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DUANE ARNOLD ENERGY CENTER
PLANT UNIQUE ANALYSIS REPORT
VOLUME 5
SAFETY RELIEF VALVE DISCHARGE LINE PIPING ANALYSIS

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nutech ENGINEERS

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Plant Unique Analysis Report
Volume 5

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5-v	0	JDS	WJS	JWAx	5-1.3	0	JDS	TB	JWAx
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ABSTRACT

The primary containment for the Duane Arnold Energy Center (DAEC), was designed, erected, pressure-tested, and ASME Code N-stamped during the early 1970's for Iowa Electric Light and Power Company by the Chicago Bridge and Iron Company. Since that time new requirements have been generated. These requirements affect the design and operation of the primary containment system and are defined in the Nuclear Regulatory Commission's Safety Evaluation Report NUREG-0661. The requirements to be addressed include an assessment of additional containment design loads postulated to occur during a loss-of-coolant accident or a safety relief valve discharge event, as well as an assessment of the effects that these postulated events have on the operational characteristics of the containment system.

This plant unique analysis report documents the efforts undertaken to address and resolve each of the applicable NUREG-0661 requirements, and demonstrates, in accordance with NUREG-0661 acceptance criteria, that the design of the primary containment system is adequate and that original design safety margins have been restored. The report is composed of the following six volumes and appendix.

- Volume 1 - GENERAL CRITERIA AND LOADS METHODOLOGY
- Volume 2 - SUPPRESSION CHAMBER ANALYSIS
- Volume 3 - VENT SYSTEM ANALYSIS
- Volume 4 - INTERNAL STRUCTURES ANALYSIS
- Volume 5 - SAFETY RELIEF VALVE DISCHARGE LINE PIPING ANALYSIS
- Volume 6 - TORUS ATTACHED PIPING AND SUPPRESSION CHAMBER PENETRATIONS ANALYSES
- Appendix A - DAEC RESPONSES TO CURRENT CONTAINMENT AND PIPING LICENSING ISSUES

Volume 5 documents the evaluation of the safety relief valve discharge line piping and has been prepared by NUTECH Engineers, Inc. (NUTECH), acting as an agent to the Iowa Electric Light and Power Company.

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LIST OF ACRONYMS

ABS	Absolute Sum
ASME	American Society of Mechanical Engineers
CDF	Cumulative Distribution Function
CO	Condensation Oscillation
DAEC	Duane Arnold Energy Center
DBA	Design Basis Accident
DLF	Dynamic Load Factor
DW	Drywell
FSI	Fluid-Structure Interaction
IBA	Intermediate Break Accident
IELP	Iowa Electric Light and Power
LDR	Load Definition Report
LOCA	Loss-of-Coolant Accident
MSL	Main Steam Line
NEP	Non-Exceedance Probability
NOC	Normal Operating Conditions
NPS	Nominal Pipe Size
NRC	Nuclear Regulatory Commission
NSC	Nuclear Services Corporation
OBE	Operating Basis Earthquake
PS	Pool Swell
PUA	Plant Unique Analysis
PUAAG	Plant Unique Analysis Application Guide
PUAR	Plant Unique Analysis Report

LIST OF ACRONYMS (Concluded)

PULD	Plant Unique Load Definition
QSTF	Quarter-Scale Test Facility
RPV	Reactor Pressure Vessel
SBA	Small Break Accident
SRSS	Square Root of the Sum of the Squares
SRV	Safety Relief Valve
SRVDL	Safety Relief Valve Discharge Line
SSE	Safe Shutdown Earthquake
SV	Safety Valve
VCL	Vent Clearing Loads
VL	Vent Line
VLP	Vent Line Penetration
WW	Wetwell

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5-1.0 INTRODUCTION AND SUMMARY

In conjunction with Volume 1 of the Plant Unique Analysis Report (PUAR), this volume documents the efforts undertaken to address the requirements defined in NUREG-0661 (Reference 1) which affect the Duane Arnold Energy Center (DAEC) safety relief valve discharge line (SRVDL) piping system, including the T-quencher and related support structures. The SRVDL piping system PUAR is organized as follows.

- INTRODUCTION AND SUMMARY
  - Scope of Analysis
  - Summary and Conclusions
- SAFETY RELIEF VALVE DISCHARGE LINE PIPING ANALYSIS
  - Component Description
  - Loads and Load Combinations
  - Analysis Acceptance Criteria
  - Methods of Analysis
  - Analysis Results

The INTRODUCTION AND SUMMARY section contains an overview of the scope of the SRVDL piping system evaluation as well as a summary of the results and conclusions resulting from the comprehensive evaluations presented in later sections.

The SAFETY RELIEF VALVE DISCHARGE LINE PIPING ANALYSIS section contains a description of the components of the piping system, a comprehensive discussion of the loads and load combinations to be considered, the methodology used to evaluate the effects of the loads and load combinations, and the evaluation results and acceptance limits to which the results are compared to ensure that the design is adequate.

5-1.1 Scope of Analysis

The general criteria presented in Volume 1 are used as the basis for the DAEC SRVDL piping system evaluation described in this report. The investigation includes an evaluation of the SRVDL piping system for the effects of loss of coolant accident (LOCA)-related loads and SRV discharge-related loads discussed in Volume 1 of this report, and defined by the NRC's Safety Evaluation Report NUREG-0661 and the "Mark I Containment Program Load Definition Report" (LDR) (Reference 2). Portions of the main steam line (MSL) piping system affected by these loads are also evaluated as part of this investigation.

The LOCA and SRV discharge loads used in this evaluation are formulated using procedures and test results which include the effects of the plant unique geometry and operating parameters contained in the "Plant Unique Load Definition" (PULD) report (Reference 3). Other loads and methodology which have not been redefined by NUREG-0661, such as the evaluation for seismic loads, are taken from the original piping stress analysis report (Reference 4).

The evaluation includes performing a structural analysis of the SRVDL, T-quenchers, and affected portions of the MSL piping systems for the effects of LOCA and SRV discharge-related loads to verify that the design of these piping systems is adequate. The rigorous analytical techniques used in this evaluation include detailed analytical models and refined methods for computing the dynamic response of the SRVDL piping system. This analysis also considers the interaction effects of the vent system and suppression chamber (torus) with the SRV piping.

The results of the structural analysis for each load are used to evaluate load combinations for the SRVDL piping system and local effects on the vent line penetration (VLP) in accordance with NUREG-0661 and the "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide" (PUAAG) (Reference 5). Fatigue effects as specified in the PUAAG have been considered on a generic basis with the Nuclear Regulatory Commission (NRC) and are not included in this report, but are contained in a separate report to the NRC (Reference 6). The analysis results are compared with the acceptance limits specified by the PUAAG and the applicable sections of the ASME Code (Reference 7) for Class 2 piping and piping supports and Class MC components.

5-1.2 Summary and Conclusions

An evaluation of the DAEC MSL and SRVDL piping and piping supports, the SRVDL vent line penetrations, and the T-quenchers and T-quencher supports has been performed for the modified system described in Section 5-2.1.

The loads considered in the evaluation consist of the original loads as documented in Reference 4, 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 responses of the piping systems. A combination of static, dynamic, and equivalent static analyses are performed and the results appropriately combined in accordance with NUREG-0661 requirements. Results of the analyses are compared to the NUREG-0661 criteria (Section 1-3.2).

The evaluation results show that the DAEC MSL and SRVDL piping and piping supports, the SRVDL VLP, and the T-quencher, T-quencher support and associated components meet the requirements of NUREG-0661.

5-2.0 SAFETY RELIEF VALVE DISCHARGE LINE PIPING ANALYSIS

An evaluation of each of the NUREG-0661 requirements which affect the design adequacy of the DAEC SRVDL piping system is presented in the following sections. The general criteria used in this evaluation are contained in Volume 1 of this report.

The components of the SRVDL piping system which are analyzed are described in Section 5-2.1. The loads and load combinations for which the piping system is evaluated are described and presented in Section 5-2.2. The acceptance limits to which the analysis results are compared are discussed and presented in Section 5-2.3. The analysis methodology used to evaluate the effects of the loads and load combinations on the piping system is discussed in Section 5-2.4. The analysis results are presented in Section 5-2.5.

5-2.1 Component Description

The main steam line (MSL) piping system for DAEC consists of four 20", Schedule 80, ASTM A-106, Grade B pipe lines. The MSL piping is anchored at the reactor pressure vessel (RPV) nozzle at one end, runs vertically down and encircles the RPV and passes through the drywell penetration before being anchored outside the primary containment.

The SRV discharge line piping system consists of six ASTM A-106, Grade B pipe lines, each a 10", Schedule 40 pipe at the outlet flange of the SRV, changing to 10", Schedule 80 as it passes through the jet deflector and then to 12", Schedule 80 at the T-quencher in the wetwell. Figure 5-2.1-1 shows the routing, support locations, and support types for a representative SRVDL. Figure 5-2.1-2 shows more detail of the typical SRVDL routing and supports in the wetwell. Six of the eight vent lines contain one SRVDL (Figure 5-2.1-3).

In the drywell, the six SRV discharge lines connect to the four MSL's at the safety relief valves (Figures 5-2.1-4 and 5-2.1-5). Two of the MSL's each have two

SRV discharge lines. The other two MSL's each have one SRV discharge line and one safety valve (SV). The safety valves discharge into the drywell airspace a short distance beyond the valve and through an 8" NPS tee (Figure 5-2.1-6). Each SRVDL also has an attached vacuum breaker valve (Figures 5-2.1-7 and 5-2.1-8).

The SRV discharge lines are routed from the drywell area through the jet deflector and vent lines and into the suppression chamber (Figures 5-2.1-9 through 5-2.1-12).

The SRV discharge lines exit the vent lines vertically downward through the vent line penetrations (VLP) for approximately nine feet and are routed 22.5° off the horizontal and perpendicular to the centerline of the suppression chamber mitered segment up to the T-quencher junction.

The support system for the SRV discharge lines in the drywell consists of an assortment of snubbers, struts, and hangers which are connected to the drywell floor steel by intermediate steel framing. Figure 5-2.1-13 shows an example of a typical SRV discharge line support in the drywell. The spring hanger attachment loads on the floor steel have been analyzed in accordance with the 10% stress rule specified in the PUAAG (Reference 5).

The vent line portion of the SRV discharge line is supported by two rigid struts, one vertical and one horizontal (Figure 5-2.1-9). The vertical strut attaches to the 2" thick cylindrical nozzle section of the vent line next to the drywell. The horizontal strut attaches to a 16" diameter pad plate which is welded to the 1/2" thick conical section of the vent line.

Each SRV piping penetration through the vent line is reinforced by an insert plate assembly with plates varying in thickness from 3" thick to 3/4" thick. The nozzle is a 1-5/8" thick pipe section and is connected to the insert plate by full penetration welds (Figure 5-2.1-14). A 1" thick pipe is connected to the suppression chamber side of the nozzle and extends to the water level in the suppression chamber (Figure 5-2.1-15). The SRVDL-VLP assembly provides an effective means of taking loads which act on the SRV piping and transferring them to the vent line.

In the suppression chamber the SRV discharge line is supported by an elbow support beam and the T-quencher device is supported by a T-quencher support beam (Figure 5-2.1-10). Both the quencher support beam and elbow support beam are connected to the ring beams at the miter joints of the suppression chamber.

The elbow support beam is a fabricated box section made up of plates 1" to 2" thick. The beam is located approximately 9 feet away from the T-quencher toward the center of the reactor (Figures 5-2.1-10 and 5-2.1-16).

The T-quencher support beam is constructed from 16" diameter, Schedule 160 pipe and is located approximately 1'7" directly below the T-quencher arms. Three brackets per arm connect the T-quencher support beam to the T-quencher arms (Figure 5-2.1-17). The T-quencher support system provides an effective means of transferring thrust loads and submerged structure loads acting on the T-quenchers to the suppression chamber. The T-quencher support system also permits thermal expansion of the T-quencher arms during SRV discharge.

The SRV discharge T-quencher devices are standard Mark I T-quenchers. A total of six T-quenchers (with ramsheads) are located on the suppression chamber centerline (Figure 5-2.1-3) and are located vertically about 9'-0" below the horizontal centerline of the suppression chamber. Each T-quencher consists of a ramshead assembly and two T-quencher arms (Figure 5-2.1-17). The T-quencher arms are constructed from 12" diameter, Schedule 80 stainless steel pipe, which is capped on the ends. Figures 5-2.1-18 and 5-2.1-19 show the arrangement of the 0.391" diameter holes drilled in the T-quencher arms. The T-quenchers provide an effective means of mitigating air clearing loads during an SRV discharge.

The 10" diameter SRV discharge line piping is connected to the T-quencher ramshead assemblies at the centerline of the suppression chamber mitered segments by a 10" X 12" reducer section (Figure 5-2.1-20). A typical ramshead assembly is constructed from 12" diameter short-radius elbows, reinforced with 1" thick gusset plates. The ramshead assembly is supported by the lateral support beam (Figure 5-2.1-21).

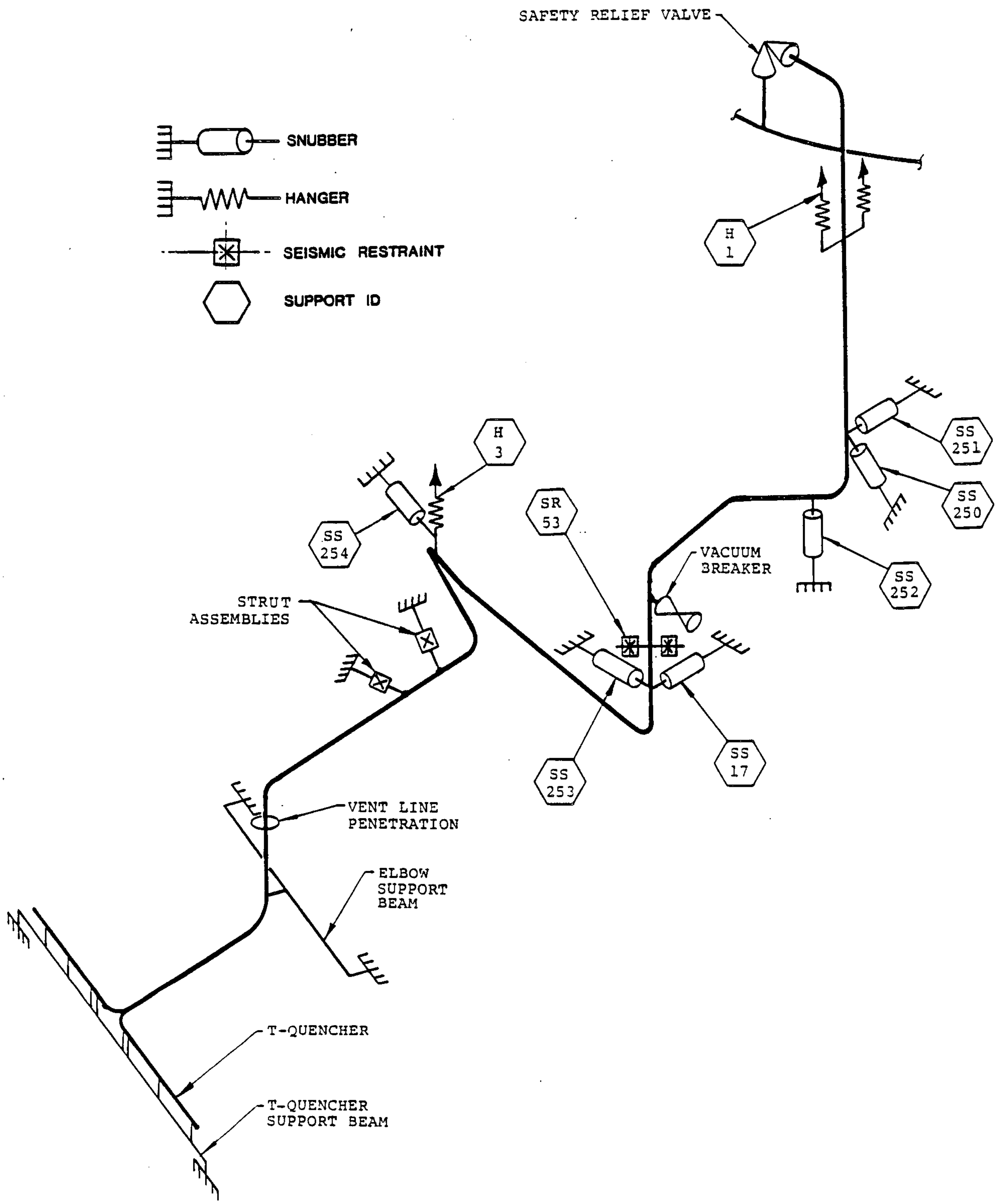


Figure 5-2.1-1

REPRESENTATIVE SRVDL ISOMETRIC AND SUPPORT LOCATIONS (LINE GBC-6)

