ATTACHMENT A

Marked-up Technical Specification Pages:

3/4 4-8
B 3/4 4-3

EJW2/024/3

SURVEILLANCE REQUIREMENTS (Continued)

5. Defect means an imperfection of such severity that it exceeds the plugging limit. A tube containing a defect is defective. Any tube which does not permit the passage of the eddy-current inspection probe shall be deemed a defective tube.

6. Plugging Limit means the imperfection depth at or beyond which the tube shall be removed from service because it may become unserviceable prior to the next inspection and is equal to ~~40%*~~ 54% of the nominal tube wall thickness, EXCEPT THAT THE PLUGGING LIMIT IS EQUAL TO 50% FOR LOCATIONS AT OR ABOVE THE TOP PARTIAL SUPPORT PLATE IN TUBE ROWS 117 THROUGH 120 INCLUSIVE.

7. Unserviceable describes the condition of a tube if it leaks or contains a defect large enough to affect its structural integrity in the event of an Operating Basis Earthquake, a loss-of-coolant accident, or a steam line or feedwater line break as specified in 4.4.5.3.c, above.

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

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

4.4.5.5 Reports

a. Following each inservice inspection of steam generator tubes, the number of tubes plugged in each steam generator shall be reported to the Commission within 15 days.

b. The complete results of the steam generator tube inservice inspection shall be included in the Annual Operating Report for the period in which this inspection was completed. This report shall include:

1. Number and extent of tubes inspected.

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

3. Identification of tubes plugged.

~~*This 40% plugging limit is not applicable during the cycle 7 operation up to June 30, 1986. If at any time during this period the unit enters any Modes other than Modes 1 and 2, or Mode 3 for greater than 24 hours, the unit shall be placed in cold shutdown and the tubes with indications greater than 40% through-wall penetration shall be removed from service prior to exceeding 200°F.~~ Remove

3/4.4.5 STEAM GENERATORS (Continued)

The plant is expected to be operated in a manner such that the secondary coolant will be maintained within those parameter limits found to result in negligible corrosion of the steam generator tubes. If the secondary coolant chemistry is not maintained within these parameter limits, localized corrosion may likely result in stress corrosion cracking. The extent of cracking during plant operation would be limited by the limitation of steam generator tube leakage between the primary coolant system and the secondary coolant system (primary-to-secondary leakage = 1 gallon per minute, total). Cracks having a primary-to-secondary leakage less than this limit during operation will have an adequate margin of safety to withstand the loads imposed during normal operation and by postulated accidents. Operating plants have demonstrated that primary-to-secondary leakage of 1 gallon per minute can readily be detected by radiation monitors of steam generator blowdown. Leakage in excess of this limit will require plant shutdown and an unscheduled inspection, during which the leaking tubes will be located and plugged.

Wastage-type defects are unlikely with the all volatile treatment (AVT) of secondary coolant. However, even if a defect of similar type should develop in service, it will be found during scheduled inservice steam generator tube examinations. Plugging will be required of all tubes with imperfections exceeding the plugging limit which, by the definition of Specification 4.4.5.4.a, is 40% of the tube nominal wall thickness. Steam generator tube inspections of operating plants have demonstrated the capability to reliably detect degradation that has penetrated 20% of the original tube wall thickness.

ATTACHMENT B

SAFETY EVALUATION

This is a request to revise Section 4.4.5.4 (steam generator) Acceptance Criteria of the Technical Specifications for St. Lucie Unit 1.

DESCRIPTION

Technical Specification 3/4.4.5 requires steam generator operability and specifies Surveillance Requirements to verify steam generator integrity. The current steam generator tube plugging limit as defined in 4.4.5.4 is 40% of the nominal tube wall thickness. The proposed change will specify a tube plugging limit of 54% for all regions except that a limit of 50% will apply to locations at or above the top support plate for tube rows 117 through 120, inclusive.

The proposed change specifies a more accurate tube plugging limit based on analysis to the criteria of Regulatory Guide 1.121,"Bases for Plugging Degraded PWR Steam Generator Tubes". In addition, the proposed change prevents unnecessary (1) plugging of tubes, (2) associated high personnel radiation exposure and (3) decreases in the steam generator heat transfer surface area.

The proposed steam generator tube plugging acceptance criteria have been established by analysis in CENC-1747 (Attachment D) in accordance with the provisions of Regulatory Guide 1.121. It was determined that the limiting event as regards to tube loading was a combination of Loss of Coolant Accident (LOCA) and Safe Shutdown Earthquake (SSE). The limiting event was found to control the allowable tube degradation in the region above the top support in tube rows 117 through 120. The analysis shows that tube degradation of up to 59% is acceptable for this region.

The allowable degradation in the remainder of the tube bundle, including the regions of tube rows 117 through 120 below the top support, is governed by the normal operating differential pressure criteria of Regulatory Guide 1.121. The criteria states that during normal operating condition no tube will a) be stressed beyond the elastic range of the tube material and b) display a factor of safety of less than 3 against tube rupture. The analysis shows that tube degradation of up to 63% meets the nornmal operating differential pressure criteria.

The allowable tube wall degradation was also determined for the effects of Main Steam Line Break (MSLB) combined with SSE. It was determined, for this event, that tube degradation of up to 66% is acceptable; therefore MSLB combined with SSE is not controlling.

In establishing the Technical Specification limits for St. Lucie Unit 1, the above allowable degradation was reduced by 10% to cover Eddy Current Testing (ECT) measurement error and continued degradation through the next fuel cycle. Justification for the 10% allowance is provided in Attachment C.

