

INFORMAL TECHNICAL COMMUNICATION

Date AUG 4, 1982

To: JAI RAJAN / RICK JACOBS

U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

From: TED SHOOK / LARRY LEONARD

Franklin Research Center
Philadelphia, PA 19103

(TO BE OPENED BY ADDRESSEE ONLY)

Reference: NRC Contract NRC-03-81-130
NRC TAC No. _____
Plant TMI-1

FRC Project C5506 ASSIGNMENT 10
FRC Generic Topic TMI-1
FRC Task(s) 311, 312, 313 (A,B,C)

Title: _____

Attachment: TRIP REPORT OF JULY 21 MEETING AT
LIVINGSTON, N.J.

Message: TECHNICAL COMMENTS ARE GIVEN, BASED ON
PRESENTATION GIVEN. SUMMARY OF MEETING BE-
TWEEN VINCE LUK AND JIM MOORE OF GPU IS
INCLUDED. THERE IS STILL CONCERN ABOUT RECEIVING
INFORMATION WE NEED TO PERFORM OUR REVIEW
AND EVALUATION

Copy of message form only: .

NOTE TO SENDER: Include
attachments if information is
pertinent to program management.

S. S. Bajwa

NRC Performance Monitor

NRC Lead Project Manager

HERBERT BRAHMER

CONRAD McCracken

FRC Distribution: SPC, SP, TS, LL, BL, CD, ., ., .

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Franklin Research Center
A Division of The Franklin Institute

TRIP REPORT: PROJECT C5506, Assignment 10.
PLACE VISITED: Foster Wheeler, Livingston, NJ
DATE: July 21, 1982
THOSE PRESENT: Representatives from:

NRC
FRC
GPU
FW
B&W

Present from FRC:

L. Leonard
C. T. Davey
V. Luk
T. A. Shook

PURPOSE OF MEETING: To present schedule for qualification program of tube repair, and result of preliminary tests performed. Interface with technical personnel on the status of analytical work.

1. This meeting revealed newer, more up to date plans than previous meetings. It allowed more direct interactions among technical personnel present.
2. Progress was announced on the Ordnance Cord-booster concept for candle Initiation. This initiation process should result in less explosive reaction outside the expansion space, and thereby reduce contamination and potential damage as a result of the more brisant primacord initiation process that the Ordnance Cord replaced. Further studies are planned to confirm that Ordnance Cord is appropriate.

Dr. Pai (Foster Wheeler) expresses belief that the booster will have no more explosive effect than an equivalent length of primacord.

3. The schedule for delivery of the six single-tube and two ten-tube test specimens was discussed. Delivery was to be in late September to FRC, however, more recent information indicates that FRC should have all fixtures and hardware by mid-August.

Foster-Wheeler has partially completed their apparatus for cyclic testing of the ten-tube mock-ups. The test parameters are slightly different than FRC's but at this time it appears that results should be comparable.

4. The pull-out tests showed that the load required to pull out an expanded tube (after the two step process) is essentially independent of the extended length for lengths above about 5 inches. Accordingly, Foster Wheeler is qualifying a six inch length even though the minimum expansion at this time will be 17 in. For tubes which leak in the tube sheet after the 17" expansion, a follow-up 23" expansion can be utilized to seal a new 6" qualified length below the original expansion. Peripheral tubes may cause problems; the candle cannot be injected easily.

5. There were some serious concerns if the expansion is performed too close to the juncture of the tube and the tube sheet, placing the transition near the inside surface of the tube sheet. A double ended rupture was feared that would potentially cause serious leaks.

Particular concern was expressed in the event of a steam line break during which time a temperature difference would exist in which the tube would be at a lower temperature than the tube sheet. The accompanying tube shrinkage would result in a tensile load on the tube.

This situation will be investigated by B&W.

6. X-ray diffraction residual stress measurements will be made at Penn State University to evaluate the relative magnitude of stresses induced by tube rolling and explosive expansion both in fully expanded areas and in the transition to the unexpanded region. These tests will take about 2 to 2½ months to complete, and, thus, all results will not be available until the beginning of October. This should present no problem with regard to the implementation of repairs since it is highly likely that the expansion residual stresses will be less than those from rolling. The tests are to demonstrate how much more uniform and less severe the stresses are resulting from explosive expansion than from rolling.
7. Candles will be supplied to FRC by Foster Wheeler for any experiments we wish to run. It was confirmed that FRC is fully licensed to store explosives (Federal, State and City licenses).
8. Multiple expansions are planned at Mount Vernon, Indiana on 5 August 1982. This is a B&W "graveyard" for old steam generators. FRC observers will attend.
9. Materials presented during this meeting will be mailed to FRC by GPU after appropriate approvals. As of this writing these materials have not been received.
10. A meeting was held between Vincent Luk of FRC and Jim Moore of GPU at GPU. The purpose of the meeting was to discuss the Licensee's stress evaluation program. At the meeting, FRC reviewed a draft GPU Stress Report, TDR No. 346, "TMI-1 OTSG As-Built Stress Analyses." The report focuses on the review and evaluation of the performance of the as-built steam generator, and it does not address the effects of the kinetic expansion process on the performance of the unit. The report will probably be released to public domain by 7/23/82. FRC may get a copy of the report before the end of July 1982. At the meeting, the scope of stress analyses which FRC would like to be covered by licensee was discussed in detail. According to Jim Moore, most items covered in FRC's scope will be included in licensee's test qualification program and the remaining few items will be evaluated analytically by either GPU or B&W. All the results from qualification and stress evaluation programs will be reviewed by FRC when they become available.
11. A request was made to Mary Jane Graham for the following documents:
 - a. Mechanical drawings of tube bundle and tubesheet assembly together with tube support system.

