



MPR Associates, Inc.
320 King Street
Alexandria, VA 22314

CALCULATION TITLE PAGE

Client FLORIDA POWER	Page 1 of 7
Project CR UNIT 3 STEAM GENERATOR	Task No. 102-071
Title ALLOWABLE TUBE WALL DEGRADATION FOR PIT-TYPE DEFECTS	Calculation No. 102-071-HWM 3

Preparer/Date	Checker/Date	Reviewer/Date	Rev. No.
HWMCCOY 3-25-94	A. Zarechnak 3-25-94	A. Zarechnak 3-25-94	0



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320 King Street
Alexandria, VA 22314

RECORD OF REVISIONS

Calculation No. 102-071-HWM3	Prepared By HWMCCURDY	Checked By A. Zaccaro	Page 2
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Revision	Description
0	ORIGINAL ISSUE



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320 King Street
Alexandria, VA 22314

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SUMMARY

THIS CALCULATION DETERMINES THE ALLOWABLE TUBE WALL DEGRADATION FOR CR UNIT 3 STEAM GENERATOR TUBES FOR PIT-TYPE, OUTSIDE - DIAMETER INITIATED DEFECTS. BASED ON ACTUAL MATERIAL PROPERTIES, THE REQUIRED REMAINING WALL THICKNESS IS 0.0029 IN. TO AVOID DEVELOPING A LEAK DURING A STEAM LINE BREAK ACCIDENT. THIS EQUATES TO A DEGRADATION OF ABOUT 91.5% OF TUBE WALL.



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Alexandria, VA 22314

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THE PURPOSE OF THIS CALCULATION IS TO DETERMINE THE ALLOWABLE WALL DEGRADATION FOR CRYSTAL RIVER (CR) UNIT 3 STEAM GENERATOR TUBES FOR PIT-TYPE, OUTSIDE DIAMETER (OD) INITIATED DEFECTS.

BURST-TEST DATA IS CONTAINED IN REFERENCE 1 FOR TUBES WITH ELLIPTICAL-TYPE DEFECTS WHICH WERE MACHINED PART WAY THROUGH THE WALL.

THIS DATA IS CLOSELY APPLICABLE BUT MUST BE ADJUSTED FOR THE DIFFERENCE IN THE MATERIAL ULTIMATE STRESS BETWEEN THE TESTED TUBING AND THE CR UNIT 3 STEAM GENERATOR TUBING.

BURST PRESSURE RESULTS FOR $0.625\text{in} \times 0.034\text{in}$ TUBING ARE SHOWN IN FIGURE 21 OF REFERENCE 1. (CR UNIT 3 TUBING IS THE SAME $0.625\text{in} \times 0.034\text{in}$ PER REFERENCE 2, TABLE 3-4). FIGURE 21 IS



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HW McCurdy

Checked By

A. Zaccaro

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SHOWN BELOW INCLUDING A "BEST-FIT" LINE.

