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STRUCTURAL INTEGRITY Associates, Inc.	CALCULATION PACKAGE	FILE No: **DUKE-11Q-303-5** PROJECT No: **DUKE-11Q-1**

PROJECT NAME: **ASME Class 1 Analysis of Oconee Piping**

CLIENT: **Duke Power Company**

CALCULATION TITLE: **Class 1 Fatigue Reconciliation for HPI Nozzle**

PROBLEM STATEMENT OR OBJECTIVE OF THE CALCULATION:

The purpose of this calculation is to reconcile the Class 1 fatigue evaluation of the High Pressure Injection Nozzle considering the new piping loads due to the valves recently replaced at Oconee Unit 2 and planned for replacement at Oconee Unit 3.

FOR INFORMATION ONLY

Document Revision	Affected Pages	Revision Description	Project Mgr. Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
0	1 - 8 A0-A3 B0-B9 C0-C9 D0-D9 1 Disk	Original Issue	Gary L. Stevens 11/26/96	DAC 11/25/96 Denise A. Curd GLS 11/26/96 Gary L. Stevens
1	1-5, 8 C0-C9 D0-D9 E0-E3 1 Disk	Revised Data Point for Thermal Moments	Gary L. Stevens 4/1/97	DAC Apr 1, 1997 Denise Curd Gary L. Stevens Gary L. Stevens GLS 4/1/97

1.0 INTRODUCTION

The purpose of this calculation is to reconcile the Class 1 fatigue evaluation of the High Pressure Injection Nozzle [1] considering the new piping loads due to the valves recently replaced at Oconee Unit 2 and planned for replacement at Oconee Unit 3.

2.0 METHODOLOGY

2.1 New Piping Loads

The methodology of Reference 1 was used in recalculate the usage factor for the 40 year design life of the HPI nozzle with the new piping loads. The piping loads were extracted from the SUPERPIPE runs made by Duke Power Company personnel [2]. The output files were named "P25124N.GLA" and "P25315N.GLA" and were reflective of the piping problem numbers being run: (1) Problem 2-51-24, and (2) Problem 2-53-15. According to Duke personnel, these problem numbers correspond to the East Coolant Loop (Problem 2-53-15) which is the normal line, and the West Coolant Loop (Problem 2-51-24) which is the emergency line. These descriptions are consistent with the problem numbers and layouts given on the Reference 3 and 4 drawings.

According to Duke personnel, the emergency lines are more limiting -- this is consistent with conclusions made on page 23 of Reference 5. Therefore, the forces and moments from file "P25124N.GLA" were extracted for use in the stress and fatigue analyses. Based on Reference 6, the following load cases were extracted from the SUPERPIPE output file:

Load Case Name	Description
FPTH	Full Power thermal conditions.
STRS	Stratified Stress Conditions
OBXY	Horizontal earthquake (X-Y Direction).
OBZY	Horizontal earthquake (Z-Y Direction).

From the Reference 3 drawing, nodes 175A and 300A represent the nozzle location in each leg of the West Coolant Loop.

The SUPERPIPE output file [2] is extremely large and could not easily be printed. Therefore, the applicable portions of the file were "cut and pasted" into a separate file using a DOS editor. The resulting smaller file is listed in Appendix A. That file provides the necessary forces and moments.

The forces and moments from Appendix A are summarized in Table 1 for the locations and load

cases under consideration. The maximum absolute value of the forces and moments is tabulated for subsequent use in the fatigue analysis.

2.2 Fatigue Analysis

A spreadsheet was used to recreate the original fatigue analysis (FATIGUE1.XLS). The new piping loads (full power thermal and OBE) were then substituted into the analysis to determine the new fatigue usage (FATIGUE2.XLS). For the new analysis, the OBE piping loads were analyzed without Deadweight, unlike the original analysis in which OBE+Deadweight was conservatively used. Consistent with the original fatigue analysis, the elastic-plastic correction factor, K_e, was determined from Figure F-105(a) of Reference 7 (reproduced in Figure 1). The fatigue curve for stainless steel from Reference 7 is reproduced in Figure 2. A program to interpolate the fatigue curve was used (FATIGUE.EXE) to obtain more exact results. A third analysis was conducted with the stratified stress condition loads to determine which would be more limiting (FATIGUE3.XLS). The full power thermal piping loads proved to be more limiting. The spreadsheets used for the analysis are reproduced in Appendices B-D and the reconciled fatigue usage is summarized in Table 2.

3.0 RESULTS

The reconciled 40 year fatigue usage for the HPI nozzle is 0.884.

Table 1

Piping Loads for HPI Nozzle Analysis

Loads Obtained from File "NOZZLE.TXT")

Load Case = FPTH
Multiplier [8] 1.102

	Node No.	Axial Force (lbs)	Y Force (lbs)	Z Force (lbs)	Torsional Moment (ft-lbs)	YY Moment (ft-lbs)	ZZ Moment (ft-lbs)
Nozzle	175A	204.54	-291.84	142.8	-188.07	611.03	2105.47
Nozzle	300A	200.11	-71.87	-136.33	549.82	139.03	645.57
Maximums		**225.4031**	**321.6077**	**157.3656**	**605.9016**	**673.3551**	**2320.228**

Load Case = OBXY

	Node No.	Axial Force (lbs)	Y Force (lbs)	Z Force (lbs)	Torsional Moment (ft-lbs)	YY Moment (ft-lbs)	ZZ Moment (ft-lbs)
Nozzle	175A	65.48	57.69	63.87	65.87	118.73	112.83
Nozzle	300A	52.64	99.67	260.21	207.54	662	253.51

Load Case = OBZY

	Node No.	Axial Force (lbs)	Y Force (lbs)	Z Force (lbs)	Torsional Moment (ft-lbs)	YY Moment (ft-lbs)	ZZ Moment (ft-lbs)
Nozzle	175A	84.69	60.42	52.09	50.82	105.91	150.29
Nozzle	300A	54.45	89.83	189.31	145.98	472.56	235.09

Load Case = SRSS of OBXY and OBZY

	Node No.	Axial Force (lbs)	Y Force (lbs)	Z Force (lbs)	Torsional Moment (ft-lbs)	YY Moment (ft-lbs)	ZZ Moment (ft-lbs)
Nozzle	175A	107.05	83.54	82.42	83.20	159.10	187.93
Nozzle	300A	75.73	134.18	321.79	253.74	813.36	345.74
Maximums		**107.05**	**134.18**	**321.79**	**253.74**	**813.36**	**345.74**

Load Case = STRS
Multiplier [8] 1.03

	Node No.	Axial Force (lbs)	Y Force (lbs)	Z Force (lbs)	Torsional Moment (ft-lbs)	YY Moment (ft-lbs)	ZZ Moment (ft-lbs)
Nozzle	175A	716.74	62.24	40.18	54.31	587.45	1560.22
Nozzle	300A	353.56	-86.08	-315.48	-234.61	-210.72	540.44
Maximums		**738.2422**	**88.6624**	**324.9444**	**241.6483**	**605.0735**	**1607.027**

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TABLE 2

Reconciled Fatigue Usage

		Fig F-106(b)		
Transient Pair	Salt	N	Nreq	U
Dpz	188.09	191	40	0.209424
Dpz				
Test	119.21	755	40	0.05298
Zero Load				
A+OBE	261.19	81	30	0.37037
B-OBE				
A	202.17	159	40	0.251572
B				
OBE	9.95	1.00E+21	610	6.1E-19
OBE				
			Total Usage	0.884347

FIGURE 1
Elastic-Plastic Correction Factor, K_ϵ

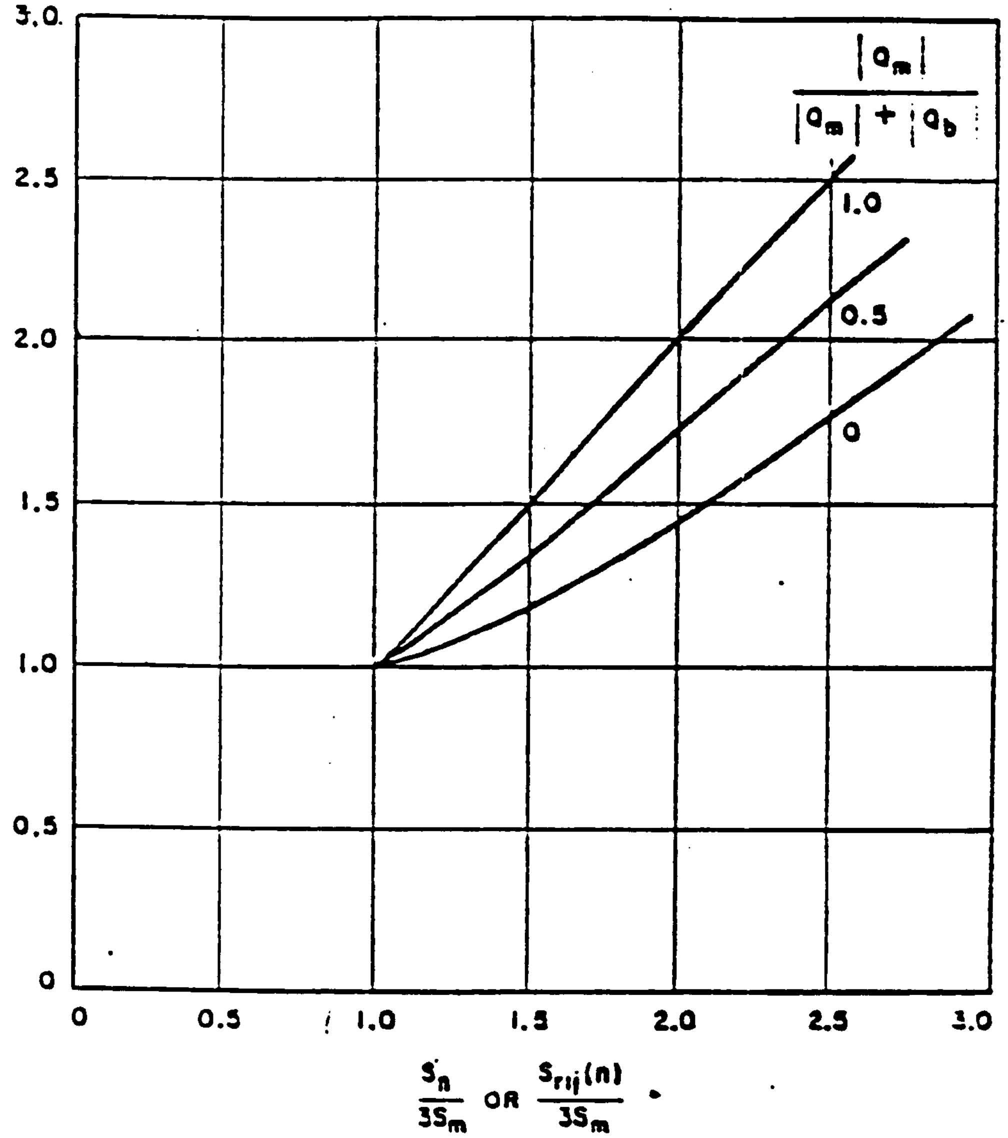

FIGURE F-105(a) USAS B31.7 ELASTIC-PLASTIC CORRECTION FACTOR, K_ϵ

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Checked by: [initials] 11/26/96
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Figure 2

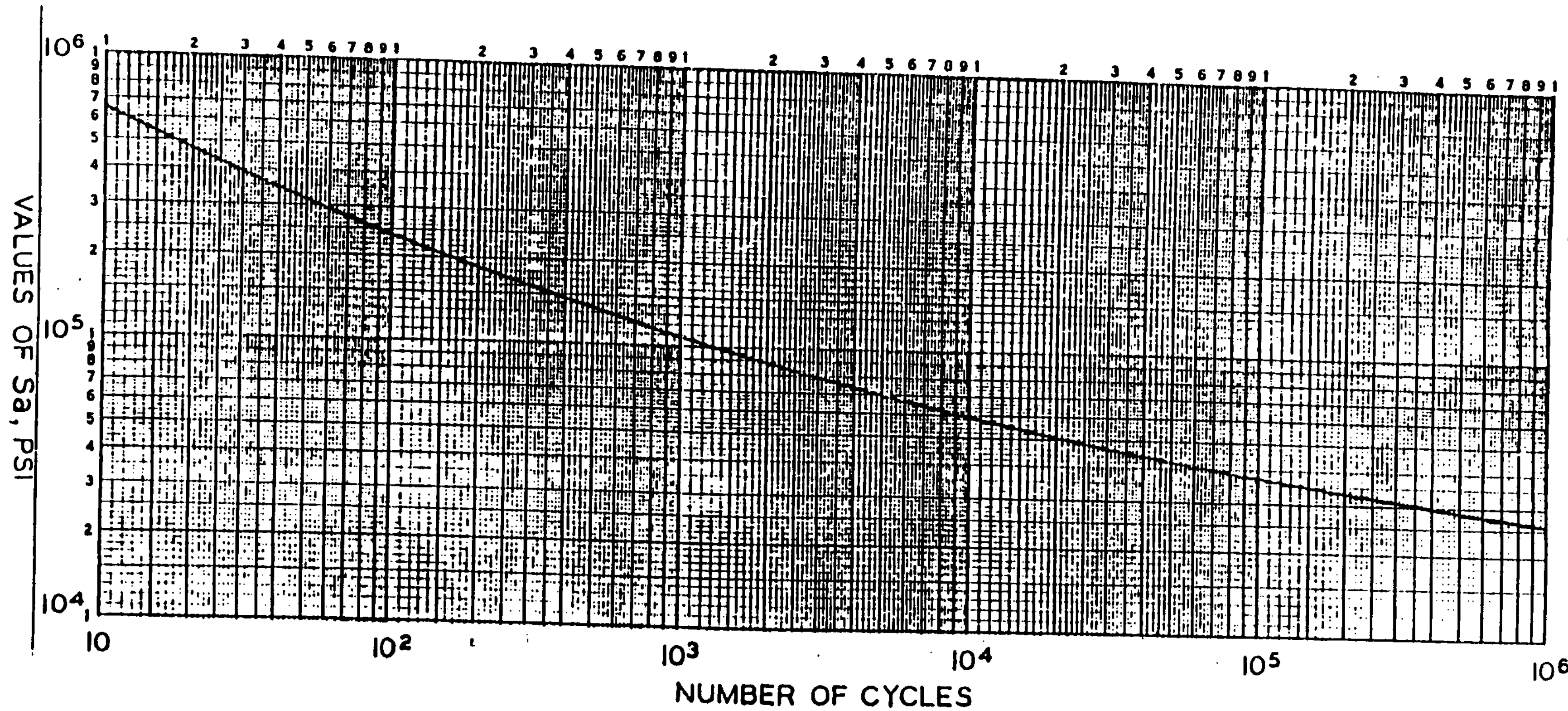

FIGURE F-106(b) ALLOWABLE AMPLITUDE OF ALTERNATING STRESS INTENSITY, S_a, FOR AUSTENITIC STAINLESS STEELS, NICKEL-IRON-CHROMIUM, NICKEL-CHROME-IRON, AND NICKEL-COPPER ALLOYS WITH METAL TEMPERATURES NOT EXCEEDING 800° F, $E = 26(10)^6$ psi.

4.0 REFERENCES

1. B&W Calculation No. 32-1128224-02, Revision 2, "Revised HPI Nozzle Usage Factor," SI File No. DUKE-11Q-263-B.

2. E-mail transmittal from mflangel@dpcmail.dukepower.com (Duke) to Art Deardorff (SI), "fwd: PKZipped Files from G L Armentrout @ Oconee," 10/29/96, 9:50 am, SI File No. DUKE-11Q-263-I.

3. Duke Power Co. Drawing, Calc. No. OSC-1323-06, Sheet 1 of 1, Rev. D19, "Reactor Building -- Unit 2, Piping Analysis Isometric, System 51, Problem 2-51-24, HPI West Coolant Loop/North & South Leg," pages: 6(1)30 and 6(1)31.1, 8/25/95, SI File No. DUKE-11Q-262-2.

4. a. Duke Power Co. Drawing, Calc. No. OSC-1324-06, Sheet 3 of 5, Rev. D18, "Reactor Building -- Unit 2, Piping Analysis Isometric, System 53, Problem 2-53-15, HP Inj. Sys. East Coolant Loop N. Leg," page 62, 8/25/95, SI File No. DUKE-11Q-262-2
   b. Duke Power Co. Drawing, Calc. No. OSC-1324-06, Sheet 4 of 5, Rev. D18, "Reactor Building -- Unit 2, Piping Analysis Isometric, System 53, Problem 2-53-15, HP Inj. Sys. East Coolant Loop S. Leg," page 63, 8/25/95, SI File No. DUKE-11Q-262-2

5. B&W Document No. 51-1235058-00, "Fatigue Usage Summary," Release Date 11-8-94, SI File No. DUKE-11Q-217.

6. FAX transmittal from Geary Armentrout (Duke) to Gary Stevens (SI), 4 pages total, 11/8/96, SI File No. DUKE-11Q-263-I.

7. ASME Nuclear Power Piping, USAS B31.7 - 1969.[(1)]

8. E-mail transmittal from gla8363@pdrc.dukepower.com (Duke) to Denise Curd (SI), "HPI Emergency Injection Lines; Ec/Eh Values," 3/13/97, 4:32 pm, SI File No. DUKE-11Q-103, attached as Appendix E.

Notes: (1) The Reference 1 analysis used the 1968 DRAFT edition. As this edition was not available, the 1969 Edition was used instead.

APPENDIX A

Piping Loads - Nozzle Location
(3 pages total)

Revision	0				
Preparer/Date	DAC 11/24/96				
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1IMPELL CORPORATION PAGE 1
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OCONEE NUCLEAR STATION UNIT 2
OSC-1323-06 REV D24
PROBLEM 2-51-24
AS-BUILD NSM ON-22975 CONFIGURATION

RESPONSE SPECTRUM ANALYSIS NO. 1 (OBXY). FORCES, MOMENTS AND STRESSES ALONG PIPE RUNS (CONTD.)

RUN NAME	SOP NO.	DCP NAME	COMP TYPE	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	TORS MOMENT (LB.FT)	YY MOMENT (LB.FT)	ZZ MOMENT (LB.FT)	M/Z (PSI)
RUN1A										
	81	160T	VALV	52.83	45.88	49.03	60.58	49.18	120.44	N/A
	82	161	VALV	52.83	45.88	49.03	60.58	38.27	111.52	N/A
	83	162	VALV	52.83	45.92	49.09	60.58	34.23	107.63	N/A
	84	165	VALV	52.81	46.26	49.62	60.63	30.68	102.49	N/A
	85	167	VALV	52.82	46.30	49.69	60.63	32.51	96.40	N/A
	86L	170	VALV	65.35	57.34	63.19	65.87	70.88	98.30	N/A
	86W	170	AWTT	65.35	57.34	63.19	65.87	70.88	98.30	1011.31
	86R	170	STRP	65.42	57.61	63.65	65.87	70.88	98.30	1011.31
	87L	175A	STRP	65.42	57.61	63.65	65.87	118.73	112.83	1294.38
	87R	175A	STRP	65.48	57.69	63.87	65.87	118.73	112.83	563.36
	88L	175B	STRP	65.48	57.69	63.87	65.87	160.41	137.21	705.63
	88R	175B	NONS	65.48	57.69	63.87	65.87	160.41	137.21	N/A
	89L	175C	NONS	65.48	57.69	63.87	65.87	188.50	156.83	N/A
	89R	175C	NONS	65.48	57.69	63.87	65.87	188.50	156.83	N/A
	90	175D	NONS	65.48	57.69	63.87	65.87	272.63	222.90	N/A
RN2A										
	134	280T	VALV	61.23	82.50	240.59	191.51	69.21	52.18	N/A
	135	281	VALV	61.23	82.50	240.59	191.51	107.39	67.09	N/A
	136	282	VALV	61.24	82.58	240.67	191.51	137.26	76.41	N/A
	137	285	VALV	61.19	83.24	241.25	191.36	185.96	91.84	N/A
	138	287	VALV	61.19	83.32	241.32	191.36	262.33	116.50	N/A
	139L	290	VALV	52.47	99.15	259.57	207.54	434.38	168.03	N/A
	139W	290	AWTT	52.47	99.15	259.57	207.54	434.38	168.03	3738.48
	139R	290	STRP	52.56	99.58	260.06	207.54	434.38	168.03	3738.48
	140L	300A	STRP	52.56	99.58	260.06	207.54	662.00	253.51	5415.58
	140R	300A	STRP	52.64	99.67	260.21	207.54	662.00	253.51	2357.07
	141L	300B	STRP	52.64	99.67	260.21	207.54	841.98	321.77	2951.63
	141R	300B	NONS	52.64	99.67	260.21	207.54	841.98	321.77	N/A
	142L	300C	NONS	52.64	99.67	260.21	207.54	960.50	366.86	N/A
	142R	300C	NONS	52.64	99.67	260.21	207.54	960.50	366.86	N/A
	143	300D	NONS	52.64	99.67	260.21	207.54	1310.14	500.21	N/A

RESPONSE SPECTRUM ANALYSIS NO. 2 (OBZY). FORCES, MOMENTS AND STRESSES ALONG PIPE RUNS

RUN NAME	SOP NO.	DCP NAME	COMP TYPE	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	TORS MOMENT (LB.FT)	YY MOMENT (LB.FT)	ZZ MOMENT (LB.FT)	M/Z (PSI)
RN1A										
	81	160T	VALV	66.14	51.67	41.95	48.52	40.32	141.68	N/A
	82	161	VALV	66.14	51.67	41.95	48.52	30.45	133.25	N/A
	83	162	VALV	66.15	51.72	42.00	48.52	26.70	129.70	N/A
	84	165	VALV	66.21	52.15	42.37	48.51	23.30	125.20	N/A
	85	167	VALV	66.22	52.20	42.41	48.51	24.99	120.29	N/A
	86L	170	VALV	84.24	60.02	51.79	50.82	62.78	129.33	N/A
	86W	170	AWTT	84.24	60.02	51.79	50.82	62.78	129.33	1117.93
	86R	170	STRP	84.48	60.34	52.04	50.82	62.78	129.33	1117.93
	87L	175A	STRP	84.48	60.34	52.04	50.82	105.91	150.29	1398.58
	87R	175A	STRP	84.69	60.42	52.09	50.82	105.91	150.29	608.72
	88L	175B	STRP	84.69	60.42	52.09	50.82	141.18	176.73	739.83
	88R	175B	NONS	84.69	60.42	52.09	50.82	141.18	176.73	N/A
	89L	175C	NONS	84.69	60.42	52.09	50.82	164.60	197.10	N/A
	89R	175C	NONS	84.69	60.42	52.09	50.82	164.60	197.10	N/A
	90	175D	NONS	84.69	60.42	52.09	50.82	234.07	264.88	N/A

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RN2A										
	134	280T	VALV	50.41	76.18	173.67	132.58	53.49	47.62	N/A
	135	281	VALV	50.41	76.18	173.67	132.58	72.92	61.97	N/A
	136	282	VALV	50.42	76.26	173.74	132.58	92.83	70.76	N/A
	137	285	VALV	50.51	76.86	174.24	132.45	126.73	85.21	N/A
	138	287	VALV	50.53	76.93	174.30	132.45	181.06	108.16	N/A
	139L	290	VALV	53.69	89.35	188.86	145.98	306.42	157.66	N/A
	139W	290	AWTT	53.69	89.35	188.86	145.98	306.42	157.66	2743.89
	139R	290	STRP	54.09	89.75	189.24	145.98	306.42	157.66	2743.89
	140L	300A	STRP	54.09	89.75	189.24	145.98	472.56	235.09	4015.10
	140R	300A	STRP	54.45	89.83	189.31	145.98	472.56	235.09	1747.53
	141L	300B	STRP	54.45	89.83	189.31	145.98	603.75	296.75	2196.73
	141R	300B	NONS	54.45	89.83	189.31	145.98	603.75	296.75	N/A
	142L	300C	NONS	54.45	89.83	189.31	145.98	690.09	337.45	N/A
	142R	300C	NONS	54.45	89.83	189.31	145.98	690.09	337.45	N/A
	143	300D	NONS	54.45	89.83	189.31	145.98	944.68	457.75	N/A

STATIC ANALYSIS NO. 4 (FPTH). FORCES, MOMENTS AND STRESSES ALONG PIPE RUNS (CONTD.)