- b. Proprietary Topical Report, B&W-10002,
"Once Through Steam Generator Research
and Development Report."
- c. B&W-10146, "Determination of Minimum
Required Tube Wall Thickness for 177
F/A OTSG's, "Babcock & Wilcox Report."

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

August 17, 1982

To: R. W. McClung

From: C. V. Dodd *C.V. Dodd*

Subject: Travel to Harrisburg, Pennsylvania, August 8-9, 1982

On Monday, August 8, I met with General Public Utilities (GPU) and NRC personnel to discuss the eddy-current inspection of the Three-Mile Island Unit 1 steam generators. A partial list of attendees is attached. Nick Kazanas of GPU gave a presentation of the development and qualification program for the eddy-current inspection of the steam generators. A set of inside diameter calibration standards with circumferential notch lengths of 0.060, 0.100, and 0.187 in., notch depths of 20, 40, 60, and 80%, and widths of typically 0.004 to 0.005 in. were constructed. In addition, an axial notch standard with 0.060 in. long notches was constructed.

These standards were used to test circumferential differential probes of 0.510 and 0.540 in., and an eight-coil array with 0.187 in. outside diameter pancake coils. Various gain and other conditions were run. The best combination for the differential coil system was the 0.540 in. outside diameter probe with a permanent magnet saturating core and a gain setting of 60. The permanent magnet should not have increased the signal any but only reduce the noise a small amount. I examined a probe and its field did not seem strong enough to saturate any ferromagnetism associated with Inconel (about 0.3 T is usually needed). However, it did seem to be more carefully made than the regular 0.540 in. probe. An additional mix of the 200 and 400 kHz mixed signal with an 800 kHz signal reduced the noise due to probe chatter and pilgering.

The 8X1 absolute probe showed more signal to the small defects at a gain of 53, but a fairly large lift-off signal was also present. The 8X1 probe array is being revised to increase the probe body from 0.520 to 0.540 in, which should reduce the lift-off problem.

A correlation of the defects seen by the pancake coils with the defects seen with the 0.540 in. outside diameter differential probe showed that of 3233 defects detected by the pancake coil, 3216 were also detected by the differential probe. This number was improved to 3229 by using the mix to reduce the inside diameter noise. This shows an excellent match and also showed that the 0.540 in. differential probe, operated under these conditions, can reliably detect the same type of circumferential crack. In order to directly apply the results obtained from the electrodischarge machined standards, an "effective axial crack width" for these intergranular stress-corrosion cracks must be determined.

On Monday afternoon, John Janiszewski of GPU gave a presentation of the results of the metallography of the cracks. Some cracks appeared to have regions of bulk intergranular attack associated with them, and some appeared to be very narrow with very little branching and axial component. However, the crack would only need a few branches to effectively disrupt the flow of eddy currents.

John Janiszewski will generate an "effective axial component" by reviewing the results of the previous metallography and furnish it to us. This number will show how applicable the calibration results from electrodischarge machined notches is for the circumferential cracks, and furnish an independent verification of the ability to detect the defects with a different probe. The results of a dimensional analysis experiment using large scale models at ORNL will be used to correct the sensitivity at one length to the sensitivity at another. It was stated that the region near the crack was depleted in chrome, but no estimate was made of the bulk electrical and magnetic properties of the region. A total of 19 ft of "good" tubing has been examined by metallography, with an additional 6 ft to be examined. No defects were detected by this test that were missed by the eddy-current test. Some of the defects detected by the eddy currents were not found by the metallographic examination, probably due to the way the samples were cut. Some of the eddy-current signals turned out to be due to manufacturing, handling, and assembly artifacts, and would not be detrimental to the service of the tube.

On Tuesday I visited the data reduction site at the Host Inn near the plant. I reviewed the results of the scan on tube A71-126. This tube was pulled and a section sent to ORNL for examination. A through-wall defect was detected using a high-frequency (5 MHz) scan with a small (0.020 in. mean radius) probe from the outside. The defect was then etched and showed a 0.005 to 0.010-in.-wide affected region on the outer surface. It is not known if this entire region appears as a low conductivity region or not. The defect was recorded as 80% through-wall by ConAm, and a blind remeasurement of the defect from tape showed 84%. The magnitude of the signal was 1/2 V at a gain of 34, and an 0.510 in. outside diameter differential probe was used.