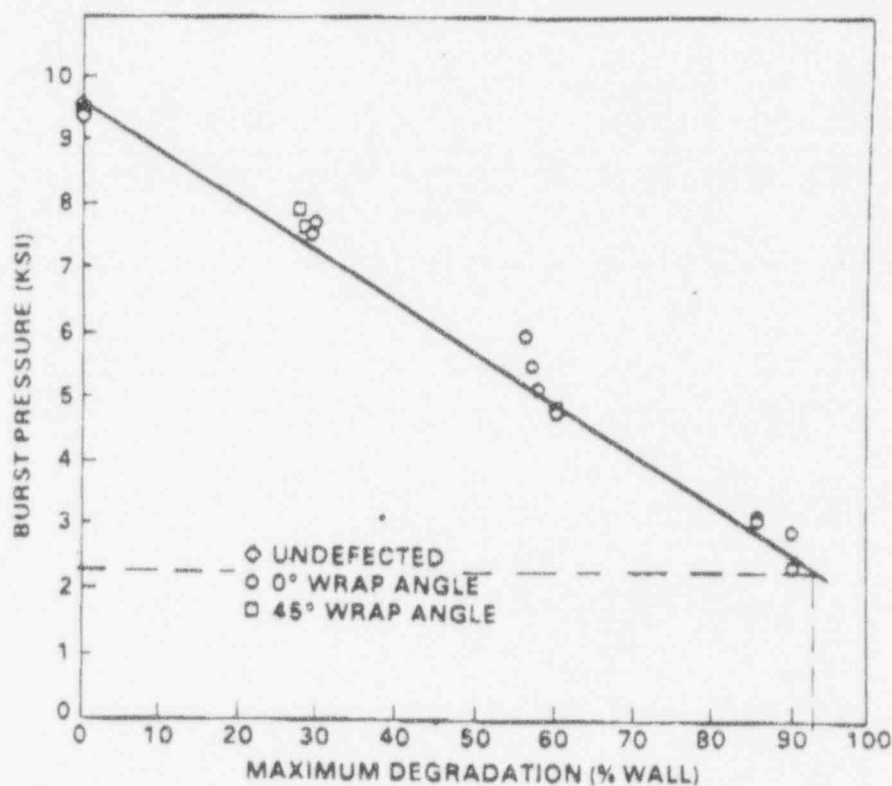


FIGURE 21. Burst Pressures for 0.625 x 0.034 in. Elliptical Wastage

FROM THE ABOVE FIGURE FOR A BURST PRESSURE OF 2250 PSI (THE NORMAL REACTOR COOLANT SYSTEM FROM REF. 2, PG. G-3), THE ALLOWABLE WALL DEGRADATION IS 92% WALL. THE REQUIRED.



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REMAINING WALL THICKNESS IS,

$$t_r = (1 - 0.92) \cdot .034 \text{ in.} = 0.0027 \text{ in.}$$

FROM REFERENCE 3, THE ADJUSTED REMAINING WALL THICKNESS WITH THE CR UNIT 3 ACTUAL MATERIAL PROPERTIES (AT OPERATING TEMPERATURE) IS,

$$t_r = 0.0027 \text{ in.} \cdot \frac{99.8 \text{ ksi}}{92.9 \text{ ksi}} = 0.0029 \text{ in.}$$

THE WALL DEGRADATION IS,

$$\text{DEGRADATION} = 1 - \frac{0.0029 \text{ in.}}{.034 \text{ in.}} = 0.915 \text{ or } 91.5\%$$



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REFERENCES

1. NUREG/CR-0277 (DNL-2684), "STEAM GENERATOR TUBE INTEGRITY PROGRAM - ANNUAL PROGRESS REPORT JAN. 1 TO DEC. 31, 1977," BATTALIA PACIFIC NORTHWEST LABS, AUGUST 1978.
2. BAW-10146, "DETERMINATION OF MINIMUM REQUIRED TUBE WALL THICKNESS FOR 177-FA DUCS-THROUGH STEAM GENERATORS," BABCOCK+WILCOX, APRIL 1980.
3. MPR CALCULATION 102-071-HWM-1, REV. NO. 0, DATED 1-12-94.

NUREG/CR-0277
PNL-2684
R5

STEAM GENERATOR TUBE INTEGRITY PROGRAM

Annual Progress Report
January 1 — December 31, 1977

M. Vagins
J. M. Alzheimer R. L. England
C. J. Morris R. A. Clark

Manuscript Completed: June 1978
Date Published: August 1978

Battelle Pacific Northwest Laboratory
Richland, WA 99352

Division of Reactor Safety Research
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Under FIN No. B-2097

