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Status and Suggested Course of Action for Nondenting-Related Primary-Side IGSCC of Westinghouse-Type Steam Generators

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ENCLOSURE 1

Consumers Power Company
Palisades Plant
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"Status and Suggested Course of Action
for Nondenting-Related Primary-Side IGSCC
of Westinghouse-Type Steam Generators"
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ABSTRACT

The current status of non denting related primary side intergranular stress corrosion cracking (IGSCC) in Westinghouse type PWR steam generators with non thermally treated alloy 600 tubing is summarized. This includes cracks in first and second row U-bends, at tube sheet expansion transitions, and at expanded areas within the tube sheet. Details of the cracking which has occurred at a number of lead units are described.

The conditions which lead to primary side IGSCC are described. These conditions include: susceptible material, aggressive environment, and tensile stresses. A method is outlined to make rough estimates of the time to failure at each of the locations where primary side IGSCC has occurred to date. The method requires that tube material susceptibility be determined by test or experience, and is subject to large errors due to unknown levels of residual stress.

The possible consequences of primary side IGSCC are discussed. These include: secondary side contamination, possible derating of the plant due to plugged tubes, exceeding technical specification leakage limits if affected tubes are not plugged, and increased risk of tube ruptures.

A data base is presented covering each of the Westinghouse type plants with nonthermally treated alloy 600 tubing located in the United States and abroad. This data base includes key data relating to primary side IGSCC for these plants including: steam generator manufacturer, steam generator model number, date of commercial operation, tube supplier, tube material grain size, tube expansion method and length, hot leg coolant temperature, and where primary side IGSCC has occurred to date in the plant. A method is then outlined to assess the risk of primary side IGSCC occurring at a given plant. This assessment takes into account material susceptibility and fabrication details.

The current status of remedial measures to minimize primary side IGSCC is outlined.

A suggested course of action for utilities regarding primary side IGSCC is outlined. This suggested course of action takes into account material susceptibility, fabrication details, and the plant operating history.

ACKNOWLEDGMENTS

This report was made possible by the cooperation and assistance of the nuclear power utilities and supporting organizations in Belgium and France. The assistance of Mr. P. Hernalsteen of Tractionel and Mr. J.-R. Donati of Electricite de France was of great importance in this regard and is gratefully acknowledged. The Swedish State Power Board (Mr. J. Engstrom) also provided much useful information.

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INTRODUCTION

Primary side intergranular stress corrosion cracking (IGSCC) of Ni-Cr-Fe alloy 600 steam generator tubing has been almost exclusively* limited to Westinghouse type steam generators fabricated by Westinghouse or its licensees (i.e. Cockerill, Framatome, Siemens, and Mitsubishi) from non thermally treated alloy 600 material. Such cracking can be either related to denting or not related to denting. Denting related cracking can be minimized or eliminated by following recommendations contained in the EPRI Steam Generator Owners Group Design and Operating Guidelines, and should therefore not be a continuing problem. Non denting related primary side IGSCC, on the other hand, is a continuing problem. The purposes of this report are to:

- Summarize the current status of non denting related primary side IGSCC in Westinghouse type steam generators
- Outline the current thinking regarding the cause and consequences of primary side IGSCC
- Tabulate key data on Westinghouse type steam generators which have non thermally treated alloy 600 tubing
- Describe the corrective and remedial action programs currently being pursued
- Suggest a method to assess the risk of primary side IGSCC at a particular plant and a course of action for utilities relative to the primary IGSCC problems

CURRENT STATUS OF PRIMARY SIDE IGSCC

Primary side IGSCC is a widespread and continuing problem in Westinghouse type steam generators. For example:

- Of the 47 plants operating at least 5 years (startup prior to 1980), over half of the plants have experienced varying degrees of primary side IGSCC. This has ranged from cracking of a few tubes at Zorita 1 and Prairie Island 1 to extensive cracking of thousands of expansion transitions at Doel 2 and the preventive plugging of all row 1 U-bends at a number of stations.

* There is one recent exception, where nonheat treated tubing at San Onofre 2 and/or 3 suffered primary side cracking in straight sections of tubing.

- In several cases, such as Farley 1, North Anna 1, and Tihange 2, cracking occurred during the first year of operation.
- Primary side IGSCC has occurred in steam generators fabricated by each of the suppliers of Westinghouse type steam generators, i.e. Westinghouse, Cockerill, Framatome, and Mitsubishi.
- The Obrigheim steam generators (Siemens made) were replaced due to continual low level leaks resulting from primary side IGSCC. Steam generator replacement is being considered for several other plants.
- Even the earliest plants which are generally thought to have been fabricated using tubing processed under more optimum conditions, have shown signs of primary side IGSCC as evidenced by experience at Zorita 1 and Beznau 2. For example, the first cracking at Zorita 1 was reported after about 14 years of operation.

While many plants have exhibited primary side IGSCC problems, there are also many plants of similar vintage, and fabricated by four of the five manufacturers, which have so far been free of primary side IGSCC. While this is encouraging, the oldest of these plants have only been in operation about 15 years. Primary side IGSCC may still become a problem at some of these plants before their design life is reached.

CAUSE OF PRIMARY SIDE IGSCC

As is the case with all stress corrosion cracking, primary side IGSCC requires the coincidence of three factors: susceptible material, aggressive environment, and tensile stress. Operating experience and laboratory tests have demonstrated that alloy 600 tubing in some heat treatment conditions will crack in a normal PWR primary water environment. The rate at which cracking occurs appears to be dependent primarily upon the material microstructure, temperature, and local tensile stresses (residual and applied).

Material susceptibility appears to correlate most strongly with carbide morphology (i.e., the concentration of grain boundary carbides); however, there is also some correlation with grain size and material strength and hardness. Tubes with copious grain boundary carbides (intergranular carbides) are less susceptible to primary side IGSCC than tubes with few grain boundary carbides and copious carbides within the grain (intragranular carbides). The main fabrication variable which controls carbide morphology is the final mill anneal heat treatment. Higher mill anneal temperatures generally result in less susceptible material.

The tensile stresses involved in primary side IGSCC are the sum of residual plus operating stresses. Residual tensile stresses are induced in the tubing during fabrication, and in the case of Combustion Engineering and Westinghouse type steam generators are not reduced by a stress relief heat treatment. Based on operating experience and laboratory tests it is believed that tensile residual stresses on the inside of the tube are much higher than the operating stresses, and can equal or exceed the material yield strength. Many of the remedial measures being developed are directed towards reducing the tensile residual stresses or applying a compressive residual stress on the surface by peening.

CONSEQUENCES OF CRACKING

The potential consequences of primary side IGSCC include: secondary side contamination, possibly having to derate the plant electrical output in the event that the number of plugged tubes exceeds the available tube margin, exceeding the plant Technical Specification allowable leakage limits, and increased risk of sudden tube rupture.

To date, the general experience with U-bend cracks has been that the leakage is relatively low and increases gradually over a long period of time (i.e., months or years). The major exception to this general sequence of events has been for cases of U-bend apex cracking resulting from high ovality. In several of these cases tubes have ruptured suddenly resulting in large leakage rates. The high ovality has resulted from initial fabrication (Doel 2) and also from closing up of the flow slots as a result of denting (Surry and Turkey Point). The remedial action taken has been to plug the leaking tubes, and in many cases to plug all of the row 1 tubes on a preventive basis.

For the case of expansion transitions and expanded areas within the tube sheet, leakage has also been relatively low and has increased gradually over long periods of time. There are no reported cases of sudden rupture of tubes in the expansion region. In a few cases where the cause of the IGSCC has been identified and affects small numbers of tubes, the general course of action has been to inspect the tubes for the condition known to cause cracking and then plug affected tubes on a preventive basis. This is not practical, of course, where there are large numbers of cracked tubes which were fabricated within tolerance. In these cases, the approach to date has been to accept low levels of leakage while remedial measures are being developed in the laboratory and tested on a trial basis in the plant. However, this type of problem has led to steam generator replacement at one plant (Obrigheim) and is a contributing factor in planning for replacement at another (Ringhals 2).

While tubes can be plugged or sleeved when cracks or leakage reach the established acceptance criteria, the better approach would appear to be to take appropriate action to prevent a significant problem from developing in the first place.

PLANTS POTENTIALLY AT RISK

A data base of key parameters pertaining to primary side IGSCC has been compiled for each of the 97 plants containing Westinghouse type steam generators fabricated from non thermally treated alloy 600 tubing. The purpose of this compilation is to assist in assessing risk of primary side IGSCC occurring at a specific plant.

Based on the extent of primary side IGSCC which has already occurred, and the current state of predictive modeling, none of the Westinghouse plants with non thermally treated alloy 600 tubing should be considered as being immune to primary side IGSCC over its design lifetime. Rather, it is considered that primary side IGSCC will continue to be an increasing concern as plants age and that there will be a wide range of time to crack initiation and extent of cracking between different plants and within individual steam generators.

In making plans regarding inspection programs and possible remedial measures, it is desirable to be able to assess the relative risk of primary side IGSCC occurring at a particular plant. There are two major factors which should be taken into account in such an assessment.

Material Susceptibility

Material susceptibility appears to be the most significant single factor regarding potential for primary side IGSCC. If the material is at the high end of the susceptibility range, then the evidence suggests that primary side IGSCC will most likely be a significant problem regardless of the specific fabrication processes used. On the other hand, if the material is at the low end of the susceptibility range, then the evidence indicates that primary side IGSCC will most likely not be a significant problem unless there are unique situations such as denting which produce very high and persistent tensile stresses. There are several ways of assessing the material susceptibility. In order of increasing accuracy, and increasing effort required, the methods and indication of material susceptibility are as follows:

Characteristic	Material Susceptibility Low	Material Susceptibility High
• Material Grain Size	Large (<ASTM 6)	Small (>ASTM 10)
• Mill Annealing Metal Temperature	>1850°F (1010°C)	<1750°F (955°C)
• Carbide Morphology	Copious intergranular carbides	Few intergranular carbides
• Cracking of Reverse U-bends in High Temperature Water	Not determined	Cracking in 2-8 wks.

The first of these checks can sometimes be performed by review of material records, although many records must be reviewed since there can be more than 200 heats of material per steam generator. The mill anneal temperature can sometimes be obtained from fabrication records, but oftentimes can only be estimated based on the typical conditions known to be in use when the tubing was manufactured. The last two tests require archive material or material removed from the steam generator.

Fabrication Details

For susceptible material, the rate at which primary side IGSCC cracking problems develop and the ultimate extent of the problem appears to be significantly affected by the fabrication details. In particular, fabrication details which produce higher levels of tensile residual stresses on the inside surface of the tube lead to more rapid and severe cracking than processes which produce lower stresses. Fabrication details known to produce more rapid and severe cracking include:

- First and second row U-bends formed by Westinghouse ball mandrel process
- First and second row U-bends with more than 10% ovality
- Out of tolerance tube expansion including: oversize holes in the tube sheet, incomplete expansion in the tube sheet (skip rolls, incomplete overlap), over expansion in the DAM* area, etc.
- Tube sheet expansion process which produces high residual stresses such as by roller expansion

* A DAM or kiss roll is a partial expansion, located immediately above the tube sheet.

Even though out of tolerance conditions accelerate cracking, plant experience and SCC tests have indicated that highly susceptible tubes fabricated within normal manufacturing tolerances can also develop cracks.

REMEDIAL MEASURES

A number of corrective and remedial measures have been discussed, and extensive analysis and testing has been accomplished in support of many of these concepts. For cases where cracking has already occurred, the only currently viable corrective measures are to install plugs or sleeves. The choice between the two generally depends upon the number of excess tubes, and how extensive the cracking problem is and is likely to become. In the longer term, it is hoped that some of the remedial measures, such as in-situ stress relief or peening can be shown to stop the further propagation of small cracks. However, this has not been demonstrated to date.

For tubes which have not yet cracked there are a number of possible remedial measures. The most attractive and most thoroughly explored measures at present include the following:

- Local thermal stress relief of U-bends using an electric resistance heater.
- Local thermal stress relief of expansion transitions using an induction heater.
- Global heat treatment of the entire tube sheet using electric resistance heaters.
- Rotopeening or shot peening of expansion transitions.

In each case, there are still some outstanding technical concerns. For the case of U-bend stress relief and local thermal stress relief of expansion transitions, the major concern at present is process temperature control. For the case of global thermal heat treatment of the tube sheet the major concern is sensitization of the tubing. For the case of peening, the major concern is the level of tensile residual stress induced on the outside surface of the tube, and its effect on secondary side cracking. A complete discussion of each of the remedial measures is beyond the scope of this summary and can be found in section 6 of the report.

SUGGESTED COURSE OF ACTION

There are two sides to the decision as to whether or not to take remedial measures to prevent primary side IGSCC in steam generator tubing:

1. It is undesirable to apply remedial measures if they are not necessary. Such work is costly and there is some level of risk that the remedial measures may produce an undesirable side effect.

2. On the other hand, it is also undesirable to let primary side IGSCC initiate. It is far easier to prevent cracks from initiating in the first place than it is to arrest the propagation of existing cracks. A complicating factor in this regard is that the best current ECT inspection techniques can only reliably pick up cracks when they reach about 40% of wall thickness.

In this light, the following course of action is suggested for three categories of plants:

- Plants with Low Material Susceptibility - For plants with known low material susceptibility (as demonstrated by about 8-10 years operation without problems, or by materials examination and SCC tests), cracking should develop slowly, if at all. In these cases, primary attention should be directed towards using the best available inservice inspection methods to detect cracks at the earliest possible stage. Remedial measures can be considered at a future date if warranted.

- Plants with High Material Susceptibility - For plants with known high material susceptibility (as demonstrated by more than a few isolated cracks occurring in operation, or by materials evaluation), remedial action should be seriously considered for implementation in the near future. In most of these cases, the first and second row U-bends should be either stress relieved or plugged depending primarily on available tube margin. Expansion transitions should be stress relieved, heat treated, or peened. It should further be confirmed that the sections of expanded tubing immediately below the expansion transitions which must resist tube pullout are properly expanded and free from cracks.

- Plants with Unknown Material Susceptibility - For plants with unknown material susceptibility (i.e. new plants, or those which have been in operation less than 8-10 years without cracks), initial priority should be placed on assessing the material susceptibility. The approach to be used in this assessment is outlined in the section titled PLANTS POTENTIALLY AT RISK. For material of questionable susceptibility after such evaluation, the decision to take remedial measures could well depend on the plant status. For new plants where the cost of applying remedial measures is relatively low and the risk of problems due to application of remedial measures is also low, it will usually be preferable to proceed with remedial measures prior to going into operation. For plants already in service, it may be preferable to proceed with a rigorous inspection program and hold off on remedial measures until it is known whether there will be a problem.

In addition to this course of action for utilities, it is suggested that EPRI and the industry pursue development and qualification testing of field hardened corrective action procedures such as in-situ stress relief, shot peening, rotopeening, and global heat treatment. This effort is required to assist utilities in evaluating the cost and risk of various alternative approaches. Further effort is also warranted in development of ECT methods to provide early indication of this type of cracking.

Section 1

INTRODUCTION

There have been a significant number of occurrences of cracking of Ni-Cr-Fe alloy 600 tubing in PWR steam generators (1). The types of cracking problems which have been experienced and the basic conditions under which they have occurred are indicated in Table 1-1. This report is directed towards the first of these problems: primary side intergranular stress corrosion cracking (IGSCC). Primary side IGSCC, also known as Coriou or "pure water" cracking, is a particularly significant problem in that it can develop over a period of years under normal primary side water chemistry conditions with no identifiable contaminants. Problems related to caustic attack and sulfur species attack, on the other hand, can be minimized or avoided by careful attention to water chemistry control.

There are two basic categories of primary side IGSCC. The first is denting related and has occurred at tube support plate intersections and U-bend apexes, and could potentially occur at the top of the tube sheet. This type of primary side IGSCC can be minimized or eliminated by following recommendations in the Steam Generator Owners Group Design and Operating Guidelines (2) and is, therefore, not addressed in this report. The second category of primary side IGSCC is non denting related and occurs at U-bends, expansion transitions and roll expanded areas. This type of IGSCC is not prevented by following the Design and Operating Guidelines and is the subject of the remainder of this report.

With few exceptions, primary side IGSCC problems have been limited to Westinghouse type steam generators fabricated by Westinghouse or its licensees. The main reasons that primary side IGSCC has not occurred extensively in Babcock and Wilcox and Combustion Engineering plants are believed to be as follows:

- Babcock and Wilcox - During fabrication, Babcock and Wilcox once through steam generators were subjected to a global stress relief heat treatment. This process reduced local residual stresses in the tubing which are a necessary factor for primary side IGSCC to occur, and also resulted in carbide precipitation at the grain boundaries, which made the material less susceptible to pure water type cracking. These improvements were achieved, however, at the expense of sensitizing the tubing which makes the tubing more susceptible to the sulfur species attack described in Table 1-1.

- Combustion Engineering - There are two main factors believed to account for the absence of primary side IGSCC in Combustion Engineering steam generators. First, most tubing was mill annealed at a higher temperature than the tubing used in Westinghouse type steam generators. Higher mill anneal temperatures tend to reduce susceptibility of the material to primary side IGSCC. Second, the procedures used to expand the tubing in the tube sheet and to fabricate the U-bends are believed to have resulted in lower tensile residual stresses.

The purposes of this report are to 1) summarize the current status of nondenting related primary side IGSCC in Westinghouse type steam generators, 2) tabulate the specific Westinghouse type plants which appear to have potential for primary side IGSCC, 3) describe the corrective action programs being pursued, and 4) suggest a course of action relative to primary side IGSCC.

It should be noted that the written text of this report was largely finalized in January 1985, but that some later primary side cracking occurrences were added to the data base and tables to make them as current as practical.

Table 1-1

TYPES OF PWR STEAM GENERATOR TUBE CRACKING PROBLEMS

Problem	Time to Develop	Water Conditions	Contaminants	Locations in Steam Generator	Typical Plants Experiencing Problems
Primary Side Intergranular Stress Corrosion Cracking (Coriou Cracking)	Years	Primary Water 316°C (600°F) High pH (5.5 - 8.0) Zero Oxygen (Reducing Environment) Lithium Hydroxide, Boric Acid, Dissolved Hydrogen	None Identified	Points of High Stress - U-Bend Tangent - U-Bend Apex - Roll Transition - Dented Tube Support Plate Intersections - Rolled Tubes in Tube Sheets	- Trojan - Surry 2 - Doel 2 - Surry 1&2 - Doel 3
Secondary Side Caustic Stress Corrosion Cracking	Weeks	288-324°C (550-615°F) 10% NaOH (Reducing Environment)	Sodium, Potassium and Possibly Carbonates	Points Where Sodium Concentration can Build to High Levels - Tube Sheet Crevice - Sludge Pile	- Ringhals 2 - Point Beach
Sulfur Species Attack	Hours	21-93°C (70-200°F) Low Levels of Sulfur (few ppm Sulfur if Alternate Wetting and Drying Occurs) (Partially Oxidizing Environment)	Sulfur Oxy Anions - Organics - Resin Breakdown - Oil Inleakage - Resin Regeneration - Thiosulfates	Anyplace on Sensitized Tubes Where Chemicals Concentrate (Crevices, Stagnant Water/Air Interfaces, etc.)	- TMI #1 (Primary) - Palisades (Secondary) - Tihange 1 (Secondary)

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The following is a summary, for each location in the steam generator, of the types of cracking which have been reported:

U-BENDS

U-Bend Apex

Non denting related primary side IGSCC at the U-bend apex has only been confirmed at Doel 2 and Beznau 2, and there is an unconfirmed case at Obrigheim. The best documented of these cases is the 1979 incident at Doel 2 in which a tube ruptured suddenly at operating pressure and temperature with the plant at zero power. The leak rate was estimated to be on the order of 150 gpm. Dobbeni, et al. (4) have described this crack as longitudinal, located at the U-bend apex, and with a length of 2.75 inches (7 cm) (see Figure 2-1). The crack has been attributed to high stresses resulting from excessive ovality. Corrective action consisted of plugging all first row tubes with high ovality, and there have been no further reports of U-bend cracking at Doel 2.

In summary, non denting related primary side IGSCC at the U-bend apex region has not been a widespread problem.

U-Bend Tangent

Primary side U-bend tangent cracking has been reported at a number of plants with Westinghouse manufactured tubing. The best documented of these cases are Trojan and Takahama 1 (5, 6). As shown in Figure 2-2, cracks in both of these cases developed at the U-bend tangents between the tube flank and extrados. Visual examination of tubes removed from both Trojan and Takahama 1 showed that the cracks occur at an abrupt change in geometry at the transition from the U-bend to the straight section of tube. This change in geometry has been described as an "irregular" or "opposite" transition and has been attributed to the ball mandrel process used by Westinghouse to form the bends. Based on in situ nondestructive examination, U-bend tangent leakage at other plants is believed to have a similar cause.

Mitsubishi tests, described in Appendix C to this report, confirm the detrimental effect of the "opposite" transition on time to failure in accelerated SCC tests as compared to transitions produced by the plastic cylindrical mandrel procedure used by the Japanese tube supplier, Sumitomo. It should be noted, however, that the

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Section 2

CURRENT STATUS OF PRIMARY SIDE IGSCC PROBLEMS

Nondenting related primary side IGSCC of alloy 600 tubing has been reported at several locations within Westinghouse type steam generators. These locations, and the plants reporting primary side IGSCC at each location are outlined in Table 2-1. This cracking represents a significant problem. For example:

- Of the 47 plants operating at least 5 years (startup prior to 1980), over half of the plants have experienced varying degrees of primary side IGSCC. This has ranged from cracking of a few tubes at Zorita 1 and Prairie Island 1 to extensive cracking of thousands of expansion transitions at Doel 2 and the preventive plugging of all row 1 U-bends at a number of stations including Takahama 1, Trojan, Ringhals 2, North Anna 1, Zion 1, and Ohi 1.

- In several cases, such as Farley 1, North Anna 1, and Tihange 2, cracking has occurred within the first fuel cycle.

- Primary side IGSCC has occurred in steam generators fabricated by each of the suppliers of Westinghouse type steam generators, i.e., Westinghouse, Cockerill, Framatome, Siemens, and Mitsubishi.

- The Obrigheim steam generators were replaced due to increasing numbers of small leaks resulting from primary side IGSCC at roll transitions (3).

- Even the earliest plants, which are operated at lower temperature, and which are generally thought to have been fabricated using tubing mill annealed under more optimum conditions, have shown signs of primary side IGSCC as evidenced by experience at Zorita 1 and Beznau 2. For example, the first cracking at Zorita 1 was reported after about 14 years of operation.

While many plants have exhibited primary side IGSCC problems, there are also many plants of similar vintage, and fabricated by four of the five manufacturers, which have so far been free from such problems. Significant examples, with about 8 years or more of operating experience each, include: Ginna, Point Beach 1, Point Beach 2, Indian Point 2, Kewaunee, Prairie Island 2, Doel 1, Indian Point 3, Salem 1, Genkai 1, Fessenheim 2, and Takahama 2. While this is encouraging, the oldest of these plants has only been in operation 15 years. Primary side IGSCC may yet become a problem at some of these plants before their design life is reached.

The following is a summary, for each location in the steam generator, of the types of cracking which have been reported:

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In summary, non denting related primary side IGSCC at the U-bend apex region has not been a widespread problem.

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Primary side U-bend tangent cracking has been reported at a number of plants with Westinghouse manufactured tubing. The best documented of these cases are Trojan and Takahama 1 (5, 6). As shown in Figure 2-2, cracks in both of these cases developed at the U-bend tangents between the tube flank and extrados. Visual examination of tubes removed from both Trojan and Takahama 1 showed that the cracks occur at an abrupt change in geometry at the transition from the U-bend to the straight section of tube. This change in geometry has been described as an "irregular" or "opposite" transition and has been attributed to the ball mandrel process used by Westinghouse to form the bends. Based on in situ nondestructive examination, U-bend tangent leakage at other plants is believed to have a similar cause.

Mitsubishi tests, described in Appendix C to this report, confirm the detrimental effect of the "opposite" transition on time to failure in accelerated SCC tests as compared to transitions produced by the plastic cylindrical mandrel procedure used by the Japanese tube supplier, Sumitomo. It should be noted, however, that the

In addition, numerous ECT indications, affecting about 5% of the tubes in one sample, occurred at roll transitions or in the fully expanded areas of the tubes.

At Tihange 2, leaks occurred in 11 to 14 tubes within the first year and a half of operation. Based on ECT examination, the leaks are believed to be due to short longitudinal through wall cracks in the transition region between the top of the main roll and the DAM roll. In addition, ECT indications have been detected in roll transitions and in the fully expanded areas of 10% of the tubes inspected in one steam generator. Most of the leaks and cracks appear to have occurred in tubes with no detectable abnormalities in rolling profile.

EdF laboratory metallurgical examination of tubes removed from Doel 3 has indicated that the material has intragranular carbides and an ASTM grain size of 10-11. Mockup tests using stainless steel tubes in boiling magnesium chloride or sensitized alloy 600 tubes in sodium tetrathionate have shown that expansion transition cracks occur in tubes meeting normal manufacturing limits which indicates that residual tensile stresses over about 10 ksi (69 MPa) are present. The main remedial measures used to date at Doel 3 and Tihange 2 are ECT inspections and plugging of defective tubes, although other remedial measures are being considered.

EXPANSION TRANSITIONS - CIRCUMFERENTIAL CRACKS

Circumferential cracks are of special concern since they increase the risk of sudden tube rupture without the warning normally provided by low level leakage from longitudinal cracks. Fortunately, circumferential cracking has not been a major problem to date, and the reported examples are limited to Fessenheim 1, Obrigheim, Zorita 1, Dampierre 1, Doel 2 and Ringhals 2. The details associated with these cases are as follows:

Fessenheim 1

Fessenheim 1 steam generator tubes were originally rolled over the bottom 8 cm (3.15 inches) and then explosively expanded over the full depth prior to operation using the Wextex process. Circumferential cracks were first detected on the ID of tubes in one steam generator about four years after the plant went into service, and to date, about 80 tubes in this steam generator have been plugged due to these cracks. The cracks, shown in Figure 2-7, have been isolated to one small area in the hot leg sludge pile region. The cracks range from about 0.5 inches (1.2 cm) below the top of the tube sheet to 0.75 inches (1.9 cm) above the top of

The following is a summary, for each location in the steam generator, of the types of cracking which have been reported:

U-BENDS

U-Bend Apex

Non denting related primary side IGSCC at the U-bend apex has only been confirmed at Doel 2 and Beznau 2, and there is an unconfirmed case at Obrigheim. The best documented of these cases is the 1979 incident at Doel 2 in which a tube ruptured suddenly at operating pressure and temperature with the plant at zero power. The leak rate was estimated to be on the order of 150 gpm. Dobbeni, et al. (4) have described this crack as longitudinal, located at the U-bend apex, and with a length of 2.75 inches (7 cm) (see Figure 2-1). The crack has been attributed to high stresses resulting from excessive ovality. Corrective action consisted of plugging all first row tubes with high ovality, and there have been no further reports of U-bend cracking at Doel 2.

In summary, non denting related primary side IGSCC at the U-bend apex region has not been a widespread problem.

U-Bend Tangent

Primary side U-bend tangent cracking has been reported at a number of plants with Westinghouse manufactured tubing. The best documented of these cases are Trojan and Takahama 1 (5, 6). As shown in Figure 2-2, cracks in both of these cases developed at the U-bend tangents between the tube flank and extrados. Visual examination of tubes removed from both Trojan and Takahama 1 showed that the cracks occur at an abrupt change in geometry at the transition from the U-bend to the straight section of tube. This change in geometry has been described as an "irregular" or "opposite" transition and has been attributed to the ball mandrel process used by Westinghouse to form the bends. Based on in situ nondestructive examination, U-bend tangent leakage at other plants is believed to have a similar cause.

Mitsubishi tests, described in Appendix C to this report, confirm the detrimental effect of the "opposite" transition on time to failure in accelerated SCC tests as compared to transitions produced by the plastic cylindrical mandrel procedure used by the Japanese tube supplier, Sumitomo. It should be noted, however, that the

Dampierre 1

Alloy 600 tubes at Dampierre 1 were rolled over the full depth of the tube sheet and then subjected to a DAM treatment above the original expansion transition. Approximately three years after the plant went into service, ECT inspection revealed the presence of significant defects in the roll transition of a tube. The tube was removed for examination and found to have a circumferential defect extending all around the tube and penetrating 75-90% through the tube wall thickness. As shown in Figure 2-8, the defect was located in the overlap region between the top of the original roll and the DAM roll. A similar, though smaller, circumferential defect was found in another tube. The two tubes with circumferential defects, as well as two other pulled tubes without circumferential defects, all had short longitudinal cracks in their roll transitions.

The EdF evaluation of this defect indicates that it was the combined result of the original roll transition being too high, and the DAM roll having too large an expansion [16 mils (0.4mm) vs. the design value of 4-8 mils (0.1-0.2 mm)]. Mockup tests to determine more precisely the specific combinations of rolling conditions which can lead to early circumferential cracks are still underway at EdF. The remedial measures taken to date have been to preventively plug tubes which are judged to have susceptible geometric conditions based on earlier ECT results. The number of tubes plugged in Dampierre 1 steam generators for this reason range between 1 and 18.

In summary, the type of circumferential cracking observed at Dampierre 1 has not been reported elsewhere to date and thus does not yet represent a generic problem. However, as in the case of Fessenheim 1, this experience indicates that significantly sized circumferential cracks can occur in alloy 600 tubing before large longitudinal cracks develop, if the right conditions are present.

Doel 2

As described earlier, Doel 2 has experienced numerous short primary side longitudinal cracks in the roll transition region. In addition, during metallographic examination of a tube pulled for other reasons, it was noted that there was a short circumferential crack intersecting a longer longitudinal crack in the hard rolled area just below where the roll transition meets the fully expanded area (12).

the tube sheet, and have resulted in a leakage rate of 12 gph (48 liter/h) or less.

EdF mockup tests (11) indicate that longitudinal residual stresses on the tube ID produced by the type of explosive expansion used at Fessenheim are on the order of 15-22 ksi (103-152 MPa) in the expansion transition region. These stresses were sufficient to cause primary side SCC of explosively expanded stainless steel tubes tested in boiling magnesium chloride. Thus, the residual stresses from the explosive expansion may be a contributing factor in the cracking. It was also noted, however, that some of the tubes pulled from the plant were bowed, and that cracks, if any, occurred on the extrados of the bow. The cause and significance of the bowing have not yet been determined, although it may indicate that there was some mechanical damage which explains the localized nature of the cracking.

In summary, It is tentatively concluded that the circumferential cracking in one steam generator at Fessenheim 1 is an isolated problem without significant generic implications. However, since there are no known differences between Fessenheim 1 and other Wextex expanded steam generators, there remains the potential that this is a precursor of a more general problem.

Obrigheim

As indicated in the previous section, and shown in Figure 2-5, expansion transition cracking at Obrigheim was both longitudinal and circumferential. The leakage resulting from these cracks led ultimately to the decision to replace the steam generators.

Zorita 1

Limited data is available regarding the circumferential cracking which occurred at Zorita 1. It is understood, however, that the circumferential cracks are located at the bottom transition of an intermittent rolled area about 2-4 inches (5-10 cm) above the bottom of the tube sheet. (There apparently was a skip rolled area 1 to 2 inches (2.5 to 5 cm) above the bottom of the tube sheet.) The circumferential cracks at this location penetrate about 60% through the tube wall. There are also short longitudinal cracks in this skip roll transition as well as in the main transition at the top of the rolled area.

have been placed in compression and could easily have tensile stresses. SCC tests on stainless steel tubes and sensitized alloy 600 tubes show that ID cracking can occur in rolled tubes meeting normal manufacturing limits [i.e., with 6 mil (0.15mm) diametral waves in the tube ID profile] (14), which indicates that tensile stresses of about 10 ksi (69 MPa) were present.

The main remedial measures applied to date at Doel 3 and Tihange 2 are ECT inspections of defective tubes, although other remedial measures are being considered.

Ringhals 2

As described earlier, Ringhals 2 has experienced numerous short primary side cracks in the roll transition region. In addition, metallographic and NDE examination of pulled tubes has revealed several cases where primary side circumferential cracks exist in the fully rolled area about 0.25 inch (0.6 cm) below the bottom of the roll transition.

EXPANDED AREAS

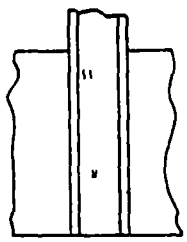
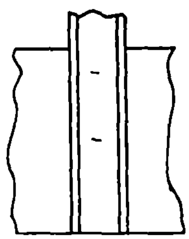
In addition to cracks in the expansion transition regions, a number of plants have reported cracks within the expanded area for tubes expanded using a multiple rolling procedure. One of the better documented examples is Doel 3. After about 10,000 hours of operation, leaks were discovered at three tubes. Subsequent examination showed that the tubes at these locations were installed in oversize holes and had not been fully expanded to provide proper contact with the tube sheet. Subsequent examinations have shown cracks at roll overlaps, skip rolls and non-overlap areas in tubes installed in normal size holes. Most of the cracks observed were short and longitudinal; however, some of the cracks have a circumferential component.

The cause of the improperly expanded tubing at Doel 3 has not been determined. The roll expansion was performed using a semi-automatic tool which is supposed to roll each pass of about 1 inch (2.5 cm) length until a preset torque is reached, and is then raised to the next higher roll position. If a tube does not contact the tube sheet when expanded (see Figure 2-9), the required torque should not be reached. However, for unknown reasons, the tool was apparently raised in some oversize holes before the required torque was reached. This resulted in the tube not being expanded into contact with the tube sheet. One factor in this situation is that the rollers had a maximum range which would not provide the required tube expansion in some oversize holes; i.e., a tool change would have been necessary to complete the expansion.

Many Doel 3 and Tihange 2 tubes in holes meeting the specified dimensional tolerances have ID profile "waves" approaching the manufacturing limit of 6 mils (0.15mm). While the cause of the "waves" has not been explained in all cases, reference (13) indicates that, in some cases, the evidence suggests that the rollers were conical rather than parallel. This could possibly be due to the result of metal pickup on rollers, or some other similar phenomenon. The dimensions of the "waves" are such that the peaks of some of the "waves" may not

Table 2-1 (Continued)

WESTINGHOUSE TYPE PLANTS WITH REPORTED PRIMARY SIDE IGSCC

LOCATION	EXPANDED AREAS			
	LONGITUDINAL IGSCC	CIRCUMFERENTIAL IGSCC		
SKETCH				
TYPICAL REPORTED LEAK RATE (GPM)				
PLANTS AFFECTED	Almaraz 1* Bugey 3 Dampierre 1&3 Doel 2&3 Ikata 1 McGuire 1* Mihama 3 Ohi 1&2 Ringhals 3&4* Summer* Tihange 2* * ECT indications only	Doel 3		

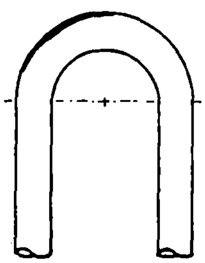
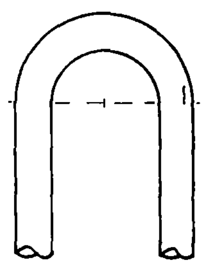
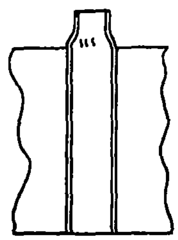
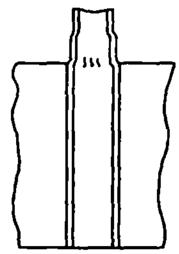
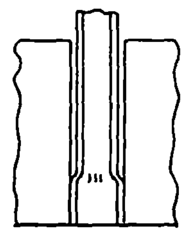
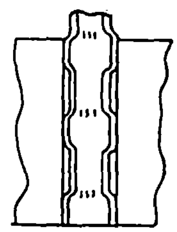
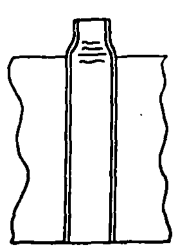
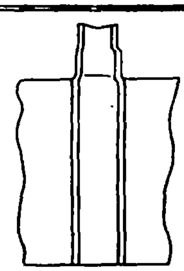
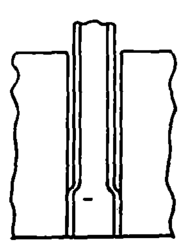
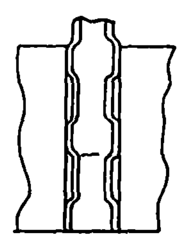
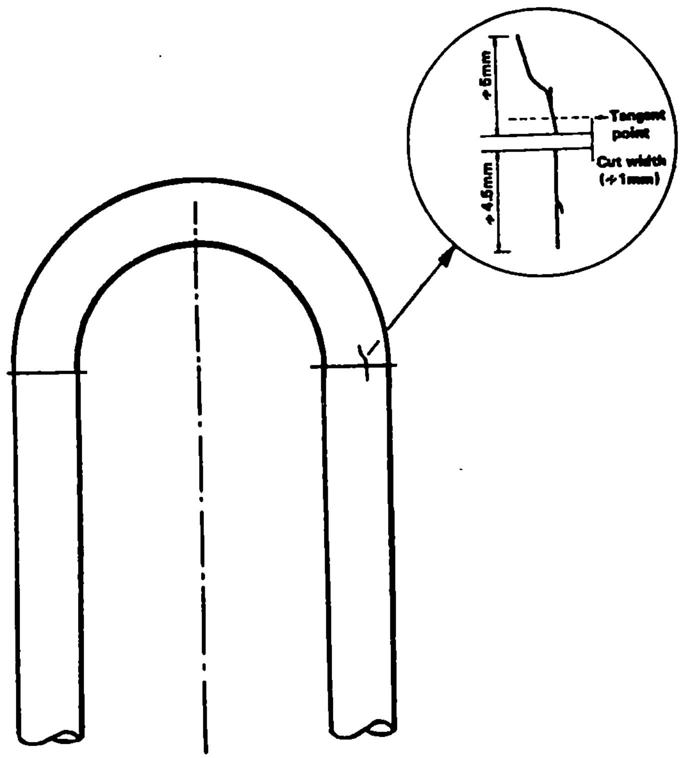
LOCATION	U - BENDS			
	APEX	TANGENT		
SKETCH				
TYPICAL REPORTED LEAK RATE (GPM)	150	0.05-0.10		
PLANTS AFFECTED	Beznau 2 Doel 2 Obrigheim	Bugey 2&3 Cook 1&2 Farley 1 Fessenheim 1 North Anna 1 Ohi 1 Prairie Island 1 Ringhals 2 Sequoyah 1 Summer Takahama 1 Trojan Zion 1&2		

Table 2-1

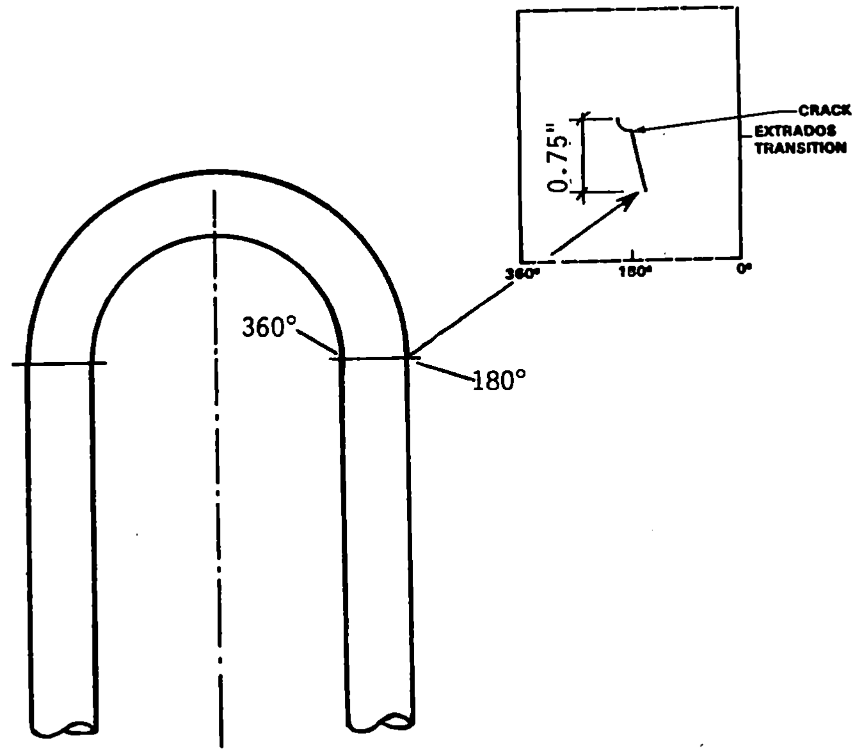
WESTINGHOUSE TYPE PLANTS WITH REPORTED PRIMARY SIDE IGSCC

LOCATION	EXPANSION TRANSITIONS - LONGITUDINAL IGSCC			
	FULL DEPTH-W/O DAM	FULL DEPTH-WITH DAM	PART DEPTH	INTERMITTENT
SKETCH				
TYPICAL REPORTED LEAK RATE (GPM)	0.05	0.005		
PLANTS AFFECTED	Almaraz 1 Bugey 3&4 Ikata 1 Mihama 3 Ohi 2	Bugey 5 Dampierre 1&3 Doel 3 Gravelines 3 Tihange 2 Tricastin 3	Cook 2 Doel 2 Mihama 2 Ringhals 2 Takahama 1	Doel 2* Obrigheim Zorita** *hybrid mech.-hydraulic expansion at mid height **top expanded area 2-4" above bottom of tube sheet

LOCATION	EXPANSION TRANSITIONS - CIRCUMFERENTIAL IGSCC			
	FULL DEPTH-W/O DAM	FULL DEPTH WITH DAM	PART DEPTH	INTERMITTENT
SKETCH				
TYPICAL REPORTED LEAK RATE (GPM)				
PLANTS AFFECTED	Fessenheim 1 (explosive expansion) (central tubes of one steam generator only)	Dampierre 1 (improper rolling)	Doel 2 Ringhals 2 (cracks all very short, ≤5 mm)	Obrigheim Zorita (bottom roll transitions)



a. U-Bend Crack at Takahama 1



b. U-Bend Crack at Trojan

Figure 2-2. Typical U-Bend Tangent Region Cracks

Source: Based on references (5) and (6)

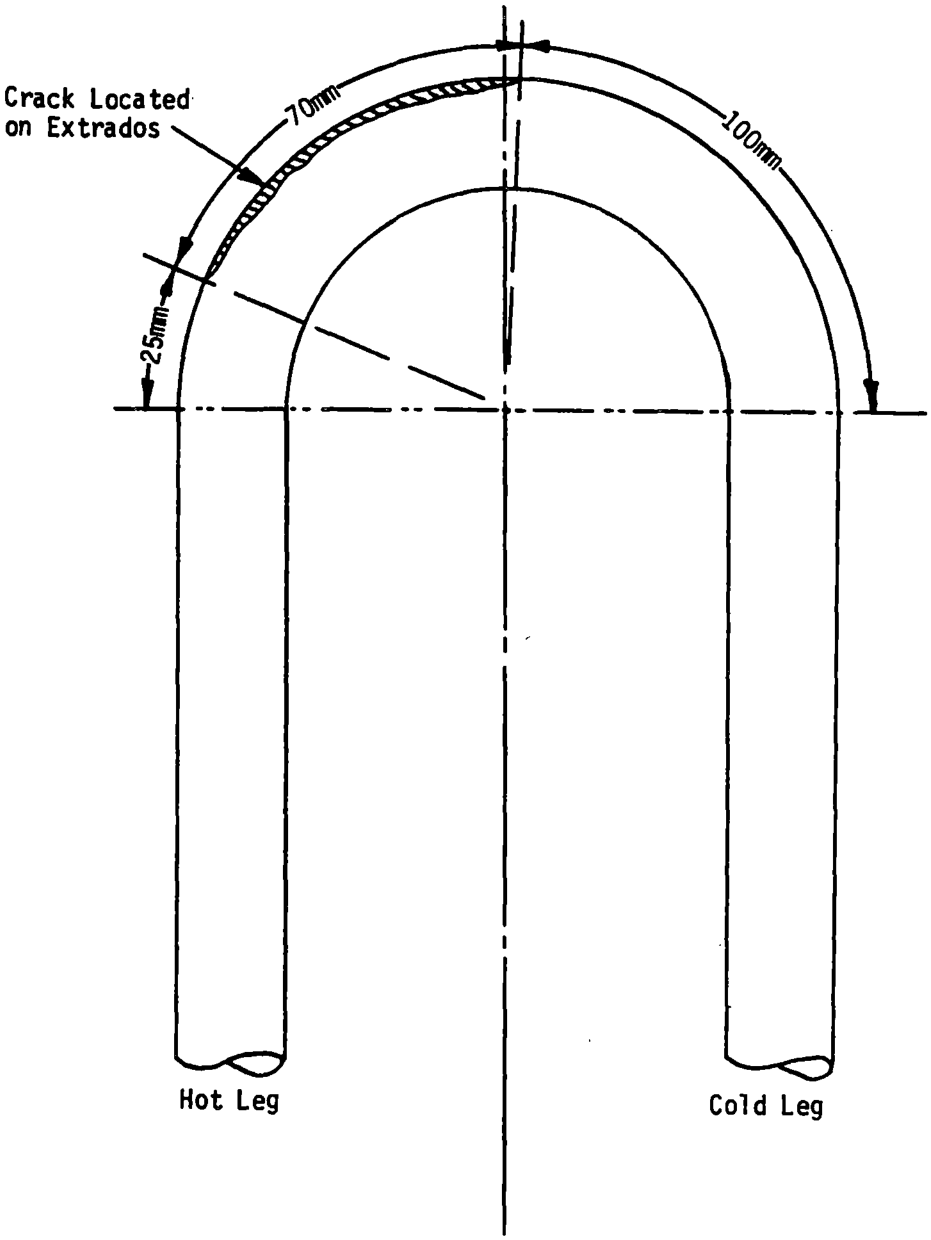
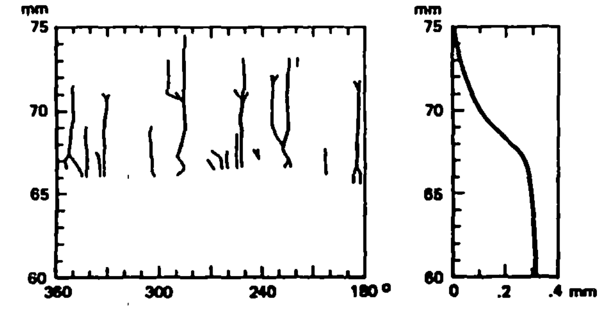
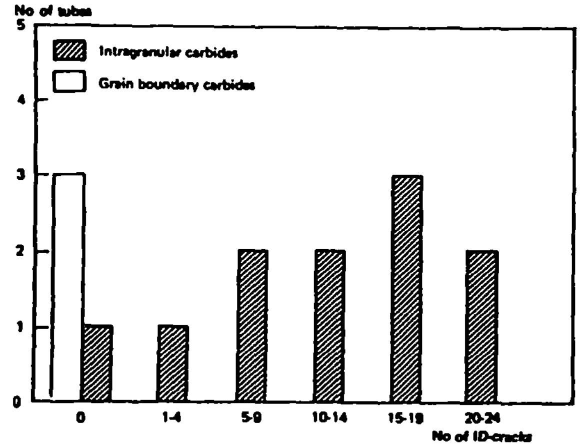


Figure 2-1. U-Bend Crack at Doel 2

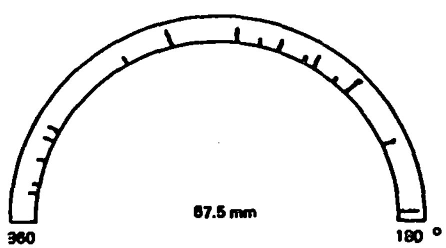
Source: Based on information in reference (4)



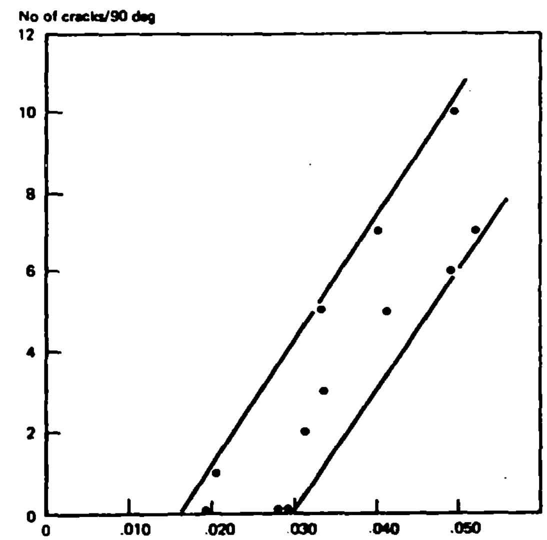
a. Location of Cracks vs. Rolling Profile



c. Cracks vs. Carbide Morphology



b. Crack Thickness



d. Cracks vs. Transition (r/l) Ratio

Figure 2-4. Expansion Transition Cracks at Ringhals 2
Source: From reference (7)

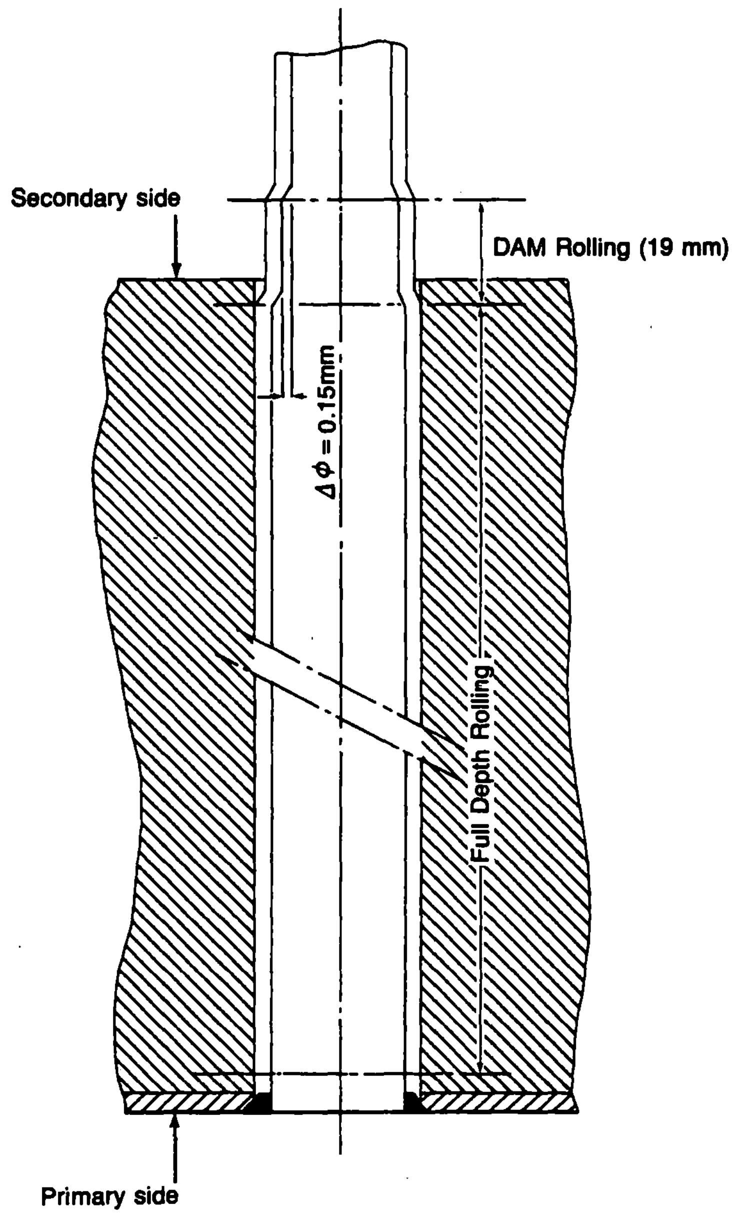


Figure 2-3. DAM Rolling (from TRABEL)