RUN NAME	SOP NO.	DCP NAME	COMP TYPE	AXIAL FORCE (LB)	Y FORCE (LB)	Z FORCE (LB)	TORS MOMENT (LB.FT)	YY MOMENT (LB.FT)	ZZ MOMENT (LB.FT)	M/Z (PSI)
RUN1A										
	81	160T	VALV	204.54	-291.84	142.80	-188.07	242.91	1353.14	N/A
	82	161	VALV	204.54	-291.84	142.80	-188.07	287.54	1444.34	N/A
	83	162	VALV	204.54	-291.84	142.80	-188.07	309.10	1488.41	N/A
	84	165	VALV	204.54	-291.84	142.80	-188.07	341.09	1553.78	N/A
	85	167	VALV	204.54	-291.84	142.80	-188.07	388.68	1651.05	N/A
	86L	170	VALV	204.54	-291.84	142.80	-188.07	483.88	1845.62	N/A
	86W	170	AWTT	204.54	-291.84	142.80	-188.07	483.88	1845.62	15021.87
	86R	170	STRP	204.54	-291.84	142.80	-188.07	483.88	1845.62	15021.87
	87L	175A	STRP	204.54	-291.84	142.80	-188.07	611.03	2105.47	17240.40
	87R	175A	STRP	204.54	-291.84	142.80	-188.07	611.03	2105.47	7503.69
	88L	175B	STRP	204.54	-291.84	142.80	-188.07	710.69	2309.14	8263.98
	88R	175B	NONS	204.54	-291.84	142.80	-188.07	710.69	2309.14	N/A
	89L	175C	NONS	204.54	-291.84	142.80	-188.07	776.14	2442.89	N/A
	89R	175C	NONS	204.54	-291.84	142.80	-188.07	776.14	2442.89	N/A
	90	175D	NONS	204.54	-291.84	142.80	-188.07	968.77	2836.58	N/A
RN2A										
	134	280T	VALV	200.11	-71.87	-136.33	549.82	490.47	460.29	N/A
	135	281	VALV	200.11	-71.87	-136.33	549.82	447.87	482.75	N/A
	136	282	VALV	200.11	-71.87	-136.33	549.82	427.28	493.61	N/A
	137	285	VALV	200.11	-71.87	-136.33	549.82	396.75	509.70	N/A
	138	287	VALV	200.11	-71.87	-136.33	549.82	351.31	533.66	N/A
	139L	290	VALV	200.11	-71.87	-136.33	549.82	260.42	581.58	N/A
	139W	290	AWTT	200.11	-71.87	-136.33	549.82	260.42	581.58	6594.37
	139R	290	STRP	200.11	-71.87	-136.33	549.82	260.42	581.58	6594.37
	140L	300A	STRP	200.11	-71.87	-136.33	549.82	139.03	645.57	6732.76
	140R	300A	STRP	200.11	-71.87	-136.33	549.82	139.03	645.57	2930.36
	141L	300B	STRP	200.11	-71.87	-136.33	549.82	43.89	695.73	3027.70
	141R	300B	NONS	200.11	-71.87	-136.33	549.82	43.89	695.73	N/A
	142L	300C	NONS	200.11	-71.87	-136.33	549.82	-18.59	728.67	N/A
	142R	300C	NONS	200.11	-71.87	-136.33	549.82	-18.59	728.67	N/A
	143	300D	NONS	200.11	-71.87	-136.33	549.82	-202.49	825.62	N/A

LOAD CASE NO. 4 (STRS). FORCES, MOMENTS AND STRESSES ALONG PIPE RUNS (CONTD.)

RUN NAME	SOP NO.	DCP NAME	COMP TYPE	AXIAL FORCE (LB) (LB)	Y FORCE (LB) (LB)	Z FORCE (LB) (LB)	TORS MOMENT (LB.FT) (LB.FT)	YY MOMENT (LB.FT) (LB.FT)	ZZ MOMENT (LB.FT) (LB.FT)	M/Z (PSI) (PSI)
RN1A										
	81	160T	VALV	716.74	62.24	40.18	54.31	481.56	1721.80	N/A
	82	161	VALV	716.74	62.24	40.18	54.31	494.40	1702.21	N/A
	83	162	VALV	716.74	62.24	40.18	54.31	500.60	1692.75	N/A
	84	165	VALV	716.74	62.24	40.18	54.31	509.80	1678.71	N/A
	85	167	VALV	716.74	62.24	40.18	54.31	523.49	1657.82	N/A
	86L	170	VALV	716.74	62.24	40.18	54.31	550.88	1616.03	N/A
	86W	170	AWTT	716.74	62.24	40.18	54.31	550.88	1616.03	12524.34
	86R	170	STRP	716.74	62.24	40.18	54.31	550.88	1616.03	12524.34

	87L	175A	STRP	716.74	62.24	40.18	54.31	587.45	1560.22	12229.80
	87R	175A	STRP	716.74	62.24	40.18	54.31	587.45	1560.22	5322.88
	88L	175B	STRP	716.74	62.24	40.18	54.31	616.12	1516.48	5226.27
	88R	175B	NONS	716.74	62.24	40.18	54.31	616.12	1516.48	N/A
	89L	175C	NONS	716.74	62.24	40.18	54.31	634.94	1487.75	N/A
	89R	175C	NONS	716.74	62.24	40.18	54.31	634.94	1487.75	N/A
	90	175D	NONS	716.74	62.24	40.18	54.31	690.36	1403.20	N/A
RN2A										
	134	280T	VALV	353.56	-86.08	-315.48	-234.61	654.56	308.76	N/A
	135	281	VALV	353.56	-86.08	-315.48	-234.61	549.67	336.84	N/A
	136	282	VALV	353.56	-86.08	-315.48	-234.61	498.99	350.41	N/A
	137	285	VALV	353.56	-86.08	-315.48	-234.61	423.80	370.54	N/A
	138	287	VALV	353.56	-86.08	-315.48	-234.61	311.93	400.50	N/A
	139L	290	VALV	353.56	-86.08	-315.48	-234.61	88.15	460.41	N/A
	139W	290	AWTT	353.56	-86.08	-315.48	-234.61	88.15	460.41	3843.41
	139R	290	STRP	353.56	-86.08	-315.48	-234.61	88.15	460.41	3843.41
	140L	300A	STRP	353.56	-86.08	-315.48	-234.61	-210.72	540.44	4587.65
	140R	300A	STRP	353.56	-86.08	-315.48	-234.61	-210.72	540.44	1996.72
	141L	300B	STRP	353.56	-86.08	-315.48	-234.61	-444.97	603.16	2506.28
	141R	300B	NONS	353.56	-86.08	-315.48	-234.61	-444.97	603.16	N/A
	142L	300C	NONS	353.56	-86.08	-315.48	-234.61	-598.80	644.35	N/A
	142R	300C	NONS	353.56	-86.08	-315.48	-234.61	-598.80	644.35	N/A
	143	300D	NONS	353.56	-86.08	-315.48	-234.61	-1051.60	765.58	N/A

APPENDIX B

Reproduced Original Nozzle
Fatigue Analysis
(9 Pages total)

	Revision	0			
	Preparer/Date	DAC 11/26/96			
	Checker/Date	[signature] 11/26/96			
	File No. **DUKE-11Q-303-5**			Page No. B0 of B9	

Table 1
Primary + Secondary Stress Intensities
At Juncture #8

	Iteration	Pressure	Pressure Stress		Thermal Expansion Stress		Stress Report Thermal Stress		Total Stress Intensity (ksi)	
			Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Test 40 Cycles	3	2200	4.84	1.32	13.63	19.24	63.7	-58.2	82.17	-37.64
	6	2200	4.84	1.32	13.63	19.24	77.5	-70.8	95.97	-50.24
	8	2200	4.84	1.32	13.63	19.24	78.8	-71.9	97.27	-51.34
	15	2200	4.84	1.32	13.63	19.24	69.3	-63	87.77	-42.44
	30	2200	4.84	1.32	13.63	19.24	7.7	-6.9	26.17	13.66
	1211	2200	4.84	1.32	13.63	19.24	-0.4	0.3	18.07	20.86
Heatup	1491	2200	4.84	1.32	13.63	19.24	0	0	18.47	20.56
240 Cycles	42021	2200	4.84	1.32	13.63	19.24	0	0	18.47	20.56
	27976	2200	4.84	1.32	13.63	19.24	-0.7	0.6	17.77	21.16
Rapid Dprz 40 Cycles	5060	2200	4.84	1.32	13.63	19.24	86	-78.3	104.47	-57.74
	5063	2200	4.84	1.32	13.63	19.24	73.1	-66.8	91.57	-46.24
	5072	2200	4.84	1.32	13.63	19.24	97.9	-89.3	116.37	-68.74
	5124	2100	4.62	1.26	13.63	19.24	33	-29.7	51.25	-9.20
	5237	1800	3.96	1.08	13.63	19.24	11.5	-10.4	29.09	9.92
	6059	1000	2.2	0.6	13.63	19.24	0.4	-0.4	16.23	19.44
	6307	800	1.76	0.48	0.00	0.00	0.4	-0.4	2.16	0.08
	6338	700	1.54	0.42	0.00	0.00	-7.7	7	-6.16	7.42
	6850	600	1.32	0.36	0.00	0.00	-3.5	3.1	-2.18	3.46
	A	1500	3.3	0.9	13.63	19.24	103.7	-94.6	120.63	-74.46
	B	1100	2.4	0.7	0.00	0.00	-8.7	7.9	-6.30	8.60
	OBE	0	0	0	0.00	0.00	0	0	1.24	1.76
	2OBE	0	0	0	0.00	0.00	0	0	2.49	3.51

HPI Loads	Thermal Expansion	OBE
Fx (lb)	-255	31
Fy (lb)	-365	-264
Fz (lb)	-111	73
Mx (ft-lb)	2226	186
My (ft-lb)	-914	161
Mz (ft-lb)	-1043	-106

Prepared by: DAC 11/24/96
Checked by: [illegible] 11/26/96
File No: DUKE-110-303-5 Rev: 0
Page B1 - B[illegible]9 of B[illegible] 9

Table 2
Peak Stress Intensities
At Juncture #8 - Inside

	Iteration	Pressure	Pressure Stress	Thermal Expansion Stress	Stress Report Thermal Stress	Total Stress (ksi)	Iteration
Test	3	2200	5.5	17.44	109	131.94	Test
Test	6	2200	5.5	17.44	115	137.94	Test
Test	8	2200	5.5	17.44	113.3	136.24	Test
Test	15	2200	5.5	17.44	95	117.94	Test
Test	30	2200	5.5	17.44	8.7	31.64	Test
Test	1211	2200	5.5	17.44	-0.4	22.54	Test
Heatup	1491	2200	5.5	17.44	0	22.94	Heatup
Heatup	42021	2200	5.5	17.44	0	22.94	Heatup
Heatup	27976	2200	5.5	17.44	-0.8	22.14	Heatup
Dpz	5060	2200	5.5	17.44	147.4	170.34	Dpz
Dpz	5063	2200	5.5	17.44	143.3	166.24	Dpz
Dpz	5072	2200	5.5	17.44	117.3	140.24	Dpz
Dpz	5124	2100	5.25	17.44	39.9	62.59	Dpz
Dpz	5237	1800	4.5	17.44	14.2	36.14	Dpz
Dpz	6059	1000	2.5	17.44	0.5	20.44	Dpz
Dpz	6307	800	2	0.00	0.5	2.50	Dpz
Dpz	6338	700	1.75	0.00	-9.6	-7.85	Dpz
Dpz	6850	600	1.5	0.00	-1.3	0.20	Dpz
	A	1500	3.8	17.44	156.24	177.48	A
	B	1100	2.75	0.00	-10.81	-8.06	B
	OBE	0	0	0.00	0	1.59	OBE
	2OBE	0	0	0.00	0	3.18	2OBE

Maximum Peak Stress Intensity Range			
	Value	Transient	
Max	170.34	Dpz	
Min	-7.85	Dpz	
Peak (ksi)	**178.19**		
Corresponding Primary + Bending Range			
	Inside	Outside	
Max	116.37	-68.7398	
Min	-6.16	7.42	
Mem+Ben	**122.53**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.77		
Sn/3Sm	2.39		
1a: Qm	23.81		
1a: Qb	92.55		
1b: Qm	0.63		
1b: Qb	-6.79		
Qm/Qm+Qb	0.19		
	From Fig. F-105(a)		
	Qm/Qm+Qb	21	
	Sn/3Sm	141	
Ke	**1.82**		
Sa (no E)	197.94		
Salt	**189.69**		

R 3

Second Maximum Peak Stress Intensity Range			
	Value	Iteration	
Max	137.94	Test	
Min	0.00	Zero Load	
Peak (ksi)	**137.94**		
Corresponding Primary + Bending Range			
	Inside	Outside	Iteration
Max	97.27	-51.3398	8
Min	0.00	0	0
Mem+Ben	**97.27**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.71		
Sn/3Sm	1.90		
1a: Qm	22.96		
1a: Qb	74.30		
1b: Qm	0.00		
1b: Qb	0.00		
Qm/Qm+Qb	0.24		
	From Fig. F-105(a)		
	Qm/Qm+C	26	
	Sn/3Sm	92	
Ke	**1.51**		
Sa (no E)	125.89		
Salt	**120.87**		

HPI - OBE Maximum Peak Stress Intensity Range			
	Value	Iteration	
Max	179.08	A+OBE	
Min	-9.65	B-OBE	
Peak (ksi)	**188.73**		
Corresponding Primary + Bending Range			
	Inside	Outside	Iteration
Max	121.87	-72.70	A+OBE
Min	-7.54	6.84	B-OBE
Mem+Ben	**129.42**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.78		
Sn/3Sm	2.52		
1a: Qm	24.58		
1a: Qb	97.29		
1b: Qm	-0.35		
1b: Qb	-7.19		
Qm/Qm+Qb	0.19		
	From Fig. F-105(a)		
	Qm/Qm+Q	22	
	Sn/3Sm	155	
Ke	**1.93**	.	
Sa (no E)	222.17		
Salt	**213.55**		

R5

HPI Maximum Peak Stress Intensity Range			
	Value	Iteration	
Max	177.48	A	
Min	-8.06	B	
Peak (ksi)	**185.54**		
Corresponding Primary + Bending Range			
	Inside	Outside	Iteration
Max	120.63	-74.46	A
Min	-6.30	8.60	B
Mem+Ben	**126.93**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.79		
Sn/3Sm	2.47		
1a: Qm	23.08		
1a: Qb	97.54		
1b: Qm	1.15		
1b: Qb	-7.45		
Qm/Qm+Qb	0.17		
	From Fig. F-105(a)		
	Qm/Qm+Q	20	
	Sn/3Sm	150	
Ke	**1.88**		
Sa (no E)	212.82		
Salt	**204.56**		

	OBE Maximum Peak Stress Intensity Range				
		Value	Iteration		
	Max	1.59	OBE		
	Min	-1.59	OBE		
	Peak (ksi)	**3.18**			
	Corresponding Primary + Bending Range				
		Inside	Outside	Iteration	
	Max	1.24	1.76	OBE	
	Min	-1.24	-1.76	OBE	
	Mem+Ben	**2.49**			
	3Sm	**51.30**			
	Mem+Ben < 3Sm				
	Sa (no E)	1.59			
	Salt	**1.61**			

Transient	Nreq
A	40
A+OBE	30
Dpz	40
OBE	610
Test	40

B

		Fig F-106(b)		
Transient Pair	**Salt**	**N**	**Nreq**	**U**
Dpz	189.69	**180**	40	0.222222
Dpz				
Test	120.87	**750**	40	0.053333
Zero Load				
A+OBE	213.55	**145**	30	0.206897
B-OBE				
A	204.56	**155**	40	0.258065
B				
OBE	1.61	**1.00E+21**	610	6.1E-19
OBE				
			Total Usage	0.740517

APPENDIX C

Reconciled Nozzle Fatigue Analysis
(with Full Power Thermal Piping Loads)
(9 Pages total)

	Revision	0	1		
	Preparer/Date	DAC 11/26/96	DAC 4/1/97		
	Checker/Date	[illegible] 11/26/96	[illegible] 4/1/97		
	File No. **DUKE-11Q-303-5**			Page No. C0 of C9	

Table 1

Primary + Secondary Stress Intensities

At Juncture #8

	Iteration	Pressure	Pressure Stress		Thermal Expansion Stress		Stress Report Thermal Stress		Total Stress Intensity (ksi)	
			Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Test 40 Cycles	3	2200	4.84	1.32	12.94	18.27	63.7	-58.2	81.48	-38.61
	6	2200	4.84	1.32	12.94	18.27	77.5	-70.8	95.28	-51.21
	8	2200	4.84	1.32	12.94	18.27	78.8	-71.9	96.58	-52.31
	15	2200	4.84	1.32	12.94	18.27	69.3	-63	87.08	-43.41
	30	2200	4.84	1.32	12.94	18.27	7.7	-6.9	25.48	12.69
	1211	2200	4.84	1.32	12.94	18.27	-0.4	0.3	17.38	19.89
Heatup	1491	2200	4.84	1.32	12.94	18.27	0	0	17.78	19.59
240 Cycles	42021	2200	4.84	1.32	12.94	18.27	0	0	17.78	19.59
	27976	2200	4.84	1.32	12.94	18.27	-0.7	0.6	17.08	20.19
Rapid Dprz 40 Cycles	5060	2200	4.84	1.32	12.94	18.27	86	-78.3	103.78	-58.71
	5063	2200	4.84	1.32	12.94	18.27	73.1	-66.8	90.88	-47.21
	5072	2200	4.84	1.32	12.94	18.27	97.9	-89.3	115.68	-69.71
	5124	2100	4.62	1.26	12.94	18.27	33	-29.7	50.56	-10.17
	5237	1800	3.96	1.08	12.94	18.27	11.5	-10.4	28.40	8.95
	6059	1000	2.2	0.6	12.94	18.27	0.4	-0.4	15.54	18.47
	6307	800	1.76	0.48	0.00	0.00	0.4	-0.4	2.16	0.08
	6338	700	1.54	0.42	0.00	0.00	-7.7	7	-6.16	7.42
	6850	600	1.32	0.36	0.00	0.00	-3.5	3.1	-2.18	3.46
	A	1500	3.3	0.9	12.94	18.27	103.7	-94.6	119.94	-75.43
	B	1100	2.4	0.7	0.00	0.00	-8.7	7.9	-6.30	8.60
	OBE	0	0	0	0.00	0.00	0	0	7.70	10.87
	2OBE	0	0	0	0.00	0.00	0	0	15.39	21.73

HPI Loads	Thermal Expansion			OBE
Fx (lb)		225.4		107.05
Fy (lb)		321.61		134.18
Fz (lb)		157.37		321.79
Mx (ft-lb)		605.9		253.74
My (ft-lb)		673.36		1615.2
Mz (ft-lb)		2320.23		678.05

Prepared by: DAC 3/28/97
Checked by: [signature] 4/1/97
File No: DUKE-11Q-303- Rev: 1
Page 01-C9 of C9

