ENCLOSURE 2

Analytical Evaluation of Steam Generator A Upper Shell to Transition Cone Weld Indications

27 pages follow

Structural Integrity Associates, Inc.	**CALCULATION PACKAGE**	**File No.: PBCH-14Q-302** **Project No.: PBCH-14Q**

PROJECT NAME: Point Beach Unit 1 Flaw Evaluation Fall 2005

Contract No.: P305817

CLIENT: Nuclear Management Company, LLC	**PLANT: Point Beach Nuclear Plant**

CALCULATION TITLE: Steam Generator B Flaw Evaluation

Document Revision	Affected Pages	Revision Description	Project Mgr. Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
0	1-7 Appendices A, B, C	Initial Issue	H. L. Gustin 10/26/05	H. L. Gustin 10/26/05 S. S. Tang 10/26/05
1	2, 5	Corrected typo Added discussion on applicability to flaws accepted by standards	H. L. Gustin 10/27/05	H. L. Gustin 10/27/05 S. S. Tang 10/27/05
2	3, 5	Corrected typo, client comment	H. L. Gustin 10/28/05	H. L. Gustin 10/28/05 S. S. Tang 10/28/05
3	5 Appendix C	Modified Reference 5, added e-mail reference to Appendix C	H. L. Gustin 11/28/05 H L Gustin	H. L. Gustin 11/17/05 H L Gustin J. E. Smith 11/28/05 Jennifer E Smith

SI Form F2001R2a

1 INTRODUCTION

The 2005 inservice inspection of steam generator B at Point Beach Nuclear Plant Unit 1 identified several indications in the transition cone to upper shell weld region of the steam generator. The indications were assessed per the flaw proximity rules of ASME Boiler and Pressure Vessel Code Section XI, IWA-3300 [1]. Following assessment of flaw proximity, indication dimensions were compared to the flaw acceptance standards of Section XI, IWC-3510 [1] by the plant [4]. Three indications (two simple or individual indications, plus one composite indication that resulted from proximity-based flaw combination) did not meet the flaw acceptance standards of Section XI, IWC-3510 [1]. It is therefore necessary to conduct a flaw evaluation per Section XI, IWB-3600 (since IWC-3600 is in preparation) for these three flaws. This calculation evaluates a flaw that bounds the three unacceptable flaws per the guidelines of Section XI, IWB-3610, which include acceptance criteria based on linear elastic fracture mechanics and consideration of potential flaw growth. This calculation does not apply to other flaws which may be identified, without further evaluation. Conservative assumptions have been used in this evaluation to demonstrate flaw acceptability per IWB-3610. This calculation has been design reviewed in accordance with the requirements of the Structural Integrity Associates Quality Assurance Program.

2 TECHNICAL APPROACH

Fracture mechanics methods consistent with the requirements of ASME Section XI have been applied in this flaw evaluation. The acceptance criterion is that the applied stress intensity factor due to the observed flaw, with consideration of flaw growth over the remaining life of the plant, remains below the material toughness, including applicable margins from Section XI. The flaw acceptance criteria, based on applied stress intensity factor, was determined based on Paragraph IWB-3612 of ASME Section XI [1]. The material toughness for the carbon steel steam generator shell material at operating temperature is taken to be 200 ksi-√inch, consistent with Figure A-4200-1 from ASME Section XI Appendix A for K_{Ic}. A safety factor of $\sqrt{10}$ is applied, as required by IWB-3610. This gives an allowable stress intensity factor of $200/\sqrt{10} = 63.25$ ksi-√inch.

A conservative bounding flaw was defined that envelopes the dimensions of the three unacceptable indications. The fracture mechanics analysis was performed using this enveloping flaw, and this analysis effectively evaluates all three of the unacceptable flaws.

3 FLAW CHARACTERIZATION

A total of 28 flaw indications were observed. These flaws were compared to the flaw proximity rules of IWA-3300. Table 1 (which is based on data in [4]) lists all 28 flaw dimensions and their locations, and summarizes the results of the proximity rule assessment. Of the 28 indications, only one pair had to be combined by the proximity rules (numbers 10 and 11 in Table 1). Plant personnel assessed all flaws to the IWC-3510 acceptance standards, and determined that only two individual flaws (numbers 7 and 20 in Table 1) plus the one composite flaw (10 and 11) required further evaluation. A bounding flaw with the maximum length and through wall dimension of any of these three flaws was used for the IWB-3600 evaluation in this calculation. This bounding flaw had length = 11.5 inch (from flaw 7), and depth = 0.24 inch (from flaw 20). It is located 0.74 inch below the outside surface (corresponding to flaw 20).

The observed unacceptable flaws are entirely subsurface and not exposed to any fluid chemistry.

4 DESIGN INPUTS

The as-measured wall thickness is 3.84 inches in the transition cone region (from plant UT reports [4]).

The transition cone material is SA-533 Grade A, Class 2 [6] with specified yield stress = 70 ksi. The Upper Shell material has a yield stress of less than 50 ksi.

From [5], the combined membrane, bending and secondary stress (P_L+P_B+Q) at the affected weld location is 64.7 ksi.

Welding residual stresses at the flaw location are negligible since the vessel is a thick walled shell that has been stress relieved. Residual stresses are steady state secondary stresses.

5 ASSUMPTIONS

1. To be conservative, the limiting stress value reported in Section 4.0 is used, and treated as an applied membrane stress. This is conservative because membrane stresses are more severe than bending stresses at equal magnitude.
2. The service life is assumed to be 60 years.
3. The material toughness K_{Ic} is taken as 200 ksi- √inch, from Section XI Appendix A [1].

