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3/4.4.5 STEAM GENERATORS

LIMITING CONDITION FOR OPERATION

3.4.5 Each steam generator shall be OPERABLE.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With one or more steam generators inoperable, restore the inoperable generator(s) to OPERABLE status prior to increasing T_{avg} above 200°F.

SURVEILLANCE REQUIREMENTS

4.4.5.0 Each steam generator shall be demonstrated OPERABLE by performance of the following augmented inservice inspection program and the requirement of Specification 4.0.5.

4.4.5.1 Steam Generator Sample Selection and Inspection - Each steam generator shall be determined OPERABLE during shutdown by selecting and inspecting at least the minimum number of steam generators specified in Table 4.4-1.

4.4.5.2 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 4.4-2. The inservice inspection of steam generator tubes shall be performed at the frequencies specified in Specification 4.4.5.3 and the inspected tubes shall be verified acceptable per the acceptance criteria of Specification 4.4.5.4. 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. Where experience in similar plants with similar water chemistry indicates critical areas to be inspected, then at least 50% of the tubes inspected shall be from these critical areas;

b. 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 (greater than 20%),

2) Tubes in those areas where experience has indicated potential problems, and

3) A tube inspection (pursuant to Specification 4.4.5.4a.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.

Insert A

c. The tubes selected as the second and third samples (if required by Table 4.4-2) during each inservice inspection may be subjected to a partial tube inspection provided:

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

2) The inspections include those portions of the tubes where imperfections were previously found.

Insert B

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 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 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 are degraded tubes or more than 1% of the inspected tubes are defective.
Note:	In all inspections, previously degraded tubes must exhibit significant (greater than 10%) further wall penetrations to be included in the above percentage calculations.

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4) Indications left in service as a result of application of the tube support plate voltage-based repair criteria shall be inspected by bobbin coil probe during all future refueling outages.

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d. Implementation of the steam generator tube/tube support plate repair criteria requires a 100% bobbin coil inspection for hot-leg and cold-leg tube support plate intersections down to the lowest cold-leg tube support plate with known outside diameter stress corrosion cracking (ODSCC) indications. The determination of the lowest cold-leg tube support plate intersections having ODSCC indications shall be based on the performance of at least a 20% random sampling of tubes inspected over their full length.

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4.4.5.3 Inspection Frequencies - The above required inservice inspections of steam generator tubes shall be performed at the following frequencies:

a. The first inservice inspection shall be performed after 6 Effective Full Power Months but within 24 calendar months of initial criticality. Subsequent inservice inspections shall be performed at intervals of not less than 12 nor more than 24 calendar months after the previous inspection. If two consecutive inspections not including the preservice inspection, result in all inspection results falling into the C-1 category or if two consecutive inspections demonstrate that previously observed degradation has not continued and no additional degradation has occurred, the inspection interval 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 4.4-2 at 40 month intervals fall in Category C-3, the inspection frequency 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 4.4.5.3a. The interval may then be extended to a maximum of once per 40 months; and

c. Additional, unscheduled inservice inspections shall be performed on each steam generator in accordance with the first sample inspection specified in Table 4.4-2 during the shutdown subsequent to any of the following conditions:

1) Reactor-to-secondary tube leaks (not including leaks originating from tube-to-tube sheet welds) in excess of the limits of Specification 3.4.6.2; or

2) A seismic occurrence greater than the Double Design Earthquake, or

3) A loss-of-coolant accident requiring actuation of the Engineered Safety Features, or

4) A main steam line or feedwater line break.

4.4.5.4 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 drawings 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 greater than or equal to 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 and is equal to 40% of the nominal tube wall thickness; ← Insert C

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 a Double Design Earthquake, a loss-of-coolant accident, or a steam line or feedwater line break as specified in 4.4.5.3c., above;

8) Tube Inspection means an inspection of the steam generator tube from the point of entry (hot leg side) completely around the U-bend to the top support of the cold leg; and

9) Preservice Inspection means an inspection of the full length of each tube in each steam generator performed by eddy current techniques prior to service to establish a baseline condition of the tubing. This inspection shall be performed after the field hydrostatic test and prior to initial POWER OPERATION using the equipment and techniques expected to be used during subsequent inservice inspections.

Insert D →

b. The steam generator shall be determined OPERABLE after completing the corresponding actions (plug all tubes exceeding the plugging limit) ~~and all tubes containing through-wall cracks)~~ required by Table 4.4-2.

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This definition does not apply to tube support plate intersections for which the voltage-based repair criteria are being applied. Refer to 4.4.5.4a.10) for the repair limit applicable to these intersections.

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10) Tube Support Plate Plugging Limit is used for the disposition of an alloy 600 steam generator tube for continued service that is experiencing predominantly axially oriented outside diameter stress corrosion cracking confined within the thickness of the tube support plates. At tube support plate intersections, the plugging limit is based on maintaining steam generator tube serviceability as described below:

a. Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with bobbin voltages less than or equal to the lower voltage repair limit [Note 1], will be allowed to remain in service.

b. Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than the lower voltage repair limit [Note 1], will be repaired or plugged, except as noted in 4.4.5.4a.10)c below.

c. Steam generator tubes, with indications of potential degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than the lower voltage repair limit [Note 1] but less than or equal to the upper voltage repair limit [Note 2], may remain in service if a rotating pancake coil inspection does not detect degradation. Steam generator tubes, with indications of outside diameter stress corrosion cracking degradation with a bobbin voltage greater than the upper voltage repair limit [Note 2] will be plugged or repaired.

d. Certain intersections as identified in Westinghouse letter to PG&E dated September 3, 1992, "Deformation of Steam Generator Tubes Following a Postulated LOCA and SSE Event," will be excluded from application of the voltage-based repair criteria as it is determined that these intersections may collapse or deform following a postulated LOCA + SSE event.

e. If an unscheduled mid-cycle inspection is performed, the following mid-cycle repair limits apply instead of the limits identified in 4.4.5.4a.10)a, 4.4.5.4a.10)b, and 4.4.5.4a.10)c. The mid-cycle repair limits are determined from the following equations:

$$V_{MURL} = \frac{V_{SL}}{1.0 + NDE + Gr\left(\frac{CL-\Delta t}{CL}\right)}$$

$$V_{MLRL} = V_{MURL} - (V_{URL} - V_{LRL})\left(\frac{CL-\Delta t}{CL}\right)$$

where:

V_{URL}	=	upper voltage repair limit
V_{LRL}	=	lower voltage repair limit
V_{MURL}	=	mid-cycle upper voltage repair limit based on time into cycle
V_{MLRL}	=	mid-cycle lower voltage repair limit based on V_{MURL} and time into cycle
Δt	=	length of time since last scheduled inspection during which V_{URL} and V_{LRL} were implemented
CL	=	cycle length (the time between two scheduled steam generator inspections)
VSL	=	structural limit voltage
Gr	=	average growth rate per cycle length
NDE	=	95% cumulative probability allowance for nondestructive examination uncertainty (i.e., a value of 20% has been approved by the NRC)

Implementation of these mid-cycle repair limits should follow the same approach as in TS 4.4.5.4a.10)a, 4.4.5.4a.10)b, and 4.4.5.4a.10)c.

Note 1: The lower voltage repair limit is 2.0 volts for 7/8-inch diameter tubing at DCPP Units 1 and 2.

Note 2: The upper voltage repair limit is calculated according to the methodology in Generic Letter 95-05.

4.4.5.5 Reports

a. Within 15 days 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 Commission in a Special Report pursuant to Specification 6.9.2.

b. The complete results of the steam generator tube inservice inspection shall be submitted to the Commission in a Special Report pursuant to Specification 6.9.2 within 12 months following completion of the inspection. This Special Report shall include:

1) Number and extent of tubes inspected,

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

3) Identification of tubes plugged.

c. Results of steam generator tube inspections, which fall into Category C-3, shall be reported in a Special Report to the Commission pursuant to Specification 6.9.2 within 30 days and prior to resumption of plant operation. This report shall provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence.

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d. For implementation of the voltage-based repair criteria to tube support plate intersections, notify the NRC prior to returning the steam generators to service should any of the following conditions arise:

1) If estimated leakage based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds the leak limit for the next operating cycle.

2) If circumferential crack-like indications are detected at the tube support plate intersections.

3) If indications are identified that extend beyond the confines of the tube support plate.

4) If indications are identified at the tube support plate elevations that are attributable to primary water stress corrosion cracking.

5) If the calculated conditional burst probability based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds 1×10^{-2}, notify the NRC and provide an assessment of the safety significance of the occurrence.

TABLE 4.4-1

MINIMUM NUMBER OF STEAM GENERATORS TO BE INSPECTED DURING INSERVICE INSPECTION

Preservice Inspection	No			Yes		
No. of Steam Generators per Unit	Two	Three	Four	Two	Three	Four
First Inservice Inspection	All			One	Two	Two
Second & Subsequent Inservice Inspections	One[1]			One[1]	One[2]	One[3]

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TABLE NOTATIONS

1. The inservice inspection may be limited to one steam generator on a rotating schedule encompassing 3 N % of the tubes (where N is the number of steam generators in the plant) if the results of the first or previous inspections indicate that all steam generators are performing in a like manner. Note that under some circumstances, the operating conditions in one or more steam generators may be found to be more severe than those in other steam generators. Under such circumstances the sample sequence shall be modified to inspect the most severe conditions.

2. The other steam generator not inspected during the first inservice inspection shall be inspected. The third and subsequent inspections should follow the instructions described in 1 above.

3. Each of the other two steam generators not inspected during the first inservice inspections shall be inspected during the second and third inspections. The fourth and subsequent inspections shall follow the instructions described in 1 above.

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TABLE 4.4-2

STEAM GENERATOR TUBE INSPECTION

1ST SAMPLE INSPECTION			2ND SAMPLE INSPECTION		3RD SAMPLE INSPECTION	
Sample Size	Result	Action Required	Result	Action Required	Result	Action Required
A minimum of S Tubes per S.G.	C-1	None	N.A.	N.A.	N.A.	N.A.
	C-2	Plug defective tubes and inspect additional 2S tubes in this S.G.	C-1	None	N.A.	N.A.
			C-2	Plug defective tubes and inspect additional 4S tubes in this S.G.	C-1	None
					C-2	Plug defective tubes
					C-3	Perform action for C-3 result of first sample
			C-3	Perform action for C-3 result of first sample	N.A	N.A.
	C-3	Inspect all tubes in this S.G., plug defective tubes and inspect 2S tubes in each other S.G. Notification to NRC pursuant to §50.72(b)(2) of 10 CFR Part 50	All other S.G.s are C-1	None	N.A.	N.A.
			Some S.G.s C-2 but no additional S.G. are C-3	Perform action for C-2 result of second sample	N.A.	N.A.
			Additional S.G. is C-3	Inspect all tubes in each S.G. and plug defective tubes. Notification to NRC pursuant to §50.72(b)(2) of 10CFR Part 50	N.A.	N.A.

$S = 3\frac{N}{n}$ % Where N is the number of steam generators in the unit, and n is the number of steam generators inspected during an inspection

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3/4.4.6 REACTOR COOLANT SYSTEM LEAKAGE

LEAKAGE DETECTION SYSTEMS

LIMITING CONDITION FOR OPERATION

3.4.6.1 The following Reactor Coolant System Leakage Detection Systems shall be OPERABLE:

a. The Containment Atmosphere Particulate Radioactivity Monitoring System,

b. The Containment Structure Sumps and the Reactor Cavity Sump Level and Flow Monitoring System, and

c. Either the Containment Fan Cooler Collection Monitoring System or the Containment Atmosphere Gaseous Radioactivity Monitoring System.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With only two of the above required Leakage Detection Systems OPERABLE, operation may continue for up to 30 days provided grab samples of the containment atmosphere are obtained and analyzed at least once per 24 hours when the required Gaseous and/or Particulate Radioactivity Monitoring System is inoperable; otherwise, be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.4.6.1 The Leakage Detection Systems shall be demonstrated OPERABLE by:

a. Containment Atmosphere Particulate and Gaseous (if being used) Monitoring System-performance of CHANNEL CHECK, CHANNEL CALIBRATION and CHANNEL FUNCTIONAL TEST at the frequencies specified in Table 4.3-3,

b. Containment Structure Sumps and the Reactor Cavity Sump Level and Flow Monitoring System-performance of CHANNEL CALIBRATION at least once per 18 months, and

c. Containment Fan Cooler Collection Monitoring System (if being used) - performance of CHANNEL FUNCTIONAL TEST at least once per 18 months.

LIMITING CONDITION FOR OPERATION

3.4.6.2 Reactor Coolant System leakage shall be limited to:

a. No PRESSURE BOUNDARY LEAKAGE,

b. 1 gpm UNIDENTIFIED LEAKAGE,

c. ~~1 gpm total reactor-to-secondary leakage through all steam generators and 500 gallons per day through any one steam generator,~~ 150 gallons per day of primary-to-secondary leakage through any one steam generator,

d. 10 gpm IDENTIFIED LEAKAGE from the Reactor Coolant System,

e. 40 gpm CONTROLLED LEAKAGE at a Reactor Coolant System pressure of 2235 ± 20 psig, and

f. 1 gpm leakage at a Reactor Coolant System pressure of 2235 ±20 psig for Reactor Coolant System Pressure Isolation Valves as specified in Table 3.4-1.

APPLICABILITY: MODES 1, 2, 3,* and 4.*

ACTION:

a. With any PRESSURE BOUNDARY LEAKAGE, be in at least HOT STANDBY within 6 hours and in COLD SHUTDOWN within the following 30 hours.

b. With any Reactor Coolant System leakage greater than any one of the above limits, excluding PRESSURE BOUNDARY LEAKAGE and leakage from Reactor Coolant System pressure isolation valves, reduce the leakage rate to within limits within 4 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

c. With any Reactor Coolant System pressure isolation valve leakage greater than the above limit, isolate the high pressure portion of the affected system from the low pressure portion within 4 hours by use of at least two closed manual and/or deactivated automatic valves, or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

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* For Modes 3 and 4, if steam generator water samples indicate less than the minimum detectable activity of 5.0 E-7 microcuries/ml for principal gamma emitters, the leakage requirement of Specification 3.4.6.2c may be considered met.

SURVEILLANCE REQUIREMENTS

4.4.6.2.1 Reactor Coolant System leakages shall be demonstrated to be within each of the above limits by:

a. Monitoring the containment atmosphere particulate or gaseous radioactivity monitor at least once per 12 hours;

b. Monitoring the containment structure sump inventory and discharge at least once per 12 hours;

c. Measurement of the CONTROLLED LEAKAGE to the reactor coolant pump seals at least once per 31 days when the Reactor Coolant System pressure is 2235 ± 20 psig with the modulating valve fully open. The provisions of Specification 4.0.4 are not applicable for entry into MODE 3 or 4;

d. Performance of a Reactor Coolant System water inventory balance at least once per 72 hours, except when T_{avg} is being changed by greater than 5°F/hour or when diverting reactor coolant to the liquid holdup tank, in which cases the required inventory balance shall be performed within 12 hours after completion of the excepted operation; ~~and~~

e. Monitoring the Reactor Head Flange Leakoff System at least once per 24 hours; and

4.4.6.2.2 As specified in Table 3.4-1, Reactor Coolant System pressure isolation valves shall be demonstrated OPERABLE pursuant to Specification 4.0.5, except that in lieu of any leakage testing required by Specification 4.0.5, each valve shall be demonstrated OPERABLE by verifying leakage to be within its limit:

a. Every refueling outage during startup,

b. Prior to returning the valve to service following maintenance, repair or replacement work on the valve, and

c. Within 24 hours following valve actuation due to automatic or manual action or flow through the valve. After each disturbance of the valve, in lieu of measuring leak rate, leak-tight integrity may be verified by absence of pressure buildup in the test line downstream of the valve.

The provisions of Specification 4.0.4 are not applicable for entry into MODE 3 or 4.

f. Determination of steam generator primary-to-secondary leakage at least once per 72 hours, except when source term and mass flowrates are changing, in which case an evaluation of primary-to-secondary leakage will be performed within 48 hours after stable conditions have been established.

RELIEF VALVES (Continued)

Surveillance Requirements 4.4.4.1.c and 4.4.4.1.d provide assurance of operability of the Backup Air/Nitrogen system and that the Backup Air/Nitrogen system is capable of supplying sufficient air to operate the PORV(s) if they are needed for RCS pressure control and normal instrument air is not available.

Surveillance Requirement 4.4.4.2 addresses the block valves. The block valves are exempt from the surveillance requirements to cycle the valves when they have been closed to comply with ACTION statements "b" or "c." This precludes the need to cycle the valves with a full system differential pressure or when maintenance is being performed to restore an inoperable PORV to OPERABLE status.

3/4.4.5 STEAM GENERATORS

The Surveillance Requirements for inspection of the steam generator tubes ensure that the structural integrity of this portion of the RCS will be maintained. The program for inservice inspection of steam generator tubes is based on a modification of Regulatory Guide 1.83, Revision 1. Inservice inspection of steam generator tubing is essential in order to maintain surveillance of the conditions of the tubes in the event that there is evidence of

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STEAM GENERATORS (Continued) 150

mechanical damage or progressive degradation due to design, manufacturing errors, or inservice conditions that lead to corrosion. Inservice inspection of steam generator tubing also provides a means of characterizing the nature and cause of any tube degradation so that corrective measures can be taken.

The plant is expected to be operated in a manner such that the secondary coolant will be maintained within those chemistry limits found to result in negligible corrosion of the steam generator tubes. If the secondary coolant chemistry is not maintained within these limits, localized corrosion may likely result in stress corrosion cracking. The extent of cracking during plant operation would be limited by the limitation of steam generator tube leakage between the Reactor Coolant System and the Secondary Coolant System (~~reactor-to-~~secondary leakage = ~~500~~ gallons per day per steam generator). Primary Cracks having a ~~reactor-to-~~secondary leakage less than this limit during operation will have an adequate margin of safety to withstand the loads imposed during normal operation and by postulated accidents. ~~Operating plants~~ DCPP has ~~have~~ demonstrated that ~~reactor-to-~~secondary leakage of ~~500~~ gallons per day per steam generator can readily be detected ~~by radiation monitors of steam generator blowdown.~~ during power operation. Leakage in excess of this limit will require plant shutdown and an unscheduled inspection, during which the leaking tubes will be located and plugged. 150

Insert F

Wastage-type defects are unlikely with proper chemistry treatment of the secondary coolant. However, even if a wastage defect should develop in service, it will be found during scheduled inservice steam generator tube examinations. Plugging will be required for all tubes with imperfections exceeding the plugging limit ~~of 40% of the tube nominal wall thickness.~~ defined in Surveillance Requirement 4.4.5.4a. Steam generator tube inspections of operating plants have demonstrated the capability to reliably detect degradation that has penetrated 20% of the original tube wall thickness.

Whenever the results of any steam generator tubing inservice inspection fall into Category C-3, these results will be reported to the Commission as a Special Report pursuant to Specification 6.9.2 within 30 days and prior to resumption of plant operation. Such cases will be considered by the Commission on a case-by-case basis and may result in a requirement for analysis, laboratory examinations, tests, additional eddy-current inspection, and revision of the Technical Specifications, if necessary.

3/4.4.6 REACTOR COOLANT SYSTEM LEAKAGE

3/4.4.6.1 LEAKAGE DETECTION SYSTEMS

The RCS Leakage Detection Systems required by this specification are provided to monitor and detect leakage from the reactor coolant pressure boundary. These Detection Systems are functionally consistent with the recommendations of Regulatory Guide 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," May 1973.