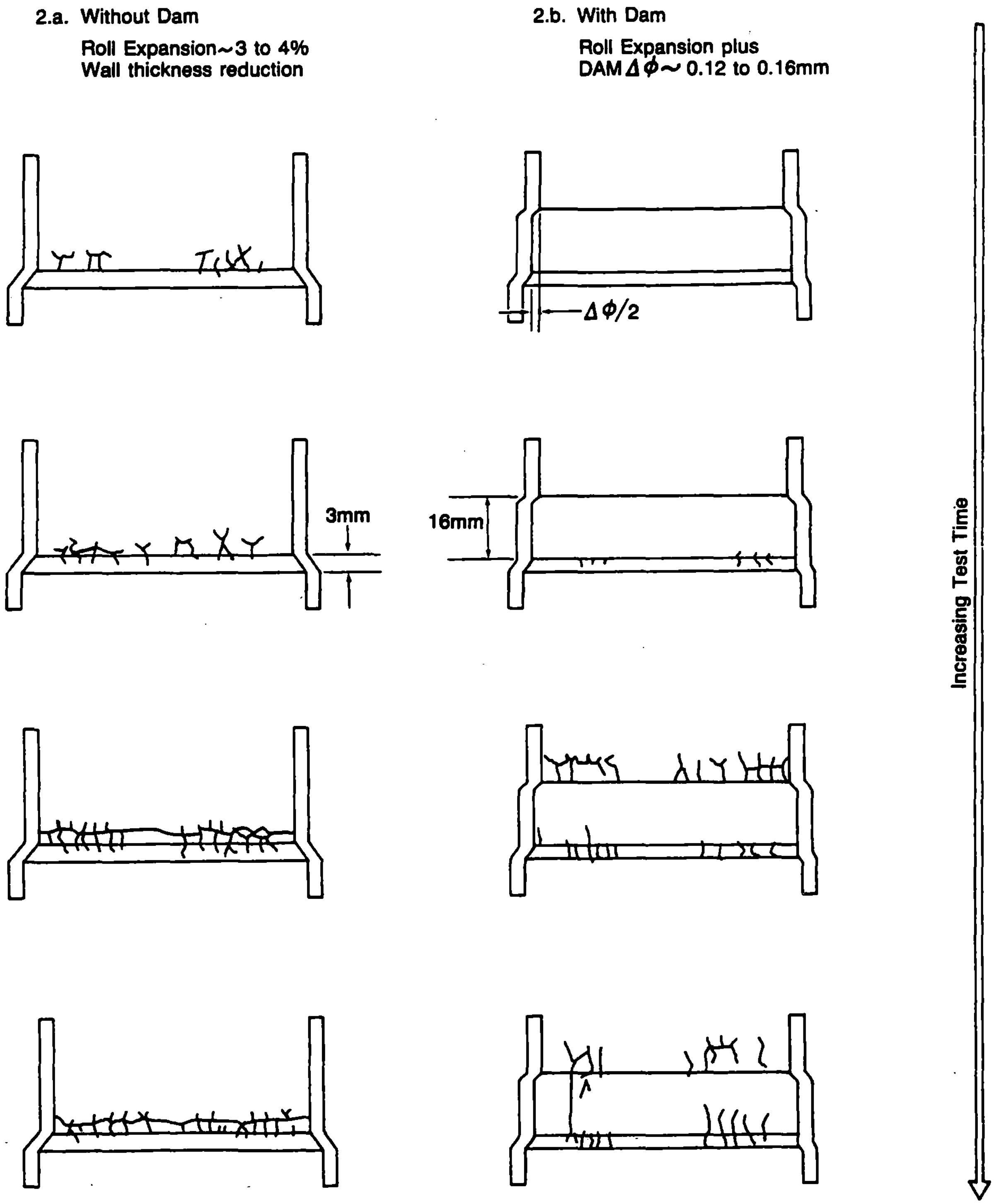


Figure 2-6. SCC Tests of Expansion Transitions With and Without DAM

Source: From EdF

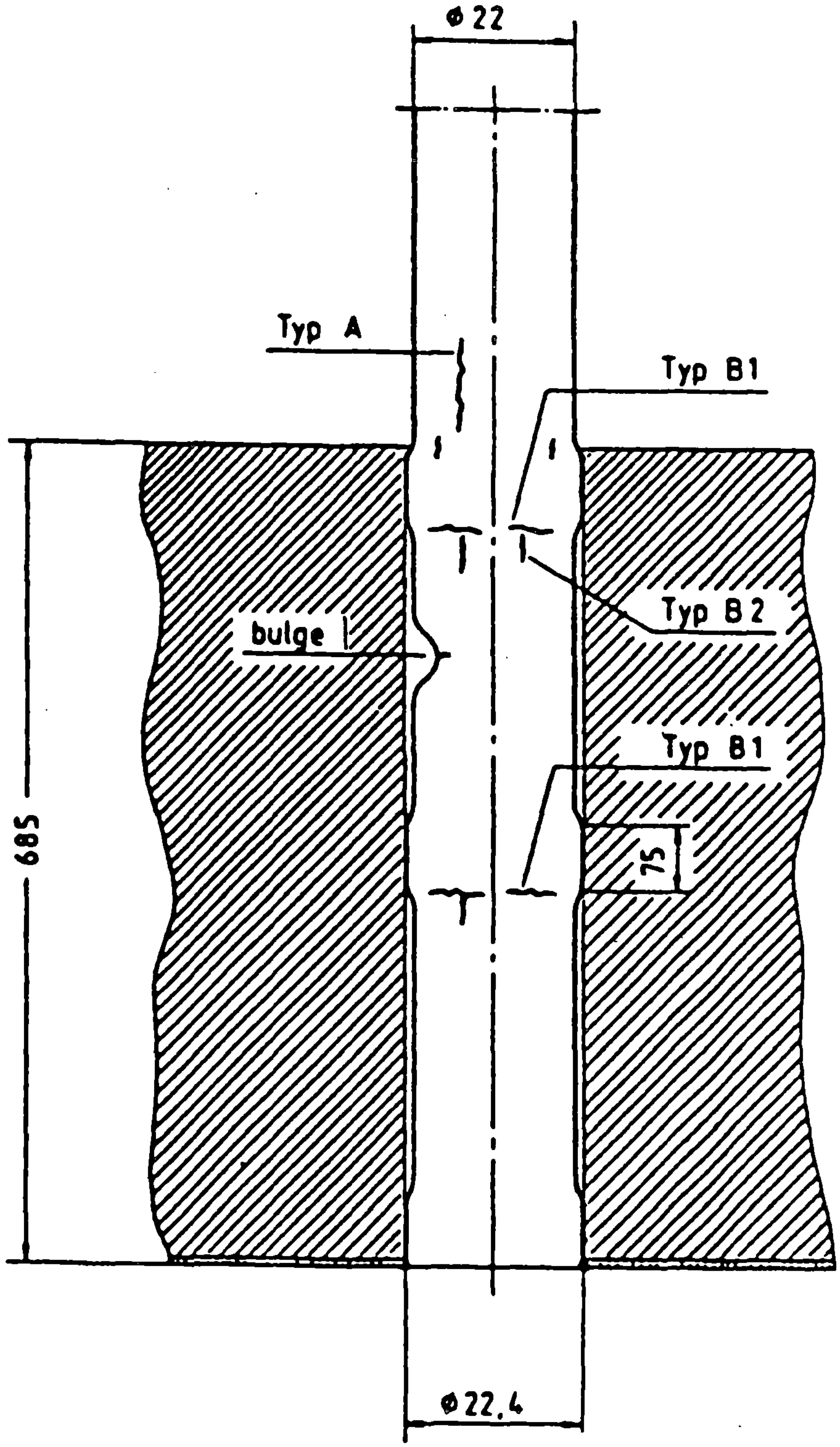


Figure 2-5. Expansion Transition Cracks and Bulge at Obrigheim

Source: From reference (3)

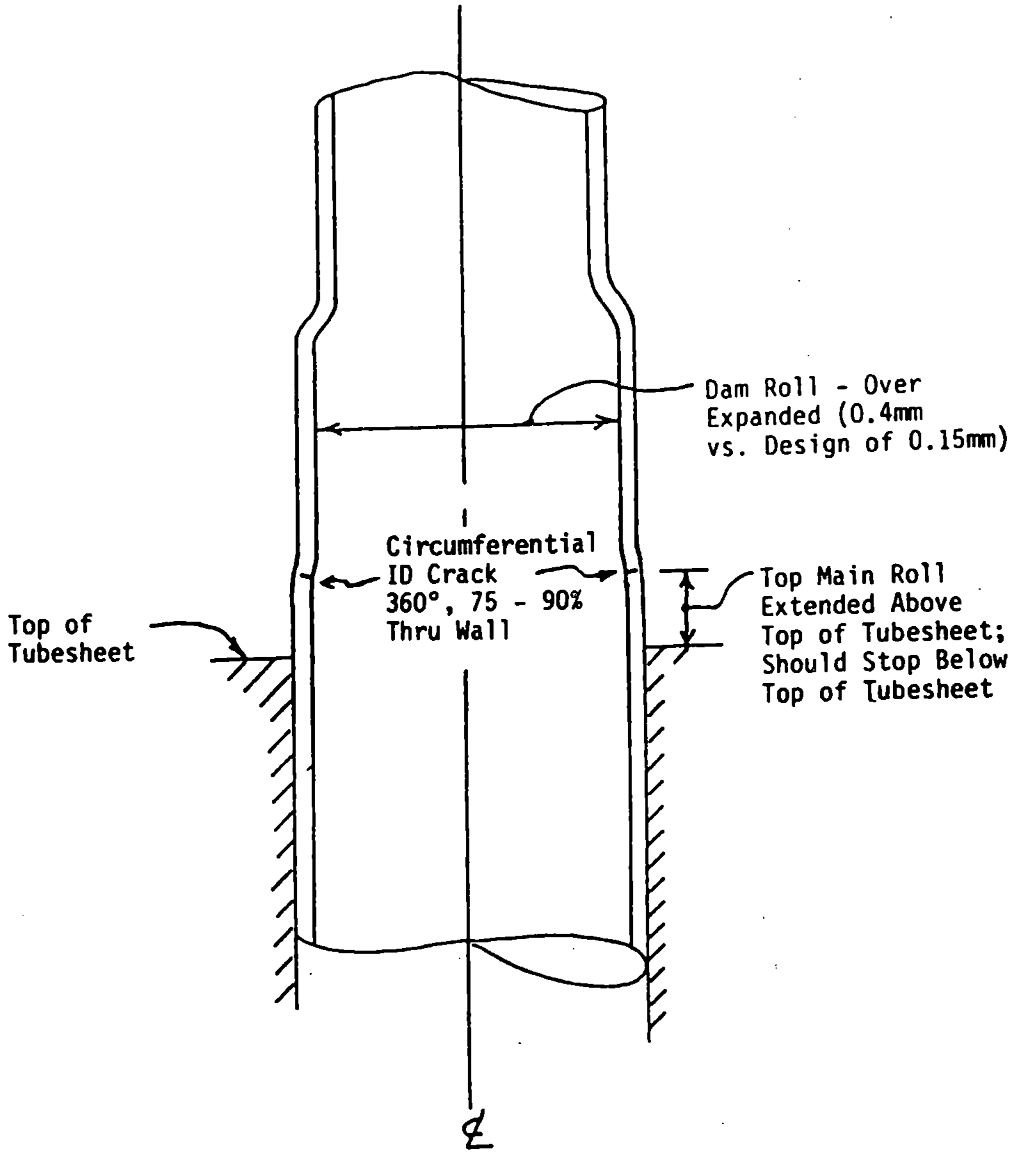
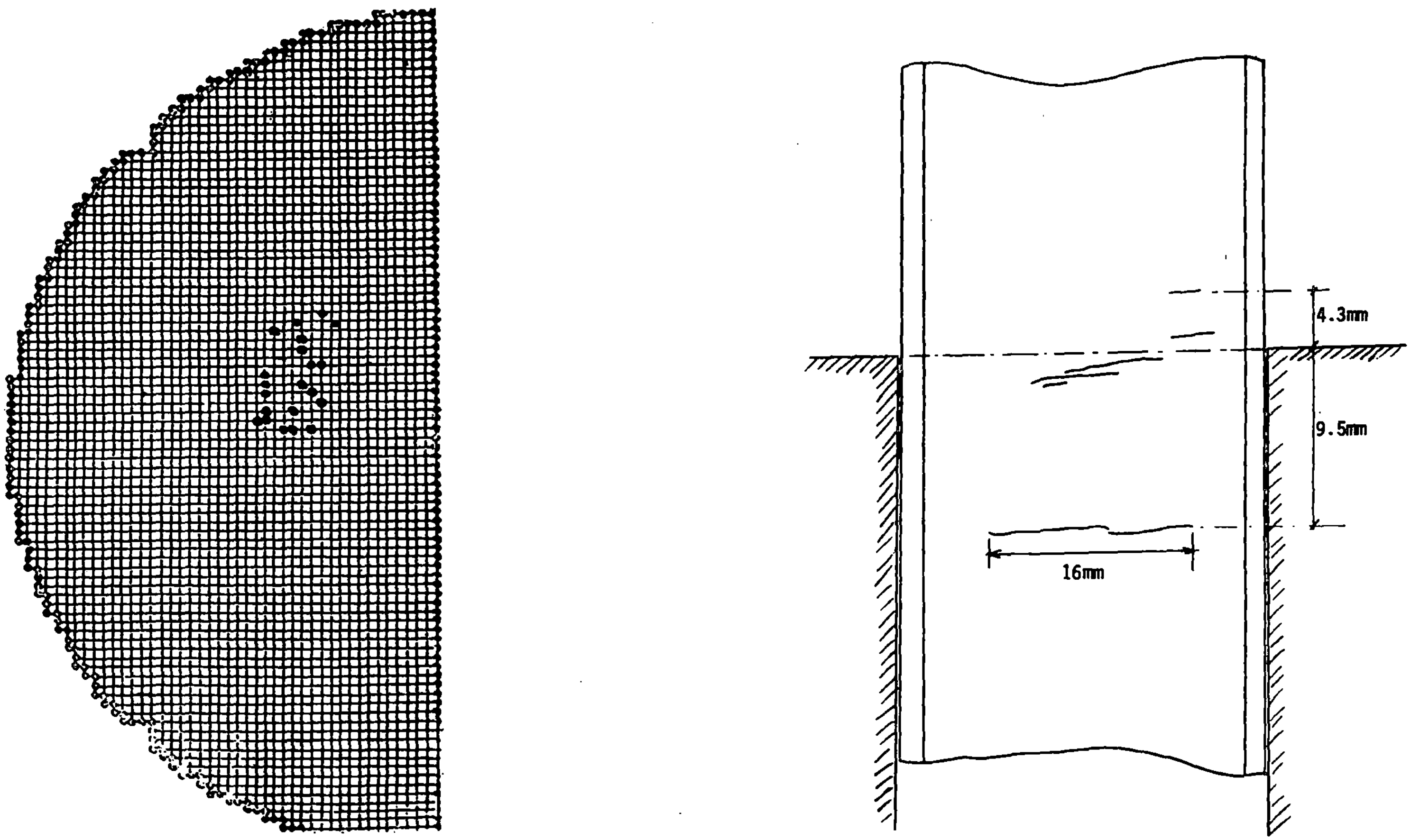


Figure 2-8. Expansion Transition Cracks at Dampierre 1

Source: From EdF



a. Location of Initial Cracked Tubes

b. Reported Cracking in Pulled Tube

Figure 2-7. Expansion Transition Cracks at Fessenheim 1

Source: From EdF

Section 3

CAUSE OF PRIMARY SIDE IGSCC

Metallurgical examination of pulled tubes has indicated that primary side cracking in the tube sheet region, at tube support plate intersections, and in U-bends of Westinghouse type steam generators has been intergranular stress corrosion cracking (IGSCC). Except for one early case at Obrigheim, this cracking has occurred under conditions of normal Westinghouse primary water chemistry with no significant abnormalities reported. It is generally considered that this cracking is classical "pure water" IGSCC of the type first reported by Coriou in 1959 (16). As is the case with all stress corrosion cracking, this type of IGSCC requires the coincidence of three factors:

1. Susceptible Material
2. Aggressive environment
3. Tensile stresses

The following is a discussion of these three factors as they relate to the problem of primary side IGSCC of alloy 600 steam generator tubing, and a rough estimate of the time to failure for susceptible material under various conditions of stress and temperature.

SUSCEPTIBLE MATERIAL

A considerable body of literature, starting with Coriou, has reported the susceptibility of alloy 600 tubing to IGSCC in pure water environments. The major question regarding primary side IGSCC of Westinghouse type steam generators is why some lots of alloy 600 tubing are more susceptible to IGSCC than other lots operating in essentially identical environments and with similar operating stresses and fabrication techniques.

Detailed investigations are being performed by a number of organizations to determine the factors which affect the susceptibility of alloy 600 tubing to primary side IGSCC. Results to date indicate that neither the chemistry nor the mechanical properties of alloy 600 are the primary factors controlling susceptibility. Rather, susceptibility appears to be most strongly related to the

STEAM GENERATOR B — ROW 15 COLUMN 29

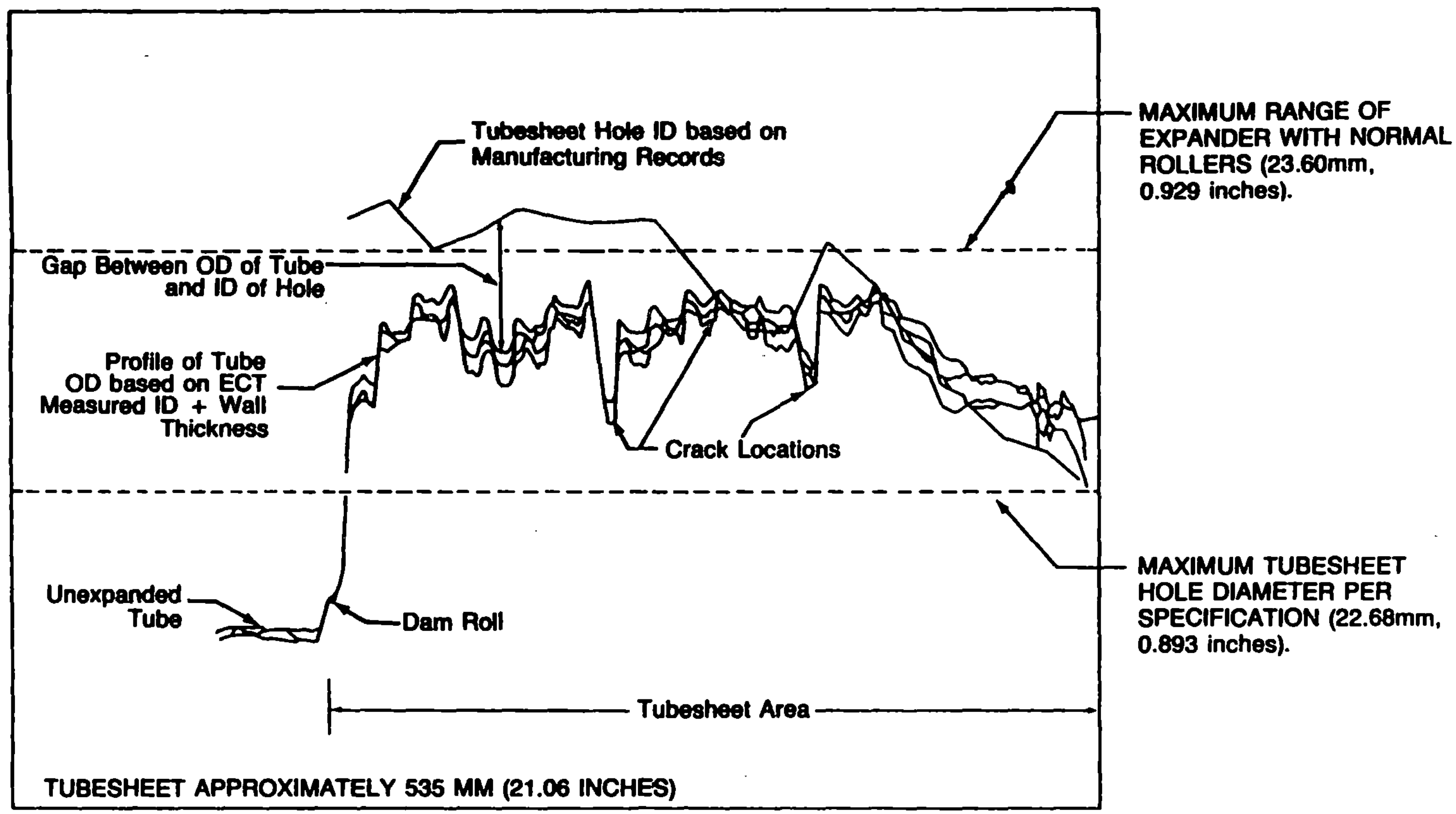


Figure 2-9. Expanded Region Profilometry at Doel 3

Source: From TRABEL

reduced dissolution (see Figure 3-1a). At a mill anneal temperature of about 1950°F(1065°C), few intragranular carbides remain after cooling, indicating improved dissolution (see Figure 3-1b).

- During cooling, carbides precipitate out at the new grain boundaries. The amount of carbide precipitation depends on the amount of carbon in solution. As carbides precipitate, they deplete the chromium concentration locally. The amount of chromium depletion is a function of the cooling rate. Sensitization will occur if the time-temperature falls into a band as indicated in Figure 3-2. Sensitization is undesirable, since it makes the material susceptible to acid sulfur species attack, as indicated in Table 1-1.

The different heat treating conditions which have been used, and the resultant effect on key tube parameters has been reviewed by Owens (21). A summary of this work and some recent data are outlined in Tables 3-1 and 3-2 and are discussed below:

- Prior to the early 1970's, alloy 600 tubing used in most Westinghouse type plants was processed by Huntington using a high 1800-1950°F (982-1065°C) final mill anneal temperature. Mill anneal conditions in this range are sufficient to produce recrystallization, large grain size (typical ASTM No. 6), and good dissolution of carbides. Carbides are then free to reprecipitate at the new grain boundaries during cooling. While this material tends to have a low yield strength, it is resistant to primary side IGSCC. Tubing for most early (pre 1971) Westinghouse type steam generators, and all Combustion Engineering steam generators, is believed to have been produced using high mill anneal temperatures, and should therefore be relatively resistant to primary side IGSCC. It should be noted, however, that a few early Westinghouse type steam generators were fabricated used tubing processed with low mill anneal temperatures and are relatively susceptible (e.g., Mannesmann tubing used in Obrigheim and Doel 2).

- Starting in the early 1970's, the mill anneal metal temperature for tubing used in most Westinghouse type plants was lowered to about 1750°F (955°C), or lower, apparently to increase the tubing yield strength. This mill anneal temperature is high enough to cause recrystallization, but is not high enough to cause much grain growth or carbide dissolution. Thus, it results in smaller size grains (typical ASTM No. 8-11), and reduced rate of carbide dissolution as compared to the previous higher mill anneal temperatures. This leads to a higher concentration of intragranular carbides and a lower concentration of desirable intergranular carbides. This material retains good resistance to sulfur species attack, but is more susceptible to primary side IGSCC than material mill annealed at higher temperatures.

- During the late 1970's, the final heat treatment of the tubing was changed primarily to increase the resistance to secondary side caustic attack. However, this change also thermo-mechanical processing used during manufacturing which establishes the final carbide morphology. Typical carbide morphologies of susceptible and resistant tubing are shown in Figure 3-1. Tubes with increased quantities of grain boundary (intergranular) carbides tend to have improved resistance to primary side IGSCC (17,18,19 & 20). Susceptibility also appears to be related to material grain size with larger grains having lower susceptibility (9). It is believed that thermo-mechanical treatment of tubing which leads to carbide precipitation at grain boundaries also leads to larger gain size and hence leads to the correlation between grain size and susceptibility to IGSCC.

The most convincing practical example of the correlation between carbide morphology and primary side IGSCC is the recent metallurgical examination of 14 tubes pulled from Ringhals 2 (7). As shown in Figure 2-4c, none of the three tubes with significant amounts of intergranular carbides evidenced primary side IGSCC, while all but one of the eleven tubes which had small amounts of intergranular carbides and significant amounts of intragranular carbides also evidenced primary side IGSCC.

There are no firm conclusions at present regarding how the grain boundary carbides improve the resistance to primary side IGSCC. Two speculative theories are that 1) the carbides act as dislocation sources and thus tend to promote plastic deformation within the grains, as opposed to at the grain boundaries, and 2) the carbides tend to mechanically strengthen the grain boundaries.

The main fabrication variable which controls the grain size and carbide morphology is the heat treatment applied to the material after cold working to final tube size. Significant aspects of the final tube forming and heat treatment process, which affect material susceptibility, are as follows:

- Carbides exist at grain boundaries prior to the final tube forming and heat treatment as a result of previous forming and heat treating.
- During the final tube forming the material is cold worked.
- As the tube is mill annealed, the cold worked material recrystallizes, leaving the old grain boundary carbides within the boundaries of the new grains (i.e. intragranular) if the temperature is below the C solvus.
- Dissolution of the carbides during recrystallization is strongly temperature dependent. At a mill anneal temperature of about 1800°F(980°C) and less, large amounts of intragranular carbides remain after cooling, indicating

Temperature variations are known to be a significant factor in the aggressiveness of the environment. There are two leading indicators of this fact. First, most of the reported primary side IGSCC in tube expansion transitions has been on the hot leg rather than the cold leg side. Second, laboratory tests in pure water using highly strained specimens show a strong temperature dependence (see Figure 3-4), which indicates that the IGSCC has an activation energy in the range of 30-50 kcal/mole (22 and recent discussions with van Rooyen). An activation energy of 34 kcal/mole would lead to a 30% decrease in time to failure per 10 F° (5.6 C°) temperature increase at 600°F (315°C).

The main conclusion regarding the environmental aspect of primary side IGSCC is that, if the material is susceptible, and the tensile stresses are high enough, the normal primary side environment will cause it to crack.

TENSILE STRESS

The first evidence of primary side IGSCC in Westinghouse type PWRs in the United States occurred in the mid 1970's at dented tube support plate intersections and in the deformed U-bends at Surry 1&2 and Turkey Point 3&4. This showed that alloy 600 tubing is susceptible to primary side cracking in the presence of yield strength level stresses. This has subsequently been confirmed by laboratory testing (22,17,18,19, & 20), and experience at non-dented plants. The experience with denting related primary side IGSCC at Surry and Turkey Point is particularly significant in that some of this material is thought to have been processed with a high mill anneal temperature, which would tend to make it more resistant to primary side IGSCC than the material in some later plants.

Test data by Bandy and van Rooyen, shown in Figure 3-5, indicate that the time to failure in elevated temperature water varies inversely with the fourth power of the applied stress (22).

TIME TO FAILURE

Rough estimates of the time to failure of susceptible alloy 600 tubing as a function of environment and stress, can be made taking into account the above factors and laboratory test data reported by Bandy and van Rooyen (22). The approach is as follows:

- For susceptible heats of material in a pure water with hydrogen environment at 689°F (365°C), and with stress at the yield point, failure occurs in about 8 weeks. (Note: The actual material in a given plant may be more or less serves to increase the resistance to primary side IGSCC. The process, called "Special Thermal Treatment," involves a high mill anneal temperature [>1950°F(1065°C)] followed by holding the tubing at a lower temperature [1300°F(705°C)] for a long period of time [15 hours]. This process results in the desirable condition of continuous carbides at the grain boundaries, and sufficient time for the chromium concentration at the grain boundaries to return to a level which will resist sulfur species attack (i.e. is not sensitized).

- One variation, used by Babcock and Wilcox on once through steam generators, is to stress relieve the entire steam generator for about 10 hours at 1150°F(620°C) after final assembly. This process results in a high concentration of desirable intergranular carbides and relief of the fabrication induced residual stresses. As a result, this tubing has been free from pure water type primary side IGSCC. However, the stress relief conditions result in chromium depletion at the grain boundaries and a resultant poor resistance to sulfur species attack. Sulfur species attack has proven to be a problem at several B&W plants.

Work is currently underway to develop methods to predict the susceptibility of alloy 600 tubing to primary side IGSCC based on material properties. To date, material susceptibility appears to correlate most strongly with the concentration of grain boundary carbides; however, there is some correlation to grain size and material strength and hardness. The correlation between IGSCC and grain size for those plants in Table 5-1 for which grain size has been reported, is shown in Figure 3-3.

In summary, it should be recognized that material susceptibility varies over a large and continuous range. The most susceptible material will lead to cracks within a year or less, while less susceptible material may not crack after 15 years of operation. Even the most resistant thermally treated material has some degree of susceptibility and can be made to crack in a pure water environment in the laboratory at high enough temperatures and stresses.

AGGRESSIVE ENVIRONMENT

Experience and tests have shown that primary water with normal chemistry and the normal operating temperature range [e.g., 550-615°F (288-324°C)] is "aggressive" towards some types of alloy 600 tubing. The presence of hydrogen appears to significantly aggravate pure water IGSCC, while lithium hydroxide plus boric acid appears to reduce this effect. The net result is that primary water appears to be intermediate in aggressiveness between the most aggressive case of pure water with hydrogen overpressure, and the least aggressive case of pure water without hydrogen overpressure (22).

These examples are in reasonable agreement with actual reported experience at some plants at which large numbers of cracks have occurred in first row U-bends and hot leg expansion transitions within the first few years of operation. The results are also consistent with the experience at Ringhals 2, where incipient cracking has been detected in the cold leg roll transitions after about 9 years of operation, while hot leg transition cracks may have initiated during the first few years of operation. Of course, there are also many plants such as Indian Point 2 and Kewaunee, with over 10 years operating experience and no reported primary side IGSCC at all.

SUMMARY

Operating experience and laboratory test data have demonstrated that alloy 600 tubing material in some heat treatment conditions will crack in a normal PWR primary water environment. The rate at which cracking occurs appears to be dependent primarily upon the material microstructure, temperature, and local tensile residual and operating stresses. Cracking will appear sooner under conditions of more susceptible material, higher temperatures, and higher stresses. Experience at Surry 1&2 and Turkey Point 3&4 indicates that even plants with material generally considered to have a low susceptibility to cracking can rapidly develop primary side cracks if exposed to high enough stresses.

In summary, no plant with non thermally treated alloy 600 tubing should be considered as immune to primary side IGSCC. Rather, plants with less susceptible material, lower temperatures, and lower stresses will take a longer time to develop primary side cracks, and the rate of crack propagation will be lower. Strong evidence of this fact is the recent report of primary side IGSCC in hot leg roll transitions in the Zorita plant after about 14 years of operation. The tube material at Zorita is a vintage which would be expected to have low susceptibility to primary side IGSCC, and the hot leg temperature is relatively low in comparison with newer plants.

susceptible than the material used for these tests. For example, tubing from Ringhals 2 failed within 2 weeks in such a test.)

- Failure in primary water occurs 1/2 as rapidly as in pure water with hydrogen overpressure.
- Temperature affects the rate of attack in accordance with the normal factor for thermally controlled processes, $e^{-Q/RT}$, where Q is the activation energy, R is the gas constant, and T is the absolute temperature. Tests and service experience (22,1 and recent discussions with van Rooyen) indicate a wide range of activation energies (30-50 kcal/mole). For purposes of this rough estimate, a Q of 40 kcal/mole has been assumed. For a hot leg temperature of 610°F (321°C), this results in a life increase by a factor of about 10.3 as compared to 689°F (365°C).
- The failure time varies inversely as the fourth power of the stress.

For yield strength level stresses, and a temperature of 610°F (321°C), the rough estimate of time to failure is about 3 years. Rough estimates of times to failure for other stress levels and tube ID temperatures are shown in Figure 3-6.

Temperature distributions at several points along the length of the tube for a typical Westinghouse type plant are computed in Appendix A. Operating and residual stresses acting at expansion transitions and U-bends are reported in Appendices B and C respectively. Using these data, and the curves in Figure 3-6, it is possible to make rough estimates of the time to failure for susceptible material at key locations within the steam generator. These predictions are reported in Table 3-2.

While there is considerable uncertainty in each of the above assumptions, these examples indicate that, for plants with susceptible material, initial cracking could be expected to occur within several years after startup at locations such as the first row U-bends and hot leg expansions within the tube sheet and sludge pile regions. The rate of crack propagation will depend, of course, upon the through thickness stress distribution. For example, propagation of cracks through the tube thickness would be expected to occur most rapidly for the case of U-bends where the externally applied operating stresses are the highest. These examples also indicate that cracking would be expected to occur at hot leg roll transitions well before cold leg roll transitions.

Table 3-2

CORRELATION BETWEEN MILL ANNEAL METAL TEMPERATURE AND MATERIAL SUSCEPTIBILITY

Source of Data	Final Mill Anneal Metal Temperature (°F)	Susceptibility to Primary Side IGSCC
Combustion Engineering	> 1850	Excellent field performance
	< 1850	Poor field performance
EdF Tests	1960	Not susceptible
	1870	Marginal
	1800	Highly susceptible
Doel 2	< 1730	Highly susceptible
	1750-1800	Not susceptible
Trojan	1650-1750	Susceptible
Surry 2	< 1800	Susceptible with high stress
Ringhals 2 & 3	1750-1800	Susceptible
Ginna	1760-1814	Not susceptible
Indian Point 3	1700-1760	Not susceptible

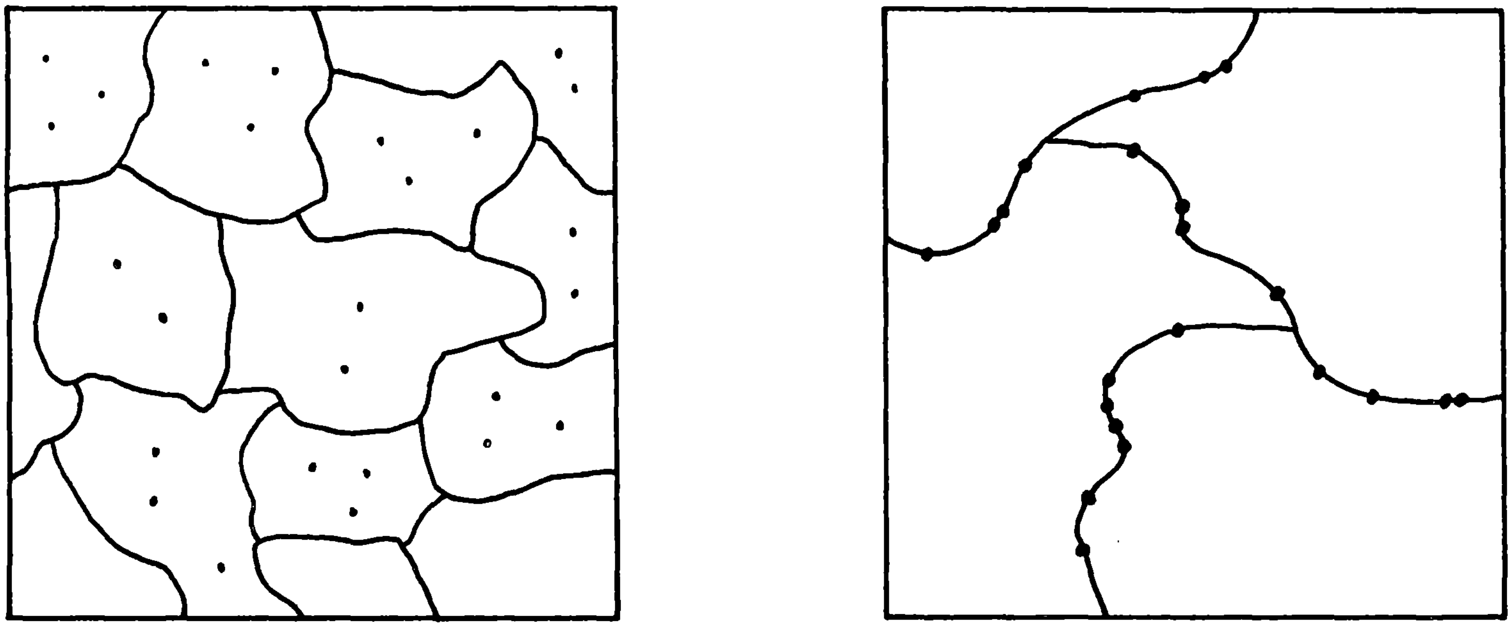
Table 3-1

SUMMARY OF TYPICAL STEAM GENERATOR TUBE CONDITIONS

Process	Metal Temp. During Annealing (°F)	Annealing Duration (min)	Yield (ksi)	Chromium at Grain Boundary	Boundary Carbides	IGSCC Resistance	Sulfur Resistance
Mill annealed	1900	3-5	45	Some Depletion	Some	Good	Variable**
Mill annealed	1750	3-5	65	Some Depletion	Few	Poor	Good
Stress relieved*	1150	600	60	Depleted	Many	Excellent	Poor
Thermally treated*	1300	900	50	Not Depleted	Many	Excellent	Excellent

* Both the stress relieved and thermally treated material received a prior mill anneal heat treatment which is not indicated in the above tables.

** Some heats of this type mill annealed tubing experienced enough grain boundary carbide precipitation to become sensitized and susceptible to sulfur species attack, e.g., Tihange 1, Palisades.



a. Susceptible to Primary Side IGSCC
- . Few Grain Boundary Carbides
- . Copious Intragranular Carbides
- . Small Grain Size

b. Resistant to Primary Side IGSCC
- . Copious Grain Boundary Carbides
- . Few Intragranular Carbides
- . Large Grain Size

Figure 3-1. Carbide Morphology of Alloy 600 Tubing (Illustrative)

Table 3-3

ESTIMATED TIME TO PRIMARY SIDE CRACKING OF SUSCEPTIBLE* MATERIAL
(Cracking due to Hoop Stresses)

Location	ID Metal Temp. (°F)	Stress (ksi) Operating	Residual	Total	Time to Cracking (Years)
• <u>With Heat Transfer</u>					
- Hot leg straight run - not in sludge pile	592	3.9	-25.0	-21.1	NA
- Tube sheet hot leg expansion above tube sheet - not in sludge pile	592	3.9	50.0	53.9	4.2
- Tube sheet cold leg expansion above tube sheet - not in sludge pile	552	9.2	50.0	59.2	11.3
- First row U-bend	565	20.0	45.0	65.0	4.9
• <u>Without Heat Transfer</u>					
- Hot leg straight run - in sludge pile	615	11.0	-25.0	-14.0	NA
- Tube sheet hot leg expansion in tube sheet or sludge pile	615	11.0	50.0	61.0	1.2
- Tube sheet cold leg expansion in tube sheet or sludge pile	558	11.0	50.0	61.0	8.1

* <u>NOTES</u>:

1. Susceptible material as used in this table, is material that leads to cracking of split reverse U-bend specimens in eight weeks time when tested in pure water with hdyrogen overpressure at 689°F (365°C). For purposes of these calculations, the split reverse U-bends were assumed to have a stress level of 50 ksi (345 MPa).
2. An activation energy of 40 kcal/mole has been assumed for these calculations.

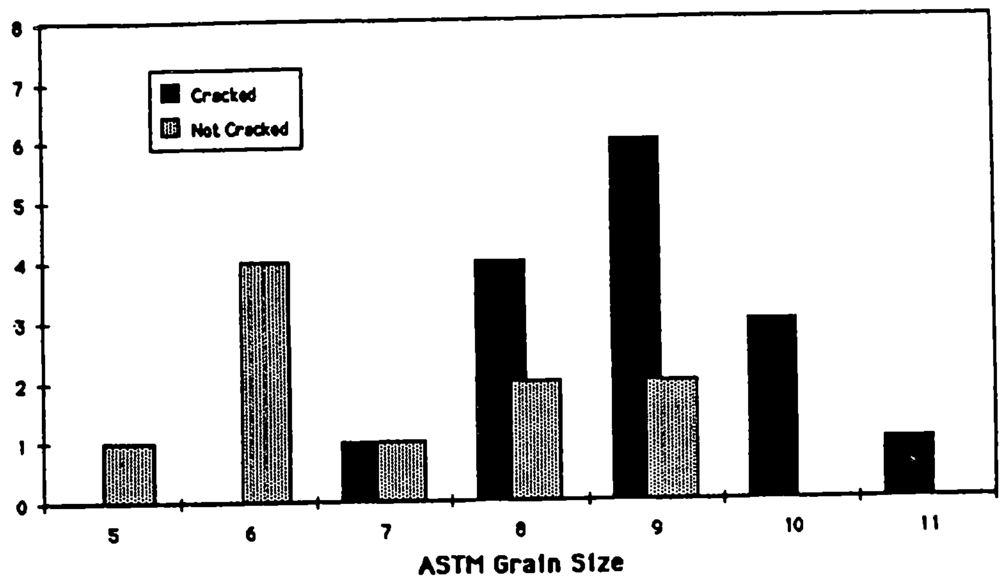
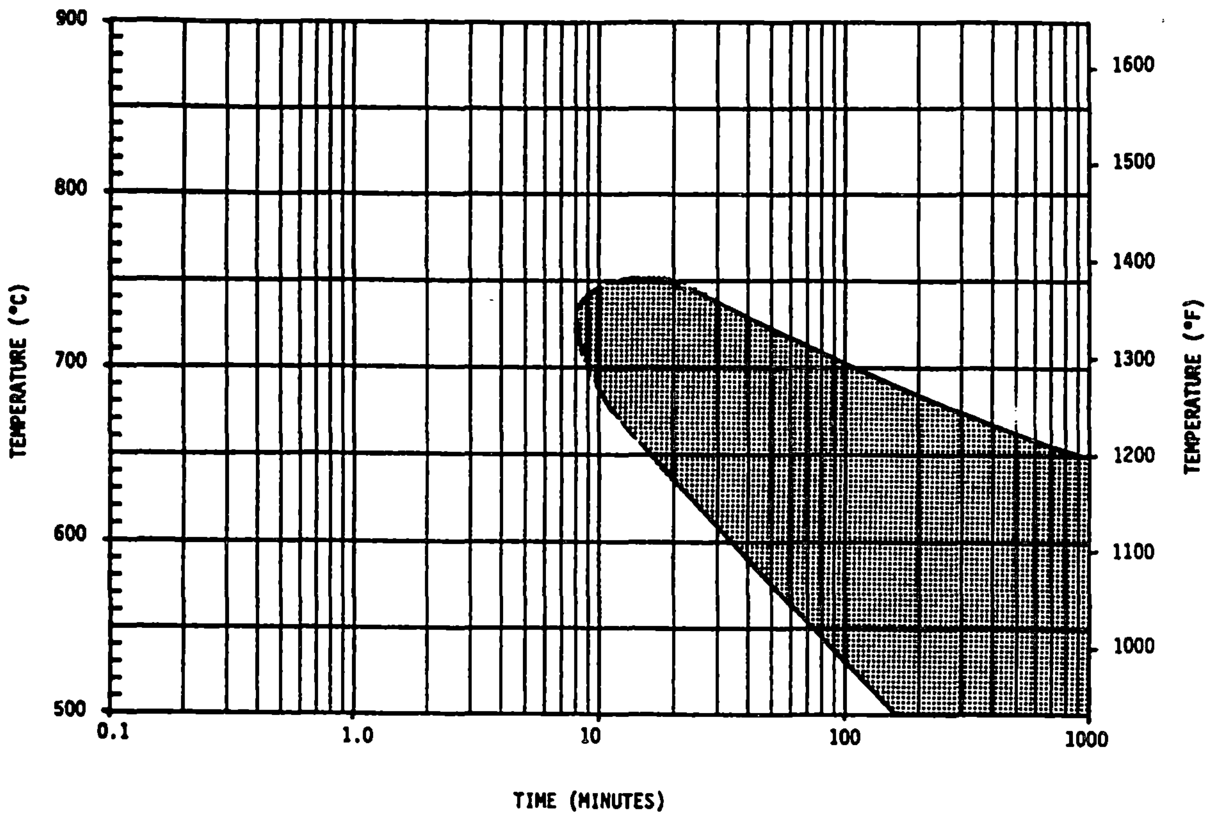


Figure 3-3. Correlation Between Primary Side IGSCC and Average Grain Size



Notes:

1. Range of conditions to be avoided is shaded.

2. Sensitization is defined as greater than 100 mpy or 500 mdd corrosion.

Figure 3-2. Time-Temperature-Sensitization Diagram for Mill-Annealed Alloy 600 Tubing

Source: Adapted from reference (19)

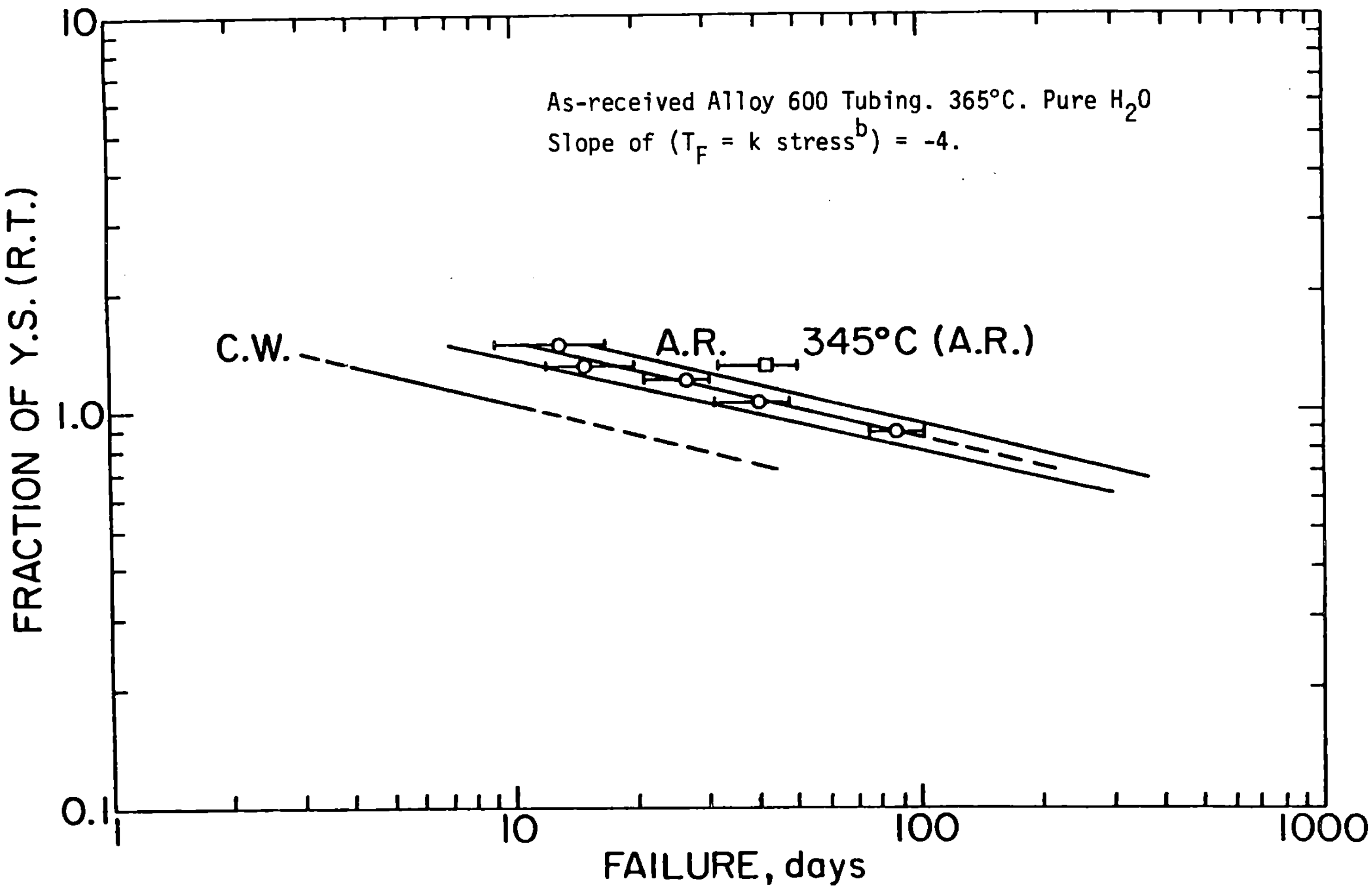


Figure 3-5. Correlation Between Stress and Time to Failure of Alloy 600 Tubing

Source: From reference (22)

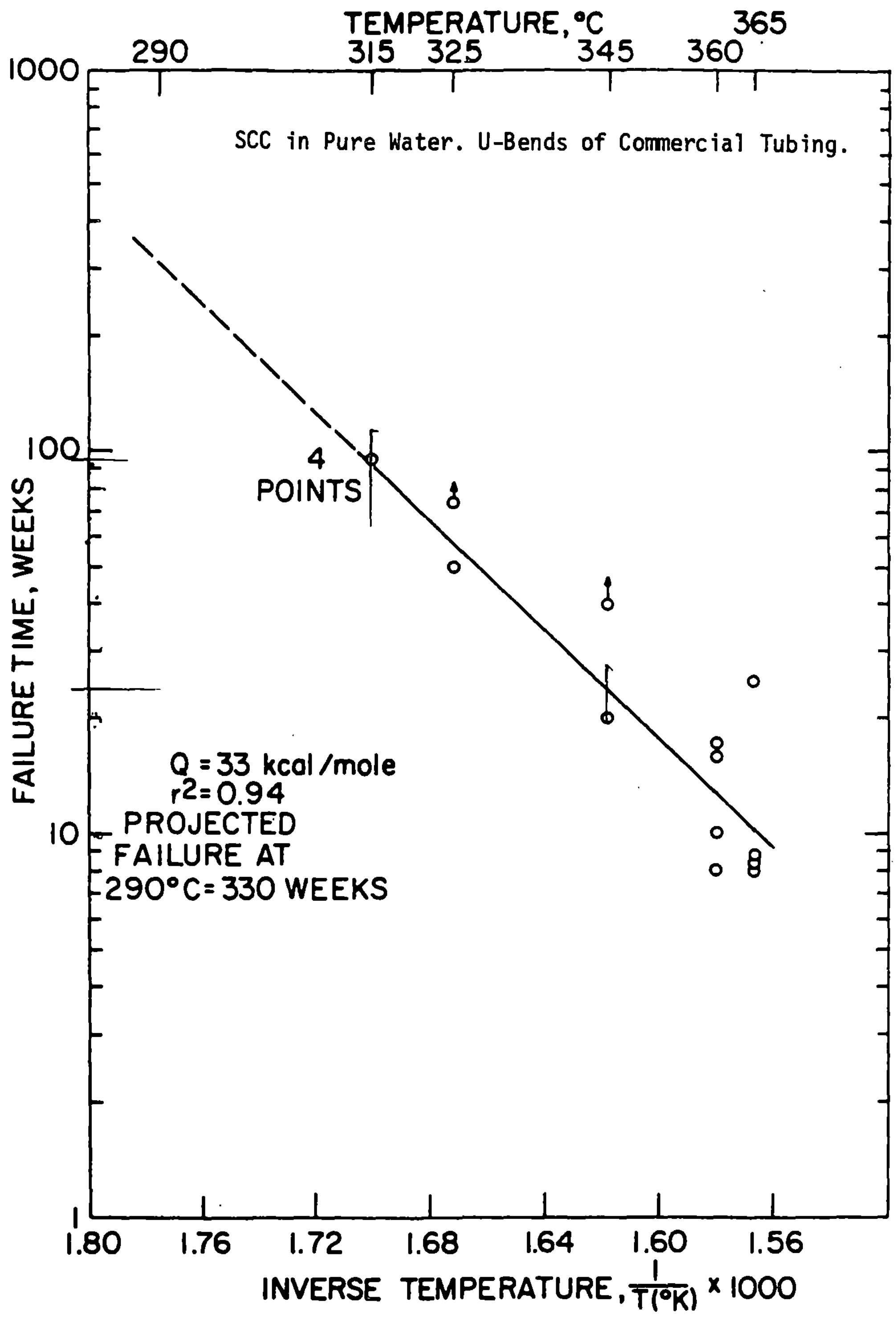


Figure 3-4. Correlation Between Temperature and Time to Failure of Alloy 600 Tubing

Source: From reference (22)

Section 4

CONSEQUENCES OF CRACKING

There are four major concerns regarding primary side IGSCC of steam generator tubing. These are sudden tube rupture, exceeding technical specification leakage limits, exceeding margin of excess tubes, and secondary contamination.

SUDDEN TUBE RUPTURE

The major safety related concern with steam generator tube leakage is that the tubes will rupture suddenly. Sudden ruptures have occurred in the U-bend region of several plants (24). These ruptures have resulted in leakage rates in the range of 80-400 gpm (320-1600 liter/h). In the two cases resulting from primary side IGSCC (Surry 2 and Doel 2) the leakage was in the range of 80-135 gpm (320-540 liter/h).

