EXHIBITS A & B

EXHIBIT A

1. BWNT Calculation Summary No. 32-1240855-00, "Flaw Evaluation for Oconee-2 CRDM Nozzle No. 23," November 1995.

EXHIBIT B

The above listed document contains information which is considered Proprietary in accordance with Criteria c of the attached affidavit.

B&W NUCLEAR TECHNOLOGIES

CALCULATION SUMMARY SHEET (CSS)

DOCUMENT IDENTIFIER 32-1240855-00

TITLE Flaw Evaluation for Oconee-2 CRDM Nozzle No. 23

PREPARED BY:		REVIEWED BY:	
NAME	D.E. Killian	NAME	K.K. Yoon
SIGNATURE	[signature]	SIGNATURE	K. K. Yoon
TITLE	Principal Engineer DATE 11/15/95	TITLE	Technical Consultant DATE 11/20/95
COST CENTER	41020 REF. PAGE(S) 12	TM STATEMENT: REVIEWER INDEPENDENCE	KKY

PURPOSE AND SUMMARY OF RESULTS:

PURPOSE:

The purpose of this analysis is to determine time-to-failure for axial and circumferential flaws of the type indicated in Oconee-2 CRDM nozzle number 23. The flaws, assumed to have an initial depth of 0.079" (2 mm) and an initial length of 0.370" (9.4 mm), are subjected to cyclic heatup and cooldown loadings and long-term steady state loadings for a maximum time period of 3 years, the equivalent of at least two fuel cycles of normal operation.

SUMMARY OF RESULTS:

Results of fracture mechanics crack growth analyses are shown in Tables 3 and 4. An axial flaw grows to 75% of the wall thickness in 26 heatup/cooldown cycles, or 2.89 years, whereas a circumferential flaw is acceptable for at least 3 years.

Note: The FORTRAN program listings in Appendices A and B are considered to be proprietary information that can not be released outside of the company.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

CODE / VERSION / REV	CODE / VERSION / REV

THIS DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK

YES ( ) NO (X)

RECORD OF REVISIONS

Revision	Description of Revision	Date
0	Original Release	11/95

TABLE OF CONTENTS

Prepared by: D.E. Killian Date: 11/14/95

Reviewed by: K.K. Yoon Date: 11/15/95

LIST OF TABLES

1.0 Introduction

During the CRDM nozzle inspection at Oconee Unit 2 completed in October 1994, several indications were detected using eddy current examination techniques. Numerous shallow crack-like indications were identified in nozzle 23 between the top and bottom of the weld on the uphill (180°) side of the nozzle. The indications occurred near the phase threshold of the indication criteria per the applicable BWNT procedure. A dye penetrant test (PT) revealed 20 individual indications in nozzle 23. Eighteen of the indications are axially oriented and two are circumferentially oriented.

An ultrasonic (UT) examination of nozzle 23 was also performed, but no indications were detected. The UT method used is qualified to size axially-oriented CRDM nozzle flaws having depths of 0.079" (2 mm) and greater. Thus, all indications were estimated to be less than 0.079" deep. In addition, the length of the longest flaw indication was 0.370" (9.4 mm), for a length-to-depth ratio of 4.70. Such indications are acceptable for one fuel cycle based on the allowable flaw sizes calculated in Reference 1 for axial flaws and in Reference 2 for circumferential flaws.

Acceptable flaw sizes in References 1 and 2 were calculated using stresses obtained from a BWNT/B&WOG nonlinear finite element model developed in 1992/1993 (Ref. 3). This model was used to generically obtain maximum stress profiles within CRDM nozzles in B&W 177-Fuel Assembly (FA) plants. Loading conditions included shrink fit of the nozzle during installation, weld shrinkage, cold hydrotest, and steady state operating conditions. Two separate models were developed, one each for a hillside location and the center nozzle. Stresses calculated from the nonlinear model were strongly dependent on the yield strength of the Alloy 600 nozzle material. A value of 64.4 ksi was used since this is the maximum yield strength of all CRDM nozzle materials in B&W 177-FA plants.

