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Revision 1
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MONTICELLO NUCLEAR GENERATING PLANT
PLANT UNIQUE ANALYSIS REPORT
VOLUME 5
SAFETY RELIEF VALVE DISCHARGE LINE PIPING ANALYSIS

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REVISION CONTROL SHEET

TITLE: Monticello Nuclear Generating Plant
Plant Unique Analysis Report
Volume 5

REPORT NUMBER: NSP-74-105
Revision 1

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5-iv					5-2.6			G.P	
5-v					5-2.7				
5-vi					5-2.8				
5-vii					5-2.9				
5-viii					5-2.10				
5-ix					5-2.11				
5-x					5-2.12				
5-xi					5-2.13				
5-xii					5-2.14				
5-xiii					5-2.15				
5-xiv					5-2.16				
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QEP-001.4-00

REVISION CONTROL SHEET
(Continued)

TITLE: Monticello Nuclear Generating Plant
Plant Unique Analysis Report
Volume 5

REPORT NUMBER: NSP-74-105
Revision 1

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5-2.35					5-2.73			NEng	
5-2.36					5-2.74			MTL	
5-2.37					5-2.75				
5-2.38			NEng		5-2.76				
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QEP-001.4-00

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REVISION CONTROL SHEET

(Continued)

TITLE: Monticello Nuclear Generating Plant
Plant Unique Analysis Report
Volume 5

REPORT NUMBER: NSP-74-105
Revision 1

EFFECTIVE PAGE(S)	REV	PREPARED	ACCURACY CHECK	CRITERIA CHECK
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QEP-001.4-00

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REVISION CONTROL SHEET
(Concluded)

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Plant Unique Analysis Report
Volume 5

REPORT NUMBER: NSP-74-105
Revision 1

EFFECTIVE PAGE(S)	REV	PREPARED	ACCURACY CHECK	CRITERIA CHECK	EFFECTIVE PAGE(S)	REV	PREPARED	ACCURACY CHECK	CRITERIA CHECK
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5-2.106				JWAk					
5-2.116			G.P	N/A					
5-2.117			G.P	N/A					
5-2.119			MTL	JWAk					
5-2.120									
5-2.121									
5-2.122									
5-2.123									
5-2.124			MTL						
5-3.1	1	ASH	NEng	JWAk					

QEP-001.4-00

ABSTRACT

The primary containment for the Monticello Nuclear Generating Plant, was designed, erected, pressure-tested, and ASME Code N-stamped during the late 1960's for the Northern States 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 five volumes.

- 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 5 documents the evaluation of the safety relief valve discharge line piping and has been prepared by NUTECH Engineers, Incorporated (NUTECH), acting as an agent to the Northern States Power Company.

In addition to the five volumes, an Appendix A has been added (as part of Volume 5) to provide Monticello plant unique responses to licensing questions asked by NRC on previous Mark I containment PUAR submittals. The questions have been modified only in respect to text references, and the responses are provided to address the Monticello plant unique features.

TABLE OF CONTENTS

LIST OF ACRONYMS

ASME	American Society of Mechanical Engineers
CDF	Cumulative Distribution Function
CO	Condensation Oscillation
DBA	Design Basis Accident
DLF	Dynamic Load Factor
FSAR	Final Safety Analysis Report
FSI	Fluid-Structure Interaction
IBA	Intermediate Break Accident
LDR	Load Definition Report
LOCA	Loss-of-Coolant Accident
MSL	Main Steam Line
NEP	Non-Exceedance Probability
NOC	Normal Operating Conditions
NRC	Nuclear Regulatory Commission
NSP	Northern States Power
OBE	Operating Basis Earthquake
PS	Pool Swell
PUA	Plant Unique Analysis
PUAAG	Plant Unique Analysis Application Guide
PUAR	Plant Unique Analysis Report
PULD	Plant Unique Load Definition
QSTF	Quarter-Scale Test Facility
RPV	Reactor Pressure Vessel
SBA	Small Break Accident

LIST OF ACRONYMS
(Concluded)

SRSS	Square Root of the Sum of the Squares
SRVDL	Safety Relief Valve Discharge Line
SSE	Safe Shutdown Earthquake
VCL	Vent Clearing Loads
VLP	Vent Line Penetration

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Concluded)

LIST OF FIGURES

LIST OF FIGURES
(Concluded)

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 Monticello safety relief valve discharge line (SRVDL) piping system, including the T-quencher and related support structures. The SRVDL piping 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 section contains an overview discussion 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 Monticello SRVDL piping system evaluation described in this report. The investigation includes an evaluation of the SRVDL piping system for the effects of 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).

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 plant's Final Safety Analysis Report (FSAR) (Reference 4).

The evaluation includes performing a structural analysis of the SRV piping and quencher 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).

The results of the structural analysis for each load are used to evaluate load combinations and fatigue effects for the SRVDL piping system and quencher in accordance with NUREG-0661 and the "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide" (PUAAG) (Reference 5). The analysis results are compared with the acceptance limits specified by the PUAAG and the applicable sections of the ASME Code (Reference 6) for Class 2 piping and piping supports.

The evaluation of the SRVDL vent line penetration for the effects of LOCA and SRV discharge-related loads is addressed in Volume 3 of this report.

5-1.2 Summary and Conclusions

An evaluation of the Monticello SRVDL piping and piping supports, and the T-quencher and T-quencher supports, has been performed for the modified systems described in Section 5-2.1.

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

Detailed structural models are developed and utilized in calculating the 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 SRVDL piping system stresses and associated component loads 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 Monticello 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, including evaluation of fatigue effects, 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 consists of four 18" 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, encircles the RPV, and passes through the drywell penetration before being anchored outside the primary containment.

The SRVDL piping system for Monticello consists of eight ASTM A-106, Grade B pipe lines. The nominal pipe size of the piping is 10" Schedule 40 at the outlet flange of the SRV, changing to 10" Schedule 80 as it passes through the jet deflector and 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 in the drywell. Figure 5-2.1-2 shows a typical wetwell SRVDL routing and supports.

The eight SRVDL's connect to the four MSL's at the safety relief valves (Figure 5-2.1-3). Two SRVDL's connect to each MSL (Figure 5-2.1-4). The lines are routed from the drywell area through the jet deflector and vent lines and into the suppression chamber (Figures 5-2.1-5, 5-2.1-6, and 5-2.1-7). Each of the eight vent lines contains one SRVDL. Each SRVDL also has an attached vacuum breaker valve connected to it (Figures 5-2.1-8, 5-2.1-9 and 5-2.1-10).

The SRV discharge lines exit the vent lines vertically through the vent line penetrations (VLP) for eight 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. Figures 5-2.1-6 and 5-2.1-7 show the routing of the SRVDL piping in the wetwell.

The support system for the SRV discharge lines in the drywell consists of snubbers, struts, and hangers which are connected to the drywell floor steel by means of intermediate steel framing. Figure 5-2.1-11 shows an example of an SRVDL support in the drywell.

The wetwell piping is connected to the 16" diameter, Schedule 160 lateral elbow support beam, which is located approximately 10 feet away from the quencher toward the center of the drywell.

The quencher support beam and elbow support beams are connected to the ring girder beams at the miter joints of the suppression chamber.

The SRV discharge T-quenchers provided for Monticello are the standard Mark I T-quenchers. A total of eight T-quenchers (with ramsheads) are located on the suppression chamber bay longitudinal centerline (Figure 5-2.1-4). Each T-quencher consists of a ramshead assembly and two quencher arms located 5'0" above the suppression chamber shell. The arms of the T-quenchers are aligned with the longitudinal axes of the suppression chamber mitered segments (Figure 5-2.1-4).

The quencher arms are constructed from 12" diameter, Schedule 80 stainless steel pipe, which is capped on the ends. Figure 5-2.1-12 shows the arrangement of the 0.391" diameter holes drilled in the quencher arms. The T-quenchers provide an effective means of mitigating air clearing loads during an SRV discharge.

The 10" diameter SRVDL piping is connected to the T-quencher ramsheads 1'1" off the centerline of the suppression chamber mitered segments. A 10" X 12" reducer is used to connect the SRVDL piping to the ramshead assembly. A typical ramshead assembly is constructed from 12" diameter short-radius elbows, reinforced with 1" thick gusset plates.

The ramshead assembly quencher arms are supported by a beam constructed from 14" diameter, Schedule 120 pipe. The quencher support beam is located approximately 1'6" directly below the quencher.

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 quencher arms to occur during SRV discharge.

Loads which are applied to the SRVDL piping system described above are presented in the following sections.

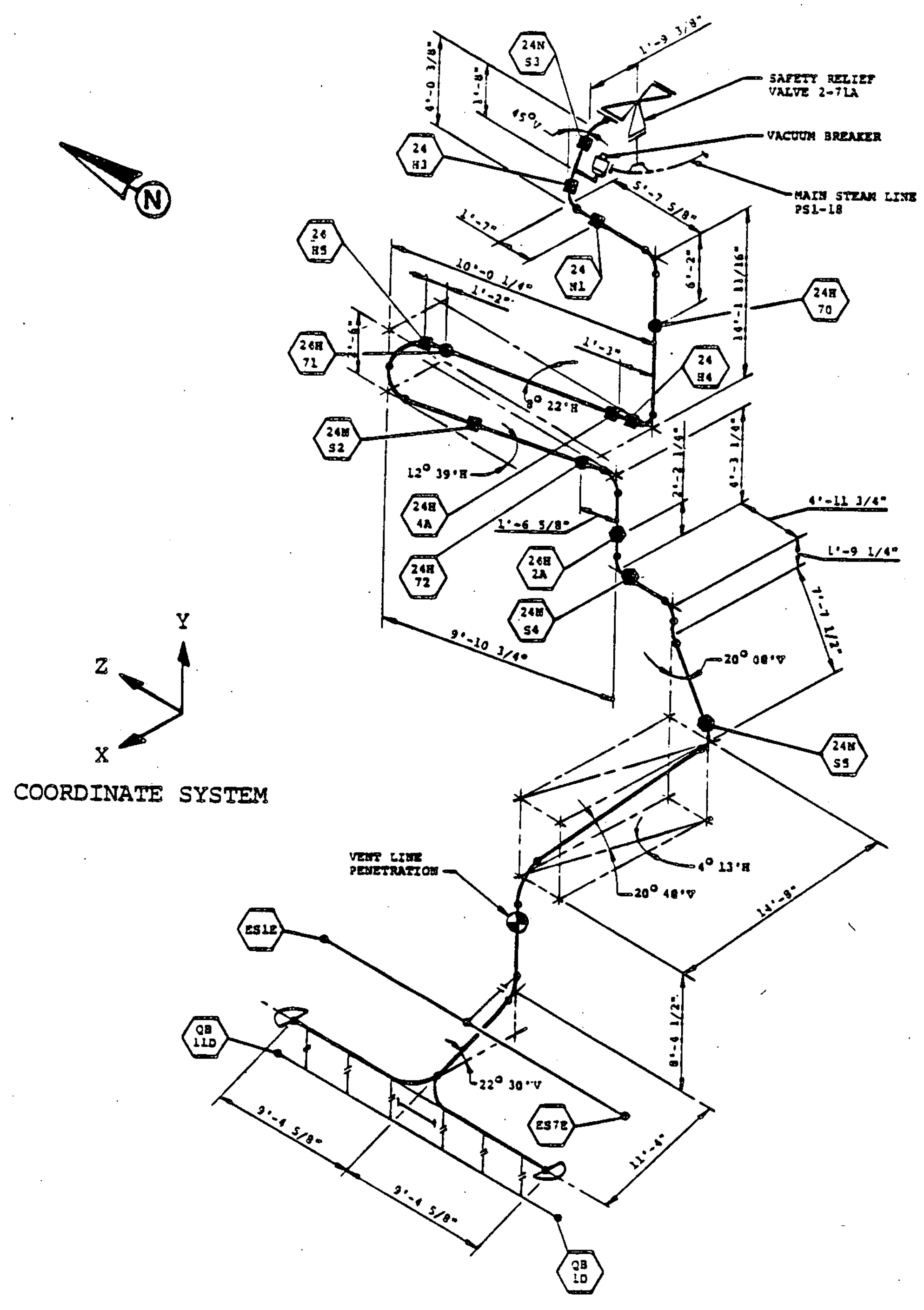


Figure 5-2.1-1

REPRESENTATIVE DRYWELL SRVDL ISOMETRIC AND SUPPORT LOCATIONS (LINE RV-24)

