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L30-85(06-07)-L
N86-85(06-07)-L
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ILLINOIS POWER COMPANY

CLINTON POWER STATION, P.O. BOX 678, CLINTON, ILLINOIS 61727

June 7, 1985

Docket No.50-461

Director of Nuclear Reactor Regulation
Attention: Mr. W. R. Butler, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Clinton Power Station Unit 1
Postulated Piping Failures
SER Outstanding Issue #5

Dear Mr. Butler:

In the Clinton Power Station (CPS) Safety Evaluation Report (SER) dated February 1982, the NRC Staff identified that Illinois Power Company had not yet completed the analysis for the effects of jet impingement and that this information would be submitted after the completion of the new loads evaluation program.

The purpose of this letter is to inform the Staff that this program has been completed. Attached to this letter is a draft version of a proposed Final Safety Analysis Report (FSAR) revision which will be submitted as part of the next FSAR amendment. Also, the next FSAR amendment will identify that the Standard Review Plan (SRP) has not been used in all cases. This letter provides the justification for those exceptions.

Jet impingement analyses performed before April 1, 1984, for CPS are based on the procedures outlined in ANSI/ANS 58.2, dated 1980, and the Standard Review Plan Section 3.6.2. This procedure is currently described in Section 3.6.2 of the CPS FSAR.

For certain jet impingement analyses performed after April 1, 1984, the report prepared by Sandia National Laboratories for the NRC entitled, "Two-Phase Jet Loads (NUREG/CR-2913 SAND 82-1935 R4)" has been used. The Sandia study (released in January 1983) provides a more realistic means of calculating jet impingement forces than previously available. The test results have been benchmarked against available jet impingement data and show good correlation with these tests.

w/Encl: R. Pichumani - MEB
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B. Siegel

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The CPS FSAR is being revised to reference how this Sandia report is used in the jet load analyses. NUREG-CR-2913 has been used to calculate jet loads for the following:

1. Drywell and Containment Isolation Valves

2. Drywell Structures at Azimuth 0°

3. Drywell Head and Bulkhead

4. Drywell Structural Steel

Using the Sandia methodology provides load relief over the current SRP procedure. The current procedure assumes that jet pressures extend an infinite distance; while the Sandia jet pressure loads become insignificant beyond eight pipe diameters from the pipe break. Also, using the Sandia methodology reduces the number of engineering calculations or many targets, thereby reducing or eliminating possible hardware modifications.

Illinois Power Company believes that the FSAR changes described above and acceptance of the use of NUREG/CR-2913 for Clinton Power Station jet impingement analyses resolves Outstanding Issue #5.

Please contact us should you have any questions on this matter.

Sincerely yours,

F. A. Spangenberg

F. A. Spangenberg
Director - Nuclear Licensing
and Configuration
Nuclear Station Engineering

JLP/lab

cc: B. L. Siegel, NRC Clinton Licensing Project Manager (w/attachment)
Regional Administrator, Region III, USNRC
NRC Resident Office
Illinois Department of Nuclear Safety

piping was designed in accordance with the criteria of Subsection 3.6.2.5.

3.6.2 Determination of Break Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

Described herein are the design bases for postulating piping breaks and cracks inside and outside of containment, the procedures used to define the jet thrust reaction at the break location, the jet impingement loading criteria, and the piping dynamic response models.

3.6.2.1 Criteria Used to Define Break and Crack Location and Configuration

3.6.2.1.1 Definition of High-Energy Fluid System

The definition of a high-energy fluid system is found in Subsection 3.6.1.1.1b.

3.6.2.1.2 Definition of Moderate-Energy Fluid System

The definition of a moderate-energy fluid system is found in Subsection 3.6.1.1.1c.

3.6.2.1.3 Postulated Pipe Breaks and Cracks

A postulated pipe break is defined as a sudden, gross failure of the pressure boundary either in the form of a complete circumferential severance (guillotine break) or as development of a sudden longitudinal split and is postulated for high-energy fluid systems only. For moderate-energy fluid systems, pipe failures are confined to postulation of controlled cracks in piping and branch runs. These cracks affect the surrounding environmental conditions only and do not result in whipping of the cracked pipe.

The following high-energy piping systems (or portions of systems) have been considered in the determination of a postulated pipe break during normal plant conditions and are evaluated for potential damage resulting from dynamic effects.

a. All piping which is part of the reactor coolant pressure boundary and subject to reactor pressure continuously during station operation.

b. All piping which is beyond the second isolation valve but which is subject to reactor pressure continuously during station operation.

c. All other piping systems or portions of piping systems considered high-energy systems.

impairment of the leaktight integrity of the containment, to assure isolation valve operability, and to meet the stress and fatigue limits in the containment penetration area.

d. Leakage cracks in the containment penetration area are postulated in accordance with Subsection 3.6.2.1.6.2.1.1.

e. The number of circumferential and longitudinal piping welds and branch connections is minimized as much as practical.

f. The length of these portions of piping is reduced to the minimum length practical.

g. An augmented ISI will be performed as discussed in Subsection 6.6.8.

The break exclusion areas are shown on Figures B3.6-1 through B3.6-28.

3.6.2.1.6.2.1.3 Details of the Containment Penetration

Details of the containment penetrations are discussed in Subsections 3.8.1 and 3.8.2.

3.6.2.1.6.2.2 Moderate-Energy Fluid System Piping Inside and Outside Containment

Leakage cracks in moderate-energy piping are postulated individually at locations that would result in the maximum effects from fluid spraying and flooding, with the consequent hazards or environmental conditions developed from the spray or flood. The consequences of these postulated breaks were analyzed for each room in the safety-related buildings. The results of these analyses are presented in FSAR Section D.3.6.3.

3.6.2.1.7 Definitions

Throughout this section, applicable definitions are located in Subsection 3.6.1.1.1.

discharge. Pipe whipping is assumed to occur in the plane defined by the piping geometry and configuration and to cause pipe movement in the direction of the jet reaction.

3.6.2.2.2.1.2 Longitudinal Breaks

The dynamic force of the fluid jet discharge is based on a circular break area equal to the cross-sectional flow area of the pipe at the break location and on a calculated fluid pressure modified by an analytically determined thrust coefficient as determined for a circumferential break at the same location. Line restrictions, flow limiters, positive pump-controlled flow, and the absence of energy reservoirs are taken into account, as applicable, in the reduction of jet discharge. Piping movement is assumed to occur in the direction of the jet reaction unless limited by structural members, piping restraints, or piping stiffness.

3.6.2.2.2.1.3 Pipe Blowdown Force and Wave Force

The calculation of the magnitude and duration of the wave force acting on bounded pipe segments is based on a design guide for estimating discharge forces by Moody (Reference 1).

The calculation of the blowdown force is based on either an exact computer model (Reference 9) or on the following simplified conservative methodology.

The calculation of the blowdown force is consistent with Reference 1, and with Section 6.0 of ANSI N176 dated January, 1978 (Reference 2). If there is a fluid reservior having sufficient capacity to develop a steady jet for a significant interval, the magnitude of the steady-state blowdown force used for saturated steam, saturated water, or a saturated steam and water mixture is equal to 1.26 P_oA_e for frictionless fluid flow (where P_o equals the stagnation pressure of the initial vessel fluid and A_e equals the break area). The magnitude of the steady-state blowdown force used for subcooled water varies from 1.26 P_oA_e to 2.0 P_oA_e for frictionless fluid flow depending on the degree of subcooling. However, the steady-state blowdown force is reduced by taking frictional effects into consideration as per Reference 2. For break locations where the frictional effects are significant, the blowdown force on the broken pipe segment is further reduced by considering the effect of wave propagation and reflection. Figure 3.6-3 shows the blowdown force on the pipe versus time for circumferential breaks. The pipe thrust used for longitudinal breaks is equal to the largest circumferential blowdown force at the same break location in accordance with Subsection 3.6.2.2.2.1.2. Nomenclature used in Figure 3.6-3 is defined below.

a. Three different blowdown magnitudes are calculated:

1. $F_{impulse} = F_{imp} = P_oA_e$

2. $F_{intermediate} = F_{int} = (P_oA_e - F_w)$

$$F_{imp} = F_{int} \text{ implies } F_w = 0$$

where

F_w = wave force (transient),

A_e = pipe flow area, and

P_o = line pressure.

3. $F_{steady\ state} = F_{ss}$

b. F_w initial is determined from Figure 9-23 of Reference 1. F_w initial for flashing water for pressures not shown in Figure 9-23 is equal to (P - 1.26 P_{sat}) A (where P_{sat} equals the saturation pressure of the initial pipe fluid).

c. $F_{steady\ state} = F_{ss}$ is determined in accordance with Reference 2.

d. T_{imp} = Time to $F_{intermediate}$ for circumferential breaks and is determined by dividing the distance to the first elbow from the break by the sonic speed of the significant fluid wave. The sonic wave speed (C) is determined from Figure 9-29 of Reference 1.

e. F_{final} = The larger of F_{int} or F_{ss}.

3.6.2.2.2.2 Methods for the Dynamic Analysis of Pipe Whip

Pipe whip restraints provide clearance for thermal expansion during normal operation. If a break occurs, the restraints or anchors nearest the break are designed to prevent unlimited movement at the point of break (pipe whip). Simplified models of the local region near the break were analyzed to calculate displacement of the pipe and restraint. These calculated displacements were then used to calculate strains in the pipe, and were compared to allowable restraint deflection.

A finite difference model was used (Reference 10) for the pipe moment-curvature and the restraint resistance-displacement functions. The simplified models shown in Figure 3.6-5 were used to represent the local region near the break and to calculate the displacement in the restaint as well as the displacements and strains in the pipe.

These pages have been deleted intentionally.

3.6.2.2.2.2.1 Finite Difference Analysis

A finite difference formulation specialized to the case of a straight beam and neglecting axial inertia and large deflection effects is used for the analysis of pipe whip of stainless and carbon steel pipes. The dynamic analysis is performed by direct numerical time integration of the equations of motion.

The equations of motion are of the form:

$$h\,(P_k - m_k \ddot{y}_k) = - M_{k+1} + 2M_k - M_{k-1} \qquad (3.6\text{-}15)$$

where:

h_k is the node spacing,

P_k is the externally applied lateral loads at node k,

m_k is the lumped mass at node k,

y_k is the lateral deflection at node k, and

M_k is the internal resisting moment in the beam at node k.

Power law moment-curvature relationship is assumed and the central difference approximation for the curvature

$$\frac{1}{h^2}\ (-y_{k+1} + 2y_k - y_{k-1})$$

is used.

A timewise central-difference scheme is used to solve the dynamic equations

$$y(t + \Delta t) = t^2 \ddot{y}\,(t) + 2y\,(t) - y\,(t - \Delta t) \qquad (3.6\text{-}16)$$

and for the first time step

$$y(\Delta t) = \Delta t^2 y(O) \qquad (3.6\text{-}17)$$

A time step not more than 1/10 the shortest period of vibration is used in the integration.

3.6.2.2.2.2.1.1 Elastic-Plastic Moment Curvature Law

The pipe is assumed to obey an elastic-strain hardening plastic moment-curvature law with isotropic strain hardening. The symbols used are defined as follows:

M = moment,

M = current yield moment,

E = elastic modulus of material at temperature,

I = moment of inertia,

Z = EI,

$\emptyset$ = curvature,

$\emptyset_e$ = M/Z = elastic curvature,

$\Delta\emptyset\rho$ = increment of plastic curvature,

$\emptyset\rho = |\Sigma\ \Delta\emptyset\ |$ = effective plastic curvature, and

$\emptyset_o = \Sigma A\emptyset\rho$ = permanent set curvature.

At the end of each integration step, new values of $\emptyset$ are calculated at each node.

The known values of $\emptyset\rho$, $\emptyset$, and M at the start of the step are used to calculate M, M, and $\Delta\emptyset\rho$ by the following procedure:

if $|\emptyset - \emptyset| < M/Z$,

$$M = Z\ (\emptyset - \emptyset_o),$$

and $\Delta\emptyset\rho = O$;

if $|\emptyset - \emptyset| > \overline{M}/Z$,

$$M = \overline{M} = F\ (|\emptyset - \emptyset_o| + \emptyset\rho)\ \text{sign}\ (\emptyset - \emptyset_o),$$

and $\emptyset\rho = \emptyset - \emptyset_o - M/Z$,

where $F(\emptyset) = K(\emptyset)^n$

3.6.2.2.2.2.1.2 Power Law Moment Curvature Relationship

The following stress strain law is assumed in the plastic range:

$$\sigma = K \left(\frac{\phi}{R_o}\right)^n \qquad (3.6\text{-}18)$$

The corresponding moment curvature law is

$$M = K \,(\phi)^n \qquad (3.6\text{-}19)$$

where:

$$K = \frac{2\sqrt{\pi}}{3 + n} \left(R_o^{\ 3+n} - R_i^{\ 3+n}\right) \quad \frac{\Gamma\,(\tfrac{1}{2}n+1)\,\overline{K}}{\Gamma\,(\tfrac{1}{2}n + 3/2)} \qquad (3.6\text{-}20)$$

or, to a good approximation,

$$K = \frac{4\overline{K}}{3 + n} \left(1 - 0.291n - .076n^2\right) \left(R_o^{\ 3+n} - R_i^{\ 3+n}\right) \qquad (3.6\text{-}21)$$

in which:

R_o = pipe outside radius, and

R_i = pipe inside radius.

In the elastic range, the moment-curvature law is:

$$M = EI\phi \qquad (3.6\text{-}22)$$

The transition from elastic to plastic behavior on initial loading occurs at:

$$\phi = \left(\frac{EI}{K}\right)^{\frac{1}{n-1}} \qquad (3.6\text{-}23)$$

3.6.2.2.2.2.1.3 Strain Rate Effects

The effect of strain rate in carbon steel is accounted for by using a rate dependent stress strain law of the form

$$\sigma(\epsilon, \dot{\epsilon}) = \left[\left(1 + \frac{\dot{\epsilon}}{(40.4)}\right)^{1/5}\right] G(\epsilon) \qquad (3.6\text{-}24)$$

where $G(\epsilon)$ is the static stress strain relationship. For stainless steels, the effect of strain rate is less pronounced so that a 10% increase in yield and ultimate strengths is used. The selection of material properties is discussed in Attachment A3.6.

3.6.2.2.2.2.1.4 Restraint Behavior

The analysis is capable of handling the bilinear or power law restraint behavior as shown in Figure 3.6-7. The behavior of the

e. Postulated design-basis breaks resulting in jet impingement loads are asumed to occur in high-energy lines at full (100%) power operation of the plant.

f. Postulated through-wall leakage cracks are postulated in moderate-energy lines and are assumed to result in wetting and spraying of safety-related structures, systems and components.

g. Reflected jets are considered only when there is an obvious reflecting surface (such as a flat plate) which directs the jet onto a safety-related target. Only the first reflection is considered in evaluating potential targets.

h. Potential targets in the jet path are considered for the full extent of pipe displacement up to the calculated final position of the broken end of the ruptured pipe. This selection of potential targets is considered adequate due to the large number of breaks analyzed and the protection provided from the effects of these postulated breaks.

Jet impingement load calculations prepared after April 1, 1984 are based on a multidimensional computer study, which also accounts for the shock effects at the jet/target interface (Reference 8). These forces are calculated using NUREG/CR-2913 (Reference 8) for the range of parameters where Reference 8 is applicable. This range includes pressures between 60 and 170 BARS (1 BAR = 14.7 psi), for steam, saturated water, and subcooled water with no more than 70° C of subcooling. For fluid parameters outside this range, the procedure in Reference 8 is extrapolated when it is determined to be appropriate, or the procedure used before April 1, 1984 is applied. When using the procedure in Reference 8, the impingement force includes the shape factor, $K\phi$, as defined in Reference 2.

Jet impingement load calculation for the range of parameters where Reference 8 is not applicable, or calculations that were prepared before April 1, 1984, are based on the following simplified, one-dimensional procedure.

The analytical methods used to determine which targets are impinged upon by a fluid jet and the corresponding jet impingement load include:

a. The impinging jet proceeds along a straight path.

b. 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 fluid blowdown force as defined below.

c. The jet impingement force is uniformly distributed across the cross-sectional area of the jet, and only the portion intercepted by the target is considered.

d. The circumferential and longitudinal break opening is assumed to be a circular orifice of cross-sectional flow area equal to the effective flow area of the break.

e. The jet impingement force is equal to the steady state value of the fluid blowdown force as calculated by the methods described in Subsection 3.6.2.2.1.1.

f. The distance of jet travel is divided into two or three regions. Region 1 (see Figure 3.6-8) extends from the break to the asymptotic area. Within this region the discharging fluid flashes and undergoes

expansion from the break area pressure to the atmospheric pressure. In Region 2 the jet remains at a constant diameter. In Region 3 interaction with the surrounding environment is assumed to start and the jet expands at a half angle of 10°.

g. Moody (Reference 1) has developed a simple analytical model for estimating the asymptotic area for steam, saturated water, and steam-water blowdown conditions. For fluids discharging from a break which are below the saturation temperature at the corresponding room pressure or have a pressure at the break area equal to the room pressure, free expansion does not occur. In these cases, the jet can be assumed to have a constant cross-sectional area equal to the break area.

h. For fluids which are above the saturation temperature at room pressure, the jet model expands at a half angle of 45° from the break to the asymptotic area (Region 1) for fully separated circumferential and longitudinal breaks. Assuming a linear expansion from the break area to the asymptotic area, the jet shape can be defined for Region 1 as well as Regions 2 and 3. Reference 2 is used to determine the asymptotic area.

i. Both longitudinal and fully separated circumferential breaks are treated similarly. The value of fl/D used in the blowdown calculation is also used for jet impingement.

j. Circumferential breaks with partial (i.e., l<D/2) separation between the two ends of the broken pipe, not significantly offset (i.e., no more than one pipe wall thickness lateral displacement) are more difficult to quantify; therefore, use of this procedure will be identified if applied. For these cases the following assumptions are made:

    1. The jet is uniformly distributed around the periphery.

    2. The jet cross section at any cut through the pipe axis has the configuration depicted in Figure 3.6-8(B) and the jet regions are as therein delineated.

    3. The jet force Fj = total blowdown F.

4. The pressure at any point intersected by the jet is:

$$P_j = \frac{F_j}{A_R}$$

where:

A_R = the total 360° area of the jet at a radius equal to the distance from the pipe centerline to the target.

5. The pressure of the jet is then multiplied by the area of the target submerged within the jet in the manner explained in Paragraphs k and l.

6. The area (A_R) of the jet at target intersection distance r_t from pipe centerline is calculated by using Reference 2 to determine r_A (the distance from the pipe centerline to the plane of asymptoticity) and the relationship

$$A_R = 2 \pi r_t \ell_R$$

[See Figure 3.6-8 (E)]

where:

A_A = asymptotic jet area

A_B = break area

D = pipe inside diameter

ℓ = distance of pipe separation

ℓ_A = width of jet at r_A and infinitely outward

ℓ_R = width of jet at r_T

k. Target loads are determined using the following procedures and assumptions:

1. For both the fully separated circumferential breaks and the longitudinal breaks, the jet is assumed to reach its asymptoticity expanding at a half angle of 45° from the break. [Region 1, Figure 3.6-8(a)]. For design purposes, the jet is assumed to have linear expansion within this region. The distance L from the break to the asymptotic area is calculated by

$$L = \frac{D_B}{2}\left[\left(\frac{A_A}{A_B}\right)^{1/2} - 1\right]$$

where:

A_A = asymptotic jet area

A_B = jet cross sectional area at break

D_B = diameter of jet at break area

The ratio of A_A/A_B is determined from Reference 2.

2. The area within Region 2 can be assumed to be constant out to the beginning of Region 3 which starts at the intersection of a line drawn at a 10° half angle dotted line Figure 3.6-8(a) and (c) and the boundary of the jet. In Region 3 the area expands at a constant 10° half angle.

3. After determination of the total area of the jet at the target, the jet pressure is calculated by

$$P_i = \frac{F_j}{A_x}$$

where:

P = incident pressure, and

A = area of the expanded jet at the target intersection.

4. The total force on any target which intercepts a portion of the jet is

$$F_{target} = K_{\phi} P_{jet} A_t$$

where:

A_t = the area of the target intercepted by the jet

K_{ϕ} = the shape factor.

The shape factor is related to the drag coefficient, C_d, by K_{ϕ} = 1/2 C_d. Values of C_d are given in Reference 2.

l. For the partially separated circumferential breaks described in Paragraph j above, the target loads are calculated similarly, with the exception that the jet geometry is different according to Paragraph j and Figure 3.6-8(B).

Evaluation of the potential targets to withstand the jet impingement loads is performed.

For analysis of piping systems as targets, evaluation of design adequacy is based on the following load combination for the faulted condition:

$$\text{Pressure} + \text{Weight} + (\text{SSE}^2 + \text{Jet}^2)^{1/2}$$

Functional capability is evaluated when required.

3.6.2.3.1.2 Protective Measures

3.6.2.3.1.2.1 Protection and Analyses Guidelines

Protection against the dynamic effects of a pipe break is provided in the form of pipe whip restraints, equipment shields as required, and physical separation of piping, equipment, and instrumentation. The precise method used in choosing the kind of protection depends on other limitations placed on the designer, such as accessibility, maintenance, and proximity to other pipes. The following are examples of present designs intended to better protect safety-related equipment from the consequences of the pipe breaks:

a. The lines as described in Attachment B3.6 of the following systems inside the containment and dry well were analyzed for restraint against pipe whip and assessed for jet impingement:

    1. main steam
    2. feed water
    3. RHR
    4. RCIC
    5. LPCS
    6. HPCS
    7. RWCU
    8. reactor recirculation
    9. nuclear boiler
    10. standby liquid control

b. The lines as described in Attachment B3.6 of the following systems outside of the containment were assessed for jet impingement and analyzed against pipe whip:

    1. main steam
    2. feed water
    3. RCIC
    4. RWCU
    5. MSIV-LCS

Dynamic effects associated with the LOCA do not compromise the integrity of the containment and drywell.

The consequences of jet impingement do not result in any of the following:

a. inability to insert control rods,

b. inability to isolate the reactor coolant pressure boundary, and

c. inability to meet the core cooling system requirements.

Valves which are normally closed and are not signalled to be open were assumed to be closed.

Impacted active equipment (e.g., valves and instruments) are considered able to perform their intended functions if loads are shown to be within allowable limits, otherwise, shields must be provided. Impacted passive equipment (pipes, restraints, and structures) are considered capable of continuing to perform their intended functions.

Protection of the reactor pressure vessel from the surface impact effects of a pipe whip need not be considered because the impact energy is insufficient to cause loss of the functional integrity of the vessel.

3.6.2.3.1.2.2 Equipment Shields for Isolation

Equipment shields are selectively provided as required in order to isolate the equipment necessary to ensure segregation of the redundant systems of an accident and prevent it from causing a further chain accident. These shields are designed to withstand the rupture forces from piping and jets.

3.6.2.3.1.2.3 Jet Impingement Shields

Jet impingement shields are also selectively provided as required to limit the consequence of rupture of the piping and are designed to withstand the resultant jet forces.

3.6.2.3.1.2.4 Separation

Independence of redundant safety systems and components is maintained in most cases by separating the redundant components so that no single postulated event can prevent the safety-related function from occurring. This is achieved by the following:

a. physical separation of source and target,

b. routing of cables so that different penetrations and paths are utilized to ensure that one event will not preclude both the primary and backup components from fulfilling their design function,

c. deflection utilized to redirect a jet spray from an essential component,

d. utilization of intermediate components and structure to intercept and defray forces, and

e. location of duplicate instrument lines to ensure that one cause will not preclude each of the redundant systems from fulfilling its design function.

3.6.2.3.1.2.5 Acceptability of Analysis

The postulation of high energy line break locations and the conservative analysis of resulting jet thrust and impingement have been used to identify areas where restraints or other protection devices are required to protect safety-related systems and components.

3.6.2.3.2 Pipe Whip Effects on Safety-Related Components

This section of the FSAR provides the criteria and methods used to evaluate the effects of pipe displacements on safety-related structures, systems and components following a postulated pipe rupture.

The criteria which are used for determining the effects of pipe displacements on components are as follows:

a. Components such as vessel safe ends and valves which are attached to the broken piping system and do not serve a safety function or whose failure would not further escalate the consequences of the accident, are not designed to meet ASME Code Section III imposed limits for essential components under faulted loading.

b. If these components are required for safe shutdown, or serve a safety function to protect the structural integrity of an essential component, limits to meet the Code requirements for faulted conditions and limits to ensure operability, if required, are met.

3.6.2.3.3 Pipe Whip Restraints

3.6.2.3.3.1 Functional Requirements

Pipe whip restraints differentiated from piping supports are designed to control the movement of a postulated ruptured pipe for an extremely low probability gross failure in a piping system carrying high-energy fluid. The piping integrity usually does not depend on the pipe whip restraints during normal, upset, emergency, or faulted conditions as defined in Section III of the ASME Boiler and Pressure Vessel Code. When piping integrity is lost because of a postulated break, the pipe whip restraint acts to limit the movement of the broken pipe to an acceptable distance.

3.6.2.3.3.4 Design Requirements

For reactor recirculation piping, the dynamic analysis for pipe whip restraints is performed using the Pipe Dynamic Analysis (PDA) program as described in Subsection 3.6.2.2.1.2. For other piping, the dynamic analysis for pipe whip restraints is performed using the Pipe Whip Restraint Reaction Analysis (PWRRA) programs. This program provides resultant force-time histories which can then be input into the Response Spectrum Generation (RSG) program to generate dynamic load factors.

The yielding protion of the restraint is designed for the peak dynamic load. The non-yielding portion of the restraint is designed for the equivalent static load.

The functions of PWRRA are explained in detail in Subsection 3.6.2.2.2.2 and Appendix C, Section 25. The description of RSG is presented in Appendix C, Section 16.

3.6.2.3.3.5 Design Limits

Allowable steel stresses for non-yielding members are taken as 1.6 times AISC allowable but not more than 0.95 F_y, where F_y = specified minimum yield stress.

Yielding in tension rods is limited to 50% of the ultimate strain.

Crushable material design is based on energy absorption principles. Deflection is controlled by the design energy. The honeycomb material thickness is designed such that the strain under this deflection is limited to 50% and lies within the horizontal portion of the stress strain curve of the material. This ensures that the honeycomb material will not experience a deflection in excess of that defined by the horizontal portion of the load deflection curve.

3.6.2.4 Guard Pipe Assembly Design Criteria

Details of all guard pipe assemblies are discussed in Subsections 3.8.1 and 3.8.2.

3.6.2.5 Material to be Submitted for the Operating License Review

3.6.2.5.1 Implementation of Criteria for Defining Pipe Break Location and Orientation

3.6.2.5.1.1 Postulated Pipe Breaks in Recirculation Piping System - Inside Containment

The criteria for selection of postulated pipe breaks in the recirculation piping system, inside containment, are provided in Subsection 3.6.2.1.6.1. The postulated pipe break locations and types selected in accordance with these criteria are shown in Figure B3.6-18. Conformance with these criteria is shown by Table B3.6-21.

3.6.2.5.1.2 Pipe Whip Restraints for Recirculation Piping System Inside Containment

The pipe whip restraints provided for this recirculation piping system are also shown in Figure B3.6-18. This system of restraints prevents unrestrained pipe whip resulting from a postulated rupture at any of the identified break locations.

3.6.2.5.1.3 Jet Effects for Postulated Ruptures of Recirculation Piping System - Inside Containment

The effects of jet impingement from breaks in the reactor recirculation piping are detailed in Subsection D3.6.2.4.

3.6.2.5.2 Piping Other Than Reactor Recirculation Piping

The following material pertains to the dynamic analyses applicable to piping systems inside and outside containment with the exception of the reactor recirculation loop piping.

3.6.2.5.2.1 Implementation of Criteria for Defining Pipe Break Locations and Configurations

The locations and number of design-basis breaks associated with whip restraints, including postulated rupture orientations for the high-energy piping systems, are based on the criteria delineated in Subsection 3.6.2.1 and are shown in Attachment B3.6.

3.6.2.5.2.2 Implementation of Criteria Dealing With Special Features

Special protective devices in the form of pipe whip restraints and impingement shields are designed in accordance with Subsection 3.6.2.3.

Pipe whip restraint locations, configurations, and orientations in relation to break locations are included in Attachment B3.6.

Where special protective devices are located in the vicinity of welds requiring augmented inservice inspection, one or both of the following criteria are met:

a. Special protective devices are located at such a distance from all welds so as to allow inservice inspection.

b. Special protective devices are removable so that inservice inspection can be performed.

3.6.2.5.2.3 Acceptability of Analyses Results

The postulation of break locations for high energy piping systems and analyses of the resulting jet thrust, impingement and pipe whip effects have been considered.

Results of pipe whip dynamic effects are included in Attachment B3.6.

3.6.2.5.2.4 Design Adequacy of Systems, Components, and Component Supports

For each of the postulated breaks, the equipment and systems necessary to mitigate the consequences of the break and to safely shut down the plant (i.e., all essential systems and components) are identified in Subsection 3.6.1. The equipment and systems are protected against the consequences of each of the postulated breaks and cracks to ensure that their design-intended functions will not be impaired to unacceptable levels.

Where it is necessary to restrict the motion of a pipe that would result from a postulated break, pipe whip restraints are included in the respective piping systems, or structural barriers or walls are designed to prevent the whipping of the pipe.

Design adequacy of the restraints is included in Attachment B3.6.

The structure and structural barriers are designed to withstand the effects of jet impingement loads. The loading construction and allowable design limits are discussed in Section 3.8.

The evaluation of essential components under dynamic effects associated with jet impingement is presented in Attachment D3.6.

3.6.2.5.2.5 Implementation of Criteria Related to Protective Assembly Design

Guard pipes are discussed in Subsections 3.8.1 and 3.8.2.

3.6.3 References

1. R. T. Lahey, Jr. and F. J. Moody, "Pipe Thrust and Jet Loads," The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, Section 9.2.3, pp. 375-409, Published by American Nuclear Society, Prepared for the Division of Technical Information, United States Energy Research and Development Administration, 1977.

2. ANSI N176 Design Basis for Protection of Nuclear Power Plants Against Effects of Postulated Pipe Rupture, Draft, January 1978.

3. GE Spec. No. 22A2625 - "System Criteria and Applications for Protection Against the Dynamic Effects of Pipe Breaks."

4. RELAP3 - A computer Program for Reactor Blowdown Analysis IN-1321, issued June 1979, Reactor Technology TID-4500.

5. GE Report NEDE-10313 - "PDA - Pipe Dynamic Analysis Program for Pipe Rupture Movement" (Proprietary Filing)

6. Nuclear Services Corporation Report No. GEN-02-02, "Final Report Pipe-Rupture Analysis of Recirculation System for 1969 Standard Plant Design."

7. GE Safety Evaluation Report for the Design of GESSAR-238, NSSS (Docket No. STN50-550), page 3-4.

8. NUREG/CR-2913, SAND 82-1935, R4, "Two-Phase Jet Loads."

9. RELAP4/MOD5, Computer Program User's Manual, 09.8.026-5.5.

10. Pipe Whip Restraint Reaction Analysis User's Manual, 09.5.125-2.1.

TABLE 3.6-2

HIGH-ENERGY FLUID SYSTEMS

SYSTEMS	NOTES
Main Steam (MS)	
Extraction Steam (ES)	(1)
Feedwater (FW)	
Condensate (CD)	(1)
Condensate Booster (CB)	(1)
Control Room HVAC (VC)	(1)
Heater Drains (HD)	(1)
Misc. Vents & Drains (DV)	(1)
Turbine Drains (TD)	(1)
Turbine Gland Steam Seal Steam (GS)	(1)
MSIV Leakage Control (IS)	(1)
Reactor Recirculation (RR)	(2)
Low Pressure Core Spray (LP)	(2)
High Pressure Core Spray (HP)	(2)
Nuclear Boiler (NB)	(2)
Residual Heat Removal (RH)	(2)
Reactor Water Cleanup (RT)	
Standby Liquid Control (SC)	(2)
Reactor Core Isolation Cooling (RI)	
Control Rod Drive (RD)	(2)
Off Gas (OG)	(1)
Radwaste Chemical Waste Process (WF)	(1)
Chemical Radwaste Reprocessing & Disposal (WZ)	(1)
Radwaste Sludge Process (WX)	(1)
Auxiliary Steam (AS)	(1)
Post Accident Sampling (PS)	(2)
Containment Monitoring (CM)	(2)

(1) Not considered an initiating system for piping failure because of complete physical separation from safety related systems, components and structures. (These systems are located in Non-Category I structures where there are no safety related components or systems.)

(2) The only high-energy portions of these systems are those portions which make up the reactor coolant boundary. (See Figure 3.6-1 for exact boundaries.)

These pages have been deleted intentionally.

FIGURE 3.6-4 has been deleted intentionally.

FIGURE 3.6-6 has been deleted intentionally

FIGURES 3.6-9 and 3.6-10 have been deleted intentionally

$$\sigma y = K\ (.002) \quad (3)$$

$$\sigma_u = Kn^n \quad (4)$$

Values of K and n obtained in this way are given in the following tabulation:

	Yield Stress σy(ksi)	Ultimate Stress σu(ksi)	K (ksi)	n
Minimum	31.60	64.40	86.486	0.16201
Mean-Sigma	32.41	67.07	90.277	0.16484
Mean	36.01	71.79	96.080	0.15792

(Material properties in the tabulation, for A106 Grade B at 600° F, are based on data from Reference 2.)

The mean-sigma values of K = 90.277 ksi and n = 0.16484 are used for all temperatures 600° F and below.

ATTACHMENT B3.6

DYNAMIC EFFECTS OF POSTULATED PIPE RUPTURES

Attachment B3.6 presents specific details required in Subsection 3.6.2.5 related to the dynamic effects of each postulated pipe rupture.

The data are presented in the following format:

1. Location of postulated breaks, associated restraints, and orientations are shown in Figures B3.6-1 through B3.6-28.

2. Definitions of breaks, break type, functional restraint, and pipe stress at break locations for comparison to stress criteria are defined in Subsection 3.6.2.1, Tables B3.6-1 through B3.6-18A.

3. Typical results of pipe whip restraint analyses inside containment for high pressure core spray system are identified in Table B3.6-19.

4. Typical results to demonstrate design adequacy of those portions of high-energy piping penetrating containment for which additional stress criteria apply (i.e., within guard pipes) and for which valve operability requirement must be met (i.e., main steam isolation valves) are shown in Table B3.6-20.

TABLE B3.6-1 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
FW-C21A	C	FW-R17	42480	58165	8160	43491	.086
FW-C21A	C	CONT. ANCH.	42480	58165	8160	43491	.086

* Break type: C = circumferential, L = longitudinal.

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TABLE B3.6-1 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
FW-C31	C	FW-R24	42480	60229	16223	40961	.226
FW-C31	C	RPV	42480	60229	16223	40961	.226
FW-C32	C	FW-R17	42480	47075	28735	23042	.211
FW-C32	C	FW-R26	42480	47075	28735	23042	.211
FW-C32	L	FW-R25A	42480	47075	28735	23042	.211
FW-C33	C	FW-R17	42480	60181	47159	14654	.312
FW-C33	C	FW-R26	42480	60181	47159	14654	.312
FW-C33	L	FW-R25A	42480	60181	47159	14654	.312
FW-C33	L	FW-R26	42480	60181	47159	14654	.312

* Break type: C = circumferential, L = longitudinal

TABLE B3.6-1 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	CALCULATED STRESS (psi) EQ.12	CALCULATED STRESS (psi) EQ.13	CUMULATIVE USAGE FACTOR
FW-C34	C	FW-R25A	42480	69546	56638	13573	.435
FW-C34	C	FW-R27A	42480	69546	56638	13573	.435
FW-C34	L	FW-R26	42480	69546	56638	13573	.435
FW-C34	L	FW-R27	42480	69546	56638	13573	.435

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-1 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
FW-C40	C	FW-R30	42480	53350	19268	36243	.21
FW-C40	C	RPV	42480	53350	19268	36243	.21

*Break type: C = circumferential, L = longitudinal.