Linear stress analysis was also performed for several repair designs for CRDM nozzles (Ref. 4) for cyclic thermal and pressure loadings experienced during heatup and cooldown transients. As a base case, this linear analysis was also conducted for the original CRDM hillside and center nozzles.

Flaws are considered to be acceptable for a given period of plant operation if it can be demonstrated that flaw growth will not violate any of the following criteria:

1. Fracture toughness margins of Section XI of the ASME Code (paragraph IWB-3612)

2. Flaw depth does not exceed 75% of the wall thickness (NEI criterion)

3. For circumferential flaws, flaw length does not exceed 1.383" on the inside surface.

For semi-elliptical inside surface flaws with a 6:1 length-to-depth ratio, the following flaw sizes were determined to be acceptable for one fuel cycle of operation (1.5 years):

Acceptable 6:1 Semi-Elliptical Inside Surface Flaws for 1.5 Years of Operation		
Flaw Orientation	Limiting Criterion	Flaw Depth
Axial	Flaw size, a/t = 0.192	0.119"
Circumferential	Flaw length = 1.383"	0.231"

Although the largest flaw indication in nozzle 23 satisfies the above acceptance criteria, it is obvious that the plant could operate with such a flaw for longer than one fuel cycle. The purpose of the present analysis is to determine how long the plant could operate with the nozzle 23 flaw indication and still satisfy all applicable safety margins.

2.0 Basis for Analysis

The basis for the present analysis to maximize the operating period for nozzle 23 is the nonlinear (Ref. 1) and linear (Ref. 2) stress results for the original CRDM nozzles at the outermost hillside location. Nonlinear, long-term steady state stresses, which include the effects of residual weld distortions, are used to predict crack growth under primary water stress corrosion cracking (PWSCC) conditions. Linear stresses for heatup and cooldown transient conditions are used to determine fatigue crack growth for cyclic loads. Furthermore, the fracture mechanics methodology utilized in the current calculations for the nozzle 23 flaw indications is the same as documented in References 1 and 2.

There are several conservatisms in the present analytical procedure, as discussed below.

1. The analyzed flaw depth is an upper bound on the depth of the actual flaw indication. The assumed depth of 2 mm is based on the threshold of detectability for the UT inspection equipment, since no indication was actually detected by UT.

2. As noted previously, a value of 64.4 ksi was used for the yield strength of the Alloy 600 nozzle material in the nonlinear analysis to determine steady state operating stresses. Since this is the maximum value for all the CRDM nozzles in 177-FA plants, nozzle 23 obviously has a lower yield strength, which would result in lower residual weld stresses and as well as lower steady state stresses. From Reference 5, the yield strength value for nozzle 23 is 55.2 ksi.

3. The P. Scott crack growth model (Ref. 6) used for PWSCC crack propagation is reported to yield higher growth rates than those experienced in European PWR plants that have a program for monitoring in-service flaws.

3.0 Results

FORTRAN computer programs AXFLAW and CIRCFLAW, listed in Appendices A and B, respectively, were used to determine time-to-failure for axial and circumferential flaws of the type indicated in Oconee-2 CRDM nozzle 23. The flaws, assumed to have an initial depth of 0.079" (2 mm) and an initial length of 0.370" (9.4 mm), were subjected to cyclic heatup and cooldown loadings and long-term steady state loadings for a maximum time period of 3 years, the equivalent of at least two fuel cycles of normal operation. Based on a total of 360 heatup and cooldown transients over the design life of the Oconee-2 plant, 9 heatup/cooldown cycles are predicted to occur in a year, or 27 overs 3 years.