~~7904130373~~ 3pp

ADREG/KR-0227

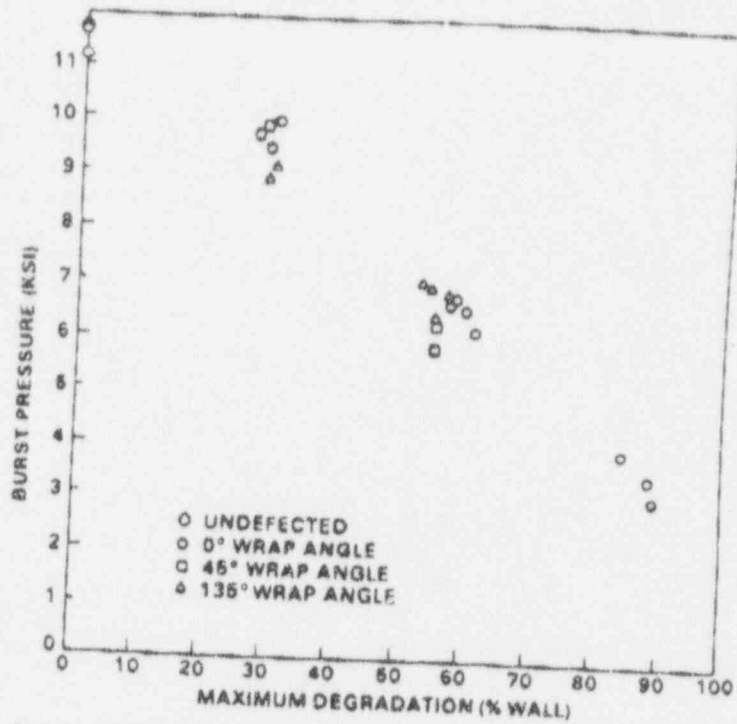


FIGURE 20. Burst Pressures for 0.750 x 0.050 in. Elliptical Wastage

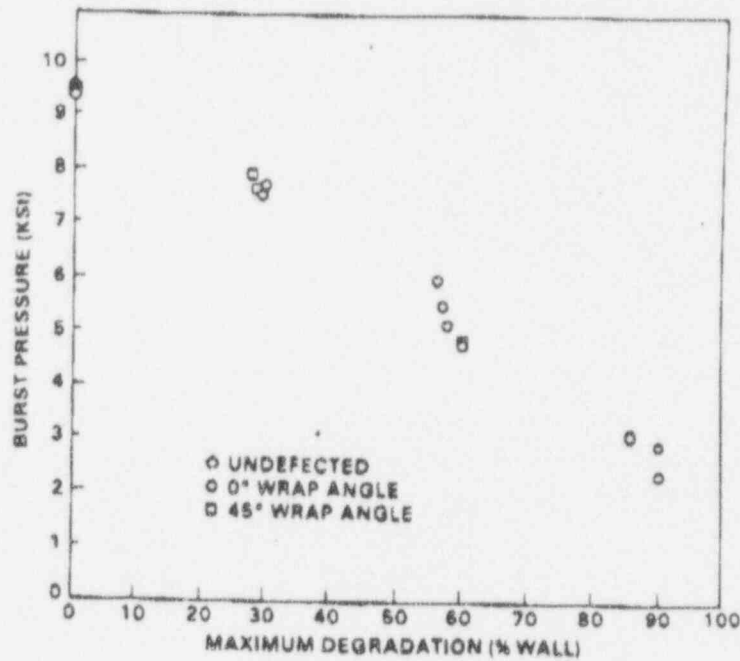


FIGURE 21. Burst Pressures for 0.625 x 0.034 in. Elliptical Wastage

FROM: MPR ASSOCIATES ALEX VA.

TO:

904 563 4575

MAR 25, 1994 1:48PM #383 P.11
NUREG/CR-0227

SPECIMEN ID NO. _____

TUBE DEFECT FABRICATION INFORMATION

SPECIMEN ID NO. _____

NOMINAL TUBE SIZE _____

DESIGN DIMENSIONS CHECKED _____

CERTIFIED FABRICATED TO DIMENSIONS _____

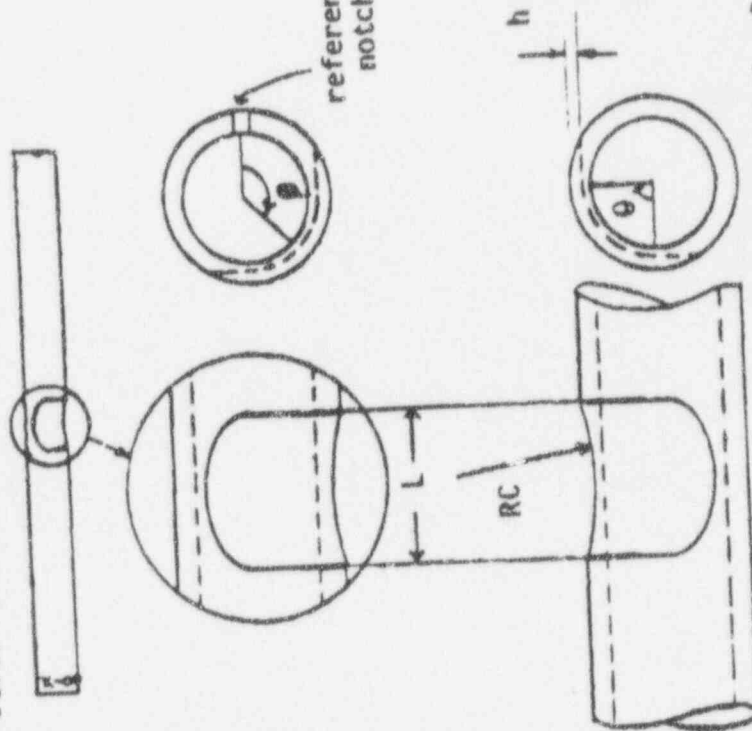
REPLICATED DIMENSIONS CHECKED _____

PRE-TEST CHECK _____

PRE-TEST ECT RECORD NO. _____

SIGNED _____

Elliptical Wastage
Defect Centered Between Ends $\pm 1/8"$



NUREG/CR-5117
PNL-6446
R5

Steam Generator Tube Integrity Program/Steam Generator Group Project

Final Project Summary Report

Manuscript Completed: April 1990
Date Published: May 1990

Prepared by
R. J. Kurtz, R. A. Clark, E. R. Bradley, W. M. Bowen,
P. G. Doctor, R. H. Ferris, F. A. Simonen

Pacific Northwest Laboratory
Richland, WA 99352

Prepared for
Division of Engineering
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555
NRC FIN B2097