	Table 2						
	Peak Stress Intensities						
	At Juncture #8 - Inside						
				Thermal	Stress Report		
			Pressure	Expansion	Thermal	Total	
	Iteration	Pressure	Stress	Stress	Stress	Stress (ksi)	Iteration
Test	3	2200	5.5	16.56	109	131.06	Test
Test	6	2200	5.5	16.56	115	137.06	Test
Test	8	2200	5.5	16.56	113.3	135.36	Test
Test	15	2200	5.5	16.56	95	117.06	Test
Test	30	2200	5.5	16.56	8.7	30.76	Test
Test	1211	2200	5.5	16.56	-0.4	21.66	Test
Heatup	1491	2200	5.5	16.56	0	22.06	Heatup
Heatup	42021	2200	5.5	16.56	0	22.06	Heatup
Heatup	27976	2200	5.5	16.56	-0.8	21.26	Heatup
Dpz	5060	2200	5.5	16.56	147.4	169.46	Dpz
Dpz	5063	2200	5.5	16.56	143.3	165.36	Dpz
Dpz	5072	2200	5.5	16.56	117.3	139.36	Dpz
Dpz	5124	2100	5.25	16.56	39.9	61.71	Dpz
Dpz	5237	1800	4.5	16.56	14.2	35.26	Dpz
Dpz	6059	1000	2.5	16.56	0.5	19.56	Dpz
Dpz	6307	800	2	0.00	0.5	2.50	Dpz
Dpz	6338	700	1.75	0.00	-9.6	-7.85	Dpz
Dpz	6850	600	1.5	0.00	-1.3	0.20	Dpz
	A	1500	3.8	16.56	156.24	176.60	A
	B	1100	2.75	0.00	-10.81	-8.06	B
	OBE	0	0	0.00	0	9.85	OBE
	2OBE	0	0	0.00	0	19.71	2OBE

Maximum Peak Stress Intensity Range			
	Value	Transient	
Max	169.46	Dpz	
Min	-7.85	Dpz	
Peak (ksi)	**177.31**		
Corresponding Primary + Bending Range			
	Inside	Outside	
Max	115.68	-69.7098	
Min	-6.16	7.42	
Mem+Ben	**121.84**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.77		
Sn/3Sm	2.38		
1a: Qm	22.99		
1a: Qb	92.70		
1b: Qm	0.63		
1b: Qb	-6.79		
Qm/Qm+Qb	0.18		
	From Fig. F-105(a)		
	Qm/Qm+Qb	21	
	Sn/3Sm	140	
Ke	**1.82**		
Sa (no E)	196.26		
Salt	**188.09**		

	Second Maximum Peak Stress Intensity Range			
		Value	Iteration	
	Max	137.06	Test	
	Min	0.00	Zero Load	
	Peak (ksi)	**137.06**		
	Corresponding Primary + Bending Range			
		Inside	Outside	Iteration
	Max	96.58	-52.3098	8
	Min	0.00	0	0
	Mem+Ben	**96.58**		
	3Sm	**51.30**		
	Mem+Ben >3Sm			
	Kf	1.71		
	Sn/3Sm	1.88		
	1a: Qm	22.14		
	1a: Qb	74.45		
	1b: Qm	0.00		
	1b: Qb	0.00		
	Qm/Qm+Qb	0.23		
		From Fig. F-105(a)		
		Qm/Qm+C	25	
		Sn/3Sm	91	
	Ke	**1.50**		
	Sa (no E)	124.16		
	Salt	**119.21**		

HPI - OBE Maximum Peak Stress Intensity Range				
	Value	Iteration		
Max	186.46	A+OBE		
Min	-17.91	B-OBE		
Peak (ksi)	**204.37**			
Corresponding Primary + Bending Range				
	Inside	Outside	Iteration	
Max	127.64	-64.56	A+OBE	
Min	-14.00	-2.27	B-OBE	
Mem+Ben	**141.64**			
3Sm	**51.30**			
Mem+Ben >3Sm				
Kf	1.75			
Sn/3Sm	2.76			
1a: Qm	31.54			
1a: Qb	96.10			
1b: Qm	-8.13			
1b: Qb	-5.87			
Qm/Qm+Qb	0.28			
	From Fig. F-105(a)			
	Qm/Qm+Q	31		
	Sn/3Sm	179		
Ke	**2.19**			
Sa (no E)	271.74			
Salt	**261.19**			

HPI Maximum Peak Stress Intensity Range			
	Value	Iteration	
Max	176.60	A	
Min	-8.06	B	
Peak (ksi)	**184.66**		
Corresponding Primary + Bending Range			
	Inside	Outside	Iteration
Max	119.94	-75.43	A
Min	-6.30	8.60	B
Mem+Ben	**126.24**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.79		
Sn/3Sm	2.46		
1a: Qm	22.26		
1a: Qb	97.69		
1b: Qm	1.15		
1b: Qb	-7.45		
Qm/Qm+Qb	0.17		
	From Fig. F-105(a)		
	Qm/Qm+C	19	
	Sn/3Sm	149	
Ke	**1.86**		
Sa (no E)	210.33		
Salt	**202.17**		

c6

OBE Maximum Peak Stress Intensity Range			
	Value	Iteration	
Max	9.85	OBE	
Min	-9.85	OBE	
Peak (ksi)	**19.71**		
Corresponding Primary + Bending Range			
	Inside	Outside	Iteration
Max	7.70	10.87	OBE
Min	-7.70	-10.87	OBE
Mem+Ben	**15.39**		
3Sm	**51.30**		
Mem+Ben < 3Sm			
Sa (no E)	9.85		
Salt	**9.95**		

Transient	Nreq
A	40
A+OBE	30
Dpz	40
OBE	610
Test	40

		Fig F-106(b)		
Transient Pair	**Salt**	**N**	**Nreq**	**U**
Dpz	188.09	**191**	40	0.209424
Dpz				
Test	119.21	**755**	40	0.05298
Zero Load				
A+OBE	261.19	**81**	30	0.37037
B-OBE				
A	202.17	**159**	40	0.251572
B				
OBE	9.95	**1.00E+21**	610	6.1E-19
OBE				
			Total Usage	0.884347

APPENDIX D

Reconciled Nozzle Fatigue Analysis
(with Stratified Stress Piping Loads)
(9 Pages total)

/DAG

Table 1
Primary + Secondary Stress Intensities
At Juncture #8

	Iteration	Pressure	Pressure Stress		Thermal Expansion Stress		Stress Report Thermal Stress		Total Stress Intensity (ksi)	
			Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Test 40 Cycles	3	2200	4.84	1.32	9.05	12.77	63.7	-58.2	77.59	-44.11
	6	2200	4.84	1.32	9.05	12.77	77.5	-70.8	91.39	-56.71
	8	2200	4.84	1.32	9.05	12.77	78.8	-71.9	92.69	-57.81
	15	2200	4.84	1.32	9.05	12.77	69.3	-63	83.19	-48.91
	30	2200	4.84	1.32	9.05	12.77	7.7	-6.9	21.59	7.19
	1211	2200	4.84	1.32	9.05	12.77	-0.4	0.3	13.49	14.39
Heatup	1491	2200	4.84	1.32	9.05	12.77	0	0	13.89	14.09
240 Cycles	42021	2200	4.84	1.32	9.05	12.77	0	0	13.89	14.09
	27976	2200	4.84	1.32	9.05	12.77	-0.7	0.6	13.19	14.69
Rapid Dprz 40 Cycles	5060	2200	4.84	1.32	9.05	12.77	86	-78.3	99.89	-64.21
	5063	2200	4.84	1.32	9.05	12.77	73.1	-66.8	86.99	-52.71
	5072	2200	4.84	1.32	9.05	12.77	97.9	-89.3	111.79	-75.21
	5124	2100	4.62	1.26	9.05	12.77	33	-29.7	46.67	-15.67
	5237	1800	3.96	1.08	9.05	12.77	11.5	-10.4	24.51	3.45
	6059	1000	2.2	0.6	9.05	12.77	0.4	-0.4	11.65	12.97
	6307	800	1.76	0.48	0.00	0.00	0.4	-0.4	2.16	0.08
	6338	700	1.54	0.42	0.00	0.00	-7.7	7	-6.16	7.42
	6850	600	1.32	0.36	0.00	0.00	-3.5	3.1	-2.18	3.46
	A	1500	3.3	0.9	9.05	12.77	103.7	-94.6	116.05	-80.93
	B	1100	2.4	0.7	0.00	0.00	-8.7	7.9	-6.30	8.60
	OBE	0	0	0	0.00	0.00	0	0	7.70	10.87
	2OBE	0	0	0	0.00	0.00	0	0	15.39	21.73

HPI Loads	Thermal Expansion		OBE
Fx (lb)		738.24	107.05
Fy (lb)		88.66	134.18
Fz (lb)		324.94	321.79
Mx (ft-lb)		241.65	253.74
My (ft-lb)		605.07	1615.2
Mz (ft-lb)		1607.03	678.05

- The 2.1e6 cycles of CYCL - cyclic stratified stress [2] are not included, as they proved to be insignificant

Prepared by: DAC 4/1/97
Checked by: [signature] 4/1/97
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Table 2
Peak Stress Intensities
At Juncture #8 - Inside

	Iteration	Pressure	Pressure Stress	Thermal Expansion Stress	Stress Report Thermal Stress	Total Stress (ksi)	Iteration
Test	3	2200	5.5	11.58	109	126.08	Test
Test	6	2200	5.5	11.58	115	132.08	Test
Test	8	2200	5.5	11.58	113.3	130.38	Test
Test	15	2200	5.5	11.58	95	112.08	Test
Test	30	2200	5.5	11.58	8.7	25.78	Test
Test	1211	2200	5.5	11.58	-0.4	16.68	Test
Heatup	1491	2200	5.5	11.58	0	17.08	Heatup
Heatup	42021	2200	5.5	11.58	0	17.08	Heatup
Heatup	27976	2200	5.5	11.58	-0.8	16.28	Heatup
Dpz	5060	2200	5.5	11.58	147.4	164.48	Dpz
Dpz	5063	2200	5.5	11.58	143.3	160.38	Dpz
Dpz	5072	2200	5.5	11.58	117.3	134.38	Dpz
Dpz	5124	2100	5.25	11.58	39.9	56.73	Dpz
Dpz	5237	1800	4.5	11.58	14.2	30.28	Dpz
Dpz	6059	1000	2.5	11.58	0.5	14.58	Dpz
Dpz	6307	800	2	0.00	0.5	2.50	Dpz
Dpz	6338	700	1.75	0.00	-9.6	-7.85	Dpz
Dpz	6850	600	1.5	0.00	-1.3	0.20	Dpz
	A	1500	3.8	11.58	156.24	171.62	A
	B	1100	2.75	0.00	-10.81	-8.06	B
	OBE	0	0	0.00	0	9.85	OBE
	2OBE	0	0	0.00	0	19.71	2OBE

D2

Maximum Peak Stress Intensity Range			
	Value	Transient	
Max	164.48	Dpz	
Min	-7.85	Dpz	
Peak (ksi)	**172.33**		
Corresponding Primary + Bending Range			
	Inside	Outside	
Max	111.79	-75.2074	
Min	-6.16	7.42	
Mem+Ben	**117.95**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.78		
Sn/3Sm	2.30		
1a: Qm	18.29		
1a: Qb	93.50		
1b: Qm	0.63		
1b: Qb	-6.79		
Qm/Qm+Qb	0.15		
	From Fig. F-105(a)		
	Qm/Qm+Qb	17	
	Sn/3Sm	132	
Ke	**1.74**		
Sa (no E)	182.58		
Salt	**174.98**		

Second Maximum Peak Stress Intensity Range			
	Value	Iteration	
Max	132.08	Test	
Min	0.00	Zero Load	
Peak (ksi)	**132.08**		
Corresponding Primary + Bending Range			
	Inside	Outside	Iteration
Max	92.69	-57.8074	8
Min	0.00	0	0
Mem+Ben	**92.69**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.72		
Sn/3Sm	1.81		
1a: Qm	17.44		
1a: Qb	75.25		
1b: Qm	0.00		
1b: Qb	0.00		
Qm/Qm+Qb	0.19		
	From Fig. F-105(a)		
	Qm/Qm+Q	21	
	Sn/3Sm	83	
Ke	**1.43**		
Sa (no E)	114.11		
Salt	**109.56**		

HPI - OBE Maximum Peak Stress Intensity Range			
	Value	Iteration	
Max	181.47	A+OBE	
Min	-17.91	B-OBE	
Peak (ksi)	**199.39**		
Corresponding Primary + Bending Range			
	Inside	Outside	Iteration
Max	123.74	-70.06	A+OBE
Min	-14.00	-2.27	B-OBE
Mem+Ben	**137.74**		
3Sm	**51.30**		
Mem+Ben >3Sm			
Kf	1.76		
Sn/3Sm	2.69		
1a: Qm	26.84		
1a: Qb	96.90		
1b: Qm	-8.13		
1b: Qb	-5.87		
Qm/Qm+Qb	0.25		
	From Fig. F-105(a)		
	Qm/Qm+Q	28	
	Sn/3Sm	171	
Ke	**2.10**	.	
Sa (no E)	254.81		
Salt	**244.92**		

D5

	HPI Maximum Peak Stress Intensity Range							
		Value	Iteration					
	Max	171.62	A					
	Min	-8.06	B					
	Peak (ksi)	**179.68**						
	Corresponding Primary + Bending Range							
		Inside	Outside	Iteration				
	Max	116.05	-80.93	A				
	Min	-6.30	8.60	B				
	Mem+Ben	**122.35**						
	3Sm	**51.30**						
	Mem+Ben >3Sm							
	Kf	1.80						
	Sn/3Sm	2.38						
	1a: Qm	17.56						
	1a: Qb	98.49						
	1b: Qm	1.15						
	1b: Qb	-7.45						
	Qm/Qm+Qb	0.13						
		From Fig. F-105(a)						
		Qm/Qm+C	16					
		Sn/3Sm	141					
	Ke	**1.79**						
	Sa (no E)	196.79						
	Salt	**189.15**						

	OBE Maximum Peak Stress Intensity Range				
		Value	Iteration		
	Max	9.85	OBE		
	Min	-9.85	OBE		
	Peak (ksi)	**19.71**			
	Corresponding Primary + Bending Range				
		Inside	Outside	Iteration	
	Max	7.70	10.87	OBE	
	Min	-7.70	-10.87	OBE	
	Mem+Ben	**15.39**			
	3Sm	**51.30**			
	Mem+Ben < 3Sm				
	Sa (no E)	9.85			
	Salt	**9.95**			

Transient	Nreq
A	40
A+OBE	30
Dpz	40
OBE	610
Test	40

		Fig F-106(b)		
Transient Pair	**Salt**	**N**	**Nreq**	**U**
Dpz	174.98	**236**	40	0.169492
Dpz				
Test	109.56	**984**	40	0.04065
Zero Load				
A+OBE	244.92	**95**	30	0.315789
B-OBE				
A	189.15	**189**	40	0.21164
B				
OBE	9.95	**1.00E+21**	610	6.1E-19
OBE				
			Total Usage	0.737572

Appendix E

Email transmittal from gla8363@prdc.dukepower.com (Duke) to Denise Curd (SI),
"HPI Emergency Injection Lines; Ec/Eh Values"

(3 pages total)

/DAG

	Revision	1			
	Preparer/Date	DAC 3/28/97			
	Checker/Date	[signature] 4/1/97			
	File No. **DUKE-11Q-303-5**			Page No. E0 of E3	

From: Denise Curd
To: Denise Curd
Subject: HPI Emergency Injection Lines; Ec/Eh Values

==NOTE==============3/13/97==4:32pm==

CC:
mail @ c2uu (g l armentrout) (gla8363@prdc.dukepower.com), mail @ c2uu
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....

From: G L Armentrout gla8363@dukepower.com

Oconee Service Water Project/Pipe Stress Complex ON02SW

Office (864)885-4322 FAX (864)885-4417 Pager 778-3947

Subject: HPI Emergency Injection Lines; Ec/Eh Values

<denise>:dcurd@structint.com

Denise

This note supersedes the note sent to you on 02/25/97. Please use it to aid in the Class I evaluation of the RCS branch lines.

It is requested that whenever you reference this note in your calculations, that a hardcopy be attached to those calculations.

Please acknowledge receipt of this note. If you have any questions, please let me know.

Thanks

Geary

*** Forwarding note from VPP533C --PRDC 03/13/97 13:54 ***

To: GLA8363 --PRDC

: Vijay Patel

Oconee Mod Engineering

Office 885-4169 Fax 885-4417 Oconee Complex ON02MO

Subject: HPI Emergency Injection Lines; Ec/Eh Values

Geary :

I Concur with the above Conclusion.

Thanks

Vijay

Prepared by:	DAC 3/28/97
Checked by:	[illegible] 4/1/97
File No:	DUKE-110-303-5 Rev: 1
Page	E1-E3 of E3

*** Forwarding note from GLA8363 --PRDC 03/13/97 12:20 ***

To: VPP533C --PRDC Vijay P. Patel

*** Resending note of 03/11/97 18:23

From: G L Armentrout gla8363@dukepower.com

To: VPP533C --PRDC Vijay P. Patel

From: G L Armentrout gla8363@dukepower.com

Oconee Service Water Project/Pipe Stress Complex ON02SW

Office (864)885-4322 FAX (864)885-4417 Pager 778-3947

Subject: HPI Emergency Injection Lines; Ec/Eh Values

This note will document how Superpipe considered the Ec/Eh values for the various load cases used in the Class I Comparative Analysis done for the HPI Emergency Injection Lines (Calculation OSC-1323-06, Volume A, Analysis Problem 1-24). This note will be forwarded to Structural Integrity (SI), as information, to aid in the Class I Evaluation of the RCS Branch Lines.

Obviously, the Ec/Eh value is only applicable to thermal load cases. The individual thermal load cases, identified as THRM are shown on pages (1)12.1

---

through 6(1)12.2 of OSC-1323-06, Vol. A. The individual thermal load cases are STRD, FPTH, DLEK and DEST. These pages have already been sent to SI. Therefore the load case definitions will not be restated. As stated on page ... of the Superpipe Manual, "The computed stresses are multiplied by Ec/Eh for all loadings of THRM type." The operative words are "computed stresses" i.e., M/Z). the individual moments are NOT multiplied by Ec/Eh, in these ...idual case summaries (flagged as Static Analyses in the Superpipe printout).

However, please note the following comments:

1) Thermal load case STRD, which used the stratification movements, however was run at 70 degrees. Therefore Ec/Eh equaled 1. Using B31.7 values and the design temperature of 650 degrees, Ec/Eh should have been equal to 1.127.

2) The other thermal cases were thermal expansion load cases, therefore Ec/Eh was considered for the specified temperature ranges. However, the Young's Modulus values were taken from the B31.1 Code and not the B31.7 Code for the Class I piping. The differences are tabulated below:

	Ec/Eh	Ec/Eh	Percentage
Load Case	B31.1	B31.7	Increase
FPTH	1.069	1.102	3%
DLEK	1.064	1.093	3%
DEST	1.089	1.127	3%

Superpipe's Results Set Combination (COMB) option, which was used in the subject analysis problem does multiply the moment results by Ec/Eh. The applicable case names are provided on page 6(1)12.3 of OSC-1323-06, Vol. A ... earlier sent to SI).

...in conclusion, if the individual static analyses from the Superpipe analysis are used, then the moment results must be multiplied by the appropriate Ec/Eh values. These static analyses are listed below as they appear in the Superpipe Output along w/ the Ec/Eh from the B31.7 code.

	Ec/Eh B31.7
STATIC ANALYSIS NO. 3 (STRD)	1.127
STATIC ANALYSIS NO. 4 (FPTH)	1.102
STATIC ANALYSIS NO. 5 (DLEK)	1.093
STATIC ANALYSIS NO. 6 (DEST)	1.127

However, if moments are taken from Superpipe's Results Set Combination COMB) option, then the moment results should be increased by an additional 3%, as earlier discussed. These combined load cases are listed below as they appear in the Superpipe Output.

LOAD CASE NO. 3 (SRAT)
LOAD CASE NO. 4 (STRS)
LOAD CASE NO. 5 (CYCL)
LOAD CASE NO. 6 (STRD)
... CASE NO. 7 (STRP)
... CASE NO. 8 (STRN)
LOAD CASE NO. 9 (EQ10)
LOAD CASE NO. 10 (SRP)
LOAD CASE NO. 11 (SRN)

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Only a very small portion of the total thermal moment loads on the nozzles is
from stratification load case (STRD), therefore the actual percentage increase
approaches the value of 3%.

Geary

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50-001-001	32-1128224-02	Revised HPI Nozzle Usage Factor	S	N	N/A

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TYPE: ___ RESEARCH & DEVELOPMENT ___ SAFETY ANALYSIS REPORT ___ NUC. SERV. INPUT ___ DESIGN RQMT. X DESIGN VERIF. ___ OTHER

TITLE Revised HPI Nozzle Usage Factor

PREPARED BY [signature] REVIEWED BY R R Schaefer

TITLE ENGINEER DATE [illegible] TITLE Engineer IV DATE 8/31/82

PURPOSE:

The purpose of this analysis is to justify, by analysis, the operational events for the HPI nozzle. The operational events include 40 test transient cycles, 240 heatup and cooldown cycles, 40 rapid depressurization cycles, 650 OBE cycles and 70 additional HPI manual actuation cycles following a reactor trip.

Revision 1 - Incorporated revised HPI flow rates and pressure.

Revision 2 - Revised Ref. 1 to the appropriate RCS Functional Specification for the AOTC program upgrade.

SUMMARY OF RESULTS (INCLUDE DOC. ID'S OF PREVIOUS TRANSMITTALS & SOURCE CALCULATIONAL PACKAGES FOR THIS TRANSMITTAL)

The HPI nozzle can withstand the 40 cycles of test transient, 240 cycles of heatup and cooldown transient, 40 rapid depressurization cycles, 650 OBE cycles and 70 additional HPI manual actuation cycles following a reactor trip.

