EVALUATION OF THE EFFECTS OF POSTULATED PIPE FAILURES OUTSIDE CONTAINMENT FOR MCGUIRE NUCLEAR STATION

May 2, 1977

REPORT NO. MDS/PDG-77-1

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FOREWORD

This report was prepared in response to Mr. A. Giambusso's December 19, 1972 letter to Duke Power Company in regard to the consequences of pipe rupture outside containment during the operation of the McGuire Nuclear Station. This report meets the intent of NRC Branch Technical Positions, MEB 3-1 and APCSB 3-1 with the exceptions identified in FSAR Table 3.6.1-3. This report has been prepared under the direction of Duke Power Company's Design Engineering Department, Mechanical and Nuclear Division.

3 The first phase of this report includes the criteria and procedures used for evaluating the postulated failures and the results of all evaluations for Unit 1. Subsequent revisions will include any pertinent differences between Unit 1 and Unit 2. For resolutions
3 to unacceptable consequences detailed in Chapter 6, alternate resolutions that may accomplish the same results may be used.

1.0 INTRODUCTION

This report presents the results of the evaluation of effects of postulated pipe failures outside containment for McGuire Nuclear Station. The report describes criteria and procedures used in the analysis as developed from the Nuclear Regulatory Commission Branch Technical Positions MEB 3-1 and APCSB 3-1. The intent of this report is to comply with all licensing commitments as provided in FSAR Section 3.6.

Postulated rupture locations and types were determined in accordance with the criteria of Section 3.0. Systems and equipment essential to achieve plant shutdown and mitigate effects of piping failures were determined in accordance with Section 4.0. Sections 5.0 and 6.0 provide the methods used to evaluate possible damage and the results of the evaluation. All required mitigative devices are identified in Section 6.0.

2.0 PLANT DESCRIPTION

2.1 General

The McGuire Nuclear Station is located on Lake Norman in Mecklenburg County, North Carolina and consists of two 1180 MWe generating units. The Nuclear Steam Supply System for each unit is a pressurized water reactor with four coolant loops and is supplied by Westinghouse Electric Corporation. Each containment consists of a free standing cylindrical steel shield enclosed by a separate reinforced concrete Reactor Building.

Major plant structures consist of the Reactor Buildings, the Auxiliary Building, Service Building, and Turbine Buildings. The Reactor Building houses the containment vessel, reactor plant and ice condenser. The common Auxiliary Building contains the spend fuel storage facilities, diesel generators, safeguards system, waste disposal systems, reactor auxiliary systems, and control room. Non-safety shared equipment is housed in the Service Building. The Turbine Building contains the turbine generators and associated secondary system pumps and heat exchangers. These structures and their relationship are shown in Figure 2-1. Figures 2-2 through Figure 2-6 show the various compartments of each Auxiliary Building elevation. Compartment locations are given by building elevation and compartment number.

2.2 Piping Layout

Main steam and feedwater piping represent the greatest damage potential from pipe ruptures outside containment due to their large size and high operating pressure. These lines have been routed outside the Auxiliary Building, which contains the bulk of the safety related equipment. The main steam and feedwater piping penetrate the Reactor Building in the doghouses (room 750-23, -24, -25, -26, Figure 2-5) and pass over the Auxiliary Building roof into the Turbine Building. While the possibility for structural damage resulting from main steam or feedwater ruptures outside containment does exist, potential consequences are minimized by this layout.

Separation of high energy piping from essential components is the most desirable method of precluding unacceptable pipe break damage. Careful attention has been given to location of essential components and the routing of piping systems. In every possible instance, equipment susceptible to pipe break damage is located remote from the piping postulated to fail. The extensive compartmentalization in the Auxiliary Building provides separation of safety related fluid system components from redundant equipment and other high and moderate energy piping systems.

The Turbine Buildings are located directly adjacent to the Auxiliary Building as shown in Figure 2-1 This plant arrangement dictates that Turbine Building piping be routed nearby the Auxiliary Building. However, efforts have been made to separate Turbine Building high energy piping from the Auxiliary Building to the greatest extent pratical. Although the potential for some damage to the Auxiliary Building wall is possible due to Turbine Building piping failures, the interferences between a broken pipe and Turbine Building structural members and piping should prevent unacceptable consequences.

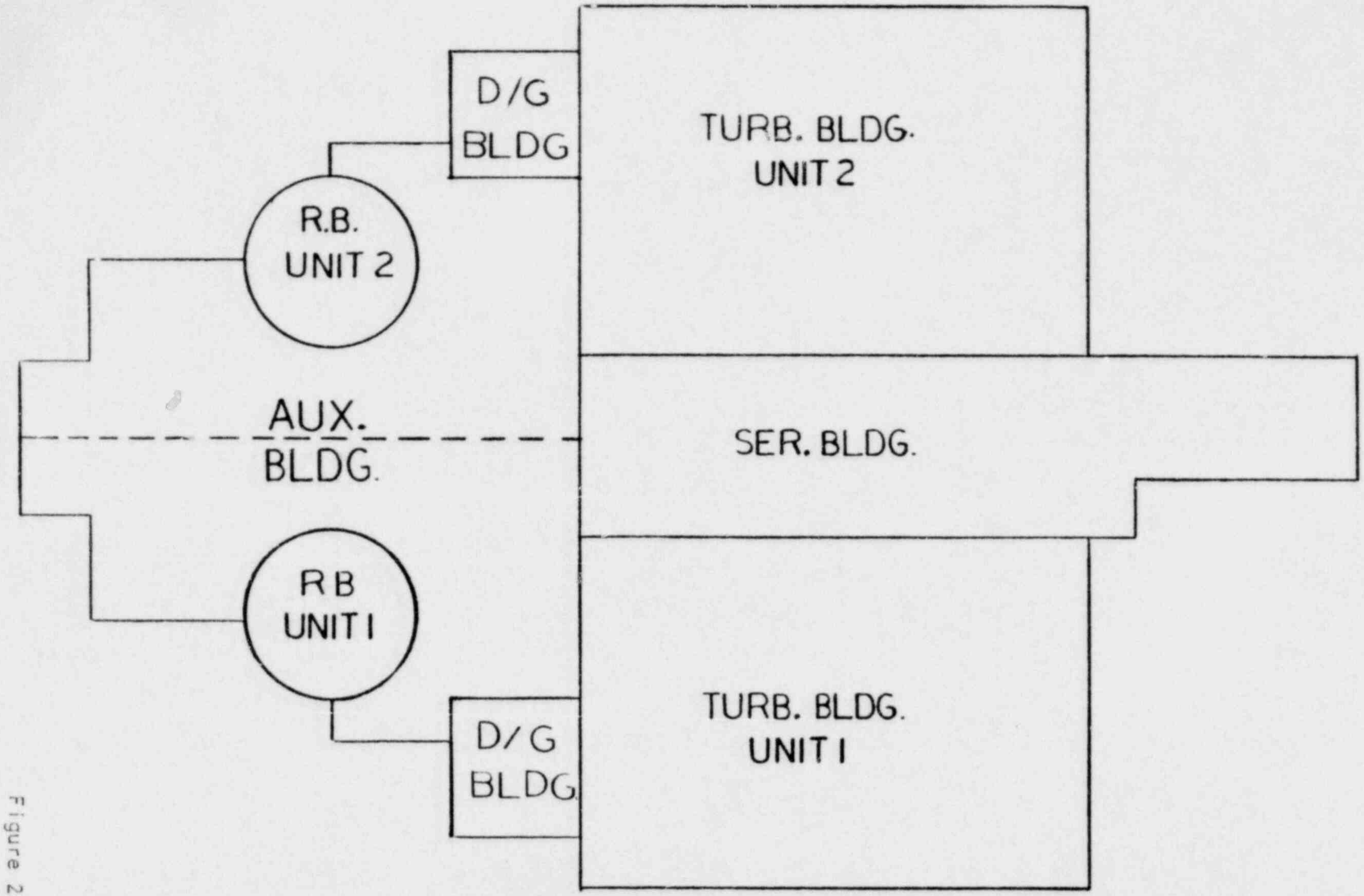
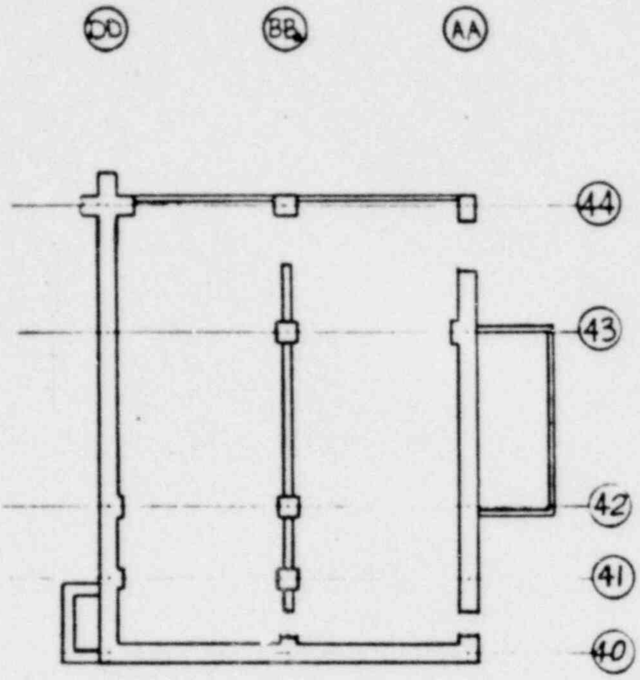
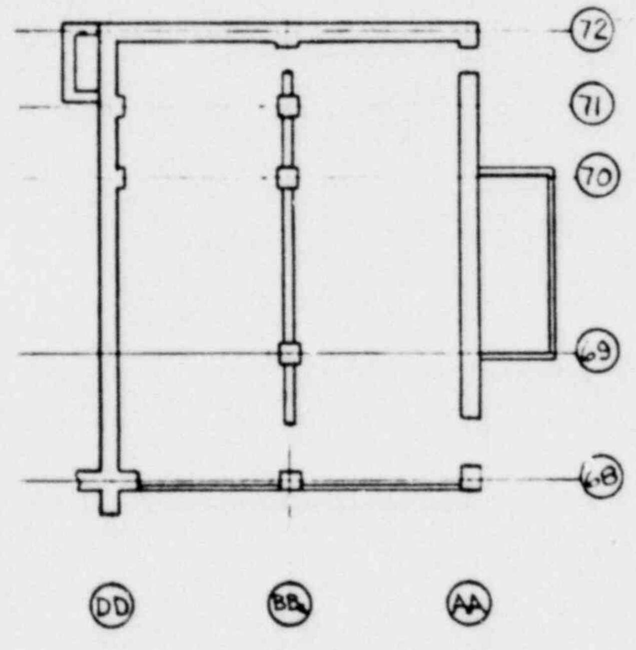


Figure 2-1

MC GUIRE NUCLEAR STATION

KEY PLAN





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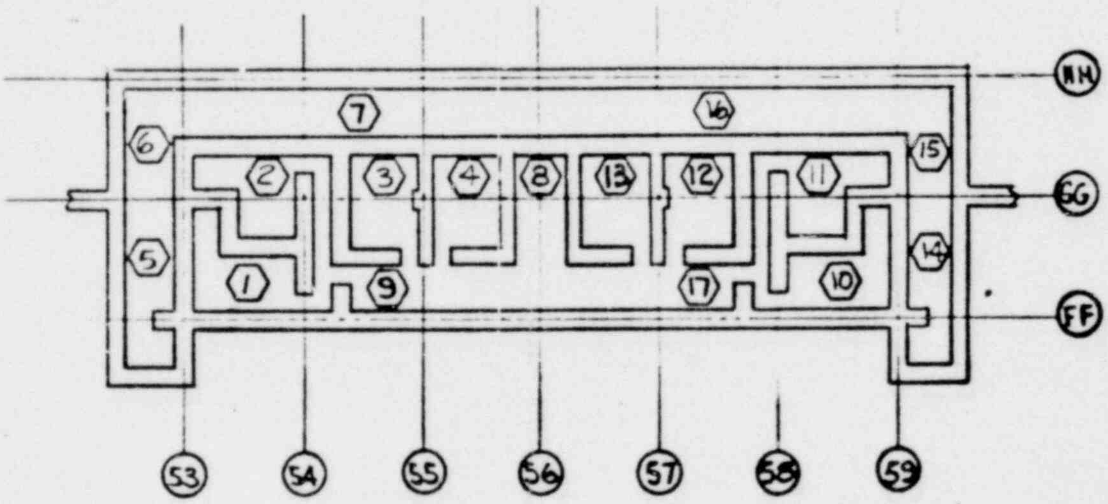

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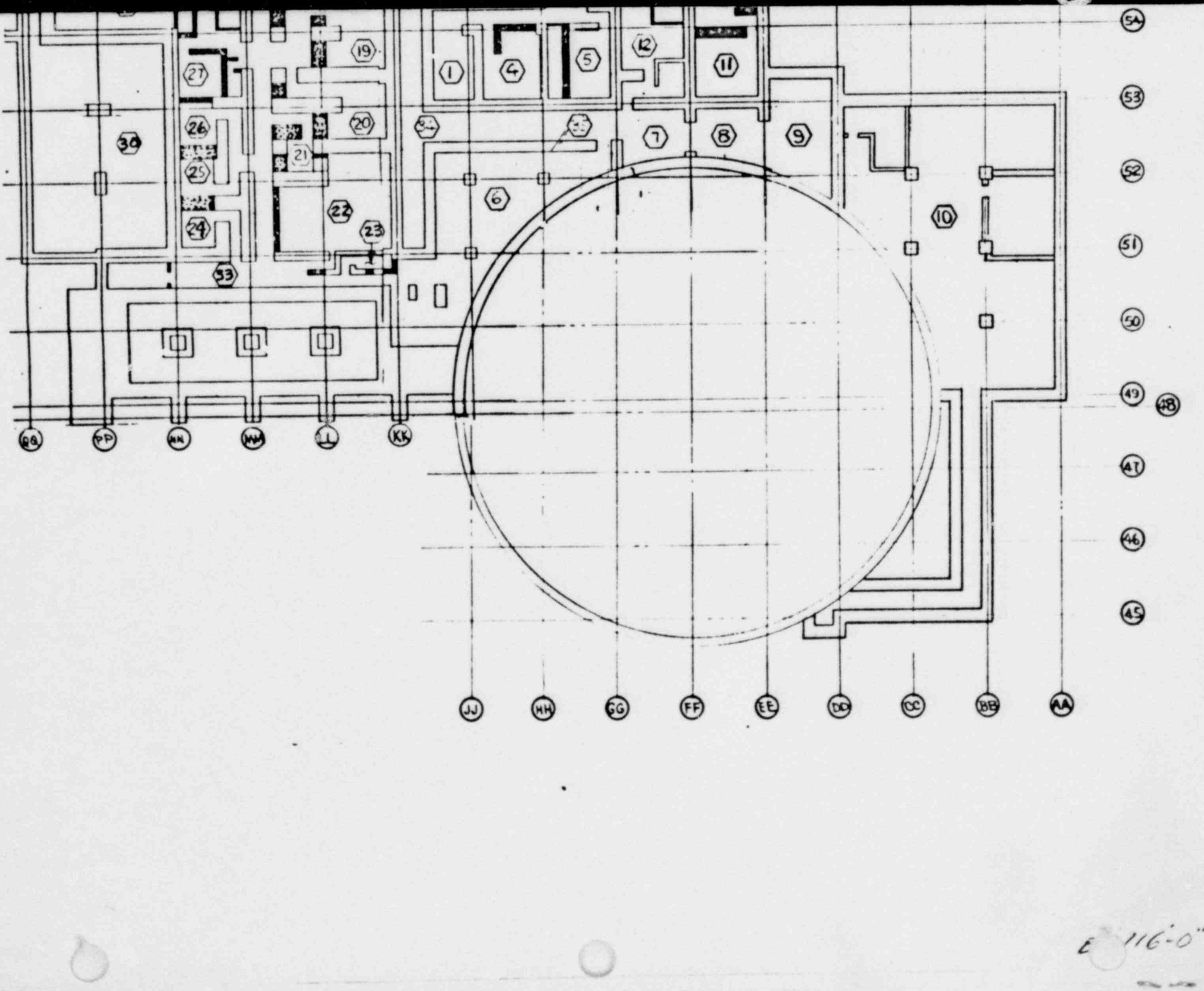
Figure 2-2
McGuire Nuclear Station
Compartment Locations



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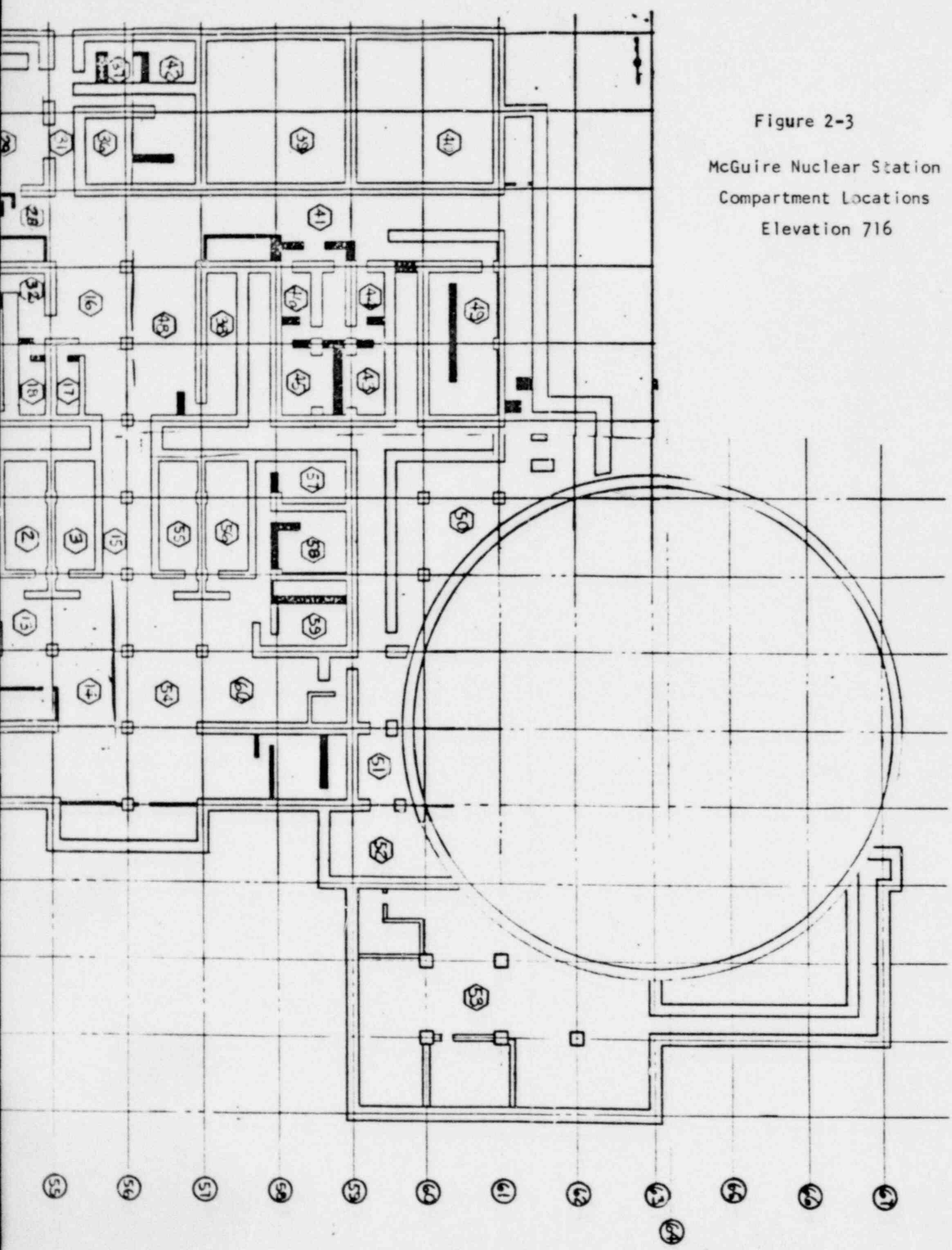

Figure 2-3

McGuire Nuclear Station

Compartment Locations

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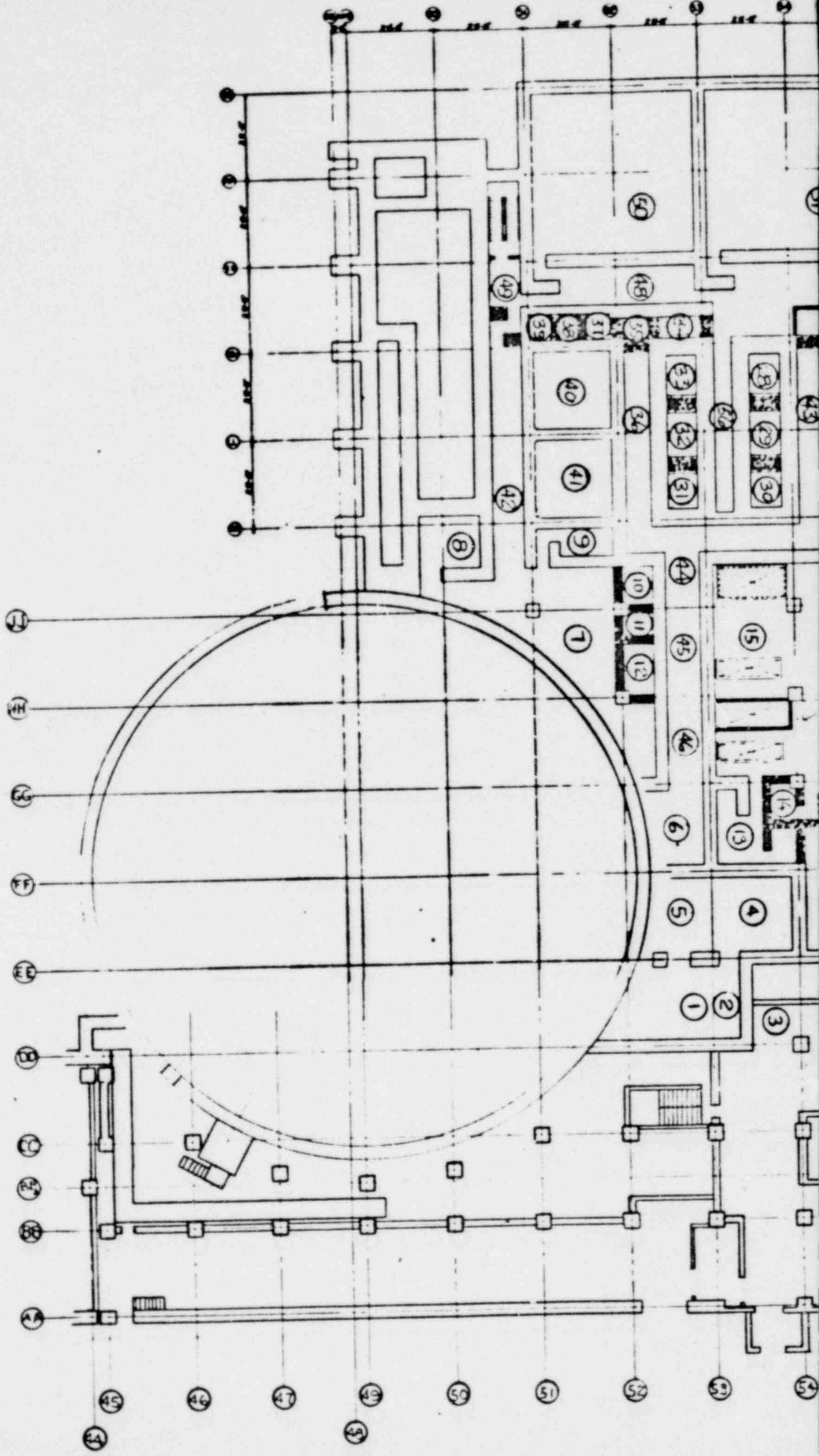


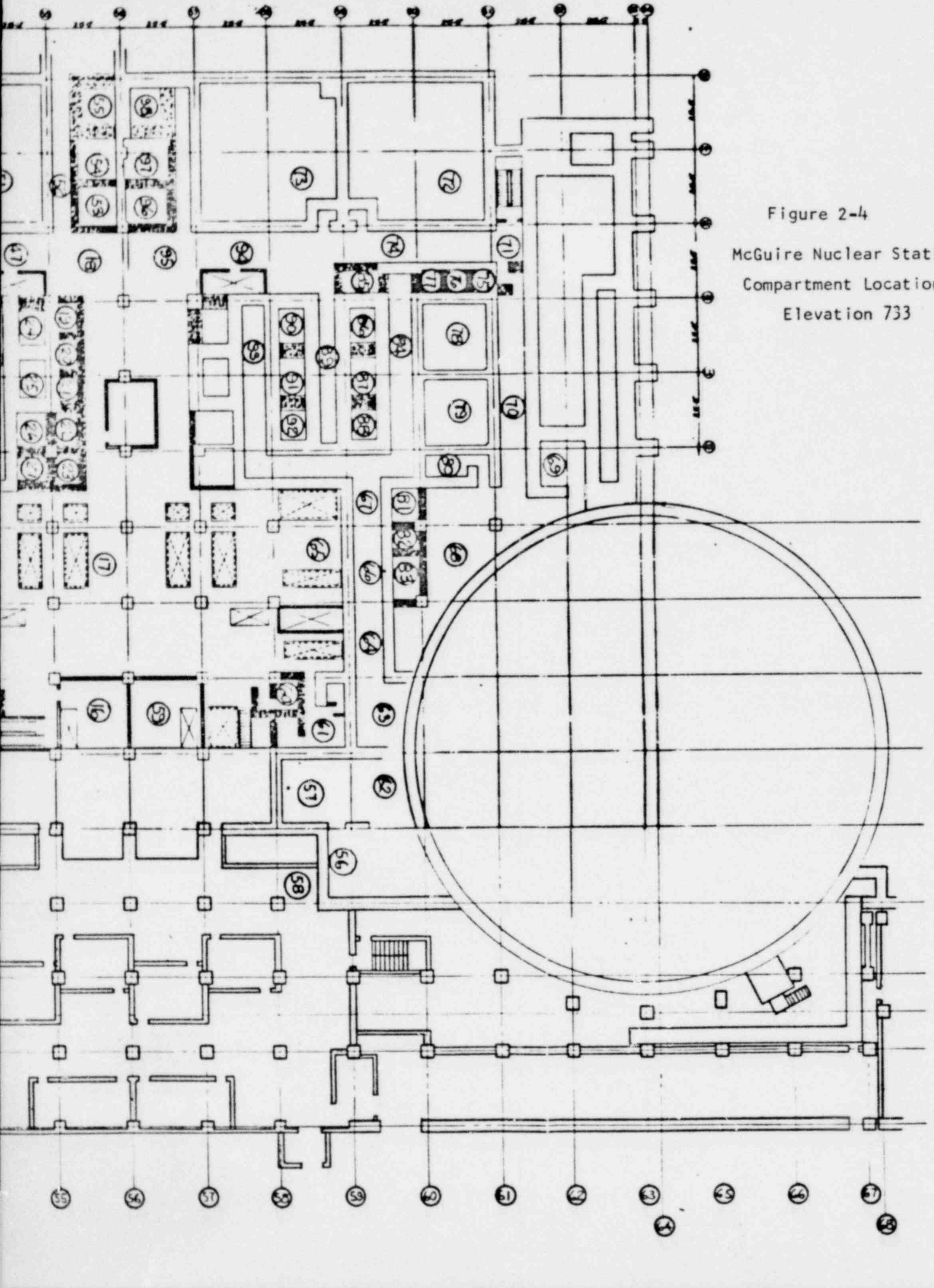
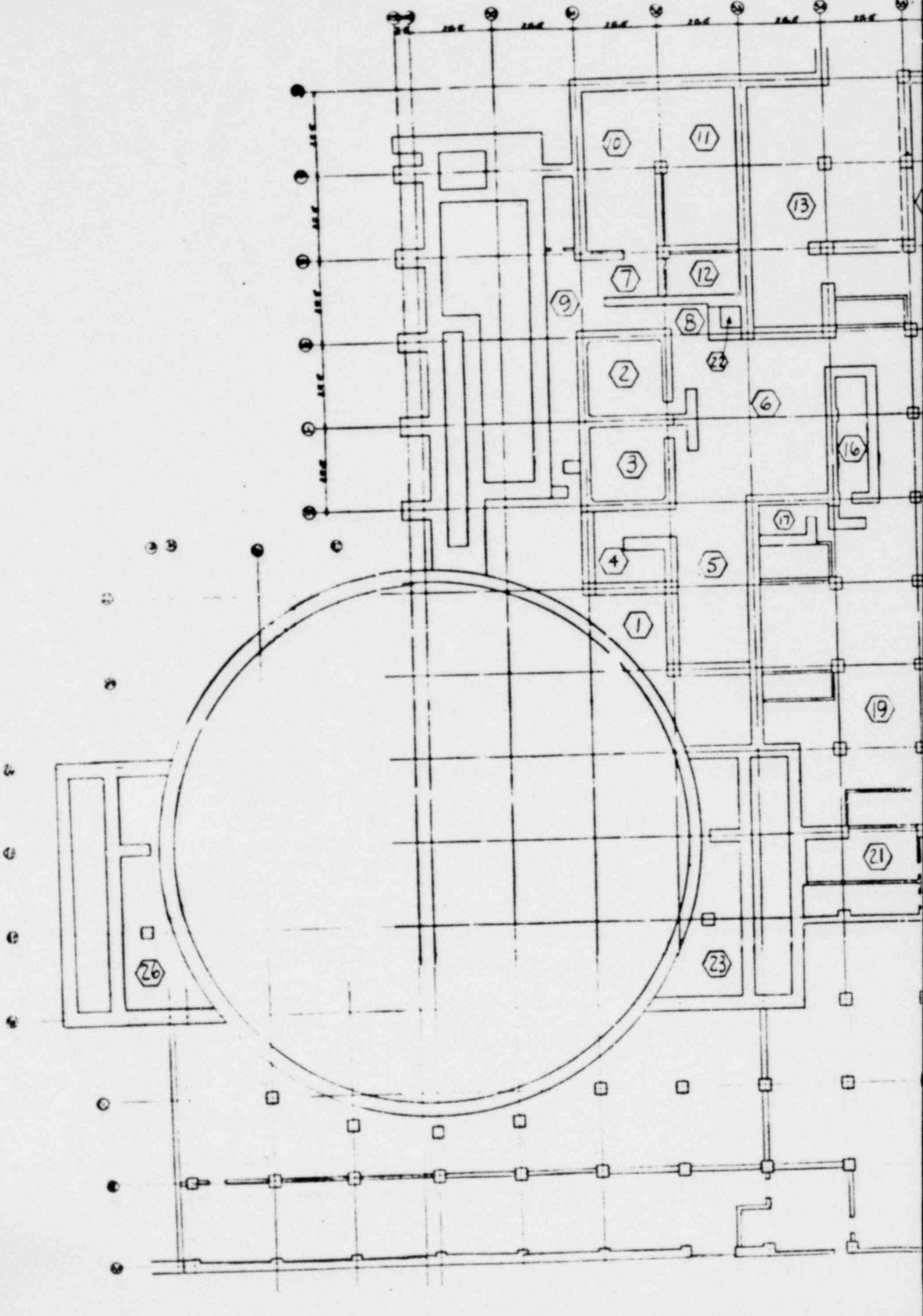


Figure 2-4

McGuire Nuclear Station

Compartment Locations

Elevation 733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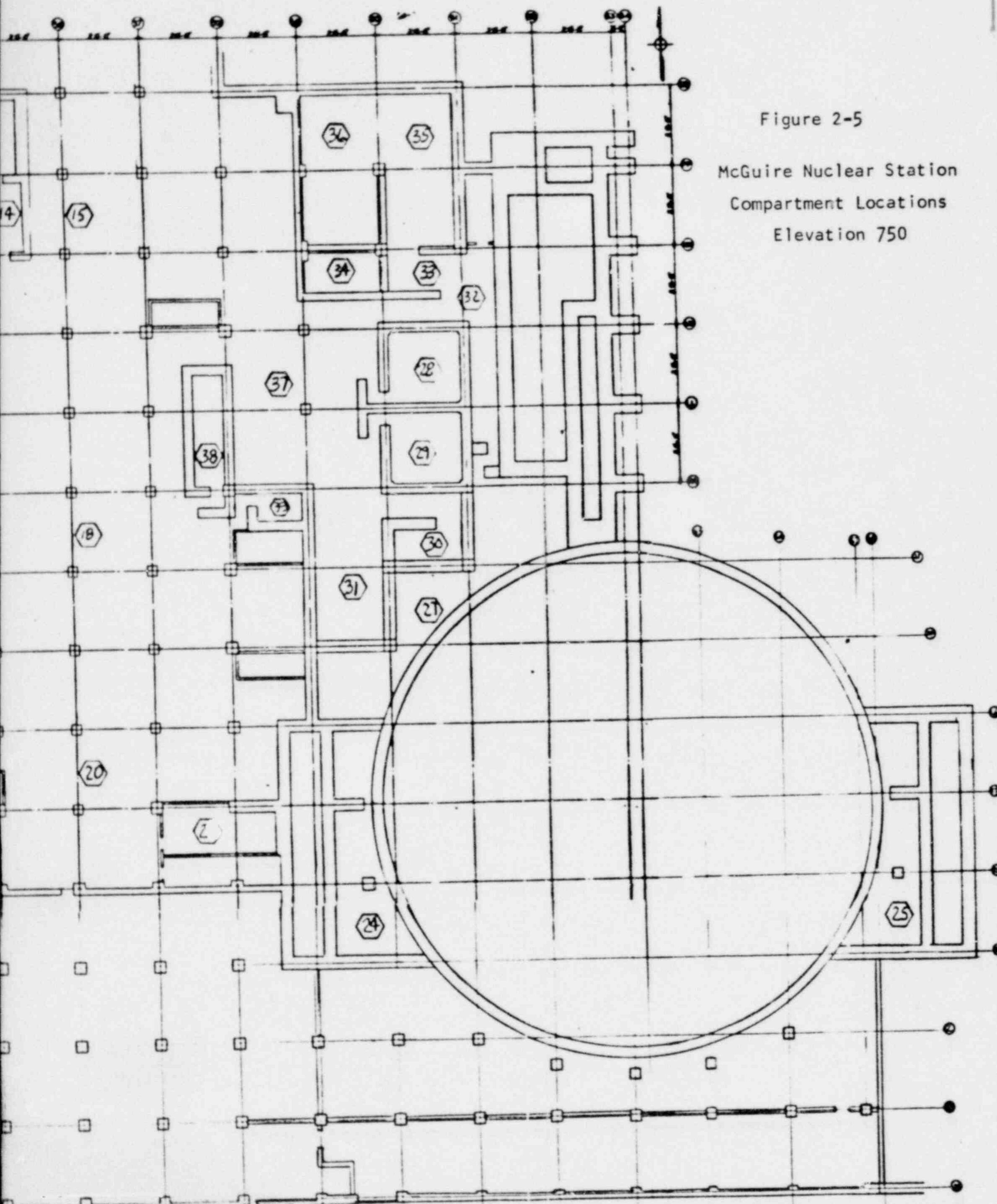
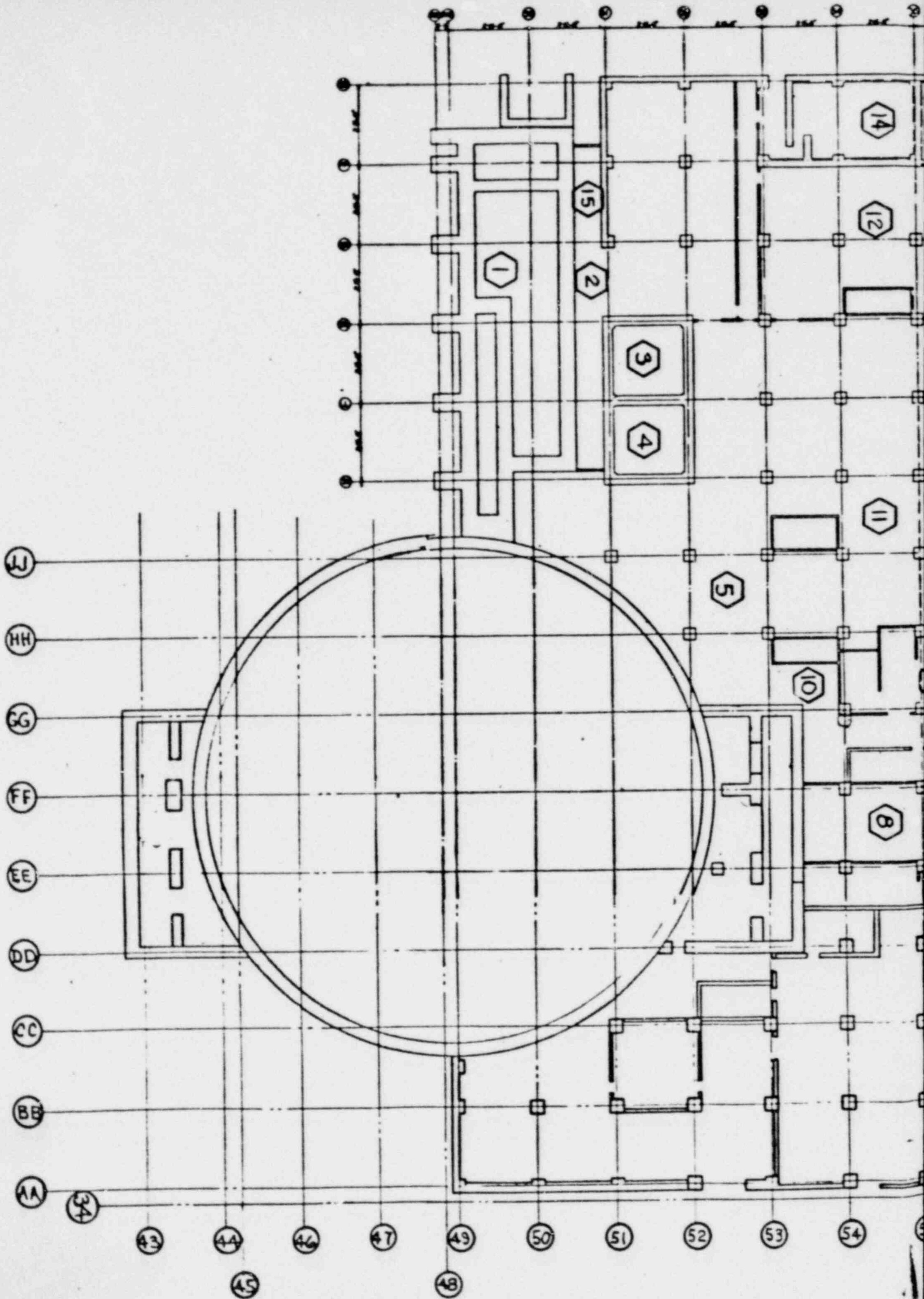


Figure 2-5

McGuire Nuclear Station

Compartment Locations

Elevation 750



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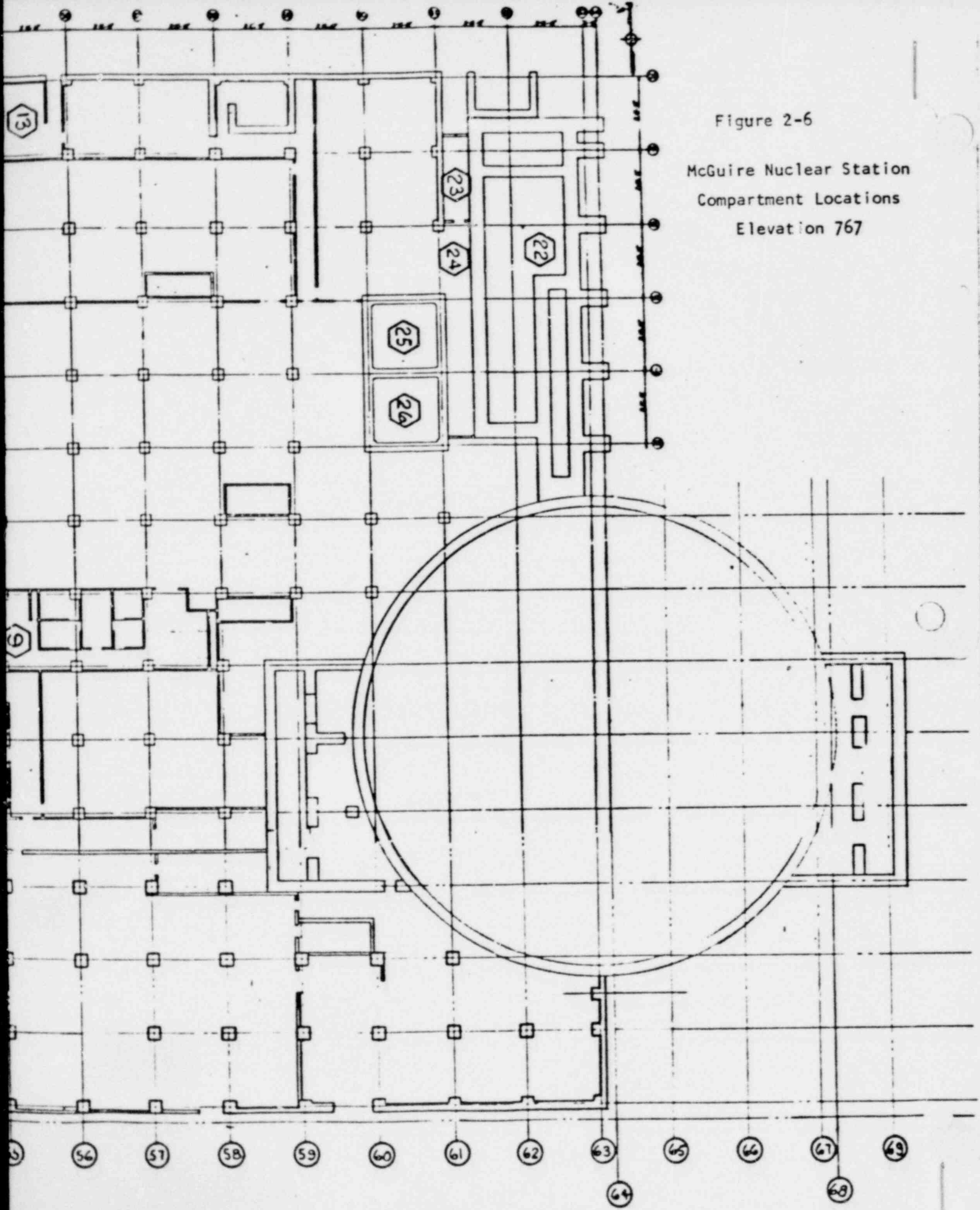


Figure 2-6

McGuire Nuclear Station
Compartment Locations
Elevation 767

3.0 CRITERIA FOR POSTULATING PIPE RUPTURES

3.1 Piping Systems Subject to Postulated Pipe Rupture

Specified ruptures are postulated to occur in plant piping systems, and the potential for damage evaluated on the basis of the level of energy stored in the system. Systems are classified as high-energy or moderate-energy.

3.1.1 High-Energy Piping Systems

High-energy piping systems are those systems, or portions of systems, that during normal plant conditions are either in operation or maintained pressurized under conditions

where either or both of the following are met:

a) Maximum temperature exceeds 200° F, or

b) Maximum pressure exceeds 275 psig.

Except that (1) non-liquid piping systems (air, gas, steam) with a maximum pressure less than or equal to 275 psig are not considered high energy regardless of the temperature, and (2) for liquid systems other than water, the atmospheric boiling temperature can be applied.

Systems are classified as moderate energy if the total time that either of the above conditions are met is less than either of the following:

a) One (1) percent of the normal operating lifespan of the plant, or

b) Two (2) percent of the time period required to accomplish its system design function.

3.1.2 Moderate-Energy Piping Systems

Moderate-Energy Piping Systems are those systems, or portions of systems, that during normal plant conditions are either in operation or maintained pressurized (above atmospheric pressure) under conditions where both of the following are met:

a) Maximum temperature is 200° F or less (or less than the atmospheric boiling temperature for non-water systems), and

b) Maximum pressure is 275 psig or less.

3.2 Break Location and Configuration

3.2.1 Break Locations in Duke Class B, C, and F Piping Runs

Breaks are postulated at the following locations in each Duke Class B, C, and F piping runs.

a) The terminal ends of the pressurized portions of the run,

b) At intermediate locations selected by either one of the following methods:

1. At each location of potential high stress or fatigue, such as pipe fittings (elbows, tees, reducers, etc.), valves, flanges, and welded attachments, or

2. At all locations where the stress, S, exceeds 0.8 $(1.2S_h + S_A)$, where

S = stresses under the combination of loadings associated with the normal and upset plant condition loadings, as calculated from the sum of equations (9) and (10) in Subarticle NC-3600 of the ASME Boiler and Pressure Vessel Code,

S_h = basic material allowable stress at maximum (hot) temperature from the allowable stress tables in Appendix I of the ASME Boiler and Pressure Vessel Code, Section III.

S_A = allowable stress range for expansion stresses, as defined in Subarticle NC-3600 of the ASME Boiler and Pressure Vessel Code, Section III.

c) If there are not at least two intermediate locations where S exceeds 0.8 $(1.2S_h + S_A)$, a minimum of two separated locations are chosen based upon highest stress. If the piping run has only one change of direction, a minimum of one intermediate break is postulated. The pattern of postulated intermediate break locations shall be determined for the normal plant condition load combination and upset plant condition which has the highest stress. Intermediate breaks are not postulated in sections of straight pipe where there are no pipe fittings, valves, flanges, nor welded attachments, nor in piping runs where S is less than 0.4 $(1.2S_h + S_A)$ over the length of the run.

3.2.2 <u>Break Locations In Other Piping Runs</u>

Breaks are postulated to occur at the following locations in each Duke Class E, G, and H piping run.

a) At each location of potential high stress or fatigue, such as pipe fittings (elbows, tees, reducers, etc.), valves, flanges, and welded attachments.

b) The terminal ends of the pressurized portions of the run.

3.2.3 Break Configuration

3.2.3.1 High-Energy Piping

The following types of breaks are postulated in high-energy piping systems:

a) No breaks are postulated in piping having a nominal diameter less than or equal to one (1) inch.

b) Circumferential breaks are postulated in piping having a nominal diameter between one (1) and four (4) inches.

c) Longitudinal and circumferential breaks are postulated, but not concurrently, in piping having a nominal diameter equal to or greater than four (4) inches. At terminal ends where piping has no longitudinal welds, no longitudinal breaks are postulated. Also, at intermediate locations where the criterion for a minimum number of break locations must be satisfied, only circumferential breaks are postulated.

Where break locations are postulated at fittings without the benefit of a detailed stress calculation, breaks are assumed to occur at each pipe-to-fitting weld. If detailed stress analyses or tests are performed, the maximum stressed location in the fitting may be selected as the break location. Where two or more breaks are postulated, break locations are selected with at least 10% difference in stress, or, if stresses differ by less than 10%, locations are selected so as to be separated by a change of direction of the pipe run.

A circumferential break results in pipe severence with full separation, except as limited by structural design features. The break is assumed perpendicular to the longitudinal axis of the pipe, and the break area assumed to be the cross-sectional flow area of the pipe at the break location. The break discharge coefficient used may be substantiated analytically or experimentally. In the absence of this data, the discharge coefficient is assumed to be 1.0.

A longitudinal break results in an axial split without severence. The split is assumed to be oriented at any point about the circumference of the pipe, or alternately at the point(s) of highest stress, as justified by detailed stress analyses. For the purpose of design, the longitudinal break is assumed to be circular or eliptical (2D x $\frac{1}{2}$D) with an area equal to the largest piping cross-sectional flow area at the point of the break, a length equal to twice the piping internal diameter at that cross-section, and have a discharge coefficient of 1.0. Any other values used for the area, diameter, or discharge coefficient associated with a longitudinal break are verified by test data or analysis which define the limiting break geometry.

For purposes of analysis, circumferential and longitudinal breaks are assumed to reach full size within one (1) millisecond after break initiation.

3.2.3.2 Moderate-Energy Piping

Crack openings are assumed as a circular orifice of cross-sectional flow area equal to that of a rectangle with a length of one-half the pipe inside diameter and a width of one-half the pipe wall thickness. The orifice is assumed to be oriented at any point about the circumference of the pipe.

Cracks are not postulated in piping that contains no pressurization equipment; i.e., systems without pumps, pressurizing tanks, boilers, etc., and which operate only from gravity flow or storage tank head. Also, cracks are not postulated in portions of Class B, C, and F piping where the stresses are less than $0.4\ (1.2S_h + S_A)$.

3.3 High Energy Piping Outside Containment

High energy piping outside containment is reviewed by plant area. Auxiliary Building high energy piping is identified in Table 3-1. This table also lists the figure for the applicable flow diagrammatic. All high energy piping is shown by system on figures 3.10 through
3 3.16. Table 3-2 identifies all Turbine Building piping that has been reviewed for pipe rupture.

3.4 Moderate Energy Piping Outside Containment

Only Auxiliary Building moderate energy piping is reviewed in detail. Turbine Building moderate energy piping is incapable of causing any unacceptable damage due to its location away from essential components. Auxiliary Building moderate energy piping systems are identified in Table 3-3.

Table 3-1

McGUIRE NUCLEAR STATION
AUXILIARY BUILDING
HIGH ENERGY PIPING REVIEWED FOR PIPE RUPTURE

1. Steam Generator Blowdown System - BB (See Figure 3.1)

   From: Containment Penetrations M-300, M-301, M-303, and M-304;
   To: 1. The outlet of valve 1BB101;
   2. The service bldg. side of the trench.

2. Auxiliary Feedwater System - CA (See Figure 3.2)

   3 From: Motor Driven Aux. FWD Pumps 1A and 1B;
   To: 1. Containment Penetrations M-156, M-286, M-3100 and M-465 up to and including check valves 1CA37, 1CA49, 1CA53 and 1CA65;
   2. The outlet of valves 1CA70 and 1CA72.

3. Feedwater System - CF (See Figure 3.3)

   From: The Turbine Bldg. header;
   To: Containment Penetrations M-153, M-262, M-308, and M-440.

4. Safety Injection System - NI (See Figure 3.4)

   From: Upper Head Injection Nitrogen Accumulator;
   To: Upper Head Injection Water Accumulator.

   From: Upper Head Injection Water Accumulator;
   To: 1. Containment Penetrations M-334 and M-349;
   2. Four 4" Stand Pipes.
   3. Valves 1NI326, 1NI255B

5. Boron Thermal Regeneration - NR (See Figure 3.5)

   From: Valve 1NR92 (See NV System);
   To: Letdown Reheat Hx.

   From: Letdown Reheat Hx;
   To: Valve 1NR95 (See NV System).

6. Chemical & Volume Control System - NV (See Figure 3.6)

From: 1. Reciprocating charging pump
2. Letdown Hx
3. Sealwater Injection Filters 1A and 1B

3 To: 1A. Penetrations M-350, M-339, M-344, M-343 and M-329;
1B. Sealwater Injection Filters 1A and 1B;
2A. Penetration M-347;
2B. Valves 1NR92 and 1NR95;
2C. Valves 1NV121 and 1NV124;
3A. Valves 1NV225, 1NV231 and BIT outlets
3B. Sealwater Injection Filters A & B.

7. Main Steam Supply to Auxiliary Equipment - SA (See Figure 3.7)

From: Main Steam lines 1B and 1C;
To: The outlet of valves 1SA48 and 1SA49.

8. Main Steam System - SM (See Figure 3.8)

From: Containment Penetrations M-154, M-261, M-393, and M-441;
To: 1. Turbine Bldg. 48" header;
3 2. The outlet of the safety valves and power operated relief valves.
3. The outlet of low point drain valves.

Note: Piping less than or equal to 1" NPS need not be considered for effects of pipe rupture.

McGUIRE NUCLEAR STATION
TURBINE BUILDING
HIGH ENERGY PIPING

1. Auxiliary Steam - AS
   From: Valve 1SM13;
   To: Valves 1AS11, 1AS88.

3

2. Steam Generator Blowdown - BB
   From: Service Bldg. trench;
   To: Valves 1BB123, 1BB124, 1BB125, 1BB126.

   From: Steam Generator Blowdown Blowoff Tank;
   To: Steam Generator Blowdown Blowoff Pumps 1A and 1B.

   From: Steam Generator Blowdown Blowoff Tank Pumps 1A and 1B;
   To: Condensate System.

3. Heating Boiler Feedwater - CB
   From: Aux. Electric Boiler A and B Feedwater Pumps;
   To: Aux. Electric Boiler A and B.

4. Feedwater - CF
   From: Main FDW Pumps 1A and 1B;
   To: 1. HP Heaters 1B1, 1B2, 1B3;
   2. Valves 1CF75, 1CF81, 1CF76.

   From: HP Heaters 1B1, 1B2, 1B3;
   To: HP Heaters 1A1, 1A2, 1A3 respectively.

   From: 1. HP Heaters 1A1, 1A2, 1A3;
   2. Valve 1CF75;
   To: 1. Auxiliary Building Roof;
   2. Valves 1CF124, 1CF107.

5. FDWP Condensate Seal - CL
   From: Valves 1CL1, 1CL4;
   To: FDWP Seal Injection Pumps 1A and 1B.

   From: FDWP Seal Injection Pumps 1A and 1B;
   To: FDWP Seal Injection Hx 1A and 1B.

   From: FDWP Seal Injection Hx 1A and 1B;
   To: Main FDW Pump 1A and 1B.

6. <u>Condensate</u> - CM

From: 1. LP Heaters 1F1, 1F2, 1F3;
2. Valves 1CM130, 1CM420;
To: Condensate Booster Pumps 1A, 1B, 1C.

From: Condensate Booster Pumps 1A, 1B, 1C;
To: 1. LP Heaters 1E1, 1E2, 1E3;
2. Valves 1CM230, 1CL1, 1CL4.

From: LP Heaters 1E1, 1E2, 1E3;
To: LP Heaters 1D1, 1D2, 1D3 respectively.

From: 1. LP Heaters 1D1, 1D2, 1D3;
2. Valve 1CM230;
To: 1. LP Heaters 1C1, 1C2, 1C3;
2. Valve 1CM231.

From: 1. LP Heaters 1C1, 1C2, 1C3;
2. Valves 1CM231, 1HW82, 1HW83, 1HW84; 1CF124;

To: 1. UST Dome;
2. Main Feedwater Pumps 1A and 1B.

7. <u>"A" Heater Bleed Steam</u> - HA

From: 1. HP Turbine;
2. Valves 1HM19, 1HM20, 1HM21, 1HM22, 1HM23, 1HM24;
To: 1. HP Heaters 1A1, 1A2, 1A3;
2. MSR's 1st Stage.

8. <u>"B" Heater Bleed Steam</u> - HB

From: 1. HP Turbine;
2. Valves 1HM34, 1HM35, 1HM36, 1HM37, 1HM38, 1HM39;
To: HP Heaters 1B1, 1B2, 1B3.

3 9. <u>Moisture - Separator - Reheater Bleed Steam</u> - HM

From: Valves 1HM1, 1HM2, 1HM3, 1HM4, 1HM5, 1HM6, 1HM13, 1HM14, 1HM15, 1HM16, 1HM17, 1HM18;
To: MSR's 2nd Stage.

From: MSR's 2nd Stage;
To: Valves 1HM19, 1HM20, 1HM21, 1HM22, 1HM23, 1HM24.

From: MSR's 1st State;
To: Valves 1HM34, 1HM35, 1HM36, 1HM37, 1HM38, 1HM39.

10. Moisture - Separator - Reheater Drain - HS

From: MSR 1A1, 1A2, 1B1, 1B2, 1C1, 1C2;
To: 1. 1st Stage Reheater Drain Tank 1A1, 1A2, 1B1, 1B2, 1C1, 1C2 respectively;
2. 2nd Stage Reheater Drain Tank 1A1, 1A2, 1B1, 1B2, 1C1, 1C2 respectively;
3. Moisture Separator Drain Tank 1A1, 1A2, 1B1, 1B2, 1C1, 1C2 respectively.

From: 1st Stage Reheater Drain Tank 1A1, 1A2, 1B1, 1B2, 1C1, 1C2;
To: 1. MSR, 1st Stage, 1A1, 1A2, 1B1, 1B2, 1C1, 1C2 respectively;
2. Valves 1HS35, 1HS36, 1HS93, 1HS94, 1HS151, 1HS152 respectively.

From: 2nd Stage Reheater Drain Tank 1A1, 1A2, 1B1, 1B2, 1C1, 1C2;
To: 1. MSR, 2nd Stage, 1A1, 1A2, 1B1, 1B2, 1C1, 1C2 respectively.
2. Valves 1HS57, 1HS58, 1HS115, 1HS116, 1HS173, 1HS174 respectively.

From: 1st Stage Reheater Drain Tank 1A1, 1A2, 1B1, 1B2, 1C1, 1C2;
To: 1. HP Heaters 1B1, 1B2, 1B3 respectively;
2. Valves 1HS31, 1HS32, 1HS89, 1HS90, 1HS147, 1HS148 respectively.

From: 2nd Stage Reheater Drain Tank 1A1, 1A2, 1B1, 1B2, 1C1, 1C2;
To: 1. HP Heater 1A1, 1A2, 1A3 respectively;
2. Valves 1HS53, 1HS54, 1HS111, 1HS112, 1HS169, 1HS170, respectively.

From: Moisture Separator Drain Tanks 1A1, 1A2, 1B1, 1B2, 1C1, 1C2;
To: 1. Heater Drain Tanks 1C1, 1C2, 1C3 respectively;
2. Valves 1HS13, 1HS14, 1HS71, 1HS72, 1HS129, 1HS130 respectively.

11. Heater Drain - HW

From: HP Heaters 1A1, 1A2, 1A3;
To: 1. HP Heaters 1B1, 1B2, 1B3 respectively;
2. Valves 1HW22, 1HW23, 1HW24 respectively.

From: HP Heaters 1B1, 1B2, 1B3;
To: 1. Heater Drain Tanks 1C1, 1C2, 1C3 respectively;
2. Valves 1HW37, 1HW38, 1HW39 respectively.

From: Heater Drain Tank 1C1, 1C2, 1C3;
To: 1. Heater Drain Tank Pumps 1C1, 1C2, 1C3 respectively;
2. Valves 1HW43, 1HW44, 1HW45 respectively.

From: Heater Drain Tank Pumps 1C1, 1C2, 1C3;
To: 1. Heater Drain Tank 1C1, 1C2, 1C3 respectively;
2. LP Heaters 1C1, 1C2, 1C3 respectively;
3. Valves 1HW85, 1HW86, 1HW87 respectively;
4. Valves 1HW82, 1HW83, 1HW84 respectively.

From: LP Heaters 1D1, 1D2, 1D3;
To: 1. LP Heaters 1E1, 1E2, 1E3 respectively;
2. Valves 1HW106, 1HW107, 1HW108 respectively;

From: LP Heaters 1E1, 1E2, 1E3;
To: 1. LP Heaters 1F1, 1F2, 1F3 respectively
2. Valves 1HW121, 1HW122, 1HW123 respectively.

12. Main Steam Bypass to Condenser - SB
From: Valve 1SB1;
To: Valves 1SB3, 1SB6, 1SB9, 1SB12, 1SB15, 1SB18, 1SB21, 1SB24, 1SB27.

13. Main Steam - SM
From: Auxiliary Building Roof;
To: 1. HP Turbine
2. Valves 1SV30, 1SV32, 1SV34, 1SV36; 1SV38, 1SV40, 1SV42, 1SV44, 1SM2, 1SP1, 1SP2, 1ZJ105, 1HM1, 1HM2, 1HM3, 1HM13, 1HM14, 1HM15, 1HM4, 1HM5, 1HM6, 1HM16, 1HM17, 1HM18, 1SM12, 1SB1.

14. Main Steam Supply to FDWP Turbine - SP
From: Valves 1SP1, 1SP2;
To: FDW Pump Turbines 1A and 1B.

15. Main Turbine Leakoff & Steam Seal - TL
From: Valves 1TL21, 1SM2;
To: Valves 1TL6 and 1TL8.

16. Plant Heating - YH

3

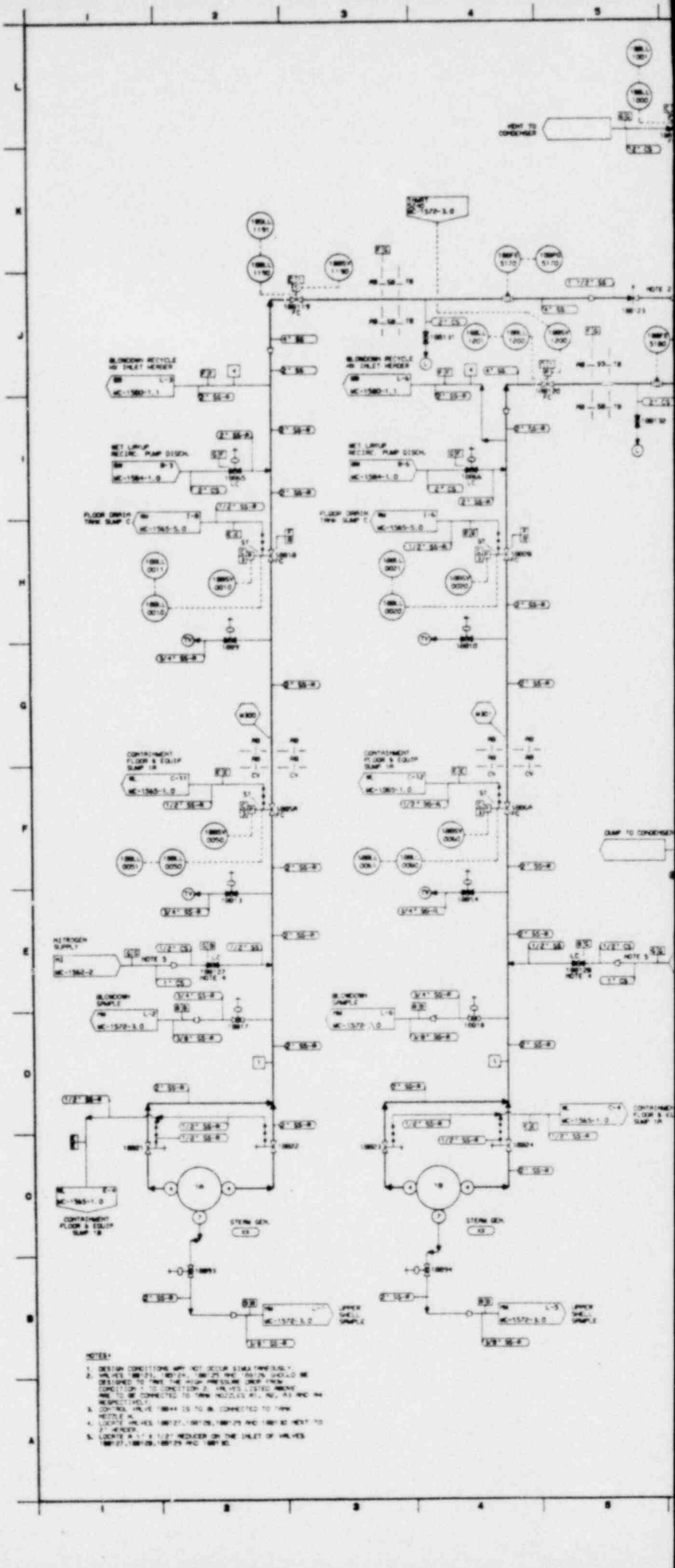
17. Condenser Steam Air Ejector - ZJ
From: Valves 1ZJ105, 1ZJ106;
To: Valves 1ZJ2, 1ZJ4, 1ZJ96.

Table 3-3

MCGUIRE NUCLEAR STATION
AUXILIARY BUILDING
MODERATE ENERGY PIPING SYSTEMS

1. Auxiliary Steam - AS
2. Steam Generator Wet Layup Recirculation - BW
3. Diesel Generator Engine Fuel Oil - FD
4. Refueling Water - FW
5. Component Cooling - KC
6. Diesel Generator Engine Cooling Water - KD
7. Spent Fuel Cooling - KF
8. Recirculated Cooling Water - KR
9. Diesel Generator Engine Lubricating Oil - LD
10. Boron Recycle - NB
11. Residual Heat Removal - ND
12. Ice Condenser Refrigeration - NF
13. Nuclear Sampling - NM
14. Containment Spray - NS
15. Fire Protection - RF
16. Nuclear Service Water - RN
17. Containment Ventilation Cooling Water - RV
18. Breathing Air - VB
19. Diesel Generator Engine Starting Air - VG
20. Diesel Generator Engine Air Intake & Exhaust - VN
21. Station Air - VS
22. Equipment Decontamination - WE
23. Waste Gas - WG
24. Liquid Waste Recycle - WL

25. Liquid Waste Monitor and Disposal - WM
26. Diesel Generator Room Sump Pump - WN
27. Nuclear Solid Waste Disposal - WS
28. Groundwater Drainage - WZ
29. Chilled Water - YC
30. Plant Heating - YH
31. Makeup Demineralized Water - YM
32. Diesel Generator Engine Crankcase Vacuum - ZD



NOTES:

1. DESIGN CONDITIONS MAY NOT OCCUR SIMULTANEOUSLY.
2. VALVES [illegible] SHOULD BE DESIGNED TO TAKE THE HIGH PRESSURE DROP FROM CONDITION 1 TO CONDITION 2. VALVES LISTED ABOVE ARE TO BE CONNECTED TO TANK NOZZLES [illegible] RESPECTIVELY.
3. CONTROL VALVE [illegible] IS TO BE CONNECTED TO TANK NOZZLE [illegible].
4. LOCATE VALVES [illegible] NEXT TO 2" HEADER.
5. LOCATE A 1" X 1/2" REDUCER ON THE INLET OF VALVES [illegible].

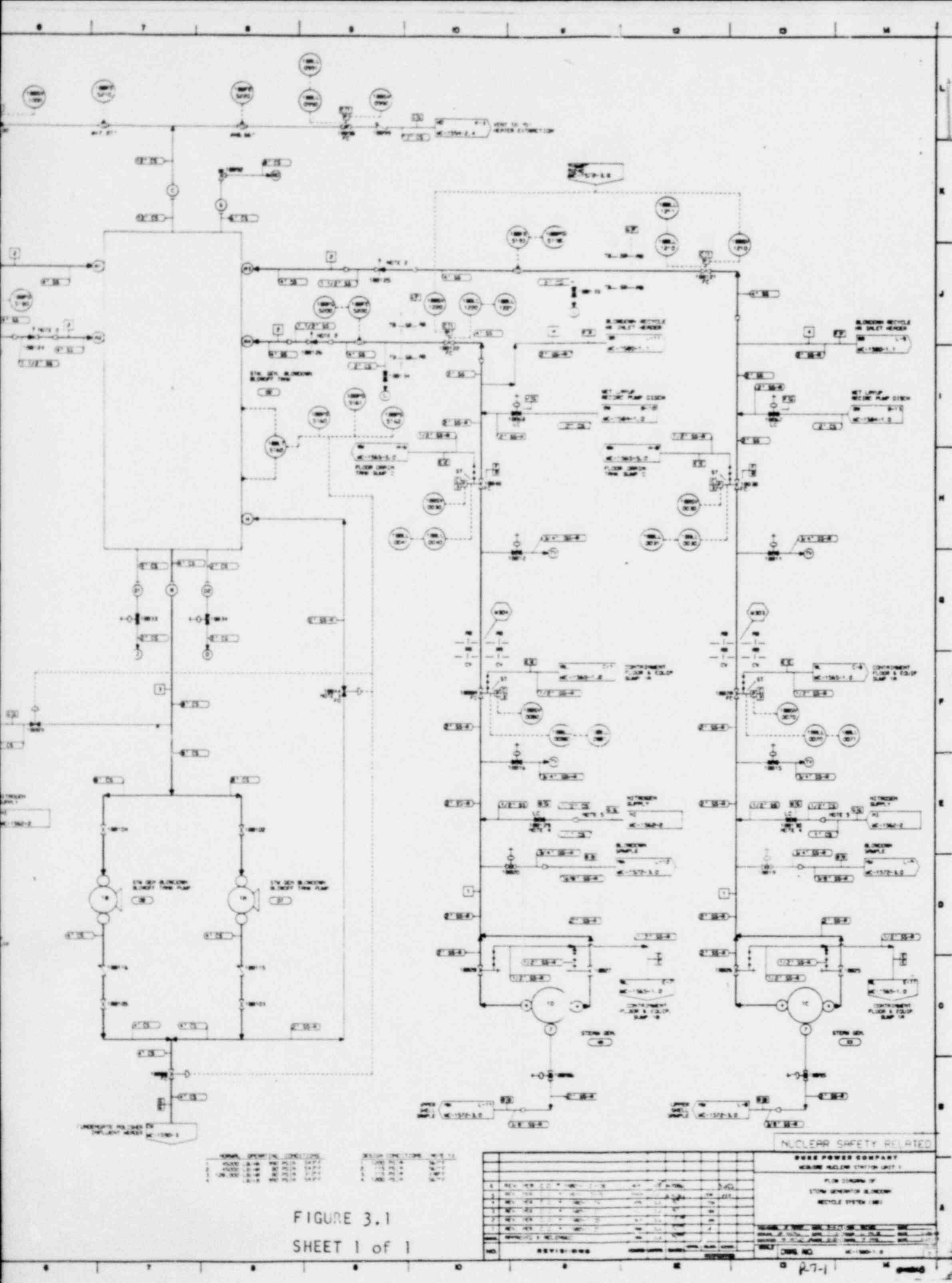
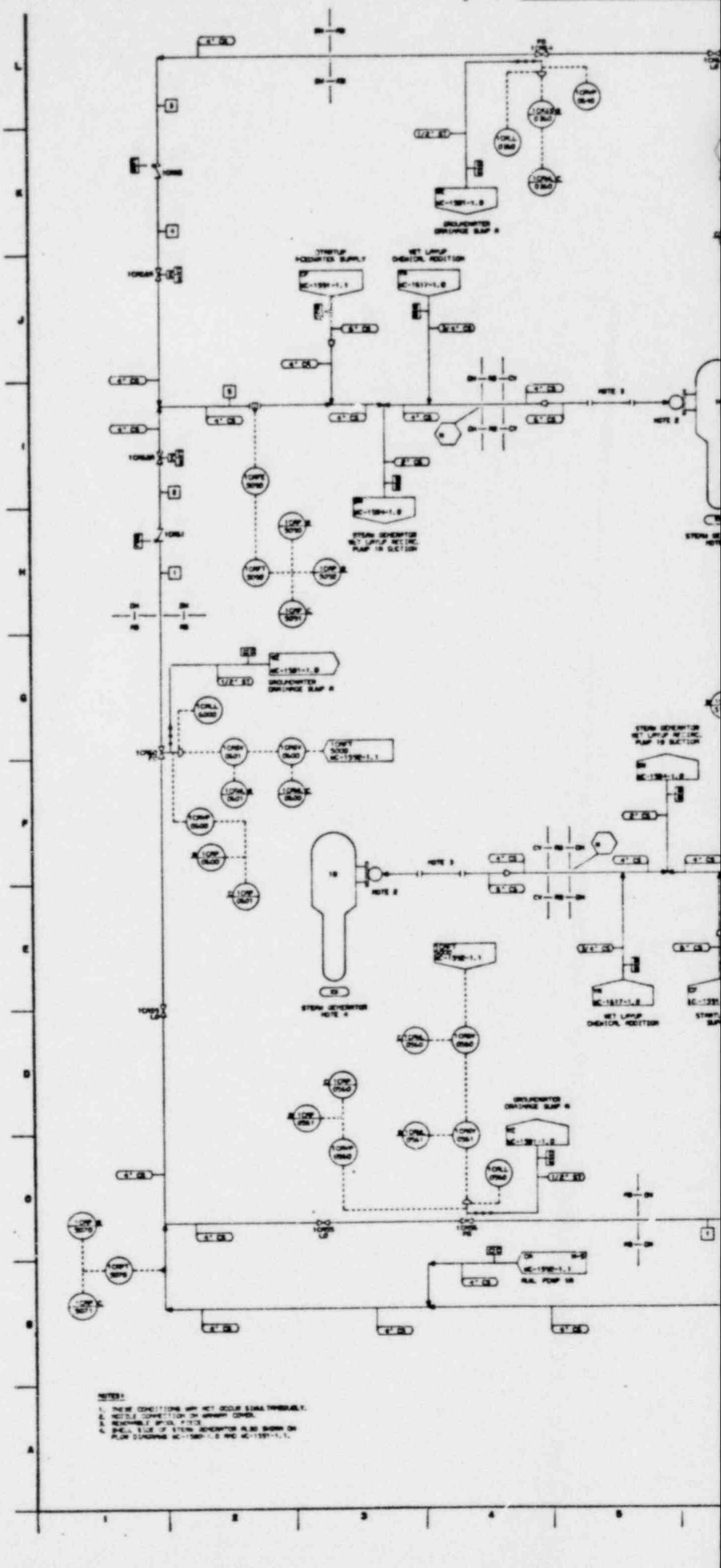


FIGURE 3.1

SHEET 1 of 1



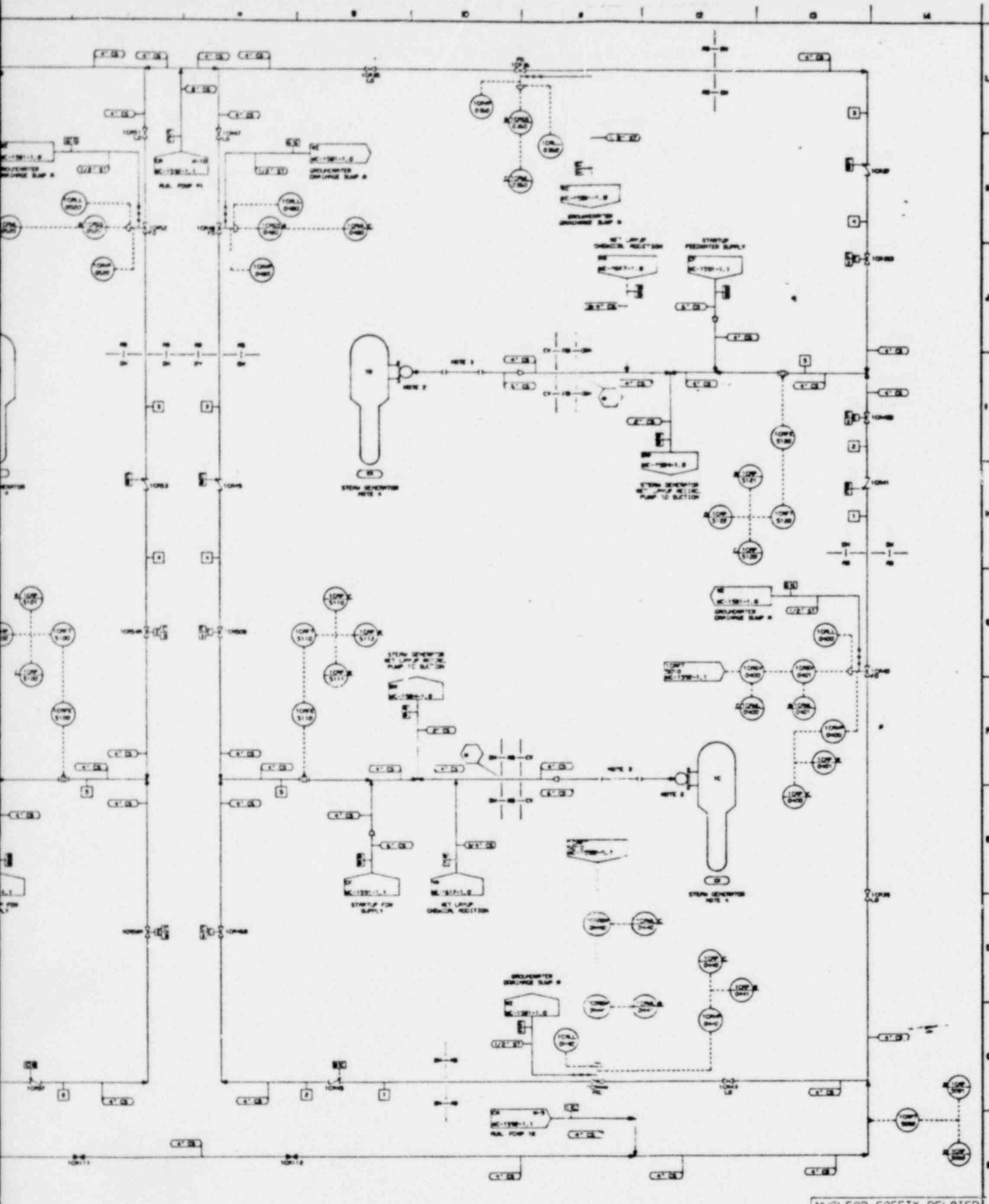
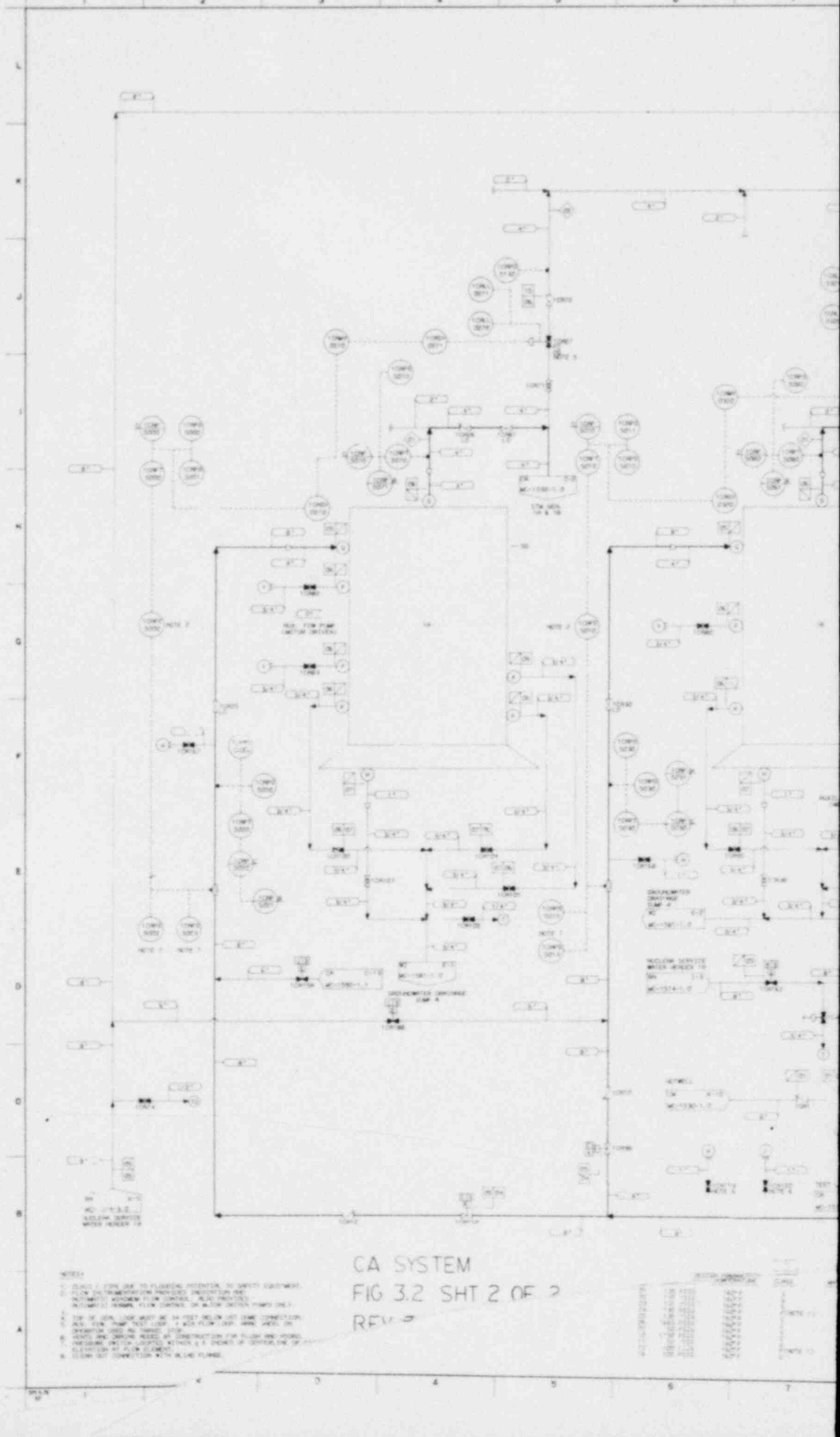


FIGURE 3.2

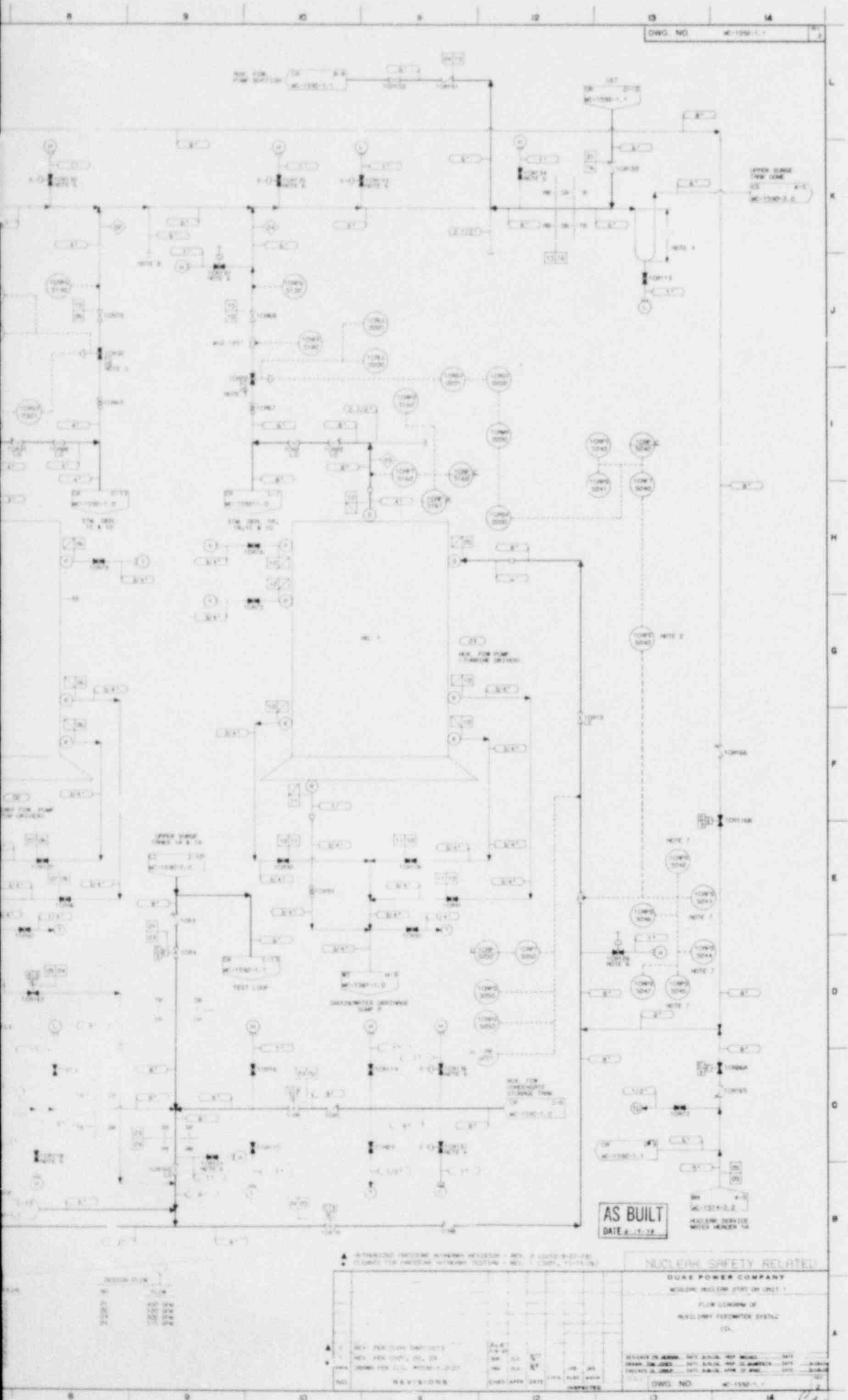
SHEET 1 of 2

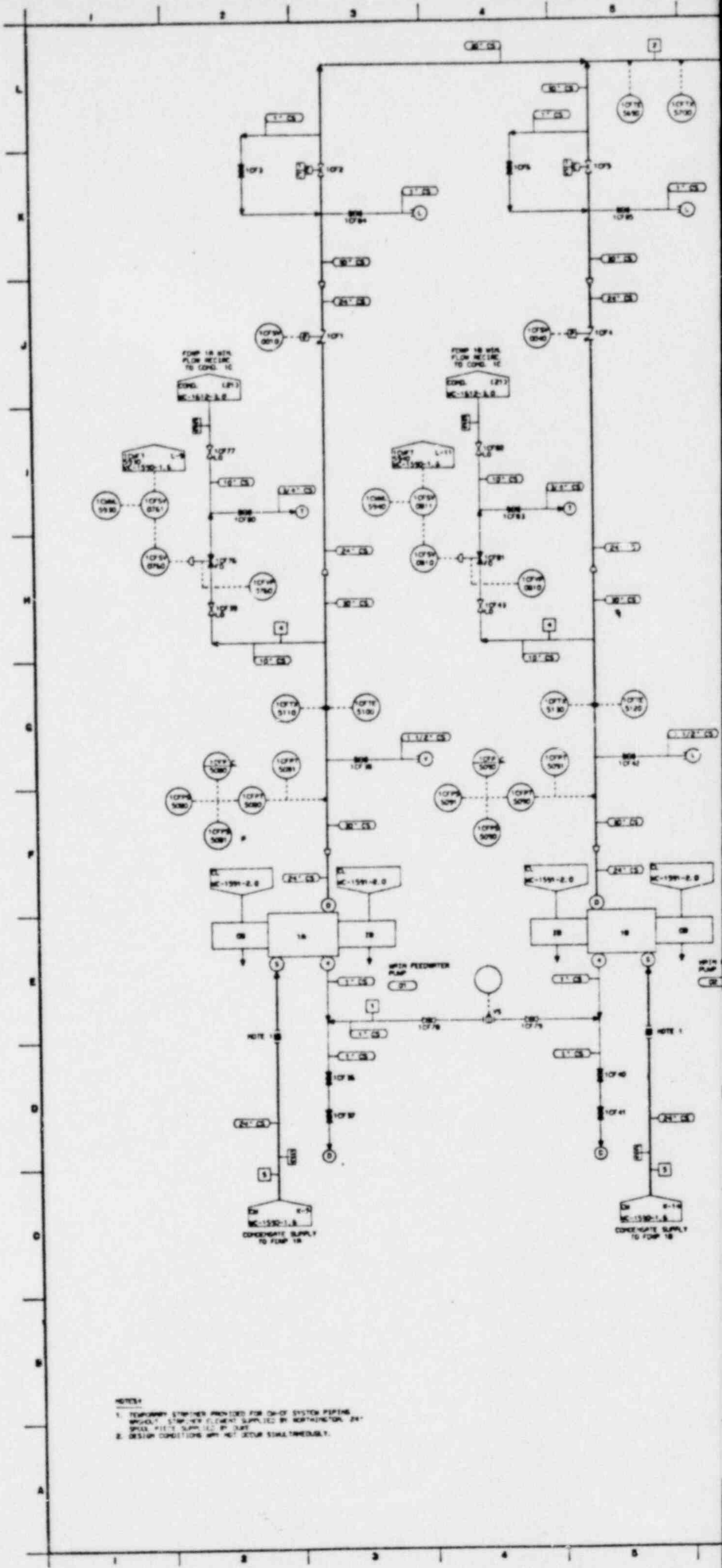


CA SYSTEM

FIG 3.2 SHT 2 OF 2

REV


DWG. NO.
UPPER SURGE TANK DOME
AUX. FDW. PUMP (TURBINE DRIVEN)
NOTE 2
TEST LOOP
AS BUILT
DATE
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
FLOW DIAGRAM OF
AUXILIARY FEEDWATER SYSTEM
REVISIONS
DWG. NO.



