DRESDEN NUCLEAR POWER STATION UNITS 2&3

MARK I PLANT UNIQUE ANALYSIS REPORT

VOLUME 5

COMMONWEALTH EDISON COMPANY

SARGENT & LUNDY
ENGINEERS

VOLUME 5

SAFETY RELIEF VALVE DISCHARGE PIPING ANALYSIS

ABSTRACT

The primary containments for Dresden Units 2 and 3 were designed, erected, pressure tested, and ASME Code N-stamped in 1966 for Unit 2, and 1967 for Unit 3. The work was performed for Commonwealth Edison Company by the Chicago Bridge & Iron Company and was carried out in accordance with the Sargent & Lundy (S&L) specification issued in 1965. Since that time of original design and construction, new load requirements have been identified as defined in the Nuclear Regulatory Commission's Safety Evaluation Report, NUREG-0661. These new loads affect the design and operation of the primary containment system. The new requirements include an assessment of additional containment loads, postulated to occur during normal safety relief valve discharge events and loss-of-coolant accidents. The requirements include an assessment of the effect of the original loads and the new loads on the structures which must be within code allowable stresses.

The Plant Unique Analysis Report documents the efforts undertaken to assess and resolve each of the applicable requirements of NUREG-0661. It demonstrates that the design of the primary containment system is adequate, and that the original design safety margins have been restored in accordance with the acceptance criteria of NUREG-0661.

Volume 5, which documents the assessment of the safety relief valve discharge piping, T-Quencher, their supports, and the vent line penetration, is prepared by Sargent & Lundy acting as an agent responsible to the Commonwealth Edison Company. The preparation of Volumes 1 through 4, 6, and 7, and the determination of the loads for which the structures are assessed, is provided by Nutech Engineers Inc., also acting as an agent to Commonwealth Edison Company.

VOLUME 5
SAFETY RELIEF VALVE DISCHARGE PIPING ANALYSIS

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

VOLUME 5
SAFETY RELIEF VALVE DISCHARGE PIPING ANALYSIS

LIST OF TABLES

VOLUME 5
SAFETY RELIEF VALVE DISCHARGE
PIPING ANALYSIS

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

VOLUME 5
SAFETY RELIEF VALVE DISCHARGE
PIPING ANALYSIS

LIST OF ACRONYMS

AISC	American Institute of Steel Construction
ASME	American Society of Mechanical Engineering
ASTM	American Society of Testing and Materials
DBA	Design Basis Accident
DNPS	Dresden Nuclear Power Station
FSAR	Final Safety Analysis Report
IBA	Intermediate Break Accident
ID	Inside Diameter
LOCA	Loss-of-Coolant Accident
MS	Main Steam
NRC	Nuclear Regulatory Commission
OBE	Operating Basis Earthquake
OD	Outside Diameter
PUAAG	Plant Unique Analysis Application Guide
PUAR	Plant Unique Analysis Report
RPV	Reactor Pressure Vessel
SBA	Small Break Accident
SIF	Stress Intensification Factor
SRSS	Square Root of the Sum of the Squares
SSE	Safe Shutdown Earthquake
SRV	Safety Relief Valve
SRVDL	Safety Relief Valve Discharge Line
SVA	Single Valve Actuation
USAS	United States of America Standards

VOLUME 5
SAFETY RELIEF VALVE DISCHARGE
PIPING ANALYSIS

LIST OF EFFECTIVE PAGES

VOLUME 5
SAFETY RELIEF VALVE DISCHARGE
PIPING ANALYSIS

LIST OF EFFECTIVE PAGES

5-1.0 INTRODUCTION AND SUMMARY

This volume documents the conformance of the Dresden Units 2 and 3 Safety Relief Valve Discharge Line (SRVDL) piping, T-Quencher, and their supports as well as the vent line penetration, to the requirements defined in NUREG-0661 (Reference 1). The text is divided into the following sections:

a. Introduction and Summary (5-1.0)

b. SRVDL Piping and T-Quencher Inside the Wetwell (5-2.0)

c. SRVDL and Main Steam Piping and Piping Supports Inside the Drywell and the Vent Line (5-3.0)

d. SRVDL Piping Supports in the Wetwell (5-4.0)

e. Vent Line Penetration and Attachments (5-5.0).

This introduction and summary section provides an overview, a discussion of the scope of analysis and evaluation, and a concluding summary statement. The remaining sections describe the comprehensive evaluation, and provide the results of the analysis throughout the following subsections:

a. Component Description

b. Loads and Load Combinations

c. Acceptance Criteria

d. Method of Analysis

e. Analysis Results

Each section addresses in detail the above subjects and presents results which indicate that the structures and components are within the Code allowable stresses for the applicable loads and load combinations.

5-1.1 Scope of Analysis

The reassessment of the SRV piping, T-Quencher, and their supports in the wetwell and the vent line penetration is performed using the general criteria presented in Volume 1 as the basis for the Dresden Units 2 and 3 SRV piping evaluation described in this volume. The loads are discussed in Volume 1 and are based on the Mark I Containment Program Load Definition Report (Reference 2) and the NRC's Safety Evaluation Report, NUREG-0661.

The SRV discharge loads and the LOCA related loads used in this evaluation are determined using procedures and test results which include the effects of the plant unique geometry and operating parameters contained in the Plant Unique Load Definition Report (Reference 3). Original design loads such as seismic loads, which have not been redefined by NUREG-0661, such as seismic loads, are the same as defined in the station's Final Safety Analysis Report (Reference 4).

The evaluation includes the performance of a structural analysis of the SRV piping, T-Quencher, and their supports for the SRV discharge related loads and LOCA related loads to verify that their design is adequate. Rigorous analytical techniques are used in this evaluation by means of detailed models and refined methods to compute the dynamic response of the SRV piping and T-Quencher. The loads are input as static, quasi-static, or dynamic loads, and the interaction between the torus and SRV line supports due to the loads is considered.

The results of the structural analysis for each load are combined in load combinations in accordance with the requirements of the "Mark I Containment Program Structural Acceptance Criteria and Plant Unique Analysis Applications Guide" (Reference 5) and NUREG-0661. The analysis results are compared with the applicable acceptance limits specified by the Plant

Unique Analysis Application Guide, the ASME Code and NUREG-0661 for the SRV piping, T-Quencher and vent line penetration, and with the acceptance limits specified by the AISC Code for the piping supports and the T-Quencher supports. Fatigue effects are evaluated and compared to allowable stresses where required.

The reassessment of the Main Steam (MS) headers and SRVDL piping inside the drywell and vent line is performed using current pipe modeling and analysis techniques. The MS and SRVDL piping are evaluated for the effects of the original loads as stated in the design specification (Reference 6). In addition to the original loads, the SRVDL is evaluated for seismic loads in accordance with the Mark I Owners' Group commitment to upgrade the SRVDL piping in the drywell to a seismically qualified system. Other loads which are considered in the evaluation of the SRVDL piping include SRV discharge transient loads using refined state-of-the-art techniques and additional temperature loads resulting from postulated accidents.

5-1.2 Summary and Conclusions

An evaluation of the Dresden Units 2 and 3 SRVDL piping, vent line penetration, piping supports, T-Quencher, and T-Quencher supports is performed as described in Subsections 5-2.1, 5-3.1, 5-4.1, and 5-5.1.

The loads considered in the evaluation consist of the original loads documented in the FSAR plus additional loadings which are postulated to occur during SBA, IBA or DBA LOCA related events and during SRV discharge events as defined generically in NUREG-0661.

Detailed structural models are developed and utilized in calculating the response of the entire SRVDL piping system including supports and the vent line penetration. A combination of static, dynamic and equivalent static analyses is performed. The results are appropriately combined according to NUREG-0661 requirements. Results of the analyses are compared to the NUREG-0661 criteria, and the Mark I Program Structural Acceptance Criteria.

The evaluation results show that the piping system, its supports and the vent line penetration meet the requirements of NUREG-0661 and the original acceptance criteria documented in the FSAR.

5-2.0 SAFETY RELIEF VALVE DICHARGE LINE PIPING AND T-QUENCHER INSIDE THE WETWELL

This section describes the structural analyses and stress evaluations of the Safety Relief Valve Discharge Line (SRVDL) piping system in the wetwell. Due to similarities between the two units, and identical piping and support configurations within the wetwell, one representative SRVDL subsystem was analyzed. Bounding loads were developed and applied to this subsystem. The wetwell SRVDL analytical model contains the discharge piping, the T-quencher device, and their supports. Results of the structural piping analyses documented in this section are utilized in the wetwell piping supports evaluation, Section 5-4.0 and in the vent line penetration analysis, Section 5-5.0.

The components of the wetwell SRVDL subsystem are described in Subsection 5-2.1. The loads and load combinations applicable to the piping and supports are described in Subsection 5-2.2. The structural and stress analysis methods are described in Subsection 5-2.4. Piping analysis acceptance criteria and piping analysis results are summarized in Subsections 5-2.3 and 5-2.5, respectively.

A generic fatigue evaluation of wetwell piping, including SRV discharge lines, was performed by the Mark I Owners' Group (Reference 7). This evaluation is based on typical Mark I

wetwell piping systems, and demonstrates that fatigue usage factors are acceptable when cyclic mechanical stress is accounted for in an augmented Class 2/3 fatigue analysis. On this basis, a Dresden plant-specific fatigue analysis of the wetwell SRVDL is not performed. The fatigue analysis of the Class MC portion of the SRVDL at the vent line penetration is required by the Code, and is not related to the generic wetwell fatigue evaluation; it is described in Subsection 5-2.4.3.

5-2.1 Component Description

The SRVDL consists of 8 inch Schedule 80, ASTM A-106, Grade B piping. It is routed through the vent line, and penetrates the bottom of the vent shell into the wetwell airspace. The piping immediately below the vent shell is stiffened with a sleeve and gusset plate arrangement to distribute the pipe load over a larger area on the vent line. A short, 10-inch O.D., ASTM A-106, Grade B spool piece is used at this location, where the gussets are welded to the process pipe. The I.D. of this spool piece matches the 8 inch Schedule 80 piping. The SRVDL is routed downward into the wetwell to the T-quencher discharge device, near the bottom center of the torus bay. A detailed view of the SRVDL-vent line penetration is shown in Figure 5-5.1.

The SRVDL is connected to the T-Quencher discharge device with a 12" x 8" Schedule 80 reducer (ASTM A-234, Grade WPB). The T-Quencher consists of a ramshead and two quencher arms. The ramshead is constructed from 12-inch Schedule XS long-radius elbows (ASTM A-234, Grade WPB) and is stiffened by three gusset plates (ASTM A-36). The T-Quencher arms are 12-inch Schedule 160 perforated and end-capped stainless steel pipes (ASTM A-312, Type 304) oriented along the torus bay longitudinal axis.

The T-Quencher and T-Quencher support beam arrangement is shown in Figure 5-2.1. Details of the ramshead and quencher arms are shown in Figures 5-2.2 and 5-2.3. The SRVDL intermediate support and the T-Quencher support are described in Section 5-4.0.

5-2.2 Loads and Load Combinations

The required loads for the structural analyses of the SRVDL are documented in NUREG-0661 (Reference 1). Volume 1 describes the load generation methodology for the plant-unique analyses. Subsection 5-2.2.1 summarizes the loads which were applied to the wetwell SRVDL subsystem.

Table 5-2.1 provides a cross-reference between the load cases analyzed and the corresponding subsections in Volume 1, where the loads are discussed in more detail.

The required event combinations for piping and supports evaluation are contained in the "Mark I Program Structural Acceptance Criteria Plant Unique Analysis Applications Guide" (PUAAG) (Reference 5), approved by the NRC in Appendix A of NUREG-0661. The governing subsets of load combinations are derived and summarized in Subsection 5-2.2.2.

The method of dynamic response combination for loads within a load combination is discussed in Subsection 5-2.2.3.

5-2.2.1 Loads

The following loads were applied to the wetwell SRVDL subsystem:

1. Dead Weight
2. Temperature
3. Pressure
4. Seismic
5. SRV Discharge
    a. SRVDL Hydraulic Transient (Thrust)
    b. T-Quencher Water Jet

c. T-Quencher Uneven Water Clearing

d. SRV Bubble Drag

e. Torus/Vent System Response (Interaction)

6. Pool Swell

a. Impact and Drag

b. Torus/Vent System Response (Interaction)

7. Condensation Oscillation

a. Drag

b. Torus/Vent System Response (Interaction)

8. Chugging

a. Drag

b. Torus/Vent System Response (Interaction)

Dead weight and seismic loads are original design basis loads. Temperature (thermal expansion) and maximum operating pressure

were also considered in the original design basis, but were redefined based on Mark I Program load generation methodology. The loads identified in items 1 and 2 include displacement analysis caused by the response of the torus and vent system.

The loads identified in item 5 are due to the water and air clearing phenomena of an SRV discharge event.

Loads 6, 7, and 8 are due to postulated LOCA events. Two other LOCA-related loads, namely LOCA water jet drag and LOCA air bubble drag, were determined to be negligible and were not analyzed. Pool fallback loading was determined to be bounded by pool swell loading. Pool swell froth impingement has no impact on the SRVDL, because the SRVDL is not in the froth impingement zone.

A brief description of each load applied to the SRVDL subsystem is provided below.

1. Dead Weight (WGHT): Uniformly distributed weight of pipe components (SRVDL, T-Quencher, support beams, etc.) and lumped weights such as SRVDL collar, quencher arm end-caps, ramshead gusset plates, etc.

2. Temperature

a. Thermal Expansion - Normal Operation (THL1): Maximum operating temperature of SRVDL plus thermal anchor movements under normal plant conditions.

b. Thermal Expansion - LOCA Condition (THL2): Envelope of two cases: (1) Maximum operating temperature of SRVDL plus thermal anchor movements; (2) Ambient temperature applied to SRVDL plus thermal anchor movements. Both cases are for plant conditions during a governing postulated LOCA event.

3. Pressure

a. Maximum Operating Pressure (PMAX): Maximum operating pressure of SRVDL and T-Quencher during SRV discharge event.

b. Design Pressure (PDES): Design condition internal pressure for SRVDL and T-Quencher.

4. Seismic

a. OBE Inertia (OBEI): Horizontal and vertical excitation of subsystem during an operating basis earthquake. This load is from the original design basis.

b. SSE Inertia (SSEI): In accordance with the original design basis, SSE is defined as twice the OBE load.

5. SRV Discharge

a. SRVDL Hydraulic Transient: Transient thrust forces in SRVDL due to SRV actuation. Three governing SRV actuation cases are identified:

A1P1 - Normal operating conditions, first actuation.

C3P1 - Normal operating conditions, subsequent actuation.

C3P2 - LOCA conditions, applicable to both first and subsequent actuations.

b. T-Quencher Water Jet (TQWJ): Water jet impingement drag load on affected submerged piping and supports due to water clearing phase of SRV discharge.

c. T-Quencher Uneven Water Clearing: Water clearing thrust loads on T-Quencher arms. Two cases are analyzed, axial and perpendicular:

UWCA: Thrust loading in the axial direction of quencher arms due to a postulated uneven flow split between the two arms during water clearing.

UWCP: Thrust loading perpendicular to the quencher arms due to a postulated uneven air/water interface during water clearing.

Because these two different loads are independently maximized as defined above, they are combined by SRSS load combinations containing SRV discharge loads.

d. SRV Bubble Drag (SRVD): Pressure loading on submerged piping and supports due to SRV air bubble oscillations. Three drag cases are analyzed, based on the possible bubble arrangements: 4 bubbles, 2 asymmetric bubbles, 2 parallel bubbles.

e. Torus/Vent System Response (SR1I): Inertial interaction loading from structural attachment points on the torus, due to acceleration of the torus during SRV discharge loading. Inertial interaction loading on the vent system penetration, due to acceleration of the vent system during the SRV discharge loading, is negligible.

6. Pool Swell

a. Impact and Drag (PSDG): Impact and subsequent drag load on affected portions of the SRVDL due to pool swell under postulated DBA LOCA.

b. Torus/Vent System Response (PS2I): Inertial interaction loading from structural attachment points on the torus, and vent system due to acceleration of these structures from pool swell loading.

The pool swell loads represent an envelope of operating ΔP and zero ΔP conditions.

7. Condensation Oscillation

a. Drag (CODG): Pressure loading on submerged piping and supports due to downcomer condensation oscillation phenomena during a postulated LOCA event. Fluid-structure interaction effects are considered in the load generation.

b. Torus/Vent System Response (CO2I): Inertial interaction loading from the structural attachment points on the torus and vent system, due to acceleration of these structures during condensation oscillation loading.

8. Chugging

a. Drag (PCDG): Pressure loading on submerged piping and supports due to downcomer chugging phenomena during a postulated LOCA event. Fluid-structure interaction effects are considered in the load generation. Two load cases are considered: pre-chug loads and post-chug loads. Only post-chug was analyzed because it bounds pre-chug.

b. Torus/Vent System Response (PC2I): Inertial interaction loading from the structural attachment points on the torus, due to torus acceleration under chugging loads. Two load cases were enveloped: pre-chug loads, and post-chug loads. Inertial interaction loading on the vent system penetration due to acceleration under chugging loads is negligible.

5-2.2.2 Load Combinations

As discussed in Subsection 5-2.3, the wetwell SRVDL is analyzed as Class 3 piping, except for the portion of piping within the limits of reinforcement at the vent shell penetration. This small portion of pipe is classified as Class MC.

The required event combinations for the Class 3 SRVDL, T-Quencher, and supports evaluation are provided in Table 5-2 (rows 10 and 11) of the PUAAG. For the portion of the SRVDL classified as Class MC, event combination Table 5-1 (row 3) of the PUAAG is applicable. The load combinations analyzed for the various components are based on the PUAAG tables. Smaller subsets of governing load combinations were developed, however.

For the Class 3 SRVDL (including the T-Quencher) and supports, the governing load combinations are shown in Tables 5-2.2 and 5-2.3, respectively. The appropriate Service Level is identified for each combination; for the piping combinations, the applicable Code equation is also provided. Included in these Tables are some original design basis load combinations, required for completeness of the stress evaluations.

Table 5-2.4 shows the correlation between the Class 3 piping and support load combinations analyzed and the event combinations from Table 5-2 of the PUAAG.

For the Class MC SRVDL, the governing combinations are shown in Table 5-2.5. The appropriate Code equations and Service Levels are identified. As discussed in Subsection 5-2.3 the analysis of this portion of the SRVDL is performed with Class 1 piping rules. A design condition load combination is also considered. Table 5-2.6 shows the correlation between the Class MC SRVDL combinations analyzed and the event combinations from Table 5-1 of the PUAAG. All loads associated with SRV discharge (T-Quencher water jet, uneven water clearing, drag, hydraulic transient, and torus response) are conservatively combined, even though the water clearing associated loads and the bubble related loads occur at different times.

5-2.2.3 Dynamic Response Combination

The SRSS method of combining multiple dynamic response is used, as recommended by the Mark I Owners in Reference 8 and approved by the NRC in Reference 25. SRSS is used for all dynamic loads (and dynamic loads analyzed as equivalent static) within a load combination. Drag and structural interaction loading resulting from the same phenomenon were also combined by SRSS, since the load generation methodology independently and conservatively maximizes drag and interaction loads (i.e., no correlation between calculated maximum response for drag and interaction).

5-2.3 Acceptance Criteria

Acceptance criteria for the stress analysis of the wetwell SRVDL piping are based on the PUAAG. Stress allowables are based on the applicable ASME Code Subsections (Reference 9).

The wetwell SRVDL piping and the T-Quencher discharge device are clasified as ASME Code Class 3 for analysis purposes. Acceptance criteria are therefore based on the requirements of Code Subsection ND, and are summarized in Table 5-2.7. Acceptance criteria for the SRVDL and T-Quencher supports in the wetwell are dis-cussed in Section 5-4.0.

The SRVDL within the limits of reinforcement normal to the vent line penetration (both above and below the vent shell) is classified as a Class MC component for analysis purposes. As permitted in Code Subsection NCA, Class 1 piping rules are employed in the stress analysis of this section of the discharge line. Class MC material stress allowables are used, however. Acceptance criteria are therefore based on the requirements of Code Subsection NB, and are summarized in Table 5-2.8. Acceptance criteria for the remainder of the SRVDL-vent line penetration are based on Code Subsection NE, and are discussed in Section 5-5.0.

5-2.4 Method of Analysis

This section describes the analytical methodology used for the wetwell SRVDL. The mathematical model used in the analyses is described in Subsection 5-2.4.1. The structural analysis methods used for the loads summarized in Subsection 5-2.2.1 are described in Subsection 5-2.4.2. The stress and fatigue evaluation methods used for the SRVDL and T-Quencher are described in Subsection 5-2.4.3.

The piping system analyses are performed using the Integrated Piping System Analysis (PIPSYS) computer program (Reference 10). PIPSYS is a linear, three-dimensional space frame, finite element program, which is primarily used to obtain structural responses for static and dynamic loadings. Static loadings may be specified in terms of weight, thermal expansion and displacement loadings. Dynamic loadings may be specified in terms of either response spectra or time histories. The resulting equation of motion is then solved either by modal superposition techniques or by direct integration. Using the results from the static and/or dynamic analyses the program can:

a. calculate stresses for piping systems based on ASME Boiler and Pressure Vessel Code, Section III, with adjustments, or USAS B31.1.0-1967 (Reference 11) specifications,

b. combine reactions due to various loads at supports, restraints, and terminal point (anchors, nozzles) for piping systems.

5-2.4.1 Mathematical Model

As mentioned in the introduction to Section 5-2.0, one representative wetwell SRVDL is analyzed. The PIPSYS model for this subsystem contains the discharge piping, the T-Quencher, and their support members in the suppression chamber. The piping and supports are modeled as a lumped mass, finite beam-element system. Although the vent line penetration is very stiff, a section of the SRVDL within the vent line is included in the wetwell subsystem for a more accurate model. The SRVDL in the vent line is modeled to a point near the jet deflector, at the drywell-vent line intersection.

Spring constants (translational and rotational) are used at the cut-off point of the SRVDL to account for the stiffness of the drywell portion of a typical discharge line.

The SRVDL-vent line penetration is modeled as a flexible anchor by a combination of rigid restraints and spring constants. The T-Quencher and intermediate support beam connections to the torus ring girders are also modeled as flexible anchors. The two SRVDL guides inside the vent line are modeled as rigid restraints.

The loads listed in Subsection 5-2.2.1 are applied to the model and are combined in accordance with the equations of Subsection 5-2.2.2. The major loads occur only in the wetwell and due to the rigid vent line penetration, their effect is small in the vent line portion of the SRVDL. Support reactions and piping stresses in the vent line are discussed in Section 5-3.0.

For dynamic analyses, hydrodynamic mass effects are considered by lumping additional masses at node points on the submerged portion of the system. The mass of water both inside and surrounding the pipe and support elements is considered.

Stress intensification factors (SIF's) are based on Subsection ND of the Code. As permitted by the Code, SIF's for non-standard components are determined by theoretical and/or experimental methods. SIF's were developed for the following non-standard components: vent line penetration (gusset plate attachment to pipe), 45 and 56 elbows, ramshead, and perforated sections of T-Quencher arms. Class 1 stress indices for the SRVDL-vent line shell intersection were also theoretically determined.

Figure 5-2.4 shows the mathematical model of the wetwell SRVDL system.

5-2.4.2 Structural Analysis Methods

Static and dynamic structural analyses were performed for each of the load cases summarized in Subsection 5-2.2.1. Static analyses were used for weight and thermal expansion loads. Pressure loading is accounted for directly in the appropriate Code stress equations.

The remaining loads are dynamic loads, and are analyzed by one of the following methods: response spectrum, force time history (direct integration method), acceleration time history (modal solution), or equivalent static.

Appropriate dynamic load factors are developed and used with the equivalent static analyses. Damping levels used for the dynamic analyses are based on Regulatory Guide 1.61. For the response spectrum analyses, X, Y, Z responses are combined by SRSS. Modal summation is by square root of the absolute double sum. For the force and acceleration time history analyses a sufficiently small integration time step was used.

Table 5-2.9 summarizes the structural analysis methods used.

5-2.4.3 Stress and Fatigue Evaluation Methods

The SRVDL and T-Quencher are analyzed as Code Class 3 piping. Code Subsection ND stress equations, as summarized in

Subsection 5-2.3, are checked for all critical components. Some non-standard stress intensification factors, as mentioned in 5-2.4.1, are applied. Special consideration is also given to the unique geometries of the ramshead and perforated T-Quencher arms in calculating the section moduli of these components. The axial T-Quencher uneven water clearing arm force was treated as an equivalent longitudinal pressure stress and added to the maximum operating internal pressure stress term for the ramshead and quencher arm, as was done in the generic Mark I T-Quencher stress report, Reference 12.

The portion of the SRVDL within the limits of reinforcement normal to the vent line shell is analyzed as a Class 1 piping component. Code Subsection NB stress equations are checked, and theoretically determined stress indices are applied. In addition, a fatigue analysis is performed. The cyclic effects of mechanical and thermal stress are evaluated to calculate a cumulative fatigue usage factor. Conservative thermal gradient stress values for the pipe wall due to SRV actuation were used. The number of load cycles and SRV actuations were based on generic Mark I information, References 13 and 14.

As permitted by NUREG-0661, SRV in-plant test data were utilized to develop SRV load adjustment factors. The adjustment factors were based on a comparison of single valve actuation (SVA)

test data vs. analytical prediction of the data, and were applied to design condition analysis results. An internal pipe pressure adjustment factor was determined from pressure data. From the in-plant test strain gauge data, a response adjustment factor was calculated, and was applied to the following SRV loads: SRVDL thrust, bubble drag, and torus response.

5-2.5 Analysis Results

Table 5-2.10 summarizes the maximum Class 3 wetwell SRVDL and T-Quencher stresses. The maximum calculated stress and Code allowable stresses are given for each applicable Code equation for each Service Level.

Table 5-2.11 summarizes the Class MC SRVDL stress and fatigue results. The calculated and Code allowable stresses are given for each applicable Code equation for each service level. The calculated and allowable fatigue usage factor is also given for the applicable service levels.

The piping stress calculation details, from which the above tables were extracted, are documented in the "SRV Discharge Piping Stress Analysis Report" (Reference 15).

The stress and fatigue evaluation results show the piping system satisfies the NUREG-0661 acceptance criteria. A minimum stress margin of 10% exists for all components for each service level.

Table 5-2.1

LOAD CASE CROSS-REFERENCE

LOAD CASE NO.	LOAD NAME	VOLUME 1 SECTION
1	Dead Weight	*
2	Temperature	1-4.2.2
3	Pressure	1-4.2.2
4	Seismic	*
5	SRV Discharge	1-4.2
5a	SRVDL Thrust	1-4.2.2
5b	T-Quencher Water Jet	1-4.2.4
5c	T-Quencher Uneven Water Clearing	1-4.2.2
5d	SRV Bubble Drag	1-4.2.4
5e	Torus Response	1-4.2.3
6	Pool Swell	1-4.1.3, 1-4.1.4
6a	Impact + Drag	1-4.1.4
6b	Torus/Vent Response	1-4.1.3
7	Condensation Oscillation	1-4.1.7
7a	Drag	1-4.1.7.3
7b	Torus/Vent Response	1-4.1.7.1, 1-4.1.7.2
8	Chugging	1-4.1.8
8a	Drag	1-4.1.8.3
8b	Torus Response	1-4.1.8.1

*Original design basis load

Table 5-2.2

GOVERNING LOAD COMBINATIONS - CLASS 3 PIPING

COMBINATION NUMBER	LOAD COMBINATION*	CODE** EQUATION	SERVICE LEVEL
1	PDES + WGHT	8	A
2	TRN1	10	A
3	PMAX + WGHT + OBEI	9	B
4	PMAX + WGHT + $[(A1P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2]^{1/2}$	9	B
5	PMAX + WGHT + $[(C3P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2]^{1/2}$	9	B
6	PMAX + WGHT + $[(A1P1)^2 + (TQJW)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (SSHI)^2]^{1/2}$	9	C
7	PMAX + WGHT + $[(C3P1)^2 + (TQJW)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (SSHI)^2]^{1/2}$	9	C
8	PMAX + WGHT + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2]^{1/2}$	9	C
9	PMAX + WGHT + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2 + (SSHI)^2]^{1/2}$	9	D
10	PMAX + WGHT + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (CODG)^2 + (CO2I)^2 + (SSHI)^2]^{1/2}$	9	D
11	PMAX + WGHT + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PSDG)^2 + (PS2I)^2 + (SSHI)^2]^{1/2}$	9	D

*See Subsection 5-2.2.1 for definition of individual loads (TRN1 = envelope of THL1 and THL2).

