



South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

January 9, 2002
NOC-AE-02001238

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

South Texas Project
Unit 2
Docket No. STN 50-499
Supplemental Response to Request for Additional Information Regarding the
2RE08 Steam Generator Tube Voltage-Based Repair Criteria 90-Day Report

Reference: Letter, M. E. Kanavos to NRC, "2RE08 Steam Generator Tube Voltage-Based
Repair Criteria 90-Day Report," dated June 28, 2001 (NOC-AE-01001108)

Supplemental information in response to an NRC request for additional information regarding
the referenced report is attached to this letter. If there are any questions regarding this response,
please contact Mr. Chet McIntyre at (361) 972-8597 or me at (361) 972-7902.

A handwritten signature in black ink, appearing to read "T. Jordan".

Thomas J. Jordan
Manager, Engineering

jtc

Attachment

A001

cc:

Ellis W. Merschhoff
Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, Texas 76011-8064

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Mohan C. Thadani
U. S. Nuclear Regulatory Commission
Project Manager
1 White Flint North
11555 Rockville Place
Rockville, MD 20852-2738
Mail Stop: O-7D1

Cornelius F. O'Keefe
U. S. Nuclear Regulatory Commission
P. O. Box 289, Mail Code: MN116
Wadsworth, TX 77483

A. H. Gutterman, Esquire
Morgan, Lewis & Bockius
1800 M. Street, N.W.
Washington, DC 20036-5869

M. T. Hardt/W. C. Gunst
City Public Service
P. O. Box 1771
San Antonio, TX 78296

Jon C. Wood
Matthews & Branscomb
112 East Pecan, Suite 1100
San Antonio, Texas 78205-3692

Institute of Nuclear Power
Operations - Records Center
700 Galleria Parkway
Atlanta, GA 30339-5957

Richard A. Ratliff
Bureau of Radiation Control
Texas Department of Health
1100 West 49th Street
Austin, TX 78756-3189

D. G. Tees/R. L. Balcom
Reliant Energy, Inc.
P. O. Box 1700
Houston, TX 77251

C. A. Johnson/A. C. Bakken III
AEP - Central Power and Light Company
P. O. Box 289, Mail Code: N5012
Wadsworth, TX 77483

A. Ramirez/C. M. Canady
City of Austin
Electric Utility Department
721 Barton Springs Road
Austin, TX 78704

ATTACHMENT

South Texas Project Unit 2 EOC-8 In situ Leak Test Data

Procedure for Adjusting Measured Leak Rate to Steam Line Break Conditions

The leak rates measured during the South Texas Project Unit 2 EOC-8 in situ leak tests were adjusted to steam line break (SLB) conditions using the adjustment methodology presented in Appendix B of Reference 1. The attached EXCEL spreadsheet contains calculations for adjusting the data from one of the tests (SG-D, R24C47-3H). The following is a step-by-step description of the leak rate adjustment process.

Input Data

The in situ test for tube R24C47-3H in SG-D contains five data points as shown in rows 6 through 10 of the spreadsheet. The various input data are:

Col. A, B	Tube identification
Col. C	Test identifier
Col. D, E	Primary and secondary side pressures during the test (psig)
Col. F	Primary to secondary differential pressure (psi)
Col. G, H	Primary and secondary side temperatures during the test (°F)
Col. I	Measured leak rate (gpm at room temperature)
Col. J, K	Test condition – Room temperature test and no prior tube expansion
Col. L	Saturation vapor pressure at primary side temperature

Data Adjustment

Brief Description of Methodology

From Equation B-11 in Reference 1, the ratio of leak rates at two conditions is obtained as:

$$R = \frac{LR_2}{LR_1} = \alpha\beta\gamma \quad (\text{B-11})$$

Subscript 1 represents the test condition and subscript 2 represents the desired condition to which the test data is to be adjusted.

The α factor accounts for the variation in the crack opening area with pressure differential across the tube wall and is given by Equation B-15 in Reference 1:

$$\alpha = 10^{\frac{(\Delta p_2 - \Delta p_1)}{b}} \quad (\text{B-15})$$

where $(\Delta p = p_p - p_s)$ represents primary-to-secondary pressure differential and b is a constant.