ATTACHMENT C

JUSTIFICATION FOR 10% UNCERTAINTY ALLOWANCE FOR ECT ERROR AND CONTINUED OPERATION FOR THE DURATION OF NEXT CYCLE

ATTACHMENT C, PART I

ALLOWANCE FOR ECT ERROR

Accuracy in measuring the depth of tube defects using the Eddy Current Testing (ECT) method is a variable, depending on the size (voltage) and depth of the tube defect as well as the nature of tube material attack. Large volume defects produced by mechanisms such as chemical "wastage" or mechanical wear are usually overestimated by ECT and the defect sizing requires no additional allowance. This position has been supported by CE-sponsored testing on behalf of Consumers Power and is referenced in Regulatory Guide 1.121, Footnote 4 (Reference C1-3). Small volume deep pitting defects are sometimes underestimated by ECT. CE demonstrated in Reference C1-5, however, that tubes with clusters of nearly through-wall pitts, still possess more than adequate margins of safety. Therefore, only crack-like defects (both IGSCC and IGA) have the potential for uncertainty, regarding the conservatism of the ECT estimate. In Reference C1-4, CE and FP&L demonstrated that IGSCC defects present no safety concern due to their characteristic "leak before break" behavior, when occurring in CE's very ductile (35 ksi $\leq$ yield stress $\leq$ 55 ksi) Inconel 600 tubes.

The purpose of this document is to present significant evidence obtained through prototypically degraded tube testing by both CE and Battelle-Pacific Northwest Laboratories (within an NRC funded project, Reference C1-1), that ECT testing of tubes with chemically induced intergranular attack (IGA) provides <u>functionally</u> correct or conservative defect depths. This means that while ECT may underestimate somewhat the deepest isolated penetration of IGA defects, the tube's burst pressure performance will be indicative of the ECT estimate, usually with some additional margin beyond that required from Reg. Guide 1.121 (Reference C1-3). This phenomenon can be explained by examining the photo-micrograph shown in Figure C2-1. The depth of general attack (represented by the dashed line) will dictate the burst pressure. This general attack is closely predicted

by ECT examination. The deep isolated penetration (shown within the circle) is typically what is sought and reported as the defect depth obtained from metallography. This deep isolated penetration will have virtually no effect on the burst pressure performance of the defected tube, due to the reinforcement provided by adjacent unattacked material. It is for the above reasons that ECT measurements provide functionally accurate data with which to predict tube burst pressures and use as a basis to calculate safety margins.

Tables C1-1 and C1-2 contain data that was specifically generated to evaluate IGA typical of that found, through removed tube metallography, in the St. Lucie 1 steam generators. Table C1-3 contains IGA data previously generated for IGA patterns found in the Palisades steam generator as well as burst data from nondegraded tubes for purpose of control and comparison. Data in all three tables was generated at high temperature (temp. $\simeq 600^{\circ}$F) using chemically induced IGA degraded tubes. The burst pressure versus defect depth data, estimated by ECT, matched extremely well with theoretical predictions, as can be observed in Figure C1-1. It is significant to note from Figure C1-1 that the region of tube differential pressure operation (with respect to tube plugging limits of either the present 40% or the proposed 54% was fully outside of the defected tube burst pressure data band. This separation includes the safety factor of three (3) on burst pressure required by Reg. Guide 1.121, Reference C1-3.

Several additional points should be made regarding Figure C1-1. The reference burst pressure curve for local tube wall degradation is determined from the following relationship:

$$P_B = 2 \sigma_u [(b-a)/(b+a)]$$

Where P_B = Burst Pressure

σ_u = Tube Ultimate Strength = 80 ksi @ 600 $^{\circ}$F

b = Tube Outside Radius (as degraded)

a = Tube Inside Radius

If a nondegraded tube or a uniformly thinned tube is being considered, the relationship for predicting burst pressure must be corrected to account for an increasing pressure radius due to tube swelling as a result of gross yielding before burst. The following correction is made:

σ_c is subsituted for σ_u in the above equation where:

$$\sigma_c = 2\,\sigma_u\,(3)^{-\left(\frac{n+1}{2}\right)} = 0.85\,\sigma_u$$

for $n = 1 - \sigma_y/\sigma_u$

and σ_y = Tube Yield Strength = 35 ksi @ 600°F

It is for these considerations that the nondegraded test samples and Palisades circumferential IGA test samples (360° by 3.0 inches long) burst data fell between the two reference curves. St. Lucie IGA samples, which were local in nature, displayed burst data above the upper curve, typically. Test samples 1-5, 2-17 and 2-23 were functionally under-called by 5% of nominal tube wall or less.

Figures C1-2 through C1-6, illustrate similar results obtained by Battelle-Pacific Northwest Laboratories (see Reference C1-1). Figures C1-2, C1-3 and C1-4 illustrate the uncertainty with regard to the ECT estimate of the EDM slot depth for the PNL test samples. However, as was the case for the CE burst testing, the ECT estimate proved to be functionally correct or conservative for purposes of predicting the burst pressure. Figure C1-5 illustrates the conservatism of the data (a portion of which is EDM crack simulation) when compared to tube plugging limits similar to that sought by Florida Power & Light for the St. Lucie 1 steam generators. Figure C1-6 compares the St. Lucie 1 operating tube differential pressure (including a safety factor of three on burst pressure) and tube geometry with the Battelle-Pacific Northwest Laboratory results for EDM cracks. The PNL data supports an allowable tube degradation of up to 63% for St. Lucie 1 parameters. This comparison corroborates the testing and analysis results developed by CE as previously discussed.

