ENCLOSURE 1
ATTACHMENT 8

NEXTERA ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

LICENSE AMENDMENT REQUEST 261
EXTENDED POWER UPRATE
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

PBNP-994-21-05-P06, REVISION 0, STEAM SUPPLY PIPING TO AFW PUMP AND RADWASTE GL 87-11 BREAK LOCATION DETERMINATION

21 pages follow

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1.0 PURPOSE

The purpose of this calculation is to establish the locations of intermediate high energy large breaks and leakage cracks utilizing the criteria given in Generic Letter 87-11 and its attachment USNRC Mechanical Engineering Branch Technical Position, MEB 3-1, Revision 2 (Reference 3).

Combined stress tables for the 3" steam supply piping from the Main Steam headers to Auxiliary Feedwater (AFW) Pump 2P-29 and Radwaste are developed for the sole purpose of determining the locations of intermediate large breaks and leakage cracks in accordance with the combined stress equations defined in Reference 3.

This calculation determines break and crack locations in the high-energy lines outside containment, based on the combined stress criteria detailed in the GL 87-11 methodology. This calculation does not address the additional postulation of "a single crack, exclusive of stress, at the most severe location with respect to essential equipment" (IE Notice 2000-20, Reference 9), nor does this calculation address the consequences of or evaluate the impacts of breaks or cracks that are required to be postulated based on this criteria.

2.0 BACKGROUND

PBNP's licensing basis for High-Energy Line Break (HELB) is documented in the Final Safety Analysis Report (FSAR) (Reference 2, Appendix A.2). Appendix A.2 of the FSAR defines a high-energy line as a line with design pressure greater than 275 psig and service temperature greater than 200°F. Both conditions have to be satisfied for a line to be designated high-energy. Additional background discussion regarding the BPNP HELB Program and details for establishing HELB break and leakage crack locations criteria (HELB Reconstitution Program) is provided in the AES technical position paper (see Attachment C).

Based on the above high energy line definition, Calculation PBNP-994-21-02 (Reference 16) identifies the Main Steam (MS) System Lines, Main Feedwater Piping, Steam Generator (SG) Blowdown Piping, and Sampling System Lines as high-energy lines (Reference 2, Appendix A.2).

The application of GL 87-11 methods to determine the new intermediate break and leakage crack locations is expected to be beneficial in addressing design concerns related to high energy line break effects. GL 87-11 still requires terminal end circumferential breaks to be postulated irrespective of the combined stress values at these locations.

Since the purpose of this calculation is only to generate stress tables to determine GL 87-11 break and or crack locations, the pipe stress analyses for the steam supply piping (Reference 6) still remain valid.

3.0 ASSUMPTIONS AND ANALYSIS NOTES

Assumptions

Piping material, geometric data and stress analysis (computer results) given in the Analysis of Record (AOR) (Reference 6) for the Steam Supply piping to the AFW Pump and Radwaste are used as input to develop the GL 87-11 combined stress tables that, in turn, are used to determine the intermediate break and leakage crack locations.

Analysis Notes

The code of record for this plant is USAS B31.1 Power Piping Code, 1967 Edition (Reference 1). The Steam Supply piping stress analysis documented in Reference 6 was performed using ASME B&PV Code, Section III, Subsection NC and ND, 1977 Edition up to and including 1978 Winter Addenda (Reference 10). A pipe code reconciliation study was used to show that no significant differences exist between the two codes for piping analysis.

Application of the MEB 3.1, Rev. 2 methodology for Class 2 and 3 piping requires combined stresses to be calculated in accordance with the 1986 ASME Section III, Class 2 requirements (Reference 4). Because the way stresses are factored in the two codes is different, the individual load components (moments) for the different load cases (weight, pressure, thermal, and OBE seismic) from the AOR are extracted and adjusted for the stress indices and stress intensification factors, and used as input to calculate the new combined stresses in accordance with Reference 4.

Stress Intensification Factors (SIFs) that are calculated per Reference 10 are identical to those calculated per Reference 4. As such, SIFs from the analysis in Reference 6 are used in the calculations of secondary stresses per Reference 4. These SIFs appear in the stress tables. Note that SIF is not specified at every point in the existing piping analysis. SIFs are equal to 1.0 for those locations without SIF specifically identified.

Factored stresses, calculated based on Reference 4, uses SIF and stress indices, B_1 and B_2. These stress indices are determined / calculated in accordance with Table NB-3681 (a)-1 and associated sections of Reference 4. Stress indices for straight pipe runs are obtained from Table NB-3681 (a)-1 (Reference 4) and they are $B_1 = 0.5$ and $B_2 = 1.0$.

4.0 METHODOLOGY AND ACCEPTANCE CRITERIA

This calculation uses the GL 87-11 (Reference 3) methodology to determine postulated pipe break and crack locations.

The analysis in Reference 6 was performed using ASME Section III, Subsection NC and ND, 1977 Edition (Reference 10) as the piping code. The results from this analysis are used to calculate the combined stresses using the methodology in ASME Section III, 1986 Edition (Reference 4) consistent with GL 87-11 criteria. All stress components for the ASME Section III stress combination, except longitudinal pressure stress, are obtained from the AOR. The resultant stresses along with appropriate stress indices, "B_1" and "B_2" and the stress intensification factor (SIF) 'i' values used in the calculation of the stress components in equations (1) and (2) are given in Sections 4.1 and 4.3 of this calculation.

The following is a discussion of the high-energy line break criteria used to establish the break locations using the GL 87-11 methodology.

4.1 Intermediate Large Breaks

The GL 87-11 and MEB 3-1, Revision 2 criteria (Reference 3) for intermediate large breaks is based on the combined stress formula given by the sum of Equations 9 and 10 of ASME B&PV Code Section III, Class 2 and 3 as follows:

$$B_1\, PD_0/2t + B_2\, M_{DW}/Z + B_2\, M_{OBE}/Z + i\, M_{TH}/Z \geq 0.8\,(1.8\, S_h + S_A) \qquad (1)$$

In above equation, the first term is the longitudinal pressure stress. The resultant stresses (M/Z) for each load case (deadweight, thermal expansion, and OBE from simultaneous X and Y directions or OBE from simultaneous Y and Z directions) are calculated on the resultant stress calculation Table in Attachment A based on the moments in X, Y and Z (M_A, M_B, M_C) directions obtained from the AOR (Reference 6).

$$S = [(M_A^2 + M_B^2 + M_C^2)^{1/2}] / Z$$

To obtain the corresponding ASME Section III factored stresses for the deadweight and seismic load cases, the stresses obtained from the resultant stress calculation Table in Attachment A, are multiplied by the corresponding B_2 values. Note that thermal expansion stresses are multiplied by the SIF (i). Replacing the M/Z term by S, the modified combined stress equation is as follows;

$$B_1\, PD_0/2t + B_2\, S_{DW} + B_2\, S_{OBE} + i\, S_{TH} \geq 0.8\,(1.8\, S_h + S_A) \qquad (1A)$$

