LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Diablo Canyon Unit 1	0 5 0 0 0 2 7 5	1 OF 10

TITLE (4) Steam Generator Primary Coolant Tubes Locked in Tube Support Plates (TSPs) Due To Corrosion Products

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MON	DAY	YR	YR	SEQUENTIAL NUMBER	REVISION NUMBER	MON	DAY	YR	FACILITY NAMES	DOCKET NUMBER (5)
09	27	96	96	- 0 1 4 -	0 1	10	07	97	Diablo Canyon Unit 2	0 5 0 0 0 3 2 3
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OPERATING MODE (9): 1

POWER LEVEL (10): 1 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (11)

____ 10 CFR

X OTHER - Voluntary

(Specify in Abstract below and in text, NRC Form 366A)

LICENSEE CONTACT FOR THIS LER (12)

	TELEPHONE NUMBER	
	AREA CODE	
Vickie Backman - Senior Regulatory Services Engineer	805	545-4289

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
[ ] YES (If yes, complete EXPECTED SUBMISSION DATE)	[X] NO				

ABSTRACT (16)

This voluntary LER is submitted for information purposes only as described in item 19 of Supplement 1 to NUREG-1022.

On September 27, 1996, with Units 1 and 2 in Mode 1 (Power Operation) at 100 percent power, PG&E determined that corrosion products in the Westinghouse 51 Series steam generators (SGs) tube support plate (TSP) / tube intersection gap would prevent movement of the tubes in relationship to the TSP. This condition affected assumptions regarding freedom of tube movement in the accident and seismic analyses and created a thermal loading condition that was not previously considered.

Based on an engineering review of existing analyses, it is judged that stresses in the tubes and TSP due to the existing constrained thermal condition are acceptable for normal operating conditions, loss-of-coolant accident, main steam line break, and safe shutdown earthquake.

Several plant modifications and chemistry changes were previously made to control TSP corrosion in the SGs.

I. Plant Conditions

Units 1 and 2 have operated at various modes and power levels while the condition described in this report existed.

II. Description of Problem

A. Summary:

This voluntary LER is being submitted for information purposes only as described in item 19 of Supplement 1 to NUREG-1022.

On September 27, 1996, upon reviewing Diablo Canyon Power Plant (DCPP) steam generator (SG) (AB)(BLR) eddy current data and industry information, PG&E determined that corrosion products in the Westinghouse 51 Series SGs tube support plate (TSP) / tube intersection crevice would prevent movement of the tubes in relationship to the TSP. This condition affected assumptions regarding freedom of tube movement in the accident and seismic analyses and created a thermal loading condition that was not previously considered.

Based on an engineering review of existing analyses, it is judged that stresses in the tubes and TSP due to the existing constrained thermal condition are acceptable for normal operating conditions, loss-of-coolant accident (LOCA), main steam line break (MSLB), and safe shutdown earthquake (SSE).

Several plant modifications and chemistry changes were previously made to control TSP corrosion in the SGs.

B. Background:

In Westinghouse 51 Series SGs such as DCPP's, the primary coolant tubes pass through seven TSPs. The original design of the TSP was for the tubes, which pass through closely fitting holes in the plates, to be restrained laterally but allowed to move freely axially.

The SG primary coolant tubes are 0.875" OD by 0.050" thick Inconel 600, and pass through 0.891" ID holes in the 0.75" thick carbon steel (SA-285) TSPs, leaving a crevice of approximately 0.008" around the tube.

NRC Information Notice (IN) 96-09, was issued February 12, 1996, to alert utilities to service induced TSP degradation in the French nuclear power plants.

Westinghouse Commercial Atomic Power (WCAP)-14707, "Model 51 Steam Generator Limited Tube Support Plate Displacement Analysis for Dented or Packed Tube to Tube Support Plate Crevices," recently submitted to the NRC, is based on the assumption that tube/TSP intersection crevices are packed with magnetite. These packed intersections have two major effects on the SG internals: (1) they constrain the tubes from freely moving vertically through the TSP, and (2) they change the support condition at the tube/TSP intersection from simply supported to clamped or fixed. The latter condition could affect the response of the tubes and TSPs during design basis load events. This may affect assumptions regarding freedom of tube movement used in the accident and seismic analyses of record. It also creates a constrained thermal loading condition that had not previously been considered.