I also looked at runs using the 0.540 in. outside diameter differential probe with a gain of 60. The practical noise level to get a reasonable measurement of the defect depth appears to be around 0.5 V, although in many cases smaller defects can be measured. Based on the 0.005 in. wide standards, this falls in the range of a 0.060 in. long defect, 40% through-wall. Depth measurements on smaller defects will probably be very inaccurate.

A 100% inspection of the full length of all the tubes is being performed using the 0.540 in. probe with a gain of 60. The number of indications is about three times as many as were observed with the 0.510 in. differential probe. Tube B10-48 showed 16 inside diameter defects, all about 1 V in amplitude, between 30 and 60% of the wall. The lowest defect was near the third support plate. The high sensitivity of this new inspection is also

picking up a number of outside diameter signals from the manufacturing process, which are not detrimental to the service and can be ignored. The tubes that exhibit the inside diameter signals should be rescanned with the 8X1 pancake coil array, and the tubes with defects greater than the plugging limit plugged. The tubes with defects below the plugging limit can be reexamined at later intervals to monitor growth of this type of defect.

There appears to be a drift and a quality assurance problem with the probes. This problem doesn't affect the accuracy of the test, but results in frequent probe changes. The inclusion of several of these types of defects in an in-line standard (for future tests) should be considered. The instrument gain in the field is set to give a repeatable voltage amplitude from a drilled hole flaw, rather than an absolute number.

The pancake coil array is operated at a single frequency and much more susceptible to different types of noise than the differential probe. This array also requires much more equipment than the differential probe. Zetec is working on a more compact system, but no estimate of the availability of this instrumentation was given.

The results that I saw on Monday and Tuesday answered all the previous questions that Emmett Murphy had submitted in his letter of April 12, 1982, except the one on safety evaluation. Some attempt should be made to determine how large a defect would have to be before it would present a safety problem. I feel that the defects that can now be reliably detected are much smaller than those that would present a hazard, but have no information to back this up.

The study, done by the utility, their contractors, and the EPRI NDE Center to determine their sensitivity limits, was outstanding.

CVD:jlb

cc: R. Barley, GPU
J. H. DeVan
L. Frank, NRC ✓
J. C. Griess
F. J. Homan
N. Kazanas, GPU
A. L. Lotts
C. McCracken, NRC
J. Muscara, NRC
P. Patriarca
G. M. Slaughter
J. H. Smith
P. Wu, NRC
C. V. Dodd/File

MEETING REPORT

Place: Bethesda, MD
Date: September 15, 1982
Present: Representatives of NRC, GPUN, FW AND B&W
FRC Representatives - C. Davey
L. Leonard
V. Luk
T. Shook

The purpose of this meeting was for the licensee, GPUN, to make its final presentation of the TMI-1 OTSG repair process description and qualification.

Miscellaneous

A video tape of parts of the Mt. Vernon demonstration was presented.

It was stated that the kinetic expansion of the TMI tubes is to begin early in October.

A third party review is being conducted to provide evaluation of the adequacy of the steam generator repair program as it relates to safe operation of the plant.

Repair Criteria

An acceptable leakage rate from primary to secondary has been established. The value is 3.2×10^{-6} lbs/hr per tube.

The pull-out strength must be greater than the maximum anticipated accident load condition (3140# for a MSLB).

Thermal and hydraulic performance of plant and structural adequacy shall be within acceptance criteria for normal and accident conditions. Evaluation has not yet been completed.

Criteria for plugging or expanding tubes was presented. It is estimated that approximately 750 tubes will have to be plugged, initially.

Sequential steps were presented for the repair process. Details of the clean-up process after the expansion have not yet been made available, however the decision to pre-coat the tubes should accelerate this process.

Tests

GPUN will publish a report by October 1, 1982, documenting all test data taken to date.

All testing will be completed by November 10th.

Penn State is approximately 25% into its test program of single and multi-tube test specimens.

Meeting Report 9/15/82

5506-001 (10000)

GPUN reported the results of pull-out tests on the Mt. Vernon generator. Three tubes were subjected to loads of 3600 lbs, and there was no movement of the tubes under these loads. This data has not yet been documented.

GPUN will perform high temperature pull-out tests on one of their test blocks. Results will be verbally relayed to FRC.

Discussion of FRC's Request for Additional Information

A formal RAI was issued on August 27, 1982 to the NRC by the FRC. The various items of this request were reviewed, and their status determined.

It was agreed to hold a meeting at Lynchburg to discuss the unresolved items. This meeting was held on September 20, 1982.

A list of items was drawn by FRC (8 in number), and presented to GPUN, FW, and B&W, for the meeting, at their request.

At the meeting, the status of each item was determined, i.e., available, not available at present, will never be available.

A trip report has been released giving details of this meeting.

FRC is proceeding with its preliminary TER based on documentation received as of this date, and on the results of its own independent test program to date.