UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
631 PARK AVENUE
KING OF PRUSSIA, PENNSYLVANIA 19406

November 16, 1983

TO: R. Conte

FROM: F. Young

SUBJECT: OTSG Repair Briefing

Attached is the requested information that can be a basis for discussion with Region I Management prior to the Commission briefing on the OTSG Repair Program. Enclosure 1 addresses the sequences of major events. This was not written to cover every step of the repair process but attempted to highlight major milestones. In the area where the technique was new, background material was added to give the reader a better but limited understanding of the process.

A summary of the inspection program implementation was presented in Enclosure 2 with the attempt to "snapshot" the remaining issues to date.

Enclosure 3 is a brief summary of the OTSG Prehearing, dated October 17, 1983. The notes were generated with the understanding that the individual who would use these notes had some prior knowledge of the subject. It was done in outline form to maintain the notes to a minimum.

Hopefully this will be found useful.

F. Young

cc: W. Baunack
E. Conner
R. Keimig
R. Starostecki

180
R (H)

ENCLOSURE 1

SEQUENCE OF MAJOR EVENTS

TMI-1 OTSG REPAIRS

In late November 1981, while increasing RCS pressure to 45 psig for testing, primary to secondary system leakage was detected. The RCS was then depressurized and partially drained to conduct OTSG leakage tests. In early December 1981, approximately 130 OTSG tubes were determined to be leaking and non-destructive examination of the OTSG tubes was commenced using eddy current testing (ECT) techniques. The initial ECT examination indicated that there were thousands of potentially defective tubes. As a result, GPU Nuclear established internal task groups to investigate the mechanism and cause of the tube failures, the extent of the problem and acceptable methods of repair.

Subsequently, as a result of metallographic examination of portions of removed tubes, it was confirmed that the cause of the tube failures was intergranular attack initiated from the primary side of the tubes resulting in the formation of stress assisted intergranular cracks. The active chemical impurity causing the corrosion was sulfur in "reduced forms". Initial ECT results, conducted in January and February, 1982, indicated approximately 8-10,000 tubes contained defects with the vast majority (approximately 95%) of the defects occurring within the top 2-3 inches of the 24 inch upper tubesheet. Subsequent ECT using special probes and techniques verified that many more defects existed at the very top of the tubes (top ½ inch).

To repair the tubes which have defects within the upper tubesheet, the licensee decided (July, 1982) to perform an explosive expansion repair technique which expanded and tightly sealed the tubes within the tubesheet, thereby establishing a new leak limiting/load carrying mechanical seal. The explosive expansion repair technique was applied to all tubes in both OTSGs, except those tubes already plugged.

Implementation of the repair technique occurred between September 1982 and February 1983. The repair technique consisted of inserting a polyethelene sheath into each tube. The polyethelene sheath contains a prima cord which, when ignited, expands the polyethlene sheath against the tube and the resultant force expands the tube. The polyethelene sheath prima cord and a booster cap was called a candle. Each candle was connected by an individual ordinance transfer cord. The transfer cord connected the candle in the tube to the blast box located outside the OTSG. The transfer cord ends were bundled together and connected to a standard type blasting cap. The candles were detonated via the transfer cord by the blasting cap which is ignited electrically by a licensed blaster.

During the expansion, a problem was noted with the kinetic expansion process which caused metal pieces from these stubs to break free from the tube. Tube stubs are tube sections that protrude approximately 1/8 inch above the primary side of the tube sheet with welds between the tube and the tube sheet. These stubs, which have circumferential cracks, are not a part of the reactor coolant system boundary. Licensee evaluated the need to mill (grind) down the tube stubs to prevent loose pieces from breaking away during power operations and decided to mill down all tube stubs in March 1983.

In May 1983, after completion of kinetic expansion, a final bubble test was performed to document the "As Left" condition of the OTSGs. The test was conducted with primary water level approximately 5% above the Upper Tube sheets (UTS) of each OTSG. Secondary water level, after the N_2 pressure was applied, was approximately 480" in the A OTSG and 560"^{2}in the B OTSG. The secondary side was pressurized via the Plant Nitrogen System to approximately 150 psig. No indications of leaks were noted in the B OTSG. Ten indications of leaks were identified in the A OTSG. Bubbles were noted emitting from a B&W welded plug. This plug was reworked prior to final closeout. The remaining nine bubble indications were from six Westinghouse style temporary plugs and three unobstructed tubes. All of the leak indications were very fine streams of minute bubbles. The licensee has decided to leave these tubes in service to aide in tube leak identifications.