C. Event Description:

PG&E letter, DCL-96-206 dated October 4, 1996, submitted WCAP-14707. WCAP-14707 describes the results of work performed to assess the potential for TSP displacement in a postulated MSLB event for a generic 51 Series SG with TSP crevices packed with corrosion products. The main conclusion of the WCAP is that the TSPs are essentially locked in place to the SG tubes by the corrosion products.

On September 27, 1996, during PG&E's final review of WCAP-14707, engineering identified a concern that primary coolant tubes being locked in place in the TSP could affect assumptions regarding freedom of tube movement in accident and seismic analyses.

On September 27, 1996, a preliminary operability evaluation (OE) was issued. The preliminary OE concluded that the safety functions of the SG tubes and TSPs were not adversely affected by this condition.

On October 8, 1996, during a telephone conference call with representatives from the NRC regional office and NRR, PG&E appraised the NRC of the concerns under review and committed to docket the information presented. This voluntary LER presents the information discussed at that telephone conference call, plus updated information. The concerns included the following:

1. Design basis analysis.

2. TSP structural integrity.

3. Constrained thermal conditions.

To address the constrained thermal expansion issue (i.e., differential vertical thermal expansion effects between tubes and adjacent components), Westinghouse has completed an analysis of the effects of constrained thermal expansion on the TSPs. The analysis was documented in WCAP-14707, Revision 1, submitted to the NRC by PG&E letter DCL-97-104 dated May 30, 1997.

D. Inoperable Structures, Components, or Systems that Contributed to the Event:

None.

E. Dates and Approximate Times for Major Occurrences:

February 12, 1996:	IN 96-09 was issued.
September 16, 1996:	WCAP-14707 was issued by Westinghouse.
September 27, 1996:	Discovery date - PG&E determined that analyses results are potentially affected because of locked tubes.
September 27, 1996:	Preliminary OE issued.
October 4, 1996:	WCAP-14707 was submitted to NRC.
October 8, 1996:	Concerns described in this report were discussed during a telephone conference call with the NRC. PG&E agreed to write a voluntary LER on concerns.
May 30, 1997:	WCAP-14707, Revision 1, was submitted to the NRC.

F. Other Systems or Secondary Functions Affected:

None.

G. Method of Discovery:

Review of DCPP SG tube eddy current data and industry information during the review of WCAP-14707.

H. Operator Actions:

None.

I. Safety System Responses:

None.

III. Cause of the Problem

A. Immediate Cause:

In the SG high temperature water and steam environment, the TSP material has corroded, creating an oxide of the carbon steel, magnetite. This was accelerated during the first and second cycles by condenser tube leakage. The magnetite has filled the crevices between the tubes and the TSPs. As the magnetite continued to form, it has become more densely packed in the crevices, causing the tubes to become held in place and preventing them from freely moving axially as designed.

B. Root Cause:

The cause of the as-found condition is a combination of secondary chemistry problems caused by condenser tube leakage and TSP material selection by the vendor.

IV. Analysis of the Event

PG&E evaluated existing design basis analyses that could be potentially affected by the locked tube/TSP condition. PG&E determined that only the tube and TSP region analyses are potentially affected. The following summarizes the evaluation of the tube and TSP design basis analyses results.

Packed crevices affect the boundary condition assumptions used in the tube and TSP analyses and may affect the results of design basis analyses. PG&E has performed an evaluation of the potential effects of this change on the qualification of

the tubes and TSP region. The TSP region consists of: TSP, wedges, wedge welds, wrapper plate, and structural channel-shaped sections used to transfer load to the SG shell. The wedges were used in the original installation of the SG internals to align the tube holes in all seven TSPs. The wedge welds, which attach the wedges to the TSP and wrapper plate, were installed to maintain this alignment and to prevent shifting of the TSP during plant operation.

Revision 1 to WCAP-14707 documents an assessment of the potential to develop fatigue cracks in the TSP and welds as a result of thermal cyclic loading associated with packed crevices. The results of this assessment are summarized under "Tube/TSP Interaction Forces," "Tube Support Plate Stresses," and "Weld Stresses."