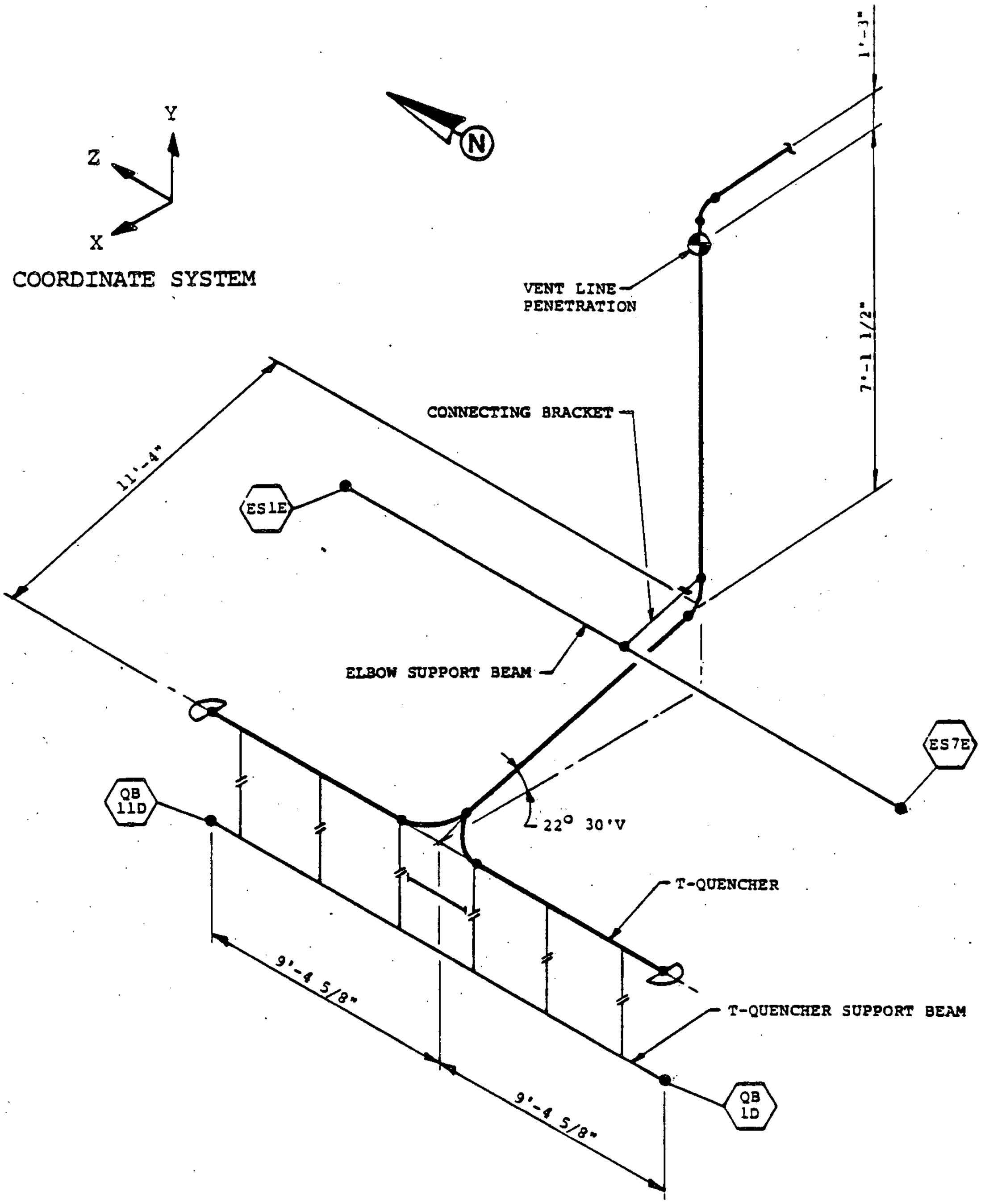


Figure 5-2.1-2

TYPICAL SRVDL WETWELL PIPING

ISOMETRIC AND SUPPORT LOCATIONS

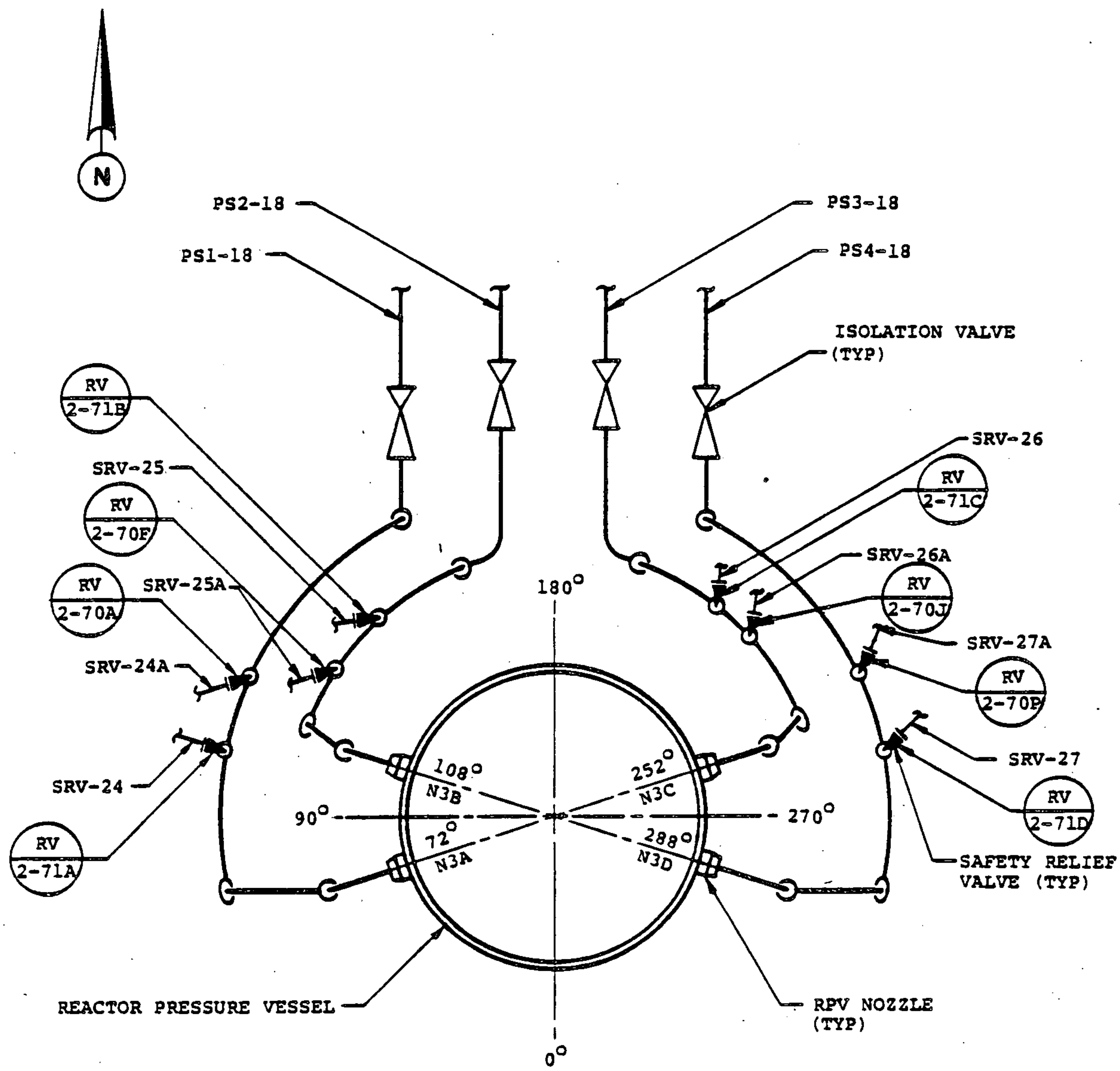


Figure 5-2.1-3

SAFETY RELIEF VALVE DISCHARGE LINE

AND MAIN STEAM LINE SCHEMATIC

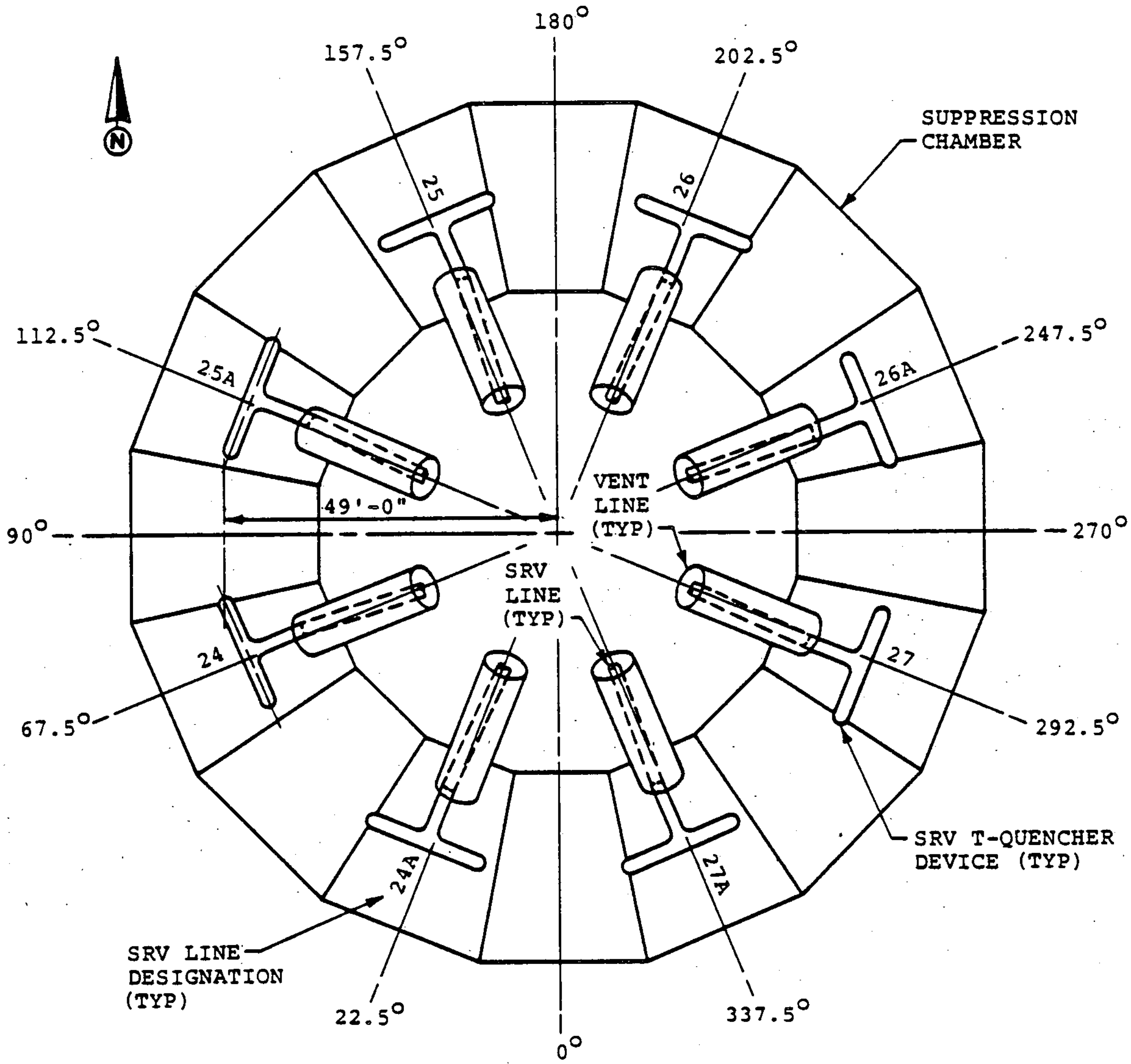
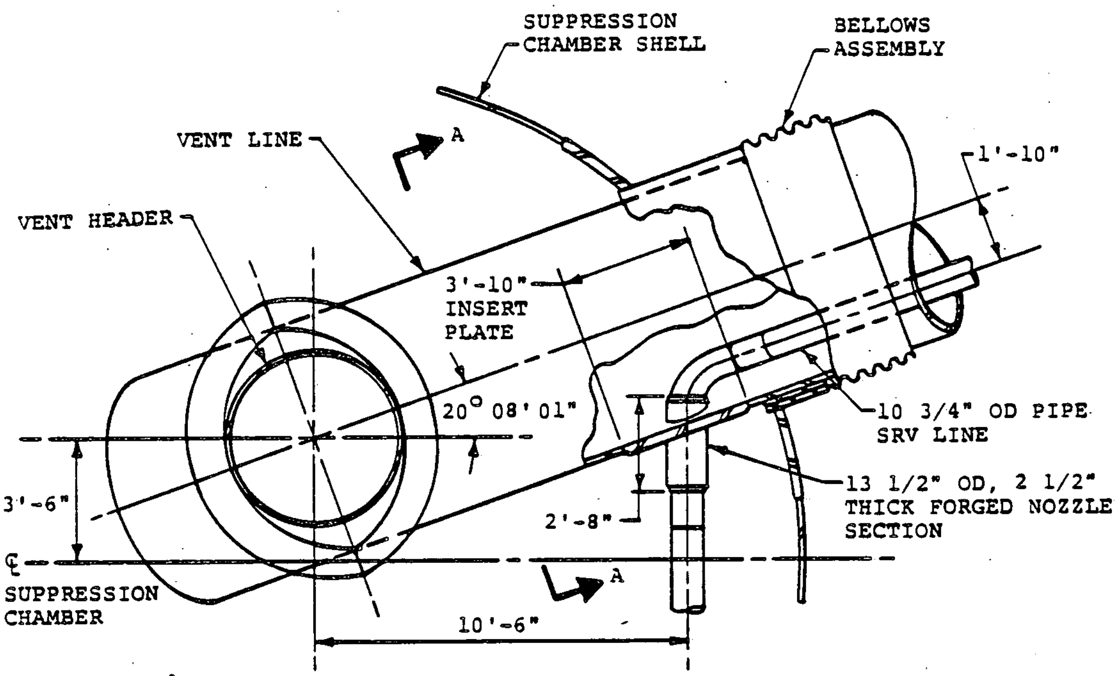
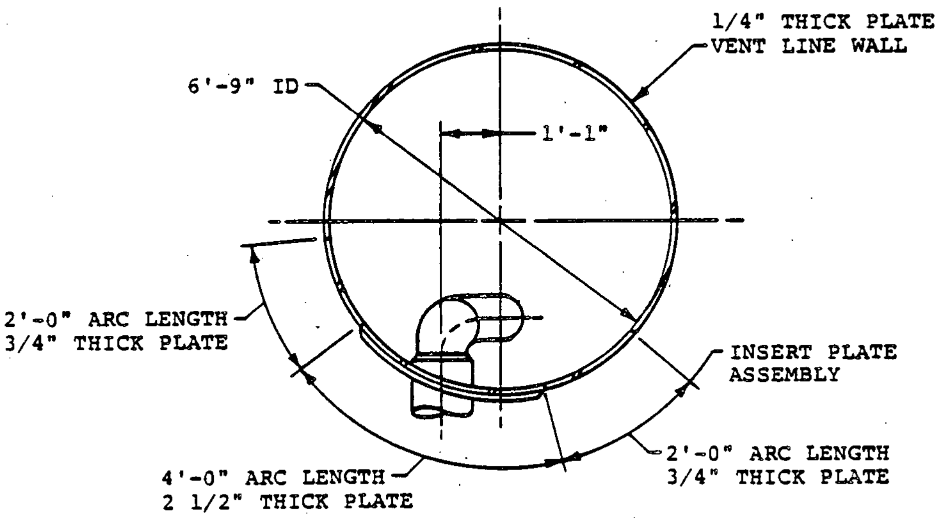