NOTES:

1. TEMPORARY STRAINER PROVIDED FOR CM-CF SYSTEM PIPING. [illegible] STRAINER ELEMENT SUPPLIED BY WORTHINGTON. 24" SPOOL PIECE SUPPLIED BY DUKE.
2. DESIGN CONDITIONS MAY NOT OCCUR SIMULTANEOUSLY.

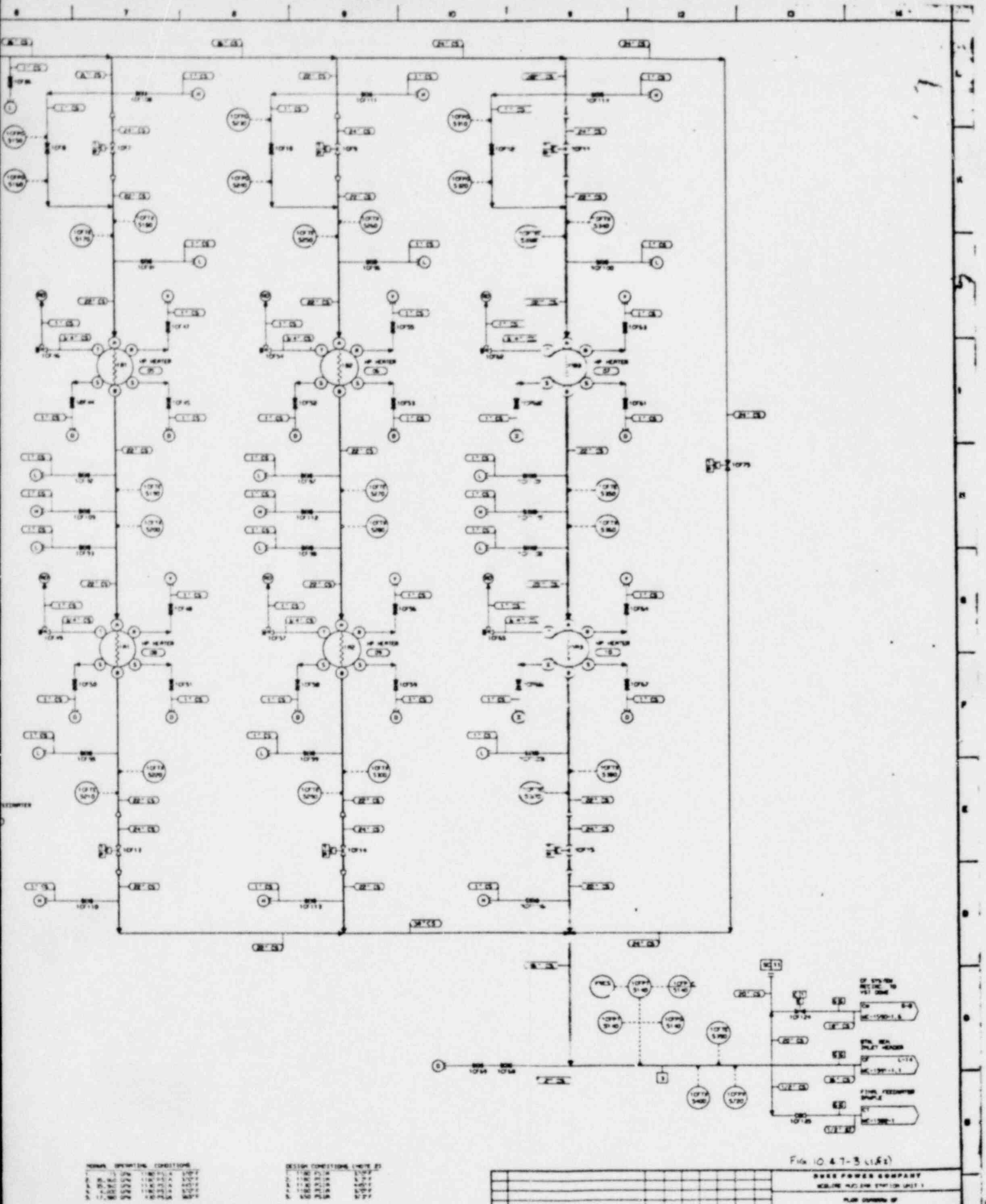
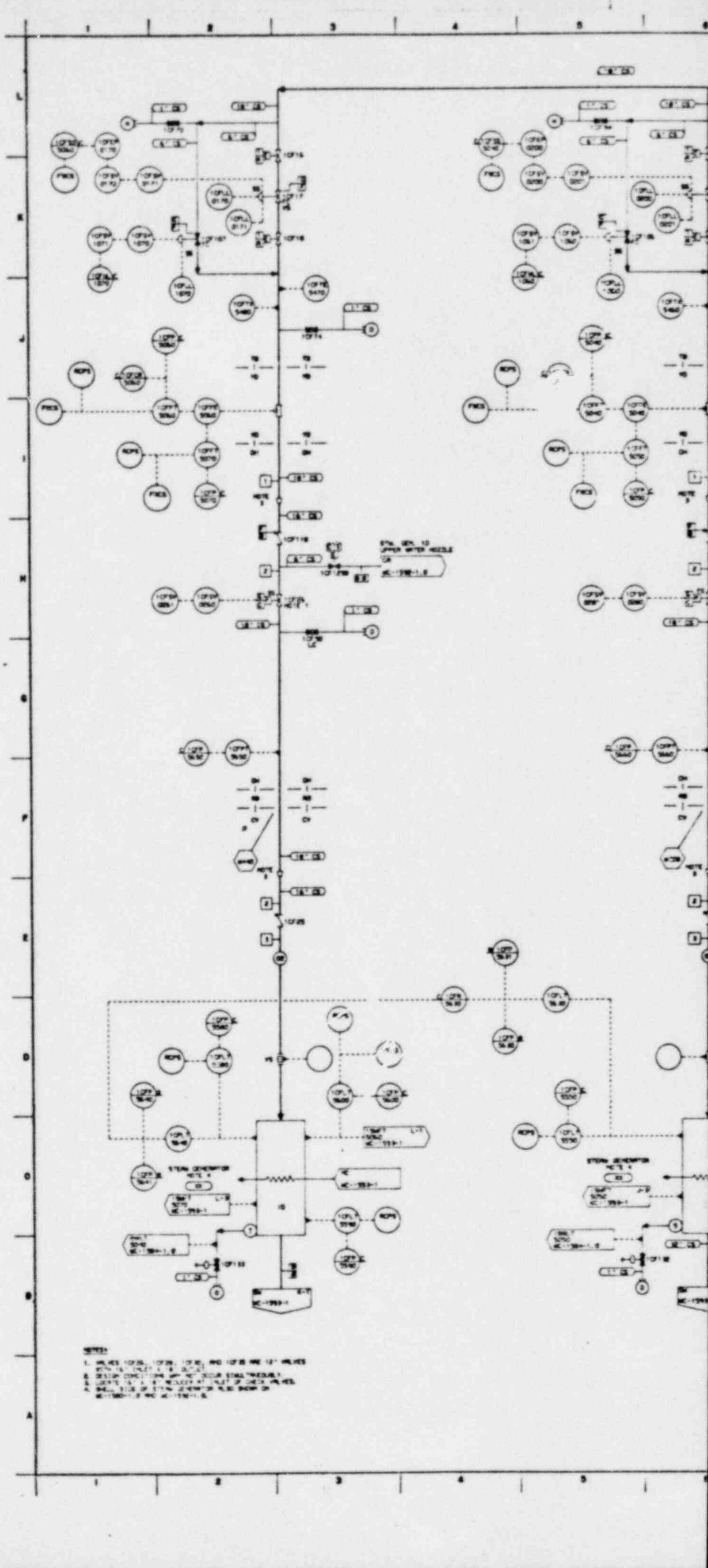


FIGURE 3.3

SHEET 1 of 2



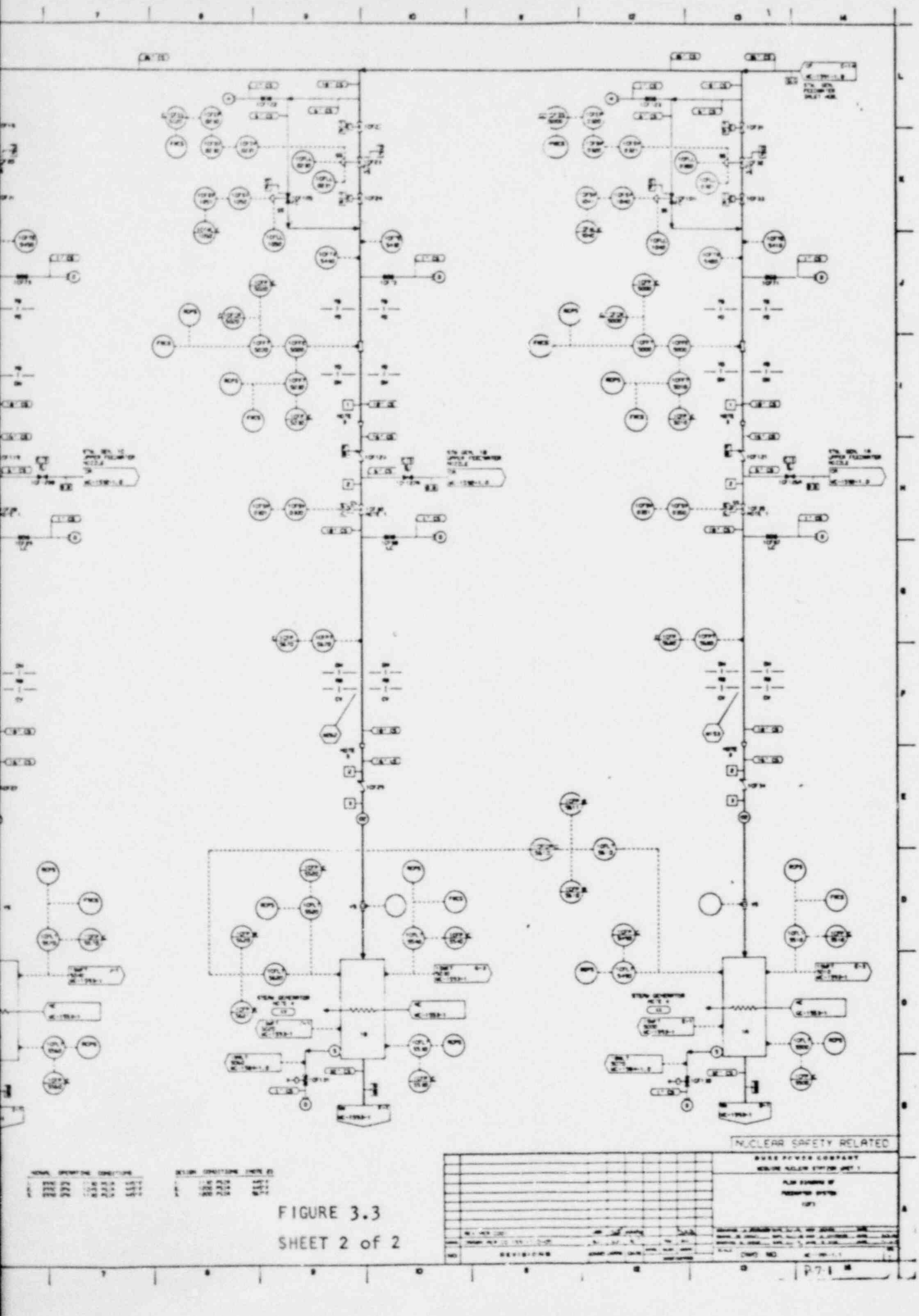
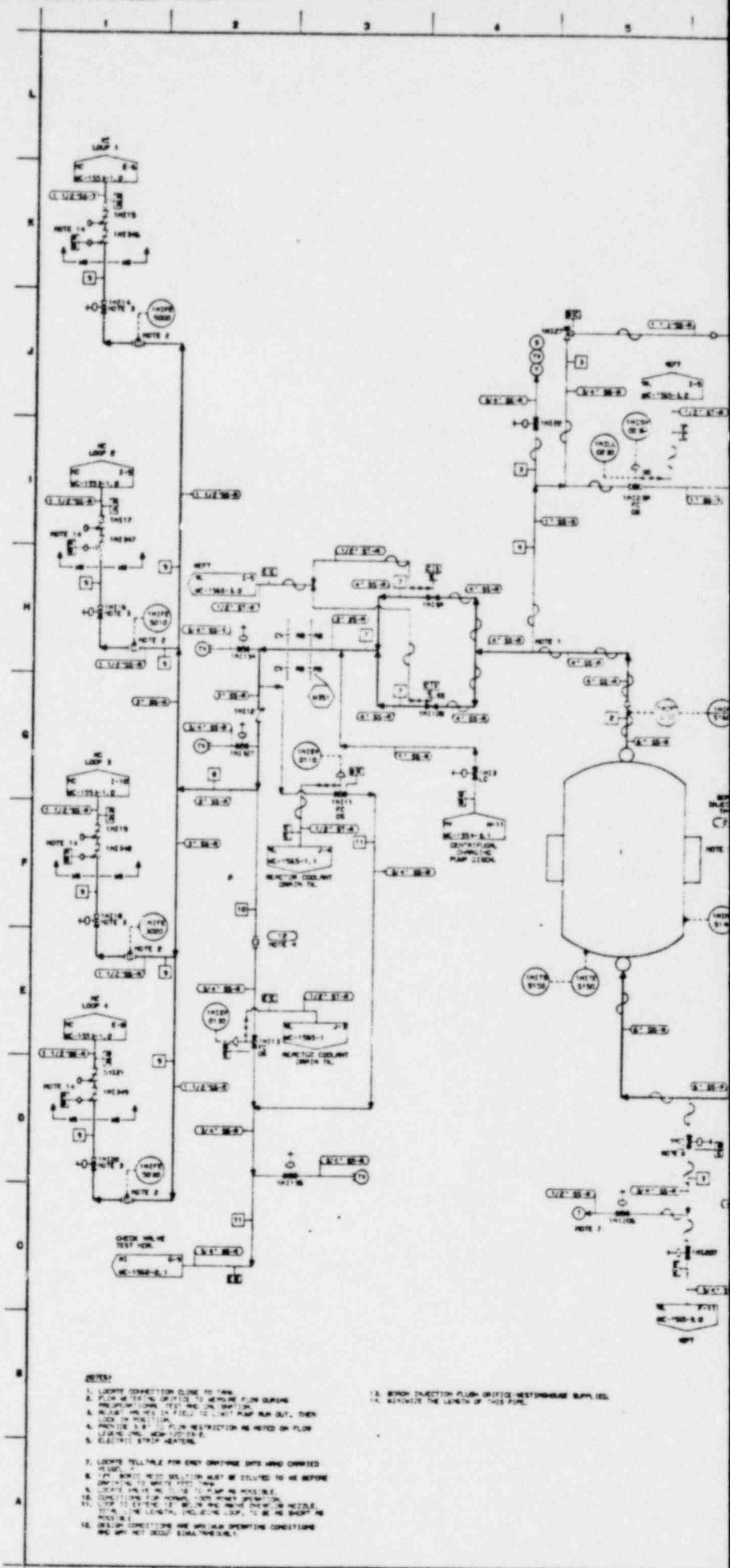


FIGURE 3.3

SHEET 2 of 2


LOOP 1
LOOP 2
LOOP 3
LOOP 4
REACTOR COOLANT DRAIN TK.
CENTRIFUGAL CHARGING PUMP
NOTES:
1. LOCATE CONNECTION CLOSE TO TANK.
5. ELECTRIC STRIP HEATERS.

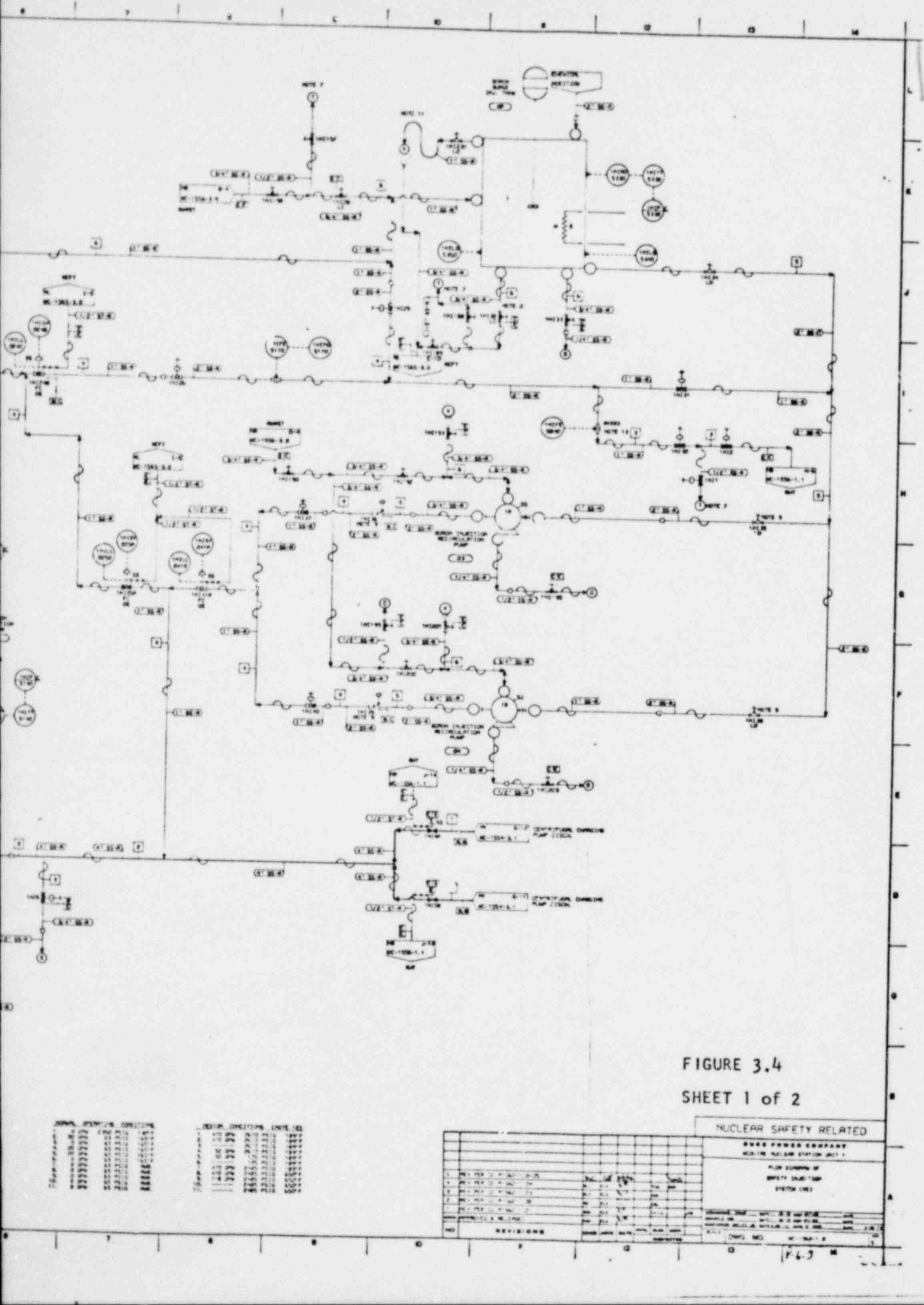
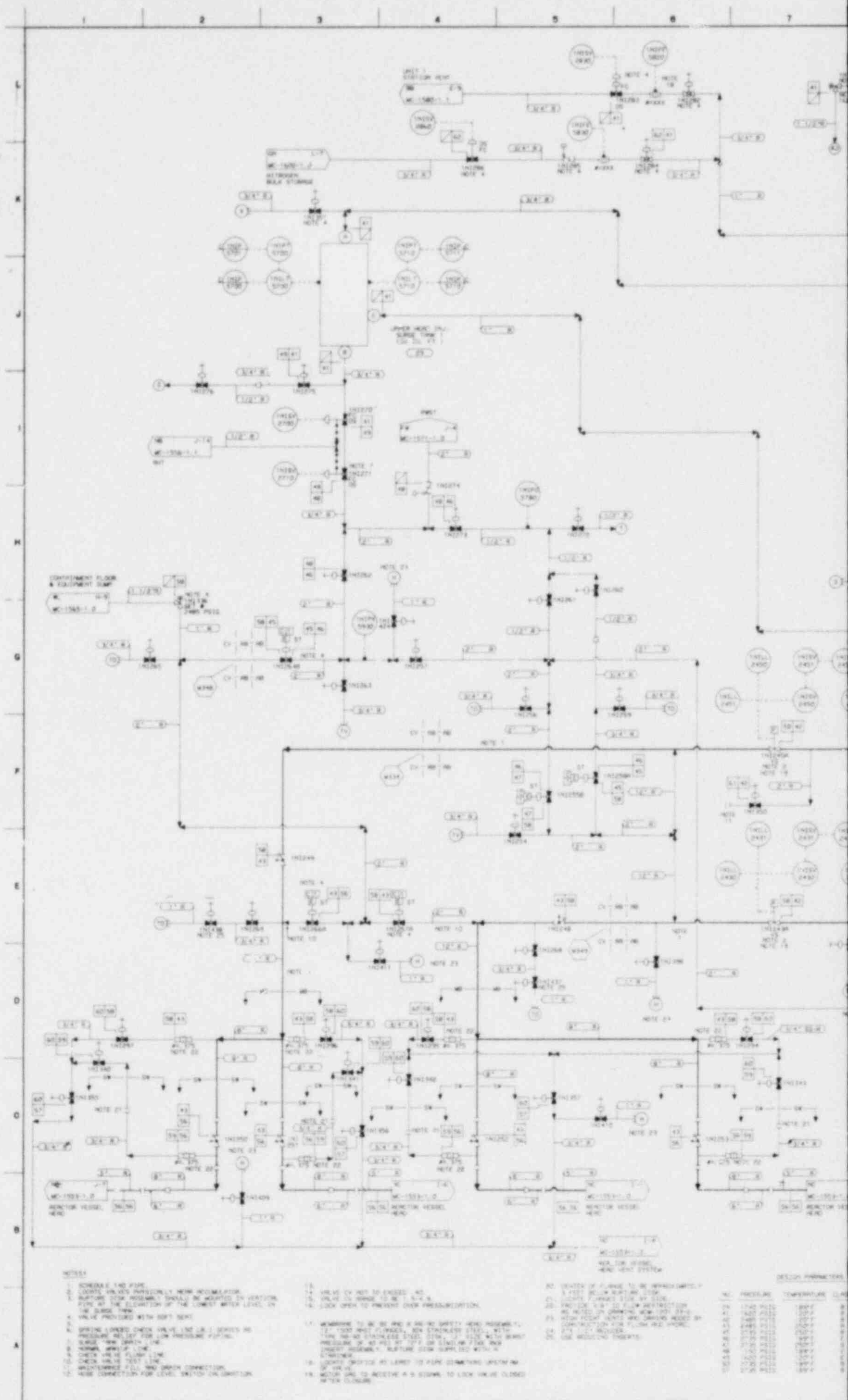
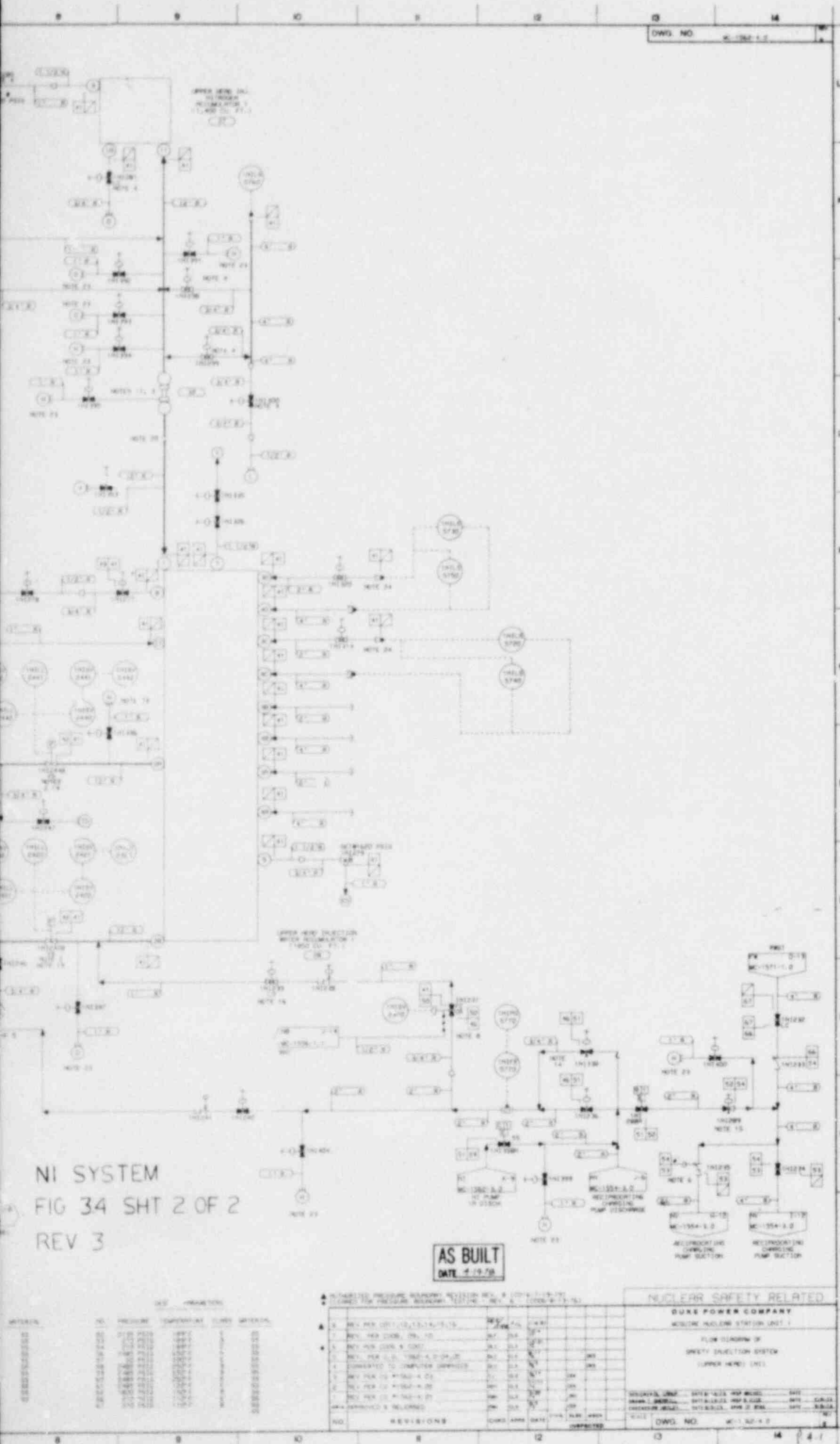


FIGURE 3.4

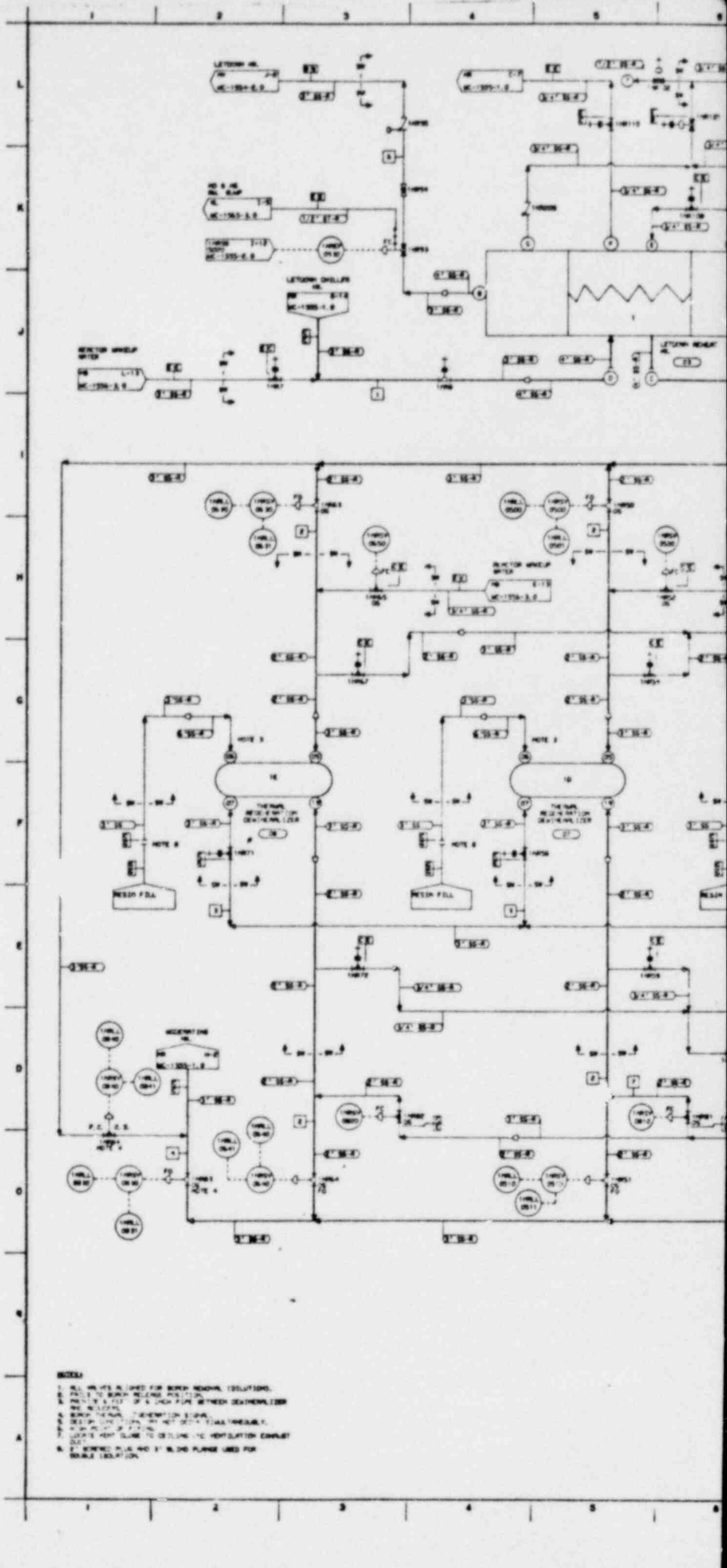
SHEET 1 of 2



UNIT 1 STATION VENT
NITROGEN BULK STORAGE
UPPER HEAD INJ. SURGE TANK
CONTAINMENT FLOOR & EQUIPMENT SUMP
REACTOR VESSEL HEAD
NOTES:
1. SCHEDULE 140 PIPE.
2. LOCATE VALVES PHYSICALLY NEAR ACCUMULATOR.
3. RUPTURE DISK ASSEMBLY SHOULD BE MOUNTED IN VERTICAL PIPE AT THE ELEVATION OF THE LOWEST WATER LEVEL IN THE SURGE TANK.
4. VALVE PROVIDED WITH SOFT SEAT.
7. SURGE TANK DRAIN LINE.
8. NORMAL MAKEUP LINE.
9. CHECK VALVE FLUSH LINE.
10. CHECK VALVE TEST LINE.
11. MAINTENANCE FILL AND DRAIN CONNECTION.
12. HOSE CONNECTION FOR LEVEL SWITCH CALIBRATION.
14. VALVE CV NOT TO EXCEED .40.
16. LOCK OPEN TO PREVENT OVER PRESSURIZATION.
18. LOCATE ORIFICE AT LEAST 10 PIPE DIAMETERS UPSTREAM OF VALVE.
DESIGN PARAMETERS



NI SYSTEM
FIG 34 SHT 2 OF 2
REV 3
AS BUILT
RECIPROCATING CHARGING PUMP SUCTION
RECIPROCATING CHARGING PUMP SUCTION
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
MCGUIRE NUCLEAR STATION UNIT 1
FLOW DIAGRAM OF
SAFETY INJECTION SYSTEM
(UPPER HEAD) (NI)
DWG. NO.
REVISIONS



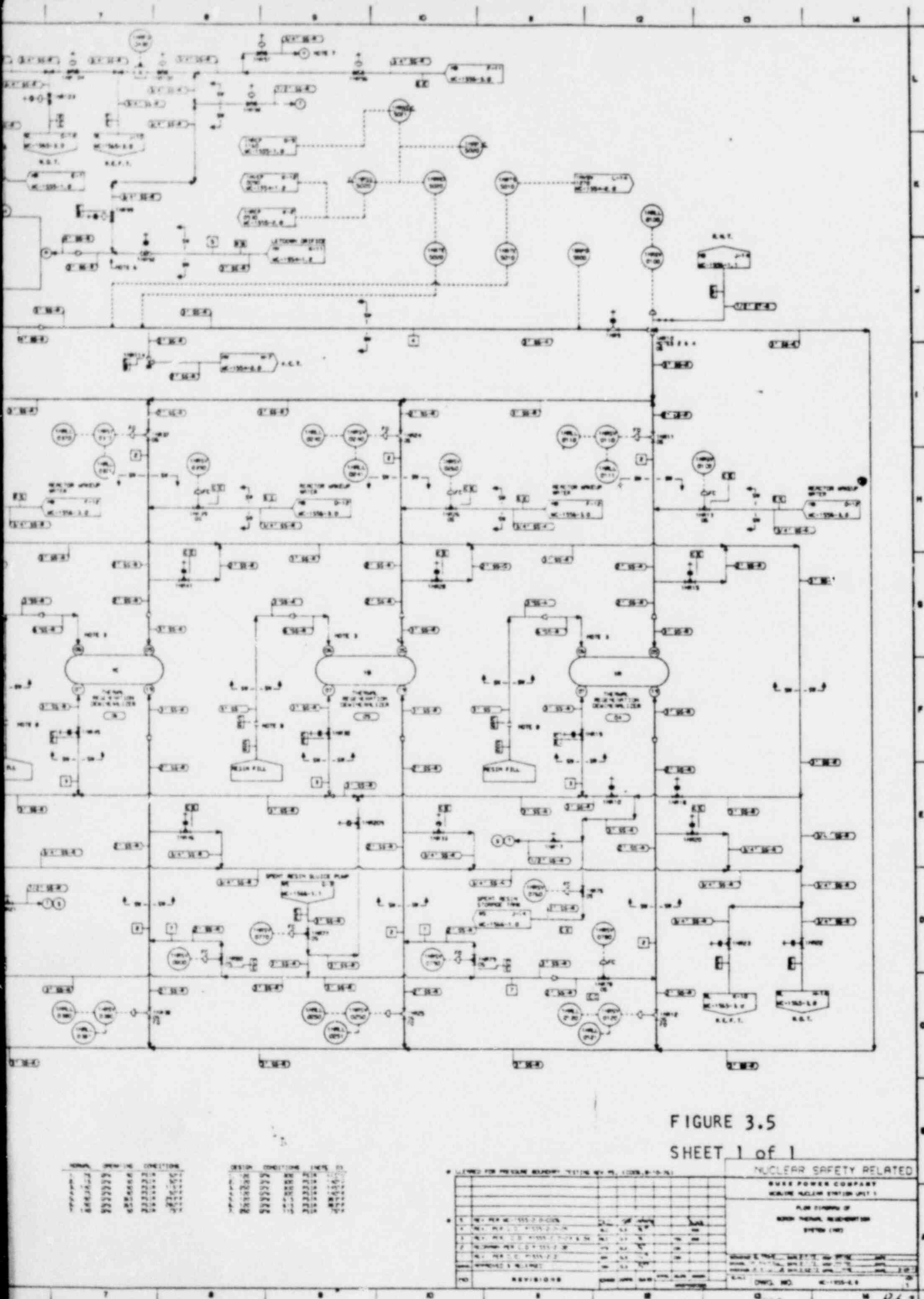
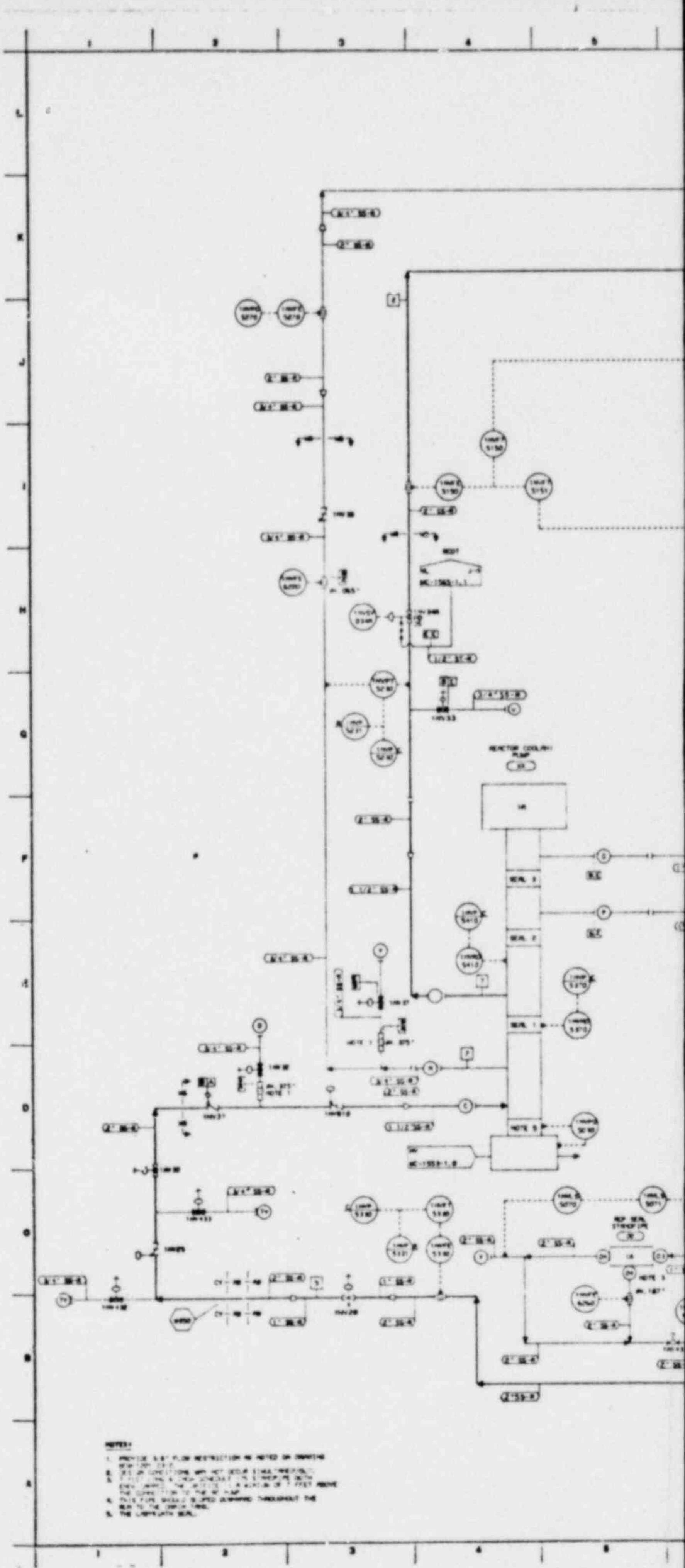


FIGURE 3.5

SHEET 1 of 1



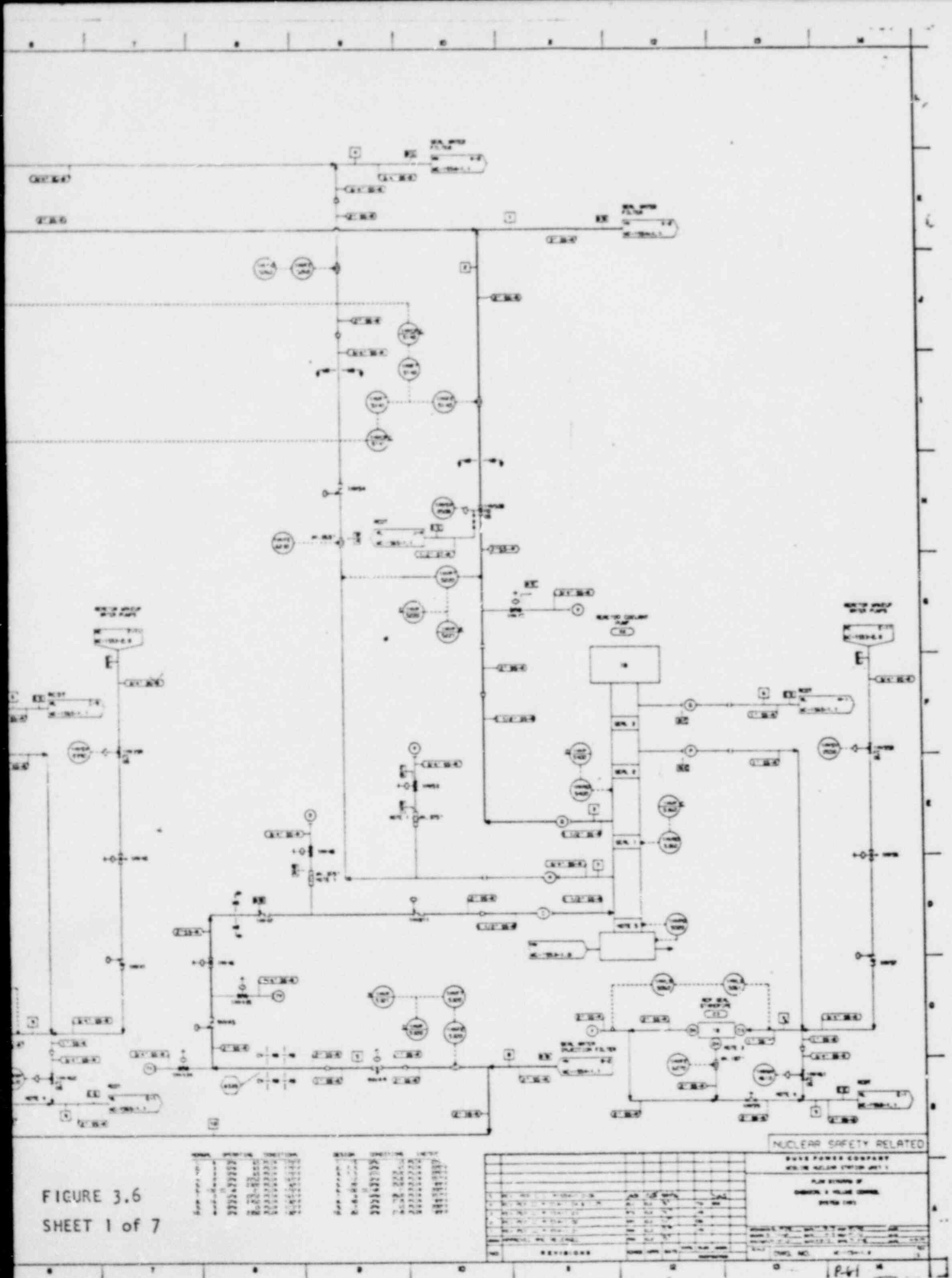
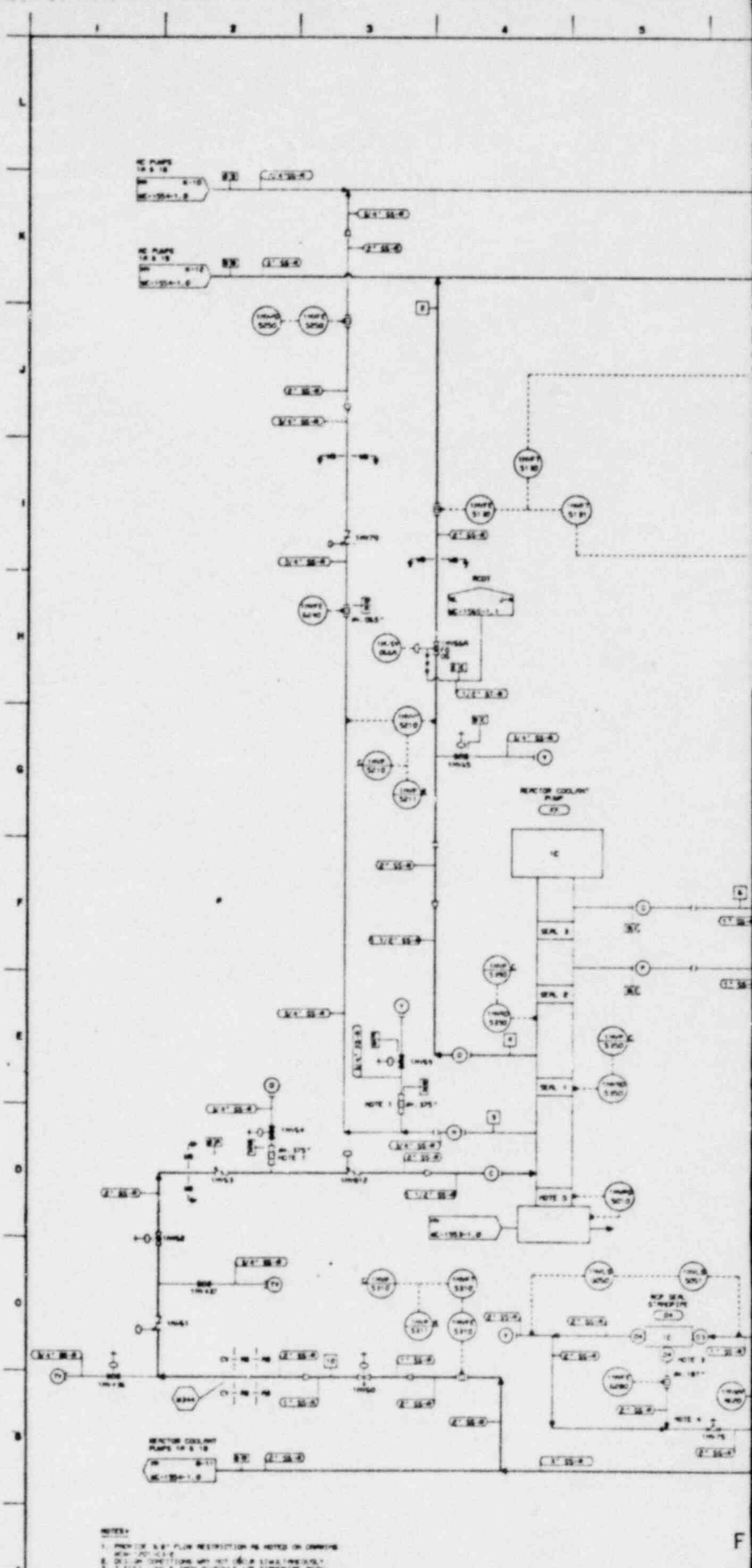
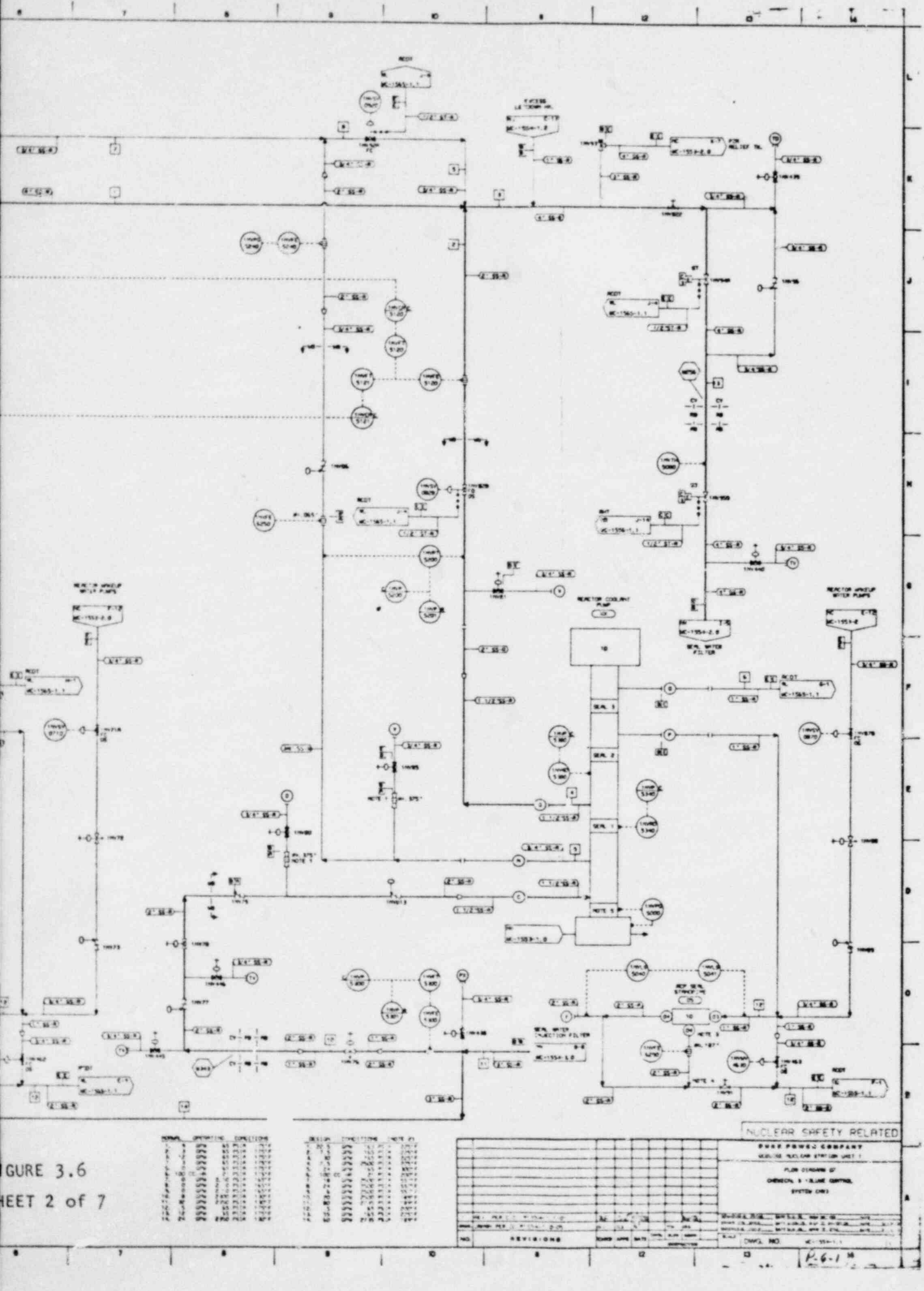


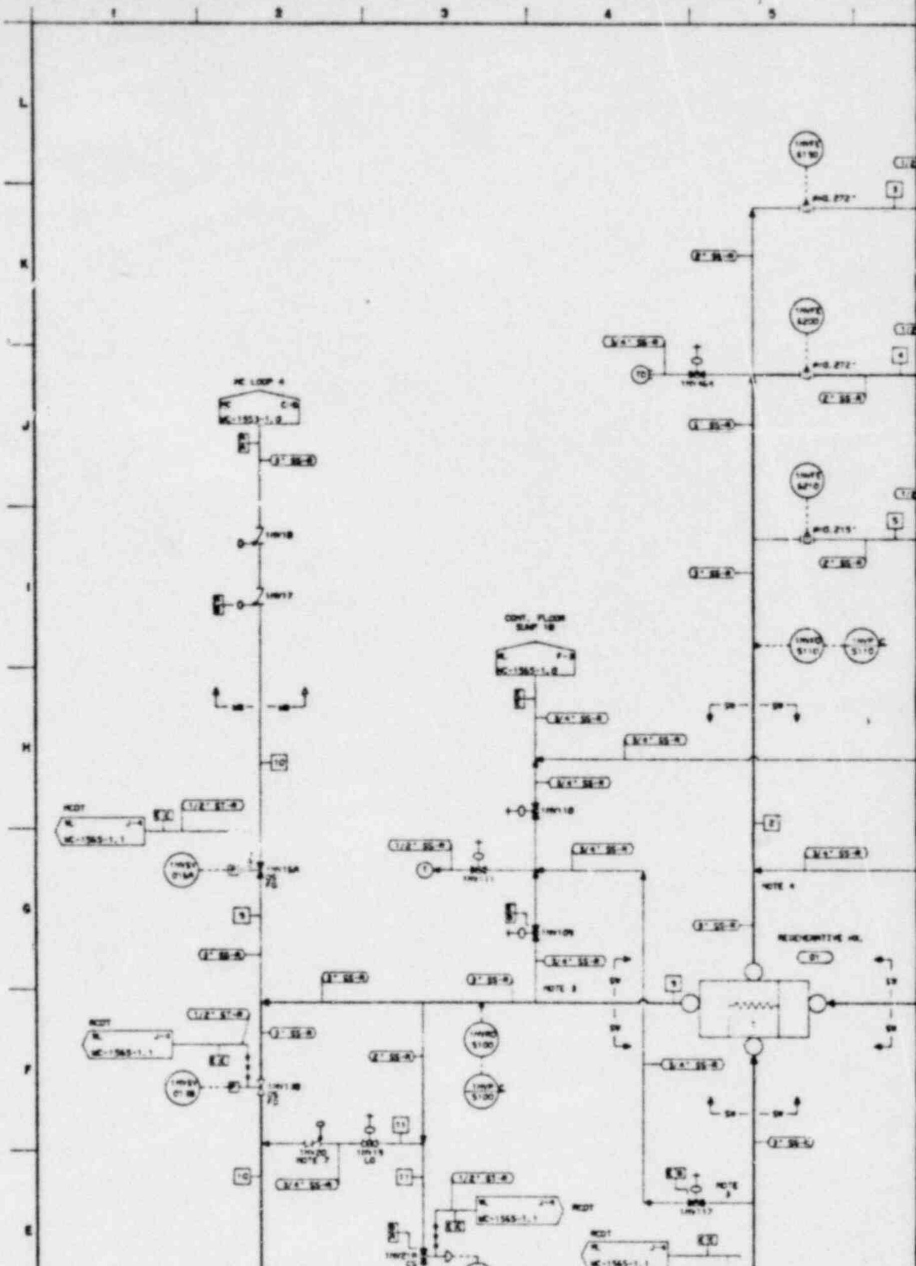
FIGURE 3.6
SHEET 1 of 7

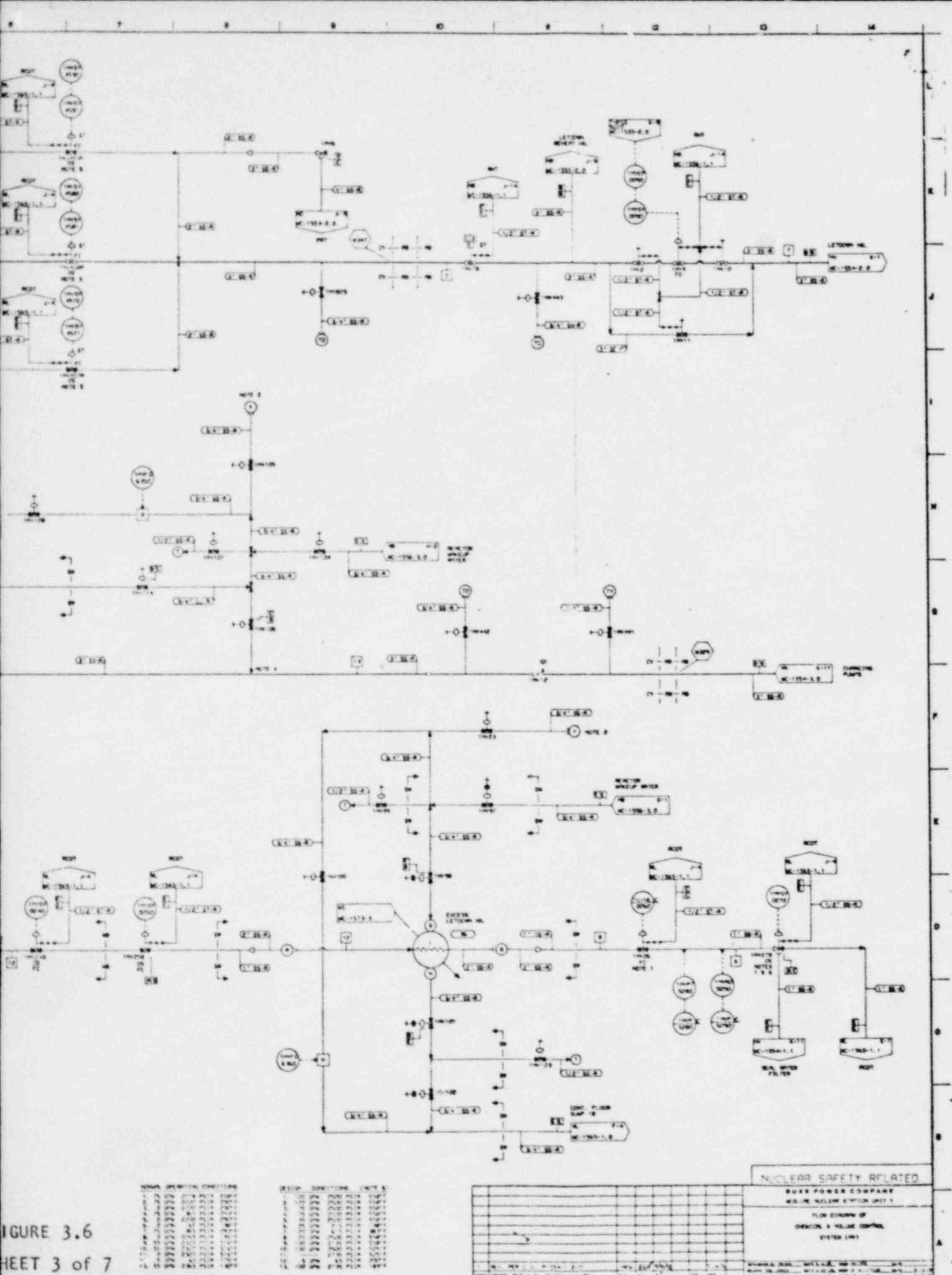

REACTOR COOLANT PUMP
SEAL 3
SEAL 2
SEAL 1
NOTE 5
NOTES:



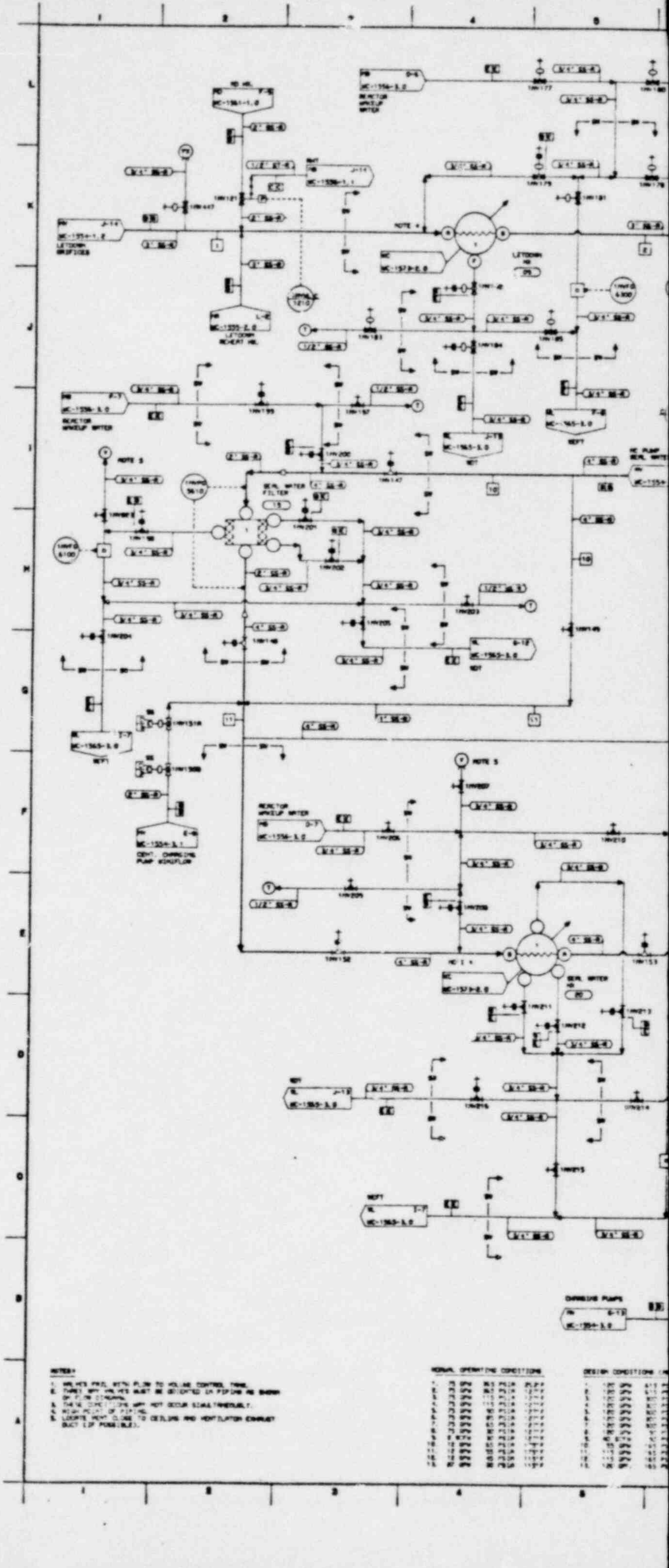
IGURE 3.6

HEET 2 of 7





IGURE 3.6
HEET 3 of 7


REACTOR MAKEUP WATER
SEAL WATER FILTER
CENT. CHARGING PUMP MINIFLOW
CHARGING PUMPS
NOTES:
NORMAL OPERATING CONDITIONS

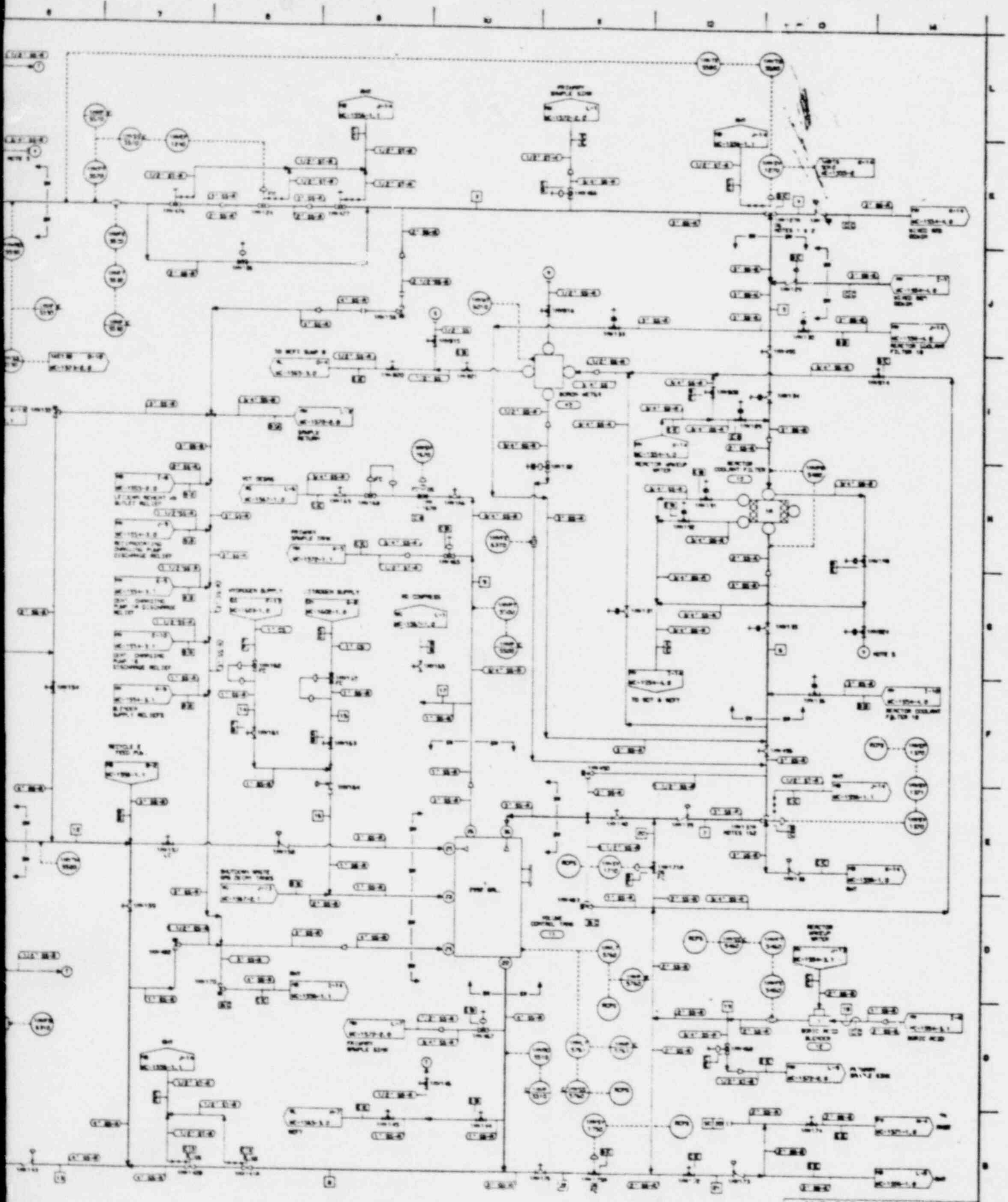
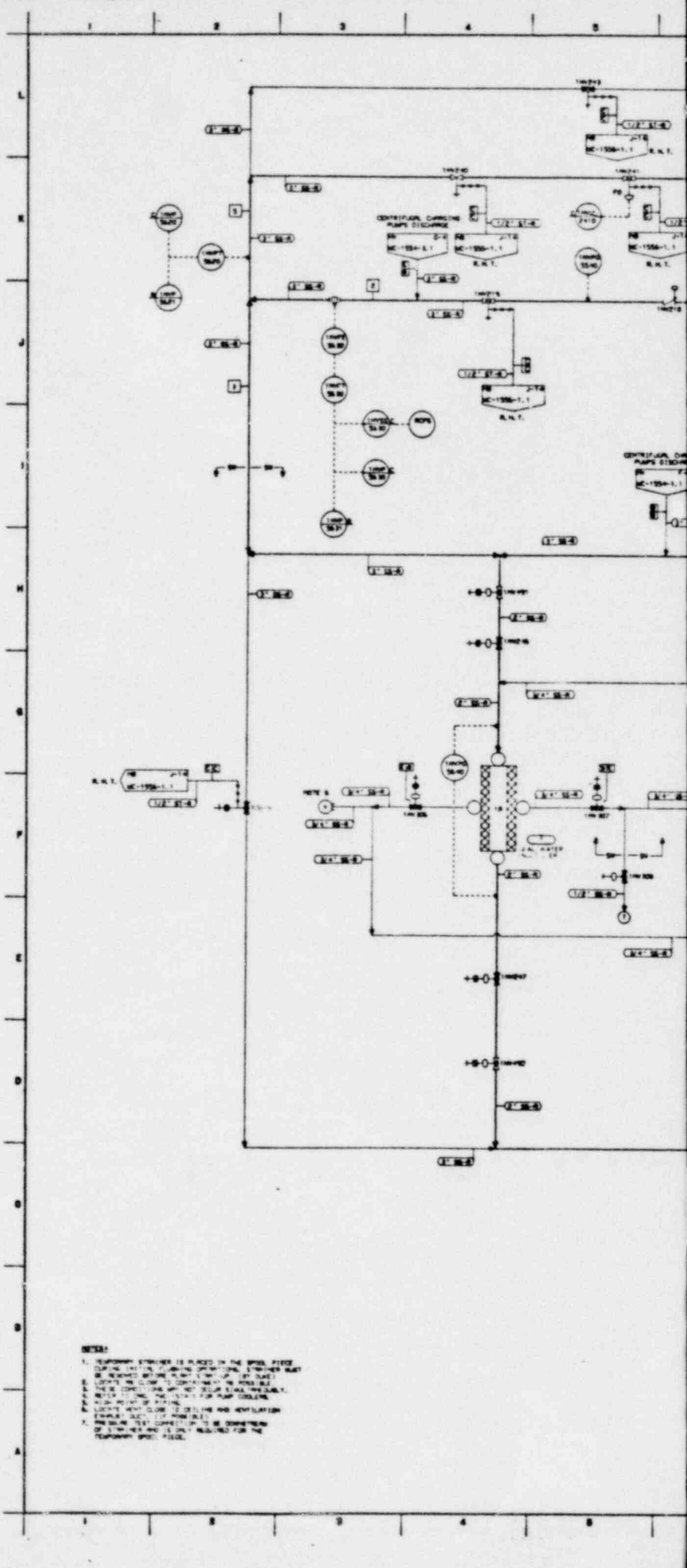


FIGURE 3.6

SHEET 4 of 7



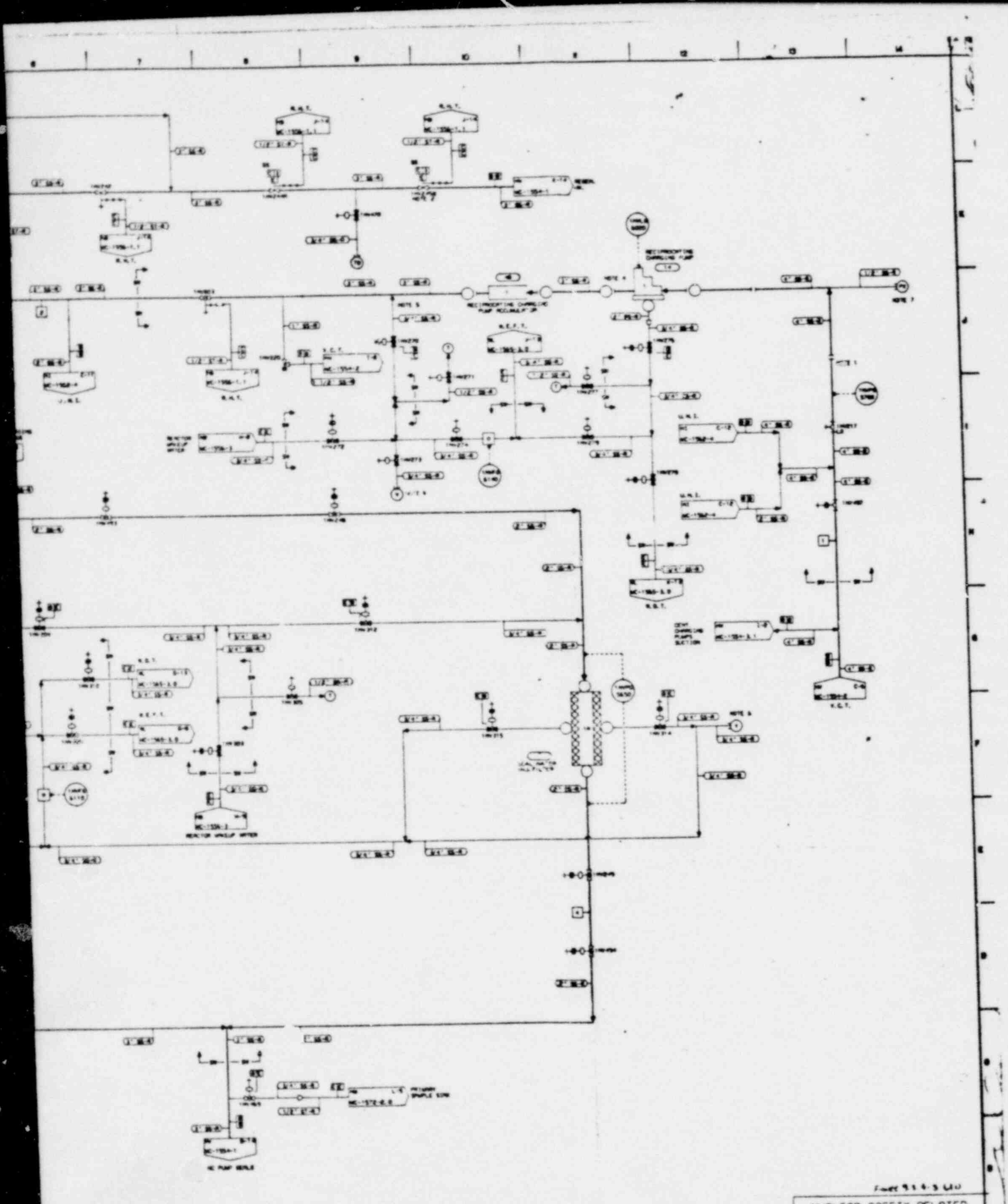
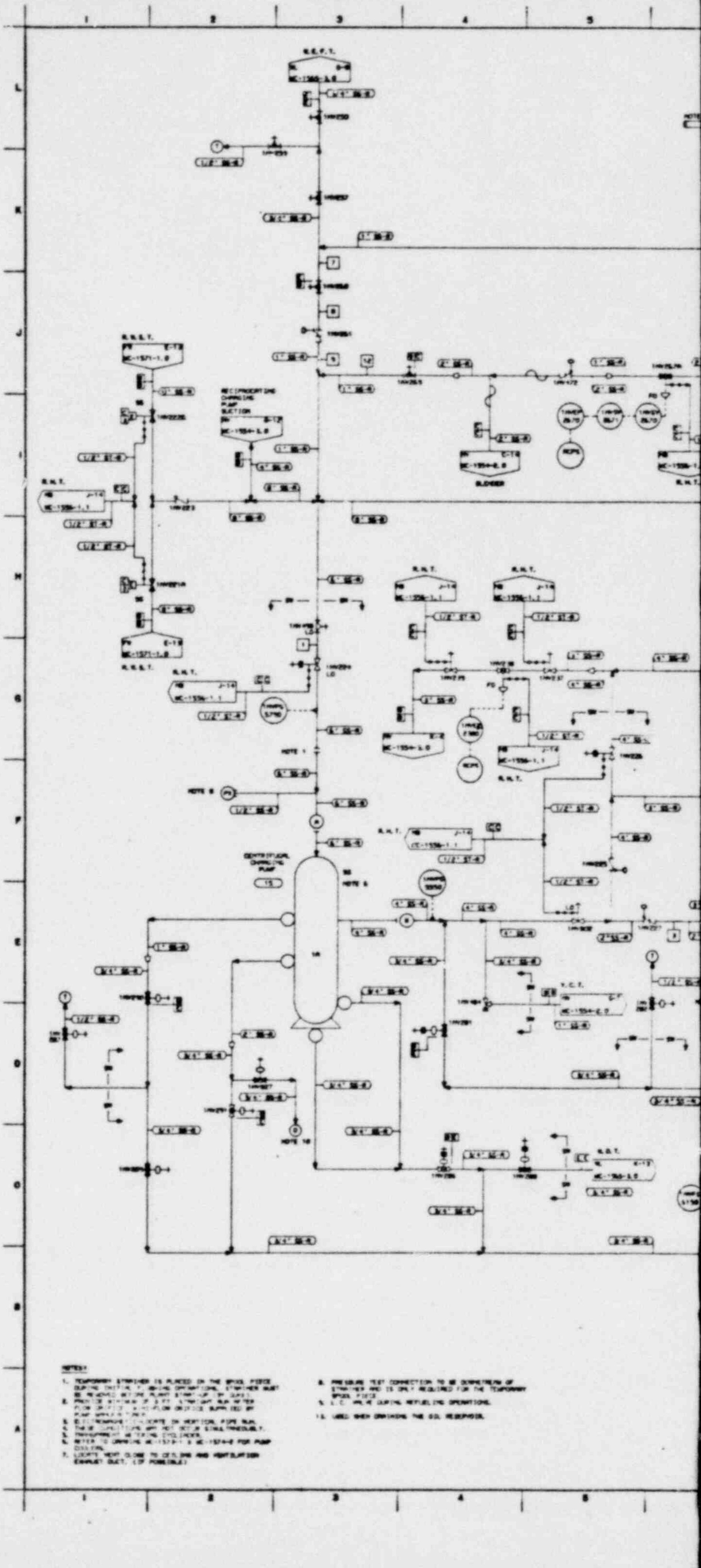


FIGURE 3.6

SHEET 5 of 7


R.H.T.
B.N.S.T.
BLENDER
V.C.T.