The β term accounts for the leak rate dependency on temperature due to the variation in crack opening area because of variation in tube material properties with temperature as well as due to fluid density variation with temperature. It is given by Equation B-21 in Reference 1 (for a room temperature test with $T_{\text{primary}} = T_{\text{ambient}}$):

$$\beta = \frac{E_1 \sigma_1}{E_2 \sigma_2} \sqrt{\frac{\rho_2}{\rho_1}} \quad (\text{B-21})$$

where ρ is the fluid density, and E and σ , respectively, represent flow stress and Young's modulus of the tube material.

The γ term accounts for the variation in fluid flow with pressure differential and is given by Equation B-22 in Reference 1. With $C_p = 1.0$ and possibility of flashing at both conditions, this factor is given by:

$$\gamma = \sqrt{\frac{\frac{(p_{p2} - p_{f2})}{\Delta p_2}}{\frac{(p_{p1} - p_{f1})}{\Delta p_1}}} \quad (\text{B-22})$$

where p_f represents fluid saturation pressure at the primary side temperature.

Step-by-Step Description of the Adjustment Process

The following is a description of the steps involved in adjusting a leak rate at a given condition to SLB condition.

Step 1: Adjust measured leak rate to the standard SLB primary side temperature ($T = 616^\circ\text{F}$) and secondary side pressure ($p_s = 15$ psi) while maintaining the same total pressure differential (Δp).

Since the total pressure differential is maintained the same $\Delta p_1 = \Delta p_2 = \Delta p$, $\alpha = 1$. Therefore,

$$R_{std} = \frac{LR_2}{LR_1} = \beta \gamma_{std}$$

where, β is given by Equation B-21, and

$$\gamma_{std} = \sqrt{\frac{p_{p2} - p_{f2}}{p_{p1} - p_{f1}}}, \quad p_{p2} = \Delta p + 15$$

Columns M through AE contain calculations involved in this step.

Col. M, N, O	Desired standard conditions: $p_{\text{secondary}} = 0$ psig, $T_{\text{primary}} = 616^{\circ}\text{F}$, Δp same as in the test.
Col. P	Does water flash to steam during the test because the secondary side pressure is below the saturation pressure at the primary side temperature?
Col. Q, R	Young's modulus at test and desired conditions
Col. S, T	Flow stress at test and desired conditions
Col. U, V	Fluid density at test and desired conditions
Col. W	Saturation pressure at the desired condition
Col. X	Calculated β factor
Col. Y, Z	Self explanatory
Col. AA	Calculated γ factor. Note that this term cannot be calculated for a test condition where the primary side pressure for the desired condition $p_p = (\Delta p + 15)$ falls below the saturation pressure at the desired primary temperature (616°F).
Col. AD	Product β times γ
Col. AE	Measured leak rate adjusted to the standard SLB primary side temperature ($T = 616^{\circ}\text{F}$) and secondary side pressure ($p_s = 15$ psi) while maintaining the same Δp as in the test

Step 2: Calculate b factor in alpha term (Equation B-15)

Step 1 adjusts the measured leak rate to a condition where the secondary pressure is 15 psi and primary side temperature is 616°F while maintaining the same total pressure differential. This leak rate is adjusted to the SLB pressure differential with the following equation:

$$R = \alpha\gamma = \gamma 10^{\frac{(\Delta p_{\text{SLB}} - \Delta p_m)}{b}}$$

where, R is the ratio of the leak rates at the SLB and test measurement total pressure differentials. (The β factor is not affected by total pressure differential.)

Three different methods were used to calculate the b factor and the value that yielded the largest leak rate at the desired SLB pressure differential was picked for use in a leak rate correlation.

Method 1

When more than two data points are available, a value for b can be obtained by fitting a linear regression line to the natural log of leak rate versus Δp data. The b value is given by the inverse of the slope value.

Cell G15 in the spreadsheet contains the b value calculated with this method.