Figure 5-2.1-4

SRVDL LOCATIONS IN VENT LINES AND SUPPRESSION CHAMBER



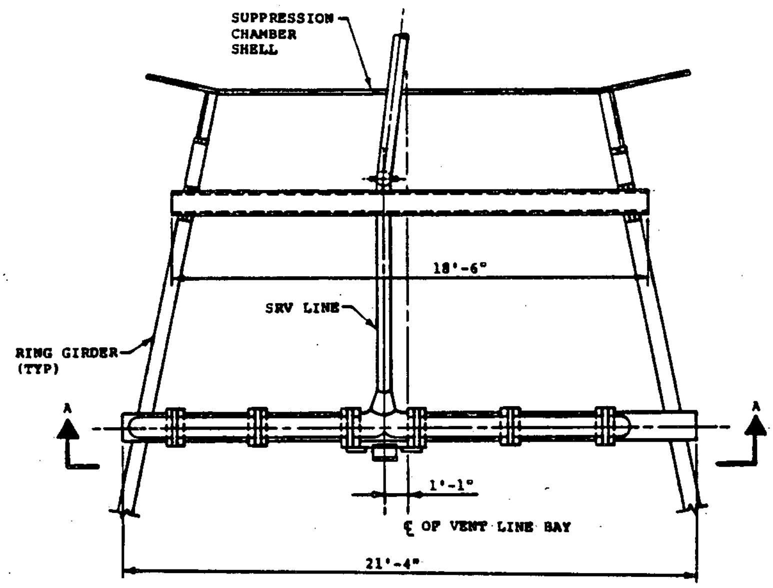
VENT LINE ELEVATION VIEW



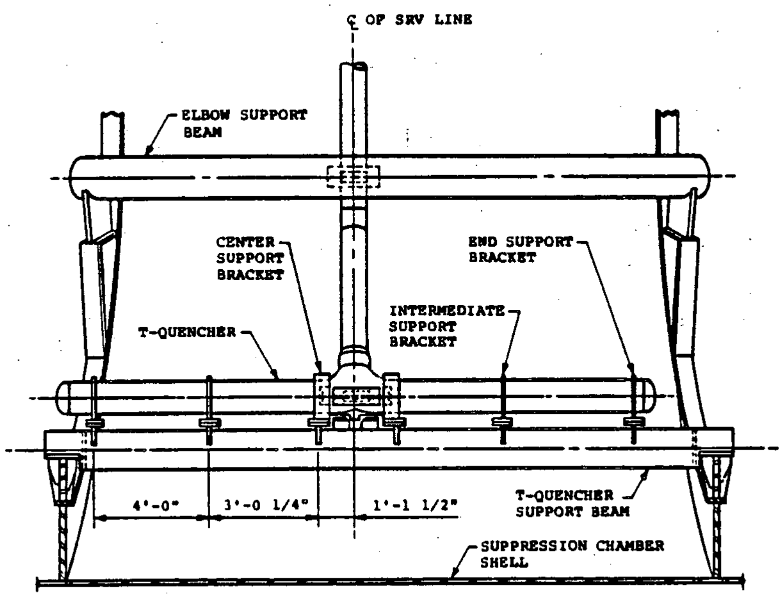
VIEW A-A

Figure 5-2.1-5

SRV-VENT LINE PENETRATION DETAILS



PLAN VIEW - VENT LINE BAY



SECTION A-A

Figure 5-2.1-6

T-QUENCHER AND WETWELL PIPE

ROUTING SUPPORT DETAILS

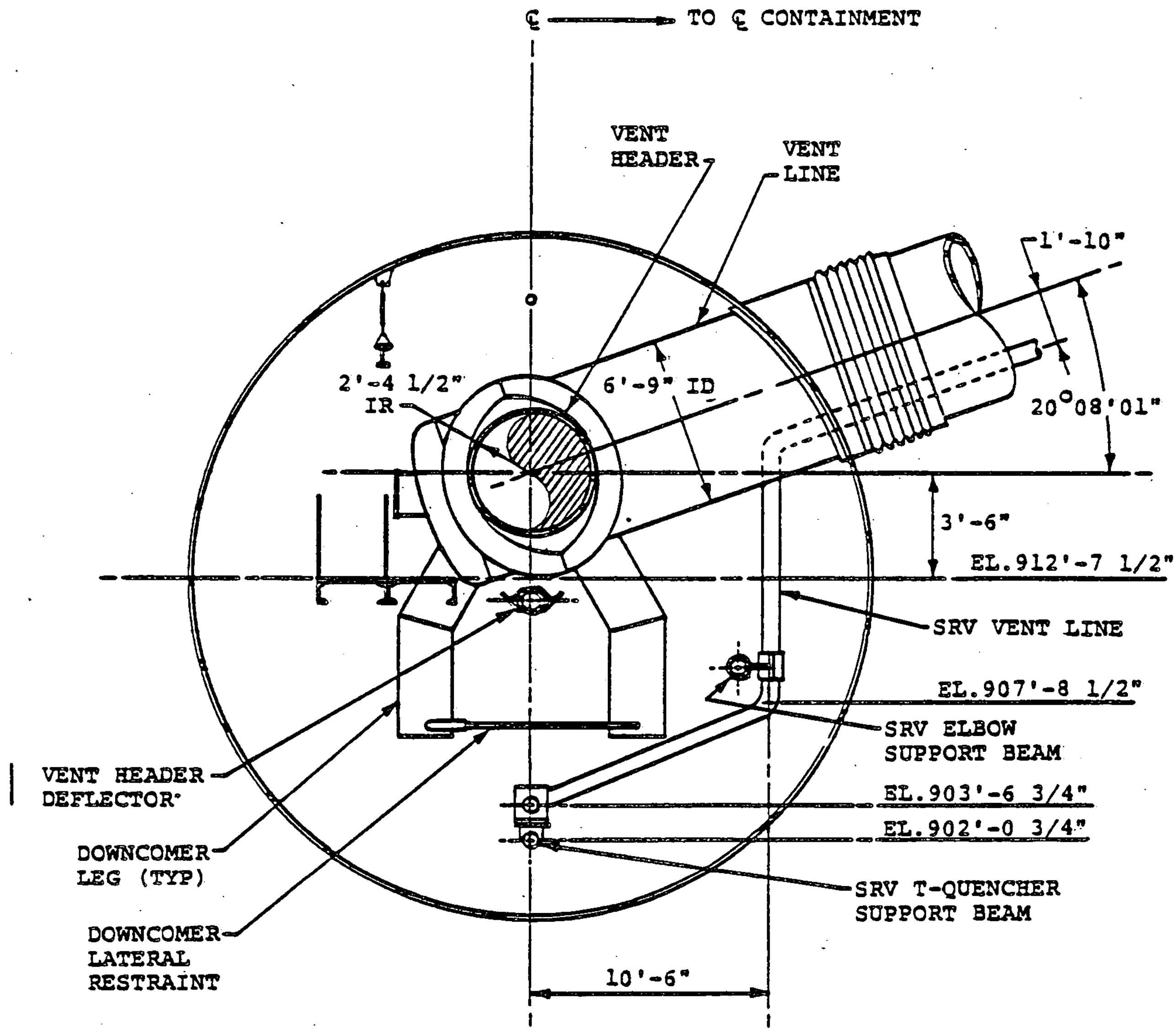


Figure 5-2.1-7

SUPPRESSION CHAMBER SECTION

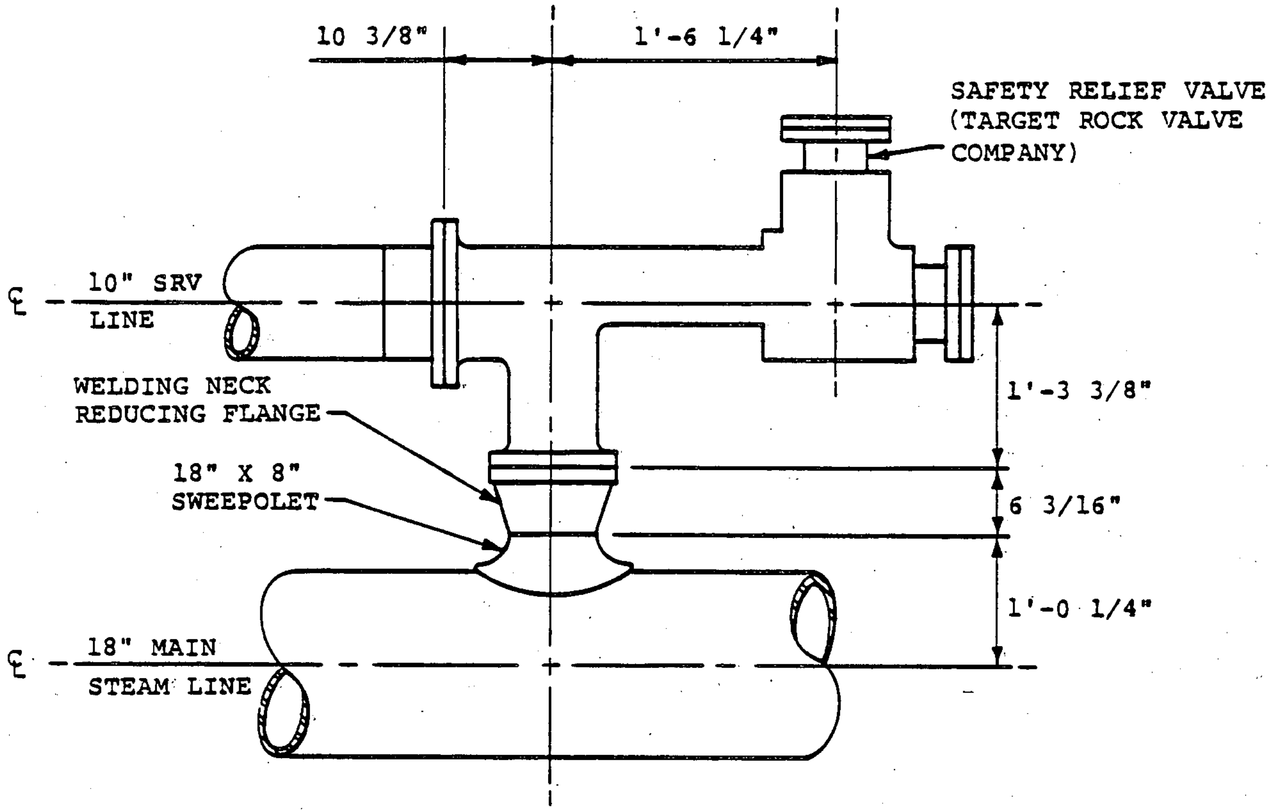


Figure 5-2.1-8

SAFETY RELIEF VALVE CONNECTION TO

SRVDL AND MSL PIPING

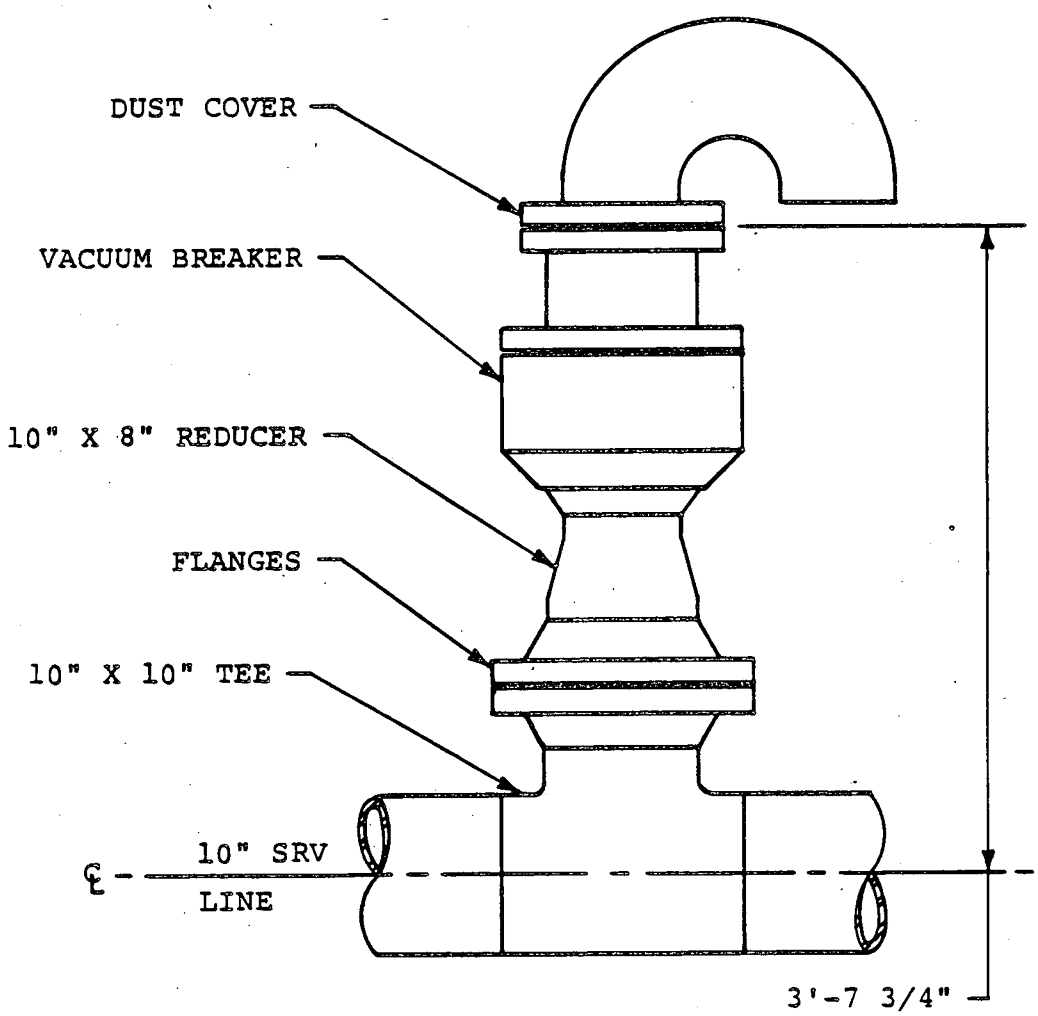


Figure 5-2.1-9

VACUUM BREAKER FOR SRV DISCHARGE LINES

25, 25A, 26, 26A, 27A

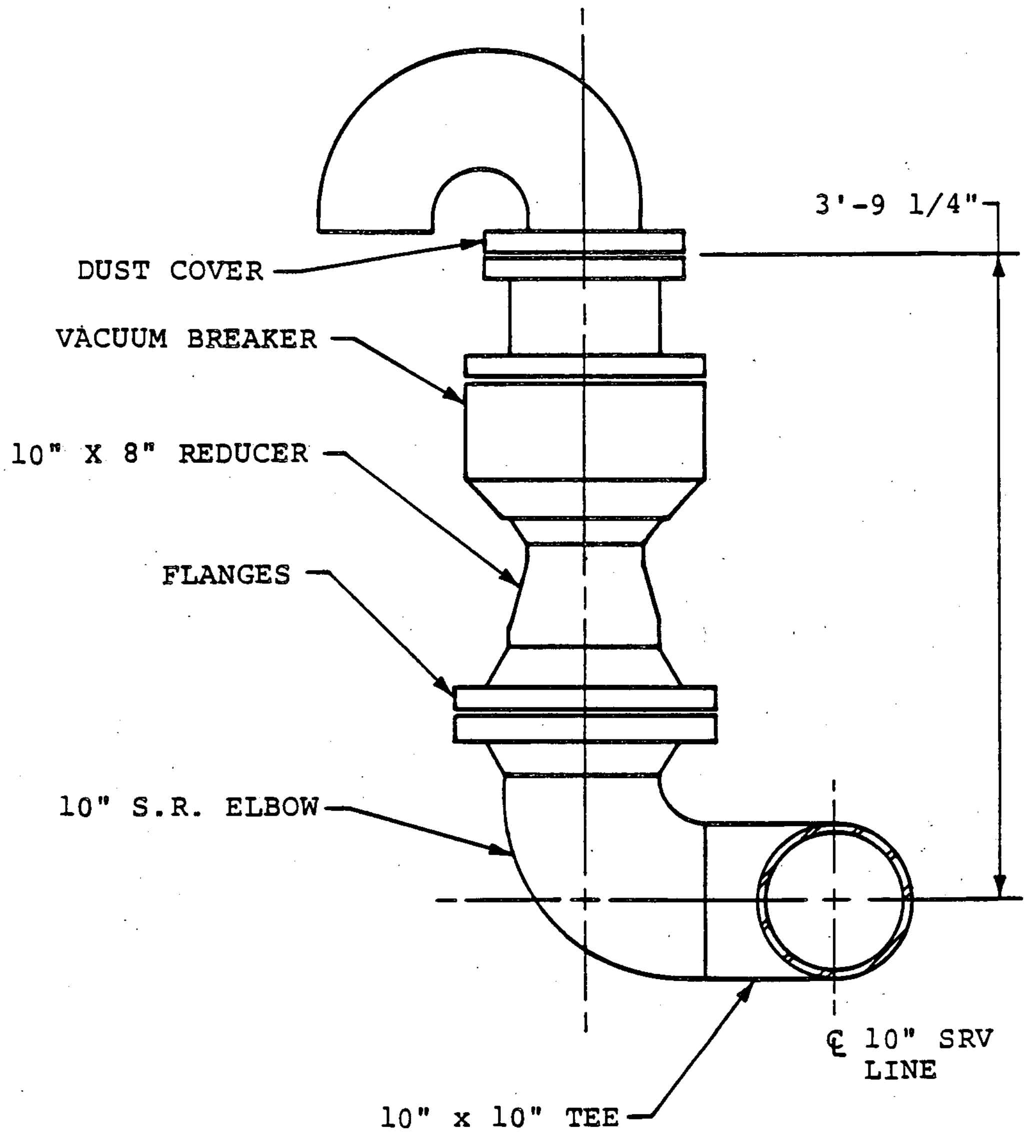


Figure 5-2.1-10

VACUUM BREAKER FOR SRV DISCHARGE LINES

24, 24A, 27

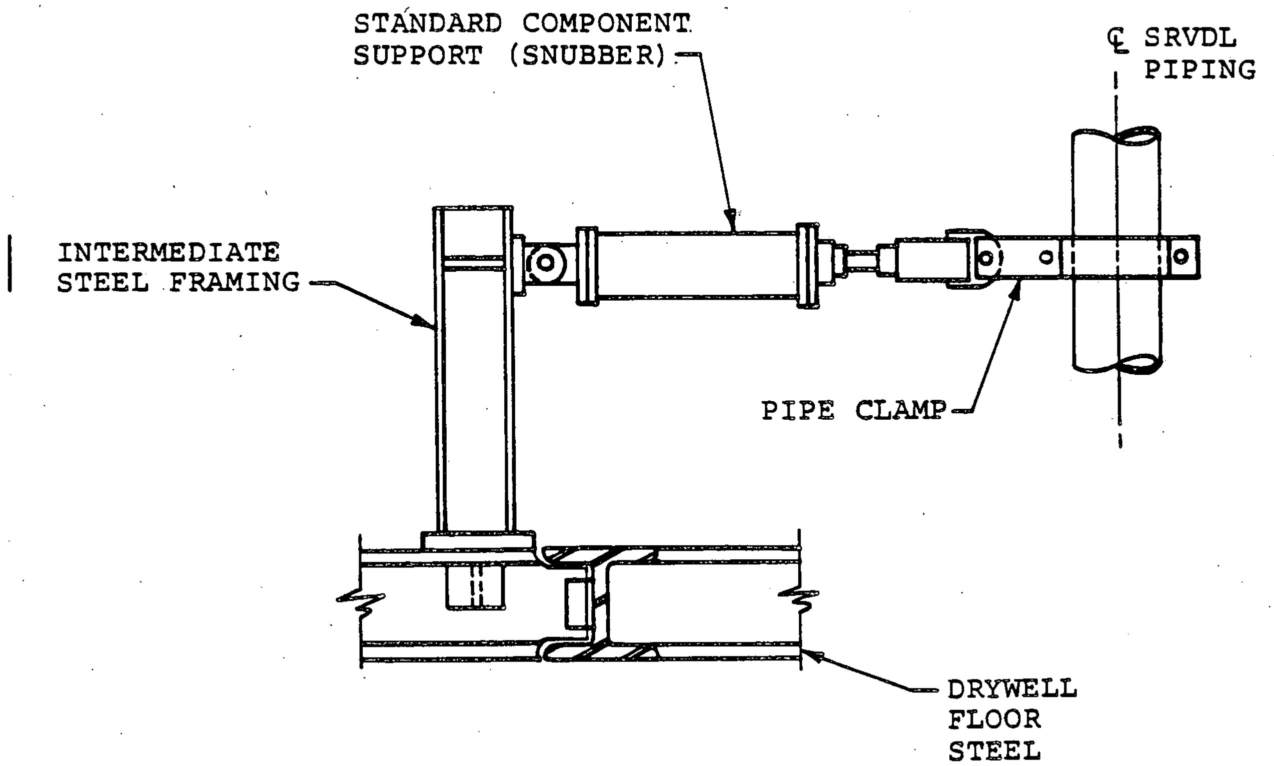
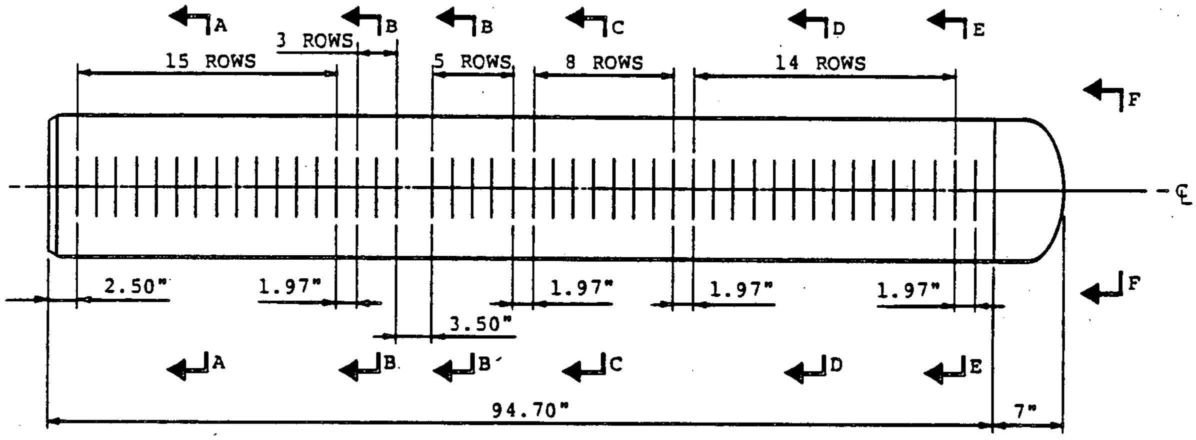
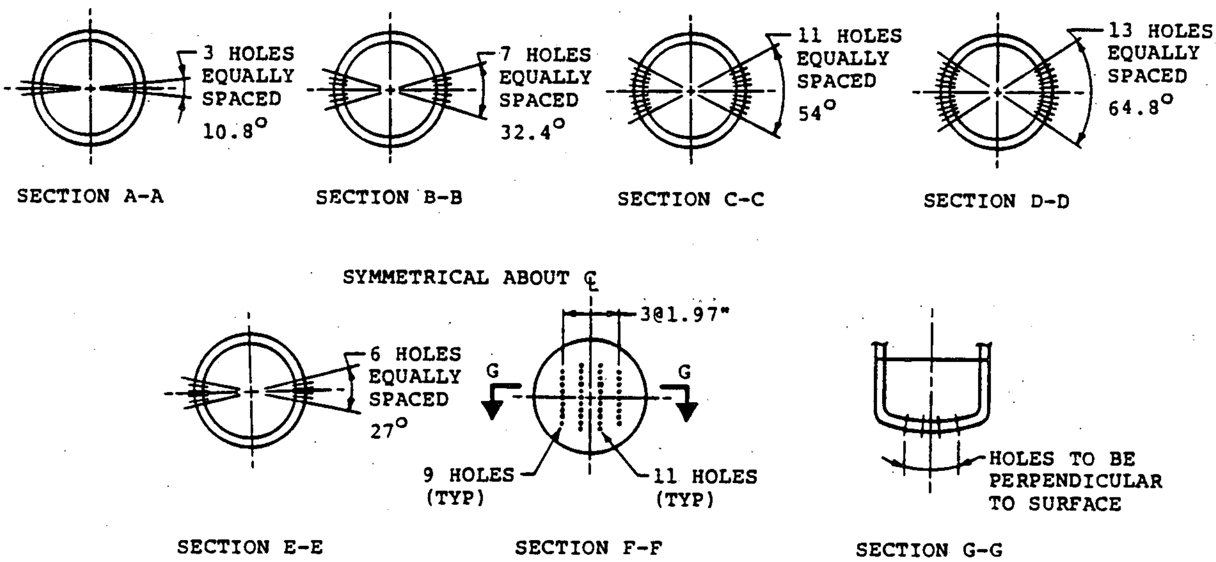


Figure 5-2.1-11

EXAMPLE OF AN SRVDL SUPPORT IN DRYWELL



TYPICAL T-QUENCHER ARM



1. ALL HOLE PATTERNS SYMMETRICAL ABOUT ℄.
2. ALL HOLES 0.391" IN DIAMETER.
3. SPACINGS NOT NOTED ARE 1.97".
4. T-QUENCHER ARM WITHOUT HOLES IS 12" DIA, SCH 80 PIPE.

Figure 5-2.1-12

T-QUENCHER ARM HOLE PATTERNS

5-2.2 Loads and Load Combinations

The loads for which the Monticello SRVDL piping is designed are defined in NUREG-0661 on a generic basis for all Mark I plants. The methodology used to develop plant unique SRVDL 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 SRVDL piping are discussed and presented in Section 5-2.2.1.

The governing load combinations which affect the SRV piping are formulated using the event combinations and event sequencing defined in NUREG-0661 and 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 Weight Loads
2. Seismic Loads
3. Pressure and Temperature Loads
4. Safety Relief 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 Torus Interaction Loads

Loads in Categories 1 through 3 are considered in the piping design as documented in the FSAR (Reference 4). Category 3 pressure and temperature loads result from postulated LOCA and SRV discharge events. Loads in Category 4 result from SRV 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 torus.

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. The loads are referred to as governing loads in the following sections.

The magnitudes and characteristics obtained using the methodology discussed in Section 1-4.0 for the governing loads in each category 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 SRVDL piping system.

1. Dead Weight Loads

    a. Dead Weight (DW) Loads: These loads are defined as the uniformly distributed weight of the pipe and the concentrated weight of piping supports, hardware attached to piping, vacuum breakers, SRV's, and flanges. Also included is the weight of water contained in the wetwell SRVDL piping and quenchers corresponding to a torus water level of 3'4" below the torus horizontal centerline.

b. Dead Weight (DW_T) Loads: 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) Loads: 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 FSAR. Horizontal building response spectra at various elevations representing piping attachment points for the drywell and RPV are enveloped to develop the N-S and E-W directions OBE_I input (Figure 5-2.2-1). The vertical direction seismic input specified in the FSAR is a constant 0.04g acceleration.

b. SSE Inertia (SSE_I) Loads: The horizontal and vertical SSE inertia loads specified in the FSAR are twice the corresponding OBE inertia loads.

3. Pressure and Temperature Loads

a. Pressure (P_O, P) Loads: 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) Loads: 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.

- THAM1 - Piping thermal anchor movement, Normal Operating Conditions without SRV actuation,
- THAM2 - Piping thermal anchor movement, Normal Operating Conditions with SRV actuation
- 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) Loads: 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 A1.2). The governing SRV actuation cases are categorized and designated as follows.

- o RV1A - SRVDL piping thrust loads for Normal Operating Conditions, first actuation (Case A1.1).

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 Normal Operating Conditions, subsequent actuation (Case C3.1). This includes the set of loadings for both lines attached to one main steam line.
- RV1C - SRVDL piping thrust loads, for SBA/IBA conditions, first actuation (Case A1.2). This includes the set of loadings for both lines attached to one main steam line. SRVDL piping thrust loads for SBA/IBA conditions, subsequent actuation, (Cases C3.2 and C3.3) are bounded by Case A1.2.

Figures 5-2.2-2 through 5-2.2-4 show typical SRV thrust force time-history plots for line RV-24 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. SRV T-quencher Discharge (QAB) Loads: 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.

- 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.

- 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 (Figure 5-2.2-5). The results are evaluated to determine the controlling loads. Table 5-2.2-5 shows the magnitudes and distribution of drag pressures acting on 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) loads: 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.

a. Impact and Drag Loads: During the initial phase of a DBA event, transient pressures are postulated to act on the horizontal projection of the SRV discharge lines. The procedure used is discussed in Section 1-4.1.4. Table 5-2.2-7 shows a sampling of pool swell impact and drag loads for selected segments of the SRVDL (Figure 5-2.2-6). The results shown are based on plant unique QSTF test data contained in the PULD (Reference 3).

b. Pool Fallback Loads: During the later phase of pool swell, transient pressures are postulated to act on the horizontal projection of the SRV discharge lines. The procedure used is discussed in Section 1-4.1.4. Table 5-2.2-8 shows a sampling of pool fallback drag loads for selected segments of the SRVDL piping (Figure 5-2.2-6). The results shown include the effects of maximum pool displacements measured in plant unique QSTF tests.

6. Condensation Oscillation Loads

Condensation Oscillation (CO) Loads: 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 5-2.2-9 and 5-2.2-10 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, torus shell FSI acceleration drag, interference effects, wall effects, and acceleration drag volumes. Figure 5-2.2-7 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) Loads: 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 5-2.2-11 shows the resulting load acting on the wetwell piping, T-quencher, and related support structures.

b. Post-Chug (CHUG) Loads: 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 5-2.2-12 and 5-2.2-13 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, torus shell FSI acceleration drag, interference effects, wall effects, and acceleration drag volumes. Figure 5-2.2-7 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.

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 supports structures. These loads are categorized as follows.

a. LOCA Water Jet Impingement Loads: 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 5-2.2-14 shows the resulting magnitudes and distributions 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 Loads: 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 5-2.2-14 shows the resulting distribution and magnitudes 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 Torus Interaction Loads

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

b. Torus Interaction Loads: 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.

- o 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

- o 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

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

All of the interaction loads listed above are derived from the structural response analyses of the vent system and torus, 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 WEIGHT	1a	(1)
	1b	(1)
SEISMIC	2a	(1)
	2b	(1)
PRESSURE AND TEMPERATURE	3a	1-4.1.1
	3b	1-4.1.1
SRV DISCHARGE	4a	1-4.2.2
	4b	1-4.2.4
POOL SWELL	5a,5b	1-4.1.4.2, 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 MONTICELLO FSAR (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	WITH SRV ACTUATION	DESIGN
MAIN STEAM	1,025	1,110	550	550	582
SRVDL (DRYWELL)	500	500	MAX 292 MIN 135	375	400
SRVDL (WETWELL)	425	500	MAX 269 MIN 60	375	400
T-QUENCHER	680	800	MAX 120 MIN 60	370	400

Table 5-2.2-3

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

LINE NUMBER	SEGMENT IDENTIFICATION NUMBER (Figure 5-2.4-8)											
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12
24	0.79	2.32	3.81	8.61	7.12	10.80	14.90	17.90	22.80	23.50	20.20	-
24A	2.02	4.41	7.81	5.81	6.35	6.85	7.48	9.42	12.90	13.90	21.10	35.10
25	4.32	3.92	5.27	6.95	7.24	14.20	19.20	35.60	11.30	6.85	6.80	10.50
25A	4.18	3.74	6.20	6.39	4.92	6.70	6.98	9.22	10.60	7.48	-	-
26	4.40	3.82	5.15	6.96	7.52	14.50	19.40	36.30	37.30	21.50	12.40	4.50
26A	4.75	4.60	8.33	6.60	7.66	6.56	8.02	10.30	7.04	-	-	-
27	0.90	1.76	3.33	5.78	7.14	8.26	6.35	6.72	5.58	5.39	6.62	7.80
27A	2.08	4.87	3.00	9.55	7.10	7.77	20.20	38.20	11.20	3.08	-	-

Table 5-2.2-4

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

LINE NUMBER	SEGMENT IDENTIFICATION NUMBER (Figure 5-2.4-8)	
	W_1	W_2
24	31.73	-94.02
24A	36.25	-91.84
25	6.49	-94.12
25A	9.51	-98.38
26	4.48	-93.30
26A	9.21	-101.20
27	7.37	-97.41
27A	6.29	-90.96