TABLE B3.6-2

BREAK DATA, LOOP 2 FEEDWATER

PIPING INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
FW-C1	C	FW-R2	42480	58165	8160	43491	.086
FW-C1	C	CONT. ANCH.	42480	58165	8160	43491	.086

* Break type; C = circumferential, L = longitudinal

TABLE B3.6-2 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
FW-C11	C	FW-R9	42480	60229	16223	40961	.226
FW-C11	C	RPV	42480	60229	16223	40961	.226

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-2 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
FW-C12	C	FW-R2	42480	47075	28735	23042	.211
FW-C12	C	FW-R11	42480	47075	28735	23042	.211
FW-C12	L	FW-R10A	42480	47075	28735	23042	.211
FW-C13	C	FW-R2	42480	60181	47159	14654	.312
FW-C13	C	FW-R11	42480	60181	47159	14654	.312
FW-C13	L	FW-R10A	42480	60181	47159	14654	.312
FW-C13	L	FW-R11	42480	60181	47159	14654	.312
FW-C14	C	FW-R10A	42480	69546	56638	13573	.435
FW-C14	C	FW-R12A	42480	69546	56638	13573	435
FW-C14	L	FW-R11	42480	69546	56638	13573	.435

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-2 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
FW-C20	C	FW-R15	42480	53350	19268	36243	.21
FW-C20	C	RPV	42480	53350	19268	36243	.21

* Break type: C = circumferential, L = longitudinal.

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TABLE B3.6-3

BREAK DATA, FEEDWATER SYSTEM

PIPING OUTSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$0.8(1.2S_h + S_A)$	STRESS (psi) (EQ.9(B) & EQ.10)
3	C	CONT. ANCH.	32,400	8360
4	L	C	32,400	8360
4	L	B	32,400	8360
4	L	A	32,400	8360
4	L	E	32,400	8360
5	C	C	32,400	8130
5	C	B	32,400	8130
5	C	A	32,400	8130
6	C	C	32,400	7117
6	C	B	32,400	7117
6	C	A	32,400	7117
7	L	C	32,400	7117
7	L	B	32,400	7117
7	L	A	32,400	7117
8	C	E	32,400	6999
9	C	E	32,400	7863
A3	C	CONT. ANCH.	32,400	8612
A4	L	H	32,400	8612
A4	L	G	32,400	8612
A4	L	F	32,400	8612
A4	L	J	32,400	8612
A5	C	H	32,400	8143
A5	C	G	32,400	8143
A5	C	F	32,400	8143

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-3 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$0.8(1.2S_h + S_A)$	STRESS (psi) (EQ.9(B) & EQ.10)
A6	C	H	32,400	7511
A6	C	G	32,400	7511
A6	C	F	32,400	7511
A7	L	H	32,400	7511
A7	L	G	32,400	7511
A7	L	F	32,400	7511
A8	C	J	32,400	7141
A9	C	J	32,400	7513

* Break type: C = circumferential, L = longitudinal

TABLE B3.6-4

BREAK DATA, HPCS PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4S_m (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
HP-C6	C	HP-R3	42480	46514	8285	32280	.013
HP-C6	C	HP-R4	42480	46514	8285	32280	.013

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-4 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4Sm (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
HP-C6	C	RPV	42480	46514	8285	32280	.013
HP-C8	C	HP-R4A	42480	56874	18825	37592	.009
HP-C8	C	HP-R3	42480	56874	18825	37592	.009
HP-C8	C	RPV	42480	56874	18825	37592	.009
HP-C9	C	HP-R5	42480	42927	155	31919	.027
HP-C9	C	RPV	42480	42927	155	31919	.027

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-5

BREAK DATA, LPCS PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
LP-C1A	C	LP-R1	42480	47658	7468	34976	.031
LP-C1A	C	LP-R2A	42480	47658	7468	34976	.031

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-3 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
LP-C8	C	LP-R4A	42480	56241	29187	35849	.006
LP-C8	C	LP-R3	42480	56241	29187	35849	.006
LP-C8	C	RPV	42480	56241	29187	35849	.006
LP-C9A	C	RPV	42480	50326	5127	36974	.011
LP-C9A	C	LP-R5	42480	50326	5127	36974	.011

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-6

BREAK DATA, LOOP 1 MAIN STEAM

PIPING INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C57	C	MS-R24, MS-R25, MS-R26. MS-R27	42480	49368	25416	19583	.0068
MS-C57	C	CONT. ANCH.	42480	49368	25416	19583	.0068
MS-C58	C	MS-R23	42480	49368	25416	19583	.0068
MS-C58	C	MS-R27, MS-R26	42480	49368	25416	19583	.0068

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-6 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C68	C	RPV	42480	59265	42233	18423	.0175
MS-C68	C	MS-R26	42480	59265	42233	18423	.0175
MS-C68	L	MS-R28, RPV	42480	67675	49264	18661	.0423
MS-C69	C	MS-R28	42480	27465	13562	15348	.0009
MS-C69	C	RPV	42480	27465	13562	15348	.0009

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-7

BREAK DATA, LOOP 2 MAIN STEAM

PIPING INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4Sm (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C21	C	MS-R10, MS-R11, MS-R12, MS-R13	42480	37886	6653	21515	.059
MS-C21	C	CONT. ANCH.	42480	37886	6653	21515	.059

* Break type: C = circumferential, L = longitudinal.

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TABLE B3.6-7 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C33	C	RPV	42480	57236	40815	28313	.0146
MS-C33	C	MS-R12	42480	57236	40815	28313	.0146
MS-C33	L	MS-R14, RPV	42480	64551	47389	23406	.0306
MS-C34	C	MS-R14	42480	26550	13034	17022	.0008
MS-C34	C	RPV	42480	26550	13034	17022	.0008

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-8

BREAK DATA, LOOP 3 MAIN STEAM

PIPING INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4Sm (psi)	CALCULATED STRESS (psi) EQ.10	CALCULATED STRESS (psi) EQ.12	CALCULATED STRESS (psi) EQ.13	CUMULATIVE USAGE FACTOR
MS-C35	C	MS-R16, MS-R18, MS-R20	42480	39029	6912	18643	.064
MS-C35	C	CONT. ANCH.	42480	39029	6912	18643	.064

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-8 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C55	C	MS-R19, Shield Wall	42480	53660	36569	19269	.0104
MS-C55	C	RPV	42480	53660	36569	19269	.0104
MS-C56	C	MS-R22	42480	25536	11785	16495	.0006
MS-C56	C	RPV	42480	25536	11785	16495	.0006

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-9

BREAK DATA, LOOP 4 MAIN STEAM

PIPING INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C1	C	MS-R2, MS-R4, MS-R6	42480	39029	6912	18643	.064
MS-C1	C	CONT. ANCH.	42480	39029	6912	18643	.064

*Break type: C = circumferential, L = longitudinal.

TABLE B3.6-9 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C19	C	MS-R5, Shield Wall	42480	53660	36569	19269	.0104
MS-C19	C	RPV	42480	53660	36569	19269	.0104
MS-C20	C	MS-R8	42480	25536	11785	16495	.0006
MS-C20	C	RPV	42480	25536	11785	16495	.0006

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-10

BREAK DATA, MAIN STEAM DRAIN LINE INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT**	2.4S_m (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
MS-C69	C		42480	69072	6139	42259	.248
MS-C74	C		42480	64445	8389	38309	.077
MS-C78	C		42480	62130	11305	38313	.317

* Break type: C = circumferential.

** Pipe breaks cause no impact on essential components; restraints are for protection of containment isolation valves. (See Figure B3.6-10 for break and restraint locations.)

TABLE B3.6-10 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT**	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	CALCULATED STRESS (psi) EQ.12	CALCULATED STRESS (psi) EQ.13	CUMULATIVE USAGE FACTOR
MS-C87	C		42480	60779	19271	38542	.335
MS-C93	C		42480	39658	—	—	.130
MS-C94	C		42480	61721	24334	38615	.409

* Break type: C = circumferential.

** Pipe breaks cause no impact on essential components; restraints are for protection of containment isolation valves. (See Figure B3.6-10 for break and restraint locations.)

TABLE B3.6-11

BREAK DATA, MAIN STEAM DRAIN

LINE OUTSIDE CONTAINMENT

BREAK** NUMBER	TYPE*	RESTRAINT	$0.8(1.2S_h + S_A)$	CALCULATED STRESS
1	C	290	Not Applicable	Not Applicable
1	C	520	Not Applicable	Not Applicable
2	C	225	Not Applicable	Not Applicable
2	C	240B	Not Applicable	Not Applicable
2	C	290	Not Applicabl	Not Applicable

* Break type: C = circumferential.

** Breaks were not postulated by stress level, but selected for the worst loading cases on the containment isolation valve.

TABLE B3.6-12

BREAK DATA, MAIN STEAM PIPING

OUTSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$0.8(1.2S_h + S_a)$	STRESS (psi) (EQ.9(B) & EQ.10)
3L	L	N	32,400	20788
3L	L	T	32,400	20788
3L	L	M	32,400	20788
3L	L	P	32,400	20788
4C	C	N	32,400	20788
4C	C	T	32,400	20788
4C	C	M	32,400	20788
5L	L	N	32,400	20760
5L	L	T	32,400	20760
5L	L	M	32,400	20760
6C	C	N	32,400	20760
6C	C	T	32,400	20760
6C	C	M	32,400	20760
6C	C	P	32,400	20760
9L	L	J	32,400	17138
9L	L	S	32,400	17138
9L	L	I	32,400	17138
9L	L	L	32,400	17138
10C	C	J	32,400	17138
10C	C	S	32,400	17138
10C	C	I	32,400	17138
11L	L	J	32,400	17049
11L	L	S	32,400	17049
11L	L	I	32,400	17049
12C	C	J	32,400	17049
12C	C	S	32,400	17049
12C	C	I	32,400	17049
12C	C	L	32,400	17049

* Break type: C = circumferential, L = longitudinal.

TABLE B3:6-12 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$0.8(1.2S_h + S_A)$	STRESS (psi) (EQ.9(B) & EQ.10)
A3L	L	F	32,400	18441
A3L	L	R	32,400	18441
A3L	L	E	32,400	18441
A3L	L	H	32,400	18441
A4C	C	F	32,400	18441
A4C	C	R	32,400	18441
A4C	C	E	32,400	18441
A5L	L	F	32,400	18429
A5L	L	R	32,400	18429
A5L	L	E	32,400	18429
A6C	C	F	32,400	18429
A6C	C	R	32,400	18429
A6C	C	E	32,400	18429
A6C	C	H	32,400	18429
A9L	L	B	32,400	17414
A9L	L	Q	32,400	17414
A9L	L	A	32,400	17414
A9L	L	D	32,400	17414
A10C	C	B	32,400	17414
A10C	C	Q	32,400	17414
A10C	C	A	32,400	17414
A11L	L	B	32,400	16995
A11L	L	Q	32,400	16995
A11L	L	A	32,400	16995
A12C	C	B	32,400	16995
A12C	C	Q	32,400	16995
A12C	C	A	32,400	16995
A12C	C	D	32,400	16995

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-13

BREAK DATA, LOOP 1 RHR PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RH-C1	C	RH-R2	42480	43906	1594	34807	.004

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-13 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4S_m (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RH-C8	C	RH-R3	42480	43192	20255	23705	.008
RH-C8	C	RPV	42480	43192	20255	23705	.008
RH-C9	C	RH-R5	42480	59810	37624	36077	.037
RH-C10	C	RH-R5	42480	54368	11160	38757	.051

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-14

BREAK DATA, LOOP 2 RHR PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RH-C20	C	RH-R10	44280	55991	12968	36823	.012
RH-R21	C	RH-R9	44280	55987	14303	36554	.012
RH-R21	C	RPV	4428C	55987	14303	36554	.012
RH-C25	C	RH-R11	48000	75354	37104	45409	.050
RH-C25	C	RPV	48000	75354	37104	45409	.050
RH-C26	C	RH-R11	44280	63668	15276	42726	.069

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-15

BREAK DATA, LOOP 3 RHR PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RH-C15	C	RPV	42480	40211	—	—	.C05
RH-C17	C	RH-R8	42480	76914	42803	39573	.075
RH-C17	C	RPV	42480	76914	42803	39573	.075
RH-C18	C	RH-R8	42480	56931	19408	40157	.047

TABLE B3.6-16

BREAK DATA, LOOP 4 RHR PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RH-C32	C	20" RR LINE	42480	50302	3267	39229	.092
RH-C35	C	RH-R14	45780	66214	30127	31654	.664
RH-C35	C	RH-R14A	45780	66214	30127	31654	.664

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-17

BREAK DATA, RCIC PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4Sm (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RI-C5	C	RI-R1	42240	65005	13171	41286	.072
RI-C5	C	RI-R2	42240	65005	13171	41286	.072
RI-C5	C	RI-R5	42240	65005	13171	41286	.072
RI-C6	C	RI-R4	42240	55994	10208	37208	.032
RI-C6	C	RI-R8	42240	55994	10208	37208	.032
RI-C5A	C	RI-R1	42240	55621	22692	34697	.019
RI-C5A	C	RI-R2	42240	55621	22692	34697	.019
RI-C5A	C	RI-R5	42240	55621	22692	34697	.019

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-17 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4Sm (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RI-C11	C	RI-R7	42240	67620	10089	48211	.181
RI-C11	C	RI-R8	42240	67620	10089	48211	.181
RI-C11	C	RI-R9	42240	67620	10089	48211	.181
RI-C11	C	RI-R10	42240	67620	10089	48211	.131

TABLE B3.6-18

BREAK DATA, RWCU PIPING

INSIDE CONTAINMENT

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RT-C1	C	CONT. PENE.	42480	(Terminal End Break)			
RT-C1	C	RT-R2	42480				
RT-C5	C	RT-R1	41520				
RT-C5	C	RT-R5	41520				
RT-C5	L	RT-R4	41520				
RT-C6	C	RT-R4	41520				
RT-C6	C	RT-R7	41520				
RT-C6	L	RT-R5	41520				
RT-C7	C	RT-R4	41520				
RT-C7	C	RT-R7	41520				
RT-C7	L	RT-R6	41520				
RT-C8	C	RT-R6	41520				
RT-C8	C	RT-R9	41520				
RT-C8	L	RT-R7	41520				

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-18 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RT-C27A	C	20" RR LINE	32940	62280	10729	33733	.179
RT-C27A	C	NONE**	32940	62280	10729	33733	.179
RT-C27A	L	20" RR LINE	32940	62280	10729	33733	.179
RT-C28	C	NONE**	32940	64601	38102	29528	.133
RT-C28	C	20" RR LINE	32940	64601	38102	29528	.133
RT-C28	L	20" RR LINE	32940	64601	38102	29528	.133

* Break type: C = circumferential, L = longitudinal.

** No impact on essential components.

TABLE B3.6-18 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RT-C28B	C	NONE**	32940	40816	16881	24234	0
RT-C28C	C	NONE**	32940	60217	38092	23971	.076
RT-C28C	L	NONE**	32940	60217	38092	23971	.076

*Break type: C = circumferential, L = longitudinal.

**No impact on essential components.

TABLE B3.6-18 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RT-C35A	C	NONE**	32940	33331	12939	20639	.000
RT-C35A	C	20" RR LINE	32940	33331	12939	20639	.000
RT-C35BB	C	NONE**	32940	50341	33449	23710	.005
RT-C35BB	C	NONE**	32940	50341	33449	23710	.005
RT-C39	C	NONE**	42480	65309	5291	40672	.372

* Break type: C = circumferential, L = longitudinal.

** No impact on essential components

TABLE B3.6-18 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	CALCULATED STRESS (psi) EQ.12	CALCULATED STRESS (psi) EQ. 13	CUMULATIVE USAGE FACTOR
RT-C40	C	NONE**	42480	42474	-	-	.172
RT-C40A	C	NONE**	42480	42818	7	30864	.116

* Break type: C = circumferential, L = longitudinal.

** No impact on essential components.

TABLE B3.6-18 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	$2.4S_m$ (psi)	CALCULATED STRESS (psi) EQ.10	EQ.12	EQ.13	CUMULATIVE USAGE FACTOR
RT-C58	C	NONE**	42480	44186	13376	30227	.133
RT-C58	L	NONE**	42480	44186	13376	30227	.133

* Break type: C = circumferential, L = longitudinal.

** No impact on essential components.

TABLE B3.6-18 (Cont'd)

BREAK NUMBER	BREAK TYPE*	RESTRAINT	2.4Sm (psi)	CALCULATED STRESS (psi) EQ.10 EQ.12 EQ.13	CUMULATIVE USAGE FACTOR
RT-C79	C	NONE**		(Terminal End Break)	

* Break type: C = circumferential, L = longitudinal.

** No impact on essential components.

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TABLE B3.6-18A

BREAK DATA, RWCU PIPING OUTSIDE CONTAINMENT

BREAK				
NUMBER	TYPE*	RESTRAINT	ALLOWABLE (psi) $0.8\ (1.2S_h + S_A)$	CALCULATED STRESS (psi) (EQ. 9B and EQ. 10)
RT-601	C	-	32400	17003
RT-602	C	-	32400	15688
RT-603	C	-	32400	1961
RT-604	C	-	32400	2531
RT-605	C	-	32400	2851

* Break type: C = circumferential, L = longitudinal.

TABLE B3.6-19

RESULTS OF WHIP RESTRAINT ANALYSES FOR HIGH PRESSURE CORE SPRAY INSIDE CONTAINMENT

PIPING SYSTEM

POSTULATED BREAK ID	RESTRAINT ID	F_{imp} (kips)	T_{imp} (10^{-3} sec.)	F_{FINAL} (kips)	GAP (inches)	TIP DISPLACEMENT (inches)	RESTRAINT INFORMATION* ACTUAL DEFLECTION (inches)	PEAK DYNAMIC LOAD (kips	ALLOWABLE DEFLECTION (inches)
HIGH-PRESSURE CORE SPRAY									
HP-C6:C	HP-R3	71.54	0.0003	0.0	10.12	19.32	3.539	268.51	5.810
HP-C6:C	HP-R4	-	-	48.42	2.01	4.44	1.176	128.3	2.00
HP-C8:C	HP-R4A	41.03	0.0023	0.0	7.53	9.947	1.403	216.0	2.00
HP-C9:C	HP-R5	-	-	100.95	7.297	18.132	4.65	281.9	6.292
HP-C8:C	HP-R3	58.59	.003	0.0	10.12	19.32	3.539	268.51	5.810

*Restraint information is based on current analysis.

TABLE B3.6-20

RESULTS OF CONTAINMENT PENETRATION PIPING ANALYSES

FOR FEEDWATER INSIDE CONTAINMENT

BREAK NUMBERS	RESTRAINT NUMBER (GUIDE)	PEAK RESTRAINT REACTION (kips)	STRESS (psi)	
			MAXIMUM PIPE STRESS IN CONTAINMENT PENETRATION AREA	ALLOWABLE
FWC22L & FWC32L	FWR16	270	23845	44381
	FWR16A	462		

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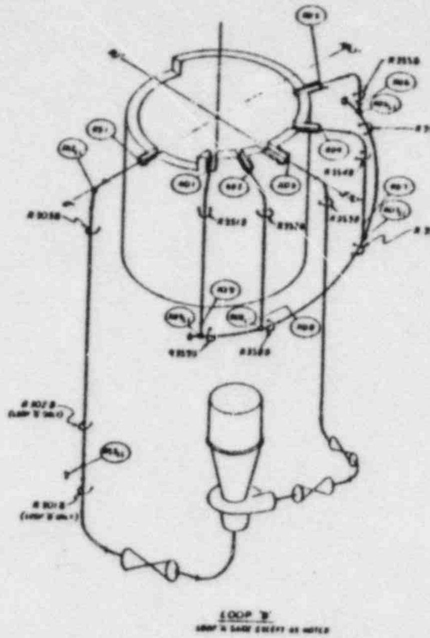

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SUBSCRIPT 'LL' INDICATES LONGITUDAL BREAK

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FIGURE B3.6-18

LOCATION OF POSTULATED BREAKS AND
ASSOCIATED RESTRAINTS
REACTOR RECIRCULATION PIPING SYSTEM

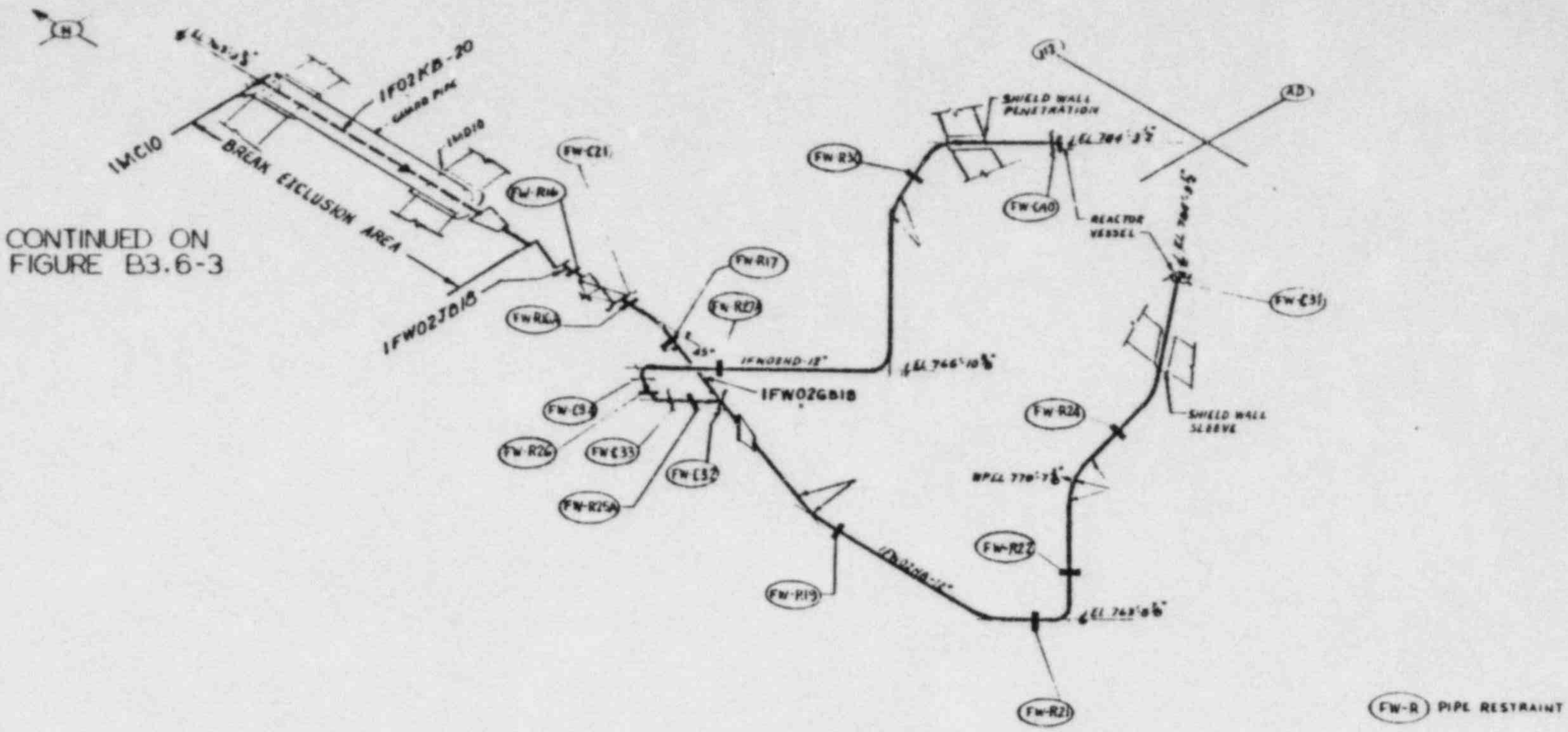
TABLE B3.6-21

BREAK DATA, REACTOR

RECIRCULATION PIPING SYSTEM*

BREAK IDENT.	STRESS RATIO PER ASME EQNS. EQ(10) $\frac{S_n}{3S_m}$	EQ(12) $\frac{S_o}{3S_m}$	EQ(13) $\frac{S}{3S}$	USAGE FACTOR	BREAK TYPE	BREAK BASES SECTION NO.
RS1	0.72	0.23	0.65	0.0	CIRCMF	3.6.2.1.6.1.a
$RS3_{LL}^{**}$	1.31	0.80	0.53	0.27	LONG	3.6.2.1.6.1.b
RD1	0.56	0.12	0.54	0.0	CIRCMF	3.6.2.1.6.1.a
RD2	0.80	0.34	0.51	0.0	CIRCMF	3.6.2.1.6.1.a
RD3	0.73	0.22	0.54	0.0	CIRCMF	3.6.2.1.6.1.a
RD4	0.67	0.19	0.50	0.0	CIRCMF	3.6.2.1.6.1.a
RD5	0.77	0.32	0.39	0.0	CIRCMF	3.6.2.1.6.1.a
RD6	0.50	0.14	0.36	0.0	CIRCMF	3.6.2.1.6.1.c
RD7	0.47	0.11	0.36	0.0	CIRCMF	3.6.2.1.6.1.c
RD8	0.38	0.04	0.36	0.0	CIRCMF	3.6.2.1.7.1.c
RD9	0.40	0.05	0.36	0.0	CIRCMF	3.6.2.1.6.1.c

* Loop A same as Loop B except as noted.
** Loop B only. Subscript "LL" indicates longitudinal break.



CONTINUED ON FIGURE B3.6-3

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FIGURE B3.6-1

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS FEEDWATER PIPING INSIDE CONTAINMENT LOOP-1

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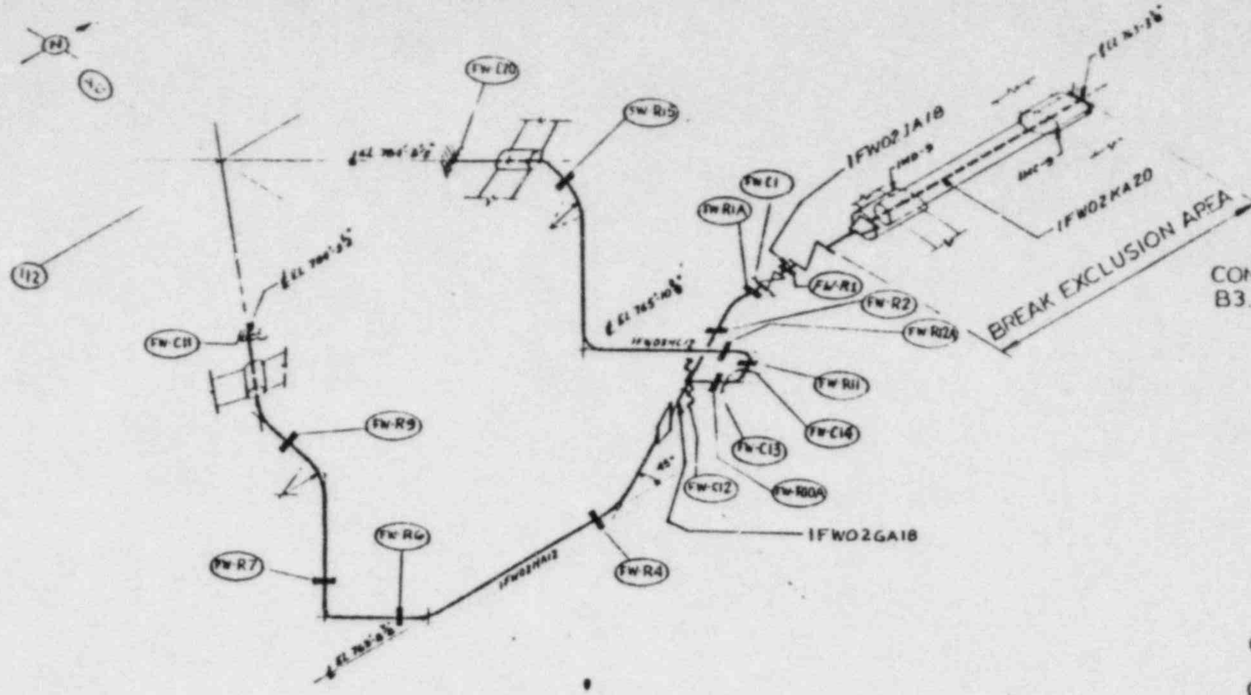

CONTINUED ON FIGURE B3.6-3

FW-R PIPE RESTRAINT

FW-C PIPE BREAK

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FIGURE B3.6-2

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS FEEDWATER PIPING INSIDE CONTAINMENT LOOP-2

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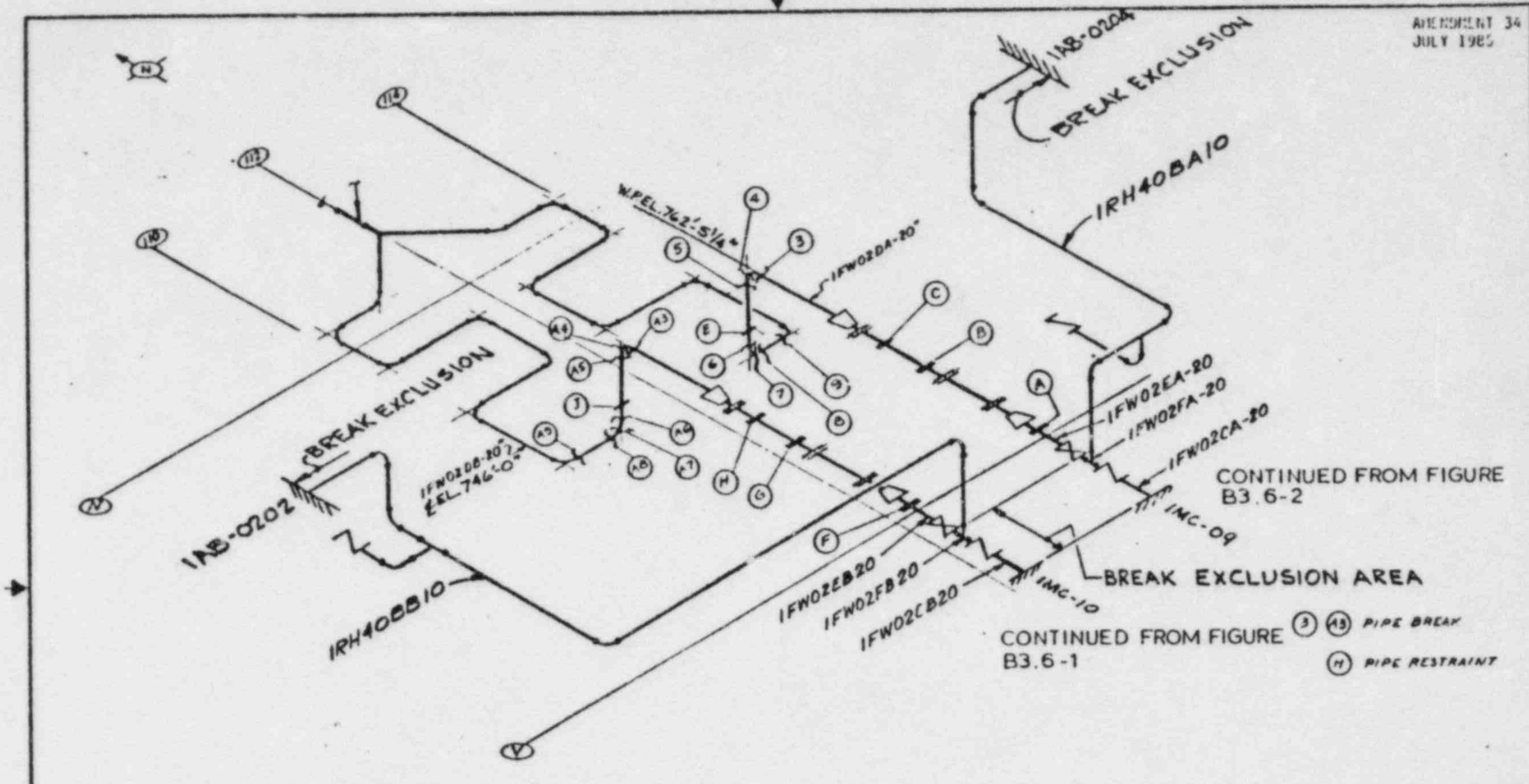

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FIGURE B3.6-3

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS FEEDWATER PIPING OUTSIDE CONTAINMENT

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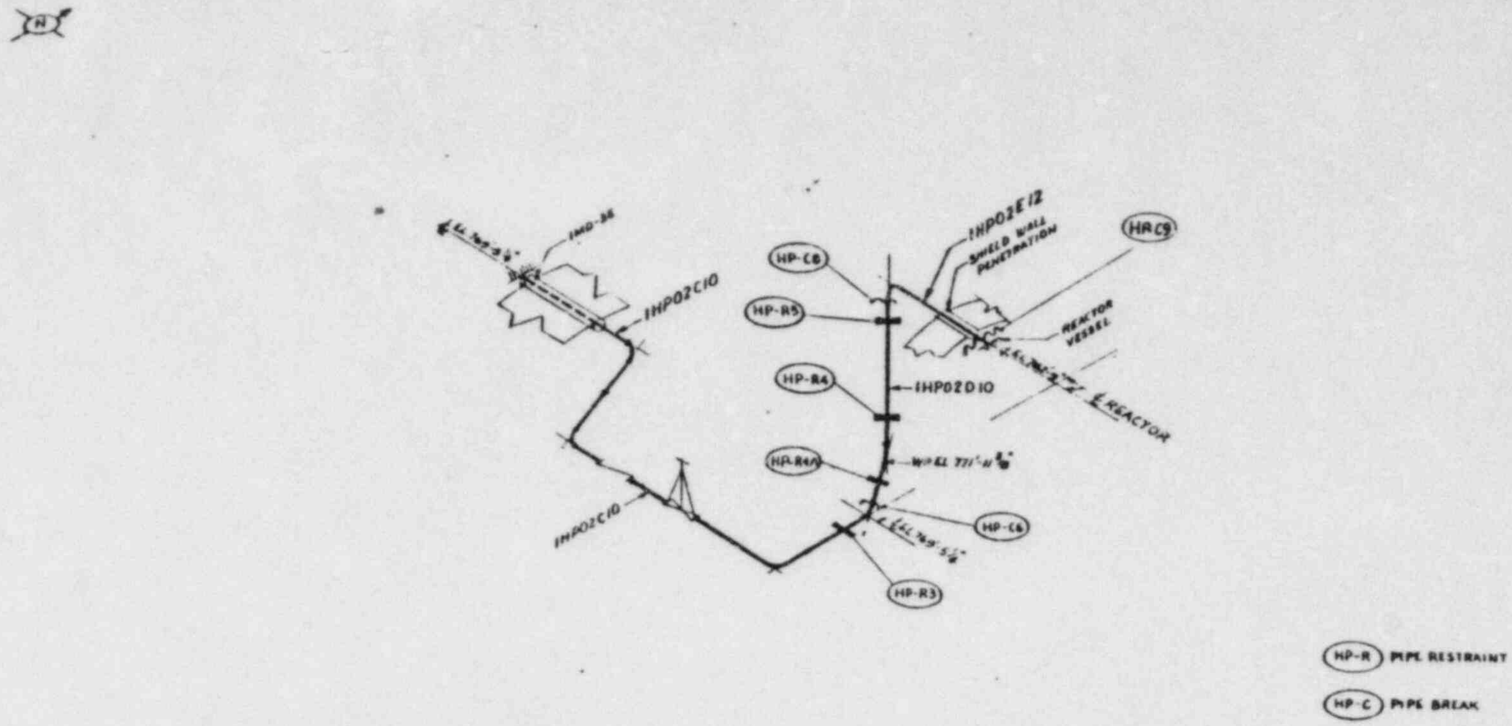