Based on the foregoing discussion, ECT estimates of IGA degradation of tubes typical of those used in the FP&L St. Lucie 1 steam generator, have proven to be functionally correct for purposes of predicting tube burst pressure. In the majority of cases, the data was conservative over and above the factor of safety of three, required by Regulatory Guide 1.121. The maximum nonconservative prediction by ECT, with regard to burst pressure, was 5% of tube wall. The results of CE's evaluation was confirmed by data obtained by PNL as part of an NRC funded research project dealing with degraded tube burst pressure and ECT examination.

REFERENCES

C1-1. NUREG/CR-0718, PNL-2937, "Steam Generator Tube Integrity Program, Phase I Report," by J.M. Alzheimer, et al., September 1979.

C1-2. NUREG/CR-3561, PNL-4695, "Eddy Current Round Robin Test on Laboratory Produced Intergranular Stress Corrosion Cracked Inconel Steam Generator Tubes," by R. L. Bickford, et al., January 1984.

C1-3. Regulatory Guide 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," August 1976.

C1-4. CENC-1740, "Tube Burst and Leakage Testing of IGA and IGSCC Defects Representative of Those Found in the St. Lucie, Unit One Steam Generators," by W. J. Heilker, et al., August 1986.

C1-5. CENC-1497, Revision 3, "Millstone II Steam Generator Analysis for Allowable Tube Degradation due to Pitting Attack Between Tubesheet and First Support," W. J. Heilker and P. L. Anderson, January 1982.

C1-6. "Steam Generator Tube Burst and Collapse Predictions," by Milton Vagins, Presented at the Sixth Water Reactor Safety Research Information Meeting Held at the National Bureau of Standards, Gaithersburg, Maryland, November 6-9, 1978.

IGA TUBE DEFECTS-CORRELATION WITH BURST PRESSURE

FP&L ST. LUCIE 1 S.G. TUBE BURST TEST DATA - SUPP. 2

TABLE C1-1

Tube	Defect Dimensions		Tested	Standard ECT Basis			Metallography Basis (Max. Depth)		
Sample I.D.[1]	Axial Length (In.)	Circum. Extent (Deg.)	Burst Pressure (psi)	Defect Depth (% Wall)	Predict. P_{Burst} (psi)	P_{Test} / $P_{Prdt.}$ -	Defect Depth (% Wall)	Predict. P_{Burst} (psi)	P_{Test} / $P_{Prdt.}$ -
Testing Conducted at 600°									
2-1	1.0	7.5°	>9150	65	4007	NA[2]	33	7499	NA[2]
2-4	1.0	7.5°	6400	48	5882	1.09	59	4674	1.37
2-5	1.0	7.5°	7750	56	5005	1.55	41	6641	1.17
2-6	1.0	7.5°	>4200	55	5115	NA[3]	46	6100	NA[3]
2-7	1.0	7.5°	>8500	28	8031	NA[2]	35	7285	NA[2]
2-8	1.0	7.5°	>4600	56	5005	NA[3]	54	5225	NA[3]
2-12	1.0	7.5°	4800	61	4452	1.08	68	3672	1.31
2-13	1.0	7.5°	6600	45	6208	1.06	54	5225	1.26
2-14	1.0	7.5°	7250	50	5664	1.28	63	4230	1.71
2-17	1.0	7.5°	4100	58	4785	0.86	74	2996	1.37
2-21	1.0	7.5°	7800	40	6749	1.16	65	4007	1.95
2-23	1.0	7.5°	4700	53	5335	0.88	66	3895	1.21

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1 The above twelve samples comprise <u>all</u> burst test data. missing numbers represent unsuccessful IGA flaw implementation.

2 Maximum safe test vessel pressure was reached. The data are plotted since they represent lower bound burst pressure.

3 These samples developed small through wall leaks and could not be pressurized to burst. While the data are not plotted, they are meaningful in that they demonstrate "leak before break" behavior.

IGA TUBE DEFECTS-CORRELATION WITH BURST PRESSURE

FP&L ST. LUCIE 1 S.G. TUBE BURST TEST DATA - SUPP. 1

TABLE C1-2

Tube Sample I.D.	Defect Dimensions Axial Length (In.)	Defect Dimensions Circum. Extent (Deg.)	Tested Burst Pressure (psi)	Standard ECT Basis Defect Depth (% Wall)	Standard ECT Basis Predict. P_{Burst} (psi)	Standard ECT Basis $\frac{P_{Test}}{P_{Prdt.}}$ -	Metallography Basis (Max. Depth) Defect Depth (% Wall)	Metallography Basis (Max. Depth) Predict. P_{Burst} (psi)	Metallography Basis (Max. Depth) $\frac{P_{Test}}{P_{Prdt.}}$ -
Testing Conducted at Approx. 565°F									
1-1	1.0	90°	>9600	15	9396	NA	18	9083	NA
1-2	1.0	90°	>8500	35	7285	NA	20	8873	NA
1-3	1.0	90°	6600	45	6208	1.06	69	3559	1.85
1-4	1.0	90°	>8000	50	5664	NA	40	6749	NA
1-5	1.0	90°	3500	65	4007	0.87	74	2996	1.17
1-6	1.0	90°	4650	85	1742	2.67	78	2542	1.83
1-7	1.0	180°	>8500	20	8873	NA	13	9603	NA
1-8	1.0	180°	>8000	40	6749	NA	42	6533	NA
1-9	1.0	180°	6650	50	5664	1.17	63	4230	1.57
1-10	1.0	180°	3450	90	1166	2.96	75	2883	1.20
1-11	1.0	360°	>8500	25	8348	NA	32	7606	NA
1-12	1.0	360°	>8500	40	6749	NA	17	9187	NA
1-13	1.0	360°	5900	50	5664	1.04	58	4785	1.23
1-14	1.0	360°	5550	70	3447	1.61	63	4230	1.31

