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HOPE CREEK GENERATING STATION
PLANT UNIQUE ANALYSIS REPORT
VOLUME 5
SAFETY RELIEF VALVE DISCHARGE PIPING ANALYSIS

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TITLE: Hope Creek Generating Station Plant Unique Analysis Report Volume 5

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ABSTRACT

The primary containment for the Hope Creek Generating Station was designed, erected, pressure-tested, and N-stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section III, 1974 Edition with addenda up to and including Winter 1974. These activities were performed by the Pittsburgh-Des Moines Steel Company for the Public Service Electric and Gas Company (PSE&G). Since then, new requirements which affect the design and operation of the primary containment system have been established. These requirements are defined in the Nuclear Regulatory Commission's (NRC) Safety Evaluation Report, NUREG-0661. The NUREG-0661 requirements define revised containment design loads postulated to occur during a loss-of-coolant accident or a safety-relief valve discharge event which are to be evaluated. In addition, NUREG-0661 requires that an assessment of the effects that these postulated events have on the operation of the containment system be performed.

This plant unique analysis report (PUAR) documents the efforts undertaken to address and resolve each of the applicable NUREG-0661 requirements for Hope Creek. It 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 Hope Creek PUAR is composed of the following six volumes:

- o Volume 1 - GENERAL CRITERIA AND LOADS METHODOLOGY
- o Volume 2 - SUPPRESSION CHAMBER ANALYSIS
- o Volume 3 - VENT SYSTEM ANALYSIS
- o Volume 4 - INTERNAL STRUCTURES ANALYSIS
- o Volume 5 - SAFETY RELIEF VALVE DISCHARGE PIPING ANALYSIS
- o Volume 6 - TORUS ATTACHED PIPING AND SUPPRESSION CHAMBER PENETRATION ANALYSES

Major portions of all volumes of this report have been prepared by NUTECH Engineers, Incorporated (NUTECH), acting as a consultant responsible to the Public Service Electric and Gas Company. Selected sections of Volumes 5 and 6 have been prepared by the Bechtel Power Corporation (acting as an agent responsible to the Public Service Electric and Gas Company). This volume, Volume 5, documents the evaluation of the safety relief valve discharge piping.

NOTE: Identification of the volume number precedes each page, section, subsection, table, and figure number.

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LIST OF ACRONYMS

ACI	American Concrete Institute
ADS	Automatic Depressurization System
AISC	American Institute of Steel Construction
ASME	American Society of Mechanical Engineers
ATWS	Anticipated Transients Without Scram
BDC	Bottom Dead Center
BWR	Boiling Water Reactor
CDF	Cumulative Distribution Function
CO	Condensation Oscillation
DBA	Design Basis Accident
DC	Downcomer
DLF	Dynamic Load Factor
ECCS	Emergency Core Cooling System
FSAR	Final Safety Analysis Report
FSI	Fluid-Structure Interaction
FSTF	Full-Scale Test Facility
HNWL	High Normal Water Level
HPCI	High Pressure Coolant Injection
IBA	Intermediate Break Accident
I&C	Instrumentation and Control
ID	Inside Diameter
IR	Inside Radius
LDR	Load Definition Report (Mark I Containment Program)

LIST OF ACRONYMS

(Continued)

LOCA	Loss-of-Coolant Accident
LPCI	Low Pressure Coolant Injection
LTP	Long-Term Program
MC	Midcylinder
MCF	Modal Correction Factor
MJ	Mitered Joint
MVA	Multiple Valve Actuation
NEP	Non-Exceedance Probability
NOC	Normal Operating Conditions
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NVB	Non-Vent Line Bay
OBE	Operating Basis Earthquake
OD	Outside Diameter
PSD	Power Spectral Density
PSE&G	Public Service Electric and Gas Company
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
RCIC	Reactor Core Isolation Cooling
RHR	Residual Heat Removal

LIST OF ACRONYMS

(Concluded)

RPV	Reactor Pressure Vessel
RSEL	Resultant Static-Equivalent Load
SBA	Small Break Accident
SBP	Small Bore Piping
SER	Safety Evaluation Report
SORV	Stuck-Open Safety Relief Valve
SRSS	Square Root of the Sum of the Squares
SRV	Safety Relief Valve
SRVDL	Safety Relief Valve Discharge Line
SSE	Safe Shutdown Earthquake
STP	Short-Term Program
SVA	Single Valve Actuation
TAP	Torus Attached Piping
VB	Vent Line Bay
VH	Vent Header
VL	Vent Line
VPP	Vent Pipe Penetration
ZPA	Zero Period Acceleration

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5-1.0 INTRODUCTION

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 Hope Creek safety relief valve (SRV) piping, including the SRV T-quencher and related support structures. The SRV piping PUAR is organized as follows:

- INTRODUCTION
  - Scope of Analysis
- ANALYSIS OF SAFETY RELIEF VALVE DISCHARGE PIPING INSIDE DRYWELL
  - Component Description
  - Loads and Load Combinations
  - Analysis Acceptance Criteria
  - Methods of Analysis
  - Analysis Results and Conclusions
- ANALYSIS OF WETWELL SAFETY RELIEF VALVE DISCHARGE PIPING AND T-QUENCHERS
  - Component Description
  - Loads and Load Combinations
  - Analysis Acceptance Criteria
  - Methods of Analysis
  - Analysis Results and Conclusions

The INTRODUCTION section contains an overview discussion of the scope of the SRV piping and T-quencher evaluation. Each of the analysis sections contains a comprehensive discussion of the loads and load combinations to be addressed, and a description of the component parts of the piping and T-quencher affected by these loads and load combinations. The analysis sections also contain a discussion of the methodology used to evaluate the effects of the loads and load combinations, the evaluation results, and the acceptance limits to which the results are compared. Also included is a discussion of the conclusions derived from the evaluation.

5-1.1 Scope of Analysis

The general criteria presented in Volume 1 are used as the basis for the Hope Creek SRV piping and T-quencher evaluation described in this report volume. The SRV piping and T-quenchers are evaluated for the effects of LOCA related loads and SRV discharge related loads discussed in Volume 1, and defined by the NRC's Safety Evaluation Repor NUREG-0661 (Reference 1) 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 T-quencher for the effects of LOCA and SRV discharge related loads to verify that the design of the SRV piping and T-quenchers is adequate. Rigorous analytical techniques are used in this evaluation, utilizing detailed analytical models and refined methods for computing the dynamic response of the SRV piping and T-quencher with consideration of the interaction effects of the vent system and torus.

The results of the structural analysis for each load are used to evaluate load combinations and fatigue effects for the SRV piping and T-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 American Society of Mechanical Engineers (ASME) Code (Reference 6) for Class 3 piping and piping supports.

The evaluation of the SRV line vent pipe penetration (VPP) and the associated vent system components for the effects of LOCA and SRV discharge related loads are addressed in Volume 3 of this report.

5-2.0 ANALYSIS OF SAFETY RELIEF VALVE DISCHARGE PIPING INSIDE DRYWELL

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

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

5-2.1 Component Description

The drywell SRV piping system for Hope Creek consists of 14 individual schedule 40, SA-106, Grade B piping lines. The nominal pipe size of the piping is 10" Schedule 40 at the outlet flange of the SRV, changing to 10" Schedule 80 immediately before the vent pipe jet deflector and 10" Schedule 160 at the vent pipe penetration (VPP). Figure 5-2.1-1 shows the routing, support locations, and support types, for a representative SRV line in the drywell. Each SRV discharge line was given a unique line designation labeled sequentially from A to R, with the exception of I, N, O, and Q which were purposely omitted.

The 14 SRV lines initiate at the 4 main steam lines and are grouped in sets of three and four, as shown schematically in Figure 5-2.1-2. The lines are routed from the drywell area through the vent lines and into the suppression chamber. As indicated in Figure 5-3.1-2, each of the 8 vent lines contains two SRV lines, except for the vent lines at azimuths 157.50° and 202.50° which contain only 1 SRV line each.

The 14 SRV lines are attached to the 4 main steam lines in the drywell at the safety-relief valves, as shown in

Figure 5-2.1-3. Each SRV line also has two attached vacuum breaker valves that are typically represented as shown in Figures 5-2.1-4 and 5-2.1-5. Each SRV line passes through a vent pipe jet deflector and is supported at an intermediate location in the vent pipe. Beyond this support, the SRV line turns 90° and exits the vent pipe at the VPP. This arrangement is shown in Figure 5-2.1-6.

The support system for the SRV lines in the drywell consists of snubbers, struts and hangers which are connected to the drywell main steel by means of intermediate steel framing. A typical SRV line support in the drywell is illustrated in Figure 5-2.1-7.