**See ND-3650 of the ASME Code.

Table 5-2.3

<u>GOVERNING LOAD COMBINATIONS - CLASS 3 PIPING SUPPORTS</u>

COMBINATION NUMBER*	LOAD COMBINATION**	SERVICE LEVEL
1A	WGHT	A
1B	WGHT + THL1	A
2A	WGHT + OBEI	B
2B	WGHT + THL1 + OBEI	B
3A	WGHT + $[(A1P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2]^{1/2}$	B
3B	WGHT + THL1 + $[(C3P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2]^{1/2}$	B
4A	WGHT + $[(A1P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (SSHI)^2]^{1/2}$	C
4B	WGHT + THL1 + $[(C3P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (SSHI)^2]^{1/2}$	C
5A	WGHT + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2]^{1/2}$	C
5B	WGHT + THL2 + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2]^{1/2}$	C
6A	WGHT + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2 + (SSHI)^2]^{1/2}$	D
6B	WGHT + THL2 + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2 + (SSHI)^2]^{1/2}$	D
7A	WGHT + $[(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (CODG)^2 + (CO2I)^2 + (SSHI)^2]^{1/2}$	D

Table 5-2.3 (Cont'd)

COMBINATION NUMBER	LOAD COMBINATION**	SERVICE LEVEL
7B	$WGHT + THL2 + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (CODG)^2 + (CO2I)^2 + (SSHI)^2]^{1/2}$	D
8A	$WGHT + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PSDG)^2 + (PS2I)^2 + (SSHI)^2]^{1/2}$	D
8B	$WGHT + THL2 + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PSDG)^2 + (PS2I)^2 + (SSHI)^2]^{1/2}$	D

*Comb. "A" = without thermal expansion load
Comb. "B" = with thermal expansion load

**See Subsection 5-2.2.1 for definition of individual loads

Table 5-2.4

BASIS FOR GOVERNING LOAD COMBINATIONS - CLASS 3 PIPING AND SUPPORTS

LOAD COMBINATIONS ANALYZED		SERVICE LEVEL	PUAAG EVENT COMBINATIONS		BASIS FOR GOVERNING COMBINATION
PIPING	SUPPORTS		CORRESPONDING COMBINATIONS	BOUNDED COMBINATIONS	
1	1A,1B	A	N/A	-	-
*2	-	A	1,11	-	-
3	2A,2B	B	N/A	-	-
4,5	3A,3B	B	1	-	-
6,7	4A,4B	C	3	2	(1)
8	5A,5B	C	11	10 4,5	(2) (3)
9	6A,6B	D	15,27	14,26 12,13 6,7,8,9,17, 20,21,23	(1) (2) (3)
10	7A,7B	D	15	14,26 12,13 4,5,6,7,8,9,23, 17,20	(1) (2) (3) (1), (3)
11	8A,8B	D	25	24 16,18,19,22	(1) (3)

* Secondary stress only

(1) - Same (or equivalent) events, SSE > OBE, same allowable.
(2) - Same (or equivalent) events, more loads, same allowable.
(3) - More events, same allowable.

Note: Chugging load is same for SBA, IBA, and DBA; CO load is same for IBA and DBA. Pool swell load is an envelope of operating ΔP and zero ΔP.

Table 5-2.5

GOVERNING LOAD COMBINATIONS - CLASS MC PIPING (NB ANALYSIS)

COMBINATION NUMBER	LOAD COMBINATION*	CODE** EQUATION	SERVICE LEVEL
1	PDES + WGHT	9	Design
2	$PDES + WGHT + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2 + (SSHI)^2]^{1/2}$	9	C
3	$PDES + WGHT + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (CODG)^2 + (CO2I)^2 + (SSHI)^2]^{1/2}$	9	C
4	$PDES + WGHT + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PSDG)^2 + (PS2I)^2 + (SSHI)^2]^{1/2}$	9	C
5	$PMAX + WGHT + THL2 + THTR + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2]^{1/2}$	***	A
6	$PMAX + WGHT + THL2 + THTR + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (CODG)^2 + (CO2I)^2]$	***	A
7	$PMAX + WGHT + THL2 + THTR + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (PCDG)^2 + (PC2I)^2 + (OBEI)^2]^{1/2}$	***	B
8	$PMAX + WGHT + THL2 + THTR + [(C3P2)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (CODG)^2 + (CO2I)^2 + (OBEI)^2]^{1/2}$	***	B
9	$PMAX + WGHT + THL1 + THTR + [(A1P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (OBEI)^2]$	***	B
10	$PMAX + WGHT + THL1 + THTR + [(C3P1)^2 + (TQWJ)^2 + (UWCP)^2 + (UWCA)^2 + (SRVD)^2 + (SR1I)^2 + (OBEI)^2]$	***	B

*See Subsection 5-2.2.1 for definition of individual loads (THTR = thermal transient stress - see Subsection 5-2.4.2).
**See NB-3652 of the ASME Code.
***Equation 10, 12, and 13 and fatigue usage calculation, per NB-3653 of the ASME Code

Table 5-2.6

BASIS FOR GOVERNING LOAD COMBINATIONS - CLASS MC PIPING

LOAD COMB. ANALYZED	SERVICE LEVEL	PUAAG EVENT COMBINATIONS		BASIS FOR GOVERNING COMBINATION
		CORRESPONDING COMBINATIONS	BOUNDED COMBINATIONS	
1	Design	-	-	-
2	C	15,27	26 13 3,7,9,21,23,16	(1) (2) (3)
3	C	15,27	26 13 3,7,9,21,23,16	(1) (2) (3)
4	C	25	24 16,19,22	(1) (3)
5	A	11	10 1,4,5,17	(2) (3)
6	A	11	10 1,4,5,17 12	(2) (3) (2)
7	B	14	6,8,20 18	(3) (4)
8	B	14	12 6,8,20 18	(2) (3) (4)
9,10	B	2	-	-

(1) - Same (or equivalent) events, SSE > OBE, same allowable.
(2) - Same (or equivalent) events, more loads, same allowable.
(3) - More events, same allowable.
(4) - CO/CH bounds PS for Class MC piping location.

Note: Chugging load is same for SBA, IBA, DBA; CO load is same for IBA and DBA. Pool swell load is an envelope of operating ΔP and zero ΔP.

Table 5-2.7

CLASS 3 PIPING ACCEPTANCE CRITERIA

CODE EQN*	SERVICE LEVEL	STRESS LIMIT	ALLOWABLE STRESS** (ksi)		LOAD COMBS.***
			CARBON	STAINLESS	
8	A	$1.0S_h$	15.0	16.32	1
10	A,B	$1.0\ S_a$	22.5	27.58	2
11	A,B	$S_h + S_a$	37.5	43.90	1+2
9	B	$1.2\ S_h$	18.0	19.58	3,4,5
9	C	$1.8\ S_h$	27.0	29.38	6,7,8
9	D	$2.4\ S_h$	36.0	39.16	9,10,11

*See ND-3650 of the ASME Code.

**Carbon: SRVDL, ramshead, and reducer
Stainless: T-Quencher arms.

***See Table 5-2.3 for Load Combinations.

Table 5-2.8

CLASS MC PIPING ACCEPTANCE CRITERIA

CODE* EQUATION	SERVICE LEVEL	STRESS/USAGE LIMIT	ALLOWABLE STRESS (ksi)	LOAD** COMBINATION
9	Design	1.5 S_m	24.75	1
9	C	2.25 S_m	37.16	2,3,4
10	A,B	3.0 S_m	49.50	5 through 10
12 †	A,B	3.0 S_m	49.50	5 through 10
13 †	A,B	3.0 S_m	49.50	5 through 10
Fatigue ††	A,B	1.0	-	5 through 10

*See NB-3652 and NB-3653 of the ASME Code.

**See Table 5-2.6 for Load Combinations.

† Required only if Equation 10 is not satisfied.

†† Cumulative fatigue usage calculation per NB-3653.

Table 5-2.9

STRUCTURAL ANALYSIS METHODS

LOAD CASE NO.	LOAD	ANALYSIS METHOD
1	Dead Weight	Static
2	Thermal Expansion	Static
3	Pressure	*
4	Seismic	Response Spectrum
5a	SRVDL Thrust	Force Time History
5b	T-Quencher Water Jet	Equivalent Static
5c	T-Quencher Uneven Water Clearing	Equivalent Static Force Time History **
5d	SRV Bubble Drag	Equivalent Static
5e	SRV Torus Response	Response Spectrum Acceleration Time History **
6a	PS Impact + Drag	Equivalent Static
6b	PS Torus/Vent Response	Response Spectrum
7a	CO Drag	Equivalent Static
7b	CO Torus/Vent Response	Response Spectrum
8a	Chugging Drag	Equivalent Static
8b	Chugging Torus Response	Response Spectrum

* Pressure stress term added directly to applicable Code equations.

** The more exact time history results are used for critical components where the equivalent static/response spectrum results are too conservative.

Table 5-2.10

STRESS ANALYSIS RESULTS - CLASS 3 PIPING

COMPONENT	CODE EQUATION	SERVICE LEVEL	STRESS (ksi)	
			CALCULATED	ALLOWABLE
SRVDL	8	A	8.01	15.0
	10	A,B	15.99	22.5
	9	B	15.94	18.0
	9	C	23.87	27.0
	9	D	30.40	36.0
T-Quencher	8	A	2.51	16.32
	10	A,B	0	27.58
	9*	B	12.26	19.58
	9*	C	12.34	29.38
	9*	D	12.40	39.16

*Calculated equation 9 stress for Service Levels B, C and D are approximately equal. Since the predominant load is perpendicular uneven water clearing this load is applicable to all three Service Levels.

Table 5-2.11

STRESS ANALYSIS RESULTS - CLASS MC PIPING

CODE PARAGRAPH	CODE EQUATION	SERVICE LEVEL	STRESS (ksi)/USAGE	
			CALCULATED	ALLOWABLE
NB-3652	9	Design	2.60	24.75
	9	C	7.50	37.13
NB-3653	10	A,B	69.26*	49.50
	12	A,B	3.98	49.50
	13	A,B	44.18	49.50
	Fatigue	A,B	0.09	1.0

*This is acceptable in accordance with the Code, as long as equations 12 and 13 are satisfied.

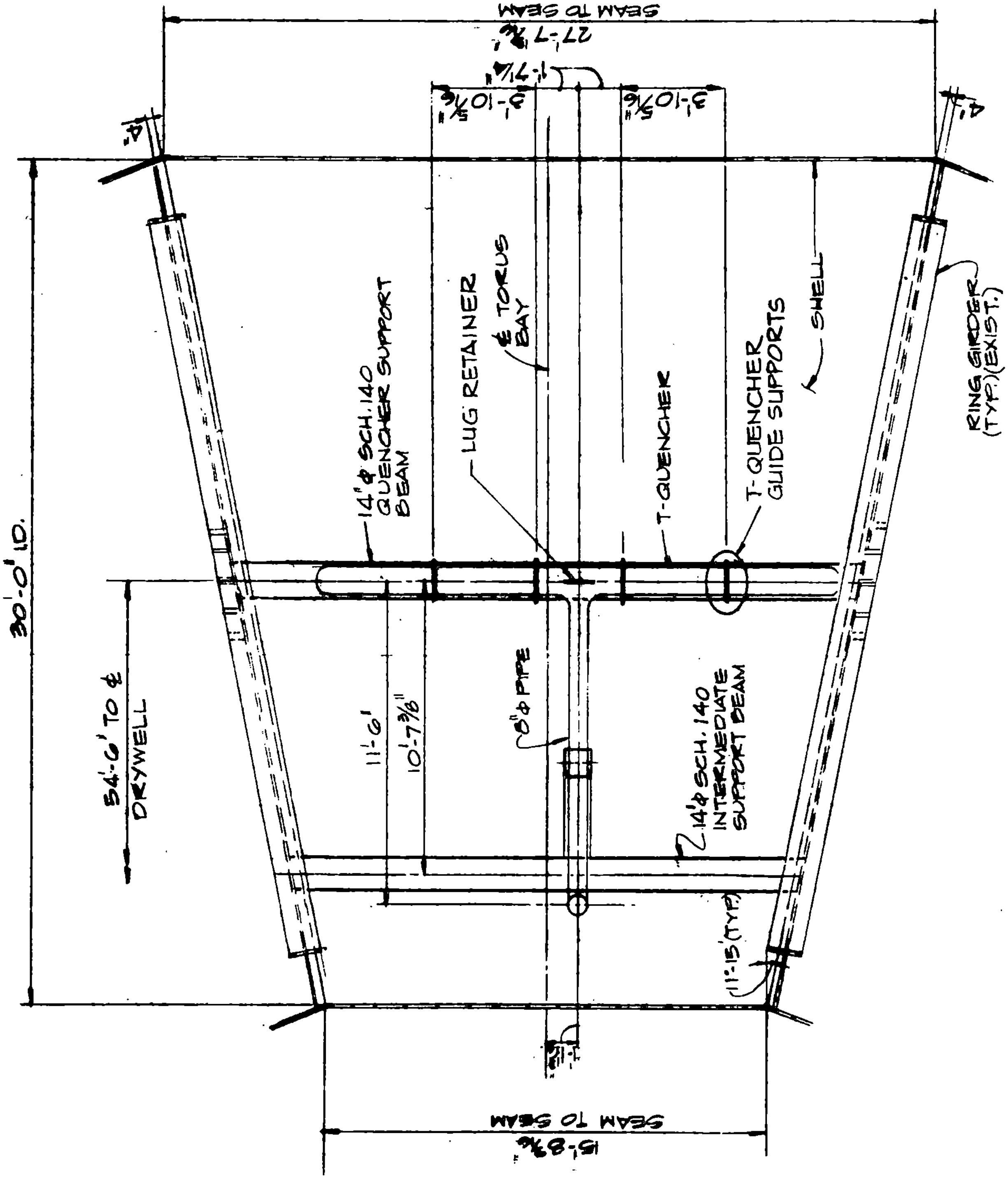


FIGURE 5-2.1 (Sheet 1 of 2)

SRVDL INTERMEDIATE AND T-QUENCHER SUPPORT BEAMS INSIDE THE WETWELL

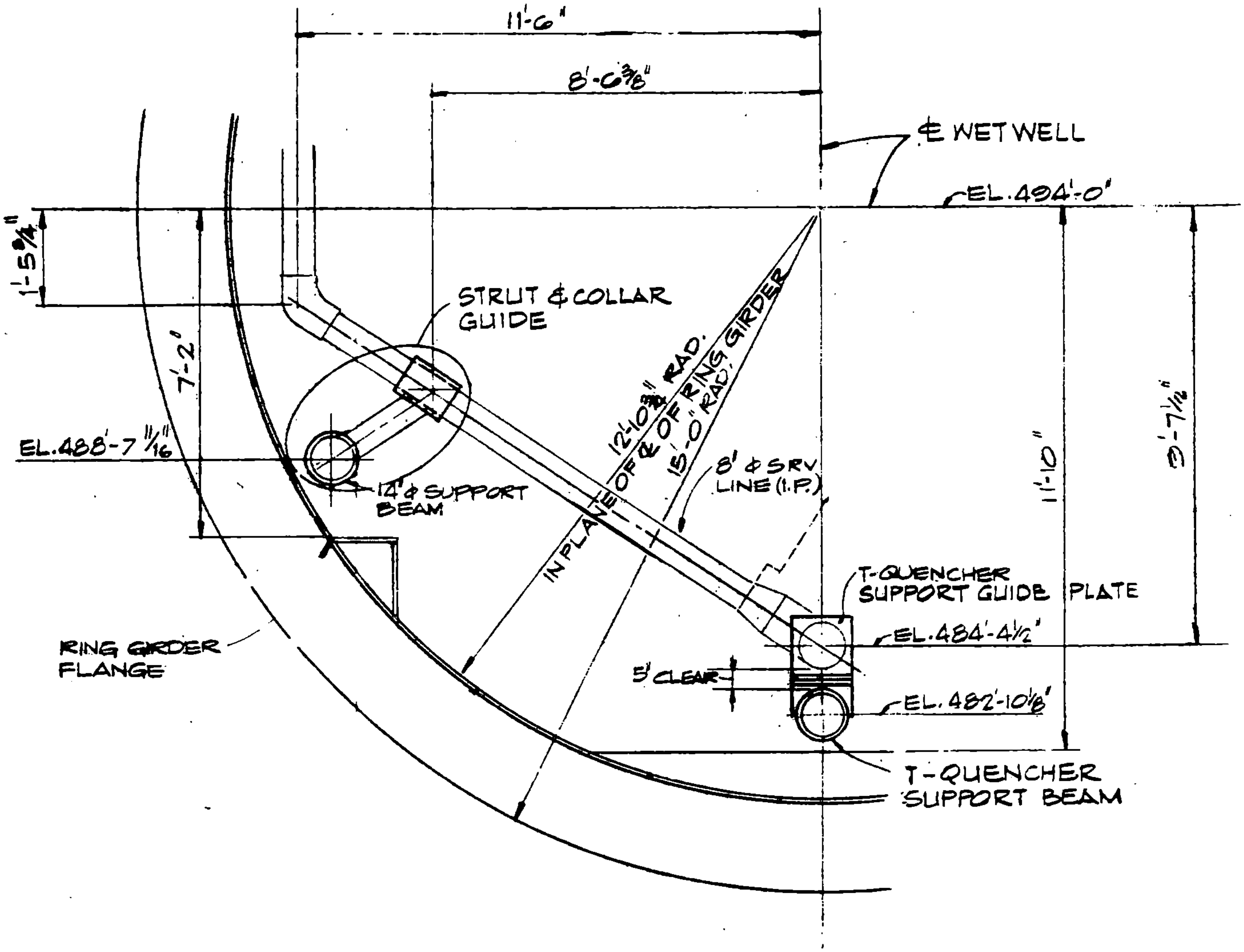


FIGURE 5-2.1 (Sheet 2 of 2)

SRVDL INTERMEDIATE AND T-QUENCHER SUPPORT

BEAMS INSIDE THE WETWELL

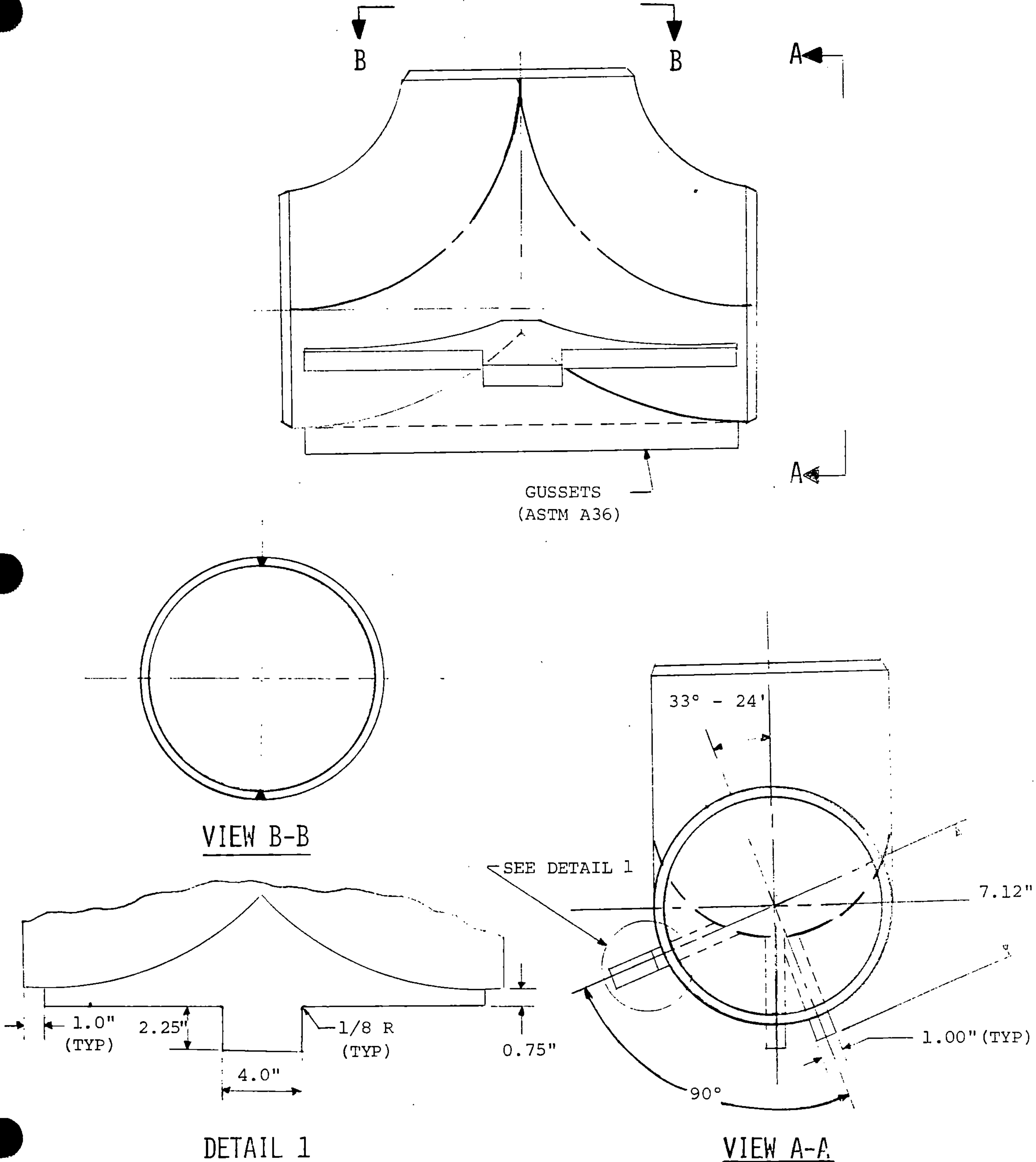


FIGURE 5-2.2

T-QUENCHER RAMSHEAD

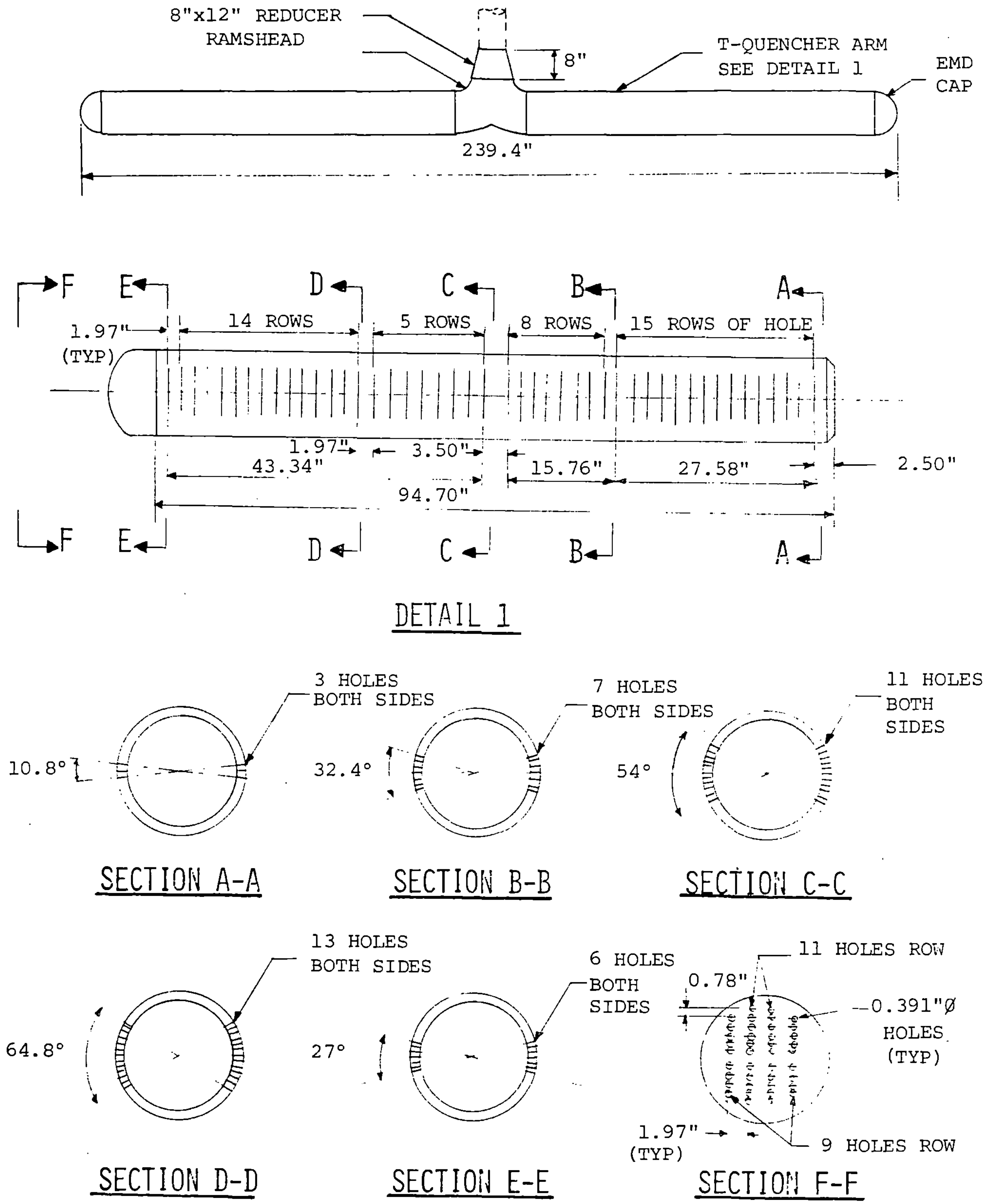


FIGURE 5-2.3

T-QUENCHER ARM

DNPS-MARK I PUAR

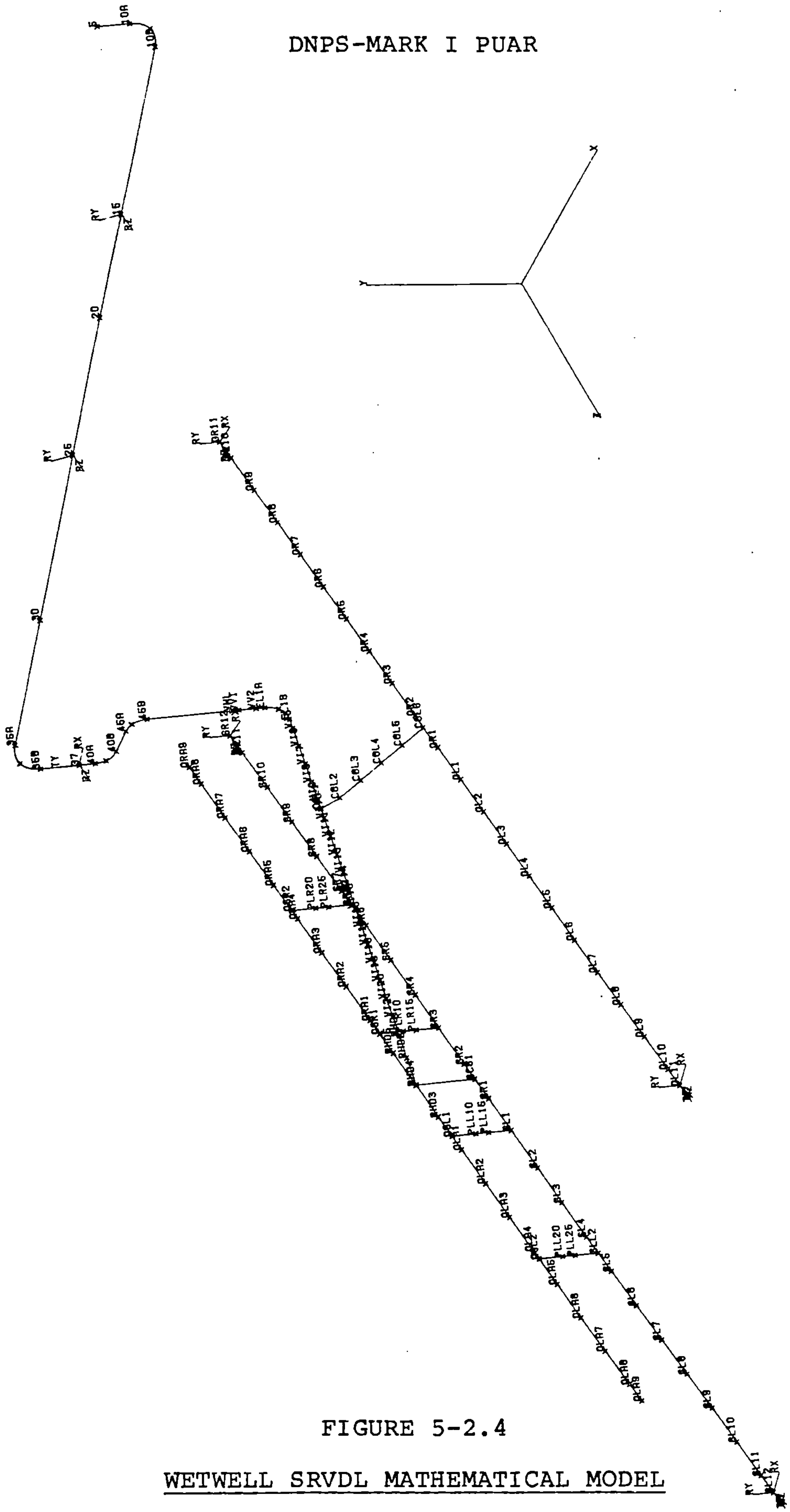


FIGURE 5-2.4

WETWELL SRVDL MATHEMATICAL MODEL

5-3.0 SAFETY RELIEF VALVE DISCHARGE LINE AND MAIN STEAM PIPING AND PIPING SUPPORTS INSIDE THE DRYWELL AND THE VENT LINE

The design adequacy of the Dresden Main Steam (MS) and Safety Relief Valve Discharge Line (SRVDL) piping is presented in the following subsections.

