

REACTOR COOLANT SYSTEM

SURVEILLANCE REQUIREMENTS (Continued)

1. All nonplugged tubes that previously had detectable wall penetrations greater than 20% that were not repaired.
2. Tubes in those areas where experience has indicated potential problems.
3. A tube inspection (pursuant to Specification 4.4.8.4.a.8) shall be performed on each selected tube. If any selected tube does not permit the passage of the eddy current probe for a tube inspection, this shall be recorded and an adjacent tube shall be selected and subjected to a tube inspection.
- c. In addition to the sample required in 4.4.8.2 b.1 through 3, all tubes which have had the P^2 criteria applied will be inspected in the tubesheet region. These tubes may be excluded from 4.4.8.2 b.1 provided the only previous wall penetration of >20% was located below the P^2 distance, or the required LA inspection area (3.5 inches).
- d. 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.
 2. The inspections include those portions of the tubes where imperfections were previously found.

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

Category

Inspection Results

C-1

Less than 5% of the total tubes inspected 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.

REACTOR COOLANT SYSTEM

SURVEILLANCE REQUIREMENTS (Continued)

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 or repair limit. A tube containing a defect is defective.
6. Tube Plugging or Repair Limit means the imperfection depth at or beyond which the tube shall be repaired (i.e. sleeving) or removed from service by plugging and is equal to 40% of the nominal tube wall thickness. This definition does not apply to the area of the tubesheet region below the F* distance provided the tube is not degraded (i.e., no indications of cracking) within the F* distance.

The portion of the tube in the tubesheet below the F* or L* distance provided the tube is not degraded (i.e., no indications of cracks) within the F* distance for F* tubes and within the L* distance for L* tubes.

7. Sleeve Plugging or Repair Limit

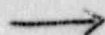
- a. For the area in the upper weld joint, any degradation shall be plugged unless it can be clearly demonstrated by a qualified NDE technique that the degradation is less than 40% of the nominal wall thickness of the sleeve for ID imperfections or less than 40% nominal wall thickness of the tube for O.D. imperfections.
- b. For the area of the tube behind the sleeve and above the upper weld joint, tubes with any degradation shall be plugged unless it can be clearly demonstrated by a qualified NDE technique, that the degradation is less than 40% of the nominal wall thickness.
- c. For the area below the upper weld joint, any defect greater than 40% of the nominal sleeve wall thickness shall be plugged.

REACTOR COOLANT SYSTEM

SURVEILLANCE REQUIREMENTS (Continued)

12. 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.
13. F* Distance is the distance into the tubesheet from the face of the tubesheet or the top of the last hardroll, whichever is lower (further into the tubesheet) that has been conservatively chosen to be 1.6 inches.
14. F* TUBE is the tube with degradation, below the F* distance, equal to or greater than 40%, and not degraded (i.e., no indications of cracking) within the F* distance.

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- b. The steam generator shall be determined OPERABLE after completing the corresponding actions (plug or repair 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 or repaired 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 the 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.
 3. Identification of tubes plugged or repaired.
- c. Results of steam generator tube inspections which fall into Category C-3 and require prompt notification of the Commission shall be reported pursuant to 10 CFR 50.72(b)2(i) prior to resumption of plant operation. A report pursuant to 10 CFR 50.73(a)2(ii) shall be submitted to provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence. *and L**
- d. The results of inspections of F*/tubes shall be reported to the Commission in a report to the Director, ONRR, prior to the restart of the unit following the inspection. This report shall include:
 1. Identification of F*/tubes, *and L**
 2. Location and size of the degradation

NRC approval of this report is not required prior to restart.

REACTOR COOLANT SYSTEMBASES3/4.4.5 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 2. 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 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 primary coolant system and the secondary coolant system (primary-to-secondary leakage = 500 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. Operating plants have demonstrated that primary-to-secondary leakage of 500 gallons per day per steam generator can readily be detected by radiation monitors of steam generator blowdown. Leakage in excess of this limit will require plant shutdown and an unscheduled inspection, during which the leaking tubes will be located and plugged or repaired.

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

~~For the tubes with degradation below the F* distance, but not degraded within the F* distance, plugging is not required.~~
Plugging is not required for tubes meeting either the F* or L* criteria.

Whenever the results of any steam generator tubing inservice inspection fall into Category C-3, these results will be promptly reported to the Commission pursuant to 10 CFR 50.72(b)(1) 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.

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15. L* Distance is the distance into the tubesheet from the face of the tubesheet or the top of the last hardroll, whichever is lower (further into the tubesheet), that has been conservatively chosen to be 0.7 inches.
16. L* Tube is a tube with short (less than 0.5 inches) axially oriented (20 degrees or less from axial) degradation occurring below the undegraded L* distance. An additional minimum of 1.0 inches of sound expanded tube (below the L* distance) separated by no more than 2 areas of axially oriented degradations must be contained in the top 3.5 inches of tube (within the tubesheet). Each area of degradation is limited to a maximum of 5 distinct indications. A maximum of 2500 tube ends per steam generator may utilize L*. Tubes qualifying as F* tubes are not classified as L* tubes.

ATTACHMENT 2

Description of Amendment Request and Safety Evaluation

Description of Amendment Request:

Technical Specification 4.4.5, "Steam Generators-Surveillance Requirements," describes the augmented inservice inspection program used in conjunction with Specification 4.0.5 to demonstrate steam generator operability. In order to utilize the L* alternate plugging criteria, several items in Technical Specification 4.4.5 must be revised. The proposed changes provide requirements for L* which are similar to the type of requirements imposed for utilization of F*. A brief description of the existing Technical Specification items and the proposed revisions is provided below.

TS 4.4.5.2.c

This item currently requires inspection in the tubesheet region for specified F* tubes. The proposed change adds the requirement to inspect all L* tubes in the tubesheet region.