The licensee's laboratory tests on sulfur contaminated tubes from the TMI-1 steam generators demonstrated that the peroxide treatment could remove 50% to 80% of the sulfur. Tests have shown that the desulfurization process will be slowed in the kinetically expanded portion of the steam generator tubes because the expansion process leaves a thin polypropylene film on the tube surface. Sulfur removal on the remainder of the RCS can be anticipated to be more effective than for the OTSG tubes because the polypropylene film does not exist outside of the OTSG. For this reason, prior to kinetic expansion, the primary side of the OTSG's was coated with immunol to alleviate this problem.

In July 1983, the licensee desulfurized Reactor Coolant System (RCS) surfaces using a dilute oxidizing solution of hydrogen peroxide (H_2O_2) to reduce the likelihood of corrosion problems from the sulfur remaining on the RCS pressure boundary component and piping surfaces. In order to enhance the cleanup boron concentration, ph, lithium ion concentration, RCS temperature and pressure were maintained in specific range as stated in the licensee Test Procedure (TP) 600/4. Actual removal rate was less than expected and sulfur continues to "leech out" in the RCS during cold shutdown conditions. This is removed by ion exchange.

The final step in the recovery process was Hot Functional Testing (HFT) in September 1983. The OTSG HFT was designed to include transients which will stress the OTSG tubes, open up any cracks which are on the threshold of propagation or open up any undetected cracks further. Leak detection

of OTSG primary to secondary leakrate was calculated using a tracer gas Krypton (Kr-85). The testing sequence and subsequent heatups and cooldowns were designed to simulate most of the same conditions in which the original cracking was initiated. The licensee is in the process of reviewing the results of the OTSG HFT with the evaluation to be completed by mid-October. Preliminary results indicate no significant increase in RCS leakrate (0.0 to 0.2 gpm).

ENCLOSURE 2

REGION I ACTIVITIES

TMI-1 OTSG REPAIRS

Summary

Direct inspection of the Licensee OTSG Repair Program totaled approximately 1460 hours by region based and resident inspectors (See Table 1). These inspections hours represent a period of November 1981 to September 1983. During the review of the inspection, several unresolved items arose which dealt with (a) adequacy of the Westinghouse plug, and the adequacy the ALARA program used during the recovery process. There were no major violations noted except during HFT. Most technical concerns by the resident and/or region based inspectors were directed to (and discussed with) NRR. The Office of NRR incorporated these concerns into previously identified concerns of their consultants or the staff. Due to the frequent meetings (see Table 2 for specific meetings) and discussions with the licensee, most issues were resolved quickly.

Conclusions

One concern of the inspectors was that the licensee should have determined the exact cause of the sulfur intrusion. Due to many possibilities, the licensee was never able to determine the specific causal event leading to this problem. The concern was noted to NRR and was addressed in the staff's SER.

The adequacy of the Westinghouse Temporary plugs from NRR point of view has been adequately addressed. From the region point of view, the final evaluation and testing on mechanical temporary plugs was incomplete. The licensee stated that final evaluation would be submitted to NRC in a written report.

Additionally, the licensee is to submit to the NRC their final evaluation of the data generated during HFT and this will be reviewed by Region I. The review of NUREG 1019 and Supp. 1 (Staff's SER addressing TMI-1 OTSG Repair Program) has not been completed. From the review of these documents, several action items are expected to develop. Two other inspection findings remain open and they are the final review of both the licensee's TER on RCS Internal Inspection and OTSG Man Rem Exposure program.

From a managerial point of view, the program at times moved very slowly. Resident Inspector's opinion is this was due to the slow interaction between corporate engineering and site engineering. Many times the plant staff would be ready to move forward, but corporate work was lagging. This caused further delays because most procedures were written on site.

ENCLOSURE 2

TABLE 1
OTSG INSPECTION PROGRAM
IMPLEMENTATION

Inspection Report	Dates	Inspector	Hours	Area of Review
81-32	11/81-1/82	Young	40	Initial Review of severity of problem Eddy Current, Bubble Test
82-01	1/82-2/82	Young	45	Eddy Current, Tube Samples, Licensee's preparation for RCS internal inspection
82-02	2/82-3/82	Young	50	Plugging/Eddy Current ALARA Review/19 tubes removed
82-03	3/82-4/82	Young	30	Review of Task Group Organization
82-06	4/82-5/82	Young Gray Jacobs	50 30	RCS Inspection Review/ Witnessing RCS Inspection Eddy current Testing
82-07	5/82-6/82	Young	45	Materials Lab Visit Tube stabilization
82-09	6/82-7/82	Young	30	Tube stabilization Kinetic expansion
82-10	7/82-8/82	Young	26	Kinetic Expansion Engineering/tube stabilization
82-14	8/82-9/82	Young	20	Flushing and drying the cracks
82-20	9/82-10/82	Young	40	Witnessing Kinetic Expansion
82-21	10/82-11/82	Young	80	Witnessing Kinetic Expansion
82-22	10/12/82-10/28/82	O'Neil, Barr	120	HP aspects of OTSG Repair - ALARA