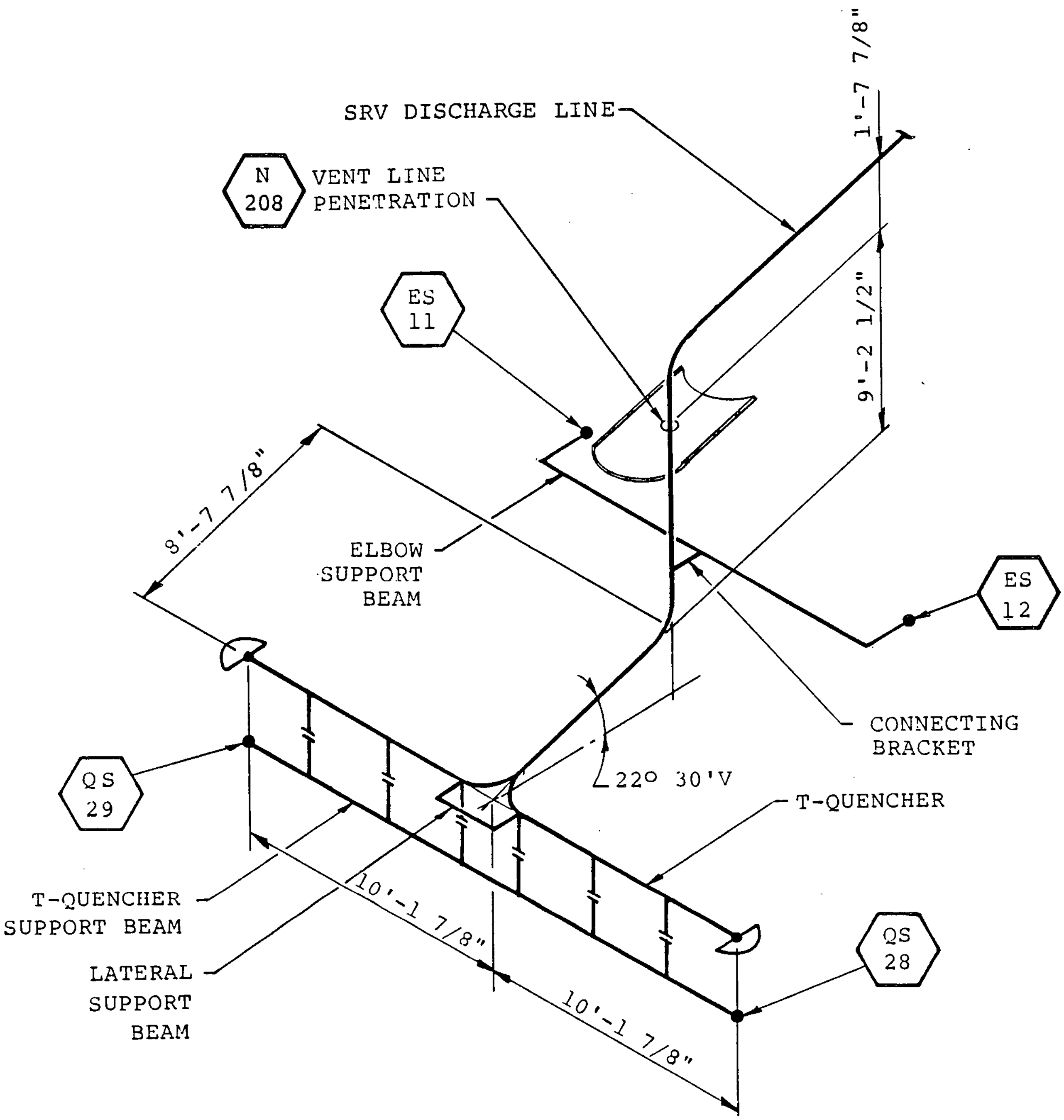


Figure 5-2.1-2

TYPICAL SRVDL WETWELL PIPING

ISOMETRIC AND SUPPORT LOCATIONS

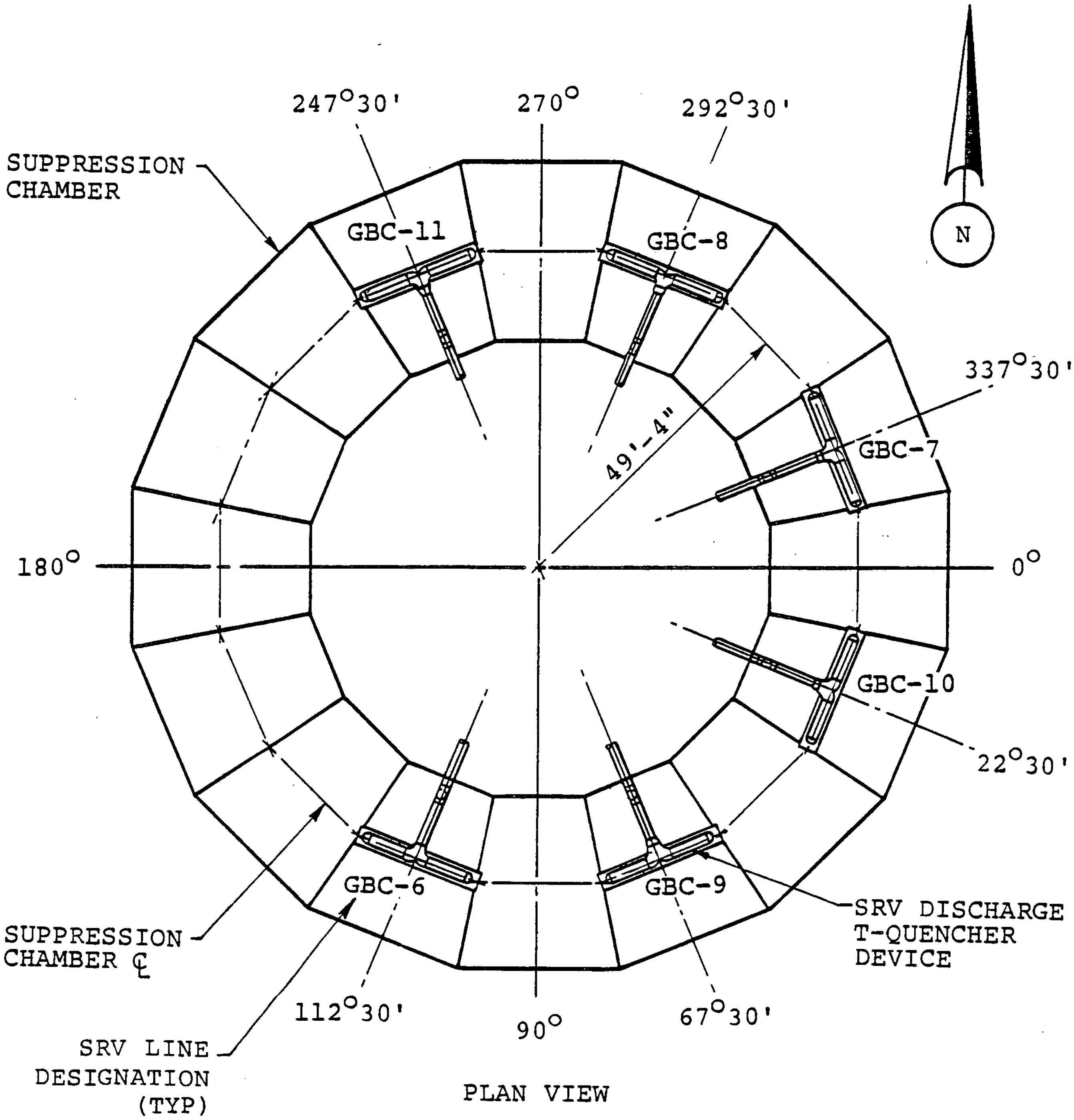


Figure 5-2.1-3

SRVDL LOCATIONS IN SUPPRESSION CHAMBER

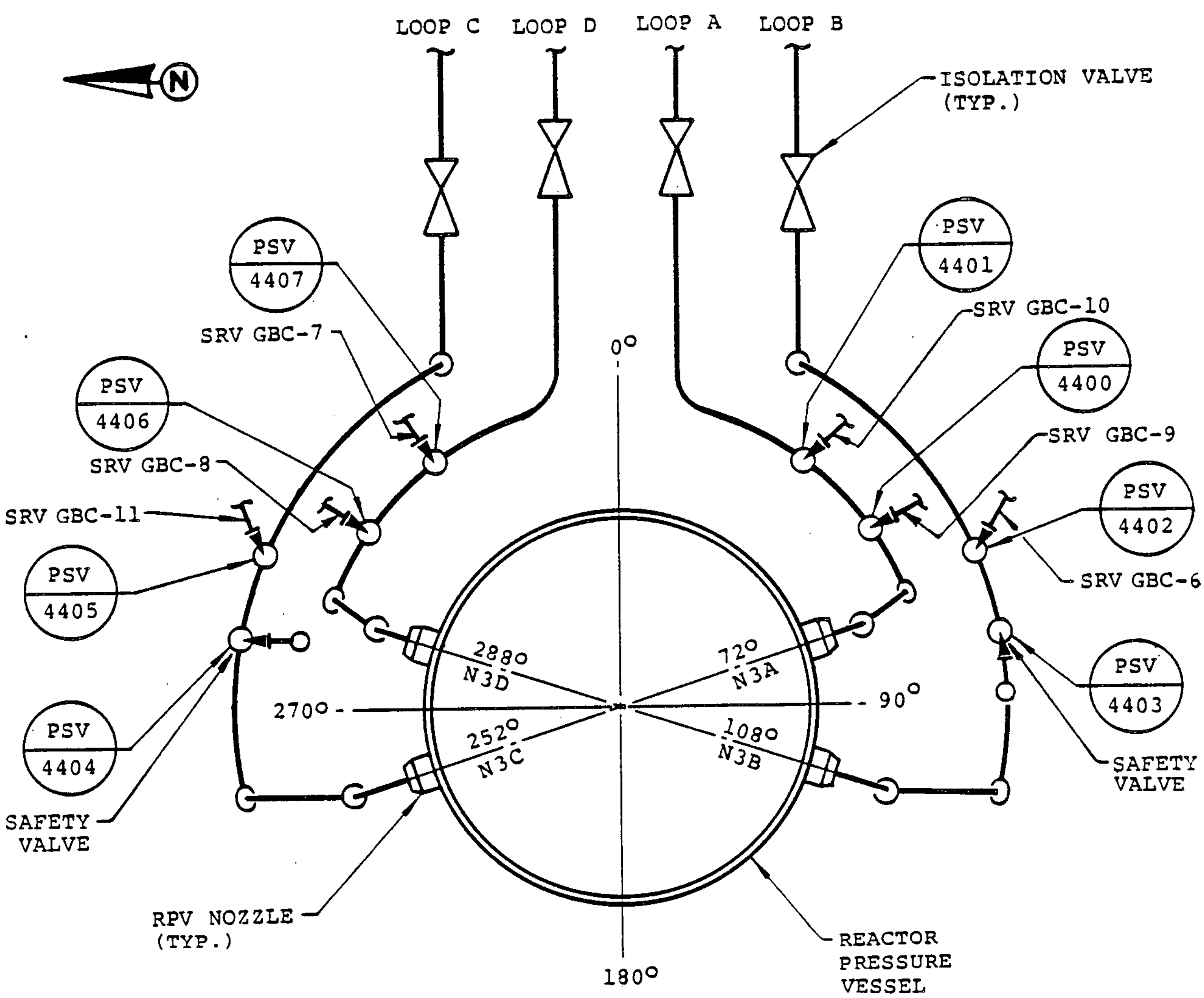


Figure 5-2.1-4

SAFETY RELIEF VALVE DISCHARGE LINE

AND MAIN STEAM LINE SCHEMATIC

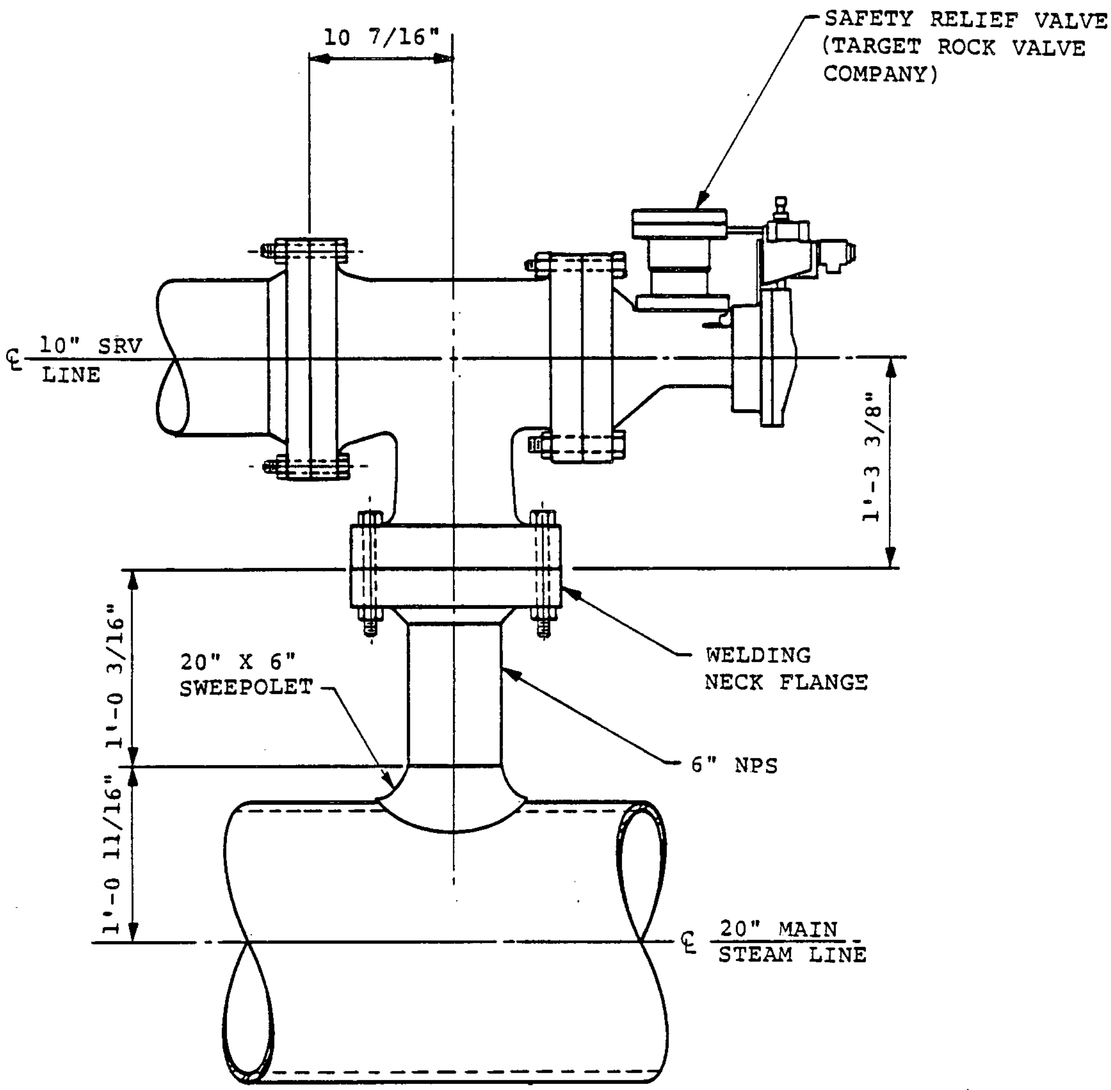


Figure 5-2.1-5

SAFETY RELIEF VALVE CONNECTION

TO SRVDL AND MSL PIPING

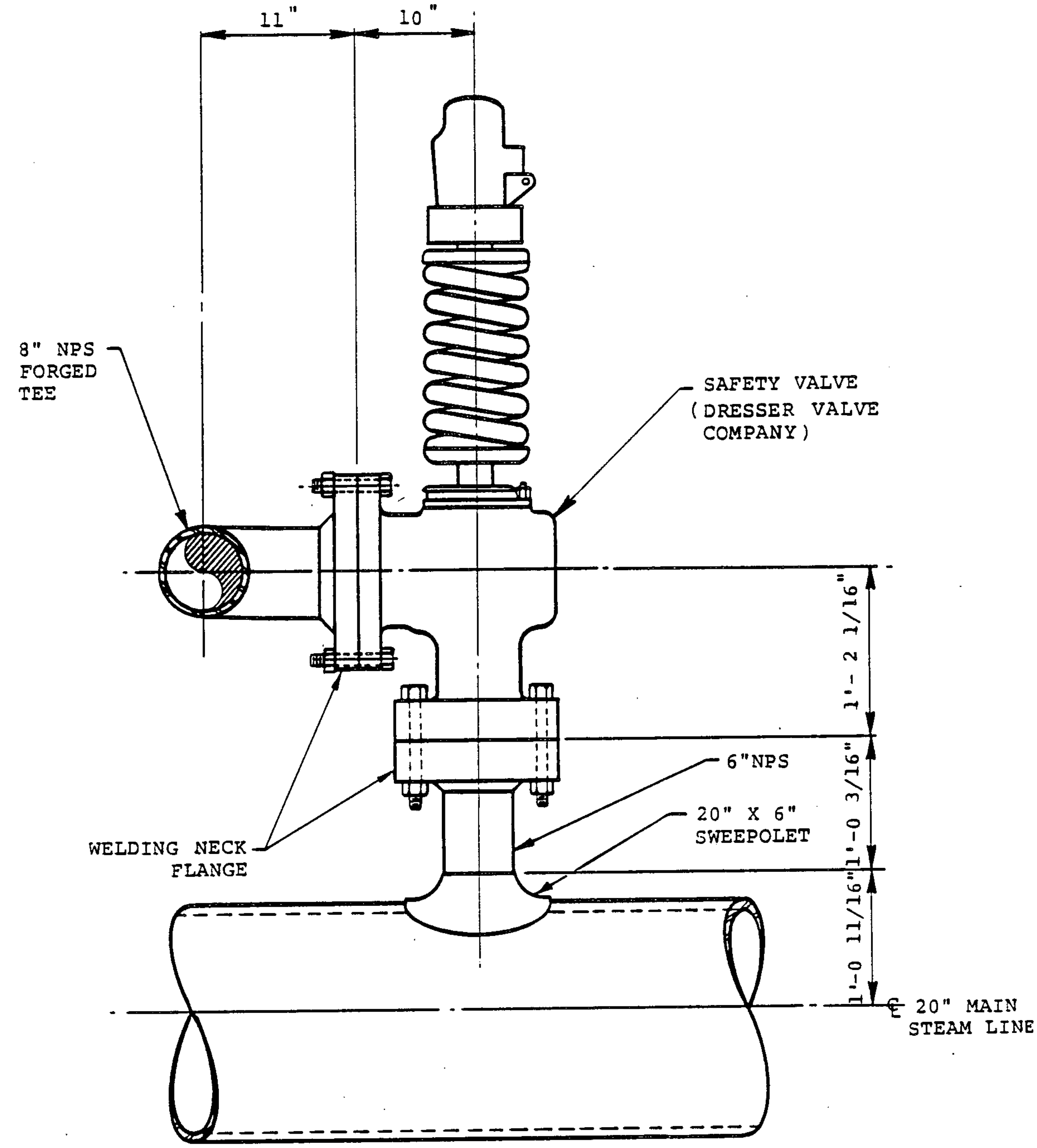


Figure 5-2.1-6

SAFETY VALVE CONNECTION TO

DISCHARGE DEVICE AND MSL PIPING

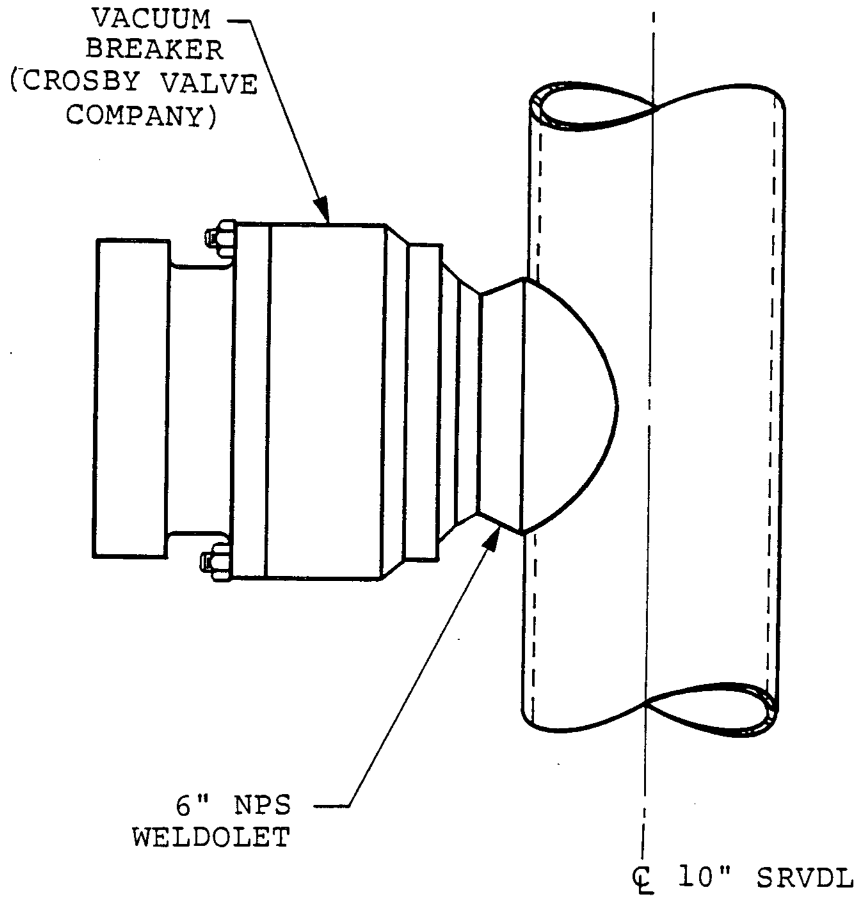


Figure 5-2.1-7

VACUUM BREAKER FOR SRV DISCHARGE LINES

GBC-6 AND GBC-8

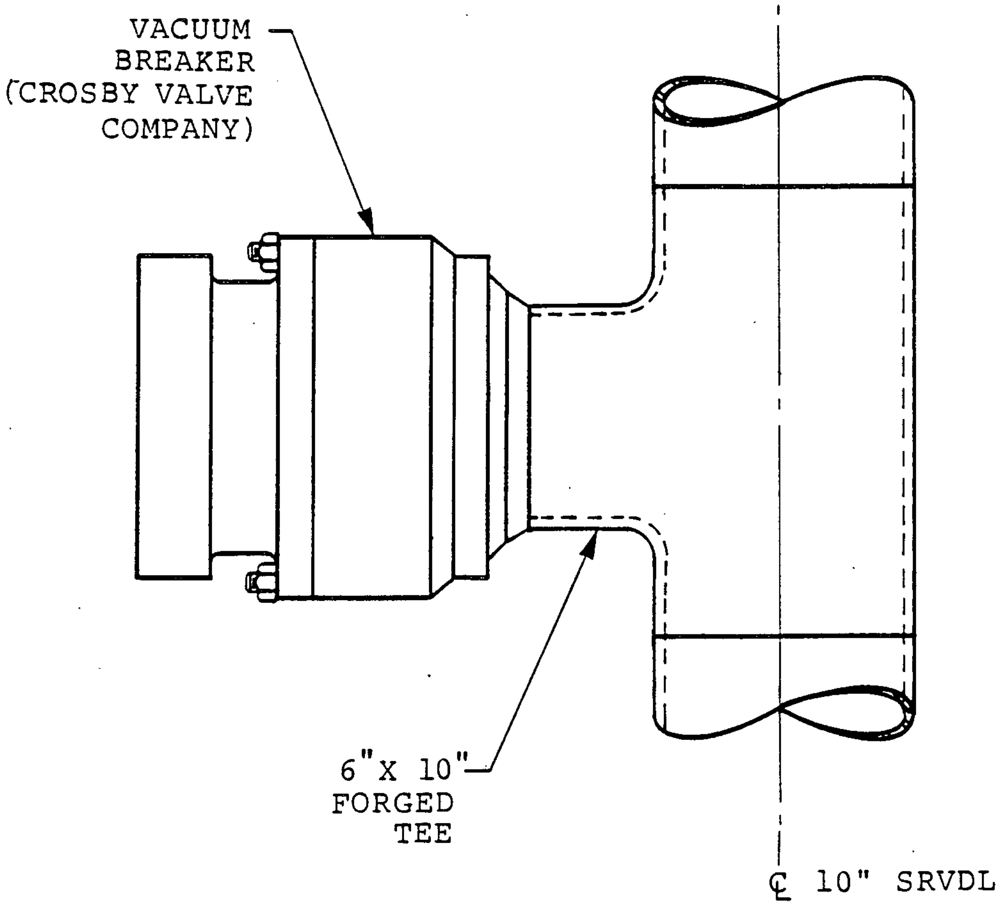


Figure 5-2.1-8

VACUUM BREAKER FOR SRV DISCHARGE LINES

GBC-7, GBC-9, GBC-10, AND GBC-11

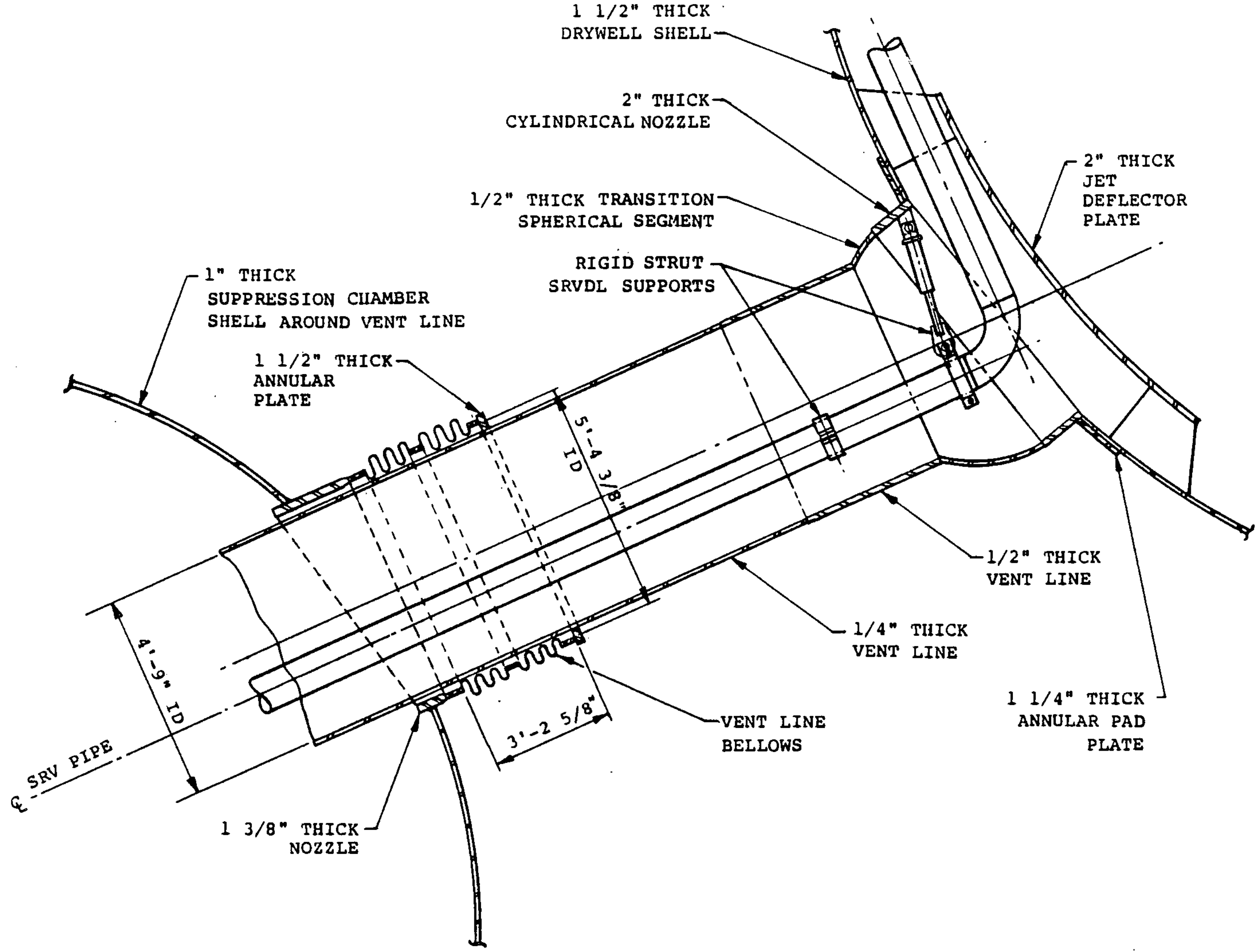


Figure 5-2.1- 9

SRV PIPE ROUTING IN VENT LINE,

MID-VENT LINE SECTION

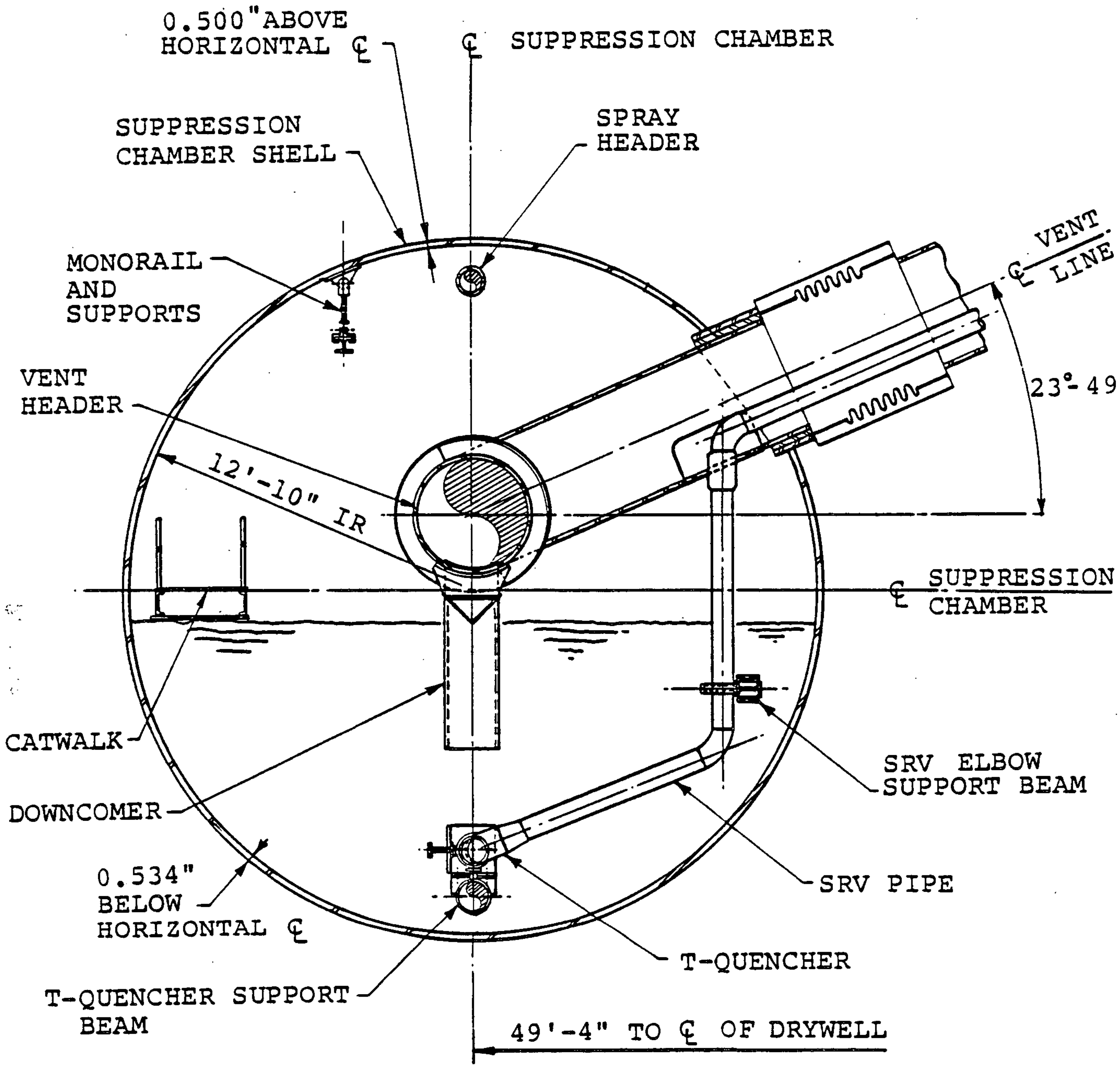
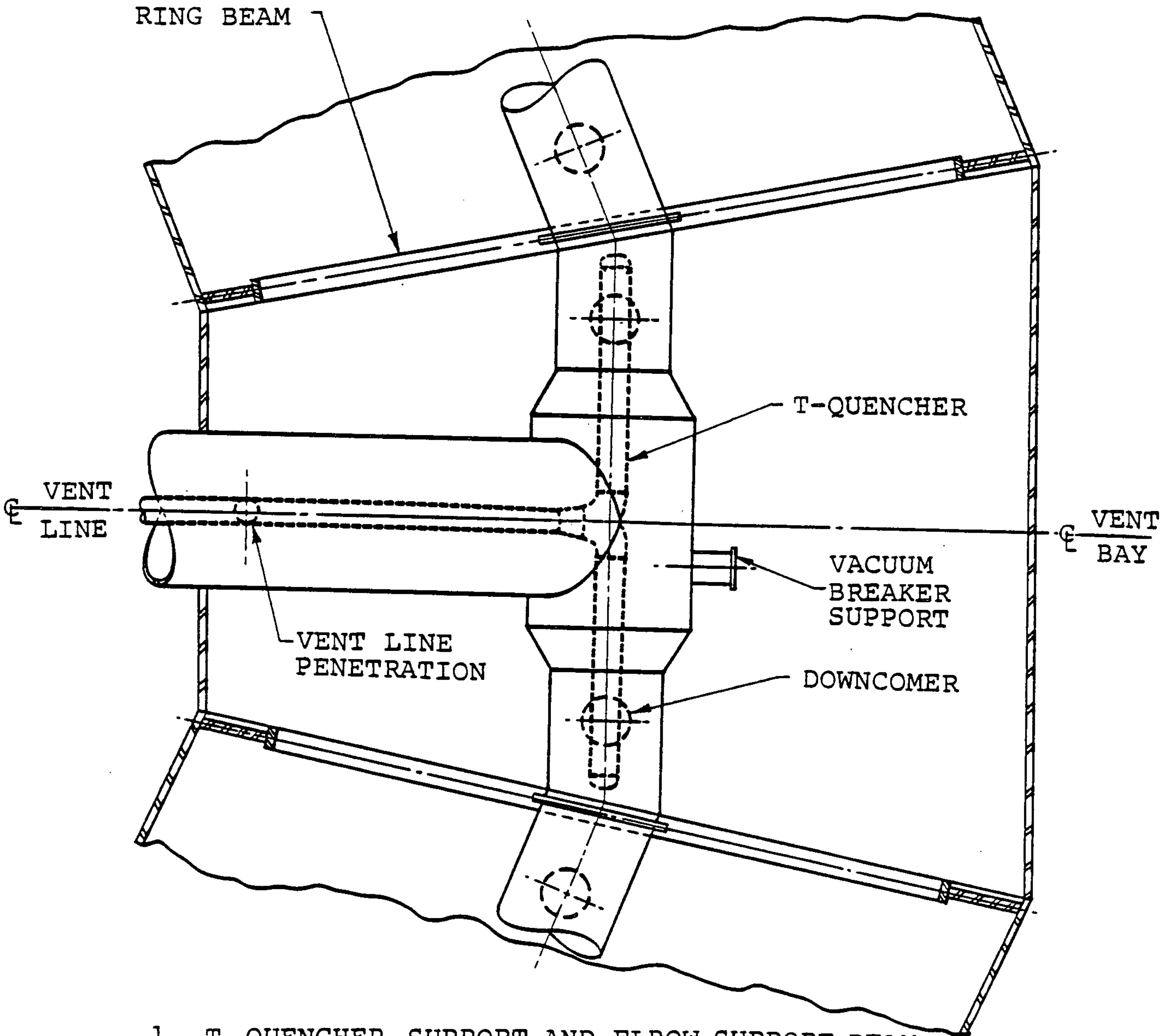


Figure 5-2.1-10

SUPPRESSION CHAMBER SECTION,

MID-VENT BAY



1. T-QUENCHER SUPPORT AND ELBOW SUPPORT BEAM NOT SHOWN FOR CLARITY

Figure 5-2.1-11

SRV PIPE ROUTING IN SUPPRESSION CHAMBER - PLAN VIEW

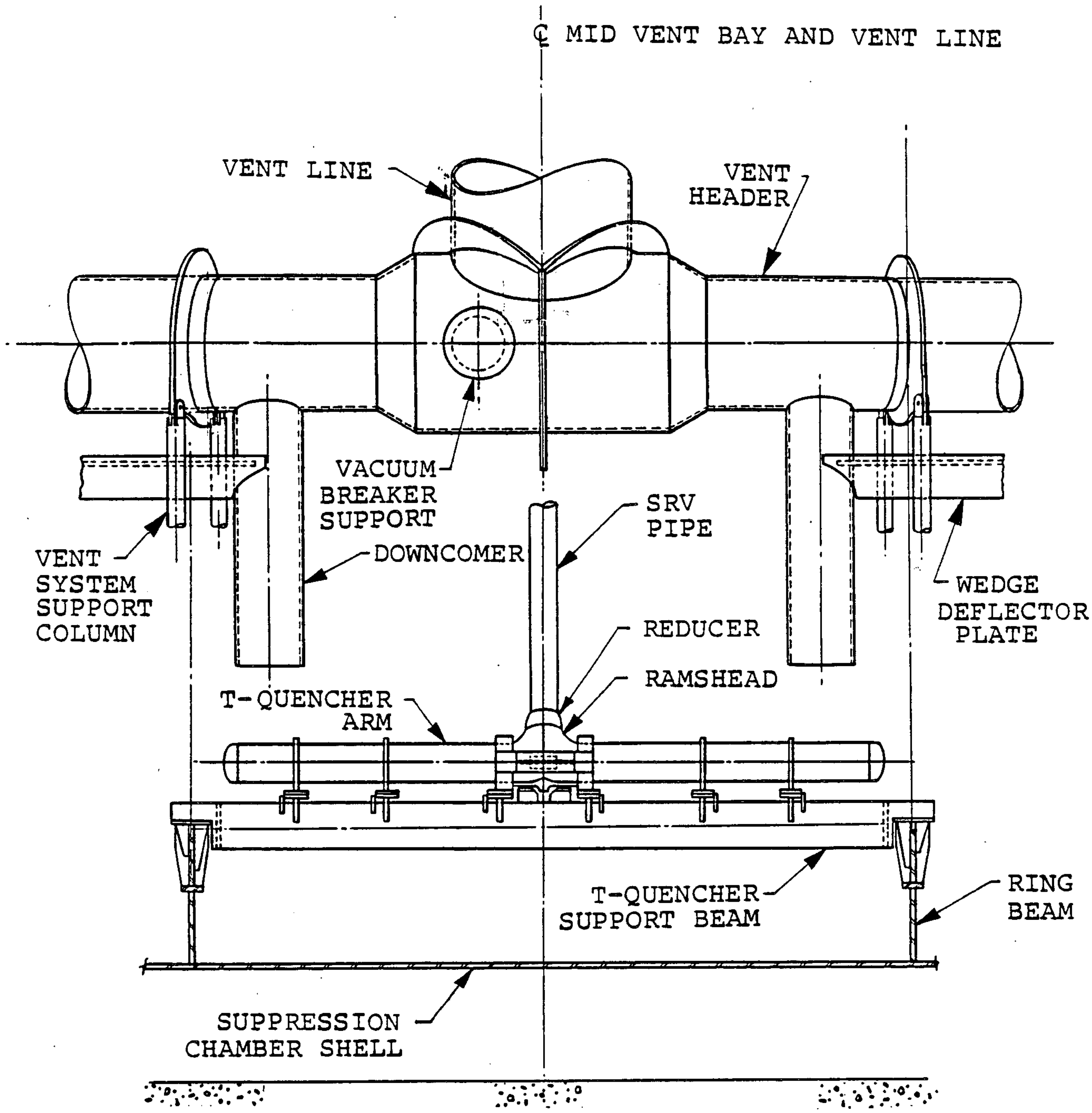


Figure 5-2.1-12

DEVELOPED VIEW OF SUPPRESSION CHAMBER SEGMENT

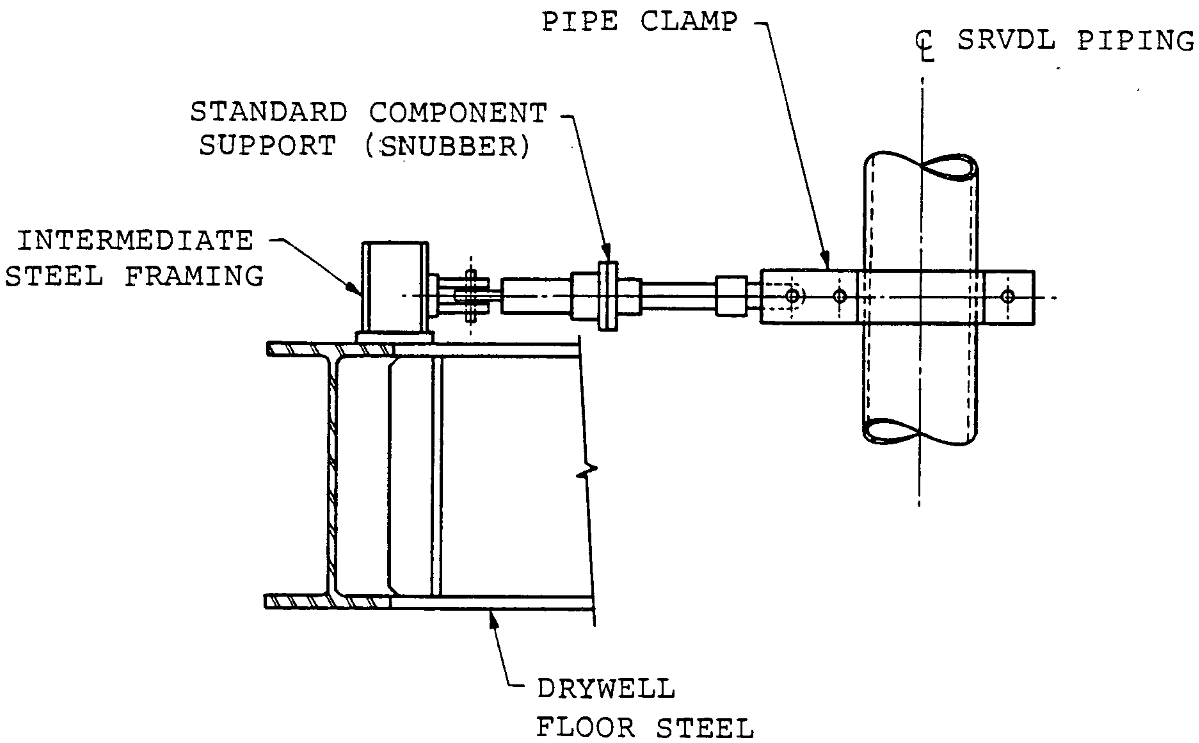
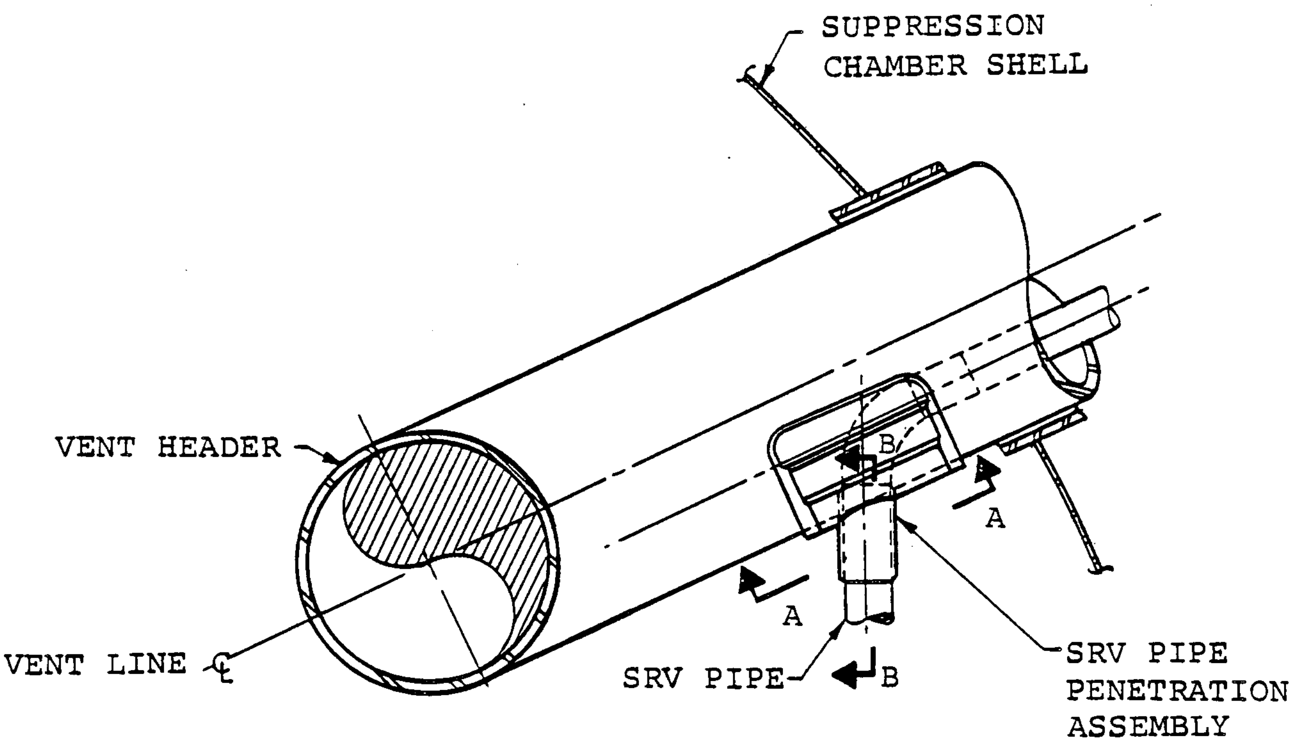
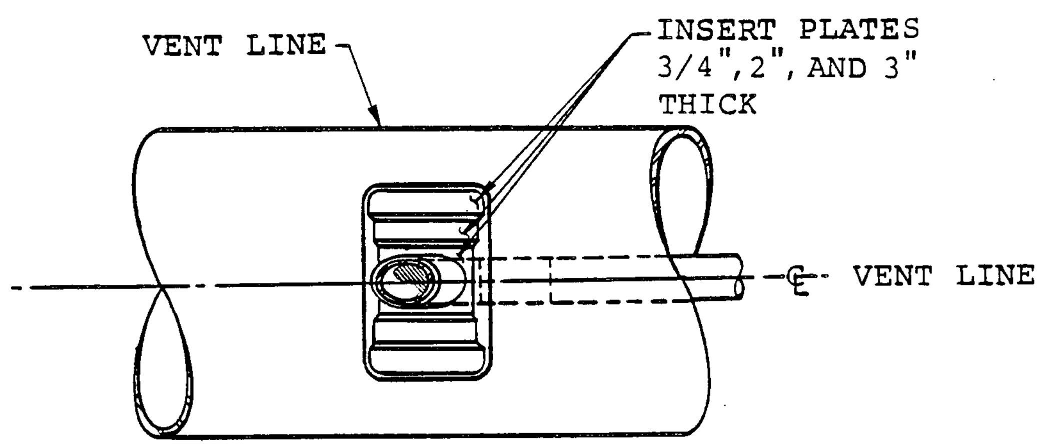