TS 4.4.5.4.a.6

This item provides tube and sleeve plugging or repair limits. It exempts F* tubes from plugging or repair provided the tube is not degraded within the F* distance. The proposed change will add an exemption to the plugging or repair limit for L* tubes provided there is no degradation within the L* distance.

TS 4.4.5.4.a.15

The proposed change adds a new item, 4.4.5.4.a.15, which defines the L* distance.

TS 4.4.5.4.a.16

The proposed change adds a new item, 4.4.5.4.a.16, which defines an L* tube including limits on the amount of tube degradation and type of cracking. A maximum number of tube ends which can utilize the L* criteria is also specified.

TS 4.4.5.5.d

This item currently requires a report on the results of the inspection of all F* tubes. The proposed change adds the requirement to report on the results of the inspection of all L* tubes.

Bases 3/4.4.5

The bases currently state that plugging is not required for F* tubes provided there is no degradation within the F* distance. The proposed change revises this statement to say that plugging is not required for tubes meeting the F* or L* criteria.

The basis for steam generator tube surveillance and plugging/repair is to ensure that the structural integrity of the tubes is maintained. The L*

criteria was developed to allow for an alternative to tube plugging or sleeving for indications which occur in the tubesheet area. The L* criteria defines a length of undegraded expanded tube in the tubesheet which is sufficient to maintain any potential leakage (resulting from cracks occurring further down in the tubesheet) to well below the Technical Specification limit and Safety Analysis assumptions. The L* criteria were premised on the fact that the tubesheet provides reinforcement of the expanded portion of the tube, provides resistance to tube rupture and collapse, and limits leakage of throughwall cracks. WCAP-11857 describes in detail the analysis and testing performed to demonstrate acceptability of the L* criteria.

The proposed Technical Specification change is requested to provide SCE&G with an alternative for dispositioning degraded steam generator tubes. Application of the L* criteria provides benefits by maintaining tube heat transfer and flow capabilities and reducing personnel radiation exposure obtained during plugging/sleeving operations.

Safety Evaluation:

Introduction

This Technical Specification change is being proposed due to the history of eddy current indications of tube degradation in the mechanical roll expanded portion of the tubes within the tubesheet in the steam generators at VCSNS. It has been determined through interpretation of eddy current examinations that the tube degradation occurring in the VCSNS steam generators is of the type associated with primary water stress corrosion cracking (PWSCC). Degradation appears to occur at sites where the residual stresses are the greatest (i.e., at the roll expansion transition and at the heel of each roll step within the depth of the tubesheet). Experience to date shows that typically the indications are short (less than 1/2 inch) axially oriented and intergranular in nature (ie. very little volumetric loss occurs). As expected, the indications primarily form rapidly and as they grow through the high stress field, the stress is relieved and the crack is arrested. Some circumferential extent or linking up of small axials may be found in some of the more susceptible/significantly degraded tubes (e.g., tubes that were poorly rolled or with poor metallurgy). However this is not expected in regions where the degradation has not progressed as extensively.

Using existing Technical Specification tube plugging criteria, many tubes experiencing only minor PWSCC degradations would have to be repaired or removed from service. However, with the analyses described in this submittal and WCAP-11857, it can be shown that tube plugging or repair is not required in many cases to maintain tube bundle integrity. WCAP-11857 was developed by Westinghouse specifically for VCSNS and provides L* criteria for the VCSNS steam generators. The proposed L* criteria were evaluated for the four tube modes recommended by Regulatory Guide 1.121 for three steam generator conditions (normal operations, feedline break and loss of coolant).

The proposed amendment takes advantage of the WCAP analyses and offers many benefits including 1) precluding occupational radiation exposure that would otherwise be incurred by plant workers involved in tube plugging or repair operations, 2) minimizing the loss of margin in the reactor coolant flow through the steam generator in LOCA analyses, and 3) avoiding loss of margin

in reactor coolant system flow and therefore assisting in assuring that minimum flow rates are maintained in excess of that required for operation at full power. Reduction in the amount of tube plugging or repair required can also reduce the length of plant outages and reduce the time that the steam generators are open to the containment environment during an outage.

Justification

The Model D-3 steam generators at VCSNS were fabricated with a full depth roll expansion in the lower end of the tube above the tube to tubesheet weld. The presence of the tubesheet acts to constrain the tube and complement its integrity in that region by essentially precluding tube deformation beyond its expanded outside diameter. In addition, the proximity of the tubesheet significantly affects the leak behavior of through wall tube cracks in this region. The elastic preload and interference fit between tube and the tubesheet due to the roll expansion provides an effective barrier to significant leakage from cracks and other tube degradation in the expanded tube.

Tube plugging criteria have been developed for indications of tube degradation in the tube expansion region below the transition of the mechanically expanded/unexpanded portions of the tube. Over the past 3 outages, SCE&G has successfully utilized the F* criterion which allows tubes with degradation occurring greater than 1.6 inches into the tubesheet to remain inservice. The F* criterion represents a length, designated F*, of continuous roll expansion in the tubesheet such that tube pullout would not occur during either normal operation or postulated accident condition loadings. The implicit assumption of a circumferential severance of a tube in the development of the F* criterion permitted the conclusion that degradation of any extent or orientation within the tubesheet below the F* distance is acceptable during normal and postulated accident conditions. This very conservative assumption results in a distance that is longer than necessary to provide a limit to significant leakage in excess of the Technical Specification allowances and Safety Analysis assumptions. Existing VCSNS steam generator tube plugging and repair criteria do not take into account the reinforcing effect of the tubesheet on the external surface of the tube in the portion of the tube expansion above the F* location.