The components of the MS and SRVDL piping system and supports which are analyzed are described in Subsection 5-3.1. The loads and load combinations for which the piping system and supports are evaluated are described and presented in Subsection 5-3.2. The acceptance limits to which the analysis results are compared are discussed and presented in Subsection 5-3.3. The analysis methodology used to evaluate the effects of the loads and load combinations on the piping system and supports is discussed in Subsection 5-3.4. The results are presented in Subsection 5-3.5.

5-3.1 Component Description

The SRVDL piping system for Dresden Units 2 and 3 consists of five individual Schedule 80, ASTM A-106, Grade B piping lines. The nominal diameter of the piping is 8 inches from the SRV through the vent pipe and into the wetwell. Figure

5-3.1 shows the routing, support locations and support types for a representative SRVDL in the drywell.

The five SRVDL originate at the four MS lines. Three of the MS lines (A, C and D) have one SRVDL each, the fourth (line B) has two SRVDL as shown in Figure 5-3.2 for Unit 2 and Figure 5-3.3 for Unit 3. The four MS lines are Schedule 80, ASTM A106, Grade B piping. The nominal diameter of the piping is 20 inches from the reactor pressure vessel (RPV) nozzle to the outboard MS isolation valve and 24 inches downstream of the valve to the structural anchor. Figure 5-3.4 shows the routing, support locations and support types for a representative MS line. Figure 5-3.5 shows a typical Crane Company 20 inch "Y-Pattern" MS isolation globe valve.

The SRVDL are routed from the SRV outlets in the drywell area through the vent lines and into the wetwell. As indicated in Figures 5-3.6 and 5-3.7 vent lines contain one SRVDL each at azimuths of 22.5°, 67.5°, $112,5^{\circ}$, $292,5^{\circ}$, and 337.5° for Unit 2 and at azimuths of 22.5°, 67.5°, 112.5°, 247.5° and 292.5° for Unit 3.

Four of the SRVDL are attached to the MS lines in the drywell at the 6" x 8" Dresser electromatic relief valve as shown in Figure 5-3.8. The fifth SRVDL is attached to the MS line

(line A) in the drywell at the 6" x 10" Target Rock safety relief valve as shown in Figure 5-3.9. Each SRVDL also has an attached vacuum breaker valve connected approximately 20 feet upstream of the jet-deflector as shown in Figure 5-3.10.

In addition to the safety relief valves, each MS line has two 6" x 8" Dresser Maxiflow safety valves as shown in Figure 5-3.11.

The support system for the MS and SRVDL in the drywell consists of snubbers, struts, hangers, and guides which are connected to the sacrificial shield wall or the drywell floor support steel by means of auxiliary support steel framing. The two existing floor elevations inside the drywell are shown in Figures 5-3.12 and 5-3.13. The floors consist of main members spanning radially with secondary members supported between them. A typical MS and SRVDL support in the drywell is illustrated in Figure 5-3.16.

The SRVDL guide attachments in the vent line consists of 1 inch thick plates, cut to accept the SRVDL pipe with 1/32 inch clearance between the guide and pipe. The guide near the drywell is attached to a 1/2 inch thick gusset, which is attached to the thickened portion of the vent line at the drywell. The guide near the SRVDL vent line penetration is

attached to auxiliary steel, which in turn, is attached to a 1-inch thick pad plate rolled to the radius of the vent line. These arrangements are shown in Figures 5-3.14 and 5-3.15.

5-3.2 Loads and Load Combinations

The loads for which the Dresden MS and SRVDL piping and supports inside the drywell and the vent line are designed for, are defined in Subsection 5-3.2.1; they are consistent with the original loads except that the SRVDL have been upgraded seismicaly as recommended by the Mark I Owners Group. The original loads for which the MS piping is designed are defined in Reference 6.

The load combinations for the MS and SRVDL piping and supports inside the drywell and the vent line are discussed in Subsection 5-3.2.2.

5-3.2.1 Loads

The loads acting on the MS and SRVDL piping inside the drywell are categorized as follows:

1) Pressure

2) Dead Weight

3) Seismic

   (a) OBE Inertia

   (b) OBE Displacement

   (c) SSE Inertia

   (d) SSE Displacement

4) Temperature

5) Safety Relief Valve Discharge

6) Safety Valve Discharge

Loads in Categories 1 through 6 were considered in the original design of the MS lines, but the analytical methods and modeling techniques were much simpler reflecting the state-of-the-art during the original design. Seismic loads (Category 3) were not considered in the original design of the SRVDL since they

are not safety related. The latest analysis, however, does consider seismic loads for the SRVDL piping as discussed in Subsection 5-1.1.

The characteristics of these loads are identified and presented in the following paragraphs.

1) Pressure (P_o, P) Loads:

These loads are defined as the maximum internal pressure (P_o) in the MS and SRVDL piping during normal operating and accident condition, and the internal pressure (P) in the MS and SRVDL piping for design conditions. Values of P_o and P used in this analysis are listed in Table 5-3.1.

2) Dead Weight (DW) Load:

This load is defined as the uniformly distributed weight of the piping, including pipe content and insulation, pipe flanges and the concentrated weights of the main steam isolation valves, safety relief valves, safety valves and vacuum breaker valves.

3) Seismic Loads

(a) Operating Basis Earthquake Inertia (OBEI) Loads:

These loads are defined as the horizontal and vertical accelerations acting on the MS and SRVDL piping during an Operating Basis Earthquake (OBE).

(b) Operating Basis Earthquake Displacement (OBED) Loads:

These loads are defined as the maximum horizontal and vertical relative seismic displacements at the pipe anchor points during an OBE. The relative seismic displacement at the Reactor Pressure Vessel (RPV) nozzle and at the vent line penetration are taken from the Design Specification (Reference 6) and Nutech Transmittal (Reference 16) and are provided in Table 5-3.2.

(c) Safe Shutdown Earthquake Inertia (SSEI) Loads:

These loads are defined as the horizontal and vertical accelerations acting on the MS and SRVDL piping during a Safe Shutdown Earthquake (SSE). These accelerations were not developed. The results to represent SSE Inertia Loads are obtained by multiplying the results due to the OBE Inertia by a conservative factor of 2.0 which is consistent with the original design basis.

(d) Safe Shutdown Earthquake Displacement (SSED) Loads:

These loads are defined as the maximum horizontal and vertical relative seismic displacements at the pipe anchor points during the SSE. The loading is taken as twice the OBE displacement loading.

4) Temperature Loads:

These loads are defined as the thermal expansion (TH-1) of the MS and SRVDL piping associated with

normal operating and accident temperature changes occurring without SRV actuation, and the thermal expansion (TH-2) of the MS and SRVDL piping associated with normal operating and accident temperature changes occurring with SRV actuation. Piping temperatures for thermal expansion used in the analysis are listed in Table 5-3.1.

Effects of thermal anchor movements at the reactor pressure vessel (RPV) nozzle and at the vent line penetration as documented in Nutech's transmittal (Reference 16) are included in the analysis.

The piping thermal anchor movements for normal operating condition (THAM-1) and for accident condition (THAM-2) are combined with the thermal expansion loadings (TH-1) and (TH-2) to describe the following thermal modes for the particular operating conditon:

Mode 1 - Normal operating condition without SRV actuation. (TH-1) + (THAM-1)

Mode 2 - Normal operating condition with SRV actuation. (TH-2) + (THAM-1)

Mode 3 - Accident condition without SRV actuation. (TH-1) + (THAM-2)

Mode 4 - Accident condition with SRV actuation. (TH-2) + (THAM-2)

A total of eight modes are considered in doing the thermal analysis for MS line B and its associated SRVDL. The eight modes are required since the two SRV's may actuate independently of each other during normal and accident conditions.

5) Safety Relief Valve Discharge Loads:

These loads are defined as the pressure and thrust forces acting along the SRVDL due to SRV actuation. The methodology used to develop the SRVDL thrust loads is described in Subsection 5-3.4 in accordance with the Design Specification (Reference 6). A typical SRV thrust force time history plot is shown in Figure 5-3.17.

6) Safety Valve Discharge Loads:

These loads are defined as the pressure and thrust forces acting at the safety valve due to safety valve actuation. The method used to develop safety valve discharge loads is described in Subsection 5-3.4.

Combinations of the previously described loads which are applied in evaluating the MS and SRVDL piping and supports are presented in the following section as defined in Reference 6.

5-3.2.2 Load Combinations

The load combinations and stress allowables for the MS and SRVDL piping in accordance with the Design Specification (Reference 6) are presented below:

Primary Stresses

1) $P + DW \leq 1.0\ S_h$

2) $P_o + DW + \left[OBEI^2 + SRVD^2 + SVD^2\right]^{1/2} \leq 1.2\ S_h$

3) $P_o + DW + \left[SSEI^2 + SRVD^2 + SVD^2\right]^{1/2} \leq 1.8\ S_h$

Secondary Stresses plus Pressure and Dead Weight

4) $E + OBED \leq S_A$

5) $E + SSED \leq S_A$

6) $E + OBED + P + DW \leq S_A + S_h$

7) $E + SSED + P + DW \leq S_A + S_h$

where,

P = Longitudinal stress due to internal design pressure - psi

DW = Stress due to dead weight loading - psi

P_o = Longitudinal stress due to internal maximum operating pressure - psi

OBEI = Stress due to OBE Inertia loads - psi

SRVD = Stress due to safety relief valve discharge loads - psi

SVD = Stress due to safety valve discharge loads - psi

SSEI = Stress due to SSE inertial loads - psi

E = Stress due to thermal expansion and thermal anchor movements - psi

OBED = Stress due to OBE displacement loads - psi

SSED = Stress due to SSE displacement loads - psi

S_h = Basic material allowable stress at maximum (hot) temperature from the Allowable Stress Tables B31.1.0-1967 Appendix A (Reference 11)

S_A = $f\ (1.25\ S_c + 0.25\ S_h)$ (Reference 11)

S_c = Basic material allowable stress at minimum (cold) temperature from Allowable Stress Tables (Reference 11)

f = Stress range reduction factor for cyclic conditions for total number N of full temperature cycles over total number of years during which system is expected to be in operation. $f = 1.0$ for $N < 7000$ (Reference 11)

Notes:

1) For MS line B with two SRVDL, the safety relief valve discharge load is the SRSS of the two individual SRV actuations.

2) The safety valve discharge load is the SRSS of the two individual safety valve actuations.

3) E is the maximum stress due to the worst thermal mode.

The load combinations for the main steam and SRVDL piping supports are presented below.

$$F_{DW} + F_{E} + \left[F_{OBEI}^{2} + F_{OBED}^{2} + F_{SRVD}^{2} + F_{SVD}^{2}\right]^{1/2} \quad \text{upset}$$

$$F_{DW} + F_{E} + \left[F_{SSEI}^{2} + F_{SSED}^{2} + F_{SRVD}^{2} + F_{SVD}^{2}\right]^{1/2} \quad \text{emergency}$$

where F is the forces and moments due to a particular load.

Notes:

1) For MS line B with two SRVDL, the safety relief valve discharge load is the SRSS of the two individual SRV actuations.

2) The safety valve discharge load is the SRSS of the two individual safety valve actuations.

3) F_E is the maximum forces and moments due to the worst thermal mode.

5-3.3 Acceptance Criteria

The acceptance criteria for the MS and SRVDL piping follows the rules contained in the USAS B31.1.0 - 1967 (Reference 11). The applicable stress limits for each of the piping load combinations are listed in Subsection 5-3.2.2. Load combination number (3), which has a stress limit of 1.8 S_h, is not addressed in USAS B31.1.0 - 1967 but was taken from the original design basis (as documented in Reference 6).

The acceptance criteria for the SRVDL vent line supports are in accordance with the Structural Design Specification (Reference 17) and are consistent with AISC "Specification for the Design, Fabrication and Erection of Structural Steel Buildings" (Reference 18). These criteria are more conservative than Section III, Subsection NF, Division 1 of the ASME Code, which is required by the Mark I Program Structural Acceptance Criteria.

The design of the auxiliary steel and floor support structure was based on the allowable stresses as given in the AISC (Reference 18). All stresses due to normal and severe environmental loading conditions were within the normal AISC allowable limits. All stresses due to extreme environmental and emergency loading conditions were within 1.6 times the AISC allowable limits, with no stress greater than 0.95 times the ASTM minimum yield stress of the material.

The acceptance criteria for the vent line are in accordance with the ASME B&PV Code, Section III (Reference 19). The allowable stress intensities for each service level are in accordance with Table NE-3221-1 of the ASME Code.

5-3.4 Method of Analysis

This section describes the methods of analysis used to evaluate the MS and SRVDL piping and supports for the effects of the loads presented in Subsection 5-3.2.1.

The methodology used to develop the structural model of the MS and SRVDL piping system is presented in Subsection 5-3.4.1. The methodology used to obtain results for the load combinations and evaluate the analysis results for comparison with the acceptance limits is discussed in Subsection 5-3.4.2.

The piping system analyses are performed using the computer program PIPSYS (Reference 10), as described previously in Subsection 5-2.4. (There are differences between the equations used in PIPSYS for evaluating the stress level and those equations in USAS B31.1.0-1967. Adjustments to the equations have been made to be consistent with the original code).

The analysis of the auxiliary steel and floor support structure was based on classical elastic techniques. Member boundary conditions were conservatively selected; this ultimately provides additional margin of safety against the allowable stresses. When necessary, a computer analysis was used to accurately represent the effect of the interaction of the structural floor framing.

SRVDL guides in the vent line are included as supports in the piping analysis models. Calculations using an elastic approach are used to determine maximum stress in these supports. These stresses are also compared to the appropriate allowable stresses as given in Section 5-4.0. The effects of local attachments on the vent line are discussed in Section 5-5.0.

5-3.4.1 Piping System Structural Modeling

The structural model used in the analysis of the MS and SRVDL piping inside the drywell includes both the drywell and wetwell piping. Only the loads listed in Subsection 5-3.2.1 are applied to the model and combined in accordance with the equations shown in Subsection 5-3.2.2. The analytical results are valid for the drywell piping and its supports including the SRVDL in the vent line. Furthermore, the portion of the SRVDL in

the vent line between the jet deflector and the vent line penetration is common to both the wetwell and drywell models. Loads acting on the supports for this portion of the piping are determined by enveloping the analyses results due to both models. The pipe stresses for this portion of the piping are determined by the drywell model as well as the wetwell model as previously discussed in Section 5-2.0. The vent line penetration itself and the wetwell portion are addressed in Section 5-2.0. Since the configuration of the SRVDL piping within the drywell may vary, all lines are modeled in the drywell piping analysis.

The five drywell lines at each unit are analyzed using four separate models, each including a main steam line and one or two attached SRVDL. The MS lines are modeled from the reactor pressure vessel (RPV) nozzle to the structural anchor after the outboard main steam isolation valve. The SRVDL are attached to the MS lines at the safety relief valves and terminate at the T-Quenchers in the wetwell. The MS and SRVDL piping systems included in each of the eight models are listed in Table 5-3.3. A computer plot of a representative MS and SRVDL piping model is presented in Figure 5-3.18.

There are five safety relief valves for each unit, one Target Rock and four Electromatic relief valves, which were modeled

as shown in Figures 5-3.8 and 5-3.9. The mass of each valve is lumped at the valve center of gravity. Also included in the piping model is one identical vacuum breaker valve attached to each SRVDL.

Figure 5-3.10 shows the modeling of the vacuum breaker valve. The mass of the vacuum breaker is lumped at the breaker center of gravity. The Maxiflow safety valve is modeled as shown in Figure 5-3.11.

The drywell models have anchor points at the MS line connection to the RPV nozzle and at the structural anchor after the outboard main steam isolation valve.

Spring constants were introduced to the SRVDL connection to the vent pipe as discussed in Subsection 5-2.4.1, to simulate the stiffness at the vent line penetration. Spring constants are also used to model the flued head support framing at the main steam drywell penetration.

Pipe supports included in the drywell piping models consist of snubber, struts, spring hangers, guides and their auxiliary support steel. Snubbers are modeled as active in seismic and other dynamic load cases, while struts are active in all load cases. Spring hangers with appropriate preloads are modeled as active in the dead weight load case only.

5-3.4.2 Analytical Techniques

The mathematical models described in Subsection 5-3.4-1 are utilized in performing the analyses for the MS and SRVDL piping, supports, and associated components. The numerous analytical techniques used to determine the piping response to the loads discussed in Subsection 5-3.2.1 are presented here.

Dynamic analysis techniques are used to determine system response to seismic inertia loads, safety relief valve discharge loads and safety valve discharge loads. These techniques utilize either response spectra or time history analysis methods depending on the input loading characteristics and forms. The seismic displacement loads and the remaining MS and SRVDL piping load cases specified in Subsection 5-3.2.1 are analyzed using static techniques.

The specific analytical techniques used for the model described in Subsection 5-3.4.1 for each load identified in Subsection 5-3.2.1 are summarized in Table 5-3.4. The analytical techniques used in the MS and SRVDL piping analysis are described in the following paragraphs:

1) Pressure (P_o, P) Loads:

The effects of the maximum pressure (P_o) and design pressure (P) are evaluated utilizing the techniques described in Paragraph 102.3.2 (d) of USAS B31.1.0 1967 (Reference 11). The values of P_o and P used in the analysis are listed in Table 5-3.1.

2) Dead Weight (DW) Loads:

A static analysis is performed for the uniformly distributed and concentrated weight loads applied to the MS and SRVDL piping.

3) Seismic Loads

(a) Operating Basis Earthquake (OBEI) Loads:

A dynamic analysis is performed independently for each of the three orthogonal directions (North-South, East-West and vertical) using the response spectra method. The seismic response spectra curves used in the analysis for the North-South and East-West directions are selected from the "Dresden Seismic Analysis Combined Reactor and Turbine Buildings" Report (Reference 20). A value of 1/2% critical

damping is used in the response spectra analysis. The response of each direction (North-South, East-West and vertical) (for Dresden the North-South direction is along the Z-axis and the East-West direction is along the X-axis) was calculated using the square root of the absolute double sum of the modal responses.

The combined dynamic response was calculated using the maximum of $\left[X+Y\right]$ vs. $\left[Y+Z\right]$ excitations in accordance with the Design Specification (Reference 6).

(b) Operating Basis Earthquake Displacement (OBED) Loads:

A static analysis is performed to determine the effects of relative seismic movement at the pipe anchor points for each of the three orthogonal directions. The relative anchor displacements are provided in Table 5-3.2.

(c) Safe Shutdown Earthquake Inertia (SSEI) Loads:

SSE Inertia loads are twice the OBE Inertia loads in accordance with (Reference 6).

(d) Safe Shutdown Earthquake Displacement (SSED) Loads:

SSE Displacement loads are twice the OBE Displacement loads in accordance with (Reference 6).

4) Temperature Loads

A static thermal analysis is performed for the MS and SRVDL piping for each of the operating thermal modes as described in Subsection 5-3.2.

5) Safety Relief Valve Discharge Loads

A dynamic analysis is performed for SRV actuation utilizing the direct integration time-history analysis techniques. A time-dependent forcing function is applied on each pipe segment along the pipe axis. The forcing function is developed using the Safety Relief Valve Blowdown Analysis (SRVA) computer program (Reference 21). SRVA is a finite difference program for the analysis of transient flow in a relief valve line discharging to the suppression pool through a ramshead or

quencher. Transient forces and the pressures at the water column and the valve outlet are calculated for relief valve lines with up to 20 straight segments. Output force time-data is compatible with PIPSYS, and force-time histories can be plotted using a subroutine. For the MS lines with two SRVDL attached, the forcing functions are applied to each SRVDL in the model separately. The peak response at a particular location in one SRVDL is then obtained by SRSS of the responses at that location due to both actuations. A typical drywell piping thrust force time history plot is shown in Figure 5-3.17. A typical application of the thrust forces along the segments of a SRVDL is shown in Figure 5-3.19.

A direct integration time-step of sufficiently small size is selected to adequately account for the critical responses of the piping system. A value of 1% critical damping is utilized in determining the appropriate values of Rayleigh damping coefficients and for use in the direct integration process.

6) Safety Valve Discharge Loads

A dynamic analysis is performed for the safety valve discharge loads utilizing modal synthesis techniques. A time-dependent forcing function is applied at the safety valve outlet flange. The forcing function associated with the safety valve actuation is developed from the safety valve opening characteristics and the methods shown in General Electric report ITY7241 (Reference 22).

5-3.5 Analysis Results

The analytical results for the MS and SRVDL piping evaluation are summarized in this section.

The maximum piping stresses resulting from the load combinations for each MS and SRVDL are within the allowable stress values for the associated code equation.

The maximum snubber reaction loads for the load combinations for each MS and SRVDL are within the appropriate allowables.

The maximum resultant loads in the rigid struts are within the appropriate strut allowables.

In summary, the design of the MS and SRVDL piping system is adequate for the loads, load combinations and acceptance criteria limits specified.

The auxiliary steel and floor support structure are within the allowable limits specified in Subsection 5-3.3. The SRVDL guides and attachments in the vent are also within the allowable limits as shown in Table 5-3.5

Table 5-3.1

PRESSURES AND TEMPERATURES FOR SRVDL AND MS PIPING

PIPING SYSTEM	PRESSURE (PSIG)		TEMPERATURE (^{o}F)	
	MAXIMUM OPERATING (P_o)	DESIGN (P)	WITHOUT SRV ACTUATION (TH-1)	WITH SRV ACTUATION (TH-2)
MAIN STEAM	1125	1250	550	550
SRVDL DRYWELL	500	550	135	380

Table 5-3.2

MAXIMUM SEISMIC RELATIVE ANCHOR DISPLACEMENT

LOCATION	RELATIVE ANCHOR DISPLACEMENT (in.)		
	OPERATING BASIS EARTHQUAKE* (OBE)		
	N-S	E-W	VERTICAL
RPV NOZZLE**	0.103	0.282	0.000
	X_1	X_2	X_3
VENT PIPE PENETRATION***	-0.021285	-0.00190620	-0.00850430

* Safe Shutdown Earthquake displacements (SSED) are twice the OBED

** Relative displacement between RPV nozzle and sacrificial shield wall (Reference 6)

*** (Reference 16)

Table 5-3.3

SRVDL AND MS PIPING STRUCTURAL MODELS

UNIT	SUBSYSTEM	MAIN STEAM LINE	SRVD LINE
2	MS-A	2-3001A-20"	2-3019A-8"
	MS-B	2-3001B-20"	2-3019B-8" 2-3019E-8"
	MS-C	2-3001C-20"	2-3019C-8"
	MS-D	2-3001D-20"	2-3019D-8"
3	MS-A	3-3001A-20"	3-3019A-8"
	MS-B	3-3001B-20"	3-3019B-8" 3-3019E-8"
	MS-C	3-3001C-20"	3-3019C-8"
	MS-D	3-3001D-20"	3-3019D-8"

Table 5-3.4

ANALYSIS TECHNIQUES

LOAD	TECHNIQUE
P_o	*
P	*
DW	STATIC
OBEI	RESPONSE SPECTRA
OBED	STATIC
SSEI	2 x OBEI
SSED	2 x OBED
THERMAL MODE 1	STATIC
THERMAL MODE 2	STATIC
THERMAL MODE 3	STATIC
THERMAL MODE 4	STATIC
SRVD	FORCE TIME HISTORY
SVD	FORCE TIME HISTORY

* The effects of internal pressure are evaluated using the techniques described in Paragraph 102.3.2 of USAS B31.1.0-1967 (reference 11)

Table 5-3.5

MAXIMUM AND CODE ALLOWABLE STRESSES FOR CRITICAL SUPPORT COMPONENTS

ITEM	MATERIAL	MAXIMUM STRESS (ksi)	ALLOWABLE STRESS (ksi)
SRV Guides in Vent:			
Guide Plate	ASTM A36	0.73*	1.0*
Auxiliary Beam	ASTM A36	0.46*	1.0*
Auxiliary Beam Connection	ASTM A36	0.30*	1.0*

*These values are the result of an interaction equation.

