ENCLOSURE 4

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

May 16, 1984

TO: R. Conte

FROM: F. Young

SUBJECT: OTSG Repair Briefing

Attached is an updated copy of the OTSG Repair Briefing dated November 16, 1983, with Enclosure 1 addressing the sequences of major events made current as of this date. In addition, the history has been updated to reflect inspections performed in early 1984.

F. Young

186

RC(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" 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's 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. Results of the OTSG HFT indicated no significant increase in RCS leakrate (0.0 to 0.2 gpm). As a revalidation of the first OTSG HFT, the licensee is planning to conduct an additional HFT during May 1984. This HFT is primarily to complete the required testing of modifications to the plant other than OTSG repair work. However, the licensee is planning on repeating the primary to secondary leakrate calculation (using Krypton tracer gas).

ENCLOSURE 2

REGION I ACTIVITIES

TMI-1 OTSG REPAIRS

Summary

Direct inspection of the Licensee OTSG Repair Program totaled approximately 1520 hours by region based and resident inspectors (See Table 1). These inspections hours represent a period of November 1981 to May 1984. During the review of the inspection, several unresolved items arose which dealt with (a) adequacy of the Westinghouse plug, and the adequacy of the ALARA program used during the recovery process. There were no major violations noted except during HFT. To date, all violations dealing with OTSG Repair have been adequately addressed except for OTSG HFT violations. 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, however, could have been better documented.

Additionally, the licensee is to submit to the NRC their final management review 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) is essentially complete. Several inspector followup items from NUREG 1019 still require closeout but have no safety significance in the evaluation of the total OTSG repair process. From the review of these documents, several action items are expected to develop. Two other inspection findings remain open and they are the review of both the licensee's response to notice of violations from OTSG HFT and OTSG Man Rem Exposure program.

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 o 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

Inspection Report	Dates	Inspector	Hours	Area of Review
84-01	1/84-2/84	Nicholas Young	20	Preoperational test results
84-07	2/84-3/84	Conte Young	30	Verification of NUREG 1019 commitments
84-11	4/84-5/84	Conte Young	10	NUREG 1019 open item closeout

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