Table 5-2.2-5

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

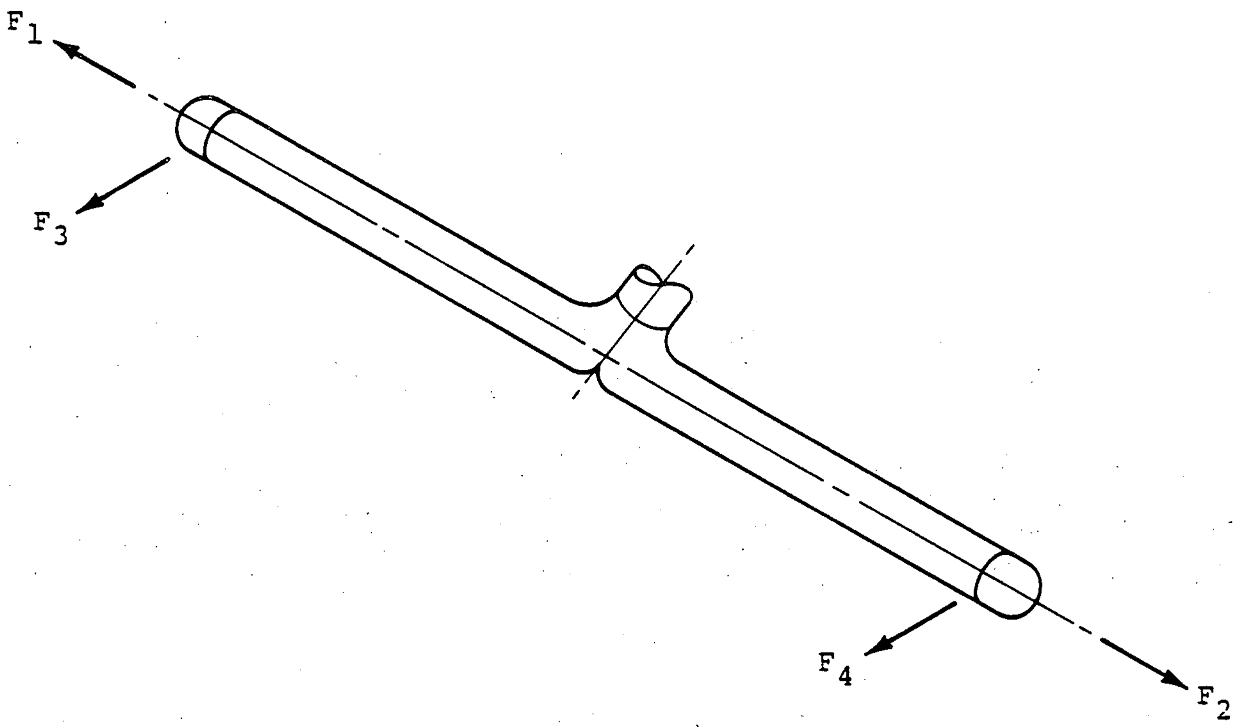
ITEM	SEGMENT NUMBER (1)	SRV BUBBLE DRAG LOAD PRESSURE (psi)(2)			SRV WATER JET PRESSURE (psi)(2)		
		P_x	P_y	P_z	P_x	P_y	P_z
SRVDL PIPING	2	0.54	0	0	0	0	0
	6	1.72	4.13	0	0	0	0
	8	1.80	4.31	0	0	0	0
	10	1.88	4.50	0	0	0	0
	15	2.20	5.28	0	0	0	0
T-QUENCHER	19	45.77	10.96	0	0	0	0
	21	28.14	6.36	0	0	0	0
	23	8.34	4.48	0	0	0	0
	25	4.37	4.63	0	0	0	0
ELBOW SUPPORT BEAM	26	1.72	11.28	0	0	0	0
	28	2.28	11.83	0	0	0	0
	30	3.56	12.19	0	0	0	0
	32	2.84	10.89	0	0	13.52	0
T-QUENCHER SUPPORT BEAM	35	8.50	1.56	0	0	0	0
	37	22.02	9.57	0	0	0	0
	39	28.11	14.15	0	0	0	0
	41	11.19	3.56	0	0	0	0
CONNECTING BRACKET	44	0	0	27.08	0	0	0
	45	0	0	21.81	0	0	0
	46	0	0	4.64	0	0	0

(1) SEE FIGURE 5-2.2-5 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 (kip)
F_1	180.20
F_2	196.20
F_3	46.60
F_4	46.60

1. LOADS SHOWN INCLUDE DLF'S.

Table 5-2.2-7

POOL SWELL IMPACT AND DRAG
LOADS ON SRV PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER[1]	PRESSURE (psi)[2]		
		P_x	P_y	P_z
SRVDL PIPING	2	0	0	0
	6	0	13.18	0
	8	0	0	0
	10	0	0	0
	15	0	0	0
T-QUENCHER	20	0	0	0
	22	0	0	0
	24	0	0	0
	26	0	0	0
ELBOW SUPPORT BEAM	27	0	17.02	0
	29	0	14.66	0
	31	0	12.56	0
	33	0	10.72	0
T-QUENCHER SUPPORT BEAM	37	0	0	0
	39	0	0	0
	41	0	0	0
	43	0	0	0
CONNECTING BRACKET	44	0	0	0
	45	0	0	0
	46	0	0	0

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

(2) LOADS SHOWN INCLUDE DLF's.

Table 5-2.2-8

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
	6	0	-6.88	0
	8	0	0	0
	10	0	0	0
	15	0	0	0
T-QUENCHER	20	0	0	0
	22	0	0	0
	24	0	0	0
	26	0	0	0
ELBOW SUPPORT BEAM	27	0	-5.89	0
	29	0	-5.65	0
	31	0	-5.31	0
	33	0	-4.90	0
T-QUENCHER SUPPORT BEAM	37	0	0	0
	39	0	0	0
	41	0	0	0
	43	0	0	0
CONNECTING BRACKET	44	0	0	0
	45	0	0	0
	46	0	0	0

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

(2) LOADS SHOWN INCLUDE DLF's.

Table 5-2.2-9

DBA CONDENSATION OSCILLATION SUBMERGED
STRUCTURE LOADS FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT(2) NUMBER	NORMALIZED(1) FORCE $\left(\frac{lbf}{ft^3/sec^2}\right)$		
		P_x	P_y	P_z
SRVDL PIPING	2	0.692	0	0.309
	6	0.807	0.364	0.299
	8	0.731	0.330	0.630
	10	0.710	0.296	0.945
	15	0.677	0.307	0.599
T-QUENCHER	20	0.987	0.619	0.986
	22	0.909	0.664	0.909
	24	0.700	0.667	0.700
	26	0.627	0.676	0.627
ELBOW SUPPORT BEAM	27	0.859	0.972	0.859
	29	1.0	1.0	1.0
	31	0.911	0.992	0.828
	33	1.0	1.0	1.0
T-QUENCHER SUPPORT BEAM	37	0.950	0.832	0.950
	39	1.0	0.961	1.0
	41	1.0	1.0	1.0
	43	1.0	1.0	1.0
CONNECTING BRACKET	44	0.780	0	0.735
	45	1.0	0	0.902
	46	0.672	0	1.0

(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 5-2.2-6 FOR LOCATION OF SEGMENT NUMBERS.

Table 5-2.2-10

AMPLITUDES AT VARIOUS FREQUENCIES FOR DBA CONDENSATION OSCILLATION

FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)	FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)
0-1	12.19	25-26	71.63
1-2	10.55	26-27	103.13
2-3	13.59	27-28	19.26
3-4	20.58	28-29	29.64
4-5	80.70	29-30	21.84
5-6	120.00	30-31	10.37
6-7	44.40	31-32	3.47
7-8	26.99	32-33	3.56
8-9	27.66	33-34	3.26
9-10	28.80	34-35	6.39
10-11	38.70	35-36	10.12
11-12	22.00	36-37	11.51
12-13	10.90	37-38	7.15
13-14	7.63	38-39	5.95
14-15	4.94	39-40	9.37
15-16	7.08	40-41	35.71
16-17	3.44	41-42	34.72
17-18	4.93	42-43	34.69
18-19	4.36	43-44	34.38
19-20	45.41	44-45	33.18
20-21	59.66	45-46	32.87
21-22	176.31	46-47	32.07
22-23	117.94	47-48	31.37
23-24	107.43	48-49	30.96
24-25	71.16	49-50	29.97

Table 5-2.2-11

PRE-CHUG SUBMERGED STRUCTURE LOADS
FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER(3)	NORMALIZED(1,2) FORCE $\left(\frac{lbf}{ft^3/sec^2}\right)$		
		P_x	P_y	P_z
SRVDL PIPING	2	-0.008	0	-0.003
	6	0	-0.110	-0.016
	8	0	-0.099	-0.030
	10	0	-0.086	-0.044
	15	0	-0.064	-0.032
T-QUENCHER	20	0.075	0.022	0
	22	0.049	-0.010	0
	24	0.035	0.076	0
	26	0.030	-0.108	0
ELBOW SUPPORT BEAM	27	-0.267	-0.777	0
	29	-0.203	-0.650	0
	31	-0.107	-0.530	0
	33	-0.058	-0.470	0
T-QUENCHER SUPPORT BEAM	37	0.085	0.051	0
	39	0.061	0.019	0
	41	0.046	-0.038	0
	43	0.040	-0.070	0
CONNECTING BRACKET	44	0.114	0	-0.075
	45	0.062	0	-0.149
	46	0.039	0	-0.109

(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 HERTZ.

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

Table 5-2.2-12

POST-CHUG SUBMERGED STRUCTURE LOADS

FOR SRVDL PIPING AND SUPPORTS

ITEM	SEGMENT NUMBER (2)	NORMALIZED (1) FORCE $\left(\frac{lbf}{ft^3/sec^2}\right)$		
		P_x	P_y	P_z
SRVDL PIPING	2	0.259	0	0.293
	6	0.127	0.413	0.161
	8	0.147	0.378	0.239
	10	0.159	0.358	0.241
	15	0.166	0.403	0.235
T-QUENCHER	20	0.559	0.765	0.918
	22	0.542	0.732	0.877
	24	0.427	0.761	0.690
	26	0.339	0.773	0.549
ELBOW SUPPORT BEAM	27	0.284	0.966	0.491
	29	0.295	0.987	0.509
	31	0.129	1.0	0.222
	33	0.136	1.0	0.184
T-QUENCHER SUPPORT BEAM	37	0.585	0.892	0.952
	39	0.623	0.966	1.0
	41	0.584	0.992	0.947
	43	0.528	1.0	0.865
CONNECTING BRACKET	44	0.667	0	0.680
	45	1.0	0	1.0
	46	0.481	0	0.478

(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 5-2.2-10.

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

Table 5-2.2-13

AMPLITUDES AT VARIOUS FREQUENCIES

FOR POST-CHUG LOADS

FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)	FREQUENCY (Hz)	AMPLITUDE (ft^3/sec^2)
0-1	7.56	25-26	198.67
1-2	7.56	26-27	241.16
2-3	6.54	27-28	160.30
3-4	6.23	28-29	103.89
4-5	10.99	29-30	74.23
5-6	10.74	30-31	27.41
6-7	11.94	31-32	13.73
7-8	11.94	32-33	24.06
8-9	11.95	33-34	32.03
9-10	11.98	34-35	26.95
10-11	55.54	35-36	39.14
11-12	48.12	36-37	26.62
12-13	26.01	37-38	13.33
13-14	22.78	38-39	15.56
14-15	4.39	39-40	18.66
15-16	4.00	40-41	142.51
16-17	2.04	41-42	142.56
17-18	2.70	42-43	142.50
18-19	1.93	43-44	142.50
19-20	11.03	44-45	142.46
20-21	11.51	45-46	142.46
21-22	28.40	46-47	142.46
22-23	59.18	47-48	142.35
23-24	59.12	48-49	142.36
24-25	85.59	49-50	142.51

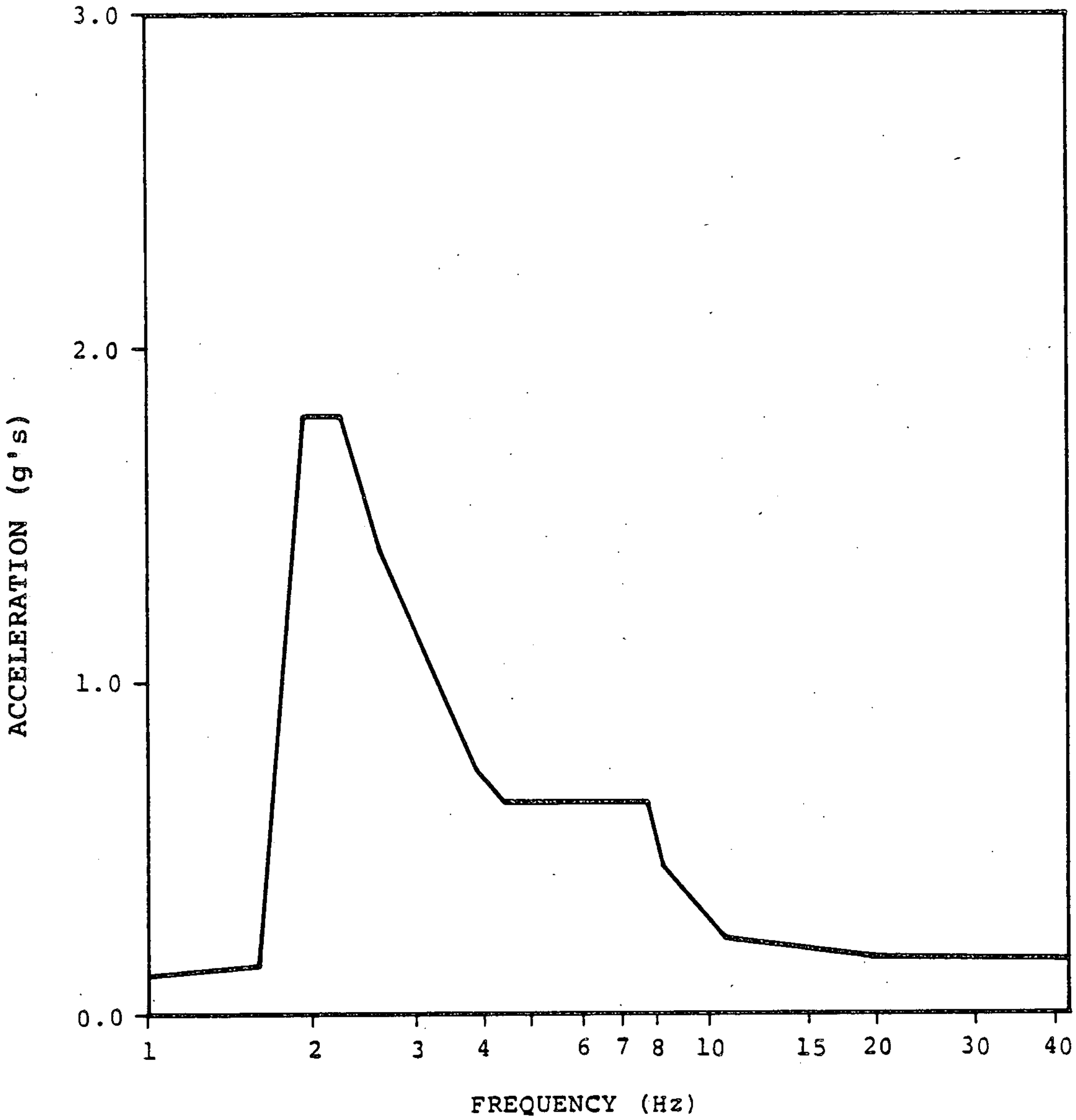
Table 5-2.2-14

LOCA WATER JET IMPINGEMENT AND AIR BUBBLE DRAG LOADS FOR T-QUENCHER AND SRVDL PIPING

ITEM	SEGMENT NUMBER(1)	WATER JET IMPINGEMENT PRESSURE (psi)(2)			AIR BUBBLE DRAG PRESSURE (psi)(2)		
		P_x	P_y	P_z	P_x	P_y	P_z
SRVDL PIPING	2	0	0	0	0.19	0	-0.06
	6	0	0	0	-1.03	2.49	-0.33
	8	-0.28	0.70	-0.53	-0.98	2.36	-0.63
	10	-0.38	0.93	-0.84	-0.90	2.18	-1.01
	15	-0.50	1.23	-0.95	-0.74	1.79	-0.92
T-QUENCHER	20	0.61	8.61	0	-0.51	-0.13	0
	22	0.22	6.66	0	-0.25	0.58	0
	24	0.11	3.44	0	-0.19	1.72	0
	26	-0.08	2.27	0	-0.18	2.25	0
ELBOW SUPPORT BEAM	27	0	0	0	2.18	7.97	0
	29	0	0	0	1.79	6.97	0
	31	0	0	0	1.06	5.87	0
	33	0	0	0	0.65	5.28	0
T-QUENCHER SUPPORT BEAM	37	-0.27	10.75	0	-0.62	-0.90	0
	39	-0.12	8.57	0	-0.37	-0.40	0
	41	-0.09	3.96	0	-0.27	0.70	0
	43	-0.08	2.60	0	-0.25	1.27	0
CONNECTING BRACKET	44	0	0	0.18	0	0	-0.59
	45	0	0	-3.72	0	0	-3.53
	46	0	0	-2.21	0	0	-2.81

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

(2) LOADS SHOWN INCLUDE DLF's.



1. USE OBE VERTICAL ACCELERATION OF 0.04g.
2. ENVELOPE OF ELEVATION 999'0" FOR REACTOR PRESSURE VESSEL AND ELEVATION UP TO & INCLUDING 985'6" FOR DRYWELL.