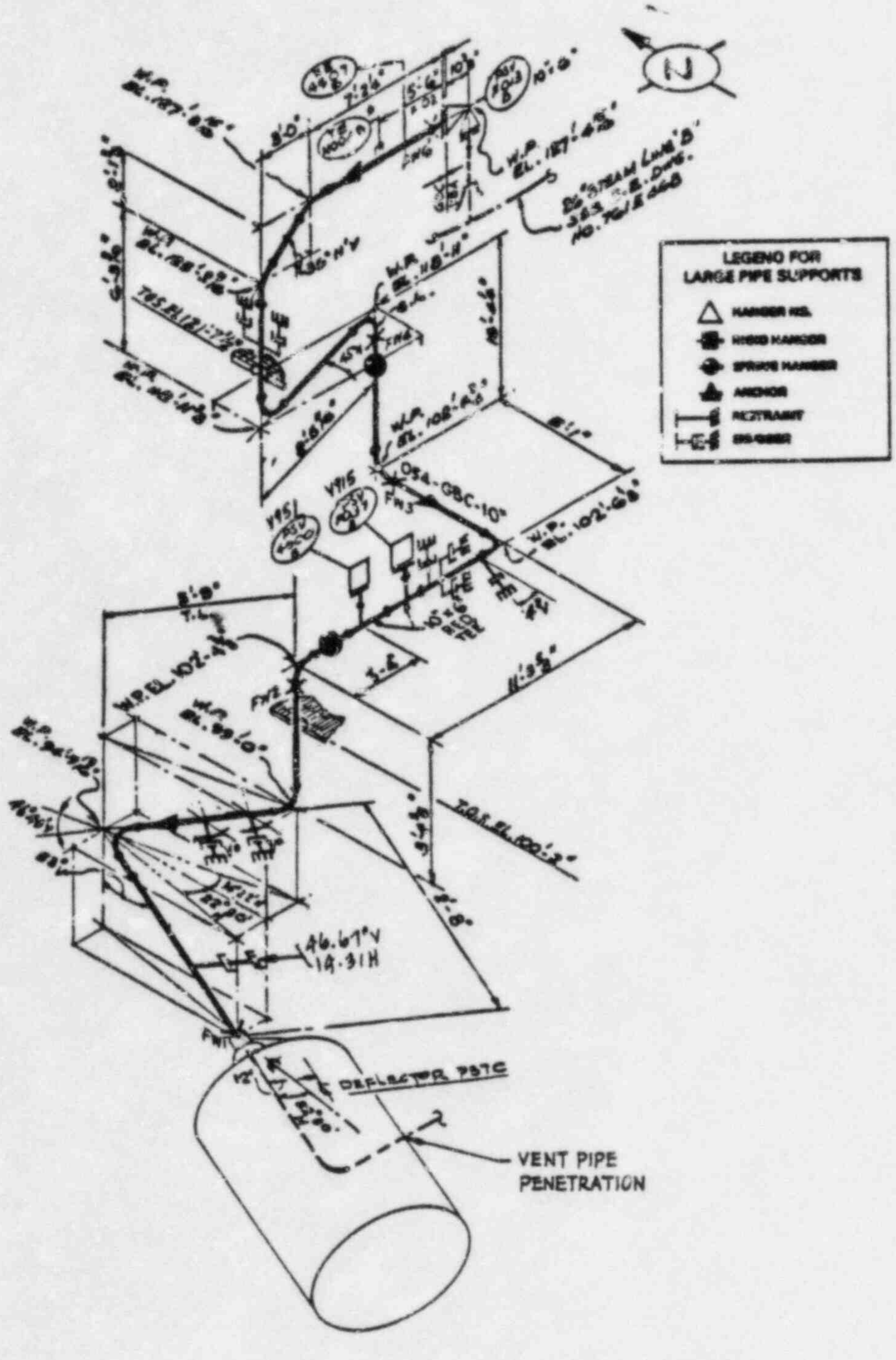

Figure 5-2.1-1

REPRESENTATIVE SRV PIPING SYSTEM IN THE DRYWELL

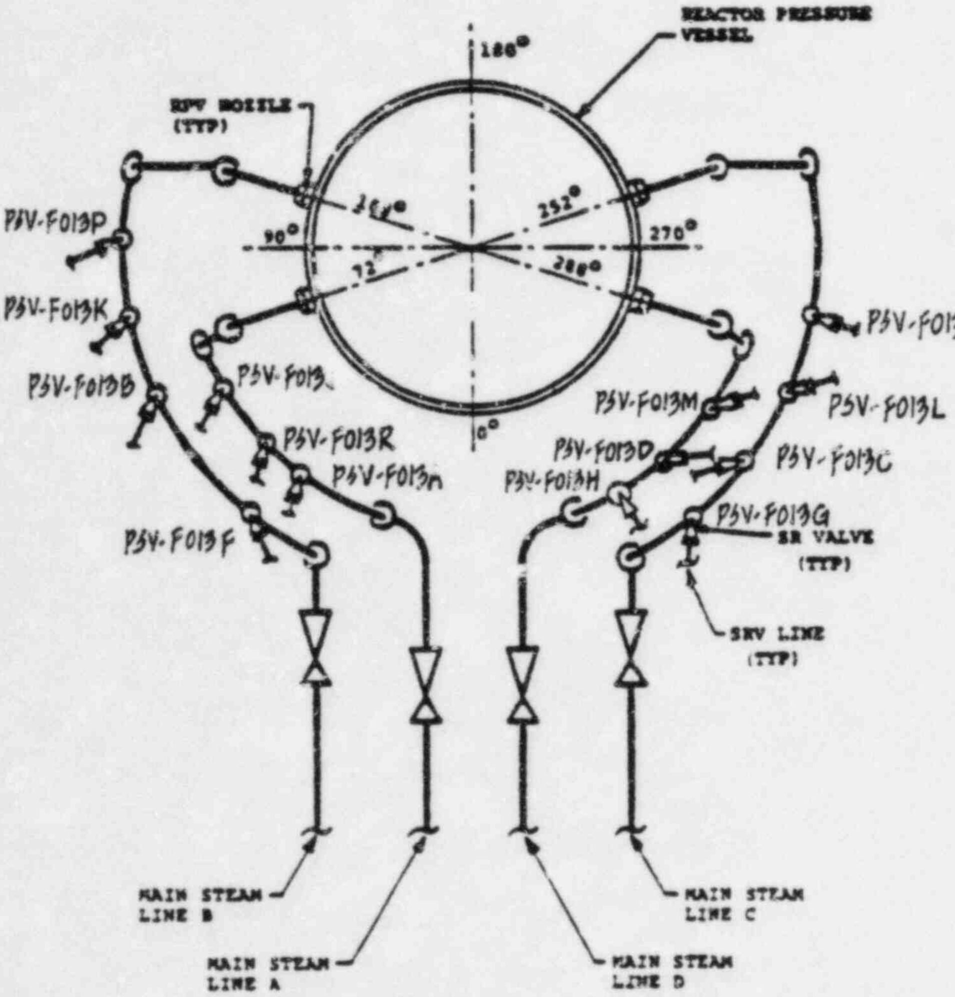

Figure 5-2.1-2

SRV DISCHARGE LINE AND MAIN STEAM LINE SCHEMATIC

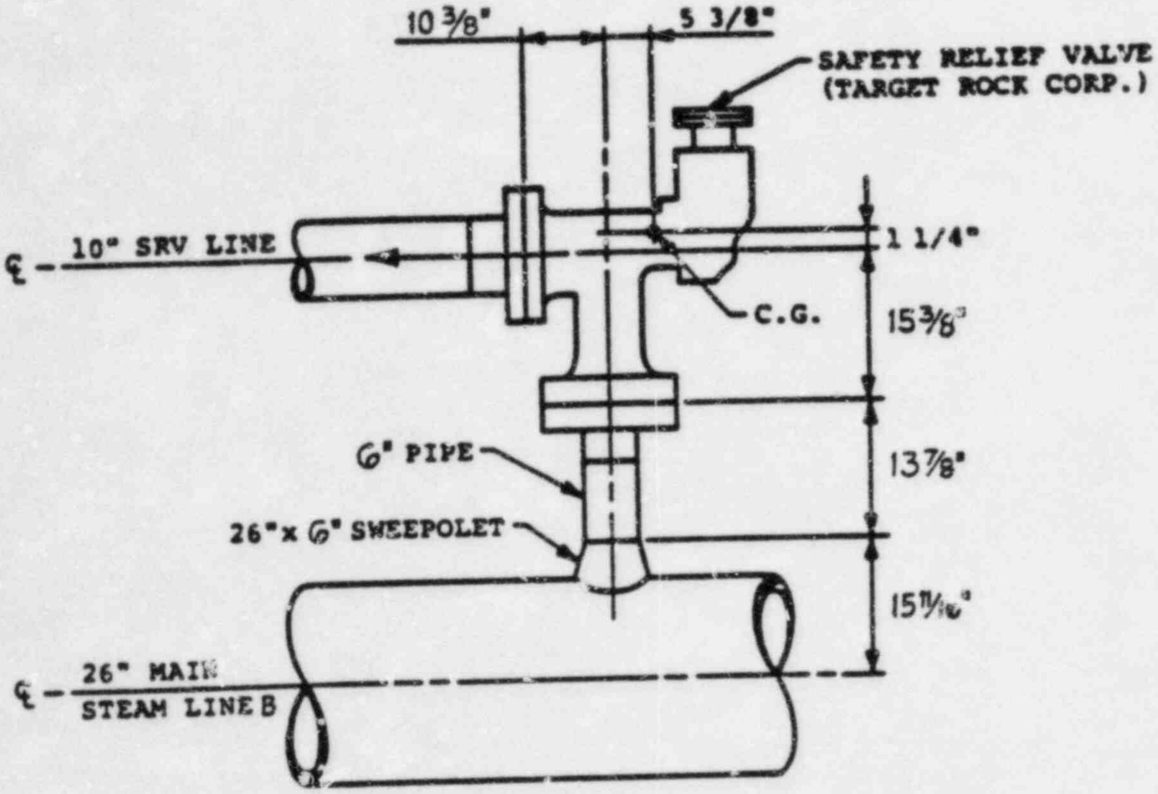

Figure 5-2.1-3

SRV DISCHARGE LINE CONNECTION TO
THE MAIN STEAM SAFETY RELIEF VALVE

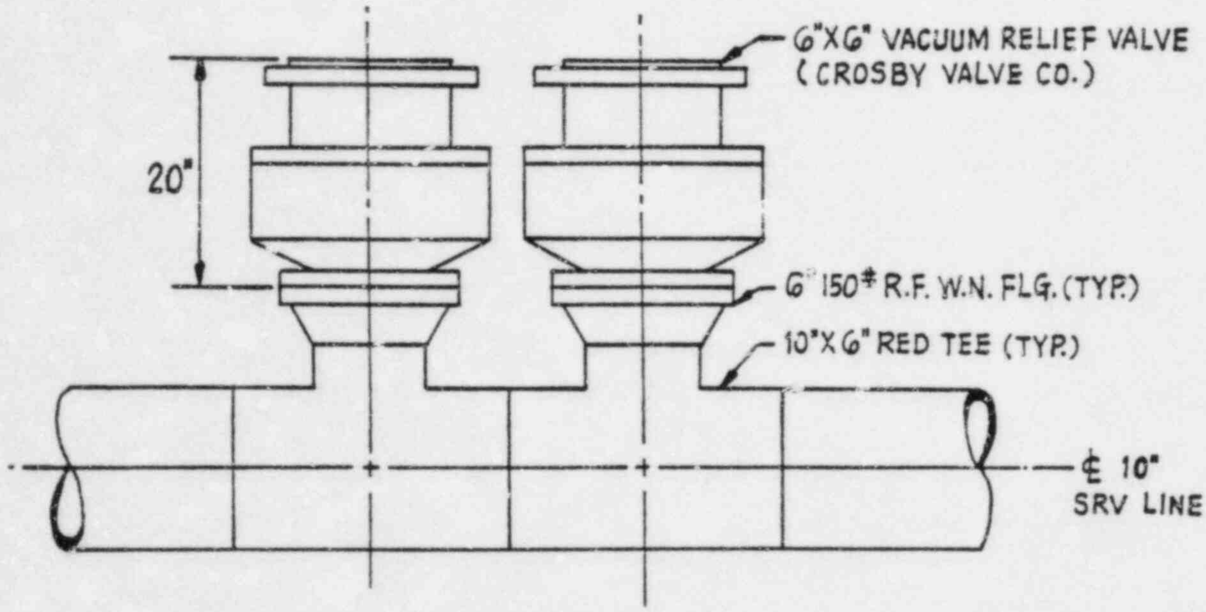

Figure 5-2.1-4

HORIZONTAL SRVDL VACUUM BREAKER INSTALLATION

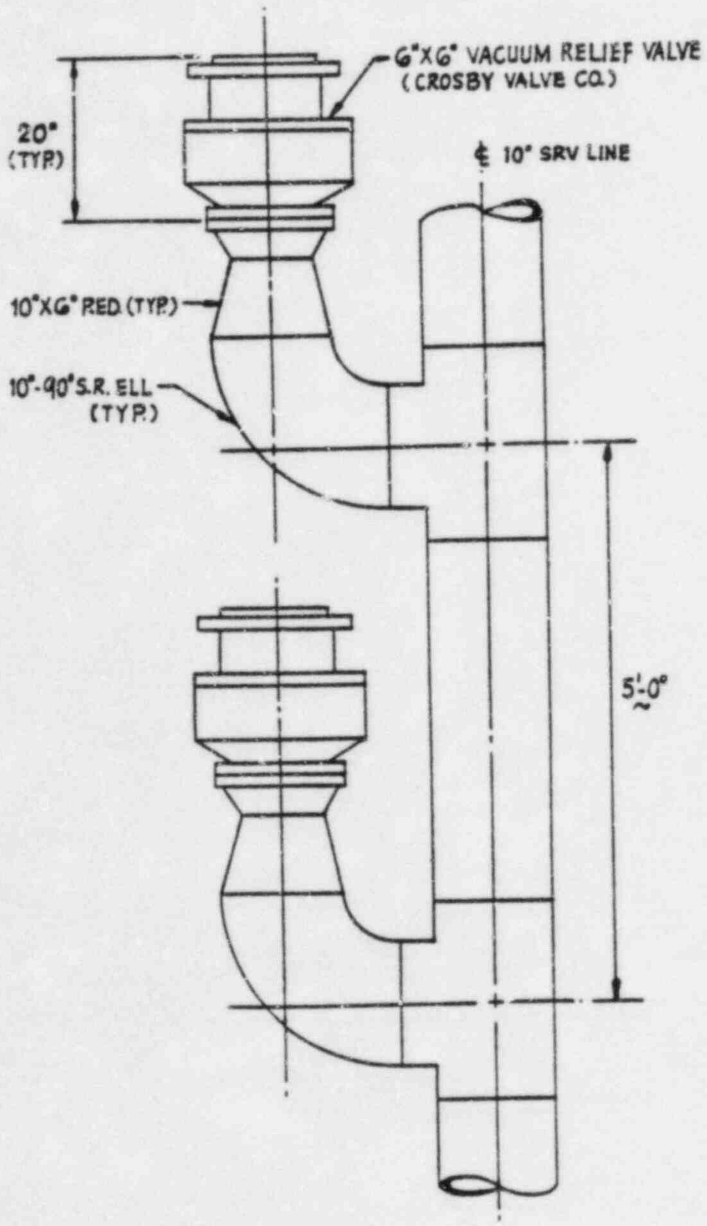

Figure 5-2.1-5

VERTICAL SRVDL

VACUUM BREAKER INSTALLATION

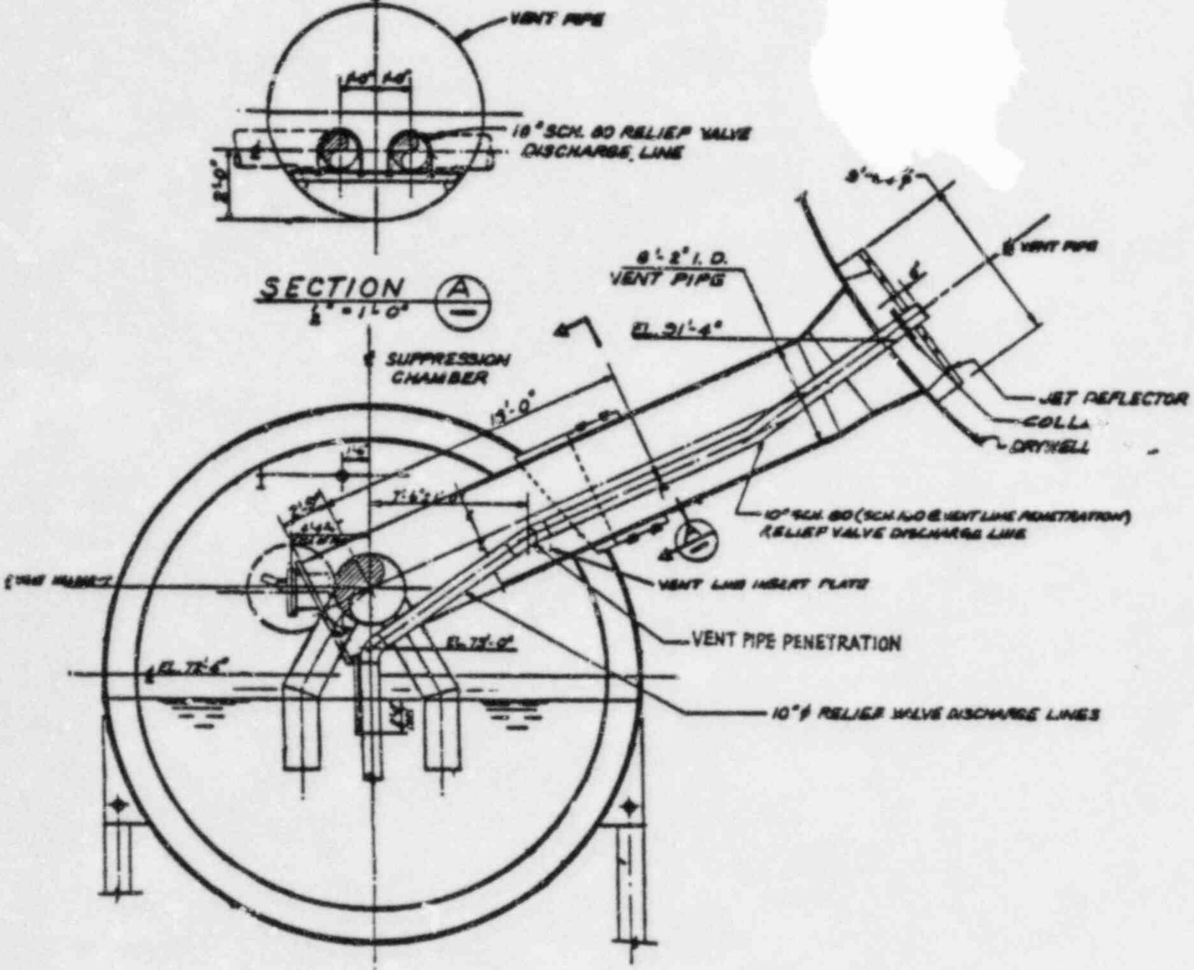

Figure 5-2.1-6

TYPICAL SRV PIPING SYSTEM IN
THE VENT PIPE

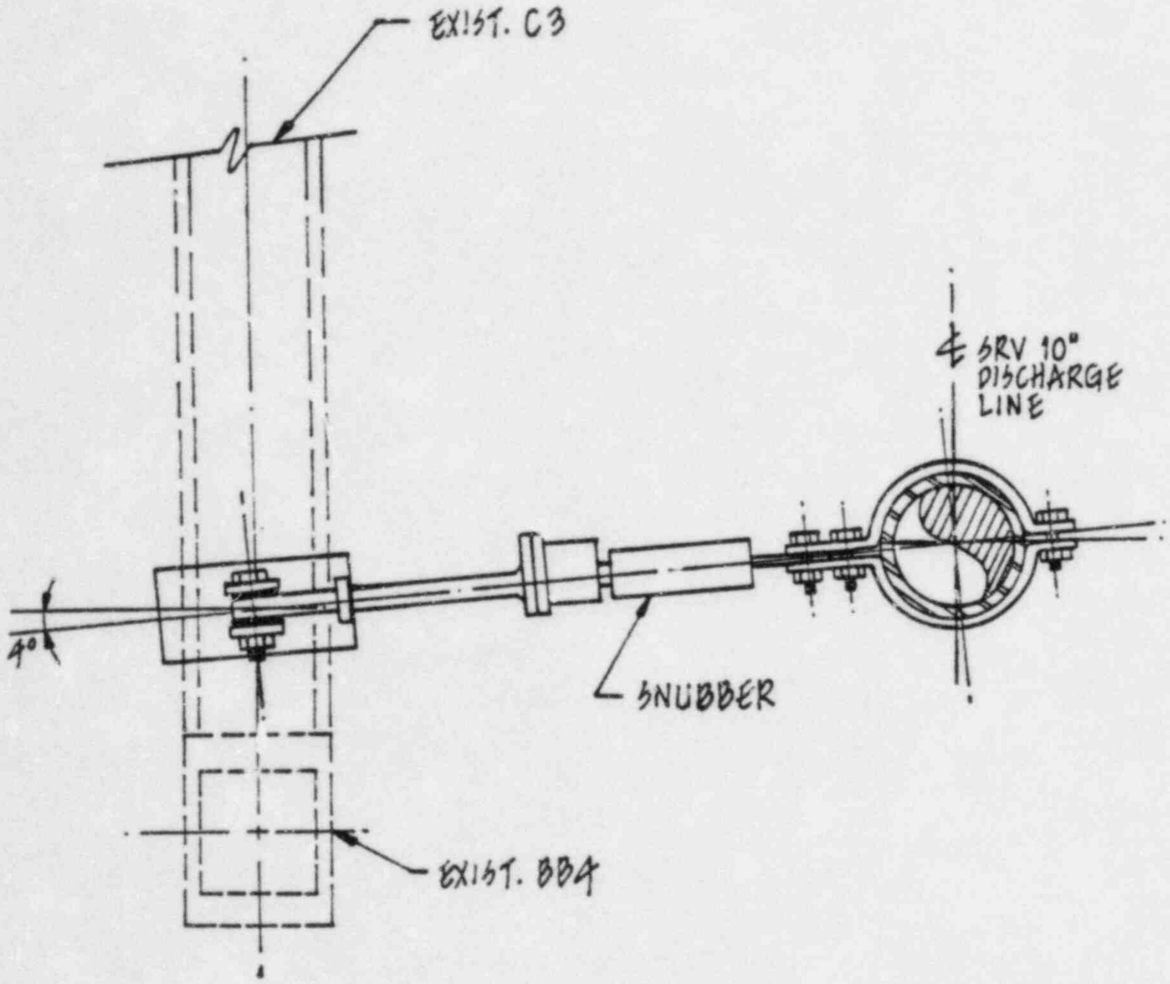

Figure 5-2.1-7

TYPICAL SRV LINE
SUPPORT IN THE DRYWELL

5-2.2 Loads and Load Combinations

The loads for which the Hope Creek drywell SRV piping and supports are designed, are defined in NUREG-0661 on a generic basis for all Mark I plants. The methodology used to develop plant unique drywell SRV piping and support 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 drywell SRV piping and supports are discussed and presented in Section 5-2.2.1.

