SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT 6201 S Street, Box 15830, Sacramento, California 95813; (916) 452-3211

February 3, 1982

DIRECTOR OF NUCLEAR REACTOR REGULATION
ATTENTION JOHN F STOLZ CHIEF
OPERATING REACTORS BRANCH 4
U S NUCLEAR REGULATORY COMMISSION
WASHINGTON DC 20555

DOCKET 50-312
RANCHO SECO NUCLEAR GENERATING
STATION UNIT NO 1
HIGH PRESSURE INJECTION NOZZLE
CYCLES

On December 11, 1981, the District responded to the Atomic Safety and Licensing Appeal Board's Memorandum and Order, ALAB-655. Since that time, we have had numerous discussions with your staff concerning the allowable number of transient cycles for the high pressure injection nozzles. We have provided the Babcock & Wilcox Company Field Change Package, "HPI Nozzle", Document No. 04-3370-00 FC-0174-00, for your review, and following additional questioning, B&W Calculation Nos. 32-1121811-00, "HPI Nozzle Usage Factor" and 32-1119809-01, "HPI Nozzle Usage Factor". These documents form the basis for including within the total number of allowable reactor trips (400) a specific provision for up to 70 actuations of high pressure injection following such a trip. (These 70 cycles are in addition to the 80 cycles included in the original stress analysis.) As noted on page 4 of Document 32-1121811-00, the original 80 cycles resulted in a usage factor of only .44, which demonstrates the conservation in the analysis. These documents are attached to this letter for your reference.

As discussed in our response to ALAB-655, these analyses do not explicitly address the Appeal Board's question concerning the ultimate number of cycles these nozzles are physically capable of safely withstanding. Our response provided the justification for not responding to this question. We feel, however, that these additional cycles demonstrate that safety limits are not being approached, and that no safety concern exists due to cycle usage at Rancho Seco Unit No. 1. Your staff has requested additional information for their use in reviewing these calculations. The workload within the Babcock & Wilcox Company (due to such factors as the Thermal Shock issue) precludes this information being generated and submitted for your review prior to July 1, 1982.

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This information relates primarily to techniques used in the original Rancho Seco Stress Analysis and we feel this information is irrelevant to the Appeal Board's concern over high pressure injection nozzle usage, but should satisfy your needs in reviewing this change to the Rancho Seco Administrative Procedures. We expect to receive a written request for information from you which will confirm the information to be supplied in July of this year.

John J Mattimoe

John J. Mattimoe
Assistant General Manager
and Chief Engineer

Attachments

cc: Mr. Tom Baxter - Shaw, Pittman, Potts & Trowbridge
Mr. Dave Holt - Babcock & Wilcox Company
Mr. Mark Padovan - Nuclear Regulatory Commission

FUS-21035-4(5/77)

T-143

DOCUMENT SUBMITTAL FORM

O	SMUD 6201 S Street Sacramento, CA 95813	DATE	10/22/80
		B&W CONTRACT NO.	620-0011
		CUST.	SMUD
		CUST. ORDER NO.	GRS95243
		SHEET	1 OF 1
TTN	Mr. R.J. Rodriguez	TYPE DOC	Field Change Package

2 pkgs. ☐ UNDER SEP COVER ☒ ENCLOSED

☐ UNDER SEP COVER ☐ ENCLOSED

EFERENCES

☐ FOR COMMENTS & APPROVAL BY

☐ FOR INFORMATION ONLY

☐ HAS BEEN REVISED AS PER YOUR PREVIOUS COMMENTS OF

☒ FOR FINAL DISTRIBUTION

☐ FURTHER EXPLANATION REQUIRED SEE BELOW OR ATTACHMENTS

DOCUMENT DESCRIPTION

GIN	SUPPLIER/CUSTOMER DOC. NO.	B&W DOC. NO.	PART/ TASK NO.	GRP. NO.	SEQ. NO.	DOC. TITLE
&W		04-3370-00 FC-0174-00	50	01		HPI Nozzle

c: R.P. Oubre'
D.G. Raasch
R.A. Dieterich
J.V. McColligan
L.G. Sweiger
J.T. Janis

DC Holt

D.C. Holt
Engineering Product Manager

FIELD CHANGE AUTHORIZATION FC-0174-00 BABCOCK & WILCOX

CUSTOMER	ORGINATOR	DATE	CONT. NO.	DOC. I.D. FCA NO. REV. NO.
SMUD	K.C. Smith	6-11-80	620-0011	04-3370-00

SUPPLIER	P.A. NO.	PART NO., OR TASK NO.	GROUP NO.	SEQ. NO.
Babcock & Wilcox		50	001	001

TITLE (MAX 30 CHARACTERS)
HPI Nozzle

DESCRIPTION AND JUSTIFICATION OF CHANGE:

It has been reported that the SMUD operators have been starting a second make-up pump following each reactor trip to obtain additional make-up flow. This was done to prevent loss of indicated pressurizer level during the transient. All four of the high pressure injection nozzles have been used for these occurrences and the three nozzles which are not continuously adding make-up flow receive a thermal shock from the cold BWST water.

The contract Functional Specification, CS(F)3-92/NSS-11/0372, defines forty cycles of high pressure injection actuation and forty cycles of high pressure injection testing. At SMUD's present usage rate, 31 cycles, the nozzles would exceed their allowable cycles before the end of their forty-year life.

B&W has performed a HPI nozzle stress analysis evaluation of the actual experienced transients (actual transients are less severe than functional specification transients) to determine their actual fatique life expectancy. In reviewing the SMUD HPI Design Analysis, it was discovered that the original analysis was performed as a generic analysis and the fatique analysis was performed to a later, more restrictive design code. In analyzing the HPI nozzle to the contractual design code, 1968 draft USAS, B31.7 with June 1968 errata, the number of allowable HPI actuations can be approximately doubled. The re-analysis must conform to the requirements of ASME Section XI which now applies to the site and allows the use of earlier codes.

This Field Change Authorization is being written to document the increase in allowable HPI system actuation cycles and therefore no hardware changes are required.

REASON FOR CHANGE:

- ☒ SITE PROBLEM
- ☐ ENGINEERING REQUIREMENT
- ☒ CUSTOMER REQUEST
- ☐ IMPROVEMENT
- ☐ OTHER (SPECIFY) ____

SPR. DOC., ~~XXXXXXXXXXXX~~ 13-11-361-00

TASKS AFFECTED

TASK NO.	TASK TITLE	NO. DOCS	COMPLETED (T.E. SIGN)	DATE
17	RCS Comp.	0	[signature]	[illegible]
50A	RC Pipe-Sys.	Des. 1	K.C. Smith	[illegible]
50	RC Piping	1	[signature]	[illegible]
10	Proj. Engr.	0	[signature]	[illegible]
09	Power Systems & Controls	1	[signature]	[illegible]

CONCUR TO PROCEED	APPROVALS NAME	DATE
KCS	K.C. Smith	10/10/80
RBR	R.B. Reynolds	10/10/80
CJH	C.J. Hudson	10/13/80
CH	[signature]	10/14/80

CUSTOMER/CUSTOMER AGENT DISPOSITION OF FIELD CHANGE:

☐ IMPLEMENTED ☐ NOT IMPLEMENTED

REF. ____

PROJECT MANAGER ____ DATE ____

AUTH. CHARGE NO. | PCA NO.

SHEET 1 OF 10

FIELD CHANGE AUTHORIZATION - AFFECTED DOCUMENTATION

CUSTOMER: SMUD CONTRACT NO. 620-0011 FCA NO. 04-3370 REV. NO. 00

DOCUMENT TITLE	*DOCUMENT NUMBER	DOCUMENT TITLE	*DOCUMENT NUMBER
SPECIFICATION FOR REACTOR COOLANT SYSTEM PIPING	CS(F)3-37/NSS-11/0372 DTD. 3-22-72		
SPECIFICATION FOR REACTOR COOLANT SYSTEM	CS(F)-3-42/NSS-11/0372 DTD. 3-22-72		
STRESS REPORT FOR PRIMARY PIPING (620-0011-50)			

*REVISION LEVEL SAME AS DOCUMENT DELIVERED TO CUSTOMER

PDS-21048A-4(12-76)

FIELD CHANGE AUTHORIZATION-CONTINUATION

☐ EXPEDITE
☒ NORMAL

REFERENCE DOCUMENT TITLE	REF DOCUMENT NO.
Specification for Reactor Coolant System Piping	CS(F)3-37/NSS-11/0372
	SHEET 1 OF 1

DESCRIPTION OF CHANGE:

1. Revise paragraph 1.1 of Appendix 1 of the reference document to read as follows:

   1.1 General Functional Specification for Reactor Coolant System Components, Specification No. CS(F)-3-92/NSS-11/0672 as modified by Field Change Authorization 04-3370-00.

2. Add paragraph 2.2 in Appendix 1 of the reference document to read as follows:

   2.2 ASME Boiler and Pressure Vessel Code

   a. Section XI, Inservice Inspection — 1974 Edition with Summer 1975 Addenda

      The reanalysis of the HPI nozzle is to be in accordance with the requirements of the code listed above.

The changes to the reference document above are certified to be correct and complete and in compliance with the requirements of ASME Boiler and Pressure Vessel Code, Section XI.

