their failure could jeopardize the containment structural integrity.

### Possible Solution

A tendon inspection, repair, and surveillance program was initiated for both Farley Units 1 and 2. The licensee evaluated the containments and concluded that the structural integrity had been maintained continuously for both units. Issuance of Regulatory Guides 1.35<sup>481</sup> and 1.35.1<sup>1360</sup> would provide guidance for future plants.

### PRIORITY DETERMINATION

A regulatory analysis<sup>1353</sup> of the proposed revision 3 to Regulatory Guide 1.35 showed that, although the changes in the guide were determined to produce an unquantifiable change in risk, they would lower the possible risk and enhance containment availability. Additional costs might be incurred by the industry (e.g., visual inspection of bottom grease caps of vertical tendons, and requirements for lift-off tests on the second containment where two identical containments exist at a site), but the relaxed requirements in other areas (i.e., tendon sample size and tendon detensioning) could produce a net cost savings, estimated to be small. It was concluded that backfitting of the revised guide would be very difficult for plants licensed before 1974 and would have to be done on a case-by-case basis, e.g., certain plants do not permit random selection of tendons for detensioning to remove a wire sample for material tests (See Section 6.2, NUREG/CR-4712).<sup>1353</sup> However, the staff believed that backfitting most plants licensed after 1974 was possible. Regulatory Guide 1.35.1<sup>1360</sup> provided essentially new guidance on predicting and evaluating prestressing forces.

Ten licensee/applicants committed to various provisions of Regulatory Guide 1.35, Rev. 3 (NUREG/CR-4712, Table 4).<sup>1353</sup> Therefore the staff's recommendation was to apply the provisions of Rev. 3 to Regulatory Guide 1.35 to new licensing applicants only and allow other licensees to use it on a voluntary basis.<sup>1361</sup>

The proposed Regulatory Guides 1.35, Rev. 3, and 1.35.1<sup>1360</sup> were reviewed by CRGR in December 1989. CRGR concluded that there did not appear to be any substantial safety improvement in backfitting nor did the matter appear to qualify as a compliance or an adequate protection backfit. CRGR recommended in Meeting No. 175 that the proposed guides be issued for forward-fit only. The guides were issued in July 1990 and only affected future plants and those operating plants that voluntarily committed to the provisions of the guides.

## CONCLUSION

A number of licensees voluntarily adopted the provisions of Regulatory Guides 1.35,<sup>481</sup> Rev. 3, and 1.35.1;<sup>1360</sup> some SEP plants also developed ISI programs. These actions by some operating plants and the application of these guides to future plants addressed the concerns raised by the Farley Unit 2 tendon anchor head failure. The CRGR decision on the issuance of Regulatory Guides 1.35, Rev. 3, and 1.35.1 indicated that there was no need to backfit operating plants. Thus, this issue was RESOLVED and new requirements were issued.

## REFERENCES

481. Regulatory Guide 1.35, "Inservice Inspection of UngROUTed Tendons in Prestressed Concrete Containment Structures," U.S. Nuclear Regulatory Commission, February 1973, (Revision 1) June 1974, (Revision 2) January 1976, (Revision 3) July 1990.
1352. Memorandum for J. Knight, et al., from H. Thompson, "Action Plan for Resolving Failure of Tendon Anchorage at Farley 2 and for Determining Need for Immediate Licensing Action on Other Facilities," June 25, 1985.
1353. NUREG/CR-4712, "Regulatory Analysis of Regulatory Guide 1.35 (Revision 3, Draft 2) In-Service Inspection of UngROUTed Tendons in Prestressed Concrete Containments," U.S. Nuclear Regulatory Commission, February 1987.
1358. Memorandum for H. Thompson from G. Arlotto, "RES Input - Action Plan for Resolving Failure of Tendon Anchorage at Farley-2 and for Determining Need for Immediate Licensing Action on Other Facilities," July 31, 1985.
1359. Memorandum for T. Speis and E. Jordan from J. Knight, "Tendon Anchor Head Failure - Needed Licensing Action at Other Facilities," December 6, 1985.
1360. Regulatory Guide 1.35.1, "Determining Prestressing Forces for Inspection of Prestressed Concrete Containments," U.S. Nuclear Regulatory Commission, July 1990.
1361. Memorandum for E. Jordan from E. Beckjord, "CRGR Review of: 1. Regulatory Guide 1.35, Rev. 3, 'Inservice Inspection of UngROUTed Tendons in Prestressed Concrete Containments,' 2. Regulatory Guide 1.35.1, 'Determining Prestressing Forces for Inspection of Prestressed Concrete Containments,'" July 28, 1989.