APPENDIX

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

Inspection Report: 50-275/94-10
50-323/94-10

Operating License: DPR-80
DPR-82

Licensee: Pacific Gas and Electric Company
Nuclear Power Generation, B14A
77 Beale Street, Room 1451
P.O. Box 770000
San Francisco, California 94177

Facility Name: Diablo Canyon, Units 1 and 2

Inspection at: PG&E Corporate Offices
333 Market Street
San Francisco, California 94177

Inspection Conducted: March 14-18, 1994

Inspector: C. J. Myers, Reactor Inspector, Plant Support Branch
Division of Reactor Safety

Approved by: Joseph A. Whitehead for 5/4/94
W. P. Ang, Chief, Plant Support Branch Date
Division of Reactor Safety

Inspection Summary

Areas Inspected (Unit 1): A routine, announced inspection was conducted in the area of inservice inspection (ISI) of steam generator tubes for Unit 1. A previous ISI inspection of Unit 2 was reported in NRC Inspection Report 50-323/93-08. Inspection Procedure 73753 was used as guidance for this inspection.

Areas Inspected (Unit 2): No inspection of Unit 2 activities was performed.

Results (Unit 1):

The licensee's planned steam generator activities for the 1R6 outage were in accordance with applicable requirements. For this outage, the licensee has expanded the scope of their bobbin probe eddy current testing (ECT) to 100 per cent of the steam generator (SG) tubes (Section 1.5). The licensee's program exceeds Technical Specification (TS) requirements. The licensee is developing state of the art enhancements of their inservice inspection techniques consistent with industry experience (Section 1.5).

- The licensee has expanded the scope of bobbin probe ECT inspection to 100 percent of Unit 1 SG tubes for the 1R6 outage (Section 1.5).

- The licensee has incorporated proactive preventative measures to minimize the susceptibility of steam generator tubes to inservice conditions known to contribute to degradation (Section 1.3).

- The licensee utilized rigorous qualification standards for eddy current data analysts (Section 1.7).

- Quality assurance involvement in the program was minimal (Section 1.9).

Summary of Inspection Findings:

- A non-cited violation was identified (Section 1.8).

Attachments:

- Attachment 1 - Persons Contacted and Exit Meeting
- Attachment 2 - Steam Generator Background Data
- Attachment 3 - Acronyms

DETAILS

1 STEAM GENERATOR TUBE INSERVICE INSPECTION (73753)

1.1 Purpose

The purpose of this inspection was to review the steam generator tube inspection activities for Unit 1 as part of the licensee's ISI program to determine if the activities were being performed in accordance with applicable requirements.

1.2 Background

During this inspection, the licensee was preparing to conduct the Unit 1 sixth refueling outage (1R6).

Section 4.0.5 of the Diablo Canyon TS required that ISI of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Class 1, 2 and 3 components be performed in accordance with Section XI of the ASME Code and applicable addenda, except where specific relief had been granted by the NRC. Section 5.2.8, "Inservice Inspection Program," of the Diablo Canyon Power Plant Final Safety Analysis Report Update stated that the ISI program follows the ASME Code, Section XI, 1977 Edition through summer 1978 Addenda. The ASME Code Section XI requirements are the basis for the inservice examinations and tests conducted during the initial 120-month interval of commercial operation, which began on March 13. 1986.

Section 4.4.5.0 of the Diablo Canyon TS specified the required SG tube inspection frequency, sample size and acceptance criteria.

The licensee had previously committed to follow the guidance of the Electric Power Research Institute (EPRI) for eddy current testing (ECT) inspection of Westinghouse Model 51 SGs. The guidance was identified in EPRI document NP-6201, "PWR Steam Generator Examination Guidelines," Revision 3, November 1992.

1.3 Steam Generator Tube Inspection Program

The inspector reviewed the scope of the SG tube cleaning and inspection activities planned for the upcoming 1R6 outage. The inspector found the licensee program to consist of the following activities:

- Sludge lancing (SL) to loosen and flush soft and hard sludge from the top of the tube sheet,
- Visual inspection of accessible regions of the tube bundle, and
- Eddy current inspection of all tubes.

Every other outage, the licensee also conducted pressure pulse cleaning (PPC)

to loosen and flush out soft sludge deposits on tubes and tube support plates by injecting bursts of nitrogen gas while lowering the water level in the tube bundle. PPC was not planned for 1R6.