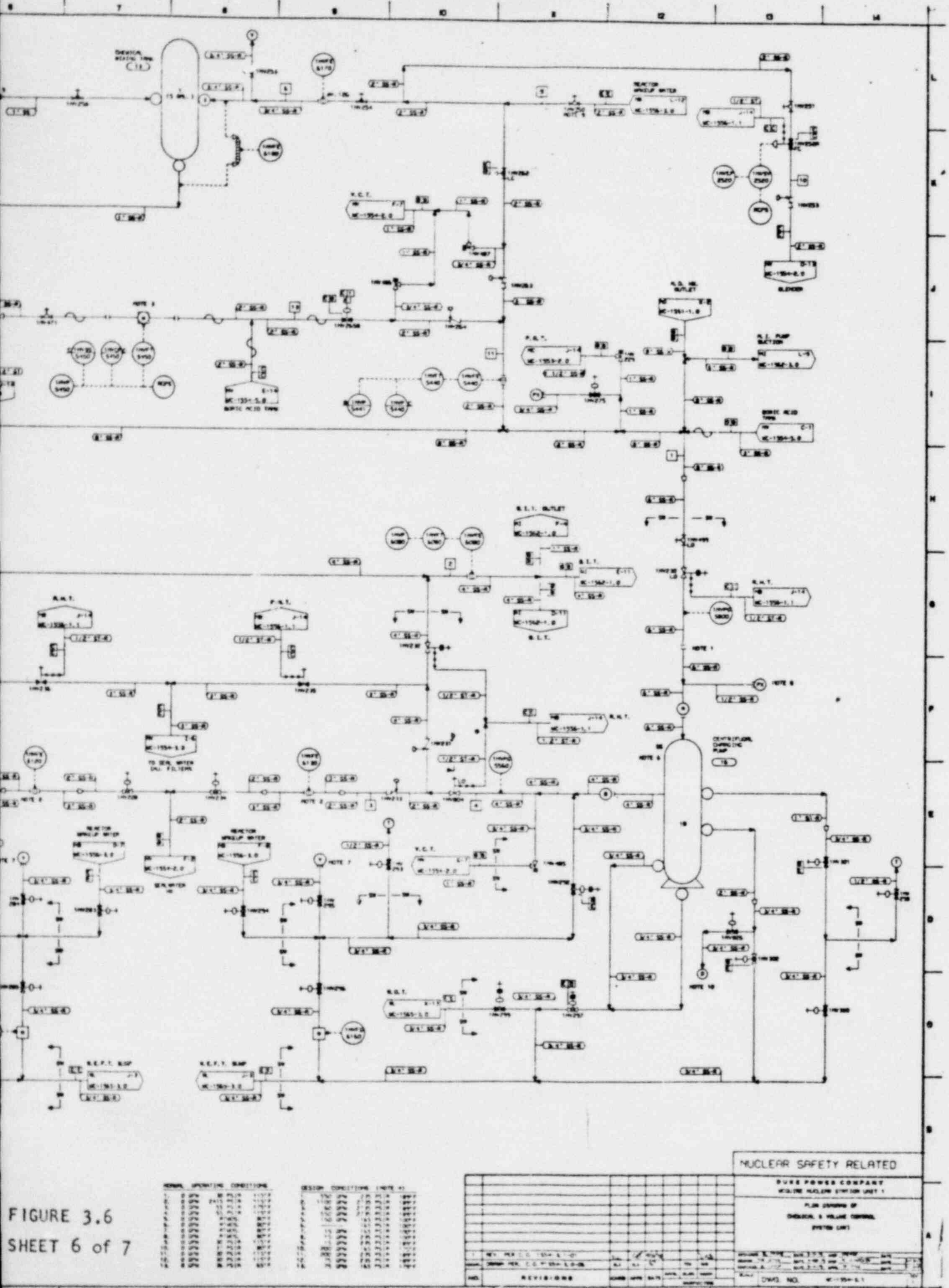
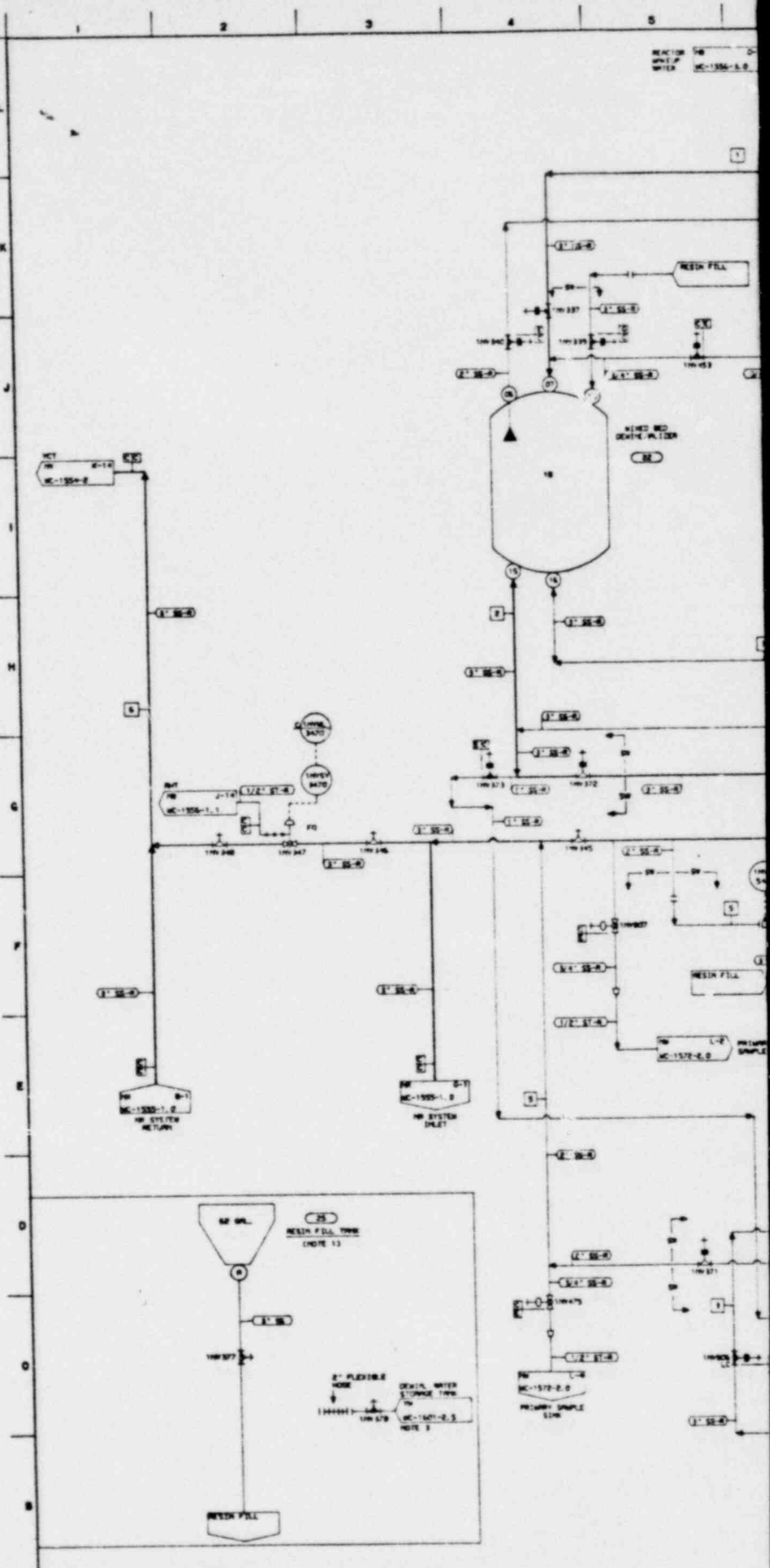


FIGURE 3.6
SHEET 6 of 7



NOTES:

1. ONE PORTABLE TANK IS PROVIDED FOR ALL DEMINERALIZERS IN AUXILIARY BUILDING
2. DESIGN CONDITIONS ARE MAXIMUM OPERATING CONDITIONS AND MAY NOT OCCUR SIMULTANEOUSLY.
3. USE "TW" CONNECTION NEAREST EQUIPMENT.
4. LOCATE VENT CLOSE TO CEILING AND VENTILATION EXHAUST DUCT (IF POSSIBLE).

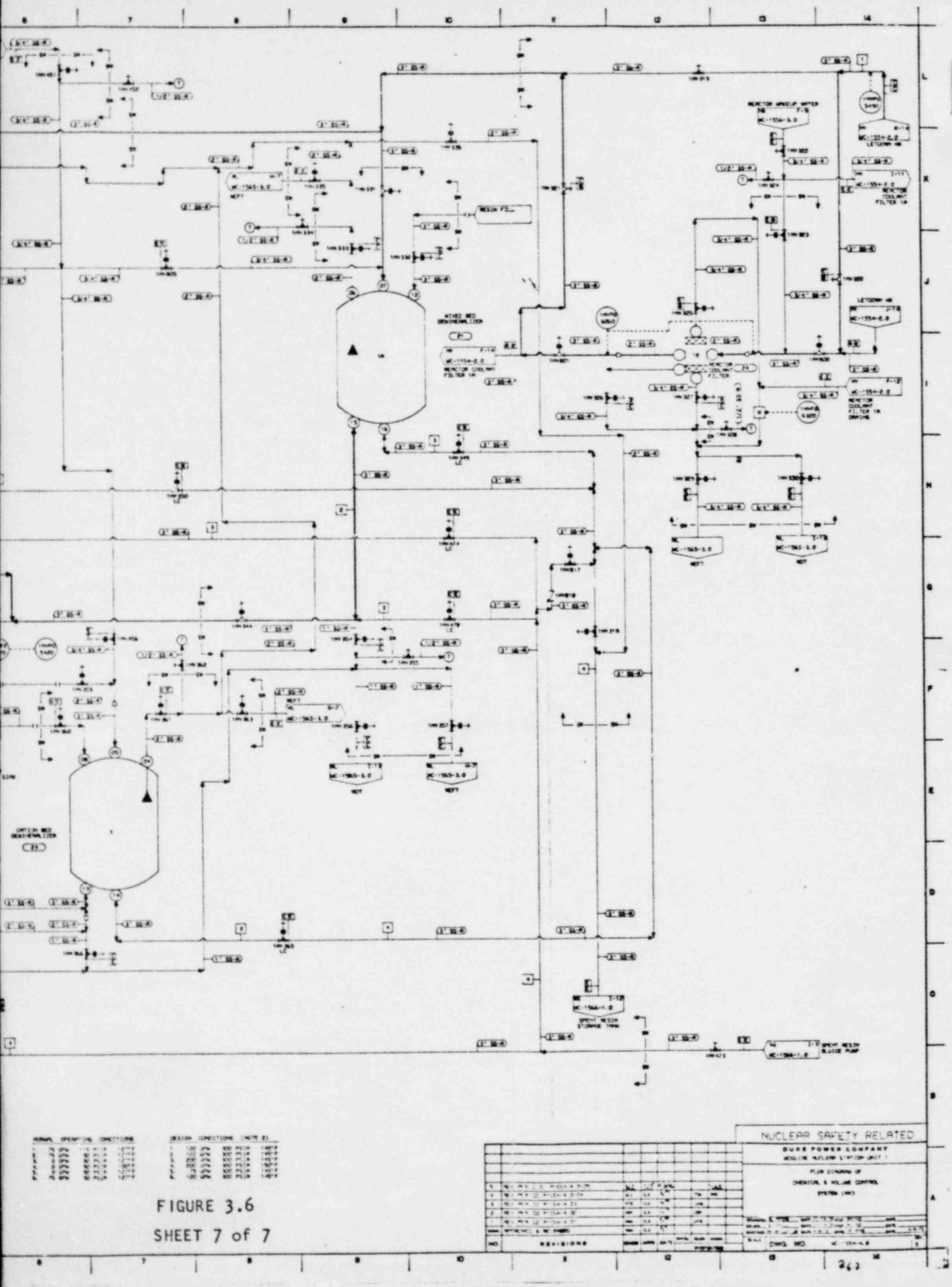
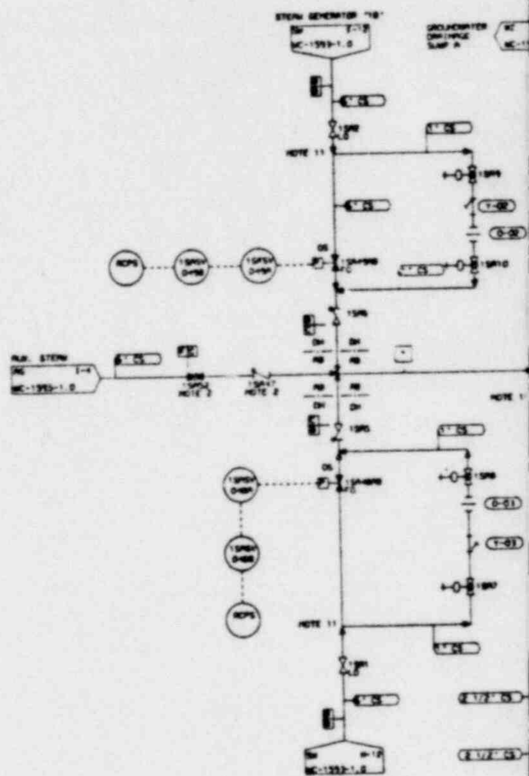


FIGURE 3.6

SHEET 7 of 7



NOTES:

1. LOCATE REDUCER AS CLOSE TO AUX. PUMP TURBINE AS POSSIBLE.
2. LOCATE VALVES AS CLOSE TO 6 INCH STEAM LINE FROM MAIN STEAM LINE AS POSSIBLE.
3. DESIGN CONDITIONS MAY NOT OCCUR SIMULTANEOUSLY.
4. ABOVE SEAT DRAIN.
5. BELOW SEAT DRAIN.
6. LEAKOFF
7. CASING DRAIN.
8. DRAIN POT
9. LOW POINT DRAIN CHANGES FROM CLASS F TO G AT CONNECTION TO EXHAUST HEADER.
10. CONDITIONS APPLY WHEN AUX. FDW PUMP TURBINE IS OPERATING.
11. LOW POINT DRAIN.

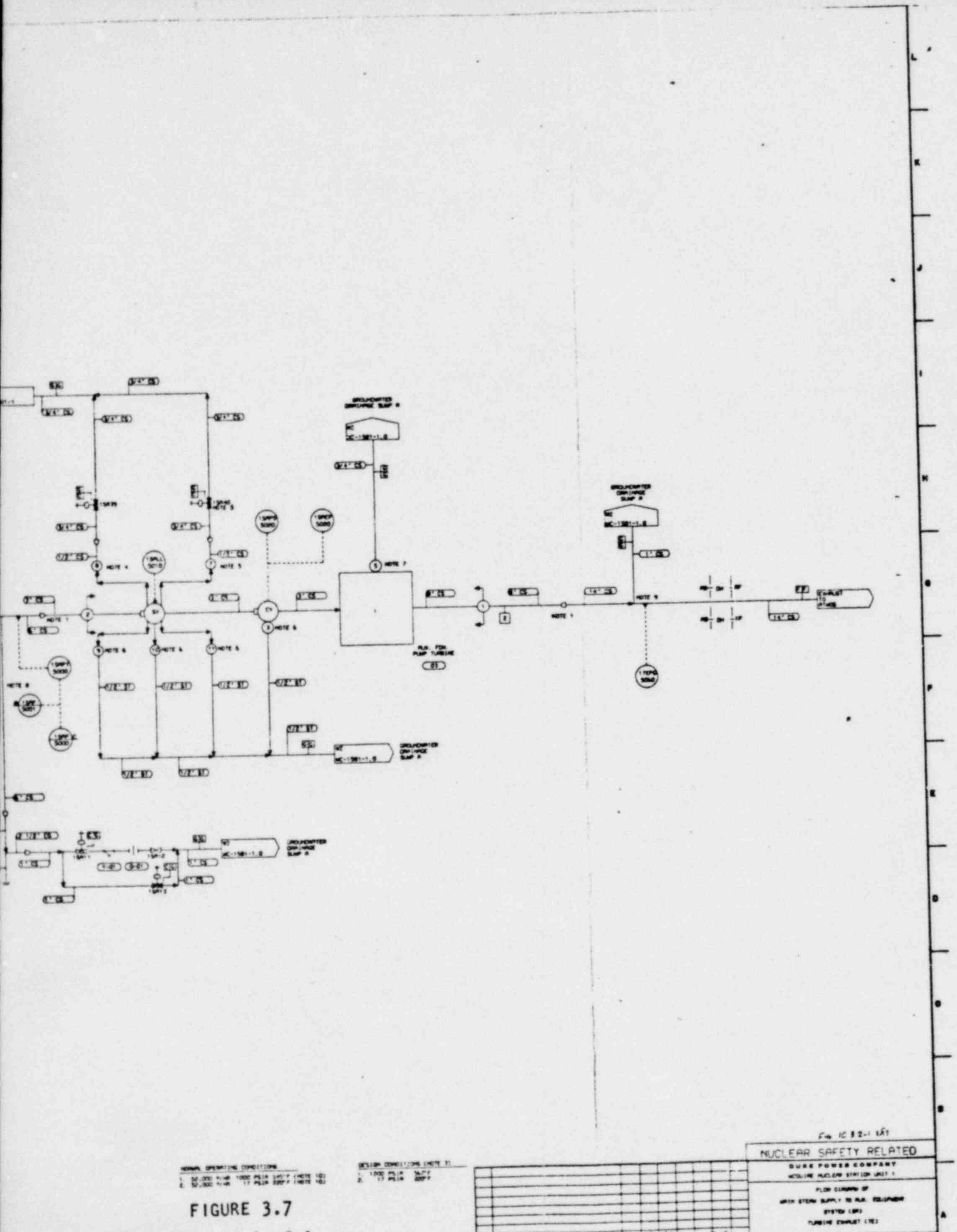
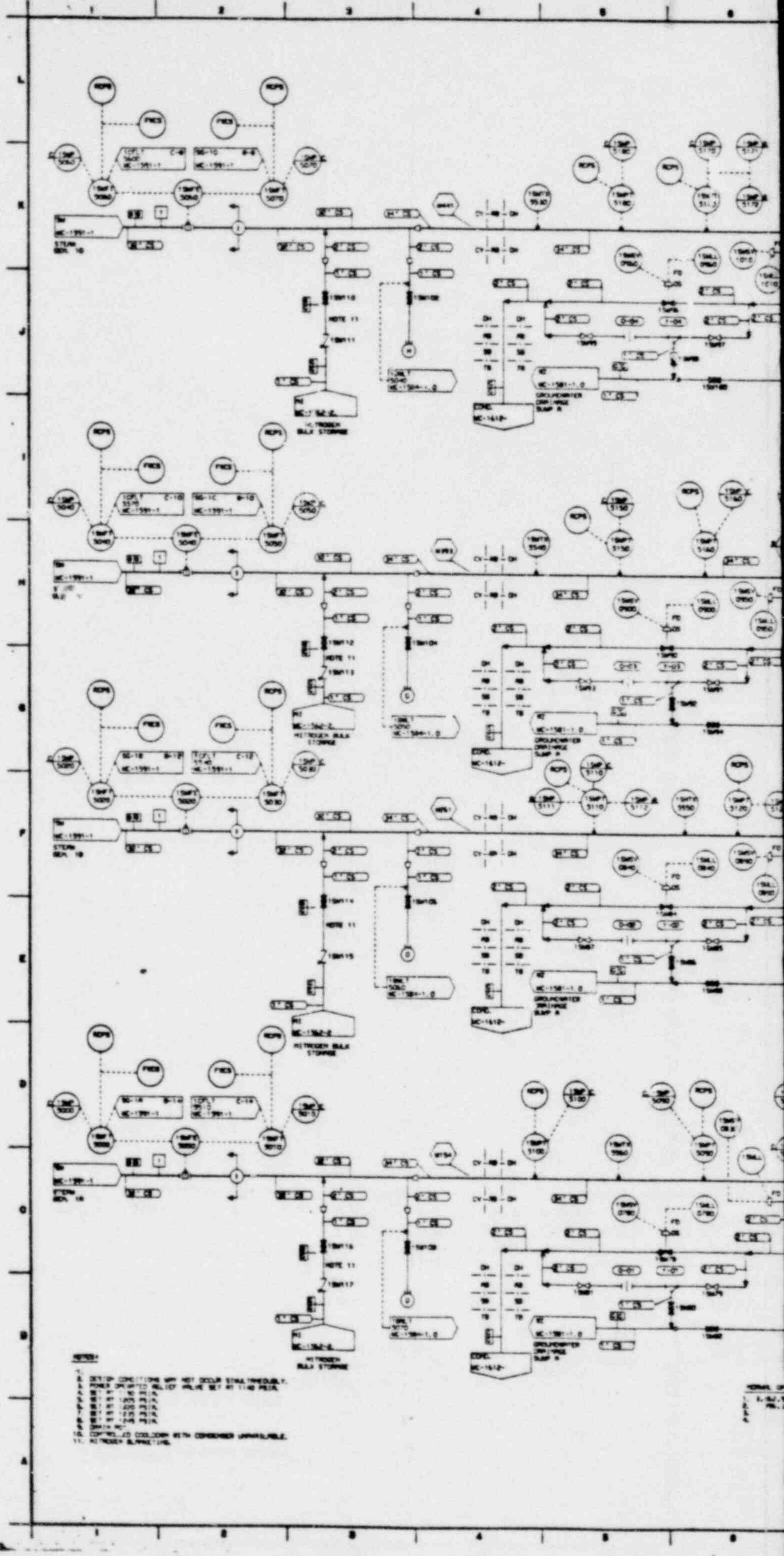


FIGURE 3.7

SHEET 1 of 1


NOTES:
DESIGN CONDITIONS MAY NOT OCCUR SIMULTANEOUSLY.
CONTROLLED COOLDOWN WITH CONDENSER UNAVAILABLE.
NITROGEN BLANKETING.
NITROGEN BULK STORAGE
GROUNDWATER DRAINAGE SUMP

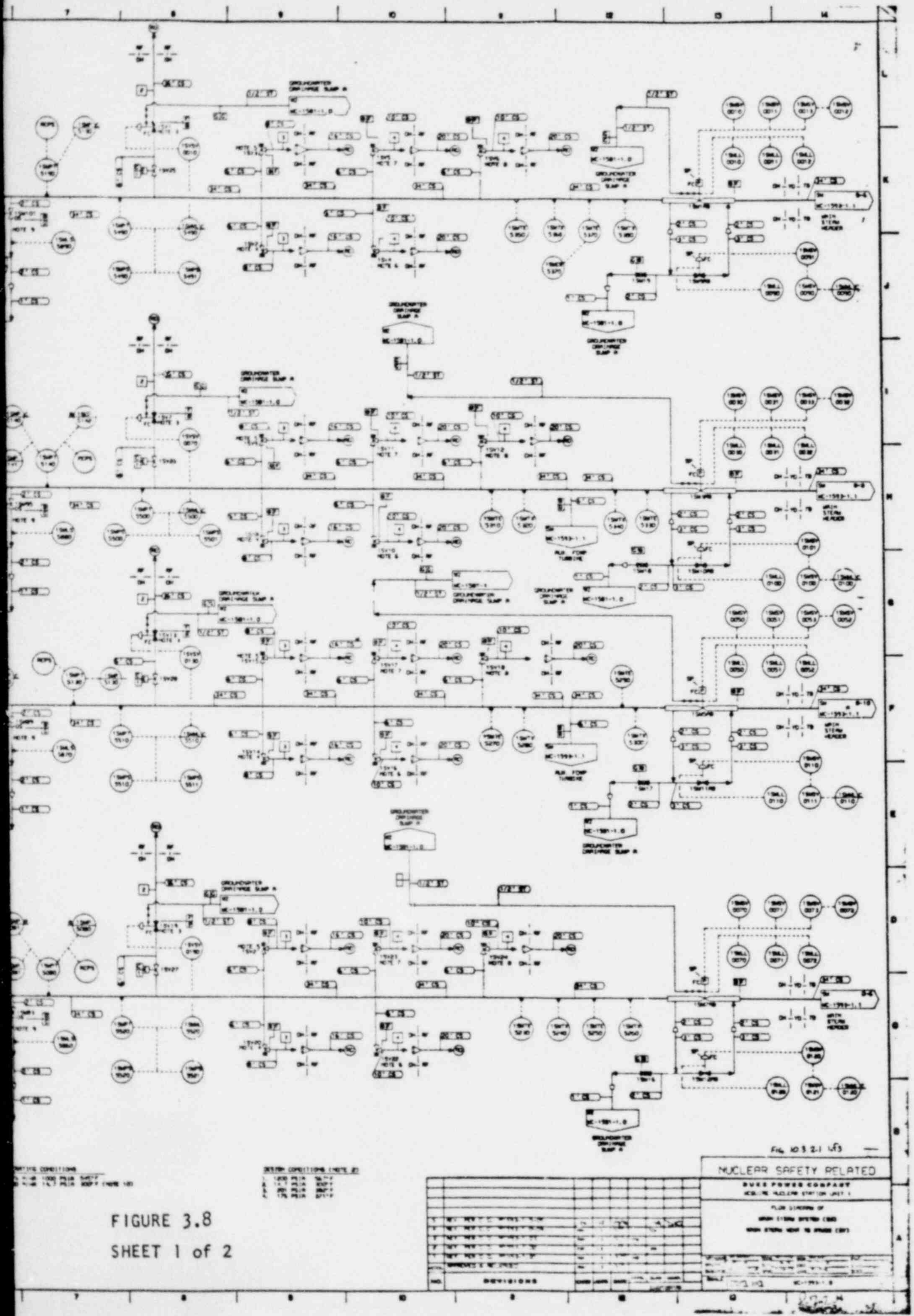
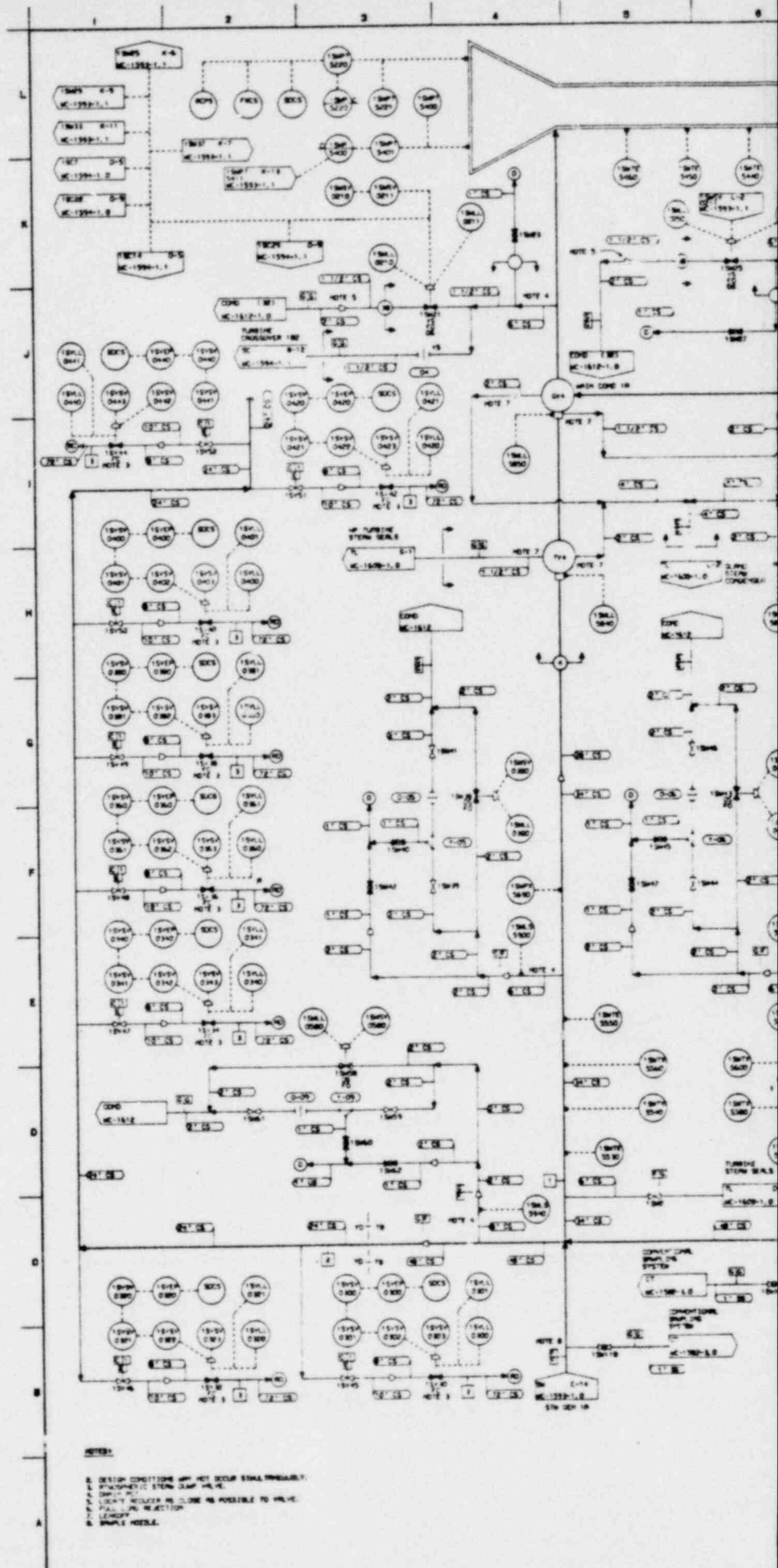


FIGURE 3.8

SHEET 1 of 2


NOTES:
2. DESIGN CONDITIONS MAY NOT OCCUR SIMULTANEOUSLY.
3. ATMOSPHERIC STEAM DUMP VALVE.
5. LOCATE REDUCER AS CLOSE AS POSSIBLE TO VALVE.
6. FULL LOAD REJECTION
7. LEAKOFF
8. SAMPLE NOZZLE.

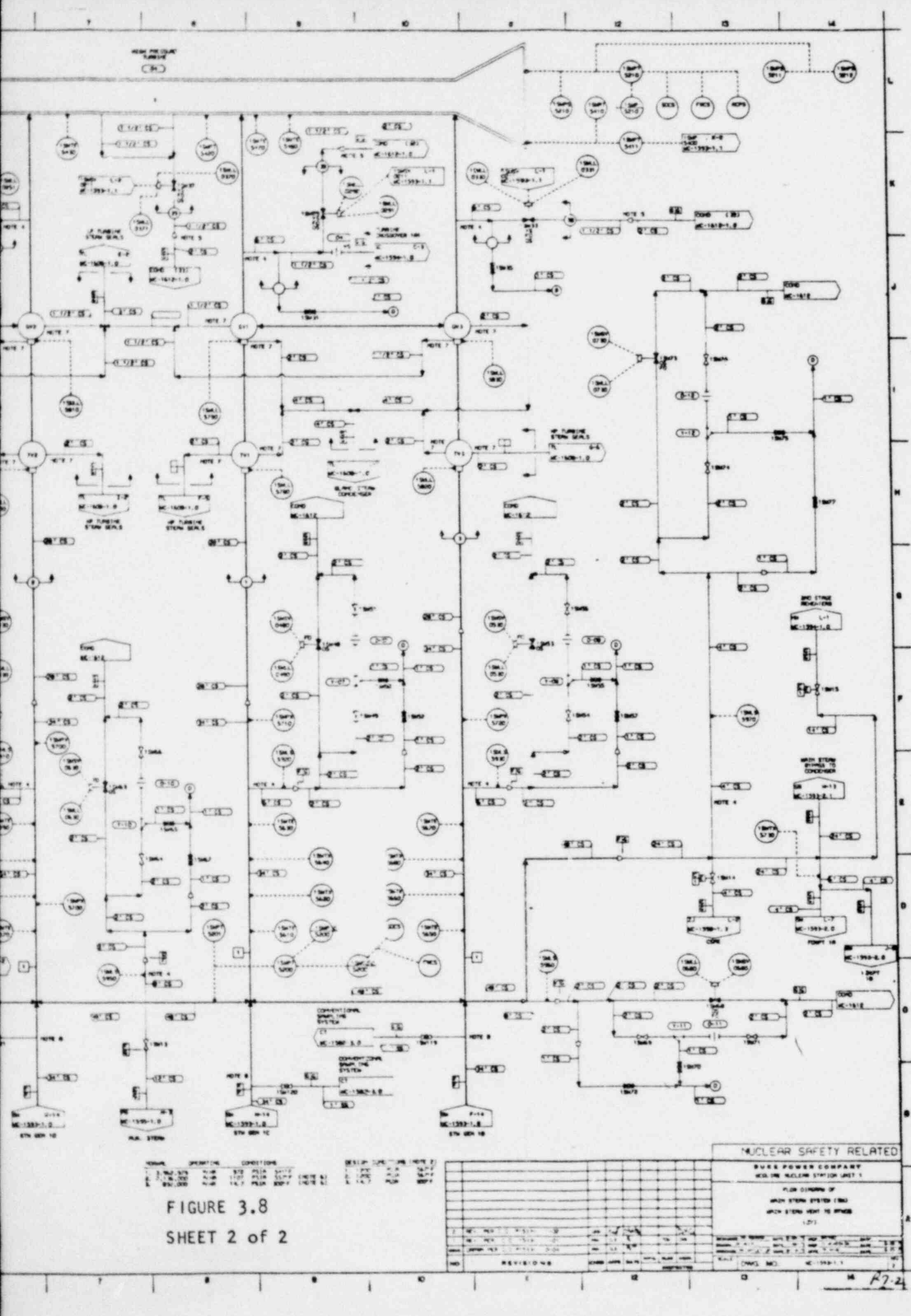
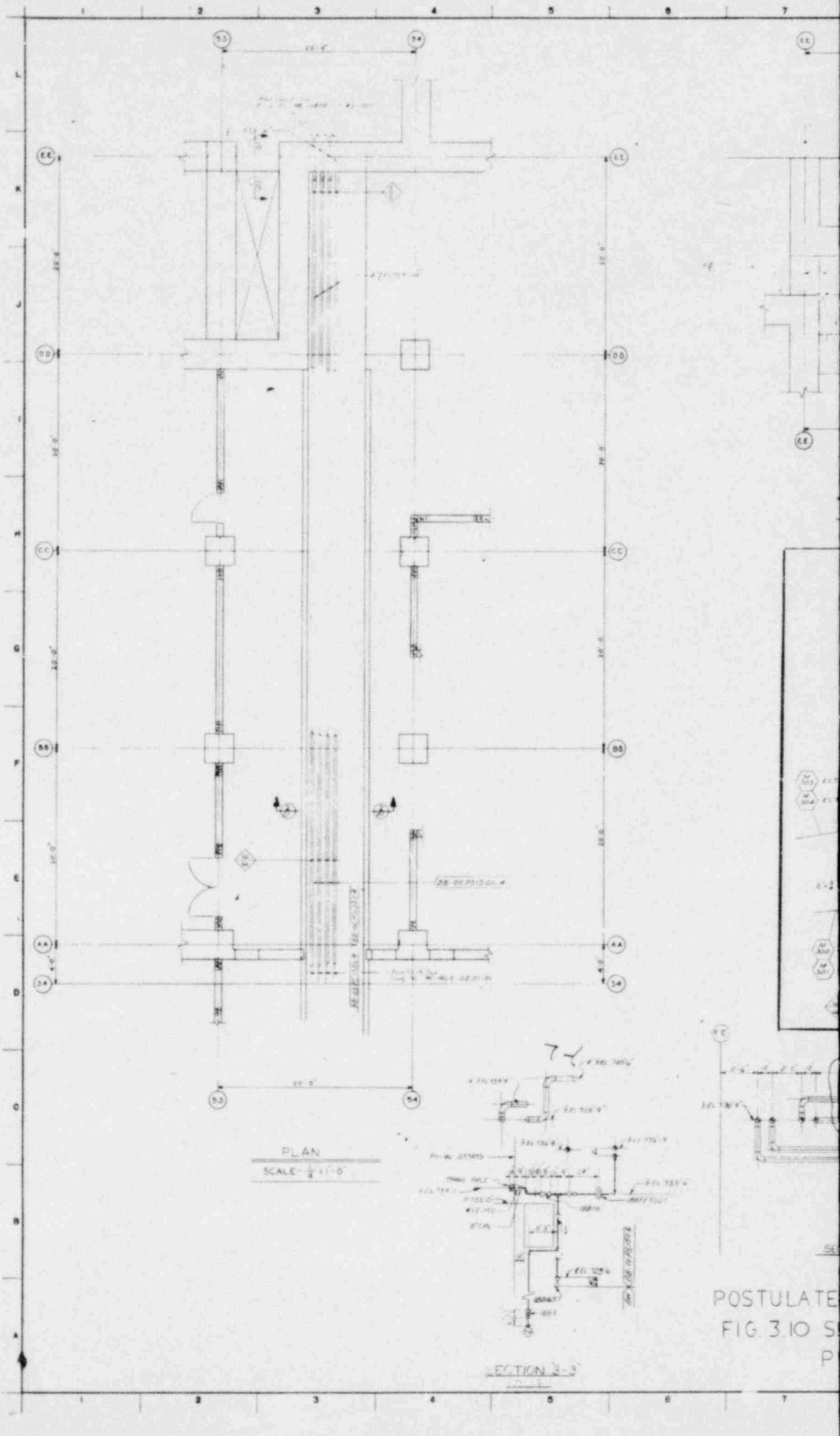
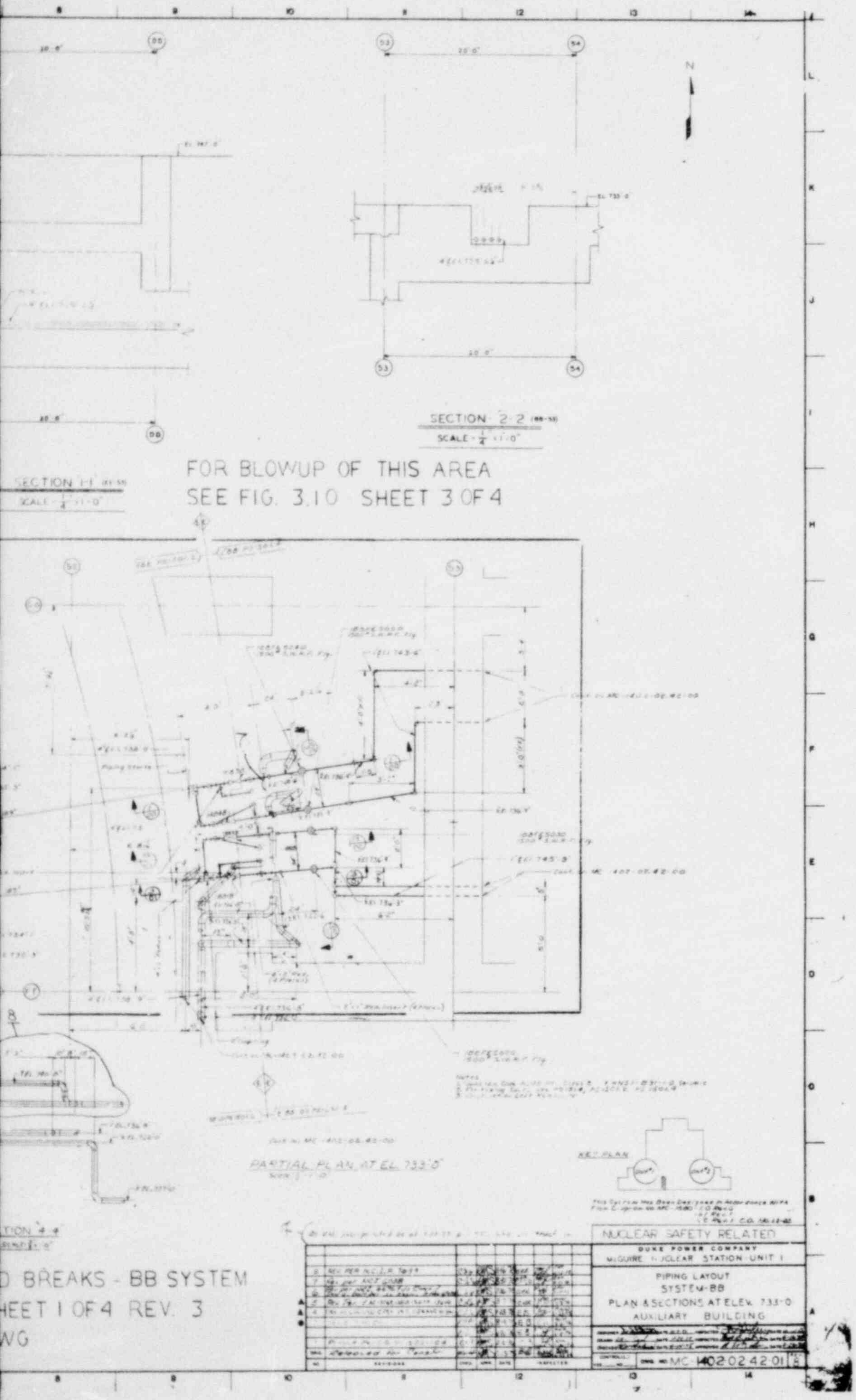


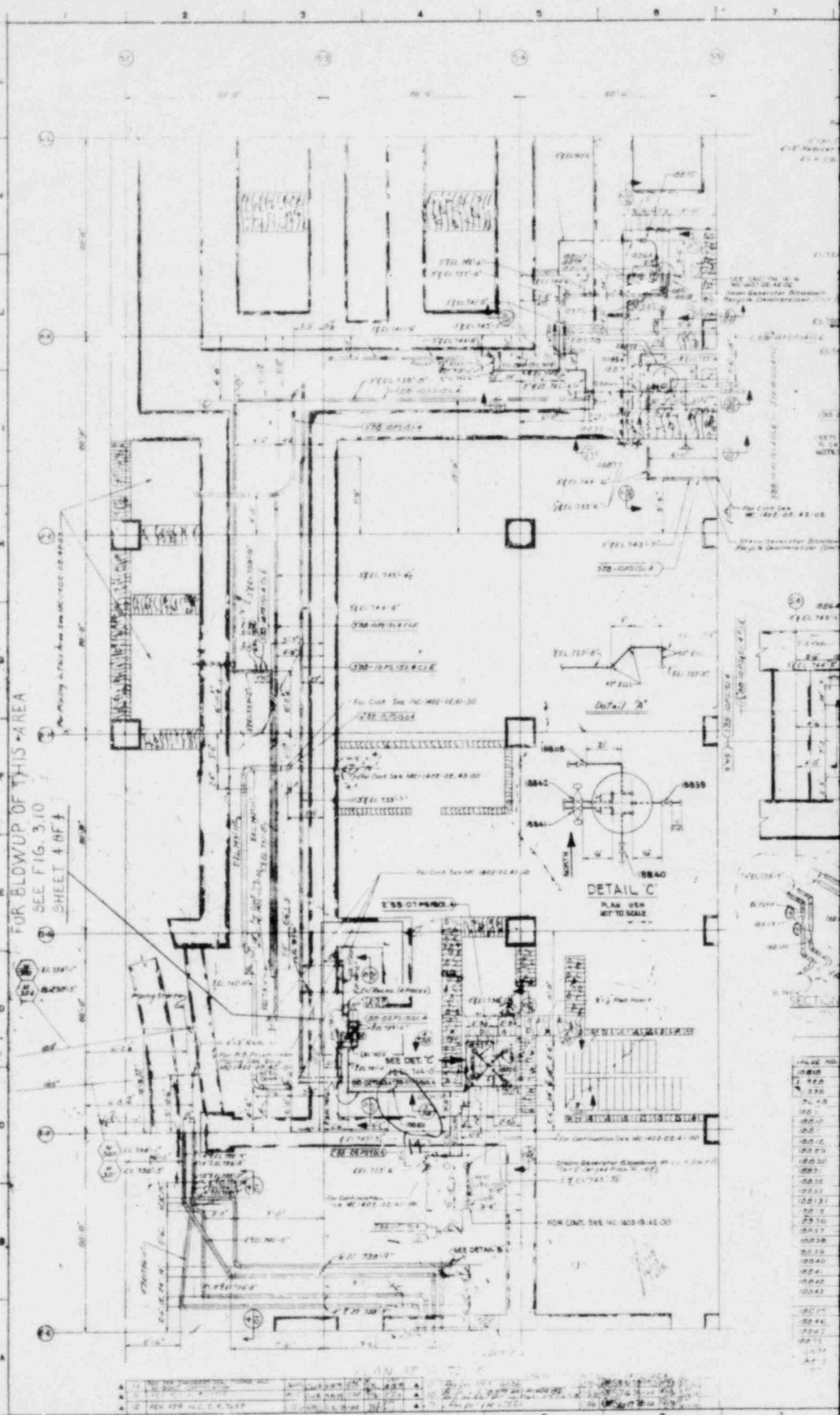
FIGURE 3.8

SHEET 2 of 2

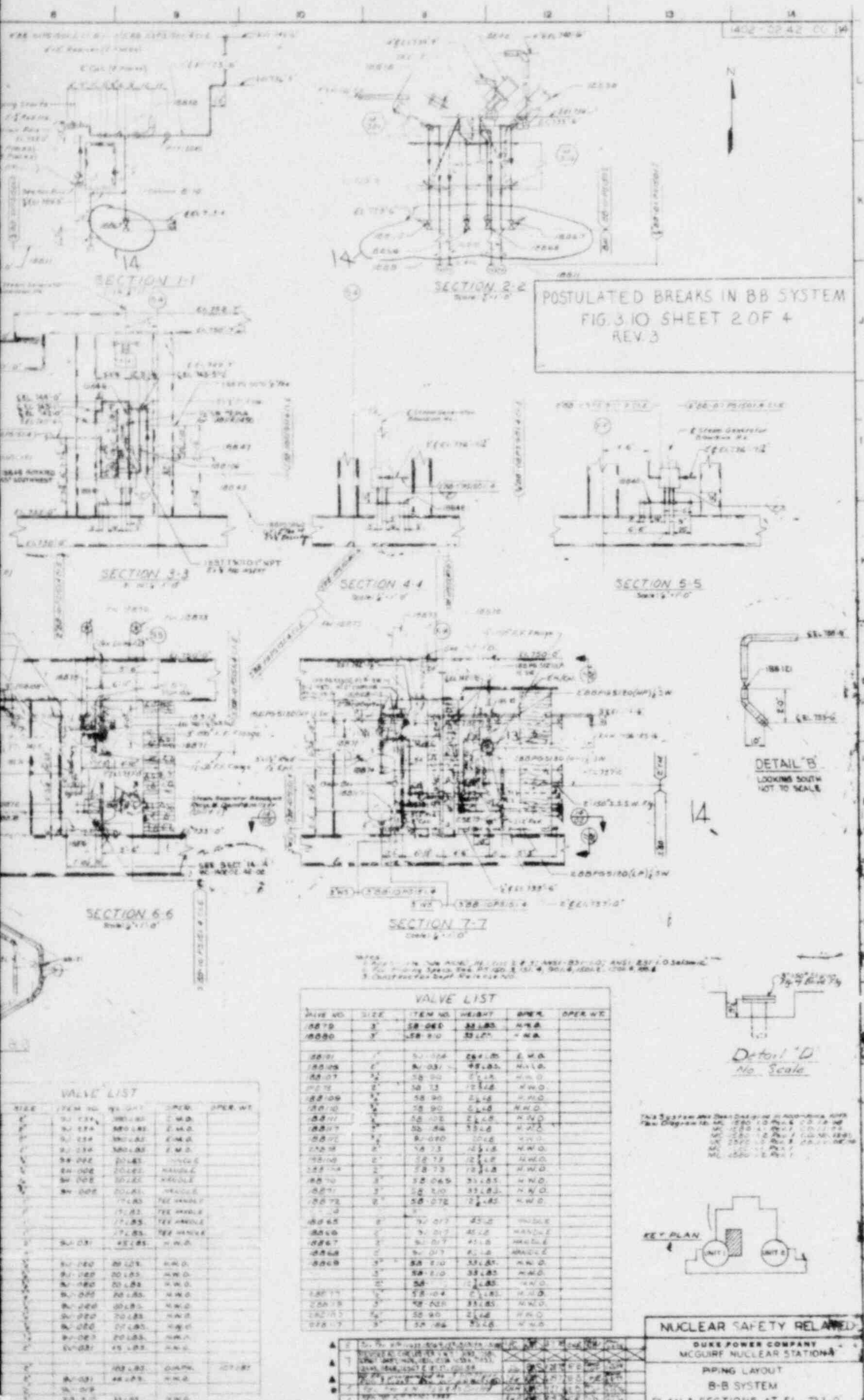


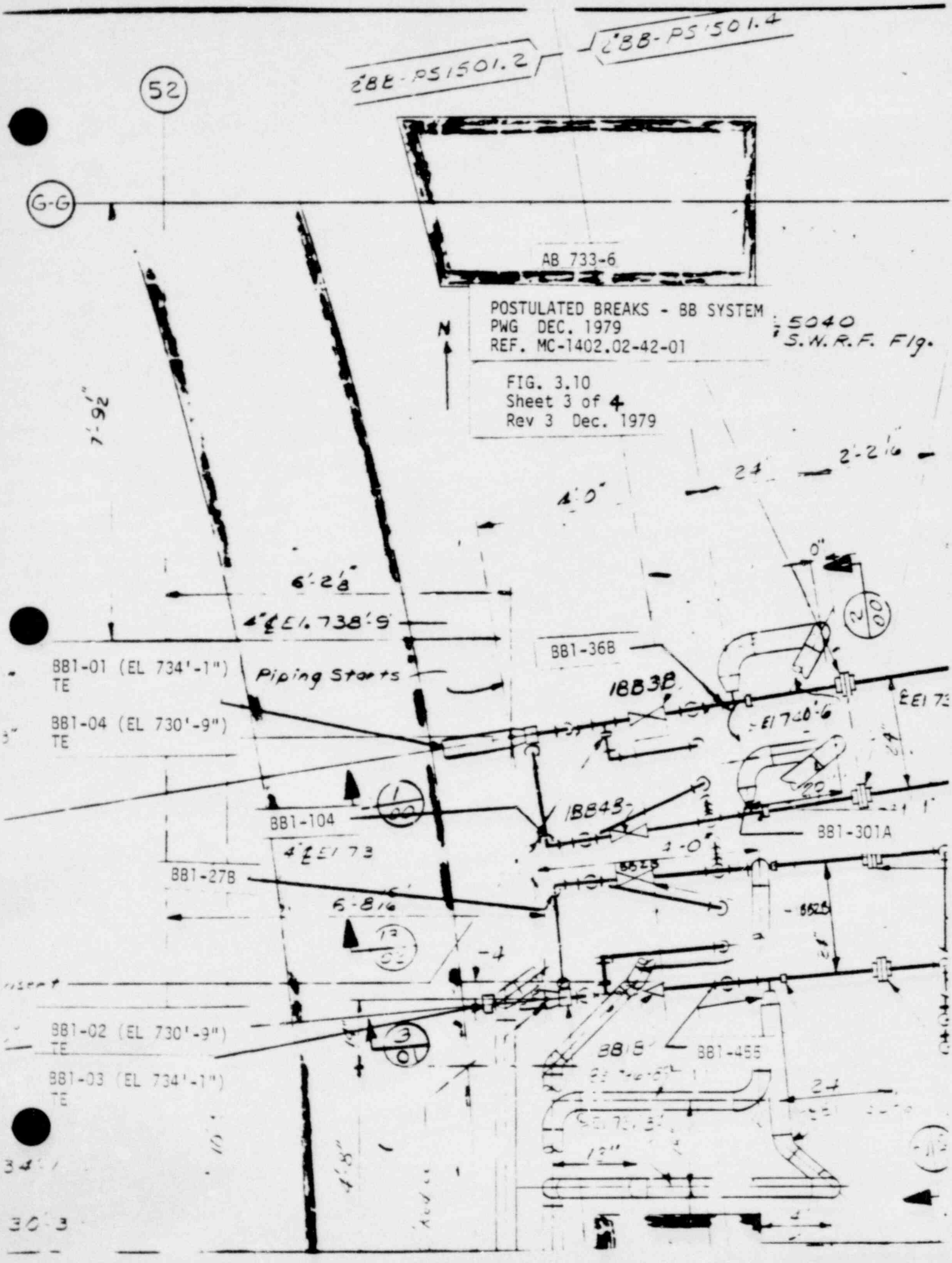
POSTULATE
FIG. 3.10 S
P


SECTION 2-2
FOR BLOWUP OF THIS AREA
SEE FIG. 3.10 SHEET 3 OF 4
SECTION 1-1
PARTIAL PLAN AT EL. 733'-0"
KEY PLAN
D BREAKS - BB SYSTEM
HEET 1 OF 4 REV. 3
WG
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION-UNIT 1
PIPING LAYOUT
SYSTEM-BB
PLAN & SECTIONS AT ELEV. 733-0
AUXILIARY BUILDING
MC-1402 02 42 01



FOR BLOWUP OF THIS AREA
SEE FIG. 3.10
SHEET 4 OF 4
Detail "A"
DETAIL "C"
PLAN VIEW
NOT TO SCALE
NORTH
SEE DET. "C"
SEE DETAIL "B"


1402-02.42-00
SECTION 1-1
SECTION 2-2
POSTULATED BREAKS IN B.B SYSTEM
FIG. 3.10 SHEET 2 OF 4
REV. 3
SECTION 3-3
SECTION 4-4
SECTION 5-5
SECTION 6-6
SECTION 7-7
DETAIL "B"
LOOKING SOUTH
NOT TO SCALE
Detail "D"
No Scale
VALVE LIST
VALVE LIST
KEY PLAN
UNIT 1
UNIT 2
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
MCGUIRE NUCLEAR STATION
PIPING LAYOUT
B-B SYSTEM
PLAN & SECTIONS AT EL. 733-0
AUXILIARY BUILDING
REVISIONS
DWG. NO. MC-1402-02.42



POSTULATED BREAKS - BB SYSTEM
PWG DEC. 1979
REF. MC-1402.02-42-01

FIG. 3.10
Sheet 3 of 4
Rev 3 Dec. 1979

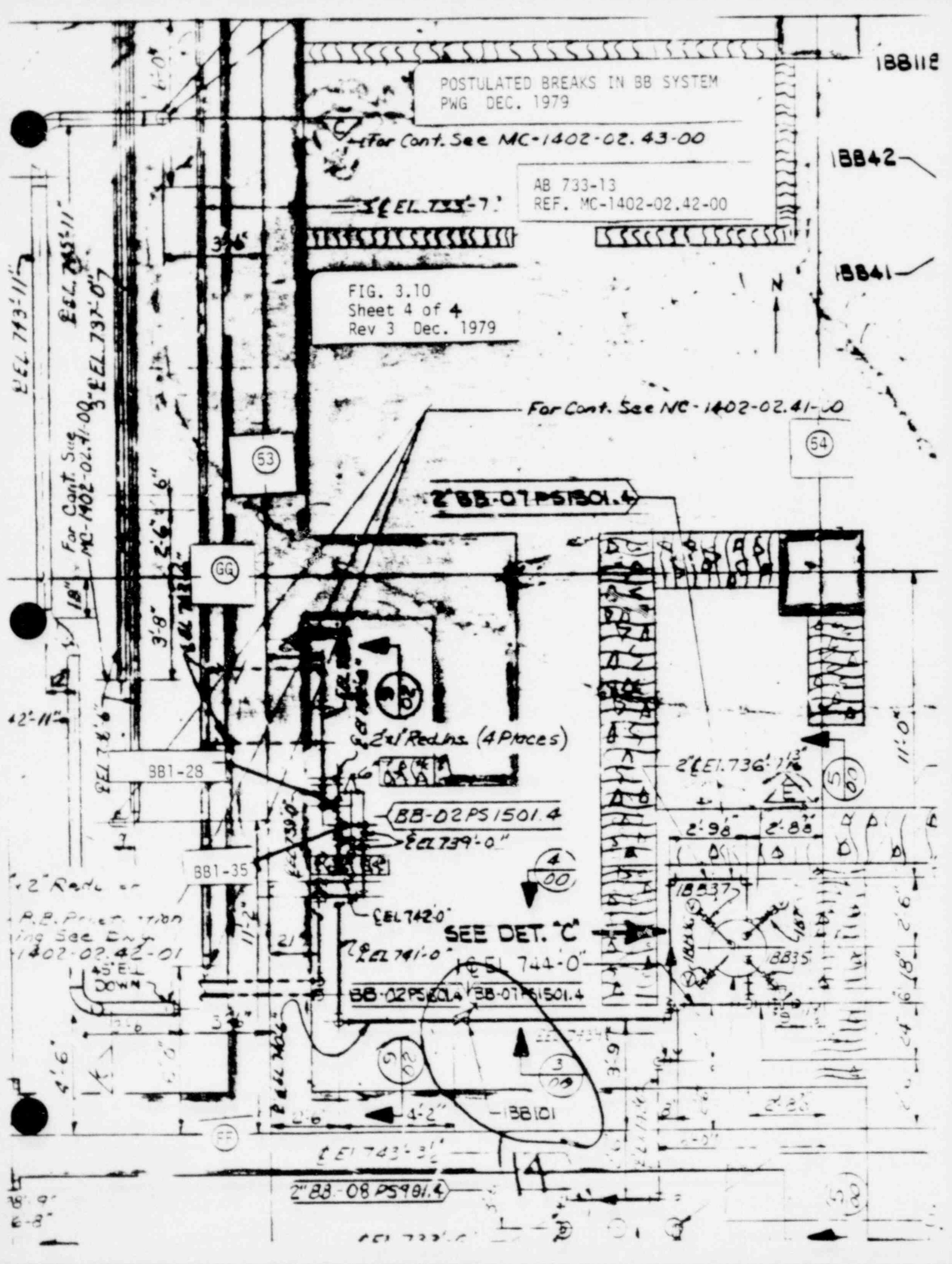
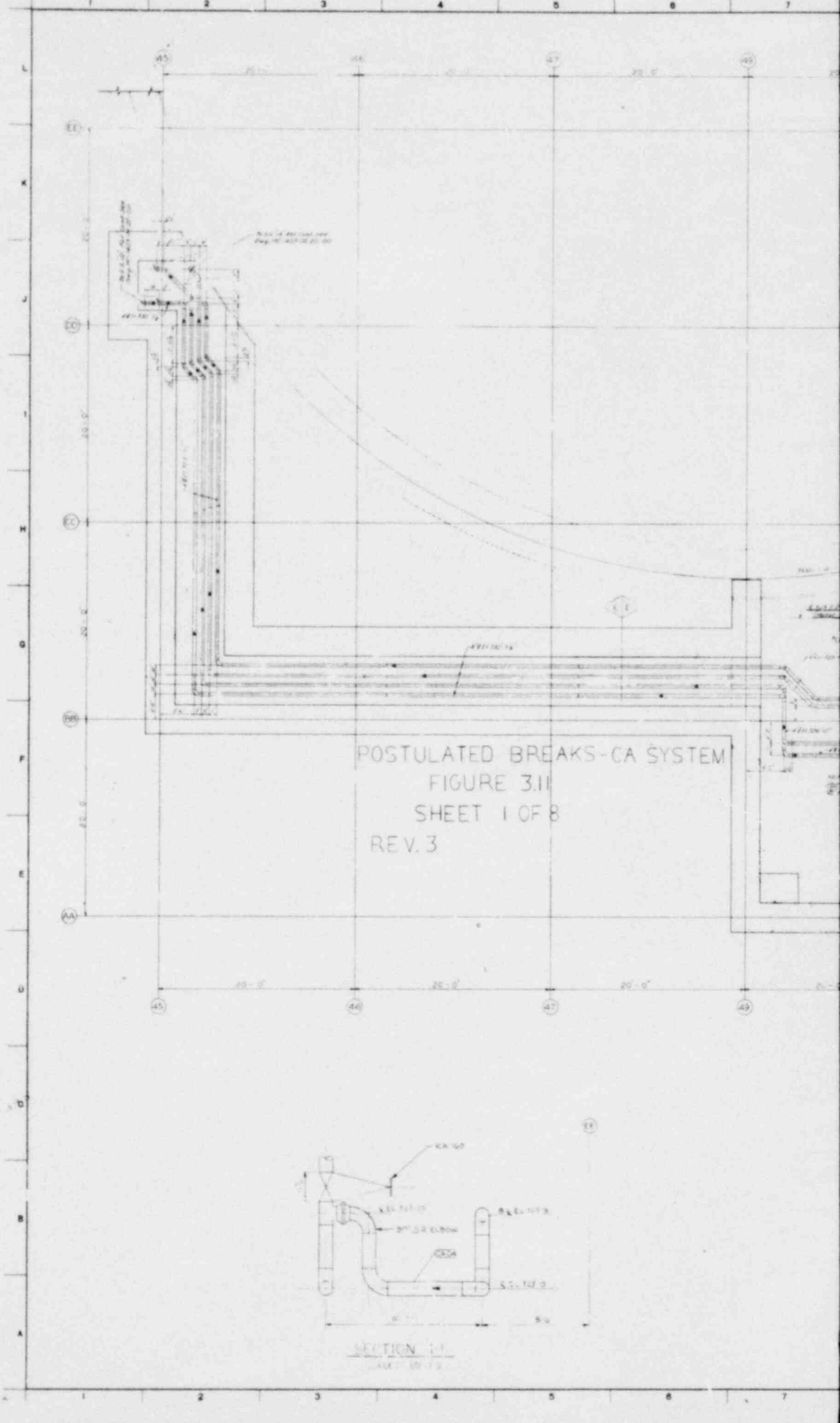
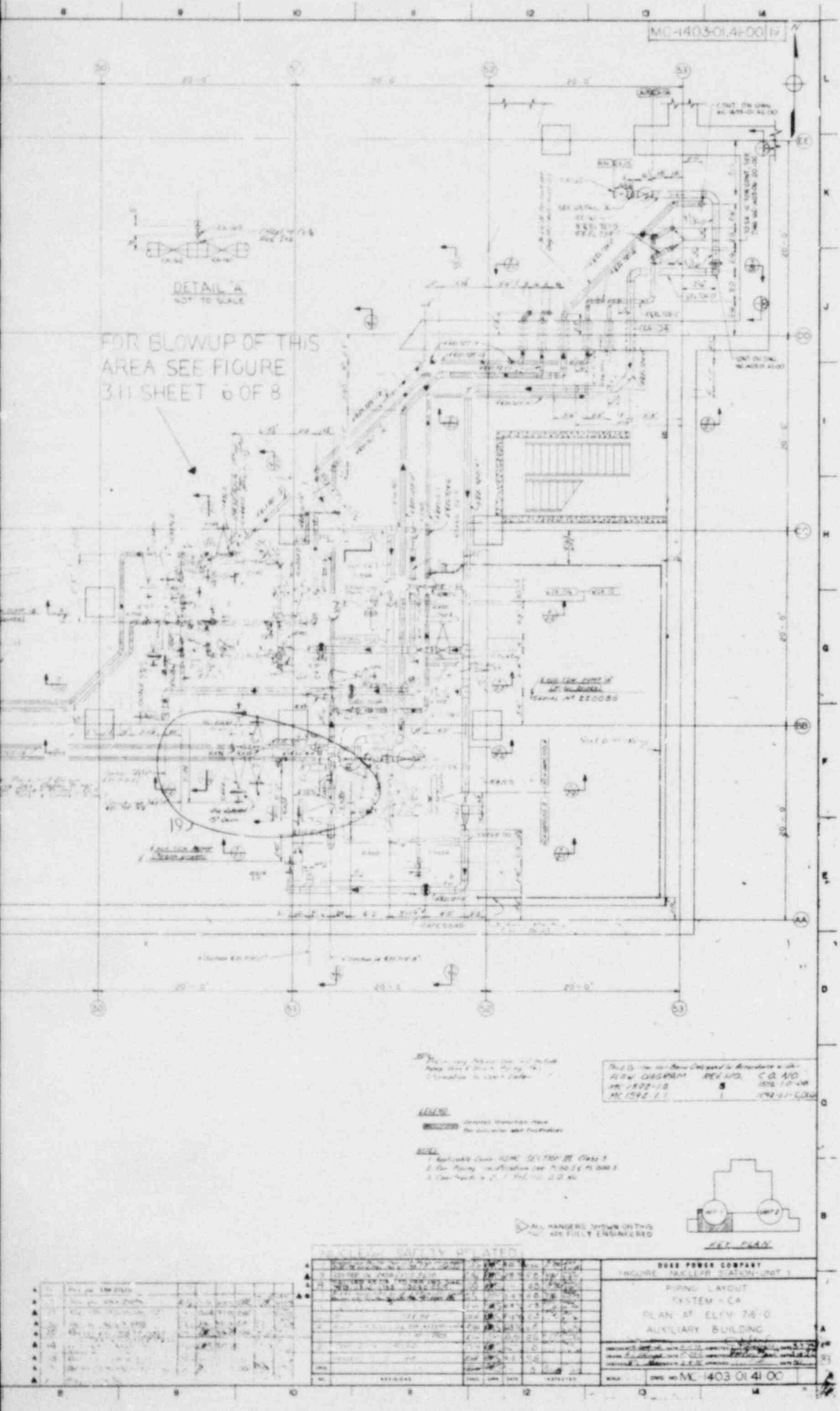
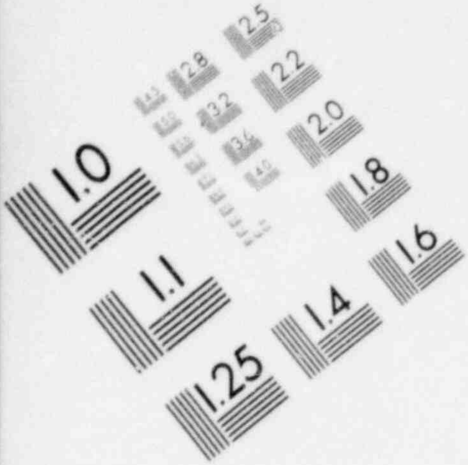


FIG. 3.10
Sheet 4 of 4
Rev 3 Dec. 1979


POSTULATED BREAKS-CA SYSTEM
FIGURE 3.11
SHEET 1 OF 8
REV. 3
SECTION



MC-1403-01.41-00
DETAIL 'A'
NOT TO SCALE
FOR BLOWUP OF THIS
AREA SEE FIGURE
3.11 SHEET 6 OF 8
KEY PLAN
ALL HANGERS SHOWN ON THIS DWG ARE FULLY ENGINEERED
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION-UNIT 1
PIPING LAYOUT
SYSTEM - CA
PLAN AT ELEV 716-0
AUXILIARY BUILDING
MC-1403-01.41-00



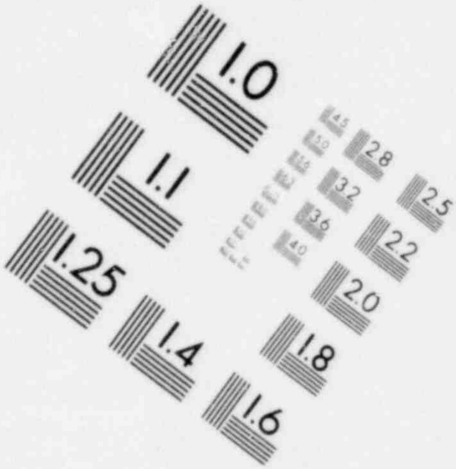
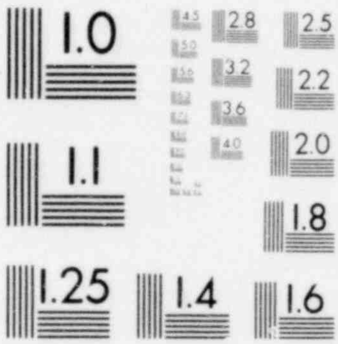
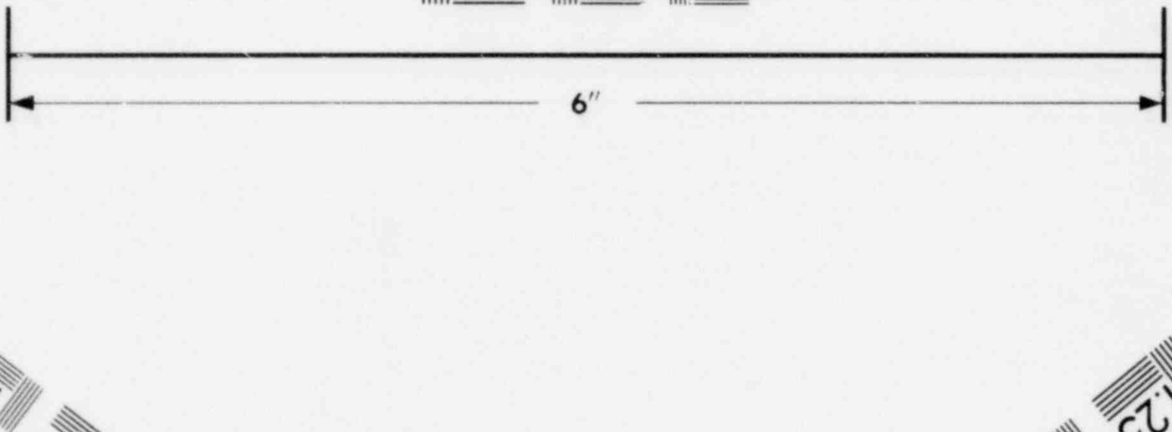
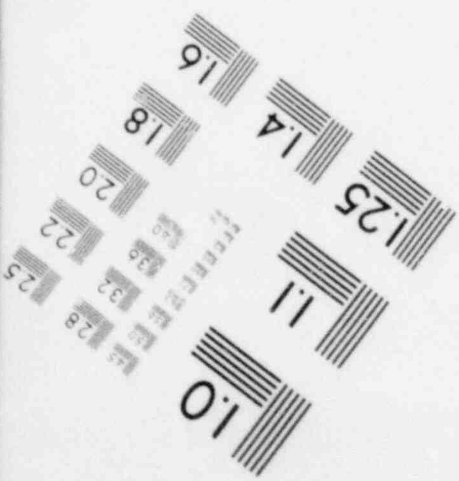


IMAGE EVALUATION TEST TARGET (MT-3)







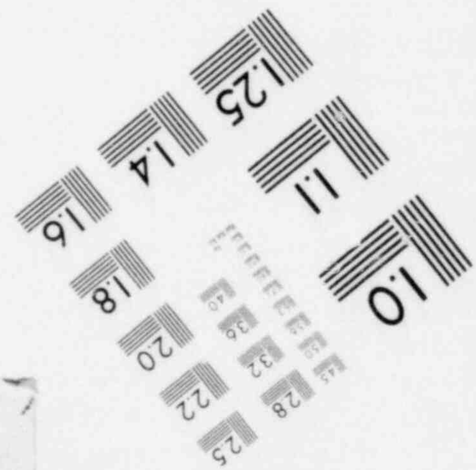
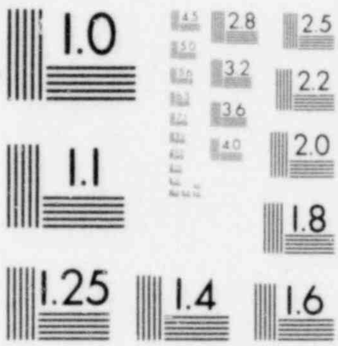
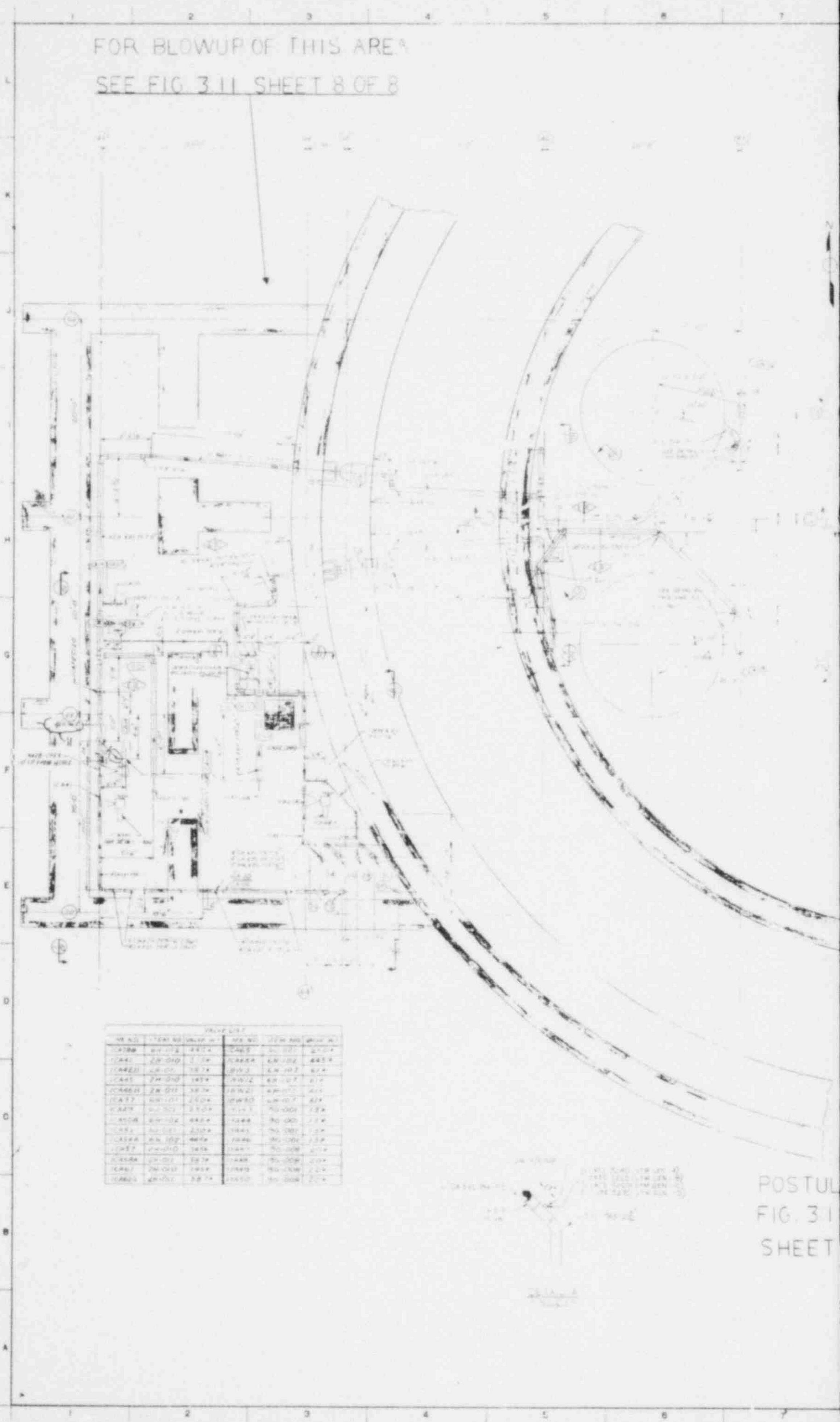
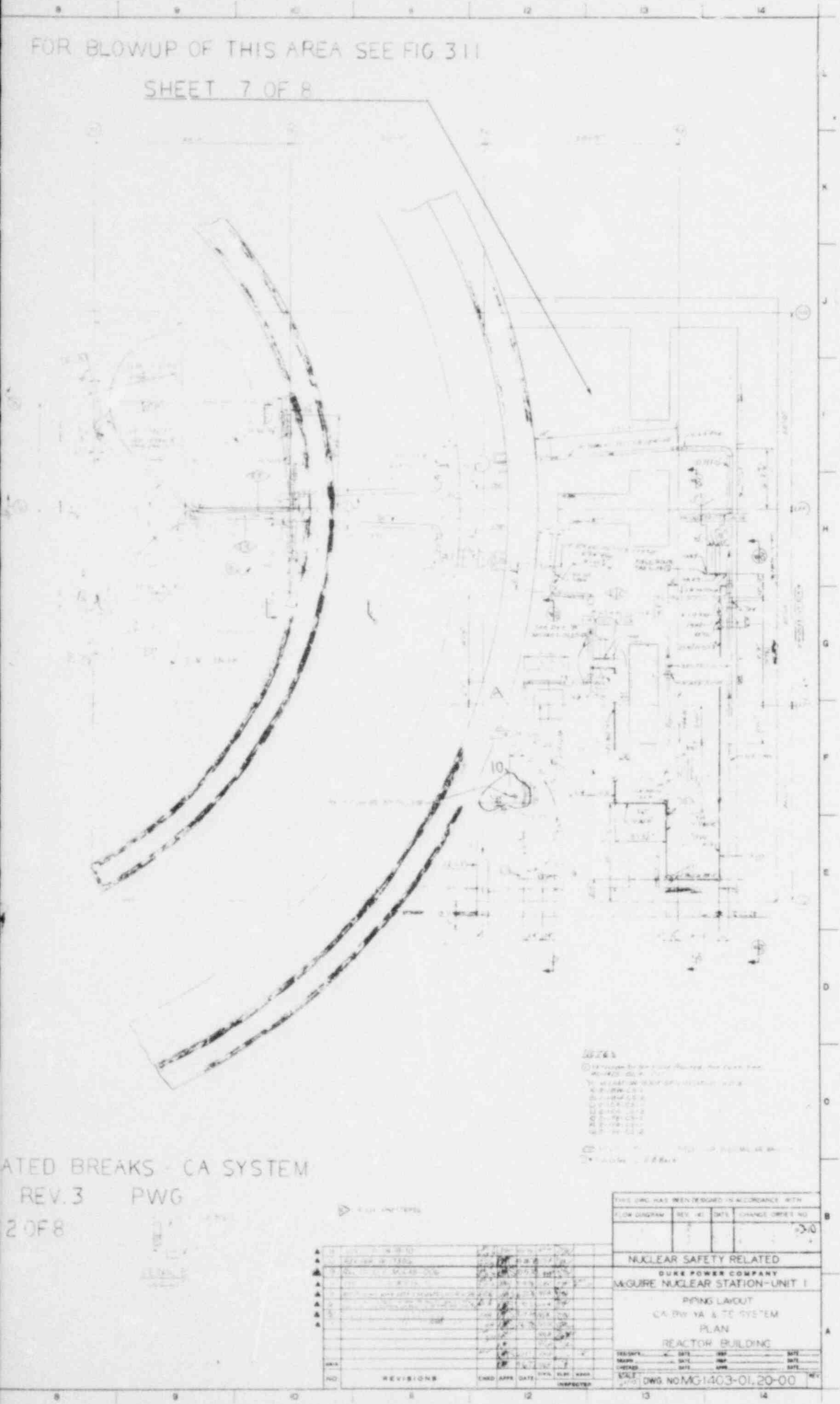


IMAGE EVALUATION
TEST TARGET (MT-3)

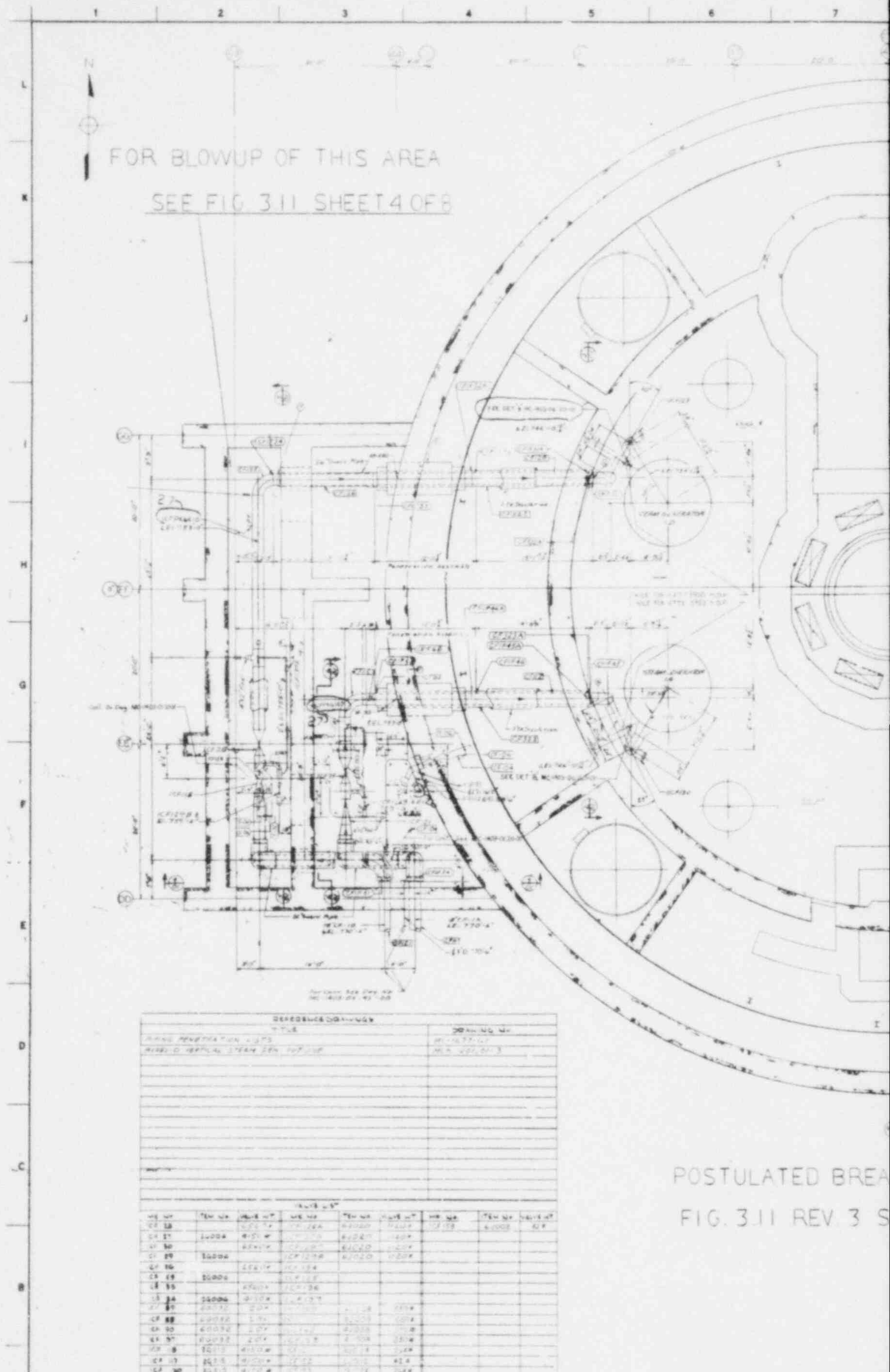




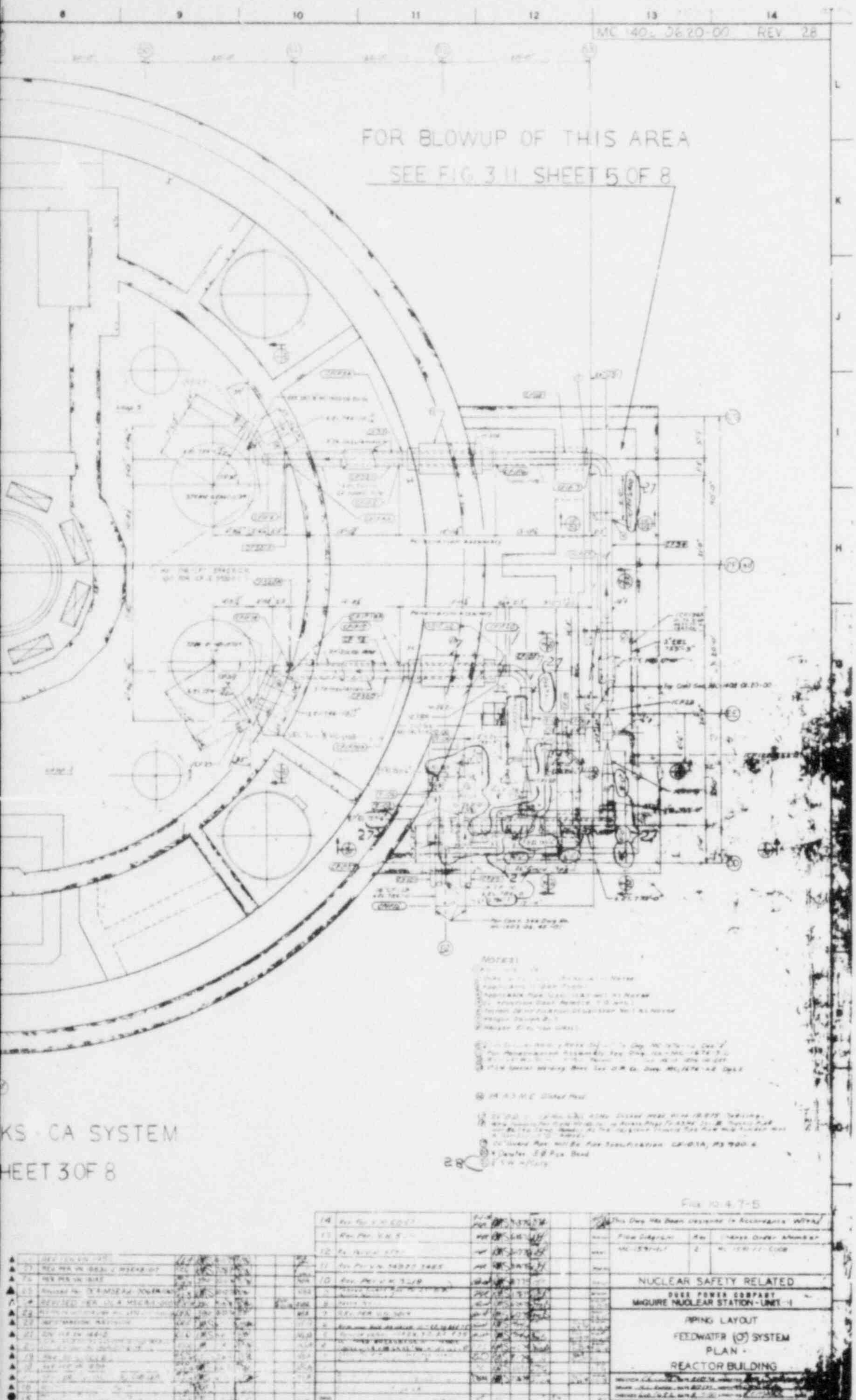
FOR BLOWUP OF THIS AREA
SEE FIG. 3.11 SHEET 8 OF 8
VALVE LIST
POSTUL
FIG. 3.1
SHEET



FOR BLOWUP OF THIS AREA SEE FIG 3.11
SHEET 7 OF 8
ATED BREAKS - CA SYSTEM
REV. 3 PWG
2 OF 8
THIS DWG HAS BEEN DESIGNED IN ACCORDANCE WITH
FLOW DIAGRAM
REV. NO.
DATE
CHANGE ORDER NO.
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION-UNIT 1
PIPING LAYOUT
CA, BW, YA & TE SYSTEM
PLAN
REACTOR BUILDING
REVISIONS
DWG. NO MG1403-01.20-00



FOR BLOWUP OF THIS AREA
SEE FIG 3.11 SHEET 4 OF 8
POSTULATED BREA
FIG. 3.11 REV. 3 S


MC 1403-06.20-00 REV. 28
FOR BLOWUP OF THIS AREA
SEE FIG. 3.11 SHEET 5 OF 8
KS - CA SYSTEM
HEET 3 OF 8
Notes:
Fig 10.4.7-5
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION - UNIT 1
PIPING LAYOUT
FEEDWATER (CF) SYSTEM
PLAN
REACTOR BUILDING
MC-1403-06.20-00

