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May 4, 1988

William G. Counsil
Executive Vice President

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
ADVANCE COPY OF FSAR REVISIONS RELATING TO JET IMPINGEMENT

Gentlemen:

By letter dated March 28, 1988, we committed to provide the NRC with an advance copy of revisions to FSAR Section 3.6B incorporating ANSI/ANS Standard 58.2 Working Draft 7, dated August 1987, as the basis for jet impingement analyses.

Attachment 1 is an advance copy of these revisions with locations of the specific changes indicated by revision bars in the margin.

Attachment 2 provides an item by item description of each change.

These revisions are currently scheduled to be included in the next FSAR amendment.

Very truly yours,

W. G. Counsil

W. G. Counsil

By: D. R. Woodlan
D. R. Woodlan
Docket Licensing Manager

BSD/amb
Attachments

c - Mr. R. D. Martin, Region IV
Resident Inspectors, CPSES (3)

B001
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3.6B.2.2.2 High-Energy Piping Other Than RCS Main Loop

The time dependent function representing the thrust forces caused by the jet flow from a postulated pipe break or crack includes the combined effects of the thrust impulse resulting from the sudden pressure drop at the initial moment of pipe rupture, the thrust transient resulting from wave propagation and reflection, and the blowdown thrust resulting from buildup of the discharge flow rate which may reach steady state if there is a fluid energy reservoir having sufficient capacity to develop a steady jet for a significant interval. Alternatively, in a simplified method, the jet thrust force is represented by a steady state function. This function, representing the force, would have a magnitude not less than:

$$F_{ss} = C_t PA$$ | ADVANCE

where: | 31

F_{ss} = steady state thrust force (lb_f) | 31

P = system pressure prior to pipe break (lb_f/in^2) | 31

A = pipe break area (in^2) | 31

C_t = steady state thrust coefficient | ADVANCE

The steady state thrust coefficient C_t is dependent on the fluid state and the frictional loss terms. The value of steady state thrust coefficient and the time to reach steady state flow conditions are calculated from references [15], [16] and [22]. | ADVANCE | 68

The rigorous time dependent blowdown forces resulting from a postulated pipe rupture are determined using the RELAP-5 computer code [6]. RELAP-5 is a thermal/hydraulic program commonly used in | 68

68 the nuclear industry to evaluate the behavior of water cooled reactor
systems during postulated accidents such as pipe ruptures. The
program is acceptable (see Reference [7]) as a means of determining
ADVANCE the hydraulic forcing function at the pipe break. CALPLOTF-III [20],
Post Processor Program to RELAP Program, is used to develop the break
force time - history plots.

68 The RELAP-5 program solves the transient energy, momentum, and fluid state equations to determine the system flow, pressure, and thermodynamic conditions. The break force is computed using the one-dimensional momentum equation and the appropriate density, internal energy, and pressure values. The rupture load is the summation of the pressure, momentum, and change in momentum terms at the time interval in question.

68 RELAP-5 has the capability of solving the fluid state equation for
subcooled water, flashing water, two-phase steam/water mixtures, and
superheated steam. The ASME steam tables [9] have been incorporated
into RELAP-5 so that the fluid state properties are accurately
ADVANCE determined. RELAP-5 has a provision for modeling components such
as valves, check valves, pumps, heat exchangers, and reactors along
with the associated piping.

Transients can be initiated by the control card added to the program which is used to describe leaks (pipe breaks), valves opening and closing, check valve pressure drop-flow-characteristics, pump coastdowns, and so forth.

The flow system is described as a series of volumes connected by flow
68 paths or junctions. RELAP-5 requires input data that completely

describe the thermodynamic conditions and physical data of the system being analyzed. Pressure, temperature, and flow conditions along with physical dimensions, flow areas, friction characteristics must all be specified as initial conditions. The break area can be reduced by an analytically or experimentally derived discharge coefficient. However, in lieu of such data it is conservatively assumed that the discharge coefficient is 1.0 for both longitudinal and circumferential breaks. In a similar manner, the break area is assumed to open within one millisecond (0.001 second). | ADVANCE | 68

The piping dynamic responses resulting from a postulated pipe rupture are determined using the PIPERUP [13], SHPLAST 2267 [24] or ABAQUS [21] computer codes. The programs are adaptations of the finite element method to the requirements of pipe rupture analyses. They perform a dynamic, nonlinear, elastic-plastic analysis of piping systems subjected to time-history forcing functions. These forces result from fluid jet thrust at the location of a postulated longitudinal or circumferential rupture of high energy piping and ensuing acoustic disturbances within the piping. | 68 | ADVANCE

The piping is mathematically modeled in the PIPERUP, SHPLAST 2267 or ABAQUS program as an assembly of weightless structural members connecting discrete nodal points. A typical pipe whip mathematical model is shown in Figure 3.6B-6. Weight of the system, including distributed weight of the piping and concentrated weights (e.g., valves), is lumped at selected mass points (lumped parameter analysis model). Nodal points are placed in such a manner as to isolate particular types of piping elements such as straight runs of pipe, valves, elbows, etc. for which force-deformation characteristics may be determined. Nodal points are also placed at all discontinuities such as piping restraints, branch lines, and changes in cross-section. Piping restraints are modeled with an initial gap and in PIPERUP with a bilinear stiffness curve, or, in SHPLAST 2267 and ABAQUS with multilinear stiffness curve. A typical piping stress-strain curve is shown in Figure 3.6B-7. The first stiffness represents linear elastic behavior and the second stiffness models linear strain hardening | 68 | ADVANCE | 68

ADVANCE behavior. All three programs utilize a direct step-by-step integration method to determine the time history response of the ruptured piping system. A typical restraint impact curve is shown in Figure 3.6B-8. An incremental procedure is used to account for the nonlinear deformation and elastic-plastic effect of the pipe and restraints.