6 CALCULATIONS

6.1 Fracture mechanics evaluation

Linear elastic fracture mechanics and fatigue flaw growth evaluations of the bounding flaw were performed. The flaw was modeled as a subsurface semi-elliptical flaw in an infinite plate subjected to membrane and bending stress as illustrated in Figure 1. This is a common fracture mechanics model applied to subsurface flaws in thick shells. Figure 1 refers to the 1986 Edition of ASME Section XI. This is the Edition to which the SI fracture mechanics program **pc-CRACK** [3] was developed. However, the flaw definition in that figure remains the same in subsequent Editions of the Code, including the committed Edition and Addenda for Point Beach [1]. For this subsurface flaw model, the flaw depth is defined as 2a. Therefore, the flaw depth, a, is half of the measured flaw depth as reported in the UT reports.

For the indication the flaw parameters were calculated as follows:

Depth [4]	2a = 0.24 inch
Length [4]	l = 11.5 inches
Aspect ratio:	a/l = 0.01
	a/t = 3.13%
Eccentricity ratio:	2e/t = 0.552

The applied stress intensity factors for the indication above were calculated using **pc-CRACK**, [3]. The aspect ratio of 0.1 was used in the evaluation for the indication (limit of the model). The applied stress intensity factor $K_{applied}$ at the limiting location on the flaw face was compared to an allowable value of $K_{Ic}/\sqrt{10}$, where K_{Ic} is the material toughness (assumed to be 200 ksi-√inch for the steam generator shell material at the service temperatures, from Section XI, Appendix A, Figure A-4200-1), and the factor of √10 represents the factor of safety that is imposed by ASME Section XI, IWB-3610 for Normal and Upset conditions. The allowable K is therefore 63.25 ksi-√inch. As long as the applied stress intensity factor remains below the allowable value for the flaw size, the flaw remains acceptable by Section XI criteria. **pc-CRACK** output for the fracture mechanics analysis is contained in Appendix A.

6.2 End of Life Fatigue Flaw Growth Calculation

Since the indications are subsurface and therefore not wetted, the end of life flaw size due to fatigue growth was calculated using the fatigue growth curves for carbon and low alloy ferritic steels exposed to air environments, Figure A-4300-1 of Appendix A of Section XI [1]. The flaw was conservatively assumed to experience cyclic stresses corresponding to a stress range from 0 to 64.7 ksi [5]. This is conservative because the latter value corresponds to the sum of the highest reported membrane plus bending plus secondary (P_L+P_B+Q) stress..

Fatigue growth results are contained in Appendix B.

7 RESULTS OF ANALYSIS

The fracture mechanics analysis shows that the bounding flaw is acceptable per the criteria of ASME Section XI, IWB-3612. The calculated maximum stress intensity factor for the observed flaw is 42 ksi-√inch, as compared to the allowable value of 63.25 ksi-√inch, which includes required safety margins (√10) as noted in Section 2 of this calculation. In fact this flaw could grow to slightly more than twice the current size and remain acceptable. All actual flaws are smaller than this assumed bounding flaw.

The fatigue growth calculation demonstrates that over more than 3900 cycles from 0 to 64.7 ksi, the resulting flaw growth of the assumed bounding flaw remains below the allowable flaw size. Most transients experienced by the component are much less severe than this transient, and would lead to negligible growth. Therefore, growth of the flaw to an unacceptable size over the remaining life of the plant is not predicted.

The bounding flaw analyzed in this calculation is much more severe than are any of the flaws in this weld that were accepted under the Acceptance Standards of IWC-3510. Therefore, although fracture mechanics evaluation of such acceptable flaws is not required, the fracture mechanics analysis in this calculation could conservatively be applied to such flaws, if necessary.

8 DEGRADATION MECHANISMS

The observed flaws are subsurface flaws that are remote from any surface (either the wetted inside surface or the air outside surface). Such a flaw is therefore not a result of chemistry-driven mechanisms such as stress corrosion cracking or corrosion. These factors lead to the conclusion that the observed flaws are in fact artifacts of original fabrication, and not due to an active degradation mechanism. The evaluation of the hypothetical flaw growth by a fatigue mechanism is therefore conservative.

9 CONCLUSIONS AND DISCUSSIONS

Based on the results of the evaluation presented in this calculation package, the indications found during the inservice inspection of the steam generator B transition cone weld are acceptable and meet the requirement of ASME Code, Section XI, IWB-3610 [1].

The total of all indication areas is about 9.2 in^2. The area of the steam generator weld is about 2012 in^2, assuming a circumference of 524 inches [4], and a wall thickness of 3.84 inches. The transverse area reduction is less than 0.5% of the original area. This area reduction will have no significant affect on the hoop stress in the weld. Thus, the steam generator stress analysis based on ASME Boiler and Pressure Vessel Code Section III is not affected. Therefore, the requirement of IWB-3610 (d) (2) is satisfied.

10 REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section XI, 1998 Edition with Addenda through 2000.
2. Steam Generator Design Summary, E-mail from Brian Kemp (NMC) to Hal Gustin (SI), dated 10/19/05 SI File: PBCH-14Q-220
3. pc-CRACK for Windows, Version 3.1-98348, Structural Integrity Associates, 1998.
4. Point Beach Ultrasonic Examination Reports , SI File: PBCH-14Q-218
5. E-mail from Brian Kemp (NMC) to Hal Gustin (SI) dated 10/22/05, supplemented by e-mail from Brian Kemp (NMC) to Hal Gustin (SI) dated 11/10/05. SI File: PBCH-14Q-220
6. Telecon, Russell Turner (NMC) to Hal Gustin (SI) 10/25/05 SI File: PBCH-14Q-220