To address some of the indications occurring at an elevation too high in the tube to meet the F* criterion an additional alternative plugging criteria, designated the L* criteria, is proposed. The L* criteria defines a length, L*, of undegraded expanded tube which, even in a worst case scenario, is sufficient to maintain (well below the Technical Specification limit and Safety Analysis assumptions) any potential leakage. Use of the L* criteria requires that the condition of the degradation below the L* distance be assessed. For those tubes in which the degradation below L* is determined to be axial or near axial (not greater than 20°) cracking, the degraded tube provides sufficient structural strength to preclude pullout of the tube and it may remain in service without repair or plugging. The approach taken in developing the L* criteria was to build on the fundamental basis of the F* criterion, thereby utilizing an accepted methodology for the groundwork and limiting the introduction of new (untried) methodologies.

The minimum required engagement length, L^* , of roll expansion to preclude significant leakage under normal operation and postulated accident loading conditions was determined to be 0.50 inches. (This value does not include an allowance for eddy current elevation measurement uncertainty.) This L^* distance is measured from the bottom of the transition between the expanded and unexpanded portions of the tube. In the case of a transition located above the top of the tubesheet, the L^* distance is measured from the top of the tubesheet.

In order to evaluate the L^* criterion concept for indications within the top portion of the tubesheet, an evaluation of the strength of degraded tubes was made. Based on plant operation and laboratory experience the configuration of any cracks, should they occur, is initially axial. For axial or nearly axial indications in the tubesheet region, the tube end remains structurally intact minimizing any potential for tube pullout. The strength of tubes with axial or near axial cracks has been evaluated using analysis and testing. In order to implement the L^* criteria, SCE&G has chosen to conservatively roundoff the bounding values established in WCAP-11857 (see Attachment 4 for a discussion on bounding assumptions). A minimum of 3.5 inches of the tube, beginning at the top of the tubesheet and extending down into the tubesheet, must be inspected using a rotating pancake coil (RPC) eddy current technique (or equivalent) to determine the condition of the tube. A minimum of 1.0 inches of sound expanded tube (below the L^* distance), separated by no more than 2 areas of tube degradation (cracks less than 1/2 inch and not greater than 20° from axial), must be found in the inspected portion of tube to ensure tube strength and prevent tube pullout.

The L^* engagement length determination was derived from preload, tube pullout, hydraulic proof (pressure), and leak testing done to develop the F^* criteria. An evaluation consisting of analysis and testing programs was conducted to verify that the strength of tubes with axial or near axial cracks in the roll expansion region is greater than that required to resist pullout forces during normal operation and postulated accident loading conditions. An additional program of tests was done to verify that a roll expansion with the length of L^* is sufficient to significantly restrict leakage during normal operating and postulated accident condition loadings. The leak testing done to validate the L^* distance used holes drilled through the tube to simulate the ends of axial cracks. The F^* leak testing had used a less sophisticated method for simulating tube degradation using a circumferential cut through the tube. The acceptance criteria for the leak testing was based on maintaining the total leakage through the L^* distance to less than the primary to secondary leakage limit in the Technical Specifications. To provide operational flexibility, the acceptance criteria was determined using a fraction of the Technical Specification limit (.117 gpm). This value was divided by a number of tubes larger than the number of tubes expected to use the L^* criteria (Note that the WCAP allows L^* to be applied to 2648 tube ends per steam generator, however, SCE&G has chosen to limit L^* to 2500) to get a final acceptance criteria for average test specimen leakage. The results of the L^* leak testing compared favorably with the acceptance criteria. For normal operating pressure differential, primary to secondary leakage for an L^* value of 0.5 inch was negligible. The leak testing included tests of lengths shorter than 0.5 inch to demonstrate that the function of leak rate versus length of sound expansion is not near a threshold value in the region of the L^* length chosen.

The total L* distance value to be contained in the Technical Specifications includes 0.2 inch as an allowance for eddy current measurement uncertainties. This value conservatively envelopes the present day capabilities of state-of-the-art eddy current technology. Attachment 4 provides a more detailed discussion of eddy current capabilities for L* implementation.

Degradation of the type for which the L* criteria has been developed, axial cracking, has been shown to be self limiting and not to rapidly grow into a length which could lead to an increased probability of a tube rupture. The use of the L* criteria could not affect the probability of occurrence of any other accident which originates from conditions outside the steam generator. The limiting of the total leakage from L* tubes to less than the Technical Specification limit will assure that the consequences of any analyzed accident are not increased by the use of the L* criteria. The use of this criteria could not cause the steam generator or any other equipment important to safety to malfunction. Existing tube rupture analyses bound the effects of any hypothetical failure of the tube due to the use of the L* criteria and use of the L* criteria does not result in the possibility of an accident different from those previously analyzed. The margin of safety is not reduced and is provided by the safety factors implicit in the use of the ASME Code to analyze the structural integrity of the tubes, the safety factors included in the recommendations of Regulatory Guide 1.121, and the margin represented by the difference in the size of a crack sufficient to exceed Technical Specification leak limits/Safety Analysis assumptions and the minimum size of crack required to result in tube rupture or exceed analysis assumptions in the steamline break analysis.

On the basis of the evaluation above and as further detailed in WCAP-11857, it is determined that tubes with tube degradation which can be categorized as axial or near axial cracking (not greater than 20°) within the tubesheet region below the L* distance (defined as 0.7 inches, including eddy current uncertainty) can be left in service. Tubes with tube degradation which is located a distance of less than L* below the bottom of the transition between the expanded and unexpanded tubes or the top of the tubesheet, whichever is lower, will be removed from service by plugging or repairing in accordance with Technical Specification requirements.

ATTACHMENT 3

Description of Amendment Request and
No Significant Hazards Evaluation

NO SIGNIFICANT HAZARDS EVALUATION

Description of Amendment Request:

Technical Specification 4.4.5, "Steam Generators-Surveillance Requirements," describes the augmented inservice inspection program used in conjunction with Specification 4.0.5 to demonstrate steam generator operability. In order to utilize the L* alternate plugging criteria, several items in Technical Specification 4.4.5 must be revised. The proposed changes provide requirements for L* which are similar to the type of requirements imposed for utilization of F*. A brief description of the existing Technical Specification items and the proposed revisions is provided below.