ADVANCE

3.6B.2.3 Dynamic Analysis Methods to Verify Integrity and Operability

3.6B.2.3.1 Reactor Coolant System Main Loop

61 The leak-before-break technology has been applied to CPSES Units 1 and 2 to exclude from the design basis the dynamic effects of postulated ruptures in the RCS main loop piping. This applies, in particular, to jet impingement loads on components and supports.

61 Jet loads from large branch nozzle breaks are addressed in Section 3.6B.2.3.2.

3.6B.2.3.2 High-Energy Piping Other than the RCS Main Loop

Pipe beaks are postulated in high-energy piping in accordance with the criteria in Section 3.6B.2.1.2. The analyses for determining the dynamic effects of pipe break are as follows:

A. Jet Impingement

A circumferential or longitudinal break in a high energy line results in a jet of fluid emanating from the break point. For subcooled high energy lines where the fluid temperature is less than its saturation temperature at the surrounding environmental pressure, the discharge jet is characterized by a nearly constant diameter jet approximately equal to the break diameter. Since the fluid temperature is below saturation it will not flash but instead will form an incompressible fluid jet. | ADVANCE

In general, most of the high energy line breaks result in a two-phase choked (critical) flow at the break exit plane. Fluid pressure at the exit plane is in general at some pressure greater than ambient. As the fluid leaves the pipe break area, it expands as the jet pressure decreases from the higher exit (break) plane pressure to the atmospheric pressure surrounding the jet. | ADVANCE

A jet discharging from a saturated steam line will accelerate and expand due to the pressure differential, and it will partially condense to a low-moisture wet steam with the liquid phase in the form of dispersed, entrained water droplets. A jet discharging from a subcooled or saturated hot water line (greater than 212°F) will flash to a low quality wet steam. The flashing will cause the jet diameter to expand very rapidly. | ADVANCE

ANSI/ANS 58.2 Working Draft Revision 7, August 1987 [22] provides an acceptable basis (including conservative analytical models) for the evaluation of jet impingement loads. The CPSES jet impingement methodologies and models are consistent with ANSI/ANS 58.2, as briefly described in the following sections: | ADVANCE

ADVANCE | a. Jet Category and Geometry

ADVANCE | The area of the break is assumed to be equal to the flow area of the ruptured pipe. All the high energy line break jets can be summarized into the following three categories:

ADVANCE | a.1 Category I Jets - Non-Expanding Jets

ADVANCE | For the liquid jets whose temperature is below the saturation temperature at ambient pressure, the initial free expansion does not occur. Incompressible liquid jets are assumed to travel with no increase in jet area. However, for target identification a conservative zone of influence of two diameters is utilized. The pressure is assumed to be uniform throughout the jet area.

ADVANCE | a.2 Category II Jets - Steam and Flashing Water Jets which meet the Criteria of NUREG-2913:

ADVANCE | The high energy two-phase jet is a complicated multidimensional flow phenomena. The high pressure and high temperature fluid that exits the break expands with supersonic velocities downstream of the break. Upon encountering a target (or obstacle) a shock wave forms in the flow field, and it is the thermodynamic properties downstream of this shock that determine the pressure field and load on the target. A multidimensional analysis, such as demonstrated in NUREG/CR-2913 [25], more realistically evaluates the thermodynamic properties of these jets. These Category II jets are assumed to expand radially at a 45 degree angle [25]. The NUREG-2913 model provides a method for calculating target loads for initial pipe rupture fluid conditions of pressure between 60 and 170 bars (870 psia - 2466 psia) and with subcooling of 0°C (0°F) to 70°C (126°F).

a.3 Category III Jets - All other steam and flashing water jets: | ADVANCE

Category III jets are assumed to expand as a three region cone defined in Figure 3.6B - 96A for circumferential breaks and Figure 3.6B - 96B for longitudinal breaks [22]. | ADVANCE

a.3.1 Circumferential Break with Full Separation: | ADVANCE

Jet Region 1 ($L < L_c$). Region 1 includes a cone-shaped region containing the jet core and the remainder of the jet. This geometry is shown in Figure 3.6B-96C. | ADVANCE

The jet core length is related to the jet subcooling at the jet break plane and has been correlated using the following expression | ADVANCE

$$L_c / D_e = 0.26 \left(\sqrt{\Delta T_{sub}} \right) + 0.5 \quad (1)$$ | ADVANCE

where: | ADVANCE

L_c = core length | ADVANCE

D_c = pipe inside diameter | ADVANCE

ΔT_{sub} = jet subcooling at stagnation conditions of ^{o}F at the break plane | ADVANCE | ADVANCE

Figure 3.6B-96D can be used to relate jet stagnation subcooling at the break plane to stagnation conditions in the vessel supplying the jet flow, accounting for irreversible losses in the blowdown line. | ADVANCE

ADVANCE | In Region 1, for $0 \leq L \leq L_c$, the jet core diameter, D_c, is given | by