Figure 5-2.1-13

EXAMPLE OF AN SRVDL SUPPORT IN DRYWELL



VENT LINE ELEVATION VIEW

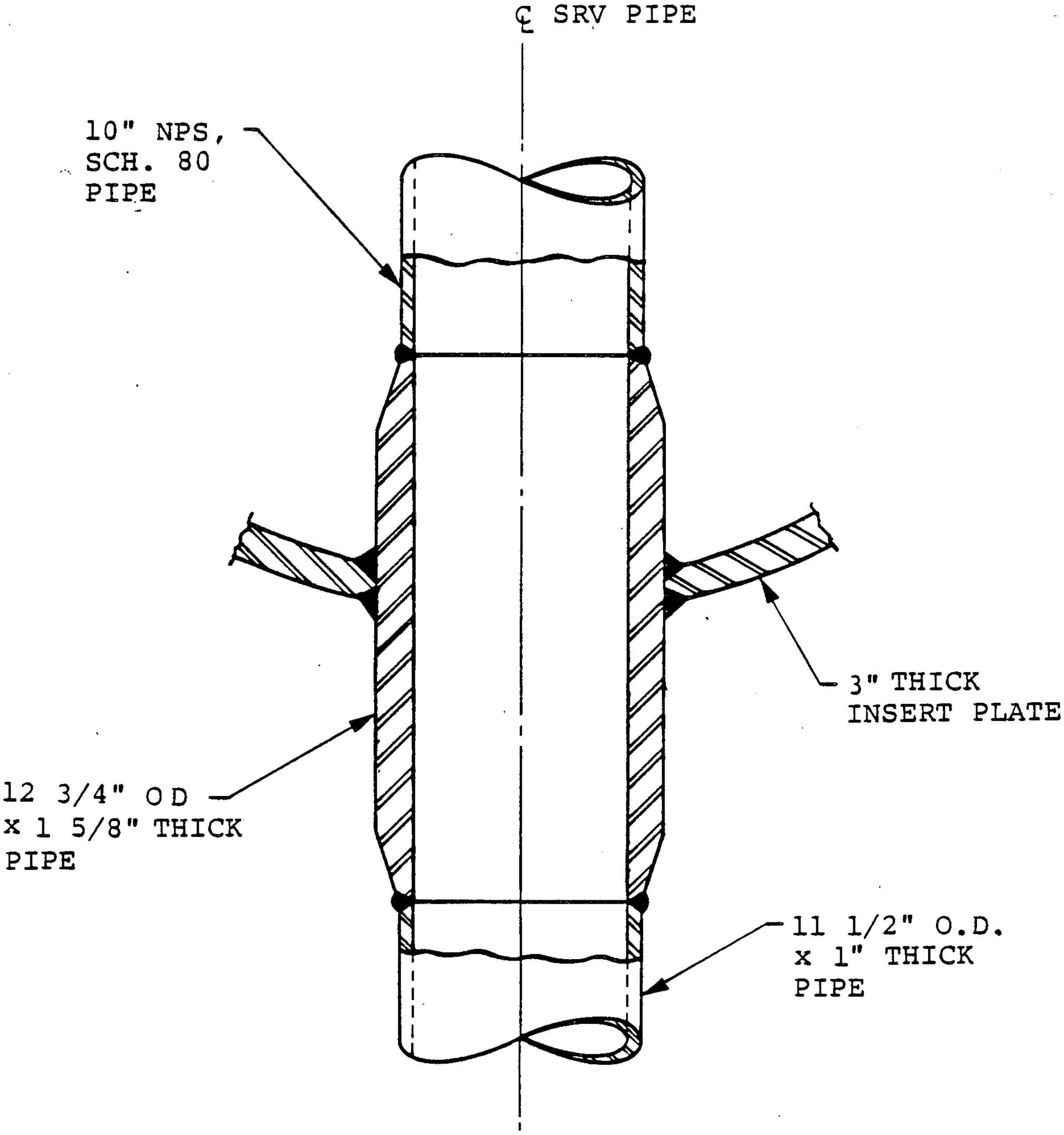


SECTION A-A

1. SEE FIGURE 5-2.1-15 FOR SECTION B-B.

Figure 5-2.1-14

SRVDL PENETRATION IN VENT LINE



SECTION B-B
(TAKEN ON FIGURE 5-2.1-14)

Figure 5-2.1-15

VENT LINE - SRV PIPING
PENETRATION NOZZLE DETAILS

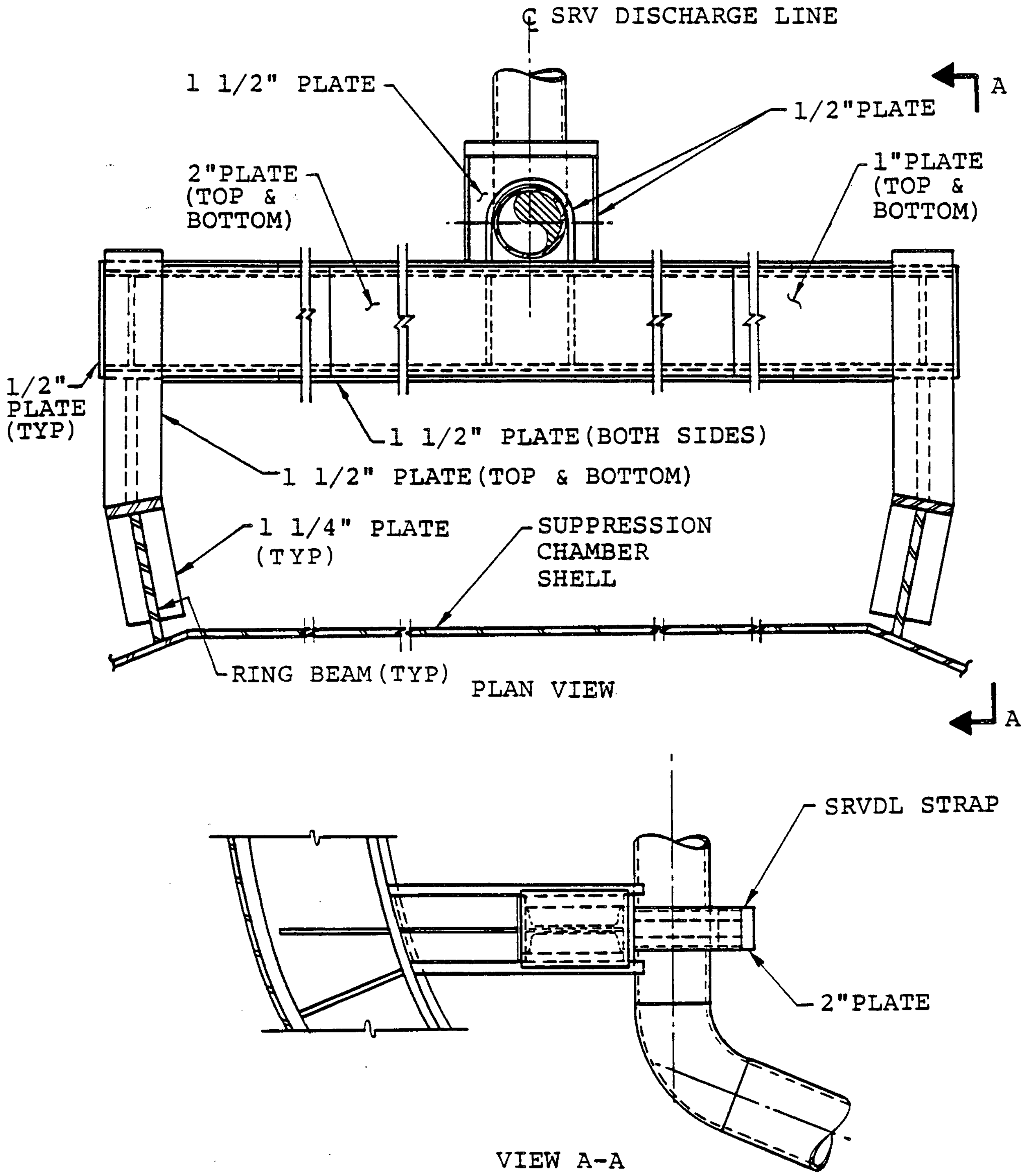


Figure 5-2.1-16

SRVDL ELBOW SUPPORT BEAM

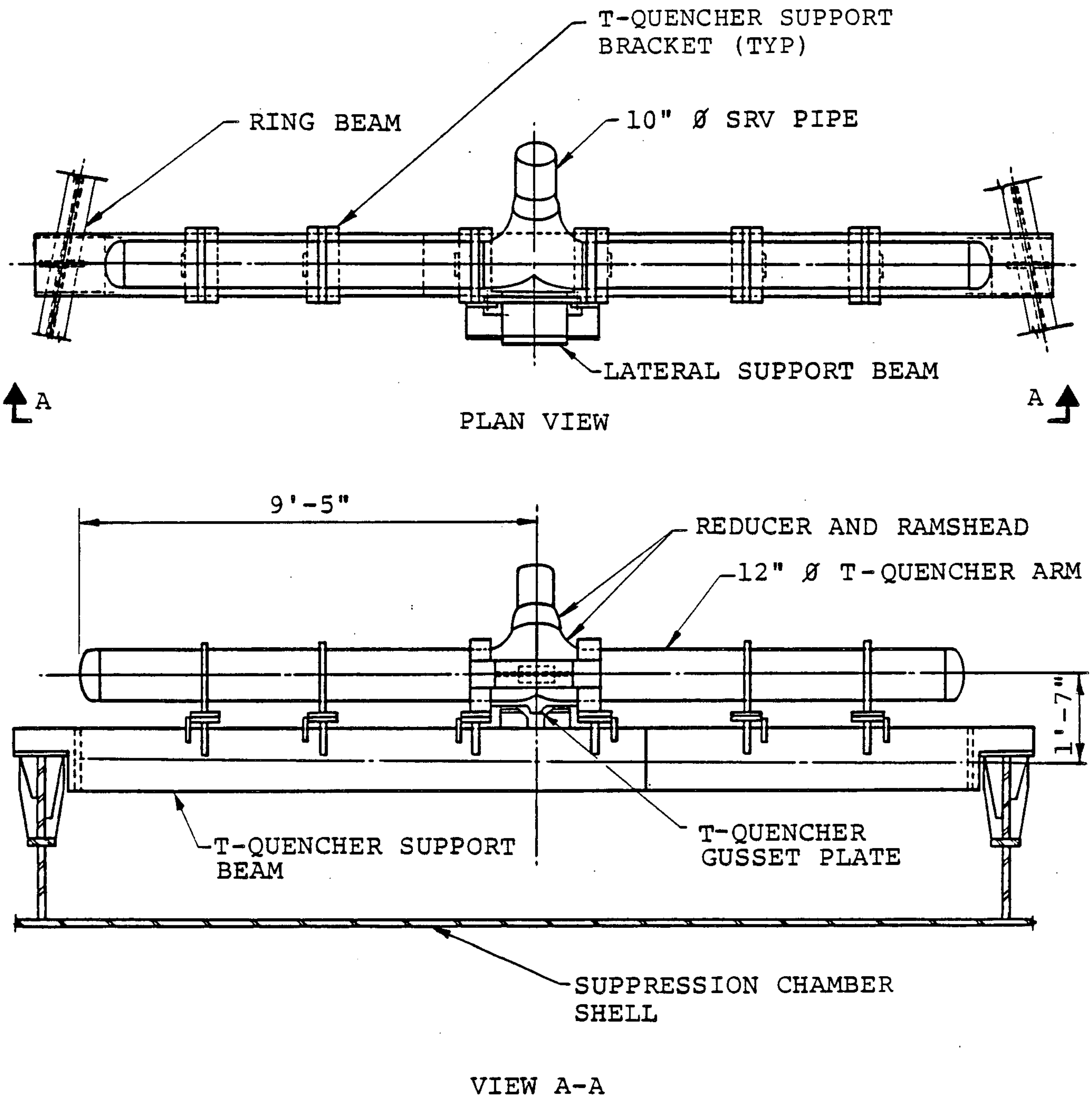
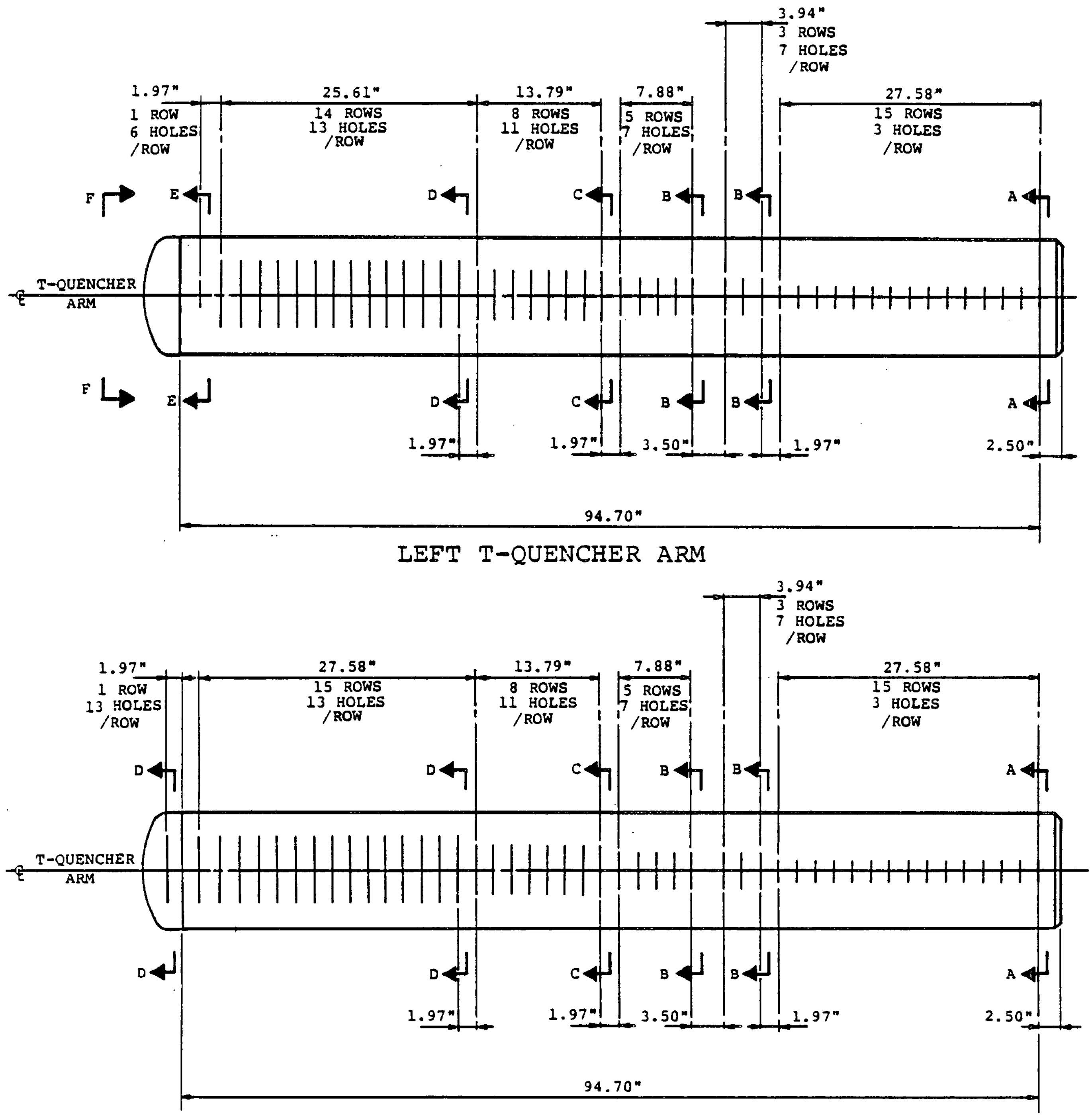


Figure 5-2.1-17

<u>T-QUENCHER AND T-QUENCHER SUPPORTS-</u>

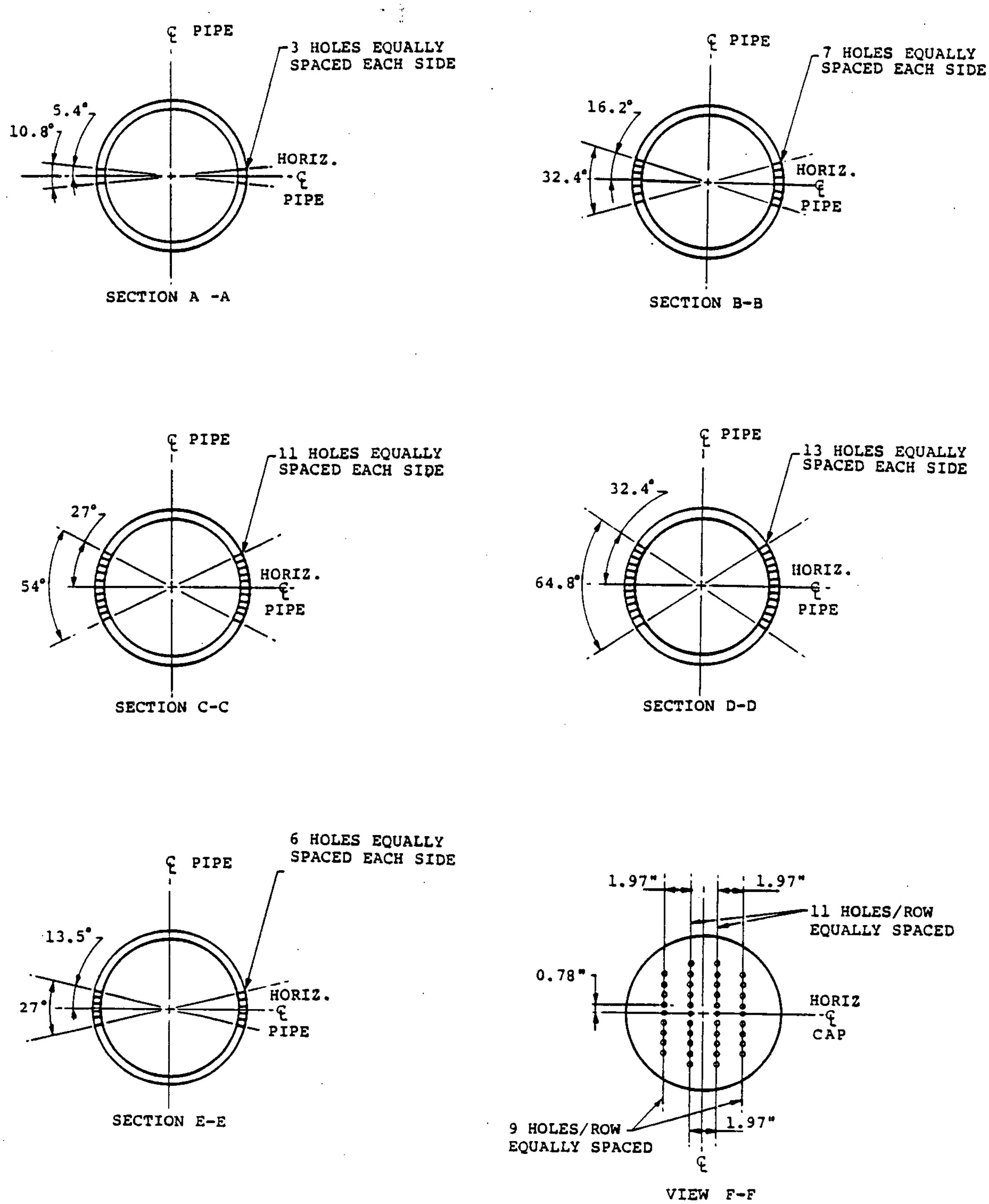
<u>PLAN VIEW AND ELEVATION</u>



1. SEE FIGURE 5-2.1-19 FOR SECTIONS AND VIEWS.
2. SEE FIGURE 5-2.1-20 FOR DEFINITION OF ARMS.

Figure 5-2.1-18

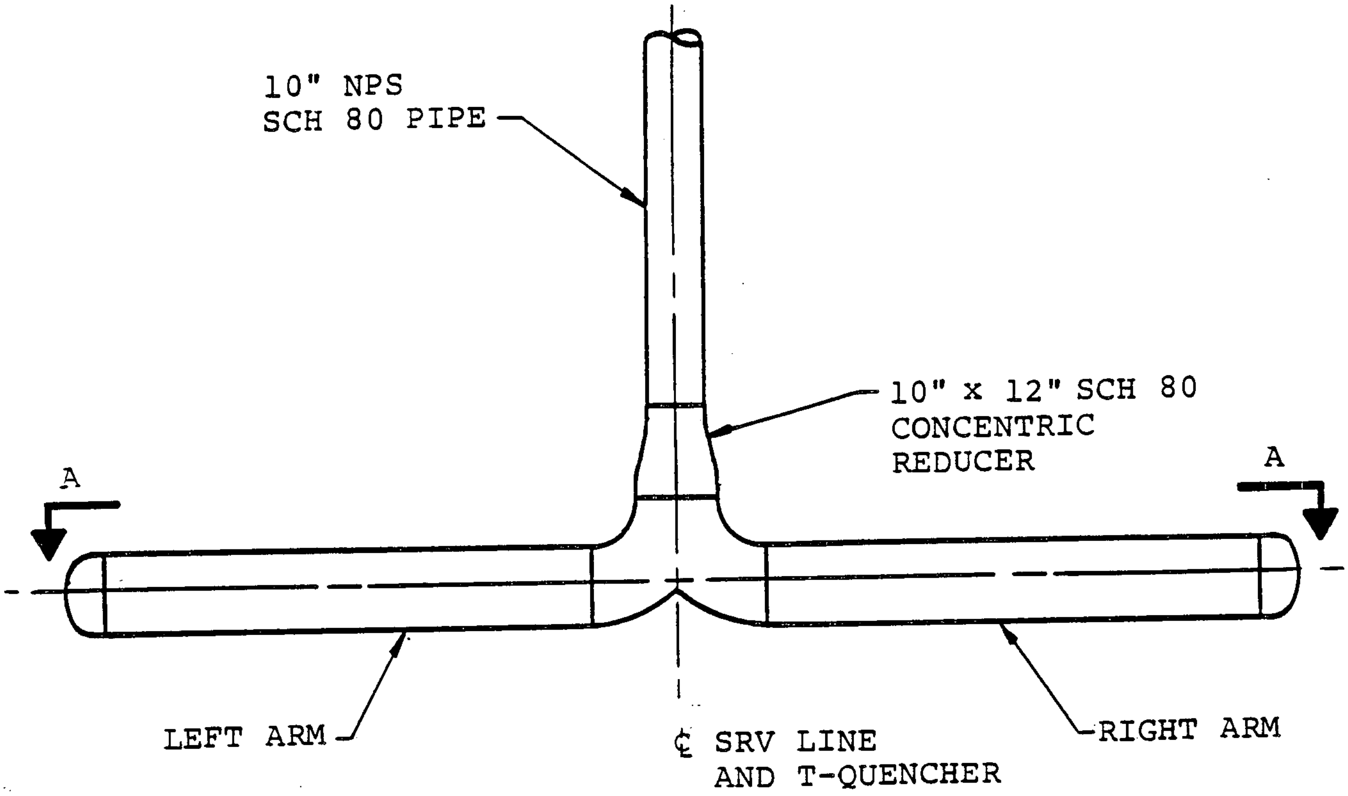
T-QUENCHER ARM HOLE PATTERN-ELEVATION VIEWS



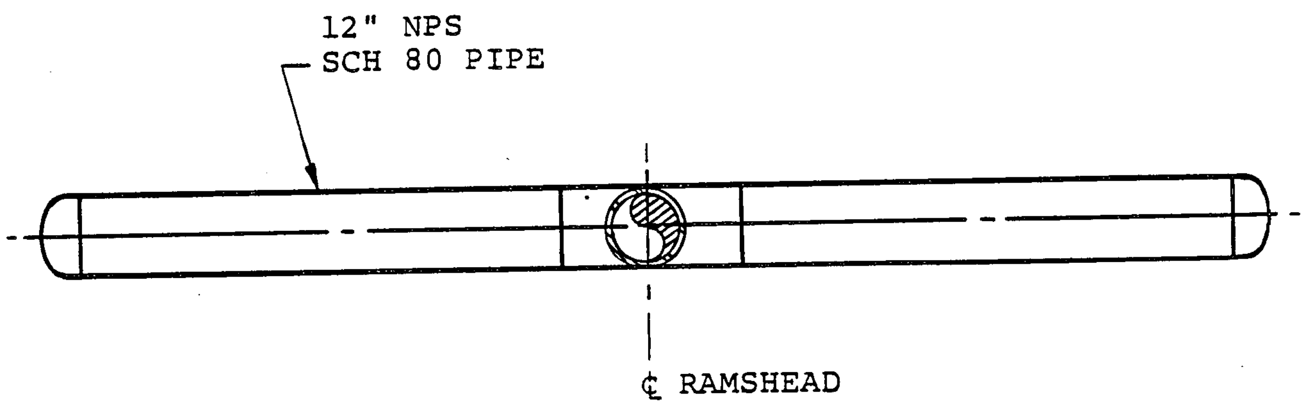
1. SECTIONS AND VIEWS TAKEN FROM FIGURE 5-2.1-18.

Figure 5-2.1-19

T-QUENCHER ARM HOLE PATTERN-SECTION VIEWS



PLAN VIEW



VIEW A-A

Figure 5-2.1-20

T-QUENCHER AND SRV LINE

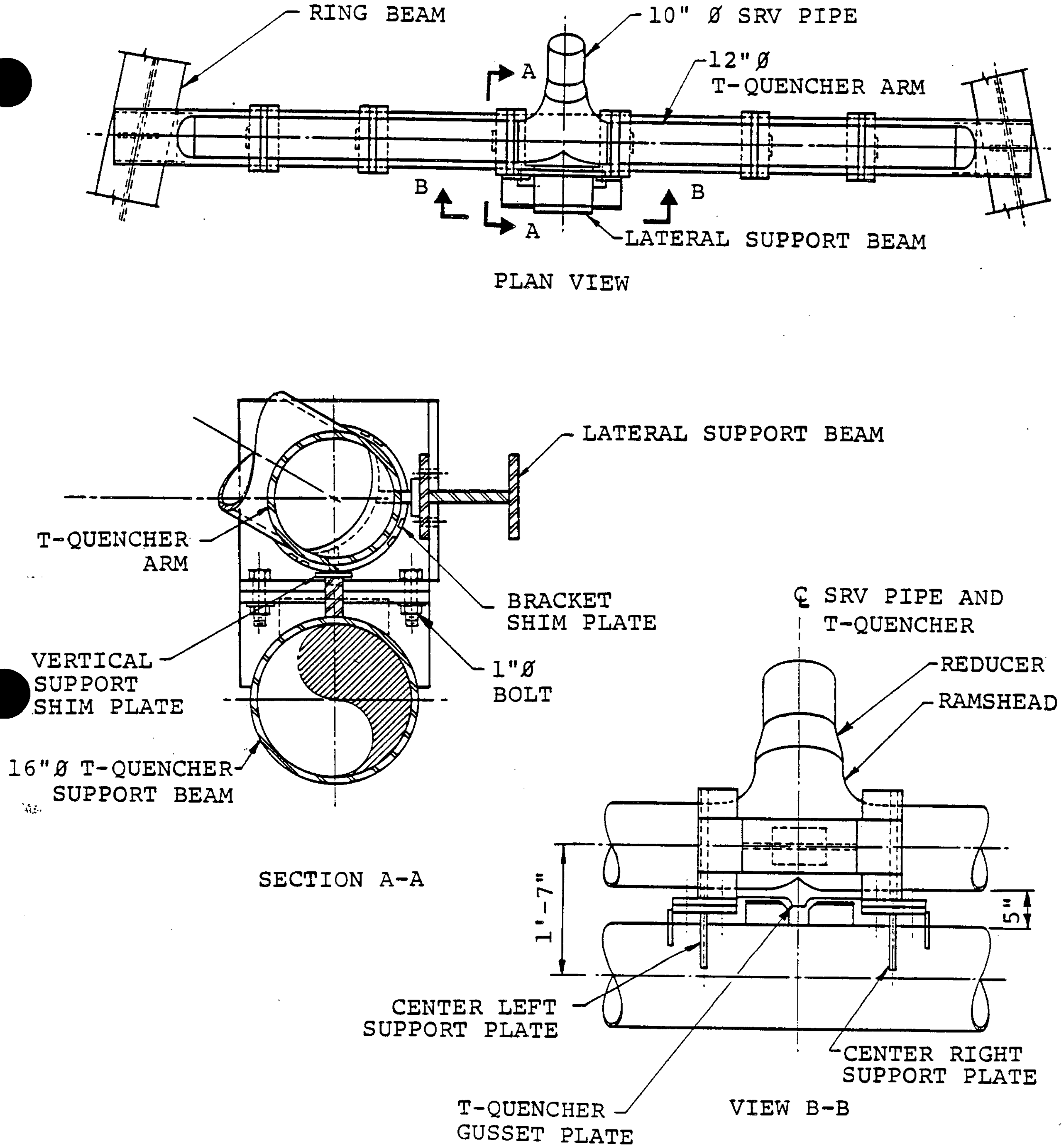


Figure 5-2.1-21

T-QUENCHER AND T-QUENCHER SUPPORTS-PLAN VIEW AND DETAILS

5-2.2 Loads and Load Combinations

The loads for which the DAEC SRV discharge line piping is designed are defined in NUREG-0661 on a generic basis for all Mark I plants. The methodology used to develop plant unique SRV discharge line piping loads for each load defined in NUREG-0661 is discussed in Section 1-4.0. The results of applying the methodology to develop specific values for each of the controlling loads which act on the SRV discharge line piping are discussed and presented in Section 5-2.2.1.

The governing load combinations which affect the SRV discharge line piping are formulated using the event combinations and event sequencing defined in NUREG-0661 and are discussed in Sections 1-3.0 and 1-4.0. The load combinations are discussed and presented in Section 5-2.2.2.

5-2.2.1 Loads

The loads acting on the SRVDL piping are categorized as follows.

1. Dead Loads
2. Seismic Loads
3. Pressure and Temperature Loads
4. Safety Relief Valve and Safety Valve Discharge Loads
5. Pool Swell Loads
6. Condensation Oscillation Loads (including FSI effects)
7. Chugging Loads (including FSI effects)
8. Vent Clearing Loads
9. Vent System and Suppression Chamber Interaction Loads

Loads in categories 1 through 3 are considered in the piping design as documented in the original stress report (Reference 4). Category 3 pressure and temperature loads result from postulated LOCA and SRV discharge events. Loads in category 4 result from SRV and SV discharge events. Loads in categories 5 through 8 result from postulated LOCA events. Loads in category 9 are structural responses which are a result of loads acting on the vent system and suppression chamber.

Not all of the loads defined in NUREG-0661 need be examined, since some are enveloped by others or have a negligible effect on the SRVDL piping. Only those loads which maximize the SRVDL piping response and lead to controlling stresses are examined and discussed. These loads are referred to as governing loads in the following sections.

The magnitudes and characteristics of the governing loads in each category, obtained using the methodology discussed in Section 1-4.0, are identified and presented in the following paragraphs. Table 5-2.2-1 provides a reference of the corresponding section in Volume 1 where the loads are discussed. The loading information presented in this section is the same as that presented in Section 1-4.0, with additional specific information relevant to the evaluation of the SRV discharge line piping system.

1. Dead Loads

a. Dead Weight (DW): These loads are defined as the uniformly distributed weight of the pipe and the concentrated weight of piping supports, piping hardware attachments, vacuum breakers, SRV's, SV's, and flanges. Also included is the weight of water contained in the wetwell SRVDL piping and T-quenchers corresponding to a torus water level of 2'5" below the torus horizontal centerline.

b. Dead Weight (DW_T): These loads are defined as the dead weight of piping and associated components as described above, plus the dead weight of water in the MSL piping during the hydrostatic test condition.

2. Seismic Loads

a. OBE Inertia (OBE_I): These loads are defined as the horizontal and vertical accelerations acting on the SRVDL piping during an Operating Basis Earthquake (OBE). The loading is taken from the design basis for the SRVDL piping as documented in the original stress report. The horizontal building response spectrum representing piping attachment points for the drywell and RPV for the N-S and E-W directions is shown in Figure 5-2.2-1. The vertical direction seismic response spectrum is shown in Figure 5-2.2-2.

b. OBE Anchor Displacement (OBE_D): These loads are defined as the horizontal static displacement at the piping anchors for an OBE event. The loading is taken from the design basis for the SRVDL piping as documented in the original stress report.

c. SSE Inertia (SSE_I): The horizontal and vertical SSE inertia loads specified in the original stress report are twice the corresponding OBE inertia loads.

d. SSE Anchor Displacement (SSE_D): The horizontal SSE anchor displacement loads specified in the original stress report are twice the corresponding OBE anchor displacement loads.

3. Pressure and Temperature Loads

a. Pressure (P_o, P): These loads are defined as the maximum internal pressure (P_o) in the MSL and SRVDL piping during normal operating and accident conditions, and the internal pressure (P) in the MSL and SRVDL piping for design conditions. Table 5-2.2-2 lists values of P_o and P used in the analysis.

b. Temperature (TE1, TE2): These loads are defined as the thermal expansion (TE1) of the MSL and SRVDL piping associated with normal operating and accident temperature changes occurring without SRV actuation, and the thermal expansion (TE2) of the MSL and SRVDL piping associated with normal operating and accident temperature changes occurring with SRV actuation. Table 5-2.2-2 lists pipe temperatures for TE1 and TE2 used in the analysis.

Effects of thermal anchor movements at the RPV nozzle and at the vent system and torus support locations are also included in the analysis. The piping thermal anchor movement loadings are categorized and designated as follows.

- o THAM1 - Piping thermal anchor movement, normal operating conditions without SRV actuation,
- o THAM2 - Piping thermal anchor movement, normal operating conditions with SRV actuation
- o THAM1A - Piping thermal anchor movement, accident condition without SRV actuation,
- o THAM2A - Piping thermal anchor movement, accident condition with SRV actuation.

4. Safety Relief Valve Discharge Loads

a. SRVDL Thrust (RV1): These loads are defined as the pressure and thrust forces acting along the SRVDL piping due to SRV actuation. The methodology used to develop SRVDL thrust loads is discussed in Section 1-4.2.2. The SRV actuation cases considered are discussed in Section 1-4.2.1. The cases which result in governing loads or load combinations for which SRV thrust force time-histories are developed include valve actuation with normal operating conditions (Cases A1.1 and C3.1) and valve actuation with SBA/IBA conditions (Case C3.2). The governing SRV actuation cases are categorized and designated as follows.