Thomas C. Helms PROFESSIONAL ENGINEER

Virginia
STATE

06223
REGISTRATION NO.

10/10/80
DATE

COMMONWEALTH OF VIRGINIA
Thomas C. Helms
06223
PROFESSIONAL ENGINEER

REVISED REQUIREMENTS (CONTINUATION SHEET)		SUPPLIER REVISIONS		TASK NO.	TASK TITLE
PREPARED BY	DATE	REVIEWED BY	DATE	50A	R.C. Pipe - System Designer
REVIEWED BY	DATE			FCA NO.	
M. Lewis	10/10/80			04-3370-00	
APPROVED BY	DATE			SHEET 3 OF 10	

PDS-21048A-4(12-76)

FIELD CHANGE AUTHORIZATION-CONTINUATION

☐ EXPEDITE
☒ NORMAL

REFERENCE DOCUMENT TITLE	REF DOCUMENT NO.
GENERAL FUNCTIONAL SPECIFICATION FOR REACTOR COOLANT SYSTEM	CS(F) 3-92/NSS-11/0672
	SHEET 1 OF 6

DESCRIPTION OF CHANGE:

Change the RCS Functional Specification as per FCA continuation sheets 2 through 6.

The changes to be incorporated in this revision (03) of the Spec include:

1. A revision to Section 6.9, Transient 8 - Reactor Trip. Specifically, paragraphs will be added to Sections 6.9.2 and 6.9.3.1 of the text to provide for manual actuation of the high pressure injection system after a reactor trip.

2. Table 2 will be revised to include 70 design cycles for the above noted change.

3. Figure 8-14 will be added to the spec.

REVISED REQUIREMENTS (CONTINUATION SHEET)		SUPPLIER REVISIONS		TASK NO.	TASK TITLE
PREPARED BY R. B. Park	DATE 8/15/80	REVIEWED BY	DATE	09	POWER SYSTEMS + CONTROLS
REVIEWED BY	DATE			FCA NO. 04-3370-00	
APPROVED BY J. W. Carlton	DATE 8/15/80			SHEET 4 OF 66	

2 in Transient 3 (Plant loading 8% to 100%). These return to power events are included in the 18000 cycles specified for Transient 3.

2) 56 Reactor trip events, followed by cooldown as described in Transient 1B (Cooldown), followed by heatup as described in Transient 1A (heatup) and Transient 3 (Plant Loading). These 56 heatup and cooldown cycles following reactor trip are included in the 240 cycles specified for Transient 1.

Insert indicated addition shown on following page.
RBP
8/15/80

6.9.3 Transient Data

6.9.3.1 Reactor Coolant System

Reactor Coolant System conditions for the reactor trip transients are presented in the following figures:

Type A Reactor Trip - Figures 8-1, 8-1A, 8-2, 8-3
Type B Reactor Trip - Figures 8-4, 8-4A, 8-5, 8-6, 8-10
Type C Reactor Trip - Figures 8-7, 8-7A, 8-8, 8-9

Insert indicated addition shown on following page.
RBP
8/15/80

6.9.3.2 Steam Generators

Steam Generator conditions for the reactor trip transients are presented in Figures 8-11, 8-12, 8-12A and 8-13.

2 6.10 Transient 9 - Rapid Depressurization (Upset Condition)

6.10.1 General Description

Rapid depressurization is a short term, rapid cooling of the Reactor Coolant System by the steam generators in order to reduce the reactor coolant system pressure to a value less than the design pressure (1065 psia) of the steam generators within 15 minutes. The objective of the rapid depressurization is to isolate a tube leak.

2 The initial conditions at the start of the transient are assumed to be hot standby with decay heat removal by the steam generators dumping steam to the condenser. The turbine bypass control pressure is assumed to be 1050 psia. This gives an average reactor coolant system temperature of about 558.7°F.

When average reactor coolant temperature has been reduced to 500°F, and reactor coolant pressure is equal to or less than 1065 psia (15 minutes), normal cooldown as described in Transient 1B is initiated.

6.10.2 Cycles

1 The number of rapid depressurization events for design shall be 40. A complete cycle consists of a) power reduction from 100% power as described in Transient 4 (Plant Unloading); b) Rapid de-

Insert in §6.9.2
RBP
8/15/80

Manual Actuation of High Pressure Injection System After Reactor Trip

Occasionally after a reactor trip, it may be necessary to manually actuate the high pressure injection system in order to obtain additional makeup flow. This should only be done to prevent the loss of indicated pressurizer level during the transient. For the total of 400 reactor trip events, an allowance of 70 cycles of high pressure injection system actuations shall be considered for design purposes.

Insert in §6.9.3.1
RBP
8/15/80

Manual Actuation of High Pressure Injection System After Reactor Trip - Figure 8-14

Table 2

Operating Transient Cycles

	Transient Number	Transient Description (ASME Category)		Design Cycles	Figure Nos.
2	1A	Heatup from 70°F to 8% Full Power (Normal)		240	1A-1 - 1A-1
2	1B	Cooldown from 8% Full Power (Normal)		240	1B-1 - 1B-5
	2	Power change 0 to 15% and 15 to 0% (Normal)		1440	2A-1 - 2A-5 2B-1 - 2B-5
2	3	Power Loading 8% to 100% power (Normal)		18,000	3-1 - 3-5
2	4	Power Unloading 100% to 8% power (Normal)		18,000	4-1 - 4-5
	5	10% Step Load Increase (Normal)		8,000	5-1 - 5-4
	6	10% Step Load Decrease (Normal)		8,000	6-1 - 6-5
	7	Step Load Reduction (100% to 8% Power)(Upset)			
		Resulting from turbine trip	160		7-1 - 7-5
		Resulting from electrical load rejection	150		
		Total		310	
	8	Reactor Trip (Upset)			
		Type A	40		8-1 - 8-13
		Type B	160		
		Type C	88		
		Trips included in transient numbers 11, 15 16, 17 & 21	112		
		Total *		400	
		* MANUAL ACTUATION OF HIGH PRESSURE INJECTION SYSTEM AFTER REACTOR TRIP		70	8-14
1	9	Rapid Depressurization (Upset)		40	[illegible]
	10	Change of Flow (Upset)		20	10-1 -10-5
	11	Rod Withdrawal Accident (Upset)		40	11-1 -11-4
2	12	Hydrotests (Test)		35	
	13	Steady-State Power Variations (Normal)		∞	13-1
	14	Control Rod Drop (Upset)		40	14-1 -14-4
	15	Loss of Station Power (Upset)		40	15-1 -15-7
	16	Steam Line Failure (Faulted)		1	16-1 -16-3
	17A	Loss of Feedwater to One Steam Generator (Upset)		20	17A-1 - 17A-
	17B	Stuck Open Turbine Bypass Valve (Emergency)		10	17B-1 - 17B-

RBP
8/15/80

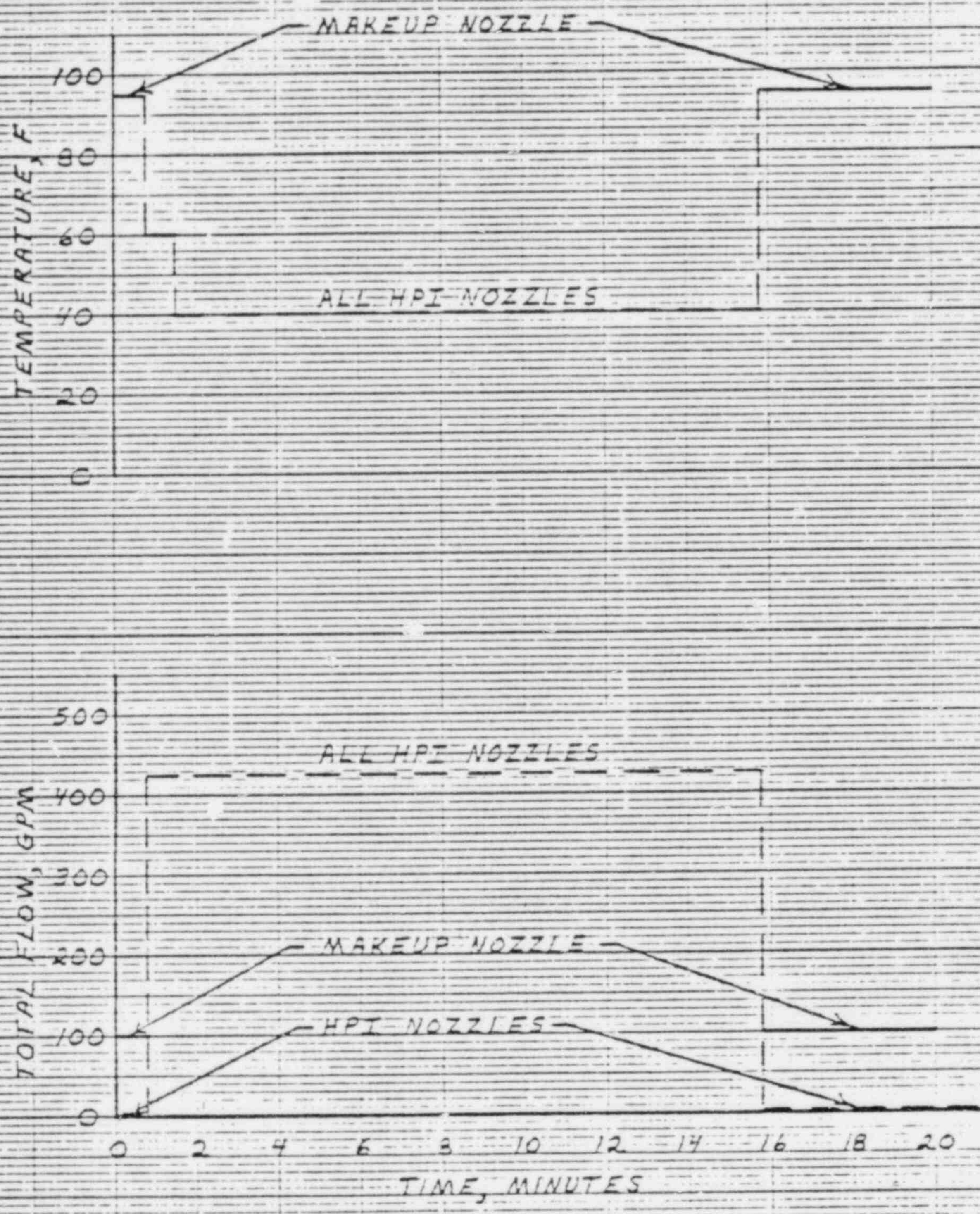

FIGURE 8-14

TRANSIENT NO. 8 (REACTOR TRIP)
MAKEUP FLOW AND TEMPERATURE - MANUAL
ACTUATION OF HIGH PRESSURE INJECTION SYSTEM

SPECIFICATION NO.
CS(F)3-92/NSS-11/0672

PDS-21048A-4(12-76)