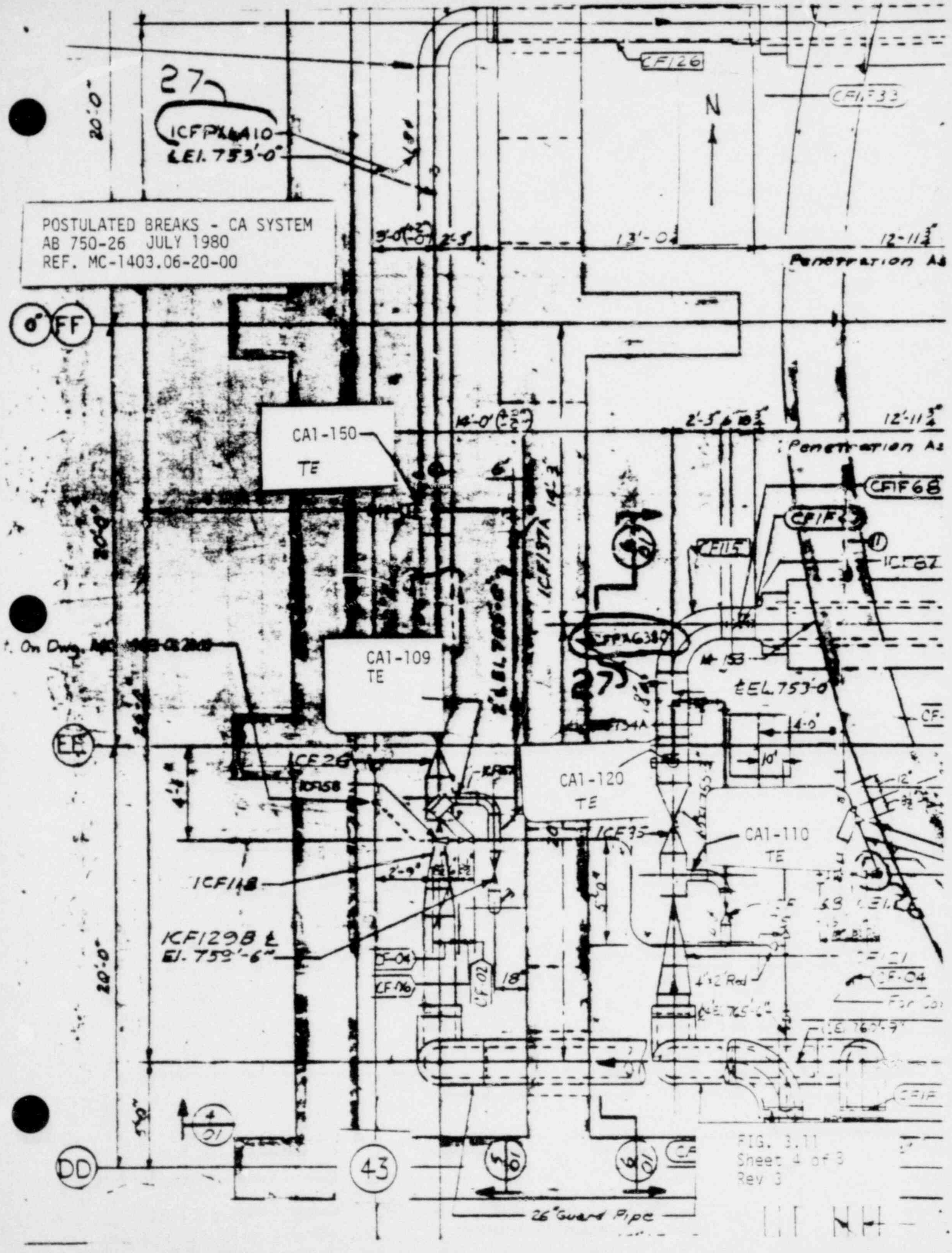


FIG. 3.11
Sheet 4 of 8
Rev 3

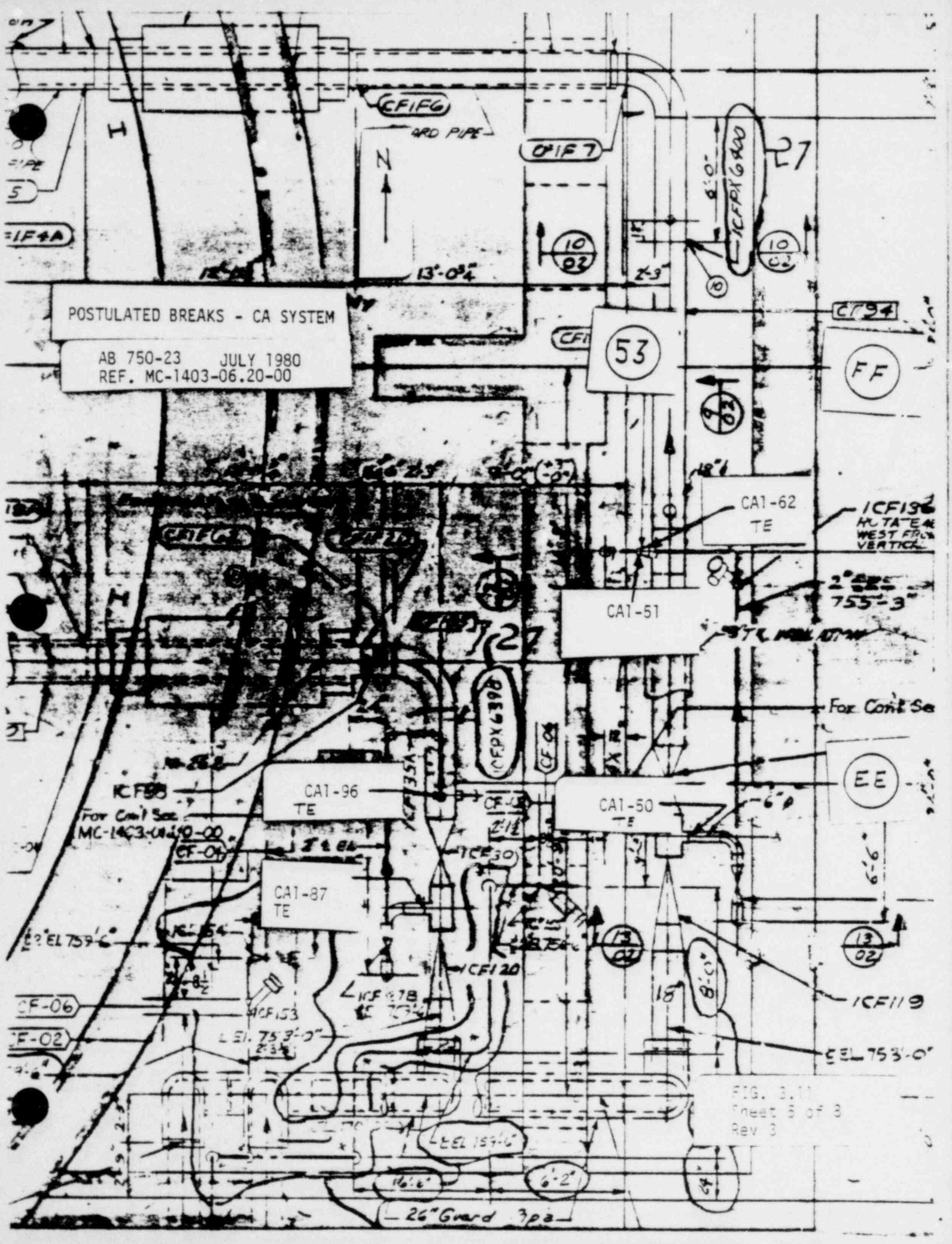


FIG. 3.11
Sheet 5 of 8
Rev 3

POSTULATED BREAKS - CA SYSTEM
AB-716-10 July 1980

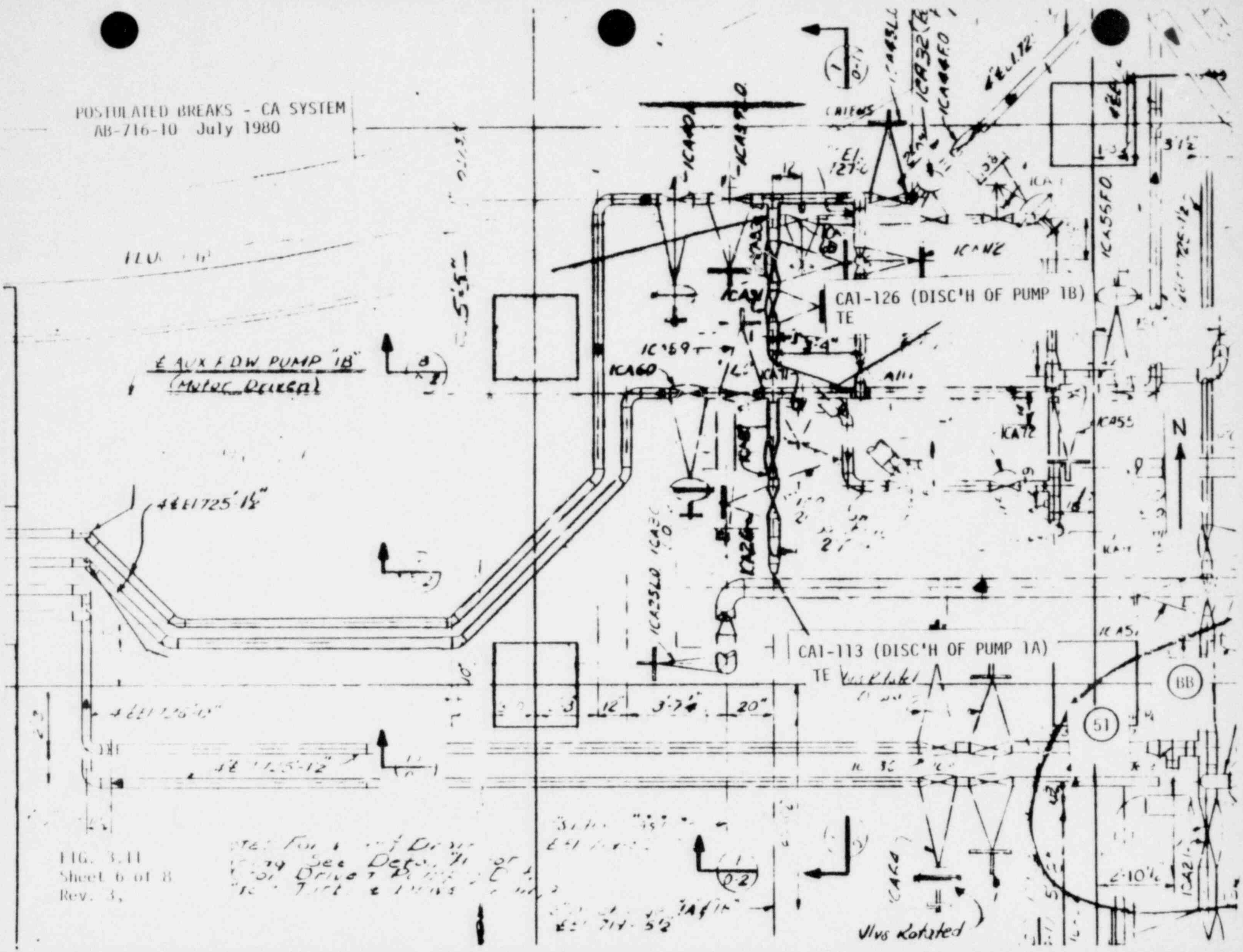


FIG. 3.11
Sheet 6 of 8
Rev. 3,

POSTULATED BREAKS - CA SYSTEM

AB 750-23 July 1980
Ref. 1403-03.20-00

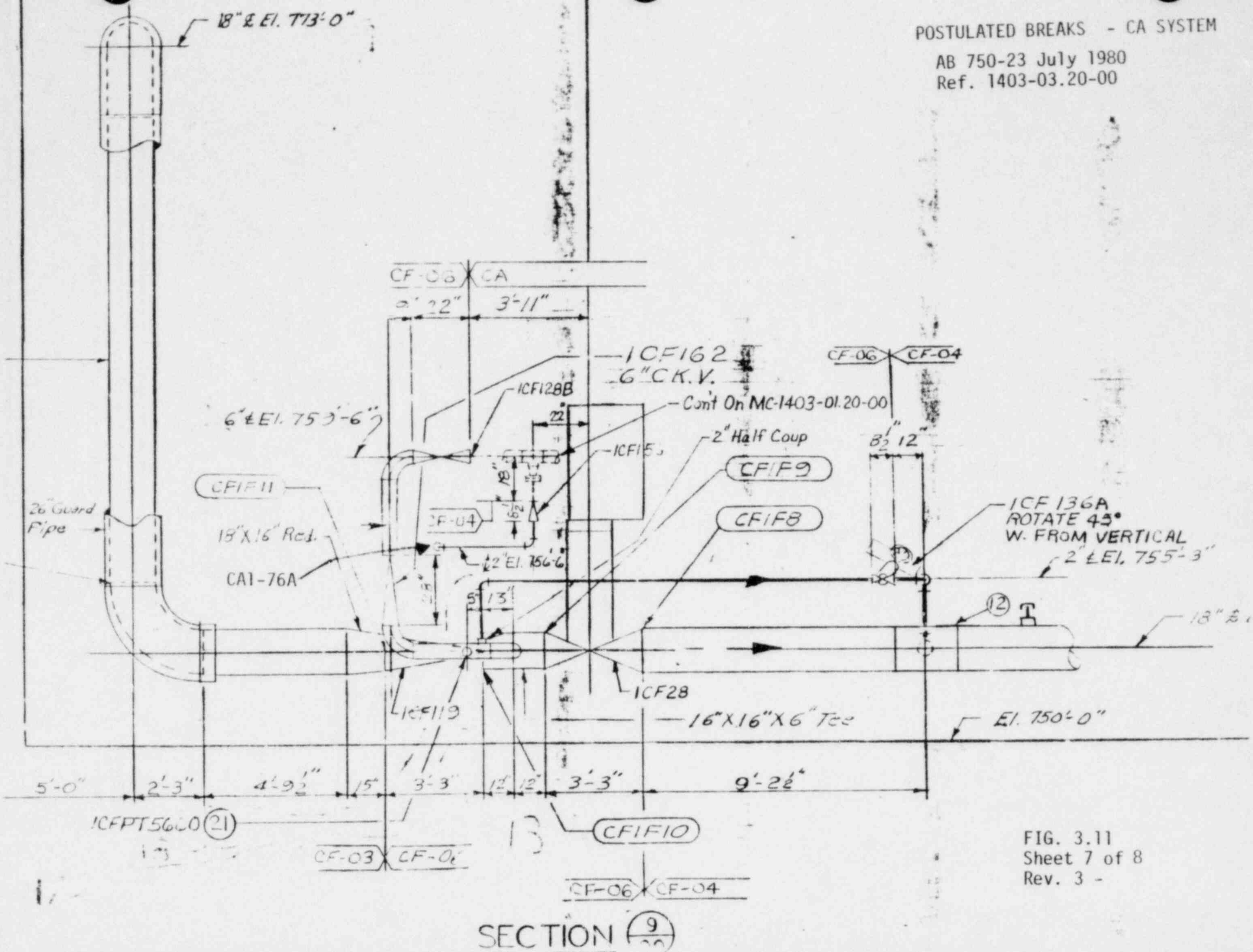


FIG. 3.11
Sheet 7 of 8
Rev. 3 -

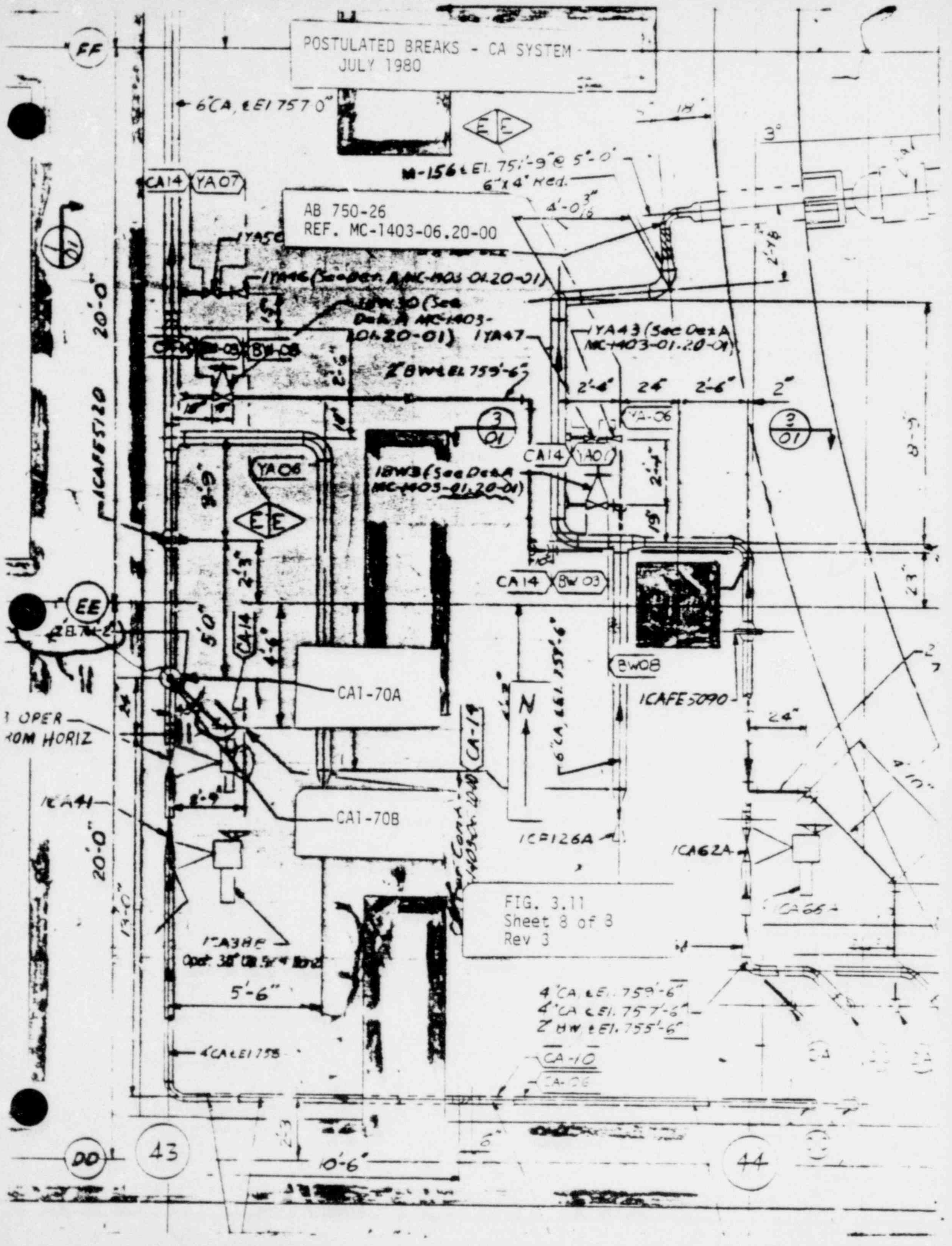


FIG. 3.11
Sheet 8 of 8
Rev 3

POSTULATED BREAKS - CA SYSTEM
AB 750-23 JULY 1980
REF: MC-1403-06.20-00

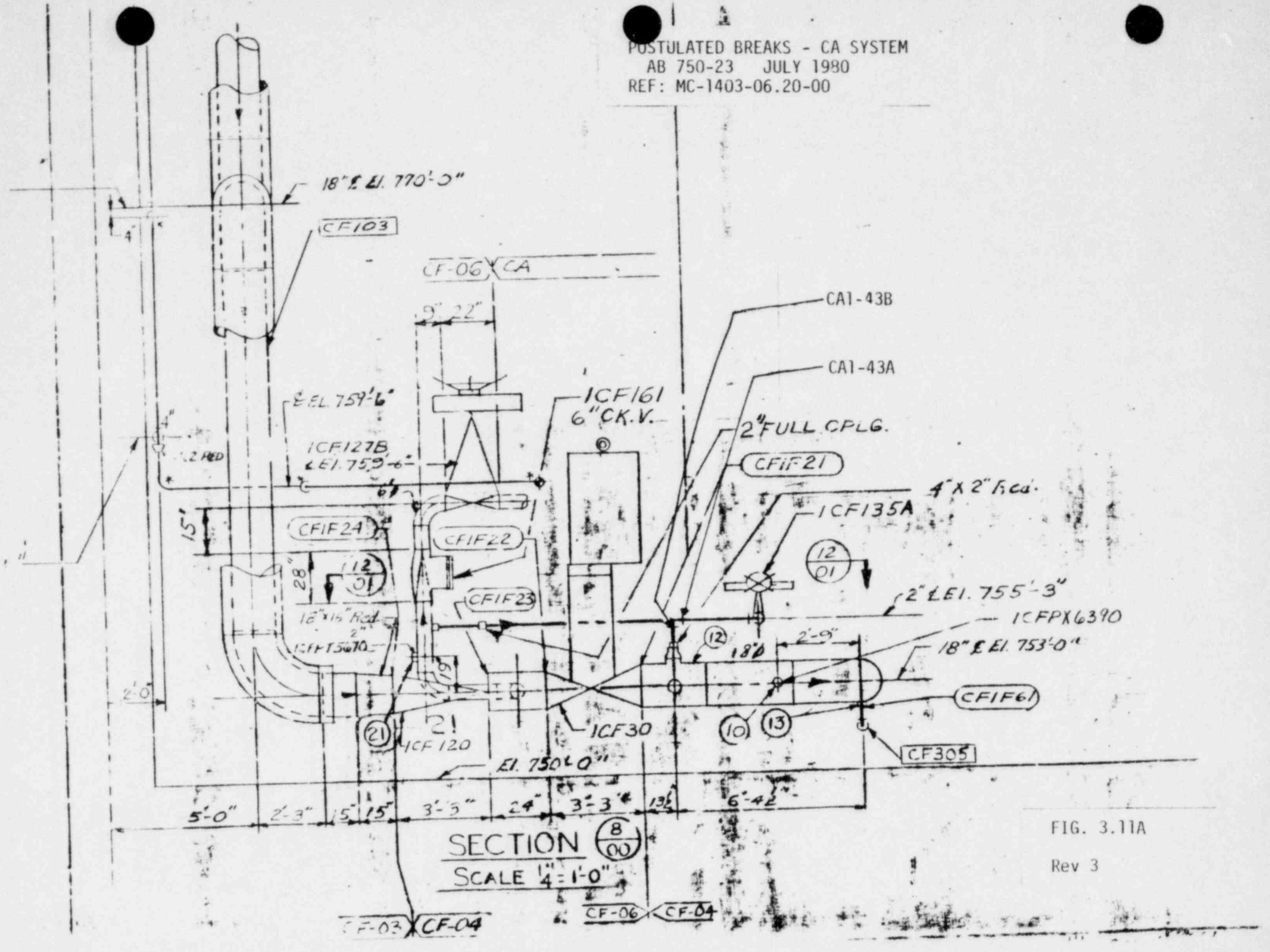
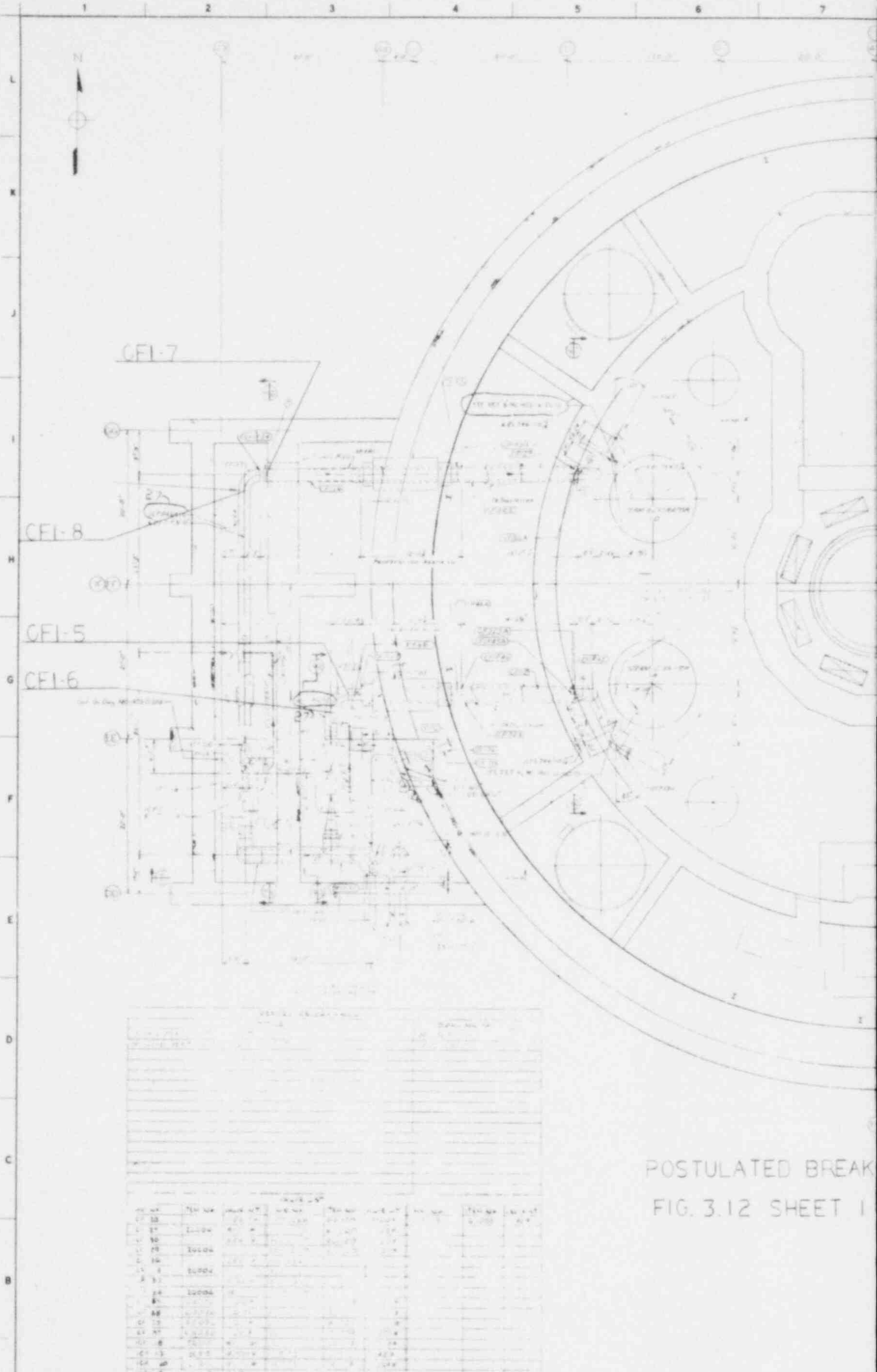
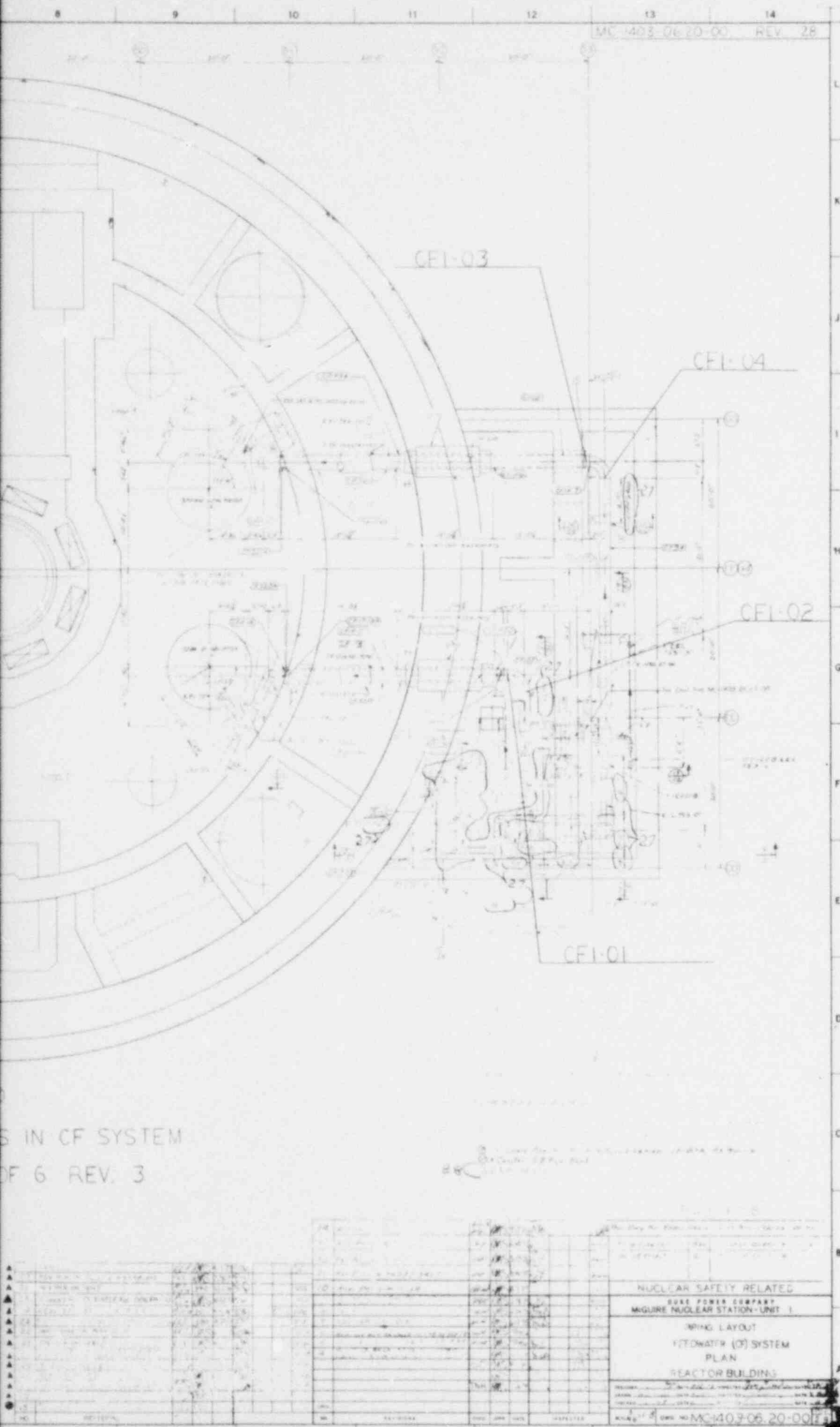


FIG. 3.11A

Rev 3



POSTULATED BREAK
FIG. 3.12 SHEET 1



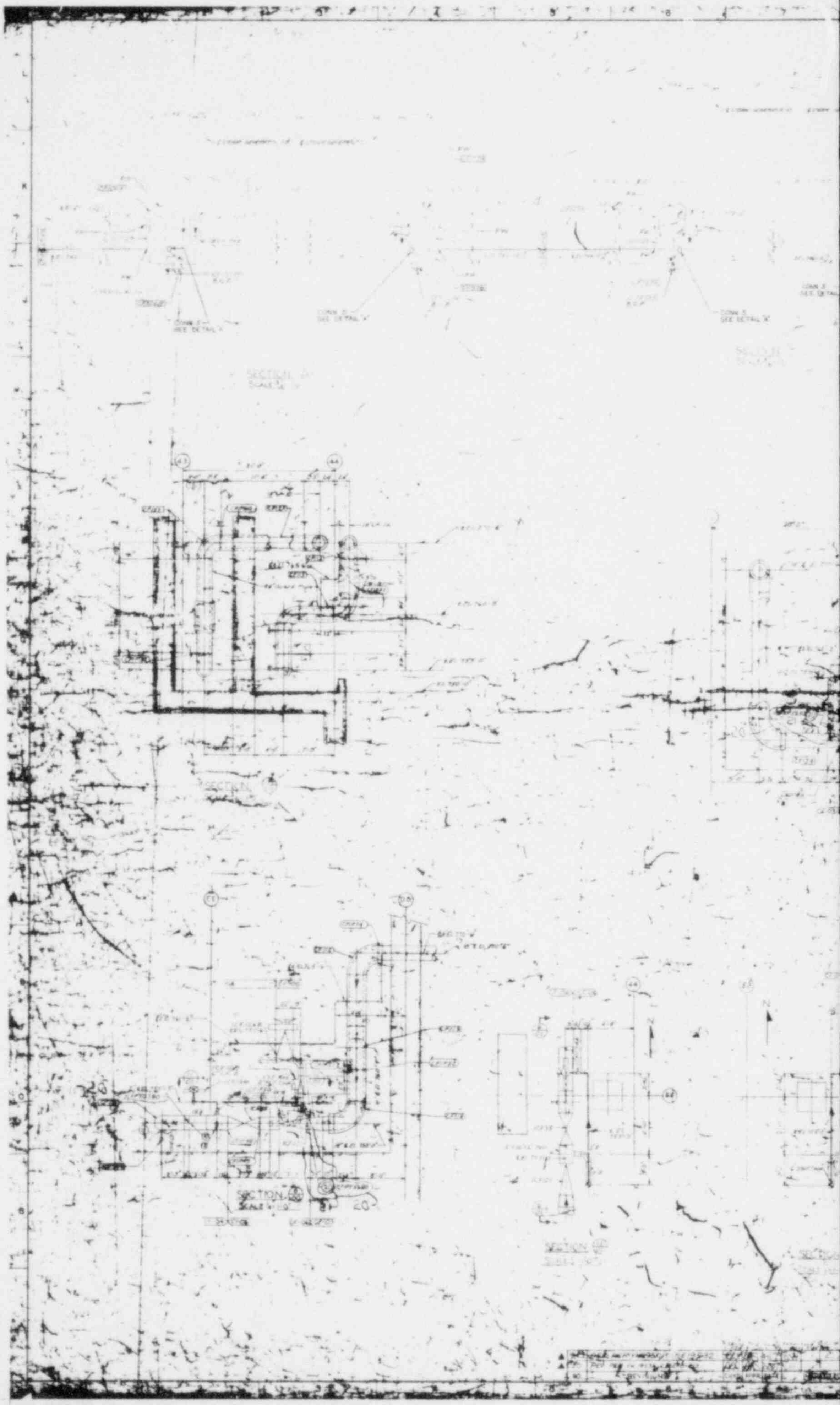
MC-1403-06.20-00 REV. 28
CF1-03
CF1-04
CF1-02
CF1-01
S IN CF SYSTEM
OF 6 REV. 3
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION - UNIT 1
PIPING LAYOUT
FEEDWATER (CF) SYSTEM
PLAN
REACTOR BUILDING
DWG NO MC-1403-06.20-00

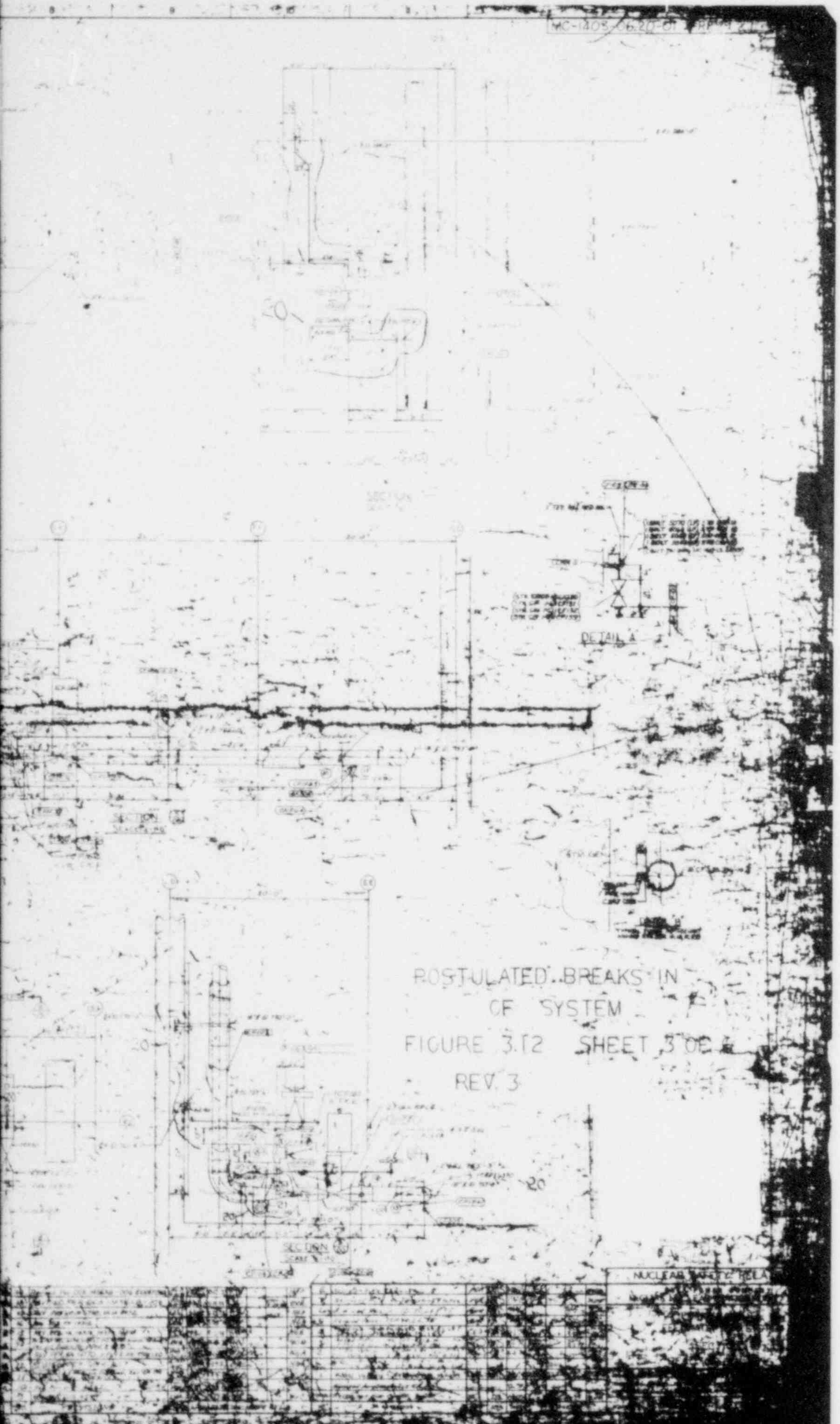
POSTULATED BREAKS
CF SYSTEM
FIG. 3.12 SHEET 2
REV 3

NUCLEAR SAFETY RELATED
COMPANY
McGUIRE NUC EAR STATION-UNIT 1
PIPING LAYOUT
PLAN
REACTOR BUILDING
DWG NO MG1403-01.20-00
REVISIONS

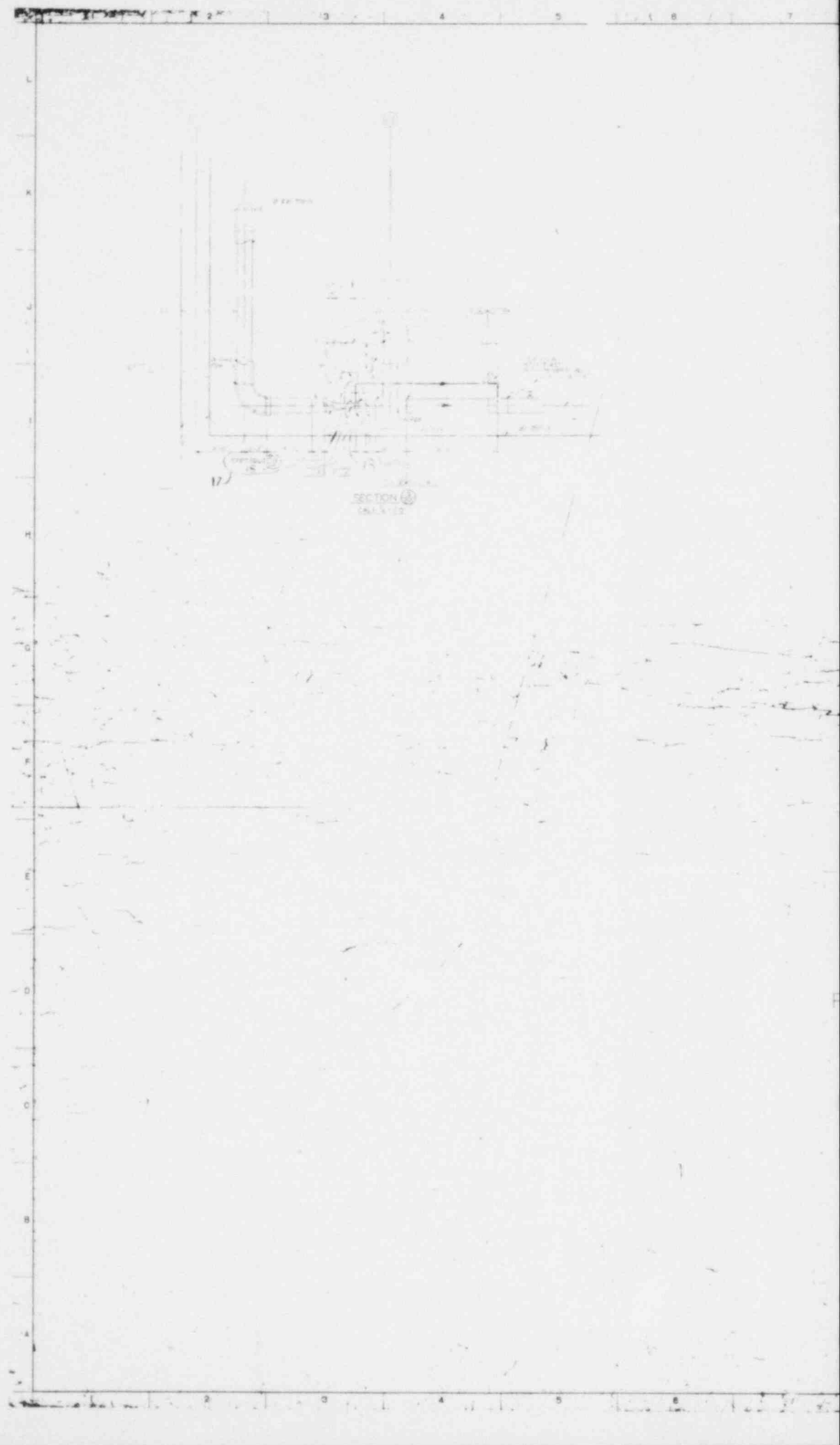
IN

OF 6





POSTULATED BREAKS IN
CF SYSTEM
FIGURE 3.12 SHEET 3 OF 4
REV. 3

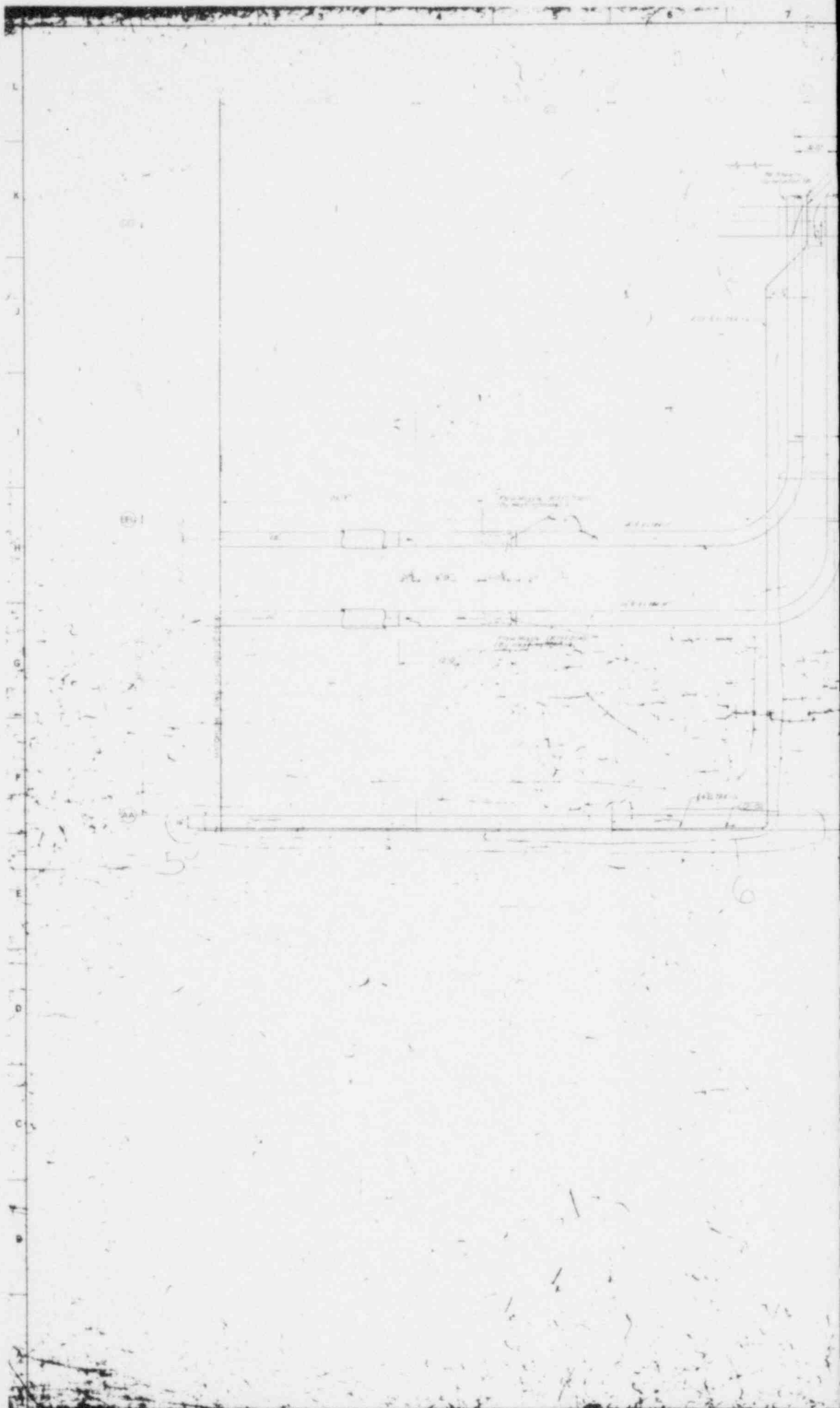


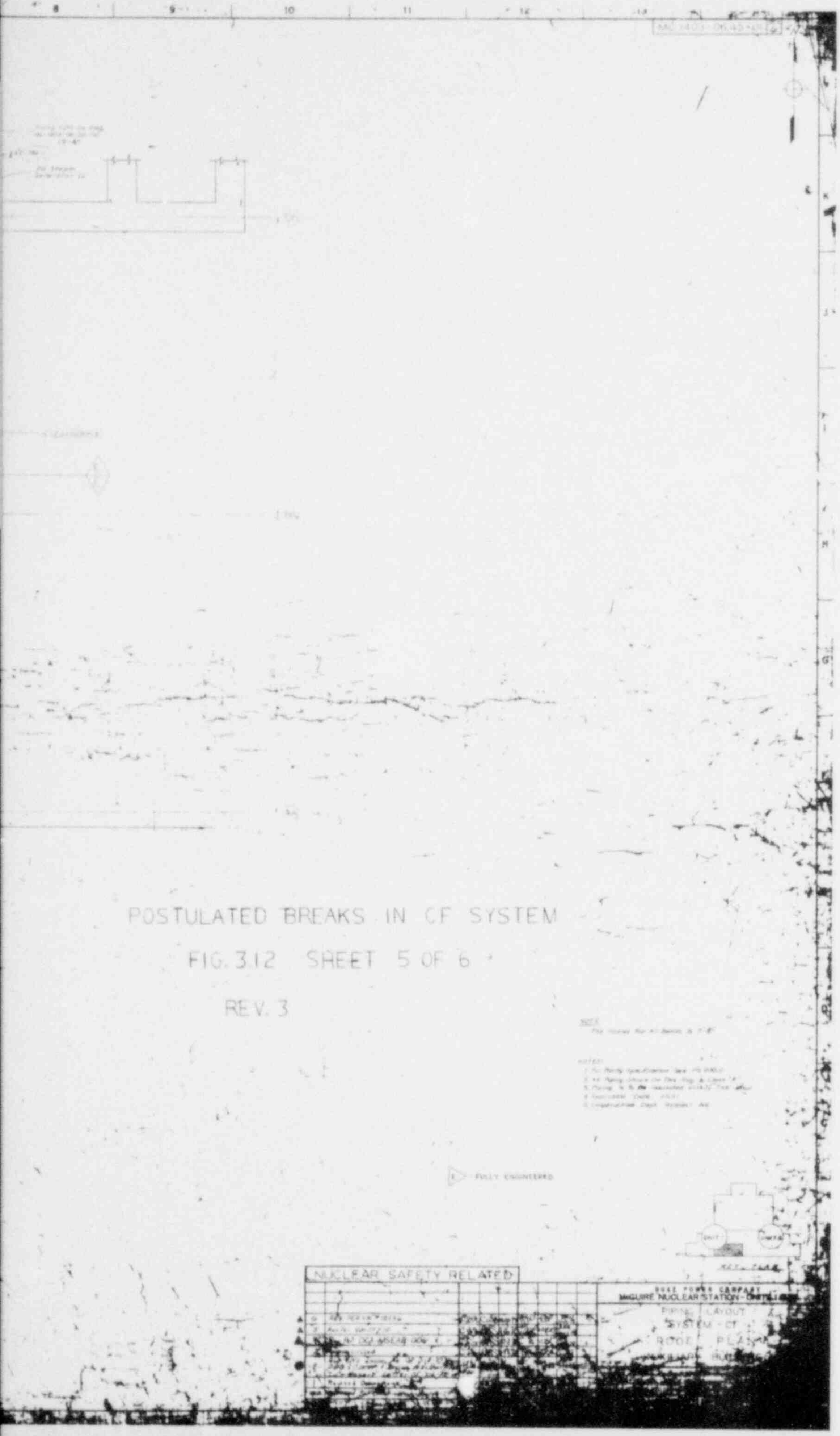
SECTION

OSTULATED BREAKS IN CF SYSTEM

FIG. 3.12 SHEET 4 OF 6

REV. 3

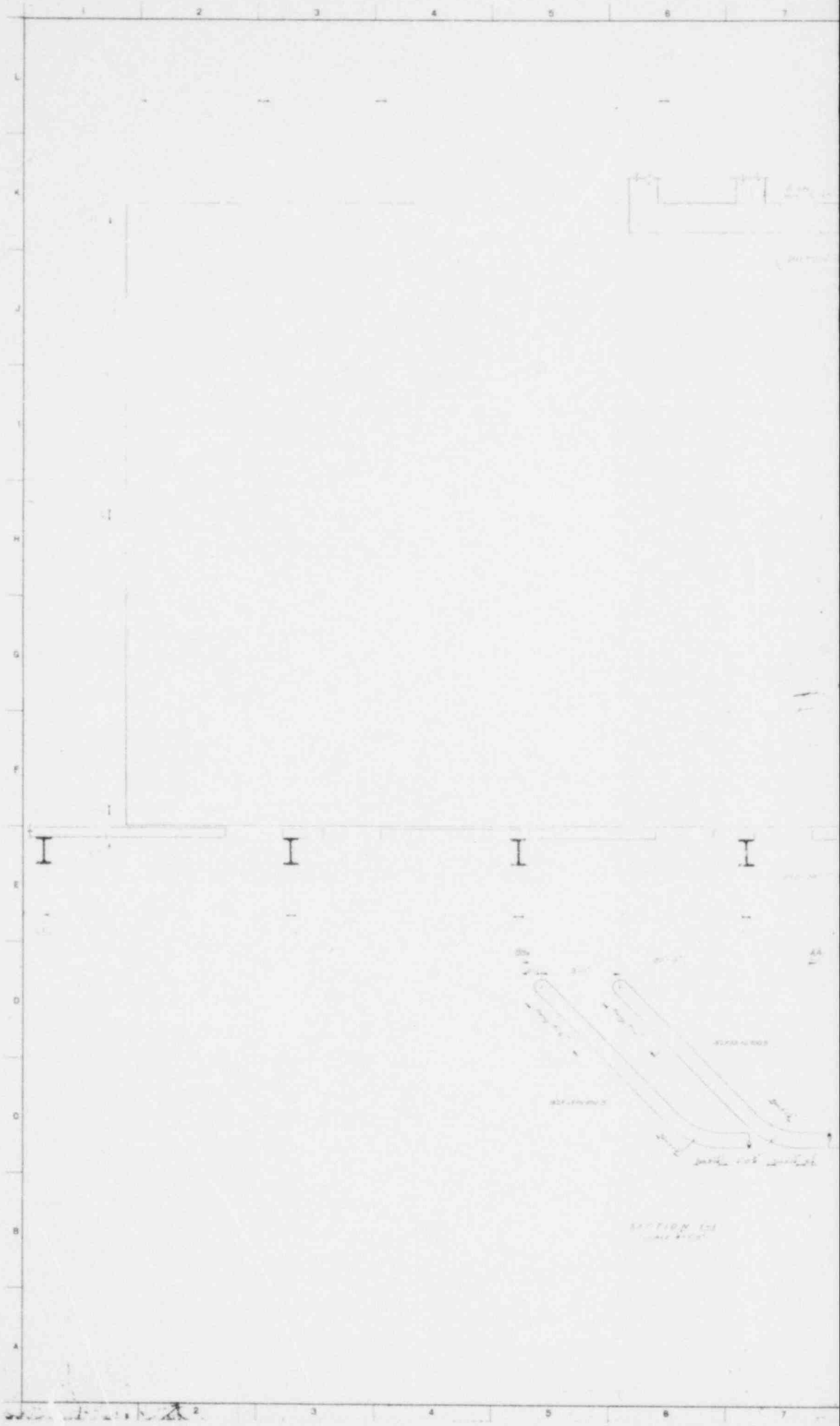


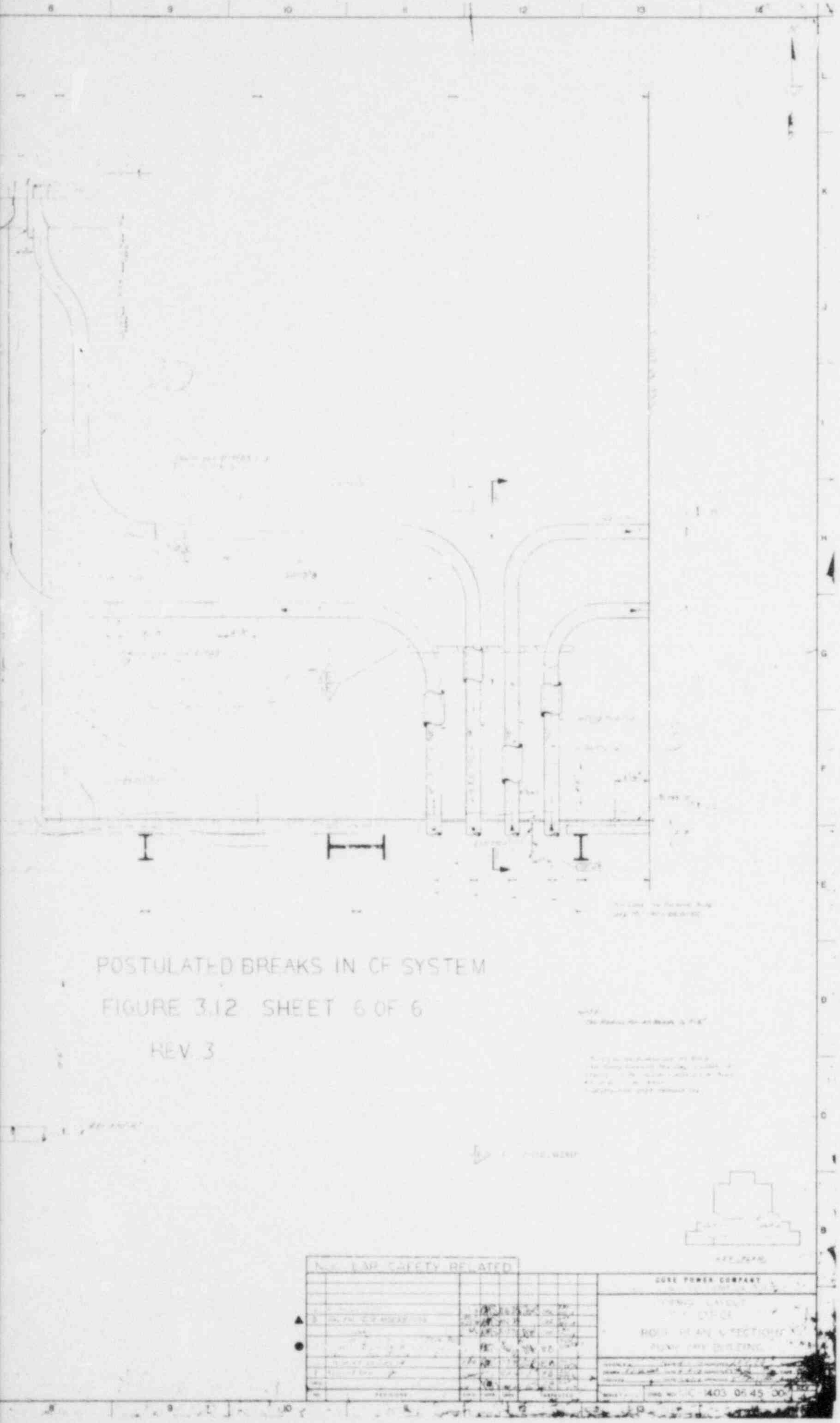


POSTULATED BREAKS IN CF SYSTEM

FIG. 3.12 SHEET 5 OF 6

REV. 3

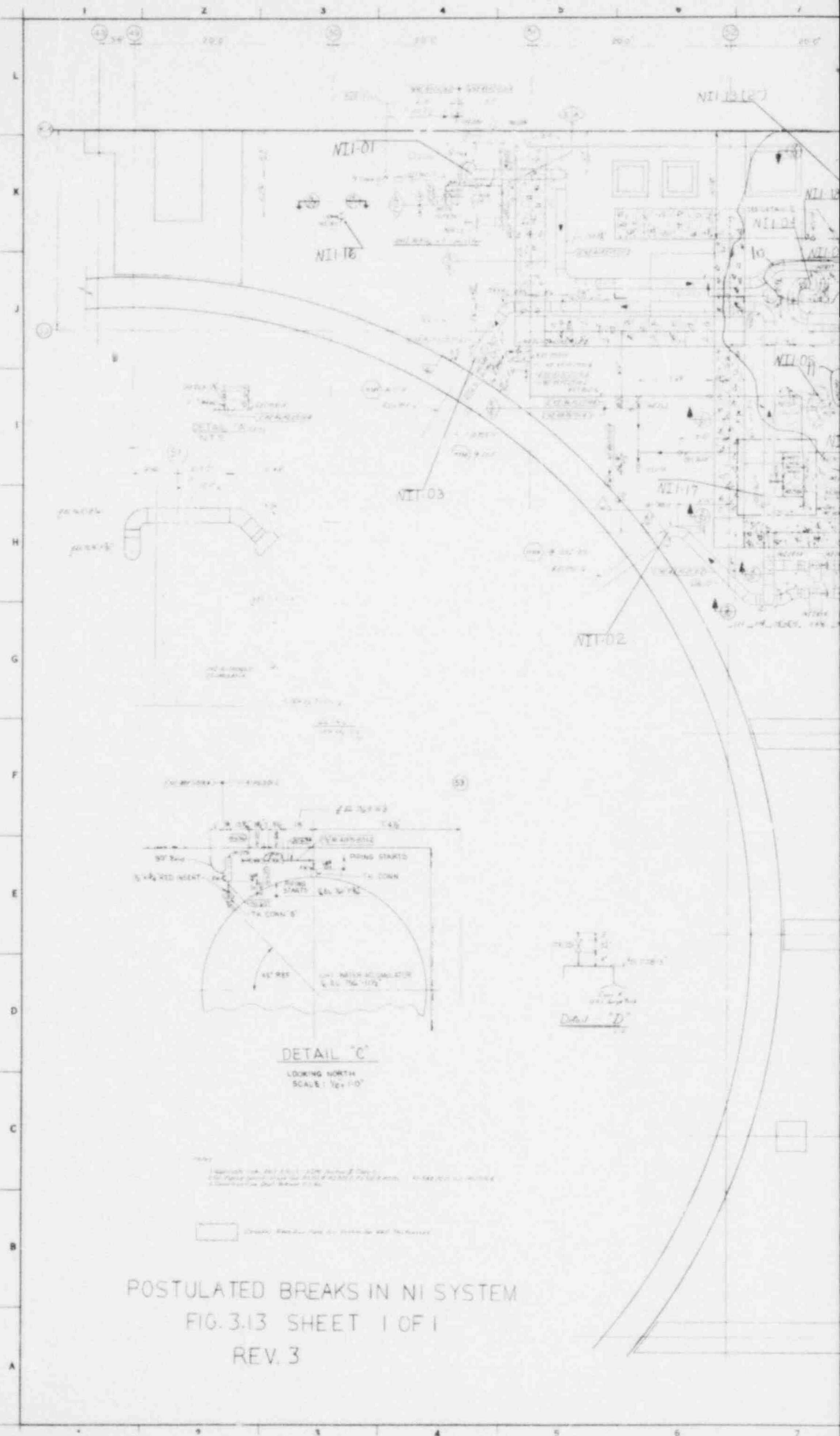

SECTION



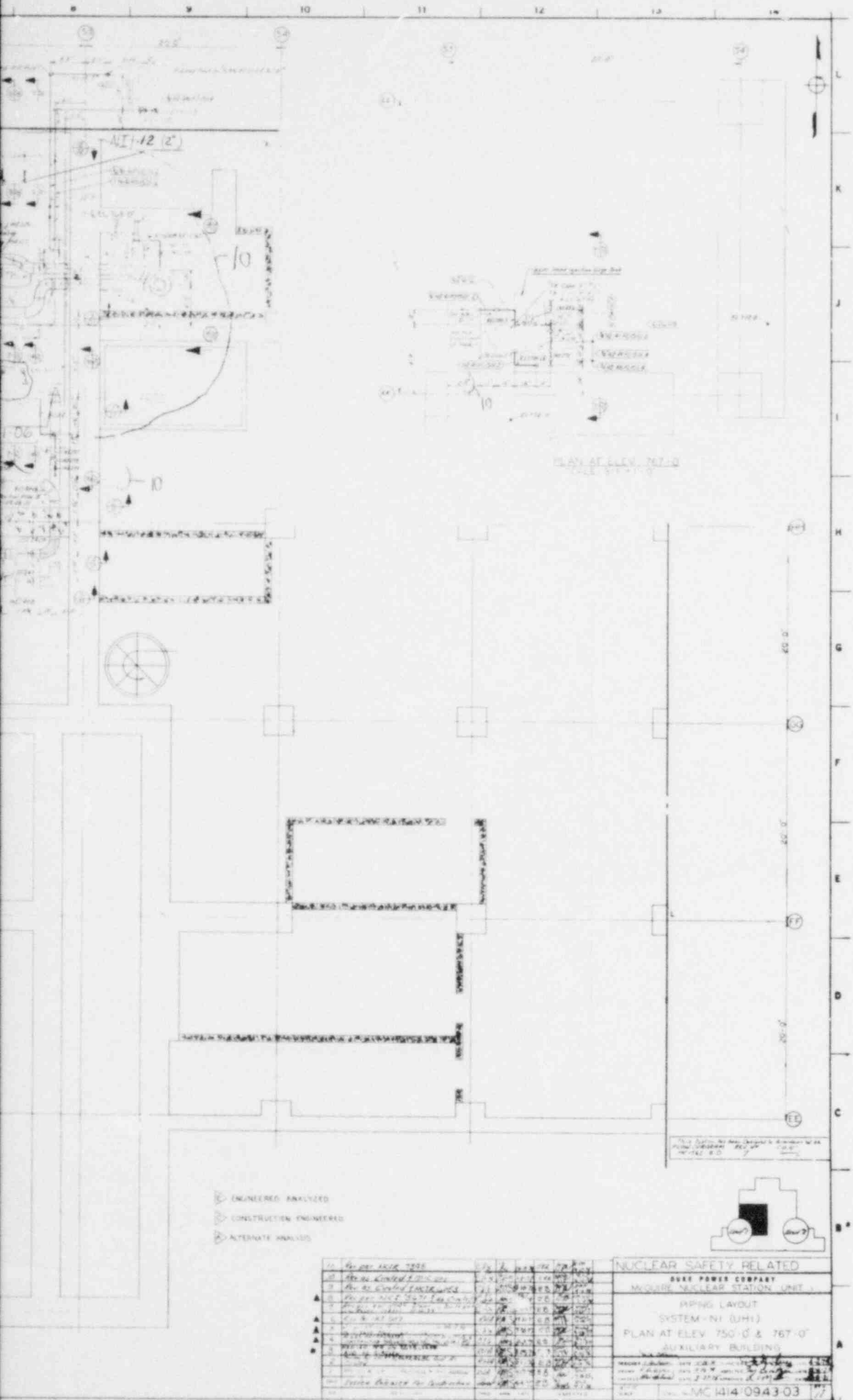
POSTULATED BREAKS IN CF SYSTEM

FIGURE 3.12 SHEET 6 OF 6

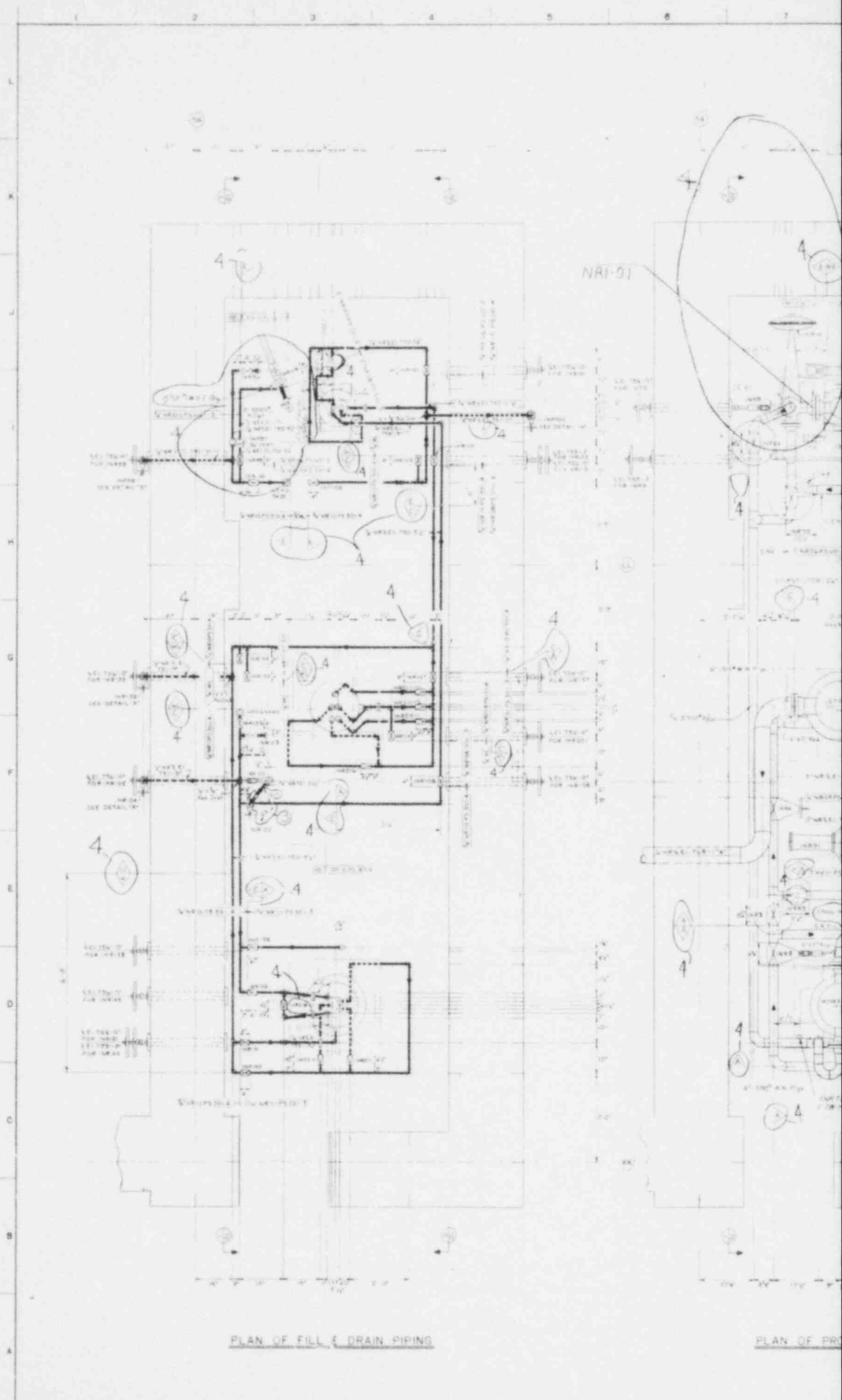
REV. 3

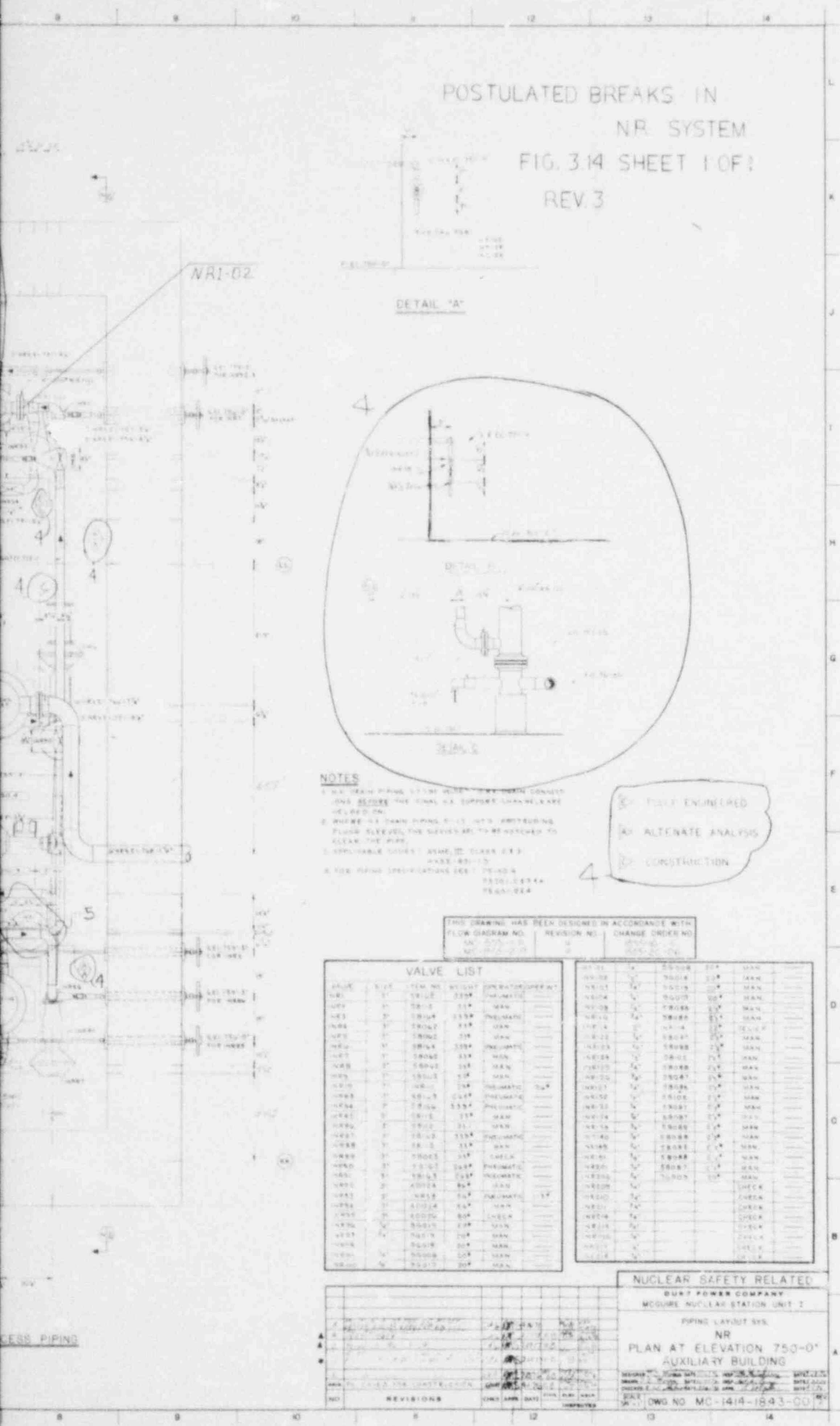


POSTULATED BREAKS IN NI SYSTEM
FIG. 3.13 SHEET 1 OF 1
REV. 3



NI-12 (2")
PLAN AT ELEV. 767'-0"
ENGINEERED ANALYZED
CONSTRUCTION ENGINEERED
ALTERNATE ANALYSIS
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION UNIT 1
PIPING LAYOUT
SYSTEM - NI (UHI)
PLAN AT ELEV. 750'-0" & 767'-0"
AUXILIARY BUILDING
MC 1414-0943-03


NRI-01
PLAN OF FILL & DRAIN PIPING
PLAN OF PR

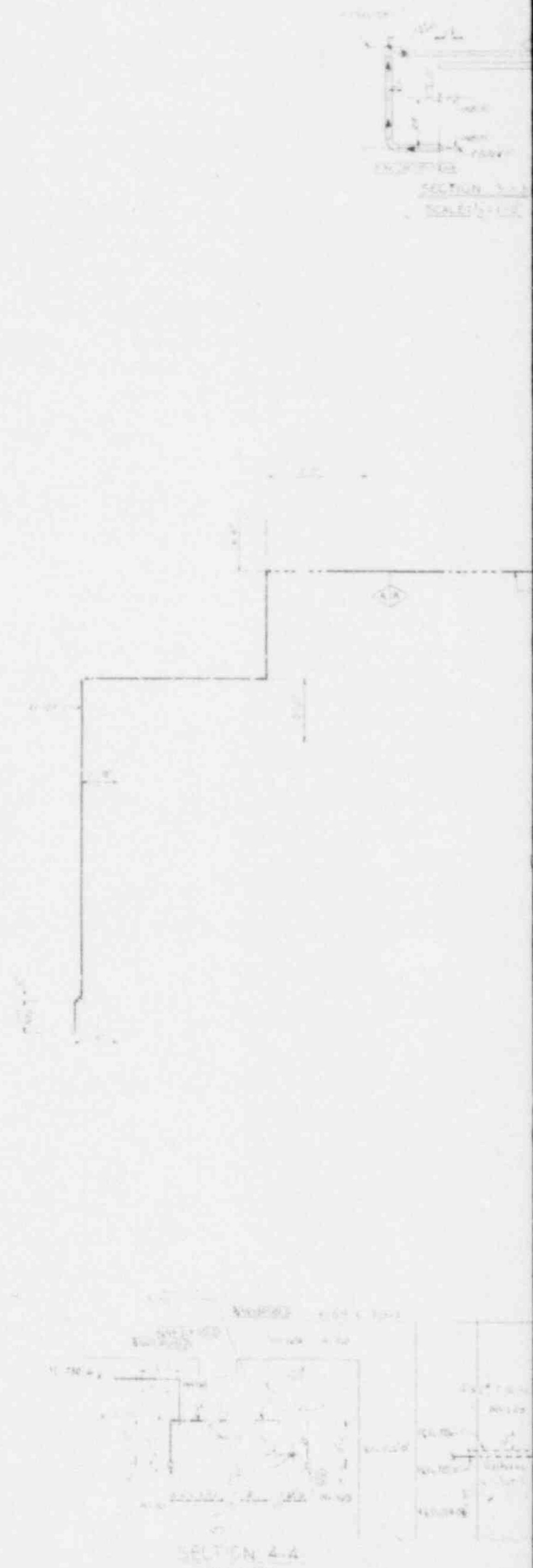


POSTULATED BREAKS IN
N.R. SYSTEM
FIG. 3.14 SHEET 1 OF 1
REV. 3
NR1-02
DETAIL "A"
NOTES
TOTAL ENGINEERED
ALTENATE ANALYSIS
CONSTRUCTION
THIS DRAWING HAS BEEN DESIGNED IN ACCORDANCE WITH
FLOW DIAGRAM NO.
REVISION NO.
CHANGE ORDER NO.
VALVE LIST
VALVE
SIZE
ITEM NO.
WEIGHT
OPERATOR
PNEUMATIC
MAN
CHECK
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
MCGUIRE NUCLEAR STATION UNIT 2
PIPING LAYOUT SYS.
NR
PLAN AT ELEVATION 750-0"
AUXILIARY BUILDING
REVISIONS
DWG. NO. MC-1414-1843-00

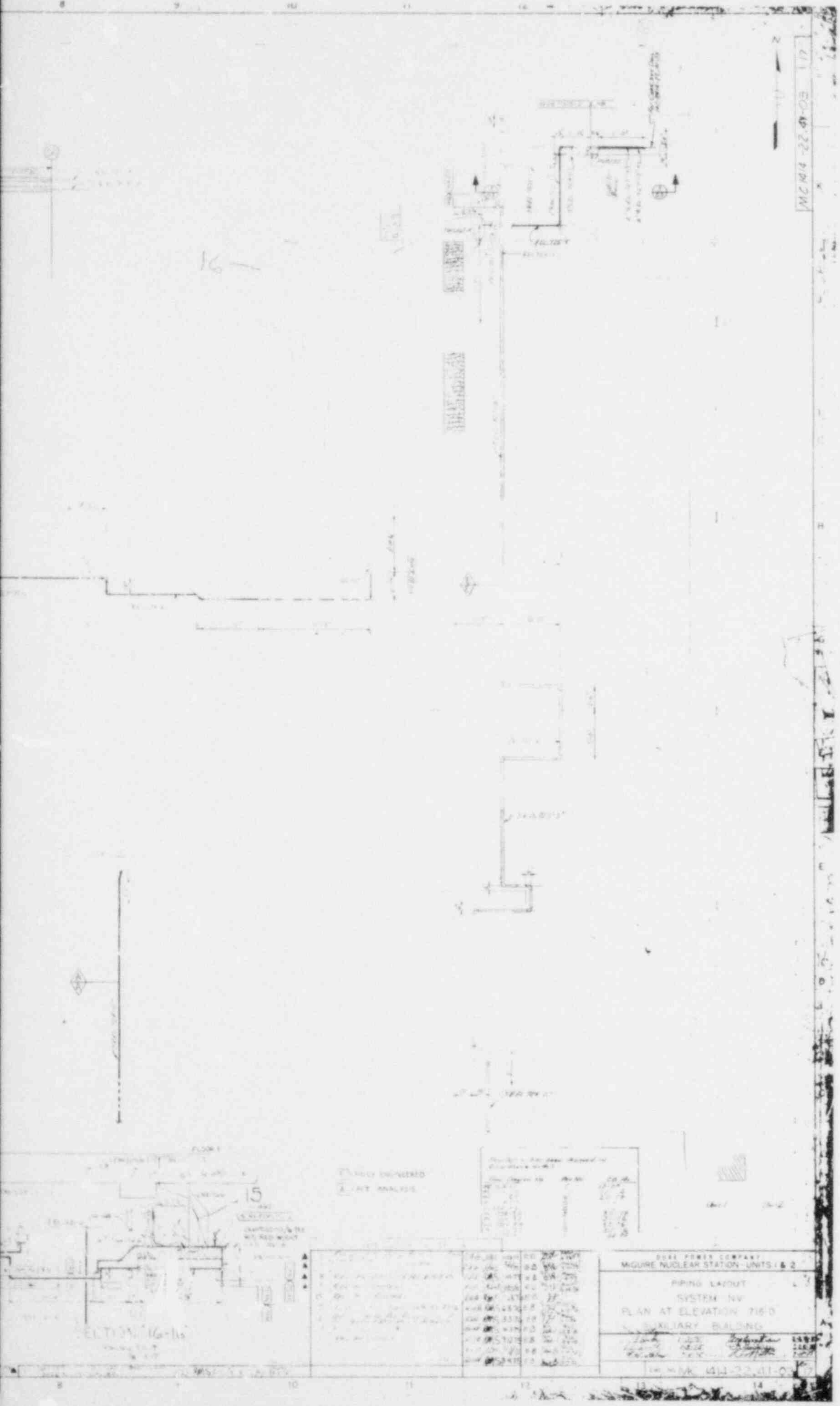
POSTULATED BREAKS - NV SYSTEM

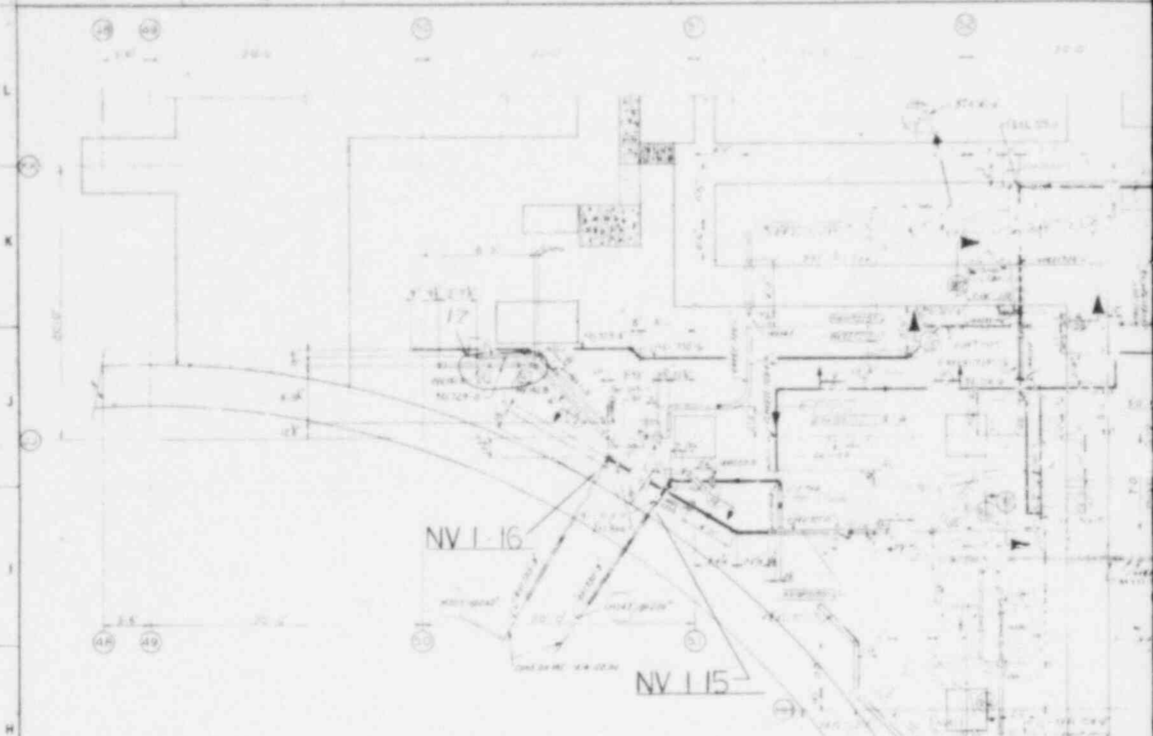
FIG. 3.15 SHEET 1 OF 9

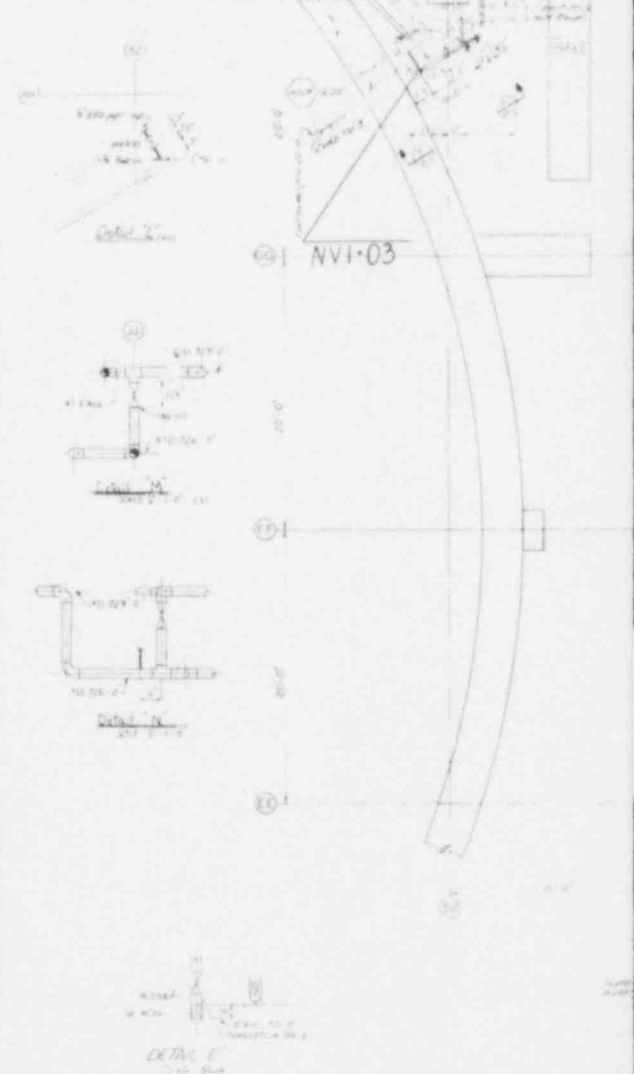
REV. 3



VALVE LIST					
VALVE No.	SIZE	[illegible]	WEIGHT	[illegible]	[illegible]
2NV163	[illegible]	[illegible]	[illegible]	[illegible]	
2NV162	[illegible]	[illegible]	[illegible]	[illegible]	
2NV157A	[illegible]	[illegible]	[illegible]	[illegible]	
2NV158	[illegible]		[illegible]	[illegible]	
2NV167	1/2	[illegible]	[illegible]	[illegible]	
2NV484	1/2	[illegible]	[illegible]	[illegible]	