The NRC has computed that a total leakage rate on the order of 1300 gpm (5200 liter/h) via the steam generators could lead to uncovering the core (24). Therefore, failure of several tubes at one time could be a serious situation. Such a multiple failure could be triggered by mechanical damage produced by one failed tube, or by the effect of a rapid secondary side depressurization causing near simultaneous rupture of several partly failed tubes.

The consequences of a tube rupture are potentially significant for all of the locations where primary side IGSCC has been reported except for the case of cracks which occur at least several inches below the top of the tube sheet for tubes in the center of the steam generator. At these locations the tube will be held in the tube sheet by adjacent tubes or antivibration bars, thereby limiting the amount of flow even if the tube is completely ruptured. This may not apply for some tubes at the start and end of the center tube lane, which would not be restrained by U-bends of adjacent tubes or antivibration bars. Even at these locations, however, the tube would have to move axially through the tube support plate holes before the end of the tube would clear the tube sheet. This is considered unlikely.

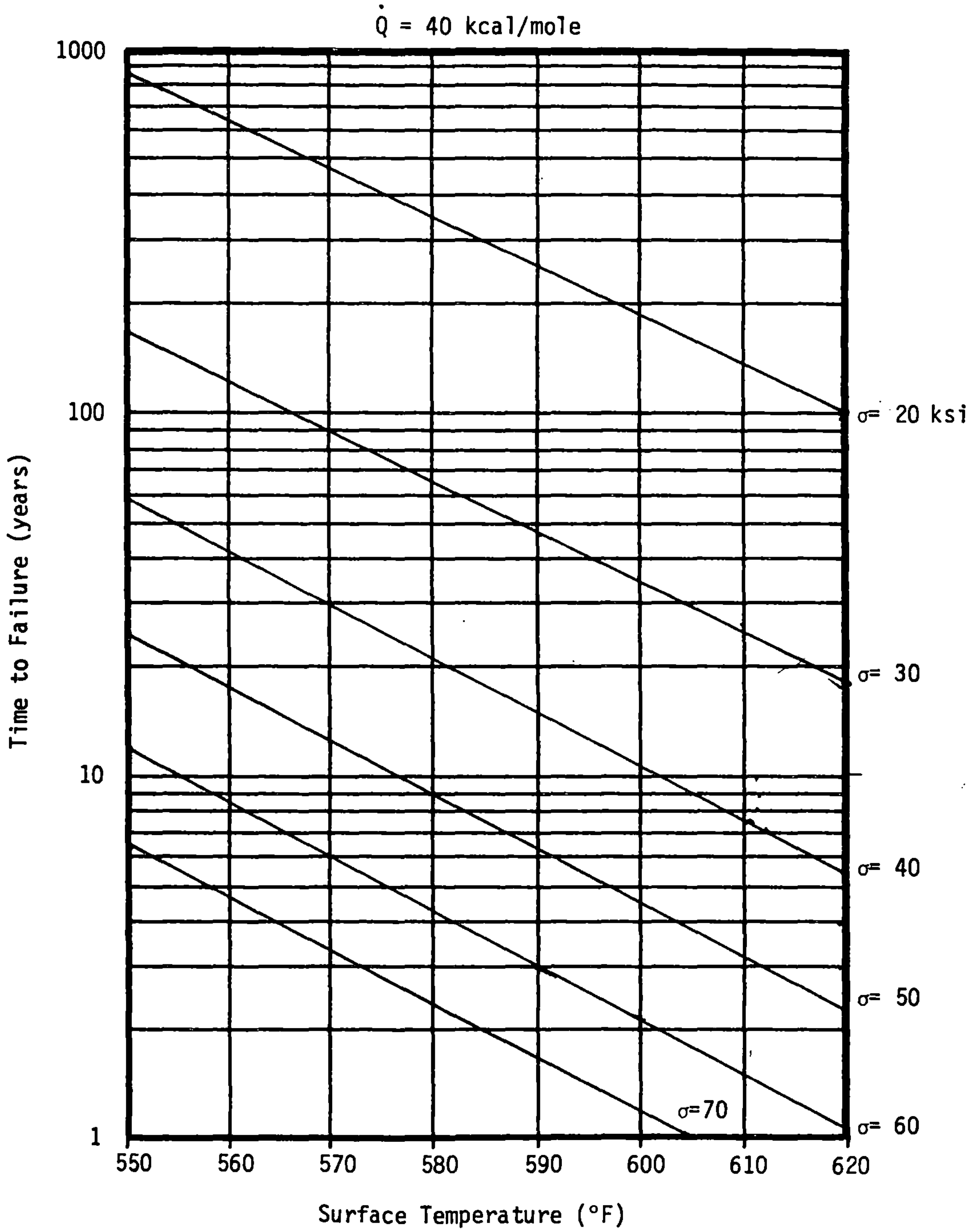


Figure 3-6. Estimated Time to Failure of Alloy 600 Tubing

side leakage will cause radioactive contamination of the secondary systems and equipment, thus leading to undesirable complications in maintenance and waste disposal.

SUMMARY

To date, the general experience with U-bend cracks has been that the leakage is relatively low and increases gradually over a long period of time (i.e., months or years). The major exception to this general sequence of events has been for cases of U-bend apex cracking resulting from high ovality. In several of these cases tubes have ruptured suddenly resulting in large leakage rates. The high ovality has resulted from initial fabrication (Doel 2) and also from closing up of the flow slots as a result of denting (Surry and Turkey Point). The remedial action taken has been to plug the leaking tubes, and in many cases to plug all of the row 1 tubes on a preventive basis.

For the case of expansion transitions and expanded areas within the tube sheet, leakage has also been relatively low and has increased gradually over long periods of time. There are no reported cases of sudden rupture of tubes in the expansion region. In a few cases where the cause of the IGSCC has been identified and affects small numbers of tubes, the general course of action has been to inspect the tubes for the condition known to cause cracking and then plug affected tubes on a preventive basis. This is not practical, of course, where there are large numbers of cracked tubes which were fabricated within tolerance. In these cases, the approach to date has been to accept low levels of leakage while remedial measures are being developed in the laboratory and tested on a trial basis in the plant. However, this type of problem has led to steam generator replacement at one plant (Obrigheim) and is a contributing factor in planning for replacement at another (Ringhals 2).

In summary, while tubes can be plugged or sleeved when cracks or leakage reach the established acceptance criteria, the better approach would appear to be to take appropriate action to prevent a significant problem from developing in the first place. This requires an assessment of the risk of primary side IGSCC occurring at a particular plant, and then selection of an appropriate corrective action if warranted. The remaining sections of this report address the topics of risk, corrective measures, and suggested course of action.

TECHNICAL SPECIFICATION LEAKAGE LIMITS

With many thousands of tubes per plant, several potential crack locations per tube, and some degree of uncertainty in eddy current inspection results, there is a possibility that some cracks will propagate through wall without being detected. Provided that these cracks propagate in a manner which will "leak-before-rupture", the cracks can be detected at an early stage by primary to secondary side leakage measurements. The evidence to date from the Trojan plant suggests that U-bend tangent point leaks in Westinghouse tubing do in fact propagate slowly. Similarly, the short longitudinal cracks which normally occur at expansion transitions also appear to have low and slowly increasing leakage rates.

If there are large numbers of small leaks there is the potential for having to shut the plant down between regularly scheduled outages to plug tubes. If this occurs frequently it can have an adverse effect on plant availability. A related concern with operating a plant with cracked tubes is that laboratory tests and experience at Ringhals 2 and Doel 2 indicate that circumferential cracks can sometimes be associated with longitudinal cracks in the transition region.

MARGIN OF EXCESS TUBES

Present steam generator tube plugging criteria in the United States are based on the requirements of Regulatory Guide 1.121. The approach taken is to remove tubes from service before they can develop through wall cracks. This is currently achieved by plugging tubes when defects reach some significant percentage of wall thickness, such as 40%.

In early steam generators there was generally a high margin (~25%) of excess tubes. In these plants many tubes can be plugged without concern over having to derate the plant. In many newer plants, however, the margin of excess tubes can be very low. In these cases, plugging of large numbers of tubes is not an acceptable long term option.

SECONDARY SIDE CONTAMINATION

Typical leakage rates from U-bend "opposite transitions" and from longitudinal cracks in the tube sheet expansion area are well below the typical Technical Specification allowables. Thus, a case can be made for continuing to operate with the low levels of leakage. However, even small amounts of primary to secondary

Section 5

PLANTS POTENTIALLY AT RISK OF PRIMARY SIDE IGSCC

As indicated in the preceding sections of this report, not all of the Westinghouse type steam generators are equally susceptible to primary side IGSCC. There are significant differences in design details, tube material processing, fabrication details, and operating temperature, which are believed to have significant bearing on whether primary side IGSCC is likely to occur, and, if so, how long it will take to develop, and how extensive the cracking will be. The purpose of this section to summarize available information for Westinghouse type steam generators with non thermally treated alloy 600 tubing, and to discuss how the relative risk of primary side IGSCC can be assessed for a particular plant.

DATA BASE OF KEY PARAMETERS

Appendix D to this report contains a compilation of data pertaining to Westinghouse type steam generators in operation through the end of 1982, as well as several additional plants which went into operation after 1982 but have already developed primary side IGSCC. This data can be used to assess the significance of reported primary side IGSCC at a particular plant, and as a source for identifying other plants which are potentially at risk.

Table 5-1 is a more limited tabulation of the parameters considered to be most relevant to primary side IGSCC for all Westinghouse type plants with non thermally treated alloy 600 tubing. This data includes the date of initial commercial operation, steam generator model number, tubing manufacturer, tubing grain size (which provides an indication of the final mill anneal conditions), location of the expansion transition, method of tubing expansion, hot leg coolant temperature, and locations of reported primary side IGSCC. The plants are separated into five groups based on the steam generator fabricator.

RISK OF PRIMARY SIDE IGSCC

Based on the extent of primary side IGSCC which has already occurred, and the current state of predictive modeling, none of the Westinghouse type steam generators fabricated from nonthermally treated alloy 600 tubing should be considered as being immune to primary side IGSCC over their design lifetimes.

(Note: Even this tubing is not immune to primary side IGSCC as indicated by the extensive denting related cracking at Surry and Turkey Point, and the small amount of non denting related cracking at Beznau 2 and Zorita 1).

Tubing in the rest of the plants in Table 5-1 may or may not be highly susceptible. The susceptibility of tubing used at a particular plant can be evaluated in several ways as outlined below in order of increasing amounts of effort required.

ASTM Grain Size. As reported in Section 3, there is some correlation between susceptibility to primary side IGSCC and the material grain size. This is illustrated by the data in Figure 3-3, which shows that plants with smaller grain size (larger ASTM grain size numbers) tend to have a greater incidence of primary side IGSCC, than plants with larger grain size. The grain size range for a particular plant can sometimes be obtained from tube material records. (Note: This may require considerable effort as there can be 200 or more heats of material used in a given steam generator). It would appear from the limited grain size data in Table 5-1 and Figure 3-3 that the following criteria can be applied as a first step to assessing the relative material susceptibility:

ASTM Grain Size	Material Susceptibility
6 and less	Not generally susceptible to date
7 - 9	May be susceptible
10 and greater	Should be considered highly susceptible

Mill Annealing Temperature. The final mill annealing temperature has been demonstrated to have a significant effect on susceptibility to primary IGSCC (Reference 21 and Table 3-2). In some cases, the mill annealing furnace temperature can be obtained from the tube supplier for each heat of material. In other cases, the mill anneal furnace temperature can only be estimated based on the temperatures typically used by a supplier during a given period of time. One major problem in this regard is that most of the research has been done using the actual mill anneal metal temperature which is lower than the mill anneal furnace temperature. Appropriate corrections must be made to estimate the metal temperature from the furnace temperature. It should also be noted that there are significant variables in the mill annealing process in addition to the temperature which can affect the response of the tubing material to the heat treatment process and the resultant susceptibility to primary side IGSCC. These variables include:

Rather, it is considered that primary side IGSCC will continue to be an increasing concern as plants age and that there will be wide variations in times to crack initiation and in extent of cracking between different plants and within individual steam generators. Predictive models may ultimately be improved to the point where it can be demonstrated that some specific plants should be immune from primary side IGSCC over their design lifetime. However, this does not appear likely considering 1) the wide range of variables involved, 2) there can be more than 200 heats of material and 3500 tubes per steam generator which increases the likelihood of at least some tube-fabrication combinations leading to susceptibility, and 3) primary side IGSCC has already been reported in over half of the steam generators in operation over 5 years.

In making plans regarding inspection programs and possible remedial measures, it is desirable to be able to assess the relative risk of primary side IGSCC occurring at a particular plant. Based on the present state of the art, there are two major factors which should be taken into account in making such an assessment. These are: material susceptibility and fabrication processes used.

Material Susceptibility

Based on information currently available, material susceptibility appears to be the most significant single factor regarding potential for primary side IGSCC. If the material is at the high end of the susceptibility range for mill annealed alloy 600 tubing, then the evidence indicates that primary side cracking will most likely be a significant problem regardless of the specific fabrication processes used. On the other hand, if the material is at the low end of the susceptibility range for mill annealed alloy 600 tubing, then the evidence indicates that primary side cracking will most likely not be a significant problem unless there are unique situations such as denting which produce very high and persistent tensile stresses. It is important, therefore, to be able to determine the relative susceptibility of alloy 600 tubing at a particular plant as compared to material in plants which have experienced severe primary side IGSCC and those which have been free of significant primary side IGSCC.

The only plants for which material susceptibility should not have to be assessed on a case basis are those plants with tubing supplied by Huntington prior to about 1971. This early Huntington tubing, used in the first 10 or so plants in Table 5-1, was apparently heat treated in a higher mill anneal temperature and has therefore proven to be more resistant to primary side IGSCC than later tubing.

expansion transitions, and incomplete expansion within the tube sheet which results in portions of the tube having tensile rather than compressive residual stresses.

For plants with susceptible material, the following fabrication details are known to produce more significant problems than other details. In some of these cases, inspections can be performed in a steam generator to determine if particularly adverse conditions exist.

- First and second row U-bends with ovality in excess of 10% - The actual ovality can be determined by in situ measurements. The most likely cracks resulting from high ovality are longitudinal and located in the apex region.

- First and second row U-bends formed by Westinghouse using their ball mandrel process - To date, we are not aware of in situ inspection methods to assess the magnitude of the bulge or wall thinning at the "opposite transition", nor has work been completed to determine the correlation between "opposite transition" geometry and likelihood of IGSCC. The most likely cracks at the "opposite transition" are longitudinal. It may be possible to develop profilometry and wall thickness measuring methods that will allow, in conjunction with tests of U-bend geometry, a reasonable assessment of the degree of risk. However, when and whether this work will be completed is not certain at this time.

- Expansion transitions in roll expanded tubing, with or without a DAM treatment above the transition - The most likely cracks are short longitudinal cracks in the transition between the expanded and unexpanded tubing. However, laboratory and field experience indicate that circumferential cracks can eventually occur. While expansions meeting normal fabrication tolerances have been shown to crack, the rate of crack initiation appears to be increased by oversize holes, steep transition slope (low l/r ratio), and out-of- tolerance DAM treatment. A review of fabrication inspection records, and some in situ inspections can be used to determine if these conditions exist.

- Expanded regions in roll expanded tubing - If tubing is properly expanded into the tube sheet, the entire inner surface of the tube wall should be in compression. If there are "waves" in the rolling, skip rolls, or uneven overlaps, there is the potential for local tensile residual stresses. These conditions can be determined by profilometry measurements. It should be noted, however, that cracking can even occur at normal "waves" in the ID surface; this probably occurs in tubes which received relatively low amounts of wall thinning after contact with the tube sheet, though this has not been proven. The actual amount of wall thinning could probably be measured ultrasonically.

belt speed (time in the furnace), tube wall thickness, amount of tubing in each load (thermal mass in furnace), amount of previous cold working, carbon content, etc. Nevertheless, the following general guidelines on mill anneal temperature have been developed from Reference (21) and the data in Table 3-2.

Final Mill Anneal Metal Temperature °(F)	Material Susceptibility
>1850	Not generally susceptible to date
1750 - 1850	May be susceptible
<1750	Should be considered highly susceptible

Carbide Morphology. As reported in Section 3, the best correlation between material properties and susceptibility to primary IGSCC appears to be carbide morphology. Using this approach, photomicrographs are prepared of archive tubing material, or tubing specimens removed from the steam generator and the observed carbide morphology is compared to reference photomicrographs. Large amounts of intergranular (grain boundary) carbides are indicative of resistance to primary side IGSCC. The suggested set of reference photomicrographs for evaluation purposes is presented in the draft EPRI specification for alloy 600 steam generator tubing (25).

Accelerated SCC Tests. A model is described in Section 3 to predict time to failure based on results of accelerated stress corrosion cracking tests in elevated temperature pure water with hydrogen overpressure. As in the previous method, archive material, or material specimens removed from the steam generator, can be tested using this approach, and the predicted time to failure compared to that for material known to be highly susceptibile (see Table 3-3).

Fabrication Details

For susceptible material, the rate at which primary side cracking problems develop and the ultimate extent of the problems appear to be significantly affected by the fabrication details. That is, fabrication processes which produce higher levels of tensile residual stresses on the inside surface of the tube lead to more rapid and severe cracking than processes which produce lower levels of tensile residual stresses. A particular concern in this regard is out-of-tolerance conditions such as high ovality in the U-bend region which leads to high stresses, oversize holes in the tube sheet which result in greater geometric discontinuities at the

Table 5-1

Westinghouse Type PWR Plants with Non Thermally Treated Alloy 600 Tubes (Preliminary Data - July 12, 1985)

Plant Name	Date Com'l	SG Model	Tubing Mfr	Grain Size	Expansion Length	Expansion Method	HL Temp	Primary Cracks or ECT Ind.
Manufactured by Westinghouse								
Connecticut Yankee	68	27	H	--	P	R	577	--
San Onofre 1	68	27	H	--	P	R	575	--
Beznau 1	69	33	H	6.5	P	R	599	--
Zorita 1	69	24	H	--	P	R	596	ET
Ginna	70	44	H	6-10	P	R	601	--
Point Beach 1	70	44	H	6	P	R	611	--
Beznau 2	72	33	H	--	P	R	597	U
Robinson 2	71	44	H	5	P	R	604	--
Point Beach 2	72	44	H	6	P	R	611	--
Surry 1	72	51	H	8-12	P	R	590	Dent
Turkey Point 3	72	44	H	--	P	R	605	Dent
Indian Point 2	73	44	H	--	P	R	576	--
Prairie Island 1	73	51	W/H	--	P	R	599	U
Surry 2	73	51	W/H	--	P	R	606	Dent
Turkey Point 4	73	44	H	--	P	R	602	Dent
Zion 1	73	51	W	8	P	R	594	U
Kewaunee	74	51	W	--	P	R	599	--
Prairie Island 2	74	51	W/H	8-9	P	R	599	--
Takahama 1	74	51	W	8-10	F*	R+HE	613	UT
Zion 2	74	51	W/H	--	P	R	594	U
Cook 1	75	51	W/H	--	P	R	599	U
Ringhals 2	75	51C	W	8-10	P	R	616	UT
Indian Point 3	76	44	W	9-10	P	R	600	--
Salem 1	76	51	W/H	7.5	F	R+E	609	--
Trojan	76	51A	W	8	F	R+E	615	U
Beaver Valley 1	77	51	W/H	--	F	R+E	610	--
Farley 1	77	51	W	--	F	R+E	603	U
Korea Nuclear 1	78	51	W	--	F	R	607	--
Cook 2	78	51	W	--	P	R	606	UT
North Anna 1	78	51	W/H	--	F	R+E	614	U
Ohi 1	79	51A	W	8-10	F	R	615	UE
North Anna 2	80	51	W	--	F	R+E	--	--
Almaraz 1	81	D3	W	--	F	R	619	ET
Farley 2	81	51	W	--	F	R	603	--
Krsko	81	D4	W	--	F	R	616	--
McGuire 1	81	D2	W	--	F	R	618	E
Ringhals 3	81	D3	W	8-9	F	R+D	618	E
Salem 2	81	51	W	--	F	R+E	611	--
Sequoyah 1	81	51	W	--	F	R+E	614	U, E
Sequoyah 2	81	51	W/H	--	F	R+E	614	--
Ringhals 4	83	D3	W	--	F	--	613	--
Almaraz 2	84	D3	W	--	F	R	619	--

In summary, for plants with susceptible material, primary side IGSCC will most likely occur over the life of the plant. The rate at which the problems will develop and the ultimate extent of the problems will depend on the level of susceptibility and the magnitude of tensile stresses induced by the specific fabrication processes used. To a certain extent, the potential significance of these problems can be determined in advance by review of material records, materials testing, review of fabrication data, and in situ inspections. A suggested course of action is included in Section 7.

Table 5-1 (Continued)

				Manufactured by Siemens				
Obrigheim	69	--	M	9-10	I	3ptR	594	UT
				Manufactured by Mitsubishi				
Mihama 2	72	44	W/SU/H	6-10	F*	R+HE	607	T
Genkai 1	75	51	SU	--	F*	R+HE	613	--
Takahama 2	75	51	SU	8-9	F*	R+HE	613	--
Mihama 3	76	51	SU	--	F	R	613	ET
Ikata 1	77	51	SU	9	F	R	613	ET
Ohi 2	79	51A	SU	--	F	R	615	ET
Genkai 2	81	51M	SU	--	F	R+R	613	--
Ikata 2	82	51M	SU	9	F	R+R	--	--
Sendai 1	84	--	--	--	F	--	--	--

Notes:

1. Tube Manufacturer
   - H Huntington Alloys
   - M Mannesmann
   - SA Sandvik
   - SU Sumitomo
   - W Westinghouse
   - V Vallourec

2. Grain Size
   - ASTM grain size

3. Expansion Length
   - F Full length expansion (no crevice)
   - F* Expanded to within 50 mm of top of tube sheet after startup
   - I Intermittent rolls
   - P Part length expansion (with crevice)

4. Expansion Method
   - R Roll
   - R+E Initial part length roll followed by Westex explosive expansion
   - R+D Roll expansion plus DAM or "kiss" roll to improve transition
   - R+HE Initial part length roll followed by combined elastomeric-hydraulic expansion after some time of service
   - R+R Initial part length roll followed by elastomeric (rubber) expansion
   - 3ptR Three intermittent rolls: top, bottom, & middle of tube sheet

5. Primary Cracks or ECT Indications
   - E Primary side IGSCC in expanded area
   - T Primary side IGSCC in expansion transition region
   - U Primary side IGSCC in U-bend region
   - Dent Primary side IGSCC which is denting related

Table 5-1 (Continued)

Angra 1	84	D3	W	--	F	R	620	--
ASCO 1	84	D3	W	--	F	R	620	--
Diablo Canyon 1	84	51	W	--	F	R+E	608	--
McGuire 2	84	D3	W	--	F	R	617	--
Summer	84	D3	W	--	F	R	619	UE
Watts Bar 1	84	D3	W	--	F	R	617	--
ASCO 2	85	D3	W	--	F	R	619	--
Byron 1	85	D4	W	--	F	R	619	--
Catawba 1	85	D3	W	--	F	R	617	--
Comanche Peak 1	85	D4	W	--	F	R	622	--
Diablo Canyon 2	85	51	W	--	F	R+E	608	--
Beaver Valley 2	86	51M	W	--	F	R	610	--
Shearon Harris	86	D4	W	--	F	R	619	--
Watts Bar 2	86	D3	W	--	F	R	619	--
South Texas 1	87	E2	W	--	F	R	626	--
Lemoniz 1	--	D3	W	--	F	R	620	--

<u>Manufactured by Cockerill</u>

Doel 1	75	44	M	5-8	P	R	598	--
Doel 2	75	44	M	6-10	P	R	598	UET
Tihange 1	75	51	SA	7-10	P	R	611	--
Doel 3	82	51M	W	7-11	F	R+D	617	ET
Tihange 2	83	51M	W	7-11	F	R+D	617	ET
Doel 4	85	E1	W	7-11	F	R+D	626	--
Tihange 3	85	E1	W	7-11	F	R+D	626	--

<u>Manufactured by Framatome</u>

Fessenheim 1	77	51A	W	7-8	F	R+E	611	UT
Fessenheim 2	78	51A	SA	--	F	R	611	--
Bugey 2	79	51A	W/SA	--	F	R	613	U
Bugey 3	79	51A	V	9-10	F	R	613	UT
Bugey 4	79	51A	W	--	F	R	613	T
Bugey 5	80	51A	V	11	F	R+D	613	ET
Dampierre 1	80	51M	W/V	--	F	R+D	613	ET
Gravelines B1	80	51M	W/V	--	F	R+D	613	--
Gravelines B2	80	51M	W	--	F	R+D	613	--
Tricastin 1	80	51M	V	--	F	R+D	613	--
Tricastin 2	80	51M	W/V	--	F	R+D	613	--
Blaylais 1	81	51M	W/V	--	F	R+D	613	--
Dampierre 2	81	51M	W/V	--	F	R+D	613	--
Dampierre 3	81	51M	W/V	--	F	R+D	613	ET
Dampierre 4	81	51M	W	--	F	R+D	613	--
Gravelines B3	81	51M	V	--	F	R+D	613	T
Gravelines B4	81	51M	W/V	--	F	R+D	613	--
Tricastin 3	81	51M	W/V	--	F	R+D	613	T
Tricastin 4	81	51M	V	--	F	R+D	613	--
San Laurent B1	81	--	V	--	F	R+D	613	--
San Laurent B2	81	--	W/V	--	F	R+D	613	--
Blaylais 2	82	51M	SA/V	--	F	R+D	613	--

Section 6

CURRENT STATUS OF REMEDIAL MEASURES

A number of remedial measures have been considered for possible use to alleviate primary side IGSCC problems, and can be categorized in terms of the three factors required for primary side IGSCC. The remedial measures are summarized in the following table and discussed in greater depth below.

<u>Reduce Aggressive Environment</u>

Reduce primary coolant temperature
Reduce hydrogen concentration
Install sleeves
Install plugs
Rotate Steam Generators

<u>Reduce Material Susceptibility</u>

Heat treat tube sheet
Electroplate tube wall

<u>Reduce Tensile Stresses</u>

Re-expand tubing
Stress relieve U-bends
Heat treat tube sheet
Stress relieve expansion transition
Shot peen expansion transition
Rotopeen expansion transition

PRIMARY COOLANT TEMPERATURE REDUCTION

As discussed in Section 3, service experience and laboratory tests have shown that primary side IGSCC is strongly influenced by temperature. Figure 3-6 shows the factor of improvement in time to cracking for a given stress level as a function of temperature on the tube inside surface. These factors are as follows for a range of temperatures and an activation energy of 40 kcal/mole:

TH, F (C)	Factor of Improvement
610 (321)	1.0
600 (316)	1.4
590 (310)	1.9
580 (304)	2.7
570 (299)	3.7
560 (293)	5.3

- Doel 2 - Mini-sleeves were installed explosively over about 185 cracked expansion transitions in the Doel 2 plant as shown in Figure 6-2 (28). The mini-sleeves have caused cracking of the tubes after service at the top and bottom of the sleeves. The cracking appears to be due to tensile residual stresses induced in the tube by the explosive welding process used during installation of the mini-sleeves. Methods were investigated to stress relieve the mini-sleeved areas after installation using an induction heating procedure so that use of mini-sleeves could remain a viable option for the case of cracks at tube expansion transition areas. Initial attempts at in situ stress relief did not result in the reduction of residual stresses below the threshold for cracking in a sodium tetrathionate environment. This was probably the result of too low a temperature being achieved in the critical areas under the ends of the sleeves. At present, the mini-sleeve approach followed by local stress relieving has been abandoned at Doel 2; however, the supplier involved (B&W) may still be doing some further development work to make this a viable approach.

- Ringhals 2 - For the installation of conventional sleeves to be successful, stresses introduced at the joints during sleeving must not be high enough to cause primary or secondary side attack. The Swedish State Power Board recently tested a variety of sleeves for Ringhals 2. These tests used sensitized alloy 600 tubing in sodium tetrathionate and mill annealed tubing in 10% NaOH. The tests showed that current sleeve designs with brazed, welded, or mechanical joints introduce relatively low residual stresses, most likely on the order of half of the yield stress. Based on these tests, trial lots of brazed and welded sleeves were recently installed in Ringhals 2, which is known to have tubing that is highly susceptible to primary side IGSCC. The types of sleeves installed at Ringhals 2 are shown in Figure 6-3.

A more complete discussion of current sleeve designs and experience, as well as a design review checklist for sleeving is included in reference (8).

PLUGGING

Installation of tube plugs has been the standard remedial measure used to date for most leaks caused by primary side IGSCC, and is currently the only viable option for leaking U-bends. In the short term, at least until the scope of the primary side IGSCC problem is identified at a particular plant, installation of plugs is a sensible solution. However, for plants where it appears that large numbers of tubes may be affected by primary side IGSCC, use of plugs is not practical as a long term solution. This is particularly true for the case of plants with low margins of excess tubes. Any plugs which are installed should be of the removable type, so that the tube can be retrieved at a later date if this becomes desirable.

As can be seen, a large measure of improvement would require a significant decrease in temperature, and thus is not practical as a long term solution. However, it may be worth considering in some cases for a short period of time to reduce the rate of damage while other longer term remedial measures are being prepared. As an example, a 40 F° (22 C°) temperature decrease was used at Point Beach 1 to reduce the rate of secondary side attack. However, this temperature reduction resulted in about a 25% loss of power output.

While large reductions in reactor coolant temperature are economically prohibitive for long periods of time, it would be desirable for plants to reduce hot leg temperatures as much as possible while still maintaining 100% power output. For example, even a 10 F° (5.6 C°) reduction in hot leg temperature would be expected to reduce the rate of primary side IGSCC attack by about 40%.

HYDROGEN CONCENTRATION REDUCTION

Another possible approach for reducing the aggressiveness of the environment is to reduce the hydrogen concentration in the primary water to the lower end of the allowable range. Tests (22, 26) have shown that hydrogen accelerates the rate of cracking when added to pure water, and EdF tests have shown that large concentrations of hydrogen (700 cc/kg) have a similar effect in primary water. However, the effect of small changes in hydrogen concentration in primary water has not been quantified, and it thus remains problematical. For pure water, going from no hydrogen to about 20-25 cc/kg resulted in a decrease in time to initiation of SCC of about a factor of 5 for material with moderate amounts of cold work (26). It is suspected, but not proven, that increasing the hydrogen concentration further, as would be allowed by normal primary water specifications, could result in a further acceleration of primary side attack.

SLEEVING

One approach which has been tried for reducing the aggressiveness of the environment in contact with susceptible areas of tubing is to install sleeves. Three examples are as follows:

- Japanese Plants - Some primary side leakage in the tube sheet area of Japanese plants has been remedied by the installation of sleeves as shown in Figure 6-1 (27). These sleeves are welded to the tube at the bottom of the tube sheet and extend to within about 5 cm (2 inches) of the top of the tube sheet. The sleeves are expanded into place hydraulically, or by use of a compressed elastomeric cylinder which exerts a radial pressure.

currently has a program (S303-22) at Foster Wheeler in which tube mockups have been explosively re-expanded. These mockups are made of sensitized alloy 600 tubing and will be tested in sodium tetrathionate to determine the degree of improvement. Results are expected in 1985. One obvious concern with this approach, which must be resolved prior to application in a plant which has been in operation, is the effect of the explosive re-expansion on preexisting cracks.

U-BEND STRESS RELIEF

Westinghouse has performed work sponsored by EPRI/SGOG to demonstrate the feasibility of heating first row U-bends with an inside diameter electric resistance heater to a temperature that will relieve residual stresses and therefore reduce the susceptibility of the tubing to primary side IGSCC (29). The arrangement of the electric resistance heater in the U-bend is illustrated in Figure 6-4. The results of this work indicate that in situ stress relief of the U-bends is practical but that there are three subjects which require some additional effort (23). These are as follows:

- Temperature Control - The equipment used for in situ stress relief of U-bends must be capable of controlling the tube wall temperature in the range of 675-725°C (1247-1337°F). As shown in Figure 6-5, lower temperatures may not produce the desired stress relief while higher temperatures may result in undesirable grain growth or recrystallization. To date, instrumentation to monitor temperatures in the U-bend during stress relief has not been demonstrated.

- Propagation of Existing Cracks - For plants which have been in service, the U-bends may already contain cracks which have not yet propagated through wall. Since the tube wall is thin and the heat up rate is low, it is unlikely that the stress relief operation will result in propagation of any existing cracks. In fact, it is more likely that the stress relief will blunt the crack tips and therefore reduce the potential for future cracking. Nevertheless, this should be demonstrated by tests prior to application on a plant which has been in service.

- Surface Contamination - The potential for surface contamination present during in situ stress relief leading to cracking or grain boundary attack has not yet been fully assessed. Westinghouse has performed some tests on simulated sludge and these tests did not indicate a problem. However, some additional testing is still required as outlined in the Dominion Engineering report on in situ stress relief (23).

In summary, in situ stress relief of U-bends is considered to be viable; however, the procedure has not yet been demonstrated at a plant and some development work

STEAM GENERATOR ROTATION

Primary side cracking has essentially all occurred on the hot leg side, leaving the cold leg side in a relatively unattacked condition. TRABEL is in the process of evaluating whether it would be practical to rotate a steam generator so as to interchange the hot and cold legs (9). This would be done by making a channel head cut so that the tube bundle could be rotated. The main advantages of the procedure are that it requires much less advance preparation time than steam generator replacement and would essentially double steam generator life. On the other hand, the cold leg tubing would be as susceptible as the original hot leg, and thus this approach would not provide a very large improvement (less than a factor of two).

ELECTROPLATING

Electroplating has been mentioned by EdF as a possible remedial measure, and Framatome and Belgatom are doing some exploratory work on the concept. No details on their processes are currently available.

The deposited material would be one that is resistant to IGSCC as well as having good bond strength and erosion/corrosion resistance. Chromium and nickel have been mentioned as possible candidates.

ADDITIONAL EXPANSION

For plants with part length rolled tubes and which are experiencing cracking at roll transitions, expansion of the tube for all or part of the tube sheet depth is a possible repair approach. This method is being used by the Japanese for all of their part length rolled plants, and is being considered for Doel 2. The Japanese have used hydraulic expansion while Tractionel is exploring the possibility of explosive expansion for Doel 2. Whatever expansion method is used, it is important that the new expansion transition result in low tensile residual stresses.

TUBING RE-EXPANSION

For plants with a poor initial expansion over the full depth of the tube sheet, re-expansion of the tube over the full depth of the tube sheet is an option. This has the potential to 1) correct areas improperly expanded during rolling, such as skip rolls, poor overlaps, etc. which lead to high local residual stresses, and 2) improve the local geometry and state of stress in the transition region. EPRI water tests of rolled specimens are underway to better quantify the expected improvement.

One potential problem with this approach is that the tubes subjected to stress relief temperatures may become sensitized, and thus become susceptible to attack by sulfur species similar to that which has occurred in the TMI-1 primary side and in the ANO-1 secondary side. However, other Babcock and Wilcox plants with once-through steam generators and Tihange-1, have operated satisfactorily with sensitized tubing by carefully avoiding oxidizing conditions. Accordingly, for a plant which has significant primary side IGSCC, the risk associated with sensitization may be warranted. There is also a risk associated with the effect of surface contamination as indicated for in situ U-bend stress relief.

LOCAL EXPANSION TRANSITION STRESS RELIEF

Brookhaven National Laboratory has performed work sponsored by EPRI/SGOG to demonstrate the feasibility of induction heating expansion transitions within the tube sheet to a temperature that will relieve residual stresses and, therefore, reduce the susceptibility of the tubing to primary side IGSCC (31). Also, Babcock and Wilcox has performed induction heating stress relief on mini-sleeved transitions at Doel 2 (32). The equipment used by Babcock and Wilcox is shown schematically in Figure 6-6. The results of this work indicate that in situ stress relief of expansion transitions should be practical, but that there are several subjects which require some additional effort (23). These are:

- Temperature Control - Use of fiber optics sensors has been demonstrated to be a practical method for measuring temperatures achieved by induction heating. Experience at Doel 2 indicated, however, that temperatures measured at one location may not accurately reflect temperatures developed at other locations due to variations in heat transfer properties in the gap between the tube and tube sheet. Accordingly, practical means must be developed and tested to provide accurate temperature control taking into account variations in tube roll transition geometry and crevice heat transfer properties. The desirable range of time/temperature conditions for expansion transition stress relief are shown in Figure 6-7.

- Surface Contamination - The same question of surface contamination applies at the expansion transition as discussed for the U-bends.

- Development of Local Buckling and/or Tensile Residual Stresses - If the tube is locked at the top of the tube sheet by denting etc. there is the potential to develop local is still required. Draft specifications to obtain stress relief services for U-bends are included in reference (23).

GLOBAL TUBE SHEET HEAT TREATMENT

Global heat treatment of the entire tube sheet is actively being considered for plants in Belgium which have been in commercial operation (30). This procedure consists of heating the tube sheet up to a temperature in the neighborhood of 1112°F (600°C) and holding the temperature for eight to ten hours. The procedure is expected to increase the resistance to primary side IGSCC by increasing the carbide precipitation at grain boundaries and possibly by reducing residual stresses somewhat.

There are several reasons why this procedure is being considered over other alternative methods such as local stress relief, shot peening, and rotopeening: 1) the plants are operational which makes application of other more time consuming remedial measures less attractive due to increased radiation exposure, 2) leaks and cracks at various elevations in the tube sheet indicate that remedial measures may have to be performed over the full tube sheet height, and 3) tests indicate that typical heats of tubing from candidate plants will experience desirable grain boundary carbide precipitation.

Considerable test and analysis work has already been performed in support of this procedure and the results indicate that it is practical (30). Two approaches to performing the heat treatment have been evaluated. These are 1) using electric strip heaters, and 2) using electric strip heaters together with circulating hot gas. Strip heaters without circulating gas has been selected as it is the simpler of the two methods. As presently envisioned: the entire lower head including divider plate will be heated to avoid harmful differential expansion; heaters will be extended along the outer walls for a length of one steam generator diameter in order to minimize temperature gradients and internal distortions; and, the secondary side will be at a vacuum to reduce convective heat losses.

Testing to confirm the factor of improvement provided by this approach has not yet been completed. High temperature caustic tests of rolled specimens indicate a factor of improvement in time to cracking of about 3 to 5, while on-going high temperature pure water tests indicate a factor of improvement of at least 5 (no cracks to date in heat treated specimens). Longer term high temperature pure

Tests of stainless steel mockups in boiling magnesium chloride, and sensitized alloy 600 in sodium tetrathionate indicate that the process can be controlled such that resistance to primary side IGSCC is obtained without causing secondary side attack.

One potential problem which has been identified by the testing is embedment of small ceramic particles in the tube wall, and a concern exists as to how well the particles can be removed. The stainless steel shot used to date does not appear to be a viable solution to this problem as tests indicate that it induces excessive outside surface tensile stresses (smaller stainless steel shot are currently being explored in an effort to resolve this problem). Glass beads do not appear to be suitable because of excessive fragmentation.

Concerns regarding opening up preexisting cracks, embedment of particles in the tube wall, clean up of abrasive particles, and spread of contamination need to resolved prior to field application of this procedure.

- Rotopeening - Rotopeening has beeen investigated by both TRABEL and EdF. In both cases, the development work has indicated that rotopeening provides a viable way of inducing a thin compressive layer on the tube inside diameter.

The Belgian rotopeening development work has been performed by Westinghouse and has used flapper wheels with small tungsten carbide beads bonded to a plastic fabric. Details of the process and supporting tests are described in reference (30). Rotopeening has been applied to two new non-radioactive plants, Doel 4 and Tihange 3. As discussed in reference (30), the rotopeening was successfully performed. However, some question remains in regard to the OD stresses generated by the rotopeening, both at the roll transition and in the straight portion of the tube where the peening stresses can combine with straightening and polishing stresses.

The rotopeening equipment developed by EdF consists of a flapper wheel with small glass beads bonded to cotton fabric. (EdF initially tried tungsten carbide beads of the same type as used by TRABEL, but found that they resulted in somewhat increased OD surface stresses.) The flapper wheel is rotated at high speeds and is offset from the tube axis such that the beads impact the tube surface nearly perpendicularly. Mockup tests have shown that an Almen intensity of 6N eliminates SCC on the tube inside surface without increasing SCC susceptibility on the tube outside surface.

The EdF procedure is to rotopeen a 2 inch (5 cm) length of tube at each roll transition. The tooling is supported by remotely controlled finger walkers and the rotopeening requires about 5 minutes per tube. EdF has experienced some problems with ineffective peening, but this appears to be controllable by regular replacement of flapper wheels. EdF has used their method on a trial basis for 19 tubes at Bugey 5.

buckling and/or tensile residual stresses. For example, the tube expands during heating, buckles or yields due to the restraint at the top, and then is put into residual tension during subsequent cooldown. The potential for this to occur, and the effect on primary and secondary side IGSCC must yet be resolved by test. Consideration must also be given to the subject of propagation of preexisting circumferential cracks, if any exist.

- Reduction in Pullout Force - When an expanded area is subjected to induction heating the resultant yielding and shrinkage upon cooling will result in some loss of the interference force holding the tube in the tube sheet. The effect of the loss of interference force must be evaluated on a case basis. Some guidance in this regard is included in Appendix A of Reference (23).

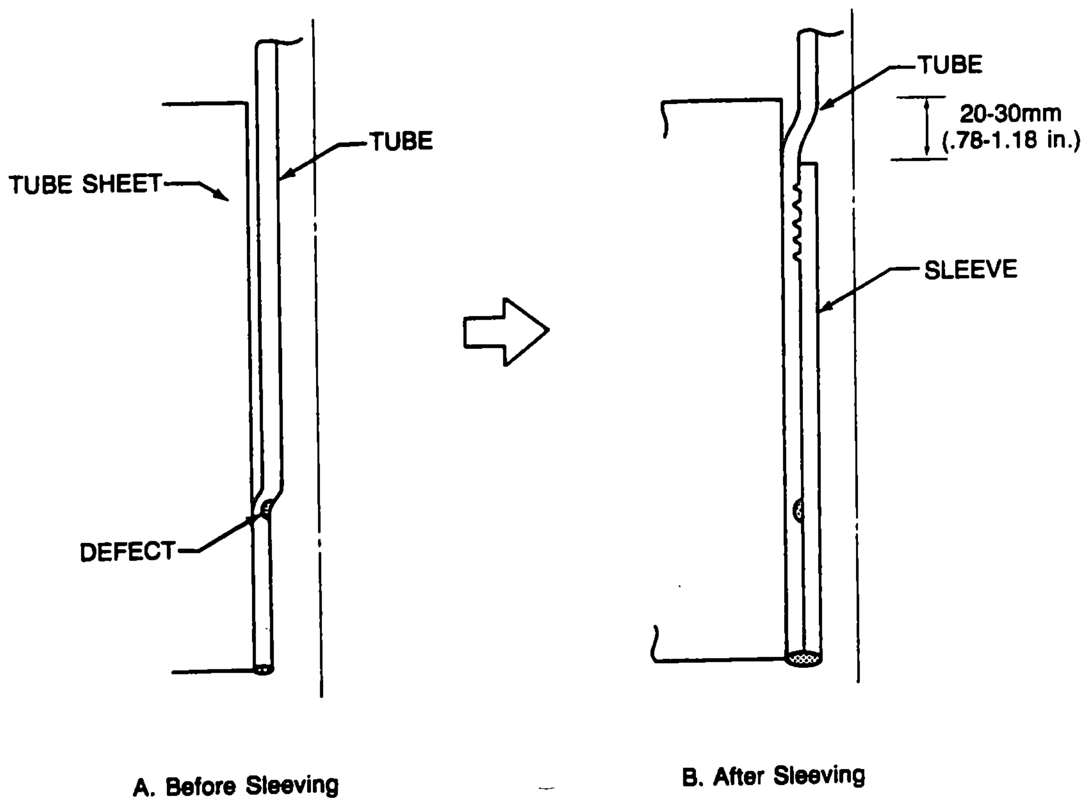
- Development of Tube to Tube Sheet Crevice - In addition to reducing pullout force, the induction heating would cause a gap of a few mils to open up between the tube and tube sheet. This gap could be as long as 1/4 inch (6mm) or more, depending on the details of the induction heating. The acceptability of this gap from a secondary side corrosion standpoint needs to be verified.

EXPANSION TRANSITION SHOT PEENING AND ROTOPEENING

The purpose of shot peening or rotopeening the tube inside surface is to form a thin compressive stress layer which will serve to inhibit the initiation of primary side IGSCC. Shot peening is performed by blasting the inside surface of the tube with small metal or ceramic shot as shown in Figure 6-8. Rotopeening is performed using shot bonded to fabric on a flapper wheel as shown in Figure 6-9. Major concerns with this type of procedure are that 1) tensile stresses will be produced on the outside of the tube which may lead to secondary side IGSCC, and 2) tensile stresses within the tube wall may lead to propagation of existing surface cracks. Both of these issues must be resolved prior to application of this procedure.

The two procedures are outlined as follows with detailed information provided in Reference (30):

- Shot Peening - Shot peening has been investigated by both TRABEL and EdF. In both cases, the development work has indicated that shot peening provides a viable way of inducing a thin compressive layer on the tube inside diameter. In the TRABEL approach, small ceramic shot are blown up the tube, impinge on a conical deflector, and impact the tube wall. The conical deflector is moved up and down the tube and rotated to provide complete and uniform coverage. Air exhaust and filtering equipment are provided on the cold leg of the tube to remove the spent shot and to limit the spread of contamination. Following shot peening, the tubes would be cleaned by blowing cotton plugs through them.



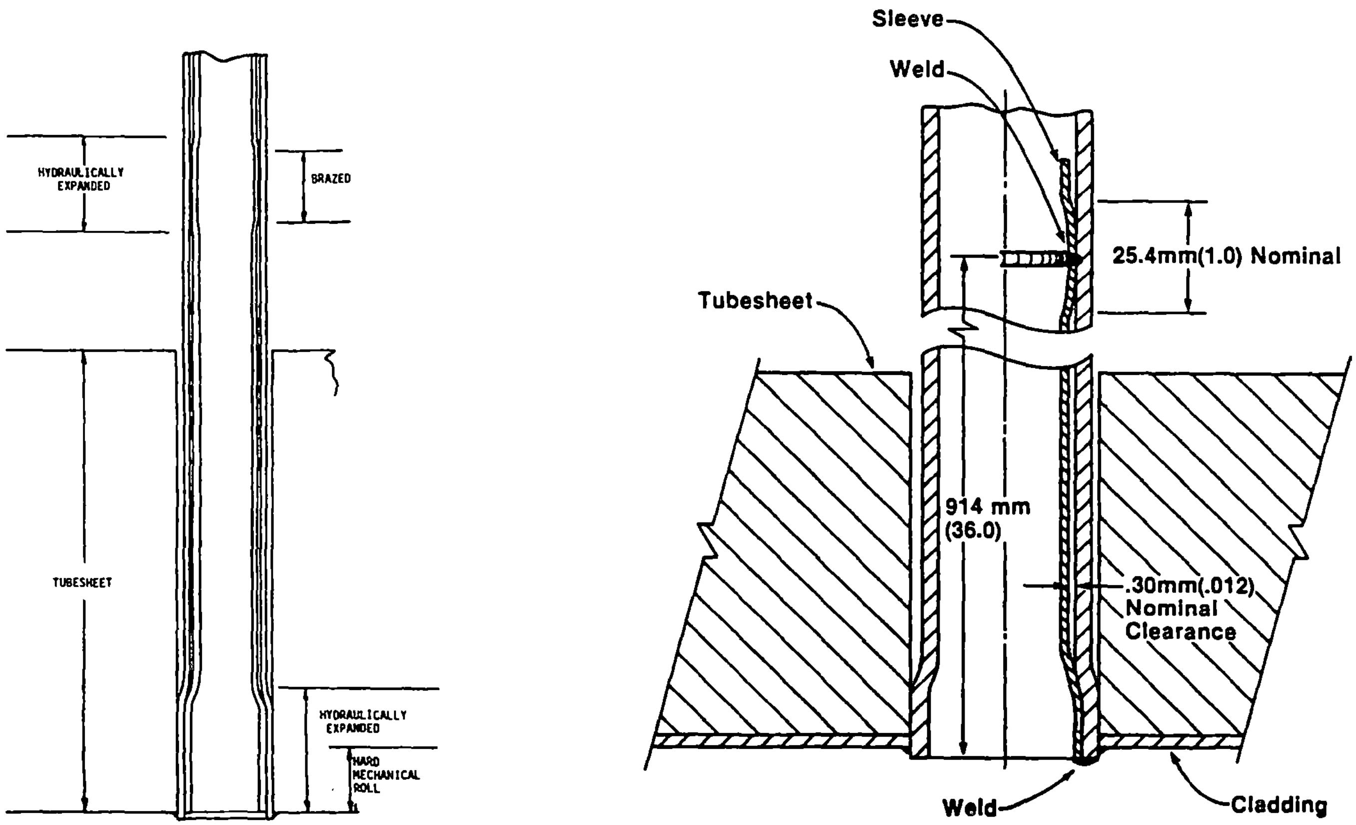
NOTES: 1. Expansion performed using rubber/ hydraulic method.

