PRELIMINARY

REPORT ON THE STATUS OF
INTERGRANULAR STRESS CORROSION CRACKING
IN STEAM GENERATOR TUBE U-BENDS

Pacific Gas and Electric Company

Diablo Canyon Units 1 and 2

Docket Numbers 50-275 and 50-323

April, 1984

C/16

9811060196

CONTENTS

PRELIMINARY

	Page
I. INTRODUCTION	1-1
II. HISTORICAL REVIEW	
A. Summary of Problem	2-1
B. Operating Experience	2-7
III. SUMMARY OF RESEARCH	
A. Stress Corrosion Studies	3-1
1. Effect of Temperature	3-2
2. Effect of Stress	3-2
3. Effect of Materials Characteristics	3-3
B. Trojan Tube Analyses	3-6
C. Stress Measurement	3-8
D. Crack Theory and Propagation	3-10
E. Nondestructive Examination	3-12
F. Potential Mitigating Actions	3-14
1. Tube Plugging	3-14
2. In-situ Heat Treatment	3-15
3. Other Potential Mitigating Actions	3-16

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CONTENTS

(Continued)

PRELIMINARY

			Page
	G.	Leak Before Break	3-18
	H.	Future Research	3-20
	I.	Roll Transition Zone	3-22
IV.	DIABLO CANYON TUBE FABRICATION HISTORY		
	A.	Remarks on Mill Heat Treatment	4-1
	B.	Diablo Canyon Tube Fabrication Dates and Heat Treatments	4-1
V.	PG&E PROGRAM FOR SHORT RADIUS U-BENDS		
	A.	Nondestructive Examination	5-1
	B.	Leak Monitoring	5-4
	C.	Evaluation of Mitigating Actions	5-4
	D.	Secondary Water Chemistry	5-5
VI.	CONCLUSION		6-1
	REFERENCES		7-1
	APPENDIX A		A-1
	Project Description - RPS303		

PRELIMINARY

List of Figures

		Page
1.	Schematic Diagram of Steam Generator	2-4
2.	Typical U-tube Geometry and Nomenclature	2-5
3.	Intergranular Stress Corrosion Cracking	2-6

PRELIMINARY

List of Tables

		Page
1.	Summary of U-Bend Leaks in Steam Generators	2-8
2.	Summary of U-Bend Eddy Current Indicators	2-9
3.	Operating Years Prior to Leakage	2-10
4.	Reported Leak Rates	2-11
5.	Tubing Identification	4-3

PRELIMINARY

I. INTRODUCTION

Nuclear power plants have experienced several types of corrosion. One type of corrosion which has appeared in pressurized water reactor plants is primary side cracking in steam generator small radius tube U-bends. This cracking has been identified as intergranular stress corrosion cracking (IGSCC). It has appeared in several plants and in some cases has resulted in primary-to-secondary leaks. Safety Evaluation Report Supplement No. 9 (1) raised the question of the particular susceptibility of the steam generator row one U-bends at Diablo Canyon to the early onset of cracking and also of possible preventive plugging of these tubes. Since that Supplement was issued, there have been few new cases of U-bend cracking, the observed leak rates have continued to be low, and research has demonstrated that cracked tubes will leak rather than break. This report will review the cracking which has occurred at other plants, discuss the research which has been conducted with regard to this cracking, describe the PGandE tubes and program, and conclude that preventive plugging of the row one tubes is not justified technically and is not required by any safety consideration.

PRELIMINARY

II. HISTORICAL REVIEW

A. SUMMARY OF PROBLEM

The earliest reported instance of steam generator row one tube U-bends (smallest bend radius) leakage (1971) was at Obrigheim. Efforts to determine the cause were unsuccessful. The earliest reported instances of primary side cracking in steam generator row one tube U-bends (1976) have been attributed to denting. In these cases, examinations of row one U-tubes which were removed from severely dented steam generators revealed that cracking occurred at the apex region due to stresses induced by movement of the tube legs as denting distorted the tube support plates. This was observed at Surry Units 1 and 2 and Turkey Point 4. In the case of Surry Unit 2, an apex crack caused a tube rupture which resulted in a major primary to secondary leak (80-140 GPM). This is the only known domestic corrosion-related U-bend tube break and was associated with severe denting. Apex cracks have been observed also in foreign plants. These have been attributed to a manufacturing problem by a foreign tube supplier.

In addition to row one apex cracking, cracking initiated on the primary side and on the secondary side has been observed at dented intersections in tube support plates due to stresses induced in the tubes as denting distorted them. It has been demonstrated that denting can be controlled by careful attention to the secondary system water quality and the number of incidents of tube cracking induced by denting have decreased.

The majority of subsequent primary side U-bend cracking which has occurred in steam generators has not been induced by denting. In nearly all cases, the cracks have been associated with row one tubing and in most cases the crack initiation occurred in the straight leg to bend transition region. This region also is referred to as the tangent point although strictly speaking it is a section of the tube. The row one tubes of some steam generators were bent with an internal mandrel. Some instances of cracking are associated with tubes which exhibit a smooth transition into the U-bend on one leg and an irregular transition on the opposite leg as a result of this method of bending. In this situation, the cracks tend to occur in the extrados (outer) side of the irregular transition, to be oriented axially, and to be of limited length. The smooth and irregular transitions have no consistent orientation in the steam generators and cracking has been observed in irregular transition regions in both hot and cold legs. In all cases where the cracks developed through wall, the resulting leak rates were characterized as low and stable.

Domestic plants which have exhibited bend transition zone cracking include Trojan, Surry Unit 2, Zion Unit 1, Cook Unit 2, North Anna Unit 1, and Farley Unit 1. Foreign plants also have reported bend transition zone cracking: Takahama Unit 1, Ringhals Unit 2, Doel Unit 2, and possibly Fessenheim Unit 1.

Figure 1 is a schematic view of a steam generator and shows the location of the row one tube U-bend. Figure 2 gives the typical geometry of a row one U-bend. Figure 3 shows a tube crack in the U-bend region which has progressed through the tube wall.

PRELIMINARY

Primary side cracking has been reported in several European and Japanese plants in the roll transition zone between the expanded and unexpanded portions of the tubing within the tubesheet. There has been no reported primary side leakage in this area in any domestic plant. The tubes in the Diablo Canyon steam generators have been field expanded by the Wextex explosive method to eliminate the crevices above the factory tube roll. Trojan, Beaver Valley Unit 1, Salem Units 1 and 2, Farley Unit 1, North Anna Units 1 and 2, and Sequoyah Unit 1, have had a similar modification and all are operating with no reported roll transition zone cracking.

PRELIMINARY

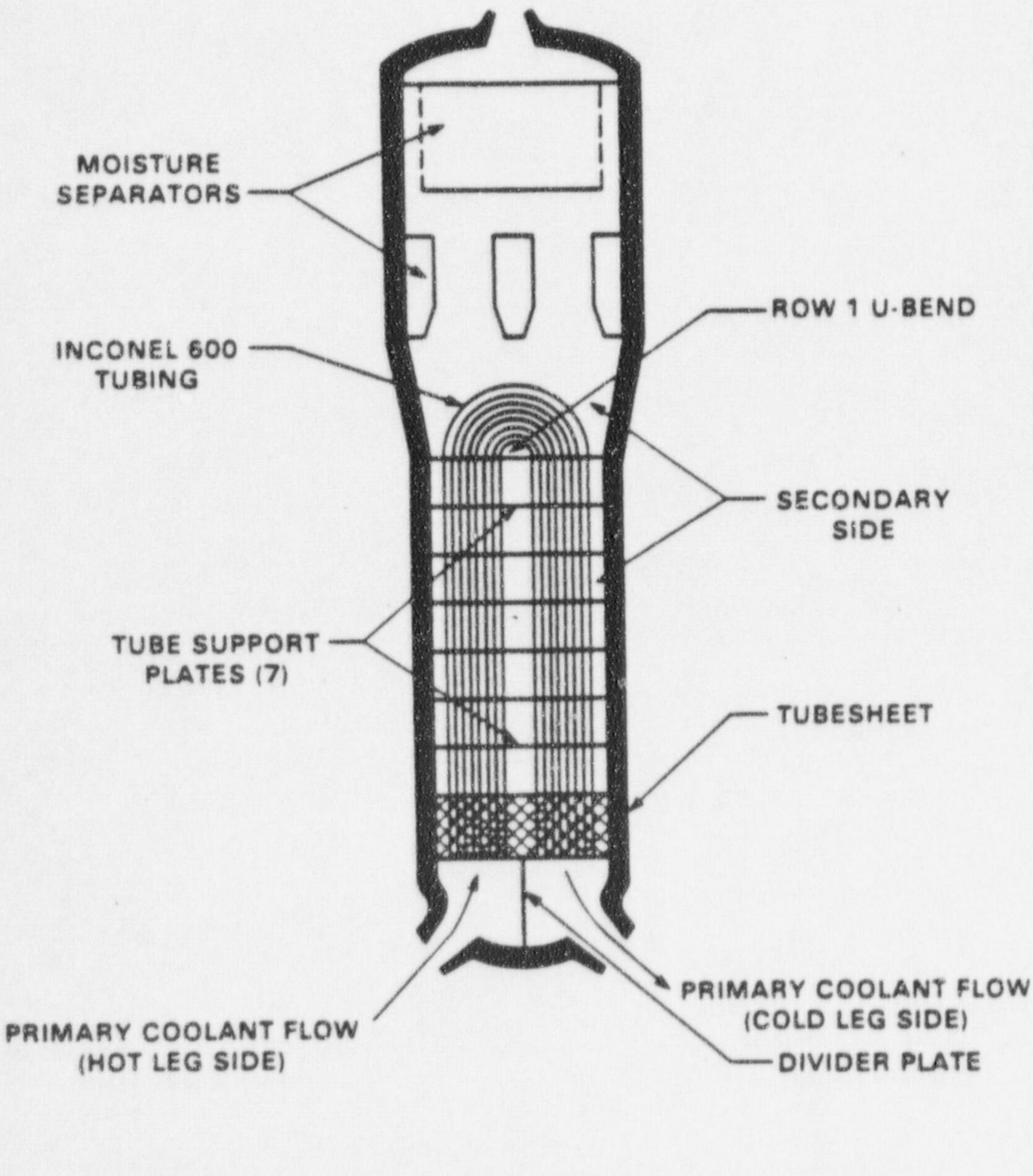
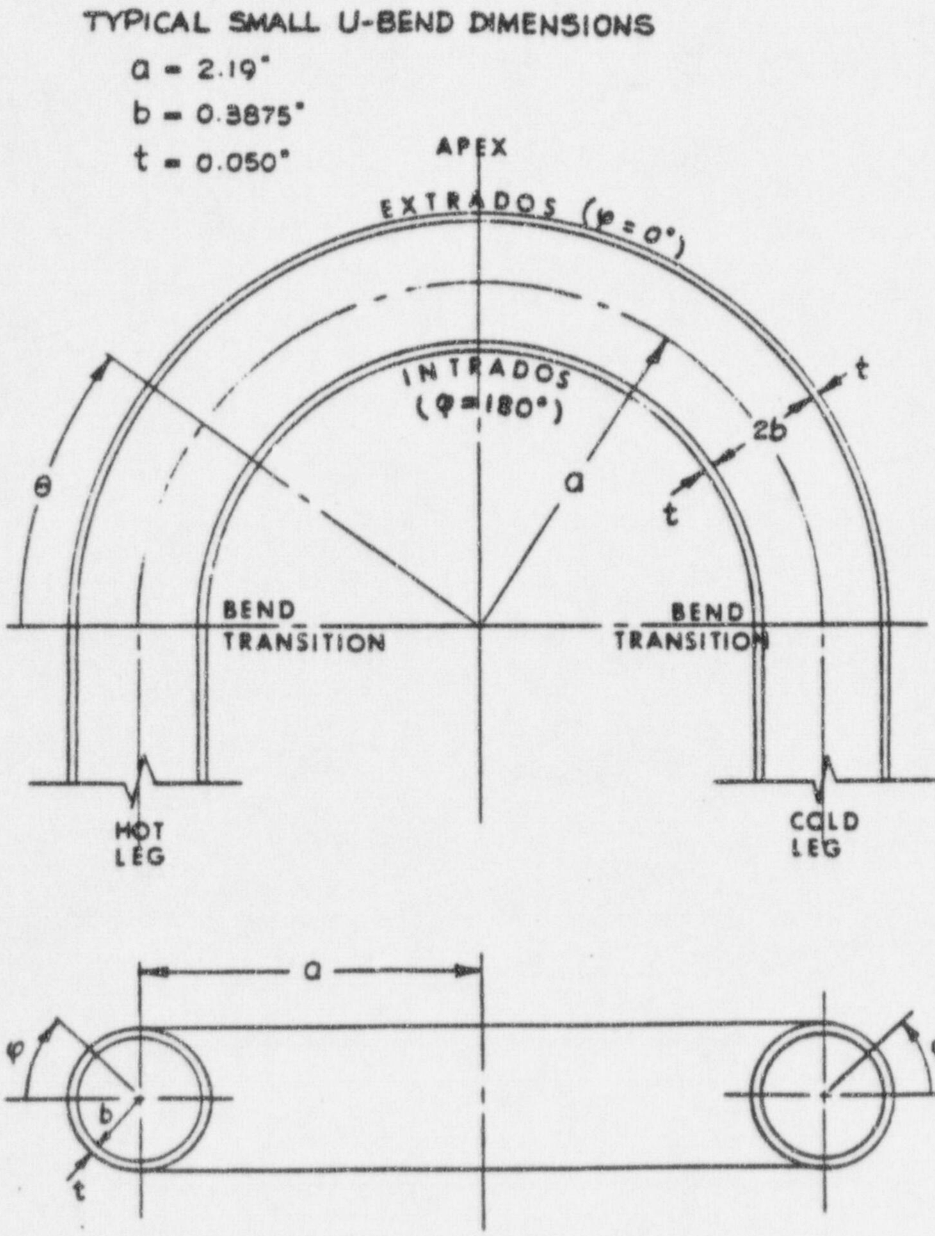


Figure 1 Schematic Diagram of Steam Generator

PRELIMINARY



TUBE AND U-BEND GEOMETRY

Figure 2 Typical U-tube Geometry and Nomenclature

PRELIMINARY

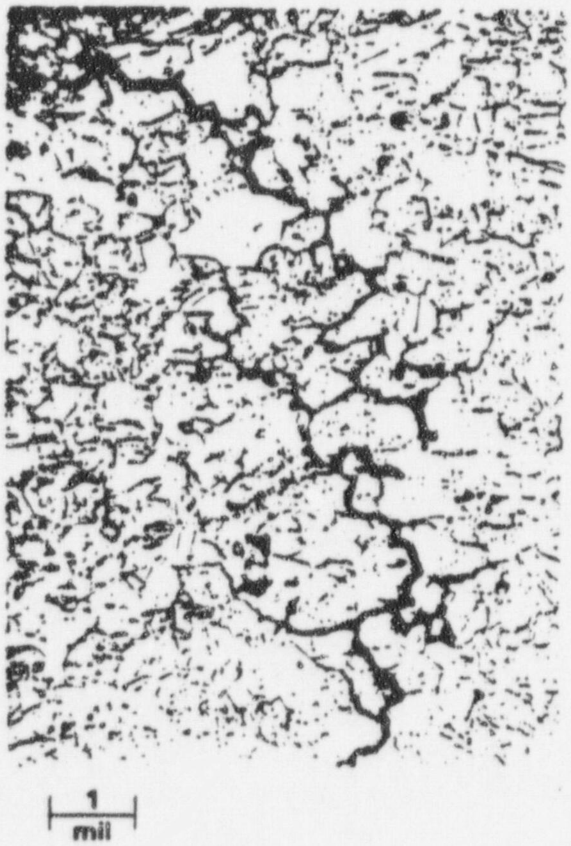


Figure 3 Intergranular stress corrosion cracking. This section is from the bend transition region of a tube with a through-wall crack removed from a steam generator at Trojan.

PRELIMINARY

B. OPERATING EXPERIENCE

The data available relative to steam generator tube U-bend leaks and indications is summarized in the following tables. There is at present no authoritative compilation of this information and the available sources are not entirely consistent. There is, however, enough data to give a reasonable description of primary side U-bend cracking. This data is presented as a list of plants which have reported leaking tubes (Table 1), a list of plants which have reported eddy current indications (Table 2), a summary of operating years prior to reported leakage (Table 3), and a table of reported leak rates (Table 4). It is evident from these tables that leaks are relatively rare, they take a long time to develop, and, with two exceptions, the leak rates are low. Both exceptions are known to have had unusually high tube stresses from specific causes: Surry Unit 2 from support plate deformation caused by denting, Doel Unit 2 from excessive ovality. The Doel tubes are of European manufacture.

PRELIMINARY

TABLE 1

SUMMARY OF U-BEND LEAKS IN STEAM GENERATORS

Plant	Startup Year	Date of Leakage	Years To Leak	Leakage Location	Number Leaking Tubes	Comments
Bugey 2	1979	1982	3		more than one	
Cook 2	1978	1980	2	Tangent	3	
Doel 2	1975	1979	4	Apex	1	Significant tube ovality due to manufacturing.
Farley 1	1977	1978-79	1	Tangent	1	
		1980	3	Tangent	2	
		1981	4		3	
North Anna 1	1978	1979	1	Tangent	2	Attributed to resin intrusion.
Obrigheim	1969	1971	2		5	Neither the cause of these leaks nor why they are all in the #2 steam generator has been reported. These tubes are of foreign manufacture.
		1972	3		3	
		1973	4		3	
		1974	5		1	
		1979	10		1	
Ohi 1	1979	1981	2	Tangent	1	
Ringhals 2	1975	1979	4	Tangent	2	
		1980	5	Tangent	1	
Surry 2	1973	1980	3	Apex	1	Extensive denting with support plate hour glassing.
Trojan	1975	1978	3	Tangent	1	
		1979	4	Tangent	5	
		1980	5	Tangent	7	
		1981	6	Tangent	6	
Zion 1	1973	1980-82	7-9			After shutdown, 23 tubes were found to leak helium.

PRELIMINARY

TABLE 2

SUMMARY OF U-BEND EDDY CURRENT INDICATIONS

PLANT	YEAR OF INSPECTION	LOCATION	NO. OF TUBES
BUGEY 2	1983	Tangent	Small number
COOK 1	1983	Tangent	3
COOK 2	1980, 1981, 1982, 1983	Tangent	20
FARLEY 1	1978, 1980, 1981	Tangent	5
KORI 1	1981	Tangent	2
NORTH ANNA 1	1979	Tangent	2
OHI 1	1981	Tangent	26
		Row 2	2
PRAIRIE ISLAND 1	1981	Row 2	1
RINGHALS 2	1979, 1980	Tangent	2
TAKAHAMA 1	1977, 1978, 1980	Tangent	91
TROJAN	1978, 1979, 1980, 1981	Tangent	33
ZION 1	1981, 1982	Tangent	32
		Row 2	22

TABLE 3

OPERATING YEARS PRIOR TO LEAKAGE
(NUMBER OF UNITS)

1 YEAR	2 YEARS	3 YEARS	4 YEARS	5 YEARS	6 YEARS	7 YEARS	10 YEARS
2	3	5	5	3	1	1	1

PRELIMINARY

TABLE 4

REPORTED LEAK RATES

PLANT	DATE	MAXIMUM LEAK RATE (gpm)	NO. OF LEAKS
Cook 2	10/80	0.01	1
Doel 2	6/79	150	1
Farley	8/78	0.006	1
	6/80	0.11	1
North Anna 1	9/79	0.007	2
Ringhals 2	4/79	0.55	1
Surry 2	9/76	140	1
Trojan	3/78	0.001	1
	10/79	0.10	5
	1/81	0.21	4
Zion 1	3/82	0.48*	23 (by helium)

*This leakage started in 1980 as 0.0035 gpm in two steam generators and involved four steam generators at the time of the outage.

PRELIMINARY

III. SUMMARY OF RESEARCH

A. STRESS CORROSION STUDIES

Analysis of the primary side initiated cracking indicates that the most probable failure mechanism is Coriou-type intergranular stress corrosion cracking (IGSCC). The details of the mechanism are not yet completely understood, but laboratory testing and steam generator failure analyses have identified the following parameters as being significant: (1) tube material characteristics (chemistry, microstructure and mechanical properties), (2) temperature, (3) tensile hoop stresses at the crack locations (I.D. surfaces at U-bend apex, opposite side bend transition, and roll expansion transition). The influence of primary water chemistry is not clear since Coriou cracking has been observed in susceptible materials in deaerated deionized water containing essentially no impurities. It is known that there is a strong influence of electrochemical potential upon the stress corrosion cracking characteristics of Alloy 600 and thus impurities in the primary water may have an effect on Coriou cracking insofar as they influence the electrochemical potential of the tube surface. It has been found in the laboratory that primary water is less agressive in cracking Alloy 600 than pure water.

1. Effect of Temperature

The effect of temperature upon the stress corrosion cracking mechanism is great. Laboratory studies conducted over the temperature range of 600°F to 700°F indicate that the crack initiation rate is 2 to 3 times faster for each 10°F rise in temperature. Although in theory a reduction of the primary hot leg temperature could be considered as a corrective measure, the magnitude of the benefit is not well defined and thus it is not possible to quantify the gain with respect to the economic loss resulting from a reduction in plant power and operating flexibility.

2. Effect of Stress

The effect of stress is known to be a major factor in stress corrosion cracking. It has been demonstrated that a tensile surface stress is necessary to cause Alloy 600 to crack in water. Currently, it is not known if there is a threshold stress associated with the cracking process. Laboratory testing has shown that crack initiation time decreases rapidly with increasing tensile stress for stress values approaching the yield stress. In the case of steam generator tube materials, the stresses would be the combination of operating pressure, thermal expansion, residual fabrication stresses and any stresses resulting from deformation by denting. The stress analyses performed on the Trojan steam generator tubes revealed the presence of axially oriented residual tensile stresses which would favor circumferential cracking rather than the observed axial cracking. Calculations have been performed to estimate the magnitude of circumferential stresses in the U-bend transition region. The pressure-induced stresses and through-wall thermal gradient stresses appear to be relatively uniform around the tube circumference. Bending moments on the U-bend due to differential thermal expansion of the hot and cold legs produce stresses that vary both circumferentially and through the wall thickness.

3. The Effect of Material Characteristics

The influence of the Alloy 600 material characteristics upon stress corrosion cracking susceptibility has been difficult to quantify. Laboratory studies have shown great variability in the performance of Alloy 600 samples tested under apparently identical conditions. The differences are observed most frequently in samples taken from different heat treatment conditions, mill processing conditions or melt chemistries, but variations have been observed between apparently identical samples cut from a single plate or tube. Similarly, the Trojan steam generator tubing evaluation was unable to establish a definite correlation of cracking susceptibility with carbide distribution in the microstructure, grain size, or minor element alloy chemistries. Although cracks were observed in some of the Trojan tubes, there were many uncracked tubes from the same heats as tubes with cracks. An overall review of the stress corrosion cracking experience has shown that certain sets of tubes appear to be more susceptible to cracking than others. An analysis of the mechanical properties of the Alloy 600 heats involved with cracking at Trojan compared to the average properties of all Alloy 600 tubing used in similar steam generators indicates that the Trojan tubes had only slightly higher yield strengths (58.6 ksi vs 55.2 ksi) and hardness values (87.6 R_B vs 85.7 R_B) than the average properties.

PRELIMINARY

The effect of mill processing upon the susceptibility of Alloy 600 to stress corrosion cracking has been studied with respect to both basic mill production techniques and post fabrication heat treatments. In the case of mill production practice, much of the Alloy 600 tubing manufactured for the early steam generators was given a relatively low temperature final mill anneal (1750°F) which produced a microstructure consisting of a fine grain size and carbides which were distributed throughout the grains rather than in the grain boundaries. The purpose for such a process was to improve mechanical properties and to avoid sensitization by removing the carbides from the grain boundaries. The resulting material also exhibited higher yield strengths (greater than 55 ksi) due to fine grain size associated with the 1750°F annealing temperature. Materials produced with higher final annealing temperatures (greater than 1800°F) exhibit carbides in the grain boundaries and have a lower yield strength (due to coarser grain size) than the material annealed at lower temperatures. Laboratory testing has shown the lower temperature material to be much more susceptible to stress corrosion cracking than the material annealed at higher temperatures. Since the presence of carbides in the grain boundaries appeared to improve stress corrosion cracking resistance, a number of studies have been conducted to investigate the effect of post fabrication thermal treatments. These thermal treatments were performed in the temperature regime of maximum carbide precipitation. Laboratory testing revealed that significant improvements in stress corrosion cracking resistance could be realized by developing a semi-continuous grain boundary precipitate. Based upon extensive testing, Westinghouse has established a 15 hour at 1300°F thermal treatment which produces a semi-continuous distribution of carbides in the grain boundaries without a chromium depleted zone adjacent to the grain boundaries.

PRELIMINARY

The final annealing operation has been shown to have a strong influence on the success of the thermal treatment. If the temperature during the annealing operation is too low, insufficient carbon is dissolved to permit grain boundary precipitation during the subsequent thermal treatment. Conversely if the final annealing temperature is too high, too much carbon will be dissolved and there is a possibility of a grain boundary chromium depleted zone being present following the thermal treatment. Although the mechanism of the improvement in stress corrosion cracking resistance due to thermal treatment is unknown at this time, the benefical effect is significant and thus the use of thermally treated Alloy 600 tubing has been incorporated into new steam generator designs.

PRELIMINARY

B. TROJAN TUBE ANALYSIS

The Trojan steam generator U-bend tubes have been subjected to extensive evaluation by both Westinghouse and Battelle Northwest Laboratories. A total of 29 tubes (26 tubes from row one and 3 tubes from row two) were removed for destructive laboratory testing. The U-bend transition regions of the tubes were characterized by a smooth transition at one leg and well-defined intrados and extrados transitions at the other (opposite) leg. (Refer to Figure 2.) The intrados transition was approximately 0.6 inches below the extrados transition. Three of the row one tubes were observed to have several branched cracks in the extrados of the opposite transition. The irregular transitions found on the opposite side are believed to be a result of the use of an internal ball mandrel during the bending operation. The occurrence of slightly deformed tubing wall regions in the transition regions indicates that local residual fabrication stresses are present. Since prior observations of primary side IGSCC all have occurred at locations where relatively high stresses were expected, it is suspected that the residual stresses are contributing to the IGSCC. During the investigation of the Trojan tubes-a number of row one tubes were characterized as having a well-defined opposite transition without any evidence of IGSCC defects. For comparison, a number of row one tubes from other steam generators were evaluated with respect to transition geometry and the presence of IGSCC. Tubes taken from Turkey Point Unit 4 and Surry Unit 1 exhibited smooth transitions on both sides of the U-bend region and no cracking was found. Tubes taken from Surry Unit 2 exhibited irregular transitions similar to those of Trojan. One of the four Surry Unit 2 tubes had primary side-branched cracks at the same location as the Trojan tubes. No consistent relationship could be established between

PRELIMINARY

cracking at Trojan and ovality, carbide distribution, grain size, or alloy chemistries.

Metallography of the cracked Trojan tubes indicated the presence of shallow intergranular cracks in the vicinity of the major cracks. These were axially oriented and exhibited evidence of degradation of the oxide on the crack surface. The frequency of the shallow cracks varied around the circumference of the irregular transition containing major cracks. The axial orientation of the major cracks in the tubes could have resulted from circumferential tensile stresses occurring on the primary side surfaces at the crack initiation sites. The presence of such circumferential stresses has not been confirmed by laboratory surface residual stress measurements. In the case of the Trojan steam generator, hoop tensile stresses of 20 to 30 ksi have been calculated to result from the differential thermal expansion between hot and cold legs. Another stress contribution arises from bending moments due to support plate contact. The leg separation distances for the Trojan U-bend tubes were observed to change by as much as 80 mils when the tubes were removed from the support plates. Calculations have shown that circumferential tensile stresses from such leg deflections would exceed 40 ksi (2). However, leg deflection did not correlate with U-bend transition cracking.

PRELIMINARY

C. STRESS MEASUREMENT

Stress is required, by definition, for IGSCC to occur. It has been observed in the laboratory that the time to failure increases significantly when the stress level is lowered (3). Laboratory data for constant stress tests in pure water suggests that time to failure by IGSCC of Alloy 600 may be inversely proportional to stress to the fourth power (4). Cracking has been experienced in locations where stress concentrations exist: U-bends, roll transition zones, and where tubes have been distorted by denting. It has been stated that all primary side Alloy 600 events have occurred at locations where relatively high stresses were expected and that the stress states in U-bends are complex and unpredictable (2).

Efforts have been made to measure the local residual stresses where cracking has occurred or might be expected to occur. Methods used to measure residual stress include stress relief by sectioning, stress relief by layer removal, chemical testing, and x-ray diffraction. These methods average local stresses, and the stress measurements have not been as helpful in understanding IGSCC as one would wish. The reasons for this are that stress is only one of the conditions required for cracking, operating stresses are not measured, most of the methods are cumbersome and time-consuming so that there are few data, the data are not consistent, and the methods cannot measure stress in the small areas of interest (on the order of grain size). EPRI has under way a program to develop an automated method of residual stress measurement by x-ray diffraction which is faster than existing techniques. This program has achieved marked reductions in the size of equipment and

PRELIMINARY
PRELIMINARY

exposure time and has indicated that both level of local residual stress and local residual stress gradients are higher than have been found by previous techniques. However, it still is not possible to measure stress in tubes in a steam generator or to measure stresses on the inside of a tube without cutting the tube.

PRELIMINARY

D. CRACK THEORY AND PROPAGATION STUDIES

One theory of the steam generator primary side IGSCC process is that metal dissolution and/or hydrogen embrittlement are responsible. The suggested mechanism is repeated local film rupture followed by metal dissolution. This theory appears to be consistent with the observations that have been made. If it is correct, the damage begins when strain is transferred from the base metal to the more brittle protective film, which suggests that strain rate is a key parameter controlling the rate of IGSCC damage (7). If the number of plant start-ups, shutdowns, and load changes, i.e., a low service factor, is associated with the progress of cracking, as seems to be the case at Trojan, it would be in agreement with the suggested significance of strain rate and film rupture.

In the laboratory, it has been observed that the initiation time of cracking decreases in the presence of hydrogen. It has been suggested that sulfur may embrittle the grain boundaries at the bottom of the crack (3). Auger spectroscopy of a section of a crack from a tube removed from a Trojan steam generator showed low nickel values in the crack surface, implying selective leaching of nickel by the solution in the crack (2).

Some investigation has been made into crack propagation velocities. Velocities calculated from crack lengths observed in the laboratory and in tubes from Trojan indicate that propagation of crack lengths is on the order of one mil per day.

There is some indication that crack propagation follows a semilogarithmic Arrhenius relationship with temperature (4). This will be a very useful insight if it can be substantiated.

E. NONDESTRUCTIVE EXAMINATION (NDE)

The EPRI Steam Generator Owners Group (SGOG) has been conducting U-bend eddy current NDE research. The most recent report (8) describes three new probe designs and initial testing results.

1. Differential Bobbin Coil Beaded Flex Probe

This 0.650-inch diameter probe is made by Zetec. The probe was used in the laboratory to examine U-bends with manufactured defects. Frequencies used were 100 KHz absolute and 100 KHz differential. Analysis of the laboratory data indicate that 60% through-wall defects are readily detectable. With careful review of the data, through-wall defects of 40% can be detected if the aspect ratio (length divided by depth) is greater than ten.

2. Series Configuration, Pancake Coil Array Probe

This probe has surface-riding, spring-loaded pancake coils arranged in an array for full circumferential coverage of the tube wall. The individual pancake coils are wired in series, requiring only three coil leads. This probe has been used for a limited amount of laboratory testing. This testing has shown that the probe can detect 40% through-wall defects reliably with considerably better signal-to-noise ratio than the bobbin coil probe. This testing also has shown that this probe is not applicable to field use because it is not reliable mechanically. This probe is being redesigned to provide greater mechanical reliability.

PRELIMINARY

3. Multiplexed Configuration, Pancake Coil Array Probe

This probe also has surface-riding, spring-loaded pancake coils arranged in an array. Multiplexing is used to allow all eight pancake coils to have independent signals. This probe has not been tested extensively; however, it is expected to produce an improved signal-to-noise ratio over the series configuration probe. The potential disadvantages are decreased mechanical reliability and more complicated signal process instrumentation.

In addition to the three probes that the EPRI SGOG is examining, the French and Japanese are developing probes to improve examination of short radius U-bends.

Improvements in steam generator NDE in recent years include remote probe positioning devices. There are at least two manipulator-type positioners and two finger-walker positioners on the market. The advantages of these positioners include computer-controlled tube selection and reduction of radiation exposure to NDE workers.

PRELIMINARY

F. POTENTIAL MITIGATING ACTIONS

1. Tube Plugging

The most straight-forward means of mitigating the consequences of tube cracking is to plug the cracked tubes. The Technical Specifications require that a tube be removed from service by plugging if there is an indication that it contains a defect, which is defined as an imperfection 40% of the tube wall thickness in depth.

The steam generator manufacturer has developed a mechanical tube plug which can be inserted remotely and can be removed without damage to the tube if a more satisfactory means of mitigation or repair is developed in the future. These plugs would be installed directly by a three-man crew if a small number of tubes were to be plugged. A robot is being developed and has been used which can install a large number of tube plugs if that should become necessary.

Some rows of short radius U-bend tubes have been plugged as a preventive measure by other utilities for either regulatory or operational reasons. Because it is not possible presently to predict the susceptibility to cracking of a given group of tubes, it is not advisable technically to plug tube rows preventively unless they have shown a propensity to crack in service. Otherwise, heat transfer surface which would not develop cracks may be removed from service unnecessarily.

PRELIMINARY

2. In-situ Heat Treatment

Heat treatment of tubes presently in service for steam generators has been suggested as a prospective method for achieving improved resistance to IGSCC (2, 6, and others). It is known that heat treatment at 700°C (1292°F) can improve the IGSCC resistance of Alloy 600 in the laboratory (5) or at least delay the initiation of cracking for the period of the test (3). These laboratory heat treatments required time periods from 1 to 100 hours, which is impractical for the field treatment of installed tubes. Short time period (2-1/2 to 7 minutes) thermal treatments have been performed in the laboratory which produced desirable semi-continuous grain boundary carbide precipitate. However, these involved higher temperatures (1740°F to 1840°F) which are not practical for field treatment.

It is now considered that stress relief, but not the thermal treatments just described, can be achieved in existing steam generators. A temperature of 1300°F or 700°C (1292°F) has been suggested for on-site stress relief heat treatment. Experimental evidence indicates that temperatures up to 1450°F can be reached and controlled in U-bends by the use of electrical resistance heaters. There was no significant sensitization or distortion of the bend The only known stress relief of tubes in a steam generator in a power plant was performed at Doel 2 in Belgium. Fifteen tube sleeves in the tube sheet region were stress relieved by induction heating to 1250°F. This was considered to show that in-situ stress relief is practical. However, it is not directly applicable to U-bends because the asymmetry of the bends makes them unsuitable for induction heating.

Stress relief of tubes in an existing steam generator is subject to several restraints. First, the time must be long enough and the temperature must be high enough to reduce the residual stresses significantly and to increase resistance to stress corrosion cracking. Second, time should be short enough so that the tubes do not become sensitized. Third, the temperature should be low enough so that recrystallization and grain growth is avoided. If these three requirements are combined, a time-temperature region remains from approximately 0.5 to 5 minutes and 1200 to 1500 ^{o}F. Furthermore, the heating element must be placed so that the entire U-bend is relieved but the temperature of the top tube support plate is kept as low as is feasible. Yielding or extension of existing cracks may be caused if the support plate is heated excessively. It is not expected that this will be a problem, but it has been recommended that any proposed stress relief procedure be demonstrated on a mockup before it is used on an actual steam generator.

3. Other Potential Mitigating Actions

The EPRI SGOG II research program RPS303 (described in Section III.H.) is designed to identify candidate remedial actions based upon findings from the laboratory studies. Several potential corrective actions may be studied, including:

(1) Lowering reactor coolant system temperatures to inhibit the onset of cracking;

(2) Orificing first row tubes to minimize flow and heat flux and thus lower the temperature of the U-bend;

PRELIMINARY

(3) Shot-peening of the inner surface of the U-bend to create residual compressive stresses rather than residual tensile stresses; and

(4) Changing the reactor coolant system water chemistry, if research shows this to be a factor.

In addition to the EPRI SGOG research, the nuclear steam supply system vendors are developing methods of stress-relieving sections of tubes, means of sleeving straight sections of tubes, and remote methods of inspecting and of plugging defective tubes.

G. LEAK BEFORE BREAK

Investigations including tests have been conducted to explore the safety inplications of the observed U-bend cracking. The possible concern, from the safety viewpoint, is that tube degradation may lead to a burst or broken tube or tubes and result in a substantial primary to secondary leak rate and a consequent release of radioactivity. The investigations show that U-bend cracking will not lead to a broken tube and is not a safety concern.

Tests have shown that through-wall cracks of the geometry which has been observed will leak at a rate in proportion to their length. A crack of this type that is one-half inch long can be expected to leak at about 0.35 gpm in service. This rate is the Tech Spec limit (500 gallons per day) for one steam generator and can be detected readily by existing monitoring methods. (See Section V.B below which describes the PGandE leak monitoring program.) Experience shows that U-bend leaks develop slowly and leak at low and slowly increasing rates. Therefore, the capability exists to detect a cracked tube which begins to leak and there would be time to respond to the leak.

The critical crack length which would lead to a tube break or rupture has been investigated. All the leaking U-bends from tubes which have been examined have been found to have cracked axially. Analysis supported by test data shows that the critical length of a crack of this type, even in the event of a main steam line break accident (the most demanding postulated accident with regard to steam generator tubes), is greater than one-half inch in length and would leak at greater than 0.35 gpm.

PRELIMINARY

Since the crack size which can be detected and would be corrected is smaller than the crack size which could lead to a tube rupture, even under the worst conditions, tube cracking is not a safety concern. The investigations that have been described were conducted for straight tube sections. The applicability of this work to the U-bend sections has been investigated also. High tube hoop stresses contribute to the axial cracking which is observed. These stresses would tend to open any crack, increasing the expected leak rate, so the crack length-leak rate data for straight sections are conservative for U-bends.

Since Alloy 600 work hardens when cold worked, both the yield strength and the ultimate strength of the U-bend are higher than those of the straight sections of the same tube. (These are the tube properties pertinent to resisting the membrane stresses which might lead to tube rupture.) This has been confirmed by tests which have shown higher burst pressures for U-bend than for straight sections. Thus both the leak rate and the burst pressure information developed for straight sections are applicable to and conservative for U-bends and it is concluded that tubes with cracked U-bends will leak before they would break.

H. FUTURE RESEARCH

Research funded by the EPRI Steam Generator Owners Group II is continuing in the area of cracking in steam generator tubing in primary water. This program is identified as RPS303 and $4.2 million will be expended through 1986. The program consists of four major tasks:

(1) Data Evaluation and Mechanism Definition - This entails review of leak experience and related operating chemistry. Removed tubes will be examined and stress patterns evaluated. Safety issues will be assessed.

(2) Evaluation of Causes - U-bends will be evaluated for geometry, residual stresses, and susceptibility to cracking. Laboratory tests will recreate cracking to evaluate acceleration techniques and separate effects of variables.

(3) Evaluation of Remedial Actions - The candidate remedial actions will be identified and application techniques developed. Corrective actions will be tested for effectiveness and techniques will be qualified with model boilers.

(4) Implementation of Selected Remedies - Procedures will be developed for field application of techniques developed in Task 3 above. A candidate steam generator in the field will be identified. The corrective action will be accomplished on that steam generator and the effectiveness will be evaluated.

PRELIMINARY

A portion of this research is under way or has been completed. Approximately $1 million of the $4.2 million has been expended. Completion of the research and data correlation in 1986 will complement the existing research. This will allow the SGOG to evaluate primary water cracking and potential remedial actions in a more comprehensive manner.

The project description for RPS303 is attached as Appendix A.

I. ROLL TRANSITION ZONE

The German experience with tube cracking on the primary side in the roll transition zone (in steam generator tubesheets) which was reported in 1975 has been investigated and has been attributed to the roller expansion design. The design included a series of three expansion zones along each tube in the tubesheet. A stress analysis revealed that high residual tensile stresses were present on the tube I.D. surface in the transition zone between the expanded and non-expanded regions. Further investigation of the tube primary side surface revealed the presence of a general intergrannular attack over the entire surface. This attack has been attributed to a final pickling process used during tubing fabrication process. It is believed that severe roller expansion, the corroded surface, and poor water chemistry control contributed to the IGSCC in the roll transition zone.

More recent cracking in the roll transition zone has been reported by the French, particularly at Fessenheim and Bugey. Most, but not all, cracking was on the primary side. They have observed both circumferential and longitudinal cracking. They believe that residual stresses from tube expansion and thermal stresses from the thermal gradient across the sludge on the tube sheet contributed to the cracking.

The Japanese have reported that seven plants have experienced primary side roll transition zone cracks. Preliminary information indicates that approximately 400 tubes were plugged as a result of roll transition zone cracks in 1982-1983. Both partial and fully rolled joints were involved in these cases. The Japanese have developed both the sleeving and plugging countermeasures to control the problem. No instances of roll expansion zone cracking have been reported in U.S. domestic plants.

PRELIMINARY

IV. DIABLO CANYON TUBE FABRICATION HISTORY

A. REMARKS ON MILL HEAT TREATMENT

At one time it was thought that the susceptability of steam generator, row one tube U-bends to IGSCC could be established by correlation with the time period in which the tubes were fabricated. This idea was based on the observation that the first cases of U-bend cracking seemed to be from one fabrication time period and on the knowledge that manufacturers' heat treatments had been varied at different time periods. It is generally agreed that susceptible material properties are one of the conditions required for IGSCC and that heat treatment affects material properties. However, the direct correlation with year of manufacture has proved to be an oversimplification. Many tubes from the "susceptible" time period are giving satisfactory service and some tubes from the "unsusceptible" time periods have suffered cracking.

B. DIABLO CANYON TUBE FABRICATION DATES AND HEAT TREATMENTS

Table 5 identifies the Alloy 600 tubing contained in the eight steam generators of Unit 1 and Unit 2. Six of the eight steam generators contain tubing fabricated at the Westinghouse Specialty Metals Division, from billets provided by Huntington Alloys. Two steam generators in Unit 1 contain tubing fabricated entirely by Huntington Alloys.

PRELIMINARY

The set number listed is a chronological designation for Westinghouse fabricated tubing; a set is a complete inventory of tubing for one steam generator bundle. Each set contains tubing from a number of heats, i.e., individual melts.

Unit 1: Set Number 10 was fabricated in June, 1969.
Set Number 11 was fabricated in July, 1969.
In this period, the mill anneal furnace temperature was approximately 1800°F. The actual tube temperature was lower, on the order of 1700°F. The mill anneal temperature of the Huntington Alloy tubing is not known, but the tube temperature was judged to be 1750°F or higher.

Unit 2: All the sets were fabricated in 1971 and 1972. In this period, the mill anneal furnace temperature was approximately 1875°F, which would have resulted in a tube temperature greater than 1750°F. The tubing in Rows 1 and 2 in the four steam generators of Unit 2 contained tubing from a number of sets.

PRELIMINARY

TABLE 5

TUBING IDENTIFICATION

Diablo Canyon Unit 1

Steam Generator Number	Tube Manufacturer	Set Number	Year of Steam Generator Manufacture
PGGT 1041 (1-1)	Westinghouse	10	1970
PGGT 1042 (1-2)	Westinghouse	11	1970
PGGT 1043 (1-3)	Huntington Alloys	n/a	1970
PGGT 1044 (1-4)	Huntington Alloys	n/a	1970

Diablo Canyon Unit 2

PEGT 1161 (2-1)	Westinghouse	47, 50, 58, 62	1972
PEGT 1162 (2-2)	Westinghouse	37, 58, 59, 60	1972
		61, 62, 63	
PEGT 1163 (2-3)	Westinghouse	06-R-51, 07-R-51	1972
		63, 64	
PEGT 1164 (2-4)	Westinghouse	06-5-51, 07-R-51	1972
		36, 49, 58, 59,	
		63, 64, 65, 66	

PRELIMINARY

V. PGandE PROGRAM FOR SHORT RADIUS U-BENDS

The PGandE program for preventing leakage in steam generator short radius U-bends includes four components: an extensive nondestructive examination program, leak monitoring, evaluation of stress corrosion cracking mitigation measures, and a water chemistry control program (which will minimize the likelihood of tube stresses caused by denting on the secondary side in the steam generators).

A. NONDESTRUCTIVE EXAMINATION

PGandE intends to use the EPRI Steam Generator Owners Group guidelines for nondestructive examination and the Diablo Canyon Technical Specifications as a basis for steam generator inspection. Recommendations that relate to the examination of short radius U-bends and PGandE's specific actions are:

(1) Perform a baseline inspection of all steam generators

Preservice inspection (PSI) baseline examinations have been performed twice on the Diablo Canyon Power Plant steam generators. The first PSI was a single frequency examination in 1975 and 1976. A second PSI was performed late in 1982 to take advantage of advances in eddy current equipment and processes to provide an additional baseline. This PSI utilized Zetec multifrequency eddy current equipment and included all tubes in both units. Supplemental examination of most tubes in rows one and two of both units was performed using a probe designed by Zetec specifically for short radius U-bend examination. This probe provided the best available examination at the time of the PSI. No defects were identified.

(2) Provide protected storage for tapes, stripcharts, and forms containing NDE data and analysis. All data are on permanent file.

(3) Inspect all steam generators during each planned steam generator outage.

The Technical Specifications require the inspection of two steam generators during the first outage, inspection of the other two steam generators in the second outage, and the inspection of one steam generator in each outage thereafter. PGandE intends to inspect all four steam generators during each outage.