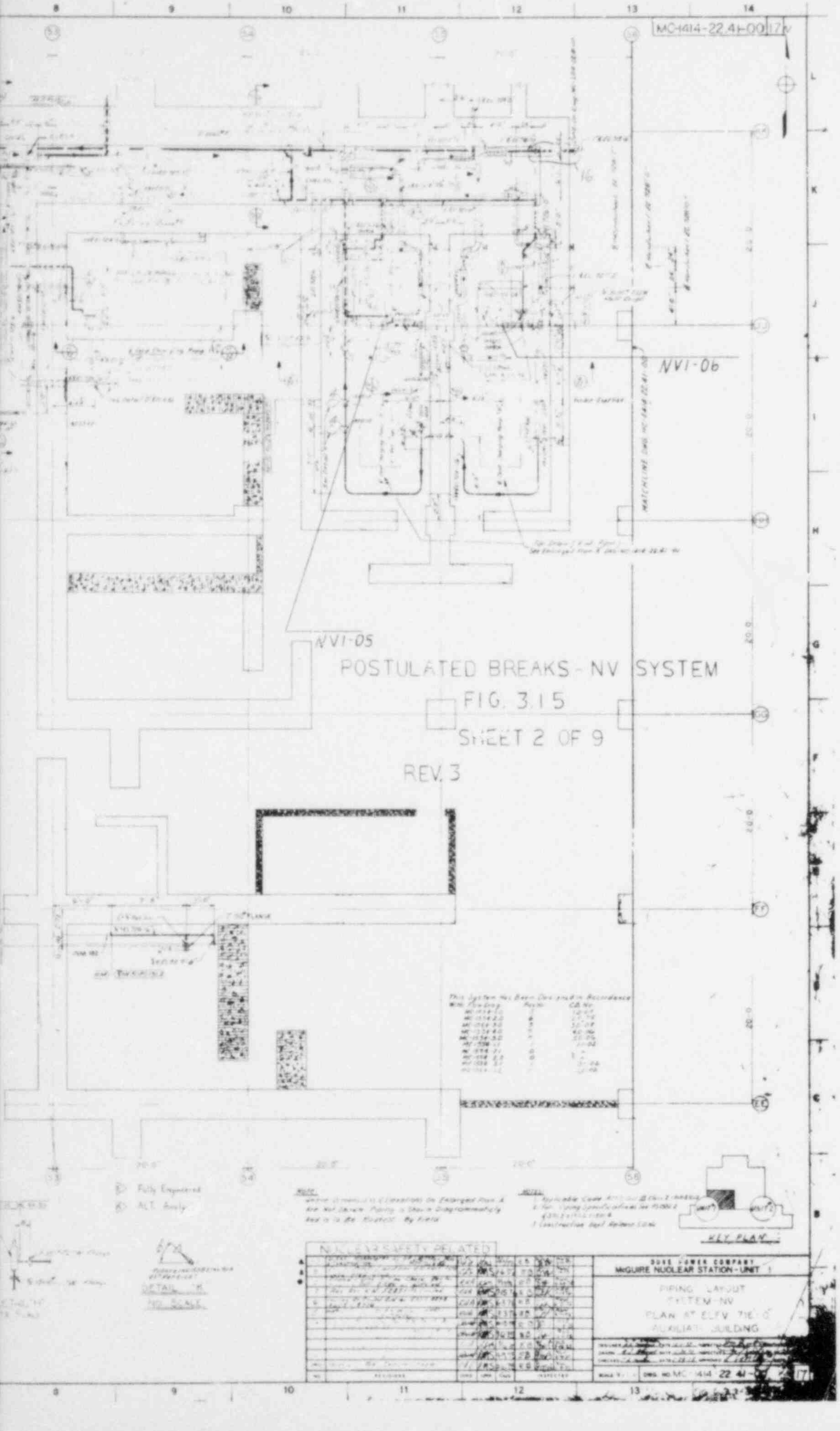

DUKE POWER COMPANY
McGUIRE NUCLEAR STATION - UNITS 1 & 2
PIPING LAYOUT
SYSTEM NV
PLAN AT ELEVATION 716-0
AUXILIARY BUILDING
MC 1414-22.01-03
15
FILTER



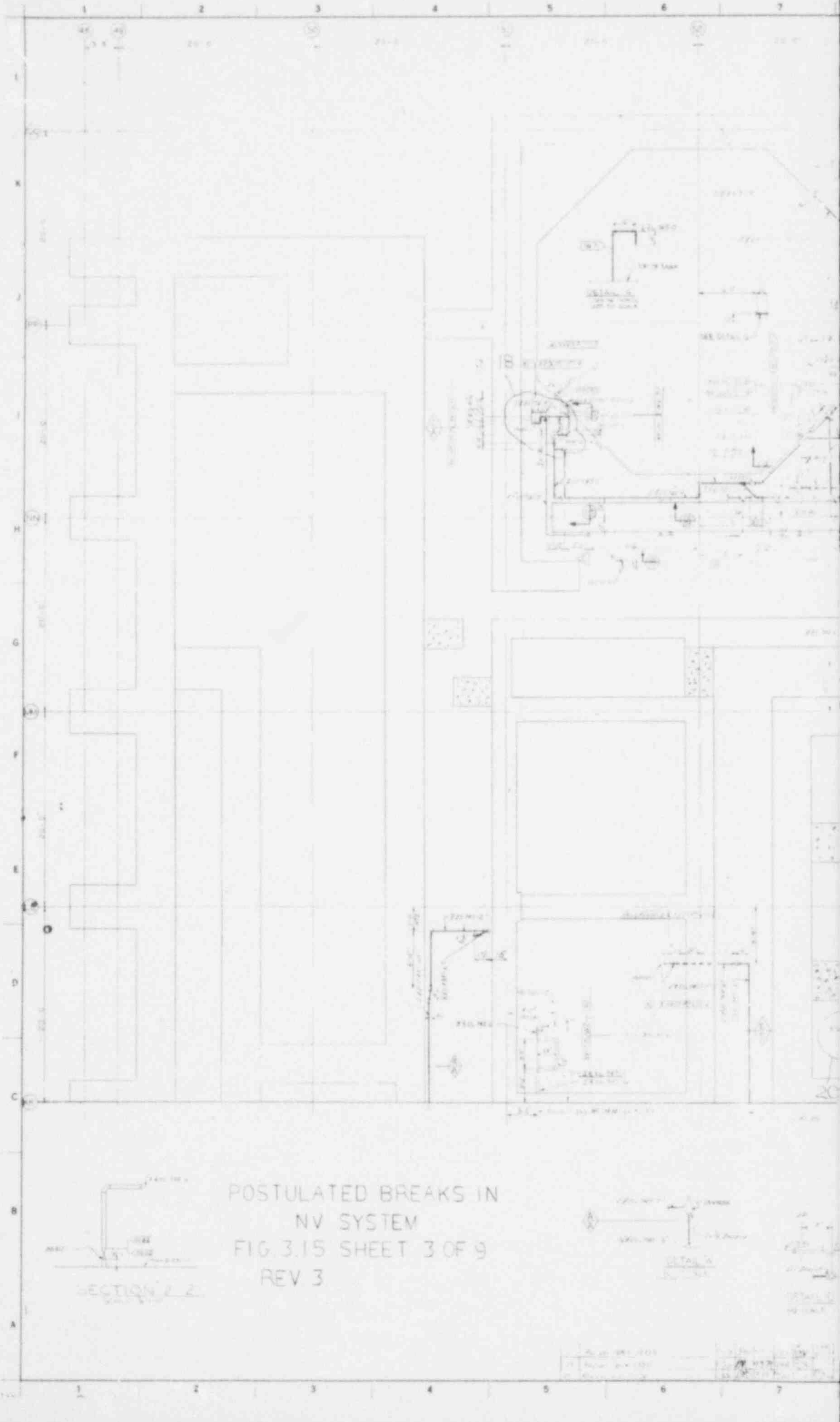


VALVE LIST

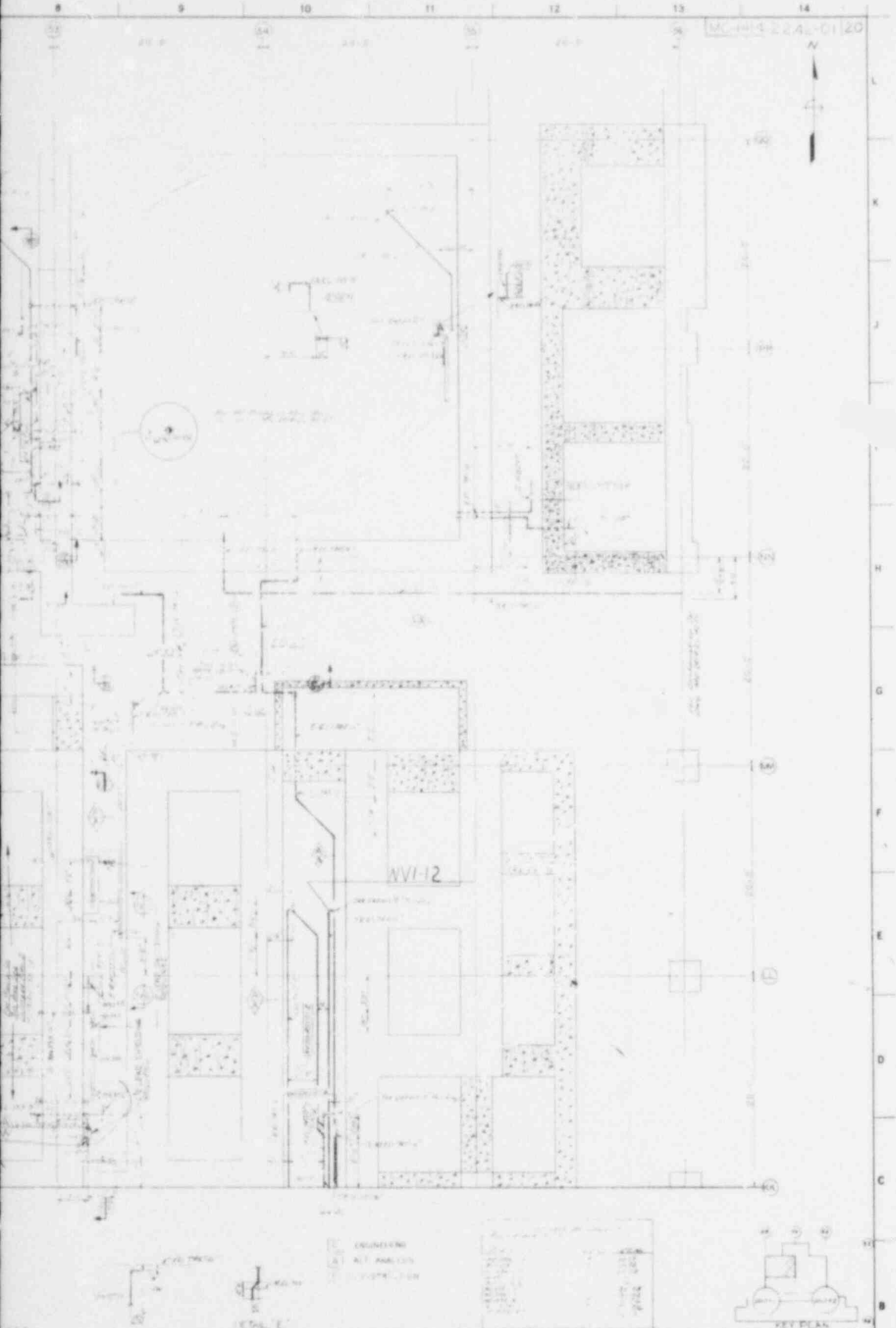
VALVE NO.	SIZE	ITEM NO.	WEIGHT	OPERATOR	OPERATOR WT.
INV1 5?	4"	58-5	35#?		—
INV1 14?	2"	91-14	43#	EMO?	
INV1 1A	2"	91-14	42#	EMO	
INV2??	4"	—		MANUAL	—
INV2-8	3"	4J-6	204#?		—
INV2 9	3"	4J-8	[illegible]	MANUAL?	
INV2170?	4-2 ...	—		—	—
INV1 1?	8"	[illegible]		EMO	
INV2020	6"	58-4		EMO	
INV223	8"	58-3	165#		—
INV224	6"	58-24	166#	MANUAL	—
INV225	4"	4J-21	220#		—
INV226	4"	4J-20	225#	MANUAL	—
INV227	2"	9J-5	42#		—
INV228	2"	9J-17	41#	MANUAL	—
INV2??	2"	58-24	154#	MANUAL	
INV2??	4"	4J-21	32?		—
INV2??	4"	4J-20	225#	MANUAL	—
INV233	2"	9J-5	42#	—	—
INV234	2"	9J-17	43#	MANUAL	—
INV235	3"	4J-16	[illegible]	MANUAL	—
INV236	3"	4J-18	[illegible]	MANUAL	—
INV237	3"	4J-17	[illegible]	MANUAL	—
INV238	3"		[illegible]	AIR DIAPHRAGM	
INV239	3"	4J-17	[illegible]	MANUAL	—
INV240	3"	4J-17	120#?	MANUAL	—
INV241	3"	—		AIR DIAPHRAGM	
INV242	3"	4J-17	120#?	MANUAL	—
INV243	3"	4J-16	100#?	MANUAL	—
INV2??	3"	4J-19		EMO	
INV2??	[illegible]	4J-19		EMO	
INV270	[illegible]	9J-8	20#	MANUAL	—
INV271	3/4"	9J-19	20#	MANUAL	—
INV272	3/4"	9J-20	20#	MANUAL	—
INV273	3/4"	9J-20	20#	MANUAL	—
INV274	3/4"	9J-20	20#	MANUAL	—
INV276	3/4"	9J-8	20#	MANUAL	—
INV277	3/4"	9J-19		MANUAL	—
INV278	3/4"	9J-20	20#	MANUAL	—
INV279	3/4"	9J-20	20#	MANUAL	—
INV281	3/4"	9J-8	20#	MANUAL	—
INV282	3/4"	9J-19		MANUAL	—
INV283	3/4"	9J-20	20#	MANUAL	—
INV284	3/4"	9J-20	20#	MANUAL	—
INV286	3/4"	9J-8	20#	MANUAL	—
INV287	3/4"	9J-19		MANUAL	—
INV288	3/4"	9J-20	20#	MANUAL	—
INV289	3/4"	9J-20	20#	MANUAL	—
INV290	3/4"	9J-8	20#	MANUAL	—
INV291	3/4"	9J-8	20#	MANUAL	—
INV292	3/4"	9J-8	20#	MANUAL	—
INV293	3/4"	9J-19		MANUAL	—
INV294	3/4"	9J-20	20#	MANUAL	—
INV295	3/4"	9J-20	20#	MANUAL	—
INV297	3/4"	9J-8	20#	MANUAL	—
INV298	3/4"	9J-19		MANUAL	—
INV299	3/4"	9J-20	20#	MANUAL	—
INV300	3/4"	9J-20	20#	MANUAL	—
INV301	3/4"	9J-8	20#	MANUAL	—
INV302	3/4"	9J-8	20#	MANUAL	—
INV4??	3"	58-73	55#	—	—
INV4??	3"	—		MANUAL	—
INV449?	3/4"	9J-8	20#	MANUAL	—
INV128?	[illegible]				
INV76?	3"?				
INV438	3/4"	9J-8	20#	MANUAL	—
INV1??	[illegible]	—		—	—
INV???	3/4"	9J-8	20#	MANUAL	—



POSTULATED BREAKS - NV SYSTEM
FIG. 3.15
SHEET 2 OF 9
REV. 3



POSTULATED BREAKS IN
NV SYSTEM
FIG. 3.15 SHEET 3 OF 9
REV 3

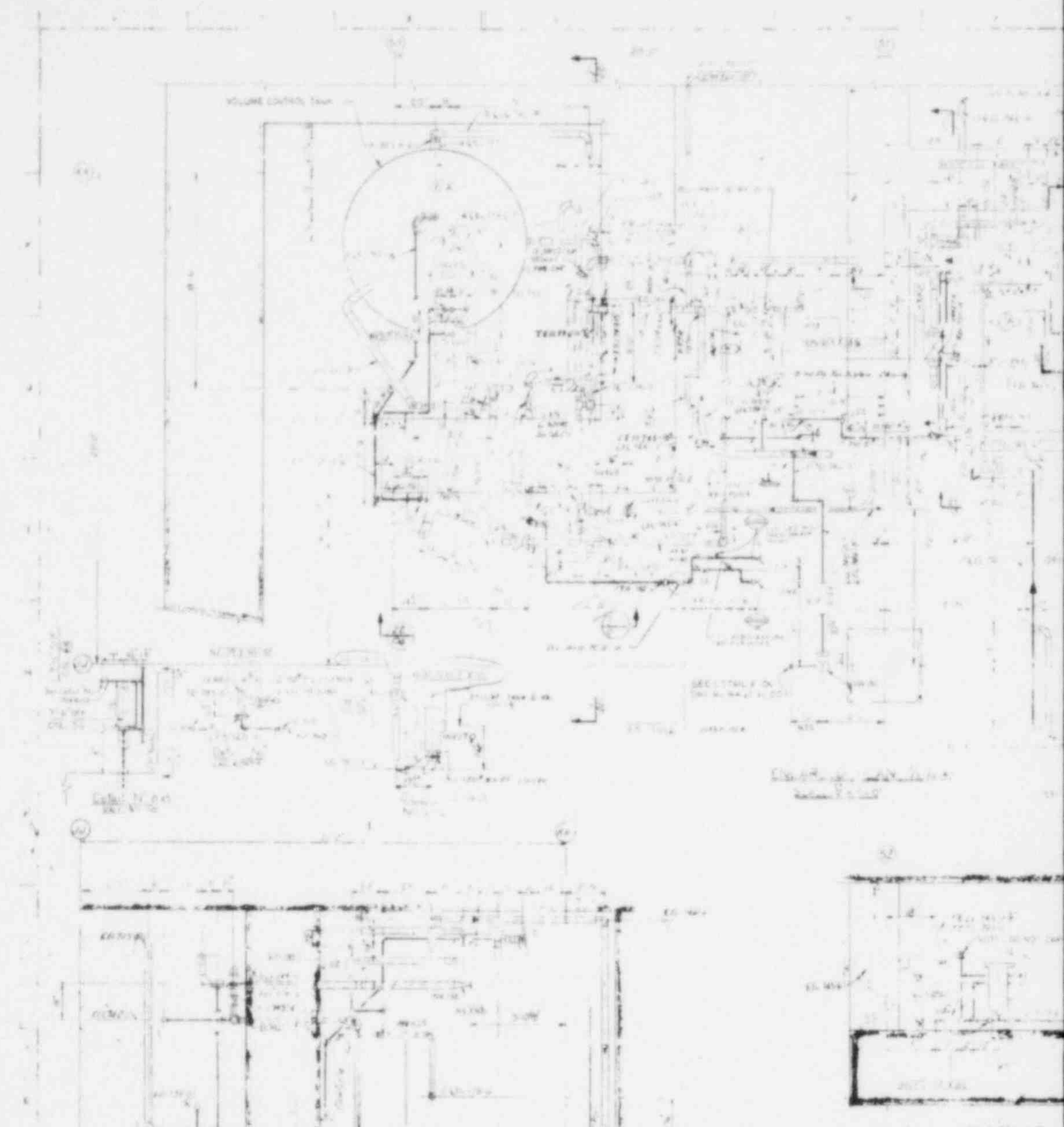


NUCLEAR SAFETY RELATED

DUKE POWER COMPANY
McGUIRE NUCLEAR STATION - UNITS 1 & 2

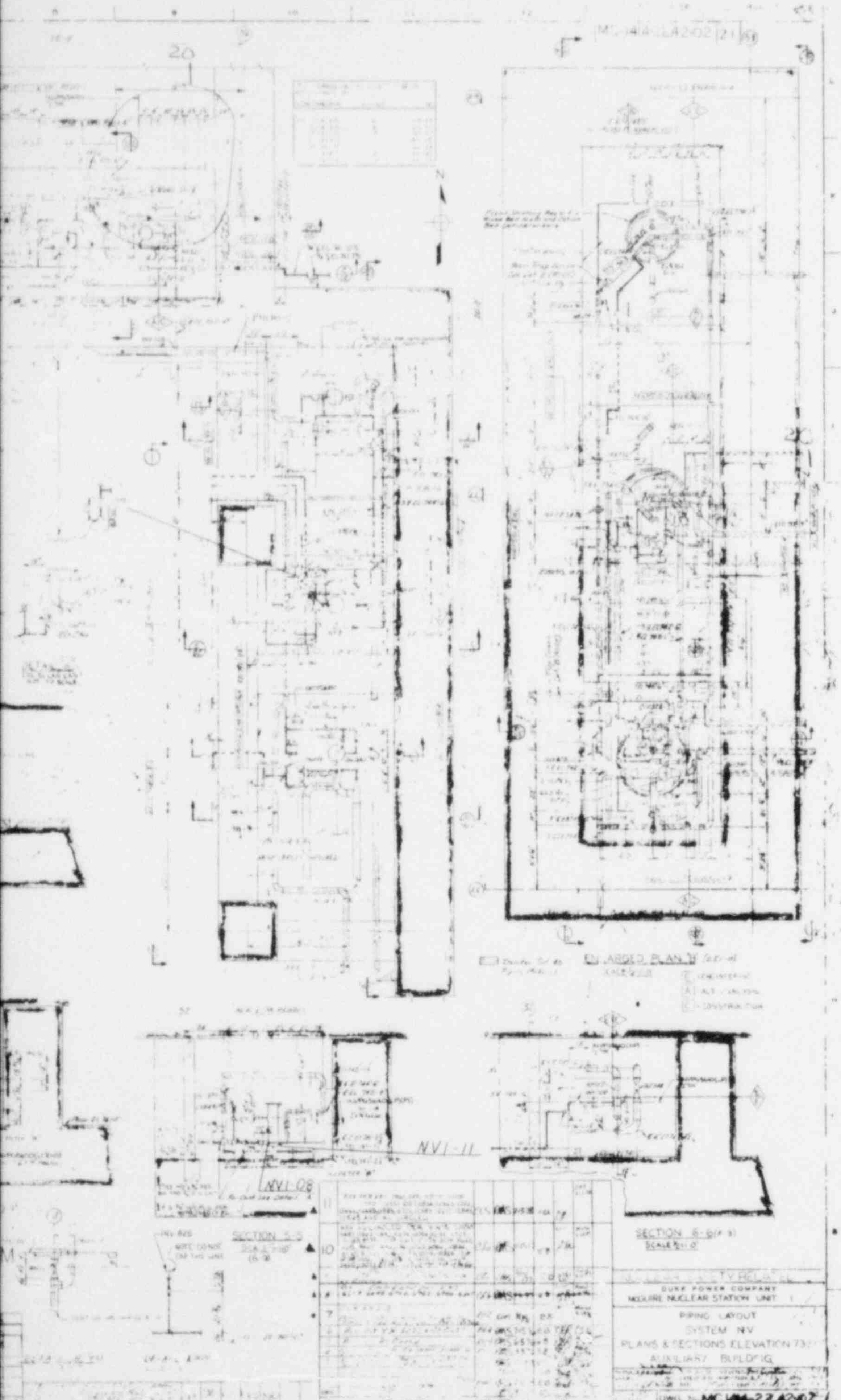
PIPING LAYOUT
SYSTEM NV
PLAN A ELEVATION 733'-0"
AUXILIARY BUILDING

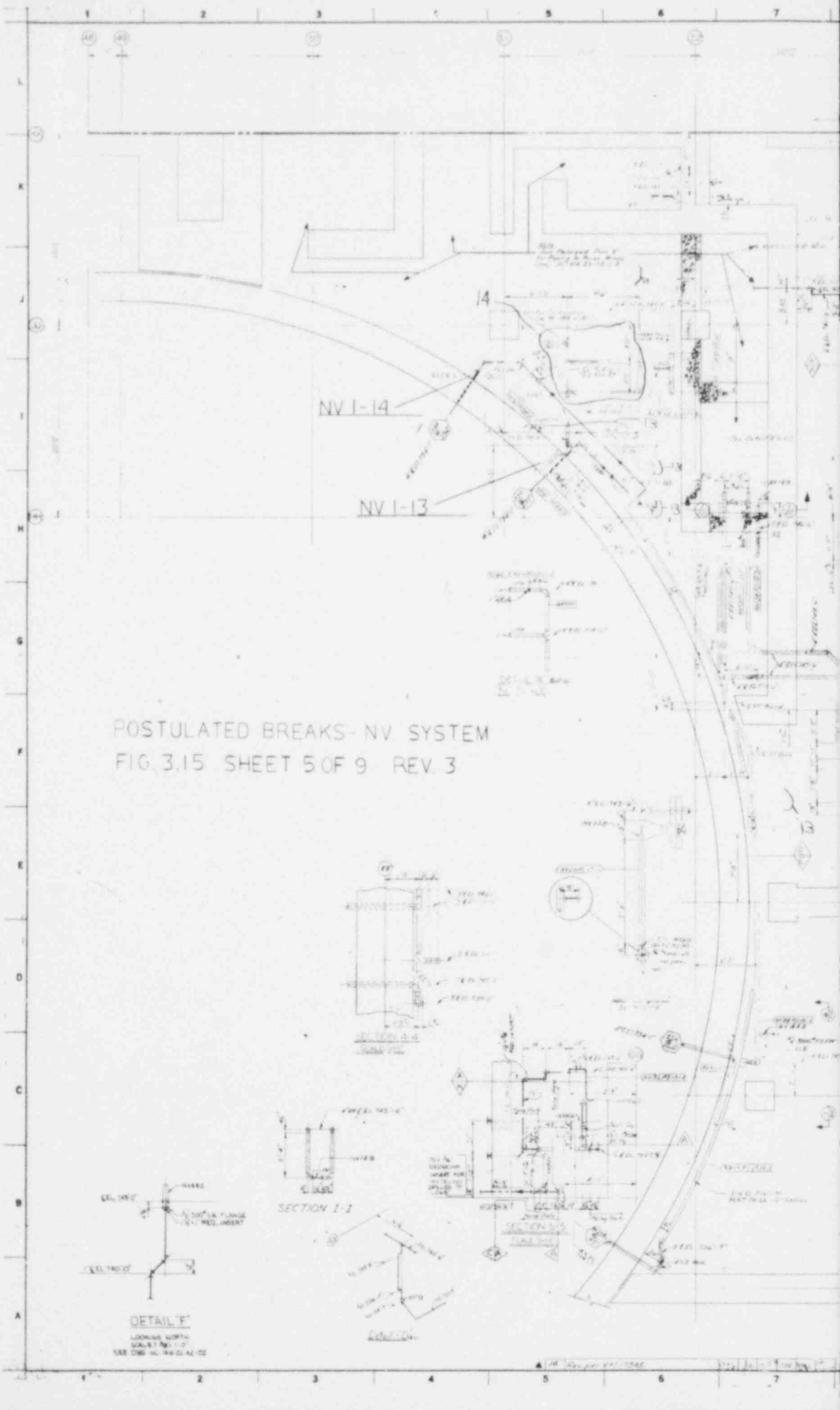
DWG. NO. MC 1414 22.42-01 | 20



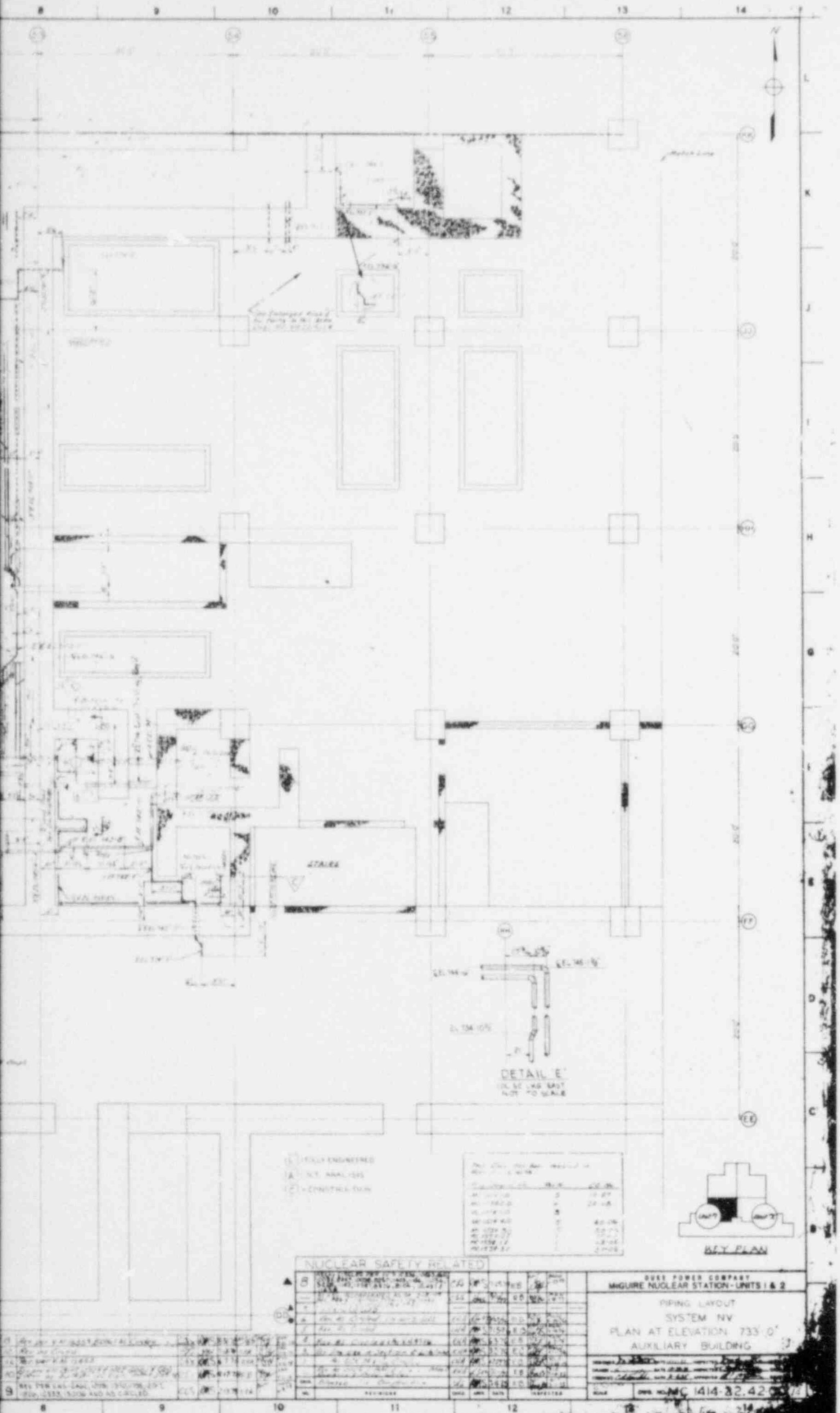
POSTULATED BREAKS-NV SYSTE

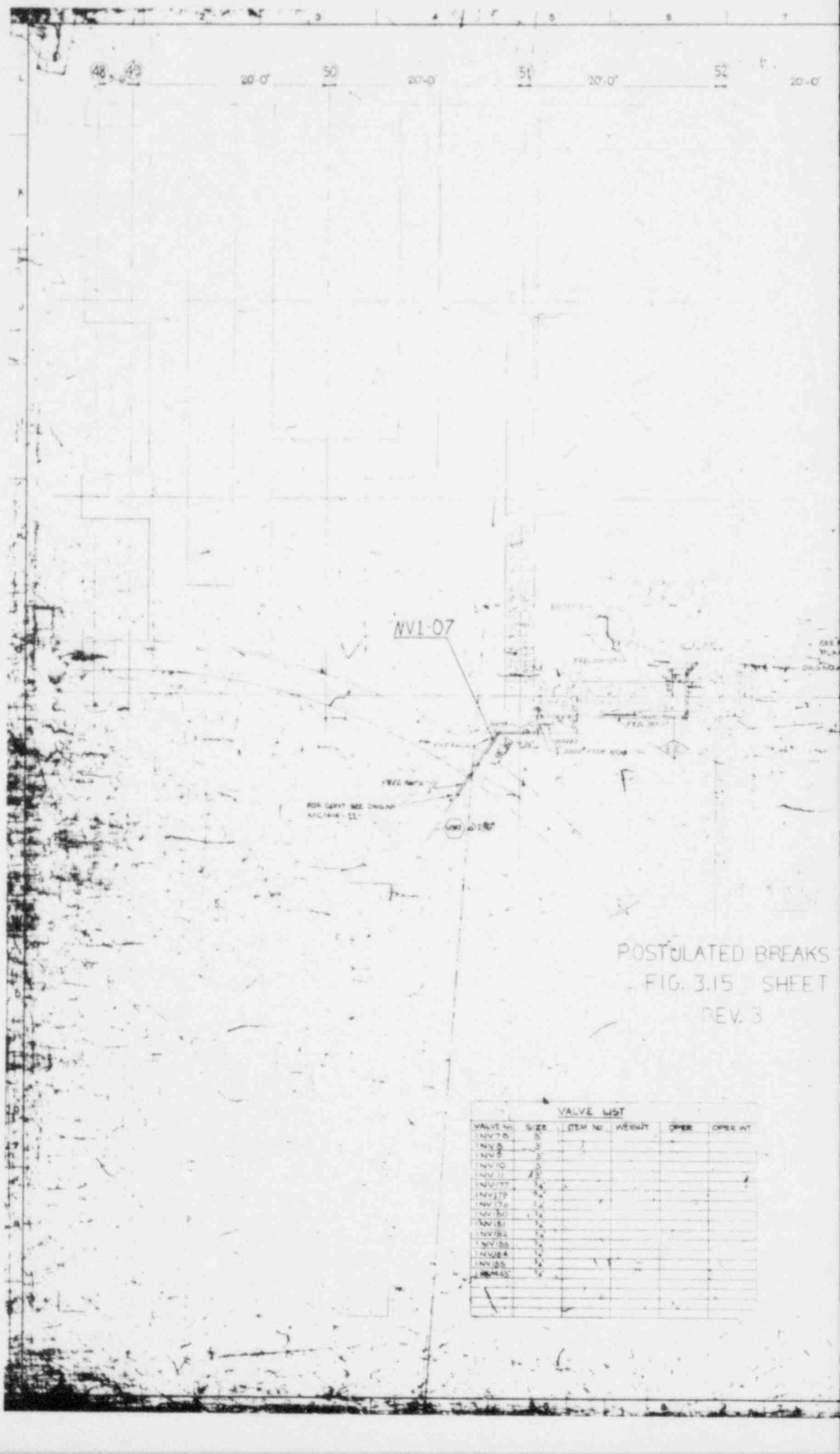
FIG. 3.15 SHEET 4 OF 9 REV. 3


ENLARGED PLAN
SECTION
NVI-11
NVI-08
SECTION 6-6
DUKE POWER COMPANY
MCGUIRE NUCLEAR STATION UNIT 1
PIPING LAYOUT
SYSTEM NV
PLANS & SECTIONS ELEVATION 733
AUXILIARY BUILDING
DWG. No. MC-1414-22.42-02



POSTULATED BREAKS - NV SYSTEM
FIG. 3.15 SHEET 5 OF 9 REV. 3

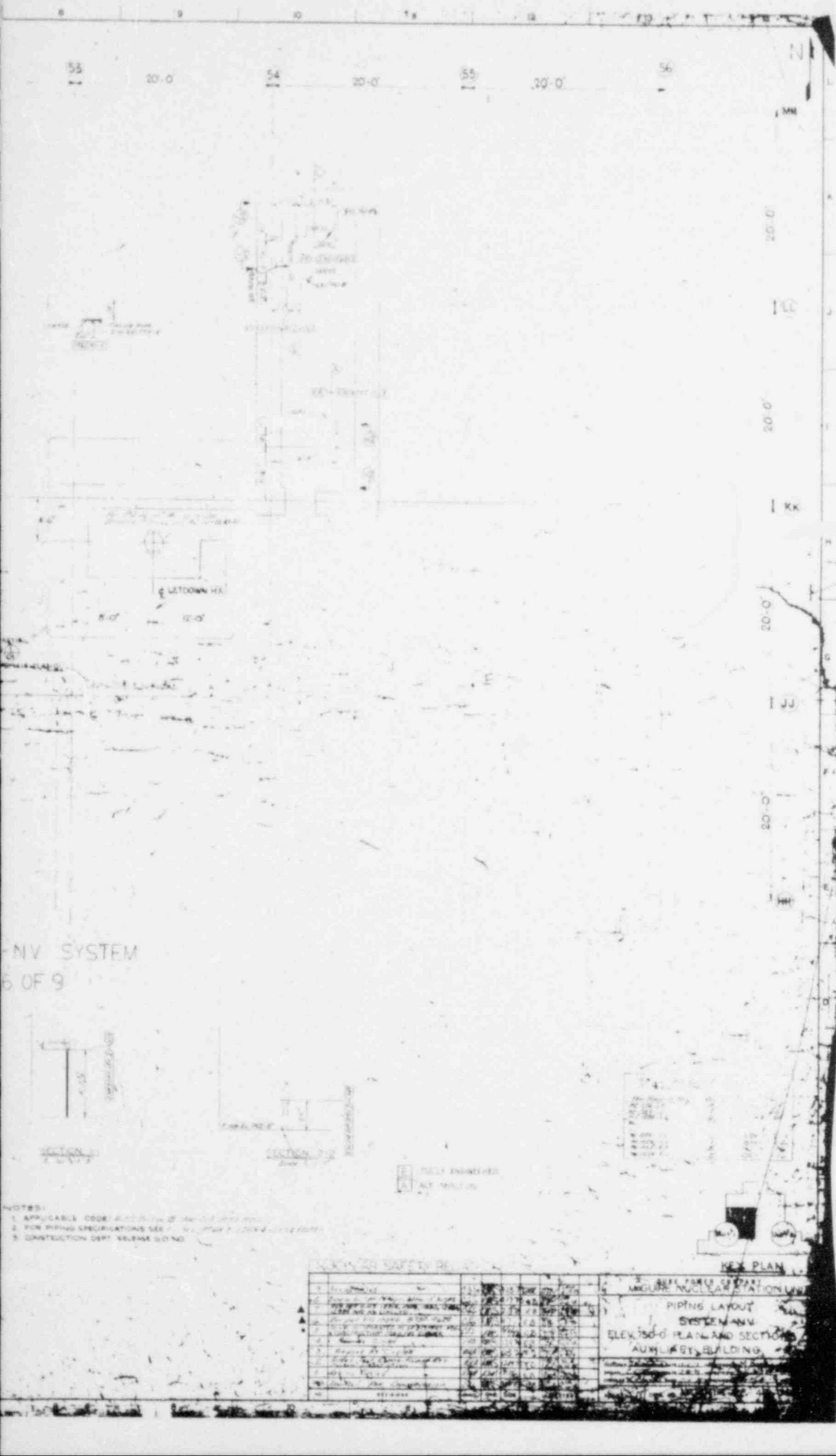

STAIRS
DETAIL 'E'
NOT TO SCALE
KEY PLAN
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION - UNITS 1 & 2
PIPING LAYOUT
SYSTEM NV
PLAN AT ELEVATION 733'0"
AUXILIARY BUILDING
MC 1414-



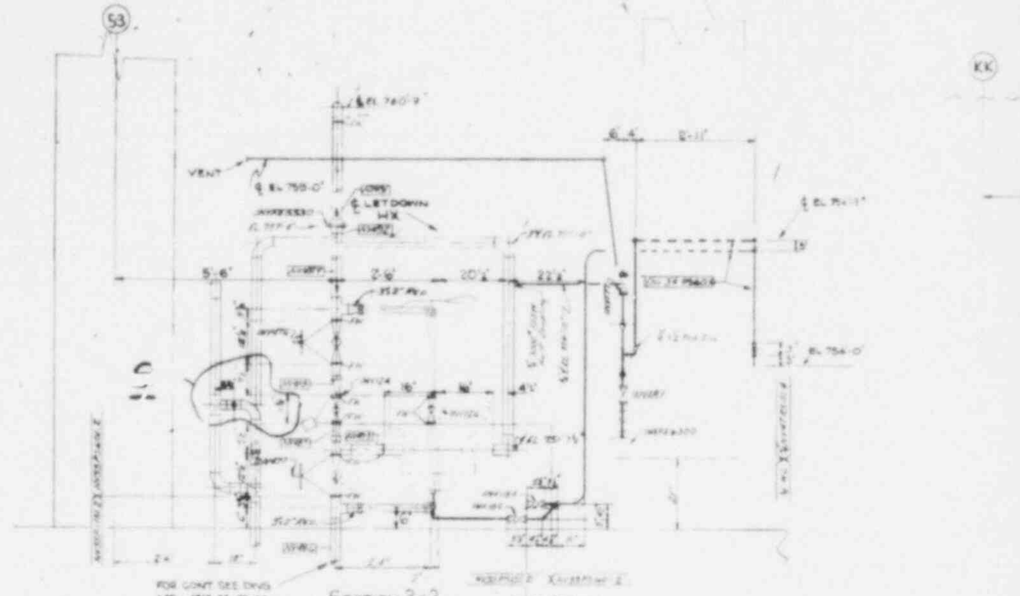
POSTULATED BREAKS
FIG. 3.15 SHEET
REV. 3

VALVE LIST

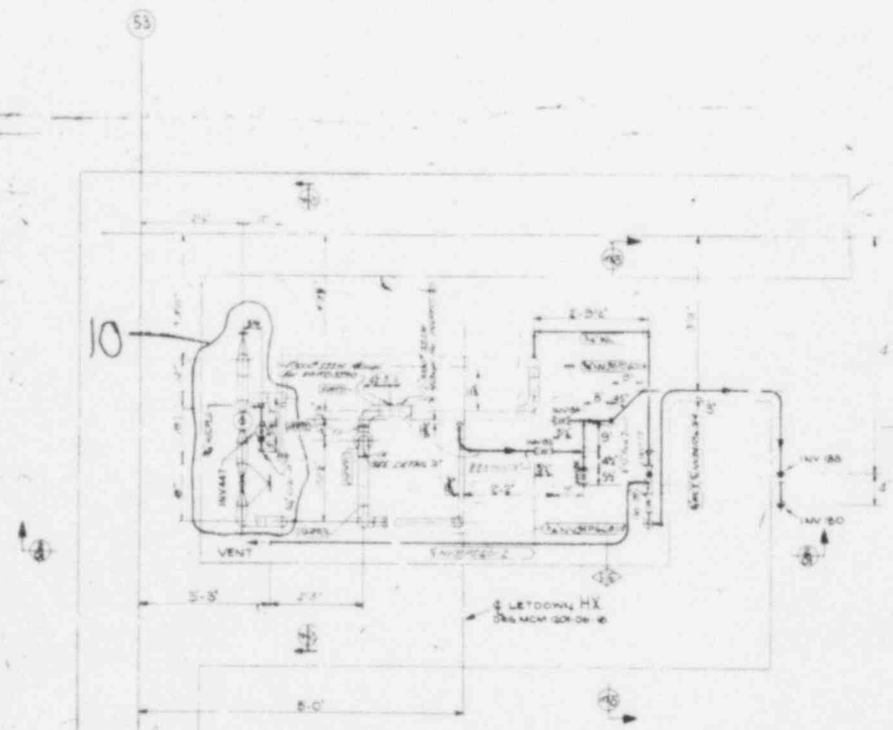
VALVE No.	SIZE	ITEM No.	WEIGHT	OPER	OPER WT
1NV7B	3"				
1NV8	3"				
1NV9	3"				
1NV10	3"				
1NV11	3"				
1NV177	3/4"				
1NV179	3/4"				
1NV170	3/4"				
1NV180	3/4"				
1NV181	3/4"				
1NV182	3/4"				
1NV186	3/4"				
1NV184	3/4"				
1NV185	3/4"				
1[illegible]	3/4"				



53
54
55
56
20'-0"
N
MM
LL
KK
JJ
HH
LETDOWN HX
-NV SYSTEM
6 OF 9
SECTION
SECTION
FULLY ENGINEERED
NOTES:
1. APPLICABLE CODE:
2. FOR PIPING SPECIFICATIONS SEE
3. CONSTRUCTION DEPT. RELEASE S.O. NO.
KEY PLAN
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION
PIPING LAYOUT
SYSTEM NV
ELEV. 750-0 PLAN AND SECTIONS
AUXILIARY BUILDING

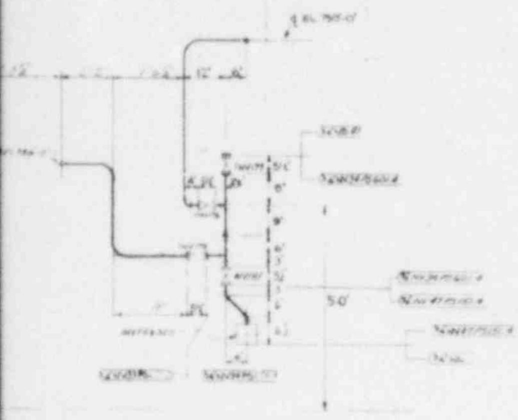


SECTION 2-2

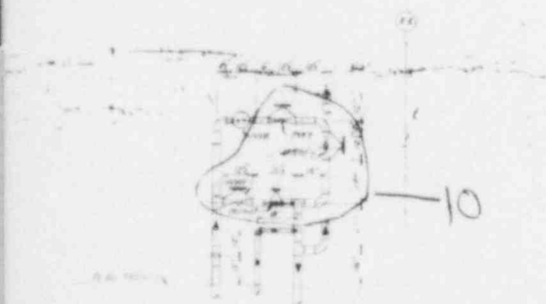


PLAN

DETAIL A
NO SCALE



Section 3-3



Section 4-4

POSTULATED BREAKS IN NV SYSTEM

FIG. 3.15 SHEET 7 OF 9

REV. 3

FULLY ENGINEERED

NUCLEAR SAFETY RELATED

DUKE POWER COMPANY

McGUIRE NUCLEAR STATION UNIT

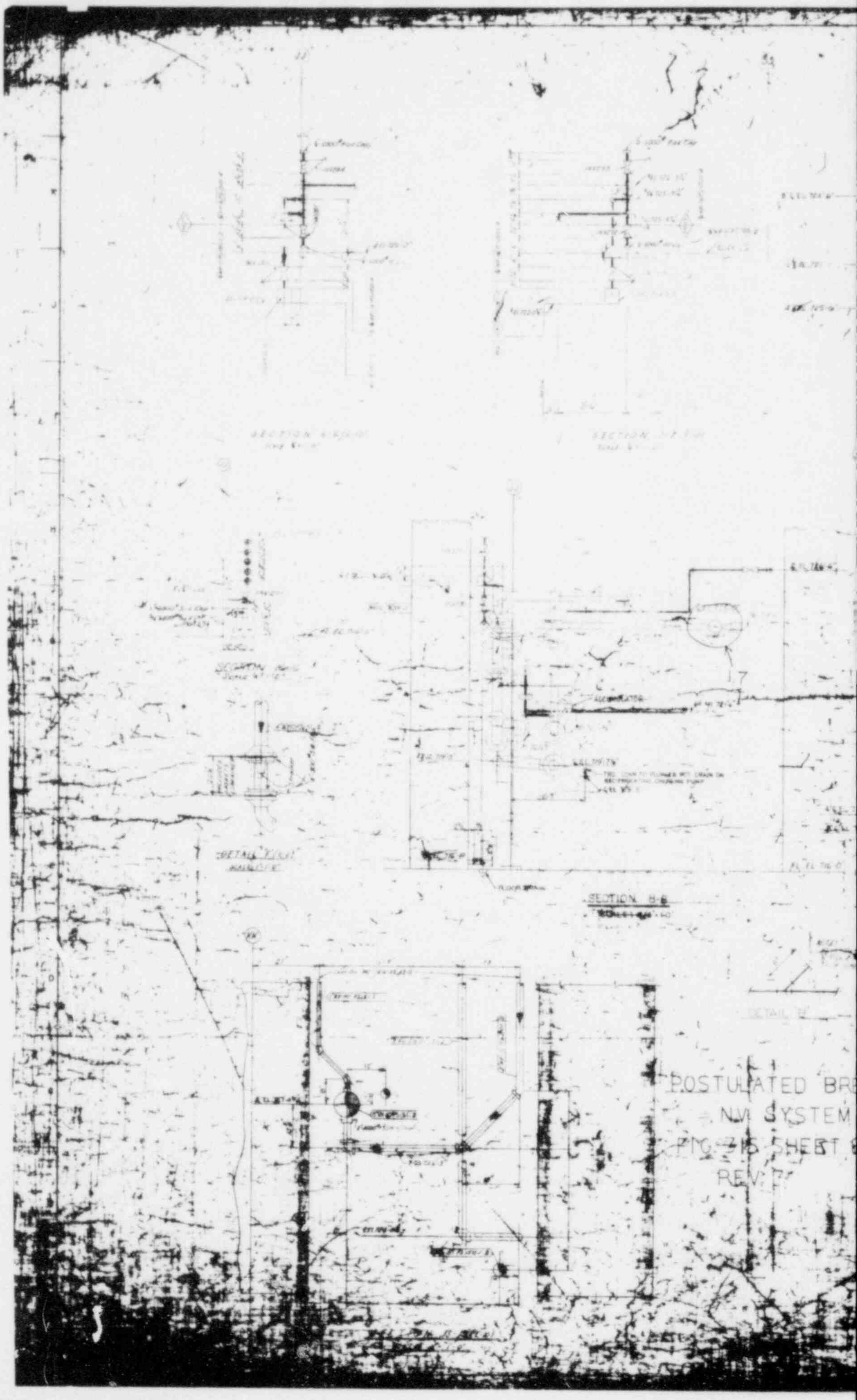
PIPING LAYOUT

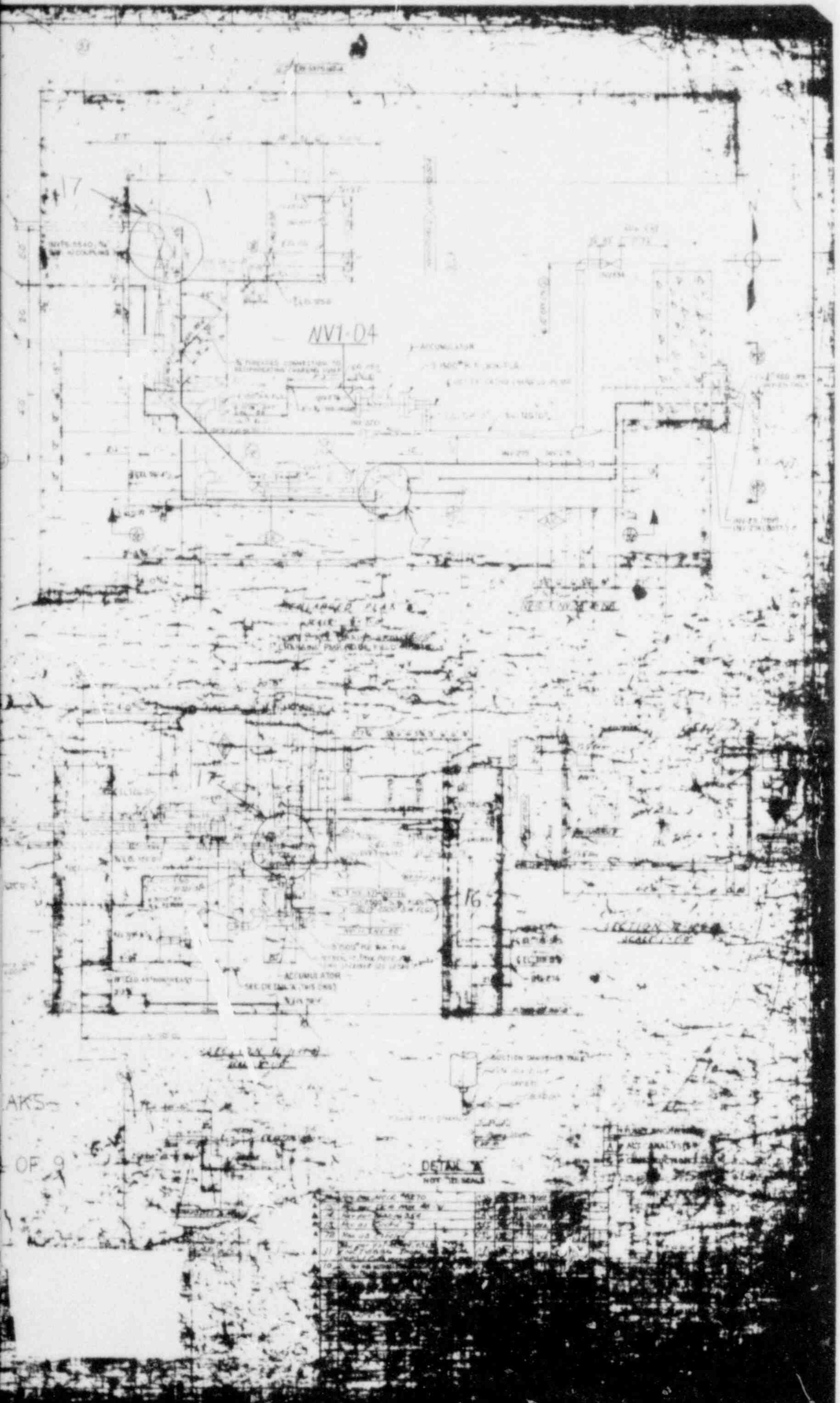
SYSTEM NV

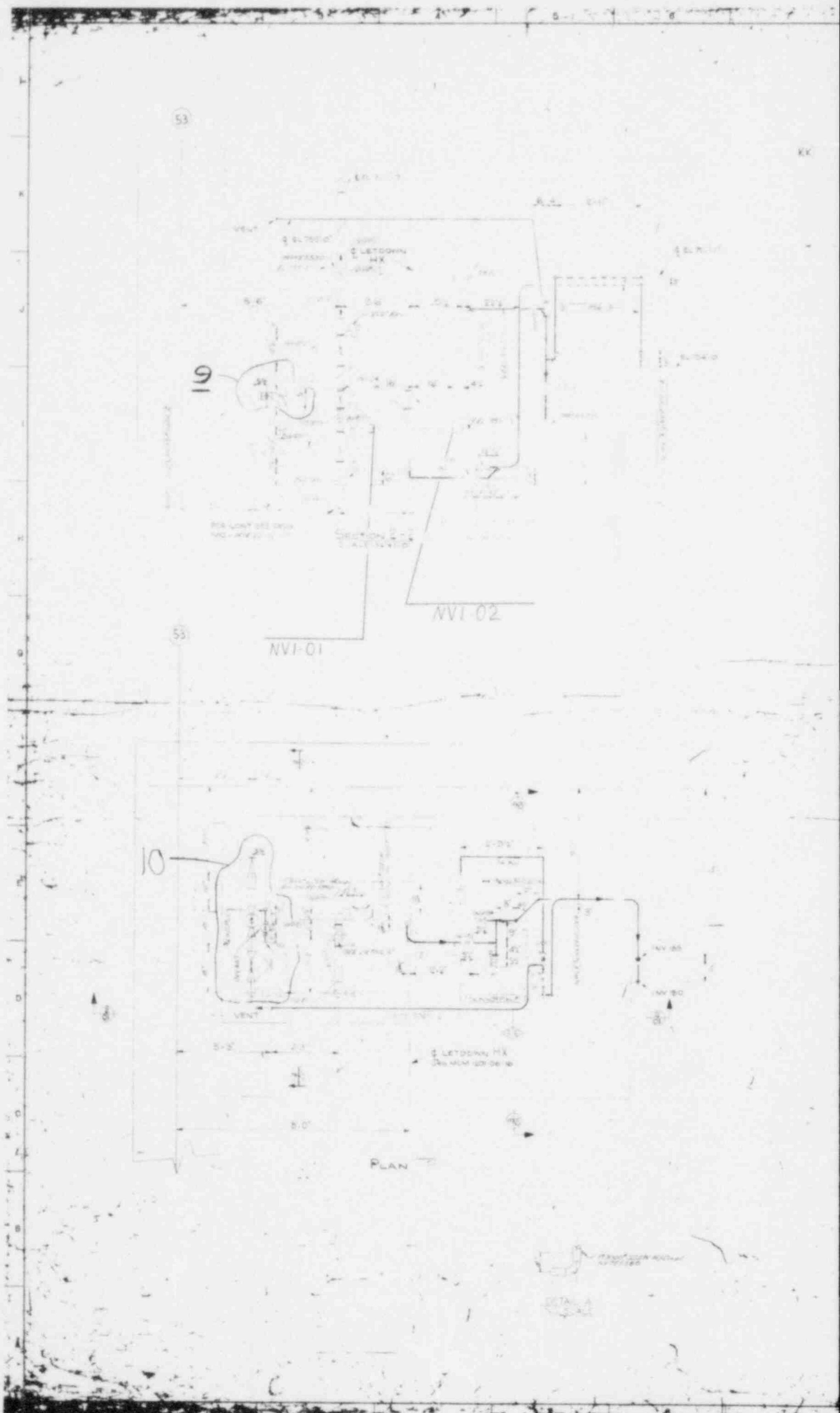
PLAN AT ELEVATION

AUXILIARY

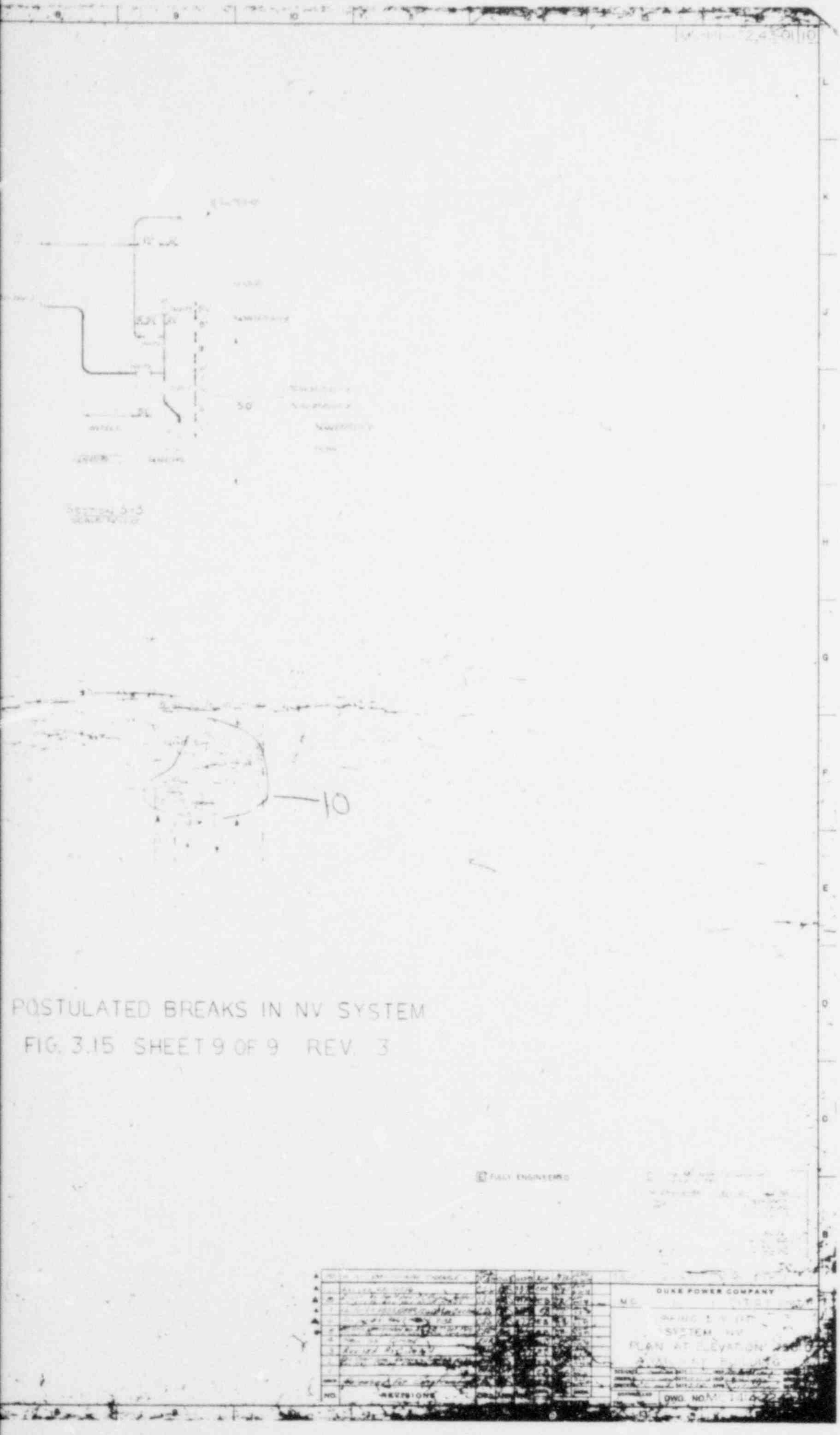
REVISIONS


SECTION B-B
POSTULATED BRE
NV SYSTEM
FIG 3.6-15 SHEET
REV. 7

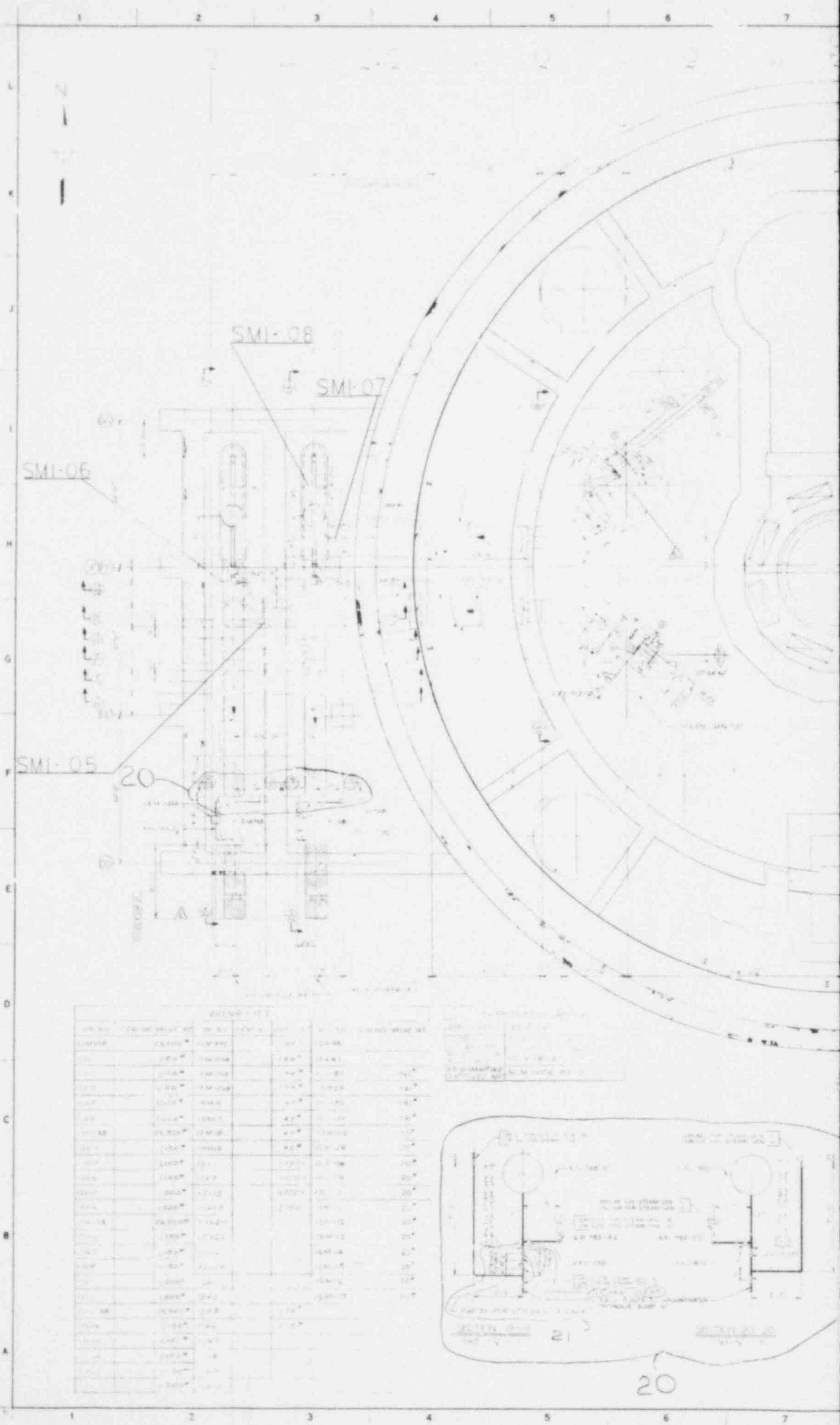

NV1-04
ACCUMULATOR
DETAIL "A"
AKS—
OF 9

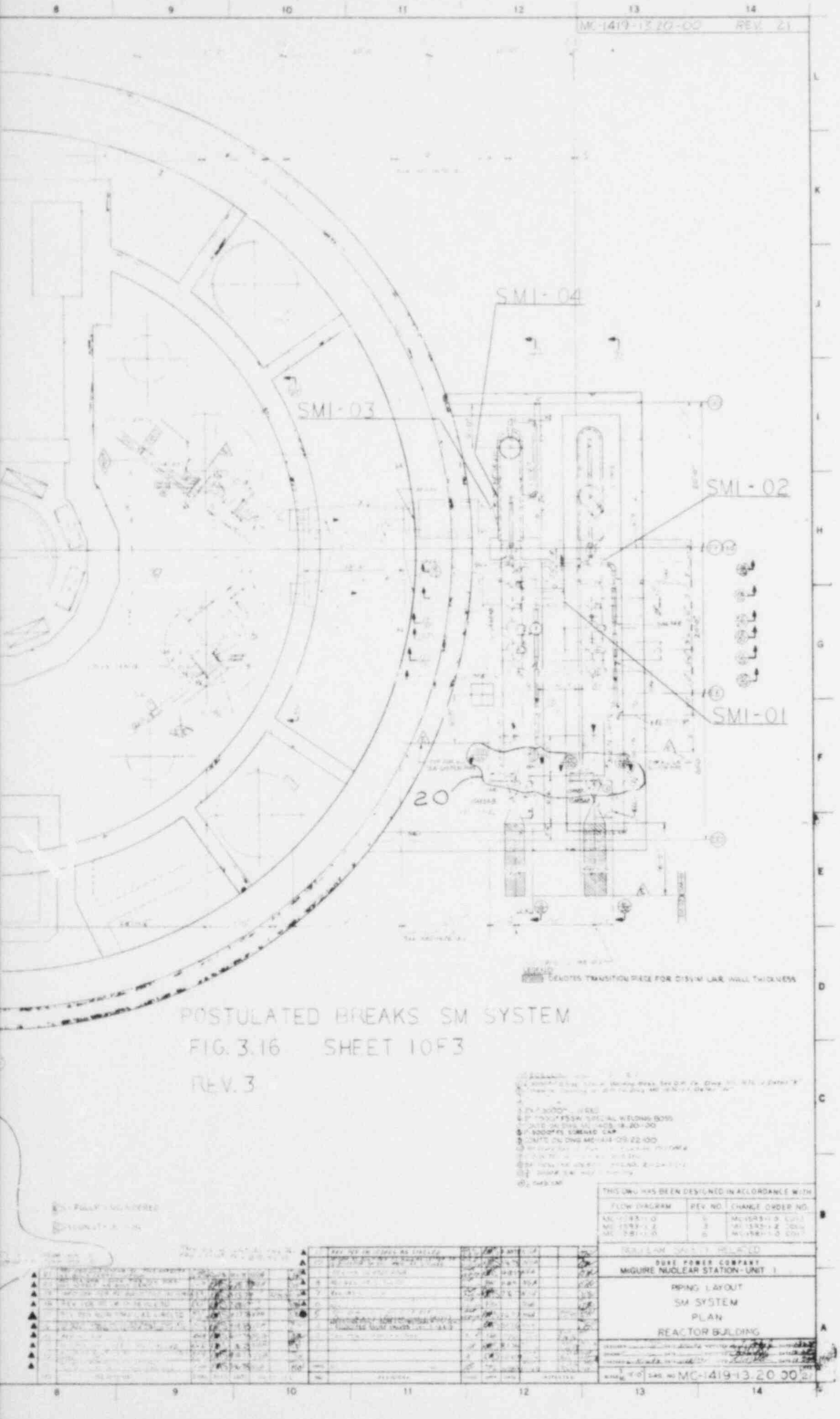


53
VENT
LETDOWN HX
9
SECTION 2-2
NVI-01
NVI-02
10
VENT
LETDOWN HX
PLAN
DETAIL A



POSTULATED BREAKS IN NV SYSTEM
FIG. 3.15 SHEET 9 OF 9 REV. 3

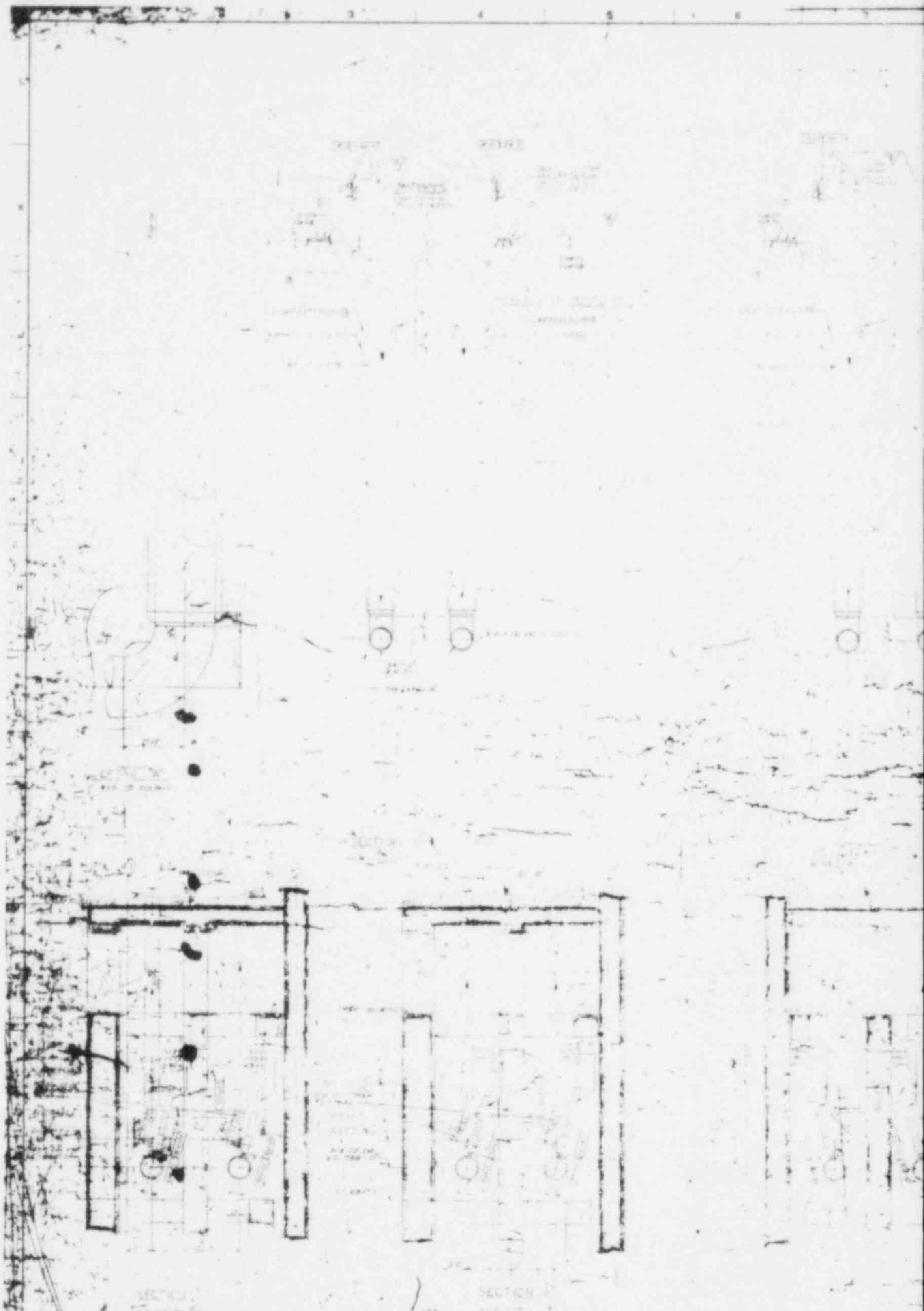

SMI-08
SMI-07
SMI-06
SMI-05
20
21
20



POSTULATED BREAKS SM SYSTEM

FIG. 3.16 SHEET 1 OF 3

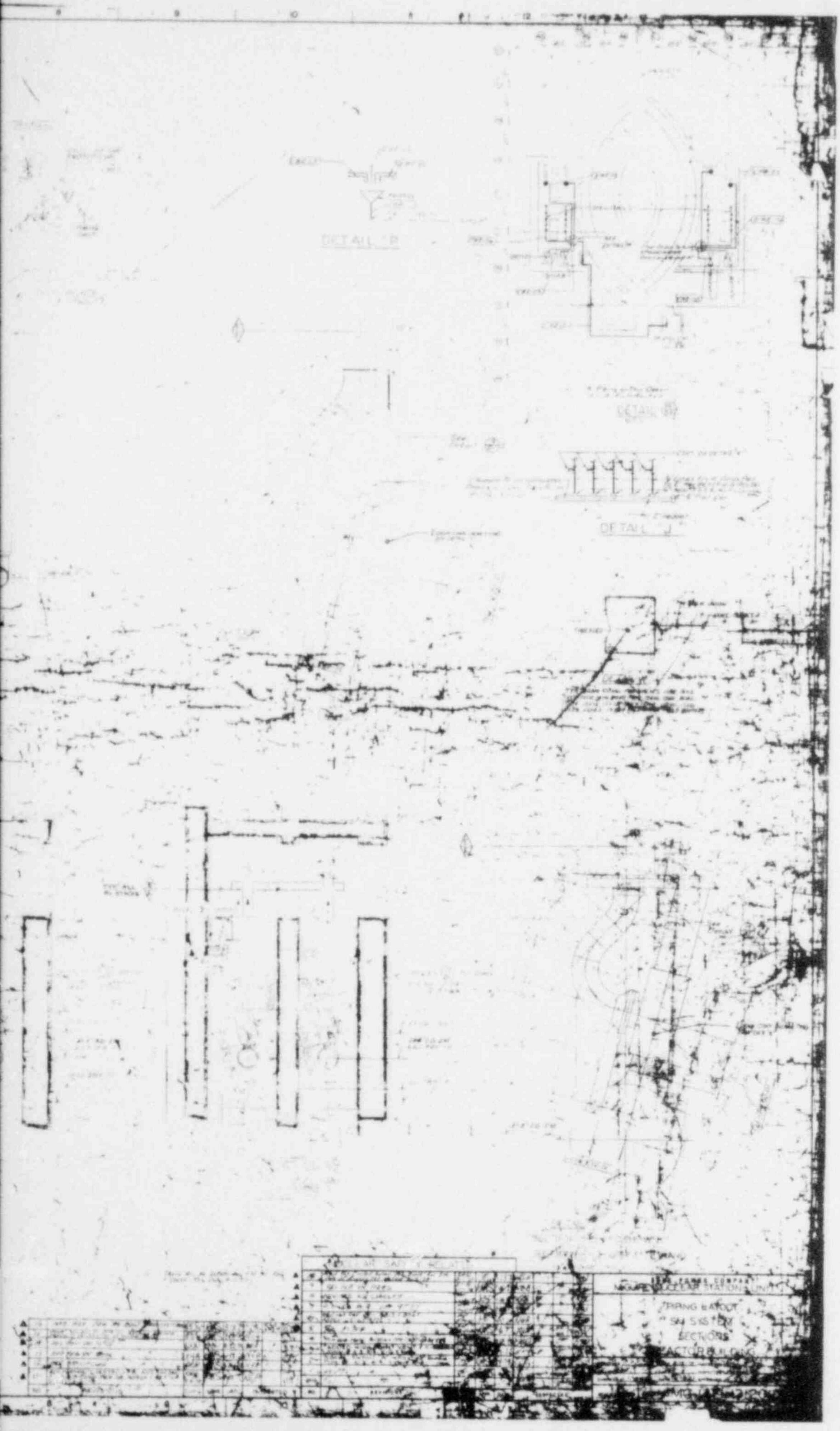
REV. 3



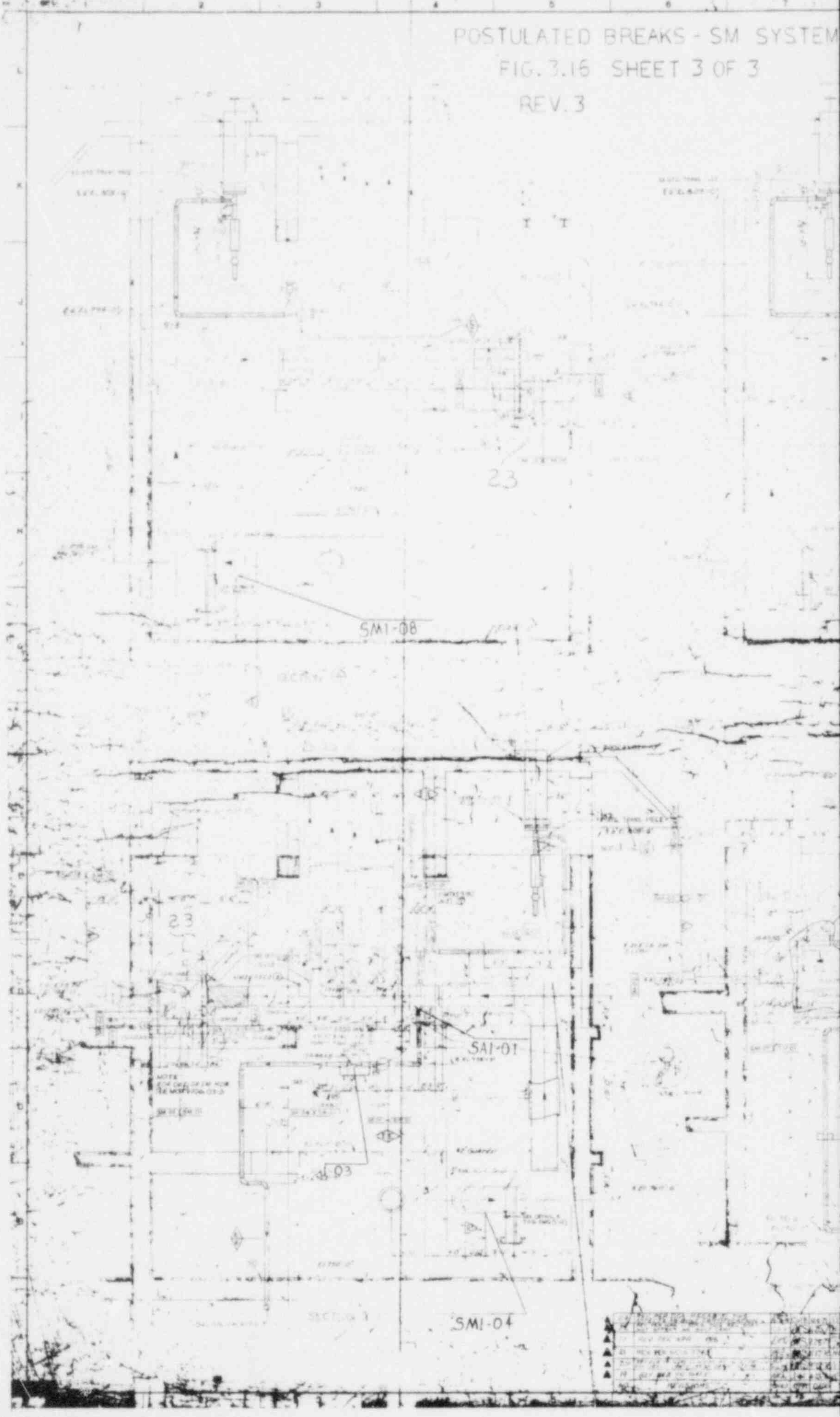
POSTULATED BREAKS IN SM SYSTEM

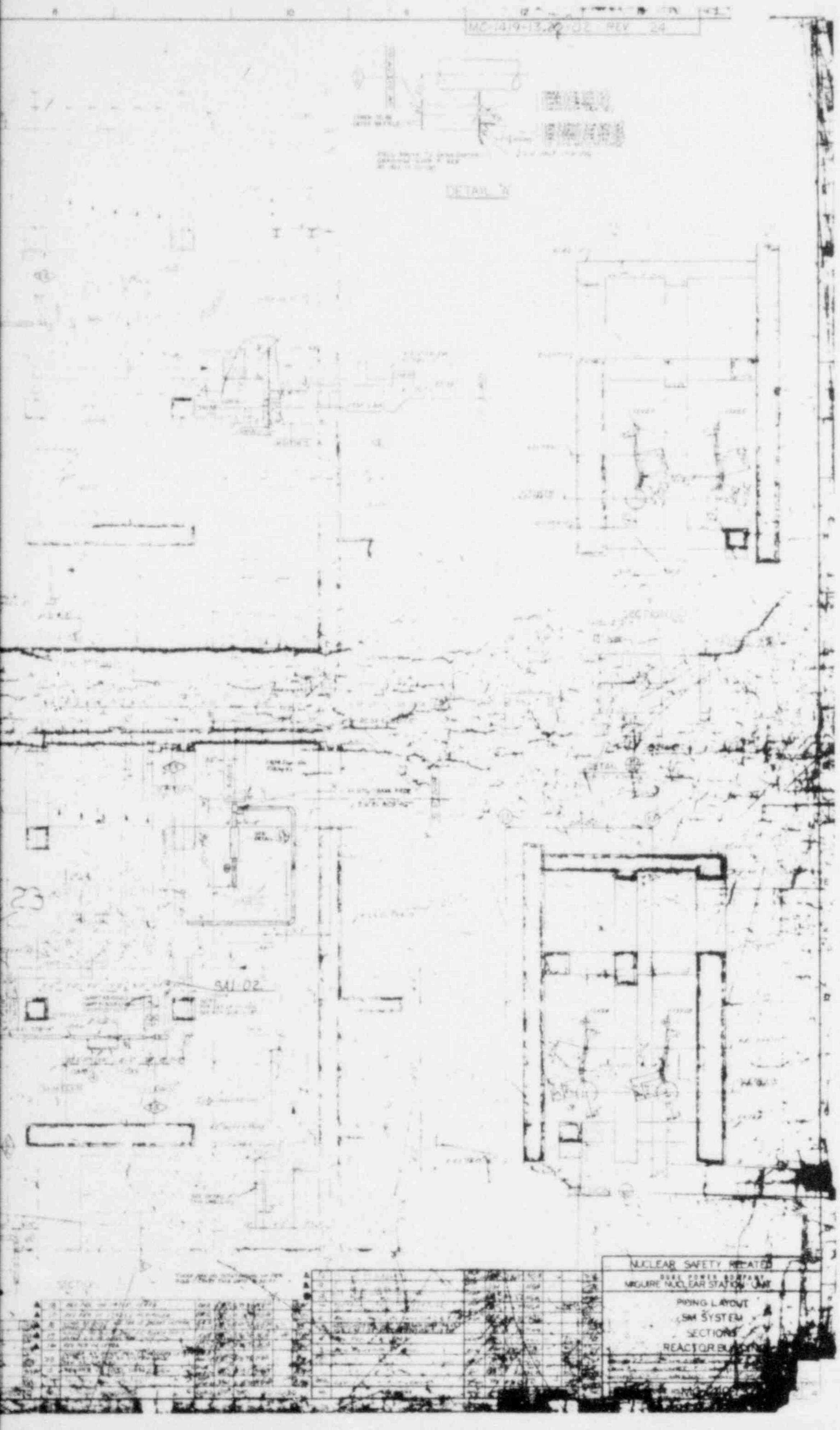
FIG. 3.6 · SHEET 2 OF 3

REV. 3


DETAIL J
NUCLEAR STATION UNIT
PIPING LAYOUT
SECTIONS
REACTOR BUILDING

POSTULATED BREAKS - SM SYSTEM
FIG. 3.16 SHEET 3 OF 3
REV. 3




MC-1419-13.20-02 REV 24
DETAIL 'A'
NUCLEAR SAFETY RELATED
DUKE POWER COMPANY
MCGUIRE NUCLEAR STATION UNIT
PIPING LAYOUT
SM SYSTEM
SECTIONS

4.0 SYSTEMS AND EQUIPMENT EVALUATION

4.1 General

Protection is provided to those plant structures and equipment essential to insure that a safe plant shutdown can be accomplished and maintained, that consequences of the postulated pipe rupture can be mitigated, and that the offsite dose consequences are less than the 10CFR100 allowable limits for a rupture of the piping system under consideration. This requirement is met by preventing unacceptable levels of damage to essential structures and equipment by one or more of the following acceptable methods, listed in their order of preference. Choice of method gives due consideration to other plant design and system requirements.

a) Separation and remote location of fluid system piping from essential structures and equipment.

b) Structural enclosure of the fluid system piping or alternatively, enclosure of the essential equipment.

c) Provision of system-redundant design features separated, or otherwise protected, from the effects of the postulated pipe rupture; or additional protection features such as restraints and barriers.

d) Design of essential structures and equipment to withstand the effects of the postulated pipe rupture.

e) Addition of guard piping for the main purpose of diverting or restricting blowdown flow.

f) In areas where none of the above can be met, or where unacceptable, more severe problems may be created, augmented inservice inspection may be used on a case by case basis with NRC approval to reduce the probability of failure to acceptable levels and not postulate the failure.

