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

April 8, 1982

MEMORANDUM FOR: R. R. Keimig, Chief, Projects Branch No. 2
Division of Project and Resident Programs

THRU: A. N. Fasano, Chief
Three Mile Island Section

D. R. Haverkamp, Senior Resident Inspector (TMI-1) 4/8/82
Three Mile Island Section

FROM: F. I. Young, Resident Inspector (TMI-1)
Three Mile Island Section

SUBJECT: ONCE THROUGH STEAM GENERATOR (OTSG) EDDY CURRENT INSERVICE INSPECTION

At present, the TMI-1 Technical Specifications require that Eddy Current Testing (ECT) inservice inspection (ISI) be performed on the portion of the tube that forms the boundary between the primary and secondary coolant systems. In the case at TMI-1 OTSG's, a severe corrosion attack, affecting between 8,000 to 10,000 tubes out of 31,000, has occurred in the upper tube sheet. This is an area not requiring ECT inservice inspection.

Periodic ISI of OTSG tubes are essential to monitor their integrity for safe operation. The primary safety consideration for degraded tubes at any location is that they retain adequate structural integrity without excessive leakage for the full range of normal and postulated accidents. ECT is the primary means for performing tube inspections.

In light of the severity of the problem at TMI-1 (a case where approximately one third of all OTSG tubes are in a degradated mode), the required ISI program for TMI-1 is unacceptable (see enclosure 1 with 6 attachments) since ECT in the tube sheet area is not required. Licensee has been looking at the tube sheet area despite ECT requirements.

Enclosed are the details for the technical concern addressed above. Your review of the recommendations in Enclosure 1 is requested for forwarding to NRR. Further, this information should be forwarded to IE Headquarters for dissemination to all licensees with similar TS in the form of an "Information Notice".

F. I. Young
Resident Inspector (TMI-1)
Three Mile Island Section

Enclosure: As Stated

POTENTIALLY GENERIC ISSUE DATA SHEET

Facility Three Mile Island Unit 1 Docket No. 50-289

Date of Event November 25, 1981 Inspection (or other Report 289/81-32/82-01

1. Brief Description of Issue (Not required if included in supporting data)

(See Attached Sheet)

2. How Found (If appropriate)

See Attachment 6 GPU Licensee Event Report

3. Why Considered Potentially Generic (i.e. - reference applicable criteria or give reason)

Area of OTSG tube degradation is not addressed in the TMI Unit 1 Technical Specifications

4.