Total Usage Factor = U = 0.74

Revision 2 of this document completely supersedes revision 1.

Source Reference: 1. B&W Doc. No. 18-1130828-01.

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DS-21036.1 (9.81)

GENERAL CALCULATIONS

TABLE OF CONTENTS

PREPARED BY RRE DATE 7/22/82 DOC NO. 32-1125224-00
REVIEWED BY [illegible] DATE 7/22/82 PAGE NO. 2

1.0 INTRODUCTION

Following each reactor trip, additional make-up flow must be obtained to prevent loss of indicated pressurizer level during the transient. All four of the high pressure injection (HPI) nozzles, located in the cold legs on the discharge side of the pumps, have been used for these occurrences. The three nozzles which do not have continuous make-up flow to the system receive a thermal shock from the cold BWST (borated water storage tank) water. The operational events for the HPI nozzle analysis included 40 test transient cycles, 40 rapid depressurization transient cycles, 240 heatup and cooldown cycles and 650 OBE cycles. An additional 70 cycles of HPI manual actuation following a reactor trip is being added, Ref. 6. The purpose of this report is to justify, by analysis, the operational events for the HPI nozzle following a reactor trip. The analysis method utilized will be the simplified elastic-plastic discontinuity analysis in Ref. #2.

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GENERAL CALCULATIONS

[illegible] Conclusion and Results

Primary + Secondary Stress Intensity Range

40 Cycles of Rapid Depressurization Transient

σ Primary + Secondary Range = 122.5 KSI > 3Sm = 51.3 KSI

40 Cycles of Test Transient

σ Primary + Secondary Range = 97.2 KSI > 3Sm = 51.3 KSI

240 Cycles of Heat-up and Cool-down Transient

σ Primary + Secondary Range = 18.4 KSI < 3Sm = 51.3 KSI

30 Cycles of HPI Actuation With Inclusion of ± OBE Stresses

σ Primary + Secondary Range = 129.4 KSI > 3Sm = 51.3 KSI

40 Cycles of HPI Actuation Without Inclusion of ± OBE Stresses

σ Primary + Secondary Range = 126.9 KSI > 3Sm = 51.3 KSI

650 Cycles of ± OBE Stresses

σ Primary + Secondary Range = 2.43 KSI < 3Sm = 51.3KSI

Total number of cycles in which the primary + secondary stress intensity range exceeded 3Sm is 40+40+30+40 = 150 < 250.

Therefore, an elastic plastic fatigue analysis was performed.

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USAGE FACTOR

U_1 = Usage Factor For 40 Rapid Depressurization Transient Cycles = 0.22

U_2 = Usage Factor For 40 Test Transient Cycles = 0.05

U_3 = Usage Factor For 240-40 = 200 Heat-Up and Cool-Down Transient Cycles = 0.0

U_4 = Usage Factor For 30 HPI Manual Actuation Cycles (With Inclusion of $\pm$ OBE Stresses) = 0.21

U_5 = Usage Factor For 40 HPI Manual Actuation Cycles (Without Inclusion of $\pm$ OBE Stresses) = 0.26

U_6 = Usage Factor For Remainder of $\pm$ OBE Stress Cycles = 0.0

$\bar{U}$ = Total Usage Factor

$$\bar{U} = U_1 + U_2 + U_3 + U_4 + U_5 + U_6$$

$$\bar{U} = 0.22 + 0.05 + 0.0 + 0.21 + 0.26 + 0.0$$

$$\bar{U} = 0.74 < 1$$

In conclusion, the HPI nozzle can withstand the operational events of 40 rapid depressurization, 40 test, 240 heat-up and cool-down, 550 OBE and 70 HPI actuation transient cycles.

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REVIEWED BY [illegible]	DATE [illegible]	PAGE NO 5	

3.0 Discussion and Method of Analysis

This analysis calculates the additional fatigue usage factor on the HPI/Makeup Nozzles resulting from seventy additional HPI actuations following a reactor trip. The method of analysis utilizes the thermal/mechanical stresses calculated in the original stress report. The following discussion is provided as background information to the methods used in the original HPI analysis. The discussion will address three topics; 1) thermal analysis, (2) structural model and 3) stress analysis.

Thermal Analysis

A two-dimensional heat transfer analysis utilizing B&W computer code P91167, reference #3, was performed to obtain the temperature distribution in the nozzle and local shell region. A model of the nozzle and local shell region is shown in Figure 1. The nozzle and shell components are represented by a system of blocks with a nodal point at the center of each block. Program P91167 solves a heat balance equation between each block and the four adjacent blocks.

The following transients were selected for thermal analysis, because these transients either contribute significantly to the usage factor or are of short duration and have larger temperature differences than other transients.

(1) Heatup and cooldown (Transient 1A or 1B)
(2) Power loading and unloading (Transients 2A, 2B, 3 and 4)
(3) Rapid Depressurization (Transient 9)
(4) Test transient-HPI system (Transient 22)

The heat transfer boundary conditions consist of convective heat transfer at the inside surfaces of the nozzle and shell. The HPI nozzle contains a thermal sleeve (see Figure 2). There is an enclosed water gap between the thermal sleeve and the nozzle inside surface. The cut-off surfaces of the nozzle and shell are assumed insulated. Also, the outer surfaces of the nozzle and shell are considered

3.0 Discussion and Method of Analysis - Continued

insulated.

The results of this thermal analysis consist of temperature at each nodal point of the grid thermal model, Figure 1. Several nodes and pairs of nodes representing critical locations of the nozzle are selected to evaluate the radial and axial thermal gradients resulting from the application of each transient condition. These thermal gradients for each selected node are plotted. From these plots, selection of critical transient times for subsequent stress evaluation was made.

Structural Model

The thermal stress calculations were performed utilizing B&W Computer Programs P91206 and P91032, References #4 & #5 respectively. Program P91206 uses the virtual work method to solve axisymmetric shells of revolution (see Figure 3). Program P91032 is a general thermal motion and stress program solving for various shapes using appropriate classical theory. The portion used in this analysis is the opening in a cylinder using flat plate theory modified to account for curvature in the circumferential direction.

The stresses were generated by inputting appropriate temperatures and geometry into the programs assuming no reactions at the nozzle to shell intersection. A two element discontinuity analysis was then performed and forces and moments generated were then superimposed on the thermal stresses to give a total thermal stress picture.

Stress Analysis

Several computer runs were made to obtain the stresses in the nozzle resulting from the application of selected transients. The loads for each selected critical transient time consisted of the temperature distribution, operating pressure at that transient time and the nozzle to shell interaction loads. The pressure was

Stress Analysis - Continued

applied at the inside surfaces of the nozzle and the shell.

The resulting stresses in the elements included stress concentration effects at structural discontinuities. Stress concentration factors were obtained by using the indices of USAS B31.7, "Nuclear Power Piping", 1968 Draft, and other sources. Program P91206 also output primary plus secondary stresses. The range of these linearized stresses was then compared to the associated 3Sm stress limit. The peak stresses and associated usage factors were determined for the selected critical locations in the nozzle and the shell.

In the calculations following, some of the inherent conservatism in the original stress calculations is removed. The tabulation for primary plus secondary stresses (Table 1), external load and peak stresses (Table 2) are taken directly from the original stress report.

The required thermal analysis for the HPI transient following a reactor trip is performed using temperature distribution program P91232, Reference #11. This program calculates the temperature distribution through the thickness of a cylinder as a function of time by solving one dimensional heat transfer equations. This program also determines the linear and non-linear portions of the radial temperature gradient and the associated stresses. This program was run for various types of transients to develop a simplified "temperature gradient/stress" ratio method to determine stresses for the added reactor trip HPI actuation transient.

This simplified stress ratio method utilizes the stresses in the original design analysis for the rapid depressurization transients to obtain stresses for the added reactor trip transients. The stresses and the associated cycles for the reactor trip transients were used in conjunction with the stresses and cycles in the original design analysis for the test and rapid depressurization transients to determine a total usage factor.

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Stress Analysis - Continued

To conservatively analyze earthquake stresses, the following was used. There are 650 OBE cycles to consider consisting of 30 separate earthquake events, with each event having approximately 22 cycles. The full range of OBE stress was added to the thermal, pressure and thermal expansion stresses for a HPI transient following a reactor trip. This stress range was evaluated for 30 cycles. The 620 (650-30) remaining cycles of full range of OBE stress (± OBE) were analyzed separately.

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GENERAL CALCULATIONS

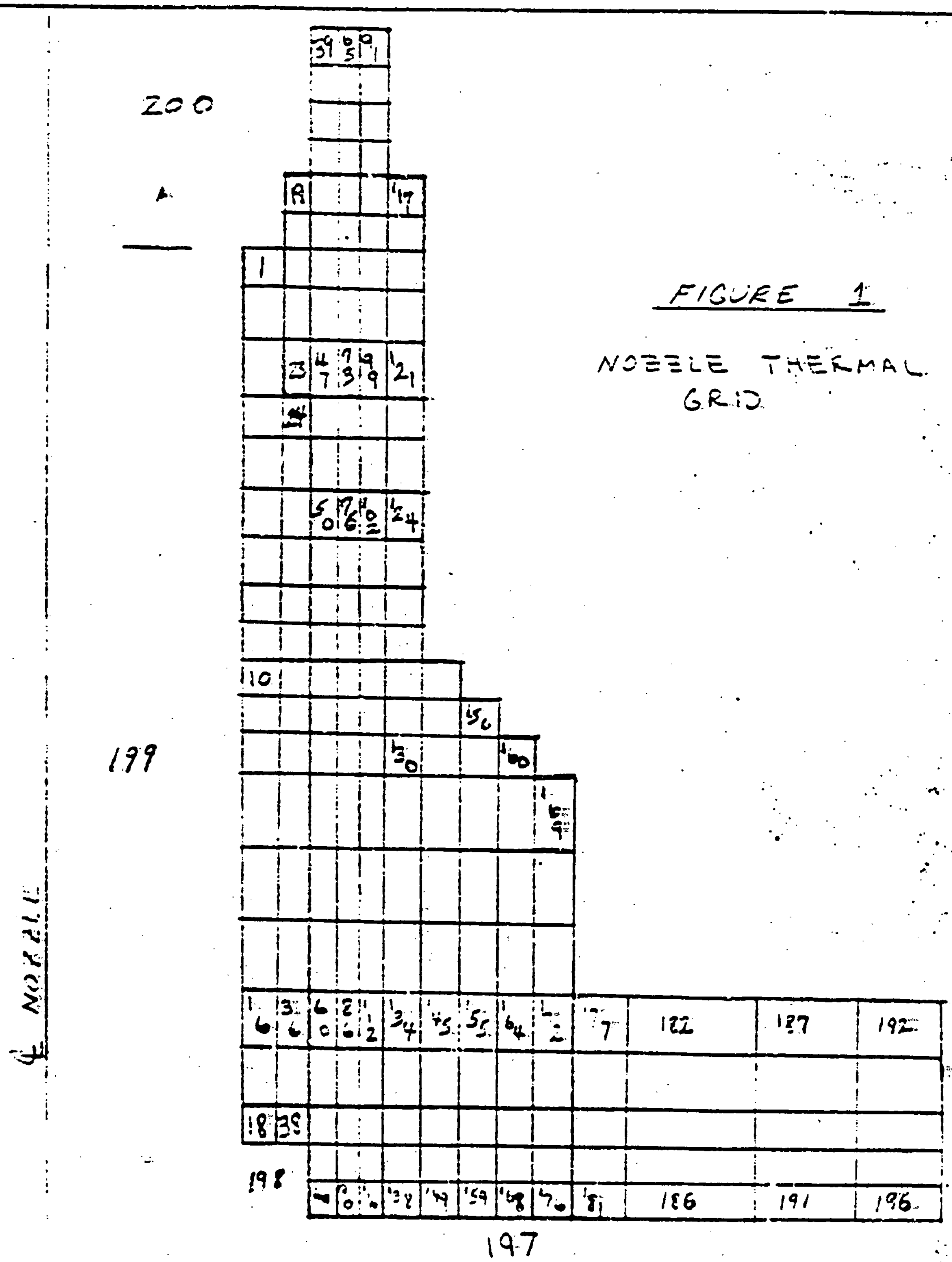

FIGURE 1

NOZZLE THERMAL GRID

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GENERAL CALCULATIONS

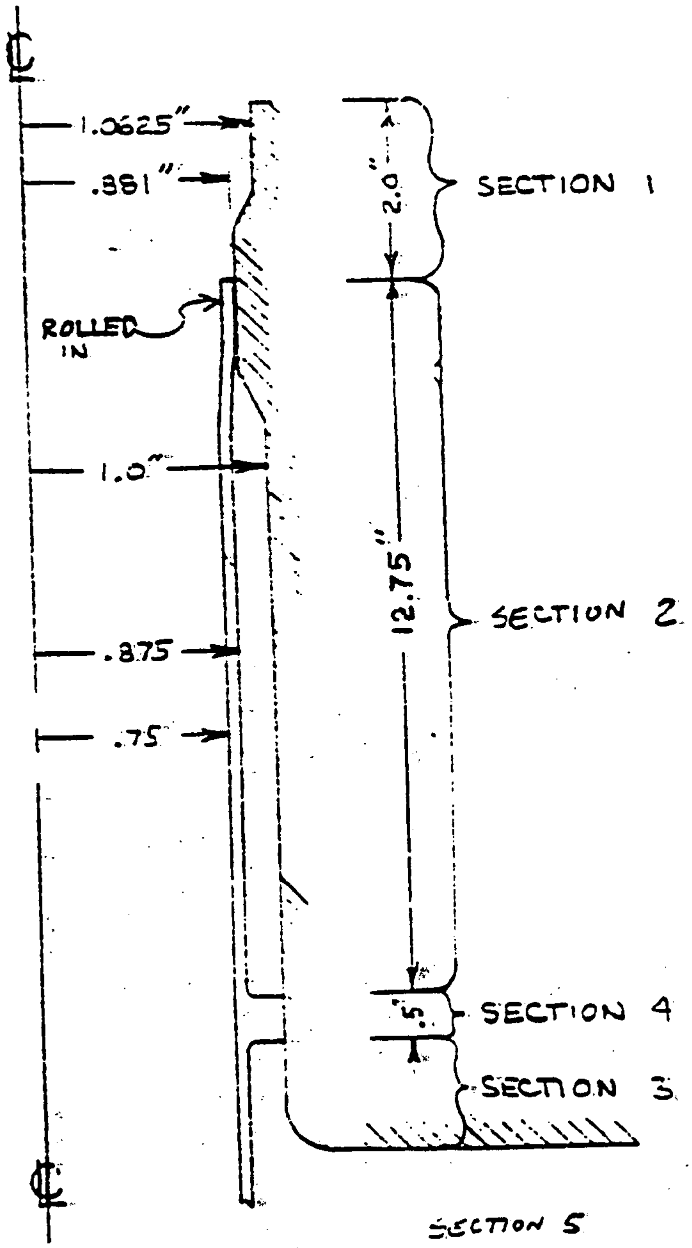

FIGURE 2
THERMAL SLEEVE GEOMETRY

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GENERAL CALCULATIONS

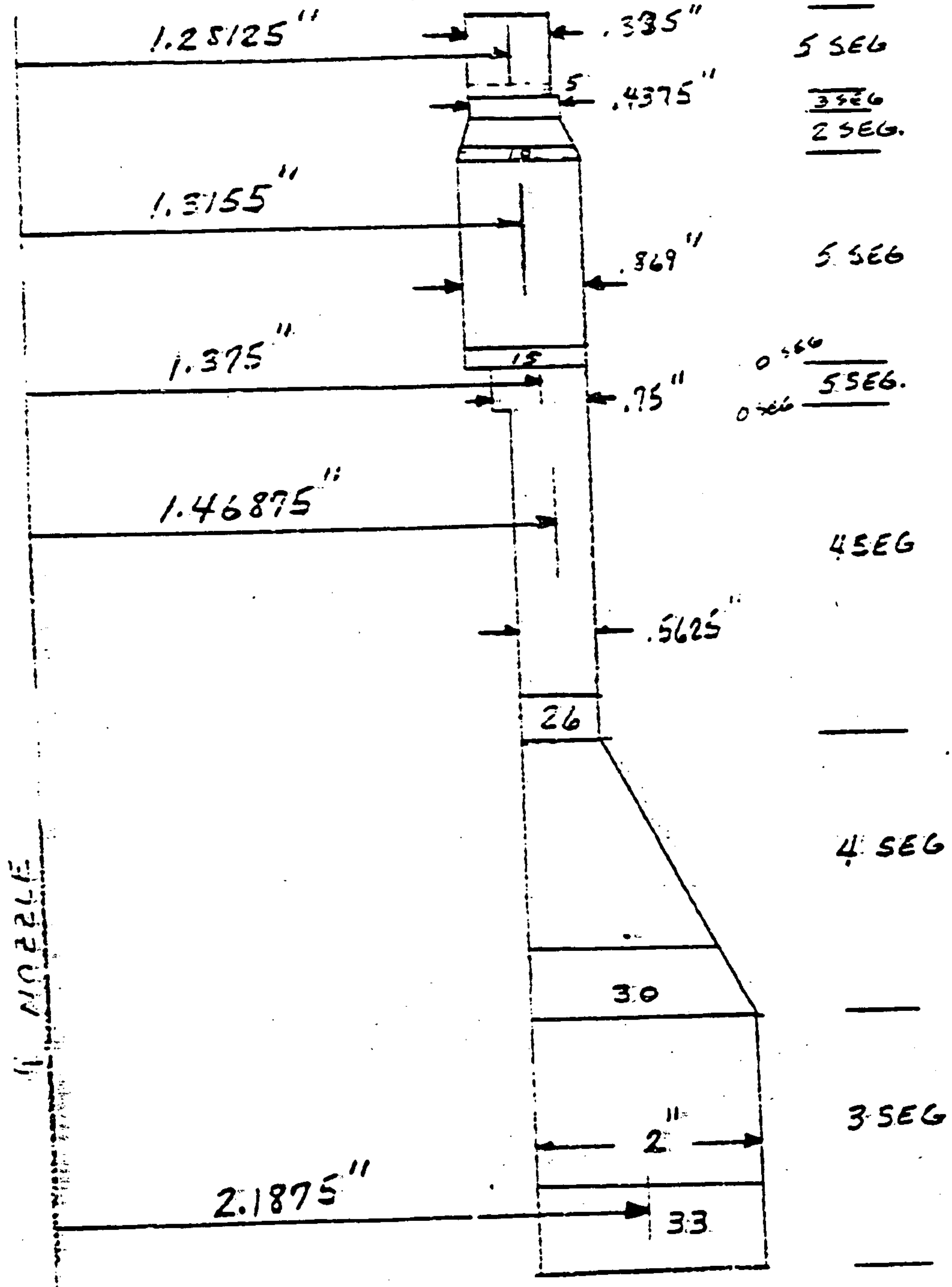

FIGURE 3

NOZZLE AXISYMMETRIC MODEL

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4.0 Description of Transients

The temperature transient for the 40 cycles of test and 40 cycles of rapid depressurization is shown in Figure 4. The test transient starts at a temperature of 550°F and a pressure of 2200 psi, drops down to 60°F and ends at a temperature of 550°F and a pressure of 2200 psi. This transient lasts for 10 seconds. The rapid depressurization transient starts at a temperature of 550°F and a pressure of 2200 psi, drops down to 60°F for 45 seconds, drops down to 40°F and ends at a temperature of 500°F and a pressure of 600 psi. This transient lasts for 15 minutes.

The temperature transient for the 70 cycles of HPI manual actuation is shown in Figure 5. The transient starts at a temperature of 579°F and a pressure of 1600 psi, drops down to 60°F for 45 seconds, drops down to 40°F and ends at a temperature of 558.0°F and a pressure of 1100 psi, References #8 and #9. This transient lasts for 15 minutes. The maximum flow rate through each nozzle is 335 gpm.

The temperature transient for heat-up and cool-down consists of heat-up from 70°F to 550° and 2200 psi and cool-down to 70°F. This transient occurs at a temperature change rate of 100 degrees per hour.