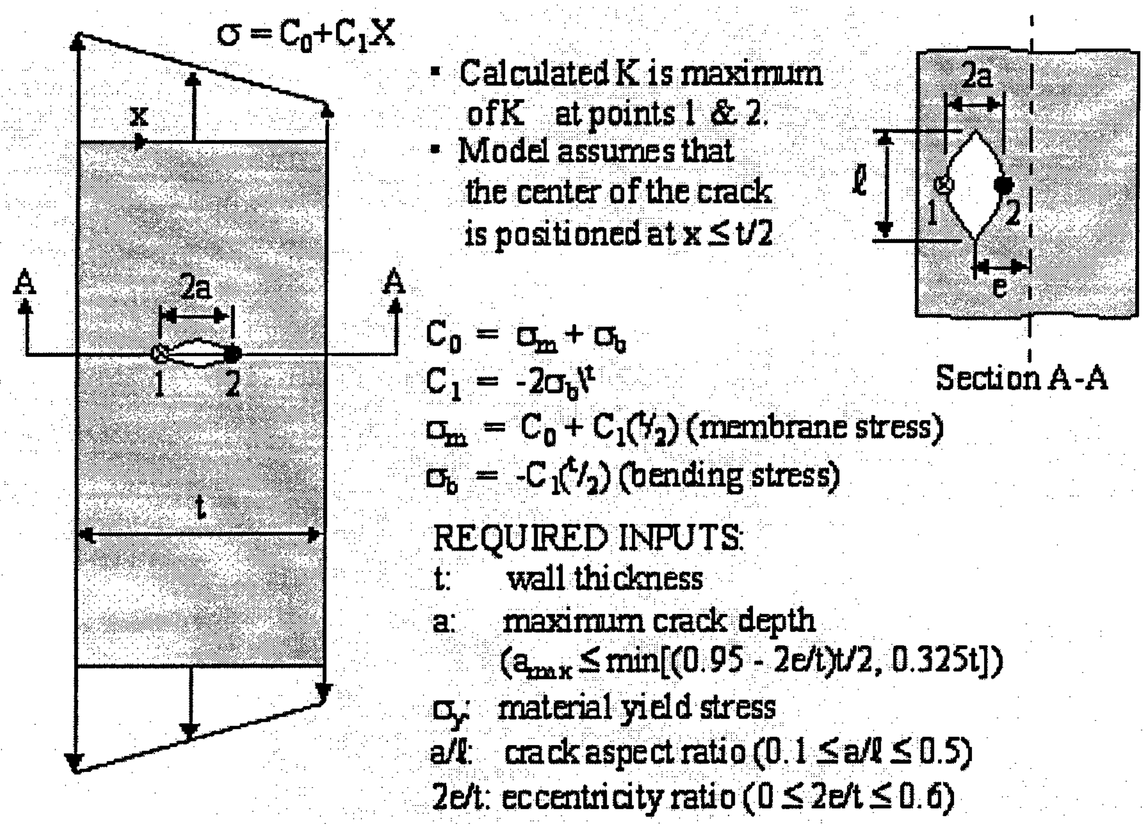

Figure 1: ASME B&PV Code Section XI Subsurface Crack Model

STEP3IN3

Table 1: ASME CODE, SECTION XI, IWA-3300 PROXIMITY CHECK

INPUT INSPECTION DATA FOR c:\proxtest\step3in3.dat

NO.	START	END	LENGTH	UP. TIP	LW. TIP	DEPTH
1	24.000	27.000	3.000	2.750	2.870	.120
2	16.000	18.250	2.250	2.570	2.700	.130
3	19.750	20.750	1.000	1.440	1.600	.160
4	24.250	25.250	1.000	1.510	1.630	.120
5	30.380	33.000	2.620	1.250	1.350	.100
6	43.380	45.000	1.620	1.160	1.250	.090
7	47.500	59.000	11.500	2.810	3.020	.210
8	61.500	63.000	1.500	2.810	2.930	.120
9	67.500	74.500	7.000	2.480	2.630	.150
10	82.000	85.500	3.500	1.050	1.150	.100
11	78.500	82.000	3.500	1.130	1.260	.130
12	86.500	88.000	1.500	2.120	2.250	.130
13	133.630	134.380	.750	.740	.820	.080
14	130.130	130.750	.620	.950	1.120	.170
15	165.250	165.500	.250	1.950	2.100	.150
16	227.880	228.380	.500	1.410	1.480	.070
17	255.250	257.500	2.250	2.550	2.610	.060
18	295.250	295.750	.500	1.280	1.370	.090
19	384.750	385.250	.500	.950	1.050	.100
20	377.250	381.500	4.250	.740	.980	.240
21	408.000	409.000	1.000	2.770	2.890	.120
22	465.500	466.500	1.000	1.760	1.830	.070
23	474.250	475.250	1.000	1.560	1.630	.070
24	476.000	478.000	2.000	1.530	1.590	.060
25	496.000	498.500	2.500	1.280	1.360	.080
26	509.750	512.500	2.750	1.180	1.280	.100
27	513.500	518.000	4.500	1.180	1.280	.100
28	519.500	524.000	4.500	1.110	1.200	.090

PROXIMITY RESULTS FOR THE ABOVE FLAWS:

FLAWS 10 AND 11 MUST BE COMBINED.

