AUG 2 7 1984

MEMORANDUM FOR: Richard M. Denise, Director
Division of Resident, Reactor Project
and Engineering Programs, Region IV

FROM: Darrell G. Eisenhut, Director
Division of Licensing

SUBJECT: TIA NO. 84-41, FORT CALHOUN-S/G TUBE FAILURE

In my letter to you dated June 22, 1984 on the above subject, I stated that I would forward to you our evaluation of the licensee's final report on the steam generator tube failure mechanism. Our evaluation, which is enclosed, concludes (1) that the results described in the final destructive examination report by Combustion Engineering, Inc. concerning the failed Fort Calhoun steam generator tube does not alter the conclusions in our Safety Evaluation provided to you previously, and (2) that the destructive examinations confirm that tube failure was due to outside diameter initiated stress corrosion cracking with caustic a likely candidate as the causative agent.

This completes our work under the TIA.

Original signed by:

Darrell G. Eisenhut, Director
Division of Licensing

Enclosure:
As stated

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ATTACHMENT

REVIEW OF REPORT BY COMBUSTION ENGINEERING, INC.
"DESTRUCTIVE EXAMINATION OF TUBE L29 R84
FROM THE B STEAM GENERATOR AT FORT CALHOUN "JUNE 1984

INSERVICE INSPECTION SECTION
MATERIALS ENGINEERING BRANCH

Ref: Omaha Public Power District Letter
dated July 17, 1984

BACKGROUND

On May 16, 1984 a tube leak of approximately 110 gpm occured in the B steam generator at Fort Calhoun Station during hydrostatic tests in preparation for return to power operation after a refueling and maintenance outage.

Subsequent non-destructive inspection indicated a large throughwall defect in tube L29R84 in the area of the first (hot leg) vertical support strap on the horizontal run. The location of the failure in the horizontal run and the location of the tube in the second peripheral row of tube made removal of the failed section possible. Accordingly, Combustion Engineering removed by cutting with a TIG torch that part of tube L29R84 extending from near the hot-leg 90° bend to the center vertical support. To gain access to tube L29R84, C-E removed an equivalent section of tube L29R86, a first peripheral row tube. After a brief on-site visual examination, the removed sections of both tubes were shipped to C-E's laboratory facilities for detailed destructive examinations.

DISCUSSION

The laboratory examinations of tube L24 R84 included:

- Visual and eddy current examinations
- Dimensional checks
- Microscopic examinations
- Chemical analyses of deposits

The results of these examinations are summarized below. Two (2) cracks were observed visually on the failed tube section. The first was a large, axial "fishmouth" type crack measuring 1¼"long, while the second was a series of small (approxfmately 1/4") length fissures which made an acute angle (45°) relative to the axis of the tube. Using field eddy current test equipment, a 100% throughwall signal was identified at the location of the "fishmouth" failure and approximately 1/4 of an inch from the hot-leg end of the first defect. A second O.D. initiated defect signal was observed which corresponded to the second crack.

Dimensional measurement indicated that the tube was ovalized. The major axis (6-12 o'clock) was elongated by 0.046-0.122 inch, while the minor axis (3-9 o'clock) was compressed by 0.045-0.070 inch diametrically.

Metallographic examination revealed the presence of IGSCC. There was no evidence of the presence of a network of intergranular attack between the fissures.

The scanning electron microscope showed that approximately 95% of the crack surface exhibited a distinct intergranular appearence. Only a small amount of ductile tearing, approximately 5% of the wall thickness, was evident at the I. D. surface. The "fishmouth" fracture was thought to be formed from a series of essentially throughwall axially oriented intergranular penetrations and the remaining tube wall thickness. There was no evidence of tube wall thinning as a result of corrosion or plastic deformation.

Chemical analyses found only Ni, Cr, and Fe on the crack surface. However, at one location weak indications of-potassium and sulfur were present. X-ray dot mapping showed no indications of concentrations of these elements. In another area there were weak indications of calcium, chloride, copper, magnesium, and aluminum along with silica. At no locations were there any significant concentrations of chemical species that could have contributed to the failure.

Combustion Engineering concludes that the analysis indicated that the cause of tube failure was intergranular stress corrosion cracking which propagated essentially throughwall prior to the final ductile rupture. The examination of the stress corrosion cracks and deposits removed from the tube failed to identify a causative species for the failure. The tube was confirmed to be typical of mill annealed Ni-Cr-Fe Alloy 600 tubing used in C-E supplied steam generators.

Based on the information available, it was further concluded that the failure was most likely the result of caustic stress corrosion cracking with the caustic environment resulting from the concentration buildup from condenser cooling water in-leakage in steam blanketed areas.

CONCLUSIONS

We find that the results described in the final destructive examination report by Combustion Engineering, Inc., concerning the failed Fort Calhoun steam generator tube do not alter the conclusions in our Safety Evaluation dated June 21, 1984, which was based on preliminary laboratory findings.

The destructive examinations confirm that tube failure was due to outside diameter initiated stress corrosion cracking with caustic a likely candidate as the causative agent.