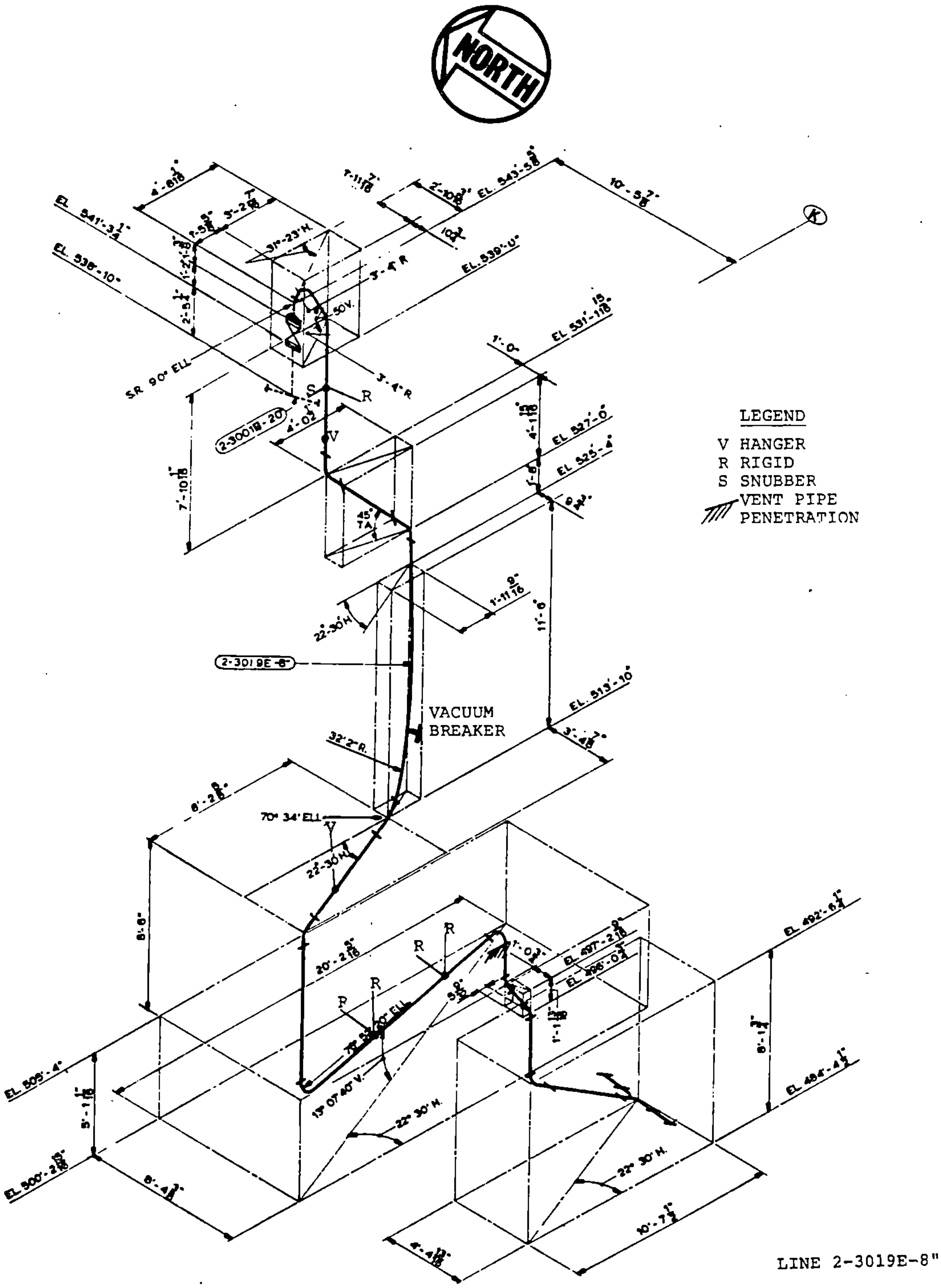


FIGURE 5-3.1

REPRESENTATIVE SRVDL ISOMETRIC

WITH SUPPORT LOCATIONS

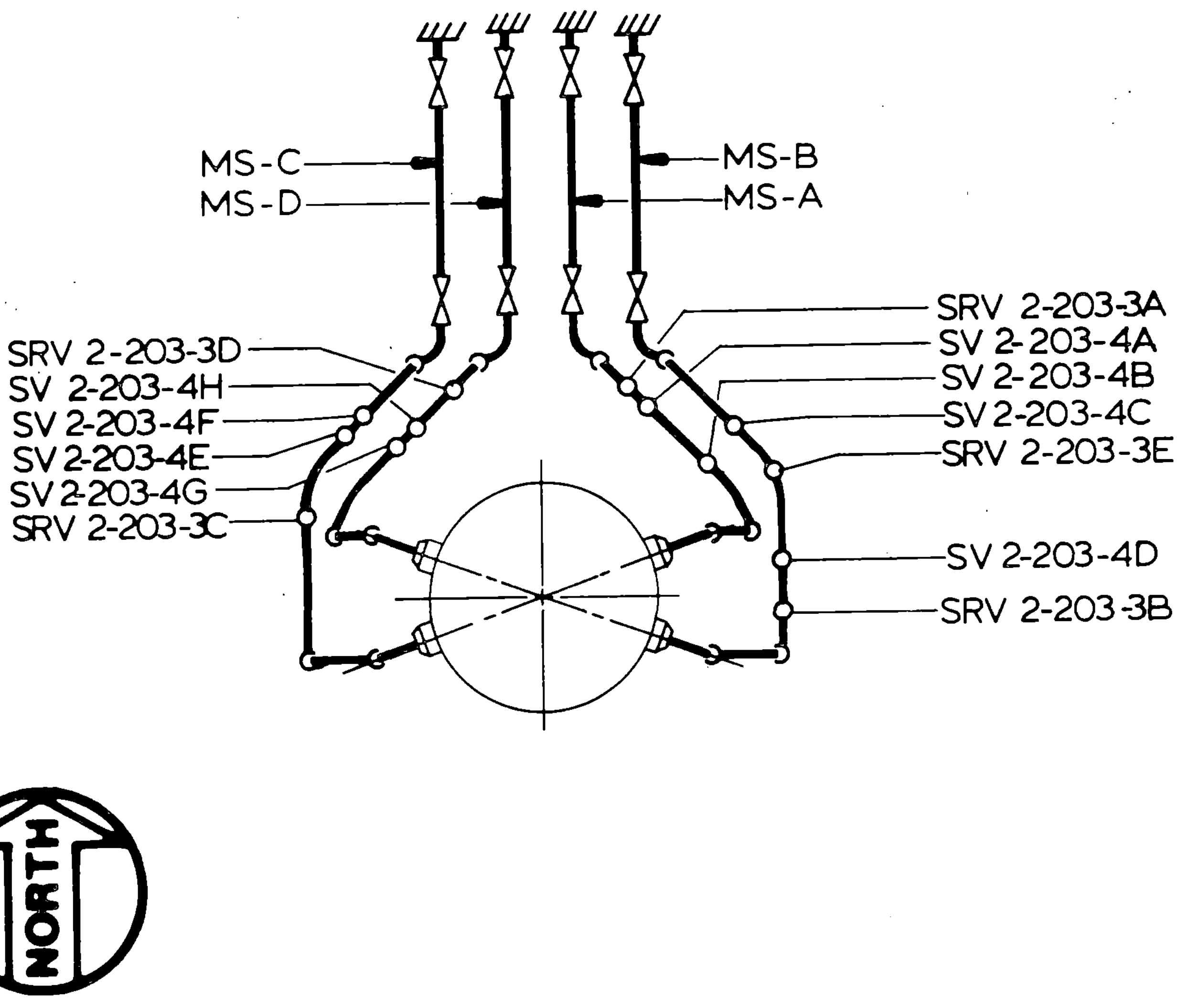


FIGURE 5-3.2

MS AND SRVDL SCHEMATIC - UNIT 2

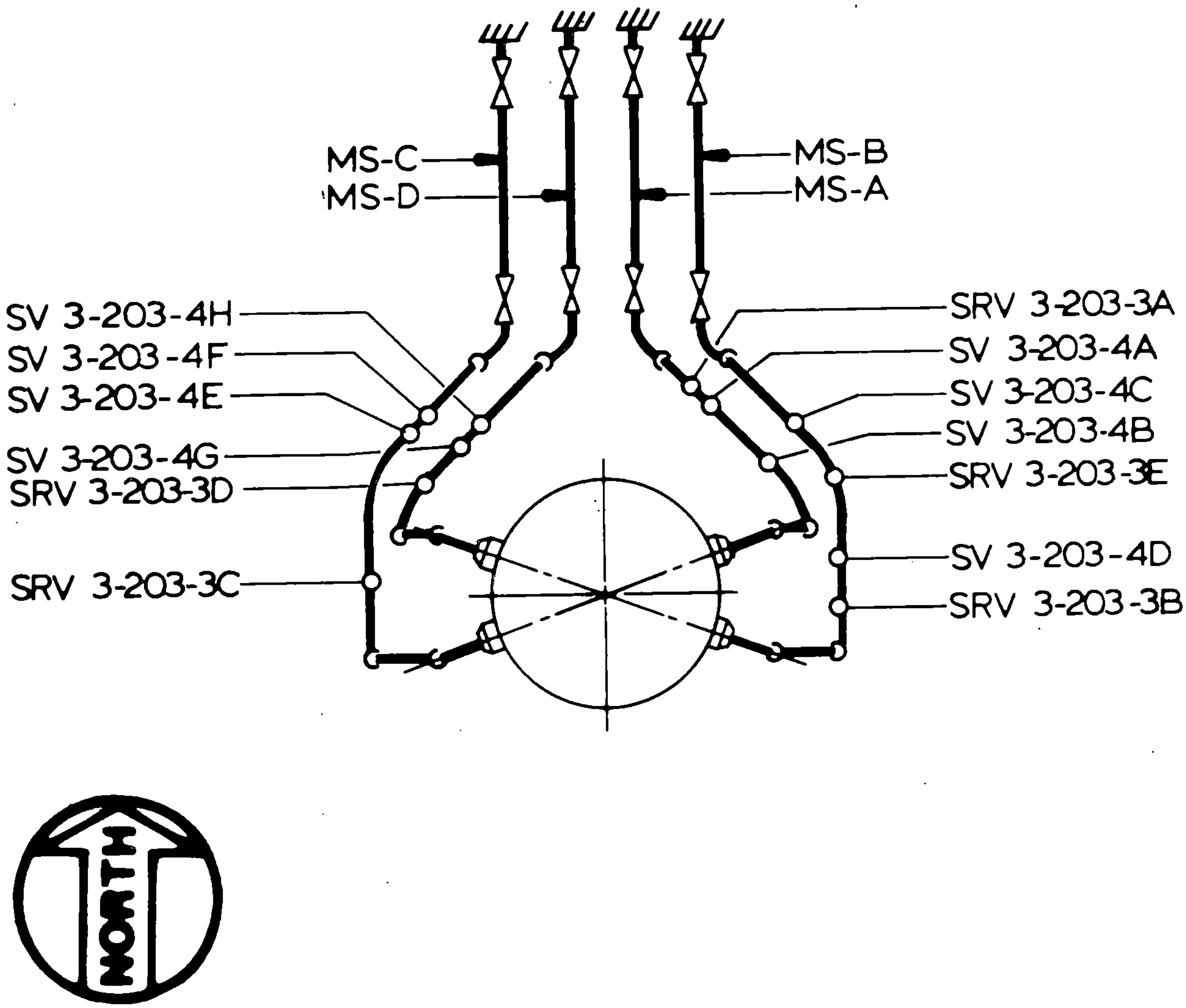


FIGURE 5-3.3

MS AND SRVDL SCHEMATIC - UNIT 3

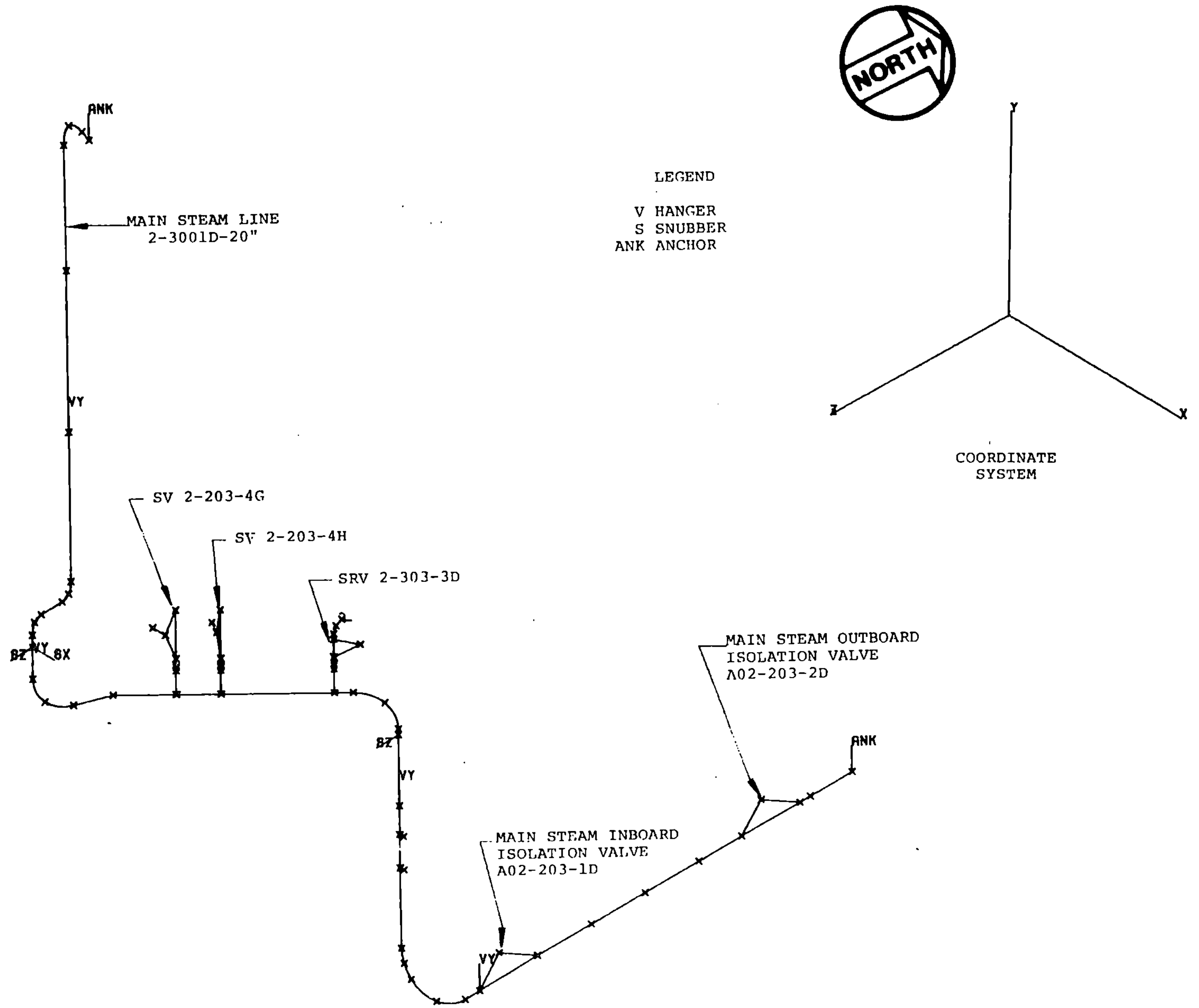


FIGURE 5-3.4

REPRESENTATIVE MS LINE ISOMETRIC

WITH SUPPORT LOCATIONS

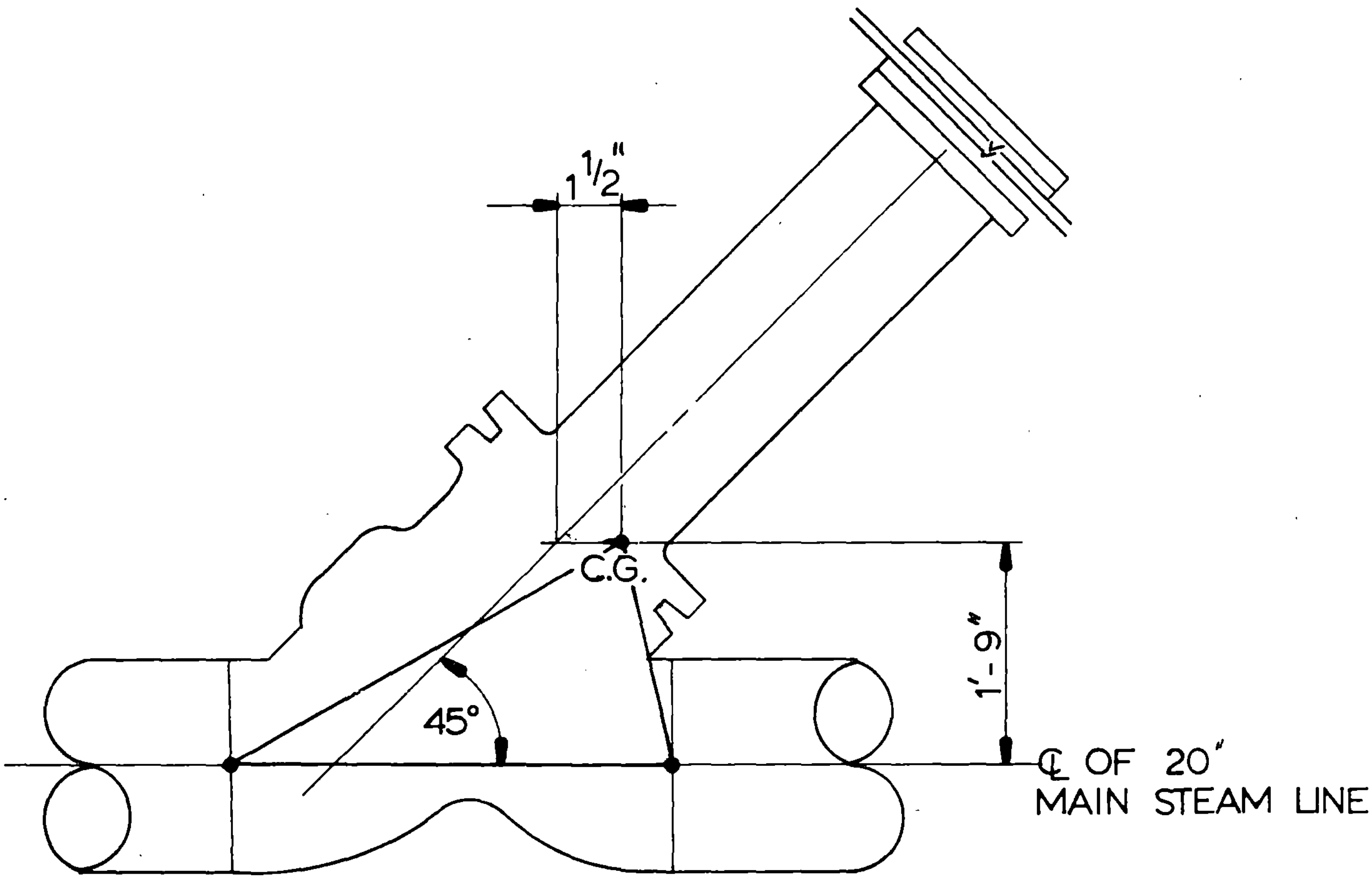


FIGURE 5-3.5

MAIN STEAM ISOLATION VALVE

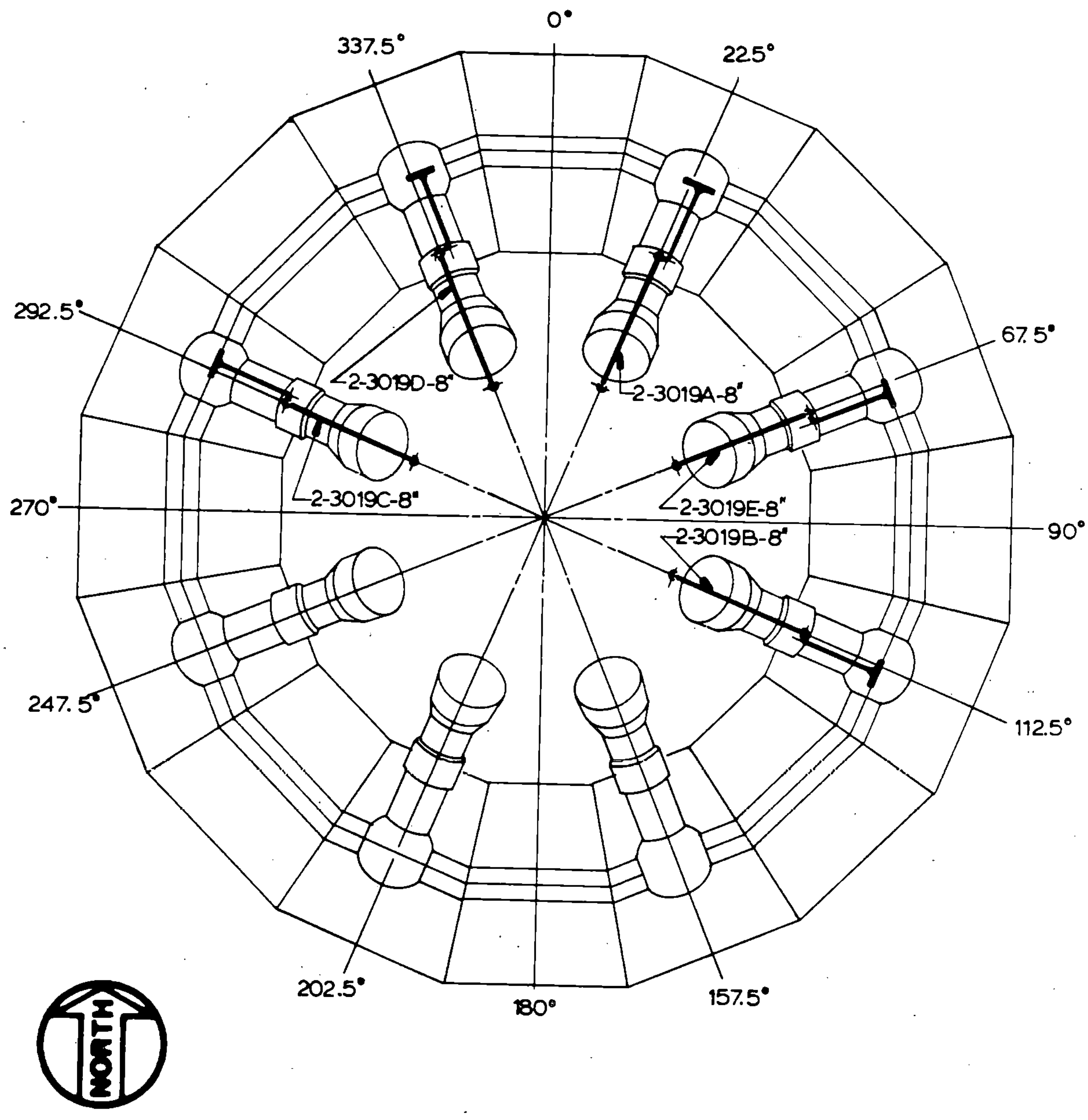


FIGURE 5-3.6

SRVDL LOCATIONS IN VENT LINES - UNIT 2

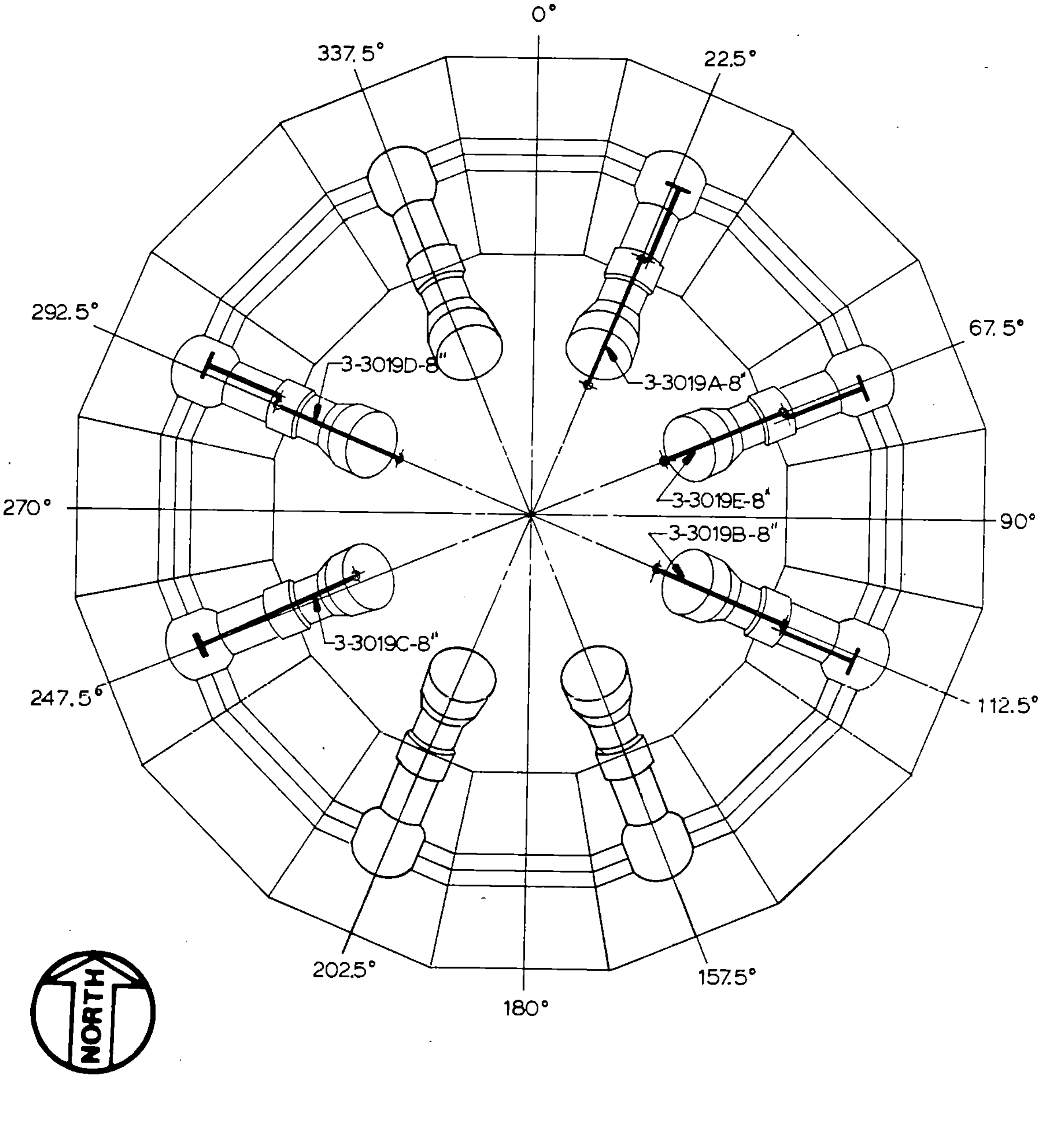