-----END OF OUTPUT -----

APPENDIX A

pc-CRACK OUTPUT FILES: ALLOWABLE FLAW DETERMINATION

SGBREV1

pc-CRACK tm for Windows
Version 3.1-98348

Structural Integrity Associates, Inc.
3315 Almaden Expressway, Suite 24
San Jose, CA 95118-1557
Voice: 408-978-8200
Fax: 408-978-8964
E-mail: pccrack@structint.com

Linear Elastic Fracture Mechanics

Date: Thu Oct 27 13:21:11 2005
Input Data and Results File: SGBREV1.LFM

Title: PBCH-14Q: Steam Generator B Flaw Evaluation

Load Cases:

Case ID	Stress Coefficients C0	C1	C2	C3	Type
PL+PB+Q	64.7	0	0	0	Coeff

------Through Wall Stresses for Load Cases With Stress Coeff-------

Wall Depth	Case PL+PB+Q
0.0000	64.7
0.0400	64.7
0.0800	64.7
0.1200	64.7
0.1600	64.7
0.2000	64.7
0.2400	64.7
0.2800	64.7
0.3200	64.7
0.3600	64.7
0.4000	64.7

Crack Model: Elliptical Subsurface Cracked Plate Under Membrane & Bending Stresses

Reference: ASME Boiler and Pressure Vessel Code, Section XI, '86 Ed.
WARNING: The stress intensity factor (K) is the maximum of
K at point 1 and K at point 2 as identified in Section XI.

Crack Parameters:
Wall thickness: 3.8400
Max. crack depth: 0.4000
Crack aspect ratio: 0.1000
Eccentricity ratio: 0.5520
Material yield strength: 70.0000
Co = Sigma(membrane) + Sigma(bending)
C1 = -2*Sigma(bending)/thickness

------------------------Stress Intensity Factor-------------------

Crack Size	Case PL+PB+Q
0.0080	10.6473
0.0160	15.0756
0.0240	18.486
0.0320	21.3714
0.0400	23.9226
0.0480	26.2373
0.0560	28.3734
0.0640	30.3687
0.0720	32.2493
0.0800	34.0342
0.0880	35.7379
0.0960	37.3713
0.1040	38.9435
0.1120	40.4615
0.1200	41.9313
0.1280	43.3577
0.1360	44.7449
0.1440	46.0964
0.1520	47.4154
0.1600	48.7044
0.1680	49.9659
0.1760	51.2018
0.1840	52.414
0.1920	53.6041
0.2000	54.7734
0.2080	55.9235
0.2160	57.0554
0.2240	58.1701
0.2320	59.2687
0.2400	60.3521
0.2480	61.421
0.2560	62.4763
0.2640	63.5185
0.2720	64.5485
0.2800	65.5666
0.2880	66.5735
0.2960	67.6868
0.3040	68.7931
0.3120	69.8926
0.3200	70.9858
0.3280	72.0729
0.3360	73.1544
0.3440	74.2304
0.3520	75.3012
0.3600	76.3672
0.3680	77.4285
0.3760	78.4854
0.3840	79.5381
0.3920	80.5868
0.4000	81.6317

Material fracture toughness:

Material ID: SG Plate

Depth	K1c
0.0000	63.2500

1.0000	63.2500
3.0000	63.2500
4.0000	63.2500

Load combination for critical crack size:

Load Case	Scale Factor
PL+PB+Q	1.0000

Crack Size	Total K	K1c
0.008	10.6473	63.25
0.016	15.0756	63.25
0.024	18.486	63.25
0.032	21.3714	63.25
0.04	23.9226	63.25
0.048	26.2373	63.25
0.056	28.3734	63.25
0.064	30.3687	63.25
0.072	32.2493	63.25
0.08	34.0342	63.25
0.088	35.7379	63.25
0.096	37.3713	63.25
0.104	38.9435	63.25
0.112	40.4615	63.25
0.12	41.9313	63.25
0.128	43.3577	63.25
0.136	44.7449	63.25
0.144	46.0964	63.25
0.152	47.4154	63.25
0.16	48.7044	63.25
0.168	49.9659	63.25
0.176	51.2018	63.25
0.184	52.414	63.25
0.192	53.6041	63.25
0.2	54.7734	63.25
0.208	55.9235	63.25
0.216	57.0554	63.25
0.224	58.1701	63.25
0.232	59.2687	63.25
0.24	60.3521	63.25
0.248	61.421	63.25
0.256	62.4763	63.25
0.264	63.5185	63.25
0.272	64.5485	63.25
0.28	65.5666	63.25
0.288	66.5735	63.25
0.296	67.6868	63.25
0.304	68.7931	63.25
0.312	69.8926	63.25
0.32	70.9858	63.25
0.328	72.0729	63.25
0.336	73.1544	63.25
0.344	74.2304	63.25
0.352	75.3012	63.25
0.36	76.3672	63.25
0.368	77.4285	63.25
0.376	78.4854	63.25
0.384	79.5381	63.25
0.392	80.5868	63.25
0.4	81.6317	63.25

SGBREV1

Critical crack size = 0.2619

End of pc-CRACK Output

APPENDIX B

pc-CRACK OUTPUT FILE: FATIGUE CRACK GROWTH

FCG302

pc-CRACK[tm] for Windows
Version 3.1-98348

Structural Integrity Associates, Inc.
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Linear Elastic Fracture Mechanics

Date: Thu Oct 27 13:27:16 2005
Input Data and Results File: FCG302.LFM

Title: PBCH-14Q: Steam Generator B Flaw Evaluation

Load Cases:

Case ID	Stress Coefficients C0	C1	C2	C3	Type
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------Through Wall Stresses for Load Cases with Stress Coeff-------

Wall Depth	Case PL+PB+Q
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0.0800	64.7
0.1200	64.7
0.1600	64.7
0.2000	64.7
0.2400	64.7
0.2800	64.7
0.3200	64.7
0.3600	64.7
0.4000	64.7

Crack Model: Elliptical Subsurface Cracked Plate Under Membrane & Bending Stresses

Reference: ASME Boiler and Pressure Vessel Code, Section XI, '86 Ed.
WARNING: The stress intensity factor (K) is the maximum of
K at point 1 and K at point 2 as identified in Section XI.