2. Not used for full tube sheet depth expanded tubes.

Figure 6-1. Japanese Sleeves

Source: From reference (27)

Rotopeening was initially selected over shot peening by both TRABEL and EdF as this process provides a similar compressive layer, generates much less abrasive debris, and does not spread contamination throughout the steam generator. However, both TRABEL and EdF are reconsidering this situation since shot peening may be simpler to perform remotely in a radioactive plant, might provide more uniform coverage and might facilitate use of smaller beads, leading to lower OD stresses. Framatome is currently developing a shot peening process using fine stainless alloy shot.



a. Westinghouse Brazed Sleeve

b. Combustion Engineering Welded Sleeve

Figure 6-3. Sleeves Installed at Ringhals 2

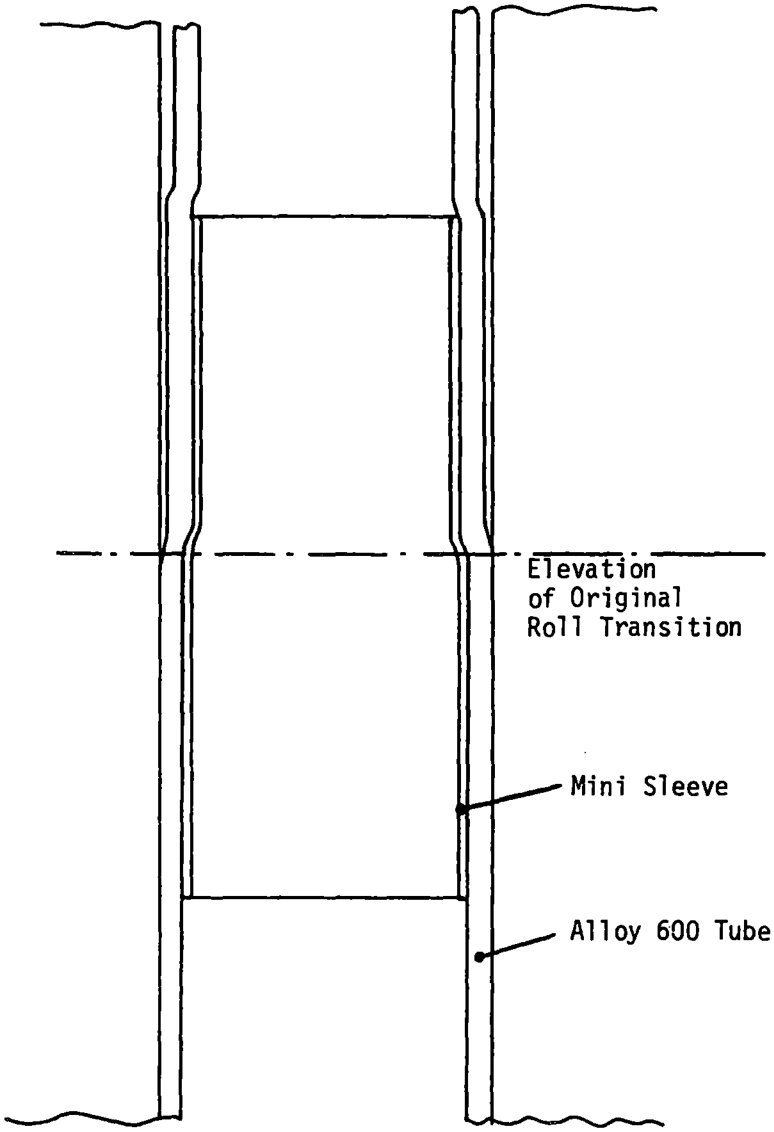
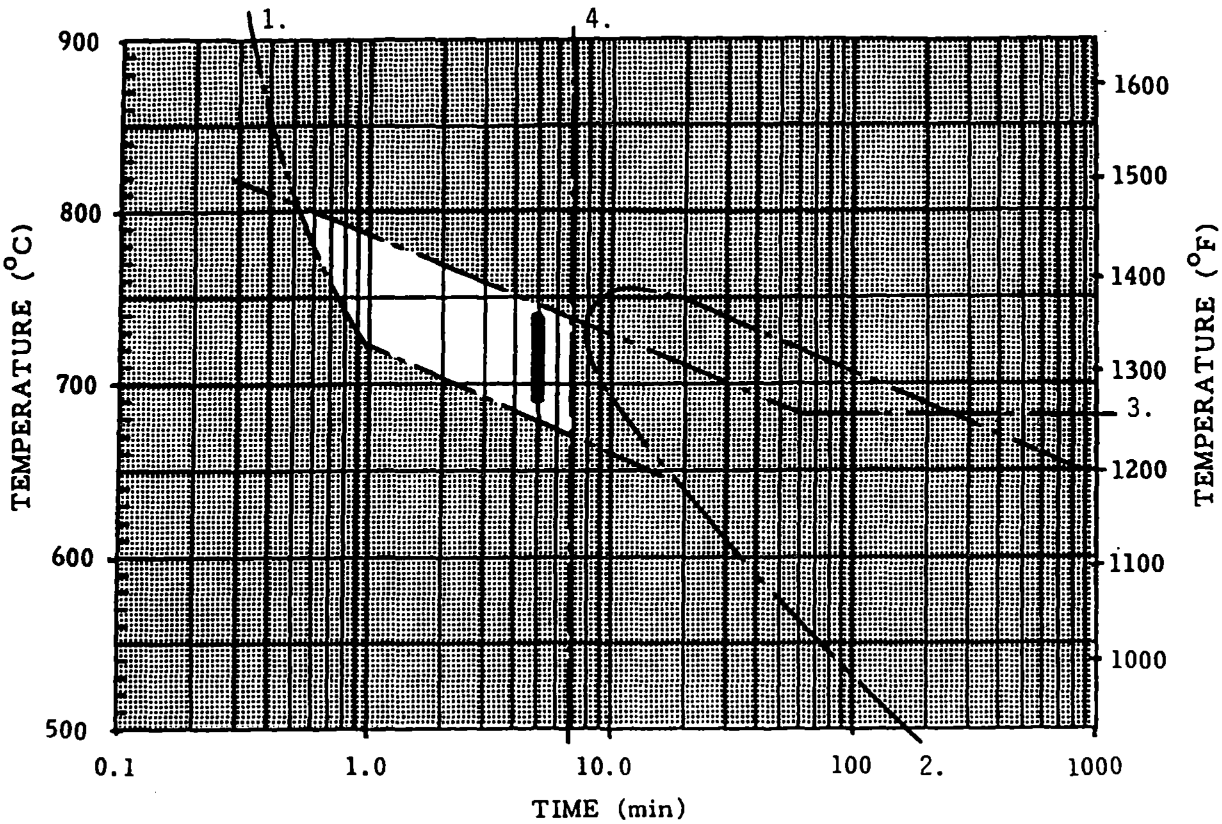


Figure 6-2. Babcock & Wilcox Mini-sleeve Used at Doel 2

Source: From reference (32)



Notes on Limits:

1. Effective stress relief (Modified from reference 23 per van Rooyen data in reference 44)
2. Sensitization
3. Recrystallization/grain growth
4. Practical time for in situ work

▬▬▬ Suggested Range of Time/Temperature Conditions

Figure 6-5. Range of Suggested Time-Temperature Target Conditions for Stress Relief of Alloy 600 U-Bends

Source: From reference (23)

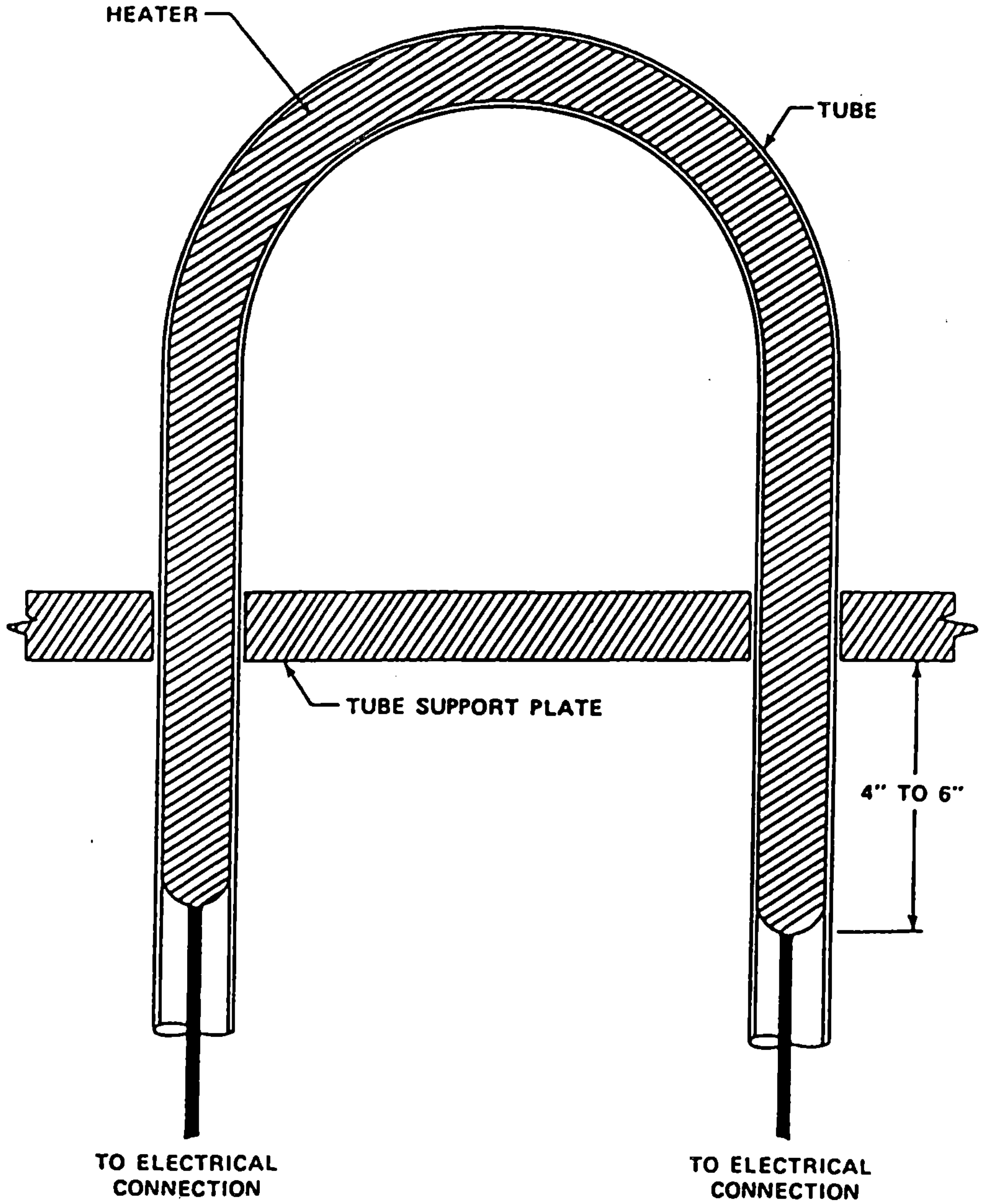
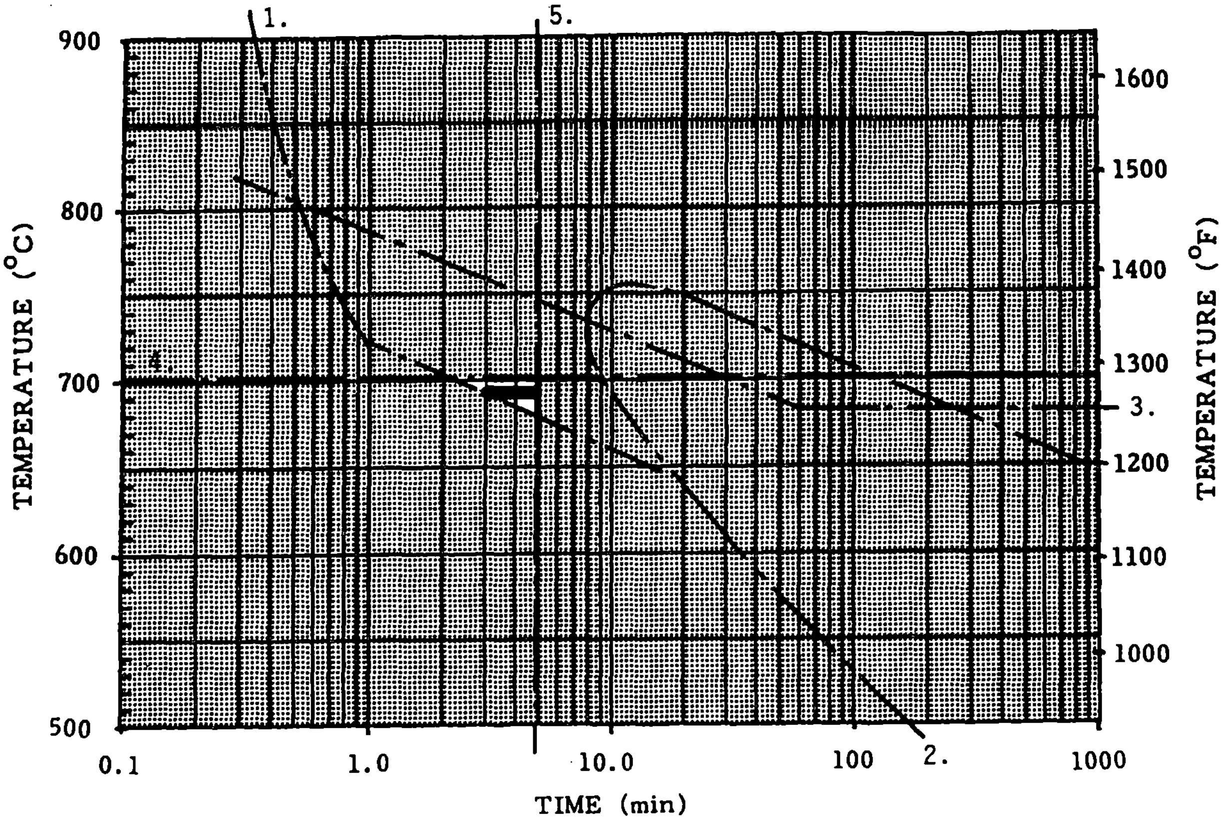


Figure 6-4. Westinghouse U-Bend Stress Relief Heater Arrangement

Source: From reference (29)



Notes on Limits:

1. Effective stress relief (Modified from reference 23 per van Rooyen data in reference 44)
2. Sensitization
3. Recrystallization/grain growth
4. Tube sheet transformation temperature
5. Practical time for in situ work

▬ Suggested Range of Time/Temperature Conditions

Figure 6-7. Range of Suggested Time-Temperature Target Conditions for Stress Relief of Alloy 600 Expansion Transitions

Source: From reference (23)

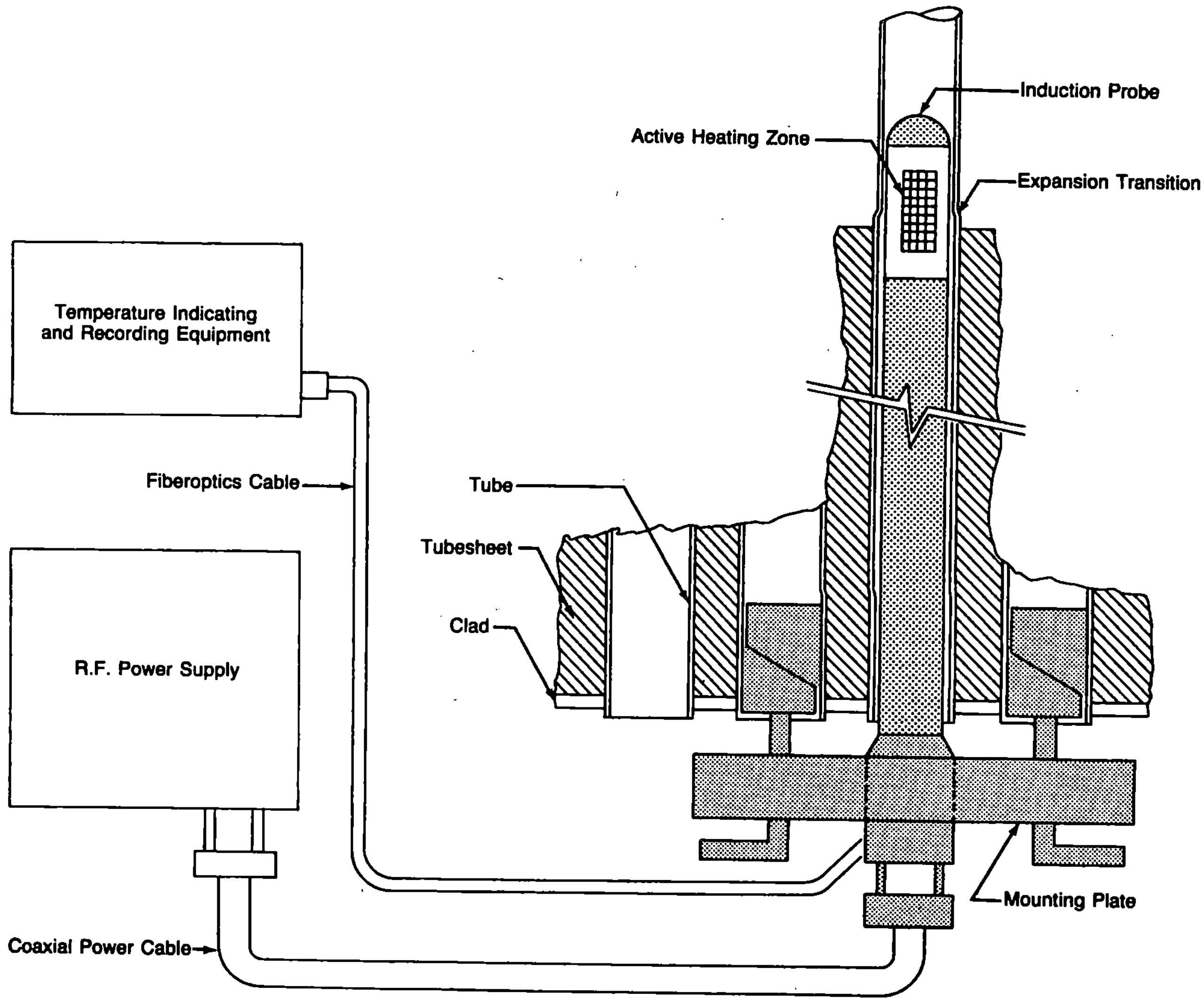


Figure 6-6. Equipment Arrangement for Doel 2 Expansion Transition Stress Relief

Source: From reference (32)

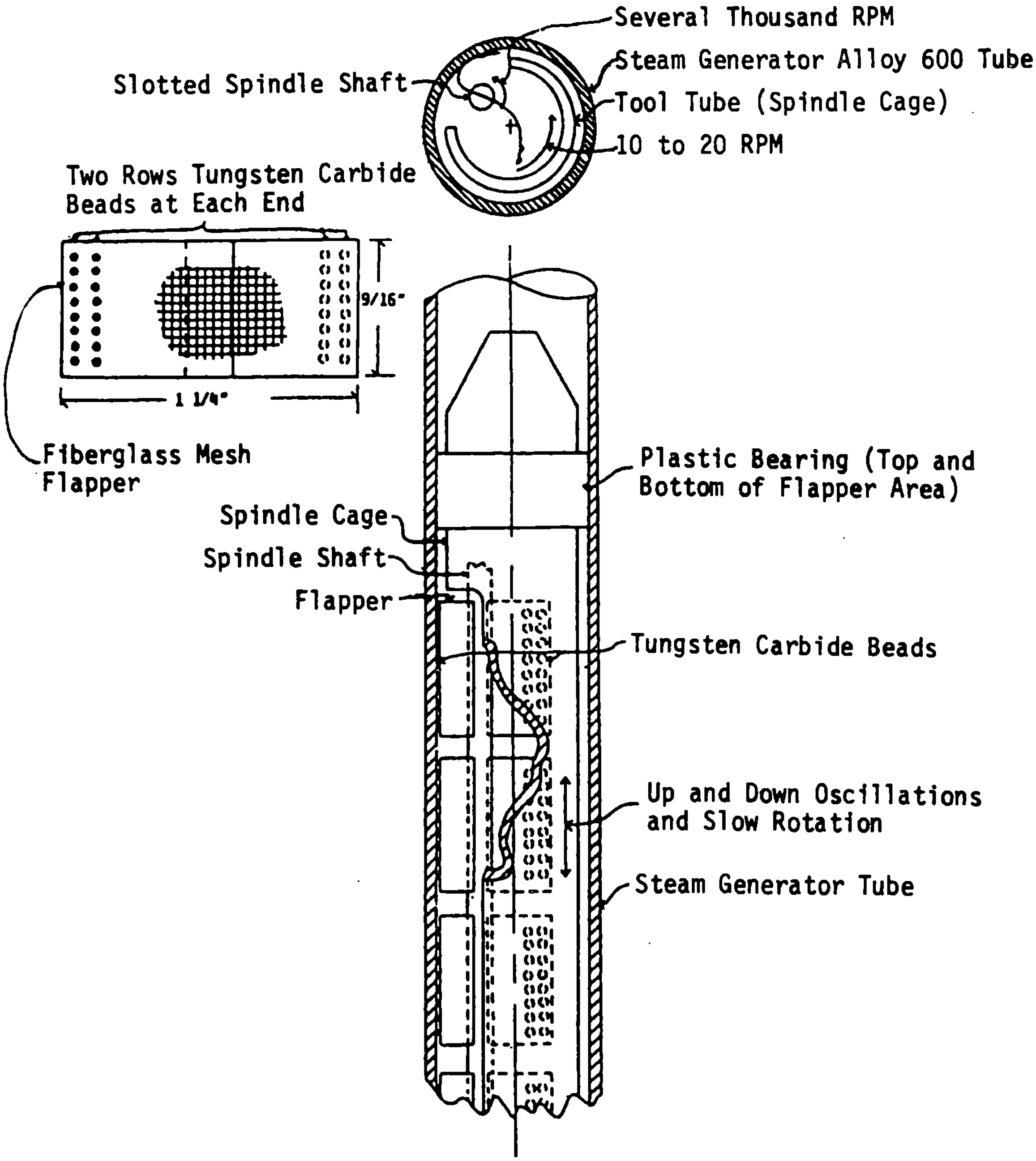


Figure 6-9. Equipment Used for Rotopeening of Alloy 600 Tubing

Source: Based on information provided by EdF

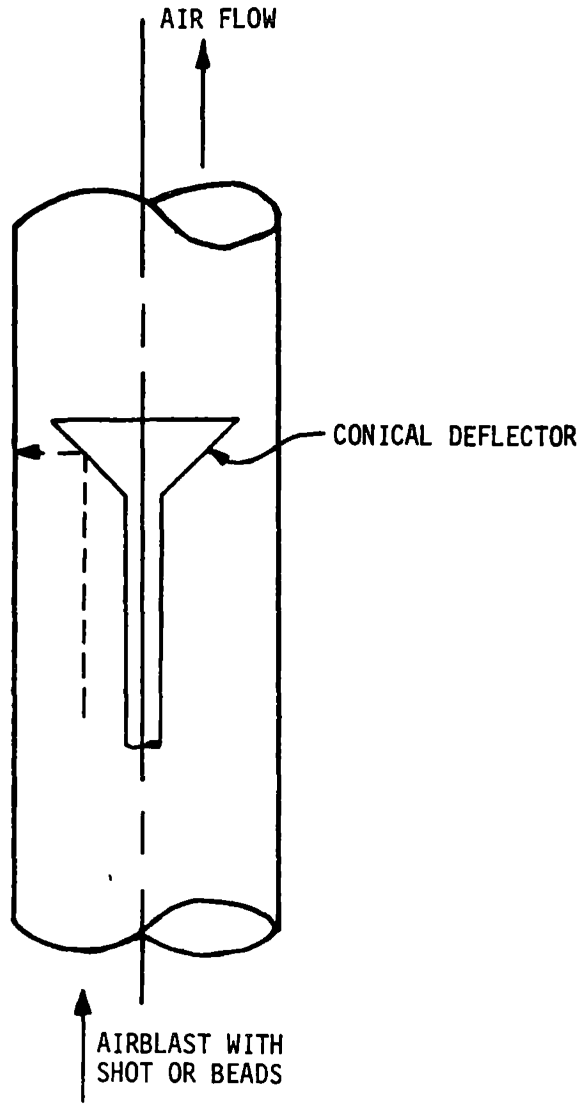


Figure 6-8. Equipment Used for Shot Peening of Alloy 600 Tubing

Section 7

SUGGESTED COURSE OF ACTION

It must be recognized that there are a number of significant uncertainties concerning primary side IGSCC which have an important bearing on any suggested course of action. These uncertainties lie primarily in the areas of 1) difficulty in accurately predicting the likelihood of primary side IGSCC occurring at any specific location in a particular steam generator, and 2) the risks associated with and effectiveness of particular remedial measures. Nevertheless, it is desirable to outline a current suggested course of action in order to stimulate discussion and to assist utilities in their planning processes. The following suggested course of action regarding primary side IGSCC is based on the current status of reported cracking, current understanding of the causes of the cracking, and current (January 1985) status of development regarding remedial measures.

There are two sides to the decision as to whether or not to take remedial measures to prevent primary side IGSCC in steam generator tubing. These are:

1. It is undesirable to apply remedial measures if they are not necessary. Such work is costly and there is some level of risk that the remedial measures may produce an undesirable side effect.

2. On the other hand, it is also undesirable to let primary side IGSCC initiate. It is far easier to prevent cracks from initiating in the first place than it is to arrest the propagation of existing cracks. A complicating factor in this regard is that the best current ECT inspection techniques can only pick up cracks when they reach about 40% of wall thickness; thus, crack initiation can be fairly widespread before the cracking problem is detected.

In establishing a course of action regarding primary side IGSCC there are three basic categories of plants to be considered. These are:

1. Plants which have operated for many years (e.g., 8 to 10 or more) without significant primary side IGSCC (Low Material Susceptibility)

2. Plants which have experienced significant amounts of primary side IGSCC. (High Material Susceptibility)

PLANTS WITH HIGH MATERIAL SUSCEPTIBILITY

For those plants which have experienced more than a few isolated cases of primary side IGSCC in service, it should generally be assumed that the tubing material is highly susceptible, that the cracking is likely to get worse with time, and that some remedial measures are required. The only exception should be for cases where it can be clearly demonstrated that the problem was due to some extremely localized and limited condition; for example, where the IGSCC is known to have been caused by some abnormal rolling geometry that affects only a few tubes.

Possible remedial measures include the following:

U-bends

If the material is highly susceptible, it is likely that cracking will ultimately occur in the U-bends of the first and probably also the second row tubes. The probability of cracking appears to be higher for tubing fabricated using the Westinghouse ball mandrel than for tubing fabricated using other processes, but none of the processes should be considered as immune over the plant lifetime. This is because the residual stress levels associated with forming tight radius U-bends are high even for the best bending conditions, and the stresses applied in operation are also fairly high. These residual and applied stresses result in a total stress sufficiently high to make primary side IGSCC likely to occur in susceptible material over a 40 year design life.

To date there are three main potential remedial measures for U-bend cracking. These are 1) thermal stress relief of U-bends, 2) preventive plugging of U-bends, and 3) plugging in response to NDT indications or leaks. Each utility with susceptible tubing material will have to select between these three options taking into account the degree of material susceptibility, the margin of excess tubes, and the cost and risk associated with inspecting and plugging in response to ECT indications and/or cracks. In most cases, options 1 or 2 appear to be the prudent course of action to ensure that in-service leaks do not occur. The choice between the two options will most likely be made based on available tube margin.

Expansion Transitions

If the tubing material is highly susceptible, it is likely that cracking will occur in the expansion transition region. SCC tests and residual stress measurements indicate that stresses in this region are such that cracking must be expected to occur in "normal" transitions, with or without a DAM treatment. It

3. New plants, and those operated less than about 8-10 years without significant amounts of primary side IGSCC. (Unknown Susceptibility)

PLANTS WITH LOW MATERIAL SUSCEPTIBILITY

Those plants which have operated for long periods of time without occurrence of significant amounts of primary side IGSCC can be considered to have tubing with demonstrated low material susceptibility. An arbitrary cutoff for using operating experience to assess material susceptibility is about 8-10 years, or 20-25% of the design operating life. In such plants, primary side IGSCC is likely to be a slow process if it occurs at all. Further, there should be adequate time to take remedial measures if primary side IGSCC is detected later in life, assuming it is detected at an early stage. Based on the data in Table 5-1, the plants in this category would include: Connecticut Yankee, San Onofre 1, Beznau 1, Ginna, Point Beach 2, Indian Point 2, Kewaunee, Prairie Island 2, Indian Point 3, Salem 1, Doel 1, Tihange 1, Genkai 1, and Takahama 2.

In cases of known low material susceptibility, the primary objective of the IGSCC program should be to monitor the steam generators carefully to make sure that cracks are not initiating. This objective can be achieved by periodically inspecting the U-bends, expansion transitions, and expanded areas using the most accurate inspection methods currently available. If any indications are found using these methods, tube specimens should be pulled in order to determine if there is incipient IGSCC. Material and fabrication records should also be obtained and reviewed, although this is a lower priority than performing accurate inspections.

If and when significant occurrence of primary side IGSCC is detected, decisions will then need to be made as to whether to merely monitor the IGSCC to ensure that it does not increase rapidly, or to take corrective measures. Because of the demonstrated low susceptibility of tubing in these plants, it is expected that monitoring for at least a few years would be reasonable prior to the need for taking any active remedial measures. If required, the remedial measures would be similar to those discussed below for plants with high material susceptibility although plugging or sleeving may also be good solutions if the problem is isolated to small numbers of tubes.

or explosive re-expansion, as long as the procedure is demonstrated to not result in high residual stresses. It may further be necessary to revise the Technical Specification requirements to permit cracks in the tube below the area which is required to resist pullout and to provide a seal. Cracks in these areas are not considered to be a source of technical concern since they should not lead to tube pullout or to significant leaks.

PLANTS WITH UNKNOWN MATERIAL SUSCEPTIBILITY

For new plants or plants which have been in operation less than about 8-10 years the material may be of unknown susceptibility. In these cases, attention should initially be focussed on assessing the material susceptibility. This should be accomplished following the approach suggested in Section 5 under "RISK OF PRIMARY SIDE IGSCC". This approach starts with a review of the tube material and fabrication records to determine the grain size and mill anneal temperature. Depending upon the results of this evaluation it may also be necessary to perform some metallography and SCC tests of archival material or material removed from the steam generators.

For material found to have high or low susceptibility to primary side IGSCC, the remedial action program should follow the lines previously indicated.

For material of questionable material susceptibility after such an evaluation, the remedial measures could well depend upon the plant status. For new plants where costs of applying remedial measures are low and the risk of problems due to application of remedial measures are also low, it will usually be preferable to proceed with remedial measures prior to going into operation. On the other hand, for plants already in operation, it may be preferable to proceed with a rigorous inspection program and hold off remedial measures until it is known whether or not there will be a problem.

REQUIRED INDUSTRY EFFORT

Based on the current status, the area requiring greatest effort is the development and qualification testing of field hardened corrective action procedures such as in situ stress relief, shot peening, rotopeening, and global heat treatment. This effort is required to assist utilities in evaluating the cost and risk of various alternative approaches.

is suggested that in these cases, remedial measures should be taken unless it can be demonstrated that there is a convincing reason that primary side IGSCC will not occur. There are three remedial measures currently available for the expansion transition region.

1. Local Thermal Stress Relief - The area of the expansion transition can be stress-relieved using the induction heating procedure discussed in Section 6. This procedure is somewhat more difficult to apply than shot peening or rotopeening but has a significant advantage over these alternate procedures in that it can reduce the residual stresses on both the inside and outside of the tube wall. At present, this approach cannot be suggested without qualifications as there are several outstanding questions regarding temperature control and the effect of tube boundary conditions as discussed in Section 6.

2. Shot Peening and Rotopeening - Significant development work has been performed regarding shot peening and rotopeening, and the processes appear to be practical in the field. These processes may be somewhat less desirable than a proven local thermal stress relief in that they result in an increase in tensile stresses on the outside of the tubing, and could possibly lead to increased susceptibility to secondary side attack. As in the case of the local thermal stress relief, there are still several unresolved questions regarding these processes and some additional development work is required.

3. Global Thermal Heat Treatment - Global thermal heat treatment offers an advantage over local thermal stress relief of each tube in that it takes less time to perform and is less costly. These advantages are achieved at the significant disadvantage of sensitizing all of the tubing and thereby increasing its susceptibility to sulfur species attack. Also, the factor of improvement that can be achieved is still not certain, and may not be sufficiently high to warrant its use. Finally, this method may be difficult to apply to steam generators with preheaters.

A utility must select one of the above remedial measures based on the particular circumstances at the plant and the latest results of the procedure qualification programs.

In conjunction with treating the expansion transition region, it should be confirmed that the section of tube about 2 inches (5 cm) immediately below the expansion transition is properly expanded. The tube in this region must be under a high residual compressive stress in order to preclude cracking, to resist pullout, and to prevent leakage from possible cracks in the tube below this region. If the tube is not properly expanded in this region it may be necessary to re-expand before or after remedial measures are taken at the expansion transition. This re-expansion could be performed by re-rolling, or by hydraulic

Section 8

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A second area warranting industry attention is improved detection of primary side IGSCC so that remedial measures can be taken before too many cracks have become so large that prevention of further growth is very difficult. Use of the latest ECT techniques, such as developed in Belgium and France is warranted. In addition, removal and examination of tube samples (e.g., where the tube is to be plugged for other reasons) is desirable. In situ metallography using replicas also appears to have potential in the tube sheet region.

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Appendix A

LOCAL HEAT FLUX AND PRESSURE STRESSES IN TUBE WALL

The purpose of this appendix is to compute the approximate local heat flux stresses and pressure stresses for straight sections of tubing along the length of a typical first row tube from the hot let inlet to the cold leg outlet. These stresses can then be combined with other applied and residual stresses at the expansion transitions and U-bends to estimate the total stresses. The total stresses are then used to estimate time to crack initiation for various locations along the tube length.

ASSUMED DIMENSIONS AND OPERATING CONDITIONS

The following typical dimensions and operating conditions were assumed for purposes of this analysis:

- Primary pressure 2250 psi
- Secondary pressure 920 psi
- HL inlet temperature 615 F
- Average CL outlet temperature 555 F
- Secondary water temperature 535 F
- Coolant flow per steam generator 33.15E6 lb/hr
- Number of tubes 3388
- Tube outside diameter 0.875 in
- Tube wall thickness 0.050 in
- Length of first row tubes 60 ft
- Length of outer row tubes 80 ft
- Hot leg heat flux 114000 BTU/hr*ft²
- Cold leg heat flux 24000 BTU/hr*ft²

33.15x10⁶ lb/hr

THERMAL ANALYSIS

The thermal model is shown in Figure A-1. The inside heat transfer coefficient for forced convection with turbulent flow is taken from equation 8-10 of Kreith (33) using an average flow velocity through all of the tubes. The outside surface boiling temperature drop is taken from Figure 10-6 of Kreith, and the inside and outside surface fouling factors were selected iteratively to produce the reported hot leg and cold leg heat fluxes. The computations were performed using a step approach in which the heat flux out through each one foot long segment of tubing is used to compute the coolant water temperature entering the next segment of tube.

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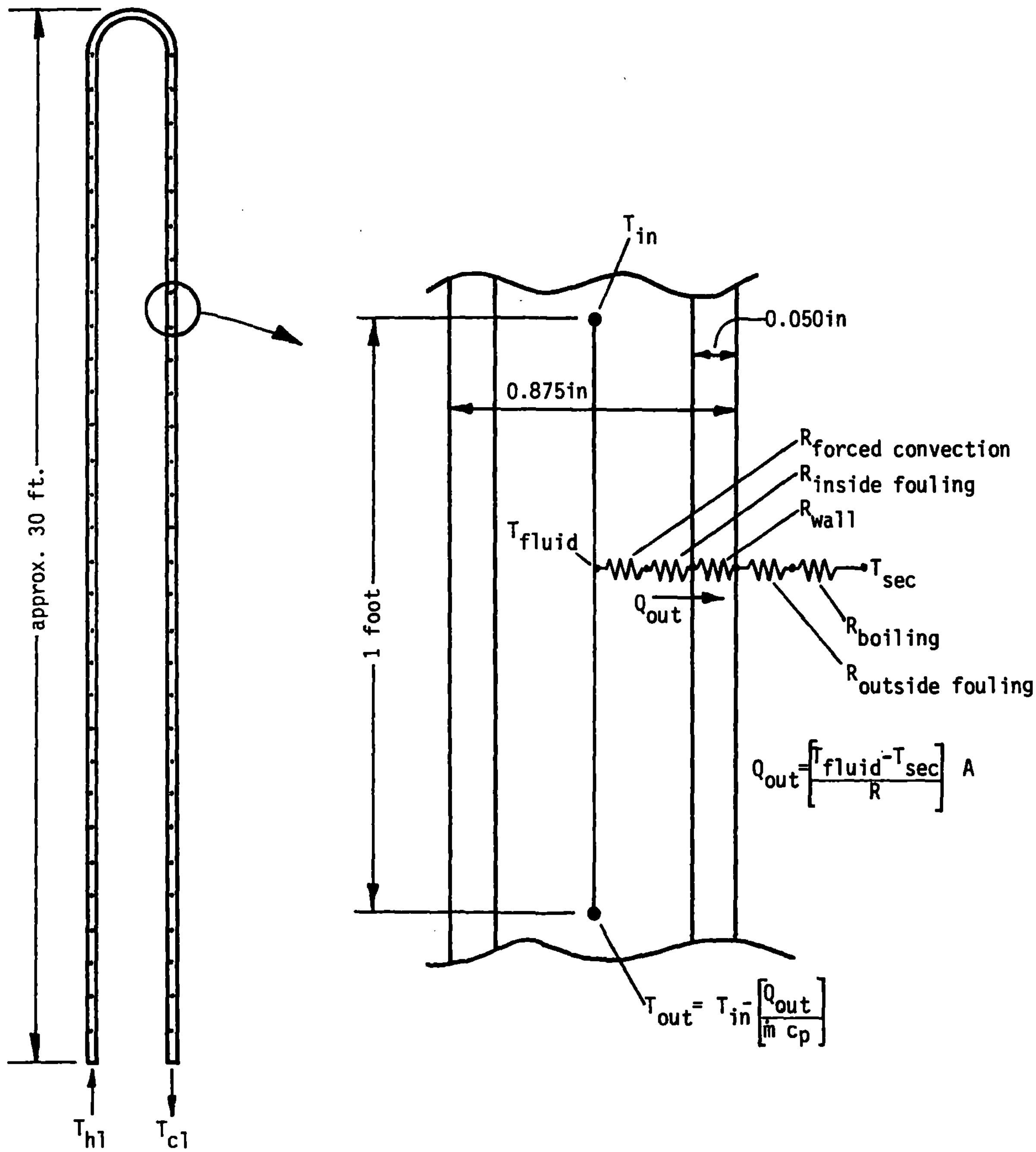


Figure A-1. Thermal Analysis Model of Typical First Row Tube

STRESS ANALYSIS

The pressure induced hoop stress is computed from the primary to secondary side pressure differential using a thick wall formula. For a differential pressure of 1330 psi, the inside surface hoop stress is 11,013 psi (76 MPa). The inside surface thermal stress due to heat flux (but not due to hot/cold leg tubing thermal expansion) is computed from the temperature drop across the tube wall using the classical equation for a thick wall cylinder, i.e., equation 15.6 from Roark (34).

RESULTS

The pressure and heat flux stresses on the inside surface of the tube at the three locations of primary interest are as follows:

	Temperature (°F)		Inside Surface Hoop Stress (psi)		
Location	Fluid	Inside Surface	Pressure	Heat Flux	Total
Hot Leg Inlet	615	592	11,013	-7,016	3,997
U-Bend	577	565	11,013	-3,539	7,474
Cold Leg Outlet	558	552	11,103	-1,773	9,240

It should be noted that residual stresses and local bending stresses due to pressure and overall U-tube thermal expansion are not included in the above values, and would need to be added to the above values to determine total stresses.

Appendix B

STRESSES IN TUBE WALL AT EXPANSION TRANSITIONS

The purpose of this appendix is to summarize the reported operating and residual stresses in tube expansion transitions. These results include work by Brookhaven National Laboratory, Mitsubishi Heavy Industries, EdF, and Dominion Engineering.

BROOKHAVEN NATIONAL LABORATORY

Brookhaven National Laboratory has measured the inside surface residual stresses in the area of tube expansion transitions using X-ray analysis (31,35). The first series of stress measurements was taken at intervals of about 6mm (0.24 in) along the tube wall in the region of the expansion transition (31). The results of these measurements are shown in Figure B-1a. These results show that the longitudinal and hoop stresses are compressive in areas on either side of the transition, but both are tensile near the top of the expansion transition. The measurements were repeated at 1mm (0.04 in) intervals in the area of the transition (35). The results of these measurements, shown in Figure B-1b, indicate that peak tensile residual stresses can be on the order of 125 ksi (862 MPa) hoop and 35 ksi (241 MPa) longitudinal.

MITSUBISHI HEAVY INDUSTRIES

Mitsubishi has determined the residual stresses in the roll expanded region and the roll transition by several different methods (27). These methods included released strain measurements, and SCC tests in polythionic acid. The results of this work show residual tensile stresses at the ID surface in the roll transition region in the range of 20-28 ksi (138-193 MPa). The residual stresses measured by these methods would be expected to be less than obtained using the x-ray technique applied by Brookhaven National Laboratory. Residual stresses in the roll expanded area were determined to be compressive when properly rolled, but to be tensile if insufficient rolling was performed.

ELECTRICITE DE FRANCE

Elctricite de France (EdF) performed finite element analyses to determine the inside surface residual stresses associated with roll transitions (36). The

SUMMARY

In summary, the above data indicates that the residual stresses are most likely controlling. Specific values assumed to estimate the time to cracking are reported in Section 3.

results of their analyses are shown in Figure B-2. In summary, the analyses indicate that the following stresses should be present:

Location	Stresses ksi (MPa) Hoop	Longitudinal
• Fully expanded region	-94(-650)	-29(-200)
• 5-7mm (0.2-0.3 in) above top of expanded region	+52(360)	+65(450)

DOMINION ENGINEERING

To the best of our knowledge, there are no detailed finite element analyses of the tube expansion transition reported in the public literature. Accordingly, elastic stresses due to operating pressure and temperature, but excluding residual stresses, were computed for these regions as part of this study. The model used for the calculations is shown in Figure B-3 and the results of the calculations are as follows:

- Expansion Transition Within Tube Sheet - For the case of the expansion transition within the tube sheet the model in Figure B-3 was assumed with a uniform temperature of 615°F(324°C) and a differential pressure of 1330 psi (9.2 MPa). Axial load was applied to the end of the tube to simulate axial pressure stress. The geometric discontinuity was not simulated as previous calculations had indicated that the local stress concentration factor is very low. The results of this calculation are plotted in Figure B-4 and indicate low + 4 ksi (28 MPa) tensile stresses at the inside surface of the tube.

- Expansion Transition at Top of Tube Sheet - Analyses were also performed to determine the stresses which exist in the tube at the top of the tube sheet due to internal pressure and the local axial thermal gradients at this discontinuity. The thermal boundary conditions for this analysis and resultant thermal gradients are shown in Figure B-5. The stresses in the tube at the transition are compressive, or low tensile for this case as shown in Figure B-6.

- Straight Run of Tube at Top of Sludge Pile - A final calculation was made of the local thermal gradients and thermal stresses at the point where a straight run of tubing leaves the sludge pile region. The thermal boundary conditions for this case and resultant thermal gradients are shown in Figure B-7a. The stresses at this interface are on the order of -7 ksi (48 MPa) on the inside of the tube and +8 ksi (55 MPa) on the outside of the tube. These stresses are identical to the thermal stresses computed in Appendix A and indicate that the thermal bending stresses are insignificant as shown in Figure B-8b.

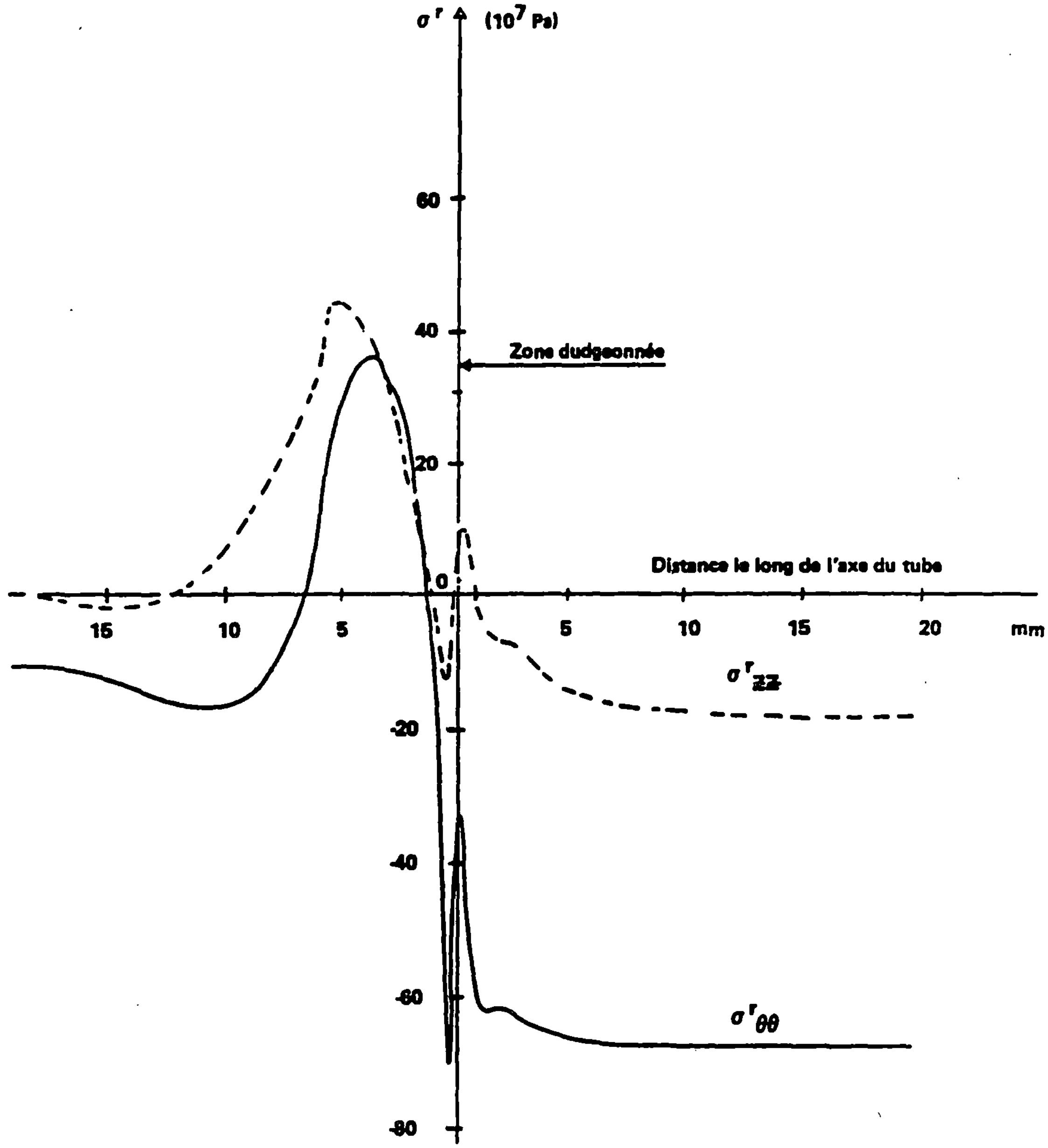
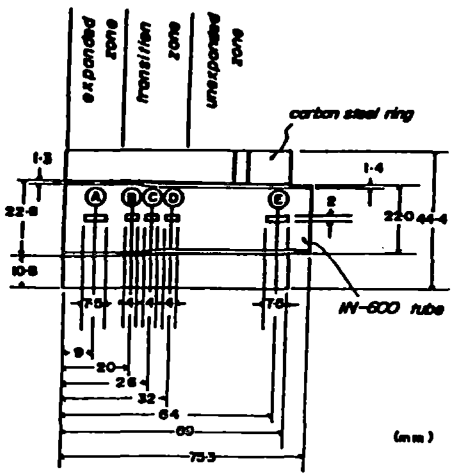


Figure B-2. EdF Computed Residual Stresses at Roll Transition

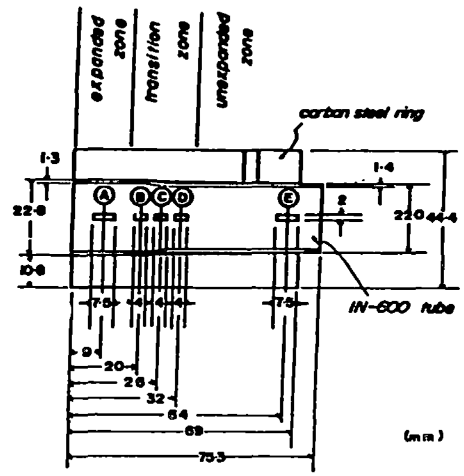
Source: From reference (36)



RESIDUAL STRESS EVALUATION ON INNER SURFACE

Direction Zone and Location		Circumferential ksi (MPa)	Longitudinal ksi (MPa)
Expanded	A	-36.07(-248.75)	-28.93(-199.45)
	B	-35.19(-242.66)	-28.93(-199.45)
Transition	C	- 1.70(- 11.75)	+ 8.90(+ 61.37)
	D	+20.01(+138.00)	+ 6.74(+ 46.46)
Unexpanded	E	-24.29(-167.49)	- 0.73(- 5.06)

a. Preliminary Stress Measurement



DETAILED ANALYSIS OF ROLL TRANSITION REGION

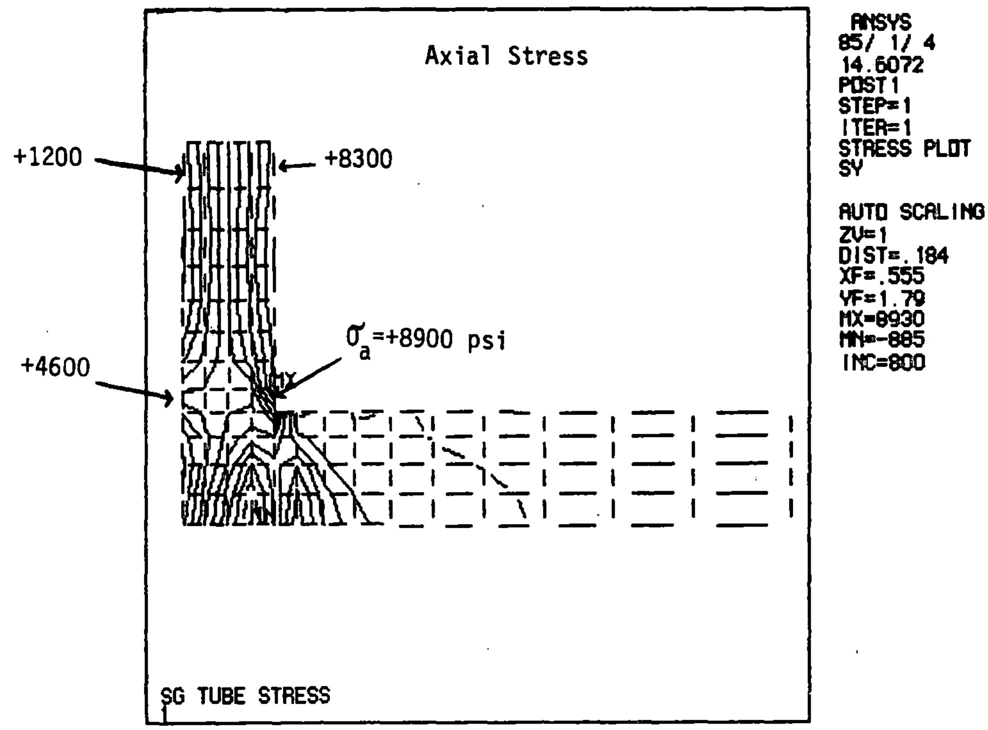
Region 'C' analysed in four 1 mm steps, L to R, R1 - R4

Direction Location	Circumferential ksi (MPa)	Longitudinal ksi (MPa)
C	- 1.70(- 11.75)	+ 8.90(+ 61.37)
R1	+ 8.55(+ 58.93)	-40.30(-277.87)
R2	+ 48.11(+331.73)	-21.04(-145.08)
R3	+ 77.04(+531.23)	-43.13(-297.40)
R4	+125.74(+867.11)	+34.42(+237.32)

b. Detailed Stress Measurement Region C-D

Figure B-1. Brookhaven Residual Stress Measurements at Roll Transition

Source: From reference (31)