During the previous operating cycle, the licensee changed their secondary chemistry control to use ethanolamine addition to assist in reducing sludge deposits in the SGs. The licensee planned to be able to assess the benefit of the change in chemistry from the results of the 1R6 SG cleaning activities. The licensee had no current plans for conducting chemical cleaning of the SG tubes.

The inspector found the licensee actions to be adequate.

1.4 Eddy Current Testing

The inspector reviewed the following licensee procedures and documents:

- Technical and Environmental Services (TES) Procedure, PG&E Non Destructive Examination (NDE) Manual Procedure 2.1, "Qualification and Certification of Personnel," Revision 6, dated September 9, 1992;
- TES Procedure, PG&E NDE Manual Procedure N-ET-3, "Eddy Current Examination with Surface Riding Probes," Revision 0, dated September 11, 1992;
- TES Procedure, PG&E NDE Manual Procedure N-ET-4, "Eddy Current Data Analysis of DCPP Units 1 & 2 Steam Generator Tubing," Revision 0, dated January 26, 1994;
- TES Procedure, "Steam Generator Eddy Current Data Analysis Guidelines," Revision 2, dated February 22, 1993;
- PG&E Nuclear Power Generation, Interdepartmental Administrative Procedure AD5.ID2, "Inservice Inspection Program," Revision 0, dated January 26, 1994;
- PG&E Nuclear Power Generation, Interdepartmental Administrative Procedure AD5.ID4, "Steam Generator Tube Plugging," Revision 0, dated March 26, 1993; and
- Diablo Canyon Power Plant 1R5 Steam Generator Outage Activities Report, dated January 11, 1993.

1.5 Outage 1R6 ECT Plan

The licensee had expanded the scope of their ECT examinations of SG tubing for the 1R6 outage from their previous program due to the results of the recent 2R5 outage. The licensee's program for 1R6 was planned to consist of the following:

- Bobbin inspection of the full length of 100 percent of the tubes in service in each SG (with the exception of the short bend radius U-bend regions in the Row 1 & 2 tubes);

- Rotating pancake coil (RPC) inspection of the following areas:

  - All U-bend regions of the Rows 1 & 2 tubes,

  - 50 percent of the Zone 4 tubes (not done during 1R5),

  - 100 percent of the Zone 5 tubes (precautionary inspection resulting from a concern for circumferential cracking due to PPC activities),

  - 100 percent of all dents at tube support plate intersections,

  - 100 percent of all tube sheet anomalies,

  - All "implant" tube sections and welds (16) (implant tube sections are discussed in Attachment 2),

  - Confirmation of bobbin defect indications, and

  - Selected examination of anomalous bobbin indications;

- Dent Profilometry performed on 26 tubes in SG 1-4 to trend the growth of previously detected dents at tube support plates; and

- Supplemental bobbin examinations using developmental bobbin coil probes (700 spring flex).

The inspector noted that the licensee did not plan to perform any random RPC inspection of free span tube regions between tube support plates. The inspector discussed recent experience at other utilities with free span cracking. According to the licensee, they had reviewed the industry experience with free span cracking and had concluded that the concern was not applicable at Diablo Canyon. The licensee had conducted a computer analysis of their SG design to identify any areas of the upper tube bundle which may susceptible to deposit formation due to localized dryout. Although not completed at the time of the inspection, the licensee identified that their analysis indicated no significant concern for the type of deposit which has been experienced in the upper tube bundle of other SG designs.

The inspector found the planned licensee actions to be proactive and exceed minimum requirements.

1.6 "Blairsville Bump"

The licensee had identified a unique defect location associated with tubing manufactured by Westinghouse at their Blairsville facility. Two of the steam generators in Unit 1 at Diablo Canyon contain tubing from the Blairsville facility. According to the licensee, tubing which was bent at the Blairsville facility frequently contains an irregularity, dubbed the "Blairsville bump," at the point of tangency of the U-bend to the straight tube. According to Westinghouse, the bump consists of a small area where their tubing had been over expanded during the bending process due to manufacturing variations. Westinghouse considered the bump to be a minor manufacturing irregularity. However, according to the licensee, Westinghouse has identified that a high percentage of the tubing defects identified in the U-bend region have been located at the bump.

The inspector reviewed the eddy current traces for selected Row 1 & 2 tubes to observe the Blairsville bump indication. The inspector determined that the location of the indication was within the heat treated zone for the Row 1 & 2 tubes. The licensee emphasized the existence of Blairsville tubing during their site-specific orientation of data analysts. The inspector found the licensee's actions to be appropriate.