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FIGURE B3.6-4

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS HIGH PRESSURE CORE SPRAY PIPING INSIDE CONTAINMENT

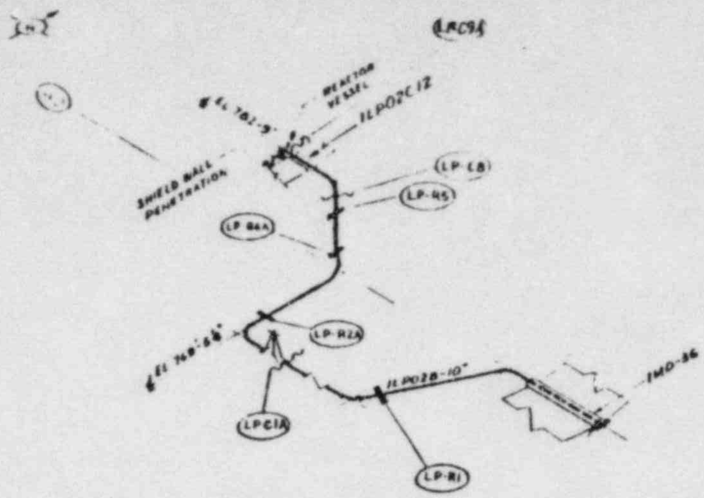

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FIGURE B3.6-5

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS LOW PRESSURE CORE SPRAY PIPING INSIDE CONTAINMENT

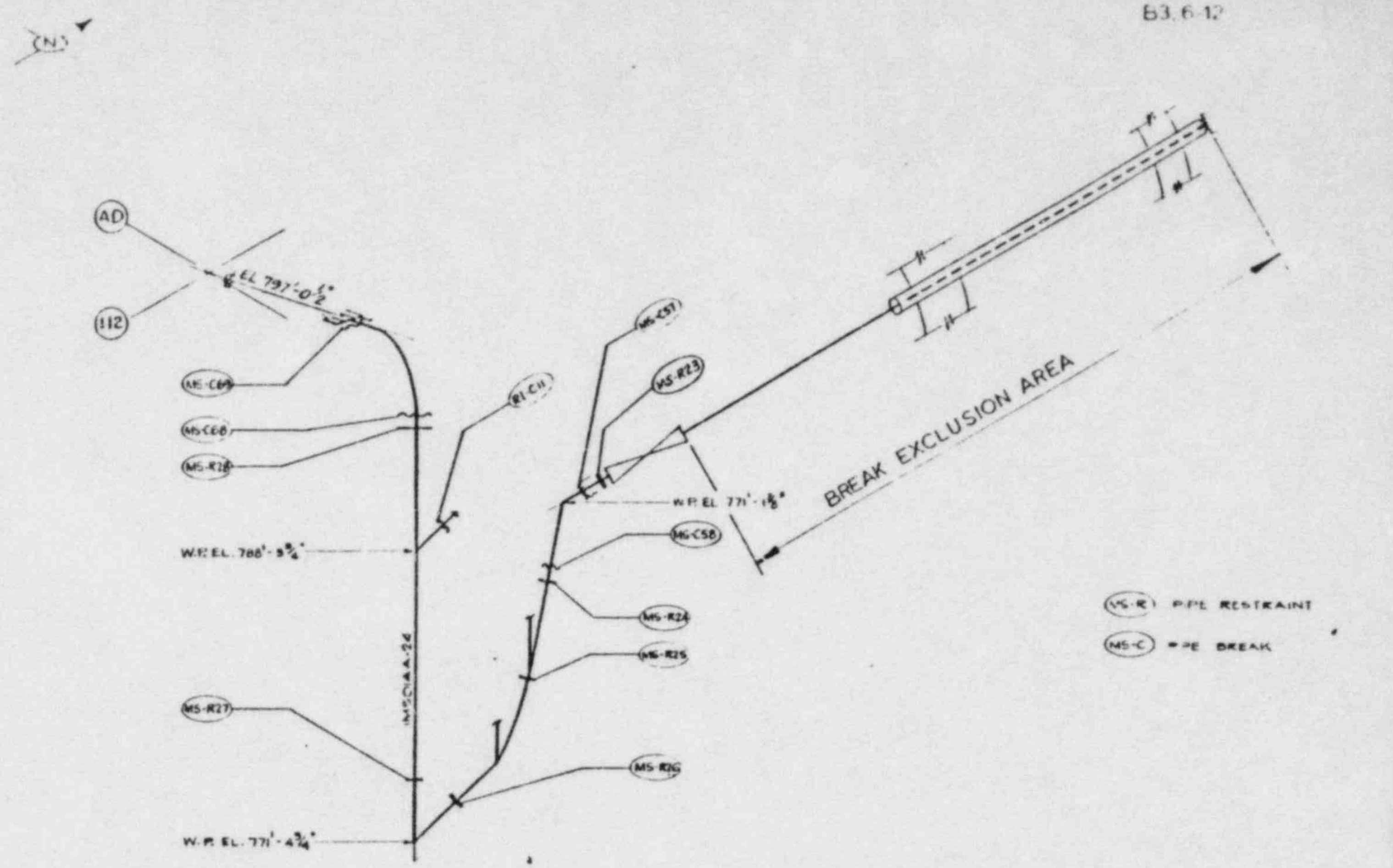

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FIGURE B3.6-6

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS MAIN STEAM PIPING INSIDE CONTAINMENT LOOP-1

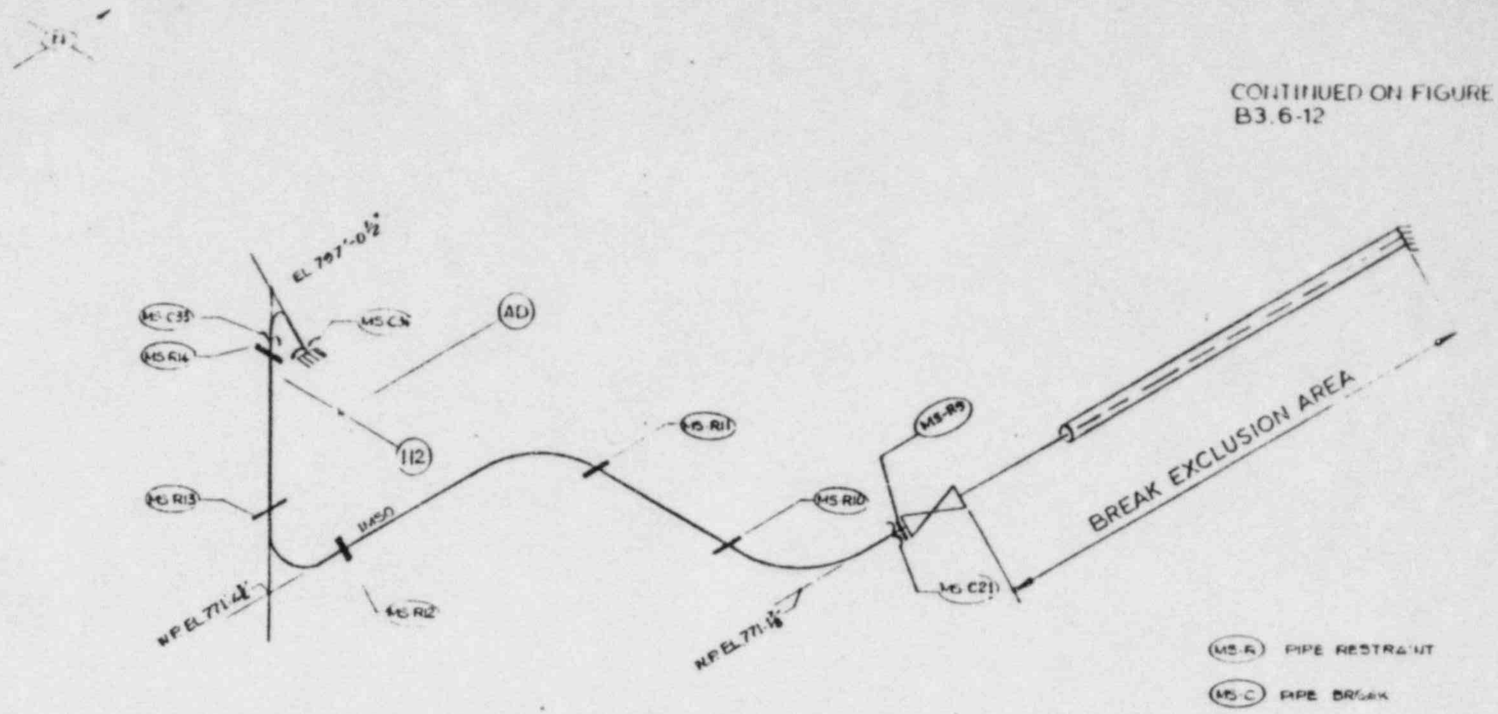

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FIGURE B3.6-7

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS MAIN STEAM PIPING INSIDE CONTAINMENT LOOP-2

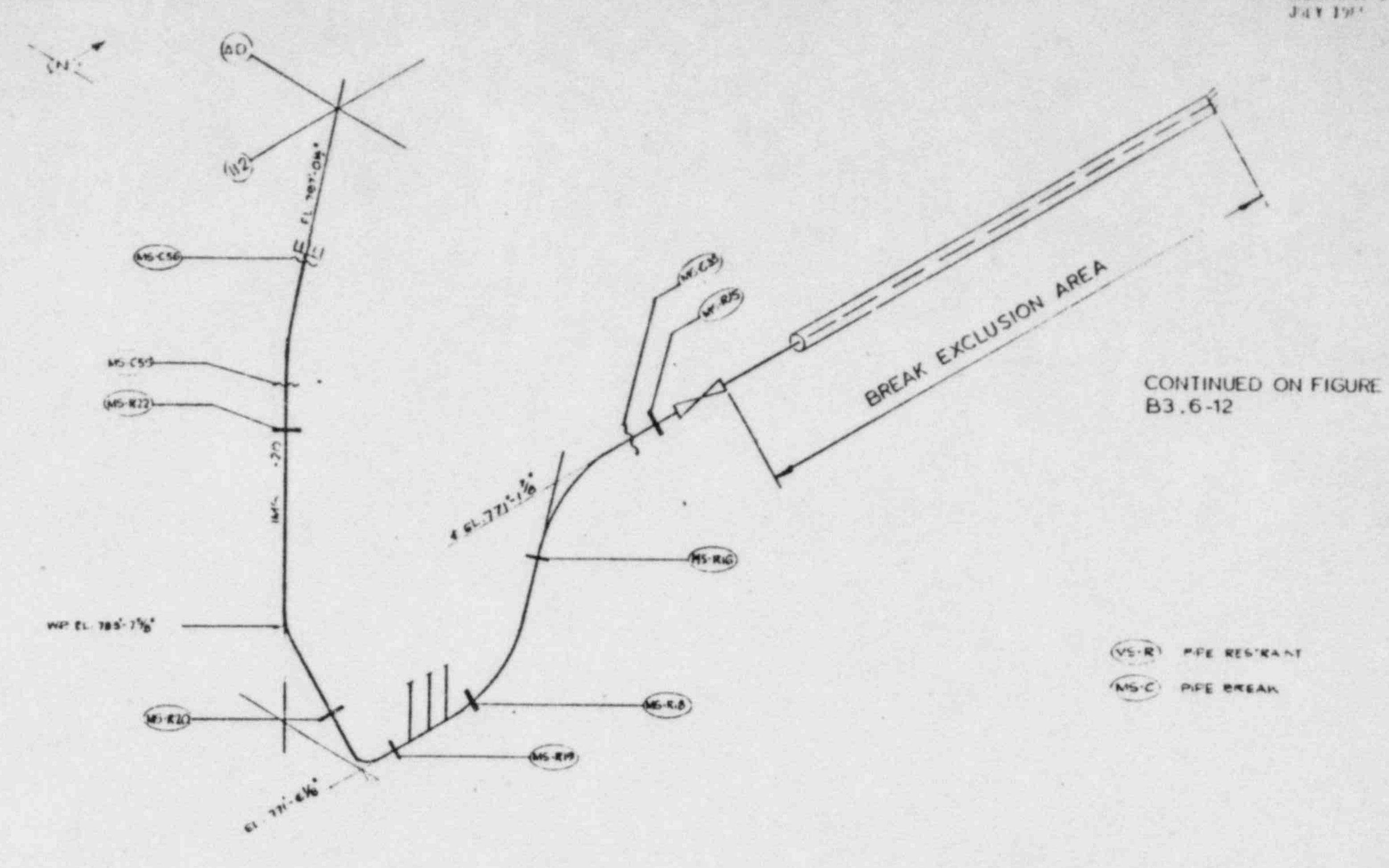

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FIGURE B3.6-8

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS MAIN STEAM PIPING INSIDE CONTAINMENT LOOP-3

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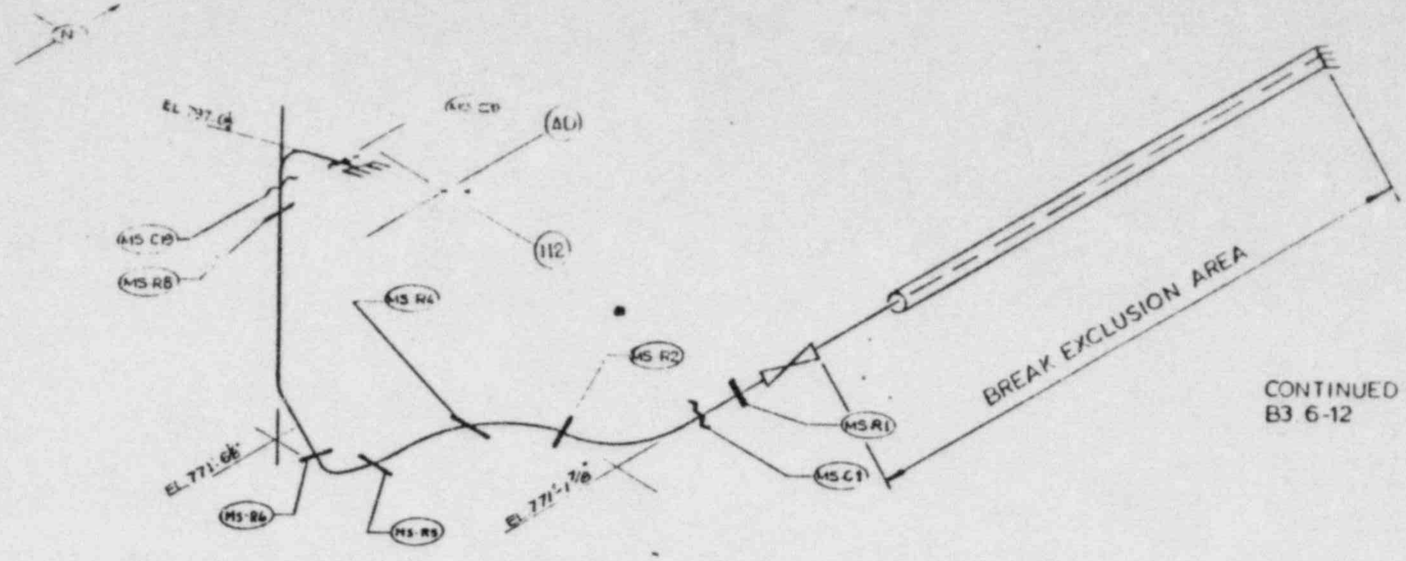

CONTINUED ON FIGURE B3.6-12

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FIGURE B3.6-9

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS MAIN STEAM PIPING INSIDE CONTAINMENT LOOP-4

CONTINUED ON FIGURE
B3.6-11

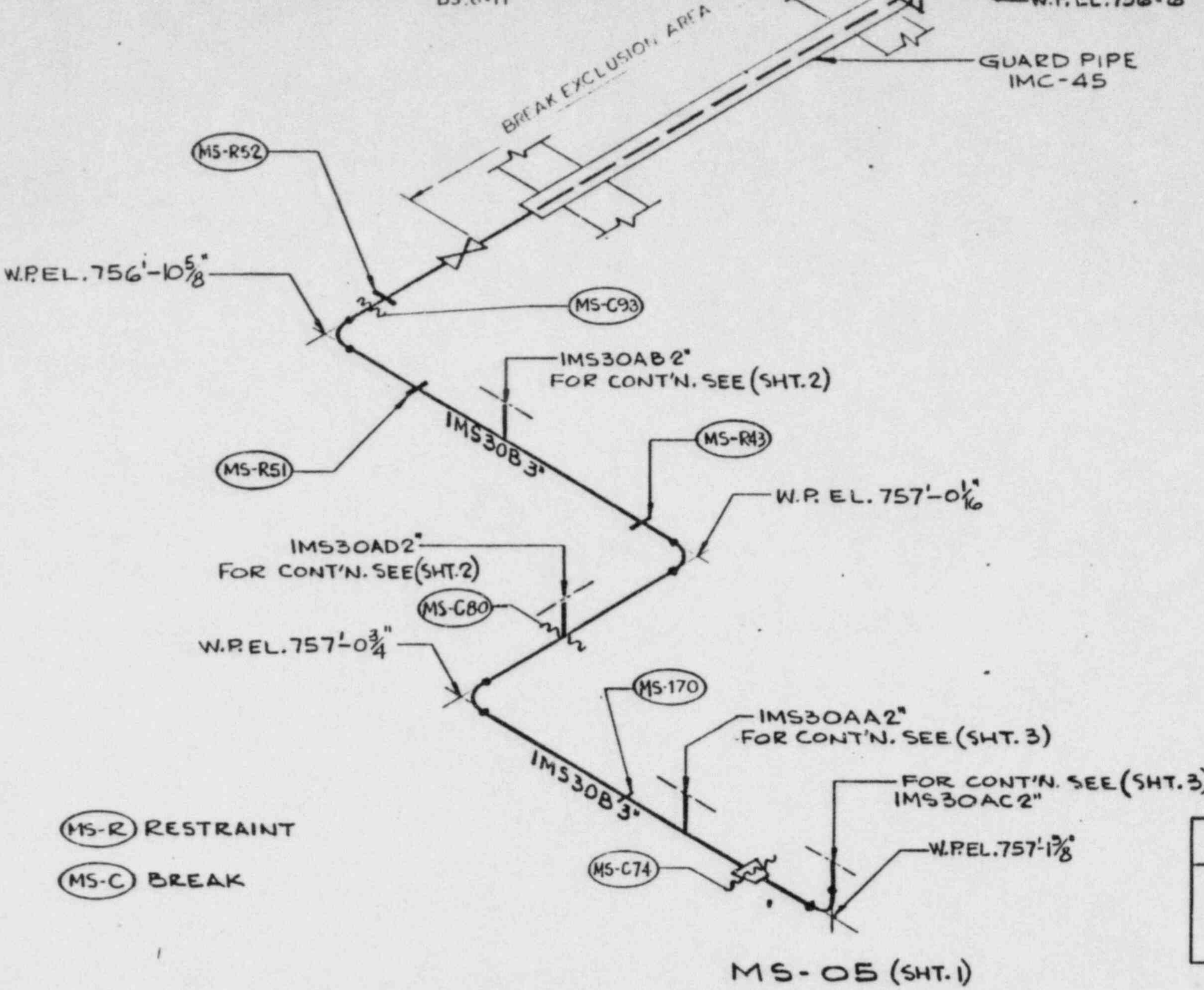

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FIGURE B3.6-10

LOCATION OF POSTULATED BREAKS AND
ASSOCIATED RESTRAINTS MAIN
STEAM DRAIN LINE INSIDE CONTAINMENT
(SHEET 1 OF 2)

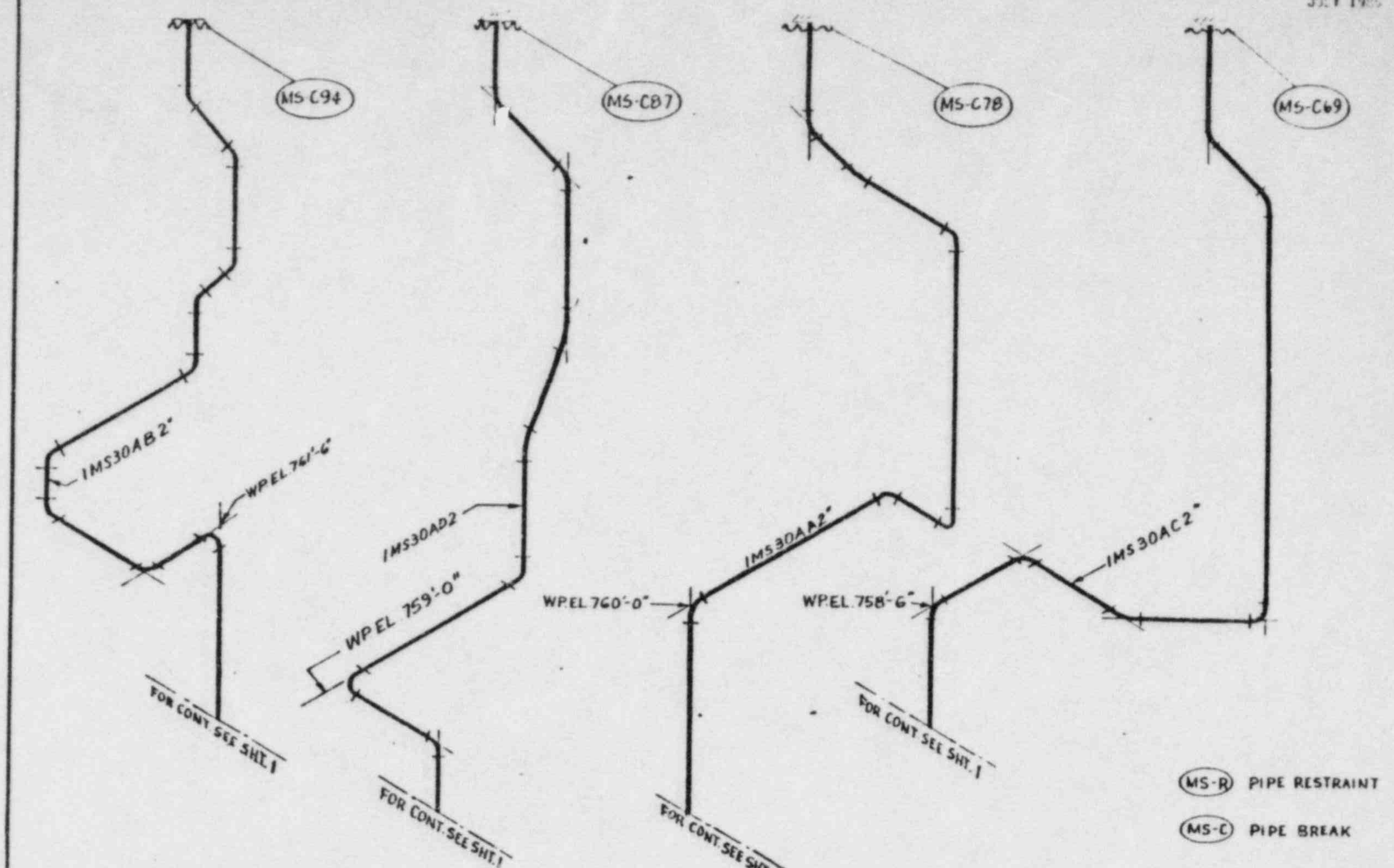

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FIGURE B3.6-10

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS MAIN STEAM DRAIN LINE INSIDE CONTAINMENT (SHEET 2 OF 2)

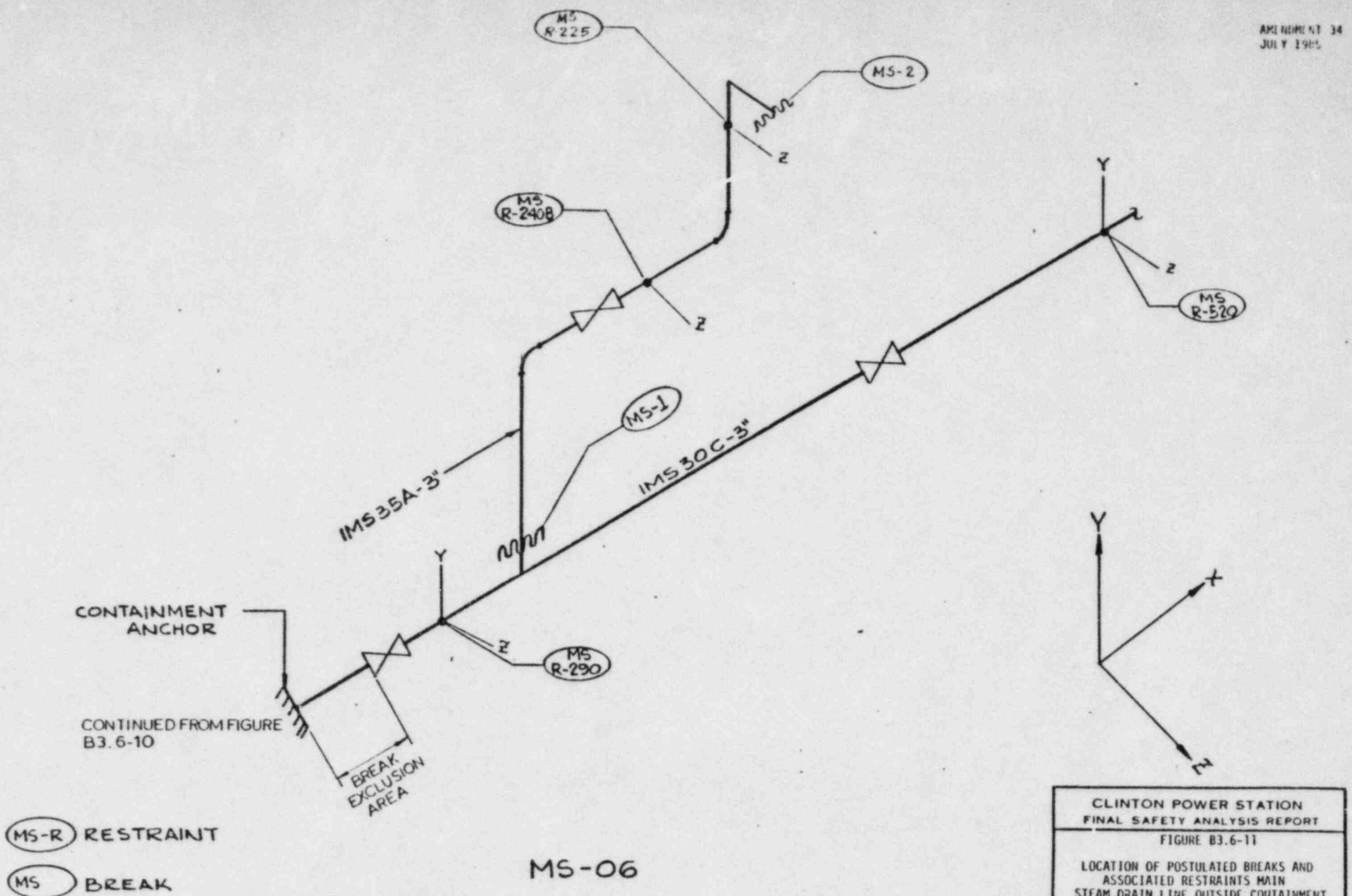

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FIGURE B3.6-11

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS MAIN STEAM DRAIN LINE OUTSIDE CONTAINMENT

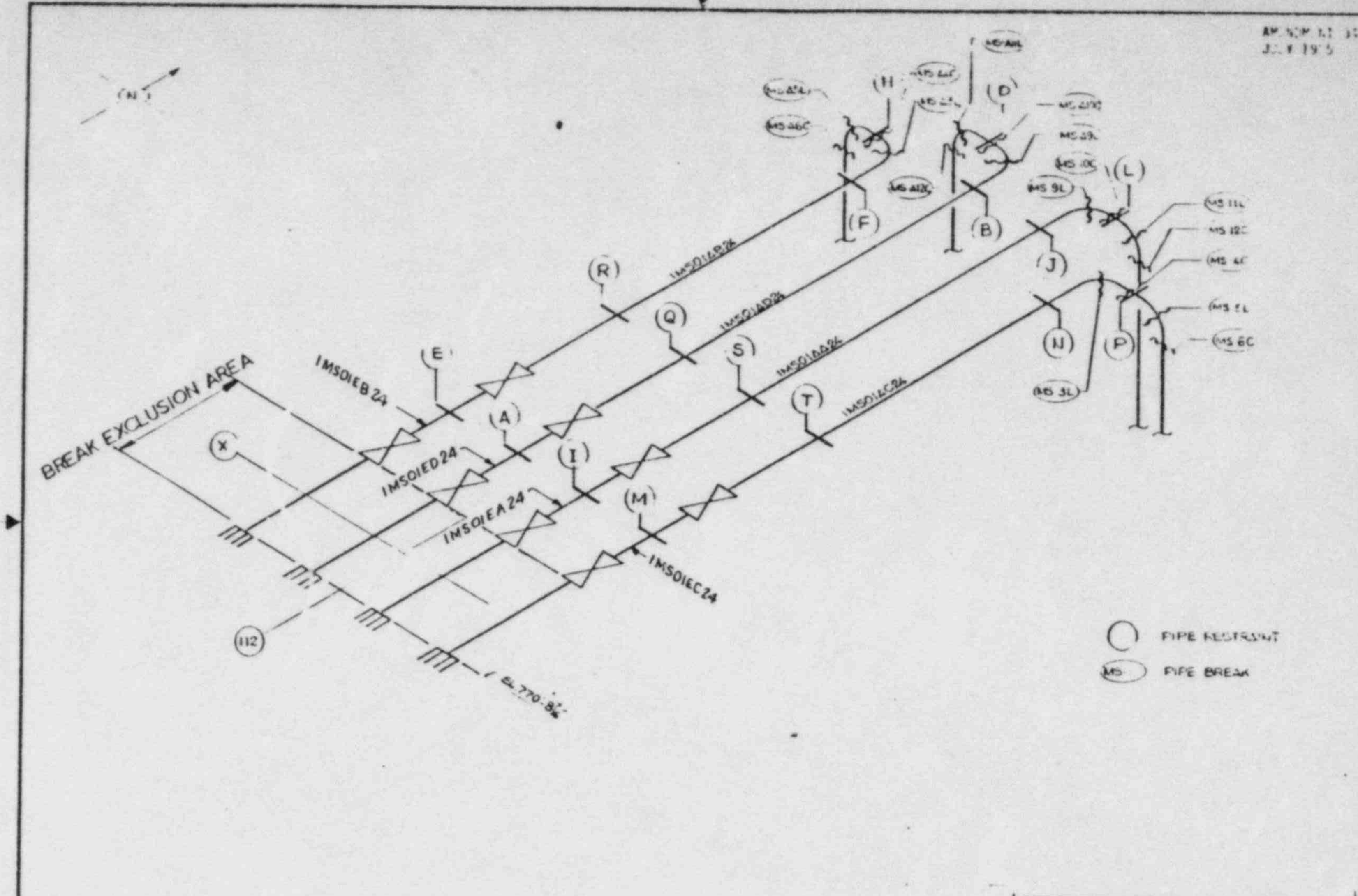

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FIGURE B3.6-12

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS MAIN STEAM OUTSIDE CONTAINMENT