(4) Choose instrumentation and ISI vendors based on expected data quality and experience.

PGandE will select only ISI vendors with experienced and qualified analysts. PGandE nondestructive examination personnel independently will review all data from short radius U-bend examinations.

(5) Choose the sample of tubes to inspect on the basis of operating history in the unit to be inspected and similar units.

PRELIMINARY

PGandE intends to use the EPRI SGOG guidelines as a basis for selecting tubes for examination. The guidelines suggest examination of all row one and two tubes during each ISI in addition to the examinations required by the Technical Specifications.

(6) Analyze all data collected; document all degradation and anomalous signals.

Data will be reviewed carefully by ISI contractors and by qualified PGandE personnel. All degradation and anomalous signals will be documented.

(7) Choose probe designs, instrument settings, and signal interpretation methods that are appropriate for the steam generator design and suspected damage.

As probe design evolves, PGandE will continue to evaluate the new designs and will use the most appropriate probes during future examinations.

(8) Take corrective actions to prevent damage progression.

If damage is detected, PGandE will evaluate the damage to determine causes and potential corrective actions. PGandE will carry out appropriate corrective actions.

PRELIMINARY

B. LEAK MONITORING

Primary-to-secondary leakage will be indicated in two ways at Diablo Canyon. (1) Radiation is detected at the air ejector discharge, main steam line, steam generator blowdown, or elsewhere in the secondary system. All radiation monitors have alarms. (2) A reactor coolant system water balance will be performed at least twice each day. When a leak is indicated, the leaking steam generator is determined by comparing the activity in all four steam generator blowdown lines. The leak rate is determined utilizing flow rates and results from radiochemical analyses of the reactor coolant and steam generator blowdown. This leak rate determination is assisted by a computer program. The minimum detectable leak rate is dependent on reactor coolant activity, but will be below the 0.35 gpm Technical Specification limit.

The Diablo Canyon Power Plant procedures that govern this process are EP OP-3B, STP R-10, CAP D-15, and CAP F-11.

C. EVALUATION OF MITIGATING ACTIONS

PGandE continues to monitor research in this field and is an active participant in the EPRI Steam Generator Owners Group. Current investigations include three methods of in-situ stress relieving, orificing row one tubes, and lowering reactor coolant temperatures. Other research that may lead to mitigating measures include studies to measure reactor coolant corrosion potential and chemistry. Should the Diablo Canyon U-bends prove to be susceptible to cracking, all available mitigating actions, including tube plugging, will be evaluated for applicability.

PRELIMINARY

D. SECONDARY WATER CHEMISTRY CONTROL PROGRAM

PGandE has developed an extensive water chemistry control program designed to minimize corrosion of the secondary side of the Diablo Canyon steam generators. Particular emphasis will be on control of dissolved oxygen and chloride, which are primary contributors to denting. An inleakage reduction program, including the use of helium leak detection equipment, has been developed to minimize air and seawater inleakage. Removal of all copper alloys from the secondary cycle also is being evaluated. Control of denting is important to the prevention of steam generator short radius tube U-bend apex leaks because the only domestic tube U-bend rupture was induced by deformation resulting from denting.

PRELIMINARY

VI. CONCLUSION

Some nuclear plants have experienced cracking in steam generator row one tube U-bends. Although there have been relatively few tubes involved, there has been a great deal of research undertaken to investigate these and related stress corrosion problems. It has been established that the problem in the U-bend area is intergranular stress corrosion cracking (IGSCC). It is known that IGSCC has no single or simple cause but results from a combination of susceptible material, environment, and tensile stress.

Although the conditions necessary for IGSCC to occur are present in some steam generator row one tube U-bends, the number of cases where such cracking has occurred is small. Those tubes which leaked as a result of cracking in the row one U-bends have done so at a slow rate: the time to leakage has varied from one to nine years after being placed in service. Those which leak do so at a slow rate: the leak rates reported vary from 0.001 gpm to 0.55 gpm and average about 0.02 gpm. (The row one U-bend apex leak at Surry 2 had a higher leak rate but was associated with severe denting.)

At the present state of knowledge, it is difficult to determine which tubes are most susceptible to IGSCC, and it is not possible to predict that susceptible tubes will crack in service. Therefore, it is not possible to plug those tubes preventively which may leak in the future without plugging a large number of tubes which otherwise may continue to provide satisfactory service.

PRELIMINARY

Relatively few row one tubes crack at the U-bend, leakage occurs after the elapse of time, and the leaks that result are small and detectable. PGandE concludes that there is no safety-related reason for preoperational plugging of row one tubes in the Diablo Canyon steam generators.

PRELIMINARY

REFERENCES

(1) NUREG-0675 Supplement No. 9, "Safety Evaluation Report related to the operation of Diablo Canyon Nuclear Power Station Units 1 and 2," June 1980. Refer to paragraph 5.2.7.3.

(2) A.B. Johnson, Jr., Et Al., "Primary Water-Initiated IGSCC of In-600 Steam Generator Tubes-Metallurgical Analysis," Corrosion Forum Sponsored by National Association of Corrosion Engineers, March 1982.

(3) J. Blanchet, H. Coriou, Et Al. "Historical Review of the Principal Research Concerning the Phenomena of Cracking of Nickel Base Alloys," Stress Corrosion Cracking and Hydrogen Embrittlement of Iron Base Alloys National Association of Corrosion Engineers 1977.

(4) T.S. Bulischeck and D. Van Rooyen, "Effect of Environmental Variables on the Stress Corrosion Cracking of Inconel 600 Steam Generator Tubing," Nuclear Technology, November 1981.

(5) M. Kowaka Et Al. "Effect of Heat Treatment on the Susceptibility to Stress Corrosion Cracking of Alloy 600," Nuclear Technology, November 1981

(6) Evaluation of Steam Generator U-Bend Tubes From the Trojan Nuclear Power Plant, EPRI NP-2629-LD, September 1982

PRELIMINARY

REFERENCES

(7) Intergranular Stress Corrosion Cracking of Ni-Cr-Fe Alloy 600 Tubes in PWR Primary Water-Review and Assessment for Model Development, EPRI NP-3057, May 1983

(8) Steam Generator U-Bend Eddy-Current NDE, EPRI NP-3010, April 1983

PRELIMINARY

VIII APPENDIX A

PROJECT DESCRIPTION - RPS303

CAUSES AND CORRECTIVE ACTIONS FOR PRIMARY WATER CRACKING OF STEAM GENERATOR TUBING

STATEMENT OF THE PROBLEM

Cracking of Alloy 600 steam generator tubes from the primary side has occurred in steam generators in at least 11 PWR nuclear power plants. Initially primary side cracks occurred in sections of tube deformed due to progression of denting (i.e., at deformed U-bends and at dented support plate intersections). More recently primary side cracks have occurred in steam generators in which there is no denting. These cracks have occurred in sections of tubes intentionally deformed during normal manufacturing (i.e., at U-bends and in expanded sections of tubes within the tubesheet). The precise mechanism is not known.

PROJECT DESCRIPTION

Research Objective: The objectives are to evaluate the causes of primary water cracking occurring in steam generators, determine the scope of tubes susceptible to cracking, and identify, verify, and follow the implementation of practical solutions. Emphasis will be on identifying those conditions in steam generators (e.g., loading, environment, results of material processing) which have caused primary water cracking of steam generator tubes. The project addresses "mill annealed," "stress relieved," and "thermally treated" Alloy 600 as well as other corrective heat treatments proposed. In addition, Alloys 800 and 690 will be tested as comparison materials.

Project Methodology: This project will begin with a detailed review of the extensive work already done or ongoing concerning cracking of Alloy 600 in primary water in order to identify the most likely causes. This will include reviewing the results of previous examinations of sections of cracked tubes removed from steam generators. Also, newly obtained samples will be examined. Emphasis of these examinations will be on confirming the common metallographic characteristics of the cracks, measuring detailed tube shape, and determining amount of cold work.

Potential corrective actions will be identified early in the project based on judgment, results of previous projects, and speculation as to mechanisms. Evaluation of potential corrective actions will proceed in parallel with evaluation of causes.

Tubing mockups will be prepared to duplicate what exists in steam generators. Care will be taken to process these mockups in the same way that tubes and steam generators are processed, to achieve the same geometry as in tube samples, and to duplicate other measurable parameters such as cold work. These mockups will be used for several purposes:

a. Stress and strain information not obtained from cracked samples will be measured and calculated. This will include determining the magnitude of residual stress, residual stress patterns, and operating stresses.

b. Autoclave tests will be run on the mockups to recreate the cracking observed in steam generator tubes, to identify methods for accelerating testing (e.g., higher temperatures) without affecting the validity of the conclusions, and to separate the effects of variables such as load stress, residual stress, cold work, environment, and tube processing history.

c. Tube mockups will be treated with potential corrective actions to decrease the effect of factors determined to cause cracks. Autoclave screening tests will be conducted to evaluate the effectiveness of these corrective actions.

Results of the accelerated tests on tube mockups will be reviewed to determine the principal factors causing cracking and the effectiveness of actions taken to reduce their severity. Based on this information, consideration of actions practical in the field and consideration of potential side effects, candidate corrective actions and techniques for applying them will be identified. Techniques for applying corrective actions will be further developed and then qualified in model boiler tests.

PROJECT METHODOLOGY

Logic Plan: The causes of primary water cracking of steam generator tubing will be evaluated and corrective actions identified in accordance with the following logic plan:

I. Task 1: Data Evaluation and Mechanism Definition
   A. Review Leak Experience
   B. Review Operating Chemistry of Affected Plants
   C. Examine Removed Tubes
   D. Review Stress Pattern in Typical and Cracked Material
      1. Applied Stress
      2. Thermal Stress
      3. Residual Stress
   E. Evaluate Safety Issues
II. Task 2: Evaluation of Causes
   A. Mockup Affected Tube Sections
   B. Characterize Mockups by Measurement and Calculation
      1. Geometry
      2. Residual Stress Magnitude and Patterns
      3. Load Stress Magnitude and Patterns

PRELIMINARY

VIII APPENDIX A

PROJECT DESCRIPTION - RPS303 (Page 2)

CAUSES AND CORRECTIVE ACTIONS FOR PRIMARY WATER CRACKING OF STEAM GENERATOR TUBING

C. Perform Screening Tests
   1. Simulate Steam Generator Cracking
   2. Identify Acceleration Technique
   3. Separate Effects of Variables

III. Task 3: Evaluation of Remedial Actions
   A. Identify Candidate Corrective Actions
      1. Stress Redistribution
      2. Metallurgical Action
      3. Chemistry Control
      4. Operational Changes
   B. Identify Techniques for Applying Corrective Actions
   C. Test Effectiveness of Correction Action in Mockup Tests
   D. Qualify Corrective Actions/Techniques in Model Boilers

IV. Task 4: Implementation of Selected Remedies
   A. Prepare Generic Procedure
   B. Identify a Field Steam Generator for Application
   C. Follow Application and Effectiveness

Task Description:

Task 1: Data Evaluation and Definition of Problem

a. The occurrence, location, and time of steam generator tube leaks due to primary water cracking will be reviewed to establish a data base and to identify any obvious correlations. The data base will be updated as necessary. This effort will only supplement that of RPS306E and RP2163 where the bulk of data will be collected

b. Operating primary water chemistry of selected plants will be reviewed to establish a data base and to identify any obvious correlations. This work will be a continuation of work begun under subprogram 0808

c. Cracked and uncracked tubes removed from steam generators will be examined to characterize metallography, crack characteristics, deposits, and tube geometry. This is needed to assess the role of phenomena such as oxide wedging and the importance of cold work and processing history. Part of this will have been completed under subprogram 0818 and the bulk of new work will be done as part of RPS304E

d. The sources, locations, and magnitude of stresses in steam generator tubes will be calculated and residual stresses will be measured. The effect of steady-state and transient loadings and the effect of local tube stress will be related to tube geometry, tube processing, tube bending, and steam generator fabrication.

e. The leakage and rupture characteristics of primary water cracks will be assessed. Rupture tests of U-bends and expanded sections (typical of the tubesheet region) will be performed to establish the margin to rupture of cracked tubes and to evaluate the validity of "leak before break" assumptions. In addition, tests will be performed to simulate transient tube loadings typical of steam generator operation. Work on U-bends will be a continuation of that started under subprogram 0803. So far, attempts under that project to create axial cracks have not been successful.

Task 2: Evaluation of Causes

a. Mockups of the affected tube sections will be fabricated. These, for example, would duplicate U-bends and the transition between expanded and unexpanded portions of the tube in the tubesheet

b. Careful characterization will permit measurement and/or calculation of parameters that cannot be determined from samples removed from steam generators

(1) Geometry and hardness measurements provide some confirmation that steam generator conditions have been simulated.

(2) Residual stress magnitude can be measured by strain gage and radiographic techniques (with difficulty and imprecision). Residual stress patterns can be determined by immersing samples in an environment that causes stress corrosion cracking.

(3) Similar techniques can be used to obtain information on load stresses.

c. Screening tests will be performed on the mockups in autoclaves

(1) Initial tests will attempt to recreate cracking in mockups which are prototypical of installed tubes.

(2) Once cracks can be reproduced, techniques to accelerate the tests will be assessed to ensure that they do not alter the cracking.

(3) Accelerated tests will be performed to separate effects of variables such as residual stress, load stress, geometry, cold work, and material processing history.

PRELIMINARY

VIII APPENDIX A

PROJECT DESCRIPTION - RPS303 (Page 3)

CAUSES AND CORRECTIVE ACTIONS FOR PRIMARY WATER CRACKING OF STEAM GENERATOR TUBING

Task 3: Evaluation of Remedial Actions

a. Based on results of Task 2, candidate corrective actions will be identified. For example, if residual stress is found to be a dominant factor in causing cracking, methods to relieve or redistribute stresses will be considered candidate corrective actions. Changes to metallurgy, chemistry control, and operation are other examples of potential corrective actions. All these candidates will be reviewed for practicality as well

b. Techniques for applying corrective actions will be identified. These techniques will be developed to the prototype stage

c. Effectiveness of correction actions will be checked n autoclave tests (Note 3).

d. Corrective actions will be applied with techniques identified to tubes in model boilers which simulate steam generator operation. After operation, the model boilers will be examined to qualify the corrective action

Task 4: Implementation of Selected Remedies

a. Generic procedures will be prepared for applying corrective actions to steam generators.

b. Field steam generators with tubes subject to cracking will be identified for application of corrective actions. Inspections will be performed to establish baselines.

c. Assistance will be provided to apply the corrective actions in the selected steam generators. The steam generators will be inspected periodically to verify the effectiveness of the actions taken.

RELATIONSHIP TO EPRI PROJECTS, PROGRAMS, AND SIMILAR EFFORTS ELSEWHERE

EPRI has the following related projects in its program:

RP1166 - Corrosion Programs to Support Reliability of Nuclear LWR Systems: The project explores metallurgical and environmental factors that limit the lifetime of structural materials used in light water reactors for piping, pressure vessels, steam generator and condenser tubes, turbine blades, and other components. (Considerable portions of this work apply to coal-fired plants as well.) Contractors are Ohio State University, Massachusetts Institute of Technology, and Westinghouse Electric Corporation.

RP1708 - Optimization of Metallurgical Variables to Improve the Corrosion Resistance of Thermally-Treated Alloy 600: This project demonstrates the improved corrosion resistance of thermally-treated Alloy 600. The Alloy 600 will be tested under conditions of various caustic concentrations, at a range of temperatures, in contaminated all-volatile treatment solutions, and in a primary coolant. A model explaining the improvements of heat-treated Alloy 600 will be developed, and laboratory work on the carbide dissolution precipitation kinetics of this material will be conducted during later stages of this project. Westinghouse Electric Corporation is the contractor for this project.

Other related work is as follows:

The principal investigators of Inconel 600 cracking, the variables they considered, and the environments in which they tested are summarized in the following table:

NAME	VARIABLES(*)	ENVIRONMENT
Coriou (EdF)	T, Carbon Content	Pure Water, Caustic
Berge (EdF)	T, σ, Heat Treatment	Caustic
Theus (B&W)	T, σ, Heat Treatment	AVT, Caustic
Airey (W)	T, σ, Heat Treatment, Potential	Caustic
Bettis (not public)	T, Microstructure, Heat Treatment, Chemistry	Primary Water
Van Rooyen (Brookhaven)	T, Heat & Carbon Content, Heat Treatment, Strain Rate	Caustic
Klein (W)	Heat Treatment, Bend radius, shot peening (U-bend mockups)	Primary Water
Berge (EdF)/Van Melsen (Laborelec)	Manufacturing Method, Tube Cross Section, Residual Stress	304SS and $MgCl_2$ Polythionic acid

(*) T = Temperature; σ = stress.

As can be seen, extensive work has been and is being done on cracking of Alloy 600; however, it is not well coordinated and interrelated. As a consequence, there are big gaps in the work and results of one investigator often cannot be related to the results of another.

PRELIMINARY

VIII APPENDIX A

PROJECT DESCRIPTION - RPS303 (Page 4)

CAUSES AND CORRECTIVE ACTIONS FOR PRIMARY WATER CRACKING OF STEAM GENERATOR TUBING

The mechanism of Alloy 600 cracking in primary water, pure water, AVT, or caustic is not known. Testing has shown that cracking is strongly dependent on temperature and applied stress; however, quantitative relationships are not known. There is disagreement among investigators concerning the effects of material chemistry, processing, and microstructure; however, there is general agreement that a post annealing heat treatment of 1100°F to 1300°F increases resistance of Alloy 600 to cracking in the various environments tested.

It is difficult to reproducibly crack Alloy 600 in pure water; therefore, an accelerating environment of NaOH at various concentrations has been used for most tests. It is hoped that trends observed are the same for the various test environments; however, quantitative relationships for comparing results in different environments have not been well justified.

Westinghouse and Battelle Northwest are both conducting failure exams of cracked tube U-bends removed from a Trojan steam generator. Battelle will measure residual stresses in uncracked tubes and has measured a U-bend removed from a Farley steam generator to characterize the geometry of the transition from the straight to the bent portion.

Robert Cloud Associates has been working under a TSA to calculate the sources, locations, and magnitudes of operating stresses in tube U-bends.

The subject of cracking of tube U-bends in steam generators was reviewed in a workshop by the Steam Generator Owners Group in August 1980. Results are reported in EPRI-WS-80-136, Workshop Proceedings: U-Bend Tube Cracking in Steam Generators, April 1981.

RP2163 consists of a complementary theoretical evaluation of mechanisms of cracking of Inconels in steam generators. Work is to start in 1982 and to continue at a steady level through 1986.

Press Release

Agency of Natural Resources and Energy
Ministry of International Trade and Industry
Japanese Government

November 25, 1991

Results of the Investigation on the Steam Generator Tube Break at Mihama Unit No. 2 of the Kansai Electric Power Company, Inc.

Investigations have been conducted on the steam generator tube break at Mihama unit No. 2 (pressurized water type reactor with capacity of 500 MWe) of the Kansai Electric Power Co., Inc. based on the reviews of the Special Committee Investigating the Mihama unit No. 2 Incident (chaired by Iida Kunihiro, Professor Emeritus at University of Tokyo, who is also a Professor at Shibaura Institute of Technology) which has been established by MITI in the Technical Advisory Council for MITI on Nuclear Power Generation. The results of the investigations into the causes of the steam generator tube break and the actions taken at the time of the occurrence of the incident, as well as the countermeasures to be taken to prevent a recurrence, have been summarized as in Attachment 1.

Also, based on the results of the investigation, the Agency of Natural Resources and Energy has directed the electric utility companies owning pressurized water reactors and the electric utility companies owning boiling water reactors to take the recurrence prevention actions and other measures according to Attachment 2 and Attachment 3 respectively.

Contacts: Nuclear Power Safety Examination Division
Phone 03-3591-8092
Nuclear Power Safety Administration Division
Phone 03-3501-9547
Nuclear Power Operating Administration Office
Phone 03-3501-1739

ℓ117

(Attachment 1)

The Steam Generator Tube Break at
Mihama Unit No. 2 of the Kansai Electric Power Company, Inc.
(Summary Report)

1. History of Investigation

(1) On February 9, 1991, Mihama unit No. 2 of the Kansai Electric Power Company, Inc. was automatically shut down due to a tube break in A-steam generator followed by the automatic actuation of the emergency core cooling system (ECCS).

(2) MITI started investigation into the causes of the incident immediately after the occurrence of the incident. They continued investigations based on the reviews and site surveys performed by the Special Committee Investigating the Mihama unit No. 2 Incident, which was established on February 20, 1991, by MITI in the Technical Advisory Council on Nuclear Power Generation, and compiled an interim findings of the investigation on June 6, 1991.

(3) MITI then continued further investigations, and compiled the report on the steam generator tube break at Mihama unit No. 2. The report describes the chronology and analysis of the incident, evaluation of the incident, the causes of the tube break, countermeasures to prevent a recurrence, and lessons to be derived from the incident, etc.

2. Chronology and Analysis of the Incident

(1) Chronology of the Events

February 9, 1991

Around 12.40 hrs. : An operator discovered that the record given by the steam generator blow-down water monitor (to be termed "R-19" hereafter), by which the leakage of the reactor coolant to the secondary side is monitored, was increasing slightly.

Instruction was given to analyze the radioactivity concentration by collecting a sample.

Around 13.45 hrs. : The alarm of R-19 was sounded.

Around 13.47 hrs. : Operation was started to reduce the generator output with the intention of shutting down the reactor.

13:50 hrs. : The reactor trip signal was activated, and the reactor and the turbine were automatically shut down in accordance with normal sequence. And then, the safety injection signal was activated, and the injection of water into the reactor coolant system was started automatically.

Around 14.02 hrs. : Since the complete closure of the main steam isolation valve of A-steam generator (to be termed "the damaged steam generator" hereafter) could not be confirmed, the operator tightened the said valve manually.

14.02 hrs. to 14.17 hrs. : The main steam relief valve of B-steam generator was opened to cool the reactor coolant system.

Around 14.10 hrs. to around 14.25 hrs. : It turned out that the two pressurizer relief valves, which are used to reduce the reactor coolant system pressure, failed to open.

14:34 hrs. : Operation was started to reduce the reactor coolant system pressure using a pressurizer auxiliary spray.

14.37 hrs. : Two high pressure injection pumps were stopped after confirmation that the pressurizer water level had been recovered.

14.48 hrs. : The reactor coolant system pressure and the pressure of the secondary side of the damaged steam generator became almost equal, and the leakage of reactor coolant into the secondary side stopped.

(2) Investigation of the Plant's Response

It is estimated that, due to the damage of the tube, the small amount of reactor coolant which leaked into the secondary side of the damaged steam generator occurred by around 12.40 hrs., that the damage of the tube propagated rapidly at around 13.45 hrs., and that the tube was then completely broken circumferentially.

(3) Investigation of the Plant Operation

* It is evaluated that the operators responded appropriately to this incident, and safely led the incident to subsidence, despite the occurrence of such events as the incomplete closure of the main steam isolation valve and the in-operativeness of the pressurizer relief valves.

* The operations manual did not contain instructions for operating procedures in the event of malfunction of equipment such as incomplete closure of the main steam isolation valve and the in-operativeness of the pressurizer relief valve. Also some instructions for the timing, sequence, conditions, etc. of equipment operation were not explicit.

(4) Other Investigations

<1> Incomplete Closure of the Main Steam Isolation Valve

As mirror finishing was applied to the sliding surface of the valve stem during the last periodical inspection, the grease component that seeped out from the asbestos packing during plant operation was heated inside the gap between the graphite packing and the sliding surface of the valve stem, thereby turning to a very sticky, degenerated substance. This made the graphite packing stick to the sliding surface of the valve stem. As the sliding resistance of the packing increased to 1.5 times the designed value, the valve closing resistance at the position near complete closure exceeded the valve closing force. It is judged that this was the reason why the main steam isolation valve did not close completely.

<2> Failure of Operation of Pressurizer Relief Valve

An operator assumed that the air supply valve in the air junction box was not commonly used as an air supply valve for the air system to operate the pressurizer relief valves, and, assuming that it was a valve supplying an auxiliary air system, he closed the valve in question based on the assumption that it is not normally used.

The closure of this air supply valve was overlooked in the checking process of the inspection record. Therefore, the operating air was not supplied to the pressurizer relief valves, and the two pressurizer relief valves did not operate.

<3> Plant Computer

As the processing capacity of the plant computer was not sufficient, some of the trend record of PAM (post accident monitor) was not renewed, and some alarm typewriter records were lost.

<4> Reporting and Liaison

* The Kansai Electric Power Company, Inc. reported the occurrence of this incident to the Fukui Prefectural Government at 14.17 hrs., and to the Mihama Town Office at 14.44 hrs. The Company explained the situation to the Tsuruga Municipal Government the following day, February 10.

* As the procedure for dealing with general plant visitors had not been specified at the time of the occurrence of this incident, no explanation of the incident was given to the visitors who were at the plant at the time.

3. Evaluation of the Incident

(1) Result of Reproduction Analysis of the Incident

The amount of the reactor coolant leaked into the secondary side of the damaged steam generator: Approximately 55 tons

The amount of the steam discharged from the main steam relief valve of the damaged steam generator: Approximately 1.3 tons

The amount of the steam leaked into the down stream of the main steam isolation valve of the damaged steam generator: Approximately 6.8 tons

The amount injected water from the safety system: Approximately 50 tons

(2) Result of Evaluation of Core Integrity

The minimum departure from nucliate boiling ratio at the location under severest condition in the core was approximately 2.76 at the moment before the reactor was automatically shut down. Since this was not below the allowable limit of 1.17, this incident did not create the condition under which the heat transfer from fuel cladding to reactor coolant is reduced and the fuel clad temperature rapidly rises, and therefore, the fuel rods were not damaged.

(3) Evaluation of Radioactive Materials Released to the Environment and Their Impact

<1> Evaluation of Amount of Radioactive Materials Released to the Environment

The amount of radioactive materials released to the environment was approximately 0.6 Ci (approximately 2.3×10^{10} Bq), which is substantially below the annual discharge control target value.

<2> Evaluation of Effective Dose on the Public

The effective dose on the public around the plant received from the radioactive materials released during this incident is 1×10^{-8} Sv (approximately 1×10^{-6} rem), which is approximately a 100,000th of the effective dose received from natural radioactivity for a period of one year (approximately 1×10^{3} Sv), an amount that does not affect the public around the plant.

(4) Comparison of This Incident with Safety Analysis Accompanying the Application Document for Reactor Establishment Change Permit and Its Evaluation

When this incident is compared with the analysis (safety analysis) for safety evaluation contained in the Application Document for Reactor Establishment Change Permit of Mihama Power Plant (September 17, 1990), the incident as a whole is generally in agreement with the safety analysis result, although the lapse of this incident is different from the conditions of safety analysis in such points as the in-operativeness of the pressurizer relief valve.

In terms of the fuel integrity and the radiation exposure risk on the public around the plant, which are noteworthy items in safety analysis, there is no problem, and it is judged that this incident was within the scope evaluated by the safety analysis.

(5) Evaluation of Integrity of Reactor Vessel, etc.

<1> Investigation of Pressurized Thermal Shock

<a> Evaluation of Thermal Shock on Reactor Vessel

The minimum attainable temperature of the core region of the reactor vessel was obtained by analysis, and it was verified that the reactor vessel was not in the temperature zone where there is the possibility of a brittle fracture, with sufficient margin of safety.

<b> Evaluation by Method of Fracture Mechanics

A fracture mechanics evaluation was conducted by assuming stress conditions under which thermal stress was applied on a hypothetical reactor vessel flaw, and it was verified that the hypothetical flaw did not propagate during this incident, and there was no possibility of a brittle fracture in the reactor vessel.

* Therefore, no effect was created on the reactor vessel so far as pressurized thermal shock evaluation is concerned, and it is judged that the pressurized thermal shock poses no problem for future use of this reactor vessel.

<2> Investigation of Thermal Fatigue

* When water is injected into the reactor coolant, temperature difference arises in the structural materials, thereby creating thermal strain. The effect of repetition of such strain on the fatigue failure has been evaluated in the design. The contribution of this event to fatigue has been evaluated, and it was verified that such contribution is practically null.

* Therefore, there is practically no effect on the equipment integrity so far as fatigue evaluation is concerned, and it is judged that this factor poses no problem for future use of the equipment.

(6) Other Investigations Concerning Core Integrity

<1> Investigation of the Condition

* According to analysis, the temperature at the center of the fuel dropped rapidly as the reactor power reduced, and the fuel cladding temperature also dropped with reduced reactor power. For this reason, there was not a sufficient temperature rise to cause fuel damage.

* Considering the iodine-131 concentration in the reactor coolant and the result of the fuel assembly shipping inspection, it is judged that leakage through fuel cladding did not occur.

<2> Investigation of the Condition of Reactor

* The temperature of the reactor coolant at the top of the core remained below the saturation temperature throughout the period from occurrence to subsidence of the incident.

* A void having the maximum volume of approximately 5 m^3 was created inside the reactor coolant system as the system was depressurized, but this void did not prevent the natural circulation of the sound loop.

* It is judged that the high pressure injection pumps functioned as designed as the reactor coolant pressure changed, and the core was kept flooded.

4. Investigation into the Cause of the Steam Generator Tube Break

(1) Anti-Vibration Bar

* Concerning the anti-vibration bars inserted between lines X44 and X45, and X45 and X46, both the upper and lower anti-vibration bars were not inserted into the location specified in the design, and tubes located from X45 - Y12 to X45 - Y23, which include broken tube, were not supported by anti-vibration bars on either side.

* All the anti-vibration bars in question were distorted from the designed shape, and evidence of cutting, which was in conflict with the design, was observed at the end of the upper anti-vibration bar, whose total length was from 40 to 50 cm shorter than required in the original design.

* It is estimated that the anti-vibration bars were not inserted at the location specified in the design, because sufficient attention was not given to work supervision or quality control of the anti-vibration bars when the damaged steam generator was manufactured.

* The location of the anti-vibration bars was never confirmed after the plant was commissioned to commercial operation.

(2) Broken Tube

* The broken tube was located at X45 - Y14. The tube was broken off circumferentially at the upper edge of the No. 6 tube support plate on the cold leg side.

* Since the following features were observed, it is judged that the cause of break was high cycle (Note 1) fretting fatigue (Note 2).

  * Fracture surface near the initiating point:

    The facet (accumulation of innergranular cracks having minute steps) which is a characteristic of the low speed propagation fatigue fracture surface of Inconel materials.

  * Fracture surface at outer side of the initiating point:

    Fracture surface which has an angle to the axial direction, that features fretting fatigue.

  * Fracture surface of propagation region which is far from the initiating point:

    Striation which is a characteristic of a high cycle fatigue fracture surface.

  * Outer surfaces including the initiating point:

    Traces of abrasion in axial direction indicating contact with tube support plate, which include numerous minute circumferential cracks which has an angle to the axial direction, being characteristic of fretting fatigue.

* As the broken tube was not supported by anti-vibration bars, the fluid elastic vibration occurred in the U-bend portion of the tube (Note 3). As the tube was subjected to a repetitive load of fluid elastic vibration while the contact pressure was loaded at the No. 6 tube support plate where the tube was supported fixedly, a crack was generated at the position of the No. 6 support plate due to high cycle fretting fatigue, which finally caused the tube break.

* It is deemed that had the broken tube been supported by anti-vibration bars, the fluid elastic vibration would not have occurred, nor would the tube break.

* No feature that suggests denting, stress corrosion cracking, nor intergranular attack was observed on the broken tube. Also, it is deemed that there was no effect of corrosion fatigue, hydrogen embrittlement nor irradiation embrittlement.

(Note 1) High Cycle Fatigue: Fatigue caused by 10^5 or more cycles of repeated stress before breakdown.

(Note 2) Fretting Fatigue: Slip of metal over the surface of contacting material creates minute cracks that lead to fatigue breakdown.

(Note 3) Fluid Elastic Vibration : A phenomenon in which a vibration of large amplitude is quickly developed when fluid flow above a certain speed is applied to a tube bundle.

(3) Adjacent Tubes

* The U-bend portion of the tubes which had a larger radius than the broken tube and which were not supported by anti-vibration bars were subjected to fluid elastic vibration. These tubes were supported at the No. 6 tube support plate with clearance, and since they were subjected to a repetitive load by fluid elastic vibration, they slipped along the circumferential direction within the support plate tube holes, and suffered from wear thinning. The tubes on which wear thinning was observed were limited to those in the zone where insertion of anti-vibration bars was substantially insufficient.

* Had these tubes been supported by anti-vibration bars, the fluid elastic vibration would not have occurred on tubes on which wear thinning was observed, and these damages would not have been caused.

* The effect of the broken tube on neighboring tubes was slight, with the scale surface of neighboring tubes being lightly scratched, and it is deemed that the broken tube did not cause damage to the neighboring tubes.

5. Countermeasure to Prevent a Recurrence and Lessons

(1) Further Improvement and Intensification of Safety Assurance Measures by MITI

<1> Inclusion Into Review of Anti-Vibration Bar with Construction Plan and Inspection Items

* The anti-vibration bar shall be included in the items of construction plan review and preservice inspection, to intensify the Technical Standards.

* The conditions of insertion and installation of anti-vibration bars shall be checked during periodical inspections.

<2> Improvement and Intensification of Periodical Inspection

* The inspection of major equipment, including the main steam isolation valve and the pressurizer relief valve, shall be intensified.

* The deformation of the steam generator tube at the tube support plate shall be inspected.

<3> Improvement of Safety Evaluation Concerning Steam Generator Tube Break Incident

The reliability of the closure of the main steam isolation valve shall be evaluated more conservatively.

<4> Intensification of Guidance and Supervision of Quality Assurance Activities

The guidance and supervision of quality assurance activities shall be further intensified by conducting periodical surveys.

(2) Intensification of Self-Safety Assurance Efforts

<1> Intensification of Quality Assurance Activities

* It is required that the quality assurance activities in electric utilities, plant manufacturers, etc. are intensified.

* In electric utility companies, in particular, it is necessary that departments in charge of nuclear power take the initiative and reflect the lessons learned from the failures and incidents in Japan and abroads in their existing plants, and improve and intensify the auditing of quality assurance activities in plant manufacturers and others.

* It is required that the quality assurance inspection organization, which has been newly established as an organization independent from departments in charge of nuclear power, is actively utilized.

<2> Improvement of Integrity of the Steam Generator Tube

The quality assurance activities on the anti-vibration bars must be improved and intensified, new knowledge and technology shall be aggressively introduced to deal with the damage status of existing tubes, for prevention and suppression of such damage.

<3> Improvement of Maintenance and Management System

a. Main Steam Isolation Valve

* The roughness of the sliding surface of valve stem of the main steam isolation valve shall be confirmed.

* The closing force of the main steam isolation valve must be increased, and a tightening device shall be installed.

b. Pressurizer Relief Valve

* Concerning the instrumentation air supply system for equipment with important safety functions such as the pressurizer relief valve, considerations shall be provided to prevent misoperation.

* Measures for prevention of misoperation, such as locking management, shall be thoroughly provided to manually operated valves which are related to the operation of equipment with important safety functions.

* In addition, it is desirable to eliminate, as much as possible, the factors which could be the cause of simultaneous failure in designing equipment which have important safety functions.

<4> Improvement of Operations Manual

* The adaptable operations which are required in the case of an anomaly in equipment with important safety functions, such as failure of the pressurizer relief valve to operate or incomplete closure of the main steam isolation valve, shall be specifically detailed in the operations manual.

<5> Improvement of Monitoring System and Instrumentation and Control System

a. Improvement of steam generator leak monitoring system.

b. Improvement of PAM trend system and alarm typewriter.

c. Improvement of instrumentation systems (study of installation of reactor vessel level indication system and main steam radiation measurement.)

d. Improvement in plant control system (effective use of equipment which is powered by normal power supply during the occurrence of an incident.

(3) Medium and Long Term Requirements Including Technology Development

* The eddy current test technology shall be enhanced, including further improvement of detection accuracy, and the inspection technology, by which the fatigue of steam generator tubes caused by vibration can be detected more accurately and at an early stage, shall be developed.

* The efforts to develop technology to prevent human errors shall be continued.

* The method of evaluating fluid induced vibrations, etc. shall be improved by experiment and other means.

(4) Improvement of Prompt Response in the Occurrence of an Incident

<1> Improvement of Reporting and Liaison System

The reporting and liaison systems between related authorities and organizations shall be improved.

<2> Prompt and Appropriate Way of Dealing with General Plant Visitors

Manuals are prepared and utilized in dealing with general plant visitors in the occurrence of an incident, but this shall be made more effective by exercising in-house training.

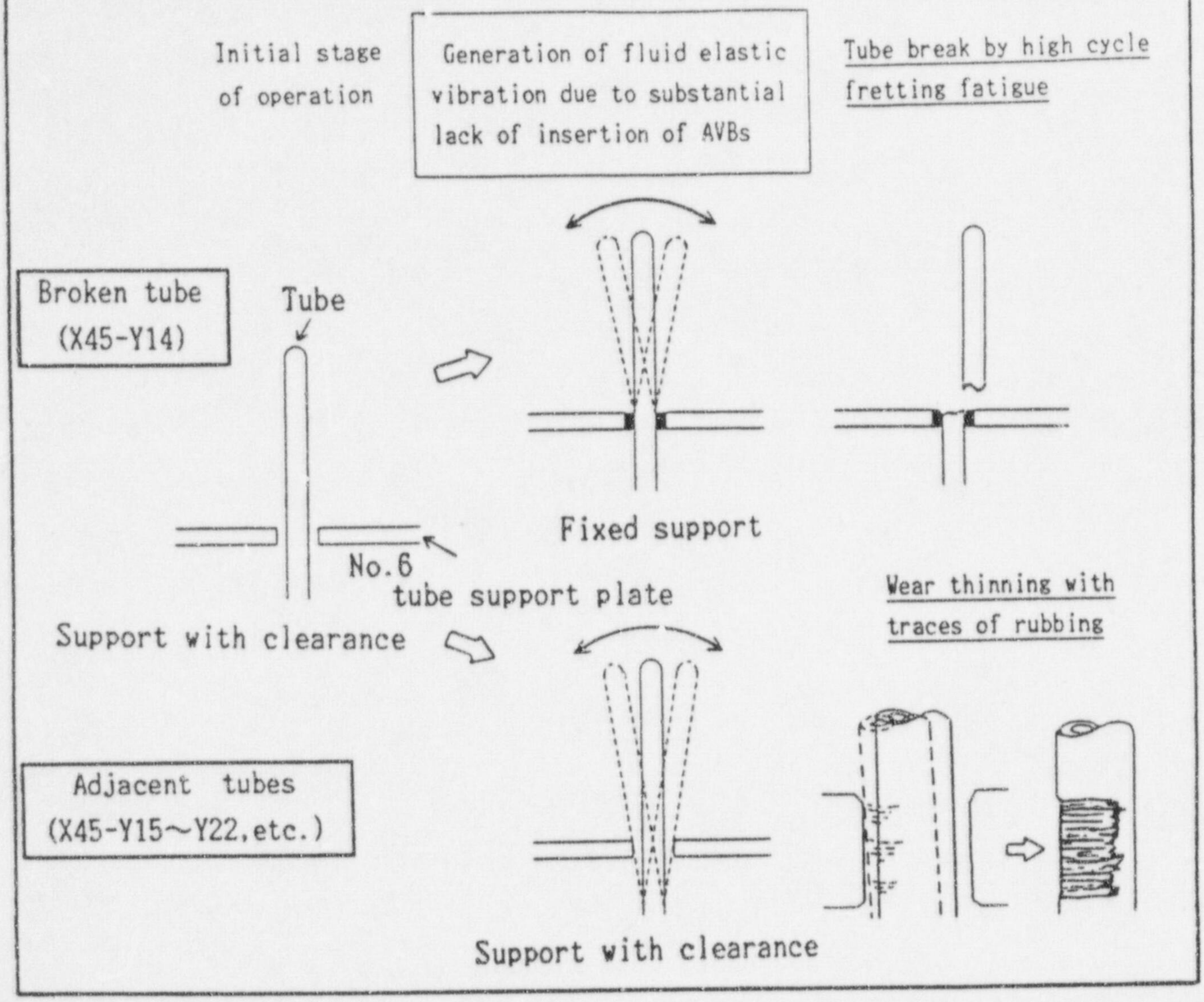
<3> Prompt Evaluation of Released Radioactivity

It is required to attempt to improve the system by which the release of radioactivity to the environment surrounding a power plant in the occurrence of an incident can be evaluated more promptly and accurately.

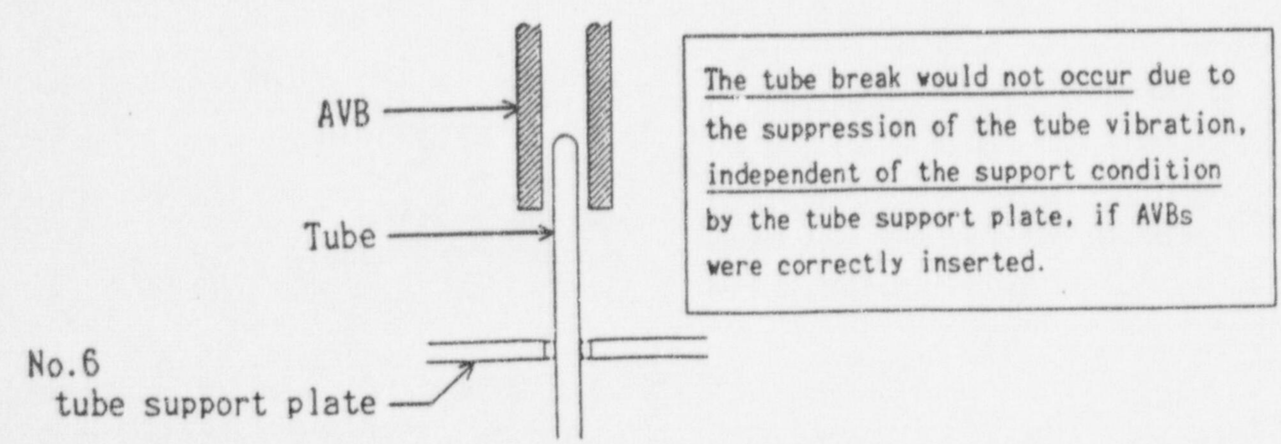
[Reference]

The integrity of steam generators of pressurized water reactors in Japan, other than Mihama unit No. 2, have been investigated. It is judged that the design of steam generator tubes against fluid elastic vibration and random vibration is appropriate for the maintenance of integrity.

THE ESTIMATION OF BREAK AND WEAR MECHANISM OF THE TUBE

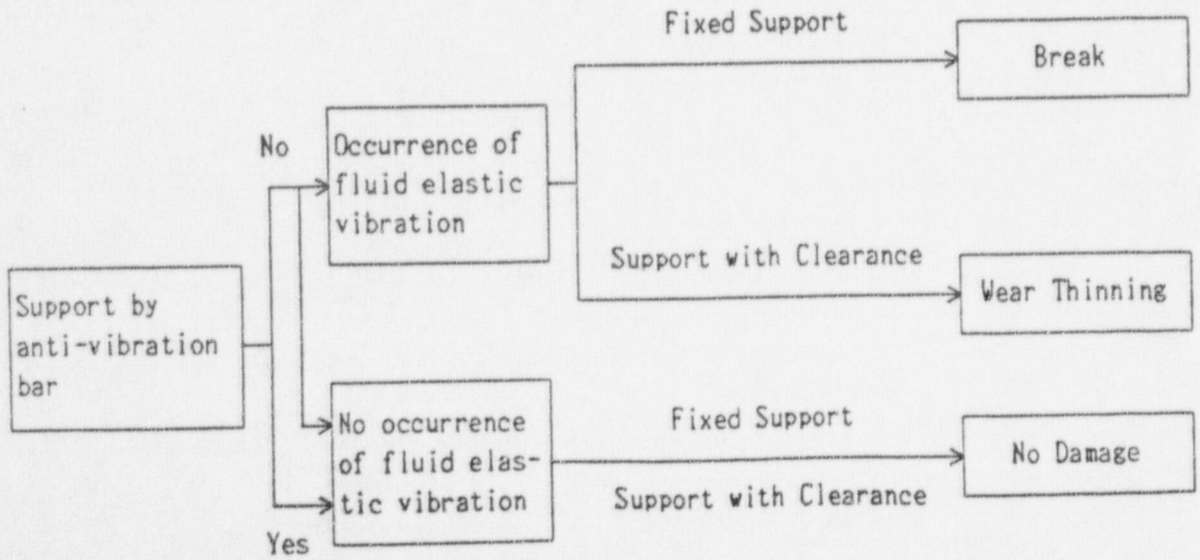


EVALUATION OF THE CONDITION WHEN AVBS WERE CORRECTLY INSERTED



RESULTS OF THE INVESTIGATION INTO THE CAUSES OF THE TUBE DAMAGES ON LINE X45

		X45-Y11	X45-Y12	X45-Y13	X45-Y14 (Broken Tube)	X45-Y15	X45-Y16 ~ X45-Y22
Active Tube or Plugged Tube		Active		Plugged	Active		Plugged
Supporting Condition at the No.6 Tube Support Plate		Fixed Support		Support with Clearance	Fixed Support	Support with Clearance	
Metallurgical Investigation	Minute Cracks	Not Observed			Observed	Not Observed	
	Wear Thinning	Not Observed				Observed	
Maximun Value of the Stability Ratio by the Fluid Elastic Vibration Analysis		Less than 1		1 or more			
Evaluation for the Occurrence of the Fluid Elastic Vibration		not Occured		Small Probability of occurrence	Occurred		



(Attachment 2)

1. Intensification of Self-Safety Assurance Efforts

(1) Intensification of Quality Assurance Activities

The quality assurance activities in design, construction and operation stages shall be further intensified with full understanding of the requirement for high quality.