Figure 5-2.2-1

ACCELERATION RESPONSE SPECTRA ENVELOPE

FOR OBE IN N-S AND E-W DIRECTIONS, 1/2% DAMPING

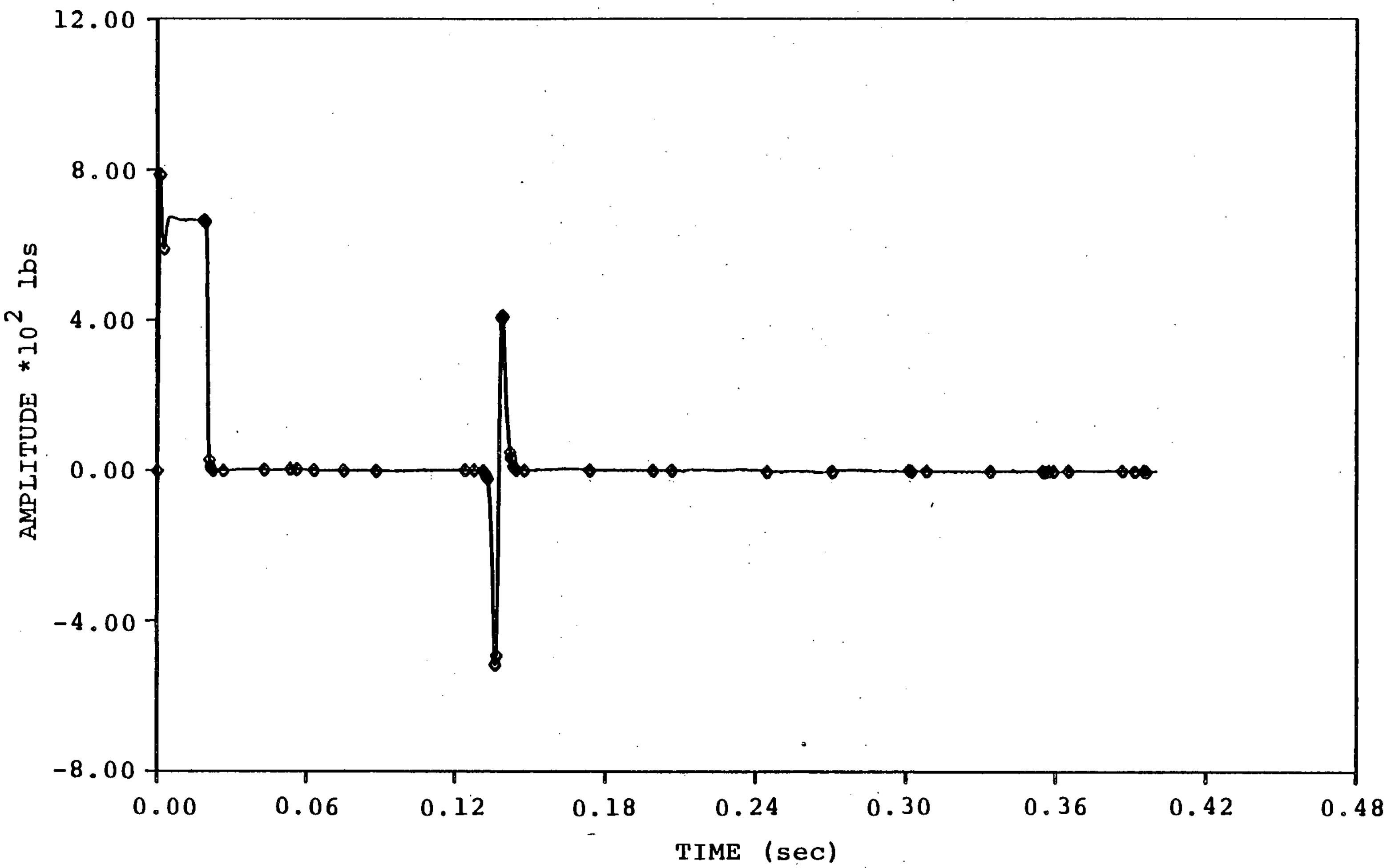


Figure 5-2.2-2

LINE RV-24-SRV DISCHARGE (CASE C3.1) FORCE

TIME-HISTORY AT SEGMENT D1

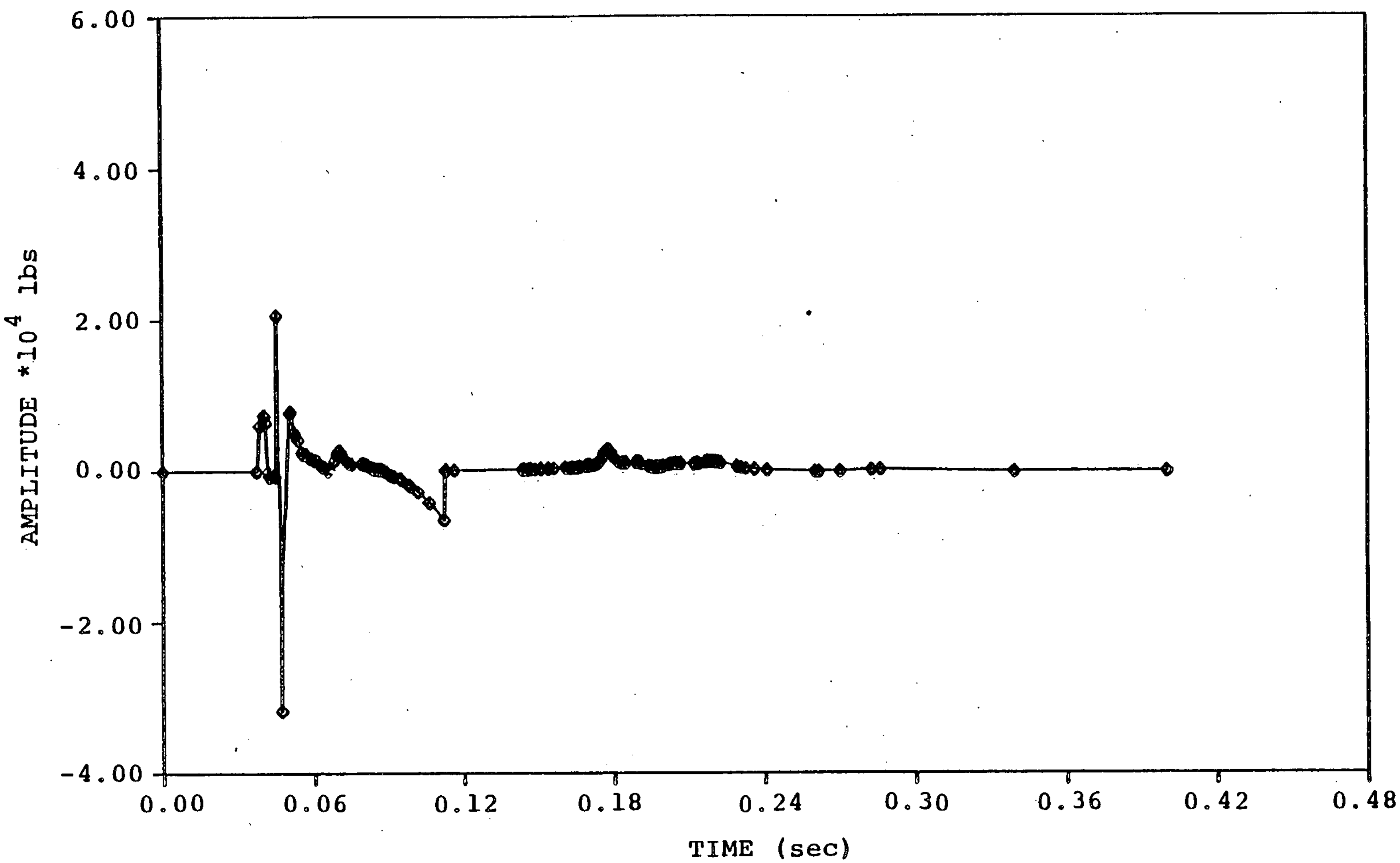


Figure 5-2.2-3

LINE RV-24-SRV DISCHARGE (CASE C3.1) FORCE

TIME-HISTORY AT SEGMENT W1

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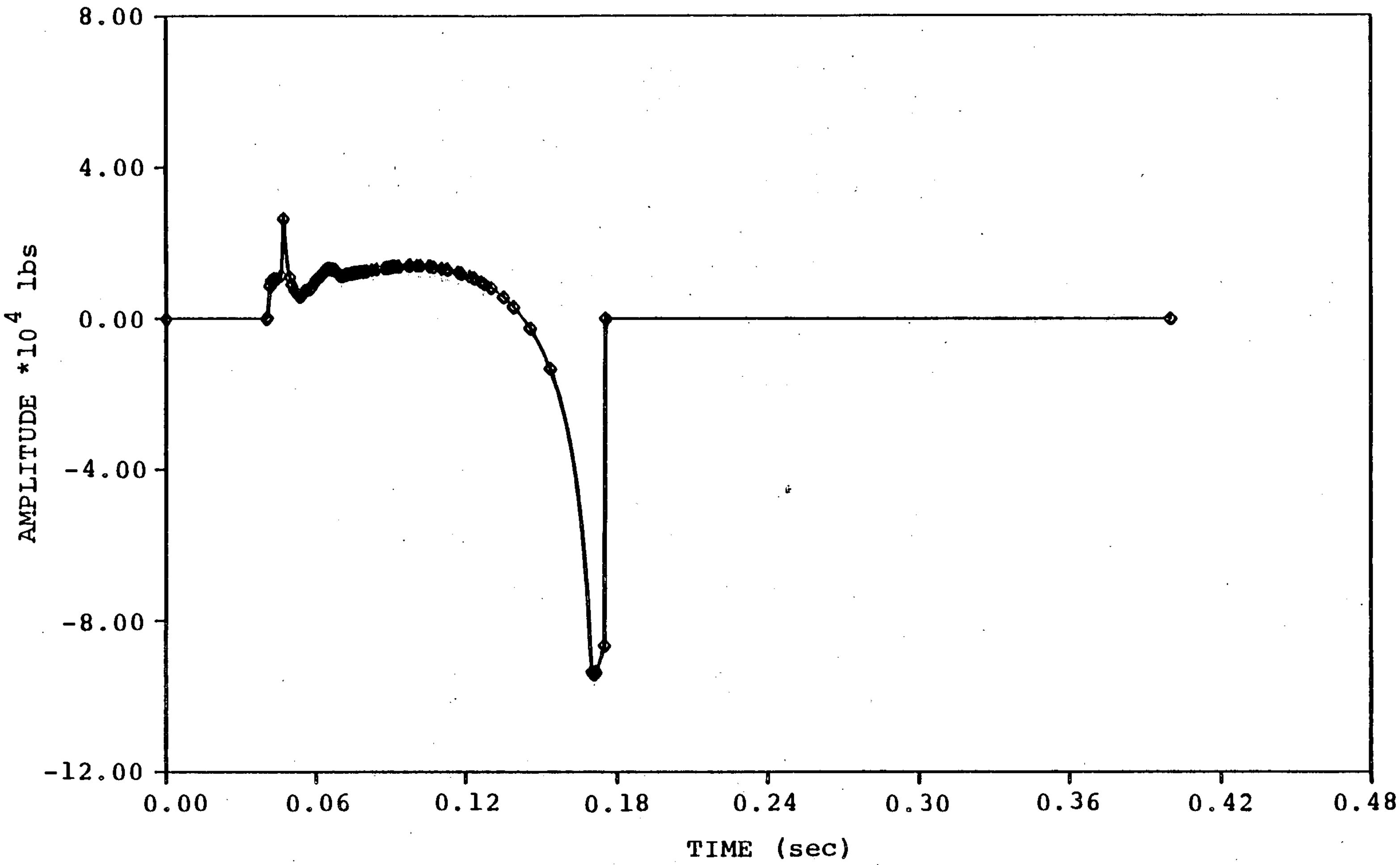


Figure 5-2.2-4

LINE RV-24-SRV DISCHARGE (CASE C3.1) FORCE TIME-HISTORY AT SEGMENT W2

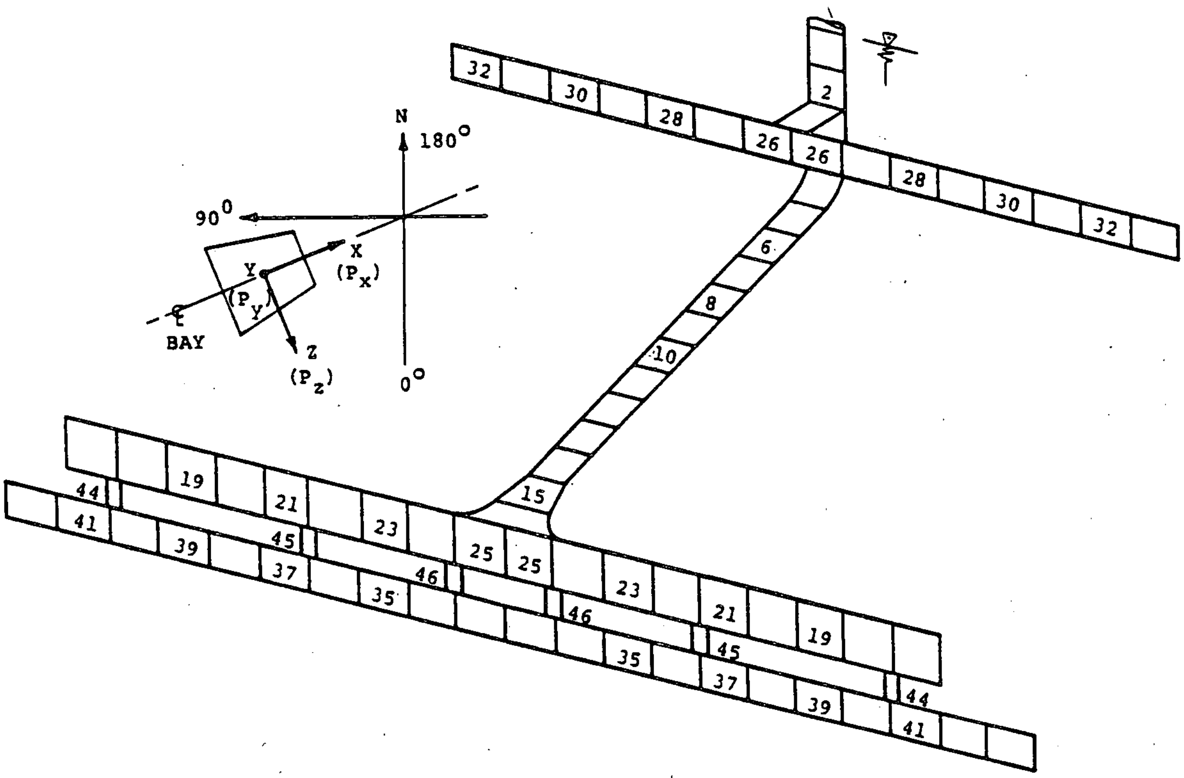
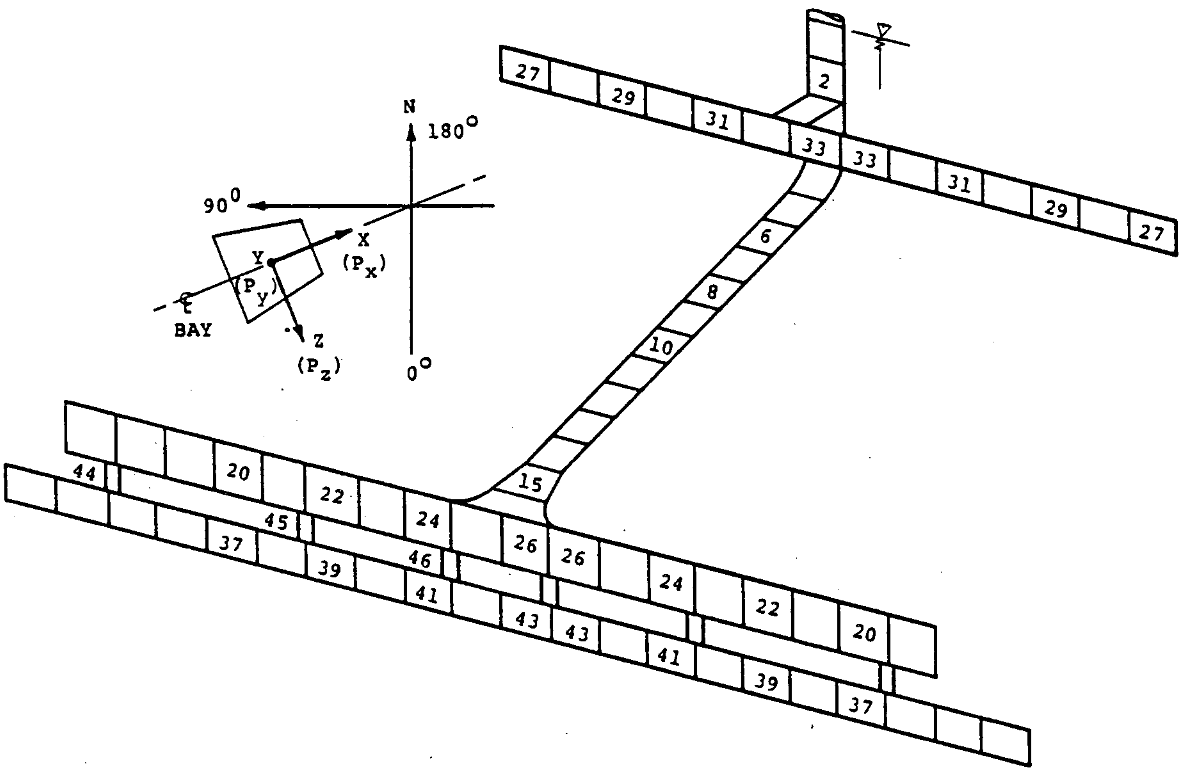


Figure 5-2.2-5

SEGMENT NUMBERS FOR THE WETWELL PIPING FOR SRV DISCHARGE WATER JET IMPINGEMENT AND AIR BUBBLE DRAG LOADS

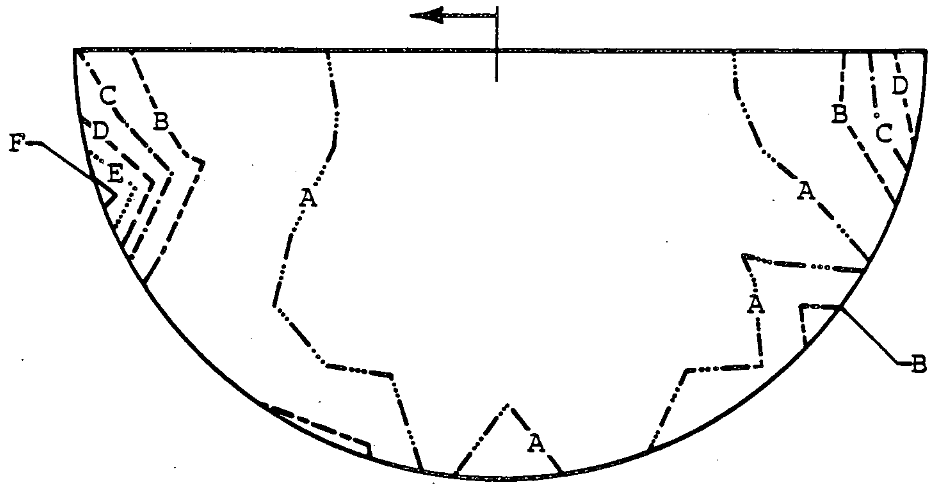


(1) THE X AND Z COORDINATES FOR DBA CO AND POST-CHUG ARE PARALLEL TO E-W AND N-S RESPECTIVELY.

Figure 5-2.2-6

SEGMENT NUMBERS FOR THE WETWELL PIPING FOR LOCA LOADS

TO ℄ DRYWELL



KEY DIAGRAM

NORMALIZED POOL ACCELERATIONS	
PROFILE	POOL ACCELERATION (ft/sec^2)
A	50.0
B	100.0
C	150.0
D	200.0
E	250.0
F	300.0

1. POOL ACCELERATIONS DUE TO HARMONIC APPLICATION OF TORUS SHELL PRESSURES SHOWN IN FIGURE 2-2.2-10 AT A SUPPRESSION CHAMBER FREQUENCY OF 24.14 HERTZ.

Figure 5-2.2-7

TYPICAL POOL ACCELERATION PROFILE FOR DBA CO FSI

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 Table 5-2.2-15.

Table 5-2.2-15 shows 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 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 5-2.2-16 and 5-2.2-17 present the governing load combinations for SRVDL piping and piping supports. Tables 5-2.2-18 and 5-2.2-19 provide the basis for establishing the governing load combinations for the SRVDL piping and supports.

Stress allowables corresponding to the following service levels are used for evaluation of the SRVDL piping and supports:

A - Design and Test conditions

B - Normal Operating Conditions including SRV discharge

C - Normal Operating Conditions including SRV discharge, plus 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 eight combinations which do not result from the 27 event combinations listed in Table 5-2.2-15. These are: Load Combinations A-1 and SA-1 which relate to the design pressure plus dead weight condition; Load Combinations A-2, B-1, SB-1, and SB-2 which include the combination of normal and seismic loads, and Load Combinations T-1 and ST-1 which relate to the hydrostatic test condition. Evaluation of combinations T-1 and ST-1 is a requirement of the ASME Code (Reference 6). Load Combinations A-1, A-2, B-1, SA-1, SB-1, and SB-2 are consistent with the requirements as specified in the FSAR (Reference 4).

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

Each of the listed governing load combinations for the SRVDL piping and piping supports (Tables 5-2.2-16 and 5-2.2-17) has been considered in the analysis methods described in Section 5-2.4.

Table 5-2.2-15

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
	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
	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
	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
	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	
	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)
	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 ALL 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 MONTICELLO 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 REQUIREMENTS 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 5-2.2-16

GOVERNING LOAD COMBINATIONS - SRVDL PIPING

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
B-3	P_O+DW+RV1B+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+SSE_I	9
C-3	P_O+DW+RV1C+QAB+QAB_I+PCHUG+$PCHUG_I$	9
C-4	P_O+DW+RV1C+QAB+QAB_I+CHUG+$CHUG_I$	9
D-1 (4)	P_O+DW+OBE_I+CO+CO_I	9
D-2	$P_O+DW+RV1C+QAB+QAB_I+[SSE_I^2+(PCHUG+PCHUG_I)^2]^{1/2}$	9
D-3	$P_O+DW+RV1C+QAB+QAB_I+[SSE_I^2+(CHUG+CHUG_I)^2]^{1/2}$	9
D-4	$P_O+DW+RV1A+QAB+QAB_I+[(SSE_I)^2+(PS+PS_I+VCL)^2]^{1/2}$	9
T-1 (7)	1.25P+DW_T	8

NOTES FOR TABLE 5-2.2-16

(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 6).

(3) AS AN ALTERNATE, MEET EQUATION 11 OF THE ASME CODE (REFERENCE 6).

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

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

(6) ONLY GOVERNING MARK I LOAD COMBINATIONS FROM TABLE 5-2.2-18 ALONG WITH ORIGINAL LOAD COMBINATIONS ARE CONSIDERED HERE.

(7) HYDROSTATIC TEST CONDITION. DW_T FOR ALL LINES SHALL BE WITH LINES FULL OF WATER AT $70^{o}F$.