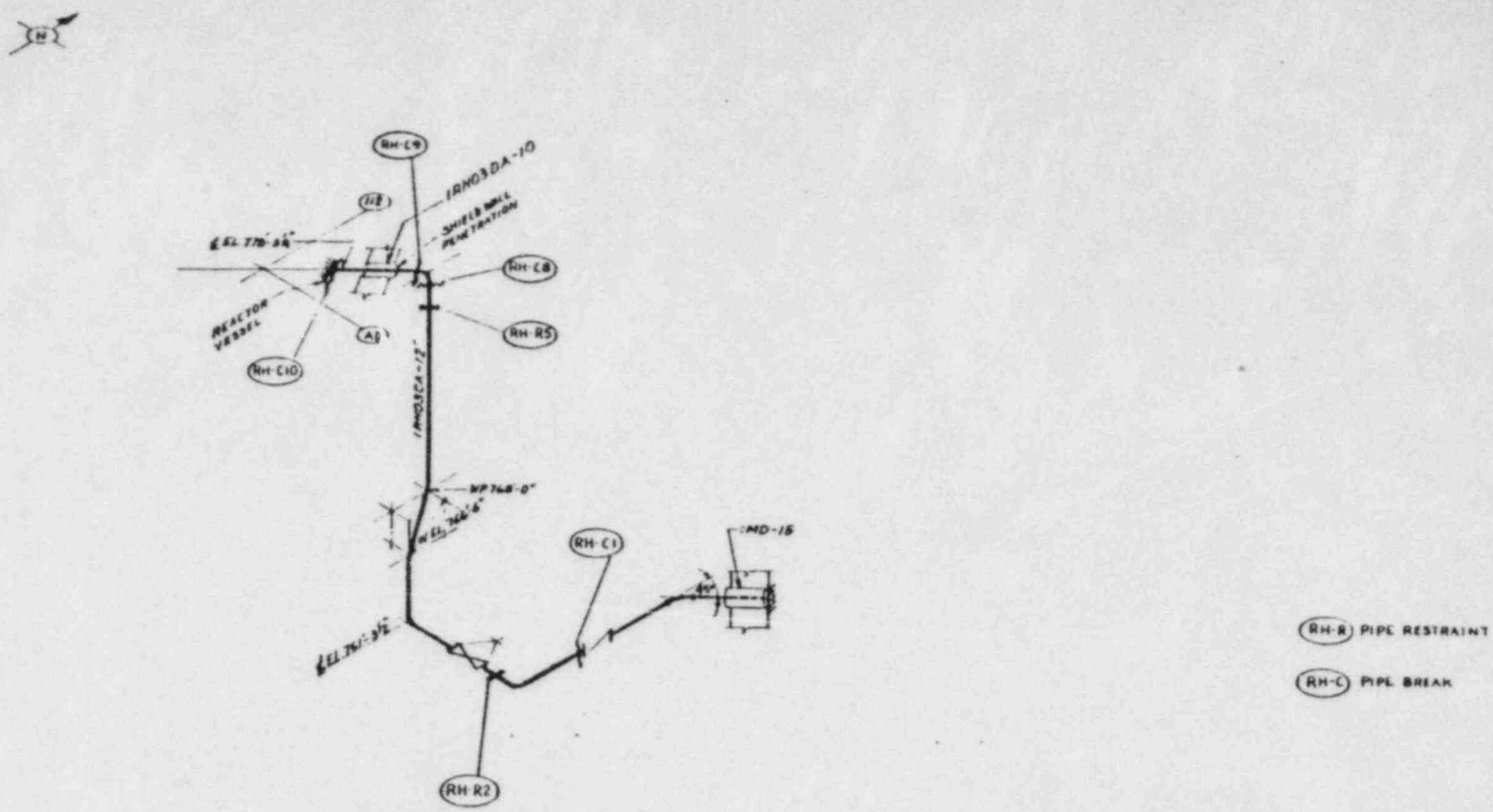

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FIGURE B3.6-13

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS RESIDUAL HEAT REMOVAL SYSTEM INSIDE CONTAINMENT LOOP-1

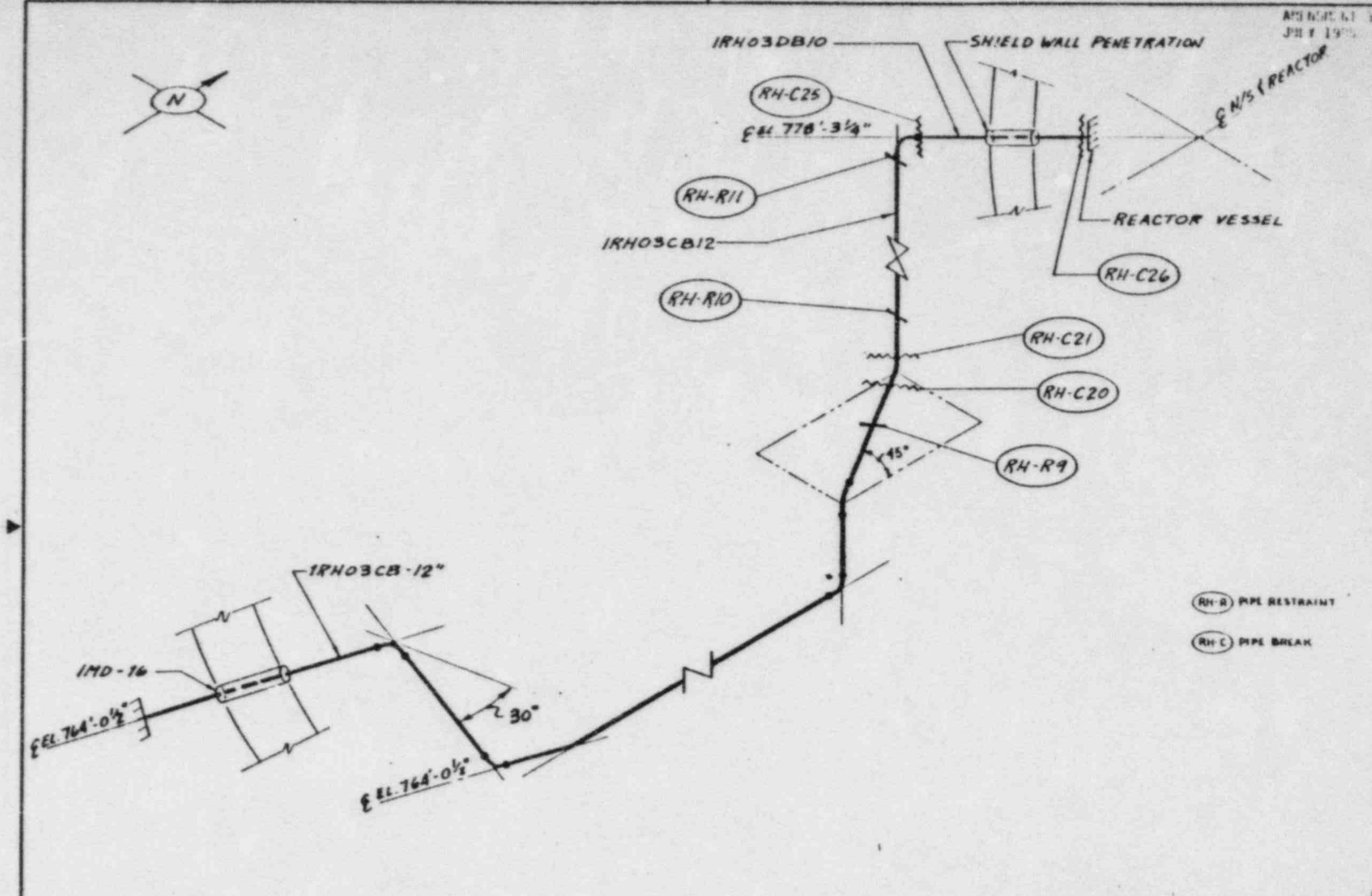

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FIGURE B3.6-14

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS RESIDUAL HEAT REMOVAL SYSTEM INSIDE CONTAINMENT LOOP-2

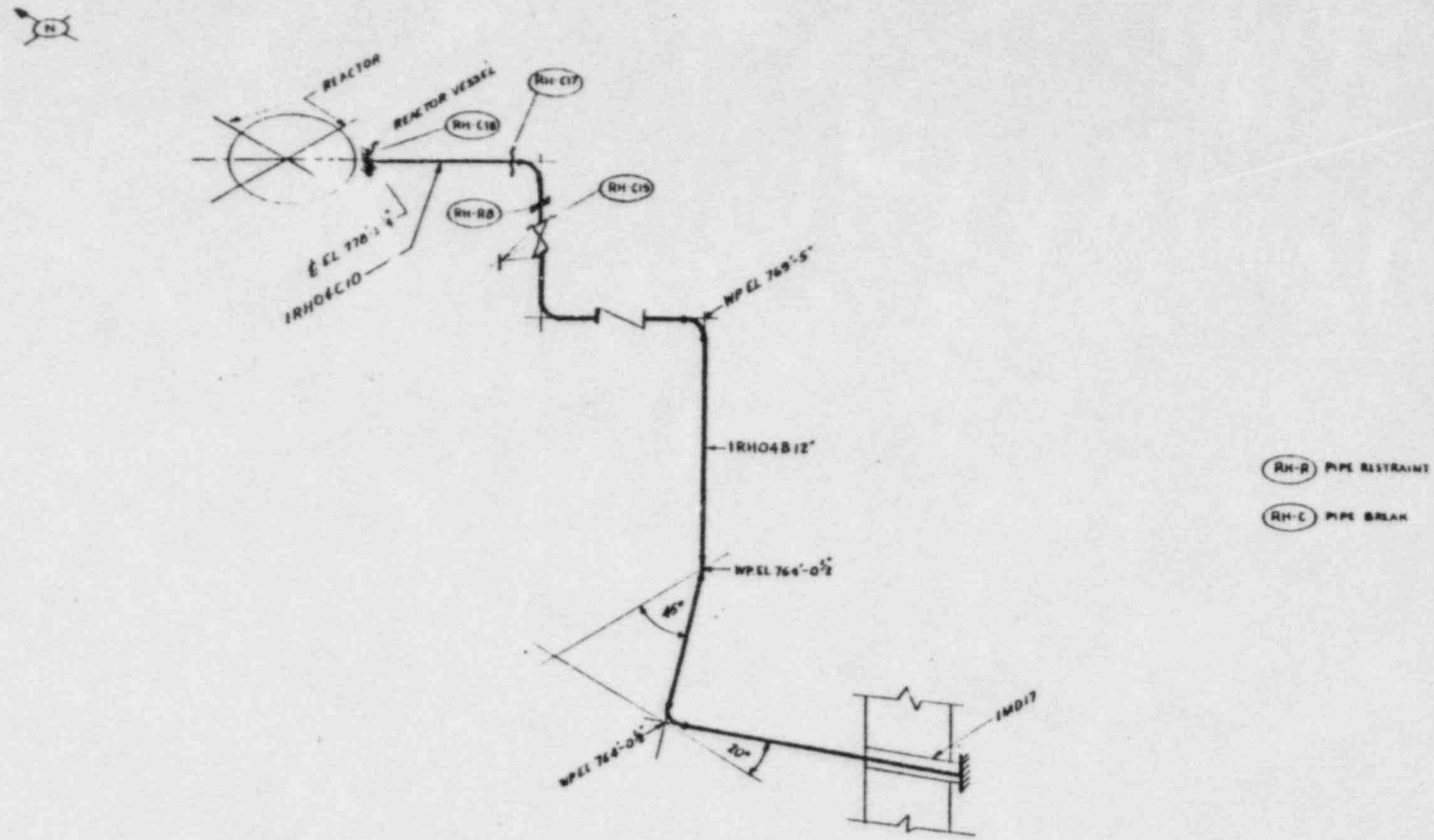

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FIGURE B3.6-15

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS RESIDUAL HEAT REMOVAL SYSTEM INSIDE CONTAINMENT LOOP-3

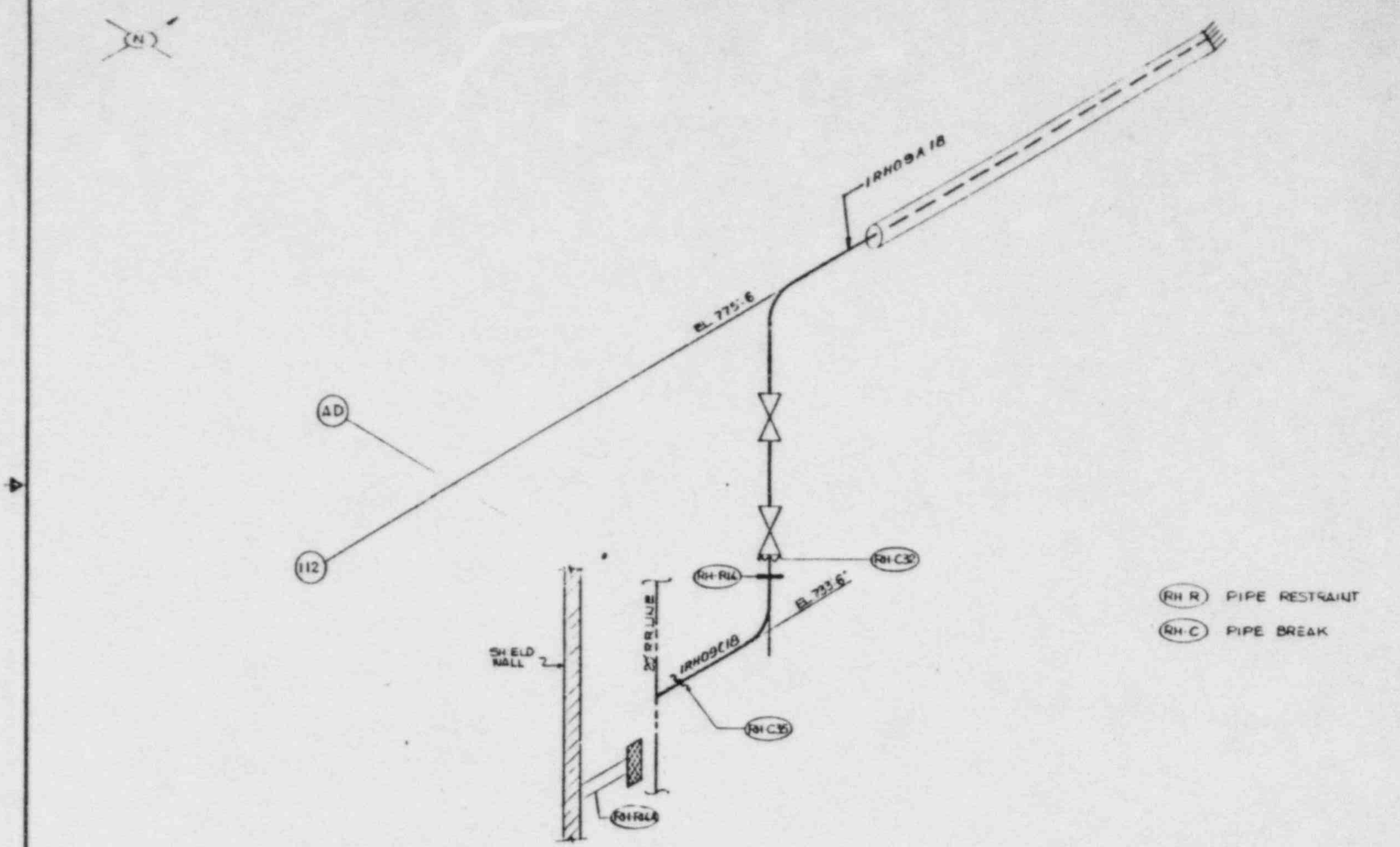

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FIGURE B3.6-16

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS RESIDUAL HEAT REMOVAL SYSTEM INSIDE CONTAINMENT LOOP-4

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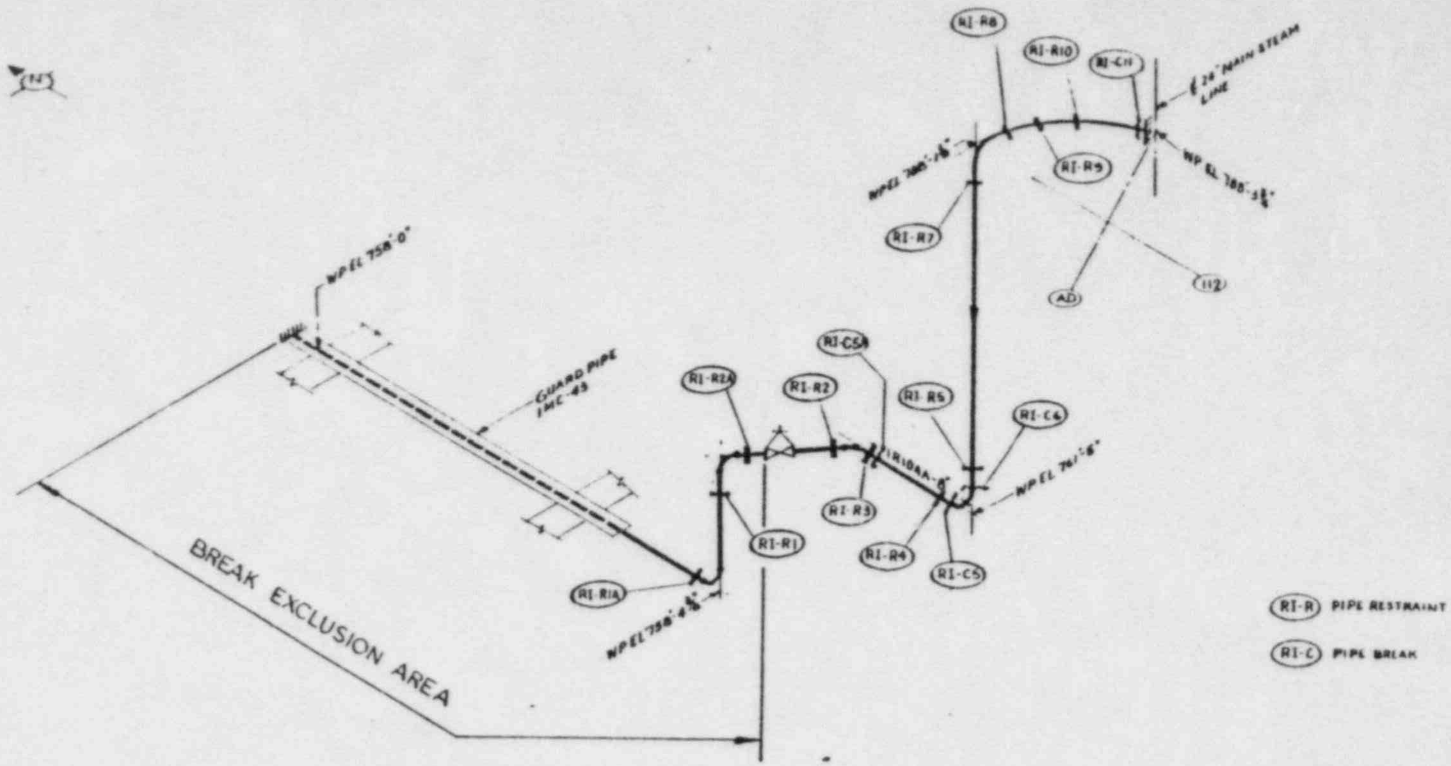

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FIGURE B3.6-17

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR CORE ISOLATION COOLING PIPING SYSTEM INSIDE CONTAINMENT

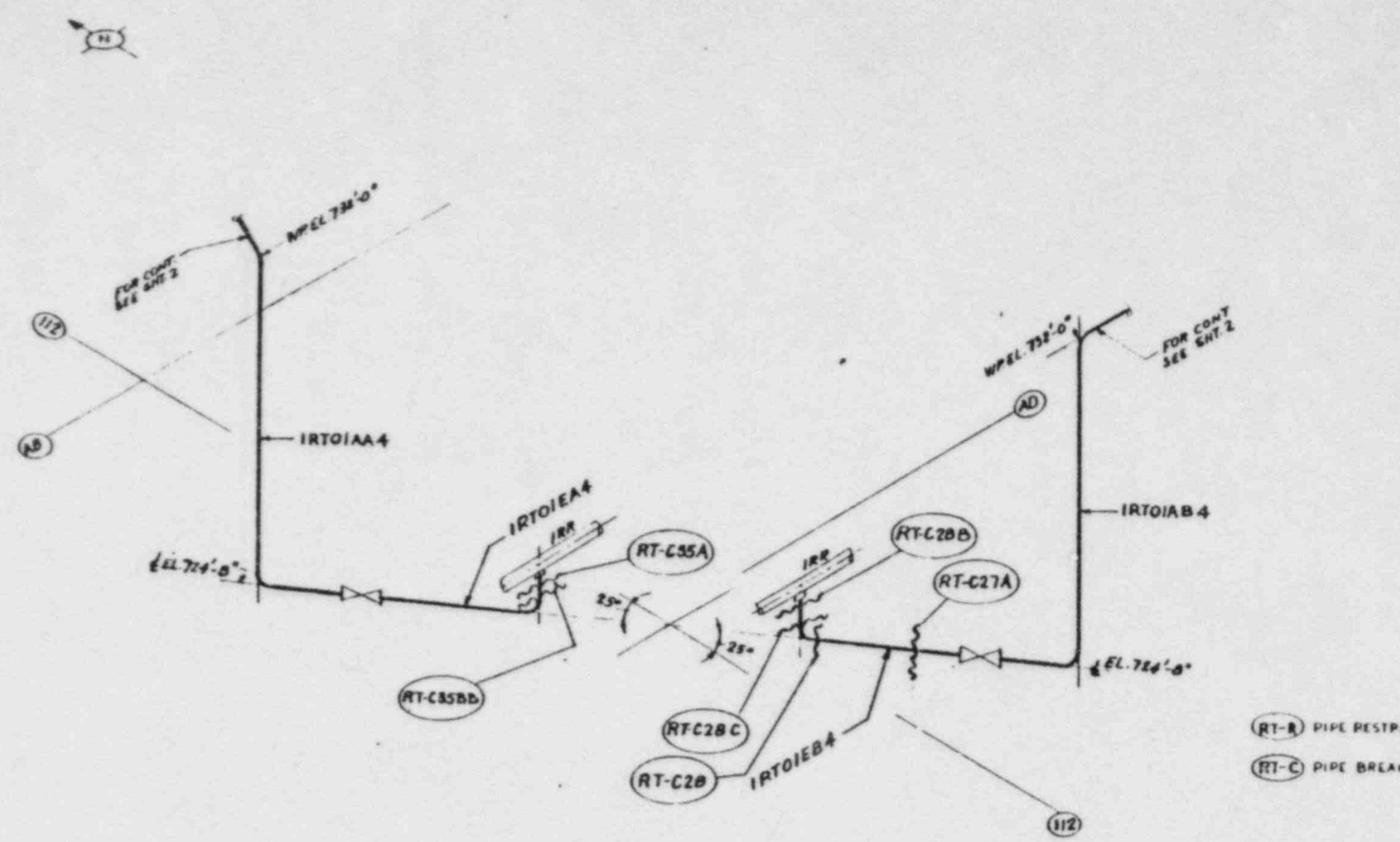

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FIGURE B3.6-19

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR WATER CLEAN UP PIPING SYSTEM INSIDE CONTAINMENT (SHEET 1 OF 6)

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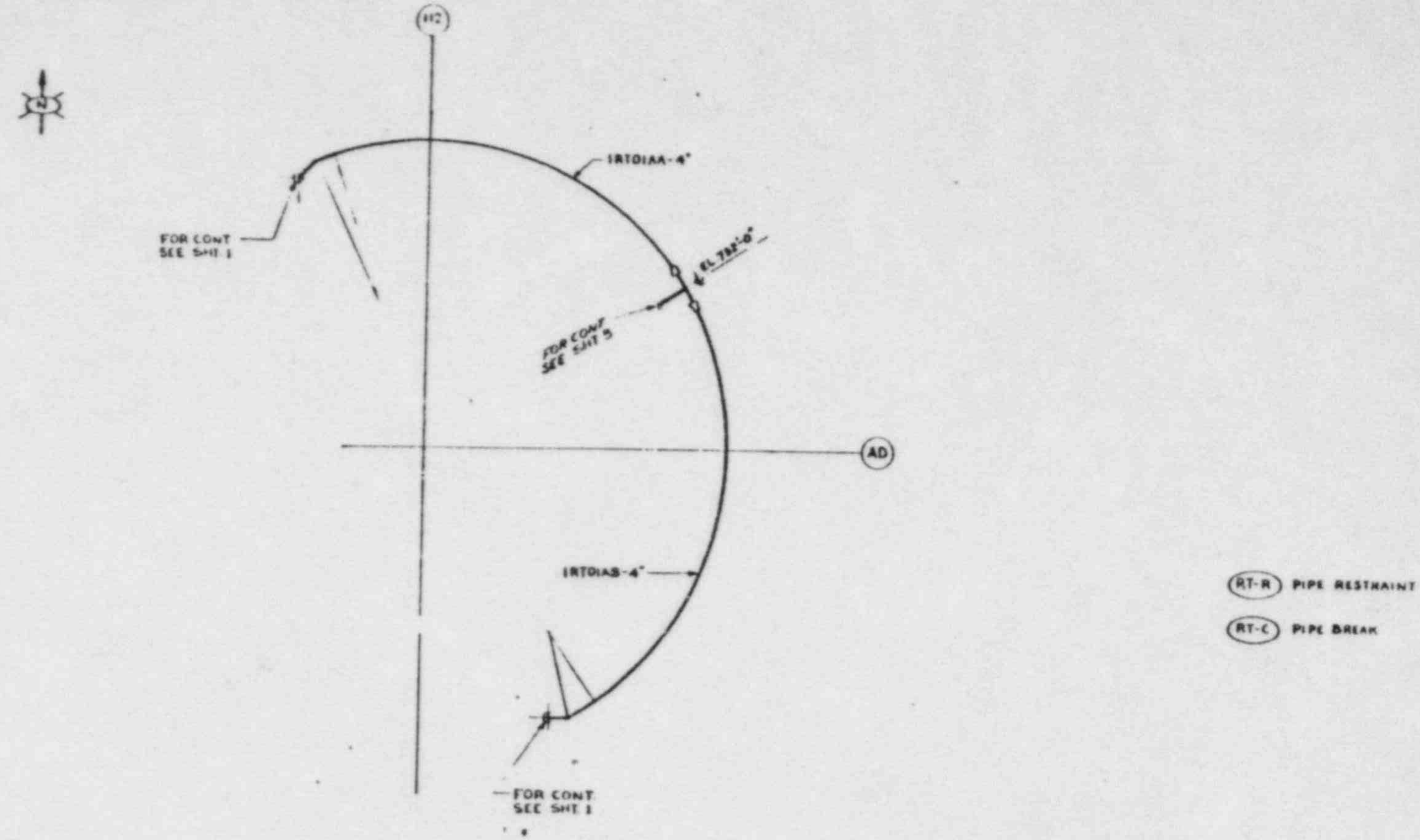

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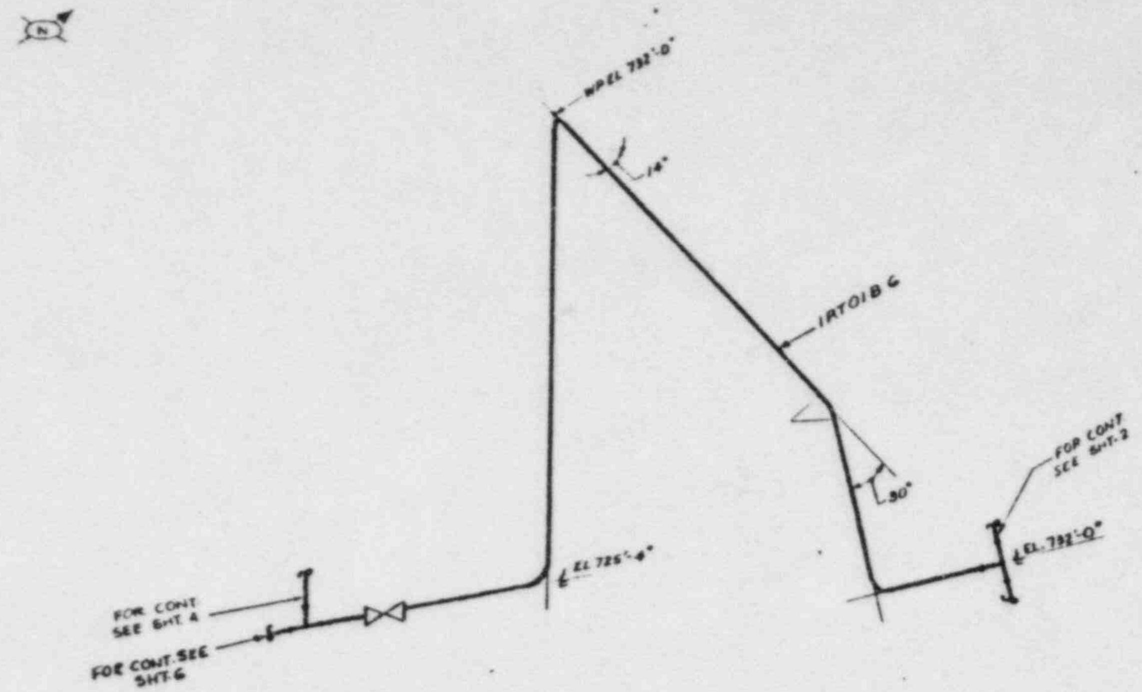
FIGURE B3.6-19

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR WATER CLEAN UP PIPING SYSTEM INSIDE CONTAINMENT (SHEET 2 OF 6)

AMENDMENT [illegible]
JULY 19[illegible]



(RT-R) PIPE RESTRAINT

(RT-C) PIPE BREAK

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FIGURE B3.6-19

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR WATER CLEAN UP PIPING SYSTEM INSIDE CONTAINMENT (SHEET 3 OF 6)

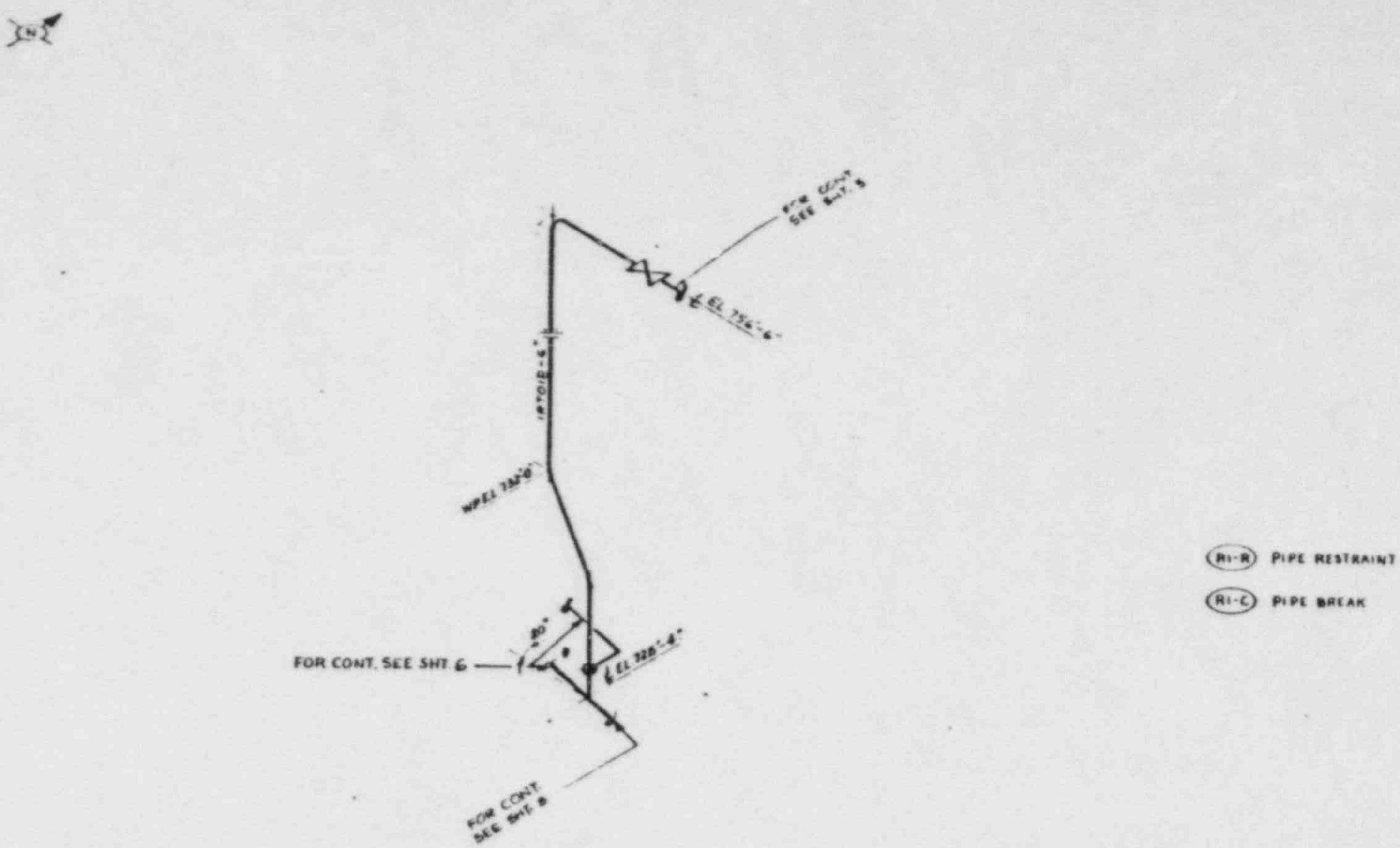

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FIGURE B3.6-19

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR WATER CLEAN UP PIPING SYSTEM INSIDE CONTAINMENT (SHEET 4 OF 6)

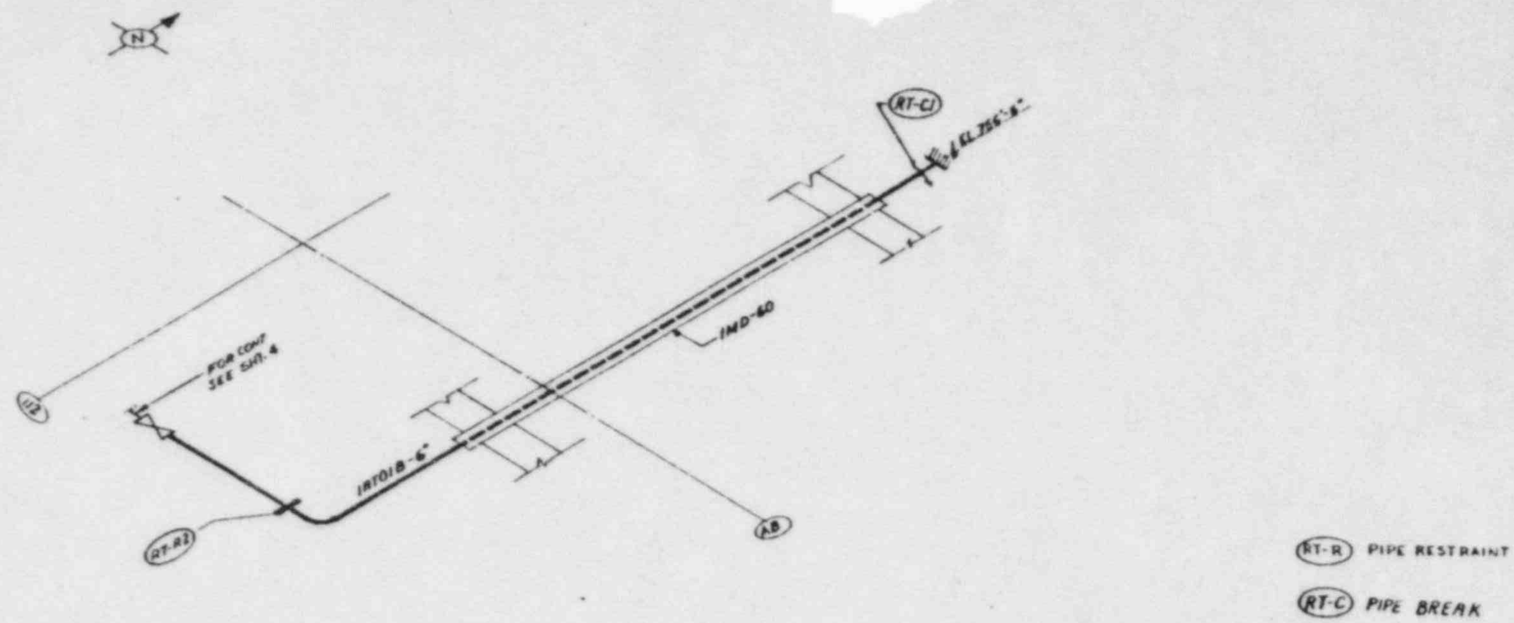

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FIGURE B3.6-19

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR WATER CLEAN UP PIPING SYSTEM INSIDE CONTAINMENT (SHEET 5 OF 6)

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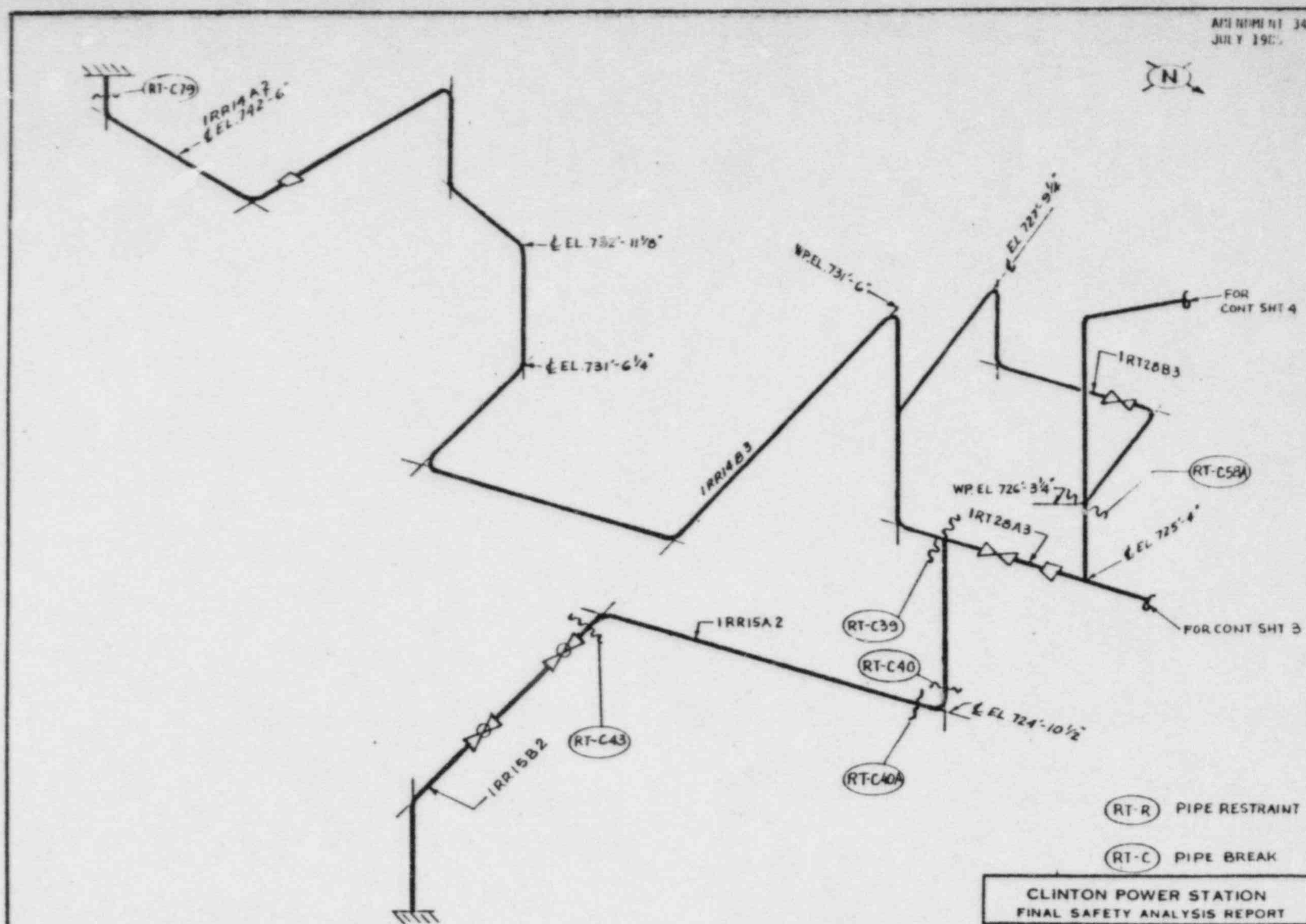

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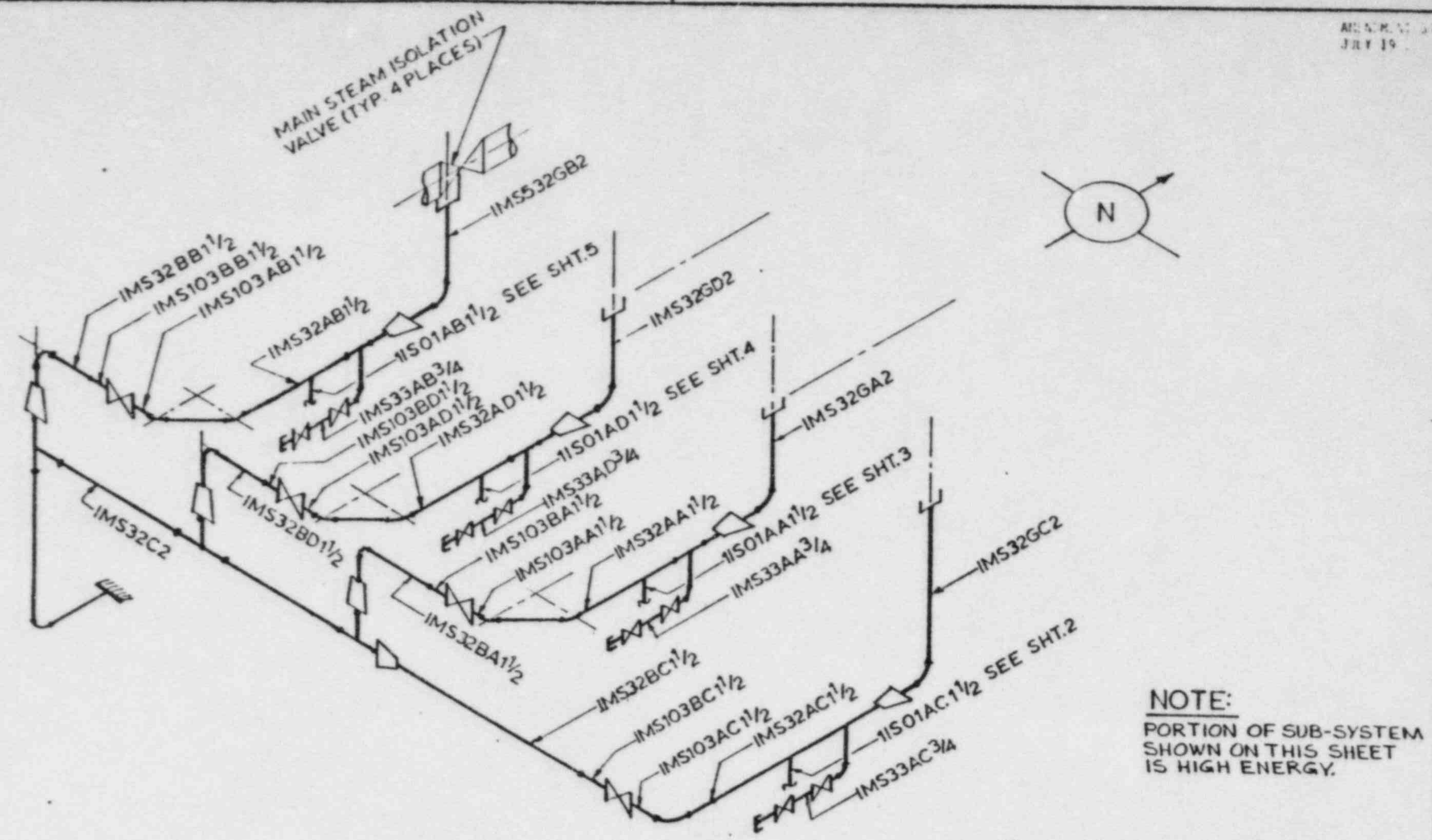
FIGURE B3.6-19
LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR WATER CLEAN UP PIPING SYSTEM INSIDE CONTAINMENT
(SHEET 6 OF 6)



NOTE:
PORTION OF SUB-SYSTEM SHOWN ON THIS SHEET IS HIGH ENERGY.