In particular, the departments in charge of nuclear power shall further improve and intensify their efforts to reflect new knowledge, new technology as well as lessons learned from failures/incidents in Japan and abroads into existing plants, in order to manage design modification, to prevent human error; to improve the autonomous quality assurance standards, and to improve/intensify the inspection of quality assurance activities of plant manufacturers, equipment manufacturers, etc. In implementing these efforts, the quality assurance inspection organizations, which have been newly established independently from the nuclear departments, shall be actively utilized.

(2) Improvement of Integrity of Steam Generator Tubes

The quality assurance activities in the design, construction and operation stage shall be improved and intensified so that the anti-vibration bar is inserted into the designed position without mistake, and maintained and supervised to stay at that position.

New knowledge, technology, etc. shall be actively introduced to deal with the current damaged status of tubes, to prevent a recurrence and to suppress such damages.

(3) Improvement of Maintenance and Management Procedures, etc.

<1> The roughness of the sliding surface of the valve stem of the main steam isolation valve shall be confirmed.

The closing force of the said valve shall be increased, and a tightening device shall be installed so that the said valve can be promptly closed by manual operation.

<2> The work supervisory system shall be improved, in addition, concerning the instrumentation air supply system for equipment with important safety functions such as the pressurizer relief valve, considerations shall be provided to prevent misoperation, for example, by avoiding as much as possible the installation of manually operated valves which may interfere with the safety function.

Concerning the manually operated valves which are related to the operation of equipment with important safety functions, thorough provisions shall be implemented to prevent misoperation, for example, by providing a locking management, by clearly indicating the open/close status, and by clearly defining the scope of inspection in the inspection manual.

It is desirable to eliminate, as much as possible, the factors which could be cause of simultaneous failure in designing equipment with an important safety function such as the pressurizer relief valve.

(4) Improvement of Operations Manual

The operations manual shall be further improved based on the following points of view, and the manual shall be further substantiated by incorporating the lessons learned from faults/incidents in Japan and abroads, and the education and training based on such operations manuals shall be implemented.

First, the adapting procedures to be followed in the case of inoperability of the pressurizer relief valve and the case of incomplete closure of the main steam isolation valve shall be prescribed in the operations manual.

In addition, the specific operating procedures by which operators can easily identify the situation involved and take appropriate actions even in the case of the occurrence of an incident or the occurrence of an anomaly in equipment with important safety functions, shall be added to the operations manual.

Further, the instructions for timing, sequence, conditions, etc. of operation of equipment in each operations manual shall be clarified.

(5) Improvement of Monitoring System and Instrumentation and Control System

<1> A monitoring system, by which leakage of radioactive materials from a tube can be more promptly and accurately detected, and by which the leaking steam generator can be identified, shall be introduced.

<2> The computation capacity of the plant parameter related to the PAM trend system, and the processing capacity of the alarm typewriter, and other improvements shall be implemented.

<3> The capability of identifying the plant status during the occurrence of an incident shall be improved, including the attempt of introducing the reactor vessel level indication system and the main steam radiation measuring instrument by taking into account recent technological progress.

<4> It is desirable to modify the plant control system in such a manner that, when off-site power is available, the plant condition can be settled down to the normal status by employing equipment powered by normal power supply, in addition to the supplied by emergency power, and to prepare a corresponding operations manual.

2. Medium and Long Term Requirements Including Technology Development

(1) The eddy current test technology shall be enhanced, including further improvement of detection accuracy and the inspection technology, by which the fatigue of steam generator tubes by vibration can be detected more accurately and at an early stage, shall be advanced.

(2) The efforts to develop technology to prevent of human errors in plant operation and maintenance work shall be continued.

(3) Concerning the flow induced vibration and thermo-hydraulic behavior of major components of nuclear power plants, further efforts shall be exercised to improve the methods of evaluation of these phenomena, for example, by conducting experiments.

3. Improvement of Prompt Response in the Occurrence of an Incident

(1) Improvement of Reporting and Liaison System

The reporting and liaison system with the relevant authorities/organizations shall be improved, including the improvement of liaison procedures and further improvement of reporting/liaison means.

(2) Prompt and Appropriate Way of Dealing with General Plant Visitors

Manuals are prepared and utilized in dealing with general plant visitors in the occurrence of an incident, but this shall be made more effective by exercising in-house training.

(3) Prompt Evaluation of Released Radioactivity

It is required to attempt to improve the system by which the release of radioactivity to the environment surrounding a power plant in the occurrence of an incident can be evaluated more promptly and accurately.

The above measures shall be implemented in order to prevent the recurrence of this incident and to make effective use of the lessons learned. The following measures shall also be implemented from the point of view of fostering a sense of trust in nuclear power generation among the general public.

(1) From the point of view of further improving the integrity of steam generator tubes, the anti-vibration bars in plants employing the conventional ones shall be systematically replaced with the improved anti-vibration bars to suppress wear thinning of a tube at the contacting surface with anti-vibration bars.

(2) In view of the fact that the steam generator tube break has actually occurred, the actions to shut down a reactor shall be immediately taken in the event that a significant change in the parameter (radioactivity concentration) of the secondary water is observed.

(Attachment 3)

1. Intensification of Self-Safety Assurance Efforts

(1) Intensification of Quality Assurance Activities

The quality assurance activities in design, construction and operation stages shall be further intensified with full understanding of the requirement for high quality.

In particular, the departments in charge of nuclear power shall further improve and intensify their efforts to reflect new knowledge, new technology as well as lessons learned from failures/incidents in Japan and abroads into existing plants, in order to manage design modification, to prevent human error; to improve the autonomous quality assurance standards, and to improve/intensify the inspection of quality assurance activities of plant manufacturers, equipment manufacturers, etc. In implementing these efforts, the quality assurance inspection organizations, which have been newly established independently from the nuclear departments, shall be actively utilized.

(2) Improvement of Maintenance and Management Procedures, etc.

The work supervisory system shall be improved, in addition, concerning the control air supply system for equipment with important safety functions such as the pressurizer relief valve, considerations shall be provided to prevent misoperation, for example, by avoiding as much as possible the installation of manually operated valves which may interfere with the safety function.

Concerning the manually operated valves which are related to the operation of equipment with important safety functions, thorough provisions shall be implemented to prevent misoperation, for example, by providing a locking management, by clearly indicating the open/close status, and by clearly defining the scope of inspection in the inspection manual.

It is desirable to eliminate, as much as possible, the factors which could be cause of simultaneous failure in designing equipment with an important safety function.

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First, the specific operating procedures by which operators can easily identify the situation involved and take appropriate actions even in the case of the occurrence of an incident or the occurrence of an anomaly in equipment with important safety functions, shall be added to the operations manual.

In addition, instructions for timing, sequence, conditions, etc. of operation of equipment in each operation manual shall be clarified.

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The computation capacity of the plant parameter related to the PAM trend system, and the processing capacity of the alarm typewriter, and other improvements shall be implemented.

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(1) The efforts to develop technology to prevent human errors in plant operation and maintenance work shall be continued.

(2) Concerning the flow induced vibration and thermo-hydraulic behavior of major components of nuclear power plants, further efforts shall be exercised to improve the methods of evaluation of these phenomena, for example, by conducting experiments.

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NRC STAFF PRESENTATION TO THE ACRS

SUBJECT: GENERIC LETTER
"Degradation of Steam Generator Internals"

DATE: April 15, 1997

PRESENTER: Stephanie M. Coffin
Materials Engineer
Materials and Chemical Engineering Branch
Division of Engineering
415-2778

SUBCOMMITTEE: Materials and Metallurgy

PURPOSE OF GENERIC LETTER

- Communicate findings of damage to steam generator internals at foreign PWR facilities

- Emphasize importance of performing examinations of steam generator internals to ensure steam generator tube structural integrity is maintained

- Request information to verify acceptable condition of steam generator internals

DAMAGE TO STEAM GENERATOR INTERNALS AT FOREIGN PWR FACILITIES

Plants similar to Westinghouse Model 51 Steam Generators

1) Wastage of the uppermost support plate--
Misapplication of a chemical cleaning process

2) Broken tube support plate ligaments at uppermost TSP--
Excessive stress during final thermal treatment

3) Wastage of tube support plates at various elevations--
Cause is undetermined; not associated with chemical cleaning

4) Tube bundle wrapper drop and cracking of the wrapper--
Excessive stress during cooling transient, poor welds; cause of cracking unknown

SIGNIFICANCE OF EVENTS

- Degradation of the tube support plates and the tube bundle wrapper could affect the integrity of the steam generator tubes

- Tube support plates prevent lateral displacement, vibration, and minimize bending moments in the tubes

- Fall of the tube bundle wrapper can lead to a loss of feedwater, damage to steam generator tubes

FOREIGN RESPONSE TO STEAM GENERATOR INTERNALS DEGRADATION

To detect wastage and cracking of tube support plates:

- Eddy current testing of the steam generator tubes
- Visual and video camera inspections of the secondary side

Response:

- Tubes without adequate lateral support are stabilized and plugged

FOREIGN RESPONSE TO STEAM GENERATOR INTERNALS DEGRADATION

To detect tube bundle wrapper drop:

- Visual and video camera inspections of the secondary side
- Online instrumentation of the bundle wrapper

Response:

- Repairs completed on damaged bundle wrappers

DOMESTIC EXPERIENCE

Cracked or deformed tube support plates found at dented intersections in U.S. steam generators (Surry 1&2, Turkey Point 3&4, San Onofre 1, Indian Point 2, Millstone 2)***

EDF experience indicates there may be other mechanisms which lead to support plate damage

- Eddy current indications will be visually inspected this spring outage at Diablo Canyon

- Eddy current and visual inspections performed at Braidwood Unit 1 and Byron Unit 1 found no evidence of tube support plate or tube bundle wrapper degradation

***Except for IP-2, all SGs replaced or plant was shutdown

APPENDIX B CRITERIA

CRITERION XI, "TEST CONTROL"

Program shall be established to assure that all testing required to demonstrate that SSCs will perform satisfactorily in service is identified and performed

CRITERION XVI, "CORRECTIVE ACTION"

Measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment and nonconformances are promptly identified and corrected

REQUESTED INFORMATION

Request the following information:

- Discuss program to detect degradation of internals, if such a program exists
  - Reviews of past eddy current data
  - Secondary side visual/video camera inspection results
  - Description of degradation, how assessed and dispositioned
- Discuss plans for establishing a program or justification as to why no such program is needed

PUBLIC COMMENTS

NUBARG

- GL implies licensees should perform inspections of SG internals

- Complete a backfit analysis, justify the need for the information and any new positions on inspection requirements

NRC POSITION

- Appendix B Criteria XI and XVI, "Test Control" and "Corrective Action" apply

- GL does not promulgate new or revised staff position or requirements

- GL requests information to assess the applicability of the foreign experience to U.S. SGs

PUBLIC COMMENTS, continued

NEI

- GL imposes actions for licensees to perform inspections of SG internals

- Industry task force formed which will address GL concerns; no need for GL

NRC POSITION

- GL requests information on actions taken in accordance with Appendix B criteria

- GL needed to obtain and document information from licensees

STATUS OF GENERIC LETTER

Public comment period expired March 15th

NRC staff addressing comments

Expect coordinated industry response to GL through NSSS vendors and NEI/EPRI

H. F. CONRAD

STEAM GENERATOR PROGRESS REPORT REVISION 10

EPRI
November 1994

Prepared by

Energy Management Services, Inc.
Little Rock, Arkansas

Steam Generator Strategic Management Project

A3

9502170095 301 pp.

Steam Generator Progress Report Revision 10

Research Project RP3580-06

Final Report, November 1994

Prepared by
ENERGY MANAGEMENT SERVICES
P.O. Box 5493
Little Rock, Arkansas 72215

Principal Investigator
B. L. Dow, Jr.

Prepared for
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Progect Manager
R. C. Thomas

Steam Generator Management
Nuclear Power Group

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

Prepared by:
Energy Management Services, Inc.
Little Rock, Arkansas

ABSTRACT

The status of steam generator problems is presented through December 1993. Older problems such as wastage and denting are reasonably under control. Newer problems include SCC/IGA in tubesheet crevices, at the tube support plates, and under tubescale in the freespan region. Additional damage mechanisms include primary side cracking in high stress regions, pitting and tube fretting. Lost generation due to steam generator outages is presented along with steam generator problems reported at operating plants, the number of steam generator tubes plugged and sleeved, the number of forced outages caused by tube leaks, the plants which have chemically cleaned steam generators, and the plants which have replaced steam generators.

ACKNOWLEDGMENTS

Grateful appreciation is extended to the many utility organizations, vendors and individuals who supplied data used in this report.

CONTENTS

Section		Page
1	Introduction	1-1
2	Current Status	2-1
3	Lost Generation	3-1
4	Forced Outages	4-1
5	Plants Reporting Problems	5-1
6	Tube Fretting and Wear	6-1
7	Steam Generator Tube Sleeving	7-1
8	Steam Generator Chemical Cleaning	8-1
9	Steam Generator Replacement	9-1
10	References	10-1

Appendix

A Historical Tube Plugging Data

FIGURES

Figure		Page
2-1	World Wide Percentage of Plants Plugging Steam Generator Tubes	2-4
2-2	World Wide Percentage of Steam Generator Tubes Plugged	2-5
2-3	World Wide Number of Steam Generator Tubes Plugged	2-6
2-4	World Wide Causes of Steam Generator Plugging	2-7
2-5	United States Causes of Steam Generator Plugging	2-8
2-6	Non-U.S. Causes of Steam Generator Plugging	2-9
3-1	U.S. Capacity Factor Loss Due to Steam Generator Problems	3-2
3-2	U. S. PWR Capacity Factor Components (1980-84)	3-3
3-3	U. S. PWR Capacity Factor Components (1993)	3-4
4-1	U. S. Steam Generator Tube Leak Forced Outages	4-3
4-2	U. S. Steam Generator Tube Leak Forced Outage Rate	4-4

TABLES

Table		Page
3-1	Steam Generator Program Goals	3-5
4-1	U. S. Tube Leak Forced Outages (1993)	4-2
5-1	Status of Units Reporting Problems (Dec. 1993)	5-2
5-2	Units Reporting Steam Generator Problems	5-11
5-3	Status of U. S. Steam Generators (Dec. 1993)	5-12
6-1	Tube Fretting and Wear	6-2
7-1	Sleeving Experience	7-2
7-2	Major Sleeving Operations	7-8
7-3	Major Nickel Plating Operations	7-11
8-1	EPRI SGOG Chemical Cleaning (Dec. 1993)	8-2
8-2	KWU and EDF Chemical Cleaning (Dec. 1993)	8-3
9-1	Replacement Steam Generators	9-2
9-2	Planned Steam Generator Replacements (Orders Placed)	9-4

1

INTRODUCTION

This report is intended to provide EPRI members with the status of operating PWR steam generators. Considerable progress has been made since the formation of the EPRI Steam Generator Owners Group (SGOG I) in early 1977. At that time the industry was beginning to recover from wide scale steam generator tube wastage but was plagued by even wider scale tube denting. In addition to denting, stress corrosion cracking and apparent fatigue cracking were reported at a number of operating units. By the end of the SGOG I effort in December 1982, the causes and remedies for denting were much better understood and the occurrences of denting had dramatically decreased.

As these older problems were brought under control, newer problems were emerging. These problems included tube cracking and intergranular attack in the open tubesheet crevices, primary side tube cracking at high stress locations, pitting between the tubesheet and first support plate, and tube fretting in preheater sections and at antivibration bar locations. SGOG II followed SGOG I and focused on these newer problem areas.

Together utility members in SGOG I and SGOG II pledged more than 65 million dollars to help understand and resolve steam generator problems. The SGOG II project formally ended December 30, 1986. The work started by SGOG I and SGOG II has been continued in the EPRI base program. A five year Steam Generator Reliability Project (SGRP) began January 1, 1987 and was extended through December 1992. EPRI steam generator activities are now managed by the Steam Generator Strategic Management Project. Steam generator performance goals will be set and monitored to ensure that the Steam Generator Strategic Management Project addresses the most significant problems facing nuclear utilities. Although significant progress has been made in resolving steam generator problems, considerable work still remains. Steam generator forced outages, tube degradation, and steam generator replacements are still occurring. This report is an updated status of the progress that has been made through December 31, 1993. It is intended that this report be updated annually through the duration of the Steam Generator Strategic Management Project.

A report such as this is only as good as the data from which it is generated. Data for 1993 was collected directly from U.S. and foreign utilities. Individual data sheets for each plant were sent to the Technical Advisory Group members for confirmation. It is hoped that this process will provide the most accurate data possible. If you have any corrections or suggestions, please send them to the author at the address listed on the front page. This report contains the best available data at the time of printing and includes information from the EPRI Steam Generator Data Base, the Atomic Energy of Canada Limited, the Nuclear Regulatory Commission and individual utilities. Data trending is used to illustrate the progress that has been made and the problems that still exist. Appendix A provides a history of tube plugging and sleeving at each plant.

2

CURRENT STATUS

The Atomic Energy of Canada Limited (AECL) has been keeping track of the causes of tube plugging since 1971 (1). Much of the data prior to 1985 presented in this report is from information collected by AECL. The data for 1993 was collected directly from the U.S. and foreign utilities whose plants are listed.

Figure 2-1 shows the percentage of reactors in the surveys which plugged tubes from 1976 through 1993. During the last 10 years the average percentage of reactors plugging steam generator tubes has been 47%. Figure 2-1 shows that this trend has not changed significantly. In 1993, 56% of the operating units were required to plug steam generator tubes.

Figure 2-2 shows the tubes plugged per year as a percentage of the total number of steam generator tubes in service. The number of tubes included in the survey has risen from less than 200,000 in 1971 to more than 3.4 million in 1993. The percentage of tubes plugged per year over the last ten years has averaged .24 percent. This trend has decreased from an average of .39% for 1971 through 1979, to .24% for 1983 through 1993. Steam generator degradation is still widely occurring, however, and utilities are required to take expensive remedial action. Although the ten year average of .24 percent may not appear significant, over a 30 or 40 year steam generator life this amounts to plugging 7.2% to 9.6% of the available tubes. Even though this average value might be acceptable, not all steam generators are degrading equally. Extensive plugging efforts over the last few years have occurred at the following units:

- 548 tubes in 1990 at Farley 2 due to primary side SCC and secondary side IGA
- 617 tubes preventively plugged in 1990 at Palisades due to AVB fretting concerns
- 624 tubes in 1990 at ASCO 1 due to primary side SCC and secondary side IGA
- 468 tubes in 1991 at St. Lucie 1 due to secondary side SCC/IGA
- 1580 tubes in 1991 at Trojan due to secondary side SCC/IGA
- 600 tubes in 1991 at North Anna 1 due to secondary side IGA and primary side SCC
- 760 tubes in 1991 at Beaver Valley 1 due to secondary side SCC/IGA
- 331 tubes in 1991 at Bugey 5 due to primary side SCC

- 400 tubes in 1991 at Angra 1 due to secondary side SCC/IGA
- 306 tubes in 1992 at ANO-1 due to secondary side SCC/IGA
- 354 tubes in 1992 at D.C. Cook 1 due to secondary side SCC/IGA
- 527 tubes in 1992 at North Anna 2 due to secondary side SCC/IGA
- 612 tubes in 1992 at Oconee 1 due to secondary side erosion/corrosion
- 353 tubes in 1992 at ASCO 1 due to secondary side SCC/IGA
- 648 tubes in 1993 at V. C. Summer due to secondary side IGA and primary side SCC
- 620 tubes in 1993 at North Anna 2 due primarily to secondary side IGA and primary side SCC
- 608 tubes in 1993 at Byron 1 due primarily to secondary side IGA and primary side SCC
- 740 tubes in 1993 at Catawba 1 due primarily to secondary side IGA and primary side SCC
- 431 tubes in 1993 at ASCO 2 due primarily to secondary side IGA/IGSCC
- 440 tubes in 1993 at Bruce-A 2 due primarily to secondary side IGA/IGSCC

Degradation rates at these units are higher than the average rate. Tube degradation has already caused the steam generators to be replaced at eighteen nuclear units.

Figure 2-3 shows the total number of tubes plugged per year. In 1985, 6093 tubes were plugged. This was due in part to the 1880 tubes plugged in French steam generators due to actual or anticipated SCC in the U-bend region and 1081 tubes plugged in U.S. steam generators due to actual or anticipated AVB wear. In 1986 a total of 3669 tubes were plugged. This reduction was due in part to less preventive plugging and an increase in the number of tubes sleeved. In 1987 a total of 4822 tubes were plugged. This increase from 1986 was due in part to fewer tubes being sleeved and an increase in primary side SCC and secondary side IGA at a number of U.S. plants. In 1988 a total of 6309 tubes were plugged. This increase from 1987 was due in part to a larger number of tubes plugged in the U.S. and Spain due to primary side stress corrosion cracking and a larger number of tubes plugged in Sweden and Japan due to secondary side IGA. In 1989 a total of 6106 tubes were plugged. Compared to 1988, the number of tubes plugged due to I.D. SCC decreased slightly while the number of tubes plugged due to O.D. SCC/IGA increased slightly. In addition, almost seven hundred tubes were plugged in the French 1300 MW units due to denting caused by debris located on top of the tubesheet. In 1990, 7412 tubes were plugged. Compared to 1989, the number of plants plugging tubes increased, and the number of tubes plugged due to primary side SCC and fretting increased. In 1991, 9550 tubes were plugged. A small part of this increase was due to adding the PWR units from Germany and Korea to the report. Looking at the same units for each year, approximately 30% more tubes were plugged in 1991 compared to 1990. The largest increases in plugged tubes were due to secondary side SCC/IGA, especially at support plate intersections. In 1992 a total of 7860 tubes were plugged. This is approximately 20% fewer than were plugged in 1991. The reduction in tube plugging was almost equally divided between U.S. and non-U.S. plants. In 1993 a total of 10,317 tubes were plugged. Part of this increase was due to adding twenty Ontario Hydro units to the survey. Looking at the same number of units each year, approximately 25% more tubes were plugged in 1993 than 1992. This was primarily due to a larger percentage of units plugging tubes in 1993 and a larger number of tubes plugged due to primary side SCC and secondary side IGA in the U.S.

Figure 2-4 shows the causes of steam generator plugging on a world wide basis from 1973 to 1993. When the SGOG I was formed in early 1977, denting was responsible for almost 90% of the tube plugging. By the end of SGOG I in 1982, this figure was less than 2%. During the existence of SGOG II, SCC/IGA in the tubesheet, primary side SCC, pitting, and fretting surfaced as the primary causes of plugging. Although significant progress has been made with wastage and denting, the data in this section shows that the percentage of reactors plugging tubes and the percentage of tubes being plugged each year has remained relatively constant. In 1993 I.D. stress corrosion cracking (21.9%), O.D. stress corrosion cracking and intergranular attack (41.2%), and fretting (5.0%) accounted for over 68% of all the tubes plugged. Figures 2-5 and 2-6 show the causes of steam generator tube plugging separated into U.S. and non-U.S. plants. Pitting and fretting have been slightly more of a problem for U.S. plants while primary side stress corrosion cracking, SCC(ID), has been slightly more of a problem for non-U.S. plants. The diversity of these damage mechanisms means that no one solution is likely to resolve all problems. The task of maintaining steam generator integrity continues to remain formidable and challenging. The Steam Generator Strategic Management Project will utilize the results of earlier programs to focus on the resolution of current damage mechanisms.

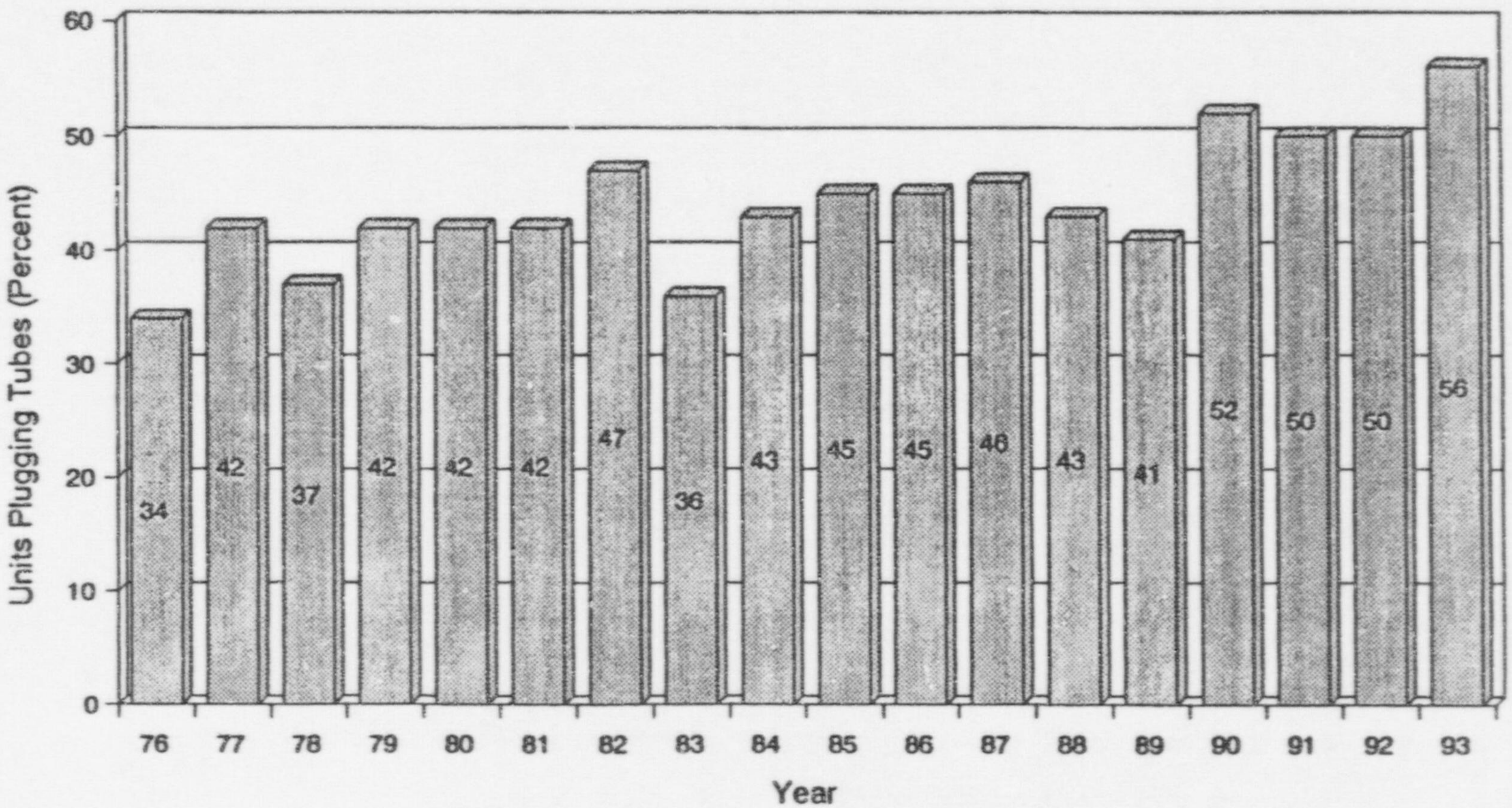

Figure 2-1
World Wide Percentage of Plants Plugging Steam Generator Tubes

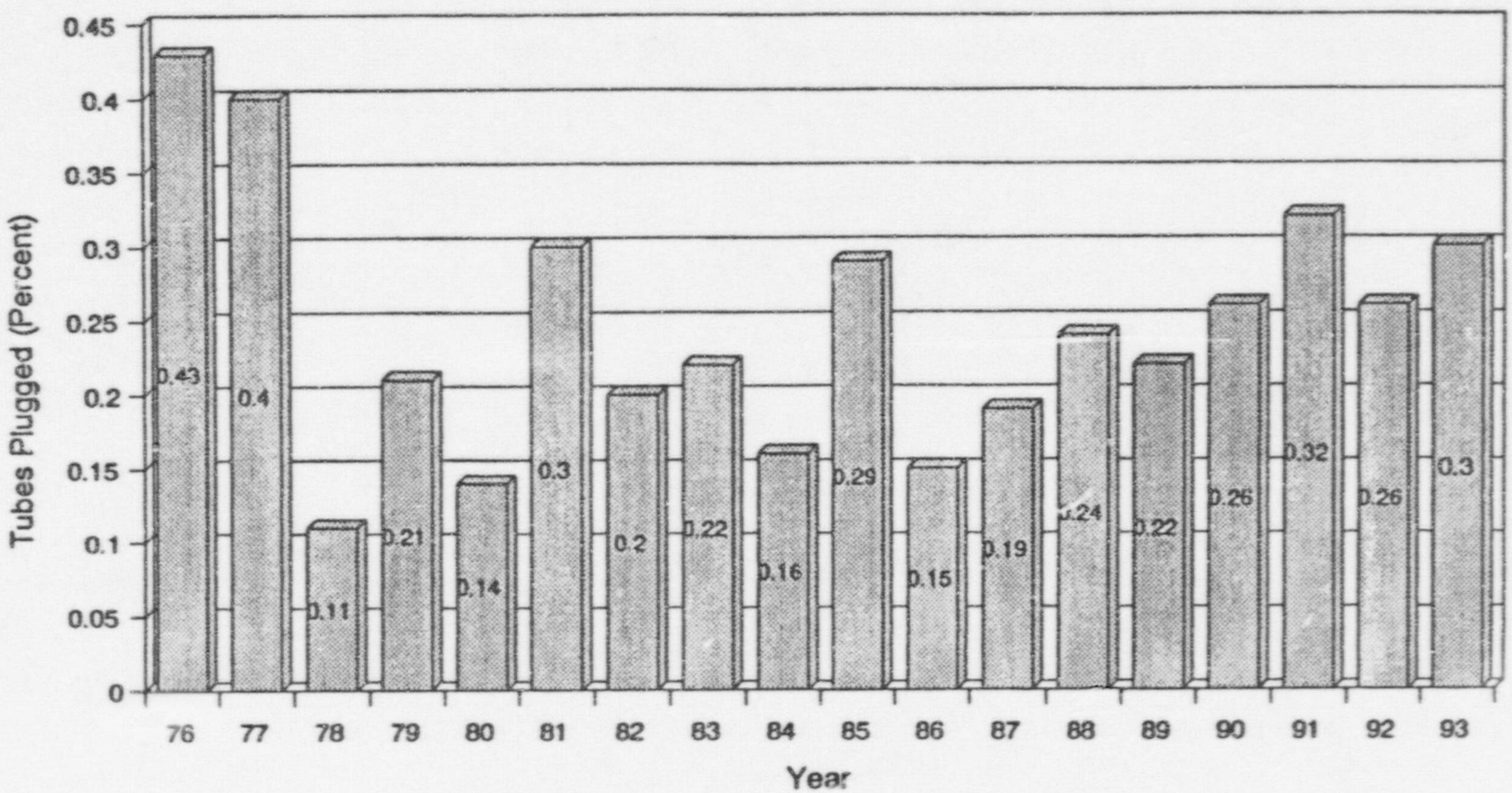

Figure 2-2
World Wide Percentage of Steam Generator Tubes Plugged

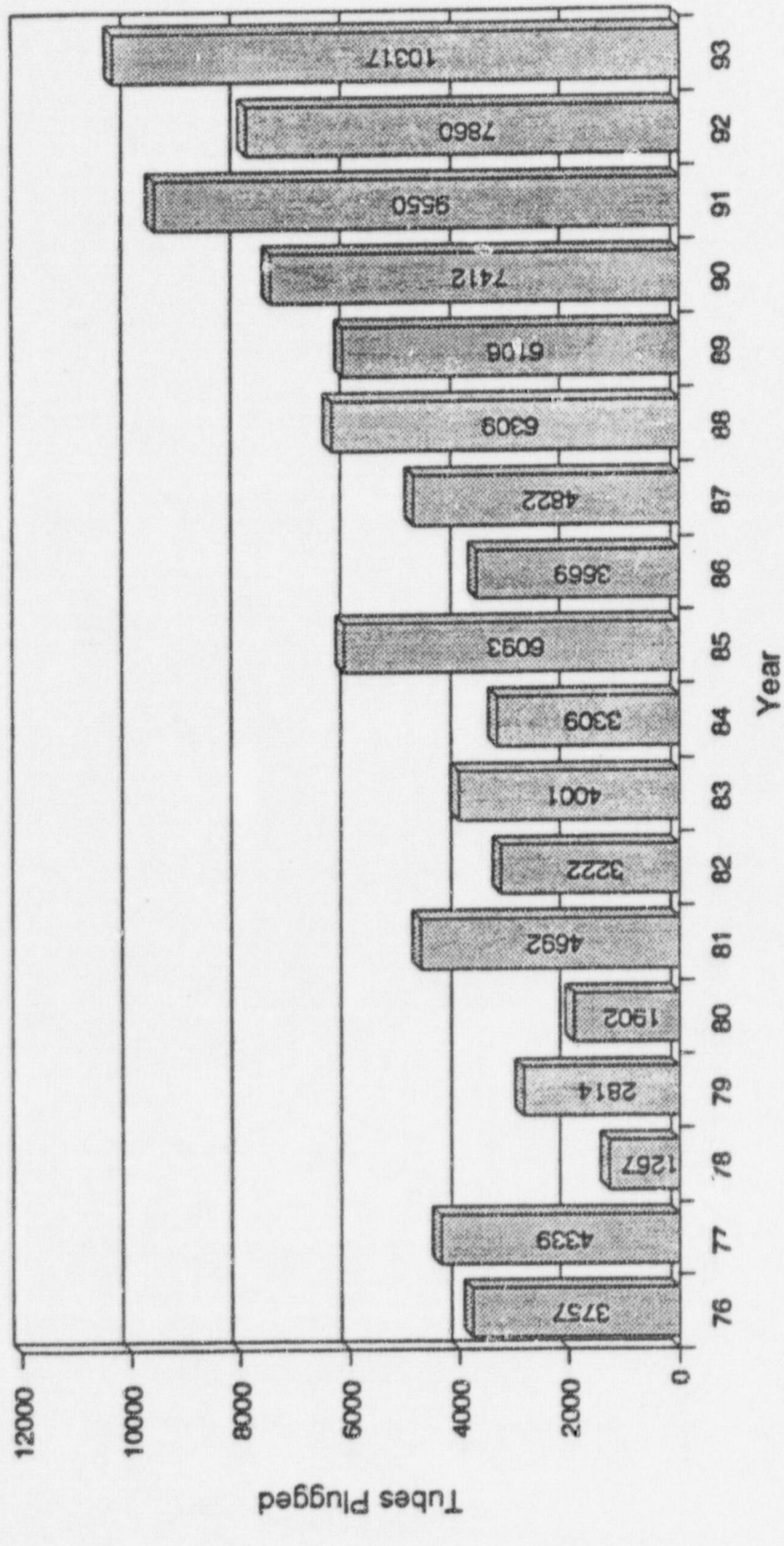

Figure 2-3
World Wide Number of Steam Generator Tubes Plugged

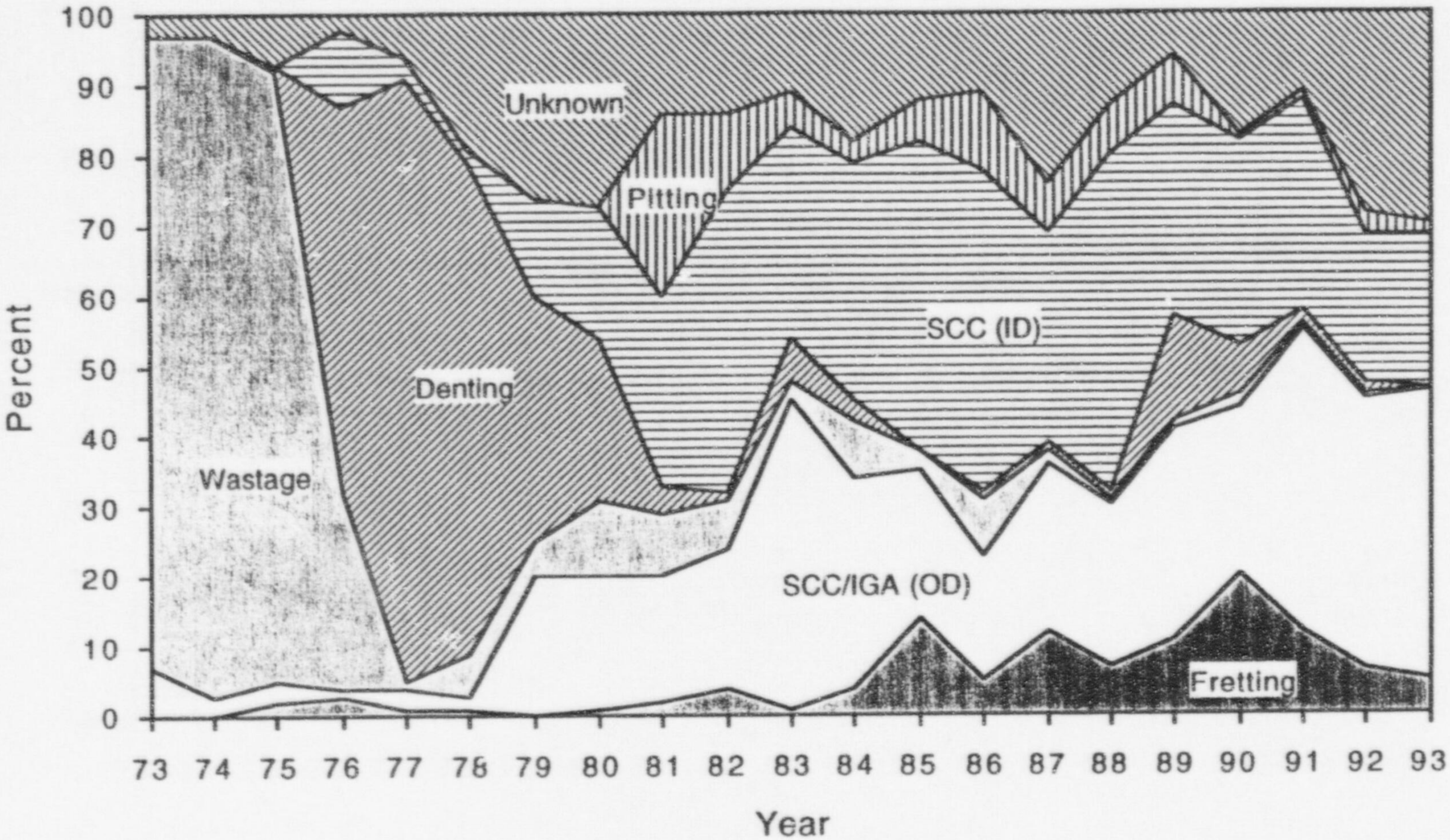

Figure 2-4
World Wide Causes of Steam Generator Plugging

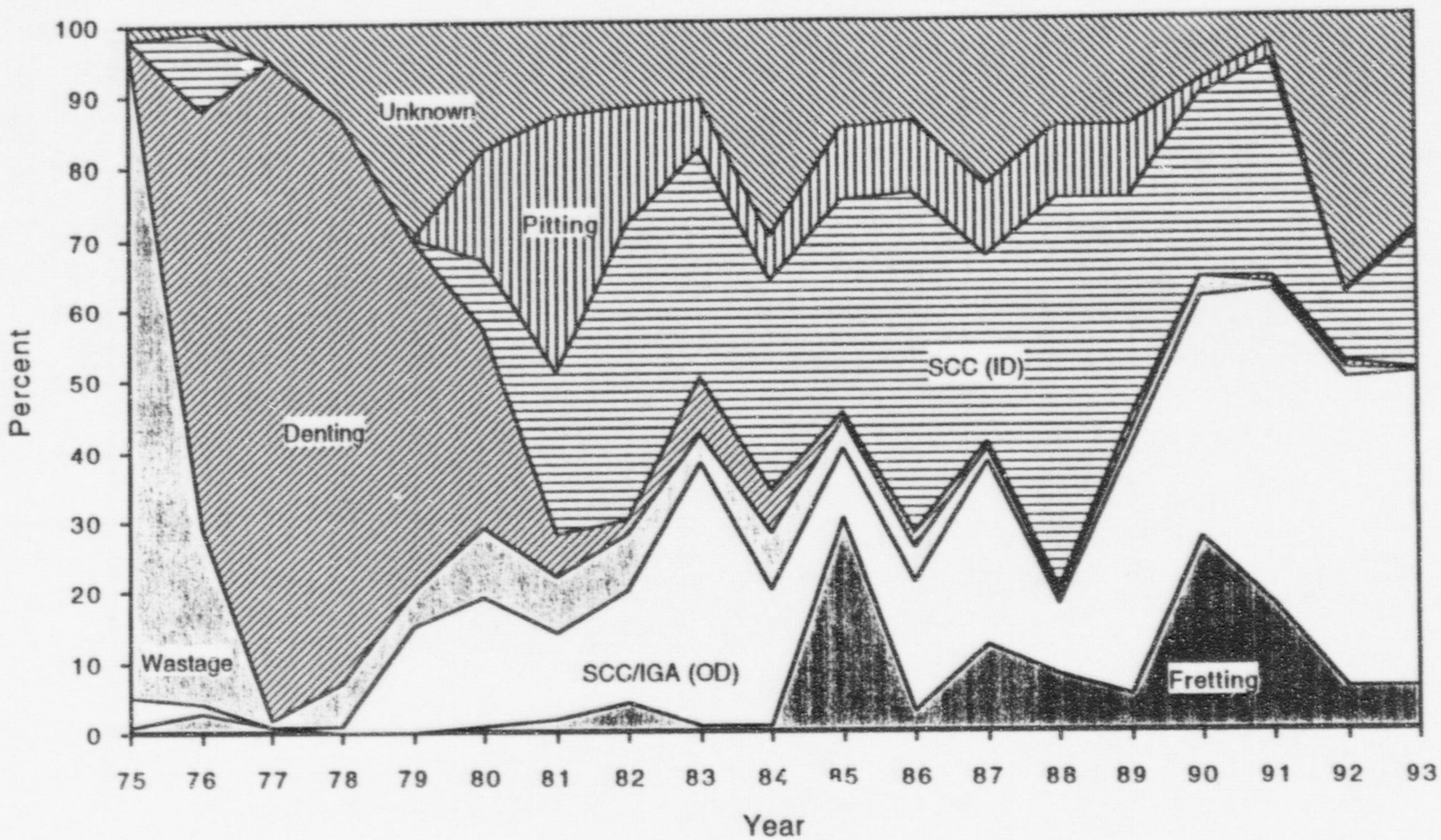

Figure 2-5
United States Causes of Steam Generator Plugging

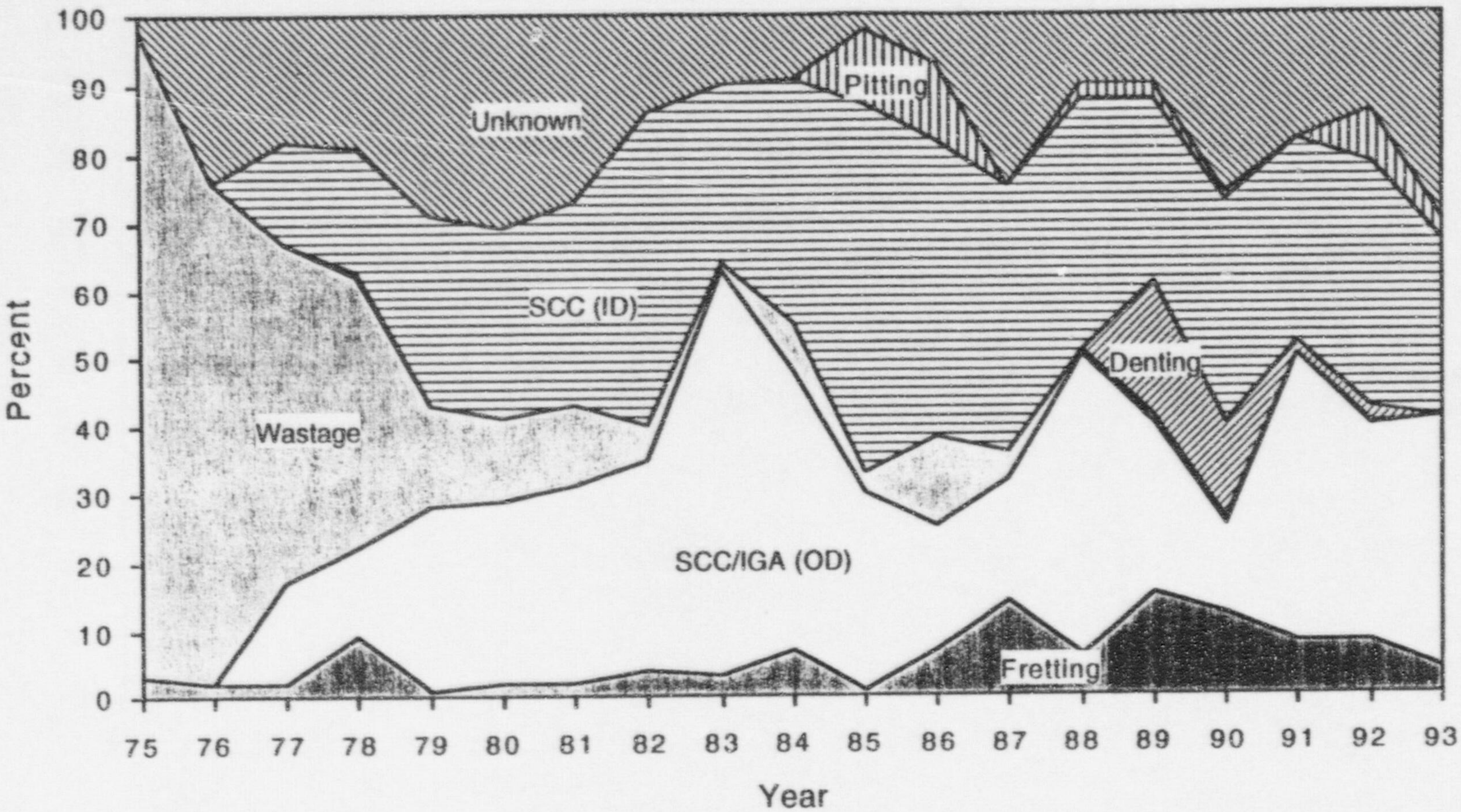

Figure 2-6
Non-U.S. Causes of Steam Generator Plugging

3

LOST GENERATION

One of the real incentives for improving steam generator integrity is the increased electrical generation due to improved capacity factors. In fact, over the last ten years, steam generator problems in the United States rank second behind refueling outages as the most significant contributor to lost generation.