I	F. Young	A. Fasano
Region	Originator	Section Chief/Branch Chief

5. Other Region Reporting That The Problem Has Also Been Identified By Them

Region _____, Chief Reporting _____, Docket No. _____

6. Evaluation by Headquarters

Bulletin ☐ Circular ☐ Information Notice ☐

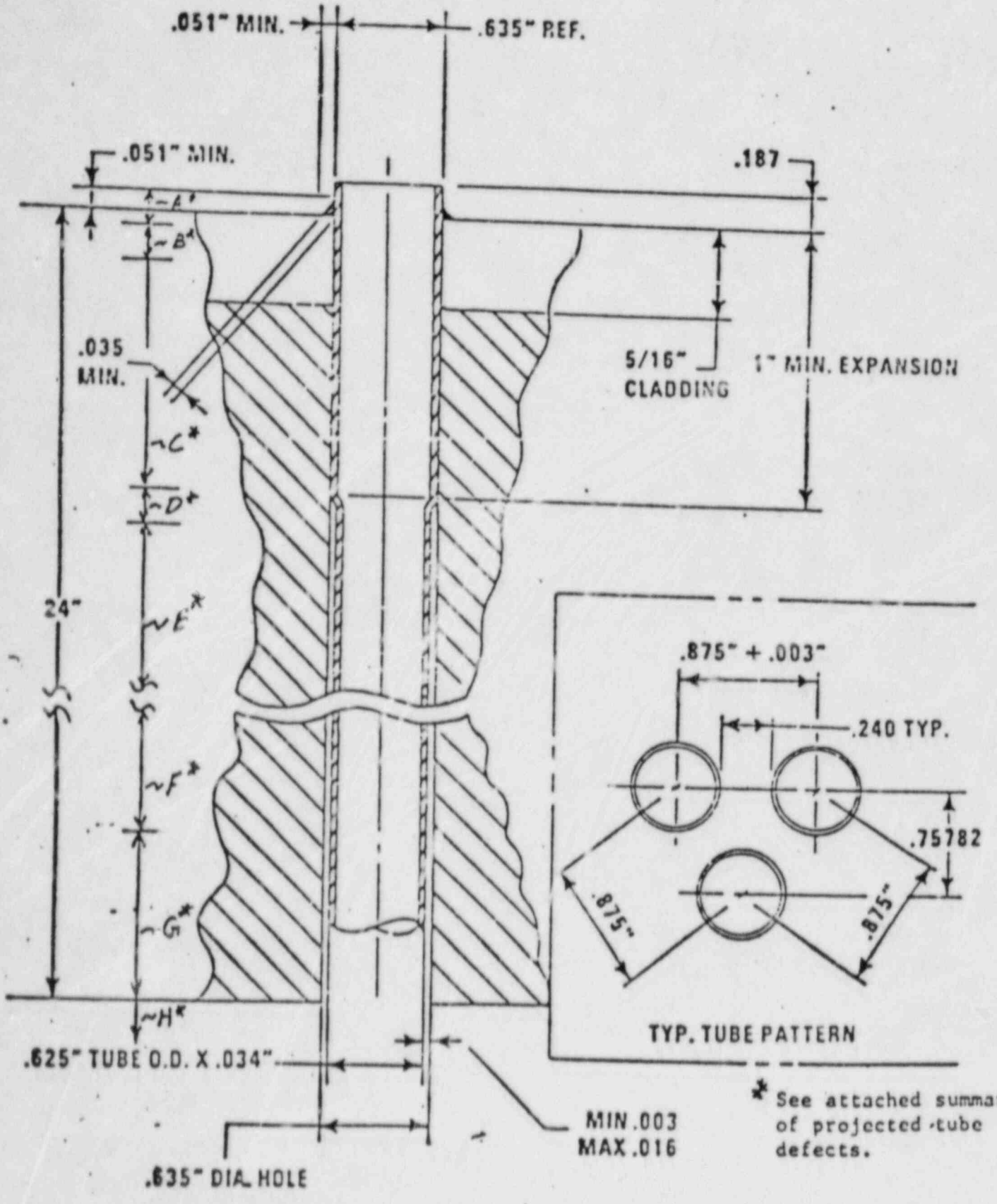
Other ☐ _____

No further action required ☐

*1. (1) TMI Unit 1 Technical Specifications requires that only the area between the lower face of the upper tube sheet and upper face of the lower tube sheet be inspected using standard eddy current testing. Ninety percent of the tube problems found in Unit 1 OTSG's are in the area known as the roll transition in the upper tube sheet (see Attachment 1 and 2). Due to the definition eddy current testing requirement which is standard throughout the industry, the area in question is not addressed in the Technical Specifications (see Attachment 3). In the inspector's judgement this concern should be evaluated to determine if OTSG eddy current program should be redefined and amendment made to Technical Specifications.

(2) With the use of a standard differential eddy current probe (industry standard), a signal defection is normally generated in the roll transition zone. This signal from roll transition zone is normally ignored due to the inability of the standard probe to distinguish between roll and/or a fault. In the case of TMI-1, the licensee did take the time to look at this area. GPU with the aid of Conam (Eddy Current Contractor) and Zetec (Eddy Current Vendor) developed a new probe commonly known as 4 by 1 absolute pancake probe. This probe has been very successful in determining faults in the transition zone as compared to metallurgical data obtained. In the inspector's judgement, the roll transition zone is normally overlooked by the standard probe and due to the severity of the problem at TMI-1, this item should be evaluated for its safety significance (see Attachment 4 and 5).

TMI-1 Tube Sheet Detail (Typ.)