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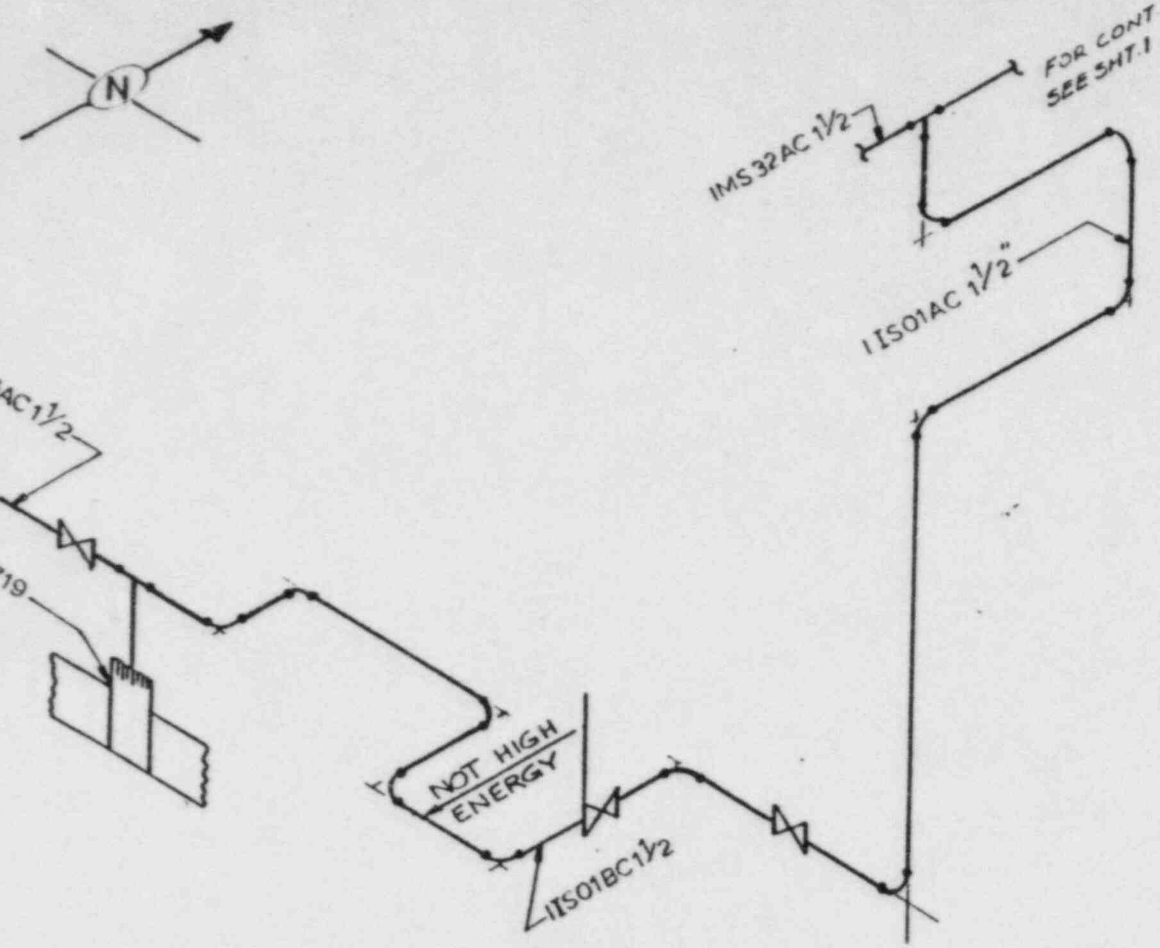
FIGURE B3.6-20

BREAK EXCLUSION AREA FOR MAIN STEAM DRAIN PIPING OUTSIDE CONTAINMENT FROM OUTSIDE MAIN STEAM ISOLATION VALVES

(SHEET 1 OF 5)



NOTE:
ENTIRE SUB-SYSTEM IS BREAK EXCLUSION AREA EXCEPT FOR PORTION OF SUB-SYSTEM THAT IS NOT HIGH ENERGY.

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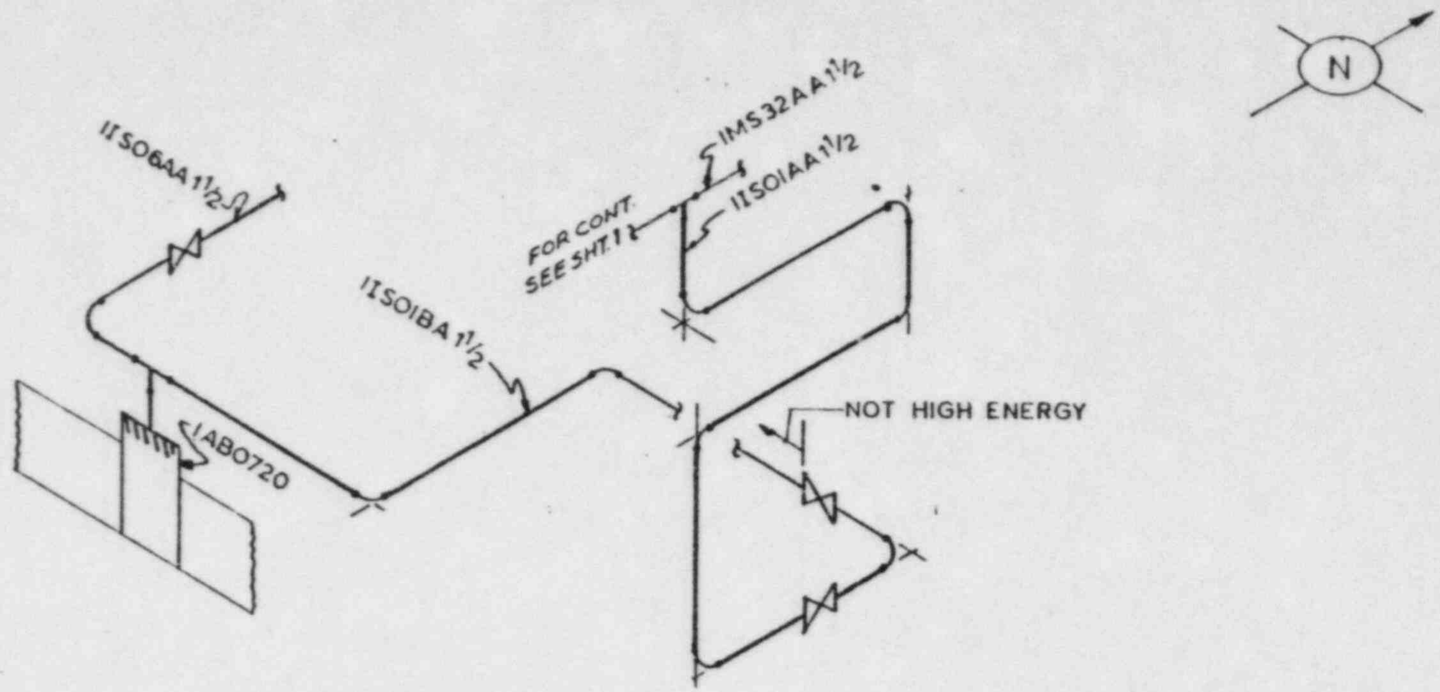
FIGURE B3.6-20

BREAK EXCLUSION AREA FOR MAIN STEAM DRAIN PIPING OUTSIDE CONTAINMENT FROM OUTSIDE MAIN STEAM ISOLATION VALVES

(SHEET 2 OF 5)



NOTE:

ENTIRE SUB-SYSTEM IS BREAK EXCLUSION AREA EXCEPT FOR PORTION OF SUB SYSTEM, THAT IS NOT HIGH ENERGY.

CLINTON POWER STATION
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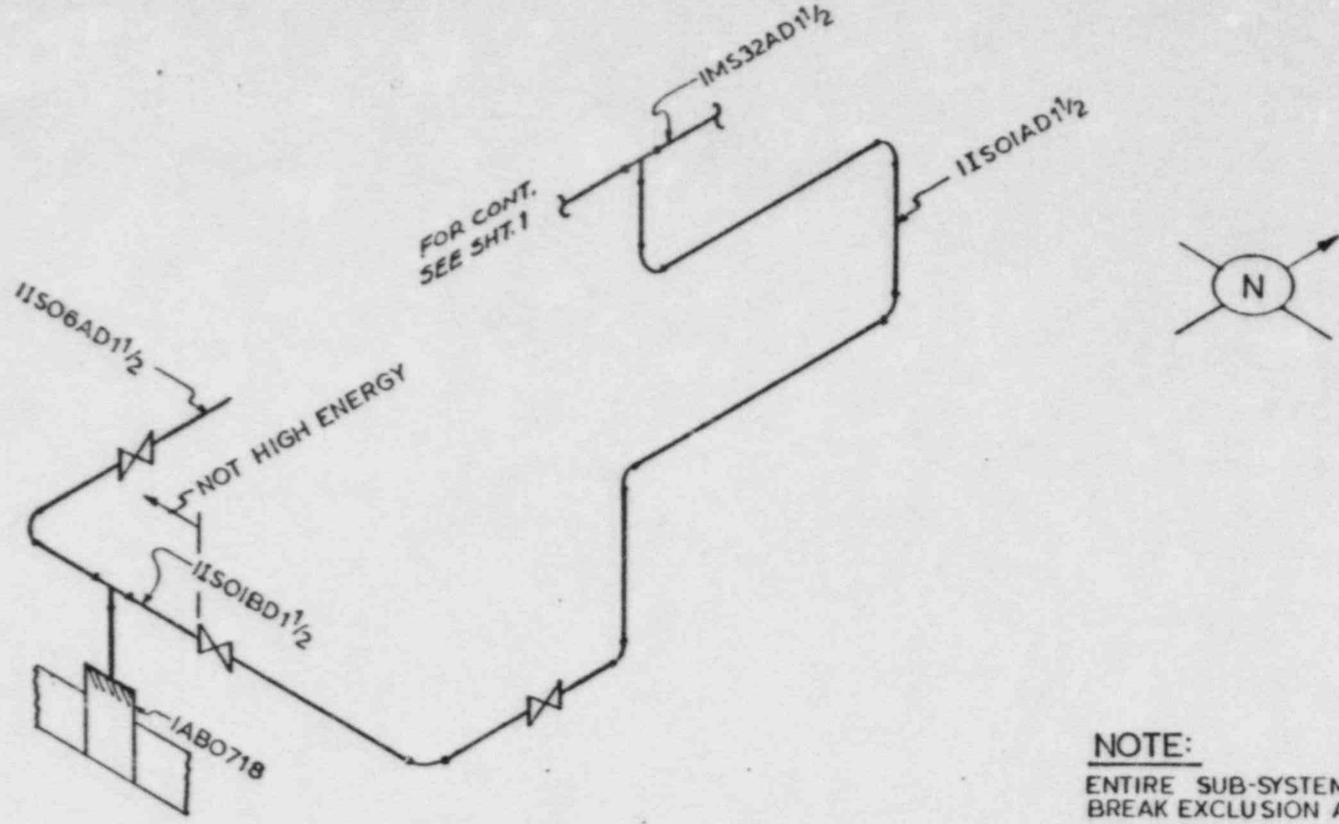
FIGURE B3.6-20

BREAK EXCLUSION AREA FOR MAIN STEAM DRAIN PIPING OUTSIDE CONTAINMENT FROM OUTSIDE MAIN STEAM ISOLATION VALVES

(SHEET 3 OF 5)



NOTE:

ENTIRE SUB-SYSTEM IS BREAK EXCLUSION AREA EXCEPT FOR PORTION OF SUB-SYSTEM THAT IS NOT HIGH ENERGY.

CLINTON POWER STATION
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FIGURE B3.6-20

BREAK EXCLUSION AREA FOR MAIN STEAM DRAIN PIPING OUTSIDE CONTAINMENT FROM OUTSIDE MAIN STEAM ISOLATION VALVES

(SHEET 4 OF 5)

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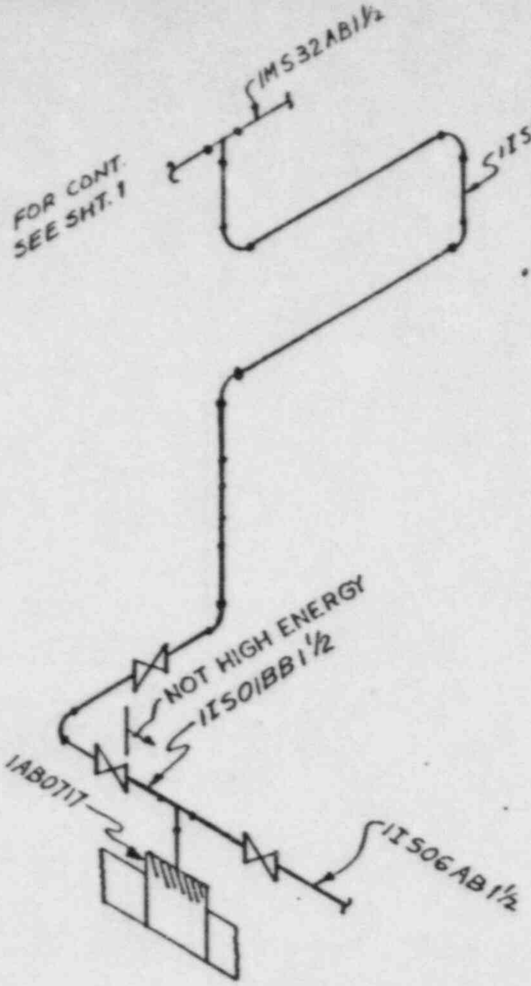

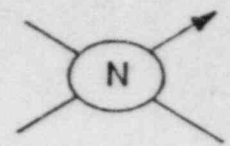

NOTE:

ENTIRE SUB-SYSTEM IS BREAK EXCLUSION AREA EXCEPT FOR PORTION OF SUB SYSTEM THAT IS NOT HIGH ENERGY.

CLINTON POWER STATION FINAL SAFETY ANALYSIS REPORT
FIGURE B3.6-20 BREAK EXCLUSION AREA FOR MAIN STEAM DRAIN PIPING OUTSIDE CONTAINMENT FROM OUTSIDE MAIN STEAM ISOLATION VALVES (SHEET 5 OF 5)

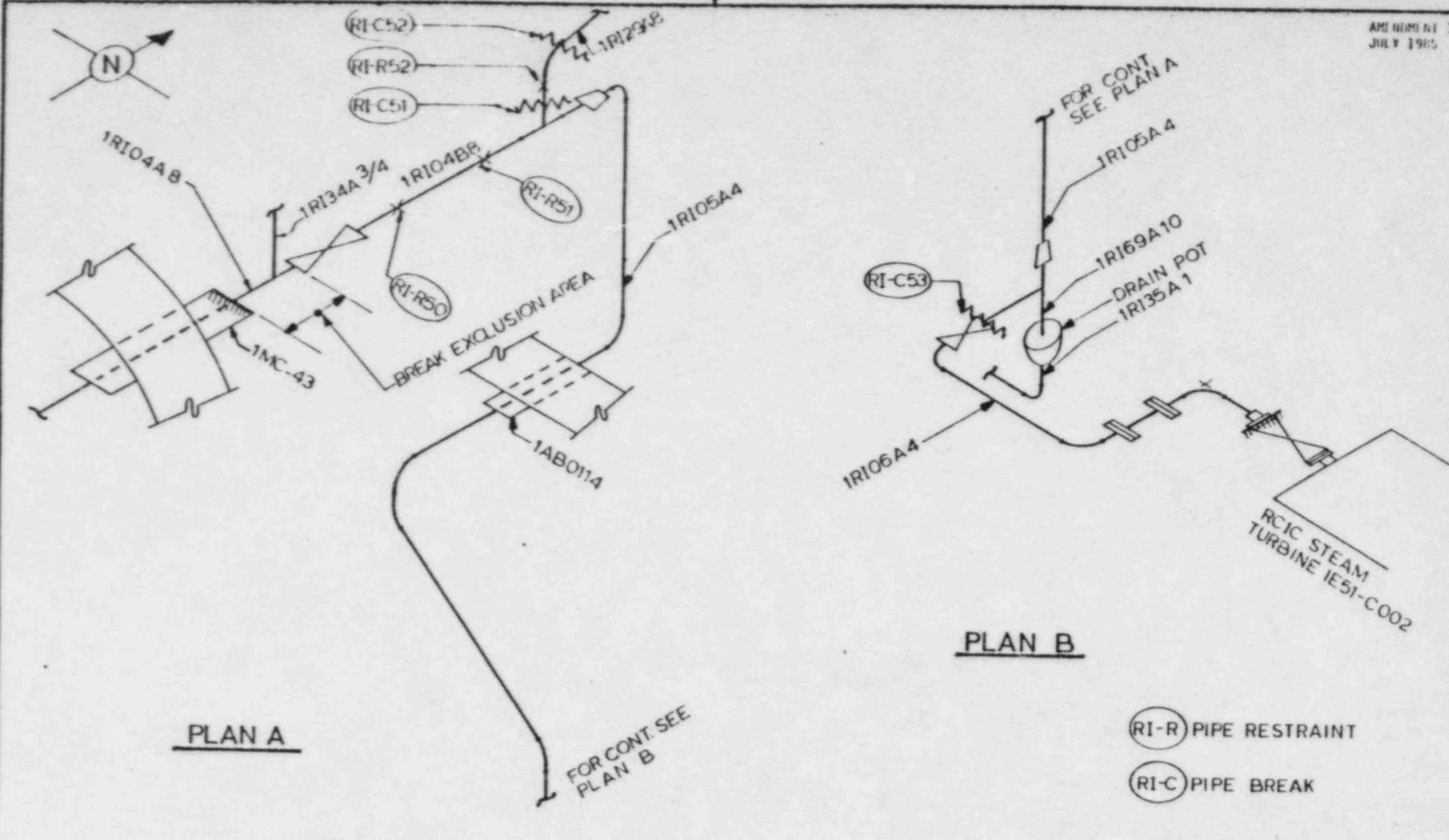

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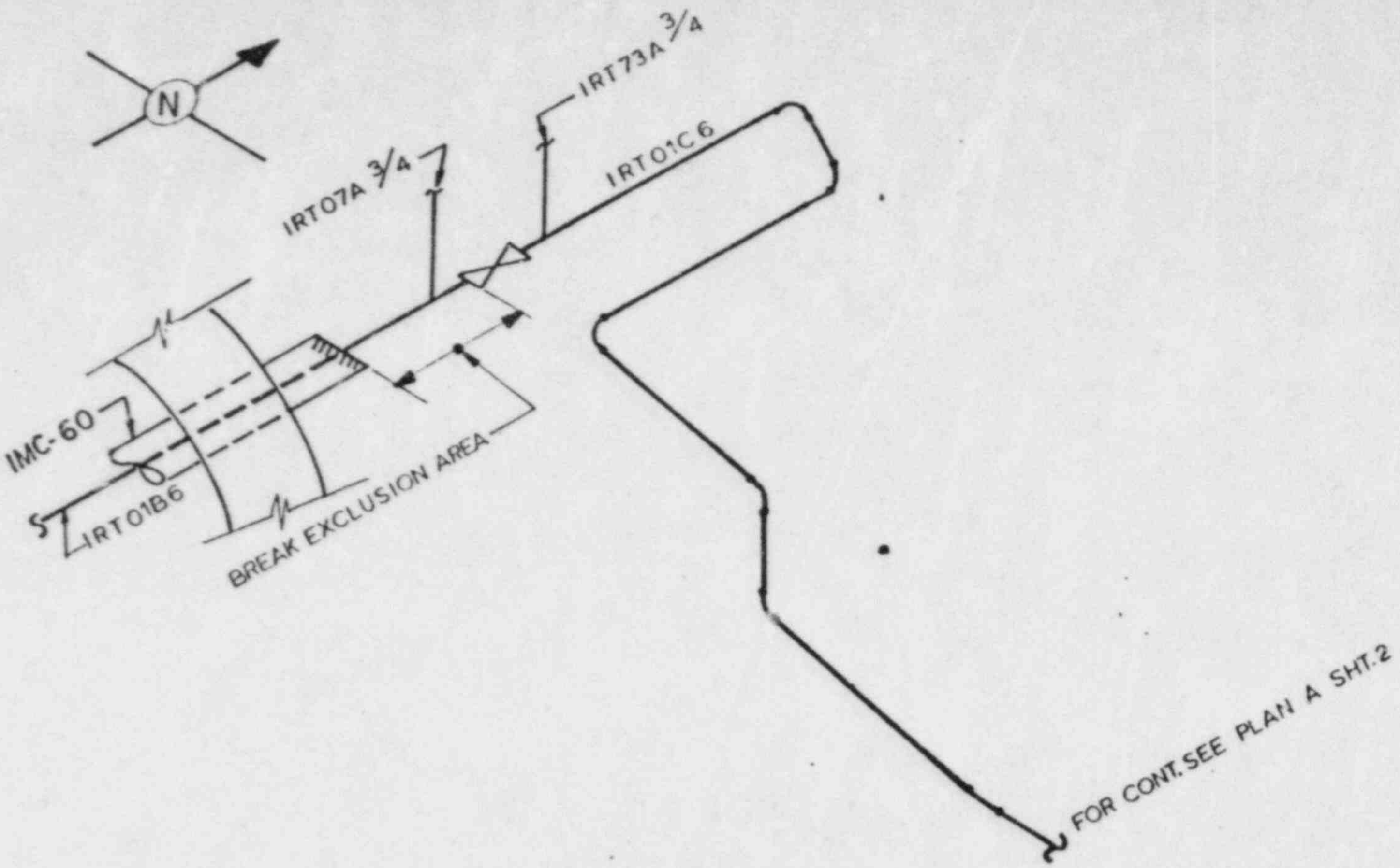
FIGURE B3.6-21

LOCATION OF POSTULATED BREAKS AND ASSOCIATED RESTRAINTS REACTOR CORE ISOLATION COOLING PIPING OUTSIDE CONTAINMENT



(RT-R) PIPE RESTRAINT

(RT-C) PIPE BREAK

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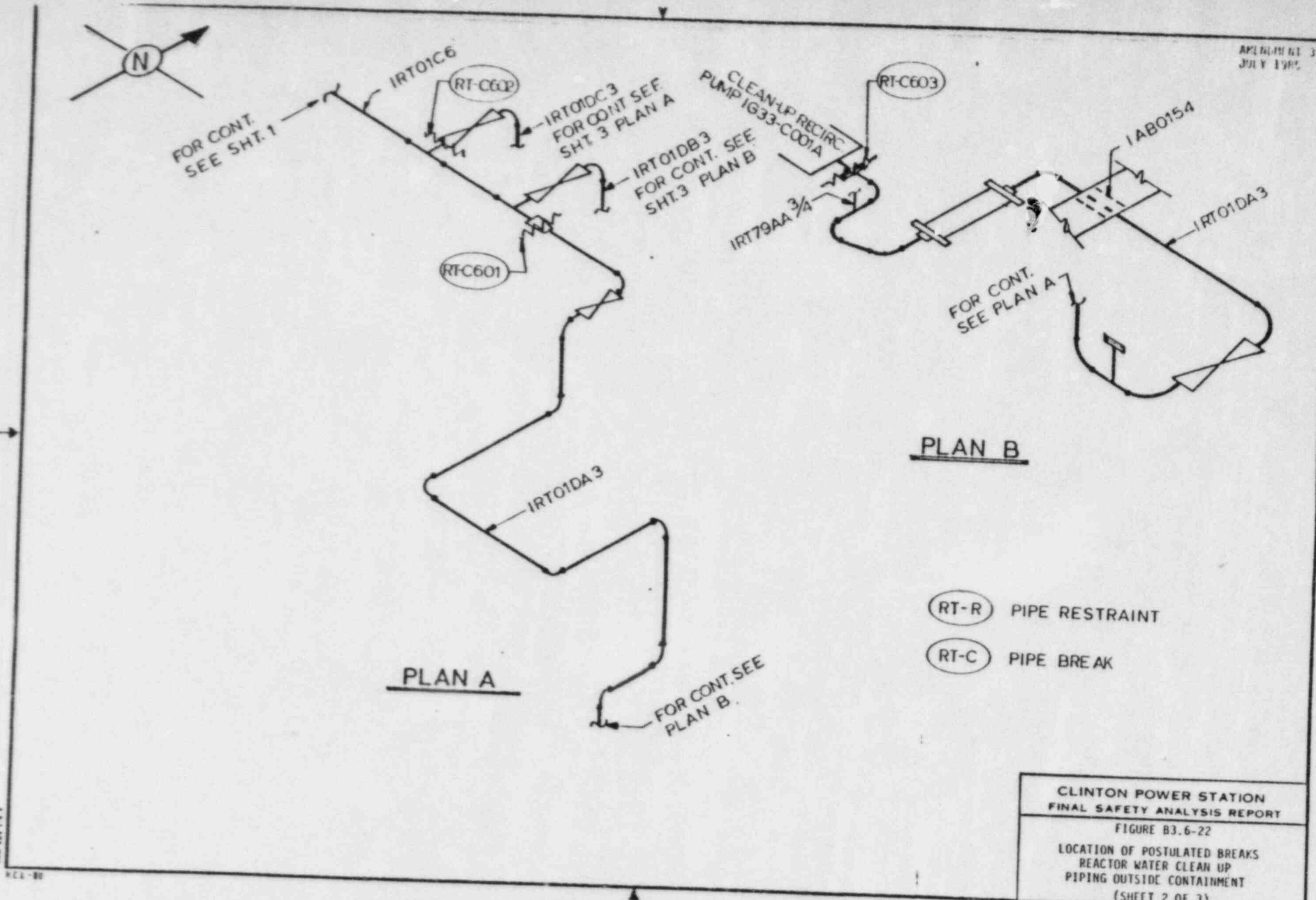
FIGURE B3.6-22

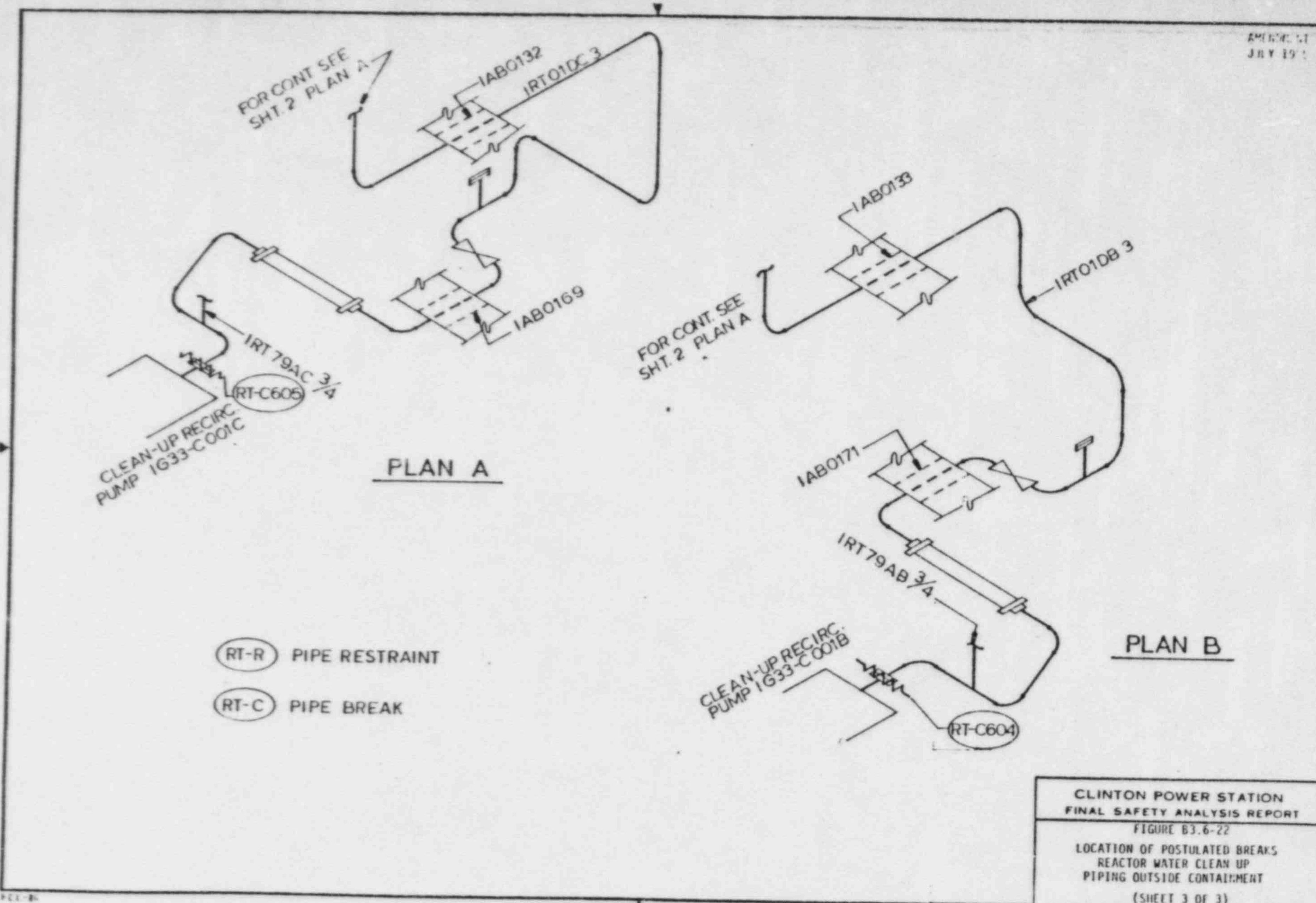
LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING OUTSIDE CONTAINMENT
(SHEET 1 OF 3)



CLINTON POWER STATION
FINAL SAFETY ANALYSIS REPORT

FIGURE B3.6-22

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING OUTSIDE CONTAINMENT
(SHEET 2 OF 3)



CLINTON POWER STATION
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FIGURE B3.6-22

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING OUTSIDE CONTAINMENT

(SHEET 3 OF 3)

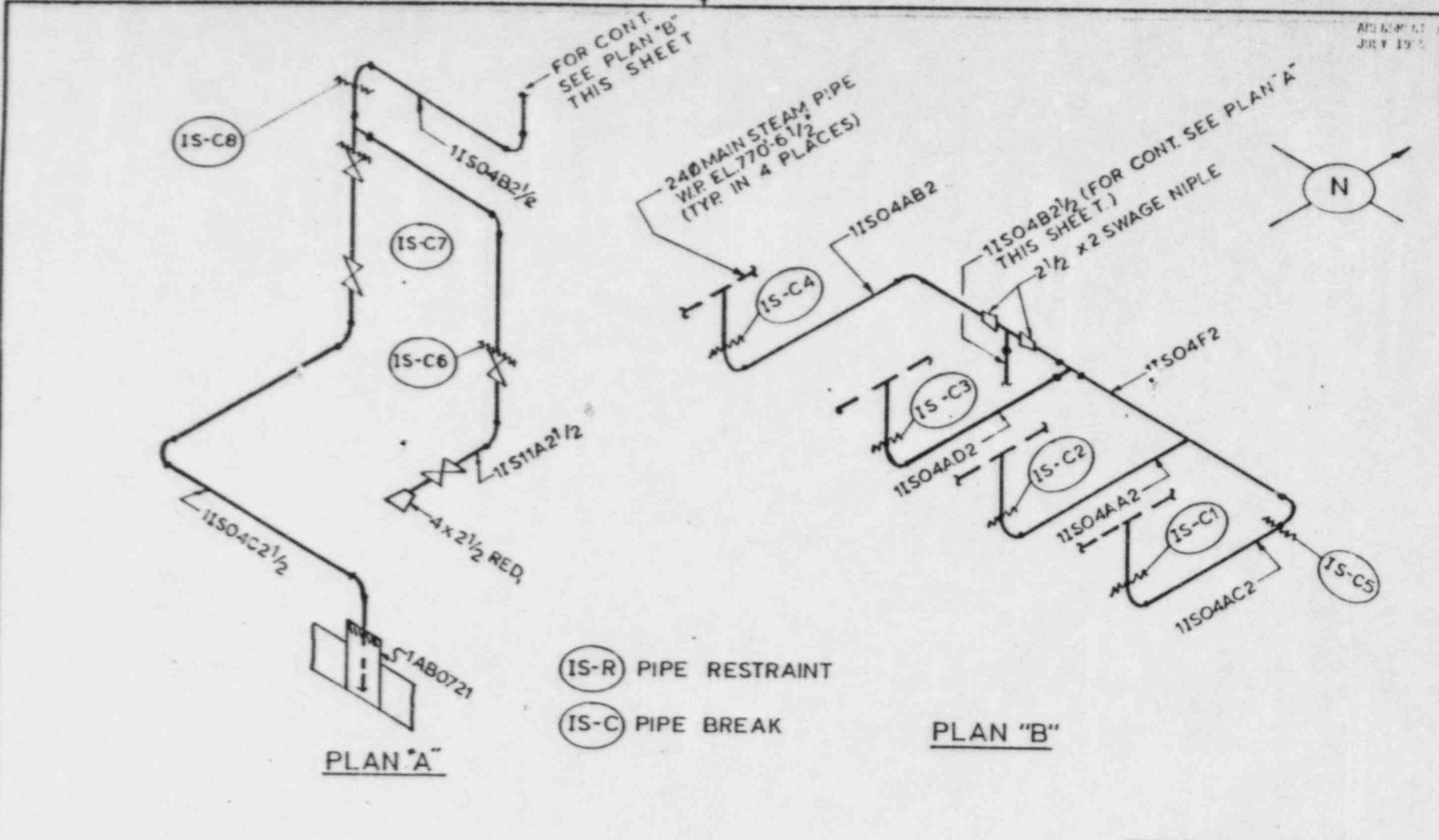

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FIGURE B3.6-23

LOCATION OF POSTULATED BREAKS MSIV LEAKAGE CONTROL PIPING OUTSIDE CONTAINMENT

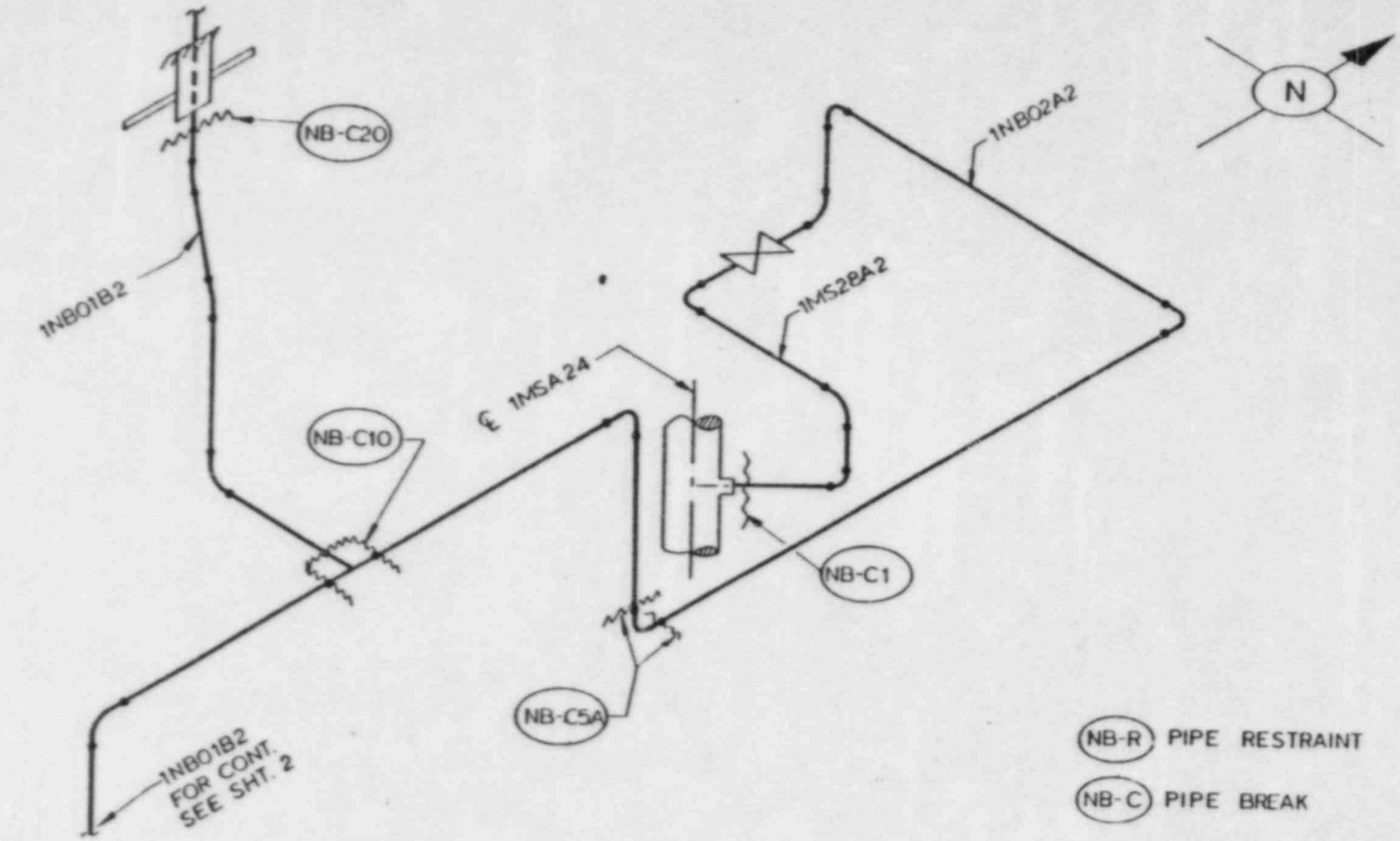

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FIGURE B3.6-24
LOCATION OF POSTULATED BREAKS
NUCLEAR BOILER PIPING
INSIDE CONTAINMENT
(SHEET 1 OF 2)