- RV1A - SRVDL piping thrust loads for normal operating conditions, first actuation (Case A1.1), and subsequent actuation (Case C3.1). This includes the set of loadings for both lines attached to one main steam line. SRVDL piping thrust loads for DBA conditions, first actuation (Case A1.3) are bounded by Case A1.1.
- RV1B - SRVDL piping thrust loads for SBA/IBA condition, first actuation (Case A1.2), and subsequent actuation (Cases C3.2 and C3.3). This includes

the set of loadings for both lines attached to one main steam line. SRVDL thrust loads for Cases A1.2 and C3.3 are bounded by Case C3.2.

- RV1C - SRVDL piping thrust loads for DBA conditions, first actuation (Case A1.3). This includes the set of loadings for both lines attached to one main steam line.

Figures 5-2.2-3, 5-2.2-4 and 5-2.2-5 show typical SRV thrust force time-history plots for line GBC-6 during the C3.1 actuation case. Tables 5-2.2-3 and 5-2.2-4 list the peak thrust force resulting from the C3.1 actuation case on each segment for each of the SRV lines.

b. Safety Valve Thrust: These loads are defined as the pressure and thrust forces acting on the valve and tee due to SV actuation. The procedure used to develop the transient forces of these loads is discussed in Section 1-4.2.2.

c. SRV T-quencher Discharge (QAB): During an SRV discharge, transient pressure loads are postulated to act on the SRVDL wetwell piping, T-quencher, and related support structures. These loads are categorized as follows.

- o Water Jet Impingement Loads: During the water clearing phase of an SRV discharge event, transient drag pressure loads are postulated to act on the wetwell piping and related support structures. The procedure used to develop the transient forces and spatial distribution of these loads is discussed in Section 1-4.2.4. Table 5-2.2-5 shows the resulting magnitudes and distribution of drag pressures. The results shown include the effects of velocity drag and acceleration drag.

- o Air Bubble Drag Loads: During the air clearing phase of an SRV discharge event, transient drag pressure loads are postulated to act on the wetwell piping, T-quencher, and related support structures. The procedure used to develop the transient forces and spatial distribution of these loads is discussed in Section 1-4.2.4.

Loads are developed for several possible patterns of air bubbles for both single and multiple T-quencher discharge cases. The results are evaluated to determine the controlling loads. Table 5-2.2-5 shows the magnitudes and distribution of drag pressures acting on selected segments of the wetwell piping, T-quencher, and related support structures for the controlling SRV discharge air bubble drag load cases. The results shown include the effects of velocity drag, acceleration drag, interference effects, wall effects, an adjusted bubble pressure factor, and acceleration drag volumes.

o T-quencher and End Cap Thrust Loads: During an SRV discharge event, water clearing thrust loads are postulated to act on the wetwell piping, T-quencher, and related support structures. The procedure used to develop bounding values of these loads is discussed in Section 1-4.2.2. Table 5-2.2-6 shows the resulting magnitudes of the T-quencher arm and end cap thrust loads.

5. Pool Swell Loads

Pool Swell (PS): During the initial phase of a DBA event, transient pressure loads are postulated to act on the portion of SRVDL piping above the suppression pool. These loads are categorized as follows.

- o Impact and Drag Loads: During the initial phase of a DBA event, transient pressures are postulated to act on the portion of the SRV discharge line above the suppression pool. The pool swell load development procedure is discussed in Section 1-4.1.4.2. Table 5-2.2-7 shows a sampling of pool swell impact and drag loads for selected segments of the SRVDL. The results shown are based on plant unique QSTF test data contained in the PULD (Reference 3).

- Pool Swell Froth Impingement Loads: During the final stages of the pool swell phase, a two-phase froth of air and water are postulated to act on the SRV discharge line above the pool surface. The froth load development procedure used is discussed in Section 1-4.1.4.3. Table 5-2.2-8 shows a sampling of pool swell froth impingement loads for selected segments of the SRVDL.

- Pool Fallback Loads: After the pool swell phase, transient pressures resulting from pool fallback are postulated to act on the horizontal projection of the SRVDL elbow support beam. The pool fallback load development procedure used is discussed in Section 1-4.1.4.4. Table 5-2.2-9 shows a sampling of pool fallback drag loads for selected segments of the SRVDL piping and piping supports. The results shown include the effects of maximum pool displacements measured in plant unique QSTF tests.

6. Condensation Oscillation Loads

Condensation Oscillation (CO): During the condensation oscillation phase of a DBA event, harmonic drag pressures are postulated to act on the SRVDL wetwell piping, T-quencher, and related support structures. The procedure used to develop the harmonic forces and spatial distribution of drag loads on these components is discussed in Section 1-4.1.7.

Loads are developed for the case with the average source strength at all downcomers and for the case with twice the average source strength at the nearest downcomer. The results are evaluated to determine the controlling loads. Tables 5-2.2-10 and 5-2.2-11 show the resulting distribution and magnitudes of DBA condensation oscillation drag pressures acting on the wetwell piping, T-quencher, and related support structures for the controlling load case. These results include the effects of velocity drag, acceleration drag, interference effects, wall effects, and acceleration drag volumes. Tables 5-2.2-12 and 5-2.2-13 show the resulting distribution and magnitudes of DBA condensation oscillation FSI effects. Figure 5-2.2-8 shows a typical pool acceleration profile from which the FSI accelerations are derived. The results of each harmonic in the loading are combined using the methodology discussed in Section 1-4.1.7.

7. Chugging Loads

a. Pre-Chug (PCHUG): During the chugging phase of an SBA, IBA, or DBA event, harmonic drag pressure loads associated with the pre-chug portion of a chug cycle are postulated to act on the wetwell piping, T-quencher, and related support structures. The procedure used to develop the harmonic forces and spatial distribution of pre-chug drag loads on these components is discussed in Section 1-4.1.8.

Loads are developed for the case with the average source strength at all downcomers, and for the case with twice the average source strength at the nearest downcomer. The results are evaluated to determine the controlling loads. Table 5-2.2-14 shows the resulting load acting on the wetwell piping, T-quencher, and related support structures.

b. Post-Chug (CHUG): During the chugging phase of an SBA, IBA, or DBA event, harmonic drag pressure loads associated with the post-chug portion of a chug cycle are postulated to act on the wetwell piping, T-quencher, and related support structures. The procedure used to develop post-chug drag loads on the wetwell piping, T-quencher and related support structures is discussed in Section 1-4.1.8.

Loads are developed for the case with the maximum source strength at the nearest two downcomers acting both in-phase and out-of-phase. The results are evaluated to determine the controlling loads. Tables 5-2.2-15 and 5-2.2-16 show the resulting distribution and magnitudes of drag pressures acting on the wetwell piping, T-quencher and related support structures for the controlling post-chug drag load cases.

The results shown in the table include the effects of velocity drag, acceleration drag, interference effects, wall effects, and acceleration drag volumes. Tables 5-2.2-17 and 5-2.2-18 show the resulting distribution and magnitudes for the FSI effects. Figure 5-2.2-8 shows a typical pool acceleration profile from which the post-chug FSI accelerations are derived. The results of each harmonic in the loading are combined using the methodology discussed in Section 1-4.1.8.

8. Vent Clearing (VCL) Loads

During the vent system water and air clearing phase of a DBA event, transient pressure loads are postulated to act on the wetwell piping, T-quencher, and related support structures. These loads are categorized as follows.

a. LOCA Water Jet Impingement: During the water clearing phase of a DBA event, transient drag pressure loads are postulated to act on the wetwell piping, T-quencher, and related support structures. The procedure used to develop these transient drag forces is discussed in Section 1-4.1.5. Table 5-2.2-19 shows the resulting magnitudes and distribution of LOCA water jet drag pressures acting on the wetwell piping, T-quencher, and related support structures. These results include the effects of velocity drag and acceleration drag.

b. LOCA Air Bubble Drag: During the air clearing phase of a DBA event, the wetwell piping, T-quencher, and related support structures are subjected to transient drag pressure loads. The procedure used to develop these transient drag forces is discussed in Section 1-4.1.6. Table 5-2.2-20 shows the resulting magnitudes and distribution of DBA air clearing drag pressures acting on the wetwell piping, T-quencher, and related support structures. These results include the effects of velocity drag and acceleration drag.

9. Vent System and Suppression Chamber Interaction Loads

a. Vent System Interaction: These loads are defined as the interaction effects at the vent line penetration due to loads acting on the vent system.

b. Suppression Chamber Interaction: These loads are defined as the interaction effects at the wetwell piping attachment points to the suppression chamber due to loads acting on the suppression chamber shell.

Both types of interaction loads are discussed in the following paragraphs.

- TD - The drywell, vent system and torus displacements due to normal operating pressure, and torus displacements due to the weight of water in the torus

- TD1 - The drywell, vent system and torus displacements due to accident condition pressures, and torus displacements due to the weight of water in the torus

- o QAB_I - The interaction effects of torus and vent system motions due to SRV T-quencher discharge loads
- o PS_I - The interaction effects of torus and vent system motions due to pool swell loads
- o CO_I - The interaction effects of torus and vent system motions due to DBA condensation oscillation loads
- o $PCHUG_I$ - The interaction effects of torus and vent system motions due to pre-chug loads
- o $CHUG_I$ - The interaction effects of torus and vent system motions due to post-chug loads

All of the interaction loads listed above are derived from the structural response analyses of the torus and vent system, discussed in Volumes 2 and 3 of this report.

Combinations of the previously described loads which are applied in evaluating the SRVDL piping and supports are presented in the following sections.

Table 5-2.2-1

SRVDL PIPING LOADING
IDENTIFICATION CROSS-REFERENCE

VOLUME 5 LOAD DESIGNATION		VOLUME 1 SECTION REFERENCE
LOAD CATEGORY	LOAD CASE NUMBER	
DEAD	1a	(1)
	1b	(1)
SEISMIC	2a	(1)
	2b	(1)
	2c	(1)
	2d	(1)
PRESSURE AND TEMPERATURE	3a	1-4.1.1
	3b	1-4.1.1
SRV DISCHARGE	4a	1-4.2.2
	4b	1-4.2.2
	4c	1-4.2.4
POOL SWELL	5	1-4.1.4.2, 1-4.1.4.3, 1-4.1.4.4
CONDENSATION OSCILLATION	6	1-4.1.7.3
CHUGGING	7a	1-4.1.8.3
	7b	1-4.1.8.3
VENT CLEARING	8a,8b	1-4.1.5, 1-4.1.6
VENT SYSTEM AND TORUS INTERACTION	9a	1-4.1, 1-4.2
	9b	1-4.1, 1-4.2

(1) THESE ARE ORIGINAL LOADS. SEE THE DAEC NSC ORIGINAL STRESS REPORT (REFERENCE 4) FOR DETAILED EXPLANATIONS OF THESE LOADS.

Table 5-2.2-2

PRESSURES AND TEMPERATURES FOR MSL AND SRVDL PIPING

PIPING SYSTEM	PRESSURE (psig)		TEMPERATURE (^{o}F)		
	MAXIMUM OPERATING (P_o)	DESIGN (P)	WITHOUT SRV ACTUATION (TE 1)	WITH SRV ACTUATION (TE 2)	DESIGN
MAIN STEAM	1,250 (1)	1,250 (1)	550	550	575
SRVDL (DRYWELL)	505 (2)	505 (2)	MAX 292 MIN 135	375	375
SRVDL (WETWELL)	505 (2)	505 (2)	MAX 269 MIN 60	375	375
T-QUENCHER	505 (2)	505 (2)	MAX 178 MIN 60	370	375

(1) MAXIMUM OPERATING PRESSURE IS TAKEN AS THE DESIGN PRESSURE.

(2) VALUES SHOWN ARE HIGHER THAN THOSE OF THE ORIGINAL ANALYSIS. THE VALUES USED ARE DEVELOPED FROM THE MARK I PROGRAMS FOR SRV DISCHARGE. THE MAXIMUM VALUES FROM THE ANALYSIS OF ALL SIX SRVDL'S IS SHOWN.

Table 5-2.2-3

SRV DISCHARGE THRUST LOADS (CASE C3.1) -
PEAK SEGMENT FORCES FOR DRYWELL PIPING

LINE NUMBER	SEGMENT IDENTIFICATION NUMBER (Figure 5-2.4-10)										
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
GBC-6	1.23	5.28	4.01	5.23	7.55	10.51	5.55	6.81	12.26	27.30	–
GBC-7	2.81	2.72	4.31	6.06	11.43	8.49	9.18	13.24	21.43	35.99	–
GBC-8	2.40	4.66	4.80	6.72	11.63	8.71	5.28	5.11	7.47	8.42	–
GBC-9	2.52	5.38	7.12	7.81	6.77	6.37	8.16	6.66	5.39	7.58	8.63
GBC-10	3.78	4.00	4.98	7.33	14.53	14.76	12.54	23.70	37.06	–	–
GBC-11	1.31	7.07	4.58	8.56	8.41	5.51	13.86	25.11	–	–	–

1. LOADS SHOWN ARE IN KIPS.

Table 5-2.2-4

SRV DISCHARGE THRUST LOADS (CASE C3.1) -
PEAK SEGMENT FORCES FOR WETWELL PIPING

LINE NUMBER	SEGMENT IDENTIFICATION NUMBER (Figure 5-2.4-10)	
	W_1	W_2
GBC-6	17.27	93.06
GBC-7	15.91	98.11
GBC-8	15.62	89.50
GBC-9	17.01	89.31
GBC-10	15.14	97.08
GBC-11	20.30	90.27

1. LOADS SHOWN ARE IN KIPS.

Table 5-2.2-5

SRV DISCHARGE WATER JET IMPINGEMENT AND AIR BUBBLE DRAG LOADS FOR SRVDL PIPING AND SUPPORTS

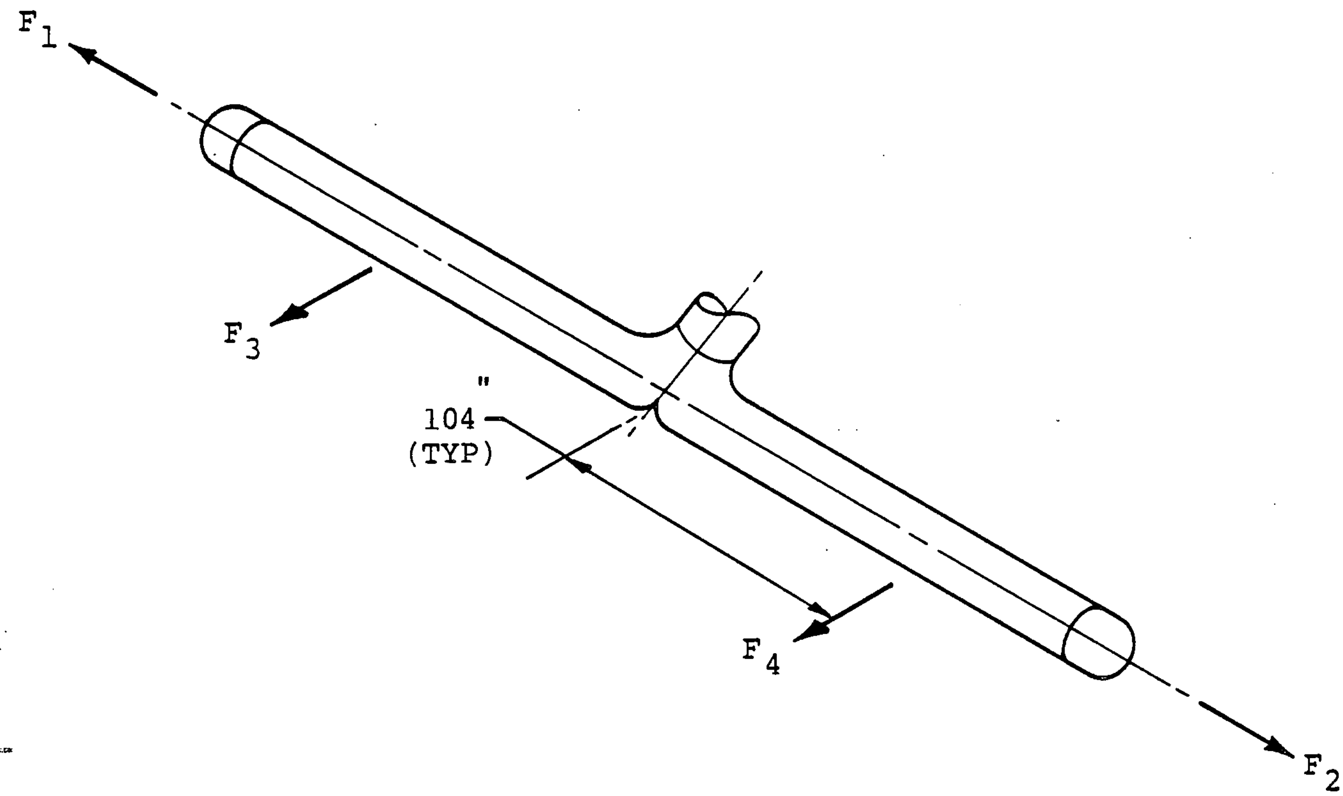
ITEM	SEGMENT NUMBER (1)	SRV BUBBLE DRAG LOAD PRESSURE (psi) (2)			SRV WATER JET PRESSURE (psi) (2)		
		P_x	P_y	P_z	P_x	P_y	P_z
SRVDL PIPING	2	0.80	0	0	0	0	0
	4	1.76	0	0	0	0	0
	6	1.86	4.23	0	0	0	0
	10	1.99	4.53	0	0	0	0
	14	4.21	9.59	0	0	0	0
T-QUENCHER	15	43.29	9.33	0	0	0	0
	19	29.02	9.50	0	0	0	0
	21	9.40	8.43	0	0	0	0
	23	10.01	17.24	0	0	0	0
ELBOW SUPPORT BEAM	24	2.10	8.77	0	0	5.96	0
	25	2.37	9.44	0	0	4.48	0
	27	1.45	9.18	0	0	0	0
	28	1.20	8.92	0	0	0	0
T-QUENCHER SUPPORT BEAM	29	19.03	6.54	0	0	0	0
	33	28.09	19.41	0	0	0	0
	35	11.38	2.86	0	0	0	0
	37	6.93	5.42	0	0	0	0
CONNECTING BRACKET	38	0	0	18.09	0	0	0
	39	0	0	14.24	0	0	0
	40	0	0	3.06	0	0	0

(1) SEE FIGURE 5-2.2-6 FOR LOCATION OF SEGMENT NUMBERS.

(2) LOADS SHOWN INCLUDE DLF'S.

Table 5-2.2-6

SRV DISCHARGE T-QUENCHER AND END CAP THRUST LOADS



KEY DIAGRAM

THRUST LOAD COMPONENT	FORCE MAGNITUDE (kips)
F_1	144.95
F_2	162.95
F_3	16.00
F_4	18.80

1. LOADS SHOWN INCLUDE DLF'S.

Table 5-2.2-7

POOL SWELL IMPACT AND DRAG LOADS
ON SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER(1)	PRESSURE (psi)(2)		
		P_x	P_y	P_z
SRVDL PIPING	2	0	0	0
	4	0	0	0
	6	0	0	0
	10	0	0	0
	14	0	0	0
T-QUENCHER	16	0	0	0
	20	0	0	0
	22	0	0	0
	24	0	0	0
ELBOW SUPPORT BEAM	25	0	1.03	0
	26	0	.97	0
	28	0	.77	0
	29	0	.68	0
T-QUENCHER SUPPORT BEAM	31	0	0	0
	35	0	0	0
	37	0	0	0
	39	0	0	0
CONNECTING BRACKET	40	0	0	0
	41	0	0	0
	42	0	0	0

(1) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.
(2) LOADS SHOWN INCLUDE DLF'S.

Table 5-2.2-8

POOL SWELL FROTH IMPINGEMENT LOADS

ITEM	SEGMENT NUMBER(1)	PRESSURE (psi) (2)		
		P_x	P_y	P_z
SRVDL PIPING	2	8.38	0	0
	4	8.68	0	0
	6	0	0	0
	10	0	0	0
	14	0	0	0
T-QUENCHER	16	0	0	0
	20	0	0	0
	22	0	0	0
	24	0	0	0
ELBOW SUPPORT BEAM	25	0	0	0
	26	0	0	0
	28	0	0	0
	29	0	0	0
T-QUENCHER SUPPORT BEAM	31	0	0	0
	35	0	0	0
	37	0	0	0
	39	0	0	0
CONNECTING BRACKET	40	0	0	0
	41	0	0	0
	42	0	0	0

(1) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.

(2) LOADS SHOWN INCLUDE DLF'S.

Table 5-2.2-9

POOL FALLBACK LOADS ON
SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER(1)	PRESSURE (psi)(2)		
		P_x	P_y	P_z
SRVDL PIPING	2	0	0	0
	4	0	0	0
	6	0	0	0
	10	0	0	0
	14	0	0	0
T-QUENCHER	16	0	0	0
	20	0	0	0
	22	0	0	0
	24	0	0	0
ELBOW SUPPORT BEAM	25	0	3.30	0
	26	0	3.28	0
	28	0	3.16	0
	29	0	3.09	0
T-QUENCHER SUPPORT BEAM	31	0	0	0
	35	0	0	0
	37	0	0	0
	39	0	0	0
CONNECTING BRACKET	40	0	0	0
	41	0	0	0
	42	0	0	0

(1) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.

(2) LOADS SHOWN INCLUDE DLF'S.

Table 5-2.2-10

DBA CONDENSATION OSCILLATION SUBMERGED STRUCTURE LOADS FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER (2)	NORMALIZED FORCE (1) lbf/(ft³/sec²)		
		P_x	P_y	P_z
SRVDL PIPING	2	.005	0	.005
	4	.010	0	.010
	6	-.017	-.041	.019
	10	-.013	-.031	.046
	14	-.052	-.126	.357
T-QUENCHER	16	-.049	.592	0
	20	-.016	.309	0
	22	-.011	.068	0
	24	-.082	-.394	0
ELBOW SUPPORT BEAM	25	.071	-.453	0
	26	.072	-.408	0
	28	.047	-.346	0
	29	.032	-.332	0
T-QUENCHER SUPPORT BEAM	31	-.090	.275	0
	35	-.031	.328	0
	37	-.022	.115	0
	39	-.020	.015	0
CONNECTING BRACKET	40	0	0	4.180
	41	0	0	4.811
	42	0	0	2.401

(1) THE ACTUAL FORCE ON ANY SEGMENT IS CALCULATED BY MULTIPLYING THE NORMALIZED FORCE BY THE AMPLITUDE FOR A GIVEN FREQUENCY RANGE SHOWN IN TABLE 5-2.2-11.

(2) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.

Table 5-2.2-11

AMPLITUDES AT VARIOUS FREQUENCIES FOR DBA CONDENSATION OSCILLATION

FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)	FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)
0-1	28.38	25-26	24.46
1-2	24.46	26-27	56.75
2-3	31.31	27-28	12.72
3-4	46.97	28-29	18.59
4-5	182.00	29-30	13.70
5-6	267.13	30-31	7.83
6-7	96.87	31-32	2.94
7-8	57.73	32-33	2.94
8-9	57.73	33-34	2.94
9-10	57.73	34-35	4.89
10-11	77.30	35-36	7.83
11-12	44.03	36-37	9.79
12-13	16.63	37-38	6.85
13-14	11.74	38-39	5.87
14-15	6.85	39-40	8.81
15-16	9.79	40-41	32.29
16-17	3.91	41-42	32.29
17-18	3.91	42-43	32.29
18-19	3.91	43-44	32.29
19-20	26.42	44-45	32.29
20-21	19.57	45-46	32.29
21-22	29.36	46-47	32.29
22-23	33.27	47-48	32.29
23-24	32.29	48-49	32.39
24-25	15.66	49-50	32.29

Table 5-2.2-12

FSI EFFECTS FROM DBA CONDENSATION OSCILLATION SUBMERGED STRUCTURE LOADS FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER (2)	NORMALIZED FORCE (1) $lbf/(ft^3/sec^2)$		
		P_x	P_y	P_z
SRVDL PIPING	2	.172	0	0
	4	.178	0	0
	6	.105	.196	0
	10	.078	.146	0
	14	.359	.478	0
T-QUENCHER	16	.112	.209	0
	20	.128	.188	0
	22	.133	.152	0
	24	1.000	1.000	0
ELBOW SUPPORT BEAM	25	.641	.872	0
	26	.869	.951	0
	28	.992	1.000	0
	29	1.000	1.000	0
T-QUENCHER SUPPORT BEAM	31	.228	.365	0
	35	.355	.390	0
	37	.486	.345	0
	39	.547	.376	0
CONNECTING BRACKET	40	0	0	1.000
	41	0	0	1.000
	42	0	0	.576

(1) THE ACTUAL FORCE ON ANY SEGMENT IS CALCULATED BY MULTIPLYING THE NORMALIZED FORCE BY THE AMPLITUDE FOR A GIVEN FREQUENCY RANGE SHOWN IN TABLE 5-2.2.13.

(2) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.

Table 5-2.2-13

AMPLITUDES AT VARIOUS FREQUENCIES FOR FSI EFFECTS FROM DBA CONDENSATION OSCILLATION

FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)	FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)
0-1	0.106	25-26	227.783
1-2	0.414	26-27	194.460
2-3	1.114	27-28	0.000
3-4	3.432	28-29	61.761
4-5	26.712	29-30	51.299
5-6	40.223	30-31	17.786
6-7	20.836	31-32	15.373
7-8	17.309	32-33	14.603
8-9	17.309	33-34	10.949
9-10	0.000	34-35	10.957
10-11	154.398	35-36	17.888
11-12	0.000	36-37	23.304
12-13	59.412	37-38	13.892
13-14	0.000	38-39	15.714
14-15	50.050	39-40	22.501
15-16	89.242	40-41	75.885
16-17	67.205	41-42	74.371
17-18	26.136	42-43	68.094
18-19	0.000	43-44	0.000
19-20	0.000	44-45	78.868
20-21	352.650	45-46	79.428
21-22	0.000	46-47	76.319
22-23	332.411	47-48	76.235
23-24	296.474	48-49	73.966
24-25	164.489	49-50	80.458

Table 5-2.2-14

PRE-CHUG SUBMERGED STRUCTURE LOADS

FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER (3)	NORMALIZED FORCE (1)(2) lbf/(ft^3/sec^2)		
		P_x	P_y	P_z
SRVDL PIPING	2	-.005	0	0
	4	-.010	0	0
	6	.017	-.041	0
	10	.013	-.031	0
	14	.052	-.126	0
T-QUENCHER	16	.049	.289	0
	20	.016	.107	0
	22	.011	-.014	0
	24	.082	-.394	0
ELBOW SUPPORT BEAM	25	-.071	-.453	0
	26	-.057	-.408	0
	28	-.036	-.346	0
	29	-.030	-.332	0
T-QUENCHER SUPPORT BEAM	31	.090	.186	0
	35	.031	.122	0
	37	.022	.011	0
	39	.020	-.036	0
CONNECTING BRACKET	40	0	0	.098
	41	0	0	-2.820
	42	0	0	-.701

(1) THE ACTUAL FORCE ON ANY SEGMENT IS CALCULATED BY MULTIPLYING THE ABOVE NORMALIZED FORCE BY 195.70 ft^3/sec^2.

(2) THIS LOAD IS APPLIED IN THE FREQUENCY RANGE OF 6.9 TO 9.5 Hz.

(3) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.

Table 5-2.2-15

POST-CHUG SUBMERGED STRUCTURE LOADS

FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER (2)	NORMALIZED FORCE (1) lbf/(ft^3/sec^2)		
		P_x	P_y	P_z
SRVDL PIPING	2	.004	0	0.005
	4	−.009	0	0.010
	6	−.007	−.018	0.019
	10	−.004	−.011	0.046
	14	−.012	−.030	0.357
T-QUENCHER	16	.028	.326	0
	20	.006	.143	0
	22	.003	.022	0
	24	.017	−.105	0
ELBOW SUPPORT BEAM	25	−.036	−.120	0
	26	−.036	−.120	0
	28	−.023	−.099	0
	29	−.016	−.084	0
T-QUENCHER SUPPORT BEAM	31	.043	.220	0
	35	.012	.158	0
	37	.006	.047	0
	39	.004	.003	0
CONNECTING BRACKET	40	0	0	2.252
	41	0	0	-3.007
	42	0	0	-1.512

(1) THE ACTUAL FORCE ON ANY SEGMENT IS CALCULATED BY MULTIPLYING THE NORMALIZED FORCE BY THE AMPLITUDE FOR A GIVEN FREQUENCY RANGE SHOWN IN TABLE 5-2.2-16.

(2) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.

Table 5-2.2-16

AMPLITUDES AT VARIOUS FREQUENCIES
FOR POST-CHUG LOADS

FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)	FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)
0-1	11.98	25-26	313.84
1-2	11.98	26-27	377.83
2-3	10.36	27-28	251.89
3-4	9.87	28-29	163.32
4-5	17.40	29-30	116.66
5-6	17.00	30-31	43.14
6-7	18.88	31-32	21.57
7-8	18.88	32-33	37.91
8-9	18.88	33-34	50.54
9-10	18.88	34-35	42.54
10-11	87.90	35-36	61.87
11-12	76.18	36-37	41.95
12-13	41.01	37-38	20.97
13-14	35.89	38-39	24.47
14-15	6.82	39-40	29.37
15-16	6.20	40-41	224.90
16-17	3.14	41-42	224.90
17-18	4.18	42-43	224.90
18-19	2.94	43-44	224.90
19-20	16.82	44-45	224.90
20-21	17.53	45-46	224.90
21-22	30.67	46-47	224.90
22-23	92.39	47-48	224.90
23-24	92.39	48-49	224.90
24-25	134.50	49-50	224.90

Table 5-2.2-17

FSI EFFECTS FROM POST-CHUG SUBMERGED STRUCTURE LOADS FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER(2)	NORMALIZED FORCE(1) $lbf/(ft^3/sec^2)$		
		P_x	P_y	P_z
SRVDL PIPING	2	.172	0	0
	4	.178	0	0
	6	.105	.196	0
	10	.078	.146	0
	14	.359	.478	0
T-QUENCHER	16	.112	.209	0
	20	.128	.188	0
	22	.133	.152	0
	24	1.000	1.000	0
ELBOW SUPPORT BEAM	25	.641	.872	0
	26	.869	.951	0
	28	.992	1.000	0
	29	1.000	1.000	0
T-QUENCHER SUPPORT BEAM	31	.228	.365	0
	35	.355	.390	0
	37	.486	.345	0
	39	.547	.376	0
CONNECTING BRACKET	40	0	0	1.000
	41	0	0	1.000
	42	0	0	.576

(1) THE ACTUAL FORCE ON ANY SEGMENT IS CALCULATED BY MULTIPLYING THE NORMALIZED FORCE BY THE AMPLITUDE FOR A GIVEN FREQUENCY RANGE SHOWN IN TABLE 5-2.2-18.

(2) SEE FIGURE 5-2.2-7 FOR LOCATION OF SEGMENT NUMBERS.

Table 5-2.2-18

AMPLITUDES AT VARIOUS FREQUENCIES

FOR FSI EFFECTS FROM POST-CHUG LOADS

FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)	FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)
0-1	0.015	25-26	18.223
1-2	0.059	26-27	93.877
2-3	0.169	27-28	0.000
3-4	0.307	28-29	28.505
4-5	0.591	29-30	32.978
5-6	0.737	30-31	6.670
6-7	2.105	31-32	4.392
7-8	2.934	32-33	5.841
8-9	2.934	33-34	5.474
9-10	0.000	34-35	4.383
10-11	11.726	35-36	6.708
11-12	0.000	36-37	10.593
12-13	8.912	37-38	5.954
13-14	0.000	38-39	10.476
14-15	9.100	39-40	10.000
15-16	17.848	40-41	34.493
16-17	16.801	41-42	33.805
17-18	5.227	42-43	30.952
18-19	0.000	43-44	0.000
19-20	0.000	44-45	35.894
20-21	46.000	45-46	36.104
21-22	0.000	46-47	34.690
22-23	44.920	47-48	34.652
23-24	44.920	48-49	33.621
24-25	29.907	49-50	36.572

Table 5-2.2-19

LOCA WATER JET IMPINGEMENT LOADS ON SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER(1)	WATER JET IMPINGEMENT PRESSURE (psi) (2)		
		P_x	P_y	P_z
SRVDL PIPING	2	0	0	0
	4	0	0	0
	6	0.077	0.187	0
	10	0.150	0.365	0
	14	0.485	1.173	0
T-QUENCHER	16	0.167	-34.394	0
	20	0.028	16.176	0
	22	0.020	2.067	0
	24	0.203	12.031	0
ELBOW SUPPORT BEAM	25	0	0	0
	26	0	0	0
	28	0	0	0
	29	0	0	0
T-QUENCHER SUPPORT BEAM	31	0.933	5.187	0
	35	0.034	-2.579	0
	37	0.022	2.049	0
	39	0.026	1.509	0
CONNECTING BRACKET	40	0	0	24.154
	41	0	0	9.706
	42	0	0	-1.133

(1) SEE FIGURE 5-2.2-7 FOR LOCATION SEGMENT NUMBERS.
(2) LOADS SHOWN INCLUDE DLF'S.