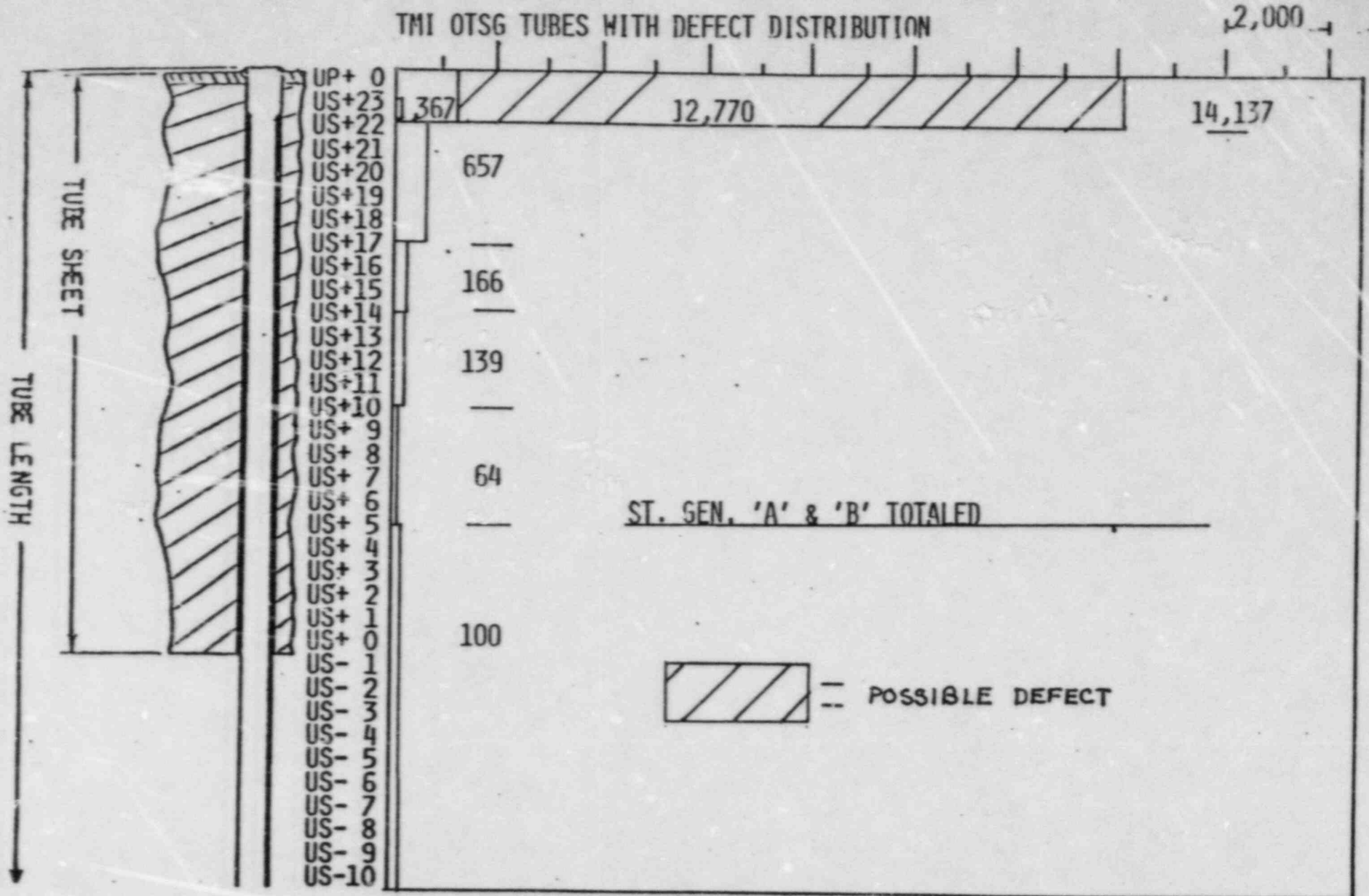


* See attached summary of projected tube defects.

TMI-1

SUMMARY OF PROJECTED DEFECTIVE TUBES - 3/2/82

Location	Length	Metallurgical Summary	ECT Summary
A	~.312"	No information - this section drilled out during sample removal.	No information due to ECT signal distortion at tube exit.
B	~.125"	9 of 9 tube samples have circumferential cracks 95% to 100% thru wall and 1 of 9 also had several longitudinal cracks.	Limited information due to ECT signal distortion at tube exit.
C	~1" (Rolled Section)	Circumferential cracks on 3 tube samples.	Limited information due to ECT signal distortion by roll transition. Some indications on sample of tubes done with absolute pancake probe.
D	~.250" (Roll Transition)	Circumferential cracks on 5 tube samples.	12,770 tubes have distorted ECT signals in this area -- We project about 7,000 tubes will have circumferential cracks. Additional ECT in March/April to define status.
E	~7"	Circumferential cracks confirmed.	~2,227 defective tubes.
F	~5"	Circumferential cracks confirmed.	~123 defective tubes.
G	~10"	Circumferential cracks confirmed.	~67 defective tubes.
H	All tubes below UTS	Circumferential cracks confirmed.	~68 defective tubes.