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The voltage-based repair limits of SR 4.4.5.4a.10) implement the guidance in GL 95-05 and are applicable only to Westinghouse-designed steam generators (SGs) with outside diameter stress corrosion cracking (ODSCC) located at the tube-to-tube support plate intersections. The voltage-based repair limits are not applicable to other forms of SG tube degradation nor are they applicable to ODSCC that occurs at other locations within the SG. Additionally, the repair criteria apply only to indications where the degradation mechanism is dominantly axial ODSCC with no significant cracks extending outside the thickness of the support plate. Refer to GL 95-05 for additional description of the degradation morphology.

Implementation of SR 4.4.5.4a.10) requires a derivation of the voltage structural limit from the burst versus voltage empirical correlation and then the subsequent derivation of the voltage repair limit from the structural limit (which is then implemented by this surveillance).

The voltage structural limit is the voltage from the burst pressure/bobbin voltage correlation, at the 95-percent prediction interval curve reduced to account for the lower 95/95-percent tolerance bound for tubing material properties at 650 °F (i.e., the 95-percent LTL curve). The voltage structural limit must be adjusted downward to account for potential flaw growth during an operating interval and to account for NDE uncertainty. The upper voltage repair limit, V_{URL}, is determined from the structural voltage limit by applying the following equation:

$$V_{URL} = V_{SL} - V_{Gr} - V_{NDE}$$

where V_{Gr} represents the allowance for flaw growth between inspections and V_{NDE} represents the allowance for potential sources of error in the measurement of the bobbin coil voltage. Further discussion of the assumptions necessary to determine the voltage repair limit are discussed in GL 95-05.

The mid-cycle equation in SR 4.4.5.4a.10)e. should only be used during unplanned inspections in which eddy current data is acquired for indications at the tube support plates.

SR 4.4.5.5d implements several reporting requirements recommended by GL 95-05 for situations which the NRC wants to be notified prior to returning the SGs to service. For the purposes of this reporting requirement, leakage and conditional burst probability can be calculated based on the as-found voltage distribution rather than the projected end-of-cycle voltage distribution (refer to GL 95-05 for more information) when it is not practical to complete these calculations using the projected EOC voltage distributions prior to returning the SGs to service. Note that if leakage and conditional burst probability were calculated using the measured EOC voltage distribution for the purposes of addressing the GL Section 6.a.1 and 6.a.3 reporting criteria, then the results of the projected EOC voltage distribution should be provided per the GL Section 6.b (c) criteria.

3/4.4.6.2 OPERATIONAL LEAKAGE

PRESSURE BOUNDARY LEAKAGE of any magnitude is unacceptable since it may be indicative of an impending gross failure of the pressure boundary. Therefore, the presence of any PRESSURE BOUNDARY LEAKAGE requires the unit to be promptly placed in COLD SHUTDOWN.

Industry experience has shown that while a limited amount of leakage is expected from the RCS, the unidentified portion of this leakage can be reduced to a threshold value of less than 1 gpm. This threshold value is sufficiently low to ensure early detection of additional leakage.

The total steam generator tube leakage limit of 150 gpd for any one steam generator ~~1 gpm for all steam generators~~ ensures that the dosage contribution from the tube leakage will be limited to a small fraction of 10 CFR Part 100 dose guideline values in the event of either a steam generator tube rupture or steam line break. ~~The 1 gpm~~ This limit is consistent with the assumptions used in the analysis of these accidents. The ~~500~~ 150 gpd leakage limit per steam generator ensures that steam generator tube integrity is maintained in the event of a main steam line rupture or under LOCA conditions. ← Insert G

The 10 gpm IDENTIFIED LEAKAGE limitation provides allowance for a limited amount of leakage from known sources whose presence will not interfere with the detection of UNIDENTIFIED LEAKAGE by the leakage detection systems.

The CONTROLLED LEAKAGE limitation restricts operation when the total flow supplied to the reactor coolant pump seals exceeds 40 GPM with the modulating valve in the suppl line fully open at a nominal RCS pressure of 2235 psig. This limitation ensures that in the event of a LOCA, the safety injection flow will not be less than assumed in the safety analyses.

The 1 gpm leakage from any RCS pressure isolation valve is sufficiently low to ensure early detection of possible in-series check valve failure. It is apparent that when pressure isolation is provided by two in-series check valves and when failure of one valve in the pair can go undetected for a substantial length of time, verification of valve integrity is required. Since these valves are important in preventing overpressurization and rupture of the ECCS low pressure piping which could result in a LOCA that bypasses containment, these valves should be tested periodically to ensure low probability of gross failure.

The Surveillance Requirements for RCS pressure isolation valves provide added assurance of valve integrity thereby reducing the probability of gross valve failure and consequent intersystem LOCA. Leakage from the RCS pressure isolation valves is IDENTIFIED LEAKAGE and will be considered as a portion of the allowed limit.

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The primary-to-secondary operational leakage limit of 150 gpd per steam generator is more restrictive than the standard operating leakage limits and is intended to provide an additional margin to accommodate a crack which might grow at a greater than expected rate or unexpectedly extend outside the thickness of the tube support plate. Hence, the reduced leakage limit, when combined with an effective leak rate monitoring program, provides additional assurance that should a significant leak be experienced in service, it will be detected, and the plant shut down in a timely manner.

Calculations for primary-to-secondary leakage are performed using approximate Standard Reference State of 25°C. When determining primary-to-secondary leakage of 150 gpd, indeterminent inaccuracies associated with determination of leakage are not considered.

For Modes 3 and 4, the primary system radioactivity level (source term) may be very low, making it difficult to measure primary-to-secondary leakage of 150 gallons per day. Therefore, if steam generator water samples indicate less than the minimum detectable activity of 5.0 E-7 microcuries/ml for principal gamma emitters, the 150 gallons per day leakage limit may be considered met.

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2) Tubes in those areas where experience has indicated potential problems, and

3) A tube inspection (pursuant to Specification 4.4.5.4a.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) Indications left in service as a result of application of the tube support plate voltage-based repair criteria shall be inspected by bobbin coil probe during all future refueling outages.

c. The tubes selected as the second and third samples (if required by Table 4.4-2) during each inservice inspection may be subjected to a partial tube inspection provided:

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

2) The inspections include those portions of the tubes where imperfections were previously found.

d. Implementation of the steam generator tube/tube support plate repair criteria requires a 100% bobbin coil inspection for hot-leg and cold-leg tube support plate intersections down to the lowest cold-leg tube support plate with known outside diameter stress corrosion cracking (ODSCC) indications. The determination of the lowest cold-leg tube support plate intersections having ODSCC indications shall be based on the performance of at least a 20% random sampling of tubes inspected over their full length.

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 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 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 are degraded tubes or more than 1% of the inspected tubes are defective.

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

4.4.5.4 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 drawings 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 greater than or equal to 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 and is equal to 40% of the nominal tube wall thickness. This definition does not apply to tube support plate intersections for which the voltage-based repair criteria are being applied. Refer to 4.4.5.4a.10) for the repair limit applicable to these intersections;

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 a Double Design Earthquake, a loss-of-coolant accident, or a steam line or feedwater line break as specified in 4.4.5.3c., above;

8) Tube Inspection means an inspection of the steam generator tube from the point of entry (hot leg side) completely around the U-bend to the top support of the cold leg; and

9) Preservice Inspection means an inspection of the full length of each tube in each steam generator performed by eddy current techniques prior to service to establish a baseline condition of the tubing. This inspection shall be performed after the field hydrostatic test and prior to initial POWER OPERATION using the equipment and techniques expected to be used during subsequent inservice inspections.

SURVEILLANCE REQUIREMENTS (Continued)

10) Tube Support Plate Plugging Limit is used for the disposition of an alloy 600 steam generator tube for continued service that is experiencing predominantly axially oriented outside diameter stress corrosion cracking confined within the thickness of the tube support plates. At tube support plate intersections, the plugging limit is based on maintaining steam generator tube serviceability as described below:

a. Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with bobbin voltages less than or equal to the lower voltage repair limit [Note 1], will be allowed to remain in service.

b. Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than the lower voltage repair limit [Note 1], will be repaired or plugged, except as noted in 4.4.5.4a.10)c below.

c. Steam generator tubes, with indications of potential degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than the lower voltage repair limit [Note 1] but less than or equal to the upper voltage repair limit [Note 2], may remain in service if a rotating pancake coil inspection does not detect degradation. Steam generator tubes, with indications of outside diameter stress corrosion cracking degradation with a bobbin voltage greater than the upper voltage repair limit [Note 2] will be plugged or repaired.

d. Certain intersections as identified in Westinghouse letter to PG&E dated September 3, 1992, Deformation of Steam Generator Tubes Following a Postulated LOCA and SSE Event, will be excluded from application of the voltage-based repair criteria as it is determined that these intersections may collapse or deform following a postulated LOCA + SSE event.

e. If an unscheduled mid-cycle inspection is performed, the following mid-cycle repair limits apply instead of the limits identified in 4.4.5.4.a.10)a, 4.4.5.4a.10b, and 4.4.5.4a.10)c. The mid-cycle repair limits are determined from the following equations:

$$V_{MURL} = \frac{V_{SL}}{1.0 + NDE + Gr\left(\frac{CL-\Delta t}{CL}\right)}$$

$$V_{MLRL} = V_{MURL} - (V_{URL} - V_{LRL})\left(\frac{CL-\Delta t}{CL}\right)$$

where:

V_{URL} = upper voltage repair limit

V_{LRL} = lower voltage repair limit

V_{MURL} = mid-cycle upper voltage repair limit based on time into cycle

V_{MLRL} = mid-cycle lower voltage repair limit based on V_{MURL} and time into cycle

Δt = length of time since last scheduled inspection during which V_{URL} and V_{LRL} were implemented

CL = cycle length (the time between two scheduled steam generator inspections)

VSL = structural limit voltage

Gr = average growth rate per cycle length

NDE = 95% cumulative probability allowance for nondestructive examination uncertainty (i.e., a value of 20% has been approved by NRC)

Implementation of these midcycle repair limits should follow the same approach as in TS 4.4.5.4a.10)a, 4.4.5.4a.10)b, and 4.4.5.4a.10)c.

NOTE 1: The lower voltage repair limit is 2.0 volts for 7/8-inch diameter tubing at DCPP Units 1 and 2.

NOTE 2: The upper voltage repair limit is calculated according to the methodology in Generic Letter 95-05.

b. The steam generator shall be determined OPERABLE after completing the corresponding actions (plug all tubes exceeding the plugging limit) required by Table 4.4-2.

4.4.5.5 Reports

a. Within 15 days 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 Commission in a Special Report pursuant to Specification 6.9.2.

b. The complete results of the steam generator tube inservice inspection shall be submitted to the Commission in a Special Report pursuant to Specification 6.9.2 within 12 months following completion of the inspection. This Special Report shall include:

   1) Number and extent of tubes inspected,

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

   3) Identification of tubes plugged.

c. Results of steam generator tube inspections, which fall into Category C-3, shall be reported in a Special Report to the Commission pursuant to Specification 6.9.2 within 30 days and prior to resumption of plant operation. This report shall provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence.

d. For implementation of the voltage-based repair criteria to tube support plate intersections, notify the NRC prior to returning the steam generators to service should any of the following conditions arise:

   1) If estimated leakage based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds the leak limit for the next operating cycle.

   2) If circumferential crack-like indications are detected at the tube support plate intersections.

   3) If indications are identified that extend beyond the confines of the tube support plate.

   4) If indications are identified at the tube support plate elevations that are attributable to primary water stress corrosion cracking.

   5) If the calculated conditional burst probability based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds 1×10^{-2}, notify the NRC and provide an assessment of the safety significance of the occurrence.

LIMITING CONDITION FOR OPERATION

3.4.6.2 Reactor Coolant System leakage shall be limited to:

a. No PRESSURE BOUNDARY LEAKAGE,

b. 1 gpm UNIDENTIFIED LEAKAGE,

c. 150 gallons per day of primary-to-secondary leakage through any one steam generator,

d. 10 gpm IDENTIFIED LEAKAGE from the Reactor Coolant System,

e. 40 gpm CONTROLLED LEAKAGE at a Reactor Coolant System pressure of 2235 ± 20 psig, and

f. 1 gpm leakage at a Reactor Coolant System pressure of 2235 ± 20 psig for Reactor Coolant System Pressure Isolation Valves as specified in Table 3.4-1.

APPLICABILITY: MODES 1, 2, 3*, and 4*.

ACTION:

a. With any PRESSURE BOUNDARY LEAKAGE, be in at least HOT STANDBY within 6 hours and in COLD SHUTDOWN within the following 30 hours.

b. With any Reactor Coolant System leakage greater than any one of the above limits, excluding PRESSURE BOUNDARY LEAKAGE and leakage from Reactor Coolant System pressure isolation valves, reduce the leakage rate to within limits within 4 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

c. With any Reactor Coolant System pressure isolation valve leakage greater than the above limit, isolate the high pressure portion of the affected system from the low pressure portion within 4 hours by use of at least two closed manual and/or deactivated automatic valves, or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

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* For Modes 3 and 4, if steam generator water samples indicate less than the minimum detectable activity of 5.0 E-7 microcuries/ml for principal gamma emitters, the leakage requirement of Specification 3.4.6.2c may be considered met.

SURVEILLANCE REQUIREMENTS

4.4.6.2.1 Reactor Coolant System leakages shall be demonstrated to be within each of the above limits by:

a. Monitoring the containment atmosphere particulate or gaseous radioactivity monitor at least once per 12 hours;

b. Monitoring the containment structure sump inventory and discharge at least once per 12 hours;

c. Measurement of the CONTROLLED LEAKAGE to the reactor coolant pump seals at least once per 31 days when the Reactor Coolant System pressure is 2235 ± 20 psig with the modulating valve fully open. The provisions of Specification 4.0.4 are not applicable for entry into MODE 3 or 4;

d. Performance of a Reactor Coolant System water inventory balance at least once per 72 hours, except when T_{avg} is being changed by greater than 5°F/hour or when diverting reactor coolant to the liquid holdup tank, in which cases the required inventory balance shall be performed within 12 hours after completion of the excepted operation;

e. Monitoring the Reactor Head Flange Leakoff System at least once per 24 hours; and

f. Determination of steam generator primary-to-secondary leakage at least once per 72 hours, except when source term and mass flowrates are changing, in which case an evaluation of primary-to-secondary leakage will be performed within 48 hours after stable conditions have been established.

4.4.6.2.2 As specified in Table 3.4-1, Reactor Coolant System pressure isolation valves shall be demonstrated OPERABLE pursuant to Specification 4.0.5, except that in lieu of any leakage testing required by Specification 4.0.5, each valve shall be demonstrated OPERABLE by verifying leakage to be within its limit:

a. Every refueling outage during startup,

b. Prior to returning the valve to service following maintenance, repair or replacement work on the valve, and

c. Within 24 hours following valve actuation due to automatic or manual action or flow through the valve. After each disturbance of the valve, in lieu of measuring leak rate, leak-tight integrity may be verified by absence of pressure buildup in the test line downstream of the valve.

The provisions of Specification 4.0.4 are not applicable for entry into MODE 3 or 4.

STEAM GENERATORS (Continued)

mechanical damage or progressive degradation due to design, manufacturing errors, or inservice conditions that lead to corrosion. Inservice inspection of steam generator tubing also provides a means of characterizing the nature and cause of any tube degradation so that corrective measures can be taken.

The plant is expected to be operated in a manner such that the secondary coolant will be maintained within those chemistry limits found to result in negligible corrosion of the steam generator tubes. If the secondary coolant chemistry is not maintained within these limits, localized corrosion may likely result in stress corrosion cracking. The extent of cracking during plant operation would be limited by the limitation of steam generator tube leakage between the Reactor Coolant System and the Secondary Coolant System (primary-to-secondary leakage = 150 gallons per day per steam generator). Cracks having a primary-to-secondary leakage less than this limit during operation will have an adequate margin of safety to withstand the loads imposed during normal operation and by postulated accidents. DCPP has demonstrated that primary-to-secondary leakage of 150 gallons per day per steam generator can readily be detected during power operation. Leakage in excess of this limit will require plant shutdown and an unscheduled inspection, during which the leaking tubes will be located and plugged.

The voltage-based repair limits of SR 4.4.5.4a.10) implement the guidance in GL 95-05 and are applicable only to Westinghouse-designed steam generators (SGs) with outside diameter stress corrosion cracking (ODSCC) located at the tube-to-tube support plate intersections. The voltage-based repair limits are not applicable to other forms of SG tube degradation nor are they applicable to ODSCC that occurs at other locations within the SG. Additionally, the repair criteria apply only to indications where the degradation mechanism is dominantly axial ODSCC with no significant cracks extending outside the thickness of the support plate. Refer to GL 95-05 for additional description of the degradation morphology.

Implementation of SR 4.4.5.4a.10) requires a derivation of the voltage structural limit from the burst versus voltage empirical correlation and then the subsequent derivation of the voltage repair limit from the structural limit (which is then implemented by this surveillance).

The voltage structural limit is the voltage from the burst pressure/bobbin voltage correlation, at the 95-percent prediction interval curve reduced to account for the lower 95/95-percent tolerance bound for tubing material properties at 650°F (i.e., the 95-percent LTL curve). The voltage structural limit must be adjusted downward to account for potential flaw growth during an operating interval and to account for NDE uncertainty. The upper voltage repair limit, V_{URL}, is determined from the structural voltage limit by applying the following equation:

$$V_{URL} = V_{SL} - V_{Gr} - V_{NDE}$$

where V_{Gr} represents the allowance for flaw growth between inspections and V_{NDE} represents the allowance for potential sources of error in the measurement of the bobbin coil voltage. Further discussion of the assumptions necessary to determine the voltage repair limit are discussed in GL 95-05.

STEAM GENERATORS (Continued)

The mid-cycle equation in SR 4.4.5.4a.10)e should only be used during unplanned inspections in which eddy current data is acquired for indications at the tube support plates.

SR 4.4.5.5d implements several reporting requirements recommended by GL 95-05 for situations which the NRC wants to be notified prior to returning the SGs to service. For the purposes of this reporting requirement, leakage and conditional burst probability can be calculated based on the as-found voltage distribution rather than the projected end-of-cycle voltage distribution (refer to GL 95-05 for more information) when it is not practical to complete these calculations using the projected EOC voltage distributions prior to returning the SGs to service. Note that if leakage and conditional burst probability were calculated using the measured EOC voltage distribution for the purposes of addressing the GL Section 6.a.1 and 6.a.3 reporting criteria, then the results of the projected EOC voltage distribution should be provided per the GL Section 6.b(c) criteria.

Wastage-type defects are unlikely with proper chemistry treatment of the secondary coolant. However, even if a wastage defect should develop in service, it will be found during scheduled inservice steam generator tube examinations. Plugging will be required for all tubes with imperfections exceeding the plugging limit defined in Surveillance Requirement 4.4.5.4a. Steam generator tube inspections of operating plants have demonstrated the capability to reliably detect degradation that has penetrated 20% of the original tube wall thickness.

Whenever the results of any steam generator tubing inservice inspection fall into Category C-3, these results will be reported to the Commission as a Special Report pursuant to Specification 6.9.2 within 30 days and prior to resumption of plant operation. Such cases will be considered by the Commission on a case-by-case basis and may result in a requirement for analysis, laboratory examinations, tests, additional eddy-current inspection, and revision of the Technical Specifications, if necessary.

3/4.4.6 REACTOR COOLANT SYSTEM LEAKAGE

3/4.4.6.1 LEAKAGE DETECTION SYSTEMS

The RCS Leakage Detection Systems required by this specification are provided to monitor and detect leakage from the reactor coolant pressure boundary. These Detection Systems are functionally consistent with the recommendations of Regulatory Guide 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," May 1973.

3/4.4.6.2 OPERATIONAL LEAKAGE

PRESSURE BOUNDARY LEAKAGE of any magnitude is unacceptable since it may be indicative of an impending gross failure of the pressure boundary. Therefore, the presence of any PRESSURE BOUNDARY LEAKAGE requires the unit to be promptly placed in COLD SHUTDOWN.