Crack Parameters:
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Max. crack depth: 0.4000
Crack aspect ratio: 0.1000
Eccentricity ratio: 0.5520
Material yield strength: 70.0000
Co = Sigma(membrane) + Sigma(bending)
C1 = -2*Sigma(bending)/thickness

------------------------Stress Intensity Factor--------------------

Crack Size	Case PL+PB+Q
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0.0640	30.3687
0.0720	32.2493
0.0800	34.0342
0.0880	35.7379
0.0960	37.3713
0.1040	38.9435
0.1120	40.4615
0.1200	41.9313
0.1280	43.3577
0.1360	44.7449
0.1440	46.0964
0.1520	47.4154
0.1600	48.7044
0.1680	49.9659
0.1760	51.2018
0.1840	52.414
0.1920	53.6041
0.2000	54.7734
0.2080	55.9235
0.2160	57.0554
0.2240	58.1701
0.2320	59.2687
0.2400	60.3521
0.2480	61.421
0.2560	62.4763
0.2640	63.5185
0.2720	64.5485
0.2800	65.5666
0.2880	66.5735
0.2960	67.6868
0.3040	68.7931
0.3120	69.8926
0.3200	70.9858
0.3280	72.0729
0.3360	73.1544
0.3440	74.2304
0.3520	75.3012
0.3600	76.3672
0.3680	77.4285
0.3760	78.4854
0.3840	79.5381
0.3920	80.5868
0.4000	81.6317

Crack Growth Laws:

Law ID: SG subsurface
Model: ASME Section XI - ferritic steel in air environment

da/dN = C * S * dK^3.07

where

```
S = 25.72 * (2.88 - R')^(-3.07)
 R = 0      for  R < 0
 R'= R      for  R >= 0
dK = Kmax - Kmin
 R = Kmin / Kmax
```

where:
  C = 1.9900e-010
is for the currently selected units of:
   force: kip
  length: inch

Material Fracture Toughness KIc:

Material ID: SG Plate

Depth	KIc
0.0000	63.2500
1.0000	63.2500
3.0000	63.2500
4.0000	63.2500

Initial crack size= 0.1200
Max. crack size= 0.4000

Number of blocks= 1
Print increment of block= 1

Subblock	Cycles /Time	Calc. incre.	Print incre.	Crk. Grw. Law	Mat. K1c
FCG302	10000	100	100	SG subsurface	SG Plate

Subblock	Kmax Case ID	Kmax Scale Factor	Kmin Case ID	Kmin Scale Factor
FCG302	PL+PB+Q	1.0000	PL+PB+Q	0.0000

Crack growth results:

Total Cycles /Time	Subblock Cycles /Time	Kmax	Kmin	DeltaK	R	DaDn /DaDt	Da	a	a/thk
Block: 1									
100	100	4.19e+001	0.00e+000	4.19e+001	0.00	1.91e-005	1.91e-003	0.1219	0.03
200	200	4.23e+001	0.00e+000	4.23e+001	0.00	1.95e-005	1.95e-003	0.1239	0.03
300	300	4.26e+001	0.00e+000	4.26e+001	0.00	2.00e-005	2.00e-003	0.1259	0.03
400	400	4.30e+001	0.00e+000	4.30e+001	0.00	2.05e-005	2.05e-003	0.1279	0.03
500	500	4.33e+001	0.00e+000	4.33e+001	0.00	2.11e-005	2.11e-003	0.13	0.03
600	600	4.37e+001	0.00e+000	4.37e+001	0.00	2.16e-005	2.16e-003	0.1322	0.03
700	700	4.41e+001	0.00e+000	4.41e+001	0.00	2.22e-005	2.22e-003	0.1344	0.04
800	800	4.45e+001	0.00e+000	4.45e+001	0.00	2.28e-005	2.28e-003	0.1367	0.04
900	900	4.49e+001	0.00e+000	4.49e+001	0.00	2.34e-005	2.34e-003	0.139	0.04