During the last ten years, the capacity factor loss for U.S. PWR's due to steam generator problems has averaged 2.8%. In 1993 the capacity factor loss was 1.9% (see Figure 3-1). From 1980 to 1984 the average U.S. PWR capacity factor was 57.2%. During this time steam generator problems resulted in a reduction in the average U.S. PWR capacity factor of 5.7 percent. Of this amount, Figure 3-2 shows that 1.5 % was due to steam generator replacement and 4.2 % due to steam generator tube problems. Figure 3-3 shows the improvement in U.S. PWR capacity factors (73.0%) in 1993. Figure 3-3 also shows the reduction in lost generation (.18%) due to steam generator replacement and in lost generation (1.73%) due to steam generator tube problems.

Using the 1980 - 1984 average values for tube plugging, sleeving, radiation exposure, and lost generation due to steam generator outages and replacement, the EPRI Steam Generator Project Office initially established steam generator performance goals for the period 1986 through 1990 and then extended these goals through 1991. Revised performance goals are now being established. Table 3-1 shows that steam generator performance in 1993 relative to lost generation was ahead of previous target goals and resulted in a conservatively estimated savings of $132 million. The number of tubes plugged in 1993 exceeded (was worse than) previous target goals, while the number of tubes sleeved did not exceed (was better than) previous target goals As a result of this, the estimated radiation exposure slightly exceeded the target goal. The expenditures for these three items result in an estimated savings of an additional $16 million. Combining the tube plugging and sleeving results with the improvements in electrical generation results in a savings of approximately $148 million when compared with the average annual expenditures in the 1980 to 1984 time frame. These savings are conservatively estimated and indicate that utilities are making progress in managing steam generator degradation. However, a number of utilities are planning steam generator replacements and this needs to be factored into new target goals.

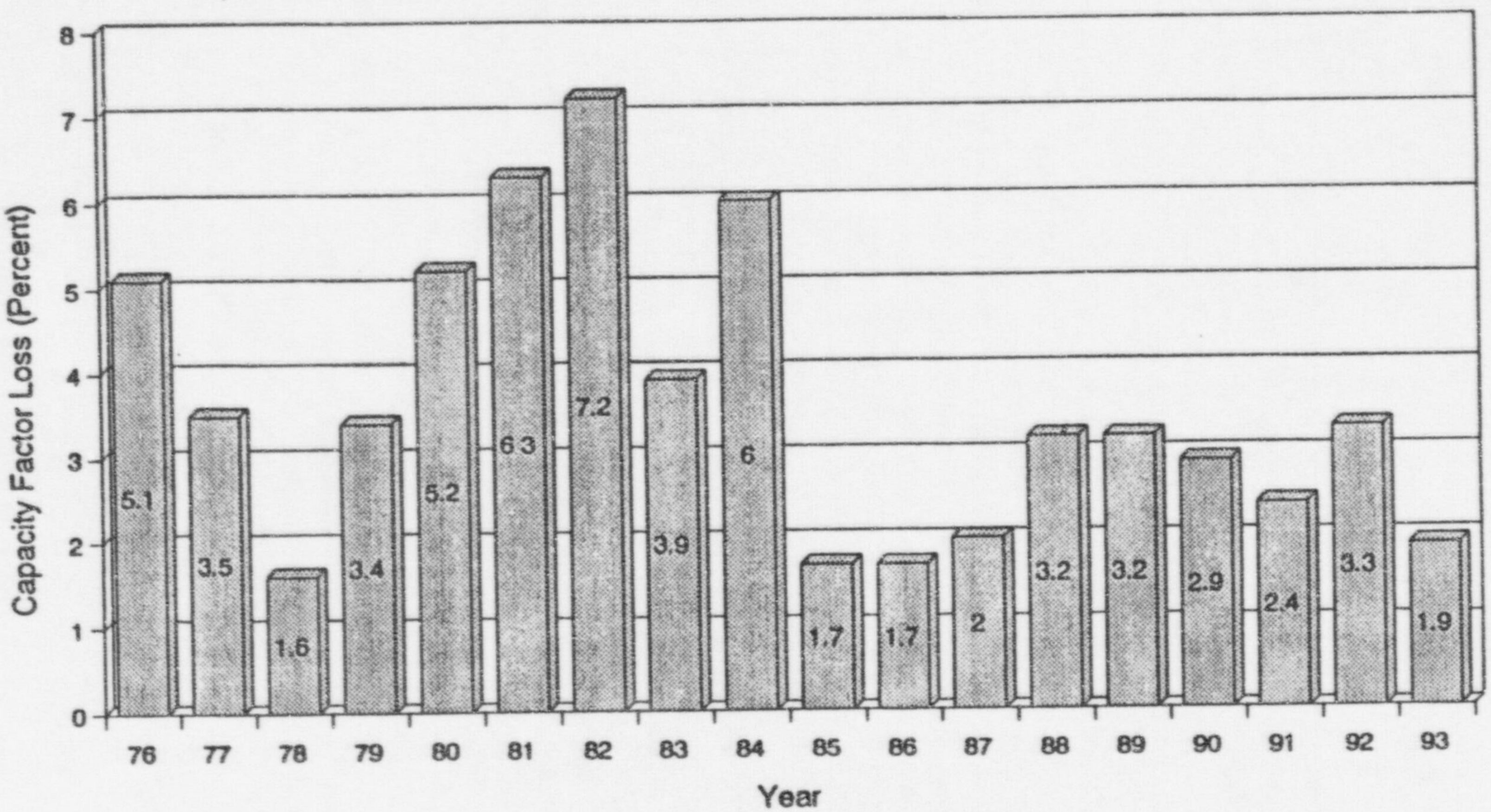

Figure 3-1
U.S. Capacity Factor Loss Due to Steam Generator Problems
(Including Steam Generator Replacement)

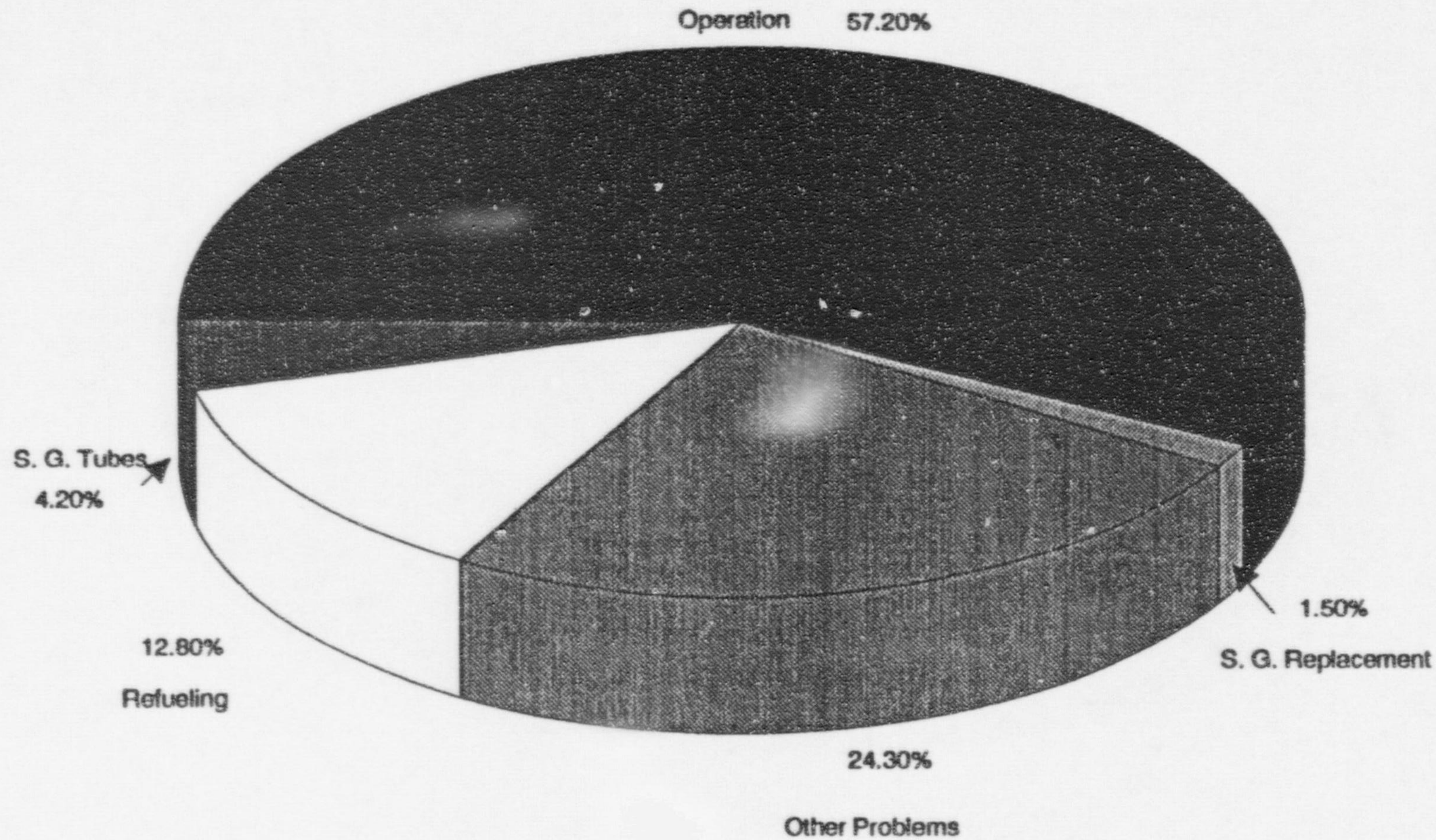

Figure 3-2
U.S. PWR Capacity Factor Components (1980-1984)

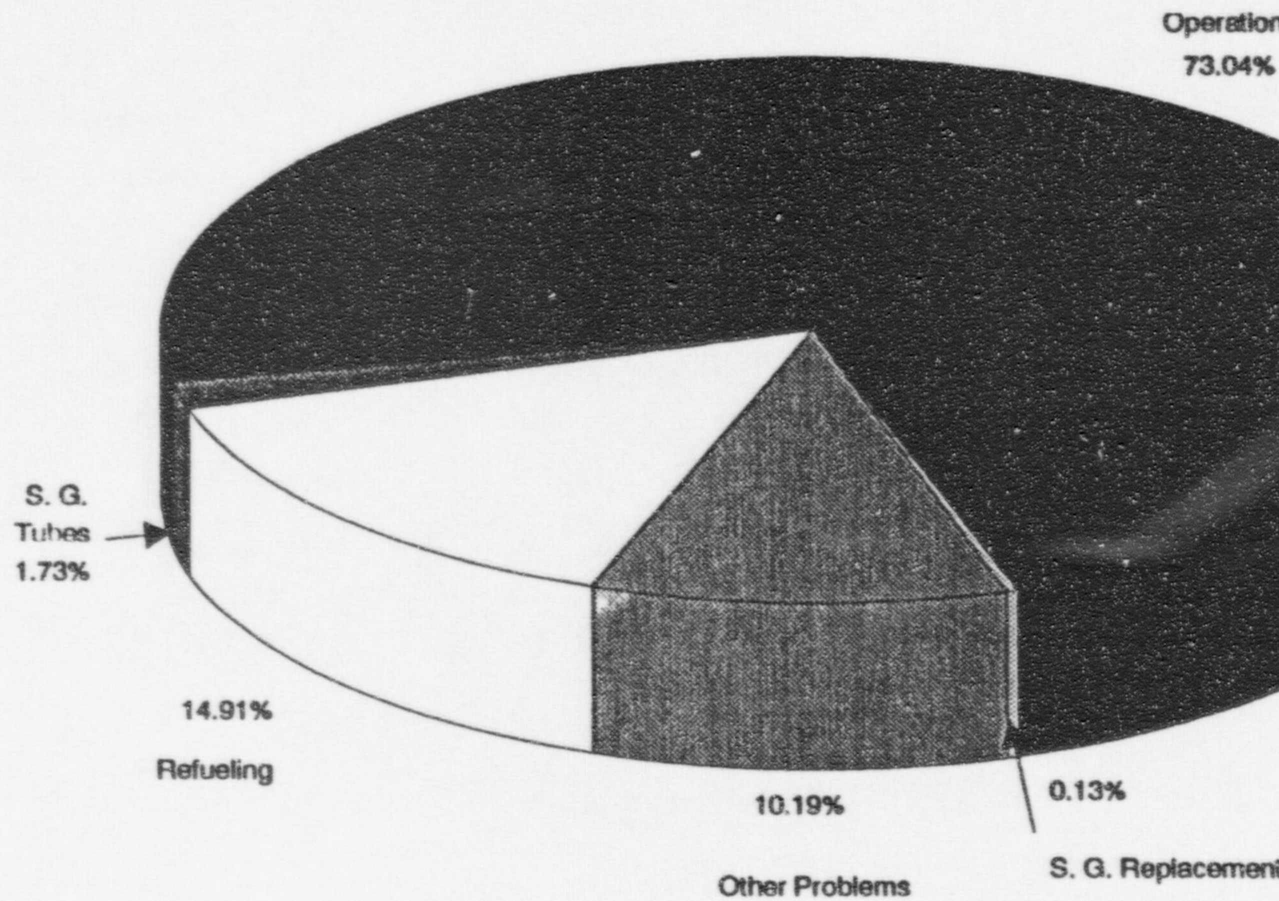

Figure 3-3
U.S. PWR Capacity Factor Components (1993)

Table 3-1
Steam Generator Program Goals

	U. S. YEARLY AVERAGES						SAVINGS	
	ACTUAL 1980-1984		TARGET 1986-1991		ACTUAL 1993		TARGET 1986-1991	ACTUAL 1993
LOST CAPACITY	NO.	COST (MILLION $)	NO.	COST (MILLION $)	NO.	COST (MILLION $)	SAVINGS (MILLION $)	SAVINGS (MILLION $)
S/G REPLACEMENT	1.5%	$51	.5%	$17	.13%	$4	$34	$47
FORCED & EXTENDED OUTAGES	4.2%	$145	2.5%	$86	1.73%	$60	$59	$85
REPAIR & MAINTENANCE								
TUBE PLUGGING	2242	$5	2000	$4	6099	$12	$1	($7)
TUBE SLEEVING	3181	$32	3000	$30	847	$8	$2	$24
RAD. EXPOSURE	4670 mr	$5	4000 mr	$4	5500* mr	$6	$1	($1)

*Estimated

4

FORCED OUTAGES

Another indication of the ability of utilities to successfully manage steam generator issues is the number of forced outages caused by steam generator tube leaks. Forced outages not only cause a loss of production, but are expensive because repair teams have to be mobilized on short notice. In 1993 there were four forced outages in the U.S. due to steam generator tube leaks (Table 4-1). This compares with an average of 10 forced outages per year from 1976 to 1993 (Figure 4-1). By dividing the number of forced outages per year by the number of operating PWR's, a tube leak forced outage rate can be determined. In 1993 the forced outage rate was .06 which means there was one tube leak outage for every seventeen generating PWR's. The average tube leak forced outage rate per year in the U.S. from 1976 to 1993 was .22 or approximately one tube leak outage per year for every five operating PWR's (Figure 4-2). Although Figure 4-2 shows an improving trend, the long range goal of utilities is to have no forced outages due to steam generator tube leaks. The verdict is still out on whether or not this goal is achievable.

TABLE 4-1
U. S. TUBE LEAK FORCED OUTAGES (1993)

Plant	Date	Leak Rate	Outage Duration	Probable Cause
Palo Verde 2	3/93	240 gpm	105 days	Freespan IGSCC in upper bundle
Kewaunee	6/93	100 gpd	7 days	Leaking tubesheet plug
Mc Guire 1	8/93	185 gpd	35 days	Sleeve failure
Braidwood 1	10/93	300 gpd	18 days	Freespan crack between 2 AVB's

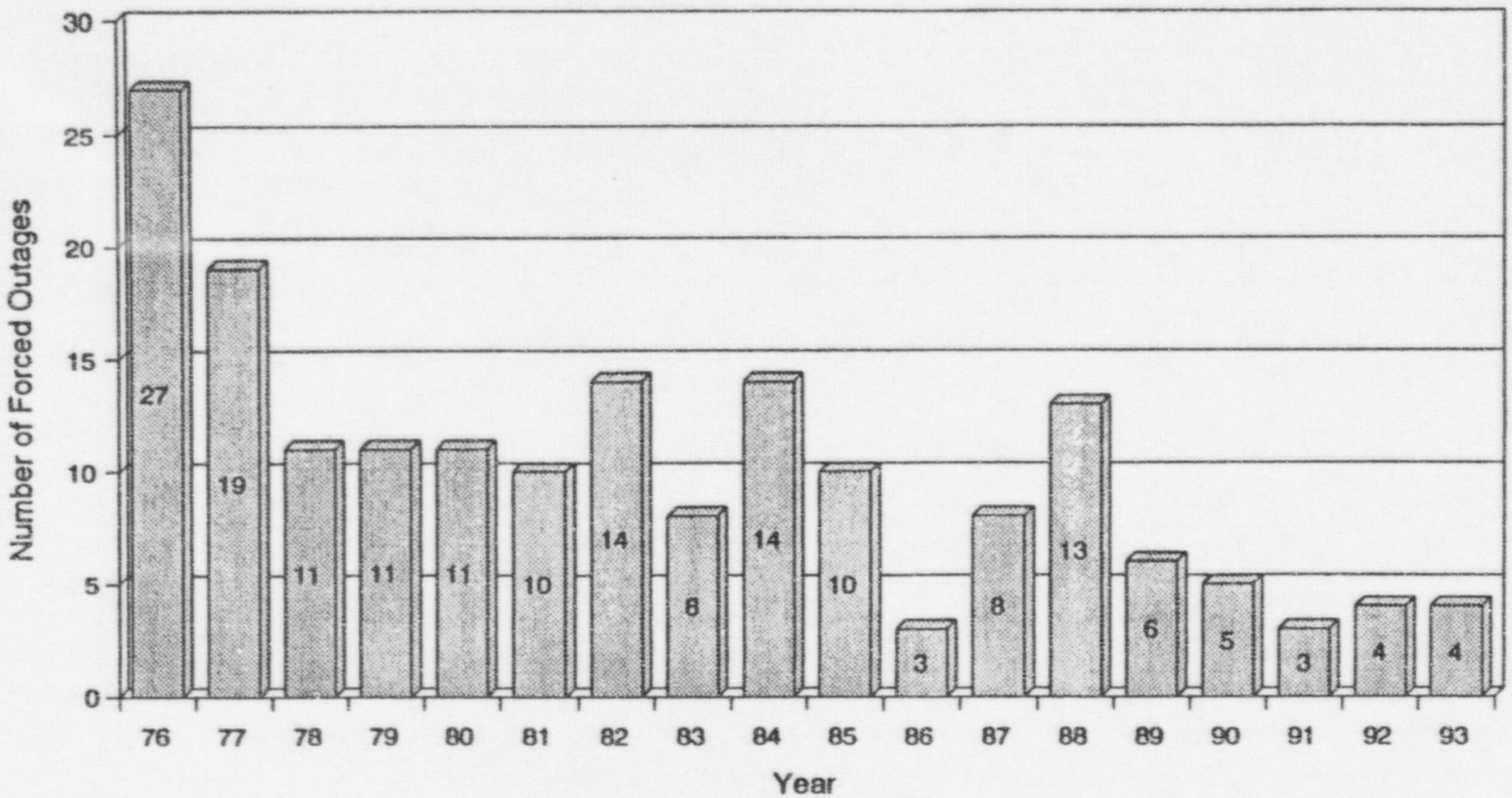

Figure 4-1
U.S. Steam Generator Tube Leak Forced Outages

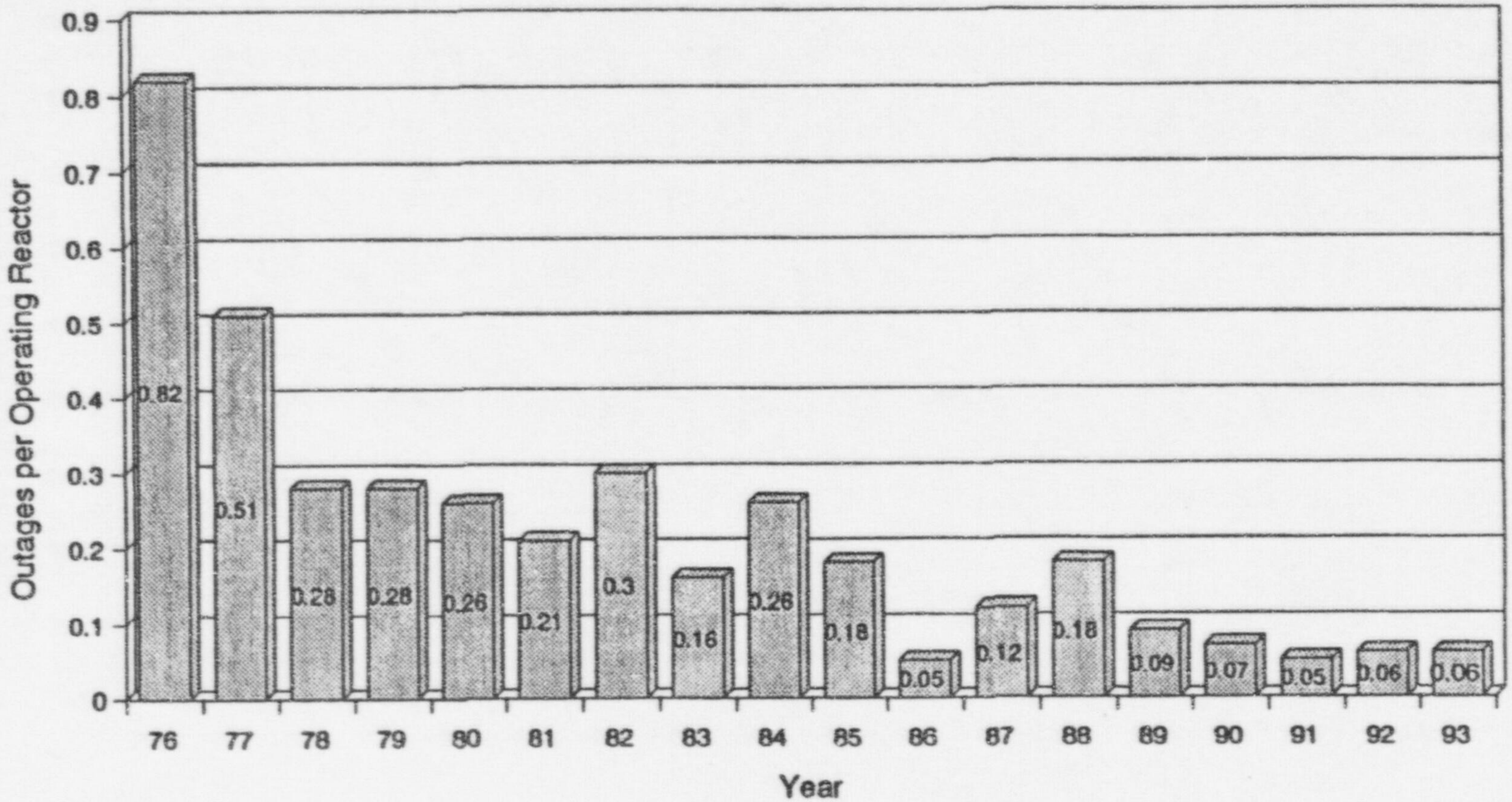

Figure 4-2
U.S. Steam Generator Tube Leak Forced Outage Rate

5

PLANTS REPORTING PROBLEMS

EPRI has been tracking reported plant problems since early 1977. Table 5-1 shows the status of reported problems as of December 1993. Table 5-2 compares the 1993 results with those from 1977 and 1982. The largest increases in reported problems are I.D. initiated cracking, O.D. initiated SCC/IGA, and tube fretting. Over fifty percent of the units covered in this report indicate some occurrence of tube fretting and wear. The Steam Generator Strategic Management Project is focused on addressing these problems. Although the type of information provided in Tables 5-1 and 5-2 is useful for general trending of reported problems, the criteria for reporting is not always consistent and the data is difficult to verify. A more definitive method at looking at problem areas is to review the number of tubes plugged at each unit and the reported damage mechanism causing the tube to be removed from service. Appendix A provides this information on a yearly basis for each plant. A summary of the number of tubes plugged and sleeved at U.S. plants is provided in Table 5-3.

Table 5-1
Status of Units Reporting Problems (Dec. 1993)

Plant	Date Com'l	NSSS	REPORTED PROBLEMS: Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carryover
Almaraz 1	Dec-81	W					O	O			O				
Almaraz 2	Sep-83	W					O	O			O				
Angra 1	Dec-84	W				O	O	O	O						
ANO 1	Dec-74	B					O		O			O	O		
ANO 2	Nov-80	B		O	O		O		O		O				
Asco 1	Dec-84	W		O			O	O			O				
Asco 2	Mar-86	W					O	O			O				
Atucha 1	Mar-74	KWU	O								O				
Beaver Valley 1	Oct-76	W	O				O	O	O		O	O			
Beaver Valley 2	Nov-87	W		O							O	O			
Belleville 1	Jun-88	F			O										
Belleville 2	Jan-89	F			O										
Beznau 1 (Org)	Dec-69	W					O		O		O				
Beznau 1 (Rpl)	Apr-93	F													
Beznau 2	Mar-72	W					O	O	O		O				
Biblis A	Aug-74	KWU	O								O				
Biblis B	Apr-76	KWU	O			O	O				O				
Blayais 1	Dec-81	F			O			O			O				
Blayais 2	Feb-83	F			O			O			O				
Blayais 3	Nov-83	F			O			O			O				
Blayais 4	Oct-83	F			O			O			O				
Borssele	Jul-73	KWU	O								O				
Braidwood 1	Jul-88	W					O				O				
Braidwood 2	Oct-88	W									O				
Brokdorf	Oct-86	KWU													
Bruce-A 1	Sep-77	AECL										O			
Bruce-A 2	Sep-77	AECL					O		O			O			
Bruce-A 3	Feb-78	AECL										O			

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com'l	NSSS	REPORTED PROBLEMS: Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carryover
Bruce-A 4	Jan-79	AECL											O		
Bruce-B 5	Mar-85	AECL													
Bruce-B 6	Sep-84	AECL									O				
Bruce-B 7	Apr-86	AECL											O		
Bruce-B 8	May-87	AECL									O				
Bugey 2	Feb-79	F					O	O	O		O				
Bugey 3	Feb-79	F					O	O	O		O				
Bugey 4	Jul-79	F					O	O	O		O				
Bugey 5 (Org)	Jan-80	F					O	O	O		O				
Bugey 5 (Rpl)	Feb-94	F													
Byron 1	Sep-85	W					O	O	O						O
Byron 2	Aug-87	W									O				
Callaway	Apr-85	W									O				
Calvert Cliffs 1	May-75	C		O			O		O		O		O	O	
Calvert Cliffs 2	Apr-77	C		O			O		O		O		O	O	
Catawba 1	Jun-85	W					O	O	O		O				
Catawba 2	Aug-86	W									O				
Cattenom 1	Apr-87	F			O										
Cattenom 2	Feb-88	F			O										
Cattenom 3	Jul-90	F													
Cattenom 4	May-91	F													
Chinon B1	Feb-84	F						O							
Chinon B2	Aug-84	F						O							O
Chinon B3	Mar-87	F													
Chinon B4	Apr-88	F						O							
Comanche Peak 1	Aug-90	W													
Comanche Peak 2	Aug-93	W													
Conn. Yankee	Jan-68	W	O	O	O	O		O			O				

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com1	NSSS	REPORTED PROBLEMS												
			Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carryover
Cook 1	Aug-75	W	O		O		O	O	O		O		O		
Cook 2 (Org)	Jul-78	W	O		O		O	O	O		O		O		
Cook 2 (Rpl)	Mar-89	W													
Cruas 1	Apr-84	F			O			O							
Cruas 2	Apr-85	F						O			O				
Cruas 3	Sep-84	F													
Cruas 4	Feb-85	F													
Crystal River 3	Mar-77	B							O		O	O			
Dampierre 1 (Org)	Sep-80	F						O			O				
Dampierre 1 (Rpl)	Jun-90	F													
Dampierre 2	Feb-81	F					O	O			O				
Dampierre 3	May-81	F			O		O	O			O				
Dampierre 4	Nov-81	F			O		O	O			O				
Darlington 1	Nov-92	AECL													
Darlington 2	Oct-90	AECL													
Darlington 3	Feb-93	AECL													
Darlington 4	Jul-93	AECL													
Davis Besse 1	Jul-78	B				O			O						
Diablo Canyon 1	May-85	W		O				O			O				
Diablo Canyon 2	Mar-86	W		O			O	O	O						
Doel 1	Feb-75	W		O	O		O	O	O		O				
Doel 2	Nov-75	W		O	O		O	O	O		O				
Doel 3 (Org)	Oct-82	FC		O			O	O	O		O				
Doel 3 (Rpl)	Jun-93	FC													
Doel 4	Jul-86	ACW	O			O	O	O	O		O				
Emsland	Apr-88	KWU													
Farley 1	Dec-77	W					O	O	O						
Farley 2	Jul-81	W					O	O	O						

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com'l	NSSS	Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carryover
			REPORTED PROBLEMS												
Fessenheim 1	Jan-78	F			O		O	O	O		O				
Fessenheim 2	Apr-78	F					O	O	O	O	O				O
Flamanville 1	Dec-86	F						O							
Flamanville 2	Mar-87	F			O						O				
Ft. Calhoun	Sep-73	C		O			O		O						
Genkai 1	Oct-75	M					O		O						
Genkai 2	Mar-81	M													
Ginna	Jul-70	W	O				O	O	O		O	O			
Golfech 1	Jun-90	F													
Gosgen	Feb-79	KWU	O								O				
Grafenrheinfeld	Dec-81	KWU													
Gravelines 1	Nov-80	F			O		O	O			O				
Gravelines 2	Dec-80	F			O		O	O			O				
Gravelines 3	Jun-81	F			O		O	O			O				
Gravelines 4	Oct-81	F			O		O	O			O				
Gravelines 5	Jan-85	F			O			O			O				
Gravelines 6	Nov-85	F						O			O				
Grohnde	Aug-84	KWU									O				
Ikata 1	Sep-77	M						O			O				
Ikata 2	Mar-82	M									O				
Indian Point 2	Aug-74	W		O		O								O	
Indian Point 3 (Org)	Aug-76	W	O	O	O	O								O	
Indian Point 3 (Rpl)	Jun-89	W													
Isar 2	Jan-88	KWU													
Jose Cabrera	Aug-69	W	O					O	O		O				
Kewaunee	Jun-74	W		O	O		O	O	O						
Kori 1	Jun-77	W				O		O				O			
Kori 2	Jul-83	W					O		O		O				

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com'l	NSSS	Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carryover
			REPORTED PROBLEMS												
Kori 3	Sep-85	W									O				
Kori 4	Apr-86	W									O				
Lovilsa 1	May-77	AEE													
Lovilsa 2	Jan-81	AEE													
Maine Yankee	Dec-72	C	O	O		O	O	O	O		O				
McGuire 1	Aug-80	W					O	O	O		O				
McGuire 2	Mar-84	W					O	O	O		O				
Mihama 1	Nov-70	W	O			O									
Mihama 2 (Org)	Jul-72	M	O				O	O	O		O	O			
Mihama 2 (Rpl)	Apr-94	M													
Mihama 3	Dec-76	M						O	O		O				
Millstone 2 (Org)	Dec-75	C	O	O	O	O	O		O						
Millstone 2 (Rpl)	Jan-93	BWC													
Millstone 3	Apr-86	W									O				
Neckarwestheim 1	Jun-76	KWU	O								O				
Neckarwestheim 2	Jan-89	KWU													
Nogent/Seine 1	Feb-83	F			O			O			O				
Nogent/Seine 2	May-89	F			O						O				
North Anna 1 (Org)	Jun-78	W		O			O	O	O		O	O			
North Anna 1 (Rpl)	Apr-93	W													
North Anna 2	Dec-80	W	O	O			O	O	O		O				
Obrigheim (Org)	Oct-68	KWU					O	O							
Obringheim (Rpl)	Aug-83	KWU													
Oconee 1	Jul-73	B										O	O		
Oconee 2	Sep-74	B										O	O		
Oconee 3	Dec-74	B										O	O		
Ohi 1	Mar-79	W						O	O						
Ohi 2	Dec-79	M						O			C				

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com'l	NSSS	REPORTED PROBLEMS: Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carrryover
Ohl 3	Dec-91	M													
Ohl 4	Feb-93	M													
Palisades (Org)	Dec-71	C	O	O			O		O					O	
Palisades (Rpl)	Mar-91	C													
Palo Verde 1	Jan-86	C					O	O	O		O				
Palo Verde 2	Sep-86	C					O	O	O		O				
Palo Verde 3	Jan-88	C					O	O	O		O				
Paluel 1	Dec-85	F			O			O			O				
Paluel 2	Dec-85	F			O			O			O				
Paluel 3	Feb-86	F			O			O			O				
Paluel 4	Jun-86	F			O			O			O				
Penly 1	Dec-90	F													
Penly 2	Feb-92	F													
Philippsburg 2	Dec-84	KWU													
Pickering-A 1	Jul-71	AECL				O									
Pickering-A 2	Dec-71	AECL											O		
Pickering-A 3	Jun-72	AECL													
Pickering-A 4	Jun-73	AECL													
Pickering-B 5	May-83	AECL				O									
Pickering-B 6	Feb-84	AECL				O									
Pickering-B 7	Jan-85	AECL													
Pickering-B 8	Feb-86	AECL													
Point Beach 1 (Org)	Dec-70	W	O	O			O		O		O				
Point Beach 1 (Rpl)	Apr-84	W									O				
Point Beach 2	Oct-72	W	O	O			O		O						
Prairie Island 1	Dec-73	W	O				O	O	O		O				
Prairie Island 2	Dec-74	W	O					O			O				
Rancho Seco	Apr-75	B					O		O			O		O	

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com'l	NSSS	Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carryover
			REPORTED PROBLEMS												
Ringhals 2 (Org)	May-75	W		O			O	O	O		O			O	
Ringhals 2 (Rpl)	Aug-89	W													
Ringhals 3	Apr-81	W					O	O	O		O			O	
Ringhals 4	Oct-83	W						O			O				
Robinson 2 (Org)	Mar-71	W	O	O			O		O						
Robinson 2 (Rpl)	Oct-84	W													
Saint-Alban 1	Aug-85	F			O										
Saint-Alban 2	Jul-86	F			O			O			O				
Salem 1	Jun-77	W	O	O				O			O				
Salem 2	Oct-81	W				O		O			O				
San Onofre 1	Jan-68	W	O	O	O		O	O	O		O			O	O
San Onofre 2	Aug-83	C			O						O				
San Onofre 3	Apr-84	C			O						O				
Seabrook	Jul-90	W									O				
Sendai 1	Jul-84	M									O				
Sendai 2	Nov-85	M									O				
Sequoyah 1	Jul-81	W	O	O			O	O			O				
Sequoyah 2	Jun-82	W	O	O			O	O			O				
Shearon Harris	May-87	W		O	O		O	O	O		O				
South Texas Proj. 1	Aug-88	W					O	O	O		O				
South Texas Proj. 2	Jun-89	W									O				
St. Lucie 1	Dec-76	C		O	O		O		O					O	
St. Lucie 2	Aug-83	C					O		O		O				
St.-Laur.-des-Eaux B1	Aug-83	F					O	O	O		O				
St.-Laur.-des-Eaux B2	Aug-83	F					O	O			O				
Stade	Jan-72	KWU	O												
Summer 1	Jan-84	W					O	O	O						
Surry 1 (Org)	Dec-72	W	O	O	O			O						O	

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com'l	NSSS	REPORTED PROBLEMS: Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carrryover
Surry 1 (Rpl)	Jul-81	W									O				
Surry 2 (Org)	May-73	W	O	O	O			O							
Surry 2 (Rpl)	Sep-80	W									O				
Takahama 1	Nov-74	W	O				O	O	O						
Takahama 2	Nov-75	M					O		O						
Takahama 3	Jan-85	M									O				
Takahama 4	Jun-85	M									O				
Three Mile Island 1	Sep-74	B						O		O	O				
Tihange 1	Sep-75	W	O	O	O	O	O	O	O		O				
Tihange 2	Feb-83	FC		O			O	O							
Tihange 3	Nov-85	FC					O	O	O		O				
Tomari 1	Jun-89	M													
Tomari 2	Apr-91	M													
Tricastin 1	Dec-80	F			O		O	O			O				
Tricastin 2	Dec-80	F			O		O	O			O				
Tricastin 3	May-81	F					O	O							
Tricastin 4	Nov-81	F			O		O	O			O				
Trillo 1	Aug-88	K													
Trojan	May-76	W				O	O	O	O						
Tsuruga 2	Feb-87	M									O				
Turkey Point 3 (Org)	Dec-72	W	O	O	O			O							
Turkey Point 3 (Rpl)	Apr-82	W									O				
Turkey Point 4 (Org)	Sep-73	W	O	O	O			O		O				O	
Turkey Point 4 (Rpl)	May-83	W			O						O				
Uljin 1	Sep-88	F													
Uljin 2	Sep-89	F													
Unterwesser	Oct-78	KWU			O										
Vandellos 2	Dec-87	W									O				

Table 5-1
Status of Units Reporting Problems (Dec. 1993) cont.

Plant	Date Com'l	NSSS	REPORTED PROBLEMS												
			Wastage	Denting Sup Plate	Denting Tubesheet	Pitting	SCC (OD)	SCC (ID)	IGA (OD)	IGA (ID)	Fretting	High Cy Fatigue	Erosion	Water-hammer	Moisture Carryover
Vogtle 1	May-87	W									O				
Vogtle 2	May-89	W									O				
Waterford 3	Sep-85	C									O				
Watts Bar 1		W													
Watts Bar 2		W													
Wolf Creek	Sep-85	W									O				
Wolsung 1	Apr-83	AECL													
Yankee Rowe	Jul-61	W	O					O							
Younggwang 1	Aug-86	W									O				
Younggwang 2	Jun-87	W									O				
Zion 1	Jan-73	W	O				O	O	O		O				
Zion 2	Sep-74	W	O				O	O	O		O				

TABLE 5-2
UNITS REPORTING STEAM GENERATOR PROBLEMS

DATE	3/77	8/82	12/93
NO. UNITS:	52	99	235
REPORTED PROBLEMS:			
Denting			
-Tube Support Corrosion	15	30	36
-Tube Sheet Corrosion	6	12	50
Tubing Corrosion			
-Wastage	19	28	39
-Pitting	0	3	16
-ID Cracking	1	22	102
-OD SCC/IGA	6	22	85
Mechanical Damage			
-Fretting	9	15	128
-Fatigue Cracking	3	4	15
-Impingement	0	2	10
No Problems	26	32	48
No problems after 5 years ops (no. of units / no. > 5 yrs. ops) .	1/14	4/57	20/205

Units reporting no problems after five years of operation

3/77	8/82	12/9 3	
Trino	Kewaunee	Bruce-B 5	Obrigheim (Rpl)
	Mihama 3	Brokdorf	Philippsburg 2
	Neckarwestheim	Chinon B 3	Pickering-A 3
	Davis Besse	Cruas 3	Pickering-A 4
		Cruas 4	Pickering-B 7
		Genkai 2	Pickering-B 8
		Grafenrheinfeld	Robinson 2 (Rpl)
		Isar 2	Trillo 1
		Lovilsa 1	Uljin 1
		Lovilsa 2	Wolsing 1

Table 5-3
Status of U.S. Steam Generators (Dec. 1993)

	COMM. OPS.	NO. OF LOOPS	SG MODEL	NO. OF TUBES PER S.G.	TUBE MATERIAL	NO. OF TUBES PLUGGED	NO. OF SLEEVES
BABCOCK & WILCOX							
Arkansas Nuclear One 1	Dec-74	2	OTSG	15531	Inc-600S	676	978
Crystal River 3	Mar-77	2	OTSG	15531	Inc-600S	162	0
Davis Besse	Jul-78	2	OTSG	15547	Inc-600S	438	212
Oconee 1	Jul-73	2	OTSG	15531	Inc-600S	1266	475
Oconee 2	Sep-74	2	OTSG	15531	Inc-600S	318	228
Oconee 3	Dec-74	2	OTSG	15531	Inc-600S	622	247
Rancho Seco (Retired)	Apr-75	2	OTSG	15547	Inc-600TT	221	508
Three Mile Island 1	Sep-74	2	OTSG	15531	Inc-600S	1641	502
COMBUSTION ENG.							
Arkansas Nuclear One 2	Mar-80	2	2815	8411	Inc-600MA	417	444
Calvert Cliffs 1	May-75	2	67	8519	Inc-600MA	195	0
Calvert Cliffs 2	Apr-77	2	67	8519	Inc-600MA	133	0
Fort Calhoun	Sep-73	2	N/A	5005	Inc-600MA	110	0
Maine Yankee	Dec-72	3	67	5703	Inc-600MA	264	0
Millstone 2 (Repl.)	Dec-75	2	BWC	8523	Inc-690TT	0	0
Palisades (Repl.)	Dec-71	2	N/A	8219	Inc-600MA	618	0
Palo Verde 1	Jan-86	2	80	11012	Inc-600MA	323	0
Palo Verde 2	Sep-86	2	80	11012	Inc-600MA	558	0
Palo Verde 3	Jan-88	2	80	11012	Inc-600MA	235	0
San Onofre 2	Aug-83	2	3410	9350	Inc-600MA	646	0
San Onofre 3	Apr-84	2	3410	9350	Inc-600MA	614	0

Table 5-3
Status of U.S. Steam Generators (cont.)

	COMM. OPS.	NO. OF LOOPS	SG MODEL	NO. TUBES PER S.G.	TUBE MATERIAL	NO. OF TUBES PLUGGED	NO. OF SLEEVES
COMBUSTION ENG.							
St. Lucie 1	Dec-76	2	67	8519	Inc-600MA	1818	0
St. Lucie 2	Aug-83	2	3410	8411	Inc-600MA	467	0
Waterford 3	Sep-85	2	3410	9350	Inc-600MA	518	0
WESTINGHOUSE							
Beaver Valley 1	Oct-76	3	51	3388	Inc-600MA	1620	0
Beaver Valley 2	Nov-87	3	51M	3376	Inc-600MA	121	0
Braidwood 1	Jul-88	4	D4	4578	Inc-600MA	333	0
Braidwood 2	Oct-88	4	D5	4530	Inc-600TT	29	0
Byron 1	Sep-85	4	D4	4578	Inc-600MA	847	0
Byron 2	Aug-87	4	D5	4530	Inc-600TT	104	0
Callaway	Dec-84	4	F	5626	Inc-600MA	141	0
Catawba 1	Jun-85	4	D3	4674	Inc-600MA	1480	183
Catawba 2	Aug-86	4	D5	4530	Inc-600TT	135	0
Comanche Peak 1	Aug-90	4	D4	4578	Inc-600MA	31	0
Comanche Peak 2	Aug-93	4	D5	4570	Inc-600TT	20	0
Connecticut Yankee	Jan-68	4	27	3794	Inc-600MA	1228	0
Cook 1	Aug-75	4	51	3388	Inc-600MA	952	1840
Cook 2 (Repl.)	Jul-78	4	54F	3592	Inc-690TT	0	0
Diablo Canyon 1	May-85	4	51	3388	Inc-600MA	43	0
Diablo Canyon 2	Mar-86	4	51	3388	Inc-600MA	76	0
Farley 1	Dec-77	3	51	3388	Inc-600MA	358	136

Table 5-3
Status of U.S. Steam Generators (cont.)

	COMM. OPS.	NO. OF LOOPS	SG MODEL	NO. OF TUBES PER S.G.	TUBE MATERIAL	NO. OF TUBES PLUGGED	NO. OF SLEEVES
WESTINGHOUSE							
Farley 2	Jul-81	3	51	3388	Inc-600MA	710	275
Ginna	Jul-70	2	44	3260	Inc-600MA	483	1953
Indian Point 2	Aug-74	4	44	3262	Inc-600MA	1131	0
Indian Point 3 (Repl.)	Aug-76	4	44F	3214	Inc-690TT	0	0
Kewaunee	Jun-74	2	51	3388	Inc-600MA	517	4274
McGuire 1	Dec-81	4	D2	4674	Inc-600MA	1819	841
McGuire 2	Mar-84	4	D3	4674	Inc-600MA	1387	615
Millstone 3	Apr-86	4	F	5626	Inc-600TT	28	0
North Anna 1 (Repl.)	Jun-78	3	54F	3592	Inc-600TT	0	0
North Anna 2	Dec-80	3	51	3388	Inc-600MA	1332	0
Point Beach 1 (Repl.)	Dec-70	2	44F	3214	Inc-600TT	5	0
Point Beach 2	Oct-72	2	44	3260	Inc-600MA	622	3895
Prairie Island 1	Dec-73	2	51	3388	Inc-600MA	193	319
Prairie Island 2	Dec-74	2	51	3388	Inc-600MA	249	0
Robinson 2 (Repl.)	Mar-71	3	44F	3214	Inc-600TT	5	0
Salem 1	Ju[illegible]	4	51	3388	Inc-600MA	508	0
Salem 2	Jul-81	4	51	3388	Inc-600MA	478	0
San Onofre 1 (Retired)	Jan-68	3	27	3794	Inc-600MA	1456	6929
Seabrook	Jul-90	4	F	5626	Inc-600TT	24	0
Sequoyah 1	Jul-81	4	51	3388	Inc-600MA	181	0
Sequoyah 2	Jun-82	4	51	3388	Inc-600MA	434	0

Table 5-3
Status of U.S. Steam Generators (cont.)