Where:

P = Design internal pressure, psi
D_0 = Outside diameter of the pipe, in

t = Nominal thickness of the pipe, in
M_{DW} = Resultant moment due to dead weight, in-lbs
M_{OBE} = Resultant moment due to operating basis earthquake, in-lbs
M_{TH} = Resultant moment due to thermal expansion, in-lbs
S_{DW} = Resultant stress due to dead weight, psi, from Resultant Stress Table in Attachment A
S_{OBE} = Resultant stress due to OBE (Max of X & Y or Y & Z earthquake), psi, from Resultant Stress Table in Attachment A
S_{TH} = Resultant stress due to thermal expansion, psi, from Resultant Stress Table in Attachment A
S_h = Material allowable stress at temperature, psi
S_A = Material allowable stress range, psi
Z = Section modulus of pipe, in^3
i = stress intensification factor, as given in Figure NC-3673.2(b)-1
B_1 = primary stress index for pressure stress as given in Table NB-3681(a)-1 and further defined in Section 4.4
B_2 = primary stress index for bending stresses as given in Table NB-3681(a)-1 and further defined in Section 4.4

Large intermediate breaks are to be postulated only at locations where the combined stress exceeds the threshold value of $0.8(1.8S_h + S_A)$ (Reference 3). The requirements for arbitrary intermediate large breaks are eliminated by Reference 3.

4.2 Circumferential Breaks at Terminal Ends of Main and Branch Lines

Terminal Ends

The GL 87-11 criteria state that circumferential breaks have to be postulated at terminal ends of the main run as well as the branch piping. Terminal ends of a piping run are defined as the ends terminating at components, or at other piping (run pipe), or at intermediate anchors. Footnote 3 of MEB 3-1, Rev. 2 provides a definition for the term "terminal ends" which was missing in the Giambusso letter (Reference 5). The footnote defines terminal ends as "Extremities of piping runs that connect to structures, components (e.g., vessels, pumps, valves), or pipe anchors that act as rigid constraints to the piping motion and thermal expansion. A branch connection to a main piping run is a terminal end of the branch run, except where the branch run is classified as part of the main run and is shown to have a significant effect on the main run behavior..."

Terminal ends for the Steam Supply piping to AFW Pump 2P-29 are summarized on Table 7.1 (Section 7.0).

Branch Lines

The 3" steam supply piping to AFW pump 2P-29 and Radwaste is modeled and analyzed in a separate analytical part (Ref. 6) from the Main Steam header piping. These lines are affected by and in turn affect the main line, and as such, the branch connections to the Main Steam header (Node Points 16 & G20) are considered terminal ends.

4.3 High-Energy Line Leakage Cracks (Small Breaks)

The GL 87-11 and MEB 3-1, Revision 2 criterion for leakage cracks is based on the same combined stress formula given in equation (1) above, except the threshold stress value on the right side of the equation is reduced by one-half as follows:

$$B_1 PD_0/2t + B_2 M_{DW}/Z + B_2 M_{OBE}/Z + i M_{TH}/Z \geq 0.4 (1.8 S_h + S_A) \quad \textbf{(2)}$$

In equation 2, the term M/Z is also replaced by the resultant stress S term similar to the modification to equation 1. The modified equation is as follows:

$$B_1 PD_0/2t + B_2 S_{DW} + B_2 S_{OBE} + i S_{TH} \geq 0.4 (1.8 S_h + S_A) \quad \textbf{(2A)}$$

Leakage cracks are to be postulated in locations where the combined stress exceeds the threshold value of $0.4 (1.8S_h + S_A)$.

4.4 Calculation of Stress Indices

Calculated values for various pipe sizes and schedules associated with the piping in the stress tables are provided on Table – 1 in Attachment A. Stress Indices are calculated in accordance with ASME Section III, Subsection NB, Table NB-3681 (a)-1 found in Reference 4, and SIFs are calculated in accordance with ASME Section III, Subsection NC, Figure NC-3673.2(b)-1.

The following equations are used to calculate the stress indices (B_1 and B_2) and SIF (i) for welding elbows and welding tees in accordance with ASME Section III, NC and NB rules (Reference 4).

- Curved Pipe or Butt Welding Elbows (NB-3683.7):

$B_1 = -0.1 + 0.4 \cdot h$ but not < 0 nor > 0.5

$B_2 = \frac{1.30}{h^{\left(\frac{2}{3}\right)}}$ but not < 1.0

and from Figure NC-3673.2(b)-1

$h = \frac{t \cdot R}{r_m^{2}}$ $\quad i = \frac{0.9}{h^{\left(\frac{2}{3}\right)}}$

where:

R = nominal bend radius of curved pipe or elbow, in
r_m = mean pipe radius, in, = $(D_o - t)/2$
t = nominal wall thickness of pipe, in
D_o = outside diameter of pipe, in
h = flexibility characteristic

- Butt Welding Tees (NB-3683.9):

$B_1 = 0.5$ (Table NB-3681(a)-1)

$B_{2b} = 0.4 \cdot \left(\frac{R_m}{T_r}\right)^{\frac{2}{3}}$ but not < 1.0

$B_{2r} = 0.5 \cdot \left(\frac{R_m}{T_r}\right)^{\frac{2}{3}}$ but not < 1.0

and from Figure NC-3673.2(b)-1

$h = \frac{4.4 \cdot T_r}{R_m}$ $\quad i = \frac{0.9}{h^{\left(\frac{2}{3}\right)}}$

where:

R_m = mean radius of run pipe, in, = $(D_o - t)/2$
T_r = nominal thickness of run pipe, in
D_o = outside diameter of pipe, in
B_{2b} = B_2 stress index for branch pipe
B_{2r} = B_2 stress index for run pipe

Stress Indices for straight pipe run are obtained from Table NB-3681(a)-1 (Ref. 4), and they are: B_1 =0.5, and B_2 = 1.0.