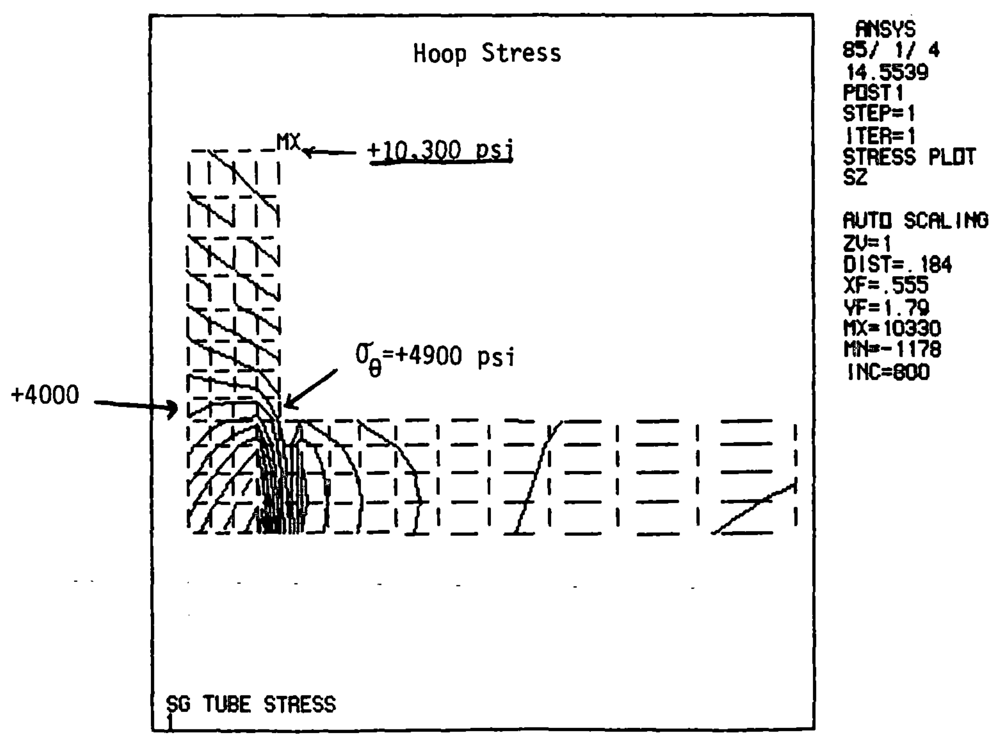


Figure B-4. Operating Stresses in Expansion Transition Within Tube Sheet

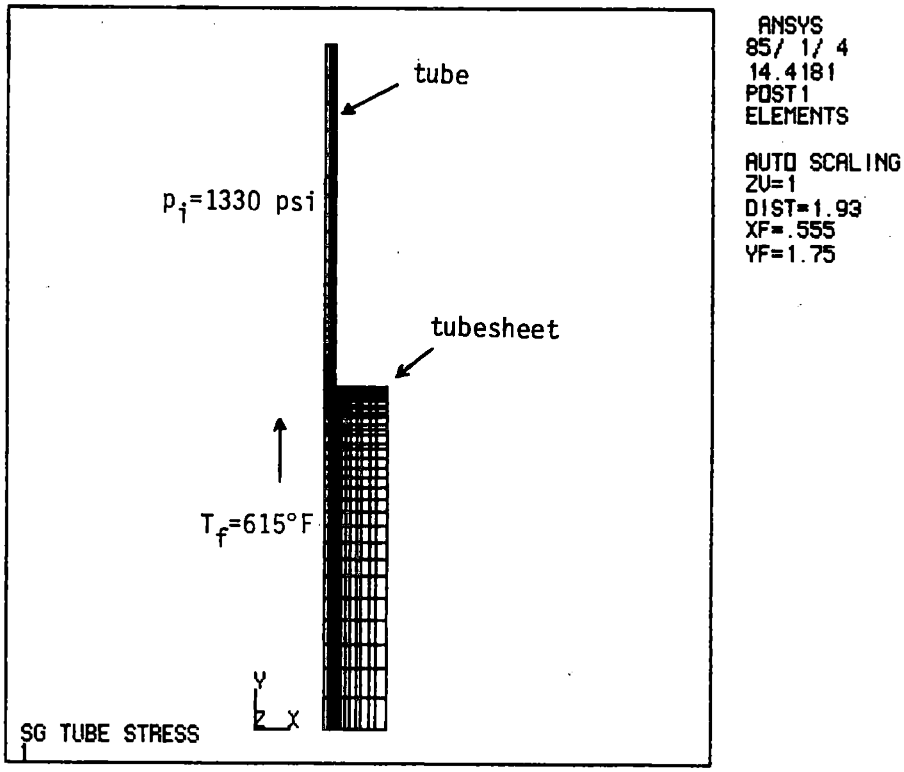
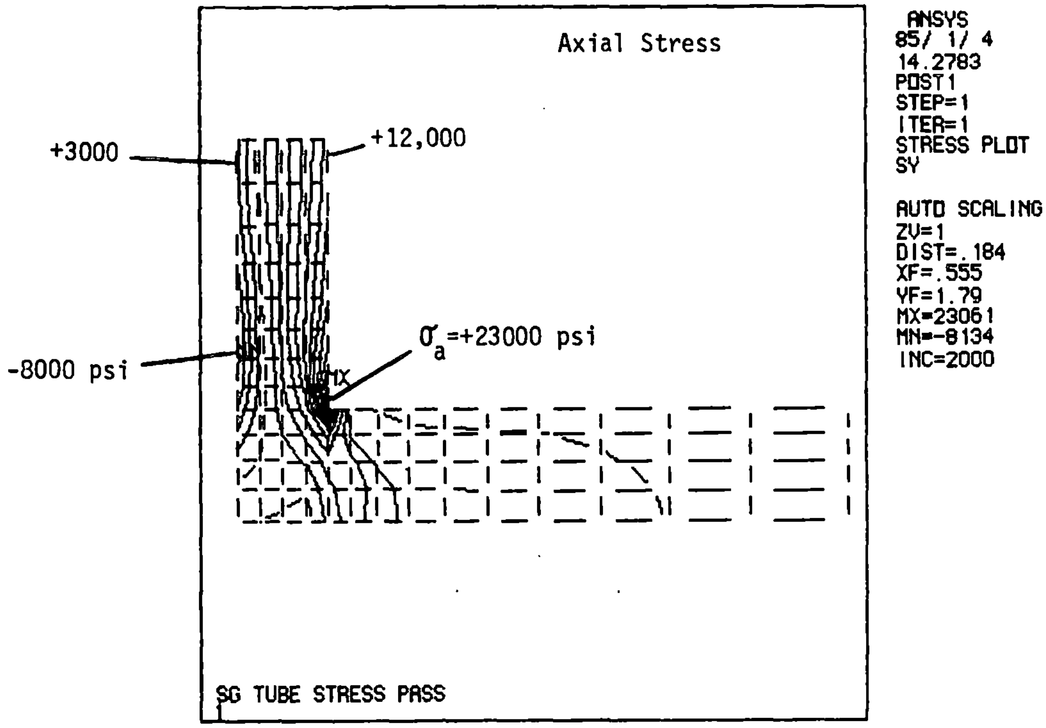


Figure B-3. Finite Element Analysis Model of Tube/Tube Sheet Interface



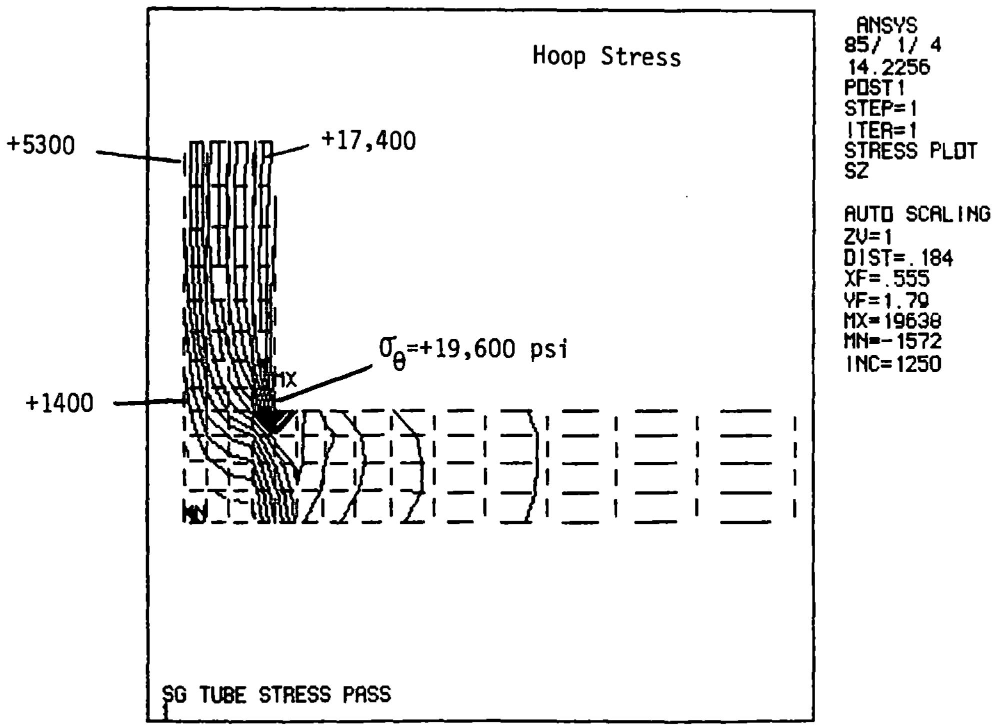
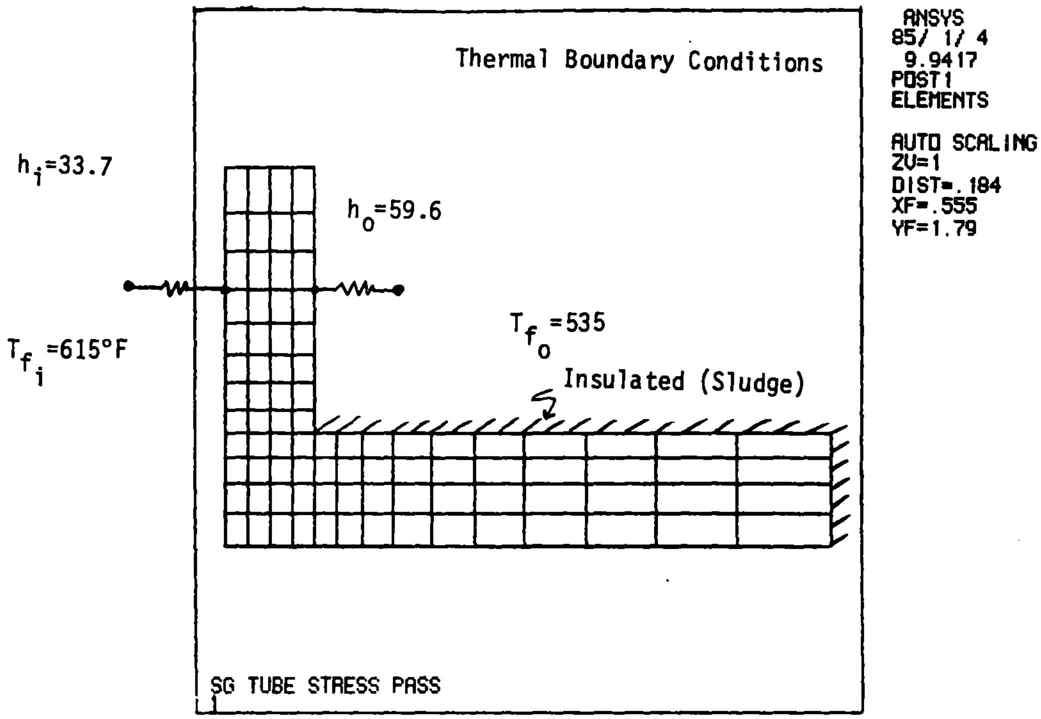


Figure B-6. Operating Stresses in Expansion Transition at Top of Tube Sheet



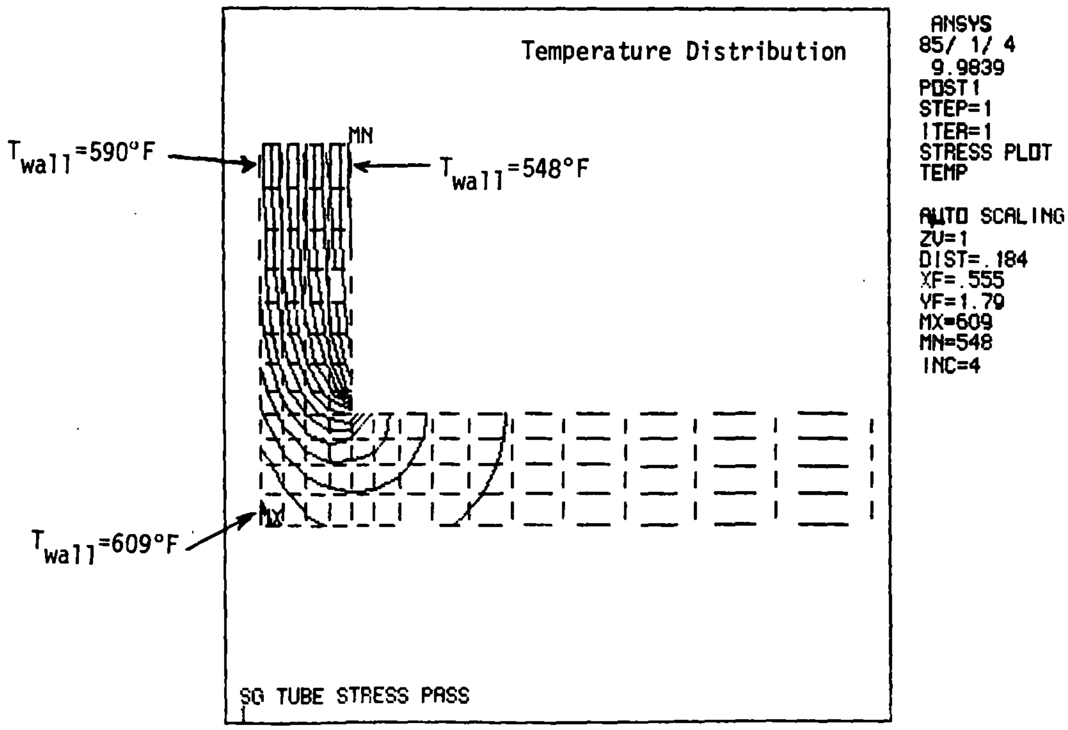
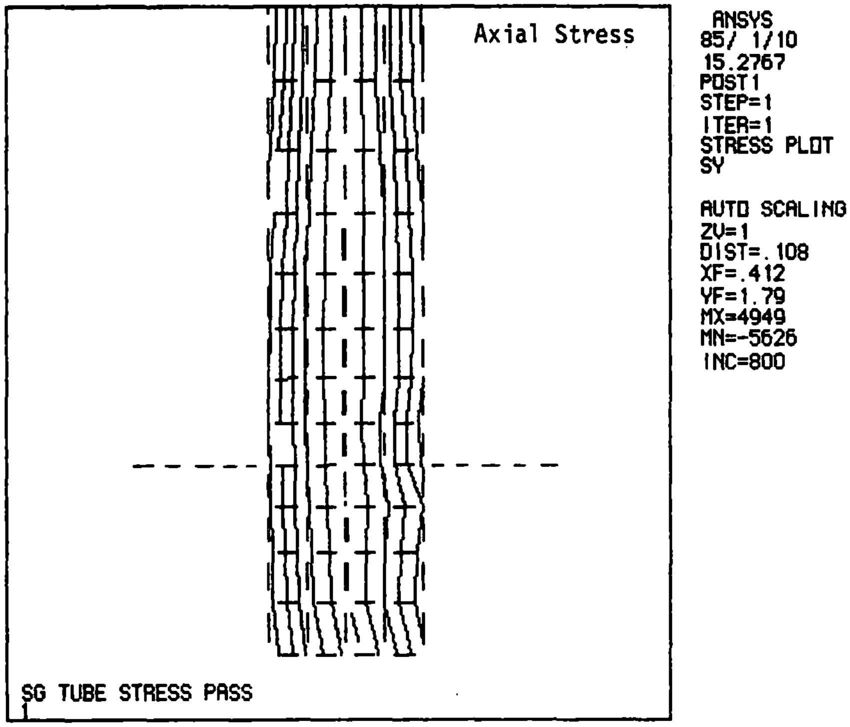


Figure B-5. Temperature Distribution in Expansion Transition at Top of Tube Sheet



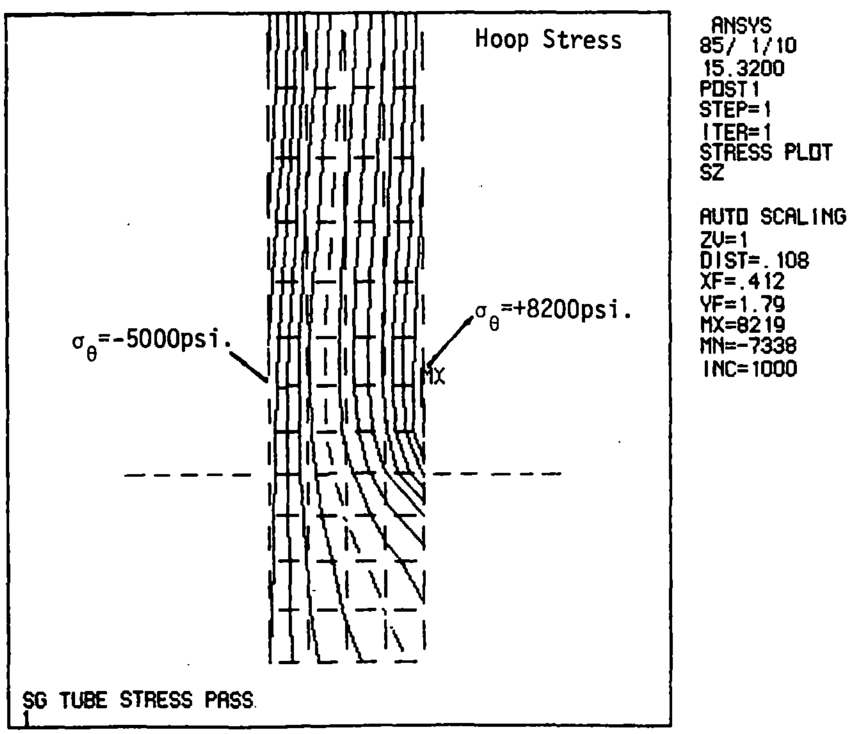


Figure B-8. Thermal Stresses in Tube Wall at Sludge Pile Interface

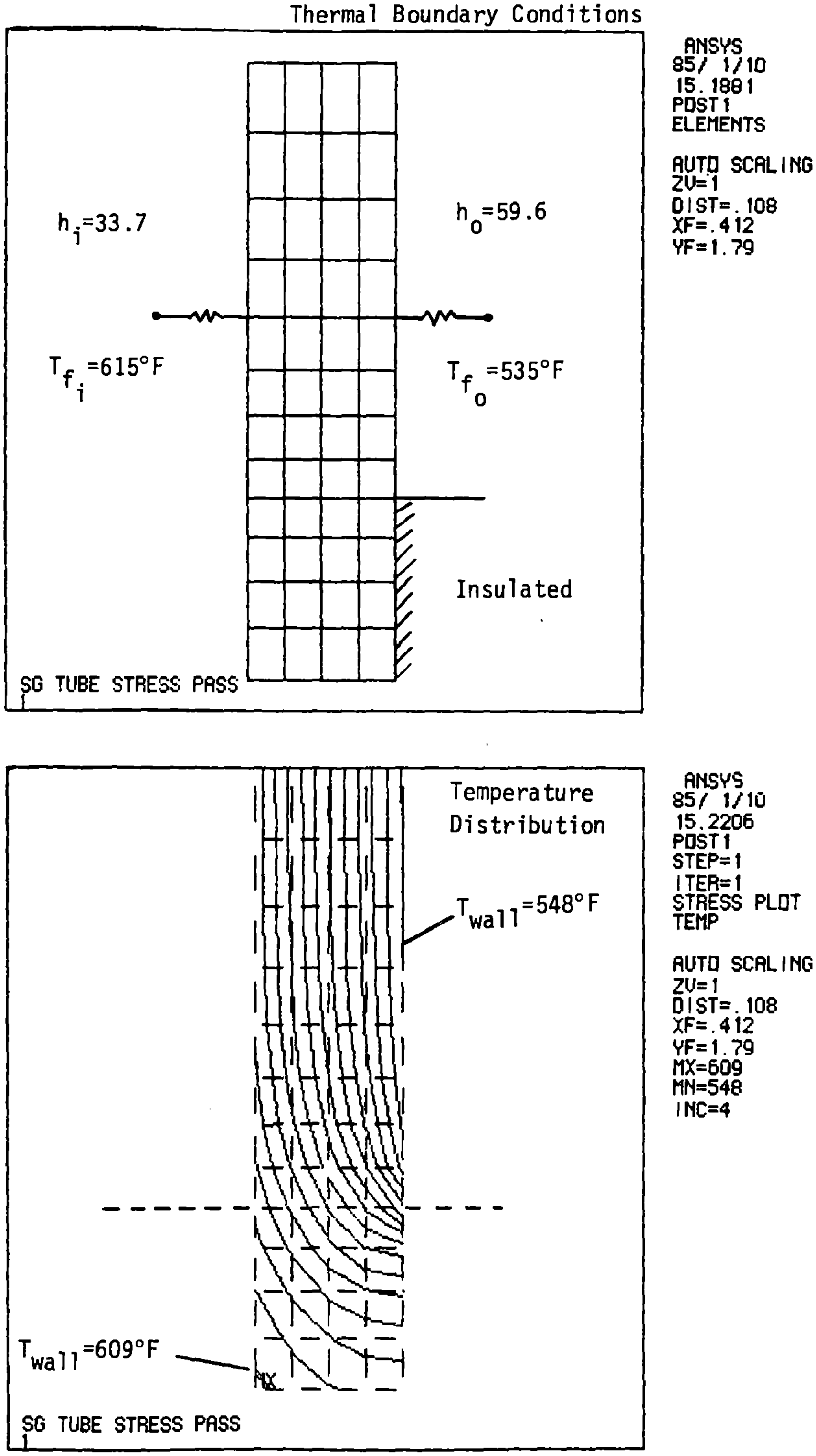


Figure B-7. Temperature Distribution in Tube Wall at Sludge Pile Interface

Appendix C

STRESSES IN TUBE WALL AT U-BENDS

The purpose of this appendix is to summarize the reported operating and residual stresses in the U-bend region of first row tubes. These results include work by Robert L. Cloud Associates, Inc., Mitsubishi Heavy Industries, Ltd., and Penn State University.

R. L. CLOUD ASSOCIATES

Cloud, Leung, and Loey, of R. L. Cloud Associates, Inc. have computed elastic pressure and thermal stresses in U-bend region of a typical Model 51 steam generator row 1 tube (37). The analyses consisted of two models as shown in Figure C-1. The first model was of an entire tube from the tube sheet to the U-bend including both the hot and cold legs. The purpose of this model was to obtain the displacements of the tube at the elevation of the upper tube support plate. The second, more detailed, model was of the U-bend region and straight legs above the upper tube support plate. The purpose of this model was to obtain the stresses in the U-bend region for combined internal pressure and thermal displacements. The analyses were carried out with and without a "bump" simulating the transition region between the straight and bent portions of the tube.

The highest reported hoop tensile stresses on the inside surface of a tube without a "bump" were 31 ksi (214 MPa) on the flank of the tube. This is shown in Figure C-2. The analysis of the case with a "bump" showed that operating stresses were not significantly increased.

It should be noted that the stresses reported above do not include the effect of a through thickness temperature gradient. Based on work in Appendix A, the through thickness thermal gradient produces a compressive hoop stress on the order of -3.5 ksi (24 MPa) on the inside surface of the tube at the U-bend location. This lowers the computed inside surface hoop tensile stress by about 10 percent to 27.5 ksi (190 MPa).

- Strain Gage Sectioning Tests - Residual stresses along the axis of the U-bends were measured using a strain gage sectioning technique. These results indicate inside surface tensile hoop residual stresses on the order of 15 ksi (97 Ma) for the tubes formed using the cylindrical plastic mandrel, and 50 ksi (345 MPa) for tubes formed using the ball mandrel.

In summary, the Mitsubishi results indicate that operating tensile stresses on the inside of the tube are on the order of 17 ksi (117 MPa), and that residual tensile stresses are on the order of 15-50 ksi (103-345 MPa).

PENN STATE UNIVERSITY

C. Ruud, of Penn State University, has determined outside surface hoop stresses in first row U-bends by the X-ray diffraction technique (38). The results of this work indicate stresses on the order of 50 ksi (345 MPa) compressive. It has been inferred from this data that the stresses on the inside are on the order of 50 ksi (345 MPa) tensile. These results are in reasonably good agreement with the Mitsubishi results obtained by the strain gage sectioning technique. It is noted, however, that local surface stresses can be much higher due to surface work hardening.

SUMMARY

In summary, the inside surface tensile hoop stress for tubes formed by the Westinghouse ball mandrel method could be on the order of 65 ksi (448 MPa). This consists of a residual stress of about 45 ksi (310 MPa) and an operating stress of about 20 ksi (138 MPa). Higher peak surface stresses are believed to exist due to local surface work hardening. For the case of tubes formed with the plastic cylindrical mandrel, the stresses should be reduced by at least 15 ksi (103 MPa) to about 50 ksi (345 MPa).

MITSUBISHI HEAVY INDUSTRIES

Kansai Electric Power Co. and Mitsubishi Heavy Industries performed finite element analyses similar to those performed by R. L. Cloud Associates, a series of polythionic acid tests, and residual stress measurements (6). This work is as follows:

- Analyses - Mitsubishi analyses of a first row U-bend included a global model to obtain boundary conditions representative of the upper tube support plate elevation, and a local model of the U-bend above the upper support plate. While the reference does not provide complete assumptions, it is possible to infer that their boundary conditions did not include the effect of a through thickness thermal gradient. The Mitsubishi analysis results, shown in Figure C-3, indicate an inside surface hoop stress of 11.6 ksi (80 MPa) in the region two tube diameters below the tangent point, and a peak inside surface hoop stress of about 17 ksi (117 MPa) on the flank about 25 degrees above the tangent. The location of the peak stress is the same as identified by R. L. Cloud Associates, however, the magnitude of the peak stress is about half. The difference in computed peak stress may be due to differing boundary conditions in the global model but this has not been confirmed. Subtracting the 3.5 ksi (24 MPa) compresive stress produced by the through thickness thermal gradient would result in a inside surface tensile hoop stress of about 13.5 ksi (93 MPa).

- Polythionic Acid Tests - First row U-bend specimens were formed form sensitized alloy 600 tubing using the ball mandrel procedure used by Westinghouse, and by the plastic cylindrical procedure used by Sumitomo. The tubes were filled with polythionic acid, pressurized to 1422 psi (9.94 MPa), and then subjected to the boundary condition loads and moments predicted by the global finite element model. The stress level in the tube was estimated based on the results of separate load controlled tests. The results indicated that cracks typically develop 10-30 degrees above the tangent point and are indicative of stress levels on the order of 50-60 ksi (345-414 MPa).

  Results of examination of failed tubes from Takahama 1 and the polythionic acid tests show that the actual failures do not occur at exactly the same location where the peak operating stresses are computed using the finite element programs. Rather, they occur at the tangent point where an abrupt change in ovality occurs for the case of tubes formed using the ball mandrel process. Mitsubishi infers from this that local residual stresses due to the forming process are a significant factor in explaining primary side IGSCC, and that the susceptibility increases when this high residual stress location occurs on the cold leg.

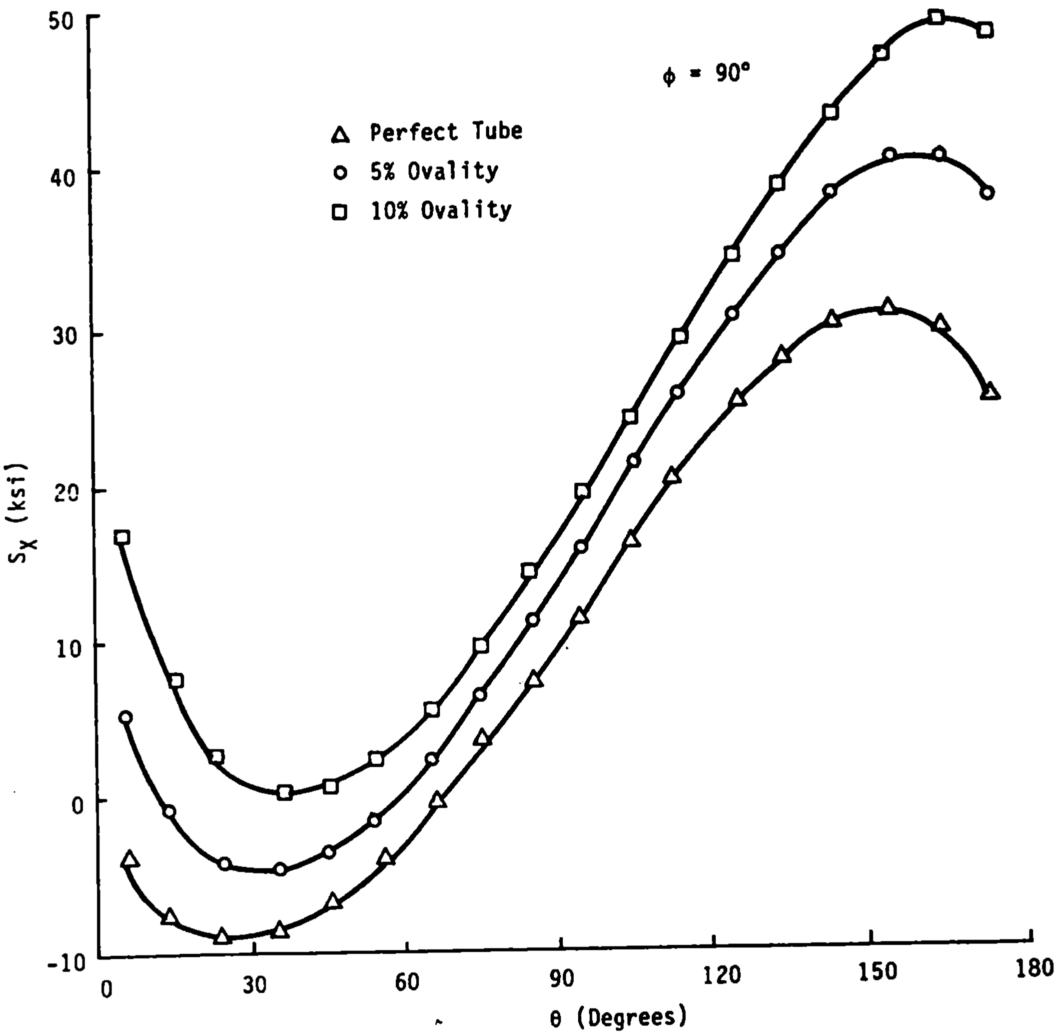


Figure C-2. Inside Surface Hoop Stress on Flank of U-Bend

Source: From reference (37)

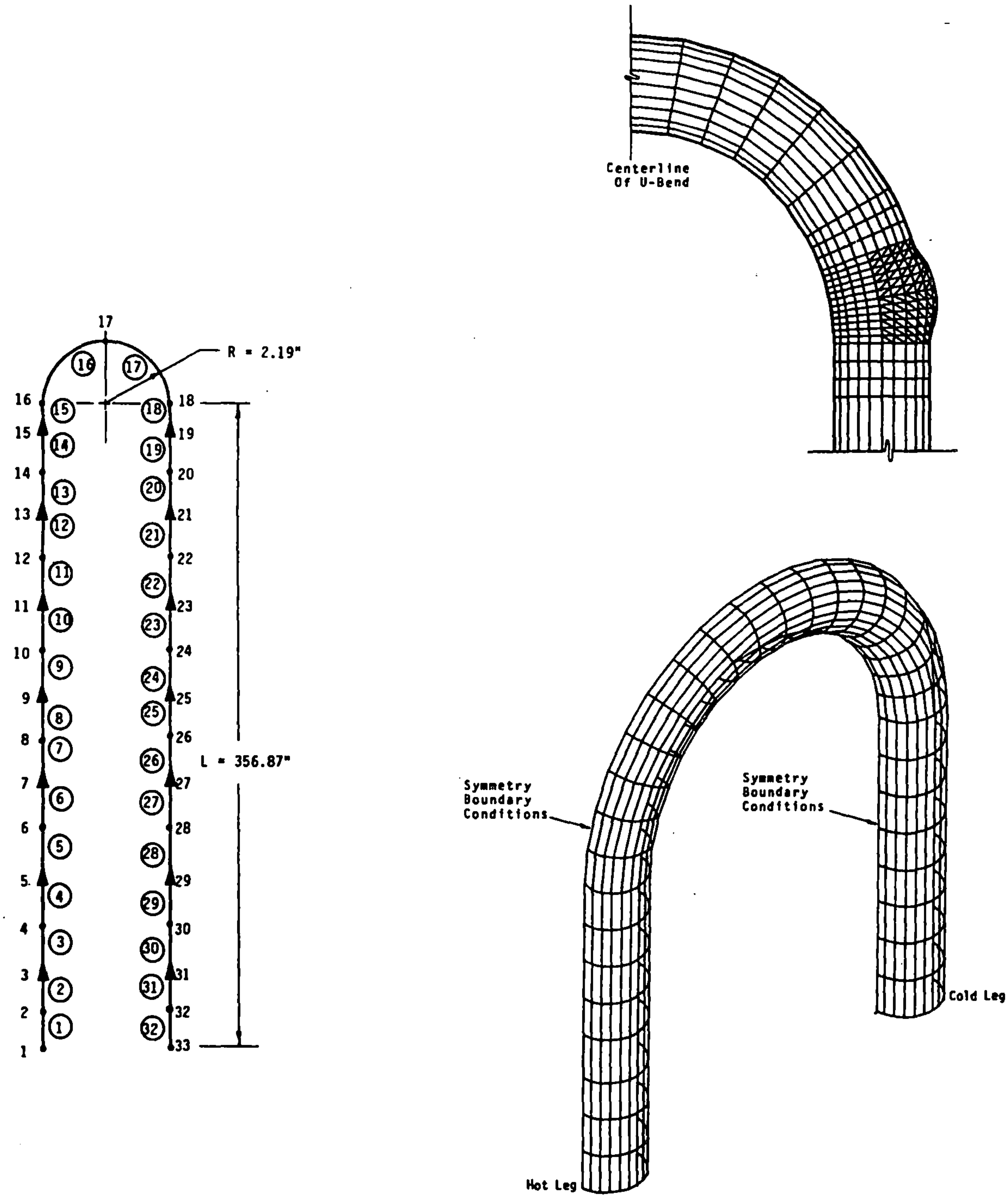
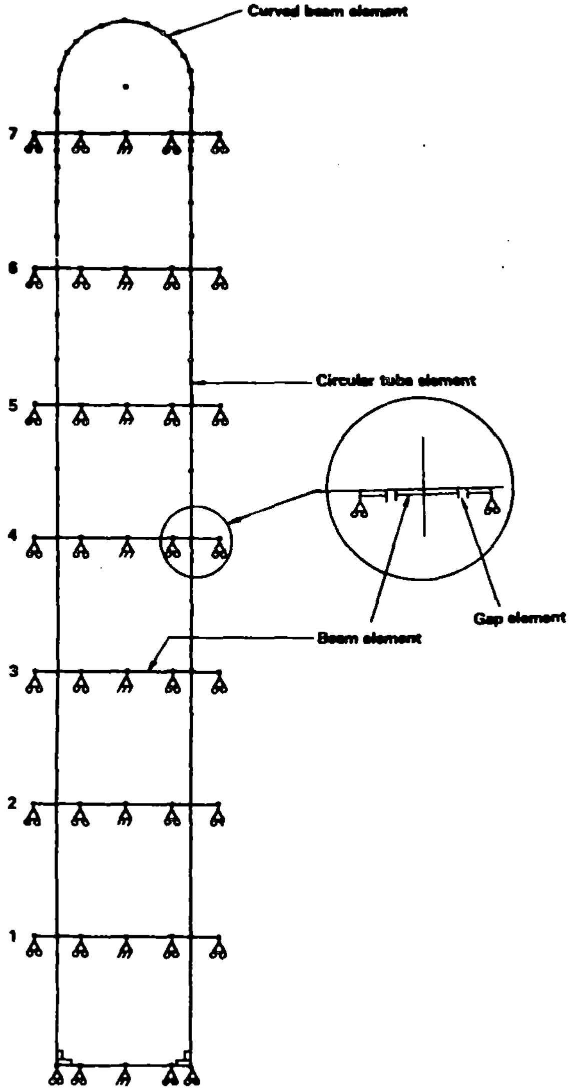
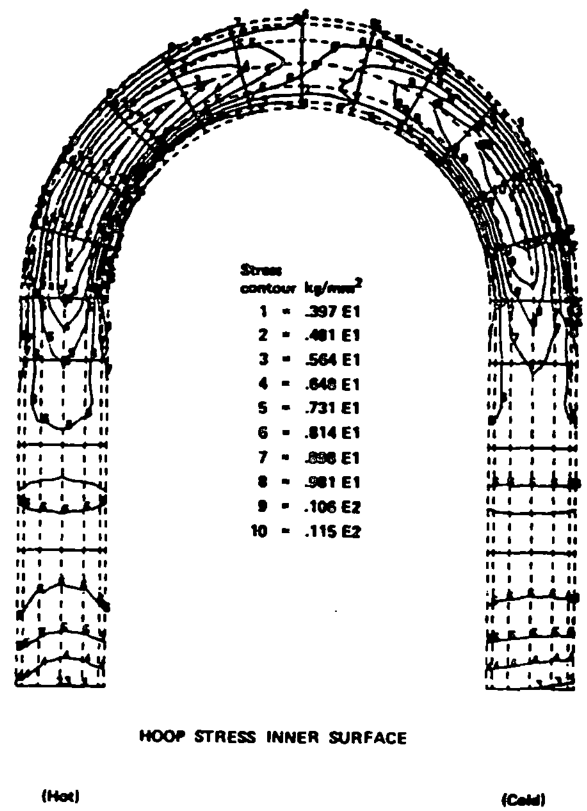


Figure C-1. R.L. Cloud U-Bend Finite Element Analysis Model

Source: From reference (37)



a. Global Model



b. Local Model

Figure C-3. Mitsubishi Finite Element Models and Results
Source: From reference (6)

Appendix D

DATA BASE

The purpose of this appendix is to tabulate key design and operating data for Westinghouse type steam generators with non-thermally treated alloy 600 tubing, and which were in operation prior to the start of 1983. In addition, several plants which went into commercial operation subsequent to the start of 1983, but which have already reported primary side IGSCC, are included.

Information for the data base was obtained from a number of different sources including: the EPRI Steam Generator Data Base (39); published lists of power plants (40,41); NRC Public Documents Room; other EPRI publications (1,42) and discussions with EPRI, utility, and NSSS personnel, etc.

Where data is provided for tube material properties, it should be noted that the information is from tests on limited samples. In fact, there can be as many as 200 heats of material in a single steam generator, and each of the heats can differ somewhat in properties.

The data base is not complete since the work scope for this project was limited to compiling the data which could be obtained within the scope of this project.

The following abbreviations are used in the data base:

AVT	AVT water treatment
CS	Carbon steel
CYL PLAST MNDRL	Cylindrical plastic mandrel
DAM	Dudgeonnage Ameliore Mecaniquement treatment
F.D.ROLL	Full depth roll
H BALL MANDREL	Huntington ball mandrel
PHOS	Phosphate water treatment
MHI	Mitsubishi Heavy Industries
RWE	Recirculating type S.G. with economizer
RWOE	Recirculating type S.G. without economizer
WH BALL MANDREL	Westinghouse ball mandrel

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
ALMARAZ 1

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	ALMARAZ 1
1.2	UTILITY......................................	HIDROELECTRICA SA
1.3	NSSS SUPPLIER................................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE).................	930
1.5	THERMAL POWER RATING (MWT)..................	2686
1.6	DATE OF COMMERCIAL OPERATION................	10/15/81
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS..................	3
2.2	STEAM GENERATOR TYPE........................	RWE *
2.3	STEAM GENERATOR MODEL NO....................	D3
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	
2.5	DATE OF STEAM GENERATOR COMPLETION..........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)................	21.0
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.750
3.3	TUBE WALL THICKNESS (inches)................	.043
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	4674
3.5	TUBE PITCH (inches).........................	1.063
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL..........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL.................	CS
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE....................	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE.......................	
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS...................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.250,3.312
6.3	PROCESS USED TO FORM BENDS..................	W. BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)..............	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	619
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	556
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

* Recirculating Westinghouse steam generator with economizer

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
ALMARAZ 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
8.1 PRIMARY SIDE IGSCC
8.1.1 EXPANSION TRANSITION................ YES
8.1.2 EXPANDED REGION..................... YES
8.1.3 U-BEND TRANSITION...................
8.1.4 U-BEND APEX-DENTING RELATED.........
8.1.5 U-BEND APEX-NOT DENTING RELATED.....
8.1.6 TSP INTERSECTION-DENTING RELATED....
8.1.7 PLUGS...............................
8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
9.1 SECONDARY SIDE IGSCC
9.1.1 EXPANSION TRANSITION................
9.1.2 TUBESHEET CREVICE...................
9.1.3 SLUDGE PILE REGION..................
9.1.4 TSP INTERSECTION....................
9.2 INTERGRANULAR ATTACK (IGA)
9.2.1 EXPANSION TRANSITION................
9.2.2 TUBESHEET CREVICE...................
9.2.3 SLUDGE PILE REGION..................
9.2.4 TSP INTERSECTION....................
9.3 DENTING................................. YES-MINOR
9.4 CORROSION FATIGUE.......................
9.5 EROSION-CORROSION.......................
9.6 PITTING.................................
9.7 WASTAGE.................................
9.8 WEAR.................................... YES
9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
10.1 TOTAL TUBES PLUGGED.......................
10.2 TOTAL TUBES SLEEVED.......................
10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BEAVER VALLEY 1

1.	**PLANT DESCRIPTION**	
1.1	PLANT NAME AND UNIT NO......................	BEAVER VALLEY 1
1.2	UTILITY....................................	DUQUENSE LIGHT
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)................	852
1.5	THERMAL POWER RATING (MWT).................	2652
1.6	DATE OF COMMERCIAL OPERATION...............	4/15/77
2.	**STEAM GENERATOR GENERAL INFORMATION**	
2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE **
2.3	STEAM GENERATOR MODEL NO...................	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	**STEAM GENERATOR DIMENSIONS**	
3.1	TUBESHEET THICKNESS (inches)...............	21.0
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	**STEAM GENERATOR MATERIALS**	
4.1	TUBESHEET MATERIAL.........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WEST/HUNTINGTON
4.5	DATE OF TUBE MANUFACTURE...................	//
5.	**TUBE MATERIAL PROPERTIES**	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	**TUBE EXPANSION PARAMETERS**	
6.1	TYPE OF EXPANSION PROCESS..................	ROLL/EXPLOSIVE
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	WH BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	**STEAM GENERATOR OPERATING PARAMETERS**	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	610
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	543
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	517
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	825
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

** Recirculating Westinghouse steam generator without economizer

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............. YES(LOOSE PARTS)

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED........................ 9
    10.2 TOTAL TUBES SLEEVED........................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BEZNAU 1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... BEZNAU 1
   1.2 UTILITY.................................... NOK
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 350
   1.5 THERMAL POWER RATING (MWT)................. 1130
   1.6 DATE OF COMMERCIAL OPERATION............... 12/15/69

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 2
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 33
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 20.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 2604
   3.5 TUBE PITCH (inches)........................
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE...................... 6.5
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)......
   6.3 PROCESS USED TO FORM BENDS................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 599
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 544
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 506
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 730
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ AVT,PHOS,AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION....................
      8.1.3 U-BEND TRANSITION..................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS..............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE................... YES-2 yrs
      9.1.3 SLUDGE PILE REGION.................. YES
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE................... YES-2 yrs
      9.2.3 SLUDGE PILE REGION.................. YES
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING...................................
   9.4 CORROSION FATIGUE.........................
   9.5 EROSION-CORROSION.........................
   9.6 PITTING...................................
   9.7 WASTAGE................................... YES
   9.8 WEAR...................................... YES
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED........................ 1117
   10.2 TOTAL TUBES SLEEVED........................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

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   11.4

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BEZNAU 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... BEZNAU 2
   1.2 UTILITY.................................. NOK
   1.3 NSSS SUPPLIER............................ WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 350
   1.5 THERMAL POWER RATING (MWT)................. 1130
   1.6 DATE OF COMMERCIAL OPERATION............... 12/15/72

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 2
   2.2 STEAM GENERATOR TYPE...................... RWOE
   2.3 STEAM GENERATOR MODEL NO.................. 33
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 20.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 2604
   3.5 TUBE PITCH (inches)........................
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE......................
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)......
   6.3 PROCESS USED TO FORM BENDS................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 597
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 542
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 512
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 773
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ EARLY PHOS, AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BEZNAU 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION.....................
  - 8.1.3 U-BEND TRANSITION...................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED..... YES
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS...............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE................... YES
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE................... YES
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING.................................
- 9.4 CORROSION FATIGUE.......................
- 9.5 EROSION-CORROSION.......................
- 9.6 PITTING.................................
- 9.7 WASTAGE................................. YES
- 9.8 WEAR.................................... YES
- 9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED....................... 282
- 10.2 TOTAL TUBES SLEEVED.......................
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BLAYLAIS 1

1.	**PLANT DESCRIPTION**	
1.1	PLANT NAME AND UNIT NO.	BLAYLAIS 1
1.2	UTILITY	EDF
1.3	NSSS SUPPLIER	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)	925
1.5	THERMAL POWER RATING (MWT)	
1.6	DATE OF COMMERCIAL OPERATION	12/15/81
2.	**STEAM GENERATOR GENERAL INFORMATION**	
2.1	NUMBER OF STEAM GENERATORS	3
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO.	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION	FRAMATOME
2.5	DATE OF STEAM GENERATOR COMPLETION	//
3.	**STEAM GENERATOR DIMENSIONS**	
3.1	TUBESHEET THICKNESS (inches)	
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3381
3.5	TUBE PITCH (inches)	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)	00.00
4.	**STEAM GENERATOR MATERIALS**	
4.1	TUBESHEET MATERIAL	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL	CS
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	WEST/VALLOUREC
4.5	DATE OF TUBE MANUFACTURE	//
5.	**TUBE MATERIAL PROPERTIES**	
5.1	ASTM GRAIN SIZE RANGE	
5.2	CARBON CONTENT RANGE (percent)	
5.3	YIELD STRESS RANGE (ksi)	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	
6.	**TUBE EXPANSION PARAMETERS**	
6.1	TYPE OF EXPANSION PROCESS	F.D. ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7.	**STEAM GENERATOR OPERATING PARAMETERS**	
7.1	PRIMARY COOLANT PRESSURE (psi)	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	
7.9	WATER CHEMISTRY	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BLAYLAIS 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION....................
      8.1.3 U-BEND TRANSITION..................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR.....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED.......................
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BUGEY 2

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO......................	BUGEY 2
1.2	UTILITY....................................	EDF
1.3	NSSS SUPPLIER..............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)................	920
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	2/15/79

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51A
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	FRAMATOME
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)...............	
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL.........................	FORG. STL.
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WEST/SANDVIK
4.5	DATE OF TUBE MANUFACTURE...................	//

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS..................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi).............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION.................. YES
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING....................................
   9.4 CORROSION FATIGUE..........................
   9.5 EROSION-CORROSION..........................
   9.6 PITTING....................................
   9.7 WASTAGE....................................
   9.8 WEAR.......................................
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 91
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BUGEY 3

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO......................	BUGEY 3
1.2	UTILITY....................................	EDF
1.3	NSSS SUPPLIER..............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)................	920
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	2/13/79

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51A
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	FRAMATOME
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)...............	
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL.........................	FORG.STL.
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	VALLOUREC
4.5	DATE OF TUBE MANUFACTURE...................	//

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE......................	9-10
5.2	CARBON CONTENT RANGE (percent).............	.02
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS..................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi).............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BUGEY 3

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................ YES
      8.1.2 EXPANDED REGION....................
      8.1.3 U-BEND TRANSITION.................. YES
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR.....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS............. FOREIGN OBJECTS

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 6
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BUGEY 4

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	BUGEY 4
1.2	UTILITY....................................	EDF
1.3	NSSS SUPPLIER..............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE).................	900
1.5	THERMAL POWER RATING (MWT)..................	
1.6	DATE OF COMMERCIAL OPERATION................	6/15/79
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS..................	3
2.2	STEAM GENERATOR TYPE........................	RWOE
2.3	STEAM GENERATOR MODEL NO....................	51A
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	FRAMATOME
2.5	DATE OF STEAM GENERATOR COMPLETION..........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)................	
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.875
3.3	TUBE WALL THICKNESS (inches)................	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	3388
3.5	TUBE PITCH (inches).........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL..........................	
4.2	TUBE SUPPORT PLATE MATERIAL.................	
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE....................	
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE.......................	
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS...................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches).......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS..................	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)....	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)..............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)......	
7.7	STEAM GENERATOR OPERATING PRESS.(psi).......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches)..........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................. YES
        8.1.2 EXPANDED REGION......................
        8.1.3 U-BEND TRANSITION....................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS................................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED........................
    10.2 TOTAL TUBES SLEEVED........................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

    11.2

    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BUGEY 5

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... BUGEY 5
   - 1.2 UTILITY...................................... EDF
   - 1.3 NSSS SUPPLIER................................ FRAMATOME
   - 1.4 ELECTRIC POWER RATING (MWE)................. 900
   - 1.5 THERMAL POWER RATING (MWT)..................
   - 1.6 DATE OF COMMERCIAL OPERATION................ 1/15/80

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS.................. 3
   - 2.2 STEAM GENERATOR TYPE........................ RWOE
   - 2.3 STEAM GENERATOR MODEL NO.................... 51A
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION......... FRAMATOME
   - 2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)................
   - 3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   - 3.3 TUBE WALL THICKNESS (inches)................ .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   - 3.5 TUBE PITCH (inches)......................... 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL..........................
   - 4.2 TUBE SUPPORT PLATE MATERIAL.................
   - 4.3 TUBE MATERIAL............................... ALLOY 600
   - 4.4 TUBE SUPPLIER............................... VALLOUREC
   - 4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE....................... 11
   - 5.2 CARBON CONTENT RANGE (percent).............. .04
   - 5.3 YIELD STRESS RANGE (ksi)....................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS................... FULL ROLL/DAM
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS..................
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi).............. 2248
   - 7.2 HOT LEG INLET TEMPERATURE (deg F)........... 613
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 546
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)......
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)....... 840
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
   - 7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
BUGEY 5

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................ YES
    8.1.2 EXPANDED REGION..................... YES
    8.1.3 U-BEND TRANSITION...................
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE...................
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE...................
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING.....................................
  9.4 CORROSION FATIGUE...........................
  9.5 EROSION-CORROSION...........................
  9.6 PITTING.....................................
  9.7 WASTAGE.....................................
  9.8 WEAR..
  9.9 OTHER SECONDARY SIDE PROBLEMS...............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED........................ 12
  10.2 TOTAL TUBES SLEEVED........................
  10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
  11.1

  11.2

  11.3

  11.4

  11.5

  11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
CONNECTICUT YANKEE

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... CONNECTICUT YANKEE
   1.2 UTILITY.................................... CYAP
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 575
   1.5 THERMAL POWER RATING (MWT)................. 1825
   1.6 DATE OF COMMERCIAL OPERATION............... 1/15/68

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 4
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 27
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 22.6
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .750
   3.3 TUBE WALL THICKNESS (inches)............... .055
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3794
   3.5 TUBE PITCH (inches)........................ 1.031
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG. STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE......................
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)......
   6.3 PROCESS USED TO FORM BENDS................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2000
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 577
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 533
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 506
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 700
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ 5 CY PHOS, AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE................... YES
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE................... YES
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING.................................... YES
    9.4 CORROSION FATIGUE..........................
    9.5 EROSION-CORROSION..........................
    9.6 PITTING.................................... YES
    9.7 WASTAGE.................................... YES
    9.8 WEAR....................................... YES
    9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 69
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

    11.2

    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
COOK 1

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO..................... COOK 1
   - 1.2 UTILITY.................................... INDIANA MICHIGAN ELE
   - 1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE)................ 1054
   - 1.5 THERMAL POWER RATING (MWT)................. 3250
   - 1.6 DATE OF COMMERCIAL OPERATION............... 8/15/75

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS................. 4
   - 2.2 STEAM GENERATOR TYPE....................... RWOE
   - 2.3 STEAM GENERATOR MODEL NO................... 51
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   - 2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)............... 21
   - 3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   - 3.3 TUBE WALL THICKNESS (inches)............... .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   - 3.5 TUBE PITCH (inches)........................ 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches).......... .0080
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL......................... SA 508
   - 4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   - 4.3 TUBE MATERIAL.............................. ALLOY 600
   - 4.4 TUBE SUPPLIER.............................. WEST/HUNTINGTON
   - 4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE......................
   - 5.2 CARBON CONTENT RANGE (percent).............
   - 5.3 YIELD STRESS RANGE (ksi)...................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS................. WH BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   - 7.2 HOT LEG INLET TEMPERATURE (deg F).......... 599
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 536
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 512
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 758
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   - 7.9 WATER CHEMISTRY............................ AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
COOK 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   - 8.1 PRIMARY SIDE IGSCC
     - 8.1.1 EXPANSION TRANSITION................
     - 8.1.2 EXPANDED REGION.....................
     - 8.1.3 U-BEND TRANSITION.................. YES
     - 8.1.4 U-BEND APEX-DENTING RELATED.........
     - 8.1.5 U-BEND APEX-NOT DENTING RELATED..... YES
     - 8.1.6 TSP INTERSECTION-DENTING RELATED....
     - 8.1.7 PLUGS...............................
   - 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   - 9.1 SECONDARY SIDE IGSCC
     - 9.1.1 EXPANSION TRANSITION................
     - 9.1.2 TUBESHEET CREVICE...................
     - 9.1.3 SLUDGE PILE REGION..................
     - 9.1.4 TSP INTERSECTION....................
   - 9.2 INTERGRANULAR ATTACK (IGA)
     - 9.2.1 EXPANSION TRANSITION................
     - 9.2.2 TUBESHEET CREVICE...................
     - 9.2.3 SLUDGE PILE REGION.................. YES
     - 9.2.4 TSP INTERSECTION.................... YES
   - 9.3 DENTING..................................
   - 9.4 CORROSION FATIGUE........................
   - 9.5 EROSION-CORROSION........................
   - 9.6 PITTING..................................
   - 9.7 WASTAGE..................................
   - 9.8 WEAR.....................................
   - 9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    - 10.1 TOTAL TUBES PLUGGED....................... 39
    - 10.2 TOTAL TUBES SLEEVED.......................
    - 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    - 11.1
    - 11.2
    - 11.3
    - 11.4
    - 11.5
    - 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
COOK 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO..................... COOK 2
   1.2 UTILITY.................................... INDIANA MICHIGAN ELE
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 1100
   1.5 THERMAL POWER RATING (MWT)................. 3391
   1.6 DATE OF COMMERCIAL OPERATION............... 7/15/78