FCG302

1000	1000	4.53e+001	0.00e+000	4.53e+001	0.00	2.41e-005	2.41e-003	0.1414	0.04
1100	1100	4.57e+001	0.00e+000	4.57e+001	0.00	2.48e-005	2.48e-003	0.1439	0.04
1200	1200	4.61e+001	0.00e+000	4.61e+001	0.00	2.55e-005	2.55e-003	0.1465	0.04
1300	1300	4.65e+001	0.00e+000	4.65e+001	0.00	2.62e-005	2.62e-003	0.1491	0.04
1400	1400	4.69e+001	0.00e+000	4.69e+001	0.00	2.69e-005	2.69e-003	0.1518	0.04
1500	1500	4.74e+001	0.00e+000	4.74e+001	0.00	2.77e-005	2.77e-003	0.1546	0.04
1600	1600	4.78e+001	0.00e+000	4.78e+001	0.00	2.85e-005	2.85e-003	0.1574	0.04
1700	1700	4.83e+001	0.00e+000	4.83e+001	0.00	2.94e-005	2.94e-003	0.1603	0.04
1800	1800	4.88e+001	0.00e+000	4.88e+001	0.00	3.03e-005	3.03e-003	0.1634	0.04
1900	1900	4.92e+001	0.00e+000	4.92e+001	0.00	3.12e-005	3.12e-003	0.1665	0.04
2000	2000	4.97e+001	0.00e+000	4.97e+001	0.00	3.22e-005	3.22e-003	0.1697	0.04
2100	2100	5.02e+001	0.00e+000	5.02e+001	0.00	3.32e-005	3.32e-003	0.173	0.05
2200	2200	5.07e+001	0.00e+000	5.07e+001	0.00	3.42e-005	3.42e-003	0.1764	0.05
2300	2300	5.13e+001	0.00e+000	5.13e+001	0.00	3.53e-005	3.53e-003	0.18	0.05
2400	2400	5.18e+001	0.00e+000	5.18e+001	0.00	3.65e-005	3.65e-003	0.1836	0.05
2500	2500	5.24e+001	0.00e+000	5.24e+001	0.00	3.77e-005	3.77e-003	0.1874	0.05
2600	2600	5.29e+001	0.00e+000	5.29e+001	0.00	3.89e-005	3.89e-003	0.1913	0.05
2700	2700	5.35e+001	0.00e+000	5.35e+001	0.00	4.03e-005	4.03e-003	0.1953	0.05
2800	2800	5.41e+001	0.00e+000	5.41e+001	0.00	4.16e-005	4.16e-003	0.1995	0.05
2900	2900	5.47e+001	0.00e+000	5.47e+001	0.00	4.31e-005	4.31e-003	0.2038	0.05
3000	3000	5.53e+001	0.00e+000	5.53e+001	0.00	4.46e-005	4.46e-003	0.2082	0.05
3100	3100	5.60e+001	0.00e+000	5.60e+001	0.00	4.62e-005	4.62e-003	0.2129	0.06
3200	3200	5.66e+001	0.00e+000	5.66e+001	0.00	4.79e-005	4.79e-003	0.2177	0.06
3300	3300	5.73e+001	0.00e+000	5.73e+001	0.00	4.97e-005	4.97e-003	0.2226	0.06
3400	3400	5.80e+001	0.00e+000	5.80e+001	0.00	5.15e-005	5.15e-003	0.2278	0.06
3500	3500	5.87e+001	0.00e+000	5.87e+001	0.00	5.35e-005	5.35e-003	0.2331	0.06
3600	3600	5.94e+001	0.00e+000	5.94e+001	0.00	5.56e-005	5.56e-003	0.2387	0.06
3700	3700	6.02e+001	0.00e+000	6.02e+001	0.00	5.77e-005	5.77e-003	0.2444	0.06
3800	3800	6.09e+001	0.00e+000	6.09e+001	0.00	6.01e-005	6.01e-003	0.2505	0.07
3900	3900	6.17e+001	0.00e+000	6.17e+001	0.00	6.25e-005	6.25e-003	0.2567	0.07
4000	4000	6.26e+001	0.00e+000	6.26e+001	0.00	6.51e-005	6.51e-003	0.2632	0.07
4100	4100	6.34e+001	0.00e+000	6.34e+001	0.00	6.78e-005	6.78e-003	0.27	0.07

End of pc-CRACK Output

APPENDIX C

DESIGN INPUT MEMOS (E-MAIL) FROM NMC

Hal L. Gustin

From: Kemp, Brian [Brian.Kemp@nmcco.com]
Sent: Saturday, October 22, 2005 11:08 AM
To: Kemp, Brian; Hal L. Gustin
Subject: Additional PBNP Design Input

Hal,

The following information should be used as a design input for the U1R29 SG structural evaluation that SIA is performing.

This information is an exerpt from the Westinghouse Report titled "PBNP Power Uprate Project

NSSS Engineering Report Volume 1."

===

The PBNP Unit 1 Steam Generators (Westinghouse Model 44F) calculated stress for normal and abnormal conditions (PL+PB+Q) in the flaw region (upper shell to upper head weld) is 64.7 ksi.

===

Brian Kemp

Hal L. Gustin

From: Kemp, Brian [Brian.Kemp@nmcco.com]
Sent: Thursday, November 10, 2005 9:21 AM
To: Hal L. Gustin
Cc: Turner, Russell
Attachments: design paramters r1.doc

Hal,

As described in my email to you (dated October 22, 2005), the calculated stress for normal and abnormal conditions (P_L+P_B+Q) that should be used in the SIA analysis for the PBNP-1 SG flaw region (upper shell to upper head weld) is 64.7 ksi. This value was selected because it represented the highest stress values in the Model 44F SG transition cone region and is clearly referenced in the text of the Westinghouse SG Analysis [1]. This is a conservative value that is appropriate to use for the SIA analysis of upper shell to transition cone weld.

Additionally, the file that I forwarded to you October 19, 2005 titled "design parameters.doc" has a *.pdf to *.doc conversion error in it's note 1. The correct note should read "Parameters reflect Model Δ47 replacement steam generators but also bound operation with Model 44F in Unit 1." The note is corrected and the revised file is attached to this email.

Please call with questions.

Brian Kemp

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[1] "PBNP Power Uprate Project NSSS Engineering Report Volume 1."

Brian Kemp
NMC Fleet Lead - Materials
715-426-6960 (office)
612-202-9286 (cell)

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[1] "PBNP Power Uprate Project NSSS Engineering Report Volume 1."

Hal L. Gustin

From: Kemp, Brian [Brian.Kemp@nmcco.com]
Sent: Wednesday, October 19, 2005 9:30 AM
To: Hal L. Gustin
Subject: PBNP design input

Attachments: design paramters.doc; load cycles.doc; Pzr Fatigue Usage.doc; SG Design Information.doc; Transition Cone Region Figure.doc; Transition Cone Region Figure - Thicknesses.doc

design aramters.doc (70 KE | load cycles.doc (68 KB) | Pzr Fatigue Usage.doc (43 KB) | SG Design)formation.doc (37 . | Transition Cone Region Figure.... | Transition Cone Region Figure ...