5.0 REFERENCES

1. USAS B31.1.0 – 1967, Power Piping Code.
2. PBNP FSAR (08/04), Appendix A.2.
3. Generic Letter 87-11 – Relaxation in Arbitrary Intermediate Pipe Rupture Requirements, June 19, 1987.
4. ASME Section III, 1986 Editions.
5. AEC-DOLs Letter to WPS of December 15, 1972 (Mr. Giambusso to Mr. James).
6. PBNP Pipe Stress Analysis Reports.
   a) PBNP Accession No. WE-200044, 2EB8A/B-3" Auxiliary Steam to Auxiliary FW Pump 2P-29, Revision 0 including Addendum A.
   b) PBNP Accession No. WE-200101, Piping System Qualification Report for Main Steam Piping to Anchor EB-8-A118 (Outside Containment), Unit 2, Revision 0A.
   c) PBNP Accession No. WE-200102, Piping System Qualification Report for Main Steam Piping to Anchor EB-8-A121 (Outside Containment), Unit 2, Revision 0.
   d) PBNP Accession No. WE-300042, Piping System Qualification Report for Radwaste Steam, Units 1 & 2, Revision 2 including Addenda A, B, and C.
   e) PBNP Accession No. WE-300004, Auxiliary Steam Line 3" SA-3 from Anchors SA-3, S-32, and S-29 to Anchor S-408, Units 1 & 2, Revision 1.
7. DG-M09, Rev. 2, Design Requirements for Piping Stress Analysis.
8. Drawing M–2201 Sh. 1, Revision 45, Piping Subsystems P&ID – Main & Reheat Steam System.
9. NRC Information Notice 2000-20, Potential Loss of Redundant Safety Related Equipment Because of the Lack of High Energy Line Break Barriers, 12/11/2000.
10. ASME Section III B&PV Code, Subsection NC and ND, 1977 Edition up to and including 1978 Winter Addenda.
11. Isometric Drawing P-206, Revision 7, "Main Steam to Aux. Feedwater Pump 2P-29, 3"-EB-8".
12. Isometric Drawing PBA-2044 Sheet 1, "Aux Steam to Aux FW Pump 2P-29", Revision 0.
13. Isometric Drawing PBA-2044 Sheet 2, "Aux Steam to Aux FW Pump 2P-29", Revision 0.
14. Isometric Drawing PBA-3004, "Aux Steam to W.D. Blowdown Area Elevation 44'-0, Aux. Building Central", Revision 4.
15. Isometric Drawing PBA-3042, "Radwaste Steam Supply", Revision 2.
16. Calc. No. PBNP-994-21-02, HELB Reconstitution Program-Task 2, High Energy System Selection, Rev. 0.

6.0 GL 87-11 BREAK AND LEAK LOCATION CALCULATIONS

As discussed in Section 4.0, the threshold stress limits used by GL 87-11 are determined in accordance with the requirements of ASME Section III Code, for Class 2 and 3 piping. This Section provides additional information on the GL 87-11 method to determine postulated break and crack locations.

6.1 Application of GL 87-11 Criteria

The requirements of GL 87-11 (Reference 3) are applied to the Steam Supply piping from the branch connection points at the 30" Main Steam headers to AFW Pump 2P-29 and Radwaste. Part of the requirements to implementing GL 87-11 is that the stress evaluation is to be in accordance with ASME Section III, 1986 edition. Table 1 in Attachment A calculates the B_1 and B_2 stress indices and SIF (i) for the steam supply piping. These indices are calculated in accordance with Paragraphs NB-3683.7, NB-3683.8, NB-3683.9, Table NB-3681(a)-1 and Figure NC-3673.2(b)-1.

6.2 Manipulation of Stress Equations in EXCEL Spreadsheets

A spreadsheet or stress table for each line segment of concern was developed taking piping stress data from References 6 computer analyses. Appropriate stress indices were included for each analytical point under consideration. This information was then used to calculate the combined stress value for comparison to threshold values established per equations (1A) and (2A) that were defined in section 4.0.

A detailed explanation of the different columns used in the stress tables (spreadsheets) is as follows:

Column	Description	Remarks
A & X	Node or Analysis Point Number	Taken from Ref. 6.
B	Outside Diameter of pipe segment, in	
C	Nominal Thickness of pipe segment, in	
D	Internal pressure = design pressure, psi	
E	Resultant Dead Weight Stress, S_{DW}, psi	Calculated in Resultant Stress Table based on moments from computer output of Ref. 6
F	Resultant Thermal Expansion Stress, S_{TH}, psi	
G	Resultant Seismic Stress (Due to X & Y earthquake), S_{OBEXY}, psi	
H	Resultant Seismic Stress (Due to Y & Z earthquake), S_{OBEYZ}, psi	
J	Stress Intensification Factor (SIF), (i)	
K	B1 stress index	Calculated as shown in Section 4.4 and Table - 1
L	B2 stress index	
M	Longitudinal Pressure Stress, psi. This is the first component in equations (1) and (2) shown in sections 4.1 and 4.3	$= B_1*P*D_o/2*t$
N	Deadweight stress, psi. This is the second component in equations (1A) and (2A) shown in sections 4.1 and 4.3	$= B_2*(S_{DW})$

Column	Description	Remarks
P	Thermal expansion stress, psi. This is the fourth component in equations (1A) and (2A) shown in sections 4.1 and 4.3	$= i * (S_{TH})$
Q	Operating basis earthquake (OBE) stress, psi. This is the third component in equations (1A) and (2A) shown in sections 4.1 and 4.3	$= B_2 * [S_{OBE}$ (max of S_{OBEXY} or S_{OBEYZ})]
R	Combined Stress, psi	= Sum of columns M, N, P, and Q
S	Threshold Limit for Leakage Crack Postulation	$= 0.4\ (1.8\ S_h + S_A)$
T	Threshold Limit for Large Break Postulation	$= 0.8\ (1.8\ S_h + S_A)$
V	Ratio of combined stress / threshold crack limit	Crack postulated if > 1
W	Ratio of combined stress / threshold break limit	Break postulated if > 1

The Steam Supply piping material is A106 Gr. B (Reference 6). At temperatures < 650 °F, the allowable hot condition stress, S_h and allowable stress range, S_A, per Reference 4 are as follows:

$S_c = S_h = 15000$ psi   from Reference 4, Table I.7.1
$S_A = 22500$ psi,   where $S_A = f\,(1.25 S_c + 0.25\ S_h)$ and $f = 1.0$, per NC-3611.2(e)

Threshold Limit for Intermediate Large Circumferential or Longitudinal Breaks: $0.8(1.8*S_h + S_A) = 39600$ psi

Threshold Limit for Leakage Cracks: $0.4(1.8*S_h + S_A) = 19800$ psi

6.3 Sample Calculations

Sample of Resultant Stress Calculations (Table – 2, Attachment A2):

For Example Nodes 485 and 530 (Ref. 6a)

$D := 3.50\cdot in \quad t := 0.216\cdot in \quad D_I := D - 2\cdot t \quad D_I = 3.068in$

Section Modulus $S := \frac{\pi\cdot\left(D^4 - D_I^{\,4}\right)}{32\cdot D}$ $\quad S = 1.72in^3$