TS 4.4.5.2.c

This item currently requires inspection in the tubesheet region for specified F* tubes. The proposed change adds the requirement to inspect all L* tubes in the tubesheet region.

TS 4.4.5.4.a.6

This item provides tube and sleeve plugging or repair limits. It exempts F* tubes from plugging or repair provided the tube is not degraded within the F* distance. The proposed change will add an exemption to the plugging or repair limit for L* tubes provided there is no degradation within the L* distance.

TS 4.4.5.4.a.15

The proposed change adds a new item, 4.4.5.4.a.15, which defines the L* distance.

TS 4.4.5.4.a.16

The proposed change adds a new item, 4.4.5.4.a.16, which defines an L* tube including limits on the amount of tube degradation and type of cracking. A maximum number of tube ends which can utilize the L* criteria is also specified.

TS 4.4.5.5.d

This item currently requires a report on the results of the inspection of all F* tubes. The proposed change adds the requirement to report on the results of the inspection of all L* tubes.

Bases 3/4.4.5

The bases currently state that plugging is not required for F* tubes provided there is no degradation within the F* distance. The proposed change revises this statement to say that plugging is not required for tubes meeting the F* or L* criteria.

The basis for steam generator tube surveillance and plugging/repair is to ensure that the structural integrity of the tubes is maintained. The L* criteria was developed to allow for an alternative to tube plugging or sleeving for indications which occur in the tubesheet area. The L* criteria defines a length of undegraded expanded tube in the tubesheet which is sufficient to maintain any potential leakage (resulting from cracks occurring further down in the tubesheet) to well below the Technical Specification limit and Safety Analysis assumptions. The L* criteria were premised on the fact that the tubesheet provides reinforcement of the expanded portion of the tube, provides resistance to tube rupture and collapse, and limits leakage of throughwall cracks. WCAP-11857 describes in detail the analysis and testing performed to demonstrate acceptability of the L* criteria.

The proposed Technical Specification change is requested to provide SCE&G with an alternative for dispositioning degraded steam generator tubes. Application of the L* criteria provides benefits by maintaining tube heat transfer and flow capabilities and reducing personnel radiation exposure obtained during plugging/sleeving operations.

No Significant Hazards Evaluation:

Pursuant to 10CFR50.91, the following analyses provide a determination that the proposed change poses no significant hazard as defined by 10CFR50.92.

- 1) The proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

The presence of the tubesheet enhances steam generator tube integrity in the region of the hardroll by precluding tube deformation beyond its initial expanded outside diameter. The resistance to both tube rupture and tube collapse is strengthened by the presence of the tubesheet in that region. The result of the hardroll of the tube into the tubesheet is an interference fit between the tube and the tubesheet. Tube rupture can not occur because the contact between the tube and tubesheet does not permit sufficient movement of tube material. In a similar manner, the tubesheet does not permit sufficient movement of tube material to permit buckling collapse of the tube during postulated LOCA loadings.

The type of degradation for which the L* criteria has been developed (cracking with an axial or near axial orientation) has been found not to significantly reduce the axial strength of a tube. An evaluation including analysis and testing has been done to determine the strength reduction for axial loads with simulated axial and near axial cracks. This evaluation provided the basis for the acceptance criteria for tube degradation subject to the L* criteria.

The length of roll expansion above L* is sufficient to preclude significant leakage from tube degradation located below the L* distance. The existing Technical Specification leakage rate requirements and accident analysis assumptions remain unchanged in the unlikely event that significant leakage from this region does occur. As noted above,

tube rupture and pullout is not expected for tubes using the alternate plugging criteria. In addition, SCE&G has chosen to define the L* criteria more conservatively than the WCAP.

Any leakage out of the tube from within the tubesheet at any elevation in the tubesheet is fully bounded by the existing steam generator tube rupture analysis included in the V. C. Summer Final Safety Analysis Report. The proposed alternate plugging criteria do not adversely impact any other previously evaluated design basis accident.

- 2) The proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

Implementation of the proposed alternate tubesheet tube plugging criteria does not introduce changes to the plant design basis. Use of the criteria does not provide a mechanism to result in an accident outside of the region of the tubesheet expansion. Any hypothetical accident as a result of any tube degradation in the expanded portion of the tube would be bounded by the existing tube rupture accident analysis.

- 3) The proposed change does not involve a significant reduction in a margin of safety.

The use of the alternate tubesheet plugging criteria has been demonstrated to maintain the integrity of the tube bundle commensurate with the requirements of Reg. Guide 1.121 for indications in the free span of tubes and the primary to secondary pressure boundary under normal and postulated accident conditions. Acceptable tube degradation for the L* criteria is any degradation indication with axial or nearly axial cracking in the tubesheet region, more than the L* distance below the bottom of the transition between the roll expansion and the unexpanded tube. For tubes with axial or nearly axial cracks the strength of the tube relative to an axial load would not be reduced below the strength required to resist potential axial loads. The safety factors used in the verification of the strength of the degraded tube are consistent with the safety factors in the ASME Boiler and Pressure Vessel Code used in steam generator design. The L* distance has been verified by testing to be greater than the length of roll expansion required to preclude significant leakage during normal and postulated accident conditions. The leak testing acceptance criteria are based on the primary to secondary leakage limit in the Technical Specifications and the leakage assumptions used in the FSAR accident analyses.

