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MEMO

Docket No. 50-206

MEMORANDUM FOR: R. H. Vollmer, Director  
Division of Engineering

D. G. Eisenhut, Director  
Division of Licensing

THRU: V. S. Noonan, Assistant Director  
for Materials and Qualifications Engineering  
Division of Engineering

FROM: S. S. Pawlicki, Chief  
Materials Engineering Branch  
Division of Engineering

SUBJECT: SAN ONOFRE UNIT 1 - STEAM GENERATOR LEAK - WIDESPREAD INTER-  
GRANULAR ATTACK AND CIRCUMFERENTIAL CRACKING AT TOP OF  
TUBESHEET

Plant Name: San Onofre Unit 1  
Supplier: Westinghouse  
Docket Number: 50-206  
Responsible Branch and Project Manager: ORB 5; T. Wambach  
Reviewers: E. L. Murphy; F. M. Almeter  
Description of Task: Review Steam Generator Inspection Results  
Review Status: Licensee's Final Report Required Prior to Return to Power

The Inservice Inspection Section of the Materials Engineering Branch, Division of Engineering, has learned through the Project Manager and Southern California Edison that initial findings of the steam generator inspection currently in progress at San Onofre Unit 1 indicate the recent development of caustic intergranular attack and associated circumferential cracking at the top of the tubesheet, affecting approximately 460 tubes. Sixty one percent of the quantifiable indications exceed 95% through wall. We consider these findings to be significant in view of the apparent high rate at which the tube degradation is developing at the top of the tubesheet and our concerns regarding the detectability of this type of degradation.

A brief summary of the latest findings from San Onofre and of additional actions to be taken by the licensee to establish the condition of the steam generators is attached. The Project Manager has requested a meeting with the licensee to be held in Bethesda (probably during the week of July 6, 1980) to discuss this matter in detail prior to startup of the unit. Following this meeting we will

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be requesting a meeting with the Director, Division of Licensing, to discuss what actions will be required for continued safe operation of this unit.

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Enclosure:  
MTEB's Evaluation

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SAN ONOFRE UNIT 1 - STEAM GENERATOR LEAK  
WIDESPREAD INTERGRANULAR ATTACK AND CIRCUMFERENTIAL CRACKING  
AT TOP OF TUBESHEET

SUMMARY

Initial findings of the steam generator inspection still in progress at San Onofre Unit 1 indicate the recent development of caustic intergranular attack (IGA) and associated circumferential cracking at the top of the tubesheet affecting approximately 460 tubes. Sixty one percent of the quantifiable defect indications exceed 95% through wall. The Inservice Inspection Section of the Materials Engineering Branch, Division of Engineering, is continuing to monitor the inspection results as they become available.

The San Onofre findings to date raise concerns regarding (1) the circumferential cracking failure mode at the top of the tubesheet, (2) the apparent high rate of tube degradation since the previous inspection, and (3) the detectability of defects with between 40% (plugging limit) and 90% through wall penetration.

DISCUSSION

San Onofre Unit 1 shutdown on April 9, 1980 with a 270 gpd primary to secondary steam generator leak. Subsequent hydrostatic testing of the steam generators revealed five (5) confirmed leakers in steam generator C and three (3) probable leakers in steam generator B. Multifrequency eddy current inspection was performed on 100% of the tubes in each steam generator and revealed these leakers to be among 329 tubes with quantifiable defect indications and 130 tubes with non-quantifiable defect indications located at the top of the tubesheet elevation. Almost all of the quantifiable indications exceed 50% through wall, and 61% of these exceed 95% through wall. The affected tubes also contain dent indications at the top of the tubesheet elevation. One (1) defect indication within the thickness of the tubesheet (deep crevice indication) was also identified.

Three (3) tube specimens, two containing top of the tubesheet indications and one containing the deep crevice indication, were removed from the steam generators and subjected to laboratory examination. This examination revealed the top of the tubesheet indications to be associated with caustic intergranular attack and cracking within approximately a 0.2 inch axial zone extending non-uniformly around the circumference of the tubes. Cracks (large grain boundary separations) appear to be circumferentially oriented. The tube sample containing the deep crevice indication revealed this indication also to be associated with intergranular attack and cracking approximately two inches below the top of the tubesheet.

Approximately 20 top of the tubesheet indications had been identified during the previous inspection in June 1979. A review of the single frequency eddy current tapes from the previous inspection for some of the tubes identified during this inspection to contain top of the tubesheet indications indicates

that some level of degradation may have been present during the previous inspection for a few of these tubes, but that other tubes were apparently clean. In general, the preliminary data indicates that the top of the tubesheet degradation phenomenon to be a relatively recent development and that the phenomenon may be highly active.

San Onofre Unit 1 is one of two operating plants which continue to operate with phosphate secondary chemistry control. A data review covering the last two years of operation indicates the presence of free caustic in the steam generator bulk water. Average chloride levels (near 1 ppm) indicate chronic low level sea water condenser in-leakage. Na/PO<sub>4</sub> ratios typically ranged from 2.6 to 2.8 with significant hideout return observed during transients indicative of free caustic in various steam generator crevices and the sludge layer.

#### FUTURE ACTIONS

The observed distribution of the top of the tubesheet indications as a function of the percent through wall penetration raises concerns regarding whether the general condition of the steam generators has been adequately established by this inspection. In particular, there is a concern as to whether a significant number of tubes between 40% (plugging limit) and 90% through wall degradation at the top of the tubesheet may have escaped detection during this inspection. To address these issues, the licensee plans to perform supplementary eddy current inspections in one steam generator using a pancake (multifrequency, surface coil type) probe. The pancake probe is still in the developmental stage at Westinghouse, but is believed by both the licensee and Westinghouse to be possibly better suited to detect circumferentially oriented defects than conventional probes. The licensee also plans to remove four (4) additional tubes for laboratory examination including a tube with no field eddy current indication, but which is located in a region affected by the top of the tubesheet phenomenon for purposes of confirming that such a tube is free of significant through wall degradation.

The licensee is working with Westinghouse to assemble available test data regarding the mechanical integrity of tubes containing circumferentially oriented defects, and leak rates from such defects in the event of tube failures. Depending upon the availability of this information, test equipment availability, and outage scheduler considerations, the licensee is considering performing an in-situ pressure test of selected leaking tubes to obtain actual leak rate versus pressure data and to determine actual burst pressures for these tubes. In addition, selected tubes would be tested at conservative pressures to correlate tube strength with observed eddy current indications.

In order to improve the secondary phosphate chemistry control, the licensee has proposed in a letter dated June 24, 1980 a number of short term remedial actions including (1) performing cold and hot water flushing of all steam generators prior to startup, (2) adjusting the secondary chemistry to slightly lower than Na/PO<sub>4</sub> ratio and increase the phosphate concentration (2.3 to 2.6 Na/PO<sub>4</sub>, 20 ppm PO<sub>4</sub>), and (3) checking treatment purity and closely monitoring makeup evaporation purity.