ENCLOSURE 1
ATTACHMENT 12

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-994-21-12, REVISION 0, TASK 12 JET IMPINGEMENT CALCULATIONS

189 pages follow

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1. PURPOSE

The purpose of this calculation is to prepare new jet impingement centerline pressure and temperature versus distance calculations utilizing the methodology contained in ANSI/ANS 58.2-1988 [7.1] and the break and crack sizes and operating parameters identified in Tasks 3 and 6 [7.2, 7.3]. This calculation supersedes the extensive discussion of jet impingement methodology provided in FSAR Appendix A.2, Addendum 1 [7.4] to reflect changes in methodologies used to determine HELB parameters, including those used for environmental qualification of equipment outside containment. This is considered an operable but non-conforming condition and is addressed by this calculation.

ANSI/ANS 58.2-1988 [7.1] is used in accordance with Section 3.6.2.III.3.F of NUREG-0800 [7.8] and satisfies the six assumptions stated there:

A. "The jet area expands uniformly at a half angle, not exceeding 10 degrees." This calculation uses 10 degrees.

B. "The impinging jet proceeds along a straight path." That is assumed here.

C. "The total impingement force acting on any cross-sectional area of the jet is time and distance invariant, with a total magnitude equivalent to the jet thrust force as defined in" Section 3.6.2III.2.C(iv) of NUREG-0800 [7.8]. This involves target analysis which is not considered here.

D. "The impingement force is uniformly distributed across the cross-sectional area of the jet, and only the portion intercepted by the target is considered." This involves target analysis which is not considered here.

E. "The break opening may be assumed to be a circular orifice of cross-sectional area equal to the effective flow areas of the break." A circular orifice is assumed here for circumferential breaks; an elliptical one for longitudinal breaks and cracks.

F. "Jet expansion with a zone of five pipe diameters from the break location is acceptable if substantiated by a valid analysis or testing, i.e., Moody's expansion model." Moody's expansion model [7.6] is used here.

2. NOMENCLATURE

A area of the jet

A_a area of the jet at the point at which the fluid has undergone free expansion from the break pressure to a static jet pressure P_a

A_e effective pipe break area

A_j jet area at any location in Regions 1 and 2

A_{je} jet area at the break plane

B exponential parameter in von Glahn empirical relationship between x and α

D_e effective pipe break diameter, the diameter of the effective cross-sectional flow area of the pipe

F_c factor in Region 2 jet centerline pressure equation in ANSI/ANS 58.2-1988 [7.1]

$f(h_o)$ factor in expression for jet pressure at asymptotic plane in ANSI/ANS 58.2-1988 [7.1]

F_2 Region 2 jet impingement centerline pressure graphing factor

g_c conversion factor, 32.174 lbm-ft/lbf-sec^2(Appendix G of El-Wakil [7.5])

G_e mass flux from break

h_f saturated liquid enthalpy

h_{fg} vaporization enthalpy

h_o stagnation enthalpy

J Joule's mechanical equivalent of heat, 778.16 ft-lbf/Btu (El-Wakil [7.5])

L distance from the break

L_a distance to the point at which the fluid has undergone free expansion from the break pressure to static jet pressure P_a

L_c jet core length

L_1 width of break

L_2 length of break

L_{31}	Region 3 graphing parameter
L_{32}	Region 3 graphing parameter
P	jet impingement centerline pressure
P_a	static pressure of the fluid in the jet
P_e	exit pressure
P_o	system pressure prior to pipe break
P_∞	atmospheric pressure
S	slip ratio of liquid and vapor phases
S_e	exit slip ratio of liquid and vapor phases
s_f	saturated liquid entropy
s_{fg}	vaporization entropy
s_g	saturated vapor entropy
s_o	stagnation entropy
T/A_e	jet impingement thrust force per unit effective pipe break area
T_e	Region 3 jet impingement centerline pressure graphing parameter
T_o	system temperature prior to pipe break
T_{sat}	saturation temperature for P_o
v_f	saturated liquid specific volume

v_g saturated vapor specific volume

v_{ma} momentum specific volume at pressure P_a

v_{me} momentum specific volume at pressure P_e

x quality

α vapor volume fraction

ΔT jet subcooling at stagnation conditions in F° at the break plane

Φ divergence angle

3. METHODOLOGY

The methodology discussed in ANSI/ANS 58.2-1988 [7.1] is based on work by Moody [7.6]. The jet is divided into three regions (see Attachment 1). Region 1 extends from the high energy line break to the end of a cone-shaped jet core region within which a target experiences full recovery of the jet stagnation pressure upstream of the break. Region 2 extends from the end of the core to the point at which the discharging fluid experiences free expansion to the static pressure of the fluid in the jet. Normally this static pressure is the ambient pressure in the subsonic region of the jet. Per Assumption [3.1] this is atmospheric pressure. In ANSI/ANS 58.2-1988 [7.1], however, static pressure is not necessarily the ambient pressure in the subsonic region of the jet as will be discussed later. Region 3 begins after Region 2; in Region 3 interaction with the surrounding environment starts and the jet expands at a half-angle of ten degrees (see Assumption [3.2]).

For Region 1 the jet core length, L_c, is related to the jet subcooling at the jet break plane and has been correlated using the following expression [7.2]:

$$L_c/D_e = 0.26(\Delta T)^{1/2} + 0.5 \qquad \text{Equation (1)}$$

where $D_e = (4A_e/\pi)^{1/2}$ Equation (2)

The maximum impingement pressure along the centerline of the jet and the jet centerline temperature are the system pressure and temperature, respectively, prior to pipe break.

In Region 2 the area A_a of the jet at the point at which the fluid has undergone free expansion from the break pressure to a static jet pressure P_a is (see Eqs C-3 and D-2 of ANSI/ANS-58.2 [7.1]):

$$A_a = A_e(G_e^2/g_c)[v_{ma}/(T/A_e)] \qquad \text{Equation (3)}$$

where G_e is given by (Moody [7.6]):

$$G_e=(2g_cJ[h_o-h_f-(h_{fg}/s_{fg})(s_o-s_f)]/\{[S_e(s_g-s_o)v_f/s_{fg}+(s_o-s_f)v_g/s_{fg}]^2[(s_o-s_f)/s_{fg}+(s_g-s_o)/(S_e^2s_{fg})]\})_e^{1/2}$$

Equation (4)

where $S_e = (v_g/v_f)^{1/3}$ Equation (5)

(Moody [7.6])

(Equation (5) is from the Moody critical flow model [7.6]. ANSI/ANS-58.2-1988 [7.1] states that this model is acceptable for flashing of steam water mixtures with qualities greater than zero percent at stagnation conditions at the discharge plane, so this model was used for the cases with saturated stagnation fluid analyzed in this calculation.)

For saturated stagnation fluid the thermodynamic properties are evaluated at the fluid pressure, P_e, for which G_e is a maximum, i.e. for which

$$(dG_e/dP) = 0 \qquad \text{(Moody [7.6])} \qquad \text{Equation (6)}$$

For subcooled stagnation fluid Nuclear Services Corporation feedwater analyses for Prairie Island, which is similar to Point Beach, show that [7.7], immediately after the pipe rupture occurs, exit pressure is equal to the initial pressure. Exit pressure increases until the pressure wave from the break leaves the break volume, after which exit pressure drops down to saturation pressure. Since the flow is isentropic (see Assumption [3.3]), then, for subcooled stagnation fluid the thermodynamic properties are evaluated at the fluid pressure, P_e, for which the saturated liquid entropy, s_f, is equal to the stagnation entropy, s_o.

v_{ma} is given by (see Equation (31) of Moody [7.6]):

$$v_{ma} = [xv_g + (1-x)Sv_f]_a[x+(1-x)/S] \qquad \text{Equation (7)}$$

where $x = (s_o-s_f)/ s_{fg}$ Equation (8)

S is given by (Equation 12-8 of El-Wakil [7.5]):

$$S = [x/(1-x)][(1-\alpha)/\alpha] (v_g/v_f) \qquad \text{Equation (9)}$$

where α can be determined from Von Glahn's relationship [7.5]:

$$1/x = 1-(v_g/v_f)^{0.67}[1-(1/\alpha)^B] \qquad \text{Equation (10)}$$

where $B = (v_g/v_f)^{0.1}$ Equation (11)

T/A_e is given by (see (Eq. D-1) of ANSI/ANS-58.2-1988 [7.1]):

$$T/A_e = G_e^2v_{me}/g_c + (P_e - P_a) \qquad \text{Equation (12)}$$

where v_{me} is given by (see Equation (31) of Moody [7.6]):

$$v_{me} = [xv_g + (1-x)S_e v_f]_e[x+(1-x)/S_e] \qquad \text{Equation (13)}$$

P_a has been correlated using the following expression [7.1]:

$$P_a/P_\infty = 1 - 0.5(1-2\,P_\infty/P_o)f(h_o) \qquad \text{Equation (14)}$$

where $f(h_o) = \{0.1 + [(h_o-h_f)/h_{fg}]\}^{1/2}$ for $[(h_o-h_f)/h_{fg}] > -0.1$ Equation (15)

$= 0$ for $[(h_o-h_f)/h_{fg}] < -0.1$ Equation (16)

where h_f and h_{fg} are evaluated at the stagnation pressure.

In Equation (14), if P_∞/P_o is greater than 0.5, it is taken equal to 0.5.

The distance to the point at which the fluid has undergone free expansion from the break pressure to static jet pressure P_a, L_a, is found by solving the following equation for the area of the elliptically shaped jet (see Assumption [4.7]) for L_a:

$$A_a = [L_1/2 + L_a \tan(\Phi/2)]*[L_2/2 + L_a \tan(\Phi/2)]*\pi \qquad \text{Equation (17)}$$

where, for a circumferential break, $L_1 = L_2 = D_e$, the diameter of the effective cross-sectional flow area of the pipe (see Assumption [3.4]); for a longitudinal break, L_2 is the length of the break (= $2D_e$) and L_1 is the width of the break to give a break area equal to the effective cross-sectional flow area of the pipe upstream of the break location (see Assumptions [3.5] and [3.7]); and, for a crack, L_1 is the width of the break (equal to one-half the pipe wall thickness) and L_2 the length of the break (= $D_e/2$) (see Assumptions [3.6] and [3.7]).

Φ = divergence angle. Depressurization is almost equal in the axial and radial directions so, per ANSI/ANS-58.2-1988 [7.1], the free expansion from P_e to P_a is assumed to be at a divergence half angle of 45 degrees (see Assumption [3.8]). This seems to be allowed by Section 3.6.2III.3.F of NUREG-0800 [7.8]. Therefore, Equation (17) is solved with $\Phi = 90$ degrees. With this divergence angle Equation (17) becomes:

$$A_a = [L_1/2 + L_a]*[L_2/2 + L_a]*\pi \qquad \text{Equation (17a)}$$

If $L_a \le L_c$, there is no Region 2 along the jet centerline; the jet centerline goes directly from Region 1 to Region 3. Whether a case has a Region 2 or not is indicated in the right-hand column of the tables in Attachment 10 with a "Reg. 2?" "Yes" or "No".

For calculating the jet area, A_j, at any location in Regions 1 and 2, at a distance L from the break, Eq. C-6 of ANSI/ANS-58.2-1988 [7.1], in conjunction with Eq. D-2 of that reference, defines a jet area at the break plane, A_{je}, larger than the effective pipe break area, A_e:

$$A_{je} = \{[(T/A_e) + P_\infty]/P_o\}A_e \qquad \text{Equation (18)}$$

Equation (17) can be used, with A substituted for A_a and L substituted for L_a, to obtain an area A which can be adjusted to get A_j:

$$A_j = A + (A_{je} - A_e)(A_a - A)/(A_a - A_e) \qquad \text{Equation (19)}$$

For Region 2, for $L_c < L < L_a$, the jet impingement centerline pressure, P, is given by [7.1]:

$$P/P_o = F_c - (F_c - 3\{[(T/A_e) + P_\infty]/P_o\}A_e/A_a)\, L_a(L - L_c)/[L(L_a - L_c)] \qquad \text{Equation (20)}$$

where $F_c = 1.0$ for $(A_j/A_e) < 6\{[(T/A_e) + P_\infty]/P_o\}$ at $L = L_c$ Equation (21)

$= 6\{[(T/A_e)+P_\infty]/P_o\}(A_e/A_a)$ for $(A_j/A_e) \geq 6\{[(T/A_e) + P_\infty]/P_o\}$ at $L = L_c$ at $L = L_c$ Equation (22)

For ease in graphing the results this can be written as:

$$P = P_o[F_c - F_2(L - L_c)/L] \qquad \text{Equation (23)}$$

where $F_2 = (F_c - 3\{[(T/A_e) + P_\infty]/P_o\}A_e/A_a)L_a/(L_a - L_c)$ Equation (24)

In Region 3, for $L \geq L_a$, Eq. D-13 of ANSI/ANS-58.2-1988 [7.1] in conjunction with the exact form of Eq. D-2 of that reference leads to the following equation for jet impingement centerline pressure:

$$P = 3[(T/A_e) + P_\infty](A_e/A) \qquad \text{Equation (25)}$$

In Region 3 the area of the jet expands beyond A_a (see Equation (17a)) with a divergence angle Φ of 20 degrees (see Assumption 4.2), so A in Equation (25) is given by:

$$A = [L_1/2 + L_a + (L - L_a)\tan(\Phi/2)][L_2/2 + L_a + (L - L_a)\tan(\Phi/2)]\pi \qquad \text{Equation (26)}$$

For ease in graphing the results Equations (25) and (26) can be written as:

$$P = T_e/A \qquad \text{Equation (27)}$$

$$A = [L_{31} + L\tan(\Phi/2)][L_{32} + L\tan(\Phi/2)]\pi \qquad \text{Equation (28)}$$

where $T_e = 3[(T/A_e) + P_\infty]A_e$ Equation (29)

$L_{31} = L_1/2 + L_a(1 - \tan(\Phi/2))$ Equation (30)

$L_{32} = L_2/2 + L_a(1 - \tan(\Phi/2))$ Equation (31)

For Regions 2 and 3 the jet impingement centerline temperature is determined as the saturation temperature for the jet impingement centerline pressure.

Calculating jet impingement centerline pressure, then, over the entire course of the jet involves using Equation (1) to determine the length out to which the centerline pressure is maintained at system pressure prior to pipe break (Region 1), using Equation (23) to determine the pressure from the end of

Region 1 out to the point at which the fluid experiences free expansion to the static pressure of the fluid in the jet (Region 2), and using Equations (27) and (28) for the jet centerline pressure beyond Region 2 (Region 3).

4. ASSUMPTIONS

1. The ambient pressure outside the jet is atmospheric pressure. The atmospheric pressure is calculated in [7.13] to be 14.389 psia.

2. After the fluid in a jet has undergone free expansion from the break pressure to ambient pressure, the jet area expands uniformly at a divergence half angle of 10 degrees (ANSI/ANS-58.2-1988 [7.1], Section 3.6.2.III.3.A of NUREG-0800 [7.8])

3. Flow is ideal gas critical isentropic flow.

4. A circumferential break opening is taken as circular with the effective cross-sectional flow area of the pipe (enclosure to Giambusso letter [7.9], Section B.3.a.(4) of Branch Technical Position MEB 3-1 [7.10])

5. A longitudinal break opening is taken as rectangular with break area equal to the effective cross-sectional flow area of the pipe upstream of the break location and the length of the break equivalent to twice the inside pipe diameter [7.9].

6. A through-wall leakage (small area) crack break opening is taken as a rectangle one-half pipe diameter in length and one-half pipe wall thickness in width (Giambusso letter [7.9], Section B.3.c.(2) of Branch Technical Position MEB 3-1 [7.10]).

7. For longitudinal breaks and small area cracks, at some distance from the point of the crack, the jet assumes an elliptical shape with axes equal to the expanded width and length of the rectangular break (see Figure 7.2(C) of ANSI/ANS-58.2-1988 [7.1]).

5. ACCEPTANCE CRITERION

This calculation prepares new jet impingement centerline pressure and temperature versus distance tables and graphs. Therefore, there is no acceptance criterion.

6. DESIGN INPUT

The break and crack sizes and operating parameters identified in Attachment 2 are evaluated [7.2 and 7.3]. Both circumferential and longitudinal breaks are evaluated.

7. REFERENCES

1. American Nuclear Society, *Design Basis for Protection of Light Water Nuclear Power Plants Against the Effects of Postulated Pipe Rupture*, an American National Standard, ANSI/ANS-58.2-1988, American Nuclear Society, La Grange Park, Illinois, October 6, 1988 (Withdrawn October 6, 1998)

2. AES Corporation PBNP HELB Reconstitution Program Task 3 Report, Revision 0

3. AES Corporation PBNP HELB Reconstitution Program Task 6 Report, Revision 0

4. PBNP FSAR (08/04), Appendix A.2, *High Energy Pipe Failure Outside Containment*, Addendum 1, *Jet and Fluid Forces*

5. M. M. El-Wakil, *Nuclear Heat Transport*, International Textbook Company, Scranton, Pennsylvania, 1971

6. F. J. Moody, "Maximum Flow Rate of a Single Component, Two Phase Mixture", *Transactions of the ASME, Journal of Heat Transfer, Volume 87*, February 1965, pages 134 and following

7. S. Khatri, A. J. Elliott, D. P. Munson, V. K. Chexal, *Prairie Island Unit 1 Pipe Rupture Analyses of Feedwater Piping Outside Containment*, PI0-01-02, prepared for Pioneer Service & Engineering Company by Nuclear Services Corporation, Campbell, California, June 12, 1973

8. *U. S. Nuclear Regulatory Commission Standard Review Plan*, Office of Nuclear Reactor Regulation, NUREG-0800, Revision 2, March 2007

9. Enclosure (*General Information Required for Consideration of the Effects of a Piping System Break Outside Containment*) to letter sent by A. Giambusso, Deputy Director for Reactor Projects, Directorate of Licensing, U. S. Atomic Energy Commission, to Wisconsin Electric, December 19, 1972, with errata sheet

10. *Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment*, Branch Technical Position MEB 3-1, Rev. 2 - June 1987 – see Attachment 15

11. ASME International Steam Tables for Industrial Use based on IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam, published 2000

12. United States Nuclear Regulatory Commission, *Relaxation in Arbitrary Intermediate Pipe Rupture Requirements (Generic Letter 87-11)*, June 19, 1987

13. Automated Engineering Services Calculation Number: 2005-0051, *GOTHIC Model of the PAB*, Rev. 1

8. CALCULATION

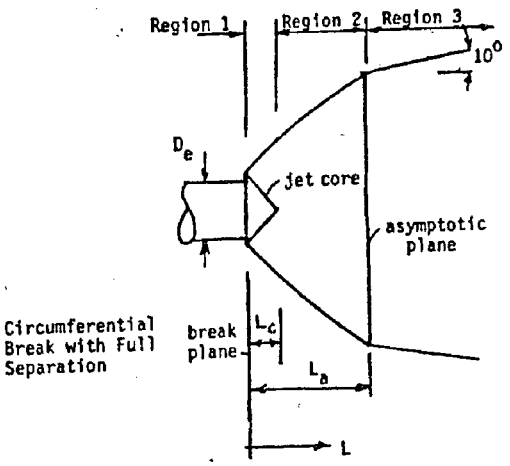
The methodology of Section 2 was applied to the break sizes and operating parameters in Attachment 2 with the assumptions in Section 3. The results are shown in Attachments 3 through 12. New jet impingement centerline pressure and temperature versus distance tables and graphs for all cases are given in Attachment 13.

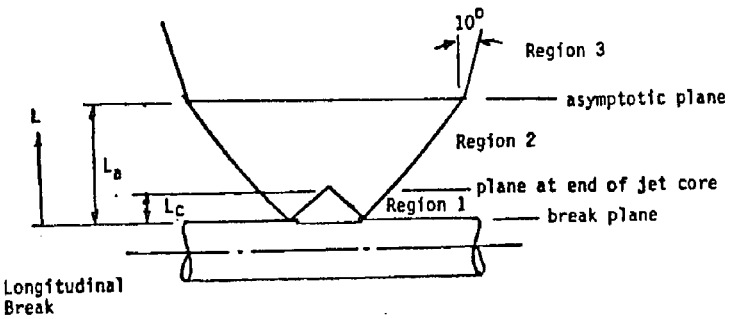
9. CONCLUSION

New jet impingement centerline pressure and temperature versus distance calculations utilizing the methodology contained in ANSI/ANS 58.2-1988 [7.1] and the break and crack sizes and operating parameters identified in Tasks 3 and 6 [7.2, 7.3] have been prepared and are presented in this calculation. This calculation supersedes the extensive discussion of jet impingement methodology provided in FSAR Appendix A.2, Addendum 1 [7.4].

ATTACHMENT 1

Fluid Jet Geometry


Region 1
Region 2
Region 3
10°
D_e
jet core
asymptotic plane
Circumferential Break with Full Separation
break plane
L_c
L_a
L


10°
Region 3
asymptotic plane
L
Region 2
L_a
plane at end of jet core
L_c
Region 1
break plane
Longitudinal Break

ATTACHMENT 2

Break and Crack Sizes and Operating Parameters

FSAR Appendix A.2 identified high energy systems as main steam to various services, feedwater, steam generator blowdown and sampling. The appendix did not address CVCS letdown or other systems in the Turbine Hall. Addendum 1 to the appendix provided a discussion of the methodology for determining jet impingement loads, but only presented the results for a few main steam HELB events.

This calculation is generating jet impingement data for a spectrum of break/crack sizes for main steam, feedwater, steam generator blowdown and CVCS letdown. This task did not generate jet impingement data for the other high energy systems in the Turbine Hall.

The operating parameters for main steam and steam generator blowdown are determined at hot shutdown, which are the same at the current power level and the EPU power level. The operating parameters for CVCS letdown are determined at full power and are the same for both power levels. Therefore, EPU has no effect on jet impingement license basis issues for these systems.

The operating parameters for feedwater are determined at full power and are slightly higher at the EPU power level. FSAR Appendix A.2.8 discusses the routing of the feedwater lines and concludes that there is no safeguard equipment in any of the areas traversed by main feedwater and that wall barriers and drainage are adequate. Therefore, EPU has no effect on the plant license basis.

The only HELB required components identified that are located in the Turbine Hall are associated with the feedwater flow control valves, feedwater pumps and condensate storage tank level. The feedwater components are required to terminate flow to a faulted steam generator (main steam or blowdown HELB event). The EPU Project will be adding a fast closing valve in each feedwater line in the Facade, thereby relegating the flow control valves and feedwater pumps to the status of back-up to the new valves. The condensate storage tank level was identified as a Reg Guide 1.97 component and is mentioned in numerous emergency procedures. However, the auxiliary feedwater pumps are protected by safety related low suction pressure switches located in the safety related portion of the Turbine Hall and can be supplied from the safety-related service water system.

The other identified high energy systems located in the Turbine Hall (condensate, heater drain tank pump discharge, heater drains, etc.) do not require any of the previously mentioned components, except condensate storage tank level. Therefore, it was determined that jet impingement data was not required.

With this background the following cases were analyzed in this calculation.

<u>Break and Crack Sizes</u>

Circumferential break area is equal to the net internal cross-sectional area of the process pipe (Assumption [3.4])

Longitudinal breaks are twice the inside diameter of the process pipe long with a width that would result in area equal to the internal cross-sectional area (Assumption [3.5])

Cracks are one-half the inside diameter of the process pipe long and one-half the pipe wall thickness wide (Assumption [3.6])

Main Steam

Task 6 used the guidance contained in Generic Letter 87-11 to determine the break and crack sizes in the main steam lines outside containment. The significant breaks and cracks occurring at hot shutdown, saturated steam at 1005 psig, 547° F, are as follows:

MS1. 30" Main Line Break at containment and turbine nozzle

MS2. 30" Safety Valve Header crack

MS3. 8" break at Safety Valve Inlet

MS4. 6" break at Power Operated Relief Valve inlet and Dump to Condenser Valve Inlet

MS5. 3" break at Steam Supply to TDAFWP and MSIV By-pass Connection

MS6. 30" Main Steam Line crack at identified locations and most adverse location

MS7. 24" Turbine Inlet and Dump to Condenser crack at identified locations and most adverse location

MS8 16" Dump to Condenser crack at identified locations and most adverse location

Main steam piping is identified as follows (Reference 3):

30.00" O.D. x 0.908" minimum wall thickness (main steam line)
30.00" O.D. x 1.500" minimum wall thickness (safety valve header)
8" through 24": Schedule 60
2-1/2" through 6": Schedule 40

2" and smaller: Schedule 80

Applicable piping internal areas for breaks and cracks in square inches corresponding to the breaks and cracks identified above are as follows.

	Break or Crack Areas in inch^2
MS1 (28.184" ID and 0.908" wall)	623.872
MS2 (27.000" ID and 1.500" wall)	10.125
MS3 (7.813" ID and 0.406" wall)	47.943
MS4 (6.065" ID and 0.280" wall)	28.890
MS5 (3.068" ID and 0.216" wall)	7.393
MS6 (28.184" ID and 0.908" wall)	6.398
MS7 (22.062"ID and 0.969" wall)	5.345
MS8 (14.688" ID and 0.656" wall)	2.409

Steam Generator Blowdown

The significant break and crack occurring at hot shutdown, saturated liquid at 1005 psig, 547° F, are as follows:

BD1. 2" Schedule 80 break

BD2. 2" Schedule 80 crack

Applicable piping internal areas for the break and crack in square inches corresponding to the break and crack identified above are as follows.

	Break or Crack Areas in inch^2
BD1 (1.939" ID and 0.218" wall)	2.953
BD2 (1.939" ID and 0.218" wall)	0.106

CVCS Letdown

The significant break and crack occurring at full power, sub-cooled liquid at 285 psig, 280° F, are as follows:

LD1. 2" Schedule 40 break

LD2. 2" Schedule 40 crack

Applicable piping internal areas for the break and crack in square inches corresponding to the break and crack identified above are as follows.

	Break or Crack Areas in inch^2
LD1 (2.067" ID and 0.154" wall)	3.356
LD2 (2.067" ID and 0.154" wall)	0.080

Feedwater

The significant breaks and cracks occurring at full power, sub-cooled liquid at 905 psig, 365° F, are as follows:

FW1. 6" Schedule 80 break

FW2. 6" Schedule 80 crack

FW3. 16" Schedule 100 break

FW4. 16" Schedule 100 crack

FW5. 20" Schedule 100 break

FW6. 20" Schedule 100 crack

The significant breaks and cracks occurring at full power, sub-cooled liquid at 880 psig, 457° F, are as follows:

FW7. 6" Schedule 80 break

FW8. 6" Schedule 80 crack

FW9. 16" Schedule 100 break

FW10. 16" Schedule 100 crack

FW11. 20" Schedule 100 break

FW12. 20" Schedule 100 crack

Applicable piping internal areas for breaks and cracks in square inches corresponding to the breaks and cracks identified above are as follows.

	Break or Crack Areas in inch^2
FW1, FW7 (5.761" ID and 0.432" wall)	26.067
FW2, FW8 (5.761" ID and 0.432" wall)	0.622
FW3, FW9 (13.938" ID and 1.031" wall)	152.578
FW4, FW10 (13.938" ID and 1.031" wall)	3.593
FW5, FW11 (17.438" ID and 1.281" wall)	238.827
FW6, FW12 (17.438" ID and 1.281" wall)	5.585

ATTACHMENT 3

Region 1 Jet Core Lengths

System	P_o psig (Att. 2)	T_o °F (Att. 2)	T_{sat} °F [7.11]	ΔT F° T_{sat}- T_o	Break/ Crack	A_e in^2 (Att. 2)	D_e in Eq. (2)	L_c in Eq. (1)
MS1	1005	547	547	0	Break	623.872	28.184	14.092
MS2	1005	547	547	0	Crack	10.125	3.590	1.795
MS3	1005	547	547	0	Break	47.943	7.813	3.906
MS4	1005	547	547	0	Break	28.890	6.065	3.032
MS5	1005	547	547	0	Break	7.393	3.068	1.534
MS6	1005	547	547	0	Crack	6.398	2.854	1.427
MS7	1005	547	547	0	Crack	5.345	2.609	1.304
MS8	1005	547	547	0	Crack	2.409	1.751	0.876
BD1	1005	547	547	0	Break	2.953	1.939	0.970
BD2	1005	547	547	0	Crack	0.106	0.367	0.183
LD1	285	280	417	137	Break	3.356	2.067	7.328
LD2	285	280	417	137	Crack	0.080	0.318	1.128
FW1	905	365	535	170	Break	26.067	5.761	22.410
FW2	905	365	535	170	Crack	0.622	0.890	3.462
FW3	905	365	535	170	Break	152.578	13.938	54.219
FW4	905	365	535	170	Crack	3.593	2.139	8.320
FW5	905	365	535	170	Break	238.827	17.438	67.834
FW6	905	365	535	170	Crack	5.585	2.666	10.373
FW7	880	457	531	74	Break	26.067	5.761	15.766
FW8	880	457	531	74	Crack	0.622	0.890	2.435
FW9	880	457	531	74	Break	152.578	13.938	38.143
FW10	880	457	531	74	Crack	3.593	2.139	5.853

System	P_o psig (Att. 2)	T_o °F (Att. 2)	T_{sat} °F [7.11]	ΔT F° T_{sat}- T_o	Break/ Crack	A_e in^2 (Att. 2)	D_e in Eq. (2)	L_c in Eq. (1)
FW11	880	457	531	74	Break	238.827	17.438	47.721
FW12	880	457	531	74	Crack	5.585	2.666	7.298

ATTACHMENT 4

Mass Flux from Breaks

System	Main Steam	SG Blowdown	CVCS Letdown	Feedwater 905/365	Feedwater 880/457
h_o, Btu/lbm [7.11]	1192	546	250	339	438
s_o, Btu/lbmR [7.11]	1.3883	0.7463	0.4095	0.5208	0.6353
P_e, psia (Sect. 2)	579.66	683.64	48.98	160.1	447.4
h_{fe}, Btu/lbm [7.11]	467.4	488.5	248.9	336.1	436.7
h_{fge}, Btu/lbm [7.11]	736.8	713.8	924.9	859.4	768.5
s_{fge}, Btu/lbmR [7.11]	0.7819	0.7434	1.2510	1.0438	0.8395
s_{fe}, Btu/lbmR [7.11]	0.6679	0.6896	0.4095	0.5208	0.6353
s_{ge}, Btu/lbmR [7.11]	1.4498	1.4330	1.6605	1.5646	1.4748
v_{fe}, ft^3/lbm [7.11]	0.0201	0.0205	0.0173	0.0182	0.0195
v_{ge}, ft^3/lbm [7.11]	0.7980	0.6724	8.6838	2.8320	1.0384
S_e, Eq. (5)	3.4136	3.2034	7.9540	5.3833	3.7596
G_e, lbm/sec-ft^2 Eq (4)	2117.7	7960.8	11593	19671	14549

ATTACHMENT 5

Static Pressure of Fluid in Jets

System	h_o Btu/lbm (Att. 2)	h_{fo} Btu/lbm [7.11]	h_{fgo} Btu/lbm [7.11]	$(h_o-h_{fo})/h_{fgo}$	$f(h_o)$ Eq. (15)/(16)	P_o psig (Att. 2)	P_a psia Eq. (14)
Main Steam	1192	545.5	646.3	1	1.05	1005	7.1
SG Blowdown	545.5	545.5	646.3	0	0.316	1005	12.2
CVCS Letdown	249.7	393.8	809.6	-0.178	0	285	14.4
Feedwater 905/365	338.7	529.9	665.6	-0.287	0	905	14.4
Feedwater 880/457	438.3	525.8	670.5	-0.131	0	880	14.4

ATTACHMENT 6

Quality at Static Pressure of Fluid in Jets

System	P_a psia (Att. 5)	s_o Btu/lbmR (Att. 4)	s_{fa} Btu/lbmR [7.11]	s_{fga} Btu/lbmR [7.11]	x_a Eq (8)
Main Steam	7.1	1.3883	0.2587	1.5571	0.7255
SG Blowdown	12.2	0.7463	0.2980	1.4736	0.3042
CVCS Letdown	14.4	0.4095	0.3105	1.4477	0.0684
Feedwater 905/365	14.4	0.5208	0.3105	1.4477	0.1453
Feedwater 880/457	14.4	0.6353	0.3105	1.4477	0.2243

ATTACHMENT 7

Momentum Specific Volume at Static Pressure of Fluid in Jets

System	x_a (Att. 6)	v_{fa} ft³/lbm [7.11]	v_{ga} ft³/lbm [7.11]	B Eq (11)	α_a Eq (10)	S_a Eq (9)	v_{ma} ft³/lbm Eq (7)
Main Steam	0.7255	0.01649	53.25	2.2434	0.99925	6.4099	29.7020
SG Blowdown	0.3042	0.01665	31.95	2.1297	0.99329	5.6683	4.1778
CVCS Letdown	0.0684	0.01671	27.34	2.0960	0.95731	5.3542	0.4732
Feedwater 905/365	0.1453	0.01671	27.34	2.0960	0.98086	5.4271	1.2256
Feedwater 880/457	0.2243	0.01671	27.34	2.0960	0.98861	5.4507	2.2745

ATTACHMENT 8

Jet Impingement Thrust Force per Unit Effective Pipe Break Area

System	Main Steam	SG Blowdown	CVCS Letdown	Feedwater 905/365	Feedwater 880/457
s_o, Btu/lbmR (Att. 4)	1.3883	0.7463	0.4095	0.5208	0.6353
P_e,psia (Att. 4)	579.66	683.64	48.98	160.1	447.4
s_{fe}, Btu/lbmR (Att. 4)	0.6679	0.6896	0.4095	0.5208	0.6353
s_{fge}, Btu/lbmR (Att. 4)	0.7819	0.7434	1.2510	1.0438	0.8395
x_e, Eq (8)	0.9214	0.0762	0	0	0
v_{fe}, ft^3/lbm (Att. 4)	0.0201	0.0205	0.0173	0.0182	0.0195
v_{ge}, ft^3/lbm (Att. 4)	0.7980	0.6724	8.6838	2.8320	1.0384
S_e, (Att. 4)	3.4136	3.2034	7.9540	5.3833	3.7596
v_{me}, ft^3/lbm Eq (13)	0.6995	0.0408	0.0173	0.0182	0.0195
G_e, lbm/sec-ft^2 (Att. 4)	2117.7	7960.8	11593	19671	14549
P_a,psia (Att. 5)	7.1	12.2	14.4	14.4	14.4
T/A_e, psi Eq (12)	1250	1229	535	1662	1326

ATTACHMENT 9

Jet Areas A_a

System	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	A_e in^2 (Att. 2)	G_e, lbm/ sec-ft^2 (Att. 4)	v_{ma} ft^3/lbm (Att. 7)	T/A_e, psi (Att. 8)	A_a ft^2 Eq (3)
MS1	1005	547	Break	623.872	2117.7	29.7020	1250	99.675
MS2	1005	547	Crack	10.125	2117.7	29.7020	1250	1.618
MS3	1005	547	Break	47.943	2117.7	29.7020	1250	7.660
MS4	1005	547	Break	28.890	2117.7	29.7020	1250	4.616
MS5	1005	547	Break	7.393	2117.7	29.7020	1250	1.181
MS6	1005	547	Crack	6.398	2117.7	29.7020	1250	1.022
MS7	1005	547	Crack	5.345	2117.7	29.7020	1250	0.854
MS8	1005	547	Crack	2.409	2117.7	29.7020	1250	0.385
BD1	1005	547	Break	2.953	7960.8	4.1778	1229	0.954
BD2	1005	547	Crack	0.106	7960.8	4.1778	1229	0.034
LD1	285	280	Break	3.356	11593	0.4732	535	0.598
LD2	285	280	Crack	0.080	11593	0.4732	535	0.014
FW1	905	365	Break	26.067	19671	1.2256	1662	11.150
FW2	905	365	Crack	0.622	19671	1.2256	1662	0.266
FW3	905	365	Break	152.578	19671	1.2256	1662	65.264
FW4	905	365	Crack	3.593	19671	1.2256	1662	1.537
FW5	905	365	Break	238.827	19671	1.2256	1662	102.157
FW6	905	365	Crack	5.585	19671	1.2256	1662	2.389
FW7	880	447	Break	26.067	14549	2.2745	1326	14.189
FW8	880	447	Crack	0.622	14549	2.2745	1326	0.339

System	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	A_e in^2 (Att. 2)	G_e, lbm/ sec-ft^2 (Att. 4)	v_{ma} ft^3/lbm (Att. 7)	T/A_e, psi (Att. 8)	A_a ft^2 Eq (3)
FW9	880	447	Break	152.578	14549	2.2745	1326	83.052
FW10	880	447	Crack	3.593	14549	2.2745	1326	1.956
FW11	880	447	Break	238.827	14549	2.2745	1326	130
FW12	880	447	Crack	5.585	14549	2.2745	1326	3.04

ATTACHMENT 10

Distances L_a

Case	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	A_a ft^2 (Att. 9)	L_1 in	L_2 in	L_a in Eq (17)	L_c in (Att. 3)	Reg. 2?
MS1C	1005	547	Circ Brk	99.675	28.184	28.184	53.5006	14.092	Yes
MS1L	1005	547	Long Brk	99.675	11.068	56.368	51.6758	14.092	Yes
MS2	1005	547	Crack	1.618	0.750	13.500	5.6195	1.795	Yes
MS3C	1005	547	Circ Brk	7.660	7.813	7.813	14.8311	3.906	Yes
MS3L	1005	547	Long Brk	7.660	3.068	15.626	14.3253	3.906	Yes
MS4C	1005	547	Circ Brk	4.616	6.065	6.065	11.5130	3.032	Yes
MS4L	1005	547	Long Brk	4.616	2.382	12.130	11.1203	3.032	Yes
MS5C	1005	547	Circ Brk	1.181	3.068	3.068	5.8239	1.534	Yes
MS5L	1005	547	Long Brk	1.181	1.205	6.136	5.6253	1.534	Yes
MS6	1005	547	Crack	1.022	0.454	14.092	4.0105	1.427	Yes
MS7	1005	547	Crack	0.854	0.484	11.031	3.9100	1.304	Yes
MS8	1005	547	Crack	0.385	0.328	7.344	2.6335	0.876	Yes
BD1C	1005	547	Circ Brk	0.954	1.939	1.939	5.6417	0.970	Yes
BD1L	1005	547	Long Brk	0.954	0.761	3.878	5.4970	0.970	Yes
BD2	1005	547	Crack	0.034	0.109	0.970	1.0000	0.183	Yes
LD1C	285	280	Circ Brk	0.598	2.067	2.067	4.2007	7.328	No
LD1L	285	280	Long Brk	0.598	0.812	4.134	4.0631	7.328	No
LD2	285	280	Crack	0.014	0.077	1.034	0.5620	1.128	No
FW1C	905	365	Circ Brk	11.150	5.761	5.761	19.7264	22.410	No
FW1L	905	365	Long Brk	11.150	2.262	11.522	19.2790	22.410	No
FW2	905	365	Crack	0.266	0.216	2.880	2.7815	3.462	No
FW3C	905	365	Circ Brk	65.264	13.938	13.938	47.7255	54.219	No

Case	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	A_a ft^2 (Att. 9)	L_1 in	L_2 in	L_a in Eq (17)	L_c in (Att. 3)	Reg. 2?
FW3L	905	365	Long Brk	65.264	5.473	27.876	46.6432	54.219	No
FW4	905	365	Crack	1.537	0.516	6.969	6.6751	8.320	No
FW5C	905	365	Circ Brk	102.157	17.438	17.438	59.7100	67.834	No
FW5L	905	365	Long Brk	102.157	6.848	34.876	58.3558	67.834	No
FW6	905	365	Crack	2.389	0.640	8.719	8.3170	10.373	No
FW7C	880	457	Circ Brk	14.189	5.761	5.761	22.6218	15.766	Yes
FW7L	880	457	Long Brk	14.189	2.262	11.522	22.1610	15.766	Yes
FW8	880	457	Crack	0.339	0.216	2.880	3.2216	2.435	Yes
FW9C	880	457	Circ Brk	83.052	13.938	13.938	54.7305	38.143	Yes
FW9L	880	457	Long Brk	83.052	5.473	27.876	53.6158	38.143	Yes
FW10	880	457	Crack	1.956	0.516	6.969	7.7329	5.853	Yes
FW11C	880	457	Circ Brk	130	17.438	17.438	68.4740	47.721	Yes
FW11L	880	457	Long Brk	130	6.848	34.876	67.0794	47.721	Yes
FW12	880	457	Crack	3.039	0.640	8.719	9.6356	7.298	Yes