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

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5-2.2.1 Loads

The loads acting on the drywell SRV piping and supports 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
7. Chugging Loads
8. Vent Clearing Loads
9. Vent System and Torus Interaction Loads

Loads in Categories 1 through 3 are analyzed in the SRV piping design per the FSAR (Reference 4). Additional 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 motion loads which result from loads acting on the vent system and torus. For the drywell SRV piping and supports, loads in Categories 5 through 8 do not directly act on the drywell piping. The Category 5 through 8 loads are evaluated by Category 9 - the resulting vent system and torus motion.

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

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

1. Dead Weight Loads

   a. Dead Weight (DW) Loads: These loads are defined as the uniformly distributed weight of the piping plus the concentrated weight of piping, supports and associated hardware.

   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 SRVDL 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 SRV piping and supports during an Operating Basis Earthquake (OBE). The loading is taken from the design basis for the SRV piping as documented in the FSAR.

   b. OBE Displacement (OBE_D) Loads: These loads are defined as the maximum horizontal and vertical relative seismic displacements at the SRV piping and piping support attachment points to the drywell structure and vent system during an OBE. The displacements at the drywell structure are taken from the original design basis analysis. Vent system displacements are determined from the analyses described in Volume 3.

c. SSE Inertia (SSE_I) Loads: These loads are defined as the horizontal and vertical accelerations acting on the SRV piping and supports during a Safe Shutdown Earthquake (SSE). The loading is taken from the design basis for the SRV piping as documented in the FSAR.

d. SSE Displacement (SSE_D) Loads: These loads are defined as the maximum horizontal and vertical relative seismic displacements at the SRV piping and piping support attachment points to the drywell structure and vent system during a SSE. The displacements at the drywell structure are taken from the original design basis analysis. Vent system displacements are determined from the analyses described in Volume 3.

3. Pressure and Temperature Loads

a. Pressure (P_O, P) Loads: These loads are defined as the maximum internal pressure (P_O) in the drywell SRV piping during normal operating and accident conditions, and the internal pressure (P) in the piping for design conditions.

b. Temperature (TE1, TE2) Loads: These loads are defined as the thermal expansion (TE1) of the drywell SRV piping and supports associated with normal operating and accident conditions occurring without concurrent SRV actuation; and the thermal expansion (TE2) of the SRV piping, associated with normal operating and accident conditions occurring with concurrent SRV actuation.

The effects of thermal anchor movements at attachment points of the SRV piping support and VPP on the vent system are also considered. The piping and support thermal anchor movement loadings are categorized and designated as follows:

- o THAM1 - Thermal anchor movement, Normal Operating condition without SRV actuation,

- o THAM2 - Thermal anchor movement, Normal Operating condition with SRV actuation,

- o THAM1A - Thermal anchor movement, accident condition without SRV actuation,

- o THAM2A - Thermal anchor movement, accident condition with SRV actuation.

4. Safety Relief Valve Discharge Loads

   a. SRV Discharge Line Thrust (RV1) Loads: These loads are defined as the pressure and thrust forces acting along the SRV piping due to SRV actuation. The methodology used to develop SRV discharge line thrust loads is described 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

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load combinations for which SRV thrust force time-histories are developed include a SRV actuation with Normal Operating conditions (Cases A1.1 and C3.1), and a SRV actuation with SBA/IBA conditions (Case A1.2). These governing SRV actuation cases are categorized and designated as follows:

- RV1A - SRV discharge piping thrust loads for Normal Operating conditions, first actuation (Case A1.1). SRV discharge piping thrust loads for DBA conditions, first actuation (Case A1.3) are bounded by Case A1.1.

- RV1B - SRV discharge piping thrust loads for Normal Operating conditions, subsequent actuation (Case C3.1).

- RV1C - SRV discharge piping thrust loads, for SBA/IBA conditions, first actuation (Case A1.2). SRV discharge piping thrust loads for other SBA/IBA conditions (Cases C3.2 and C3.3), are bounded by Case A1.2.

9. Vent System and Torus Interaction Loads

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

b. Torus Interaction Loads: These loads are defined as the interaction effects of the VPP and the SRV support inside the vent line due to loads acting on the suppression chamber shell.

The vent system and torus interaction loads include the following:

- TD - The vent system and torus displacements due to Normal Operating Pressure, and due to the dead weight of the suppression chamber and its contained water.

- o TD1 - The vent system and torus displacements due to accident condition pressures, and due to the dead weight of the suppression chamber and its contained water.

- o QAB_I - The interaction effects of torus and vent system motions due to SRV T-quencher discharge loads.

- o PS_I - The interaction effects of torus and vent system motions due to pool swell loads.

- o $PCHUG_I$ - The interaction effects of torus and vent system motions due to pre-chug loads.

- o $CHUG_I$ - The interaction effects of torus and vent system motions due to post-chug loads.

- o 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 analyses of the vent system and torus discussed in Volumes 2 and 3 of this report.

The loads presented in the preceding paragraphs envelop those postulated to occur during an actual LOCA or SRV discharge event. An evaluation for the effects of these loads results in conservative drywell SRV piping stresses and support reaction loads.

5.2.2.2 Load Combinations

The loads for which the Hope Creek drywell SRV piping and supports 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 5-2.2-2.

It is apparent from examining Table 5-2.2-2 that the load combinations specified for each event can be expanded into many more load combinations than those shown. 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 in Table 5-2.2-2 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.

The governing load combinations for the SRV piping are presented in Table 5-2.2-3. The governing load combinations for piping supports are presented in Table 5-2.2-4. The basis for establishing the governing loading combinations for the SRV piping and supports is provided in Tables 5-2.2-5 and 5-2.2-6. The appropriate ASME Code equations for the SRV piping as well as Service Levels for piping supports are also provided in Tables 5-2.2-5 and 5-2.2-6.

Included in the lists of governing load combinations are eight combinations which do not result from the 27 event combinations listed in Table 5-2.2-2. These are: load combinations A-1 and SA-1 which relate to the design pressure plus dead weight condition; load combinations A-2, SB-1, B-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, SA-1, A-2, SB-1, B-1, and SB-2 are consistent with the requirements as specified in the FSAR (Reference 4).

The pressure and temperature loads include those occurring within the range of the Mark I Program event durations as defined in the LDR (Reference 2).

In performing loading combinations, the dynamic loading components of the structural response are combined using the square root of the sum of the squares (SRSS) method. Use of the SRSS methodology for the SRV piping has been permitted by the NRC as described in Reference 8.

Each of the listed governing load combinations for the SRV piping and supports as provided in Tables 5-2.2-3 and 5-2.2-4 has been considered in the analysis methods described in Section 5-2.4.

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

Table 5-2.2-1

DRYWELL SRV PIPING LOADING
IDENTIFICATION CROSS-REFERENCE

VOLUME 5 LOAD DESIGNATION		VOLUME 1 SECTION REFERENCE
LOAD CATEGORY	LOAD CASE NUMBER	
DEAD WEIGHT	1a	1-3.1
	1b	1-3.1
SEISMIC	2a	1-3.1
	2b	1-3.1
	2c	1-3.1
	2d	1-3.1
PRESSURE AND TEMPERATURE	3a	1-3.1, 1-4.1.1
	3b	1-3.1, 1-4.1.1
SRV DISCHARGE	4a	1-4.2.2
	4b	1-4.2.2, 1-4.2.4
POOL SWELL (1)	5a	1-4.1.4.2,1-4.1.4.3,1-4.1.4.4
CONDENSATION (1) OSCILLATION	6a	1-4.1.7.3
CHUGGING (1)	7a	1-4.1.8.3
	7b	1-4.1.8.3
VENT CLEARING (1)	8a	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

Note:

1. For drywell SRV piping, inclusion of hydrodynamic loads from cases 5, 6, 7, and 8 are performed by considering vent system and torus motion displacements due to hydrodynamic loads applied at the VPP and the SRVDL support in the vent line.

Table 5-2.2-2

EVENT COMBINATIONS AND ALLOWABLE LIMITS FOR SRV DISCHARGE PIPING

EVENT COMBINATIONS			SRV	SRV + EQ		SBA IBA		SBA + EQ IBA + EQ				SBA+SRV IBA+SRV		SBA + SRV + EQ IBA + SRV + EQ				DBA		DBA + 2Q				DBA+SRV		DBA + EQ + SRV			
							CO, CH			CO, CH			CO, CH			CO,CH		PS (1)	CO, CH	PS		CO, CH		PS	CO, CH	PS		CO, CH	
TYPE OF EARTHQUAKE				O	S			O	S	O	S			O	S	O	S			O	S	O	S			O	S	O	S
COMBINATION NUMBER			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
LOADS	NORMAL (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)	-	-	-	-	-	-	-	-	-	-	-	-

Table 5-2.2-2

(Concluded)

Notes:

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 Hope Creek 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 ND-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 ND-3652.2, 2.4 S_h is used.

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Table 5-2.2-3

GOVERNING LOAD COMBINATIONS - DRYWELL SRV DISCHARGE PIPING

LOAD COMBINATION NUMBER	LOAD COMBINATIONS (1,5,6)	ASME CODE EQUATION (2)
A-1	P+DW	8
A-2	$TE1+THAM1+OBE_D+TD$	10 (3)
A-3	$TE2+THAM2+OBE_D+TD$	10 (3)
A-4	$TE2+THAM2A+OBE_D+TD1$	10 (3)
A-5	$TE1+THAM1A+OBE_D+TD1$	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	$P_O+DW+RV1C+QAB+QAB_I+SSE_I+PCHUG+PCHUG_I$	9
D-3	$P_O+DW+RV1C+QAB+QAB_I+SSE_I+CHUG+CHUG_I$	9
D-4	$P_O+DW+RV1A+QAB+QAB_I+ SSE_I + PS+PS_I+VCL$	9
T-1 (7)	$1.25P+DW_T$	8

Table 5-2.2-3

(Concluded)

Notes:

1. See Section 5-2.2.1 for definition of individual loads.

2. Equations are defined in Subsection ND-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 5-2.2.2 for combination of dynamic loads.

6. Only governing load combinations from Table 5-2.2-5 are considered here.

7. Hydrostatic test condition. DW_T for all lines shall be with lines full of water at 70°F.

Table 5-2.2-4

GOVERNING LOAD COMBINATIONS - DRYWELL SRV PIPING SUPPORTS

LOAD COMBINATION NUMBER	LOAD COMBINATION (1,2,5)		SERVICE LEVEL
	PRIMARY	SECONDARY	
SA-1	DW+	TE1+THAM1	A
SB-1	$DW+OBE_I+$	$TE1+THAM1+OBE_D+TD$	B
SB-2	$DW+OBE_I+$	$TE2+THAM2+OBE_D+TD$	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	$DW+RV1A+QAB+QAB_I+SSE_I+$	$TE2+THAM2+SSE_D+TD$	C
SC-2	$DW+RV1B+QAB+QAB_I+SSE_I+$	$TE2+TAHM2+SSE_D+TD$	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)	$DW+OBE_I+CO+CO_I+$	$TE1+THAM1A+OBE_D+TD1$	D
SD-2 (3)	$DW+RV1C+QAB+QAB_I+SSE_I+PCHUG+PCHUG_I+$	$TE2+THAM2A+SSE_D+TD1$	D
SD-3 (3)	$DW+RV1C+QAB+QAB_I+SSE_I+CHUG+CHUG_I+$	$TE2+THAM2A+SSE_D+TD1$	D
SD-4 (3)	$DW+RV1A+QAB+QAB_I+SSE_I+PS+PS_I+VCL+$	$TE2+THAM2A+SSE_D+TD1$	D
ST-1 (6)	DW_T		A

Table 5-2.2-4

(Concluded)

Notes:

1. See Section 5-2.2.1 for definition of individual loads.

2. Only governing load combinations from Table 5-2.2-6 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 combined with CO and chugging loads.

5. See Section 5-2.2.2 for combination of dynamic loads.

6. Hydrostatic test condition. DW_T for all lines shall be with lines full of water at $70^{o}F$.

Table 5-2.2-5

BASIS FOR GOVERNING LOAD COMBINATIONS-
DRYWELL SRV 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	C-1, C-2, A-3	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	C-3, C-4, A-4	FOR SBA ONLY. IBA BOUNDED BY EVENT COMBINATION NUMBER 15.	(3b)
15	D-2, D-3, A-4	N/A	N/A
14	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15	(3a)
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	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25	(3a)
25	D-4, A-4	N/A	N/A
26	D-1, A-5	FOR CO ONLY, DBA CHUGGING BOUNDED BY EVENT COMBINATION NUMBER 14	(3b)

Table 5-2.2-5

(Concluded)

Notes:

1. Event combination numbers refer to the numbers used in Table 5-2.2-2.

2. Governing load combinations are listed in Table 5-2.2-3.

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 5-2.2-6

BASIS FOR GOVERNING LOAD COMBINATIONS-
DRYWELL SRV PIPING SUPPORTS

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)
15	SD-2, SD-3	N/A	N/A
14	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15.	(3a)
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	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25	(3a)
25	SD-4	N/A	N/A
26	SD-1	FOR CO ONLY, DBA CHUGGING BOUNDED BY EVENT COMBINATION NUMBER 14.	(3b)

Table 5-2.2-6

(Concluded)

Notes:

1. Event combination numbers refer to the numbers used in Table 5-2.2-2.

2. Governing load combinations are listed in Table 5-2.2-4

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.

5-2.3 Analysis Acceptance Criteria

The acceptance criteria defined in NUREG-0661 on which the Hope Creek drywell SRV piping and supports analysis is based, are discussed in Section 1-3.2. In general, the acceptance criteria follow the rules contained in ASME Code, Section III, Division 1, up to and including the 1977 Summer Addenda for Class 3 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 acceptance criteria used in the analysis of the SRV piping and supports are summarized in the following paragraphs.

The drywell SRV piping is analyzed and evaluated in accordance with the requirements for Class 3 piping systems contained in Subsection ND of the Code. Table 5-2.3-1 lists the applicable ASME Code equations and stress limits for each of the governing piping load combinations.