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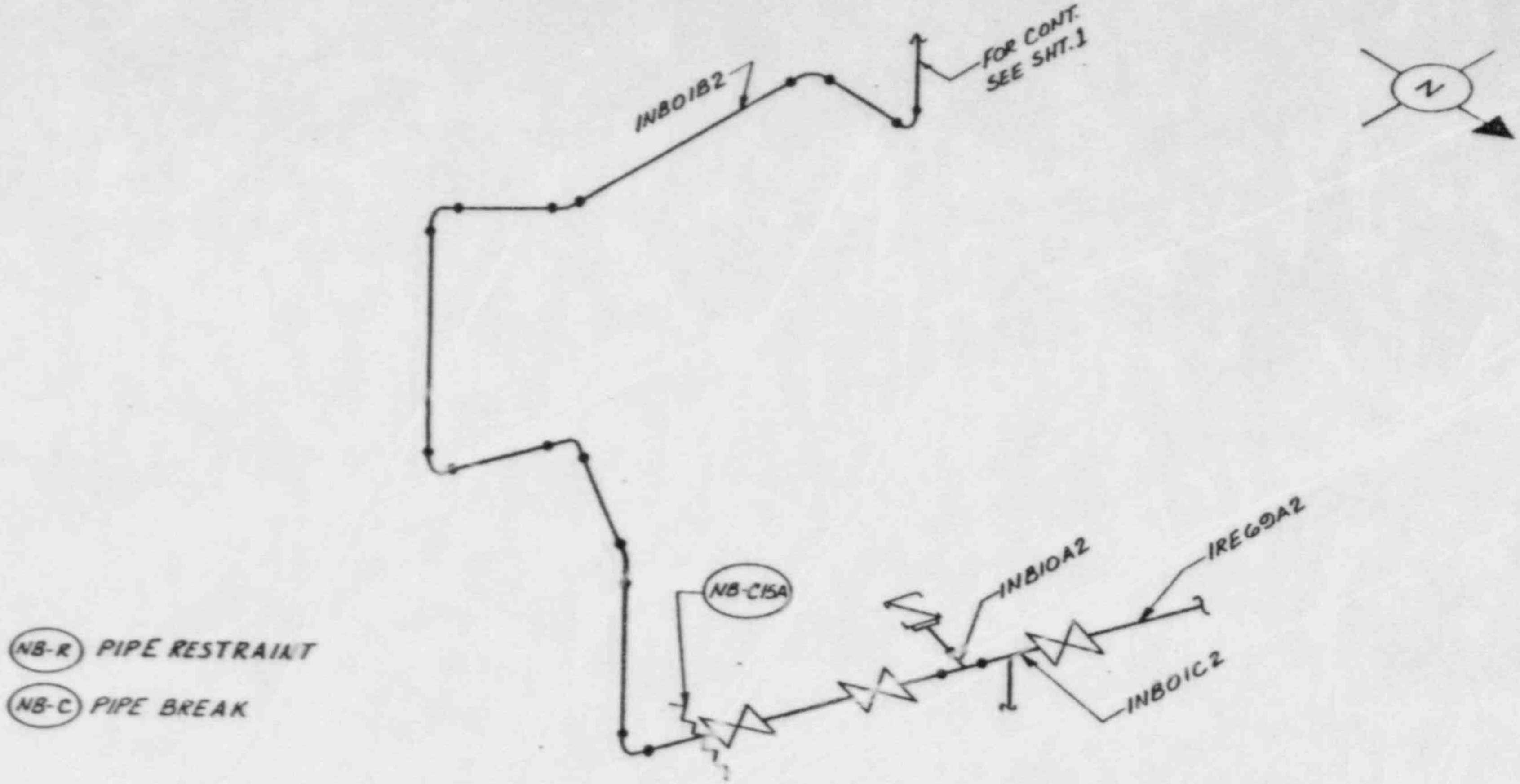

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FIGURE B3.6-24
LOCATION OF POSTULATED BREAKS
NUCLEAR BOILER PIPING
INSIDE CONTAINMENT

(SHEET 2 OF 2)

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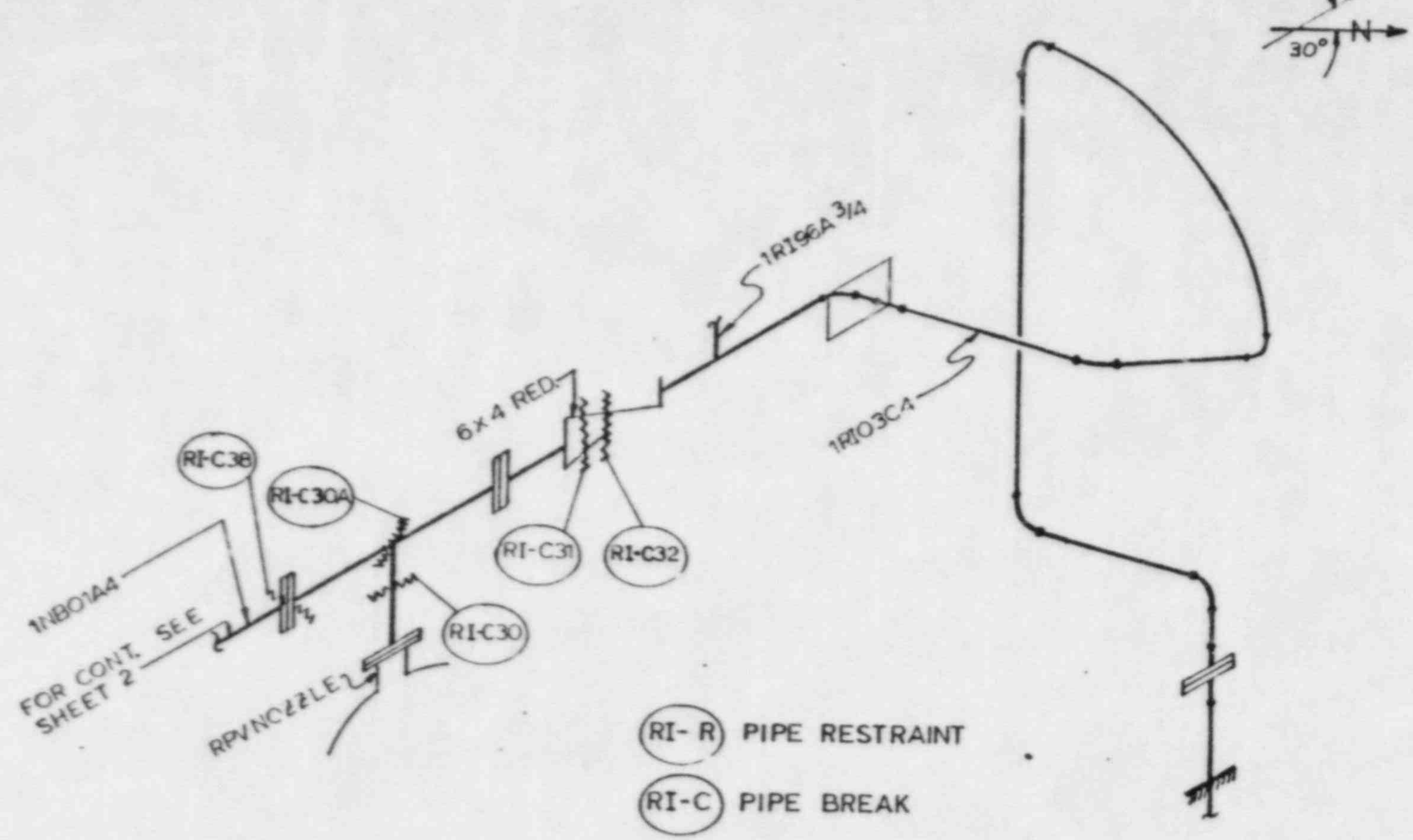

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FIGURE B3.6-25

LOCATION OF POSTULATED BREAKS
RCIC HEAD SPRAY PIPING
INSIDE CONTAINMENT
(SHEET 1 OF 2)

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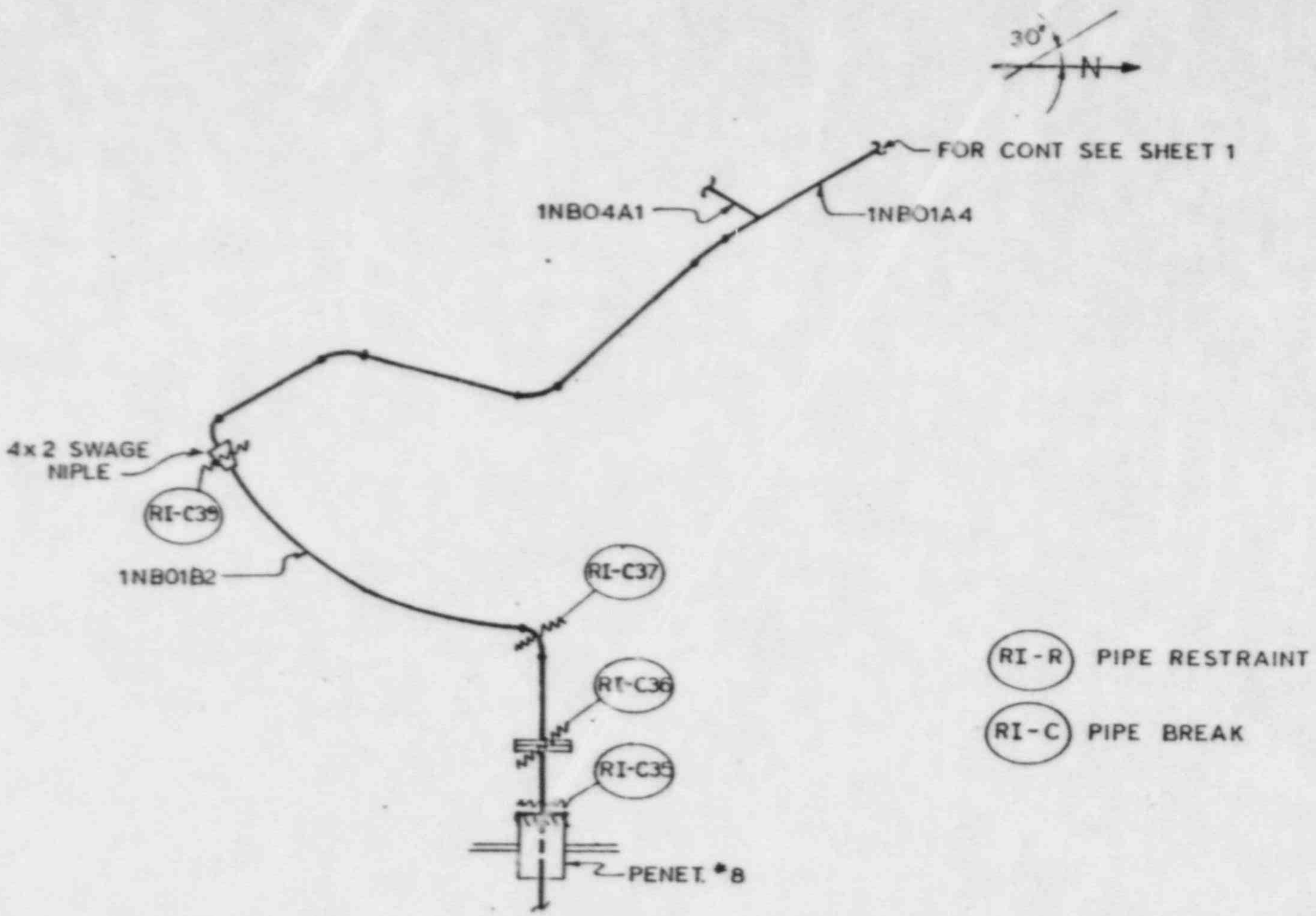

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FIGURE B3.6-25

LOCATION OF POSTULATED BREAKS
RCIC HEAD SPRAY PIPING
INSIDE CONTAINMENT
(SHEET 2 OF 2)

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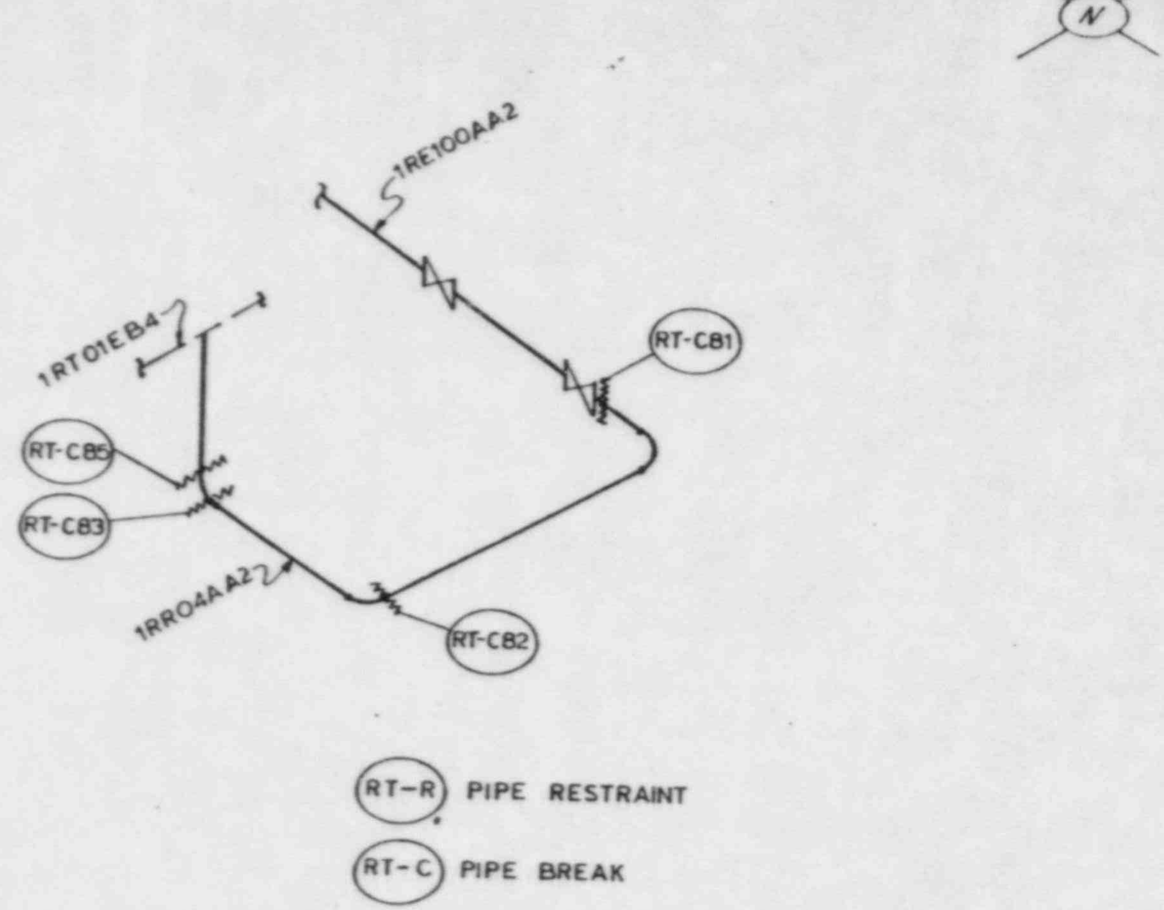

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FIGURE B3.6-26

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP DRAIN LINE
PIPING INSIDE CONTAINMENT
(SHEET 1 OF 2)

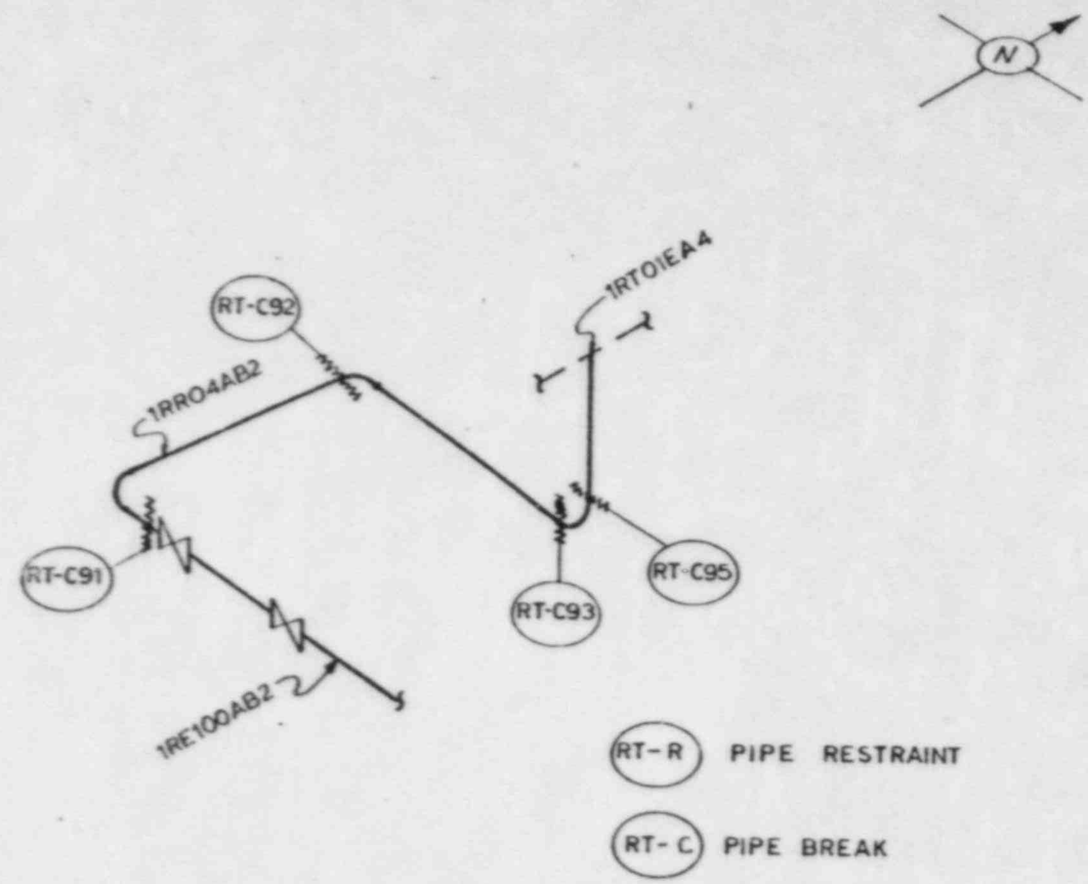

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FIGURE B3.6-26

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP DRAIN LINE
PIPING INSIDE CONTAINMENT

(SHEET 2 OF 2)

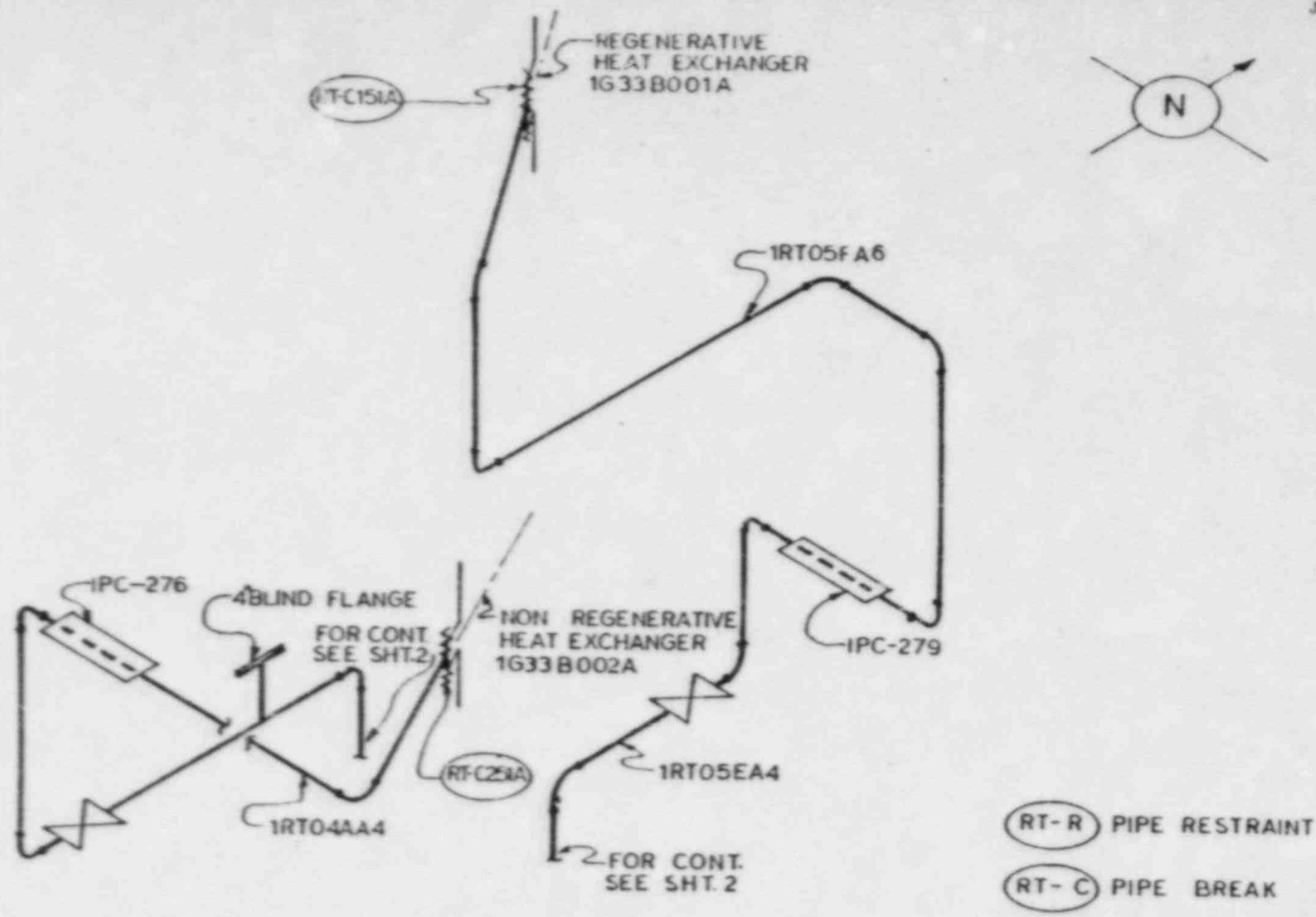

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FIGURE B3.6-27

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT

(SHEET 1 OF 8)

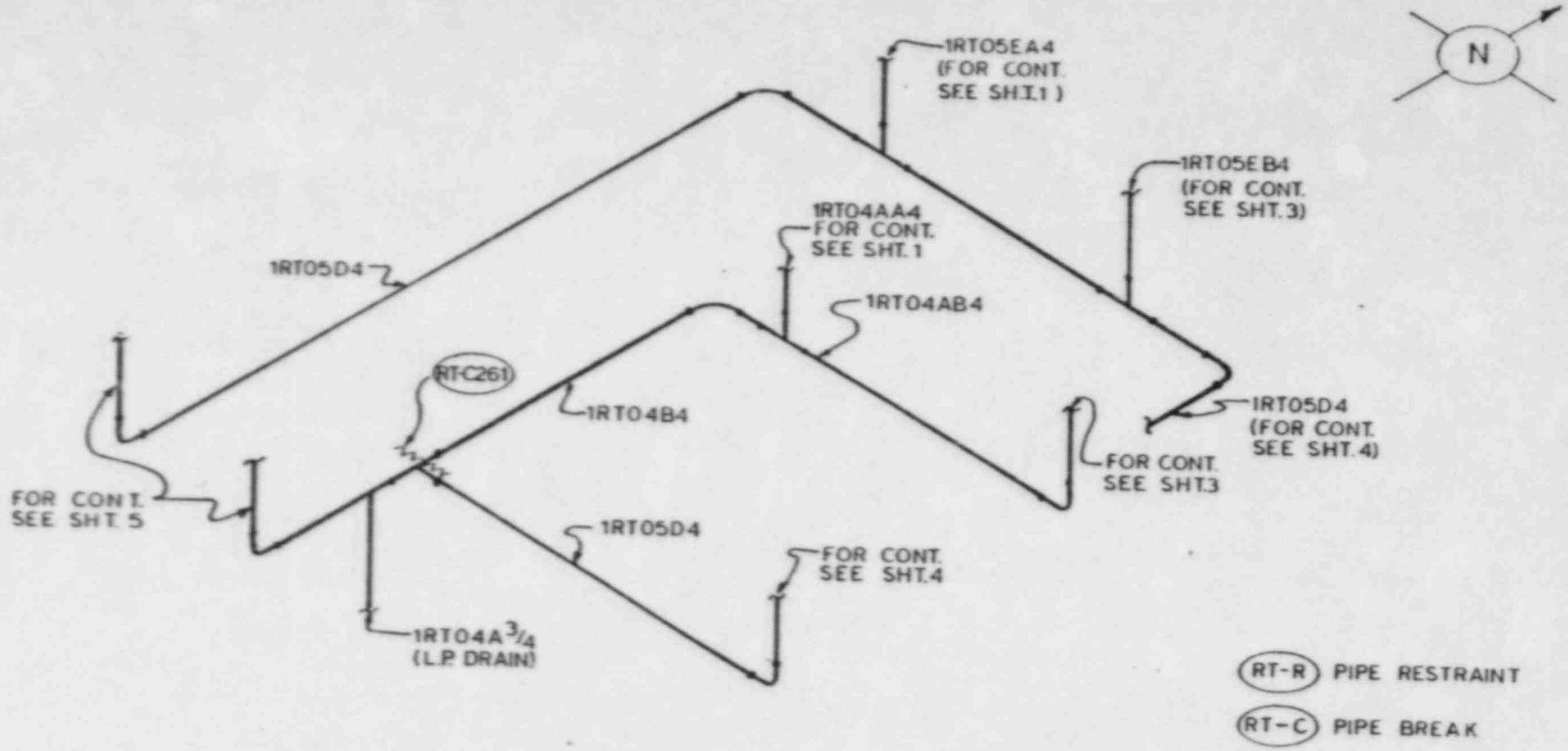

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FIGURE B3.6-27

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT
(SHEET 2 OF 8)

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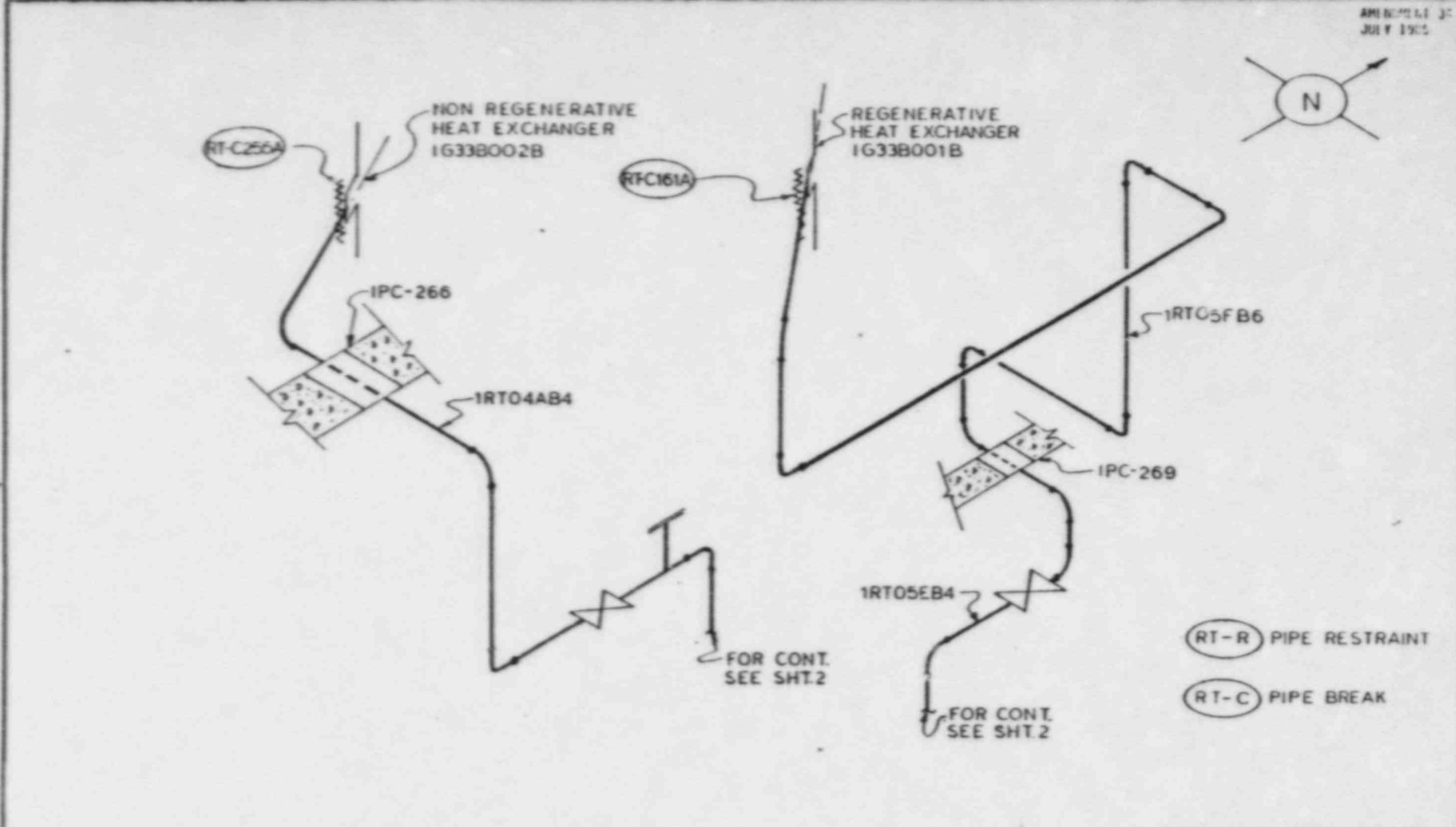

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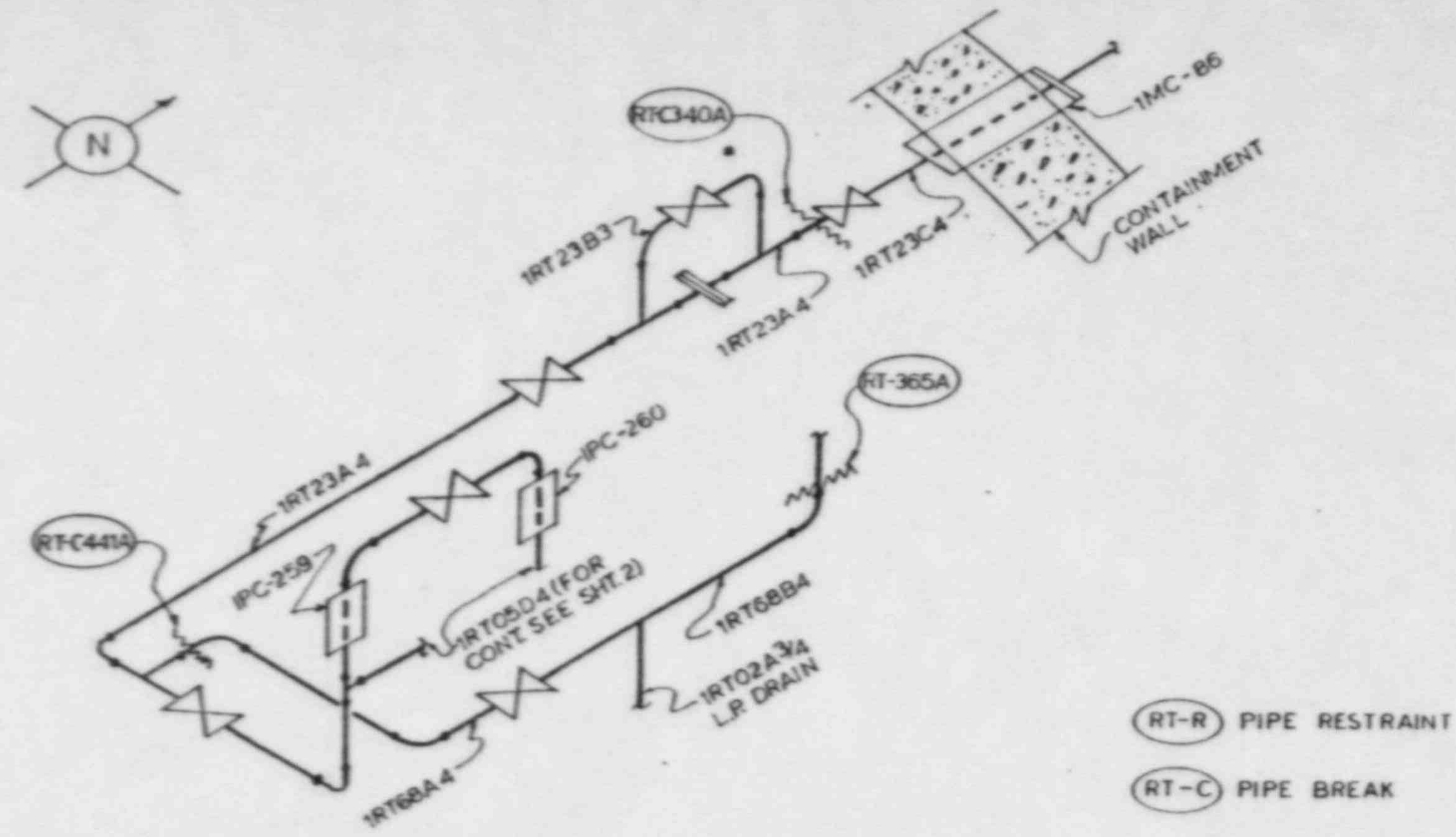
FIGURE B3.6-27