Based on Revision 1 to WCAP-14707 and PG&E engineering evaluation of existing design basis analyses, stresses in the tubes and TSP are judged acceptable for normal operating conditions, LOCA, MSLB, SSE, and the constrained thermal condition. Although the final engineering evaluation of the SG tube bundle has not been completed for the DCPP locked tube/TSP condition, it is PG&E's engineering judgment that there is no significant safety concern. An OE was developed by PG&E engineering with assistance from Westinghouse.

Tube Stresses

The seismic analyses of the tubes, employing the original support conditions, was reviewed. The results indicated a maximum out-of-plane stress at the uppermost TSP for the SSE event when using 1 percent of critical damping. SSE stresses due to in-plane motion of the tubes are significantly less. It is PG&E's engineering judgment that given the support conditions, combined with usage of Regulatory Guide 1.61 damping, the SSE stresses will be less than the value reported for the original support conditions.

Maximum stresses due to SSE and LOCA do not occur at the same location. Therefore, the combined SSE and LOCA results are judged to be acceptable.

Additional analyses are being performed by Westinghouse to qualify the DCPP SG tubes for new boundary conditions and design basis loading commitments.

Tube/TSP Interaction Forces

The constrained thermal evaluation documented in WCAP-14707, Revision 1, concludes that, in the vicinity of the wedge regions, a limited number of tubes are predicted to exceed the breakaway force associated with a packed crevice. The

number of tubes exceeding the breakaway force at a particular wedge location is small and should not effect the dynamic response of the TSPs to MSLB loading.

Tube Support Plate Stresses

WCAP-14707, Revision 1, documents an assessment of the potential to develop fatigue cracks in the TSP as a result of thermal cyclic loading associated with packed crevices. The analysis predicts locally high stresses to occur in the TSPs in the wedge region. Cracks could develop after 30 plant full heatups and cooldowns at the most highly stressed location. At other locations, the margin to crack initiation is significantly greater.

DCPP Units 1 and 2 have undergone approximately 36 and 23 full and partial heatups and cooldowns, respectively, since installation; and approximately 19 and 16 full and partial heatups and cooldowns, respectively, since commercial operation. PG&E believes that the packed crevice condition occurred sometime after the units went into commercial operation since the condition is created by operation for an extended period of time at a high temperature such as that experienced at full power operation. Conservatively assuming 19 and 16 full range heatup and cooldown events under a constrained thermal expansion condition for Units 1 and 2, respectively, crack initiation would not be predicted.

Given the potential for high fatigue usage predicted by this analysis, WCAP-14707, Revision 1, recommended that plants with high levels of dented or packed crevices: (1) include a sampling of tubes in and around the wedge regions for eddy current inspection in order to check for any TSP ligament cracking that might develop; (2) a visual examination of the wedge regions could also be used to look for the presence of cracks; and (3) should TSP cracking be observed, perform an evaluation to identify any tubes that might be at risk due to the presence of the cracks.

PG&E has implemented all of these recommendations, as described below under "TSP Ligament Indications."

Weld Stresses

Thermal cycling with dented or packed intersections also results in potentially high fatigue usage in the welds joining the wedges and the TSP, and the welds between the vertical bar supports and the TSPs. However, Westinghouse indicated that cracking of the welds would not impact the ability of the TSPs to provide lateral support to the tubes. With the assumption of dented or packed intersections, the dynamic response of the TSPs under MSLB loads should not be significantly affected by the presence of cracks in these welds. The tubes provide significant

restraint to the TSPs under MSLB loads, and would continue to hold the TSPs in place. Thus, cracking of these welds would not have a negative effect on the limited TSP displacement analysis.

TSP Ligament Indications

PG&E has reviewed SG tube eddy current data to check for any TSP ligament cracking. Relatively few "suspect ligament cracking" (SLC) indications were found in a screening review of bobbin eddy current data, i.e., only 241 SLC indications in Unit 1 and 126 SLC indications in Unit 2, out of approximately 190,000 intersections reviewed per unit. A historical review of the identified indications traced the majority of the SLC indications to preservice inspection data, indicating that they were present prior to plant operation and not service induced.

To provide a more detailed assessment of the condition of the TSPs, the inspection program for Unit 1 (1R8) involved Plus Point eddy current inspection and visual inspection of TSPs. The results of these inspections and a structural integrity assessment of the findings are documented in Westinghouse safety evaluation checklist 97-104, and are summarized below.