	COMM. OPS.	NO. OF LOOPS	SG MODEL	NO. OF TUBES PER S.G.	TUBE MATERIAL	NO. OF TUBES PLUGGED	NO. OF SLEEVES
WESTINGHOUSE							
Shearon Harris	May-87	3	D4	4578	Inc-600MA	35	0
South Texas 1	Aug-88	4	E	4850	Inc-600MA	66	0
South Texas 2	Jun-89	4	E	4850	Inc-600MA	18	0
Summer	Jan-84	3	D3	4674	Inc-600MA	2221	735
Surry 1 (Repl.)	Dec-72	3	51F	3342	Inc-600TT	14	0
Surry 2 (Repl.)	May-73	3	51F	3342	Inc-600TT	5	0
Trojan (Retired)	May-76	4	51	3388	Inc-600MA	2444	1063
Turkey Point 3 (Repl.)	Dec-72	3	44F	3214	Inc-600TT	62	0
Turkey Point 4 (Repl.)	Sep-73	3	44F	3214	Inc-600TT	33	0
Vogtle 1	May-87	4	F	5626	Inc-600TT	15	0
Vogtle 2	May-89	4	F	5626	Inc-600TT	15	0
Wolf Creek	Sep-85	4	F	5626	Inc-600TT	44	0
Yankee Rowe (Retired)	Jul-61	4	13	1620	304 SS	334	0
Zion 1	Dec-73	4	51	3388	Inc-600MA	948	806
Zion 2	Sep-74	4	51	3388	Inc-600MA	525	252

6

TUBE FRETTING AND WEAR

The Steam Generator Strategic Management Project has also been studying steam generator vibration induced tube wear. This wear is caused by relative movement between the tube and support structure and is enhanced by clearances provided for ease of manufacturing. Depending on the tube dynamics, tube leaks due to fretting and wear can be produced within a relatively short period of time. Fifty-four percent of the nuclear units covered in this survey report some type of fretting and wear problem. In 1993, 516 steam generator tubes were plugged due to fretting and wear.

In order to better understand the magnitude and severity of this problem, additional information on the number of indications, general location and wear rate (mils/year) was requested from TAG members. Table 6-1 summarizes the information received. As expected, the majority of fretting and wear indications reported are in the preheater areas and at the AVB intersections. The reported wear rates ranged from .3 to 3.4 mils per year with a maximum wear rate reported by the Japanese of 12.1 mils per year. It is realized that Table 6-1 represents only a limited amount of industry data and it is hoped that additional information on the number of indications and wear rates can be obtained and reported in future publications.

Table 6-1
Tube Fretting and Wear

PLANT	GENERAL AREA	NO. OF INDICATIONS	NO. OF TUBES PLUGGED	WEAR RATE (mils/year)
Almaraz 1	Preheater (<1992)	180	25	0.6
	Preheater (1992)	228	16	1.1
	Preheater (1993)	244	11	0.6
	AVB (<1992)	278	12	1.5
	AVB (1992)	378	0	1.1
	AVB (1993)	371	6	0.6
Almaraz 2	Preheater (<1992)	139	17	1.3
	Preheater (1992)	144	24	1.7
	AVB (<1992)	192	4	1.6
	AVB (1992)	205	2	0.5
ANO-2	Batwing	332	60	-
ASCO 1	Preheater (<1992)	79	4	2.8
	Preheater (1992)	105	6	2.2
	Preheater (1993)	105	10	2.6
	AVB (<1992)	221	13	2
	AVB (1992)	254	5	1.3
	AVB (1993)	249	12	2.2
ASCO 2	AVB (<1992)	52	2	-
	AVB (1992)	67	0	0.6
	AVB (1993)	93	3	1.3
Beaver Valley 1	AVB	10	10	-
	Cold Leg	88	0	<3.0
Beaver Valley 2	AVB	13	0	-
Connecticut Yankee	AVB	184	16	0.6
Diablo Canyon 1	AVB	54	0	-
Diablo Canyon 2	AVB	28	0	-
Jose Cabrera	AVB (<1992)	135	19	0.3
	AVB (1992)	147	2	0.5
Millstone 3	AVB	61	10	-

Table 6-1
Tube Fretting and Wear (cont.)

PLANT	GENERAL AREA	NO. OF INDICATIONS	NO. OF TUBES PLUGGED	WEAR RATE (mils/year)
Palo Verde 1	Eggcrate	127	0	-
	Batwing	121	8	-
	Verticle Strap	98	6	-
Palo Verde 2	Eggcrate	862	35	-
	Batwing	723	13	-
	Verticle Strap	578	10	-
Palo Verde 3	Eggcrate	165	6	-
	Batwing	211	8	-
	Verticle Strap	82	5	-
St. Lucie 2	Diagonal & Vertical Straps	478	353	-
Sequoyah 1	AVB	44	3	3.1
Sequoyah 2	AVB	125	14	2.8
Turkey Point 3	AVB	95	10	<2.0
Turkey Point 4	AVB	2	0	<2.0
Vandellos 2	AVB (<1992)	733	172	2.5
	AVB (1992)	1529	30	3.4
	AVB (1993)*	1548	0	0

* AVB's replaced in 1992

7

STEAM GENERATOR TUBE SLEEVING

Steam generator tube sleeving has been used as an effective alternative to plugging. Sleeving consists of installing a smaller diameter tube (sleeve) into a damaged tube. The sleeve ends are expanded and sealed to provide both a seal and redundant load carrying path. Although sleeving is generally more expensive than plugging, it has the advantage of leaving the tube in service and providing additional tube strength. Most sleeves to date have been installed in the tubesheet region. A few sleeves have been installed at other locations in the steam generator and have been used to improve structural support and provide vibration damping. Table 7-1 is a listing of the number of tubes sleeved at each plant. As of December 31, 1993, over 55,000 tubes have been sleeved. Table 7-2 (2) gives additional information on sleeving times and radiation exposure for selected sleeving campaigns. As more automated techniques have been developed, the installation time and exposure per sleeve have been dramatically reduced. Sleeving will play an important role in maintaining steam generator tube integrity. A number of utilities are using sleeving as a preventative measure to reduce the number of forced outages caused by steam generator tube leaks. Nickel plating has been developed as an alternative to sleeving for some damage mechanisms. Table 7-3 is a summary of three major nickel plating campaigns.

Table 7-1
Sleeving Experience

PLANT	YEAR	TUBES SLEEVED	REPORTED CAUSE
ALMARAZ 1	89	3	SCC(ID)
	90	100	SCC(ID)
ANO 1	84	10	SCC/IGA (OD)
	86	40	SCC/IGA (OD)
	88	174	SCC/IGA (OD)
	90	106	SCC/IGA (OD)
	92	572	SCC/IGA (OD)
	93	76	SCC/IGA (OD)
ANO 2	92	444	SCC/IGA (OD)
ASCO 1	91	115	SCC/IGA (OD)
	93	87	SCC/IGA (OD)
BEZNAU 1 (Org)	81	3	SCC/IGA (OD)
	82	24	SCC/IGA (OD)
	83	37	SCC/IGA (OD)
	84	35	SCC/IGA (OD)
	85	79	SCC/IGA (OD)
	86	174	SCC/IGA (OD)
	87	80	SCC/IGA (OD)
	88	53	SCC/IGA (OD)
	89	12	SCC/IGA (OD)
	90	24	SCC/IGA (OD)
	91	10	SCC/IGA (OD)
	92	11	SCC/IGA (OD)
BEZNAU 2	83	17	SCC/IGA (OD)
	84	17	SCC/IGA (OD)
	85	39	SCC/IGA (OD)
	86	86	SCC/IGA (OD)
	87	42	SCC/IGA (OD)
	88	13	SCC/IGA (OD)
	89	14	SCC/IGA (OD)
	90	20	SCC/IGA (OD)
	91	15	SCC/IGA (OD)
	92	13	SCC/IGA (OD)
	93	39	SCC/IGA (OD)

Table 7-1
Sleeving Experience (cont)

PLANT	YEAR	TUBES SLEEVED	REPORTED CAUSE
BUGEY 5 (Org)	89	76	SCC(ID)
CATAWBA	91	75	SCC(ID), SCC/IGA (OD)
	92	108	SCC(ID), SCC/IGA (OD)
DAVIS BESSE	93	212	PREVENTIVE
D.C. COOK 1	92	1840	SCC/IGA (OD)
DOEL 2	82-83	187	SCC(ID)
	85	10	SCC(ID)
	86	81	SCC(ID)
DOEL 3	88	55	SCC(ID)
DOEL 4	93	1736	SCC (OD)
FARLEY 1	92	136	SCC(ID), SCC(OD-TSP)
FARLEY 2	92	29	SCC(ID), SCC (OD-TSP)
	93	246	SCC(ID), SCC (OD-TSP)
FESSENHEIM 1	84	10	SCC(ID)
GENKAI 1	85	147	SCC/IGA (OD)
	86	342	SCC/IGA (OD)
	87	384	SCC/IGA (OD)
	89	870	SCC/IGA (OD)
	90	805	SCC/IGA (OD)
	91	447	SCC/IGA (OD)
	93	169	SCC/IGA (OD)

Table 7-1
Sleeving Experience (cont)

PLANT	YEAR	TUBES SLEEVED	REPORTED CAUSE
GINNA	80	5	SCC/IGA (OD)
	81	16	SCC/IGA (OD)
	83	77	SCC/IGA (OD)
	84	8	SCC/IGA (OD)
	85	69	SCC/IGA (OD)
	86	39	SCC/IGA (OD)
	87	101	SCC/IGA (OD)
	89	502	SCC/IGA (OD)
	90	241	SCC/IGA (OD)
	91	207	SCC/IGA (OD)
	92	425	SCC/IGA (OD)
	93	266	SCC/IGA (OD)
IKATA 1	84	14	SCC(ID)
INDIAN POINT 3	82	2971	PITTING
(ORG)	85	635	PITTING
KEWAUNEE	88	1940	SCC/IGA (OD)
	89	1698	SCC/IGA (OD)
	91	690	SCC/IGA (OD)
	92	16	SCC/IGA (OD)
KORI 1	88	558	PITTING
	89	178	PITTING
	90	415	PITTING/SCC (ID)
	92	330	PITTING/SCC (ID)
	93	97	PITTING/SCC (ID)
MC GUIRE 1	90	397	SCC(ID)
	91	444	SCC(ID)
MC GUIRE 2	90	478	SCC(ID)
	92	137	SCC(ID)
MIHAMA 2	82	3	SCC(OD)
	83	14	SCC(OD)
	84	25	SCC(OD)

Table 7-1
Sleeving Experience (cont)

PLANT	YEAR	TUBES SLEEVED	REPORTED CAUSE
MILLSTONE 2 (ORG)	83	2022	PITTING
	85	2917	PITTING, WASTAGE
	86	225	PITTING, WASTAGE
OCONEE 1	78	6	FATIGUE
	87	469	FATIGUE
OCONEE 2	89	228	FATIGUE
OCONEE 3	88	247	FATIGUE
OHI 1	84	81	SCC(ID)
	85	443	SCC(ID)
	86	650	SCC(ID), SCC/IGA (OD)
	87	743	SCC(ID), SCC/IGA (OD)
	88	162	SCC(ID), SCC/IGA (OD)
	89	1122	SCC(ID), SCC/IGA (OD)
	90	863	SCC(ID), SCC/IGA (OD)
	91	877	SCC(ID), SCC/IGA (OD)
	93	570	SCC(ID), SCC/IGA (OD)
OHI 2	84	8	SCC(ID)
PALISADES (ORG)	76	14	WASTAGE
	78	23	WASTAGE
POINT BEACH 1 (ORG)	81	13	SCC/IGA (OD)

Table 7-1
Sleeving Experience (cont)

PLANT	YEAR	TUBES SLEEVED	REPORTED CAUSE
POINT BEACH 2	83	3001	SCC/IGA, WASTAGE
	87	87	SCC/IGA, WASTAGE
	88	509	SCC/IGA, WASTAGE
	89	298	SCC/IGA, WASTAGE
PRAIRIE ISLD 1	87	26	SCC/IGA (OD)
	88	73	SCC/IGA (OD)
	90	62	SCC/IGA (OD)
	92	158	SCC/IGA (OD)
RANCHO SECO	86	508	FATIGUE
RINGHALS 2 (ORG)	84	35	SCC/IGA (OD)
	85	50	SCC/IGA (OD)
	86	596	SCC/IGA (OD)
	87	554	SCC/IGA (OD)
RINGHALS 3	91	68	SCC/IGA (OD)
SAN ONOFRE 1	81	6929	WASTAGE, SCC/IGA
SUMMER	90	125	SCC(ID)
	91	610	SCC(ID)
TAKAHAMA 1	80	2	SCC(OD)
	81	4	SCC(OD)
	82	32	SCC(ID), SCC(OD)
	84	59	SCC(OD)
	88	6	SCC/IGA

Table 7-1
Sleeving Experience (cont)

PLANT	YEAR	TUBES SLEEVED	REPORTED CAUSE
TAKAHAMA 2	84	231	SCC/IGA (OD)
	86	330	SCC/IGA (OD)
	87	466	SCC/IGA (OD)
	88	1007	SCC/IGA (OD)
	90	1139	SCC/IGA (OD)
	91	675	SCC/IGA (OD)
	92	644	SCC/IGA (OD)
TMI 1	91	250	FATIGUE
	93	252	FATIGUE
TRICASTIN 2	85	14	SCC/IGA (OD)
TROJAN	90	2	SCC/IGA(TSP)
	91	1061	SCC/IGA(TSP)
ZION 1	86	128	SCC/IGA (OD)
	88	47	SCC/IGA (OD)
	89	445	SCC/IGA (OD)
	92	125	SCC/IGA (OD)
	93	61	SCC(ID), SCC/IGA (OD)
ZION 2	90	82	SCC/IGA (OD)
	92	170	SCC/IGA (OD)

Table 7-2
Major Sleeving Operations

	San Onofre 1	Point Beach 2	Indian Point 3	Doel 2	Doel 3	Doel 4
Sleeving Dates	9/80 - 6/81	4/83 - 6/83	10/82 - 1/83	9/82 - 9/83	1988	1993
Number of Sleeves Installed	6929	3001	2971	187	55	1736
Damage Type	IGA	IGA	Pitting	IGSCC	PWSCC	IGSCC
Location	Top of TS	TS Crevice	Sludge Pile	TS Roll Trans	Top of TS	Top of TS
Sleeving Contractor	W	W	W	B&W	W	W
Sleeve Length (in)	27-30-36	36	36-40-44	1.5	36	31-36
Sleeve Base Material	Alloy 600-TT	Alloy 600-TT	Alloy 600-TT	Alloy 600-TT	Alloy 600-TT	Alloy 690
OD Clad Materail	None	None	None	None	None	Nono
Expansion Material	Hydraulic	Hydraulic	Hydraulic	Explosive	Laser	Hydraulic/Mech
Total Installation Time (weeks)	30	10	14	-	-	4
Installation per Sleeve (hrs)	0.94	0.53	0.74	-	-	2.6
Exposure Total (man-rem)	3496	660	860	[illegible]	-	34.5
Exposure per Sleeve	0.5	0.22	0.29	-	-	0.02

Table 7-2
Major Sleeving Operations (cont.)

	R.E. Ginna			Palisades		Ringhals 2		Ringhals 3
Sleeving Dates	11/80	5/81	5/83	3/76	3/78	5/84	5/84	6/91
Number of Sleeves Installed	5	16	77	14	23	18	17	68
Damage Type		IGA/IGSCC			Wastage	IAG/IGSCC	IAG/IGSCC	PWSCC/ODSCC
Location		Tubesheet Crevice			TSP Intersections	TS Crevice	TS Crevice	TS/RTZ
Sleeving Contractor		B&W and RGE			CE	CE	W	CE
Sleeve Length (in)		20-36			12 (nominal)	30	30	TSP/TS
Sleeve Base Material		Alloy 600-TT			Alloy 600	Alloy 600-TT	Alloy 600-TT	690TT
OD Clad Material		Nickel			None	None	None	-
Expansion Material		Hydraulic Explosive			Hydraulic	Elastomeric	Hydraulic	Weld
Total Installation Time (weeks)	-	-	-	8	-	-	-	-
Installation per Sleeve (hrs)	8	2	0.33	-	-	-	3.5	.9 - 1.5
Exposure Total (man-rem)	-	-	-	15	-	4	3.4	3.4
Exposure per Sleeve		Ave. 0.4 - 0.5		-	-	0.22	0.17	0.13

Table 7-2
Major Sleeving Operations (cont.)

	Point Beach 1	Millstone 2	Kewaunee			
Sleeving Dates	8/81	7/83 - 9/83	3188	3189	3191	3192
Number of Sleeves Installed	13	2022	1940	1698	690	16
Damage Type	IGA	Pitting	IGA/IGSCC	IGA/IGSCC	IGA/IGSCC	IGA/IGSCC
Location	TS Crevice	Sludge Pile	TS Crevice	TS Crevice	TS Crevice	TS Crevice
Sleeving Contractor	W	W	W	W	W	ABB/CE
Sleeve Length (in)	36	40	30-36	30-36	27-30-36	27
Sleeve Base Material	Alloy 600-TT	Alloy 690	Alloy 600-TT	Alloy 600-TT	Alloy 600-TT	Alloy 690-TT
OD Clad Materail	None	Alloy 625	None	None	None	None
Expansion Material	Hydraulic	Hydraulic	HEJ	HEJ	HEJ	Welded
Total Installation Time (weeks)	2	8	2.4	2.2	-	-
Installation per Sleeve (hrs)	-	0.6	0.21	0.21	-	-
Exposure Total (man-rem)	-	385	66.8	41.2	-	-
Exposure per Sleeve	-	0.19	0.034	0.024	-	-

Table 7-3
Major Nickel Plating Operations

	Doel 2	Tihange 2	Tihange 2
Sleeving Dates	1990	1992	1993
Number of Plated Tubes	345	602	554
Damage Type	Top of TS	Top of TS	Top of TS
Plating Contractor	Framatome	Framatome	Framatome
Plating Length (in)	4	4	4
Plating Method	Electrochemical	Electrochemical	Electrochemical
Total Installation Time (weeks)	3	3	3
Installation per Plated Tube (hrs)	1.5	2	2
Exposure Total (man-rem)	11	25.6	22.1
Exposure per Sleeve (man-rem)	0.03	0.04	0.04

8

STEAM GENERATOR CHEMICAL CLEANING

One of the primary causes of steam generator degradation is the accumulation and buildup of corrosion products transported to the steam generators. Aggressive impurities from sources such as condenser cooling water leakage concentrate in these deposits and corrosively attack the steam generator tubes and support structures. One method of removing accumulated corrosion products and aggressive chemical species from steam generators is by chemical cleaning. As of December 1993, forty-five steam generator cleanings have been performed (3). All nine cleanings done in the United States and Canada have used the Electric Power Research Institute Steam Generator Owners Group (EPRI SGOG) process or a modification of this process. Additionally, the EPRI SGOG solvents were applied in Korea and Belgium for a total of eleven applications. Electricite de France (EdF) developed a process for the French utility community and has performed four cleaning applications to date. Siemens Kraftwerk Union (KWU) developed its own methodology and as of December 31, 1993, has applied this process thirty times. Those applications made for iron oxide dissolution prior to 1991 used a different chelating agent than later KWU applications.

Each process, EPRI SGOG, EdF and KWU, was tested by its respective application vendor and qualified for use with particular attention to site specific requirements. Tables 8-1 and 8-2 list each cleaning performed and the amount of corrosion products removed.

Most of the cleanings to date have been considered a success by the utility performing the cleaning. The chemical cleanings have been especially effective at removing deposits from steam generator tubes and in cleaning tube support plate broached holes. Several of the most quantifiable successes include cleaning of four once-through-steam-generator (OTSG) units in order to return to full power operation, cleaning of the broached holes at Bruce 4 to correct water level oscillation problems, and cleaning two Paks units in Hungary to recover heat transfer capability. The cleaning of packed tube support plate crevices and hard tubesheet sludge piles has been only partially successful. Tubesheet cleaning can be improved by an effective water lancing program before and after the cleaning. Vendors are continuing to look at ways to improve crevice cleaning. Steam generators cleaned before large accumulations occur will have a minimum of corrosion during the cleaning and the greatest chance of removing the deposits. Utilities can expect the best overall results if they choose to clean the steam generators when inspections first reveal an impending problem.

Table 8-1
EPRI SGOG Chemical Cleanings (December 1993)

UNIT	YEAR	VENDOR	APPLICATION	PROCESS	TOTAL REMOVED Pounds	Kg
Millstone 2	1985	PNS/CE	Tubesheet	Mod. SGOG Fe+Cu	567	258
Maine Yankee	1987	PNS/CE	Tubesheet	Mod. SGOG Fe+Cu	2381	1082
Oconee 1	1987	DP/B&W	Partial Height	Mod. SGOG Fe	6648	3022
Oconee 2	1988	DP/B&W	Partial Height	Mod. SGOG Fe	8909	4050
Arkansas 1	1990	PNS/CE	Part. Height-9th TSP	Mod. SGOG Fe+Cu	10040	4564
KORI 1	1990	PNS/ABBR/CE	Tubesheet	Mod. SGOG Fe+Cu	876	398
Three Mile Is. 1	1991	B&W	Part. Height-9th TSP	Mod. SGOG Fe	6540	2973
Pickering 5	1992	B&W	Full Height	Mod. SGOG Fe+Cu	9134	4152
DOEL 4	1992	PNS/ABBR/CE	Full Height	Mod. SGOG Crevice Fe	6574	2988
Bruce 4	1993	PNS/BWNT	Full Height	Mod. SGOG Fe+Cu	13759	6254
Pickering 6	1993	BWNT	Full Height	Mod. SGOG Fe+Cu	7539	3427

Vendors

PNS:	Pacific Nuclear Services now Vectra
CE:	Combustion Enginering
DP:	Duke Power
B&W:	Babcock&Wilcox now B&W Nuclear Technologies
ABBR:	Asea Brown Boveri Reaktor

Process

Crev.	Crevice Step

Table 8-2
KWU and EDF Chemical Cleanings (December 1993)

UNIT	YEAR	VENDOR	APPLICATION	PROCESS	TOTAL REMOVED Pounds	Kg
Biblis B	1985	KWU	Full Height	KWU Cu	1.3	0.6
Neckarwestheim	1985	KWU	Full Height	KWU Cu	6.2	2.8
Stade	1985	KWU	Full Height	KWU Cu	24.2	11
Stade	1986	KWU	Full Height	KWU Cu	67.3	30.6
Neckarwestheim	1986	KWU	Full Height	KWU Fe(NTA)	920	418
Almaraz 1	1986	KWU	Full Height	KWU Fe(NTA)+Cu	7456	3389
Grafenrheinfeld	1987	KWU	Full Height	KWU Cu	1.5	0.7
Stade	1987	KWU	Full Height	KWU Fe(NTA)	3586	1630
Almaraz 2	1987	KWU	Full Height	KWU Fe(NTA)+Cu	6682	3037
ASCO 2	1987	KWU	Full Height	KWU Cu	2048	931
ASCO 1	1987	KWU	Full Height	KWU Cu	3419	1554
Tihange 1	1988/89	EdF	Full Height	EdF Fe+Cu	9910	4505
Almaraz 1	1988	KWU	Full Height	KWU Cu	215	98
ASCO 1	1988	KWU	Full Height	KWU Cu	856	389
Ringhals 3	1988	KWU	Tubesheet	KWU Fe(NTA)	2495	1134
Almaraz 2	1988	KWU	Full Height	KWU Fe(NTA)+Cu	5028	2285
Almaraz 1	1988	KWU	Various Heights	KWU Fe(NTA)	4437	2017
Ringhals 4	1988	KWU	Tubesheet	KWU Fe(NTA)	2102	955
ASCO 2	1989	KWU	Full Height	KWU Cu	695	316
Tihange 2	1989	KWU	Full Height	KWU Fe(NTA)+Cu	4079	1854
Almaraz 1	1989	KWU	Full Height	KWU Fe(NTA)+Cu	4263	1938
ASCO 1	1989	KWU	Full Height	KWU Cu	636	289
Ringhals 3	1989	KWU	Full Height	KWU Fe(NTA)	5315	2416
Ringhals 4	1989	KWU	Full Height	KWU Fe(NTA)	5861	2664
Nogent 1	1989	EdF	Full Height	EdF Fe+Cu	14136	6425
Almaraz 2	1989	KWU	Full Height	KWU Fe(NTA)+Cu	4165	1893
Mihama 1	1990	KWU/MHI	Tubesheet	KWU Fe(NTA)+Cu	962	437
Almaraz 1	1990	KWU	Full Height	KWU Fe(NTA)+Cu	5486	2494
Ohi1	1990	KWU/MHI	Part. Height-1st TSP	KWU Fe(NTA)+Cu	1643	747
Saint Alban 2	1990	EdF	Partial Height	EdF Fe+Cu	2618	1190
Paks 1	1991	KWU	Full Bundle (Horiz.)	KWU Fe(EDTA)	19186	8721
Paks 2	1992	KWU	Full Bundle (Horiz.)	KWU Fe(EDTA)	10572	4805
Fessenheim 2	1992	EdF	Full Height	EdF Fe+Cu	21670	9850
DOEL 4	1993	KWU	Full Height	KWU Fe(EDTA)+Cu+Pb	542	246

Vendors

KWU: Kraftwerk Union
EdF Electricite de France
MHI: Mitsubishi Heavy Industry

9

STEAM GENERATOR REPLACEMENT

Steam generators were replaced at North Anna 1, Doel 3, Bugey 5, Beznau 1, and Mihama 2 during 1993 (Table 9-1). This level of activity is likely to remain high during the next several years. To date eight United States, one German, one French, one Swedish, one Belgian, one Swiss, and one Japanese utility have replaced a total of 50 steam generators at 18 nuclear units. Several techniques have been utilized to replace steam generators. These techniques include the pipe cut and channel head cut methods. In the pipe cut method, the steam generators are removed from the reactor coolant system by cutting the hot and cold leg primary piping adjacent to the primary channel head of the steam generator. Replacement steam generators or replacement portions are installed by reconnection to the primary piping to complete the repair operation. In initial replacements the upper steam dome was cut from the lower portion of the steam generator and refurbished inside the containment building. Where sufficient containment hatch size was available, the entire steam generator assemblies were removed and replaced.

In the channel cut technique the steam generator is separated by cutting the channel head just below the tubesheet. This leaves the lower primary piping in place and simplifies the fit up operation. The upper portion of the steam generator can be replaced in its entirety or the upper steam dome can be cut and refurbished in the containment building. Operation before steam generator replacement has ranged from 7 to 24 years. However, effective full years of operation (EFPY) has ranged from 3.6 to 19.5 EFPY. The steam generators replaced in 1993 had an average of 12.1 EFPY. This average was greater than the effective full power operation of any of the previous replacements. The impact to a utility of having to replace steam generators is still substantial. Table 9-1 shows that replacement durations have ranged from 70 days up to 260 days. Total doses received by personnel performing the changeout have ranged from 110 to 2141 man rems. Replacement costs have ranged from 37 to 190 million dollars excluding replacement power costs. An encouraging trend is that the costs for replacement have appeared to level off while both the replacement duration and man rem exposure have been decreasing. The replacements during 1993 required on the average only 25% of the time and 8% of the exposure as the first replacement at Surry 2.

Replacement steam generators have been ordered for at least 28 plants. Table 9-2 shows the steam generator replacement orders that have been announced to date. These orders indicate that steam generator replacement activity will continue to remain high over the next several years.

Table 9-1
Replacement Steam Generators

UNIT	NO. SG.	REPL. METHOD	REPL. S.G.	TUBE MATERIAL	COMM. OPER.	COMP. DATE	OPER. (YEARS)	EFPY OPER.	REPL. DURATION (DAYS)	EXPOSURE (MAN-REM)	REPL. COSTS (1) (MILLIONS)
Surry 2	3	Pipe Cut (Lower Shell)	W	I-600TT	May-73	Sep-80	7	3.6	260	2141	$94
Surry 1	3	Pipe Cut (Lower Shell)	W	I-600TT	Dec-72	Jul-81	8	4.4	200	1759	$94
Turkey Point 3	3	Channel Head cut	W	I-600TT	Dec-72	Apr-82	10	5.2	217	2152	$90
Turkey Point 4	3	Channel Head Cut	W	I-600TT	Sep-73	May-83	9	5.9	150	1305	$90
Obrigheim	2	Pipe Cut (Entire SG)	KWU	I-800	Mar-69	Sep-83	14	11.2	72 (2)	690	$37 (3)
Point Beach 1	2	Pipe cut	W	I-600TT	Dec-70	Mar-84	13	9.2	118 (2)	575	$47 (3)
H B Robinson	3	Channel Head cut	W	I-600TT	Mar-71	Oct-84	13	8.5	130	1207	$85
D C Cook 2	4	Pipe Cut	W	I-690TT	Jun-78	Mar-89	11	6.6	175	561	$112
Indian Pt. 3	4	Pipe Cut (Entire SG)	W	I-690TT	Aug-76	Jun-89	13	6.4	140	541	$120
Ringhals 2	3	Pipe Cut (Entire SG)	KWU	I-690TT	May-76	Aug-89	14	8.1	72 (2)	290	$130

Table 9-1
Replacement Steam Generators (cont.)

UNIT	NO. SG.	REPL. METHOD	REPL. S.G.	TUBE MATERIAL	COMM. OPER.	COMP. DATE	OPER. (YEARS)	EFPY OPER.	REPL. DURATION (DAYS)	EXPOSURE (MAN-REM)	REPL. COSTS (1) (MILLIONS)
Dampierre 1	3	Pipe Cut (Entire SG)	FRA	I-690TT	Sep-80	Jun-90	10	6.7	70	220	$104
Palisades	2	Pipe Cut (Entire SG)	CE	I-600MA	Dec-71	Mar-91	19	8.3	121	487	$100
Millstone 2	2	Pipe Cut (Partial SG)	BWC	I-690TT	Dec-75	Jan-93	17	10.9	192	697	$190
Bugey 5	3	Pipe Cut (Entire SG)	Fra	I-600TT	Jan-80	Feb-94	13	9.8	75	150	$91
Doel 3	3	Pipe Cut (Entire SG)	S-F	I-800	Oct-82	Jun-93	11	10	44	196	$98
North Anna 1	3	Pipe Cut (Lower Shell)	W	I-690TT	Jun-78	Apr-93	15	9.6	96 (4)	240	$125
Beznau 1	2	Pipe Cut (Entire SG)	FRA	I-690TT	Dec-69	Apr-93	24	19.5	44 (2)	110	$50
Mihama 2	2	Pipe Cut (Entire SG)	MHI	I-690TT	Jul-72	Aug-94	18	11.5	–	–	–

(1) Excluding replacement power costs (2) Shutdown until start of hydro (3) Partial warranty provision
(4) Outage duration breaker to breaker; 51 days for steam generator work

Table 9-2
Planned Steam Generator Replacements (Orders Placed)

Plant	Number of Steam Generator Units	Net Capacity (MWe)	Replacement Supplier	Tube Material	Projected Year of Replacement
Takahama 2	3	780	MHI	I-690TT	1993/94
Gravelines 1	3	910	Fra	I-690TT	1994
Genkai 1	2	529	MHI	I-690TT	1994
Summer	3	895	W	I-690TT	1994
Ohi 1	4	1120	MHI	I-690TT	1994/95
Tihange 1	3	870	MHI	I-690TT	1995
Ringhals 3	3	915	S-F	I-690TT	1995
Dampierre 3	3	900	Fra	I-690TT	1995
St. Laurent B1	3 *	900	Fra	I-690TT	1995
Asco 1&2	6	887	S-F	I-800	1995/96
Mihama 1	2	320	W	I-690TT	1995/96
Takahama 1	3	780	MHI	I-690TT	1995/96
Doel 4	3	1010	S-F	I-690TT	1996
Mihama 3	3	780	MHI	I-690TT	1996
North Anna 2	3	887	W	I-690TT	1996
Ginna	2	470	BWC	I-690TT	1996
Almaraz 1&2	6	900	S-F	I-800	1996/97
Catawba 1	4	1129	BWC	I-690TT	1996/97
McGuire 1	4	1129	BWC	I-690TT	1996/97
McGuire 2	4	1129	BWC	I-690TT	1996/97
Point Beach 2	2	497	W	I-690TT	1996/97
Ohi 2	4	1120	MHI	I-690TT	1996/97
St. Lucie 1	2	839	BWC	I-690TT	1997
Zion 1	4	1040	BWC	I-690TT	1998
Farley 2	3	872	W	I-690TT	2005
Farley 1	3	873	W	I-690TT	After 2005

W=Westinghouse Fra=Framatome S-F=Siemens/Framatome
MHI=Mitsubishi Heavy Industries BWC=B&W Canada

* Either 1 or 3 generators to be replaced, depending upon 1994 inspection results

10

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1. O. S. Tatone and R. S. Pathania, *Steam Generator Tube Performance: Experience with Water-Cooled Nuclear Power Reactors During 1982*, Report AECL 8268, October 1984.

2. E. S. Hunt and J. A. Gorman, *Design Review Checklist: Steam Generator Sleeving*, EPRI Report NP-4296 LD, November 1985.

3. B. L. Dow Jr., *Utility Experiences with Steam Generator Chemical Cleaning*, EPRI Report TR-104555, October 1994.

APPENDIX A: HISTORICAL TUBE PLUGGING DATA

Appendix A Abbreviations

Abbreviation	Includes
Wastage	Wastage and thinning
Denting S P	Denting at support plate intersections
Denting T S	Denting at and above the tubesheet
Pitting	Pitting
OD S/IGA SP	Secondary side stress corrosion and/or intergranular attack (support plate)
OD S/IGA TS	Secondary side stress corrosion and/or intergranular attack (tubesheet)
ID SCC TS	Primary side stress corrosion cracking (tubesheet locations)
ID SCC UB	Primary side stress corrosion cracking (U-bend locations)
FRET (PREH)	Tube fretting and wear (preheater locations)
FRET (AVB)	Tube fretting and wear (AVB locations)
FRET (LP)	Tube fretting and wear caused by a loose part or foreign object
HC FATIGUE	High cycle fatigue
ERR/COR	Erosion and/or corrosion
OTHER	Unknown cause or a cause other than above
TOT PLUGGED	Total number of tubes plugged
TOT SLEEVED	Total number of tubes sleeved
T.L. OUTAGE	Number of forced outages caused by steam generator tube leaks

UTILITY : CSES

PLANT : ALMARAZ 1

PLUGGED : 1068

EFPY : 9.1

TOTAL TUBES : 14,022

TUBE MATERIAL : I-600 MA

SG MODEL : W-D3

H. L. TEMP (F) : 616

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP														371	47	2		18	48	486
OD S/IGA TS																			4	4
ID SCC TS											74	32		223	6	3		27	16	381
ID SCC UB																				0
FRET (PREH)							4	2		14						5		16	11	52
FRET (AVB)														3	3	6		15	6	33
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER						2					1			5	2	5		1	96	112
TOT PLUGGED	0	0	0	0	0	2	4	2	0	14	75	32	0	602	58	21	0	77	181	1068
TOT SLEEVED															3	100*			-101	2
T. L. OUTAGE														1						1

UTILITY CONTACT: Gustavo Bollini

PHONE NUMBER: 34-1-6516700

* Six sleeves plugged after installation

UTILITY : CSES

PLANT : ALMARAZ 2

PLUGGED : 779

EFPY : 8.8

TOTAL TUBES : 14,022

TUBE MATERIAL : I-600 MA

SG MODEL : W-D3

H. L. TEMP (F) : 616

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP													2	39	87		101	157		386
OD S/IGA TS																	21	12		33
ID SCC TS												10	22	27	46		131	66		302
ID SCC UB													1							1
FRET (PREH)															7		10	24		41
FRET (AVB)															2		2	2		6
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								5			1		2		2					10
TOT PLUGGED	0	0	0	0	0	0	0	5	0	0	1	10	27	66	144	0	265	261	0	779
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Gustavo Bollini

PHONE NUMBER: 34-1-6516700

UTILITY : FURNAS CENTRAIS

PLANT : ANGRA 1

PLUGGED : 467

EFPY : 2.5

TOTAL TUBES : 8,918

TUBE MATERIAL : I-600 MA

SG MODEL : W-D3

H. L. TEMP (F) : 620

C.L. TEMP (F) : 549

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING															20		7			27
OD S/IGA SP															2		364			366
OD S/IGA TS															8		15		17	40
ID SCC TS														6			14		3	23
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									4				7							11
TOT PLUGGED	0	0	0	0	0	0	0	0	4	0	0	0	7	6	30	0	400	0	20	467
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Werdine, Jr.

PHONE NUMBER: (0243) 42-3355

UTILITY : ENTERGY OPERATIONS, INC.

PLANT : ANO-1

PLUGGED : 676

EFPY : 11.6

TOTAL TUBES : 31062

TUBE MATERIAL : I-600

SG MODEL : OTSG

H. L. TEMP (F) : 602

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP						2		26	2	9				4						43
OD S/IGA TS				1		9		116	37	101						9		196	12	481
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE													1							1
ERR/CORR									1											1
OTHER									3	1		5		9				110	22	150
TOT PLUGGED	0	0	0	1	0	11	0	142	43	111	0	5	1	13	0	9	0	306	34	676
TOT SLEEVED										10		40		174		106		572	76	978
T. L. OUTAGE						2		1	1				1							5

UTILITY CONTACT: Randy Smith

PHONE NUMBER: (501) 858-4917

UTILITY : ENTERGY OPERATIONS, INC.

PLANT : ANO-2

PLUGGED : 417

EFPY : 10

TOTAL TUBES : 16,822

TUBE MATERIAL : I-600

SG MODEL : CE-2815

H. L. TEMP (F) : 600

C.L. TEMP (F) : 544

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	52	129		181
OD S/IGA TS																	5	76	50	131
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)														6			16	38		60
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER				44				1												45
TOT PLUGGED	0	0	0	44	0	0	0	1	0	0	0	0	0	6	0	0	73	243	50	417
TOT SLEEVED																		444		444
T. L. OUTAGE																		1		1

UTILITY CONTACT: Randy Smith

PHONE NUMBER: (501) 858-4917

UTILITY : ANA	TOTAL TUBES : 14,022
PLANT : ASCO 1	TUBE MATERIAL : I-600 MA
PLUGGED : 1473	SG MODEL : W-D3
EFPY : 7.8	H. L. TEMP (F) : 620
	C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP														14	132	385*	120**	334	81	1066
OD S/IGA TS																	1	3	14	18
ID SCC TS											6	15	21	28	15	231	1	2	5	324
ID SCC UB																				0
FRET (PREH)																1	3	6	10	20
FRET (AVB)																6	7	5	12	30
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									7		1	2				1	1	3		15
TOT PLUGGED	0	0	0	0	0	0	0	0	7	0	7	17	21	42	147	624	133	353	122	1473
TOT SLEEVED																	115	[4]	87/[3]	195#
T. L. OUTAGE																			1	1

UTILITY CONTACT: Gustavo Bollini

PHONE NUMBER: 34-1-6516700

* 20 tubes plugged for C. L. indications

** 30 tubes plugged for C. L. indications

\# 4 tubes sleeved in 1991 were plugged in 1992, 3 plugged in 1993

UTILITY : ANA		TOTAL TUBES	: 14,022
PLANT : ASCO 2		TUBE MATERIAL	: I-600 MA
PLUGGED : 873		SG MODEL	: W-D3
EFPY : 6.8		H. L. TEMP (F)	: 620
		C.L. TEMP (F)	: 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP														2	36	105	126**	97	413	779
OD S/IGA TS																	9	3	8	20
ID SCC TS														4		32	10	3	4	53
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	2		3	5
FRET (LP)																				0
HC FATIGUE															1 *					1
ERR/CORR																				0
OTHER								4						1		7			3	15
TOT PLUGGED	0	0	0	0	0	0	0	4	0	0	0	0	0	7	37	144	147	103	431	873
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Gustavo Bollini

PHONE NUMBER: 34-1-6516700

* Plugged after evaluation for tube vibration induced fatigue

** 3 tubes plugged for ODSCC in free span tube and 5 tubes plugged for C. L. indications

UTILITY : CNEA

PLANT : ATUCHA-1

PLUGGED : 104

EFPY : 11.7

TOTAL TUBES : 7,890

TUBE MATERIAL : I-800

SG MODEL : KWU

H. L. TEMP (F) : 582

C.L. TEMP (F) : 521

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE								1					2							3
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)									1			2	74					2	15	94
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER													* 7							0
TOT PLUGGED	0	0	0	0	0	0	0	1	1	0	0	2	83	0	0	0	0	2	15	104
TOT SLEEVED																				0
T. L. OUTAGE									1			2	2							5

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

* Plugged preventively

UTILITY	: DUQUESNE LIGHT CO.	TOTAL TUBES	: 10,164
PLANT	: BEAVER VALLEY 1	TUBE MATERIAL	: I-600 MA
PLUGGED	: 1620	SG MODEL	: W-51
EFPY	: 9.7	H. L. TEMP (F)	: 606
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE									2	15		27	15		11		18		25	113
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP													8		117		733		435	1293
OD S/IGA TS																			83	83
ID SCC TS																				0
ID SCC UB													42		8				23	73
FRET (PREH)																				0
FRET (AVB)										3		4			2		1		1	11
FRET (LP)								1	6				1		9		1			18
HC FATIGUE													6				5			11
ERR/CORR																				0
OTHER										6		6			3		2		1	18
TOT PLUGGED	0	0	0	0	0	0	0	1	8	24	0	37	72	0	150	0	760	0	568	1620
TOT SLEEVED																				0
T. L. OUTAGE								1												1

UTILITY CONTACT: Greg Kammerdeiner

PHONE NUMBER: 412-393-5677

UTILITY : DUQUESNE LIGHT CO.