IGA TUBE DEFECTS-CORRELATION WITH BURST PRESSURE

CPC PALISADES S.G. TUBE BURST TEST DATA

TABLE C1-3

Tube Sample I.D.	Defect Dimensions: Axial Length (In.)	Defect Dimensions: Circum. Extent (Deg.)	Tested Burst Pressure (psi)	Standard ECT Basis: Defect Depth (% Wall)	Standard ECT Basis: Predict. P_{Burst} (psi)	Standard ECT Basis: $\frac{P_{Test}}{P_{Prdt.}}$ -	Metallography Basis (Max. Depth): Defect Depth (% Wall)	Metallography Basis (Max. Depth): Predict. P_{Burst} (psi)	Metallography Basis (Max. Depth): $\frac{P_{Test}}{P_{Prdt.}}$ -
Uniform Circumferential IGA Tested at 600°F (1974)									
P-1	3.0"	360°	4625	53	4535*	1.02	58	4067*	1.14
P-12	3.0"	360°	4125	56	4255*	0.97	58	4067*	1.01
P-13	3.0"	360°	5950	43	5461*	1.09	46	5185*	1.15
P-14	3.0"	360°	6000	45	5277*	1.14	43	5461*	1.10
2 Samples	3.0"	360°	450	-	-	-	100	0	N/A
Local 20% Wall Thinning + IGA Tested at 600°F (1974)									
P-39	0.5"	75°	7500	49	5773	1.29	54	5225	1.44
P-40	0.5"	75°	6500	55	5115	1.27	77	2656	2.45
P-42	0.5"	75°	5300	50	5664	0.94	70	3447	1.54
3 Samples	0.5"	75°	2400-3300	-	-	-	100	0	NA
Nondegraded Tubes Tested at 600°F (1975)									
A-1	NA	NA	9550	0	9300*	1.03	NA	NA	NA
A-2	NA	NA	9600	0	9300*	1.03	NA	NA	NA
A-3	NA	NA	9850	0	9300*	1.06	NA	NA	NA
A-4	NA	NA	10,150	0	9300*	1.09	NA	NA	NA
A-5	NA	NA	10,150	0	9300*	1.09	NA	NA	NA
B-1	NA	NA	10,200	0	9300*	1.10	NA	NA	NA
B-2	NA	NA	10,350	0	9300*	1.11	NA	NA	NA

Note* - Based on General Surface Attack (Corrected for Tube Swelling)

IGA TUBE BURST TEST DATA - LABORATORY DEFECTS

GEOMETRY: TUBE O.D. = 3/4 INCH
WALL t = 0.048 INCH

MATERIAL: INCONEL 600 ANNEALED
CE SPEC.: 55 KSI $\geq \sigma_y \geq$ 35 KSI
MILL TEST: $\sigma_u \geq$ 90 KSI
@ 600°F: $\sigma_u \geq$ 80 KSI

DEFECT KEY:
○ ST. LUCIE IGA
⊘ ST. LUCIE IGA (UNBURSTED)
◇ PALISADES WASTAGE + IGA
□ PALISADES CIRCUM. IGA
△ CE NONDEGRADED 0.048 IN. WALL