FIELD CHANGE AUTHORIZATION-CONTINUATION

☐ EXPEDITE
☒ NORMAL

REFERENCE DOCUMENT TITLE	REF DOCUMENT NO.
STRESS REPORT FOR PRIMARY PIPING (620-0011-50)	NONE
	SHEET 1 OF 1

DESCRIPTION OF CHANGE:

The following documents are added as addenda to the original stress report:

32-1119809-01 HPI Nozzle Usage Factor

32-1121811-00 HPI Nozzle Usage Factor

I certify that the two (2) above mentioned analysis when taken as a whole justify the modifications to be made under the authority of FCA No. 04-3370-00 and that these two (2) analysis when considered as a whole meet the requirements imposed by the applicable Equipment Specification, as modified by FCA No. 04-3370-00. Attested to this date: October 10, 1980

COMMONWEALTH OF VIRGINIA
GEORGE J. VAMES
CERTIFICATE NO.
7507
CERTIFIED PROFESSIONAL ENGINEER

G J Vames

George J. Vames
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Engineers

REVISED REQUIREMENTS (CONTINUATION SHEET)	SUPPLIER REVISIONS	TASK NO.	TASK TITLE
PREPARED BY: R R Schaefer DATE: 10/9/80	REVIEWED BY: R B Reynolds DATE: 10/10/80	50	Reactor Coolant Piping
REVIEWED BY: G. J. Vames DATE: 10-10-80	R C Reims 10/10/80	FCA NO. 04-3370-00	
APPROVED BY: Gerald R Barber DATE: 10-10-80		SHEET 1/? OF 1?	

CONTRACT/STANDARD NO. 620-0011	DOCUMENT RELEASE NOTICE (DRN)
RELEASE DATE OCT 13 1980 / PAGE 1 of 1	

PART-MARK/TASK-GROUP-SEQ.	B&W DOCUMENT NO.	DOCUMENT TITLE	PUL STAT.	RRL.NO.
50/001/001	32-1121811-00	HPI NOZZLE USAGE FACTOR	~	~

FILE COPY

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RELEASED BY
RRSchaefer 10/9/80
NAME DATE

REVIEWED BY
A.D. McKim 10/9/80
NAME DATE

CALCULATION DATA/TRANSMITTAL SHEET

DOCUMENT IDENTIFIER CALC. 32 - 1121811 - 00

TRANS. 86 - -

TYPE: ___RESEARCH & DEVELOPMENT ___SAFETY ANALYSIS REPORT ___NUC. SERV. INPUT ___DESIGN RQMT. X DESIGN VERIF. ___OTHER

TITLE HPI Nozzle Usage Factor

PREPARED BY R R Schaefer REVIEWED BY Alvin D. McKim

TITLE Senior Engineer DATE 10/9/80 TITLE Supervisory Engineer DATE 10/9/80

PURPOSE:

To determine if the HPI nozzle can withstand 70 HPI actuations following a reactor trip condition. These will be in addition to the 40 rapid depressurization and 40 test transient cycles specified in the contract functional specification CS(F)3-92/NSS-11/0372.

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

The HPI Nozzle can withstand 40 test transient cycles, 40 rapid depressurization transients and 70 reactor trip transients as described in FCA 04-3370-00.

DISTRIBUTION

21036 (2-71)

BABCOCK & WILCOX
GENERAL CALCULATIONS

32	1121811	00
DOC I.D.	SERIAL NUMBER	REV

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CUSTOMER		PROP NO	FILE NO
PROJECT		DWG NO	COMP NO
CONT NO 620.00		GROUP NO	
CALC BY RLS	DATE 8/27/80		SHEET NO 2 of 18
CHKD BY GGM	DATE 10/3/80		

PURPOSE

The purpose of this calculation is to amend CDS 32-1119809-00, Ref (1). Ref (1) justified an additional 70 cycles of rapid depressurization transient. This calculation will justify 70 cycles of HPI actuation following a reactor trip instead of 70 additional rapid depressurization transient cycles was done in Ref (1).

DISCUSSION

CDS 32-1119809-00, Ref. (1), determined the maximum allowable number of rapid depressurization transient cycles. This calculation was based upon the assumption that FCA 04-3370-00 would characterize the 70 additional HPI transients as required by SPR #13-11-361-00, Ref. (5) as rapid depressurization transients.

When FCA 04-3370-00 was issued the additional 70 HPI transients were assumed to follow a reactor trip transient. Thus, this calculation will show that the HPI can withstand 70 cycles of HPI Actuation following a reactor trip transient instead of 70 additional rapid depressurization cycles as shown in Ref. (1).

RESULTS

MAXIMUM PRIMARY + SECONDARY STRESS INTENSITY RANGE

$S = 128.9$ KSI $> 3S_m$ (PG. 5, REF [1])

THEREFORE AN ELASTIC-PLASTIC FATIGUE ANALYSIS WAS PERFORMED.

USAGE FACTOR = 0.441 < 1.0 FOR 40 TEST TRANSIENTS AND 40 RAPID DEPRESSURIZATION TRANSIENTS. (PG. 5, REF. [1])

USAGE FACTOR = 0.26 FOR 70 HPI ACTUATIONS FOLLOWING A REACTOR TRIP TYPE TRANSIENT.

TOTAL CUMMULATIVE USAGE FACTOR IS;

$U_T = 0.44 + 0.26 = 0.70 < 1.0$
(PG. 16)

CONCLUSION

THE HPI NOZZLE CAN WITHSTAND 40 TEST TRANSIENT AND 40 RAPID DEPRESSURIZATION TRANSIENT CYCLES. IN ADDITION THE HPI NOZZLE CAN WITHSTAND 70 ADDITIONAL CYCLES OF HPI ACTUATION FOLLOWING A REACTOR TRIP TRANSIENT AS DESCRIBED IN REF. [7].

THERMAL PARAMETERS

PAGE 4-2 OF REF [2] GIVES THE FILM COEFFICIENT VALUES USED IN THE ANALYSIS FOR THE RAPID DEPRESSURAZATION TRANSIENT. THIS FILM COEFFICIENT CALC. ASSUMED A FLOW RATE OF 425 GPM THROUGH EACH NOZZLE. THE ACTUAL FLOW IS 425 GPM TOTAL FLOW SPLIT EQUALLY BETWEEN ALL 4 HPI NOZZLES. THUS, THE FILM COEFFICIENT SHOULD HAVE BEEN;

IN BRANCH (PER PG. 4-2, REF. [2]

FOR 60°F WATER

$C_p = 1.$ $\rho = 62.34\ LB/FT^3$ $\mu = 2.71$
$K = 0.344$ $D = 0.177\ FT$ $A = 0.0246\ FT^2$

$$hD^{0.2} = 0.023K\left(G/\mu\right)^{0.8}\left(C_p\mu/K\right)^{0.4}$$

$$G = \frac{(425\ GPM/4)\left(60\ \frac{MIN}{HR}\right)\left(0.1337\ \frac{FT^3}{GAL}\right)\left(62.34\ \frac{LB}{FT^3}\right)}{0.0246\ FT^2}$$

$G = 2159948\ LB/FT^2\text{-}HR$

$$hD^{0.2} = 0.023\left[\frac{2159948}{2.71}\right]^{0.8}\left[\frac{(1.0)(2.71)}{0.344}\right]^{0.4}(0.344)$$

$hD^{0.2} = 950.8$

$h = 1345\ BTU/HR\text{-}FT^2\text{-}°F$

$h = 4100\ BTU/HR\text{-}FT^2\text{-}°F$ (USED IN REF'S. [1 & 2]

THE FILM COEFFICIENT USED IN REFERENCES [1 & 2] FOR THE TEST TRANSIENT IS 1300 BTU/HR-FT²-°F. BOTH OF THESE TRANSIENTS INITIATE AT 550°F.

FROM PAGE 4-11, REF. [2], ITERS 3, 6 & 8 EACH OCCUR IN THE FIRST TEN SECONDS. FROM PAGE 6 OF REF. [1] THE MAXIMUM STRESS INTENSITY OCCURS AT ITERATION 8 WHICH HAS A TIME POINT EQUAL TO 5.7 SECONDS. THUS, THE MAXIMUM STRESS INTENSITY AT THE NOZZLE END FOR THE TEST TRANSIENT IS FULLY DEVELOPED BEFORE THE TRANSIENT ENDS.

THUS, THE STRESS INTENSITY CALCULATED FOR THE TEST TRANSIENT INITIATION IS ESSENTIALLY WHAT THE ACTUAL RAPID DEPRESSURIZATION TRANSIENT SHOULD HAVE BEEN. THE ONLY SIGNIFICANT DIFFERENCE BETWEEN THE TWO TRANSIENTS IS THE RETURN TO POWER AND TEMPERATURE. THIS PORTION OF THE ANALYZED RAPID DEPRESSURIZATION TRANSIENT IS CORRECT.

