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GENERAL ELECTRIC COMPANY
CLAMP INDUCED STRESS ON HOPE CREEK
RECIRCULATION PIPING
JULY 27, 1984

DESIGN MEMO #170-107

PREPARED BY: C. A. Farrell, Engineer
Plant Piping Analysis I

REVIEWED BY: M. Zaliznyak, Engineer
Plant Piping Analysis I

APPROVED BY: J. L. Thompson, Manager
Plant Piping Analysis I

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1.0 BACKGROUND

ASME III requires that the effects of attachment in producing thermal stresses, stress concentration and restraints on pressure retaining members shall be taken into account in checking for compliance with stress criteria. (NB-3645)

Attachments to piping are generally categorized as integral attachments and non-integral attachments. Lugs and stanchions welded to the pipe wall are examples of integral attachments. Clamps used for attaching hangers and snubbers to the pipe by bolting are non-integral attachments.

The design reports prepared by General Electric specifically address local stresses at integral attachments (lugs) if the loads on the lug are significant. Rules for evaluating local stress at lugs have been defined by ASME Code cases N-?2 and N318. GE computer programs evaluate local stress at lugs in a manner consistent with these Code cases.

In November of 1983, the Nuclear Regulatory Committee issued IE information Notice 83-80: Use of Specialized "Stiff" Pipe Clamps, (Appendix B). The information notice identified three concerns with stiff pipe clamps: excessive bolt preload induced stresses in the pipe, small clamp contact bearing areas that could induce local overstress and the effect of clamp on elbow stress indices. Although no response was required from the notice, the issue was raised in question 210.53 of the Hope Creek final safety analysis report. The response to the question committed to evaluate the affect of stiff clamps on the piping.

2.0 PURPOSE

This analysis evaluates the stresses induced by E-System clamps attached to the recirculation piping in General Electric's scope of supply.

3.0 DISCUSSION

The Code does not have rules for the evaluation of non-integral attachments; however, methods consistent with the intent of the Code have been developed to address the concerns of Information Notice 83-80 and the Code.

3.1 Primary Membrane Stresses

The existence of a pipe clamp will not affect the calculation for minimum wall, in fact, membrane stresses in the circumferential direction due to pressure will be less in the vicinity of the clamp than in the areas away from the clamp. The primary membrane stress is less than that of straight pipe due to clamp reinforcement of effective thickness.

3.2 Primary Membrane Plus Primary Bending Stresses

Equation 9 is aimed at preventing collapse of the piping system due to loads that produce primary stresses. Collapse is prevented by keeping the stresses due to pressure, dead weight, and inertia effects of dynamic loads to less than prescribed values. The existence of clamps on piping systems do not adversely affect the moment carrying capability nor do they reduce the ability of the piping system to resist collapse under combined loadings that produce primary stresses.

The only concern is the loading transmitted from the snubber through the clamp pad to the pipe. This bearing load will result in local stress in the pipe wall. These stresses are conservatively calculated using the indice method and added to the membrane and overall bending stresses computed by equation 9 of the Code.

3.3 Stresses Due to Preload

When the clamp is initially installed on the piping system and the bolts are tightened, the preload will produce stress in the pipe wall. The stress produced by preload is applied one time and produces a stress of only one quarter cycle. Stresses of this type need not be included in the stress evaluations required by NB-3600. Although bolt preloads are not addressed under the Code, bolt preloads could result in damage to a pipe if a clamp was poorly designed. Calculations have been made to ensure that bolt preloads could not result in local plastic deformation of the piping.

3.4 Clamp Design Criteria

The stiff type clamps were designed to provide a high strength attachment for the pipe which would not slip and would fit on the smallest practical length of pipe. Clamp design of the strap type are too wide to fit in many locations and require lugs to hold them in position. The stiffness of a compact high strength clamp is inherently greater than that of a strap type. General Electric specifications require that all clamps be significantly stiffer than the snubber attached to it. The stiffness requirement does not govern the design of stiff type clamps.