DW TH OBE(X+Y) OBE(Y+Z)

$$M_X := \begin{pmatrix} 104 & 54 & 262 & 262 \\ 104 & 2 & 262 & 262 \end{pmatrix}\cdot ft\cdot lbf \qquad M_Y := \begin{pmatrix} 177 & 350 & 306 & 306 \\ 3 & 429 & 156 & 156 \end{pmatrix}\cdot ft\cdot lbf$$

DW TH OBE(X+Y) OBE(Y+Z)

$$M_Z := \begin{pmatrix} 345 & 240 & 248 & 248 \\ 82 & 703 & 205 & 205 \end{pmatrix}\cdot ft\cdot lbf$$

Resultant Stress

DW TH OBE(X+Y) OBE(Y+Z)

$$\sigma := \overrightarrow{\frac{\sqrt{M_X^{\,2} + M_Y^{\,2} + M_Z^{\,2}}}{S}} \qquad \sigma = \begin{pmatrix} 2794 & 2978 & 3293 & 3293 \\ 922 & 5732 & 2557 & 2557 \end{pmatrix} psi \quad \begin{matrix} 485 \\ 530 \end{matrix}$$

Sample of Stress Table Calculation (Table – 3, Attachment A3):

For example row of Node Point 485 is considered

COLUMN

A	Choose Node 485 from the Stress Table for Steam Supply to AFW Pump 2P-29		
B:	Outside Diamter of pipe,	$D_0 := 3.50\,in$	
C:	Pipe Thickness,	$t_n := 0.216\,in$	
D:	Internal pressure,	$P := 1145\,psi$	
E:	Resultant Deadweight stress,	$S_{DW} := 2794\,psi$	
F:	Resultant Thermal Expansion stress,	$S_{TH} := 2978\,psi$	
G & H:	Resultant Seismic (max OBE) stress,	$S_{OBE} := \max(3293, 3293)\cdot psi$	
J:	Stress intensification factor,	$i := 1.777$	
K:	Stress index,	$B_1 := 0.044$	
L:	Stress index,	$B_2 := 2.566$	
M:	Longitudinal pressure stress,	$Col\_M := \frac{B_1 \cdot P \cdot D_0}{2 \cdot t_n}$	$Col\_M = 408\,psi$
N:	Deadweight stress,	$Col\_N := B_2 \cdot S_{DW}$	$Col\_N = 7169\,psi$
P:	Thermal Expansion stress,	$Col\_P := i \cdot S_{TH}$	$Col\_P = 5292\,psi$
Q:	OBE stress,	$Col\_Q := B_2 \cdot S_{OBE}$	$Col\_Q = 8450\,psi$
R:	Combined stress,	$Col\_R := Col\_M + Col\_N + Col\_P + Col\_Q$	$Col\_R = 21319\,psi$
S:	Limit for Crack,	$Col\_S := 19800\,psi$	
T:	Limit for Break,	$Col\_T := 39600\,psi$	
V:	Ratio of combined stress to limit for crack,	$Col\_V := \frac{Col\_R}{Col\_S}$	$Col\_V = 1.077$
W:	Ratio of combined stress to limit for break,	$Col\_W := \frac{Col\_R}{Col\_T}$	$Col\_W = 0.538$

7.0 RESULTS & CONCLUSIONS

Results

The 3" Steam Supply lines from the 30" Main Steam headers (Node Points 16 & G20) to AFW Pump 2P-29 and Radwaste have been evaluated for break and crack locations following the requirements and criteria of Generic Letter GL 87-11.

Large Breaks

Terminal end circumferential breaks are to be postulated at the terminal ends of the steam supply lines at the branch connection (Node Points 16 & G20) to the Main Steam headers in the Auxiliary Building, at intermediate anchors EB-8-A118 & EB-8-A121, and at the inlet side of Motor Operated Valves 2MOV-2019 and 2MOV-2020 upstream of the AFW Pump. Locations where large breaks are required to be postulated are summarized in Table 7.1 below.

As seen from the stress table in Attachment A, all steam supply piping combined stresses are well below the Intermediate Large Break Threshold Limit. Therefore, no intermediate large breaks need be postulated for the 3" Steam Supply Lines from the MS headers to the AFW Pump and Radwaste.

Table 7.1 – Postulated Large Breaks at Terminal Ends and Intermediate Locations

Break Location	Node Point	Notes
3" Steam Supply lines from MS Header Branch Connections to AFW Pump	16, G20	Terminal End
3" Steam Supply line at anchor EB-8-A118	5	Terminal End
3" Steam Supply line at anchor EB-8-A121	1190	Terminal End
3" Steam Supply at inlet of 2MOV-2019	550	Terminal End
3" Steam Supply at inlet of 2MOV-2020	785	Terminal End
3" Steam supply line at anchor SA-3-S32 (Ref. 13)	1535	Terminal End
3" Auxiliary steam supply line at anchor SA-1-S408 (Ref. 14)	400	Terminal End
6" Radwaste steam supply line at orifice flange downstream of valve SA-1 (Ref. 15)	130	Terminal End

Leakage Cracks (Small Breaks)

Leakage cracks need to be postulated at locations where the combined stress exceeds the threshold limits as shown in the stress table (Attachment A). Locations where leakage cracks are required to be postulated are summarized in the Table 7.2 below.

Table 7.2 – Leakage Crack (Small Break) Locations for Steam Supply Lines

Crack Location	Node Point	Notes
Riser elbows upstream of 3"tee conn. to relief valve 2MS-252	485	
Elbow upstream of MOV 2MS-2020	800	
2nd Elbow (top of riser) upstream of MOV 2MS-2020	835, 845, 848B	
3" tee downstream of 2MS-252	1275	
3rd Elbow downstream of relief valve 2MS-251	1285	
1 ½" line downstream of 3" tee by anchor EB-8-A118	400, 585	
3" Radwaste steam supply line at inlet of valve RS-3	55	

Conclusions

An evaluation of the Steam Supply lines from the 30" MS headers to AFW Pump using the GL 87-11 and its associated USNRC Branch Technical Position MEB 3.1, Rev. 2 (Reference 3) is described in this calculation. The calculation shows that:

- Intermediate stress related and arbitrary large breaks need not be postulated anywhere along the entire Steam Supply lines to AFW Pump and Radwaste.
- Circumferential large breaks are required to be postulated at the terminal ends as shown in Table 7.1.
- Leakage cracks (break size = ½ times the pipe wall thickness x ½ the pipe internal diameter) are required to be postulated at the locations summarized in Table 7.2.

This calculation does not address the postulation of a single crack, exclusive of stress, at the most severe location with respect to essential equipment (IE Notice 2000-20, Reference 9), nor does this calculation address the consequences or evaluate the impacts of breaks or cracks that are required to be postulated based on this criteria.