HOWEVER, FOR THE PURPOSES OF THIS CALCULATION, THE TEST TRANSIENT CYCLES (40 CYCLES) AND THE RAPID DEPRESSURIZATION TRANSIENT CYCLES (40) WILL BE JUSTIFIED BY CDS-32-1119809-00. THEY HAVE A CUMMULATIVE USAGE FACTOR OF, U=0.441, AS SHOWN ON PAGE 23 OF REF. [1].

PDS 21036 (2-73)

BABCOCK & WILCOX
GENERAL CALCULATIONS

32 DOC I.D. | 1121811 SERIAL NUMBER | 00 REV

THE ADDITIONAL 70 CYCLES OF HPI ACTUATION FOLLOWING A REACTOR TRIP WILL BE JUSTIFIED BY ADJUSTING THE STRESS INTENSITY RANGES DISCUSSED FOR THE TEST AND RAPID DEPRESSURIZATION TRANSIENTS PREVIOUSLY. CALCULATIONS AND DATA ARE PRESENTED ON THE FOLLOWING PAGES FOR EACH TRANSIENT JUSTIFICATION.

CUSTOMER	PROP NO / FILE NO
SUBJECT	DWG NO / COMP NO
CONT NO 620.00	GROUP NO
CALC BY RRS DATE 1/ /80	SHEET NO 7 of 18
[illegible] DATE [illegible]/80	

TABLE OF REACTOR TRIP CONDITIONS
(PER REF. 3)

TRANSIENT	HIGHEST TEMP	INITIAL TEMP. AT 45 SEC	RETURN TEMP	PRESSURE AT 45 SEC	RETURN PRESSURE
8A	570	550	550	2200	2150
8B	575	550	550	1850	2200
8C	590	575	565	2200	2200
11	592	585	540	2300	1800
15	575	550	550	2200	2150
16	575	560	560		
17A	577	565	550	2100	1850
17B	565	565	560	2450	2200
21	575	575	300	1600	0

FROM THE ABOVE TABLE, TRANSIENT 11 EXHIBITS THE HIGHEST INITIAL TEMPERATURE AND PRESSURE. THE HIGHEST RETURN TEMPERATURE IS 565. THE JUSTIFICATION WILL CONSERVATIVELY USE THE MAXIMUM VALUES.

TO JUSTIFY THE ANALYSIS OF THE 70 CYCLES FOR THE HIGHER STARTING TEMPERATURE, THREE ANALOGOUS THERMAL STRESS RUNS WERE MADE. B&W COMPUTER PROGRAM F91232 WAS USED. USING THIS SLAB TEMPERATURE PROGRAM, THE HPI RAPID DEPRESSURIZATION AND TEST TRANSIENTS WERE ANALYZED AS TO THEIR EFFECT ON THE NOZZLE END THERMAL STRESS WITHOUT DISCONTINUITY EFFECTS. THE RESULTS OF THIS ANALYSIS ARE CONTAINED ON REF FICHE SHAFØ3Z AND ARE TABULATED BELOW.

CASE	INITIAL TEMP	ΔT (T-60)	FILM COEFF.	ΔT RATIO (1)	LINEAR THERMAL STRESS	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 = $\Delta T / \Delta T_1$ = $\Delta T / 490$

(2) STRESS RATIO = $S_{2 \text{ OR } 3} / S_1$

OR = $S_{5 \text{ OR } 6} / S_4$

FDS 21036 (2-73)

BABCOCK & WILCOX
GENERAL CALCULATIONS

32
DOC I D | SERIAL NUMBER | REV

TO JUSTIFY THE ANALYSIS OF THE 70 CYCLES FOR A HIGHER RETURN TEMPERATURE, THE FOLLOWING RESULTS FROM P91232 ARE TABULATED. THESE RESULTS ARE FROM REF. FICHE SHAFØGZ.

CASE	RETURN TEMP	ΔT (T-40)	FILM COEFF.	$\Delta T^{(1)}$ RATIO	LINEAR THERMAL STRESS	STRESS[1] RATIO
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

FROM THE TABULATIONS ON PAGE 6 AND ABOVE, THERE IS SUFFICIENT JUSTIFICATION FOR USING A ΔT RATIO METHOD TO JUSTIFY THE DIFFERING TEMPERATURE FROM SPR #13-11-361-00 VERSUS THE RAPID DEPRESSURIZATION TRANSIENT ANALYZED. IN ORDER TO CALCULATE A STRESS INTENSITY RANGE FOR THE REACTOR TRIP FOLLOWED BY HPI ACTUATION, THE FOLLOWING METHOD WILL BE USED.

THERMAL GRADIENT STRESSES FROM PAGE 6 OF REF. [1] WILL BE MULTIPLIED BY THE RATIO, 1.07. PRESSURE STRESS WILL APPROPRIATELY ADJUSTED.

CUSTOMER	PROP NO / FILE NO
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BABCOCK & WILCOX
GENERAL CALCULATIONS

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THERMAL DISCONTINUITY

THE THERMAL DISCONTINUITY EFFECTS WILL ALSO BE LOWER WITH THE LOWER FILM COEFFICIENTS BEING USED. THE AXIAL ΔT WOULD BE SMALLER. SINCE, THE LONGITUDINAL AND HOOP STRESSES ARE ADDITIVE, AS LONG AS THE LINEAR RADIAL GRADIENT STRESSES ARE LESS, THE DISCONTINUITY STRESSES WILL BE LESS.

CUSTOMER
SUBJECT
CONT NO 620.00
CALC BY RFS DATE 10/9/80
PROP NO
DWO NO
GROUP NO
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GENERAL CALCULATIONS

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PRIMARY PLUS SECONDARY STRESS (INSIDE)

USING TEMPERATURES AND PRESSURE FROM PAGE 6 AND STRESS FOR ITER 8.

PRESSURE STRESS = (4.84 KSI)(2300 PSI/2200 PSI)
= 5.06 KSI (INSIDE)

THERMAL EXPANSION = 5.1 KSI (INSIDE)

THERMAL STRESS = 78.8 (1.07) = 84.32 KSI

TOTAL STRESS = 5.06 + 5.1 + 84.32 = 94.48 KSI

ITERATION 6333 (MAXIMUM THERMAL STRESS)

PRESSURE STRESS = (1.54 KSI)(1800 PSI / 700 PSI)
= 3.96 KSI (INSIDE)

THERMAL EXPANSION = 5.1 KSI (INSIDE)

THERMAL STRESS = (-7.7 KSI)(565/500)
= -8.7 KSI (INSIDE)

TOTAL STRESS = 3.96 + 5.1 - 8.7 = 0.36 KSI

MAXIMUM PRIMARY + SECONDARY STRESS INTENSITY RANGE

σ_{P+S} = 94.48 + 20.3E = 94.48 + 20.0 = 114.48 KSI

114.48 KSI > $3S_m$ = 51.2 KSI

CUSTOMER | PROP NO | FILE NO
SUBJECT | DWG NO | COMP NO
CONT NO 620.00 | GROUP NO

CALC BY RRS DATE 8/27/80 SHEET NO 12 of 18

[illegible] 10/2/80

PDS-21036 (2-73)

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PRIMARY PLUS SECONDARY STRESS (OUTSIDE)

ITER 8

PRESSURE STRESS = 1.32 (2300/2200) = 1.38 KSI

THERMAL EXPANSION = 7.3 KSI

THERMAL GRADIENT STRESS = -71.9 (1.07) = -76.93 KSI

TOTAL STRESS = -68.3 KSI

ITER 6338

PRESSURE STRESS = 0.42 (1800/700) = 1.08 KSI

THERMAL EXPANSION = 7.3 KSI

THERMAL GRADIENT STRESS = 7.0 (565/500) = 7.91 KSI

TOTAL STRESS = 1.08 + 7.30 + 7.91 = 16.3 KSI

MAXIMUM P+S STRESS INTENSITY RANGE

$\sigma_{P+S} = -68.3 + 16.3 + 28.1 = 112.7$ KSI

CUSTOMER
SUB
CONT NO 620.00
CALC BY RRS DATE 10/8/80
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32 DOC I.D. | 1121811 SERIAL NUMBER | 00 REV

PEAK STRESS INTENSITY (INSIDE)

ITER 8 (STRESS FROM PG. 12 OF REV 00)

$\sigma = 5.5(2300/2200) + 6.5 + 113.3(1.07)$

$\sigma = 133.48$ KSI (INSIDE)

ITER 6338

$\sigma = 1.8(1800/700) + 6.5 - 9.6(565/500)$

$\sigma = -0.3$ KSI (INSIDE)

TOTAL STRESS INTENSITY RANGE

$S_{L-R} = 133.48 + 0.3 = 133.8$ KSI

$\sigma_{PEAK}^{RANGE} = 133.8 \text{ KSI} + 2 OBE = 133.8 + 25.5$

$= 159.3$ KSI

NOTE: OBE STRESS INTENSITY RANGES WERE ALSO ADDED TO THE ANALYSIS OF 70 ADDITIONAL CYCLES. THIS PROVIDES ADDITIONAL CONSERVATISM TO THE ANALYSIS.