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT
(SHEET 3 OF 8)



CLINTON POWER STATION
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FIGURE B3.6-27

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT
(SHEET 4 OF 8)

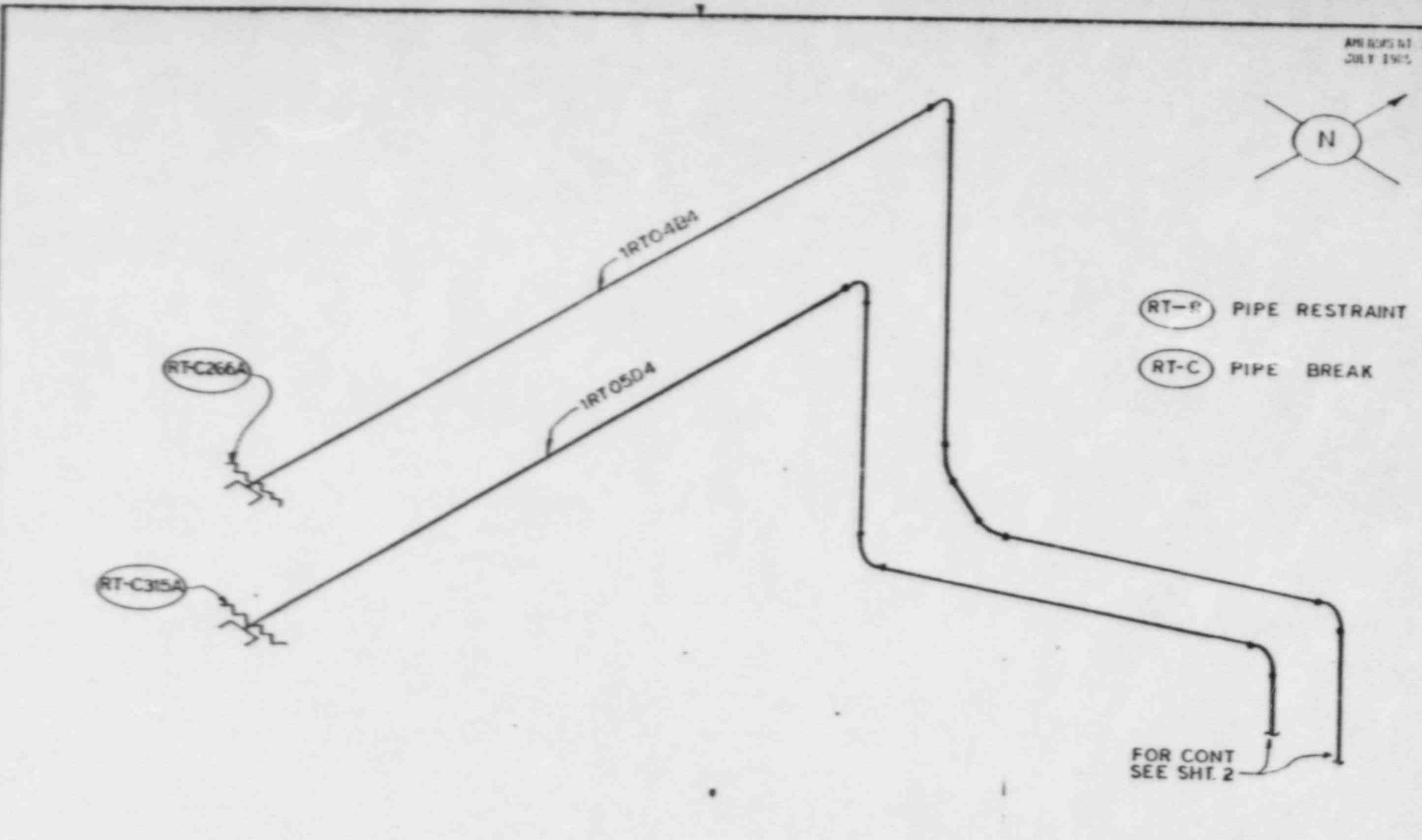

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FIGURE B3.6-27

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT
(SHEET 5 OF 8)

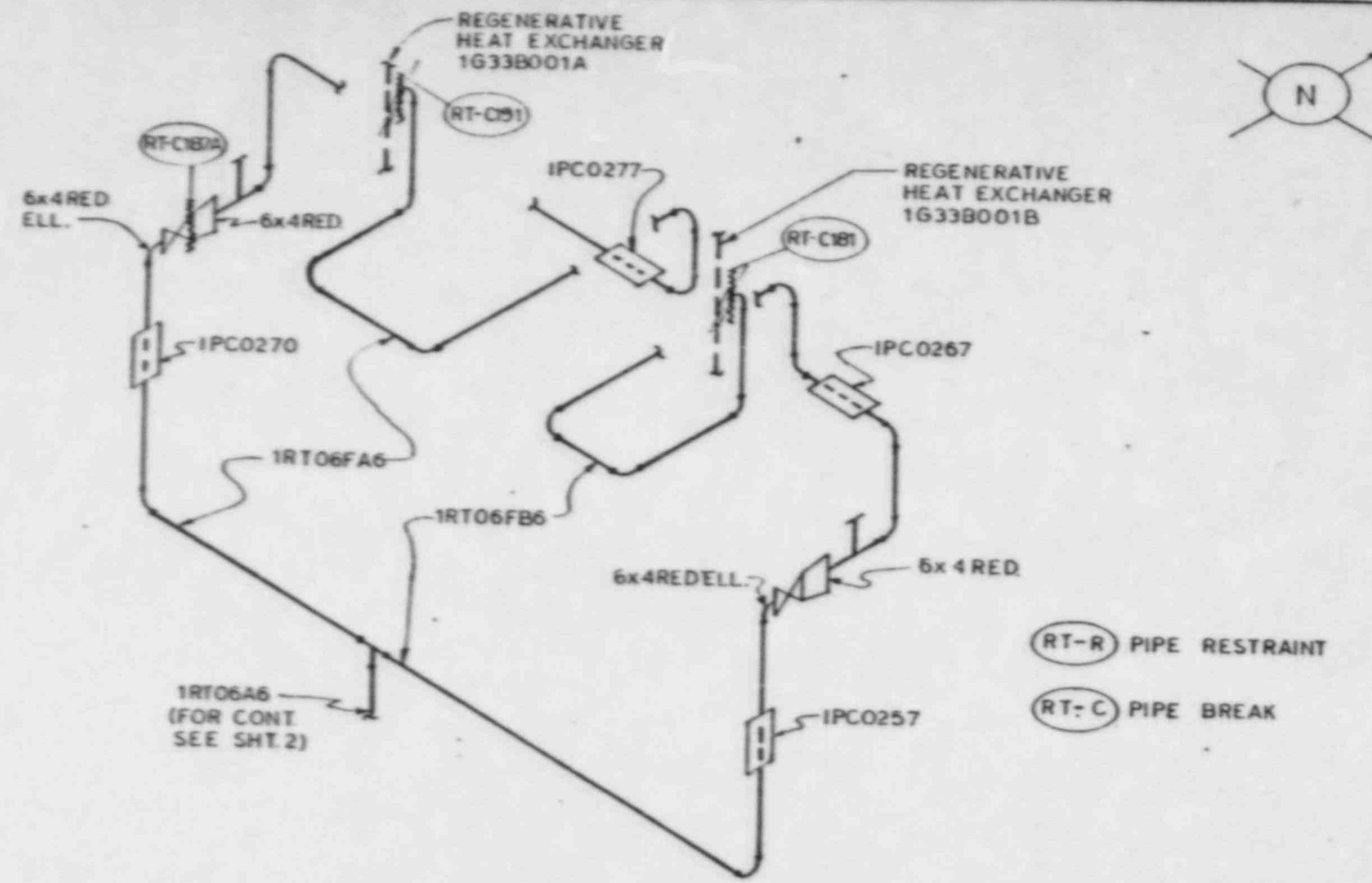

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FIGURE B3.6-27
LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT
(SHEET 6 OF 8)

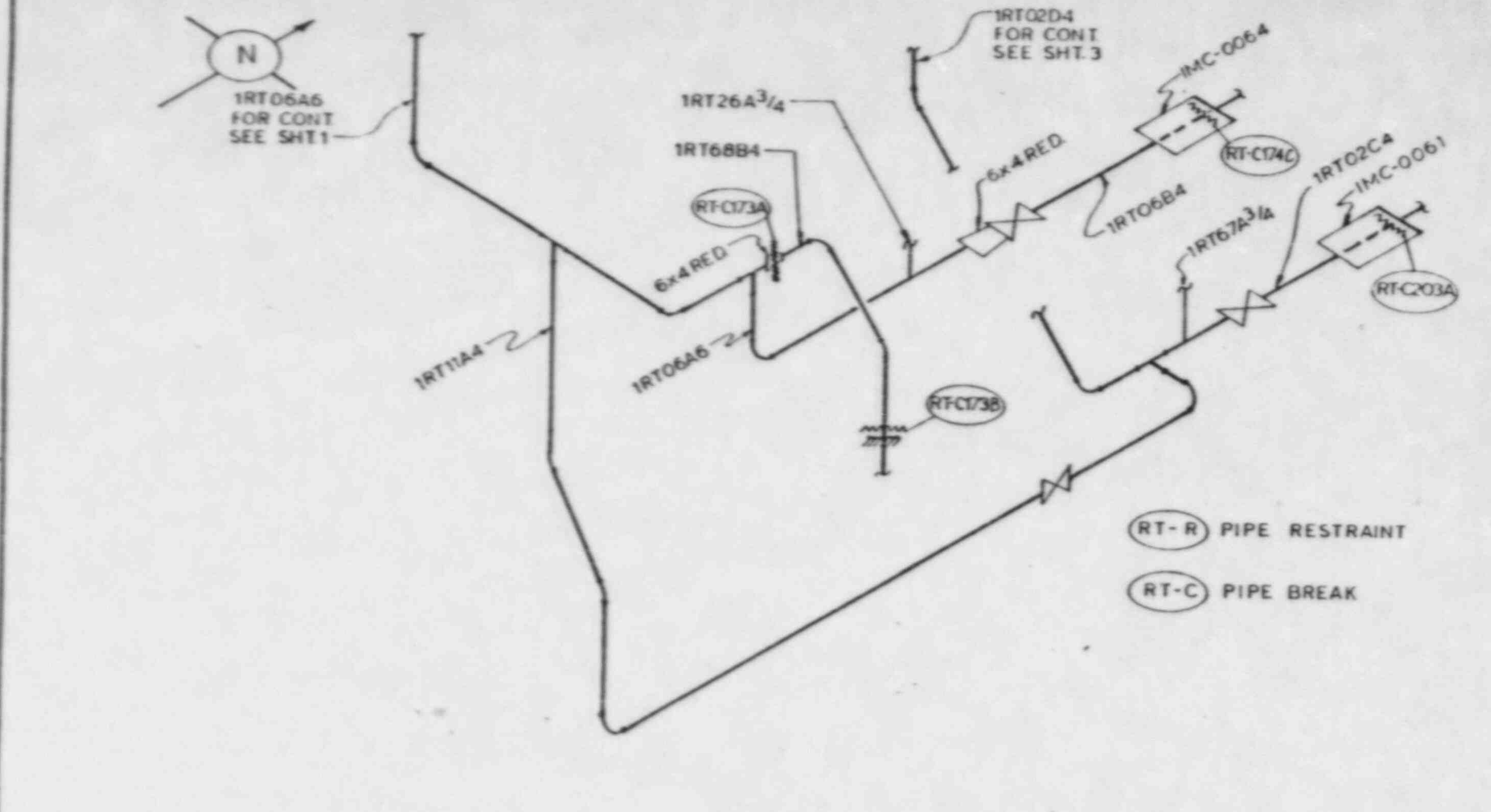

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FIGURE B3.6-27

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT
(SHEET 7 OF 8)

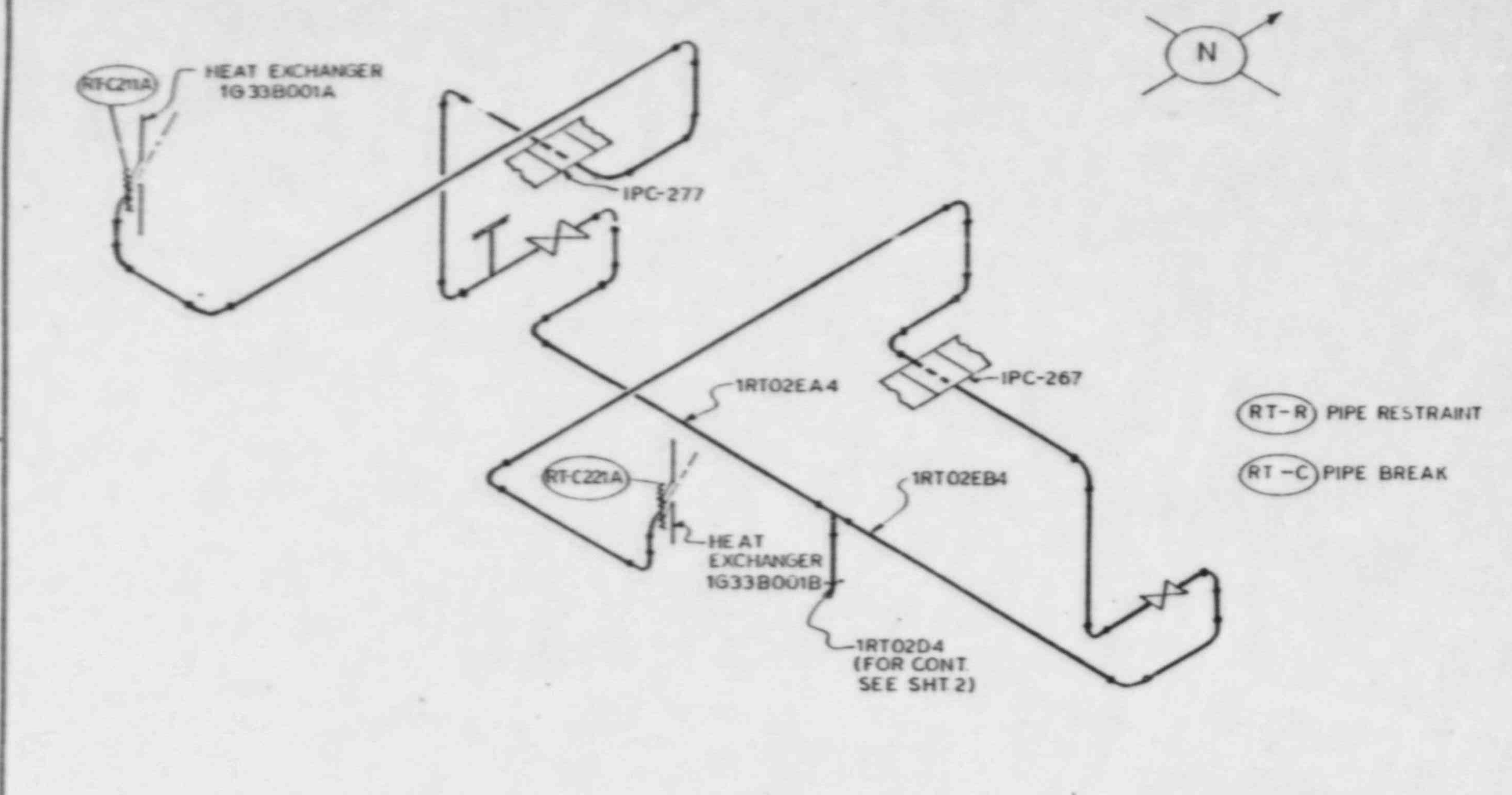

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FIGURE B3.6-27

LOCATION OF POSTULATED BREAKS
REACTOR WATER CLEAN UP
PIPING INSIDE CONTAINMENT

(SHEET 8 OF 8)

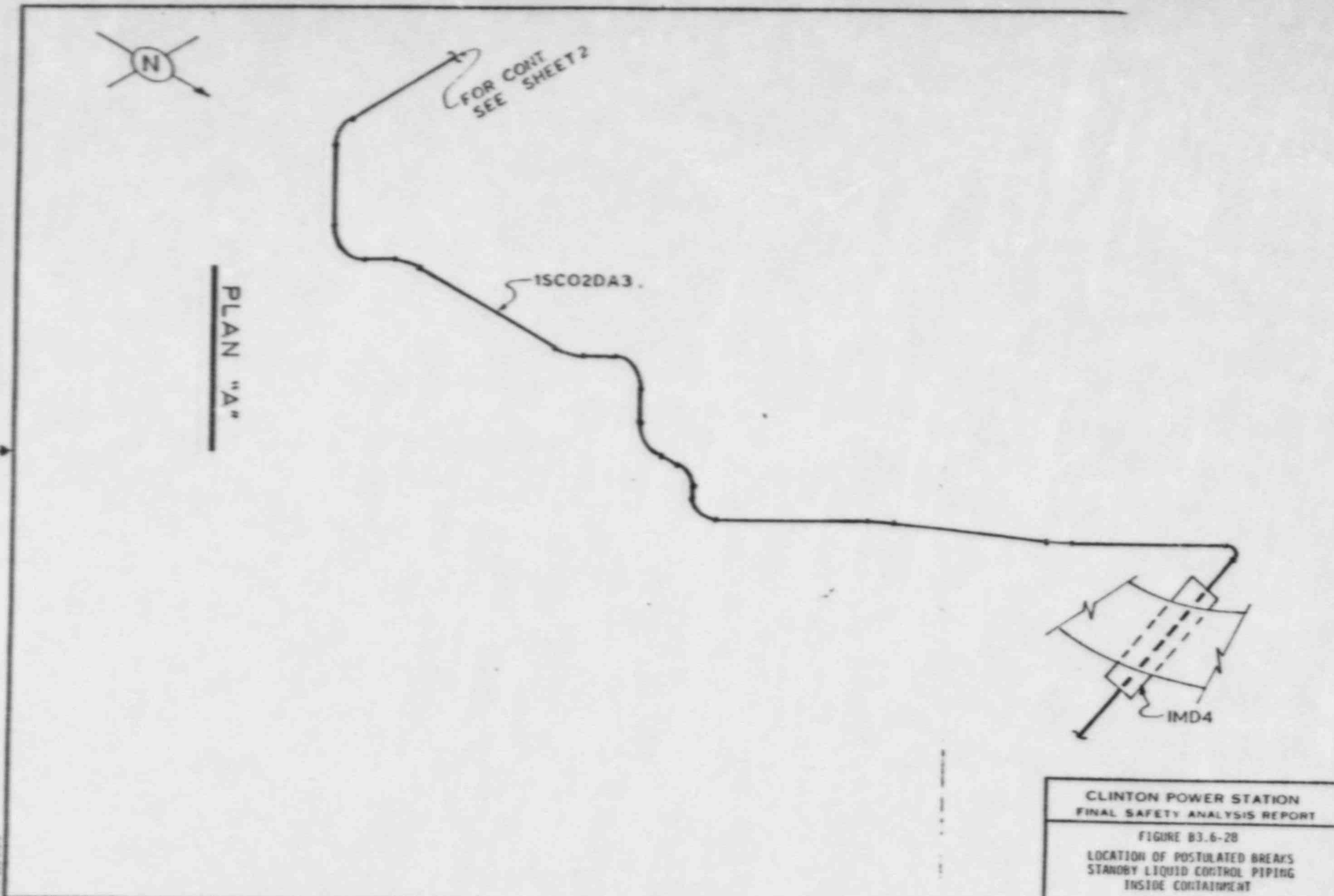

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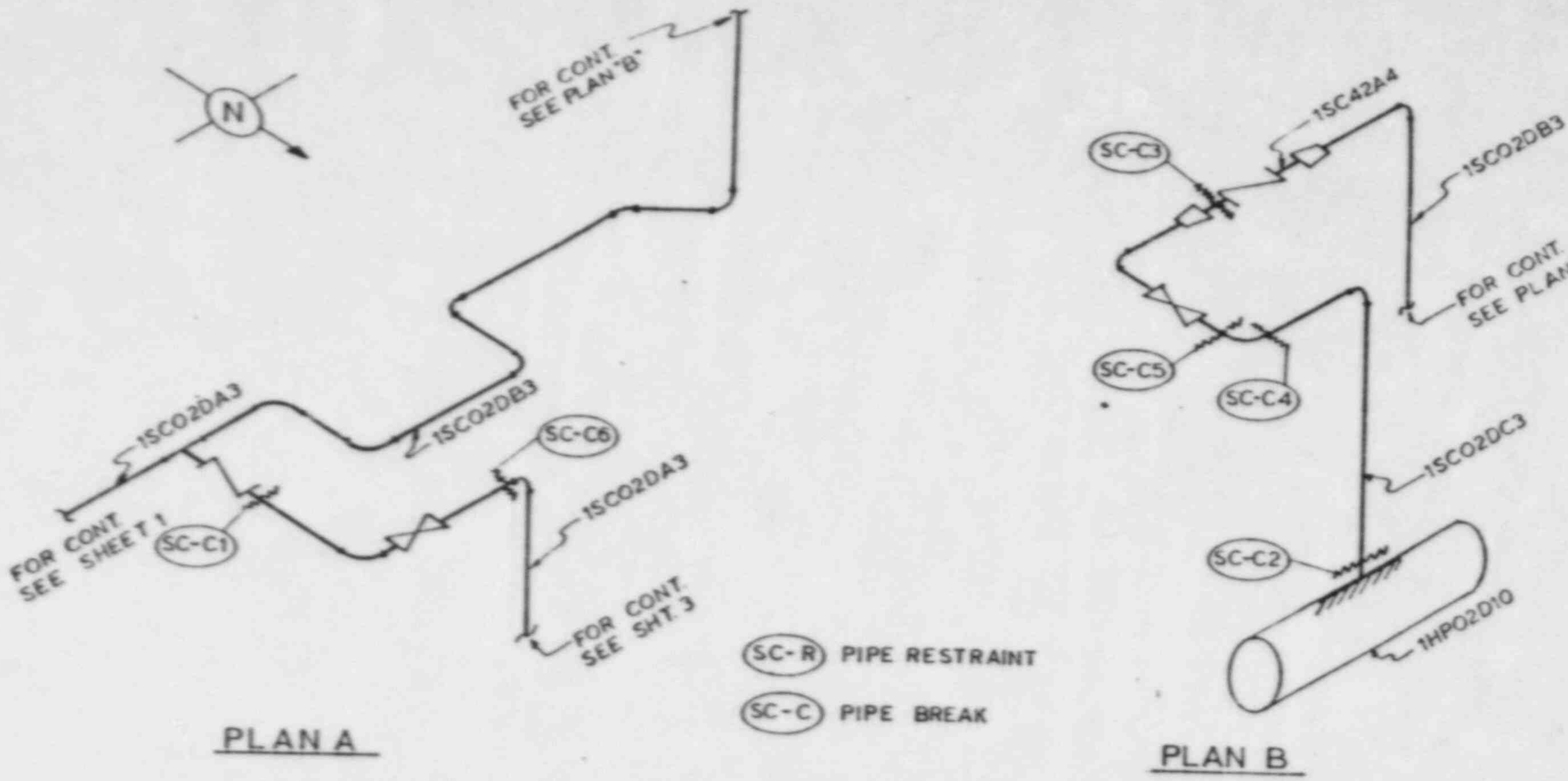
FIGURE B3.6-28

LOCATION OF POSTULATED BREAKS
STANDBY LIQUID CONTROL PIPING
INSIDE CONTAINMENT

(SHEET 1 OF 3)



CLINTON POWER STATION
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FIGURE B3.6-28

LOCATION OF POSTULATED BREAKS
STANDBY LIQUID CONTROL PIPING
INSIDE CONTAINMENT
(SHEET 2 OF 3)

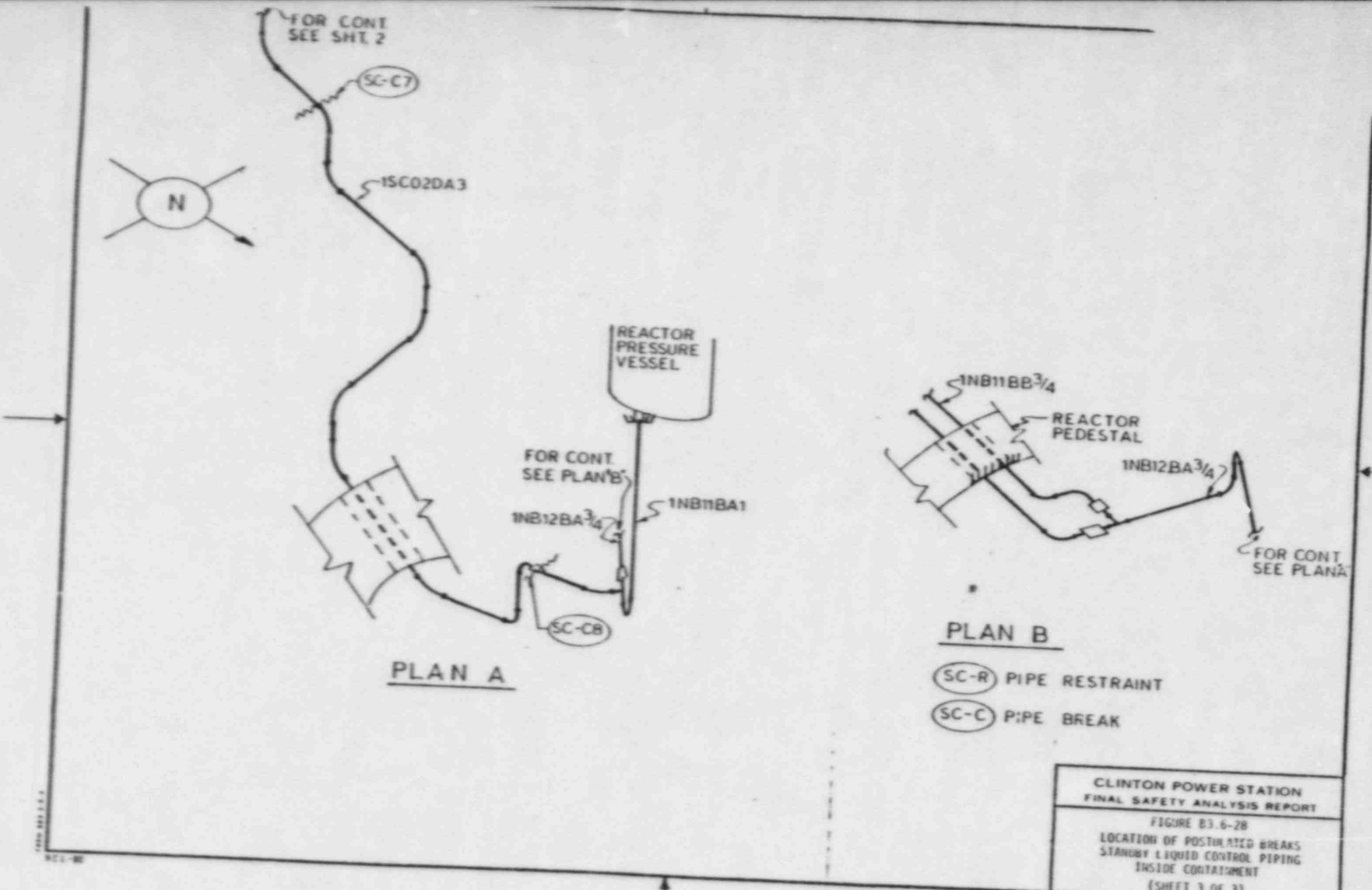

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FIGURE B3.6-28
LOCATION OF POSTULATED BREAKS
STANDBY LIQUID CONTROL PIPING
INSIDE CONTAINMENT
(SHEET 3 OF 3)

b. The distance to be maintained between equipment within different safety divisions precluded disabling or degrading of more than one nuclear safety-related division from a single event.

c. Non-nuclear safety-related equipment which contains high-energy pipelines, corrosive or flammable fluids or presents the potential for plant flooding (see Section 3.4) was located to preclude the disabling or degrading of more than one nuclear safety-related division by a single event.

d. In areas where adequate distance could not be maintained between two or more safety-related divisions or between high-energy non-divisional safety-related equipment and a nuclear safety-related division, a failure mode analysis approach was taken to determine that the safety-related equipment involved was not adversely affected by pipe breaks or cracks in the immediate area. If the analysis indicated that a nuclear safety-related system required protection, barriers were employed (see f. below).

e. Nuclear safety-related equipment incapable of operating unprotected during fire, flooding or a seismic event was housed in seismically qualified floodproofed and/or fireproofed cubicles with appropriate fire protection equipment.

f. In areas where cubicles or wall-type barriers are impractical, mechanical restraints and/or localized barriers were employed between potential hazards and the nuclear safety-related equipment.

The implementation of separation barriers was as follows: (1) distance separation; (2) general or area barriers, such as rooms and walls (see Figures 3.5-3 through 3.5-5, Missile-Proof Walls); and (3) localized or point protection barriers. Methods 1 and 2 were used in all areas, while Method 3 was used primarily for those areas inside the containment.

Color-coded piping and instrument diagrams and color-coded composite diagrams were used to ensure that the routing of high-energy lines throughout the plant did not adversely affect essential systems, components and equipment.

It should be noted here that the pipe whip analysis was performed for those high-energy lines as discussed in Section D3.6.2.

Figures D3.6-1 through D3.6-132 show only the high-energy piping (cross-hatched) and divisional piping, equipment, ductwork and instrument lines. Two inch and smaller piping and instrument tubing or electrical conduit which is presently being routed will be protected in accordance with the requirements of Subsection 3.6.1.

For a description of pipe/crack locations and types, break exclusion areas (no-break zones, that is, areas where a pipe break is not postulated due to meeting the criteria of the Standard Review Plan (SRP) and Branch Technical Position (BTP) MEB 3-1), guard pipes, and pipe whip restraints, refer to Subsection 3.6.2. Attachment B3.6 identifies all pipe whip restraints and associated break locations on isometric drawings.

High-energy lines 8-inch nominal diameter and larger in the areas of the containment drywell are restrained; therefore, the dynamic effects of pipe whip are minimal on essential components. The most limiting problem in these areas is jet impingement. To protect these essential components from jet impingement, the following guidelines are being used in their routing: (1) routing along walls or columns; (2) routing within webs of structural steel; (3) routing using galleries as support; and (4) routing totally within a single divisional area. If routing can not provide adequate protection, then conduit or pipe shield flow diverters or wide-flanged supports will be used in conjunction with heavier conduit or pipe able to withstand the jet loads. The protective measures will conform to the requirements of Subsection 3.6.1.

D3.6.2 HIGH-ENERGY PIPING

High-energy fluid systems are considered to be pipe rupture initiating systems. These systems are listed in Table 3.6-2.

Several of the high-energy systems are located in areas or buildings which house no safety-related systems, equipment or components. Therefore, these high-energy systems cannot impact on safety-related equipment and were not analyzed. Those systems are as follows:

a. extraction steam,

b. condensate,

c. condensate booster,

d. heater drains,

e. miscellaneous vents and drains,

f. turbine drains,

g. turbine gland steam seal steam,

h. radwaste chemical waste process,

i. chemical radwaste reprocessing and disposal,

j. radwaste sludge process, and

k. auxiliary steam.

The remaining high-energy fluid systems are described in the following subsections. Appropriate isometric drawings with break locations and restraints are shown in Attachment B3.6 and Figures D3.6-1 through D3.6-132. These figures depict areas both inside and outside the containment.

For this analysis, the movement of the restrained piping (tip displacement) was calculated using the PWRRA program as described in Subsection 3.6.2.3.3.

D3.6.2.1 Main Steam Piping

The main steam system isometric drawings, Figures B3.6-6 through B3.6-13, as well as composite drawings, Figures D3.6-14, D3.6-112,, D3.6-113, D3.6-115, D3.6-117, D3.6-118, D3.6-119, D3.6-121, D3.6-123, D3.6-125, and D3.6-127 show the location of the postulated pipe breaks and the pipe whip restraints. The stress analysis used for the main steam system is summarized in Tables B3.6-6 through B3.6-13.

D3.6.2.1.1 General

Each of the four 24-inch main steamlines is welded to the appropriate reactor nozzle at elevation 797 feet-½ inch. This is approximately 7 feet above the top of the shield wall. After an elbow, the pipe is routed downward to elevation 771 feet, then horizontally around the reactor to the area between azimuthal angles 341° and 19°, where all four main steamlines then pass through their respective inboard MSIV's and the drywell wall penetrations. The main steamlines then pass through the containment steam tunnel, inside guardpipes, exiting the north wall of the containment and entering the auxiliary building main steam tunnel. Within the auxiliary building main steam tunnel, the main steamline passes through the outboard MSIV, a third safety-related isolation valve, and runs horizontally through the steam tunnel into the turbine building.

No breaks were postulated inboard of the inboard main steam isolation valve and extending beyond the third isolation valve to the north wall of the auxiliary building steam tunnel up to the first elbow fitting from the isolation valve (see Figures B3.6-6 through B3.6-9 and B3.6-12). The piping from the reactor vessel through the second isolation valve satisfies all the requirements of ASME Code, Section III, Class 1, Quality Group A. Between the second and third isolation valves, the piping is Class 2, Quality Group B. After the third isolation valve, the piping complies with ANSI Standard B31.1, Quality Group D.

A total of 16 safety/relief valves are mounted on the horizontal runs between the reactor and the first isolation valve inside the drywell. The discharge piping and vents lines from these safety/relief valves are normally unpressurized; therefore, there is no potential for dynamic pipe whip or similar hazards.

In addition, an 8-inch line branching from main steamline A supplies steam to the RCIC turbine and to the RHR heat exchanger during the steam condensing mode. This line, which passes through the containment and auxiliary building steam tunnels, is discussed in the analysis of the RCIC System in Subsection D3.6.2.9.

the 10-inch LPCS, the 10-inch HPCS, the CRD hydraulic system, and the relief/ADS valve system. A ruptured main steamline would rapidly depressurize the reactor as discussed in Chapters 6 and 15, therefore, the RCIC, the HPCS and the ADS systems would be unnecessary in mitigating the consequences of a main steamline break.

To preclude any likelihood of loss of a system required for safe plant shutdown, pipe restraints and guides have been installed inside the drywell as shown on the isometric and the composite drawings (see Attachment B3.6 Figures).

The environmental conditions are the same as the local environment in the drywell. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification).

The effects of jet impingement from jets originating in the main steam system have been evaluated. The main concerns are the effects of jet impingement on the hydrogen ignitors, shutdown instrumentation, ECCS and the CRD piping. The essential equipment and piping required to mitigate the consequences of a postulated main steamline break do not hit sufficient redundant equipment to prevent safe shutdown of the reactor.

D3.6.2.1.3 Inside the Containment Steam Tunnel

The main steam piping from the deflection-limiting restraint inboard of the inboard isolation valve, through the steam tunnel in the containment, has been qualified as a no-break zone. This piping is inside guard pipes, consequently no analysis of failure modes was performed.

D3.6.2.1.4 Inside the Auxiliary Building Steam Tunnel

The main steam piping in the auxiliary building steam tunnel has no breaks from inboard of the outboard isolation valve, through the third isolation valve and through the north wall of the auxiliary building steam tunnel into the turbine building. Consequently, no analysis of failure modes was performed.