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Date: 8/19/2008

TABLE - 1: STRESS INDICES
(FOR USE IN STRESS TABLES)

Nominal Pipe Size	Outside Diameter of Pipe (Do)	Pipe Schedule	Nominal Thickness of pipe (t)	Mean Radius of pipe (r_m) Note 1	Curved pipe or Butt Welding Elbows					Welding Tees			
					Bend Radius (R) Note 2	Flex. Char. (h) Note 1	SIF (i) Note 1	Index B_1 Note 1	Index B_2 Note 1	Flex. Char.(h) Note 1	SIF (I) Note 1	Index B_2 Note 1 Tee-Run	Tee-Br
3	3.50	40	0.216	1.6420	4.5	0.3605	1.7768	0.0442	2.5664	0.5788	1.2958	1.933	1.547
3	3.50	40	0.216	1.6420	3.0	0.2403	2.3282	0.0000	3.3630	0.5788	1.2958	1.933	1.547

Notes:
1) For applicable equations for calculating r_m, R_m, r, h, i, B_1 and B_2, see Section 4.4 of main calculation.
2) Bend Radius is long radius elbows (1.5 x diameter) or special radius given in pipe stress analysis input (Ref. 6).

TABLE - 2

Resultant Stress Calculation Table for Steam Supply Piping from Anchors EB-8-A118 & -A121 to AFW Pump 2P-29

(Based on analysis results from Accession No. WE-200044 Rev. 0, Dated 9-21-87)

Input Data from Analysis					Moments From Analysis												Calculated Resultant Stress			
NODES	Outside dia.	Pipe thickness	Section Modulus	SIF Calc.	Dead Weight Moments			Thermal Expansion Moments			Max X + Y Seismic Moments			Max Y + Z Seismic Moments			DW	THR	Seis X+Y	Seis Y+Z
					X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	Res. Stress	Res. Stress	Res. Stress	Res. Stress
	D_O (in)	t_n (in)	S (in^3)		ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	psi	psi	psi	psi
485	3.5	0.216	1.72	1.777	104	177	345	54	350	240	262	306	248	262	306	248	2794	2978	3293	3293
530	3.5	0.216	1.72	1.300	104	3	82	2	429	703	262	156	205	262	156	205	922	5732	2557	2557
800	3.5	0.216	1.72	1.777	12	144	126	124	92	571	258	370	194	258	370	194	1334	4117	3418	3418
810	3.5	0.216	1.72	1.300	12	64	58	227	348	368	268	299	153	258	299	153	607	3863	2948	2948
835	3.5	0.216	1.72	1.777	7	119	57	227	139	1268	52	35	102	52	35	102	920	9018	833	833
845	3.5	0.216	1.72	1.777	37	49	94	1109	861	97	90	77	33	90	77	33	781	9795	856	856
846B	3.5	0.216	1.72	1.777	30	12	27	5	945	1007	33	70	84	33	70	84	293	9612	795	795
1190	3.5	0.216	1.72	2.100	6	27	221	256	437	348	78	1000	59	78	1000	59	1550	4277	6993	6993
1265	3.5	0.216	1.72	1.777	46	17	177	256	197	738	212	62	166	212	62	166	1278	5607	1923	1923
1275	3.5	0.216	1.72	1.300	195	193	169	376	1484	824	182	166	258	182	166	258	2243	12101	2483	2483
1285	3.5	0.216	1.72	1.777	195	127	116	376	552	447	182	157	144	182	157	144	1810	5594	1950	1950
1325	3.5	0.216	1.72	1.777	20	54	16	510	928	150	100	124	64	100	124	64	416	7444	1195	1195

Resultant Stress Calculation Table for Steam Supply Piping from 30" MS Header to Anchor EB-8-A118

(Based on analysis results from Accession No. WE-200101 Rev. 0, Dated 12-29-95)

Input Data from Analysis					Moments From Analysis												Calculated Resultant Stress			
NODES	Outside dia.	Pipe thickness	Section Modulus	SIF Calc.	Dead Weight Moments			Thermal Expansion Moments			Max X + Y Seismic Moments			Max Y + Z Seismic Moments			DW	THR	Seis X+Y	Seis Y+Z
					X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	Res. Stress	Res. Stress	Res. Stress	Res. Stress
	D_O (in)	t_n (in)	S (in^3)		ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	psi	psi	psi	psi
115	3.5	0.216	1.72	2.000	230	13	174	33	2	7	35	17	43	46	15	26	2009	235	404	382
210	3.5	0.216	1.72	1.777	54	12	14	96	279	439	18	25	39	92	21	10	397	3682	346	660
400	1.9	0.200	0.41	2.100	353	3	20	40	2	2	30	50	9	29	13	8	10303	1169	1719	955
585	1.9	0.200	0.41	2.100	161	1	297	10	1	12	34	10	48	33	8	48	9845	456	1739	1713

Resultant Stress Calculation Table for Steam Supply Piping from 30" MS Header to Anchor EB-8-A121

(Based on analysis results from Accession No. WE-200102 Rev. 0, Dated 12-18-95)

Input Data from Analysis					Moments From Analysis												Calculated Resultant Stress			
NODES	Outside dia.	Pipe thickness	Section Modulus	SIF Calc.	Dead Weight Moments			Thermal Expansion Moments			Max X + Y Seismic Moments			Max Y + Z Seismic Moments			DW	THR	Seis X+Y	Seis Y+Z
					X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	Res. Stress	Res. Stress	Res. Stress	Res. Stress
	D_O (in)	t_n (in)	S (in^3)		ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	psi	psi	psi	psi
225	3.5	0.216	1.72	1.879	153	2	280	213	32	307	48	53	70	55	69	61	2221	2610	696	747
235	3.5	0.216	1.72	1.879	145	2	282	326	32	277	163	53	195	210	69	185	2207	2986	1807	2006

Resultant Stress Calculation Table for Auxiliary Steam line 3" SA-3 from Anchors SA-3-S32 and -S29 to Anchor SA-3-S408

(Based on analysis results from Accession No. WE-300004 Rev. 1, Dated 03-08-86)

Input Data from Analysis					Moments From Analysis												Calculated Resultant Stress			
NODES	Outside dia.	Pipe thickness	Section Modulus	SIF Calc.	Dead Weight Moments			Thermal Expansion Moments			Max X + Y Seismic Moments			Max Y + Z Seismic Moments			DW	THR	Seis X+Y	Seis Y+Z
					X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	Res. Stress	Res. Stress	Res. Stress	Res. Stress
	D_O (in)	t_n (in)	S (in^3)		ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	psi	psi	psi	psi
105	3.5	0.216	1.72	1.300	28	3	14	37	175	199	53	595	81	53	595	81	219	1862	4196	4196
110	3.5	0.216	1.72	1.879	28	2	64	38	156	15	143	433	77	143	433	77	488	1122	3219	3219
290	3.5	0.216	1.72	1.777	21	4	11	10	825	13	20	218	28	20	218	28	167	5743	1536	1536