Industry experience has shown that while a limited amount of leakage is expected from the RCS, the unidentified portion of this leakage can be reduced to a threshold value of less than 1 gpm. This threshold value is sufficiently low to ensure early detection of additional leakage.

The total steam generator tube leakage limit of 150 gpd for any one steam generator ensures that the dosage contribution from the tube leakage will be limited to a small fraction of 10 CFR Part 100 dose guideline values in the event of either a steam generator tube rupture or steam line break. This limit is consistent with the assumptions used in the analysis of these accidents. The 150 gpd leakage limit per steam generator ensures that steam generator tube integrity is maintained in the event of a main steam line rupture or under LOCA conditions. The primary-to-secondary operational leakage limit of 150 gpd per steam generator is more restrictive than the standard operating leakage limits and is intended to provide an additional margin to accommodate a crack which might grow at a greater than expected rate or unexpectedly extend outside the thickness of the tube support plate. Hence, the reduced leakage limit, when combined with an effective leak rate monitoring program, provides additional assurance that should a significant leak be experienced in service, it will be detected, and the plant shut down in a timely manner.

Calculations for primary-to-secondary leakage are performed using approximate Standard Reference State of 25°C. When determining primary-to-secondary leakage of 150 gpd, indeterminent inaccuracies associated with determination of leakage are not considered.

For Modes 3 and 4, the primary system radioactivity level (source term) may be very low, making it difficult to measure primary-to-secondary leakage of 150 gallons per day. Therefore, if steam generator water samples indicate less than the minimum detectable activity of 5.0 E-7 microcuries/ml for principal gamma emitters, the 150 gallons per day leakage limit may be considered met.

The 10 gpm IDENTIFIED LEAKAGE limitation provides allowance for a limited amount of leakage from known sources whose presence will not interfere with the detection of UNIDENTIFIED LEAKAGE by the leakage detection systems.

The CONTROLLED LEAKAGE limitation restricts operation when the total flow supplied to the reactor coolant pump seals exceeds 40 GPM with the modulating valve in the supply line fully open at a nominal RCS pressure of 2235 psig. This limitation ensures that in the event of a LOCA, the safety injection flow will not be less than assumed in the safety analyses.

Attachment D
PG&E Letter DCL-97-034

PG&E TECHNICAL SUPPORT DOCUMENT FOR LICENSE AMENDMENT REQUEST 97-03

PG&E Technical Support Document for License Amendment Request 97-03

Voltage-Based Alternate Steam Generator Tube Repair Limit for Outside Diameter Stress Corrosion Cracking at the Tube Support Plate Intersections

This technical support document has been prepared to provide a response to each recommendation in Generic Letter (GL) 95-05. The GL guidance is provided in italics, and then PG&E's response is provided. Proposed alternatives and clarifications to the GL guidance are described and technically justified.

1.0 Introduction

This guidance is the NRC staff position on the implementation of the voltage-based repair criteria in steam generators designed by Westinghouse for outside diameter stress corrosion cracking (ODSCC) located at the tube-to-TSP intersections. This guidance is not applicable to other forms of steam generator (SG) tube degradation nor is it applicable to ODSCC that occurs at other locations within the SG. The voltage-based repair criteria have been developed for, and are currently applicable only to, Westinghouse designed SGs with 2.2-cm [7/8-inch] or 1.9-cm [3/4-inch] diameter alloy 600 tubes with drilled-hole TSPs. Application of the alternate repair criteria to other vendor designed SGs would require both the development and NRC staff review and approval of a comparable data base and the associated correlations for each vendor's SG type.

The NRC staff emphasizes that although the NRC has approved the implementation of the voltage-based repair criteria (described in this generic letter) as a short-term measure, this guidance should not be construed as discouraging the development and use of better acquisition techniques, eddy current technology, and eddy current data analysis techniques. The staff strongly encourages the industry to continue to improve the nondestructive examination (NDE) of SG tubes.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the application guidance contained in Section 1.0.

DCPP Units 1 and 2 are Westinghouse 4 loop PWRs with Series 51 SGs. Each of the eight SGs have 7/8-inch diameter mill annealed (MA) alloy 600 tubes with drilled-hole carbon steel TSPs. As such, the voltage-based repair criteria are applicable to all steam generators at both units.

1.a ODSCC

The voltage-based repair criteria are applicable only to indications at TSP intersections where the degradation mechanism is dominantly axial ODSCC with no NDE detectable cracks extending outside the thickness of the support plate.

For purposes of this guidance, ODSCC refers to degradation whose dominant morphology consists of axial stress corrosion cracks which occur either singularly or in networks of multiple cracks, sometimes with limited patches of general intergranular attack (IGA). Circumferential cracks may sometimes occur in the IGA affected regions producing a grid-like pattern of axial and circumferential cracks, termed "cellular corrosion." Cellular corrosion is assumed to be relatively shallow (based on data from tube specimens removed from the field), transitioning to dominantly axial cracks as the cracking progresses in depth. The circumferential cracks are assumed (based on available data) to be of insufficient size to produce a discrete, crack-like circumferential indication during field NDE inspections. Thus, the failure mode of ODSCC is axial and the burst pressure is controlled by the geometry of the most limiting axial crack or array of axial cracks.

It is also assumed for purposes of this guidance that the ODSCC is confined to within the thickness of the TSP, based on data from tube specimens removed from the field. Very shallow microcracks are sometimes observed on these specimens to initiate at locations slightly outside the thickness of the TSP; however, these microcracks are small compared to the cracks within the thickness of the TSP and are too small to produce an eddy current response.

The degradation mechanism should be confirmed as dominantly axial ODSCC by periodically removing tube specimens from the SGs and by examining and testing them as specified in Section 4 of this guidance. The acceptance criteria should consist of demonstrating that the dominant degradation mechanism affecting the burst and leakage properties of the tube is axially oriented ODSCC. In addition, results of inservice inspections with rotating pancake coil (RPC) probes should be evaluated in accordance with Section 3.b of this guidance to confirm the absence of detectable crack-like circumferential indications and detectable ODSCC indications extending outside the TSP thickness.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 1.a.

The voltage-based repair criteria will only be applied to indications at TSP intersections where the degradation mechanism is dominantly axial ODSCC with no NDE detectable cracks extending outside the thickness of the support plate.

The degradation mechanism will be confirmed as dominantly axial ODSCC by periodically removing tube specimens from the SGs and by examining and testing them as specified in Section 4. The acceptance criteria will consist of demonstrating that the dominant degradation mechanism affecting the burst and leakage properties of the tube is axially oriented ODSCC. In addition, results of inservice inspections with RPC probes will be evaluated in accordance with Section 3.b to confirm the absence of detectable crack-like circumferential indications and detectable ODSCC indications extending outside the TSP thickness.

1.b Exclusion of Intersections

The voltage-based repair criteria of this guidance do not apply to intersections meeting the criteria specified below.

1.b.1 The repair criteria do not apply to tube-to-TSP intersections where the tubes with degradation may potentially collapse or deform as a result of the combined postulated loss-of-coolant accident and safe shutdown earthquake loadings (e.g., intersections near the wedge supports at the upper TSPs). Licensees should perform or reference an analysis that identifies which intersections are to be excluded.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 1.b.1.

PG&E will not apply the repair criteria to tube-to-TSP intersections where the tubes with degradation may potentially collapse or deform as a result of the combined postulated loss-of-coolant accident (LOCA) and safe shutdown earthquake (SSE) loadings. A Westinghouse analysis documented in their letter to PG&E dated September 3, 1992, "Deformation of Steam Generator Tubes Following a Postulated LOCA and SSE Event," indicates that a maximum of 7.5 percent of tubes per SG (252 tubes per SG) located adjacent to wedge regions are subject to potential collapse and in-leakage during combined LOCA and SSE. To account for uncertainty in selecting the susceptible tube locations, an enveloping group of tubes were selected at each of the six wedge locations. As a result, a total of 468 susceptible tubes per SG were identified in the Westinghouse letter. All of these tubes are conservatively included in the wedge region exclusion zone and will be excluded from application of voltage-based repair criteria, even though a maximum of 252 of these tubes can collapse following a LOCA + SSE.

To reduce the likelihood that cracked tubes in the wedge region would be subjected to collapse loads, enhanced eddy current inspection requirements have been established at DCPP Units 1 and 2 at these locations. Tubes in the wedge region exclusion zone are inspected by bobbin coil every outage. If degradation is identified at the wedge region support plate intersection by the bobbin coil, then the intersection is inspected

by rotating pancake coil (RPC) and the tube would be plugged upon confirmation of any crack-like indication.

A discussion of the Westinghouse LOCA + SSE evaluation is provided in Section 7.0 of this Attachment. Tables 8 through 13 provide a listing of tubes excluded from voltage-based repair criteria.

1.b.2 The repair criteria do not apply to tube-to-TSP intersections having dent signals greater than 5.0 volts as measured with the bobbin probe.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 1.b.2.

PG&E will not apply the repair criteria to tube-to-TSP intersections having dent signals greater than 5.0 volts as measured with the bobbin probe.

1.b.3 The repair criteria do not apply to intersections at which there are mixed residuals of sufficient magnitude to cause a 1.0 volt ODSCC indication (as measured with a bobbin probe) to be missed or misread.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 1.b.3.

PG&E will not apply the repair criteria to intersections at which there are mixed residuals of sufficient magnitude to cause a 1.0 volt ODSCC indication (as measured with a bobbin probe) to be missed or misread.

1.b.4 The repair criteria do not apply to intersections with interfering signals from copper deposits.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 1.b.4.

PG&E will not apply the repair criteria to intersections with interfering signals from copper deposits.

1.b.5 The repair criteria do not apply to the tube-to-flow distribution baffle plate intersections except as discussed in Section 2.a.3.

DCPP Units 1 and 2 Compliance

The DCPP SGs do not have flow distribution baffle plates. Therefore, Section 1.b.5 is not applicable.

2.0 Tube Integrity Evaluation

Licensees should perform an evaluation to confirm that the SG tubes will retain adequate structural and leakage integrity until the next scheduled inspection. The first portion of this evaluation, referred to as the "conditional burst probability calculation," assesses the voltage distribution left in service against a threshold value of 1×10^{-2} probability of rupture under postulated main steamline break (MSLB) conditions. The conditional burst probability calculation is intended to provide a conservative assessment of tube structural integrity during a postulated MSLB occurring at the end of cycle (EOC). It is used to determine whether the NRC needs to focus additional attention on the particular voltage repair limit application. If the calculated conditional burst probability exceeds 1×10^{-2}, the licensee should notify the NRC according to the guidance in Section 6.

The second portion of the tube integrity evaluation is intended to ensure that the total leak rate from the affected SG during a postulated MSLB occurring at EOC would be less than a rate that could lead to radiological releases in excess of the licensing basis for the plant. If calculated leakage exceeds the allowable limit determined by the licensing basis dose calculation, licensees can either repair tubes, beginning with the largest voltage indications until the leak limit is met, reduce reactor coolant system specific iodine activity [refer to example technical specification (TS) pages of Attachment 2], or reduce the length of the operating cycle. The analyses discussed above may incorporate or reference previous analyses, or portions thereof, to the extent that they continue to bound the conditions of the SG as determined by inspection.

For plants in which the TS do not require the pressurizer power-operated relief valves (PORVs) to be operable during power operation, these tube integrity analyses should be conducted for an assumed differential pressure across the tube walls equal to the pressurizer safety valve setpoint plus 3 percent for the valve accumulation, less atmospheric pressure in faulted SGs. For plants in which the TS do require the PORVs to be operable, the assumed differential pressure for the conditional burst probability calculation may be based on the PORV setpoint in lieu of the safety valve setpoint with similar adjustments. The TS requirements for operation with PORV block valves closed due to leaking PORVs should be in accordance with Enclosure A of Generic Letter 90-06, "Resolution of Generic Issue 70, 'Power-Operated Relief Valve and Block Valve Reliability,' and Generic Issue 94, 'Additional Low-Temperature Overpressure Protection for Light-Water Reactors,' Pursuant to 10 CFR 50.54(f)." That is, electrical power to the block valves must be maintained to allow continued operation with the

block valves closed, as required in the sample technical specification Section 3.4.4 of GL 90-06.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance in Section 2.0.

Prior to each plant restart where voltage-based repair criteria will be implemented (beginning with 1R8 and 2R8), PG&E will perform a two-part evaluation to confirm that the SG tubes will retain adequate structural and leakage integrity until the next scheduled inspection.

- As discussed in Section 2.a, PG&E will perform a conditional burst probability calculation to assess the voltage distribution left in service against a threshold value of 1×10^{-2} probability of rupture under postulated end of cycle MSLB conditions. If the calculated conditional burst probability exceeds 1×10^{-2}, PG&E will notify the NRC according to the guidance in Section 6.

- As discussed in Section 2.b, PG&E will perform a leak rate calculation to ensure that the total leak rate from the affected SG during a postulated MSLB occurring at EOC will be less than a rate that could lead to radiological releases in excess of the DCPP licensing basis. If calculated leakage exceeds the allowable limit determined by the DCPP licensing basis dose calculation, PG&E will either repair tubes (beginning with the largest voltage indications until the leak limit is met), reduce reactor coolant system specific iodine activity (via a Technical Specification amendment), or reduce the length of the operating cycle.

DCPP TS 3/4.4.4 requires all three pressurizer power-operated relief valves (PORVs) and block valves to be operable during power operation. The DCPP TS requirements for operation with PORV block valves closed due to leaking PORVs are in accordance with Enclosure A of Generic Letter 90-06. That is, electrical power to the block valves are maintained to allow continued operation with the block valves closed, as required by GL 90-06. Therefore, as allowed by GL 95-05, the DCPP tube integrity analyses may be conducted using an assumed differential pressure across the tube walls equal to the pressurizer PORV setpoint (in lieu of the pressurizer safety valve setpoint), plus adjustments, less atmospheric pressure in faulted SGs. The highest PORV setpoint is 2335 psig.

However, for simplicity and consistent with other utility SG tube integrity analyses, PG&E intends to conduct the near term DCPP tube integrity analyses using an assumed differential pressure across the tube walls equal to the pressurizer safety valve setpoint plus 3 percent for valve accumulation, less atmospheric pressure in faulted SGs. This results in an assumed differential pressure following a MSLB of 2560 psig.

Should additional tube burst or leakage margin be required for future tube integrity analyses, PG&E may credit the pressurizer PORV to lower the differential pressure across the tube walls, as allowed by GL 95-05.

2.a Conditional Probability of Burst During an MSLB

For this generic letter, the conditional probability of burst refers to the probability that the burst pressures associated with one or more indications in the faulted SG will be less than the maximum pressure differential associated with a postulated MSLB assumed to occur at EOC. A methodology should be submitted for NRC approval for calculating this conditional burst probability. After the NRC approves a method for calculating conditional probability of burst, licensees may reference the approved method. This methodology should involve (1) determining the distribution of indications as a function of their voltage response at the beginning of cycle (BOC) as discussed in Section 2.b.1, (2) projecting this BOC distribution to an EOC voltage distribution based on consideration of voltage growth due to defect progression between inspections as discussed in Section 2.b.2(2) and voltage measurement uncertainty as discussed in Section 2.b.2(1), and (3) evaluating the conditional probability of burst for the projected EOC voltage distribution using the correlation between burst pressure and voltage discussed in Section 2.a.1. The solution methodology should account for uncertainties in voltage measurement [Section 2.b.2(1)], the distribution of potential voltage growth rates applicable to each indication [Section 2.b.2(2)], and the distribution of potential burst pressures as a function of voltage (Section 2.a.1). Monte Carlo simulations are an acceptable approach for accounting for these various sources of uncertainty.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance in Section 2.a.

A conditional probability of burst will be calculated for the projected EOC voltage distribution. The calculations will follow the Monte Carlo probabilistic methodology in WCAP-14277, Revision 1, "SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections." WCAP-14277 Revision 1 includes the methodology prescribed in Section 2.a and was recently submitted to the NRC Staff by American Electric Power (AEP) in support of voltage-based plugging criteria for Donald C. Cook Nuclear Plant Unit 1.

2.a.1 Burst Pressure Versus Bobbin Voltage

An empirical model, for 7/8-inch or 3/4-inch diameter tubing, as applicable, should be used to relate burst pressure to bobbin voltage response for purposes of estimating the conditional probability of burst during a postulated MSLB. The model should consider, at a minimum, the scale factors for the coordinate system (e.g., linear or logarithmic), the detection and treatment of outliers, the order of the regression equation, the

potential influence of measurement errors in the variables, and the evaluation of the residuals following the development of a relationship. This model should explicitly account for burst pressure uncertainty as indicated by scatter of the supporting test data and should also account for the parametric (i.e., slope and intercept) uncertainty of the regression fit of the data. Currently, an approved model consists of determining a linear first-order equation between the burst pressure and the logarithm (base 10) of the bobbin voltage amplitude with standard least-squares linear regression analysis. The model may need to be changed as additional information is acquired; however, such changes should be submitted to the NRC staff for approval. The supporting data sets for 7/8-inch diameter and 3/4-inch diameter tubing should contain all applicable data consistent with the latest revision of the industry data base as approved by the NRC. The currently approved data base for burst pressure as a function of voltage is given in Reference 7, as supplemented by References 1 and 2.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 2.a.1.

The empirical model for 7/8-inch diameter tubing provided in WCAP-14277 Revision 1 will be used to relate burst pressure to bobbin voltage response for purposes of estimating the conditional probability of burst during a postulated MSLB. The supporting data sets for 7/8 inch diameter tubing will contain all applicable data consistent with the latest revision of the industry database approved by the NRC. The most current revision of the database has been submitted to the NRC for approval. (EPRI Topical Report NP-7480-L, Addendum 1, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates Database for Alternate Repair Limits, 1996 Database Update," Final Report November 1996.)

2.a.2 Determination of the Upper Voltage Repair Limit for TSP Intersections

From the regression relationship (discussed above in Section 2.a.1), a lower 95-percent prediction bound should be determined for the burst pressure as a function of bobbin voltage amplitude. The lower 95-percent prediction interval is further reduced to account for the lower 95/95-percent tolerance bound for tubing material properties at 650°F. Using this reduced lower prediction bound curve, the structural limit is determined for a free span burst pressure of 1.4 times MSLB differential pressure (DP_{MSLB}) consistent with the structural limits in RG 1.121.

To determine the upper voltage repair limit, the structural limit is reduced to account for flaw growth and voltage measurement uncertainty. The method for determining the flaw growth allowance is discussed in Section 2.b.2(2) and should be a plant-specific average growth rate or 30-percent per effective full power year (EFPY), whichever is larger. The voltage measurement uncertainty allowance should be the 95-percent cumulative probability value for the voltage measurement uncertainty models. Eddy

current voltage measurement uncertainty is discussed in Section 2.b.2(1). Currently the 95-percent cumulative probability value is 20 percent of the BOC voltage amplitude. The upper voltage repair limit should be determined prior to each outage, using the most recently approved NRC data base.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 2.a.2.

From the regression relationship using the latest revision of the industry database approved by the NRC, a lower 95-percent prediction bound will be determined for the burst pressure as a function of bobbin voltage amplitude. The lower 95-percent prediction interval will be further reduced to account for the lower 95/95-percent tolerance bound for tubing material properties at 650 °F. Using this reduced lower prediction bound curve, the structural limit will be determined for a free span burst pressure of 1.4 times MSLB differential pressure (ΔP_{MSLB}) consistent with the structural limits in RG 1.121.

Based on the latest revision of the industry database (Figure 6-9 of EPRI NP 7480-L Addendum 1), and assuming NRC approval of this database, the DCPP SG tubing structural limit is 8.7 volts for a free span burst pressure of 3657 psid (i.e., 1.4 ΔP_{MSLB}).