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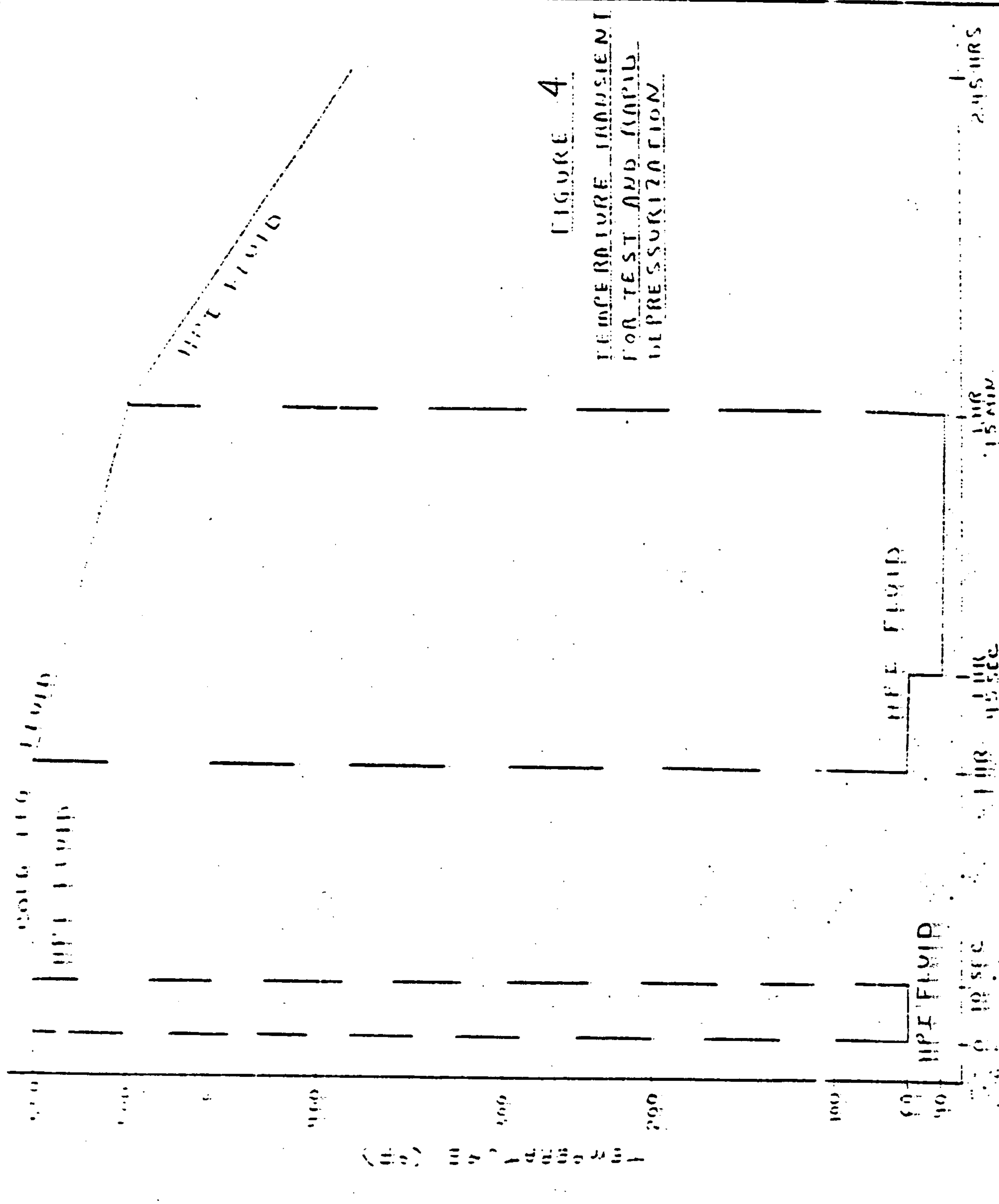
GENERAL CALCULATIONS



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GENERAL CALCULATIONS

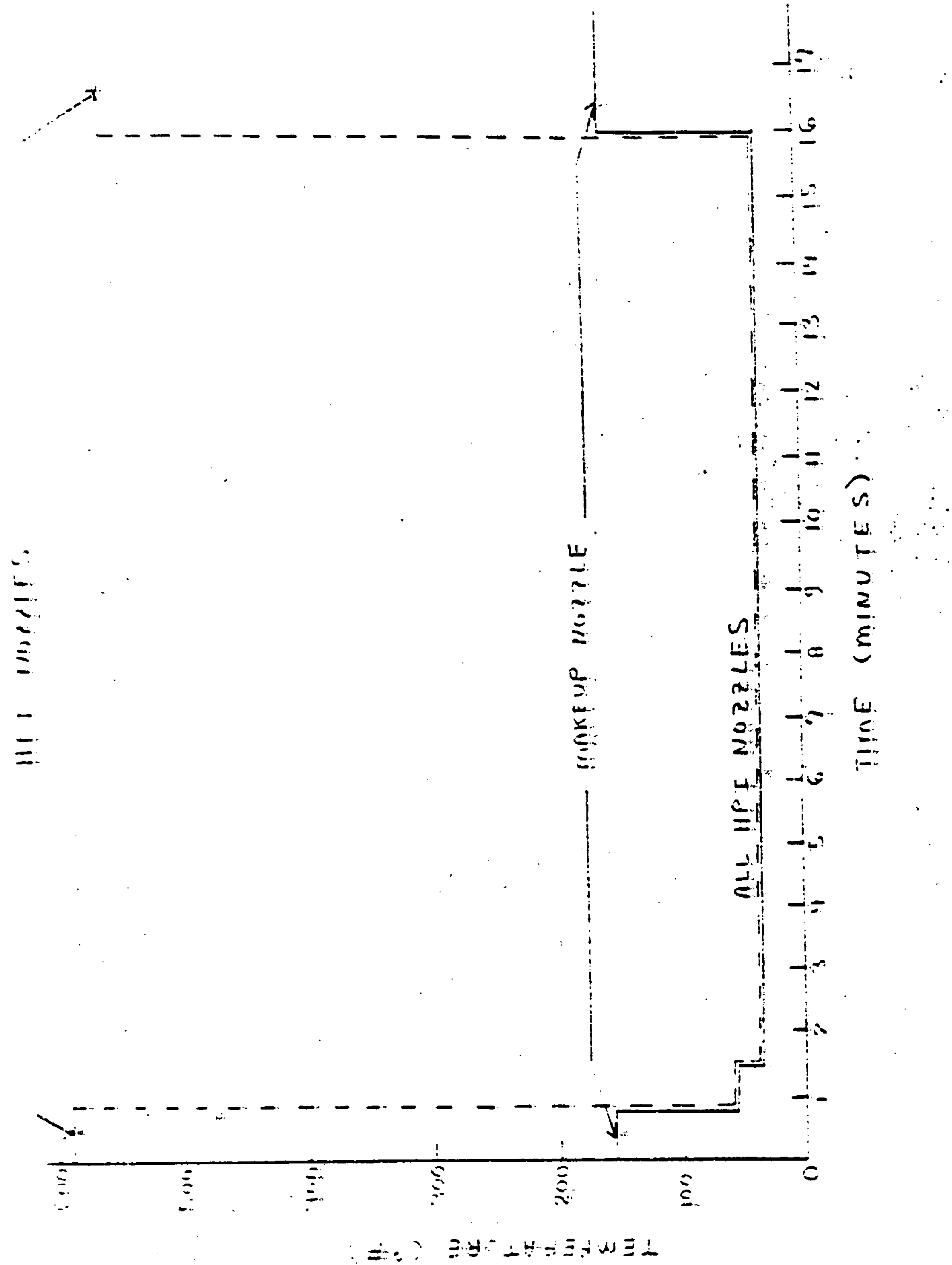

FIGURE 5
TEMPERATURE TRANSIENT FOR HPI MANUAL ACTIVATION

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5.0 Thermal Parameters

On Page 4-2 of Reference #6, the film coefficient values used in the analysis for the rapid depressurization transient were calculated. This film coefficient calculation assumed a flow rate of 425 GPM through each nozzle. The actual flow is a maximum of 335 GPM per nozzle, References #8 and #9. The actual film coefficient that should have been used is calculated below:

In Branch (Per Page 4-2, Reference 6)

The film coefficients were calculated from equation (VIII-1), Ref. #10, Page 139:

$$h = 0.023\left(\frac{k}{D}\right)\left(\frac{DG}{\mu}\right)^{0.8}\left(\frac{\mu C_p}{k}\right)^{0.4}$$

Where:
- h = Film coefficient, BTU/HR-FT^2-^oF,
- k = Thermal Conductivity, BTU/HR-FT - ^oF,
- D = Diameter Of Pipe, FT,
- G = Rate Of Flow/Unit Area, LBm/FT^2 - HR,
- μ = Dynamic Viscosity, LBm/FT - HR,
- C_p = Specific Heat, BTU/LBm - ^oF,

All at the fluid temperature. The properties will be evaluated at 60^oF since the highest stresses developed occurred over the first 46 seconds, at which time the temperature was 60^oF.

FOR 60°F WATER, [REF. #6, PAGE 4-2]

C_p = 1.0 Btu/Lbm-°F k = 0.344 Btu/hr-ft-°F
ρ = 62.34 Lbm/ft^3 D = 0.177 ft
μ = 2.71 Lbm/ft-hr A = 0.0246 ft^2

$$G = \frac{(335\ gal\ min/...)(60\ min/hr)(0.1337\ ft^3/gal)(62.34\ Lbm/ft^3)}{0.0246\ ft^2}$$

G = 6,810,188.9 Lbm/ft^2-hr

5.0 Thermal Parameters-Continued

$$h = 0.023\left(\frac{0.344}{0.177}\right)\left[\frac{(0.177)(6\,810{,}188.9)}{(2.71)}\right]^{0.8}\left[\frac{(2.71)(1.0)}{(0.344)}\right]^{0.4}$$

$h = 3368.3$ Btu/hr - ft^2 - °F

A film coefficient of 4100 BTU/HR - FT^2 - ^{0}F for the rapid depressurization transient was used in Reference #6. The film coefficient used in Reference #6 for the test transient is 1300 BTU/HR - FT^2 - ^{0}F. This film coefficient was calculated using the correct flow rate.

On page 31 of this calculation package, it has been determined that with a film coefficient value of 4100 BTU/HR - FT^2 - ^{0}F, the same ΔT and stress ratios were computed as with a film coefficient value of 1300 BTU/HR - FT^2 - ^{0}F. Therefore, it has been concluded that using a film coefficient value of 3368.3 BTU/HR - FT^2 - ^{0}F would give the same ΔT and stress ratios. Therefore, no adjustment needs to be made during the ratio method of analysis.

6.0 Thermal Discontinuity

The thermal discontinuity effects would also be lower if the lower film coefficient value of 3368.3 BTU/HR - FT^2 - ^oF for the rapid depressurization transient was used. With a lower film coefficient value, the metal temperatures would change at a slower rate, thus decreasing the axial ΔT temperature at the time point being evaluated. Therefore, using a film coefficient value of 4100 BTU/HR - FT^2 - ^oF produces a desired conservatism in the analysis.

7.0 HPI NOZZLE LOADS AND STRESSES

THERMAL EXPANSION LOADS (PER REF. #13)

$F_x = -255$ LBS $M_x = 2226$ FT-LB
$F_y = -365$ LBS $M_y = -914$ FT-LB
$F_z = -111$ LBS $M_z = -1043$ FT-LB

$R_i = 1.0625''$ $D_i = 2.125''$
$R_o = 1.5''$ $D_o = 3.0''$

$$I = \frac{\pi}{64}(D_o^4 - D_i^4) = 2.98 \text{ IN}^4$$

$$\sigma = C_2 D M_I / 2I$$

WHERE: $C_2 = 1.2$ {REF. 2, TABLE D-201, TAPERED TRANSITION JOINT}

$$M_I = (M_x^2 + M_y^2 + M_z^2)^{1/2} + VL$$

$$V = (F_y^2 + F_z^2)^{1/2}$$

$L = 0.0833$ FT = DISTANCE TO JUNCTURE #8

INSIDE

$$S_L^i = \frac{1.2(2.125)(12)\{(2226^2 + 914^2 + 1043^2)^{1/2} + (365^2 + 111^2)^{1/2}(.0833)\}}{2(2.98)}$$

$S_L^i = 13.6$ KSI

$S_L^o = 13.6(3.0/2.125) = 19.2$ KSI

DEADWEIGHT + OBE (PER REF. #13)

F_X = 31 LB M_X = 186 FT-LB
F_Y = -264 LB M_Y = 161 FT-LB
F_Z = 73 LB M_Z = -106 FT-LB

FOR CONSERVATISM DEADWEIGHT + OBE WILL BE USED AS OBE SINCE OBE IS NOT SPECIFIED SEPARATELY.

$$S = B_2 D M_I / 2I$$

WHERE: $B_2 = 1.0$ (REF. 13, PG. B-52.5)

INSIDE (OBE)

$$S_L = \frac{1.0(2.125)(12)\{(186^2+161^2+106^2)^{1/2}+(264^2+73^2)^{1/2}(.0833)\}}{2(2.08)}$$

S_L = 1.24 KSI

OUTSIDE (OBE)

S_L = 1.24 (3.0/2.125) = 1.75 KSI

8.0 Primary + Secondary Stress Intensities

Tabulated on page 22 are the primary + secondary stress intensities at Juncture #8 for the HPI nozzle. Juncture #8 is the most critical location in the HPI nozzle.

Reference #2, paragraph F-104.4, gives the primary plus secondary stress intensity range limit as 3 Sm. If the 3 Sm limit is exceeded, then an elastic-plastic fatigue analysis must be performed in accordance with Ref. #2, paragraph F-105.2.7. (The 3 Sm value at the critical location, Juncture #8, is 51.3 ksi, Ref. #6). This fatigue method is valid only if the number of cycles that exceed 3 Sm are less than 250. The number of cycles that exceed 3 Sm are determined on page 27.

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GENERAL CALCULATIONS

Table 1
Primary + Secondary Stress Intensities
At Juncture #8 (L-R Intensity)#

L - Longitudinal
R - Radial

Table references and explanations are included on the following page.

Iteration	Pressure	Pressure Stress (ksi)[1]		Thermal Expansion Stress (ksi)[2]		Stress Report Thermal Stress (ksi)[3]		Total Stress Intensity (ksi)[7]	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
3	2200	4.84	1.32	13.6	19.2	63.7	-58.2	82.1	-37.7
6	2200	4.84	1.32	13.6	19.2	77.5	-70.8	95.9	-50.3
8	2200	4.84	1.32	13.6	19.2	78.8	-71.9	97.2	-51.4
15	2200	4.84	1.32	13.6	19.2	69.3	-63.0	87.7	-42.5
30	2200	4.84	1.32	13.6	19.2	7.7	- 6.9	26.1	13.6
1211	2200	4.84	1.32	13.6	19.2	-0.4	0.3	18.0	20.8
1491	2200	4.84	1.32	13.6	19.2	0.0	- 0.0	18.4	20.5
42021	2200	4.84	1.32	13.6	19.2	0.0	0.0	18.4	20.5
27976	2200	4.84	1.32	13.6	19.2	-0.7	0.6	17.7	21.1
5072	2200	4.84	1.32	13.6	19.2	86.0	-78.3	104.4	-57.8
5060	2200	4.84	1.32	13.6	19.2	73.1	-66.8	91.5	-46.3
5063	2200	4.84	1.32	13.6	19.2	97.9	-89.3	116.3	-68.8
5124	2100	4.62	1.26	13.6	19.2	33.0	-29.7	51.2	-9.2
5237	1800	3.96	1.08	13.6	19.2	11.5	-10.4	29.1	9.9
6059	1000	2.2	0.6	13.6	19.2	0.4	- 0.4	16.2	19.4
6307	800	1.76	0.48	0.0*	0.0*	0.4	- 0.4	2.2	0.1
6338	700	1.54	0.42	0.0*	0.0*	-7.7	7.0	-6.2	7.4
6850	600	1.32	0.36	0.0*	0.0*	-3.5	3.1	-2.2	3.5
A(4)	1500	3.3	0.9	13.6	19.2	103.7	-94.6	120.6	-74.5
B(4)	1100	2.4	0.7	0.0*	0.0*	-8.7	7.9	-6.3	8.6
OBE[6]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.24	1.75
2(OBE)[5]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.48	3.5

PREPARED BY RRS DATE 7/22/82
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Table References and Explanations

1. In the Stress Report, Ref. #6, Iteration 1 was run of pressure only on the nozzle at a pressure of 1000 psi. Therefore, pressure stresses are obtained by multiplying the pressure stresses from Ref. #6, page 5-17 times the ratio of actual pressure/1000 psi.

2. Thermal expansion stresses are calculated on page 19 of this analysis.

3. Stress Report Thermal Stresses are from Ref. #6, Page 5-17. These thermal stresses are conservative since they were calculated with a flow rate of 425 gpm instead of the new flow rate of 335 gpm (Ref. #8 and 9). Therefore, the film coefficient were higher than necessary, thus increasing the thermal stresses.

4. Transient A is the start of the 70 cycles of HPI manual actuation. Transient B is the end of the 70 cycles of HPI manual actuation. This transient occurs following a reactor trip transient. The pressure stresses are calculated according to Note 1 above. The thermal expansion and thermal stresses are calculated using iterations 5060 and 6338, and adjusting the stresses using a ΔT ratio. These calculations are presented in Section 8.2 of this analysis.

5. Full range OBE (2 x OBE) stresses are calculated on page 20 of the analysis for juncture #8. This is the stress range for a cold earthquake.

6. Hot earthquake stresses and cycles will be applied and analyzed for in the primary + secondary and peak stress intensity range sheets in this calculation package. OBE stresses are calculated on page 20 of this analysis.

7. Total stress intensity is obtained by adding pressure stress + thermal expansion stress + stress report thermal stress.

* Note - A value of 0.0 ksi is used to approximate the range of thermal expansion stress at the HPI nozzle end due to the change in temperature of the HPI line.

- The cross-section position that experiences positive thermal expansion stresses is used to maximize the inside intensity which is the critical intensity.

- A graph of the L-R inside intensities is shown on page 25 of this calculation package to aid in determining ranges for maximum and minimum intensity values.

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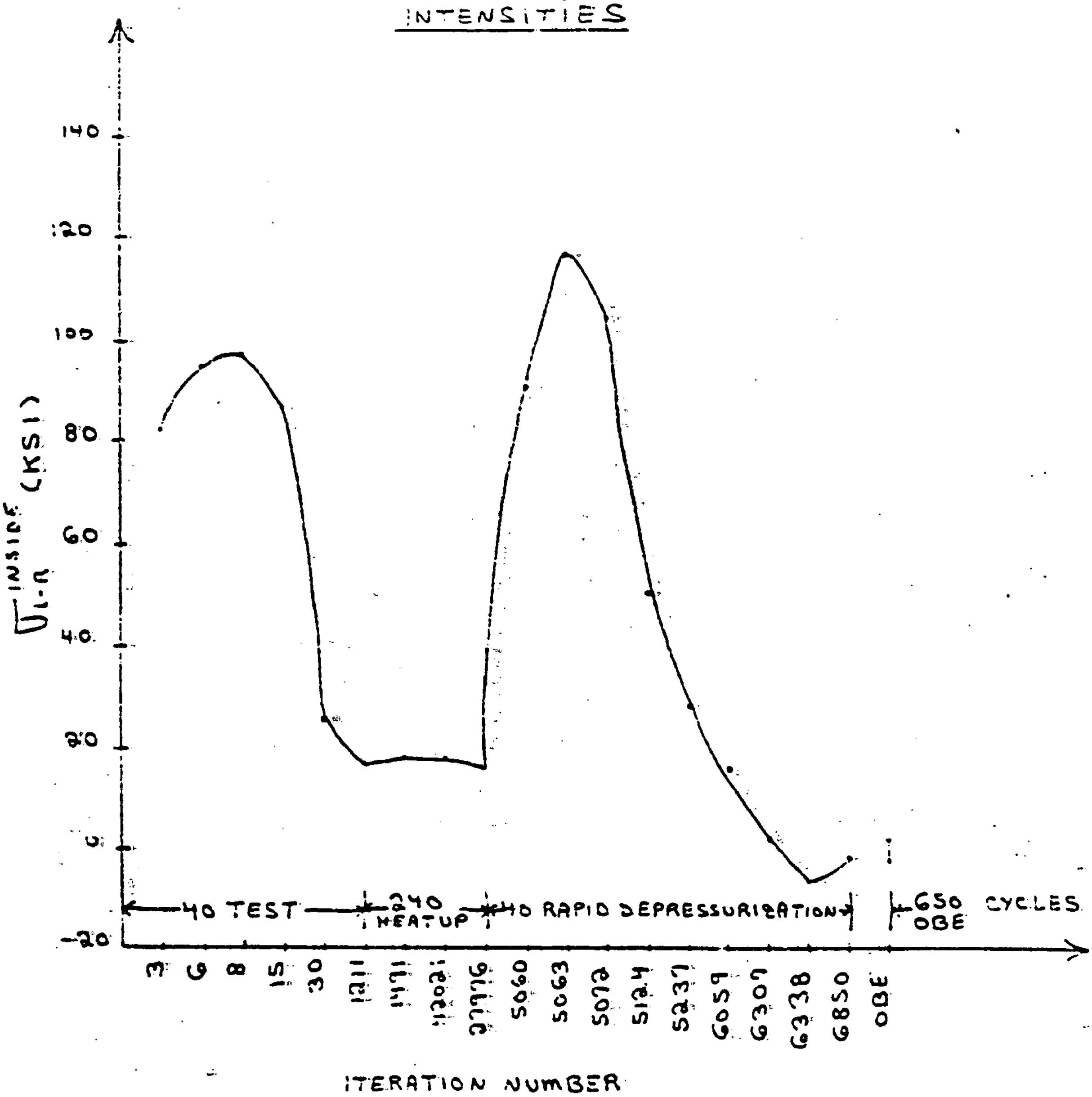
GENERAL CALCULATIONS

FIGURE 6
PRIMARY + SECONDARY STRESS
INTENSITIES



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8.1 40 Test, 240 Heatup and Cooldown, and 40 Rapid Depressurization Transient Cycles

The primary + secondary stress intensity range will now be calculated for the 40 cycles of test transient, 240 cycles of heatup and cooldown transient, and 40 cycles of rapid depressurization transient. The temperature transient for these cycles is shown in Figure #1, Ref. #6. The stress intensities are tabulated on page 22 and shown in graphic form on page 25 of this analysis.

Maximum Primary + Secondary Stress Intensity Range

This range is comprised of |(Iteration 5063) - (Iteration 6338)|.
It occurs during rapid depressurization and can occur for 40 cycles.

$$\sigma_{\substack{pri + sec \\ range}} = |116.3 - (-6.2)| = 122.5 \text{ ksi} > 3\ Sm = 51.3 \text{ ksi}$$

2nd Maximum Primary + Secondary Stress Intensity Range

This range is comprised of |(Iteration 3) - (Zero Stress State)|.
It occurs during testing and can occur for 40 cycles.

$$\sigma_{\substack{pri + sec \\ range}} = |97.2 - 0.0| = 97.2 \text{ ksi} > 3\ Sm = 51.3 \text{ ksi}$$

3rd Maximum Primary + Secondary Stress Intensity Range

This range is comprised of |(Iteration 42021) - (Zero Stress State)|.
It occurs during heatup and can occur for 240-40 = 200 cycles.

$$\sigma_{\substack{pri + sec \\ range}} = |18.4 - 0.0| = 18. \text{ ksi} < 3\ Sm = 51.3 \text{ ksi}$$

The number of cycles in which the primary plus secondary stress intensity range exceeds 3 Sm is 80.