Implementation of the alternate tubesheet plugging criteria will decrease the number of tubes which must be taken out of service with tube plugs or repaired with sleeves. Both plugs and sleeves reduce the RCS flow margin, thus implementation of the alternate plugging criteria will maintain the margin of flow that would otherwise be reduced in the event of increased plugging or sleeving. Based on the above, it is concluded that the proposed change does not result in a reduction in a loss of margin with respect to plant safety as defined in the Final Safety Analysis Report or the bases of the Technical Specifications.

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August 30, 1990
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Based on the preceding analysis, SCE&G has determined that this change does not involve a significant hazards consideration.

BOUNDING ANALYTICAL ASSUMPTIONS FOR L*

The L* criteria is premised on the fact that the tubesheet provides reinforcement of the expanded portion of the tube, provides resistance to tube rupture and collapse, and limits leakage of throughwall indications. The L* analysis requires adequate axial tube strength to prevent pullout and an acceptable primary to secondary leakage limit.

The evaluation performed for L* is documented in WCAP-11857 which was submitted to the NRC on August 1, 1988. Testing was performed on tubes manufactured to simulate plant tube conditions to confirm the adequacy of analytical assumptions made for L*. The bounding assumption for leakage considerations concerned limiting primary to secondary leakage well below Technical Specification limits. This required specifying a minimum sound tube length within the tubesheet called the L* distance. Test results indicated that acceptable leakage was obtained with a minimum L* distance of 1/4 inch. The maximum number of a tube ends which could utilize L* and limit leakage to an acceptable level was 2778 for 1/4 inch (2648 for 1/2 inch).

Tests were also performed to determine the bounding parameters to ensure the adequate axial strength of the tube. The key parameters were:

- A maximum of 30 indications per band.
- A maximum indication length of 1/2 inch.
- A maximum angularity of the indication of 45 degrees from axial.
- The minimum L* distance (sound tube length) was 1/4 inch.

The proposed L* criteria for VCSNS utilizes the WCAP-11857 evaluation as a bounding analysis. To ensure conservatism and allow for demonstrable implementation, the key L* parameters were defined for Technical Specification purposes as follows:

- A maximum of 5 distinct indications per degradation band.
- A maximum indication length of 0.5 inches.
- A maximum angularity of the indication of 20 degrees from axial.
- An L* distance of 0.7 inches
- A minimum enhanced inspection area of 3.5 inches of tube containing at least 1.0 inches of sound tube (below the L* distance) separated by no more than 2 areas of degradation.
- A limit of 2500 tube ends per steam generator to be dispositioned as L*.

EDDY CURRENT TECHNIQUES

The L* criteria being proposed has conservatively taken into account the present day limitations of state-of-the-art eddy current techniques. Current industry studies indicate that rotating pancake coil (RPC) systems exist that are capable of estimating crack lengths within 0.1 inch accuracy. VCSNS tube length measurement requirements to implement L* have incorporated 0.2 inches to account for ECT uncertainties. Since the SCE&G intent in utilizing the L* criteria is to address only axial indications, a conservative limit of 20° from axial was chosen to address angularity. Resolution capabilities of the ECT are addressed by limiting the number of indications allowed per band of degradation to 5 distinct indications. These conservatisms ensure the analytical/tested requirements are satisfied.

The following information relates to specific details on hardware, data acquisition and analysis systems currently available to support L* implementation with rotating pancake coil (RPC) ECT methods. This description is provided to aid understanding of the ECT methods available today.

Rotating Pancake Coils

The three coil rotating probe consists of three individual coils mounted on the same probe head. This is an external reference probe and requires that a similar probe be placed in a piece of tubing made of the same material as the tubing under test. The three coils which make up this probe are used for detection, orientation and location of signals as follows:

- The test coil is a self reference, mid-range pancake coil, used for signal detection and identification.
- The axial indicator coil is an external reference coil oriented in such a way that it is more sensitive to signals which occur in the axial direction of a tube. This coil is used to characterize the orientation of an indication.
- The circumferential indicator coil is an external reference coil oriented such that it is more sensitive to signals that occur around the circumference of the tube wall. This coil is used to further characterize the orientation of an indication.

Graphic Presentations

With the use of inside diameter surface riding RPC examination the near surface flaw related signals are accentuated while the geometrical variations within the tube sheet region are negated. The insitu examination of steam generator tubes with RPC requires that several display options be chosen prior to inspection and data evaluation.

The generation of the graphic presentations that depict the results of the examination is probably the most complicated part of the RPC analysis. Many features are involved in the graphic presentation of the ECT data, the most critical include:

- The up-stream/down-stream plotting phase.
- The pull/rotate ratio selection.
- The trigger location selection.
- Angle measurement.
- Length measurement and indication resolution.

Up-stream/Down-stream Plotting

At an expansion transition region an offset signal can be seen in the ECT plots. This can be attributed to tube support plate, top of tube sheet intersections or skip rolls and is typically more visible at lower frequencies. Low level flaw signals that can be present at these locations may be hidden by the signal offset responses. Special displays are used for viewing of low level anomalies without the interference of the plotting of offset signals. For example, the "Downstream" view is plotted from a perspective inside the tube looking toward the tube end. The "Upstream" view is from the reverse direction (see attached Figures A and B).

Pull/Rotate Ratio Selection

It is possible to emphasize one axis more than another (pull/rotate ratio) and change the appearance of the signal of interest. This could lead to erroneous interpretation of the signal. The pull/rotate ratio will be procedurally controlled to resolve the potential error by mandating that a proper ratio be set and left unchanged after calibration for the tubing size being examined.

Trigger Location Selection

It is possible that a signal of interest may fall at the point where the plot starts or ends. To improve the display of this signal it may be necessary to use the Trigger +/- function key to increment/decrement the start position of the trace. This trigger is a constant signal generated during data acquisition. It is the basis for start/stop points and proper alignment of the inspection data when displayed for evaluation.