1.7 Data Analyst Qualifications

According to the licensee, all primary ECT data analysis will be performed by contractor (Westinghouse) personnel. An independent secondary analysis will be performed by licensee personnel (TES). The inspector was informed that the licensee planned to utilize inspection personnel qualified to the data analysis standards (QDA) of the Electric Power Research Institute (EPRI) during the 1R6 outage ECT. Of the 13 analysts, 10 were QDA qualified.

The inspector found the licensee use of QDA qualified personnel to be a strength in the licensee's program.

1.8 Tube Plugging Acceptance Criteria

The inspector reviewed licensee Procedure AD5.ID4, which established the criteria for plugging steam generator tubes based on evaluation of eddy current data. The inspector concluded that the licensee had not included all appropriate acceptance criteria in their procedure. It is required by TS 4.4.5.4 that SG tubes with defects exceeding the plugging limit be plugged. However, the licensee's procedure allowed SG tubes with bobbin indication of more than 40 percent through wall to remain in service, if the defect indication could not be confirmed using RPC inspection. Paragraph 6.1.2 of Procedure AD5.ID4 stated that "bobbin flaws >40 percent through wall which are not confirmed by RPC may remain in service." The licensee stated that they applied the criterion only to support plate bobbin indications to prevent false defect calls and unnecessary tube plugging. Furthermore, the licensee stated that their approach was consistent with EPRI recommendations.

The licensee stated that no SG tubes with bobbin defect indications more than 40 percent through wall have been allowed to remain in service. Further the licensee stated that they had intended the criterion to apply to in-process determination of tube defects rather than an alternative disposition of legitimate defects. The licensee initiated changes in their procedure to clarify their acceptance criteria to specifically reflect the TS requirements.

The inspector also determined that the licensee's procedure did not include the appropriate acceptance criteria for plugging tubes in the wedge region. Wedge region tubes are in the area of attachments of the tube support plates to the shell. Due to additional loads imposed under a postulated LOCA and SSE event, Westinghouse had recommended that tubes in these areas that exhibit any degradation, regardless of the through wall penetration, should be removed from service. The Westinghouse recommendation was contained in a letter to PG&E, dated September 3. 1992. The licensee incorporated the Westinghouse recommendation into the ECT inspection plan for the 1R6 outage. However, the licensee had not incorporated the recommended plugging criteria for the wedge region tubes into Procedure AD5.ID4. The licensee stated that no degraded wedge region tubes had been allowed to remain in service during previous outages. The licensee initiated changes to their Procedure AD5.ID4 to incorporate the recommended plugging criteria for the wedge region tubes.

The inspector identified these two examples of procedural inadequacies to be a violation of 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings."

The inspector considered the significance of these procedural inadequacies to be low because they had not resulted in any defective SG tubes being left in service and because appropriate evaluations of eddy current data were being made by cognizant licensee personnel despite the incomplete acceptance criteria in Procedure AD5.ID4. The licensee initiated prompt procedural changes to Procedure AD5.ID4 to specifically reflect TS requirements and all applicable plugging acceptance criteria. The inspector considered the procedural weakness to be an isolated case and the licensee's corrective actions to be adequate. Therefore, this violation is not being cited because the requirements of Section VII.B.(1) of the Enforcement Policy were satisfied (Violation 50-361/9402-01).

1.9 Quality Assurance Involvement

The inspector noted that QA had not conducted any surveillance of ECT or data analysis during the previous 2R5 outage, nor were there any surveillances planned for the upcoming 1R6 outage. The licensee indicated that QA monitoring activities had been reduced due to a lack of performance based deficiencies with steam generator tube integrity and previous adequate surveillance observations.

The inspector found that the scope of the licensee's SG inspection program had changed substantially over the last year, expanding from a sampling plan to 100 percent inspection, and incorporating developmental inspection techniques. The licensee's program had been proactively expanded, based on a small number of unexpected types of tube degradation found during previous outages and industry experience. Furthermore, the licensee was anticipating that the Diablo Canyon SGs were approaching a service age at which more degradation could be expected, if preventive measures were not effective. The inspector was concerned that the stated basis for the limited QA involvement was not consistent with the expanded inspection program and industry experience. Furthermore, the inspector noted that the procedural weaknesses identified in Section 1.8 of this report had not been identified by the licensee's quality assurance program.

In response to the inspector's concern, the licensee decided to perform an independent surveillance of the ECT program and data analysis during the 1R6 outage. The inspector found the licensee's actions in response to the inspectors concern to be adequate. However, the initial lack of planned QA involvement in the SG tube inspections activities was identified as a QA weakness.