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GENERAL CALCULATIONS

8.2 70 Cycles of HPI Actuation and OBE Cycles

The 70 additional cycles of HPI actuation following a reactor trip undergo a different temperature transient. (Ref. #8). The transient starts at a temperature of 579°F and a pressure of 1600 psig, drops to 80°F during the next 48 seconds and then drops to 40°F. The transient ends at a temperature of 558.2°F and a pressure of 1100 psig. The maximum flow rate is 335 gpm per nozzle. (References 8 and 9) These additional 70 cycles will be justified by adjusting the stress intensity ranges calculated on the preceding pages for the rapid depressurization transient.

To justify the analysis of the 70 additional cycles for the higher starting temperature (579°F versus 550°F), three (3) analogous thermal stress runs were made using B&W computer program P91232. Using this slab temperature program, the HPI test and rapid depressurization transients were analyzed as to their effect on the nozzle end thermal stress without discontinuity effects. The results of this analysis are contained in Reference #7, Microfiche AC3IMJU.

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The pertinent results are tabulated below:

Case	Initial Temp. (°F)	ΔT (T-60) °F	Film Coeff. (BTU/HR-FT²-°F)	ΔT Ratio (1)	Linear Thermal Stress (PSI)	Stress Ratio (2)
1	550	490	4100	1.00	73106	1.00
2	570	510	4100	1.04	76023	1.04
3	585	525	4100	1.07	78204	1.07
4	550	490	1300	1.00	57131	1.00
5	570	510	1300	1.04	59350	1.04
6	585	525	1300	1.07	61005	1.07

Notes - (1) ΔT Ratio = $\Delta T/\Delta T_1$ = ΔT/490

(2) Stress Ratio = S_2 or $_3/S_1$ for Cases 1, 2, 3

Stress Ratio = S_5 or $_6/S_4$ for Cases 4, 5, 6

To justify the analysis of the 70 additional cycles for a higher return temperature (585.2°F versus 500°F), the following results from B&W computer program P91232 are tabulated below. These results are from Reference #7, Microfiche: AC3IMJU.

Case	Return Temp. (°F)	ΔT (T-40) °F	Film Coeff. (BTU/HR-FT²-°F)	ΔT Ratio (1)	Linear Thermal Stress (PSI)	Stress Ratio (2)
1	550	510	35	1.00	-5658	1.00
2	570	530	35	1.04	-5876	1.04
3	585	545	35	1.07	-6039	1.07

Notes - (1) ΔT Ratio = $\Delta T/\Delta T_1$ = ΔT/510

(2) Stress Ratio = S_2 or $_3/S_1$

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GENERAL CALCULATIONS

From the tabulations on the preceding pages, one can see that the ΔT ratio is the same as the stress ratio for each case. Therefore, there is sufficient justification for using a ΔT ratio method to justify the different temperature transient from Reference #8 versus the test and rapid depressurization transient from Ref. #6, Page 4-4.

In order to calculate a stress intensity range for the reactor trip followed by HPI Manual actuation, the following method will be utilized: Thermal gradient stresses from the rapid depressurization transient will be multiplied by the ΔT ratio to obtain the thermal gradient stresses for the HPI manual actuation transient. Pressure stresses for the HPI manual actuation transient will be similarly adjusted. Thermal expansion stresses will not be ratioed because these stresses are due to the temperature in the HPI Line, and the only transient that changed was the cold leg temperature.

The following calculations apply to the 70 additional cycles of HPI actuation following a reactor trip. Two cases will be analyzed during these 70 additional cycles; one with the inclusion of 30 ± OBE stresses and the other without the inclusion of ± OBE stresses. The number of ± OBE cycles analyzed is 650 - 30 = 620.

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GENERAL CALCULATIONS

MAXIMUM PRIMARY + SECONDARY STRESS INTENSITY (INSIDE)

SECTION 2

PRESSURE STRESS = (4.84 KSI)$\left(\frac{1500 \text{ PSI}}{2200 \text{ PSI}}\right)$ = 3.3 KSI

THERMAL EXPANSION STRESS = 13.6 KSI

THERMAL STRESS = (97.9 KSI)$\left(\frac{579°F - 60°F}{550°F - 60°F}\right)$ = 103.7 KSI

TOTAL STRESS = 3.3 + 13.6 + 103.7 = 120.6 KSI

SECTION 3

PRESSURE STRESS = (1.54 KSI)$\left(\frac{1100 \text{ PSI}}{700 \text{ PSI}}\right)$ = 2.4 KSI

THERMAL EXPANSION STRESS = 0.0 KSI

THERMAL STRESS = −7.7 KSI$\left(\frac{558.2°F - 40°F}{500°F - 40°F}\right)$ = −8.7 KSI

TOTAL STRESS = 2.4 + 0.0 − 8.7 = −6.3 KSI

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[illegible] PRIMARY + SECONDARY STRESS INTENSITY (OUTSIDE)

HEAT ON A

PRESSURE STRESS = ([illegible].32 KSI) $\left(\frac{1500\ PSI}{2200\ PSI}\right)$ = 0.9 KSI

THERMAL EXPANSION STRESS = 19.2 KSI

THERMAL STRESS = (-89.3 KSI) $\left(\frac{579°F - 60°F}{550°F - 60°F}\right)$ = -94.6 KSI

TOTAL STRESS = 0.9 + 19.2 - 94.6 = -74.5 KSI

HEAT ON B

PRESSURE STRESS = (0.[illegible]2 KSI) $\left(\frac{1100\ PSI}{700\ PSI}\right)$ = 0.7 KSI

THERMAL EXPANSION STRESS = 0.0 KSI

THERMAL STRESS = ([illegible].0 KSI) $\left(\frac{358.2°F - 40°F}{300°F - 40°F}\right)$ = 7.9 KSI

TOTAL STRESS = 0.7 + 0.0 - 7.9 = 3.6 KSI

Case 1 - Primary + Secondary Stress Intensity Range w/Inclusion of ± OBE Stresses

The maximum primary + secondary stress intensity range is comprised of |(Iteration A + OBE) - (Iteration B - OBE)| and can occur for 30 cycles.

$\overline{\sigma}^{pri + sec}_{range}$ (inside) = $|(120.6 + 1.24) - (-6.3 - 1.24)| = 129.4$ KSI
$> 3Sm = 51.3$ ksi

$\overline{\sigma}^{pri + sec}_{range}$ (outside) = $|(-74.5 - 1.75) - (8.6 + 1.75)| = 86.6$ KSI
$> 3 Sm = 51.3$ ksi

Case 2 - Primary + Secondary Stress Intensity Range w/o ± OBE Stresses

$\overline{\sigma}^{pri + sec}_{range}$ (inside) = $|120.6 - (-6.3)| = 126.9$ KSI

$\overline{\sigma}^{pri + sec}_{range}$ (outside) = $|(-74.5 - 8.6)| = 83.1$ ksi > 3 Sm $= 51.3$ ksi

This range of stresses can occur for 70 - 30 = 40 cycles

OBE Primary + Secondary Stress Intensity Range (inside)

This range is comprised of ± OBE and can occur for the remainder of the earthquake cycles = 650 - 30 = 620.

$\overline{\sigma}^{pri + sec.}_{range}$ (inside) = $|1.24 + 1.24| = 2.48$ KSI

The number of cycles in which the primary plus secondary stress intensity range exceeds 3 Sm is 70.

The total number of cycles during the operational events in which the primary plus secondary stress intensity range exceeds 3 Sm is 80 + 70 = 150 < 250. Therefore, the elastic-plastic fatigue analysis is valid.

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9.0 Peak Stress Intensities

Following is a tabulation of the peak stress intensities at juncture #9 of the HPI nozzle. Only the stresses at the inside of segment #8 will be tabulated as they are the most critical.

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L - Longitudinal
R - Radial

Table 2

Peak Stress Intensities

At Juncture #8, L-R Inside*

*Table references and explanations are included on following page.

Iteration	Pressure (psi)	Pressure Stress (ksi)[1]	Thermal Expansion Stress (ksi)[2]	Stress Report Thermal Stress (ksi)[3]	Total Stress (ksi)[6]
3	2200	5.5	17.4	109.0	131.9
6	2200	5.5	17.4	115.0	137.9
9	2200	5.5	17.4	113.3	136.2
15	2200	5.5	17.4	95.0	117.9
30	2200	5.5	17.4	8.7	31.6
1211	2200	5.5	17.4	-0.4	22.5
1491	2200	5.5	17.4	0.0	22.9
42021	2200	5.5	17.4	0.0	22.9
27976	2200	5.5	17.4	-0.8	22.1
5060	2200	5.5	17.4	147.4	170.3
5063	2200	5.5	17.4	143.3	166.2
5072	2200	5.5	17.4	117.3	140.2
5124	2100	5.25	17.4	39.9	62.6
5237	1800	4.5	17.4	14.2	36.1
5959	1000	2.5	17.4	0.5	20.4
6307	800	2.0	0.0*	0.5	2.5
6338	700	1.75	0.0*	-9.6	-7.9
6850	600	1.5	0.0*	-1.3	0.2
1(4)	1500	3.8	17.4	156.24	177.3
2(4)	1100	2.75	0.0*	-10.81	-8.0
OBE	0.0	0.0	0.0	0.0	1.6
2(OBE)	0.0	0.0	0.0	0.0	3.2

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Table References and Explanations

1. Pressure Stresses are obtained by multiplying the peak pressure stress from Ref. #6, Page 5-17 (Iteration #1) times the ratio of actual pressure/1000 psi.

2. Thermal expansion stresses are from page 19 of this calculation package for juncture #8, multiplied by the bending stress concentration factor from Ref. #6, Page 1-4 (KB = 1.28).

3. Stress Report thermal stresses are from Ref. #6, page 5-17.

4. Transient A is the start of the 70 cycles of HPI manual actuation. Transient B is the end of the 70 cycles of HPI manual actuation. This transient occurs following a reactor trip. The pressure stresses are calculated according to note (1). The thermal expansion and thermal stresses are calculated using iterations 5060 and 6338, and adjusting the stresses using a ΔT ratio. These calculations are presented in Section 10.2 of this analysis.

5. Full range OBE (2xOBE) stresses are from page 20 of this calculation package multiplied times the bending stress concentration factor from Ref. #6, page 1-4 (KB=1.28). This is the range for a cold earthquake.

6. Total stress intensity is obtained by adding pressure stress + thermal expansion stress + stress report thermal stress.

*- Note - A value of 0.0 ksi is used to approximate the range of thermal expansion stress at the HPI nozzle end due to the change in temperature of the HPI line.

- The cross sectional position that experiences positive thermal expansion stresses is used to maximize the critical inside intensity.

- A graph of the L-R inside peak stress intensities is shown on the following page to aid in determining ranges for maximum and minimum intensity values.

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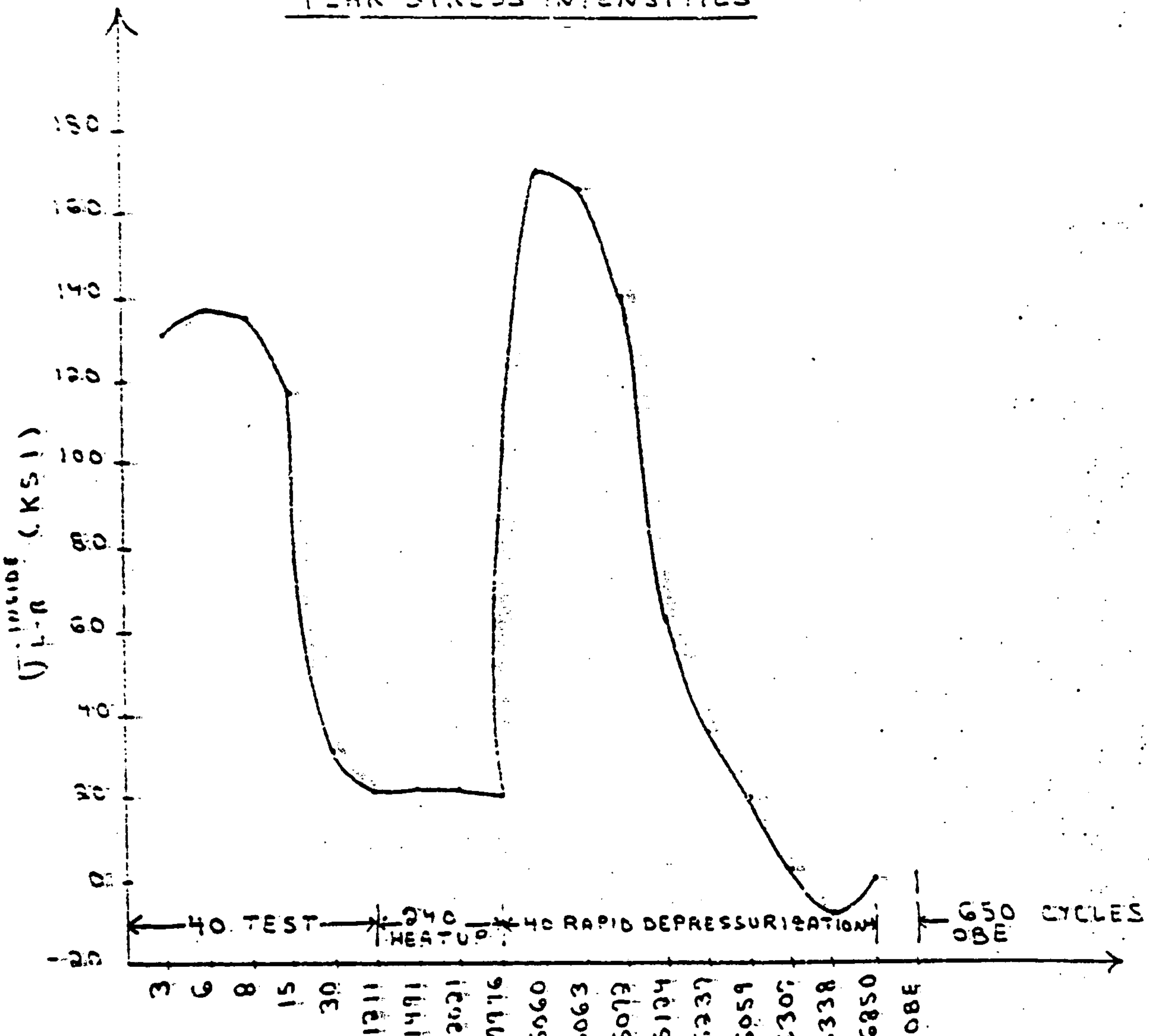
GENERAL CALCULATIONS

FIGURE 7
PEAK STRESS INTENSITIES



PREPARED BY RRS DATE 7/21/82 DOC NO 32-1128224-08

REVIEWED BY [illegible] DATE 7/22/82 PAGE NO. 38

10.0 Fatigue Analysis

The fatigue analysis is performed in accordance with paragraph F-1323.2.7 of Ref. #2, "Simplified Elastic-Plastic Discontinuity Analysis." The peak stress intensities and cycles are presented in graphic form on page 36. These are used to determine maximum peak stress intensity ranges and cycles used in the usage factor calculations. Actual peak stress intensity values can be obtained from the tabulation on page 35. Primary + Secondary stress intensities are also used in the fatigue analysis: these values are obtained from the tabulation on page 22.

C. 40 TEST, 240 HEAT-UP AND COOL-DOWN AND 40 RAPID DEPRESSURIZATION TRANSIENT CYCLES

MAXIMUM PEAK STRESS INTENSITY RANGE

THIS RANGE IS COMPRISED OF |(ITERATION 5060) - (ITERATION 6338)|. IT OCCURS DURING RAPID DEPRESSURIZATION AND CAN OCCUR FOR 40 CYCLES.

$\sigma^{PEAK}_{RANGE} = |(170.3) - (-7.9)| = 178.2$ KSI

THE PRIMARY - SECONDARY STRESS INTENSITY RANGE ASSOCIATED WITH THESE TRANSIENTS = 122.5 KSI > $3S_m$ = 51.3 KSI (ITERATIONS 5063 AND 6335). THEREFORE, AN ELASTIC-PLASTIC ANALYSIS MUST BE PERFORMED FOR THESE 40 CYCLES FOLLOWING THE PROCEDURE OF REF. #2 PARAGRAPH F-05.2.7. THE FINAL PEAK ALTERNATING STRESS INTENSITY, σ_{ALT}, IS:

$\sigma_{ALT} = 1/2\, K_f K_e S_{R_3}$

WHERE: $K_f = K_{\ell} - A(K_{\ell} - 1)$ = OVERALL FATIGUE STRENGTH REDUCTION FACTOR

$K_{\ell} = \frac{S^{P}_{R_3}}{S_{R_3}}$ = PEAK STRESS INTENSITY RANGE / PRIMARY - SECONDARY STRESS INTENSITY RANGE

= OVERALL EFFECTIVE STRESS CONCENTRATION FOR THE CYCLIC LOADING

A = 0.7 FOR STAINLESS STEEL A-376, TP 316 FROM FIG. D-201(c), REF. #2

[illegible]:

$$K_t = \frac{178.2}{122.5} = 1.45$$

$$\therefore K_e = 1.45 + 0.7(1.45 - 1.0) = 1.77$$

K_e IS DETERMINED FROM FIG. F-105(a).

FOLLOWING IS THE CALCULATION OF THE PARAMETERS NECESSARY TO OBTAIN K_e:

$$\frac{S_n}{3S_m} = \frac{\text{PRIMARY + SECONDARY STRESS INTENSITY RANGE}}{3S_m}$$

$$\frac{S_n}{3S_m} = \frac{122.5}{3 \times [illegible] \text{ KSI}} = 2.39$$

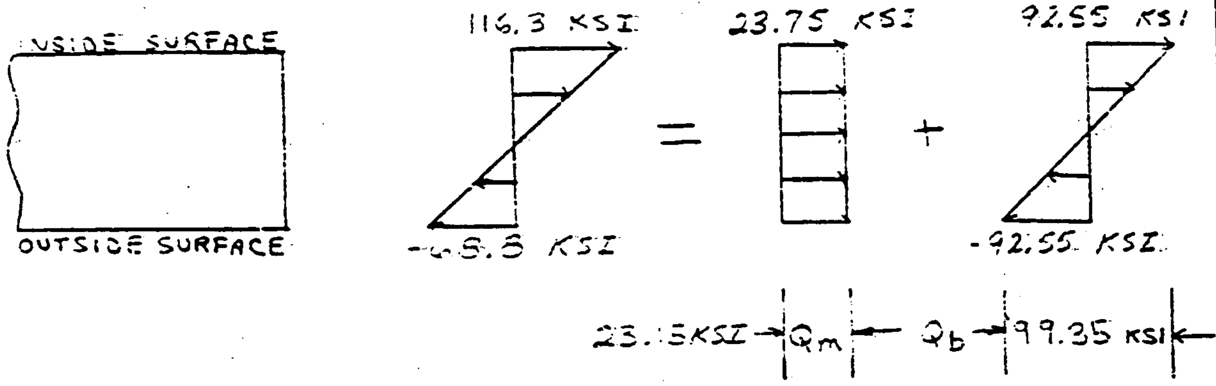
$S_m / [3S_m - S_b]$ IS DETERMINED NEXT, WHERE:

S_m IS THE MAGNITUDE OF PRIMARY + SECONDARY MEMBRANE STRESS INTENSITY RANGE AVERAGED THROUGH THE THICKNESS OF THE SECTION.

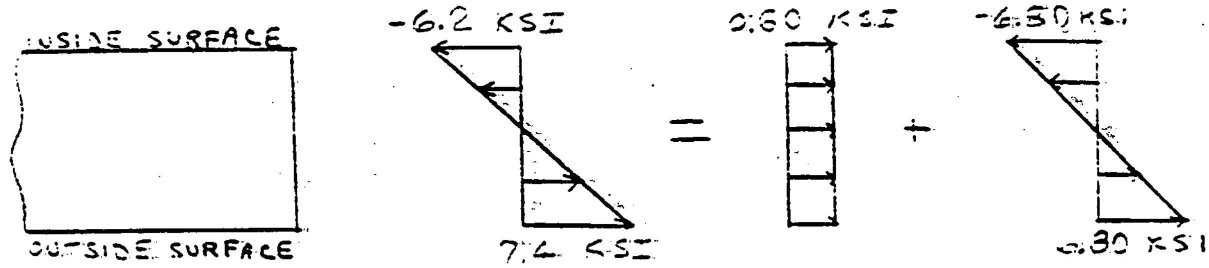
S_b IS THE MAGNITUDE OF PRIMARY + SECONDARY BENDING STRESS INTENSITY RANGE

AVERAGED THROUGH THE THICKNESS OF THE SECTION.

(CONDITION 1a = ITERATION 5063)



(CONDITION 1b = ITERATION 6338)



$$\frac{Q_m}{Q_m + Q_b} = \frac{23.15}{23.15 + 99.35} \text{ KSI} = 0.19$$

FROM FIG. F-105(a), REF. #2,

$$K_e \approx 1.75$$

$$S_{ALT} = \tfrac{1}{2} K_? K_e S_{rang}^{(n)}$$

$$S_{ALT} = \tfrac{1}{2}(1.77)(55)/(122.5) = 200.6 \text{ KSI}$$

TO TAKE INTO ACCOUNT THE EFFECT OF ELASTIC MODULUS, MULTIPLY S_{ALT} BY THE RATIO OF THE MODULUS OF ELASTICITY GIVEN ON THE DESIGN FATIGUE CURVE TO THE VALUE OF THE MODULUS OF ELASTICITY USED IN THE ANALYSIS. DURING THE RAPID DEPRESSURIZATION TRANSIENT, THE TEMPERATURE VARIES FROM 550°F TO 40°F. AT AN AVERAGE TEMPERATURE OF

$$\frac{550°F + 40°F}{2} = 295°F,$$

$$E = 27.13 \times 10^6 \text{ PSI} \qquad [\text{REF. \#2}]$$

$$\therefore S_a = 200.6 \left(\frac{26 \times 10^6}{27.13 \times 10^6}\right) = 192.2 \text{ KSI}$$

[THE DESIGN FATIGUE CURVE USED IS FIG. F-106(b), REF. #2. $E_{CURVE} = 26 \times 10^6$ PSI.]