The upper voltage repair limit will be determined prior to each outage, using the latest revision of the industry database approved by the NRC. To determine the upper voltage repair limit, the structural limit will be reduced to account for flaw growth and voltage measurement NDE uncertainty, according to the following equations:

$$V_{URL} = V_{SL} - V_{Gr} - V_{NDE}$$

or

$$V_{URL} = 8.7 \text{ volts} - (\text{Growth})(V_{URL}) - (\text{NDE})(V_{URL})$$

or

$$V_{URL} = 8.7 \text{ volts divided by } (1 + \text{Growth} + \text{NDE})$$

- As specified by the GL, the flaw growth allowance will be either a DCPP unit-specific average growth rate or 30-percent per effective full power year (EFPY), whichever is larger. Currently, there is insufficient DCPP unit-specific growth data (only 16 Unit 1 and 80 Unit 2 ODSCC indications have been identified and plugged to date). As a result, DCPP will use a flaw growth allowance of 30 percent per EFPY. For 21 month cycles (1.75 EFPY), starting in Unit 2 Cycle 8 and Unit 1 Cycle 9, the growth allowance is (1.75)(0.30), which equals 52.5 percent.

- The voltage measurement uncertainty allowance will be the 95-percent cumulative probability value for the voltage measurement uncertainty models. Currently, as

specified by the GL, the 95-percent cumulative probability value is 20 percent of the BOC voltage amplitude.

Therefore, starting with 1R8 and 2R8, the upper voltage repair limit is calculated as follows:

$$V_{URL} = 8.7 \text{ volts divided by } (1 + 0.525 + 0.20) = 5.0 \text{ volts}$$

2.a.3 Determination of the Upper Voltage Repair Limit for Flow Distribution Baffle Plate Intersections

DCPP Units 1 and 2 Compliance

Section 2.a.3 is not applicable to DCPP because the SGs do not have flow distribution baffle plates.

2.b Total Leak Rate During MSLB

A leak rate methodology is approved in Reference 8 and is described in Reference 9. Licensees may reference the approved method. The leak rate methodology involves (1) determining the distribution of indications as a function of their voltage response at BOC as discussed in Section 2.b.1, (2) projecting this BOC distribution to an EOC voltage distribution based on consideration of voltage growth due to defect progression between inspections as discussed in Section 2.b.2(2) and voltage measurement uncertainty as discussed in Section 2.b.2(1), and (3) evaluating the total leak rate for the projected EOC voltage distribution using a probability of leakage (POL) model, as discussed in Section 2.b.3(1), and the conditional leak rate model, as discussed in Section 2.b.3(2). The solution methodology should account for uncertainties in voltage measurement [Section 2.b.2(1)], the distribution of potential voltage growth rates applicable to each indication [Section 2.b.2(2)], the uncertainties in the probability of leakage as a function of voltage [Section 2.b.3(1)], and the distribution of potential conditional leak rates as a function of voltage [Section 2.b.3(2)]. Monte Carlo simulations are an acceptable method for accounting for these sources of uncertainty, provided that the calculated total leak rate reflects an upper 95-percent quartile value at an upper 95-percent confidence bound.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 2.b.

The calculations of MSLB leakage will follow the Monte Carlo probabilistic methodology provided in WCAP-14277, Revision 1.

2.b.1 Distribution of Bobbin Indications as a Function of Voltage at BOC

The frequency distribution by voltage of bobbin indications actually found during inspection should be scaled upward by a factor of 1/POD to account for non-detected cracks which can potentially leak or rupture under postulated MSLB conditions during the next operating cycle. This adjusted frequency distribution minus detected indications for tubes that have been plugged or repaired should constitute, for purposes of the tube integrity analyses, the assumed frequency distribution of bobbin indications at BOC as a function of voltage. This can also be expressed as

$$N_I = (1/POD)(N_d) - N_r$$

where:

N_I = *assumed frequency distribution of bobbin indications*
N_d = *frequency distribution of indications actually detected*
N_r = *frequency distribution of repaired indications*
POD = *probability of detection of ODSCC flaws*

POD should be assumed to have a value of 0.6, or as an alternative, an NRC-approved POD function can be used, if such a function becomes available.

N_d includes all flaw indications detected by the bobbin coil, regardless of whether these indications are confirmed by rotating pancake coil (RPC) inspection. Alternatively, a fraction of bobbin indications at locations which have been inspected with an RPC probe, but where the RPC failed to confirm the bobbin indication, may be excluded from N_d subject to NRC approval.

If the steam generators have been chemically cleaned, the impact of the chemical cleaning on the BOC voltage distribution needs to be evaluated.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 2.b.1, with clarification regarding probability of detection.

For purposes of the tube integrity analyses, the assumed frequency distribution of bobbin indications at BOC as a function of voltage will be expressed as

$$N_I = (1/POD)(N_d) - N_r$$

where:

N_I = assumed frequency distribution of bobbin indications

N_d = frequency distribution of indications actually detected
N_r = frequency distribution of repaired indications
POD = probability of detection of ODSCC flaws

As an alternative to using a very conservative constant POD value of 0.6, PG&E requests the use of a more realistic POD. This more realistic POD is a function of voltage and is referred to as Probability of Prior Cycle Detection (POPCD). Use of POPCD is recommended in EPRI Topical Report NP 7480-L, Addendum 1, and the industry has previously requested that the NRC review and approve the use of POPCD. The current POPCD values as a function of voltage are listed under the "Recommended POD" column in Table 7-4 of EPRI NP 7480-L, Addendum 1. PG&E requests that the NRC approve the use of the POPCD for DCPP Units 1 and 2. If this request cannot be granted, then PG&E will use a POD of 0.6.

N_d will include all flaw indications detected by the bobbin coil, regardless of whether these indications are confirmed by rotating pancake coil (RPC) inspection. At this time, PG&E does not have a plant-specific adjustment factor for excluding those bobbin calls that were inspected by RPC and were determined to be NDD. The development and usage of such an adjustment factor for use in future inspections at DCPP (after 1R8 and 2R8) will be submitted after enough plant-specific inspection data becomes available.

The DCPP steam generators have not been chemically cleaned. If they are chemically cleaned in the future, the impact of the chemical cleaning on the BOC voltage distribution will be evaluated.

2.b.2 Projected End-of-Cycle (EOC) Voltage Distribution

As discussed above, the calculation of both conditional burst probability and leakage (during a postulated MSLB) requires the generation of the projected EOC voltage distribution. To project an EOC voltage distribution from the BOC voltage distribution determined above, requires consideration of (1) eddy current voltage measurement uncertainty and (2) the addition of voltage growth to account for defect progression. Monte Carlo techniques are an acceptable means for sampling eddy current measurement uncertainty and the voltage growth distribution to determine the projected EOC voltage distribution. Eddy current measurement uncertainty and voltage growth are discussed below.

2.b.2(1) Eddy Current Voltage Measurement Uncertainty

Uncertainty in eddy current voltage measurements stems primarily from two sources:

- *voltage response variability (i.e., test repeatability error) which stems primarily from probe wear*

- *voltage measurement variability among data analysts (i.e., measurement repeatability error)*

Each of these uncertainties should be quantified. An acceptable characterization of these uncertainties is contained in EPRI TR-100407, Revision 1, Draft Report August 1993, "PWR Steam Generator Tube Repair Limits-Technical Support Document for Outside Diameter Stress Corrosion Cracking at the Tube Support Plates" (Reference 3), Sections 2.4.1, 2.4.2, and D.4.2.3, with the exception that no distribution cutoff should be applied to the voltage measurement variability distribution. (However, the assumed 15 percent cutoff for the voltage response variability distribution in Reference 3 is acceptable.)

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 2.b.2(1).

An EOC voltage distribution will be projected based on the BOC voltage distribution, considering (1) eddy current voltage measurement uncertainty and (2) the addition of voltage growth to account for defect progression. Monte Carlo techniques will be used to sample the eddy current measurement uncertainty and the voltage growth distribution to determine the projected EOC voltage distribution. Test repeatability error and measurement repeatability error will be quantified in accordance with EPRI TR-100407, Revision 1 (Draft Report August 1993) and WCAP-14277, Revision 1. No distribution cutoff will be applied to the voltage measurement variability distribution. A 15 percent distribution cutoff will be applied to the voltage response variability distribution.

2.b.2(2) Voltage Growth Due to Defect Progression

Potential voltage growth rates during the next inspection cycle (i.e., operating cycle between two scheduled SG inspections) should be based on voltage growth rates observed during the last one or two inspection cycles. For a given inspection, previous inspection results at tube-to-TSP intersections currently exhibiting a bobbin indication should be evaluated consistent with the data analysis guidelines in Section 3 below. In cases in which data acquisition guidelines employed during previous inspections differ from those discussed in Section 3, the evaluation of the previous data should be adjusted to compensate for the difference. Voltage growth rates should only be evaluated for those intersections at which bobbin indications can be identified at two successive inspections, except if an indication changes from non-detectable to a relatively high voltage (e.g., 2.0 volts).

The distribution of voltage growth rates (based on the change in voltage on an intersection-to-intersection basis) should be determined for each of the last one or two inspection cycles. When only the current or only the current and previous inspections

employed data acquisition guidelines similar to those discussed in Section 3, only the growth rate distribution for the previous cycle should be used to estimate the voltage growth rate distribution for the next inspection cycle. If both of the two previous inspections employed such similar guidelines, the most limiting of the two previous growth rate distributions should be used to estimate the voltage growth rate distribution for the next inspection cycle. However, the two distributions should be combined if one or both of the distributions is based on a minimal number (i.e., < 200) of indications. If the growth rate distribution, or combined distribution from two cycles, consists of fewer than 200 indications, a bounding probability distribution function of growth rates should be used based on consideration of experience to date at similarly designed and operated units.

It is acceptable to use a statistical model fit of the observed growth rate distribution as part of the tube integrity analysis provided that the statistical model conservatively accounts for the tail of the distribution. It is also acceptable that the voltage growth distribution be in terms of D volts rather than percent D volts, provided the conservatism of this approach continues to be supported by operating experience. For the purposes of assessing the conditional probability of burst and conditional leak rate, negative growth rates should be included as zero growth rates in the assumed growth rate distribution. However, for the purposes of determining the upper voltage repair limit in accordance with Sections 2.a.2 and 2.a.3, it is appropriate to consider negative growth rates as part of the estimate for average growth rate.

If the steam generators have been chemically cleaned, the impact of the chemical cleaning on voltage growth rates needs to be evaluated.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 2.b.2(2).

Following implementation of voltage-based repair criteria, potential voltage growth rates during the next inspection cycle will be based on voltage growth rates observed during the last one or two inspection cycles. For a given inspection, previous inspection results at tube-to-TSP intersections currently exhibiting a bobbin indication will be re-evaluated consistent with the data analysis guidelines in Section 3. In cases in which data acquisition and analysis guidelines employed during previous inspections differ from those discussed in Section 3, the evaluation of the previous data will be adjusted to compensate for the difference. Voltage growth rates will only be evaluated for those intersections at which bobbin indications can be identified at two successive inspections, except if an indication changes from non-detectable to a relatively high voltage (e.g., 2.0 volts).

A bounding distribution of voltage growth rates will be determined for each of the last one or two inspection cycles. When only the current or only the current and previous

inspections employed data acquisition guidelines similar to those in Section 3, only the growth rate distribution for the previous cycle will be used to estimate the voltage growth rate distribution expected for the next inspection cycle. If both of the two previous inspections employed such similar guidelines, the most limiting of the two previous growth rate distributions will be used to estimate the voltage growth rate distribution for the next inspection cycle. The two distributions will be combined if one or both of the distributions is based on a minimal number (i.e., < 200) of indications. If the growth rate distribution, or combined distribution from two cycles, consists of fewer than 200 indications, a bounding probability distribution function of growth rates will be used based on consideration of experience to date at Model 51 SGs with 7/8 inch diameter tubing.

The statistical model fit of the observed growth rate distribution will conservatively account for the tail of the distribution. The voltage growth distribution may be in terms of delta volts rather than percent delta volts. For the purposes of assessing the conditional probability of burst and conditional leak rate, negative growth rates will be included as zero growth rates in the assumed growth rate distribution. For the purposes of determining the upper voltage repair limit, negative growth rates will be considered as part of the estimate for average growth rate.

The steam generators have not been chemically cleaned. If they are chemically cleaned in the future, the impact of the chemical cleaning on voltage growth rates will be evaluated.

2.b.3 Calculation of Projected MSLB Leakage

Once the projected EOC voltage distribution is determined, the leakage for the postulated MSLB is calculated utilizing the EOC voltage distribution and the use of two models: (1) the probability of leakage model and (2) the conditional leak rate model. As previously discussed in Section 2.b, Monte Carlo techniques are an acceptable approach for accounting for the uncertainties implicit in these models. These models are discussed below.

2.b.3(1) Probability of Leakage as a Function of Voltage

An empirical model, for 7/8-inch and 3/4-inch diameter tubing as applicable, should be used to relate the probability of leakage (POL) to the bobbin voltage response. This model should explicitly account for parameter uncertainty of the POL functional fit of the data (i.e., "model fit" uncertainty). Currently, the staff has approved a model which uses a log-logistic function to fit the data. This model may need to be changed as additional leakage data is acquired. Revisions to this model should be submitted to the NRC for review and approval.

The supporting data sets for 2.2-cm (7/8-inch) diameter and 1.9-cm (3/4-inch) diameter tubing should include all applicable data consistent with the latest revision of the industry data base as approved by the NRC. The currently approved data base for POL as a function of voltage is given in Reference 7, as supplemented by References 1 and 2.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 2.b.3(1).

The empirical model for 7/8-inch diameter tubing provided in WCAP-14277 Revision 1 will be used to relate the probability of leakage (POL) to the bobbin voltage response. Monte Carlo methodology will be used. The model will account for parameter uncertainty of the POL functional fit of the data. The model uses a log-logistic function to fit the data.

The supporting data sets for 7/8-inch diameter tubing will include all applicable data consistent with the latest revision of the industry database approved by the NRC. The latest database for POL is contained in EPRI NP 7480-L, Addendum 1, which has been submitted to the NRC for approval.

2.b.3(2) Conditional Leakage Rate under MSLB Conditions

An empirical model, for 7/8-inch or 3/4-inch diameter tubing as applicable, should be used to relate the conditional leak rate to the bobbin voltage response. This empirical model should account for both data scatter and parameter uncertainty of the empirical fit. Currently, an approved model consists of determining a linear first-order equation between the logarithm (base 10) of the conditional leak rate and the logarithm (base 10) of the bobbin voltage amplitude with standard least-squares linear regression analysis. The model may need to be changed as additional information is acquired; such changes should be submitted to the NRC staff for review and approval.

Use of the linear regression fit of the logarithm of the conditional leak rate to the logarithm of the bobbin voltage is subject to demonstrating that the linear regression fit is valid at the 5-percent level with a "p-value" test. If this condition is not satisfied, the linear regression fit should be assumed to have zero slope (i.e., the linear regression fit should be assumed to be constant with voltage).

The supporting data sets for 2.2-cm (7/8-inch) diameter and 1.9-cm (3/4-inch) diameter tubing should include all applicable data consistent with the latest revision of the industry data base as approved by the NRC. The currently approved data base for conditional leak rate as a function of voltage is given in Reference 7, as supplemented by References 1 and 2, with certain exceptions. Specifically, data excluded under criteria 3a, 3b, and 3c in References 1 and 2 should not be excluded pending NRC

review and approval of these criteria. In addition, an MSLB leak rate of 2496 liters per hour should be utilized for the data point obtained from V. C. Summer tube R28C41, pending staff review and approval of any proposed alternative estimate.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 2.b.3(2).

The empirical model for 7/8-inch diameter tubing provided in WCAP-14277 Revision 1 will be used to relate the conditional leak rate to the bobbin voltage response. Monte Carlo methodology will be used. The model will account for both data scatter and parameter uncertainty of the empirical fit. The model consists of determining a linear first-order equation between the logarithm (base 10) of the conditional leak rate and the logarithm (base 10) of the bobbin voltage amplitude with standard least-squares linear regression analysis.

The supporting data sets for 7/8-inch diameter tubing will include all applicable data consistent with the latest revision of the industry database. The latest database for conditional leak rate as a function of voltage is contained in EPRI NP 7480-L Addendum 1.

2.b.4 Calculation of Offsite and Control Room Doses

For the MSLB leak rate calculated above, offsite and control room doses should be calculated utilizing currently accepted licensing basis assumptions. Licensees should note that Attachment 2 to this generic letter provides example TS pages for reducing reactor coolant system specific iodine activity limits. Licensees who wish to take credit for reduced reactor coolant system iodine activities (below 0.35 microcuries per gram dose equivalent I-131) in the radiological dose calculation should provide a justification supporting the request that evaluates the release rate data described in Reference 6. Reduction of reactor coolant iodine activity is an acceptable means for accepting higher projected leakage rates and still meeting the applicable limits of Title 10 of the Code of Federal Regulations Part 100 and GDC 19 utilizing licensing basis assumptions.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 2.b.4.

Following each inspection where voltage-based repair criteria were implemented, the projected EOC conditional leak rate calculated in accordance with Section 2.b.3(2) above will be compared to the allowable leak rate limit to ensure that a postulated MSLB occurring at EOC would result in radiological consequences that are within the dose limits of 10 CFR 100 and GDC 19. If the calculated EOC leakage exceeds the allowable limit, PG&E will either repair tubes, beginning with the largest voltage

indications until the leak limit is met, reduce reactor coolant system specific iodine activity (via submittal of an LAR), or reduce the length of the operating cycle.

PG&E has calculated that the maximum allowable primary-to-secondary leak rate in the SG in the faulted loop for a MSLB accident is 12.8 gpm. This allowable leak rate is based on performance of a radiological dose analysis using currently accepted licensing basis assumptions that demonstrate that DCPP Units 1 and 2 are within the acceptance criteria of GDC 19 for the control room and 10 CFR 100 for the exclusion area boundary (EAB) and low population zone (LPZ) in the event of a MSLB accident. This bounding leak rate limit uses the DCPP TS allowable RCS iodine activity level of 1.0 microcuries per gram dose equivalent I-131 and the recommended Iodine-131 transient spiking values consistent with NUREG-0800 (NRC Standard Review Plan 15.1.5). Detailed input parameters and results of the dose analysis are provided in Section 8 of this Attachment.

2.c Alternative Tube Integrity Calculation

As discussed above, licensees should calculate (1) primary-to-secondary leakage under postulated accident conditions and (2) conditional probability of burst given an MSLB, to confirm that the SG will retain adequate structural and leakage integrity until the next scheduled SG inspection. Section 6 of this attachment contains reporting guidance that recommends that licensees notify the staff prior to returning the SGs to service when conditional burst probability exceeds 1 x 10^{-2} or when calculated accident leakage exceeds the licensing limit. These calculations are to be performed using the projected EOC voltage distribution; however, it may not always be practical to complete these calculations prior to returning the SGs to service. Under these circumstances, it is acceptable to use the actual measured bobbin voltage distribution instead of the projected EOC voltage distribution to determine whether the reporting criteria in Section 6 of this guidance are satisfied. The actual measured bobbin voltage distribution should contain all bobbin indications detected, regardless of whether the RPC probe confirmed the degradation to be present and the NDE uncertainty distribution should be sampled. The postulated accident leakage and the conditional probability of burst should be calculated in accordance with Sections 2.a. and 2.b.3 of this attachment. This calculation is intended to assess whether the SGs can be returned to service and the plant can be operated until the full assessment (submitted within 90 days of restart) from the projected EOC voltage distribution is performed.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 2.c.