The analysis calculated crack growth due to fatigue and PWSCC and evaluated fracture toughness margins and size limitations at each incremental crack depth against the acceptance criteria outlined in Section 1.0. The AXFLAW and CIRCFLAW computer programs are verified in Appendices C and D, respectively. Input files for the two FORTRAN programs are listed in Tables 1 and 2, and the printed output is shown in Tables 3 and 4.

A review of the analytical results in Tables 3 and 4 reveals that an axial flaw grows to 75% of the wall thickness in 26 heatup/cooldown cycles, or 2.89 years, whereas a circumferential flaw is acceptable for at least 3 years.

4.0 Conclusions

Analysis has determined that a 0.370" long by 0.079" deep inside surface flaw, which bounds the indications found in Oconee-2 CRDM nozzle 23, is acceptable for 2.89 years of continuous, normal reactor operation.

Table 1. Input File for Program AXFLAW

Filename AX.INP

```
0.1274        ! a/t                Uphill at top of weld for cooldown
4.7           ! l/a
1.3825                                    ! inner radius of cylinder
2.000                                     ! outer radius of cylinder
4.09E-10                                  ! Paris Law scaling constant
3.349                                     ! Paris Law slope constant
303.085                                   ! KIc
56.80                                     ! yield stress
86.80                                     ! flow stress
1                                         ! number of fatigue groups
1                                         ! fatigue group ID
27                                        ! number of fatigue cycles
 0.000  0.250  0.500  0.750  1.000        ! x/t locations for hoop stresses
19.133 21.638 22.871 28.399 42.275        ! maximum operating stresses
54.307 57.011 67.774 75.840 73.148        ! steady state residual + operating
```

Table 2. Input File for Program CIRCFLAW

Filename CIRC.INP

```
0.1274        ! a/t                Uphill at 7/8" above weld for cooldown
4.7           ! l/a
1.3825                                    ! inner radius of cylinder
2.000                                     ! outer radius of cylinder
4.09E-10                                  ! Paris Law scaling constant
3.349                                     ! Paris Law slope constant
303.085                                   ! KIc
56.80                                     ! yield stress
86.80                                     ! flow stress
1                                         ! number of fatigue groups
1                                         ! fatigue group ID
27                                        ! number of fatigue cycles
 0.000  0.250  0.500  0.750   1.000       ! x/t locations for axial stresses
 7.774  5.037  2.492 -0.043  -2.648       ! maximum operating stresses
49.826 36.004 21.156  5.656  -9.469       ! steady state residual + operating
```

Table 3. Output File for Program AXFLAW

Filename AX.OUT Date 11/14/95

Semi-Elliptical Inside Surface Axial Flaw in a Cylinder

Evaluation for Normal/Upset Conditions per IWB-3612 for l/a = 4.7

Cycle	a (in)	c (in)	KI(a_e) (ksi*in^.5)	KI(c_e) (ksi*in^.5)	po (ksi)	a/t
Group 1						
0	.0787	.1849	9.02	6.31	26.701	.1274
1	.0834	.1960	9.43	6.60	26.681	.1351
2	.0886	.2081	9.86	6.90	26.658	.1434
3	.0941	.2212	10.31	7.23	26.628	.1524
4	.1002	.2354	10.78	7.57	26.593	.1622
5	.1067	.2507	11.28	7.92	26.549	.1728
6	.1137	.2673	11.79	8.30	26.495	.1842
7	.1213	.2851	12.34	8.69	26.429	.1965
8	.1295	.3043	12.90	9.11	26.348	.2097
9	.1383	.3250	13.49	9.54	26.249	.2240
10	.1478	.3473	14.10	10.00	26.128	.2393
11	.1580	.3712	14.75	10.48	25.980	.2558
12	.1689	.3969	15.43	10.99	25.799	.2735
13	.1806	.4245	16.15	11.54	25.579	.2925
14	.1932	.4541	16.91	12.13	25.313	.3129
15	.2068	.4860	17.73	12.77	24.990	.3349
16	.2214	.5202	18.62	13.46	24.600	.3585
17	.2371	.5572	19.60	14.23	24.129	.3839
18	.2540	.5970	20.68	15.08	23.561	.4114
19	.2724	.6402	21.89	16.04	22.878	.4411
20	.2923	.6870	23.27	17.13	22.056	.4734
21	.3141	.7381	24.84	18.37	21.069	.5086
22	.3379	.7940	26.68	19.81	19.884	.5471
23	.3640	.8554	28.83	21.49	18.462	.5895
24	.3929	.9233	31.37	23.45	16.755	.6363
25	.4250	.9988	34.41	25.73	14.709	.6883
26	.4609	1.0830	38.07	28.39	12.257	.7463
27	.5011					.8114 > 0.75