ADVANCE | $$\frac{D_c}{D_e} = \left(\sqrt{C_{Te}}\right)\left(1 - \frac{L}{L_c}\right) \qquad (2)$$

ADVANCE | Jet area at the break plane, A_{je}, is given by

ADVANCE | $$A_{je} = C_{Te}{}^{*}A_e$$

ADVANCE | where

ADVANCE |
ADVANCE | $$C_{Te}{}^{*} = \begin{cases} 2.0 \text{ for } \Delta T_{sub} > 0 \\ 1.26 \text{ for } \Delta T_{sub} = 0 \end{cases}$$
ADVANCE |

ADVANCE | A_e = inside cross sectional area of the pipe

ADVANCE | L = distance from break plane to target

ADVANCE | The outside area of the jet is given by equation (6) and will be | discussed in the following sections.

ADVANCE | Jet Region 2 ($L_c < L < L_a$). In Region 2, the jet expands to its | asymptotic area which can be calculated as:

ADVANCE | $$A_a / A_e = G_e{}^2 / (g_c \rho_{ma} C_T P_o) \qquad (3)$$

ADVANCE | where

ADVANCE | A_a = jet area at the asymptotic plane

ADVANCE | A_e = break plane area

C_T = steady-state thrust coefficient | ADVANCE

G_e = mass flow rate per unit area from the break plane | ADVANCE

g_c = gravitational constant | ADVANCE

P_o = initial total (stagnation) pressure in the vessel | ADVANCE

ρ_{ma} = asymptotic plane density. If two-phase, density will be given by | ADVANCE

$\rho_{ma} = 1/[x/\rho_g + (1-x)/\rho_f]$ | ADVANCE

x = mixture vapor mass fraction i.e. quality, at the asymptotic plane pressure, P_a, and stagnation enthalpy | ADVANCE

ρ_f = saturated liquid density at the asymptotic plane pressure | ADVANCE

ρ_g = saturated vapor density at the asymptotic plane pressure | ADVANCE

[Note: Figure 3.6B-96E may be used in place of Equation (3)] | ADVANCE

The jet pressure at the asymptotic plane, P_a can be expressed as the following expression | ADVANCE

$$\frac{P_a}{P_{amb}} = 1 - 0.5 \left(1 - \frac{2P_{amb}}{P_o}\right) f(h_o) \quad (4)$$ | ADVANCE

where | ADVANCE

P_{amb} = ambient pressure | ADVANCE

P_a = asymptotic plane static pressure | ADVANCE

ADVANCE |

$$f(h_o) = \begin{cases} \sqrt{0.1 + \dfrac{h_o + h_f}{h_{fg}}} & \text{for} \left(\dfrac{h_o - h_f}{h_{fg}}\right) > -0.1 \\ 0 & \text{for} \left(\dfrac{h_o - h_f}{h_{fg}}\right) < -0.1 \end{cases}$$

ADVANCE | h_o = stagnation enthalpy in the vessel*

ADVANCE | h_f. h_{fg} = saturated liquid enthalpy and heat of vaporization
ADVANCE | in the vessel

ADVANCE | *h_o in the vessel and at the break plane are assumed to be equal.

ADVANCE | The distance from the break plane to the asymptotic plane is defined
| by:

ADVANCE |

$$\frac{L_a}{D_e} = 1/2 \left(\sqrt{\frac{A_a}{Ae}} - 1 \right) \qquad (5)$$

ADVANCE | The jet area at any location from the break plane to the asymptotic
| plane (Regions 1 and 2) may be calculated from the following
| relationship:

ADVANCE |

$$A_j/A_{je} = [1 + L/L_a\ (A_a/A_{je} - 1)], \qquad (6)$$

ADVANCE | where

ADVANCE | A_j = jet area

ADVANCE | A_{je} = jet area at break plane

Jet Region 3 ($L \geq L_a$). In Region 3, the jet area is given by | ADVANCE

$$A_j / A_a = (1 + (2(L - L_a)/D_a)(\tan 10°))^2 \quad (7)$$ | ADVANCE

where | ADVANCE

D_a = jet diameter at the asymptotic plane | ADVANCE

a.3.2 Longitudinal Break | ADVANCE

The jet shape for longitudinal breaks, as shown in Figure 3.6B-96B shall be assumed to be the same as the círcumferencial break defined in a.3.1. A jet diameter for a circular break of the same area may be used and the jet direction taken to be perpendicular to the axis of the pipe. | ADVANCE

B. Effective Target Distance | ADVANCE

b.1 Category II Jets | ADVANCE

For steam and flashing water jets within the limits of NUREG/CR-2913 [i.e., stagnation pressure from 60 bars (870 psia) to 170 bars (2466 psia) and subcooling of 0°C (0°F) to 70°C (126°F)] the effective target distance is taken as ten (10) times the inside diameter of the ruptured pipes [25]. | ADVANCE

b.2 Category I & III Jets | ADVANCE

For all other high energy line break jets, jets are assumed to travel until impact with a target or a barrier. | ADVANCE

ADVANCE | C. Jet Force

ADVANCE | c.1 Category I Jets

ADVANCE | If the stagnation pressure at the break flow area is sufficiently close to the ambient pressure, the core length, L_c, calculated by equation (1) may be greater than the distance to the asymptotic surface L_a, calculated by equation (5). For this bounding case, the core length may be set to zero ($L_c = 0$) and the jet pressure distribution assumed to be uniform over the jet cross section and equal to F_j/A_j.