FIGURE 5-3.7

SRVDL LOCATIONS IN VENT LINES - UNIT 3

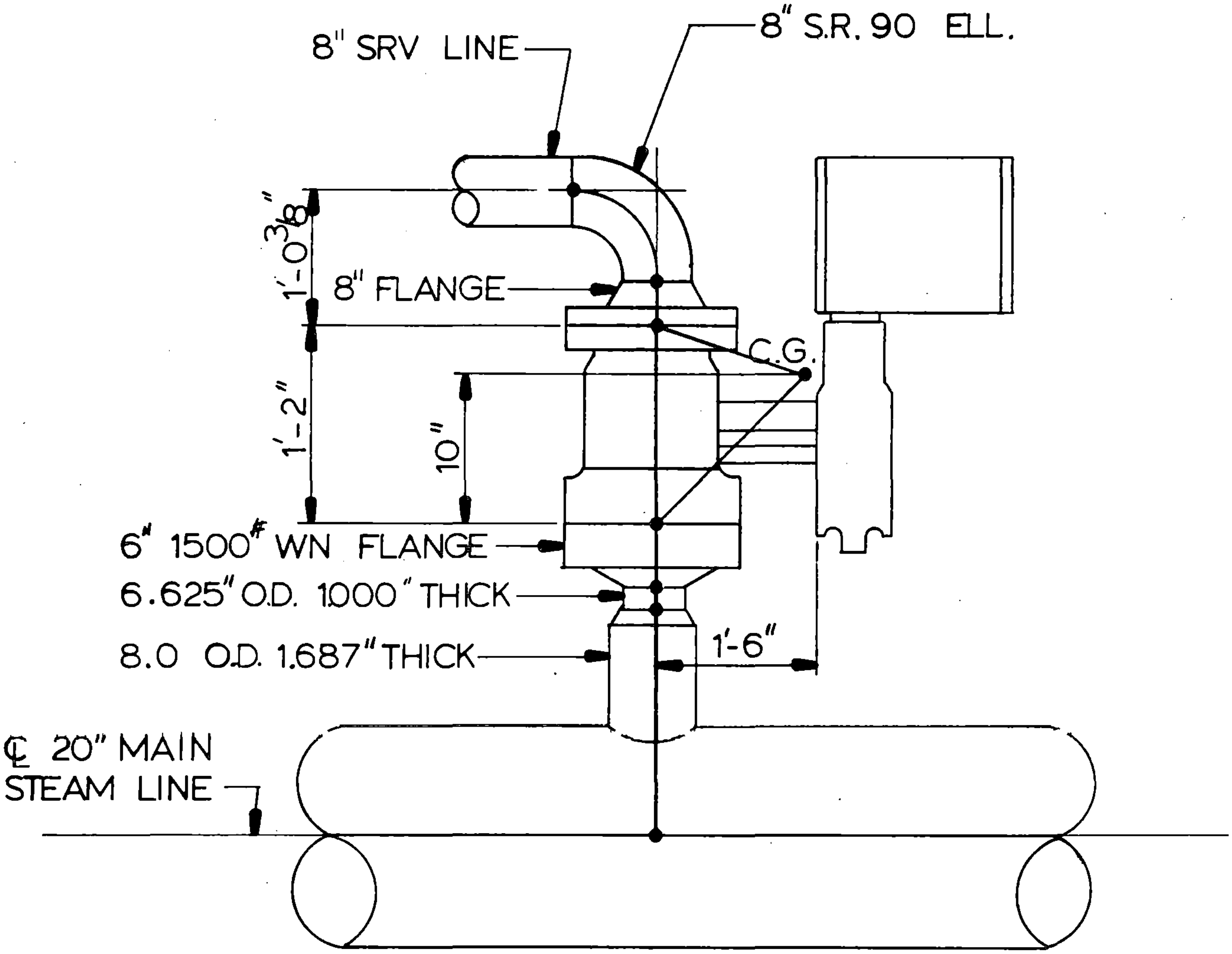


FIGURE 5-3.8

6" x 8" ELECTROMATIC RELIEF VALVE

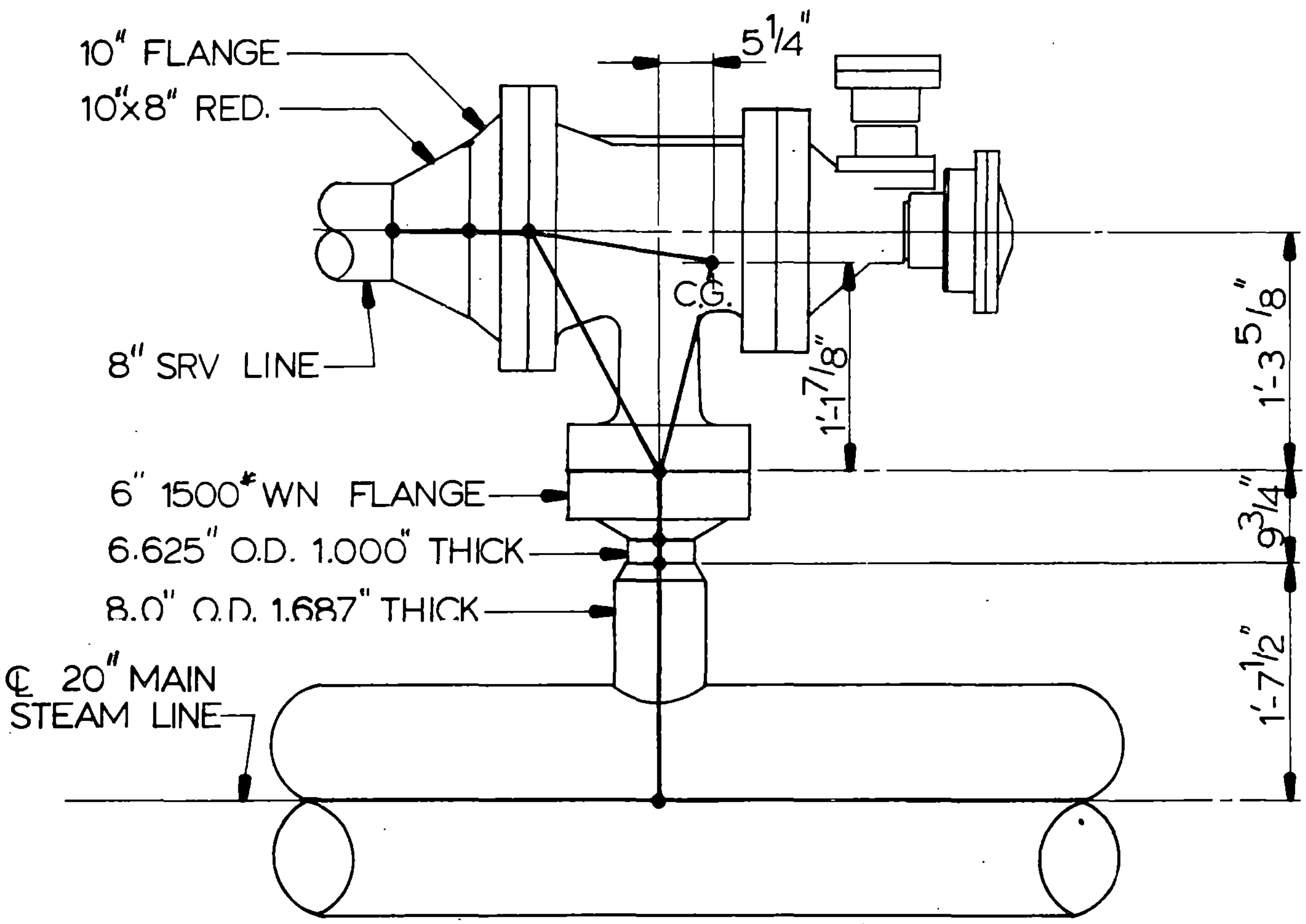


FIGURE 5-3.9

TARGET ROCK RELIEF VALVE

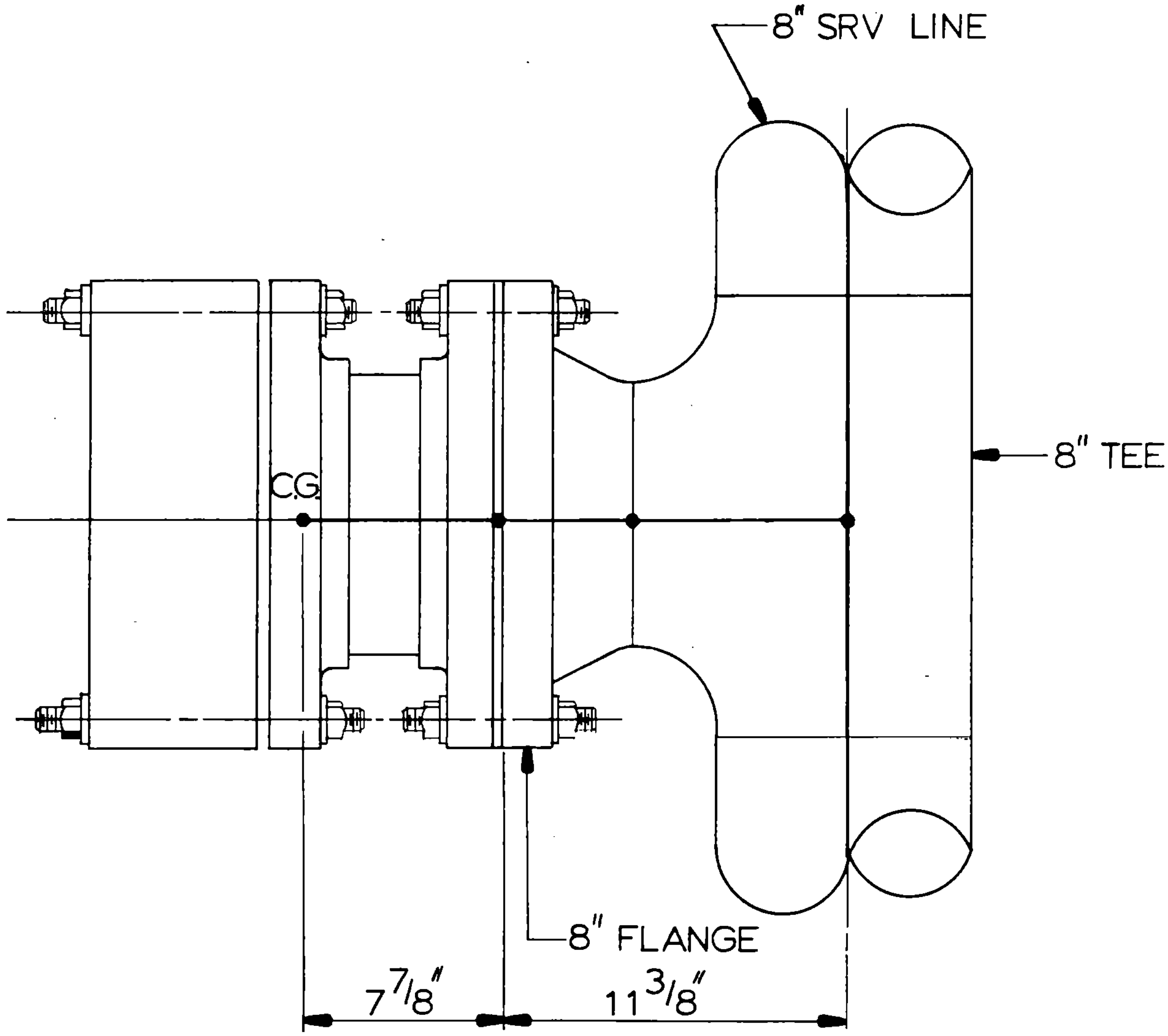


FIGURE 5-3.10

SRVDL VACUUM BREAKER

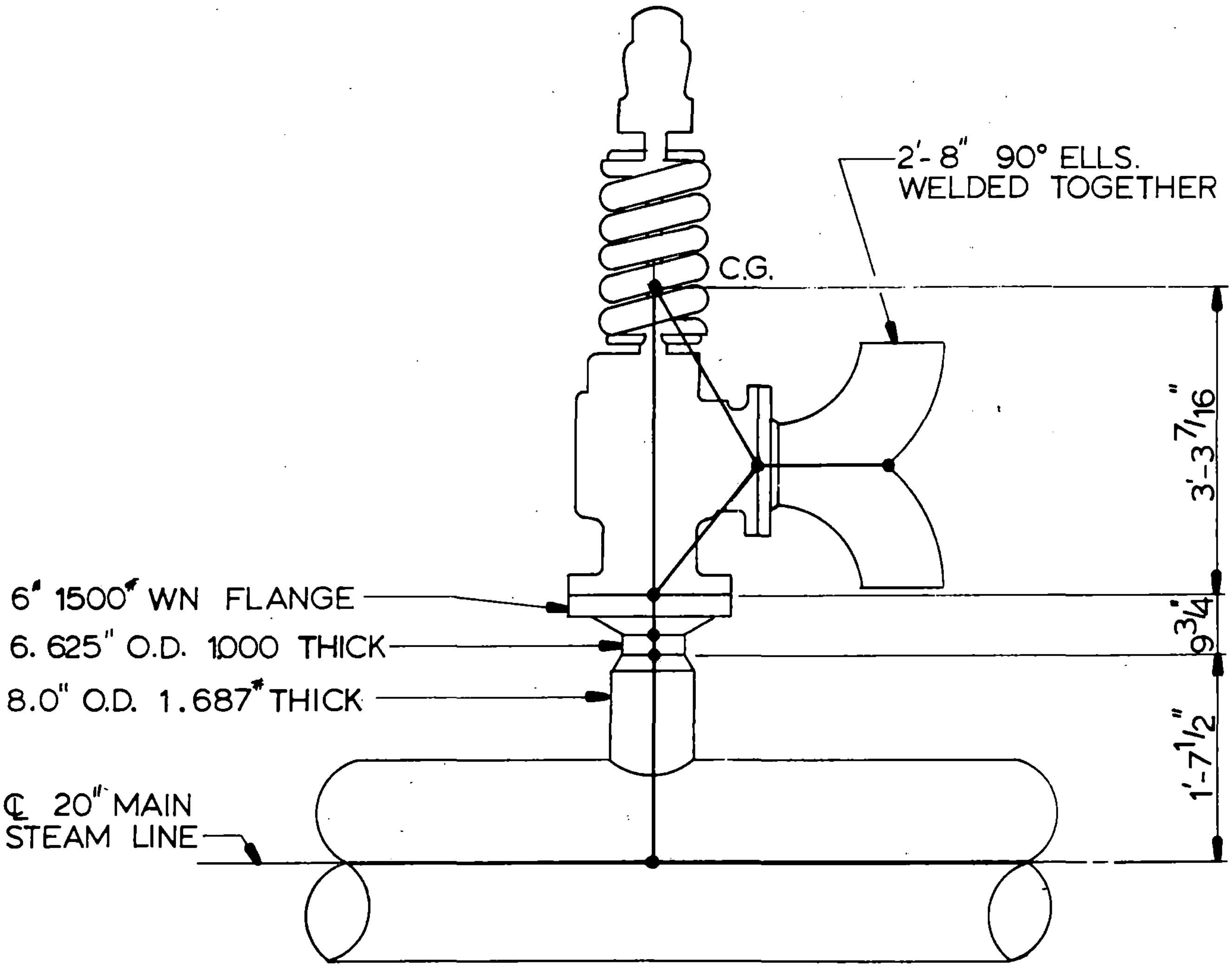


FIGURE 5-3.11

6" x 8" MAXIFLOW SAFETY VALVE

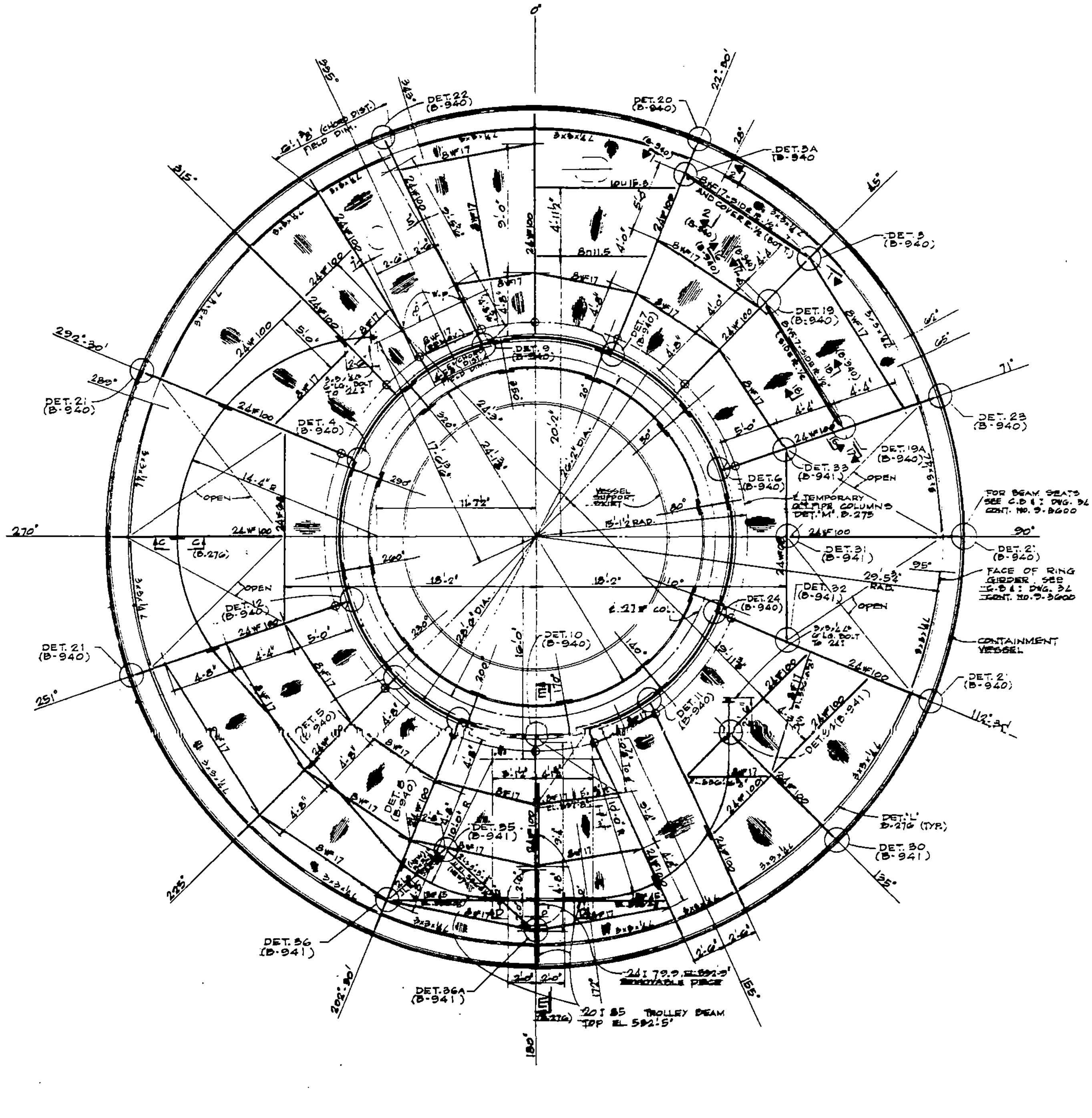


FIGURE 5-3.12

STRUCTURAL STEEL SUPPORT FRAMING INSIDE

DRYWELL, EL. 537'-1"

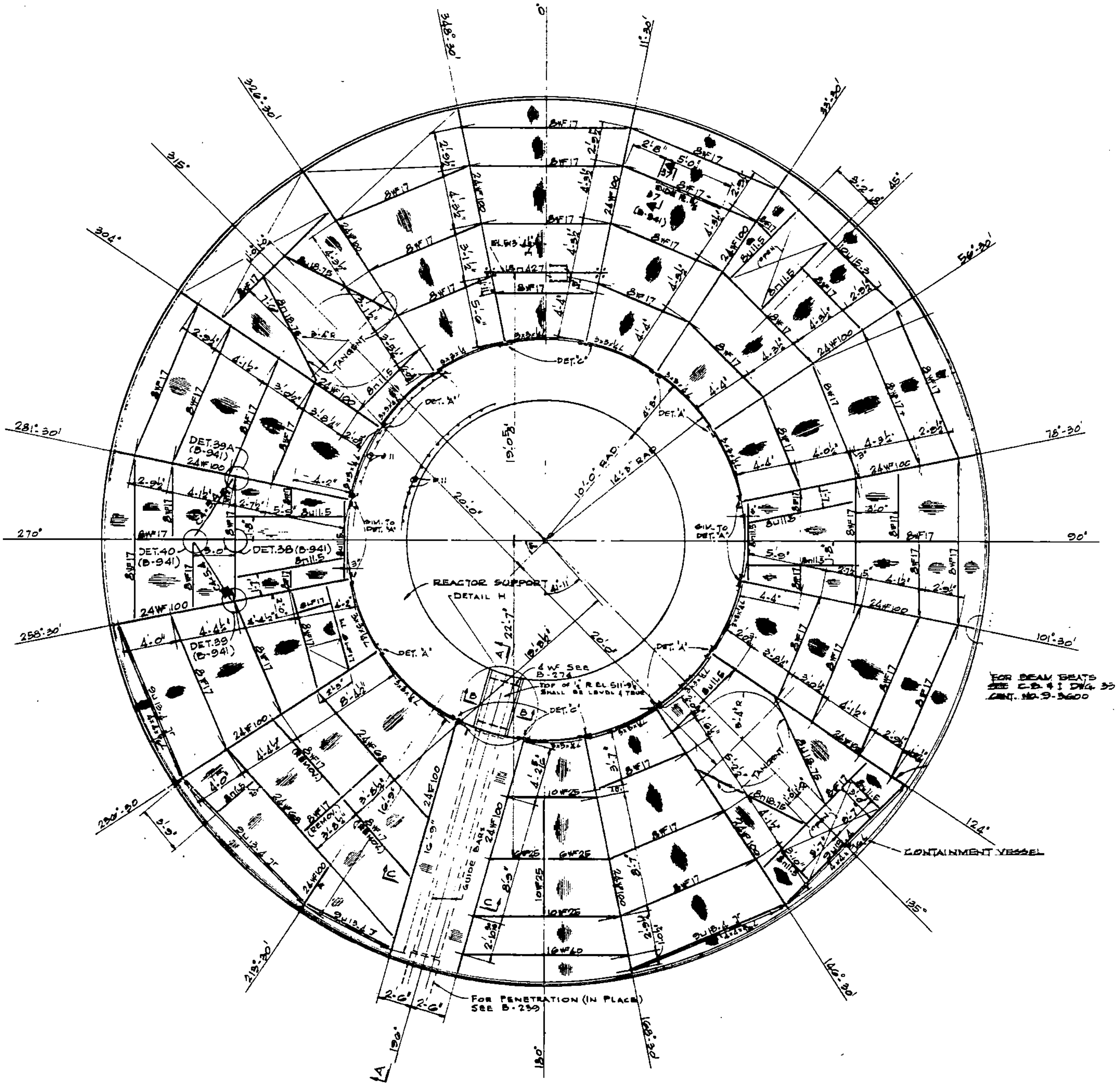


FIGURE 5-3.13

STRUCTURAL STEEL SUPPORT FRAMING INSIDE

DRYWELL, EL. 515'-5"