Summary of Results for a/t = .7463

p = 2.500 ksi
KIc = 303.085 (ksi*in^.5)

Fracture Toughness Margins:
at deepest location: 7.960 > 3.162 (OK)
at surface location: 10.676 > 3.162 (OK)
Limit Load Margin: 4.903 > 1.000 (OK)

Table 4. Output File for Program CIRCFLAW

Filename CIRC.OUT Date 11/14/95

Semi-Elliptical Inside Surface Circumferential Flaw in a Cylinder

Evaluation for Normal/Upset Conditions per IWB-3612 for l/a = 4.7

Cycle	a (in)	c (in)	KI(a_e) (ksi*in^.5)	Po (kips)	a/t	l (in)
Group 1						
0	.0787	.1849	2.80	565.834	.1274	.3697
1	.0819	.1925	2.88	565.512	.1327	.3851
2	.0854	.2007	2.96	565.155	.1383	.4013
3	.0890	.2093	3.04	564.760	.1442	.4185
4	.0929	.2184	3.12	564.322	.1505	.4368
5	.0970	.2280	3.21	563.838	.1571	.4560
6	.1013	.2382	3.29	563.303	.1641	.4763
7	.1059	.2489	3.38	562.712	.1715	.4978
8	.1107	.2601	3.46	562.060	.1793	.5203
9	.1157	.2720	3.55	561.342	.1874	.5440
10	.1210	.2844	3.63	560.552	.1960	.5687
11	.1265	.2973	3.72	559.685	.2049	.5947
12	.1323	.3109	3.80	558.736	.2142	.6218
13	.1383	.3250	3.88	557.697	.2240	.6500
14	.1445	.3397	3.95	556.563	.2341	.6793
15	.1510	.3549	4.02	555.329	.2445	.7097
16	.1577	.3706	4.09	553.989	.2554	.7412
17	.1646	.3869	4.16	552.536	.2666	.7738
18	.1718	.4037	4.22	550.967	.2782	.8073
19	.1791	.4209	4.27	549.275	.2901	.8419
20	.1867	.4386	4.32	547.456	.3023	.8773
21	.1944	.4568	4.37	545.505	.3148	.9136
22	.2023	.4753	4.41	543.419	.3276	.9507
23	.2103	.4943	4.44	541.194	.3406	.9885
24	.2185	.5135	4.47	538.828	.3539	1.0271
25	.2269	.5331	4.50	536.317	.3674	1.0663
26	.2353	.5530	4.52	533.660	.3811	1.1060
27	.2439	.5731	4.53	530.856	.3950	1.1463

Summary of Results for a/t = .3950

P = 51.012 kips
KIc = 303.085 (ksi*in^.5)

Fracture Toughness Margin
at deepest location: 66.834 > 3.162 (OK)
Limit Load Margin: 10.407 > 1.000 (OK)

Prepared by: D.E. Killian Date: 11/14/95

Reviewed by: K.K. Yoon Date: 11/15/95

5.0 References

1. Hill, L.T., "Calculation of Allowable Flaws in CRDM Nozzles," BWNT Doc. No. 32-1229754-01, September 1994.

2. Hill, L.T., "Fracture Mechanics Assessment of Circumferential CRDM Nozzle Flaws," BWNT Doc. No. 32-1234569-00, September 1994.