Hal,

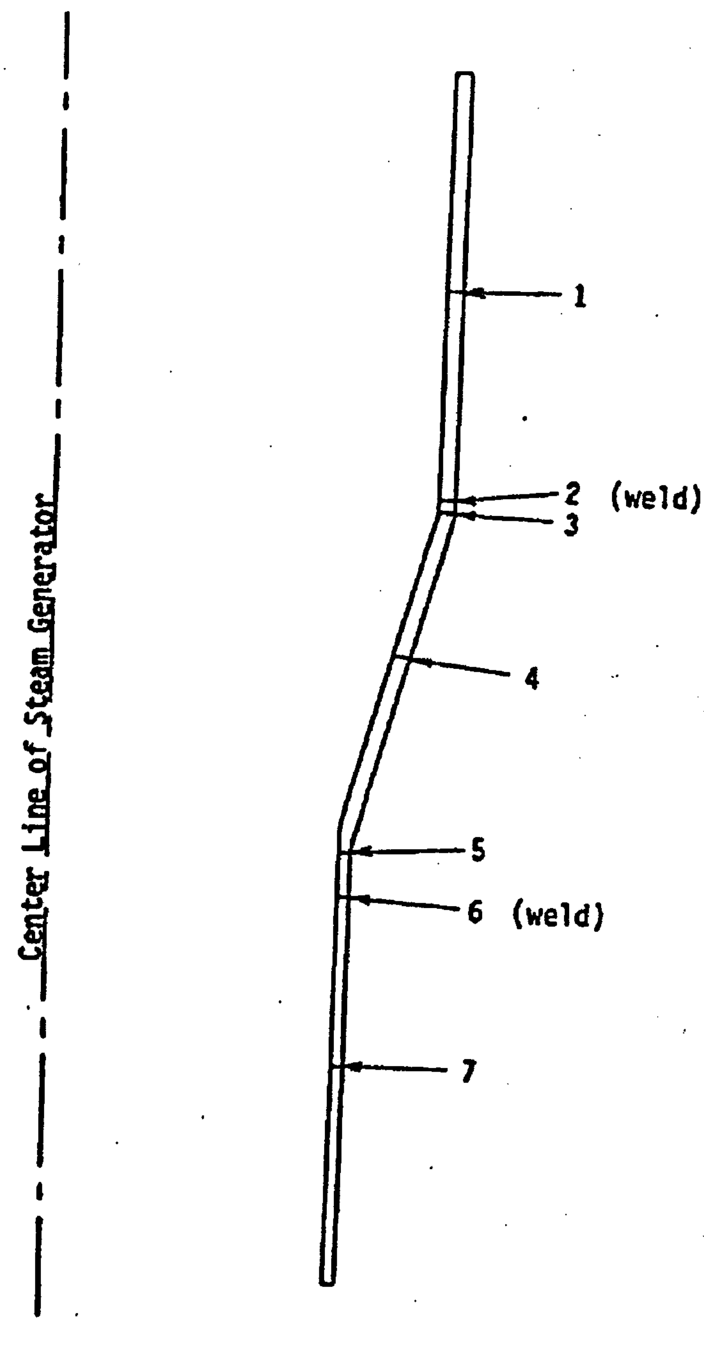
The attached information should be used as design inputs for the U1R29 SG & PZR structural evaluations that SIA is performing.

This information is non-proprietary exerpts from the Westinghouse Report titled "PBNP Power Uprate Project

NSSS Engineering Report Volume 1."

Please call with questions.

Brian Kemp



Transition Cone Region

PBNP Unit 1 Model 44F And Δ47 Steam Generator Loading Cycles				
Description of Loading Conditions	**Number of Load Cycles**			
	44F Design Spec. (Ref. 1)	**Δ47 Design Spec. (Ref. 2)**	**Sect. 3.1**	**60-Year Transients**
Heatup/Cooldown	200	200		200
Hot Standby at No Power	--			--
Feedwater Cycling at HSB	25,000	10,000		25,000
Loading/Unloading @5% PWR/min	14,500	18,300		18,300
Steady-state at Full Load	--	--		--
10% Step-Load Increase	2,000	2,000		2,000
10% Step-Load Decrease	2,000	2,000		2,000
Large Step-Load Decrease (50% Step-Load Decrease)	200	200		200
Reactor Trip	400	400		400
Loss of Load	80	80		80
Partial Loss of Flow	80	80		80
Loss of Power (Power Blackout)	40	40		40
Inadvertent Auxiliary Spray		10		10
Primary Hydrotest @ 3106 psig	1	5		5
Primary Pressure Test @ 2485 psig	50	120	94 (100)	100
Secondary Hydrotest @ 1356 psig	1	10		10
Secondary Pressure Test @ 1085 psig	50	10		50
Prim-to-Sec Leak Tests	5		27 (30)	30
Sec-to-Prim Leak Tests	5	120	128 (130)	130

PBNP Power Uprate Project (Bounding 10.5% Core Power Uprate)
NSSS Design Parameters[1,2] Used for Systems, Components & Accident Analyses

Parameter	Case 1 Low T_{avg} 0% SGTP	Case 2 Low T_{avg} 10% SGTP	Case 3 High T_{avg} 0% SGTP	Case 4 High T_{avg} 10% SGTP
Steam Generator				
Steam Pressure (psia)	662[3,4]	637[3,4]	764[4]	737[3,4]
Steam Temperature (°F)	496.8[3]	492.7[3]	512.9	508.8[3]
Steam Flow, Total (10^6 lb_m/hr)	7.37	7.37	7.39[5]	7.39[5]
Feedwater Temperature (°F)	442.9	442.9	442.9	442.9
Tube Plugging (%)	0	10	0	10

Notes:

1. Parameters reflect Model Δ47 replacement steam generators but also bound operation with Model 44F in Unit 1
2. Systems and components analyses have been performed using the parameters identified in Table 1-1.
3. Steam pressure/temperature must be greater than 745.7 psia/510.0°F due to the steam generator design pressure differential requirements.
4. Steam pressure at the outlet of the steam generator nozzle.
5. A maximum moisture carry over of 0.10% was assumed; however, this value cannot be warranted at this high power level and low steam pressure. The maximum moisture carry over for the Model 44F steam generators is 0.25% and the maximum steam flow associated with this value is 7.40×10^6 lb/hr.