The drywell SRV piping supports are analyzed in accordance with requirements for Class 3 piping supports as provided in Subsection NF of the Code.

Table 5-2.3-1

ALLOWABLE STRESSES FOR DRYWELL SRV PIPING

STRESS TYPE	ASME CODE EQUATION NUMBER	SERVICE LEVEL	STRESS LIMIT	ALLOWABLE VALUE (ksi)	GOVERNING LOAD COMBINATION NUMBER(1)
PRIMARY	8	DESIGN	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)

Notes:

1. Governing load combination numbers are listed in Table 5-2.2-3.

2. See ASME Section III subsection ND paragraph ND-3652.3 (Reference 6) for combination of loads.

5-2.4 Methods of Analysis

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

The methodology used to develop the structural models of the SRV 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.

5-2.4.1 Drywell SRV Piping Structural Models

The drywell SRV piping models were analyzed by utilizing the Bechtel in-house structural computer code ME101. ME101 performs static, response spectrum, and dynamic time-history analyses, as well as ASME Section III piping code evaluations.

The 14 drywell lines are analyzed using four separate models, each including a main steam line and three or four attached SRV lines except for the SRV discharge load case where 14 separate models were utilized composed of a main steam line and one attached SRV line only. The main steam lines are modeled from the reactor pressure vessel (RPV) nozzle to the drywell penetration. The SRV lines attach to the main steam line at the safety relief valves and terminate at the vent pipe penetrations. The main steam and SRV piping systems included in each of the four drywell models are listed in Table 5-2.4-1.

The 14 identical safety relief valves are modeled with the mass of each valve lumped at the valve center of gravity. Also included in the piping models are 28 identical vacuum breakers, two attached to each SRV line. The mass of the vacuum breaker is lumped at its center of gravity.

The drywell models have fully rigid anchor points at the main steam line connection to the RPV nozzle and at the main steam line flued head at the drywell wall. The diagonal terms of a 6 x 6 stiffness matrix are modeled at the SRV line connection at the VPP. The matrix simulates the stiffness at the VPP and is derived from the vent system analyses described in Section 3-2.4.

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

Snubbers are modeled as active in seismic and other dynamic load cases, while struts are active in all load cases. Spring hangers are modeled as active in the dead weight load case only. The effects of the mass of supports and connecting hardware attached to the piping are included in the piping models.

Stiffness values at a piping support location are established and input into the SRV piping analytical models.

5-2.4.2 Analysis Methods

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

Dynamic analysis techniques are used to determine system response to the major loads defined by NUREG-0661 acting on the SRV piping. These techniques utilize either response spectra or time-history analysis methods, depending on the input loading characteristics. The remaining SRV 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 amplification factors are developed and applied to the individual dynamic loads when performing equivalent static analyses.

The specific analytical techniques used for each piping model described in Section 5-2.4.1 for each load as identified in Section 5-2.2.1, are described in the following paragraphs:

The mathematical models of the drywell SRV piping are discussed in Section 5-2.4.1. The following analysis methods utilized for each of the drywell SRV piping models are presented herein.

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 drywell SRV 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 piping system during the hydrostatic test condition.

2. Seismic Loads

   a. OBE Inertia (OBE_I) Loads: A dynamic analysis is performed for each of the three orthogonal directions (N-S, E-W, and vertical) using the uniform response spectra method. The seismic response spectra curves used in the analysis are in accordance with the FSAR. A value of 1% critical damping is used in accordance with the FSAR. All modes up to 33 hertz are dynamically analyzed in calculating the peak response of the drywell SRV piping system. The rigid range response of the piping system greater than 33 hertz is also incorporated into all seismic spectral analyses by calculating the piping response to a static seismic load case using acelerations from the enveloped spectrum curves at the 33 hertz cutoff frequency.

b. OBE Displacement (OBE_D) Loads: A static analysis is performed independently for each of the three orthogonal directions. The relative anchor displacements of the RPV nozzle, the drywell structure and the vent pipe penetration and support are considered to be out of phase for conservatism.

c. SSE Inertia (SSE_I) Loads: A dynamic analysis is performed for each of the three orthogonal directions using the uniform response spectra method. A value of 2% critical damping is used in accordance with the FSAR.

d. SSE Displacement (SSE_D) Loads: A static analysis is performed for each of the three orthogonal directions. The relative anchor displacements of the RPV nozzle, the drywell structure and the vent pipe penetration and support are considered to be out of phase for conservatism.

The methodology used to combine modal responses and spatial components in the seismic analysis is defined in NRC Regulatory Guide 1.92, Revision 1, "Combining Modal Responses and Spatial Components in Seismic Response Analysis," (Reference 7). The seismic analysis is performed independently for each of the two horizontal directions and for the vertical direction. The resulting peak responses obtained for each of the three directions are combined by SRSS. The individual modal responses are grouped by frequencies (within 10%), and the modal responses within each group are combined by absolute sum. The individual responses of the groups are combined by SRSS.

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 ND-3650 of the ASME Code, Section III (Reference 6).

b. Temperature Loads: Static thermal expansion analyses are performed for the SRV piping to envelop all postulated plant conditions. A static analysis is performed for anchor movement at the vent pipe penetrations as described in Section 5-2.2.1. Thermal anchor movements at the RPV nozzle are also considered in the temperature load analyses.

4. Safety Relief Valve Discharge Loads

a. SRV Discharge Line Clearing Loads: A dynamic analysis is performed for each of the three bounding SRV actuation cases (RV1A, RV1B, RV1C) utilizing the modal superposition time-history analysis technique. A time-dependent forcing function is applied on each pipe segment along the pipe axis.

An integration time-step of sufficiently small size is selected to adequately account for the responses of the piping system up to 200 hertz. A value of 1% critical damping is utilized in accordance with the NRC Regulatory Guide 1.61.

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 drywell SRV piping for the vent pipe penetration and the SRVDL vent pipe guide displacements due to thermal and pressure loads which are described in Section 5-2.2.1. An equivalent static analysis is performed on the drywell SRV piping for the vent pipe penetration and guide displacements due to the QAB_I, OBE_I, and SSE_I loads which are described in Section 5-2.2.1.

A rigorous dynamic analysis is performed on the drywell SRV piping for the PS_I, CO_I, $CHUG_I$, and QAB_I loads described in Section 5-2.2.1. The modal superposition displacement time-history analysis technique is utilized.

Response at the VPP and guide due to the above loads is taken from the vent system analysis presented in Section 3-2.0. A time-step of sufficiently small size is selected to adequately account for the critical responses of the piping system up to 100 hertz. A value of 1% critical damping is conservatively utilized in accordance with NRC Regulatory Guide 1.61.

b. Torus Interaction Loads:

The torus interaction loads transferred into the drywell SRV piping through the vent system and wetwell SRV piping have been analyzed by applying displacements at the VPP and SRVDL support location in the vent line. These displacements were calculated by the torus analyses described in Section 3-2.0.

Table 5-2.4-1

DRYWELL SRV PIPING STRUCTURAL MODELS

MODEL NUMBER	MAIN STEAM LINE	SRV LINES
1	A	A R J
2	B	F B K P
3	C	G C L E
4	D	H D M

5.2.5 Analysis Results and Conclusions

The geometry, loads and load combinations, acceptance criteria and analysis methods used in the evaluation of the Hope Creek drywell SRV piping and supports, are presented and discussed in the preceding sections. The results from the evaluation of the piping and supports are presented in the paragraphs and tables which follow.

The maximum stresses resulting from the governing load combinations for locations on the drywell SRV piping are presented in Table 5-2.5-1. The maximum stresses for each Service Level are listed along with the associated allowable stress values. Reaction loads for the supports are incorporated into the support design and analyzed per the requirements of ASME Section III, Subsection NF.

The maximum resultant moments at each of the 14 SRV outlet flanges are presented in Table 5-2.5-2. The maximum moments are listed for each Service Level, along with the allowable flange moments.

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

Table 5-2.5-1

ANALYSIS RESULTS FOR DRYWELL SRV PIPING STRESS

SRV LINE	DESIGN (KSI)	LEVEL B (KSI)	LEVEL C (KSI)	LEVEL D (KSI)	SECONDARY (KSI)
A	6.55	16.14	20.49	20.67	19.17
B	7.21	17.54	23.70	23.85	20.25
C	6.05	14.09	16.29	16.53	17.19
D	6.83	15.65	16.78	17.31	18.35
E	6.05	14.10	16.30	16.54	17.19
F	7.21	16.53	16.80	17.51	20.25
G	6.05	14.79	16.85	17.08	17.19
H	6.83	14.19	14.88	15.19	18.35
J	6.55	16.56	20.89	21.07	19.17
K	7.21	16.53	19.55	20.63	20.25
L	6.05	15.45	17.39	17.61	17.19
M	6.83	13.36	14.40	15.08	18.35
P	7.21	16.53	19.92	20.69	20.25
R	6.55	16.73	21.49	22.12	19.17
ALLOWABLE STRESS (KSI)	15.0	18.0	27.0	36.0	22.5

Table 5-2.5-2

ANALYSIS RESULTS FOR SRV OUTLET FLANGE MOMENTS

SRV LINE	LEVEL A (IN-KIP)	LEVEL B (IN-KIP)	LEVEL C (IN-KIP)	LEVEL D (IN-KIP)
A	108.40	121.07	124.51	124.55
B	105.59	113.81	126.55	126.59
C	54.23	103.03	114.51	114.54
D	96.46	118.25	141.69	141.71
E	148.58	56.00	71.12	71.17
F	50.10	65.04	89.04	89.08
G	53.17	60.89	74.22	74.28
H	71.08	103.56	105.26	105.29
J	100.32	61.36	63.07	63.14
K	59.48	101.50	112.80	112.83
L	92.60	49.49	63.85	63.91
M	121.34	57.32	60.61	60.68
P	89.20	99.15	111.09	111.13
R	66.40	66.20	86.84	86.88
ALLOWABLE MOMENT (IN-KIP)	300	300	300	300

5-3.0 ANALYSIS OF WETWELL SAFETY RELIEF VALVE DISCHARGE PIPING AND T-QUENCHERS

An evaluation of each of the NUREG-0661 requirements which affect the design adequacy of the Hope Creek wetwell SRV discharge piping, T-quenchers and supports is presented in the following sections. The general criteria used in this evaluation are contained in Volume 1 of this report.

The component parts of the wetwell SRV piping, T-quenchers and supports which are examined are described in Section 5-3.1. The loads and load combinations for which the wetwell SRV piping, T-quenchers and supports are examined are described and presented in Section 5-3.2. The analysis methodology used to evaluate the wetwell SRV piping, T-quenchers and supports is discussed in Section 5-3.4. The acceptance limits to which the analysis results are compared are discussed and presented in Section 5-3.3. The analysis results and conclusions are presented in Section 5-3.5.

5-3.1 Component Description

The wetwell SRV piping system for Hope Creek consists of fourteen 10" diameter, Schedule 80, SA-106 Grade B piping lines. Figure 5-3.1-1 shows a typical wetwell SRV line and support locations. As indicated in Figure 5-3.1-2, each of the 8 vent pipes contains two SRV lines, except for the single SRV lines in the vent pipes at azimuths 157.5° and 202.5°. Each SRV line enters the suppression chamber horizontally at the vent pipe penetration (VPP), and runs parallel to the vent header toward the mitered joint, as shown in Figure 5-3.1-3. The line is then routed diagonally and vertically in the plane of the mitered joint down to the bottom of the suppression chamber, as shown in Figure 5-3.1-4.

The support system for the wetwell SRV piping consists of a stiffened penetration support at the VPP, vertical and horizontal struts attached to the ring girder, and a lateral strut attached to the vent header, as shown in Figures 5-3.1-3 and 5-3.1-4. Details of the VPP support are discussed in Section 3-2.1. Details of the strut supports attached to the ring beam and vent header are shown in Figure 5-3.1-5.

At the lower end of each SRV line is a 12" diameter T-quencher device. The SRV line and T-quencher are connected by a 12" x 10" concentric reducer. Each T-quencher consists of a ramshead assembly and two quencher arms located 5'-0" above the suppression chamber shell. The T-quencher ramsheads are centered on the suppression chamber ring girders, as shown in Figure 5-3.1-3. The arms of the T-quenchers are aligned parallel to the longitudinal axes of the suppression chamber mitered segments, as shown in Figure 5-3.1-2.

The T-quencher arms are constructed from 12" diameter Schedule 80, stainless steel pipes, which are capped on the ends. The 0.391" diameter holes drilled in the T-quencher arms are arranged as shown in Figure 5-3.1-6. A typical T-quencher ramshead assembly is constructed from 12" diameter short radius elbows, reinforced with a 1-1/2" thick crotch plate and a 1-1/2" thick saddle plate, as shown in Figure 5-3.1-9.

The T-quencher is supported by a 14" diameter pipe beam located directly below the T-quencher arms. The T-quencher support beam spans between the mitered joint ring girder and the mid-bay girder as shown in Figures

5-3.1-2 and 5-3.1-3. The T-quencher support beam is attached to the suppression chamber as shown in Figure 5-3.1-8.

The T-quencher arms are connected to the support beam by plate-type supports as shown in Figures 5-3.1-3 and 5-3.1-9. The T-quencher ramshead support assembly consists of the ramshead saddle plate and two attached pin plates with stiffeners. The assembly pin plates are connected to pin plates on the mitered joint ring girder by a 2-1/2" diameter pin as shown in Figures 5-3.1-7 through 5-3.1-9.