4.2 Protection From Rupture of High-Energy Piping Systems

4.2.1 High Energy Piping Systems Physically Separated From Essential Systems and Structures

For the purpose of assuring compliance with the separation requirements of Section 4.1, breaks are postulated in accordance with Section 3.2; and it is clearly demonstrated by review of piping layout that the effects of pipe whip, jet impingement, compartment pressurization, environmental conditions, and flooding associated with the escape of the contained fluids cannot cause any damage to essential structures and systems. In this regard, the following assumptions are utilized in the evaluation of damage to essential structure and systems.

a) Whipping Pipe and Jet Impingement Interactions

1) A whipping pipe or jet is assumed not to cause failure of other pipes of equal or greater size and equal or greater thickness. Smaller and thinner pipes are assumed to encounter unacceptable damage upon impact. A whipping pipe or jet is considered capable of developing through-wall leakage cracks in larger nominal pipe sizes with thinner wall thicknesses, except where experimental or analytical data for the expected range of impact energies demonstrate the capability to withstand the impact without failure.

2) For purposes of evaluating the mechanical integrity effects of the impact of a whipping pipe or jet on piping components (i.e., pumps, valves, flanges, etc.), piping component pressure boundaries are considered to be pipe of the same size and wall thickness as the main process piping to which the components are attached. Bodies of valves (including check valves) are assumed not to fail upon impact by a smaller whipping pipe or jet from a smaller pipe.

3) An active component is assumed to be incapable of performing its active function following impact by a whipping pipe or jet, unless proved otherwise by detailed impact analysis. External valve operators are assumed to be incapable of performing their intended function following impact by a whipping pipe or jet.

4) Electrical and instrument cables are assumed severed upon impact by a whipping pipe or jet, unless it can be demonstrated otherwise.

5) If pipe supports are damaged by whipping pipes or jets, the target pipe supported by the hangers is assumed to remain supported upon the loss of one hanger.

b) Environmental Interactions

1) Structures are assumed failed if their design pressure is exceeded, unless integrity can be demonstrated.

2) Electrical cabling and instrument wiring are assumed to be severed upon exceeding the environmental qualifications of the cabling or wiring, unless it can be demonstrated otherwise.

3) An active component is assumed incapable of performing its active function upon experiencing environmental conditions exceeding the environmental qualifications of the active component.

4.2.2 Piping Systems Enclosed Within Structures

For the purpose of assuring compliance with the requirements of Section 4.1 for piping systems within enclosures, breaks are postulated in accordance with Section 3.2, and it is demonstrated by analysis that such enclosure is adequately designed to prevent damage to essential structures and equipment from the effects of pipe whip, jet impingement, pressurization of the enclosure compartment, environmental conditions, and flooding associated with the escape of the contained fluid. Piping restraints within the enclosure may by accounted for in limiting the effects of the postulated pipe rupture.

4.2.3 Other High-Energy Piping Systems

For the purpose of assuring compliance with the requirements of Section .1 for piping systems neither physically separated from essential structures and equipment nor enclosed, breaks are postulated in accordance with Section 3.2; and it is demonstrated by analysis that the effects of pipe whip, jet impingement, compartment pressurization, environmental conditions, and flooding associated with the escape of the contained fluids cannot cause unacceptable damage to essential structures and equipment.

4.3 Protection From Through-Wall Cracks In Moderate-Energy Piping

For the purpose of assuring compliance with the requirements of Section 4.1, through-wall cracks are postulated in moderate-energy systems in accordance with Section 3.2; and it is demonstrated by analysis that environmental conditions and flooding associated with the escape of the contained fluids cannot cause unacceptable levels of damage to essential structures and equipment. In this regard, the following assumptions are utilized in the evaluation of damage to essential structures and systems.

a) Electrical cabling and instrument wiring are assumed to be severed upon exceeding the environmental qualifications of the cabling or wiring, unless it can be demonstrated otherwise.

b) An active component is assumed incapable of performing its active function upon experiencing environmental conditions exceeding the environmental qualifications of the active component.

4.4 Protection Criteria And Assumptions

If separation, remote location, and enclosure of fluid piping or essential components and systems do not prevent all possible damage resulting from a pipe rupture, then the following plant protection criteria are utilized in determining which systems, structures, or components must be protected to assure a safe plant shutdown.

a) Plant Operating Conditions

1) Power Level - At the time of the postulated pipe rupture,

the plant is assumed to be in the normal mode of plant operation in which the piping under investigation experiences the maximum conditions of pressure and temperature. In cases where this mode is full power operation, the power level assumed is that assumed in the evaluation of the loss-of-coolant accident, steamline break accident, or feedwater line break accident, in Chapter 15 of the FSAR.

2) Offsite Power - If the pipe rupture results in a loss-of-coolant accident, steam line break accident, or feedwater line break accident, a loss of offsite power is assumed to occur subsequent to the pipe rupture.

3) Seismic Loadings equivalent to either the Safe Shutdown Earthquake (SSE) or the Operating Basis Earthquake (OBE), as appropriate, will be used in the analysis of piping, equipment, protective devices, etc.

b) Consideration is given to the potential for a random single failure of an active component subsequent to the postulated pipe rupture. Where the postulated piping rupture is assumed to occur in one of two or more redundant trains of a dual-purpose moderate-energy essential system, i.e., one required to operate during normal plant conditions as well as to shut down the reactor and mitigate the consequences of the piping rupture, single failures of components in the other train or trains of that system only are not assumed, provided the system is designed to seismic Category I standards, is powered from both offsite and onsite sources, and is constructed, operated, and inspected to quality assurance, testing, and inservice inspection standards appropriate for nuclear safety systems.

c) In the event of a postulated rupture in the piping in one unit, safe reactor shutdown of the affected unit cannot preclude the capability for safe shutdown of the reactor of the unaffected unit.

d) Minimum essential systems performance is provided as required for the type of break.

e) The conditions within the control room or any other location where manual action is required to assure safe shutdown to the cold condition is such as to assure habitability and comply with the requirements of General Design Criterion 19.

f) The effects of high-energy pipe ruptures are not allowed to result in offsite doses in excess of 10CFR100 allowable limits.

g) A pipe rupture cannot cause a steam or feedwater line break.

h) All non-LOCA breaks (except Steam and Feedwater Line breaks) are allowed to damage the non-LOCA portion of a single train of an ESF System, provided that unit shutdown can be achieved.

i) All non-LOCA breaks (excluding Steam and Feedwater Line breaks) are allowed to damage any non-LOCA, non-Essential lines (except Steam and Feedwater Lines).

j) A pipe rupture in one train of a redundant essential system or a pipe rupture which damages one train of a redundant essential system cannot result in damage to the opposite train of that system or any other essential system.

k) A pipe rupture in a non-Seismic system (Duke System Piping Class E, G, H) cannot result in damage to an essential system.

l) Steam and feed line ruptures are allowed to damage steam and feed lines, respectively, of the same steam generator, provided that the aggregate break size does not exceed the applicable maximum break size considered in the safety analysis.

m) Steam and Feedwater Line breaks can damage any non-LOCA lines except required Essential System Lines.

n) If two lines are connected to each other and are schematically the same line, then a rupture of one of these lines is allowed to damage the other.

o) The capability for automatic and manual shutdown of the reactor shall be maintained.

p) The capability for the removal of decay heat shall be maintained.

q) High energy piping will only have sufficient energy to cause critical cracks in piping of larger nominal pipe size but thinner wall thickness. A critical crack is not deemed to significantly inhibit the functionability of a piping system.

4.5 Essential Systems

This section describes the systems normally employed for safe shutdown purposes. It goes on to enumerate the shutdown capability required for each event associated with the failures dealt with in this evaluation. Logic diagrams are given in Figure 4-1 through Figure 4-6. These diagrams show logic for turbine trip, main and auxiliary feedwater pump start/trip, reactor trip, reactor coolant pump start/trip, main steam isolation valves, safeguards actuation, feedwater isolation, and makeup control.

4.5.1 Normal Shutdown

The systems necessary for normal, controlled safe shutdown of the reactor are those systems associated with the major functions in both the primary and secondary sides of the Nuclear Steam Supply System. There are no individually identifiable safe shutdown systems per se. However, prescribed procedures for normally securing and maintaining the plant in a safe condition will be instituted by appropriate alignment of selected fluid and control systems. The system functions required to be aligned for maintaining normal, controlled safe shutdown of the reactor are the minimum number that will:

1) Prevent the reactor from achieving criticality.
2) Provide an adequate heat sink such that design and safety limits are not exceeded.

The designation of systems that can be used for a safe normal shutdown depends on identifying those systems which provide the following capabilities for maintaining a safe shutdown condition:

1) Reactor coolant boration.
2) Adequate supply of auxiliary feedwater.

3

All systems required for a safe shutdown associated with these functions have been designed in accordance with the single failure criteria, as stated in Section 4.4. The following subsections identify systems which are required for safe shutdown of the reactor in the specific faulted conditions which this report is analyzing; these are conditions precipitated by the rupture of piping systems outside containment.

4.5.2 Emergency Shutdown

An emergency shutdown may be caused by any natural or accidental event of infrequent occurrence. This includes related consequences which affect the plant operations and require the use of other than preferred systems or Engineered Safety Feature (ESF) Systems to bring the reactor to a safe shutdown condition. In the context of this report, an emergency shutdown is also considered to be precipitated by a pipe rupture that is of sufficient magnitude that a plant shutdown is deemed necessary even though normal shutdown systems can be used to affect a reactor shutdown. All events are analyzed independently and are not assumed to occur simultaneously. In this analysis, loss of offsite power is assumed to occur in those events which cause Protection System actuation effecting a plant trip. In this case, loss of function of onsite a-c power (emergency diesels) and batteries must be prevented.

4.5.2.1 Emergency Shutdown With A Main Steam Line Rupture

The equipment necessary for a safe shutdown of the reactor is the same for any pipe break location on the main steam line. The effect of any main steam break on plant shutdown is the loss of one steam generator for reactor decay heat removal immediately after reactor trip.

For a large steam line break, the following must be available to accomplish safety functions:

1) Safety injection to pump borated water into the core and, thereby, limit the core power transient following the break.

2) Isolation of main feedwater to the steam generators to limit the Reactor Coolant System (RCS) cooldown.

3) Closure of the main steam isolation valves to limit RCS cooldown and reverse flow.

4) Auxiliary feedwater is required to dissipate reactor decay heat. In the event of a concurrent loss of offsite power, at least one of the auxiliary feed pumps would be required.

In order to cool the plant down to the Residual Heat Removal System temperature and pressure, auxiliary feedwater must be available and the steam generator power-operated relief valves must be operable.

4.5.2.2 <u>Emergency Shutdown with a Feedwater Line Rupture</u>

A feedwater rupture between the Containment and the feedwater check valve is considered to be the worst-case feedwater rupture because of the complete blowdown of one steam generator in addition to almost unrestricted flow from the feedwater pumps. For this rupture, the following must be available to accomplish their safety functions:

1) Safety injection to pump borated water into the core and, thereby, limit the core power transient following the break.

2) Feedwater to the intact steam generators.

3) Closure of main steam isolation valves.

In order to cool the plant down to the Residual Heat Removal System operating temperature and pressure, auxiliary feedwater from at least one auxiliary feedwater pump must be available and the steam generator power-operated relief valves must be operable.

For a large break between the feedwater pump and the main feedwater check valve, the feed line check valve will prevent water or steam release from any of the steam generators through the break. A large break at this point is, thus, essentially a loss of normal feedwater. In this case, the equipment that must be available to accomplish the safety function consists of the Auxiliary Feedwater System and the intact portion of the Feedwater System; safety injection is not required. This case covers all lesser Feedwater and Condensate System high energy line breaks.

4.5.2.3 Emergency Shutdown With An Auxiliary Feedwater Pump Steam Supply Line Rupture

A rupture of the auxiliary feedwater pump steam supply line between the main steam line and the normally closed piston-operated valves, shown in Figure 3.7, is considered a less severe main steam line rupture, and its necessary emergency shutdown equipment is discussed in Section 4.5.2.1. After the rupture, Auxiliary Feedwater can be provided by one of the motor-driven Auxiliary Feedwater Pumps. The check valves in each steam supply line limit the blowdown from this rupture to a single steam generator.

Based on the fact that the steam is supplied to the turbine driver only during test conditions, and upon the following considerations, the probability of a rupture in this system between the motor-operated valves and the auxiliary feedwater pump turbine driver is considered to be extremely remote.

1) High level of system quality control.
2) Periodic inspection.
3) Low usage factor.
4) Short time the system exceeds 200° and 275 psig annually.

Thus, the piping downstream of the isolation valves is considered moderate energy based on total time of operation.

4.5.2.4 <u>Emergency Shutdown With A Steam Generator Blowdown Line Rupture</u>

A steam generator blowdown line rupture outside the Containment would not cause a reactor or turbine trip. In this case, availability of offsite power is assumed and a "normal" plant shutdown can be effected.

For a steam generator blowdown line rupture, the affected line could be isolated and an evaluation of the severity of the leak or rupture would determine the need to shut down the reactor. If needed, the shutdown would use normal shutdown procedures.

4.5.2.5 <u>Emergency Shutdown With A CVCS Letdown Line Rupture</u>

For a break in the letdown line between the Containment and the letdown heat exchanger, the following must be available:

1) Charging plus either normal makeup or makeup from the primary makeup water storage tank, to maintain liquid inventory in the RCS until the break is identified and the letdown line isolated.
2) Letdown line Containment isolation valves.
3) Auxiliary feedwater, to cool the plant down to the conditions necessary to initiate operation of the RHRS.

3

4.5.2.6 <u>Emergency Shutdown With A CVCS Charging Line Rupture</u>

For a full area break in the charging line between the Containment and the charging pumps, the following must be available:

1) Charging (from safety injection pipe) plus either normal makeup from the primary makeup water storage tank, to maintain liquid inventory in the RCS.

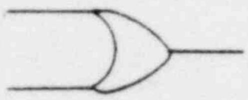
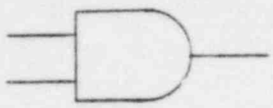
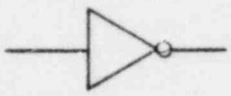
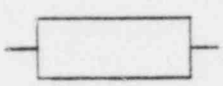
2) Auxiliary feedwater, to cool the plant down to the conditions necessary to initiate operation of the RHRS.

3

4.5.2.7 <u>Emergency Shutdown With An Auxiliary Feedwater Line Rupture</u>

The Auxiliary Feedwater System is an ESF System. It is not only required to mitigate the consequence of accidents, eg, loss of coolant, feedwater line break, etc., but it is also required as a means of dissipating the energy from the RCS during periods when the main heat sink (main condenser dump and Main Feedwater System) is unavailable; for example, during a blackout situation.

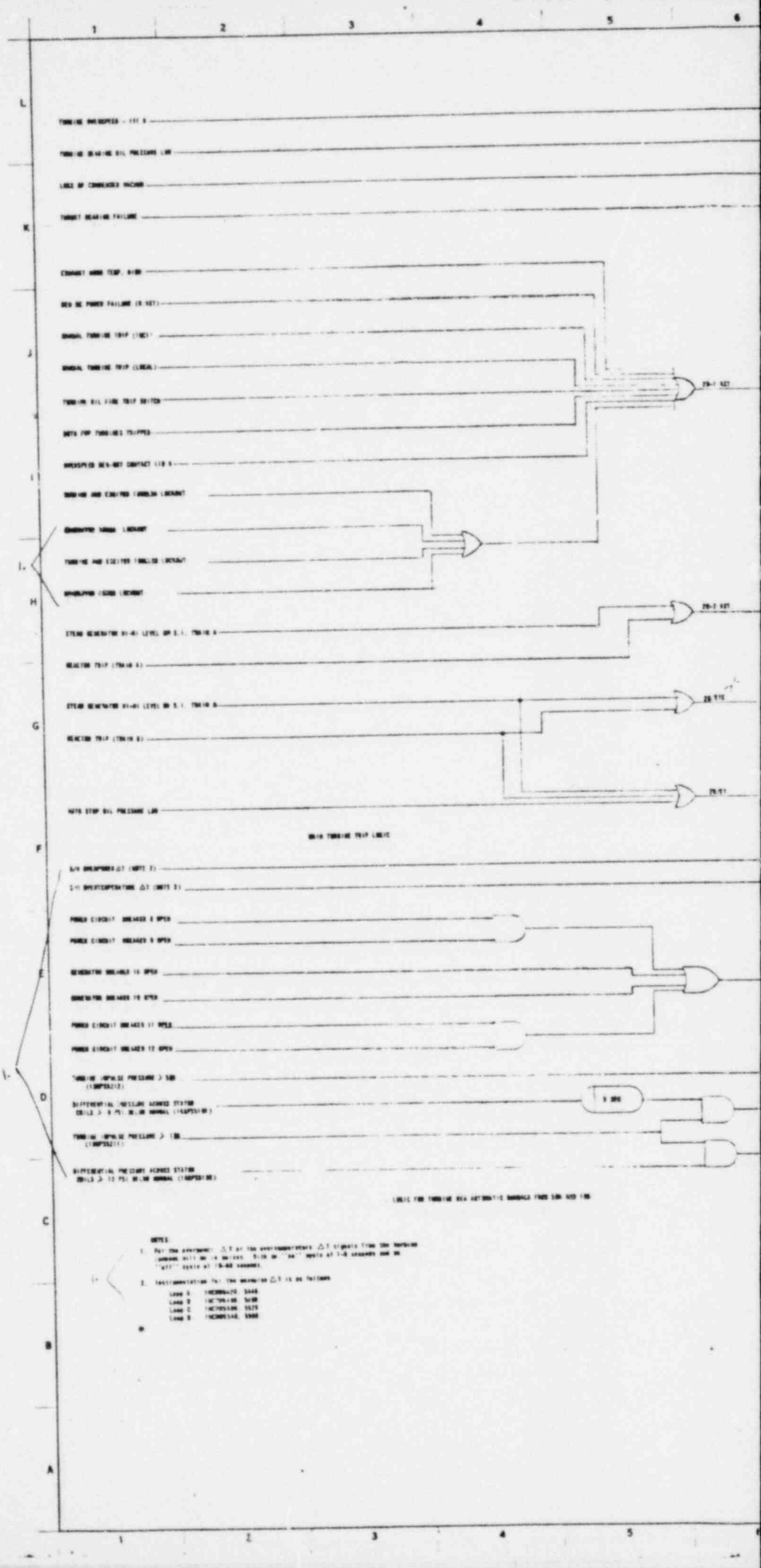
A pipe rupture in the high energy portion of the Auxiliary Feedwater System, between the main feedwater line and the first check valve is considered a less severe main feedwater line rupture. The necessary emergency shutdown equipment is discussed in Section 4.5.2.2 Following pipe rupture in one of the Auxiliary Feedwater Pump discharge lines, feedwater could be provided by one of the remaining two auxiliary feedwater pumps or through the normal feedwater system assuming offsite power availability.

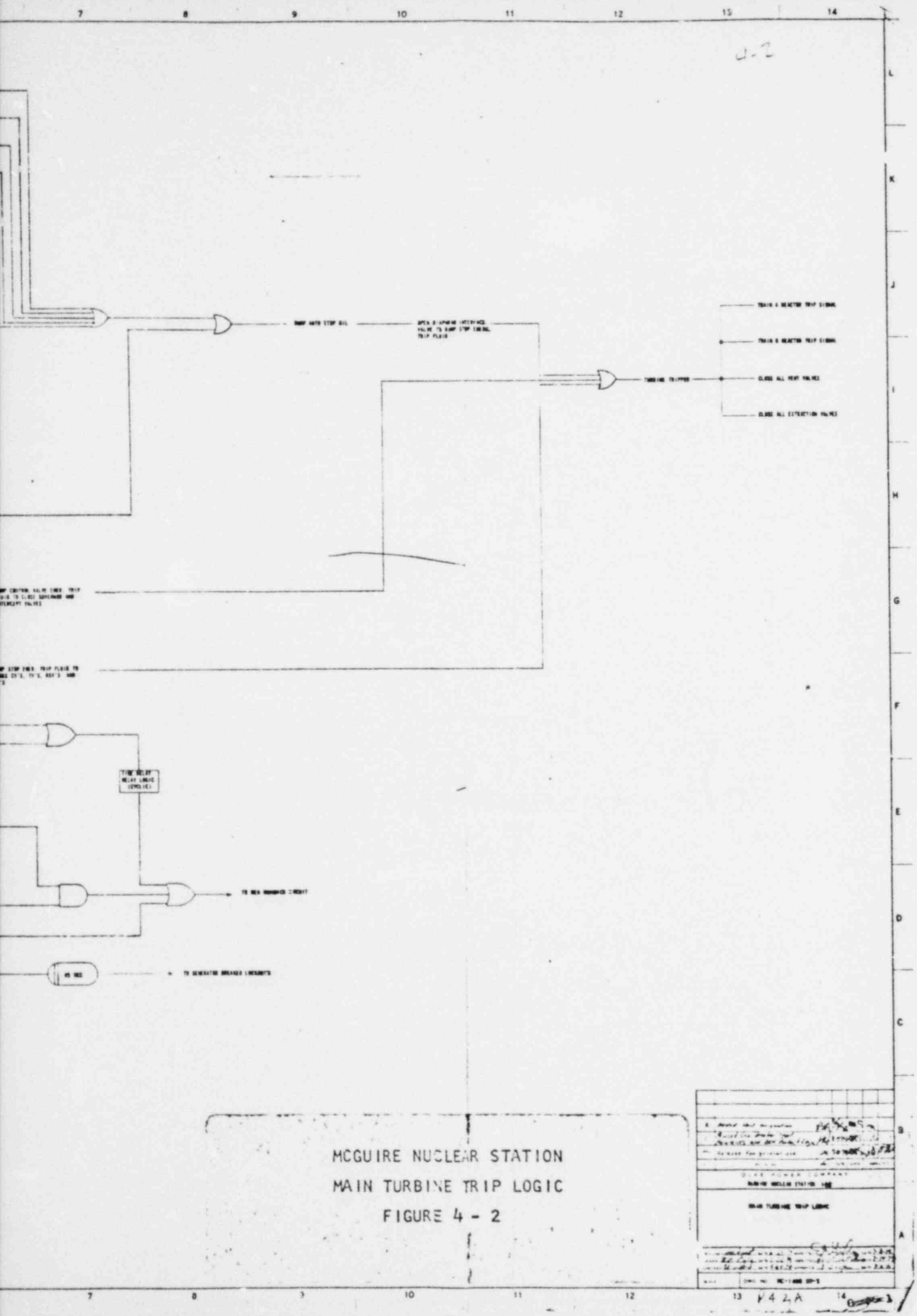
LOGIC SYMBOLS	LOGIC FUNCTION
	OR
	AND
	INVERTER - NOT FUNCTION
	TIME DELAY
	ADMINISTRATIVE PROCEDURE
	CONTROL SWITCH (TYPICAL)
	MISCELLANEOUS CONTROL FUNCTION OR INFORMATION
	INDICATES CONTROL SIGNAL TO RESPECTIVE PUMP, FAN, VALVE, ETC.
	INDICATES SIGNAL TO ALL PUMPS, FANS, OR DEVICES OF A GIVEN TYPE

MCGUIRE NUCLEAR STATION

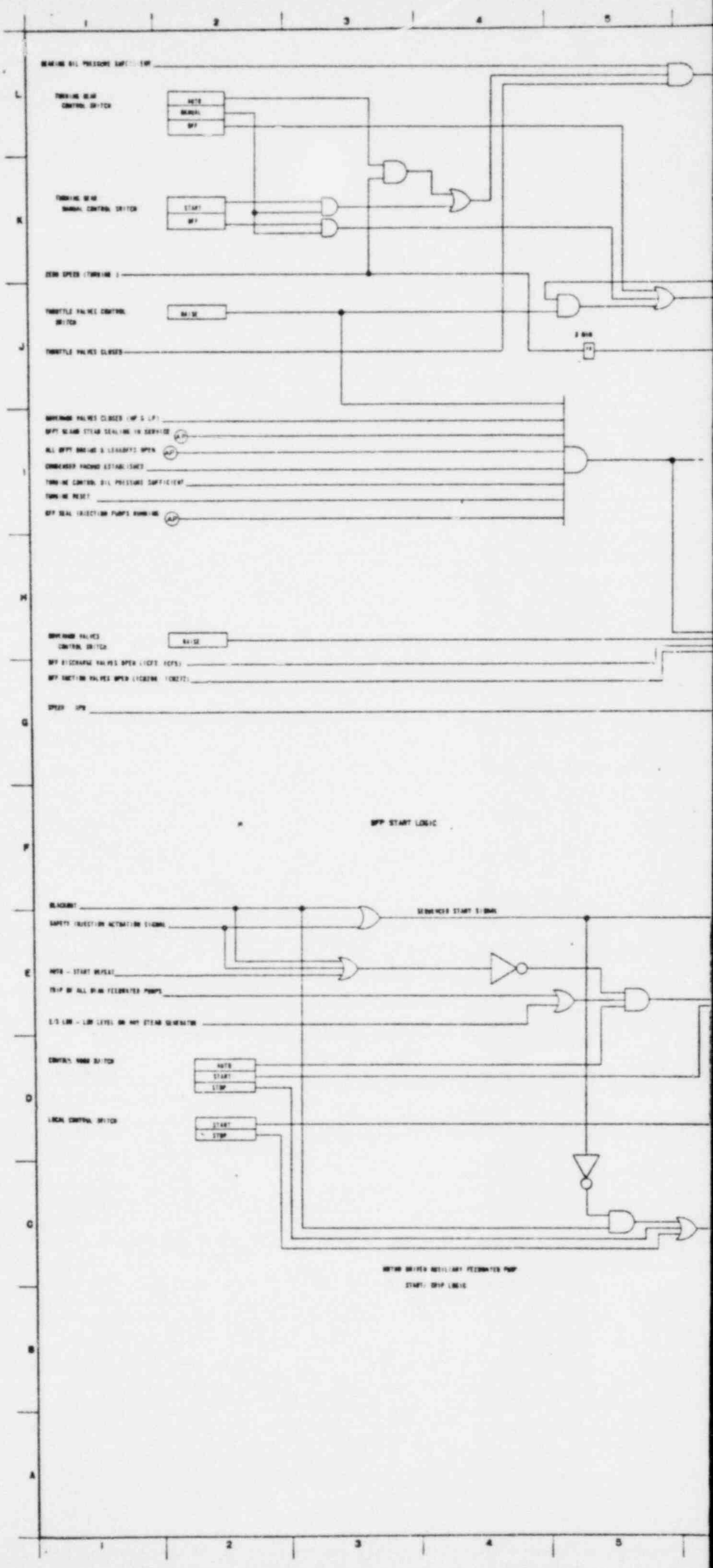
LOGIC SYMBOLS

FIGURE 4 - 1

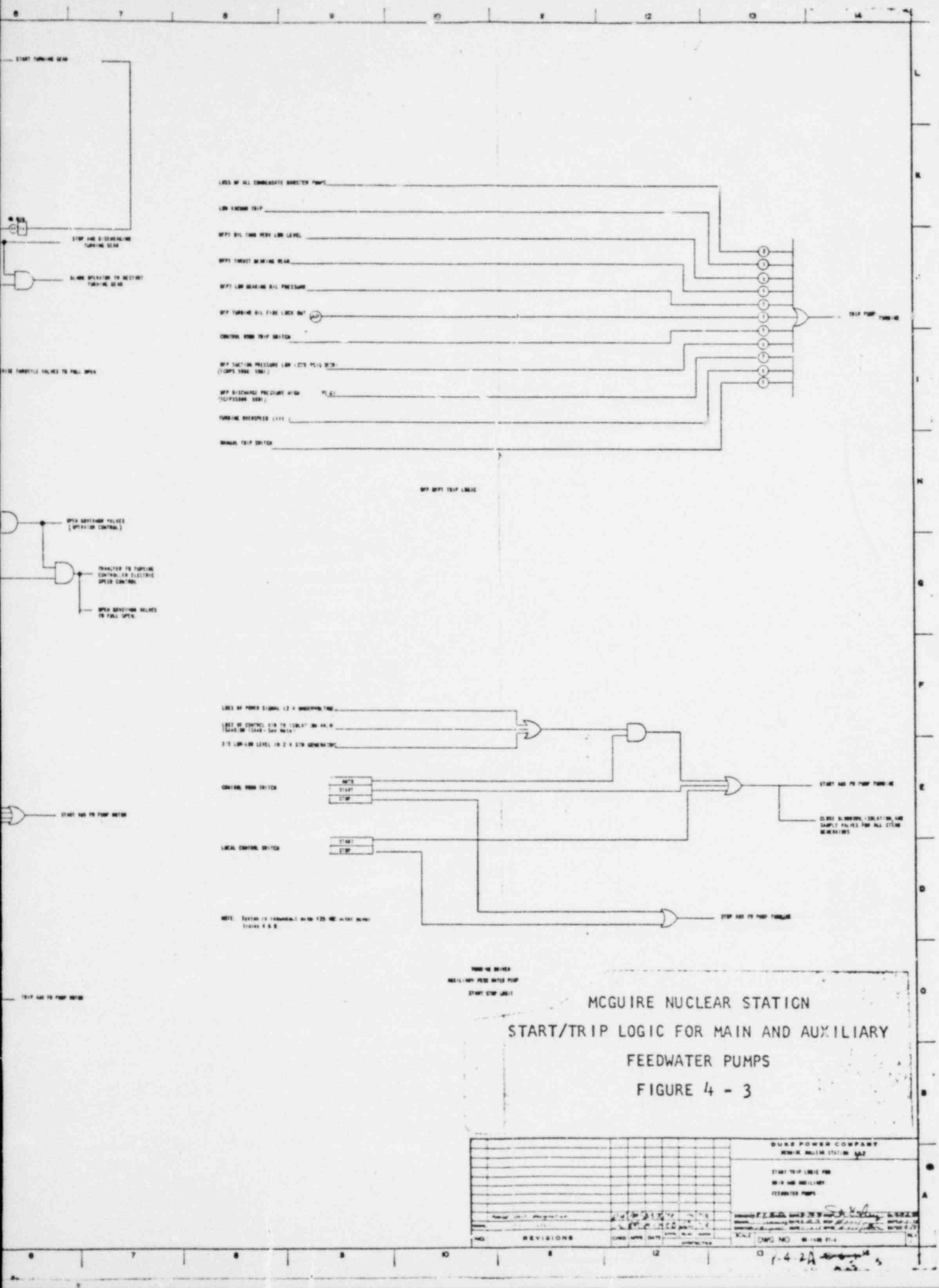




MCGUIRE NUCLEAR STATION
MAIN TURBINE TRIP LOGIC
FIGURE 4 - 2



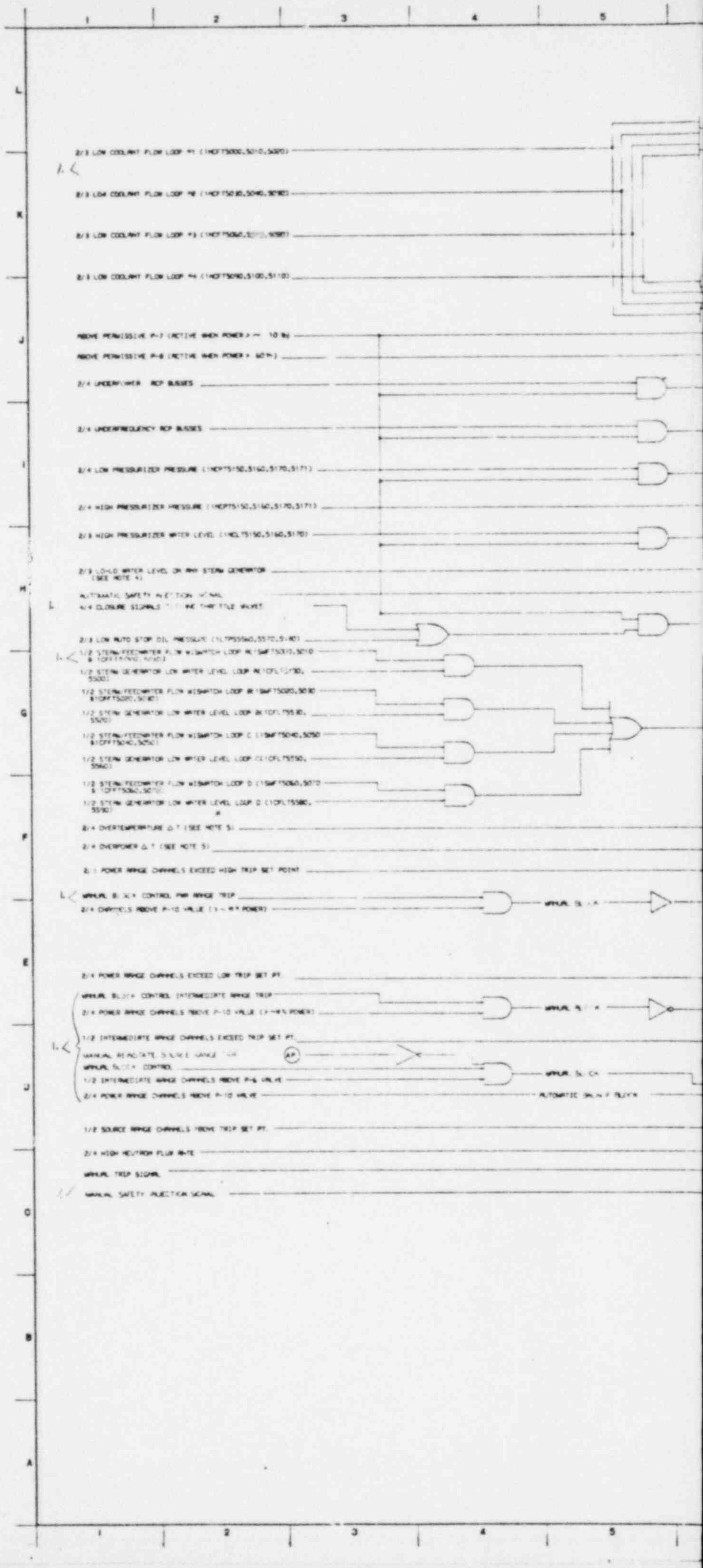
THROTTLE VALVES CLOSED
START
OFF
RAISE
BFP START LOGIC
AUTO
START
STOP
START
STOP



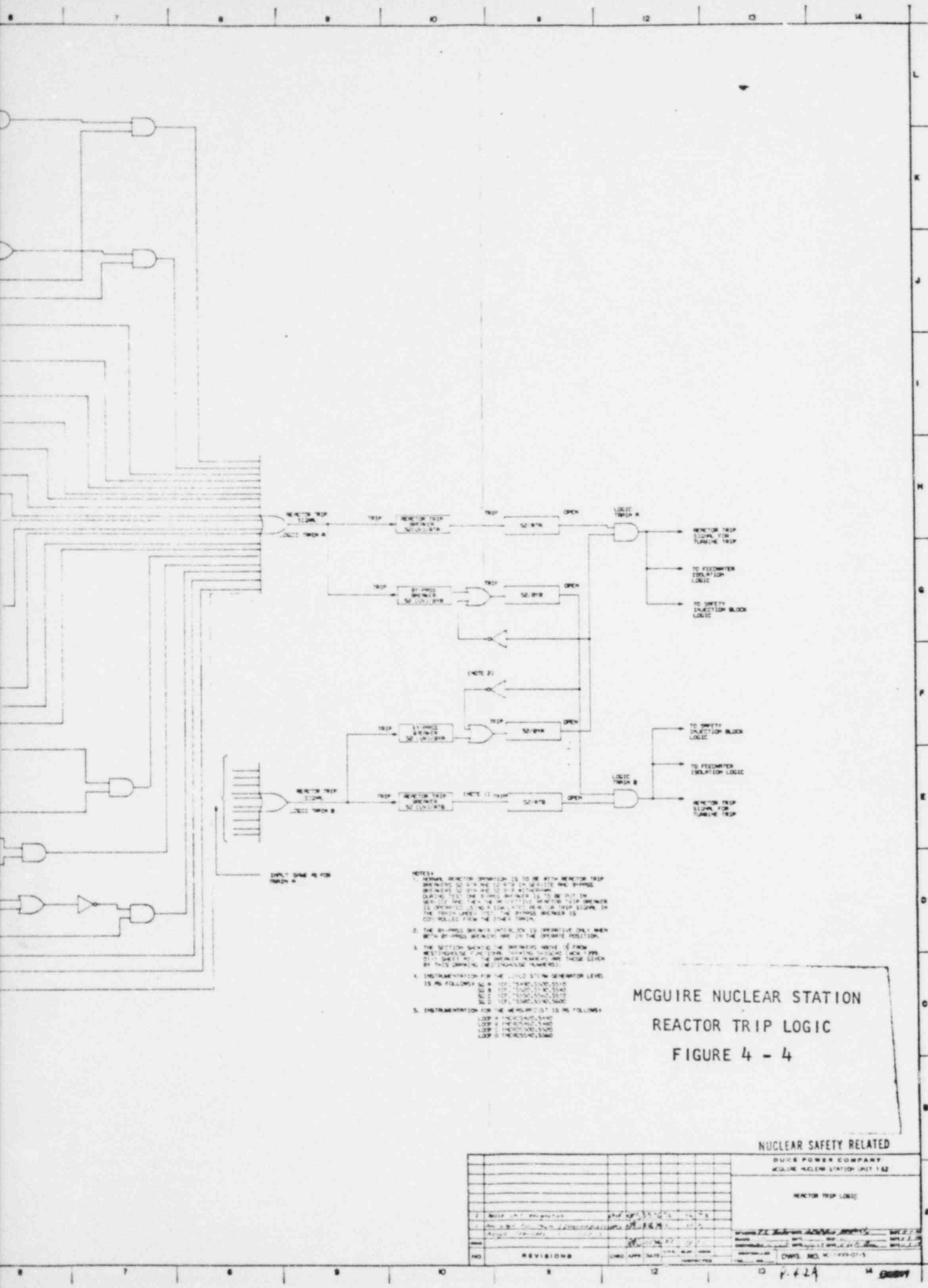
MCGUIRE NUCLEAR STATION

START/TRIP LOGIC FOR MAIN AND AUXILIARY FEEDWATER PUMPS

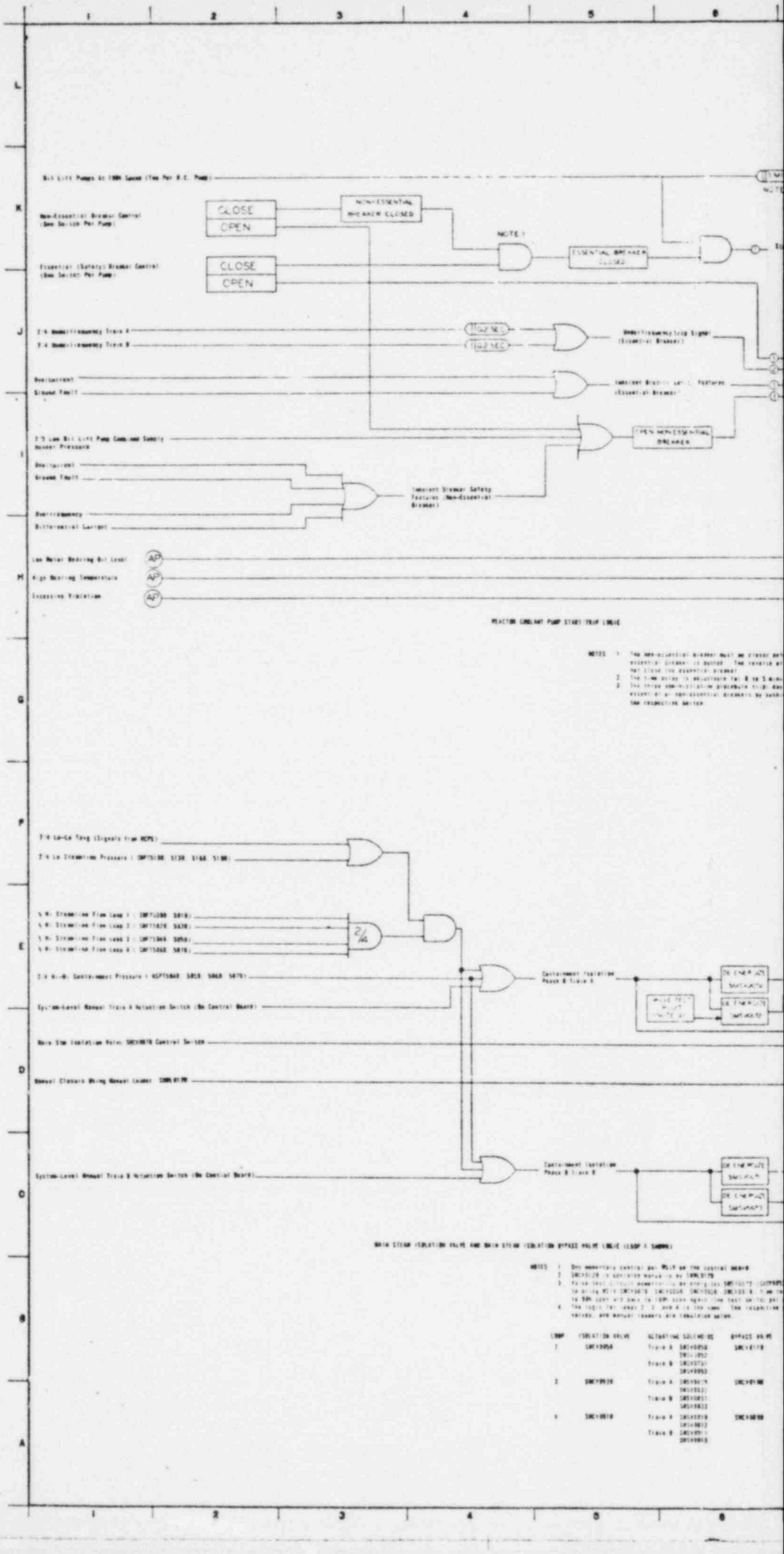
FIGURE 4 - 3



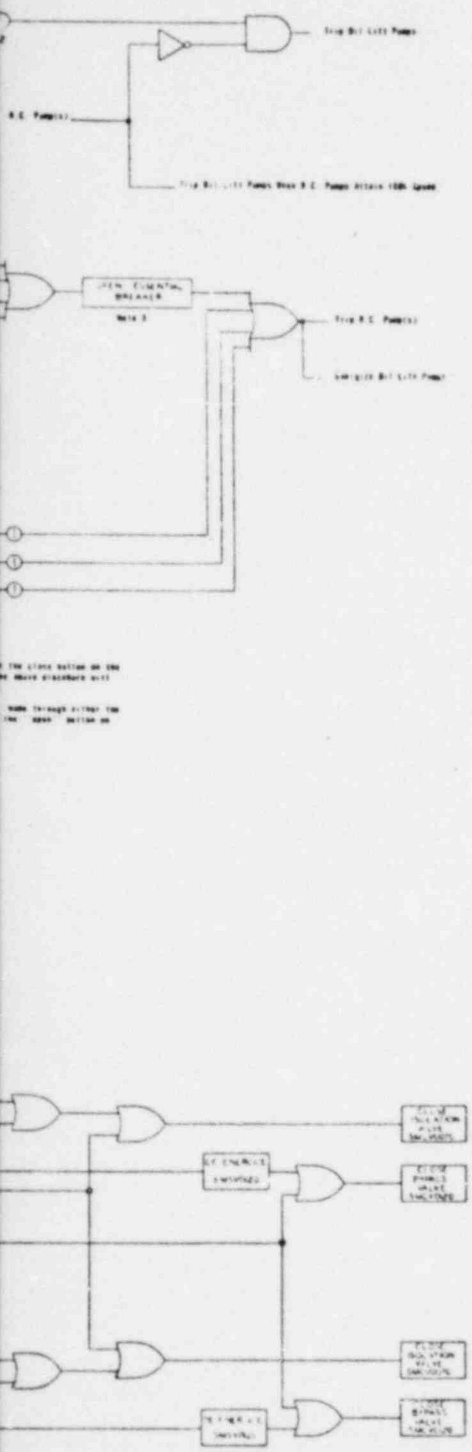
2/3 LOW COOLANT FLOW LOOP #1 (1HCFT5000,5010,5020)
2/3 LOW COOLANT FLOW LOOP #2 (1HCFT5030,5040,5050)
2/3 LOW COOLANT FLOW LOOP #4 (1HCFT5090,5100,5110)
ABOVE PERMISSIVE P-7 (ACTIVE WHEN POWER > 10 %)
ABOVE PERMISSIVE P-8 (ACTIVE WHEN POWER > 50%)
2/4 UNDERFREQUENCY RCP BUSSES
2/4 LOW PRESSURIZER PRESSURE (1HCPT5150,5160,5170,5171)
2/4 HIGH PRESSURIZER PRESSURE (1HCPT5150,5160,5170,5171)
2/3 HIGH PRESSURIZER WATER LEVEL (1HCLT5150,5160,5170)
2/3 LO-LO WATER LEVEL ON ANY STEAM GENERATOR (SEE NOTE 4)
2/4 OVERTEMPERATURE ΔT (SEE NOTE 5)
2/4 OVERPOWER ΔT (SEE NOTE 5)
MANUAL BLOCK CONTROL PWR RANGE TRIP
2/4 POWER RANGE CHANNELS EXCEED LOW TRIP SET PT.
MANUAL BLOCK CONTROL INTERMEDIATE RANGE TRIP
1/2 INTERMEDIATE RANGE CHANNELS EXCEED TRIP SET PT.
MANUAL BLOCK CONTROL
1/2 INTERMEDIATE RANGE CHANNELS ABOVE P-6 VALUE
2/4 POWER RANGE CHANNELS ABOVE P-10 VALUE
1/2 SOURCE RANGE CHANNELS ABOVE TRIP SET PT.
2/4 HIGH NEUTRON FLUX RATE
MANUAL TRIP SIGNAL
MANUAL SAFETY INJECTION SIGNAL



MCGUIRE NUCLEAR STATION
REACTOR TRIP LOGIC
FIGURE 4 - 4



CLOSE
OPEN
NON-ESSENTIAL BREAKER CLOSED
NOTE 1
ESSENTIAL BREAKER CLOSED
OPEN NON-ESSENTIAL BREAKER
AP
2/4



MCGUIRE NUCLEAR STATION

REACTOR COOLANT PUMP START/TRIP AND

MAIN STEAM ISOLATION VALVE LOGIC

FIGURE 4 - 5

NUCLEAR SAFETY RELATED

DUKE POWER COMPANY

MCGUIRE NUCLEAR STATION UNIT 1&2

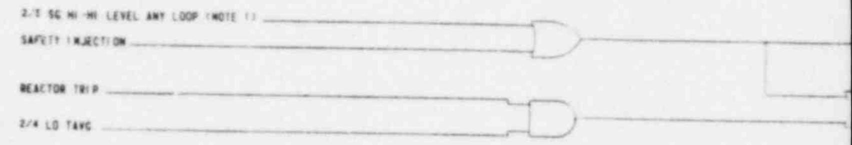
REACTOR COOLANT PUMP START/TRIP

AND MAIN STEAM ISOLATION VALVE LOGIC

NO	REVISIONS			

DWG NO

p. 4-2A



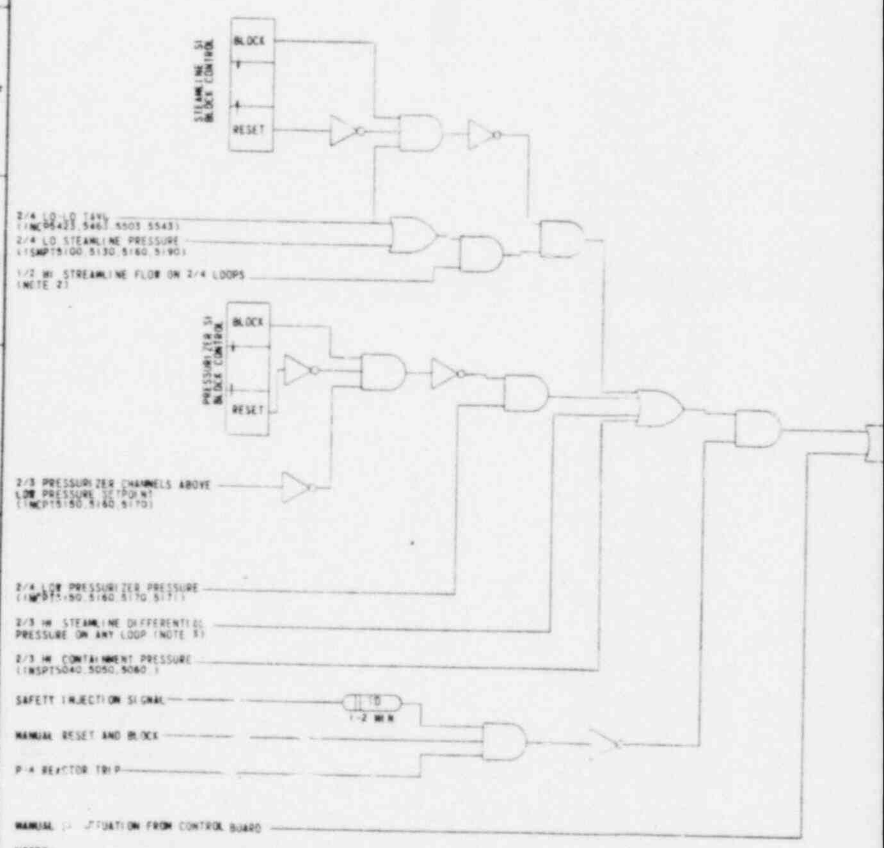
FEEDWATER ISOLATION LOGIC

NOTES:

1. THE INSTRUMENTATION FOR THE SG HI-HI LEVEL IS AS FOLLOWS

DUKE MK#	LOOP	CHANNEL	DUKE MK#	LOOP	CHANNEL
1CFLT5490	SG-A	# 4	1CFLT5550	SG-C	# 4
1CFLT5500	SG-A	# 3	1CFLT5560	SG-C	# 3
1CFLT5510	SG-A	# 2	1CFLT5570	SG-C	# 1
1CFLT5520	SG-B	# 4	1CFLT5580	SG-D	# 4
1CFLT5530	SG-B	# 3	1CFLT5590	SG-D	# 3
1CFLT5540	SG-B	# 1	1CFLT5600	SG-D	# 2

FEEDWATER ISOLATION LOGIC



NOTES:

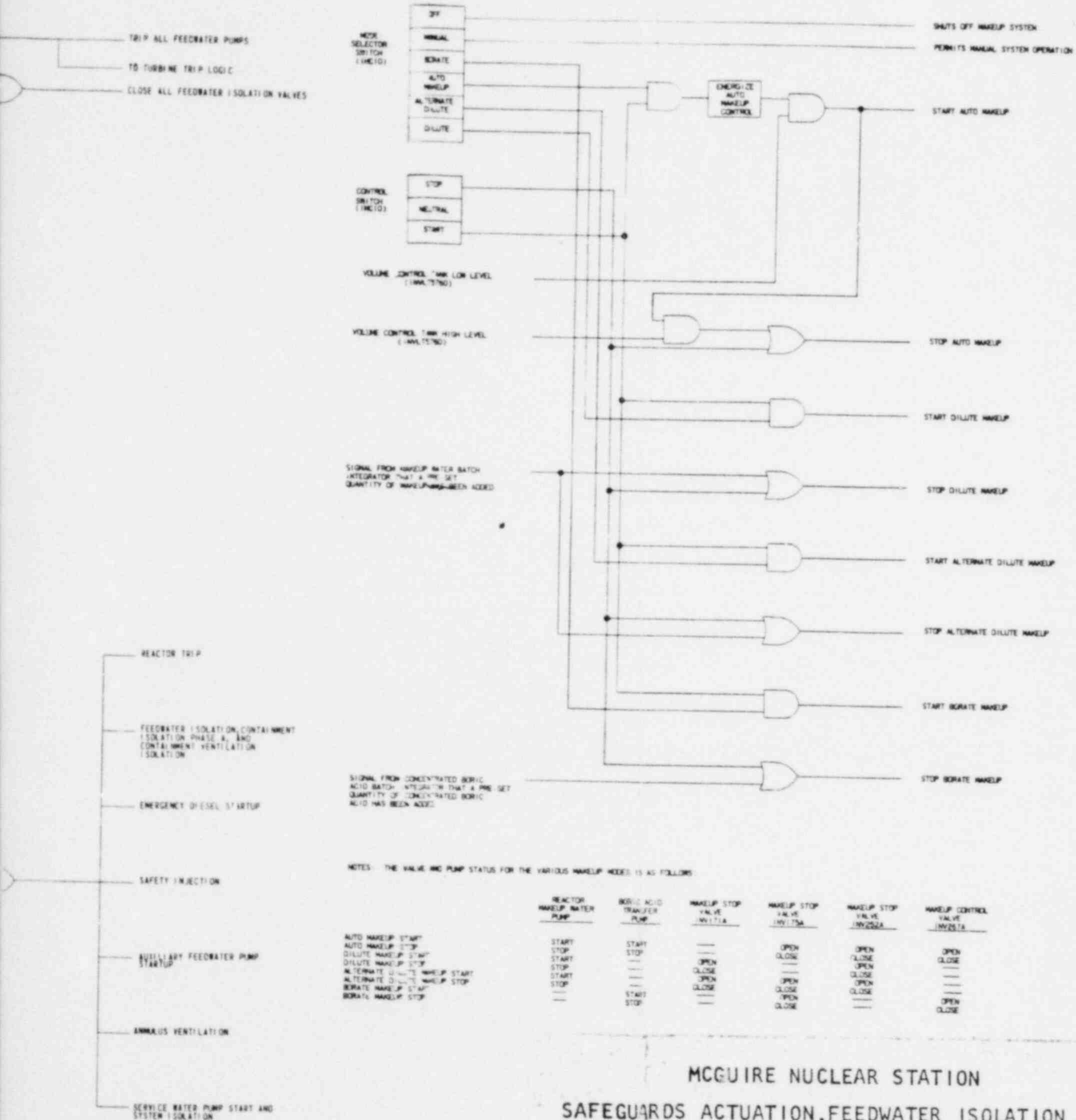
1. THE ABOVE LOGIC IS REDUNDANT
2. INSTRUMENTATION FOR THE 1/2 HI STEAMLINE FLOW LOGIC IS AS FOLLOWS:

LOOP	INSTRUMENTS
1	1SMFT5000, 5010
2	1SMFT5020, 5030
3	1SMFT5040, 5050
4	1SMFT5060, 5070

3. INSTRUMENTATION FOR THE 2/3 HI STEAMLINE DIFFERENTIAL PRESSURE LOGIC IS AS FOLLOWS:

LOOP	CHANNEL	CHANNEL 2	CHANNEL 3	CHANNEL 4
1	1SMPT5080	MPT5090	N/A	1SMPT5100
2	1SMPT5110	MPT5120	1SMPT5130	N/A
3	1SMPT5140	MPT5150	1SMPT 5160	N/A
4	1SMPT5170	MPT5180	N/A	1SMPT5190

SAFEGUARD ACTUATION LOGIC



NOTES: THE VALVE AND PUMP STATUS FOR THE VARIOUS MAKEUP MODES IS AS FOLLOWS:

	REACTOR MAKEUP WATER PUMP	BORIC ACID TRANSFER PUMP	MAKEUP STOP VALVE 1NV171A	MAKEUP STOP VALVE 1NV175A	MAKEUP STOP VALVE 1NV252A	MAKEUP CONTROL VALVE 1NV267A
AUTO MAKEUP START	START	START	—	OPEN	OPEN	OPEN
AUTO MAKEUP STOP	STOP	STOP	—	CLOSE	CLOSE	CLOSE
DILUTE MAKEUP START	START	—	OPEN	—	OPEN	—
DILUTE MAKEUP STOP	STOP	—	CLOSE	—	CLOSE	—
ALTERNATE DILUTE MAKEUP START	START	—	OPEN	OPEN	OPEN	—
ALTERNATE DILUTE MAKEUP STOP	STOP	—	CLOSE	CLOSE	CLOSE	—
BORATE MAKEUP START	—	START	—	OPEN	—	OPEN
BORATE MAKEUP STOP	—	STOP	—	CLOSE	—	CLOSE

MCGUIRE NUCLEAR STATION

SAFEGUARDS ACTUATION, FEEDWATER ISOLATION, AND MAKEUP CONTROL LOGIC

FIGURE 4 - 6

DUKE POWER COMPANY
MCGUIRE NUCLEAR STATION UNIT 1
SAFEGUARDS ACTUATION, FEEDWATER ISOLATION, AND MAKEUP CONTROL LOGIC

REVISIONS

5.0 DAMAGE EVALUATION

A damage evaluation has been performed for each of the breaks postulated by application of the criteria in Section 3.0.

5.1 Pipe Whip/Jet Impingement

The following describes the activities performed to determine acceptable and unacceptable damage caused by postulated high energy pipe breaks.

5.1.1 Break Criteria

Breaks are postulated according to the criteria given in Section 3.0.

5.1.2 Establish Plant Arrangement and Layout

The piping systems and other systems and equipment are arranged to provide maximum separation between piping subject to failure and those components requiring protection. Naturally other factors are considered, such as space limitations and fluid flowrate requirements. The combination of all layout considerations results in the final plant arrangement design.

5.1.3 Preliminary Interaction Matrices

Once all targets have been identified, an initial investigation is performed that evaluates the effects of potential interactions between source piping and targets. Due to the size of the plant and the complexity of the piping layouts, the plant is divided, for analysis purposes, into sections. The determinations of the size of each section is based upon the amount of piping located and physical barriers which provide separation. For example, a section may comprise the area of a mechanical penetration room.

A Preliminary Interaction Matrix is developed for each area defined. The matrix documents the results of the effects of pipe breaks within each area. Since this is a preliminary interaction analysis, discrete break locations are not postulated; instead, breaks are assumed to occur throughout an entire piping run. In addition, actual pipe whips and jets are not postulated. Instead, if targets are within close proximity to the broken piping, they are considered to be impacted by the source pipe. These occurrences are called unacceptable interactions.

5.1.4 Final Interaction Analysis

Following plant layout modification resulting from the preliminary interaction analysis, the final interaction analysis is performed. This analysis is based on investigating the actual pipe whip and jet effects due to breaks at discrete locations; i.e., terminal end and intermediate locations. The analysis of the terminal end breaks can be performed immediately following the layout modifications. The analysis of the intermediate breaks cannot be performed until the piping stress analysis is completed.

The results of the final interaction analysis are documented on Pipe Whip Interaction Matrices and Jet Impingement Interaction matrices. These matrices indicate if the targets are beyond the range of the whipping pipe and jet, or if an unacceptable interaction occurs. This determination is accomplished through the use of the pipe whip and jet models that are developed prior to performing the final interaction analysis. These models are based on the criteria established in FSAR Section 3.6.

The unacceptable interactions must be prevented in order to allow safe plant shutdown. The method of prevention depends upon the cause of interaction. Typically, pipe whip restraints are used to prevent unacceptable pipe whip interactions, while jet deflectors are used to prevent unacceptable jet interactions.

5.1.5 Pipe Whip Model

In order to determine the extent of pipe whip, several factors must be considered. These include location of plastic hinge, direction of pipe whip, and degree of pipe whip. Each item is described in the following paragraphs as they are postulated to exist for circumferential breaks only. Pipe whip is not expected to occur for longitudinal breaks.

A plastic hinge is considered to occur due to the jet thrust force from a circumferential pipe break. Calculations were performed on typical, unsupported piping runs to determine the approximate location of the hinge. These calculations indicate that the hinge locations would occur within a few feet of the break location.

The physical geometry of the piping runs, however, allowed the analysts to determine, based on force vector and moment arms, the probable locations of the plastic hinge. This typically occurs at the second elbow away from the break. Using this method, the hinge lengths were considerably longer than the calculated lengths. For conservatism, it was decided to use the geometrically determined hinge length because this would result in a larger sweeping of the whipping pipe and, thus, a larger area of potential interactions.

The direction of the pipe whip is also determined based on the geometric configuration of the pipe, and the resultant force vector and moment arm due to the pipe breaks. The pipe is assumed to move in the prescribed direction until it impacts another object (i.e., a target or structural interference) or it impacts the attached portion of its piping run. The pipe is assumed to whip in only one direction; and once it impacts another object or its own piping run, it is assumed to remain in that position.

5.1.6 Jet Model

The FSAR criteria of a 10° jet half angle is the basis for the jet model. This type of jet is postulated to emit from a circumferential rupture throughout the range of pipe whip. It is also postulated to emit from a longitudinal break as the pipe remains in the stationary position.

The jet is assumed to extend until it impacts either a target or structural interference. If the jet is partially obstructed, it is assumed to extend beyond the interference at the angle at the point of interference.

5.2 Cor. artment Pressurization

Compartment pressurization analyses were performed for breaks of the high energy lines outside containment containing pressurized gas, steam, or subcooled water that could flash. Turbine Building piping was considered uncapable of producing any unacceptable pressurization effects on safety class structures. The following lines and locations were considered:

1) Main Steam, Doghouse; 2) Feedwater, Doghouse; 3) Main Steam Supply to Auxiliary Equipment, Doghouse; 4) Blowdown Lines, Auxiliary Building; 5) Letdown Line, Auxiliary Building and; 6) Upper Head Injection, Auxiliary Building.

5.2.1 TMD Code - Short Term Analysis

The TMD Code was used to determine compartment pressures for main steam and feedwater breaks in the Doghouse. Flow rates and energy release rates were calculated using hand calculation methods based on Moody's two phase choked flow model [1,2]. See Section 5.2.2 for Auxiliary Building breaks.

5.2.1.1 General Description

The mathematical modeling in TMD (Transient Mass Distribution) is similar to that of the SATAN blowdown code in that the analytical solution is

1 F. J. Moody, "Maximum Flow Rate of a Single Component, Two--Phase Mixture," Journal of Heat Transfer, Trans, ASME, Series C, Vol. 86, February, 1965, p.134.

2 F. J. Moody, "Maximum Two--Phase Vessel Blowdown from Pipes," Journal of Heat Transfer, August, 1966, p. 285.

developed by considering the conservation equations of mass, momentum and energy and the equation of state, together with the control volume technique for simulating spatial variation. The governing equations for TMD are somewhat different in that a two phase (liquid water droplets and steam - air vapor) two component (air - water) system is considered.

The control volume technique is used to spatially represent the structure. The structure is nodalized into many compartments or elements to provide a detailed representation of the structure transient pressures on the internal concrete structures for the design basis pipe break. The structural elements are connected into a flow network with volumes, flow area, flow path length, flow resistance and initial conditions specified as input for all elements and flow paths available.

For control volume analysis, time dependent equations of conservation of mass, conservation of energy and state are evaluated. The boundary conditions for each control volume are provided by the adjacent one. Nothing is lost in the integration process by shrinking the control volumes as small as we please, thus a detailed spatial solution is possible. As a second step in spatial representation, the control volume in which momentum is conserved is displaced from the control volume in which mass and energy is conserved.

The air and steam in each control volume are assumed to be uniformly mixed throughout. Thermal equilibrium is assumed whereby the temperatures for these constituents are equal within each control volume. As a result of uniform mixed assumption, each constituent occupies the entire control volume. The total pressure is the sum of the partial pressures.

5.2.2 RELAP Code

The RELAP Code was used to determine pressurization effects for all Auxiliary Building high energy pipe breaks containing steam or flashing water (see Section 5.2.1 for Doghouse Breaks). Program RELAP4/MOD5 is a computer program for investigating the
3 transients expected in thermal-hydraulic systems. RELAP4/MOD5 was originally developed by W. H. Rittig, et al, at the Idaho Nuclear Corporation and provides a numerical method for analyzing the transient thermal-hydraulic behavior of pressurized water reactors, boiling water reactors, and experimental water reactor simulators.

3

RELAP4/MOD5 is a comprehensive program that predicts the interrelated effects of coolant thermal-hydraulics, system heat transfer, core neutronics, and system component interactions. Because the program was developed to solve a large variety of problems, the user must specify the program and system to be analyzed.

3 The fluid dynamics portion of the RELAP4/MOD5 program solves
the fluid mass, energy and flow equations for the system being
modeled. In order to provide a reasonable degree of versatility
3 in RELAP4/MOD5, a choice of the following basic forms of the flow
equation is provided:

a) Compressible single-stream flow with momentum flux.

b) Compressible two-stream flow with one-dimensional momentum mixing.

c) Incompressible single-stream flow without momentum flux.

The compressible two-stream flow equation has four forms to
represent different flow patterns of the streams. The fluid
3 system to be analyzed by RELAP4/MOD5 must be specified by the
user and is modeled by fluid volumes and junctions (flow paths) between volumes. Fluid volumes (control volumes) are used to represent the fluid in the system piping, plenums, reactor core, pressurizer and heat exchangers. Any fluid volume may be chosen independently to represent a region of the system associated with a heat sink or source, such as fuel rods or a heat exchanger. The fluid volumes are connected by junctions which are used to transfer fluid into and out of fluid volumes. Options are available for selecting pump, valve and bubble rise models.

3

A heat conductor model is used to transfer heat to or from the fluid in a fluid volume. The geometry and conditions of the heat conductor are specified by the user.

3 Several options are also available for describing heat exchangers.

3 RELAP4/MOD5 is the most recent of a series of computer programs developed at the Idaho National Engineering Laboratory to describe the thermal-hydraulic conditions attendant to various
3 postulated transients in light water reactor systems. RELAP4/MOD5 incorporates various improvements and modifications to previous versions which include:

1. A metal-heat conduction solution is available and the capability of describing both the primary and secondary flow systems with a "heat exchanger" heat conduction path connecting the two systems.
3 2. The RELAP4/MOD5 fluid conservation equations include approximations of all terms contained in the theoretical derivations for one-dimensional, homogeneous, thermal equilibrium flow. The solution to the conservation equations describing the flow of energy and momentum of the coolant has been extended to include the kinetic and potential energy terms and an optional one-dimensional momentum flux description of area and density changes. This modification to the solution of the conservation equations fundamentally allows description

of the incompressible Bernoulli effect as well as the compressible fluid flow phenomena. Additionally, flow choking can be calculated from these modified equations. The inclusion of the momentun flux and kinetic energy
3 terms makes the RELAP4/MOD5 conservation equations more general than the equations contained in previous versions and provides the program with the capability of predicting the hydrodynamic behavior of jet pumps.

3. An improved pump model is available which accounts for inertial and friction effects and allows the simulation according to homologous characteristics.
4. Steam tables that contain the derivatives of fluid properties.
5. An implicit integration technique is included. The implicit weighting factor can be modified to obtain a fully explicit calculation as well as the normal fully implicit calculation for the flow solution.
6. Flow models have been incorporated in RELAP4/MOD5 which allow the flow of any combination of air, steam and water.
3 This homogeneous equalibrium (HEM) flow model uses a perfect gas assumption for air.

5.2.3 Hand Calculations

Conservative hand calculations were performed for the Upper Head Injection System in the Auxiliary Building. This method assumes a constant isentropic choked flow into the compartment from the nitrogen source. After entering the compartment, the nitrogen flow is assumed to decelerate to stagnation conditions and mix with the air in the compartment. The mixing is assumed to occur at constant temperatures. The air-nitrogen mixture leaves the compartment through vent openings at subsonic velocities.

As long as the flow rate into the compartment exceeds the flow rate out of the compartment, the pressure will rise. When the flow into and out of the compartment is equal, the peak compartment pressure can be obtained.

5.3 Flooding Effects

All high energy and moderate energy systems have been reviewed to determine conservative maximum flooding levels in the Auxiliary Building. The Auxiliary Building doorways, stairwells, and floor drains are such that discharged fluids will drain into either the Auxiliary Feedwater Pump Room at Elevation 716 (see Figure 2-3, Rooms 10 and 53) or the Containment Spray and Residual Heat Removal Pump Rooms at Elevation 695 (see Figure 2-2). Pipe breaks in the Auxiliary Feedpump Room would be contained in the room. Breaks in all other areas containing fluid piping would eventually result in flow to the pump rooms at Elevation 695.

5.3.1 Discharge Rates

Discharge rates are based on Bernoulli's equation for non-flashing water and either Moody's two-phase choked flow model or Duke program SONVEL (reference FSAR Section 3.6.4.2) for steam and flashing water. All steam and steam/water mixtures were assumed to condense for the flooding analysis.

5.3.2 Moderate Energy Piping

All moderate energy systems are reviewed by system to determine maximum discharge rates from cracks. System fluid capacity is considered in determining the severity of each system's flooding potential.

5.3.3 High Energy Piping

Each high energy pipe break is reviewed to determine maximum discharge rates from the break. In addition, all piping or equipment (non-essential) that could be damaged by an unrestrained whipping pipe is considered failed and the resulting discharge of fluid considered.

5.4 Environmental Consequences

Environmental consequences as discussed in this report include the effects of water spray from all moderate energy piping and the temperature effects from all high and moderate energy piping containing steam or subcooled water that could flash to steam.

5.4.1 Water Spray

All moderate energy piping has been reviewed to determine if critical cracks could cause unacceptable damage to essential components. Several methods were used to eliminate unacceptable consequences: (1) relocate equipment, (2) reroute piping, (3) eliminate cracks in Class B, C or F piping by showing stresses are less than $0.4\ (1.2S_h + S_A)$, (4) upgrade equipment , (5) add spray shields.

5.4.2 Temperature Effects

All Auxiliary Building piping containing steam or subcooled water capable of flashing has been reviewed to determine peak temperatures due to postulated failures. The RELAP Code was used to calculate compartment temperatures in the Auxiliary

Building. This code is discussed in Section 5.2.2. The following lines were considered: (1) Steam Generator Blowdown, (2) Chemical and Volume Control, (3) Residual Heat Removal System, (4) Auxiliary Steam, (5) Boron Recycle System and (6) Liquid Waste Recycle System.

Temperature effects in the Doghouses were evaluated using the RELAP4/MOD5 code and considering a circumferential break within the guard pipe of the Main Steam (SM) system (See Figure 3-16). The SM break enveloped all other piping breaks in the Doghouse.

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6.0 SUMMARY AND CONCLUSIONS

In the following sections, the analysis of postulated high energy and moderate energy piping failures is summarized. These sections include the effects of the breaks and the plant modifications required to mitigate the effects.

6.1 Pipe Whip and Jet Impingement Effects

In accordance with the criteria and methods in Sections 4.0 and 5.0, Table 6-1 and Table 6-2 have been prepared to identify each high energy break considered in this analysis and to identify those breaks that result in unacceptable consequences. For those cases where unacceptable consequences occur, pipe whip restraints, jet impingement barriers, guard pipes or other mitigation devices are provided. The criteria used for design of these devices is presented in Appendix A.

6.1.1 Main Steam and Feedwater Systems

The Main Steam and Feedwater Systems have the greatest potential for damage from postulated pipe breaks. The pipe sizes, operating temperatures and pressures, and the large amount of stored energy require that these systems receive the most thorough review with respect to pipe rupture effects. Portions of the main steam and feedwater piping have been provided with guard pipe to limit pipe movement and restrict blowdown flow rates in the event of a process pipe failure inside the guard pipe. Main steam and feedwater piping drawings are shown in Figures 3.16 and 3.12 respectively.

Main steam breaks are chosen based on consequence as described in FSAR Table 3.6.5-1. Pipe whip restraints are provided for each postulated break to assure that essential structures and components are not damaged. Only circumferential breaks are postulated since the stress at all locations is less than 0.8 $(1.2S_h + S_A)$. It should be noted that the main steam and feedwater penetrations are free floating and do not constitute an anchor. Figure 6-1 shows the main steam system isometric drawings. Typical guard pipe to process pipe internal restraints are shown in Figure 6-2. Energy absorber and rigid pipe rupture restraints are shown in Figures 6-3 and Figure 6-4.

Feedwater break locations are chosen at those locations shown on Figure 3.12 based on high stress points; only circumferential breaks are postulated since the stresses are less than 0.8 $(1.2S_h + S_A)$ at all locations. Pipe rupture restraints are provided for all postulated feedwater breaks to assure that essential components and structures are not damaged.

6.1.2 Steam Generator Blowdown System

The high energy portion of the blowdown system consists of one blowdown line per steam generator entering the Auxiliary Building in the Elevation 716/733 penetration room and exiting to the Turbine Building (see figures 3.1 and 3.10). Only circumferential breaks are postulated since the piping is of seamless construction
3 and the stresses are less than 0.8 $(1.2S_h + S_A)$ at all locations*.

The pipe whip and jet impingement evaluation indicates that damage to several essential valves is possible for breaks

3 *In Section AB 716-07 only one intermediate break location is shown for 2 of the four lines because of the low stress levels.

3 BB1-01, -03. Pipe whip restraints will be provided to protect these valves.

6.1.3 Auxiliary Feedwater System

The high energy portion of this system consists of the Motor Driven Auxiliary Feedwater Pump 1A and 1B discharges
3 from the pumps at Elevation 716 (room 716-10 on Figure 203) to the main feedwater lines in the doghouse (rooms 750-23
3 and -26, Figure 205). The flow diagrammatic is shown in Figure 3.2 and the piping layout is shown on Figure 3.11 and 3.12. The Turbine Driven Pump is considered moderate energy since it will only be used for emergency or testing conditions. The stress levels in the system are less than 0.8. $(1.2S_h + S_A)$ and seamless piping is used. As a result, only circumferential breaks are postulated.

3 A review of the potential consequences resulting from pipe whip and jet impingement indicates pipe whip restraint and jet impingement barriers are required for postulated breaks CA1-51 and CA1-70A to protect essential electric equipment.

6.1.4 Safety Injection System (Upper Head)

The high energy portion of the Safety Injection System consists of the Upper Head Injection Accumulator Tanks and connecting piping. The flow diagrammatic is given in Figure 3.4, sheet 2 and the piping layout is shown on Figure 3.13. The stresses at all locations are less than 0.4 $(1.2S_h + S_A)$ and seamless piping is used; therefore, only circumferential terminal end breaks are
3 postulated.

The pipe whip and jet impingement evaluation of the UHI postu-
lated pipe breaks shows that no unacceptable damage to essential
3 components results for any of the postulated breaks. A rupture
restraint is provided for the 12" diameter line break at NI1-02
to prevent unacceptable interaction with the building column
at HH and 52.

6.1.5 Boron Thermal Regeneration System

The high energy portion of this system consist of the piping from the letdown line to the Letdown Reheat Heat Exchanger and back to the letdown line. This piping can be seen on the flow diagram on Figure 3.5 and on the piping drawing shown on
Figure 3.14. Only circumferential terminal end breaks were
postulated (at inlet and outlet of Letdown Reheat Heat Exchanger)
3 since terminal ends are flanged; these would cause no unaccep-
table damage to essential components. No intermediate breaks
were postulated since the stress levels are less than 0.4 (1.2
$S_h + S_A$).

6.1.6 Chemical and Volume Control System (CVCS)

The high energy portion of the CVCS System consists of the normal charging and sealwater injection lines and the letdown line. The flow diagrammatics for this system are shown in Figure 3.6 while the pipe routings are shown in Figure 3.15.

Circumferential breaks are postulated in the normal charging and sealwater lines only at terminal ends since the stresses are less than 0.4 ($1.2S_h + S_A$) at all locations. The pipe whip and jet impingement evaluation indicates that no damage to essential components would occur for these breaks.

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In the letdown line, breaks are postulated to occur at the
3 terminal ends and at the only two locations where stress levels in excess of 0.4 $(1.2S_h + S_A)$ occur.

Only circumferential breaks are postulated since the stress levels are less than 0.8 $(1.2S_h + S_A)$ at all locations. The pipe whip and jet impingement evaluation shows that damage to electrical cables, containment spray piping and/or nuclear service water piping is possible due to breaks NV1-07 and NV1-13. Pipe whip restraints will be provided to preclude this damage.

6.1.7 Main Steam Supply to Auxiliary Equipment - SA

The high energy portion of the SA System consists of the piping from main steam headers B and C to the normally closed piston operated valves. Figure 3.7 shows the flow diagrams for the system while Figure 3.16 shows the piping configuration. Circumferential pipe breaks are postulated at the terminal ends and at the highest stressed intermediate locations in the seamless
3 piping. All other stresses in the nigh energy portion are less than 0.4 $(1.2S_h + S_A)$. The pipe ship and jet evaluation indicate that no unacceptable damage would occur for these breaks.

6.2 Compartment Pressurization Effects

The only breaks outside containment that result in significant differential pressures are the main steam and feedwater systems which are located in the doghouse areas. Inside the Auxiliary Building, the venting through HVAC ducts, hallways and doors prevent excessive pressure differentials from occuring.

6.2.1 Main Steam and Feedwater

Main steam and feedwater breaks in the doghouse were reviewed for pressurization effects using the TMD Code (see Section

5.2.1 for description). Pressure time histories were calculated for Main Steam and Feedwater breaks. Figure 6-5 shows the doghouse model (see areas 23, 24, 25, and 26 on Figure 2-5 for location) used for all calculations. The doghouses vent directly to atmosphere. Table 6-4 provides the compartment volumes, flow paths, areas, loss coefficients, and blowdown data used in the analysis. The most severe peak pressure calculated was 5.83 psig for main steam breaks and 8.85 psig for feedwater breaks.

6.2.2 Upper Head Injection System

The Upper Head Injection Accumulator and piping are located in Rooms 750-01, -04, and -05 (see Figure 2-5 and Figure 3.13). Ruptures in the twelve inch piping would not cause unacceptable consequences.

3

Breaks N11-07 through N11-18 were reviewed using the methods described below. The most severe differential pressure was found to be 0.03 psig. This would not cause unacceptable consequences.

The differential pressures for Upper Head Injection System breaks were determined as follows.

The nitrogen in the accumulator and the air in the compartment are considered to be in thermal equilibrium initially, and the discharge process is conservatively assumed to produce an isothermal process in the nitrogen remaining in the tank.

The nitrogen flow from the accumulator into the compartment is assumed to be a constant isentropic choked flow:

$$W_1 = \frac{AP_o}{\sqrt{T_o}} \sqrt{\frac{kg}{R}\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

where W_1 = Flow rate, lbm/sec.

A = Pipe break flow area, in^2.

P_o = Reservoir pressure, psia.

T_o = Reservoir temperature, ^oR

k = Ratio of specific heats

R = Gas constant, ftlb/lbm ^oR.

g = Acceleration of gravity, ft/sec^2.

After entering the compartment, the nitrogen flow is assumed to decelerate to stagnation conditions and mix with the air in the compartment. The mixing is assumed to occur at constant temperature. The air-nitrogen mixture leaves the compartment through the vent openings normally at subsonic velocities and enters the atmosphere. The equation of flow thus is:

$$W_2 = CP_cA_c\sqrt{\left(\frac{2g}{RT_c}\right)\left(\frac{k}{K-1}\right)\left[\left(\frac{P_A}{P_c}\right)^{2/k} - \left(\frac{P_A}{P_c}\right)^{\frac{k+1}{k}}\right]}$$

where W_2 = Flow rate, lbm/sec.

P_c = Pressure in the compartment, psia.

A_c = Vent area of the compartment, in^2.

P_A = Atmospheric pressure, psia.

T_c = Temperature in the compartment, ^oR.

k,R,g = Same as previously defined.

C = Discharge coefficient (0.6).

As long as the flow rate into the compartment exceeds the flow rate out of the compartment, the pressure will rise. When the flow rate into and out of the compartment are equal, the peak compartment pressure will be attained. Therefore, setting $w_1 = w_2$:

$$\frac{AP_o}{T_o}\sqrt{\frac{kg}{R}\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}} = CP_cA_c\sqrt{\left(\frac{2g}{RT_c}\right)\left(\frac{k}{k+1}\right)\left[\left(\frac{P_A}{P_c}\right)^{2/k}-\left(\frac{P_A}{P_c}\right)^{\frac{k+1}{k}}\right]}$$

3 from which P_c can be obtained by iteration.