Methods 2A and 2B

Alternately, a value for b can be obtained using only the two data points with Δp values that bound the SLB Δp ($\Delta p_2 < \Delta p_{SLB} < \Delta p_1$):

$$b = \frac{\Delta p_2 - \Delta p_1}{\log(R/\gamma)}$$

Two slightly different methods were used to pick the leak rate values used to calculate the “R” term in the above equation. In one method (Method 2A), measured leak rates adjusted to standard conditions (in Step 1) were used. In the second method (Method 2B), leak rate values at Δp_2 and Δp_1 were calculated using the correlation between $\log(\text{leak rate})$ vs. Δp developed in Method 1, and their ratio yielded R . The values for b obtained with Methods 2A and 2B are shown in Cells G27 and G34, respectively.

Step 3: Convert leak rate at test pressure differential to SLB pressure differential

The measured leak rates adjusted to standard conditions in Step 1 are adjusted to the SLB pressure differential with the following equation:

$$R = \alpha\gamma = \gamma 10^{\frac{(\Delta p_{SLB} - \Delta p_m)}{b}}$$

Columns AE to AG show the leak rates adjusted to SLB $\Delta p = 2560$ psi using the three values for factor b obtained in Step 2. Columns AH to AJ show the corresponding adjusted leak rates at SLB $\Delta p = 2405$ psi. Note that each test measurement is adjusted to the SLB condition with the exception of measurements that cannot be adjusted to the standard conditions in Step 1 (tests with $\Delta p < p_{sat}$ at 616°F). The adjusted SLB leak rate value for the test measurement with Δp closest to and higher than the SLB Δp is chosen for use in a leak rate correlation (Test # 3 in Row 8). There are three choices corresponding to the three values for the b factor (values in Cells AE8, AF8 and AG8 for SLB $\Delta p = 2560$ psi) and the largest of the three values is chosen (Cell AE8).

Reference

1. EPRI Report NP-7480-L, “Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates – Database for Alternate Repair Criteria, Volume 2: ¾ Inch Diameter Tubing,” October 1993

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	South Texas Unit-2 InSitu Leak Test Results SG-D R24 C47 TSP 3H Adjustment to Steamline Break Conditions															
2	Test Data Entry									Describe the Test			Enter the Desired Conditions for Each Test			
3	Test Spec	Test ID/ Setup	Test Seq. #	Pp (psig)	Ps (psig)	Δp_{test}	T _p	T _s	Measured Leak Rate (@Tp) (gpm - RT)	Is leak rate a room temperature msmt. of a hot test? (yes/no)	Was the Specimen Previousl y Expanded with a Bladder? (yes/no)	P _{sat} at T _p (psia)	Desired Conditions			Water Flash to Steam At Test Conditions?
4													P _g gauge	Δp	T _p	
5																
6	South Texas 2	R24C47-3H	1	1440	0	1440	75	75	0.0002	no	no	0.44	0	1440	616	no
7	2001		2	2046	0	2046	75	75	0.08466	no	no	0.44	0	2046	616	no
8			3	2530	0	2530	75	75	0.24024	no	no	0.44	0	2530	616	no
9			4	2700	0	2700	75	75	0.40074	no	no	0.44	0	2700	616	no
10			5	2849	0	2849	75	75	0.53798	no	no	0.44	0	2849	616	no
11																
12																
13		Col F	Col AE													
14		Leak Rate	Total Δp (psi)	Log of Adjusted Leak Rate	Label											
15		#VALUE!	1440	#VALUE!	a1											
16		0.032854602	2046	-1.4834	b1											
17		0.132505802	2530	-0.8778	c1											
18		0.235415259	2700	-0.6282	d1											
19		0.330287014	2849	-0.4811	e1											
20																
21																
22																
23																
24																
25																
26																
27																
28																
29																
30																
31																
32																
33																
34																
35																
36																
37																
38																

Estimation of "b" Constant

Method 1
Linear Regression
Log(adjusted leak rate-col AG)
versus Δp
789.8 <-- "b" constant
m 0.0012662 -4.073 b
se_m 3.684E-05 0.0939 se_b
r2 0.9983101 0.0223 se_y
F 1181.4888 2 df
ssreg 0.5850319 0.001 ssresid

Regression Line - Log (leak rate) vs. Δp
(Used for Plotting)