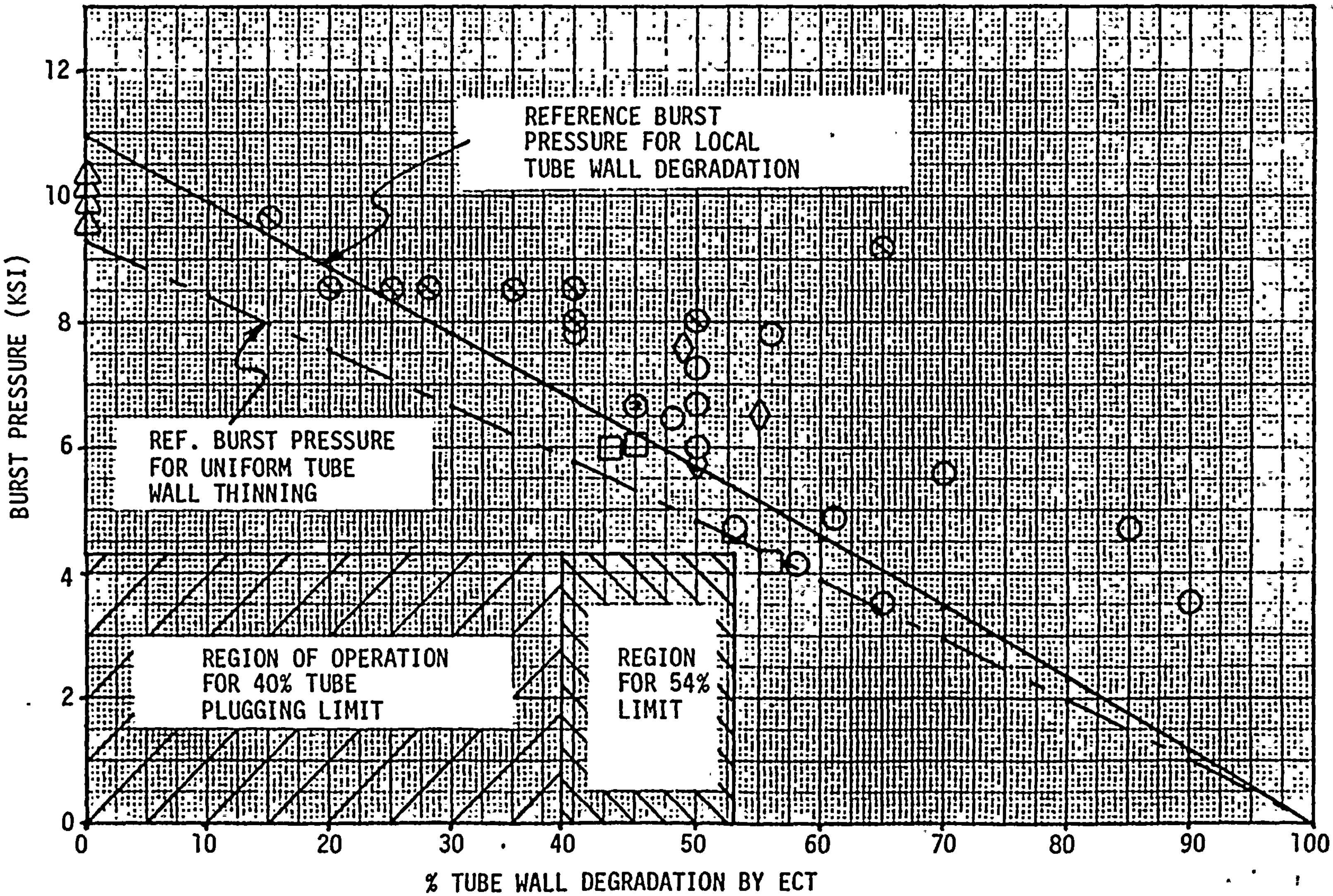


FIGURE C1-1

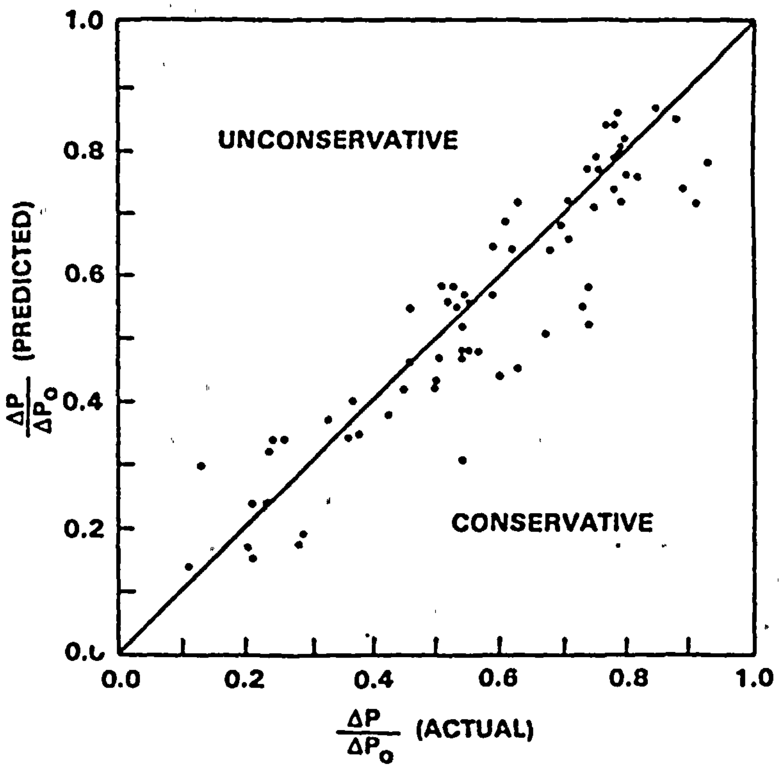


FIGURE C1-2 Comparison of Predicted and Actual Burst Pressure Parameters for All EDM Slot Specimens

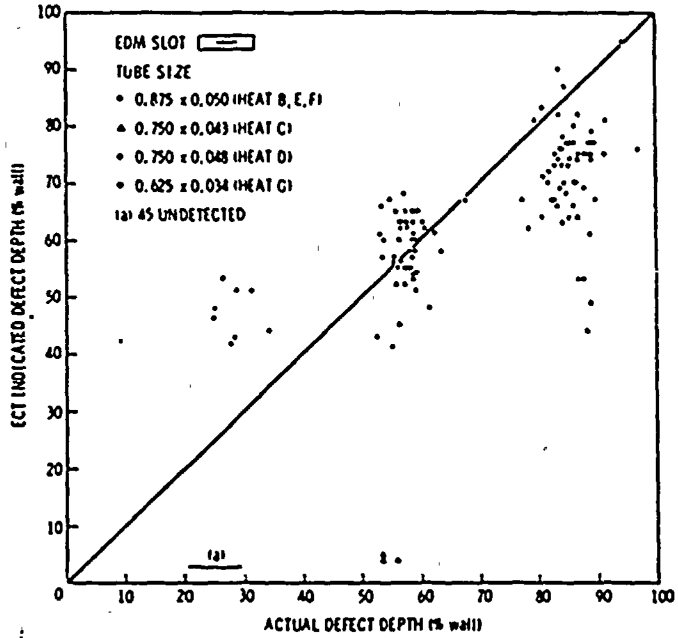


FIGURE C1-3 Eddy-Current Indicated Defect Depth Versus Actual Depth for EDM Slot Specimens