ATTACHMENT 11

Region 2 Jet Impingement Centerline Pressure Graphing Factors

System	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	A_{je} in^2 Eq (18)	A_j/A_e at $L=L_c$ Eqs (17,19)	$6\{[(T/A_e) + P_\infty]/P_o\}$ at $L=L_c$	F_c Eqs (21,22)	F_2 Eq (24)
MS1C	1005	547	Circ Brk	773.618	4.2073	7.4402	1.0	1.1381
MS1L	1005	547	Long Brk	773.618	4.3835	7.4402	1.0	1.1526
MS2	1005	547	Crack	12.555	5.9416	7.4402	1.0	1.2318
MS3C	1005	547	Circ Brk	59.451	4.2068	7.4402	1.0	1.1380
MS3L	1005	547	Long Brk	59.451	4.3829	7.4402	1.0	1.1526
MS4C	1005	547	Circ Brk	35.825	4.2067	7.4402	1.0	1.1380
MS4L	1005	547	Long Brk	35.825	4.3827	7.4402	1.0	1.1526
MS5C	1005	547	Circ Brk	9.167	4.2073	7.4402	1.0	1.1381
MS5L	1005	547	Long Brk	9.167	4.3835	7.4402	1.0	1.1526
MS6	1005	547	Crack	7.933	7.0575	7.4402	1.0	1.3013
MS7	1005	547	Crack	6.627	6.3816	7.4402	1.0	1.2578
MS8	1005	547	Crack	2.987	6.3524	7.4402	1.0	1.2561
BD1C	1005	547	Circ Brk	3.602	4.2073	7.3181	1.0	1.1126
BD1L	1005	547	Long Brk	3.602	4.3847	7.3181	1.0	1.1187
BD2	1005	547	Crack	0.129	4.9164	7.3181	1.0	1.1277
FW7C	880	457	Circ Brk	39.059	42.1393	8.9906	0.1147	0.1892
FW7L	880	457	Long Brk	39.059	44.0616	8.9906	0.1147	0.1987
FW8	880	457	Crack	0.932	49.9437	8.9906	0.1147	0.2349
FW9C	880	457	Circ Brk	228.628	42.1378	8.9906	0.1147	0.1892
FW9L	880	457	Long Brk	228.628	44.0601	8.9906	0.1147	0.1987

System	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	A_{je} in^2 Eq (18)	A_j/A_e at $L=L_c$ Eqs (17,19)	$6\{[(T/A_e) + P_\infty]/P_o\}$ at $L=L_c$	F_c Eqs (21,22)	F_2 Eq (24)
FW10	880	457	Crack	5.383	50.0806	8.9906	0.1147	0.2359
FW11C	880	457	Circ Brk	357.868	42.1375	8.9906	0.1147	0.1892
FW11L	880	457	Long Brk	357.868	44.0598	8.9906	0.1147	0.1987
FW12	880	457	Crack	8.368	50.1433	8.9906	0.1147	0.2364

ATTACHMENT 12

Region 3 Jet Impingement Centerline Pressure Graphing Parameters

System	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	T_e lbf Eq (29)	L_{31} in Eq (30)	L_{32} in Eq (31)
MS1C	1005	547	Circ Brk	2365852	58.159	58.159
MS1L	1005	547	Long Brk	2365852	48.098	70.748
MS2	1005	547	Crack	38396	5.004	11.379
MS3C	1005	547	Circ Brk	181810	16.122	16.122
MS3L	1005	547	Long Brk	181810	13.333	19.612
MS4C	1005	547	Circ Brk	109558	12.515	12.515
MS4L	1005	547	Long Brk	109558	10.350	15.224
MS5C	1005	547	Circ Brk	28035	6.331	6.331
MS5L	1005	547	Long Brk	28035	5.236	7.701
MS6	1005	547	Crack	24262	3.530	10.349
MS7	1005	547	Crack	20268	3.463	8.736
MS8	1005	547	Crack	9135	2.333	5.841
BD1C	1005	547	Circ Brk	11014	5.616	5.616
BD1L	1005	547	Long Brk	11014	4.908	6.467
BD2	1005	547	Crack	394	0.878	1.308
LD1C	285	280	Circ Brk	5533	4.494	4.494
LD1L	285	280	Long Brk	5533	3.752	5.414
LD2	285	280	Crack	131	0.501	0.980
FW1C	905	365	Circ Brk	131087	19.129	19.129
FW1L	905	365	Long Brk	131087	17.011	21.641
FW2	905	365	Crack	3129	2.399	3.731
FW3C	905	365	Circ Brk	767300	46.279	46.279

System	P_o psig (Att. 2)	T_o °F (Att. 2)	Break/ Crack	T_e lbf Eq (29)	L_{31} in Eq (30)	L_{32} in Eq (31)
FW3L	905	365	Long Brk	767300	41.155	52.357
FW4	905	365	Crack	18066	5.756	8.983
FW5C	905	365	Circ Brk	1201040	57.900	57.900
FW5L	905	365	Long Brk	1201040	51.490	65.504
FW6	905	365	Crack	28084	7.171	11.210
FW7C	880	457	Circ Brk	104803	21.514	21.514
FW7L	880	457	Long Brk	104803	19.385	24.014
FW8	880	457	Crack	2502	2.762	4.094
FW9C	880	457	Circ Brk	613448	52.049	52.049
FW9L	880	457	Long Brk	613448	46.899	58.100
FW10	880	457	Crack	14444	6.627	9.854
FW11C	880	457	Circ Brk	960218	65.119	65.119
FW11L	880	457	Long Brk	960218	58.675	72.690
FW12	880	457	Crack	22453	8.257	12.296

ATTACHMENT 13

Tables and Graphs of Pressure/Temperature Versus Distance

30" MAIN LINE CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
0		1005	547
1.17		1005	547
2		526	475
3		299	421
4.46	100	150	366
5	103	145	363
6	110	136	358
7	116	127	354
8	123	119	349
9	130	112	345
10	137	105	341
11	145	99.2	337
12	152	93.5	333
13	160	88.2	330
14	168	83.3	326
15	176	78.8	323
16	185	74.6	319
17	193	70.6	316
18	202	66.9	313
19	211	63.4	310
20	220	60.2	307
21	230	57.2	304
22	239	54.3	302
23	249	51.6	299
24	259	49.1	296
25	269	46.7	294
26	279	44.4	291
27	290	42.3	289
28	301	40.2	287
29	312	38.3	284
30	323	36.5	282
31	334	34.8	280
32	346	33.1	278
33	357	31.6	276
34	369	30.1	274
35	381	28.7	272
36	394	27.3	270

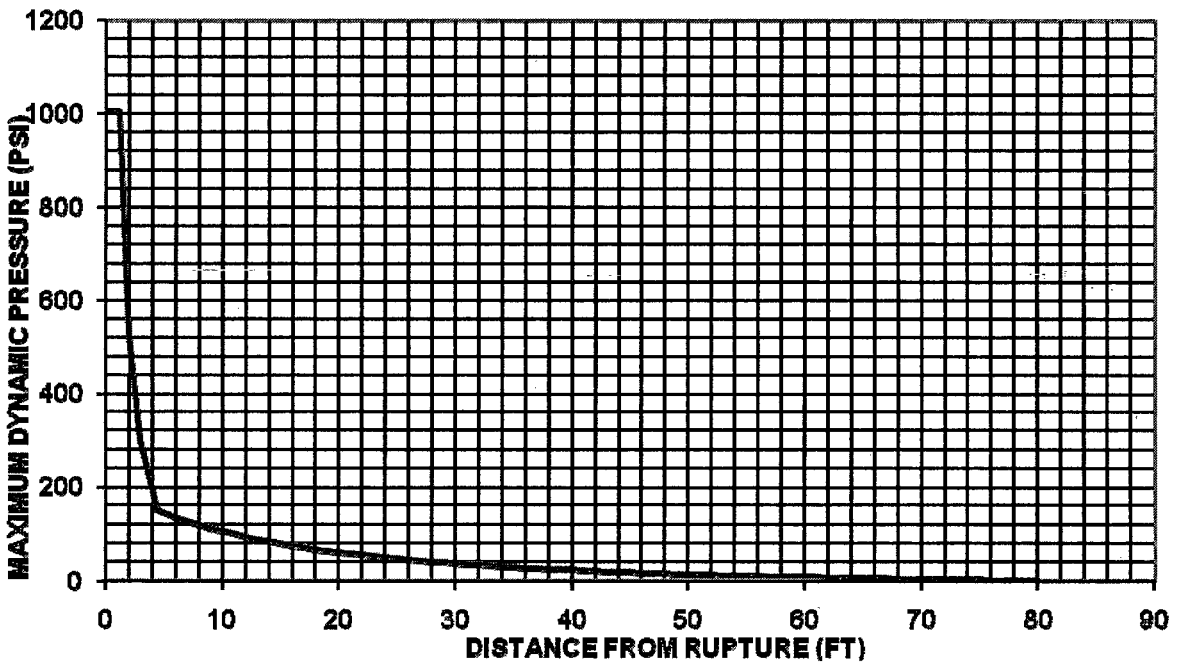
30" MAIN LINE CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
37	406	26.1	268
38	419	24.8	266
39	432	23.7	264
40	445	22.5	262
41	458	21.5	261
42	472	20.4	259
43	485	19.5	257
44	499	18.5	256
45	513	17.6	254
46	527	16.8	252
47	542	15.9	251
48	557	15.1	249
49	571	14.4	248
50	586	13.6	246
51	602	12.9	245
52	617	12.2	244
53	633	11.6	242
54	649	10.9	241
55	665	10.3	239
56	681	9.7	238
57	697	9.2	237
58	714	8.6	235
59	731	8.1	234
60	748	7.6	233
61	765	7.1	232
62	782	6.6	231
63	800	6.2	229
64	818	5.7	228
65	835	5.3	227
66	854	4.9	226
67	872	4.5	225
68	891	4.1	224
69	909	3.7	223
70	928	3.3	221
71	947	3.0	220
72	967	2.6	219
73	986	2.3	218
74	1006	1.9	217

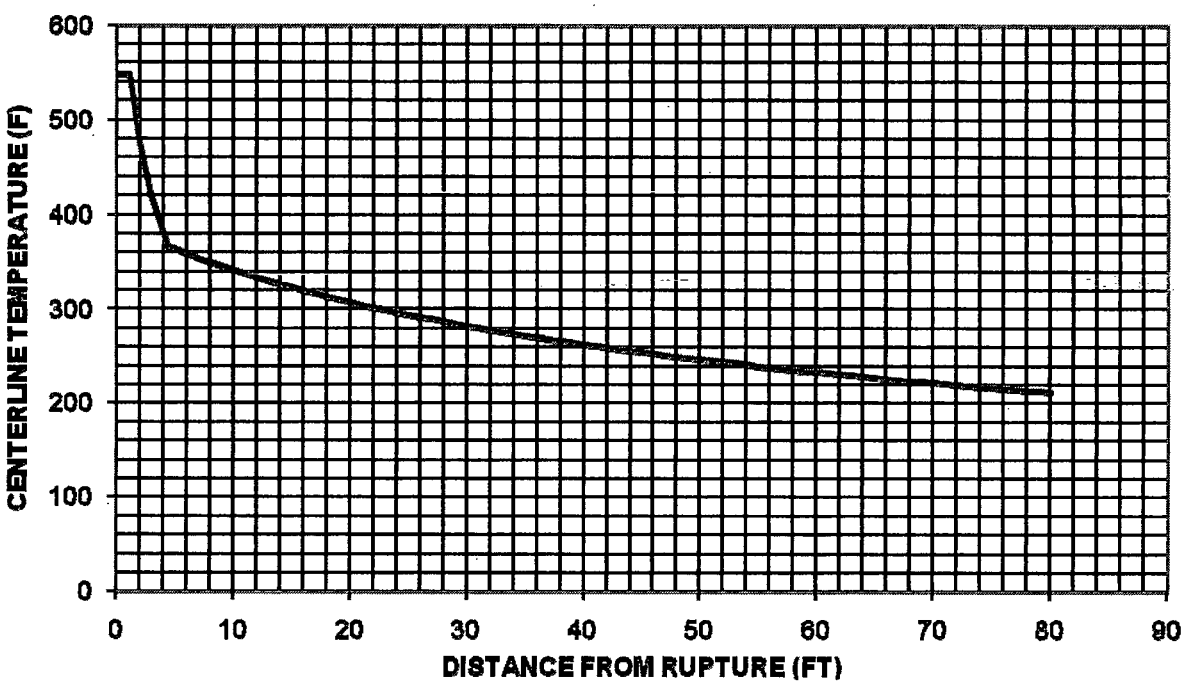
30" MAIN LINE CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
75	1026	1.6	216
76	1046	1.3	215
77	1066	1.0	214
78	1087	0.7	213
79	1108	0.4	212
80	1128	0.2	211

PRESSURE VERSUS DISTANCE, 30" MAIN LINE CIRCUMFERENTIAL BREAK



TEMPERATURE VERSUS DISTANCE, 30" MAIN LINE CIRCUMFERENTIAL BREAK



30" MAIN LINE LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
0		1005	547
1.17		1005	547
2		520	474
3		290	419
4.31	100	150	366
5	104	143	362
6	111	134	358
7	117	126	353
8	124	118	349
9	132	111	344
10	139	104	340
11	146	97.8	336
12	154	92.2	332
13	162	87.0	329
14	170	82.1	325
15	179	77.6	322
16	187	73.5	319
17	196	69.5	315
18	205	65.9	312
19	214	62.5	309
20	223	59.3	306
21	233	56.3	304
22	242	53.4	301
23	252	50.8	298
24	262	48.3	296
25	272	45.9	293
26	283	43.7	291
27	294	41.6	288
28	304	39.6	286
29	315	37.7	284
30	327	35.9	281
31	338	34.2	279
32	350	32.6	277
33	362	31.0	275
34	374	29.6	273

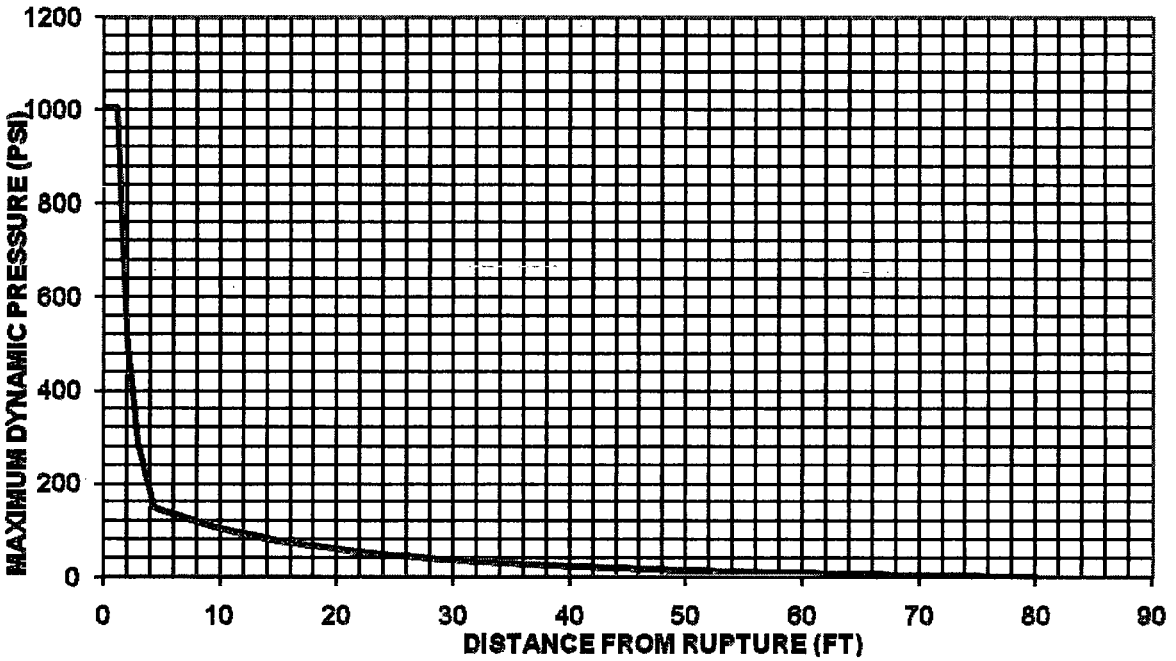
30" MAIN LINE LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
35	386	28.2	271
36	398	26.9	269
37	411	25.6	267
38	424	24.4	265
39	437	23.2	264
40	450	22.1	262
41	463	21.1	260
42	477	20.1	258
43	491	19.1	257
44	505	18.2	255
45	519	17.3	253
46	533	16.4	252
47	548	15.6	250
48	563	14.8	249
49	578	14.1	247
50	593	13.3	246
51	608	12.6	244
52	624	12.0	243
53	639	11.3	242
54	655	10.7	240
55	671	10.1	239
56	688	9.5	238
57	704	8.9	236
58	721	8.4	235
59	738	7.9	234
60	755	7.4	232
61	772	6.9	231
62	790	6.4	230
63	808	6.0	229
64	825	5.5	228
65	844	5.1	227
66	862	4.7	225
67	880	4.3	224
68	899	3.9	223
69	918	3.5	222
70	937	3.1	221
71	956	2.8	220
72	976	2.5	219

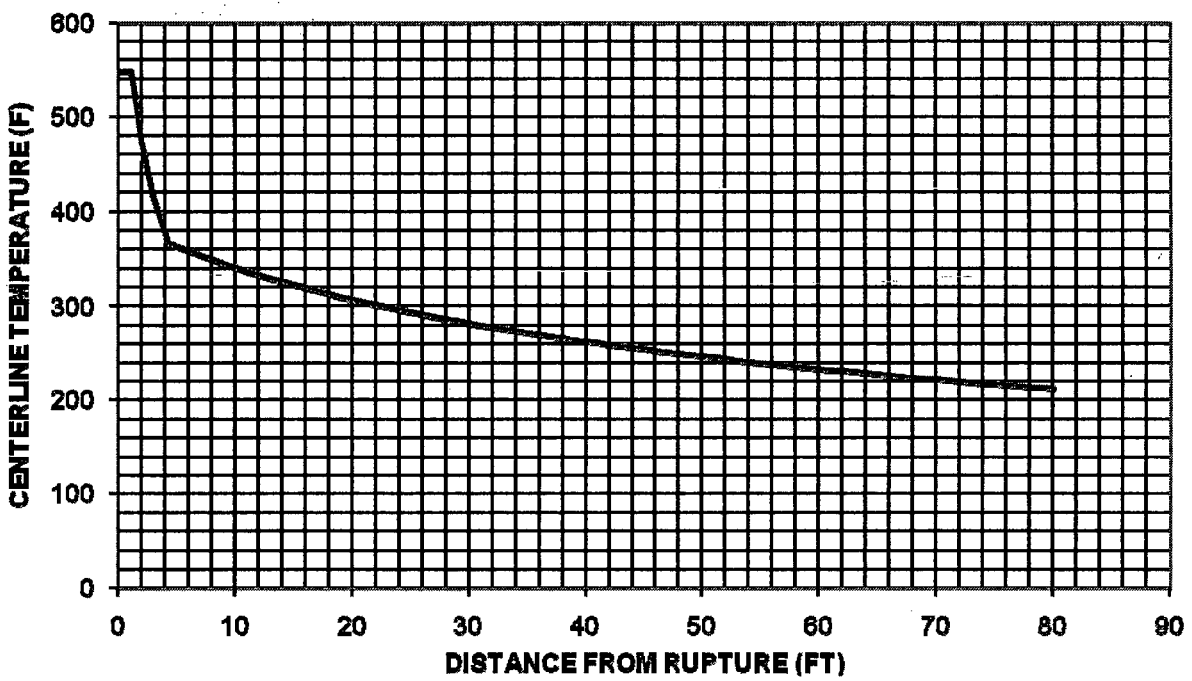
30" MAIN LINE LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
73	995	2.1	218
74	1015	1.8	217
75	1035	1.5	216
76	1055	1.2	215
77	1076	0.9	214
78	1096	0.6	213
79	1117	0.3	212
80	1138	0.0	211

PRESSURE VERSUS DISTANCE, 30" MAIN LINE LONGITUDINAL BREAK



TEMPERATURE VERSUS DISTANCE, 30" MAIN LINE LONGITUDINAL BREAK

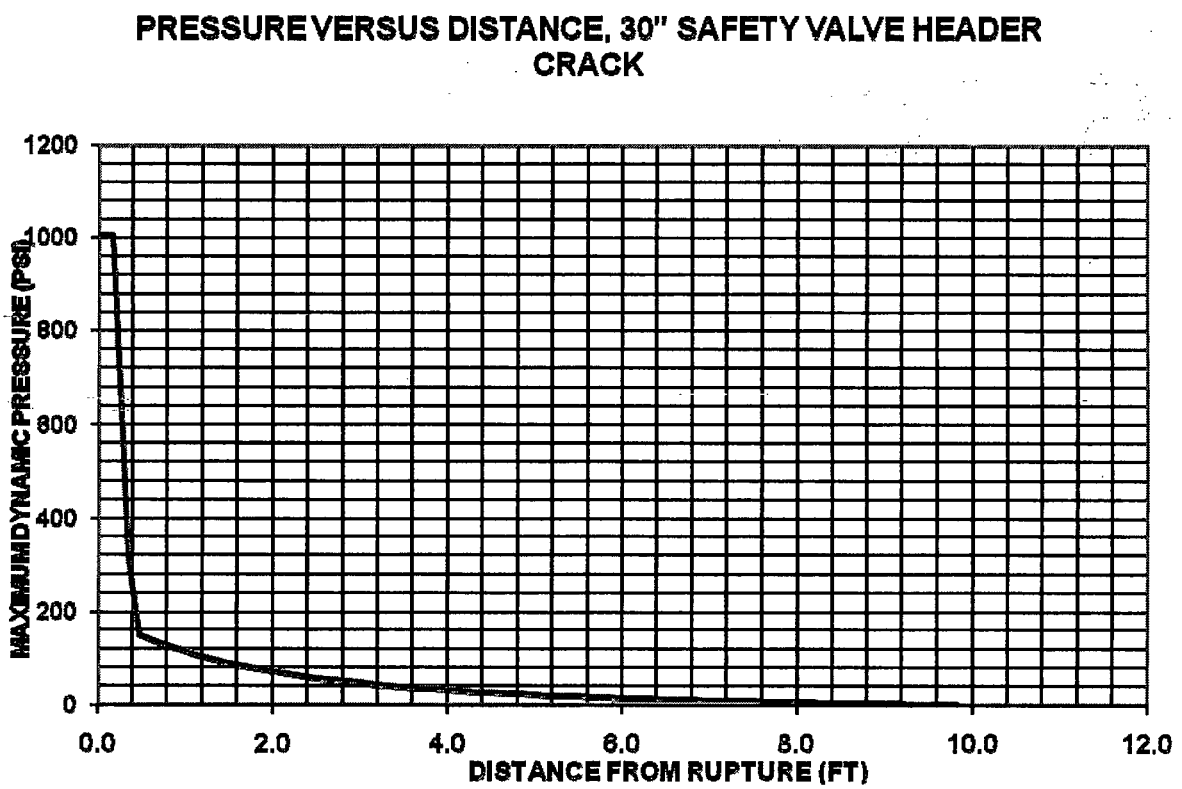


30" SAFETY VALVE HEADER CRACK

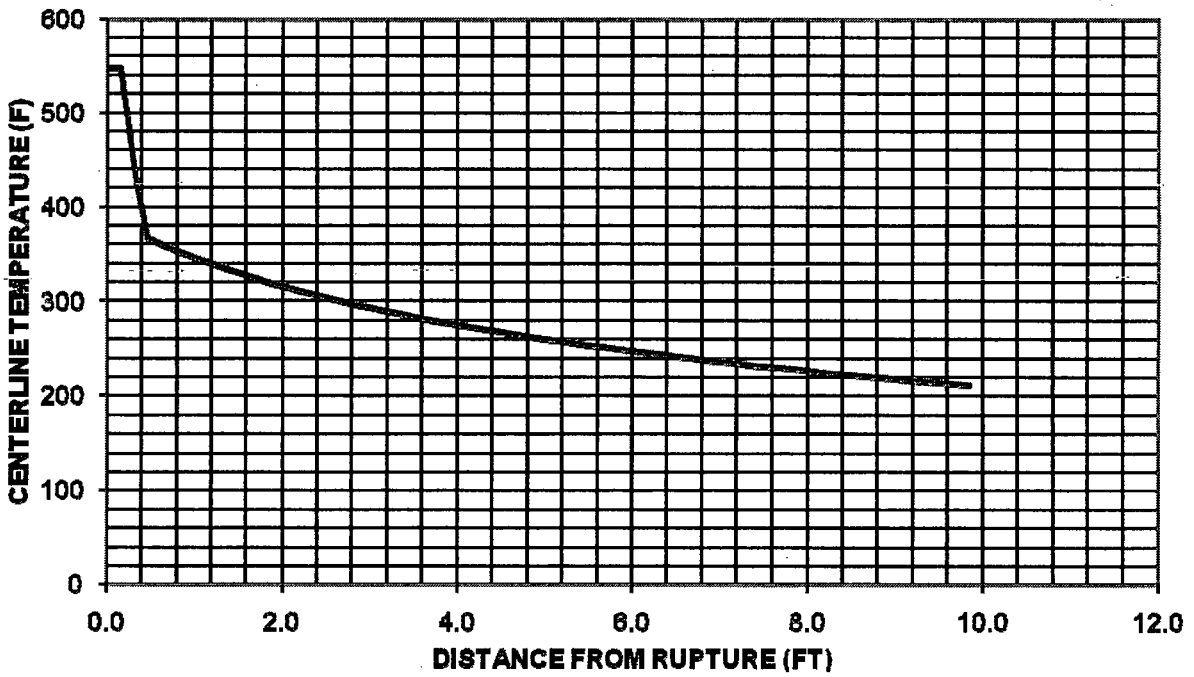
L FT	A SQ FT	P PSI	T F
0.0		1005	547
0.15		1005	547
0.3		313	425
0.47	1.6	150	366
0.7	1.8	135	358
0.8	1.9	123	352
1.0	2.1	113	346
1.2	2.3	104	340
1.3	2.4	95.6	335
1.5	2.6	88.3	330
1.7	2.8	81.7	325
1.8	3.0	75.8	320
2.0	3.1	70.4	316
2.2	3.3	65.5	312
2.3	3.5	61.0	308
2.5	3.7	56.8	304
2.7	4.0	53.1	300
2.8	4.2	49.6	297
3.0	4.4	46.4	293
3.2	4.6	43.4	290
3.3	4.8	40.6	287
3.5	5.1	38.0	284
3.7	5.3	35.7	281
3.8	5.6	33.4	278
4.0	5.8	31.3	275
4.2	6.1	29.4	273
4.3	6.4	27.6	270
4.5	6.6	25.9	268
4.7	6.9	24.3	265
4.8	7.2	22.8	263
5.0	7.5	21.3	260
5.2	7.8	20.0	258
5.3	8.1	18.7	256
5.5	8.4	17.5	254
5.7	8.7	16.4	252

30" SAFETY VALVE HEADER CRACK

L FT	A SQ FT	P PSI	T F
5.8	9.0	15.3	250
6.0	9.3	14.3	248
6.2	9.6	13.3	246
6.3	9.9	12.4	244
6.5	10.3	11.5	242
6.7	10.6	10.7	240
6.8	11.0	9.9	238
7.0	11.3	9.2	237
7.2	11.7	8.4	235
7.3	12.0	7.8	233
7.5	12.4	7.1	232
7.7	12.8	6.5	230
7.8	13.2	5.9	229
8.0	13.5	5.3	227
8.2	13.9	4.7	226
8.3	14.3	4.2	224
8.5	14.7	3.7	223
8.7	15.1	3.2	221
8.8	15.5	2.8	220
9.0	16.0	2.3	218
9.2	16.4	1.9	217
9.3	16.8	1.5	216
9.5	17.2	1.1	215
9.7	17.7	0.7	213
9.8	18.1	0.3	212


PRESSURE VERSUS DISTANCE, 30" SAFETY VALVE HEADER CRACK
MAXIMUM DYNAMIC PRESSURE (PSI)
1200
1000
800
600
400
200
0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
DISTANCE FROM RUPTURE (FT)

TEMPERATURE VERSUS DISTANCE, 30" SAFETY VALVE HEADER CRACK



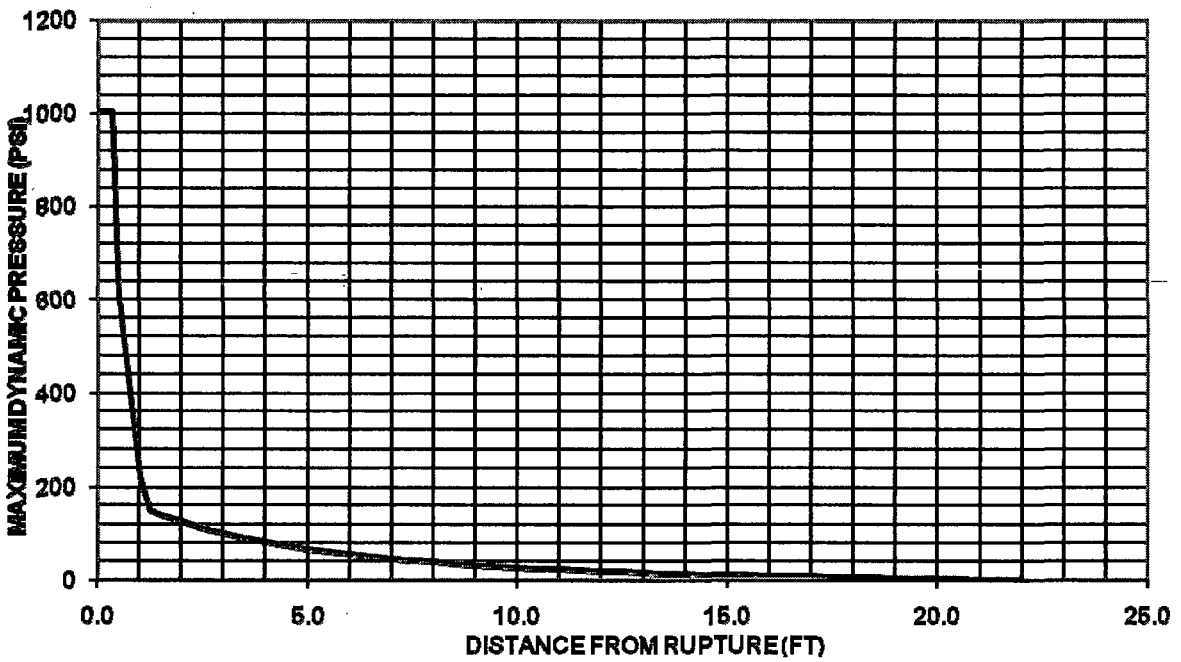
8" MAIN STEAM CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
0.0		1005	547
0.33		1005	547
0.5		600	489
1.0		223	396
1.24	7.7	150	366
1.5	8.1	141	361
2.0	9.0	125	353
2.5	10	112	345
3.0	11	100	338
3.5	12	90	331
4.0	13	81	325
4.5	14	74	319
5.0	16	67	313
5.5	17	61	308
6.0	18	55	303
6.5	19	50	298
7.0	21	46	293
7.5	22	42	289
8.0	24	39	285
8.5	25	35	281
9.0	27	32	277
9.5	29	30	273
10.0	30	27	270
10.5	32	25	266
11.0	34	23	263
11.5	36	21	260
12.0	38	19	257
12.5	40	18	254
13.0	42	16	251
13.5	44	15	248
14.0	46	13	246
14.5	48	12	243
15.0	50	11	241
15.5	52	10	238
16.0	54	8.8	236

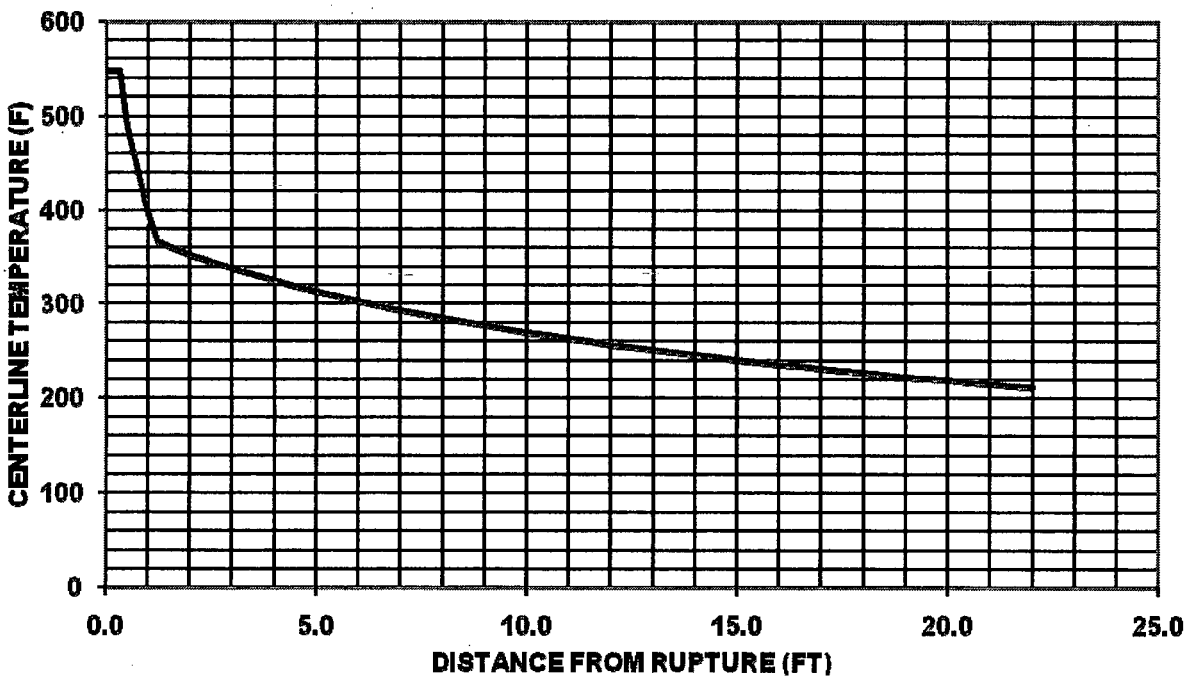
8" MAIN STEAM CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
16.5	57	7.8	234
17.0	59	6.9	231
17.5	62	6.1	229
18.0	64	5.3	227
18.5	67	4.6	225
19.0	69	3.9	223
19.5	72	3.2	221
20.0	75	2.6	219
20.5	77	2.0	217
21.0	80	1.4	216
21.5	83	0.9	214
22.0	86	0.3	212

PRESSURE VERSUS DISTANCE, 8" MAIN STEAM CIRCUMFERENTIAL BREAK



TEMPERATURE VERSUS DISTANCE, 8" MAIN STEAM CIRCUMFERENTIAL BREAK



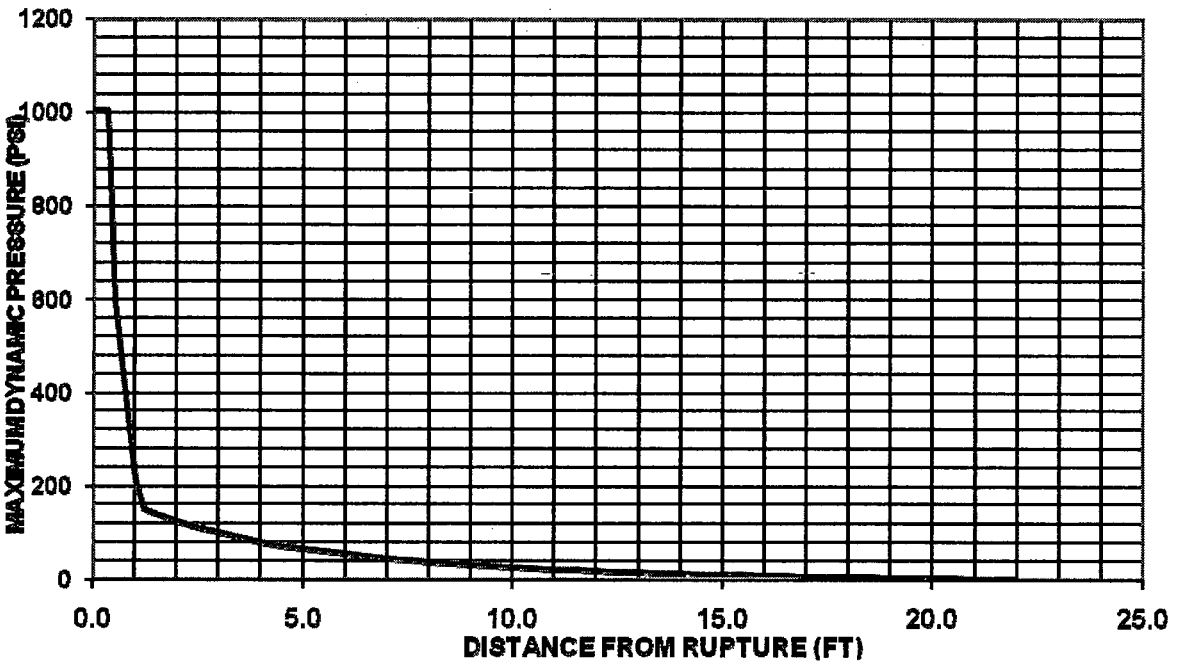
8" MAIN STEAM LONGITUDINAL BREAK

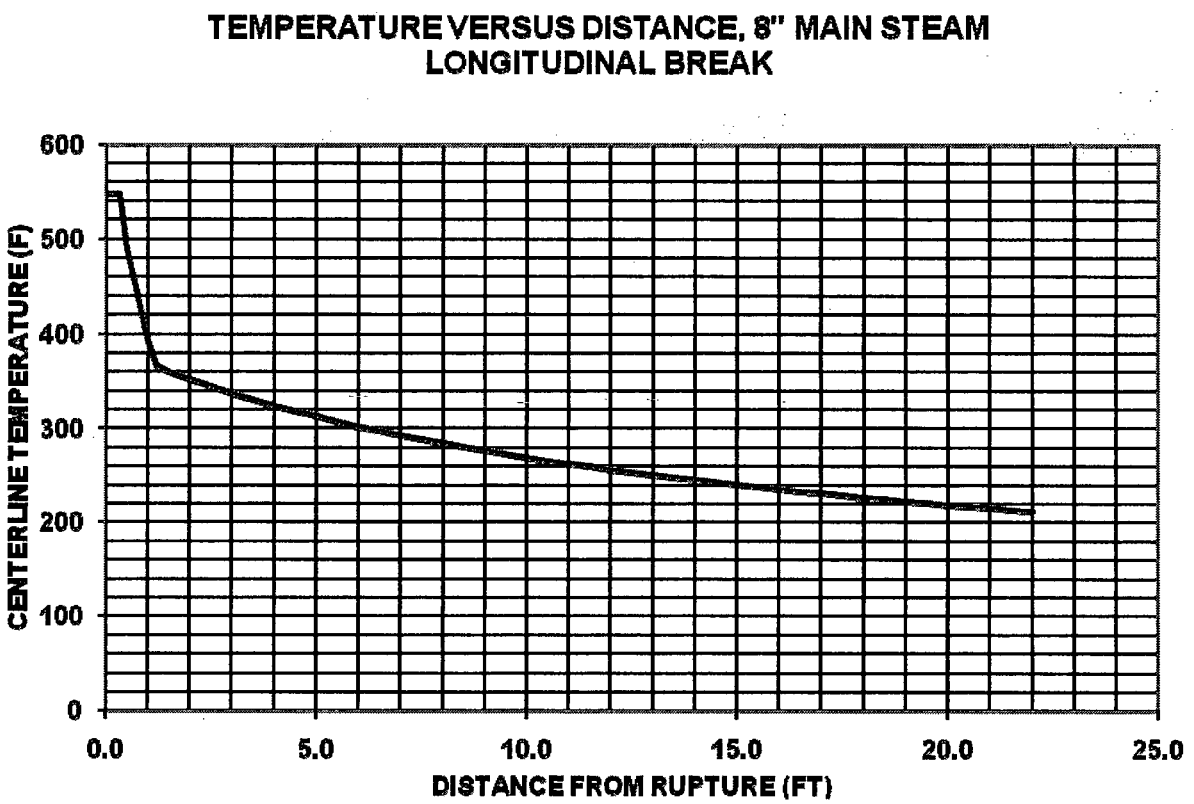
L FT	A SQ FT	P PSI	T F
0.0		1005	547
0.33		1005	547
0.5		595	488
1.0		212	393
1.19	7.7	150	366
1.5	8.2	139	360
2.0	9.1	124	352
2.5	10.1	110	344
3.0	11.1	99	337
3.5	12.2	89	330
4.0	13.4	80	324
4.5	14.5	73	318
5.0	15.8	66	312
5.5	17.0	60	307
6.0	18.3	54	302
6.5	19.7	50	297
7.0	21.1	45	292
7.5	22.6	41	288
8.0	24.1	38	284
8.5	25.7	35	280
9.0	27.3	32	276
9.5	29.0	29	272
10.0	30.7	27	269
10.5	32.4	25	266
11.0	34.3	22	262
11.5	36.1	21	259
12.0	38.0	19	256
12.5	40.0	17	253
13.0	42.0	16	250
13.5	44.0	14	248
14.0	46.1	13	245
14.5	48.3	12	243
15.0	50.5	11	240
15.5	52.7	10	238
16.0	55.0	8.5	235