Angle Measurement

A software function for determining the size and angle of an indication is available and can be set based on as measured ASME/EDM notch standard flaws. This software function is a "measuring box" which can be readily moved to any portion of the displayed data and adjusted, in mils, to the proper size for the indication being used for calibration.

In addition to the ability to size a signal, the box is capable of determining the angle of the indication, providing a "box angle" value. The range of this value is from 0 to 90 degrees. A value of 0 relates to an indication oriented in an axial direction and a value of 90 indicates a signal oriented in the circumferential direction.

Length Measurement and Indication Resolution

Utilizing a motorized rotating pancake coil (MRPC) in combination with a digital eddy current instrument allows data to be gathered in a circumferential grid of data points. This is accomplished by utilizing a 1.2 mm diameter coil and rotating it around the inside surface of the tube at a 1 mm pitch. The sampling rate can be carefully controlled by utilizing the output of a very precise rotary encoder attached to the system. At a rate of 64 data points per one revolution, an eddy current "grid" of data points approximately 1 mm apart is obtained. Therefore, combining the pitch and data sampling points per revolution, the data array is composed of 1x1 mm grid spaces.

The processing of the data array contains several steps which are designed to provide accurate analysis information. The first step applies filters to smooth the data and spurious signals. Next, limiting threshold values are established such that data less than the value is discounted. The subsequent steps involve processing the data to extract distinct crack indications. First, in the circumferential direction, a minimum of two valid data points (i.e., above the threshold value) must be present for a possible crack indication to be present. Second, greater than one adjoining valid data point in the axial direction is required. This adjoining point(s) can either be directly axial or one position away in the circumferential direction. Provided both the axial and circumferential conditions described above are met, a crack segment is considered to exist.

Resolution of numerous small, individual cracks axially located around the tube within a band of degradation is limited even with the state-of-the-art techniques currently available. Based on the preceding discussions, approximately 12 individual cracks in one crack band is considered the maximum number which can be individually discerned and characterized with ECT. As shown and explained in the examples attached to this submittal, implementation of the L* criteria by SCE&G will be conservatively applied only to tubes in which indications can be distinctly characterized.

SCE&G IMPLEMENTATION PLAN

As stated previously, WCAP-11857 is a bounding, analytical document providing the analytical basis and test results of the L* criteria. The purpose of the document was to provide a bounding worst-case scenario to encompass anticipated plant conditions. The Technical Specification changes now being requested to encompass the L* criteria are considered more realistic and consistent with conceptualized implementation plans. The intended application of the L* criteria is to prevent plugging/repairing a subset of tubes with indications that are not significant, but do occur higher in the tubesheet than can be dispositioned with the F* criterion.

The attached examples provide illustrations of potential L* tube candidates along with those tubes which would not be considered further for L* application.

The purpose of these examples is to illustrate the initial RPC screening process to be used to make an initial L* applicability determination.

ATTACHMENT 4

FIGURES

Note: The following figures illustrate the Upstream/Downstream Plotting capability.