1.10 Loose Parts Monitoring

In response to previous observations by the inspector, the licensee had reviewed their program for enhancement of their monitoring for loose parts in the secondary side of the steam generator. The licensee's program for monitoring for loose parts consisted solely of foreign object search and retrieval (FOSAR) by visual inspection. No analysis of eddy current data to detect and locate loose parts was performed. The licensee had determined that no changes to their current program were warranted for the following reasons:

- Loose parts have not been a problem at Diablo Canyon. No SG tube defects in either Unit 1 or Unit 2 have been attributed to loose parts. Only minor debris has been identified and removed during visual inspections.

- Existing hand holes in the steam generator shell offer adequate access for visual inspection of the secondary side of the tubes.

Enhancements in visual inspection techniques are being developed for inclusion in their program.

1.10.1 Foreign Object Search and Retrieval

The inspector reviewed the visual inspection program which the licensee performed on the secondary side of the steam generators during each outage. The inspector found that the licensee conducted a foreign object search and removal (FOSAR) as part of their soft sludge lancing operations to remove soft

(loose) sludge from the top of the tube sheet. According to the licensee, during soft sludge lancing, a wand is inserted through the SG hand holes located above the tube sheet into the unoccupied lane formed by the Row 1 U-tubes. While the wand traverses through the lane across the diameter of the tube bundle, it directs a high pressure spray at 90 degrees to its path to wash silt and debris from the tube sheet outboard into the annulus region between the outermost tubes and the wrapper. A wash return suction is taken from the annulus area. The sludge lancing operations were effective only up to the open lane close to the spray nozzle.

Following sludge lancing, a FOSAR visual inspection of the annulus region was conducted to locate and remove any larger debris. A video probe was inserted through the hand hole into the annulus area above the tube sheet to perform the inspection.

1.10.2 Hard Sludge Removal

As an enhancement of their sludge lancing operations for the tube sheet, the licensee planned to utilize during this outage a hard sludge lancing tool, which traversed between selected tube rows to position the spray nozzle close to the sludge pile. The licensee planned to use the hard sludge lancing tool on a trial basis in one SG.

The licensee also planned to insert a hard sludge lancing tool through the SG hand hole into the unoccupied lane of the tube bundle. At approximately every fifth tube row, the tool would be turned 90 degrees and inserted between the tubes, traversing outboard to the annulus region. A small spray nozzle at the end of the tool directed would direct a high pressure spray forward along the path as the tool was moved outboard.

Subsequent to hard sludge lancing, the licensee also planned to perform a video inspection between the tubes to map the remaining hard sludge pile. Small loose parts identified during the mapping inspection would also be removed.

1.10.3 Upper Bundle Inspection

The licensee further planned to use a visual inspection tool (Brooks, tradename) to map the sludge accumulating on tube sheets. The licensee planned to utilize the Brooks inspection on a trial basis in one SG (1-2).

The tool would be inserted horizontally through the SG hand hole into the unoccupied lane above the tube sheet and turned vertically to continue up from the tubesheet through the tube support plate flow channels unoccupied by tubes. A video inspection of the tubes surrounding the flow channel and sludge accumulation on the top of the support plates would then be performed. According to the licensee, added attention to the midspan area of the tubes would be incorporated, based on recent industry experience with bridging deposit buildups.

1.10.4 Observations

The licensee incorporated visual inspection, primarily as a supplement to their sludge lancing operations, to map the remaining sludge pile and to inspect for loose parts. The licensee conducted these visual inspections using state-of-the-art equipment. The inspections were limited to areas of concern for sludge buildup. The inspector noted the following limitations in the use of the licensee's visual inspection for identification of loose parts:

- The FOSAR visual inspections were limited to the top of the tube sheet.
- The FOSAR visual inspection following soft sludge lancing was limited to the annulus region for debris which had been washed out from between the tubes. Only the annulus region and the lane regions were actually inspected.
- The FOSAR visual inspection following hard sludge removal was limited to selected tube lanes. The insertion length of the video probe for some tube lanes was limited by obstructions and the reach of the equipment.
- Upper bundle visual inspections were limited to the tube areas surrounding the flow channels.
- Loose parts or remaining debris were documented and evaluated on a case-by-case basis. No procedure existed for conducting the visual inspection operation and identifying the characteristics to be observed.