8" MAIN STEAM LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
16.5	57.4	7.6	233
17.0	59.8	6.7	231
17.5	62.2	5.9	229
18.0	64.7	5.1	227
18.5	67.3	4.4	225
19.0	69.9	3.7	223
19.5	72.5	3.0	221
20.0	75.2	2.4	219
20.5	77.9	1.8	217
21.0	80.7	1.3	215
21.5	83.6	0.7	213
22.0	86.4	0.2	212

PRESSURE VERSUS DISTANCE, 8" MAIN STEAM LONGITUDINAL BREAK




TEMPERATURE VERSUS DISTANCE, 8" MAIN STEAM LONGITUDINAL BREAK
CENTERLINE TEMPERATURE (F)
600
500
400
300
200
100
0
0.0
5.0
10.0
15.0
20.0
25.0
DISTANCE FROM RUPTURE (FT)

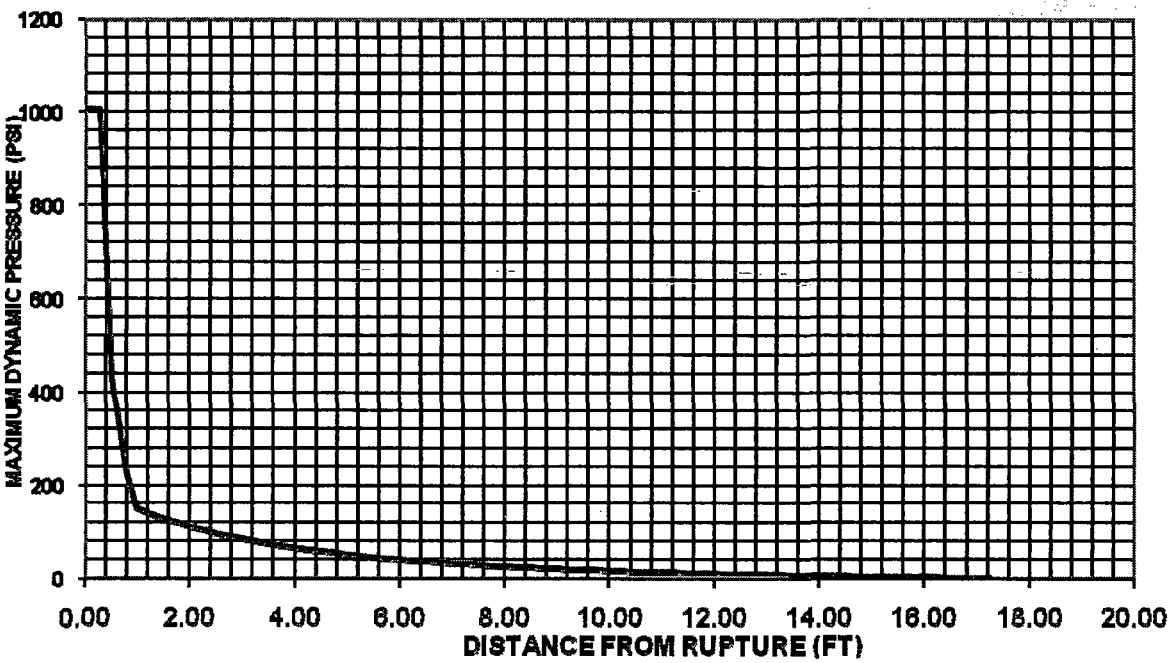
6" MAIN STEAM CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.25		1005	547
0.50		431	455
0.75		236	401
0.96	4.6	150	366
1.25	5.0	137	359
1.50	5.4	127	354
1.75	5.7	118	349
2.00	6.1	110	344
2.25	6.5	102	339
2.50	6.9	95.6	335
2.75	7.3	89.4	330
3.00	7.8	83.6	326
3.25	8.2	78.3	322
3.50	8.7	73.5	319
3.75	9.1	69.0	315
4.00	9.6	64.8	311
4.25	10.1	61.0	308
4.50	10.6	57.4	305
4.75	11.1	54.1	301
5.00	11.6	51.0	298
5.25	12.2	48.1	295
5.50	12.7	45.4	292
5.75	13.3	42.9	290
6.00	13.9	40.5	287
6.25	14.5	38.2	284
6.50	15.1	36.1	282
6.75	15.7	34.2	279
7.00	16.3	32.3	277
7.25	16.9	30.6	274
7.50	17.6	28.9	272
7.75	18.2	27.3	270
8.00	18.9	25.8	268
8.25	19.6	24.4	265
8.50	20.3	23.1	263

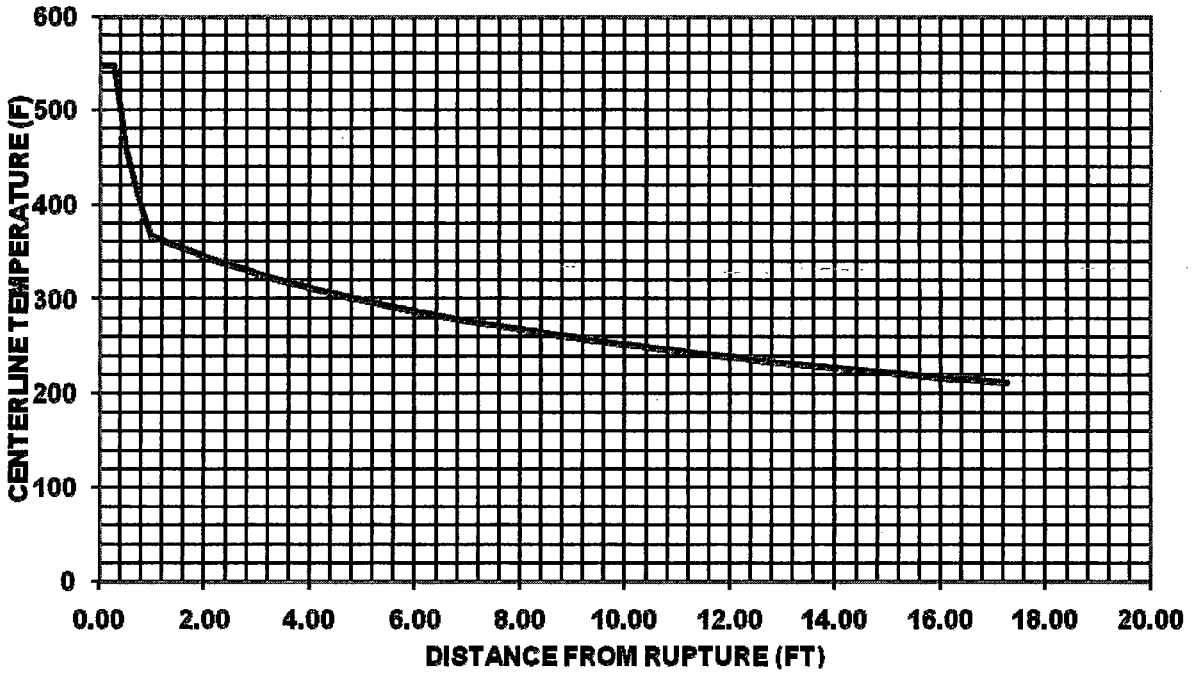
6" MAIN STEAM CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
8.75	21.0	21.8	261
9.00	21.7	20.6	259
9.25	22.5	19.5	257
9.50	23.2	18.4	255
9.75	24.0	17.4	254
10.00	24.7	16.4	252
10.25	25.5	15.4	250
10.50	26.3	14.5	248
10.75	27.1	13.7	246
11.00	27.9	12.8	245
11.25	28.8	12.0	243
11.50	29.6	11.3	242
11.75	30.5	10.6	240
12.00	31.3	9.9	238
12.25	32.2	9.2	237
12.50	33.1	8.6	235
12.75	34.0	8.0	234
13.00	34.9	7.4	232
13.25	35.9	6.8	231
13.50	36.8	6.3	230
13.75	37.8	5.8	228
14.00	38.7	5.3	227
14.25	39.7	4.8	226
14.50	40.7	4.3	224
14.75	41.7	3.9	223
15.00	42.7	3.4	222
15.25	43.8	3.0	221
15.50	44.8	2.6	219
15.75	45.8	2.2	218
16.00	46.9	1.8	217
16.25	48.0	1.5	216
16.50	49.1	1.1	215
16.75	50.2	0.8	214
17.00	51.3	0.4	212
17.25	52.4	0.1	211

PRESSURE VERSUS DISTANCE, 6" MAIN STEAM CIRCUMFERENTIAL BREAK



TEMPERATURE VERSUS DISTANCE, 6" MAIN STEAM CIRCUMFERENTIAL BREAK



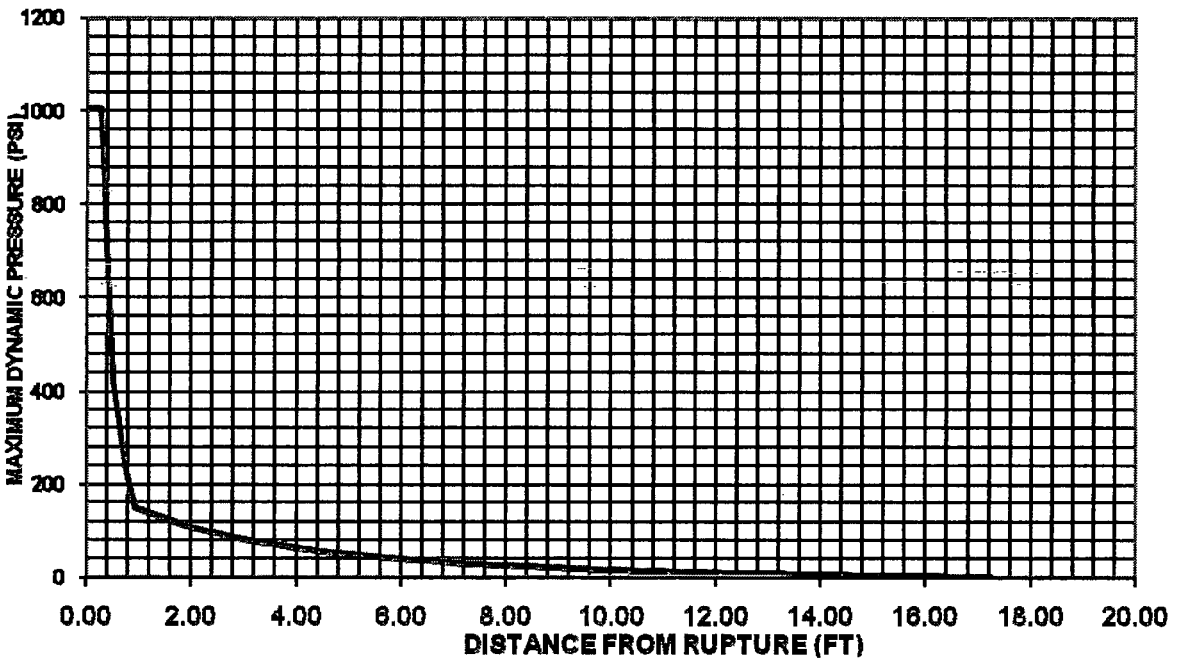
6" MAIN STEAM LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.25		1005	547
0.50		424	454
0.75		226	398
0.93	4.6	150	366
1.25	5.1	136	359
1.50	5.4	126	353
1.75	5.8	117	348
2.00	6.2	109	343
2.25	6.6	101	338
2.50	7.0	94.3	334
2.75	7.4	88.1	330
3.00	7.9	82.4	325
3.25	8.3	77.2	322
3.50	8.8	72.4	318
3.75	9.2	68.0	314
4.00	9.7	63.9	311
4.25	10.2	60.1	307
4.50	10.7	56.5	304
4.75	11.2	53.2	301
5.00	11.8	50.2	298
5.25	12.3	47.3	295
5.50	12.9	44.7	292
5.75	13.5	42.2	289
6.00	14.0	39.8	286
6.25	14.6	37.6	283
6.50	15.2	35.5	281
6.75	15.9	33.6	278
7.00	16.5	31.8	276
7.25	17.1	30.0	274
7.50	17.8	28.4	271
7.75	18.5	26.8	269
8.00	19.1	25.4	267
8.25	19.8	24.0	265
8.50	20.5	22.7	263

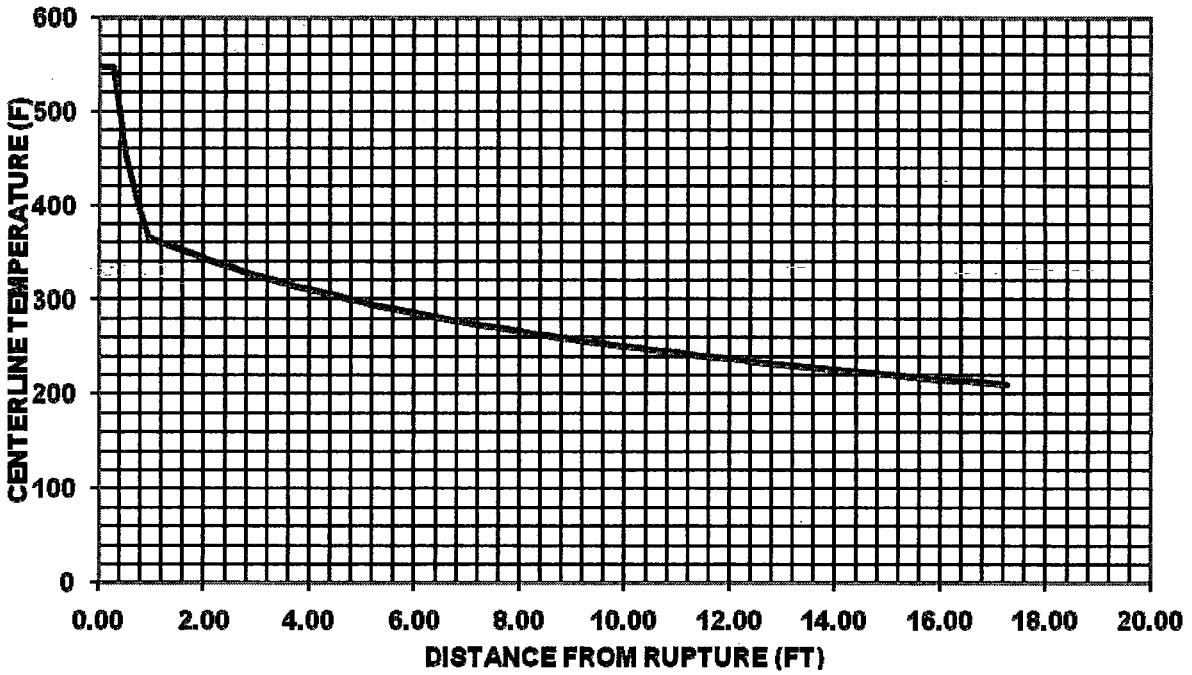
6" MAIN STEAM LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
8.75	21.2	21.4	261
9.00	22.0	20.2	259
9.25	22.7	19.1	257
9.50	23.5	18.0	255
9.75	24.2	17.0	253
10.00	25.0	16.0	251
10.25	25.8	15.1	249
10.50	26.6	14.2	248
10.75	27.4	13.4	246
11.00	28.2	12.5	244
11.25	29.1	11.8	243
11.50	29.9	11.0	241
11.75	30.8	10.3	239
12.00	31.7	9.6	238
12.25	32.6	9.0	236
12.50	33.5	8.4	235
12.75	34.4	7.7	233
13.00	35.3	7.2	232
13.25	36.2	6.6	231
13.50	37.2	6.1	229
13.75	38.1	5.6	228
14.00	39.1	5.1	226
14.25	40.1	4.6	225
14.50	41.1	4.1	224
14.75	42.1	3.7	223
15.00	43.1	3.3	221
15.25	44.2	2.8	220
15.50	45.2	2.4	219
15.75	46.3	2.1	218
16.00	47.3	1.7	217
16.25	48.4	1.3	215
16.50	49.5	1.0	214
16.75	50.6	0.6	213
17.00	51.7	0.3	212
17.25	52.9	0.0	211

PRESSURE VERSUS DISTANCE, 6" MAIN STEAM LONGITUDINAL BREAK



TEMPERATURE VERSUS DISTANCE, 6" MAIN STEAM LONGITUDINAL BREAK



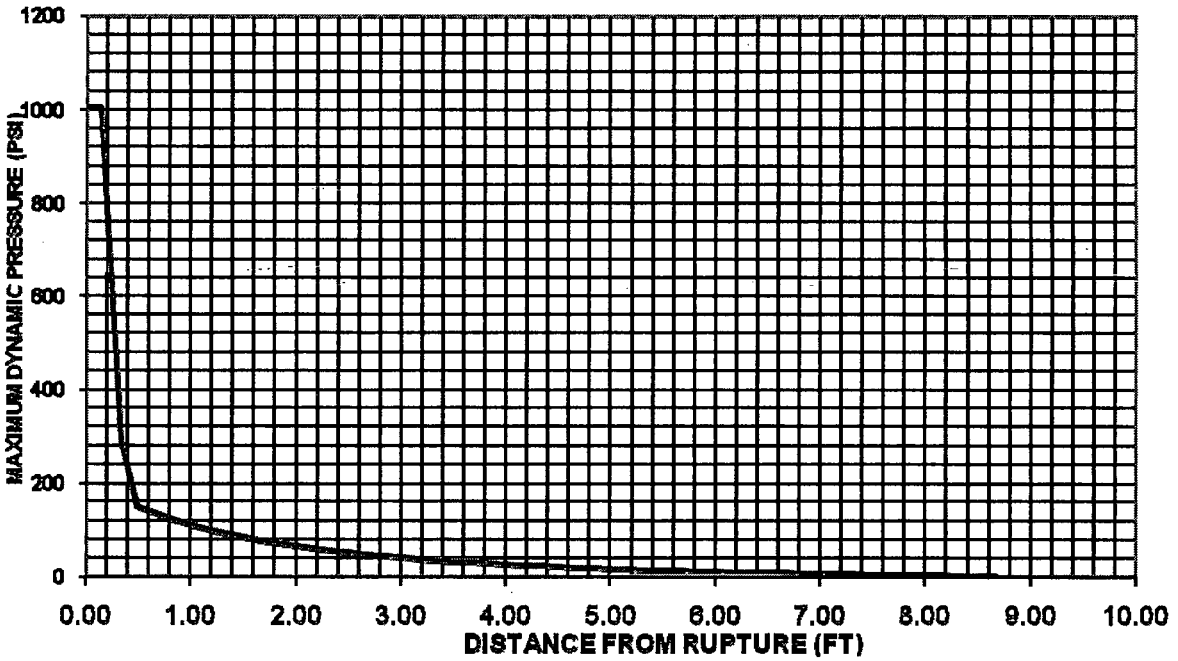
3" MAIN STEAM CIRCUMFERENTIAL BREAK

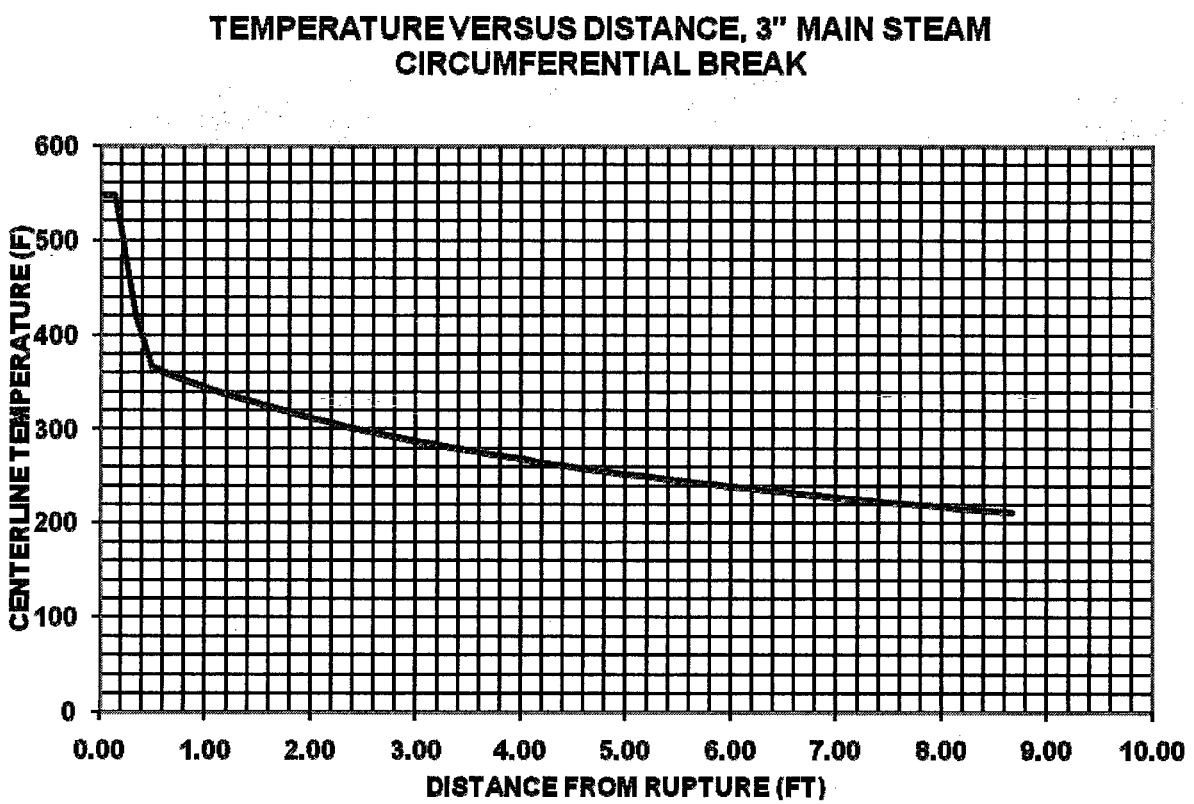
L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.13		1005	547
0.33		290	419
0.49	1.2	150	366
0.67	1.3	135	358
0.83	1.4	122	351
1.00	1.6	111	344
1.17	1.7	101	338
1.33	1.8	92	332
1.50	2.0	84	327
1.67	2.1	77	322
1.83	2.3	71	317
2.00	2.4	66	312
2.17	2.6	61	308
2.33	2.8	56	303
2.50	2.9	52	299
2.67	3.1	48	295
2.83	3.3	44	291
3.00	3.5	41	288
3.17	3.7	38	284
3.33	3.9	35	281
3.50	4.1	33	278
3.67	4.3	31	274
3.83	4.6	28	271
4.00	4.8	26	268
4.17	5.0	25	266
4.33	5.2	23	263
4.50	5.5	21	260
4.67	5.7	20	258
4.83	6.0	18	255
5.00	6.2	17	253
5.17	6.5	16	250
5.33	6.8	14	248
5.50	7.0	13	246
5.67	7.3	12	243

3" MAIN STEAM CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
5.83	7.6	11	241
6.00	7.9	10	239
6.17	8.2	9.4	237
6.33	8.5	8.5	235
6.50	8.8	7.7	233
6.67	9.1	7.0	231
6.83	9.4	6.3	230
7.00	9.8	5.6	228
7.17	10.1	4.9	226
7.33	10.4	4.3	224
7.50	10.8	3.7	223
7.67	11.1	3.2	221
7.83	11.4	2.6	219
8.00	11.8	2.1	218
8.17	12.2	1.6	216
8.33	12.5	1.2	215
8.50	12.9	0.7	213
8.67	13.3	0.3	212

PRESSURE VERSUS DISTANCE, 3" MAIN STEAM CIRCUMFERENTIAL BREAK




TEMPERATURE VERSUS DISTANCE, 3" MAIN STEAM CIRCUMFERENTIAL BREAK
CENTERLINE TEMPERATURE (F)
600
500
400
300
200
100
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
DISTANCE FROM RUPTURE (FT)

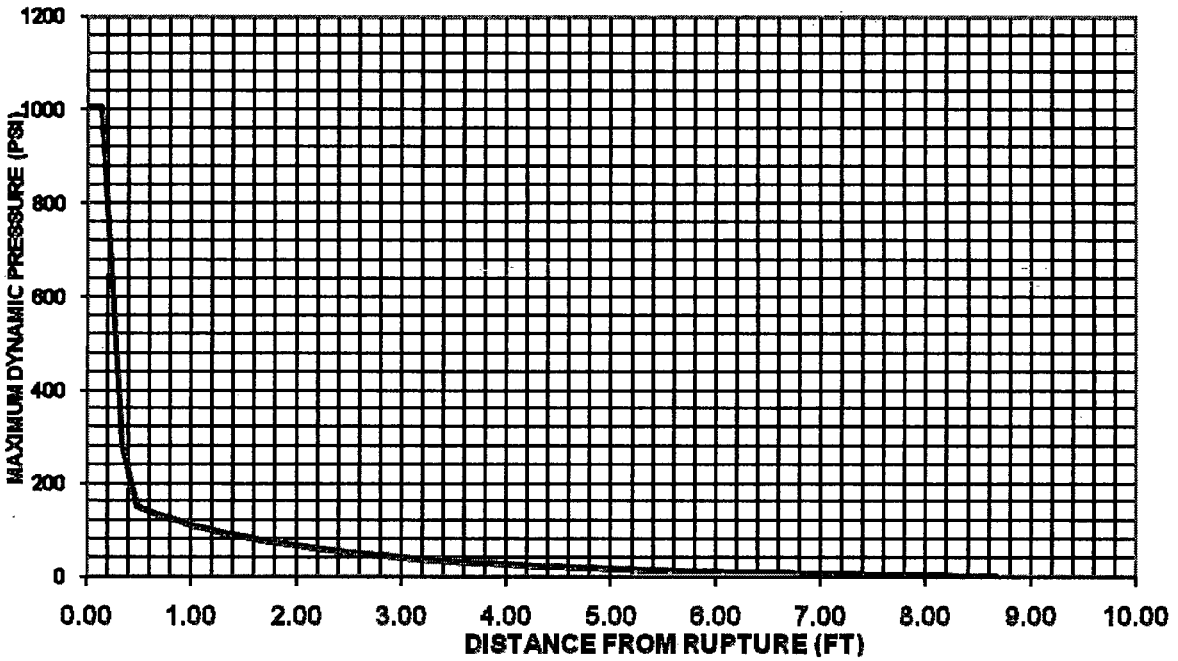
3" MAIN STEAM LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.13		1005	547
0.33		281	416
0.47	1.2	150	366
0.67	1.3	133	357
0.83	1.4	120	350
1.00	1.6	109	344
1.17	1.7	100	337
1.33	1.8	91	332
1.50	2.0	83	326
1.67	2.1	76	321
1.83	2.3	70	316
2.00	2.5	65	311
2.17	2.6	60	307
2.33	2.8	55	302
2.50	3.0	51	298
2.67	3.2	47	294
2.83	3.4	44	290
3.00	3.6	40	287
3.17	3.8	38	283
3.33	4.0	35	280
3.50	4.2	32	277
3.67	4.4	30	274
3.83	4.6	28	271
4.00	4.8	26	268
4.17	5.1	24	265
4.33	5.3	22	262
4.50	5.5	21	259
4.67	5.8	19	257
4.83	6.0	18	254
5.00	6.3	16	252
5.17	6.6	15	250
5.33	6.8	14	247
5.50	7.1	13	245
5.67	7.4	12	243

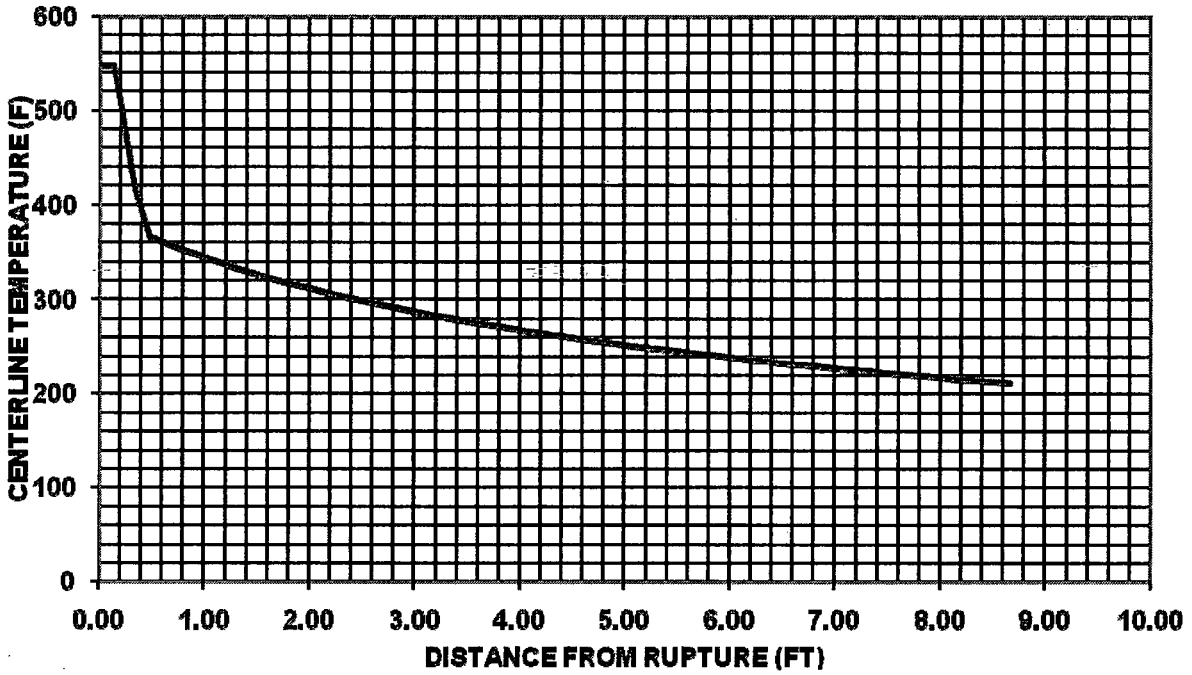
3" MAIN STEAM LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
5.83	7.7	11	241
6.00	8.0	10	239
6.17	8.3	9.1	237
6.33	8.6	8.3	235
6.50	8.9	7.5	233
6.67	9.2	6.8	231
6.83	9.5	6.1	229
7.00	9.8	5.4	227
7.17	10.2	4.7	226
7.33	10.5	4.1	224
7.50	10.9	3.5	222
7.67	11.2	3.0	221
7.83	11.6	2.5	219
8.00	11.9	2.0	217
8.17	12.3	1.5	216
8.33	12.6	1.0	214
8.50	13.0	0.6	213
8.67	13.4	0.1	211

PRESSURE VERSUS DISTANCE, 3" MAIN LONGITUDINAL BREAK



TEMPERATURE VERSUS DISTANCE, 3" MAIN STEAM LONGITUDINAL BREAK



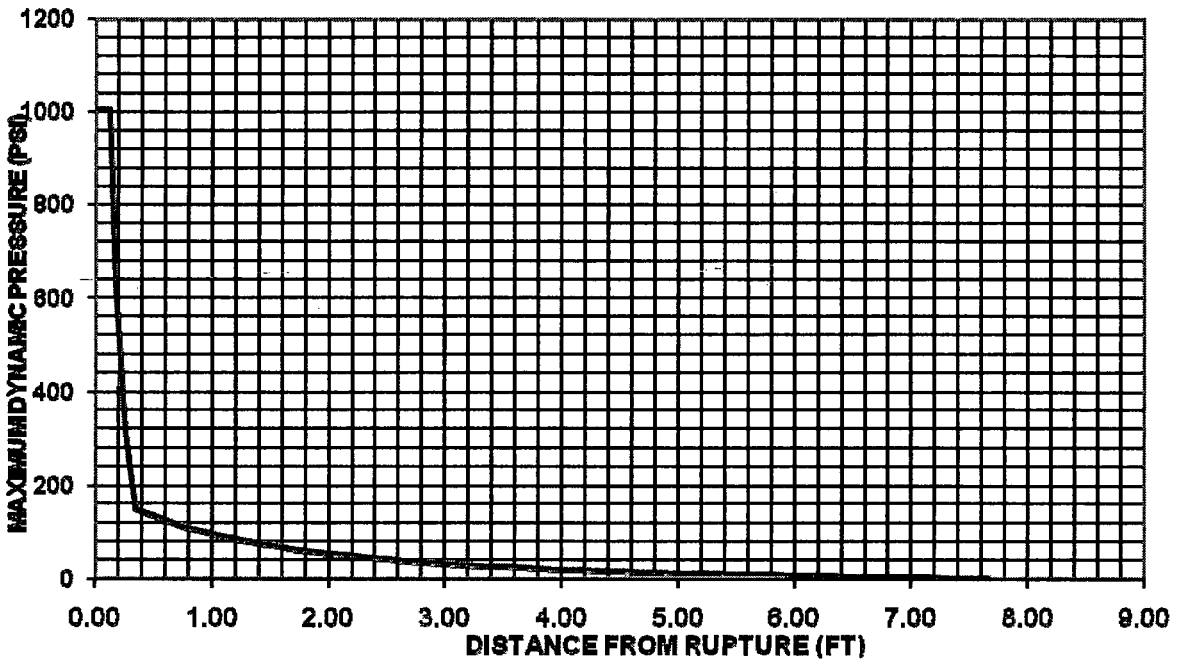
30" MAIN STEAM LINE CRACK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.12		1005	547
0.17		625	493
0.25		309	424
0.33	1.02	150	366
0.42	1.08	141	361
0.50	1.14	133	357
0.58	1.20	126	353
0.67	1.27	119	349
0.75	1.33	112	345
0.83	1.40	106	342
0.92	1.47	101	338
1.00	1.54	95	335
1.08	1.61	91	331
1.17	1.68	86	328
1.25	1.75	82	325
1.33	1.83	78	322
1.42	1.90	74	319
1.50	1.98	71	316
1.58	2.06	68	314
1.67	2.14	64	311
1.83	2.30	59	306
2.00	2.47	54	301
2.17	2.64	49	297
2.33	2.82	45	292
2.50	3.01	42	288
2.67	3.20	38	284
2.83	3.40	35	280
3.00	3.60	32	277
3.17	3.81	30	273
3.33	4.02	28	270
3.50	4.24	25	267
3.67	4.46	23	264
3.83	4.69	22	261
4.00	4.92	20	258

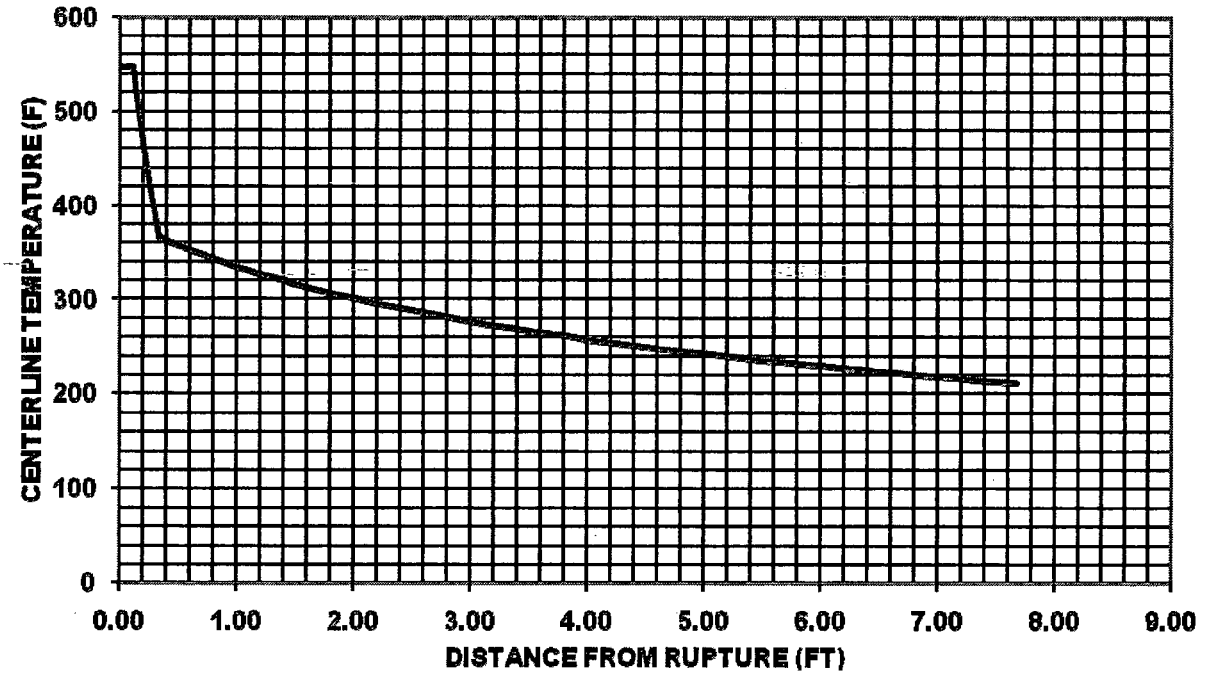
30" MAIN STEAM LINE CRACK

L FT	A SQ FT	P PSI	T F
4.17	5.16	18	255
4.33	5.41	17	252
4.50	5.66	15	250
4.67	5.91	14	247
4.83	6.18	13	245
5.00	6.44	12	243
5.17	6.71	11	240
5.33	6.99	10	238
5.50	7.28	8.8	236
5.67	7.56	7.9	234
5.83	7.86	7.1	232
6.00	8.16	6.3	230
6.17	8.46	5.5	228
6.33	8.77	4.8	226
6.50	9.09	4.1	224
6.67	9.41	3.5	222
6.83	9.74	2.9	220
7.00	10.07	2.3	219
7.17	10.41	1.8	217
7.33	10.75	1.3	215
7.50	11.10	0.8	214
7.67	11.45	0.3	212

PRESSURE VERSUS DISTANCE, 30" MAIN STEAM LINE CRACK



TEMPERATURE VERSUS DISTANCE, 30" MAIN STEAM LINE CRACK



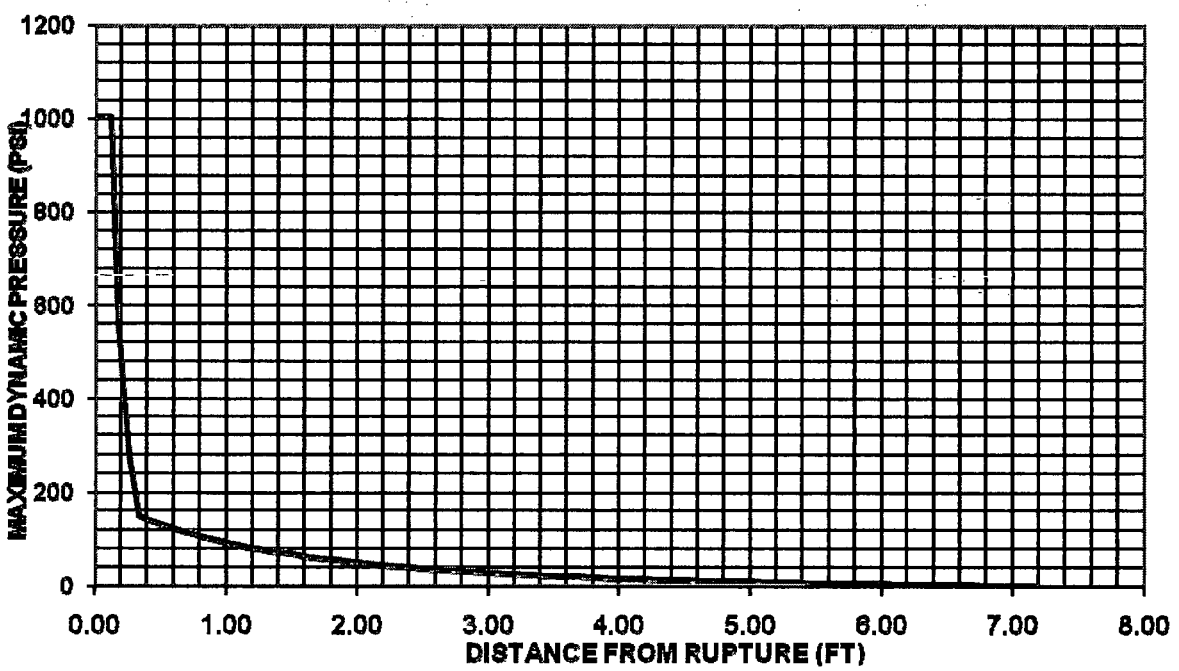
24" MAIN STEAM CRACK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.11		1005	547
0.17		559	481
0.25		280	416
0.33	0.85	150	366
0.42	0.91	140	361
0.50	0.97	131	356
0.58	1.02	123	352
0.67	1.08	116	348
0.75	1.14	109	344
0.83	1.20	103	340
0.92	1.26	97	336
1.00	1.32	92	332
1.08	1.38	87	329
1.17	1.45	83	326
1.25	1.52	78	322
1.33	1.58	74	319
1.42	1.65	71	316
1.50	1.72	67	313
1.58	1.80	64	311
1.67	1.87	61	308
1.83	2.02	55	303
2.00	2.18	50	298
2.17	2.34	46	293
2.33	2.51	42	288
2.50	2.68	38	284
2.67	2.86	35	280
2.83	3.04	32	276
3.00	3.23	29	272
3.17	3.42	27	269
3.33	3.62	24	265
3.50	3.83	22	262
3.67	4.04	20	259
3.83	4.25	19	256
4.00	4.48	17	253