TUBES WITH MULTIPLE INDICATIONS ARE CATEGORIZED INTO THE ZONE FURTHEST FROM THE TUBE SHEET FACE.

3/5/82

Attachment 2

4.19 OTSG TUBE INSERVICE INSPECTION

Applicability

This Technical Specification applies to the inservice inspection of the OTSG tube portion of the reactor coolant pressure boundary.

Objective

The objective of this inservice inspection program is to provide assurance of continued integrity of the tube portion of the Once-Through Steam Generators, while at the same time minimizing radiation exposure to personnel in the performance of the inspection.

Specification

Each steam generator shall be demonstrated OPERABLE by performance of the following augmented inservice inspection program and the requirements of Specification 3.1.6.3.

4.19.1 Steam Generator Sample Selection and Inspection Methods

a. Each steam generator shall be determined OPERABLE during shutdown by selecting and inspecting at least the minimum number of steam generators specified in Table 4.19.1 at the frequency specified in 4.19.3.

b. Inservice inspection of steam generator tubing shall include nondestructive examination by eddy-current testing or other equivalent techniques. The inspection equipment shall be calibrated to provide a sensitivity that will detect defects with a penetration of 20 percent or more of the minimum allowable as-manufactured tube wall thickness.

4.19.2 Steam Generator Tube Sample Selection and Inspection

The steam generator tube minimum sample size, inspection result classification, and the corresponding action required shall be as specified in Table 4.19.2. The inservice inspection of steam generator tubes shall be performed at the frequencies specified in Specification 4.19.3 and the inspected tubes shall be verified acceptable per the acceptance criteria of Specification 4.19.4. The tubes selected for

each inservice inspection shall include at least 3% of the total number of tubes in all steam generators; the tubes selected for these inspections shall be selected on a random basis except:

a. The first sample of tubes selected for each inservice inspection (subsequent to the preservice inspection) of each steam generator shall include:
   1. All nonplugged tubes that previously had detectable wall penetrations (>20%).

   2. At least 50% of the tubes inspected shall be in those areas where experience has indicated potential problems.

   3. A tube inspection (pursuant to Specification 4.19.4.a.8) shall be performed on each selected tube. If any selected tube does not permit the passage of the eddy current probe for a tube inspection, this shall be recorded and an adjacent tube shall be selected and subjected to a tube inspection.

   4. Tubes in the following groups may be excluded from the first random sample if all tubes in a group in both steam generators are inspected. No credit will be taken for these tubes in meeting minimum sample size requirements.

      (1) Group A-1: Tubes within one, two or three rows of the open inspection lane.

      (2) Group A-2: Tubes having a drilled opening in the 15th support plate.

b. The tubes selected as the second and third samples (if required by Table 4.19.2) during each inservice inspection may be subjected to a partial tube inspection provided:

   1. The tubes selected for these second and third samples include the tubes from those areas of the tube sheet array where tubes with imperfections were previously found.

   2. The inspection includes those portions of the tubes where imperfections were previously found.

The results of each sample inspection shall be classified into one of the following three categories:

Category	Inspection Results
C-1	Less than 5% of the total tubes inspected in a steam generator are degraded tubes and none of the inspected tubes are defective.
C-2	One or more tubes, but not more than 1% of the total tubes inspected in a steam generator are defective, or between 5% and 10% of the total tubes inspected are degraded tubes.

C-3	More than 10% of the total tubes inspected in a steam generator are degraded tubes or more than 1% of the inspected tubes are defective.

NOTES: (1) In all inspections, previously degraded tubes must exhibit significant (>10%) further wall penetrations to be included in the above percentage calculations.

(2) Where special inspections are performed pursuant to 4.19.2.a.4, defective or degraded tubes found as a result of the inspection shall be included in determining the Inspection Results Category for that special inspection but need not be included in determining the Inspection Results Category for the general steam generator inspection.

4.19.3 Inspection Frequencies

The required inservice inspections of steam generator tubes shall be performed at the following frequencies:

a. The first (baseline) inspection was performed after 6 effective full power months but within 24 calendar months of initial criticality. The subsequent inservice inspections shall be performed not more than 24 calendar months after the previous inspection. If the results of two consecutive inspections for a given group of tubes* encompassing not less than 18 calendar months all fall into the C-1 category or demonstrate that previously observed degradation has not continued and no additional degradation has occurred, the inspection interval for that group may be extended to a maximum of once per 40 months.

b. If the results of the inservice inspection of a steam generator conducted in accordance with Table 4.19-2 at 40 month intervals for a given group of tubes* fall into Category C-3, the inspection frequency for that group shall be increased to at least once per 20 months. The increase in inspection frequency shall apply until the subsequent inspections satisfy the criteria of Specification 4.19.3.a; the interval may then be extended to a maximum of once per 40 months.

c. Additional, unscheduled inservice inspections shall be performed on each steam generator in accordance with the first sample inspection specified in Table 4.19-2 during the shutdown subsequent to any of the following conditions:

1. Primary-to-secondary tubes leaks (not including leaks originating from tube-to-tube sheet welds) in excess of the limits of Specification 3.1.6.3.