3. Killian, D.E., "CRDM Nozzle Stress Analysis," BWNT Doc. No. 32-1224271-00, May 1993.

4. Killian, D.E., "Stress Analysis for CRDM Nozzle Repair Designs," BWNT Doc. No. 32-1228411-00, June 1994.

5. Campbell, C.A., "CRDM Nozzle Characterization," BWNT Doc. No. 51-1219143-00, December 1992.

6. Scott, P.M., "An Analysis of Primary Water Stress Corrosion Cracking in PWR Steam Generators," Proceedings of the Specialists Meeting on Operating Experience with Steam Generators, Paper No. 5-6, Brussels, Belgium, September 16-20, 1991.

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY INFORMATION REMOVED

PROPRIETARY
INFORMATION
REMOVED

Appendix C Verification of FORTRAN Program AXFLAW

Referenced output file: AX.OUT

Geometry Data:

Ro =	2.0000	in.
Ri =	1.3825	in.
t =	0.6175	in.
R =	1.6913	in.
Ri/t =	2.2389	
R/t =	2.7389	
l/a =	4.7	
a =	0.4609	in.
c =	1.0831	in.

Material Data:

Sy =	56.8	ksi (yield strength)
Sf =	86.8	ksi (flow stress)
KIc =	303.085	ksi*in^.5

Internal Pressure: p = 2.500 ksi

Hoop Stresses:

Thru-Wall Stress Distributions

Position x/t	Oper. S (ksi)	SS S (ksi)
0.00	19.133	54.307
0.25	21.638	57.011
0.50	22.871	67.774
0.75	28.399	75.840
1.00	42.275	73.148

3rd Order Polynomial Fits

Coeff.	Oper. Si (ksi)	SS Si (ksi)
S0	19.15463	54.269
S1	17.8959	-15.922
S2	-46.0606	135.120
S3	51.30667	-100.357

C.1 Limit Load

				Spread-sheet	Program Output	
M	=	[1 + (1.61c^2)/(R t)]^0.5	=	1.675873		
x	=	a/t	=	0.746397		
po	=	Sf (t/Ro) [1-x]/[1-(x/M)]	=	12.254	12.257	ksi
po/p			=	4.902	4.903	

C.2 Stress Intensity Factor Solutions

i	A1	A2	A3	A4	A5	A6	A7	m	r
0	1.77670	-2.59750	2.75200	-1.32370	0.23630	1.06	0.28	0.58	0.41
1	0.10450	0.41890	0.00000	0.00000	0.00000	0.25	0.20	0.22	0.26
2	0.02038	-0.00397	0.42126	0.00000	0.00000	0.07	0.16	0.10	0.06
3	0.07283	-0.36006	0.66883	0.00000	0.00000	0.085	0.02	0.05	0.00

Stress Intensity Factor at Deepest Point

KI = (pi*t)^.5 * SUM(Si * Gi), i=0,1,2,3

Gi = (A1*alpha_i + A2*alpha_i^2 + A3*alpha_i^3 + A4*alpha_i^4 + A5*alpha_i^5) / F
alpha_i = (a/t)/(a/c)^m

F = [0.102(Ri/t) - 0.02]^0.05 = 0.924573

ry = 1/(6 pi)*(KI(a)/Sy)^2
ae = a + ry

			ry =	0.021388	
a =	0.4609	in.	ae =	0.4823	in.
c =	1.0831	in.	c =	1.0831	in.

i	alpha(a)	G(a)	KI(a) - ksi*in^.5 Spread-sheet	alpha(ae)	G(ae)	KI(ae) - ksi*in^.5 Spread-sheet	KI(ae) - ksi*in^.5 Program Output
0	1.22515	1.090923		1.282002	1.135528		
1	0.900751	0.46941		0.942549	0.509042		
2	0.812974	0.259897		0.850699	0.296147		
3	0.778974	0.166987		0.815122	0.197239		
For max. operating conditions:			36.06			38.08	38.07
For steady state conditions:			97.62				