PLANT : BEAVER VALLEY 2

PLUGGED : 121

EFPY : 4.7

TOTAL TUBES : 10,128

TUBE MATERIAL : I-600 MA

SG MODEL : W-51M

H. L. TEMP (F) : 606

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																		8		8
DENTING TS																				0
PITTING																				0
OD S/IGA SP																		1	2	3
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																		2		2
FRET (LP)															4				7	11
HC FATIGUE															2	2				4
ERR/CORR																				0
OTHER													14						79	93
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	14	0	6	2	0	11	88	121
TOT SLEEVED																				0
T. L. OUTAGE															1					1

UTILITY CONTACT: Greg Kammerdeiner

PHONE NUMBER: 412-393-5677

UTILITY : EDF

PLANT : BELLEVILLE 1

PLUGGED : 29

EFPY : 3.3

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	TOTAL
WASTAGE																			0
DENTING SP																			0
DENTING TS																2		10	12
PITTING																			0
OD S/IGA SP																			0
OD S/IGA TS																			0
ID SCC TS																			0
ID SCC UB																			0
FRET (PREH)																			0
FRET (AVB)																			0
FRET (LP)															2				2
HC FATIGUE																			0
ERR/CORR																			0
OTHER															1	11		3	15
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	0	13	29
TOT SLEEVED																			0
T. L. OUTAGE																			0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : BELLEVILLE 2

PLUGGED : 58

EFPY : 3.8

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																	2	3		5
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)															8					8
HC FATIGUE																				0
ERR/CORR																				0
OTHER																9	31	5		45
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	9	33	8	0	58
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : NOK-BEZNAU

PLANT : BEZNAU 1 (ORIGINAL SG)

PLUGGED : 1500

EFPY : 19.5

TOTAL TUBES : 5,208

TUBE MATERIAL : I-600 MA

SG MODEL : W-33

H. L. TEMP (F) : 599

C.L. TEMP (F) : 545

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																			R	0
OD S/IGA SP																			E	0
OD S/IGA TS	990	7	3		6	5	46	39	51	40	79	180	83	54	13	24	10		P	1630
ID SCC TS																			L	0
ID SCC UB																			A	0
FRET (PREH)																			C	0
FRET (AVB)					1			41		4									E	46
FRET (LP)																			D	0
HC FATIGUE																				0
ERR/CORR																				0
OTHER					8			1	1				1					1		12
PLUGGED	990	7	3	0	15	5	46	81	52	44	79	180	84	54	13	24	10	1		1688
UNPLUGGED								[3]	[3]	[13]	[12]	[20]	[74]	[63]						[188]
TOT PLUGGED																				1500
TOT SLEEVED							3	24	37	35	79	174	80	53	12	24	10	11		542
T. L. OUTAGE	4	1	1			1	1	1							1					10

UTILITY CONTACT: D. BAUMANN

PHONE NUMBER: 44-56-99-7322

UTILITY : NOK-BEZNAU

PLANT : BEZNAU 2

PLUGGED : 711

EFPY : 18.7

TOTAL TUBES : 5,208

TUBE MATERIAL : I-600 MA

SG MODEL : W-33

H. L. TEMP (F) : 599

C.L. TEMP (F) : 545

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	07	118	40	4			5						1							275
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS			1	1	1	6	17	11	22	17	40	91	42	13	14	20	15			311
ID SCC TS																				0
ID SCC UB				2		1					5					11			75	94
FRET (PREH)																				0
FRET (AVB)					1		12	2	1		2	1								19
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							2					1	9							12
TOT PLUGGED	107	118	41	7	2	7	36	13	23	17	47	93	52	13	14	31	15	0	75	711
TOT SLEEVED									17	17	39	86	42	13	14	20	15	13	39	315
T. L. OUTAGE	1			2	1	2					1									7

UTILITY CONTACT: D. BAUMANN

PHONE NUMBER: 44-56-99-7322

UTILITY : RHEINISCH-WESTFALISCHES ELEKTRIZITATSWERK AG

PLANT : BIBLIS-A

PLUGGED : 604

EFPY : 13.1

TOTAL TUBES : 16,240

TUBE MATERIAL : I-800

SG MODEL : KWU

H. L. TEMP (F) : 596

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE						1	10*	1	2	101	140	179	19	2	3	6	4	12		480
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)										37	2		4	5				1		49
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER			2**							66***				2***	4***	1***				75
TOT PLUGGED	0	0	2	0	0	1	10	1	2	204	142	179	23	9	7	7	4	13	0	604
TOT SLEEVED																				0
T. L. OUTAGE									1											1

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

* 3 tubes out of 10 were pulled for investigation

** 2 tubes were pulled for investigation

*** Total of 73 tubes were plugged preventively (63 due to AVB repair, 10 due to uninsoectability of the tubes)

UTILITY : RHEINISCH-WESTFALISCHES ELEKTRIZITATSWERK AG

PLANT : BIBLIS-B

PLUGGED : 61

EFPY : 11.0

TOTAL TUBES : 16,084

TUBE MATERIAL : I- 800

SG MODEL : KWU

H. L. TEMP (F) : 607

C.L. TEMP (F) : 551

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE						* 3	1**		1				2							7
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)									6		22	1	1	1	7		5	7		50
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER				3														1		4
TOT PLUGGED	0	0	0	3	0	3	1	0	7	0	22	1	3	1	7	0	5	8	0	61
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

* 2 tubes out of 3 were pulled because of uninterpretable ECT-signals
Result: Wastage + Pitting

** Tube was pulled because of uninterpretable ECT-signals. Result: Wastage + ODSCC

UTILITY	: EDF	TOTAL TUBES	: 10,083
PLANT	: BLAYAIS 1	TUBE MATERIAL	: I-600 MA
PLUGGED	: 170	SG MODEL	: FRAM-51M
EFPY	: 8.8	H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																27		4		31
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS									1	16	1		5		11	13	8	30		85
ID SCC UB															2					2
FRET (PREH)																				0
FRET (AVB)															1		1	2		4
FRET (LP)										2	1				3	2				8
HC FATIGUE																				0
ERR/CORR																				0
OTHER								18								1	21			40
TOT PLUGGED	0	0	0	0	0	0	0	18	1	18	2	0	5	0	17	43	30	36	0	170
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : BLAYAIS 2

PLUGGED : 93

EFPY : 8.1

TOTAL TUBES : 9,987

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51B1

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																54	2			56
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS										2	1	2			2		1		2	10
ID SCC UB															1				1	2
FRET (PREH)																				0
FRET (AVB)															1	1	1	1	1	5
FRET (LP)											3	2	1							6
HC FATIGUE																				0
ERR/CORR															1					1
OTHER									4							1	1	2	5	13
TOT PLUGGED	0	0	0	0	0	0	0	0	4	2	4	4	1	0	5	56	5	3	9	93
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : BLAYAIS 3

PLUGGED : 111

EFPY : 7.5

TOTAL TUBES : 9,987

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51B1

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																62	20			82
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS										1	1					5	3			10
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)															1	1		1	2	5
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									6					1		2			5	14
TOT PLUGGED	0	0	0	0	0	0	0	0	6	1	1	0	0	1	1	70	23	1	7	111
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : BLAYAIS 4

PLUGGED : 215

EFPY : 7.6

TOTAL TUBES : 9,990

TUBE MATERIAL : I-600 MA (SG1,SG2)
: I-600 TT (SG3)

SG MODEL : FRAM-51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																53	2	4		59
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS														6					1	7
ID SCC UB														1					2	3
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)											4	1		5	3	3			1	17
HC FATIGUE																				0
ERR/CORR																				0
OTHER							3			8	1		1	4		106	6			129
TOT PLUGGED	0	0	0	0	0	0	3	0	0	8	5	1	1	16	3	162	8	4	4	215
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EPZ

PLANT : BORSSELE

PLUGGED : 123

EFPY : 15.2

TOTAL TUBES : 8,468

TUBE MATERIAL : I-800

SG MODEL : KWU

H. L. TEMP (F) : 606

C.L. TEMP (F) : 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE					49		41	1		3		3		3		13	1			114
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	9			9
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	49	0	41	1	0	3	0	3	0	3	0	13	10	0	0	123
TOT SLEEVED																				0
T. L. OUTAGE																	1			1

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : COMMONWEALTH EDISON

PLANT : BRAIDWOOD 1

PLUGGED : 333

EFPY : 4.0

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 MA

SG MODEL : W-D4

H. L. TEMP (F) : 608

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	30	166	116	312
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)															2		4	6		12
FRET (LP)																				0
HC FATIGUE																	1			1
ERR/CORR																				0
OTHER															4		1	2	1	8
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	36	174	117	333
TOT SLEEVED																				0
T. L. OUTAGE																			1	1

UTILITY CONTACT: John Blomgren

PHONE NUMBER: 708-663-7215

UTILITY : COMMONWEALTH EDISON

PLANT : BRAIDWOOD 2

PLUGGED : 29

EFPY : 4.0

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 TT

SG MODEL : W-D5

H. L. TEMP (F) : 608

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																2	11		16	29
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	0	16	29
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: John Blomgren

PHONE NUMBER: 708-C63-7215

UTILITY : KERNKRAFTWERK BROKDORF GmbH
PLANT : BROKDORF
PLUGGED : 0
EFPY : 5.7

TOTAL TUBES : 16,344
TUBE MATERIAL : I-800
SG MODEL : KWU-54GS
H. L. TEMP (F) : 618
C.L. TEMP (F) : 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : ONTARIO HYDRO

PLANT : BRUCE-A 1

PLUGGED : 46

EFPY : 12.9

TOTAL TUBES : 33,600

TUBE MATERIAL : I-600 (SR)

SG MODEL : B&W CANADA

H. L. TEMP (F) : 579

C.L. TEMP (F) : 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																	9			9
ERR/CORR																				0
OTHER								1					5				31			37
TOT PLUGGED	0	0	0	0	0	0	0	1	0	0	0	0	5	0	0	0	40	0	0	46
TOT SLEEVED																				0
T. L. OUTAGE																	5	1		6

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

(SR) STRESS RELIEVED

UTILITY : ONTARIO HYDRO

PLANT : BRUCE-A 2

PLUGGED : 1447

EFPY : 11.1

TOTAL TUBES : 33,600

TUBE MATERIAL : I-600 (SR)

SG MODEL : B&W CANADA

H. L. TEMP (F) : 579

C.L. TEMP (F) : 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	*103	*856	*440	1399
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE			4	3	3											1				11
ERR/CORR					1															1
OTHER				2	1										1		32			36
TOT PLUGGED	0	0	4	5	5	0	0	0	0	0	0	0	0	0	1	1	135	856	440	1447
TOT SLEEVED																				0
T. L. OUTAGE				2												1	2	1		6

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

*Lead assisted SCC

UTILITY : ONTARIO HYDRO

PLANT : BRUCE-A 3

PLUGGED : 20

EFPY : 12.3

TOTAL TUBES : 33,600

TUBE MATERIAL : I-600 (SR)

SG MODEL : B&W CANADA

H. L. TEMP (F) : 579

C.L. TEMP (F) : 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE									3									1		4
ERR/CORR																				0
OTHER									4	1								11		16
TOT PLUGGED	0	0	0	0	0	0	0	0	7	1	0	0	0	0	0	0	0	12	0	20
TOT SLEEVED																				0
T. L. OUTAGE								1	2									2	1	6

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY	: ONTARIO HYDRO	TOTAL TUBES	: 33,600
PLANT	: BRUCE-A 4	TUBE MATERIAL	: I-600 SR)
PLUGGED	: 51	SG MODEL	: B&W CANADA
EFPY	: 11.8	H. L. TEMP (F)	: 579
		C.L. TEMP (F)	: 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE									1											1
ERR/CORR									1										1	2
OTHER								1	3										44	48
TOT PLUGGED	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	45	51
TOT SLEEVED																				0
T. L. OUTAGE									1											1

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : BRUCE-B 5

PLUGGED : 7

EFPY : 7.5

TOTAL TUBES : 33,600

TUBE MATERIAL : I-600 (SR)

SG MODEL : B&W CANADA

H. L. TEMP (F) : 579

C.L. TEMP (F) : 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																			7	7
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : BRUCE-B 6

PLUGGED : 13

EFPY : 7.3

TOTAL TUBES : 33,600

TUBE MATERIAL : I-600 (SR)

SG MODEL : B&W CANADA

H. L. TEMP (F) : 579

C.L. TEMP (F) : 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)															1					1
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER														1	11					12
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	0	0	0	0	13
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : BRUCE-B 7

PLUGGED : 4

EFPY : 6.4

TOTAL TUBES : 33,600

TUBE MATERIAL : I-600 (SR)

SG MODEL : B&W CANADA

H. L. TEMP (F) : 579

C.L. TEMP (F) : 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																	1			1
OTHER																	3			3
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : BRUCE-B 8

PLUGGED : 19

EFPY : 5.2

TOTAL TUBES : 33,600

TUBE MATERIAL : I-600 (SR)

SG MODEL : B&W CANADA

H. L. TEMP (F) : 579

C.L. TEMP (F) : 509

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																3			10	13
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																4			2	6
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	12	19
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : EDF		TOTAL TUBES	: 10,164
PLANT : BUGEY 2		TUBE MATERIAL	: I-600 MA
PLUGGED : 342		SG MODEL	: FRAM-51A
EFPY : 9.2		H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS															2	1	26	4		33
ID SCC TS															1	7	13	3		24
ID SCC UB									10	84	94					1				189
FRET (PREH)																				0
FRET (AVB)												10	2		3		4	4		23
FRET (LP)										1	4				12		3	8		28
HC FATIGUE																				0
ERR/CORR																				0
OTHER										4						29	10	2		45
TOT PLUGGED	0	0	0	0	0	0	0	0	10	89	98	10	2	0	18	38	56	21	0	342
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY	: EDF	TOTAL TUBES	: 10,164
PLANT	: BUGEY 3	TUBE MATERIAL	: I-600 MA
PLUGGED	: 209	SG MODEL	: FRAM-51A
EFPY	: 9.2	H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP														10						10
OD S/IGA TS																2	6			8
ID SCC TS									1		1	3	2			1	13		10	31
ID SCC UB									1					2						3
FRET (PREH)																				0
FRET (AVB)												34	7	3		28	8		15	95
FRET (LP)						1								11			9			21
HC FATIGUE																				0
ERR/CORR																				0
OTHER						11			1					1			1		27	41
TOT PLUGGED	0	0	0	0	0	12	0	0	3	0	1	37	9	27	0	31	37	0	52	209
TOT SLEEVED																				0
T. L. OUTAGE									1											1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF	TOTAL TUBES : 10,164
PLANT : BUGEY 4	TUBE MATERIAL : I-600 MA
PLUGGED : 440	SG MODEL : FRAM-51A
EFPY : 9.4	H. L. TEMP (F) : 613
	C.L. TEMP (F) : 546

DEFEC'S	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																2				2
OD S/IGA TS															2	53		27	11	93
ID SCC TS										3		1		2	1	2		6	1	16
ID SCC UB										94	186				3			4		287
FRET (PREH)																				0
FRET (AVB)												5		2	4			1		12
FRET (LP)															9			9		18
HC FATIGUE																				0
ERR/CORR																				0
OTHER									6					1	2			1	2	12
TOT PLUGGED	0	0	0	0	0	0	0	0	6	97	186	6	0	5	21	57	0	48	14	440
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : BUGEY 5 (ORIGINAL SG)

PLUGGED : 1064

EFPY : 9.5

TOTAL TUBES : 10,164

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51A

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																			R	0
PITTING																			E	0
OD S/IGA SP															1		3	2	P	6
OD S/IGA TS																	2	1	L	3
ID SCC TS								9	3	62	12	19	61		53	215	312	203	A	949
ID SCC UB										1		3	6		3				C	13
FRET (PREH)																			E	0
FRET (AVB)							1				6	8			4	7	7		D	33
FRET (LP)							4								1			11		16
HC FATIGUE																				0
ERR/CORR																				0
OTHER				6						4					9	2	7	16		44
TOT PLUGGED	0	0	0	6	0	0	5	9	3	67	18	30	67	0	71	224	331	233		1064
TOT SLEEVED															76					76
T. L. OUTAGE												1	1					1		3

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : COMMONWEALTH EDISON

PLANT : BYRON 1

PLUGGED : 847

EFPY : 6.2

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 MA

SG MODEL : W-D4

H. L. TEMP (F) : 608

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE													4	5					4	13
DENTING SP																				0
DENTING TS																				0
PITTING																	11			11
OD S/IGA SP																13	135		548	696
OD S/IGA TS																				0
ID SCC TS													2	1		1	2		49	55
ID SCC UB													1	39						40
FRET (PREH)																				0
FRET (AVB)																			1	1
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR													1							1
OTHER									19				2	1		2			6	30
TOT PLUGGED	0	0	0	0	0	0	0	0	19	0	0	0	10	46	0	16	148	0	608	847
TOT SLEEVED																				0
T. L. OUTAGE														2						2

UTILITY CONTACT: John Blomgren

PHONE NUMBER: 708-663-7215

UTILITY : COMMONWEALTH EDISON

PLANT : BYRON 2

PLUGGED : 104

EFPY : 4.8

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 TT

SG MODEL : W-D5

H. L. TEMP (F) : 608

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																		24	32	56
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER													11			32		5		48
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	32	0	29	32	104
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: John Blomgren

PHONE NUMBER: 708-663-7215

UTILITY : UNION ELECTRIC COMPANY

PLANT : CALLAWAY

PLUGGED : 141

EFPY : 7.3

TOTAL TUBES : 22504

TUBE MATERIAL : I-600MA

SG MODEL : W-F

H. L. TEMP (F) : 618

C.L. TEMP (F) : 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)													10		12	22		29	31	104
FRET (LP)																			5	5
HC FATIGUE																				0
ERR/CORR																				0
OTHER									25				3			1		2	1	32
TOT PLUGGED	0	0	0	0	0	0	0	0	25	0	0	0	13	0	12	23	0	31	37	141
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Ron Affolter

PHONE NUMBER: (314) 676-8240

UTILITY : BALTIMORE GAS & ELECTRIC	TOTAL TUBES : 17038
PLANT : CALVERT CLIFFS 1	TUBE MATERIAL : I-600 MA
PLUGGED : 195	SG MODEL : CE-67
EFPY : 12.4	H. L. TEMP (F) : 595
	C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS											14	20		63	2	11		10		120
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)											2	9		1				8		20
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER				3				26	5		6	10		4		1				55
TOT PLUGGED	0	0	0	3	0	0	0	26	5	0	22	39	0	68	2	12	0	18	0	195
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Craig Smith

PHONE NUMBER: (301) 260-3871

UTILITY : BALTIMORE GAS & ELECTRIC

PLANT : CALVERT CLIFFS 2

PLUGGED : 133

EFPY : 11.7

TOTAL TUBES : 17038

TUBE MATERIAL : I-600 MA

SG MODEL : CE-67

H. L. TEMP (F) : 595

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																			4	4
OD S/IGA TS										3	7		36		13				9	68
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)										1	2		9		7					19
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER				9				2		2	4		16		2				7	42
TOT PLUGGED	0	0	0	9	0	0	0	2	0	6	13	0	61	0	22	0	0	0	20	133
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Craig Smith

PHONE NUMBER: (301) 260-3871

UTILITY : DUKE POWER CO.

PLANT : CATAWBA 1

PLUGGED : 1480

EFPY : 6.0

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 MA

SG MODEL : W-D3

H. L. TEMP (F) : 617

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																17				17
OD S/IGA TS																	158	89	290	537
ID SCC TS														53		140	45	41	143	422
ID SCC UB														1			15	5	2	23
FRET (PREH)																3	1	6	17	27
FRET (AVB)																		1	2	3
FRET (LP)																	7			7
HC FATIGUE																				0
ERR/CORR																				0
OTHER												12		8		22	4	112	286	444
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	[illegible]	12	0	62	0	182	230	254	740	1480
TOT SLEEVED																	75	108		183
T. L. OUTAGE														1						1

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: 704-382-4211

UTILITY : DUKE POWER CO.

PLANT : CATAWBA 2

PLUGGED : 135

EFPY : 5.3

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 TT

SG MODEL : W-D5

H. L. TEMP (F) : 618

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																14	6		2	22
FRET (LP)														3	4	3	5		6	21
HC FATIGUE																				0
ERR/CORR																				0
OTHER												46		4	4	2	1		35	92
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	46	0	7	8	19	12	0	43	135
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: 704-382-4211

UTILITY : EDF

PLANT : CATTENOM 1

PLUGGED : 52

EFPY : 3.9

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																21		3		24
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																		12		12
HC FATIGUE																				0
ERR/CORR																				0
OTHER																	15		1	16
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	15	15	1	52
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : CATTENOM 2

PLUGGED : 164

EFPY : 4.0

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS															72		1			73
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)															4			5		9
HC FATIGUE																				0
ERR/CORR																				0
OTHER																2	74	2	4	82
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76	2	75	7	4	164
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : CATTENOM 3

PLUGGED : 11

EFPY : 2.3

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																		9	2	11
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	2	11
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF	TOTAL TUBES : 21,368
PLANT : CATTENOM 4	TUBE MATERIAL : I-600 TT
PLUGGED : 22	SG MODEL : FRAM-68/19
EFPY : 1.7	H. L. TEMP (F) : 616
	C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																15			7	22
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	7	22
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : CHINON B1

PLUGGED : 6

EFPY : 7.7

TOTAL TUBES : 9,987

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51BI

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB															2					2
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							2							2						4
TOT PLUGGED	0	0	0	0	0	0	2	0	0	0	0	0	0	2	2	0	0	0	0	6
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : CHINON B2

PLUGGED : 42

EFPY : 6.9

TOTAL TUBES : 9,990

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																9	3	20		32
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							7										3			10
TOT PLUGGED	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	9	6	20	0	42
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : CHINON B3

PLUGGED : 12

EFPY : 5.0

TOTAL TUBES : 9,987

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																			1	1
HC FATIGUE																				0
ERR/CORR																				0
OTHER											10								1	11
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	2	12
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : CHINON B4

PLUGGED : 13

EFPY : 4.4

TOTAL TUBES : 9,987

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																5				5
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																		5		5
HC FATIGUE																				0
ERR/CORR																				0
OTHER												2					1			3
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5	1	5	0	13
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY	TEXAS UTILITIES ELECTRIC	TOTAL TUBES	18,312
PLANT	COMANCHE PEAK 1	TUBE MATERIAL	I-600 MA
PLUGGED	31	SG MODEL	W-D4
EFPY	2.4	H. L. TEMP (F)	618
		C.L. TEMP (F)	557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								31												31
TOT PLUGGED	0	0	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0	0	0	31
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: James Hoss

PHONE NUMBER: 817-897-5210

UTILITY	: TEXAS UTILITIES ELECTRIC	TOTAL TUBES	: 18,280
PLANT	: COMANCHE PEAK 2	TUBE MATERIAL	: I-600 MA
PLUGGED	: 20	SG MODEL	: W-D4
EFPY	: 0.4	H. L. TEMP (F)	: 618
		C.L. TEMP (F)	: 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																		20		20
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	20
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: James Hoss

PHONE NUMBER: 817-897-5210

UTILITY : NORTHEAST UTILITIES

TOTAL TUBES : 15,176

PLANT :CONNECTICUT YANKEE (HADDAM NECK

TUBE MATERIAL : I-600 MA

PLUGGED : 1228

SG MODEL : W-27

EFPY : 18.4

H. L. TEMP (F) : 585

C.L. TEMP (F) : 534

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	30	1	1														4			36
DENTING SP							3		200	20		6				1	1		1	232
DENTING TS									12											12
PITTING		1					12		7	32		51	50		18		15		12	198
OD S/IGA SP																				0
OD S/IGA TS																	4			4
ID SCC TS	2											119	289		141		104		16	671
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)	2	2	1		1		2					2	4				1		1	16
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	4					2	8		1	15		9	10				1		9	59
TOT PLUGGED	38	4	2	0	1	2	25	0	220	67	0	187	353	0	159	1	130	0	39	1228
TOT SLEEVED																				0
T. L. OUTAGE	1																			1

UTILITY CONTACT: John Klisiewicz

PHONE NUMBER: 203-665-3969

UTILITY	: EDF	TOTAL TUBES	: 9,990
PLANT	: CRUAS 1	TUBE MATERIAL	: I-600 TT
PLUGGED	: 49	SG MODEL	: FRAM-51B
EFPY	: 7.0	H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																18		2		20
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS															1	2				3
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																		17		17
HC FATIGUE																				0
ERR/CORR																				0
OTHER								8											1	9
TOT PLUGGED	0	0	0	0	0	0	0	8	0	0	0	0	0	0	1	20	0	19	1	49
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-4[illegible]-22-86-78

UTILITY : EDF

PLANT : CRUAS 2

PLUGGED : 10

EFPY : 6.3

TOTAL TUBES : 9,990

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM 51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																	4			4
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																2				2
HC FATIGUE																				0
ERR/CORR																				0
OTHER												2				2				4
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4	4	0	0	10
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF	TOTAL TUBES : 9,990
PLANT : CRUAS 3	TUBE MATERIAL : I-600 TT
PLUGGED : 10	SG MODEL : FRAM-51B
EFPY : 6.8	H. L. TEMP (F) : 613
	C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									1							3	4	2		10
TOT PLUGGED	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	4	2	0	10
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : CRUAS 4

PLUGGED : 33

EFPY : 6.2

TOTAL TUBES : 9,990

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)															1			1		2
HC FATIGUE																				0
ERR/CORR																				0
OTHER									3				4		3		18		3	31
TOT PLUGGED	0	0	0	0	0	0	0	0	3	0	0	0	4	0	4	0	18	1	3	33
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY	: FLORIDA POWER CORP.	TOTAL TUBES	: 31,062
PLANT	: CRYSTAL RIVER 3	TUBE MATERIAL	: I-600
PLUGGED	: 162	SG MODEL	: OTSG
EFPY	: 10.1	H. L. TEMP (F)	: 603
		C.L. TEMP (F)	: 554

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																2				2
ERR/CORR																				0
OTHER	3	3		8	17	1	1						3		1	31		92		160
TOT PLUGGED	3	3	0	8	17	1	1	0	0	0	0	0	3	0	1	33	0	92	0	162
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Rocky Thompson

PHONE NUMBER: (904) 563-4548

UTILITY : AMERICAN ELECTRIC POWER

PLANT : D. C. COOK 1

PLUGGED : 952

EFPY : 12.4

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600

SG MODEL : W-51

H. L. TEMP (F) : 599

C.L. TEMP (F) : 536

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE											1		9		14	10		20		54
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP													1		2			45		48
OD S/IGA TS									6		23		255		131	104		284		803
ID SCC TS													4		133	51				188
ID SCC UB									3									1		4
FRET (PREH)																				0
FRET (AVB)									5		4				1	5				15
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR									1											1
OTHER	1					20		20	3									*4		48
PLUGGED	1	0	0	0	0	20	0	20	18	0	28	0	269	0	281	170	0	354	0	1161
UNPLUGGED																		[209]		[209]
TOT PLUGGED																				952
TOT SLEEVED																		1840**		1840
T. L. OUTAGE																				0

UTILITY CONTACT: John Jensen

PHONE NUMBER: 614-223-1975

* Does not include 4 good tubes plugged with sentinel plugs.

** 209 previously plugged tubes were sleeved and returned to service.

UTILITY : AMERICAN ELECTRIC POWER

PLANT : D. C. COOK 2 (ORIGINAL S. G.)

PLUGGED : 951

EFPY : 6.6

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600

SG MODEL : W-51

H. L. TEMP (F) : 606

C.L. TEMP (F) : 541

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE										3	1	1								5
DENTING SP																				0
DENTING TS																				0
PITTING														R						0
OD S/IGA SP											16	20	34	E						70
OD S/IGA TS									3	68	125	129	133	P						458
ID SCC TS													19	L						19
ID SCC UB							3	5	6					A						14
FRET (PREH)														C						0
FRET (AVB)								3		1				E						4
FRET (LP)														D						0
HC FATIGUE																				0
ERR/CORR										2	1									3
OTHER			1			6	14	22		328	4	1	2							378
TOT PLUGGED	0	0	1	0	0	6	17	30	9	402	147	151	188	0	0	0	0	0	0	951
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: John Jensen

PHONE NUMBER: 614-223-1975

UTILITY : AMERICAN ELECTRIC POWER

PLANT : D. C. COOK 2 (REPLACEMENT S. G.)

PLUGGED : 0

EFPY : 3.3

TOTAL TUBES : 14,368

TUBE MATERIAL : I-690 TT

SG MODEL : W-54F

H. L. TEMP (F) : 606

C.L. TEMP (F) : 541

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: John Jensen

PHONE NUMBER: 614-223-1975

UTILITY : EDF

PLANT : DAMPIERRE 1 (ORIGINAL S. G.)

PLUGGED : 714

EFPY : 6.7

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																R				0
PITTING																E				0
OD S/IGA SP																P				0
OD S/IGA TS																L				0
ID SCC TS										22	89	53	57	93		A				314
ID SCC UB											90	172	85			C				347
FRET (PREH)																E				0
FRET (AVB)														2		D				2
FRET (LP)									2				1							3
HC FATIGUE																				0
ERR/CORR																				0
OTHER				14						1	12	14		7						48
TOT PLUGGED	0	0	0	14	0	0	0	0	2	23	191	239	143	102	0	0	0	0	0	714
TOT SLEEVED																				0
T. L. OUTAGE									1		1		1							3

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : DAMPIERRE 1 (REPLACEMENT S. G.)

PLUGGED : 0

EFPY : 2.5

TOTAL TUBES : 10,083

TUBE MATERIAL : I-690 TT

SG MODEL : FRAM-51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : DAMPIERRE 2

PLUGGED : 426

EFPY : 8.7

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM 51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																		1		1
OD S/IGA TS																	23		1	24
ID SCC TS									2	1	14	7	30		39	13	42	15	19	182
ID SCC UB											180							6		186
FRET (PREH)																				0
FRET (AVB)													1			7		2	3	13
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER					11					1			1						7	20
TOT PLUGGED	0	0	0	0	11	0	0	0	2	2	194	7	32	0	39	20	65	24	30	426
TOT SLEEVED																				0
T. L. OUTAGE											1									1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF		TOTAL TUBES	: 10,083
PLANT : DAMPIERRE 3		TUBE MATERIAL	: I-600 MA
PLUGGED : 869		SG MODEL	: FRAM-51M
EFPY : 9.2		H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																88				88
PITTING																				0
OD S/IGA SP																		14	28	42
OD S/IGA TS																	3	1	18	22
ID SCC TS										12	15		7	93	38	36	24	44	42	311
ID SCC UB															1		163	83		247
FRET (PREH)																				0
FRET (AVB)													1	1			4	2	7	15
FRET (LP)										2	2		1	2	2	6				15
HC FATIGUE																				0
ERR/CORR														2						2
OTHER						7				1	2				2	1	37	65	12	127
TOT PLUGGED	0	0	0	0	0	7	0	0	0	15	19	0	9	98	43	131	231	209	107	869
TOT SLEEVED																				0
T. L. OUTAGE										1										1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : DAMPIERRE 4

PLUGGED : 402

EFPY : 8.7

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																10		7		17
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																		13	37	50
ID SCC TS										30				3	1			1	4	39
ID SCC UB										90	88									178
FRET (PREH)																				0
FRET (AVB)																1		4	3	8
FRET (LP)																1		4		5
HC FATIGUE																				0
ERR/CORR																				0
OTHER						10				1	3			1		63		22	5	105
TOT PLUGGED	0	0	0	0	0	10	0	0	0	121	91	0	0	4	1	75	0	51	49	402
TOT SLEEVED																				0
T. L. OUTAGE											1									1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : ONTARIO HYDRO	TOTAL TUBES : 18,652
PLANT : DARLINGTON 1	TUBE MATERIAL : I-800
PLUGGED : 0	SG MODEL : B&W CANADA
EFPY : 0.9	H. L. TEMP (F) : 588
	C.L. TEMP (F) : 512

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO	TOTAL TUBES : 18,652
PLANT : DARLINGTON 2	TUBE MATERIAL : I-800
PLUGGED : 0	SG MODEL : B&W CANADA
EFPY : 1.2	H. L. TEMP (F) : 588
	C.L. TEMP (F) : 512

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : DARLINGTON 3

PLUGGED : 0

EFPY : 0.8

TOTAL TUBES : 18,652

TUBE MATERIAL : I-800

SG MODEL : B&W CANADA

H. L. TEMP (F) : 588

C.L. TEMP (F) : 512

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : DARLINGTON 4

PLUGGED : 1

EFPY : 0.4

TOTAL TUBES : 18,652

TUBE MATERIAL : I-800

SG MODEL : B&W CANADA

H. L. TEMP (F) : 588

C.L. TEMP (F) : 512

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																			1	1
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY	: TOLEDO EDISON	TOTAL TUBES	: 30,914
PLANT	: DAVIS BESSE	TUBE MATERIAL	: I-600 S
PLUGGED	: 438	SG MODEL	: OTSG
EFPY	: 8.5	H. L. TEMP (F)	: 608
		C.L. TEMP (F)	: 555

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																	10			10
OD S/IGA SP																				0
OD S/IGA TS																2				2
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER			18				2	7		1		19		2		10	3		364	426
TOT PLUGGED	0	0	18	0	0	0	2	7	0	1	0	19	0	2	0	12	13	0	364	438
TOT SLEEVED																			212	212
T. L. OUTAGE							1													1

UTILITY CONTACT: Gene Matranga

PHONE NUMBER: 419-321-8369

UTILITY : PACIFIC GAS & ELECTRIC

PLANT : DIABLO CANYON 1

PLUGGED : 43

EFPY : 6.9

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 603

C.L. TEMP (F) : 545

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB														1	4			17		22
FRET (PREH)																				0
FRET (AVB)															2	1		12		15
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER											1				6					7
PLUGGED	0	0	0	0	0	0	0	0	0	0	1	0	0	1	12	1	0	29	0	44
UNPLUGGED															[1]					[1]
TOT PLUGGED																				43
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: David Hampshire

PHONE NUMBER: 415-972-6568

UTILITY	: PACIFIC ELECTRIC & GAS	TOTAL TUBES	: 13,552
PLANT	: DIABLO CANYON 2	TUBE MATERIAL	: I-600 MA
PLUGGED	: 76	SG MODEL	: W-51
EFPY	: 6.2	H. L. TEMP (F)	: 603
		C.L. TEMP (F)	: 545

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																			4	4
OD S/IGA TS																			1	1
ID SCC TS																			25	25
ID SCC UB														7					10	17
FRET (PREH)																				0
FRET (AVB)																			1	1
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER													2	24			1		21	48
PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	2	31	0	0	1	0	62	96
UNPLUGGED															[19]				[1]	[20]
TOT PLUGGED																				76
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: David Hampshire

PHONE NUMBER: 415-972-6568

UTILITY : EBES

PLANT : DOEL 1

PLUGGED : 291

EFPY : 16.4

TOTAL TUBES : 6520

TUBE MATERIAL : I-600

SG MODEL : ACE-44

H. L. TEMP (F) : 598

C.L. TEMP (F) : 544

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																	5		2	7
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)															32		19			51
FRET (LP)		1	8	13						3				2						27
HC FATIGUE																				0
ERR/CORR																		1		1
OTHER	3	1	1			11				2	1					4		5	177	205
TOT PLUGGED	3	2	9	13	0	11	0	0	0	5	1	0	0	2	32	4	24	6	179	291
TOT SLEEVED																				0
T. L. OUTAGE			3																	3

UTILITY CONTACT: Paul Hernalsteen

PHONE NUMBER: (02) 3820551

UTILITY : EBES

PLANT : DOEL 2

PLUGGED : 700

EFPY : # #

TOTAL TUBES : 6520

TUBE MATERIAL : I-600

SG MODEL : ACE-44

H. L. TEMP (F) : 598

C.L. TEMP (F) : 544

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP						1			1		3	4						4		13
OD S/IGA TS																	8	3	26	37
ID SCC TS	1		2	25	34	6	7	10	18	43	149	40				57	5		10	407
ID SCC UB					1						107									108
FRET (PREH)																				0
FRET (AVB)															8	2				10
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	3			3	77	1					1	2	22		8	1		6	1	125
TOT PLUGGED	4	0	2	28	112	8	7	10	19	43	260	46	22	0	16	60	13	13	37	700 *
MINI SLEEVE								133**	54**											187**
KISS SLEEVE											10	81								91#
NICKEL PLATE														33		345				378
T. L. OUTAGE								1	1						1					3

UTILITY CONTACT: Paul Hemalsteen

PHONE NUMBER: (02) 3820551

* 175 of the 700 plugs removed for repair

** 186 of the 187 sleeved tubes subsequently plugged

10 of the kiss sleeves subsequently removed

UTILITY : EBES

PLANT : DOEL 3

PLUGGED : 555

EFPY : 8.8

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600

SG MODEL : FRAM-51M

H. L. TEMP (F) : 617

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	TOTAL
WASTAGE																			0
DENTING SP																			0
DENTING TS																			0
PITTING																			0
OD S/IGA SP																	35	17	52
OD S/IGA TS																			0
ID SCC TS									5	3	1	2	51	16	16	28	42	35	199
ID SCC UB																			0
FRET (PREH)																			0
FRET (AVB)															14				14
FRET (LP)																			0
HC FATIGUE																			0
ERR/CORR																			0
OTHER								23		1			266*						290
TOT PLUGGED	0	0	0	0	[illegible]	0	0	23	5	4	1	2	317	16	30	28	77	52	555
TOT SLEEVED														55					55
T. L. OUTAGE													3					1	4

UTILITY CONTACT: Paul Hernalsteen

PHONE NUMBER: (02) 3820551

* 264 preventive row 1 plugging

UTILITY : EBES

PLANT : DOEL 3 (ORIGIONAL S.G.)

PLUGGED : 555

EFPY : 8.8

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600

SG MODEL : FRAM-51M

H. L. TEMP (F) : 617

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																			R	0
PITTING																			E	0
OD S/IGA SP																	35	17	P	52
OD S/IGA TS																			L	0
ID SCC TS									5	3	1	2	51	16	16	28	42	35	A	199
ID SCC UB																			C	0
FRET (PREH)																			E	0
FRET (AVB)															14				D	14
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								23		1			266*							290
TOT PLUGGED	0	0	0	0	0	0	0	23	5	4	1	2	317	16	30	28	77	52		555
TOT SLEEVED														55						55
NICKEL PLATE														11						11
T. L. OUTAGE													3					1		4

UTILITY CONTACT: Paul Hernalsteen

PHONE NUMBER: (02) 3820551

* 264 preventive row 1 plugging

UTILITY : EBES

PLANT : DOEL 3 (REPLACEMENT S.G.)

PLUGGED : 0

EFPY : 1.0

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600

SG MODEL : FRAM-51M

H. L. TEMP (F) : 617

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																			R	0
PITTING																			E	0
OD S/IGA SP																			P	0
OD S/IGA TS																			L	0
ID SCC TS																			A	0
ID SCC UB																			C	0
FRET (PREH)																			E	0
FRET (AVB)																			D	0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Paul Hernalsteen

PHONE NUMBER: (02) 3820551

UTILITY	: EBES	TOTAL TUBES	: 14,592
PLANT	: DOEL 4	TUBE MATERIAL	: I-600
PLUGGED	: 992	SG MODEL	: ACE-E
EFPY	: 7.5	H. L. TEMP (F)	: 616
		C.L. TEMP (F)	: 560

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																3	50	24		77
OD S/IGA TS																		43	2	45
ID SCC TS																3	17	5		25
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	2			2
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																			2	2
OTHER										19							8	142	672	841
TOT PLUGGED	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	6	77	214	676	992
TOT SLEEVED																			1736	1736
T. L. OUTAGE																		1		1

UTILITY CONTACT: Paul Hemalsteen

PHONE NUMBER: (02) 3820551

UTILITY : KERNKRAFTWERKE LIPPE-EMS GmbH	TOTAL TUBES : 16,472
PLANT : EMSLAND	TUBE MATERIAL : I-800
PLUGGED : 0	SG MODEL : KWU-54SK
EFPY : 5.1	H. L. TEMP (F) : 616
	C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : ALABAMA POWER COMPANY

PLANT : FARLEY 1

PLUGGED : 358

EFPY : 12.3

TOTAL TUBES : 10,164

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 607

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP												3			2		95	22		122
OD S/IGA TS											1	3		16	22		42*	9		93
ID SCC TS														1			75	2		78
ID SCC UB					1	4	277**													282
FRET (PREH)																				0
FRET (AVB)										9										9
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
PLUGGED	0	0	0	0	1	4	277	0	0	9	1	6	0	17	24	0	212	33	0	584
UNPLUGGED																	[226]			[226]
TOT PLUGGED																				358
TOT SLEEVED																		136		136
T. L. OUTAGE						1														1

UTILITY CONTACT: Forrest Hundley

PHONE NUMBER: 205-870-6998

* ODSCC above tubesheet (full depth exansion)
(some pitting associated with these indications)

** 274 Row 1 tubes preventively plugged

UTILITY : ALABAMA POWER COMPANY	TOTAL TUBES : 10,164
PLANT : FARLEY 2	TUBE MATERIAL : I-600 MA
PLUGGED : 710	SG MODEL : W-51
EFPY : 10.2	H. L. TEMP (F) : 607
	C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP										1	2	28	76		10	243		19	7	386
OD S/IGA TS											1									1
ID SCC TS												40	30		16	310		22	13	431
ID SCC UB								*280												280
FRET (PREH)																				0
FRET (AVB)											6	2	2		1					11
FRET (LP)								3												5
HC FATIGUE																				0
ERR/CORR																				0
OTHER					1		1				5		1						4	12
PLUGGED	0	0	0	0	1	0	1	283	0	3	14	70	109	0	27	272	0	41	24	1125
UNPLUGGED																[280]			[135]	[415]
TOT PLUGGED																				710
TOT SLEEVED																		29	246	275
T. L. OUTAGE										1										1

UTILITY CONTACT: Forrest Hundley

PHONE NUMBER: 205-870-6998

* Row 1 preventively plugged

UTILITY	: EDF	TOTAL TUBES	: 10,164
PLANT	: FESSENHEIM 1	TUBE MATERIAL	: I-600 MA
PLUGGED	: 508	SG MODEL	: FRAM-51A
EFPY	: 10.3	H. L. TEMP (F)	: 611
		C.L. TEMP (F)	: 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP												20							8	28
OD S/IGA TS															1	3	1			5
ID SCC TS							26	2	45	1	9	1			5		2			91
ID SCC UB									2	15	89	171		2	3	3	10		6	301
FRET (PREH)																				0
FRET (AVB)									1	6	1	5			1	1	1			16
FRET (LP)																	3			3
HC FATIGUE																				0
ERR/CORR																				0
OTHER	6							1	12	11	3	5		7	3	2	12		2	64
TOT PLUGGED	6	0	0	0	0	0	26	3	60	33	102	202	0	9	13	9	29	0	16	508
TOT SLEEVED										10*										10
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

* Subsequently Plugged

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF		TOTAL TUBES	: 10,164
PLANT : FESSENHEIM 2		TUBE MATERIAL	: I-600 MA
PLUGGED : 104		SG MODEL	: FRAM-51A
EFPY : 10.7		H. L. TEMP (F)	: 611
		C.L. TEMP (F)	: 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	1			1
OD S/IGA TS																31	27	7		65
ID SCC TS																	6			6
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)												1				4	1			6
FRET (LP)							1													1
HC FATIGUE																				0
ERR/CORR																				0
OTHER		12							4			1	1				4	3		25
TOT PLUGGED	0	12	0	0	0	0	1	0	4	0	0	2	1	0	0	35	39	10	0	104
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : FLAMANVILLE 1

PLUGGED : 56

EFPY : 5.2

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																		4		4
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER										11			7	2		3	29			52
TOT PLUGGED	0	0	0	0	0	0	0	0	0	11	0	0	7	2	0	3	29	4	0	56
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : FLAMANVILLE 2

PLUGGED : 57

EFPY : 4.8

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS															5					5
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)														2				1		3
HC FATIGUE																				0
ERR/CORR																				0
OTHER														18			25	6		49
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	20	5	0	25	7	0	57
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : OMAHA PUBLIC POWER DISTRICT

PLANT : FORT CALHOUN

PLUGGED : 110

EFPY : 13.5

TOTAL TUBES : 10,010

TUBE MATERIAL : I-600 MA

SG MODEL :

H. L. TEMP (F) : 593

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE										1										1
DENTING SP										9	28									37
DENTING TS																				0
PITTING																				0
OD S/IGA SP										8	2									10
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR				1						1									1	3
OTHER	49			3						4	3									59
TOT PLUGGED	49	0	0	4	0	0	0	0	0	23	33	0	0	0	0	0	0	0	1	110
TOT SLEEVED																				0
T. L. OUTAGE										1										1

UTILITY CONTACT: J.M. Cate

PHONE NUMBER: (402) 533-6834

UTILITY : KYUSHU ELECTRIC POWER CO.