The inspector discussed the potential enhancement of the licensee's loose parts inspection using eddy current data from inspection of 100 percent of the tubes to supplement the limited scope of the visual inspections. The licensee acknowledged the inspector's observations, but did not consider additional eddy current analysis to be warranted at this time. The licensee was aware of the industry problem of loose parts and the resulting concern for the integrity of steam generator tubes.

The inspector concluded that the licensee's measures to preclude loose parts had been effective and that current inspections for loose parts were adequate based on their experience with the problem.

1.11 Conclusions

The licensee's plan for the inspection of Unit 1 SGs during the 1R6 outage appeared to meet or exceed the TS requirements. One violation was identified by the NRC inspector concerning inadequate acceptance criteria in the procedure for plugging SG tubes (See Section 1.8).

ATTACHMENT 1

1 PERSONS CONTACTED

1.1 Licensee Personnel

*W. Crockett, Manager, Technical and Support Services
*R. Exner, Project Manager, Steam Generators, Maintenance
*R. Flohaug, Supervisor, Quality Assurance
*B. Giffin, Manager, Maintenance
*C. Groff, Director, Plant Engineering
*R. Glynn, III, Supervisor, Quality Assurance
D. Gonzales, Coordinator, Inservice Inspection, Technical Services
*A. Hardy, Engineer, Quality Assurance
*K. Hubbard, Engineer, Regulatory Compliance
J. Kang, Analyst, Technical and Ecological Services (TES)
H. Karnar, Auditor, Quality Assurance
*M. Leger, Supervisor, ISI
*E. Nelson, Engineer, System Engineering
C. Polidoroff, Engineer, Nuclear Engineering Services
*R. Powers, Manager, Nuclear Quality Services
*J. Shoulders, Director, Nuclear Engineering Services
*D. Taggart, Director, Site Quality Assurance
*J. Townsend, Plant Manager

1.2 NRC Personnel

*J. Winton, Acting Resident Inspector

In addition to those listed above, the inspectors contacted other personnel during this inspection period.

*Denotes personnel that attended the exit meeting.

2 EXIT MEETING

An exit meeting was conducted on March 18, 1994. During this meeting, the inspectors reviewed the scope and findings of the report. The licensee acknowledged the inspection findings documented in this report. The licensee did not identify as proprietary any information provided to, or reviewed by, the inspectors.

ATTACHMENT 2

BACKGROUND INFORMATION
Unit 1 Steam Generators

Type: Westinghouse Model 51 (4 per Unit)
Manufactured at Westinghouse Tampa

Service: Commercial operation May 7, 1985

U-Tubes: 3388 total number per steam generator
0.875-inch OD
0.050-inch wall thickness
Inconel 600 material, cold drawn (not pilgered), mill annealed
Manufactured at Westinghouse Blairsville (Sgs 1-1 and 1-2) and Huntington Alloys (Sgs 1-3, 1-4)
Implant sections in 16 tubes (SG 1-1 only), 30-inch length, butt-welded to parent tube with Inconel 606 inserts

Tube Support Plates: 7 total number per steam generator
Carbon steel material
0.75-inch thick
50.50-inch spacing

Construction: Rolled 2-4 inches into tube sheet
Wextex expanded into tubesheet prior to startup
Shotpeened Wextex expansion regions of hot leg tubes during 1R5
Heat treated U-bends region of all Row 1 and 2 tubes during 1R2, March 1988

Plugging History:

	SG 1-1	SG 1-2	SG 1-3	SG 1-4	Total
Pre-start	0	1	0	0	1
1R1	0	0	0	0	0
1R2	0	1	0	0	1
1R3	5	4	3	0	12
1R4	0	0	1	0	1
1R5	6	15	4	4	29
	11	21	8	4	44

29 tubes plugged in Unit 1 during 1R5
- 17 PWSCC in U-bend regions (Rows 1 & 2)
- 13 axial indications
- 4 circumferential indications
- 12 AVB wear

ATTACHMENT 3

ACRONYMS

ASME	American Society of Mechanical Engineers
AVB	anti-vibration bar
CODE	ASME Boiler and Pressure Vessel Code
ECT	eddy current testing
EPRI	Electric Power Research Institute
FOSAR	foreign object search and retrieval
ISI	in service inspection
NDE	non destructive examination
PPC	pressure pulse cleaning
PWSCC	primary water stress corrosion cracking
QDA	qualifications for data analysts
RPC	rotating pancake coil
SG	steam generator
SL	sludge lancing
TES	Technical and Environmental Services
TS	Technical Specification