Inspection Report	Dates	Inspector	Hours	Area of Review
82-24	11/82-12/82	Young	42	Kinetic Expansion.
82-26	11/12/82-12/31/82	Gray	40	Records review
82-28	12/82-1/83	Young	30	Kinetic Expansion, Eddy Current Candle Debris removal
83-01	1/83-2/83	Young	40	Debris removal Tube End Milling
83-02	1/83-2/83	Young Gray Moslak	45	Final steps of kinetic expansion
83-05	2/83-3/83	Young	85	Tube end milling
83-06	2/83-3/83	Gray	39	QA/Welding
83-07	3/21-24/83	Gray/Reynolds	60	Kinetic Expansion (Welding Aspects)
83-08	2/83-3/29/83	Young Conte O'Neil	85	Man Rem tracking
83-09	3/83-4/8/83	Gregg	10	PORV Inspection
83-11	3/83-5/83	Young Conte	60	OTSG Quality Assurance Review Internal Inspection of Pressurizer
83-12	5/83-6/83	Nicholas	40	OTSG HFT Procedure Review
83-14	6/83-7/83	Young	60	Tube plugging
83-15	7/83-8/83	Young	50	Desulphurization TP (600/4)
83-22	7/83-8/83	Young	35	Desulphurization RCS cleanup
83-25	8/83-10/83	Young Conte Nicholas	60	HFT

TABLE 2
REGION I SUPPORT TO NRR

Topic	Location	Date
OTSG Meeting Status Licensee Approach to problem	Bethesda, MD	1/24/82
Chemical Analysis/ Destruction Analysis performed	Columbus, OH	2/9/82
Status OTSG work	Parrsippany, NJ	3/8/82
Status of the work of each of its task groups	Bethesda, MD	4/6/82
Status OTSG work	Parrsippany, NJ	6/15/82
Task RC Inspection	Parrsippany, NJ	6/21/82
Kinetic Expansion	Mount Vernon, IN	8/5/82
Kinetic Expansion	Parrsippany, NJ	8/25/82
QA Control of Explosives	Mount Top, PA	10/13/82
Status OTSG Work	Bethesda, MD	10/19/82
Third Party Review	Parrsippany, NJ	12/9/82

ENCLOSURE 3
OTSG PREHEARING SUMMARY

The following is a synopsis of Steam Generator Repair Prehearing conference. The Board received statements on contentions from the Intervenor Groups:

TMIA (Mr. Doroshow and Ms. Bradford)
LEE ET ALL (Mr. Aamodt, Mr. Lee)

Introductions: Judges: Hetrick, Lamb, Wolfe for ASLB
Ms. Wagner, Mr. Rawson, Mr. McCracken for NRC
Mr. Trowbridge, Mr. Blake, Mr. Slear for GPUN

Contention 1(a)

TMIA

-- Int. Position. (1) Kinetic Expansion technique is inadequate
(2) Testing relied on during operation is inadequate to detect a tube leak
-- Two conclusions based on Third Party, Dillion (NRC consultant), Staff SER

Rambling -- fracture mechanic -- non-linear method should have been used instead of linear method.
-- other licensee conditions and eddy current testing will detect crack before they could progate and cause a problem -- not supported (no calculations)

STAFF

-- position remains the same -- contention has no specifics; therefore, it is not litigable

TMIA

-- There is a problem in retrieving documents from the PDR in Harrisburg. (FOIA for Doroshow was poorly handled.)

-- Their expert stated that axial symmetric stress analysis is incorrect for this type of crack
-- Data supplied is inadequate for us to make a determination or see where the license drew his conclusions.

Contention 1(b)

TMIA

-- Basis for 1b is Memo by Dr. Shewmon ". . . simultaneous rupture in both OTSG's is not an incredible event."
-- SECY 82-72
-- Third party stated "important issue for company to be prepared for"
-- No emergency procedure in the event of simultaneous rupture in both OTSG to instruct operator to keep radiation release within limits.

LICENSEE -- This contention is unrelated to the repair.