PLANT : GENKAI 1

PLUGGED : 683

EFPY : 12.4

TOTAL TUBES : 6,776

TUBE MATERIAL : I-600 MA

SG MODEL : MHI-51

H. L. TEMP (F) : 613

C.L. TEMP (F) : 551

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP							233	167		105	17	38					26		17	603
OD S/IGA TS								9		15	124	62	90		20		14		17	351
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)	1																			1
HC FATIGUE																				0
ERR/CORR																				0
OTHER	4	2									1		1							8
PLUGGED	5	2	0	0	0	0	233	176	0	120	142	100	91		20	0	40	0	34	963
UNPLUGGED													[106]		[7]	[67]	[100]			[280]
TOT PLUGGED																				683
TOT SLEEVED											147	342	384		870	805	447		169	3164
T. L. OUTAGE	1																			1

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KYUSHU ELECTRIC POWER COMPANY

PLANT : GENKAI 2

PLUGGED : 1

EFPY : 10.6

TOTAL TUBES : 6,764

TUBE MATERIAL : I-600 MA

SG MODEL : MHI-51M

H. L. TEMP (F) : 599

C.L. TEMP (F) : 551

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER											1									1
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : ROCHESTER GAS & ELECTRIC

PLANT : GINNA

PLUGGED : 483

EFPY : 17.9

TOTAL TUBES : 6520

TUBE MATERIAL : I-600 MA

SG MODEL : W-44

H. L. TEMP (F) : 601

C.L. TEMP (F) : 552

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	32	19		1		1				1					4					58
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS	46	39	13		13	34	7	49	5	2	6	24	85	59	14	10		37	25	468
PWSCC TS																6				6
PWSCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)								1												1
HC FATIGUE														25						25
ERR/CORR																				0
OTHER	1		6	23	6			3						2						41
PLUGGED	79	58	19	24	19	35	7	53	5	3	6	24	85	86	18	16	0	37	25	599
UNPLUGGED																[8]	[13]	[49]	[46]	[116]
TOT PLUGGED																				483
TOT SLEEVED						5	16		77	8	69	39	101	-3	502	241	207	425	266	1953
T. L. OUTAGE	1	1	1	1	1			1						1						7

UTILITY CONTACT: John Smith

PHONE NUMBER: (716) 724 8363

UTILITY : KERNKRAFTWERK GOSGEN-DANIKEN

PLANT : GOSGEN

PLUGGED : 12

EFPY : 12.2

TOTAL TUBES : 12,318

TUBE MATERIAL : I-800

SG MODEL : KWU

H. L. TEMP (F) : 610

C.L. TEMP (F) : 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE								* 1												1
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)														1		4		5		10
HC FATIGUE																				0
ERR/CORR																				0
OTHER							* 1													0
TOT PLUGGED	0	0	0	0	0	0	1	1	0	0	0	0		1		4	0	5	0	12
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

* Tube pulled for investigation

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : EDF

TOTAL TUBES : 21,368

PLANT : GOLFECH 1

TUBE MATERIAL : I-600 TT

PLUGGED : 17

SG MODEL : FRAM-68/19

EFPY : 2.3

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER														10				4	3	17
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	4	3	17
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : BAYERNWERK AG		TOTAL TUBES	: 16,344
PLANT : GRAFENRHEINFELD		TUBE MATERIAL	: I-800
PLUGGED : 0		SG MODEL	: KWU-54GS
EFPY : 10.1		H. L. TEMP (F)	: 618
		C.L. TEMP (F)	: 555

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : EDF

PLANT : GRAVELINES 1

PLUGGED : 678

EFPY : 8.8

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																4				4
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																	20			20
ID SCC TS										2	12	18	10	25	38	203	11		14	333
ID SCC UB											179									179
FRET (PREH)																				0
FRET (AVB)																2	1		1	4
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER				10			2		1		2					86	36		1	138
TOT PLUGGED	0	0	0	10	0	0	2	0	1	2	193	18	10	25	38	295	68	0	16	678
TOT SLEEVED																				0
T. L. OUTAGE													1							1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : GRAVELINES 2

PLUGGED : 721

EFPY : 9.4

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																19				19
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																	50		1	51
ID SCC TS											7		11	15	16	25	72	7	6	159
ID SCC UB											179						5	2	1	187
FRET (PREH)																				0
FRET (AVB)														2	2	1	1	5	1	12
FRET (LP)														10	6	3	1		2	22
HC FATIGUE																				0
ERR/CORR																				0
OTHER					4						2					176	81	5	3	271
TOT PLUGGED	0	0	0	0	4	0	0	0	0	0	188	0	11	27	24	224	210	19	14	721
TOT SLEEVED																				0
T. L. OUTAGE														1						1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : GRAVELINES 3

PLUGGED : 332

EFPY : 9.3

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																6				6
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																			1	1
ID SCC TS										2	4		11		1	10	8	30	14	80
ID SCC UB											90							4	1	95
FRET (PREH)																				0
FRET (AVB)													9		24	8	3	5	8	57
FRET (LP)											4		1		16	4	4			29
HC FATIGUE																				0
ERR/CORR																				0
OTHER					8						3					11	38	4		64
TOT PLUGGED	0	0	0	0	8	0	0	0	0	2	101	0	21	0	41	39	53	43	24	332
TOT SLEEVED																				0
T. L. OUTAGE											1	1								2

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF	TOTAL TUBES : 10,083
PLANT : GRAVELINES 4	TUBE MATERIAL : I-600 MA
PLUGGED : 477	SG MODEL : FRAM-51M
EFPY : 8.9	H. L. TEMP (F) : 613
	C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																22		9		31
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																		4		4
ID SCC TS										15				1	4	11		18	78	127
ID SCC UB											180			10					11	201
FRET (PREH)																				0
FRET (AVB)															2			1		3
FRET (LP)									2					2	3	9				16
HC FATIGUE																				0
ERR/CORR																				0
OTHER						6				1			2		1	52		24	9	95
TOT PLUGGED	0	0	0	0	0	6	0	0	2	16	180	0	2	13	10	94	0	56	98	477
TOT SLEEVED																				0
T. L. OUTAGE									1	1	1									3

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : GRAVELINES 5

PLUGGED : 16

EFPY : 6.6

TOTAL TUBES : 9,990

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-51B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																9				9
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)												1			2	1				4
HC FATIGUE																				0
ERR/CORR																				0
OTHER									2			1								3
TOT PLUGGED	0	0	0	0	0	0	0	0	2	0	0	2	0	0	2	10	0	0	0	16
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY	: EDF	TOTAL TUBES	: 9,990
PLANT	: GRAVELINES 6	TUBE MATERIAL	: I-600 TT
PLUGGED	: 32	SG MODEL	: FRAM-51B
EFPY	: 6.0	H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)													6		10		1	8		25
HC FATIGUE																				0
ERR/CORR																				0
OTHER										5		1							1	7
TOT PLUGGED	0	0	0	0	0	0	0	0	0	5	0	1	6	0	10	0	1	8	1	32
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : GEMEINSCHAFTSKERN-KRAFTWERK GROHNDE GmbH

PLANT : GROHNDE

PLUGGED : 1

EFPY : 8.1

TOTAL TUBES : 16,344

TUBE MATERIAL : I-800

SG MODEL : KWU-54GS

H. L. TEMP (F) : 620

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																	* 1			1
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

* Probably FRET (AVB)

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : SHIKOKU ELECTRIC POWER

PLANT : IKATA 1

PLUGGED : 349

EFPY : 12.6

TOTAL TUBES : 6,776

TUBE MATERIAL : I-600 MA

SG MODEL : MHI-51

H. L. TEMP (F) : 603

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS								134		18	6	12			12	14	55		77	328
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)							9													9
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								12												12
TOT PLUGGED	0	0	0	0	0	0	9	146	0	18	6	12	0	0	12	14	55	0	77	349
TOT SLEEVED										14									-1	13
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : SHIKOKU ELECTRIC POWER

PLANT : IKATA 2

PLUGGED : 4

EFPY : 9.7

TOTAL TUBES : 6,764

TUBE MATERIAL : I-600 MA

SG MODEL : MHI-51M

H. L. TEMP (F) : 604

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																		4		4
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : CONSOLIDATED EDISON

PLANT : INDIAN POINT 2

PLUGGED : 1131

EFPY : 12.9

TOTAL TUBES : 13,040

TUBE MATERIAL : I-600 MA

SG MODEL : W-44

H. L. TEMP (F) : 589

C.L. TEMP (F) : 530

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP		3		8	26	16	10	20		84		33	19		55		1			275
DENTING TS																				0
PITTING										79		76	90		76		27		49	397
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																			5	5
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																			2	2
FRET (LP)												3								3
HC FATIGUE																				0
ERR/CORR																				0
OTHER	394	3		14				2		6			2		13		12		3	449
TOT PLUGGED	394	6	0	22	26	16	10	22	0	169	0	112	111	0	144	0	40	0	59	1131
TOT SLEEVED																				0
T. L. OUTAGE		1					1			1				1						4

UTILITY CONTACT: Jimmy Mark

PHONE NUMBER: 212-460-3599

UTILITY	: NEW YORK POWER AUTHORITY	TOTAL TUBES	: 13,040
PLANT	: INDIAN POINT 3 (ORIGIONAL S. G.)	TUBE MATERIAL	: I-600
PLUGGED	: 1828	SG MODEL	: W-44
EFPY	: 6.4	H. L. TEMP (F)	: 595
		C.L. TEMP (F)	: 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE											2									2
DENTING SP				4	69	9		19		5			6							112
DENTING TS																				0
PITTING							367	377		23	246	94	176	7						1290
OD S/IGA SP															R					0
OD S/IGA TS															E					0
ID SCC TS															P					0
ID SCC UB															L					0
FRET (PREH)															A					0
FRET (AVB)															C					0
FRET (LP)															E					0
HC FATIGUE															D					0
ERR/CORR																				0
OTHER					379					32	1	1		11						424
TOT PLUGGED	0	0	0	4	448	9	367	396	0	60	249	95	182	18	0	0	0	0	0	1828
TOT SLEEVED								2971			635									*3606
T. L. OUTAGE				1	1		1	1						1	1					6

UTILITY CONTACT: Jim Gillen

PHONE NUMBER: 914-736-8450

* Total of 3606 tubes sleeved.
Of these, 155 have subsequently been plugged, leaving 3451 tubes previously sleeved.

UTILITY : NEW YORK POWER AUTHORITY

TOTAL TUBES

PLANT : INDIAN POINT 3 (REPLACEMENT S. G.)

TUBE MATERIAL : I-690 TT

PLUGGED : 0

SG MODEL : W-44F

EFPY : 2.7

H. L. TEMP (F) :

C.L. TEMP (F) :

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Jim Gillen

PHONE NUMBER: 914-736-845(

UTILITY	: GEMEINSCHAFTSKERN-KRAFTWERK ISAR 2 GmbH	TOTAL TUBES	: 16,472
PLANT	: ISAR-2	TUBE MATERIAL	: I-800
PLUGGED	: 0	SG MODEL	: KWU-54SK
EFPY	: 4.7	H. L. TEMP (F)	: 615
		C.L. TEMP (F)	: 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : UNION ELECTRICA FENOSA

PLANT : JOSE CABERA (ZORITA)

PLUGGED : 147

EFPY : 17.7

TOTAL TUBES :2,604

TUBE MATERIAL : I-600 MA

SG MODEL : W-24

H. L. TEMP (F) : 584

C.L. TEMP (F) : 537

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	3				1	4	2						7	2						19
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS														1		2	1	1		5
ID SCC TS							7	51			4	5	5	4	2	3				81
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)	1			1	2	1	1	2			1		1		3	5	1	2		21
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	5			7	1		1	1			2	1	2				1			21
TOT PLUGGED	9	0	0	8	4	5	11	54	0	0	7	6	15	7	5	10	3	3	0	147
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Gustavo Bollini

PHONE NUMBER: 34-1-6516700

UTILITY : WISCONSIN PUBLIC SERVICE CORP. | TOTAL TUBES : 6,776

PLANT : KEWAUNEE | TUBE MATERIAL : I-600

PLUGGED : 517 | SG MODEL : W-51

EFPY : 16.0 | H. L. TEMP (F) : 590

C.L. TEMP (F) : 536

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP											6	1	6	10	12	43	66	56	17	217
OD S/IGA TS									63	25	43	71	116	29	36	185	91	8	4	671
ID SCC TS															4					4
ID SCC UB												2	1	1				1		5
FRET (PREH)																				0
FRET (AVB)									9											9
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER														3		3				6
PLUGGED	0	0	0	0	0	0	0	0	72	25	49	74	123	43	52	231	157	65	21	912
UNPLUGGED																	*[395]			[395]
TOT PLUGGED																				517
TOT SLEEVED														1940	1698	-14	690/-19	16/-29	-8	4274
T. L. OUTAGE															1				1	2

UTILITY CONTACT: Tim Olson

PHONE NUMBER: 414-388-2560 EXT. 2443

* 395 tubes deplugged, sleeved and returned to service.

UTILITY	: KOREA ELECTRIC POWER CO.	TOTAL TUBES	: 6,776
PLANT	: KORI 1	TUBE MATERIAL	: I-600 MA
PLUGGED	: 383	SG MODEL	: W-51
EFPY	: 11.7	H. L. TEMP (F)	: 607
		C.L. TEMP (F)	: 541

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING											419	123	52	54	15	37		4	100	804
OD S/IGA SP																3				3
OD S/IGA TS																				0
ID SCC TS																1		13	41	55
ID SCC UB																2		3	2	7
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																		30	4	34
ERR/CORR																				0
OTHER					1										14	28		25	7	75
PLUGGED	0	0	0	0	1	0	0	0	0	0	419	123	52	54	29	71	0	75	154	978
UNPLUGGED														[577]		[18]				[595]
TOT PLUGGED																				383
TOT SLEEVED														558	178	415		330	97	*1578
T. L. OUTAGE												1				1				2

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

* Approximately 220 of these sleeves have been removed

UTILITY : KOREA ELECTRIC POWER CO.

PLANT : KORI 2

PLUGGED: 215

EFPY : 8.3

TOTAL TUBES : 11,252

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 616

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS												7	116					2		125
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)												14	10	1		8	4	12	9	58
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								27				2	1	1					1	32
TOT PLUGGED	0	0	0	0	0	0	0	27	0	0	0	23	127	2	0	8	4	14	10	215
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

UTILITY : KOREA ELECTRIC POWER CO.

PLANT : KORI 3

PLUGGED : 37

EFPY : 6.8

TOTAL TUBES : 16,878

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 619

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)														7	6	4	3	9	4	33
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER											2			1					1	4
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	2	0	0	8	6	4	3	9	5	37
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

UTILITY : KOREA ELECTRIC POWER CO.

PLANT : KORI 4

PLUGGED : 58

EFPY : 5.8

TOTAL TUBES : 16,878

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 619

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)														5	3	2	9	13	4	36
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER											22									22
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	22	0	0	5	3	2	9	13	4	58
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

UTILITY	: IMATRAN VOIMA OY	TOTAL TUBES	: 33216
PLANT	: LOVIISA 1	TUBE MATERIAL	: AISI 321
PLUGGED	: 1	SG MODEL	: AEE-B-213
EFPY	: 13.2	H. L. TEMP (F)	: 567
		C.L. TEMP (F)	: 505

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER						1*														1
TOT PLUGGED	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: THOMAS BUDDAS

PHONE NUMBER: 358 15 5501

* Defect in manufacture

UTILITY : IMATRAN VOIMA OY

PLANT : LOVIISA 2

PLUGGED : 1

EFPY : 11.3

TOTAL TUBES : 33216

TUBE MATERIAL : AISI 321

SG MODEL : AEE-B-213

H. L. TEMP (F) : 567

C.L. TEMP (F) : 505

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								1*												1
TOT PLUGGED	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: THOMAS BUDDAS

PHONE NUMBER: 358 15 5501

* Defect in manufacture

UTILITY : MAINE YANKEE ATOMIC POWER CO.

PLANT : MAINE YANKEE

PLUGGED : 264

EFPY : 14.8

TOTAL TUBES : 17109

TUBE MATERIAL : I-600 MA

SG MODEL : CE-67

H. L. TEMP (F) : 602

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE								12			11									23
DENTING SP														5				25		30
DENTING TS													1							1
PITTING											20		1	6		17		12		56
OD S/IGA SP																1			29	30
OD S/IGA TS																			11	11
ID SCC TS																31		21		52
ID SCC UB																10		4		14
FRET (PREH)											2									2
FRET (AVB)																				0
FRET (LP)														2						2
HC FATIGUE																				0
ERR/CORR																				0
OTHER	6			15				1			3					3		1	14	43
TOT PLUGGED	6	0	0	15	0	0	0	13	0	0	36	0	2	13	0	62	0	63	54	264
TOT SLEEVED																				0
T. L. OUTAGE																1				1

UTILITY CONTACT: LINCOLN SPEED

PHONE NUMBER: (207) 798-4282

UTILITY : DUKE POWER CO.

PLANT : McGUIRE 1

PLUGGED : 1819

EFPY : 7.3

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 MA

SG MODEL : W-D2

H. L. TEMP (F) : 618

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																			4	4
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	30	13	34	77
OD S/IGA TS																2			4	6
ID SCC TS											2	37	128	105	55	168	30	5	123	653
ID SCC UB												383		2					10	395
FRET (PREH)								7	2					7	1	1		3	1	22
FRET (AVB)																	7		1	8
FRET (LP)															1	4	13	4	4	26
HC FATIGUE																				0
ERR/CORR																				0
OTHER						85		2			2		5	11	17	11	101	233	161	628
TOT PLUGGED	0	0	0	0	0	85	0	9	2	0	4	420	133	125	74	186	181	258	342	1819
TOT SLEEVED																397	444			841
T. L. OUTAGE											1				1			1	1	4

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: 704-382-4211

UTILITY : DUKE POWER CO.

TOTAL TUBES : 18,696

PLANT : McGUIRE 2

TUBE MATERIAL : I-600 MA

PLUGGED : 1387

SG MODEL : W-D3

EFPY : 7.2

H. L. TEMP (F) : 618

C.L. TEMP (F) : 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																			4	4
DENTING TS																				0
PITTING																				0
OD S/IGA SP																		6	5	11
OD S/IGA TS																		4		4
ID SCC TS												5	141	152	139	4			132	573
ID SCC UB											50	406							1	457
FRET (PREH)															3			3		6
FRET (AVB)																1		4	4	9
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								15							31	12		137	128	323
TOT PLUGGED	0	0	0	0	0	0	0	15	0	0	50	411	141	152	173	17	0	154	274	1387
TOT SLEEVED																478		137		615
T. L. OUTAGE											1									1

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: 704-382-4211

UTILITY : KANSAI ELECTRIC POWER

PLANT : MIHAMA 1

PLUGGED : 1891

EFPY : 10.[illegible]

TOTAL TUBES : 8,852

TUBE MATERIAL : I-600 MA

SG MODEL : CE

H. L. TEMP (F) : 599

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	1149	180																		1329
DENTING SP																				0
DENTING TS																				0
PITTING															6			243	16	265
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	870	15					13											1		899
PLUGGED	2019	195	0	0	0	0	13	0	0	0	0	0	0	0	6	0	0	244	16	2493
UNPLUGGED														[47]	[320]	[235]				[602]
TOT PLUGGED																				1891
TOT SLEEVED																				0
T. L. OUTAGE	2																	1		3

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KANSAI ELECTRIC POWEP.

PLANT : MIHAMA 2

PLUGGED : 412

EFPY : 11.5

TOTAL TUGES : 6,520

TUBE MATERIAL : I-600 MA

SG MODEL : MHI-44

H. L. TEMP (F) : 599

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	266															11				277
DENTING SP																				0
DENTING TS																			R	0
PITTING																			E	0
OD S/IGA SP								13											P	13
OD S/IGA TS					25	17			7	6			2	1					L	58
ID SCC TS									36							5			A	41
ID SCC UB												1							C	1
FRET (PREH)																			E	0
FRET (AVB)												1	4							5
FRET (LP)																				0
HC FATIGUE																	1			1
ERR/CORR																				0
OTHER		4		8		1						1		2						16
TOT PLUGGED	266	4	0	8	25	18	0	13	43	6	0	3	6	3	0	16	1	0		412
TOT SLEEVED								3	14	25		-1								41
T. L. OUTAGE	1				1				1								* 1			4

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

* Longterm outage due to tube break by highcycle fretting fatigue

UTILITY : KANSAI ELECTRIC POWER	TOTAL TUBES : 10,164
PLANT : MIHAMA 3	TUBE MATERIAL : I-600 MA
PLUGGED : 797	SG MODEL : MHI-51
EFPY : 12.1	H. L. TEMP (F) : 608
	C.L. TEMP (F) : 551

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	51	61	72	184
OD S/IGA TS																				0
ID SCC TS									108	3	17		12	22	60		108	88	190	608
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)											2									2
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	2													1						3
TOT PLUGGED	2	0	0	0	0	0	0	0	108	3	19	0	12	23	60	0	159	149	262	797
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY	: NORTHEAST UTILITIES	TOTAL TUBES	: 17,038
PLANT	: MILLSTONE 2 (ORIGINAL S. G.)	TUBE MATERIAL	: I-600 MA
PLUGGED	: 3080	SG MODEL	: CE-67
EFPY	: 10.9	H. L. TEMP (F)	: 604
		C.L. TEMP (F)	: 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	TOTAL
WASTAGE																			0
DENTING SF			763		4	1						3		6		6	13		796
DENTING TS							4		11		3								18
PITTING							704		180		56	22	36	366	236	54	1		1655
OD S/IGA SP																	2		2
OD S/IGA TS													1	26	413	30	34		504
ID SCC TS																		R	0
ID SCC UB																		E	0
FRET (PREH)																		P	0
FRET (AVB)																		L	0
FRET (LP)																		A	0
HC FATIGUE																		C	0
ERR/CORR																		E	0
OTHER	30				1		1		1		4	3	44	3		4	14	D	105
TOT PLUGGED	30	0	763	0	5	1	709	0	192	0	63	28	81	401	649	94	64		3080
TOT SLEEVED									2022		2917	225							*5164
T. L. OUTAGE									1				1			1			3

UTILITY CONTACT: John Kliesiewick

PHONE NUMBER: 203-665-3969

* Approximately 535 sleeved tubes have been plugged.

UTILITY : NORTHEAST UTILITIES

PLANT : MILLSTONE 2 (ORIGINAL S. G.)

PLUGGED : 3080

EFPY 10.9

TOTAL TUBES : 17,038

TUBE MATERIAL : I-600 MA

SG MODEL : CE-67

H. L. TEMP (F) : 604

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP			763		4	1						3		6		6	13			796
DENTING TS							4		11		3									18
PITTING							704		180		56	22	36	366	236	54	1			1655
OD S/IGA SP																	2			2
OD S/IGA TS													1	26	413	30	34			504
ID SCC TS																		R		0
ID SCC UB																		E		0
FRET (PREH)																		P		0
FRET (AVB)																		L		0
FRET (LP)																		A		0
HC FATIGUE																		C		0
ERR/CORR																		E		0
OTHER	30				1		1		1		4	3	44	3		4	14	D		105
TOT PLUGGED	30	0	763	0	5	1	709	0	192	0	63	28	81	401	649	94	64		0	3080
TOT SLEEVED									2022		2917	225								*5164
T. L. OUTAGE									1				1			1				3

UTILITY CONTACT: John Klisiewicz

PHONE NUMBER: 203-665-3969

* Approximately 535 sleeved tubes have been plugged.

UTILITY : NORTHEAST UTILITIES

PLANT : MILLSTONE 2 (REPLACEMENT S. G.)

PLUGGED : 0

EFPY : 0.0

TOTAL TUBES : 17,056

TUBE MATERIAL : I-690 TT

SG MODEL : B&W CANADA

H. L. TEMP (F) : 596

C.L. TEMP (F) : 548

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: John Klisiewicz

PHONE NUMBER: 203-665-3969

UTILITY : NORTHEAST UTILITIES

PLANT : MILLSTONE 3

PLUGGED : 28

EFPY : 5.2

TOTAL TUBES : 22054

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 621

C.L. TEMP (F) : 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)													2		3		5		7	17
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER										5	5				1					11
TOT PLUGGED	0	0	0	0	0	0	0	0	0	5	5	0	2	0	4	0	5	0	7	28
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: John Klisiewicz

PHONE NUMBER: 203-665-3969

UTILITY	: GEMEINSCHAFTSKERN-KRAFTWERK NECKAR GmbH	TOTAL TUBES	: 12,063
PLANT	: NECKARWESTHEIM-1	TUBE MATERIAL	: I-800
PLUGGED	: 18	SG MODEL	: KWU
EFPY	: 13.4	H. L. TEMP (F)	: 612
		C.L. TEMP (F)	: 560

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE						3		1	1				1	5		1				12
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																	3			3
HC FATIGUE																				0
ERR/CORR																				0
OTHER						* 3														0
TOT PLUGGED	0	0	0	0	0	6	0	[illegible]	1	0	0	0	1	5	0	1	3	0	0	18
TOT SLEEVED																				0
T. L. OUTAGE																	1			1

UTILITY CONTACT: S. Odar / R. Bouecke

* 3 Tubes pulled for investigation

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : GEMEINSCHAFTSKERN-
KRAFTWERK NECKAR GmbH

PLANT : NECKARWESTHEIM-2

PLUGGED : 0

EFPY : 4.3

TOTAL TUBES : 16,472

TUBE MATERIAL : I-800

SG MODEL : KWU-54SK

H. L. TEMP (F) : 616

C.L. TEMP (F) : 558

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : EDF

PLANT : NOGENT / SEINE 1

PLUGGED : 284

EFPY : 3.7

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS															246	8	3	2		259
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																1			2	3
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)															6					6
HC FATIGUE																				0
ERR/CORR																				0
OTHER																1	11	1	3	16
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	252	10	14	3	5	284
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : NOGENT / SEINE 2

PLUGGED : 83

EFPY : 3.7

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																1	1	10		12
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																		4	1	5
FRET (LP)															15					15
HC FATIGUE																				0
ERR/CORR																				0
OTHER													3				21	2	25	51
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	3	0	15	1	22	16	26	83
TOT SLEEVED																				0
T. L. OUTAGE															1					1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : Virginia Power

PLANT : North Anna 1

PLUGGED : 2065

EFPY : 10.2

TOTAL TUBES : 10164

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 618

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE													1							1
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP															2		92	470		564
OD S/IGA TS										1	2		45		3		49			100
ID SCC TS													45		28		198	36		307
ID SCC UB					279*		3						1		2					285
FRET (PREH)																				0
FRET (AVB)															3					3
FRET (LP)																				0
HC FATIGUE													1							1
ERR/CORR																				0
OTHER					2					24	84		423^		118		268/136#	21		804
TOT PLUGGED	0	0	0	0	281	0	3	0	0	25	86	0	516	0	156	0	471	527	0	2065
TOT SLEEVED																				0
T. L. OUTAGE										1	1		1		1					4

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

* 279 preventively plugged

^ 245 plugged to IDSCC at tube support plate
178 plugged due to 7th support plate fatigue issue.

\# 136 previously plugged tubes returned to service

UTILITY : VIRGINIA POWER

PLANT : NORTH ANNA 1 (ORIGINAL SG)

PLUGGED : 2065

EFPY : 9.6

TOTAL TUBES : 10164

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 618

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE													1							1
DENTING SP																				0
DENTING TS																			R	0
PITTING																			E	0
OD S/IGA SP															2		92	470	P	564
OD S/IGA TS										1	2		45		3		49		L	100
ID SCC TS													45		28		198	36	A	307
ID SCC UB					279*		3						1		2				C	285
FRET (PREH)																			E	0
FRET (AVB)															3				D	3
FRET (LP)																				0
HC FATIGUE													1							1
ERR/CORR																				0
OTHER					2					24	84		423^		118		268	21		940
PLUGGED	0	0	0	0	261	0	3	0	0	25	86	0	516	0	156	0	607	527		2201
UNPLUGGED																	[136]			[136]
TOT PLUGGED																				2065
TOT SLEEVED																				0
T. L. OUTAGE										1	1		1		1					4

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

* 279 preventively plugged

^ 245 plugged to IDSCC at tube support plate
178 plugged due to 7th support plate fatigue issue.

UTILITY : VIRGINIA POWER

PLANT : NORTH ANNA 1 (REPLACEMENT SG)

PLUGGED : 0

EFPY : 0.7

TOTAL TUBES : 10776

TUBE MATERIAL : I-600 TT

SG MODEL : W-54 F

H. L. TEMP (F) : 613

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

UTILITY : VIRGINIA POWER

PLANT : NORTH ANNA 2

PLUGGED : 1332

EFPY : 10.1

TOTAL TUBES : 10164

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 614

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE										1		1	16						1	19
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP															8	30		204	301	543
OD S/IGA TS															1	30		9	36	76
ID SCC TS												2	5		7	18		13	104	149
ID SCC UB					282*							6	5		6	2			3	304
FRET (PREH)																				0
FRET (AVB)													7		6	11		9	18	51
FRET (LP)										2			2							4
HC FATIGUE																				0
ERR/CORR																				0
OTHER													120^		1	9		15	**157	302
PLUGGED	0	0	0	0	282	0	0	0	0	3	0	9	155	0	29	100	0	250	620	1448
UNPLUGGED																[116]#				[116]
TOT PLUGGED																				1332
TOT SLEEVED																				0
T. L. OUTAGE										1	1		1		1					4

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

* 282 preventively plugged (Row 1)

^ 118 preventively plugged due to 7th support plate fatigue issue

116 previously plugged tubes returned to service (7th support plate fatigue issue)

** 85 plugged due to ID indications at tube support plate Balance for other attributions and "boxing" of tubes in which stabalizers could not be inserted.

UTILITY : KERNKRAFTWERK OBRIGHEIM GmbH

PLANT : OBRIGHEIM (ORIGIONAL S. G.)

PLUGGED : 461

EFPY : 11.2

TOTAL TUBES : 5,210

TUBE MATERIAL : I-600 MA

SG MODEL : KWU

H. L. TEMP (F) : 589

C.L. TEMP (F) : 541

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS									R											0
PITTING									E											0
OD S/IGA SP									P											0
OD S/IGA TS	26		1			3	2		L											32
ID SCC TS					5	16	29	88	A											138
ID SCC UB	12				1	2			C											15
FRET (PREH)									E											0
FRET (AVB)									D											0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER *	160	8	23	32	9	28	14	2												276
TOT PLUGGED	198	8	24	32	15	49	45	90	0	0	0	0	0	0	0	0	0	0	0	461
TOT SLEEVED																				0
T. L. OUTAGE	6	1	2																	9

UTILITY CONTACT: S. Odar / R. Bouecke

* Probably SCC

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : KERNKRAFTWERK OBRIGHEIM GmbH

PLANT : OBRIGHEIM (REPLACEMENT S. G.)

PLUGGED : 0

EFPY : 7.7

TOTAL TUBES : 6,020

TUBE MATERIAL : I-800

SG MODEL : KWU

H. L. TEMP (F) : 589

C. L. TEMP (F) : 534

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : DUKE POWER

PLANT : OCONEE 1

PLUGGED : 1266

EFPY : 14.5

TOTAL TUBES : 31,062

TUBE MATERIAL : I-600

SG MODEL : OTSG

H. L. TEMP (F) : 604

C.L. TEMP (F) : 554

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE		6	2				1						20					2		31
ERR/CORR			45		75		41		24	48			59		50	50	49	550		991
OTHER	2		8	47	9		3	2		8	3	81			11	10		60		244
TOT PLUGGED	2	6	55	47	84	0	45	2	24	56	3	81	79	0	61	60	49	612	0	1266
TOT SLEEVED				6									469							475
T. L. OUTAGE		2	4	1	1		1	2			1	2								14

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: (704) 382-4211

UTILITY : DUKE POWER

PLANT : OCONEE 1

PLUGGED : 1266

EFPY : 13.6

TOTAL TUBES : 31,062

TUBE MATERIAL : I-600

SG MODEL : OTSG

H. L. TEMP (F) : 604

C.L. TEMP (F) : 554

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	TOTAL
WASTAGE																			0
DENTING SP																			0
DENTING TS																			0
PITTING																			0
OD S/IGA SP																			0
OD S/IGA TS																			0
ID SCC TS																			0
ID SCC UB																			0
FRET (PREH)																			0
FRET (AVB)																			0
FRET (LP)																			0
HC FATIGUE		6	2				1						20					2	31
ERR/CORR			45		75		41		24	48			59		50	50	49	550	991
OTHER	2		8	47	9		3	2		8	3	81			11	10		60	244
TOT PLUGGED	2	6	55	47	84	0	45	2	24	56	3	81	79	0	61	60	49	612	1266
TOT SLEEVED													469						475
T. L. OUTAGE		2	4		1		1	2			1	2							14

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: (704) 382-4211

UTILITY : DUKE POWER

PLANT : OCONEE 2

PLUGGED : 318

EFPY : 13.9

TOTAL TUBES : 31,062

TUBE MATERIAL : I-600

SG MODEL : OTSG

H. L. TEMP (F) : 604

C.L. TEMP (F) : 554

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE	1			5			1							12	1	4			5	29
ERR/CORR		1							8					16	5	20		70	109	229
OTHER	10	3		8		1		9			9			9	3	1		7		60
TOT PLUGGED	11	4	0	13	0	1	1	9	8	0	9	0	0	37	9	25	0	77	114	318
TOT SLEEVED																228				228
T. L. OUTAGE		1		1			1							1		1				5

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: (704) 382-4211

UTILITY : DUKE POWER	TOTAL TUBES : 31,062
PLANT : OCONEE 3	TUBE MATERIAL : I-600
PLUGGED : 622	SG MODEL : OTSG
EFPY : 13.7	H. L. TEMP (F) : 604
	C.L. TEMP (F) : 554

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE		3	3			5							18	8			2		3	42
ERR/CORR										13			55	41	15		31	114	132	401
OTHER	84		12	1	2			22			16	7		23				12		179
TOT PLUGGED	84	3	15	1	2	5	0	22	0	13	16	7	73	72	15	0	33	126	135	622
TOT SLEEVED														247						247
T. L. OUTAGE		1	3			1		2		1	2	1	1	1						13

UTILITY CONTACT: Dan Mayes

PHONE NUMBER: (704) 382-4211

UTILITY : KANSAI ELECTRIC POWER

PLANT : OHI 1

PLUGGED : 2253

EFPY : 8.1

TOTAL TUBES : 13,552

TUBE MATERIAl : I-600 MA

SG MODEL : W-51A

H. L. TEMP (F) : 613

C.L. TEMP (F) : 552

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP								26	285		475		31	89			150		163	1219
OD S/IGA TS																				0
ID SCC TS								46	105		185	42	25	121			76		72	672
ID SCC UB							31													31
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							723				1			1						725
PLUGGED	0	0	0	0	0	0	754	72	390	0	661	42	56	211			226	0	235	2647
UNPLUGGED												[60]			[116]	[58]	[160]			[394]
TOT PLUGGED																				2253
TOT SLEEVED									81		443	650	743	162	1122	863	877		570	5511
T. L. OUTAGE							1													1

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KANSAI ELECTRIC POWER

PLANT : OHI 2

PLUGGED : 485

EFPY : 10.2

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600 MA

SG MODEL : MHI-51A

H. L. TEMP (F) : 613

C.L. TEMP (F) : 552

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS								63		19	8		9	14		34	32	286		465
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)													1	7		5	4			17
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							3													3
TOT PLUGGED	0	0	0	0	0	0	3	63	0	19	8	0	10	21	0	39	36	286	0	485
TOT SLEEVED										8				-1				-3		4
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY	: KANSAI ELECTRIC POWER	TOTAL TUBES	: 13,528
PLANT	: OHI 3	TUBE MATERIAL	: I-690 TT
PLUGGED	: 0	SG MODEL	: MHI-52FA
EFPY	: 1.8	H. L. TEMP (F)	: 617
		C.L. TEMP (F)	: 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KANSAI ELECTRIC POWER

PLANT : OHI 4

PLUGGED : 0

EFPY : 0.9

TOTAL TUBES : 13,528

TUBE MATERIAL : I-690 TT

SG MODEL : MHI-52FA

H. L. TEMP (F) : 617

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY :	CONSUMERS POWER CO.	TOTAL TUBES	: 17,038
PLANT :	PALISADES (ORIGINAL S. G.)	TUBE MATERIAL	: I-600
PLUGGED :	4486	SG MODEL	: CE
EFPY :	8.3	H. L. TEMP (F)	: 599
		C.L. TEMP (F)	: 548

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	2951	711		12	14		44			3										3735
DENTING SP				4	6		5			6	8		3	19						51
DENTING TS																				0
PITTING																R				0
OD S/IGA SP										27			15	18	96	E				156
OD S/IGA TS																P				0
ID SCC TS																L				0
ID SCC UB																A				0
FRET (PREH)																C				0
FRET (AVB)																E				0
FRET (LP)																D				0
HC FATIGUE																				0
ERR/CORR													2	4						6
OTHER								2		244				5	287					538
TOT PLUGGED	2951	711	0	16	20	0	49	2	0	280	8	0	20	46	383	0	0	0	0	4486
TOT SLEEVED		14		23																37
T. L. OUTAGE	2								1				1	2	2					8

UTILITY CONTACT: Tom Rexius

PHONE NUMBER: 616-764-8913 ext. 0168

UTILITY : CONSUMERS POWER CO.

PLANT : PALISADES (REPLACEMENT S. G.)

PLUGGED : 618

EFPY : 1.2

TOTAL TUBES

TUBE MATERIAL : I-600 MA

SG MODEL : CE

H. L. TEMP (F) : 591

C.L. TEMP (F) : 545

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																R				0
DENTING SP																E				0
DENTING TS																P				0
PITTING																L				0
OD S/IGA SP																A				0
OD S/IGA TS																C				0
ID SCC TS																E				0
ID SCC UB																D				0
FRET (PREH)																				0
FRET (AVP)																*617				617
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																			1	1
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	618
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Tom Rexius

PHONE NUMBER: 616-764-8913 ext. 0168

* Preventively plugged

UTILITY : ARIZONA PUBLIC SERVICE CO.

PLANT : PALO VERDE 1

PLUGGED : 323

EFPY : 4.6

TOTAL TUBES : 22,024

TUBE MATERIAL : I-600 MA

SG MODEL : CE-80

H. L. TEMP (F) :621

C.L. TEMP (F) :565

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																		9	63	72
ID SCC TS																			37	37
ID SCC UB																				0
FRET (PREH)													32		4			7	11	54
FRET (AVB)													1		6			4	20	31
FRET (LP)															2			19	6	27
HC FATIGUE																				0
ERR/CORR																				0
OTHER										*34			13		8			2	45	102
TOT PLUGGED	0	0	0	0	0	0	0	0	0	34	0	0	46	0	20	0	0	41	182	323
TOT SLEEVED																				0
T. L. OUTAGE													1							1

UTILITY CONTACT: Kevin Sweeney

PHONE NUMBER: (602) 393-5049

* Baseline

UTILITY : ARIZONA PUBLIC SERVICE CO.

PLANT : PALO VERDE 2

PLUGGED : 558

EFPY : 4.8

TOTAL TUBES : 22,024

TUBE MATERIAL : I-600 MA

SG MODEL : CE-80

H. L. TEMP (F) : 621

C.L. TEMP (F) : 565

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																			125	125
OD S/IGA TS																			2	2
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)													51	12		2	7		64	136
FRET (AVB)														49		100	25			174
FRET (LP)																	9		5	14
HC FATIGUE																				0
ERR/CORR																				0
OTHER											*47					8			52	107
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	47	0	51	61	0	110	41	0	248	558
TOT SLEEVED																				0
T. L. OUTAGE																			1	0

UTILITY CONTACT: Kevin Sweeney

PHONE NUMBER: (602) 393-5049

* Baseline

UTILITY : ARIZONA PUBLIC SERVICE CO. TOTAL TUBES : 22,024

PLANT : PALO VERDE 3 TUBE MATERIAL : I-600 MA

PLUGGED : 235 SG MODEL : CE-80

EFPY : 4.1 H. L. TEMP (F) : 621

C.L. TEMP (F) : 565

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																			4	4
ID SCC UB																				0
FRET (PREH)													**120							120
FRET (AVB)															8		2	13	14	37
FRET (LP)															9			3		12
HC FATIGUE																				0
ERR/CORR																				0
OTHER												*36					1	7	18	62
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	36	120	0	17	0	3	23	36	235
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Kevin Sweeney

PHONE NUMBER: (602) 393-5049

* Baseline

** Preventively plugged

UTILITY : EDF

PLANT : PALUEL 1

PLUGGED : 139

EFPY : 6.1

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																13	8	1		22
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS															1	1				2
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)															4	2		15		21
HC FATIGUE																				0
ERR/CORR															2					2
OTHER								32				22	1		13	5	19			92
TOT PLUGGED	0	0	0	0	0	0	0	32	0	0	0	22	1	0	20	21	27	16	0	139
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : PALUEL 2

PLUGGED : 130

EFPY : 5.9

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																40				40
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS														2		47	1			50
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)												1				2		1		4
HC FATIGUE																				0
ERR/CORR																				0
OTHER									9			3	3	1		5	4	11		36
TOT PLUGGED	0	0	0	0	0	0	0	0	9	0	0	4	3	3	0	94	5	12	0	130
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF		TOTAL TUBES	: 21,368
PLANT : PALUEL 3		TUBE MATERIAL	: I-600 TT
PLUGGED : 132		SG MODEL	: FRAM-68/19
EFPY : 5.7		H. L. TEMP (F)	: 616
		C.L. TEMP (F)	: 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS															48	2				50
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)												4		6	29					39
HC FATIGUE																				0
ERR/CORR															1					1
OTHER									25							15		2		42
TOT PLUGGED	0	0	0	0	0	0	0	0	25	0	0	4	0	6	78	17	0	2	0	132
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : PALUEL 4

PLUGGED : 166

EFPY : 5.2

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS															68	1	6	2		77
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																2	1		6	9
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																		1		1
FRET (LP)														1	26					27
HC FATIGUE																				0
ERR/CORR																				0
OTHER										16			1	2		4	13		16	52
TOT PLUGGED	0	0	0	0	0	0	0	0	0	16	0	0	1	3	94	7	20	3	22	166
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : PENLY 1

PLUGGED : 37

EFPY : 2.4

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																17				17
HC FATIGUE																				0
ERR/CORR																				0
OTHER														16			4			20
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	17	4	0	0	37
TOT SLEEVED																				0
T. L. OUTAGE																1				1

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : PENLY 2

PLUGGED : 4

EFPY : 1.1

TOTAL TUBES : 21,368

TUBE MATERIAL : I-690 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																4				4
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : KERNKRAFTWERK PHILIPPSBURG GmbH

PLANT : PHILIPPSBURG-2

PLUGGED : 0

EFPY : 7.5

TOTAL TUBES : 16,424

TUBE MATERIAL : I-800

SG MODEL : KWU-54S

H. L. TEMP (F) : 622

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-A 1

PLUGGED : 13

EFPY : 14.5

TOTAL TUBES : 31,200

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 559

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																			8	8
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER										1			3						1	5
TOT PLUGGED	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	9	13
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-A 2

PLUGGED : 3

EFPY : 13.9

TOTAL TUBES : 31,200

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 559

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR														1						1
OTHER	1									1										2
TOT PLUGGED	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	3
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-A 3

PLUGGED : 1

EFPY : 15.3

TOTAL TUBES : 31,200

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 559

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																	1			1
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
TOT SLEEVED																				0
T. L. OUTAGE																	1			1

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-A 4

PLUGGED : 0

EFPY : 14.6

TOTAL TUBES : 31,200

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 559

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-B 5

PLUGGED : 1924

EFPY : 8.3

TOTAL TUBES : 30,876

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 554

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																	233	1691		1924
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	233	1691	0	1924
TOT SLEEVED																				0
T. L. OUTAGE																	1	1		2

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-B 6

PLUGGED : 4

EFPY : 8.3

TOTAL TUBES : 30,876

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 554

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																			1	1
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																			3	3
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-B 7

PLUGGED : 0

EFPY : 7.9

TOTAL TUBES : 30,876

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 554

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : ONTARIO HYDRO

PLANT : PICKERING-B 8

PLUGGED : 21

EFPY : 6.9

TOTAL TUBES : 30,876

TUBE MATERIAL : MONEL 400

SG MODEL : B&W CANADA

H. L. TEMP (F) : 554

C.L. TEMP (F) : 480

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER														11					10	21
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	10	21
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: C. C. Maruska

PHONE NUMBER: (416) 592-5668

UTILITY : WISCONSIN ELECTRIC POWER

PLANT : POINT BEACH 1 (ORIGINAL S. G.)

PLUGGED : 905

EFPY : 9.2

TOTAL TUBES : 6,520

TUBE MATERIAL : I-600 MA

SG MODEL : W-44

H. L. TEMP (F) : 597

C.L. TEMP (F) : 542

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	167		1			1	1	6												176
DENTING SP			10	1																11
DENTING TS																				0
PITTING										R										0
OD S/IGA SP	180				5					E										185
OD S/IGA TS			3	10	271	110	20	59		P										473
ID SCC TS										L										0
ID SCC UB										A										0
FRET (PREH)										C										0
FRET (AVB)										E										0
FRET (LP)				2				11		D										13
HC FATIGUE																				0
ERR/CORR																				0
OTHER	18				14	12		3												47
TOT PLUGGED	365	0	14	13	290	123	21	79	0	0	0	0	0	0	0	0	0	0	0	905
TOT SLEEVED							13													13
T. L. OUTAGE	1		1	3	4															9

UTILITY CONTACT: Elizabeth Sullivan

PHONE NUMBER: 414-221-3235

UTILITY : WISCONSIN ELECTRIC POWER

PLANT : POINT BEACH 1 (REPACEMENT S. G.)

PLUGGED : 5

EFPY : 8.3

TOTAL TUBES : 6,428

TUBE MATERIAL : I-600 TT

SG MODEL : W-44F

H. L. TEMP (F) : 597

C.L. TEMP (F) : 542

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	2			2
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER										2				1						3
TOT PLUGGED	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	2	0	0	5
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Elizabeth Sullivan

PHONE NUMBER: 414-221-3235

UTILITY : WISCONSIN ELECTRIC POWER

PLANT : POINT BEACH 2

PLUGGED : 622

EFPY : 17.4

TOTAL TUBES : 6,520

TUBE MATERIAL : I-600 MA

SG MODEL : W-44

H. L. TEMP (F) : 597

C.L. TEMP (F) : 541

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	3	16	5		1	35	39	7	2	1	43	55		3	4				1	215
DENTING SP			2										1							3
DENTING TS															2					2
PITTING																				0
OD S/IGA SP	7												2	1		7			5	22
OD S/IGA TS						1	2	9	8	14	11	17	41	21	27	109		85	25	370
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																			1	1
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	1									2			4			1			1	9
TOT PLUGGED	11	16	7	0	1	36	41	16	10	17	54	72	48	25	33	117	0	85	33	622
TOT SLEEVED									3001				87	509	298					*3895
T. L. OUTAGE	1					1														2

UTILITY CONTACT: Elizabeth Sullivan

PHONE NUMBER: 414-221-3235

* 3001 tubes with hot leg sleeve
894 tubes with cold leg sleeve

UTILITY : NORTHERN STATE POWER CO.

PLANT : PRAIRIE ISLAND 1

PLUGGED : 193

EFPY : 15.9

TOTAL TUBES : 6,776

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 590

C.L. TEMP (F) : 530

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE							4		4	3	4	5	7	4		10	1	2		44
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																1				1
OD S/IGA TS						1			9	5	6	6	22	9		4	14	46		122
ID SCC TS																				0
ID SCC UB																	1			1
FRET (PREH)																				0
FRET (AVB)							18		5		5									28
FRET (LP)					6							1								7
HC FATIGUE																				0
ERR/CORR																				0
OTHER							4			1	1	3	2	4			1	1		17
PLUGGED	0	0	0	0	6	1	26	0	18	9	16	15	31	17	0	15	17	49	0	220
UNPLUGGED																*[27]				[27]
TOT PLUGGED																				193
TOT SLEEVED													26	73		62		158		319
T. L. OUTAGE					1	1			1	2			1					1		7

UTILITY CONTACT: Richard Pearson

PHONE NUMBER: (612) 388-1121

* Total of 27 tubes returned to service

EPRI
Electric Power
Research Institute Leadership in Science and Technology

December 20 1994

To: Steam Generator Strategic Management Project
Vendors
Contractors

From: Robert C. Thomas

Subject: STEAM GENERATOR PROGRESS REPORT - REVISION 10

Enclosed is a copy of the Steam Generator Progress Report, Revision 10. This report covers steam generator performance through December 31, 1993. During the last ten years, the capacity factor loss for U.S. PWR's due to steam generator tube problems averaged 2.8 percent. In 1993, the U.S. capacity factor loss improved to 1.9 percent. There were four tube leak forced outages in the U.S. in survey plugged steam generator tubes. A total of 10,317 tubes, or .30 percent of the tubes in service, were plugged. This is approximately 30 percent more than were plugged in 1992. Steam Generators were replaced in 1993 at North Anna 1, DOEL 3, Bugey 5, Beznau 1, and Mihama 2. Replacement steam generators have been ordered for 28 additional units. These orders indicate that the level of steam generator replacement activity will likely remain high for the next several years.

RCT:bds

UTILITY : NORTHERN STATE POWER CO.

PLANT : PRAIRIE ISLAND 2

PLUGGED : 249

EFPY : 15.3

TOTAL TUBES : 6,776

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 590

C.L. TEMP (F) : 530

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE						13	18	18	19	27	12	24		5	7	29		10	1	183
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS															1					1
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)							23	6		6	4									39
FRET (LP)						4														4
HC FATIGUE																				0
ERR/CORR							1													1
OTHER			1			1		3	1		3							1	11	21
TOT PLUGGED	0	0	1	0	0	18	42	27	20	33	19	24	0	5	8	29	0	11	12	249
TOT SLEEVED																				0
T. L. OUTAGE							1													1

UTILITY CONTACT: Richard Pearson

PHONE NUMBER: (612) 388-1121

UTILITY : SACRAMENTO MUNICIPAL UTIL. DIST.