ADVANCE | For liquid jets whose temperature is below the saturation temperature at ambient pressure and for gas jets whose pressure at the break plane is equal to the ambient pressure, a uniform pressure over the jet cross-section can be assumed, which is consistent with the jet area and the total jet force as defined by equation (8) or (9) as shown in the following:

ADVANCE | The generalized momentum equation that describes the jet force is;

ADVANCE |
$$F_j = \frac{G_e^2 A_e}{\rho_e g_c} + A_e (P_e - P_{amb}) \qquad (8)$$

ADVANCE | where

ADVANCE | P_e = fluid pressure at the break flow area

ADVANCE | ρ_e = fluid density at the break flow area

And for calculating target loads a conservative quasi-steady-state jet force is used: | ADVANCE

$$F_j = A_c(C_T P_o - P_{amb}) \cong C_T P_o A_e \quad (9)$$ | ADVANCE

However, the above equation for F_j is modified as follows: | ADVANCE

1. For jets where $\Delta T_{sub} > 0$, C_T will be increased by $(2.0/C_{Te})$ in region 1. C_{Te} is defined in C.3. | ADVANCE

2. Unless otherwise justified, F_j is not to be less than the initial jet force based on equation (8). | ADVANCE

c.2 Category II Jets | ADVANCE

The jet force is a function of the pressure field downstream of the shock wave that forms in the flow field when a target or obstacle is encountered. The jet force is given by: | ADVANCE

$$F_j = F_r = \int P_j \, dA_t \quad (10)$$ | ADVANCE

where F_r = total target force given in NUREG/CR-2913 [25]. | ADVANCE

c.3 Category III Jets | ADVANCE

The jet force is a function of jet geometry as discussed below. | ADVANCE

c.3.1 | ADVANCE

Region 1, defined as $0 \leq L \leq L_c$, the jet pressure in the core and outside the core is given by | ADVANCE

ADVANCE | Jet Core; for $0 \leq r \leq D_c/2$,

ADVANCE |
$$P_j = P_{oe} = (C_T/C_{Te})P_o \qquad (11)$$

ADVANCE | where

ADVANCE | $C_{Te} = C_T$ based on $FL/D = 0$ and the break flow area stagnation conditions. Where these conditions are not known and $\Delta T_{sub} > 0$, C_{Te} and P_{oe} can be determined through an interative process, first using vessel conditions to estimate C_{Te}, then the resulting estimate for P_{oc}, etc. (Note that h_o at the break may be assumed equal to h_e in the vessel).

ADVANCE | Outside Core; for $D_c/2 \leq r \leq D_j/2$,

ADVANCE |
$$\frac{P_j}{P_{oc}} = \left(\frac{D_j - 2r}{D_j - D_c}\right)\left[1 - \frac{2\left[D_j^2 + D_jD_c + D_c^2 - 3D_c^2\,C_{Te}^{*}\right]}{(D_j^2 - D_c^2)}\left(\frac{2r - D_c}{D_j - D_c}\right)\right] \qquad (12)$$

ADVANCE | C.3.2 For Region 2, defined as $L_c < L < L_a$, the jet pressure is given by

ADVANCE |
$$\frac{P_j}{P_{jc}} = \left(1 - \frac{2r}{D_j}\right)\left[1 - 2\left(\frac{2r}{D_j}\right)\left[1 - 3C_{Te}\left(\frac{D_e}{D_j}\right)^2\left(\frac{P_{oe}}{P_{jc}}\right)\right]\right] \qquad (13)$$

where | ADVANCE

$$\frac{P_{jc}}{P_{oe}} = 1 - \left[1 - 3C_{Te}\left(\frac{D_e}{D_a}\right)^2\right] \frac{L_a(L-L_c)}{L(L_a-L_c)} = \text{Jet centerline pressure for } (L_c < L < L_a) \quad (14)$$

| ADVANCE

c.3.3 For Region 3, defined as $L \geq L_a$, the jet pressure is given by | ADVANCE

$$\frac{P_j}{P_{jc}} = \left(\frac{D_j - Z_r}{D_j}\right) \quad (15)$$

| ADVANCE

where | ADVANCE

$P_{jc} = 3F_j/A_j$, jet centerline pressure for $(L > L_a)$ (16) | ADVANCE

D. Jet Impingement Force | ADVANCE

The jet impingement force which is applied to a given target is a function of the fraction of the jet which is intercepted by the target. If the entire jet is intercepted, then the entire jet force is applied to the target. | ADVANCE

$$F_{jt} = F_j \quad (17)$$

| ADVANCE

If the target intercepts a fraction of the jet, but not the entire jet, the jet pressure distribution over the target must me integrated to obtain the jet force. | ADVANCE

ADVANCE | $F_{jt} = \int P_j \, dA_t$ (18)

ADVANCE | where

ADVANCE | P_j = radial jet pressure distribution at the impingement plane, as described in Section C above.

ADVANCE | A_t = Target area

ADVANCE | The impingement load may be estimated from the jet axial force and an approximate correction factor,

ADVANCE | $F_{imp} = K\phi \; F_{jt}(DLF)$ (19)

ADVANCE | Where

ADVANCE | F_{imp} = impingement force on the target, as a function of time

ADVANCE | $K\phi$ = the shape factor, a measure of the target's potential for changing the momentum of the jet, as described in Appendix D of Reference 22.