Plus Point eddy current inspection of all TSP intersections with SLC indications was performed in 1R8 to confirm the indications and measure the circumferential extent of the ligament gap response. Out of 225 SLC indications confirmed by Plus Point, 116 exhibited ligament gap responses. The largest measured gap response was 66 degrees, which is well below the calculated threshold gap of 146 degrees required for the tube to enter the flow hole region and experience large amplitudes of vibration. Also, no indications of outside diameter tube wear were noted at SLC indications.

Limited visual examinations of the TSPs were performed in 1R8 to characterize the eddy current indications. Upper bundle in-bundle visual inspection techniques were employed. The visual inspections were performed in 2 SGs at 10 TSPs comprising a total of 59 specific locations corresponding to Plus Point indications. The visual inspections identified missing TSP ligaments at 18 locations where intersecting tube and flow hole locations were clearly evident. The vertical edges of the tube and flow hole intersections were consistent and straight, suggesting a mechanical nature to the condition, not service-induced by a corrosion mechanism. The circumferential extent of the missing ligaments were observed to be small, confirming the Plus Point measurements. Thinned TSP ligaments were also noted. Also included in the visual inspections were patch plate seams and plug welds, wedge areas, wrapper/wedge weld, and wrapper seam weld. No irregularities were noted.

Although a detailed Plus Point eddy current inspection of SLC indications and visual inspection of the TSPs has not been performed on Unit 2, the observed condition in Unit 1 is expected to bound the Unit 2 condition in terms of the potential for missing TSP ligaments.

Westinghouse has concluded that the missing TSP ligaments are related to suspected TSP drilled hole manufacturing anomalies. The TSP manufacturing practices employed at the time that the DCPP SGs were produced used a stacked drilling procedure. Several TSPs were clamped together and drilled simultaneously. A review of the SLC locations indicates distinct location patterns, indicative of manufacturing anomalies of the automatic drilling equipment.

A TSP structural integrity evaluation was performed by Westinghouse for Units 1 and 2 to evaluate in-plane loading and potential TSP deformation under a postulated LOCA and SSE event assuming misdrilled SLC locations. The results of the analysis indicates that tubes adjacent to SLC locations outside of previously established wedge region zones will not experience deformation or collapse during a postulated LOCA and SSE event. As no additional tubes are subject to collapse or deformation (other than tubes adjacent to SLC locations within wedge region zones), the current results of the DCPP LOCA analysis remain bounding.

NRC Information Notice 96-09

The French utility, Electricite de France, has reported significant cracking in the TSPs in the vicinity of the wedge regions at several French nuclear plants (Reference NRC IN 96-09). In response to the French degradation, an NEI/EPRI task force was formed. This task force has commissioned various owner's groups, including the WOG, to evaluate: (1) the applicability of the French data to domestic plants; (2) experience in this area at domestic plants to date; and (3) design considerations for internals degradation. This evaluation will result in an industry program with recommendations for future inspections. In support of this program, PG&E has provided the inspection experience at DCPP Units 1 and 2 to the WOG.

V. Corrective Actions

A. Immediate Corrective Actions:

As discussed in the above evaluation, PG&E has reviewed the SG analyses to ensure that the tubes and TSPs will perform their safety functions. This is documented in an OE. A final engineering evaluation will be documented for all applicable loading combinations.

B. Corrective Actions to Prevent Recurrence:

1. Several plant modifications and chemistry changes were previously made to control TSP corrosion in the SGs.

2. An INPO nuclear network notification was issued.

3. Additional analyses are being performed by Westinghouse to qualify the DCPP SG tube bundle for new boundary conditions and design basis loading commitments.

4. Regarding recent degradation of French SG internals, PG&E will evaluate the NEI task force findings and recommendations.

5. PG&E performed eddy current testing and a limited visual inspection of the TSPs during the eighth refueling outage for Unit 1 to assess their condition. The results are summarized in the analysis section of this LER.

6. Analysis for this loading condition has been performed by Westinghouse and the results are documented in WCAP-14707, Revision 1, and summarized in the analysis section of this LER.

VI. Additional Information

A. Failed Components:

None.

B. Previous LERs on Similar Problems:

None.