*A group of tubes means: (a) All tubes inspected pursuant to 4.19.2.a.4, or
(b) All tubes in a steam generator less those inspected pursuant to 4.19.2.a.4.

2. A seismic occurrence greater than the Operating Basis Earthquake.

3. A loss of coolant accident requiring actuation of the engineering safeguards, or

4. A major main steam line or feedwater line break.

4.19.4 Acceptance Criteria

a. As used in this Specification:

1. Imperfection means an exception to the dimensions, finish or contour of a tube from that required by fabrication drawing or specifications. Eddy current testing indications below 20% of the nominal tube wall thickness, if detectable, may be considered as imperfections.

2. Degradation means a service-induced cracking, wastage, wear or general corrosion occurring on either inside or outside of a tube.

3. Degraded Tube means a tube containing imperfections ≥20% of the nominal wall thickness caused by degradation.

4. % Degradation means the percentage of the tube wall thickness affected or removed by degradation.

5. Defect means an imperfection of such severity that it exceeds the plugging limit. A tube containing a defect is defective.

6. Plugging Limit means the imperfection depth at or beyond which the tube shall be removed from service because it may become unserviceable prior to the next inspection and is equal to 40% of the nominal tube wall thickness, unless higher limits are shown to be acceptable by analysis and approved by the NRC.

7. Unserviceable describes the condition of a tube if it leaks or contains a defect large enough to affect its structural integrity in the event of an Operating Basis Earthquake, a loss of coolant accident, or a steam line or feedwater line break as specified in 4.19.3.c, above.

* 8. Tube Inspection means an inspection of the steam generator tube from the bottom of the upper tubesheet completely to the top of the lower tubesheet, except as permitted by 4.19.2.b.2, above.

b. The steam generator shall be determined OPERABLE after completing the corresponding actions (plugging including all tubes exceeding the plugging limit and all tubes containing throughwall cracks) required by Table 4.19.2.

4.19.5 Reports

a. Following the completion of each inservice inspection of steam generator tubes, the number of tubes plugged in each steam generator shall be reported to the NRC within 15 days.

b. The complete results of the steam generator tube inservice inspection shall be reported to the NRC within 3 months following completion of the inspection. This report shall include:

1. Number and extent of tubes inspected.

2. Location and percent of wall-thickness penetration for each indication of an imperfection.

3. Identification of tubes plugged.

c. Results of steam generator tube inspections which fall into Category C-3 and require prompt notification of the NRC shall be reported pursuant to Specification 6.9.2 prior to resumption of plant operation. The written followup of this report shall provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence.

Bases

The Surveillance Requirements for inspection of the steam generator tubes ensure that the structural integrity of this portion of the RCS will be maintained.

Attachment 4

January 27, 1982

SECY-82-35

POLICY ISSUE
(Information)

FOR: The Commission

FROM: William J. Dircks
Executive Director for Operations

SUBJECT: TMI-1 STEAM GENERATOR PROBLEM

PURPOSE: To provide the Commissioners with information concerning the status of the tube leak problems on the TMI-1 steam generators.

DISCUSSION: At the Commission briefing on TMI-1 status held on December 21, 1981, the nature and extent of the leaking steam generator tubes at TMI-1 was discussed. At that time, it was stated that at least two months were needed for the utility to identify the causes and correct the problem.

On January 25, 1982, at the staff's request, General Public Utilities (GPU) presented an update on this problem. The licensee has nearly completed eddy current testing (ECT) of all tubes in both steam generators. To date, approximately 2250 tubes have been identified to have defects. There are also indications on many other tubes, which will require additional testing using a more sensitive probe to verify the presence of defects. At the present time, it is estimated that several thousand additional tubes may have defects needing repair.