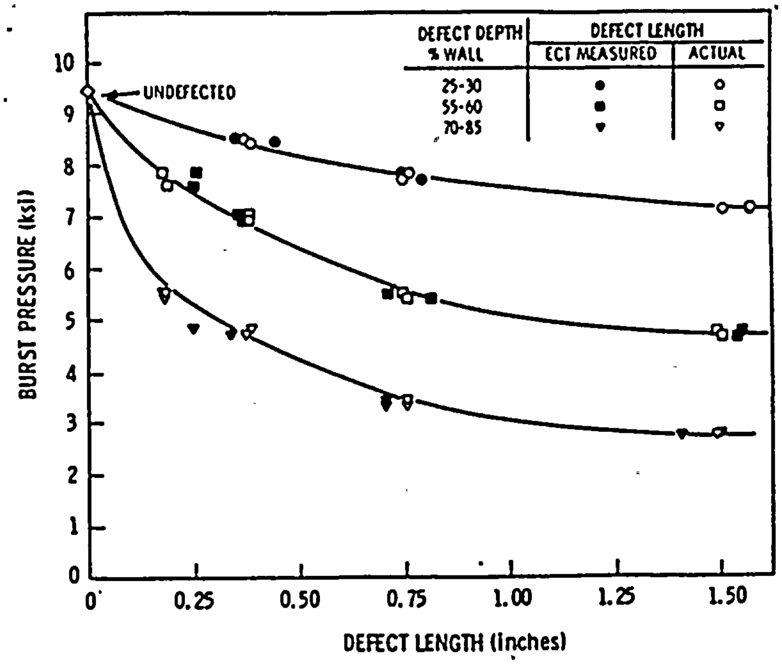


FIGURE C1-4 Burst Pressure Versus Defect Length for EDM Slot Heat B (0.875 x 0.050) Tubing

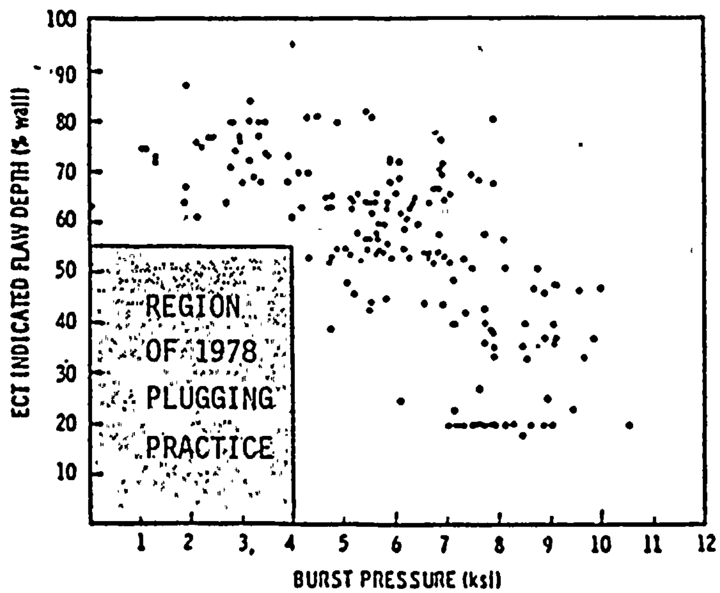
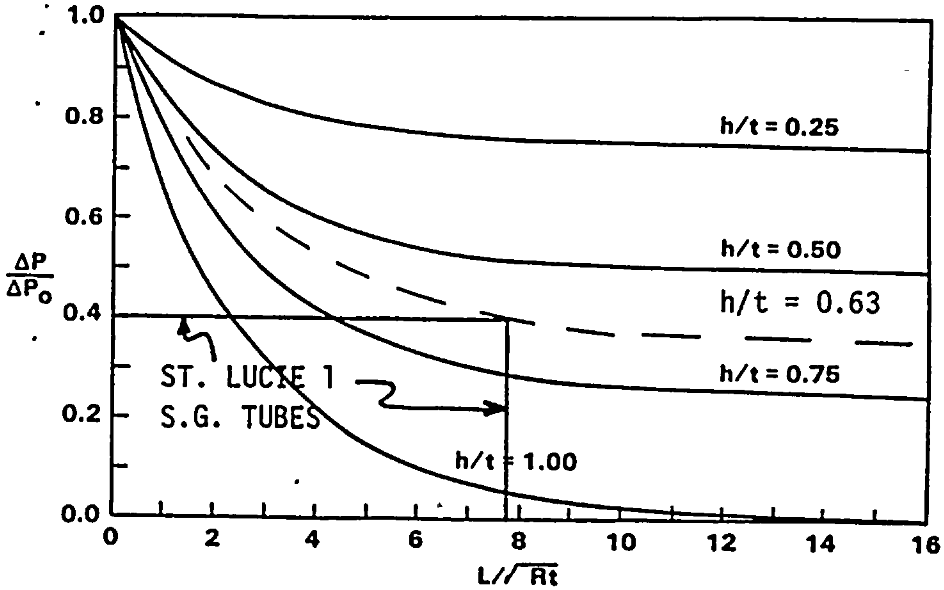


FIGURE C1-5 ECT Indicated Flaw Depth Versus Burst Pressure for Various Flaw Types, Ref. C1-6.