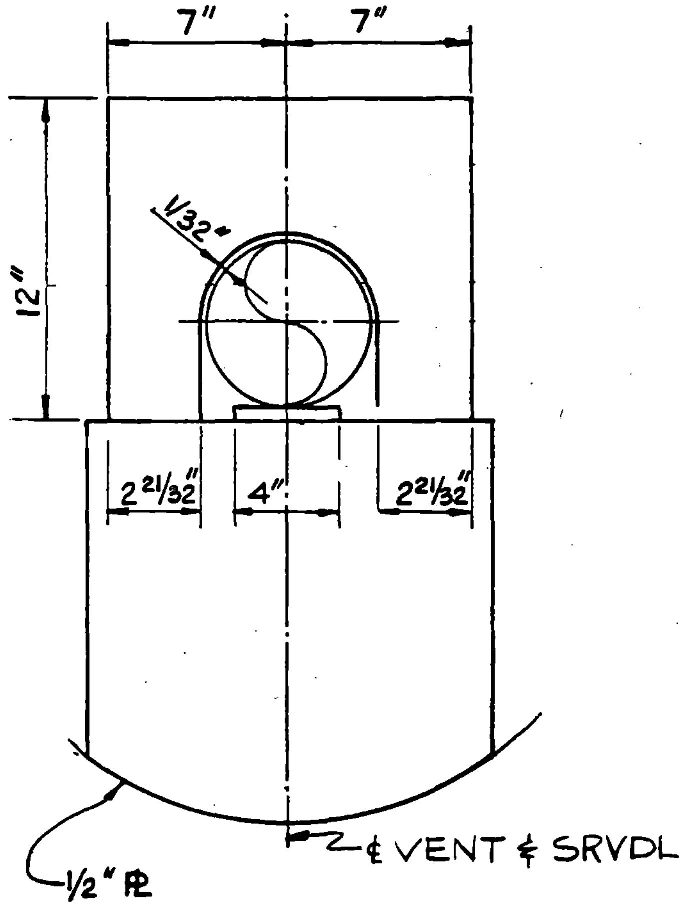


FIGURE 5-3.14

VENT LINE GUIDE NEAR DRYWELL

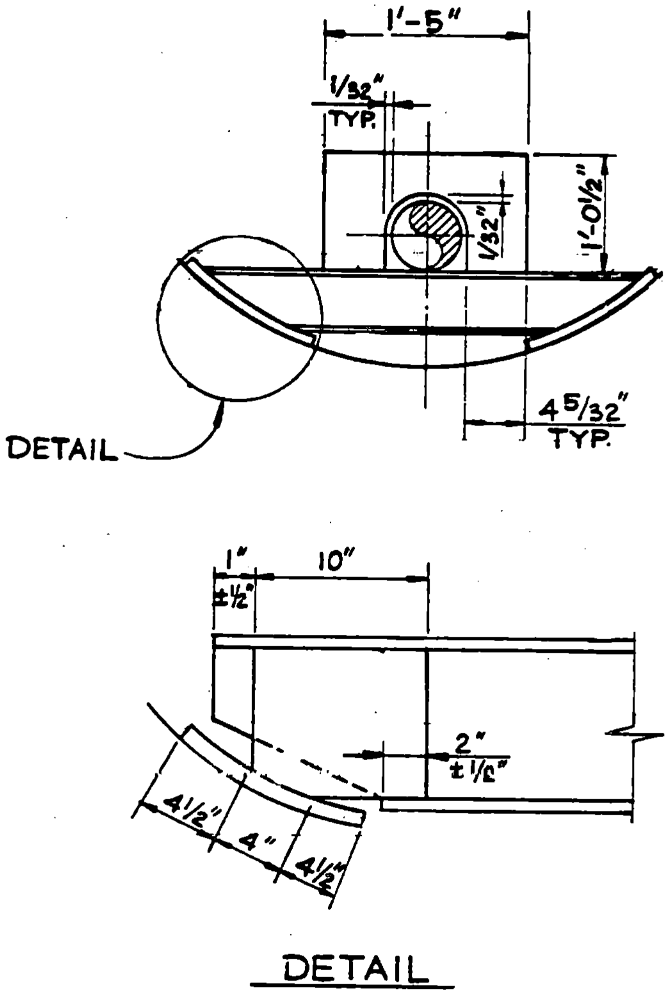


FIGURE 5-3.15

VENT LINE GUIDE NEAR SRVDL PENETRATION

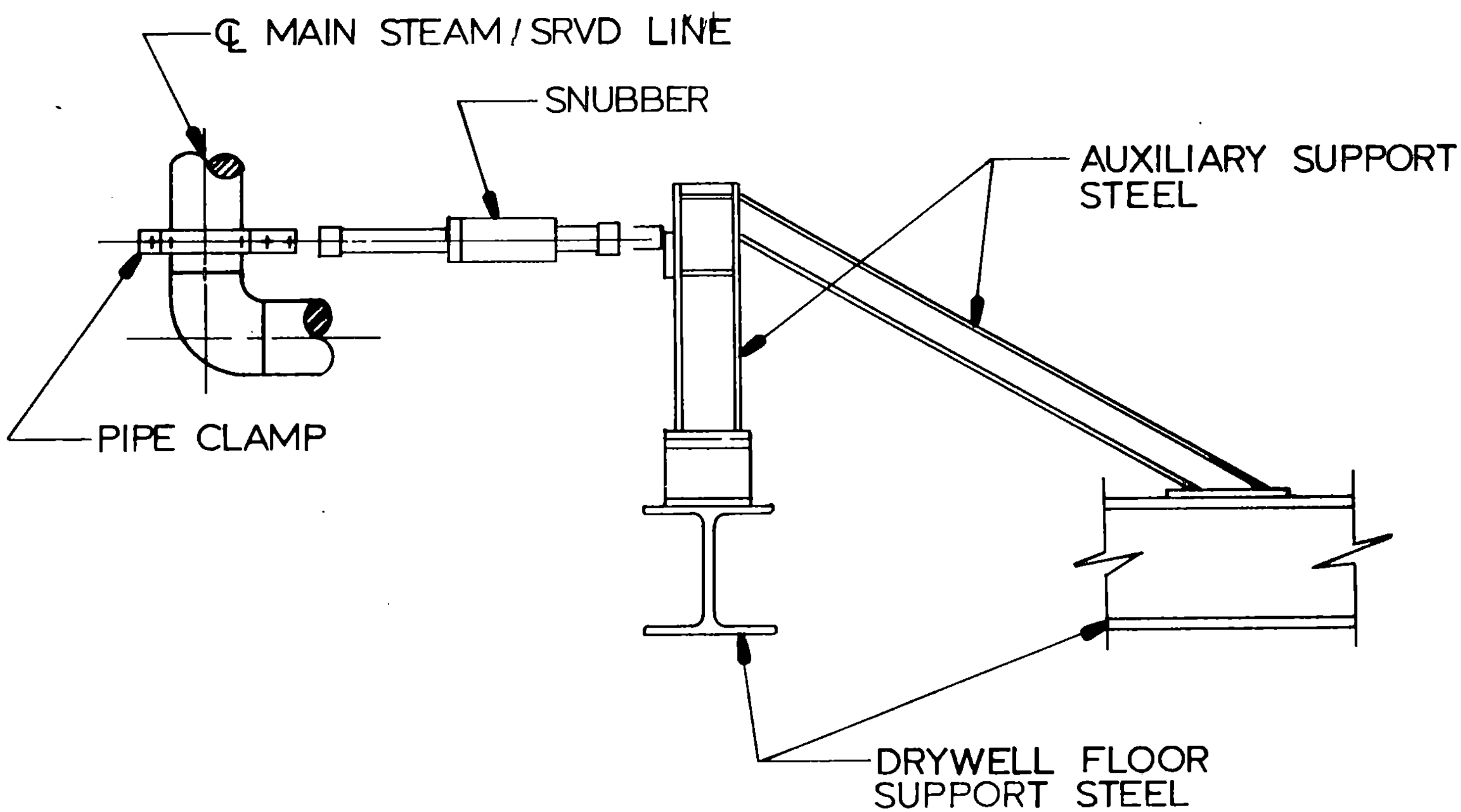


FIGURE 5-3.16

TYPICAL MS AND SRVDL SUPPORT IN DRYWELL

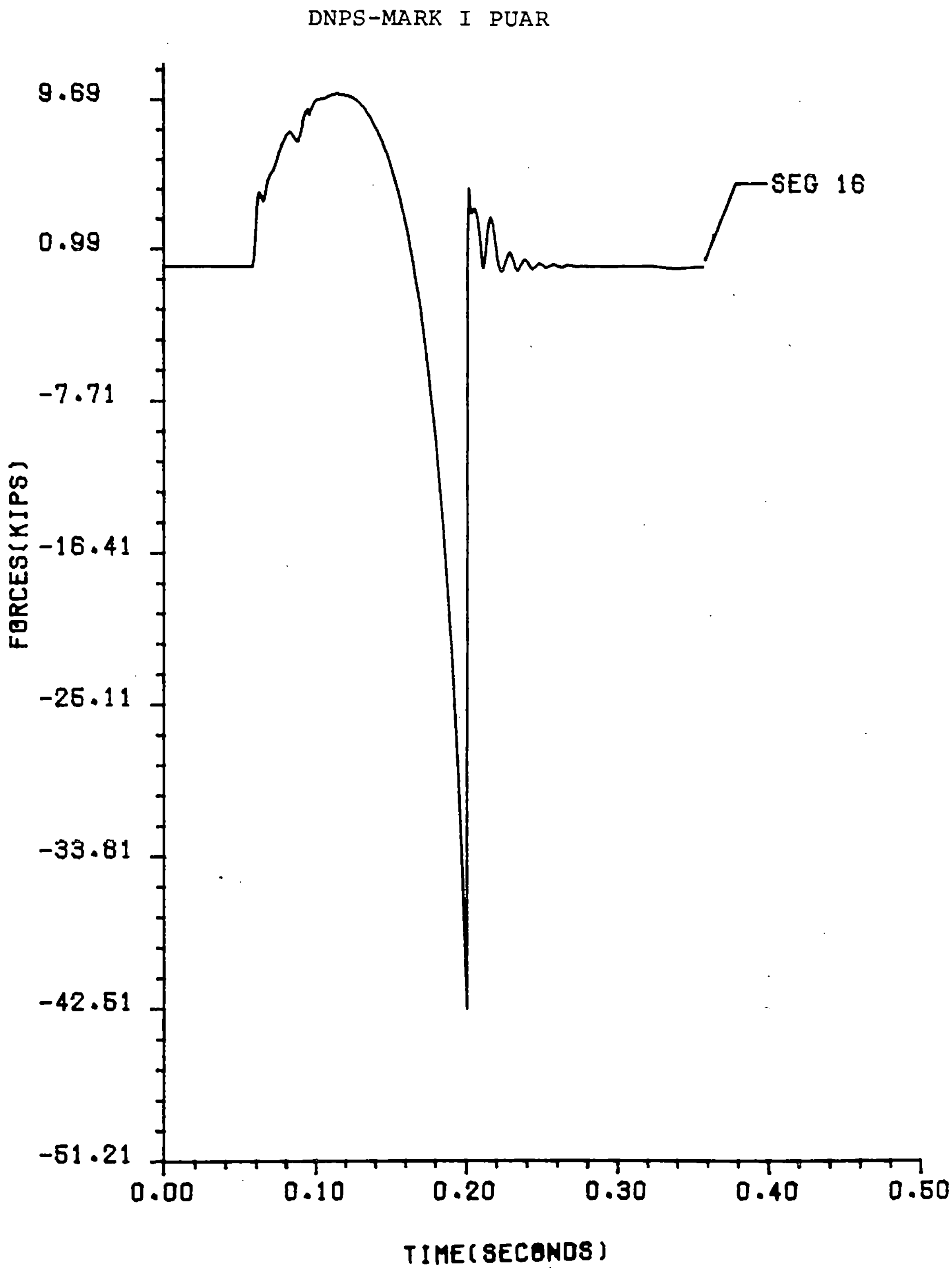


FIGURE 5-3.17

TYPICAL SRV DISCHARGE FORCE-TIME

HISTORY AT LAST SEGMENT

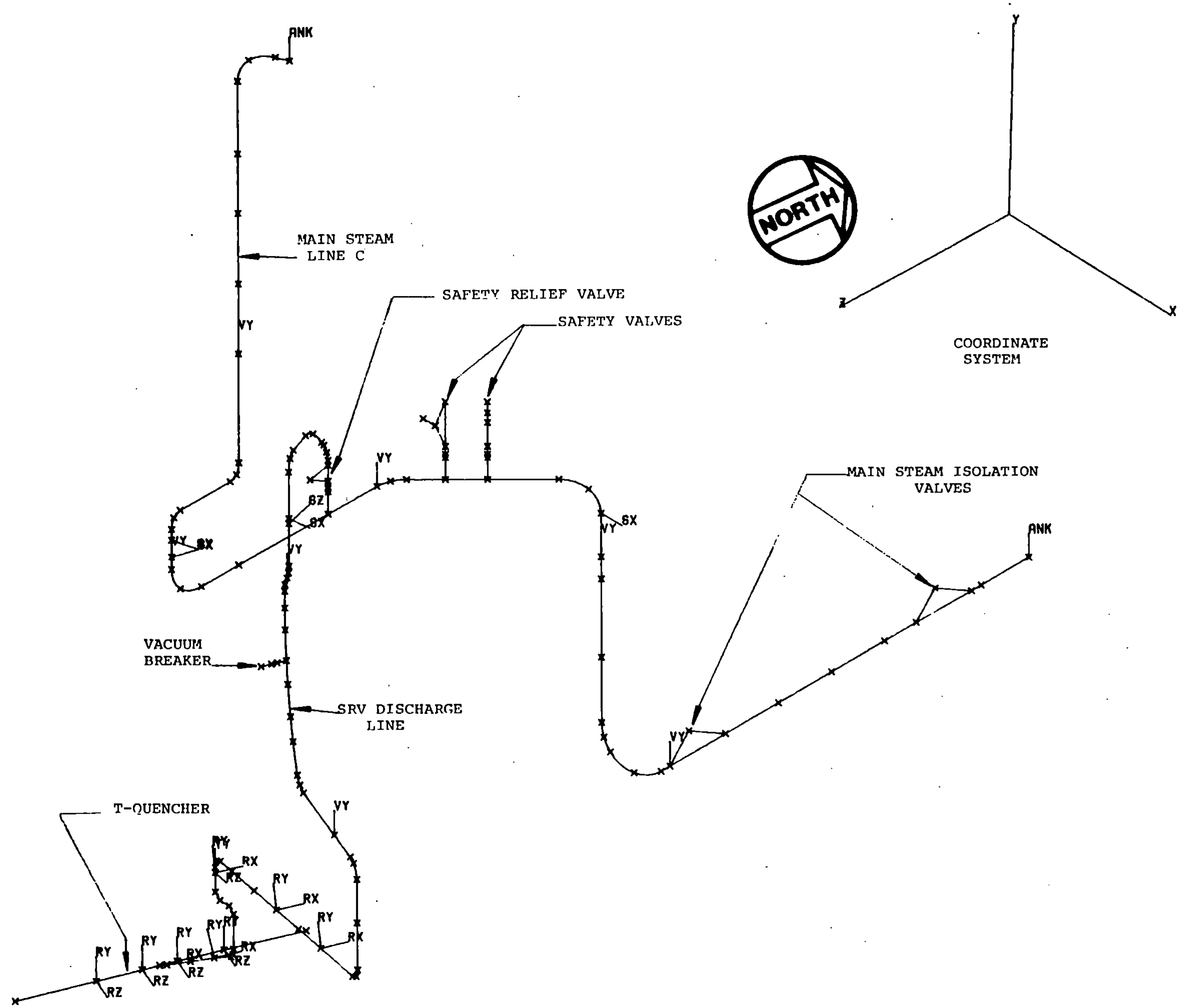


FIGURE 5-3.18

REPRESENTATIVE MS AND SRVDL PIPING MODEL

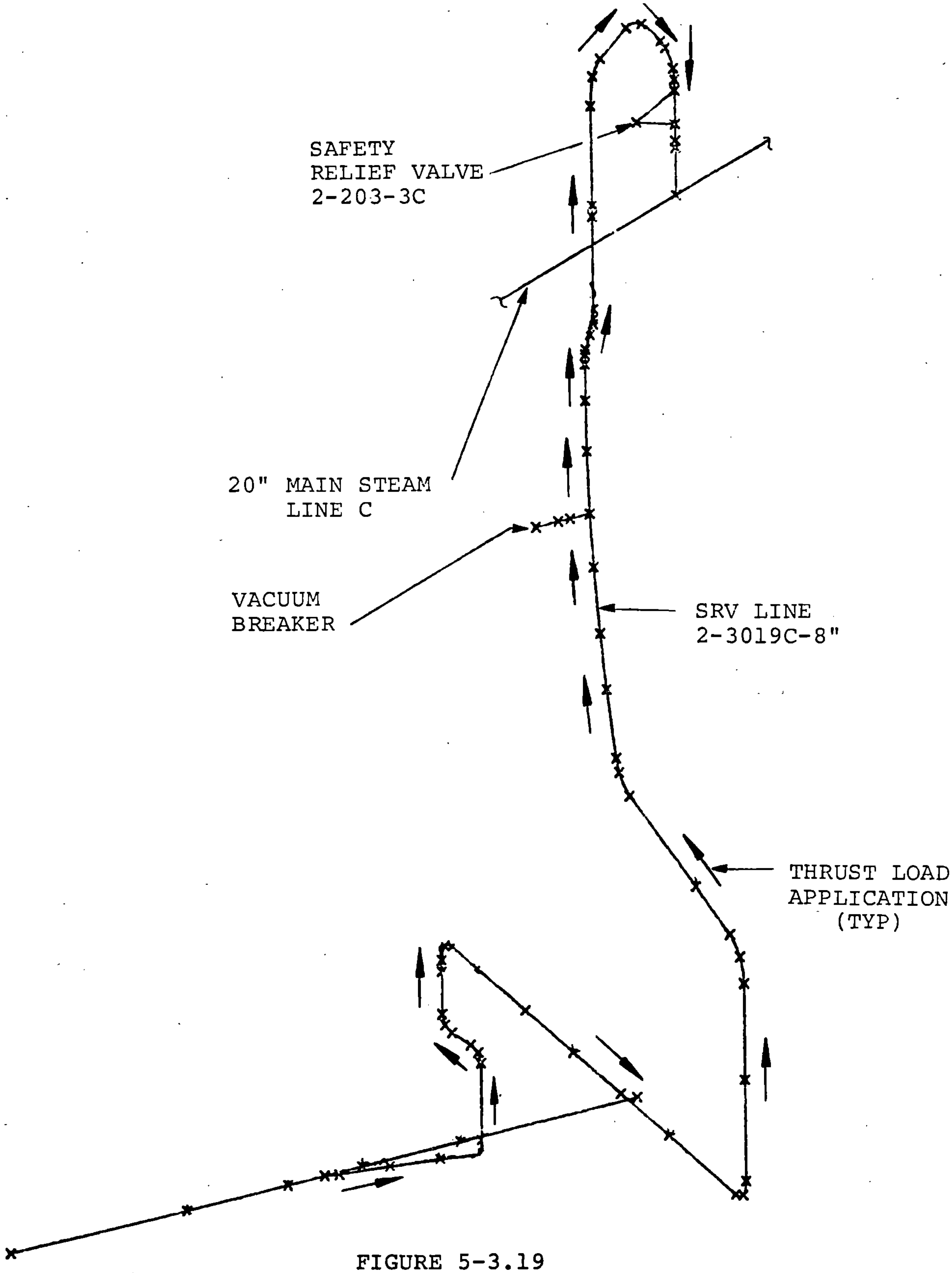


FIGURE 5-3.19

TYPICAL APPLICATION OF SRV DISCHARGE THRUST LOADS

5-4.0 SAFETY RELIEF VALVE DISCHARGE LINE PIPING SUPPORTS INSIDE THE WETWELL

5-4.1 Component Description

Safety Relief Valve Discharge Line (SRVDL) piping component supports in the wetwell include the SRVDL intermediate support and the T-Quencher support.

The SRVDL intermediate support in the wetwell consists of an 8-inch diameter, Schedule 80 pipe strut attached to a 10-inch diameter, Schedule 140 guide collar, which surrounds the SRVDL. The pipe strut is supported by a 14-inch diameter Schedule 140 pipe, which spans adjacent ring girders in the wetwell. This arrangement is shown on Figures 5-2.2 and 5-4.1.

The T-Quencher support consists of four 1 1/2-inch thick support plate guides and two ramshead lug retainers attached to a 14-inch diameter Schedule 140 pipe support beam. This beam spans the adjacent ring girders of the wetwell. This arrangement is shown on Figures 5-2.1 and 5-4.2.

5-4.2 Loads and Load Combinations

All loads and load combinations for the SRVDL wetwell supports are presented in Subsection 5-2.2.

5-4.3 Acceptance Criteria

The acceptance criteria for SRVDL wetwell supports is in accordance with the Structural Design Specification (Reference 17) and is consistent with the AISC "Specification for the Design, Fabrication and Erection of Structural Steel Buildings" (Reference 18). All stresses due to normal and severe environmental loading condi-tions are within normal AISC allowable limits. All stresses due to extreme environmental and emergency loading conditions are within 1.6 times the AISC allowable, with no stress exceeding 0.95 times the ASTM minimum specified yield strength of the material. These criteria are more conservative than Section III of the ASME Code (Reference 19), which is required by Mark I Program Structural Acceptance Criteria.

5-4.4 Method of Analysis

The SRVDL intermediate and T-Quencher supports are included in the piping analysis model as described in Subsection 5-2.4. Therefore, the forces and moments on these components are readily available from this analysis. Calculations, using an elastic approach are used to determine the maximum stress values in the critical elements of the intermediate and T-Quencher supports. These maximum stresses are then compared to the appropriate allowable stresses given in Subsection 5-4.5.

5-4.5 Analysis Results

Maximum stress values and the corresponding appropriate code allowable stresses of the critical components of the intermediate support, and T-Quencher supports are listed in Table 5-4.1. All critical stress values are within AISC Code requirements, and therefore meet the requirements of the ASME Code, Subsection NF.

Table 5-4.1

MAXIMUM AND CODE ALLOWABLE STRESSES FOR CRITICAL COMPONENTS

ITEM	MATERIAL	MAXIMUM STRESS (ksi)	ALLOWABLE STRESS (ksi)
T-Quencher Support			
Beam	ASTM A53	0.85*	1.0*
Beam End Connection Bolts	ASTM A325	7.1	16.9
Beam End Header Support Plate	ASTM SA516 GR. 70	14.9	22.8
Support Plate Guides	ASTM SA516 GR. 70	23.3	28.5
Support Plate Bolts	ASTM A564; F_u = 190 ksi	39.5	62.7
Support Plate Welds (Full Penetration)	ASTM SA516 GR. 70	13.4	22.8
Ramshead Lug Retainer	ASTM SA516 GR. 70	20.9	22.8
Intermediate Support			
Beam	ASTM A53	0.74*	1.0*
Beam End Connection Bolts	ASTM A325	5.8	15.8
Beam End Connection Plates	ASTM SA516 GR. 70	9.2	19.4
Collar Support Strut	ASTM A53 GR. B	0.80*	1.0*
Collar Bolts	ASTM A325	3.0	25.8

*These values are the results of an interaction equation.

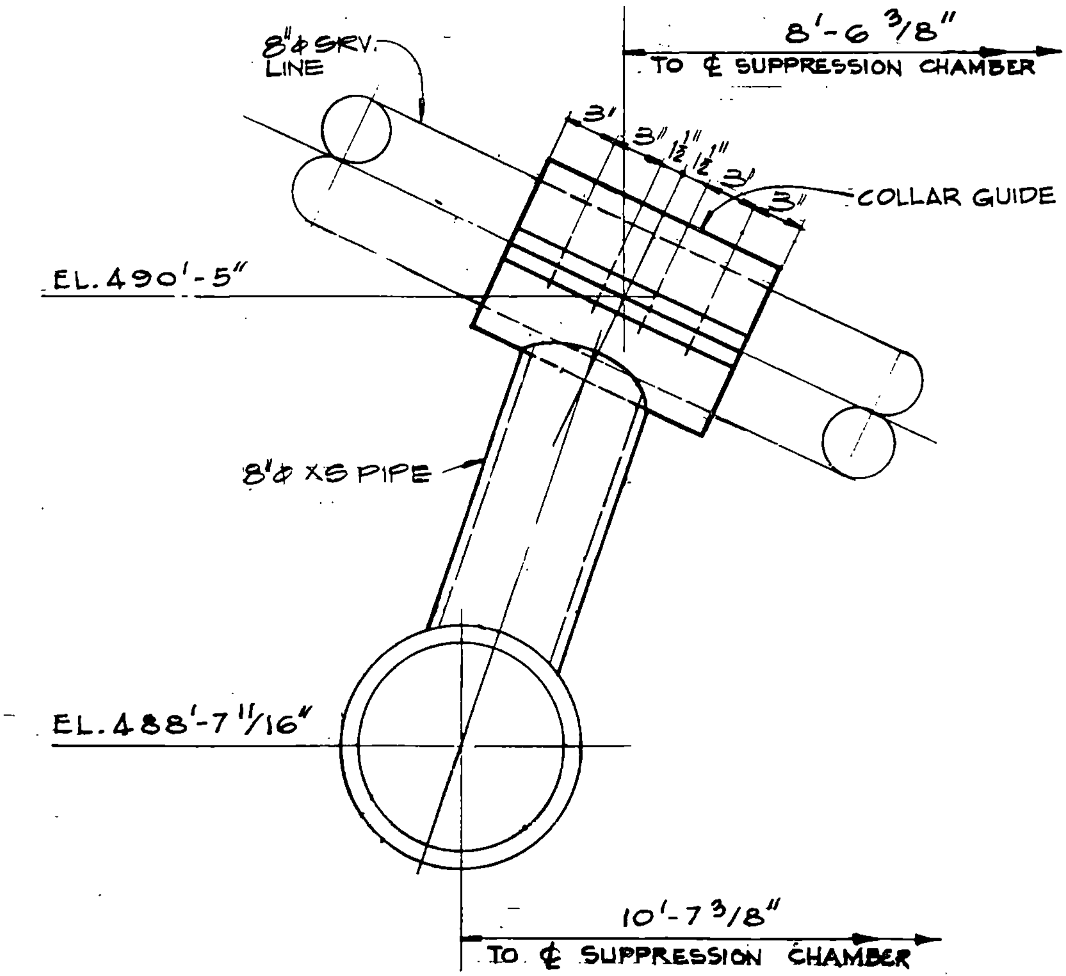


FIGURE 5-4.1

SRVDL INTERMEDIATE SUPPORT

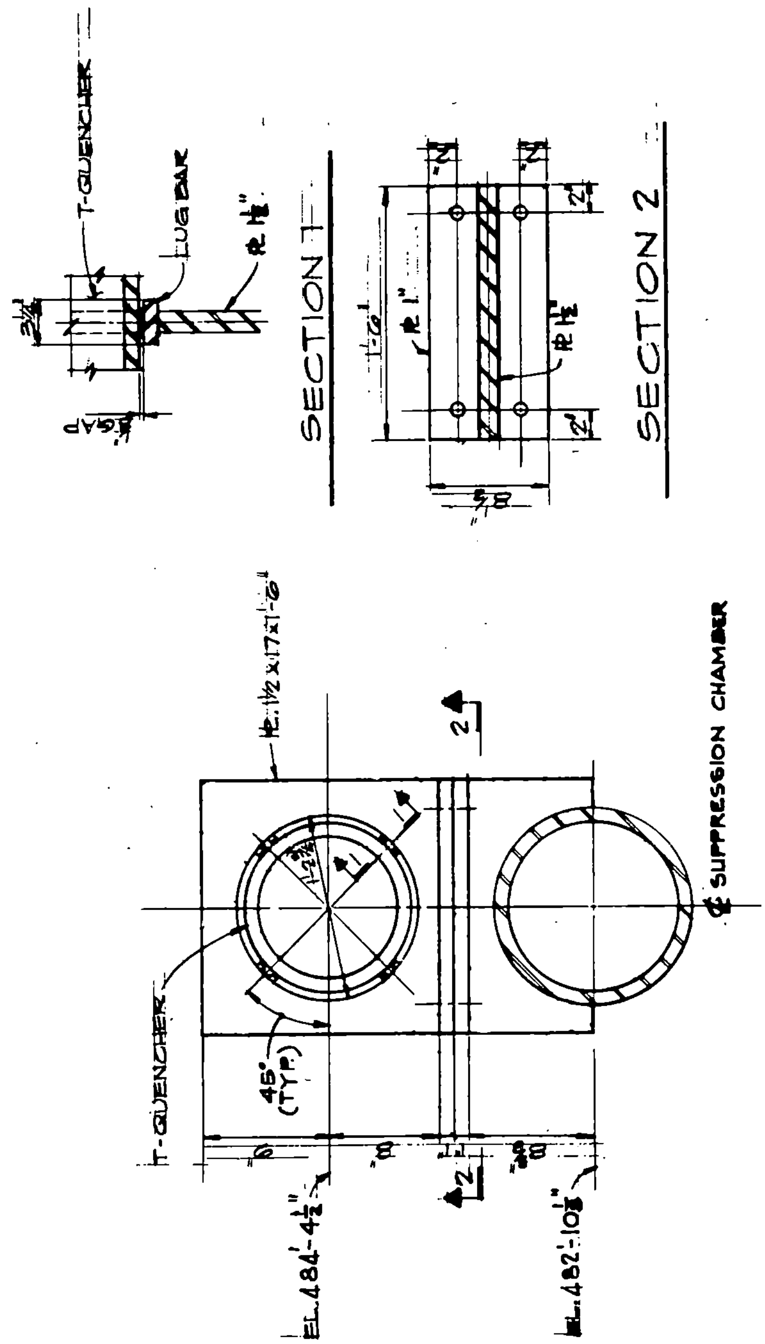


FIGURE 5-4.2

T-QUENCHER SUPPORT PLATE

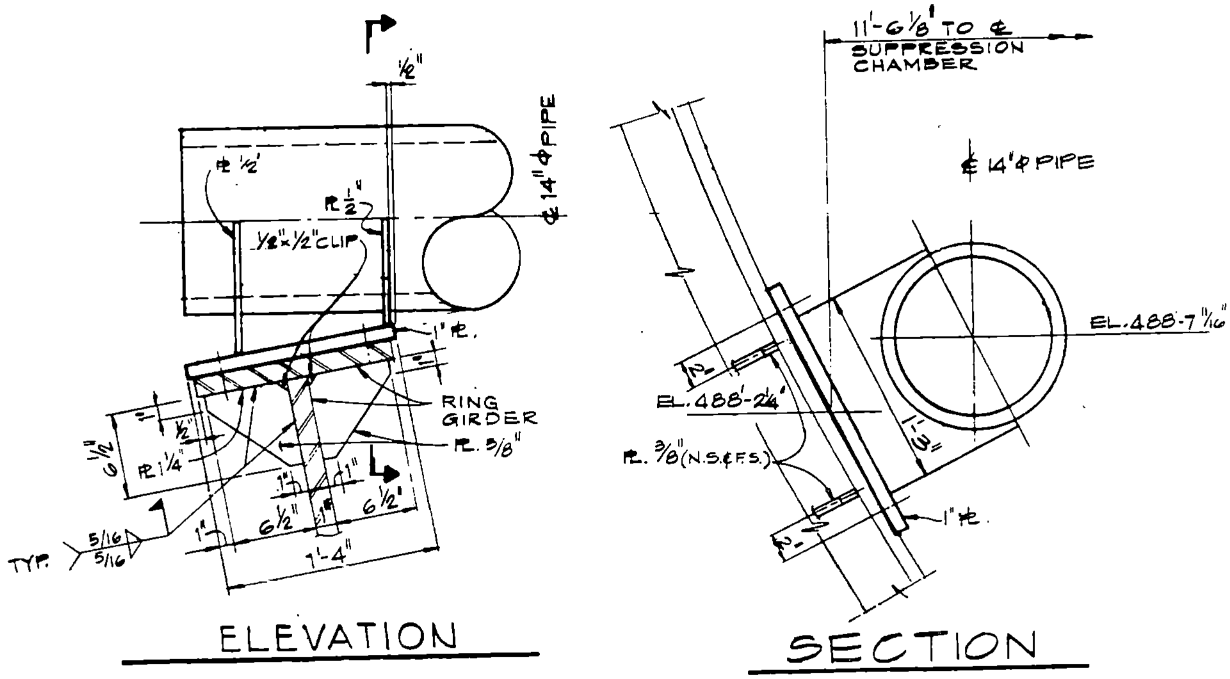
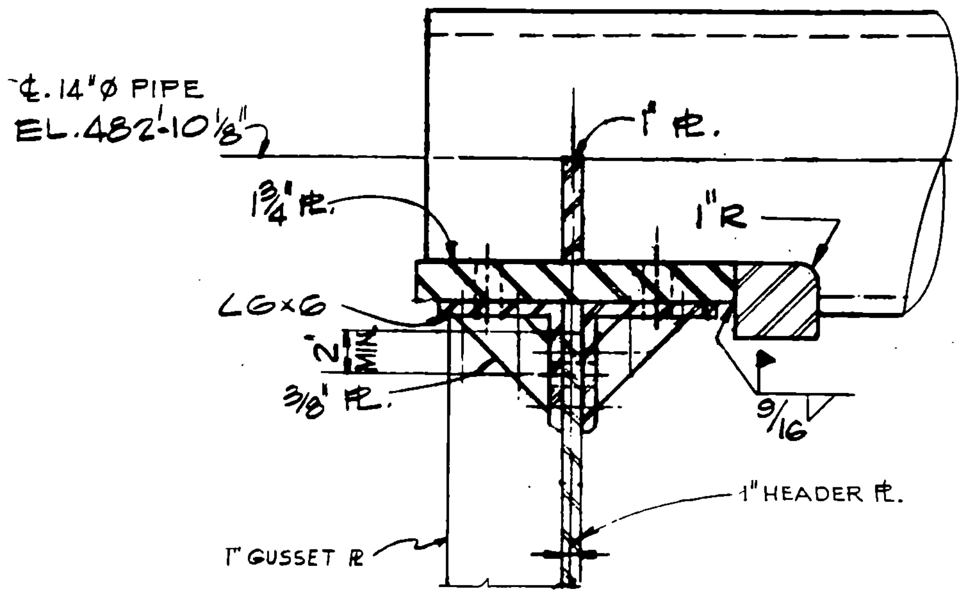
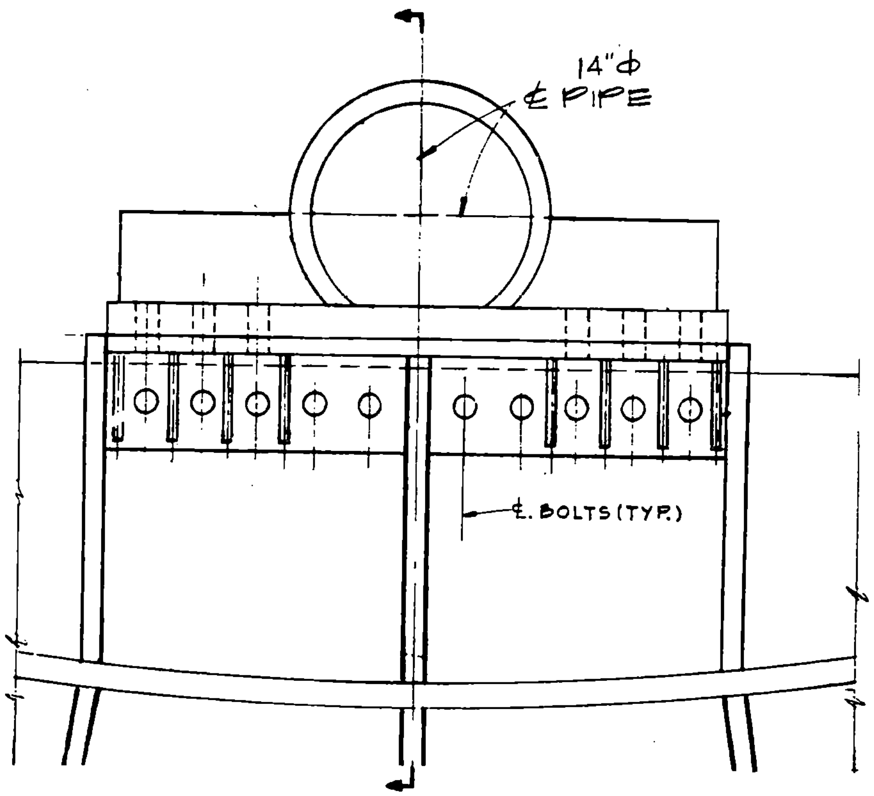


FIGURE 5-4.3

SRVDL INTERMEDIATE SUPPORT BEAM END CONNECTION



SECTION



ELEVATION

FIGURE 5-4.4

T-QUENCHER SUPPORT BEAM END CONNECTION

5-5.0 VENT LINE PENETRATION AND ATTACHMENTS

5-5.1 Component Description

The general location and description of surrounding elements for the Safety Relief Valve Discharge Line (SRVDL) penetration are shown in Figure 5-2.1. The SRVDL penetration through the vent line consists of a thickened 5/8-inch thick 2 foot 9 inch diameter insert plate with 8-3/4-inch x 6-inch minimum radial stiffeners on the interior of the vent line, and a 24-inch diameter Schedule 80 sleeve with 4-1/2-inch thick stiffeners, surrounding a 1-3/16-inch thick, 10-inch outer diameter 1 foot 9 inch long portion of SRVDL pipe on the exterior of the vent line. This arrangement is shown on Figure 5.5-1.