STAFF -- 1(b)1 and 1(b)(2) were not opposed but in light of more discussion, junctaposition, this is unresolved safety Issue No. A47.

TMIA -- Contention is multiple tubes in same generator.

GENERAL -- Discussion what is multiple.

Contention (1c)

TMIA -- Third Party expressed a great deal of concern about the licensee's decision not to plug 66 degraded tubes.
-- Other concern is the type of plugs

LICENSEE -- Third Party revised their position in Rev. 3 of their report after discussion with Licensee

STAFF -- This contention is too vague to be litigable.

TMIA -- Third Party recommended plugging 3 rows from the tube lane

LICENSEE -- This was based on prior OTSG history problems.
Third Party - GPU discussion -- Third party changes position.

TMIA -- Type of plug unqualified
Inaccurate discussion on plugs.

Contention (1d)

TMIA -- Staff's SER doesn't support their conclusion of significant safety hazard from this repair
-- No firm scenario for how this happened
-- Third party review stated that "fatigue cracks grow faster along the circumference and towards the OD. SER doesn't address this.
-- Licensee and staff are not qualified to render expert opinion on fracture mechanics and people involved have a conflict of interest. Expert from Lehigh Univ. is prof. of Aerospace linear fracture--mechanics theory is not correct.
-- Withdrawn contention about analysis is based on laboratory conditions

LICENSEE -- Third Party Resumes are attached to SER. "An expert" says fracture mechanic is wrong. This is not specific.

STAFF -- Our SER not written to review third party review.
-- Linear Fracture Mechanics is set forth in ASME code and 10CFR50 and no facts shown why this approach is in fault.

Contention (1e)

TMIA -- SER and third party review raise the issue of adequacy of repairs and no discussion or replacement of OTSG's. A comparison should have been done.

LICENSEE -- We are not obliged to consider alternatives.

STAFF -- We stand on our submittal [not admissable].

Contention 2(a)

TMIA -- Causative agent has not been conclusively determined which undermines the reliability. Cannot assure the problem will not happen again.

LICENSEE -- TDR 341 addressed this.

STAFF -- No Comment

TMIA -- Too many inconsistencies
-- A variety of conclusions by different people, maybe wrong causative agent occurred have not been determined.

JUDGE LAMB -- This hearing deals with Repairs.

LICENSEE -- (Comes to the aid of TMIA)
-- The reliability of the repair program has to begin with knowing what caused the problem.

AAMODT -- We hold same view as above.

TMIA -- Dr. Dillon's Report and staff conclusions were not definitive.

Contention 2(b)

TMIA -- Cleanup process (assurance that cleanup will work)
-- Dillon's report concluded it is better to leave the sulfur in the primary from a risk point of view.
-- Dillon, additional testing should be conducted with cold oxgenated conditions
-- Staff rejected this recommendation.
-- Process will remove 50-80% sulfur; therefore, allowing a clear hazardous solution to exist

LICENSEE -- SER addresses these items

JUDGE WOLFE -- Participants could have gotten together to solve this one.

LICENSEE -- No. We shouldn't.

STAFF -- 2(b)(2) admitted 2b(1), and 2b(2) opposed.

LICENSEE -- Cannot understand Staff's position when SER addresses these items. No basis for this contention that our conclusions were wrong.

Contention 2(c)

TMIA
- -- Similar to 1(d)
- -- Basically attacking the SER in the area of evaluation of causative agent, cleanup, and procedures to prevent happening again
- -- Fracture mechanics analysis is wrong.
- -- Licensee and staff do not have the proper expertise; therefore, analysis is inadequate

LICENSEE -- Stand on our response

STAFF -- No further comments.

Jane Lee Et Al

Dr. Molholt accepted as advisor to Lee Et Al but must have Aamodt or Lee present (i.e. cannot stand alone because he doesn't have standing).

AAMODT -- States his background

Rambles
- -- Dominant factor in evaluating the long term performance of a mechanical joint is "CREEP"
  Creep was not considered.
- -- Swipe program not control/many uncertainties.
- -- Dillon relationship of lithium-sulfur is obscure
- -- SER doesn't address if any changes to area outside the observed intergranular stress cracking
- -- Dynamic stress on repair area of tube was not analyzed.

Contentions 1 and 2

AAMODT
- -- No assurance that OTSG repairs have not contributed to a condition which will cause early failure upon restart
- -- Regeneration polytheonic species is not unlikely
- -- Accuracy of eddy current testing was poor

LICENSEE -- No basis for this contention

AAMODT
- -- Licensee program is void of preductive data
- -- Discuss aggressive environment

LICENSEE -- This is just rambling and not defining the contentions

AAMODT -- OTSG analysis is void of assurance
-- OLD tubes look differently than new so must have superspecial control program.