Table 5-2.2-20

LOCA AIR BUBBLE DRAG LOADS ON SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER(1)	AIR BUBBLE DRAG (2) PRESSURE (psi)		
		P_x	P_y	P_z
SRVDL PIPING	2	0.140	0	0
	4	0.312	0	0
	6	0.475	1.148	0
	10	0.390	0.942	0
	14	0.649	1.568	0
T-QUENCHER	16	-1.144	-14.918	0
	20	-0.251	-3.165	0
	22	0.168	0.555	0
	24	-1.199	-10.170	0
ELBOW SUPPORT BEAM	25	0.189	1.949	0
	26	0.218	2.017	0
	28	0.328	2.307	0
	29	0.385	2.496	0
T-QUENCHER SUPPORT BEAM	31	1.201	-3.606	0
	35	0.349	-3.080	0
	37	0.227	-0.261	0
	39	0.206	0.654	0
CONNECTING BRACKET	40	0	0	13.839
	41	0	0	17.015
	42	0	0	3.163

(1) SEE FIGURE 5-2.2-7 FOR LOCATION SEGMENT NUMBERS.

(2) LOADS SHOWN INCLUDE DLF'S.

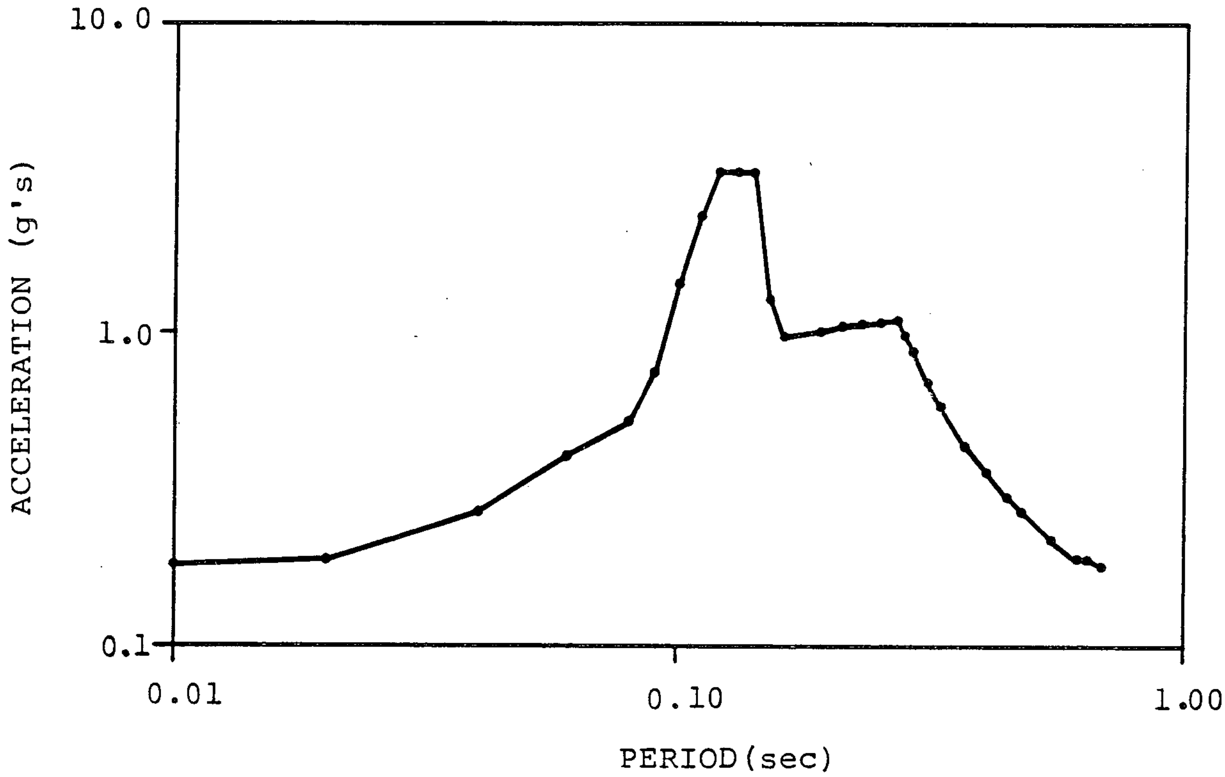


Figure 5-2.2-1

ACCELERATION RESPONSE SPECTRUM FOR HORIZONTAL OBE IN N-S AND E-W DIRECTIONS, 0.5% DAMPING

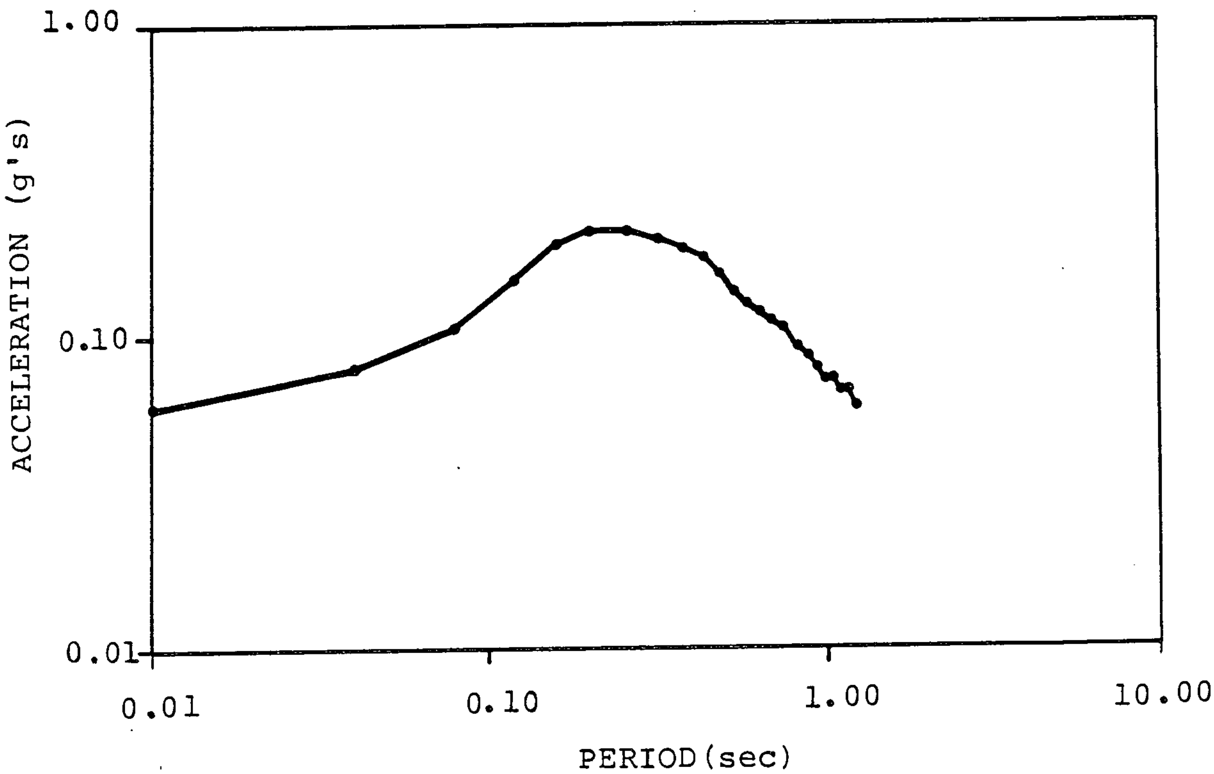


Figure 5-2.2-2

ACCELERATION RESPONSE SPECTRUM
FOR VERTICAL OBE, 0.5% DAMPING

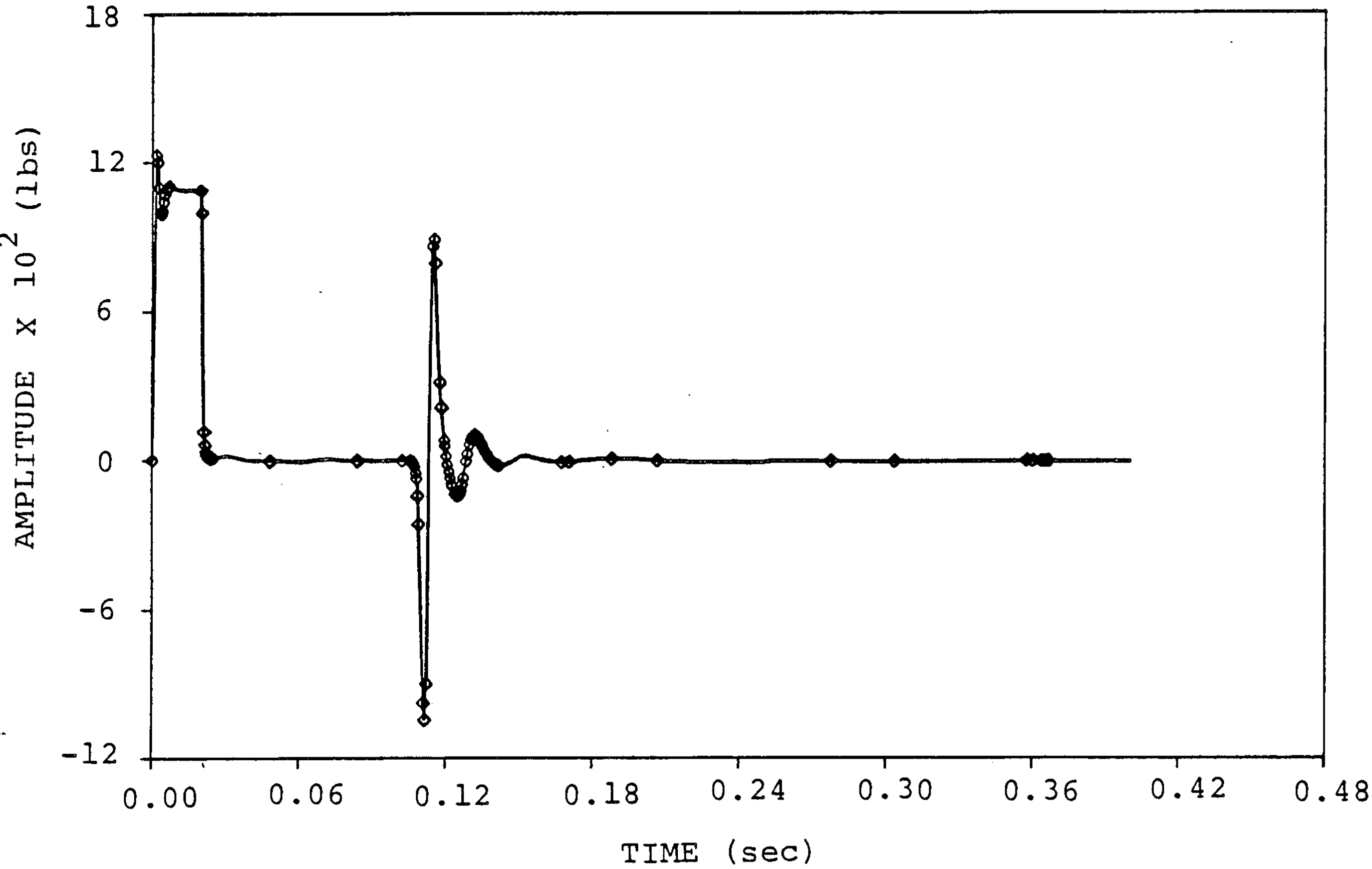


Figure 5-2.2-3

LINE GBC-6 SRV DISCHARGE (CASE C3.1) FORCE

TIME-HISTORY AT SEGMENT D1

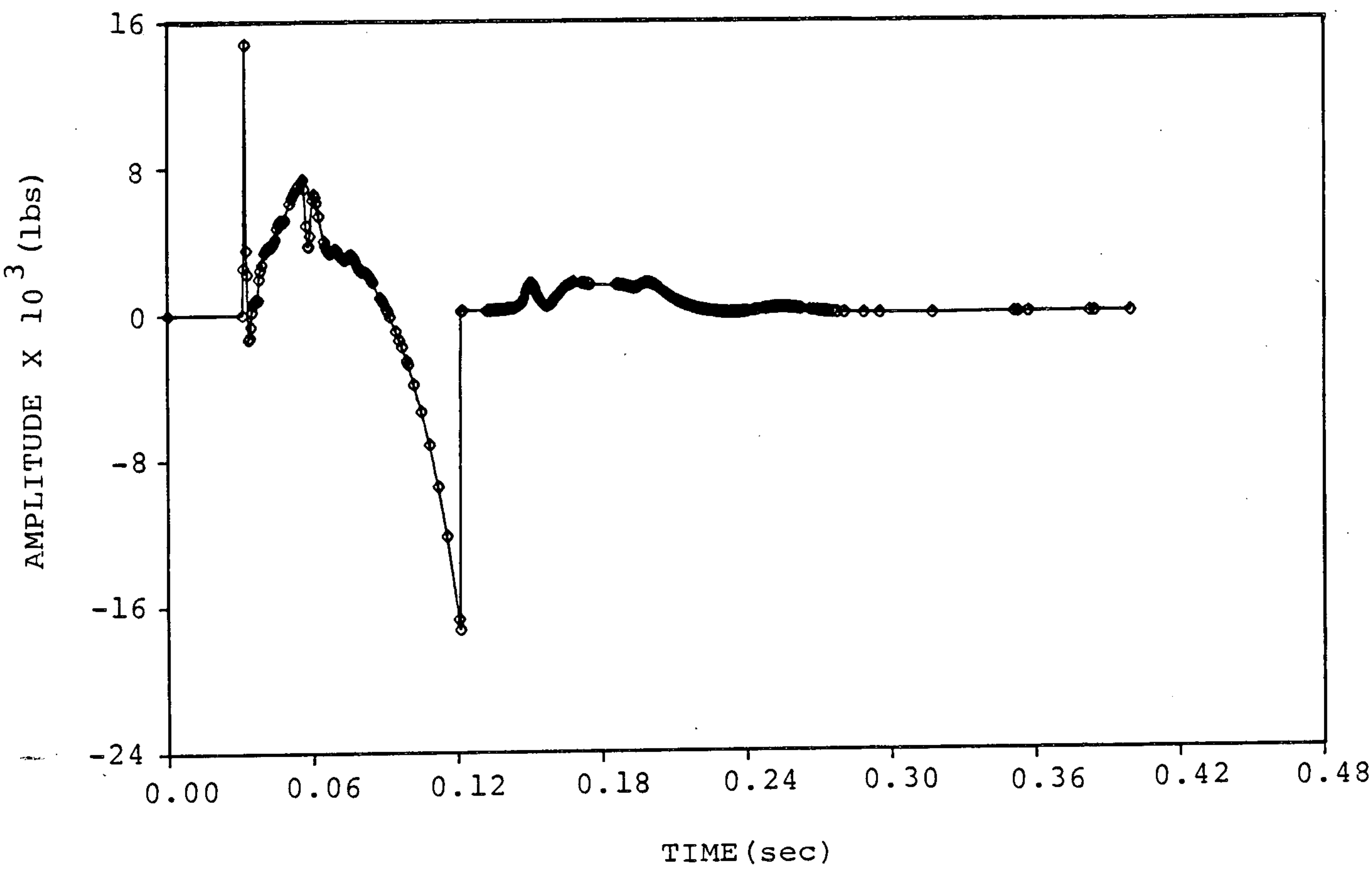


Figure 5-2.2-4

LINE GBC-6 SRV DISCHARGE(CASE C3.1) FORCE

TIME-HISTORY AT SEGMENT W1

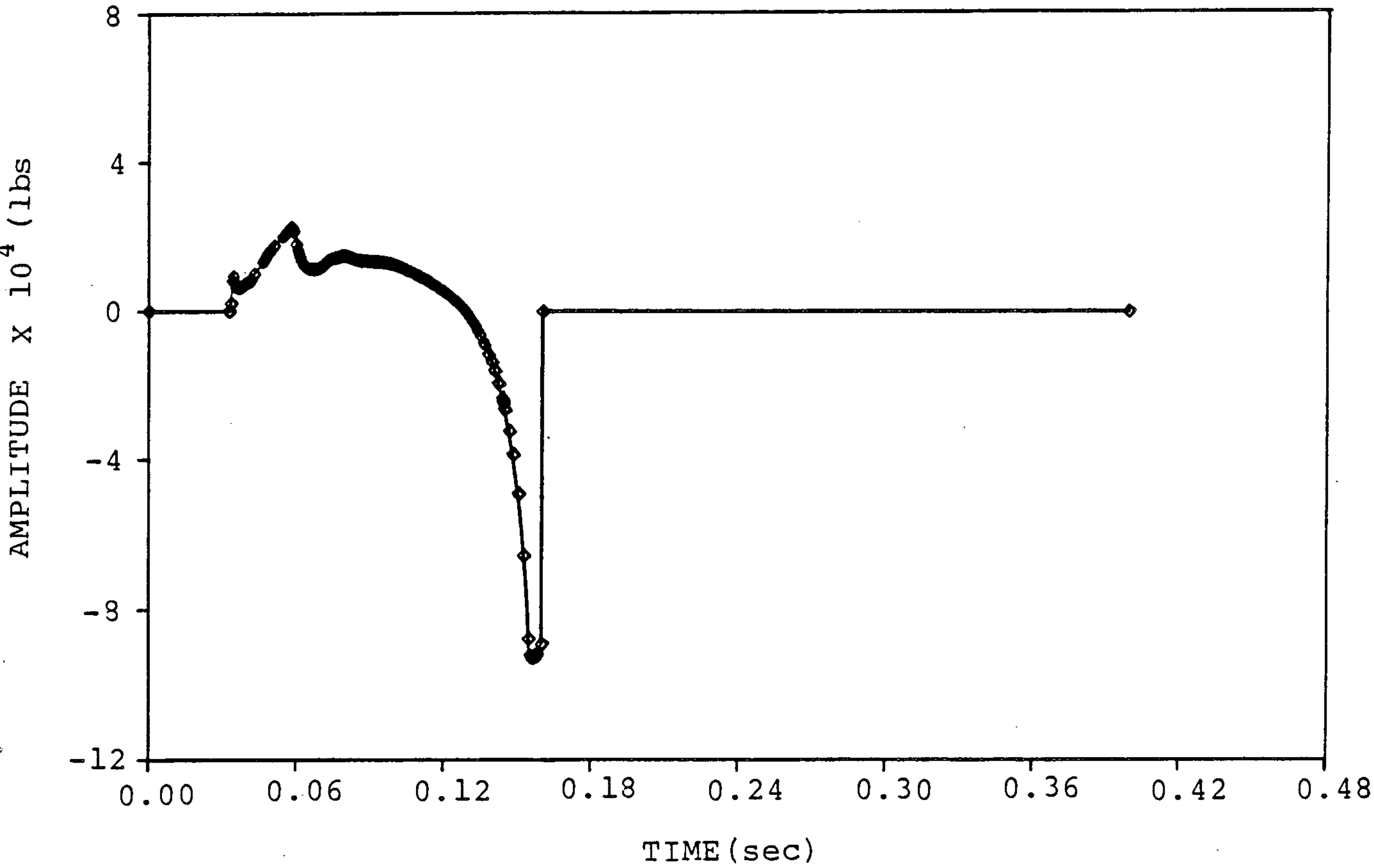


Figure 5-2.2-5

LINE GBC-6 SRV DISCHARGE(CASE C3.1) FORCE
TIME-HISTORY AT SEGMENT W2

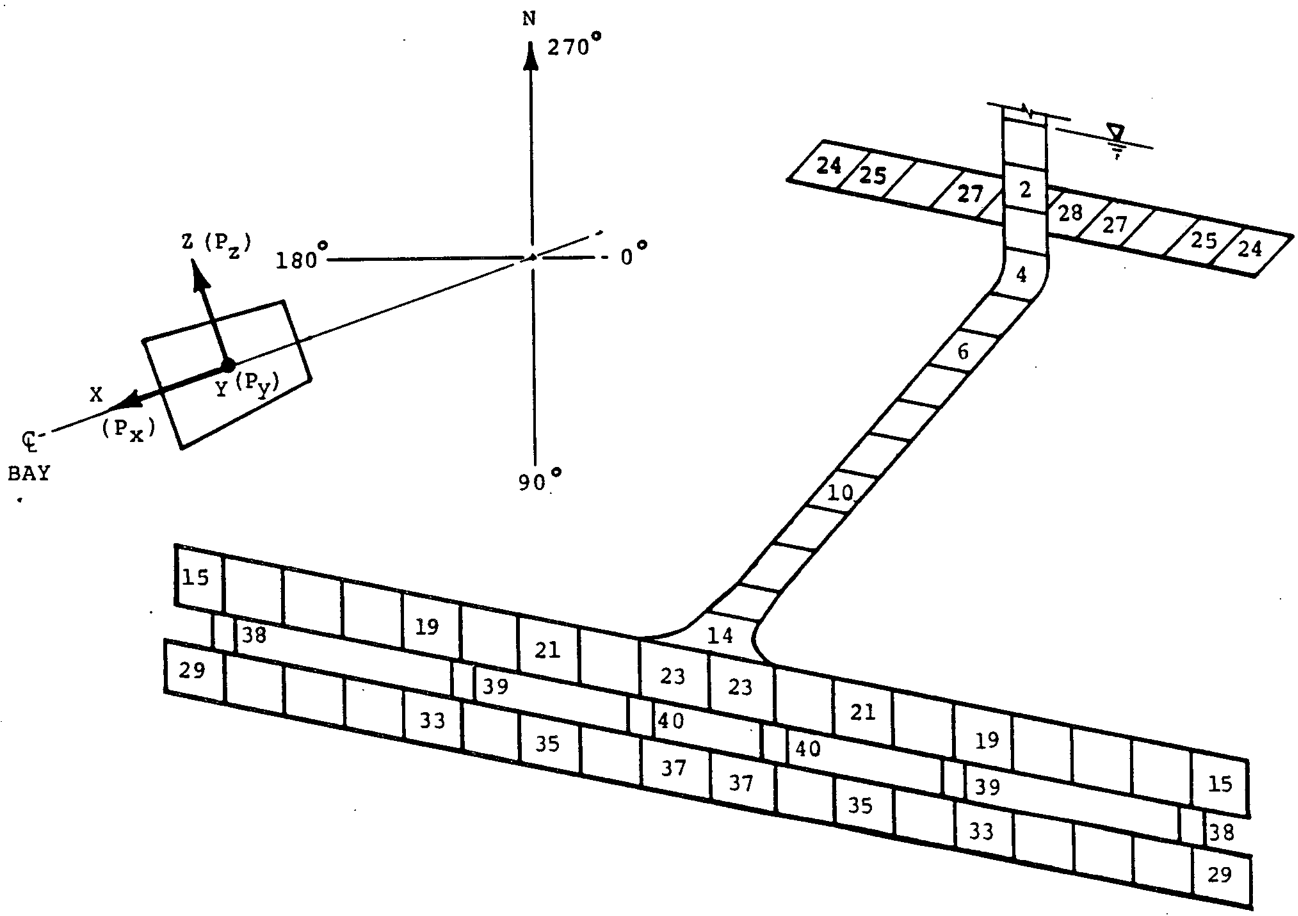


Figure 5-2.2-6

SEGMENT NUMBERS FOR THE
WETWELL PIPING FOR SRV LOADS

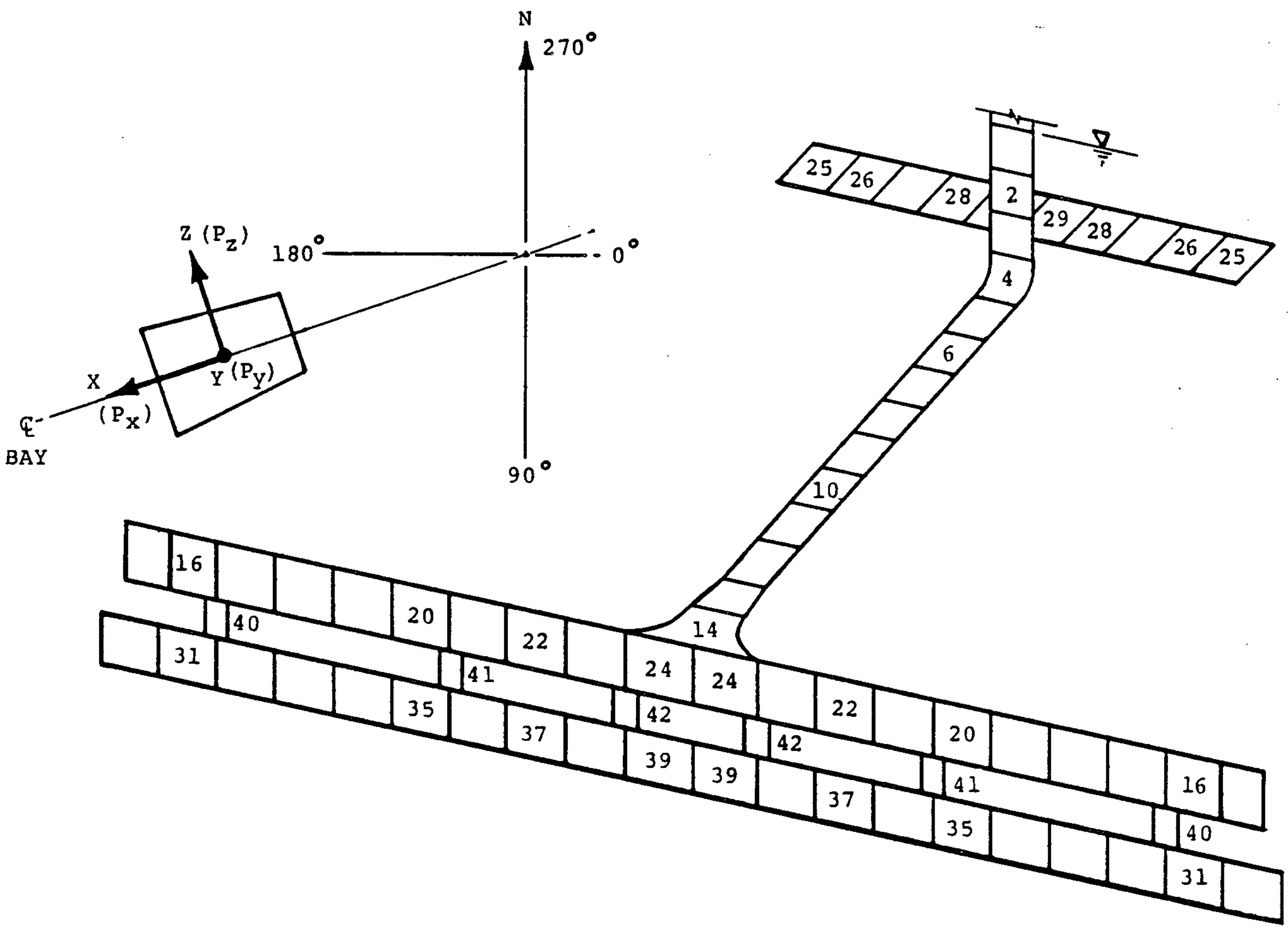
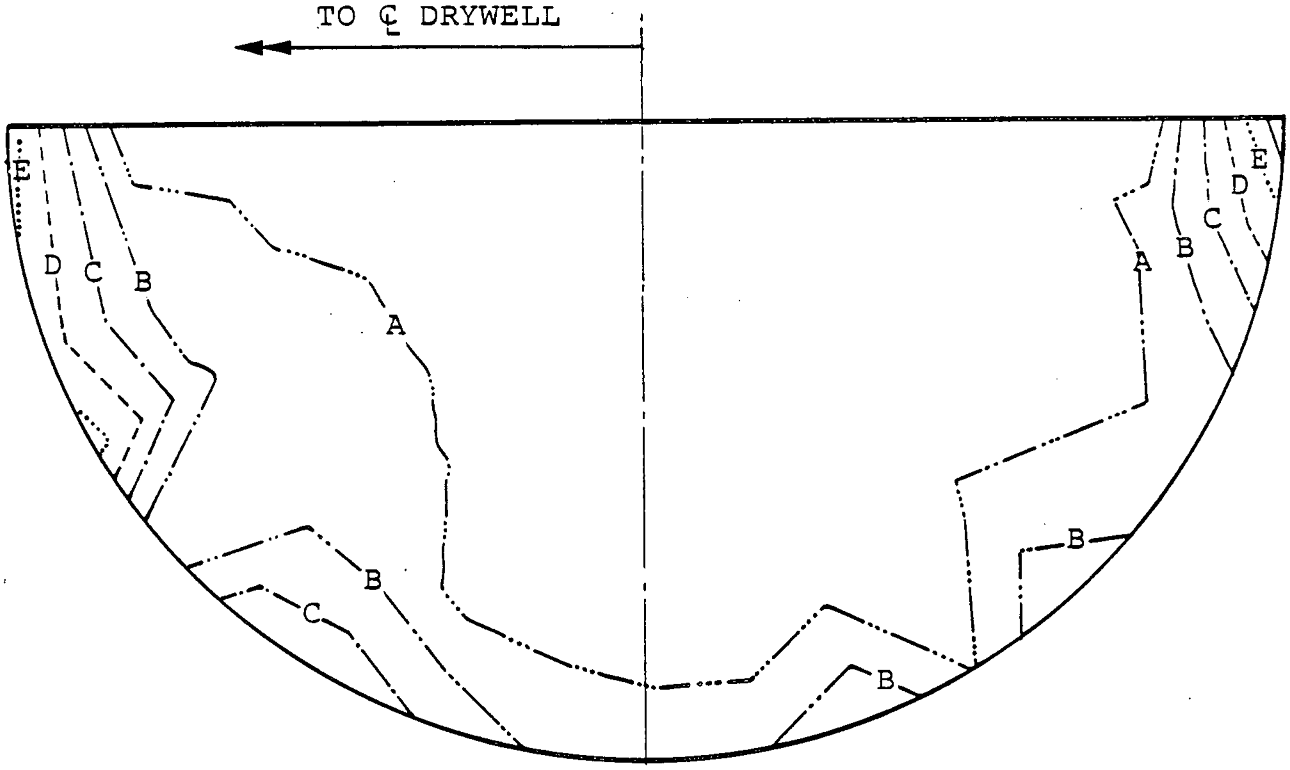


Figure 5-2.2-7

SEGMENT NUMBERS FOR THE
WETWELL PIPING FOR LOCA LOADS

TO ℄ DRYWELL



KEY DIAGRAM

NORMALIZED POOL ACCELERATIONS	
PROFILE	POOL ACCELERATION (ft/sec^2)
A	100.0
B	200.0
C	300.0
D	400.0
E	500.0
F	600.0
POOL ACCELERATIONS DUE TO HARMONIC APPLICATION OF TORUS SHELL PRESSURES (FIGURE 2-2.2-9) AT A SUPPRESSION CHAMBER FREQUENCY OF 20.98Hz.	

Figure 5-2.2-8

FSI POOL ACCELERATION PROFILE FOR DOMINANT SUPPRESSION CHAMBER FREQUENCY AT MIDBAY LOCATION

5-2.2.2 Load Combinations

The loads for which the SRVDL piping systems are evaluated are presented in Section 5-2.2.1. The general NUREG-0661 criteria for grouping the loads into load combinations are discussed in Sections 1-3.1 and 1-4.3 and summarized in Tables 5-2.2-21 and 5-2.2-22.

Tables 5-2.2-21 and 5-2.2-22 show that the load combinations specified for each event can be expanded into many more load combinations than those given. However, not all load combinations for each event need to be examined since many have the same allowable stresses and are enveloped by others which contain the same or additional loads. Many of the load combinations listed are actually pairs of load combinations with all of the same loads except for seismic loads. The first load combination in the pair contains OBE loads, while the second contains SSE loads.

Tables 5-2.2-23, 5-2.2-24 and 5-2.2-25 present the governing load combinations for the main steam line piping, SRV discharge line piping, piping supports, and the vent line penetration. Tables 5-2.2-26, 5-2.2-27 and 5-2.2-28 provide the basis for establishing the governing load combinations for these components.

Stress allowables corresponding to the following service levels are used for evaluation of the MSL, VLP, and SRVDL piping and supports.

A - Design and test conditions

B - Normal operating conditions including SRV discharge

C - Normal operating conditions including SRV discharge and seismic loads, or SBA conditions including SRV discharge

D - SBA, IBA and DBA conditions including SRV discharge, plus seismic loads

Also included in the lists of governing load combinations are seven combinations which do not result from the 27 event combinations listed in Tables 5-2.2-21 and 5-2.2-22. These are: load combination A-1, which relates to the design pressure plus dead weight condition; load combinations B-1 and SB-3, which include the combinations of normal and seismic loads; load combinations A-2 and A-5, which include the combination of normal or accident thermal loads without SRV discharge; and load combinations T-1 and SB-2, which relate to the hydrostatic test condition. Evaluation of combinations T-1 and SB-2 is a requirement of the ASME Code (Reference 7). Load combinations A-1, A-2, A-5, B-1, and SB-3 are consistent with the requirements as specified in the original stress report (Reference 4).

The appropriate ASME Code equations for the MSL, VLP, and SRVDL piping, and service levels for the MSL, VLP, and SRVDL piping supports and SRV flanges are also provided in the governing load combination tables.