ADVANCE | DLF = Dynamic Load Factor [26]

20. EBASCO Services Inc., "CALPLOTF-III" computer code to calculate blowdown loads using output from RELAP-5 Rev. 0, Nov. 1985. | 68

21. Hibbit and Karrisson Inc., "ABAQUS-ND" A Finite Element Code for Nonlinear Dynamic Analysis. | 68

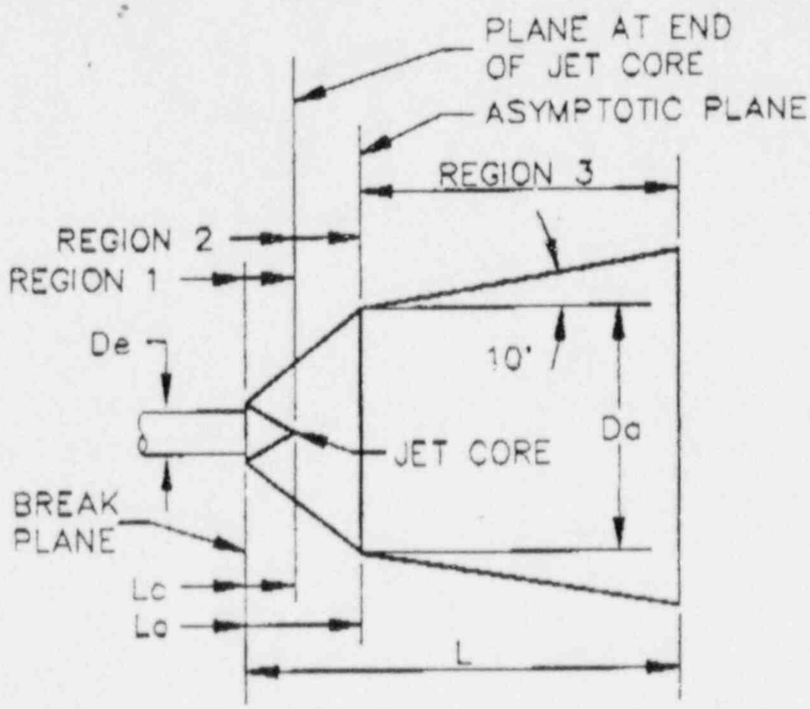
22. Design Basis for Protection o, Light Water Nuclear Power Plants Against Effects of Pipe Rupture, American National Standard ANSI/ANS 58.2 (Working Draft, Revision 7, August 1987). | ADVANCE

23. Federal register 12502 Vol. 51, No. 70, April 11, 1986 "Modification of General Design Criterion 4 Requirements for Protection Against Dynamic Effects of Postulated Pipe Ruptures". | 68

24. EBASCO Services Inc., "SHPLAST 2267, Dynamic Pipe Whip Analysis" version 0 Rev. 27, June 1983. | 68

25. NUREG/CR-2913 "Two-Phase Jet Loads", G.G. Weigand, S. L. Thompson, and D. Tomasco January 1983. | ADVANCE

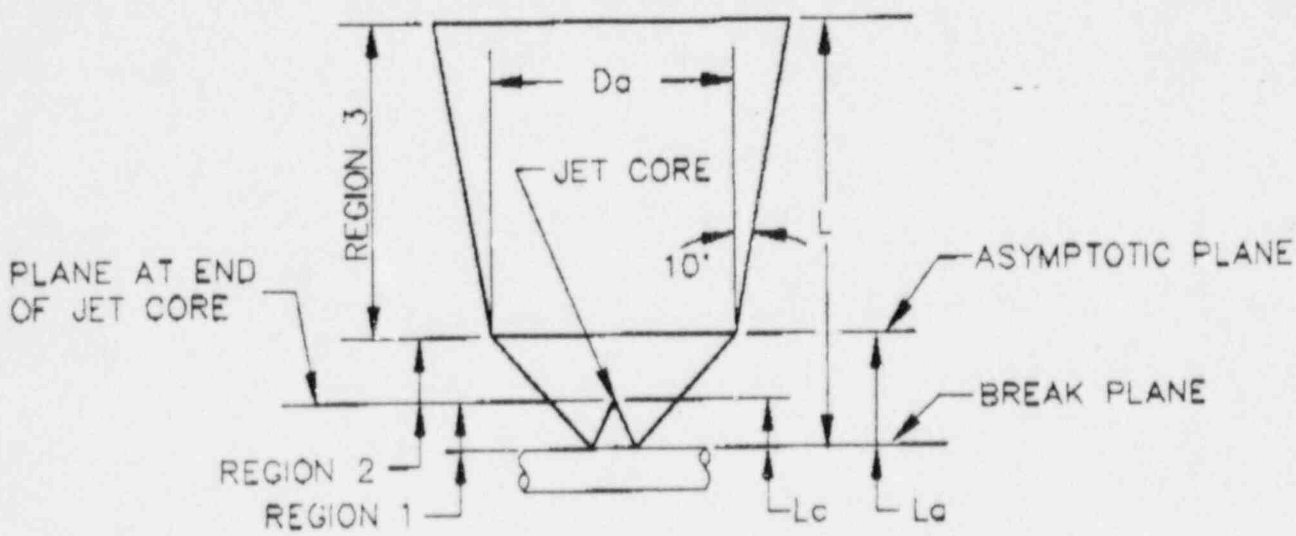
26. Biggs, J.M., et.al, "Structural Design For Dynamic Loads", McGraw-Hill, 1959. | ADVANCE