In the event that growth rate determinations cannot be completed prior to returning the SGs to service, an alternative tube integrity calculation will be performed based on the actual measured bobbin voltage distribution instead of the projected EOC voltage

distribution to determine whether the reporting criteria in Section 6 are satisfied. The actual measured bobbin voltage distribution will contain all bobbin indications detected, regardless of whether the RPC probe confirmed the degradation to be present, and the NDE uncertainty distribution will be sampled. The postulated accident leakage and the conditional probability of burst will be calculated in accordance with the Monte Carlo methodology of WCAP-14277 Revision 1. This calculation will be used to assess whether the SGs can be returned to service and the plant can be operated until the full assessment from the projected EOC voltage distribution is performed, which will be submitted within 90 days of restart.

3.0 Inspection Criteria

The inspection scope, data acquisition, and data analysis should be performed in a manner consistent with the methodology utilized to develop the voltage limits (e.g., the methodology described in Reference 4, Appendix A, and Reference 5, Appendix A) with the exceptions and clarifications noted below.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 3.

The inspection scope, data acquisition, and data analysis will be performed in a manner consistent with the methodology utilized to develop the voltage limits. Subject to the exceptions and clarifications noted below, PG&E will conform to the NDE data acquisition and analysis guidelines described in Appendix A to WCAP-12985, Revision 1, "Kewaunee Steam Generator Tube Plugging Criteria for ODSCC at Tube Support Plates."

3.a Bobbin Coil Inspection Scope and Sampling

The bobbin coil inspection should include 100 percent of the hot-leg TSP intersections and cold-leg intersections down to the lowest cold-leg TSP with known ODSCC. The determination of TSPs having ODSCC should be based on the performance of at least a 20-percent random sampling of tubes inspected over their full length.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 3.a.

The bobbin coil inspection will include 100 percent of the hot-leg and cold-leg TSP intersections down to the lowest cold-leg TSP with known ODSCC. The determination of TSPs having ODSCC will be based on the performance of at least a 20-percent random sampling of tubes inspected over their full length.

It is PG&E's standard practice to inspect each TSP intersection (hot and cold leg) with bobbin coil each cycle, thereby bounding the above inspection requirements.

3.b Rotating Pancake Coil (RPC) Inspection

RPC inspections should be conducted as discussed below for purposes of obtaining additional characterization of ODSCC flaws found with the bobbin probe and to inspect intersections with significant bobbin interference signals (due to copper, dents, large mix residuals) which may impair the detectability of degradation with the bobbin probe or which may unduly influence the bobbin voltage measurement. With respect to ODSCC flaw characterization, a key purpose of the RPC inspections is to ensure the absence of detectable crack-like circumferential indications and detectable indications extending outside the thickness of the TSP. The voltage-based repair criteria are not applicable to intersections exhibiting such indications, and special reporting requirements pertaining to the finding of such indications are described in Section 6.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 3.b.

RPC inspections will be conducted as discussed below for purposes of obtaining additional characterization of ODSCC flaws found with the bobbin probe and to inspect intersections with significant bobbin interference signals which may impair the detectability of degradation with the bobbin probe or which may unduly influence the bobbin voltage measurement. Key purposes of the RPC inspections are to ensure the absence of detectable PWSCC, circumferential indications, and detectable indications extending outside the thickness of the TSP. The voltage-based repair criteria are not applicable to intersections exhibiting such indications, and special reporting requirements pertaining to the finding of such indications are described in Section 6.

In lieu of the specific RPC standard requirements described in Appendix A to WCAP-12985, Revision 1, PG&E will use RPC standards that have EDM notches qualified to Appendix H of the EPRI PWR Steam Generator Examination Guidelines for detection of degradation specific to the DCPP steam generators.

In this technical support document and associated Technical Specifications, use of the term rotating pancake coil (RPC) includes the use of comparable or improved nondestructive examination techniques (such as the Plus Point rotating coil), consistent with Note 1 on page 3 of GL 95-05.

3.b.1 RPC inspection should be performed for all indications exceeding 2.0 volts as measured by bobbin coil for 2.2-cm [7/8-inch] diameter tubes or 1.0 volt as measured by bobbin coil for 1.9-cm [3/4-inch] diameter tubes.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.b.1.
RPC probes will be used to inspect all indications exceeding 2.0 volts as measured by bobbin coil. In addition, as described in Section 3.b.3.ii) below, PG&E will RPC inspect all less than 5 volt dented intersections having bobbin indications that could remain in service under voltage based repair criteria.

3.b.2 All intersections with interfering signals from copper deposits should be inspected with RPC. Any indications found at such intersections with RPC should cause the tube to be repaired.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance in Section 3.b.2.

All intersections with interfering signals from copper deposits will be inspected with RPC. Any indications found at such intersections with RPC will cause the tube to be repaired.

3.b.3 'All intersections with dent signals greater than 5 volts should be inspected with RPC. Any indications found at such intersections with RPC should cause the tube to be repaired. If circumferential cracking or primary water stress corrosion cracking indications are detected, it may be necessary to expand the RPC sampling plan to include dents less than 5.0 volts.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.b.3, with alternatives described below.

i) Greater than or Equal to 5 Volt Dented Intersections

A large number of intersections with dent signals greater than or equal to 5 volts exist in the SGs in DCPP Units 1 and 2: approximately 2,085 dented intersections in Unit 1 and 576 dented intersections in Unit 2 (Tables 1 and 3). For Unit 2, PG&E will inspect 100 percent of dented intersections greater than or equal to 5 volts in accordance with the guidance contained in Section 3.b.3. However, because of the very large population of greater than or equal to 5 volt dented intersections in Unit 1, PG&E is proposing an alternative to the guidance contained in Section 3.b.3 for Unit 1 only. Rather than RPC inspecting all intersections with dent signals greater than 5 volts as recommended in Section 3.b.3, PG&E will focus on inspecting dents at the lower hot leg TSP intersections where PWSCC indications have been previously detected.

PG&E's dent inspection plan is predicated on the experience-based conclusion that temperature is a greater contributor to PWSCC than high stress level. Based on RPC inspections of dented intersections (hot leg only) conducted in 1R6 and 1R7 for Unit 1 and 2R5, 2R6, and 2R7 for Unit 2, 85 percent of the combined Unit 1 and Unit 2 PWSCC indications have been located at either 1H and 2H (Tables 5 and 6). The 2R6 and 2R7 inspections included 100 percent of the greater than or equal to 5 volt dents. The 1R6 inspections included 20 percent of the greater than or equal to 5 volt dents using the following selection criteria: (a) dents were selected for inspection from 1H (higher temperature) through 7H (lower temperature) to provide a representative distribution of dented intersections; (b) dents with higher voltages (i.e., larger dents with potentially higher stress levels) were selected for inspection over those with lower voltages. The 1R7 inspections included 100 percent of the greater than or equal to 5 volt dents from 1H through 3H.

For future inspections, the Unit 1 initial sampling plan for greater than or equal to 5 volt dented intersections is as follows:

- In each Unit 1 SG, PG&E will RPC inspect 100 percent of the greater than or equal to 5 volt hot leg dented intersections up to and including the highest TSP where PWSCC or circumferential cracking indications has been previously detected in any Unit 1 SG. To date, the highest hot leg TSP where PWSCC has been detected in Unit 1 is 4H.

The Unit 1 expansion plan for greater than or equal to 5 volt dented intersections is as follows:

- If, at the highest TSP inspected, PWSCC or circumferential cracking indications are identified at greater than or equal to 5 volt dented intersections, then, in the affected SG, PG&E will RPC inspect 20 percent of the greater than or equal to 5 volt dented intersections at the next highest TSP to bound the problem. If PWSCC or circumferential cracking indications are subsequently found in the 20 percent sample, PG&E will inspect 100 percent of the greater than or equal to 5 volt dented intersections at that TSP and 20 percent of the greater than or equal to 5 volt dented intersections at the next highest TSP to bound the problem. This step-wise expansion will be continued until no further PWSCC or circumferential cracking indications are detected in greater than or equal to 5 volt dented intersections.

ii) Less than 5 Volt Dented Intersections

A very large number of intersections with dent signals less than 5 volts exist in the DCPP Units 1 and 2 SGs: approximately 11,959 intersections in Unit 1 and at least 4,933 intersections in Unit 2. If PWSCC or circumferential cracking indications are detected at dented intersections, Section 3.b.3 recommends an expansion of the RPC

sampling plan to include dents less than 5 volts. To meet this recommendation, the following policy will be implemented on Units 1 and 2:

PG&E will RPC inspect all less than 5 volt dented intersections having bobbin indications that could remain in service under voltage-based repair criteria. If this RPC inspection identifies PWSCC or circumferential cracking indications, then the tube will be repaired. The purpose of this RPC inspection is to verify that voltage-based repair criteria will not be applied to tubes containing either PWSCC or circumferential cracks at TSP intersections because the repair criteria in GL 95-05 apply only to predominately axially oriented cracks caused by ODSCC.

iii) Augmented Inspection Program to Detect PWSCC in Less than 5 Volt Dented Intersections

PWSCC (axial and circumferential) indications at dented TSP intersections have been previously detected in the DCPP Units 1 and 2 SGs. PWSCC axial indications have been found at less than 5 volt dented intersections. Based on this experience, PG&E has an augmented inspection program in place to detect PWSCC at less than 5 volt dented TSP intersections. (For example, PG&E's augmented inspection program planned for 1R8 includes RPC inspection of 100 percent of the less than 5 volt dented intersections from 1H to 4H, plus 20 percent at 5H.) This augmented inspection program supplements the GL 95-05 inspection program described in i) and ii) above. Both of the programs are experienced-based. However, the scope of the augmented PWSCC inspection program may change as experience and technology evolves and is not governed by voltage-based repair criteria. Therefore, the augmented program may be revised at PG&E's discretion.

iv) Summary of Repair Criteria for Degradation at Dented Intersections

ODSCC indications found with RPC at greater than 5 volt dented TSP intersections will cause the tube to be repaired, as required by GL 95-05. PWSCC indications found by RPC at any dented TSP intersection will cause the tube to be repaired, as GL 95-05 repair criteria do not apply to PWSCC degradation.

3.b.4 All intersections with large mixed residuals should be inspected with RPC. For purposes of this guidance, large mixed residuals are those that could cause a 1.0 volt bobbin signal to be missed or misread. Any indications found at such intersections with RPC should cause the tube to be repaired.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 3.b.4.

Intersections with large mixed residuals will be inspected with RPC. Large mixed residuals are those that could cause a 1.0 volt bobbin signal to be missed or misread. Any indications found at such intersections with RPC will cause the tube to be repaired.

3.c Data Acquisition and Analysis

3.c.1 The bobbin coil should be calibrated against the reference standard used in the laboratory as part of the development of the voltage-based approach by direct testing or through use of a transfer standard.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.c.1.

The bobbin coil will be calibrated against the reference standard used in the laboratory as part of the development of the voltage-based approach by direct testing or through use of a transfer standard.

3.c.2 Once the probe has been calibrated on the 20-percent through-wall holes, the voltage response of new bobbin coil probes for the 40-percent to 100-percent American Society of Mechanical Engineers (ASME) through-wall holes should not differ from the nominal voltage by more than ± 10 percent.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.c.2.

Once the probe has been calibrated on the 20-percent through-wall holes, the voltage response of new bobbin coil probes for the 40-percent to 100-percent American Society of Mechanical Engineers (ASME) through-wall holes will not differ from the nominal voltage by more than ± 10 percent.

PG&E will implement the industry methodology for meeting the ± 10 percent new probe variability criteria. This methodology is documented in NEI letter to the NRC dated January 23, 1996 (New Probe Variability for Use in the ODSCC Alternate Repair Criteria), as supplemented in NEI letter to the NRC dated October 15, 1996. The methodology requires, in part, that the voltage response of a new probe at both the primary and mix frequencies be compared to the nominal response determined by the vendor to ensure that the new probe is within ± 10 percent of the nominal response.

3.c.3 Probe wear should be controlled by either an inline measurement device or through the use of a periodic wear measurement. When utilizing the periodic wear measurement approach, if a probe is found to be out of specification, all tubes inspected since the last successful calibration should be reinspected with the new

calibrated probe. Alternatives to this approach, which provide equivalent detection and sizing and are consistent with the tube integrity analyses discussed in Section 2, may be permitted subject to NRC approval.

DCPP Units 1 and 2 Compliance

As an alternative to the probe wear criteria recommended in Section 3.c.3, PG&E will follow the probe wear criteria provided in NEI letter to the NRC dated January 23, 1996 (Eddy Current Probe Replacement Criteria for use in ODSCC Alternate Repair Criteria). This alternate criteria was approved in NRC letter to NEI dated February 9, 1996. The probe wear criteria is discussed below.

Monitoring of probe wear using a wear standard will follow normal industry practice associated with probe calibration requirements and frequency. Normal field practice involves applying the ASME standard at each reel change, at each probe change due to application of probe rejection criteria, or after 4 hours of service for a given probe. If the probe does not satisfy the voltage variability criterion for wear of ± 15 percent, all locations which exhibited flaw signals with amplitudes greater than or equal to 75 percent of the repair voltage limit will be re-examined with a new, acceptable probe. The signal amplitudes obtained with the new probe will be those used in the alternate repair criteria methodology.

In order to use the alternate probe wear criteria, PG&E will implement the following requirements as requested in NRC letter dated February 9, 1996.

1. The 90-day report will provide a comparison between the actual and projected EOC distributions. If any significant differences exist (e.g., number of indications, size of largest indication, distribution of indications, etc.) the root cause will be evaluated and reported to the NRC. The effects of probe wear will be explicitly considered in this evaluation. If probe wear is determined to be one of the factors for the difference, actions will be taken to prevent recurrence.

2. Actions will be taken to minimize the potential for tubes to be inspected with probes that fail the probe wear check. Probes that fail the probe wear check during an inspection will be replaced immediately.

3. All tubes with indications above 1.5 volts (i.e., 75 percent of the 2.0 volt repair limit) that were inspected with a probe that failed the probe wear check will be reinspected with a good probe over the length of the tube inspected by the worn probe. All of the eddy current data from the good probe will be evaluated. If a large indication (greater than approximately 1.5 volts) is detected which was previously missed with the failed probe, an assessment of the significance will be performed during the outage. The assessment will address the need to reinspect

tubes which were inspected using a worn probe. This assessment, along with a description of the actions taken, will be provided to the NRC in the 90-day report.

4. An evaluation will be included in the 90-day report if "large" indications and/or a non-proportionate number of new indications are detected in tubes which were inspected with a probe that failed the probe wear check. The evaluation will address whether or not a more restrictive probe wear criteria is needed.

5. Data acquired during the outage will be continuously monitored and evaluated to ensure the adequacy of the 75 percent criteria. If an indication is resized during the reinspection and is significantly larger than its previous voltage, an evaluation will be provided in the 90-day report.

3.c.4 Data analysts should be trained and qualified in the use of the analyst's guidelines and procedures. Data analyst performance should be consistent with the assumptions for analyst measurement variability [Section 2.b.2(1)] utilized in the tube integrity evaluation (Section 2).

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.c.4.

Data analysts will be trained and qualified in the use of the analysis guidelines and procedures. Data analyst performance will be consistent with the assumptions for analyst measurement variability utilized in the tube integrity evaluation.

3.c.5 Quantitative noise criteria (resulting from electrical noise, tube noise, calibration standard noise) should be included in the data analysis procedures. Data failing to meet these criteria should be rejected, and the tube should be reinspected.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.c.5.

Quantitative noise criteria (resulting from electrical noise, tube noise, calibration standard noise) will be included in the data analysis procedures. Data failing to meet these criteria will be rejected and the tube will be reinspected.

3.c.6 Data analysts should review the mixed residuals on the standard itself and take action as necessary to minimize these residuals.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.c.6.

Data analysts will review the mixed residuals on the standard itself and take action as necessary to minimize these residuals.

3.c.7 Smaller and larger diameter probes can be used to inspect tubes where it is impractical to utilize a nominal-size probe (i.e., 0.610 inch diameter for 3/4-inch tubing and 0.720 inch diameter for 7/8-inch tubing) provided that the probes and procedures have been demonstrated on a statistically significant basis to give an equivalent voltage response and detection capability when compared to the nominal-size probe. This can be demonstrated on a plant-specific or generic basis. Data supporting the use of alternate probe sizes should be submitted for NRC approval.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.c.7.

Smaller diameter probes (e.g., 0.700 inch diameter) may be used to inspect the U-bend region of certain low row tubes where it is impractical to utilize a nominal-size probe (i.e., 0.720 inch diameter). Voltage-based repair criteria will not be applied to tubes inspected with smaller diameter probes until the probes and procedures have been demonstrated, to the satisfaction of the NRC, to give an acceptable voltage response and detection capability when compared to the nominal-size probe.

3.c.8 Data analysts should be trained on the potential for primary water stress corrosion cracking to occur at TSP intersections. The analysts should be sensitized to identifying indications attributable to primary water stress corrosion cracking.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 3.c.8.

PWSCC indications have been identified at dented TSP intersections in previous inspections at DCPP Unit 1 (1R6 and 1R7) and DCPP Unit 2 (2R5, 2R6 and 2R7). Data analysts will continue to be trained and sensitized to identify indications attributable to PWSCC at dented TSP intersections.

4.0 Tube Removal and Examination/Testing

Implementation of voltage-based repair criteria should include a program of tube removals for testing and examination as described below. The purpose of this program is to (1) confirm axial ODSCC as the dominant degradation mechanism as discussed in Section 1.a; (2) monitor the degradation mechanism over time; (3) provide additional data to enhance the burst pressure, probability of leakage, and conditional leak rate correlations described in Sections 2.a.1, 2.b.3(1), and 2.b.3(2), respectively; and (4) assess inspection capability.

4.a Number and Frequency of Tube Pulls

Two pulled tube specimens with an objective of retrieving as many intersections as is practical (a minimum of four intersections) should be obtained for each plant either during the plant SG inspection outage that implements the voltage-based repair criteria or during an inspection outage preceding initial application of these criteria. On an ongoing basis, an additional (follow-up) pulled tube specimen with an objective of retrieving as many intersections as is practical (minimum of two intersections) should be obtained at the refueling outage following accumulation of 34 effective full power months of operation or at a maximum interval of three refueling outages, whichever is shorter, following the previous tube pull.

Alternatively, the request to acquire pulled tube specimens may be met by participating in an industry sponsored tube pull program endorsed by the NRC that meets the objectives of this guidance. Such a program would have to satisfy the following objectives: (1) to confirm the degradation mechanism for plants utilizing the generic letter for the first time, (2) to continue monitoring the ODSCC mechanism over time, (3) to enhance the burst pressure, probability of leakage, and conditional leak rate correlations, and (4) to assess inspection capability.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 4.a, with alternatives for DCPP Unit 1.

i) DCPP Unit 1

During the last DCPP Unit 1 refueling outage (1R7) in October - November 1995, portions of 4 tubes (7 intersections) were pulled for detected PWSCC at dented TSP intersections. The tubes were pulled from SG 1-2. Three intersections had detected axial PWSCC, 1 intersection had detected circumferential PWSCC, and 3 intersections had no detectable degradation (NDD). Six intersections were destructively examined and 1 intersection was archived. All detected PWSCC indications were confirmed by destructive testing. In addition, 5 of the 6 intersections which were destructively examined (3 NDD intersections and 2 intersections with detected axial PWSCC) were found to have shallow axial OD intergranular corrosion present. None of the OD indications were detected by field bobbin or RPC (Plus Point) inspection. All OD indications were confined to the TSP crevice region. The maximum size OD indication (R21C43 TSP-2) was 0.255 inches long with an average depth of 13 percent and a maximum depth of 32 percent. The summary of the destructive exam data for the 5 pulled tube intersections with OD indications present is provided in Table 7.