Stress Intensity Factor at Surface Point

KI = (pi*t)^.5 * SUM(Si * Gsi), i=0,1,2,3

Gsi = Gi * [A6 + A7(a/t)^2] * (a/c)^r

i	Gs(a)	KI(a) - ksi*in^.5 Spread-sheet	Gs(ae)	KI(ae) - ksi*in^.5 Spread-sheet	KI(ae) - ksi*in^.5 Program Output
0	0.934515		0.984574		
1	0.135859		0.151643		
2	0.039293		0.047154		
3	0.016055		0.019172		
For max. operating conditions:		26.94		28.39	28.39
For steady state conditions:		72.77			

C.3 Crack Growth for One Design Cycle

Let:	a	=	0.4609	in.

Fatigue Crack Growth for One Design Cycle of Operating Stress

KImax	=	36.06	ksi*in^.5
KImin	=	0.00	ksi*in^.5

da/dN = C*(dK)^n   in/cycle

where	C	=	4.09E-10	
	n	=	3.349	
and	dN	=	1	cycle
	dK	=	36.06	ksi*in^.5
Then:	da/dN	=	0.0001	in/cycle
	da_fatigue	=	0.0001	in.

Stress Corrosion Crack Growth for One Equivalent Design Cycle of Steady State Stress

KImax	=	97.62	ksi*in^.5
KIscc	=	8.19	ksi*in^.5

da/dt = C*(KImax-KIscc)^n   in/sec

where	C	=	6.241E-11	
	n	=	1.16	
and	dt	=	(1/9 yr) * (365 days/yr) * (24 hr/day) * (3600 sec/hr)	
		=	3504000	sec.
Then:	da/dt	=	1.15E-08	in/sec
	da_SCC	=	0.0401	in.

Total Crack Growth

da = da_fatigue + da_SCC = 0.0402 in.

	Spread-sheet	Program Output	
New crack depth = a + da =	0.5011	0.5011	in.

Appendix D — Verification of FORTRAN Program CIRCFLAW

Referenced output file: CIRC.OUT

Geometry Data:

Ro =	2.0000	in.
Ri =	1.3825	in.
t =	0.6175	in.
R =	1.6913	in.
Ri/t =	2.2389	
R/t =	2.7389	
l/a =	4.7	
a =	0.2439	in.
c =	0.5732	in.

Material Data:

Sy =	56.8	ksi (yield strength)
Sf =	86.8	ksi (flow stress)
KIc =	303.085	ksi*in^.5

Axial Load: P = MAX[S(oper)]*pi*(Ro^2-Ri^2) = 51.012 kips

Axial Stresses:

Thru-Wall Stress Distributions

Position x/t	Oper. S (ksi)	SS S (ksi)
0.00	7.774	49.826
0.25	5.037	36.004
0.50	2.492	21.156
0.75	-0.043	5.656
1.00	-2.648	-9.469

3rd Order Polynomial Fits

Coeff.	Oper. Si (ksi)	SS Si (ksi)
S0	7.772543	49.817
S1	-11.4338	-51.836
S2	2.409143	-14.931
S3	-1.39733	7.472

D.1 Limit Load

			Spread-sheet	Program Output	
z =	t / Ro	=	0.30875		
theta =	(pi c) / (4 Ri)	=	0.325615		
x =	a / t	=	0.39498		
A1 =	x [(1-z)(2-2z+xz)+(1-z+xz)^2]/{2[1+(2-z)(1-z)]}	=	0.154895		
alpha =	arc cos [A1*sin(theta)]	=	1.521226		
Po =	2 pi R t Sf [2*alpha/pi - (x*theta/pi)(2-2z+xz)/(2-z)]	=	530.851	530.856	kip
Po/P =		=	10.406	10.407	