5-5.2 Loads and Load Combinations

The loads and load combinations for the SRVDL vent line penetration and attachments are consistent with the Mark I Owners Load Definition Report and the Structural Acceptance Criteria (References 2 and 5).

The 27 general event combinations shown in Table 5-5.2 are evaluated to determine the governing load combinations for Normal Operating, SBA, IBA, and DBA events. The specific

load combinations that were assessed, were those governing general event combinations, including distinctions between SBA and IBA, distinctions between pre-chug and post-clug, distinctions between SRV actuation cases, and considerations of multiple cases of particular loadings, consistent with the combinations discussed in Section 5-2.0.

Several different service level limits and corresponding sets of allowable stresses are associated with these load combinations. There is no distinction between load combinations with service level A or B conditions for the vent line penetration since the allowable stress values for service level A and B are the same.

The loads are considered as static, quasi-static or dynamic depending on the nature of the phenomena causing the loads. The dynamic loads are superimposed using the SRSS method in a methodology consistent with the approach approved by the NRC for Mark II wetwell. These loads and load combinations are given in Table 5-5.1 and 5-5.2 respectively.

5-5.3 Acceptance Criteria

The acceptance criteria are in accordance with ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection

NE, 1977 Edition, including Summer 1977 Addenda. The allowable stress intensities for each service level are in accordance with Table NE-3221-1 of the ASME Code and are listed in Table 5-5.3.

Fatigue stress intensities are evaluated in accordance with requirements of NE-3221.5 of the ASME code. The number of cycles used for the fatigue evaluation are based on the Mark I fatigue evaluation report and actual plant data as given in References 7 and 14 respectively. When the total number of cycles is plotted on Figure I-9.0 of the ASME Code, the modified value of S_a equal to 41.2 ksi is derived.

5-5.4 Method of Analysis

A finite element analysis is utilized in order to determine the stress intensities of the penetration of the SRVDL through the vent line. The analytical model is composed of 260 nodes, 37 elastic beam elements, and 227 elastic plate elements. Included in the model are a 24-inch diameter pipe ring, 3/4-inch x 6-inch stiffener plates, and portions of the SRVDL and vent line. Two dimensional plate elements and beam elements are used in the modeling. Beam elements are used to model the 3/4-inch thick stiffener plates. The vent line penetration has node spacing of approximately 5 inches, with additional mesh refinement near discontinuities to permit examination

of local stresses. The stiffness properties used in the model are based on the nominal dimensions of the materials used to construct the vent line penetration. Small displacement linear-elastic behavior is assumed throughout. The boundary conditions reflect symmetry, anti-symmetry, or a combination of both depending on the characteristics of the load being evaluated. A three-dimensional plot of the model is shown in Figure 5-5.2.

Internal pressure loads are applied directly to the vent line where applicable. Loads due to the SRVDL reactions are applied to the circumference of the pipe. The generation of these pipe loads is discussed in Subsection 5-2.2.

The finite element analysis output consists of plate element membrane and fiber stresses in addition to primary membrane and fiber stresses. Moments, shears, and axial loads are given for the beam elements.

Stresses due to the overall response of the vent line are combined with those due to the penetration analysis. A discussion of the vent line overall response is presented in Volume 3. The total stress was used to compute stress intensities which were compared to the allowable stresses.

The effects of local attachments on the vent line are evaluated using Welding Research Council Bulletin #107, (Reference 23). These stress intensities are combined with the stresses due to the overall response of the vent line. Maximum total stresses are then compared with allowable stresses.

In addition, a fatigue analysis is performed. The fatigue analysis consisted of evaluation of stress intensities of all elements in the finite element model for the cyclic loads. These stress intensities are then compared to the appropriate ASME allowable in Subsection NE. The analysis input and output are documented in the "SRV Line Associated Torus Internals and Vent Line Modifications Stress Report," (Reference 24) in accordance with Section NCA-3350 of the ASME code.

5-5.5 Analysis Results

Maximum stresses in the vent line penetration and the local area of the vent at the SRVDL guides are compared to allowable stresses and are listed in Table 5-5.4. All stresses are within ASME code allowables.

Stretchouts of the finite element model showing the stress intensities in the critical elements of the vent line penetration are given in Figures 5-5.3 through 5-5.9.

Table 5-5.1

LOADS FOR SRVDL VENT LINE PENETRATION AND ATTACHMENTS

SYMBOL	DEFINITION
N	Normal loads
D	Dead load (included hydrostatic load)
L	Live load
T_O	Thermal effects during operation
T_A	Thermal effects due to LOCA
R_O	Pipe reactions during operation
R_A	Pipe reaction due to LOCA
EQ(0)	Operating basis earthquake loads
EQ(S)	Safe shutdown earthquake loads
SRV	Loads induced by discharge of one or more safety relief valves as defined in the LDR
P_A	Quasi-static loads associated with a LOCA LOCA events are indicated by: SBA - Small Break Accident IBA - Intermediate Break Accident DBA - Design Basis Accident
P_{PS}	Loads due to DBA pool swell (transient pressure, impact, drag, etc.)
P_{CH}	Loads due to post-LOCA chugging
P_{CO}	Loads due to post-LOCA condensation oscillation

Table 5-5.2

LOAD COMBINATIONS FOR SRVDL VENT LINE PENETRATION AND ATTACHMENTS*

EVENT COMBINATIONS		SRV	SRV + EQ		SBA IBA		SBA + EQ IBA + EQ				SBA + SRV IBA + SRV		SBA + SRV + EQ IBA + SRV + EQ				DBA		DBA + EQ				DBA + SRV		DBA + EQ + SRV			
						CO, CH			CO, CH			CO, CH			CO, CH		PS (1)	CO, CH	PS		CO, CH		PS	CO, CH	PS		CO, CH	
TYPE OF EARTHQUAKE			O	S			O	S	O	S			O	S	O	S			O	S	O	S			O	S	O	S
COMBINATION NUMBER		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
LOADS																												
Normal (4)	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Earthquake	EQ		X	X			X	X	X	X			X	X	X	X			X	X	X	X			X	X	X	X
SRV Discharge	SRV	X	X	X							X	X	X	X	X	X							X	X	X	X	X	X
LOCA Thermal	T_A				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LOCA Reactions	R_A				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LOCA Quasi-Static Pressure	P_A				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LOCA Pool Swell	P_{PS}																X		X	X			X		X	X		
LOCA Condensation Oscillation	P_{CO}					X			X	X		X			X	X		X			X	X		X			X	X
LOCA Chugging	P_{CH}					X			X	X		X			X	X		X			X	X		X			X	X
Applicable Service Level		A	B	C	A	A	B	C	B	C	A	A	B	C	B	C	A (3, 6)	A	B (3, 6)	C	B	C	C	C	C	C	C	C

* From Reference 5

(1) Where drywell to wetwell pressure differential is normally utilized as a load mitigator, an additional evaluation shall be performed without SRV loadings but assuming loss of the pressure differential. In the additional evaluation, Level D Service Limits shall apply for all structural elements except Row 8 Internal Structures, which need not be evaluated. If drywell to wetwell pressure differential is not employed as a load mitigator, the listed Service Limits shall be applicable.

(2) Evaluation of primary-plus-secondary stress intensity range (NE-3221.4) and of fatigue (NE-3221.5) are not required.

(3) For the torus shell, the S_{mc} value may be replaced by 1.0 S_{mc} times the dynamic load factor derived from the torus structural model. As an alternative, the 1.0 multiplier may be replaced by the plant unique ratio of the torus dynamic failure pressure to the static failure pressure.

(4) Normal loads consist of the combination of dead loads, live loads, thermal effects during operation and pipe reactions during operation.

Table 5-5.3

ALLOWABLE STRESS INTENSITIES - CLASS MC COMPONENTS

(ASME 1977 EDITION INCLUDING SUMMER 1977 ADDENDA)

Service Levels (A-C Only) \ Load Types	P_m	P_L	$P_L + P_B$	$P_L + P_B + Q$
A	S_{m_c}	1.5 S_{m_c}	1.5 S_{m_c}	3 S_{m_1}
B	S_{m_c}	1.5 S_{m_c}	1.5 S_{m_c}	3 S_{m_1}
C	1.2 S_{m_c} or* S_y	1.8 S_{m_c} or* 1.5 S_y	1.8 S_{m_c} or* 1.5 S_y	N/A

P_m - General Membrane

P_B - Stress Due to Bending

P_L - Local Membrane

Q - Secondary or Self-Equilibratory Membrane + Bending

S_{m_c} - Stress Intensities per I-10.0

S_{m_1} - Stress Intensity per I-1.0

S_y - Minimum Specified Yield Stress at Maximum Operating Temperature

* - Greater of 2 Values

N/A - Not Applicable

Table 5-5.3

ALLOWABLE STRESS INTENSITIES - CLASS MC COMPONENTS

(ASME 1977 EDITION)

Service Levels (A-C Only) \ Load Types	P_m	P_L	$P_L + P_B$	$P_L + P_B + Q$
A	S_m	1.5 S_m	1.5 S_m	3 S_m
B	S_m	1.5 S_m	1.5 S_m	3 S_m
C	1.2 S_m or* S_y	1.8 S_m or* 1.5 S_y	1.8 S_m or* 1.5 S_y	N/A

P_m - General Membrane

P_B - Stress Due to Bending

P_L - Local Membrane

Q - Secondary or Self-Equilibratory Membrane + Bending

S_m - Stress Intensities per I-10.0

S_y - Minimum Specified Yield Stress at Maximum Operating Temperature

* - Greater of 2 Values

N/A - Not Applicable

Table 5-5.4

MAXIMUM STRESS INTENSITIES AND CODE ALLOWABLE STRESSES

IN VENT LINE PENETRATION & ATTACHMENTS

ITEM	MATERIAL	MATERIAL * PROPERTIES (ksi)	STRESS TYPE	SERVICE LEVEL A&B (ksi)		SERVICE LEVEL C (ksi)		FATIGUE EVALUATION (ksi)	
				MAXIMUM	ALLOWABLE	MAXIMUM	ALLOWABLE	MAXIMUM	ALLOWABLE
Vent Line Penetration-Shell	SA516 GR. 70	S_m=19.3,S_y=35.9	Primary General Membrane	13.90	19.30	18.00	35.90	N/A	N/A
			Primary Local Membrane	25.70	28.95	30.80	53.85	N/A	N/A
			Principal Extreme Fiber	28.80	28.95	40.60	53.85	33.40	41.20
			Primary & Secondary Extreme Fiber	53.80	57.90	N/A	N/A	N/A	N/A
Vent Line Penetration-Stiffeners	SA516 GR. 70	S_m=19.3,S_y=35.9	Principal Extreme Fiber	28.80	28.95	36.50	53.85	34.40	41.20
Vent Line Penetration-Ring	SA516 GR. 70	S_m=19.3,S_y=35.9	Principal Extreme Fiber	22.10	28.95	25.80	53.85	20.20	41.20
Vent Line Penetration-Fin	SA516 GR. 70	S_m=19.3,S_y=35.9	Principal Extreme Fiber	27.70	28.95	32.00	53.85	26.00	41.20
SRVDL Guide Attachment-Shell	SA516 GR. 70	S_m=19.3,S_y=35.9	Principal Extreme Fiber	15.40	28.95	23.60	53.85	15.40	41.20
			Primary & Secondary Extreme Fiber	41.0	57.90	N/A	N/A	N/A	N/A

*Material properties are based on the maximum operating temperature.

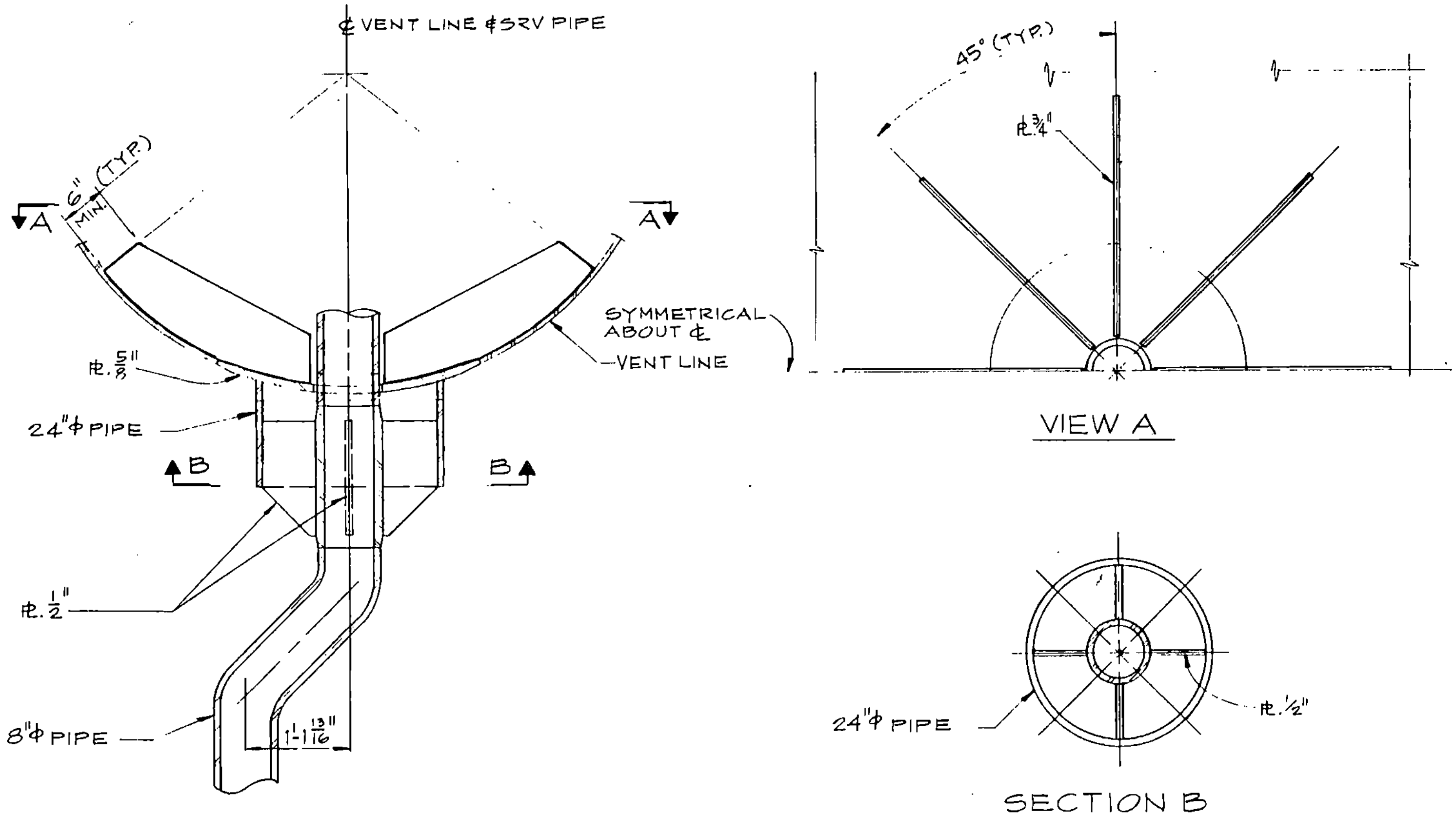


FIGURE 5-5.1

SRVDL VENT LINE PENETRATION

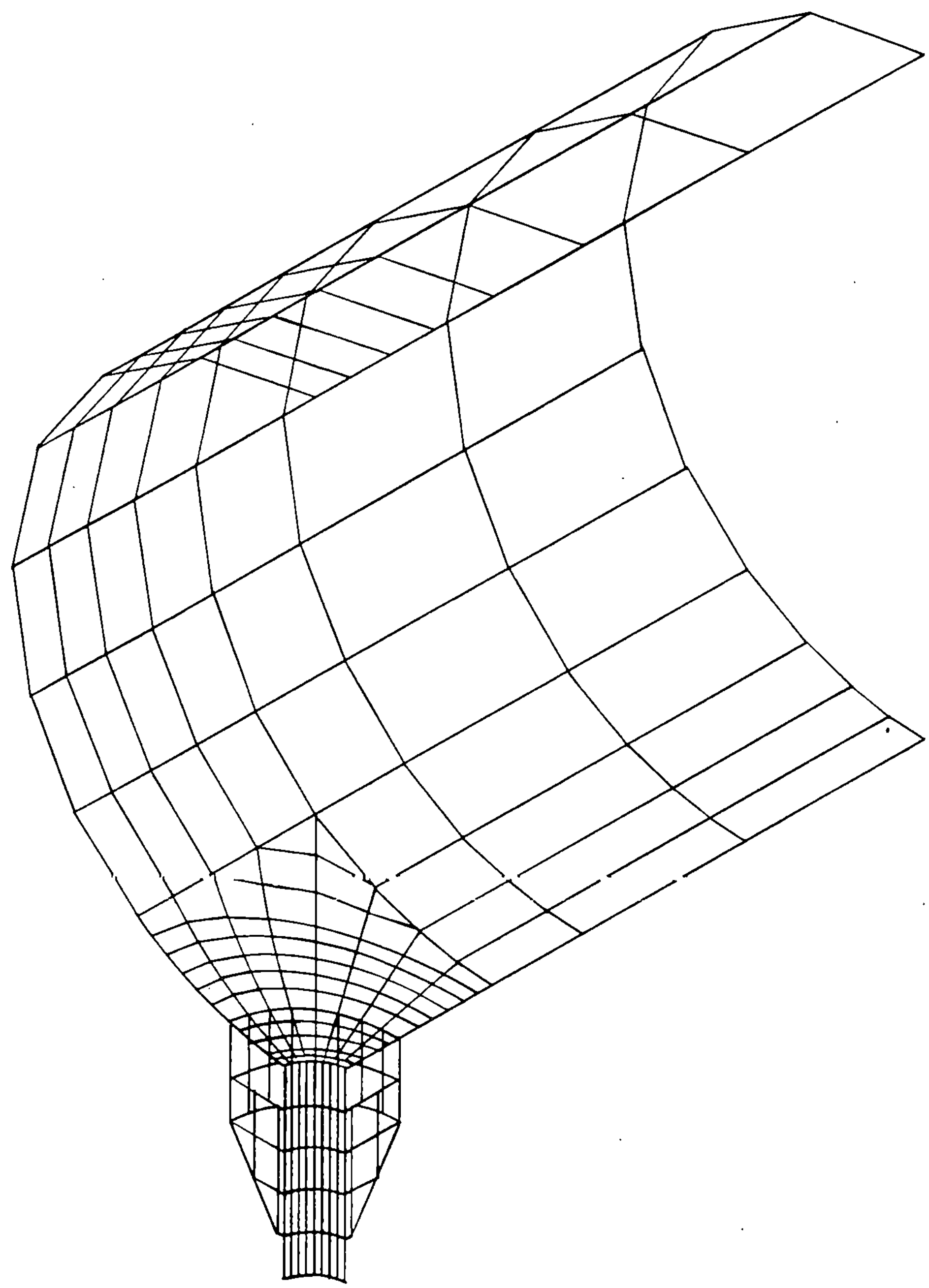


FIGURE 5-5.2

SRVDL VENT LINE PENETRATION

FINITE ELEMENT MODEL - ISOMETRIC

Allowable Stress
Intensity = 3 S_{m_1}
(68.1 ksi)

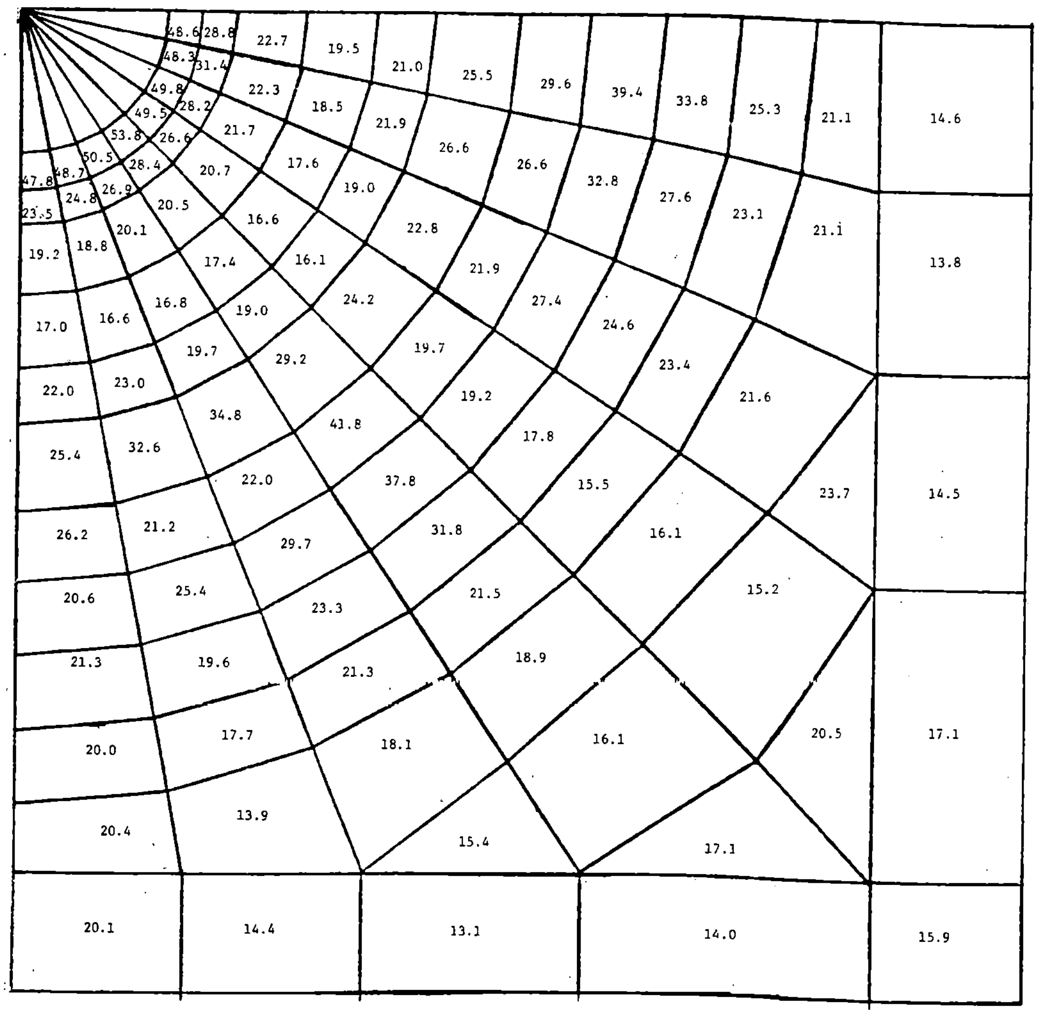
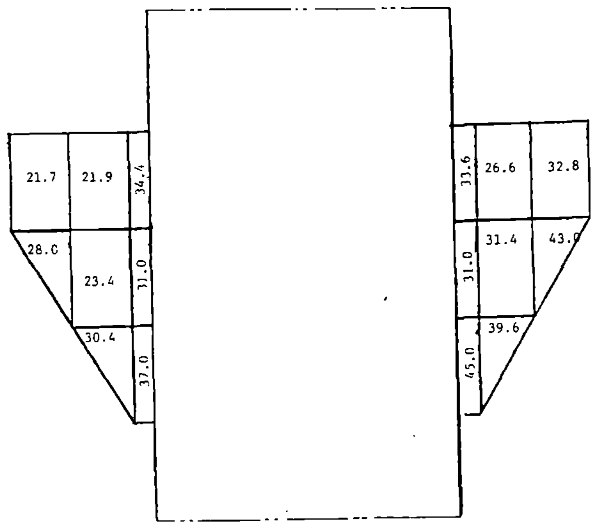
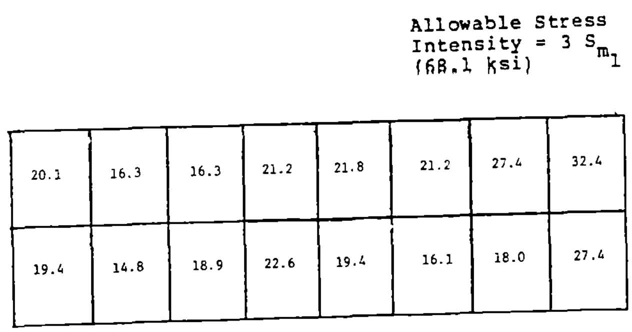


FIGURE 5-5.3 (Sheet 1 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL EXTREME FIBER STRESS INTENSITIES FOR SERVICE LEVEL A & B WITH THERMAL EXPANSION



PIPE & FINS



SLEEVE

FIGURE 5-5.3 (Sheet 2 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL
EXTREME FIBER STRESS INTENSITIES FOR
SERVICE LEVEL A & B WITH THERMAL EXPANSION

Allowable Stress
Intensity = 1.5 S_{m_c}
(28.95 ksi)

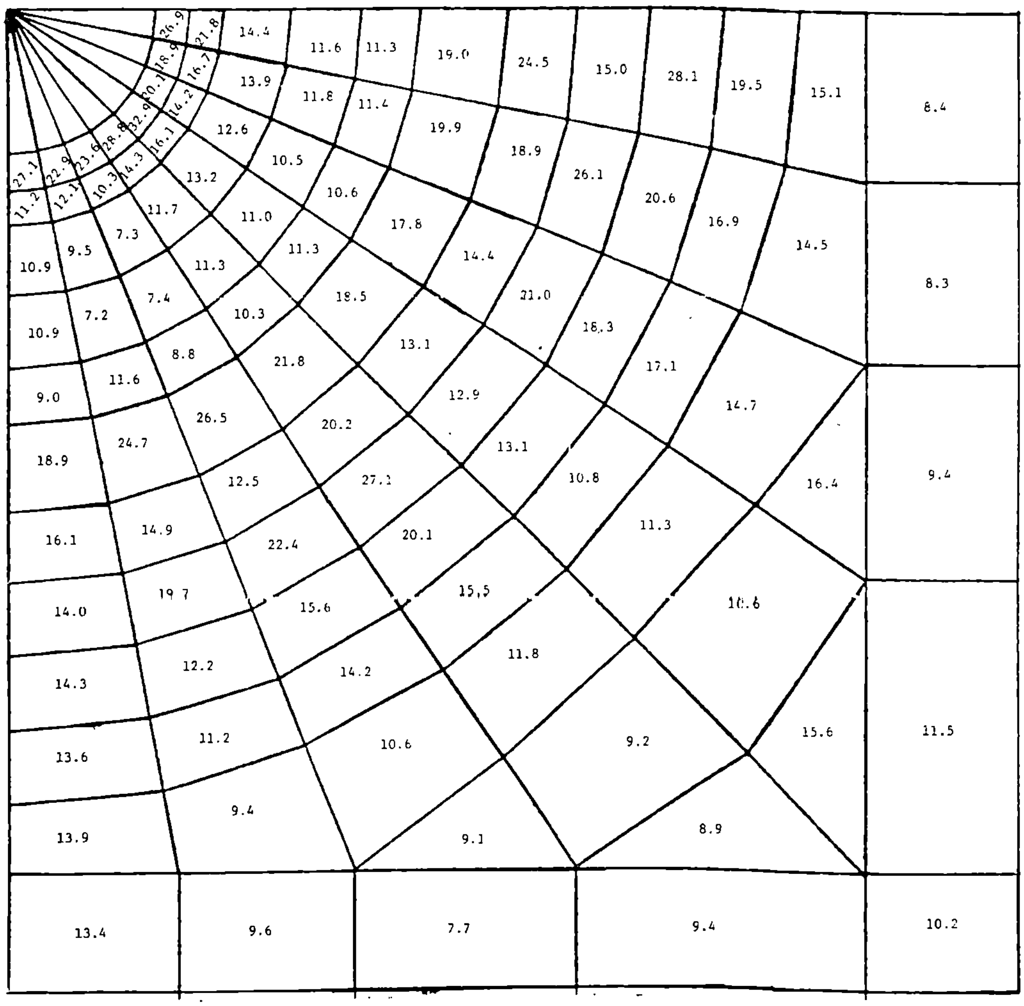
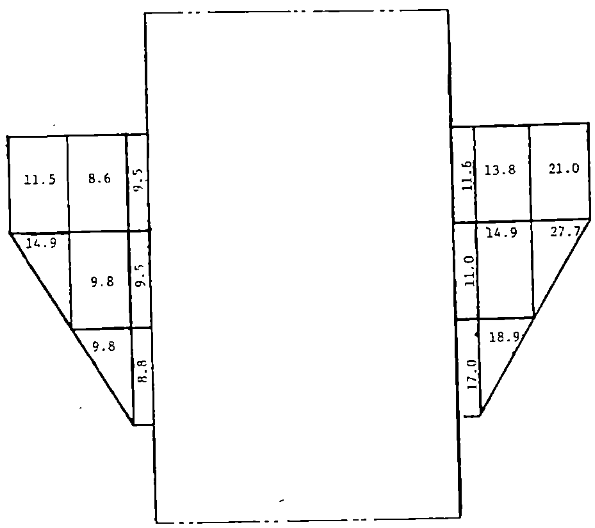