Resultant Stress Calculation Table for Radwaste Steam

(Based on analysis results from Accession No. WE-300042 Rev. 2, Dated 01-18-02)

Input Data from Analysis					Moments From Analysis												Calculated Resultant Stress			
NODES	Outside dia.	Pipe thickness	Section Modulus	SIF Calc.	Dead Weight Moments			Thermal Expansion Moments			Max X + Y Seismic Moments			Max Y + Z Seismic Moments			DW	THR	Seis X+Y	Seis Y+Z
					X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	Res. Stress	Res. Stress	Res. Stress	Res. Stress
	D_O (in)	t_n (in)	S (in^3)		ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	ft-lbs	psi	psi	psi	psi
30	3.5	0.216	1.72	1.777	10	5	56	477	332	584	19	20	79	37	47	153	411	5734	582	1143
40	3.5	0.216	1.72	1.777	11	6	26	395	415	671	15	19	50	31	49	165	201	6141	387	1217
55	3.5	0.216	1.72	1.879	56	6	20	895	395	290	101	23	113	260	53	163	416	7102	1067	2167
65	3.5	0.216	1.72	1.879	107	4	20	642	304	290	38	42	113	65	96	163	758	5340	880	1392

Prepared by: Dan Quijano
Checked by: Chris Kandalepas
Date: 8/19/2008

TABLE - 3

Stress Table for Steam Supply Piping from Anchors EB-8-A118 & -A121 to AFW Pump 2P-29

(Based on analysis results from Accession No. WE-200044 Rev. 0, Dated 9-21-87)

A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	V	W	X
Input Data from Analysis				Resultant Stress from Analysis																
NODES	Outside dia. D_O (in)	Pipe thickness t_n (in)	Internal Pressure P (psi)	Dead Weight psi	Thermal Expansion psi	Max X+Z Seismic psi	Max Y+Z Seismic psi	SIF Calc.	INDEX B1	INDEX B2	Long. Pr. Stress psi	Dead Weight Stress psi	Thermal Expansion Stress psi	OBE Stress psi	Comb. Stress psi	Limit for Crack	Limit for Break	Ratio = Comb. St. / Crack Limit	Ratio = Comb. St. / Break Limit	NODES
485	3.5	0.216	1145	2794	2978	3293	3293	1.777	0.044	2.566	408	7170	5291	8449	21318	19800	39600	1.0767	0.5383	485
530	3.5	0.216	1145	922	5732	2557	2557	1.300	0.500	1.933	4638	1782	7452	4943	18816	19800	39600	0.9503	0.4751	530
800	3.5	0.216	1145	1334	4117	3418	3418	1.777	0.044	2.566	408	3424	7316	8770	19918	19800	39600	1.0059	0.5030	800
810	3.5	0.216	1145	607	3863	2948	2948	1.300	0.500	1.933	4638	1173	5022	5698	16532	19800	39600	0.8349	0.4175	810
835	3.5	0.216	1145	920	9018	833	833	1.777	0.044	2.566	408	2360	16025	2138	20931	19800	39600	1.0571	0.5286	835
845	3.5	0.216	1145	781	9795	856	856	1.777	0.044	2.566	408	2005	17406	2196	22016	19800	39600	1.1119	0.5560	845
848B	3.5	0.216	1145	293	9612	795	795	1.777	0.044	2.566	408	752	17080	2040	20280	19800	39600	1.0243	0.5121	848B
1190	3.5	0.216	1145	1550	4277	6993	6993	2.100	0.750	1.500	6957	2325	8982	10490	28755	19800	39600	1.4523	0.7261	1190
1265	3.5	0.216	1145	1278	5607	1923	1923	1.777	0.044	2.566	408	3280	9964	4935	18587	19800	39600	0.9387	0.4694	1265
1275	3.5	0.216	1145	2243	12101	2483	2483	1.300	0.500	1.933	4638	4335	15731	4799	29504	19800	39600	1.4901	0.7450	1275
1285	3.5	0.216	1145	1810	5594	1950	1950	1.777	0.044	2.566	408	4644	9940	5004	19996	19800	39600	1.0099	0.5050	1285
1325	3.5	0.216	1145	416	7444	1195	1195	1.777	0.044	2.566	408	1067	13228	3086	17769	19800	39600	0.8974	0.4487	1325

Stress Table for Steam Supply Piping from 30" MS Header to Anchor EB-8-A118

(Based on analysis results from Accession No. WE-200101 Rev. 0, Dated 12-29-95)

115	3.5	0.216	1145	2009	235	404	382	2.000	1.000	1.000	9277	2009	470	404	12160	19800	39600	0.6141	0.3071	115
210	3.5	0.216	1145	397	3682	346	660	1.777	0.044	2.566	408	1019	6542	1695	9664	19800	39600	0.4881	0.2440	210
400	1.9	0.2	1145	10303	1169	1719	955	2.100	0.750	1.500	4079	15455	2454	2579	24567	19800	39600	1.2408	0.6204	400
585	1.9	0.2	1145	9845	456	1739	1713	2.100	0.750	1.500	4079	14767	958	2608	22412	19800	39600	1.1319	0.5660	585

Stress Table for Steam Supply Piping from 30" MS Header to Anchor EB-8-A121

(Based on analysis results from Accession No. WE-200102 Rev. 0, Dated 12-18-95)

225	3.5	0.216	1145	2221	2610	696	747	1.879	0.500	1.000	4638	2221	4905	747	12510	19800	39600	0.6318	0.3159	225
235	3.5	0.216	1145	2207	2986	1807	2006	1.879	0.500	1.000	4638	2207	5610	2006	14462	19800	39600	0.7304	0.3652	235

Stress Table for Auxiliary Steam line 3" SA-3 from Anchors SA-3-S32 and -S29 to Anchor SA-3-S408

(Based on analysis results from Accession No. WE-300004 Rev. 1, Dated 03-08-86)