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 4
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 21
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   3.5 TUBE PITCH (inches)........................ 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0080
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... SA 508
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. WESTINGHOUSE
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE......................
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS................. W BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 606
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 540
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 521
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 803
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
COOK 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................. YES
      8.1.2 EXPANDED REGION......................
      8.1.3 U-BEND TRANSITION................... YES
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING.................................
   9.4 CORROSION FATIGUE.......................
   9.5 EROSION-CORROSION.......................
   9.6 PITTING.................................
   9.7 WASTAGE.................................
   9.8 WEAR....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED........................ 79
   10.2 TOTAL TUBES SLEEVED........................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 1

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	DAMPIERRE 1
1.2	UTILITY....................................	EDF
1.3	NSSS SUPPLIER..............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)................	890
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	6/20/80
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	
4.2	TUBE SUPPORT PLATE MATERIAL................	
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WEST/VALLOUREC
4.5	DATE OF TUBE MANUFACTURE...................	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	FULL ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................. YES
  - 8.1.2 EXPANDED REGION...................... YES
  - 8.1.3 U-BEND TRANSITION....................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS...............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION.................
  - 9.1.2 TUBESHEET CREVICE...................
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION.................
  - 9.2.2 TUBESHEET CREVICE...................
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING....................................
- 9.4 CORROSION FATIGUE..........................
- 9.5 EROSION-CORROSION..........................
- 9.6 PITTING....................................
- 9.7 WASTAGE....................................
- 9.8 WEAR.......................................
- 9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED........................ 9
- 10.2 TOTAL TUBES SLEEVED........................
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 2

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	DAMPIERRE 2
1.2	UTILITY.....................................	EDF
1.3	NSSS SUPPLIER...............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE).................	890
1.5	THERMAL POWER RATING (MWT)..................	
1.6	DATE OF COMMERCIAL OPERATION................	2/16/81
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS..................	3
2.2	STEAM GENERATOR TYPE........................	RWOE
2.3	STEAM GENERATOR MODEL NO....................	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	
2.5	DATE OF STEAM GENERATOR COMPLETION..........	
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)................	
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.875
3.3	TUBE WALL THICKNESS (inches)................	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	3388
3.5	TUBE PITCH (inches).........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL..........................	
4.2	TUBE SUPPORT PLATE MATERIAL.................	
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	WEST/VALLOUREC
4.5	DATE OF TUBE MANUFACTURE....................	
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE.......................	
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS...................	FULL ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches).......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS..................	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)....	
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)..............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)......	
7.7	STEAM GENERATOR OPERATING PRESS.(psi).......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches)..........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED......................
    10.2 TOTAL TUBES SLEEVED......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

    11.2

    11.3

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    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 3

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO.	DAMPIERRE 3
1.2	UTILITY	EDF
1.3	NSSS SUPPLIER	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)	890
1.5	THERMAL POWER RATING (MWT)	
1.6	DATE OF COMMERCIAL OPERATION	4/10/81

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS	3
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO.	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION	
2.5	DATE OF STEAM GENERATOR COMPLETION	

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)	
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3388
3.5	TUBE PITCH (inches)	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)	00.00

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL	
4.2	TUBE SUPPORT PLATE MATERIAL	
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	WEST/VALLOUREC
4.5	DATE OF TUBE MANUFACTURE	

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE	
5.2	CARBON CONTENT RANGE (percent)	
5.3	YIELD STRESS RANGE (ksi)	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS	FULL ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi)	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	
7.9	WATER CHEMISTRY	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 3

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................ YES
      8.1.2 EXPANDED REGION..................... YES
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR.....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED.....................
   10.2 TOTAL TUBES SLEEVED.....................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

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   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 4

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	DAMPIERRE 4
1.2	UTILITY....................................	EDF
1.3	NSSS SUPPLIER..............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)................	890
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	11/ 5/81
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	
2.5	DATE OF STEAM GENERATOR COMPLETION.........	
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	
4.2	TUBE SUPPORT PLATE MATERIAL................	
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE...................	
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	FULL ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DAMPIERRE 4

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
 8.1 PRIMARY SIDE IGSCC
  8.1.1 EXPANSION TRANSITION................
  8.1.2 EXPANDED REGION.....................
  8.1.3 U-BEND TRANSITION...................
  8.1.4 U-BEND APEX-DENTING RELATED.........
  8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  8.1.6 TSP INTERSECTION-DENTING RELATED....
  8.1.7 PLUGS...............................
 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
 9.1 SECONDARY SIDE IGSCC
  9.1.1 EXPANSION TRANSITION................
  9.1.2 TUBESHEET CREVICE...................
  9.1.3 SLUDGE PILE REGION..................
  9.1.4 TSP INTERSECTION....................
 9.2 INTERGRANULAR ATTACK (IGA)
  9.2.1 EXPANSION TRANSITION................
  9.2.2 TUBESHEET CREVICE...................
  9.2.3 SLUDGE PILE REGION..................
  9.2.4 TSP INTERSECTION....................
 9.3 DENTING.................................
 9.4 CORROSION FATIGUE.......................
 9.5 EROSION-CORROSION.......................
 9.6 PITTING.................................
 9.7 WASTAGE.................................
 9.8 WEAR....................................
 9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
 10.1 TOTAL TUBES PLUGGED.......................
 10.2 TOTAL TUBES SLEEVED.......................
 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
 11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DOEL 1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... DOEL 1
   1.2 UTILITY.................................... INDIVISION DOEL
   1.3 NSSS SUPPLIER.............................. ACECOWEN
   1.4 ELECTRIC POWER RATING (MWE)................ 390
   1.5 THERMAL POWER RATING (MWT)................. 1192
   1.6 DATE OF COMMERCIAL OPERATION............... 2/15/75

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 2
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 44
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ COCKERILL
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 22.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3260
   3.5 TUBE PITCH (inches)........................ 1.200
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 19.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. MANNESMAN
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE...................... 5-8
   5.2 CARBON CONTENT RANGE (percent)............. .015-.05
   5.3 YIELD STRESS RANGE (ksi)................... 35.8-46.6
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.188,3.47
   6.3 PROCESS USED TO FORM BENDS................. NO MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2240
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 598
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 544
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 526
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 839
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)......... H6,C1
   7.9 WATER CHEMISTRY............................ EARLY PHOS, AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DOEL 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION....................
  - 8.1.3 U-BEND TRANSITION..................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS..............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE...................
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE...................
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING.................................. YES(MILD)
- 9.4 CORROSION FATIGUE........................
- 9.5 EROSION-CORROSION........................
- 9.6 PITTING..................................
- 9.7 WASTAGE..................................
- 9.8 WEAR.....................................
- 9.9 OTHER SECONDARY SIDE PROBLEMS.............. FOREIGN OBJECT

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED........................ 14
- 10.2 TOTAL TUBES SLEEVED........................
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DOEL 2

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	DOEL 2
1.2	UTILITY...................................	INDIVISION DOEL
1.3	NSSS SUPPLIER.............................	ACECOWEN
1.4	ELECTRIC POWER RATING (MWE)................	0390
1.5	THERMAL POWER RATING (MWT).................	1192
1.6	DATE OF COMMERCIAL OPERATION...............	11/15/75
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	2
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	44
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	COCKERILL
2.5	DATE OF STEAM GENERATOR COMPLETION.........	
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	22.0
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3260
3.5	TUBE PITCH (inches)........................	1.200
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0060
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	19.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	SA-336
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	MANNESMAN
4.5	DATE OF TUBE MANUFACTURE...................	
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	SCC-9-10,OK-6-7
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	SCC1730,OK-1750-1800
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	PART DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.188,3.47
6.3	PROCESS USED TO FORM BENDS.................	NO MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2240
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	598
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	544
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	526
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	839
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	HL-3
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DOEL 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................. YES
    8.1.2 EXPANDED REGION...................... YES
    8.1.3 U-BEND TRANSITION....................
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED..... YES
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION.................
    9.1.2 TUBESHEET CREVICE.................... YES
    9.1.3 SLUDGE PILE REGION...................
    9.1.4 TSP INTERSECTION.....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION.................
    9.2.2 TUBESHEET CREVICE....................
    9.2.3 SLUDGE PILE REGION...................
    9.2.4 TSP INTERSECTION.....................
  9.3 DENTING.................................... YES,MILD-TS-TSP
  9.4 CORROSION FATIGUE..........................
  9.5 EROSION-CORROSION..........................
  9.6 PITTING....................................
  9.7 WASTAGE....................................
  9.8 WEAR.......................................
  9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED....................... 147
  10.2 TOTAL TUBES SLEEVED....................... 185/1983
  10.3 OTHER (tube expn.,stress relief,peening)... SR MINI SLEEVES

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DOEL 3

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... DOEL 3
   1.2 UTILITY..................................... EBES
   1.3 NSSS SUPPLIER............................... FRAMACECO
   1.4 ELECTRIC POWER RATING (MWE)................. 897
   1.5 THERMAL POWER RATING (MWT)..................
   1.6 DATE OF COMMERCIAL OPERATION................ 10/15/82

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 3
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51M
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... COCKERILL
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 21.1
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3361
   3.5 TUBE PITCH (inches)......................... 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... SA 508
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... WESTINGHOUSE
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE....................... 7-11
   5.2 CARBON CONTENT RANGE (percent).............. .051-.056
   5.3 YIELD STRESS RANGE (ksi).................... 44-55
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)........... Furn.-1875

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... FULL ROLL/DAM
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS.................. W BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)..............
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 617
   7.3 COLD LEG OUTLET TEMPERATURE (deg F).........
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)......
   7.7 STEAM GENERATOR OPERATING PRESS.(psi).......
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
   7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
DOEL 3

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................. YES
        8.1.2 EXPANDED REGION...................... YES
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED......................
    10.2 TOTAL TUBES SLEEVED......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
FARLEY 1

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... FARLEY 1
   - 1.2 UTILITY.................................... ALABAMA POWER
   - 1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE)................ 860
   - 1.5 THERMAL POWER RATING (MWT)................. 2252
   - 1.6 DATE OF COMMERCIAL OPERATION............... 12/15/77

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS................. 3
   - 2.2 STEAM GENERATOR TYPE....................... RWOE
   - 2.3 STEAM GENERATOR MODEL NO................... 51
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   - 2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)............... 21.0
   - 3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   - 3.3 TUBE WALL THICKNESS (inches)............... .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   - 3.5 TUBE PITCH (inches)........................ 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 00.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL......................... SA 508
   - 4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   - 4.3 TUBE MATERIAL.............................. ALLOY 600
   - 4.4 TUBE SUPPLIER.............................. WESTINGHOUSE
   - 4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE......................
   - 5.2 CARBON CONTENT RANGE (percent).............
   - 5.3 YIELD STRESS RANGE (ksi)...................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS.................. ROLL/EXPLOSIVE
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS................. W BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   - 7.2 HOT LEG INLET TEMPERATURE (deg F).......... 603
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 543
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 522
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 811
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   - 7.9 WATER CHEMISTRY............................ AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
FARLEY 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION.................. YES
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR.....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED...................... 282
   10.2 TOTAL TUBES SLEEVED......................
   10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1 U-BENDS PLUGGED

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
FARLEY 2

1.	**PLANT DESCRIPTION**	
1.1	PLANT NAME AND UNIT NO......................	FARLEY 2
1.2	UTILITY....................................	ALABAMA POWER
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)................	860
1.5	THERMAL POWER RATING (MWT).................	2252
1.6	DATE OF COMMERCIAL OPERATION...............	7/15/81
2.	**STEAM GENERATOR GENERAL INFORMATION**	
2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	**STEAM GENERATOR DIMENSIONS**	
3.1	TUBESHEET THICKNESS (inches)...............	21.0
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	**STEAM GENERATOR MATERIALS**	
4.1	TUBESHEET MATERIAL.........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE...................	//
5.	**TUBE MATERIAL PROPERTIES**	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	**TUBE EXPANSION PARAMETERS**	
6.1	TYPE OF EXPANSION PROCESS..................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	**STEAM GENERATOR OPERATING PARAMETERS**	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	603
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	543
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	516
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	800
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	0.4
7.9	WATER CHEMISTRY............................	AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION.................. YES
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE...................
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE...................
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING.....................................
  9.4 CORROSION FATIGUE...........................
  9.5 EROSION-CORROSION...........................
  9.6 PITTING.....................................
  9.7 WASTAGE.....................................
  9.8 WEAR..
  9.9 OTHER SECONDARY SIDE PROBLEMS.............. FOREIGN OBJECT DENTS

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED........................
  10.2 TOTAL TUBES SLEEVED........................
  10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1 TUBES PLUGGED

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
FESSENHEIM 1

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO.	FESSENHEIM 1
1.2	UTILITY	EDF
1.3	NSSS SUPPLIER	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)	890
1.5	THERMAL POWER RATING (MWT)	
1.6	DATE OF COMMERCIAL OPERATION	12/15/77
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS	3
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO.	51A
2.4	STEAM GENERATOR FABRICATOR/LOCATION	
2.5	DATE OF STEAM GENERATOR COMPLETION	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)	
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3350
3.5	TUBE PITCH (inches)	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL	
4.2	TUBE SUPPORT PLATE MATERIAL	
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE	7-8
5.2	CARBON CONTENT RANGE (percent)	.007-.060
5.3	YIELD STRESS RANGE (ksi)	44-59
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS	ROLL/EXPLOSIVE
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)	611
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	543
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP. (deg F)	
7.7	STEAM GENERATOR OPERATING PRESS. (psi)	789
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	
7.9	WATER CHEMISTRY	AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................ YES
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION.................. YES
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................ YES
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION.................. YES
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 84
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
FESSENHEIM 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... FESSENHEIM 2
   1.2 UTILITY...................................... EDF
   1.3 NSSS SUPPLIER................................ FRAMATOME
   1.4 ELECTRIC POWER RATING (MWE).................. 890
   1.5 THERMAL POWER RATING (MWT)...................
   1.6 DATE OF COMMERCIAL OPERATION................. 3/15/78

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................... 3
   2.2 STEAM GENERATOR TYPE......................... RWOE
   2.3 STEAM GENERATOR MODEL NO..................... 51A
   2.4 STEAM GENERATOR FABRICATOR/LOCATION.........
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL..........................
   4.2 TUBE SUPPORT PLATE MATERIAL.................
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... SANDVIK
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE.......................
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... FULL DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS..................
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2248
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 611
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 543
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F).....
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 789
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
FESSENHEIM 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING....................................
   9.4 CORROSION FATIGUE..........................
   9.5 EROSION-CORROSION..........................
   9.6 PITTING....................................
   9.7 WASTAGE....................................
   9.8 WEAR.......................................
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED.......................
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GENKAI 1

1. PLANT DESCRIPTION

1.1 PLANT NAME AND UNIT NO.	GENKAI 1
1.2 UTILITY	KYUSHU ELECTRIC
1.3 NSSS SUPPLIER	MHI
1.4 ELECTRIC POWER RATING (MWE)	559
1.5 THERMAL POWER RATING (MWT)	1650
1.6 DATE OF COMMERCIAL OPERATION	10/15/75

2. STEAM GENERATOR GENERAL INFORMATION

2.1 NUMBER OF STEAM GENERATORS	2
2.2 STEAM GENERATOR TYPE	RWOE
2.3 STEAM GENERATOR MODEL NO.	51
2.4 STEAM GENERATOR FABRICATOR/LOCATION	MHI
2.5 DATE OF STEAM GENERATOR COMPLETION	//

3. STEAM GENERATOR DIMENSIONS

3.1 TUBESHEET THICKNESS (inches)	
3.2 TUBE OUTSIDE DIAMETER (inches)	.875
3.3 TUBE WALL THICKNESS (inches)	.050
3.4 NUMBER OF TUBES PER STEAM GENERATOR	3388
3.5 TUBE PITCH (inches)	1.214
3.6 TUBESHEET RADIAL CREVICE (inches)	.0080
3.7 DEPTH OF TUBESHEET CREVICE (inches)	19.00

4. STEAM GENERATOR MATERIALS

4.1 TUBESHEET MATERIAL	FORG.STL.
4.2 TUBE SUPPORT PLATE MATERIAL	SA 533
4.3 TUBE MATERIAL	ALLOY 600
4.4 TUBE SUPPLIER	SUMITOMO
4.5 DATE OF TUBE MANUFACTURE	//

5. TUBE MATERIAL PROPERTIES

5.1 ASTM GRAIN SIZE RANGE	
5.2 CARBON CONTENT RANGE (percent)	
5.3 YIELD STRESS RANGE (ksi)	
5.4 MILL ANNEAL TIME/TEMP (min/deg F)	

6. TUBE EXPANSION PARAMETERS

6.1 TYPE OF EXPANSION PROCESS	ROLL/HYDRAULIC
6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3 PROCESS USED TO FORM BENDS	CYL.PLAST.MNDRL
6.4 STRESS RELIEF AFTER TUBING (hours/deg F)	NONE

7. STEAM GENERATOR OPERATING PARAMETERS

7.1 PRIMARY COOLANT PRESSURE (psi)	2235
7.2 HOT LEG INLET TEMPERATURE (deg F)	613
7.3 COLD LEG OUTLET TEMPERATURE (deg F)	551
7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6 STEAM GENERATOR OPERATING TEMP.(deg F)	
7.7 STEAM GENERATOR OPERATING PRESS.(psi)	835
7.8 TYPICAL SLUDGE PILE DEPTH (inches)	
7.9 WATER CHEMISTRY	AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GENKAI 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION.................... YES
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION.................... YES
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR...................................... YES-FOREIGN MTL
    9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 536
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)... CREVICE HYD. EXPANDED

11. NOTES
    11.1

    11.2

    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GENKAI 2

1. PLANT DESCRIPTION	
1.1 PLANT NAME AND UNIT NO	GENKAI 2
1.2 UTILITY	KYUSHU ELECTRIC
1.3 NSSS SUPPLIER	MHI
1.4 ELECTRIC POWER RATING (MWE)	559
1.5 THERMAL POWER RATING (MWT)	1650
1.6 DATE OF COMMERCIAL OPERATION	3/15/81
2. STEAM GENERATOR GENERAL INFORMATION	
2.1 NUMBER OF STEAM GENERATORS	2
2.2 STEAM GENERATOR TYPE	RWOE
2.3 STEAM GENERATOR MODEL NO	51M
2.4 STEAM GENERATOR FABRICATOR/LOCATION	MHI
2.5 DATE OF STEAM GENERATOR COMPLETION	//
3. STEAM GENERATOR DIMENSIONS	
3.1 TUBESHEET THICKNESS (inches)	
3.2 TUBE OUTSIDE DIAMETER (inches)	.875
3.3 TUBE WALL THICKNESS (inches)	.050
3.4 NUMBER OF TUBES PER STEAM GENERATOR	3382
3.5 TUBE PITCH (inches)	1.214
3.6 TUBESHEET RADIAL CREVICE (inches)	.0000
3.7 DEPTH OF TUBESHEET CREVICE (inches)	00.00
4. STEAM GENERATOR MATERIALS	
4.1 TUBESHEET MATERIAL	FORG. STL.
4.2 TUBE SUPPORT PLATE MATERIAL	CS
4.3 TUBE MATERIAL	ALLOY 600
4.4 TUBE SUPPLIER	SUMITOMO
4.5 DATE OF TUBE MANUFACTURE	
5. TUBE MATERIAL PROPERTIES	
5.1 ASTM GRAIN SIZE RANGE	
5.2 CARBON CONTENT RANGE (percent)	
5.3 YIELD STRESS RANGE (ksi)	
5.4 MILL ANNEAL TIME/TEMP (min/deg F)	
6. TUBE EXPANSION PARAMETERS	
6.1 TYPE OF EXPANSION PROCESS	FD ROLL/RUBBER
6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3 PROCESS USED TO FORM BENDS	CYL.PLAST.MNDRL
6.4 STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7. STEAM GENERATOR OPERATING PARAMETERS	
7.1 PRIMARY COOLANT PRESSURE (psi)	2235
7.2 HOT LEG INLET TEMPERATURE (deg F)	613
7.3 COLD LEG OUTLET TEMPERATURE (deg F)	551
7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6 STEAM GENERATOR OPERATING TEMP.(deg F)	
7.7 STEAM GENERATOR OPERATING PRESS.(psi)	
7.8 TYPICAL SLUDGE PILE DEPTH (inches)	
7.9 WATER CHEMISTRY	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GENKAI 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION.....................
  - 8.1.3 U-BEND TRANSITION...................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS..............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE...................
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE...................
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING..................................
- 9.4 CORROSION FATIGUE........................
- 9.5 EROSION-CORROSION........................
- 9.6 PITTING..................................
- 9.7 WASTAGE..................................
- 9.8 WEAR.....................................
- 9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED....................... 0
- 10.2 TOTAL TUBES SLEEVED.......................
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GINNA

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO.	GINNA
1.2	UTILITY	ROCHESTER ELECTRIC
1.3	NSSS SUPPLIER	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)	490
1.5	THERMAL POWER RATING (MWT)	1520
1.6	DATE OF COMMERCIAL OPERATION	3/15/70
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS	2
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO.	44
2.4	STEAM GENERATOR FABRICATOR/LOCATION	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)	22.0
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3260
3.5	TUBE PITCH (inches)	1.234
3.6	TUBESHEET RADIAL CREVICE (inches)	.0080
3.7	DEPTH OF TUBESHEET CREVICE (inches)	20.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL	FORG. STL.
4.2	TUBE SUPPORT PLATE MATERIAL	CS
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	HUNTINGTON
4.5	DATE OF TUBE MANUFACTURE	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE	6
5.2	CARBON CONTENT RANGE (percent)	.037
5.3	YIELD STRESS RANGE (ksi)	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	1760-1814
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS	PART DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	
6.3	PROCESS USED TO FORM BENDS	H BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)	601
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	552
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	94000
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)	514
7.7	STEAM GENERATOR OPERATING PRESS.(psi)	755
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	2.00
7.9	WATER CHEMISTRY	EARLY PHOS,AVT 11/74

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GINNA

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)

- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION...................
  - 8.1.3 U-BEND TRANSITION.................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS.............................. YES
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)

- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE................... YES
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE................... YES
  - 9.2.3 SLUDGE PILE REGION.................. YES
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING.................................. YES
- 9.4 CORROSION FATIGUE........................
- 9.5 EROSION-CORROSION........................
- 9.6 PITTING..................................
- 9.7 WASTAGE.................................. YES
- 9.8 WEAR..................................... YES
- 9.9 OTHER SECONDARY SIDE PROBLEMS.............. FOREIGN MATL/WEAR

10. INSERVICE REMEDIAL MEASURES

- 10.1 TOTAL TUBES PLUGGED........................ 289
- 10.2 TOTAL TUBES SLEEVED........................ 99-1980/83
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES

- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GRAVELINES B1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... GRAVELINES B1
   1.2 UTILITY..................................... EDF
   1.3 NSSS SUPPLIER............................... FRAMATOME
   1.4 ELECTRIC POWER RATING (MWE)................. 910
   1.5 THERMAL POWER RATING (MWT)..................
   1.6 DATE OF COMMERCIAL OPERATION................ 8/ 1/80

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 3
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51M
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... FRAMATOME
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .005
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL..........................
   4.2 TUBE SUPPORT PLATE MATERIAL.................
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... WEST/VALLOUREC
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE.......................
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... FULLROLL/DAM
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS..................
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2248
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 613
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 546
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)......
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)....... 840
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
   7.9 WATER CHEMISTRY............................. AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR.....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED.......................
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GRAVELINES B2

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO.......................	GRAVELINES B2
1.2	UTILITY......................................	EDF
1.3	NSSS SUPPLIER................................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE).................	910
1.5	THERMAL POWER RATING (MWT)..................	
1.6	DATE OF COMMERCIAL OPERATION................	11/ 1/80
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS..................	3
2.2	STEAM GENERATOR TYPE........................	RWOE
2.3	STEAM GENERATOR MODEL NO....................	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	FRAMATOME
2.5	DATE OF STEAM GENERATOR COMPLETION..........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)................	
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.875
3.3	TUBE WALL THICKNESS (inches)................	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	3388
3.5	TUBE PITCH (inches).........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL..........................	
4.2	TUBE SUPPORT PLATE MATERIAL.................	
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE....................	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE.......................	
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS...................	FULL ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS..................	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)..............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GRAVELINES B2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  - 8.1 PRIMARY SIDE IGSCC
    - 8.1.1 EXPANSION TRANSITION.................
    - 8.1.2 EXPANDED REGION.....................
    - 8.1.3 U-BEND TRANSITION...................
    - 8.1.4 U-BEND APEX-DENTING RELATED.........
    - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    - 8.1.6 TSP INTERSECTION-DENTING RELATED....
    - 8.1.7 PLUGS...............................
  - 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  - 9.1 SECONDARY SIDE IGSCC
    - 9.1.1 EXPANSION TRANSITION................
    - 9.1.2 TUBESHEET CREVICE...................
    - 9.1.3 SLUDGE PILE REGION..................
    - 9.1.4 TSP INTERSECTION....................
  - 9.2 INTERGRANULAR ATTACK (IGA)
    - 9.2.1 EXPANSION TRANSITION................
    - 9.2.2 TUBESHEET CREVICE...................
    - 9.2.3 SLUDGE PILE REGION..................
    - 9.2.4 TSP INTERSECTION....................
  - 9.3 DENTING..................................
  - 9.4 CORROSION FATIGUE........................
  - 9.5 EROSION-CORROSION........................
  - 9.6 PITTING..................................
  - 9.7 WASTAGE..................................
  - 9.8 WEAR.....................................
  - 9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
  - 10.1 TOTAL TUBES PLUGGED........................
  - 10.2 TOTAL TUBES SLEEVED........................
  - 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
  - 11.1
  - 11.2
  - 11.3
  - 11.4
  - 11.5
  - 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GRAVELINES B3

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... GRAVELINES B3
   - 1.2 UTILITY...................................... EDF
   - 1.3 NSSS SUPPLIER................................ FRAMATOME
   - 1.4 ELECTRIC POWER RATING (MWE)................. 910
   - 1.5 THERMAL POWER RATING (MWT)..................
   - 1.6 DATE OF COMMERCIAL OPERATION................ 2/18/81

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS.................. 3
   - 2.2 STEAM GENERATOR TYPE........................ RWOE
   - 2.3 STEAM GENERATOR MODEL NO.................... 51M
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION......... FRAMATOME
   - 2.5 DATE OF STEAM GENERATOR COMPLETION..........

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)................
   - 3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   - 3.3 TUBE WALL THICKNESS (inches)................ .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   - 3.5 TUBE PITCH (inches)......................... 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL..........................
   - 4.2 TUBE SUPPORT PLATE MATERIAL.................
   - 4.3 TUBE MATERIAL............................... ALLOY 600
   - 4.4 TUBE SUPPLIER............................... VALLOUREC
   - 4.5 DATE OF TUBE MANUFACTURE....................

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE.......................
   - 5.2 CARBON CONTENT RANGE (percent)..............
   - 5.3 YIELD STRESS RANGE (ksi)....................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS................... FULL ROLL/DAM
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches).......
   - 6.3 PROCESS USED TO FORM BENDS..................
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi).............. 2248
   - 7.2 HOT LEG INLET TEMPERATURE (deg F)........... 613
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 546
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F).....
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 840
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   - 7.9 WATER CHEMISTRY............................. AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................ YES
        8.1.2 EXPANDED REGION....................
        8.1.3 U-BEND TRANSITION..................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS..............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED.......................
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GRAVELINES B4

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	GRAVELINES B4
1.2	UTILITY...................................	EDF
1.3	NSSS SUPPLIER.............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)................	910
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	9/11/81
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	FRAMATOME
2.5	DATE OF STEAM GENERATOR COMPLETION.........	
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	
4.2	TUBE SUPPORT PLATE MATERIAL................	
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WEST/VALLOUREC
4.5	DATE OF TUBE MANUFACTURE...................	
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	FULL ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
GRAVELINES B4

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING....................................
   9.4 CORROSION FATIGUE..........................
   9.5 EROSION-CORROSION..........................
   9.6 PITTING....................................
   9.7 WASTAGE....................................
   9.8 WEAR.......................................
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED........................
   10.2 TOTAL TUBES SLEEVED........................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
IKATA 1

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO......................	IKATA 1
1.2	UTILITY....................................	SHIKOKU ELECTRIC
1.3	NSSS SUPPLIER..............................	MHI
1.4	ELECTRIC POWER RATING (MWE).................	566
1.5	THERMAL POWER RATING (MWT)..................	1650
1.6	DATE OF COMMERCIAL OPERATION................	9/15/77

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS..................	2
2.2	STEAM GENERATOR TYPE........................	RWOE
2.3	STEAM GENERATOR MODEL NO....................	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	MHI
2.5	DATE OF STEAM GENERATOR COMPLETION..........	11/15/75

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)................	21.6
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.875
3.3	TUBE WALL THICKNESS (inches)................	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	3388
3.5	TUBE PITCH (inches).........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL..........................	FORG.STL.
4.2	TUBE SUPPORT PLATE MATERIAL.................	CS
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	SUMITOMO
4.5	DATE OF TUBE MANUFACTURE....................	1/15/75

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE.......................	9
5.2	CARBON CONTENT RANGE (percent)..............	0.03%
5.3	YIELD STRESS RANGE (ksi)....................	42.7
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	1780

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS...................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS..................	CYL.PLAST.MNDRL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi)..............	2242
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	550
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)......	524
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	839
7.8	TYPICAL SLUDGE PILE DEPTH (inches)..........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
IKATA 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................ YES
      8.1.2 EXPANDED REGION..................... YES
      8.1.3 U-BEND TRANSITION..................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING....................................
   9.4 CORROSION FATIGUE..........................
   9.5 EROSION-CORROSION..........................
   9.6 PITTING....................................
   9.7 WASTAGE....................................
   9.8 WEAR....................................... YES (AVB)
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 173
   10.2 TOTAL TUBES SLEEVED....................... 14
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
IKATA 2

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO......................	IKATA 2
1.2	UTILITY......................................	SHIKOKU ELECTRIC
1.3	NSSS SUPPLIER................................	MHI
1.4	ELECTRIC POWER RATING (MWE).................	566
1.5	THERMAL POWER RATING (MWT)..................	
1.6	DATE OF COMMERCIAL OPERATION................	3/15/82

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS..................	
2.2	STEAM GENERATOR TYPE........................	RWOE
2.3	STEAM GENERATOR MODEL NO....................	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	MHI
2.5	DATE OF STEAM GENERATOR COMPLETION..........	8/15/80

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)................	
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.875
3.3	TUBE WALL THICKNESS (inches)................	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	3382
3.5	TUBE PITCH (inches).........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL..........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL.................	CS
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	SUMITOMO
4.5	DATE OF TUBE MANUFACTURE....................	11/15/78

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE.......................	9
5.2	CARBON CONTENT RANGE (percent)..............	0.016
5.3	YIELD STRESS RANGE (ksi)....................	42.7
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	1760

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS...................	F.D.ROLL-RUBBER
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS..................	CYL.PLSTC.MNDRL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi)..............	
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
IKATA 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION...................
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE...................
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE...................
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING.....................................
  9.4 CORROSION FATIGUE...........................
  9.5 EROSION-CORROSION...........................
  9.6 PITTING.....................................
  9.7 WASTAGE.....................................
  9.8 WEAR..
  9.9 OTHER SECONDARY SIDE PROBLEMS...............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED........................
  10.2 TOTAL TUBES SLEEVED........................
  10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
INDIAN POINT 2

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	INDIAN POINT 2
1.2	UTILITY....................................	CON. EDISON
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)................	873
1.5	THERMAL POWER RATING (MWT).................	2758
1.6	DATE OF COMMERCIAL OPERATION...............	8/15/73
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	4
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	44
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	22.0
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3260
3.5	TUBE PITCH (inches)........................	1.234
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0060
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	18.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	FORG. STL.
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE...................	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	PART DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	576
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	523
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	115000
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	506
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	704
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	EARLY PHOS,AVT,BORON

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
INDIAN POINT 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION.....................
  - 8.1.3 U-BEND TRANSITION...................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS...............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE...................
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE...................
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING.................................... YES (SEVERE)
- 9.4 CORROSION FATIGUE..........................
- 9.5 EROSION-CORROSION..........................
- 9.6 PITTING.................................... YES
- 9.7 WASTAGE.................................... YES
- 9.8 WEAR.......................................
- 9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED........................ 492
- 10.2 TOTAL TUBES SLEEVED........................
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
INDIAN POINT 3

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO......................	INDIAN POINT 3
1.2	UTILITY....................................	PASNY
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)................	965
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	8/15/76

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS.................	4
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	44
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)...............	22.0
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3260
3.5	TUBE PITCH (inches)........................	1.234
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0080
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	19.00

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL.........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE...................	//

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE......................	9-10
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	1700-1760

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS..................	PART DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.188,3.47
6.3	PROCESS USED TO FORM BENDS.................	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi).............	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	600
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	543
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	512
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	10-12
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
INDIAN POINT 3

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   - 8.1 PRIMARY SIDE IGSCC
     - 8.1.1 EXPANSION TRANSITION................
     - 8.1.2 EXPANDED REGION.....................
     - 8.1.3 U-BEND TRANSITION...................
     - 8.1.4 U-BEND APEX-DENTING RELATED.........
     - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
     - 8.1.6 TSP INTERSECTION-DENTING RELATED....
     - 8.1.7 PLUGS...............................
   - 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   - 9.1 SECONDARY SIDE IGSCC
     - 9.1.1 EXPANSION TRANSITION................
     - 9.1.2 TUBESHEET CREVICE...................
     - 9.1.3 SLUDGE PILE REGION.................. YES
     - 9.1.4 TSP INTERSECTION....................
   - 9.2 INTERGRANULAR ATTACK (IGA)
     - 9.2.1 EXPANSION TRANSITION................
     - 9.2.2 TUBESHEET CREVICE...................
     - 9.2.3 SLUDGE PILE REGION..................
     - 9.2.4 TSP INTERSECTION....................
   - 9.3 DENTING.................................. YES
   - 9.4 CORROSION FATIGUE........................
   - 9.5 EROSION-CORROSION........................
   - 9.6 PITTING.................................. YES
   - 9.7 WASTAGE..................................
   - 9.8 WEAR.....................................
   - 9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
    - 10.1 TOTAL TUBES PLUGGED....................... 2053
    - 10.2 TOTAL TUBES SLEEVED....................... 2970-12/83
    - 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    - 11.1
    - 11.2
    - 11.3
    - 11.4
    - 11.5
    - 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
KEWAUNEE

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO.	KEWAUNEE
1.2	UTILITY	WI. PUBLIC SERVICE
1.3	NSSS SUPPLIER	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)	535
1.5	THERMAL POWER RATING (MWT)	1650
1.6	DATE OF COMMERCIAL OPERATION	6/15/74
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS	2
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO.	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)	21.0
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3388
3.5	TUBE PITCH (inches)	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)	.0060
3.7	DEPTH OF TUBESHEET CREVICE (inches)	18.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL	CS
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE	
5.2	CARBON CONTENT RANGE (percent)	
5.3	YIELD STRESS RANGE (ksi)	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS	PART DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS	W BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)	599
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	536
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)	511
7.7	STEAM GENERATOR OPERATING PRESS.(psi)	775
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	1.0
7.9	WATER CHEMISTRY	EARLY PHOS, AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
KEWAUNEE

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION....................
      8.1.3 U-BEND TRANSITION..................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS..............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE................... YES
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING.................................... YES
   9.4 CORROSION FATIGUE..........................
   9.5 EROSION-CORROSION..........................
   9.6 PITTING....................................
   9.7 WASTAGE....................................
   9.8 WEAR.......................................
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 72
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
KOREA NUCLEAR 1

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... KOREA NUCLEAR 1
   - 1.2 UTILITY...................................... KOREA ELECTRIC POWER
   - 1.3 NSSS SUPPLIER................................ WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE).................. 587
   - 1.5 THERMAL POWER RATING (MWT)................... 1729
   - 1.6 DATE OF COMMERCIAL OPERATION................. 6/15/78

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS................... 2
   - 2.2 STEAM GENERATOR TYPE......................... RWOE
   - 2.3 STEAM GENERATOR MODEL NO..................... 51
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........
   - 2.5 DATE OF STEAM GENERATOR COMPLETION........... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)................. 21.0
   - 3.2 TUBE OUTSIDE DIAMETER (inches)............... .875
   - 3.3 TUBE WALL THICKNESS (inches)................. .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR.......... 3388
   - 3.5 TUBE PITCH (inches).......................... 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches)............ .0000
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches).......... 00.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL........................... FORG.STL.
   - 4.2 TUBE SUPPORT PLATE MATERIAL.................. CS
   - 4.3 TUBE MATERIAL................................ ALLOY 600
   - 4.4 TUBE SUPPLIER................................
   - 4.5 DATE OF TUBE MANUFACTURE..................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE........................
   - 5.2 CARBON CONTENT RANGE (percent)...............
   - 5.3 YIELD STRESS RANGE (ksi).....................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)............

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS.................... FULL DEPTH ROLL
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)........ 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS................... BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)..... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi)............... 2235
   - 7.2 HOT LEG INLET TEMPERATURE (deg F)............ 607
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F).......... 541
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)..............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2).............
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)....... 519
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)........ 805
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches)...........
   - 7.9 WATER CHEMISTRY.............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
KOREA NUCLEAR 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION...................
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE...................
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE...................
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING....................................
  9.4 CORROSION FATIGUE..........................
  9.5 EROSION-CORROSION..........................
  9.6 PITTING....................................
  9.7 WASTAGE....................................
  9.8 WEAR.......................................
  9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED.......................
  10.2 TOTAL TUBES SLEEVED.......................
  10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
  11.1

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  11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
KRSKO

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO.......................	KRSKO
1.2	UTILITY....................................	SAVSKE ELEC
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)................	615
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	2/15/81
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	2
2.2	STEAM GENERATOR TYPE.......................	RWE
2.3	STEAM GENERATOR MODEL NO...................	D4
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)................	21.0
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.750
3.3	TUBE WALL THICKNESS (inches)................	.043
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	4674
3.5	TUBE PITCH (inches).........................	1.060
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL..........................	
4.2	TUBE SUPPORT PLATE MATERIAL.................	
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	
4.5	DATE OF TUBE MANUFACTURE....................	
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE.......................	
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS...................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.250,3.312
6.3	PROCESS USED TO FORM BENDS..................	W. BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)..............	
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)......	
7.7	STEAM GENERATOR OPERATING PRESS.(psi).......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches)..........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
KRSKO

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION....................
        8.1.3 U-BEND TRANSITION..................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS..............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No, Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR...................................... YES
    9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED.......................
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
MCGUIRE 1

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	MCGUIRE 1
1.2	UTILITY....................................	DUKE POWER
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)................	1180
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	8/15/81
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	4
2.2	STEAM GENERATOR TYPE.......................	RWE
2.3	STEAM GENERATOR MODEL NO...................	D2
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	21.0
3.2	TUBE OUTSIDE DIAMETER (inches).............	.750
3.3	TUBE WALL THICKNESS (inches)...............	.043
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	4674
3.5	TUBE PITCH (inches)........................	1.060
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	WEST/HUNTINGTON
4.5	DATE OF TUBE MANUFACTURE...................	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.250,3.312
6.3	PROCESS USED TO FORM BENDS.................	WH BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2250
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	618
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	559
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	545
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
MCGUIRE 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION..................... YES
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR..................................... YES
   9.9 OTHER SECONDARY SIDE PROBLEMS............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED........................ 87
   10.2 TOTAL TUBES SLEEVED........................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
MIHAMA 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... MIHAMA 2
   1.2 UTILITY.................................... KANSAI ELECTRIC
   1.3 NSSS SUPPLIER.............................. MHI
   1.4 ELECTRIC POWER RATING (MWE)................ 500
   1.5 THERMAL POWER RATING (MWT)................. 1456
   1.6 DATE OF COMMERCIAL OPERATION............... 4/15/72

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 2
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 44
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WEST/MITSUBISHI
   2.5 DATE OF STEAM GENERATOR COMPLETION......... 11/15/70

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 22.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .870
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3260
   3.5 TUBE PITCH (inches)........................ 1.230
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0080
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 19.30

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. WEST/SUMIT/INCO
   4.5 DATE OF TUBE MANUFACTURE................... 11/15/69

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE...................... 6-10
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. ROLL/HYD. EXP.
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.188;3.47
   6.3 PROCESS USED TO FORM BENDS................. W.BALL/CYL PLST
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2236
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 607
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 553
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 521
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 822
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ EARLY PHOS, AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................ YES
  - 8.1.2 EXPANDED REGION.....................
  - 8.1.3 U-BEND TRANSITION...................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS...............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE................... YES
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION.................... YES
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE................... YES
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION.................... YES
- 9.3 DENTING.................................
- 9.4 CORROSION FATIGUE.......................
- 9.5 EROSION-CORROSION.......................
- 9.6 PITTING.................................
- 9.7 WASTAGE................................. YES
- 9.8 WEAR....................................
- 9.9 OTHER SECONDARY SIDE PROBLEMS...............

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED...................... 377
- 10.2 TOTAL TUBES SLEEVED......................
- 10.3 OTHER (tube expn.,stress relief,peening)... CREVICE HYD. EXPANSION

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
MIHAMA 3

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	MIHAMA 3
1.2	UTILITY....................................	KANSAI ELECTRIC
1.3	NSSS SUPPLIER..............................	MHI
1.4	ELECTRIC POWER RATING (MWE)................	826
1.5	THERMAL POWER RATING (MWT).................	2240
1.6	DATE OF COMMERCIAL OPERATION...............	12/ 1/76
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	MITSUBISHI
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	21.7
3.2	TUBE OUTSIDE DIAMETER (inches).............	.880
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.280
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	FORG.STL.
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	SUMITOMO
4.5	DATE OF TUBE MANUFACTURE...................	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	CYL.PLSTC.MNDRL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2236
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	551
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	531
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	889
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
MIHAMA 3

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................ YES
        8.1.2 EXPANDED REGION..................... YES
        8.1.3 U-BEND TRANSITION..................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS..............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 113
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

    11.2

    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
NORTH ANNA 1

1.	**PLANT DESCRIPTION**	
1.1	PLANT NAME AND UNIT NO......................	NORTH ANNA 1
1.2	UTILITY.....................................	VIRGINIA ELEC.PWR.CO
1.3	NSSS SUPPLIER...............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE).................	934
1.5	THERMAL POWER RATING (MWT)..................	
1.6	DATE OF COMMERCIAL OPERATION................	6/15/78
2.	**STEAM GENERATOR GENERAL INFORMATION**	
2.1	NUMBER OF STEAM GENERATORS..................	3
2.2	STEAM GENERATOR TYPE........................	RWOE
2.3	STEAM GENERATOR MODEL NO....................	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION..........	//
3.	**STEAM GENERATOR DIMENSIONS**	
3.1	TUBESHEET THICKNESS (inches)................	
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.875
3.3	TUBE WALL THICKNESS (inches)................	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	3388
3.5	TUBE PITCH (inches).........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00
4.	**STEAM GENERATOR MATERIALS**	
4.1	TUBESHEET MATERIAL..........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL.................	CS
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	WEST/HUNTINGTON
4.5	DATE OF TUBE MANUFACTURE....................	//
5.	**TUBE MATERIAL PROPERTIES**	
5.1	ASTM GRAIN SIZE RANGE.......................	
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	
6.	**TUBE EXPANSION PARAMETERS**	
6.1	TYPE OF EXPANSION PROCESS...................	ROLL/EXPLOSIVE
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches).......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS..................	WH BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)....	NONE
7.	**STEAM GENERATOR OPERATING PARAMETERS**	
7.1	PRIMARY COOLANT PRESSURE (psi)..............	
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	614
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	547
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)......	525
7.7	STEAM GENERATOR OPERATING PRESS.(psi).......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches)..........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
NORTH ANNA 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION....................
  - 8.1.3 U-BEND TRANSITION.................. YES
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS.............................. YES
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE...................
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION.................... YES
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE...................
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION.................... YES
- 9.3 DENTING.................................. YES(MILD)
- 9.4 CORROSION FATIGUE........................
- 9.5 EROSION-CORROSION........................
- 9.6 PITTING..................................
- 9.7 WASTAGE..................................
- 9.8 WEAR.....................................
- 9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED....................... 284
- 10.2 TOTAL TUBES SLEEVED.......................
- 10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1 U BENDS PLUGGED

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
NORTH ANNA 2

1. PLANT DESCRIPTION
    1.1 PLANT NAME AND UNIT NO...................... NORTH ANNA 2
    1.2 UTILITY.................................... VIRGINIA ELEC.PWR.CO
    1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
    1.4 ELECTRIC POWER RATING (MWE)................. 890
    1.5 THERMAL POWER RATING (MWT)..................
    1.6 DATE OF COMMERCIAL OPERATION................ 8/15/80

2. STEAM GENERATOR GENERAL INFORMATION
    2.1 NUMBER OF STEAM GENERATORS..................
    2.2 STEAM GENERATOR TYPE........................ RWOE
    2.3 STEAM GENERATOR MODEL NO.................... 51
    2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
    2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
    3.1 TUBESHEET THICKNESS (inches)................
    3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
    3.3 TUBE WALL THICKNESS (inches)................ .050
    3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
    3.5 TUBE PITCH (inches)......................... 1.281
    3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
    3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
    4.1 TUBESHEET MATERIAL.......................... SA 508
    4.2 TUBE SUPPORT PLATE MATERIAL................. CS
    4.3 TUBE MATERIAL............................... ALLOY 600
    4.4 TUBE SUPPLIER............................... WESTINGHOUSE
    4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
    5.1 ASTM GRAIN SIZE RANGE.......................
    5.2 CARBON CONTENT RANGE (percent)..............
    5.3 YIELD STRESS RANGE (ksi)....................
    5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
    6.1 TYPE OF EXPANSION PROCESS................... ROLL/EXPLOSIVE
    6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
    6.3 PROCESS USED TO FORM BENDS.................. W. BALL MANDREL
    6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
    7.1 PRIMARY COOLANT PRESSURE (psi)..............
    7.2 HOT LEG INLET TEMPERATURE (deg F)...........
    7.3 COLD LEG OUTLET TEMPERATURE (deg F).........
    7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
    7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
    7.6 STEAM GENERATOR OPERATING TEMP.(deg F)......
    7.7 STEAM GENERATOR OPERATING PRESS.(psi).......
    7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
    7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
NORTH ANNA 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING.................................. YES(MINOR)
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR.....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 284
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1 U BENDS PLUGGED

11. NOTES
   11.1

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   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
OBRIGHEIM(ORIG SG)

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... OBRIGHEIM(ORIG SG)
   1.2 UTILITY.................................... KWO
   1.3 NSSS SUPPLIER.............................. SIEMENS
   1.4 ELECTRIC POWER RATING (MWE)................ 345
   1.5 THERMAL POWER RATING (MWT)................. 1050
   1.6 DATE OF COMMERCIAL OPERATION............... 3/15/69

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 2
   2.2 STEAM GENERATOR TYPE.......................
   2.3 STEAM GENERATOR MODEL NO...................
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 27.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .866
   3.3 TUBE WALL THICKNESS (inches)............... .047
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 2605
   3.5 TUBE PITCH (inches)........................
   3.6 TUBESHEET RADIAL CREVICE (inches)..........
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.........................
   4.2 TUBE SUPPORT PLATE MATERIAL................ SS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. MANNESMANN
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE...................... 9-10
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. 3 PART.ROLLS
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)......
   6.3 PROCESS USED TO FORM BENDS.................
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)...

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2146
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 594
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 541
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............ 80808
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)........... 40404
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 516
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 798
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)......... TO 10
   7.9 WATER CHEMISTRY............................ AVT ONLY (?)