The crack morphology found in the industry database supporting GL 95-05 includes single and multiple axial indications with varying degrees of short, multiple initiation

sites in addition to the principal macrocracks. In some cases, there are small patches of cellular corrosion formed within the multiple initiation sites. Figures 1 and 2 show sketches of the OD crack morphology for the more significant OD indications at R12C32 TSP-2 and R21C43 TSP-2. This morphology shows the short, multiple initiation sites in addition to the burst crack opening. Radial grinds were also performed on R21C43 TSP-2. This examination showed shallow cellular corrosion with the oblique angle microcracks being less than 16 percent deep. There were no ID indications found at these two TSP intersections.

The removed tubes are consistent with GL 95-05 selection criteria 4.b.2 for removing tube intersections with no detectable degradation. PG&E recognizes that the removed tubes are not consistent with GL 95-05 selection criteria 4.b.1 (for removing intersections with large voltage indications) and criteria 4.b.3 (for removing intersections containing RPC signatures of a single dominant crack). However, based on the above discussion, it is concluded that the DCPP Unit 1 crack morphology is typical of the industry database and, therefore, GL 95-05 is applicable to the OD indications. This conclusion on morphology is considered to be the most important factor for application of voltage-based repair criteria under GL 95-05.

PG&E intends to use the 1R7 removed tubes and morphology verification to postpone further tube intersection removals until 1R9, scheduled for January 1999, on the basis that the expected indications in 1R8 will be small and would not contribute significantly to the industry database. Of the 9 OD indications detected and plugged in 1R7, the largest bobbin voltage was 0.8 volts. Therefore, PG&E intends to remove tube specimens from Unit 1 in 1R9 with an objective of retrieving a minimum of two intersections. However, if bobbin indications greater than 3 volts in pullable tube locations are found during the 1R8 inspection (the outage that implements voltage-based repair criteria) and confirmed by RPC, the intersection containing the largest indication, along with at least one other intersection, will be removed to support the industry database. The selection of 3 volts is based on the extensive industry database below 3 volts for 7/8 inch tubing such that additional indications above 3 volts are needed for a meaningful contribution to the database. PG&E believes that this alternative is a more effective use of resources for both PG&E and the industry in general.

On an ongoing basis, an additional pulled tube specimen (with an objective of retrieving a minimum of two intersections) will be obtained at the refueling outage following accumulation of 34 effective full power months of operation or at a maximum interval of three refueling outages, whichever is shorter, following the previous tube pull.

ii) DCPP Unit 2

For DCPP Unit 2, no tubes have been pulled. In 2R8, the outage that implements the voltage-based repair criteria for Unit 2, PG&E will pull two tube specimens with an

objective of retrieving a minimum of four intersections. On an ongoing basis, an additional pulled tube specimen (with an objective of retrieving a minimum of two intersections) will be obtained at the refueling outage following accumulation of 34 effective full power months of operation or at a maximum interval of three refueling outages, whichever is shorter, following the previous tube pull.

An industry sponsored tube pull program is being developed as an alternative to the tube pull program requirements of GL 95-05. PG&E intends to participate in an alternative program once it is submitted by the industry and endorsed by the NRC.

4.b Selection Criteria

Selection of the tubes to be removed should consider the following criteria:

4.b.1 There should be an emphasis on removing tube intersections with large voltage indications.

4.b.2 Where possible, the removed tube intersections should cover a range of voltages, including intersections with no detectable degradation.

4.b.3 As a minimum, selected intersections should ensure that the total data set includes a representative number of intersections with RPC signatures indicative of a single dominant crack as compared to intersections with RPC signatures indicative of two or more dominant cracks about the circumference.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 4.b.

PG&E will consider the following criteria when selecting tubes for removal:

- There will be an emphasis on removing tube intersections with large voltage indications.
- Where possible, the removed tube intersections will cover a range of voltages, including intersections with no detectable degradation.
- As a minimum, selected intersections will ensure that the total data set includes a representative number of intersections with RPC signatures indicative of a single dominant crack as compared to intersections with RPC signatures indicative of two or more dominant cracks about the circumference.

As noted in Section 4.a, the intersections where OD indications were found based on destructive examination of the intersections removed in 1R7 were NDD by bobbin and

RPC. As a result, there are no voltage correlations available. Future tube pulls will include intersections with the largest available voltage indications.

4.c Examination and Testing

Removed tube intersections should be subjected to leak and burst tests under simulated MSLB conditions to confirm that the failure mode is axial and to permit enhancement of the supporting data sets for the burst pressure and leakage correlations. The systems for future tests should accommodate, and permit the measurement of, as high a leak rate as is practical, including leak rates that may be in the upper tail of the leak rate distribution for a given voltage. Leak rate data should be collected at temperature for the differential pressure loadings associated with the maximum postulated MSLB. When it is not practical to perform hot temperature leak tests, room temperature leak rate testing may be performed as an alternative. Burst testing may be performed at room temperature. The burst and leak rate correlations and/or data should be normalized to reflect the appropriate pressure and temperature assumptions for a postulated MSLB.

Subsequent to burst testing, the intersections should be destructively examined to confirm that the degradation morphology is consistent with the assumed morphology for ODSCC at the tube-to-TSP intersections. The destructive examinations should include techniques such as metallography and scanning electron microscope (SEM) fractography as necessary to characterize the degradation morphology (e.g., axial ODSCC, circumferential ODSCC, IGA involvement, cellular IGA, and combinations thereof) and to characterize the largest crack networks with regard to their orientation, length, depth, and ligaments. The purpose of these examinations is to verify that the degradation morphology is consistent with the assumptions made in Section 1.a of this attachment. This includes demonstrating that the dominant degradation mechanism affecting the tube burst and leakage properties is axially oriented, ODSCC.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 4.c.

Removed tube intersections will be subjected to leak and burst tests under simulated MSLB conditions to confirm that the failure mode is axial and to permit enhancement of the supporting data sets for the burst pressure and leakage correlations. The systems for future tests will accommodate, and permit the measurement of, as high a leak rate as is practical, including leak rates that may be in the upper tail of the leak rate distribution for a given voltage. Leak rate data will be collected at temperature for the differential pressure loadings associated with the maximum postulated MSLB. When it is not practical to perform hot temperature leak tests, room temperature leak rate testing will be performed as an alternative. Burst testing will be performed at room

temperature. The burst and leak rate correlations and/or data will be normalized to reflect the appropriate pressure and temperature assumptions for a postulated MSLB.

Subsequent to burst testing, the intersections will be destructively examined to confirm that the degradation morphology is consistent with the assumed morphology for ODSCC at the tube-to-TSP intersections. The destructive examinations will include techniques such as metallography and scanning electron microscope (SEM) fractography as necessary to characterize the degradation morphology (e.g., axial ODSCC, circumferential ODSCC, IGA involvement, cellular IGA, and combinations thereof) and to characterize the largest crack networks with regard to their orientation, length, depth, and ligaments. The purpose of these examinations will be to verify that the degradation morphology is consistent with the assumptions made in Section 1.a, including demonstration that the dominant degradation mechanism affecting the tube burst and leakage properties is axially oriented ODSCC.

5. Operational Leakage

5.a The operational leakage limit should be reduced in the TS to 150 gallons per day (gpd) through each SG.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 5.a.

The operational primary-to-secondary leakage limit will be reduced in the Technical Specifications to 150 gallons per day (gpd) through each SG. For Modes 3 and 4, the primary system radioactivity level (source term) may be very low, making it difficult to measure primary-to-secondary leakage of 150 gallons per day. Therefore, if SG water samples indicate less than the minimum detectable activity of 5.0 E-7 microcuries/ml for principal gamma emitters, the requirement of 150 gallons per day leakage may be considered met.

5.b Licensees should review their leakage monitoring measures to ensure that should a significant leak occur in service, it will be detected and the plant will be shut down in a timely manner to reduce the likelihood of a potential tube rupture. Specifically, the effectiveness of these procedures for ensuring the timely detection, trending, and response to rapidly increasing leaks should be assessed. The licensee should consider the appropriateness of alarm setpoints on the primary-to-secondary leakage detection instrumentation and the various criteria for operator actions in response to detected leakage.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 5.b.

PG&E has reviewed the DCPP Units 1 and 2 SG leakage monitoring measures against the current industry guidelines contained in EPRI topical report TR-104788, "PWR Primary-to-Secondary Leak Guidelines," May 1995. SG primary-to-secondary leakage is determined in accordance with PG&E chemical analysis procedure CAP D-15, "Steam Generator Leak Rate Determination." Plant shutdown limits are specified in operating procedure OP O-4, "Dented Steam Generators." OP O-4 is in compliance with the Action Level 2 plant shutdown limits in the EPRI guidelines (i.e., leakage greater than or equal to 150 gpd or leak rate increasing at greater than 60 gpd per hour). PG&E's measures ensure that should a significant leak occur during power operation, it will be detected and the plant will be shut down in a timely manner to reduce the likelihood of a potential tube rupture. The measures also ensure the timely detection, trending, and response to rapidly increasing leaks. Alarm setpoints on the primary-to-secondary leakage detection instrumentation and operator action criteria in response to detected leakage are consistent with current industry guidelines.

5.c SG tubes with known leaks should be repaired prior to returning the SGs to service following an SG inspection outage.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 5.c.

PG&E will repair SG tubes with known leaks prior to returning the SGs to service following an SG inspection outage.

6. Reporting Requirements

6.a Threshold Criteria for Requiring Prior Staff Notification To Continue With Voltage-Based Criteria

This guidance allows licensees to implement the voltage-based repair criteria on a continuing basis after the NRC staff has approved the initial TS amendment. However, in several situations, the NRC staff must receive notification to enable the staff to assess whether a licensee can continue with the implementation of the voltage-based repair criteria:

6.a.1 If the projected EOC voltage distribution results in an estimated leakage greater than the leakage limit (determined from the licensing basis calculation), then the licensee should notify the NRC of this occurrence and provide an assessment of its significance prior to returning the SGs to service. If it is not practical to complete this calculation prior to returning the SGs to service, the measured EOC voltage distribution can be used (from the previous cycle of operation) as an alternative (refer to Section 2.c). If it is determined that the projected calculated leakage will exceed the leakage limit (during the operating cycle) after the SGs are returned to service, then

licensees should provide an assessment of the safety significance of the occurrence, describe the compensatory measures being taken to resolve the issue, and follow any other applicable reportability regulations.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 6.a.1.

If the projected EOC voltage distribution results in an estimated leakage greater than the allowable licensing basis leakage limit, PG&E will notify the NRC of this occurrence and provide an assessment of its significance prior to returning the SGs to service. If it is not practical to complete this calculation prior to returning the SGs to service, the measured EOC voltage distribution will be used (from the previous cycle of operation) as an alternative as discussed in Section 2.c. If it is determined that the projected calculated leakage will exceed the leakage limit (during the operating cycle) after the SGs are returned to service, then PG&E will provide an assessment of the safety significance of the occurrence, describe the compensatory measures being taken to resolve the issue, and follow any other applicable reportability regulations.

6.a.2 If indications are identified that (1) extend beyond the confines of the TSP, or (2) appear to be circumferential in nature, or (3) are attributable to primary water stress corrosion cracking, the NRC staff should be notified prior to returning the SGs to service.

DCPP Units 1 and 2 Compliance

PG&E complies with the guidance contained in Section 6.a.2.

If indications are identified that (1) extend beyond the confines of the TSP, or (2) appear to be circumferential in nature, or (3) are attributable to primary water stress corrosion cracking (PWSCC), PG&E will notify the NRC staff prior to returning the SGs to service.

None of the ODSCC indications identified to date have extended beyond the confines of the TSP, nor are they circumferential in nature. PWSCC indications have been identified at dented TSP intersections in previous inspections of DCPP SGs (Tables 5 and 6). PWSCC axial indications at dented intersections were identified in Unit 1 in 1R6 and 1R7 and in Unit 2 in 2R5, 2R6, and 2R7. PWSCC circumferential indications at dented intersections were identified in 1R7 and 2R7. Some of the axial indications extended beyond the confines of the TSP. As discussed in Section 4.a, portions of tubes with PWSCC axial and circumferential indications were pulled in 1R7, destructively examined, and burst tested to verify their morphology and structural integrity.

As discussed in Section 3.b.3, PG&E has a comprehensive program for inspecting dented TSP intersections with RPC.

6.a.3 If the calculated conditional probability of rupture under postulated MSLB conditions based on the projected EOC voltage distribution exceeds 1×10^{-2}, licensees should notify the NRC and provide an assessment of the significance of this occurrence prior to returning the SGs to service. This assessment should address the safety significance of the calculated conditional probability and can account for operator actions to prevent primary pressure from reaching the PORV or safety valve setpoint provided that the assessment includes a probabilistic assessment of the operator actions. If it is not practical to complete this calculation prior to returning the SGs to service, the measured EOC voltage distribution can be used (from the previous cycle of operation) as an alternative (refer to Section 2.c).

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 6.a.3.

If the calculated conditional probability of rupture under postulated MSLB conditions based on the projected EOC voltage distribution exceeds 1×10^{-2}, PG&E will notify the NRC and provide an assessment of the significance of this occurrence prior to returning the SGs to service. This assessment will address the safety significance of the calculated conditional probability and may account for operator actions to prevent primary pressure from reaching the PORV or safety valve setpoint. If the assessment accounts for operator actions, the assessment will include a probabilistic assessment of the operator actions. If it is not practical to complete this calculation prior to returning the SGs to service, the measured EOC voltage distribution will be used (from the previous cycle of operation) as an alternative (as discussed in Section 2.c).

6.b Information To Be Provided Following Each Restart

The following information should be submitted to the NRC staff within 90 days of each restart following an SG inspection:

(a) The results of metallurgical examinations performed for tube intersections removed from the SG. If it is not practical to provide all the results within 90 days, as a minimum, the burst test, leakage test and morphology conclusions should be provided within 90 days. The remaining information should be submitted when it becomes available.

(b) The following distributions should be provided in both tabular and graphical form. This information will enable the staff to assess the effectiveness of the methodology, determine whether the degradation is changing significantly, determine whether the data supports different voltage repair limits, and perform

confirmatory calculations. The voltages reported should be adjusted to account for differences between the laboratory standard and the standard used in the field (i.e., transfer standard corrections should be made).

(i) EOC voltage distribution - all indications found during the inspection regardless of RPC confirmation

(ii) cycle voltage growth rate distribution (i.e., from BOC to EOC) - the data should indicate whether the distribution has been adjusted for the length of the operating interval, and the length of the operating interval should be provided (i.e., in EFPYs). The planned length of the next operating interval should also be provided (in EFPYs).

(iii) voltage distribution for EOC repaired indications - distribution of indications presented in (i) above that were repaired (i.e., plugged or sleeved)

(iv) voltage distribution for indications left in service at the beginning of the next operating cycle regardless of RPC confirmation - obtained from (i) and (iii) above

(v) voltage distribution for indications left in service at the beginning of the next operating cycle that were confirmed by RPC to be crack-like or not RPC inspected

(vi) non-destructive examination uncertainty distribution used in predicting the EOC (for the next cycle of operation) voltage distribution

(c) The results of the tube integrity evaluation (calculated accident leakage and conditional burst probability) described in Section 2, including the repair limits that were implemented (i.e., the upper voltage repair limit, the average growth rate at the tube support plates and flow distribution baffle, if applicable, the measurement variability allowance, and the correlation used). Note that if the leakage and conditional burst probability were calculated using the measured EOC voltage distribution for the purposes of addressing the 6.a.1 and 6.a.3 reporting criteria, then the results of the projected EOC voltage distribution should be given in this report.

<u>DCPP Units 1 and 2 Compliance</u>

PG&E complies with the guidance contained in Section 6.b.

PG&E will submit the following information to the NRC staff within 90 days of each restart following an SG inspection:

(a) The results of metallurgical examinations performed for tube intersections removed from the SG will be provided. If it is not practical to provide all the results within 90 days, as a minimum, the burst test, leakage test and morphology conclusions will be provided within 90 days. The remaining information will be submitted when it becomes available.

(b) The following distributions will be provided in both tabular and graphical form. The voltages reported will be adjusted to account for differences between the laboratory standard and the standard used in the field.

- EOC voltage distribution - all indications found during the inspection regardless of RPC confirmation
- cycle voltage growth rate distribution (i.e., from BOC to EOC) - the data will indicate whether the distribution has been adjusted for the length of the operating interval, and the length of the operating interval will be provided (i.e., in EFPYs). The planned length of the next operating interval will also be provided (in EFPYs).
- voltage distribution for EOC repaired indications - distribution of indications that were repaired (i.e., plugged or sleeved)
- voltage distribution for indications left in service at the beginning of the next operating cycle regardless of RPC confirmation
- voltage distribution for indications left in service at the beginning of the next operating cycle that were confirmed by RPC to be crack-like or not RPC inspected
- non-destructive examination uncertainty distribution used in predicting the EOC (for the next cycle of operation) voltage distribution

(c) The results of the tube integrity evaluation will be provided (calculated accident leakage and conditional burst probability), including the repair limits that were implemented (i.e., the upper voltage repair limit, the average growth rate at the tube support plates, the measurement variability allowance, and the correlation used). If the leakage and conditional burst probability were calculated using the measured EOC voltage distribution, then the results of the projected EOC voltage distribution will be given in this report.

7.0 Tube Deformation/Collapse Considerations (LOCA + SSE)

As described in Section 1.b.1, PG&E will not apply voltage-based repair criteria to tube-to-TSP intersections where the tubes with degradation may potentially collapse or deform as a result of the combined postulated loss-of-coolant accident (LOCA) and safe shutdown earthquake (SSE) loadings. The specific tubes that are susceptible to collapse and in-leakage during a postulated LOCA plus SSE event have been identified by Westinghouse in Westinghouse letter to PG&E dated September 3, 1992, "Deformation of Steam Generator Tubes Following a Postulated LOCA and SSE Event." A maximum of 254 tubes per SG can be affected, and these tubes are located near the wedge supports at each TSP.

This section provides a discussion of the Westinghouse evaluation for the most critical loads and load combinations for tube deformation/collapse considerations. Other loads which are not described are considered bounded by the described load combinations.

7.1 Introduction

For the combined LOCA + SSE loading condition, the potential exists for yielding of the TSP in the vicinity of the wedge groups, followed by collapse of deformed tubes and subsequent loss of flow area. In addition to tubes that may collapse following a SSE + LOCA event, there will be a number of tubes that will undergo a limited amount of permanent deformation. This deformation may also lead to loss of flow area. The area reduction considers the combined effects of these two types of deformation.

An analysis was performed using conservative extrapolations of plate loads and inelastic plate response. The design basis dynamic analyses for DCPP did not include the in-plane stiffness of the support plate that transfers the load from the tubes to the wedges and wrapper. Due to the similarity in plate geometries (in terms of penetration patterns and plate material), analysis results for the Model D steam generators are used as a basis in calculating the plate loads and the inelastic plate response. The analysis considers several key parameters in approximating the response of the steam generators. These parameters include the seismic spectra, LOCA loads, gaps that develop between the shell/wrapper/TSP, and the stiffness of the Series 51 plates relative to the Model D plates. Based on the analysis results, the estimated flow area loss for combined LOCA + SSE loads is 7.5 percent.

Calculations to determine flow area reduction under LOCA + SSE for other plants with Series 51 steam generators, but with lower seismic spectra, predicted a flow area reduction of 5.0 percent. Subsequent calculations, using analysis and test results specific to the Series 51 steam generators have shown the predicted flow areas to be less than 1.0 percent. Thus, the analysis methodologies summarized below, used to estimate the 7.5 percent flow area reduction, have been shown to be conservative.

7.2 LOCA Analysis

For a LOCA event, the tubes are subject to both a rarefaction pressure wave that travels through the tube bundle, and to loads resulting from shaking of the overall steam generator. The rarefaction wave results in a hot leg to cold leg pressure differential that causes a lateral load to be imposed on the tube U-bend. The lateral load is reacted by the TSP through wedges that bear against the wrapper and shell wall. The lateral load varies from row to row both in amplitude and period due to the different bend radii. Integrating this load over the entire bundle may result in a significant load on the TSP. For the LOCA rarefaction loading, the top TSP reacts the majority of the load.