Each of the listed governing load combinations for the MSL piping, SRVDL piping, piping supports, and VLP (Tables 5-2.2-23, 5-2.2-24 and 5-2.2-25) has been considered in the analysis methods described in Section 5-2.4.

Table 5-2.2-21

EVENT COMBINATIONS AND ALLOWABLE LIMITS

FOR SRVDL PIPING

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 + SRV + EQ			
						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 (2)	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
LOADS: EARTHQUAKE	EQ		X	X			X	X	X	X			X	X	X	X			X	X	X	X			X	X	X	X
LOADS: SRV DISCHARGE	SRV	X	X	X							X	X	X	X	X	X							X	X	X	X	X	X
LOADS: 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	X	X	X
LOADS: PIPE 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	X	X	X
LOADS: LOCA POOL SWELL	P_{PS}																X		X	X			X		X	X		
LOADS: LOCA CONDENSATION OSCILLATION	P_{CO}					X			X	X		X			X	X		X			X			X			X	
LOADS: LOCA CHUGGING	P_{CH}					X			X	X		X			X	X		X			X	X		X			X	X
STRUCTURAL ELEMENT	ROW																											
ESSENTIAL PIPING SYSTEMS: WITH IBA/DBA	10	B	B (3)	B (3)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)	B (4)
ESSENTIAL PIPING SYSTEMS: WITH SBA	11				B (3)	B (3)	B (4)	B (4)	B (4)	B (4)	B (3)	B (3)	B (4)	B (4)	B (4)	B (4)	–	–	–	–	–	–	–	–	–	–	–	–

(1) REFERENCE 1 STATES "WHERE DRYWELL-TO-WETWELL PRESSURE DIFFERENTIAL IS NORMALLY UTILIZED AS A LOAD MITIGATOR, AN ADDITIONAL EVALUATION WILL BE PERFORMED WITHOUT SRV LOADINGS BUT ASSUMING THE LOSS OF THE PRESSURE DIFFERENTIAL. SERVICE LEVEL D LIMITS SHALL APPLY FOR STRUCTURAL ELEMENTS OF THE PIPING SYSTEM FOR THIS EVALUATION. THE ANALYSIS NEED ONLY BE ACCOMPLISHED TO THE EXTENT THAT INTEGRITY OF THE FIRST PRESSURE BOUNDARY ISOLATION VALVE IS DEMONSTRATED. IF THE NORMAL PLANT OPERATING CONDITION DOES NOT EMPLOY A DRYWELL-TO-WETWELL PRESSURE DIFFERENTIAL, THE LISTED SERVICE LEVEL ASSIGNMENTS WILL BE APPLICABLE." SINCE DAEC DOES NOT UTILIZE A DRYWELL-TO-WETWELL DIFFERENTIAL PRESSURE, THE LISTED SERVICE LIMITS ARE APPLIED.

(2) "NORMAL LOADS (N) CONSIST OF DEAD LOADS (D)."

(3) "AS AN ALTERNATIVE, THE 1.2 S_h LIMIT IN EQUATION 9 OF NC-3652.2 MAY BE REPLACED BY 1.8 S_h, PROVIDED THAT ALL OTHER LIMITS ARE SATISFIED AND OPERABILITY OF ACTIVE COMPONENTS IS DEMONSTRATED. FATIGUE REQUIREMEMENTS ARE APPLICABLE TO ALL COLUMNS, WITH THE EXCEPTION OF 16, 18, AND 19."

(4) "FOOTNOTE 3 APPLIED EXCEPT THAT INSTEAD OF USING 1.8 S_h IN EQUATION 9 OF NC-3652.2, 2.4 S_h IS USED."

Table 5-2.2-22

EVENT COMBINATIONS AND ALLOWABLE LIMITS FOR SRVDL-VL PENETRATION

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				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 (2)	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
STRUCTURAL ELEMENT		ROW																											
INTERNAL VENT PIPE	GENERAL AND ATTACHMENT WELDS	2	A	B	C	A	A	B	C	B	C	A	A	B	C	B	C	A (3, 4)	A	B (3, 4)	C	B	C	C	C	C	C	C	C
	AT PENETRATIONS (e.g., HEADER)	3	A	B	C	A	A	B	C	B	C	A	A	B	C	B	C	A (3)	A	B (3)	C	B	C	C	C	C	C	C	C

REFERENCE 1 STATES

(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. IF DRYWELL TO WETWELL PRESSURE DIFFERENTIAL IS NOT EMPLOYED AS A LOAD MITIGATOR, THE LISTED SERVICE LIMITS SHALL BE APPLICABLE." SINCE DAEC DOES NOT UTILIZE A DRYWELL-TO-WETWELL DIFFERENTIAL PRESSURE, THE LISTED SERVICE LIMITS, ARE APPLIED.

(2) NORMAL LOADS (N) CONSIST OF THE COMBINATION OF DEAD LOADS (D), LIVE LOADS (L), THERMAL EFFECTS DURING OPERATION (T_O), AND PIPE REACTIONS DURING OPERATION (R_O).

(3) EVALUATION OF PRIMARY-PLUS-SECONDARY STRESS INTENSITY RANGE (NE-3221.4) AND OF FATIGUE (NE-3221.5) IS NOT REQUIRED.

(4) SERVICE LEVEL LIMITS SPECIFIED APPLY TO THE OVERALL STRUCTURAL RESPONSE OF THE VENT SYSTEM. AN ADDITIONAL EVALUATION SHALL BE PERFORMED TO DEMONSTRATE THAT SHELL STRESSES DUE TO THE LOCAL POOL SWELL IMPINGEMENT PRESSURES DO NOT EXCEED SERVICE LEVEL C LIMITS.

Table 5-2.2-23

GOVERNING LOAD COMBINATIONS - MSL,SRVDL PIPING AND SRV OUTLET FLANGES

LOAD COMBINATION NUMBER	LOAD COMBINATIONS (1,5,6)	ASME (2) CODE EQUATION
A-1	P+DW	8
A-2	TE1+THAM1+TD	10 (3)
A-3	TE2+THAM2+TD	10 (3)
A-4	TE2+THAM2A+TD1	10 (3)
A-5	TE1+THAM1A+TD1	10 (3)
B-1	P_O+DW+OBE_I	9
B-2	P_O+DW+RV1A+QAB+QAB_I	9
C-1	P_O+DW+RV1A+QAB+QAB_I+SSE_I	9
C-2	P_O+DW+RV1B+QAB+QAB_I+PCHUG+$PCHUG_I$	9
C-3	P_O+DW+RV1B+QAB+QAB_I+CHUG+$CHUG_I$	9
D-1 (4)	P_O+DW+OBE_I+CO+CO_I	9
D-2 (8)	$P_O+DW+RV1B+QAB+QAB_I+[(SSE_I)^2+(PCHUG+PCHUG_I)^2]^{1/2}$	9
D-3 (8)	$P_O+DW+RV1B+QAB+QAB_I+[(SSE_I)^2+(CHUG+CHUG_I)^2]^{1/2}$	9
D-4 (8)	$P_O+DW+RV1C+QAB+QAB_I+[(SSE_I)^2+(PS+PS_I+VCL)^2]^{1/2}$	9
T-1 (7)	1.25P+DW_T	8

NOTES FOR TABLE 5-2.2-23

(1) SEE SECTION 5-2.2.1 FOR DEFINITION OF INDIVIDUAL LOADS.

(2) EQUATIONS ARE DEFINED IN SUBSECTION NC-3650 OF THE ASME CODE (REFERENCE 7).

(3) AS AN ALTERNATE, MEET EQUATION 11 OF THE ASME CODE, AFTER ADDING DW AND P_O LOADS (REFERENCE 7).

(4) FOR THE DBA CONDITION, SRV DISCHARGE LOADS NEED NOT BE COMBINED WITH CO LOADS.

(5) SEE SECTION 5-2.2.3 FOR COMBINATION OF DYNAMIC LOADS.

(6) ONLY GOVERNING MARK I LOAD COMBINATIONS FROM TABLE 5-2.2-26 AND GOVERNING NON-MARK I LOAD COMBINATIONS ARE CONSIDERED HERE.

(7) HYDROSTATIC TEST CONDITION. DW_T FOR ALL LINES SHALL BE WITH MSL FULL OF WATER AT 70°F.

(8) LOCA AND SSE LOADS ARE COMBINED BY THE SRSS METHOD. IF THE COMBINATION OF LOCA AND SSE LOADS IS LESS THAN LOCA LOADS ADDED ABSOLUTELY WITH OBE, THE COMBINATION OF LOCA LOADS ADDED ABSOLUTELY WITH OBE IS USED.

Table 5-2.2-24

GOVERNING LOAD COMBINATIONS - MSL AND SRVDL

PIPING SUPPORTS

LOAD COMBINATION NUMBER	LOAD COMBINATION (1,2,5,7)		SERVICE LEVEL
	PRIMARY	SECONDARY (3)	
SB-1	$DW+RV1A+QAB+QAB_I+$	TE1+THAM1+TD	B
SB-2 (6)	DW_T+	TE1+THAM1+TD	B
SB-3	$DW+OBE_I+$	TE1+THAM1+TD	B
SC-1	$DW+RV1A+QAB+QAB_I+SSE_I$	(8)	C
SC-2	$DW+RV1B+QAB+QAB_I+PCHUG+PCHUG_I$	(8)	C
SC-3	$DW+RV1B+QAB+QAB_I+CHUG+CHUG_I$	(8)	C
SD-1 (9)	$DW+RV1B+QAB+QAB_I+[(SSE_I)^2+(CHUG+CHUG_I)^2]^{1/2}$	(8)	D
SD-2 (9)	$DW+RV1B+QAB+QAB_I+[(SSE)_I^2+(PCHUG+PCHUG_I)^2]^{1/2}$	(8)	D
SD-3 (9)	$DW+RV1C+QAB+QAB_I+[(SSE_I)^2+(PS+PS_I+VCL)^2]^{1/2}$	(8)	D
SD-4 (4)	$DW+OBE_I+CO+CO_I$	(8)	D

NOTES FOR TABLE 5-2.2-24

(1) SEE SECTION 5-2.2.1 FOR DEFINITION OF INDIVIDUAL LOADS.

(2) ONLY GOVERNING MARK I LOAD COMBINATIONS FROM TABLE 5-2.2-27 AND GOVERNING NON-MARK I LOAD COMBINATIONS ARE CONSIDERED HERE.

(3) WHEN THE COMBINATION OF TE2 AND THAM2 IS GREATER THAN THE COMBINATION OF TE1 AND THAM1, THE TE2 AND THAM2 COMBINATION IS USED.

(4) FOR THE DBA CONDITION, SRV DISCHARGE LOADS NEED NOT BE COMBINED WITH CO LOADS.

(5) SEE SECTION 5-2.2.3 FOR COMBINATION OF DYNAMIC LOADS.

(6) HYDROSTATIC TEST CONDITION. DW_T FOR ALL LINES SHALL BE WITH MSL FULL OF WATER AT 70°F.

(7) PRIMARY PLUS SECONDARY LOAD ALLOWABLES ARE THREE TIMES THE SERVICE LEVEL B ALLOWABLES.

(8) STRESS RANGE ANALYSIS IS NOT REQUIRED.

(9) LOCA AND SSE LOADS ARE COMBINED BY THE SRSS METHOD. IF THE COMBINATION OF LOCA AND SSE LOADS IS LESS THAN LOCA LOADS ADDED ABSOLUTELY WITH OBE, THE COMBINATION OF LOCA LOADS ADDED ABSOLUTELY WITH OBE IS USED.

Table 5-2.2-25

GOVERNING LOAD COMBINATIONS -

SRVDL - VL PENETRATION

LOAD COMBINATION NUMBER	LOAD COMBINATION (1,2,3)		SERVICE LEVEL
	PRIMARY	SECONDARY (8)	
SB-1 (5)	$DW+OBE_I+RVIA+QAB+QAB_I+PCHUG+PCHUG_I$ +	TE1+THAM1 + TD	B
SB-2 (5)	$DW+OBE_I+RVIA+QAB+QAB_I+CHUG+CHUG_I$ +	TE1+THAM1 + TD	B
SB-3	$DW+OBE_I+VCL+PS_I+P_S$ +	TE1+THAM1 + TD	B
SB-4 (7)	$DW+OBE_I+CO+CO_I$ +	TE1+THAM1 + TD	B
SB-5	$DW+OBE_I+CHUG+CHUG_I$ +	TE1+THAM1 + TD	B
SC-1 (5,6)	$DW+RVIA+QAB+QAB_I+\left[(SSE_I)^2+(VCL+PS+PS_I)^2\right]^{1/2}$	(4)	C
SC-2 (6)	$DW+\left[(SSE_I)^2+(CO+CO_I)^2\right]^{1/2}$	(4)	C
SC-3 (5,6)	$DW+RVIA+QAB+QAB_I+\left[(SSE_I)^2+(PCHUG+PCHUG_I)^2\right]^{1/2}$	(4)	C
SC-4 (5,6)	$DW+RVIA+QAB+QAB_I+\left[(SSE_I)^2+(CHUG+CHUG_I)^2\right]^{1/2}$	(4)	C

NOTES FOR TABLE 5-2.2-25

(1) SEE SECTION 5-2.2.1 FOR DEFINITION OF INDIVIDUAL LOADS.

(2) ONLY GOVERNING MARK I LOAD COMBINATIONS FROM TABLE 5-2.2-28 AND GOVERNING NON-MARK I LOAD COMBINATIONS ARE CONSIDERED HERE.

(3) SEE SECTION 5-2.2.3 FOR COMBINATION OF DYNAMIC LOADS.

(4) STRESS RANGE ANALYSIS IS NOT REQUIRED.

(5) LOAD RV1B IS USED IF LARGER THAN RV1A.

(6) LOCA AND SSE LOADS ARE COMBINED BY THE SRSS METHOD. IF THE COMBINATION OF LOCA AND SSE LOADS IS LESS THAN LOCA LOADS ADDED ABSOLUTELY WITH OBE, THE COMBINATION OF LOCA LOADS ADDED ABSOLUTELY WITH OBE IS USED.

(7) FOR THE DBA CONDITION, SRV DISCHARGE LOADS NEED NOT BE COMBINED WITH CO LOADS.

(8) WHEN THE COMBINATION OF EITHER TE2 AND THAM2 OR TE1 AND THAM1A OR TE2 AND THAM2A IS GREATER THAN THE COMBINATION OF TE1 AND THAM1, THE MAXIMUM COMBINATION IS USED.

Table 5-2.2-26

BASIS FOR GOVERNING LOAD COMBINATIONS-

MSL, SRVDL PIPING AND SRV OUTLET FLANGES

EVENT COMBINATION NUMBER (1)	GOVERNING LOAD COMBINATIONS (2)	DISCUSSION	EVENT COMBINATION GOVERNING BASIS
1	B-2	SECONDARY STRESS BOUNDED BY EVENT COMBINATION NUMBER 3.	(3b)
2	N/A	BOUNDED BY EVENT COMBINATION NUMBER 3.	(3a)
3	A-3, C-1	N/A	N/A
6,8,12,14, 20,26	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15.	(3a)
4,5,7,9,10,11, 13,17,21,23,27	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15.	(3b)
15	A-4, C-2, C-3 D-1, D-2, D-3	N/A	N/A
16,19,22	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25.	(3b)
18,24	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25.	(3a)
25	A-4, D-4	N/A	N/A

NOTES FOR TABLE 5-2.2-26

(1) EVENT COMBINATION NUMBERS REFER TO THE NUMBERS USED IN TABLE 5-2.2-21.

(2) GOVERNING LOAD COMBINATIONS ARE LISTED IN TABLE 5-2.2-23.

(3) EVENT COMBINATION GOVERNING BASIS:

A. THE GOVERNING EVENT COMBINATION CONTAINS SSE LOADS WHICH BOUND OBE LOADS.

B. THE GOVERNING EVENT COMBINATION CONTAINS MORE LOADS, WHILE THE ALLOWABLE LIMITS ARE THE SAME.

Table 5-2.2-27

BASIS FOR GOVERNING LOAD COMBINATIONS-
MSL AND SRVDL PIPING SUPPORTS

EVENT COMBINATION NUMBER (1)	GOVERNING LOAD COMBINATIONS (2)	DISCUSSION	EVENT COMBINATION GOVERNING BASIS
1	SB-1	N/A	N/A
2	N/A	BOUNDED BY EVENT COMBINATION NUMBER 3.	(3a)
3	SC-1	N/A	N/A
4,5,7,9,10,11 13,17,21,23,27	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15.	(3b)
6,8,12 14,20,26	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15.	(3a)
15	SC-2, SC-3 SD-1, SD-2, SD-4	N/A	N/A
16,19,22	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25.	(3b)
18, 24	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25.	(3a)
25	SD-3	N/A	N/A

NOTES FOR TABLE 5-2.2-27

(1) EVENT COMBINATION NUMBERS REFER TO THE NUMBERS USED IN TABLE 5-2.2-21.

(2) GOVERNING LOADS COMBINATIONS ARE LISTED IN TABLE 5-2.2-24.

(3) EVENT COMBINATION GOVERNING BASIS:

A. THE GOVERNING EVENT COMBINATION CONTAINS SSE LOADS WHICH BOUND OBE LOADS.

B. THE GOVERNING EVENT COMBINATION CONTAINS MORE LOADS, WHILE THE ALLOWABLE LIMITS ARE THE SAME.

Table 5-2.2-28

BASIS FOR GOVERNING LOAD COMBINATIONS - SRVDL - VL PENETRATION

EVENT COMBINATION NUMBER (1)	GOVERNING LOAD COMBINATIONS (2)	DISCUSSION	EVENT COMBINATION GOVERNING BASIS
1, 2, 4, 5, 6, 8, 10, 11, 12, 17, 20	N/A	BOUNDED BY EVENT COMBINATION NUMBER 14	(3b)
3, 7, 13, 19, 22	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25	(3b)
9, 15, 21, 23	N/A	BOUNDED BY EVENT COMBINATION NUMBER 27	(3b)
14	SB-1, SB-2 SB-4, SB-5	N/A	N/A
16	N/A	BOUNDED BY EVENT COMBINATION NUMBER 18	(3b)
18	SB-3	N/A	N/A
24	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25	(3a)
25	SC-1	N/A	N/A
26	N/A	BOUNDED BY EVENT COMBINATION NUMBER 27	(3a)
27	SC-2, SC-3, SC-4	N/A	N/A

NOTES FOR TABLE 5-2.2-28

(1) EVENT COMBINATION NUMBERS REFER TO THE NUMBERS USED IN TABLE 5-2.2-22.

(2) GOVERNING LOAD COMBINATIONS ARE LISTED IN TABLE 5-2.2-25.

(3) EVENT COMBINATION GOVERNING BASIS:

A. THE GOVERNING EVENT COMBINATION CONTAINS SSE LOADS WHICH BOUND OBE LOADS.

B. THE GOVERNING EVENT COMBINATION CONTAINS MORE LOADS, WHILE THE ALLOWABLE LIMITS ARE THE SAME.

5-2.2.3 Combination of Dynamic Loads

When the time-phase relationship between the responses caused by two or more sources of dynamic loading is undefined or random, the peak responses from the individual loads are combined by absolute sum (except for combined SSE and LOCA loads). The peak responses which result from SSE and LOCA loads are combined using the square root of the sum of the squares (SRSS) technique. However, in cases where the combination of two dynamic events by the absolute sum (ABS) method is excessively conservative, the PUAAG (Reference 5) permits the use of the cumulative distribution function (CDF) method, with an 84% non-exceedance probability (NEP).

5-2.3 Analysis Acceptance Criteria

The acceptance criteria defined in NUREG-0661 on which the SRVDL piping analysis is based are discussed in Section 1-3.2. In general, the acceptance criteria follow the rules contained in the ASME Code, Section III, Division 1, 1977 Edition with Addenda up to and including the 1978 Winter Addenda for Class 2 piping and piping supports (Reference 7). These criteria are equivalent to those of the 1977 Edition with Addenda up to and including the Summer 1977 Addenda with respect to the requirements of NUREG-0661. The corresponding service level limits, allowable stresses, and fatigue requirements are also consistent with the requirements of the ASME Code and NUREG-0661. The following paragraphs provide a summary of the acceptance criteria used in the analysis of the SRVDL piping.

The MSL, SRVDL piping, and T-quencher are analyzed in accordance with the requirements for Class 2 piping systems contained in Subsection NC of the ASME Code. Tables 5-2.3-1 and 5-2.3-2 list the applicable ASME Code equations and stress limits for each of the governing load combinations for piping and T-quenchers.

The MSL and SRVDL piping supports are analyzed in accordance with requirements for Class 2 piping supports as provided in Subsection NF of the ASME Code. The applicable stress limits for support structures are based on the service level assignments listed for the governing piping support load combinations. Table 5-2.3-3 provides the allowable load limits for snubber and strut support components.

The acceptance criteria for the safety relief valve outlet flanges are specified in terms of maximum allowable moments. Table 5-2.3-4 lists the allowable moments for the SRV outlet flanges.

Table 5-2.3-5 lists the allowable stress limits for the T-quencher and elbow support beam and connecting brackets. The welds are evaluated according to code requirements of the supporting structure. The local effects on the vent line penetration are analyzed in accordance with requirements for Class MC components as provided in Subsection NE of the ASME Code. Table 5-2.3-6 lists the allowable stress limits for the SRVDL-VL penetration.

Table 5-2.3-1

ALLOWABLE STRESSES FOR MSL AND SRVDL PIPING

STRESS TYPE	ASME CODE EQUATION NUMBER	SERVICE LEVEL	STRESS LIMIT	ALLOWABLE VALUE (ksi)	GOVERNING LOAD COMBINATION NUMBER (1)
PRIMARY	8	A	1.0 S_h	15.0	A-1, T-1
PRIMARY	9	B	1.2 S_h	18.0	B-1 AND B-2
PRIMARY	9	B	1.8 S_h	27.0	C-1 THROUGH C-3
PRIMARY	9	B	2.4 S_h	36.0	D-1 THROUGH D-4
SECONDARY	10	A AND B	1.0 S_a	22.5	A-2 THROUGH A-5
PRIMARY AND SECONDARY	11	A AND B	S_h+S_a	37.5	(2)

(1) TABLE 5-2.2-23 LISTS THE GOVERNING LOAD COMBINATION NUMBERS.

(2) SEE ASME CODE, SECTION III, SUBSECTION NC, PARAGRAPH NC-3652.3 (REFERENCE 7) FOR LOADS TO BE CONSIDERED IN EQUATION 11.

Table 5-2.3-2

ALLOWABLE STRESSES FOR T-QUENCHER ARMS

STRESS TYPE	ASME CODE EQUATION NUMBER	SERVICE LEVEL	STRESS LIMIT	ALLOWABLE VALUE (ksi)	GOVERNING LOAD COMBINATION NUMBER (1)
PRIMARY	8	A	1.0 S_h	15.55	A-1
PRIMARY	9	B	1.2 S_h	18.66	B-1 AND B-2
PRIMARY	9	B	1.8 S_h	27.99	C-1 THROUGH C-3
PRIMARY	9	B	2.4 S_h	37.32	D-1 THROUGH D-4
SECONDARY	10	A AND B	1.0 S_a	23.51	A-2 THROUGH A-5
PRIMARY + SECONDARY	11	A AND B	$S_h + S_a$	39.06	(2)

(1) TABLE 5-2.2-23 IDENTIFIES GOVERNING LOAD COMBINATIONS.

(2) SEE ASME CODE, SECTION III, SUBSECTION NC, PARAGRAPH NC-3652.3 (REFERENCE 7) FOR LOADS TO BE CONSIDERED IN EQUATION 11.

Table 5-2.3-3

ALLOWABLE LOADS FOR MSL AND SRVDL PIPE SUPPORTS (SNUBBERS AND STRUTS)

SERVICE LEVEL	GOVERNING LOAD COMBINATION NUMBER(2)	SNUBBER AND STRUT ALLOWABLE LOAD LIMIT(1)
A,B	SB-1 THROUGH SB-3	1.0 x RATED LOAD
C	SC-1 THROUGH SC-3	1.33 x RATED LOAD
D	SD-1 THROUGH SD-4	STRUTS: 1.88 X RATED LOAD(4) SNUBBERS (3)
RANGE	SB-1 THROUGH SB-3	STRUTS: 2.0 X RATED LOAD (5) SNUBBERS (N/A)

(1) RATED LOADS FOR SNUBBERS/STRUTS OF VARIOUS SIZES ARE ACCORDING TO THE MANUFACTURER'S CATALOG.

(2) TABLE 5-2.2-24 LISTS THE GOVERNING LOAD COMBINATION NUMBERS.

(3) FOR EVALUATION OF LEVEL D LOADS, LEVEL C ALLOWABLES ARE USED.

(4) ALLOWABLE FOR THE VERTICAL STRUT IN THE VENT LINE IS 1.55 X RATED LOAD.

(5) ALLOWABLE FOR THE HORIZONTAL STRUT IN THE VENT LINE IS 1.5 X RATED LOAD.

Table 5-2.3-4

ALLOWABLE MOMENTS FOR SRV OUTLET FLANGES

SERVICE LEVEL	GOVERNING LOAD COMBINATION NUMBER (1)	ALLOWABLE RESULTANT MOMENT (in-kips)
A	A-1, T-1	372.0
B	B-1, B-2	745.0
C, D	C-1 THROUGH C-3 D-1 THROUGH D-4	1,095.7
SECONDARY	A-2 THROUGH A-5	745.0

(1) TABLE 5-2.2-23 LISTS THE GOVERNING LOAD COMBINATION NUMBERS.

Table 5-2.3-5

ALLOWABLE STRESSES FOR T-QUENCHER SUPPORT AND ELBOW SUPPORT BEAMS AND CONNECTING BRACKETS

ITEM	MATERIAL	MATERIAL PROPERTIES (ksi) (2)	STRESS TYPE	ALLOWABLE STRESSES (ksi)(1)			
				SERVICE LEVEL B	SERVICE LEVEL C	SERVICE LEVEL D	STRESS RANGE
T-QUENCHER SUPPORT BEAM	A53 GR B or A 106 GR B	S_y=30.25 S_u=60.0	TENSILE	18.70	24.87	37.40	56.10
			BENDING	20.56	27.41	41.12	61.68
			INTERACTION	1.00	1.00	1.00	1.00
ELBOW SUPPORT BEAM	A516 GR70 or SA-516 GR70	S_y=33.85 S_u=70.0	TENSILE	20.31	27.08	40.62	60.93
			BENDING	20.31	27.08	40.62	60.93
			INTERACTION	1.00	1.00	1.00	1.00
LATERAL SUPPORT BEAM	A516 GR70 or SA-516 GR70	S_y=32.83 S_u=70.0	TENSILE	19.70	26.27	39.40	59.10
			BENDING	19.70	26.27	39.40	59.10
			INTERACTION	1.00	1.00	1.00	1.00
CONNECTING BRACKETS	A516 GR70 or SA-516 GR70	S_y=32.83 S_u=70.0	TENSILE	19.70	26.27	39.40	59.10
			BENDING	19.70	26.27	39.40	59.10
			INTERACTION	1.00	1.00	1.00	1.00
BOLTS	ASTM A325 TYPE 1	S_u=105.0	TENSION	52.50	52.50	52.50	157.50
			SHEAR	21.70	21.70	21.70	65.10
			INTERACTION	1.00	1.00	1.00	1.00
WELDS	ASME SFA-S1 Class E7018	S_y=70.0	SHEAR	21.00	28.00	42.00	63.00
			INTERACTION	1.00	1.00	1.00	1.00

(1) SEE TABLE 5-2.2-21 FOR LOAD COMBINATION LEVEL ASSIGNMENTS.

(2) S_y = YIELD STRESS AND S_u = ULTIMATE STRENGTH AT DESIGN TEMPERATURE.

Table 5-2.3-6

ALLOWABLE STRESSES FOR SRVDL - VL PENETRATION

ITEM	MATERIAL	MATERIAL PROPERTIES (ksi) (2)	STRESS TYPE	ALLOWABLE STRESS (ksi) (1) SERVICE LEVEL B	SERVICE LEVEL C
VENT LINE	SA-516 GR 70	S_{mc}=19.30 S_{ml}=22.60 S_y =34.06	LOCAL PRIMARY MEMBRANE	28.95	51.09
			PRIMARY + SECONDARY STRESS RANGE	67.80	N/A (3)
SRV PIPING PENETRATION INSERT PLATE	SA-516 GR 70	S_{mc}=19.30 S_{ml}=22.60 S_y=34.06	LOCAL PRIMARY MEMBRANE	28.95	51.09
			PRIMARY + SECONDARY STRESS RANGE	67.80	N/A (3)
SRV PIPING PENETRATION NOZZLE	SA-333 GR 6	S_{mc}=16.50 S_{ml}=20.00 S_y=30.25	LOCAL PRIMARY MEMBRANE	24.75	45.38
			PRIMARY + SECONDARY STRESS RANGE	60.00	N/A (3)

(1) SEE TABLE 5-2.2-25 FOR LOAD COMBINATION LEVEL ASSIGNMENTS.

(2) S_y = YIELD STRESS, S_{ml} AND S_{mc} = STRESS INTENSITIES AT DESIGN TEMPERATURES.

(3) N/A - NO EVALUATION REQUIRED

5-2.4 Methods of Analysis

This section describes the methods of analysis used to evaluate the SRVDL piping and supports for the effects of the governing loads as presented in Section 5-2.2.1.

The methodology used to develop the mathematical models of the SRVDL piping system is presented in Section 5-2.4.1. The methodology used to obtain results for the governing load combinations and to evaluate the analysis results for comparison with the acceptance limits is discussed in Section 5-2.4.2.

A standard, commercially available computer code (PISTAR) is used in performing the piping system analyses. The computer code PISTAR is based on the well-known SAP4 structural analysis computer program and has been verified using ASME and NRC benchmark problems. This code performs static, modal extraction, response spectrum, and dynamic time-history analyses of piping systems. It also performs the ASME Code, Section III piping evaluation.

5-2.4.1 SRVDL Piping System Mathematical Modeling

A total of five mathematical models are used in the analyses of all normal and hydrodynamic loads on the SRVDL piping. However, only four of the five models are used to evaluate normal loads. Two of these models consist of one main steam line, two SRV discharge lines, and two T-quenchers. The other two models consist of one main steam line, one SRV discharge line, one T-quencher, one safety valve with tee, and the related support structures. Since all six wetwell piping lines are identical between the jet deflector and the T-quencher (including related support structures), only one mathematical model is used to analyze hydrodynamic loads. The four models used for normal load analysis are described in Section (A) below and the model used for hydrodynamic load analysis is described in Section (B) below. A separate description of the model of the SRV discharge line penetration through the vent line is presented in Section (C) below.

The SRV discharge line piping systems are modeled as multi-degree of freedom finite element systems consisting of straight and curved beam elements with a lumped mass formulation. A sufficient amount of detail is used to accurately represent the dynamic behavior of the piping systems for the applied loads. Flexibility and stress intensification factors based on the ASME Code, Section III, Class 2 piping requirements are included in the model formulations.

A separate mathematical model is used in the analysis of the SRV discharge line-vent line penetration for normal loads as well as hydrodynamic loads. The penetration is modeled as a multi-degree of freedom finite element system consisting of plate elements.

A. SRVDL Piping Full Mathematical Models

The six SRV discharge lines in the drywell are analyzed using four separate models. Two models include a main steam line with two attached SRV discharge lines. The two other models include a main steam line, one attached SRV discharge line and one safety valve. The main steam lines are modeled from the RPV nozzle to the drywell penetration and include all attached piping which would significantly affect the response of the SRVDL. The SRV discharge lines are connected to the main steam lines at the safety relief valves and terminate at the T-quencher. Table 5-2.4-1 lists the main steam and SRV discharge line piping systems included in each of the four full models. A mathematical model of a representative SRV discharge line full piping model is presented in Figures 5-2.4-1 and 5-2.4-2.

Figure 5-2.4-3 shows the modeling of the safety relief valve, which is identical for the six SRV discharge lines. The mass of each valve is lumped at the center-of-gravity of the valve. Figure 5-2.4-4 shows the modeling of the two safety valves. Also included in the piping models are vacuum breakers, one attached to each SRV discharge line. Figure 5-2.4-5 shows the modeling of the vacuum breaker for SRV discharge lines GBC-6 and GBC-8; Figure 5-2.4-6 shows the modeling of the vacuum breaker for SRV discharge lines GBC-7, GBC-9, GBC-10 and GBC-11. The mass of the vacuum breaker is lumped at the center-of-gravity of the valve.

The full models have restraints at the main steam line connection to the RPV nozzle and at the main steam line penetration through the drywell wall. A 6 x 6 stiffness matrix is modeled at the SRV discharge line connection to the vent line penetration and at the end connections of the elbow support beam and T-quencher support beam to the ring beams. The matrices, simulating the stiffnesses at the connections, are derived from the SRVDL-VL penetration and ring beam analyses. The ring beam analysis is included in Volume 2 of this report; the SRVDL-VL penetration model description is included in Section 5-2.4.1(C).

Piping supports included in the full models consist of snubbers, struts, spring hangers, and their backup structures. Snubbers are modeled as active members in seismic and other dynamic load cases, whereas struts are modeled as active members in all load cases. Spring hangers with appropriate preloads are modeled as active members in all load cases. The effective mass of the pipe supports and connecting hardware attached to the piping is included in the piping models. Stiffness values at piping support locations include the combined effects of the snubber or strut, supplementary steel, and supporting structural steel.