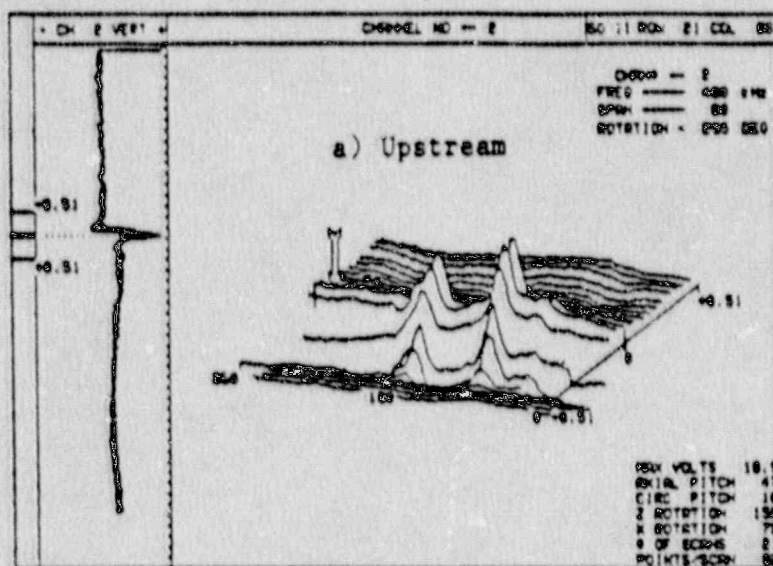


Figure A

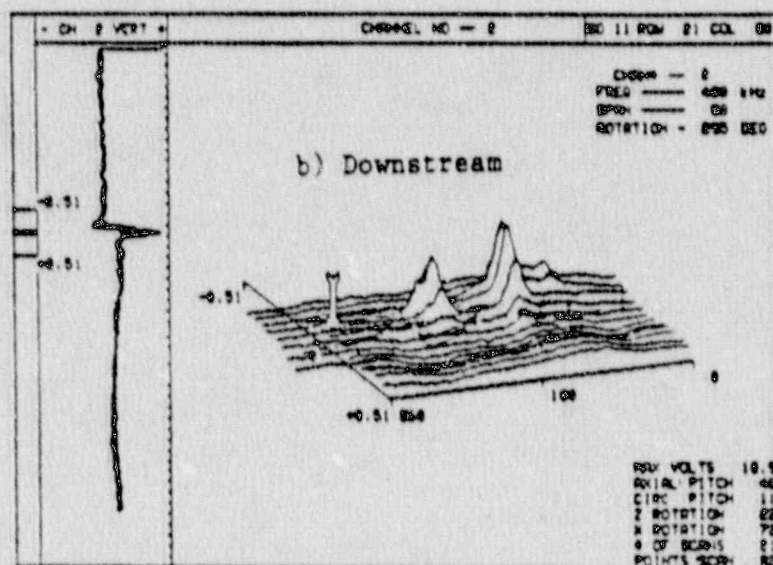
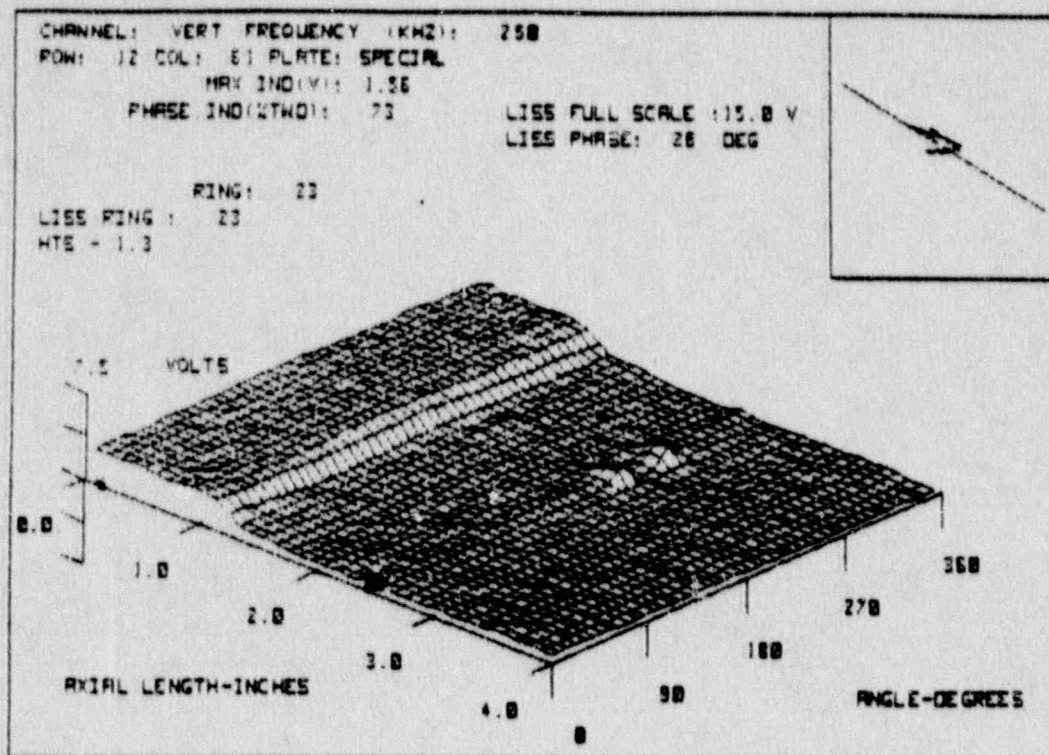


Figure B

ATTACHMENT 4

EXAMPLES

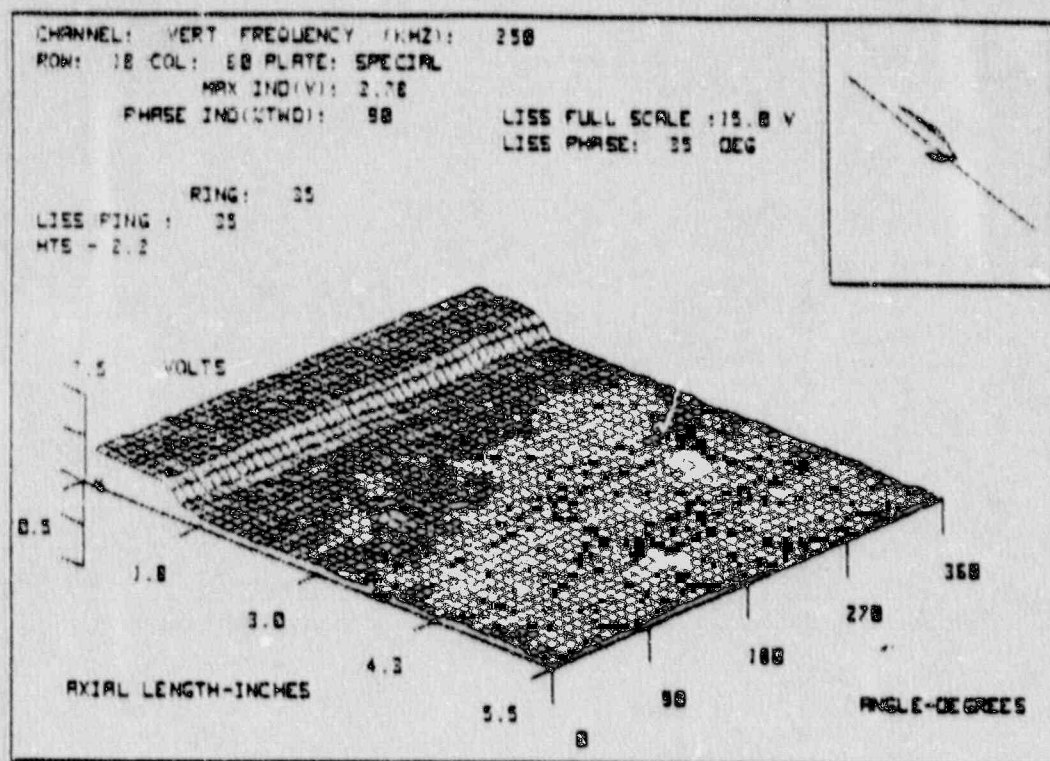
Note: The following examples illustrate potential L* candidates and tubes that are not L* candidates.