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
OBRIGHEIM(ORIG SG)

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................ YES
        8.1.2 EXPANDED REGION....................
        8.1.3 U-BEND TRANSITION................... YES
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED..... YES
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION.................. YES
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 273
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

    11.2

    11.3

    11.4

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
OHI 1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... OHI 1
   1.2 UTILITY..................................... KANSAI ELECTRIC
   1.3 NSSS SUPPLIER............................... WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................. 1175
   1.5 THERMAL POWER RATING (MWT).................. 3423
   1.6 DATE OF COMMERCIAL OPERATION................ 3/27/79

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 4
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51A
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .870
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.280
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... WEST/HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE....................... 8-10
   5.2 CARBON CONTENT RANGE (percent).............. .01-.04
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... FULL DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS.................. WH BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2236
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 615
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 550
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 533
   7.7 STEAM GENERATOR OPERATING PRESS.(psi).......
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
   7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
OHI 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................ YES
      8.1.2 EXPANDED REGION.................... YES
      8.1.3 U-BEND TRANSITION.................. YES
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION.................... YES
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION.................... YES
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR.....................................
   9.9 OTHER SECONDARY SIDE PROBLEMS............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED...................... 1216
   10.2 TOTAL TUBES SLEEVED......................
   10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1&2 UB PLUGGED

11. NOTES
   11.1

   11.2

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
OHI 2

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO......................	OHI 2
1.2	UTILITY....................................	KANSAI ELECTRIC
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)................	1175
1.5	THERMAL POWER RATING (MWT).................	3436
1.6	DATE OF COMMERCIAL OPERATION...............	12/ 5/79

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS.................	4
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51A
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	MITSUBISHI
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)...............	21.7
3.2	TUBE OUTSIDE DIAMETER (inches).............	.880
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.280
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL.........................	FORG.STL.
4.2	TUBE SUPPORT PLATE MATERIAL................	CS
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	SUMITOMO
4.5	DATE OF TUBE MANUFACTURE...................	//

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS..................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	CYL.PLSTC.MNDRL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi).............	2236
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	615
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	550
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	533
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
OHI 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   - 8.1 PRIMARY SIDE IGSCC
     - 8.1.1 EXPANSION TRANSITION................ YES
     - 8.1.2 EXPANDED REGION..................... YES
     - 8.1.3 U-BEND TRANSITION...................
     - 8.1.4 U-BEND APEX-DENTING RELATED.........
     - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
     - 8.1.6 TSP INTERSECTION-DENTING RELATED....
     - 8.1.7 PLUGS...............................
   - 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   - 9.1 SECONDARY SIDE IGSCC
     - 9.1.1 EXPANSION TRANSITION................
     - 9.1.2 TUBESHEET CREVICE...................
     - 9.1.3 SLUDGE PILE REGION..................
     - 9.1.4 TSP INTERSECTION....................
   - 9.2 INTERGRANULAR ATTACK (IGA)
     - 9.2.1 EXPANSION TRANSITION................
     - 9.2.2 TUBESHEET CREVICE...................
     - 9.2.3 SLUDGE PILE REGION..................
     - 9.2.4 TSP INTERSECTION....................
   - 9.3 DENTING...................................
   - 9.4 CORROSION FATIGUE.........................
   - 9.5 EROSION-CORROSION.........................
   - 9.6 PITTING...................................
   - 9.7 WASTAGE...................................
   - 9.8 WEAR......................................
   - 9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    - 10.1 TOTAL TUBES PLUGGED....................... 84
    - 10.2 TOTAL TUBES SLEEVED.......................
    - 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    - 11.1
    - 11.2
    - 11.3
    - 11.4
    - 11.5
    - 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
POINT BEACH 1 (ORIG.SG)

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO..................... POINT BEACH 1 (ORIG.SG)
   1.2 UTILITY.................................... WISCONSIN ELECTRIC
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 497
   1.5 THERMAL POWER RATING (MWT)................. 1519
   1.6 DATE OF COMMERCIAL OPERATION............... 12/15/70

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 2
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 44
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 22.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3260
   3.5 TUBE PITCH (inches)........................ 1.234
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0070
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 20.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... MN,MO
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE...................... 6
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.188,3.47
   6.3 PROCESS USED TO FORM BENDS................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 611
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 555
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............ 102000
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 500
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 720
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ TO CY 3 PHOS, AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
POINT BEACH 1 (ORIG.SG)

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION....................
      8.1.3 U-BEND TRANSITION..................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS.............................. YES
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE.................... YES
      9.1.3 SLUDGE PILE REGION.................. YES
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE.................... YES
      9.2.3 SLUDGE PILE REGION.................. YES
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING...................................
   9.4 CORROSION FATIGUE.........................
   9.5 EROSION-CORROSION.........................
   9.6 PITTING...................................
   9.7 WASTAGE................................... YES
   9.8 WEAR......................................
   9.9 OTHER SECONDARY SIDE PROBLEMS.............. FOREIGN OBJECTS

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 895
   10.2 TOTAL TUBES SLEEVED....................... 12-12/83
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
POINT BEACH 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... POINT BEACH 2
   1.2 UTILITY..................................... WISCONSIN ELECTRIC
   1.3 NSSS SUPPLIER............................... WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................. 497
   1.5 THERMAL POWER RATING (MWT).................. 1519
   1.6 DATE OF COMMERCIAL OPERATION................ 10/15/72

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 2
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 44
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 22.0
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3260
   3.5 TUBE PITCH (inches)......................... 1.234
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0070
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 20.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... MN,MO
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE....................... 6
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.188,3.47
   6.3 PROCESS USED TO FORM BENDS.................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 611
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 555
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............. 102000
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 516
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)....... 790
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).......... 2.00
   7.9 WATER CHEMISTRY............................. CY1 PHOS, AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION.....................
  - 8.1.3 U-BEND TRANSITION...................
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS...............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE................... YES
  - 9.1.3 SLUDGE PILE REGION.................. YES
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE................... YES
  - 9.2.3 SLUDGE PILE REGION.................. YES
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING....................................
- 9.4 CORROSION FATIGUE..........................
- 9.5 EROSION-CORROSION..........................
- 9.6 PITTING....................................
- 9.7 WASTAGE.................................... YES
- 9.8 WEAR.......................................
- 9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED........................ 133
- 10.2 TOTAL TUBES SLEEVED........................ 4150-12/83
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
PRAIRE ISLAND 1

1.	**PLANT DESCRIPTION**	
1.1	PLANT NAME AND UNIT NO.	PRAIRE ISLAND 1
1.2	UTILITY	NORTHERN STATES PWR
1.3	NSSS SUPPLIER	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)	530
1.5	THERMAL POWER RATING (MWT)	1650
1.6	DATE OF COMMERCIAL OPERATION	12/15/73
2.	**STEAM GENERATOR GENERAL INFORMATION**	
2.1	NUMBER OF STEAM GENERATORS	2
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION	//
3.	**STEAM GENERATOR DIMENSIONS**	
3.1	TUBESHEET THICKNESS (inches)	21.0
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3388
3.5	TUBE PITCH (inches)	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)	.0060
3.7	DEPTH OF TUBESHEET CREVICE (inches)	18.00
4.	**STEAM GENERATOR MATERIALS**	
4.1	TUBESHEET MATERIAL	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL	CS
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	WEST/HUNTINGTON
4.5	DATE OF TUBE MANUFACTURE	//
5.	**TUBE MATERIAL PROPERTIES**	
5.1	ASTM GRAIN SIZE RANGE	
5.2	CARBON CONTENT RANGE (percent)	
5.3	YIELD STRESS RANGE (ksi)	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	
6.	**TUBE EXPANSION PARAMETERS**	
6.1	TYPE OF EXPANSION PROCESS	ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS	WH BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7.	**STEAM GENERATOR OPERATING PARAMETERS**	
7.1	PRIMARY COOLANT PRESSURE (psi)	2240
7.2	HOT LEG INLET TEMPERATURE (deg F)	599
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)	530
7.7	STEAM GENERATOR OPERATING PRESS.(psi)	710
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	
7.9	WATER CHEMISTRY	EARLY PHOS, AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
- 8.1 PRIMARY SIDE IGSCC
  - 8.1.1 EXPANSION TRANSITION................
  - 8.1.2 EXPANDED REGION.....................
  - 8.1.3 U-BEND TRANSITION................... YES
  - 8.1.4 U-BEND APEX-DENTING RELATED.........
  - 8.1.5 U-BEND APEX-NOT DENTING RELATED.....
  - 8.1.6 TSP INTERSECTION-DENTING RELATED....
  - 8.1.7 PLUGS...............................
- 8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
- 9.1 SECONDARY SIDE IGSCC
  - 9.1.1 EXPANSION TRANSITION................
  - 9.1.2 TUBESHEET CREVICE...................
  - 9.1.3 SLUDGE PILE REGION..................
  - 9.1.4 TSP INTERSECTION....................
- 9.2 INTERGRANULAR ATTACK (IGA)
  - 9.2.1 EXPANSION TRANSITION................
  - 9.2.2 TUBESHEET CREVICE................... YES
  - 9.2.3 SLUDGE PILE REGION..................
  - 9.2.4 TSP INTERSECTION....................
- 9.3 DENTING...................................
- 9.4 CORROSION FATIGUE.........................
- 9.5 EROSION-CORROSION.........................
- 9.6 PITTING...................................
- 9.7 WASTAGE................................... YES (TSP)
- 9.8 WEAR...................................... YES (TSP)
- 9.9 OTHER SECONDARY SIDE PROBLEMS.............. FOREIGN OBJECT

10. INSERVICE REMEDIAL MEASURES
- 10.1 TOTAL TUBES PLUGGED....................... 34
- 10.2 TOTAL TUBES SLEEVED.......................
- 10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
- 11.1
- 11.2
- 11.3
- 11.4
- 11.5
- 11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
PRARIE ISLAND 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... PRARIE ISLAND 2
   1.2 UTILITY..................................... NORTHERN STATES PWR
   1.3 NSSS SUPPLIER............................... WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................. 530
   1.5 THERMAL POWER RATING (MWT).................. 1650
   1.6 DATE OF COMMERCIAL OPERATION................ 12/15/74

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 2
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... SA 508
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... WEST/HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE....................... 8-9
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS.................. WH BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2240
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 599
   7.3 COLD LEG OUTLET TEMPERATURE (deg F).........
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 511
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 710
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
   7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
PRARIE ISLAND 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION...................
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE...................
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE...................
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING.................................
  9.4 CORROSION FATIGUE.......................
  9.5 EROSION-CORROSION.......................
  9.6 PITTING.................................
  9.7 WASTAGE................................. YES (TSP)
  9.8 WEAR.................................... YES (TSP)
  9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED...................... 84
  10.2 TOTAL TUBES SLEEVED......................
  10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
  11.1

  11.2

  11.3

  11.4

  11.5

  11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
RINGHALS 2

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO. .... RINGHALS 2
   - 1.2 UTILITY .... SWED. STATE POWER BD
   - 1.3 NSSS SUPPLIER .... WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE) 820
   - 1.5 THERMAL POWER RATING (MWT) 2432
   - 1.6 DATE OF COMMERCIAL OPERATION 5/15/74

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS 2
   - 2.2 STEAM GENERATOR TYPE .... RWOE
   - 2.3 STEAM GENERATOR MODEL NO. 51C
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION ....
   - 2.5 DATE OF STEAM GENERATOR COMPLETION .... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches) 21.0
   - 3.2 TUBE OUTSIDE DIAMETER (inches) .... .875
   - 3.3 TUBE WALL THICKNESS (inches) .... .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR 3388
   - 3.5 TUBE PITCH (inches) 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches) .... .0060
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches) 18.75

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL .... FORG.STL.
   - 4.2 TUBE SUPPORT PLATE MATERIAL .... SA 508
   - 4.3 TUBE MATERIAL .... ALLOY 600
   - 4.4 TUBE SUPPLIER .... WESTINGHOUSE
   - 4.5 DATE OF TUBE MANUFACTURE .... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE 8-10
   - 5.2 CARBON CONTENT RANGE (percent) .... .03-.05
   - 5.3 YIELD STRESS RANGE (ksi) ....
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F) .... 1875Furn,1775 Tube

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS .... PART DEPTH ROLL
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches) 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS .... W BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F) ... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi) 2235
   - 7.2 HOT LEG INLET TEMPERATURE (deg F) 616
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F) 558
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2) ....
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2) ....
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F) 528
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi) 855
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches) 1.1
   - 7.9 WATER CHEMISTRY .... 6 MO PHOS LO PWR,AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
RINGHALS 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................ YES
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION................... YES
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE................... YES
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE................... YES
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING.................................
  9.4 CORROSION FATIGUE.......................
  9.5 EROSION-CORROSION.......................
  9.6 PITTING.................................
  9.7 WASTAGE.................................
  9.8 WEAR....................................
  9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED........................ 300
  10.2 TOTAL TUBES SLEEVED........................
  10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1 U BENDS PLUGGED

11. NOTES
  11.1

  11.2

  11.3

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  11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
RINGHALS 3

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... RINGHALS 3
   - 1.2 UTILITY.................................... SSPB
   - 1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE)................ 900
   - 1.5 THERMAL POWER RATING (MWT).................
   - 1.6 DATE OF COMMERCIAL OPERATION................ 4/15/81

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS.................. 3
   - 2.2 STEAM GENERATOR TYPE........................ RWE
   - 2.3 STEAM GENERATOR MODEL NO.................... D3
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   - 2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)................ 21.0
   - 3.2 TUBE OUTSIDE DIAMETER (inches).............. .750
   - 3.3 TUBE WALL THICKNESS (inches)................ .043
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 4674
   - 3.5 TUBE PITCH (inches)......................... 1.060
   - 3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL..........................
   - 4.2 TUBE SUPPORT PLATE MATERIAL.................
   - 4.3 TUBE MATERIAL............................... ALLOY 600
   - 4.4 TUBE SUPPLIER............................... WESTINGHOUSE
   - 4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE....................... 8-9
   - 5.2 CARBON CONTENT RANGE (percent)..............
   - 5.3 YIELD STRESS RANGE (ksi)....................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)........... 1875 Furn.,1775 Tube

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS................... F.D.ROLL/DAM
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.250,3.312
   - 6.3 PROCESS USED TO FORM BENDS.................. W. BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi).............. 2250
   - 7.2 HOT LEG INLET TEMPERATURE (deg F)........... 618
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 553
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 547
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)......
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches).......... 0.25
   - 7.9 WATER CHEMISTRY............................. AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION..................... YES-BY ECT
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR...................................... YES(PREHEATER)
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED.......................
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
ROBINSON 2 (ORIG SG)

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO....................... ROBINSON 2 (ORIG SG)
   - 1.2 UTILITY.. CAROLINA P&L
   - 1.3 NSSS SUPPLIER.................................. WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE).................. 770
   - 1.5 THERMAL POWER RATING (MWT)................... 2300
   - 1.6 DATE OF COMMERCIAL OPERATION................ 3/15/71

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS.................. 3
   - 2.2 STEAM GENERATOR TYPE........................ RWOE
   - 2.3 STEAM GENERATOR MODEL NO.................... 44
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   - 2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)................ 22.0
   - 3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   - 3.3 TUBE WALL THICKNESS (inches)................ .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3260
   - 3.5 TUBE PITCH (inches)......................... 1.234
   - 3.6 TUBESHEET RADIAL CREVICE (inches)........... .0070
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL.......................... MN,MO
   - 4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   - 4.3 TUBE MATERIAL............................... ALLOY 600
   - 4.4 TUBE SUPPLIER............................... HUNTINGTON
   - 4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE....................... 5
   - 5.2 CARBON CONTENT RANGE (percent).............
   - 5.3 YIELD STRESS RANGE (ksi).................... 48
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS................... PART DEPTH ROLL
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.188,3.47
   - 6.3 PROCESS USED TO FORM BENDS.................. H BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi).............. 2235
   - 7.2 HOT LEG INLET TEMPERATURE (deg F)........... 604
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 546
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............ 104000
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 518
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 786
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches)......... 11-22
   - 7.9 WATER CHEMISTRY............................. PHOSPHATE

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
ROBINSON 2 (ORIG SG)

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE................... YES
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE................... YES
        9.2.3 SLUDGE PILE REGION.................. YES
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE................................... YES
    9.8 WEAR...................................... YES
    9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED........................ 360
    10.2 TOTAL TUBES SLEEVED........................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SALEM 1

1. PLANT DESCRIPTION
    1.1 PLANT NAME AND UNIT NO...................... SALEM 1
    1.2 UTILITY...................................... PUBLIC SERVICE E&G
    1.3 NSSS SUPPLIER................................ WESTINGHOUSE
    1.4 ELECTRIC POWER RATING (MWE).................. 1090
    1.5 THERMAL POWER RATING (MWT)...................
    1.6 DATE OF COMMERCIAL OPERATION................. 12/15/76

2. STEAM GENERATOR GENERAL INFORMATION
    2.1 NUMBER OF STEAM GENERATORS................... 4
    2.2 STEAM GENERATOR TYPE......................... RWOE
    2.3 STEAM GENERATOR MODEL NO..................... 51
    2.4 STEAM GENERATOR FABRICATOR/LOCATION.......... WESTINGHOUSE
    2.5 DATE OF STEAM GENERATOR COMPLETION........... //

3. STEAM GENERATOR DIMENSIONS
    3.1 TUBESHEET THICKNESS (inches)................. 21.0
    3.2 TUBE OUTSIDE DIAMETER (inches)............... .875
    3.3 TUBE WALL THICKNESS (inches)................. .050
    3.4 NUMBER OF TUBES PER STEAM GENERATOR.......... 3388
    3.5 TUBE PITCH (inches).......................... 1.281
    3.6 TUBESHEET RADIAL CREVICE (inches)............ .0000
    3.7 DEPTH OF TUBESHEET CREVICE (inches).......... 00.00

4. STEAM GENERATOR MATERIALS
    4.1 TUBESHEET MATERIAL........................... SA 508
    4.2 TUBE SUPPORT PLATE MATERIAL.................. CS
    4.3 TUBE MATERIAL................................ ALLOY 600
    4.4 TUBE SUPPLIER................................ WEST/HUNTINGTON
    4.5 DATE OF TUBE MANUFACTURE..................... //

5. TUBE MATERIAL PROPERTIES
    5.1 ASTM GRAIN SIZE RANGE........................ 7.5
    5.2 CARBON CONTENT RANGE (percent)...............
    5.3 YIELD STRESS RANGE (ksi).....................
    5.4 MILL ANNEAL TIME/TEMP (min/deg F)............

6. TUBE EXPANSION PARAMETERS
    6.1 TYPE OF EXPANSION PROCESS.................... ROLL/EXPLOSIVE
    6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)........ 2.1875,3.4685
    6.3 PROCESS USED TO FORM BENDS................... WH BALL MANDREL
    6.4 STRESS RELIEF AFTER TUBING (hours/deg F)..... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
    7.1 PRIMARY COOLANT PRESSURE (psi)............... 2235
    7.2 HOT LEG INLET TEMPERATURE (deg F)............ 609
    7.3 COLD LEG OUTLET TEMPERATURE (deg F).......... 544
    7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)..............
    7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2).............
    7.6 STEAM GENERATOR OPERATING TEMP.(deg F)....... 576
    7.7 STEAM GENERATOR OPERATING PRESS.(psi)........ 790
    7.8 TYPICAL SLUDGE PILE DEPTH (inches)........... 0.25
    7.9 WATER CHEMISTRY.............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SALEM 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING................................... YES(MILD)
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE................................... YES
    9.8 WEAR...................................... YES
    9.9 OTHER SECONDARY SIDE PROBLEMS.............. TLBD DAMAGE

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 101
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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    11.4

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SALEM 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... SALEM 2
   1.2 UTILITY..................................... PUBLIC SERVICE E&G
   1.3 NSSS SUPPLIER............................... WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................. 1090
   1.5 THERMAL POWER RATING (MWT)..................
   1.6 DATE OF COMMERCIAL OPERATION................ 10/15/81

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 4
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .005
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... SA 508
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... WEST/HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE.......................
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... ROLL/EXPLOSIVE
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS.................. WH BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)..............
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 611
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 545
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 519
   7.7 STEAM GENERATOR OPERATING PRESS.(psi).......
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).......... 0.25
   7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SALEM 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR..................................... YES
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED.......................
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

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   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SAN ONOFRE 1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... SAN ONOFRE 1
   1.2 UTILITY.................................. SOUTH CAL EDISON
   1.3 NSSS SUPPLIER............................ WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 436
   1.5 THERMAL POWER RATING (MWT)................. 1347
   1.6 DATE OF COMMERCIAL OPERATION............... 1/15/68

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 3
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 27
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 22.6
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .750
   3.3 TUBE WALL THICKNESS (inches)................ .055
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3794
   3.5 TUBE PITCH (inches)........................ 1.026
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0115
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG. STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE......................
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)......
   6.3 PROCESS USED TO FORM BENDS................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2050
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 575
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 528
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............ 108000
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 505
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 600
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)......... 18
   7.9 WATER CHEMISTRY............................ PHOSPHATE (BRIEF AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION...................
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE................... YES
    9.1.3 SLUDGE PILE REGION.................. YES
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE................... YES
    9.2.3 SLUDGE PILE REGION.................. YES
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING.................................... YES
  9.4 CORROSION FATIGUE..........................
  9.5 EROSION-CORROSION..........................
  9.6 PITTING....................................
  9.7 WASTAGE.................................... YES
  9.8 WEAR....................................... YES
  9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED....................... 954
  10.2 TOTAL TUBES SLEEVED....................... 7000-12/83
  10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
  11.1

  11.2

  11.3

  11.4

  11.5

  11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SEQUOYAH 1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... SEQUOYAH 1
   1.2 UTILITY..................................... TVA
   1.3 NSSS SUPPLIER............................... WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................. 1148
   1.5 THERMAL POWER RATING (MWT).................. 3411
   1.6 DATE OF COMMERCIAL OPERATION................ 5/15/81

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 4
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .852
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.233
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... WESTINGHOUSE
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE.......................
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... ROLL/EXPLOSIVE
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS.................. W BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 614
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 546
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............ 39762
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 526
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)....... 857
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).......... 2.0
   7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SEQUOYAH 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION................... YES
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING.................................. YES
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED.......................
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SEQUOYAH 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... SEQUOYAH 2
   1.2 UTILITY...................................... TVA
   1.3 NSSS SUPPLIER................................ WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE).................. 1148
   1.5 THERMAL POWER RATING (MWT)................... 3411
   1.6 DATE OF COMMERCIAL OPERATION................. 6/ 1/82

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................... 4
   2.2 STEAM GENERATOR TYPE......................... RWOE
   2.3 STEAM GENERATOR MODEL NO..................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION.......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION........... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................. 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............... .875
   3.3 TUBE WALL THICKNESS (inches)................. .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR.......... 3388
   3.5 TUBE PITCH (inches).......................... 1.233
   3.6 TUBESHEET RADIAL CREVICE (inches)............ .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches).......... 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL........................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL.................. CS
   4.3 TUBE MATERIAL................................ ALLOY 600
   4.4 TUBE SUPPLIER................................ WEST/HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE..................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE........................
   5.2 CARBON CONTENT RANGE (percent)...............
   5.3 YIELD STRESS RANGE (ksi).....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)............

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................... ROLL/EXPLOSIVE
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)........ 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS................... WH BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)..... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............... 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F)............ 614
   7.3 COLD LEG OUTLET TEMPERATURE (deg F).......... 546
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)..............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............. 39762
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)....... 526
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)........ 857
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)...........
   7.9 WATER CHEMISTRY.............................. AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED...................... 1
    10.2 TOTAL TUBES SLEEVED......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SUMMER

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	SUMMER
1.2	UTILITY....................................	S.C. PUBLIC SERVICE
1.3	NSSS SUPPLIER..............................	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE).................	900
1.5	THERMAL POWER RATING (MWT)..................	
1.6	DATE OF COMMERCIAL OPERATION................	1/15/84
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS..................	3
2.2	STEAM GENERATOR TYPE........................	RWE
2.3	STEAM GENERATOR MODEL NO....................	D3
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	WESTINGHOUSE
2.5	DATE OF STEAM GENERATOR COMPLETION..........	
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)................	21.0
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.750
3.3	TUBE WALL THICKNESS (inches)................	.043
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	4674
3.5	TUBE PITCH (inches).........................	1.060
3.6	TUBESHEET RADIAL CREVICE (inches)...........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL..........................	SA 508
4.2	TUBE SUPPORT PLATE MATERIAL.................	CS
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE....................	
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE.......................	
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS...................	FULL DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.25,3.312
6.3	PROCESS USED TO FORM BENDS..................	W. BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)..............	2250
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	619
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	556
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	547
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SUMMER

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION..................... YES
        8.1.3 U-BEND TRANSITION.................. YES
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED......................
    10.2 TOTAL TUBES SLEEVED......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SURRY 1 (ORIG SG)

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO..................... SURRY 1 (ORIG SG)
   1.2 UTILITY.................................... VIRGINIA ELEC.PWR.CO
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 816
   1.5 THERMAL POWER RATING (MWT)................. 2441
   1.6 DATE OF COMMERCIAL OPERATION............... 12/15/72

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 3
   2.2 STEAM GENERATOR TYPE....................... RWE
   2.3 STEAM GENERATOR MODEL NO................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   3.5 TUBE PITCH (inches)........................ 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... SA 508
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE...................... 8-12
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 590
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 536
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............ 115000
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 516
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 770
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ EARLY PHOS, AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
SURRY 2 (ORIG SG)

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... SURRY 2 (ORIG SG)
   1.2 UTILITY.................................... VIRGINIA ELEC PWR CO
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 816
   1.5 THERMAL POWER RATING (MWT)................. 2441
   1.6 DATE OF COMMERCIAL OPERATION............... 5/15/73

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 3
   2.2 STEAM GENERATOR TYPE....................... RWE
   2.3 STEAM GENERATOR MODEL NO................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   3.5 TUBE PITCH (inches)........................ 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG. STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. WEST/HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE......................
   5.2 CARBON CONTENT RANGE (percent).............
   5.3 YIELD STRESS RANGE (ksi)...................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F).......... 1750-1800(tubes)

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS................. WH BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2485
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 606
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 543
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 565
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 770
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   7.9 WATER CHEMISTRY............................ EARLY PHOS, AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION...................
    8.1.4 U-BEND APEX-DENTING RELATED......... YES
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED.... YES
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE...................
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE...................
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION....................
  9.3 DENTING.................................... YES
  9.4 CORROSION FATIGUE..........................
  9.5 EROSION-CORROSION..........................
  9.6 PITTING....................................
  9.7 WASTAGE.................................... YES
  9.8 WEAR.......................................
  9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED........................ 1834
  10.2 TOTAL TUBES SLEEVED........................
  10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TAKAHAMA 1

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... TAKAHAMA 1
   - 1.2 UTILITY.................................... KANSAI ELECTRIC
   - 1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE)................ 826
   - 1.5 THERMAL POWER RATING (MWT)................. 2440
   - 1.6 DATE OF COMMERCIAL OPERATION............... 3/15/74

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS................. 3
   - 2.2 STEAM GENERATOR TYPE....................... RWOE
   - 2.3 STEAM GENERATOR MODEL NO................... 51
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   - 2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)............... 21.0
   - 3.2 TUBE OUTSIDE DIAMETER (inches)............. .870
   - 3.3 TUBE WALL THICKNESS (inches)............... .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   - 3.5 TUBE PITCH (inches)........................ 1.280
   - 3.6 TUBESHEET RADIAL CREVICE (inches).......... .0080
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.70

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL......................... FORG.STL.
   - 4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   - 4.3 TUBE MATERIAL.............................. ALLOY 600
   - 4.4 TUBE SUPPLIER.............................. WEST/HUNTINGTON
   - 4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE...................... 8-10
   - 5.2 CARBON CONTENT RANGE (percent)............. .03
   - 5.3 YIELD STRESS RANGE (ksi)...................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS.................. ROLL,HYD.EXP.
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS................. WH BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi)............. 2236
   - 7.2 HOT LEG INLET TEMPERATURE (deg F).......... 613
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 551
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 531
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 889
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   - 7.9 WATER CHEMISTRY............................ EARLY PHOS, AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION................... YES
        8.1.4 U-BEND APEX-DENTING RELATED......... YES
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED.... YES
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING.................................... YES (SEVERE)
    9.4 CORROSION FATIGUE..........................
    9.5 EROSION-CORROSION..........................
    9.6 PITTING....................................
    9.7 WASTAGE.................................... YES
    9.8 WEAR.......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 1924
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TAKAHAMA 2

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... TAKAHAMA 2
   1.2 UTILITY..................................... KANSAI ELECTRIC
   1.3 NSSS SUPPLIER............................... MHI
   1.4 ELECTRIC POWER RATING (MWE)................. 826
   1.5 THERMAL POWER RATING (MWT).................. 2440
   1.6 DATE OF COMMERCIAL OPERATION................ 11/15/75

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 3
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... MITSUBISHI
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 21.7
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .880
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.280
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0080
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 18.70

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... FORG.STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... SUMITOMO
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE....................... 8-9
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... ROLL/HYD.EXP.
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS.................. CYL.PLSTC.MNDRL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2236
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 613
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 551
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 530
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)....... 889
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
   7.9 WATER CHEMISTRY............................. AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TAKAHAMA 1

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................. YES
    8.1.2 EXPANDED REGION.....................
    8.1.3 U-BEND TRANSITION................... YES
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE................... YES
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION.................... YES-1 TUBE
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE................... YES
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION.................... YES-1 TUBE
  9.3 DENTING.....................................
  9.4 CORROSION FATIGUE...........................
  9.5 EROSION-CORROSION...........................
  9.6 PITTING.....................................
  9.7 WASTAGE..................................... YES
  9.8 WEAR..
  9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED........................ 502
  10.2 TOTAL TUBES SLEEVED........................
  10.3 OTHER (tube expn.,stress relief,peening)... ROW1 UB PLUG,CREV HYD EXP

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TIHANGE 1

1. PLANT DESCRIPTION

1.1	PLANT NAME AND UNIT NO......................	TIHANGE 1
1.2	UTILITY.....................................	SEMO
1.3	NSSS SUPPLIER...............................	ACLF
1.4	ELECTRIC POWER RATING (MWE).................	880
1.5	THERMAL POWER RATING (MWT)..................	
1.6	DATE OF COMMERCIAL OPERATION................	9/15/75

2. STEAM GENERATOR GENERAL INFORMATION

2.1	NUMBER OF STEAM GENERATORS..................	3
2.2	STEAM GENERATOR TYPE........................	RWOE
2.3	STEAM GENERATOR MODEL NO....................	51
2.4	STEAM GENERATOR FABRICATOR/LOCATION.........	COCKERILL
2.5	DATE OF STEAM GENERATOR COMPLETION..........	//

3. STEAM GENERATOR DIMENSIONS

3.1	TUBESHEET THICKNESS (inches)................	
3.2	TUBE OUTSIDE DIAMETER (inches)..............	.875
3.3	TUBE WALL THICKNESS (inches)................	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR.........	3388
3.5	TUBE PITCH (inches).........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)...........	
3.7	DEPTH OF TUBESHEET CREVICE (inches).........	

4. STEAM GENERATOR MATERIALS

4.1	TUBESHEET MATERIAL..........................	
4.2	TUBE SUPPORT PLATE MATERIAL.................	CS
4.3	TUBE MATERIAL...............................	ALLOY 600
4.4	TUBE SUPPLIER...............................	SANDVIK
4.5	DATE OF TUBE MANUFACTURE....................	//

5. TUBE MATERIAL PROPERTIES

5.1	ASTM GRAIN SIZE RANGE.......................	7-10
5.2	CARBON CONTENT RANGE (percent)..............	
5.3	YIELD STRESS RANGE (ksi)....................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)...........	

6. TUBE EXPANSION PARAMETERS

6.1	TYPE OF EXPANSION PROCESS...................	PART DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches).......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS..................	NO MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	NONE

7. STEAM GENERATOR OPERATING PARAMETERS

7.1	PRIMARY COOLANT PRESSURE (psi)..............	
7.2	HOT LEG INLET TEMPERATURE (deg F)...........	611
7.3	COLD LEG OUTLET TEMPERATURE (deg F).........	
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2).............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)............	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)......	
7.7	STEAM GENERATOR OPERATING PRESS.(psi).......	
7.8	TYPICAL SLUDGE PILE DEPTH (inches)..........	
7.9	WATER CHEMISTRY.............................	AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION.................... YES
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION.................... YES
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 599
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)... CREVICE HYDRAULIC EXPAN.

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TIHANGE 2

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO.	TIHANGE 2
1.2	UTILITY	EBES
1.3	NSSS SUPPLIER	FRAMACECO
1.4	ELECTRIC POWER RATING (MWE)	900
1.5	THERMAL POWER RATING (MWT)	
1.6	DATE OF COMMERCIAL OPERATION	2/15/83
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS	3
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO.	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION	COCKERILL
2.5	DATE OF STEAM GENERATOR COMPLETION	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)	
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3388
3.5	TUBE PITCH (inches)	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL	
4.2	TUBE SUPPORT PLATE MATERIAL	CS
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	WESTINGHOUSE
4.5	DATE OF TUBE MANUFACTURE	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE	7-11
5.2	CARBON CONTENT RANGE (percent)	
5.3	YIELD STRESS RANGE (ksi)	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	SG1&2-1925,SG3-1875F
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS	F.D. ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS	NO MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)	
7.2	HOT LEG INLET TEMPERATURE (deg F)	617
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)	
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	
7.9	WATER CHEMISTRY	AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION.................. YES,SULFUR
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING..................................
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE..................................
   9.8 WEAR..................................... YES
   9.9 OTHER SECONDARY SIDE PROBLEMS............. OD SUL ATT, FOR OBJS

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 120
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TRICASTIN 1

1. PLANT DESCRIPTION	
1.1 PLANT NAME AND UNIT NO.	TRICASTIN 1
1.2 UTILITY	EDF
1.3 NSSS SUPPLIER	FRAMATOME
1.4 ELECTRIC POWER RATING (MWE)	900
1.5 THERMAL POWER RATING (MWT)	
1.6 DATE OF COMMERCIAL OPERATION	8/14/80
2. STEAM GENERATOR GENERAL INFORMATION	
2.1 NUMBER OF STEAM GENERATORS	
2.2 STEAM GENERATOR TYPE	RWOE
2.3 STEAM GENERATOR MODEL NO.	51M
2.4 STEAM GENERATOR FABRICATOR/LOCATION	
2.5 DATE OF STEAM GENERATOR COMPLETION	//
3. STEAM GENERATOR DIMENSIONS	
3.1 TUBESHEET THICKNESS (inches)	
3.2 TUBE OUTSIDE DIAMETER (inches)	.875
3.3 TUBE WALL THICKNESS (inches)	.050
3.4 NUMBER OF TUBES PER STEAM GENERATOR	3388
3.5 TUBE PITCH (inches)	1.281
3.6 TUBESHEET RADIAL CREVICE (inches)	.0000
3.7 DEPTH OF TUBESHEET CREVICE (inches)	00.00
4. STEAM GENERATOR MATERIALS	
4.1 TUBESHEET MATERIAL	
4.2 TUBE SUPPORT PLATE MATERIAL	
4.3 TUBE MATERIAL	ALLOY 600
4.4 TUBE SUPPLIER	VALLOUREC
4.5 DATE OF TUBE MANUFACTURE	
5. TUBE MATERIAL PROPERTIES	
5.1 ASTM GRAIN SIZE RANGE	
5.2 CARBON CONTENT RANGE (percent)	
5.3 YIELD STRESS RANGE (ksi)	
5.4 MILL ANNEAL TIME/TEMP (min/deg F)	
6. TUBE EXPANSION PARAMETERS	
6.1 TYPE OF EXPANSION PROCESS	F.D.ROLL/DAM
6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)	2.1875,3.4685
6.3 PROCESS USED TO FORM BENDS	
6.4 STRESS RELIEF AFTER TUBING (hours/deg F)	
7. STEAM GENERATOR OPERATING PARAMETERS	
7.1 PRIMARY COOLANT PRESSURE (psi)	2248
7.2 HOT LEG INLET TEMPERATURE (deg F)	613
7.3 COLD LEG OUTLET TEMPERATURE (deg F)	546
7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)	
7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6 STEAM GENERATOR OPERATING TEMP.(deg F)	
7.7 STEAM GENERATOR OPERATING PRESS.(psi)	840
7.8 TYPICAL SLUDGE PILE DEPTH (inches)	
7.9 WATER CHEMISTRY	AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................ YES
      8.1.2 EXPANDED REGION..................... YES
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING...................................
   9.4 CORROSION FATIGUE.........................
   9.5 EROSION-CORROSION.........................
   9.6 PITTING...................................
   9.7 WASTAGE...................................
   9.8 WEAR......................................
   9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED.......................
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TRICASTIN 2

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... TRICASTIN 2
   - 1.2 UTILITY...................................... EDF
   - 1.3 NSSS SUPPLIER................................ FRAMATOME
   - 1.4 ELECTRIC POWER RATING (MWE)................. 915
   - 1.5 THERMAL POWER RATING (MWT)..................
   - 1.6 DATE OF COMMERCIAL OPERATION................ 11/ 4/80

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS.................. 3
   - 2.2 STEAM GENERATOR TYPE........................ RWOE
   - 2.3 STEAM GENERATOR MODEL NO.................... 51M
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........
   - 2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)................
   - 3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   - 3.3 TUBE WALL THICKNESS (inches)................ .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   - 3.5 TUBE PITCH (inches)......................... 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches)........... .0000
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 00.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL..........................
   - 4.2 TUBE SUPPORT PLATE MATERIAL.................
   - 4.3 TUBE MATERIAL............................... ALLOY 600
   - 4.4 TUBE SUPPLIER............................... VALLOUREC/WEST
   - 4.5 DATE OF TUBE MANUFACTURE....................

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE.......................
   - 5.2 CARBON CONTENT RANGE (percent)..............
   - 5.3 YIELD STRESS RANGE (ksi)....................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS................... F.D. ROLL/DAM
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS..................
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)...

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi).............. 2248
   - 7.2 HOT LEG INLET TEMPERATURE (deg F)........... 613
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 546
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F).....
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 840
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   - 7.9 WATER CHEMISTRY............................. AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 49
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

    11.2

    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TRICASTIN 3

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO......................	TRICASTIN 3
1.2	UTILITY..................................	EDF
1.3	NSSS SUPPLIER..............................	FRAMATOME
1.4	ELECTRIC POWER RATING (MWE)................	915
1.5	THERMAL POWER RATING (MWT).................	
1.6	DATE OF COMMERCIAL OPERATION...............	4/21/81
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS.................	3
2.2	STEAM GENERATOR TYPE.......................	RWOE
2.3	STEAM GENERATOR MODEL NO...................	51M
2.4	STEAM GENERATOR FABRICATOR/LOCATION........	
2.5	DATE OF STEAM GENERATOR COMPLETION.........	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)...............	
3.2	TUBE OUTSIDE DIAMETER (inches).............	.875
3.3	TUBE WALL THICKNESS (inches)...............	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR........	3388
3.5	TUBE PITCH (inches)........................	1.281
3.6	TUBESHEET RADIAL CREVICE (inches)..........	.0000
3.7	DEPTH OF TUBESHEET CREVICE (inches)........	00.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL.........................	
4.2	TUBE SUPPORT PLATE MATERIAL................	
4.3	TUBE MATERIAL..............................	ALLOY 600
4.4	TUBE SUPPLIER..............................	VALLOUREC/WEST
4.5	DATE OF TUBE MANUFACTURE...................	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE......................	
5.2	CARBON CONTENT RANGE (percent).............	
5.3	YIELD STRESS RANGE (ksi)...................	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)..........	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS..................	F.D. ROLL/DAM
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)......	2.1875,3.4685
6.3	PROCESS USED TO FORM BENDS.................	
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)...	
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi).............	2248
7.2	HOT LEG INLET TEMPERATURE (deg F)..........	613
7.3	COLD LEG OUTLET TEMPERATURE (deg F)........	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)............	
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)...........	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F).....	
7.7	STEAM GENERATOR OPERATING PRESS.(psi)......	840
7.8	TYPICAL SLUDGE PILE DEPTH (inches).........	
7.9	WATER CHEMISTRY............................	AVT ONLY

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TRICASTIN 2

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED......................
    10.2 TOTAL TUBES SLEEVED......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TRICASTIN 4

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO..................... TRICASTIN 4
   - 1.2 UTILITY.................................. EDF
   - 1.3 NSSS SUPPLIER............................ FRAMATOME
   - 1.4 ELECTRIC POWER RATING (MWE)............... 915
   - 1.5 THERMAL POWER RATING (MWT)................
   - 1.6 DATE OF COMMERCIAL OPERATION.............. 10/ 2/81

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS................ 3
   - 2.2 STEAM GENERATOR TYPE...................... RWOE
   - 2.3 STEAM GENERATOR MODEL NO.................. 51M
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........
   - 2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)...............
   - 3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   - 3.3 TUBE WALL THICKNESS (inches)............... .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   - 3.5 TUBE PITCH (inches)........................ 1.281
   - 3.6 TUBESHEET RADIAL CREVICE (inches).......... .0000
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 00.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL.........................
   - 4.2 TUBE SUPPORT PLATE MATERIAL................
   - 4.3 TUBE MATERIAL.............................. ALLOY 600
   - 4.4 TUBE SUPPLIER.............................. VALLOUREC
   - 4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE......................
   - 5.2 CARBON CONTENT RANGE (percent).............
   - 5.3 YIELD STRESS RANGE (ksi)...................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS.................. F.D. ROLL/DAM
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS.................
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)...

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi)............. 2248
   - 7.2 HOT LEG INLET TEMPERATURE (deg F).......... 613
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 546
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F).....
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 840
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches).........
   - 7.9 WATER CHEMISTRY............................ AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................ YES
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED.......................
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
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DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TROJAN

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO..................... TROJAN
   1.2 UTILITY.................................... PORTLAND GENERAL ELE
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................ 1130
   1.5 THERMAL POWER RATING (MWT)................. 3411
   1.6 DATE OF COMMERCIAL OPERATION............... 5/15/76

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................. 4
   2.2 STEAM GENERATOR TYPE....................... RWOE
   2.3 STEAM GENERATOR MODEL NO................... 51A
   2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)............... 22.0
   3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   3.3 TUBE WALL THICKNESS (inches)............... .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   3.5 TUBE PITCH (inches)........................ 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches).......... .0000
   3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 00.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL......................... FORG. STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   4.3 TUBE MATERIAL.............................. ALLOY 600
   4.4 TUBE SUPPLIER.............................. WESTINGHOUSE
   4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE...................... 8
   5.2 CARBON CONTENT RANGE (percent)............. .037
   5.3 YIELD STRESS RANGE (ksi)................... 56-59 (AVG 58.6)
   5.4 MILL ANNEAL TIME/TEMP (min/deg F).......... 1750-1800(tubes)

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................. ROLL/EXPLOSIVE
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS................. W BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F).......... 615
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 555
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 533
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 910
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)......... 0.30
   7.9 WATER CHEMISTRY............................ AVT ONLY

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED......................
    10.2 TOTAL TUBES SLEEVED......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

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    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TROJAN

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION................... YES
        8.1.4 U-BEND APEX-DENTING RELATED.........
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED....
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING...................................
    9.4 CORROSION FATIGUE.........................
    9.5 EROSION-CORROSION.........................
    9.6 PITTING...................................
    9.7 WASTAGE...................................
    9.8 WEAR......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED........................ 405
    10.2 TOTAL TUBES SLEEVED........................
    10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1 UB PLUGGED

11. NOTES
    11.1

    11.2

    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TURKEY POINT 3 (ORIG SG)

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... TURKEY POINT 3 (ORIG SG)
   1.2 UTILITY.................................... FLORIDA POWER&LIGHT
   1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................. 676
   1.5 THERMAL POWER RATING (MWT).................. 2200
   1.6 DATE OF COMMERCIAL OPERATION................ 12/15/72

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 3
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 44
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 22.0
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3214
   3.5 TUBE PITCH (inches)......................... 1.234
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... FORG. STL.
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE.......................
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.188,3.47
   6.3 PROCESS USED TO FORM BENDS.................. H BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2235
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 605
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 556
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 516
   7.7 STEAM GENERATOR OPERATING PRESS.(psi).......
   7.8 TYPICAL SLUDGE PILE DEPTH (inches).......... 2.00
   7.9 WATER CHEMISTRY............................. EARLY PHOS, AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TURKEY POINT 3 (ORIG SG)

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION...................
      8.1.4 U-BEND APEX-DENTING RELATED......... YES
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED.... YES
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE...................
      9.2.3 SLUDGE PILE REGION..................
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING.................................... YES (SEVERE)
   9.4 CORROSION FATIGUE..........................
   9.5 EROSION-CORROSION..........................
   9.6 PITTING....................................
   9.7 WASTAGE.................................... YES
   9.8 WEAR.......................................
   9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED....................... 2119
   10.2 TOTAL TUBES SLEEVED.......................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

1.	PLANT DESCRIPTION	
1.1	PLANT NAME AND UNIT NO.	TURKEY POINT 4 (ORIG SG)
1.2	UTILITY	FLORIDA POWER&LIGHT
1.3	NSSS SUPPLIER	WESTINGHOUSE
1.4	ELECTRIC POWER RATING (MWE)	676
1.5	THERMAL POWER RATING (MWT)	2200
1.6	DATE OF COMMERCIAL OPERATION	9/15/73
2.	STEAM GENERATOR GENERAL INFORMATION	
2.1	NUMBER OF STEAM GENERATORS	3
2.2	STEAM GENERATOR TYPE	RWOE
2.3	STEAM GENERATOR MODEL NO	44
2.4	STEAM GENERATOR FABRICATOR/LOCATION	
2.5	DATE OF STEAM GENERATOR COMPLETION	//
3.	STEAM GENERATOR DIMENSIONS	
3.1	TUBESHEET THICKNESS (inches)	22.0
3.2	TUBE OUTSIDE DIAMETER (inches)	.875
3.3	TUBE WALL THICKNESS (inches)	.050
3.4	NUMBER OF TUBES PER STEAM GENERATOR	3260
3.5	TUBE PITCH (inches)	1.234
3.6	TUBESHEET RADIAL CREVICE (inches)	.0060
3.7	DEPTH OF TUBESHEET CREVICE (inches)	18.00
4.	STEAM GENERATOR MATERIALS	
4.1	TUBESHEET MATERIAL	MN,MO
4.2	TUBE SUPPORT PLATE MATERIAL	CS
4.3	TUBE MATERIAL	ALLOY 600
4.4	TUBE SUPPLIER	HUNTINGTON
4.5	DATE OF TUBE MANUFACTURE	//
5.	TUBE MATERIAL PROPERTIES	
5.1	ASTM GRAIN SIZE RANGE	
5.2	CARBON CONTENT RANGE (percent)	
5.3	YIELD STRESS RANGE (ksi)	
5.4	MILL ANNEAL TIME/TEMP (min/deg F)	
6.	TUBE EXPANSION PARAMETERS	
6.1	TYPE OF EXPANSION PROCESS	PART DEPTH ROLL
6.2	RADII OF ROW 1 AND 2 U-BENDS (inches)	
6.3	PROCESS USED TO FORM BENDS	H BALL MANDREL
6.4	STRESS RELIEF AFTER TUBING (hours/deg F)	NONE
7.	STEAM GENERATOR OPERATING PARAMETERS	
7.1	PRIMARY COOLANT PRESSURE (psi)	2235
7.2	HOT LEG INLET TEMPERATURE (deg F)	602
7.3	COLD LEG OUTLET TEMPERATURE (deg F)	546
7.4	HOT LEG HEAT FLUX (BTU/hr/ft^2)	104000
7.5	COLD LEG HEAT FLUX (BTU/hr/ft^2)	
7.6	STEAM GENERATOR OPERATING TEMP.(deg F)	510
7.7	STEAM GENERATOR OPERATING PRESS.(psi)	770
7.8	TYPICAL SLUDGE PILE DEPTH (inches)	1.50
7.9	WATER CHEMISTRY	EARLY PHOS, AVT

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
TURKEY POINT 4 (ORIG SG)

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
    8.1 PRIMARY SIDE IGSCC
        8.1.1 EXPANSION TRANSITION................
        8.1.2 EXPANDED REGION.....................
        8.1.3 U-BEND TRANSITION...................
        8.1.4 U-BEND APEX-DENTING RELATED......... YES
        8.1.5 U-BEND APEX-NOT DENTING RELATED.....
        8.1.6 TSP INTERSECTION-DENTING RELATED.... YES
        8.1.7 PLUGS...............................
    8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
    9.1 SECONDARY SIDE IGSCC
        9.1.1 EXPANSION TRANSITION................
        9.1.2 TUBESHEET CREVICE...................
        9.1.3 SLUDGE PILE REGION..................
        9.1.4 TSP INTERSECTION....................
    9.2 INTERGRANULAR ATTACK (IGA)
        9.2.1 EXPANSION TRANSITION................
        9.2.2 TUBESHEET CREVICE...................
        9.2.3 SLUDGE PILE REGION..................
        9.2.4 TSP INTERSECTION....................
    9.3 DENTING.................................... YES(SEVERE)
    9.4 CORROSION FATIGUE..........................
    9.5 EROSION-CORROSION..........................
    9.6 PITTING....................................
    9.7 WASTAGE.................................... YES
    9.8 WEAR.......................................
    9.9 OTHER SECONDARY SIDE PROBLEMS..............

10. INSERVICE REMEDIAL MEASURES
    10.1 TOTAL TUBES PLUGGED....................... 2498
    10.2 TOTAL TUBES SLEEVED.......................
    10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
    11.1

    11.2

    11.3

    11.4

    11.5

    11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
ZION 1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO...................... ZION 1
   1.2 UTILITY..................................... COMMONWEALTH EDISON
   1.3 NSSS SUPPLIER............................... WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE)................. 1085
   1.5 THERMAL POWER RATING (MWT).................. 3250
   1.6 DATE OF COMMERCIAL OPERATION................ 10/15/73

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS.................. 4
   2.2 STEAM GENERATOR TYPE........................ RWOE
   2.3 STEAM GENERATOR MODEL NO.................... 51
   2.4 STEAM GENERATOR FABRICATOR/LOCATION......... WESTINGHOUSE
   2.5 DATE OF STEAM GENERATOR COMPLETION.......... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches)................ 21.0
   3.2 TUBE OUTSIDE DIAMETER (inches).............. .875
   3.3 TUBE WALL THICKNESS (inches)................ .050
   3.4 NUMBER OF TUBES PER STEAM GENERATOR......... 3388
   3.5 TUBE PITCH (inches)......................... 1.281
   3.6 TUBESHEET RADIAL CREVICE (inches)........... .0060
   3.7 DEPTH OF TUBESHEET CREVICE (inches)......... 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL.......................... SA 508
   4.2 TUBE SUPPORT PLATE MATERIAL................. CS
   4.3 TUBE MATERIAL............................... ALLOY 600
   4.4 TUBE SUPPLIER............................... WESTINGHOUSE
   4.5 DATE OF TUBE MANUFACTURE.................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE....................... 8
   5.2 CARBON CONTENT RANGE (percent)..............
   5.3 YIELD STRESS RANGE (ksi)....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)...........

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS................... PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)....... 2.1875,3.4685
   6.3 PROCESS USED TO FORM BENDS.................. W BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F).... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi).............. 2250
   7.2 HOT LEG INLET TEMPERATURE (deg F)........... 594
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)......... 530
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2).............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F)...... 506
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)....... 720
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)..........
   7.9 WATER CHEMISTRY............................. EARLY PHOS, AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION................... YES
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE................... YES
      9.2.3 SLUDGE PILE REGION.................. YES
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING.................................. YES
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE.................................. YES
   9.8 WEAR..................................... YES
   9.9 OTHER SECONDARY SIDE PROBLEMS............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED...................... 498
   10.2 TOTAL TUBES SLEEVED......................
   10.3 OTHER (tube expn.,stress relief,peening)... ALL ROW 1 UB PLUGGED

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
ZION 2

1. PLANT DESCRIPTION
   - 1.1 PLANT NAME AND UNIT NO...................... ZION 2
   - 1.2 UTILITY.................................... COMMONWEALTH EDISON
   - 1.3 NSSS SUPPLIER.............................. WESTINGHOUSE
   - 1.4 ELECTRIC POWER RATING (MWE)................ 1085
   - 1.5 THERMAL POWER RATING (MWT)................. 2760
   - 1.6 DATE OF COMMERCIAL OPERATION............... 11/15/74

2. STEAM GENERATOR GENERAL INFORMATION
   - 2.1 NUMBER OF STEAM GENERATORS................. 4
   - 2.2 STEAM GENERATOR TYPE....................... RWOE
   - 2.3 STEAM GENERATOR MODEL NO................... 51
   - 2.4 STEAM GENERATOR FABRICATOR/LOCATION........ WESTINGHOUSE
   - 2.5 DATE OF STEAM GENERATOR COMPLETION......... //

3. STEAM GENERATOR DIMENSIONS
   - 3.1 TUBESHEET THICKNESS (inches)............... 21.0
   - 3.2 TUBE OUTSIDE DIAMETER (inches)............. .875
   - 3.3 TUBE WALL THICKNESS (inches)............... .050
   - 3.4 NUMBER OF TUBES PER STEAM GENERATOR........ 3388
   - 3.5 TUBE PITCH (inches)........................ 1.280
   - 3.6 TUBESHEET RADIAL CREVICE (inches).......... .0060
   - 3.7 DEPTH OF TUBESHEET CREVICE (inches)........ 18.00

4. STEAM GENERATOR MATERIALS
   - 4.1 TUBESHEET MATERIAL......................... SA 508
   - 4.2 TUBE SUPPORT PLATE MATERIAL................ CS
   - 4.3 TUBE MATERIAL.............................. ALLOY 600
   - 4.4 TUBE SUPPLIER.............................. WEST/HUNTINGTON
   - 4.5 DATE OF TUBE MANUFACTURE................... //

5. TUBE MATERIAL PROPERTIES
   - 5.1 ASTM GRAIN SIZE RANGE......................
   - 5.2 CARBON CONTENT RANGE (percent).............
   - 5.3 YIELD STRESS RANGE (ksi)...................
   - 5.4 MILL ANNEAL TIME/TEMP (min/deg F)..........

6. TUBE EXPANSION PARAMETERS
   - 6.1 TYPE OF EXPANSION PROCESS.................. PART DEPTH ROLL
   - 6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)...... 2.1875,3.4685
   - 6.3 PROCESS USED TO FORM BENDS................. WH BALL MANDREL
   - 6.4 STRESS RELIEF AFTER TUBING (hours/deg F)... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   - 7.1 PRIMARY COOLANT PRESSURE (psi)............. 2250
   - 7.2 HOT LEG INLET TEMPERATURE (deg F).......... 594
   - 7.3 COLD LEG OUTLET TEMPERATURE (deg F)........ 530
   - 7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)............
   - 7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2)...........
   - 7.6 STEAM GENERATOR OPERATING TEMP.(deg F)..... 506
   - 7.7 STEAM GENERATOR OPERATING PRESS.(psi)...... 720
   - 7.8 TYPICAL SLUDGE PILE DEPTH (inches)......... 0.50
   - 7.9 WATER CHEMISTRY............................ EARLY PHOSPHATE,AVT

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
   8.1 PRIMARY SIDE IGSCC
      8.1.1 EXPANSION TRANSITION................
      8.1.2 EXPANDED REGION.....................
      8.1.3 U-BEND TRANSITION.................. YES
      8.1.4 U-BEND APEX-DENTING RELATED.........
      8.1.5 U-BEND APEX-NOT DENTING RELATED.....
      8.1.6 TSP INTERSECTION-DENTING RELATED....
      8.1.7 PLUGS...............................
   8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
   9.1 SECONDARY SIDE IGSCC
      9.1.1 EXPANSION TRANSITION................
      9.1.2 TUBESHEET CREVICE...................
      9.1.3 SLUDGE PILE REGION..................
      9.1.4 TSP INTERSECTION....................
   9.2 INTERGRANULAR ATTACK (IGA)
      9.2.1 EXPANSION TRANSITION................
      9.2.2 TUBESHEET CREVICE................... YES
      9.2.3 SLUDGE PILE REGION.................. YES
      9.2.4 TSP INTERSECTION....................
   9.3 DENTING.................................. YES
   9.4 CORROSION FATIGUE........................
   9.5 EROSION-CORROSION........................
   9.6 PITTING..................................
   9.7 WASTAGE.................................. YES
   9.8 WEAR..................................... YES
   9.9 OTHER SECONDARY SIDE PROBLEMS............