[illegible]



$$\frac{\Delta P}{\Delta P_o}\text{(PREDICTED)} = 1 - \frac{h}{t} + \frac{h}{t} e^{-0.373 \frac{L}{\sqrt{Rt}}}$$

<u>FIGURE C1-6</u> Burst Pressure Parameter Prediction Curves for EDM Slot Specimens - Length Parameter Variation

ATTACHMENT C, PART II

IGA GROWTH RATES FOR THE ST. LUCIE STEAM GENERATORS

Intergranular attack (IGA) has occurred at locations within the sludge piles and at tube support locations in the steam generators at St. Lucie-1. The postulated environment producing this IGA is acidic sulfates which apparently entered the steam generators with make-up water. Acidic sulfates have been identified in several studies (1 , 2 , 3) as being capable of producing IGA in Alloy 600 steam generator tubes. Although the ability of acid sulfates to produce IGA has been demonstrated, the rate at which sulfate induced IGA defects propagate has not been established. [redacted]

IGA is the most pervasive form of corrosion affecting the secondary side of steam generator tubes. Although seawater sites are not immune to this type of corrosion, IGA is more common at freshwater sites. Essentially all fresh water site PWRs with significant operating times have experienced IGA. At these locations, the fresh water used for condenser cooling tends to become alkaline when concentrated and, as a result, most of the studies of IGA have used alkaline environments. Table 1, extracted from (1), pr[redacted] IGA propagation rates for Alloy 600 at 650^{o}F in various alkaline environments. These data indicate IGA propagation rates of from 2 to approximately 8 mils per year.

C-E conducted a literature survey to determine if propagation rate data were available for Alloy 600 in acid sulfate environments at typical operating temperatures. Limited data were available. Reference (3) presented data on IGA and other forms of corrosion in Alloy 600 heat transfer tubes in a 19 tube model boiler test which operated for 358 days with a secondary environment severely faulted with simulated acidified (H_2SO_4) cooling tower water. The nominal sulfate level for this test was 40 ppm. Post-test destructive examination indicated IGA was present in Alloy 600 in various metallurgi[redacted] conditions. At the locations examined, the depth of IGA was 0.7, 1.0 and [redacted] mils which is equivalent to propagation rates of 0.7 mpy, 1.0 mpy and 2.2 mpy.

Reference (4) described a pot boiler test designed to assess the effects of sulfuric acid on the corrosion of steam generator materials under high temperature heat transfer conditions. This test operated for 122 days with an average sulfate level of 270 ppb. IGA was noted in two locations in the post-test examination. The estimated depths of attack were 1 and 2 mils which corresponded to propagation rates of 3 and 6 mpy, respectively.

In a third test (5), a pot boiler operated at an average sulfate level of 85 ppm for 214 days. IGA, with a maximum depth of 4.6 mils, was present at two locations examined during the destructive examination. This corresponds to a propagation rate of 7.8 mpy. However, at these locations, the average depth of IGA was 2-4 grains (1.5 mils) which is equivalent to an average growth rate of 2.5 mpy.

Table 2 tabulates the IGA growth rate data discussed above. The data show some variation, as expected. Comparison with Table 1 also suggests somewhat lower growth rates for Alloy 600 in sulfates as compared to caustic solutions. This reflects a difference in the corrosivity of the environments and lower temperature for the sulfates test which will result in reduced growth rates. Based on a review of the data, an assumed IGA growth rate of 2.5 mils/year is appropriate for establishing a cycle-to-cycle operation allowance for the St. Lucie-1 steam generator tubes if IGA is presumed to be progressing and if the conditions promoting IGA still exist in the steam generators. This number is judged conservative because changes to the make-up water system at St. Lucie-1 has resulted in a reduction in the quantity of sulfates entering the steam generators.

Recent re-analysis of ECT data from several St. Lucie-1 steam generator inspections indicates that there has been no substantial defect growth for a least two cycles (6). C-E judges that this is the result of improved water chemistry with respect to reduction of sulfates entering the steam generator via the make-up water systems. This action may have eliminated the conditions required for the development and propagation of IGA. This data supports a zero growth per cycle operational allowance. However, for conservatism, a 5 percent per cycle allowance is appropriate.

REFERENCES

1. EPRI NP-3046, Evaluation of Condensate Polishers, EPRI Research Project 623-3, Final Report, June 1983.

2. EPRI NP-3138, PWR Model Steam Generator Corrosion Studies, EPRI Research Project 623-1, Final Report, June 1983.

3. EPRI NP-3044, Corrosion Performance of Alternative Steam Generator Materials and Designs, Volume 3, July 1983.

4. CE-NSPD-188, The Effect of Sulfuric Acid on the Corrosion of Steam Generator Materials Under High Temperature Heat Transfer Conditions.

5. Unpublished C-E data.

6. Private communication, Frank Carr of FP&L.

Table 1

IGA GROWTH RATES DATA FOR
ALLOY 600 IN CAUSTIC SOLUTIONS

Environment	Duration, Days	Average Corrosion Rate, mils/year
Caustic	84 - 91	6.5
Caustic + 12% Na_2SO_4 12% SiO_2 12% Na_2HPO_4 12% Na_2CO_3 12% NaF	21 - 180	4.5 - 8.3
Caustic + 12% NaCl 12% Al 12% $MgSO_4$ 12% $CaSO_4$	63 - 180	2 - 3

Table 2

IGA GROWTH RATE DATA FOR
ALLOY 600 IN ACID SULFATE SOLUTIONS

Test	Duration, Days	Corrosion Rate, mils/year
1	358	0.7
		1.0
		2.2
2	122	3.0
		6.0
3	214	2.5*
		2.5