Calculate
Calculated d
Leak Rate Leak Rate
Total using m & b using m & b
 Δp Log (leakrate) Leakrate
(psi)
1440 -2.2493 0.0056 a2
2046 -1.4820 0.0330 b2
2530 -0.8692 0.1351 c2
2700 -0.6539 0.2218 d2
2849 -0.4653 0.3425 e2

Method 2a
Based on Two Neighboring Datapoints
Using As-Measured Leak Rate
"b" constant
b = 1068.51 b1 and c1

Method 2b
Based on Two Neighboring Datapoints
Leak Rate Estimated from Regression
Fit
"b" constant
b = 1051.81 b2 and c2

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1													
2													
3	Young's Modulus for Temp. Correction		Flow Stress for Temp Correction		Density for Temp Correction		Psat	β For the Desired Temperature	Primary Pressure Greater Than Psat At the Desired Condition?	Does the Test Flash at the desired conditions?	γ factor for desired temperature and pressure	$\beta\gamma$	Corrected for Temp and Pressure ($\beta\gamma$) at the desired conditions
4	Test Temp.	Desired Temp.	Test Temp.	Desired Temp.	Test Temp.	Desired Temp.	Desired Temp.						(gpm - RT)
5	31.23	28.52	78.92	71.70	62.23	40.85	1738	0.977	no	yes	undefined	undefined	-
6	31.23	28.52	78.92	71.70	62.23	40.85	1738	0.977	yes	yes	0.397	0.388	0.0329
7	31.23	28.52	78.92	71.70	62.23	40.85	1738	0.977	yes	yes	0.565	0.552	0.1325
8	31.23	28.52	78.92	71.70	62.23	40.85	1738	0.977	yes	yes	0.602	0.587	0.2354
9	31.23	28.52	78.92	71.70	62.23	40.85	1738	0.977	yes	yes	0.629	0.614	0.3303
10	31.23	28.52	78.92	71.70	62.23	40.85	1738	0.977	yes	yes	0.629	0.614	0.3303
11													
12													
13													
14													
15	SLB Leak Rate - Plot Data												
16	1600 0.146415 33.3												
17	2560 0.146415												
18	2560 0.0001												
19													
20													
21													
22	SLB Leak Rate - Plot Data												
23	1600 0.095437 21.7												
24	2405 0.095437												
25	2405 0.0001												
26													
27													
28													
29													
30													
31													
32													
33													
34													
35													
36													
37													
38													

	AD	AE	AF	AG	AH	AI	AJ
1	Steamline Break $\Delta p = 2560$ psi			Steamline Break $\Delta p = 2405$ psi			
2	Method 1	Method 2a	Method 2b	Method 1	Method 2a	Method 2b	
3	Leak Rate 2560 psi Steamline Break Ref. Condn.	Leak Rate 2560 psi Based on "b" from L.S. Fit Slope (Cell G15)	Leak Rate 2560 psi Based on 'b' Factor from Cell G27	Leak Rate 2560 psi Based on "b" from 'b' Factor from Cell G34	Leak Rate 2405 psi Based on "b" from L.S. Fit Slope (Cell G15)	Leak Rate 2405 psi Based on 'b' Factor from Cell G27	Leak Rate 2405 psi Based on 'b' Factor from Cell G34
4	(gpm)	(gpm - RT)	(gpm - RT)	(gpm - RT)	(gpm - RT)	(gpm - RT)	(gpm - RT)
5	-	-	-	-	-	-	-
6	1.47E-01	2.12E-01	1.43E-01	1.46E-01	1.26E-01	9.54E-02	9.66E-02
7	1.45E-01	1.46E-01	1.43E-01	1.43E-01	8.74E-02	9.54E-02	9.50E-02
8	1.57E-01	1.49E-01	1.65E-01	1.65E-01	8.88E-02	1.10E-01	1.09E-01
9	1.42E-01	1.29E-01	1.61E-01	1.60E-01	7.72E-02	1.07E-01	1.06E-01
10							
11							
12							
13	Pick these values for inclusion in the leak rate correlation as the total Δp for this case is closest to the desired SLB pressure differential						
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							

South Texas -2 SG-D R24C47-3H In Situ Leak Test Data
(Normalized to $T_p = 616^\circ\text{F}$ and $p_s = 15$ psia Reference SLB Conditions)