9008070393 2 pp

NUREG/CA-5117

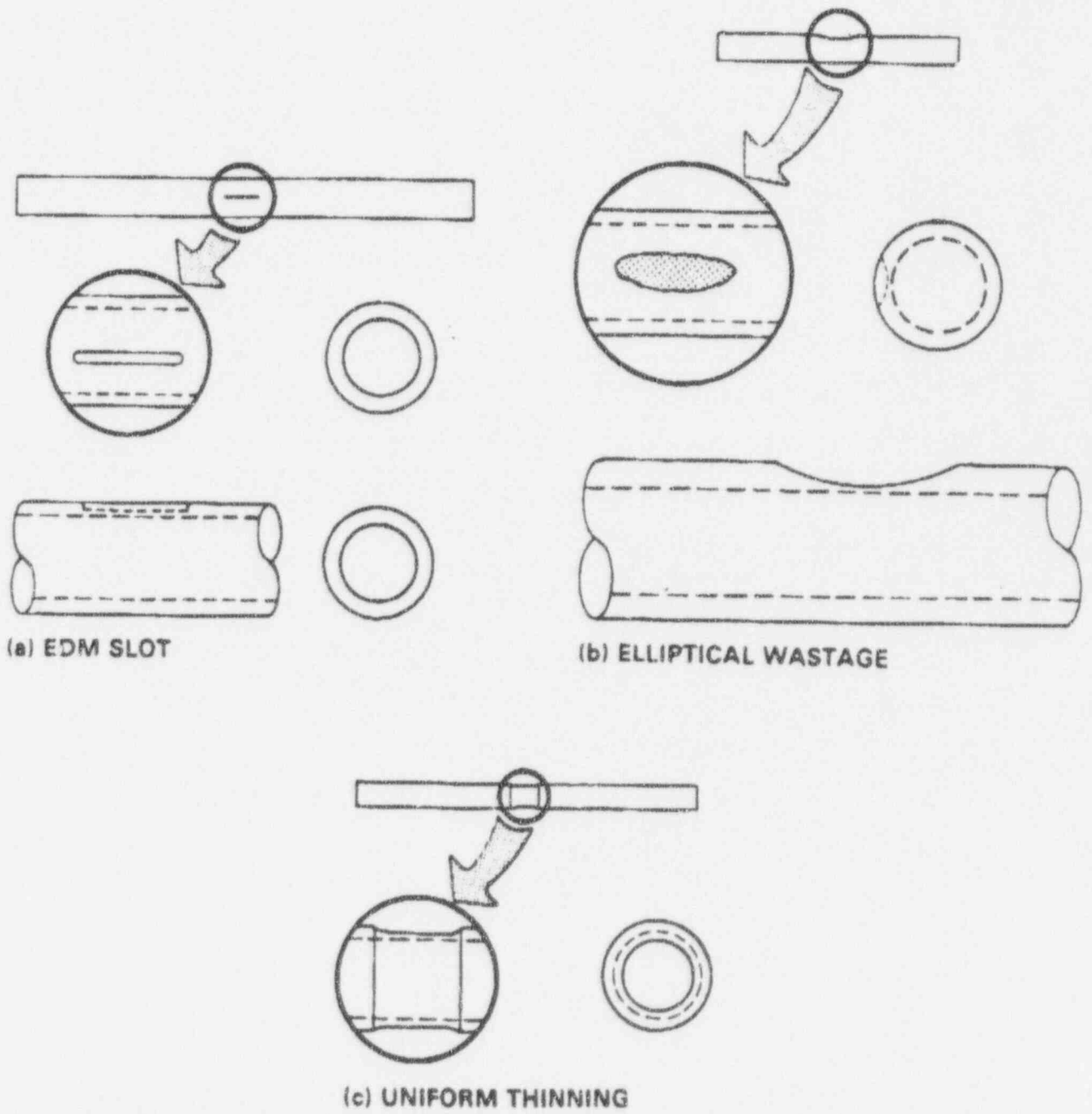


FIGURE 1.1. EDM-Slots, Elliptical-Wastage, and Uniform-Thinning Wastage Flaw Specimens

APPENDIX F

95% CONFIDENCE LEVEL CALCULATION FOR FIGURE 18

[12] From: JW Pegram at NEFS1 4/7/94 10:55AM (1697 bytes: 37 ln)
 Priority: Urgent
 To: JC Brown at SGE-BWNS
 Receipt Requested
 Subject: PREDICTION LIMITS FOR SIMPLE LINEAR REGRESSION

----- Message Contents -----

If the fitted model is

$$\begin{aligned} \hat{y} &= a + b * x, \\ \text{given a true model} \\ Y &= A + B * x + \hat{Y} \end{aligned}$$

and you know: n (sample size used in fitting),
 xbar = average of x's used in fitting
 SUMXSQ = sum of (x(i) - xbar) * (x(i) - xbar) over i= 1 to n
 then the basic formula for a prediction limit, at a 95% level, is

$$\hat{y} + t * s * \sqrt{\left(1 + 1/n + ((x(p) - \bar{x}) * (x(p) - \bar{x})) / \text{SUMXSQ})\right)}$$

WHERE t is from Student's t (also called just the t distribution) for the 95% percentile, and for n-2 degrees of freedom; and s is the standard error from the regression fit. x(p) is the particular value of the independent variable of interest.

A prediction limit is used to estimate a bound on a value of the dependent variable at some value of x.

The only difference between the computation of a 95% upper confidence limit on the average value vs the prediction limit, is that in the 95% upper confidence case, the 1 is omitted from the square root. This makes the interval smaller, of course.

The difference is caused by the fact that for the prediction interval estimate, the random element of the model is an additional source of uncertainty.

If your customer has a statistics book, this would be in the simple linear regression chapter, probably under the heading of something like "prediction of an individual Y" or so.

Questions, please call.

Jim

FOR CALCULATION OF UPPER LIMIT (ONE SIDE), 95%

t = 1.86 FOR 10 DATA POINTS

FOR TWO-SIDE (+/-), t = 2.31 FOR 10 DATA POINTS

$$y + t s \sqrt{1 + \frac{1}{n} + \frac{(x_p - \bar{x})^2}{\sum x^2}}$$

KENJI'S CURVE FIT VALUES

PREDICTED 95% CONFIDENCE VALUES

X ²	400 KHZ VMAX	DE %TW	V(P)	PREDICTED %TW	95% CONF. UP BOUND	DELTA U.B. - PRED.
0.25	0.50	53	0.00	31.7	41.5	9.9
0.04	0.19	34	0.25	36.7	46.3	9.6
0.04	0.19	33	0.50	41.7	51.3	9.6
0.17	0.41	45	0.75	46.7	56.3	9.6
1.08	1.04	54	1.00	51.7	61.5	9.8
0.67	0.82	46	1.25	56.7	66.8	10.1
1.66	1.29	54	1.50	61.7	72.2	10.5
0.08	0.28	29	1.75	66.8	77.7	11.0
0.12	0.34	40	2.00	71.8	83.3	11.6
0.08	0.29	36	2.25	76.8	89.0	12.2
			2.50	81.8	94.7	13.0
			2.73	86.3	100.0	13.7
			3.00	91.8	106.4	14.6
			3.25	96.8	112.2	15.4
			3.50	101.8	118.1	16.3
			3.75	106.8	124.1	17.2
			4.00	111.8	130.0	18.2