Table 5-2.2-17

GOVERNING LOAD COMBINATIONS

SRVDL PIPING SUPPORTS AND SRV OUTLET FLANGES

LOAD COMBINATION NUMBER	LOAD COMBINATION[1,2]		SERVICE LEVEL
	PRIMARY	SECONDARY	
SA-1	DW+	TE1+THAM1	A
SB-1	$DW+OBE_I+$	TE1+THAM1+TD	B
SB-2	$DW+OBE_I+$	TE1+THAM2+TD	B
SB-3	$DW+RV1A+QAB+QAB_I+$	TE2+THAM2+TD	B
SB-4	$DW+RV1B+QAB+QAB_I+$	TE2+THAM2+TD	B
SC-1	$DW+RV1A+QAB+QAB_I+SSE_I+$	TE2+THAM2+TD	C
SC-2	$DW+RV1B+QAB+QAB_I+SSE_I+$	TE2+THAM2+TD	C
SC-3[3]	$DW+RV1C+QAB+QAB_I+PCHUG+PCHUG_I+$	TE2+THAM2A+TD1	C
SC-4[3]	$DW+RV1C+QAB+QAB_I+CHUG+CHUG_I+$	TE2+THAM2A+TD1	C
SD-1[4]	$DW+OBE_I+CO+CO_I+$	TE1+THAM1A+TD1	D
SD-2[3,5]	$DW+RV1C+QAB+QAB_I+[SSE_I^2+(PCHUG+PCHUG_I)^2]^{1/2}+$	TE2+THAM2A+TD1	D
SD-3[3,5]	$DW+RV1C+QAB+QAB_I+[SSE_I^2+(CHUG+CHUG_I)^2]^{1/2}+$	TE2+THAM2A+TD1	D
SD-4[3,5]	$DW+RV1A+QAB+QAB_I+[SSE_I^2+(PS+PS_I+VCL)^2]^{1/2}+$	TE2+THAM2A+TD1	D
ST-1[6]	DW_T		A

NOTES FOR TABLE 5-2.2-17

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

(2) ONLY GOVERNING MARK I LOAD COMBINATIONS FROM TABLE 5-2.2-19 ALONG WITH ORIGINAL LOAD COMBINATIONS ARE CONSIDERED HERE.

(3) WHEN THE COMBINATION OF SRV DISCHARGE LOADS PLUS TE2 AND THAM2A IS LESS THAN THE COMBINATION OF TE1 AND THAM1A, THE TE1 AND THAM1A COMBINATION IS USED.

(4) FOR THE DBA CONDITION, SRV DISCHARGE LOADS NEED NOT BE CONBINED WITH CO AND CHUGGING 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 LINES FULL OF WATER AT $70^{o}F$.

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Table 5-2.2-18

BASIS FOR GOVERNING LOAD COMBINATIONS

SRVDL PIPING

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

NOTES FOR TABLE 5-2.2-18

(1) EVENT COMBINATION NUMBERS REFER TO THE NUMBERS USED IN TABLE 5-2.2-15.

(2) GOVERNING LOAD COMBINATIONS ARE LISTED IN TABLE 5-2.2-16.

(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 5-2.2-19

BASIS FOR GOVERNING LOAD COMBINATIONS

SRVDL PIPING SUPPORTS AND SRV OUTLET FLANGES

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

NOTES FOR TABLE 5-2.2-19

(1) EVENT COMBINATION NUMBERS REFER TO THE NUMBERS USED IN TABLE 5-2.2-15.

(2) GOVERNING LOADS COMBINATIONS ARE LISTED IN TABLE 5-2.2-17.

(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

The methods used in the analyses for combining dynamic loads are based on NUREG-0484, Revision 1, "Methodology for Combining Dynamic Responses" (Reference 7). As described in NUREG-0484, 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 LOÇA 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, up to and including the 1977 Summer Addenda for Class 2 piping and piping supports (Reference 6). 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 SRVDL piping and T-quencher are analyzed in accordance with the requirements for Class 2 piping systems contained in Subsection NC of the 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 SRVDL piping supports are analyzed in accordance with requirements for Class 2 piping supports as provided in Subsection NF of the 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.

Table 5-2.3-1

ALLOWABLE STRESSES FOR 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 THROUGH B-3
PRIMARY	9	B	$1.8\ S_h$	27.0	C-1 THROUGH C-4
PRIMARY	9	B	$2.4\ S_h$	36.0	D-1 THROUGH D-4
SECONDARY	10	B	$1.0\ S_a$	22.5	A-2 THROUGH A-5
PRIMARY AND SECONDARY	11	B	S_h+S_a	37.5	(2)

(1) TABLE 5-2.2-16 LISTS THE GOVERNING LOAD COMBINATION NUMBERS.

(2) SEE ASME CODE, SECTION III, SUBSECTION NC, PARAGRAPH NC-3652.3 (REFERENCE 6) 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	14.95	A-1
PRIMARY	9	B	1.2 S_h	17.94	B-1 THROUGH B-3
PRIMARY	9	B	1.8 S_h	26.91	C-1 THROUGH C-4
PRIMARY	9	B	2.4 S_h	35.88	D-1 THROUGH D-4
SECONDARY	10	B	1.0 S_a	23.36	A-2 THROUGH A-5
PRIMARY + SECONDARY	11	B	$S_h + S_a$	38.31	(2)

(1) TABLE 5-2.2-16 IDENTIFIES GOVERNING LOAD COMBINATIONS.

(2) SEE ASME CODE, SECTION III, SUBSECTION NC, PARAGRAPH NC-3652.3 (REFERENCE 6) FOR LOADS TO BE CONSIDERED IN EQUATION 11.

Table 5-2.3-3

ALLOWABLE LOADS FOR SRVDL PIPE
SUPPORTS, SNUBBERS, AND STRUTS

SERVICE LEVEL	GOVERNING LOAD COMBINATION NUMBER (1)	SNUBBER AND STRUT ALLOWABLE LOAD LIMIT (2,3)
A,B	SB-1 THROUGH SB-4, ST-1	1.0 x RATED LOAD
C	SC-1 THROUGH SC-4	1.30 x RATED LOAD (SNUBBERS) K_1 x RATED LOAD (STRUTS)
D	SD-1 THROUGH SD-4	1.50 x RATED LOAD (SNUBBERS) K_2 x RATED LOAD (STRUTS)

(1) TABLE 5-2.2-17 LISTS THE GOVERNING LOAD COMBINATION NUMBERS.

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

(3) K_1 = 1.33 FOR 10 kip (RATED CAPACITY) STRUTS
= 1.26 FOR 28 kip (RATED CAPACITY) STRUTS

K_2 = 1.46 FOR 10 kip (RATED CAPACITY) STRUTS
1.26 FOR 28 kip (RATED CAPACITY) STRUTS

Table 5-2.3-4

ALLOWABLE MOMENTS FOR SRV OUTLET FLANGES

SERVICE LEVEL	GOVERNING LOAD COMBINATION NUMBER(1)	ALLOWABLE RESULTANT MOMENT (in-lbs)
A	SA-1, ST-1	372,000
B	SB-1 THROUGH SB-4	745,000
C,D	SC-1 THROUGH SC-4, SD-1 THROUGH SD-4	1,095,000

(1) TABLE 5-2.2-17 LISTS THE GOVERNING LOAD COMBINATION NUMBERS.

Table 5-2.3-5

ALLOWABLE STRESSES FOR T-QUENCHER SUPPORTS 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
T-QUENCHER SUPPORT BEAM	ASTM A-106 GRADE B	$S_y = 30.0$ $S_u = 60.0$	AXIAL	15.41	20.50	30.82
			BENDING	19.80	26.33	39.60
			INTERACTION	1.0	1.0	1.0
ELBOW SUPPORT BEAM	ASTM A-106 GRADE B	$S_y = 30.0$ $S_u = 60.0$	AXIAL	16.17	21.50	32.33
			BENDING	19.80	26.33	39.60
			INTERACTION	1.0	1.0	1.0
CONNECTING BRACKETS	ASTM A-516 GRADE 70	$S_y = 32.6$ $S_u = 70.0$	AXIAL	19.56	26.08	39.12
			BENDING	24.45	32.52	48.90
			INTERACTION	1.0	1.0	1.0
BOLTS	ASTM A-325	$S_u = 120.0$	AXIAL	60.0	60.0	60.0
			SHEAR	24.8	24.8	24.8
			INTERACTION	1.0	1.0	1.0
WELDS	E70XX	$S_y = 70.0$	SHEAR	21.00	28.00	42.00
			INTERACTION	1.0	1.0	1.0

(1) SEE TABLE 5-2.2-15 FOR LOAD COMBINATION LEVEL ASSIGNMENTS.

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

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. The procedure used to examine fatigue effects on wetwell piping is presented in Section 5-2.4.3.

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 SRVDL piping to evaluate normal loads as well as hydrodynamic loads. However, four complete models, each consisting of one main steam line, two SRV discharge lines, two T-quenchers and their related support structures, are used to analyze for normal loads. This is done in order to account for the effects of flexibility of the SRV discharge lines in the drywell, thus eliminating conservatism in calculating the reactions at the vent line penetrations. Since all eight wetwell piping lines running from the vent line penetration to the T-quencher (including related support structures) are identical, only one mathematical model is analyzed for hydrodynamic loads.

The SRVDL 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 also included in the model formulations.

A. SRVDL Piping Full Mathematical Models

The eight SRV discharge lines in the drywell are analyzed using four separate models, each including a main steam line and two attached SRV discharge lines. The main steam lines are modeled from the RPV nozzle to the drywell penetration. The SRV discharge lines attach to the main steam line at the safety relief valves and terminate at the T-quencher. Table 5-2.4-1 lists the main steam and SRVDL piping systems included in each of the four full models. Mathematical models of a representative SRVDL full piping model are presented in Figures 5-2.4-1 through 5-2.4-3.

Figure 5-2.4-4 shows the modeling of the eight safety relief valves. The mass of each valve is lumped at the center and at each end of the valve body. Also included in the piping models are eight vacuum breakers, one attached to each SRV discharge line. Figure 5-2.4-5 shows the modeling of the vacuum breakers for SRV Discharge Lines 25, 25A, 26, 26A, and 27; Figure 5-2.4-6 shows the modeling of the vacuum breaker and attached piping for SRV Discharge Lines 24, 24A and 27A. The mass of the vacuum breakers is uniformly distributed along their length; however, the mass of the dust cover is lumped at the top of the vacuum breaker.

The full models have anchor points at the main steam line connection to the RPV nozzle and at the main steam line penetration to the drywell wall. A 6 x 6 stiffness matrix is modeled at the SRVDL connection to the VLP and at the end connections of the elbow support and T-quencher support beams on the ring girders. The matrices, simulating the stiffnesses at the connections, are derived from the vent system and ring girder analyses described in Volumes 2 and 3 of this report.

Piping supports included in the full models consist of snubbers, struts, spring hangers, and their backup structures.

Snubbers are modeled as active in seismic and other dynamic load cases, whereas struts are modeled as active in all load cases. Spring hangers with appropriate preloads are modeled as active in all load cases. The effective mass of supports and connecting hardware attached to the piping is included in the piping models.

Stiffness values at a piping support location include the combined effects of the snubber or strut, supplementary steel, and its supporting drywell structural steel.

B. SRVDL Wetwell Piping Model

The SRVDL wetwell piping model includes the SRVDL piping from its junction to the main steam lines down to and including the T-quencher (Figure 5-2.4-7). Boundary conditions for the wetwell model consist of anchors at the main steam line junction (sweepolets). The boundary conditions for the model at the T-quencher support beam and elbow support beam end connections to the ring girder are represented by a 6 X 6 stiffness matrix simulating the ring girder effects. The intermediate junction point where the SRVDL penetrates the vent line is also represented by a 6 X 6 stiffness matrix simulating the vent line effects.

The connecting brackets between the elbow support beam and SRVDL piping are modeled as a 2 X 2 stiffness matrix simulating the as-built design. The six connecting brackets between the T-quencher and quencher support beam are also modeled as a set of 2 X 2 matrices simulating the design. The lateral support beam for the ramshead is modeled as a set of springs with the applicable stiffness values.

Table 5-2.4-1

FULL SRVDL PIPING MATHEMATICAL MODELS

MODEL NUMBER	MAIN STEAM LINE	SRV DISCHARGE LINES
1	PS1	RV-24 RV-24A
2	PS2	RV-25 RV-25A
3	PS3	RV-26 RV-26A
4	PS4	RV-27 RV-27A