7.2.1 LOCA Rarefaction Wave Analysis

The principal tube loading during a LOCA is caused by the rarefaction wave in the primary fluid. This wave initiates at the postulated break location and travels around the tube U-bends. A differential pressure is created across the two legs of the tube which causes an in-plane horizontal motion of the U-bend. This differential pressure, in turn, induces significant lateral loads on the tubes.

The pressure-time histories to be input in the structural analysis are obtained from transient thermal-hydraulic (T/H) analyses using the MULTIFLEX computer code. A break opening time of 1.0 msec to full flow area (that is, instantaneous double-ended rupture) is assumed to obtain conservative hydraulic loads. Pressure time histories are determined for three tube radii, identified as the minimum, medium, and maximum radius tubes. For the structural evaluation, the pressures of concern occur at the hot and cold leg U-bend tangent points.

For the rarefaction wave induced loadings, the predominant motion of the U-bends is in the plane of the U-bend. Thus, the individual tube motions are not coupled by the anti-vibration bars. Also, only the U-bend region is subjected to high bending loads. Therefore, the structural analysis is performed using single tube models limited to the U-bend and the straight leg region over the top two TSPs. The LOCA rarefaction pressure wave imposes a time varying loading condition on the tubes. The tubes are evaluated using the time history analysis capability of the WECAN computer program. The structural tube model consists of three-dimensional beam elements. The mass inertia is input as effective material density and includes the weight of the tube as well as the weight of the primary fluid inside the tube, and the hydrodynamic mass effects of the secondary fluid.

To account for the varying nature of the tube/TSP interface with increasing tube deflection, three sets of boundary conditions are considered. For the first case, the tube is assumed to be laterally supported at the TSP, but is free to rotate. This is designated as the "continuous" condition, in reference to the fact that the finite element

model for this case models the tube down to the second TSP location. As the tube is loaded, it moves laterally and rotates within the TSP. After a finite amount of rotation, the tube will become wedged within the TSP and will no longer be able to rotate. The second set of boundary conditions, therefore, considers the tube to be fixed at the top TSP location, and is referred to as the "fixed" case. Continued tube loading causes the tube to yield in bending at the top TSP and eventually a plastic hinge develops. This represents the third set of boundary conditions, and is referred to as the "pinned" case.

The hot to cold leg ΔP resulting from a LOCA pipe break is strongly dependent on the representation of the divider plate located in the inlet chamber of the steam generator that separates the primary inlet and outlet flows. When LOCA rarefaction analyses were first performed, the divider plate was modeled as a rigid structural member. Later analyses accounted for the divider plate flexibility and a significant reduction in the hot to cold leg ΔP resulted.

Based on LOCA rarefaction analyses for Model D and Series 51 steam generators with rigid divider plates and a comparison of geometrical parameters, the Model D LOCA plate loads are concluded to envelope the Series 51.

7.2.2 LOCA Shaking Loads

Concurrent with the rarefaction wave loading during a LOCA, the tube bundle is subjected to additional bending loads due to the shaking of the steam generator caused by the break hydraulics and reactor coolant loop motion. However, the resulting tube stresses from this motion are small compared to those due to the rarefaction wave induced motion.

To obtain the LOCA induced hydraulic forcing functions, a dynamic blowdown analysis is performed to obtain the system hydraulic forcing functions assuming an instantaneous (1.0 msec break opening time) double-ended guillotine break. The hydraulic forcing functions are then applied, along with the displacement time-history of the reactor pressure vessel (obtained from a separate reactor vessel blowdown analysis), to a system structural model, which includes the steam generator, the reactor coolant pump and the primary piping. This analysis yields the time history displacements of the steam generator at its upper lateral and lower support nodes. These time-history displacements formulate the forcing functions for obtaining the tube stresses due to LOCA shaking of the steam generator.

To evaluate the steam generator response to LOCA shaking loads, the computer code WECAN is used. Input to the WECAN model is in the form of acceleration time histories at the tube/tubesheet interface. These accelerations are obtained by differentiation of the system model displacement time histories at this location. Acceleration time histories for all six degrees of freedom are used.

Past experience has shown that LOCA shaking loads are small when compared to LOCA rarefaction loads. For this analysis, these loads are obtained from the results of a prior analysis for a Model D steam generator.

7.3 Seismic Analysis

Seismic (SSE) loads are developed as a result of the motion of the ground during an earthquake. A nonlinear time-history analysis is used to account for the effects of radial gaps between the secondary shell and the TSPs, and between the wrapper and shell. The seismic excitation defined for the steam generators is in the form of acceleration response spectra at the steam generator supports. In order to perform the non-linear time history analysis, it is necessary to convert the response spectrum input into acceleration time history input. Acceleration time-histories for the nonlinear analysis are synthesized from El Centro Earthquake motions, using a frequency suppression/raising technique, such that the resulting time history spectra closely envelopes the corresponding specified spectra. The three orthogonal components of the earthquake are applied simultaneously to perform the analysis.

The seismic analysis is performed using the WECAN computer program. The mathematical model consists of three-dimensional lumped mass, beam, and pipe elements as well as general matrix input to provide a plant specific representation of the steam generator and reactor coolant piping stiffnesses. In the nonlinear analysis, the TSP/shell, and wrapper/shell interactions are represented by a concentric spring-gap dynamic element, using impact damping to account for energy dissipation at these locations.

The tube bundle straight leg region on both the hot-leg side and cold-leg side is modeled by two equivalent beams. The U-bend region, however, is modeled as five equivalent tubes of different bend radii, each equivalent tube representing a group of steam generator tubes. In addition, a single tube representing the outermost tube row is also modeled. Continuity between the straight leg and U-bend tubes, as well as between the U-bend tubes themselves, is accomplished through appropriate nodal couplings. Note that the five equivalent tube groups are extended down two support plates before the single tube representation begins. This allows dissipation of tube response differences due to the variation in U-bend stiffnesses. Typically, the tubes are coupled to the TSP for translational degree of freedom. Packed intersections, which exist for DCPP, are not expected to significantly affect the resulting TSP loads. As discussed previously, the results from an analysis for a Model D steam generator were used, applying a scale factor to account for the relative energy content of the Model D spectra versus the Diablo Canyon DDE spectra (with 1% damping).

7.4 Combined Plate Loads

In calculating a combined TSP load, the LOCA rarefaction and LOCA shaking are combined directly, while the LOCA and SSE loads are combined using the square root of the sum of the squares. The overall TSP load is transferred to the steam generator shell through wedge groups located at discrete locations around the plate circumference.

For the Series 51 steam generators, there are six wedge groups located every 60 degrees around the plate circumference. The distribution of load among wedge groups is approximated as a cosine function among those groups reacting the load, which corresponds to half the wedge groups. Except for the bottom TSP, the wedge groups for each of the TSPs are located at the same angular location as for the top TSP. Thus, if TSP deformation occurs at the lower plates, the same tubes are affected as for the top TSP. For the top TSP, however, the wedge groups have a 10 inch width, compared to a 6 inch width for the other plates. This larger wedge group width distributes the load over a larger portion of the plate, resulting in less plate and tube deformation for a given load level. For the bottom TSP, the wedge group width is 6 inches, and the wedge groups are rotated 36 degrees relative to the other TSPs. The distribution of load among the various wedge groups for the LOCA load results in a maximum wedge load of 0.634 of the total plate load. For seismic loads, which can have a random orientation, the maximum wedge load is 0.667 of the maximum TSP load. For this analysis, however, it is conservatively assumed that the factor of 0.667 of the total TSP load applies to both the LOCA and seismic loads.

7.5 Flow Area Reduction Calculations

In estimating the flow area reduction, one of the key parameters is the force / deflection characteristics of the TSP. The analysis used data for the Model D plates as a basis, and extrapolates those values based on a geometrical comparison of the plates for the two model steam generators.

The Model D crush test force / deflection results represent inelastic behavior of the plate and tubes. In order to make use of this data, an approximation must be made between the elastic analyses that determine the plate loads, and the inelastic crush test. This approximation is based on the area under the force / deflection curve for the crush test versus the area corresponding to the elastic plate response. Comparing the areas from the two sets of calculations shows that the elastic areas are greater than the inelastic areas for both the seismic alone and the combined LOCA + SSE loads for the Diablo Canyon steam generators.

Since it is estimated that the LOCA + SSE plate loads exceed the Model D crush test plate loads, a factor of 3.0 is conservatively applied to the number of collapsed tubes at each wedge location. This results in a total of 42 tubes at each of the six wedge

locations. Therefore, the total number of affected tubes is 252 and, out a total of 3388 tubes, the reduction in flow area is 7.5 percent.

7.6 Identification of Potentially Susceptible Tubes

Identification of the potentially susceptible tubes is based on crush test results performed for Series 51 steam generators subsequent to the calculations to establish the 7.5 percent flow area reduction. Wedge group orientations typical of Series 51 steam generators were considered in the tests. In performing each of the crush tests, the plate samples were loaded to the point of load instability. In each case, load instability corresponds to the load level where the plate samples were bowing out-of-plane, resulting in the plates contracting out of the guides located at the sides of the test pieces. Evaluation of the tube deformations experienced in each of these tests shows the level of tube deformation (diameter reduction) does not exceed the diameter change that would result in tube collapse under the post-LOCA secondary to primary ΔP. Thus, the test results show general tube deformation trends, but do not provide specific tubes that will potentially collapse at any given load level. As such, it is not possible to identify exactly the 42 tubes that might be limiting at each wedge group.

To account for uncertainty in selecting the susceptible tube locations, an enveloping group of tubes were selected at each of the six wedge locations, resulting in more than 42 tubes identified at each wedge group as being limiting. As a result, a total of 468 tubes per SG have been conservatively included in the wedge region exclusion zone and will be excluded from application of voltage-based repair criteria, even though a maximum of 252 of these tubes can collapse and cause in-leakage following a LOCA + SSE. Tabular summaries of the potentially susceptible tubes, showing tube row and column numbers and associated wedge location, are provided in Tables 8 through 13.

8.0 DCPP Main Steam Line Break Accident: Input Parameters and Results

As described in Section 2.b.4, PG&E has performed a radiological dose analysis to establish the limiting maximum primary-to-secondary post-main steam line break (MSLB) leak rates in the DCPP steam generator in the faulted loop and intact loops. These leak rates have been calculated to be 12.8 gpm and 0.3125 gpm (150 gpd per SG), respectively.

Consistent with the current licensing basis (DCPP FSAR Update Section 15.1.5) and Standard Review Plan (SRP) 15.1.5, two cases were analyzed:

- An accident initiated iodine spike of 500 times the release rate corresponding to the Technical Specification limit of 1 microcurie per gram in the reactor coolant system.

- A pre-existing iodine spike of 60 microcuries per gram I-131 Dose Equivalent Concentration (DEC) in the reactor coolant system and 0.1 microcuries per gram I-131 DEC in the secondary system.

The limiting maximum primary-to-secondary post-MSLB leak rate of 12.8 gpm in the faulted steam generator was determined by calculations. The limiting dose case was determined to be the exclusion area boundary (EAB) thyroid dose for the accident-initiated iodine spike case. This limiting thyroid dose of 29.77 rem is within the 30 rem acceptance limit. Thirty rem represents 10 percent of the 10 CFR 100 guideline value as recommended in SRP 15.1.5 for the EAB and low population zone (LPZ).

Items "a" through "r" provide the assumptions made to determine the limiting maximum primary-to-secondary post-MSLB leak rate in the faulted steam generator loop. Item "s" provides the resultant doses and acceptance criteria.

a. The pre-MSLB primary-to-secondary leak rate was assumed to be at the current TS leak rate limit of 1 gpm to yield a conservatively high isotopic concentration in the secondary system. Use of 1 gpm is more conservative than the proposed voltage-based repair criteria TS leak rate limit of 150 gpd per SG.

b. During the accident, the primary-to-secondary leak rate in each intact steam generator was assumed to be at the proposed voltage-based repair criteria TS limit of 150 gpd. Therefore, the total leakage is 450 gpd, or 0.3125 gpm. The primary-to-secondary leak rate in the faulted steam generator is assumed at the maximum rate of 12.8 gpm.

c. The MSLB occurred in the section of piping between the containment building and the main steam line isolation valves (MSIVs). Prior control room isolation and pressurization, the control room HVAC intake χ/Q is the unfiltered χ/Q taken from the LOCA condition outside containment.

d. Loss of offsite power is assumed to occur coincident with MSLB accident.

e. Conservatively, based on the current TS requirements for the safety injection signal and containment Phase A isolation, the control room will be isolated well within 35 seconds. To add more conservatism in this calculation, the control room is assumed to be isolated in 2 minutes.

f. All releases were assumed to end after 8 hours, when the plant is placed on the Residual Heat Removal (RHR) system.

g. For a pre-existing iodine spike, the activity in the reactor coolant is based upon an iodine spike which has raised the reactor coolant concentration to 60 micro Ci/gm of I-131 DEC, based on DCPP TS Figure 3.4-1. The secondary coolant activity is

0.1 micro Ci/gm of I-131 DEC, based on DCPP TS 3.7.1.4. Noble gas activity is based on 1 percent failed fuel.

h. For an accident-initiated (concurrent) iodine spike, the accident initiates an iodine spike in the reactor coolant system (RCS) which increases the iodine release rate from the fuel to a value 500 times greater than the release rate corresponding to an RCS concentration of 1 micro Ci/gm I-131 DEC. 1 micro Ci/gm I-131 DEC is based on DCPP TS 3.4.8. The iodine activity released to the RCS for the duration of the accident is conservatively assumed to mix instantaneously and uniformly in the RCS. Noble gas activity is based on 1 percent failed fuel.

i. Following the pipe rupture, auxiliary feedwater to the faulted loop is isolated and the steam generator is allowed to steam dry. The iodine partition factor for the faulted steam generator is assumed to be 1.0. Also, the partition factor for the intact steam generators is conservatively assumed to be 1.0, i.e., no credit is taken for iodine partition.

j. All activity in the steam generators is released to the atmosphere in accordance with the release rates in FSAR Update Table 15.5-34, with added releases from primary-to-secondary leaks in the faulted loop and intact loops.

Atmospheric steam releases (not included primary to secondary leaks):

Ruptured loop	162,784 lb at 45.0 lb/cf (0-2 hr)
	0 lb (2-8 hr)
Intact loops	393,464 lb at 45.0 lb/cf (0-2 hr)
	860,461 lb at 50.0 lb/cf (2-8 hr)

k. The source term is based on a composite source term of 3.5 percent and 4.5 percent fuel enrichment. An evaluation has been performed and concluded that the current source term bounds the 5 percent enrichment fuel up to 50,000 MWD/MTU for a 21 month operating cycle.

l. Atmospheric Dispersion Factors (sec/m^3)
(Reference DCPP FSAR Update Tables 15.5-3 and 15.5-6)

Time	EAB	LPZ	Control Room	
			Pressurized	Infiltration
0 -2 hr	5.29E-4	2.20E-5	7.05E-5	1.96E-4
2 - 8 hr		2.20E-5	7.05E-5	1.96E-4
8 - 24 hr		4.75E-6	5.38E-5	1.49E-4
24-96 hr		1.54E-6	3.91E-5	1.08E-4
96-720 hr		3.40E-7	2.27E-5	6.29E-5

m. Reactor coolant iodine activity based on 1 percent failed fuel

Isotope	Gap Activity (micro Ci/gm)	500 Iodine Spike Activity Release Rate (Ci/hr)
I-131	2.744	6.484E+3
I-132	0.7	9.338E+3
I-133	3.85	1.323E+4
I-134	0.48	1.493E+4
I-135	2.04	1.232E+4
Kr-83m	0.38	3.701E+1
Kr-85m	2.14	8.585E+1
Kr-85	6.21	2.439E+0
Kr-87	1.23	1.729E+2
Kr-88	3.91	2.446E+2
Kr-89	0.09	3.096E+2
Xe-131m	2.52	2.557E+0
Xe-133m	3.91	1.439E+1
Xe-133	256.3	4.513E+2
Xe-135m	0.45	9.127E+1
Xe-135	8.66	1.303E+2
Xe-137	0.15	4.128E+2
Xe-138	0.57	4.280E+2

n. Secondary coolant activity based on 1 percent failed fuel

Isotope	Secondary Activity (micro Ci/gm)
I-131	3.536E-4
I-132	8.772E-5
I-133	4.941E-4
I-134	5.704E-5
I-135	2.596E-4
Kr-83m	4.691E-5
Kr-85m	2.712E-4
Kr-85	8.001E-4
Kr-87	1.499E-4
Kr-88	4.905E-4
Kr-89	4.923E-6
Xe-131m	3.250E-4
Xe-133m	5.030E-4
Xe-133	3.299E-2
Xe-135m	5.393E-5
Xe-135	1.109E-3
Xe-137	8.743E-6
Xe-138	5.553E-5

o. Reactor coolant iodine activity based on 60 micro Ci/gm I-131 DEC

Isotope	Gap Activity (micro Ci/gm)
I-131	46.74
I-132	11.97
I-133	65.5
I-134	8.18
I-135	34.68
Kr-83m	0.38
Kr-85m	2.14
Kr-85	6.21
Kr-87	1.23
Kr-88	3.91
Kr-89	0.09
Xe-131m	2.52
Xe-133m	3.91
Xe-133	256.3
Xe-135m	0.45
Xe-135	8.66
Xe-137	0.15
Xe-138	0.57

p. Secondary coolant activity based on 0.1 micro Ci/gm I-131 DEC

Isotope	Gap Activity (micro Ci/gm)
I-131	7.789E-2
I-132	1.995E-2
I-133	1.092E-1
I-134	1.363E-2
I-135	5.780E-2
Kr-83m	3.791E-2
Kr-85m	2.141E-1
Kr-85	6.209E-1
Kr-87	1.232E-1
Kr-88	3.907E-1
Kr-89	9.223E-3
Xe-131m	2.523E-1
Xe-133m	3.911E-1
Xe-133	2.563E+1
Xe-135m	4.491E-2
Xe-135	8.663E-1
Xe-137	1.477E-2
Xe-138	5.679E-2

q. Control Room HVAC Flow Rates and Filtration Efficiencies:

Filtered Intake Flow	2100 cfm
Unfiltered Intake Flow	10 cfm
Exhaust Flow	2110 cfm
Filtered Recirculation Flow	2100 cfm

Charcoal Filter Iodine Removal Efficiency

Elemental	95%
Organic	95%
Particulate	95%

r. RCS and Secondary Water Volume and Water Mass

RCS water volume	94,000 gallons
RCS water mass	566,000 pounds
Water in SGs	6735.54 ft^3 at 45.0 lb/ft^3 (0-2 hr) and 50.0 lb/ft^3 (2-8 hr)
	Loop 1 1683.88 ft^3
	Loops 2,3,4 5051.65 ft^3
Water in Condensers	27243.59 ft^3 at 62.4 lb/ft^3
Water in SGs and Condensers	33979.13 ft^3

s. Results and Acceptance Criteria

The resultant doses from a MSLB outside of containment building with primary to secondary leakage of 12.8 gpm in the faulted loop and 0.3125 gpm in the intact loops during the entire MSLB event are listed below. The limiting case is the accident initiated spike as the thyroid dose at the EAB is just under the 30 Rem limit.