A good L^* candidate

because:

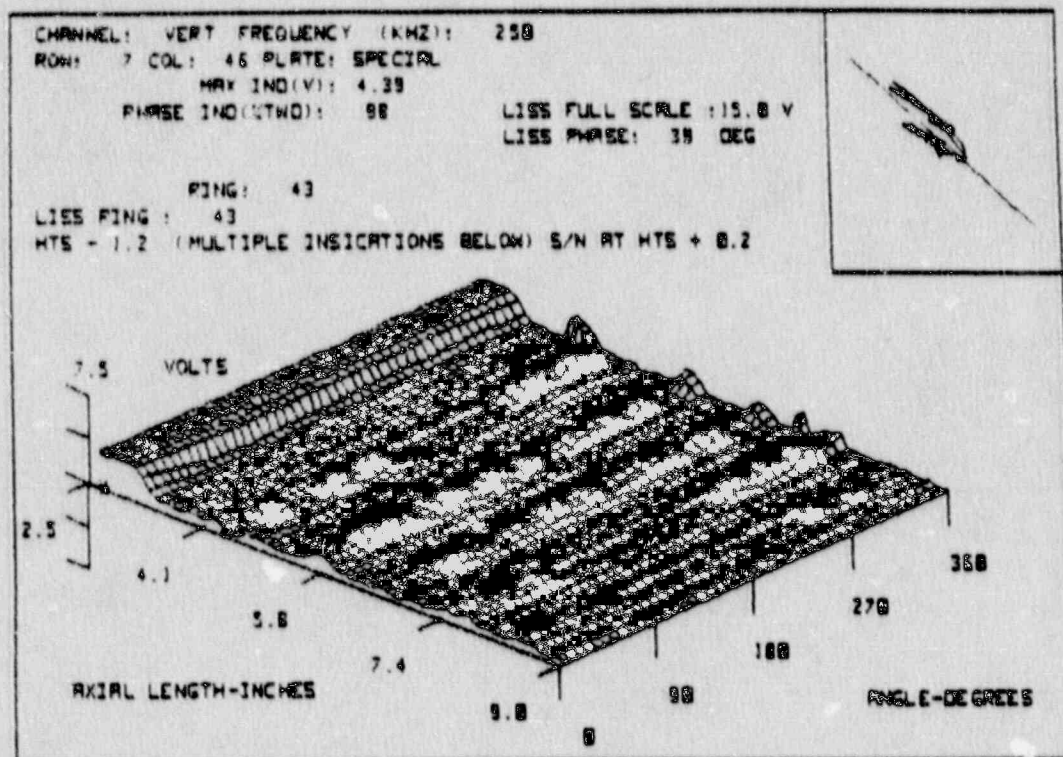
- 1) Initially the indications appear to be just greater than 1 inch below the bottom of the roll transition (i.e., below L^* distance, but still within the F^* distance).
- 2) Apparent small number of indications within the band of degradation (i.e., ability to distinguish individual indications with additional analysis)
- 3) Smooth roll transition.



A good L* candidate

because:

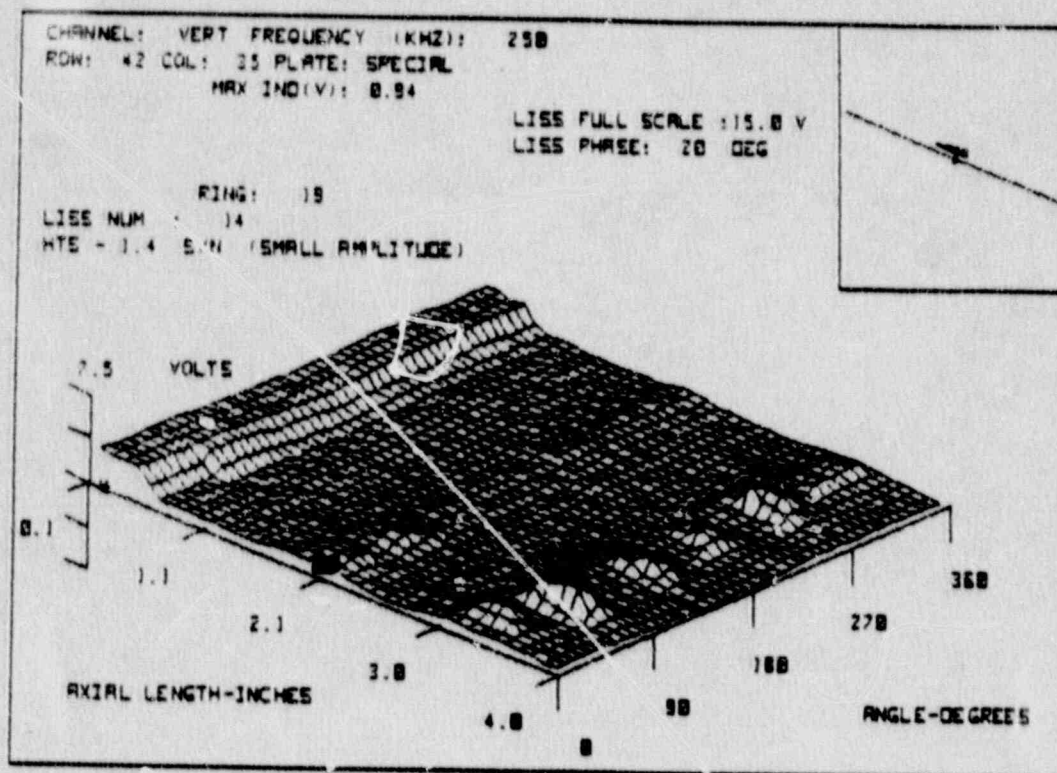
- 1) Uppermost indication appears to fall within the F* distance but below the L* distance.
- 2) Small number of indications within each band of degradation (i.e., ability to distinguish individual cracks).
- 3) Indications appear to be small and separated by distinct bands of sound tube.
- 4) Smooth roll transition.



NOT a L* candidate

because:

- 1) Indications within bands of degradation spaced such that distinct crack identification is difficult.



NOT a L* candidate

because:

- 1) Second band of degradation has a group of indication spaced such that distinct crack identification is not clear.