3.5 Protection from Loosening

In order for the clamp to hold its position during vibratory loads, it must grip the pipe with enough force to prevent sliding. The two mechanisms for clamp loosening are loss of tension in the bolt due to nut backing off and bolt stress relaxation. To prevent backing off of the nuts, all bolts have double nuts. The bolt material selected for the clamp is an A490 type commonly used for flange bolts. This material was selected because at the temperatures of concern, it is resistent to relaxation.

3.6 Stress Due to Contraint of Expansion from Internal Pressure

Clamp induced stresses caused by the constraint of pipe expansion due to internal pressure have been added to other operating secondary and peak stresses by calculating special C_1 and K_1 indices for the clamp.

3.7 Stress Due to Constraint of Differential Thermal Expansion

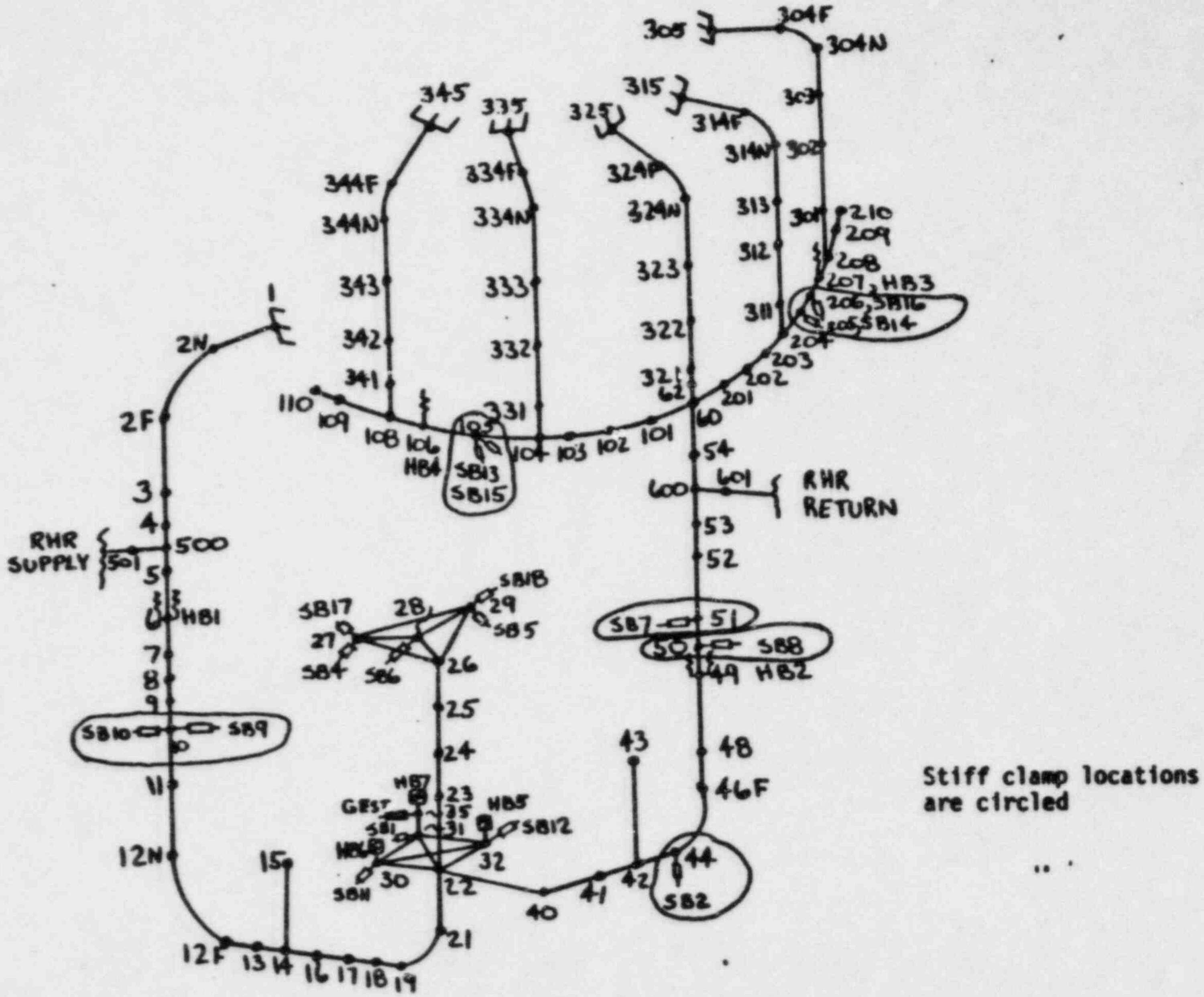
Clamp induced stresses due to differential temperatures and material expansion coefficients have been accounted for by computing special C_3 and K_3 indices for the clamp. The stresses have been added to other operating secondary and peak stresses.