6.2.3 Blowdown System

The Blowdown System piping is shown in Figure 3.10. All postulated break locations are located in Volume 716-07 (see Figure 2-3). The differential pressures were calculated using the RELAP Code as described in Section 5.2.2. The most severe differential
1 pressure was found to be 0.27 psig, at a time of 2.2 sec. This condition would not result in unacceptable consequences.

6.2.4 Letdown Line, CVCS System

The letdown line is shown on Figure 3.15, sheets 3, 5, and 6. The letdown flow is restricted by a 0.272" diameter flow orifice inside containment (see Figure 3.6, sheet 3). Differential pressures calculated from the RELAP Code are negligible.

6.3 Flooding Effects

The review of flooding effects from postulated piping failures includes moderate energy and high energy systems. As discussed in Section 5.3, fluid discharged in the Auxiliary Building would eventually drain to
3 either elevation 695 or to the Auxiliary Feedwater Pump rooms, depending on the location of the break. The doghouse has been sealed to prevent fluid from a main steam or feedwater break from draining to the Auxiliary Feedwater Pump rooms. Curbs are provided around passageways to the Auxiliary.

Building from the Turbine Building. These curbs are of adequate height to contain flood water caused by the break of the main condenser circulating water expansion joint, or the most severe Condensate System failure for a minimum of fifteen minutes. There are no pipe or cable chase entrances below the elevation of the top of the curbs. This flooding condition does not render any essential system or component inoperable.

6.3.1 Auxiliary Feedwater Pump Room

The most severe pipe rupture discharging into the Auxiliary Feedwater Pump Room (Room 716-10, Figure 2-3) is a break at the discharge nozzle of one of the Auxiliary Feedwater Pumps. This flow would be 700 gpm with a flooding capacity of 30,000 gal. in the room. Detection of such a break or similar break would be from the redundant, high sump level alarms in the control room. No damage to essential components would occur, assuming operator action after thirty minutes.

6.3.2 Containment Spray/Residual Heat Removal Pump Rooms

A review of all postulated failures in the remainder of the Auxiliary Building indicates that the most severe discharge rate is due to a critical crack in the 36" nuclear service water piping. This flow of 1335. gpm would accumulate in the pump rooms and hall at Elevation 695 (See figure 2-2, rooms 1, 2, 3, 4, 8, 9, 10, 11, 12, 13, and 17). A capacity of 80,000 gallons in these rooms is adequate assuming operator action after 30 minutes. Detection of such a break or similar break would be from the redundant high sump level alarms in the control room.

1 6.4 Environmental Consequences

6.4.1 Water Spray

Most essential components are sealed against the adverse effects of water spray. Those components which cannot be sealed were identified and all high and moderate energy systems in the Auxiliary Building were reviewed to determine water spray effects. Those essential components that could be sprayed
3 and are not sealed are identified in Table 6-3.

6.4.2 Temperature Effects

High energy lines identified in Table 6-5 are evaluated for direct results of jet impingement and for all adverse environmental effects
1 (pressure and temperature). Moderate energy lines identified in Table 6-5 are evaluated for water spray and temperature effects.
3 A relative humidity of 100% is assumed to result from any high or flashing moderate energy pipe break.

A matrix of lines, line breaks and safety-related equipment within Auxiliary Building compartments was developed and the pipe breaks
1 determined in accordance with Section 3.0. Flow rates and enthalpy release rates for each break were calculated using either the
3 RELAP4/MOD5 code or by hand calculation using the Moody two-phase
1 choked flow model. Non-restricted, frictionless blowdown was assumed in all break cases except for the BB System breaks where

two-phase choked flow model. Non-restricted, frictionless blowdown was assumed in all break cases except for the BB system breaks where

3 restrictions for friction and equipment were accounted for. Table 6-5 provides a list of the system line breaks, break types, initial line conditions and mass and energy release rates of the breaks under consideration.

A preliminary enveloping was performed for all break cases
1 identified in Table 6-5 by estimating the maximum temperatures expected, either local to the rupture or throughout the build-
3 ing. Detailed RELAP4/MOD5 computer models were built for each floor of the Auxiliary Building using as many as 50 volumes
1 and 100 connecting flow paths. The regions in the vicinity where the pipe break was postulated were extensively nodalized while the
3 more distant regions, including the upper and lower floors, were modeled with less detail. All portals, stairways, pipe chases and HVAC equipment were modeled as flow paths in addition to
1 doorways and corridors.

The break flow was introduced as a fill into the appropriate volume housing the broken piping and the temperature of each
3 volume in the model, as calculated by the RELAP4/MOD5 computer code, was analyzed for environmental consequences. Through the use of enveloping runs, the entire series of over 55 individual break cases was reduced to a set of breaks causing the worst case environmental responses. The peak node temperature which occurs anywhere within the first 30 minutes following pipe rupture
1 is considered as the criteria for defining the worst case or enveloping environmental temperature. The equipment design temperature was then compared to the worst environmental temperature

due to the break cases analyzed. Enveloping was performed for the environmental response only and all individual break
1 cases were considered for jet impingement or water spray effects.

6.4.2.1 Auxiliary Building Environmental Analysis Assumptions

The following assumptions were made for all analyses:

1. Initial Auxiliary Building compartment pressures and temperatures were assumed to be 14.7 psia and
3 70°F.

2. All lines were assumed to be at their maximum normal operating pressures and temperatures.

3. All blowdown mass and energy release rates were based on unrestricted and frictionless blowdown
1 except for the Steam Generator Blowdown System (BB). The mass and energy release rates for the BB System include restrictions for friction and mechanical equipment in the piping system.

4. All doors were assumed to be closed. Communications
3 between floors occurs only via open HVAC ducts, spiral stairways, and through gratings along the containment penetration areas.

5. Through the use of temperature activated HVAC dampers and sealed portals, all connections between the
1 regions where pipe ruptures occur and the Battery Rooms (areas along columns AA to EE in El. 733'), the Control Room (areas between columns AA to EE in El. 767'), the HVAC equipment room (areas between columns DD to GG in El. 767') and also, areas along columns AA to EE in
3 El. 750 and El. 716 are isolated.

3 from pipe rupture effects.

6. The YH line has a fluid boiling point temperature
1 of 240°F and the fluid will not flash to steam in
the case of a pipe rupture. This line is, therefore, reviewed only for water spray effects.

3 7. Initial doghouse pressure and temperature were
assumed to be 14.7 psia and 135°F.

6.4.2.2 Auxiliary Building Environmental Analysis Results

1 #### 6.4.2.2.1 Auxiliary Steam Line

A crack was postulated in the 2" Auxiliary
3 Steam line in the southwest corner (region
along columns 51-52, PP-NN on El. 750',
Figure 6-6)of the Auxiliary Building. Line
fluid conditions of 65 psia and 298°F were
1 used for this analysis.

No significant environmental effects will
occur due to the low mass and energy release
rates (90.6 BTU/sec. and 0.077 lbm/sec.)
calculated for this break.

3 Because the crack was postulated in an open
area, the temperature rise will be so slow
1 that the environmental effects produced by this
crack are enveloped by the NV and ND line breaks
on this floor. Thus, a detailed analysis was
3 not performed on this break.

1 #### 6.4.2.2.2 Steam Generator Blowdown (BB)

Design basis circumferential breaks were postu-
3 lated in the 2" and 4" BB

3 lines along the Unit 1 and 2 penetrations
between El. 716' and El. 733' (see
Figure 3.10). The 4" line was analyzed
due to the fact that its higher mass and
energy release rates envelop the 2" lines.
This line has an initial temperature and
pressure of 557°F and 1107 psia. Due to
the friction and high upstream restrictions,
the blowdown flow rate was calculated to be
287 lbm/sec during the first 1.95 sec. of
the break transient. After 1.95 seconds,
the blowdown would stay at a constant
rate of 75 lbm/sec. The energy release
1 followed the same pattern with a value of
5.9×10^5 BTU/sec for the first 1.95 seconds
and 42.3×10^3 BTU/sec thereafter.
Typical environmental temperature response
curves for this break are provided in Figure
6-7 which illustrates the environmental
response to the changing blowdown energy
release rates. Following a postulated
design basis break in the penetration area,
the whole penetration area and the pipe
shafts heat up rapidly, reaching a peak tem-
perature of 212°F. The steam soon propagates
3 to the lower level (El. 716') through the gratings

around the penetration area, causing regions on that floor to heat up to a peak of 212°F in 30 minutes.

6.4.2.2.3 Boron Recycle System (NB)

A crack was postulated in the 6" line (Auxiliary Steam Supply) in the boron
1 recycle unit room (between columns 56-57, NN-PP) at El. 710'. This line has an initial operating temperature and pressure of 298°F and 65 psia, and the blowdown rate was calculated to be 0.75 lbm/sec.

No significant environmental effects will occur. The temperature of the room in which
3 the crack is postulated rises very slowly (7° in 2 minutes) due to the small blowdown rate. The hot mixture vents through a small opening to the rest of the building' thus,
1 no rise in temperature will be observed in other regions. The room contains no essential equipment. It is concluded that this crack is enveloped by other breaks on this floor and no adverse results occur.

3

6.4.2.2.4 Residual Heat Removal (ND)

1 Cracks were postulated to occur in the RHR lines at their maximum normal operating

condition of 350°F and 365 psia. The cracks were assumed to occur in various locations in the 3", 8", 14" and the 18" piping. A total of 16 cracks were considered. Successive enveloping of the cracks reduced them to three cases with severe
1 environmental effects capability.

6.4.2.2.4a <u>Residual Heat Removal Pump Room</u>

Cracks were postulated to occur in the 8" RHR lines in the residual heat removal pump room at El. 695 (see Fig. 2-2-areas 1,2, 10,11). The floor reaches a maximum temperature of 212° in 30 minutes. The heated air/ steam mixture soon fills the floor and propa-
3 gates to higher levels through the spiral staircase.

6.4.2.2.4b <u>Pipe Chase at El. 695'</u>

1 A crack postulated in the 18" ND line in the pipe chase at El. 695' (see Fig. 2-2-areas 5,6, 14,15) causes the break node to heat up to 212°F.

3

The air/steam mixture propagates into the other regions in El. 695', mainly through the HVAC ducts. The mixture also vents to El. 716 through pipe shafts

The heated air/steam mixture also vents to the central regions of El. 716' through HVAC ducts and El. 733' through the gratings around the penetration area,

6.4.2.2.4c <u>Residual Heat Removal Heat Exchanger Room</u>

A postulated crack in the 8" RHR pipe in the heat exchanger room (see Fig. 2-5-areas 2,3,28, 29) causes the room temperature to rise to 212°F in 30 minutes. The only communication between this room and the rest of the building is through a wire gate at El. 750'. Due to the fact that regions on this floor are quite open and have comparatively few restrictions, the air/steam mixture soon propagates freely throughout the floor and establishes regional temperatures around the vicinity of the heat exchanger room between 132°F and 212°F in 30 minutes. Temperatures on Elevation 767 reach 130°F within 30 minutes.

6.4.2.2.5 Chemical and Volume Control (NV)

Based on break enveloping, two 3"NV line break cases in the Letdown Line were analyzed to determine environmental effects. The NV line breaks were postulated to occur at their maximum normal operating condition of 350°F and 365 psia. The postulated breaks considered are located in the Mechanical penetration areas at El. 750' (see fig. 2-5-areas 1 and 2).

3 These breaks produced localized temperature effects due to upstream restrictions. The temperatures in the areas reached 132°F within 30 minutes with the rest of El. 750' being enveloped by ND breaks in the RHR Heat Exchanger Rooms.

6.4.2.2.6 Liquid Waste Recycle (WL)

1 Two cracks were postulated to occur in the 4" WL line (Auxiliary Steam supply) at El. 710' (room between columns LL-KK, 60-61,

Figure 6-6). This line has a blowdown con-
dition of 298°F and 65 psia and is enveloped
1 by the ND break for environmental effects.
No computer simulation was performed for
this line.

6.4.2.3. <u>Doghouse Environmental Analysis Results</u>

A circumferential break was postulated
within the guard pipe of the SM line inside
the Doghouse. Saturated steam conditions at
1107 psia were used for the analysis.
A peak temperature of 330°F was obtained
3 seconds after the break initiation due to the
large mass and energy release (4655 lb/sec
and 5.5×10^6 BTU/sec, respsectively) and
relatively small Doghouse volume. The steam
environment propagates directly to atmosphere
through large vents located in the upper
portion of the structure.

6.4.2.4 <u>Temperature Effects Due to Jet Impingement & Water Spray</u>

Jet impingement and/or water spray effects were eva-
luated for each of over 55 individual pipe rupture
locations identified in Table 6-5. Break case enve-
1 loping, which was performed for the Auxiliary Building
Environmental Analysis, was not permitted for the jet
impingement/water spray analysis.

Targets were chosen by the construction of a jet cone

with a 10° half angle from each circumferential or crack
break. Minor jet obstructions such as HVAC ducting or
mechanical equipment were not considered to be barriers
1 in the target selection and only permanent partitions
and structures were taken to be jet barriers. In some
regions (notably, elevation 695') where the compartments
are very small, the structural barriers themselves were
3 assumed to act as jet deflectors, directing the water spray
into the target, thus creating additional targets.
1 Target impingement temperatures were conservatively set
at the stagnation temperature of the source piping.

6.4.2.5 <u>Evaluation of Consequences</u>

3 All essential equipment affected by these temperature
effects (both environmental and water spray) are re-
viewed to assure that equipment qualification tempera-
tures are not exceeded. The worst case environmental
temperatures within the first 30 minutes for the Auxiliary
3 Building compartment due to breaks on both the Unit 1
and Unit 2 sides are summarized in Figure 6-6.

TABLE 6-1

HIGH ENERGY PIPE BREAK LOCATION

Break Number	System	Description	Fig. No.	Location	Stress Ratio to Allowable (1)
BB1-01	Steam Gen. Blowdown Recycle Sys.	4" BB Blowdown "1A" T.E. @ M-300	3.10 Sheet 3 of 4	AB-716-07	Terminal End Break
BB1-02	Steam Gen. Blowdown Recycle Sys.	4" BB Blowdown "1B" T.E. @ M-301	3.10 Sheet 3 of 4	AB-733-06	Terminal End Break
BB1-03	Steam Gen. Blowdown Recycle Sys.	4" BB Blowdown "1C" T.E. @ M-303	3.10 Sheet 3 of 4	AB-733-06	Terminal End Break
BB1-04	Steam Gen. Blowdown Recycle Sys.	4" BB Blowdown "1D" T.E. @ M-304	3.10 Sheet 3 of 4	AB-716-07	Terminal End Break
BB1-36B	Steam Gen. Blowdown Recycle Sys.	2" Intermediate break @ inlet of 2nd tee downstream of valve 1BB3B	3.10 Sheet 3 of 4	AB-733-06	0.56
BB1-27B	Steam Gen. Blowdown Recycle Sys.	2" Intermediate break @ 1st standard elbow downstream of M-301	3.10 Sheet 3 of 4	AB-733-06	0.57
BB1-28	Steam Gen. Blowdown Recycle Sys.	2" Intermediate break @ outlet of 1st tee downstream of valve 1BB32	3.10 Sheet 4 of 4	AB-733-13	0.64
BB1-35	Steam Gen. Blowdown Recycle Sys.	2" Intermediate break @ outlet of 1st tee downstream of valve 1BB29	3.10 Sheet 4 of 4	AB-733-13	0.80

(1) Ratio = Stress, $S/(0.8\ (1.2S_h + S_A))$; intermediate breaks only

Table 6-1 2 of 15

(Deleted)

TABLE 6-1

HIGH ENERGY PIPE BREAK LOCATION

BREAK NO.	SYSTEM	DESCRIPTION	FIG. NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
CAI-43A	Auxiliary Feedwater	Inlet of elbow downstream of valve 1CF135A	3.11A	AB-750-23	0.836
CAI-43B	Auxiliary Feedwater	Outlet of elbow downstream of valve 1CF135A	3.11A	AB-750-23	0.882
CAI-76A	Auxiliary Feedwater	At inlet of elbow upstream of valve 1CF156	3.11 Sheet 7 of 8	AB-750-23	0.733
CAI-51	Auxiliary Feedwater	At 4" x 2" half coupling downstream of valve 1CF136A	3.11 Sheet 5 of 8	AB-750-23	0.784
CAI-50	Auxiliary Feedwater	At 6" takeoff from 18" CF line between valves 1CF119 and 1CF28	3.11 Sheet 5 of 8	AB-750-23	Terminal End Break
CAI-87	Auxiliary Feedwater	Terminal end at 6" takeoff from 16" x 16" x 6" tee between the valves 1CF30 and 1CF120	3.11 Sheet 5 of 8	AB-750-23	Terminal End Break
CAI-96	Auxiliary Feedwater	Terminal end at 6" takeoff from 18" x 18" x 6" tee downstream of valve 1CF135A	3.11 Sheet 5 of 8	AB-750-23	Terminal End Break
CAI-62	Auxiliary Feedwater	Terminal end at 6" takeoff from 18" x 18" x 6" tee downstream of valve 1CF136A	3.11 Sheet 5 of 8	AB-750-23	Terminal End Break

(1) Ratio = Stress, S/[0.8(1.2 Sh + SA)]; intermediate breaks only.

(2) Stress is less than 0.4(1.2 Sh + SA).

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HIGH ENERGY PIPE BREAK LOCATION

BREAK NO.	SYSTEM	DESCRIPTION	FIG. NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
CAI-113	Auxiliary Feedwater	Terminal end at motor driven FDW pump 1A discharge	3.11 Sheet 6 of 8	AB-716-10	Terminal End Break
CAI-126	Auxiliary Feedwater	Terminal end at motor driven FDW pump 1B discharge	3.11 Sheet 6 of 8	AB-716-10	Terminal End Break
CAI-70A	Auxiliary Feedwater	Intermediate break at inlet of elbow downstream of valve 1CF158	3.11 Sheet 8 of 8	AB-750-26	0.966
CAI-70B	Auxiliary Feedwater	Intermediate break at outlet of elbow downstream of valve 1CF158	3.11 Sheet 8 of 8	AB-750-26	0.990
CAI-110	Auxiliary Feedwater	Terminal end at 6" takeoff from 18" CF line upstream of valve 1CF160	3.11 Sheet 4 of 8	AB-750-26	Terminal End Break
CAI-120	Auxiliary Feedwater	Terminal end at 6" takeoff from 16" x 16" x 6" tee downstream of valve 1CF134A	3.11 Sheet 4 of 8	AB-750-26	Terminal End Break
CAI-109	Auxiliary Feedwater	Terminal end at 6" takeoff from 18" CF line upstream of valve 1CF163	3.11 Sheet 4 of 8	AB-750-26	Terminal End Break
CAI-150	Auxiliary Feedwater	Terminal end at 6" takeoff from 16" x 16" x 6" tee downstream of valve 1CF137A	3.11 Sheet 4 of 8	AB-750-26	Terminal End Break

(1) Ratio = Stress, $S/[0.8(1.2\ Sh + SA)]$; intermediate breaks only.

(2) Stress is less than $0.4(1.2\ Sh + SA)$.

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3

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
CF1-01	Feedwater	@ Inlet of first elbow before penet. M-262	Fig. 3.12 Sht. 1 of 6	AB-750-23	0.519
CF1-02	Feedwater	@ Outlet of first elbow before penet. M-262	Fig. 3.12 Sht. 1 of 6	AB-750-23	0.465
CF1-03	Feedwater	@ Inlet of first elbow before pene. M-308	Fig. 3.12 Sht. 1 of 6	AB-750-23	0.630
CF1-04	Feedwater	@ Outlet of first elbow before penet. M-308	Fig. 3.12 Sht. 1 of 6	AB-750-23	0.474
CF1-05	Feedwater	@ Inlet of first elbow before penet. M-153	Fig. 3.12 Sht. 1 of 6	AB-750-26	0.431
CF1-06	Feedwater	@ Outlet of first elbow before penet. M-153	Fig. 3.12 Sht. 1 of 6	AB-750-26	0.411
CF1-07	Feedwater	@ Inlet of first elbow before penet. M-440	Fig. 3.12 Sht. 1 of 6	AB-750-26	0.511
CF1-08	Feedwater	@ Outlet of first elbow before penet. M-440	Fig. 3.12 Sht. 1 of 6	AB-750-26	0.456

(1) Ratio = Stress, S/ (0.8 $(1.2S_h + S_A)$); intermediate breaks only

(2) Stresses at all locations in the piping run are less than 0.4 $(1.2S_h + S_A)$.

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

	BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
	CF1-09	Feedwater	18" CF to steam generator 1A @ feedwater header	See Turbine Building	TB-739	Terminal End Break
	CF1-10	Feedwater	18" CF to steam generator 1B @ feedwater header	See Turbine Building	TB-739	Terminal End Break
3	CF1-11	Feedwater	18" CF to steam generator 1C@ feedwater header	See Turbine Building	TB-739	Terminal End
	CF1-12	Feedwater	18" CF to steam generator 1D @ feedwater header	See Turbine Building	TB-739	Terminal End

(1) Ratio = Stress, $S/(0.8\ (1.2S_h + S_A))$; intermediate breaks only

(2) Stresses at all locations in the piping run are less than $0.4\ (1.2S_h + S_A)$

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
NI1-01	Safety Injection	12" NI-T.E. Brk. @ upper head injection nitrogen accumulator	3.13	AB-750-01	Terminal End Break (2)
NI1-02	Safety Injection	12" NI-T.E. Brk. @ Penet. M-334	3.13	AB-750-01	Terminal End Break (2)
NI1-03	Safety Injection	12" NI-T.E. Brk. @ Penet. M-349	3.13	AB-750-01	Terminal End Break (2)
NI1-04	Safety Injection	12" NI- From UHI nitrogen accumulator to water accumulator, T.E. Brk. @ upper head inj. water accum.	3.13	AB-750-05	Terminal End Break (2)
NI1-05	Safety Injection	12" NI-To Valve 1NI244B. T.E. Brk. @ upper Head Inj. water accumulator.	3.13	AB-750-05	Terminal End Break (2)
NI1-06	Safety Injection	12" NI-To Valve 1NI242B. T.E. Brk. @ upper head inj water accumulator.	3.13	AB-750-05	Teminal End Break (2)
NI1-07	Safety Injection	1½"NI-To Vlv. 1NI326. T.E. brk @ water accumulator.	3.13	AB-750-05	Terminal End Break (2)

(1) Ratio = Stress, S/ (0.8 $(1.2S_h + S_A)$); intermediate breaks only.

(2) Stresses at all locations in the piping run are less than 0.4 $(1.2S_h + S_A)$.

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE(1)
NI1-12	Safety Injection	2" NI To valve 1NI320. T.E. Brk. @ Upper Head Inj. Water Accumulator	3.13	AB-750-05	Terminal End Break (2)
NI1-13	Safety Injection	2" NI To valve 1NI314 T.E. Brk. @ Water Accumu.	3.13	AB-750-05	Terminal End Break (2)

1. Ratio = Stress, S/ (0.8 ($1.2S_h + S_A$)); intermediate breaks only.

2. Stresses at all locations in the piping run are less than 0.4 ($1.2S_h + S_A$).

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
NI1-16	Safety Injection	$1\frac{1}{2}$" NI To valve 1NI280. T.E. Brk. @ Nitrogen Accumulator.	3.13	AB-750-01	Terminal End Break (2)
NI1-17	Safety Injection	2" NI To valve 1NI255B. T.E. Brk. @ 12" NI Line	3.13	AB-750-05	Terminal End Break (2)
NI1-18	Safety Injection	$1\frac{1}{2}$" To valve 1NI279. T.E. brk. @ Water Accumulator.	3.13	AB-750-05	Terminal End Break (2)

(1) Ratio = Stress, S/ $(0.8\ (1.2S_h + S_A))$; intermediate breaks only.

(2) Stresses at all locations in the piping run are less than $0.4\ (1.2S_h + S_A)$.

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
NR1-01	Boron Thermal Regeneration Sys.	4" NR to letdown reheat H.X.-T.E. Brk. @ Inlet of Letdown Reheat H.X.	3.14	AB-750-16	Terminal End Break (2)
NR1-02	Boron Thermal Regeneration Sys.	4" NR To letdown reheat H.X.-T.E. Brk. @ Outlet of letdown reheat H.X.	3.14	AB-750-16	Terminal End Break (2)

(1) Ratio = Stress, S/ $(0.8\ (1.2S_h + S_A))$; intermediate breaks only.

(2) Stresses at all locations in the piping run are less than $0.4\ (1.2S_h + S_A)$.

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
NV1-01	Chemical and Volume Control	3"NV -Letdown H.X. T.E. @ Inlet of Letdown H.X.	Fig. 3.15 Sht. 9 of 9	AB-750-17	Terminal End Break
NV1-02	Chemical and Volume Control	3" NV-From Letdown H.X., Outlet of Letdown H.X.	Fig. 3.15 Sht. 9 of 9	AB-750-17	Terminal End Break
NV1-03	Chemical and Volume Control	3" NV-To Regenerative H.X. T.E. Brk. @ Penet. M-329	Fig. 3.15 Sht. 2 of 9	AB-716-06	Terminal End Break
NV1-04	Chemical and Volume Control	T.E. Brk. @ Discharge of Reciprocating Charging Pmp	Fig. 3.15 Sht. 8 of 9	AB-716-01	Terminal End Break (2)
NV1-05	Chemical and Volume Control	4" NV To Cent. Charging Pump "1A". T.E. @ Cent. Chg. Pump 1A Disch. Nozzle	Fig. 3.15 Sht. 2 of 9	AB-716-02	Terminal En Break (2)
NV1-06	Chemical and Volume Control	T.E. Brk. @ the Cent. Chg. Pump "1B". Discharge Nozzle	Fig. 3.15 Sht. 2 of 9	AB-716-03	Terminal End Break (2)
NV1-07	Chemical and Volume Control	3" NV to Letdown H.X. T.E Brk. @ M-347	Fig. 3.15 Sht. 6 of 9	AB-750-01	Terminal End Break
NV1-08	Chemical and Volume Control	T.E. Brk. @ Outlet of seal-water Inj. Filter 1B	Fig. 3.15 Sheet 4 of 9	AB-733-11	Terminal End Break (2)

(1) Ratio = Stress, S/ $(0.8\ (1.2S_h + S_A))$; intermediate breaks only.

(2) Stresses at all locations in the piping run are less than $0.4\ (1.2S_h + S_A)$.

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
NVI-09	Chemical and Volume Control	T.E. Brk. @ Inlet of seal-water Inj. Filter "IA."	Fig. 3.15 Sht. 4 of 9	AB-733-10	Terminal End Break (2)
NVI-10	Chemical and Volume Control	T.E. Brk. @ Outlet of seal-water Inj. Filter "IA."	Fig. 3.15 Sht. 4 of 9	AB-733-10	Terminal End Break (2)
NVI-11	Chemical and Volume Control	T.E. Brk. @ Inlet of Seal-water Inj. Filter "IB."	Fig. 3.15 Sht. 4 of 9	AB-733-11	Terminal End Break (2)
NVI-12	Chemical and Volume Control	Int. Brk. in 3" NV to Letdown Reheat H.X.	Fig. 3.15 Sht. 3 of 9	AB-750-17	0.5032
NVI-13	Chemical and Volume Control	T.E. Brk. @ Penetration M-339 4" dia.	Fig. 3.15 Sht. 5 of 9	AB-733-7	Terminal End Break (2)
NVI-14	Chemical and Volume Control	T.E. Brk. @ Penetration M-344 4" dia.	Fig. 3.15 Sht. 5 of 9	AB-733-7	Terminal End Break (2)
NVI-15	Chemical and Volume Control	T.E. Brk. @ Penetration M-343 4" dia.	Fig. 3.15 Sht. 2 of 9	AB-733-7	Terminal End Break (2)
NVI-16	Chemical and Volume Control	T.E. Brk. @ Penetration M-350 4" dia.	Fig. 3.15 Sht. 2 of 9	AB-733-7	Terminal End Break (2)

2

(1) Ratio = Stress, S/ $(0.8\ (1.2S_h + S_A))$; intermediate breaks only.

(2) Stresses at all locations in the piping run are less than $0.4\ (1.2S_h + S_A)$.

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
SA1-01	Main Steam Supply to Aux. Equip.	6" SA To CA Turbine T.E.brk @SM Line 1B	Fig. 3.16 Sht. 3 of 3	AB-750-23	Terminal End Break
SA1-02	Main Steam Supply to Aux. Equip.	6" SA To CA Turbine T.E. Brk. @ SM Line 1C	Fig. 3.16 Sht. 3 of 3	AB-750-23	Terminal End Break
SA1-03	Main Steam Supply to Aux. Equip.	6" SA Int. Brk. @ Inlet of valve 1SA48	Fig. 3.16 Sht. 3 of 3	AB-750-23	0.5543

(1) Ratio = Stress, S/ (0.8 ($1.2S_h + S_A$)); intermediate breaks only.

(2) Stresses at all locations in the piping run are less than 0.4 ($1.2S_h + S_A$)

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE (1)
SMI-01	Main Steam	Inter. Brk. @ Inlet 1st (SM) elbow downstream of M-261	Fig. 3.16 Sht. 1 of 3	AB-750-23	0.3258
SMI-02	Main Steam	Inter. Brk. @ outlet 1st (SM) elbow downstream of M-261	Fig. 3.16 Sht. 1 of 3	AB-750-23	0.365
SMI-03	Main Steam	Inter. Brk. @ Inlet 1st (SM) elbow downstream of M-393	Fig. 3.16 Sht. 1 of 3	AB-750-23	0.493
SMI-04	Main Steam	Inter. Brk. @ Outlet 1st (SM) elbow downstream of M-393	Fig. 3.16 Sht. 1 of 3	AB-750-23	0.520
SMI-05	Main Steam	Inter. Brk. @ Inlet of 1st (SM) elbow downstream of M-154	Fig. 3.16 Sht. 1 of 3	AB-750-26	0.323
SMI-06	Main Steam	Inter. Brk. @ Outlet 1st (SM) elbow downstream of M-154	Fig. 3.16 Sheet 1 of 3	AB-750-26	0.362
SMI-07	Main Steam	Inter. Brk. @ Inlet of 1st (SM) elbow downstream M-441.	Fig. 3.16 Sht. 1 of 3	AB-750-26	0.486

(1) Ratio = Stress, S/ $(0.8 (1.2S_h + S_A))$; intermediate breaks only.

(2) Stresses at all locations in the piping run are less than $0.4 (1.2S_h + S_A)$

TABLE 6-1
HIGH ENERGY PIPE BREAK LOCATIONS

BREAK NUMBER	SYSTEM	DESCRIPTION	FIGURE NO.	LOCATION	STRESS RATIO TO ALLOWABLE(1)
SMI-08	Main Steam	Inter. Brk. @ Outlet of 1st (SM) elbow downstream of M-441.	Fig. 3.16 Sht. 1 of 3	AB-750-26	0.510
SMI-09	Main Steam	34" (SM) 1A @ High Pressure Turbine T.E. @ Inlet of H.P. Turbine	Turbine Bldg.	TB-786	Terminal End Break
SMI-10	Main Steam	34" (SM) 1B @ High Pressure Turbine T.E. Brk. @ Inlet of H.P. Turbine	Turbine Bldg.	TB-786	Terminal End Break
SMI-11	Main Steam	34" (SM) 1C @ High Pressure Turbine. T.E. Brk. @ Inlet of H. P. Turbine	Turbine Bldg.	TB-786	Terminal End Break
SMI-12	Main Steam	34" (SM) 1D @ H.P. Turbine T.E. Brk. @ Inlet of H.P. Turbine.	Turbine Bldg.	TB-786	Terminal End Break

(1) Ratio = Stress, S/ $(0.8\ (1.2S_h + S_A))$; intermediate breaks only

(2) Stresses at all locations in the piping run are less than $0.4\ (1.2S_h + S_A)$.

TABLE 6-2
RESULTS OF DAMAGE EVALUATION
UNACCEPTABLE PIPE WHIP/JET IMPINGEMENT EFFECTS

BREAK NUMBER	TYPE BREAK	EFFECT ON REQUIRED COMPONENTS	RESOLUTION
BB1-01	Circumferential (forward flow)	Pipe whip damage to: Valve1NI173A, 1NI121A. Jet impingement damage to:Vlv. 1NI173A.	Added pipe whip restraint
BB1-03	Circumferential (forward flow)	Pipe whip damage to: Valve 1NI173A, 1NI121A. Jet damage to valve 1NI173A.	Add pipe whip restraint

3

TABLE 6-2
RESULTS OF DAMAGE EVALUATION
UNACCEPTABLE PIPE WHIP/JET IMPINGEMENT EFFECTS

BREAK NUMBER	TYPE BREAK	EFFECT ON REQUIRED COMPONENTS	RESOLUTION
CA1-51	Circumferential (forward flow)	Pipe whip and jet impingement on essential electrical cable to valve 1CA50B.	Add whip restraint and jet barrier.
CA1- 70A	Circumferential (forward flow)	Jet impingement on essential electrical cables to valves 1CA38B and 1CA42B.	Add jet barrier

TABLE 6-2
RESULTS OF DAMAGE EVALUATION
UNACCEPTABLE PIPE WHIP/JET IMPINGEMENT EFFECTS

BREAK NUMBER	TYPE BREAK	EFFECT ON REQUIRED COMPONENTS	RESOLUTION
CF1-01	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
CF1-02	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential component located inside the doghouse.	Add pipe whip restraints.
CF1-03	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
CF1-04	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located inside the doghouse.	Add pipe whip restraints.
CF1-05	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
CF1-06	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located inside the doghouse.	Add pipe whip restraints.
CF1-07	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
CF1-08	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located inside the doghouse.	Add pipe whip restraints.

3

TABLE 6-2
RESULTS OF DAMAGE EVALUATION
UNACCEPTABLE PIPE WHIP/JET IMPINGEMENT EFFECTS

BREAK NUMBER	TYPE BREAK	EFFECT ON REQUIRED COMPONENTS	RESOLUTION
NI1-02	Circumferential (forward flow)	Pipe whip damage to Column at HH and 52	Add pipe whip restraint.
NV1-03	Circumferential (forward and reverse flow)	Essential electrical components	Add pipe whip restraint.
NV1-07	Circumferential (forward flow)	Pipe whip damage to: a) 8" NS - To M-362 b) NSR Electrical "B" c) Valves: 1NS32A, 1NS43A, 1NV7B Jet damage to: a) NSR Electrical "B" b) NS Valves c) 8" RN - To Pond d) 8" ND/NS - To M-369 e) 8" NS - To M-362	Add pipe whip restraint.
NV1-07	Circumferential (reverse flow)	Jet damage to: a) NSR Electrical "B" b) 8" NS - To M-362 c) Valve 1NV7B	

3

TABLE 6-2
RESULTS OF DAMAGE EVALUATION
UNACCEPTABLE PIPE WHIP/JET IMPINGEMENT EFFECTS

2

BREAK NUMBER	TYPE BREAK	EFFECT ON REQUIRED COMPONENTS	RESOLUTION
SMI-01	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located in the doghouse.	Add pipe whip restraint.
SMI-02	Circumferential (forward flow) (reverse flow)	Unacceptable damage to Doghouse structure and essential components located in the doghouse.	Add pipe whip restraint.
SMI-03	Circumferential (forward flow) (reverse flow)	Unacceptable damage to doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.

3

TABLE 6-2
RESULTS OF DAMAGE EVALUATION
UNACCEPTABLE PIPE WHIP/JET IMPINGEMENT EFFECTS

BREAK NUMBER	TYPE BREAK	EFFECT ON REQUIRED COMPONENTS	RESOLUTION
SMI-04	Circumferential (forward flow) (reverse flow)	Unacceptable damage to doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
SMI-05	Circumferential (forward flow) (reverse flow)	Unacceptable damage to doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
SMI-06	Circumferential (forward flow) (reverse flow)	Unacceptable damage to doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
SMI-07	Circumferential (forward flow) (reverse flow)	Unacceptable damage to doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.
SMI-08	Circumferential (forward flow) (reverse flow)	Unacceptable damage to doghouse structure and essential components located inside the doghouse.	Add pipe whip restraint.

TABLE 6-3

RESULTS OF DAMAGE EVALUATION

WATER SPRAY - MODERATE ENERGY PIPING

3

LOCATION (SEE FIGURES 2-2 thru 2-6)	EFFECT ON ESSENTIAL COMPONENTS	RESOLUTION
AB-695-1	Water spray affecting the following: TB212	Add seal to cabinet doors and add sealant to cable entrance.
AB-695-3	Water spray affecting the following: TB211	Add seal to cabinet doors and add sealant to cable entrance.
AB-716-06 AB-733-07	Water spray affecting the following: a) TB182 b) TB183 c) TB189 d) TB184 e) TB185	Add seal to cabinet doors add sealant to cable entrance.
AB-716-12 AB-716-13	Water spray affecting the following: a) TB108 b) TB188 c) TB201 d) TB113 e) 1ATC21 f) 1ATC3 g) TB192 h) ATB149 i) TB150	Add seal to cabinet doors add sealant to cable entrance.

TABLE 6-3

RESULTS OF DAMAGE EVALUATION

WATER SPRAY - MODERATE ENERGY PIPING

3

LOCATION (SEE FIGURES 2-2 thru 2-6)	EFFECT ON ESSENTIAL COMPONENTS	RESOLUTION
AB-716-10	Water spray affecting the following: a) TB406 b) TB232 c) TB112 d) TB203 e) Aux. Shutdown Panel	Add seal to cabinet doors, add sealant to cable entrance.
AB-716-53	Water spray affecting the following: a) TB407 b) TB195 c) TB204 d) TB202 e) TB193 f) TB233	Add seal to cabinet doors, add sealant to cable entrance.
AB-733-42	Water spray affecting the following: a) TB111	Add seal to cabinet doors, and add sealant to cable entrance.

3

TABLE 6-3

RESULTS OF DAMAGE EVALUATION

WATER SPRAY - MODERATE ENERGY PIPING

3

LOCATION (SEE FIGURES 2-2 thru 2-6)	EFFECT ON ESSENTIAL COMPONENTS	RESOLUTION
AB-733-16 AB-733-17	Water spray affecting the following: a) TB107 b) 1ATC22 c) 1ATC4A d) 1ATC4	Add seal to cabinet doors, add sealant to cable entrance.
AB-750-01	Water spray affecting the following: a) TB415 b) TB416 c) TB146 d) TB224 e) TB239 f) TB225 g) TB238	Add seal to cabinet doors, and add sealant to cable entrance.
AB-750-09	Water spray affecting the following: a) Refueling water storage tank panel.	Add seal to panel doors, add sealant to cable entrance.
AB-750-18 AB-750-19 AB-750-20	Water spray affecting the following: a) 1ATC2A b) 1ATC2 c) TB109 d) TB148 e) TB147 f) Nuclear Ser. Water Relay Cabinet # 1	Add seal to cabinet doors, add sealant to cable entrance.

TABLE 6-3

RESULTS OF DAMAGE EVALUATION

WATER SPRAY - MODERATE ENERGY PIPING

3

LOCATION (SEE FIGURES 2-2 thru 2-6)	EFFECT ON ESSENTIAL COMPONENTS	RESOLUTION
AB-750-26	Water spray affecting the following: a) TB262	Add seal to cabinet doors, add sealant to cable entrance.
AB-767-05	Water spray affecting the following: a) IRBECP5	Add seal to cabinet doors, add sealant to cable entrance.
AB-750-23	Water spray affecting the following: a) TB260 b) ISMTC	Add seal to cabinet doors, add sealant to cable entrance.
AB-767-11	Water spray affecting the following: a) !ATC10 b) IRBECP4	Add seal to cabinet doors, add sealant to cable entrance.

TABLE 6-3

RESULTS OF DAMAGE EVALUATION

WATER SPRAY - MODERATE ENERGY PIPING

3

Sheet 5 of 7

LOCATION (SEE FIGURES 2-2 thru 2-6)	EFFECT ON ESSENTIAL COMPONENTS	RESOLUTION
AB-767-08	Water spray affecting the following: a) HVAC-A b) HVAC-B c) R-CP-3 d) TB368 e) TB367 f) 1ATC11 g) CRAC-1 h) CRAC-2 i) CRA-OAPFT-2 j) CRACP1 k) CRACP2 l) R-CP-2 m) R-CP-1 n) CRA-OAPFT-1	Add seal to cabinet doors, add sealant to cable entrance.
3 AB-767-10	Water Spray affecting the following: a) 1EMXG	Add spray shield

TABLE 6-3

RESULTS OF WATER SPRAY EVALUATION

LOCATION (SEE FIG. 2.2 - 2-6)	EFFECT ON ESSENTIAL COMPONENTS	RESOLUTION
AB-733 Unit 1 Switchgear Room	1ELXD 1EMXB4 Busswork D/G Relay Cab. 1B 1ETB D/G Load Seq. Pnl. 1B	Add spray shields.
AB-750 Unit 1 Cable Splitting Room	Aux. Relay Cabinet	Add spray shields.
AB-750 Unit 1 Switchgear Room	1ELXC 1ELXE 1SSFARC D/G Load Seq. Pnl. 1A 1ETA 1ATC7 1ATC23 D/G Relay Cab. 1A	Add spray shields.
AB-767 Unit 1 Elec. Penetration Room	West RX Trip Switchgear	Add spray shields.
AB-767-8	2EMXG	Add spray shields.
AB-767-10	1EMXG	Add spray shields.
AB-750-27	2EMXA 2EMXA-1	Add spray shields.

TABLE 6-3

RESULTS OF WATER SPRAY EVALUATION

LOCATION (SEE FIG. 2.2 - 2-6)	EFFECT ON ESSENTIAL COMPONENTS	RESOLUTION
AB-733 Unit 2 Switchgear Room	D/G Load Seq. Pnl. 2B 2ATC9 D/G Relay Cab. 2B 2ETB 2ELXF 2ELXD	Add spray shields.
AB-750 Unit 2 Cable Splitting Room	Aux. Relay Cab. 2IR2 2IR3 2IC8 2IC5	Add spray shields.
AB-750 Unit 2 Switchgear Room	D/G Load Seq. Pnl. 2A 2ATC7 2ATC23 2ETA 2ELXC 2EMXA-3	Add spray shields.
AB-767 Unit 2 Elec. Penetration Room	West RX Trip Switchgear	Add spray shields.
AB-750 21	1EMXA	Add spray shields.
AB-733-17	2EMXA	Add spray shields.

TABLE 6-4
MCGUIRE NUCLEAR STATION
DOGHOUSE PRESSURE RISE ANALYSIS

Data for TMD Model

1. Doghouse ambient conditions

Temperature = 135°F

Relative Humidity = 20%

Barometric Pressure = 28.06-30.14 In Hg

2. Compartment Net Volumes

Compartment Number	Compartment Net Volume (FT^3)
1	2683
2	2824
3	4834
4	1743
5	2674
6	2603
7	2998
8	3388
9	4981
10	2403
11	3080
12	2505
13	4221
14	4360
15	6598
16	3397
17	3619
18	3315
19	2840
20	2530
21	4154
22	2953
23	2668
24	2953

TABLE 6-4 (Continued)

3. Flow Path Minimum Areas, Inertial Lenghts, and Loss Coefficients (K-Factor)

Flow Path	Minimum Area (FT^2)	Inertial Length (FT)	K-Factor
1-2	38	7.75	0.86
1-4	12	3.38	1.37
1-7	119	12.73	0.24
2-3	158	13.54	0.10
2-5	107	6.09	0.76
2-8	135	12.50	0.24
3-6	78	5.98	0.90
3-9	182	11.23	0.32
4-5	82	15.57	0.08
4-10	66	10.05	0.34
5-6	109	16.93	0.08
5-11	120	13.98	0.08
6-12	107	13.32	0.10
7-8	101	13.64	0.26
7-10	96	6.24	0.77
7-13	118	13.92	0.28
8-9	133	13.23	0.28
8-11	144	7.23	0.58
8-14	135	15.05	0.28
9-12	102	6.91	0.75
9-15	199	14.33	0.26
10-11	112	17.00	0.06
10-16	84	13.76	0.28
11-12	112	17.00	0.08
11-17	80	11.77	0.48
12-18	74	11.63	0.48
13-14	191	18.54	0.06
13-16	110	5.71	0.77
13-19	135	11.48	0.39
14-15	174	14.04	0.34
14-17	132	4.53	0.80
14-20	125	11.04	0.37
15-18	93	6.02	0.90
15-21	232	12.78	0.19
16-17	154	18.99	0.04
16-ATM(Front)	40	4.40	1.41
16-22	134	13.32	0.58
17-18	144	17.80	0.17
17-ATM(Front)	54	4.50	1.41
17-23	126	12.99	0.27
18-24	136	13.64	0.24
18-ATM(Front)	38	4.38	1.42
19-20	94	18.34	1.74
19-22	187	10.90	0.98
19-ATM(Side)	99	11.10	2.71
20-21	104	16.38	1.96
20-23	165	10.76	0.96
21-24	187	10.90	0.98
21-ATM(Side)	208	11.10	2.71
22-23	88	13.47	2.04
22-ATM(Front)	187	7.16	1.94
22-ATM(Side)	88	8.33	2.87
23-24	88	13.47	2.04

TABLE 6-4 (Continued)

3. (Continued)

Flow Path	Minimum Area (FT^2)	Inertial Length (FT)	K-Factor
23-ATM(Front)	165	6.78	1.92
24-ATM(Front)	187	7.16	1.94
24-ATM(Side)	88	8.33	1.87

4. Blowdown Flowrates
   a. Main Steam
      Blowdown in compartment # 1

      Constant flow = 2300 lbm/sec
      Enthalpy = 1188.0 btu/lbm

   b. Main Steam
      Blowdown in compartment # 2

      Constant flow = 4830 lbm/sec
      Enthalpy = 1188.0 btu/lbm

   c. Main Steam
      Blowdown in compartment # 14 or #17

      Constant flow = 4830 lbm/sec
      Enthalpy = 1188.0 btu/lbm

   d. Feedwater Blowdown in compartments 3, 4, 6, & 9

3

Flow Direction	Time (sec)	Enthalpy (Btu/lbm)	Total Flow
Forward	$0 < t \leq 1.648$	424.6	7090.0
Forward	$1.648 \leq t$	424.6	5252.2
Reverse	$0 < t \leq 1.665$	424.6	7090.0
Reverse	$1.665 \leq t$	0	0

5. Computer Runs

Run #	System	Location of blowdown	Time Duration
1	Main Steam	Compartments #1 and # 14 simultaneously	2.00 sec
2	Main Steam	Compartments # 2 and # 17 simultaneously	2.00 sec
3	Feedwater	Compartment # 3	2.00 sec
4	Feedwater	Compartment # 4	2.00 sec
5	Feedwater	Compartment # 6	2.00 sec
6	Feedwater	Compartment # 9	2.00 sec

TABLE 6-5
LIST OF SYSTEM LINE CONDITIONS, BREAK AREAS, MASS AND ENERGY RELEASE RATES

System	Pipe Size (in)		Type	Area[(1)] (in^2)	Line Fluid Temp. (^oF)	Line Fluid Pressure (psia)	Mass Flux (#m/sec-ft^2)	Energy Flux (Btu/sec-ft^2)
AS	2"		Crack	0.08	298	65	138	163069
BB	4"		Circum	(2)	557	1107	(2)	(2)
BB	2"		Circum	(2)	557	1107	(2)	(2)
ND	18"		Crack	1.617	350	365	2888	930514
ND	14"		Crack	0.844	350	365	2888	930514
ND	8"		Crack	0.508	350	365	2888	930514
ND	3"		Crack	0.166	350	365	2888	930514
NV	3"		Circum	7.393	350	365	2888	930514
NB	6"		Crack	0.42	298	65	138	163069
WL	4"		Crack	0.239	298	65	138	163069
YH	6"		Crack	28.890	240	140	(3)	(3)
YH	5"		Crack	20.005	240	140	(3)	(3)
YH	4"		Crack	12.73	240	140	(3)	(3)
YH	3"		Crack	7.393	240	140	(3)	(3)
YH	2½"		Crack	4.778	240	140	(3)	(3)
YH	1½"		Crack	2.036	240	140	(3)	(3)
SM	31.5		Circum	291.5(4)	557	1107	2300	2732400

(1) Circumferential areas shown here are for single ended break only.

(2) See text. (Section 6.4.2.2.2.)

(3) Non-flashing liquid, included for water spray only.

(4) Area considers guard pipe restrictions and is total flow area.

Revision 3
Entire Page Revised

TABLE 6-6

ESSENTIAL COMPONENTS WITH EXCESSIVE ENVIRONMENTAL CONSEQUENCES

LOCATION	EQUIPMENT	DESIGN TEMPERATURE	PIPE BREAK TEMPERATURE	RESOLUTION
El. 716'	TB1366	150	212	Requalified for environment.
	1ATC 21	150	212	Requalified for environment.
	Nuclear Service Water Pump Motors	104	212	Requalified for environment.
	Centrifugal Charging Pump Motors	110	212	Requalified for environment.
	Safety Injection Pump Motors	110	212	Requalified for environment.
	2ATC3	150	212	Requalified for environment.
	2ATC21	150	212	Requalified for environment.
	2ATC6	165	212	Requalified for environment.
	TB366	150	212	Requalified for environment.
	1ATC3	150	212	Requalified for environment.
	TB408	150	212	Requalified for environment.

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Entire Page Revised

TABLE 6-6

ESSENTIAL COMPONENTS WITH EXCESSIVE ENVIRONMENTAL CONSEQUENCES

LOCATION	EQUIPMENT	DESIGN TEMPERATURE	PIPE BREAK TEMPERATURE	RESOLUTION
El. 733'	2ATC4	150	212	Requalified for environment.
	2ATC4A	150	212	Requalified for environment.
	2ATC22	150	212	Requalified for environment.
	TB1184	311	350 (JET)	Requalified for environment.
	1ATC22	125	212	Requalified for environment.
	1ATC4	150	212	Requalified for environment.
	1ATC4A	125	212	Requalified for environment.
	Nuclear Service Water Cabinet #2	150	212	Requalified for environment.
	Component Cooling Pump Motors	104	212	Requalified for environment.

Revision 3
Entire Page Revised

TABLE 6-6

ESSENTIAL COMPONENTS WITH EXCESSIVE ENVIRONMENTAL CONSEQUENCES

LOCATION	EQUIPMENT	DESIGN TEMPERATURE	PIPE BREAK TEMPERATURE	RESOLUTION
El. 750'	TB415	150	293 (JET)	Rupture restraint added for break.
	TB416	150	293 (JET)	Rupture restraint added for break.
	1ATC2	150	240 (JET)	Detailed stress analysis showed all stresses less than 0.4 (1.2 Sh + SA).
	1ATC2A	150	240 (JET)	Detailed stress analysis showed all stresses less than 0.4 (1.2 Sh + SA).
	Nuclear Service Water Cabinet #1	150	240 (JET)	Detailed stress analysis showed all stresses less than 0.4 (1.2 Sh + SA).
	Component Cooling Pump Motors	104	240 (JET)	Detailed stress analysis showed all stresses less than 0.4 (1.2 Sh + SA).
	2EMXA	125	240 (JET)	Spray shield added.
	2EMXA-1	125	240 (JET)	Spray shield added.
	Feedwater Level Control Panel 2	110	208	Requalified for environment.
	TB1238	185	191	Requalified for environment.
	TB1239	185	191	Requalified for environment.
	TB1489	150	208	Requalified for environment.

TABLE 6-6

ESSENTIAL COMPONENTS WITH EXCESSIVE ENVIRONMENTAL CONSEQUENCES

LOCATION	EQUIPMENT	DESIGN TEMPERATURE	PIPE BREAK TEMPERATURE	RESOLUTION
El. 750' (cont.)	TB1490	150	208	Requalified for environment.
	TB1491	150	208	Requalified for environment.
	2ATC2	150	240 (JET)	Requalified for environment.
	2ATC2A	150	240 (JET)	Requalified for environment.
	TB1415	150	191	Requalified for environment.
	TB1416	150	191 350 (JET)	Requalify for environment. Rupture restraint added for break.
	1EMXH	125	240 (JET)	Spray shield added.
	TB416	150	350 (JET)	Rupture restraint added for break.
	Feedwater Level Control Panel 1	114	132	Requalify for environment.

TABLE 6-6

ESSENTIAL COMPONENTS WITH EXCESSIVE ENVIRONMENTAL CONSEQUENCES

LOCATION	EQUIPMENT	DESIGN TEMPERATURE	PIPE BREAK TEMPERATURE	RESOLUTION
El. 767'	2ATC10	90	130 240 (JET)	Requalify for environment.
	2RB-ECP-4A	150	240 (JET)	Requalify for environment.
	TB1442	150	240 (JET)	Requalify for environment.
	TB1443	150	240 (JET)	Requalify for environment.
	ISMTCI	150	204	Requalify for environment.
	IATC!0	90	130 240 (JET)	Requalify for environment.
	TB442	150	240 (JET)	Requalify for environment.
	TB443	150	240 (JET)	Requalify for environment.
Doghouse	TB260	150	330	Relocate to auxiliary building.
	TB261	311	330	Relocate to auxiliary building.
	TB262	311	330	Relocate to auxiliary building.

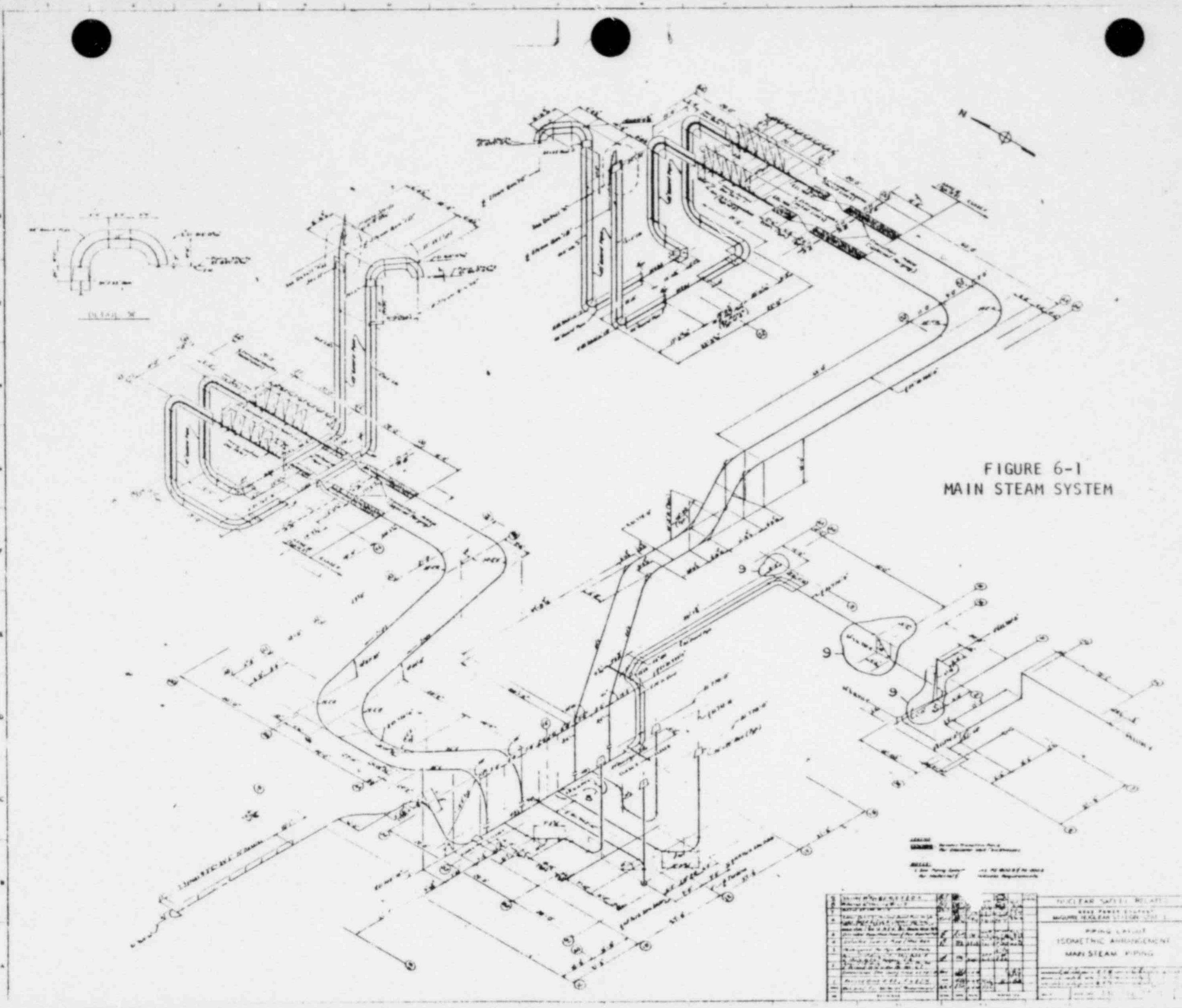

FIGURE 6-1
MAIN STEAM SYSTEM

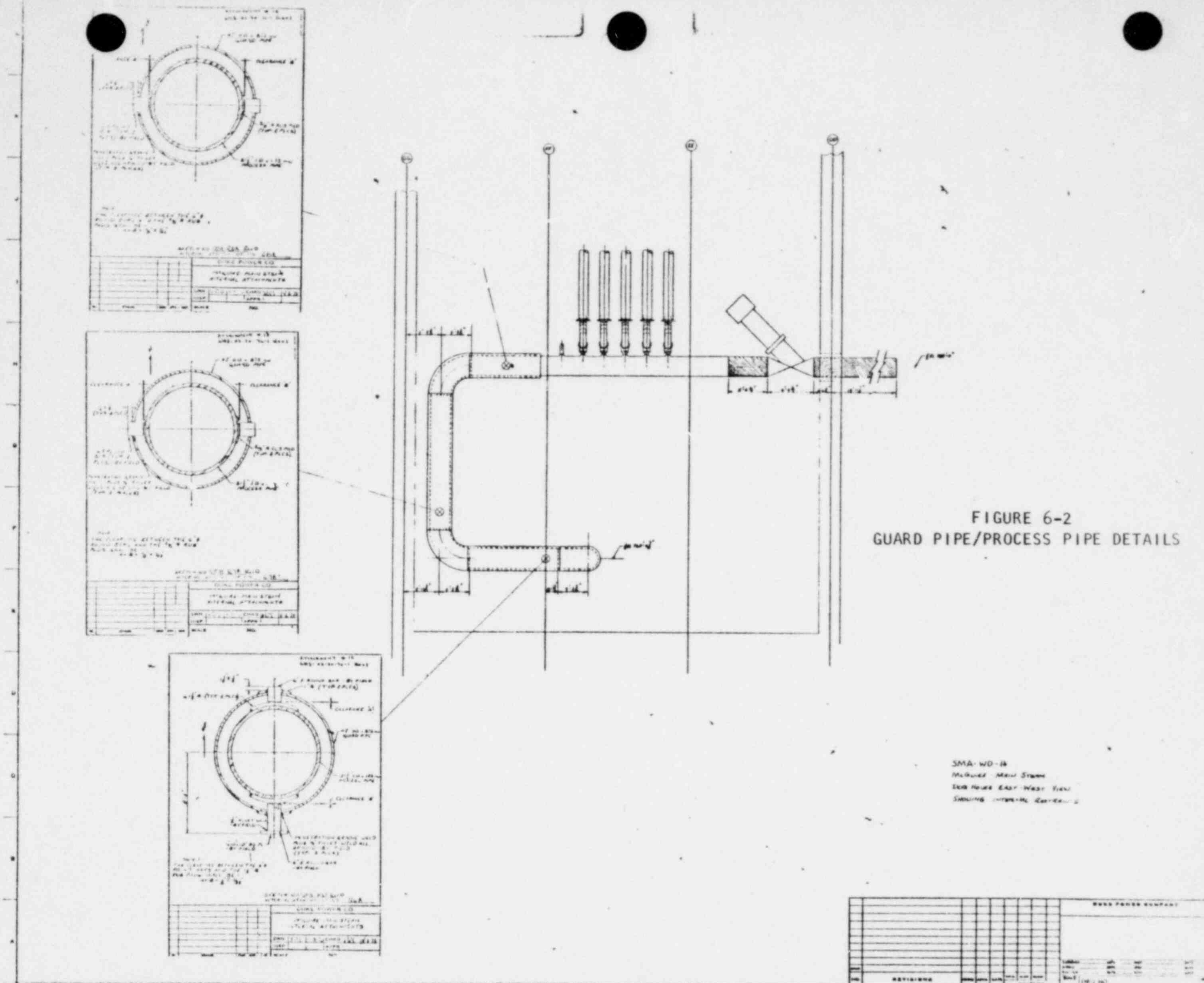

FIGURE 6-2
GUARD PIPE/PROCESS PIPE DETAILS

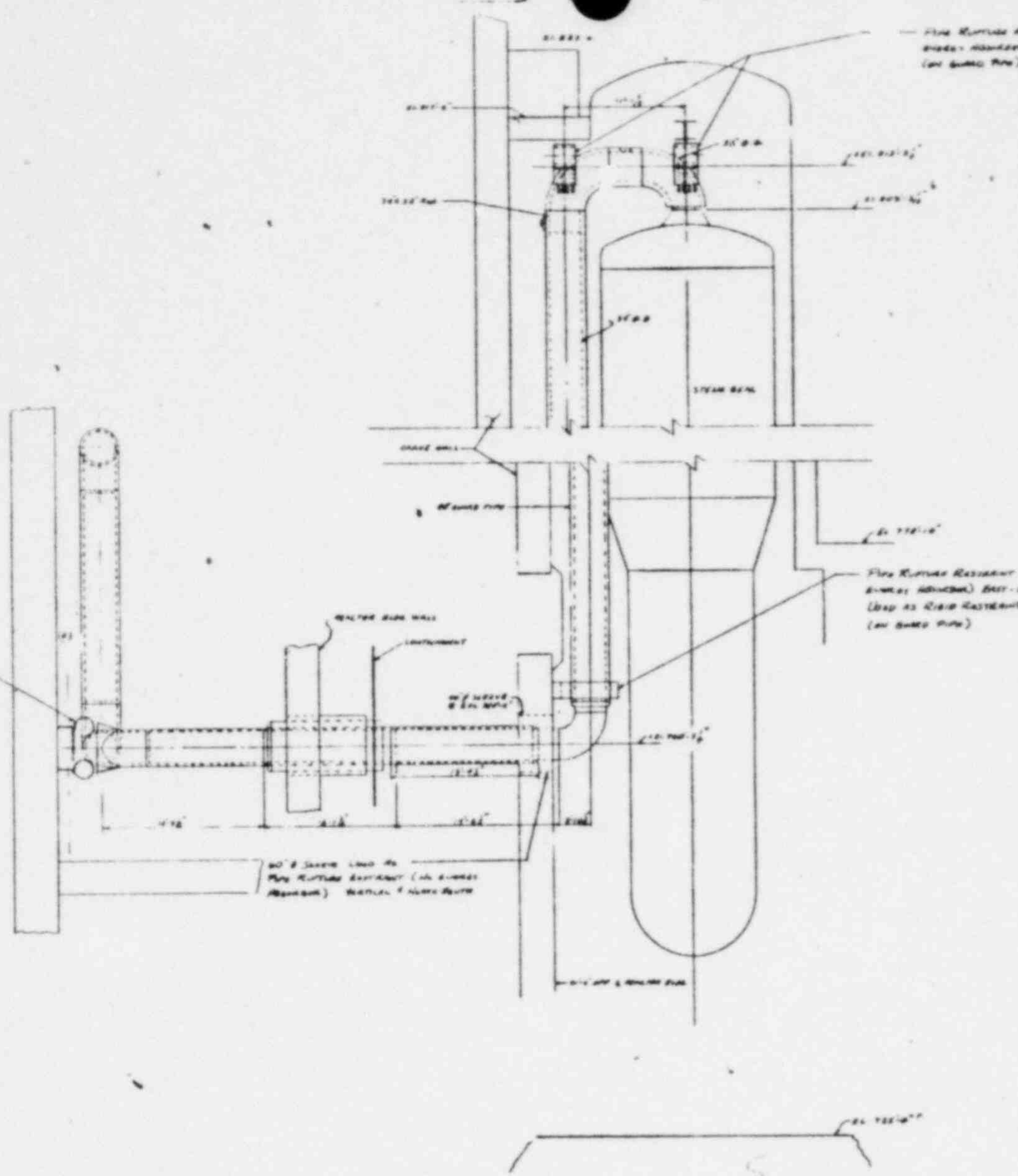

FIGURE 6-3
PIPE RUPTURE RESTRAINTS

SMA-WD-26
McGuire - Main Steam

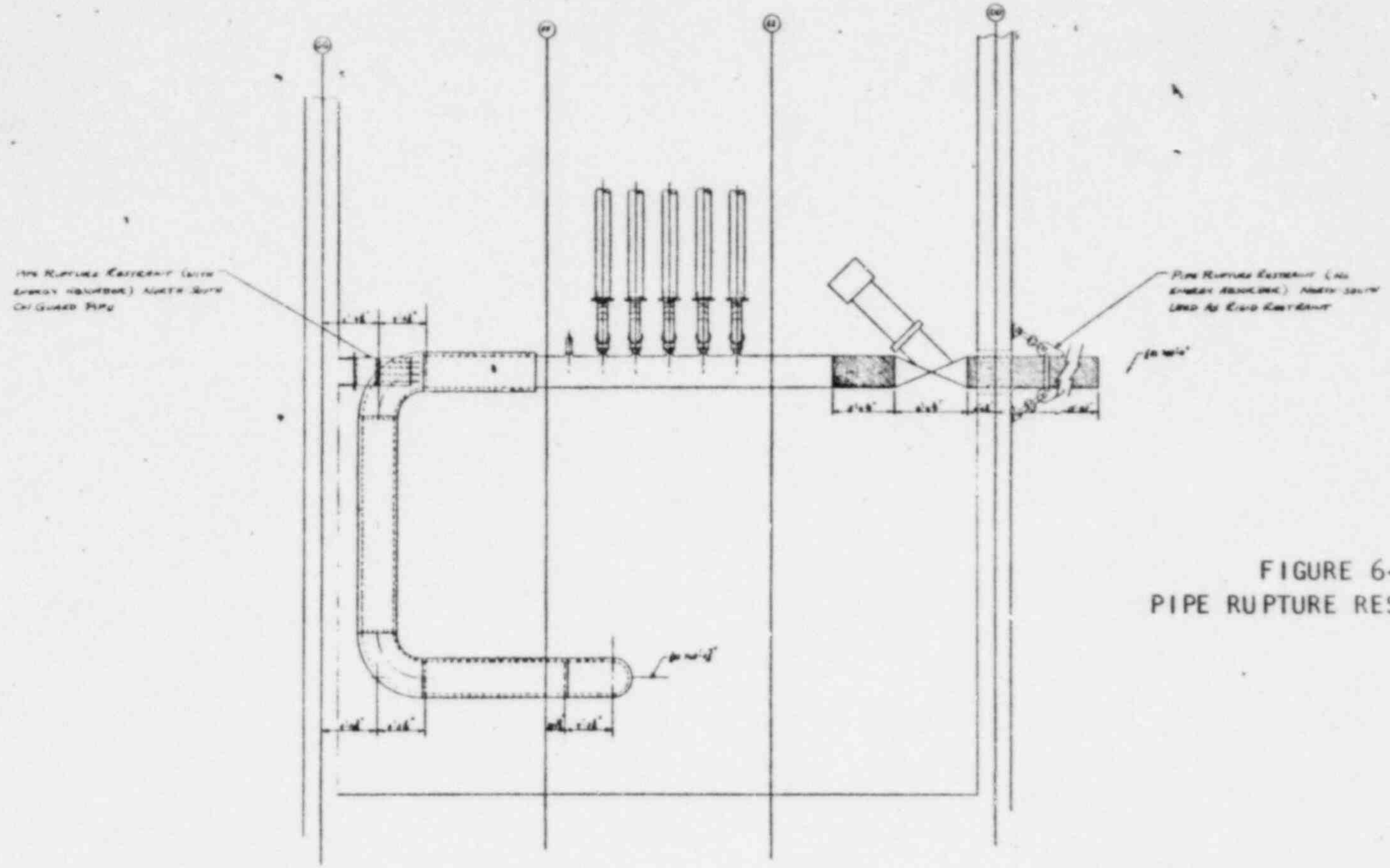

FIGURE 6-4
PIPE RUPTURE RESTRAINTS

SMA-WD-26

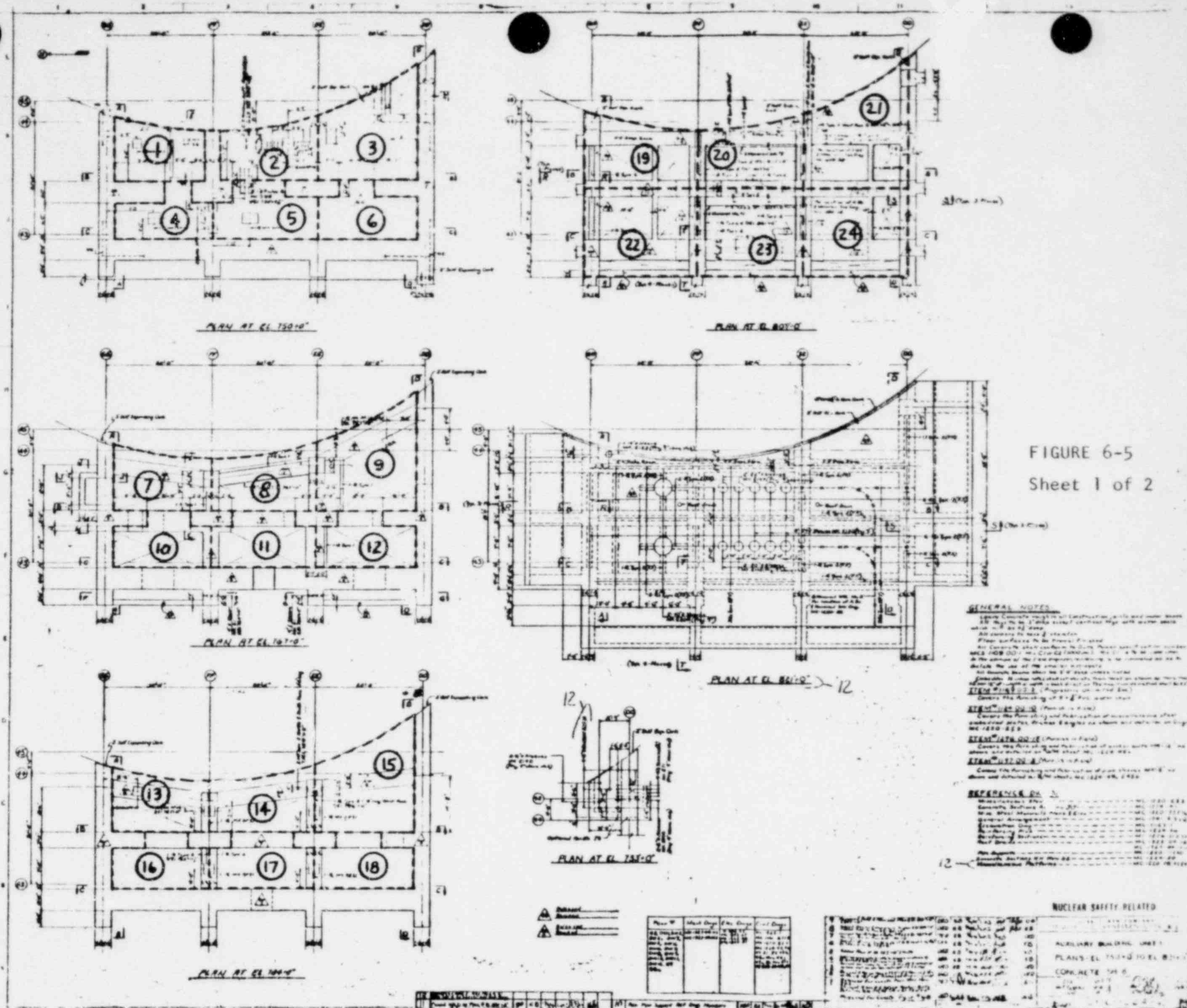

FIGURE 6-5
Sheet 1 of 2

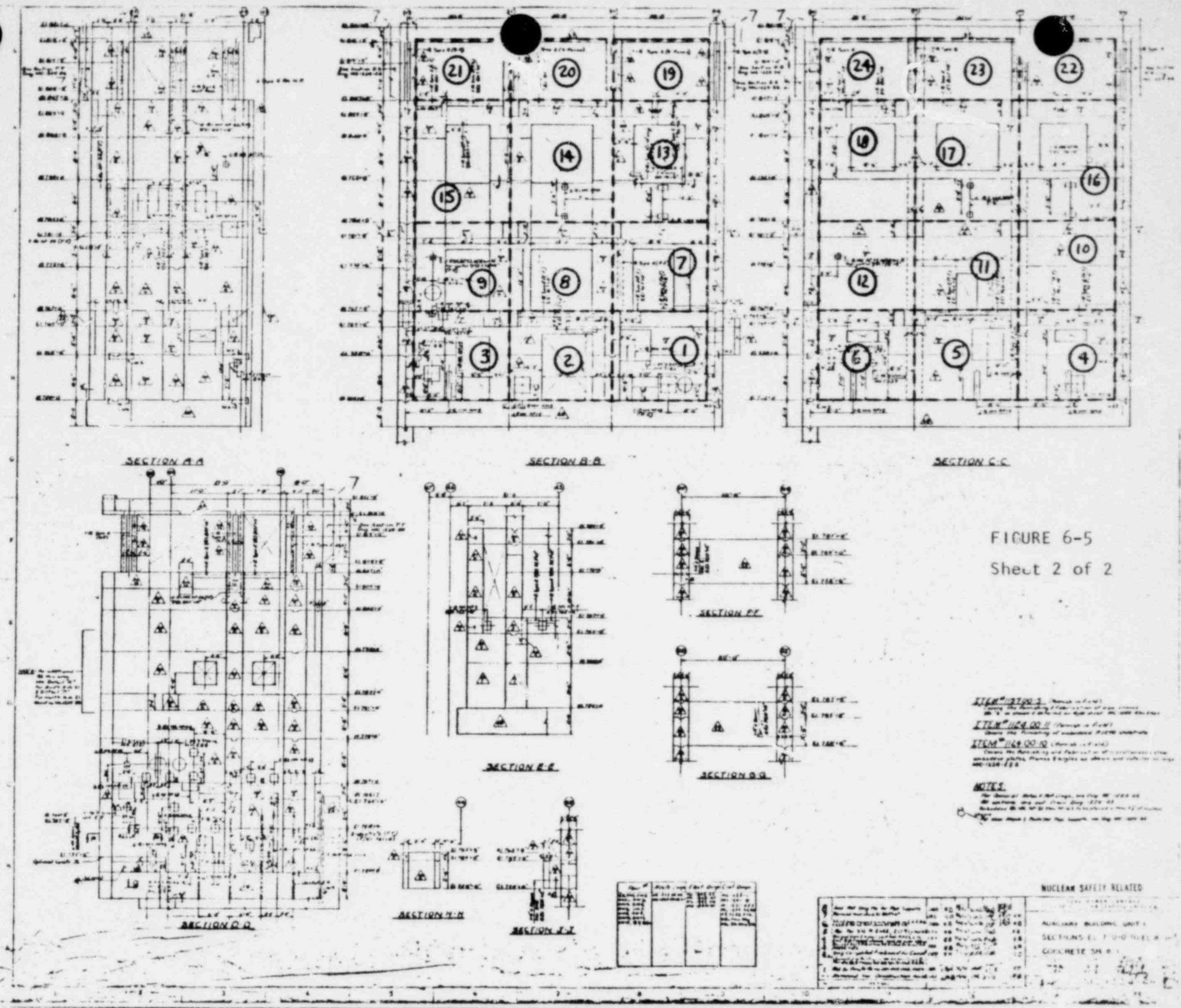

FIGURE 6-5

Sheet 2 of 2

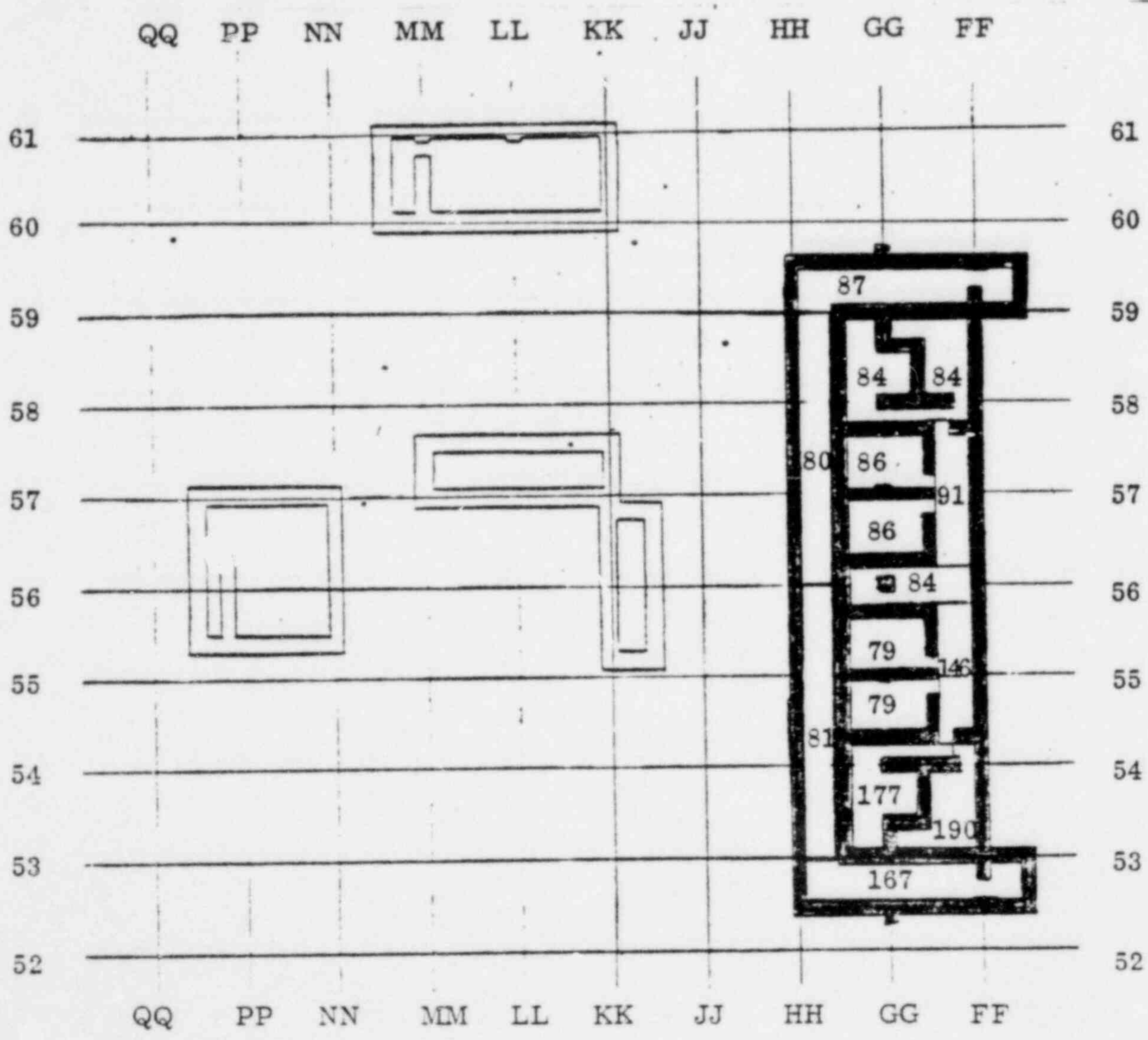

FIGURE 6-6 ELEVATION 695'-0" PEAK TEMPERATURES

Sheet 1 of 5

Revision 1
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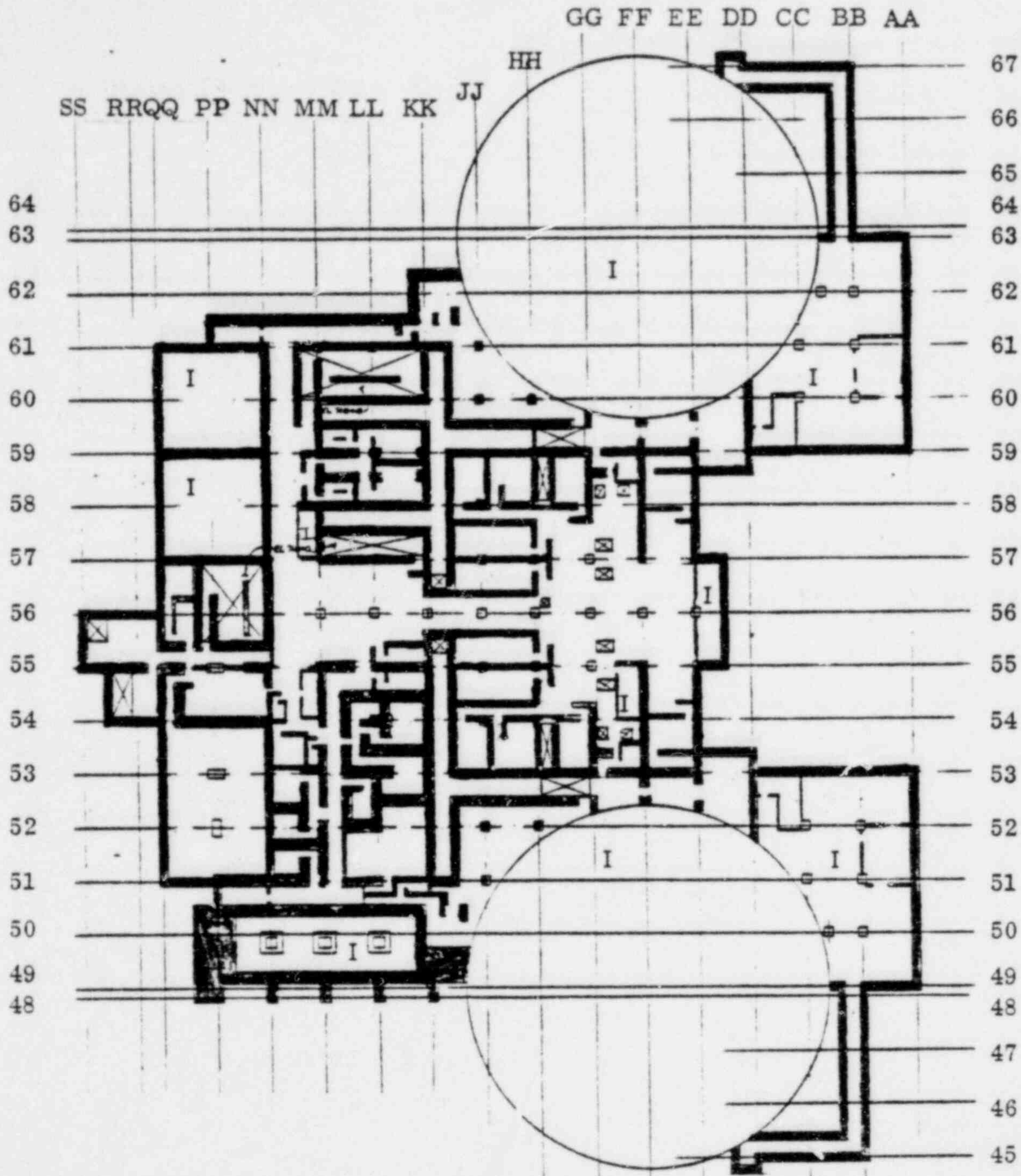


Regions Denoted I are Isolated from Environmental Temperature Effects.

This Entire Floor is at 212°F Except Where Denoted I.