B. SRVDL Wetwell Piping Model

The SRVDL wetwell piping model includes the SRV discharge line piping from the vertical support in the vent line down to and including the T-quencher (Figure 5-2.4-7). The boundary conditions for the model at the T-quencher support beam and elbow support beam end connections to the ring beam are represented by a 6 X 6 stiffness matrix simulating the ring beam stiffness. The intermediate junction point where the SRV discharge line penetrates the vent line is also represented by a 6 X 6 stiffness matrix simulating the vent line stiffness.

The connecting bracket between the elbow support beam and SRV discharge line is modeled as a pipe element and a 2 X 2 stiffness matrix.

The six connecting brackets between the T-quencher and T-quencher support beam are modeled as a pipe element with a 2 X 2 stiffness matrix to represent the connection to the T-quencher. The lateral support beam for the ramshead is modeled with pipe elements and several stiffness matrices (4 X 4, 1 X 1).

The accuracy of the wetwell model results have been verified based upon a comparison of these results with those from the complete (full) model. The results were compared for both equivalent static and dynamic submerged structure load cases.

C. SRVDL-VL Penetration Model

The SRV discharge line-vent line penetration model includes the vent line from the drywell to the vent header and the insert plate-nozzle assembly (Figures 5-2.4-8 and 5-2.4-9). The boundary conditions for the model at the drywell and vent header connections are represented by 6 X 6 stiffness matrices. A sufficient amount of detail for the plate elements is used to accurately represent the flexibility and stress of the nozzle and insert plate and to predict local effects on the vent line shell.

5-2.4.2 Analysis Methods

The mathematical models described in Section 5-2.4.1 are utilized in performing the analyses on the SRV discharge line piping, supports, and associated components.

Dynamic analysis techniques are used to determine system response to the major loads defined by NUREG-0661 acting on the SRVDL piping. These techniques utilize either response spectra, harmonic, or time-history analysis methods, depending on the input loading characteristics. The remaining SRVDL piping load cases specified in Section 5-2.2.1 are either static loads or dynamic loads, which are examined using an equivalent static approach. Conservative values of dynamic loading factors (DLF) are developed and applied to the individual dynamic loads when performing equivalent static analyses.

Summarized in Table 5-2.4-2 are the specific analytical techniques used for each piping model described in Section 5-2.4.1 for each load identified in Section 5-2.2.1. The analytical techniques used in the SRVDL piping analyses are described in the following paragraphs.

A. Full SRVDL Piping Analysis

The following hydrodynamic loads (Section 5-2.2.1) are applied directly to the SRVDL piping in the wetwell and their effect on drywell piping is negligible. Hence, no analysis was performed on the drywell SRV piping for the following loads:

- 4c SRV T-quencher Discharge (QAB),
- 5 Pool Swell (PS),
- 6 Condensation Oscillation (CO),
- 7a Pre-Chug (PCHUG),
- 7b Post-Chug (CHUG),
- 8a LOCA Water Jet Impingement,
- 8b LOCA Air Bubble Drag,
- 9b Suppression Chamber Interaction

The full mathematical models of the SRVDL piping are discussed in Section 5-2.4.1. Figures 5-2.4-1 and 5-2.4-2 show a representative model used in the drywell piping analysis. Table

5-2.4-2 summarizes the analysis methods utilized for each of the four full SRVDL piping models. These methods are discussed in the following paragraphs for the loads not tabulated above.

1. Dead Loads

   a. Dead Weight (DW): A static analysis is performed for the uniformly distributed and concentrated weight loads applied to the SRVDL piping system.

   b. Dead Weight (DW_T): A static analysis is performed for the dead weight of piping (DW) plus the dead weight of water in the MSL piping system during the hydrostatic test condition.

2. Seismic Loads

   a. OBE Inertia (OBE_I): A response spectra method is used to perform a dynamic analysis for two sets of seismic loads. The first set of seismic loads is a N-S horizontal acceleration spectrum with a vertical acceleration spectrum applied simultaneously. The second set is an E-W horizontal acceleration spectrum with a vertical acceleration spectrum applied simultaneously. Figure 5-2.2-1 shows the horizontal (N-S and E-W) seismic acceleration response spectra and Figure 5-2.2-2 shows the vertical seismic acceleration response spectrum used in the analysis. A value of 1/2% critical damping is used in accordance with the original stress report (Reference 4). All modes up to and including 33 Hz are considered in calculating the dynamic modal responses. The maximum of the two sets of seismic loads analyzed is taken as the net response of the OBE_I loads.

b. OBE Anchor Displacement (OBE_D): Static displacements at the piping anchors (restraints) are applied as in the original analysis.

c. SSE Inertia (SSE_I): The horizontal and vertical SSE inertia loads specified in the original stress report are twice the corresponding OBE inertia loads. The application of the load is the same as specified for OBE_I.

d. SSE Anchor Displacement (SSE_D): The horizontal SSE anchor displacement loads specified in the original stress report are twice the corresponding OBE anchor displacement loads.

The methodology used to combine modal responses and spatial components in the seismic inertia analysis is defined in the original stress report (Reference 4). The individual modal responses are combined by SRSS and directional responses are combined by the absolute sum method (ABS).

3. Pressure and Temperature Loads

a. Pressure: The effects of maximum pressure (P_o) and design pressure (P) are evaluated utilizing the techniques described in Subsection NC-3650 of the ASME Code, Section III (Reference 7). Table 5-2.2-2 lists the values of P_o and P used in the analysis.

b. Temperature: A static thermal expansion analysis is performed for SRVDL piping temperature cases TE1 and TE2 (Table 5-2.2-2). A static analysis is performed for anchor movements at the RPV, the VLP, and at torus attachment points by applying responses separately and then combining with the TE1 and TE2 load cases.

4. Safety Relief Valve Discharge Loads

a. SRVDL Thrust (RV1): A dynamic analysis is performed for each of the three bounding SRV actuation cases (A1.1, C3.1, C3.2) using the direct integration time-history analysis technique. A time-dependent forcing function is applied on each pipe segment along the pipe axis.

In the analysis, the forcing functions associated with a single SRV actuation are first applied separately to each SRVDL in the model. The peak response due to actuation of the adjacent safety relief valve at a particular location in one SRVDL is then obtained by absolute summation of the responses at that location, except where the CDF method is used. This absolute summation considers the worst case phasing between any multiple valve actuations. Component responses at one location out of the total of over 500 locations were combined by the use of the CDF method. The responses obtained for Cases A1.1 are termed RV1A or RV1C and the responses for C3.1 are termed RV1A. The response for Case C3.2 is termed RV1B. Figures 5-2.2-3, 5-2.2-4, and 5-2.2-5 show typical SRV piping thrust force time-history plots. Figure 5-2.4-10 shows a typical application of the thrust segment forces to an SRV discharge line.

A direct integration time-step of sufficiently small size is selected to adequately account for the critical responses of the piping system up to 60 Hz. A value of 1% and 2% critical damping is utilized in accordance with NUREG-0661 in determining the appropriate values of Rayleigh damping coefficients and for use in the direct integration process. For Level A and B loading conditions a 1% damping value is used and for Level C and D a 2% critical damping value is used.

b. Safety Valve Thrust: An equivalent static analysis is performed for safety valve thrust loads. The loads include a dynamic load factor which is computed by first principles.

9. Vent System and Suppression Chamber Interaction Loads

a. Vent System Interaction:

Vent system interaction is evaluated using as input the interface loads from the spring element representing the SRVDL in the vent system model described in Section 3-2.4.

A static analysis is performed on the full SRVDL piping for the vent line penetration displacements due to TD and TD1 loads which are described in Section 5-2.2.1.

B. SRVDL Wetwell Piping Analysis

The mathematical model of the wetwell SRVDL piping (Figure 5-2.4-7) is discussed in Section 5-2.4.1. Loads 1a, 1b, 2a, 2b, 2c, 2d, 3a, 3b, 4a, 4b and 9a are not reanalyzed for wetwell piping. The results from the full model are used. The following analysis methods are utilized in evaluating the wetwell SRVDL piping for additional loads (Table 5-2.4-2).

4. Safety Relief Valve Discharge Loads:

c. SRV T-quencher Discharge (QAB):

- Water Jet Impingement: An equivalent static analysis is performed for the drag loads shown in Table 5-2.2-5. The values of the loads shown include a dynamic load factor which is computed using first principles.

- T-quencher and End Cap Thrust: An equivalent static analysis is performed for the thrust loads shown in Table 5-2.2-6. The values of the loads shown include a dynamic load factor which is computed using first principles.

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- Air Bubble Drag: An equivalent static analysis is performed for the loads shown in Table 5-2.2-5. The values of the loads include a dynamic load factor determined by the methodology discussed in Section 1-4.2.4.

5. Pool Swell Loads:

- Impact and Drag: An equivalent static analysis is performed for the pool swell impact and drag loads shown in Table 5-2.2-7.

- Pool Swell Froth Impingement: An equivalent static analysis is performed for the two-phase froth of air and water pressure loads shown in Table 5-2.2-8.

- Pool Fallback: An equivalent static analysis is performed for the pressure loads shown in Table 5-2.2-9.

The values for pool swell impact, drag, froth and pool fallback loads include a dynamic load factor which is computed using first principles.

6. Condensation Oscillation Loads:

Condensation Oscillation (CO): A harmonic dynamic analysis is performed for the normalized loads shown in Table 5-2.2-10. The distribution of the loads uses the magnitudes shown in Table 5-2.2-11. For the FSI portion of the loading the procedure is the same, except Table 5-2.2-12 and Table 5-2.2-13 are used for the distribution and magnitudes of the load.

7. Chugging Loads:

a. Pre-Chug (PCHUG): Post-chug loads bound pre-chug loads (Section 5-2.2.1). Therefore the analysis results for post-chug loads are used in combinations which include pre-chug loads (Table 5-2.2-14).

b. Post-Chug (CHUG): A harmonic dynamic analysis is performed for the normalized loads shown in Table 5-2.2-15. This distribution of the load uses the magnitudes shown in Table 5-2.2-16. For the FSI portion of the loading the procedure is the same except Table 5-2.2-17 and Table 5-2.2-18 are used for the distribution and magnitude of the load.

8. Vent Clearing (VCL) Loads:

a. LOCA Water Jet Impingement: An equivalent static analysis is performed for the loads shown in Table 5-2.2-19. The values of the loads shown include a dynamic load factor which is computed using first principles.

b. LOCA Air Bubble Drag: An equivalent static analysis is performed for the loads shown in Table 5-2.2-20. The values of the loads shown include a dynamic load factor which is computed using first principles.

9. Vent System and Suppression Chamber Interaction Loads:

b. Suppression Chamber Interaction: A time-history dynamic analysis is performed for the suppression chamber support motions derived from the analyses of the structure, described in Volume 2 of this report. The dynamic loads considered at the ring beam attachment points are motions due to LOCA and SRV related loads.

In order to determine piping stress levels in the SRVDL wetwell piping, the results obtained from the analyses described in Section 5-2.4.2(A) are combined with these results to evaluate the load combinations presented in Table 5-2.2-21.

NUREG-0661 permits the use of in-plant test data model prediction and comparison to reduce the responses for design cases. For SRV thrust, SRV air bubble drag, SRV torus motions, pipe pressure and uneven clearing an adjustment factor was developed which accounted for the differences between test strain gauge data (Reference 8) and the analysis results for test condition loads. This adjustment factor was then applied to the analysis results at design conditions, as described in NUREG-0661, Section 2.1.3.9. The structural components which utilized this factor are the wetwell SRVDL piping, the elbow support beam, the T-quencher, and the T-quencher support structure.

Table 5-2.4-1

FULL SRVDL PIPING MATHEMATICAL MODELS

MODEL NUMBER	MAIN STEAM LINE	SRV DISCHARGE LINES
1	LOOP A	GBC-9 GBC-10
2	LOOP B	GBC-6
3	LOOP C	GBC-11
4	LOOP D	GBC-7 GBC-8

Table 5-2.4-2

ANALYSIS METHODS - SRVDL PIPING

LOAD	LOAD CASE NUMBER	FULL SRV PIPING MODEL	WETWELL SRV PIPING MODEL
DW	1a	STATIC	(2)
DW_T	1b	STATIC	(2)
OBE_I	2a	RESPONSE SPECTRUM	(2)
OBE_D	2b	STATIC	(2)
SSE_I	2c	RESPONSE SPECTRUM	(2)
SSE_D	2d	STATIC	(2)
P_O	3a	(1)	(1)
P	3a	(1)	(1)
TE1	3b	STATIC	(2)
TE2	3b	STATIC	(2)
THAM1	3b	STATIC	(2)
THAM2	3b	STATIC	(2)
THAM1A	3b	STATIC	(2)
THAM2A	3b	STATIC	(2)
RV1A, RV1C	4a	FORCE TIME-HISTORY	(2)
RV1B	4a	FORCE TIME-HISTORY	(2)
RV1A, RV1C	4b	EQUIVALENT STATIC	(2)
RV1B	4b	EQUIVALENT STATIC	(2)
QAB	4c	(3)	EQUIVALENT STATIC
PS		(3)	EQUIVALENT STATIC
CO	6	(3)	HARMONIC
PCHUG	7a	(3)	HARMONIC
CHUG	7b	(3)	HARMONIC
VCL	8a, 8b	(3)	EQUIVALENT STATIC
TD	9a, 9b	(3)(5)	STATIC
TD1	9a, 9b	(3)(5)	STATIC
QAB_I	9a, 9b	(3)(5)	COUPLING (4)
PS_I	9a, 9b	(3)(5)	DISPL TIME-HISTORY (5)
CO_I	9a, 9b	(3)(5)	DISPL TIME-HISTORY (5)
$PCHUG_I$	9a, 9b	(3)(5)	DISPL TIME-HISTORY (5)
$CHUG_I$	9a, 9b	(3)(5)	DISPL TIME-HISTORY (5)

(1) THE EFFECTS OF INTERNAL PRESSURE ARE EVALUATED UTILIZING THE TECHNIQUES DESCRIBED IN SUBPARAGRAPH NC-3650 OF THE ASME CODE, SECTION III (REFERENCE 7).

(2) RESULTS FROM THE FULL MODEL WILL BE USED FOR THESE LOADS.

(3) RESULTS FROM THE WETWELL MODEL WILL BE USED FOR THESE LOADS.

(4) COUPLED TIME-HISTORY ANALYSIS.

(5) LOAD CASE 9A RESULTS ARE TAKEN FROM THE FULL MODEL USING STATIC OR EQUIVALENT STATIC ANALYSIS.