Location	Dose (rem)		
	Thyroid	Beta Skin	Whole Body
Case 1: Accident-Initiated Spike			
EAB (0-2 hr)	29.77	3.37E-2	8.56E-2
LPZ (30 days)	7.29	4.92E-3	1.24E-2
• Dose Limit (10% of 10 CFR 100)	30	2.5	2.5
Control Room (30 days)	7.49E-1	3.70E-3	2.11E-4
• Dose Limit (GDC 19)	30	5	5

Case 2: Pre-Existing Spike			
EAB (0-2 hr)	74.73	4.15E-2	9.83E-2
LPZ (30 days)	6.45	3.39E-3	7.61E-3
• Dose Limit (10 CFR 100)	300	25	25
Control Room (30 days)	7.78E-1	3.33E-3	1.80E-4
• Dose Limit (GDC 19)	30	5	5

Table 1
Unit 1 Dent Distribution (≥ 5 volt dents)

TSP	1-1	1-2	1-3	1-4	Total
1H	2	113	20	391	526
2H	28	66	4	58	156
3H	5	67	10	72	154
4H	2	80	6	96	184
5H	4	24	39	40	107
6H	1	2	15	260	278
7H	168	35	113	364	680
Total	210	387	207	1281	2085

Table 2
Unit 1 Dent Distribution (< 5 volt dents)

TSP	1-1	1-2	1-3	1-4	Total
1H	269	563	347	908	2087
2H	300	536	239	626	1701
3H	184	335	240	770	1529
4H	189	378	252	552	1371
5H	216	333	277	561	1387
6H	183	241	281	802	1507
7H	558	503	653	663	2377
Total	1899	2889	2289	4882	11959

Note: Vast majority of dents are less than 2 volts.

Table 3
Unit 2 Dent Distribution (≥ 5 volt dents)

TSP	2-1	2-2	2-3	2-4	Total
1H	0	399	0	0	399
2H	0	10	0	2	12
3H	5	2	3	30	40
4H	1	105	3	7	116
5H	2	1	0	1	4
6H	0	0	1	1	2
7H	0	0	1	2	3
Total	8	517	8	43	576

Table 4
Unit 2 Dent Distribution (< 5 volt dents)

TSP	2-1	2-2	2-3	2-4	Total
1H	225	504	226	381	1336
2H	180	309	132	224	845
3H	160	216	121	277	774
4H	186	404	110	207	907
5H	325	214	157	235	931
6H	6	5	11	8	30
7H	26	25	18	41	110
Total	1108	1677	775	1373	4933

Note 1: Vast majority of dents at 1H through 5H are less than 2 volts.
Note 2: Dent population at 6H and 7H does not include dents less than 2 volts. These have not yet been analyzed.

Table 5
Number of Dented TSP Intersections with PWSCC Indications - Unit 1

TSP	1R6	1R7	Total
1H	13	34	47
2H	10	36	46
3H	1	6	7
4H	0	1	1
Total	24	77	101

Table 6
Number of Dented TSP Intersections with PWSCC Indications - Unit 2

TSP	2R5	2R6	2R7	Total
1H	16	3	52	71
2H	0	0	4	4
3H	0	0	10	10
4H	2	0	7	9
5H	0	0	1	1
Total	18	3	74	95

Table 7
Summary of DCPP Unit 1 Pulled Tube Data - ODSCC Only

		DESTRUCTIVE EXAM DATA			
TUBE	BOB/RPC VOLTS	MAX DEPTH	AVG DEPTH	CRACK LENGTH	BURST PRESSURE
R10C22, TSP1	NDD	4 percent	not measured	not measured	12,437 psi at OD indication
R10C22, TSP2	NDD	26 percent	not measured	not measured	12,085 psi at ID indication
R12C32, TSP2	NDD	20 percent	6 percent	0.20 in, macro	13,081 psi at OD indication
R14C69, TSP1	NDD	shallow by visual exam	not measured	not measured	13,096 psi at NDD location
R21C43, TSP2	NDD	32 percent	13 percent	0.255 in, macro	14,063 psi at OD indication

Table 8

DCPP SG Tubes Potentially Susceptible to Collapse and In-Leakage
Tube Support Plate 1, Left-Hand Steam Generators
DCPP Unit 1 SGs 1-1, 1-3
DCPP Unit 2 SGs 2-2, 2-4

Hot Leg			Cold Leg		
Wedge Location	Row	Column	Wedge Location	Row	Column
48 degrees	28	19-21	228 degrees	28	74-76
	29	17-22		29	73-78
	30	15-23		30	72-80
	31	14-24		31	71-81
	32	16-24		32	71-79
	33	16-23		33	72-79
	34	16-22		34	73-79
	35	17-21		35	74-78
	36	18-20		36	75-77
108 degrees	37	57-65	288 degrees	37	30-38
	38	57-65		38	30-38
	39	57-65		39	30-38
	40	57-65		40	30-38
	41	57-65		41	30-38
	42	57-65		42	30-38
	43	57-65		43	30-38
	44	57-62		44	33-38
	45	57-59		45	36-38
168 degrees	5	86-94	348 degrees	5	1-9
	6	86-94		6	1-9
	7	86-94		7	1-9
	8	86-93		8	2-9
	9	86-93		9	2-9
	10	86-93		10	2-9
	11	86-93		11	2-9
	12	86-93		12	2-9

Nozzle and tube column 1 located at 0 degrees.

Table 9

DCPP SG Tubes Potentially Susceptible to Collapse and In-Leakage
Tube Support Plates 2 through 6, Left-Hand Steam Generators
DCPP Unit 1 SGs 1-1, 1-3
DCPP Unit 2 SGs 2-2, 2-4

Hot Leg			Cold Leg		
Wedge Location	Row	Column	Wedge Location	Row	Column
12 degrees	5	1-9	192 degrees	5	86-94
	6	1-9		6	86-94
	7	1-9		7	86-94
	8	2-9		8	86-93
	9	2-9		9	86-93
	10	2-9		10	86-93
	11	2-9		11	86-93
	12	2-9		12	86-93
72 degrees	37	30-38	252 degrees	37	57-65
	38	30-38		38	57-65
	39	30-38		39	57-65
	40	30-38		40	57-65
	41	30-38		41	57-65
	42	30-38		42	57-65
	43	30-38		43	57-65
	44	33-38		44	57-62
	45	36-38		45	57-59
132 degrees	28	74-76	312 degrees	28	19-21
	29	73-78		29	17-22
	30	72-80		30	15-23
	31	71-81		31	14-24
	32	71-79		32	16-24
	33	72-79		33	16-23
	34	73-79		34	16-22
	35	74-78		35	17-21
	36	75-77		36	18-20

Nozzle and tube column 1 located at 0 degrees.

Table 10

DCPP SG Tubes Potentially Susceptible to Collapse and In-Leakage
Tube Support Plate 7, Left-Hand Steam Generators
DCPP Unit 1 SGs 1-1, 1-3
DCPP Unit 2 SGs 2-2, 2-4

Hot Leg			Cold Leg		
Wedge Location	Row	Column	Wedge Location	Row	Column
12 degrees	4	1-6	192 degrees	4	89-94
	5	1-6		5	89-94
	6	1-6		6	89-94
	7	1-6		7	89-94
	8	2-6		8	89-93
	9	2-6		9	89-93
	10	2-6		10	89-93
	11	2-6		11	89-93
	12	2-6		12	89-93
	13	3-6		13	89-92
	14	3-6		14	89-92
72 degrees	39	28-38	252 degrees	39	57-67
	40	28-38		40	57-67
	41	28-38		41	57-67
	42	28-38		42	57-67
	43	30-38		43	57-65
	44	33-38		44	57-62
	45	36-38		45	57-59
132 degrees	28	77-79	312 degrees	28	16-18
	29	76-80		29	15-19
	30	75-81		30	14-20
	31	74-82		31	13-21
	32	73-79		32	16-22
	33	72-79		33	16-23
	34	72-79		34	16-23
	35	73-78		35	17-22
	36	74-77		36	18-21
	37	75-76		37	19-20

Nozzle and tube column 1 located at 0 degrees.

Table 11

DCPP SG Tubes Potentially Susceptible to Collapse and In-Leakage
Tube Support Plate 1, Right-Hand Steam Generators
DCPP Unit 1 SGs 1-2, 1-4
DCPP Unit 2 SGs 2-1, 2-3

Hot Leg			Cold Leg		
Wedge Location	Row	Column	Wedge Location	Row	Column
48 degrees	28	74-76	228 degrees	28	19-21
	29	73-78		29	17-22
	30	72-80		30	15-23
	31	71-81		31	14-24
	32	71-79		32	16-24
	33	72-79		33	16-23
	34	73-79		34	16-22
	35	74-78		35	17-21
	36	75-77		36	18-20
108 degrees	37	30-38	288 degrees	37	57-65
	38	30-38		38	57-65
	39	30-38		39	57-65
	40	30-38		40	57-65
	41	30-38		41	57-65
	42	30-38		42	57-65
	43	30-38		43	57-65
	44	33-38		44	57-62
	45	36-38		45	57-59
168 degrees	5	1-9	348 degrees	5	86-94
	6	1-9		6	86-94
	7	1-9		7	86-94
	8	2-9		8	86-93
	9	2-9		9	86-93
	10	2-9		10	86-93
	11	2-9		11	86-93
	12	2-9		12	86-93

Nozzle and tube column 1 located at 180 degrees.

Table 12

DCPP SG Tubes Potentially Susceptible to Collapse and In-Leakage
Tube Support Plates 2 through 6, Right-Hand Steam Generators
DCPP Unit 1 SGs 1-2, 1-4
DCPP Unit 2 SGs 2-1, 2-3

Hot Leg			Cold Leg		
Wedge Location	Row	Column	Wedge Location	Row	Column
12 degrees	5	86-94	192 degrees	5	1-9
	6	86-94		6	1-9
	7	86-94		7	1-9
	8	86-93		8	2-9
	9	86-93		9	2-9
	10	86-93		10	2-9
	11	86-93		11	2-9
	12	86-93		12	2-9
72 degrees	37	57-65	252 degrees	37	30-38
	38	57-65		38	30-38
	39	57-65		39	30-38
	40	57-65		40	30-38
	41	57-65		41	30-38
	42	57-65		42	30-38
	43	57-65		43	30-38
	44	57-62		44	33-38
	45	57-59		45	36-38
132 degrees	28	19-21	312 degrees	28	74-76
	29	17-22		29	73-78
	30	15-23		30	72-80
	31	14-24		31	71-81
	32	16-24		32	71-79
	33	16-23		33	72-79
	34	16-22		34	73-79
	35	17-21		35	74-78
	36	18-20		36	75-77

Nozzle and tube column 1 located at 180 degrees.

Table 13

DCPP SG Tubes Potentially Susceptible to Collapse and In-Leakage
Tube Support Plate 7, Right-Hand Steam Generators
DCPP Unit 1 SGs 1-2, 1-4
DCPP Unit 2 SGs 2-1, 2-3

Hot Leg			Cold Leg		
Wedge Location	Row	Column	Wedge Location	Row	Column
12 degrees	4	89-94	192 degrees	4	1-6
	5	89-94		5	1-6
	6	89-94		6	1-6
	7	89-94		7	1-6
	8	89-93		8	2-6
	9	89-93		9	2-6
	10	89-93		10	2-6
	11	89-93		11	2-6
	12	89-93		12	2-6
	13	89-92		13	3-6
	14	89-92		14	3-6
72 degrees	39	57-67	252 degrees	39	28-38
	40	57-67		40	28-38
	41	57-67		41	28-38
	42	57-67		42	28-38
	43	57-65		43	30-38
	44	57-62		44	33-38
	45	57-59		45	36-38
132 degrees	28	16-18	312 degrees	28	77-79
	29	15-19		29	76-80
	30	14-20		30	75-81
	31	13-21		31	74-82
	32	16-22		32	73-79
	33	16-23		33	72-79
	34	16-23		34	72-79
	35	17-22		35	73-78
	36	18-21		36	74-77
	37	19-20		37	75-76

Nozzle and tube column 1 located at 180 degrees.

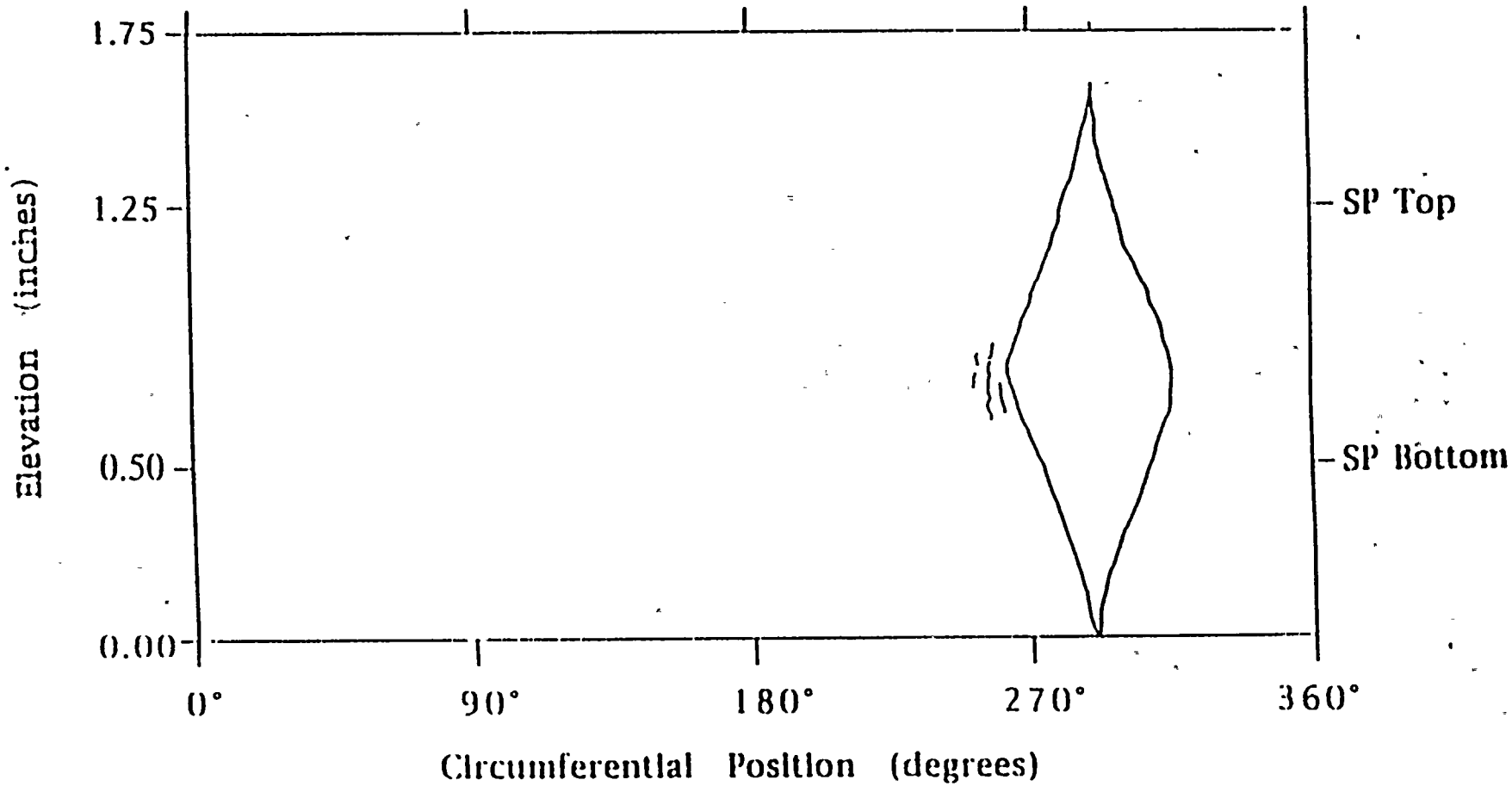

Figure 1 Sketch of the OD surface crack distribution found at the TSP2 region of Tube R12C32. Also shown is the location of the burst fracture opening, which had OD origin corrosion on its fracture face. The burst fracture opening extended beyond the TSP crevice region, but the corrosion cracking was confined to the crevice region. No ID corrosion was present.

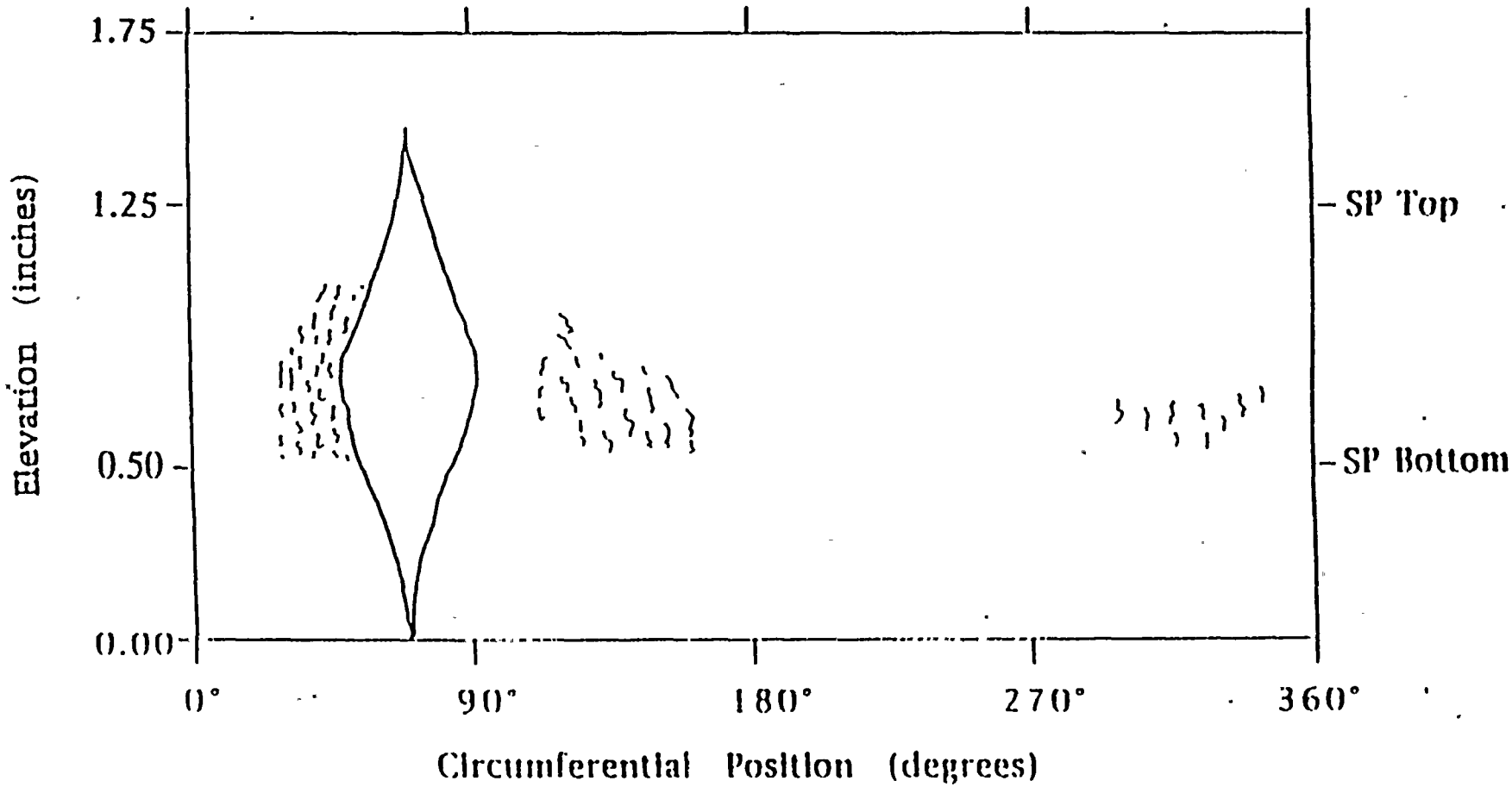

Figure 2 Sketch of the OD surface crack distribution found at the TSP2 region of Tube R21C43. Also shown is the location of the burst fracture opening, which had OD origin corrosion on its fracture face. The burst fracture opening extended beyond the TSP crevice region, but the corrosion cracking was confined to the crevice region. No ID corrosion was present.