D.2 Stress Intensity Factor Solution at Deepest Point

KI = (pi*t)^.5 * SUM(Si * (a/t)^i * Gi), i=0,1,2,3

Gi = A1*alpha_i + A2*alpha_i^2 + A3*alpha_i^3 + A4*alpha_i^4 + A5*alpha_i^5 + A6*alpha_i*(R/t-5)

alpha_i = (a/t)/(a/c)^m

i	A1	A2	A3	A4	A5	m
0	1.8143	-1.9881	1.4382	-0.4680	0.056696	0.50
1	1.0959	-0.9874	0.5399	-0.09303	0.0	0.38
2	1.1836	-2.3347	2.9756	-1.7652	0.39483	0.30
3	1.0029	-2.0160	2.5627	-1.4951	0.32759	0.25

ry = 1/(6 pi)*(KI(a)/Sy)^2
ae = a + ry

			ry =	0.000336	
a =	0.2353	in.	ae =	0.2356	in.
c =	0.5530	in.	c =	0.5530	in.
a / t =	0.3811		ae / t =	0.3816	

i	alpha(a)	G(a)	KI(a) - ksi*in^.5 Spread-sheet	alpha(ae)	G(ae)	KI(ae) - ksi*in^.5 Spread-sheet	KI(ae) - ksi*in^.5 Program Output
0	0.584143	0.617457		0.584976	0.617976		
1	0.527219	0.375254		0.527971	0.375593		
2	0.492386	0.27964		0.493088	0.279866		
3	0.471793	0.227128		0.472467	0.227307		
For max. operating conditions:			4.52			4.52	4.52
For steady state conditions:			31.81				

D.3 Crack Growth for One Design Cycle

Let: a = 0.2353 in.

Fatigue Crack Growth for One Design Cycle of Operating Stress

KImax	=	4.52	ksi*in^.5
KImin	=	0.00	ksi*in^.5

da/dN = C*(dK)^n in/cycle

where	C	=	4.09E-10	
	n	=	3.349	
and	dN	=	1	cycle
	dK	=	4.52	ksi*in^.5
Then:	da/dN	=	0.0000	in/cycle
	da_fatigue	=	0.0000	in.

Stress Corrosion Crack Growth for One Equivalent Design Cycle of Steady State Stress

KImax	=	31.81	ksi*in^.5
KIscc	=	8.19	ksi*in^.5

da/dt = C*(KImax-KIscc)^n in/sec

where	C	=	6.241E-11	
	n	=	1.16	
and	dt	=	(1/9 yr) * (365 days/yr) * (24 hr/day) * (3600 sec/hr)	
		=	3504000	sec.
Then:	da/dt	=	2.44E-09	in/sec
	da_SCC	=	0.0086	in.

Total Crack Growth

da = da_fatigue + da_SCC = 0.0086 in.

	Spreadsheet	Program Output	
New crack depth = a + da =	0.2439	0.2439	in.

PROPRIETARY INFORMATION

NOTICE

THE ATTACHED DOCUMENT CONTAINS OR IS CLAIMED TO CONTAIN PROPRIETARY INFORMATION AND SHOULD BE HANDLED AS NRC SENSITIVE UNCLASSIFIED INFORMATION. IT SHOULD NOT BE DISCUSSED OR MADE AVAILABLE TO ANY PERSON NOT REQUIRING SUCH INFORMATION IN THE CONDUCT OF OFFICIAL BUSINESS AND SHOULD BE STORED, TRANSFERRED, AND DISPOSED OF BY EACH RECIPIENT IN A MANNER WHICH WILL ASSURE THAT ITS CONTENTS ARE NOT MADE AVAILABLE TO UNAUTHORIZED PERSONS.

COPY NO. ________________

DOCKET NO. ________________

CONTROL NO. ________________

REPORT NO. ________________

REC'D W/LTR DTD. ________________

PROPRIETARY INFORMATION