* Average value, maximum value was 7.8 mpy

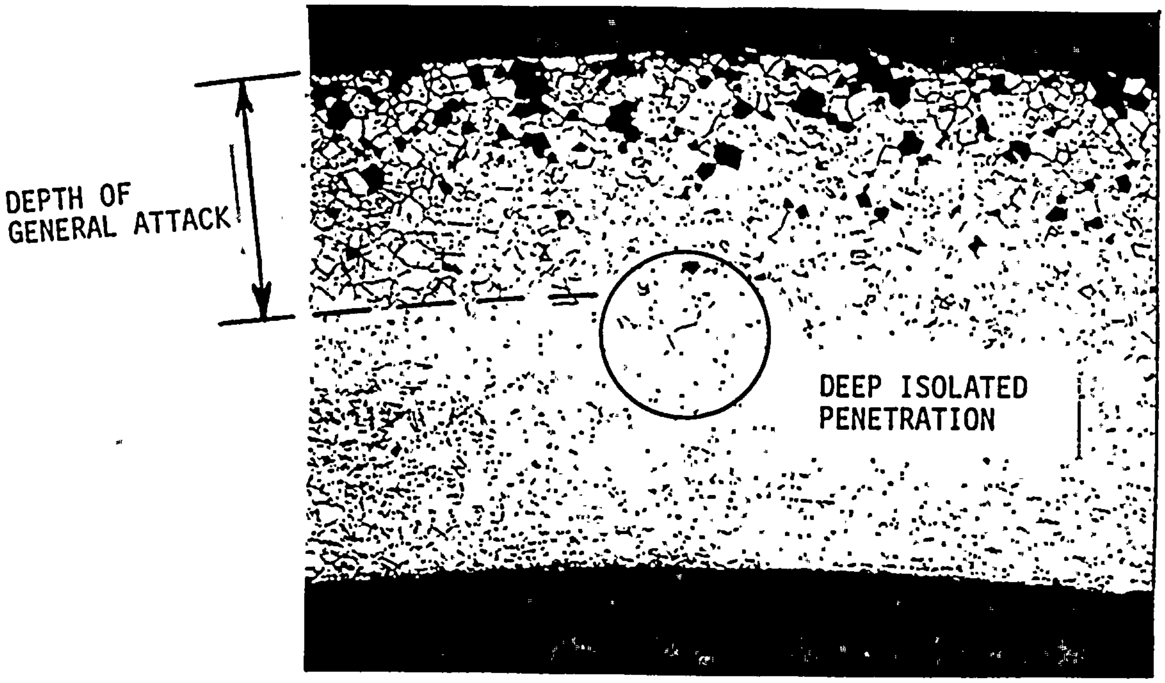


FIGURE C2-1
- IGA ATTACK - TUBE SAMPLE 78110, 50X -
MAX PENETRATION - 56%, 1 to 3 VOLTS

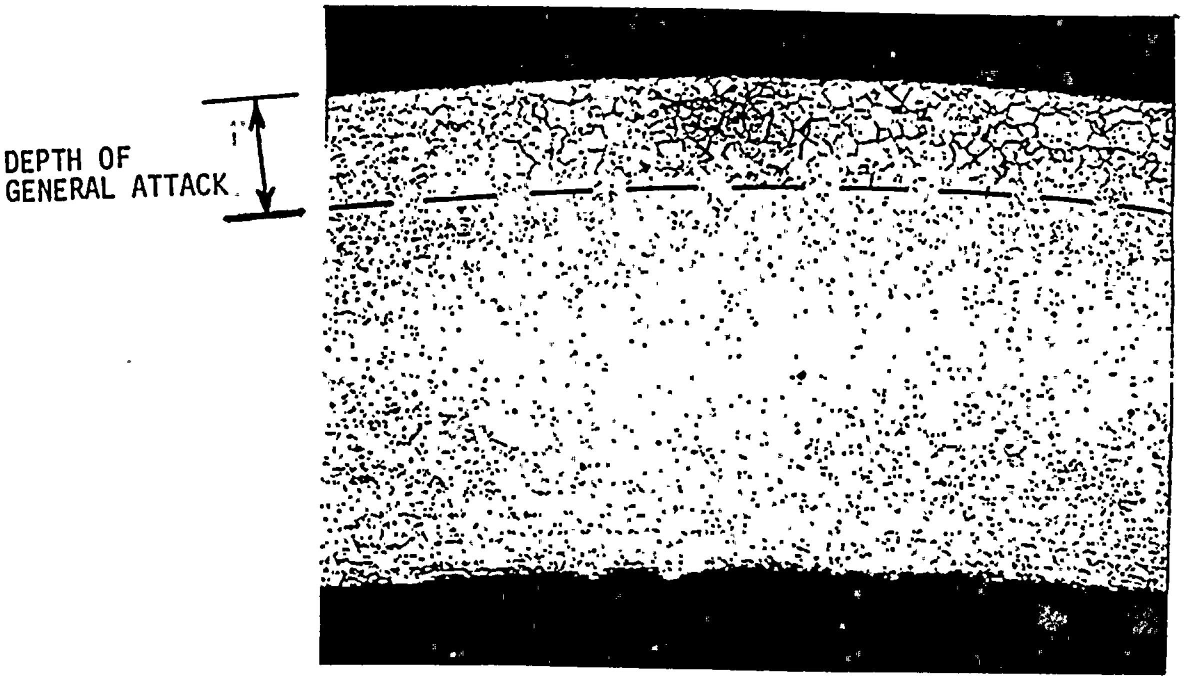


FIGURE C2-2
IGA ATTACK - TUBE SAMPLE 78109,
50X AVG PENETRATION - 25%,
0.1 to 0.4 VOLTS

ATTACHMENT D

CENC-1747, St. Lucie 1 Steam Generator Allowable Tube Wall Degradation, October 1986.