Due to the location of the postulated main steamline break and the location and design of the main steam and feedwater guide structures, jets from a break in the main steamline do not impact on any equipment required to mitigate the consequences of the main steamline break.

for the feedwater system is summarized in Tables B3.6-1 through B3.6-3.

The effects of jet impingement caused by feedwater line breaks have been evaluated. The equipment which is required for mitigating the consequences of a feedwater line break, and which may be hit by a jet from a break in the feedwater line are the hydrogen ignitors, ECCS, the CRD and shutdown instrumentation for measuring reactor pressure and level. In the event of a postulated feedwater line break, any equipment which is required for the break has sufficient redundant equipment not hit by the jet, is sufficiently separated from the break so that the equipment can withstand the jet forces, or is protected by barriers.

D3.6.2.2.1 General

From the turbine building, each of the two 20-inch feedwater lines passes through the north wall of the auxiliary building into the auxiliary building steam tunnel. Inside the auxiliary building steam tunnel, feedwater lines pass horizontally through the tunnel, through the motor-operated isolation valves, and through the air-assisted check valves into the containment building. Once inside the containment building steam tunnel, the feedwater lines, enclosed in guardpipes, pass through the tunnel into the drywell, through a check valve and a manual maintenance valve. The line then splits into two 12-inch risers which terminate at elevation 784 feet-3½ inches. At the elevation termination, each feedwater line passes through the shield wall and connects to a reactor nozzle. The only other high-energy lines connecting to the feedwater lines are the 10-inch residual heat removal lines which connect inside the auxiliary building steam tunnel to the feedwater lines between the motor-operated isolation valve and the air-assisted check valves.

No breaks were postulated in the feedwater system piping extending from inboard of the manual maintenance valve in the drywell through the containment steam tunnel, through the auxiliary building steam tunnel and into the turbine building. Breaks were postulated only inside the turbine building steam tunnel after the first elbow fitting and inboard of the manual maintenance valve in the drywell. As previously mentioned, the only other high-energy lines analyzed as part of the feedwater system are the residual heat removal 10-inch lines which connect to the feedwater lines in the auxiliary building steam tunnel between the motor-operated isolation valve and the air-assisted check valves. From the results of the pipe rupture analysis, these two 10-inch RHR lines were postulated to have no breaks between the feedwater line and the auxiliary building steam tunnel wall.

For the location of these breaks, see Figures B3.6-1 and B3.6-2 and D3.6-105, D3.6-107, D3.6-109, D3.6-111, D3.6-113, D3.6-115, D3.6-117, D3.6-119, D3.6-121, D3.6-123, D3.6-125, and D3.6-127. Lines which are in close proximity to the feedwater system risers are the ADS valves and their discharge lines, the 12-inch RHR (LPCI) injection lines Division 2, and the LPCS and HPCS injection lines. The breaks, which were postulated in the horizontal runs of the feedwater piping (outboard of the manual maintenance valve and before the risers), could endanger the following safety-related lines: the 8-inch RCIC steamline, the 12-inch RHR (LPCI) injection line Division 1, and the combustible gas control system discharge lines. To preclude any likelihood of loss of a system required for safe plant shutdown, restraints and guides have been installed inside the drywell as shown on the isometric and composite drawings.

The break of a feedwater line inside the drywell will create conditions no worse than those following a LOCA. All Class 1E electrical equipment inside the drywell whose operation, during or after a LOCA, is required for safe shutdown is qualified for the post-LOCA drywell environment as discussed in Section 3.11.

D3.6.2.2.3 Containment Steam Tunnel

All feedwater piping inside the containment steam tunnel is within the boundaries of the no-break zone and enclosed in the previously mentioned guardpipes. Consequently, a piping failure is not postulated to occur in any of these lines. Guides and restraints are located to minimize the effects of pipe movement of the feedwater pipe within the guardpipes if a break occurs outside the no-break area. The guides and restraints limit any movement to an acceptable level such that damage does not occur to either the guardpipe or any other piping in the containment steam tunnel.

D3.6.2.2.4 Outside Containment

For the feedwater piping, no breaks are postulated from the containment steam tunnel through the auxiliary building steam tunnel and into the turbine building. As previously discussed, the piping in the turbine building is Class D piping, and breaks are thus postulated at any fitting. There is, however, no essential equipment in the turbine building. The entire run of feedwater piping in the auxiliary building steam tunnel is considered to be within the no-break zone (including the RHR 10-inch return lines), therefore, no analysis of failure modes was performed. The reactor water cleanup lines and the residual heat removal lines are discussed in their respective sections in this attachment.

D3.6.2.3 Main Steam Isolation Valve Leakage Control System (MSIV-LCS)

The composite drawings which show the piping for the main steam isolation valve leakage control system are Figures D3.6-8 and D3.6-14. The piping shown on Figure D3.6-8 is not high-energy, as the isolation valves terminate the high-energy portion within the auxiliary building steam tunnel.

D3.6.2.3.1 General

The high-energy portion of the MISV-LCS, shown on Figure D3.6-14, is that between the main steam isolation valve drain line and the isolation valves for the MSIV-LCS located just inboard of the auxiliary building steam tunnel floor.

For the inboard MSIV-LCS, these high-energy lines consist of four 1½-inch lines. For the outboard system, these high-energy lines consist of four 2-inch lines terminating in a 2½-inch header which is isolated inside the main steam tunnel by normally closed motor-operated isolation valves. The size of the high-energy lines in the MSIV-LCS precludes the likelihood of their damaging any other safety-related systems in the near vicinity. Jets from postulated breaks in MSIV-LCS lines do not load any equipment required to mitigate the consequences of a break in the MSIV-LCS.

The environmental conditions associated with the breaks are the same as the local environment in the auxiliary building steam tunnel. All Class 1E electrical equipment in the steam tunnel has been qualified (refer to Section 3.11 for environmental qualification).

D3.6.2.4 Reactor Recirculation System

The reactor recirculation system isometric drawing (Figure B3.6-18) as well as the composite drawings (Figures D3.6-91, D3.6-93, D3.6-95, D3.6-97, D3.6-99, D3.6-101, D3.6-103, D3.6-105, D3.6-107, D3.6-109, and D3.6-111) show the locations of the postulated pipe breaks and pipe whip restraints. The stress analysis used for the reactor recirculation system is summarized in Table B3.6-18. The piping in this system was analyzed for pipe break and pipe restraint locations by General Electric Company.

The effects of jet impingement from breaks in the reactor recirculation piping have been evaluated. The equipment required to mitigate the consequences by a reactor recirculation line break and which may be hit by a postulated jet from the same break are the hydrogen ignitors, shutdown instrumentation, CRD insert and withdrawal piping and the ECCS. In the event of a postulated reactor recirculation line break, any equipment required for the break has sufficient redundant equipment not hit by the jet, is sufficiently separated from the break so that the equipment can withstand the jet forces or is protected by barriers.

guides have been installed to preclude any likelihood of the loss of a system required for safe plant shutdown.

The environmental conditions are the same as the local environment in the drywell. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification).

D3.6.2.5 Low-Pressure Core Spray (LPCS)

The low-pressure core spray system isometric drawing, Figure B3.6-5, as well as the composite drawings, Figures D3.6-113, D3.6-117, and D3.6-121, show the locations of the postulated pipe breaks and of the pipe whip restraints. The stress analysis used for the low-pressure core spray system is summarized in Table B3.6-5.

The effects of jet impingement from breaks in low pressure core spray piping have been evaluated. The main concerns are the hydrogen ignitors, shutdown instrumentation, ADS valves and the other ECCS. The essential equipment is sufficiently separated from both the LPCS and other redundant equipment so that jets from each break do not hit sufficient equipment to prevent safe shutdown of the reactor.

D3.6.2.5.1 General

The portion of the LPCS system which is considered to be high-energy is that piping between the reactor nozzle and the inboard isolation check valve. This system does not operate during normal plant operation; consequently, only that part of the piping which is normally exposed to reactor pressure is classified as high-energy.

The high-energy portion of the LPCS piping begins at the reactor nozzle at elevation 782 feet 9 inches at azimuthal angle 90°. The line passes through the shield wall penetration and drops to elevation 769 feet 5¼ inches, where it runs horizontally, turning at a 90° angle and passing through the locked-open maintenance valve. The line then passes through the inboard isolation valve, which is a check valve, is restrained, and passes out of the drywell. No breaks are postulated after the isolation valve.

D3.6.2.5.2 Inside the Drywell

Systems which are in the vicinity of the LPCS and could be impacted by the dynamic effects of a pipe break or crack are portions of the ADS system including operators and accumulators, the ADS system discharge line and the RCIC steamline. To ensure that no movement of the vertical leg can impact these systems, restraints have been installed to prevent whip.

The environmental conditions are the same as the local environment in the drywell. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification).

D3.6.2.6 High-Pressure Core Spray (HPCS)

The HPCS isometric drawing, Figure B3.6-4, as well as the composite drawings, Figures D3.6-115 and D3.6-123, show the locations of the postulated pipe breaks and pipe whip restraints. The stress analysis used for the HPCS system is summarized in Table B3.6-4.

D3.6.2.6.1 General

The portion of the HPCS system which is considered to be high-energy is that piping between the reactor nozzle and the inboard isolation check valve. This system does not operate during normal plant operation; consequently, only that part of the piping which is normally exposed to reactor pressure is classified as high-energy.

The high-energy portion of the HPCS system begins at the reactor nozzle at elevation 767 feet 5¼ inches and azimuthal angle 270°. The line passes through the shield wall penetration, turns vertically downward and runs to elevation 771 feet 11 3/8 inches, where it passes through one pipe bend. From here it runs horizontally through a 90° elbow at elevation 769 feet 5¼ inches, turns 90° again passing through the locked-open manual maintenance valve and through the inboard isolation check valve. It then makes two 75° turns and passes horizontally out of the drywell at elevation 769 feet 5¼ inches.

D3.6.2.6.2 Inside the Drywell

There is no essential equipment in the immediate vicinity of the HPCS piping reactor nozzle or vertical riser until the line reaches elevation 769 feet 5¼ inches. A break in the HPCS system piping at this elevation could impact the following systems: the ADS system discharge line, the combustible gas control system compressor discharge line and the inboard isolation valves for the drywell cooling system. To preclude the likelihood of loss of any of these systems, restraints and guides were installed as shown on the isometric and composite drawings.

The environmental conditions are the same as for the local environment in the drywell. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification).

The effects of jet impingement from postulated breaks in the high pressure core spray system have been evaluated. The main concerns are the effects of jets from the HPCS system on the hydrogen ignitors, shutdown instrumentation ADS valves and the other ECCS. The required essential equipment is sufficiently separated from the HPCS and the redundant equipment so that jets from any HPCS break do not prevent the safe shutdown of the reactor.

system will not be impacted by a break in the LPCI B Loop. Although these systems are located in this quadrant of the containment and are in the near vicinity of the LPCI B Loop piping, they are not in the vicinity of the high-energy portion. The restraints for breaks located on the high-energy portion of the piping will prevent any damage to these systems in the event of a break.

The effects of jet impingement from postulated breaks in the LPCI "B" system have been evaluated. The main concerns are the effects of jet impingement from the LPCI "B" line on the hydrogen ignitors, shutdown instrumentation, ADS valves and the other ECCS. Each piece of essential equipment is sufficiently separated from the LPCI "B" line and other redundant equipment so that jets from any break do not hit enough equipment to prevent the safe shutdown of the reactor.

D3.6.2.7.2.3 LPCI "C"

The high-energy portion of the LPCI C Loop, Figure B3.6-15, begins at the reactor nozzle at elevation 778 feet 3¼ inches at azimuthal angle 135°. The line passes through the shield wall and drops through the manual maintenance valve to elevation 769 feet 5 inches and through the inboard isolation check valve. Following the isolation valve, it drops down to elevation 764 feet ½ inch, where it passes out of the drywell. No breaks are postulated after the isolation valve. Systems which are in the vicinity of the LPCI C Loop and could be impacted by the dynamic effects of a pipe break are portions of the ADS system discharge piping, the LPCS injection line and the drywell purge system isolation valve. To ensure that no movement of the high-pressure portion of the LPCI C Loop piping can impact these systems, restraints have been installed to prevent pipe whip.

The effects of jet impingement from postulated breaks in the LPCI "C" system have been evaluated. The main concerns are the effects of jet impingement from the LPCI "C" line on the hydrogen ignitors, shutdown instrumentation, ADS valves and the other ECCS. Each essential equipment is sufficiently separated from the LPCI "C" line and other redundant equipment so that jets from any LPCI "C" break do not hit enough equipment to prevent safe shutdown of the reactor.

D3.6.2.7.3 RHR Suction from the Reactor Recirculation Loop B

For the shutdown cooling mode of the RHR system, Figure B3.6-12, suction is taken from reactor recirculation Loop B. This suction line begins at the tee at elevation 733 feet 6 inches and azimuthal angle 0° of the reactor recirculation loop.

The line runs vertically upward through the manual maintenance valve and through a motor-operated isolation valve. After the isolation valve, the line continues upward until at Elevation 775 feet 6 inches it turns 90° and passes out of the drywell, through a guardpipe and out of the containment. The high-energy portion of this suction line is a short L-shaped run extending about 4½ feet horizontally and about 14½ feet vertically. Breaks were postulated as shown in the Attachment B3.6 figures. The only system which is in the near vicinity of this suction line is the RCIC steamline. To ensure that no movement of the vertical leg of the suction line could impact this system, restraints were located to prevent pipe movement.

D3.6.2.7.4 Steamlines to RHR Heat Exchangers

The high-energy portion of the steamline which runs from the RCIC steamline to the RHR heat exchangers begins at the tee of the RCIC steamline located in the auxiliary building steam tunnel at elevation 757 feet 7-1/8 inches and runs upward to a tee at elevation 781 feet 7-3/8 inches. At this tee, the 8-inch line splits into two 8-inch lines which run to each of the two RHR heat exchangers. The line which runs to RHR Heat Exchanger A is routed through the auxiliary building steam tunnel, through the wall, turns vertically upward and terminates in a normally closed motor-operated isolation valve. The line which runs to RHR heat exchanger B is symmetrically opposite to line A about column 112 and also terminates in a normally closed motor-operated isolation valve. No breaks are postulated after the isolation valves. The only pipelines in the near vicinity of the two steamlines going to the RHR heat exchanger that could be impacted by the dynamic effects of a pipe break or crack are portions of the main steam system and the feedwater system. The main steamlines in this area are 24-inch lines and would therefore be unaffected by the dynamic effects of a whipping 8-inch pipe. The two feedwater lines in the vicinity are both 20-inch lines. They also would be unaffected by the dynamic effects of a whipping 8-inch pipe. Because the 8-inch size of these steamlines would not affect the piping in the near vicinity, the only restraints on these lines are those necessary for stress requirements. The only equipment required to mitigate the consequences of an RHR break is one FW or one MS isolation valve per break. There would be two isolation valves per line which remain functional to provide containment isolation.

The environmental conditions for a pipe break in the drywell for any of the LPCI lines or the suction line for the shutdown cooling mode of the RHR system are the same as the local environment in the drywell. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification). The environmental conditions for an RHR steamline break in the auxiliary building steam tunnel are the same as the local environment in the auxiliary building steam tunnel. All Class 1E electrical equipment in the steam tunnel has been qualified (refer to Section 3.11 for environmental qualification).

D3.6.2.8 Reactor Water Cleanup System (RWCU)

The reactor water cleanup system isometric drawings, Figure B3.6-19, as well as the composite drawings (Figures D3.6-8, D3.6-12, D3.6-14, D3.6-89, D3.6-93, D3.6-95, D3.6-97, D3.6-104, and D3.6-105) show the location of the whip restraints and associated postulated pipe breaks. The stress analysis used for the reactor water cleanup system is summarized in Table B3.6-18.

D3 6.2.8.1 General

For many purposes, the reactor water cleanup system can be considered as two nearly separated subsystems: (1) the loop from the reactor, through the heat exchangers, through the filter demineralizers, back through the regenerative heat exchangers, and return to the reactor through the feedwater line; and (2) the auxiliary subsystem which removes the used demineralizer resin and replaces it with new resin. The first is almost entirely classified as a high-energy system; the second, even during the small time it is in operation, is classified as moderate energy. Neither is required for a safe plant shutdown. From the standpoint of piping failure, the only concern is the possible detrimental effect on other equipment.

One 4-inch line taps off of the bottom of each reactor recirculation loop at azimuthal angles 155° and 335°. Each line runs axially out from the reactor at elevation 724 feet 8 inches. Each line passes through a motor-operated isolation valve, turns and runs vertically upward to elevation 732 feet. At this point, both lines turn and circle towards one another around the inside of the weir wall, meeting at a tee at an azimuthal angle of approximately 58°. Two feet before the tee both lines increase in diameter to 6 inches and from the tee, the combined suction 6-inch line turns and runs back to azimuthal angle 19.6°. At this point, the pump suction line drops horizontally to elevation 725 feet 4 inches, turns, and runs through a motor-operated isolation valve. Immediately after the motor-operated isolation valve, the line tees with the pump suction line from the bottom of the reactor vessel. The pump suction line from the bottom of the reactor vessel is routed from elevation 742 feet 6 inches at azimuthal angle 210° northward to where it drops to 725 feet 4 inches and joins with the pump suction line coming from the reactor recirculation lines. For the actual routing of this reactor drain line, see Figure B3.6-19, Sheet 6. One line branches off of the pump suction line from the bottom of the reactor vessel. It contains a normally closed motor-operated bypass line used in the hot standby mode. Another branch from the bypass is a 2-inch reactor drain line which runs to a sump in the drywell. The combined pump suction line (consisting of the combined line from the reactor recirculation loops and the line from the reactor pressure vessel) runs vertically upward from elevation 725 feet 4 inches to elevation 756 feet 5 inches. There the line turns and runs horizontally through the inboard motor-operated containment isolation valve. It then exits the drywell, passing through the containment inside the containment steam tunnel enclosed in a guardpipe. Upon exiting the containment, the line passes through the outboard containment motor-operated isolation valve, turns and is routed around the outside of the containment wall to the reactor water cleanup pump room cubicles. These are located on elevation 737

feet in the area bounded by column rows 117-123 and column rows Z-AB. The pump discharge line then returns to the auxiliary building steam tunnel (along the same general routing), where it passes through the outboard motor-operated containment isolation valve into the containment building steam tunnel. Then the line passes through the inboard containment isolation valve and runs up to the floor above the steam tunnel where the reactor water cleanup heat exchangers are located. Discharge lines from heat exchangers join together in one line which goes through the steam tunnel and then splits into two lines each terminating in separate RWCU filter demineralizers. They are located in cubicles at azimuth 270° and elevation 803 feet 3 inches. Discharge lines from filter demineralizers go back to the steam tunnel in the containment building and both are connected to one pipe. This pipe passes through the inboard containment isolation valve and out of the containment by way of the outboard containment isolation valve. At this point, the line is no longer considered high-energy; however, it does continue northward out of the auxiliary building steam tunnel, into the turbine building and goes to the main condenser. The elevation at which this penetration exits the containment is 762 feet 3 inches. The second line returns reactor water from the reactor water cleanup system to the feedwater system. Headers from the heat exchanger drop vertically downward into the containment building steam tunnel, along the same path as the reactor water cleanup line to the condenser. At elevation 763 feet 8 7/8 inches, the line passes through the inboard containment isolation valve and through the outboard containment isolation valve, where it tees into two branch lines, each routed to one of the feedwater lines. One leg of the tee runs westward through a motor-operated isolation valve and becomes the RHR line (at elevation 763 feet 8-7/8 inches) which terminates in the feedwater line. The other branch of the tee runs across the steam tunnel, where it turns southward through a motor-operated valve and becomes the RHR line which terminates in the second feedwater line.

Portions of the RWCU system require whip restraints. The locations of the restraints and associated postulated breaks are shown in Attachment B3.6.

D3.6.2.8.2 Inside the Drywell

In the pump suction lines, circumferential breaks have been postulated as shown in Attachment B3.6. There is a no-break zone from the containment penetration to the outboard containment isolation valve. The dynamic load of a ruptured RWCU line could impact several systems: the RHR system (suction line for shutdown cooling mode), the main steamlines, and the feedwater lines.

The RHR line itself, an 18-inch line, will not be affected by the rupture of a 6-inch RWCU line. Also in this same area are the main steam and feedwater lines. Both are of such size that they would not be affected by the rupture of the 6-inch RWCU line.

The environmental conditions in the drywell are the same as the local environment. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification).

The effects of jet impingement from postulated breaks in the RWCU lines have been evaluated. Due to the small size and remote location of the RWCU lines, jets from any RWCU line break do not hit sufficient redundant equipment to prevent safe shutdown of the reactor.

D3.6.2.8.3 Inside and Outside Containment (Auxiliary Building Steam Tunnel/Auxiliary Building)

The RWCU piping which is routed inside the containment is located in two areas: (1) the containment steam tunnel, and (2) above the containment steam tunnel in the general area of the reactor water cleanup system equipment. The pump suction line in the containment building steam tunnel is enclosed in a guardpipe. The return lines from the pump are not enclosed in guardpipes; however, they do not connect to the reactor vessel.

The effects of jet impingement and pipe whip from postulated breaks in the RWCU lines have been evaluated. Due to the small size and remote location of the RWCU lines, jets from any RWCU line break do not hit sufficient redundant equipment to prevent safe shutdown of the reactor.

D3.6.2.9 Standby Liquid Control System

The drawings which show the piping for the standby liquid control system are Attachment B3.6 Figures and Figures D3.6-99, D3.6-105, D3.6-107, D3.6-109, D3.6-113, and D3.6-120. (High-energy piping is shown only on Figure D3.6-99.)

D3.6.2.9.1 General

The high-energy portion of the standby liquid control system is that which is shown on the drawings in Attachment B3.6 and Figure D3.6.2-17. The high-energy portion is between the connection to the reactor pressure vessel at elevation 742 feet 3 inches and the first check valve. The line runs from the bottom of the reactor pressure vessel at azimuthal angle 225° outward axially approximately 1 foot, where it drops to elevation 743 feet 3 inches, turns and passes out through the shield wall at elevation 738 feet. Once outside the shield wall, the piping turns and runs vertically upward to elevation 741 feet, where it passes through a motor-operated isolation valve and a check valve. This check valve will terminate the high-energy portion of the line analyzed for pipe rupture.

D3.6.2.9.2 Inside the Drywell

The only systems within the immediate vicinity of the standby liquid control system high-energy piping are the HPCS system, the reactor recirculation system and the control rod drive system. The 20-inch reactor recirculation line and the 10-inch HP line will be unaffected by the rupture of the 3-inch standby liquid control system line. The standby liquid control line is routed such that a break within the shield wall cannot impact the control rod drive system insert or withdrawal lines.

The environmental conditions are the same as the local environment in the drywell. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification).

The effects of jet impingement from potential breaks in the SLCS piping have been evaluated. Due to its routing and small size, jets from potential breaks in the SLCS do not hit sufficient redundant equipment to prevent safe shutdown of the reactor.

D3.6.2.10 Reactor Core Isolation Cooling System (RCIC)

The RCIC isometric drawing is shown in Figure B3.6-17, and the composite drawings include the composite drawings Figures D3.6-2, D3.6-7, D3.6-8, D3.6-110, D3.6-111, D3.6-119, D3.6-121, D3.6-127, D3.6-129, and D3.6-130. The stress analysis used for the reactor core isolation cooling system is summarized in Table B3.6-17.

D3.6.2.10.1 General

Two portions of the RCIC system piping are considered to be high-energy: (1) the steamline to the RCIC turbine, and (2) the reactor pressure vessel head spray line.

to elevation 761 feet 5 inches. After two turns, the line passes through the normally open inboard containment isolation valve and drops to elevation 758 feet 4 3/8 inches, where it passes horizontally out of the drywell and through the containment building steam tunnel. The line exits the containment building steam tunnel and passes through the outboard motor-operated containment isolation valve in the auxiliary building steam tunnel. After the outboard containment isolation valve, the line runs northward approximately 19 feet, where the RHR steam condensing mode steamline branches off. After the tee, the original line reduces in size from 8 inches to 4 inches. The 4-inch line turns vertically downward and drops from elevation 757 feet 6½ inches through the auxiliary building steam tunnel floor to elevation 730 feet, where it goes into the RCIC turbine cubicle. Jets from postulated breaks in the RCIC turbine steam supply line do not impact any equipment required to mitigate the consequences of the break. The compartment at elevation 707 feet 6 inches is the RCIC turbine cubicle. All equipment in this area is for support of the RCIC turbine.

The portion of the RCIC system connected to the reactor pressure vessel head spray which is considered high-energy is that portion between the reactor pressure vessel nozzle and the first check valve. The vessel nozzle is located at elevation 813 feet 10 3/8 inches. Welded to the nozzle is a 6-inch tee. One branch of the tee (at azimuthal angle 150°) is connected to a 4-inch pipe that is reduced to 2-inch size and connected to main steamline "A" at elevation 790 feet 6-1/2 inches. The function of this line is to vent noncondensible gas from the reactor pressure vessel head. The other branch connection located at azimuthal angle 330°, is the inlet to the RPV head spray line from the RCIC pump. After the tee, this line reduces from 6 inches to 4 inches and passes through an air-assisted check valve. This terminates the portion of the line considered high-energy for pipe rupture.

D3.6.2.10.2 <u>Inside the Drywell</u>

In the immediate vicinity of the steamline to the RCIC turbine are the 3-inch main steamline drains, the 12-inch LPCI A injection line, and the 12-inch feedwater line. The dynamic load of the steamline to the RCIC turbine could not affect the larger LPCI injection line or the feedwater line. However, it could impact the 3-inch main steamline drains. The main steamline drains are not required to mitigate the consequences of an accident. To limit the movement of the vertical run and thereby the moments on the inboard containment isolation valve, restraints were located on both the vertical run and the horizontal run inboard of the inboard containment isolation valve. Outboard of the containment isolation valve between the valve and the guardpipe, three restraints were located to prevent unacceptable movement of that piping and conceivably impairment of operation of the isolation valve.

check valve. Breaks were postulated at each weld for conservatism. The actual length of piping precludes damaging any safety-related component in this area. Of primary concern in this area is the drywell head. The drywell dome is designed to accommodate jet impingement and pipe whip loads from the RCIC head spray line.

The environmental conditions from either a reactor pressure vessel head spray line break or a break of a steamline to the RCIC turbine line are the same as the local environment in the drywell. All Class 1E electrical equipment in the drywell has been qualified (refer to Section 3.11 for environmental qualification).

The effects of jet impingement from potential breaks in the RCIC piping have been evaluated. Both the RCIC steam supply and head spray lines are routed such that jets from potential breaks in these lines do not hit sufficient redundant equipment to prevent safe shutdown of the reactor.

D3.6.2.11 Control Rod Drive System

Breaks are not postulated in the CRD lines. As noted in Subsection 3.6.2.1.4f, CRD lines are exempted.

D3.6.3 MODERATE-ENERGY PIPING

Through-wall leakage cracks were postulated to occur in accordance with Subsection 3.6.2. These cracks were assumed to result in low-velocity wetting of any equipment in the area whether above or below the crack and at substantial distances from the crack. In addition, the possibility of compartment flooding was considered and is discussed in Subsection D3.6.4.

Each room, compartment and/or area in each seismic Category I building has been evaluated. Rooms which contain high energy lines as well as moderate energy lines were not evaluated for moderate energy line cracks, but were evaluated for high energy line cracks. All equipment in a room in which a moderate energy line break was postulated was assumed to become inoperable with the exception of valve actuators, junction boxes, pull boxes, conduit and cable trays. Each area of the auxiliary building, control building, diesel-generator building, fuel building, and circulating water screenhouse were evaluated for moderate energy line cracks. These areas can be identified by referring to the general arrangement drawings in Subsection 1.2 and the composite drawings in this attachment. The drywell and containment are subject to high energy line breaks and were not evaluated for moderate energy line cracks.

Concurrent with the moderate energy line crack, a single failure and SSE were postulated. For some systems (e.g., RHR and shutdown service water), a single failure in the redundant system has been excluded in accordance with Subsection B.3.b(3) of BTP ASB 3-1. In all such cases the redundant system train meets the qualification of that NRC position. Loss of offsite power was assumed where a turbine-generator or reactor protection system trip is a result of the postulated line crack. Using the above postulates and assumptions, an analysis was done which identified all equipment in the same room as a MELB and which may be required for plant shut down. A single failure analysis was performed to determine if the identified equipment was required to mitigate the consequence of the cracks in question. The results of this analysis are summarized below.

D3.6.3.1 Containment

All equipment within the containment and drywell which must operate during or after a LOCA is qualified for the appropriate accident environmental conditions as described in Section 3.11. The wetting associated with a postulated failure of any moderate-energy piping is within the bounds of that qualification.

D3.6.3.2 Auxiliary Building

Each compartment or significant area is discussed in detail starting at the lowest elevation, 707 feet 6 inches. Most of the essential equipment is located on the lower two levels in compartments north of the containment.

D3.6.3.2.9 Auxiliary Building Steam Tunnel

The auxiliary building steam tunnel is located at elevation 755 feet 0 inch between column rows 110, 114 and S,Z. Items in this area that are safety-related are primarily the isolation valves. The major pipes in this steam tunnel do not have postulated breaks in this area; however, there are also several moderate-energy pipes installed to ANSI B31.1 standards for which failures are postulated. It has been assumed that these failures could cause failure, in either the open or shut position, of any electrically or pneumatically operated valve in the tunnel. No such valve failure or combination of failures could prevent a safe shutdown or cause unacceptable radiation release. Both motor-operated valves and pneumatically-operated valves in this area fail in a "fail-safe" position.

D3.6.3.2.10 Electrical Switchgear/Motor Control Center Rooms

There are four rooms containing ESF switchgear and motor control centers. Two are located on elevation 762 feet 0 inch, just east and just west of the auxiliary building steam tunnel. The west compartment is located between column rows 102, 107 and S,AD. The east compartment is located between column rows 117, 124 and S,AD. The remaining two electrical switchgear/motor control center rooms are located on elevation 781 feet 0 inch, again on either side of the auxiliary building steam tunnel. The compartment to the west is located between column rows 102, 107 and S,AD. The compartment to the east of the auxiliary building steam tunnel is located between column rows 117, 124 and S,AD. Because all four areas are not designed to be watertight, it has been conservatively assumed that moderate-energy piping failures in either the upper or lower levels will spray the electrical switchgear equipment. The only piping in these areas that is of concern is the shutdown service water piping supplying area room coolers. This portion of piping in the area of the switchgear has been classified as a no-break area due to the low piping stresses. The motor control centers in these areas have been designed to NEMA 1 standards and are therefore sprayproof. The rooms on elevations 755 feet and 781 feet to the east of the auxiliary building steam tunnel are associated with Division 1 electrical equipment only. These rooms are completely separate from the rooms to the west of the auxiliary building steam tunnel on these elevations, which are related to Division 2 electrically. Consequently, it has been assumed that a pipe failure in a Division 1-related room may result in the loss of the switchgear and the equipment powered or controlled by it. However, Division 2 will not be affected by this failure or its consequences and vice versa for failures in Division 2 rooms. Adding to the loss of an assumed independent single failure, the plant can still be safely shut down.

D3.6.3.3 Fuel Building

The fuel building contains relatively little electrical equipment to be protected from a water spray. The only essential equipment

in the fuel building is the high-pressure core spray pump and its associated support equipment. Other items in this area which are supplied with electric power from the emergency diesels include the suction line from the RCIC storage tank and the low-frequency motor generator sets, which supply electrical power to the reactor recirculation pumps. These last two items are not required for the safe shutdown of the plant and were therefore not evaluated for damage from water spray.

D3.6.3.3.1 High-Pressure Core Spray Pump Room

The high-pressure core spray pump room is located on elevation 707 feet 6 inches between column rows 102, 106 and AD,AH. All of the equipment in this room is associated with the high-pressure core spray system and its Division 3 circuits and is assumed to be inoperable if wetted from the spray of a ruptured pipe. Even assuming an additional single failure in the ADS system, the plant could be safely shut down without the use of the high-pressure core spray.

D3.6.3.4 Control Building

Piping in the control building was located with the intention of minimizing the probability of equipment damage from pipe leaks. This approach, combined with the special separation of redundant equipment in the system, results in very low probability of any hazardous effects of leakage. The plant service water and chilled water systems are the primary sources of wetting in the control building. The chilled water lines are located in the basement of the control building. The hydrogen recombiner skids are the only essential equipment located in the basement area. The recombiners are designed to remain operable within the environment of a water spray.

Piping on other floors is limited to plant service water and cooling water for area coolers and chillers. The lines are routed to the extent feasible in areas where there is no other equipment. Therefore, a postulated failure could not wet essential switchgears, motor control centers or equipment. No piping is located in or near the main control room or in the cable spreading room below the control room.

D3.6.3.5 Diesel-Generator Building

Each of the two standby diesel generators and the one HPCS diesel generator has its own room within the building. There are no doors or similar openings in the concrete walls separating them. Consequently, a moderate energy line crack in the piping for any one diesel and a single failure will leave sufficient redundant sources of power to safely shut down the reactor.

In addition, most of the piping is located relatively low in the building, and by the arrangement of the electrical equipment, sensitive items would not be significantly wetted.

D3.6.3.6 Circulating Water Screen House

The circulating water screen house contains the shutdown service water pumps of Divisions 1 and 2 and the cooling water pump for the high-pressure core spray diesel. These pumps and their associated equipment are the only essential items located in the circulating water screen house.

The shutdown service water pumps are located on elevation 699 feet. The pumps for Unit 1 are located in the northeast corner of the building between column rows 1 and 2, close to column C. Each pump is located in its own cubicle and physically separated from all other pumps. All associated support equipment for each pump is located in its respective cubicle. Consequently, no postulated pipe failure in either pump room would disable the redundant pump for that unit. In addition, failure of the high-pressure core spray pump to supply water to the high-pressure core spray diesel cooling system would disable only the high-pressure core spray diesel. This would not prevent safely shutting down the plant.

The height of the stairway landing/door bottom (elevation 715 feet) between the turbine building (elevation 712 feet) and the auxiliary building (elevation 707 feet 6 inches) is above the water level in the turbine building that would be caused by the unlikely rupture of a line from the two condensate storage tanks and the consequent release of 800,000 gallons of water into the turbine building. In the event of a simultaneous rupture of this line and a line from the demineralized water storage tank (400,000 gallons), water will not be contained in the turbine building. However, water will not enter the core spray cooling pump (RHR, LPCS, HPCS, and RCIC) cubicles in the auxiliary building, since they are watertight to elevation 731 feet 5 inches.

In the event that an entire circulating water expansion joint fails, leaving a 6.25 inch gap between the piping and the waterbox, 244,000 gallons of water per minute will be released to the turbine building. Each condenser cavity, designed to contain flooding to elevation 715 feet, is equipped with a redundant system of level switches which will alarm in the control room if the water level in the condenser cavity reaches an elevation of more than 1 foot (elevation 710 feet) above the condenser cavity floor at elevation 709 feet. Additionally, these level switches will close a motor-operated valve in the floor drain piping between the condenser cavity and the turbine building floor drain sump to prevent flooding of the turbine building. A second system of redundant level switches will automatically stop the circulating water pumps if the flood water reaches an elevation of 714 feet within the condenser cavity. An additional foot, from elevation 714 feet to elevation 715 feet remains to contain the water flow due to the coastdown of the circulating water pumps after they are initially signaled to stop. This second set of switches will prevent flood water from entering the turbine building in the event the situation is not resolved after the initial alarm at elevation 710 feet.

In the event of failure of an expansion joint and both redundant sets of level switches, the turbine building could be flooded above 715 feet. Then, because of flow areas between the turbine building and radwaste and control buildings, they could be flooded also. The limiting level of 719 feet could be reached only after 46.6 minutes with no operator action to stop the circulating water pumps. The turbine building water level could reach 726.7 feet in this time, but no essential equipment would be affected. In addition, even assuming the failure of level switches, postulated above, the control room operator will still have adequate warning of flooding in the turbine building. By elevation 719, the CRD pumps and turbine building MCC's 1A, 1B, 1C and 1D, among other things, will be flooded, and before 726.7 feet the condensate and condensate booster pumps will be lost. The control building is protected up to 719 feet as discussed in D3.6.4.5. The radwaste building contains no equipment required for safe shutdown.