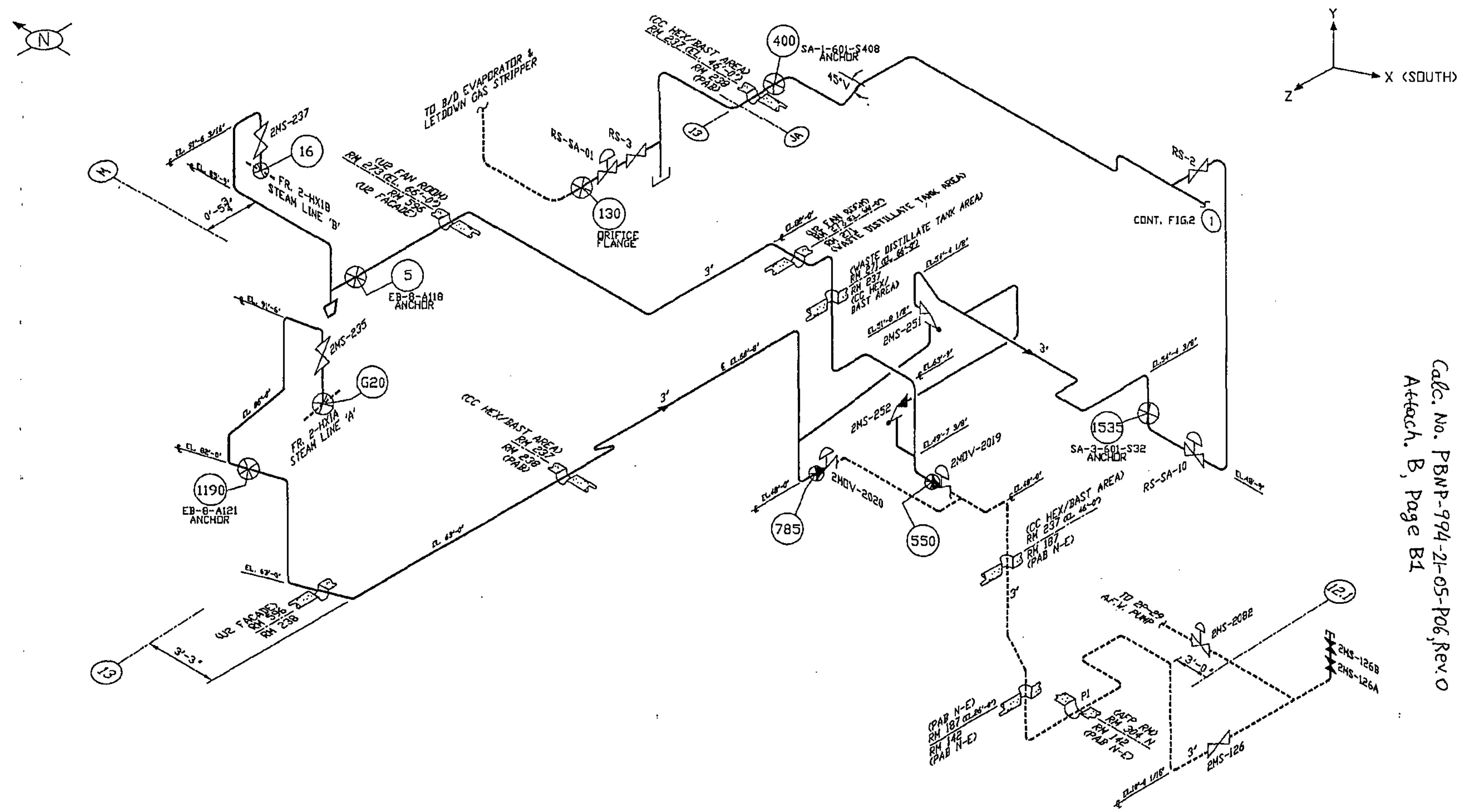
105	3.5	0.216	1085	219	1862	4196	4196	1.879	0.500	1.000	4395	219	3499	4196	12309	19800	39600	0.6217	0.3108	105
110	3.5	0.216	1085	486	1122	3219	3219	1.777	0.044	2.566	387	1248	1995	8259	11889	19800	39600	0.6004	0.3002	110
290	3.5	0.216	1085	167	5743	1536	1536	1.777	0.044	2.566	389	429	10206	3942	14965	19800	39600	0.7558	0.3779	290

Stress Table for Radwaste Steam

(Based on analysis results from Accession No. WE-300042 Rev. 0, Dated 01-18-2002)

30	3.5	0.216	1145	411	5734	582	1143	1.777	0.044	2.566	408	1055	10190	2934	14587	19800	39600	0.7367	0.3684	30
40	3.5	0.216	1145	201	6141	387	1217	1.777	0.044	2.566	408	515	10913	3124	14960	19800	39600	0.7556	0.3778	40
55	3.5	0.216	1145	416	7102	1067	2167	1.879	0.500	1.000	4638	416	13345	2167	20566	19800	39600	1.0387	0.5194	55
65	3.5	0.216	1145	758	5340	880	1392	1.879	0.500	1.000	4638	758	10034	1392	16823	19800	39600	0.8496	0.4248	65

Calc. No. PBNP-994-21-05-P06, Rev. 0
Attach. B, Page B1



LEGEND:

⊗ - DENOTES POSTULATED PIPE LINE BREAK

(XXX) - DENOTES LINE BREAK NUMBER.

AUTOMATED ENGINEERING SERVICES CORP.
40 SHUMAN BLVD. SUITE 220, NAPERVILLE, IL 60563

POINT BEACH NUCLEAR PLANT

TITLE: MAIN STEAM SYSTEM, UNIT 2 TO AUX. FEED WATER PUMP 2P-29 & RS-SA-01 LINE BREAKS ISOMETRIC					
DWN: NNC	DATE: 07-00-08	SCALE: NONE		SHT.	REV.
CHKD:	APPVD:	DWG. NO. SK-MS-FIG.4			

TECHNICAL POSITION PAPER
FOR ESTABLISHING
HELB BREAK & LEAKAGE CRACK LOCATION SELECTION CRITERIA

Rev. 0, December 4, 2006
Rev. 1, August 7, 2008

Calc. No. PBNP-994-21-05-P06, Rev. 0
Attach. C, Page C1

1.0 Introduction

Point Beach currently utilizes different Pipe Break Outside Containment (PBOC) location selection criteria in the HELB Program and EQ Program in regards to environmental parameters. The HELB Reconstitution Program (Program), as currently envisioned, will prepare documented calculations for the pressure, temperature and humidity time histories for a variety of HELB scenarios. Since the Program will reconstitute the design basis for PBOC and the resultant event environment outside Containment, these environmental parameters would be equally applicable and used as the input to the EQ Program. With this approach PBNP will have a single unified HELB approach to address impacts on EQ and structural effects including compartment pressures and temperatures, jet impingement, pipe whip among others

Before proceeding with the Program, a major consideration needs to be addressed and agreed upon by PBNP. This involves the adoption of Generic Letter 87-11 and its associated NRC Mechanical Engineering Branch Technical Position, MEB 3-1, Revision 2. Considerable discussions have taken place in the past on the extent and use of GL 87-11 and its associated MEB 3-1, Rev. 2. Currently, PBNP EQ Program uses a variation of the MEB 3-1 document involving the use of the combined stress threshold for break location of $0.8(1.2\ S_h + S_A)$ to establish the EQ parameters (Reference 4, 5). It is noted that Revision 1 of MEB 3-1 stipulates the above break location threshold limit.