COMANCHE PEAK S.E.S.
FINAL SAFETY ANALYSIS REPORT
UNITS 1 & 2

CIRCUMFERENTIAL PIPE BREAK
WITH FULL SEPARATION
JET CONE

FIGURE 3.6B-96A



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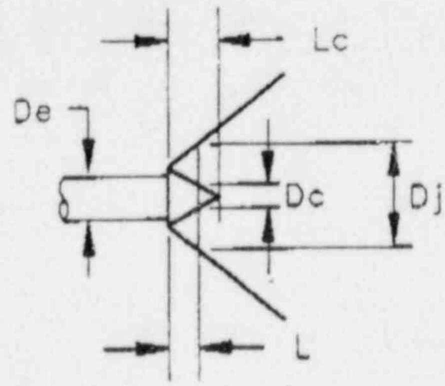
LONGITUDINAL PIPE BREAK
JET CONE

FIGURE 3.6B-96B



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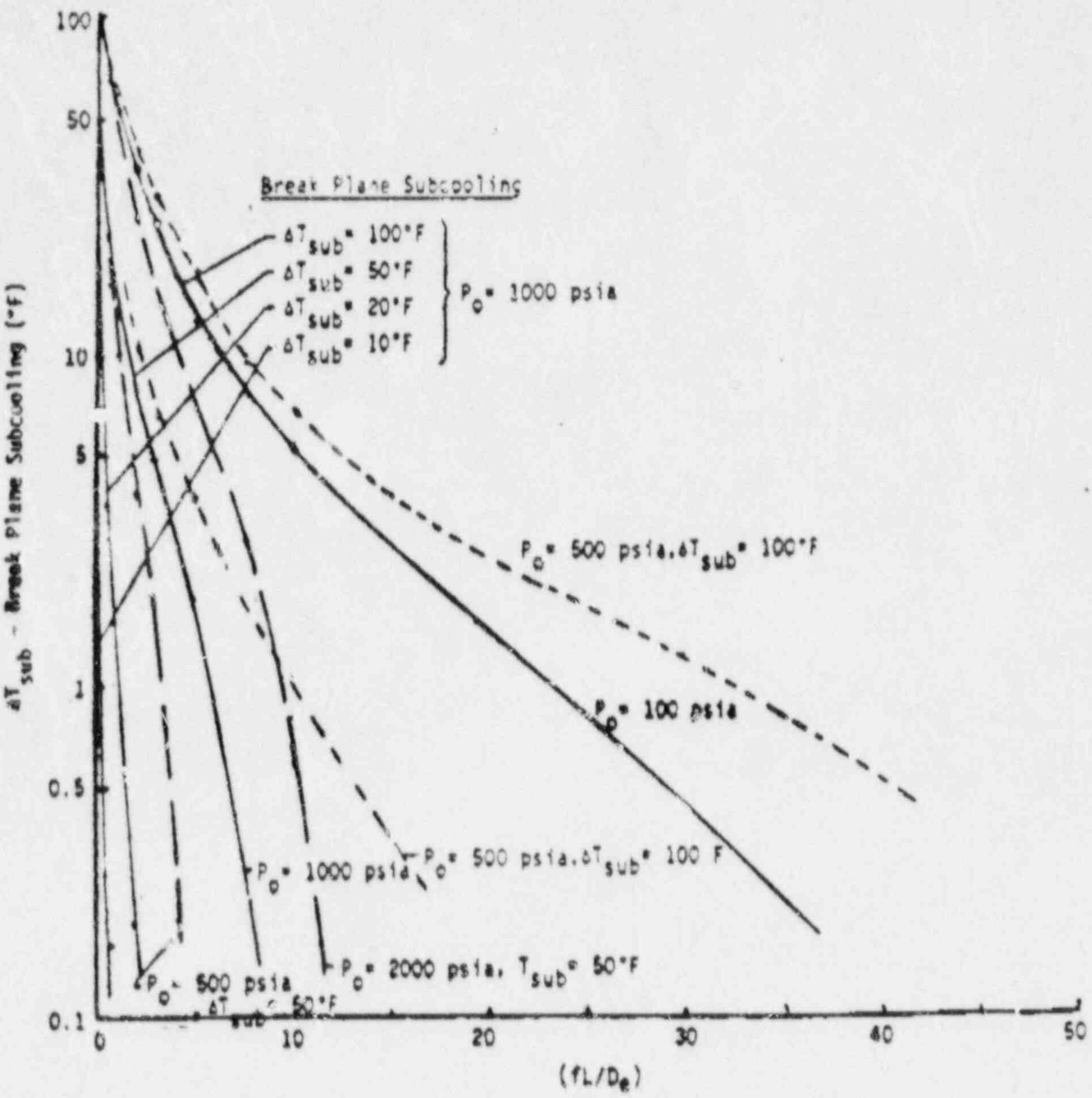
UNITS 1 & 2