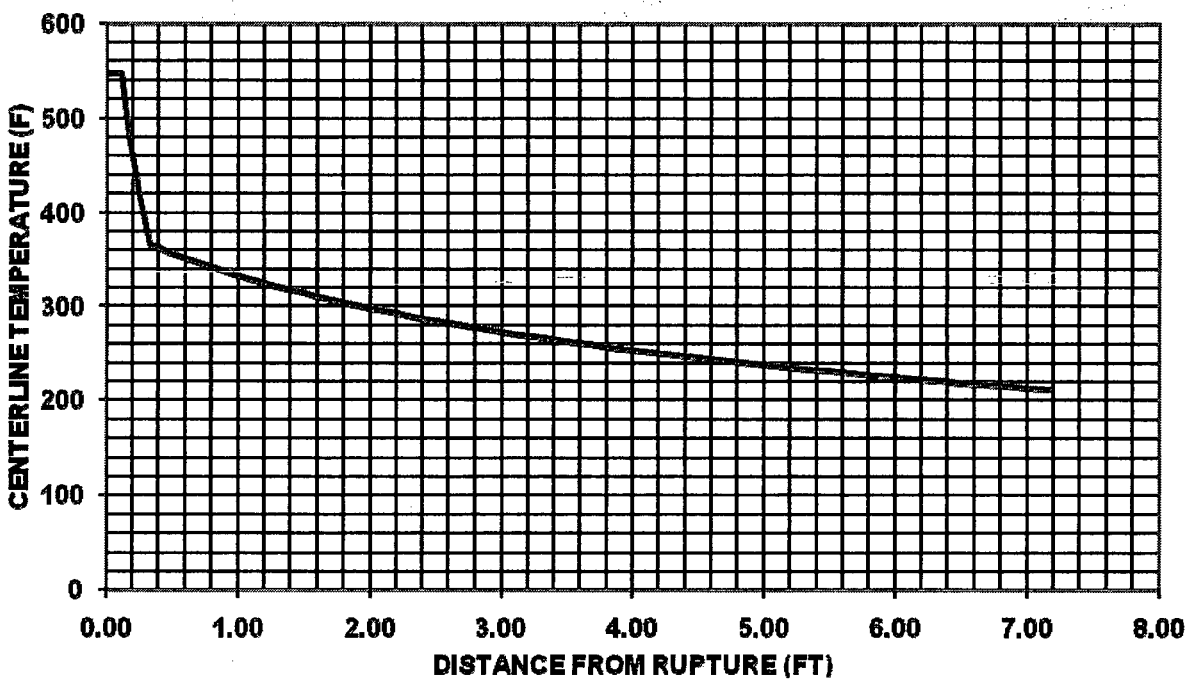
24" MAIN STEAM CRACK

L FT	A SQ FT	P PSI	T F
4.17	4.70	16	250
4.33	4.93	14	247
4.50	5.17	13	245
4.67	5.42	12	242
4.83	5.66	10	240
5.00	5.92	9.4	237
5.17	6.18	8.4	235
5.33	6.44	7.5	233
5.50	6.71	6.6	230
5.67	6.99	5.8	228
5.83	7.27	5.0	226
6.00	7.56	4.2	224
6.17	7.85	3.5	222
6.33	8.14	2.9	220
6.50	8.45	2.3	218
6.67	8.76	1.7	217
6.83	9.07	1.1	215
7.00	9.39	0.6	213
7.17	9.71	0.1	211

PRESSURE VERSUS DISTANCE, 24" MAIN STEAM CRACK



TEMPERATURE VERSUS DISTANCE, 24" MAIN STEAM CRACK



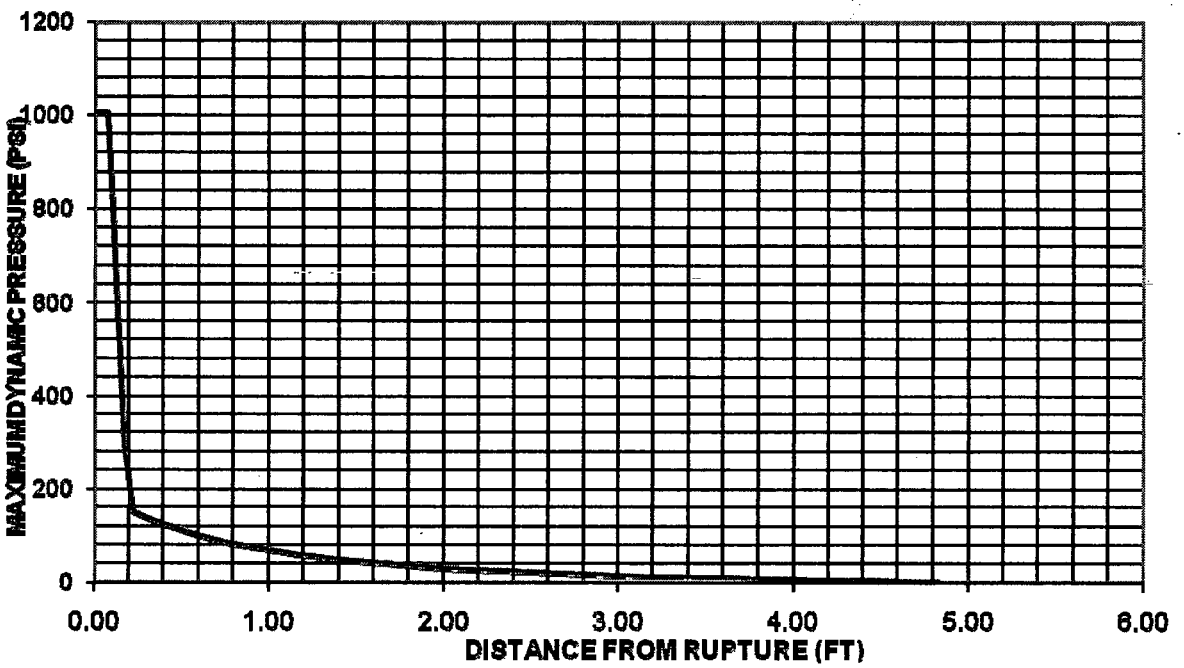
16" MAIN STEAM CRACK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.07		1005	547
0.17		285	417
0.22	0.38	150	366
0.33	0.43	132	356
0.42	0.47	120	350
0.50	0.51	110	344
0.58	0.55	101	338
0.67	0.59	93	333
0.75	0.64	85	328
0.83	0.68	79	323
0.92	0.73	73	318
1.00	0.77	68	314
1.08	0.82	63	310
1.17	0.87	58	306
1.25	0.92	54	302
1.33	0.97	51	298
1.42	1.03	47	295
1.50	1.08	44	291
1.58	1.14	41	288
1.67	1.20	39	285
1.83	1.32	34	279
2.00	1.44	30	273
2.17	1.57	26	268
2.33	1.71	23	263
2.50	1.85	20	258
2.67	2.00	17	254
2.83	2.15	15	249
3.00	2.31	13	245
3.17	2.47	11	241
3.33	2.64	10	238
3.50	2.81	8.1	234
3.67	2.99	6.8	231
3.83	3.18	5.6	228
4.00	3.37	4.4	225

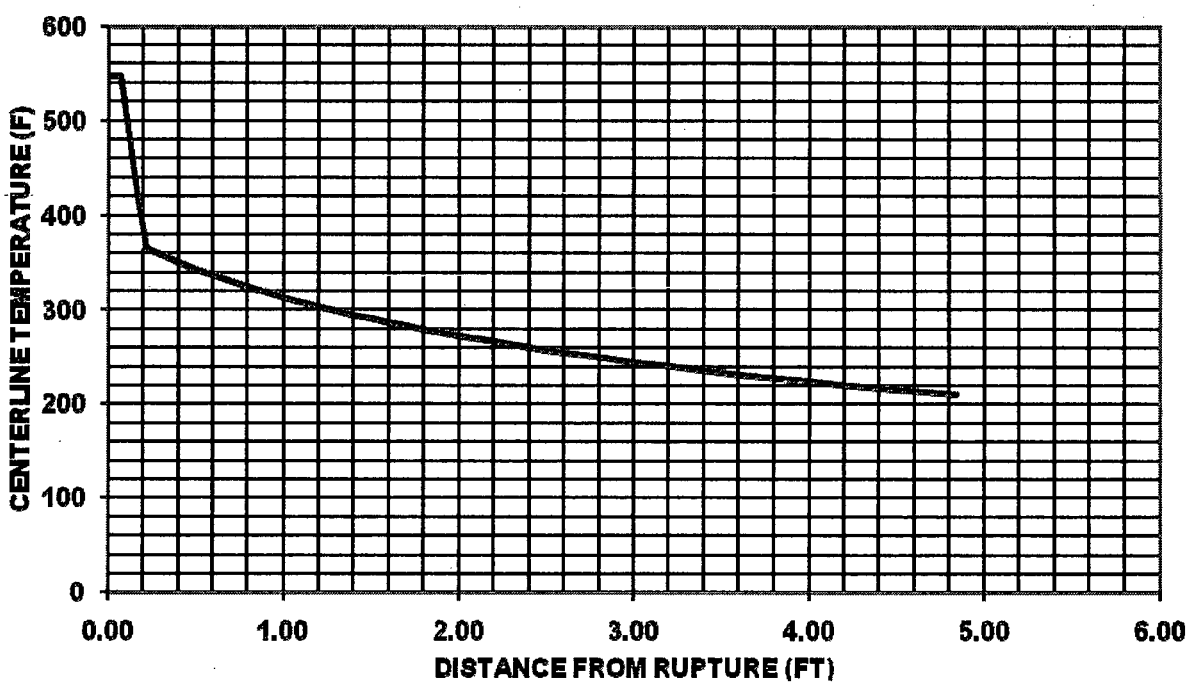
16" MAIN STEAM CRACK

L FT	A SQ FT	P PSI	T F
4.17	3.57	3.4	222
4.33	3.77	2.5	219
4.50	3.97	1.6	216
4.67	4.19	0.8	214
4.83	4.40	0.0	211

PRESSURE VERSUS DISTANCE, 16" MAIN STEAM CRACK



TEMPERATURE VERSUS DISTANCE, 16" MAIN STEAM CRACK



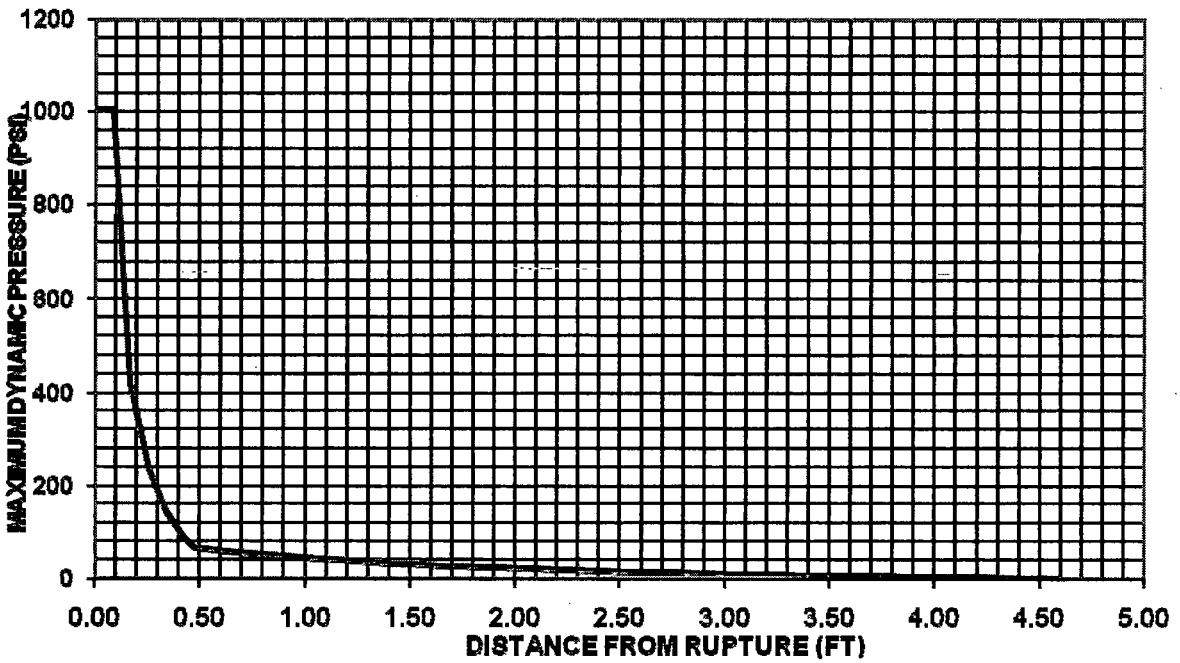
STEAM GENERATOR BLOWDOWN CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.08		1005	547
0.17		421	453
0.25		238	402
0.33		146	364
0.42		91	332
0.47	0.95	66	312
0.58	1.02	60	307
0.67	1.08	57	304
0.75	1.13	53	301
0.83	1.19	50	297
0.92	1.25	47	294
1.00	1.30	44	291
1.08	1.36	42	288
1.17	1.43	39	285
1.25	1.49	37	283
1.33	1.55	35	280
1.42	1.62	33	277
1.50	1.69	31	275
1.58	1.75	29	272
1.67	1.82	28	270
1.75	1.89	26	268
1.83	1.97	24	266
1.92	2.04	23	263
2.08	2.19	20	259
2.25	2.35	18	255
2.42	2.51	16	251
2.58	2.68	14	247
2.75	2.85	12	244
2.92	3.03	11	241
3.08	3.22	9.4	237
3.25	3.41	8.1	234
3.42	3.60	6.9	231
3.58	3.80	5.7	228
3.75	4.01	4.7	225

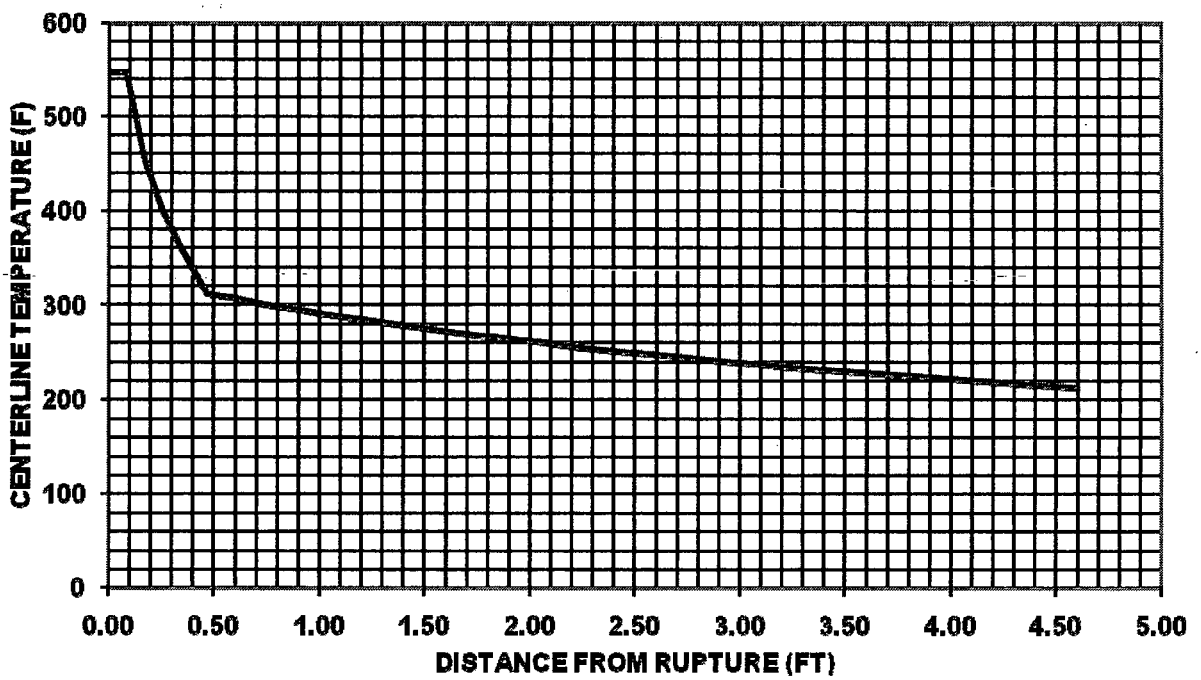
STEAM GENERATOR BLOWDOWN CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
3.92	4.22	3.7	223
4.08	4.43	2.9	220
4.25	4.66	2.0	218
4.42	4.88	1.3	215
4.58	5.12	0.6	213

PRESSURE VERSUS DISTANCE
STEAM GENERATOR BLOWDOWN CIRCUMFERENTIAL BREAK



TEMPERATURE VERSUS DISTANCE
STEAM GENERATOR BLOWDOWN CIRCUMFERENTIAL BREAK



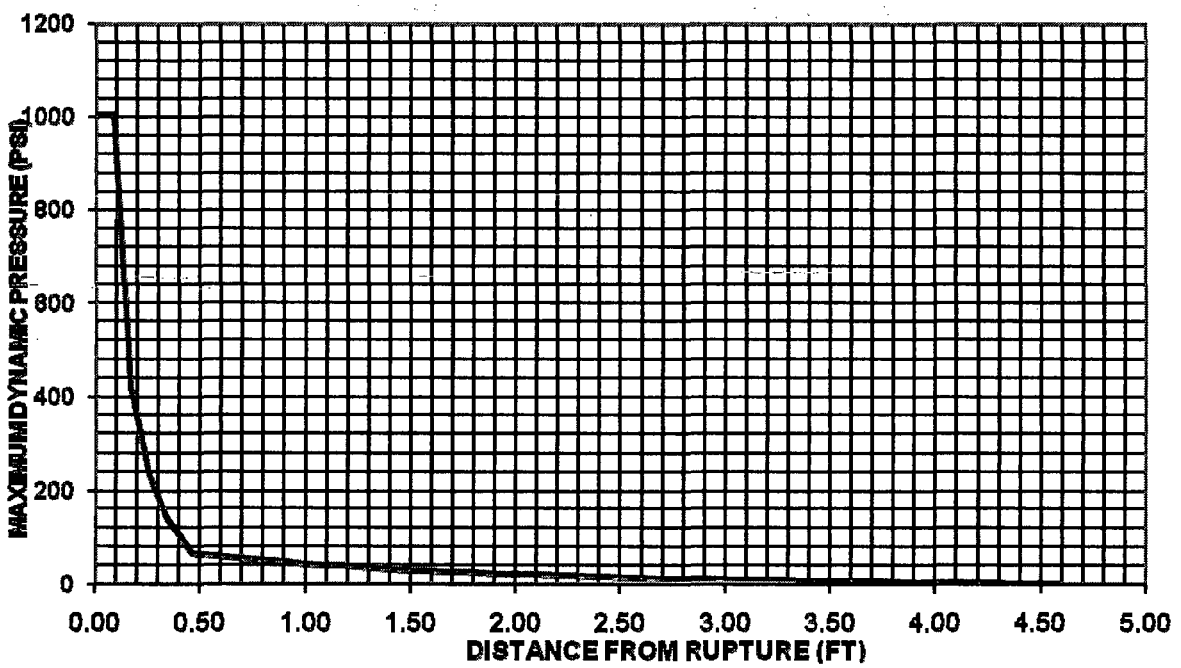
STEAM GENERATOR BLOWDOWN
LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.08		1005	547
0.17		418	452
0.25		233	400
0.33		141	361
0.46	0.95	66	312
0.50	0.98	64	310
0.58	1.03	60	307
0.67	1.09	56	303
0.75	1.14	53	300
0.83	1.20	49	297
0.92	1.26	47	294
1.00	1.32	44	291
1.08	1.38	41	288
1.17	1.44	39	285
1.25	1.50	37	282
1.33	1.57	34	280
1.42	1.63	32	277
1.50	1.70	31	274
1.58	1.77	29	272
1.67	1.84	27	270
1.75	1.91	26	267
1.92	2.06	23	263
2.08	2.21	20	259
2.25	2.37	18	255
2.42	2.53	16	251
2.58	2.70	14	247
2.75	2.88	12	243
2.92	3.05	11	240
3.08	3.24	9.2	237
3.25	3.43	7.9	234
3.42	3.63	6.7	231
3.58	3.83	5.6	228
3.75	4.04	4.6	225

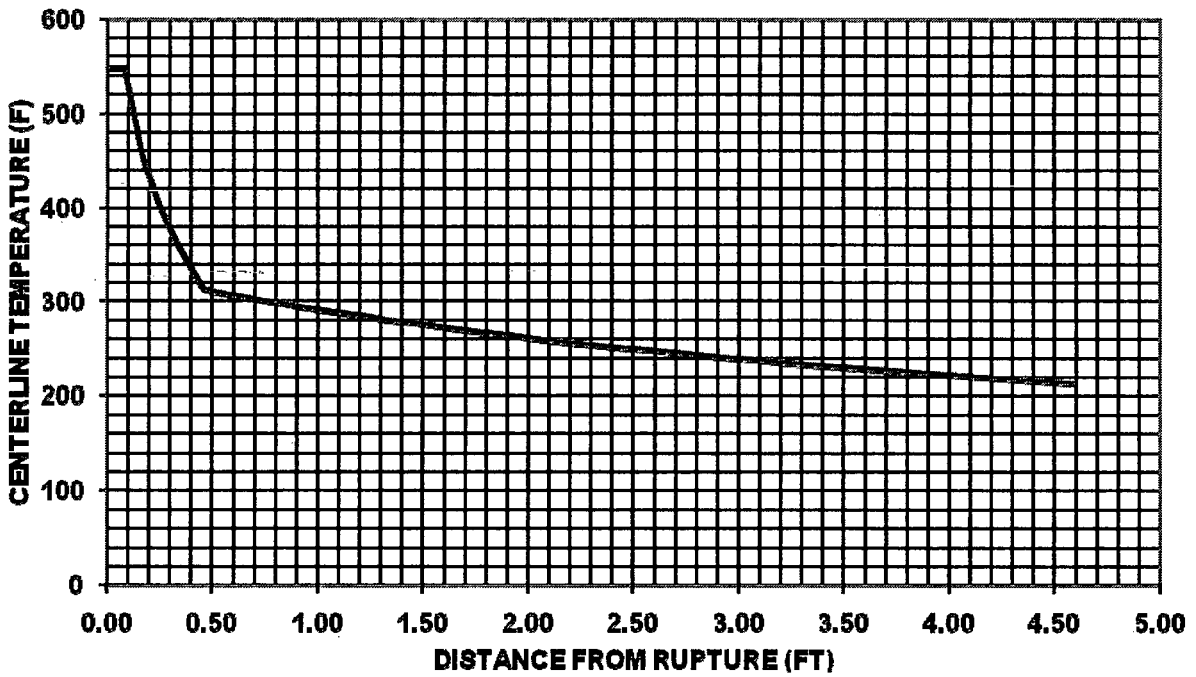
STEAM GENERATOR BLOWDOWN
LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
3.92	4.25	3.6	222
4.08	4.47	2.7	220
4.25	4.69	1.9	217
4.42	4.92	1.2	215
4.58	5.15	0.5	212

PRESSURE VERSUS DISTANCE
STEAM GENERATOR BLOWDOWN LONGITUDINAL BREAK



TEMPERATURE VERSUS DISTANCE
STEAM GENERATOR BLOWDOWN LONGITUDINAL BREAK



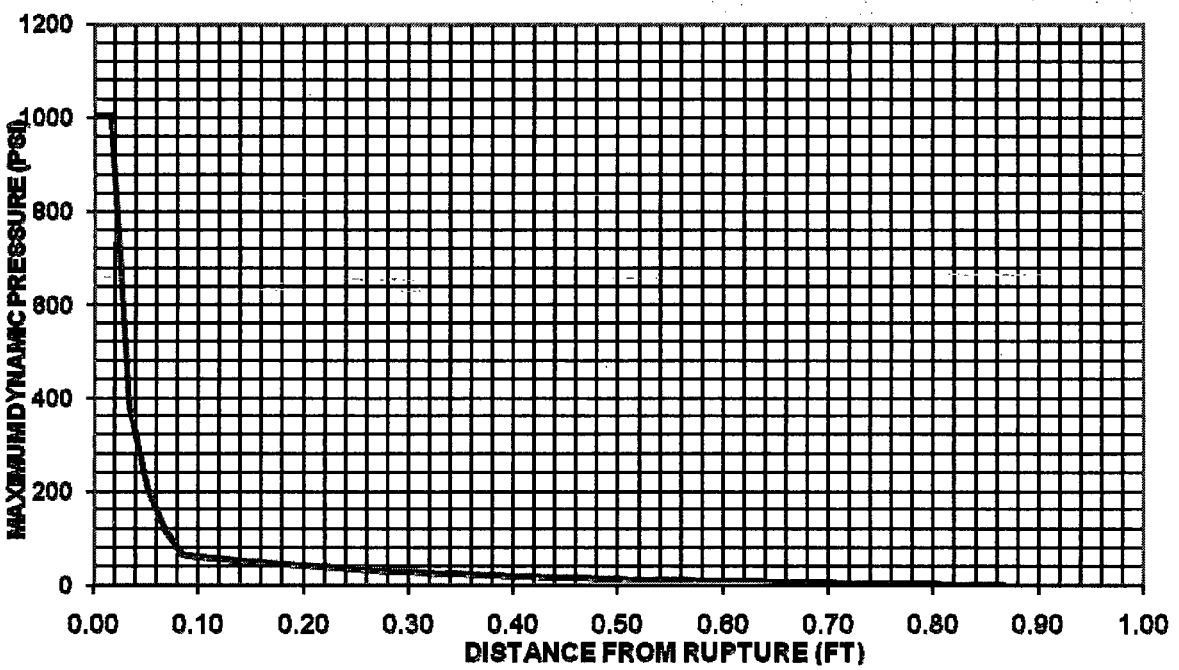
STEAM GENERATOR BLOWDOWN CRACK

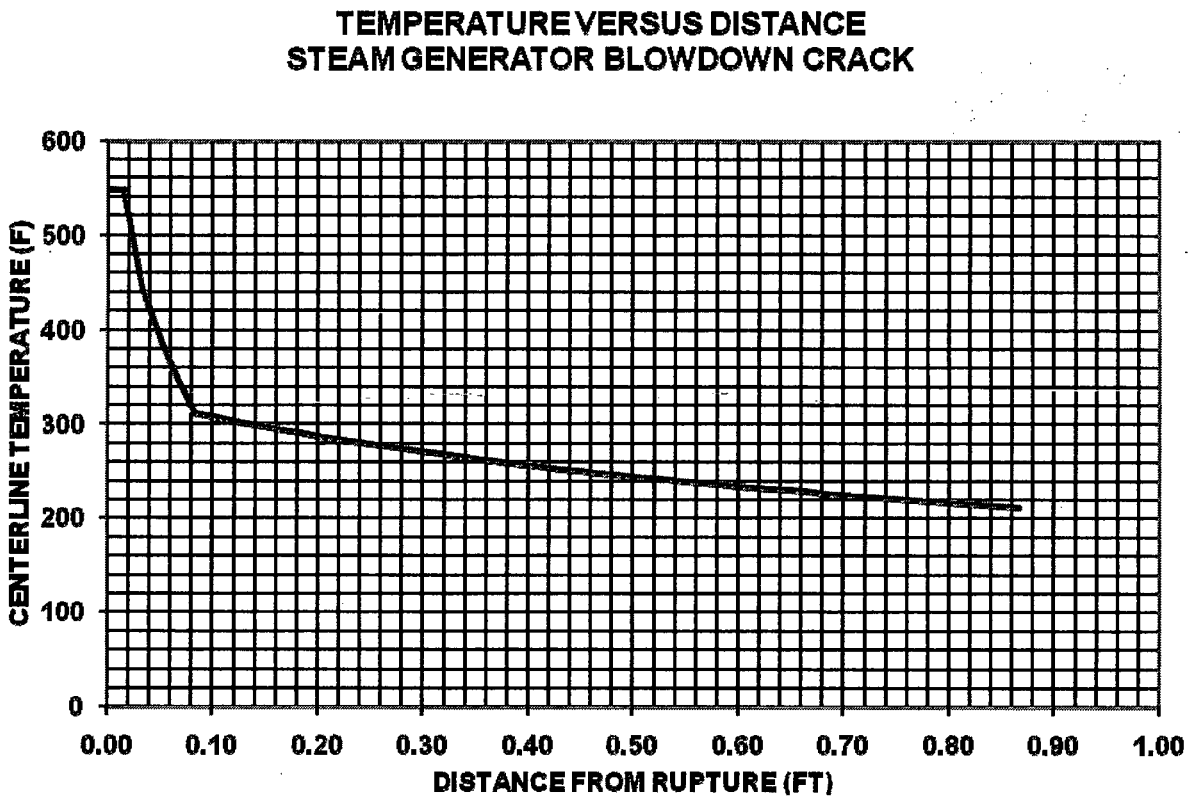
L FT	A SQ FT	P PSI	T F
0.00		1005	547
0.02		1005	547
0.03		381	444
0.05		206	390
0.07		118	349
0.08	0.034	65.7	312
0.10	0.036	61.4	308
0.12	0.038	57.3	305
0.13	0.040	53.6	301
0.15	0.042	50.2	298
0.17	0.045	47.0	294
0.18	0.047	44.0	291
0.20	0.049	41.3	288
0.22	0.052	38.7	285
0.23	0.054	36.4	282
0.25	0.056	34.1	279
0.27	0.059	32.1	276
0.28	0.062	30.1	274
0.30	0.064	28.3	271
0.32	0.067	26.6	269
0.33	0.070	25.0	266
0.35	0.072	23.4	264
0.37	0.075	22.0	262
0.38	0.078	20.7	259
0.40	0.081	19.4	257
0.42	0.084	18.2	255
0.43	0.087	17.0	253
0.45	0.090	15.9	251
0.47	0.093	14.9	249
0.48	0.097	13.9	247
0.50	0.100	13.0	245
0.52	0.103	12.1	243
0.53	0.107	11.3	241
0.55	0.110	10.5	240
0.57	0.114	9.7	238

STEAM GENERATOR BLOWDOWN CRACK

L FT	A SQ FT	P PSI	T F
0.58	0.117	9.0	236
0.60	0.121	8.3	235
0.62	0.124	7.6	233
0.63	0.128	7.0	231
0.65	0.132	6.4	230
0.67	0.136	5.8	228
0.68	0.140	5.2	227
0.70	0.144	4.7	225
0.72	0.148	4.2	224
0.73	0.152	3.7	223
0.75	0.156	3.2	221
0.77	0.160	2.7	220
0.78	0.164	2.3	218
0.80	0.168	1.9	217
0.82	0.173	1.5	216
0.83	0.177	1.1	215
0.85	0.181	0.7	213
0.87	0.186	0.3	212

PRESSURE VERSUS DISTANCE
STEAM GENERATOR BLOWDOWN CRACK

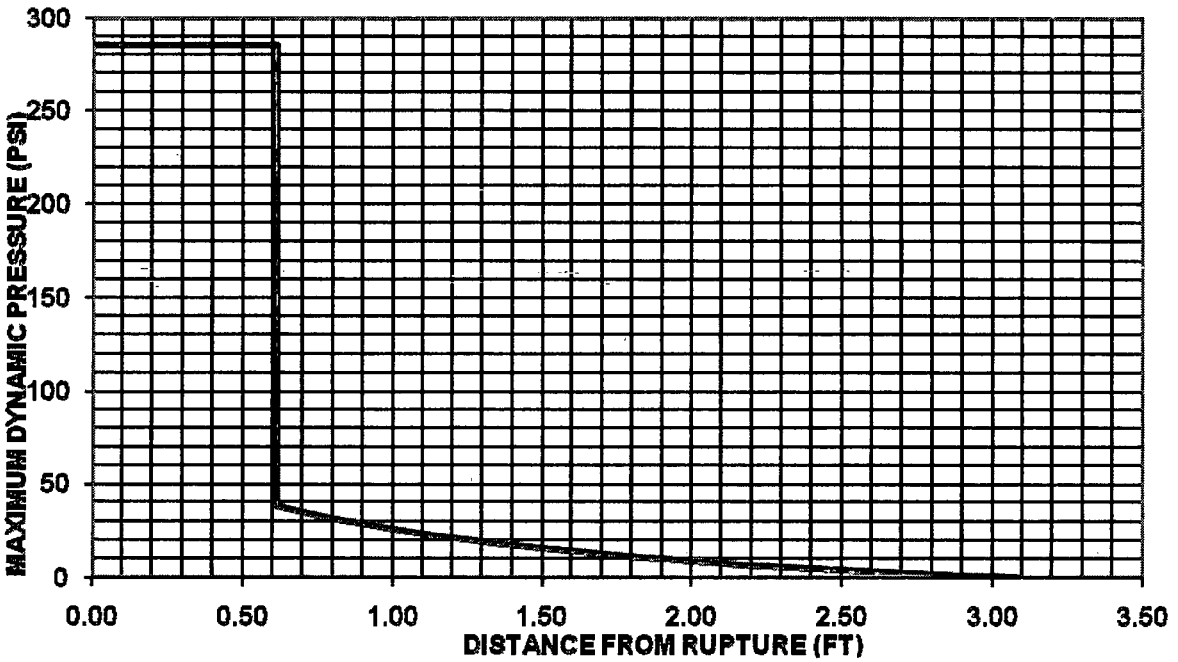


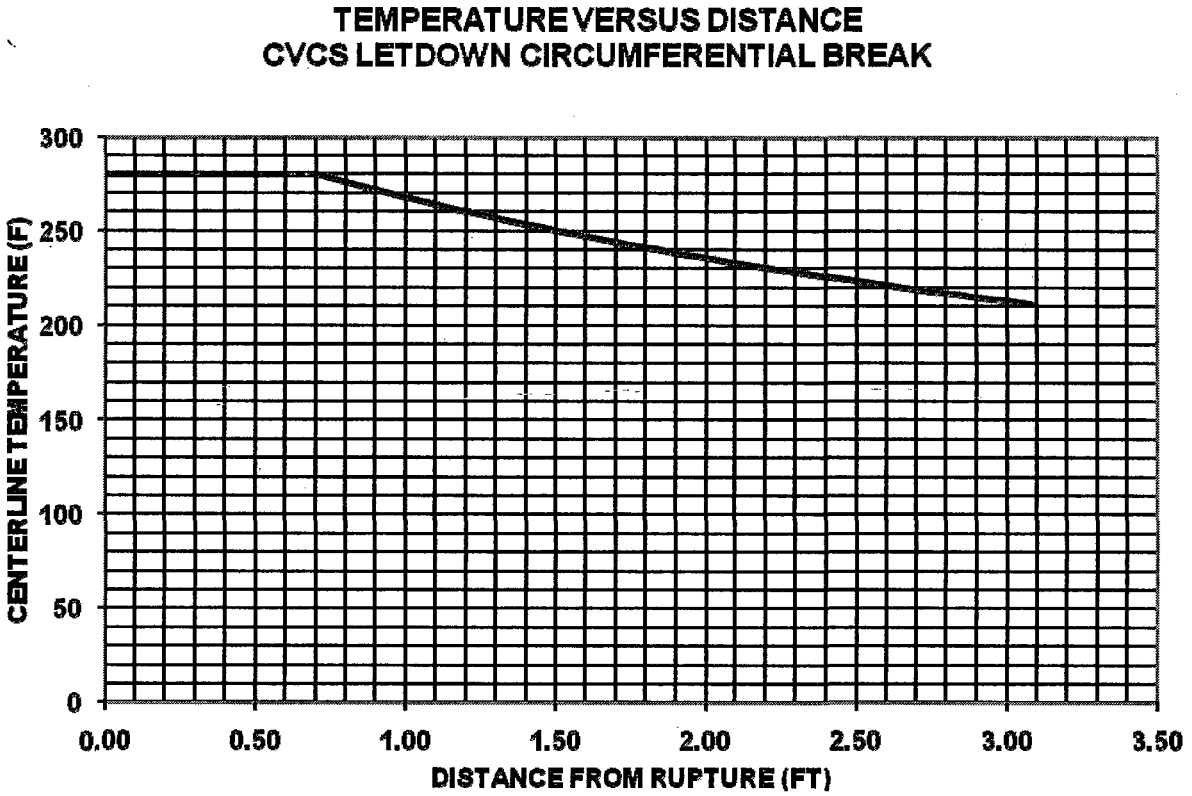

TEMPERATURE VERSUS DISTANCE
STEAM GENERATOR BLOWDOWN CRACK
CENTERLINE TEMPERATURE (F)
600
500
400
300
200
100
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
DISTANCE FROM RUPTURE (FT)

CVCS LETDOWN CIRCUMFERENTIAL BREAK

L FT	A SQ FT	P PSI	T F
0.00		285	280
0.61		285	280
0.61	0.73	38	280
0.67	0.76	36	280
0.70	0.78	35	280
0.75	0.81	33	278
0.83	0.85	31	274
0.92	0.90	28	271
1.00	0.95	26	268
1.08	1.00	24	265
1.17	1.06	22	261
1.25	1.11	20	259
1.33	1.17	19	256
1.42	1.22	17	253
1.50	1.28	16	250
1.58	1.34	14	248
1.67	1.40	13	245
1.75	1.47	12	243
1.83	1.53	11	240
1.92	1.59	9.7	238
2.00	1.66	8.7	236
2.08	1.73	7.8	234
2.17	1.80	7.0	231
2.25	1.87	6.2	229
2.33	1.94	5.4	227
2.42	2.01	4.7	225
2.50	2.09	4.0	224
2.58	2.16	3.4	222
2.67	2.24	2.8	220
2.75	2.32	2.2	218
2.83	2.40	1.6	216
2.92	2.48	1.1	215
3.00	2.56	0.6	213
3.08	2.65	0.1	211

PRESSURE VERSUS DISTANCE
CVCS LETDOWN CIRCUMFERENTIAL BREAK

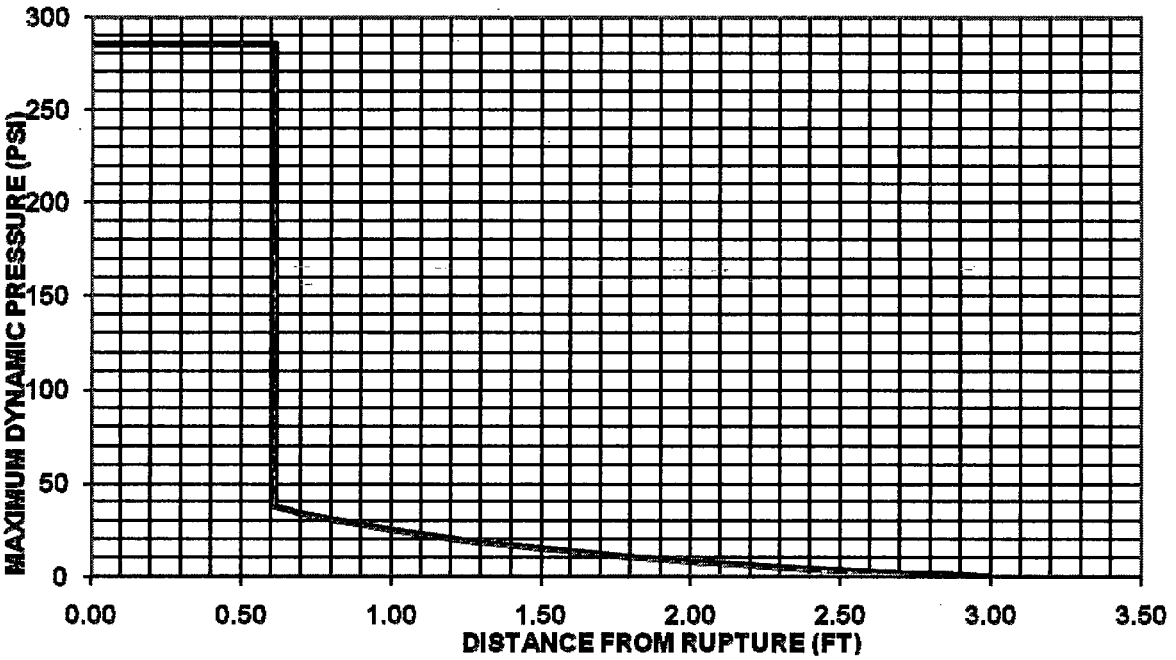



TEMPERATURE VERSUS DISTANCE
CVCS LETDOWN CIRCUMFERENTIAL BREAK
CENTERLINE TEMPERATURE (F)
300
250
200
150
100
50
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
DISTANCE FROM RUPTURE (FT)