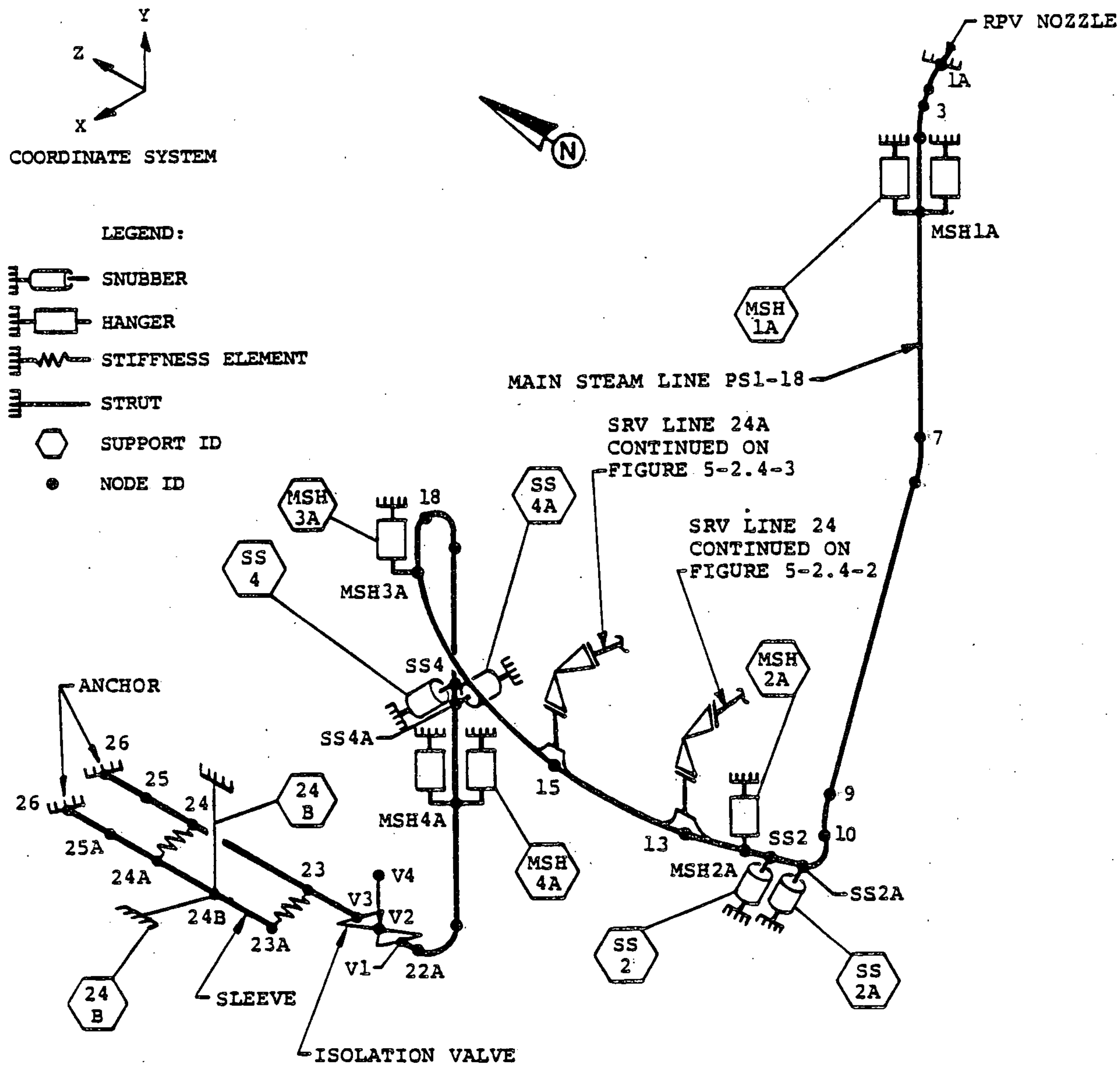

Figure 5-2.4-1

MAIN STEAM LINE PS1 MATHEMATICAL MODEL

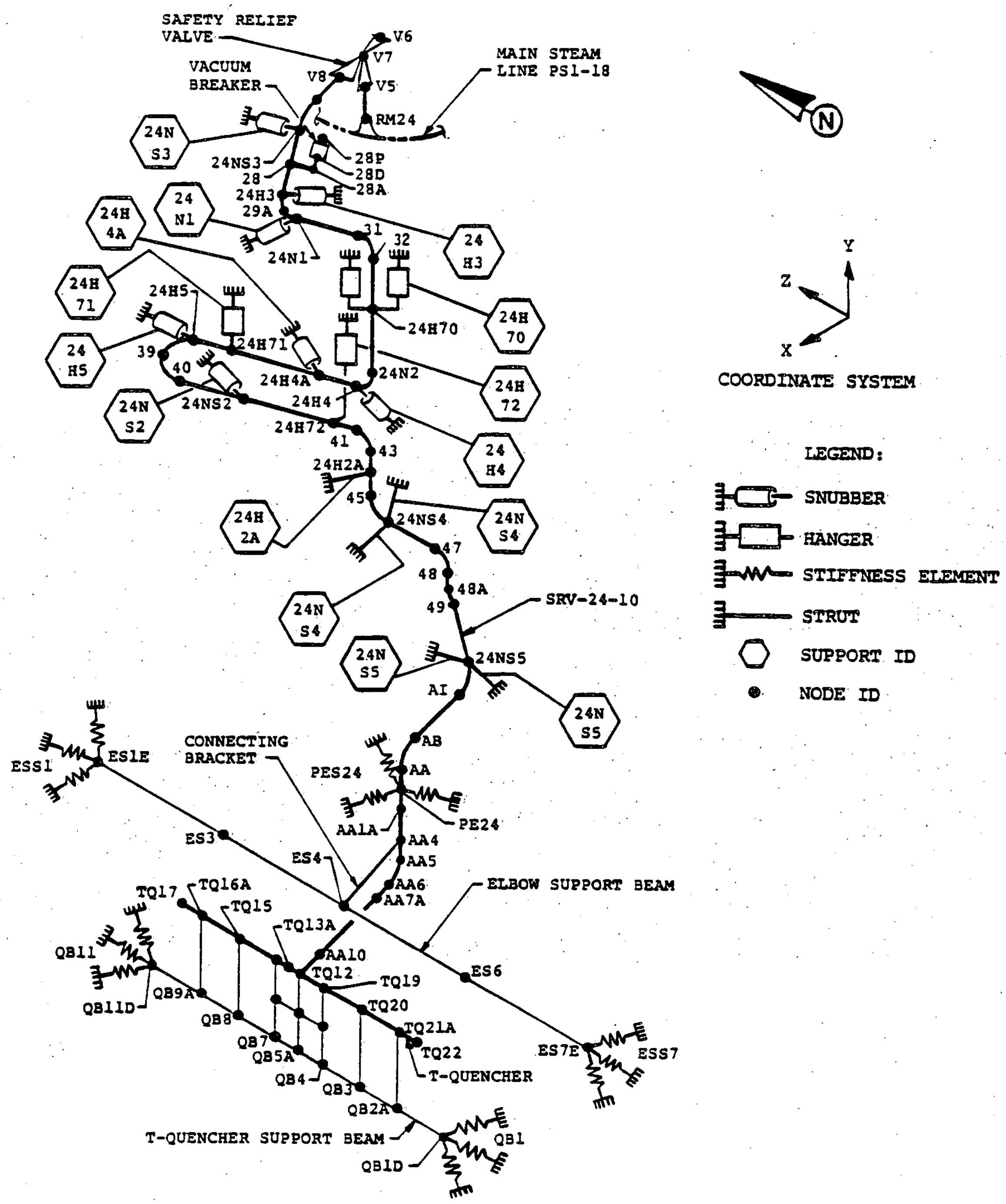

Figure 5-2.4-2

SRV DISCHARGE LINE RV-24 MATHEMATICAL MODEL

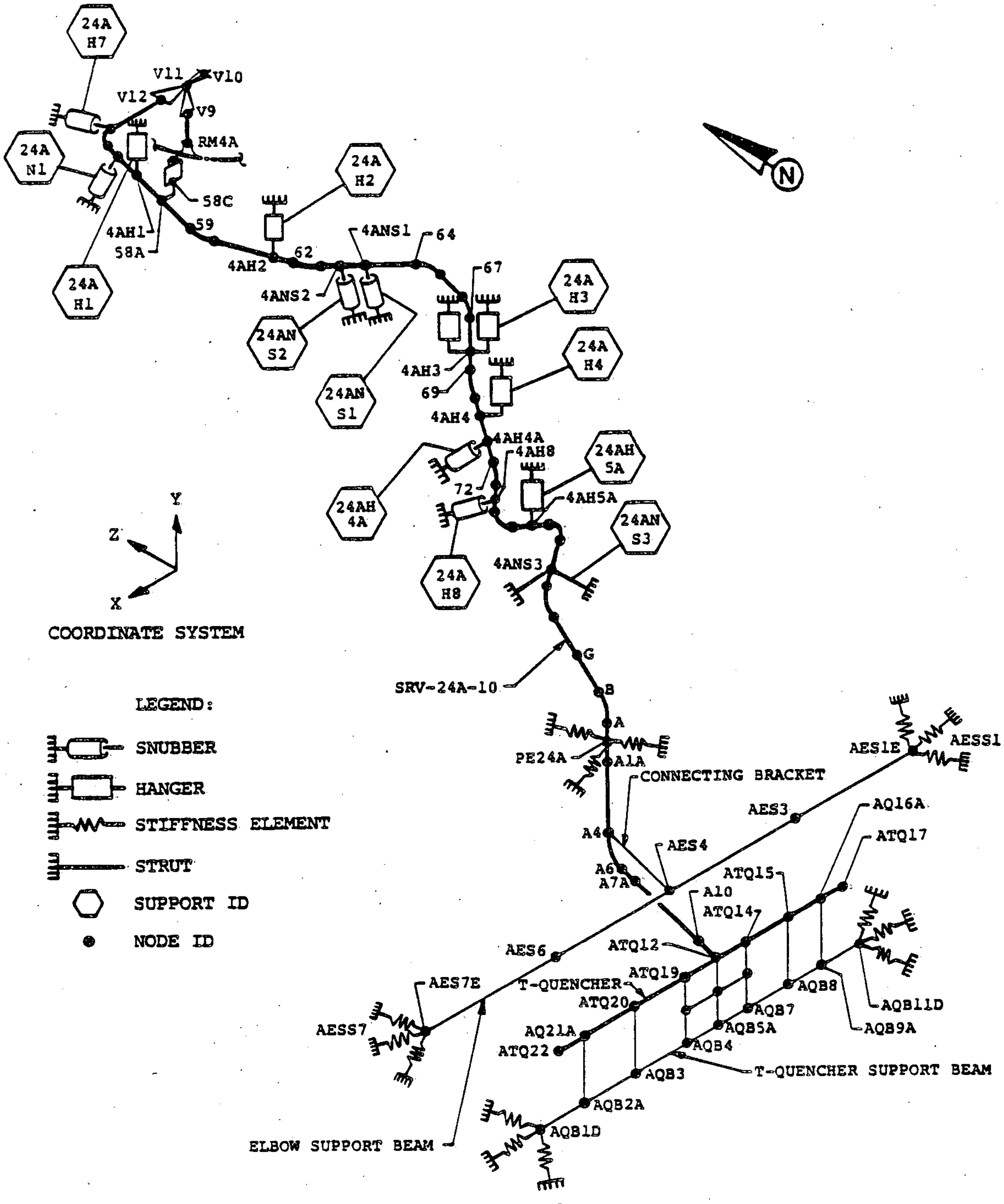

Figure 5-2.4-3

SRV DISCHARGE LINE RV-24A MATHEMATICAL MODEL

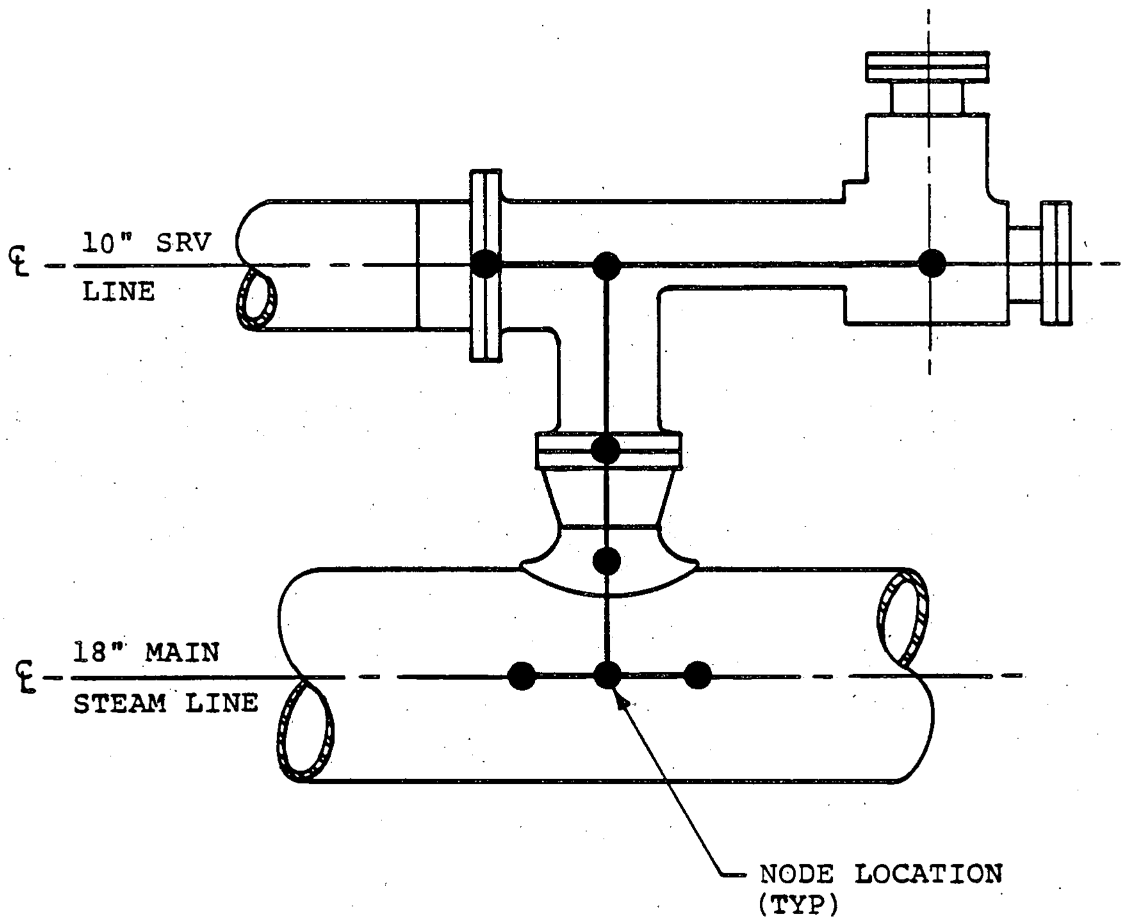

Figure 5-2.4-4

SAFETY RELIEF VALVE MATHEMATICAL MODEL

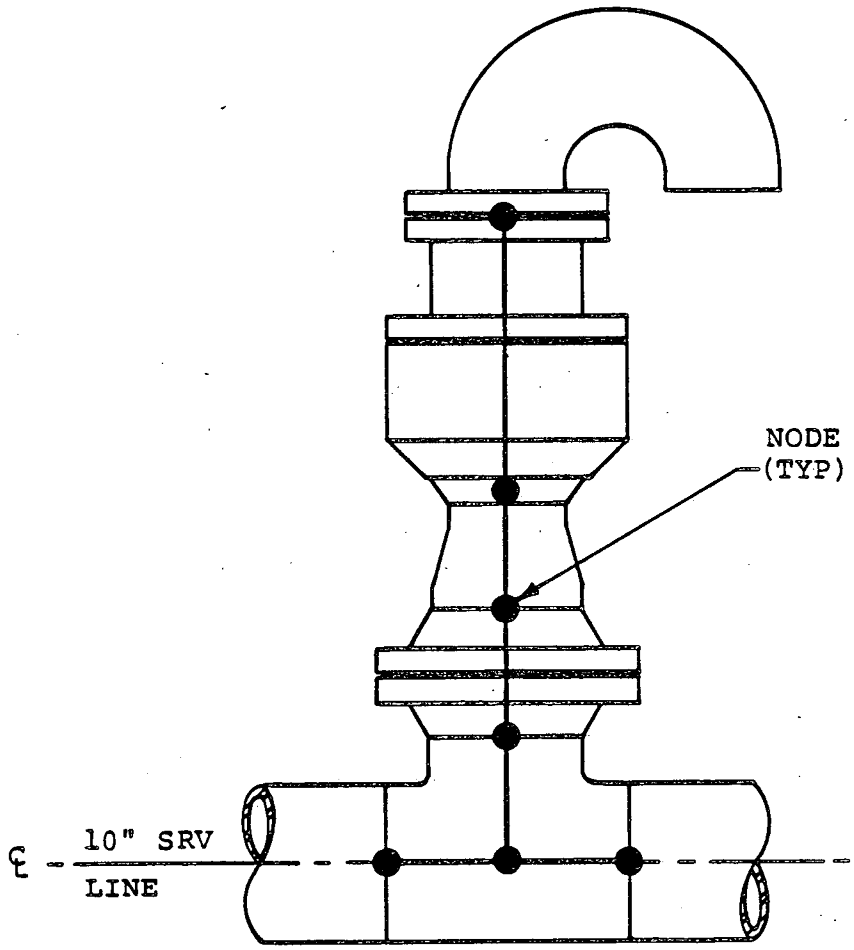

Figure 5-2.4-5

VACUUM BREAKER MATHEMATICAL MODEL

FOR SRV DISCHARGE LINES

25, 25A, 26, 26A, 27A

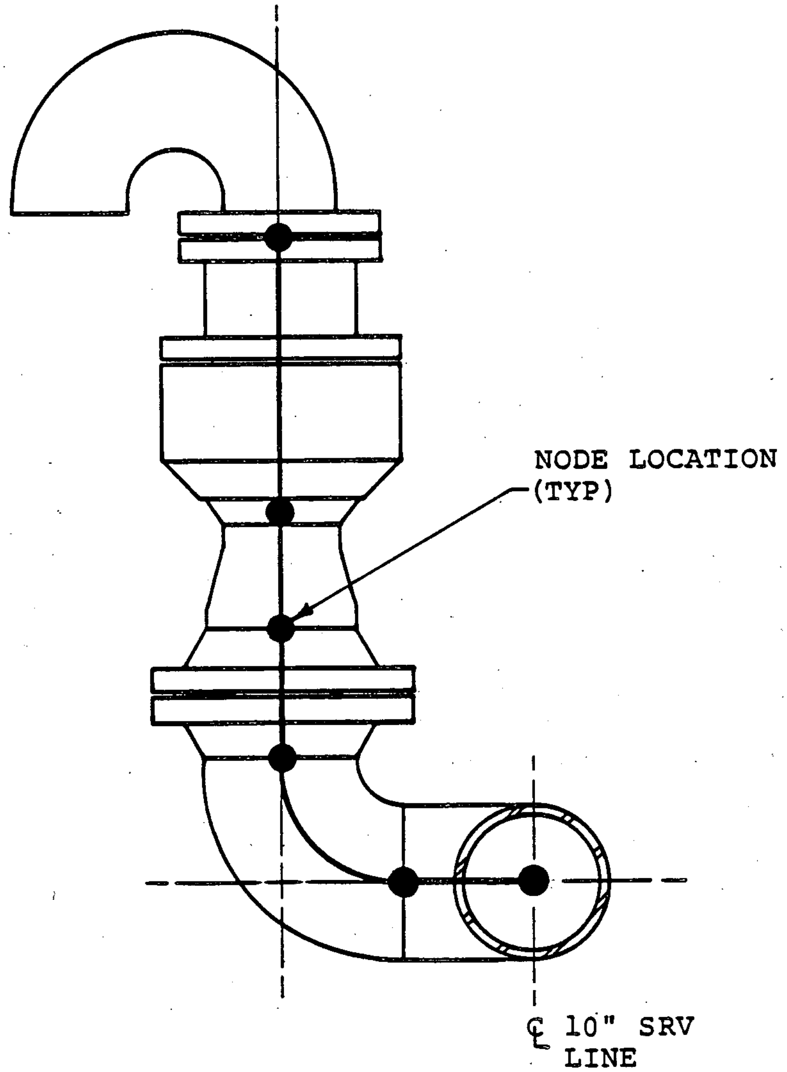

Figure 5-2.4-6

VACUUM BREAKER MATHEMATICAL MODEL

FOR SRV DISCHARGE LINES

24, 24A, 27

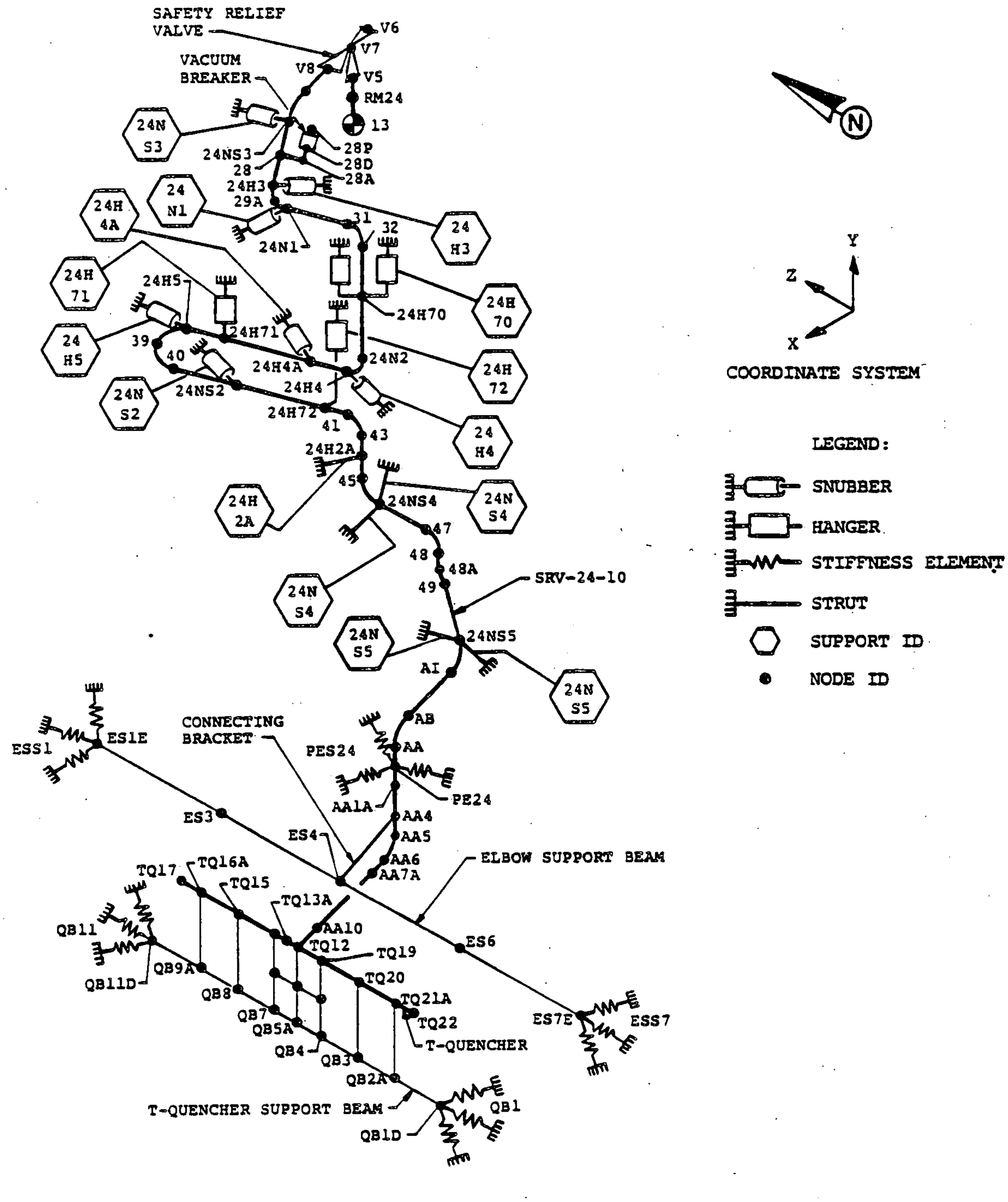

Figure 5-2.4-7

TYPICAL WETWELL SRVDL MATHEMATICAL MODEL

5-2.4.2 Analysis Methods

The mathematical models described in Section 5-2.4.1 are utilized in performing the analyses for the SRVDL piping, supports, and associated components. The numerous analytical techniques used to determine the piping response to the loads discussed in Section 5-2.2.1 are presented in the following sections.

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 full mathematical models of the SRVDL piping are discussed in Section 5-2.4.1. Figures 5-2.4-1 through 5-2.4-3 show representative models used in the drywell piping analysis. Summarized in Table 5-2.4-2 are the analysis methods utilized for each of the four full SRVDL piping models. These methods are discussed in the following paragraphs.

1. Dead Weight Loads

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

b. Dead Weight (DW_T) Loads: 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) Loads: A response spectra method is used to perform a dynamic analysis for two sets of seismic loads. The first set of seismic input is a N-S horizontal acceleration spectrum with a vertical constant acceleration of 0.04g. The second set is an E-W horizontal acceleration spectrum with a vertical constant acceleration of 0.04g, applied simultaneously. Figure 5-2.2-1 shows the horizontal (N-S and E-W) seismic acceleration response spectra used in the analysis. A value of 1/2% critical damping is used in accordance with the FSAR. All modes up to and including 33 hertz 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. SSE Inertia (SSE_I) Loads: The horizontal and vertical SSE inertia loads specified in the FSAR are twice the corresponding OBE inertia loads.

The methodology used to combine modal responses and spatial components in the seismic analysis is defined in the Monticello FSAR (Reference 4). The individual modal responses are combined by SRSS and directional responses are combined absolutely.

3. Pressure and Temperature Loads

a. Pressure Loads: 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 6). Table 5-2.2-2 lists the values of P_o and P used in the analysis.

b. Temperature Loads: A static thermal expansion analysis is performed for the 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 or in combination with the TE1 and TE2 load cases.

4. Safety Relief Valve Discharge Loads

a. SRVDL Clearing Loads: A dynamic analysis is performed for each of the three bounding SRV actuation cases (A1.1, A1.2, C3.1) 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. Component responses at five locations out of the total of over 500 locations were combined by use of the CDF method. The sum of the responses obtained for Cases A1.1, C3.1, A1.2 are termed RV1A, RV1B, and RV1C, respectively. Figures 5-2.2-2, 5-2.2-3, and 5-2.2-4 show typical SRV piping thrust force time-history plots. Figure 5-2.4-8 shows a typical application of the thrust segment forces to an SRVDL.

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 hertz. A value of 1% critical damping is utilized in accordance with NUREG-0661 in determining the appropriate values of Rayleigh damping coefficients α and β for use in the direct integration process.

The following hydrodynamic loads (Section 5-2.2.1) are applied directly to the SRVDL piping in the wetwell and therefore their methods of analysis are not described in this section:

4b. SRV T-quencher Discharge (QAB) Loads,

5a. Pool Swell (PS) Impact and Drag Loads,

5b. Pool Swell (PS) Fallback Loads

6. Condensation Oscillation (CO) Loads,

7a. Pre-Chug (PCHUG) Loads,

7b. Post-Chug (CHUG) Loads,

8a. LOCA Water Jet Impingement (VCL) Loads,

8b. LOCA Air Bubble Drag (VCL) Loads,

9b. Torus Interaction Loads

9. Vent System and Torus Interaction Loads

a. Vent System Interaction Loads:

The vent system interaction loads are evaluated using either static, equivalent static or dynamic analyses and are derived from the vent system analysis described in Section 3-2.0.

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, 3b, 4a are not reanalyzed for wetwell piping. The results from the full model are used. The methods used in analyzing the wetwell SRVDL piping for pressure (3a) loads are the same as those used in the full SRVDL piping analysis described above. The following analysis methods are utilized in evaluating the wetwell SRVDL piping for additional loads (Table 5-2.4-2).

4b. SRV T-quencher Discharge (QAB) Loads:

o Water Jet Impingement Loads: 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 Loads: 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.

- Air Bubble Drag Loads: 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 1-2.2.3.

5. Pool Swell Loads

a. Impact and Drag Loads: An equivalent static analysis is performed for the pool swell pressure transients shown in Table 5-2.2-7.

b. Pool Fallback Loads: An equivalent static analysis is performed for the pressure loads shown in Table 5-2.2-8.

6. Condensation Oscillation Loads:

Condensation Oscillation (CO) Loads: A harmonic analysis is performed for the loads shown in Table 5-2.2-9. The dominant frequencies of the SRV line, T-quencher arms and support members used in this calculation are derived from a harmonic analysis of these structures (Table 5-2.2-10).

7. Chugging Loads:

a. Pre-Chug (PCHUG) Loads: Post-chug loads bound pre-chug loads (Section 5-2.2.1).