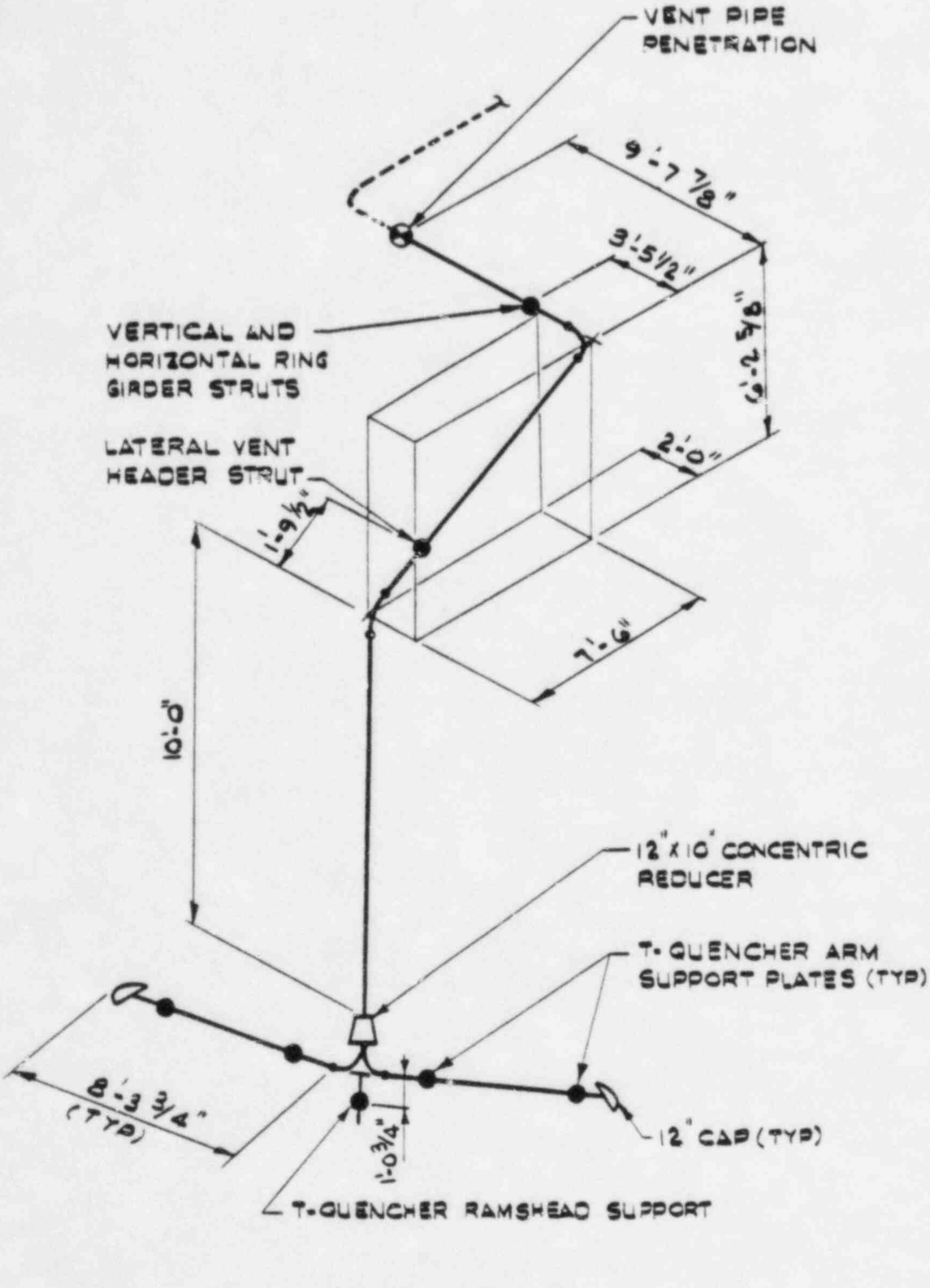
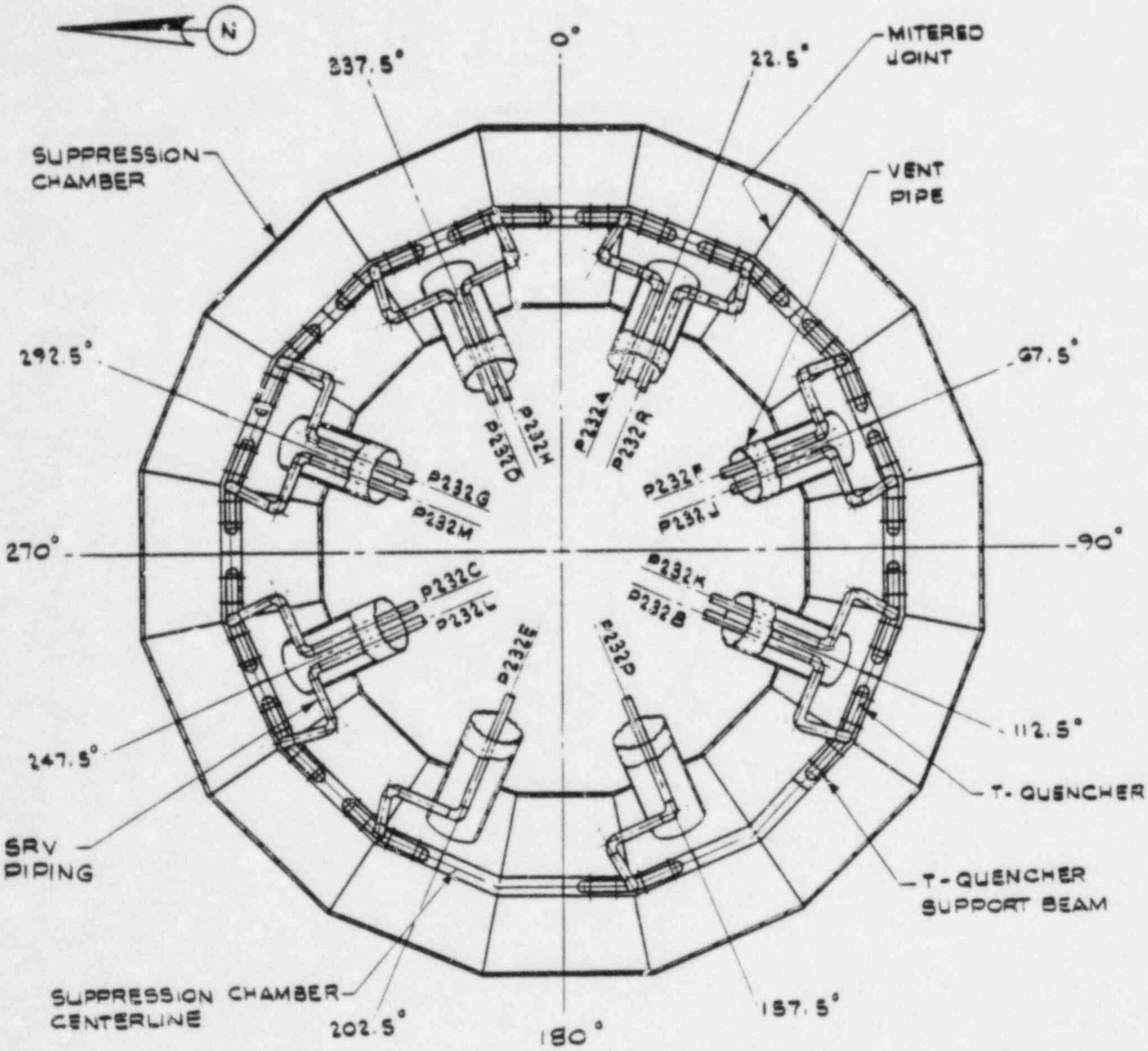


Figure 5-3.1-1

TYPICAL WETWELL SRV PIPING SYSTEM AND QUENCHER - ISOMETRIC VIEW



NOTE: VENT HEADERS AND DOWNCOMERS NOT SHOWN FOR CLARITY.

Figure 5-3.1-2

GENERAL ARRANGEMENT OF WETWELL SRV PIPING AND QUENCHERS IN CONTAINMENT

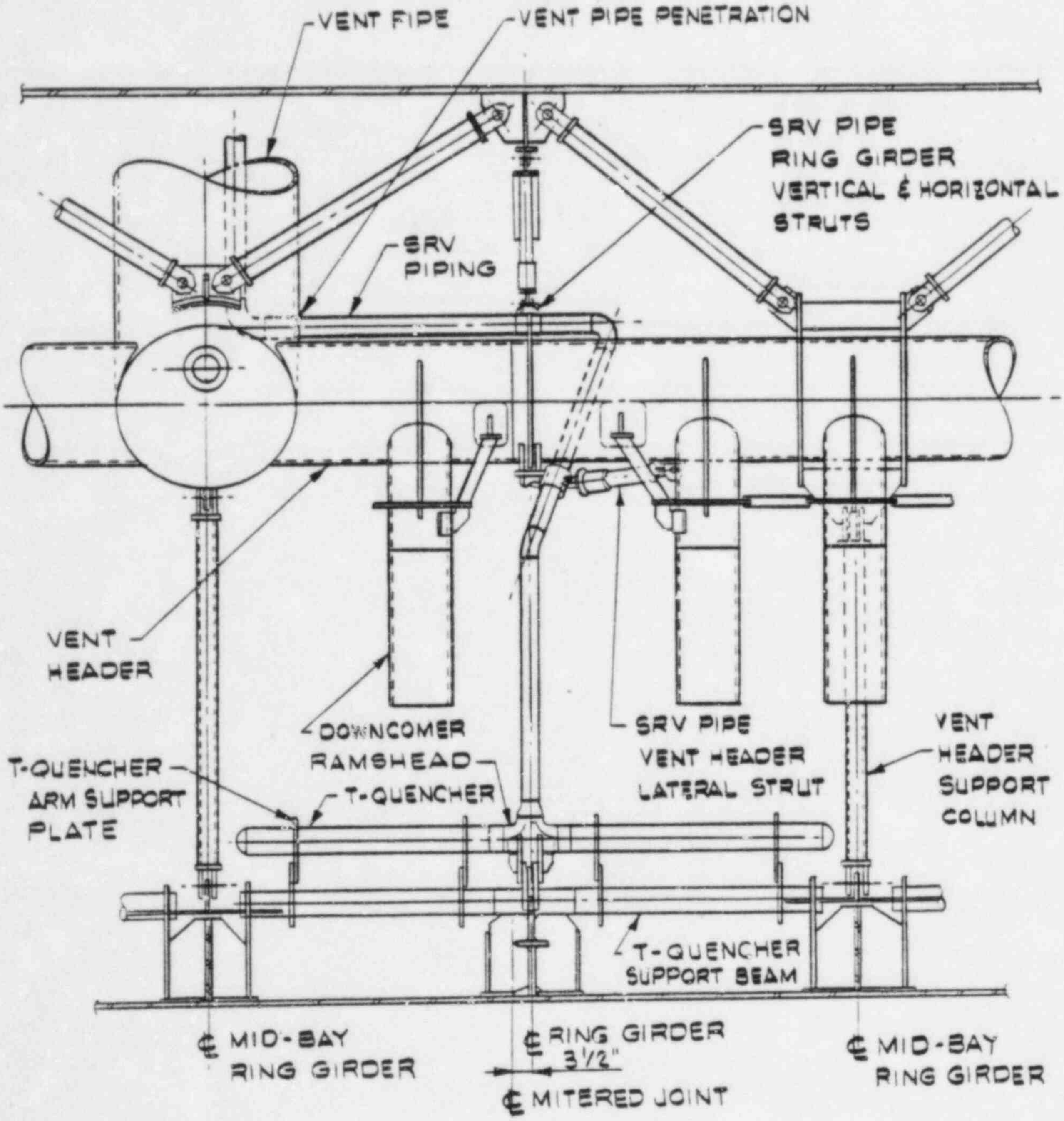


Figure 5-3.1-3

DEVELOPED VIEW OF SRV PIPING AND QUENCHER IN THE SUPPRESSION CHAMBER

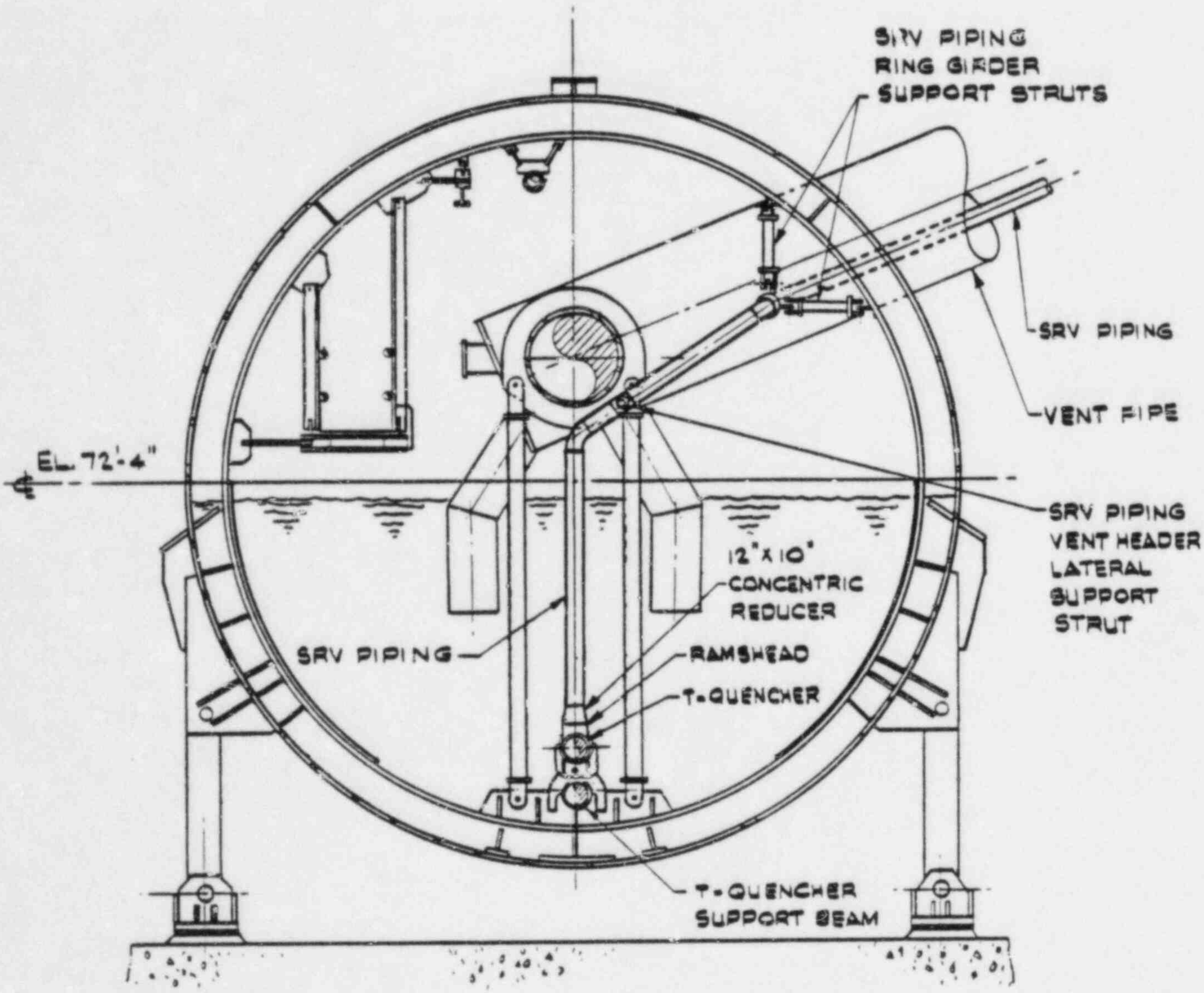


Figure 5-3.1-4

SECTION VIEW OF SRV PIPE ROUTING IN THE SUPPRESSION CHAMBER

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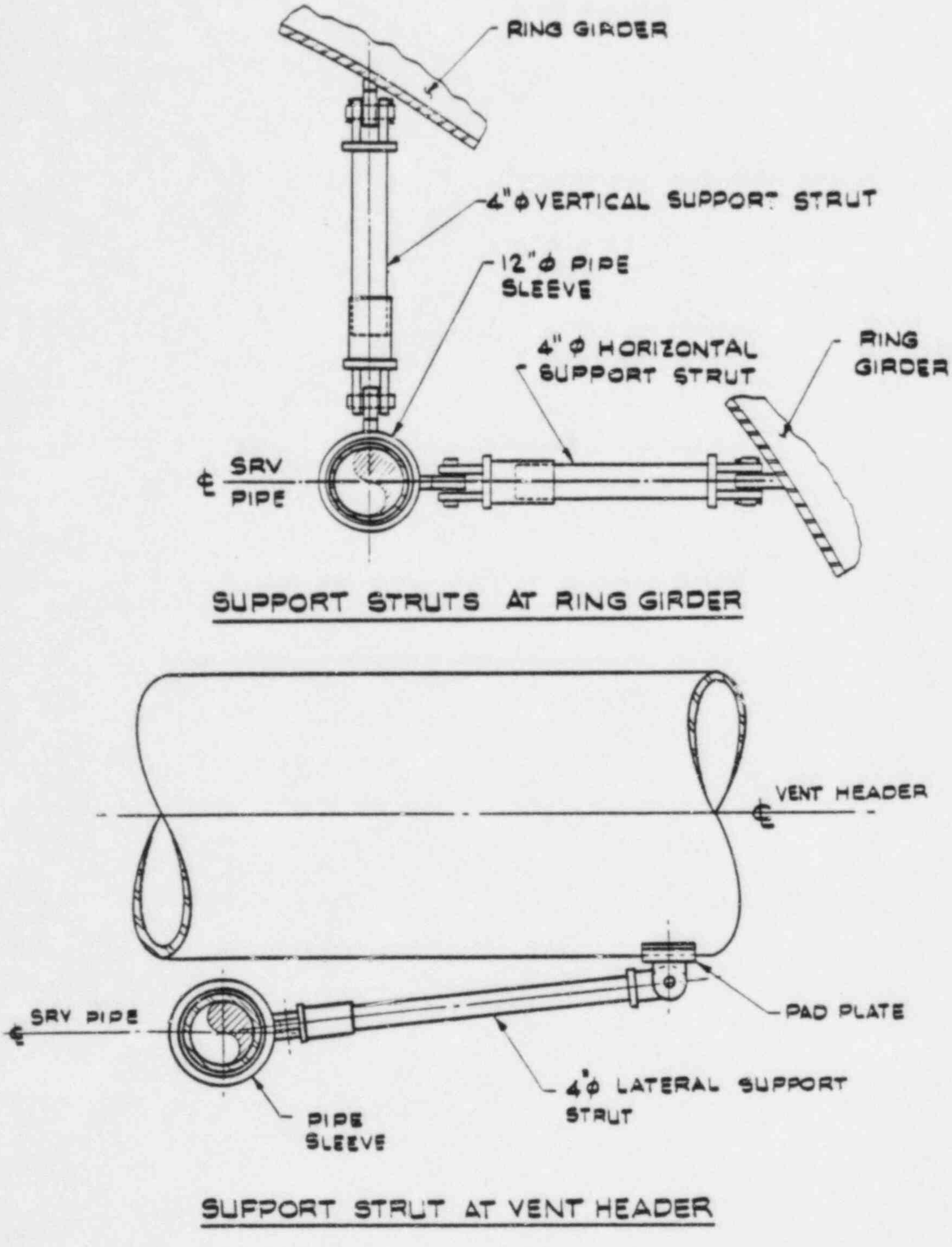