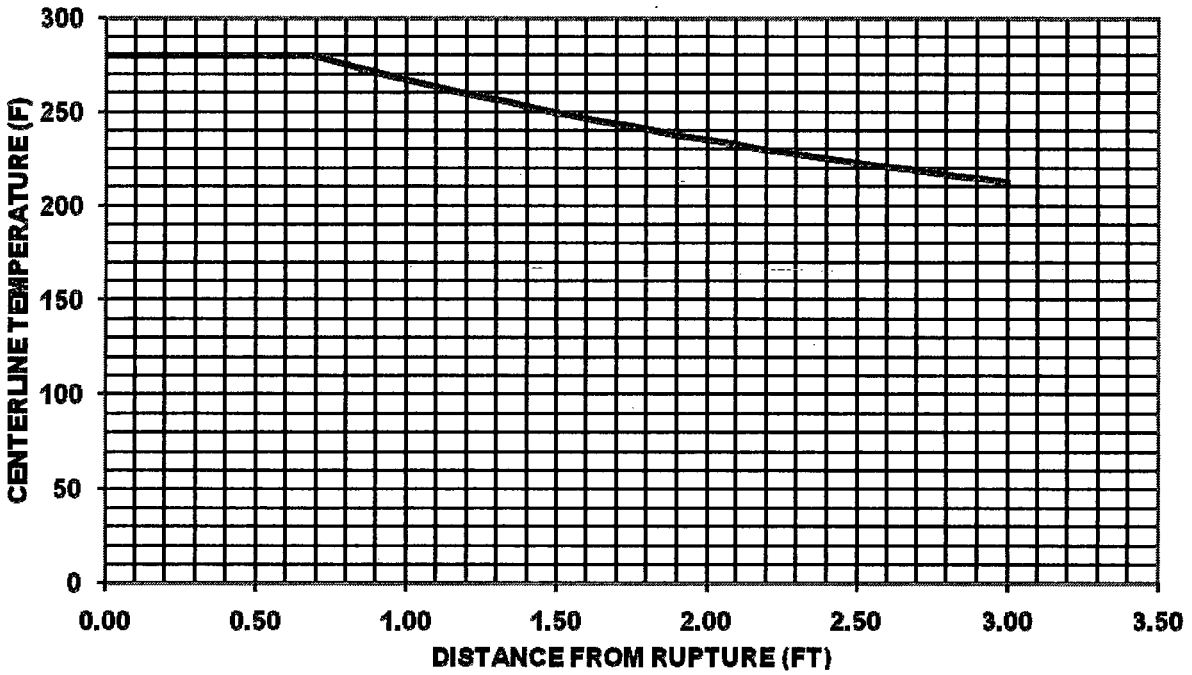
CVCS LETDOWN LONGITUDINAL BREAK

L FT	A SQ FT	P PSI	T F
0.00		285	280
0.61		285	280
0.61	0.74	38	280
0.67	0.77	36	280
0.69	0.78	35	280
0.75	0.82	33	277
0.83	0.86	30	274
0.92	0.91	28	270
1.00	0.96	25	267
1.08	1.02	23	264
1.17	1.07	22	261
1.25	1.12	20	258
1.33	1.18	18	255
1.42	1.24	17	252
1.50	1.30	15	250
1.58	1.36	14	247
1.67	1.42	13	244
1.75	1.48	12	242
1.83	1.55	10	240
1.92	1.61	9.4	237
2.00	1.68	8.5	235
2.08	1.75	7.6	233
2.17	1.82	6.7	231
2.25	1.89	5.9	229
2.33	1.96	5.2	227
2.42	2.04	4.5	225
2.50	2.11	3.8	223
2.58	2.19	3.2	221
2.67	2.27	2.6	219
2.75	2.35	2.0	217
2.83	2.43	1.4	216
2.92	2.51	0.9	214
3.00	2.59	0.4	212

PRESSURE VERSUS DISTANCE
CVCS LETDOWN LONGITUDINAL BREAK



TEMPERATURE VERSUS DISTANCE
CVCS LETDOWN LONGITUDINAL BREAK



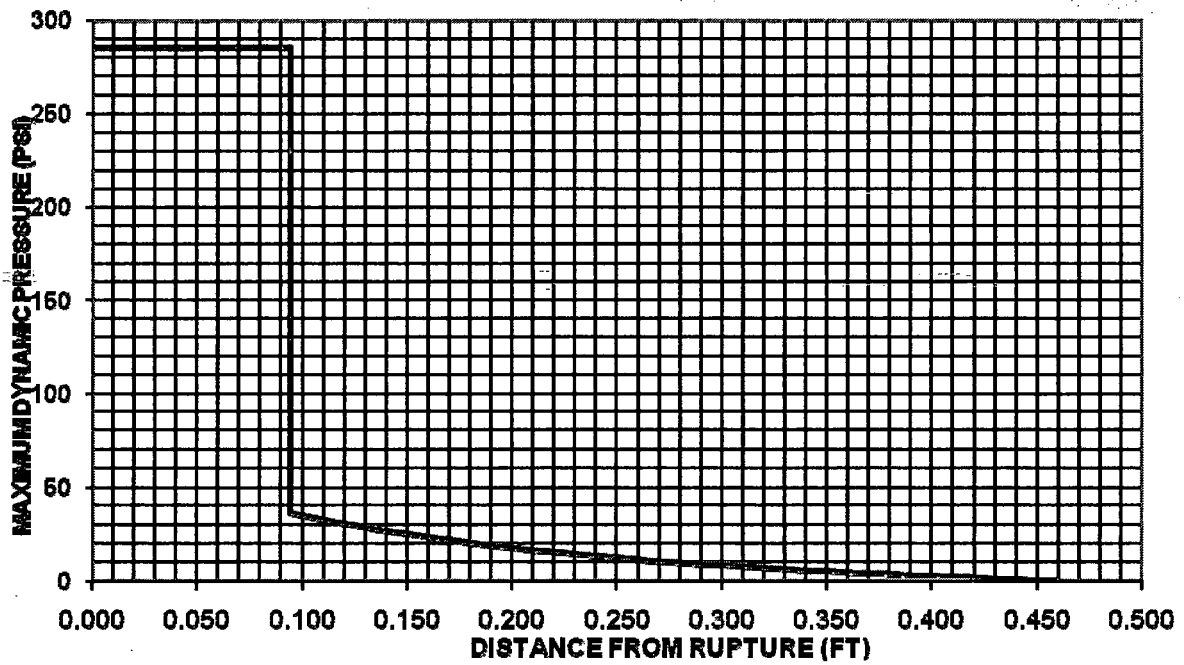
CVCS LETDOWN CRACK

L FT	A SQ FT	P PSI	T F
0.000		285	280
0.094		285	280
0.094	0.0180	36.2	280
0.100	0.0185	34.8	280
0.108	0.0193	32.9	277
0.117	0.0200	31.1	275
0.125	0.0208	29.4	273
0.133	0.0216	27.9	271
0.142	0.0224	26.4	268
0.150	0.0232	24.9	266
0.158	0.0240	23.6	264
0.167	0.0248	22.3	262
0.175	0.0257	21.1	260
0.183	0.0265	19.9	258
0.192	0.0274	18.9	256
0.200	0.0283	17.8	254
0.208	0.0292	16.8	253
0.217	0.0301	15.9	251
0.225	0.0310	15.0	249
0.233	0.0320	14.1	247
0.242	0.0329	13.3	246
0.250	0.0339	12.5	244
0.258	0.0349	11.7	242
0.267	0.0359	11.0	241
0.275	0.0369	10.3	239
0.283	0.0379	9.6	238
0.292	0.0390	9.0	236
0.300	0.0400	8.4	235
0.308	0.0411	7.8	233
0.317	0.0422	7.2	232
0.325	0.0433	6.7	231
0.333	0.0444	6.2	229
0.342	0.0455	5.6	228
0.350	0.0466	5.2	227
0.358	0.0478	4.7	225

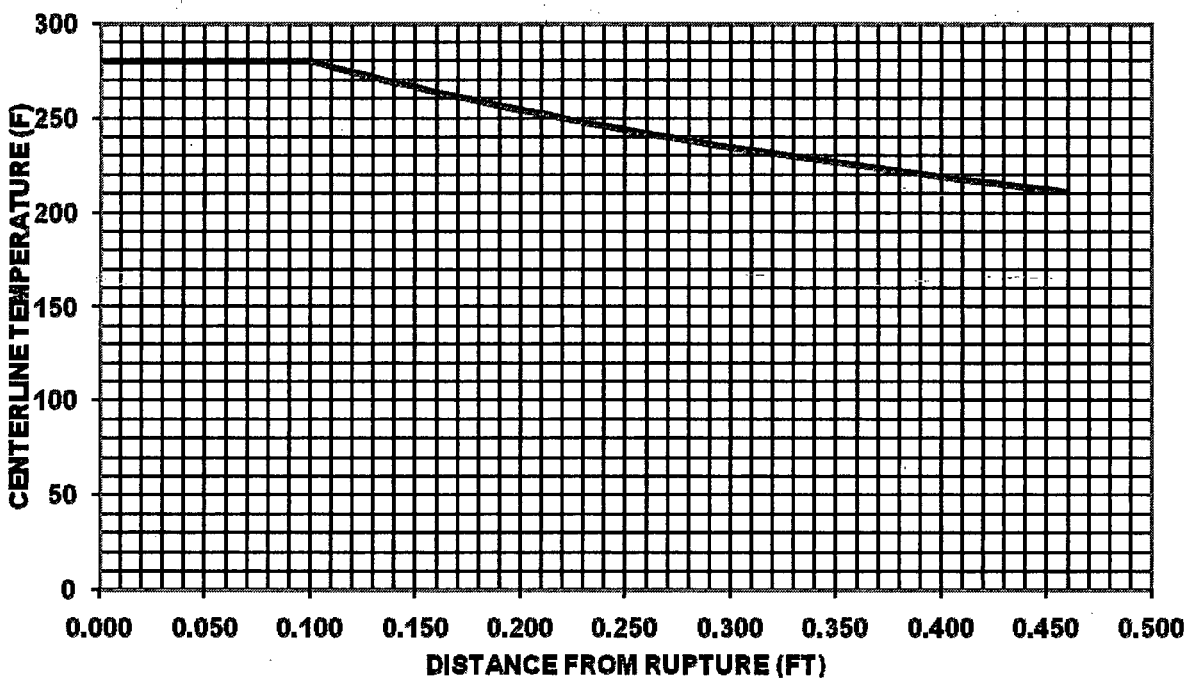
CVCS LETDOWN CRACK

L FT	A SQ FT	P PSI	T F
0.367	0.0489	4.2	224
0.375	0.0501	3.8	223
0.383	0.0513	3.4	222
0.392	0.0525	3.0	220
0.400	0.0537	2.6	219
0.408	0.0549	2.2	218
0.417	0.0562	1.8	217
0.425	0.0574	1.5	216
0.433	0.0587	1.1	215
0.442	0.0600	0.8	214
0.450	0.0613	0.5	213
0.458	0.0626	0.2	211

PRESSURE VERSUS DISTANCE, CVCS LETDOWN CRACK



TEMPERATURE VERSUS DISTANCE, CVCS LETDOWN CRACK

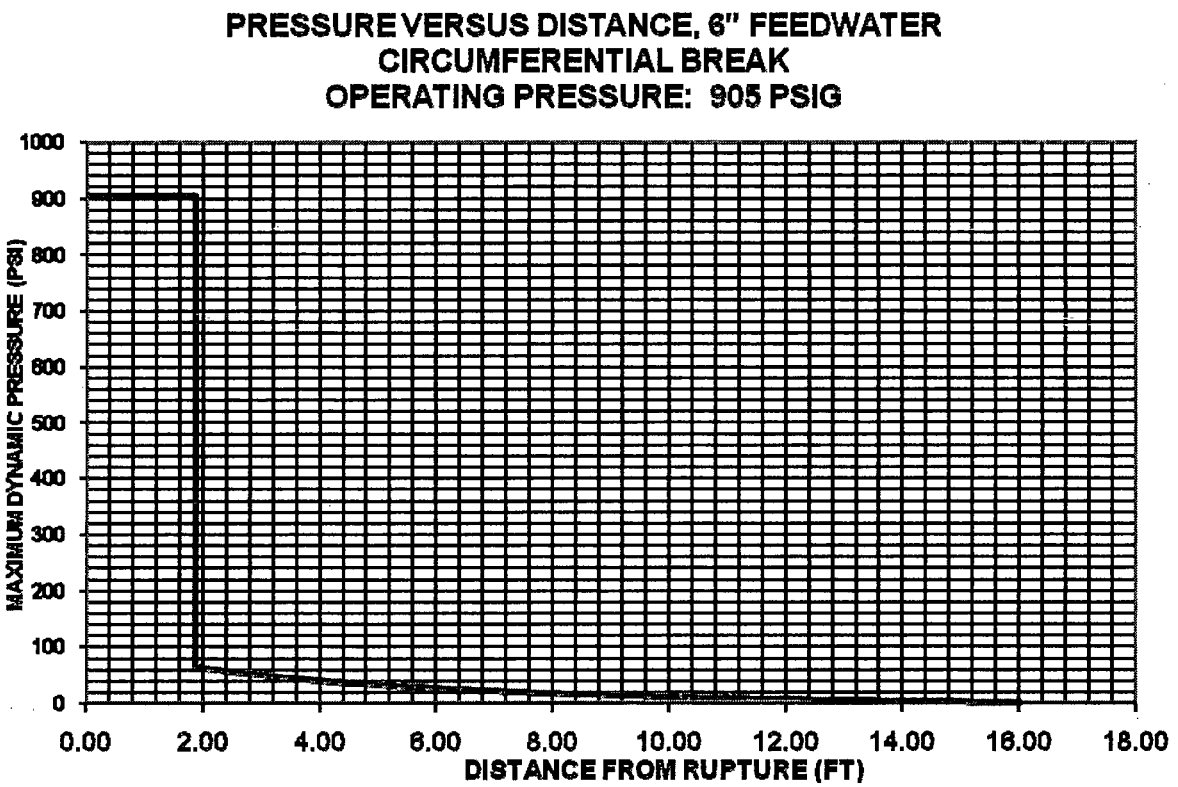


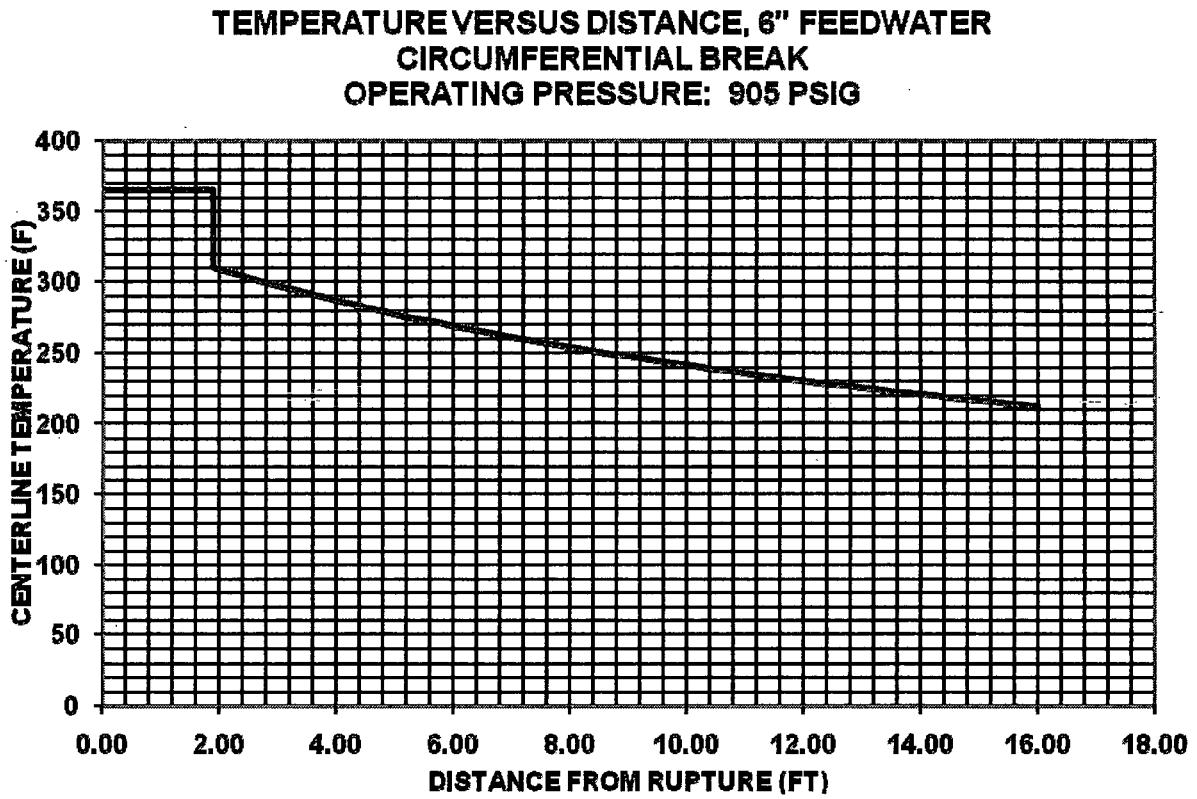
6" FEEDWATER CIRCUMFERENTIAL BREAK 905 PSIG

L FT	A SQ FT	P PSI	T F
0.00		905	365
1.87		905	365
1.87	11.6215	63.9	311
2.00	11.9056	62.1	309
2.25	12.4508	58.7	306
2.50	13.0083	55.6	303
2.75	13.5781	52.7	300
3.00	14.1600	49.9	297
3.25	14.7541	47.3	295
3.50	15.3604	44.9	292
3.75	15.9790	42.6	289
4.00	16.6097	40.4	287
4.25	17.2527	38.4	284
4.50	17.9079	36.4	282
4.75	18.5753	34.6	280
5.00	19.2549	32.9	277
5.25	19.9467	31.2	275
5.50	20.6507	29.7	273
5.75	21.3669	28.2	271
6.00	22.0953	26.8	269
6.25	22.8360	25.5	267
6.50	23.5888	24.2	265
6.75	24.3539	23.0	263
7.00	25.1312	21.8	261
7.25	25.9207	20.7	259
7.50	26.7223	19.7	258
7.75	27.5362	18.7	256
8.00	28.3624	17.7	254
8.25	29.2007	16.8	253
8.50	30.0512	15.9	251
8.75	30.9139	15.1	249
9.00	31.7889	14.2	248
9.25	32.6760	13.5	246
9.50	33.5754	12.7	245
9.75	34.4870	12.0	243

6" FEEDWATER CIRCUMFERENTIAL BREAK 905 PSIG

L FT	A SQ FT	P PSI	T F
10.00	35.4108	11.3	242
10.25	36.3468	10.7	240
10.50	37.2950	10.0	239
10.75	38.2554	9.4	237
11.00	39.2280	8.8	236
11.25	40.2128	8.2	235
11.50	41.2099	7.7	233
11.75	42.2191	7.2	232
12.00	43.2406	6.7	231
12.25	44.2743	6.2	229
12.50	45.3201	5.7	228
12.75	46.3782	5.2	227
13.00	47.4485	4.8	226
13.25	48.5310	4.4	225
13.50	49.6257	4.0	223
13.75	50.7327	3.6	222
14.00	51.8518	3.2	221
14.25	52.9832	2.8	220
14.50	54.1267	2.4	219
14.75	55.2825	2.1	218
15.00	56.4505	1.7	217
15.25	57.6306	1.4	216
15.50	58.8230	1.1	215
15.75	60.0276	0.8	214
16.00	61.2444	0.5	213
16.25	62.4735	0.2	212


PRESSURE VERSUS DISTANCE, 6" FEEDWATER
CIRCUMFERENTIAL BREAK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
DISTANCE FROM RUPTURE (FT)

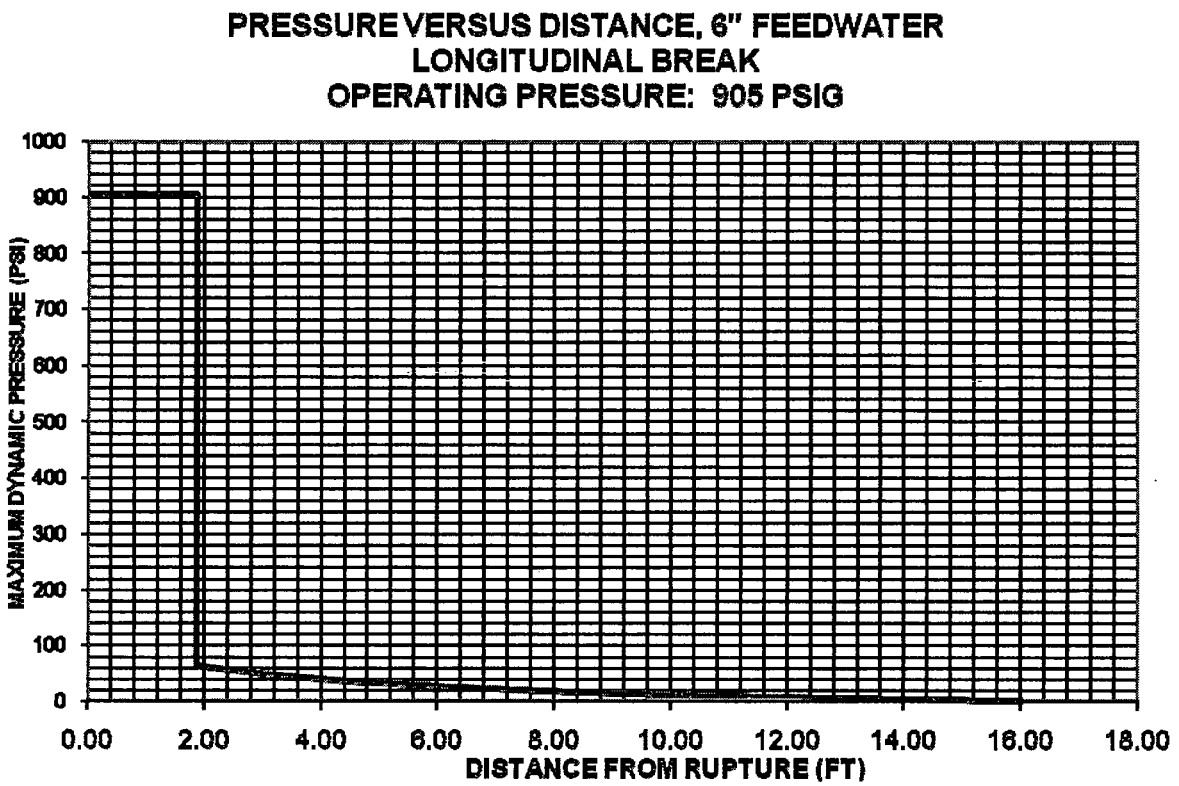

TEMPERATURE VERSUS DISTANCE, 6" FEEDWATER
CIRCUMFERENTIAL BREAK
OPERATING PRESSURE: 905 PSIG
CENTERLINE TEMPERATURE (F)
400
350
300
250
200
150
100
50
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
DISTANCE FROM RUPTURE (FT)

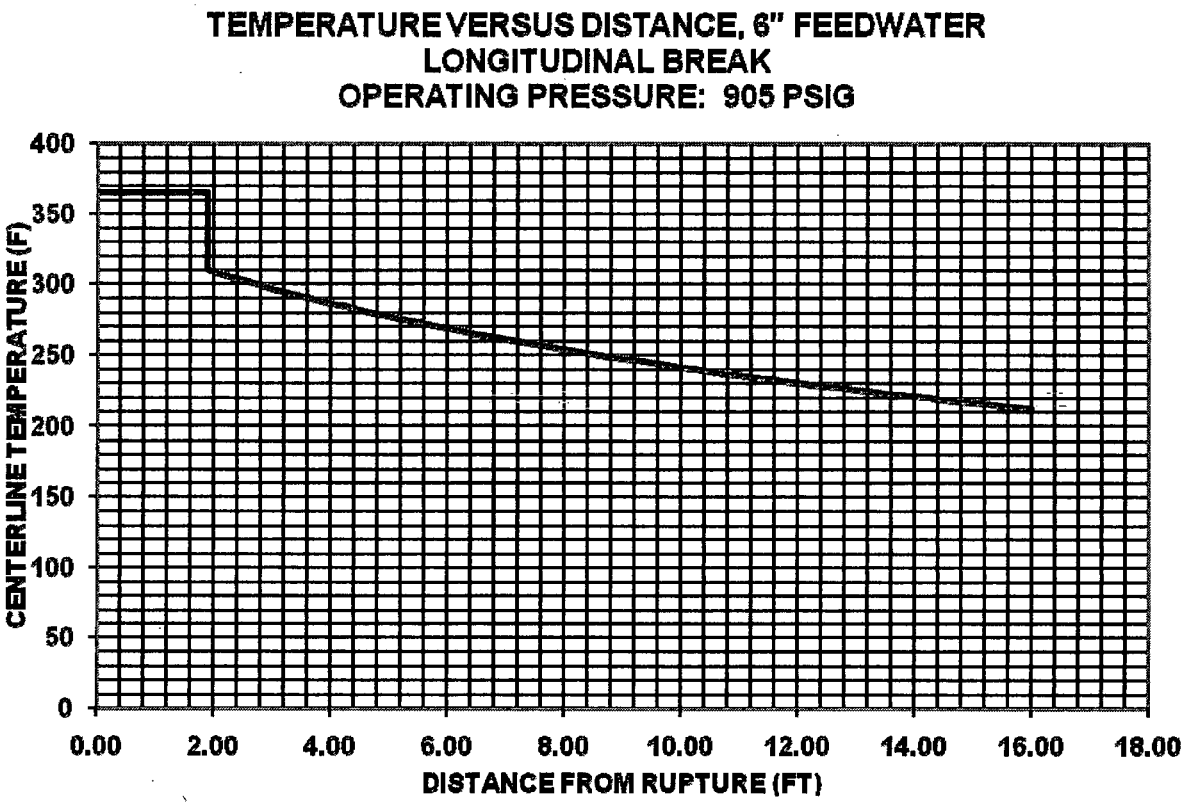
6" FEEDWATER LONGITUDINAL BREAK 905 PSIG

L FT	A SQ FT	P PSI	T F
0.00		905	365
1.87		905	365
1.87	11.7039	63.4	310
2.00	11.9904	61.5	308
2.25	12.5402	58.2	305
2.50	13.1023	55.1	302
2.75	13.6765	52.2	300
3.00	14.2630	49.4	297
3.25	14.8617	46.9	294
3.50	15.4726	44.4	291
3.75	16.0957	42.2	289
4.00	16.7310	40.0	286
4.25	17.3785	38.0	284
4.50	18.0382	36.1	282
4.75	18.7102	34.3	279
5.00	19.3943	32.5	277
5.25	20.0907	30.9	275
5.50	20.7992	29.4	273
5.75	21.5200	27.9	271
6.00	22.2530	26.5	269
6.25	22.9982	25.2	267
6.50	23.7556	23.9	265
6.75	24.5252	22.7	263
7.00	25.3070	21.6	261
7.25	26.1010	20.5	259
7.50	26.9073	19.4	257
7.75	27.7257	18.4	256
8.00	28.5564	17.5	254
8.25	29.3992	16.6	252
8.50	30.2543	15.7	250
8.75	31.1216	14.9	249
9.00	32.0011	14.1	247
9.25	32.8928	13.3	246
9.50	33.7967	12.5	244
9.75	34.7128	11.8	243

6" FEEDWATER LONGITUDINAL BREAK 905 PSIG

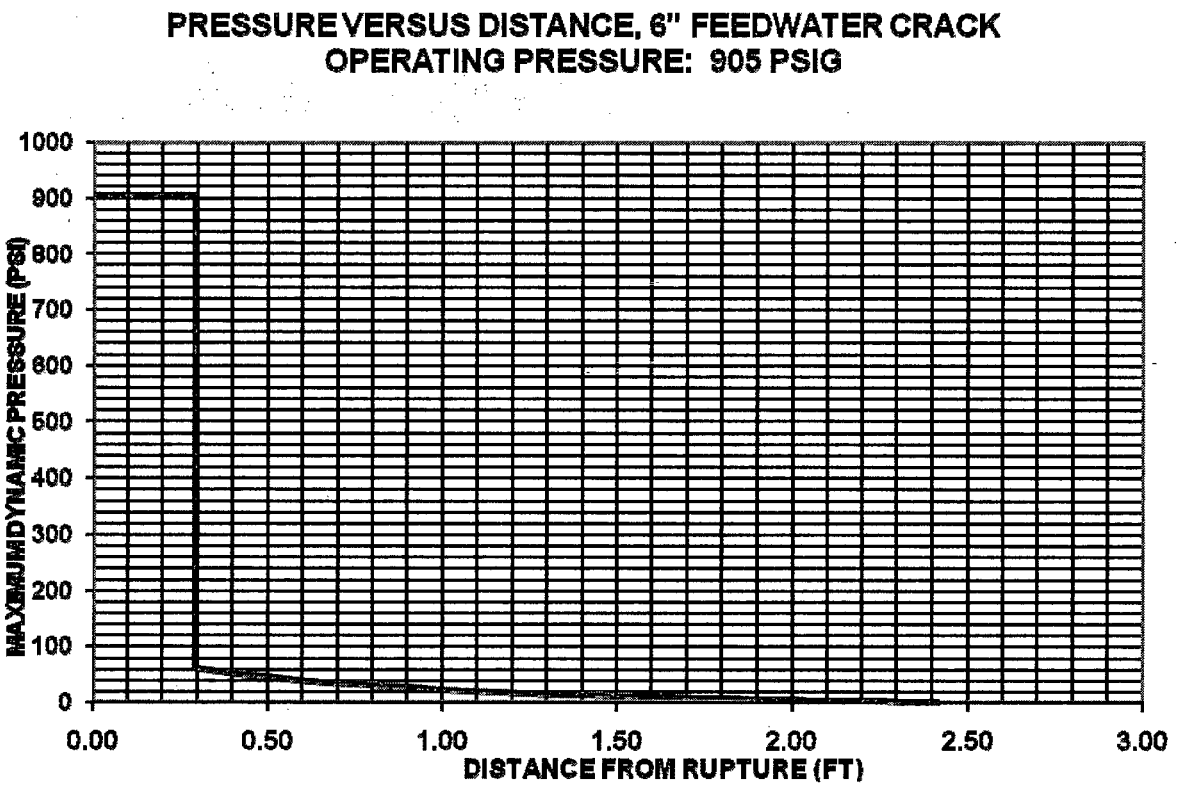
L FT	A SQ FT	P PSI	T F
10.00	35.6412	11.2	241
10.25	36.5817	10.5	240
10.50	37.5345	9.9	238
10.75	38.4994	9.3	237
11.00	39.4766	8.7	236
11.25	40.4660	8.1	234
11.50	41.4676	7.6	233
11.75	42.4814	7.0	232
12.00	43.5074	6.5	230
12.25	44.5456	6.0	229
12.50	45.5960	5.6	228
12.75	46.6587	5.1	227
13.00	47.7335	4.7	225
13.25	48.8206	4.3	224
13.50	49.9199	3.8	223
13.75	51.0313	3.4	222
14.00	52.1550	3.1	221
14.25	53.2909	2.7	220
14.50	54.4390	2.3	219
14.75	55.5993	2.0	217
15.00	56.7719	1.6	216
15.25	57.9566	1.3	215
15.50	59.1535	1.0	214
15.75	60.3627	0.7	213
16.00	61.5840	0.4	212
16.25	62.8176	0.1	211

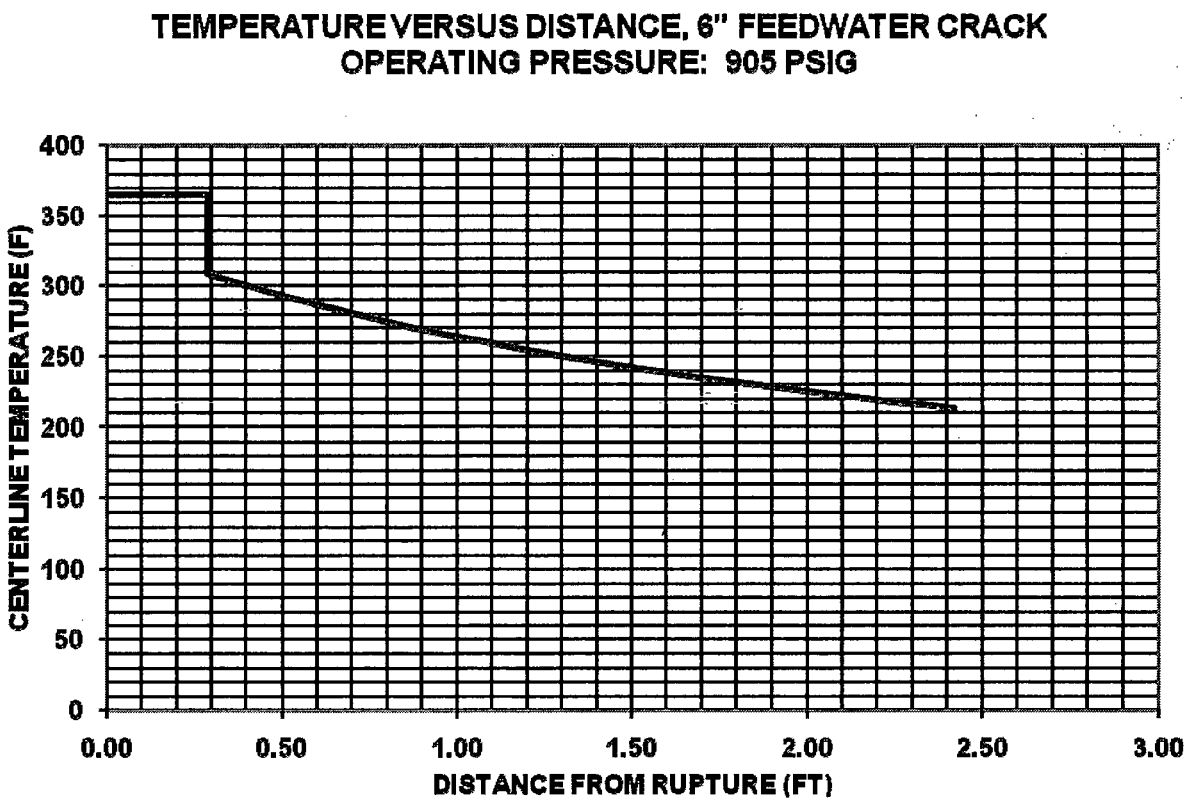

PRESSURE VERSUS DISTANCE, 6" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
DISTANCE FROM RUPTURE (FT)


TEMPERATURE VERSUS DISTANCE, 6" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 905 PSIG
CENTERLINE TEMPERATURE (F)
400
350
300
250
200
150
100
50
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
DISTANCE FROM RUPTURE (FT)

6" FEEDWATER CRACK
905 PSIG

L FT	A SQ FT	P PSI	T F
0.00		905	365
0.29		905	365
0.29	0.29	62	309
0.33	0.30	58	305
0.42	0.33	51	299
0.50	0.36	46	293
0.58	0.39	41	287
0.67	0.43	36	282
0.75	0.46	33	277
0.83	0.50	29	272
0.92	0.54	26	268
1.00	0.58	23	264
1.08	0.62	21	260
1.17	0.66	19	256
1.25	0.70	17	252
1.33	0.75	15	249
1.42	0.79	13	245
1.50	0.84	11	242
1.58	0.89	10	239
1.67	0.94	8.8	236
1.75	0.99	7.6	233
1.83	1.04	6.5	230
1.92	1.10	5.4	227
2.00	1.15	4.5	225
2.08	1.21	3.6	222
2.17	1.27	2.8	220
2.25	1.33	2.0	217
2.33	1.39	1.3	215
2.42	1.45	0.6	213


PRESSURE VERSUS DISTANCE, 6" FEEDWATER CRACK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
DISTANCE FROM RUPTURE (FT)


TEMPERATURE VERSUS DISTANCE, 6" FEEDWATER CRACK
OPERATING PRESSURE: 905 PSIG
CENTERLINE TEMPERATURE (F)
400
350
300
250
200
150
100
50
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
DISTANCE FROM RUPTURE (FT)

16" FEEDWATER CIRCUMFERENTIAL BREAK 905 PSIG

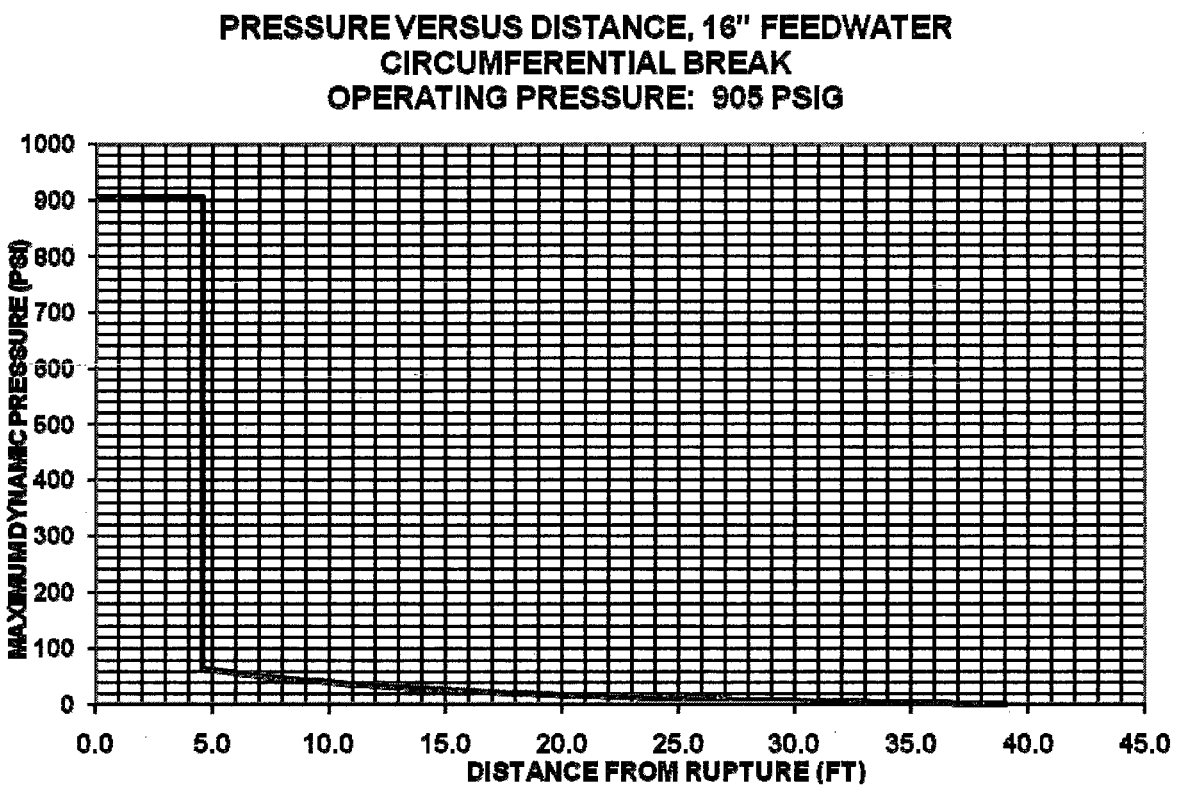
L FT	A SQ FT	P PSI	T F
0.0		905	365.0
4.5		905	365.0
4.5	68	63.9	310.6
5.0	71	61.2	308.1
5.5	73	58.4	305.6
6.0	76	55.8	303.1
6.5	79	53.4	300.7
7.0	81	51.1	298.4
7.5	84	48.8	296.1
8.0	87	46.7	293.9
8.5	90	44.7	291.8
9.0	93	42.8	289.6
9.5	96	41.0	287.6
10.0	99	39.3	285.5
10.5	102	37.7	283.5
11.0	106	36.1	281.6
11.5	109	34.6	279.7
12.0	112	33.2	277.8
12.5	115	31.8	276.0
13.0	119	30.5	274.2
13.5	122	29.2	272.5
14.0	126	28.0	270.8
14.5	129	26.8	269.1
15.0	133	25.7	267.4
15.5	136	24.7	265.8
16.0	140	23.6	264.2
16.5	144	22.7	262.6
17.0	148	21.7	261.1
17.5	151	20.8	259.6
18.0	155	19.9	258.1
18.5	159	19.1	256.6
19.0	163	18.3	255.2
19.5	167	17.5	253.8
20.0	171	16.7	252.4
20.5	175	16.0	251.0