JUDGE LAMB -- We need to have definition of your contention; therefore, second time around.

AADMOT -- Licensee has not justified his conclusions

LAMB -- Specific deficiencies

WOLFE -- Intervenor must be specific about contentions

AAMODT -- Specific mechanistic steps involved in the sulfur -- induced stress corrosion cracking phenomonen have not been clearly established
-- Carbonacious material -- major impurity at tube failures
-- Therefore, maybe the wrong causative agent tagged.

LAMB -- Is that contention 2 or 3?

AAMODT -- '3'
-- No assurance that all other compounds other than sulfur did not contribute significantly. Therefore, licensee has failed to assure us that aggressive environment cannot recur.

LICENSEE -- Cannot comment on this rambling unless given some time to study the transcript to see if there is anything to comment on.

STAFF -- Contentions 1 and 2 lack basis.

AAMODT -- No assurance that IGA is properly characterized.

LICENSEE -- TDR 341 addressed this area.

STAFF -- Stand on our written response [no basis].

Contention 4

AAMODT -- Tubes loss pretension
-- fatigue cracking of metallic sheets of long-line cables were radial cracks [work done at Bell Telephone by him]
-- Not properly addressed in SER

LICENSEE -- I am totally lost.
Discussion of experiments on cables -- how does it apply?

STAFF -- SER is not proper focus for contentions.

Contention 5

AAMODT -- Rigid operational program must be followed to maintain the margin of safety.
-- Issue of management integrity must be solved.
-- Licensee going too fast (no data to base conclusions).

LICENSEE -- I don't understand him.

AAMODT -- Contentions without proper data
-- No assurance can be given.

LICENSEE -- Stand on written response.

STAFF -- Competency and integrity are not related.

Contention 6

AAMODT -- I am not prepared (Dr. Molholt was to be here)

(Recess)
Licensee and Aamodt discussed Contention 1 and 2 off record.
Licensee: We have misread contention 1, that is repair process did not include RCS cleanup.

We will get together with Mr. Aamodt and let the board know the outcome.

Discussion turns to deciding where to meet

AAMODT -- Middletown, PA?

LEE -- Location with good acoustics.

5:25 p.m. Concluded

Graham / Broughton 11/10/83
Stolz / Silver / Quay / Mazetis / Orr

GPO letter to state tomorrow or Monday

Procedures remain unchanged

Chart meant to give relative feel for cooldown times & types - not based on detailed calcs

"Not recommended" - means not preferred. still covered by procedure.

Flexibility - senior people avail ~1 hr after event, could decide based on circumstances to ~~decide~~ change procedure would follow change procedure

Would run into trouble on App. I before hit TS limit on failed fuel - probably shut down on ~.05% failed fuel.

Post Office Box 2063
Harrisburg, Pennsylvania 17120

717-787-2480

November 16, 1983

Mr. Philip R. Clark
Executive Vice President
GPU Nuclear Corporation
100 Interpace Parkway
Parsippany, New Jersey 07054

Dear Mr. Clark:

We have received your letter dated November 14, 1983 which summarizes the agreements that were reached at a meeting dated November 9, 1983 to resolve our concern with the NRC staff's safety evaluation of the steam generator repair. The letter accurately reflects our understanding of the resolution of the various issues.

Our primary concern is the assurance that GPU Nuclear's guidelines and procedures for steam generator tube rupture are sufficiently flexible to accommodate offsite concerns about reducing potential public exposure. We would therefore appreciate your sending us a copy of the appropriate procedures/guidelines so that we can better understand how you will accommodate these concerns.

Thank you for your cooperation in these matters.

Sincerely,

Thomas M. Gerusky, Director
Bureau of Radiation Protection

TMG:WPD:adt
cc: Mr. Harold Denton
Radiation Protection
30 day file

10/18/83

Mazetis MS Graham
Orr
Silver

We need clarification

1. Times to RHR for 1 SG
   6 Hrs to 275° MJG will confirm

2. TDR-406
   Q. Propose to change RHR entry temp from 275° to 300°F ?

   A. All components OK for 300°. Procedure is changed to 300°. What is time for 1 SG to 300°F ?

3. Q Nearest 1 time to 275° & 300° w/ both SG - ignoring TS

   A. 300 <3 hrs
      275 <4 hrs
   } Conservative estimates, w/ main feed, cooldown

4. Q Actual time w/ TS & other limits

   A Normal cooldown - 2½ hrs
   What limits ?