JET CORE REGION GEOMETRY FOR A CIRCUMFERENTIAL PIPE BREAK WITH FULL SEPERATION

FIGURE 3.6B-96C



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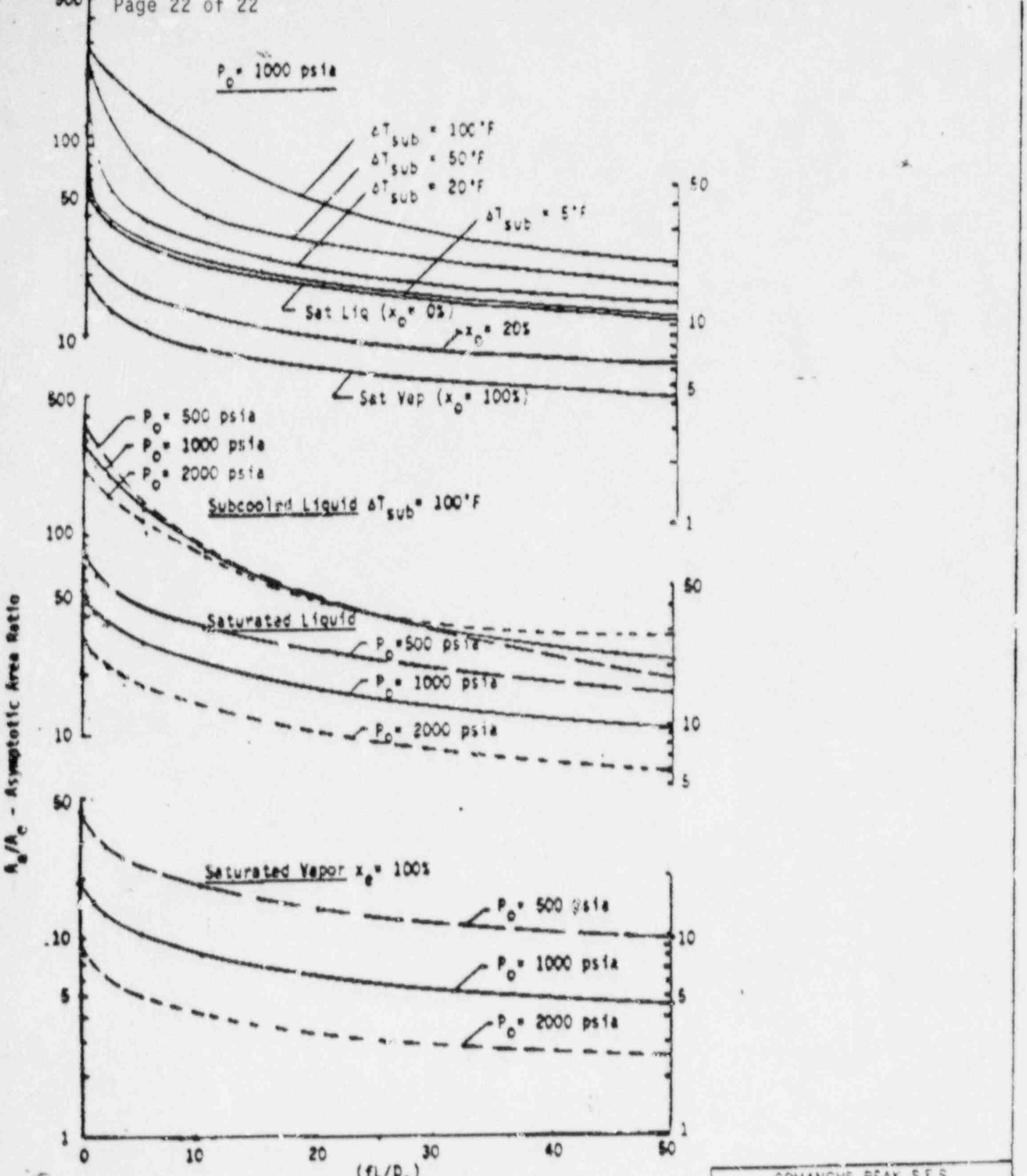
EFFECT OF IRREVERSIBLE LOSSES ON JET SUBCOOLING

FIGURE 3.6B-96D



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EFFECT OF IRREVERSIBLE LOSSES OF ASYMPTOTIC AREA RATIO
FIGURE 3.6B-96E

FSAR page (as amended)	DESCRIPTION
3.6B-29	Clarification: In order to be consistent with the terminology utilized in subsequent sections, the steady state thrust coefficient previously shown as K_t is identified as C_t. (88-438)
3.6B-30	Clarification: The full name of the post processor program to RELAP, CALPLOTF-III, is provided. (88-438)
	Revision: Deletes reference to Moody's critical flow model. This flow model was used in earlier versions of the RELAP program however an improved model was incorporated in RELAP-5. (88-438)
3.6B-31	Revision: Deletes path inertias as an initial input condition. Refinements in RELAP-5 over earlier RELAP versions have eliminated the need to include path inertias as initial inputs. (88-438)
	Clarification: To be consistent with the preceding sentence the singular nouns and pronouns are made plural to indicate that all three programs are included in the description. (88-438)
	Clarification: References acoustic disturbance flow phenomena as an additional factor in the determination of forces from fluid jet thrust at the break location. (88-438)
	Clarification: Rewords sentence discussing how piping restraints are modeled to clarify that an initial gap is utilized in all three computer codes. (88-438)
3.6B-32	Clarification: Rewords sentence discussing step-by-step integration to clarify that all three computer programs utilize the integration method. (88-438)
	Revision: Deletes reference to Newmark's method for the evaluation of the incremental equation of motion. The SHPLAST and ABAQUS programs use different methods. (88-438)

FSAR page (as amended)	DESCRIPTION
3.6B-33 thru 3.6B-44	Revision: Describes the new methodology used to determine jet impingement loads. The basis of this methodology is American National Standard ANSI/ANS 58.2 "Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Pipe Rupture", (Working Draft Rev.7, 1987). The primary differences between this method and the previous method are in; 1) the utilization of the multidimensional flow analysis methodology demonstrated in NUREG/CR-2913 (an alternate methodology endorsed by ANSI/ANS 58.2) and the primary methodology described in ANSI/ANS 58.2, and 2) the jet expansion geometry and jet attenuation used for the above models (and consequently the number of targets within the jet zone of influence).