The licensee has stated that virtually all defects are located in the upper tube sheet area of the tube. Based on extensive metallography tests on two tubes, there is now evidence that the mechanism appears to be intergranular attack from the primary side, instead of the secondary side, resulting in the development of very tight circumferential cracks. There is evidence of sulphur and chlorine impurities in every defect on the two removed tubes examined.

Contact:
R. Jacobs, DL/NRR
49-27471

DISCUSSION: (continued)

The licensee is conducting a broad based program in the areas of eddy current testing, tube failure analysis, accident analysis and tube repair techniques. The licensee presently estimates that it will take at least six months to resolve the problem.

The staff has some additional areas of concerns related to the steam generator degradation problem at TMI-1.

- A corrosive agent may exist, or have existed, in the reactor system at TMI-1 which could have corroded other primary pressure boundary materials.

- The plugging of large groups of tubes as an interim solution may not be a viable solution without significant derating to avoid the erosion-corrosion effects of moisture droplets that can impinge on the superheated portion of the tubes. The licensee is having thermal hydraulic studies performed to evaluate this concern.

The staff and its consultants will independently review eddy current data, operational chemistry data, susceptibility of other primary system materials and results of thermal hydraulic analyses. Additionally, staff consultants will be visiting Battelle and B&W (labs used by GPU) to review methods and results of tube examinations..

A copy of a news release from GPU Nuclear Corporation dated January 25, 1982 regarding the TMI-1 steam generator reports is enclosed for your information.

/ for

William J. Dircks
Executive Director for Operations

Enclosure: As Stated

Three Mile Island
Nuclear Station
Post Office Box 480
Middletown, PA 17057
717 948-8187

For Further Information
Contact: John Fidler

News Release

GPU Nuclear

Public Information Services

For Release: Immediately

Date: January 25, 1982
#6-82N

STEAM GENERATOR REPAIRS FOR TMI UNIT 1

Middletown, PA -- Officials of GPU Nuclear Corporation said today that repairs to steam generator tubes at Three Mile Island Nuclear Station's Unit 1 reactor probably will result in at least a six month delay in the readiness of the reactor for restart.

Recent testing of steam generator tubes indicates the repairs will be substantially more extensive than initially anticipated, Company officials explained.

The Company had expected the unit to be ready for restart by the end of February, subject to permission from the U.S. Nuclear Regulatory Commission.

Additional testing and evaluation will be required before the full extent of the steam generator problem is known. Company officials met with members of the NRC staff today to brief them on the information developed to date.

Company officials said it was uncertain whether the timing for restart of Unit 1 would be controlled by the steam generator problem or by a recent order of the U.S. Court of Appeals, if allowed to stand. The Court has directed the NRC to make an environmental assessment of psychological stress that might result from return of Unit 1 to operation.

The Unit 1 reactor was shut down for refueling at the time of the March 28, 1979 accident that damaged TMI Unit 2. TMI Unit 1 remained closed for modifications, and for restart hearings before the NRC's Atomic Safety Licensing Board.

Inspections and tests during the 2½-years after the accident did not reveal any abnormal conditions, Company officials said. Indeed, the hot functional tests

-more-

conducted in late summer showed no evidence of the problem. It was not until a repressurization of the system in November that small leaks were discovered in the tubes in both Unit 1 steam generators.

The tubes normally carry hot, pressurized radioactive water from the reactor. This water causes non-radioactive water outside the tubes to turn to steam. This steam turns the turbine, which in turn spins the generator to make electricity.

The tube leaks have resulted in minor additions to the routine levels of radioactive releases from the plant. All releases have been well within federal environmental technical specifications.

The two steam generators are about 70 feet high, and each contains approximately 15,500 tubes, which are 52 feet long and five-eights of an inch in diameter. The tubes are made of inconel, an alloy of iron, chromium and nickel. Their walls are three hundredths of an inch thick.

In a pressurized water reactor, such as Unit 1, the steam generators are where the plant's radioactive "primary system" and its non-radioactive "secondary system" pass each other to exchange heat. The steam generators adjoin the reactor in the Unit 1 containment building. Normally, there is no radioactivity in the "secondary system."

The Atomic Safety and Licensing Board has concluded extensive hearings into the restart of TMI-1, and has advised the NRC that the management of GPU Nuclear Corporation, technical modifications to the plant, and plans for emergency preparedness are sufficient to assure that Unit 1 can be restarted without endangering the health and safety of the public.

A special inquiry into cheating on NRC operator examinations has also been concluded, and a final report from the special hearing master is expected shortly.

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