Figure 5-3.1-5

WETWELL SRV PIPING SUPPORT DETAILS

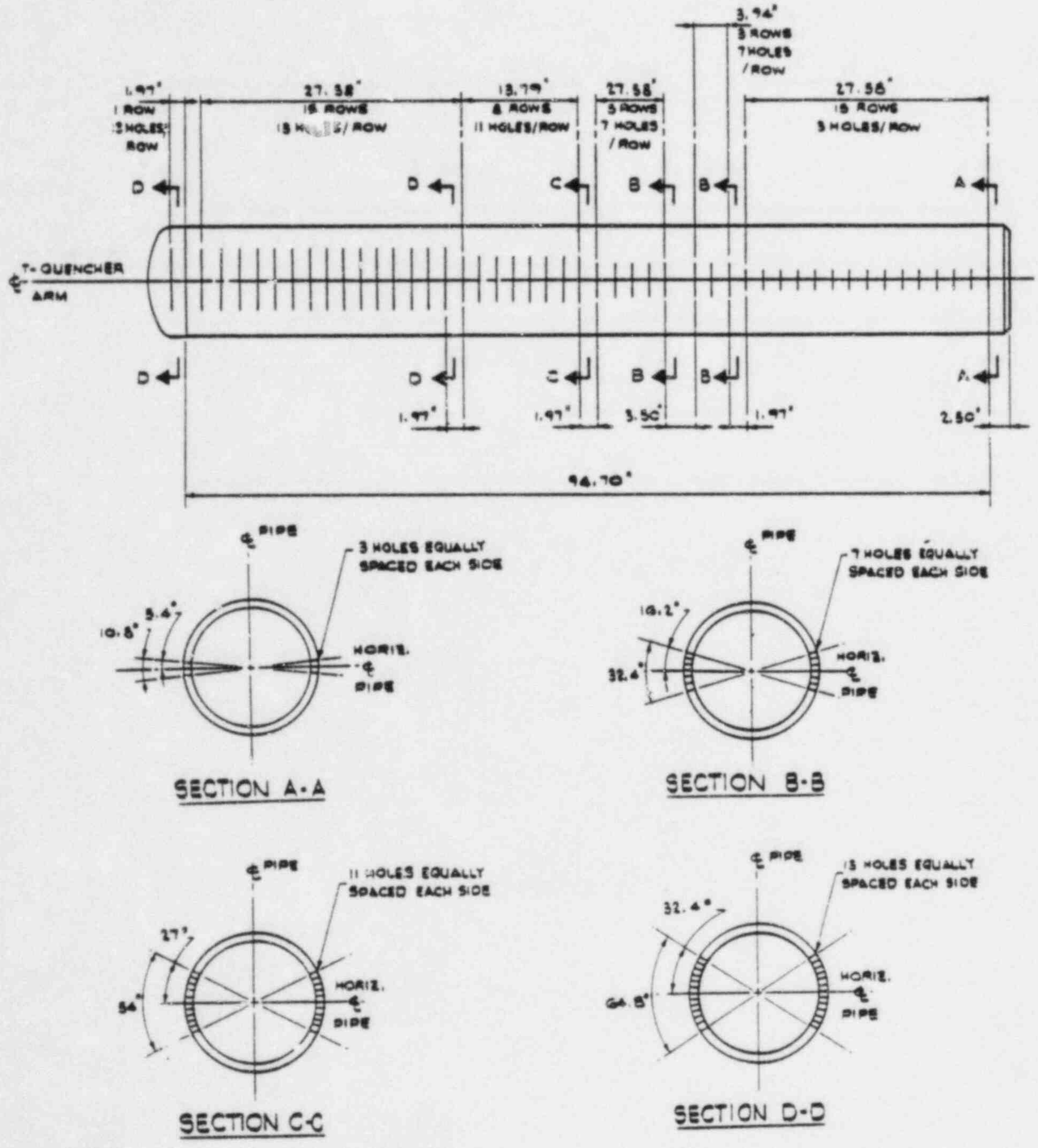


Figure 5-3.1-6

T-QUENCHER ARM HOLE PATTERN

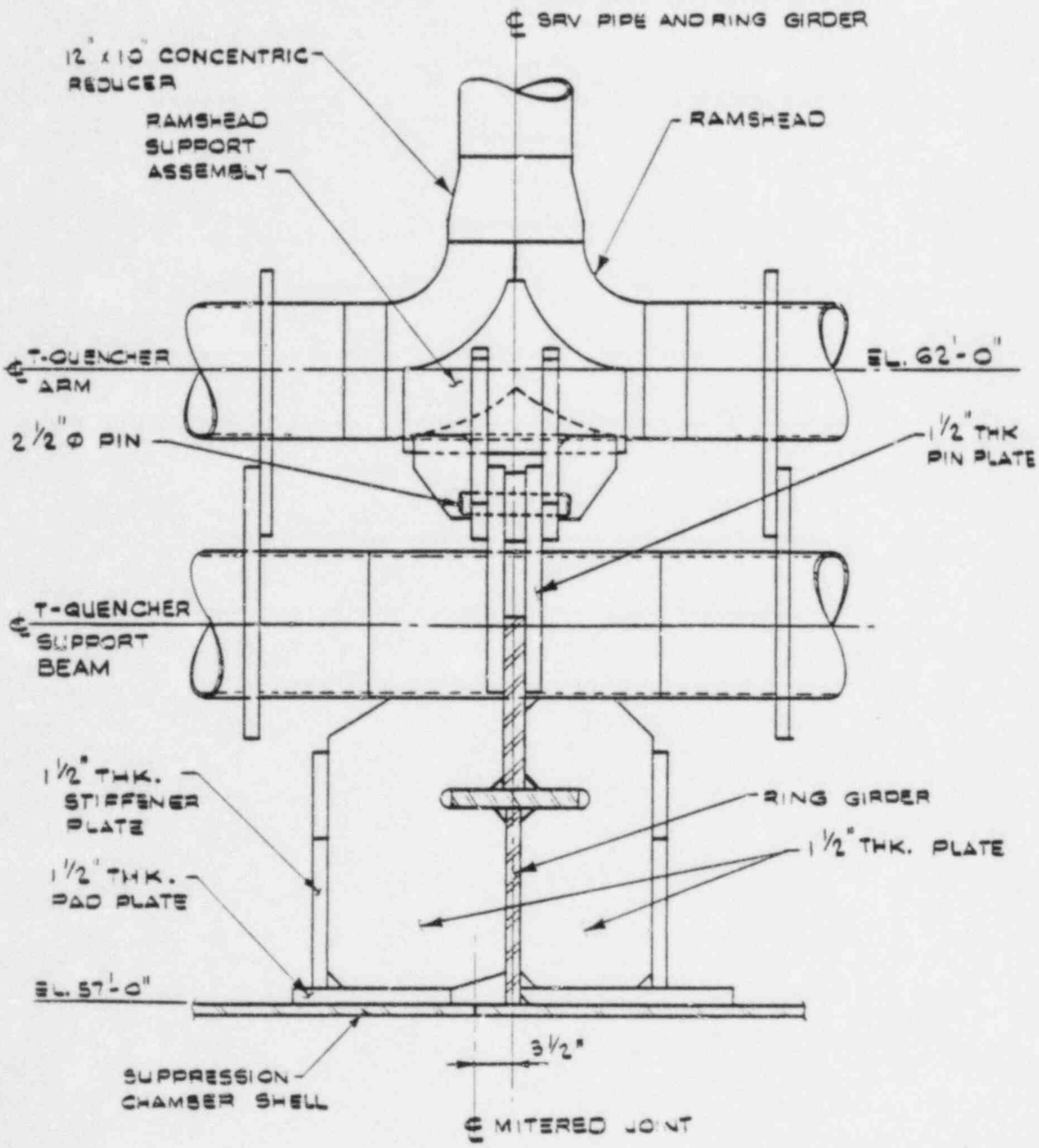
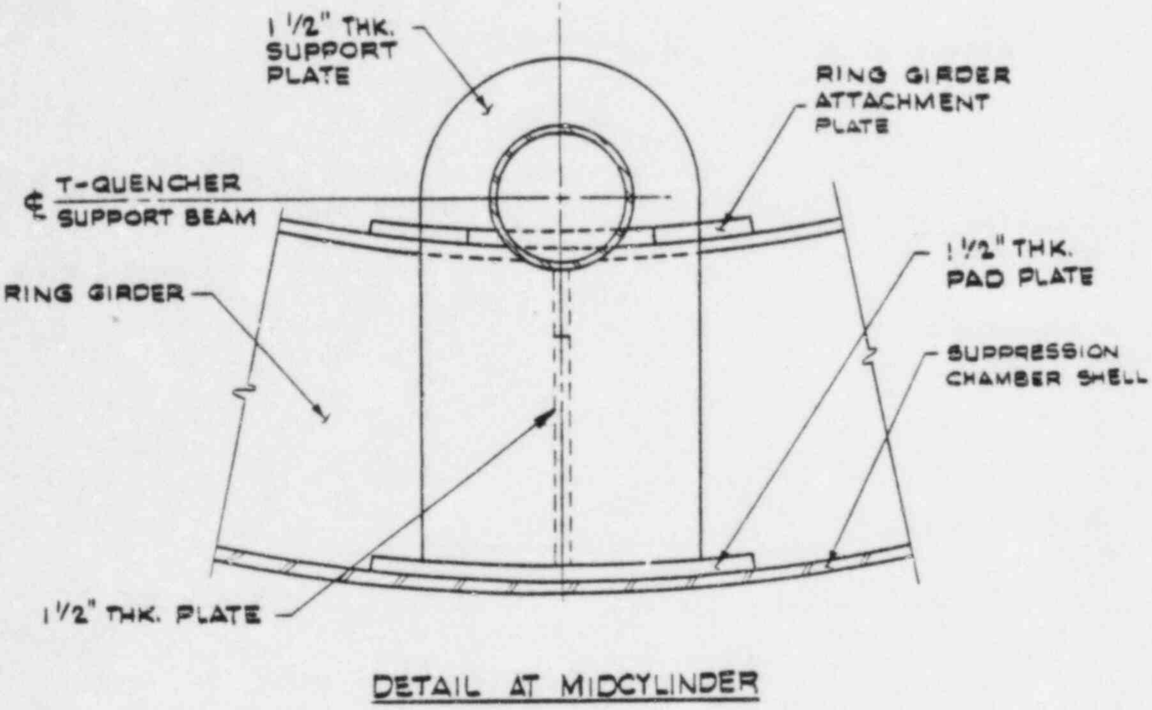
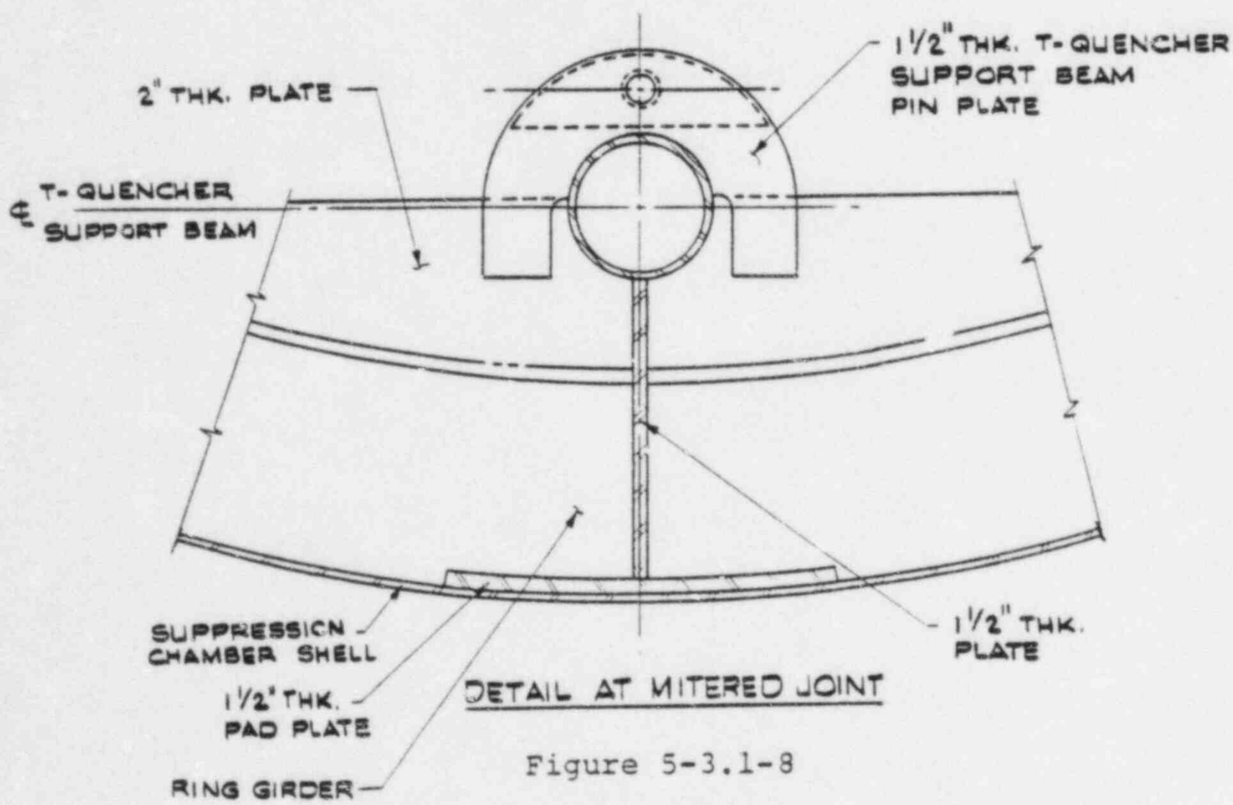