The previous FSAR method assumed that steam and flashing water jets were unattenuated. ANSI 58.2 allows the utilization of the multidimensional flow analysis demonstrated in NUREG/CR-2913 for the determination of jet forces from high energy steam and two phase jets (i.e., jets with initial fluid conditions of 870 psia to 2466 psia and with subcooling of 0 degrees F to 126 degrees F). This multidimensional analysis considers the supersonic velocities downstream of the break and the ensuing shock wave in the determination of the pressure field and load on the target. The multidimensional analysis more realistically evaluates the thermodynamic properties of these jets and yields significant jet load attenuation downstream of the shock wave. Thus for high energy steam and two phase jets analyzed using the NUREG 2913 methodology, the effective target distance is taken as ten times the inside diameter of the ruptured pipe. This effective target distance is based on extensive analytical work performed at Sandia Laboratories which is provided in the NUREG and which is compared in that NUREG to available test data. Also based on NUREG data, the jet is assumed to expand radially at a 45 degree angle. Within the effective target distance, the zone of influence of the 45 degree expansion jet envelopes the the zone of influence of the previously used 10 degree half angle expansion model.

For all other high energy line breaks (steam and two phase jets which do not meet the pressure and subcooling requirements discussed above, and water jets), the jet loads are calculated using the primary methodology described in ANSI/ANS 58.2 Working Draft 7. As in the previous FSAR model, these jets are assumed to travel unattenuated until impact with a target or barrier.

FSAR page (as amended)	DESCRIPTION
3.6B-33 thru 3.6B-44 (cont.)	For steam and two phase flow (flashing water), the previous model assumed a single region with a uniform jet expansion at a half-angle not exceeding 10 degrees. The ANSI/ANS 58.2 method provides for a more realistic three region expansion model. As can be seen from Figures 3.6B-96A and 3.6B-96B, the zone of influence of the three region model envelopes the zone of influence of the previous single region model. In the regions of the highest jet loads (L_c and L_a) the three region model has a larger zone of influence (and thus encompasses more targets) than the single region model. For water jets, the previous model assumed a cylindrical non-expanding jet with a cylinder diameter equal to the diameter of the ruptured pipe. The ANSI/ANS 58.2 model also assumes a cylindrical non-expanding jet with a cylinder diameter equal to the diameter of the rupture pipe. However, CPSES conservatively assumes a cylindrical non-expanding jet model equal to twice the diameter of the ruptured pipe. Therefore, the CPSES model has a larger zone of influence and thus encompasses more targets.
	The material revised in this FSAR section was previously reviewed (thru Amendment 45) and accepted by the NRC in SSER 6. (88-438)
3.6B-79	Revision: References ANSI/ANS 58.2 Working Draft Rev.7, August 1987 as the version utilized in the determination of jet impingement loads. Also see description at 3.6B-33 thru 3.6B-44. (88-438)
	Addition: Provides reference to NUREG/CR-2913 which is utilized to calculate two-phase jet loads. Also see description at 3.6B-33 thru 3.6B-44. (88-438)
	Addition: Provides reference to Biggs handbook for Structural Design for Structural Loads which is utilized in the determination of Dynamic Load Factors. (88-438)
Figure 3.6B-96A	Addition: Provides a new figure to illustrate the three region jet cone model for determination of jet impingement affects of a circumferential break with full separation. This figure is used in conjuction with the ANSI/ANS 58.2 primary methodology. Also see description at 3.6B-33 thru 3.6B-44. (88-438)

FSAR page (as amended)	DESCRIPTION
Figure 3.6B-96B	Addition: Provides a new figure to illustrate the three region jet cone model for determination of jet impingement affects of a longitudinal break. This figure is used in conjunction with the ANSI/ANS 58.2 primary methodology. See description at 3.6B-33 thru 3.6B-44. (88-438)
Figure 3.6B-96C	Addition: Provides a new figure to illustrate the jet cone geometry for a circumferential break with full separation. This figure is used in conjunction with the ANSI/ANS 58.2 primary methodology. Also see description at 3.6B-33 thru 3.6B-44. (88-438)
Figure 3.6B-96D	Addition: Provides a new figure which can be utilized to relate stagnation subcooling at the break plane to stagnation conditions in the vessel supplying the jet flow, accounting for irreversible losses in the blowdown line. This figure is used in conjunction with the ANSI/ANS 58.2 primary methodology. (88-438)
Figure 3.6B-96E	Addition: Provides a new figure which can be utilized to calculate the Asymptotic Area Ratio which may be used in place of FSAR Section 3.6B.2.3.2 equation (3). This figure is used in conjunction with the ANSI/ANS 58.2 primary methodology. (88-438)