3.8 Fatigue Usage

The fatigue usage at each clamp location has been conservatively computed taking into consideration clamp induced stresses from pressure, temperature and snubber loadings. The clamp induced stresses were added to the stresses computed for each load set using equation 10 and 11 of NB-3650. Cumulative fatigue usage was computed by the rules of the Code.

3.9 Clamps on Elbows

Some clamps are located on or near the ends of elbows because of lack of space. Clamp loadings on elbows due to snubbers, internal pressure and differential expansion are similar to or less than those on straight pipe. The major difference between a clamp on straight pipe and on an elbow is the couping between the pipe bending and the clamp loads due to elbow ovalization. The clamp tends to resist ovalization by stiffening the pipe wall. This local stiffening results in three effects: a slight stiffening of the elbow in bending, a slight reduction in overall elbow bending stress and a local stress concentration at the clamp pad. The first two effects are small and can be neglected in a stress analysis. The local stress concentration at the clamp pad is caused by the pad preventing the local region of elbow under it from assuming the ovalization curvature. This local resistance to curvature causes the stress concentration by crimping the pipe wall. Bending indices C_2 and K_2 for elbows with clamps have been calculated to account for this secondary stress concentration effect.



HOPE CREEK RECIRCULATION LOOP B NODE DIAGRAM

Figure A.1

Table A.2
Clamp Assembly Properties
Hope Creek Recirculation Loop B

Clamp Rating (kips)	E-System Clamp Assembly Dwg.#	Clamp U-Bolt	Preload Torque (1) (ft-lb)	Pipe O.D. (in)	Pipe Nominal Wall Thickness (in)	SNB #	Node #	Location
50	157792, Rev. B	1¼-8UN-2A	85	28.0	1.201	SB9	010	Suction Riser
50	157792, Rev. B	1¼-8UN-2A	85	28.0	1.201	SB10	010	Suction Riser
50	157794, Rev. C	1¼-8UN-2A	85	28.0	1.410	SB2	044	Discharge LR Elbow
50	157792, Rev. B	1¼-8UN-2A	85	28.0	1.410	SB8	050	Discharge Riser
70	157793, Rev. C	1¼-8UN-2A	105	28.0	1.410	SB7	051	Discharge Riser
30/30(2)	157795, Rev. B	1-8UNC-2A	70	22.0	1.134	SB13/SB15	105	Recirc Header
30	157796, Rev. C	1-8UNC-2A	70	22.0	1.134	SB14	205	Recirc Header
30	157796, Rev. C	1-8UNC-2A	70	22.0	1.134	SB16	206	Recirc Header

1 - E-Systems Snubber and Accessories Installation Drawing 152943, Rev. B

2 - Clamp consists of double yoke connected by four tie-bolts.
Used to attach two 30K snubbers.