10. INSERVICE REMEDIAL MEASURES
   10.1 TOTAL TUBES PLUGGED..................... 14
   10.2 TOTAL TUBES SLEEVED.....................
   10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
   11.1

   11.2

   11.3

   11.4

   11.5

   11.6

8. REPORTED PRIMARY SIDE PROBLEMS (Yes/No, Date or EFPD to 1st observation)
  8.1 PRIMARY SIDE IGSCC
    8.1.1 EXPANSION TRANSITION................. YES
    8.1.2 EXPANDED REGION......................
    8.1.3 U-BEND TRANSITION....................
    8.1.4 U-BEND APEX-DENTING RELATED.........
    8.1.5 U-BEND APEX-NOT DENTING RELATED.....
    8.1.6 TSP INTERSECTION-DENTING RELATED....
    8.1.7 PLUGS...............................
  8.2 OTHER PRIMARY PROBLEMS(e.g. sulfur attack).

9. REPORTED SECONDARY SIDE PROBLEMS(Yes/No,Date or EFPD to 1st observation)
  9.1 SECONDARY SIDE IGSCC
    9.1.1 EXPANSION TRANSITION................
    9.1.2 TUBESHEET CREVICE................... YES(MINOR)
    9.1.3 SLUDGE PILE REGION..................
    9.1.4 TSP INTERSECTION....................
  9.2 INTERGRANULAR ATTACK (IGA)
    9.2.1 EXPANSION TRANSITION................
    9.2.2 TUBESHEET CREVICE................... YES
    9.2.3 SLUDGE PILE REGION..................
    9.2.4 TSP INTERSECTION.................... YES
  9.3 DENTING...................................
  9.4 CORROSION FATIGUE.........................
  9.5 EROSION-CORROSION.........................
  9.6 PITTING...................................
  9.7 WASTAGE................................... YES
  9.8 WEAR...................................... AT AVB (MINOR)
  9.9 OTHER SECONDARY SIDE PROBLEMS.............

10. INSERVICE REMEDIAL MEASURES
  10.1 TOTAL TUBES PLUGGED........................
  10.2 TOTAL TUBES SLEEVED........................
  10.3 OTHER (tube expn.,stress relief,peening)...

11. NOTES
  11.1

  11.2

  11.3

  11.4

  11.5

  11.6

DOMINION ENGINEERING, INC.
EPRI/SGOG II CRACKING SURVEY
ZORITA 1

1. PLANT DESCRIPTION
   1.1 PLANT NAME AND UNIT NO....................... ZORITA 1
   1.2 UTILITY...................................... UNION ELEC.-FENOSA
   1.3 NSSS SUPPLIER................................ WESTINGHOUSE
   1.4 ELECTRIC POWER RATING (MWE).................. 153
   1.5 THERMAL POWER RATING (MWT)...................
   1.6 DATE OF COMMERCIAL OPERATION................. 8/15/69

2. STEAM GENERATOR GENERAL INFORMATION
   2.1 NUMBER OF STEAM GENERATORS................... 1
   2.2 STEAM GENERATOR TYPE.........................
   2.3 STEAM GENERATOR MODEL NO..................... 24
   2.4 STEAM GENERATOR FABRICATOR/LOCATION..........
   2.5 DATE OF STEAM GENERATOR COMPLETION........... //

3. STEAM GENERATOR DIMENSIONS
   3.1 TUBESHEET THICKNESS (inches).................
   3.2 TUBE OUTSIDE DIAMETER (inches)...............
   3.3 TUBE WALL THICKNESS (inches).................
   3.4 NUMBER OF TUBES PER STEAM GENERATOR..........
   3.5 TUBE PITCH (inches)..........................
   3.6 TUBESHEET RADIAL CREVICE (inches)............
   3.7 DEPTH OF TUBESHEET CREVICE (inches).......... 18.00

4. STEAM GENERATOR MATERIALS
   4.1 TUBESHEET MATERIAL...........................
   4.2 TUBE SUPPORT PLATE MATERIAL..................
   4.3 TUBE MATERIAL................................ ALLOY 600
   4.4 TUBE SUPPLIER................................ HUNTINGTON
   4.5 DATE OF TUBE MANUFACTURE..................... //

5. TUBE MATERIAL PROPERTIES
   5.1 ASTM GRAIN SIZE RANGE........................
   5.2 CARBON CONTENT RANGE (percent)...............
   5.3 YIELD STRESS RANGE (ksi).....................
   5.4 MILL ANNEAL TIME/TEMP (min/deg F)............

6. TUBE EXPANSION PARAMETERS
   6.1 TYPE OF EXPANSION PROCESS.................... PART DEPTH ROLL
   6.2 RADII OF ROW 1 AND 2 U-BENDS (inches)........
   6.3 PROCESS USED TO FORM BENDS................... H. BALL MANDREL
   6.4 STRESS RELIEF AFTER TUBING (hours/deg F)..... NONE

7. STEAM GENERATOR OPERATING PARAMETERS
   7.1 PRIMARY COOLANT PRESSURE (psi)...............
   7.2 HOT LEG INLET TEMPERATURE (deg F)............ 596
   7.3 COLD LEG OUTLET TEMPERATURE (deg F)..........
   7.4 HOT LEG HEAT FLUX (BTU/hr/ft^2)..............
   7.5 COLD LEG HEAT FLUX (BTU/hr/ft^2).............
   7.6 STEAM GENERATOR OPERATING TEMP.(deg F).......
   7.7 STEAM GENERATOR OPERATING PRESS.(psi)........
   7.8 TYPICAL SLUDGE PILE DEPTH (inches)...........
   7.9 WATER CHEMISTRY.............................. COORD.PHOS. ONLY

ENCLOSURE 2

Consumers Power Company
Palisades Plant
Docket 50-255

CPCo RESPONSE TO INFORMATION REQUEST 6
(Letter from PCI Energy Services)

October 20, 1993

PCI EnergyServices

FIELD MACHINING, WELDING,
TOOL DESIGN & ENGINEERING

October 11, 1993

Mr. Robert Van Wagner
Consumers Power Company
Palisades Generating Plant
27780 Blue Star Memorial Hwy
Covert, MI 49043

Subject: Independent Film Review of Pressurizer PORV and PSS Line

Dear Mr. Van Wagner:

The film and results of the welds I reviewed are listed below. The review was of final radiographs as well as root radiographs of the welding on the PORV line.

LINE NO.	WELD NUMBER	RT DATE	UTILITY EVALUATION	INDEPENDENT REVIEW (TDG)
PCS-4-PSS-IPI	XR20	9/19/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR2	9/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR3	9/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR5	9/21/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR6	9/22/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR21	9/23/93	Acceptable	Agree with Interpretation
PCS-6-PRS-IBI	XR1 (RV1040)	9/93	Acceptable	Agree with Interpretation
PCS-6-PRS-IAI	XR1 (RV1039)	9/93	Acceptable	Agree with Interpretation
PCS-6-PRS-ICI	XR1 (RV1041)	9/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR4	9/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR1	9/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR1A	10/2/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR1 *	10/93	Acceptable	Agree with Interpretation
PCS-4-PRS-IPI	XR2 *	10/93	Acceptable	Agree with Interpretation

* NOTE: These welds were previously identified as XR2 and XR3, but renumbered after cut out.

PCI EnergyServices

In addition to the above radiographs I reviewed the film for the failed weld PCS-4-PRS-IPI Weld 1A, dated June and September, 1993. The film in June clearly showed a linear (crack) like indication from station marker 9½-12. The September, 1993 radiograph shows the crack running across the weld into the stainless pipe. I was asked if that indication could be "slag". I said no due to the fact that it is adjacent within <⅛" from the root, it did not have the normal slag-like appearance rough jagged and irregular appearance. The indication appears to me to be a base metal crack at the ID. I received the construction radiographs dated 10/31/69 and the film does not meet code requirements for density etc. Interpretation with this radiograph in the area of concern was not feasible.

It appears that radiographs are in the as-welded condition for the Gas Tungsten Arc Welding interpretation would be adequate, but for the Shielded Metal Arc Welding process the stringers could mask indications. The Ultrasonic ISI inspection appears to be performed with no or very little surface preparation. I suggest that a review of the surface preparation details be performed to enhance the ultrasonic examination results.

If I can be of any further assistance in this matter, please feel free to contact me at (708) 680-8100.

Sincerely,

Timothy D. Grubbs

Timothy D. Grubbs
V.P. Quality Assurance

TDG/kls

ENCLOSURE 3

Consumers Power Company
Palisades Plant
Docket 50-255

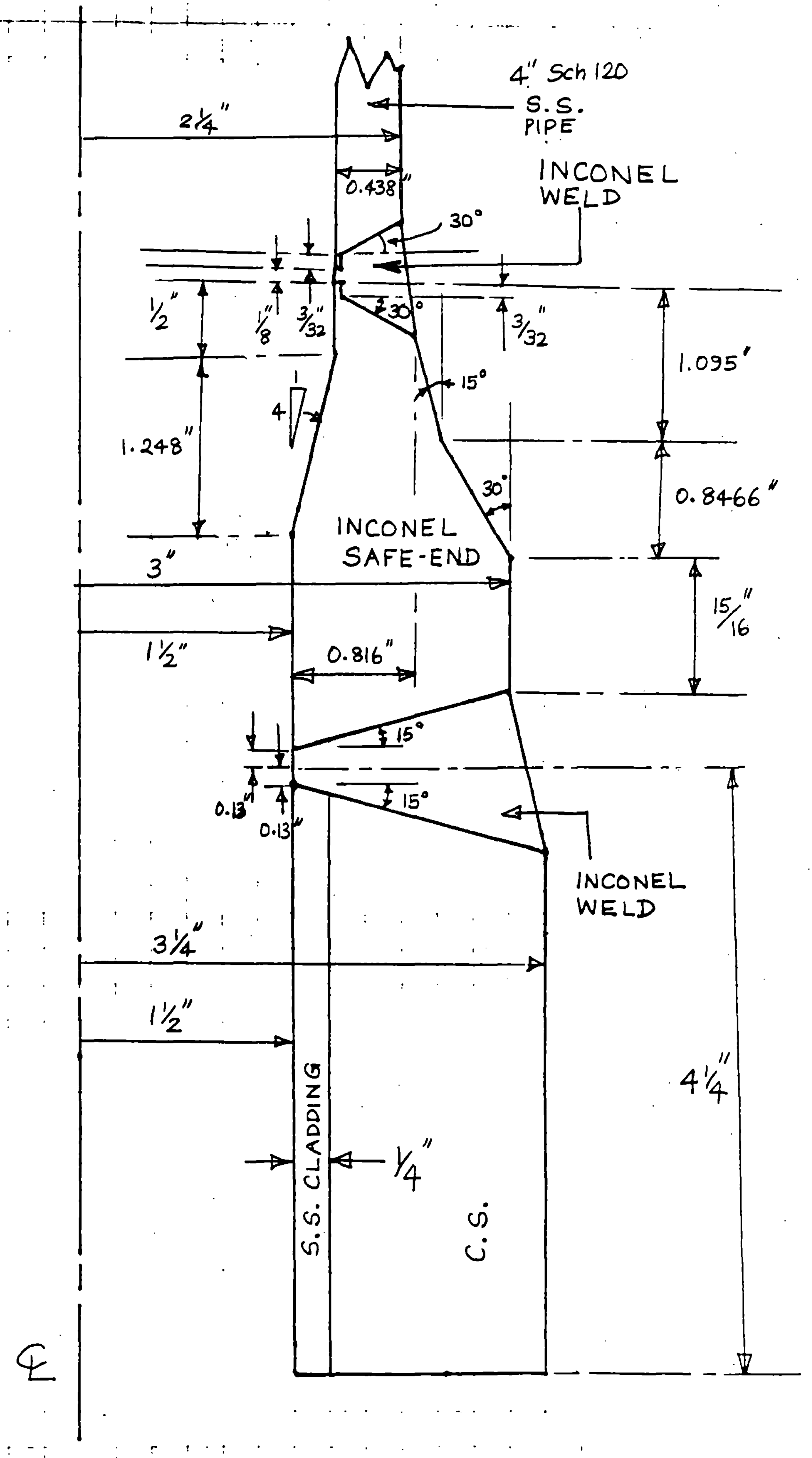
CPCo RESPONSE TO INFORMATION REQUEST 7
(Sketches and Drawings)

October 20, 1993

SECTION OF THE PORV NOZZLE ON PRESSURIZER

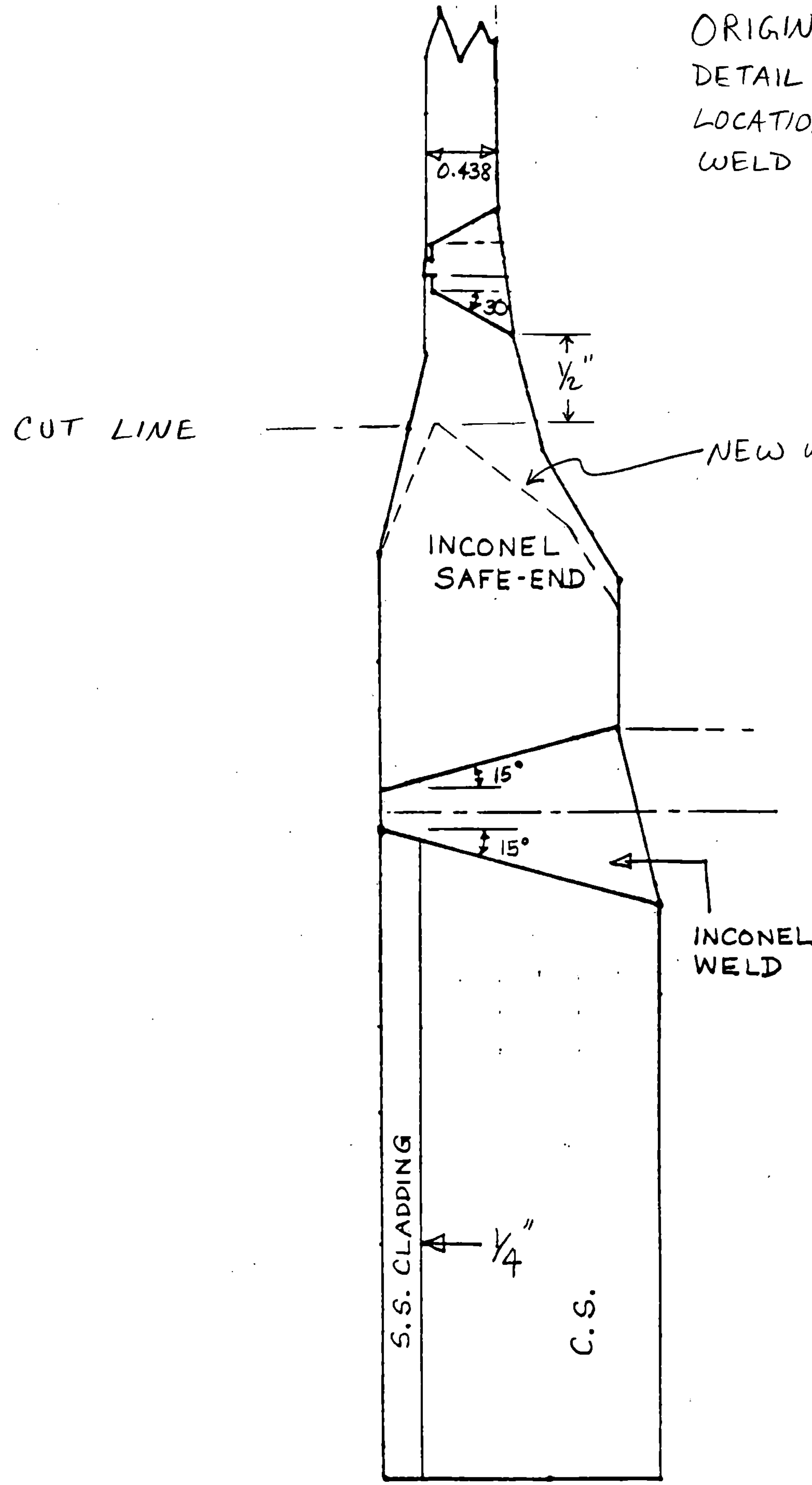
T-72

ORIGINAL DESIGN



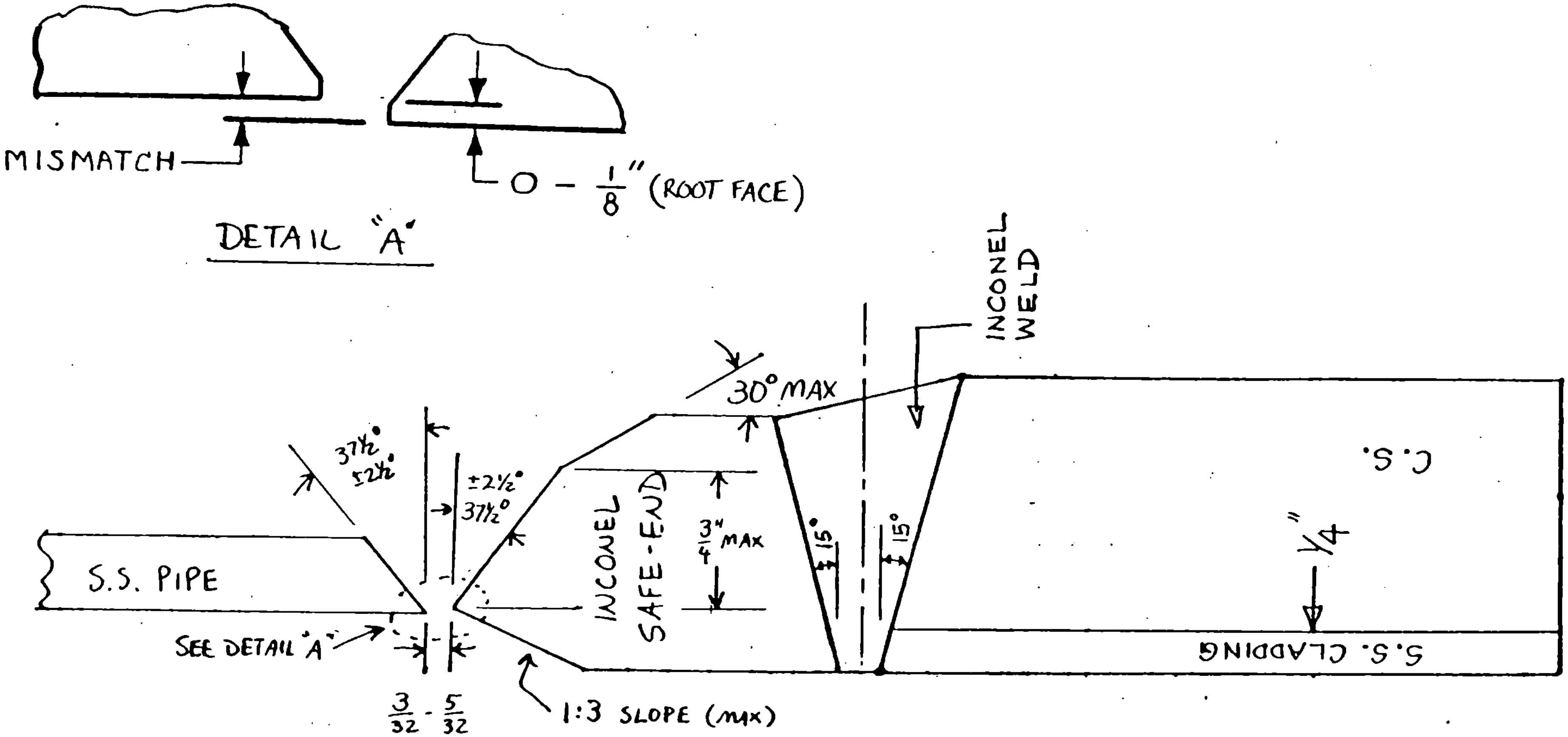
DRAWING 1

ORIGINAL PORV NOZZLE DETAIL SHOWING LOCATION OF CUT AND WELD PREP FOR REPAIR



DRAWING 2

PORV NOZZLE REPAIR
END PREP DETAILS
(NEW WELD)

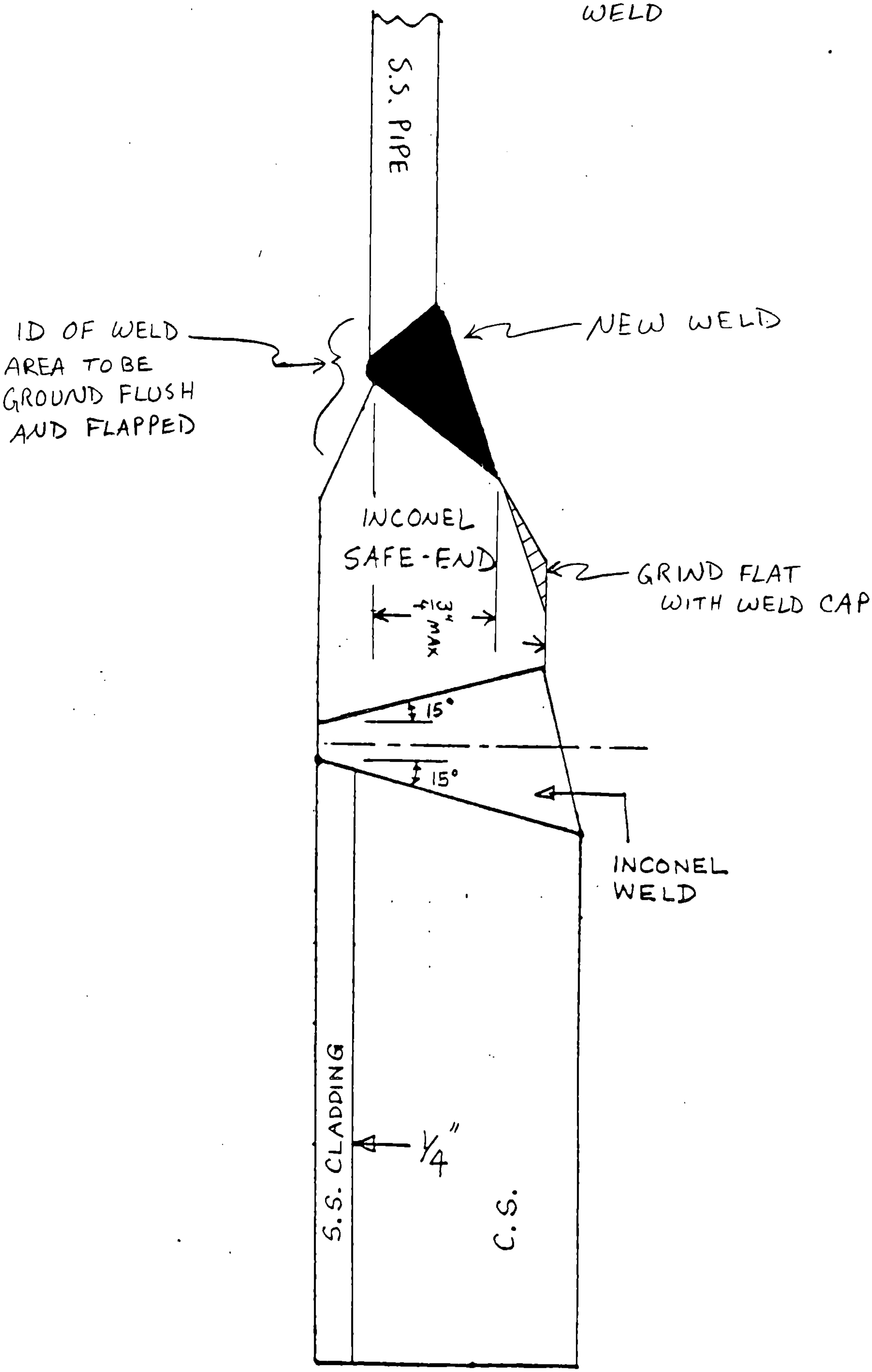


DRAWING 3

NOTES:

1. 1/16" max internal mismatch at one point; 1/32" max internal mismatch if spread uniformly around circumference.

PORV NOZZLE DETAIL SHOWING NEW REPAIR WELD



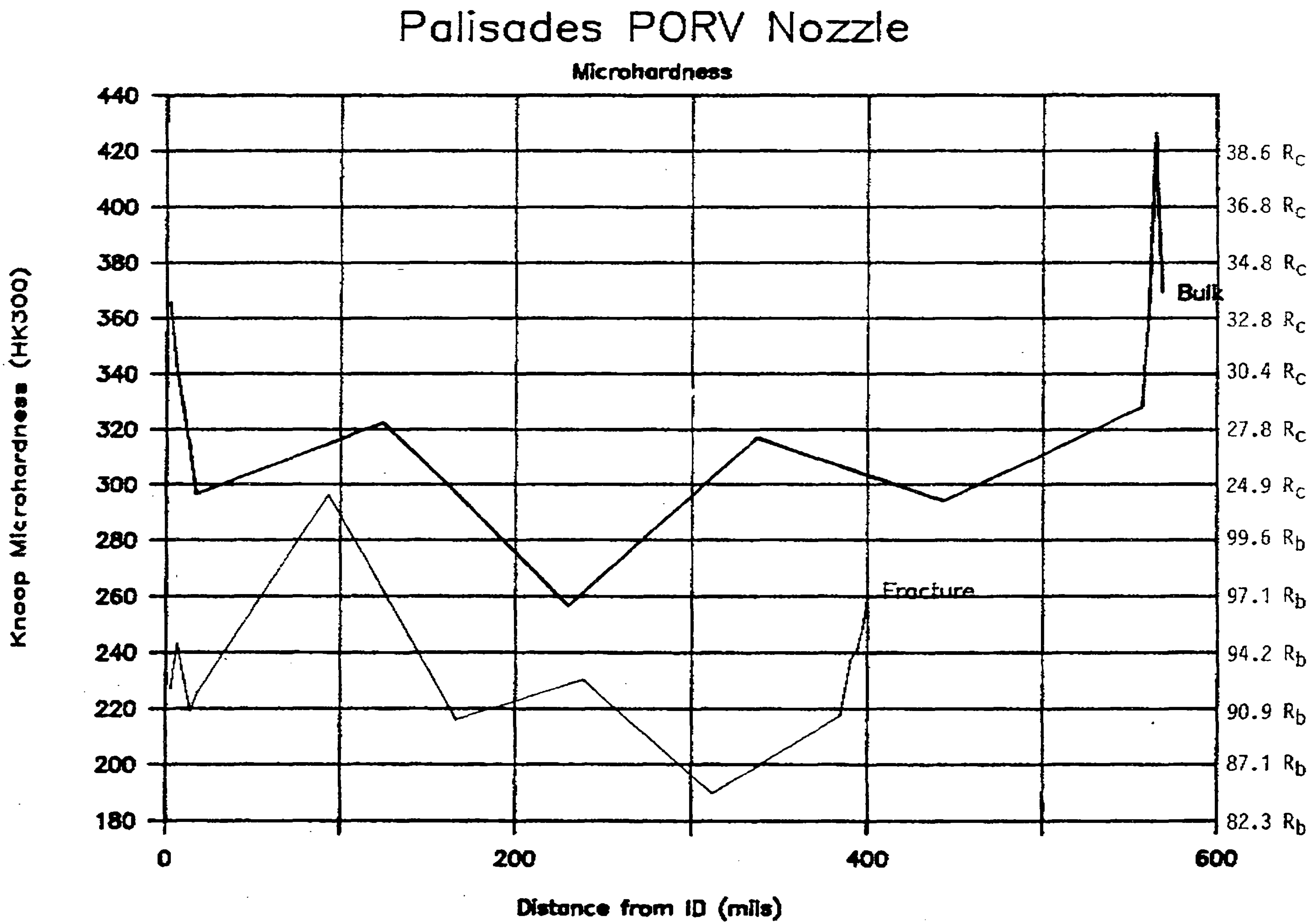
DRAWING 4

ENCLOSURE 4

Consumers Power Company
Palisades Plant
Docket 50-255

MICROHARDNESS TEST RESULTS
FOR THE BASE METAL AND FRACTURE AREA

October 20, 1993



Palisades PORV Nozzle
Microhardness
Knoop Microhardness (HK300)
Distance from ID (mils)
440
420
400
380
360
340
320
300
280
260
240
220
200
180
0
200
400
600
38.6 Rc
36.8 Rc
34.8 Rc
32.8 Rc
30.4 Rc
27.8 Rc
24.9 Rc
99.6 Rb
97.1 Rb
94.2 Rb
90.9 Rb
87.1 Rb
82.3 Rb
Bulk
Fracture

ENCLOSURE 5

Consumers Power Company
Palisades Plant
Docket 50-255

CPCo RESPONSE TO INFORMATION REQUEST 15
(1987 PORV Examination Results)

October 20, 1993

AMDATA

ULTRASONIC INSTRUMENT LINEARITY RECORD

ULTRASONIC INSTRUMENT

Mfg/Model No. KB / USD-10

Serial No. 31875-1546

Filter Setting N/A

Calibration Block

Type ∠ Beam Cal B-1

Serial No. RB01014

Transducer

Mfg. KB-A

Size 1/2" RND

Frequency 2.25 mHz

Serial No. E06142

Straight Beam (✓) Angle Beam (N/A)

VERTICAL LINEARITY

No.	Actual Higher Signal	(Calculate) 1/2 of Higher	Acceptance Limits*	Actual Lower Signal
1	100	(50)	(45)-(55)	50
2	90	(45)	(40)-(50)	45
3	80	(40)	(35)-(45)	40
4	70	(35)	(30)-(40)	35
5	60	(30)	(25)-(35)	30
6	50	(25)	(20)-(30)	25
7	40	(20)	(15)-(25)	20
8	30	(15)	(10)-(20)	15
9	20	(10)	(5)-(15)	10
10	10	(5)	(0)-(10)	5

*Acceptance Limits are 1/2 of the Higher Signal ± 5% FSH.

Signal amplitudes are in % FSH.

HORIZONTAL LINEARITY

Back Reflect.	Grid Loc.	Acceptance Limits
1	1	1
2	2	1.90-2.10
3	3	2.85-3.15
4	4	3.80-4.20
5	5	4.75-5.25
6	6	5.70-6.30
7	7	6.65-7.35
8	8	7.60-8.40
9	9	8.55-9.45
10	10	10

AMPLITUDE CONTROL LINEARITY

Initial Amplitude	dB Change	Result	Acceptance Limits
80% FSH	Down 6	38	32% - 48%
80% FSH	Down 12	19	16% - 24%
40% FSH	Up 6	80	64% - 96%
20% FSH	Up 12	82	64% - 96%

This instrument is considered: (✓) Acceptable (N/A) Not Acceptable

Test performed by: [signature] Level II Date 10/10/93

Test approved by:* N/A Level N/A Date N/A

* Level II or III approval. Only required when Level I performs the linearity verification.

Plant/Unit	PALISADES
Comp/System	PRESSURIZER
Zone	PCS-12-PLS-1H1
Contract No.	211057

ULTRASONIC CALIBRATION DATA SHEET

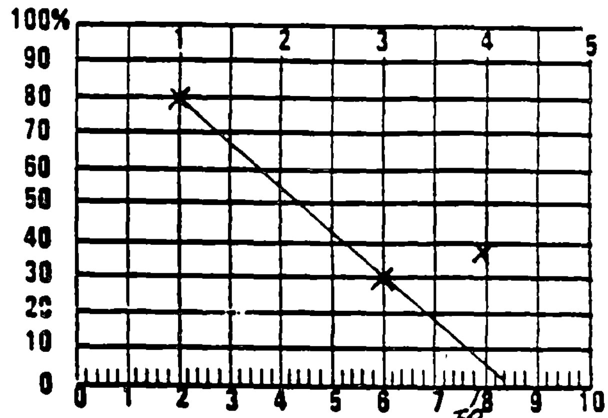
AMDATA

UT No.	TEH-01
Procedure No.	STD-AMD-007 Rev. 1
ST No.	N/A Rev. N/A
Cal. Block No.	14A-PAL
Surface (ID/OD)	OD
Block/Comp. Temp	68 °F / 80 °F

SEARCH UNIT	
Scan Angle:	60° Mode: SHEAR
Fixturing (if any):	LUCITE WEDGE
Size & Shape:	3/8" ROUND
Frequency:	2.25 mHz
Serial No/Brand:	33403 / KB-A
Measured Angle:	59°
Cable Type & Length:	RG-174/U 6'
Couplant Brand:	SONOTRACE
Couplant Batch:	093014

SCAN AREA	
0° WRV	N/A
0° Mat'l	N/A
⊥ To Weld	X
∥ To Weld	N/A

IDENT	0° or ⊥ TO WELD SWEEP POS	AMPL %	ATTEN dB	∥ TO WELD SWEEP POS	AMPL %	ATTEN dB
1/4T	2.0	80	66			
3/4T	6.0	30	66		N/A	
ID	7.9	38	66			
		N/A				



Screen Divisions, 10 = 2.5 in.

INSTRUMENT SETTINGS	
Mfg/Model No.:	KB/USD-10
Serial No.:	31875-1546
Damping	50 OHM
Mode Select: SINGLE	Reject: OFF
Freq.: 2.25 mHz	Rep. Rate: N/A
Filter: N/A	Video: N/A Jack: R
Sweep Length	C: N/A F: 128 µs
Sweep Delay	C: N/A F: 707 µs
Gain 0° or ⊥	C: 74* F: N/A
Gain ∥	C: N/A F: N/A

* 3/4T SDH SET AT 80% FSH

Scan Sensitivity 86 db

CAL. CHECKS	TIME
Initial Cal.	14:20
Intermediate	N/A
Intermediate	N/A
Intermediate	N/A
Final Cal.	18:05

EXAMINATION WELD/AREA	Recordable Indications Yes	No	Scan Limitation Yes	No	COMMENTS
WELD #1	N/A	X	N/A	X	NOZZLE TO SAFE END
WELD #2	N/A	X	N/A	X	SAFE END TO ELBOW
N/A					

INSTR. LINEARITY CAL.	High	Low		High	Low
1	90	45	5	50	25
2	80	40	6	40	20
3	70	35	7	30	15
4	60	30	8	20	10
			9	10	5

AMPL. CONTROL LINEARITY Initial	ΔdB	Result
80	-6	39
80	-12	20
40	+6	80
20	+12	82

EXAMINER [signature] LEVEL II DATE 10/10/93

EXAMINER N/A LEVEL N/A DATE N/A

REVIEWER ______ LEVEL ______ DATE ______

Authorized Inspection Agency ______ DATE ______

ADDITIONAL SHEETS? (Check Box)			
Continuation	N/A	Beam Plot	N/A
Supplements	N/A	Other	N/A

Page 1 of 1

Plant/Unit PALISADES
Comp/System PRESSURIZER
Zone PCS-12-PLS-1H1
Contract No. 211057

ULTRASONIC CALIBRATION DATA SHEET

AMDATA

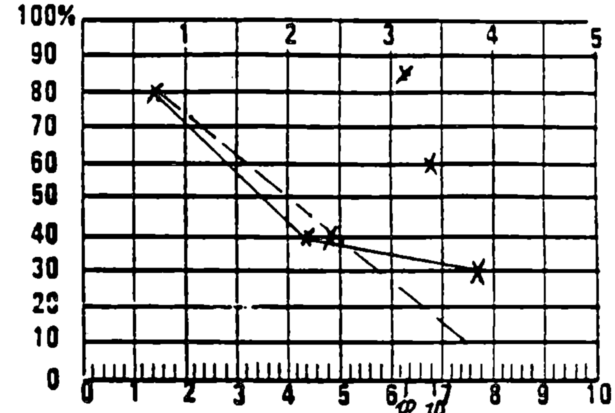
UT No. TEH-01
Procedure No. STD-AMD-007 Rev. 1
ST No. N/A Rev. N/A
Cal. Block No. 14A-PAL
Surface (ID/OD) OD
Block/Comp. Temp 68 °F/ 80 °F/

SEARCH UNIT	
Scan Angle: 45°	Mode: SHEAR
Fixturing (if any): LUCITE WEDGE	
Size & Shape: 3/8" ROUND	
Frequency: 1.5 mHz	
Serial No/Brand: 15241/KB-A	
Measured Angle: 44°	
Cable Type & Length: RG-174/U 6'	
Couplant Brand: SONOTRACE	
Couplant Batch: 093014	

SCAN AREA	
0° WRV	N/A
0° Mat'l	N/A
⊥ To Weld	X
ǁ To Weld	X

	0° or (⊥) TO WELD			ǁ TO WELD		
IDENT	SWEEP POS	AMPL %	ATTEN dB	SWEEP POS	AMPL %	ATTEN dB
1/4 T	1.5	80	68	1.5	80	67
3/4 T	4.4	40	68	4.8	40	67
ID	6.3	95	66	6.8	60	67
5/4T	7.8	30	68	N/A		
N/A						

——— AXIAL SCAN
- - - - CIRC SCAN



Screen Divisions, 10 = 2.5 in.

INSTRUMENT SETTINGS	
Mfg/Model No.: KB/USD-10	
Serial No.: 31875-1546	
Damping 50 OHM	
Mode Select: SINGLE	Reject: OFF
Freq.: 1mHz	Rep. Rate: N/A
Filter: N/A	Video: N/A Jack: R
Sweep Length C: N/A	F: 125 mS
Sweep Delay C: N/A	F: 6.06 µS
Gain 0° or (⊥) C: 74*	F: N/A
Gain ǁ C: 74*	F: N/A

* 3/4T SDH SET AT 80% FSH
Scan Sensitivity 86db

CAL. CHECKS	TIME
Initial Cal.	14:05
Intermediate	N/A
Intermediate	N/A
Intermediate	N/A
Final Cal.	17:58

EXAMINATION WELD/AREA	Recordable Indications Yes	Recordable Indications No	Scan Limitation Yes	Scan Limitation No	COMMENTS
WELD #1	N/A	X	N/A	X	NOZZLE TO SAFE END
WELD #2	N/A	X	N/A	X	SAFE END TO ELBOW
N/A					

INSTR. LINEARITY CAL.

	High	Low		High	Low
1	90	45	5	50	25
			6	40	20
2	80	40	7	30	15
3	70	35	8	20	10
4	60	30	9	10	5

AMPL. CONTROL LINEARITY

Initial	Δ dB	Result
80	-6	39
80	-12	20
40	+6	80
20	+12	82

EXAMINER [signature] LEVEL II DATE 10/10/93
EXAMINER N/A LEVEL N/A DATE N/A
REVIEWER ________ LEVEL ________ DATE ________
Authorized Inspection Agency ________ DATE ________

ADDITIONAL SHEETS? (Check Box)			
Continuation	N/A	Beam Plot	N/A
Supplements	N/A	Other	N/A

Page 1 of 1

RJK 10-10-93

ULTRASONIC CALIBRATION DATA SHEET

AMDATA

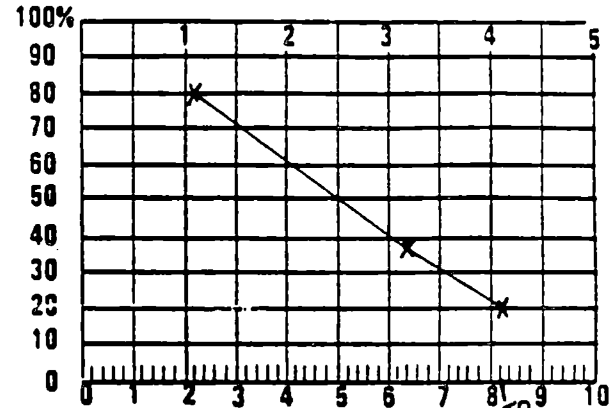
Plant/Unit: PALISADES
Comp/System: PRESSURIZER
Zone: PCS-12-PLS-1H1
Contract No.: 211057

UT No.: TERH-03
Procedure No.: STD-AMD-007 Rev. 1
ST No.: N/A Rev. N/A
Cal. Block No.: 14A-PAL
Surface (ID/OD): OD
Block/Comp. Temp: 68 °F / 80 °F

SEARCH UNIT	
Scan Angle: 60°	Mode: LONG.
Fixturing (if any): LUCITE	
Size & Shape: 2 (8mm x 8mm)	
Frequency: 2 mHz	
Serial No/Brand: 278/86 UTL	
Measured Angle: 58°	
Cable Type & Length: RG-174/U 4'	
Couplant Brand: SONOTRACE	
Couplant Batch: 093014	

SCAN AREA	
0° WRV	N/A
0° Mat'l	N/A
⊥ To Weld	X
‖ To Weld	N/A

	0° or (⊥) TO WELD			‖ TO WELD		
IDENT	SWEEP POS	AMPL %	ATTEN dB	SWEEP POS	AMPL %	ATTEN dB
1/4T	2.2	80	69			
3/4T	6.4	38	69			
ID	8.2	20	69		N/A	
		N/A				



Screen Divisions, 10 = 2.5 in.

INSTRUMENT SETTINGS		
Mfg/Model No.: KB/USD-10		
Serial No.: 31875-1546		
Damping: 50 OHM		
Mode Select: DUAL	Reject: OFF	
Freq.: 2.25 mHz	Rep. Rate: N/A	
Filter: N/A	Video: N/A	Jack: T&R
Sweep Length	C: N/A	F: 2.31" us
Sweep Delay	C: N/A	F: 8.825 us
Gain 0° or (⊥)	C: 76*	F: N/A
Gain ‖	C: N/A	F: N/A

* 3/4T SDH SET AT 80% FSH

Scan Sensitivity: 92db

CAL. CHECKS	TIME
Initial Cal.	14:28
Intermediate	N/A
Intermediate	N/A
Intermediate	N/A
Final Cal.	18:01

INSTR. LINEARITY CAL.					
	High	Low		High	Low
1	90	45	5	50	25
2	80	40	6	40	20
3	70	35	7	30	15
4	60	30	8	20	10
			9	10	5

EXAMINATION WELD/AREA	Recordable Indications Yes	Recordable Indications No	Scan Limitation Yes	Scan Limitation No	COMMENTS
WELD #1	N/A	X	N/A	X	NOZZLE TO SAFE END
WELD #2	N/A	X	N/A	X	SAFE END TO ELBOW

AMPL. CONTROL LINEARITY		
Initial	Δ dB	Result
80	-6	39
80	-12	20
40	+6	80
20	+12	82

EXAMINER [signature] LEVEL II DATE 10/10/93

EXAMINER N/A LEVEL N/A DATE N/A

REVIEWER ______ LEVEL ______ DATE ______

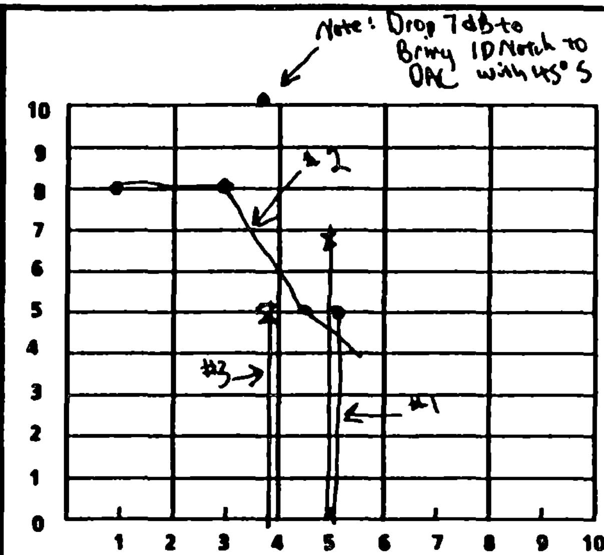
Authorized Inspection Agency ______ DATE ______

ADDITIONAL SHEETS? (Check Box)			
Continuation	N/A	Beam Plot	N/A
Supplements	N/A	Other	N/A

CONSUMERS POWER COMPANY
NONDESTRUCTIVE TESTING SERVICES
ULTRASONIC SYSTEM CALIBRATION REPORT

Examiner Richard Humphrey Level III Date 10-10-93 Sheet No. RAH-01
Examiner N/A Level N/A NDT Company CPCo
Project No. 249315 228098 Requesting Dept ISI
Job Location Palisades Total Hours Worked N/A

Search Unit	#1	#2	#3	#4	#5
Brand Name	Panametrics	KBA	Mega Sonic	Mega Sonic	N/A
Serial No.	3743 00812	43921	D0972	D0965	
Size	.5"	.5"	.375"	.22 x .50	
Frequency (MHz)	2.25	2.25	2.25	2.25	
Angle	0°	45°	30/60/70	45°	
Measured Angle	N/A	45°	N/A	45°	
Wave Propagation	L	S	S/L/L	L	
Instrument Settings					
Sweep Range	2.56	9.10	5.9	2.7	
Sweep Delay	.2	4.8	12.0	6.3	
Reference Gain (dB)	41.5	31.0	51.5	61.5	
Reject	0%	0%	0%	0%	
Damping	fixed	fixed	fixed	fixed	
Rep Rate	High	High	High	Dual	
Filter	fixed	fixed	fixed	fixed	
Initial Calibration/Hr	1400	1400	1401	1401	
Verification Time	1432	1502	1544	1621	
Verification Time	1459	1542	1619	1703	
Final Calibration/Hr	1900	1902	1905	1906	



1. Angle 0° Full Screen = 2.5" Metal
2. Angle 45° Full Screen = 5" Metal
3. Angle 30/60/70° Full Screen = 2" Metal
4. Angle 45° Full Screen = 2" Metal
5. Angle N/A° Full Screen = N/A" Metal

Verification Block Serial No. 797551

Calibation Reference Standard
Material Type SS Serial No. 14A-PAL
Diameter 12" Thickness 1.125

Ultrasonic Instrument USK-7
Serial No. 000856 Cal Due 3-15-94
Search Unit Cable Type/Length ① BNC-BNC 6ft ② BNC-MD 6ft ③ BNC-LIMD 6ft ④ BNC-LIMO 16ft
Number of Connectors N/A
Couplant Sonotrace 40 Batch No. 09304

SCREEN HEIGHT LINEARITY CHECK

100% FSH	50/50 *% FSH	50% FSH	25/25 *% FSH
90% FSH	45/45 *% FSH	40% FSH	20/20 *% FSH
80% FSH	40/40 *% FSH	30% FSH	15/15 *% FSH
70% FSH	35/35 *% FSH	20% FSH	10/10 *% FSH
60% FSH	30/30 *% FSH		

*Verification RAH

The second reflector shall be 50% of the first (±5% FSH) to meet amplitude linearity.

AMPLITUDE CONTROL LINEARITY CHECK

80% FSH -6 db	41 / 41 *	(32-48)%
80% FSH -12 db	19 / 19 *	(16-24)%
40% FSH +6 db	80 / 80 *	(64-96)%
20% FSH +12 db	82 / 82 *	(64-96)%

*Verification RAH

NDT Procedure NDT-UT-01 Rev 10

Remarks N/A

THERMOMETER

Serial No. 3743-01080 Cal Due 1-18-94
Temperature: Cal Block 68°F Item 80°F

Examiner Richard Humphrey Page 1 of 1 Reviewed By ______ Level ______ Date ______

Rev 12/92

CONSUMERS POWER COMPANY
NONDESTRUCTIVE TESTING SERVICES
ULTRASONIC EXAMINATION REPORT

Examiner: Richard Humphrey — Level: III — Date: 10-10-93 — Sheet No. RAH01
Examiner: N/A — Level: N/A — NDT Company: CPCo
Project No. 249315 228098 — Requesting Dept: ISI
Job Location: Palisades — Total Hours Worked: N/A

NDT Procedure: NDT-UT-01 — Rev: 10
T/C 4-93

Interpretation Requirements:
Code: N/A — Year: N/A — Section: N/A — Part: N/A
Other Reference: Pal ISI Spec. 6A

Material Type: Inconel/SS — Joint Design: Butt
Nominal Diameter: 12" — Nominal Thickness: 1.125"
Weld Type: Safe end to Elbow
System Name: PCS — Line No. PCS-12-PSL-1H1

BEAM DIRECTION	PERFORMED YES	PERFORMED NO	Percentage of Volume Scanned	Scan Start Hour	Scan End Hour
Axial Downstream	✓		95% ①	1505	1700
Axial Upstream	✓		↓	↓	↓
CW DS	✓				
CW US	✓				
CCW DS	✓				
CCW US	✓				
T of Weld CW	✓				
T of Weld CCW	✓		↓	↓	↓

System Calibration Sheet No. ______

Remarks: Toe of Weld limited contact of Transducer

Weld Crown: A. Height .1" — B. Width 1.9"
Thickness at: T-1 1.25 — T-2 1.125 — T-3 1.15

Surface Condition: Ground

Scanning Surface: ✓ OD N/A ID
L_0 Rule No. N/A
WO/MO: N/A

Item ID Number	Indication No.	% DAC at Max	L_1 50% DAC	L Max	L_2 50% DAC	W_1 50% DAC	W_1 50% MP	W Max	W Max MP	W_2 50% DAC	W_2 50% MP	Search Unit Location	Search Unit Angle	Search Unit Beam Direction	Evaluation NRI	Evaluation RCI	Evaluation RPI
2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	✓		

Note: Due to the High level of the reference dB setting an ID Root Geometry Indication was noted at the Center line of Weld at an amplitude of 5% of Full screen Height.

Examiner: *[signature]* — Page 1 of 1 — Reviewed By ______ — Level ______ — Date ______

Rev 12/92

CONSUMERS POWER COMPANY
NONDESTRUCTIVE TESTING SERVICES
ULTRASONIC EXAMINATION REPORT

Examiner: Richard Humphrey Level: III Date: 10-10-93 Sheet No.: RAH-a
Examiner: N/A Level: N/A NDT Company: CPCo
Project No.: 249315228098 Requesting Dept: ISI
Job Location: Palisades Total Hours Worked: N/A

NDT Procedure: NDT-UT-01 Rev: 10
T/C 4-93

Interpretation Requirements:
Code: N/A Year: N/A Section: N/A Part: N/A
Other Reference: Pal ISI Spec. App 6A

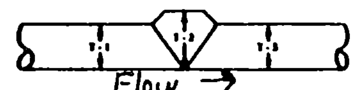
Material Type: CS/Inconel Joint Design: Butt
Nominal Diameter: 12" Nominal Thickness: 1.125
Weld Type: Nozzle to Safe end
System Name: PCS Line No.: PCS-12-PSL-1H1

BEAM DIRECTION	PERFORMED YES	PERFORMED NO	Percentage of Volume Scanned	Scan Start Hour	Scan End Hour
Axial Downstream	✓		100%	1505	1700
Axial Upstream	✓				
CW DS	✓				
CW US	✓				
CCW DS	✓				
CCW US	✓				
T of Weld CW	✓				
T of Weld CCW	✓				

System Calibration Sheet No.: RAH 01
Remarks: N/A

Weld Crown: A. Height: flush
B. Width: 1.5
Thickness at: T-1: 1.25
T-2: 1.30
T-3: 1.25

Surface Condition: Smooth
Scanning Surface: ✓ OD N/A ID
L_0 Rule No.: N/A
WO/MO: N/A



Item ID Number	Indication No.	% DAC at Max	L_1 50% DAC	L Max	L_2 50% DAC	W_1 50% DAC	W_1 50% MP	W Max	W Max MP	W_2 50% DAC	W_2 50% MP	Search Unit Location	Search Unit Angle	Search Unit Beam Direction	Evaluation NRI	Evaluation RCI	Evaluation RPI
#1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	✓		

Examiner: Richard Humphrey Page 1 of 1 Reviewed By: ______ Level: ______ Date: ______

Rev 12/92