16" FEEDWATER CIRCUMFERENTIAL BREAK 905 PSIG

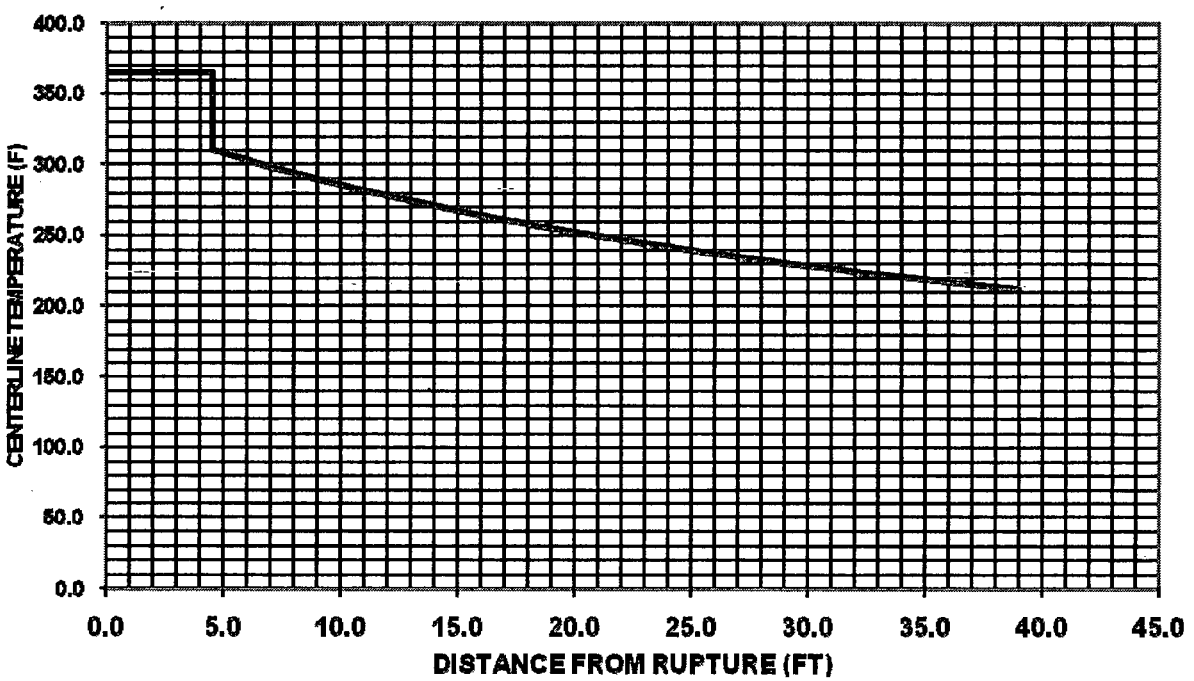
L FT	A SQ FT	P PSI	T F
21.0	180	15.3	249.7
21.5	184	14.6	248.4
22.0	188	14.0	247.1
22.5	192	13.3	245.8
23.0	197	12.7	244.5
23.5	201	12.1	243.3
24.0	206	11.5	242.1
24.5	210	11.0	240.8
25.0	215	10.4	239.7
25.5	219	9.9	238.5
26.0	224	9.4	237.3
26.5	229	8.9	236.2
27.0	233	8.5	235.1
27.5	238	8.0	234.0
28.0	243	7.5	232.9
28.5	248	7.1	231.8
29.0	253	6.7	230.7
29.5	258	6.3	229.7
30.0	263	5.9	228.6
30.5	268	5.5	227.6
31.0	273	5.1	226.6
31.5	278	4.8	225.6
32.0	283	4.4	224.6
32.5	289	4.1	223.7
33.0	294	3.7	222.7
33.5	299	3.4	221.8
34.0	305	3.1	220.8
34.5	310	2.8	219.9
35.0	316	2.5	219.0
35.5	322	2.2	218.1
36.0	327	1.9	217.2
36.5	333	1.6	216.3
37.0	339	1.4	215.4
37.5	344	1.1	214.6
38.0	350	0.8	213.7
38.5	356	0.6	212.9
39.0	362	0.3	212.0

16" FEEDWATER CIRCUMFERENTIAL BREAK 905 PSIG

L FT	A SQ FT	P PSI	T F
39.5	368	0.1	211.2


PRESSURE VERSUS DISTANCE, 16" FEEDWATER
CIRCUMFERENTIAL BREAK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
DISTANCE FROM RUPTURE (FT)

TEMPERATURE VERSUS DISTANCE, 16" FEEDWATER CIRCUMFERENTIAL BREAK OPERATING PRESSURE: 905 PSIG



16" FEEDWATER LONGITUDINAL BREAK 905 PSIG

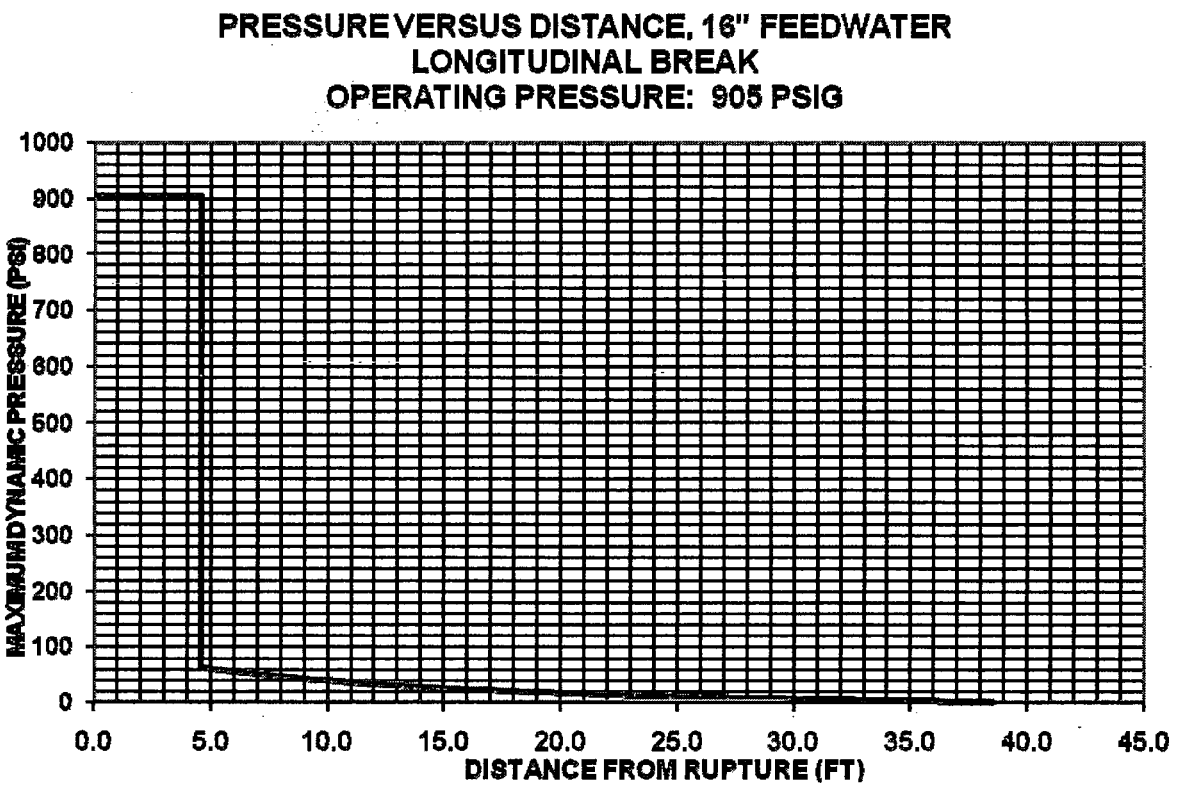
L FT	A SQ FT	P PSI	T F
0.0		905	365.0
4.5		905	365.0
4.5	69	63.4	310.1
5.0	71	60.6	307.6
5.5	74	57.9	305.1
6.0	76	55.3	302.6
6.5	79	52.9	300.3
7.0	82	50.6	297.9
7.5	85	48.4	295.7
8.0	88	46.3	293.4
8.5	91	44.3	291.3
9.0	94	42.4	289.2
9.5	97	40.6	287.1
10.0	100	38.9	285.1
10.5	103	37.3	283.1
11.0	106	35.7	281.1
11.5	110	34.2	279.2
12.0	113	32.8	277.4
12.5	116	31.5	275.6
13.0	120	30.2	273.8
13.5	123	28.9	272.0
14.0	127	27.7	270.3
14.5	130	26.6	268.6
15.0	134	25.5	267.0
15.5	137	24.4	265.4
16.0	141	23.4	263.8
16.5	145	22.4	262.2
17.0	149	21.5	260.7
17.5	152	20.6	259.2
18.0	156	19.7	257.7
18.5	160	18.9	256.2
19.0	164	18.0	254.8
19.5	168	17.3	253.4
20.0	172	16.5	252.0
20.5	177	15.8	250.6

16" FEEDWATER LONGITUDINAL BREAK 905 PSIG

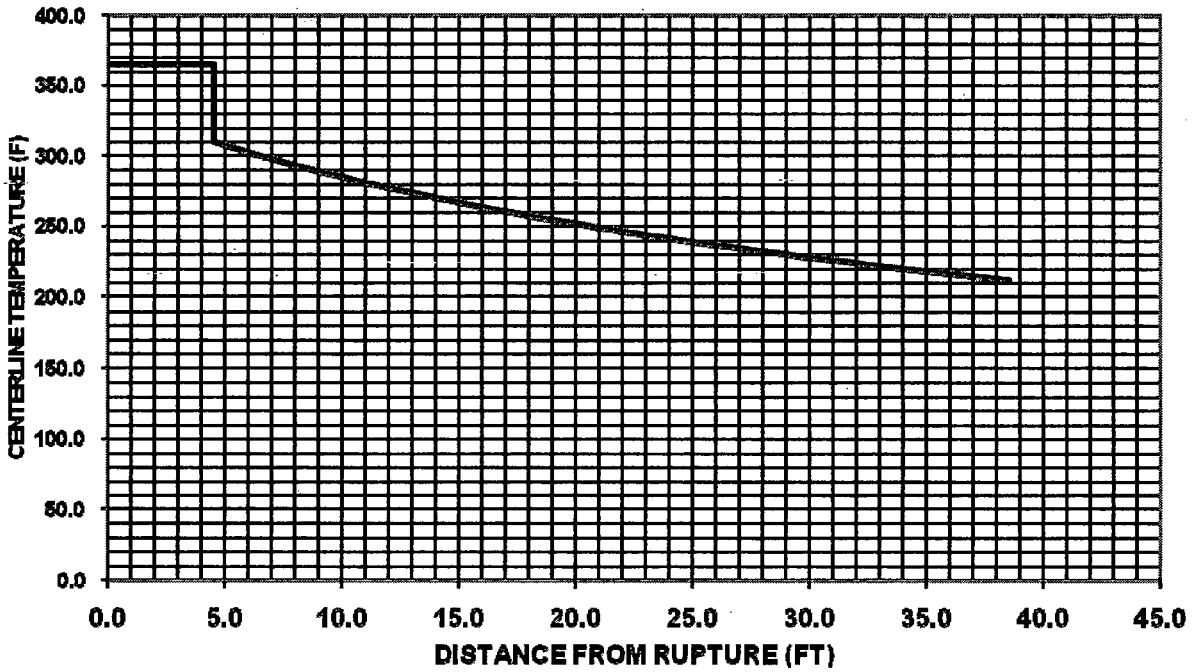
L FT	A SQ FT	P PSI	T F
21.0	181	15.1	249.3
21.5	185	14.4	248.0
22.0	189	13.8	246.7
22.5	194	13.1	245.4
23.0	198	12.5	244.2
23.5	202	11.9	242.9
24.0	207	11.4	241.7
24.5	211	10.8	240.5
25.0	216	10.3	239.3
25.5	221	9.8	238.1
26.0	225	9.3	237.0
26.5	230	8.8	235.8
27.0	235	8.3	234.7
27.5	240	7.9	233.6
28.0	244	7.4	232.5
28.5	249	7.0	231.5
29.0	254	6.6	230.4
29.5	259	6.2	229.4
30.0	264	5.8	228.3
30.5	270	5.4	227.3
31.0	275	5.0	226.3
31.5	280	4.6	225.3
32.0	285	4.3	224.3
32.5	290	4.0	223.4
33.0	296	3.6	222.4
33.5	301	3.3	221.5
34.0	307	3.0	220.5
34.5	312	2.7	219.6
35.0	318	2.4	218.7
35.5	323	2.1	217.8
36.0	329	1.8	216.9
36.5	335	1.5	216.0
37.0	340	1.3	215.1
37.5	346	1.0	214.3
38.0	352	0.7	213.4
38.5	358	0.5	212.6
39.0	364	0.3	211.8

16" FEEDWATER LONGITUDINAL BREAK 905 PSIG

L	A	P	T
FT	SQ FT	PSI	F
39.5	370	0.0	210.9


PRESSURE VERSUS DISTANCE, 16" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
DISTANCE FROM RUPTURE (FT)

TEMPERATURE VERSUS DISTANCE, 16" FEEDWATER LONGITUDINAL BREAK OPERATING PRESSURE: 905 PSIG

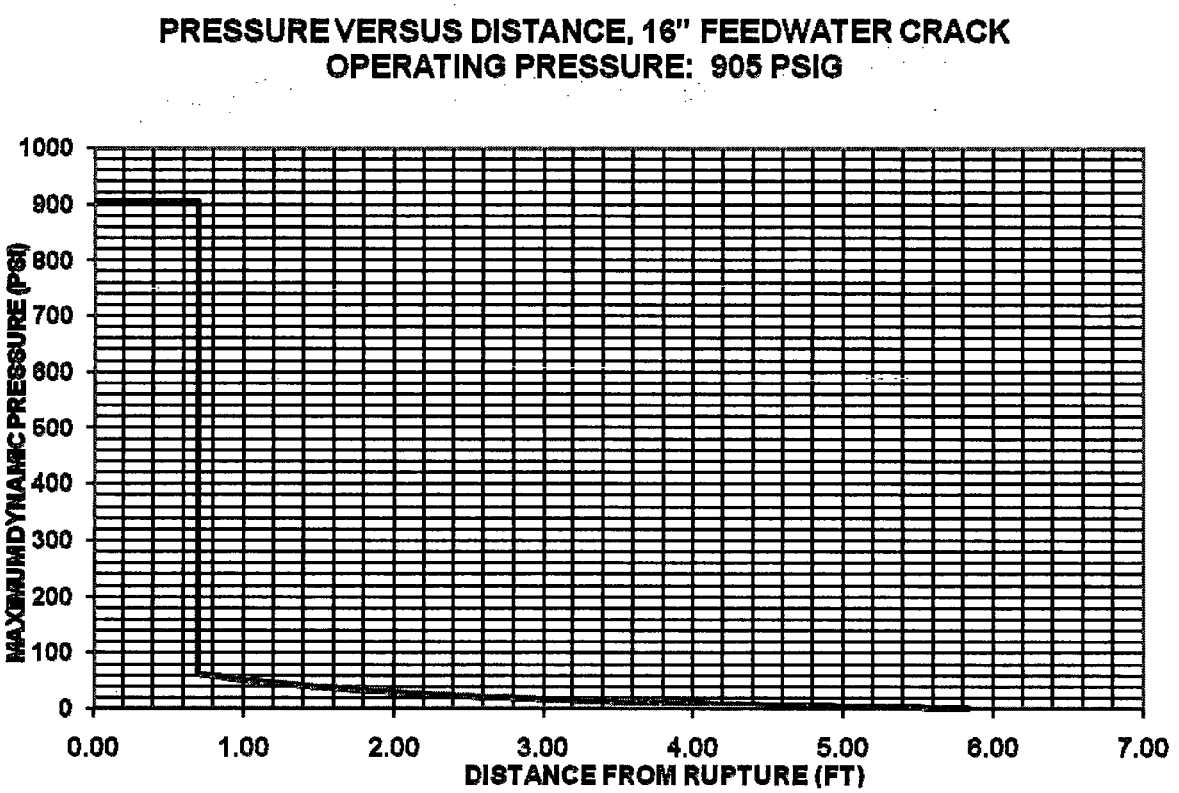


16" FEEDWATER CRACK
905 PSIG

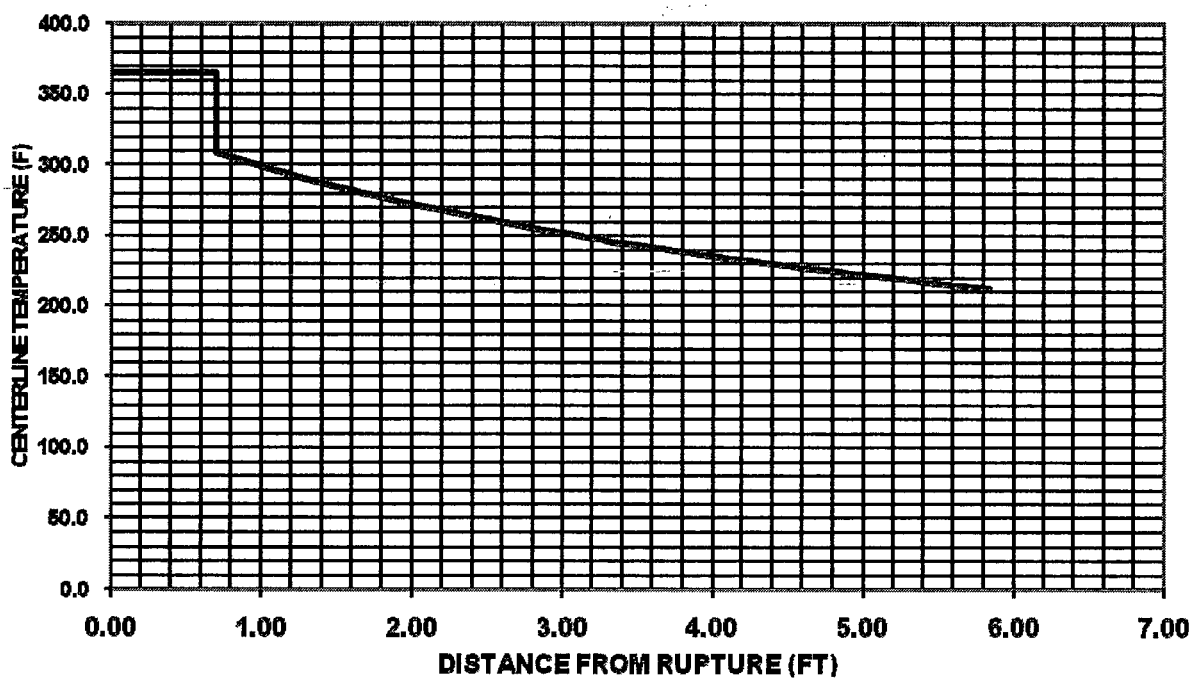
L FT	A SQ FT	P PSI	T F
0.00		905	365.0
0.69		905	365.0
0.69	1.65	61.8	308.7
0.75	1.69	59.7	306.8
0.83	1.76	56.8	304.0
0.92	1.83	54.0	301.4
1.00	1.91	51.4	298.8
1.08	1.98	49.0	296.3
1.17	2.05	46.7	293.8
1.25	2.13	44.5	291.5
1.33	2.21	42.4	289.1
1.42	2.29	40.4	286.9
1.50	2.37	38.6	284.7
1.58	2.45	36.8	282.5
1.67	2.53	35.1	280.4
1.75	2.62	33.5	278.3
1.83	2.70	32.0	276.3
1.92	2.79	30.6	274.4
2.00	2.88	29.2	272.4
2.08	2.97	27.9	270.5
2.17	3.06	26.6	268.7
2.25	3.15	25.4	266.9
2.33	3.25	24.2	265.1
2.42	3.34	23.1	263.4
2.50	3.44	22.1	261.7
2.58	3.54	21.1	260.0
2.67	3.64	20.1	258.4
2.75	3.74	19.2	256.8
2.83	3.84	18.3	255.2
2.92	3.94	17.4	253.7
3.00	4.05	16.6	252.2
3.08	4.15	15.8	250.7
3.17	4.26	15.0	249.2
3.25	4.37	14.3	247.8

16" FEEDWATER CRACK
905 PSIG

L FT	A SQ FT	P PSI	T F
3.33	4.48	13.6	245.4
3.42	4.59	12.9	245.0
3.50	4.71	12.3	243.6
3.58	4.82	11.6	242.3
3.67	4.94	11.0	241.0
3.75	5.05	10.4	239.7
3.83	5.17	9.9	238.4
3.92	5.29	9.3	237.1
4.00	5.41	8.8	235.9
4.08	5.53	8.3	234.7
4.17	5.66	7.8	233.5
4.25	5.78	7.3	232.3
4.33	5.91	6.8	231.1
4.42	6.04	6.4	230.0
4.50	6.17	6.0	228.8
4.58	6.30	5.5	227.7
4.67	6.43	5.1	226.6
4.75	6.56	4.7	225.5
4.83	6.70	4.3	224.5
4.92	6.83	4.0	223.4
5.00	6.97	3.6	222.4
5.08	7.11	3.3	221.3
5.17	7.25	2.9	220.3
5.25	7.39	2.6	219.3
5.33	7.53	2.3	218.3
5.42	7.68	1.9	217.3
5.50	7.82	1.6	216.4
5.58	7.97	1.3	215.4
5.67	8.12	1.1	214.5
5.75	8.27	0.8	213.6
5.83	8.42	0.5	212.7
5.92	8.57	0.2	211.7


PRESSURE VERSUS DISTANCE, 16" FEEDWATER CRACK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
DISTANCE FROM RUPTURE (FT)

TEMPERATURE VERSUS DISTANCE, 16" FEEDWATER CRACK
OPERATING PRESSURE: 905 PSIG

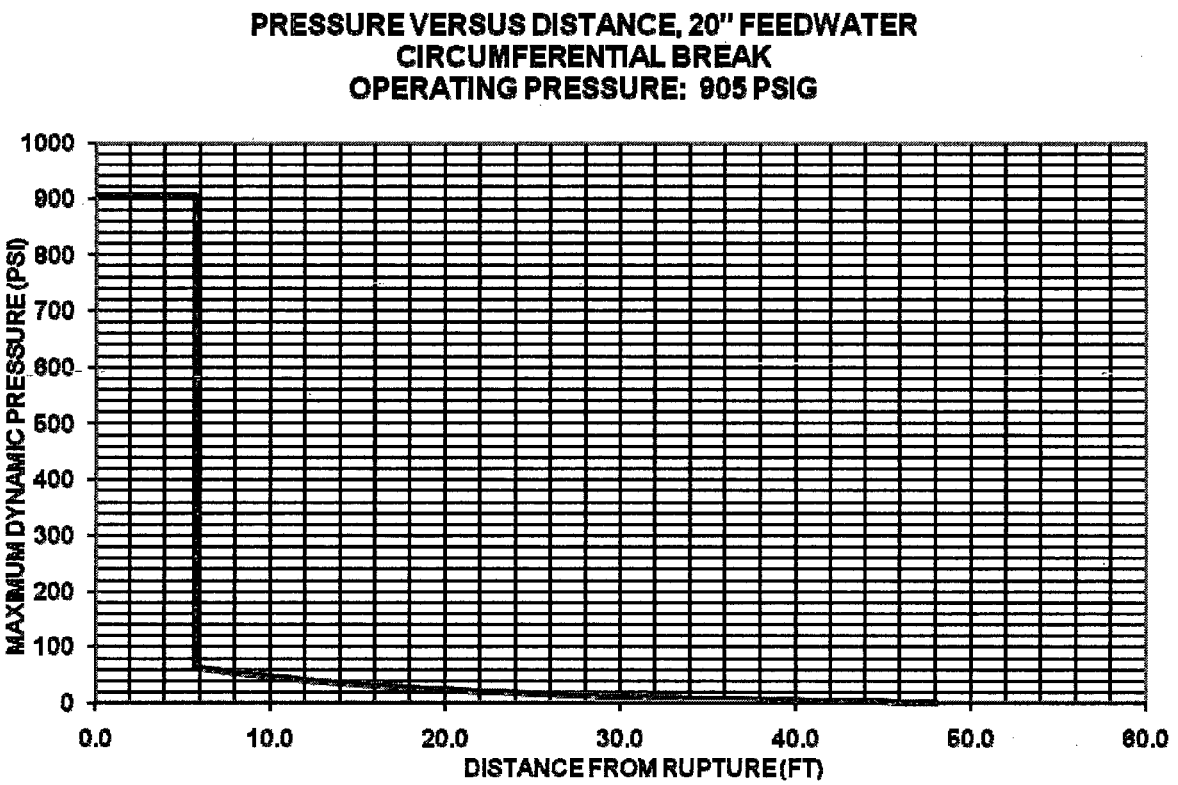


20" FEEDWATER CIRCUMFERENTIAL BREAK 905 PSIG

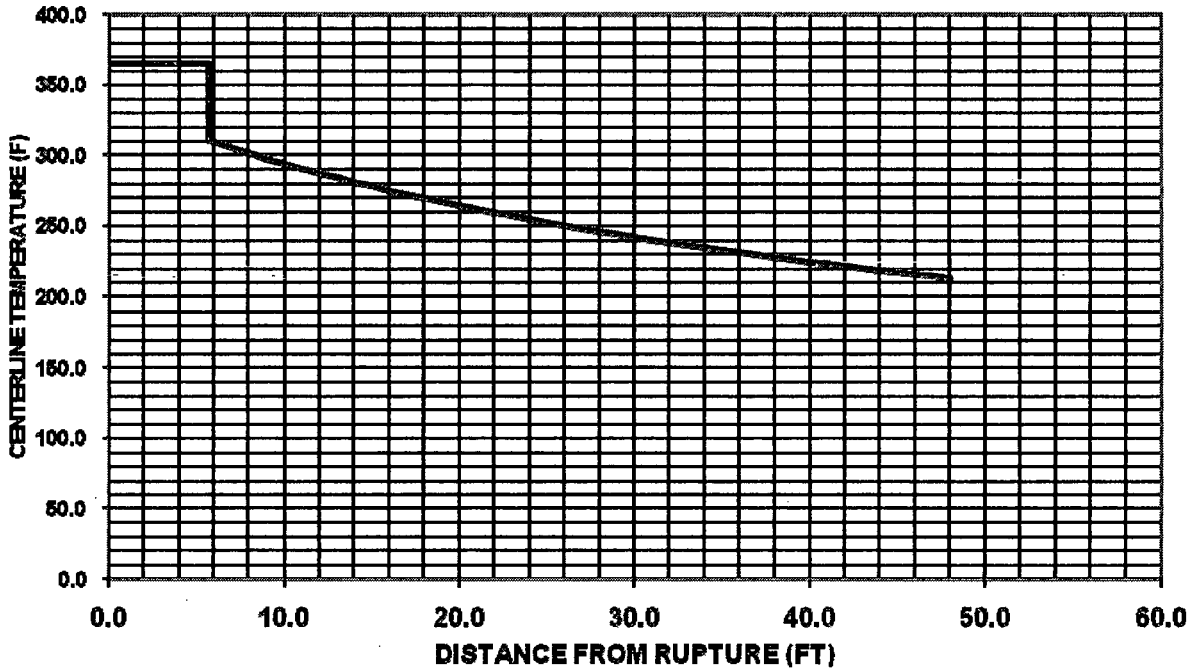
L FT	A SQ FT	P PSI	T F
0.0		905	365.0
5.7		905	365.0
5.7	106	63.9	310.6
6.0	109	62.3	309.1
7.0	115	57.9	305.1
8.0	122	53.9	301.2
9.0	129	50.2	297.5
10.0	136	46.8	294.0
11.0	144	43.6	290.5
12.0	151	40.7	287.2
13.0	159	38.0	284.0
14.0	167	35.5	280.9
15.0	175	33.2	277.9
16.0	184	31.0	275.0
17.0	192	29.0	272.2
18.0	201	27.1	269.4
19.0	210	25.3	266.8
20.0	219	23.7	264.2
21.0	228	22.1	261.7
22.0	238	20.7	259.3
23.0	248	19.3	257.0
24.0	258	18.0	254.7
25.0	268	16.8	252.4
26.0	278	15.6	250.3
27.0	289	14.5	248.2
28.0	299	13.5	246.1
29.0	310	12.5	244.1
30.0	321	11.6	242.1
31.0	333	10.7	240.2
32.0	344	9.8	238.3
33.0	356	9.0	236.5
34.0	368	8.3	234.7
35.0	380	7.6	232.9
36.0	392	6.9	231.2
37.0	405	6.2	229.5

20" FEEDWATER CIRCUMFERENTIAL BREAK 905 PSIG

L FT	A SQ FT	P PSI	T F
38.0	417	5.6	227.9
39.0	430	5.0	226.3
40.0	443	4.4	224.7
41.0	457	3.9	223.1
42.0	470	3.4	221.6
43.0	484	2.9	220.1
44.0	497	2.4	218.7
45.0	511	1.9	217.2
46.0	526	1.5	215.8
47.0	540	1.1	214.5
48.0	555	0.6	213.1
49.0	570	0.3	211.8


PRESSURE VERSUS DISTANCE, 20" FEEDWATER
CIRCUMFERENTIAL BREAK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
DISTANCE FROM RUPTURE (FT)

TEMPERATURE VERSUS DISTANCE, 20" FEEDWATER CIRCUMFERENTIAL BREAK OPERATING PRESSURE: 905 PSIG

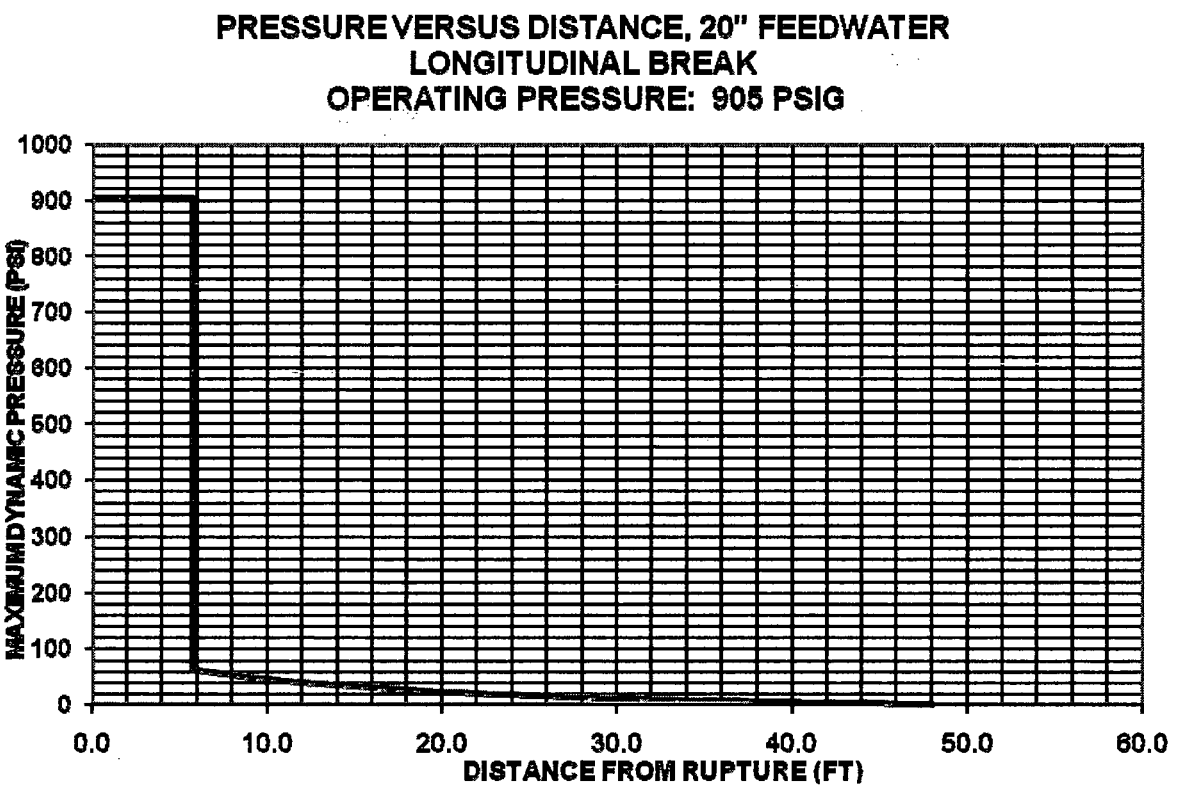


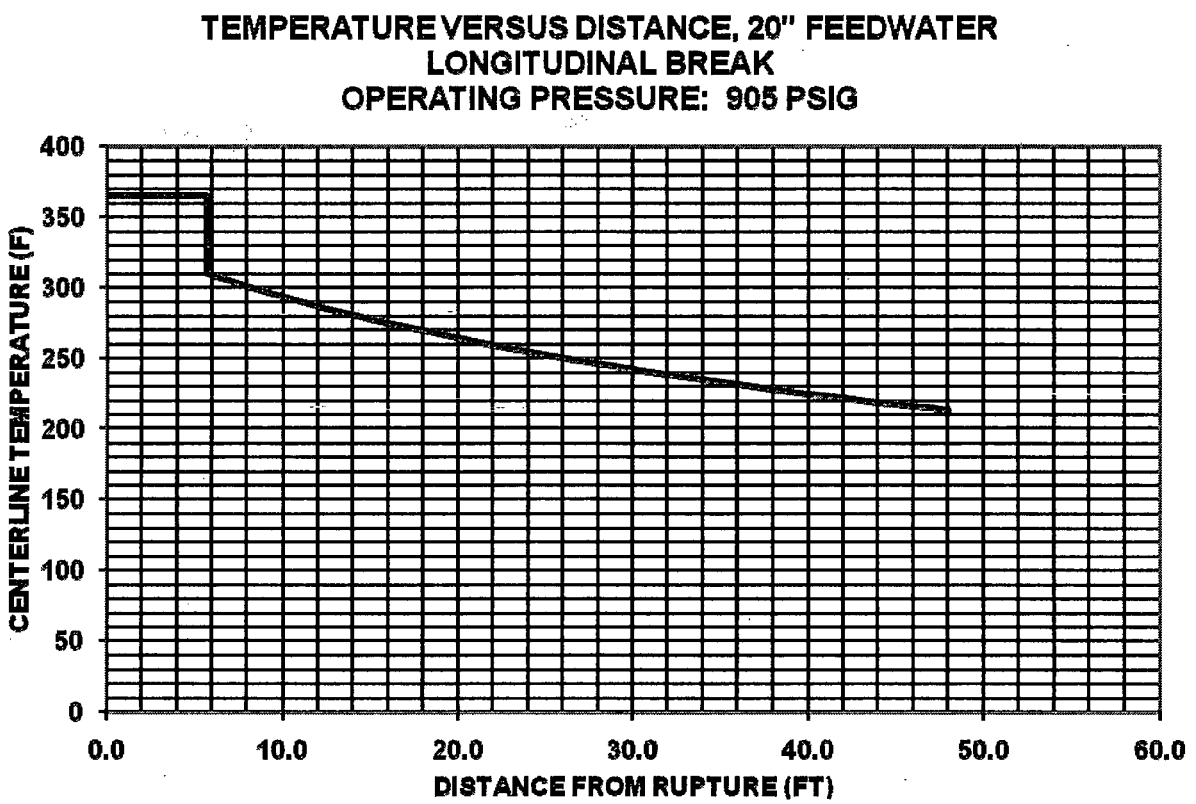
20" FEEDWATER LONGITUDINAL BREAK 905 PSIG

L FT	A SQ FT	P PSI	T F
0.0		905	365
5.7		905	365
5.7	107	63	310
6	110	62	309
7	116	57	305
8	123	53	301
9	130	50	297
10	137	46	293
11	145	43	290
12	152	40	287
13	160	38	284
14	168	35	280
15	177	33	277
16	185	31	275
17	194	29	272
18	202	27	269
19	211	25	266
20	221	23	264
21	230	22	261
22	240	20	259
23	249	19	257
24	259	18	254
25	270	17	252
26	280	15	250
27	291	14	248
28	301	13	246
29	312	12	244
30	324	11	242
31	335	11	240
32	346	10	238
33	358	8.9	236
34	370	8.1	234
35	382	7.4	233
36	395	6.7	231
37	407	6.1	229

20" FEEDWATER LONGITUDINAL BREAK 905 PSIG

L FT	A SQ FT	P PSI	T F
38	420	5.5	228
39	433	4.9	226
40	446	4.3	224
41	459	3.8	223
42	473	3.3	221
43	486	2.8	220
44	500	2.3	218
45	514	1.8	217
46	529	1.4	216
47	543	1.0	214
48	558	0.6	213
49	573	0.2	211


PRESSURE VERSUS DISTANCE, 20" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 905 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
DISTANCE FROM RUPTURE (FT)


TEMPERATURE VERSUS DISTANCE, 20" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 905 PSIG
CENTERLINE TEMPERATURE (F)
400
350
300
250
200
150
100
50
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
DISTANCE FROM RUPTURE (FT)

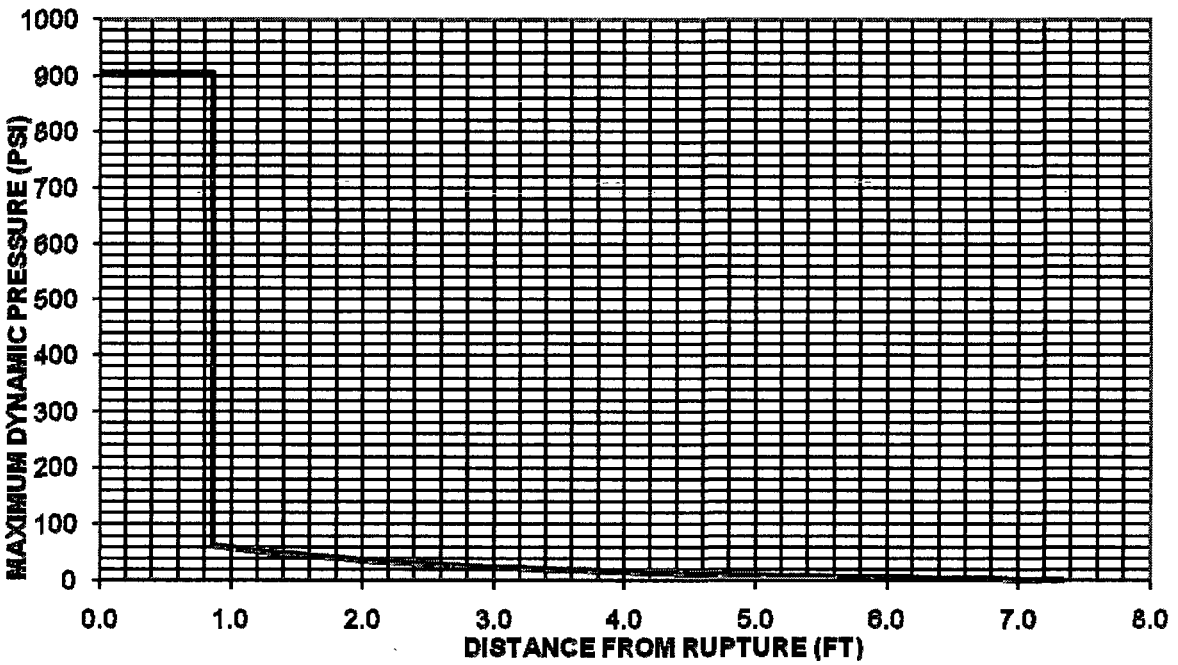
20" FEEDWATER CRACK
905 PSIG

L FT	A SQ FT	P PSI	T F
0.0		905	365
0.9		905	365
0.9	2.6	62	309
1.0	2.7	58	305
1.2	2.9	53	301
1.3	3.1	49	297
1.5	3.2	46	293
1.7	3.4	42	289
1.8	3.6	39	285
2.0	3.8	36	282
2.2	4.1	34	279
2.3	4.3	31	275
2.5	4.5	29	272
2.7	4.7	27	269
2.8	4.9	25	266
3.0	5.2	23	264
3.2	5.4	22	261
3.3	5.7	20	258
3.5	5.9	19	256
3.7	6.2	17	253
3.8	6.4	16	251
4.0	6.7	15	248
4.2	7.0	14	246
4.3	7.3	12	244
4.5	7.5	11	242
4.7	7.8	10	240
4.8	8.1	10	238
5.0	8.4	8.7	236
5.2	8.7	7.9	234
5.3	9.1	7.1	232
5.5	9.4	6.4	230
5.7	9.7	5.7	228
5.8	10.0	5.1	226
6.0	10.4	4.4	225