HOPE CREEK RECIRC B

THE LOADING COMBINATION USED FOR THE ANALYSIS ** 1*** ARE AS FOLLOW

```
DESIGN  1    PD + WT1    +  OBE1
LEVL B  1    PP + WT1    +  OBE1
LEVL C  1    PP + WT1
LEVL D  1    PP + WT1    +  SQRT((SSE1   )**2   + ( AP1    )**2   )
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NOTE ALL UNITS ARE IN POUNDS, INCHES EXCEPT NOTED

NOTE IF NO USER INPUT PRESSURE FOR EACH LOAD COMBINATION, PEAK PRESSURE WILL BE USED FOR LEVEL B,C AND D

Table A.3

GENERAL ELECTRIC COMPANY
BOILING WATER REACTOR SYSTEMS DEPARTMENT

SPEC NO. 22A REV. NO.

HOPE CREEK RECIRC B   SUCTION NOZZLE TO PUMP   NEAR NODE 010.

OD= 28.002 ID= 25.600 T= 1.201 I= 9097.6 Z= 649.8

B1 = 0.50 C1= 1.36 C2= 1.00 C3= 1.25 C3'= 0.60
B2 = 1.00 K1= 1.10 K2= 1.10 K3= 1.10

STRESS DUE TO LUG SNB 010. SB9 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7288.	681.	9766.	25013.	0.390
LEVL B	1	9163.	681.	11643.	28596.	0.407
LEVL C	1	9163.	207.	9370.	34315.	0.273
LEVL D	1	9163.	1943.	18456.	38128.	0.484

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	47409.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	976.	50025.	0.020
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	36200.	50025.	0.724
E. Clamp Preload Stress		9411.	19064.	0.494
F. Cumulative Fatigue Usage Factor		0.047	1.0	0.047

Table A.4.1

0725843

GENERAL ELECTRIC COMPANY
BOILING WATER REACTOR SYSTEMS DEPARTMENT

SPEC NO. 22A REV. NO.

HOPE CREEK RECIRC B SUCTION NOZZLE TO PUMP NEAR NODE 010.

OD= 28.002 ID= 25.600 T= 1.201 I= 9097.8 Z= 649.8

B1 = 0.50 C1= 1.38 C2= 1.00 C3= 1.25 C3'= 0.60
B2 = 1.00 K1= 1.10 K2= 1.10 K3= 1.10

STRESS DUE TO LUG SNB 010. 3810 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7286.	881.	10187.	25013.	0.407
LEVL B	1	9183.	881.	12064.	28596.	0.422
LEVL C	1	9163.	207.	9370.	34315.	0.273
LEVL D	1	9163.	1943.	19756.	38128.	0.518

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	47409.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	976.	50025.	0.020
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	36200.	50025.	0.724
E. Clamp Preload Stress		9411.	19064.	0.494
F. Cumulative Fatigue Usage Factor		0.047	1.0	0.047

Table A.4.2

0725843

GENERAL ELECTRIC COMPANY SPEC NO. 22A REV. NO.
BOILING WATER REACTOR SYSTEMS DEPARTMENT

HOPE CREEK RECIRC B PUMP DISCH TO RHR RTN TEE NEAR NODE 044.

OD= 28.000 ID= 25.180 T= 1.410 I= 10438.9 Z= 745.6

B1 = 0.50 C1= 1.64 C2= 7.92 C3= 1.19 C3'= 0.50
B2 = 2.71 K1= 1.20 K2= 1.80 K3= 1.70

STRESS DUE TO LUG SNB 044, SB2 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7447.	1513.	10241.	25013.	0.409
LEVL B	1	7804.	1513.	10599.	28596.	0.371
LEVL C	1	7804.	850.	8655.	34315.	0.252
LEVL D	1	7804.	2771.	14387.	38128.	0.377

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	50939.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	12 13	2744.	50025.	0.055
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	41370.	50025.	0.827
E. Clamp Preload Stress		7200.	19064.	0.378
F. Cumulative Fatigue Usage Factor		0.111	1.0	0.111

Table A.4.3

0725343

GENERAL ELECTRIC COMPANY
BOILING WATER REACTOR SYSTEMS DEPARTMENT

SPEC NO. 22A REV. NO.

HOPE CREEK RECIRC B PUMP DISCH TO RHR RTN TEE NEAR NODE 050.