CUSTOMER | PROP NO | FILE NO
SUBJECT | DWG NO | COMP NO
CONT NO 620.00 | GROUP NO
CALC BY RRS DATE 8/27/80 SHEET NO 14 of 18
CHKD BY [illegible] 10/3/80

ELASTIC - PLASTIC ANALYSIS FOR THE 70 ADDITIONAL HPI TRANSIENTS

FOLLOWING THE PROCEDURE OF REF [5], PARAGRAPH F-105.2.7, THE FINAL PEAK ALTERNATING STRESS INTENSITY, σ_{ALT}, IS:

$$\sigma_{ALT} = \tfrac{1}{2} K_f K_\varepsilon S_{rij}^{(n)}$$

$$K_f = K_t + A(K_t - 1)$$

$$K_t = \sigma_{PEAK} / \sigma_{P+S} = 159.3 / 114.5 = 1.39$$

$$A = 0.7 \quad (\text{PG } 17, \text{REF. } [1])$$

$$K_f = 1.39 + 0.7(1.39 - 1.0) = 1.65$$

K_ε IS FROM FIG. F-105(a), REF. [5]

$$\frac{S_n}{3S_m} = \frac{114.5}{51.3} = 2.23$$

$$|Q_m| = \left| \frac{(94.48 + 10.0) + (-68.3 + 10.0)}{2} - \frac{(0.36 - 10.0) + (16.3 - 1\ldots}{2} \right.$$

$$|Q_m| = 23.09 - (-1.67) = 24.76 \text{ KSI}$$

$$Q_b = (104.48 - 23.09) - [-9.64 - (-1.67)]$$

$$Q_b = 81.39 + 7.97 = 89.36 \text{ KSI}$$

$$\frac{Q_m}{Q_m + Q_b} = \frac{24.76}{24.76 + 89.36} \doteq 0.22$$

$$\therefore K_\varepsilon = 1.75$$

$\sigma_{ALT} = \frac{1}{2}(1.65)(1.75)(114.48) = 165.3$ KSI

ALLOWABLE CYCLES = 270 {PER REF. [5] FIG. F-106(b)}

$U_A = 70/270 = 0.26$

CUMMULATIVE USAGE FACTOR (U_{TOTAL})

USAGE FACTOR FOR ALL HPI TRANSIENTS EXCEPT THE 70 ADDITIONAL CYCLES IS 0.441 PER PAGE 23, REF. [1]. THEREFORE, THE TOTAL USAGE FACTOR FOR HPI NOZZLE CONSIDERING THE 70 ADDITIONAL HPI CYCLES DESCRIBED IN REF. [7] IS;

$U_{TOTAL} = 0.441 + 0.26 = \underline{\underline{0.70}}$

$= 0.70 < 1.0$

∴ ACCEPTABLE

FDS.21036 (2.73)

BABCOCK & WILCOX
GENERAL CALCULATIONS

32 DOC I.D. 1121811 SERIAL NUMBER

REFERENCES

1. CDS 32-1119809-00, "HPI NOZZLE USAGE FACTOR."
2. REACTOR COOLANT PRIMARY PIPING STRESS REPORT, B&W CONTRACT NO. 620-0011-50, DESIGN REPORT NO. 5, "HPI NOZZLE ANALYSIS."
3. REACTOR COOLANT SYSTEM FUNCTIONAL SPECIFICATION CS(F)3-92/NSS-11/0672.
4. SPR #13-11-361-00, B&W CONTRACT NO. 620-0011.
5. USAS B31.7 DRAFT EDITION, DATED FEBRUARY 1968 WITH JUNE 1968 ERRATA.
6. B&W COMPUTER PROGRAM P91232, VERSION 1.0, "ONE DIMENSIONAL IMPLIC TRANSIENT TEMPERATURE DISTRIBUTION.
7. FCA NO. 04-3370-00, B&W CONTR 620-0011-50.
8. MICROFICHE, SHAFDGZ, SCHAEFER RR, 8/27/80. (ATTACHED)

CUSTOMER	PROP NO	FILE NO
SUBJECT	DWG NO	COMP NO
CONT NO 620.00	GROUP NO	
CALC BY RRS DATE 10/6/82		SHEET NO 1

21036 (2-73)

32 DOC I.D. — 1121811 SERIAL NUMBER — 00 REV

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GENERAL CALCULATIONS

<u>REFERENCES</u> (ATTACHED)

FICHE SNAFØGZ, DATED 8/27/80.

CUSTOMER	PROP NO — FILE NO
SUBJECT	DWG NO — COMP NO
CONT NO 620.00	GROUP NO
CALC BY RRS — DATE 8/27/80	SHEET NO 13

BWNP-20032A-4 (10-78)

CONTRACT/STANDARD NO.	DOCUMENT RELEASE NOTICE (DRN)
620-0011	
RELEASE DATE: OCT 13 1980	PAGE 1 OF 1

PART-MARK/TASK-GROUP-SEQ.	B&W DOCUMENT NO.	DOCUMENT TITLE	PUL STAT.	RRL. NO.
50/001/001	32-1119509-01	HPI NOZZLE USAGE FACTOR	~	~

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A. D. McKim 10/9/80
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CALCULATION DATA/TRANSMITTAL SHEET

DOCUMENT IDENTIFIER CALC. 32 - 1119809 - 01

TRANS. 86 - ______ - ____

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

TITLE HPI Nozzle Usage Factor

PREPARED BY R.R. Schaefer REVIEWED BY Alvin D. McKim

TITLE Senior Engineer DATE 10/9/80 TITLE Supervisory Engineer DATE 10/9/80

PURPOSE:

This calculation is being revised to show that it is not the controlling stress document for SPR #13-11-361-00 anymore.

This document is now amended by CDS #32-1121811 -00

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

See CDS-32-1121811-00 and CDS-32-1119809-00.

DISTRIBUTION

TABLE OF CONTENTS

CUSTOMER SMUD	PROP NO	CONT NO 620-0011
SUBJECT HPI USAGE FACTOR (NOZZLE)	DWG NO	FILE NO
	COMP NO 50	GROUP NO
CALC BY ADM DATE 6/1/85 CHK'D BY RB DATE 6/24/85		SHEET NO 2 of 25

PURPOSE & INTRODUCTION

B&W Site Problem Report # 13-11-361-00 described a problem at SMUD where the operators have been starting a second makeup pump following each reactor trip to obtain additional make up flow to prevent loss of indicated pressure level during the transient. All four of the HPI nozzles have been used for these occurrences, and the three nozzle which do not have continuous makeup flow to the system receive a thermal shock from the cold BWST water. The B&W Reactor System Functional Specification defines the operational events for the HPI nozzles which include 40 cycles of HPI actuations and 40 cycles of HPI testing. At the current rate of usage, SMUD will exceed their allowable lifetime cycles before the end of the 40 year life.

The purpose of this document is to calculate the fatigue usage factor for the SMUD HPI nozzles utilizing the contractual elastic-plastic fatigue analysis in reference #1. This analysis method is not as restrictive as the method utilized in the Stress Report, reference # 3. With the present usage rate at SMUD, it is important to eliminate the Stress Report conservatisms and justify the maximum number of allowable cycles the HPI nozzles can withstand in an attempt to justify the nozzle for their lifetime cycles.

CONCLUSION & RESULTS

MAXIMUM PRIMARY + SECONDARY STRESS RANGE = 128.9 ksi $> 3\ S_m$; therefore an elastic-plastic fatigue analysis was performed.

Usage Factor = 0.441 < 1.0 for 40 test transients and 40 rapid depressurization transient

Maximum number of rapid depressurization cycles is 110 in conjunction with 40 test transient cycles.

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GENERAL CALCULATIONS

32-1119809 01

PRIMARY + SECONDARY STRESS INTENSITIES
SEGMENT # 8 (L-R INTENSITY)

Iteration	Pressure (psi)	Pressure Stress (ksi)		Thermal Expansion Stress (ksi)		Stress Report Thermal Stress (ksi)		Total Stress Intensity (ksi)	
		Ins.	Out.	Inside	Outside	Inside	Outside	Inside	Outside
3	2200	4.84	1.32	5.1	7.3	63.7	-58.2	73.64	-49.58
6	2200	4.84	1.32	5.1	7.3	77.5	-70.8	87.44	-62.18
8	2200	4.84	1.32	5.1	7.3	78.8	-71.9	88.74	-63.28
15	2200	4.84	1.32	5.1	7.3	69.3	-63.0	79.24	-54.38
30	2200	4.84	1.32	5.1	7.3	7.7	-6.9	17.64	1.72
1211	2200	4.84	1.32	5.1	7.3	-0.4	0.3	9.54	8.92
1491	2200	4.84	1.32	5.1	7.3	0.0	0.0	9.94	8.62
42021	2200	4.84	1.32	5.1	7.3	0.0	0.0	9.94	8.62
27967	2200	4.84	1.32	5.1	7.3	-0.7	0.6	9.24	9.22
5072	2200	4.84	1.32	5.1	7.3	86.0	-78.3	95.94	-69.68
5060	2200	4.84	1.32	5.1	7.3	73.1	-66.8	83.04	-58.18
5063	2200	4.84	1.32	5.1	7.3	97.9	-89.3	107.84	-80.68
5124	2100	4.62	1.26	5.1	7.3	33.0	-29.7	42.72	-21.14
5237	1800	3.96	1.08	5.1	7.3	11.5	-10.4	20.56	-2.02
6059	1000	2.2	0.6	5.1	7.3	0.4	-0.4	7.7	7.50
6307	800	1.76	0.48	5.1	7.3	0.4	0.4	7.26	8.18
6338	700	1.54	0.42	5.1	7.3	-7.7	7.0	-1.06	14.72
6850	600	1.32	0.36	5.1	7.3	-3.5	3.1	2.92	10.76
2×OBE	0.0	0.0	0.0	0.0	0.0	± 0.0	± 0.0	± 19.9	± 28.1
OBE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	± 10.0	± 14.0

See the following sheet for references and table explaination.

CUSTOMER SMUD
SUBJECT HPI NOZZLE USAGE FACTOR
CALC BY ADM DATE 6/2/80 CHK'D BY RB DATE 6/24/80
PROP NO
DWG NO
COMP NO 50
CONT NO 620-0
FILE NO
GROUP NO
SHEET NO 6

TABLE REFERENCES AND EXPLAINATIONS

- Pressure stresses are obtained by multiplying the pressure stresses from reference # 3, page 5-17 (Iteration #1) by the ratio of actual pressure / 1000 psi (pressure used in reference #3).