FROM FIG. F-106 (b), REF. #2,

N = ALLOWABLE CYCLES = 80

$$U_1 = \text{USAGE FACTOR} = \frac{\text{NO. OF REQ'D CYCLES}}{\text{NO. OF ALLOWABLE CYCLES}}$$

$$U_1 = \frac{40}{180} = 0.22$$

2nd MAXIMUM PEAK STRESS INTENSITY RANGE

THIS RANGE IS COMPRISED OF |(ITERATION 6) - (ZERO STRESS STATE)|. IT OCCURS DURING TESTING AND CAN OCCUR FOR 40 CYCLES.

$$\sigma_{RANGE}^{PEAK} = |(137.9) - (0.0)| = 137.9 \text{ KSI}$$

THE PRIMARY + SECONDARY STRESS INTENSITY RANGE ASSOCIATED WITH THESE TRANSIENTS IS 97.2 KSI > 3Sm = 51.3 KSI. [ITERATIONS 8 AND ZERO STRESS STATE] THEREFORE, AN ELASTIC-PLASTIC FATIGUE ANALYSIS MUST BE PERFORMED FOR THESE 40 CYCLES. FOLLOWING THE PROCEDURE OF REF. #2, PARAGRAPH F-105.2.7, THE FINAL PEAK ALTERNATING STRESS INTENSITY, T_{ALT}, IS:

$$T_{ALT} = 1/2\ K_2\ K_e\ S_{range}^{(n)},$$

WHERE: $K_2 = K_* + A(K_* - 1.0)$

$$K_t = \frac{S^{(P)}_{rig}}{S^{(S)}_{rig}} = \frac{137.9}{97.2} = 1.42$$

$q = 0.7$ FOR STAINLESS STEEL A-376, TP316, FROM FIG. D-201(C), REF. #2

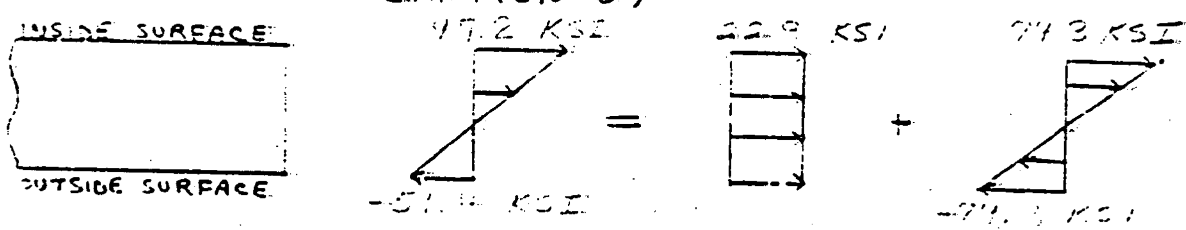
$\therefore K_f = 1.42 + 0.7(1.42 - 1.0) = 1.71$

K_ϵ IS DETERMINED FROM FIG. F-105(a). FOLLOWING IS THE CALCULATION OF THE PARAMETERS NECESSARY TO OBTAIN K_ϵ

$$\frac{S_n}{3S_m} = \frac{97.2 \text{ KSI}}{51.3 \text{ KSI}} = 1.89$$

$|Q_m| / [|Q_m| + |Q_b|]$ IS DETERMINED BELOW:

(CONDITION 2a = ITERATION 8)



(CONDITION 2b = ZERO STRESS STATE)

$\therefore Q_m = 22.9$ KSI

$Q_b = 74.3$ KSI

$$\frac{Q_m}{Q_m + Q_b} = \frac{22.9}{22.9 + 74.3} = 0.24$$

FROM FIG. F-105(a), REF. #2,

$K_E \approx$ [illegible]

$S_{ALT} = 1/2\ K_2 K_E S^{(n)}_{rig}$

$S_{ALT} = 1/2$ [illegible] $(1.71)(97.2) = 122.2$ KSI

DURING THE TESTING TRANSIENT, THE TEMPERATURE VARIES FROM 550°F TO 60°F. AT AN AVERAGE TEMPERATURE OF $\frac{550°F + 60°F}{2} = 305°F$,

$E = 27.08 \times 10^6$ PSI [REF. #2]

$S_A =$ [illegible] $\left(\frac{26 \times 10^6}{27.08 \times 10^6}\right) =$ [illegible] KSI

FROM FIG. F-106(b), REF. #2,

N = ALLOWABLE CYCLES = 750 CYCLES

U_2 = USAGE FACTOR = $\frac{40}{750} = 0.05$

3rd MAXIMUM PEAK STRESS INTENSITY RANGE

THIS RANGE IS COMPRISED OF |(ITERATION 42021) - (ZERO STRESS STATE)|. IT OCCURS DURING HEAT-UP AND COOL-DOWN AND CAN OCCUR FOR 240 - 40 = 200 CYCLES.

$$\sigma^{PEAK}_{RANGE} = |(22.9 - 0.0)| = 22.9 \text{ KSI}$$

THE PRIMARY + SECONDARY STRESS INTENSITY RANGE ASSOCIATED WITH THESE TRANSIENTS IS 18.4 KSI < $3S_m$ = 51.3 KSI. [ITERATIONS 42021 AND ZERO STRESS STATE]. THEREFORE, THE FINAL PEAK ALTERNATING STRESS INTENSITY RANGE, σ_{ALT}, IS:

$$\sigma_{ALT} = 1/2\ \sigma^{PEAK}_{RANGE} = 1/2\ (22.9) = 11.45 \text{ KSI}$$

DURING THE HEAT-UP AND COOL-DOWN TRANSIENT, THE TEMPERATURE VARIES FROM 550°F TO 70°F. AT AN AVERAGE TEMPERATURE OF $\frac{550°F + 70°F}{2}$ = 310°F,

$$E = 27.05 \times 10^6 \text{ PSI} \quad \text{[REF. \#2]}$$

$$S_a = 11.45 \left(\frac{26 \times 10^6}{27.05 \times 10^6} \right) = 11.01 \text{ KSI}$$

FROM FIG. F-106 (b), REF. #2

N = ALLOWABLE CYCLES = ∞

U_3 = USAGE FACTOR = 200/∞ = 0.0

10.2 70 CYCLES OF HPI ACTUATION AND OBE CYCLES

THE PEAK STRESSES ARE NOW CALCULATED FOR THE 70 CYCLES OF HPI MANUAL ACTUATION FOLLOWING A REACTOR TRIP. THESE 70 CYCLES UNDERGO A DIFFERENT TEMPERATURE TRANSIENT THAN FOR THE 40 CYCLES OF TEST TRANSIENT AND 40 CYCLES OF RAPID DEPRESSURIZATION TRANSIENT. THUS, THE PEAK STRESSES WILL BE ADJUSTED USING A ΔT RATIO METHOD.

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GENERAL CALCULATIONS

MAXIMUM PEAK STRESS INTENSITY (INSIDE)

ITERATION A

PRESSURE STRESS = 5.5 (1500/2200) = 3.8 KSI

THERMAL EXPANSION STRESS = 17.4 KSI

THERMAL STRESS = $147.4 \left(\frac{579-60}{550-60}\right)$ = 156.1 KSI

TOTAL STRESS = 3.8 + 17.4 + 156.1 = 177.3 KSI

ITERATION B

PRESSURE STRESS = .73 (1100/700) = 2.8 KSI

THERMAL EXPANSION STRESS = 0.0 KSI

THERMAL STRESS = $-9.6 \left(\frac{558.2-40}{500-40}\right)$ = -10.8 KSI

TOTAL STRESS = 2.8 + 0.0 + (-10.8) = -8.0 KSI

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REVIEWED BY [illegible]	DATE [illegible]	PAGE NO 50	

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GENERAL CALCULATIONS

THE FOLLOWING CALCULATIONS APPLY TO THE 70 CYCLES OF HPI MANUAL ACTUATION. TWO CASES WILL BE ANALYZED DURING THE 70 ADDITIONAL CYCLES; ONE WITH THE INCLUSION OF ± OBE STRESSES AND THE OTHER WITHOUT THE INCLUSION OF ± OBE STRESSES. THE NUMBER OF ± OBE STRESS CYCLES ANALYZED IS 650 - 30 = 620.

CASE 1 - PEAK STRESS INTENSITY RANGE WITH INCLUSION OF ± OBE STRESSES

THE MAXIMUM PEAK STRESS INTENSITY RANGE IS COMPRISED OF |(ITERATION A + OBE) - (ITERATION B - OBE)| AND CAN OCCUR FOR 30 CYCLES.

$\sigma_{PEAK\ RANGE} = |(177.3 + 1.6) - (-8.0 - 1.6)| = 188.5$ KSI

THE PRIMARY + SECONDARY STRESS INTENSITY RANGE ASSOCIATED WITH THIS TRANSIENT IS 129.4 KSI $> 3S_m = 51.3$ KSI. [ITERATIONS A AND B ± OBE].

PREPARED BY: RRS DATE: 7/22/82
REVIEWED BY: [signature] DATE: 7/22/82
DOC. NO. 32-1128224-04
PAGE NO.: 51

THEREFORE, AN ELASTIC-PLASTIC FATIGUE ANALYSIS MUST BE PERFORMED FOR THESE 30 CYCLES.

FOLLOWING THE PROCEDURE OF REF. #2, PARAGRAPH F-105.2.7, THE FINAL PEAK ALTERNATING STRESS INTENSITY, σ_{ALT}, IS:

$$\sigma_{ALT} = 1/2 \, K_f K_\varepsilon S_{rig}^{(n)} \, ,$$

WHERE: $K_\varepsilon = K_* + A\,(K_* - 1.0)$

$$K_* = \frac{S_{rig}^{(p)}}{S_{rig}^{(n)}} = \frac{189.5 \text{ KSI}}{129.4 \text{ KSI}} = 1.46$$

$A = 0.7$ FOR STAINLESS STEEL A-376, TP 316, FROM FIG. D-201 (c), REF. #2

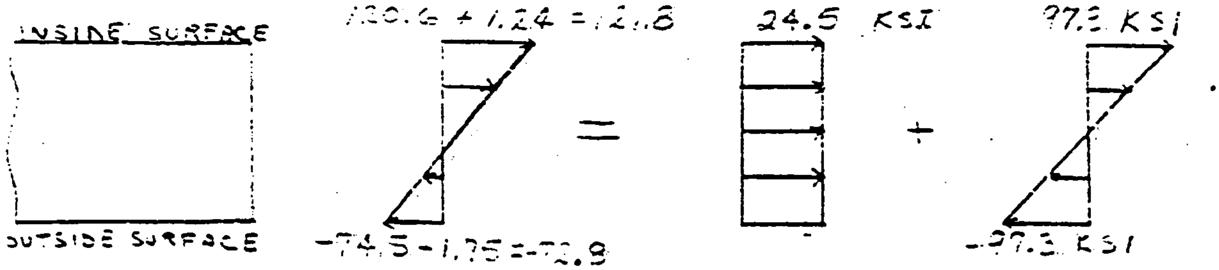
$\therefore K_\varepsilon = 1.46 + 0.7\,(1.46 - 1.0) = 1.78$

K_ε IS DETERMINED FROM FIG. F-105 (a). FOLLOWING IS THE CALCULATION OF THE PARAMETERS NECESSARY TO OBTAIN K_ε.

$$\frac{S_n}{3S_m} = \frac{129.4 \text{ KSI}}{51.3 \text{ KSI}} = 2.52$$

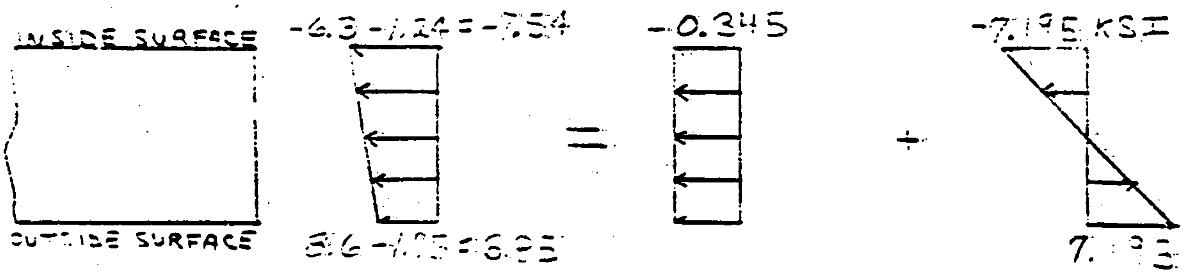
$|Q_m| / [\,|Q_m| + |Q_b|\,]$ IS DETERMINED NEXT:

(CONDITION 2 = ITERATION 4 + OBE)



$Q_m \rightarrow |24.85| \leftarrow \quad Q_b \rightarrow |104.50| \leftarrow$

(CONDITION 1B = ITERATION 3 - OBE)



$$\frac{Q_m}{Q_m + Q_b} \quad \frac{24.85}{24.85 + 104.50} = 0.19$$

FROM FIG. 3-105(a), REF. #2,

$$K_E \approx 1.59$$

$$T_{ALT} = 1/2\, K_f K_E S_{Ti_2}^{(m)}$$

$T_{ALT} = 1/2$ ( ) ( ) ( ) = 217.7 KSI

DURING THE HPI MANUAL ACTUATION TRANSIENT, THE

TEMPERATURE VARIES FROM 579°F TO 40°F. AT AN AVERAGE TEMPERATURE OF $\frac{579°F + 40°F}{2} = 309.5°F$,

$$E = 27.05 \times 10^6 \text{ PSI} \quad [\text{REF. \#2}]$$

$$S_a = 217.7 \left(\frac{26 \times 10^6}{27.05 \times 10^6}\right) = 209.2 \text{ KSI}$$

FROM FIG. F-106(b), REF. #2,

N = ALLOWABLE CYCLES = 145 CYCLES

U_4 = USAGE FACTOR = $\frac{30}{145} = 0.21$.

CASE 2 - <u>PEAK STRESS INTENSITY RANGE WITHOUT ±OBE STRESSES</u>

THE MAXIMUM PEAK STRESS INTENSITY RANGE IS COMPRISED OF |(ITERATION A) - (ITERATION B)| AND CAN OCCUR FOR 40 CYCLES.

$T^{PEAK}_{RANGE} = |177.3 - (-8.[illegible])| = 185.3$ KSI

THE PRIMARY + SECONDARY STRESS INTENSITY RANGE ASSOCIATED WITH THIS TRANSIENT IS 12[illegible] KSI $> 3S_m = 51.3$ KSI. [ITERATIONS A AND B ± OBE].

THEREFORE AN ELASTIC-PLASTIC FATIGUE ANALYSIS MUST BE PERFORMED FOR THESE 40 CYCLES.

FOLLOWING THE PROCEDURE OF REF. #2, PARAGRAPH F-105.2.7, THE FINAL PEAK ALTERNATING STRESS INTENSITY, S_{ALT}, IS:

$$S_{ALT} = 1/2 \, K_f \, K_\epsilon \, S_{rig}^{(n)},$$

WHERE: $K_f = K_t + A(K_t - 1.0)$

$$K_t = \frac{S_{rig}^{(P)}}{S_{rig}^{(n)}} = \frac{185.3 \text{ KSI}}{126.9 \text{ KSI}} = 1.46$$

A = 0.7 FOR STAINLESS STEEL A-376, TP316, FROM FIG. D-201 (c), REF. #2

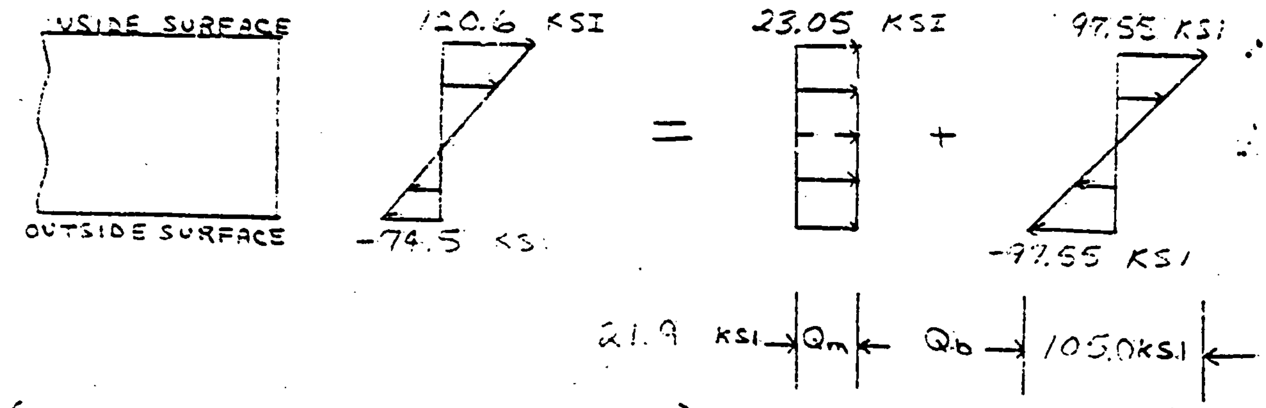
$\therefore \quad K_f = 1.46 + 0.7(1.46 - 1.0) = 1.78$

K_ϵ IS DETERMINED FROM FIG. F-105(a). FOLLOWING IS THE CALCULATION OF THE PARAMETERS NECESSARY TO OBTAIN K_ϵ.

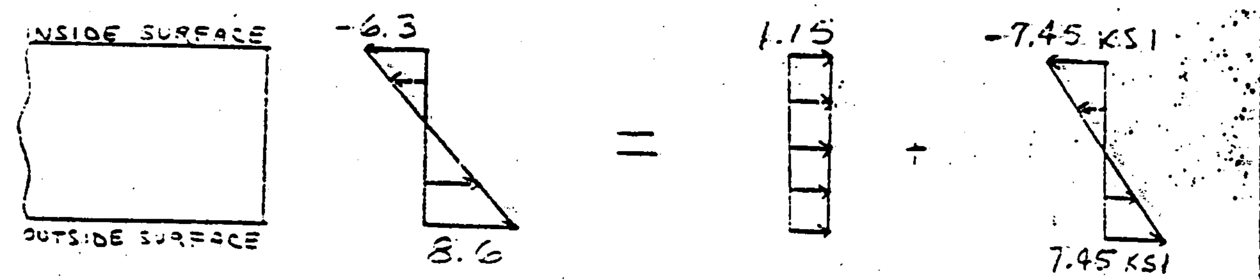
$$\frac{S_n}{3S_m} = \frac{126.9 \text{ KSI}}{51.3 \text{ KSI}} = 2.47$$

$Q_m / [\,|Q_m| + |Q_b|\,]$ IS DETERMINED NEXT.

(CONDITION 2a = ITERATION A)



(CONDITION 2b = ITERATION B)



$$\frac{Q_m}{Q_m - Q_b} = \frac{21.9}{21.9 + 105.0} = 0.17$$

FROM FIG F-105(a), REF. #2,

$$K_E \approx 1.55$$

$$T_{ALT} = 1/2 \, K_f \, K_E \, S_{r,z}^{(n)}$$

T_{ALT} = 1/2 ([illegible].75)(1.55)(126.9) = 208.9 KSI

DURING THE HPI MANUAL ACTUATION TRANSIENT,

THE TEMPERATURE VARIES FROM 579 °F TO 40 °F AT AN AVERAGE TEMPERATURE OF (579 + 40)/2 = 309.5 °F.

$E = 27.05 \times 10^{6}$ PSI (REF. #2)

S_L = 208.9 (26/27.05) = 200.8 KSI

FROM FIG. F-106 (b), REF. #2

N = ALLOWABLE CYCLES = 155

U_5 = 40/155 = 0.26

OBE PEAK STRESS INTENSITY RANGE

THIS RANGE IS COMPRISED OF ±OBE AND CAN OCCUR FOR THE REMAINDER OF THE EARTHQUAKE CYCLES, THAT IS, 650 - 30 = 620 CYCLES.

$$\sigma_{RANGE}^{PEAK} = |1.6 - (-1.6)| = 3.2 \text{ KSI}$$

THE PRIMARY + SECONDARY STRESS INTENSITY RANGE ASSOCIATED WITH THIS TRANSIENT IS 2.43 KSI < $3S_m$ = 51.3 KSI. THEREFORE, THE FINAL PEAK ALTERNATING STRESS INTENSITY RANGE, σ_{ALT}, IS:

$$\sigma_{ALT} = 1/2\, \sigma_{RANGE}^{PEAK} = 1/2\,(3.2) = 1.6 \text{ KSI}$$

THE REMAINDER OF THE EARTHQUAKE CYCLES OCCUR DURING STEADY-STATE CONDITIONS. THEREFORE, AT A TEMPERATURE OF 550°F,

$$E = 25.75 \times 10^6 \text{ PSI} \qquad [\text{REF. \#2}]$$

$S_a = 1.6\,(26/25.75) = 1.62$ KSI

FROM FIG. F-106 (b), REF. #2

N = ALLOWABLE CYCLES = ∞

$U_6 = 0.0$

11.0 TOTAL USAGE FACTOR

$U_T = U_1 + U_2 + U_3 + U_4 + U_5 + U_6$

$U_T = 0.22 + 0.05 + 0.0 + 0.21 + 0.26 + 0.0$

$U_T = 0.74 \leq 1.0$ ALLOWABLE USAGE FACTOR

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GENERAL CALCULATIONS

12.0 References

1. B&W General Functional Specification for Reactor Coolant System, 18-1130823-01, Duke Power Company.
2. Nuclear Power Piping Code, USAS B31.7 - Draft 1968.
3. B&W Computer Code P91167
4. B&W Computer Code P91206
5. B&W Computer Code P91032
6. B&W Doc. "Stress Report for Reactor Coolant Piping", B&W Contract No. 620-0009-50, Design Analysis Report No. 7, "Thermal-Mechanical Analysis of 2½ Sch. 160 Make-up and HPI Nozzle, Microfilm rolls 79-472 and 473.
7. Microfiche AC3IMJU, "Reactor Trip w/HPI Nozzle". (attached)
8. See Reference #1.
9. See Reference #1.
10. JAKOB + Hawkins, "Elements of Heat Transfer, 3rd Edition, Wiley and Sons, Inc. 1957.
11. B&W Computer Code P91232.
12. B&W Drawing No. [illegible]0156, Rev. 7, "Assembly and Detail for 2½" "Pressure Injection Nozzle".
13. B&W Doc., "Stress Report for Reactor Coolant Piping", B&W Contract No. 620-0003-50, Revision 1, Design Analysis Report No. 4, "Piping Reactions", Microfilm roll 79-479.