FIGURE 5-5.4 (Sheet 1 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL
EXTREME FIBER STRESS INTENSITIES FOR
SERVICE LEVEL A & B WITHOUT THERMAL EXPANSION



PIPE & FINS

Allowable Stress
Intensity = 1.5 S_{m_c}
(28.95 ksi)

11.0	8.6	8.9	14.4	16.8	15.7	19.5	22.1
9.5	8.0	12.1	15.2	12.3	9.9	11.1	22.0

SLEEVE

FIGURE 5-5.4 (Sheet 2 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL
EXTREME FIBER STRESS INTENSITIES FOR
SERVICE LEVEL A & B WITHOUT THERMAL EXPANSION

Allowable Stress Intensity = 1.5 S_y (50.9 ksi)

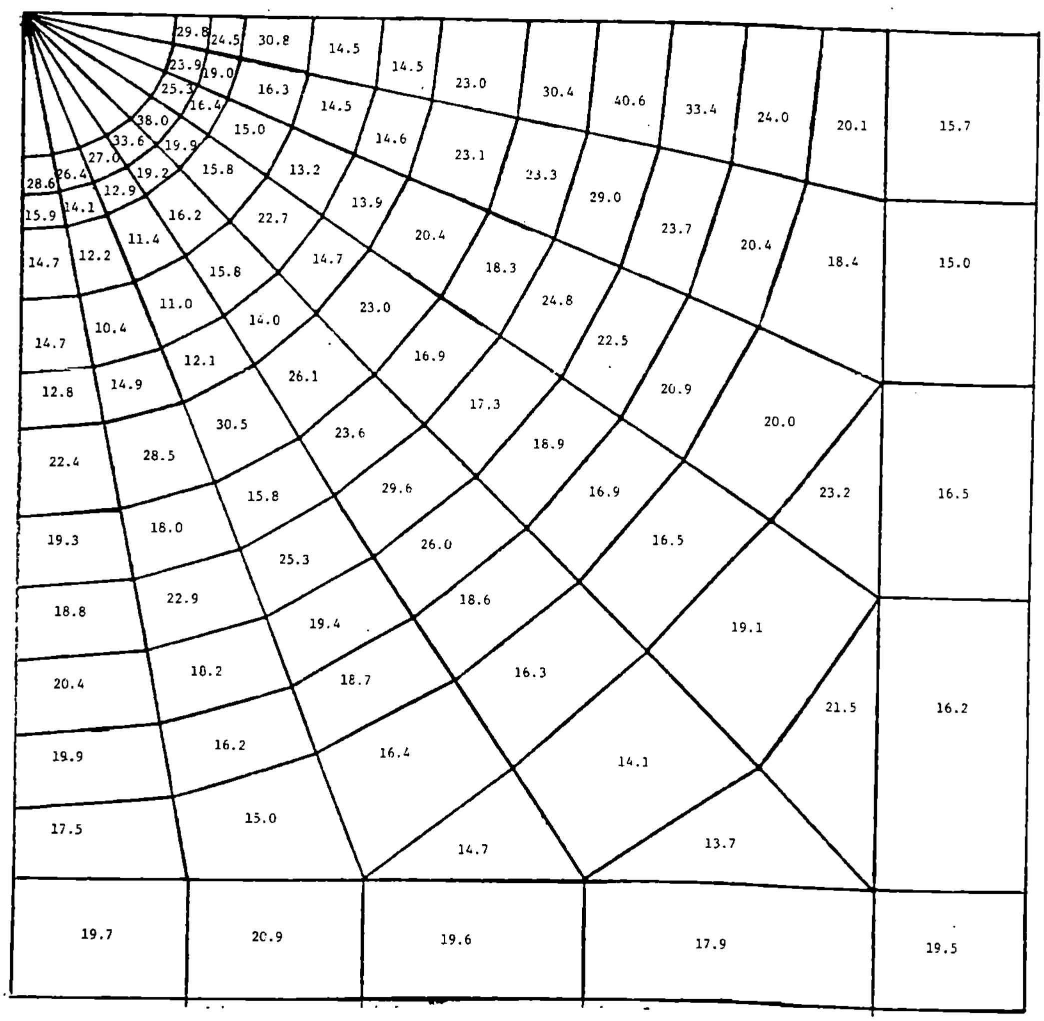
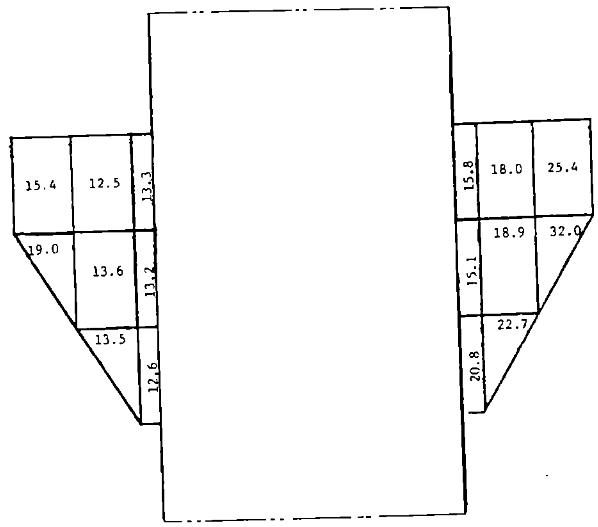


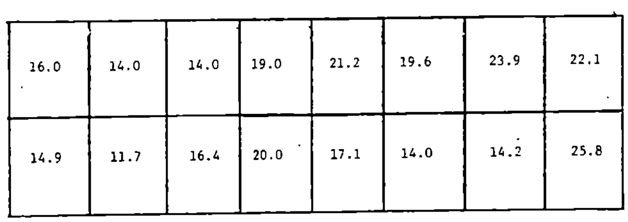
FIGURE 5-5.5 (Sheet 1 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL EXTREME FIBER STRESS INTENSITIES FOR SERVICE LEVEL C WITHOUT THERMAL EXPANSION



PIPE & FINS

Allowable Stress
Intensity = 1.5 S_y
(50.9 ksi)



SLEEVE

FIGURE 5-5.5 (Sheet 2 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL
EXTREME FIBER STRESS INTENSITIES FOR
SERVICE LEVEL C WITHOUT THERMAL EXPANSION

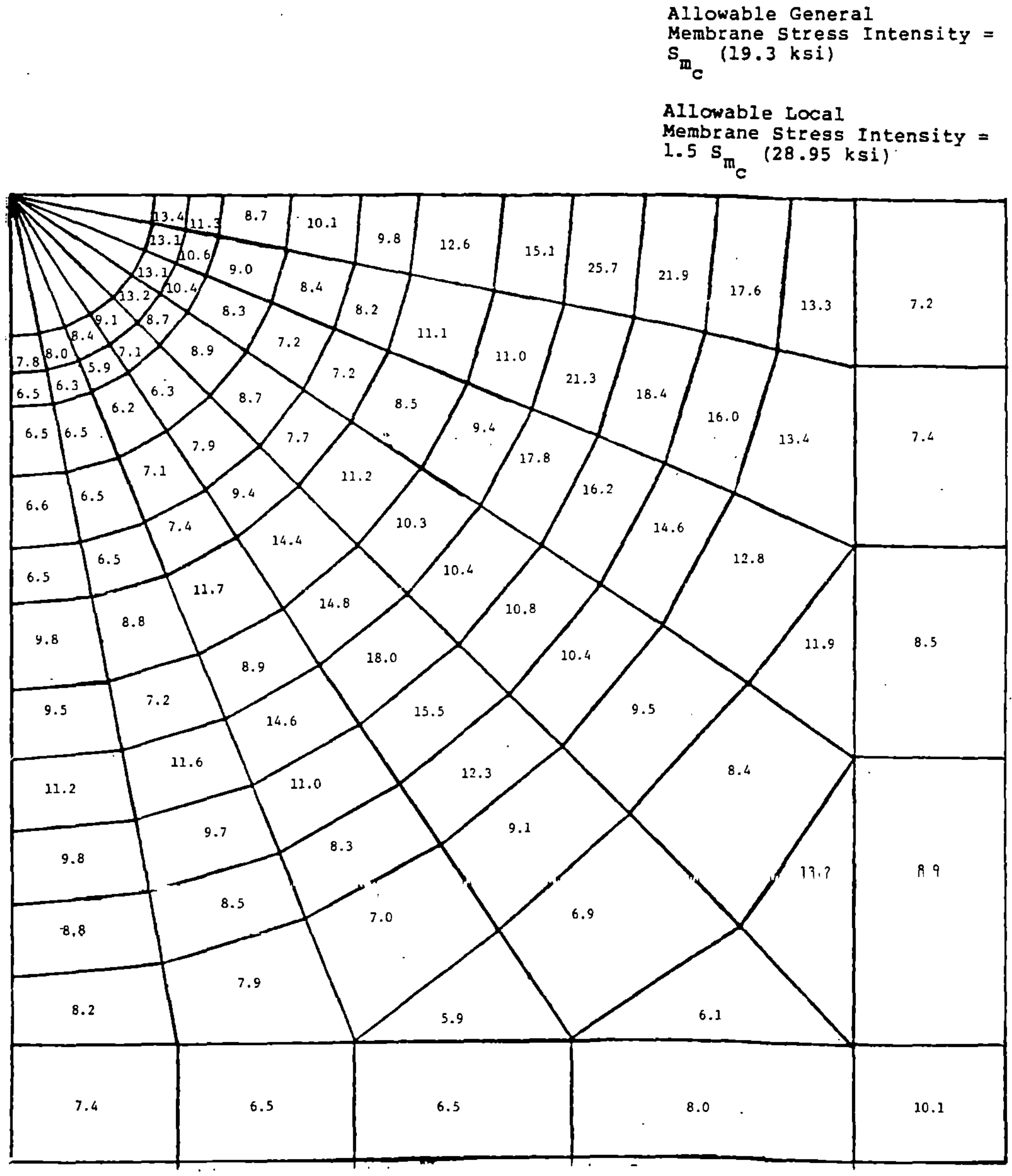
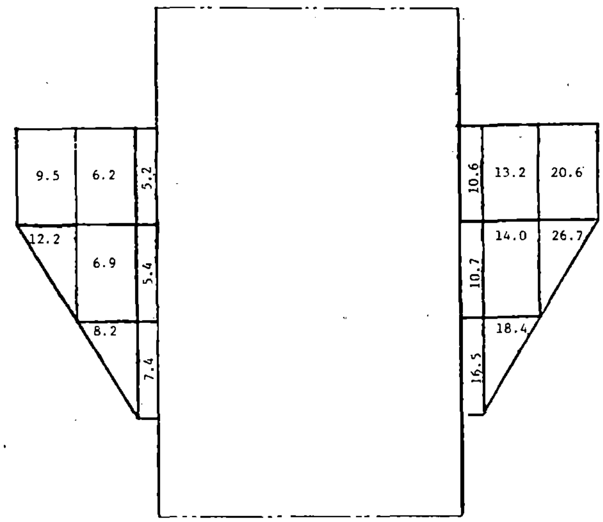


FIGURE 5-5.6 (Sheet 1 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRIMARY MEMBRANE
STRESS INTENSITIES FOR SERVICE LEVEL A & B
WITHOUT THERMAL EXPANSION



PIPE & FINS

Allowable General
Membrane Stress Intensity =
S_{m_c} (19.3 ksi)

Allowable Local
Membrane Stress Intensity =
1.5 S_{m_c} (28.95 ksi)

6.0	3.7	4.5	6.2	8.1	7.3	6.5	5.6
6.3	5.0	4.7	4.9	5.1	6.0	7.5	10.7

SLEEVE

FIGURE 5-5.6 (Sheet 2 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRIMARY MEMBRANE
STRESS INTENSITIES FOR SERVICE LEVEL A & B
WITHOUT THERMAL EXPANSION

Allowable General
Membrane Stress Intensity =
S_y (33.9 ksi)

Allowable Local
Membrane Stress Intensity =
1.5 S_y (50.9 ksi)

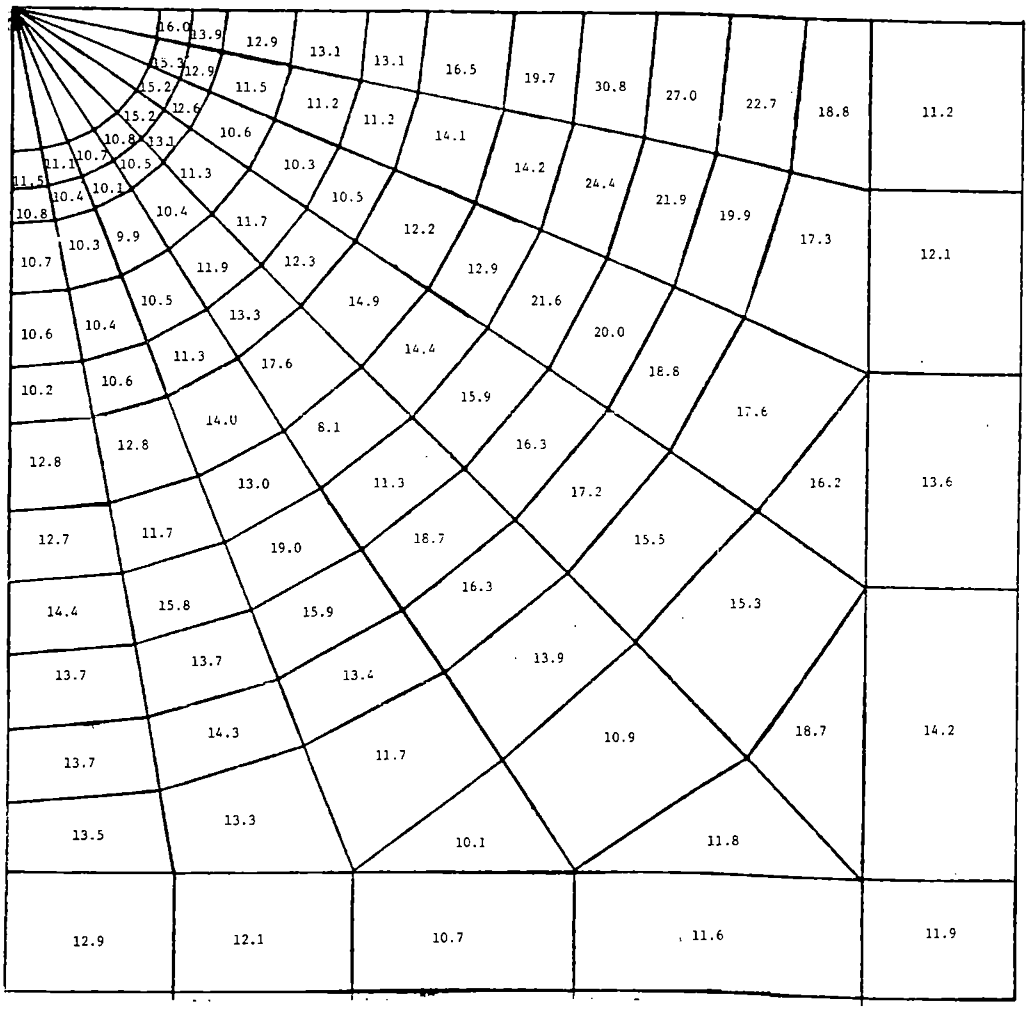
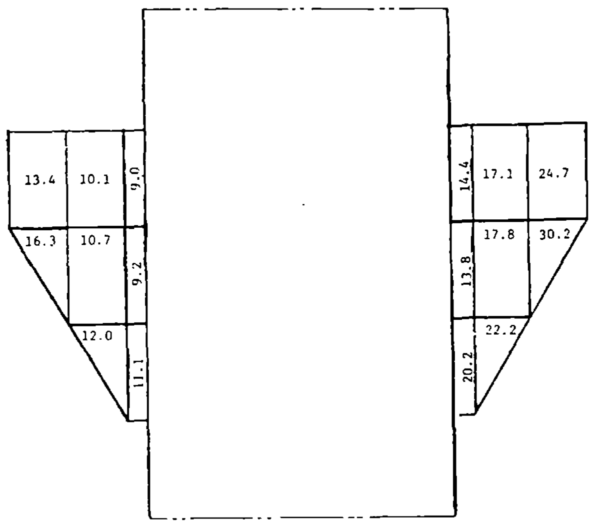


FIGURE 5-5.7 (Sheet 1 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRIMARY MEMBRANE
STRESS INTENSITIES FOR SERVICE LEVEL C
WITHOUT THERMAL EXPANSION



PIPE & FINS

Allowable General
Membrane Stress Intensity =
S_y (33.9 ksi)

Allowable Local
Membrane Stress Intensity =
1.5 S_y (50.9 ksi)

9.7	7.4	8.1	10.1	11.9	11.0	10.2	9.4
11.3	9.2	8.7	8.8	8.9	9.9	11.4	14.7

SLEEVE

FIGURE 5-5.7 (Sheet 2 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRIMARY MEMBRANE
STRESS INTENSITIES FOR SERVICE LEVEL C
WITHOUT THERMAL EXPANSION

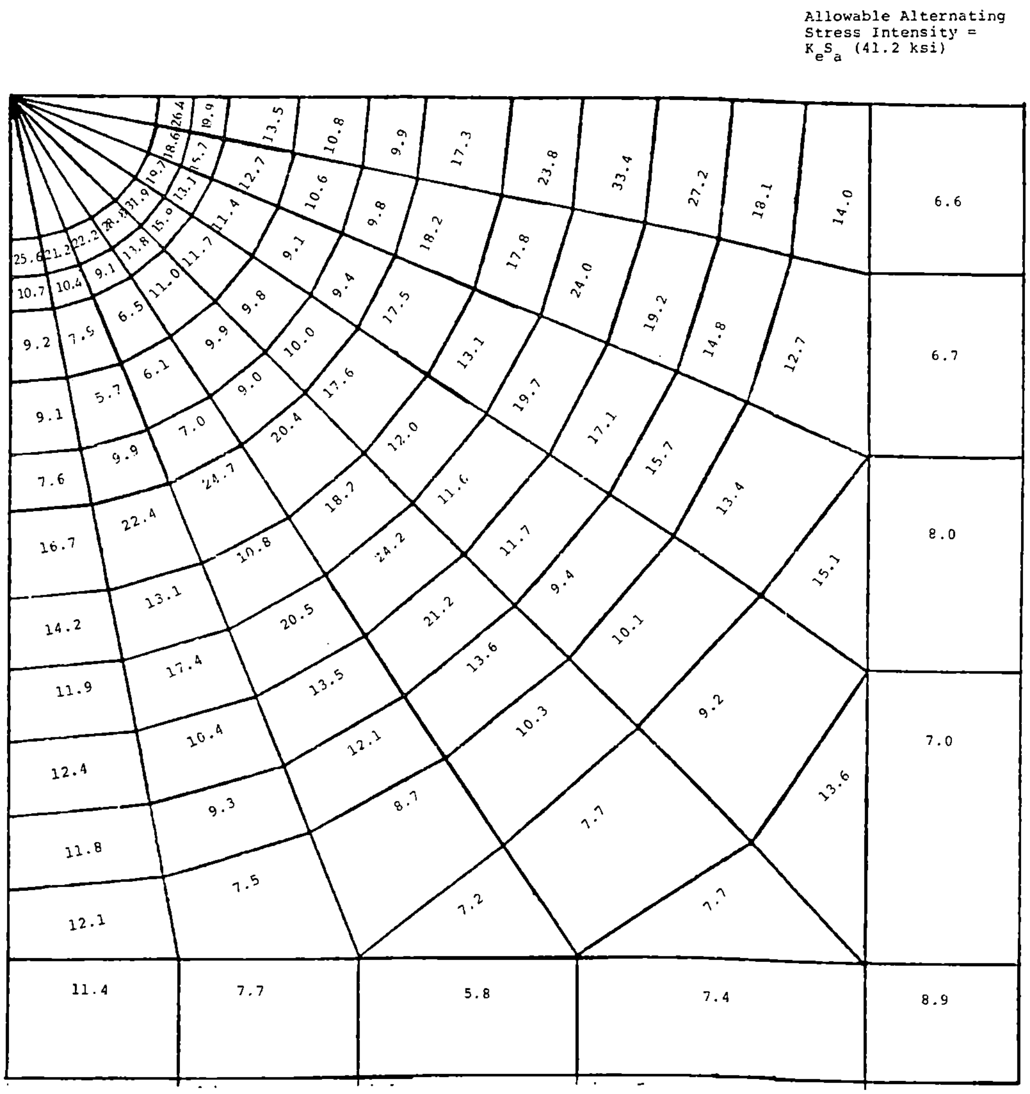
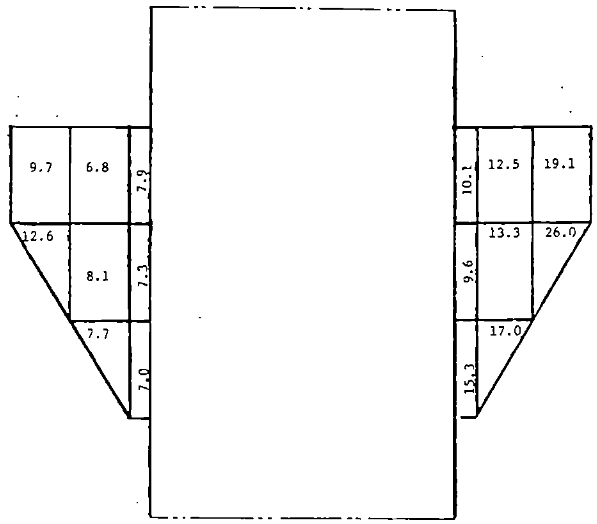


FIGURE 5-5.8 (Sheet 1 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL EXTREME
FIBER STRESS INTENSITIES FOR FATIGUE
LOAD CASE



PIPE & FINS

Allowable Alternating Stress Intensity = 41.2 ksi ($K_e S_a$)

10.0	8.3	8.3	12.9	15.2	13.7	17.6	20.2
9.2	6.4	10.9	14.3	11.6	8.4	10.0	19.6

SLEEVE

FIGURE 5-5.8 (Sheet 2 of 2)

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - CRITICAL PRINCIPAL EXTREME
FIBER STRESS INTENSITIES FOR FATIGUE
LOAD CASE

LOAD CASES	CODE ALLOW-ABLE	BEAM ELEMENTS												
		32	33	34	10	11	12	13	14	15	16	17	18	19
Serv. Level B w/Thermal	57.90	10.4	11.1	14.0	22.7	29.2	39.0	33.7	34.4	28.7	23.4	18.6	10.8	4.5
Serv. Level B w/o Thermal	28.95	4.3	7.1	14.0	20.5	24.9	26.9	28.8	28.6	23.8	19.3	15.4	8.8	3.7
Serv. Level C w/o Thermal	53.85	4.6	7.7	15.4	22.6	27.5	36.5	25.6	32.0	26.8	22.0	17.6	10.4	4.5
Fatigue Load Case	41.20	4.5	7.3	14.5	21.2	25.7	34.4	29.7	29.6	24.7	20.2	16.1	9.3	3.9

2'-10"

FIGURE 5-5.9

VENT LINE PENETRATION FINITE ELEMENT MODEL
LOCAL DEVELOPED VIEW - MAXIMUM STRESS
INTENSITIES ON INTERIOR STIFFENERS
ALL SERVICE LEVELS

5-6.0 REFERENCES

1. "Mark I Containment Long-Term Program," Safety Evaluation Report, USNRC, NUREG-0661, July 1980; Supplement 1, August 1982.

2. "Mark I Containment Program Load Definition Report," General Electric Company, NEDO-21888, Revision 2, November 1981.

3. "Mark I Containment Program Plant Unique Load Definition," Dresden Station - Units 2 and 3, General Electric Company, NEDO-24566, Revision 1, November 1981.

4. Dresden Station Units 2 and 3, Final Safety Analysis Report (FSAR), Commonwealth Edison Company, July 20, 1982.

5. "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide," Task Number 3.1.3, Mark I Owners Group, General Electric Company, NEDO-24583, Revision 1, July 1979.

6. "Main Steam/SRV Discharge Line and Support Modification" Sargent & Lundy Design Specification DS-SRV-01-DR.

7. "Mark I Containment Program Augmented Class 2/3 Fatigue Evaluation Method and Results for Typical Torus Attached and SRV Piping Systems," MPR Associate, Report No. MPR-751, November 1982; (Submitted to NRC by General Electric Letter MFN-187-82, November 30, 1982).

8. Summary of Meeting Held on September 9 and 10, 1982 with General Electric and the Mark I Owners Group in Bethesda, Maryland.

9. ASME B&PV Code Section I, 1965 Edition with Addendum through Winter 1966.

10. Integrated Piping Analysis System (PIPSYS), Sargent & Lundy Computer Program No. 09.5.065-5.3, Revision 6, June 1982.

11. Power Piping Code USAS B31.1.0-1967.

12. "Mark I Containment Program - Task 6.2.1, Monticello T-Quencher Stress Report," General Electric Company Report 22A6010, Revision 0, May 9, 1978.

13. Summary of Meeting Held on August 19 and 20, 1982 with General Electric and Mark I Architect Engineers in Knoxville, Tennessee; Subject, "Mark I Containment Program."

14. "Realistic Estimate of SRV Actuations for Plant Life," General Electric Company; Mark I SSE Question No. 319 Response, Task 9.2.1, July 2, 1982.

15. "Piping Stress Analysis Report, Mark I Program Plant Unique Analysis of the SRV Discharge Piping System in the Suppression Chamber - Dresden Units 2 and 3," Sargent & Lundy Report No. EMD-036594, Revision 00, February 16, 1983.

16. "Final Vent System Response to LDR Defined Loads at SRVDL Penetration in Vent Line" letter from H. W. Massie (Nutech) to A. Walser (S&L) dated November 30, 1982.

17. Sargent & Lundy Design Specification DC-SE-01-D, Revision C, December 29, 1982.

18. AISC Manual of Steel Construction, Eighth Edition 1980, "Specification for the Design, Fabrication, and Erection of Structural Steel Buildings."

19. ASME B&PV Code, Section III, Division 1, Subsection NE; 1977 Edition, including Summer 1977 Addenda.

20. "Dresden Seismic Analysis Combined Reactor and Turbine Buildings" Report by J. A. Blume and Associates, Engineers, October 1969.

21. Safety Relief Valve Blowdown Analysis (SRVA), Sargent & Lundy Computer Program No. 09.5.138-2.0, June 1979.

22. "Stress Analysis Safety Valve Station Dresden-2", General Electric Company, Report ITY-7241.

23. "Local Stresses in Spherical and Cylindrical Shells due to External Loadings," Wichman, Hopper, and Mershon; Welding Research Council Bulletin #107.

24. "SRV Discharge Line Associated Torus Internals and Vent Line Modifications Stress Report - Dresden Nuclear Power Station Units 2 and 3," Sargent & Lundy Calculation File No. 5486-17DR, March 1, 1983.

25. "Acceptability of SRSS Method for Combining Dynamic Responses in Mark I Piping Systems." NRC Letter from P. B. Vassallo to H. C. Pfefferley, March 10, 1983.

26. Dresden Units 2 and 3 "Drywell Floor Framing Analysis" Sargent & Lundy Calculation File No. 6005-E1 and 6005-E2, February 2, 1983.