- Thermal expansion stresses are from reference #3, page 1-6 for section 2.

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

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

- 2x OBE stresses are from reference #3, page 1-6 for section 2. This is the stress state range for a cold earthquake

- Hot earthquake stresses and cycles will be applied and analyzed for in the primary + secondary and peak stress intensity ranges sheets in this document. OBE stresses are from reference #3, page 1-6. OBE stresses = OBE + Thermal - Thermal.

- A graph of the L-R inside intensities is shown on sheet 8 to aid in determining ranges for maximum and minimum intensity values.

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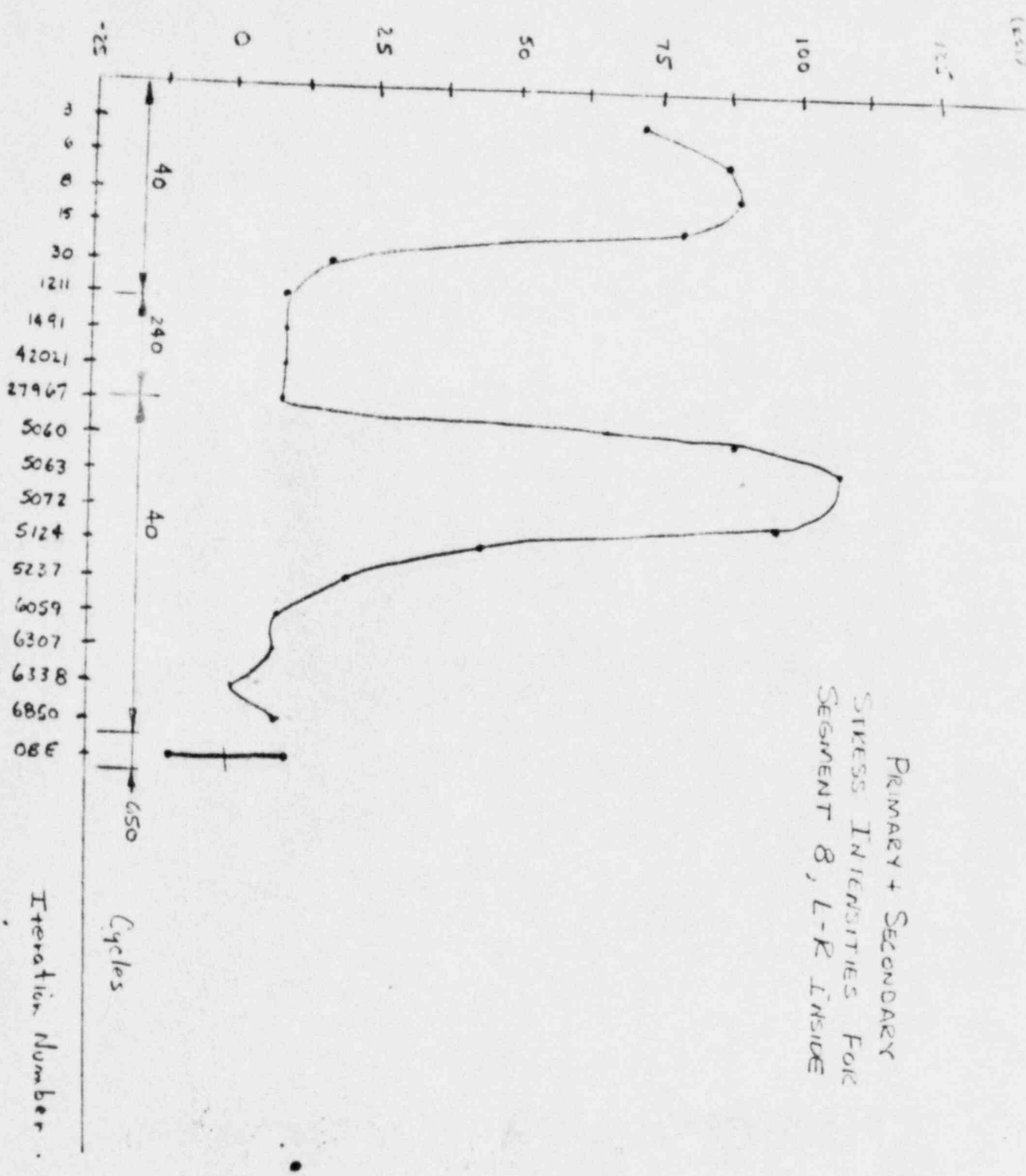
GENERAL CALCULATIONS

32-1119809 00



CUSTOMER SMUD		PROP NO	CONT NO
SUBJECT		DWG NO	FILE NO
		COMP NO	GROUP NO
CALC BY AJM DATE 6/2/80	CHK'D BY RS DATE 6/24/80		SHEET NO 8 of

Determination Of The Number Of Stress Cycles The Primary + Secondary Stress Intensity Range Exceeds $3S_m$

The primary + secondary stress intensity range limit per reference #1, paragraph F-104.4, is $3S_m$. The $3S_m$ value at the critical location, segment #8, is 51.3 ksi which is exceeded for a number of stress intensity cycles. Since the $3S_m$ limit is exceeded, an elastic-plastic fatigue analysis must be performed in accordance with reference #1, paragraph F-105.2.7. This fatigue method is valid only if the number of cycles that exceed $3S_m$ are less than 250. The number of cycles that exceed $3S_m$ are determined on sheets 10 and 11.

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GENERAL CALCULATIONS 32-1119809 0Ø1

MAXIMUM PRIMARY + SECONDARY STRESS INTENSITY RANGE

Range is comprised of |(Iteration 6338 + $\overset{-\text{Sign}}{\text{OBE}}$)| + (Iteration 5063 + $\overset{+\text{Sign}}{\text{OBE}}$) and can occur for 40 cycles.

$$\sigma_{Range}^{Pri+Sec} = 1.06 + 10.0 + 107.84 + 10.0 = 128.9 \text{ ksi} > 3S_m$$

2nd MAXIMUM PRIMARY + SECONDARY STRESS INTENSITY RANGE

Range is comprised of |0 stress state + $\overset{-\text{Sign}}{\text{OBE}}$| + (Iteration 8 + $\overset{+\text{Sign}}{\text{OBE}}$) and can occur for 40 cycles

$$\sigma_{Range}^{Pri+Sec} = 0 + 10.0 + 88.74 + 10.0 = 108.74 \text{ ksi} > 3S_m$$

3rd MAXIMUM PRIMARY + SECONDARY STRESS INTENSITY RANGE

Range is comprised of |0 stress state + $\overset{-\text{Sign}}{\text{OBE}}$| + (Iteration ~~4~~2021 + $\overset{+\text{Sign}}{\text{OBE}}$) and can occur for 40 cycles

$$\sigma_{Range}^{Pri+Sec} = 0 + 10.0 + 9.94 + 10.0 = 39.94 \text{ ksi} > 3S_m$$

CUSTOMER SMUD		PROP NO	CONT NO 620-0C
SUBJECT HPI NOZZLE USAGE FACTOR		DWG NO	FILE NO
		COMP NO 50	GROUP NO
CALC BY HM DATE 6/2/80	CHK'D BY RB DATE 6/24/80		SHEET NO 10 of

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GENERAL CALCULATIONS

32-1119309 00

Remaining stress intensity ranges are less than $3S_m$.

Total number of cycles in which the primary + secondary stress intensity range exceeds $3S_m$ is 80; therefore, the elastic-plastic fatigue analysis is valid.

CUSTOMER SMUD		PROP NO	CONT NO 620-0011
SUBJECT HPI NOZZLE USAGE FACTOR		DWG NO	FILE NO
		COMP NO 50	GROUP NO
CALC BY AFM DATE 6/19/80	CHK'D BY RB DATE 6/24/80		SHEET NO 11 of 25

Peak Stress Intensities Segment
#8 L-R Inside

Iteration	Pressure Psi	Pressure Stress Ksi	Thermal Exp. J (ksi)	Stress Rpt. Trem J (ksi)	Total Stress (ksi)
3	2200	5.5	6.5	109.0	121.0
6	2200	5.5	6.5	115.0	127.0
8	2200	5.5	6.5	113.3	125.3
15	2200	5.5	6.5	95.0	107.0
30	2200	5.5	6.5	8.7	20.7
1211	2200	5.5	6.5	-0.4	11.6
1491	2200	5.5	6.5	0.0	12.0
42021	2200	5.5	6.5	0.0	12.0
[illegible]7967	2200	5.5	6.5	-0.8	11.2
5072	2200	5.5	6.5	117.3	129.3
5060	2200	5.5	6.5	147.4	159.4
[illegible]063	2200	5.5	6.5	143.3	155.3
[illegible]124	2100	5.3	6.5	39.9	51.7
9237	1800	4.5	6.5	14.2	25.2
[illegible]059	1000	2.5	6.5	0.5	9.5
6307	800	2.0	6.5	0.5	9.0
6338	700	1.8	6.5	-9.6	-1.3
6850	600	1.5	6.5	-1.3	6.7
2 x OBE	0.0	0.0	0.0	0.0	25.5
OBE	0.0	0.0	0.0	0.0	±12.7

See the following sheet for references and table explainations.