The PBNP FSAR Appendix A.2 (Reference 2) states "Break locations are selected in accordance with Reference 1. Consideration of arbitrary intermediate pipe ruptures is no longer required per NRC Generic Letter 87-11." The Reference 1 stated in the foregoing quotation is the Giambusso Letter of December 19, 1972. The Giambusso criteria included the threshold limit of $0.8(S_h+S_A)$ and other requirements.

PBNP HELB DBD T-47 (Reference 6) provides a detailed discussion of the background history for the break location criteria. Without repeating these details, it is appropriate to state that the HELB location criteria have evolved over the years and there is a realization that these sets of criteria are "non-mechanistic" in nature. In other words, even though the pipe is designed to all design and analysis rules, additional precautions were imposed to provide added assurance for designing the plant SSCs against postulated pipe breaks. To provide a basis for establishing break locations, the AEC and NRC staff promulgated rules that tied these location selections to the stresses in the piping system. As the ASME Section III Piping Code equations (specifically Equations 9 and 10) (Reference 10) evolved so has the break location stress threshold limits. These changes in the break location criteria have led to the numerous discussions cited in the HELB DBD and the differences in the criteria used in the EQ Program and the FSAR citation.

Calc. NO. PBNP-994-21-05-P06, Rev. 0
Attach. C, Page C2

2.0 Line Characterization Criteria and Break Selection Rules

It is noted that the criteria for the identification of HE lines outside containment (Design pressure>275 psi and service temperature > 200°F) and the fact that the current licensing bases of most vintage plants, including PBNP, do not recognize moderate energy lines, are separate and distinct criteria that should not be linked to the break location selection. In other words, changes to the HE break location selection criteria do not automatically require the re-visitation of the criteria for high and moderate energy line characterization. In fact, SRP 3.6.2, GL87-11 and MEB 3-1, Rev. 2 do not address the line characterization criteria, which is reviewed in SRP 3.6.1.

Since the line characterization for line breaks remains the same as stated in the FSAR, the section of MEB 3-1, Rev. 2 pertaining to moderate energy lines do not apply since the PBNP licensing basis does not characterize lines in this category. Similarly, the HE line definition for PBNP remains unchanged and only the lines that satisfy the "and" criteria and the "normally depressurized" rule need to be included in the HELB Program.

3.0 Proposed Unified PBOC Criteria for the PBNP HELB Reconstitution Program

The following criteria for the Pipe Break Outside Containment (PBOC) are proposed for the HELB Reconstitution Program. Adoption and use of this set of criteria will be across all PBNP Programs (EQ, HELB and others).

3.1 Retain the definition that all lines outside containment are designated as ASME Section III Class 2 and 3 as stated in the FSAR, Appendix A.2 and DG-M09 (Reference 9).

3.2 Retain the current definitions for HE lines, which does not require the characterization of lines for moderate energy.

3.3 Adopt the use of GL 87-11 and MEB 3-1, Rev. 2 rules for HE lines only including the rules for break and leakage crack location selection in their entirety. These rules utilize the 1986 ASME Code Equations 9 and 10 with the use of stress indices for dead weight and OBE resultant moments (B_2 indices) and longitudinal pressure (B_1 indices) and stress intensification factors (i) for thermal expansion only. It is noted that the pipe stress analyses compute the resultant moments for the load cases. These resultant moments are independent of which Design Code is used. The code equations or in this case of establishing the break locations, the combined stress equation are computed from the stress resultants based on the specific formulations.

3.4 In addition, IN 2000-20 (Reference 7) clarifies the requirement of postulating a single open crack at the location most damaging to those essential structures and systems.

3.5 Types of breaks and cracks should be in accordance with the MEB 3-1 Section B.3.

3.6 When break criteria are based on stress calculation, it is recommended that breaks and cracks be based on the calculated stresses (Section B.1.c(2)(b)(ii)) and not at each pipe fitting (Section B.1.c(2)(b)(i)) of MEB 3-1, Rev. 2. The stress requirement of Section B.1.c(2)(b)(ii) should be based on the primary piping stress evaluation (Section NC/ND-

3653 of the ASME Code Section III) and local stresses at the integral welded attachments(IWA), where applicable.

3.7 Where breaks locations are selected without the benefit of stress calculations, it is recommended that breaks be postulated at the piping welds to each fitting, valve, or welded attachment.

Calc. No. PBNP-994-21-05-P06, Rev. 0
Attach. C, Page C3

4.0 Regulatory & Licensing Issues

Use of the MEB 3-1 equations to determine break and crack locations does not require prior NRC approval. The 50.59 process and changes to the FSAR would be required.

In order to be compatible with the activities previously performed for the EQ Program, a 50.59 Screening/Evaluation should be performed to accept the use of the of the proposed PBOC criteria for determining break and crack locations.

The proposed PBOC criteria has the potential of eliminating all intermediate large breaks and almost all small breaks (leakage cracks), except the one (single) mandatory crack at the most adverse location. The 50.59 Screening/Evaluation should also address the elimination of the longitudinal crack at the terminal ends required by the Giambusso letter, but eliminated by MEB 3-1.

5.0 Conclusion

The above approach would result in a single unified set of HELB/EQ criteria that would be applicable to all HELB related design parameters for the evaluation plant SSCs. The possible elimination of large breaks should result in lower environmental loads (compartment pressure and temperature) that would result in increasing design margins for the plant SSCs.

The HELB Reconstitution Program will utilize the Proposed PBOC Criteria and systematical address and documents the analysis and results in the various tasks outlined in the Task 1 Report (Reference 8)

6.0 References

1. "General Information Required for Consideration of the Effects of a Piping System Break Outside of Containment", AEC December 19, 1972 (Giambusso Letter)
2. PBNP FSAR Appendix A.2, High Energy Pipe Failure Outside Containment
3. USNRC Generic Letter GL 87-11, Relaxation in Arbitrary Intermediate Pipe Rupture Requirements and associated Revised MEB 3-1 of SRP 3.6.2
4. PBNP Calculation M-09334-357-HE.1
5. PBNP Calculation M-09334-357-HE.2, Rev. 01, High Energy Line Breaks in Selected Piping Systems
6. PBNP HELB DBD T-47, High Energy Line Break Design Basis Document, Rev. 0
7. USNRC Information Notice 2000-20, Potential Loss of Redundant Safety-Related Equipment Because of the Lack of High-Energy Line Break Barriers
8. AES Corp. PBNP HELB Reconstitution Program Task 1 Report, Rev. 0.
9. PBNP Design Guide DG-M09, Rev. 2, Design Requirements for Pipe Stress Analysis.
10. ASME B & PV Code Section III, Subsections NC and ND, 1986 Edition.