Figure 5-3.1-7

T-QUENCHER RAMSHEAD AND SUPPORT DETAILS



DETAIL AT MIDCYLINDER

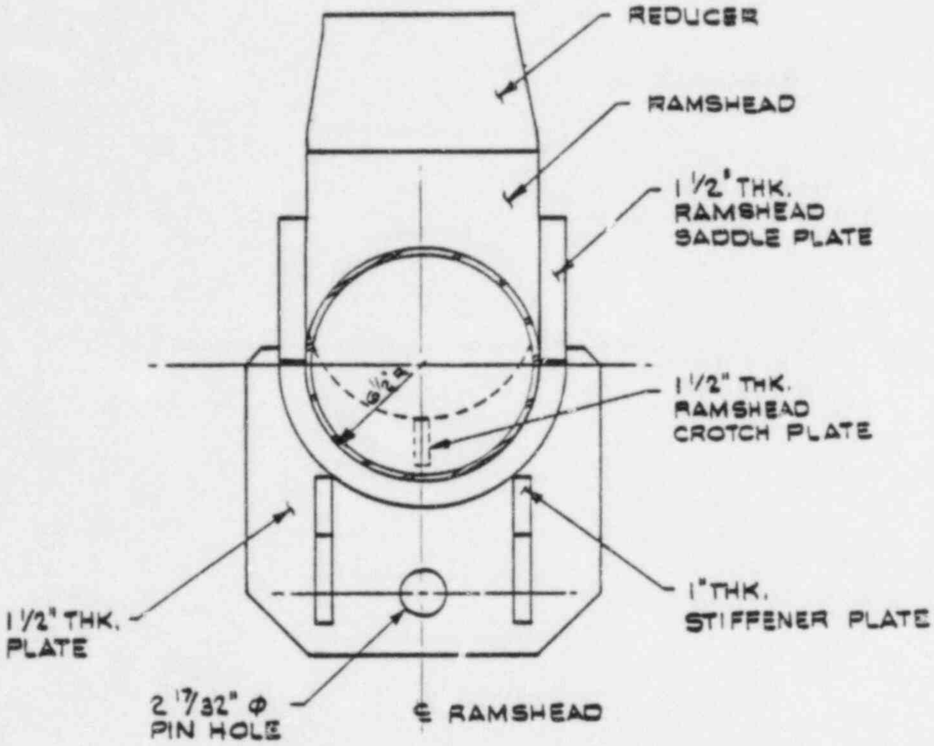


DETAIL AT MITERED JOINT

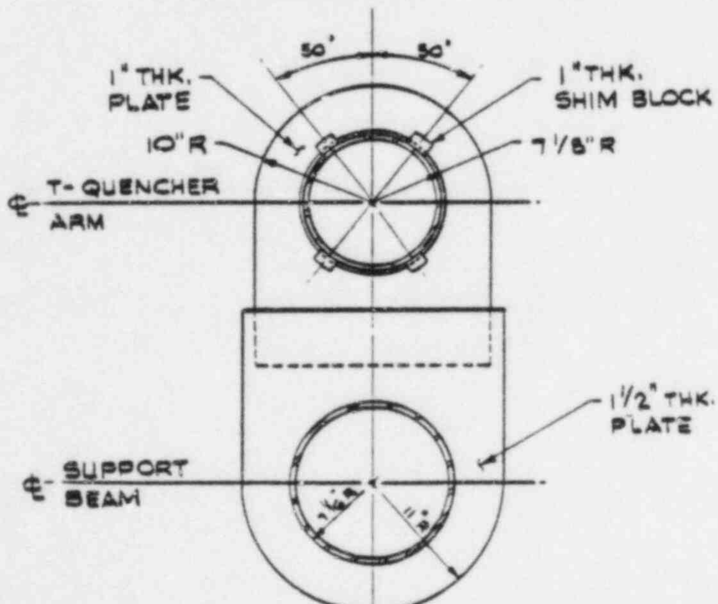
Figure 5-3.1-8

MIDCYLINDER AND MITERED JOINT

RING GIRDER T-QUENCHER SUPPORT DETAILS



RAMSHEAD SUPPORT ASSEMBLY



T-QUENCHER ARM SUPPORT PLATE

Figure 5-3.1-9

RAMSHEAD AND T-QUENCHER ARM SUPPORT DETAILS

5-3.2 Loads and Load Combinations

The loads for which the Hope Creek wetwell SRV piping, T-quenchers, and supports are designed are defined in NUREG-0661 on a generic basis for all Mark I plants. The methodology used to develop plant unique wetwell SRV piping, T-quencher, and support 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 wetwell SRV piping, T-quencher, and supports are discussed and presented in Section 5-3.2.1.

Using the event combinations and event sequencing defined in NUREG-0661 and discussed in Sections 1-3.0 and 1-4.0, the governing load combinations which affect the SRV piping, T-quenchers and supports are formulated. The load combinations are discussed and presented in Section 5-3.2.2.

5-3.2.1 Loads

The loads acting on the wetwell SRV piping, T-quenchers, and supports 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
7. Chugging Loads
8. Vent Clearing Loads
9. Vent System and Torus Interaction Loads

Loads in categories 1 through 3 are considered in the original SRV piping design as documented in the FSAR (Reference 4). Additional 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 motion loads which result from loads acting on the vent system and torus.

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

The magnitudes and characteristics of the governing loads in each category, obtained using the methodology discussed in Section 1-4.0, are identified and presented in the following paragraphs. The corresponding section of Volume 1 of this report where the loads are discussed is provided as a reference in Table 5-3.2-1. The loading information presented in this section is consistent with that presented in Section 1-4.0, with additional specific information relevant to the evaluation of the wetwell SRV piping, T-quenchers, and supports.

1. Dead Weight Loads

   a. Dead Weight (DW) Loads: These loads are defined as the uniformly distributed weight of the piping and T-quenchers plus the distributed and concentrated weight of piping and T-quencher supports, and associated hardware. Also included is the weight of water contained in the SRV piping and quenchers corresponding to a torus water level of 11-1/2" below the torus horizontal centerline.

b. Dead Weight (DW_T) Loads: These loads are defined as the dead weight of piping, T-quenchers and associated components as described above, plus the dead weight of water in the SRV 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 SRV piping, T-quenchers and supports during an Operating Basis Earthquake (OBE). The seismic response spectra are taken from the original design basis for the SRV piping.

b. OBE Displacement (OBE_D) Loads: These loads are defined as the maximum horizontal and vertical relative seismic displacements at the SRV piping, piping support, and T-quencher support attachment points to the suppression chamber and vent system during an OBE. The displacements at suppression chamber attachment points are taken from the original design basis analysis. The vent system displacements are determined from the analyses described in Volume 3.

c. SSE Inertia (SSE_I) Loads: These loads are defined as the horizontal and vertical accelerations acting on the SRV piping, T-quenchers, and supports during a Safe Shutdown Earthquake (SSE). The seismic response spectra are taken from the original design basis for the SRV piping.

d. SSE Displacement (SSE_D) Loads: These loads are defined as the maximum horizontal and vertical relative seismic displacements at the SRV piping, piping support, and T-quencher support attachment points to the suppression chamber and vent system during a

SSE. The displacements at suppression chamber attachment points are taken from the original design basis analysis. The vent system displacements are determined from the analyses described in Volume 3.

3. Pressure and Temperature Loads

a. Pressure (P_o, P) Loads: These loads are defined as the maximum internal pressure (P_o) in the wetwell SRV piping and T-quenchers during normal operating and accident conditions, and the internal pressure (P) in the piping and T-quenchers for design conditions. The values of P_o and P used in the analysis are listed in Table 5-3.2-2.

b. Temperature (TE1, TE2) Loads: These loads are defined as the thermal expansion (TE1) of the wetwell SRV piping, T-quenchers, and supports associated with normal operating and accident conditions occurring without concurrent SRV actuation; and the thermal expansion (TE2) of the SRV piping, T-quenchers, and supports associated with normal operating and accident conditions occurring with concurrent SRV actuation. Temperatures for TE1 and TE2 used in the analysis are listed in Table 5-3.2-2.

The effects of thermal anchor movements at attachment points of the SRV piping, piping supports, and T-quencher supports on the vent system and suppression chamber are also considered. The piping, T-quencher, and support thermal anchor movement loadings are categorized and designated as follows:

- o THAM1 - Thermal anchor movement, Normal Operating condition without SRV actuation,
- o THAM2 - Thermal anchor movement, Normal Operating condition with SRV actuation
- o THAM1A - Thermal anchor movement, accident condition without SRV actuation,
- o THAM2A - Thermal anchor movement, accident condition with SRV actuation.

4. Safety Relief Valve Discharge Loads

a. SRV Discharge Line Thrust (RV1) Loads: These loads are defined as the pressure and thrust forces acting along the SRV piping and T-quencher due to SRV actuation. The methodology used to develop SRV discharge line thrust loads is described 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 a SRV actuation with Normal Operating conditions (Cases A1.1 and C3.1) and a SRV actuation with SBA/IBA conditions (Case C3.2). These governing SRV actuation cases are categorized and designated as follows:

o RV1A - SRV discharge piping thrust loads for Normal Operating conditions, first actuation (Case A1.1). SRV discharge piping thrust loads for DBA conditions, first actuation (Case A1.3) are bounded by Case A1.1.

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- o RV1B - SRV discharge piping thrust loads for Normal Operating conditions, subsequent actuation (Case C3.1)
- o RV1C - SRV discharge piping thrust loads, for SBA/IBA conditions, subsequent actuation (Case C3.2). SRV discharge piping thrust loads for other SBA/IBA conditions, (Cases A1.2 and C3.3) are bounded by Case C3.2.

Peak forces on each wetwell piping segment from the SRV thrust force time-histories for the three actuation cases are listed in Table 5-3.2-3.

b. SRV T-quencher Discharge (OAB) Loads: These loads are defined as the transient pressures which act on the submerged portion of SRV discharge piping, T-quenchers and supports during an SRV discharge. These loads are categorized as follows:

- Water Jet Impingement Loads: The wetwell SRV piping, T-quenchers, and supports are not affected by this loading.

- T-Quencher and End Cap Thrust Loads: During an SRV discharge, the T-quencher arms and end caps are subjected to water clearing thrust loads. The procedure used to develop bounding values of these loads is discussed in Section 1-4.2.2. The resulting magnitudes of the T-quencher arm and end cap thrust loads are shown in Table 5-3.2-5.

- Air Bubble Drag Loads: During the air clearing phase of an SRV discharge event, transient drag pressure loads are postulated to act on the submerged SRV piping, T-quenchers and supports. 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 air bubble arrangements for both single and multiple T-quencher discharge cases. The results are evaluated to determine the controlling loads. The peak segment loads for the piping, T-quenchers, and supports are presented in Table 5-3.2-4.

5. Pool Swell Loads

a. Pool Swell (PS) Loads: During the initial phase of a DBA event, transient hydrodynamic loads are postulated to act on the SRV piping and supports located above the suppression pool. These loads are categorized as follows:

o Impact and Drag Loads: During the initial phase of a DBA event, the SRV piping and supports located above the suppression pool are subjected to transient loads. The procedure used to develop these load transients is discussed in Section 1-4.1.4.

- Pool Fallback Loads: During the latter phase of pool swell, transient drag pressures are postulated to act on portions of the SRV piping and supports located between the maximum bulk pool height and the downcomer exit. The procedure used to develop these pressure transients is discussed in Section 1-4.1.4.

- Froth Impingement and Fallback Loads: During the initial phase of a DBA event, transient impingement and fallback pressures are postulated to act on components of the wetwell SRV piping system located in specified regions above the rising suppression pool. The procedure used to develop the transient forces and spatial distribution of froth impingement and fallback loads on these components is discussed in Section 1-4.1.4.

The resulting maximum pool swell loads on the wetwell SRV piping and support components are shown in Table 5-3.2-6.

6. Condensation Oscillation Loads

a. Condensation Oscillation (CO) Loads: During the condensation oscillation phase of a DBA event, harmonic drag pressures are postulated to act on submerged portions of the SRV piping, T-quenchers, and supports. 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 the case with twice the average source strength at the nearest downcomer. The results are evaluated to determine the controlling loads. These results include the effects of velocity drag, acceleration drag, torus shell fluid-structure interaction (FSI) acceleration drag, interference effects, and wall effects. A typical pool acceleration profile from which the FSI accelerations are derived is shown in Figure 2-2.2-4. 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 chugging cycle, are postulated to act on the submerged portion of the SRV piping, T-quenchers and supports. 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 the case with twice the average source strength at the nearest downcomer. The results are evaluated to determine the controlling loads. The resulting loads acting on the SRV piping, T-quenchers, and supports are bounded by the post-chug load case 7(b).

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

Loads are developed for the case with the average source strength at the nearest two downcomers acting both in-phase and out-of-phase. The results are evaluated to determine the controlling loads. The resulting peak segment loads for the SRV piping, T-quenchers, and supports for the controlling post-chug drag load case are shown in Table 5-3.2-4.

The results shown in the table include the effects of velocity drag, acceleration drag, torus shell FSI acceleration drag, interference effects, and wall effects. A typical pool acceleration profile from which the FSI accelerations are derived is shown in Figure 2-2.2-5. The results of each harmonic in the loading are combined using the methodology discussed in Section 1-4.1.7.

8. Vent Clearing Loads

a. Vent Clearing (VCL) Loads: During the vent system water and air clearing phase of a DBA event, transient drag pressure loads are postulated to act on submerged portions of the SRV piping, T-quenchers and supports. These loads are categorized as follows:

o LOCA Water Jet Impingement Loads: During the water clearing phase of a DBA event, submerged portions of the SRV piping, T-quenchers, and supports are subjected to transient drag pressure loads. The procedure used to develop these transient drag forces is discussed in Section 1-4.1.5. The resulting peak segment forces for the SRV piping, T-quenchers, and supports are shown in Table 5-3.2-4. These results include the effects of velocity drag and acceleration drag.

- o LOCA Air Bubble Drag Loads: During the air clearing phase of a DBA event, submerged portions of the SRV piping, T-quenchers, and supports are subjected to transient drag pressure loads. The procedure used to develop these transient drag forces is discussed in Section 1-4.1.6. The resulting peak segment forces acting on the SRV piping, T-quenchers, and supports are shown in Table 5-3.2-4. 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 pipe penetration and at the SRV line support location on the vent header due to loads acting on the vent system.

   b. Torus Interaction Loads: These loads are defined as the interaction effects at the SRV piping and T-quencher support attachment points on the suppression chamber due to loads acting on the suppression chamber shell.