PLANT : RANCHO SECO

PLUGGED : 221

EFPY :

TOTAL TUBES : 15,547

TUBE MATERIAL : I-600

SG MODEL : OTSG

H. L. TEMP (F) : 608

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING															S					0
OD S/IGA SP							4								H					4
OD S/IGA TS								9							U					9
ID SCC TS															T					0
ID SCC UB															D					0
FRET (PREH)															O					0
FRET (AVB)															W					0
FRET (LP)															N					0
HC FATIGUE																				0
ERR/CORR																				0
OTHER			24			3		12		3	29	38	83	16						208
TOT PLUGGED	0	0	24	0	0	3	4	21	0	3	29	38	83	16	0	0	0	0	0	221
TOT SLEEVED												508								508
T. L. OUTAGE							1	1	1	3										6

UTILITY CONTACT: Jim Field

PHONE NUMBER: (209) 333-2935

UTILITY : SWEDISH STATE POWER BOARD

PLANT : RINGHALS 2 (ORIGIONAL S. G.)

PLUGGED : 1752

EFPY : 8.0

TOTAL TUBES : 10,164

TUBE MATERIAL : I-600

SG MODEL : W-51

H. L. TEMP (F) : 609

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP				1	1	1		1												4
DENTING TS																				0
PITTING															R					0
OD S/IGA SP															E					0
OD S/IGA TS							3	53	71	309	248	108	59	510	P					1361
ID SCC TS								10		1	2	11	15	1	L					40
ID SCC UB					2					3				1	A					6
FRET (PREH)															C					0
FRET (AVB)										1	1	1	1	1	E					5
FRET (LP)															D					0
HC FATIGUE																				0
ERR/CORR																				0
OTHER			230	1	64	1			12	10	3	2	8	5						336
TOT PLUGGED	0	0	230	2	67	2	3	64	83	324	254	122	83	518	0	0	0	0	0	1752
TOT SLEEVED										35	50	596	554							1235
T. L. OUTAGE					2		2	3	2		1									10

UTILITY CONTACT: Jan Engstrom

PHONE NUMBER: (08) 739-5000

UTILITY : SWEDISH STATE POWER BOARD

PLANT : RINGHALS 2 (REPLACEMENT S. G.)

PLUGGED : 0

EFPY : 3.0

TOTAL TUBES : 15,390

TUBE MATERIAL : I-690 TT

SG MODEL : KWU

H. L. TEMP (F) : 613

C.L. TEMP (F) : 548

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Jan Engstrom

PHONE NUMBER: (08) 739-5000

UTILITY : SWEDISH STATE POWER BOARD

PLANT : RINGHALS 3

PLUGGED : 249

EFPY : 8.4

TOTAL TUBES : 14,022

TUBE MATERIAL : I-600

SG MODEL : W-D3

H. L. TEMP (F) : 610

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP													1	1	16	3				21
OD S/IGA TS																				0
ID SCC TS												6	3	27	42	22	4	6		110
ID SCC UB													4			13	11			28
FRET (PREH)							2	23	8								1			34
FRET (AVB)														3		1	2			6
FRET (LP)										1	2	6								9
HC FATIGUE																				0
ERR/CORR																				0
OTHER										1		7	1	2	11	8	4	7		41
TOT PLUGGED	0	0	0	0	0	0	2	23	8	2	2	19	9	33	69	47	22	13	0	249
TOT SLEEVED																	68			68
NICKEL PLATE																10				10
T. L. OUTAGE							1													1

UTILITY CONTACT: Jan Engstrom

PHONE NUMBER: (08) 739-5000

UTILITY : SWEDISH STATE POWER BOARD

PLANT : RINGHALS 4

PLUGGED : 183

EFPY : 8.0

TOTAL TUBES : 14,022

TUBE MATERIAL : I-600

SG MODEL : W-D3

H. L. TEMP (F) : 610

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS										1	2	2	5	5	9	5	26	37	7	99
ID SCC UB												3	16	4	7		1	1		32
FRET (PREH)																		2		2
FRET (AVB)															2	2		5	1	10
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									1	3				11	12	10		1	2	40
TOT PLUGGED	0	0	0	0	0	0	0	0	1	4	2	5	21	20	30	17	27	46	10	183
TOT SLEEVED																				0
T. L. OUTAGE												1								1

UTILITY CONTACT: Jan Engstrom

PHONE NUMBER: (08) 739-5000

UTILITY : CAROLINA POWER & LIGHT CO.

PLANT : H. B. ROBINSON (ORIGINAL S. G.)

PLUGGED : 2290

EFPY : 8.5

TOTAL TUBES : 9,642

TUBE MATERIAL : I-600 MA

SG MODEL : W-44

H. L. TEMP (F) : 601

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	14	12	19	21	23	211	102	100	69											571
DENTING SP																				0
DENTING TS																				0
PITTING										R										0
OD S/IGA SP									66	E										66
OD S/IGA TS	70				11		300	87	800	P										1268
ID SCC TS										L										0
ID SCC UB										A										0
FRET (PREH)										C										0
FRET (AVB)										E										0
FRET (LP)										D										0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	377				5				3											385
TOT PLUGGED	461	12	19	21	39	211	402	187	938	0	0	0	0	0	0	0	0	0	0	2290
TOT SLEEVED																				0
T. L. OUTAGE	1			1	2	1	2		2	1										10

UTILITY CONTACT: Randy Lewis

PHONE NUMBER: 919-546-7754

UTILITY : CAROLINA POWER & LIGHT

PLANT : H. B. ROBINSON (REPLACEMENT S. G.)

PLUGGED : 5

ΣFPY : 6.3

TOTAL TUBES : 9,642

TUBE MATERIAL : I-600 TT

SG MODEL : W-44F

H. L. TEMP (F) : 604

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)														1		1			2	4
HC FATIGUE																				0
ERR/CORR																				0
OTHER																		1		1
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	2	5
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Randy Lewis

PHONE NUMBER: 919-546-7754

UTILITY : EDF

PLANT : SAINT-ALBAN 1

PLUGGED : 82

EFPY : 4.8

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																	9	14		23
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																			1	1
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																		3		3
HC FATIGUE																				0
ERR/CORR																				0
OTHER											7		1				1	10	36	55
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	7	0	1	0	0	0	10	27	37	82
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : SAINT-ALBAN 2

PLUGGED : 299

EFPY : 4.1

TOTAL TUBES : 21,368

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-68/19

H. L. TEMP (F) : 616

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS															260					260
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS															1	5				6
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)													1					2		3
HC FATIGUE																				0
ERR/CORR															5					5
OTHER													9		1		10	5		25
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	10	0	267	5	10	7	0	299
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : PUBLIC SERVICE ELECTRIC & GAS

PLANT : SALEM 1

PLUGGED : 508

EFPY : 10.0

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 602

C.L. TEMP (F) : 544

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE								29					1		18			2	4	54
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																	4	1	13	18
ID SCC UB														1	*335					336
FRET (PREH)																				0
FRET (AVB)								4							7		13		2	26
FRET (LP)															1					1
HC FATIGUE																				0
ERR/CORR								1												1
OTHER	1		30					13					2		2		12	3	9	72
TOT PLUGGED	1	0	30	0	0	0	0	47	0	0	0	0	3	1	363	0	29	6	28	508
TOT SLEEVED																				0
T. L. OUTAGE														1						1

UTILITY CONTACT: Mahesh Janak

PHONE NUMBER: 609-339-1872

* Preventively plugged

UTILITY : PUBLIC SERVICE ELECTRIC & GAS

PLANT : SALEM 2

PLUGGED : 478

EFPY : 6.9

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 602

C.L. TEMP (F) : 545

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																12				12
DENTING SP																				0
DENTING TS																				0
PITTING									1											1
OD S/IGA SP																				0
OD S/IGA TS																5				5
ID SCC TS																	1		31	32
ID SCC UB													2	*334						336
FRET (PREH)																				0
FRET (AVB)													3			22	7		5	37
FRET (LP)										1										1
HC FATIGUE																				0
ERR/CORR																				0
OTHER									1	41				2			8		2	54
TOT PLUGGED	0	0	0	0	0	0	0	0	2	42	0	0	5	336	0	39	16	0	38	478
TOT SLEEVED																				0
T. L. OUTAGE																				0

* Preventively plugged

UTILITY CONTACT: Mahesh Danak

PHONE NUMBER: 609-339-1872

UTILITY : SOUTHERN CALIFORNIA EDISON

PLANT : SAN ONOFRE 1

PLUGGED : 1456

EFPY : 13.4

TOTAL TUBES : 11,382

TUBE MATERIAL : I-600 MA

SG MODEL : W-27

H. L. TEMP (F) : 575

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE		12	6	5				1			40			2		6	17			89
DENTING SP	31	3	9	11		3		6		4						1				68
DENTING TS																				0
PITTING																		S		0
OD S/IGA SP																		H		0
OD S/IGA TS					21	213		21						2		3		U		260
ID SCC TS								5						147		4	1	T		157
ID SCC UB																		D		0
FRET (PREH)																		O		0
FRET (AVB)	37	87	26	3		13					23							W		189
FRET (LP)																		N		0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	9	1	3	1		450		3		1				188		15	22			693
TOT PLUGGED	77	103	44	20	21	679	0	36	0	5	63	0	0	339	0	29	40	0	0	1456
TOT SLEEVED							6929													6929
T.L. OUTAGE	3	1			1															5

UTILITY CONTACT: Al Matheny

PHONE NUMBER: 714-368-9011

UTILITY : SOUTHERN CALIFORNIA EDISON

PLANT : SAN ONOFRE 2

PLUGGED : 646

EFPY : 7.7

TOTAL TUBES : 18,700

TUBE MATERIAL : I-600 MA

SG MODEL : CE-3410

H. L. TEMP (F) : 611

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS															18		15		1	34
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)											249	17	136		44		23		10	479
FRET (LP)											2		1							3
HC FATIGUE																				0
ERR/CORR																				0
OTHER								21		1	79		5				3		21	130
TOT PLUGGED	0	0	0	0	0	0	0	21	0	1	330	17	142	0	62	0	41	0	32	646
TOT SLEEVED																				0
T. L. OUTAGE										1				1	1					3

UTILITY CONTACT: Al Matheny

PHONE NUMBER: 714-368-9011

UTILITY : SOUTHERN CALIFORNIA EDISON

PLANT : SAN ONOFRE 3

PLUGGED : 614

EFPY : 7.3

TOTAL TUBES : 18,700

TUBE MATERIAL : I-600 MA

SG MODEL : CE-3410

H. L. TEMP (F) : 611

C.L. TEMP (F) : 553

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																1		5	8	14
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)											234	19		177		17		21	19	487
FRET (LP)																15			23	38
HC FATIGUE																				0
ERR/CORR																				0
OTHER									35	2	24	1				1		3	9	75
TOT PLUGGED	0	0	0	0	0	0	0	0	35	2	258	20	0	177	0	34	0	29	59	614
TOT SLEEVED																				0
T. L. OUTAGE										2										2

UTILITY CONTACT: Al Matheny

PHONE NUMBER: 714-368-9011

UTILITY : NORTHEAST UTILITIES

PLANT : SEABROOK

PLUGGED : 24

EFPY : 2.8

TOTAL TUBES : 22,054

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 618

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	4**		1	5
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER															13*		6			19
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	6	0	1	24
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: John Kliesiewicz

PHONE NUMBER: 203-665-3969

* Baseline

** Preventively

UTILITY	: KYUSHU ELECTRIC POWER	TOTAL TUBES	: 10,146
PLANT	: SENDAI 1	TUBE MATERIAL	: I-600 TT
PLUGGED	: 17	SG MODEL	: MHI-51M
EFPY	: 7.9	H. L. TEMP (F)	: 610
		C.L. TEMP (F)	: 544

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	17			17
FRET (LP)																				0
:IC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	17
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KYUSHU ELECTRIC POWER

PLANT : SENDAI 2

PLUGGED : 19

EFPY : 6.7

TOTAL TUBES : 10,146

TUBE MATERIAL : I-600 TT

SG MODEL : MHI-51F

H. L. TEMP (F) : 610

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	19			19
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	19
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY	: TENNESSEE VALLEY AUTHORITY	TOTAL TUBES	: 13,552
PLANT	: SEQUOYAH 1	TUBE MATERIAL	: I-600 MA
PLUGGED	: 181	SG MODEL	: W-51
EFPY	: 6.1	H. L. TEMP (F)	: 609
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																	1		3	4
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																			2	2
OD S/IGA TS																2	2			4
ID SCC TS																2	68		21	91
ID SCC UB											376			50			1		1	428
FRET (PREH)																				0
FRET (AVB)																1	1		1	3
FRET (LP)																	3			3
HC FATIGUE																				0
ERR/CORR																				0
OTHER														1					* 9	10
PLUGGED	0	0	0	0	0	0	0	0	0	0	376	0	0	51	0	5	76	0	37	545
UNPLUGGED													[364]*							[364]
TOT PLUGGED																				181
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: David Goetcheus

PHONE NUMBER: 615-751-7652

* 376 row 1 u-bend tubes were unplugged, heat treated, and inspected; 12 tubes were replugged.

* 9 tubes were plugged due to ID SCC at dented TSP

UTILITY	: TENNESSE VALLEY AUTHORITY	TOTAL TUBES	: 13,552
PLANT	: SEQUOYAH 2	TUBE MATERIAL	: I-600 MA
PLUGGED	: 434	SG MODEL	: W-51
EFPY	: 6.0	H. L. TEMP (F)	: 609
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																3		12		15
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																		1		1
OD S/IGA TS																1				1
ID SCC TS																4		19		23
ID SCC UB												24		352*						376
FRET (PREH)																				0
FRET (AVB)																8		6		14
FRET (LP)									1											1
HC FATIGUE																				0
ERR/CORR																				0
OTHER	1															2				3
TOT PLUGGED	1	0	0	0	0	0	0	0	1	0	0	24	0	352	0	18	0	38	0	434
TOT SLEEVED																				0
T. L. OUTAGE									1					1						2

UTILITY CONTACT: David Goetcheus

PHONE NUMBER: 615-751-7652

* The remainder of row 1 tubes were preventively plugged.

UTILITY : CAROLINA POWER & LIGHT

PLANT : SHEARON HARRIS

PLUGGED : 35

EFPY : 5.1

TOTAL TUBES : 13,734

TUBE MATERIAL : I-600 MA

SG MODEL : W-D4

H. L. TEMP (F) : 620

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP														2						2
DENTING TS													4							4
PITTING																				0
OD S/IGA SP															2					2
OD S/IGA TS																				0
ID SCC TS																	4			4
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)														7	1					8
FRET (LP)																2				2
HC FATIGUE																				0
ERR/CORR																				0
OTHER									7					1				2	3	13
TOT PLUGGED	0	0	0	0	0	0	0	0	7	0	0	0	4	10	3	2	4	2	3	35
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Randy Lewis

PHONE NUMBER: 919-546-7754

UTILITY : HOUSTON LIGHTING & POWER

PLANT : SOUTH TEXAS PROJECT 1

PLUGGED : 66

EFPY : 2.9

TOTAL TUBES : 19,456

TUBE MATERIAL : I-600 MA

SG MODEL : W-E

H. L. TEMP (F) : 624

C.L. TEMP (F) : 560

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																			1	1
PITTING																				0
OD S/IGA SP																			4	4
OD S/IGA TS																			8	8
ID SCC TS																			10	10
ID SCC UB																				0
FRET (PREH)																			1	1
FRET (AVB)																			1	1
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								* 6		4		5							26	35
TOT PLUGGED	0	0	0	0	0	0	0	6	0	4	0	5	0	0	0	0	0	0	51	66
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Ron Baker

PHONE NUMBER: 512-972-8961

* Shop plugged

UTILITY : HOUSTON LIGHTING & POWER

PLANT : SOUTH TEXAS PROJECT 2

PLUGGED : 18

EFPY : 2.6

TOTAL TUBES : 19,404

TUBE MATERIAL : I-600 MA

SG MODEL : W-E

H. L. TEMP (F) : 624

C.L. TEMP (F) : 560

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																	1		3	4
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								* 13					1							1
TOT PLUGGED	0	0	0	0	0	0	0	13	0	0	0	0	1	0	0	0	1	0	3	18
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Ron Baker

PHONE NUMBER: 512-972-8961

* Shop plugged

UTILITY	: EDF	TOTAL TUBES	: 10,083
PLANT	: SAINT-LAURENT-DES EAUX B2	TUBE MATERIAL	: I-600 MA
PLUGGED	: 215	SG MODEL	: FRAM-51M
EFPY	: 7.8	H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																			6	6
OD S/IGA TS																				0
ID SCC TS											2			1		2			4	9
ID SCC UB											180								1	181
FRET (PREH)																				0
FRET (AVB)																2			1	3
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER						10													6	16
TOT PLUGGED	0	0	0	0	0	10	0	0	0	0	182	0	0	1	0	4	0	0	18	215
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY	: EDF	TOTAL TUBES	: 10,083
PLANT	: SAINT-' AURENT-DES EAUX B1	TUBE MATERIAL	: I-600 MA
PLUGGED	: 329	SG MODEL	: FRAM-51M
EFPY	: 7.7	H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																		1		1
PITTING																				0
OD S/IGA SP													1				33	77	44	155
OD S/IGA TS																			3	3
ID SCC TS													1			4		3		8
ID SCC UB											90		2					3		95
FRET (PREH)																				0
FRET (AVB)																			1	1
FRET (LP)																2	3	10		15
HC FATIGUE																				0
ERR/CORR																				0
OTHER					6						1						1	36	7	51
TOT PLUGGED	0	0	0	0	6	0	0	0	0	0	91	0	4	0	0	6	37	130	55	329
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : FLORIDA POWER & LIGHT

PLANT : ST LUCIE 1

PLUGGED : 1818

EFPY : 12.8

TOTAL TUBES : 17,038

TUBE MATERIAL : I-600 MA

SG MODEL : CE-67

H. L. TEMP (F) : 601

C.L. TEMP (F) : 542

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP												23		109		138	297		83	650
OD S/IGA TS																43	152		12	207
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER		23			22		103			507	66		76	129					35	961
TOT PLUGGED	0	23	0	0	22	0	103	0	0	507	66	23	76	238	0	181	449	0	130	1818
TOT SLEEVED																				0
T. L. OUTAGE																1				1

UTILITY CONTACT: G. L. Boyers

PHONE NUMBER: 407-694-4909

UTILITY : FLORIDA POWER & LIGHT

PLANT : ST. LUCIE 2

PLUGGED : 467

EFPY : 8.3

TOTAL TUBES : 16,822

TUBE MATERIAL : I-600 MA

SG MODEL : CE-3410

H. L. TEMP (F) : 601

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																8			3	11
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)											264	15	17		20	31		36	6	389
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									47			19	1							67
TOT PLUGGED	0	0	0	0	0	0	0	0	47	0	264	34	18	0	20	39	0	36	9	467
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: G. L. Boyers

PHONE NUMBER: 407-694-4909

UTILITY : KERNKRAFTWERK STADE GmbH

PLANT : STADE

PLUGGED : 328

EFPY : 17.5

TOTAL TUBES : 11,972

TUBE MATERIAL : I-800

SG MODEL : KWU

H. L. TEMP (F) : 597

C.L. TEMP (F) : 544

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE					1	45	118	43	9	24	1	18	25	11	14	4	4		2	319
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER *	3				2		1							1				1	1	9
TOT PLUGGED	3	0	0	0	3	45	119	43	9	24	1	18	25	12	14	4	4	1	3	328
TOT SLEEVED																				0
T. L. OUTAGE							1													1

UTILITY CONTACT: S. Odar / R Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

* 3 Tubes plugged preventively
6 Tubes pulled for investigation

UTILITY : SOUTH CAROLINA ELECTRIC & GAS

PLANT : V. C. SUMMER

PLUGGED : 2221

EFPY : 7.8

TOTAL TUBES : 14,022

TUBE MATERIAL : I-600 MA

SG MODEL : W-D3

H. L. TEMP (F) : 619

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	51		271	322
OD S/IGA TS																				0
ID SCC TS											164		236	556		279	150		377	1762
ID SCC UB										4	3									7
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							7	3			110		8				2			130
TOT PLUGGED	0	0	0	0	0	0	7	3	0	4	277	0	244	556	0	279	203	0	648	2221
TOT SLEEVED																125	610			735
T. L. OUTAGE										1	1									2

UTILITY CONTACT: John Frick / Rollin Kelso

PHONE NUMBER: 803-345-4379 / 4065

UTILITY : VIRGINIA POWER

PLANT : SURRY 1 (ORIGINAL SG)

PLUGGED : 2594

EFPY : 4.4

TOTAL TUBES : 10164

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 605

C.L. TEMP (F) : 536

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	502			2		90														594
DENTING SP		963	640	364	29															1996
DENTING TS					2															2
PITTING							R													0
OD S/IGA SP							E													0
OD S/IGA TS							P													0
ID SCC TS							L													0
ID SCC UB							A													0
FRET (PREH)							C													0
FRET (AVB)							E													0
FRET (LP)							D													0
HC FATIGUE																				0
ERR/CORR																				0
OTHER	2																			2
TOT PLUGGED	504	963	640	366	31	90	0	0	0	0	0	0	0	0	0	0	0	0	0	2594
TOT SLEEVED																				0
T. L. OUTAGE	2	6				1														9

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

UTILITY	: VIRGINIA POWER	TOTAL TUBES	: 10026
PLANT	: SURRY 1 (REPLACEMENT SG)	TUBE MATERIAL	: I-600 TT
PLUGGED	: 14	SG MODEL	: W-51F
EFPY	: 8.4	H. L. TEMP (F)	: 605
		C.L. TEMP (F)	: 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																		2		2
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							2			4		4				2				12
TOT PLUGGED	0	0	0	0	0	0	2	0	0	4	0	4	0	0	0	2	0	2	0	14
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

UTILITY : VIRGINIA POWER

PLANT : SURRY 2 (ORIGINAL SG)

PLUGGED : 2154

EFPY : 3.6

TOTAL TUBES : 10164

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 605

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	190																			190
DENTING SP		797	899	268																1964
DENTING TS																				0
PITTING						R														0
OD S/IGA SP						E														0
OD S/IGA TS						P														0
ID SCC TS						L														0
ID SCC UB						A														0
FRET (PREH)						C														0
FRET (AVB)						E														0
FRET (LP)						D														0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	190	797	899	268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2154
TOT SLEEVED																				0
T. L. OUTAGE		4	3																	7

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

UTILITY : VIRGINIA POWER

PLANT : SURRY 2 (REPLACEMENT SG)

PLUGGED : 5

EFPY : 9.2

TOTAL TUBES : 10026

TUBE MATERIAL : I-600 TT

SG MODEL : W-51F

H. L. TEMP (F) : 605

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																			2	2
FRET (LP)												1								1
HC FATIGUE																				0
ERR/CORR																				0
OTHER						2						1 *								3
PLUGGED	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	2	6
UNPLUGGED																	[1]			[1]
TOT PLUGGED																				5
TOT SLEEVED																				0
T. L. OUTAGE												1								1

UTILITY CONTACT: Joe Eastwood

PHONE NUMBER: (804) 273-2730

* Tube misplugged in 1986; plug removed in 1991

UTILITY : KANSAI ELECTRIC POWER

PLANT : TAKAHAMA 1

PLUGGED : 881

EFPY : 11.1

TOTAL TUBES : 10,164

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 608

C.L. TEMP (F) : 551

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE	98																			98
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP										1	7	3		2	6	7		31	56	113
OD S/IGA TS			32	25		12		9		40	6	7		7	8	4				150
ID SCC TS								1				5			20	45		61	52	184
ID SCC UB			31	10		55		1		1	2	1		1	6	13		17	10	148
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER						186					1			1						188
TOT PLUGGED	98	0	63	35	0	253	0	11	0	42	16	16	0	11	40	69	0	109	118	881
TOT SLEEVED						2	4	32		59	-6	-1		6		-3		-4	-8	81
T. L. OUTAGE			1																	1

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KANSAI ELECTRIC POWER

PLANT : TAKAHAMA 2

PLUGGED: 1610

EFPY : 10.6

TOTAL TUBES : 10,164

TUBE MATERIAL : I-600 MA

SG MODEL : MHI-51

H. L. TEMP (F) : 608

C.L. TEMP (F) : 551

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP							143		219	30						55	19	73		539
OD S/IGA TS							53		183	246	456	110	121	32			11	14		1226
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER		1												192			16			209
PLUGGED	0	1	0	0	0	0	196	0	402	276	456	110	121	224	0	55	46	87	0	1974
UNPLUGGED												[80]	[57]	[56]		[118]	[55]	[48]		[364]
TOT PLUGGED																				1610
TOT SLEEVED										231	-67	330	466	1007		1139	675	644		4425
T. L. OUTAGE											1			1						2

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KANSAI ELECTRIC POWER

PLANT : TAKAHAMA 3

PLUGGED : 26

EFPY : 7.4

TOTAL TUBES : 10,146

TUBE MATERIAL : I-600 TT

SG MODEL : MHI-51F

H. L. TEMP (F) : 610

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)															23		2			25
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER										1										1
TOT PLUGGED	0	0	0	0	0	0	0	0	0	1	0	0	0	0	23	0	2	0	0	26
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : KANSAI ELECTRIC POWER

PLANT : TAKAHAMA 4

PLUGGED : 21

EFPY : 7.3

TOTAL TUBES : 10,146

TUBE MATERIAL : I-600 TT

SG MODEL : MHI-51F

H. L. TEMP (F) : 610

C.L. TEMP (F) : 543

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																21				21
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	21
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : SEMO

PLANT : TIHANGE 1

PLUGGED : 371

EFPY : 14.7

TOTAL TUBES : 10,164

TUBE MATERIAL : I-600

SG MODEL : ACLF-51

H. L. TEMP (F) : 611

C.L. TEMP (F) : 545

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																	11			11
DENTING TS																				0
PITTING																				0
OD S/IGA SP																	17			17
OD S/IGA TS																	181			181
ID SCC TS																	7			7
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)									3	51										54
FRET (LP)								5							1					6
HC FATIGUE																				0
ERR/CORR										1										1
OTHER	3	13	2	13	27	1		1	26			2		3		2	1			94
TOT PLUGGED	3	13	2	13	27	1	0	6	29	52	0	2	0	3	1	2	217	0	0	371
TOT SLEEVED																				0
T. L. OUTAGE										1	1	1								3

UTILITY CONTACT: Paul Hernalsteen

PHONE NUMBER: (02) 3820551

UTILITY : INTERCOM

PLANT : TIHANGE 2

PLUGGED : 282

EFPY : 9.4

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600

SG MODEL : FRAM-51M

H. L. TEMP (F) : 617

C.L. TEMP (F) : 547

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS										7	20		1	30	21	39	32	11	50	211
ID SCC UB													1							1
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)													1							1
HC FATIGUE																				0
ERR/CORR																	1			1
OTHER								2									2	64		68
TOT PLUGGED	0	0	0	0	0	0	0	2	0	7	20	0	3	30	21	39	35	75	50	282
TOT SLEEVED																				0
NICKEL PLATE																		602	554	1156
T. L. OUTAGE																	1			1

UTILITY CONTACT: Paul Hemalsteen

PHONE NUMBER: (02) 3820551

UTILITY : INTERCOM	TOTAL TUBES : 14,592
PLANT : TIHANGE 3	TUBE MATERIAL : I-600
PLUGGED : 72	SG MODEL : ACE-E
EFPY : 7.5	H. L. TEMP (F) : 626
	C.L. TEMP (F) : 560

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																4	12		10	26
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																22	3		1	26
FRET (LP)															6					6
HC FATIGUE																				0
ERR/CORR												2								2
OTHER									3			4			1		4			12
TOT PLUGGED	0	0	0	0	0	0	0	0	3	0	0	6	0	0	7	26	19	0	11	72
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Paul Hernalsteen

PHONE NUMBER: (02) 3820551

UTILITY : GENERAL PUBLIC UTILITIES

PLANT : THREE MILE ISLAND 1

PLUGGED : 1641

EFPY : 10.0

TOTAL TUBES : 31,062

TUBE MATERIAL : I-600 MA

SG MODEL : OTSG

H. L. TEMP (F) : 604

C.L. TEMP (F) : 554

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP														4						4
OD S/IGA TS																				0
ID SCC TS								331	856	3	336	64		17		8	3		1	1619
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																1				1
ERR/CORR																				0
OTHER	2		9	1	3	1										1				17
TOT PLUGGED	2	0	9	1	3	1	0	331	856	3	336	64	0	21	0	10	3	0	1	1641
TOT SLEEVED																	250		252	502
T. L. OUTAGE																1				1

UTILITY CONTACT: Julien Abramovici

PHONE NUMBER: 201-316-7038

UTILITY : HOKKAIO ELECTRIC POWER

PLANT : TOMARI 1

PLUGGED : 0

EFPY : 3.8

TOTAL TUBES : 6,764

TUBE MATERIAL : I-600 TT

SG MODEL : MHI-51F

H. L. TEMP (F) : 613

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : HOKKAIO ELECTRIC POWER

PLANT : TOMARI 2

PLUGGED : 0

EFPY : 2.1

TOTAL TUBES : 6,764

TUBE MATERIAL : I-600 TT

SG MODEL : MHI-51F

H. L. TEMP (F) : 613

C.L. TEMP (F) : 550

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : EDF

PLANT : TRICASTIN 1

PLUGGED : 646

EFPY : 9.6

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																	1			1
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																	65			65
ID SCC TS											2	17	32	10	26	20	8	18	66	199
ID SCC UB													1							1
FRET (PREH)																				0
FRET (AVB)														4	5	6	3	4		22
FRET (LP)							3					3	58	54	39	10	1	7	1	176
HC FATIGUE																				0
ERR/CORR																				0
OTHER				7					1	2	1	1		3		141	17	1	8	182
TOT PLUGGED	0	0	0	7	0	0	3	0	1	2	3	21	91	71	70	177	95	30	75	646
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Com'y

PHONE NUMBER: 1-49-22-86-78

UTILITY : EDF

PLANT : TRICASTIN 2

PLUGGED : 379

EFPY : 9.2

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																9		12		21
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																	3	1	1	5
ID SCC TS										1		16	28	21		15	23	19	70	193
ID SCC UB										3	85		1							89
FRET (PREH)																				0
FRET (AVB)																	1			1
FRET (LP)										2							3			5
HC FATIGUE																				0
ERR/CORR																				0
OTHER				15						2	3	3	1					40	1	65
TOT PLUGGED	0	0	0	15	0	0	0	0	0	8	88	19	30	21	0	24	30	72	72	379
TOT SLEEVED											14*									14
T. L. OUTAGE										1	1									2

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

* 8 tubes subsequently plugged

UTILITY : EDF

PLANT : TRICASTIN 3

PLUGGED : 633

EFPY : 9.5

TOTAL TUBES : 10,083

TUBE MATERIAL : I-600 MA

SG MODEL : FRAM-51M

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																	12			12
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																	133			133
ID SCC TS										2		7	4	16	4	7	4	32	28	104
ID SCC UB										89	89					2		3		183
FRET (PREH)																				0
FRET (AVB)																	1			1
FRET (LP)														1				2		3
HC FATIGUE																				0
ERR/CORR																				0
OTHER					6											188	1		2	197
TOT PLUGGED	0	0	0	0	6	0	0	0	0	91	89	7	4	17	4	197	151	37	30	633
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY	: EDF	TOTAL TUBES	: 10,083
PLANT	: TRICASTIN 4	TUBE MATERIAL	: I-600 MA
PLUGGED	: 254	SG MODEL	: FRAM-51M
EFPY	: 8.7	H. L. TEMP (F)	: 613
		C.L. TEMP (F)	: 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																7	2			9
PITTING																				0
OD S/IGA SP																			1	1
OD S/IGA TS																	53			53
ID SCC TS										3	2	1	7	14	1	2	6		48	84
ID SCC UB														7	3				1	11
FRET (PREH)																				0
FRET (AVB)														7	4	1	2		3	17
FRET (LP)																	1			1
HC FATIGUE																				0
ERR/CORR																				0
OTHER					6					1					1	63	6		1	78
TOT PLUGGED	0	0	0	0	6	0	0	0	0	4	2	1	7	28	9	73	70	0	54	254
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: R. Comby

PHONE NUMBER: 1-49-22-86-78

UTILITY : A. N. TRILLO 1

PLANT : TRILLO 1

PLUGGED : 9

EFPY : 4.5

TOTAL TUBES : 12,258

TUBE MATERIAL : I-800

SG MODEL : KWU-54GT

H. L. TEMP (F) : 619

C.L. TEMP (F) : 561

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																4				4
HC FATIGUE																				0
ERR/CORR																				0
OTHER												4				4	1			9
PLUGGED	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	8	1	0	0	13
UNPLUGGED																	[4]			[4]
TOT PLUGGED																				9
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Gustavo Bollini

PHONE NUMBER: 34-1-6516700

* This tube was pulled and four plugs were also removed.

UTILITY : PORTLAND GENERAL ELECTRIC

PLANT : TROJAN

PLUGGED : 2444

EFPY : 8.2

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 615

C.L. TEMP (F) : 552

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																		S		0
PITTING										3	3	3			3			H		12
OD S/IGA SP															146	123	1542	U		1811
OD S/IGA TS												2		7	40	22	14	T		85
ID SCC TS															56	2	13	D		71
ID SCC UB					9	10	333			1		36	1	7			10	O		407
FRET (PREH)																		W		0
FRET (AVB)																		N		0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER				1		53				3							1			58
TOT PLUGGED	0	0	0	1	9	63	333	0	0	7	3	41	1	14	245	147*	1580			2444
TOT SLEEVED																2	1061			1063
T. L. OUTAGE					1	1	1													3

UTILITY CONTACT: Greg Kent

PHONE NUMBER: 503-556-7716

* Two tubes, previously plugged, were restored to service via sleeving in 1990.

UTILITY : JAPAN ELECTRIC POWER COMPANY		TOTAL TUBES	: 13,528
PLANT : TSURUGA 2		TUBE MATERIAL :	I-600 TT
PLUGGED : 2		SG MODEL	: M41-51FA
EFPY : 5.7		H. L. TEMP (F)	: 612
		C.L. TEMP (F)	: 552

DEFECTS	<76	76	77	78	79	80	81	82	83	[illegible]	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																2				2
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: H. Takamatsu

PHONE NUMBER: 06-441-8821

UTILITY : FLORIDA POWER & LIGHT

PLANT : TURKEY POINT 3 (ORIGIONAL S. G.)

PLUGGED : 1986

EFPY : 5.2

TOTAL TUBES : 9780

TUBE MATERIAL : I-600 MA

SG MODEL : W-44

H. L. TEMP (F) : 602

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE		51			40	21														112
DENTING SP		136	604	1	690	259	59													1749
DENTING TS																				0
PITTING								R												0
OD S/IGA SP								E												0
OD S/IGA TS	34							P												34
ID SCC TS								L												0
ID SCC US		88						A												88
FRET (PREH)								C												0
FRET (AVB)								E												0
FRET (LP)								D												0
HC FATIGUE																				0
ERR/CORR				1																1
OTHER							2													2
TOT PLUGGED	34	275	604	2	730	280	61	0	0	0	0	0	0	0	0	0	0	0	0	1986
TOT SLEEVED																				0
T. L. OUTAGE	1		5		1		1													8

UTILITY CONTACT: G. L. BOYERS

PHONE NUMBER: 407-694-4909

UTILITY : FLORIDA POWER & LIGHT

PLANT : TURKEY POINT 3 (REPLACEMENT S. G.)

PLUGGED : 62

EFPY : 7.3

TOTAL TUBES : 9642 (REPLACEMENT)

TUBE MATERIAL : I-600 TT

SG MODEL : W-44F

H. L. TEMP (F) : 602

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																7		3		10
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								39			4		1			4		4		52
TOT PLUGGED	0	0	0	0	0	0	0	39	0	0	4	0	1	0	0	11	0	7	0	62
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: G. L. Boyers

PHONE NUMBER: 407-694-4909

UTILITY : FLORIDIA POWER & LIGHT

PLANT : TURKEY POINT 4 (ORIGIONAL S. G.)

PLUGGED : 2351

EFPY : 5.9

TOTAL TUBES : 9780

TUBE MATERIAL : I-600 MA

SG MODEL : W-44

H. L. TEMP (F) : 602

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE		5		21	6	39														71
DENTING SP	5	52	629	510	179	267	93													1735
DENTING TS																				0
PITTING									R											0
OD S/IGA SP									E											0
OD S/IGA TS	159								P											159
ID SCC TS									L											0
ID SCC UB		294							A											294
FRET (PREH)									C											0
FRET (AVB)									E											0
FRET (LP)									D											0
HC FATIGUE																				0
ERR/CORR																				0
OTHER						2	11	79												92
TOT PLUGGED	164	351	629	531	185	308	104	79	0	0	0	0	0	0	0	0	0	0	0	2351
TOT SLEEVED																				0
T. L. OUTAGE	3	6	5	1				1												16

UTILITY CONTACT: G. L. Boyers

PHONE NUMBER: 407-694-4909

UTILITY : FLORIDA POWER & LIGHT

PLANT : TURKEY POINT 4 (REPLACEMENT S. G.)

PLUGGED : 33

EFPY : 6.1

TOTAL TUBES : 9,642

TUBE MATERIAL : I-600 TT

SG MODEL : W-44F

H. L. TEMP (F) : 602

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																	1			1
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									31					1						32
TOT PLUGGED	0	0	0	0	0	0	0	0	31	0	0	0	0	1	0	0	1	0	0	33
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: G. L. Boyers

PHONE NUMBER: 407-694-4909

UTILITY : KOREA ELECTRIC POWER CO.

PLANT : ULJIN 1

PLUGGED : 0

EFPY : 4.3

TOTAL TUBES : 9,990

TUBE MATERIAL : I-600 TT

SG MODEL : FRAM-51 B

H. L. TEMP (F) : 613

C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C
TOT SLEEVED																				
T. L. OUTAGE																				

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

UTILITY : KOREA ELECTRIC POWER CO.	TOTAL TUBES : 9,990
PLANT : ULJIN 2	TUBE MATERIAL : I-600 TT
PLUGGED : 0	SG MODEL : FRAM-51 B
EFPY : 3.4	H. L. TEMP (F) : 613
	C.L. TEMP (F) : 546

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				
T. L. OUTAGE																				

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

UTILITY : KERNKRAFTWERK UNTERWESER GmbH

PLANT : UNTERWESER

PLUGGED : 0

EFPY : 12.1

TOTAL TUBES : 16,084

TUBE MATERIAL : I-800

SG MODEL : KWU

H. L. TEMP (F) : 604

C.L. TEMP (F) : 548

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: S. Odar / R. Bouecke

PHONE NUMBER: 49-9131-18-2077 / 49-9131-18-9410

UTILITY : A. N. V.

PLANT : VANDELLOS 2

PLUGGED : 217

EFPY : 4.7

TOTAL TUBES : 16,878

TUBE MATERIAL I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 620

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)															30	54	88	30		202
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER												11			1		2		1	15
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	11	0	0	31	54	90	30	1	217
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Gustavo Bollini

PHONE NUMBER: 34-1-6516700

UTILITY : GEORGIA POWER

PLANT : VOGTLE 1

PLUGGED : 15

EFPY : 6.4

TOTAL TUBES : 22,504

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 618

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER											* 6			1		4			4	15
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	6	0	0	1	0	4	0	0	4	15
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Forrest Hundley

PHONE NUMBER: 205-870-6998

* Shop Plugged

UTILITY : GEORGIA POWER

PLANT : VOGTLE 2

PLUGGED : 15

EFPY : 3.9

TOTAL TUBES : 22,504

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 618

C.L. TEMP (F) : 557

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER												*13	2							15
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	13	2	0	0	0	0	0	0	15
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Forrest Hundley

PHONE NUMBER: 205-870-6998

* Shop plugged

UTILITY : ENTERGY OPERATIONS

PLANT : WATERFORD 3

PLUGGED : 518

EFPY : 5.5

TOTAL TUBES : 18,700

TUBE MATERIAL : I-600 MA

SG MODEL : CE-3410

H. L. TEMP (F) : 604

C.L. TEMP (F) : 552

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)											298*		1	3	19		156*	7		484
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									25								9			34
TOT PLUGGED	0	0	0	0	0	0	0	0	25	0	298	0	1	3	19	0	165	7	0	518
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Mike Layton

PHONE NUMBER: 504-464-3454

* Preventively plugged

UTILITY : TENNESSE VALLEY AUTHORITY

PLANT : WATTS BAR 1

PLUGGED : 8

EFPY : 0.0

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 MA

SG MODEL : W-D3

H. L. TEMP (F) : 617

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									3			4				1				8
TOT PLUGGED	0	0	0	0	0	0	0	0	3	0	0	4	0	0	0	1	0	0	0	8
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: David Goetcheus

PHONE NUMBER: 615-751-7652

UTILITY : TENNESSEE VALLEY AUTHORITY

PLANT : WATTS BAR 2

PLUGGED : 5

EFPY : 0.0

TOTAL TUBES : 18,696

TUBE MATERIAL : I-600 MA

SG MODEL : W-D3

H. L. TEMP (F) : 617

C.L. TEMP (F) : 559

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER									3				2							5
TOT PLUGGED	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0	0	0	5
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: David Goetcheus

PHONE NUMBER: 615-751-7652

UTILITY : WCNOC

PLANT : WOLF CREEK

PLUGGED : 44

EFPY : 6.4

TOTAL TUBES : 22,504

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 618

C.L. TEMP (F) : 555

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)														19		2			5	26
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER										15				3						18
TOT PLUGGED	0	0	0	0	0	0	0	0	0	15	0	0	0	22	0	2	0	0	5	44
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: Gary Pendergrass / Glen Seier

PHONE NUMBER: 316-364-8831

UTILITY : KOREA ELECTRIC POWER CO.

PLANT : WOLSUNG 1

PLUGGED : 7

EFPY : 9.0

TOTAL TUBES : 14,232

TUBE MATERIAL : I-800 M

SG MODEL : FOS/WH(CANDU)

H. L. TEMP (F) : 590

C.L. TEMP (F) : 512

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)																				0
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER								7 *												7
TOT PLUGGED	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7
TOT SLEEVED																				
T. L. OUTAGE																				

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

* 3 plugged at shop, 4 plugged at PSI

UTILITY : YANKEE ATOMIC

PLANT : YANKEE ROWE

PLUGGED : 334

EFPY : 22.0

TOTAL TUBES : 6,480

TUBE MATERIAL : 304 SS

SG MODEL : W-13

H. L. TEMP (F) : 550

C.L. TEMP (F) : 496

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING	66	2	15	30			3	9		123	1		58	8		17				332
OD S/IGA SP																		S		0
OD S/IGA TS																		H		0
ID SCC TS																		U		0
ID SCC UB													2					T		2
FRET (PREH)																		D		0
FRET (AVB)																		O		0
FRET (LP)																		W		0
HC FATIGUE																		N		0
ERR/CORR																				0
OTHER																				0
TOT PLUGGED	66	2	15	30	0	0	3	9	0	123	1	0	60	8	0	17	0			334
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: J. K. Thayer

PHONE NUMBER: 508-779-6711

UTILITY : KOREA ELECTRIC POWER CO.

PLANT : YOUNGGWANG 1

PLUGGED : 47

EFPY : 6.0

TOTAL TUBES : 16,878

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 619

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)													2	1	4	1	5	2	4	19
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER											25				2				1	28
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	25	0	2	1	6	1	5	2	5	47
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

UTILITY : KOREA ELECTRIC POWER CO.

PLANT : YOUNGGWANG 2

PLUGGED : 49

EFPY : 5.8

TOTAL TUBES : 16,878

TUBE MATERIAL : I-600 TT

SG MODEL : W-F

H. L. TEMP (F) : 619

C.L. TEMP (F) : 556

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE																				0
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																				0
OD S/IGA TS																				0
ID SCC TS																				0
ID SCC UB																				0
FRET (PREH)																				0
FRET (AVB)															6	11	2	8	13	40
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER												9								9
TOT PLUGGED	0	0	0	0	0	0	0	0	0	0	0	9	0	0	6	11	2	8	13	49
TOT SLEEVED																				0
T. L. OUTAGE																				0

UTILITY CONTACT: KYOUNG-SIK JANG

PHONE NUMBER: 822-550-4940

UTILITY : COMMONWEALTH EDISON

PLANT : ZION 1

PLUGGED : 948

EFPY : 11.7

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 591

C.L. TEMP (F) : 530

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE							2	24	3	2	9	7		12				4		63
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP														11						11
OD S/IGA TS								12	19	37	64	75			69			29	20	325
ID SCC TS																		18	19	37
ID SCC UB							19	377												396
FRET (PREH)																				0
FRET (AVB)							4	53				1			1			2	1	62
FRET (LP)																				0
HC FATIGUE																				0
ERR/CORR																				0
OTHER							2	7	6		1			13	24				1	54
TOT PLUGGED	0	0	0	0	0	0	27	473	28	39	74	83	0	36	94	0	0	53	41	948
TOT SLEEVED												128		47	445			125	61	806
T. L. OUTAGE										1										1

UTILITY CONTACT: John Blomgren

PHONE NUMBER: 708-663-7215

UTILITY : COMMONWEALTH EDISON

PLANT : ZION 2

PLUGGED : 525

EFPY : 11.8

TOTAL TUBES : 13,552

TUBE MATERIAL : I-600 MA

SG MODEL : W-51

H. L. TEMP (F) : 591

C.L. TEMP (F) : 530

DEFECTS	<76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	TOTAL
WASTAGE							2		1		1		2	8				2		16
DENTING SP																				0
DENTING TS																				0
PITTING																				0
OD S/IGA SP																1				1
OD S/IGA TS									7				3	7				1		18
ID SCC TS													16	249	1	17		101		384
ID SCC UB										2	1		3	2	6	28		29		71
FRET (PREH)																				0
FRET (AVB)							11		7	4	2		3							27
FRET (LP)														6						6
HC FATIGUE																				0
ERR/CORR																				0
OTHER																1		1		2
TOT PLUGGED	0	0	0	0	0	0	13	0	15	6	4	0	27	272	7	47	0	134	0	525
TOT SLEEVED																82		170		252
T. L. OUTAGE															1					1

UTILITY CONTACT: John Blomgren

PHONE NUMBER: 708-663-7215