CUSTOMER SMUD		PROP NO	CONT NO 620-0011
SUBJECT HPI NOZZLE USAGE FACTOR		DWG NO	FILE NO
		COMP NO 50	GROUP NO
CALC BY RDM DATE 6/17/[illegible]	CHK'D BY KB DATE 6/24/80		SHEET NO 12 of 25

TABLE REFERENCES AND EXPLAINATIONS

- Pressure stresses are obtained by multiplying the peak pressure from reference # 3, page 5-17 (Iteration #1) by the ratio of actual pressure divided by 1000 psi (pressure used in reference #3)
- Thermal expansion stresses are from reference #3, page 1-6 for section 2 multiplied time the bending stress concentration factor from reference #3, page 1-10.
- Stress Report thermal stresses are from ref. #3, page 5-17.
- The cross sectional position that experiences positive thermal expansion stresses is used to maximize the critical inside intensity.
- 2×OBE stresses are from reference #3, page 1-6 for section 2 multipied times the bending stress concentration factor from reference #3, page 1-10. This is the range for a cold earthquake.
- A graph of the L-R inside peak stress intensities is shown on the following sheet to aid in determining ranges for maximum and minimum intensity values.

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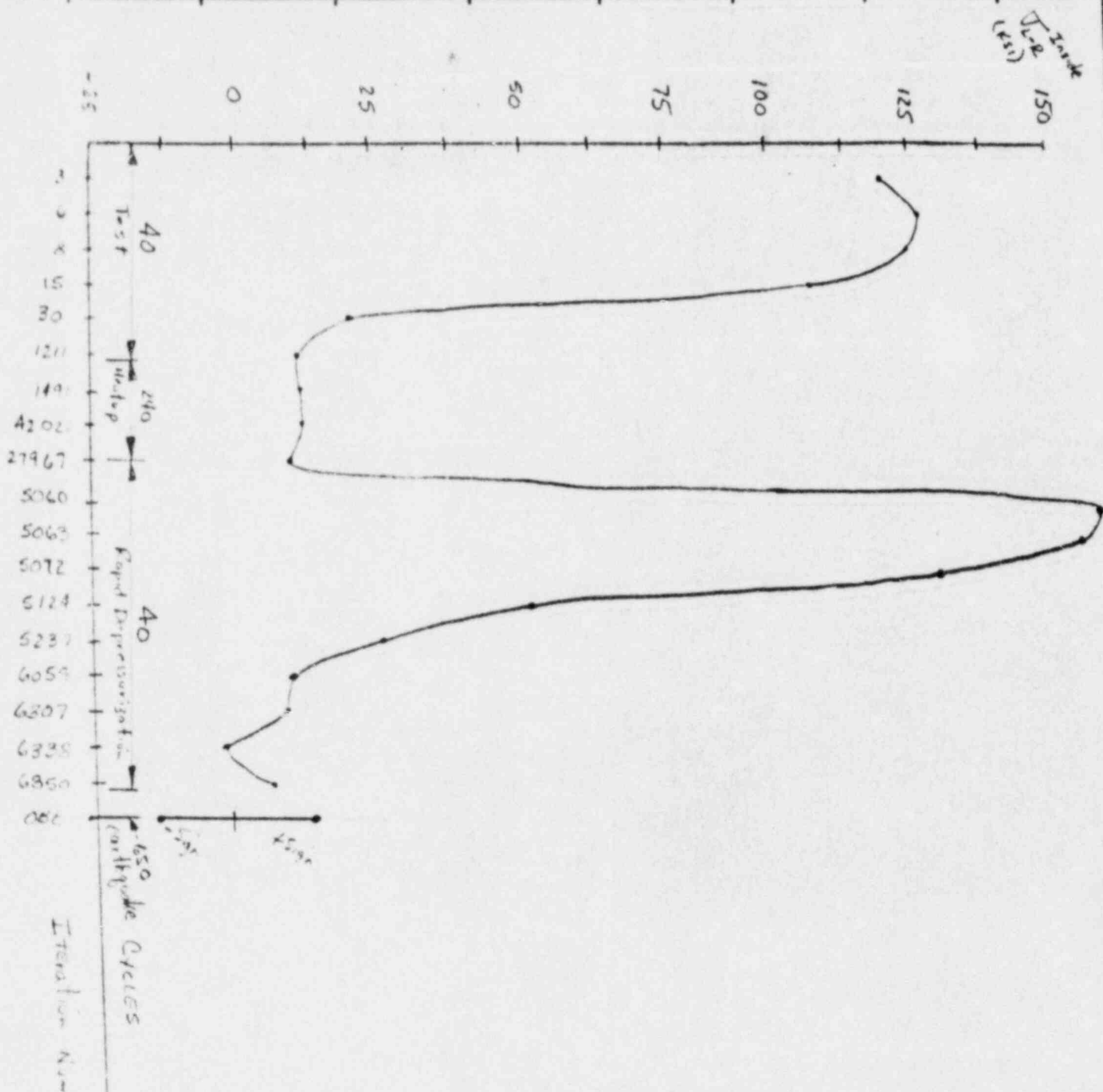
GENERAL CALCULATIONS



CUSTOMER SMUD		PROP NO	CONT NO
SUBJECT		DWG NO	FILE NO
		COMP NO	GROUP NO
CALC BY	DATE 6/2/80	CHK'D BY RB DATE 6/24/80	SHEET NO 14 of 25

FATIGUE ANALYSIS

The fatigue analysis is performed in accordance with paragraph F-105.2.7 of reference# 1, "Simplified Elastic-Plastic Discontinuity Analysis". The primary plus secondary stress intensity ranges determined on sheets 10 and 11 shows that the primary plus secondary ranges do not exceed $3S_m$ for more than 250 cycles; therefore, this method of fatigue evaluation is validated.

The peak stress intensities and cycles are presented in graphic form on sheet 14. This is used to determine maximum peak stress intensity ranges and cycles used in the usage factor calculations. Actual peak stress stress intensity value can be obtained from the tabulation on sheet 12. Primary plus secondary intensities are also used in the fatigue analysis:

These values are obtained from the tabulation on sheet 6.

MAXIMUM PEAK STRESS INTENSITY RANGE

Range is comprised of (Iteration 5060 + $\overset{+\text{sign}}{\text{OBE}}$) + (Iteration 6338 + $\overset{-\text{sign}}{\text{OBE}}$) and can occur for 40 cycles.

$$\sigma_{peak}^{range} = 159.4 + 1.3 + 25.5 = 186.2 \text{ ksi}$$

The primary + secondary range associated with these transients = 128.9 ksi > $3S_m$ = 51.3 ksi (see sht. 10, 2×OBE + iterations 6338 and 5063); therefore, an elastic plastic analysis must be performed for these 40 cycles. Following the procedure of reference #1, paragraph F-105.2.7, the final Peak Alternating Stress Intensity, σ_{alt}, is:

$$\therefore \sigma_{alt} = 1/2 \; K_f \; K_E \; S_{rij}^{(n)}$$

GENERAL CALCULATIONS

where: $K_f = K_t + A(K_t - 1)$

$$K_t = \frac{S_{rij}^{(p)}}{S_{rij}^{(n)}} = \frac{\text{Peak Stress Intensity Range}}{\text{Primary + Secondary Intensity Range}}$$

$$= 186.2/128.9 = 1.44$$

A = 0.7 for Stainless Steel, from Figure D-201, reference #1

$\therefore K_f = 1.44 + 0.7(1.44 - 1.0) = 1.798$

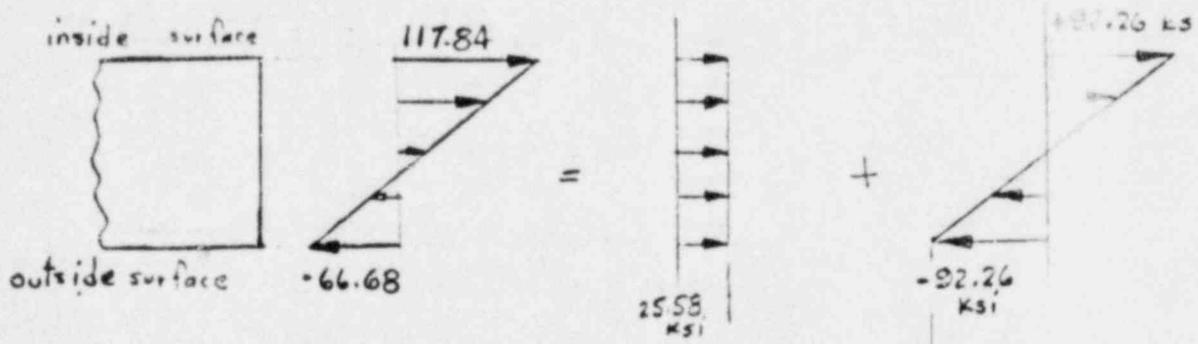
K_E is determined from Figure F-115(a). Below is the calculation of the parameters necessary to obtain K_E:

$$\frac{S_n}{3S_m} = \frac{\text{Primary + Secondary Intensity Range}}{3S_m}$$

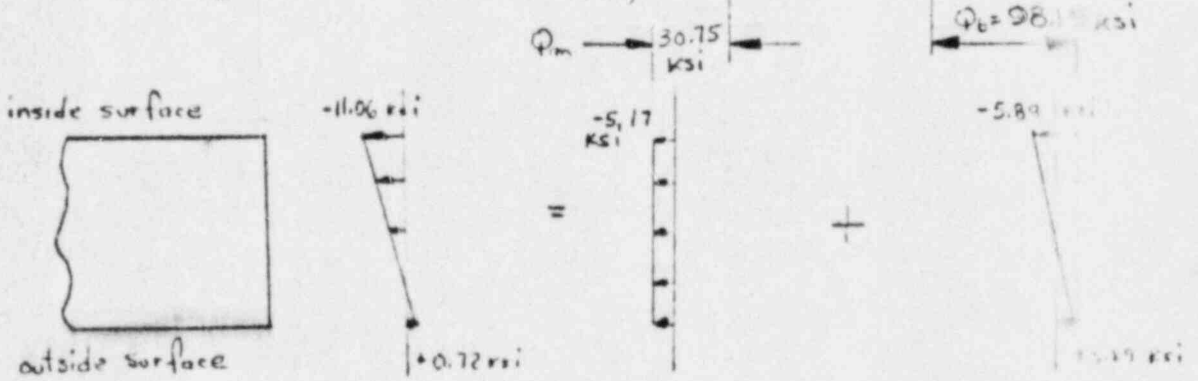
$$\frac{S_n}{3S_m} = 128.9/51.3 = 2.51$$

$|Q_m| / [|Q_m| + |Q_b|]$ is determined on the next sheet.