PREPARED BY [illegible] DATE [illegible]
REVIEWED BY R R Schaefer DATE 8/31/82

DOC NO [illegible]
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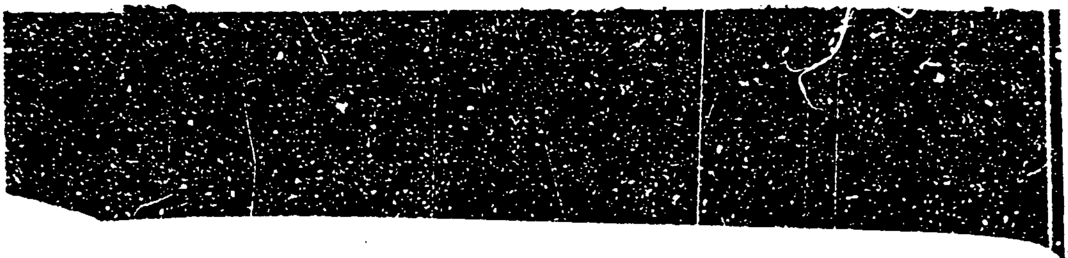
REFERENCE FICHE ACSI[illegible]



RECORD OF REVIEW

ADDENDUM TO CALCULATION PACKAGE 32 - 1128224   02

Serial   Revision

1. Calculation file not reviewed since it is deemed as: ☐ Obsolete ☐ Non-Safety

2. All present source references on calculation file source reference list are acceptable. ☐ Yes

3. Reference provides only assumptive, background, procedural or methods information (i.e., "FOR INFO ONLY")

REF. NO.	INFORMATION TYPE	REF. NO.	INFORMATION TYPE
3,4,5	BACKGROUND		

4. The following reference changed in this calculation file, as indicated:

REF. NO.	CORRECTED REFERENCE INFORMATION
11	ADD: VERSION 1.0

5. The following references require special disposition as indicated:

REF. NO.	METHOD OF DISPOSITION

Preparer of Record of Review (Signature) James G. Tilley   2/15/88
(Name)   Date

Reviewer of Record of Review (Signature) James R. [illegible]   3/2/88
(if item 4 or 5 applied) (Name)   Date

cc: Section Coordinator

Answer to Question 2(a)

Oconee Unit 1
Inspections Associated with 1A1 Discharge Make Up Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.001	1PDA1-47	1A1 HPI Nozzle Safe-End Base Material PC. 47	UT	Clear	Generic Letter 85-20
7	E5.01.002	1PDA1-47	1A1 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear	Generic Letter 85-20
8	B05.051.002A	1PDA1-11	1A1 Nozzle to Safe-End weld	PT	Clear	Section XI
9	E04.001.001	1PDA1-47	1A1 HPI Nozzle Safe-End Base Material PC. 47	UT	Recordable	Generic Letter 85-20
9	E04.001.001A	1PDA1-47	1A1 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear	Generic Letter 85-20
10	B09.032.019	1PDA1-10	1A1 HPI Nozzle to 1A1 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
11	E04.001.001	1PDA1-47	1A1 HPI Nozzle Safe-End Base Material PC. 47	UT	Clear	Generic Letter 85-20
11	E04.001.001A	1PDA1-47	1A1 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear	Generic Letter 85-20
16	B05.140.003	1-PDA1-11	1A1 Nozzle to Safe-End weld	PT	Clear	Section XI

INFORMATION

Mark Hartzman

Extracted from B&W OG submittal on HPI

CM 6/5/97
DRC 6/5/97

Oconee Unit 1

Inspections Associated with 1A2 Discharge Make Up Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.003	1PDA2-47	1A2 HPI Nozzle Safe-End Base Material PC. 47	UT	Clear	Generic Letter 85-20
7	E5.01.004	1PDA2-47	1A2 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear	Generic Letter 85-20
9	E04.001.002	1PDA2-47	1A2 HPI Nozzle Safe-End Base Material PC. 47	UT	Recordable	Generic Letter 85-20
9	E04.001.002A	1PDA2-47	1A2 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear	Generic Letter 85-20
11	B09.032.020	1PDA2-10	1A2 HPI Nozzle to 1A2 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
11	B05.051.005	1PDA2-11	1A2 Nozzle to Safe-End weld	PT	Clear	Section XI
11	E04.001.002	1PDA2-47	1A2 HPI Nozzle Safe-End Base Material	UT	Clear	Generic Letter 85-20
11	E04.001.002A	1PDA2-47	1A2 HPI Nozzle Safe-End Base Material	RT	Clear	Generic Letter 85-20
13	B09.021.060	1-51A-11-85A	Pipe to 1A2 Safe-End weld	PT	Clear	Section XI

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Oconee Unit 1

Inspections Associated with 1B1 Discharge HPI Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.005	1PDB1-47	1B1 HPI Nozzle Safe-End Base Material PC. 47	UT	Clear	Generic Letter 85-20
7	E5.01.006	1PDB1-47	1B1 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear	Generic Letter 85-20
9	E04.001.003	1PDB1-47	1B1 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear	Generic Letter 85-20
11	B09.032.021	1PDB1-10	1B1 HPI Nozzle to 1B1 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
11	E04.001.003	1PDB1-47	1B1 HPI Nozzle Safe-End Base Material	RT	Clear	Generic Letter 85-20
11	E07.001.003	1-51A-11-89	Pipe to 1B1 Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.004	1-51A-11-90	Pipe to Valve 1HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.005	1PDB1-11	1B1 Nozzle to Safe-End weld & 1 inch base metal	UT	Recordable	NRC Bulletin 88-08
13	B09.021.009A	1-51A-11-89	Pipe to 1B1 Safe-End weld	PT	Clear	Section XI
13	B05.051.008	1PDB1-11	1B1 Nozzle to Safe-End weld	PT	Clear	Section XI
13	E07.001.003	1-51A-11-89	Pipe to 1B1 Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
13	E07.001.004	1-51A-11-90	Pipe to Valve 1HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
16	G04.001.003	1-51A-11-89	Pipe to 1B1 Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
16	G04.001.004	1-51A-11-90	Pipe to Valve 1HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

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Oconee Unit 1

Inspections Associated with 1B2 Discharge HPI Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.007	1PDB2-47	1B2 HPI Nozzle Safe-End Base Material PC. 47	UT	Clear	Generic Letter 85-20
7	E5.01.008	1PDB2-47	1B2 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear .8125 gap on nozzle side	Generic Letter 85-20
9	E04.001.004	1PDB2-47	1B2 HPI Nozzle Safe-End Base Material PC. 47	RT	Clear .8125 gap on nozzle side	Generic Letter 85-20
11	E04.001.004	1PDB2-47	1B2 HPI Nozzle Safe-End Base Material	RT	Clear .875 gap on nozzle side	Generic Letter 85-20
11	E07.001.001	1-51A-11-87	Pipe to 1B2 Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.002	1-51A-11-88	Pipe to Valve 1HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.006	1PDB2-11	1B2 Nozzle to Safe-End weld & 1 inch base metal	UT	Recordable	NRC Bulletin 88-08
12	B09.021.008	1-51A-11-87	Pipe to 1B2 Safe-End weld	PT	Clear	Section XI
13	B09.021.009	1-51A-11-88	Pipe to Valve 1HP-152 weld	PT	Clear	Section XI
13	B09.032.022	1PDB2-10	1B2 HPI Nozzle to 1B2 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
13	B05.051.011	1PDB2-11	1B2 Nozzle to Safe-End weld	PT	Clear	Section XI
13	E07.001.001	1-51A-11-87	Pipe to 1B2 Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
13	E07.001.002	1-51A-11-88	Pipe to Valve 1HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

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Oconee Unit 1

Inspections Associated with 1B2 Discharge HPI Nozzle

16	G04.001.001	1-51A-11-87	Pipe to 1B2 Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
16	G04.001.002	1-51A-11-88	Pipe to Valve 1HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

Definitions:
Recordable = Indication seen was a geometric reflector and not a flaw.
Clear = No indications

Note: All of the radiographs for the Generic Letter 85-20 items have been re-reviewed during May of 1997, by the NDE Level III RT Examiner. In those instances where the NDE Level III RT Examiner identified that gaps were present on the original radiographs, the dimension and location is recorded in the Inspection Results column. In all cases where gaps were present, the thermal sleeves were still located in their proper positions. When "Clear" is mentioned and no dimension and location is recorded in the Inspection Results column of this document, this means that there were no recordable or rejectable conditions identified during the original and second reviews of the radiographs.

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Oconee Unit 2
Inspections Associated with 2A1 Discharge Make Up Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
6	E5.001.001	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
6	E5.001.002	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
7	B05.051.002A	2PDA1-11	2A1 Nozzle to Safe-End weld	PT	Clear	Section XI
7	E04.001.001	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
7	E04.001.001A	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
8	E04.001.001	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
8	E04.001.001A	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
9	E04.001.001	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
9	E04.001.001A	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
10	E04.001.001	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
10	E04.001.001A	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
11	B09.021.101	2-51A-39.3-44	Pipe to 2A1 Safe-End weld	PT	Clear	Section XI
15	B05.140.004	2PDA1-11	2A1 Nozzle to Safe-End weld	PT	Clear	Section XI

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ARC 6/5/97

Oconee Unit 2

Inspections Associated with 2A1 Discharge Make Up Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
15	B09.021.040	2-51A-39-46	Pipe to Valve 2HP-127 weld	PT	Clear	Section XI
15	G02.001.001	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
15	G02.001.001A	2PDA1-47	2A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .5" gap on pipe side and 1.25" gap on nozzle side	Generic Letter 85-20

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DRC 6/5/97

Oconee Unit 2

Inspections Associated with 2A2 Discharge Make Up Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
6	E5.001.003	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
6	E5.001.004	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear 1.125" gap on nozzle side	Generic Letter 85-20
8	E04.001.002	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
8	E04.001.002A	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear 1.5" gap on nozzle side	Generic Letter 85-20
10	E04.001.002	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
10	E04.001.002A	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear 1.25" gap on nozzle side	Generic Letter 85-20
12	B05.051.005	2PDA2-11	2A2 Nozzle to Safe-End weld	PT	Clear	Section XI
12	B09.021.108	2-51A-39.3-87A	Pipe to 2A2 Safe-End weld	PT	Clear	Section XI
15	G02.001.002	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
15	G02.001.002A	2PDA2-47	2A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear 1.25" gap on nozzle side	Generic Letter 85-20

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Oconee Unit 2

Inspections Associated with 2B1 Discharge HPI Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
6	E5.001.005	2PDB1-47	2B1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
6	E5.001.006	2PDB1-47	2B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
7	E04.001.003	2PDB1-47	2B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
8	E04.001.003	2PDB1-47	2B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
9	B05.051.008	2PDB1-11	2B1 Nozzle to Safe-End weld	PT	Clear	Section XI
9	E04.001.003	2PDB1-47	2B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .5" gap on pipe side	Generic Letter 85-20
10	B09.032.007	2PDB1-10	2B1 HPI Nozzle to 2B1 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
10	E04.001.003	2PDB1-47	2B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .5" gap on pipe side	Generic Letter 85-20
10	E07.001.001	2-51A-39-90C	Pipe to 2B1 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
10	E07.001.002	2-51A-39-90B	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
10	E07.001.003	2-51A-39-91	Pipe to Valve 2HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
10	E07.001.007	2PDB1-11	2B1 Nozzle to Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	B09.021.114	2-51A-39.3-90C	Pipe to 2B1 Safe-End weld	PT	Clear	Section XI
12	E07.001.001	2-51A-39-90C	Pipe to 2B1 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
12	E07.001.002	2-51A-39-90B	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

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Oconee Unit 2

Inspections Associated with 2B1 Discharge HPI Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
12	E07.001.003	2-51A-39-91	Pipe to Valve 2HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G02.001.003	2PDB1-47	2B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .5" gap on pipe side	Generic Letter 85-20
15	G04.001.001	2-51A-39-90C	Pipe to 2B1 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G04.001.002	2-51A-39-90B	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G04.001.003	2-51A-39-91	Pipe to Valve 2HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

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Oconee Unit 2

Inspections Associated with 2B2 Discharge HPI Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
6	E5.001.007	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
6	E5.001.008	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
8	E04.001.004	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
8	E04.001.004A	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
10	B09.032.008	2PDB2-10	2B2 HPI Nozzle to 2B2 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
10	E04.001.004	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
10	E04.001.004A	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
10	E07.001.004	2-51A-39-92A	Pipe to 2B2 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
10	E07.001.005	2-51A-39-92B	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
10	E07.001.006	2-51A-39-93	Pipe to Valve 2HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
10	E07.001.008	2PDB2-11	2B2 Nozzle to Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	B05.051.011	2PDB2-11	2B2 Nozzle to Safe-End weld	PT	Clear	Section XI
12	B09.021.122	2-51A-39.3-92A	Pipe to 2B2 Safe-End weld	PT	Clear	Section XI
12	E07.001.004	2-51A-39-92A	Pipe to 2B2 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
12	E07.001.005	2-51A-39-92B	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

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Inspections Associated with 2B2 Discharge HPI Nozzle

12	E07.001.006	2-51A-39-93	Pipe to Valve 2HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G02.001.004	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
15	G02.001.004A	2PDB2-47	2B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
15	G04.001.004	2-51A-39-92A	Pipe to 2B2 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G04.001.005	2-51A-39-92B	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G04.001.006	2-51A-39-93	Pipe to Valve 2HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

Definitions:
Recordable = Indication seen was a geometric reflector and not a flaw.
Clear = No indications

Note: All of the radiographs for the Generic Letter 85-20 items have been re-reviewed during May of 1997, by the NDE Level III RT Examiner. In those instances where the NDE Level III RT Examiner identified that gaps were present on the original radiographs, the dimension and location is recorded in the Inspection Results column. In all cases where gaps were present, the thermal sleeves were still located in their proper positions. When "Clear" is mentioned and no dimension and location is recorded in the Inspection Results column of this document, this means that there were no recordable or rejectable conditions identified during the original and second reviews of the radiographs.

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Oconee Unit 3

Inspections Associated with 3A1 Discharge Make Up Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.013	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Recordable	Generic Letter 85-20
7	E5.01.014	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .25" gap on nozzle side	Generic Letter 85-20
8	E04.001.001	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
8	E04.001.001A	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .5625" gap on pipe side and .75" gap on nozzle side	Generic Letter 85-20
9	E04.001.001	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
9	E04.001.001A	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .5625" gap on pipe side and .75" gap on nozzle side	Generic Letter 85-20
10	E04.001.001	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
10	E04.001.001A	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .625" gap on pipe side and 1" gap on nozzle side	Generic Letter 85-20
11	B05.051.002A	3PDA1-11	3A1 Nozzle to Safe-End weld	PT	Clear	Section XI
11	E04.001.001	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
11	E04.001.001A	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .5625" gap on pipe side and .875" gap on nozzle side	Generic Letter 85-20

Oconee Unit 3

Inspections Associated with 3A1 Discharge Make Up Nozzle

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13	B09.021.108	3-51A-63-36	Pipe to Valve 3HP-127 weld	PT	Clear	Section XI
13	B09.021.109	3-51A-63-40	Pipe to 3A1 Safe End weld	PT	Clear	Section XI
16	G02.001.001	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
16	G02.001.001A	3PDA1-47	3A1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear gap visible 100% through expansion area	Generic Letter 85-20

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PRC 6/5/97

Oconee Unit 3

Inspections Associated with 3A2 Discharge Make Up Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.015	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
7	E5.01.016	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
9	E04.001.002	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
9	E04.001.002A	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
10	B05.051.005	3PDA2-11	3A2 Nozzle to Safe-End weld	PT	Clear	Section XI
11	E04.001.002	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
11	E04.001.002A	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
13	B09.021.111	3-51A-64-23A	Pipe to Valve 3HP-126 weld	PT	Clear	Section XI
13	B09.021.112	3-51A-63-24A	Pipe to 3A2 Safe End weld	PT	Clear	Section XI
16	G02.001.002	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
16	G02.001.002A	3PDA2-47	3A2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20

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Oconee Unit 3
Inspections Associated with 3B1 Discharge HPI Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.017	3PDB1-47	3B1 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
7	E5.01.018	3PDB1-47	3B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear 1.125" gap on nozzle side	Generic Letter 85-20
8	E04.001.003	3PDB1-47	3B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .9375" gap on nozzle side	Generic Letter 85-20
9	E04.001.003	3PDB1-47	3B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .750" gap on nozzle side	Generic Letter 85-20
10	B05.051.008	3PDB1-11	3B1 Nozzle to Safe-End weld	PT	Clear	Section XI
10	E04.001.003	3PDB1-47	3B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .625" gap on nozzle side	Generic Letter 85-20
11	E04.001.003	3PDB1-47	3B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .250" gap on nozzle side	Generic Letter 85-20
11	E07.001.001	3-51A-61-43	Pipe to Valve 3HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.002	3-51A-61-43C	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.003	3-51A-61-44A	Pipe to 3B1 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.006	3PDB1-11	3B1 Nozzle to Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
12	B09.021.119	3-51A-61-43	Pipe to Valve 3HP-153 weld	PT	Clear	Section XI
12	B09.021.120	3-51A-61-44A	Pipe to 3B1 Safe End weld	PT	Clear	Section XI
13	B09.032.004	3PDB1-10	3B1 HPI Nozzle to 3B1 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
13	E07.001.001	3-51A-61-43	Pipe to Valve 3HP-153 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

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Inspections Associated with 3B1 Discharge HPI Nozzle

13	E07.001.002	3-51A-61-43C	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
13	E07.001.003	3-51A-61-44A	Pipe to 3B1 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G04.001.003	3-51A-61-44A	Pipe to 3B1 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
16	G02.001.003	3PDB1-47	3B1 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .250" gap on nozzle side	Generic Letter 85-20
16	G04.001.002	3-51A-61-43C	Pipe to Pipe weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

INFORMATION

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Oconee Unit 3

Inspections Associated with 3B2 Discharge HPI Nozzle

Refueling Outage	ISI Plan Item Number	Weld ID from ISI Plan	Configuration	Type of Insp.	Inspection Results	Inspection Requirements
7	E5.01.019	3PDB2-47	3B2 HPI Nozzle Safe-End Base Metal PC.47	UT	Clear	Generic Letter 85-20
7	E5.01.020	3PDB2-47	3B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
8	E04.001.004	3PDB2-47	3B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
9	E04.001.004	3PDB2-47	3B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
10	E04.001.004	3PDB2-47	3B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear .375" gap on nozzle side	Generic Letter 85-20
11	B09.021.124	3-51A-62-26	Pipe to 3B2 Safe End weld	PT	Clear	Section XI
11	E04.001.004	3PDB2-47	3B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
11	E07.001.004	3-51A-62-25	Pipe to Valve 3HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.005	3-51A-62-26	Pipe to 3B2 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
11	E07.001.007	3PDB2-11	3B2 Nozzle to Safe-End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
12	B05.051.011	3PDB2-11	3B2 Nozzle to Safe-End weld	PT	Clear	Section XI
13	B09.032.005	3PDB2-10	3B2 HPI Nozzle to 3B1 RCP Discharge Piping (Branch Weld)	MT	Clear	Section XI
13	E07.001.004	3-51A-62-25	Pipe to Valve 3HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
13	E07.001.005	3-51A-62-26	Pipe to 3B2 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08
15	G04.001.005	3-51A-62-26	Pipe to 3B2 Safe End weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

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Oconee Unit 3
Inspections Associated with 3B2 Discharge HPI Nozzle

16	G02.001.004	3PDB2-47	3B2 HPI Nozzle Safe-End Base Metal PC.47	RT	Clear	Generic Letter 85-20
16	G04.001.004	3-51A-62-25	Pipe to Valve 3HP-152 weld & 1 inch base metal	UT	Clear	NRC Bulletin 88-08

Definitions:
Recordable = Indication seen was a geometric reflector and not a flaw.
Clear = No indications

Note: All of the radiographs for the Generic Letter 85-20 items have been re-reviewed during May of 1997, by the NDE Level III RT Examiner. In those instances where the NDE Level III RT Examiner identified that gaps were present on the original radiographs, the dimension and location is recorded in the Inspection Results column. In all cases where gaps were present, the thermal sleeves were still located in their proper positions. When "Clear" is mentioned and no dimension and location is recorded in the Inspection Results column of this document, this means that there were no recordable or rejectable conditions identified during the original and second reviews of the radiographs.

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