OD= 28.000 ID= 25.180 T= 1.410 I= 10438.9 Z= 745.6

B1 = 0.50 C1= 1.29 C2= 1.00 C3= 1.19 C3'= 0.60
B2 = 1.00 K1= 1.10 K2= 1.10 K3= 1.10

STRESS DUE TO LUG SNB 050, 388 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7447.	813.	10366.	25013.	0.414
LEVL B	1	7804.	813.	10724.	28596.	0.375
LEVL C	1	7804.	140.	7944.	34315.	0.232
LEVL D	1	7804.	1436.	15627.	38128.	0.410

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	46439.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	1390.	50025.	0.028
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	36178.	50025.	0.723
E. Clamp Preload Stress		7200.	19054.	0.378
F. Cumulative Fatigue Usage Factor		0.045	1.0	0.045

Table A.4.4

GENERAL ELECTRIC COMPANY
BOILING WATER REACTOR SYSTEMS DEPARTMENT

SPEC NO. 22A REV. NO.

HOPE CREEK RECIRC B PUMP DISCH TO RHR RTN TEE NEAR NODE 051.

OD= 26.000 ID= 25.180 T= 1.410 I= 10438.9 Z= 745.6

B1 = 0.50 C1= 1.29 C2= 1.00 C3= 1.19 C3'= 0.60
B2 = 1.00 K1= 1.10 K2= 1.10 K3= 1.10

STRESS DUE TO LUG SNB 051, 587 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7447.	571.	9678.	25013.	0.387
LEVL B	1	7604.	571.	10035.	28596.	0.351
LEVL C	1	7804.	133.	7937.	34315.	0.231
LEVL D	1	7804.	1330.	15289.	38126.	0.401

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	47116.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	1500.	50025.	0.030
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	36422.	50025.	0.728
E. Clamp Preload Stress		8930.	19064.	0.468
F. Cumulative Fatigue Usage Factor		0.048	1.0	0.048

Table A.4.5

0726843

GENERAL ELECTRIC COMPANY SPEC NO. 22A REV. NO.
BOILING WATER REACTOR SYSTEMS DEPARTMENT

HOPE CREEK RECIRC B RHR RTN TEE TO RPV NOZZLES NEAR NODE 105.

OD= 21.998 ID= 19.730 T= 1.134 I= 4056.5 Z= 368.8

B1 = 0.50 C1= 1.62 C2= 1.50 C3= 1.40 C3'= 0.50
B2 = 1.01 K1= 1.00 K2= 1.00 K3= 1.00

STRESS DUE TO LUG SNB 105. 3813 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7274.	335.	8411.	25013.	0.336
LEVL B	1	7624.	335.	8760.	28596.	0.306
LEVL C	1	7624.	113.	7737.	34315.	0.225
LEVL D	1	7624.	2036.	15895.	38128.	0.417

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	55535.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	1696.	50025.	0.034
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	36703.	50025.	0.734
E. Clamp Preload Stress		15064.	19064.	0.790
F. Cumulative Fatigue Usage Factor		0.114	1.0	0.114

Table A.4.6

0726843

GENERAL ELECTRIC COMPANY SPEC NO. 22A REV. NO.
BOILING WATER REACTOR SYSTEMS DEPARTMENT

HOPE CREEK RECIRC B RHR RTN TEE TO RPV NOZZLES NEAR NODE 105.

OD= 21.998 ID= 19.730 T= 1.134 I= 4056.5 Z= 368.8

B1 = 0.50 C1= 1.62 C2= 1.50 C3= 1.40 C3'= 0.50
B2 = 1.01 K1= 1.00 K2= 1.00 K3= 1.00

STRESS DUE TO LUG SNB 105. 3B15 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7274.	335.	8034.	25013.	0.321
LEVL B	1	7624.	335.	8383.	28596.	0.293
LEVL C	1	7624.	113.	7737.	34315.	0.225
LEVL D	1	7624.	2038.	11954.	38128.	0.314

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	55535.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	1696.	50025.	0.034
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	36703.	50025.	0.734