Structural

The critical steam generator components that were evaluated for structural adequacy are:

Primary side: Primary chamber, tubesheet, primary nozzles, primary manway, divider plate, and tube-to-tubesheet weld. The primary side of the replacement steam generators was evaluated as a whole through a review of the uprating transients that affect the primary side of the steam generator, i.e., RCS transients.

Secondary side: Upper shell, transition cone, lower shell, junction of tubesheet and stub barrel, main and auxiliary feedwater and spray nozzles, secondary manway opening and bolts, inspection ports, and minor shell taps.

These components were evaluated for the effects of the uprate on the steady-state and transient conditions for the normal and upset loads in the design specifications, References 1 (Model 44F) and Reference 2 (Model Δ47). The test, emergency, and faulted loading conditions are unaffected by the uprate. The structural acceptance criteria for both steam generator models are given in the 1965 Edition through Summer 1966 Addenda of the ASME B&PV, Section III, Reference 3. Details of the actual acceptance criteria employed in the structural evaluation of both the 44F and Δ47 are given in Section 4 of Volume 1 of Reference 4.

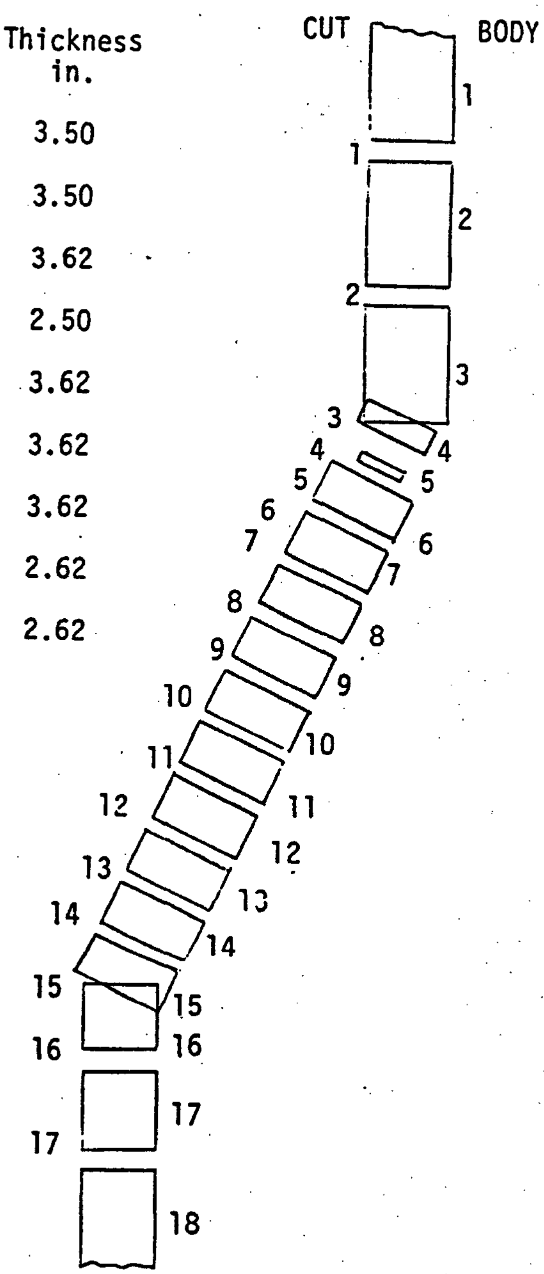
Secondary Shell – Model 44F

Summary stress results for the secondary shell transition cone are given in Table 7-44 of Reference 5 for current power rating. These results, shown in Table 5.6-9, remain bounding for the uprated conditions since a reduction in secondary pressure will reduce the stresses in the shell. Citical sections in the transition cone region are depicted in Figure 5.6-3. The results in Table 5.6-9 show that all stress limits are satisfied. For fatigue, Section BB, shown in Figure 5.6-1, is the overall governing location for the secondary shell and has been considered above in the evaluation for the channel head, the tubesheet and the tubesheet to shell junctions. The structural evaluation of the relocated PBNP Unit 1 level taps in the secondary shell is discussed below.

Upper Shell Remnant – Model 44F

The upper shell (along with its manway) and the steam outlet nozzle are remnant components from the original 44 Series steam generator. The remnant components were evaluated for continued use in Model 44F replacement steam generators in Section 7.20 of Reference 5. Figure 5.6-5 shows the locations in the upper shell remnant evaluated in Reference 5. Section DD in Figure 5.6-5 refers to the manway pad. The feedwater nozzle is evaluated above as a separate item. As discussed previously, the power uprate results in reduced secondary (steam) pressures and temperatures. Therefore, the specified loads, considered in Reference 5, bound the structural evaluation. The calculated fatigue usage factor for 40 years is less than 1.0 at the limiting location, Section BB in Figure 5.6-5. Since the maximum usage in the remnant based on 40 years is very low, extension to 60 years and ASME Code compliance within the usage limit of one are obvious.

Body No.	Meridional length, in.	Thickness in.
1	∞	3.50
2,3	8.43	3.50
4	5.15	3.62
5	1.00	2.50
6-8	7.24	3.62
9	7.29	3.62
10-15	7.24	3.62
16, 17	6.38	2.62
18	∞	2.62



Transition Cone Region – Model 44F