FIGURE 6-6 ELEVATION 716'-0" PEAK TEMPERATURES

Sheet 2 of 5

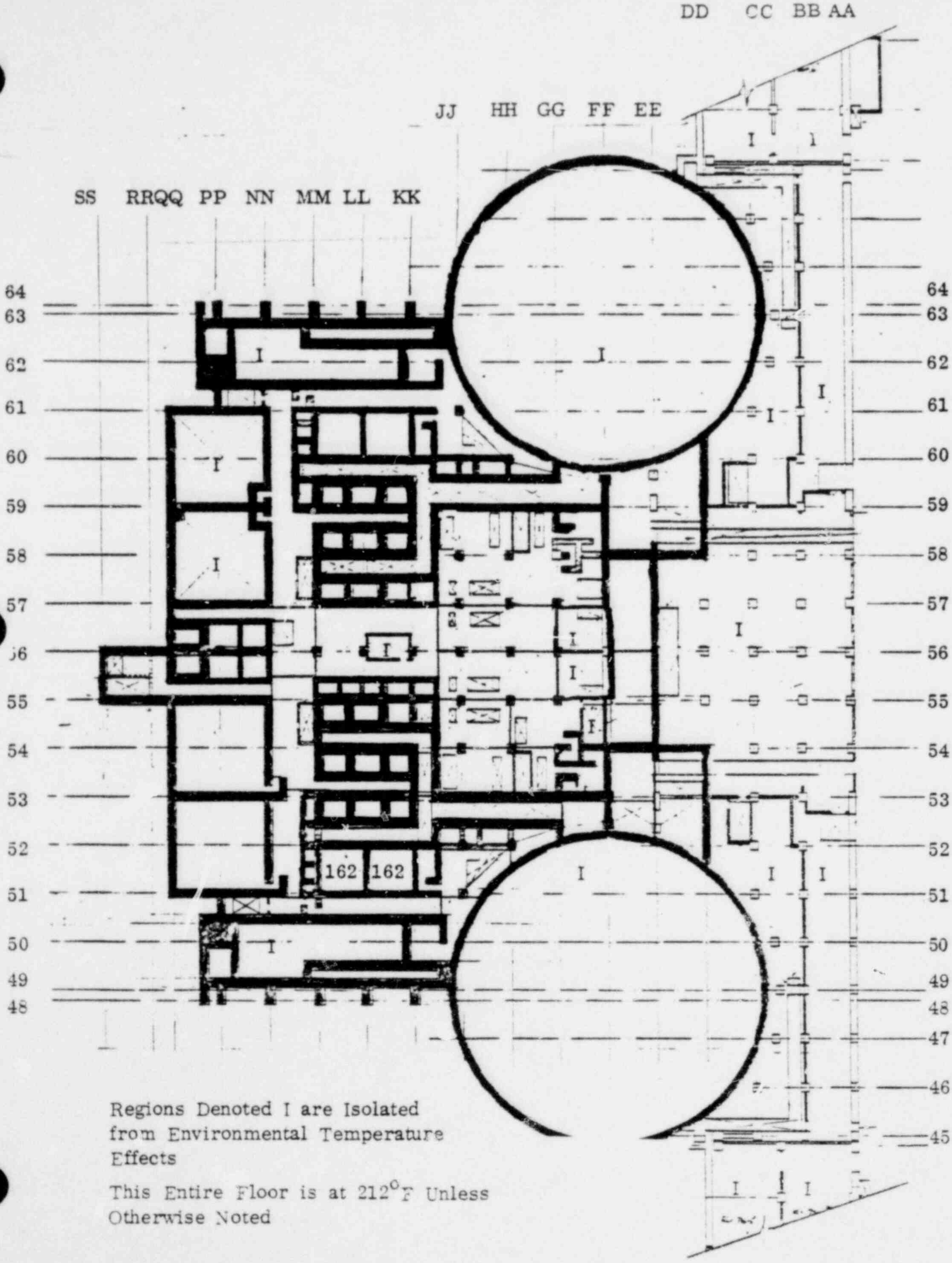
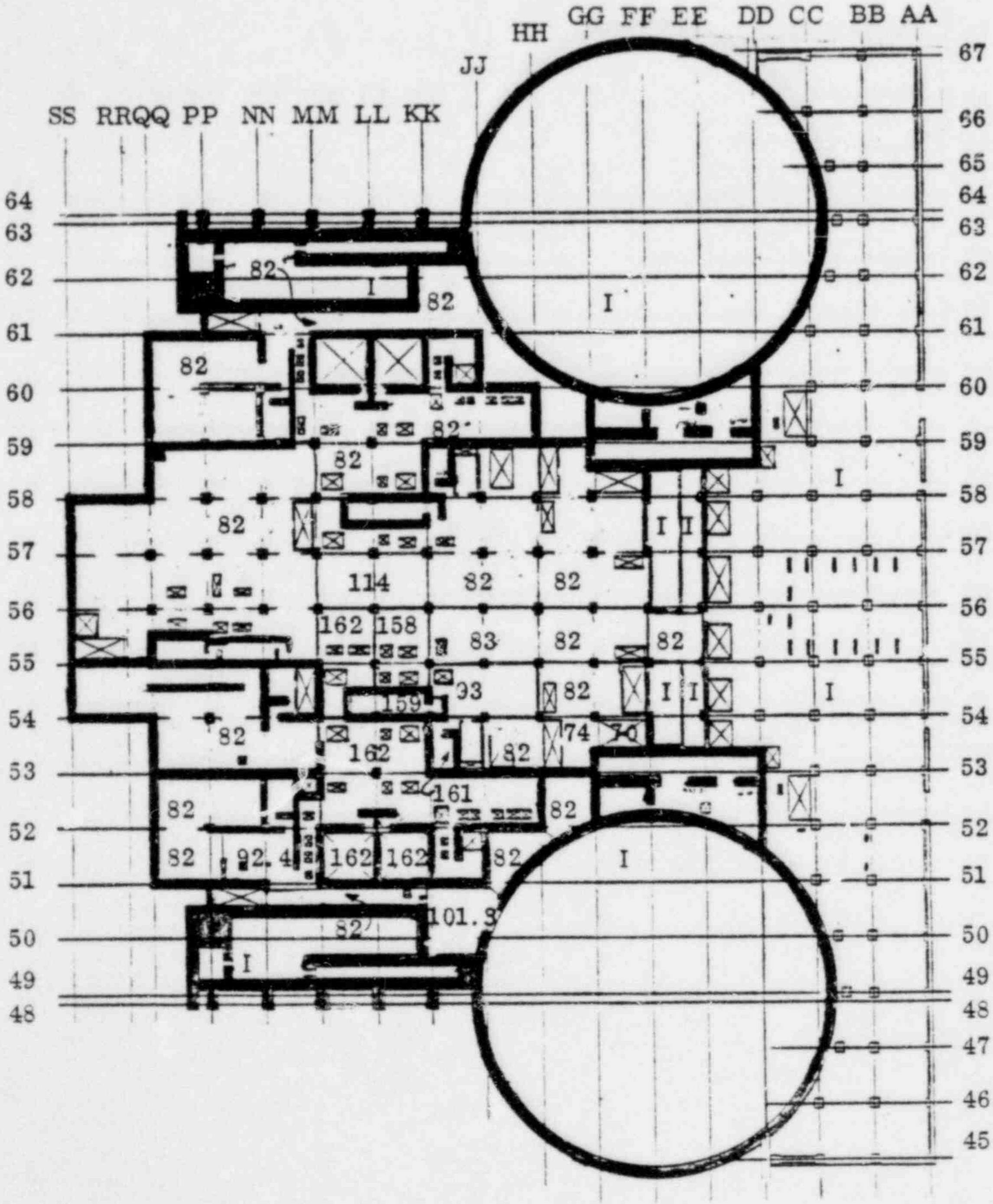


FIGURE 6-6 ELEVATION 733'-0" PEAK TEMPERATURES

Sheet 3 of 5



Regions Denoted I are Isolated From Environmental Temperature Effects

FIGURE 6-6 ELEVATION 750'-0" PEAK TEMPERATURES

Sheet 4 of 5

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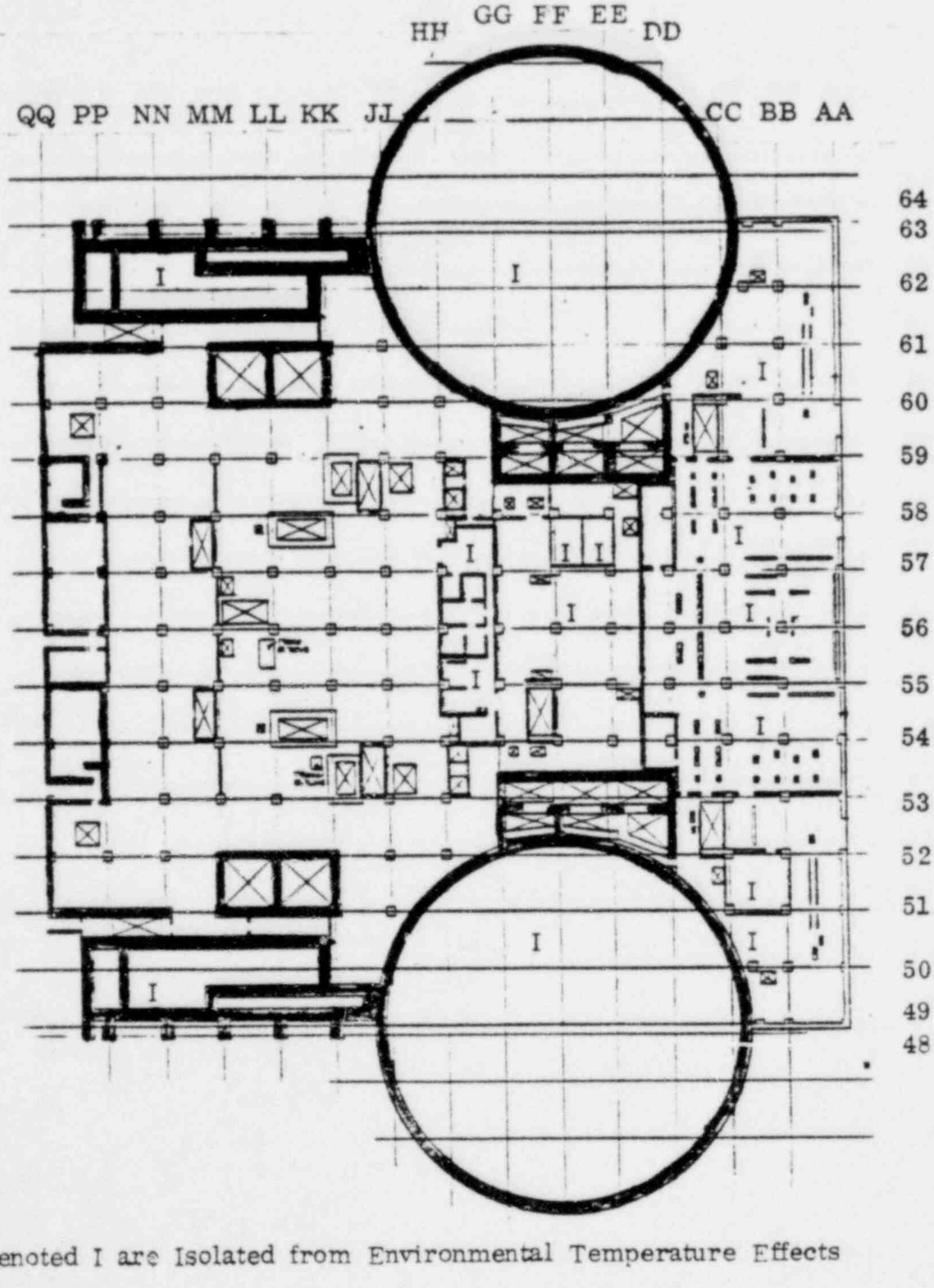

Regions Denoted I are Isolated from Environmental Temperature Effects

This Entire Floor Has Temperature 76°F Unless Where Marked I

FIGURE 6-6 ELEVATION 767'-0" PEAK TEMPERATURES

Sheet 5 of 5

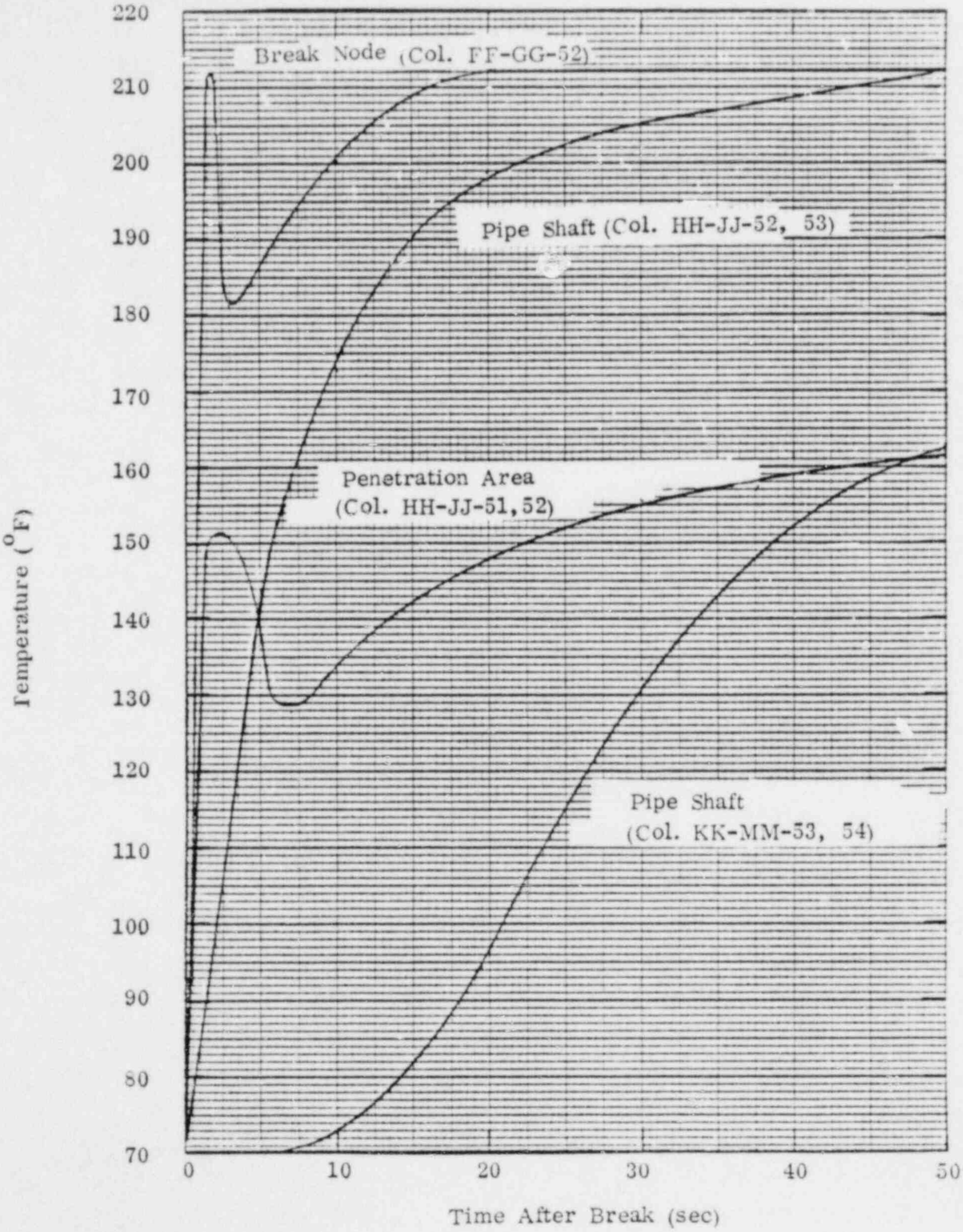

FIGURE 6-7 TYPICAL TEMPERATURE RESPONSE CURVES FOR BB LINE BREAK

Revision 1
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APPENDIX A

A.1 General Design Considerations

Pipes which have been identified as creating unacceptable adverse effects due to pipe movement are provided with means of controlling their motion through the use of separation, restraints, barriers, or some other acceptable method of protection.

In order to properly determine the adequacy of a system including pipe and restraints following a postulated pipe rupture, two design considerations are evaluated, the dynamic event and steady-state equilibrium.

The following references are used in pipe whip restraint design:

1. USNRC Regulatory Standard Review Plan, Section 3.6.2, March, 1975, Washington, D.C. 20545

2. ANSI-N176 Draft 4, May 1975, Section 6, Washington, D.C. 20555

3. AISC Manual of Steel Construction, Seventh Edition, 1970, New York, New York

a) Dynamic Event

Upon the occurrence of the postulated pipe rupture, the piping system, consisting of pipe, restraint structures, etc., will respond dynamically to the applied fluid dynamic forces. The pipe will acquire kinetic energy as the forces move it to impact against the restraint system. The additional energy imparted to the system after initial contact is also considered. The total kinetic energy is dissipated and absorbed in the piping and restraint systems. Elastic rebound is not considered because all restraint designs utilize plastic material deformation in the energy absorber.

b) Steady-State Equilibrium

Following the occurrence of the dynamic event (when motion ceases and the fluid dynamic forces reach steady-state values), the system is capable of supporting the steady-state blowdown thrust force. All systems satisfy the requirements of a static equilibrium analysis.

A.2 Restraints

The primary function of a pipe whip restraint is to control pipe motion upon the occurrence of a pipe rupture. As used in this context, a restraint is considered to be different from a support. In certain instances, a pipe rupture restraint may also function as a pipe support and should be designed according to Tables 3.9.2-3 and 3.9.2-4 of the McGuire FSAR with hanger materials per the McGuire hanger specification.

Tables 3.9.2-3 and 3.9.2-4 limit stress under faulted conditions to the yield stress.

The pipe whip restraint system is separated into three primary components: a) the Energy-Absorbing Device, b) the Restraint Structure, and c) the Plant Structure.

a. The Energy-Absorbing Device is a structural, mechanical hydraulic cushion or other material or device which is designed to minimize the forces imposed on the Restraint Structure by absorbing kinetic energy.

b. The Restraint Structure is that structural assemblage which connects the Energy-Absorbing Device to an anchorage, generally an embedded plate in the Plant Structure.

c. A Plant Structure is any major portion of a building which transmits loads to the building foundation.

A.2.1 Design Limits for Energy Absorbing Devices

Pipe whip restraints are designed for one-time usage, and as such are allowed to have greater distortion, plastic deformation, etc., than is normally permitted for support design. When an elastic dynamic system analysis is performed to determine the restraint loadings, the amount of permanent deformation is limited in order to preserve the validity of that analysis. For a plastic dynamic system analysis, wherein the effects of strain-rate, strain-hardening, etc., are included, the permitted strain in metallic ductile materials is limited to the following ductility factors (μ):

bending: $\mu \leq 12.5$ (open sections; I, WF, T, etc.)
$\mu \leq 25.0$ (closed sections; pipe, box, etc.)
$\mu \leq 6.0$ (members where shear governs design)

axial tension: $\mu \leq 50\% \frac{\varepsilon_u}{\varepsilon_y}$, where

ε_u = uniform ultimate strain
ε_y = yield strain

columns: ductility factors are not used for columns in compression.

The ductility factor, μ, is defined as the ratio of allowable deflection to the elastic deflection at specified yield stress:

$$\mu = \frac{\text{allowable deflection}}{\text{elastic deflection at yield}}$$

When crushable materials are used for Energy-Absorbing Devices, the energy-absorbing capacity is determined from recommended design values provided by the material manufacturer. Conservative Estimates of the energy absorbing capacity of materials supplied by Duke Power Company are substantiated with test data.

A.2.2 Design limits for Restraint Structures

Stresses in restraint structural members are limited to the yield stress at operating temperature according to Tables 3.9.2-3 and 3.9.2-4 of the McGuire FSAR. However, deflection may exceed the values predicted by elastic theory providing the ductility factors established in A.2.1 are not exceeded.

A.3 Method of Analysis

A.3.1 Simplified Method

Simplified methods have been developed to determine the dynamic and steady-state blowdown loads imposed on the Energy-Absorbing Device and on the Restraint Structure. The steps involved in this method are outlined below.

A.3.1.1 Analysis of Energy-Absorbing Device

a) The blowdown thrust at the time of rupture is calculated by equation 6.1, using the fluid properties at normal operating conditions. The calculated blowdown thrust is assumed to develop instantaneously at rupture, and remains constant until the fluid reservoir has dissipated.

b) The energy to be absorbed by the Energy-Absorbing Device from the whipping pipe is calculated to be the steady-state blowdown force times the distance the pipe travels, less the rotational strain energy developed in the pipe at the hinge point. The rotational strain energy may be set equal to zero for conservatism. The distance traveled by the pipe is considered to be the distance between the face-of-pipe and the face of the Energy-Absorbing Device plus the deflection of the Energy-Absorbing Device and the deflection of the restraint structure.

c) The energy to be absorbed by the Energy-Absorbing Device in "b" above is equated to the energy absorbing capability of the device as represented by its force-deflection curve. For an Energy-Absorbing Device whose response is represented by a bi-linear force deflection curve, the resulting equation is

$$F(g + d + \Delta) = \tfrac{1}{2} P_E d_E + P_E (d - d_E) + \tfrac{1}{2}(P - P_E)(d - d_E) + \frac{P\Delta}{2}$$

where

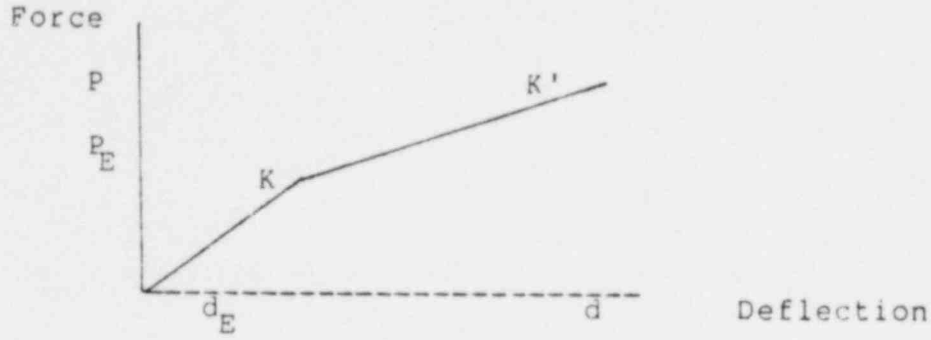
F = blowdown thrust force
g = gap distance
d = deflection of the Energy-Absorbing Device required to bring the whipping pipe to rest

P_E = yield force of bi-linear force-deflection curve

d_E = deflection at yield on force-deflecion curve

P = Energy-Absorbing Device maximum force

Δ = Elastic deflection of the restraint structure at load



Bi-linear force-deflection curve

In addition to the maximum deflection and force calculated above, optionally a time history of force and deflection may be obtained by computer techniques using a single-degree-of freedom model of the whipping pipe impacting an Energy-Absorbing Device described by the bi-linear force-deflection curve.

A.3.1.2 Analysis of Restraint Structural System

The maximum load realized by the structural system will be the maximum load transferred by the Energy-Absorbing Device (designated as P in Section A.3.1.1), times the Dynamic Amplification Factor.

$$F_{restr} = P \times DAF$$

where: F_{restr} = Force imposed on the Structural System

DAF = the Dynamic Amplification Factor

The dynamic amplification of the structural system is a function of the dynamic loading, the frequency of the Structure and the structural damping. If the structural damping is conservatively assumed equal to zero, and the dynamic loading assumed to be an instantaneously applied constant load, the Dynamic Amplification Factor for a single degree-of-freedom system can be written as follows:

$$DAF = 1 - COS(wt)$$

where: w = The frequency of the simple degree-of-freedom system representing the structural system
t = Length of time after initial loading

The maximum Dynamic Amplification Factor for the assumed conditions is equal to 2.0.

If the maximum Dynamic Amplification factor is applied to the restraint structure, the resulting loads transmitted to the plant structure can be treated as equivalent static forces.

A.3.2 Detailed Method

The larger and more complex piping and restraint systems sometimes require more detailed analysis than can be provided by the energy balance method. When these circumstances are encountered, one of the analytical methods outlined below is used:

a) Complete System Dynamic Time History Analysis

The piping and pipe whip restraint system is modeled in sufficient detail to reflect its dynamic characteristics. The lumped-mass approach is employed. Inertia and stiffness effects of the system, and gaps between piping and the restraints, are included. The pipe rupture time history forcing function(s) is applied and time history responses of restraint loads, pipe deformations, etc., are computed by numerical integration. This approach requires the use of digital computer programs.

b) Simplified Dynamic Time History Analysis

A dynamic time history analysis of a portion of a piping system is performed instead of an analysis of the complete system. Consideration is given to dynamic coupling and forcing functions acting on the complete system in the representation of the flexibility and inertial effects of the remainder of the system.

c) Quasi-Dynamic Time History Analysis

Dynamic time history analysis is performed on representative systems to develop design data in the form of curves, graphs, etc., to be used for restraint location and design. The study should be parametric in nature, considering dynamic coupling, system forcing functions, the effects of gaps, support flexibilities, the pipe size, and schedule. This approach allows interpolation between the calculated data, and therefore avoids continued reanalysis of standard designs due to small changes in a particular parameter.

A.4 Piping Design Limits

Whipping pipes are considered to be controlled when the motion of the pipe is halted, or when the pipe is prevented from impacting essential components. In order to verify that pipe motion will be controlled, the energy absorbed in the pipe and restraint system during the dynamic event is shown to be less than their energy-absorbing capacity.

When the energy balance method is used, the energy-absorbing capacity of the pipe is considered to be the rotational strain energy of the pipe at the hinge point; when more detailed methods are used, the energy-absorbing capacity of the pipe is determined from the total force-displacement characteristics of the pipe as determined by analysis.

In order to assure stability of the pipe after the dynamic event, the load-carrying capacity of the pipe is shown to be greater than the loads imposed by the steady-state blowdown thrust.

A.4.1 Material Properties

Because higher yield strengths are developed during dynamic loading, a 10% increase in the minimum specified yield strength of the process pipe, S_y, is used in the dynamic analysis. Material properties of the pipe are based on the data provided in Section III of the ASME Boiler & Pressure Vessel Code.

APPENDIX B BLOWDOWN FORCES AND METHODS OF CALCULATION

All high-energy pipe breaks are assumed to occur within one milli-second and result in either a circumferential or longitudinal rupture as defined in Section 3. Circumferential and longitudinal breaks are not assumed to occur simultaneously.

B.1 Frictional Losses

In calculating forces acting on the piping system, credit is taken for any restrictions or line losses between the break and the pressure reservoir(s). Typical restrictions to flow which are considered are: orifices, nozzles, valves, reduced cross sections, spargers, friction, and elbows.

B.2 Closed-End Lines

Depending upon the proximity of the closed-end of the line (dead end or normally closed valves) to the postulated break, if it is shown that the energy contained within the line is insufficient to cause pipe whip, the pipe whip response is not considered. However, the effects of jet impingement on non-whipping closed-end or limited flow lines are evaluated.

B.3 Calculation of Fluid Reactions

The simplified method used to calculate blowdown forces utilizes the following formula:

$$T_{SS} = C_T A P_o$$

where C_T = Steady-state thrust coefficient.

P_o = Initial total pressure in the pipe.

A = Break area of the pipe.

T_{SS} = Steady-state blowdown force.

Steady-state forces are assumed to be reached instataneously at the time of rupture and to remain constant with time thereafter. The steady-state forces are based upon the fluid properties at normal operating conditions. Figure B.1 shows typical pipe reaction rupture thrust force transients for friction and frictionless flow from a constant-pressure.

The steady-state thrust coefficient is dependent on the fluid properties and frictional characteristics of the pipe. In the following subsections, the steady-state thrust coefficient (C_T) is established as a function of the fluid state for incorporation into Eq. B-1.

B.3.1 Saturated Gas-Liquid Mixtures

Predictions of steady-state saturated gas-liquid, or two-phase mixture, flows have been made by several investigators, notably Henry and Fauske, and Moody. Moody's work generally overpredicts flow (and therefore thrust coefficient)for all but low-quality cases and non-equilibrium flow. The steady-state frictionless thrust coefficient as predicted by Moody is shown in Figure B-2. Henry and Fauske's work has been used for calculation of low-quality flowrates and subcooled blowdown; this is discussed in the following subsection.

B.3.2 Subcooled Gas-Liquid Mixture

The steady-state frictionless thrust coefficient for subcooled liquid will be between the values for gas, $C_T = 1.26$, and for liquid, $C_T = 2.0$, as shown in Figure B-2. Flashing occurs very close to the exit plane, if not just beyond, depending on frictional losses in the pipe. Effects of friction on subcooled blowdown are shown in Figure B-3.

B.3.3 Subcooled Water

Figure B-4 gives the subcooled water thrust coefficient as a function of total (stagnation) enthalpy, h_o, for total (stagnation) pressures, P_o, ranging from 800 to 2400 psi. These results were calculated using the Henry-Fauske technique developed for application to subcooled water, saturated water, and low-quality steam-water mixture blowdown through nozzles. The model is based on homogeneous non-equilibrium flow process. This method is not applicable to the case of long pipes with friction, and assumes there is negligible flashing at the exit.

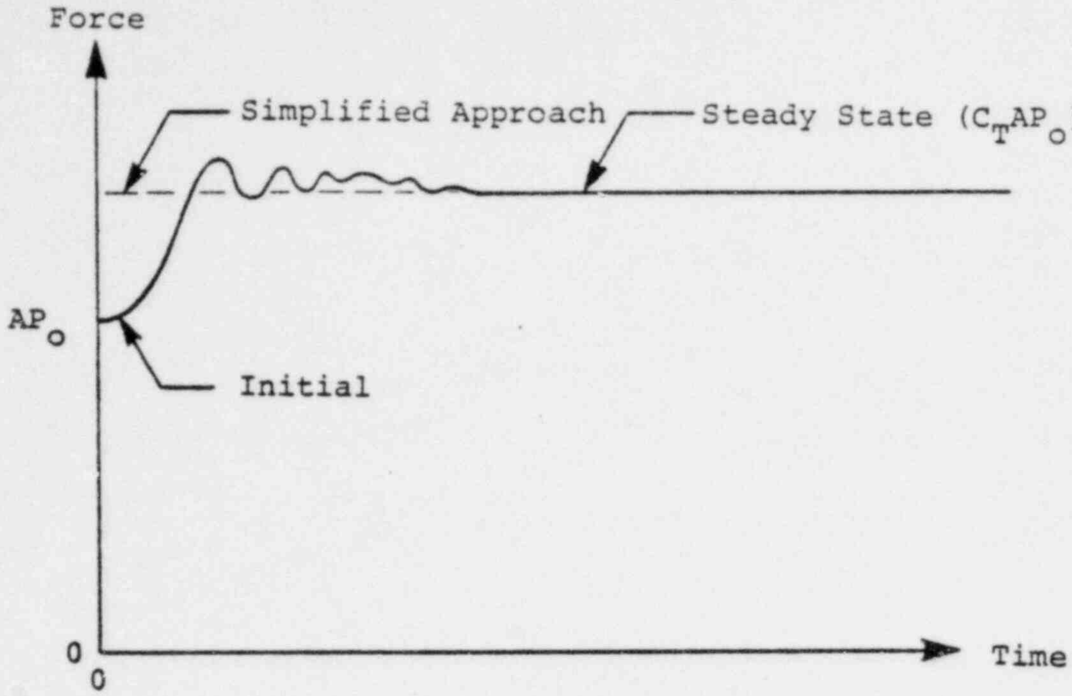
Figures B-5 and B-6 give the thrust coefficient for the case of subcooled water blowdown through long pipes with friction. Smooth entrance geometry is assumed. Flashing may occur in the pipe or at the exit plane. This model is also based on a homogeneous non-equilibrium flow process. This method gives the maximum (critical) mass flowrate, exit pressure, and exit quality in terms of stagnation pressure and enthalpy of initially subcooled or staurated water by calculating the pressure losses due to acceleration at the pipe entrance, flashing in the pipe and pipe friction.

B.3.4 Incompressible Liquid

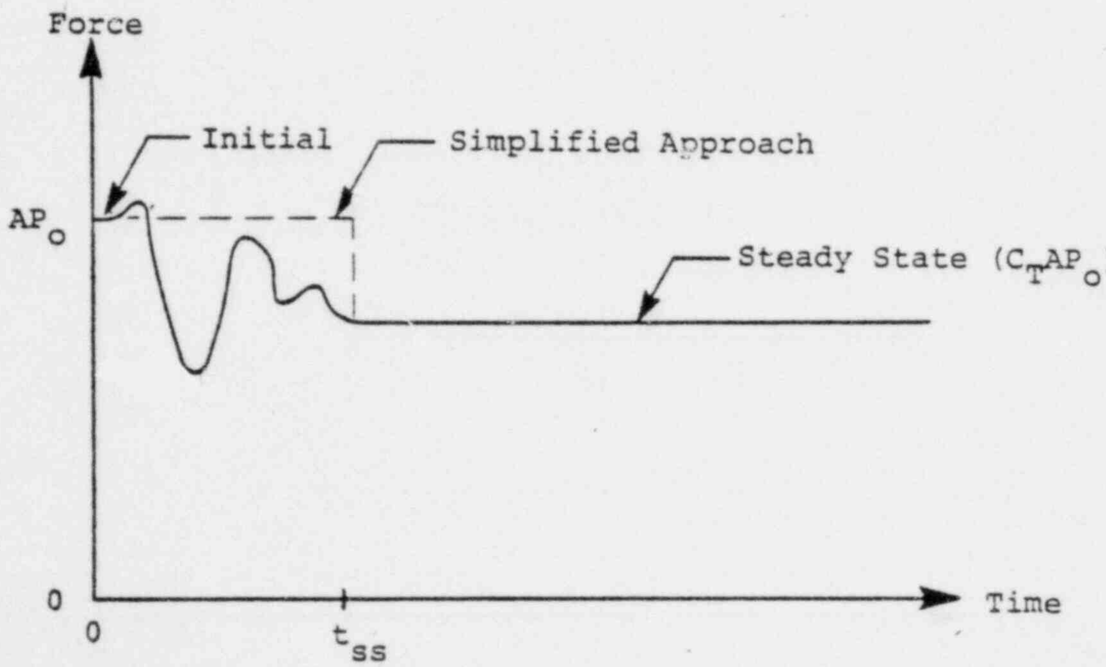
Blowdown of cold water is treated as flow of an incompressible liquid. The expression for the thrust coefficient is:

$$C_T = \frac{2}{1 + fL/D} \qquad \text{(B-2)}$$

This is seen as the lower curve in Figure B-3.



(a) Very Low Friction ($C_T \simeq 1.0$)



(b) Friction (C_T < 1.0)

FIGURE B-1 PIPE RUPTURE REACTION THRUST FORCE TRANSIENT

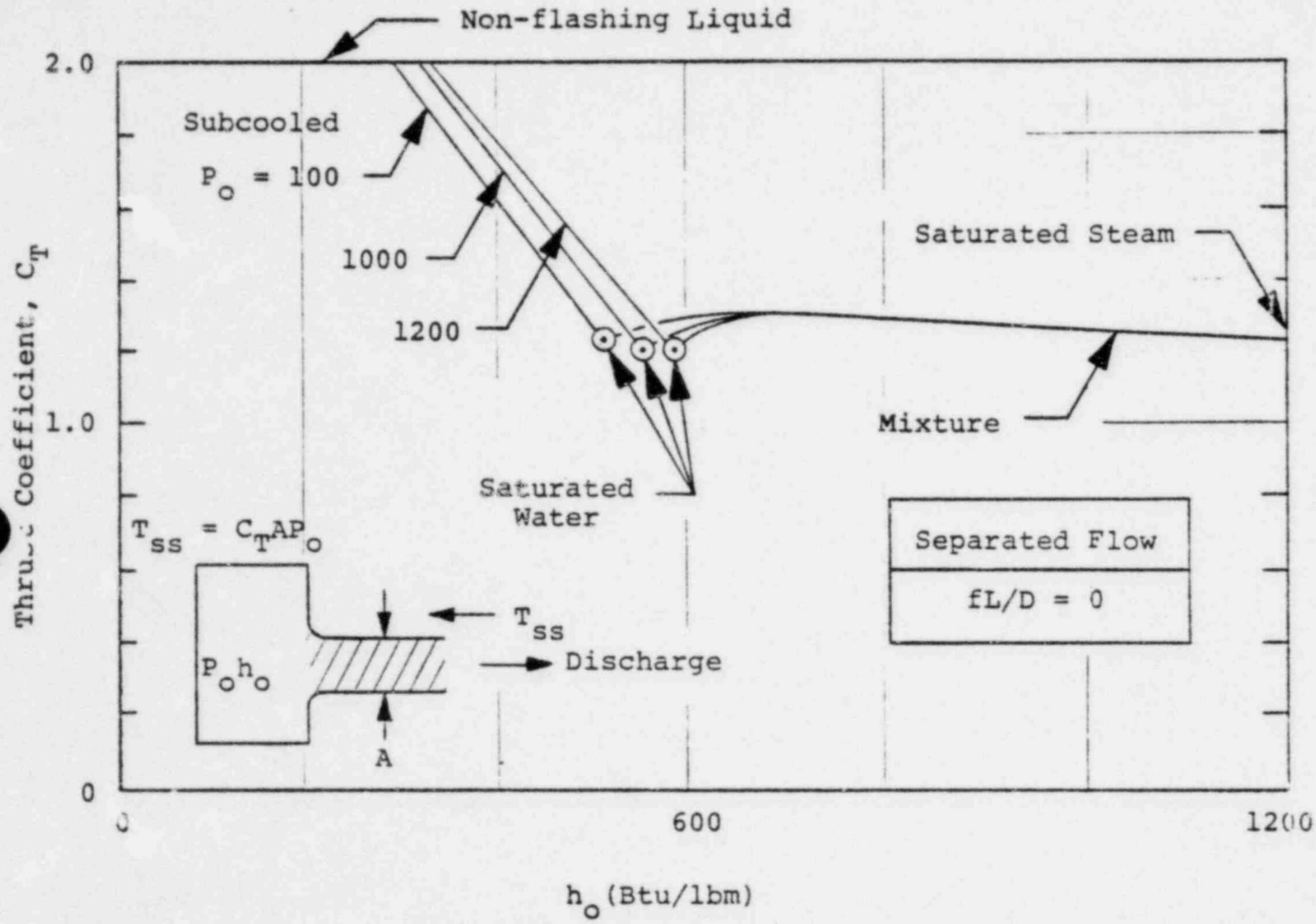


FIGURE B-2

MOODY'S STEADY-STATE SEPARATED FLOW THRUST COEFFICIENT WITHOUT FRICTIONAL EFFECTS

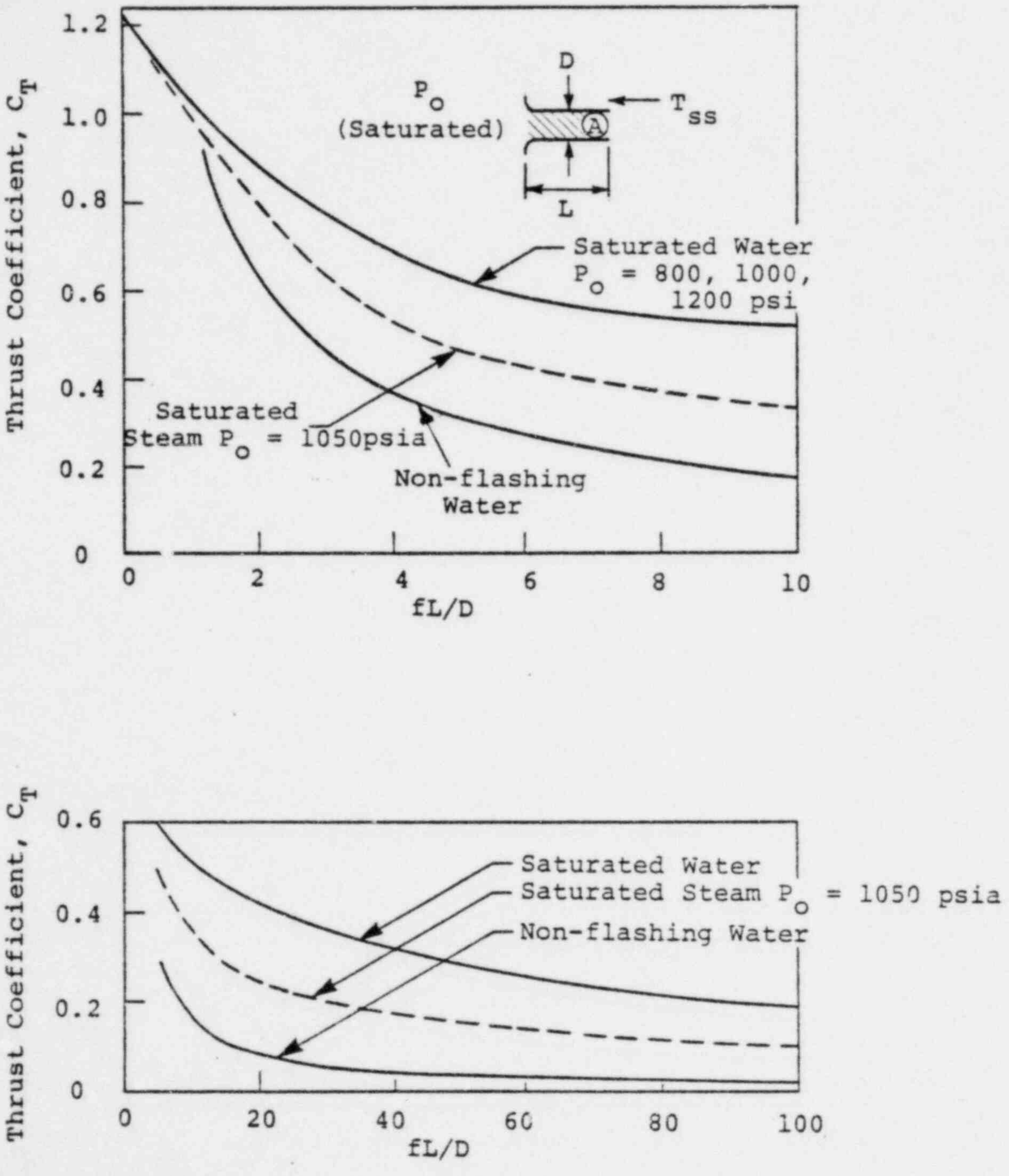


FIGURE B-3 FRICTION EFFECT ON STEADY BLOWDOWN FORCE

FIGURE B-4 THRUST FORCE AS A FUNCTION OF STAGNATION ENTHALPHY, h_o, and PRESSURE, P_o
(Henry-Fauske Model)

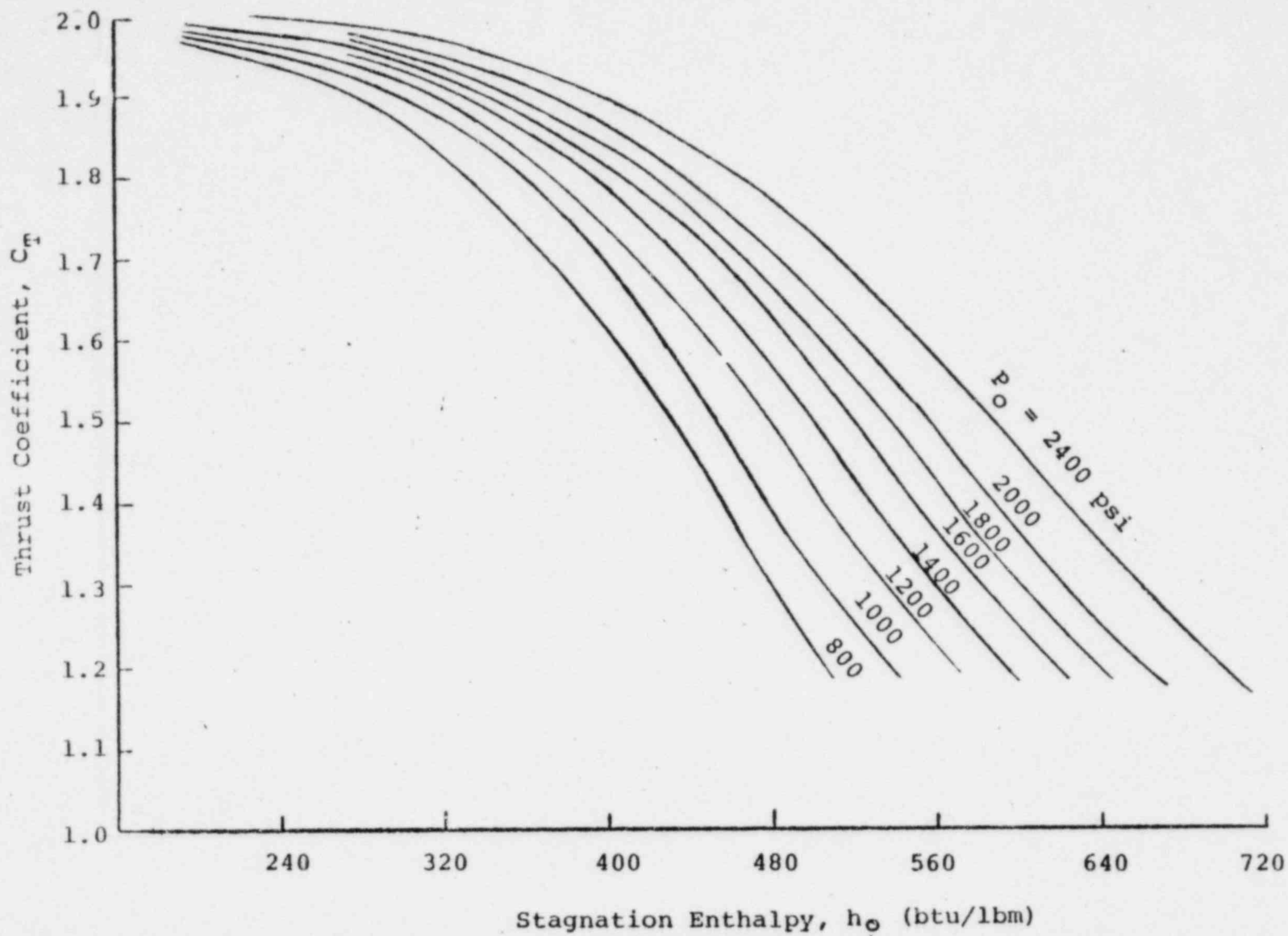


FIGURE B-5 SUBCOOLED WATER BLOWDOWN THRUST FORCE AS A FUNCTION OF STAGNATION ENTHALPHY FOR VARIOUS VALUES OF PIPE FRICTION PARAMETER, fL/D

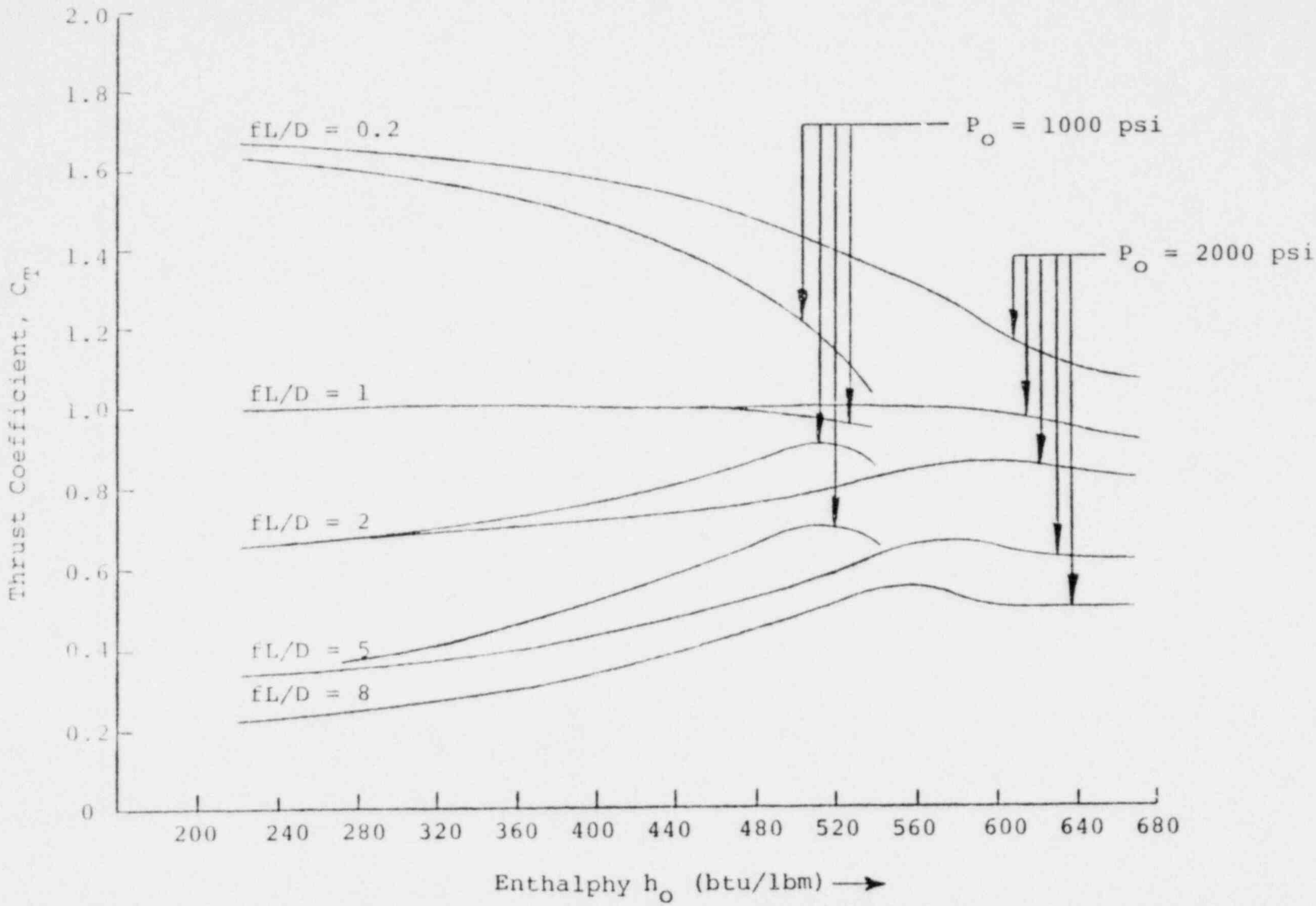
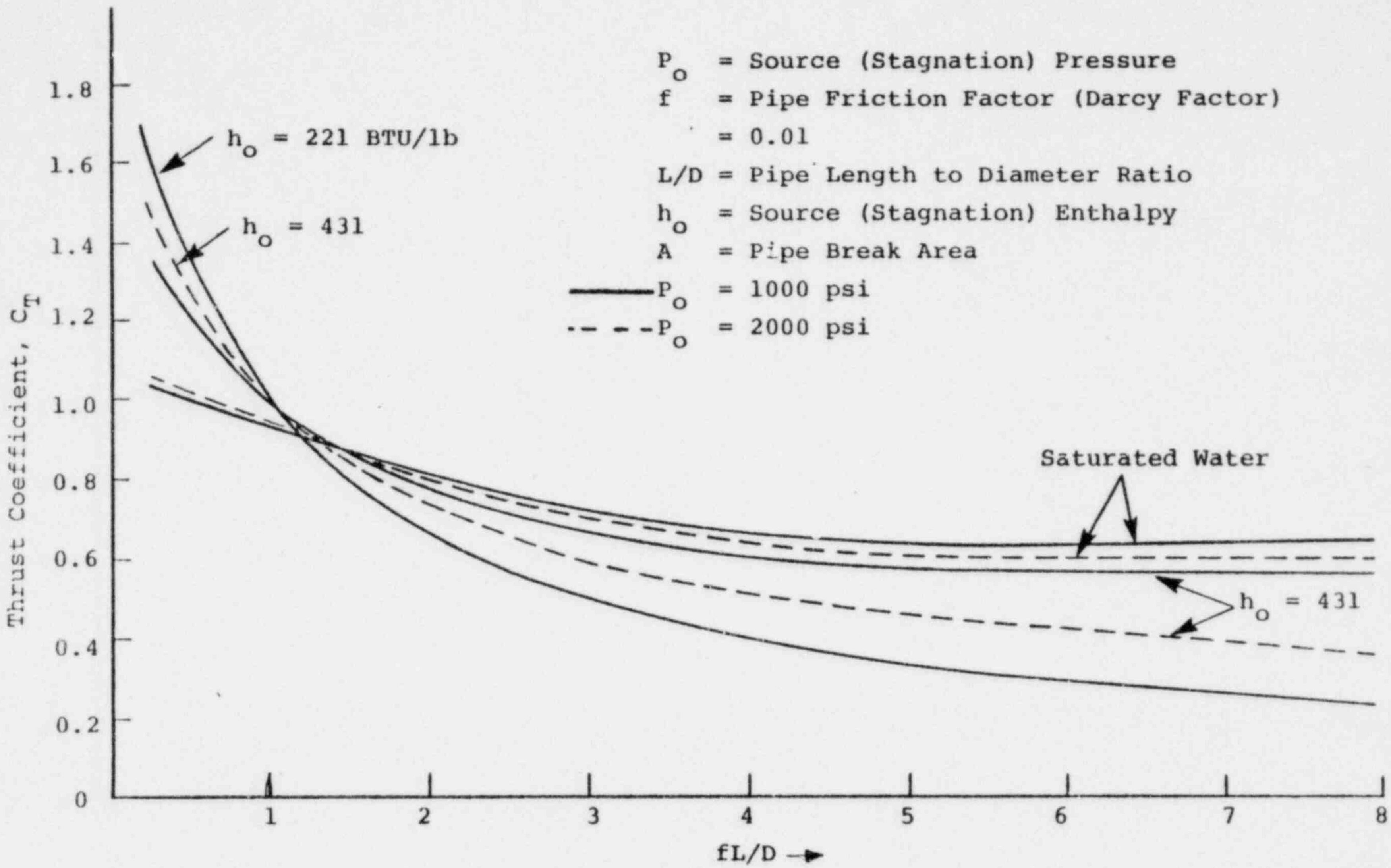


FIGURE B-6 WATER BLOWDOWN THRUST FORCE AS A FUNCTION OF PIPE FRICTION PARAMETER, fL/D, FOR VARIOUS STAGNATION ENTHALPIES



APPENDIX C

Break Postulation on the Main Steam,
Feedwater and Auxiliary Feedwater Systems
Inside Containment

C.1 INTRODUC ION

This appendix presents the results of the evaluation of effects of postulated pipe failures inside containment for the Main Steam, Feedwater and Auxiliary Feedwater Systems of McGuire Nuclear Station. The appendix describes criteria and procedures used in the analysis as developed from the Nuclear Regulatory Commission Branch Technical positions APCSB 3-1 and MEB 3-1. The intent of this appendix is also to comply with Regulatory Guide 1.46. All the terminal ends and intermediate breaks in high energy piping have been analyzed. Some break locations are subject to change if as-built stress conditions are different. Postulated rupture locations and types were determined in accordance with the criteria of Section C.3. Systems and equipment essential to achieve safe plant shutdown and mitigate effects of piping failures were determined in accordance with Section C.4. Sections C.5 and C.6 provide the methods used to evaluate possible damage and the results of the evaluation. All required mitigative devices are identified in Section C.6.

C.2 PIPING LAYOUT

Main Steam and Feedwater piping represent the greatest damage potential from pipe ruptures inside containment due to their large size and high operating pressure. The Main Steam lines are enclosed within guard pipe from the steam generator nozzles to the containment penetrations. While the possibility for structural damage resulting from main steam ruptures in the containment does exist, potential consequences are minimized by this layout. Careful attention has been given to location of essential components and routing of piping systems to minimize the effect of piping failure.

C.3 CRITERIA FOR POSTULATING RUPTURES

Refer to Section 3.0 of the main body of this report for criteria for the feedwater and auxiliary feedwater systems. Breaks on the main steam system are chosen based on consequence as described in FSAR Table 3.6.5-1.

C.4 SYSTEMS AND EQUIPMENT EVALUATION

Refer to Section 4.0 of the main body of this report.

C.5 DAMAGE EVALUATION

A damage evaluation has been performed for each of the breaks postulated by application of the criteria in C.3. Main Steam, Feedwater and Auxiliary Feedwater lines have been provided with pipe rupture restraints for all postulated break locations having unacceptable targets in the containment. This ensures that essential systems, structures and components are not damaged. Pipe rupture restraints are designed using methods of Section 5.0 of the main body of the report and Appendix A.

C.6 SUMMARY AND CONCLUSIONS

In the following sections, the analysis of postulated high energy piping failure is summarized. These sections include the effects of the breaks and the plant modifications required to mitigate the effects.

C.6.1 Pipe Whip and Jet Impingement Effects

In accordance with the criteria and methods of Sections C.4 and C.5, Tables C-1 through C-3 have been prepared to identify each high energy break considered in this analysis which results in unacceptable consequences. Pipe whip restraints, jet impingement barriers, guard pipes or other mitigative devices provided are listed in Tables C-4 through C-6. The criteria used for design of these devices is presented in Appendix A.

C.6.2 Main Steam System

The main steam system has the greatest potential for damage from postulated pipe breaks. The pipe size, the operating temperature and pressure, and the large amount of stored energy dictates the most thorough review with respect to pipe rupture effects. The Main Steam system has been provided with guard pipe to limit pipe movement and restrict blowdown flow rates in the event of a process pipe failure inside the guard pipe. Main steam breaks are chosen based on consequence as described in FSAR Table 3.6.5-1. Pipe rupture restraints are provided for each postulated break to assure that essential structures and components are not damaged. Only circumferential breaks are postulated since the stress at all locations is less than 0.8 (1.2Sh + SA). Figure C-6-1 shows postulated breaks on the main steam system isometric drawing.

C.6.3 Feedwater System

Feedwater break locations are postulated at the steam generator nozzles as indicated in Figure C-6-2. No intermediate breaks are postulated inside the containment since the stresses are less than 0.4 (1.2Sh + SA) at all locations. It should be noted that main steam and feedwater penetrations are free floating and do not constitue an anchor. Pipe rupture restraints are provided for postulated feedwater breaks to ensure that essential components and structures are not damaged. Pipe break locations are listed in Table C-2 and results of the damage evaluation are given in Table C-5.

C.6.4 Auxiliary Feedwater System

Break locations for the Auxiliary Feedwater System are postulated as shown on Figure C-6-3.1 and C-6-3.2. The Auxiliary Feedwater penetrations are the floating type and do not constitute anchors. Stresses in the auxiliary feedwater lines fall between 0.4 (1.2Sh + SA) and 0.8 (1.2Sh + SA). The distribution is such that intermediate break locations for only one loop are postulated inside containment. Pipe rupture restraints are provided for all the breaks causing unacceptable interactions. Pipe break locations are listed in Table C-3 and results of the damage evaluation are given in Table C-6.

TABLE C-1

High Energy Pipe Break Locations
For Main Steam Line Inside Containment

Break Number	System	Description	Figure No.	Location	Stress Ratio To Allowable(1)
SM1-01R	Main Steam	Terminal End at Steam Generator 1A Nozzle	C-1	RB-E1.809	Terminal End Break
SM1-02R	Main Steam	At top of Main Steam Riser at outlet of second elbow downstream of Steam Generator 1A	C-1	RB-E1.813	Intermediate Break
SM1-03R	Main Steam	At outlet of third elbow downstream of Steam Generator 1A	C-1	RB-E1.760	Intermediate Break
SM1-04R	Main Steam	Terminal End at Steam Generator 1B Nozzle	C-1	RB-E1.809	Terminal Break
SM1-05R	Main Steam	At top of Main Steam Riser at outlet of second elbow downstream of Steam Generator 1B	C-1	RB-E1.813	Intermediate Break
SM1-06R	Main Steam	At outlet of third elbow downstream of Steam Generator 1B	C-1	RB-E1.760	Intermediate Break
SM1-07R	Main Steam	Terminal End at Steam Generator 1C Nozzle	C-1	RB-E1.809	Terminal Break
SM1-08R	Main Steam	At top of Main Steam Riser at outlet of second elbow downstream of Steam Generator 1C	C-1	RB-E1.813	Intermediate Break
SM1-09R	Main Steam	At outlet of third elbow downstream of Steam Generator 1C	C-1	RB-E1.760	Intermediate Break
SM1-10R	Main Steam	Terminal End at Steam Generator 1D Nozzle	C-1	RB-E1.809	Terminal Break
SM1-11R	Main Steam	At top of Main Steam Riser at outlet of second elbow downstream of Steam Generator 1D	C-1	RB-E1.813	Intermediate Break
SM1-12R	Main Steam	At outlet of third elbow downstream of Steam Generator 1D	C-1	RB-E1.760	Intermediate Break

TABLE C-2

High Energy Pipe Break Locations For Feedwater Lines Inside Containment

Break Number	System	Description	Figure No.	Location	Stress Ratio To Allowable(1)
CF1-01R	Feedwater	Terminal End at Steam Generator 1A nozzle	C-2	RB	Terminal End Break
CF1-02R	Feedwater	Terminal End at Steam Generator 1B Nozzle	C-2	RB	Terminal End Break
CF1-03R	Feedwater	Terminal End at Steam Generator 1C Nozzle	C-2	RB	Terminal End Break
CF1-04R	Feedwater	Terminal End at Steam Generator 1D Nozzle	C-2	RB	Terminal End Break

TABLE C-3

High Energy Pipe Break Locations
For Auxiliary Feedwater Lines Inside Containment

Break Number	System	Description	Figure No.	Location	Stress Ratio To Allowable(1)
CA1-01R	Aux. Feedwater	Terminal End at Steam Generator 1A Nozzle	C-6-3.1	RB	Terminal End Break
CA1-02R	Aux. Feedwater	Terminal End at Steam Generator 1B Nozzle	C-6-3.1	RB	Terminal End Break
CA1-03R	Aux. Feedwater	Terminal End at Steam Generator 1C Nozzle	C-6-3.2	RB	Terminal End Break
CA1-04R	Aux. Feedwater	Terminal End at Steam Generator 1D Nozzle	C-6-3.2	RB	Terminal End Break
CA1-05R	Aux. Feedwater	Intermediate Break at the inlet of elbow C08	C-6-3.1	RB	Intermediate Break
CA1-06R	Aux. Feedwater	Intermediate Break at the outlet of elbow C08	C-6-3.1	RB	Intermediate Break

TABLE C-4

Results of Damage Evaluation

Unacceptable Pipe Whip/Jet Impingement Effects
For Main Steam Line Inside the Containment

Break Number	Type Break	Effect on Required Components	Resolution
SM1-01R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-02R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-03R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-04R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-05R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-06R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-07R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint

(Continued)

TABLE C-4

Results of Damage Evaluation

Unacceptable Pipe Whip/Jet Impingement Effects
For Main Steam Line Inside the Containment

Break Number	Type Break	Effect on Required Components	Resolution
SM1-08R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-09R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-010R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-011R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
SM1-012R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Structural Concrete and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint

TABLE C-5

Results of Damage Evaluation

Unacceptable Pipe Whip/Jet Impingement Effects
For Feedwater Line

Break Number	Type Break	Effect on Required Components	Resolution
CFI-01R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Crane Wall and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
CFI-02R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Crane Wall and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
CFI-03R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Crane Wall and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint
CFI-04R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Crane Wall and essential Piping Systems and Components located Inside Containment	Add Pipe Whip Restraint

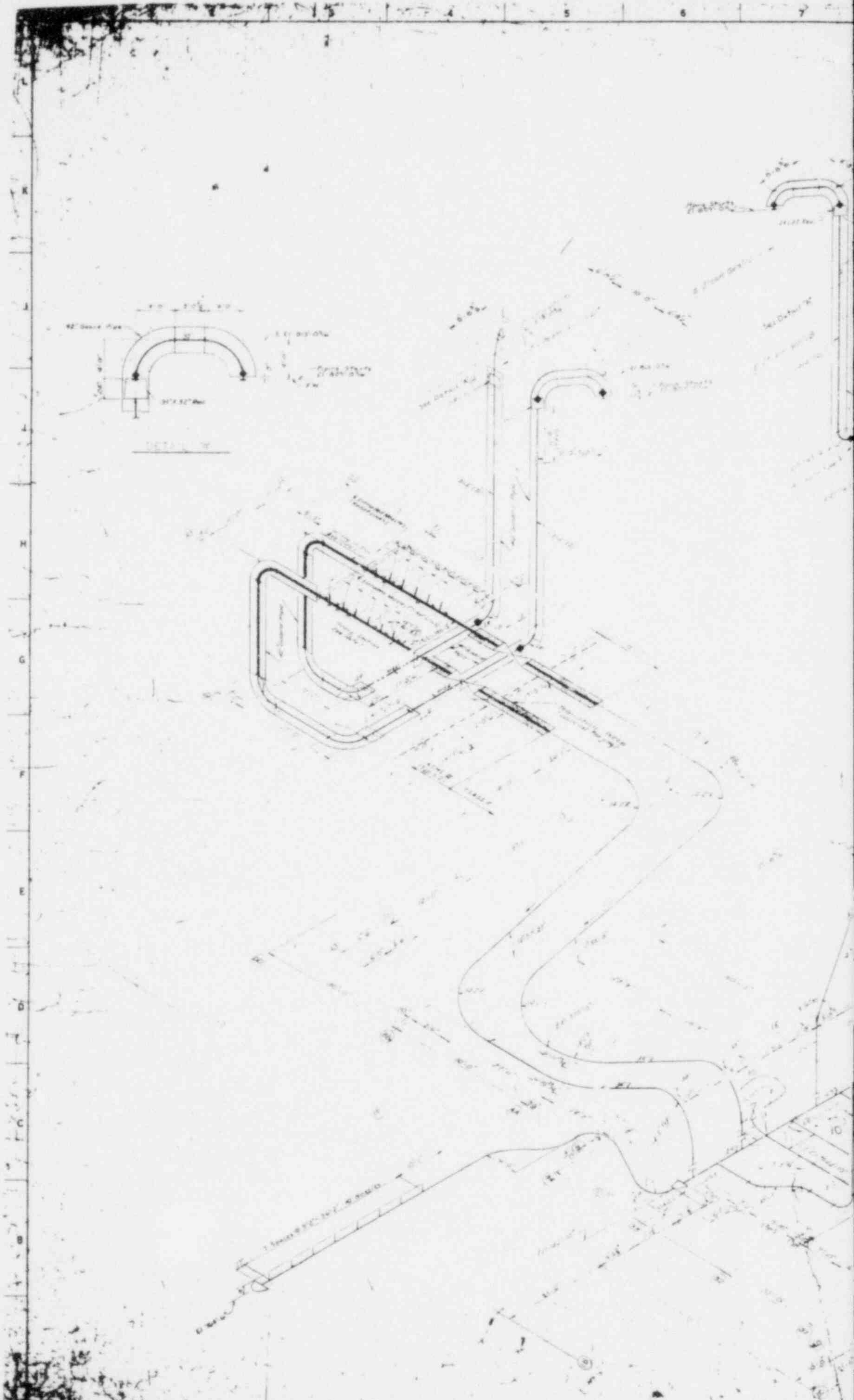
TABLE C-6

Results of Damage Evaluation

Unacceptable Pipe Whip/Jet Impingement Effects
For Auxiliary Feedwater Line

Break Number	Type Break	Effect on Required Components	Resolution
CA1-01R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Steel Enclosure of Steam Generator	Add Pipe Whip Restraint
CA1-02R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Steel Enclosure of Steam Generator	Add Pipe Whip Restraint
CA1-03R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Steel Enclosure of Steam Generator	Add Pipe Whip Restraint
CA1-04R	Circumferential (Forward Flow) (Reverse Flow)	Unacceptable damage to Steel Elosure of Steam Generator	Add Pipe Whip Restraint
CA1-05R	Circumferential (Forward Flow) (Reverse Flow)	Electrical Cable Tray segments 11202 and 11149, 3" NC Line including valve 1NC64, 2" NI Lines including valves 1NI157 and 1NI160	Add Pipe Whip Restraints
CA1-06R	Circumferential (Forward Flow) (Reverse Flow)	Electrical Cable Tray segments 11202 and 11149, 3" NC Line including valve 1NC64, 2" NI Lines including valves 1NI157 and 1NI160	Add Pipe Whip Restraint

Revision 3
New Page



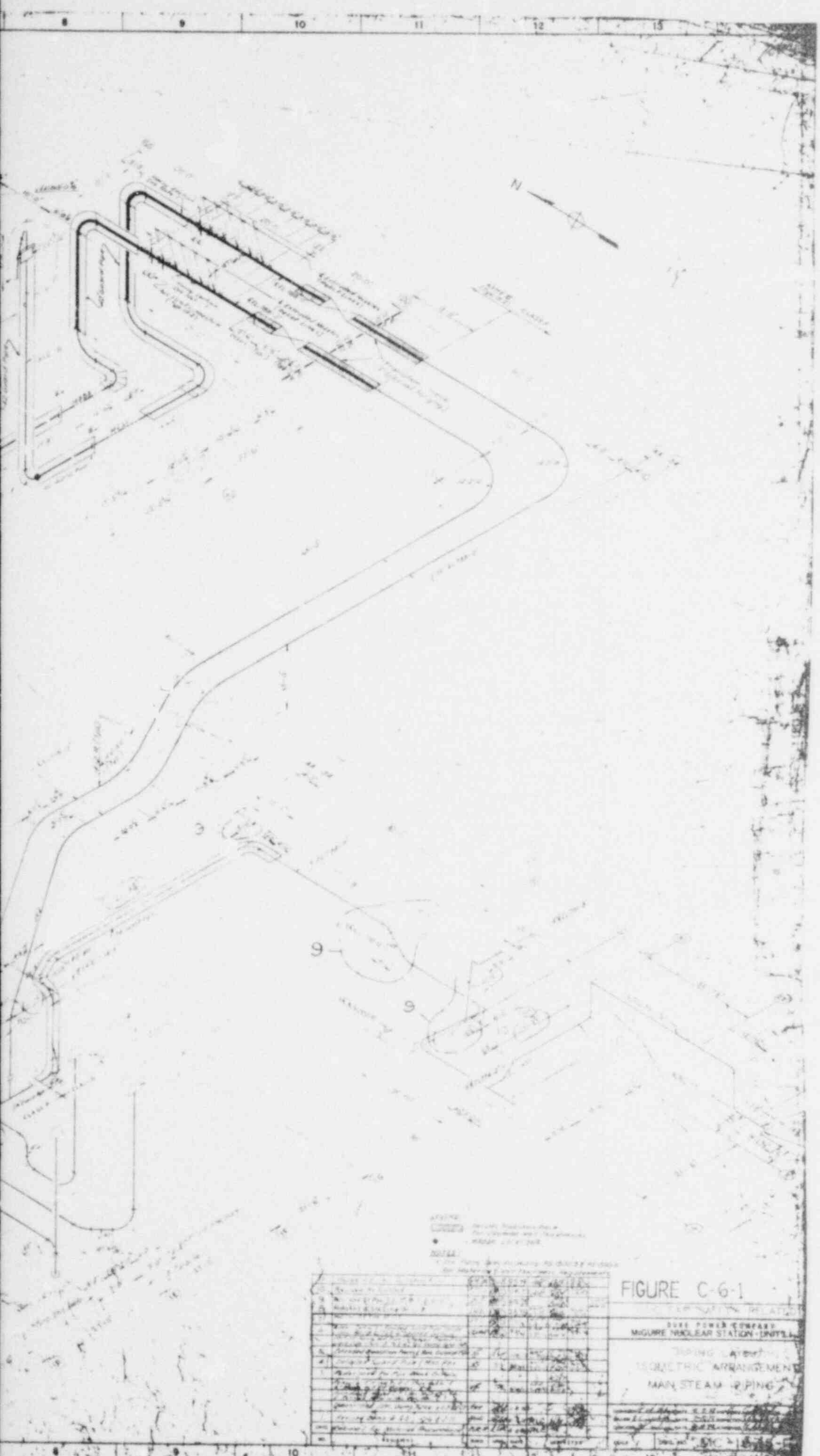


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FIGURE C-6-1
DUKE POWER COMPANY
McGUIRE NUCLEAR STATION
ISOMETRIC ARRANGEMENT
MAIN STEAM PIPING

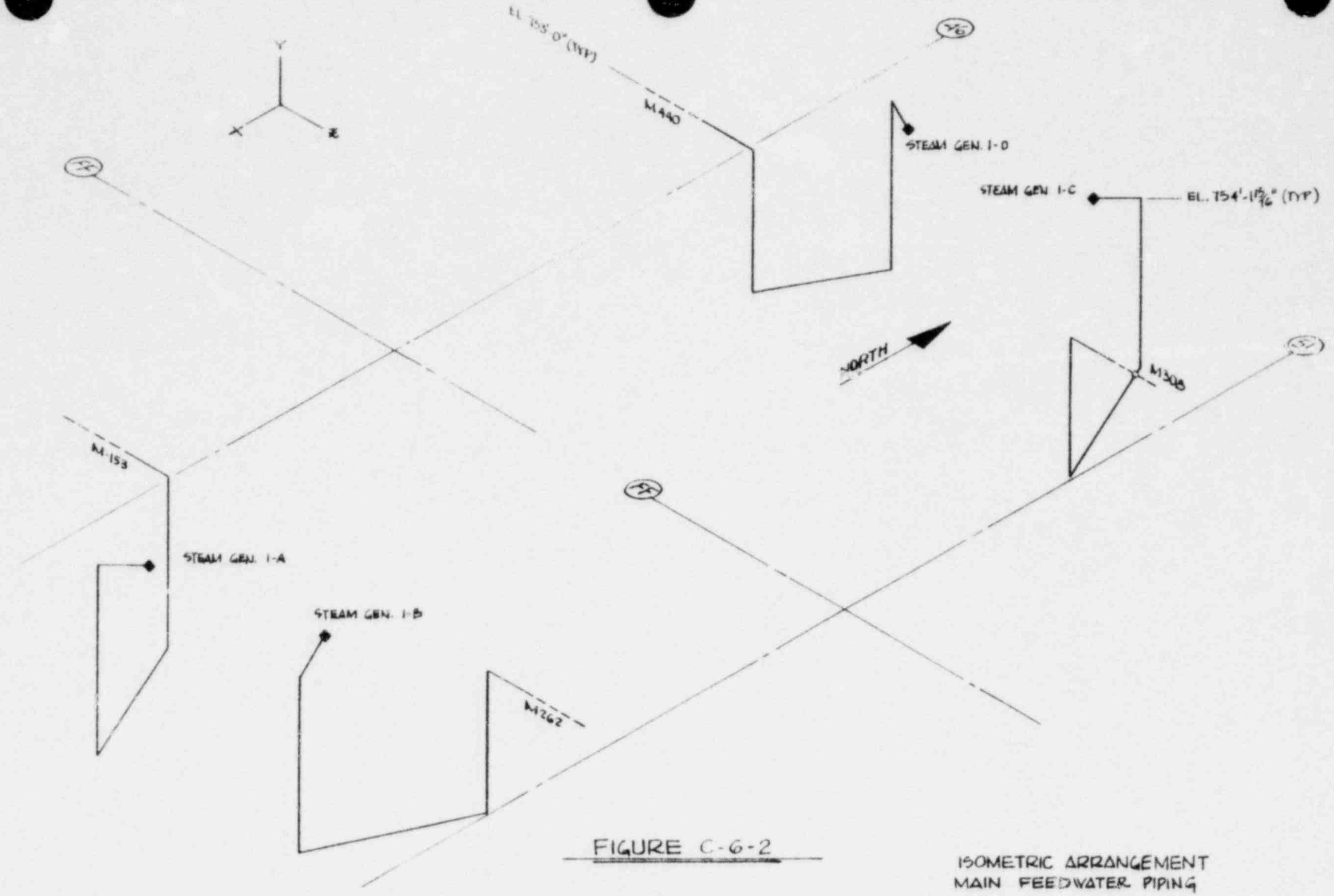

FIGURE C-6-2

ISOMETRIC ARRANGEMENT
MAIN FEEDWATER PIPING

◆ BREAK LOCATION

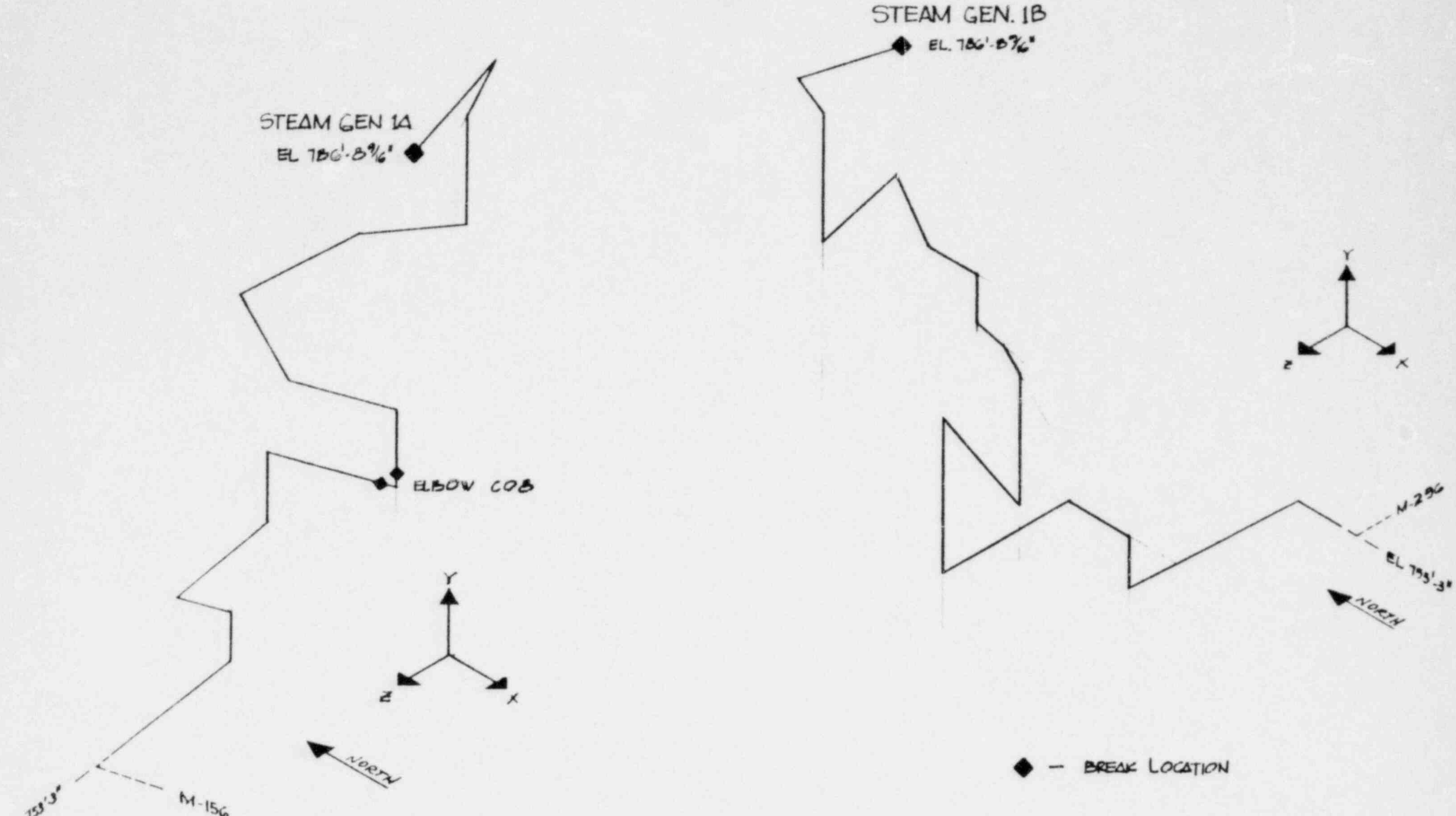

FIGURE C-6-3.1

ISOMETRIC ARRANGEMENT
AUXILIARY FEEDWATER PIPING
6-17-80 REV. 0

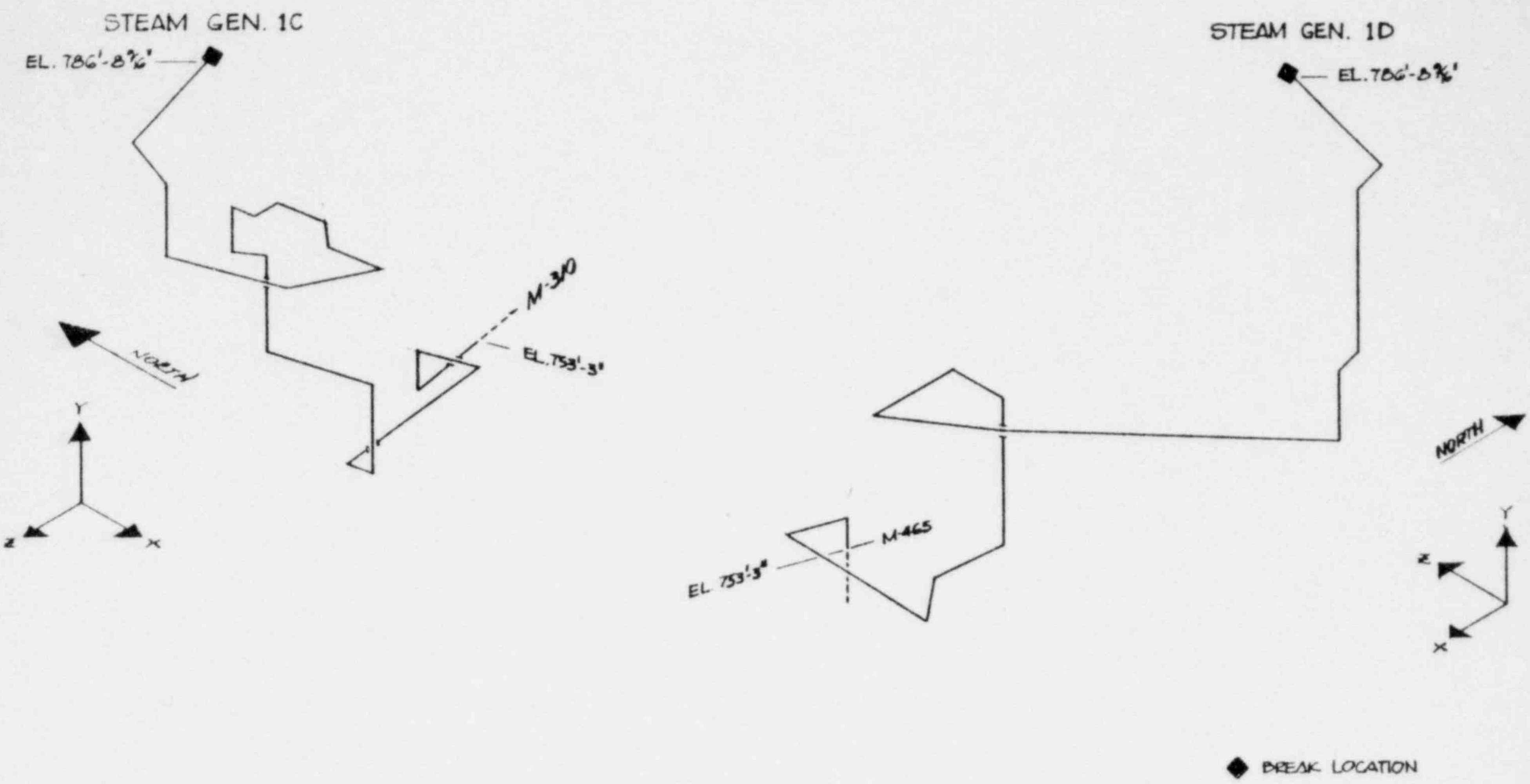

FIGURE C-6-3.2

ISOMETRIC ARRANGEMENT
AUXILIARY FEEDWATER PIPING
6-10-80 REV. 0