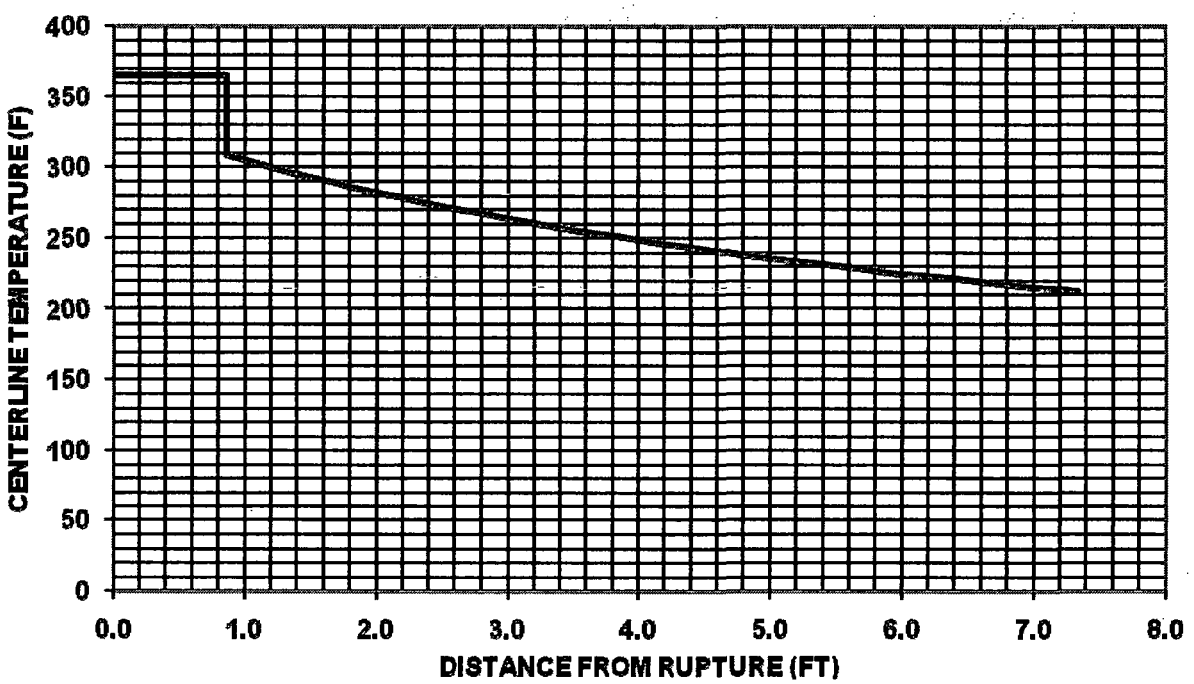
20" FEEDWATER CRACK
905 PSIG

L FT	A SQ FT	P PSI	T F
6.2	10.7	3.8	223
6.3	11.0	3.3	221
6.5	11.4	2.7	220
6.7	11.8	2.2	218
6.8	12.1	1.7	217
7.0	12.5	1.2	215
7.2	12.9	0.8	214
7.3	13.2	0.4	212

PRESSURE VERSUS DISTANCE, 20' FEEDWATER CRACK
OPERATING PRESSURE: 905 PSIG



TEMPERATURE VERSUS DISTANCE, 20" FEEDWATER CRACK
OPERATING PRESSURE: 905 PSIG



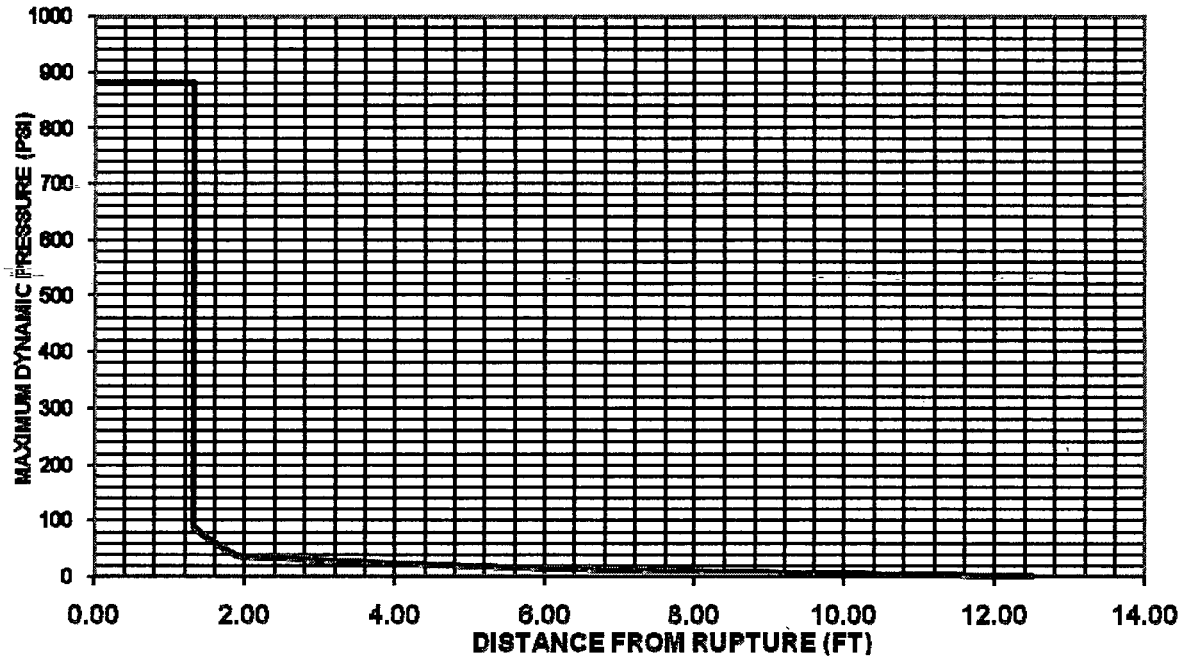
6" FEEDWATER CIRCUMFERENTIAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
0.00		880	457
1.31		880	457
1.31		88	330
1.50		67	313
1.75		46	293
1.89	14.1889	37	283
2.00	14.4606	36	281
2.25	15.0609	34	279
2.50	15.6734	32	276
2.75	16.2982	30	274
3.00	16.9352	29	272
3.25	17.5843	27	269
3.50	18.2457	25	267
3.75	18.9193	24	265
4.00	19.6051	23	263
4.25	20.3031	21	261
4.50	21.0133	20	259
4.75	21.7358	19	257
5.00	22.4704	18	255
5.25	23.2173	17	253
5.50	23.9763	16	251
5.75	24.7476	15	249
6.00	25.5311	14	247
6.25	26.3268	13	246
6.50	27.1347	12.4	244
6.75	27.9548	11.6	242
7.00	28.7871	10.9	241
7.25	29.6316	10.2	239
7.50	30.4884	9.5	237
7.75	31.3573	8.8	236
8.00	32.2385	8.2	234
8.25	33.1318	7.6	233
8.50	34.0374	7.0	231
8.75	34.9552	6.4	230
9.00	35.8852	5.9	229
9.25	36.8274	5.4	227

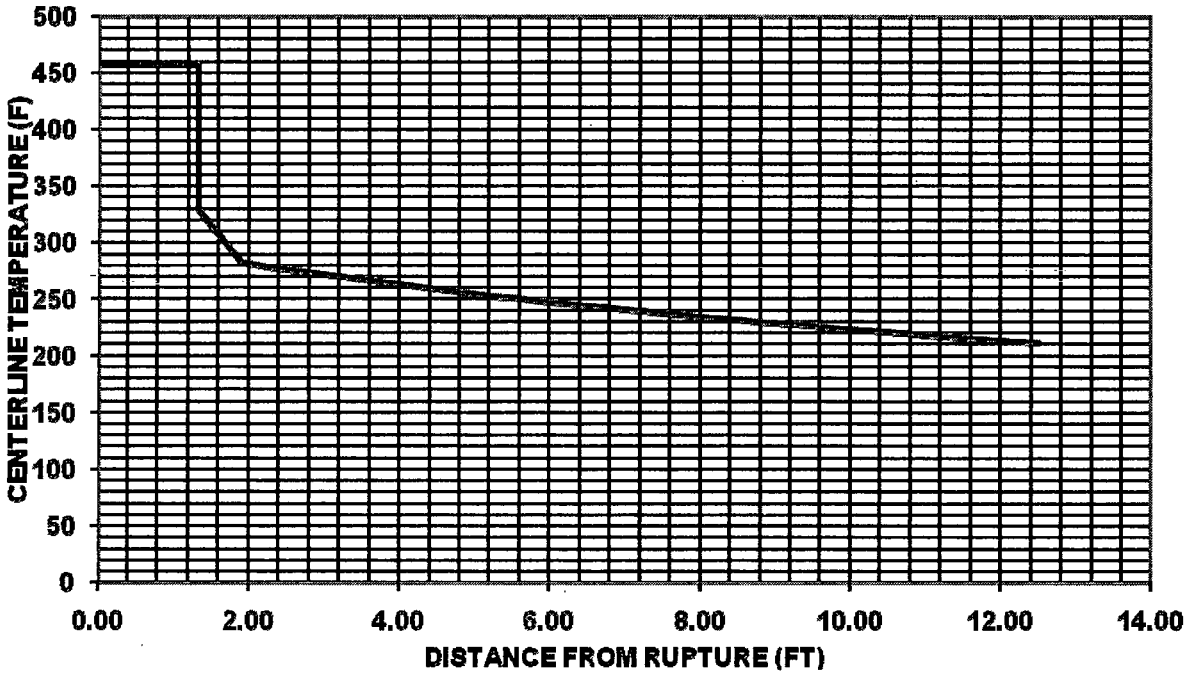
6" FEEDWATER CIRCUMFERENTIAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
9.50	37.7818	4.9	226
9.75	38.7484	4.4	225
10.00	39.7272	3.9	223
10.25	40.7183	3.5	222
10.50	41.7215	3.1	221
10.75	42.7370	2.6	219
11.00	43.7647	2.2	218
11.25	44.8045	1.9	217
11.50	45.8566	1.5	216
11.75	46.9209	1.1	215
12.00	47.9974	0.8	214
12.25	49.0861	0.4	212
12.50	50.1871	0.1	211

PRESSURE VERSUS DISTANCE, 6" FEEDWATER CIRCUMFERENTIAL BREAK OPERATING PRESSURE: 880 PSIG



TEMPERATURE VERSUS DISTANCE, 6" FEEDWATER CIRCUMFERENTIAL BREAK OPERATING PRESSURE: 880 PSIG



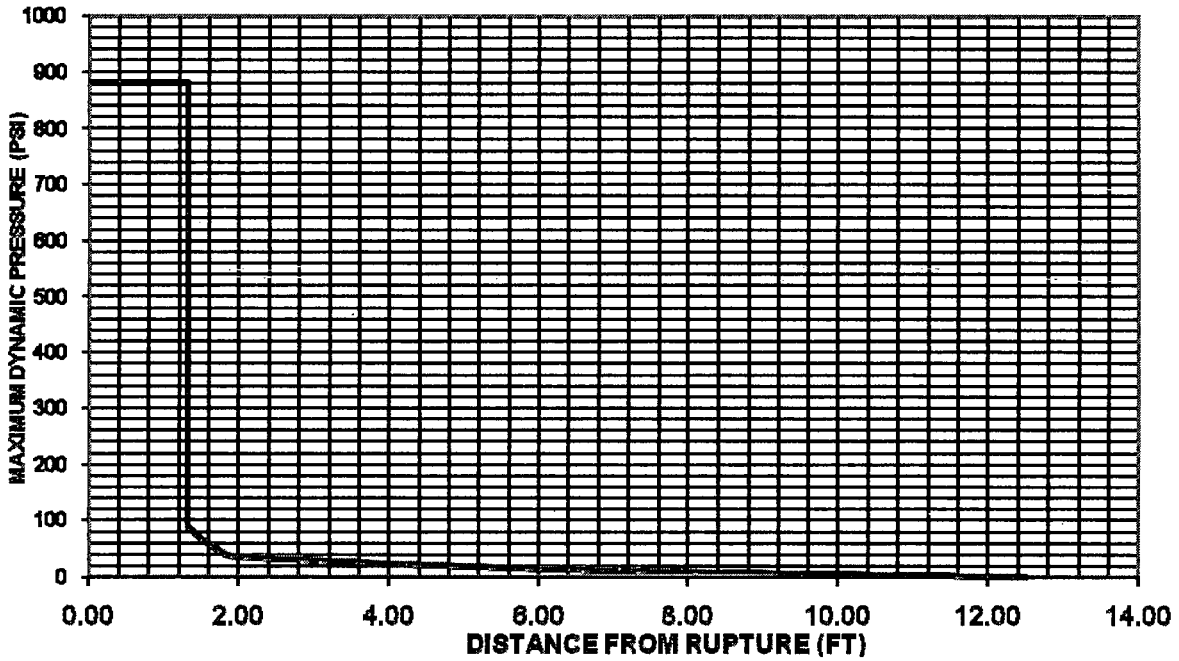
6" FEEDWATER LONGITUDINAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
0.00		880	457
1.31		880	457
1.31		88	330
1.50		66	312
1.75		44	291
1.85	14.1887	37	283
2.00	14.5533	36	281
2.25	15.1580	34	278
2.50	15.7748	32	276
2.75	16.4039	30	274
3.00	17.0451	28	271
3.25	17.6986	27	269
3.50	18.3643	25	267
3.75	19.0422	24	264
4.00	19.7322	22	262
4.25	20.4346	21	260
4.50	21.1491	20	258
4.75	21.8758	19	256
5.00	22.6147	18	254
5.25	23.3659	17	252
5.50	24.1292	16	251
5.75	24.9048	15	249
6.00	25.6926	14	247
6.25	26.4925	13	245
6.50	27.3047	12	244
6.75	28.1291	11.5	242
7.00	28.9657	10.7	240
7.25	29.8146	10.0	239
7.50	30.6756	9.3	237
7.75	31.5488	8.7	236
8.00	32.4343	8.1	234
8.25	33.3319	7.4	233
8.50	34.2418	6.9	231
8.75	35.1639	6.3	230
9.00	36.0982	5.8	228
9.25	37.0447	5.3	227

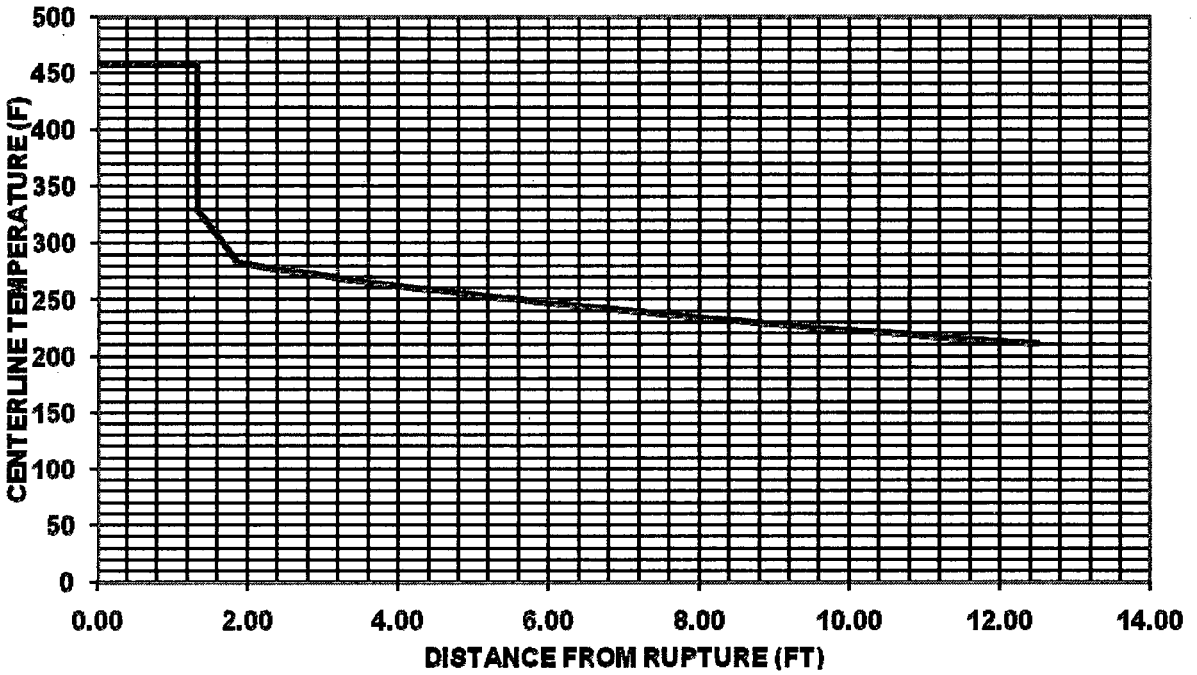
6" FEEDWATER LONGITUDINAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
9.50	38.0034	4.8	226
9.75	38.9743	4.3	224
10.00	39.9574	3.8	223
10.25	40.9527	3.4	222
10.50	41.9603	3.0	220
10.75	42.9800	2.5	219
11.00	44.0120	2.1	218
11.25	45.0562	1.8	217
11.50	46.1126	1.4	216
11.75	47.1811	1.0	214
12.00	48.2619	0.7	213
12.25	49.3550	0.4	212
12.50	50.4602	0.0	211

PRESSURE VERSUS DISTANCE, 6" FEEDWATER LONGITUDINAL BREAK OPERATING PRESSURE: 880 PSIG



TEMPERATURE VERSUS DISTANCE, 6" FEEDWATER LONGITUDINAL BREAK OPERATING PRESSURE: 880 PSIG



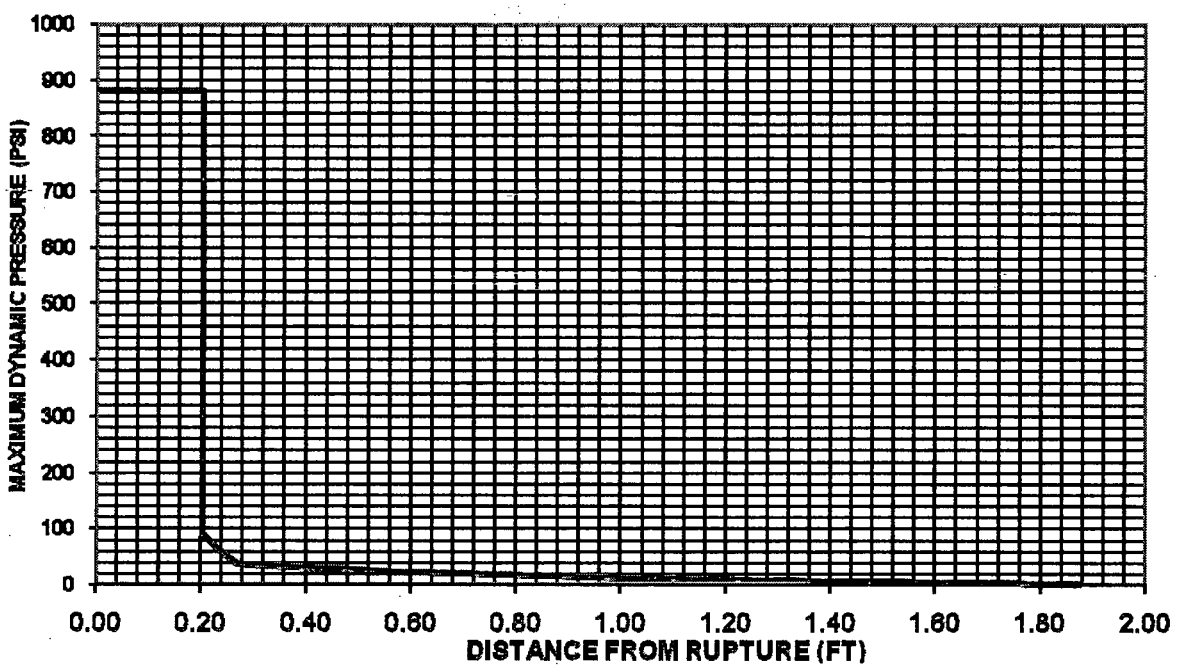
6" FEEDWATER CRACK
880 PSIG

L FT	A SQ FT	P PSI	T F
0.00		880	457
0.20		880	457
0.20		88	330
0.23		68	314
0.25		49	296
0.27	0.3386	37	283
0.29	0.3472	36	281
0.33	0.3630	33	278
0.38	0.3790	31	276
0.42	0.3955	30	273
0.46	0.4122	28	270
0.50	0.4293	26	268
0.54	0.4467	24	266
0.58	0.4645	23	263
0.63	0.4826	22	261
0.67	0.5010	20	259
0.71	0.5198	19	257
0.75	0.5389	18	254
0.79	0.5584	17	252
0.83	0.5782	16	250
0.88	0.5983	15	248
0.92	0.6188	14	247
0.96	0.6396	13	245
1.00	0.6608	12	243
1.04	0.6823	11	241
1.08	0.7041	10	239
1.13	0.7263	9.5	238
1.17	0.7488	8.8	236
1.21	0.7716	8.1	234
1.25	0.7948	7.5	233
1.29	0.8184	6.8	231
1.33	0.8422	6.2	230
1.38	0.8664	5.7	228
1.42	0.8910	5.1	227
1.46	0.9159	4.6	225

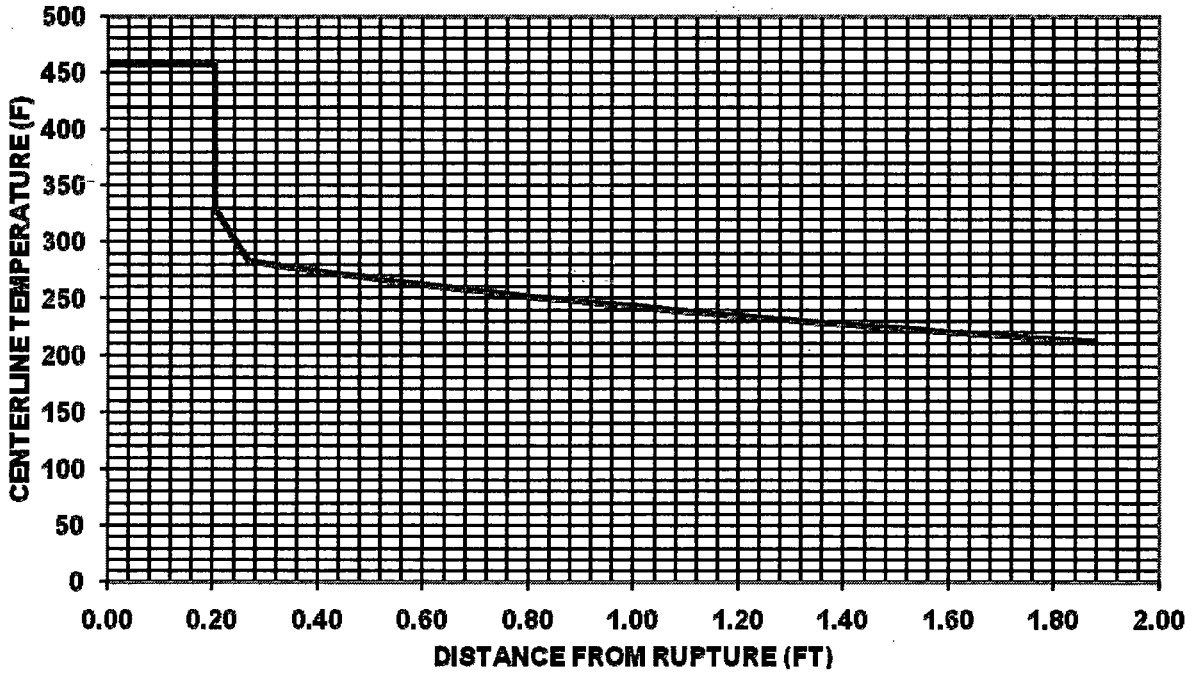
6" FEEDWATER CRACK
880 PSIG

L FT	A SQ FT	P PSI	T F
1.50	0.9411	4.1	224
1.54	0.9667	3.6	222
1.58	0.9926	3.1	221
1.63	1.0188	2.7	220
1.67	1.0454	2.2	218
1.71	1.0723	1.8	217
1.75	1.0996	1.4	216
1.79	1.1272	1.0	214
1.83	1.1551	0.7	213
1.88	1.1834	0.3	212

PRESSURE VERSUS DISTANCE, 6" FEEDWATER CRACK
OPERATING PRESSURE: 880 PSIG



TEMPERATURE VERSUS DISTANCE, 6" FEEDWATER CRACK
OPERATING PRESSURE: 880 PSIG

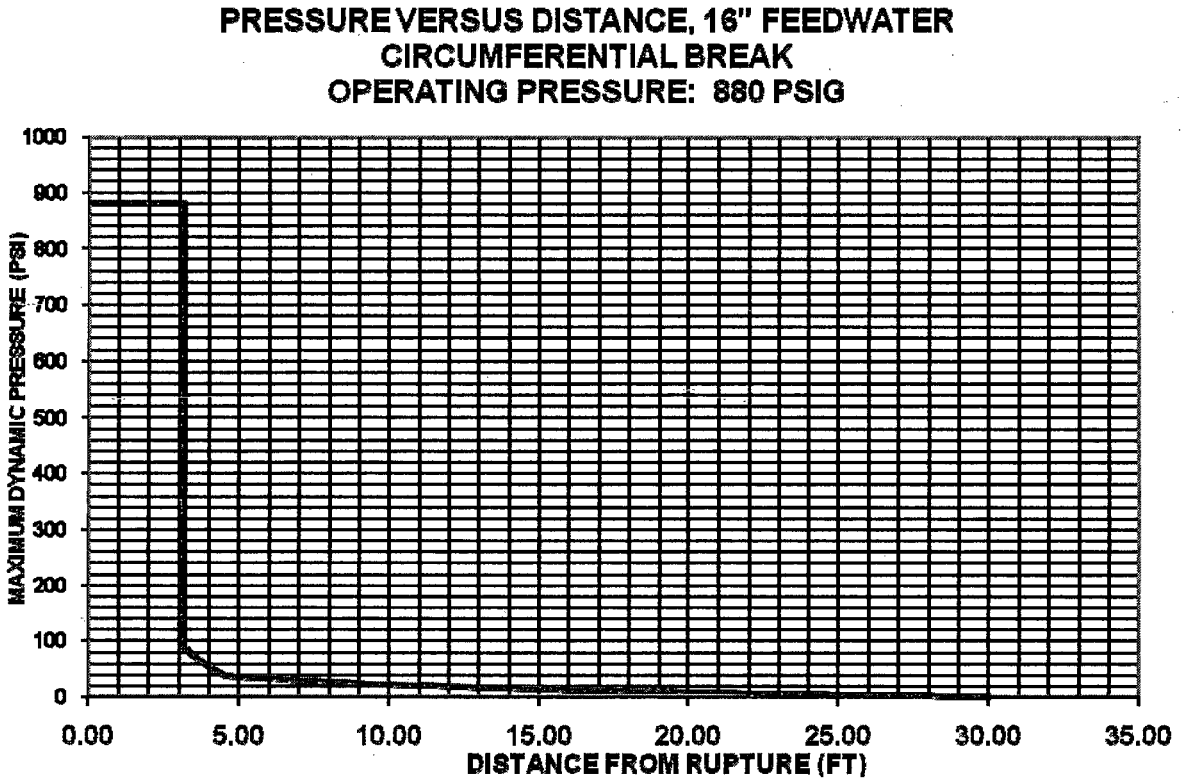


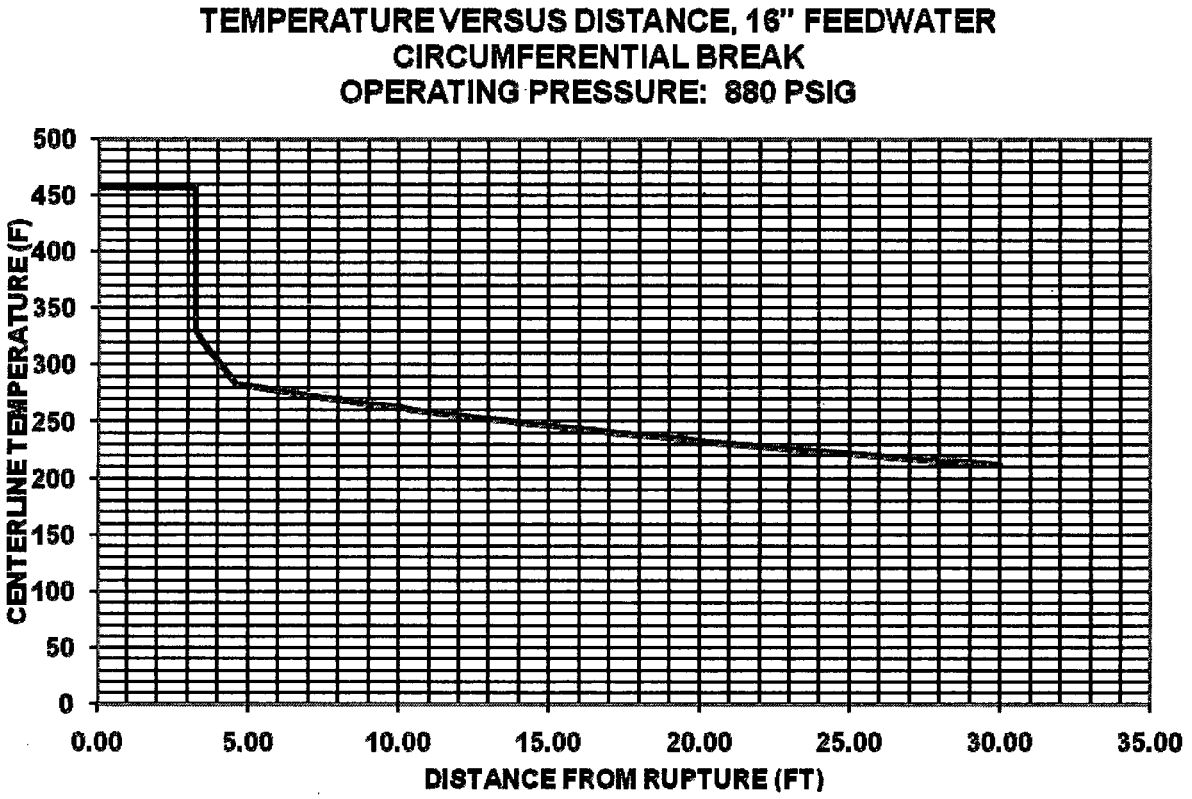
16" FEEDWATER CIRCUMFERENTIAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
0.00		880	457
3.18		880	457
3.18		88	330
3.50		73	318
4.00		53	301
4.56	83.0520	37	283
5.00	85.5723	35	281
5.50	88.4878	34	279
6.00	91.4521	32	277
6.50	94.4653	31	275
7.00	97.5273	29	273
7.50	100.6381	28	271
8.00	103.7978	27	269
8.50	107.0064	25	267
9.00	110.2637	24	265
9.50	113.5699	23	263
10.00	116.9250	22	263
10.50	120.3289	21	260
11.00	123.7816	20	258
11.50	127.2831	19	257
12.00	130.8335	18	255
12.50	134.4328	17	253
13.00	138.0808	16.5	252
13.50	141.7777	15.7	250
14.00	145.5235	14.9	249
14.50	149.3181	14.1	247
15.00	153.1615	13.4	246
15.50	157.0537	12.7	245
16.00	160.9948	12.1	243
16.50	164.9848	11.4	242
17.00	169.0235	10.8	240
17.50	173.1111	10.2	239
18.00	177.2476	9.6	238
18.50	181.4329	9.1	237
19.00	185.6670	8.6	235
19.50	189.9500	8.0	234

16" FEEDWATER CIRCUMFERENTIAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
20.00	194.2818	7.5	233
20.50	198.6624	7.1	232
21.00	203.0919	6.6	230
21.50	207.5702	6.1	229
22.00	212.0974	5.7	228
22.50	216.6733	5.3	227
23.00	221.2982	4.9	226
23.50	225.9718	4.5	225
24.00	230.6943	4.1	224
24.50	235.4657	3.7	223
25.00	240.2859	3.3	222
25.50	245.1549	3.0	221
26.00	250.0727	2.6	219
26.50	255.0394	2.3	218
27.00	260.0550	2.0	217
27.50	265.1193	1.7	216
28.00	270.2325	1.4	216
28.50	275.3946	1.1	215
29.00	280.6055	0.8	214
29.50	285.8652	0.5	213
30.00	291.1737	0.2	212


PRESSURE VERSUS DISTANCE, 16" FEEDWATER
CIRCUMFERENTIAL BREAK
OPERATING PRESSURE: 880 PSIG
MAXIMUM DYNAMIC PRESSURE (PSI)
1000
900
800
700
600
500
400
300
200
100
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
DISTANCE FROM RUPTURE (FT)


TEMPERATURE VERSUS DISTANCE, 16" FEEDWATER
CIRCUMFERENTIAL BREAK
OPERATING PRESSURE: 880 PSIG
CENTERLINE TEMPERATURE (F)
500
450
400
350
300
250
200
150
100
50
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
DISTANCE FROM RUPTURE (FT)

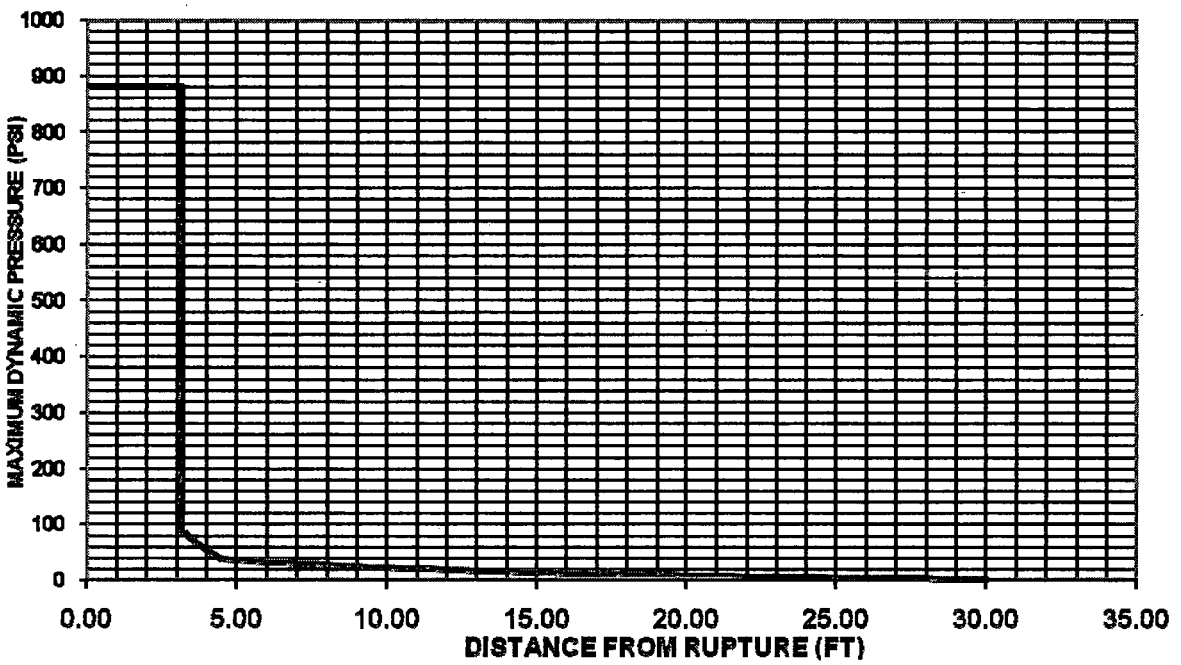
16" FEEDWATER LONGITUDINAL BREAK 880 PSIG

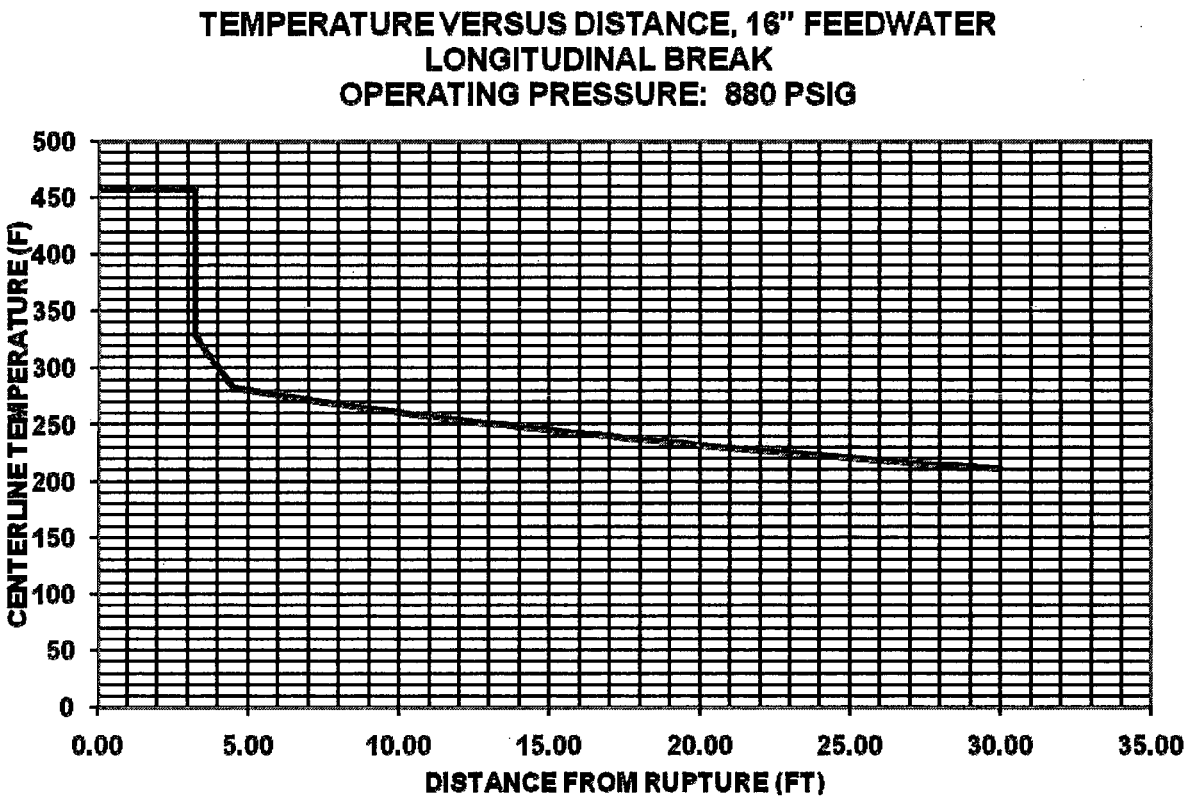
L FT	A SQ FT	P PSI	T F
0.00		880	457
3.18		880	457
3.18		88	330
3.50		72	317
4.00		52	299
4.47	83.0521	37	283
5.00	86.1228	35	280
5.50	89.0590	33	278
6.00	92.0442	32	276
6.50	95.0781	30	274
7.00	98.1609	29	272
7.50	101.2926	28	270
8.00	104.4730	26	268
8.50	107.7023	25	267
9.00	110.9805	24	265
9.50	114.3075	23	263
10.00	117.6833	22	261
10.50	121.1080	21	260
11.00	124.5815	20	258
11.50	128.1038	19	256
12.00	131.6750	18	255
12.50	135.2950	17	253
13.00	138.9639	16.3	252
13.50	142.6816	15.5	250
14.00	146.4481	14.7	249
14.50	150.2634	14.0	247
15.00	154.1277	13.3	246
15.50	158.0407	12.6	244
16.00	162.0026	11.9	243
16.50	166.0133	11.3	241
17.00	170.0729	10.7	240
17.50	174.1813	10.1	239
18.00	178.3385	9.5	238
18.50	182.5446	8.9	236
19.00	186.7995	8.4	235
19.50	191.1032	7.9	234

16" FEEDWATER LONGITUDINAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
20.00	195.4558	7.4	233
20.50	199.8572	6.9	231
21.00	204.3075	6.5	230
21.50	208.8066	6.0	229
22.00	213.3545	5.6	228
22.50	217.9513	5.2	227
23.00	222.5969	4.7	226
23.50	227.2914	4.4	224
24.00	232.0346	4.0	223
24.50	236.8268	3.6	222
25.00	241.6677	3.2	221
25.50	246.5575	2.9	220
26.00	251.4962	2.5	219
26.50	256.4837	2.2	218
27.00	261.5200	1.9	217
27.50	266.6051	1.6	216
28.00	271.7391	1.3	215
28.50	276.9219	1.0	214
29.00	282.1536	0.7	213
29.50	287.4341	0.4	212
30.00	292.7635	0.2	211

PRESSURE VERSUS DISTANCE, 16" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 880 PSIG




TEMPERATURE VERSUS DISTANCE, 16" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 880 PSIG
CENTERLINE TEMPERATURE (F)
500
450
400
350
300
250
200
150
100
50
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
DISTANCE FROM RUPTURE (FT)