E. Clamp Preload Stress		15064.	19064.	0.790
F. Cumulative Fatigue Usage Factor		0.114	1.0	0.114

Table A.4.7

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GENERAL ELECTRIC COMPANY
BOILING WATER REACTOR SYSTEMS DEPARTMENT

SPEC NO. 22A REV. NO.

HOPE CREEK RECIRC B RHR RTN TEE TO RPV NOZZLES NEAR NODE 205.

OD= 21.998 ID= 19.730 T= 1.134 I= 4056.5 Z= 368.8

B1 = 0.50 C1= 1.24 C2= 1.50 C3= 1.15 C3'= 0.50
B2 = 1.01 K1= 1.00 K2= 1.00 K3= 1.00

STRESS DUE TO LUG SNB 205. SB14 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7274.	310.	8461.	25013.	0.338
LEVL B	1	7624.	310.	8811.	28596.	0.308
LEVL C	1	7624.	78.	7701.	34315.	0.224
LEVL D	1	7624.	1556.	13357.	38128.	0.350

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	45216.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	2138.	50025.	0.043
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	31862.	50025.	0.637
E. Clamp Preload Stress		7200.	19064	0.378
F. Cumulative Fatigue Usage Factor		0.039	1.0	0.039

Table A.4.8

0725843

GENERAL ELECTRIC COMPANY
BOILING WATER REACTOR SYSTEMS DEPARTMENT

SPEC NO. 22A REV. NO.

HOPE CREEK RECIRC B RHR RTN TEE TO RPV NOZZLES NEAR NODE 206.

OD= 21.998 ID= 19.730 T= 1.134 I= 4066.5 Z= 368.8

B1 = 0.50 C1= 1.24 C2= 1.50 C3= 1.15 C3'= 0.50
B2 = 1.01 K1= 1.00 K2= 1.00 K3= 1.00

STRESS DUE TO LUG SNB 206. SB16 ARE INCLUDED

A. PRIMARY STRESSES (EQUATION 9)

SERVICE LEVEL	COMB. NO.	PRESSURE STRESS	BENDING AND TORSION STRESS	TOTAL STRESS	ALLOWABLE STRESS	STRESS RATIO
DESIGN	1	7274.	301.	8558.	25013.	0.342
LEVL B	1	7624.	301.	8905.	28596.	0.311
LEVL C	1	7624.	71.	7695.	34315.	0.224
LEVL D	1	7624.	1479.	13182.	38123.	0.346

B. PRIMARY PLUS SECONDARY (EQUAT 10)	1 13	44982.	50025.	
C. SECONDARY STRESS RANGE (EQUATION 12)	1 13	1904.	50025.	0.038
D. PRIMA PLUS SECO EXC TH EXP (EQUAT 13)	5 13	31849.	50025.	0.637
E. Clamp Preload Stress		7200.	19064.	0.378
F. Cumulative Fatigue Usage Factor		0.039	1.0	0.039

Table A.4.9

A.5 Highest Clamp Induced Stress and Fatigue
Hope Creek Recirculation Loop B

Item Evaluated (1)	Highest Usage/Factor (psi)	Allowable Limits	Ratio Actual/Allowed	Governing Load (2) Comb. No.	Identification of Location of Highest Stress Points
Primary Stress Eq. 9 $\leq$ 1.5Sm Design Condition	10366	25013	0.414	1	SB8, Discharge Riser
Primary Stress Eq. 9 $\leq$ 1.8Sm & 1.5Sy Service Level B	12064	28596	0.422	1	SB10, Suction Riser
Primary Stress Eq. 9 $\leq$ 2.25Sm & 1.8Sy Service Level C	9370	34315	0.273	1	SB10, Suction Riser
Primary Stress Eq. 9 $\leq$ 3.0Sm Service Level D	19758	38128	0.518	1	SB10, Suction Riser
Primary plus Secondary Eq. 10 $\leq$ 3.0Sm	55535	50025	1.110 (3)	-	SB13, Recirc Header
Secondary Stresses Eq. 12 $\leq$ 3.0Sm	2744	50025	0.055	-	SB2, Discharge Elbow
Primary plus Secondary Stress without Thermal Expansion Eq. 13 $\leq$ 3.0Sm	41370	50025	0.827	-	SB2, Discharge Elbow
Cumulative Usage Factor U $\leq$ 1.0	0.114	1.0	0.114	-	SB13, Recirc Header

(1) All equations used are from ASME B&PV Code, Sec. III - NB-3650.

(2) See Table A.3

(3) Eqn. 10 triggers fatigue usage calculations using low cycle fatigue method. Since fatigue usage is within allowable, the higher ratio is acceptable.