(condition 1a = Iteration 5063 + $\overset{+\text{sign}}{\text{OBE}}$)



(condition 1b = Iteration 6338 $\overset{-\text{sign}}{\text{OBE}}$)



$$\frac{Q_m}{Q_m + Q_b} = \frac{30.75}{30.75 + 98.15} = 0.239$$

$\therefore K_e = 1.95$ from Fi[illegible] F-105[illegible] reference 1

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$\sigma_{alt} = 1/2\, K_f\, K_e\, S_{rij}^{(n)}$

$\sigma_{alt} = (1/2)(1.748)(1.95)(128.9) = 220.0$ ksi

Allowable cycles = 130 from reference #1, Figure I-106(b)

Usage Factor = $U_1 = 40/130 = 0.308$

2nd MAXIMUM PEAK STRESS INTENSITY RANGE

Range is comprised of (Iteration 6 + $\overset{+\text{sign}}{\text{OBE}}$) + |(0 stress + $\overset{-\text{sign}}{\text{OBE}}$)| and can occur for 40 cycles.

$\sigma_{peak}^{range} = (12.7 + 12.7) + |(0 - 12.7)| = 152.4$ ksi

The primary + secondary range associated with these transients = $(88.74 + 10) + |(0 - 10.0)| = 108.74^*$ ksi $> 3S_m = 51.3$ ksi ; therefore, an elastic-plastic analysis must be performed for these 40 cycles. Following

* Iteration 8 + OBE + 0 stress state + OBE (see sheet 6)

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the procedure of reference #1, paragraph F-105.2.7, the final Peak Alternating Stress intensity, σ_{alt}, is :

$$\sigma_{alt} = \tfrac{1}{2} K_f K_\epsilon S_{rij}^{(n)}$$

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

$$K_t = \frac{S_{rij}^{(p)}}{S_{rij}^{(n)}} = \frac{\text{Peak Stress Intensity Range}}{\text{Primary + Secondary Intensity Range}}$$

$$= 152.4/108.74 = 1.40$$

A = 0.7 for Stainless Steel, from Figure D-201, reference #1

$$\therefore K_f = 1.40 + 0.7(1.40 - 1.0) = 1.68$$

K_ϵ is determined from Figure F-105(a). Below is the calculation of the parameter necessary to obtain K_ϵ:

$$S_n/3S_m = \frac{\text{Primary + Secondary Intensity Range}}{3S_m}$$

$$S_n/3S_m = 108.74/51.3 = 2.12$$

$|Q_m| / [|Q_m| + |Q_b|]$ is determined on the next sheet.

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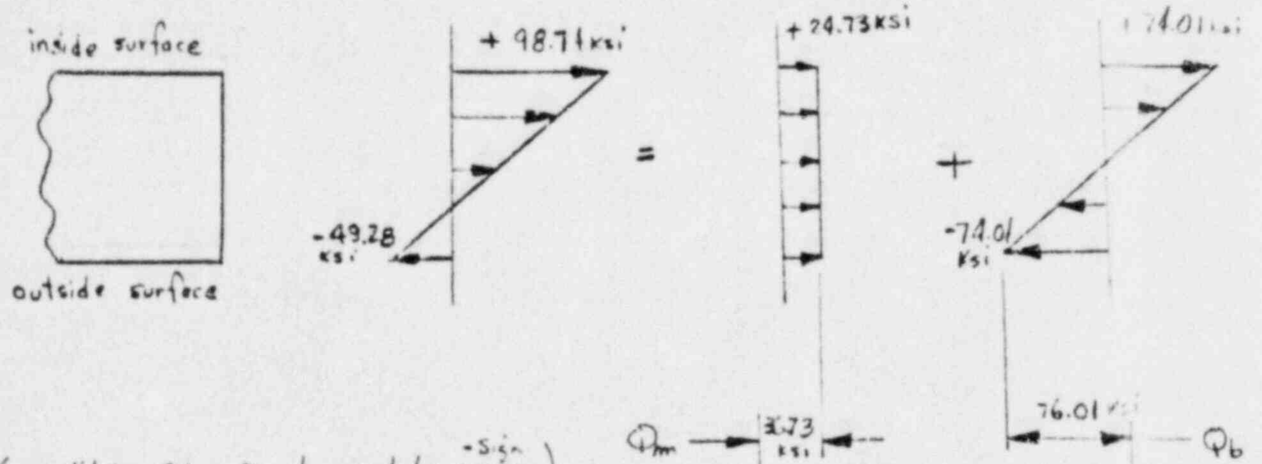
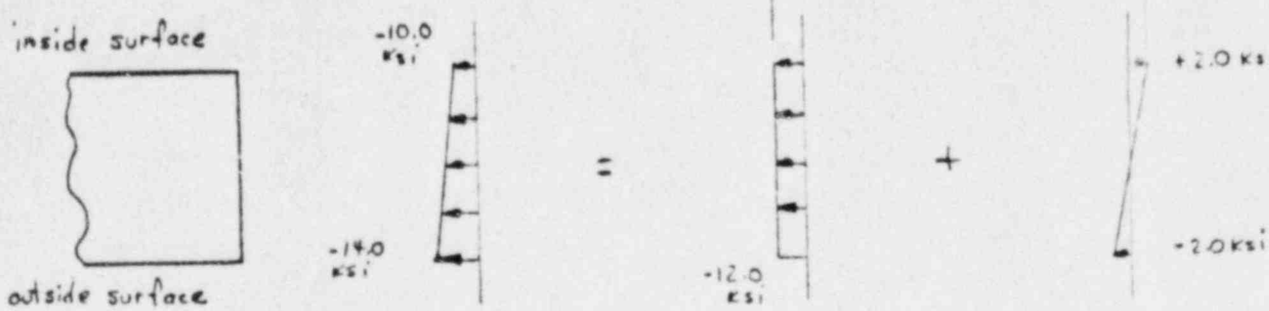
(Condition 2a – Iteration 8 + $\overset{+Sign}{OBE}$)



(condition 2b - 0 stress state $\overset{-Sign}{+OBE}$)



$$\frac{Q_m}{Q_m + Q_b} = \frac{36.73}{36.73 + 74.01} = 0.33$$

$\therefore K_\epsilon = 1.7$ from figure F-105(a) reference #1

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GENERAL CALCULATIONS

$\sigma_{alt} = \frac{1}{2} K_f K_E S_{rij}^{(n)}$

$\sigma_{alt} = \frac{1}{2}(1.68)(1.7)(108.74) = 155.3$ ksi

Allowable cycles = 300 from reference#1, Figure F-106(b)

Usage Factor = $U_2 = 40/300 = 0.133$

3rd MAXIMUM PEAK STRESS INTENSITY RANGE

Range is comprised of (Iteration 27967 $\overset{+\text{sign}}{+\text{OBE}}$) + |(0 stress state + $\overset{-\text{sign}}{\text{OBE}}$)| and can occur for 240 cycles.

$\sigma_{peak}^{range} = (11.2 + 12.7) + |(0 - 12.7)| = 36.6$ ksi

The primary + secondary range associated with these iterations = $(9.24 + 10.0) + |(0 - 10.0)| = 29.24$ ksi $< 3S_m = 51.4$ ksi ; therefore, the final Peak Alternating Stress Intensity Range, σ_{alt}, is:

$\therefore \sigma_{alt} = \sigma_{peak}^{range} / 2.0 = 36.6/2 = 18.3$ ksi

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Allowable cycles = ∞

Usage Factor = U_3 = $240/\infty$ = 0.0

4^{th} MAXIMUM PEAK STRESS RANGE

This range is comprised of ± OBE and can occur for the remainder of the earthquake cycles = 650 - 40 - 40 - 240 = 330. The peak stress range is less than case 3 range which resulted in an usage factor of 0.0; therefore, $U_4 = 0.0$

Cummulative Usage Factor = U_{TOTAL}

$$U_{TOTAL} = U_1 + U_2 + U_3 + U_4 = 0.308 + 0.133 + 0.0 + \text{[illegible]}$$

$$U_{TOTAL} = 0.441 < 1.0$$, Acceptable

DETERMINE OF ALLOWABLE RAPID DEPRESSURIZATION CYCLES ASSUMING 40 CYCLES OF TEST TRANSIENT

The usage factor for 40 cycles of test transient = 0.133 (see sheet 22, U_2)

The remaining usage factor available for rapid depressurization transient cycles = 1.0 - 0.133 = 0.867

Each rapid depressurization transient cycle results in an usage factor contribution of 1/130 = 0.0077 (see sheet 19)

Therefore, the allowable rapid depressurization transient cycles, X, is:

$$0.867 = X\,(0.0077)$$

$$X = 112\ ,\ \text{say } 110$$

DS 21036 (2-73)

BABCOCK & WILCOX
GENERAL CALCULATIONS

32-1119809 0/1

DOC I D | SERIAL NUMBER | REV

REFERENCES

1.) USAS B31.7 Draft Edition dated February 1968 with June 1968 errata.

2.) 1971 ASME Section III

3.) Design Report #5 - Thermal Mechanical Analysis of 2 ½" Sch 160 Make-up and High Pressure Injection Nozzle for Sacramento Util. District - 620-0011-50, Design Report revision #1 dated 1-15-73.

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