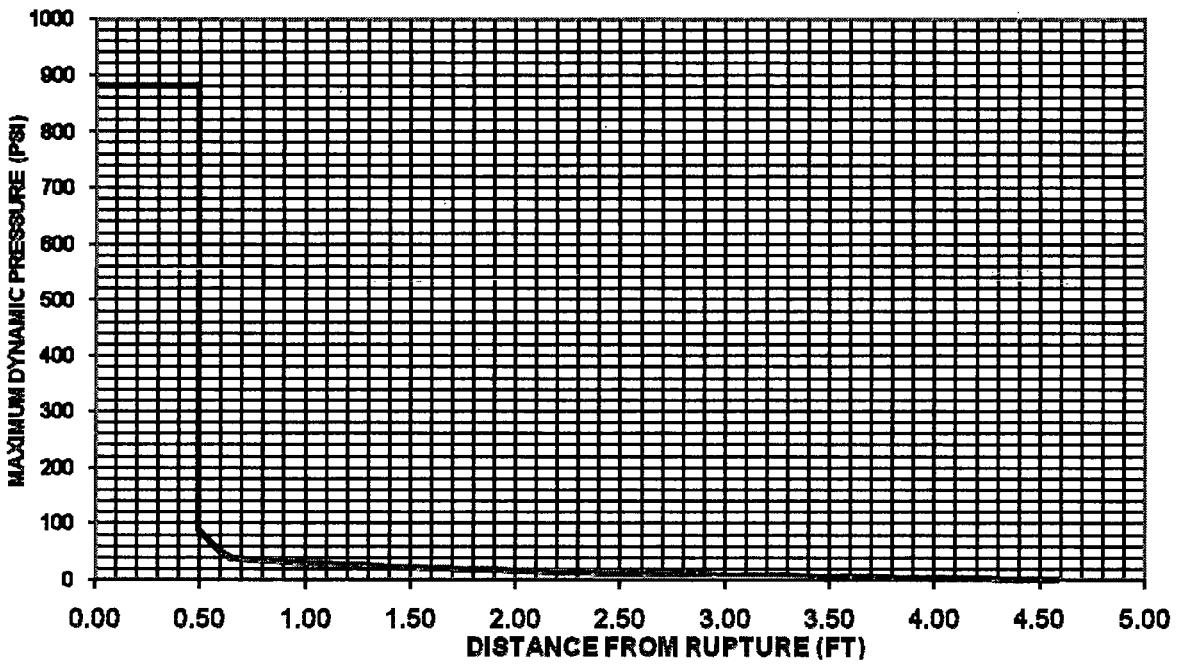
16" FEEDWATER CRACK
880 PSIG

L FT	A SQ FT	P PSI	T F
0.00		880	457
0.49		880	457
0.49		88	330
0.54		67	313
0.58		54	301
0.64	1.9555	37	283
0.67	1.9753	36	282
0.75	2.0502	35	280
0.83	2.1265	33	277
0.92	2.2042	31	275
1.00	2.2832	30	273
1.08	2.3635	28	271
1.17	2.4452	27	269
1.25	2.5283	25	267
1.33	2.6127	24	265
1.42	2.6985	23	263
1.50	2.7857	22	261
1.58	2.8742	21	259
1.67	2.9640	19	257
1.75	3.0552	18	256
1.83	3.1478	17.5	254
1.92	3.2417	16.6	252
2.00	3.3370	15.7	250
2.08	3.4336	14.8	249
2.17	3.5316	14.0	247
2.25	3.6310	13.2	246
2.33	3.7317	12.5	244
2.42	3.8337	11.8	243
2.50	3.9372	11.1	241
2.58	4.0419	10.4	240
2.67	4.1481	9.8	238
2.75	4.2556	9.2	237
2.83	4.3644	8.6	235
2.92	4.4746	8.0	234
3.00	4.5862	7.5	233

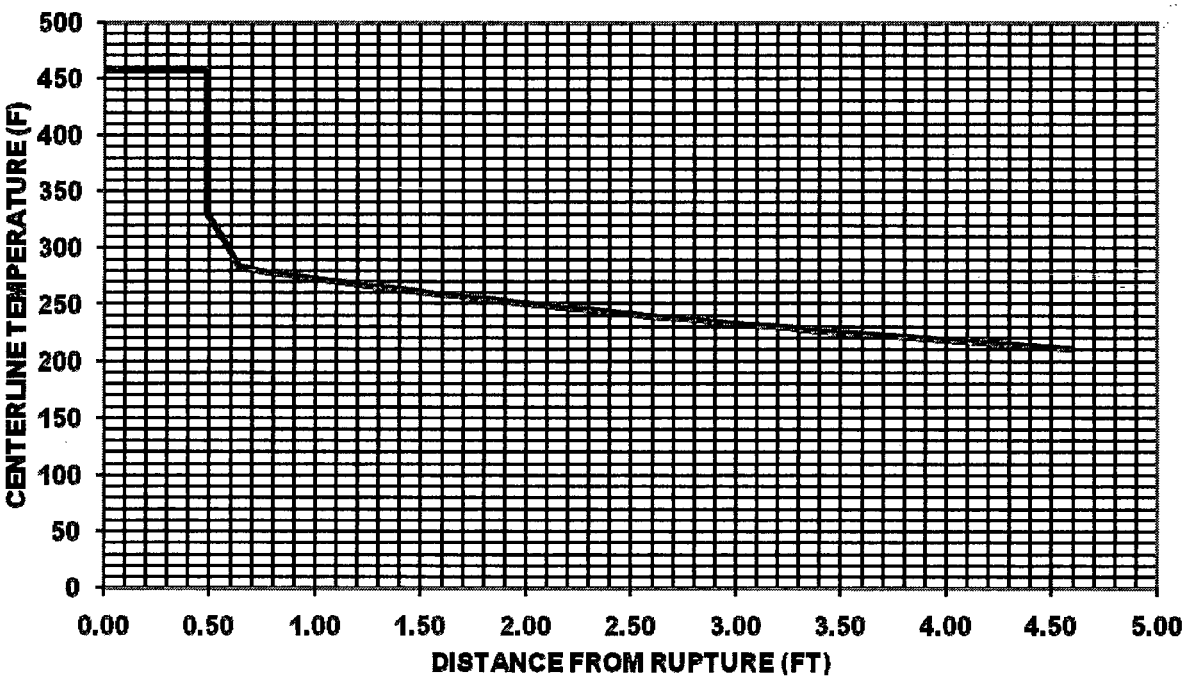
16" FEEDWATER CRACK
880 PSIG

L FT	A SQ FT	P PSI	T F
3.08	4.6991	7.0	231
3.17	4.8134	6.4	230
3.25	4.9290	6.0	229
3.33	5.0460	5.5	228
3.42	5.1643	5.0	226
3.50	5.2840	4.6	225
3.58	5.4051	4.2	224
3.67	5.5275	3.8	223
3.75	5.6513	3.4	222
3.83	5.7764	3.0	220
3.92	5.9029	2.6	219
4.00	6.0307	2.2	218
4.08	6.1599	1.9	217
4.17	6.2905	1.6	216
4.25	6.4224	1.2	215
4.33	6.5556	0.9	214
4.42	6.6902	0.6	213
4.50	6.8262	0.3	212
4.58	6.9636	0.0	211

PRESSURE VERSUS DISTANCE, 16" FEEDWATER CRACK
OPERATING PRESSURE: 880 PSIG



TEMPERATURE VERSUS DISTANCE, 16" FEEDWATER CRACK
OPERATING PRESSURE: 880 PSIG



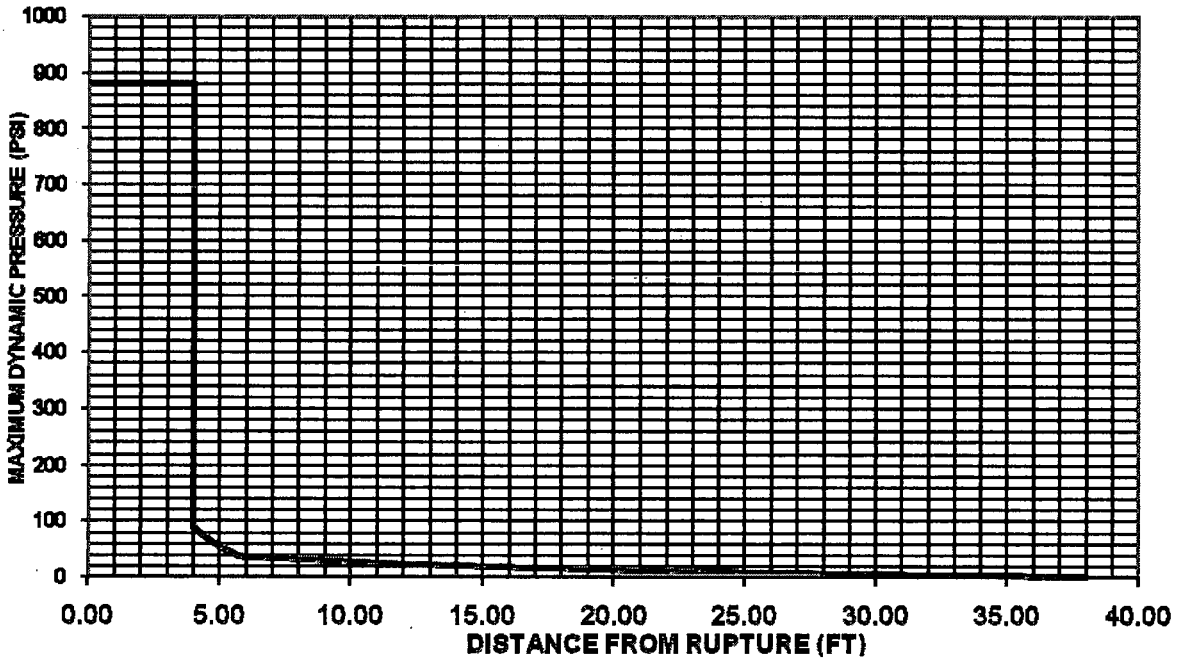
20" FEEDWATER CIRCUMFERENTIAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
0.00		880	457
3.98		880	457
3.98		88	330
4.58		66	312
5.00		54	301
5.71	130.0000	37	283
6.00	132.1025	36	282
6.50	135.7191	35	280
7.00	139.3844	33	278
7.50	143.0986	32	277
8.00	146.8617	31	275
8.50	150.6735	30	273
9.00	154.5343	29	272
9.50	158.4438	28	270
10.00	162.4022	27	269
10.50	166.4094	26	267
11.00	170.4655	25	266
11.50	174.5704	24	264
12.00	178.7242	23	263
12.50	182.9267	22	262
13.00	187.1782	21	260
13.50	191.4784	20.4	259
14.00	195.8275	19.7	258
14.50	200.2254	18.9	256
15.00	204.6722	18.2	255
15.50	209.1678	17.5	254
16.00	213.7123	16.8	253
16.50	218.3056	16.2	251
17.00	222.9477	15.5	250
17.50	227.6386	14.9	249
18.00	232.3784	14.3	248
18.50	237.1671	13.7	247
19.00	242.0045	13.2	245
19.50	246.8909	12.6	244
20.00	251.8260	12.1	243
20.50	256.8100	11.6	242

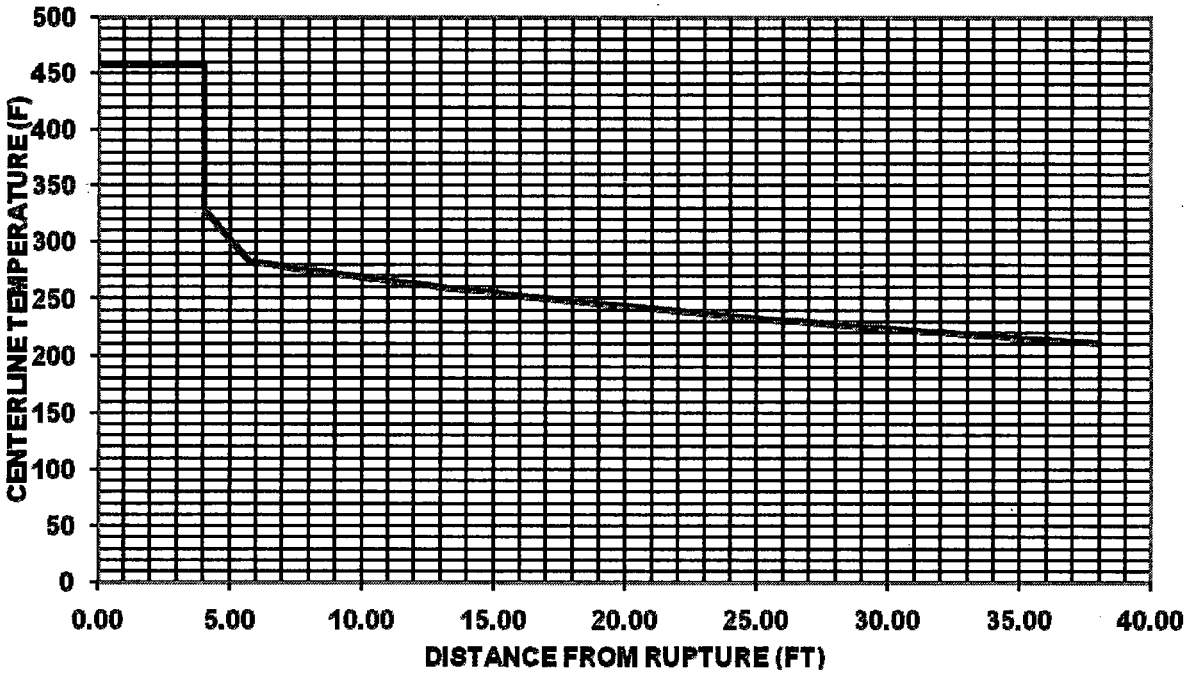
20" FEEDWATER CIRCUMFERENTIAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
21.00	261.8428	11.1	241
21.50	266.9245	10.6	240
22.00	272.0550	10.1	239
22.50	277.2343	9.7	238
23.00	282.4625	9.2	237
23.50	287.7395	8.8	236
24.00	293.0654	8.4	235
24.50	298.4401	8.0	234
25.00	303.8636	7.6	233
25.50	309.3360	7.2	232
26.00	314.8572	6.8	231
26.50	320.4272	6.4	230
27.00	326.0461	6.1	229
27.50	331.7138	5.7	228
28.00	337.4304	5.4	227
28.50	343.1958	5.0	226
29.00	349.0100	4.7	225
29.50	354.8731	4.4	225
30.00	360.7850	4.1	224
30.50	366.7457	3.8	223
31.00	372.7553	3.5	222
31.50	378.8138	3.2	221
32.00	384.9210	2.9	220
32.50	391.0771	2.7	220
33.00	397.2821	2.4	219
33.50	403.5358	2.1	218
34.00	409.8384	1.9	217
34.50	416.1899	1.6	216
35.00	422.5902	1.4	216
35.50	429.0393	1.2	215
36.00	435.5373	0.9	214
36.50	442.0841	0.7	213
37.00	448.6797	0.5	213
37.50	455.3242	0.3	212
38.00	462.0175	0.0	211

PRESSURE VERSUS DISTANCE, 20" FEEDWATER CIRCUMFERENTIAL BREAK OPERATING PRESSURE: 880 PSIG



TEMPERATURE VERSUS DISTANCE, 20" FEEDWATER CIRCUMFERENTIAL BREAK OPERATING PRESSURE: 880 PSIG



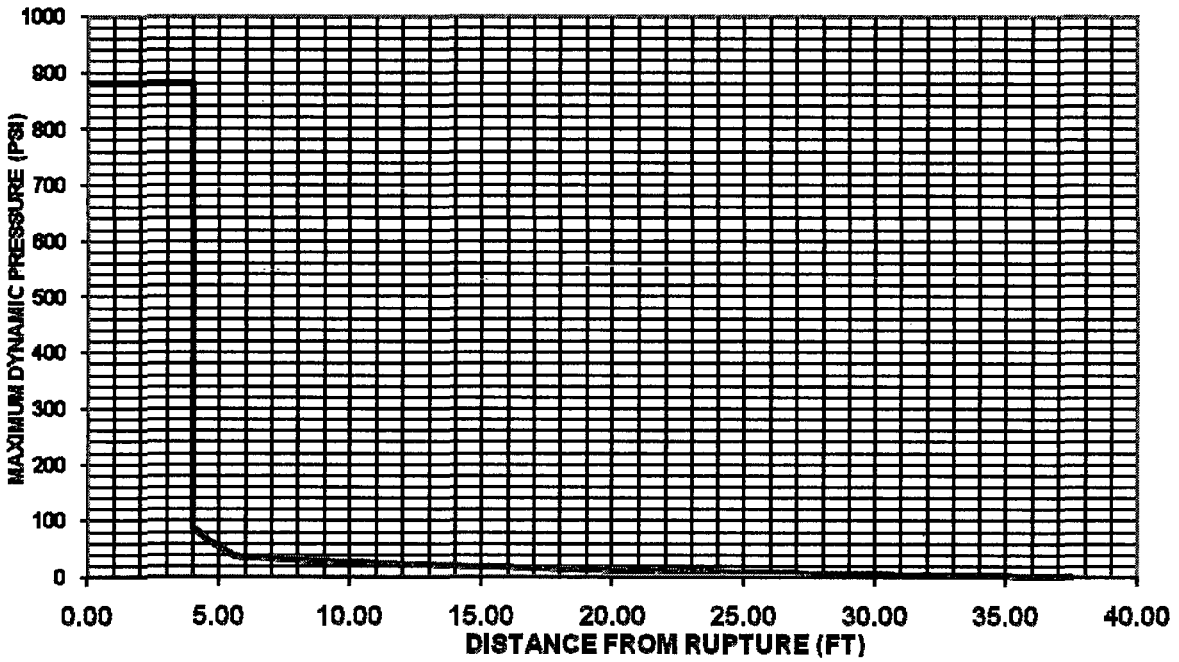
20" FEEDWATER LONGITUDINAL BREAK 880 PSIG

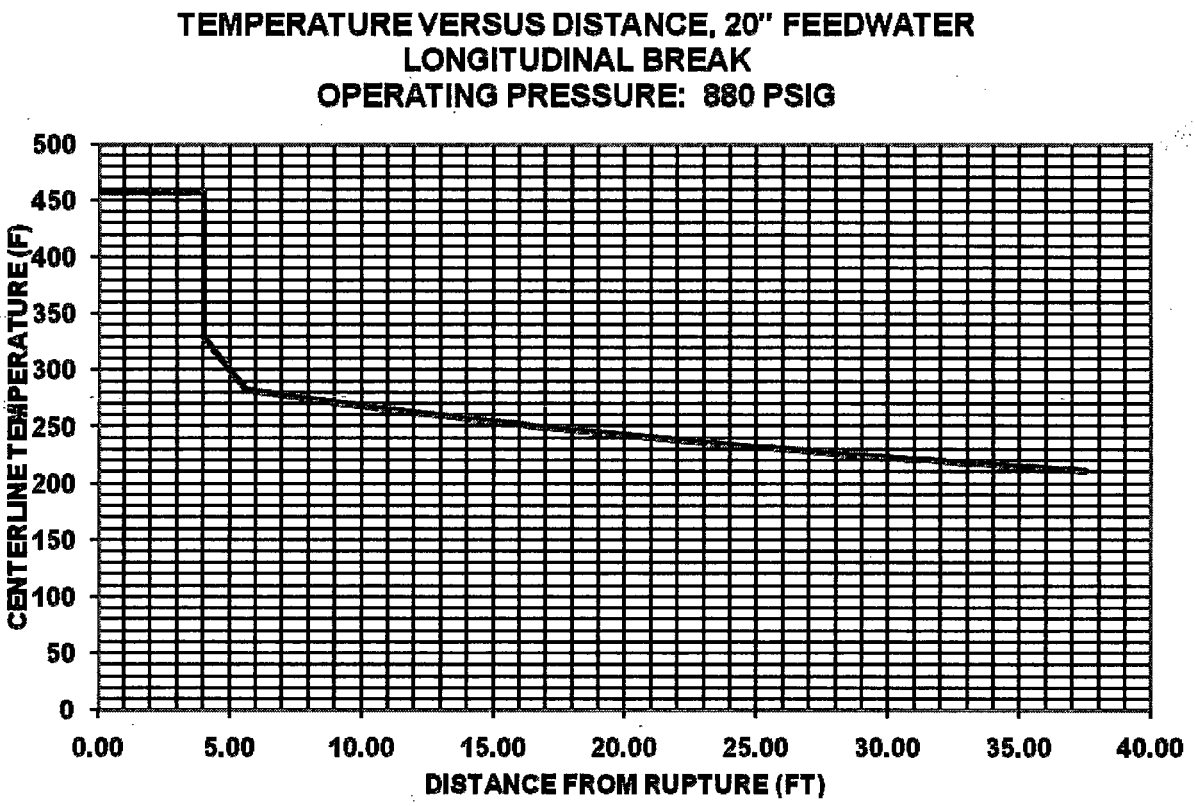
L FT	A SQ FT	P PSI	T F
0.00		880	457
3.98		880	457
3.98		88	330
4.58		65	311
5.00		52	299
5.59	129.9999	37	283
6.00	132.9507	36	281
6.50	136.5932	34	279
7.00	140.2846	33	278
7.50	144.0248	32	276
8.00	147.8138	31	275
8.50	151.6517	30	273
9.00	155.5384	28	271
9.50	159.4740	27	270
10.00	163.4584	26	268
10.50	167.4916	25	267
11.00	171.5737	24	265
11.50	175.7046	24	264
12.00	179.8843	23	263
12.50	184.1129	22	261
13.00	188.3903	21	260
13.50	192.7166	20.2	259
14.00	197.0917	19.4	257
14.50	201.5156	18.7	256
15.00	205.9884	18.0	255
15.50	210.5100	17.3	253
16.00	215.0804	16.6	252
16.50	219.6997	16.0	251
17.00	224.3679	15.3	250
17.50	229.0848	14.7	249
18.00	233.8506	14.1	247
18.50	238.6653	13.6	246
19.00	243.5287	13.0	245
19.50	248.4410	12.5	244
20.00	253.4022	11.9	243
20.50	258.4122	11.4	242

20" FEEDWATER LONGITUDINAL BREAK 880 PSIG

L FT	A SQ FT	P PSI	T F
21.00	263.4710	10.9	241
21.50	268.5787	10.4	240
22.00	273.7352	10.0	239
22.50	278.9405	9.5	238
23.00	284.1947	9.1	237
23.50	289.4977	8.6	236
24.00	294.8496	8.2	235
24.50	300.2503	7.8	234
25.00	305.6998	7.4	233
25.50	311.1982	7.0	232
26.00	316.7454	6.7	231
26.50	322.3414	6.3	230
27.00	327.9863	5.9	229
27.50	333.6800	5.6	228
28.00	339.4226	5.3	227
28.50	345.2140	4.9	226
29.00	351.0542	4.6	225
29.50	356.9433	4.3	224
30.00	362.8812	4.0	223
30.50	368.8679	3.7	223
31.00	374.9035	3.4	222
31.50	380.9880	3.1	221
32.00	387.1212	2.8	220
32.50	393.3033	2.6	219
33.00	399.5343	2.3	218
33.50	405.8140	2.0	218
34.00	412.1427	1.8	217
34.50	418.5201	1.5	216
35.00	424.9464	1.3	215
35.50	431.4215	1.1	215
36.00	437.9455	0.8	214
36.50	444.5183	0.6	213
37.00	451.1399	0.4	212
37.50	457.8104	0.2	212

PRESSURE VERSUS DISTANCE, 20" FEEDWATER LONGITUDINAL BREAK OPERATING PRESSURE: 880 PSIG




TEMPERATURE VERSUS DISTANCE, 20" FEEDWATER
LONGITUDINAL BREAK
OPERATING PRESSURE: 880 PSIG
CENTERLINE TEMPERATURE (F)
500
450
400
350
300
250
200
150
100
50
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
DISTANCE FROM RUPTURE (FT)

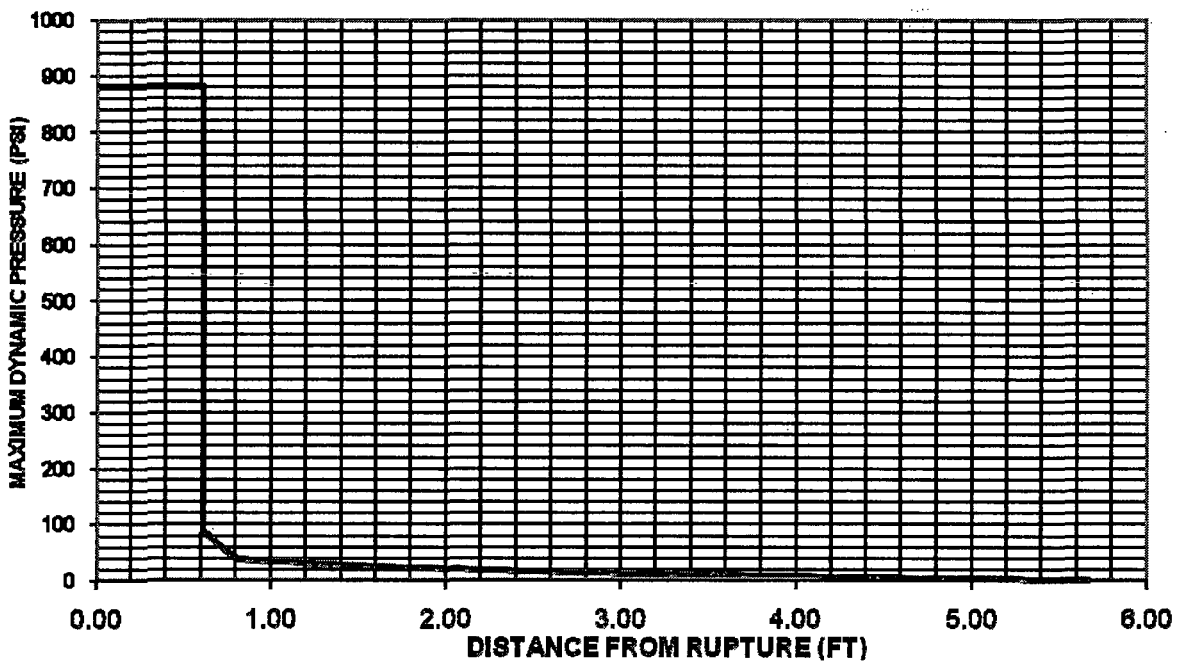
20" FEEDWATER CRACK
880 PSIG

L FT	A SQ FT	P PSI	T F
0.00		880	457
0.61		880	457
0.61		88	330
0.67		70	315
0.75		48	295
0.80	3.0398	37	283
0.83	3.0734	36	282
0.92	3.1667	35	280
1.00	3.2614	33	278
1.08	3.3574	32	276
1.17	3.4548	31	275
1.25	3.5535	29	273
1.33	3.6536	28	271
1.42	3.7551	27	269
1.50	3.8579	26	268
1.58	3.9620	25	266
1.67	4.0676	24	265
1.75	4.1744	23	263
1.83	4.2827	22	262
1.92	4.3923	21	260
2.00	4.5032	20	259
2.08	4.6155	19.4	257
2.17	4.7292	18.6	256
2.25	4.8442	17.8	254
2.33	4.9605	17.0	253
2.42	5.0783	16.3	252
2.50	5.1974	15.6	250
2.58	5.3178	14.9	249
2.67	5.4396	14.3	248
2.75	5.5628	13.6	246
2.83	5.6873	13.0	245
2.92	5.8131	12.4	244
3.00	5.9404	11.9	243
3.08	6.0689	11.3	242
3.17	6.1989	10.8	240

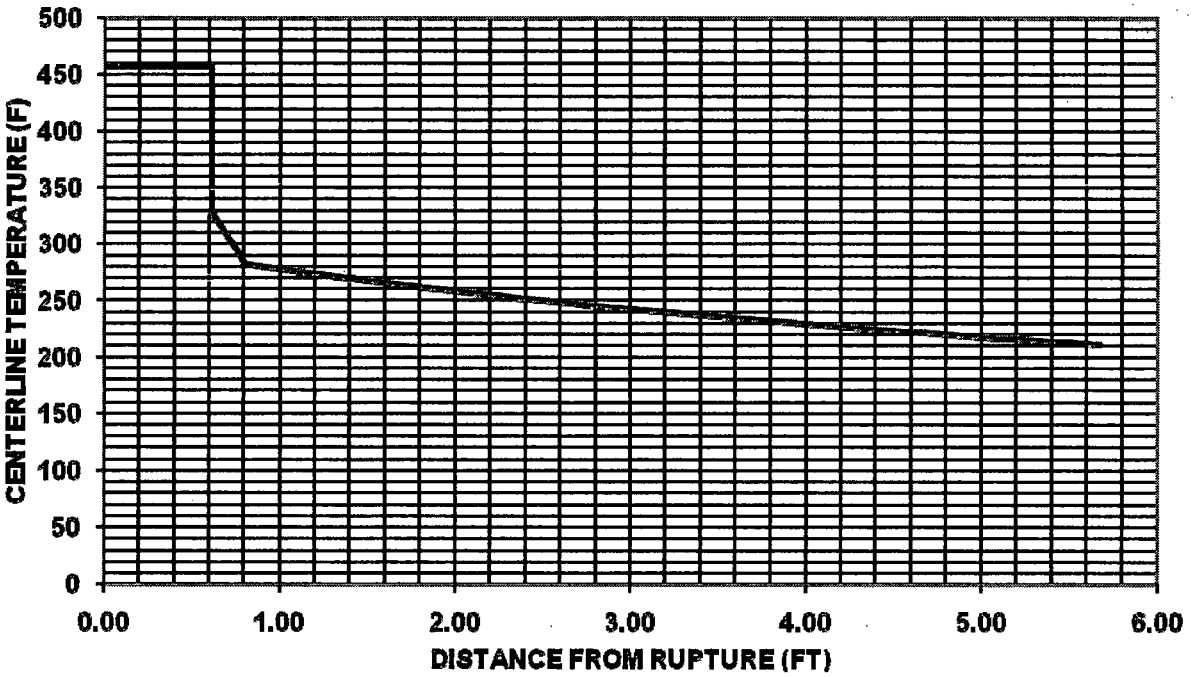
20" FEEDWATER CRACK
880 PSIG

L FT	A SQ FT	P PSI	T F
3.25	6.3302	10.2	239
3.33	6.4628	9.7	238
3.42	6.5968	9.2	237
3.50	6.7322	8.8	236
3.58	6.8689	8.3	235
3.67	7.0070	7.9	234
3.75	7.1464	7.4	233
3.83	7.2872	7.0	232
3.92	7.4294	6.6	230
4.00	7.5729	6.2	229
4.08	7.7177	5.8	228
4.17	7.8639	5.4	227
4.25	8.0115	5.1	226
4.33	8.1604	4.7	225
4.42	8.3107	4.4	225
4.50	8.4624	4.0	224
4.58	8.6154	3.7	223
4.67	8.7697	3.4	222
4.75	8.9254	3.1	221
4.83	9.0825	2.8	220
4.92	9.2409	2.5	219
5.00	9.4007	2.2	218
5.08	9.5618	1.9	217
5.17	9.7243	1.6	216
5.25	9.8882	1.4	216
5.33	10.0534	1.1	215
5.42	10.2200	0.9	214
5.50	10.3879	0.6	213
5.58	10.5572	0.4	212
5.67	10.7278	0.1	211

PRESSURE VERSUS DISTANCE, 20" FEEDWATER CRACK
OPERATING PRESSURE: 880 PSIG



TEMPERATURE VERSUS DISTANCE, 20" FEEDWATER CRACK
OPERATING PRESSURE: 880 PSIG



ENCLOSURE 1
ATTACHMENT 13

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

AUTOMATED ENGINEERING SERVICES CORP., SUBMITTAL OF TASK 14
NON-SAFETY RELATED REPORT ON OPERATOR RESPONSE TIME

6 pages follow

AUTOMATED ENGINEERING SERVICES CORP.

40 Shuman Blvd., Suite 220
Naperville, IL 60563
(630) 615-3511
Fax: (630) 357-4445
E-mail: avsetlur@aesengineering.com

September 4, 2008

Mr. Harvey Hanneman
FPL Energy
Point Beach Nuclear Plant
6590 Nuclear Road
Two Rivers, WI 54241

Dear Mr. Hanneman:

Subject: Submittal of Task 14 Non-Safety Related Report on Operator Response Time

Automated Engineering Services Corp. (AES) is pleased to transmit the attached non-safety related report documenting the results of HELB Reconstitution Program Task 14 – Operator Response Time for your review and record.

We seek clarification of whether or not to post this report on the Shawgrp eRoom since this report does not pertain to the work currently being performed by Shaw for the Power Uprate License Report. We will act according to your advice.

AES thanks you and PBNP Engineering for providing us the opportunity to be of service to the plant on this important project. If you have any questions concerning the information contained herein, please contact the undersigned at Ext.11.

Sincerely,

A.V. Setlur
President

Attachment: Task 14 Report

cc: Joe Loor, PBNP
Tom Esper, PBNP
Charles Agan, AES
Mark Reiff, AES
Robert Krukowski, AES
Erich Ziller, AES

AUTOMATED
ENGINEERING
SERVICES CORP.

40 Shuman Blvd, Suite 220
Naperville, Il 60563
(630) 357-8880
(630) 357-4445 (Fax)

September 4, 2008

Point Beach Nuclear Plant
HELB Reconstitution Program
Task 14 – Operator Response Time Evaluation

Introduction

The original scope of this task as described in the PBNP HELB Reconstitution Program Task 1 Report, Revision 0, dated December 28, 2006 assumed that three (3) evaluations would be required for HELB events that required manual operator action. It was also assumed, but not stated, that these evaluations would be performed using the guidance contained in ANSI/ANS-58.8-1994 (Time Response Design Criteria for Safety-related Operator Actions). Based on a more detailed review of various HELB events, it was determined that the smaller main steam HELB events did not initiate the necessary automatic protective functions and did require manual operator action. It was also decided to utilize the Point Beach simulator rather than the ANSI 58.8 methodology to evaluate the main steam line HELB event.

Main Steam

A review of the Westinghouse main steam mass and energy releases for a large spectrum break sizes (2.8 ft^2 to 0.01 ft^2) at hot full power, both up-stream and down-stream of the main steam isolation valves (MSIVs – MS-2017 and 2018), revealed that only the smaller break sizes (Tables 1a and 1b) required manual operator action. These manual actions include (1) termination of auxiliary feedwater flow to the faulted steam generator, (2) reactor trip and (3) closure of the MSIVs. The shortest operator response time for these actions is 600 seconds (10 minutes). Breaks up-stream of the MSIVs cannot be isolated and will continue until the faulted steam generator is empty. Blowdown of the un-faulted steam generator is prevented by closure of its associated MSIV or closure of the appropriate reverse flow check valve (MS-2017A or 2018A). Breaks down-stream of the MSIVs would normally be terminated by closure of both MSIVs. However, it is assumed that one MSIV fails to close thereby allowing one steam generator to continue feeding the beak until it goes empty.

The scenario chosen for the simulator was a break (0.05 ft^2) in the Loop A 3" steam supply line to the auxiliary feedwater pump turbine in the component cooling water heat exchanger room. A break in a Unit 1 line was chosen because it would open the blowout panel from the room to the Unit 2 main steam line pipe chase and the Turbine Hall operator would detect the steam release on the Unit 2 side of the plant. There is no control room indication that the panel has opened or elevated temperature in the room.

Two separate operating crews consisting of five (5) Simulator Training Specialists and a procedure reader were evaluated for the postulated scenario utilizing the Westinghouse Owner Group Emergency Operating Procedures. The response of the two crews was as follows:

Crew Number One

Time In Minutes	Action Taken
0	Initiation of transient
0+	Operators observed Unit 1 increase in reactor thermal output and T_{avg} deviation
1	High level in -19'level sump. Operators reduce turbine load, reactor thermal output to 90%
3	Operators enter AOP-2A "Secondary Coolant Leak", which directs reactor trip for habitability concern. Auxiliary Operators directed to evaluate field conditions
7	Reactor Trip
9	Main Steam Isolation Valves closed
10	Auxiliary feedwater secured
11	Auxiliary Operators dispatched to shut valves MS-235 and MS-237
13	Auxiliary Operator reports steam leak stopped

Crew Number Two

Time In Minutes	Action Taken
0	Initiation of transient
2	High level in -19'level sump
2	Operators observed Unit 1 increase in reactor thermal output, T_{avg} deviation and steam generator feed flow/steam flow mismatch
4	Operators enter AOP-2A "Secondary Coolant Leak". Habitability concerns reviewed
5	Auxiliary Operator reports steam leak
6	Reactor Trip

7	Main Steam Isolation Valves closed
10	Auxiliary feedwater secured
11	Auxiliary Operators directed to shut valves MS-235
13	Auxiliary Operator reports steam leak stopped

CVCS Letdown

The CVCS letdown and charging systems are normally aligned with one 40 gpm letdown orifice and two charging pumps (60 pm capacity each) in service. One charging pump is in manual control with its flow rate set at a constant 18 gpm (normal seal injection flow for two reactor coolant pumps) and the second pump is in automatic control to vary flow rate in response to pressurizer level changes. The flow rate for a break in the letdown line will be limited to 43 gpm (87 gpm if the 80 gpm orifice is in service) by the in service orifice. A break in the letdown line will terminate normal flow to the Volume Control Tank (VCT) and its level will decrease until the boric acid blender automatic makeup setpoint (17% start and 28% stop) is reached. In the event the boric acid blender is not aligned for automatic makeup, the VCT level would continue to decrease to 4% at which point motor operated valve CV-112B opens aligning the charging pump suction header to the refueling water storage tank. The operating charging pumps will be capable of maintaining pressurizer level in its normal range and reactor coolant pump seal injection for the 43 gpm flow rate. If the 80 gpm orifice is in service, the operating charging pumps would not be capable of maintaining pressurizer level and the reactor coolant loop letdown isolation valve (motor operated valve LCV-427) would automatically close at 12%decreasing pressurizer level. If this valve failed to close, the in service 80 gpm orifice isolation valve (200C) and containment isolation valve (371A) could be closed to terminate the leak. The in service 40 gpm orifice valves (200A or B) and containment isolation valve (371A) would be closed to terminate the smaller break.

Steam Generator Blowdown

A break in a steam generator blowdown line at the containment penetration, in combination with the failure of the inside containment isolation valve (MS-5958 or 5959) to close, would create a leak that cannot be readily terminated. The applicable manual valve (210 or 220) inside containment could be closed, but due to their location, they are not readily accessible. Therefore, the HELB event would continue until the faulted steam generator is empty. A significant steam flow/feedwater flow mismatch would be indicated. Upon termination of main and auxiliary feedwater flow, reactor trip would occur on low steam generator level.

Feedwater

A break anywhere in the main feedwater line would lead to a rapid decrease in steam generator level, causing a reactor trip. If the break is up-stream of the feedwater flow nozzle (FE-466 or 476), a reactor trip would also be initiated by steam flow/feedwater flow

mismatch. If the break is down-stream of the feedwater flow nozzle, a significant steam flow/feedwater flow mismatch would be indicated, but an automatic reactor trip would not occur until steam generator low level.

Other Secondary Side Systems

Breaks in other secondary side high energy systems (condensate, heater drain tank pump discharge, etc.) would produce the same effects as the feedwater line break event.

References

Westinghouse Steamline Break Mass/Energy Releases Outside Containment for the Point Beach Extended Power Uprate Program, LTR-CRA-08-112, dated May 23, 2008

Simulator Observation Notes by R Krukowski and S Witte, dated August 14, 2008 (Attached)

Prepared By: Charles Agan

Reviewed By: Robert Krukowski / Erich Ziller

Operator Response Time Analysis
August 14, 2008

Purpose: To validate operator response times to Mass/Energy release, i.e. Faulted Steam Generator. The actions evaluated were. 1. Manual Auxiliary Feedwater Isolation to the affected Steam Generator. 2. Manual MSIV closure initiation . 3. Manual Reactor Trip.

Method: The PBNP Simulator was used, as were Westinghouse Owner Group Emergency Operating Procedures. Each Crew of (5) consisted of Simulator Training Specialists. A different procedure reader was used for each validation to ensure that the pace of each scenario was independent.

Scenario: A break/fault in the 3" steam supply line to the Rad. Waste Steam, upstream of SA-9 valve, located in the CCW Heat Exchanger Room. The fault affected the Unit 1 "A" Steam Generator.

Results:

Test 1: 12:00 – start
Operators observed increase in Reactor Thermal Output and Tavg deviation
12:01 – High level in -19' level Sump
Operators reduce turbine load, Reactor Thermal Output to 90%
12:03 – Operators enter AOP-2A "Secondary Coolant Leak".
AOP-2A directs Reactor Trip for Habitability concern
Auxiliary Operators directed to evaluate field conditions
12:07 – Reactor Trip
12:09 – MSIV 's shut
12:10 – Auxiliary Feedwater secured
12:11 – Auxiliary Operators dispatched to shut valves MS-235 and MS-237
12:13 – Auxiliary Operator reports steam leak stopped.

Test 2: 12:19 – Start
12:21 – High level in -19' level Sump
12:21 – Operators observed increase in Reactor Thermal Output and Tavg Deviation and Steam Generator Feed flow/Steam flow mismatch.
12:23 – Operators enter AOP-2A "Secondary Coolant Leak".
Habitability concerns reviewd
12:24 – Auxiliary Operator reports steam Leak
12:25 – Reactor Trip
12:26 – MSIV's shut
12:29 – Auxiliary Feedwater secured
12:30 – Auxiliary Operator directed to shut MS-235
12:32 - Auxiliary Operator reports steam leak stopped.

Robert Krukowski
Sect 5 Tech