Therefore the analysis results for post-chug are used in load combinations which include pre-chug loads (Table 5-2.2-11).

b. Post-Chug (CHUG) Loads: A harmonic analysis is performed for the loads shown in Table 5-2.2-12. The values of the loads are computed using the procedures discussed in load case 6 (Table 5-2.2-13).

8. Vent Clearing Loads (VCL)

a. LOCA Water Jet Impingement Loads: An equivalent static analysis is performed for the loads shown in Table 5-2.2-14. The values of the loads shown include dynamic load factors which are computed using first principles.

b. LOCA Air Bubble Drag Loads: An equivalent static analysis is performed for the loads shown in Table 5-2.2-14. The values of the loads shown include dynamic load factors which are computed using first principles.

9b. Torus Interaction Loads

A dynamic analysis is performed for the suppression chamber and vent system support motions derived from the analyses of these structures, described in Volumes 2 and 3 of this report. The dynamic loads considered include motions due to pool swell and SRV discharge loads. An equivalent static analysis is performed for the torus and vent system support motions due to other loads.

In order to determine piping stress levels in the SRVDL wetwell piping, the results obtained from the analyses described in Section 5-2.4.2A are combined with these results to evaluate the load combinations presented in Table 5-2.2-15.

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, and pipe pressure, 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 2.13.9. The structural components which utilized this factor are the wetwell SRVDL piping, the elbow support beam, the T-quencher, and the T-quencher support beam.

Table 5-2.4-2

ANALYSIS METHODS - SRVDL PIPING

LOAD	LOAD CASE NUMBER	FULL SRV PIPING MODEL	WETWELL SRV PIPING MODEL
DW	1a	STATIC	N/A
DW_T	1b	STATIC	N/A
OBE_I	2a	RESPONSE SPECTRUM	N/A
SSE_I	2b	RESPONSE SPECTRUM	N/A
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	4a	FORCE TIME-HISTORY	(2)
RV1B	4a	FORCE TIME-HISTORY	(2)
RV1C	4a	FORCE TIME-HISTORY	(2)
QAB	4b	(3)	EQUIVALENT STATIC
PS	5a, 5b	(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)	STATIC
TD1	9a, 9b	(3)	STATIC
QAB_I	9a, 9b	(3)	COUPLING(4)
PS_I	9a, 9b	(3)	COUPLING(4)
$PCHUG_I$	9a, 9b	(3)	COUPLING(4)
$CHUG_I$	9a, 9b	(3)	COUPLING(4)
CO_I	9a, 9b	(3)	COUPLING(4)

(1) THE EFFECTS OF INTERNAL PRESSURE ARE EVALUATED UTILIZING THE TECHNIQUES DESCRIBED IN SUBPARAGRAPH NC-3650 OF THE ASME CODE, SECTION III (REFERENCE 6).

(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.

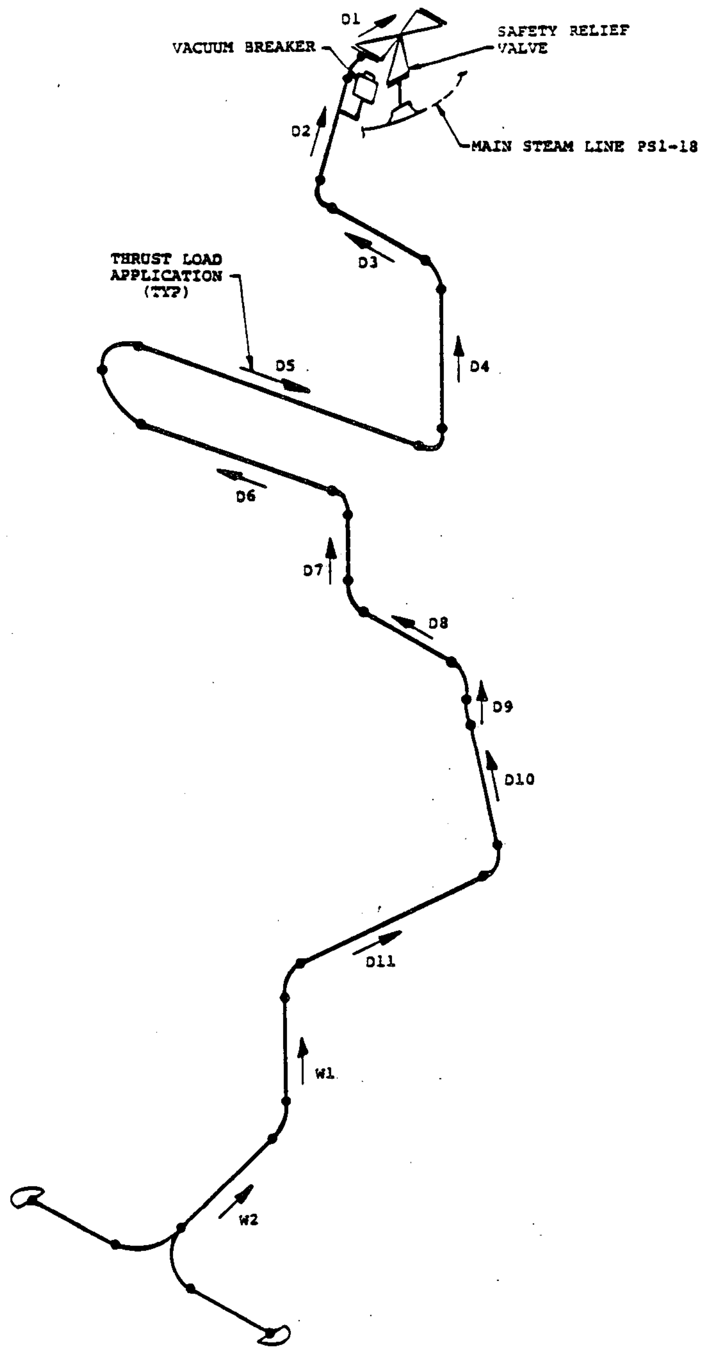

FIGURE 5-2.4-8

TYPICAL APPLICATION OF SRV DISCHARGE THRUST LOADS

5-2.4.3 Fatigue Evaluation

The analysis procedure utilized in performing the fatigue evaluation for the Monticello SRVDL wetwell piping is described in the following paragraphs.

Due to the identical routing of all eight SRV discharge piping lines in the wetwell, only a single typical line is considered in the evaluation. The fatigue evaluation is performed for SRVDL piping with the maximum resultant stresses and the maximum postulated number of SRV actuations, i.e., actuations for a line with the lowest SRV set point pressure. The governing cumulative fatigue usage factor is determined by calculating fatigue usage separately for two postulated event sequences during the plant life: 1) NOC with DBA and 2) NOC with IBA/SBA. Several possible loading combinations may occur for each event sequence.

The first step involved in the fatigue evaluation is to determine the effective number of maximum stress cycles (n_k) for each of the possible loading combinations. The number of stress cycles for individual loads are first determined as follows.

The cyclic loads considered for fatigue may be grouped into four major categories: seismic, accident, SRV discharge, and thermal. The number of stress cycles for these loads is determined according to the following parameters which apply for the Monticello plant.

a. Five operating basis earthquakes (OBE) and one safe shutdown earthquake (SSE). Each earthquake load contains ten significant stress cycles.

b. One accident condition - either Design Basis Accident (DBA), Intermediate Break Accident (IBA) or Small Break Accident (SBA). Significant stress cycles for each accident loading are determined by multiplying the characteristic frequency by the loading time, as provided below.

   - CO loading during DBA condition: The maximum characteristic frequency (f_{max}) is 30 hertz and the total time of loading is 30 seconds.
   - Pre-chug (PCHUG) loading during DBA condition: The maximum characteristic frequency

(f_{max}) is 9.5 hertz and the total time of loading is 10.7 seconds.

- Pre-chug (PCHUG) loading during IBA/SBA condition: The maximum characteristic frequency (f_{max}) is 9.5 hertz and the total time of loading is 320 seconds.
- Post-chug (CHUG) loading during DBA condition: The maximum characteristic frequency (f_{max}) is 30 hertz and the total time of loading is 10.7 seconds.
- Post-chug (CHUG) loading during SBA/IBA condition: The maximum characteristic frequency (f_{max}) is 30 hertz and the total time of loading is 320 seconds.

c. For the critical SRV discharge line, 984 SRV actuations are postulated: 50 actuations during accident (SBA/IBA) conditions and 934 actuations during normal operating conditions. Each SRV actuation contains 15 significant stress cycles and one significant thermal cycle.

Table 5-2.4-3 provides a summary of the limiting fatigue load history for the SRVDL wetwell piping.

The effective number of maximum stress cycles is calculated for each load by multiplying the actual number of stress cycles for the load by a maximum stress cycle factor (R). The "R" factors are determined considering piping system frequency, loading random phase angles and loading time-history data. Table 5-2.4-4 provides the"R" factors used for determining the effective number of stress cycles for CO, chugging, and SRV discharge loads.

After determination of the effective number of maximum stress cycles for individual loads, the effective number of maximum stress cycles (n_k) is calculated for each of the loading combinations for the two postulated event sequences (NOC with DBA and NOC with IBA/SBA).

The second step involved in performing the fatigue evaluation is to determine the maximum resultant stresses for each of the loads from the piping analyses. The mathematical model of the wetwell SRVDL piping described in Section 5-2.4.1 is used to generate resultant piping stresses due to dead weight, pressure, and SRV discharge thrust loads for both normal and accident SRV discharge conditions. The mathematical model of the SRVDL wetwell piping described in Section 5-2.4 is used to determine the resultant piping stresses due to thermal expansion, thermal anchor movement, seismic (OBE and SSE), CO, pre-chug, and post-chug loads for each DBA, IBA/SBA, and Normal Operating Condition.

The total alternating stress (S_a) due to all loads in a combination is determined next. The alternating stress due to dynamic loads is first determined and then combined with stresses due to dead weight, thermal, and pressure loads using a formulation similar to Equation 11 of the ASME Code, Section III, Subsection NC (Reference 6). In this manner, a total alternating stress (S_a) is calculated for each of the loading combinations.

The third step in performing the fatigue evaluation involves determining the allowable number of stress cycles (N_k) for each loading combination. N_k is calculated using Markl's fatigue equation and the total alternating stress (S_a) determined as follows.

$$N_k = \left(\frac{245}{S_a}\right)^5 \text{, where } S_a \text{ is in ksi.}$$

The final calculations of fatigue usage factors for each loading combination are performed by dividing the effective number of maximum stress cycles by the allowable number of stress cycles, i.e., n_k/N_k. The summation of usage factors for all the potential loading combinations which can occur during the plant life for the two postulated event sequences results in the maximum cumulative usage factor presented in Section 5-2.5.

Table 5-2.4-3

LIMITING FATIGUE LOAD HISTORIES

FOR SRVDL WETWELL PIPING

CYCLIC LOADING	STRESS CYCLES PER LOADING	STRESS CYCLES FOR EVENT SEQUENCE	
		NOC + DBA	NOC + IBA/SBA
THERMAL (ACCIDENT CONDITION)	1	1	1
P_o	1	1	1
OBE	10	50	50
SSE	10	10	10
CO	900	900	N/A
PCHUG	102 FOR DBA 3040 FOR IBA/SBA	102 -	- 3040
CHUG	321 FOR DBA 9600 FOR IBA/SBA	321 -	- 9600
CASES A1.2/ C3.2/C3.3	15	N/A	750
CASES A1.1/ C3.1	15	14010	14010
THERMAL (NOC W/SRV ACTUATION)	1	934	934

Table 5-2.4-4

MAXIMUM STRESS CYCLE FACTORS
FOR SRVDL PIPING

LOADS	FACTOR (R)
CO	0.1
CHUG	0.1
PCHUG	1.0
SRV(1)	0.3

(1) SAFETY RELIEF VALVE DISCHARGE 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 each SRV discharge line (both drywell and wetwell). The maximum stresses for each service level are listed, along with the associated Code equations and allowable stress values.

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

Table 5-2.5-3 lists maximum resultant loads in the rigid struts. Strut loads and strut ratings are provided for each service level.

Table 5-2.5-4 provides the maximum resultant moments of the eight SRV outlet flanges. The maximum moments are also listed for each service level, along with the allowable flange moments.

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

Table 5-2.5-6 shows the maximum stresses for the quencher support beam, and elbow support beam and connecting brackets for each of the governing loads.

Fatigue evaluations for the SRVDL piping are performed according to the procedure described in Section 5-2.4.3. The resultant maximum cumulative fatigue usage factor for all wetwell SRVDL piping for both the NOC plus DBA and NOC plus IBA/SBA condition is 0.309. This occurs at the SRVDL piping elbow adjacent to the elbow support beam junction. The maximum cumulative usage factor for SRVDL piping in the containment wetwell airspace is 0.283 and occurs at the junction of the SRVDL vent line penetration nozzle and wetwell SRVDL piping. Both of these factors are within the acceptable fatigue usage limit of 1.0.

In summary, the results show that the design of the SRVDL piping system is adequate for the loads, load combinations, and acceptance criteria limits specified in NUREG-0661 (Reference 1) and the PUAAG (Reference 5).

The analysis results for the SRV vent line penetration (VLP) are provided in Section 3-2.5.

Table 5-2.5-1

ANALYSIS RESULTS FOR SRVDL PIPING STRESS

SRV LINE NUMBER/ LOCATION	LEVEL A (ksi)	LEVEL B (ksi)	LEVEL C (ksi)	LEVEL D (ksi)	SECON-DARY (ksi)
SRV-24/DW	4.59	16.41	23.89	26.27	16.30
SRV-24A/DW	4.08	17.22	19.32	22.27	16.53
SRV-25/DW	4.24	11.90	13.46	14.88	11.98
SRV-25A/DW	4.64	15.48	23.13	24.33	13.17
SRV-26/DW	5.52	14.14	17.45	20.14	11.75
SRV-26A/DW	4.03	14.90	17.73	17.31	17.24
SRV-27/DW	6.23	13.83	17.18	18.25	14.45
SRV-27A/DW	5.66	15.70	18.12	21.49	16.93
ALL LINES/WW	7.74	16.65	26.74	29.36	36.37
ASME CODE EQUATION	8	9	9	9	11
ALLOWABLE STRESS (ksi)	15.0	18.0	27.0	36.0	37.5

Table 5-2.5-2

ANALYSIS RESULTS FOR SRVDL PIPING SNUBBER LOADS

SRV LINE NUMBER	RATING (kips)	LEVEL B (kips)	LEVEL C (kips)	LEVEL D (kips)
24	10	9.9	12.2	13.1
24	20	12.5	18.5	23.2
24A	10	9.3	11.8	12.9
24A	20	10.2	12.2	13.5
24A	30	7.7	11.8	15.7
25	10	9.7	10.9	11.6
25	20	9.7	14.4	15.82
25	30	9.7	13.8	14.9
25A	10	3.7	7.5	10.2
25A	20	9.2	14.9	20.1
25A	30	14.7	17.0	16.2
26	10	8.8	13.0	13.4
26	20	12.8	14.7	15.3
26A	10	4.2	8.6	10.9
26A	20	5.5	9.8	12.0
27	10	9.3	10.8	11.2
27	20	10.9	15.6	16.9
27A	10	4.9	9.3	11.8
27A	20	10.1	15.5	16.3
27A	30	9.5	13.3	16.7
ALLOWABLE LOAD (1) (kips)		1.0 x RATING	1.30 x RATING	1.5 x RATING

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

Table 5-2.5-3

ANALYSIS RESULTS FOR SRVDL PIPING STRUT LOADS

SRV LINE NUMBER	RATING (kips)	LEVEL B (kips)	LEVEL C (kips)	LEVEL D (kips)
24	28	19.3	19.7	12.3
24A	10	9.28	11.8	12.9
24A	28	10.6	11.1	10.15
25	28	12.0	12.25	7.8
26	10	5.6	6.1	6.3
26A	10	4.2	5.7	7.0
26A	28	8.7	8.9	7.75
27A	10	7.9	8.4	8.2
27A	28	11.1	11.4	10.9
ALLOWABLE LOAD (1) (kips)		1.0 x RATING	(2) K_1 x RATING	(2) K_2 x RATING

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

(2) K_1 = 1.33 FOR 10 kip (RATED CAPACITY) STRUTS
= 1.26 FOR 28 kip (RATED CAPACITY) STRUTS

K_2 = 1.46 FOR 10 kip (RATED CAPACITY) STRUTS
1.26 FOR 28 kip (RATED CAPACITY) STRUTS

Table 5-2.5-4

ANALYSIS RESULTS FOR SRV OUTLET FLANGE MOMENTS

SRV LINE	LEVEL A (kip-in)	LEVEL B (kip-in)	LEVEL C (kip-in)	LEVEL D (kip-in)
SRV-24	67.1	113.0	209.3	245.1
SRV-24A	112.5	169.5	275.9	345.6
SRV-25	77.3	165.3	311.2	352.4
SRV-25A	99.2	158.2	413.5	452.4
SRV-26	112.1	174.3	459.7	475.5
SRV-26A	59.1	152.8	357.1	372.0
SRV-27	120.2	75.2	152.4	175.6
SRV-27A	53.1	116.8	241.6	280.4

1. SEE TABLE 5-2.3-4 FOR ALLOWABLE MOMENTS.

Table 5-2.5-5

ANALYSIS RESULTS FOR T-QUENCHER ARMS

ITEM	ASME CODE EQUATION NUMBER	SERVICE LEVEL	LOAD(1) COMBINATION NUMBER	LOAD COMBINATION STRESS (ksi)(2)
T-QUENCHER ARMS	8	A	A-1	6.75
	9	B	B-3	10.70
	9	C	C-4	17.83
	9	D	D-4	20.64
	11	N/A	A-4a	21.71

(1) TABLE 5-2.2-16 GIVES LOAD COMBINATION NUMBERS.

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

Table 5-2.5-6

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

ITEM	CONTROLLING LOAD COMBINATION (1)	STRESS TYPE (ksi) (2) (6)		
		AXIAL	BENDING	INTERACTION
T-QUENCHER SUPPORT BEAM	SB-4	0.33	14.75	0.766
	SC-4	0.73	20.33	0.805
	SD-4 / SD-4	0.50 / 0.96 (7)	24.12 / 45.87 (7)	0.625 / 0.793 (7)
ELBOW SUPPORT BEAM	SB-4	0.08	11.25	0.573
	SC-4	0.42	21.71	0.844
	SD-3	0.42	21.90	0.566
CONNECTING BRACKETS FOR T-QUENCHER SUPPORT BEAM	SB-4	(4)	(4)	0.78 (3)
	SC-4	(4)	(4)	0.81 (3)
	SD-4	(4)	(4)	0.75 (3)
CONNECTING BRACKETS FOR ELBOW SUPPORT BEAM	SB-4	–	13.91	0.569
	SC-4	–	14.69	0.451
	SD-4	–	17.50	0.358
BOLTS	SB-4	40.68	3.12 (5)	0.476
	SC-4	29.26	15.74 (5)	0.640
	SD-4	51.22	4.25 (5)	0.758
WELDS	SB-4	(4)	13.07 (5)	0.623 (3)
	SC-4	(4)	23.30 (5)	0.83 (3)
	SD-4	(4)	24.06 (5)	0.578 (3)

(1) SEE TABLE 5-2.2-17 FOR THE DEFINITION OF THE LOAD COMBINATIONS.

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

(3) THESE ARE CALCULATED FOR COMBINED STRESSES.

(4) ONLY COMBINED STRESSES ARE EVALUATED.

(5) THESE ARE SHEAR STRESSES.

(6) THESE MAY NOT BE FOR ANY SINGLE LOCATION.

(7) SECONDARY STRESSES ARE INCLUDED AND THE ALLOWABLE STRESSES ARE THREE TIMES THE SERVICE LEVEL B ALLOWABLES.

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, December 1981.

3. "Mark I Containment Program Plant Unique Load Definition," Monticello Nuclear Power Plant, General Electric Company, NEDO-24576, Revision 1, October 1981.

4. Monticello Nuclear Generating Station, Final Safety Analysis Report, Northern States Power Company, Volumes I through IV (including Appendices), October 1969.

5. "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Applications Guide," Task Number 3.1.3, Mark I Owners Group, General Electric Company, NEDO-24583-1, Revision 2, October 1979.

6. ASME Boiler and Pressure Vessel Code, Section III, Division 1, 1977 Edition up to and including Summer 1977 Addenda.

7. "Methodology for Combining Dynamic Responses," USNRC, NUREG-0484, Revision 1, February 1976.

8. "Mark I Containment Program Final Report, Monticello T-Quencher Test," General Electric Company, NEDE-21864-P, July 1978.