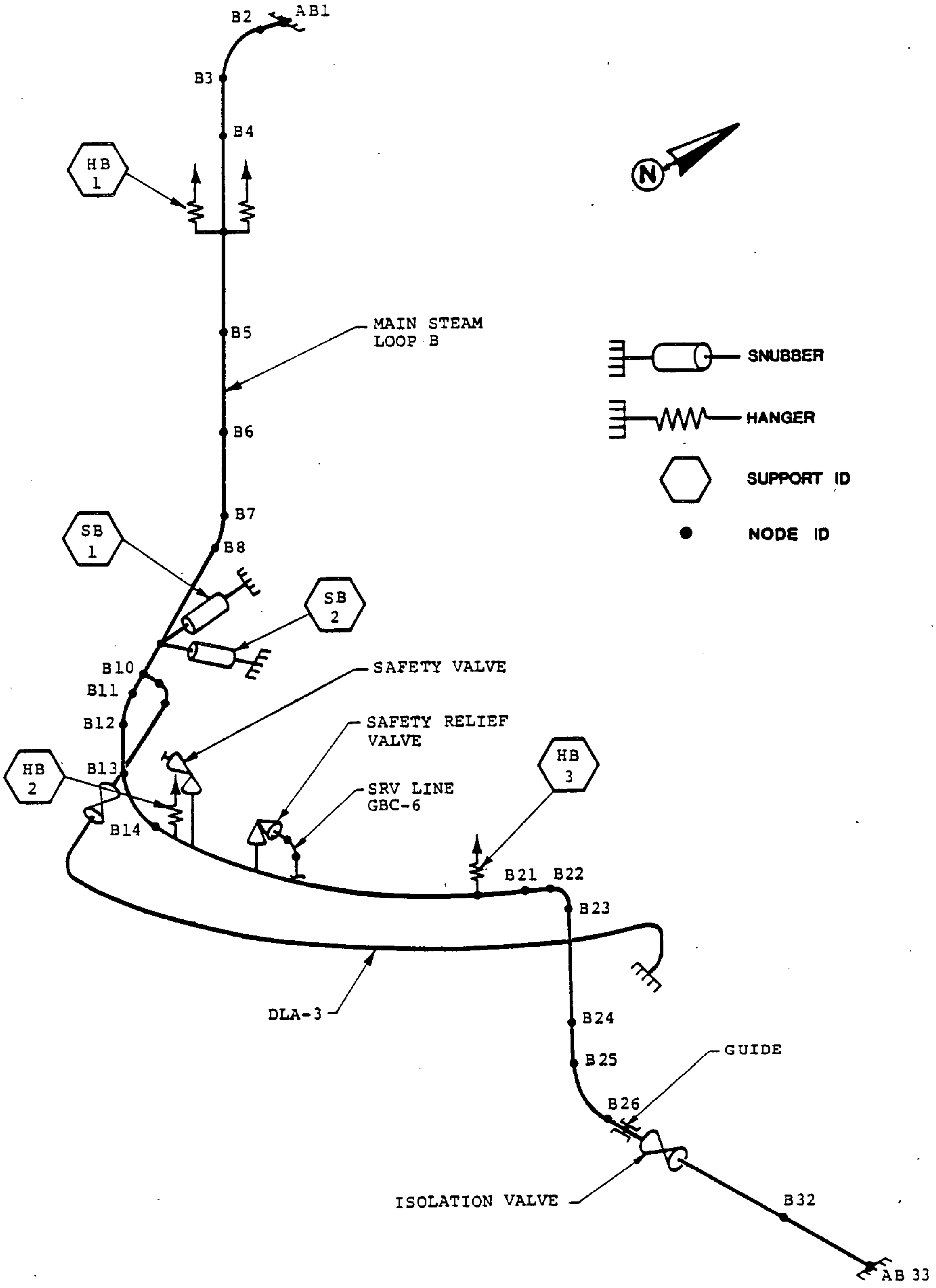


Figure 5-2.4-1

MAIN STEAM LINE LOOP B MATHEMATICAL MODEL

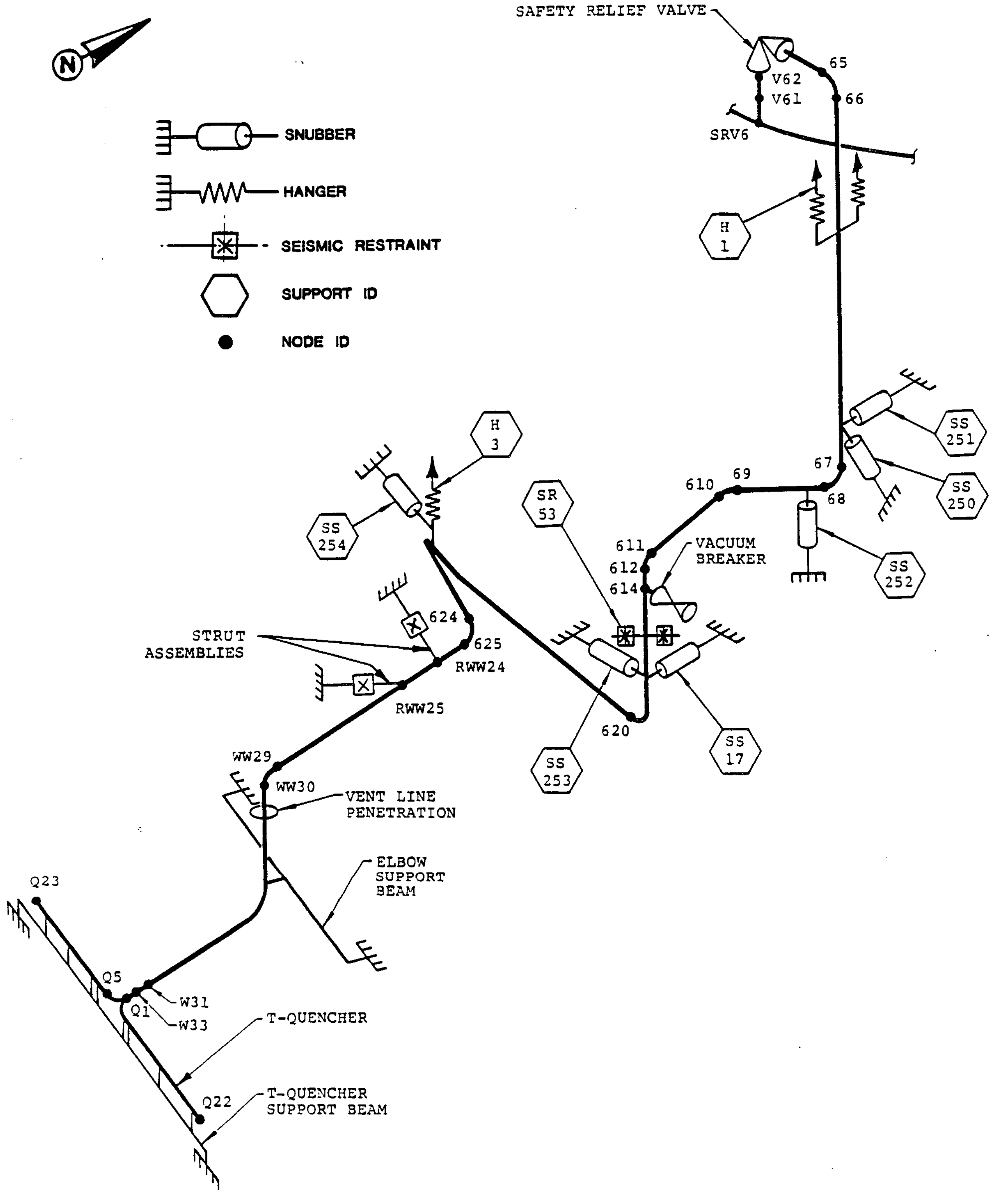


Figure 5-2.4-2

SRV DISCHARGE LINE GBC-6 MATHEMATICAL MODEL

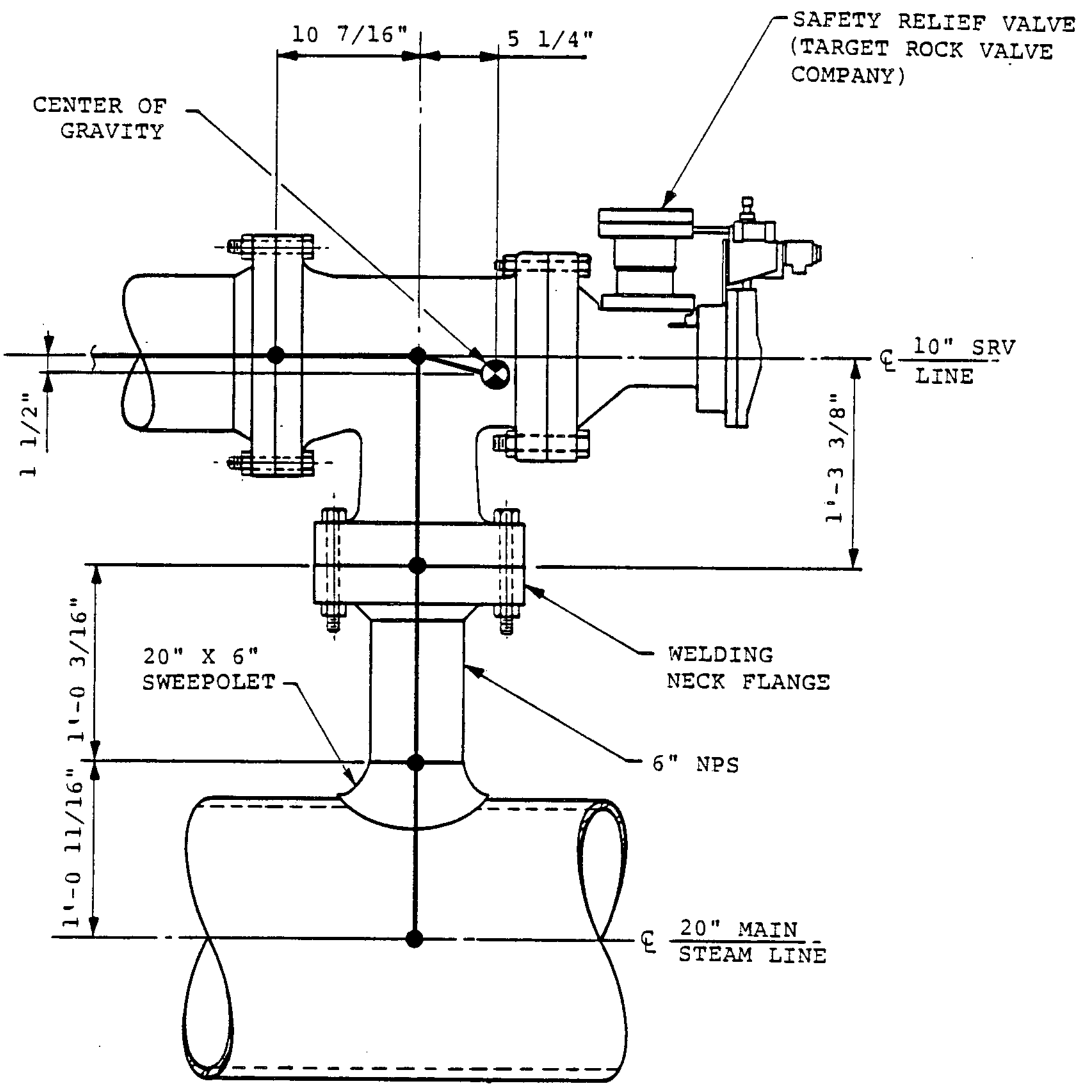


Figure 5-2.4-3

SAFETY RELIEF VALVE MATHEMATICAL MODEL

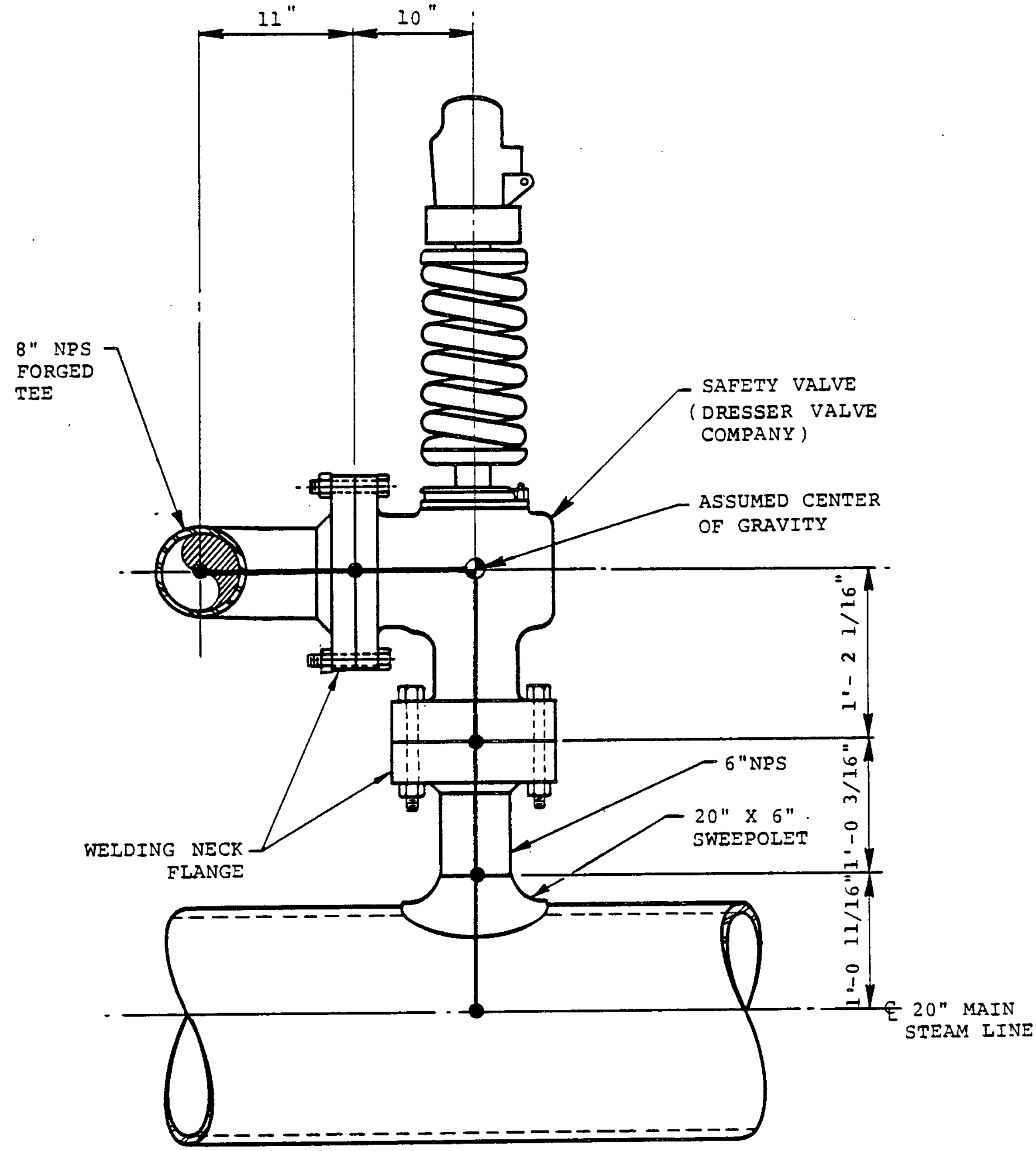


Figure 5-2.4-4

SAFETY VALVE MATHEMATICAL MODEL

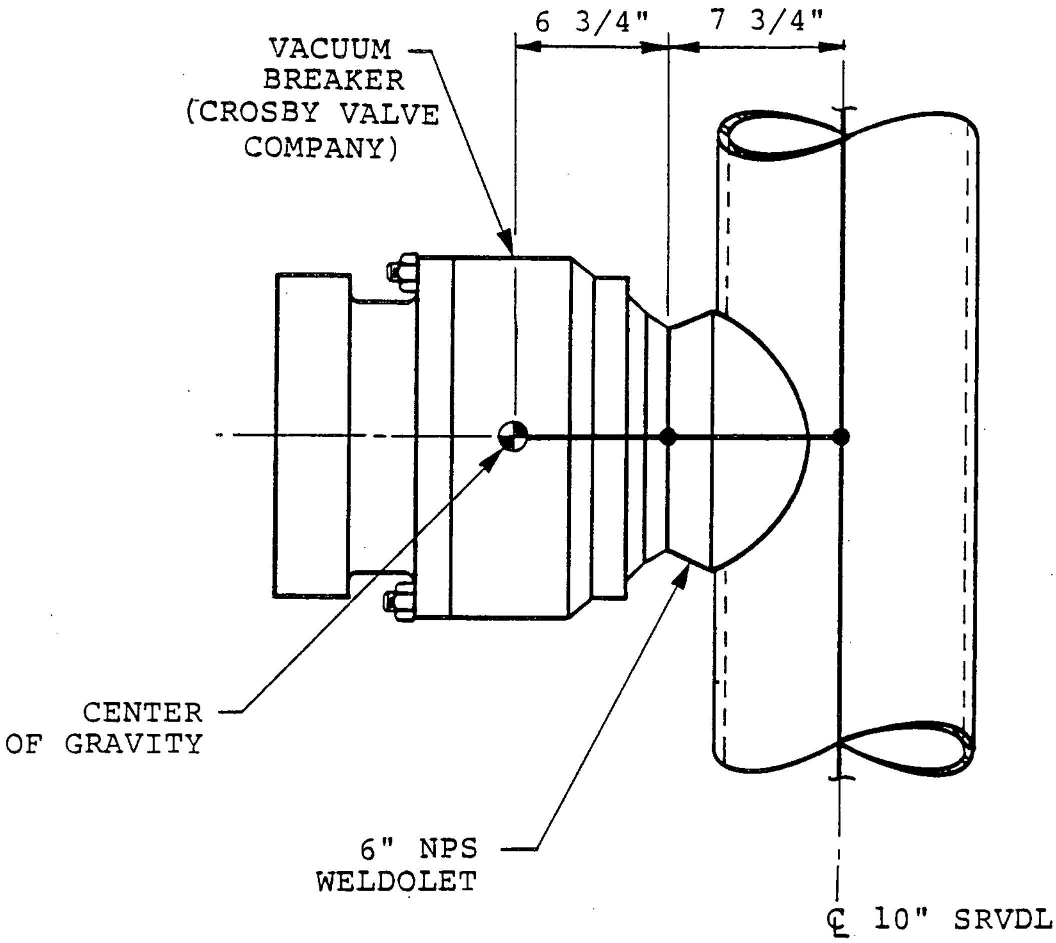


Figure 5-2.4-5

VACUUM BREAKER MATHEMATICAL MODEL

FOR SRV DISCHARGE LINES

GBC-6 AND GBC-8

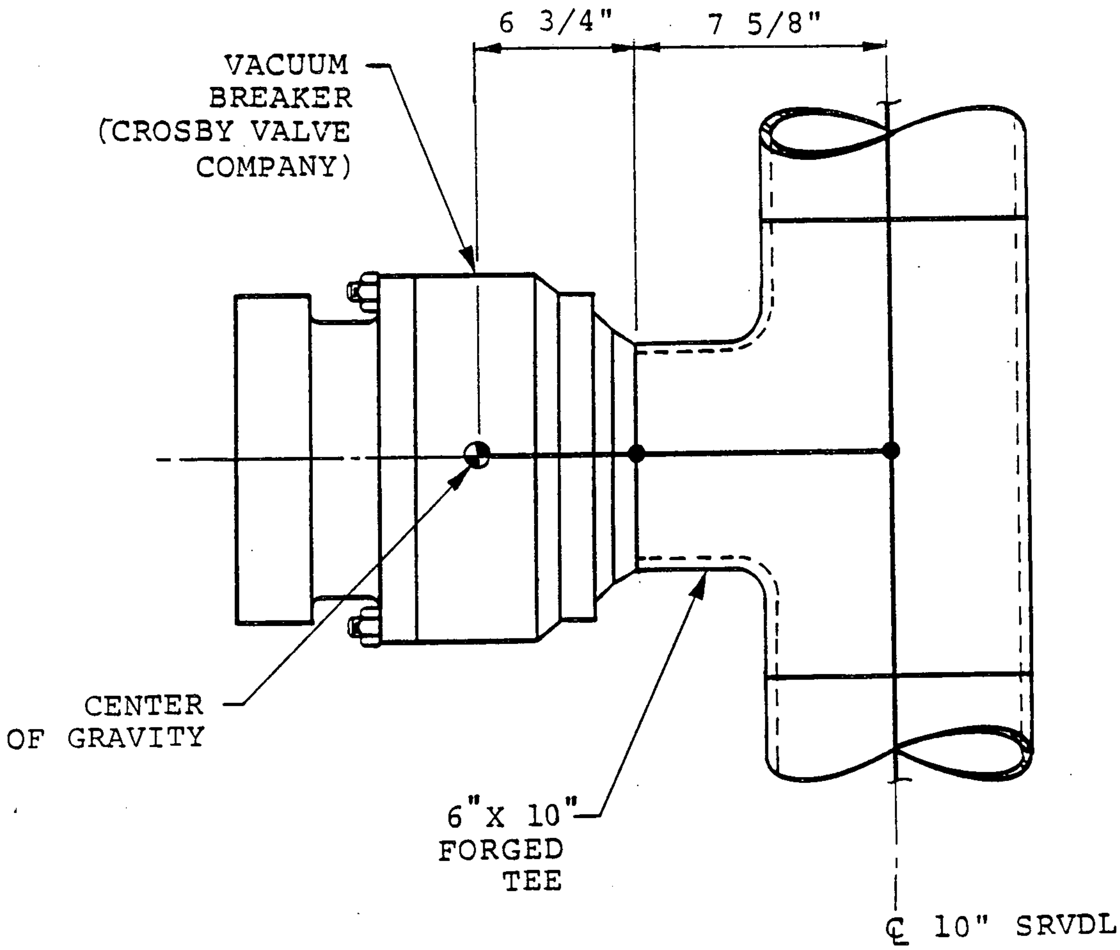


Figure 5-2.4-6

VACUUM BREAKER MATHEMATICAL MODEL
FOR SRV DISCHARGE LINES
GBC-7, GBC-9, GBC-10, AND GBC-11

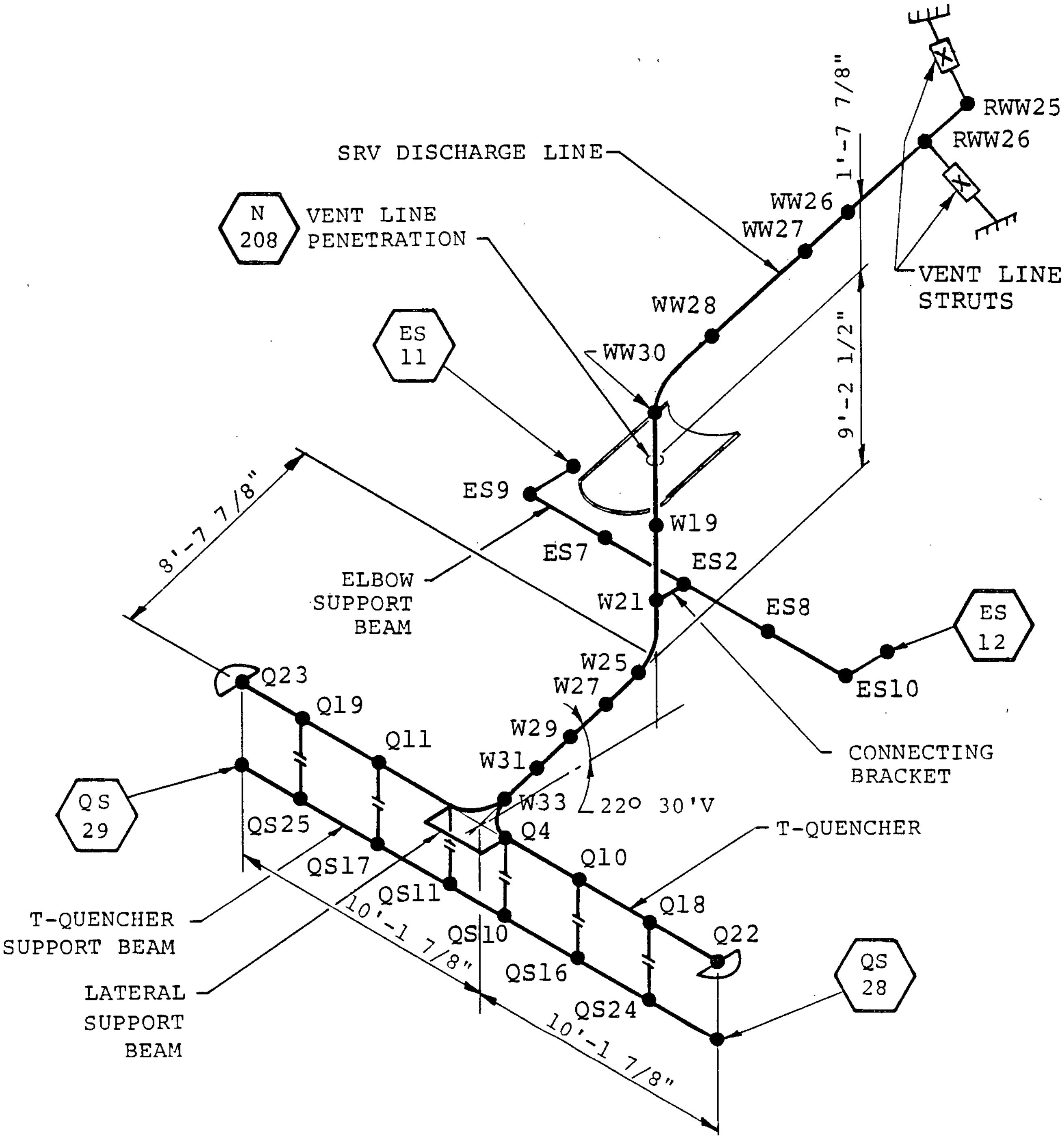
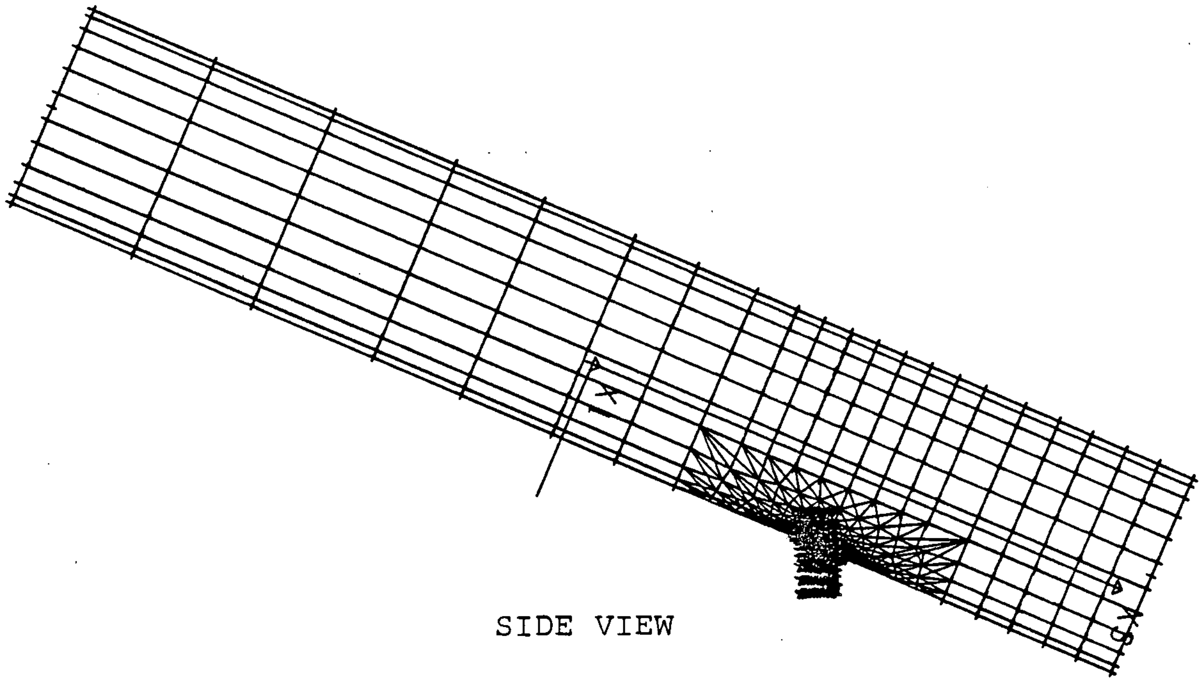
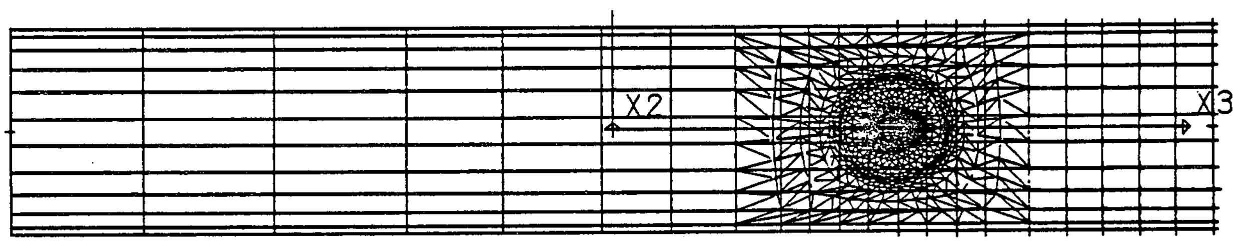


Figure 5-2.4-7

TYPICAL WETWELL SRVDL MATHEMATICAL MODEL



SIDE VIEW

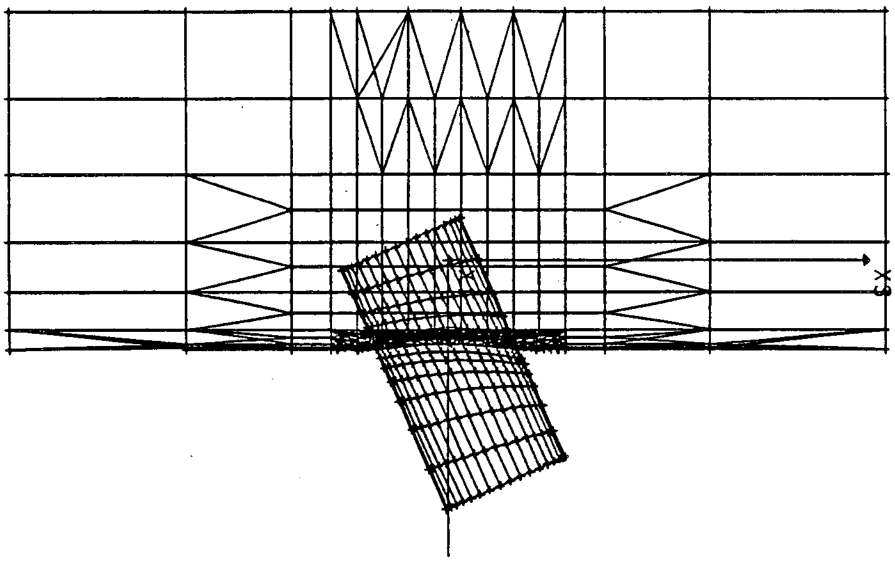


BOTTOM VIEW

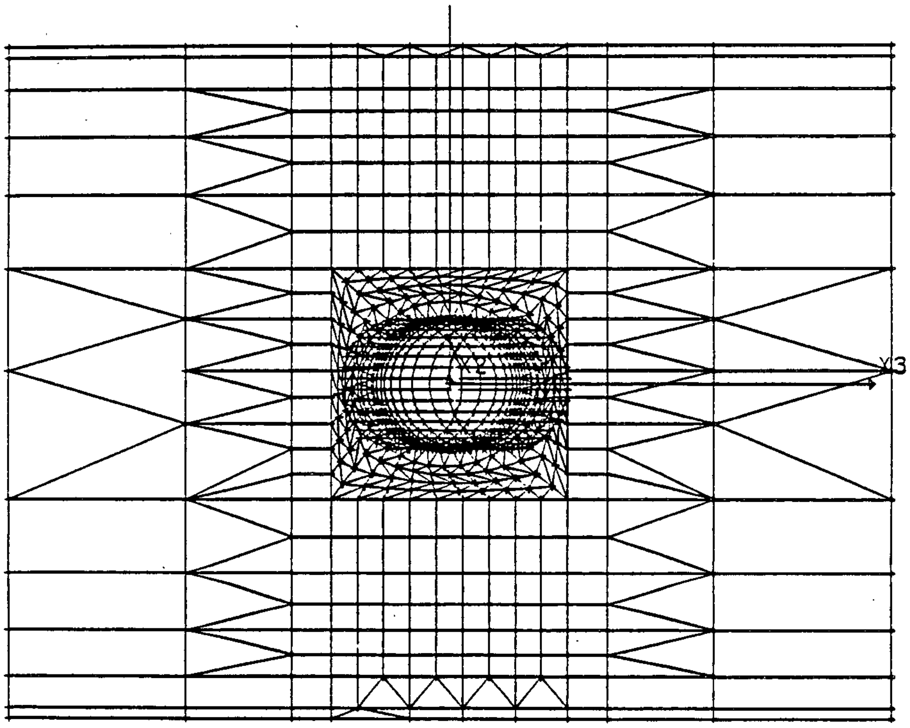
Figure 5-2.4-8

SRVDL-VL PENETRATION

FINITE ELEMENT MODEL



SIDE VIEW



BOTTOM VIEW

Figure 5-2.4-9

SRVDL-VL PENETRATION FINITE ELEMENT MODEL

(INSERT PLATE - NOZZLE ASSEMBLY)

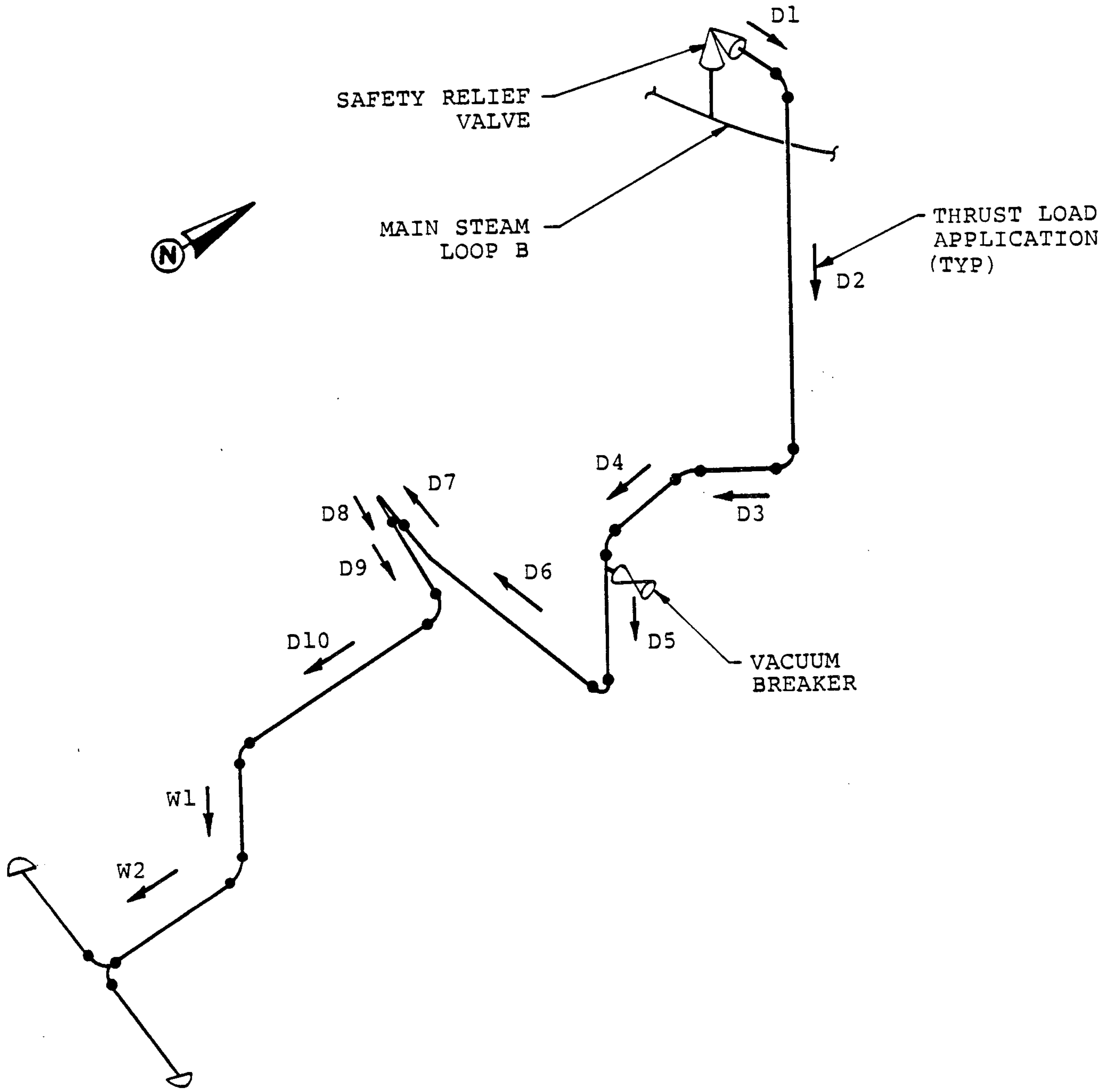


Figure 5-2.4-10

TYPICAL APPLICATION OF SRV DISCHARGE THRUST LOADS

5-2.5 Analysis Results

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

Table 5-2.5-1 presents the maximum piping stresses resulting from governing load combinations for the highest stressed locations on the MSL and on each SRV discharge line (both drywell and wetwell). The maximum stresses for each service level are listed, along with the associated ASME Code equations and allowable stress values.

Tables 5-2.5-2 and 5-2.5-3 contain the maximum snubber reaction loads for the governing load combinations. Maximum loads from six SRV discharge lines are presented for various rated snubbers and are grouped by service levels with appropriate allowables.

Table 5-2.5-4 lists maximum resultant loads in the rigid struts. Strut loads and strut ratings are provided for each service level.

Table 5-2.5-5 provides the maximum resultant moments of the six SRV outlet flanges. The maximum moments are also listed for each service level along with the allowable flange moments.

Table 5-2.5-6 shows the maximum T-quencher arm stresses resulting from ASME Code piping equations for the controlling load combinations.

Table 5-2.5-7 shows the maximum stresses for the T-quencher support beam, and elbow support beam and connecting brackets for each of the governing loads.

Table 5-2.5-8 shows the maximum stresses for the SRVDL-VL penetration nozzle, insert plates and local vent line shell.

In summary, the results show that the design of the SRV discharge line piping system, including the SRV discharge line-vent line penetration is adequate for the loads and load combinations, according to the acceptance criteria limits specified in NUREG-0661 (Reference 1) and the PUAAG (Reference 5).

Table 5-2.5-1

ANALYSIS RESULTS FOR SRVDL AND MSL PIPING STRESSES

MSL/ASSOCIATED SRV LINE(S)/ LOCATION	LEVEL A (ksi)	LEVEL B (ksi)	LEVEL C (ksi)	LEVEL D (ksi)	SECON-DARY (ksi)
LOOP A GBC-9+10/DW	9.16	17.56	24.85	23.48	34.26
LOOP B GBC-6/DW	9.05	16.17	24.51	24.17	35.34
LOOP C GBC-11/DW	8.84	14.54	26.05	27.90	34.29
LOOP D GBC-7+8/DW	9.16	17.05	26.35	28.03	34.26
ALL LINES/WW	(1)	17.12	24.06	28.05	(1)
ASME CODE EQUATION	8	9	9	9	11
ALLOWABLE STRESS (ksi)	15.00	18.00	27.00	36.00	37.50

(1) FOR LEVEL A AND SECONDARY STRESSES, THE WETWELL MODEL RESULTS ARE INCLUDED WITH THE RESULTS FOR THE RESPECTIVE SRV LINES.

(2) SEE TABLE 5-2.3-1 FOR ALLOWABLE STRESSES.

Table 5-2.5-2

ANALYSIS RESULTS FOR MAIN STEAM
LINE PIPING SNUBBER LOADS

MAIN STEAM LINE	RATING (kips)	LEVEL B (kips)	LEVEL C (kips)	LEVEL D (kips)
LOOP A	50	16.95	32.86	32.16
LOOP A	50	17.88	30.58	30.30
LOOP B	50	8.15	27.21	26.70
LOOP B	50	7.86	27.06	26.96
LOOP C	50	6.82	19.74	20.06
LOOP C	50	9.40	26.63	28.35
LOOP D	50	14.18	32.28	34.58
LOOP D	50	16.64	28.87	27.36
ALLOWABLE LOAD (kips)		1.0 x RATING	1.33 x RATING	(1)

(1) LEVEL C ALLOWABLES USED FOR LEVEL D LOADS.

Table 5-2.5-3

ANALYSIS RESULTS FOR SRVDL PIPING SNUBBER LOADS

SRV LINE NUMBER	RATING (kips)	LEVEL B (kips)	LEVEL C (kips)	LEVEL D (kips)
GBC-6	14.5	11.1	13.0	12.2
GBC-6	15.0	10.6	13.8	12.6
GBC-6	15.0	6.1	9.5	9.6
GBC-6	6.0	4.3	6.5	6.5
GBC-6	12.6	7.8	11.5	11.3
GBC-6	15.0	11.2	12.7	11.4
GBC-7	15.0	4.3	7.5	8.8
GBC-7	15.0	11.0	13.3	13.2
GBC-7	28.7	16.5	24.3	26.1
GBC-7	12.5(3)	9.8	16.4	15.4
GBC-7	15.0	8.0	8.4	6.6
GBC-7	11.3	7.1	10.2	8.9
GBC-8	15.0	7.0	10.8	11.0
GBC-8	15.0	11.7	13.7	15.5
GBC-8	15.0(3)	15.6	17.2	17.0
GBC-8	15.0	6.4	8.5	8.5
GBC-8	15.0	7.0	8.9	10.1
GBC-8	15.0	9.1	10.4	9.9
GBC-8	30.0	11.5	13.9	14.8
ALLOWABLE LOAD(1) (kips)		1.0 x RATING	1.33 x RATING	(2)

Table 5-2.5-3

ANALYSIS RESULTS FOR SRVDL PIPING SNUBBER LOADS

(Continued)

SRV LINE NUMBER	RATING (kips)	LEVEL B (kips)	LEVEL C (kips)	LEVEL D (kips)
GBC-9	15.0	11.4	12.4	11.9
GBC-9	15.0	11.4	13.8	12.4
GBC-9	15.0	7.1	8.1	7.4
GBC-9	12.5	4.9	6.1	6.6
GBC-9	15.0	9.3	10.4	10.4
GBC-9	12.5 (3)	14.1	16.2	16.6
GBC-9	26.6	18.1	18.7	18.7
GBC-9	30.0	10.4	11.2	11.7
GBC-10	15.0	12.1	13.5	10.8
GBC-10	15.0	10.6	13.1	14.5
GBC-10	12.5 (3)	6.7	7.7	7.8
GBC-10	13.3	7.7	13.0	10.6
GBC-10	15.0	8.6	10.3	9.0
GBC-11	15.0	6.5	9.6	8.4
GBC-11	15.0	6.6	12.1	13.2
GBC-11	15.0	6.6	8.4	9.0
GBC-11	24.8	12.8	14.9	15.1
GBC-11	15.0	4.6	5.2	4.6
GBC-11	12.5 (3)	8.2	8.9	8.8
GBC-11	11.9	6.4	7.5	7.8
ALLOWABLE LOAD (1) (kips)		1.0 x RATING	1.33 x RATING	(2)

(1) THE SUPPORTING DRYWELL FLOOR STEEL IS DESIGNED TO MEET THE ALLOWABLE LOADS AS A MINIMUM.

(2) FOR LEVEL D ALLOWABLE LOAD EVALUATION, LEVEL C ALLOWABLE VALUES ARE USED.

(3) THERE ARE TWO VERTICAL SNUBBERS AT THESE LOCATIONS, EACH WITH A RATING AS SHOWN. THE LISTED LOAD IS THE TOTAL LOAD AT THIS LOCATION.

Table 5-2.5-4

ANALYSIS RESULTS FOR SRVDL PIPING STRUT LOADS

SRV LINE NUMBER	RATING (kips)	(4) LEVEL B (kips)	(4) LEVEL C (kips)	(4) LEVEL D (kips)	(5) LOAD RANGE (kips)
GBC-6	36.5	11.2	16.0	16.8	22.4
GBC-6	26.5	12.1	14.5	16.2 (2)	24.2
GBC-6	15.0	7.4	8.1	8.1	14.8 (3)
GBC-7	26.5	16.6	21.6	19.8 (2)	33.2
GBC-7	15.0	5.3	7.3	6.3	10.6 (3)
GBC-8	28.0	13.0	15.5	16.8	26.0
GBC-8	26.5	10.7	12.6	14.4 (2)	21.4
GBC-8	15.0	6.0	7.7	8.3	12.0 (3)
GBC-9	26.5	20.5	20.9	20.9 (2)	41.0
GBC-9	15.0	4.2	5.1	5.4	8.4 (3)
GBC-10	26.5	20.9	22.2	22.2 (2)	41.8
GBC-10	15.0	7.2	9.0	5.4	14.4 (3)
GBC-11	26.5	14.9	15.7	13.1 (2)	29.8
GBC-11	15.0	6.2	7.2	7.4	12.4 (3)
ALLOWABLE LOAD (1) (kips)		1.0 x RATING	1.33 x RATING	1.88 x RATING	2.0 X RATED LOAD

(1) THE SUPPORTING DRYWELL FLOOR STEEL OR VENTLINE SHELL IS DESIGNED TO MEET THE ALLOWABLE LOADS AS A MINIMUM.

(2) ALLOWABLE LOAD IS 1.55 X RATED LOAD.

(3) ALLOWABLE LOAD IS 1.5 X RATED LOAD.

(4) INCLUDES SECONDARY LOADS.

(5) LOAD RANGE WAS TAKEN AS TWICE LEVEL B LOAD.

Table 5-2.5-5

ANALYSIS RESULTS FOR SRV OUTLET FLANGE MOMENTS

SERVICE LEVEL	OUTLET FLANGE MOMENT (in-kips) (1)
LEVEL A	319.0
LEVEL B	403.8
LEVEL C	658.3
LEVEL D	912.7
SECONDARY	716.4

(1) VALUE SHOWN REPRESENTS MAXIMUM MOMENT FOR ANY SRV LINE

(2) SEE TABLE 5-2.3-4 FOR ALLOWABLE MOMENTS

Table 5-2.5-6

ANALYSIS RESULTS FOR T-QUENCHER ARMS

ITEM	ASME CODE EQUATION NUMBER	SERVICE LEVEL	LOAD COMBINATION STRESS (ksi)(1)
T-QUENCHER ARMS	8	A	8.35
	9	B	18.18
	9	C	22.40
	9	D	24.22
	11	A AND B	22.75

(1) SEE TABLE 5-2.3-2 FOR ALLOWABLE STRESSES.

Table 5-2.5-7

ANALYSIS RESULTS FOR T-QUENCHER SUPPORT AND ELBOW SUPPORT BEAMS AND CONNECTING BRACKETS

ITEM	SERVICE LEVEL	STRESS TYPE (ksi) (1) (4)		
		TENSILE	BENDING	INTERACTION
T-QUENCHER SUPPORT BEAM	B	6.93 (6)	19.84	0.98
	C	6.93 (6)	26.30	0.99
	D	6.93 (6)	30.61	0.82
	(5)	6.93 (6)	50.51	0.95
ELBOW SUPPORT BEAM	B	1.21	10.72	0.80
	C	1.82	22.40	0.91
	D	1.98	37.19	0.98
	(5)	2.87	29.02	0.67
LATERAL SUPPORT BEAM	B	1.08	4.89	0.31
	C	1.44	6.52	0.31
	D	1.44	6.52	0.31
	(5)	3.24	14.67	0.31
CONNECTING BRACKETS	B	0.46	18.73	0.98
	C	0.59	23.74	0.93
	D	6.67	31.49	0.82
	(5)	1.45	46.54	0.81
BOLTS	B	40.97	7.97 (3)	0.74
	C	42.98	11.98 (3)	0.98
	D	42.98	11.98 (3)	0.98
	(5)	106.68	20.39	0.56
WELDS	B	(2)	19.78 (3)	0.94
	C	(2)	26.37 (3)	0.94
	D	(2)	39.45 (3)	0.94
	(5)	(2)	59.34 (3)	0.94

(1) SEE TABLE 5-2.3-5 FOR THE ALLOWABLE STRESSES.
(2) ONLY COMBINED STRESSES ARE EVALUATED, SHOWN IN BENDING COLUMN.
(3) THESE ARE SHEAR STRESSES.
(4) THESE MAY NOT BE FOR ANY SINGLE LOCATION, MAXIMUM VALUES SHOWN.
(5) PRIMARY PLUS SECONDARY STRESS RANGE EVALUATION.
(6) MAXIMUM STRESS COMBINATION USED.

Table 5-2.5-8

ANALYSIS RESULTS FOR SRVDL-VL PENETRATIONS

ITEM	STRESS TYPE	LOAD COMBINATION STRESSES (ksi) (1)(2)			
		LEVEL B		LEVEL C	
		CALCULATED (ksi)	CALCULATED / ALLOWABLE	CALCULATED (ksi)	CALCULATED / ALLOWABLE
VENT LINE SHELL	LOCAL PRIMARY MEMBRANE	18.46	0.64	19.33	0.38
	PRIMARY + SECONDARY STRESS RANGE	36.35	0.54	N/A (3)	N/A (3)
INSERT PLATE	LOCAL PRIMARY MEMBRANE	13.44	0.46	14.07	0.28
	PRIMARY + SECONDARY STRESS RANGE	47.51	0.70	N/A (3)	N/A (3)
PENETRATION NOZZLE	LOCAL PRIMARY MEMBRANE	13.89	0.56	14.39	0.32
	PRIMARY + SECONDARY STRESS RANGE	56.21	0.94	N/A (3)	N/A (3)

(1) SEE TABLE 5-2.2-25 FOR LOAD COMBINATION DESIGNATIONS.

(2) SEE TABLE 5-2.3-6 FOR ALLOWABLE STRESSES.

(3) N/A = NO EVALUATION REQUIRED.

5-3.0 LIST OF REFERENCES

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

2. "Mark I Containment Program Load Definition Report," General Electric Company, NEDO-21888, Revision 2, November 1981, including Errata and Addenda No. 1, April 1982.

3. "Mark I Containment Program Plant Unique Load Definition," Duane Arnold Energy Center, General Electric Company, NEDO-24571, Revision 1, March 1982.

4. "Duane Arnold Energy Center Piping Stress Analysis," Main Steam Loop A thru D, Volume I, BEC-01-13 thru BEC-01-16, March 5, 1973, prepared for Bechtel Corporation by Nuclear Services Corporation.

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

6. "Mark I Containment Program Augmented Class 2/3 Fatigue Evaluation Method and Results for Typical Torus Attached and SRV Piping Systems," MPR-751, November 1982, by MPR Associates for GPU Nuclear, Parsippany, N. J.

7. ASME Boiler and Pressure Vessel Code, Section III, Division 1, 1977 Edition with Addenda up to and including Winter 1978.

8. Final In-Plant Safety Relief Valve Discharge Test Report, Duane Arnold Energy Center, IOW-30-027, Volume 1, Revision 1, March 18, 1982; Volumes II through IX, Revision 0, January 26, 1982.