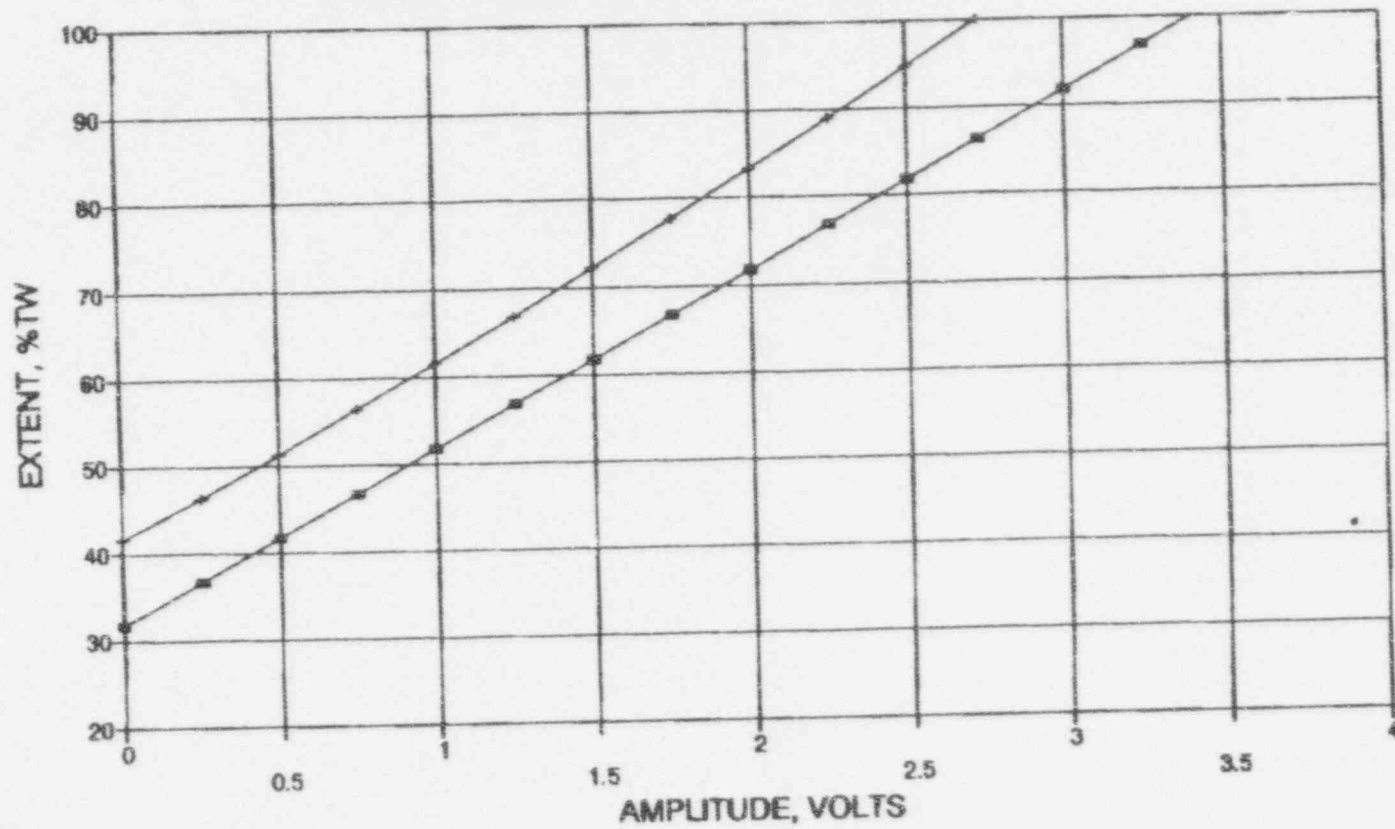
XBAR = 0.535
 SUMX SQR 4.1865

Regression Output:

Constant 31.67777988
 Std Err of Y Est 5.640231774
 R Squared 0.676376252
 No. of Observations 10
 Degrees of Freedom 8

X Coefficient(s) 20.04153
 Std Err of Coef. 4.901308

**EPRI VOLTAGE TO %TW CORRELATION
95% PREDICTION UPPER LIMIT, 400 KHZ DIF**



—■— PREDICTION FROM FIT —+— 95% UPPER LIMIT

APPENDIX G

**CRYSTAL RIVER UNIT 3 EDDY CURRENT DATA ANALYSIS
GUIDELINES DRAFT REVISION**