The vent system and torus interaction loads include the following:

- o TD - The vent system and torus displacements due to Normal Operating Pressure, and due to the dead weight of the suppression chamber and its contained water.
- o TD1 - The vent system and torus displacements due to accident condition pressures, and due to the dead weight of the suppression chamber and its contained water.
- o QAB_I - The interaction effects of torus and vent system motions due to SRV T-quencher discharge loads
- o PS_I - The interaction effects of torus and vent system motions due to pool swell loads

- o $PCHUG_I$ - The interaction effects of torus and vent system motions due to pre-chug loads
- o $CHUG_I$ - The interaction effects of torus and vent system motions due to post-chug loads
- o 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 analyses of the vent system and torus discussed in Volumes 2 and 3 of this report.

The loads presented in the preceding paragraphs envelop those postulated to occur during an actual LOCA or SRV discharge event. An evaluation for the effects of these loads results in conservative wetwell SRV piping, T-quencher, and support stresses.

Table 5-3.2-1

WETWELL SRV PIPING AND T-QUENCHER

LOADING IDENTIFICATION CROSS-REFERENCE

VOLUME 5 LOAD DESIGNATION		VOLUME 1 SECTION REFERENCE
LOAD CATEGORY	LOAD CASE NUMBER	
DEAD WEIGHT	1a	1-3.1
	1b	1-3.1
SEISMIC	2a	1-3.1
	2b	1-3.1
	2c	1-3.1
	2d	1-3.1
PRESSURE AND TEMPERATURE	3a	1-3.1, 1-4.1.1
	3b	1-3.1, 1-4.1.1
SRV DISCHARGE	4a	1-4.2.2
	4b	1-4.2.2, 1-4.2.4
POOL SWELL	5a	1-4.1.4.2,1-4.1.4.3,1-4.1.4.4
CONDENSATION OSCILLATION	6a	1-4.1.7.3
CHUGGING	7a	1-4.1.8.3
	7b	1-4.1.8.3
VENT CLEARING	8a	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

Table 5-3.2-2

PRESSURES AND TEMPERATURES FOR WETWELL SRV PIPING AND T-QUENCHERS

PIPING SYSTEM COMPONENT	PRESSURE (psig)		TEMPERATURE (^{o}F)	
	MAXIMUM OPERATING (P_o)	DESIGN (P)	WITHOUT SRV ACTUATION (TE1)	WITH SRV ACTUATION (TE2)
SRV PIPING	397	540	167	407
T-QUENCHERS	497	540	167	375

Note:

1. Temperature conditions for T-quencher supports are provided in Table 3-2.2-2.

Table 5-3.2-3

SRV DISCHARGE THRUST LOADS -
PEAK SEGMENT FORCES FOR WETWELL PIPING

SRV ACTUATION CASE	PEAK FORCE (KIPS)[1]		
	HORIZONTAL SEGMENT	DIAGONAL SEGMENT	VERTICAL SEGMENT
RV1A	19.27	20.25	89.78
RV1B	9.40	12.91	93.41
RV1C	20.56	21.09	96.55

Note:

1. Loads shown include DLF's.

Table 5-3.2-4

MAXIMUM WETWELL SRV PIPING SYSTEM

SUBMERGED STRUCTURE LOADS

LOADING	MAXIMUM PRESSURE (psi) (2)		
	SRV LINE	T-QUENCHER ARMS	T-QUENCHER SUPPORT BEAM
SRV DISCHARGE AIR BUBBLE DRAG	3.87	30.98	16.50
POST-CHUG DRAG	15.17	4.34	4.58
LOCA WATER JET	0.82	4.08	1.47
LOCA AIR BUBBLE	0.97	1.31	0.90

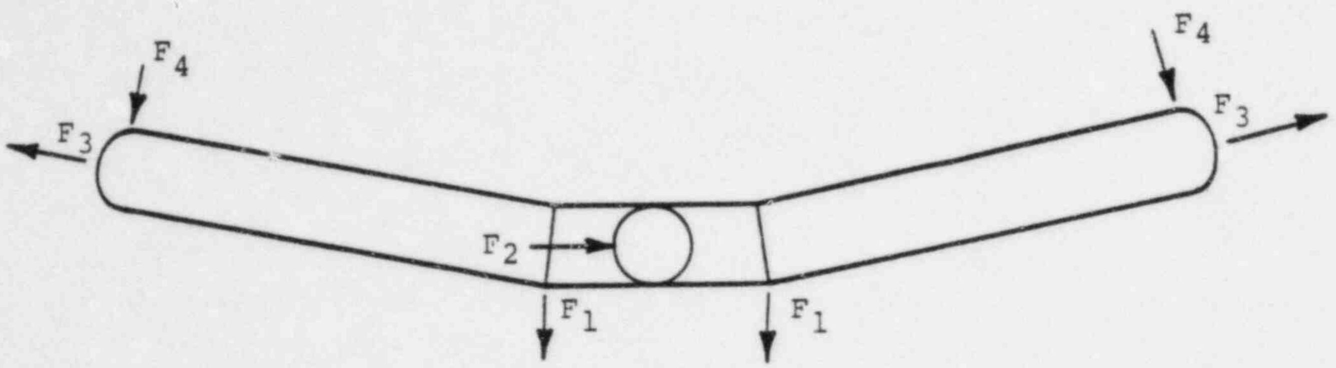
Notes:

1. For purposes of loads generation, the wetwell SRV piping is divided into 10 segments; the T-quencher is divided into 22 segments; and the T-quencher support beam is divided into 22 segments.

2. Loads shown include DLF's.

Table 5-3.2-5

SRV DISCHARGE T-QUENCHER AND END CAP THRUST LOADS



Key Diagram

Thrust Load Component	Force Magnitude (kips)
F_1	26.2
F_2 (1)	10.0
F_3	70.4
F_4 (1)	10.0

Notes:

1. F_2 and F_4 are reversible loads.
2. Loads shown include DLF's.

Table 5-3.2-6

MAXIMUM SRV PIPING POOL SWELL ELEVATED STRUCTURE LOADS

COMPONENT	MAXIMUM LOAD (psi)			
	IMPACT PRESSURE	DRAG PRESSURE	FROTH PRESSURE	POOL FALLBACK PRESSURE
HORIZONTAL SEGMENT	N/A	N/A	8.19	N/A
DIAGONAL SEGMENT	16.69	3.58	8.55	0.90
RING GIRDER SUPPORT STRUT	N/A	N/A	7.00	N/A
VENT HEADER SUPPORT STRUT	34.42	5.90	N/A	0.62

Note:

1. See Figure 1-4.1-3 for loading transient.

5-3.2.2 Load Combinations

The loads for which the Hope Creek wetwell SRV piping, T-quenchers, and supports are evaluated are presented in Section 5-3.2.1. 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 5-3.2-7.

It is apparent from examining Table 5-3.2-7 that the load combinations specified for each event can be expanded into many more load combinations than those shown. 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 in Table 5-3.2-7 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.

The governing load combinations for the SRV piping and T-quenchers are presented in Table 5-3.2-10. The governing load combinations for piping and T-quencher supports are presented in Table 5-3.2-11. The basis for establishing the governing loading combinations for the SRV piping, T-quenchers and supports is provided in Tables 5-3.2-8 and 5-3.2-9. The appropriate ASME code equations for the SRV piping and T-quenchers as well as Service Levels for piping and T-quencher supports are also provided in Tables 5-3.2-8 and 5-3.2-9.

Included in the lists of governing load combinations are eight combinations which do not result from the 27 event combinations listed in Table 5-3.2-7. These are: load combinations A-1 and SA-1 which relate to the design pressure plus dead weight condition; load combinations A-2, SB-1, B-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, SA-1, A-2, SB-1, B-1, and SB-2 are consistent with the requirements as specified in the FSAR (Reference 4).

The pressure and temperature loads considered in the loading combinations include those occurring within the range of the Mark I Program event durations as defined in the LDR (Reference 2).

In performing loading combinations, the dynamic loading components of the structural response are combined using the square root of the sum of the squares (SRSS) method. Use of the SRSS methodology for the SRV piping has been permitted by the NRC as described in Reference 8.

Each of the listed governing load combinations for the SRV piping, T-quenchers, and supports as provided in Tables 5-3.2-10 and 5-3.2-11 has been considered in the analysis methods described in Section 5-3.4.

Table 5-3.2-7

EVENT COMBINATIONS AND ALLOWABLE LIMITS FOR SRV DISCHARGE 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 + EQ + SRV			
							CO, CH			CO, CH			CO, CH			CO,CH		PS (1)	CO, CH	PS		CO, CH		PS	CO, CH	PS		CO, CH	
TYPE OF EARTHQUAKE				0	S			0	S	0	S			0	S	0	S			0	S	0	S			0	S	0	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)	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 5-3.2-7

(Concluded)

Notes:

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 Hope Creek 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 ND-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 ND-3652.2, 2.4 S_h is used.

Table 5-3.2-8

BASIS FOR GOVERNING LOAD COMBINATIONS - WETWELL SRV DISCHARGE PIPING AND T-QUENCHERS

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	C-1, C-2, A-3	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	C-3, C-4, A-4	FOR SBA ONLY. IBA BOUNDED BY EVENT COMBINATION NUMBER 15.	(3b)
15	D-2, D-3, A-4	N/A	N/A
14	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15	(3a)
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	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25	(3a)
25	D-4, A-4	N/A	N/A
26	D-1, A-5	FOR CO ONLY, DBA CHUGGING BOUNDED BY EVENT COMBINATION NUMBER 14	(3b)

Table 5-3.2-8

(Concluded)

Notes:

1. Event combination numbers refer to the numbers used in Table 5-3.2-7.

2. Governing load combinations are listed in Table 5-3.2-10.

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 5-3.2-9

BASIS FOR GOVERNING LOAD COMBINATIONS -

WETWELL SRV PIPING AND T-QUENCHER SUPPORTS

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)
15	SD-2, SD-3	N/A	N/A
14	N/A	BOUNDED BY EVENT COMBINATION NUMBER 15.	(3a)
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	N/A	BOUNDED BY EVENT COMBINATION NUMBER 25	(3a)
25	SD-4	N/A	N/A
26	SD-1	FOR CO ONLY, DBA CHUGGING BOUNDED BY EVENT COMBINATION NUMBER 14.	(3b)

Table 5-3.2-9

(Concluded)

Notes:

1. Event combination numbers refer to the numbers used in Table 5-3.2-7.

2. Governing load combinations are listed in Table 5-3.2-11.

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 5-3.2-10

GOVERNING LOAD COMBINATIONS - WETWELL SRV DISCHARGE PIPING AND T-QUENCHERS

LOAD COMBINATION NUMBER	LOAD COMBINATIONS[1,5,6]	ASME[2] CODE EQUATION
A-1	P+DW	8
A-2	$TE1+THAM1+SSE_D+TD$	10[3]
A-3	$TE2+THAM2+SSE_D+TD$	10[3]
A-4	$TE2+THAM2A+SSE_D+TD1$	10[3]
A-5	$TE1+THAM1A+OBE_D+TD1$	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	$P_O+DW+RV1C+QAB+QAB_I+SSE_I+PCHUG+PCHUG_I$	9
D-3	$P_O+DW+RV1C+QAB+QAB_I+SSE_I+CHUG+CHUG_I$	9
D-4	$P_O+DW+RV1A+QAB+QAB_I+SSE_I+PS+PS_I+VCL$	9
T-1[7]	$1.25P+DW_T$	8

Table 5-3.2-10

(Concluded)

Notes:

1. See Section 5-3.2.1 for definition of individual loads.
2. Equations are defined in Subsection ND-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 5-3.2.2 for combination of dynamic loads.
6. Only governing load combinations from Table 5-3.2-8 are considered here.
7. Hydrostatic test condition. DW_T for all lines shall be with lines full of water at $70^{\circ}F$.

Table 5-3.2-11

GOVERNING LOAD COMBINATIONS - WETWELL SRV PIPING AND T-QUENCHER SUPPORTS

LOAD COMBINATION NUMBER	LOAD COMBINATION (1,2,5)		SERVICE LEVEL
	PRIMARY	SECONDARY	
SA-1	DW+	TE1+THAM1	A
SB-1	DW+OBE_I+	TE1+THAM1+OBE_D+TD	B
SB-2	DW+OBE_I+	TE2+THAM2+OBE_D+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+SSE_D+TD	C
SC-2	DW+RV1B+QAB+QAB_I+SSE_I+	TE2+TAHM2+SSE_D+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+OBE_D+TD1	D
SD-2 (3)	DW+RV1C+QAB+QAB_I+SSE_I+PCHUG+$PCHUG_I$+	TE2+THAM2A+SSE_D+TD1	D
SD-3 (3)	DW+RV1C+QAB+QAB_I+SSE_I+CHUG+$CHUG_I$+	TE2+THAM2A+SSE_D+TD1	D
SD-4 (3)	DW+RV1A+QAB+QAB_I+SSE_I+PS+PS_I+VCL+	TE2+THAM2A+SSE_D+TD1	D
ST-1 (6)	DW_T		A

Table 5-3.2-11

(Concluded)

Notes:

1. See Section 5-3.2.1 for definition of individual loads.

2. Only governing load combinations from Table 5-3.2-9 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 combined with CO and chugging loads.

5. See Section 5-3.2.2 for combination of dynamic loads.

6. Hydrostatic test condition. DW_T for all lines shall be with lines full of water at 70^oF.

5-3.3 <u>Analysis Acceptance Criteria</u>

The acceptance criteria defined in NUREG-0661 on which the Hope Creek wetwell SRV piping, T-quencher, and supports analysis is based are discussed in Section 1-3.2. In general, the acceptance criteria follow the rules contained in ASME Code, Section III, Division 1 up to and including the 1977 Summer Addenda for Class 3 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 acceptance criteria used in the analysis of the SRV piping, T-quenchers and supports are summarized in the following paragraphs.

The wetwell SRV piping and T-quencher arms are analyzed in accordance with the requirements for Class 3 piping systems contained in Subsection ND of the Code. Table 5-3.3-1 lists the applicable ASME Code equations and stress limits for each of the governing piping load combinations.

The wetwell SRV piping and T-quencher supports are analyzed in accordance with requirements for Class 3 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 support load combinations, as provided in Table 5-3.3-2.

The T-quencher ramshead is evaluated in accordance with the requirements for Class 3 pressure vessels contained in Subsection ND of the ASME Code. Table 5-3.3-2 lists the applicable ASME Code allowables and Service Level assignments for the governing ramshead load combinations.

Table 5-3.3-1

ALLOWABLE STRESSES FOR SRV PIPING AND T-QUENCHERS

STRESS TYPE	ASME CODE EQUATION NUMBER	SERVICE LEVEL	STRESS LIMIT	ALLOWABLE VALUE (ksi)	GOVERNING LOAD COMBINATION NUMBER(1)
PRIMARY	8	DESIGN	$1.0\ S_h$	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)

Notes:

1. Governing load combination numbers are listed in Table 5-3.2-10.

2. See ASME Section III Subsection ND Paragraph ND-3652.3 (Reference 6) for combination of loads.

Table 5-3.3-2

ALLOWABLE STRESSES FOR RAMSHEAD AND WETWELL SRV PIPING AND T-QUENCHER SUPPORTS

ITEM	MATERIAL	MATERIAL PROPERTIES (ksi)	STRESS TYPE	ALLOWABLE STRESS (ksi) SERVICE LEVEL B	SERVICE LEVEL C	SERVICE LEVEL D
COMPONENTS						
RAMSHEAD ELBOW	SA-403 Type WPW316L	S = 15.56	PRIMARY MEMBRANE	17.12	23.34	31.12
			LOCAL PRIMARY MEMBRANE	25.67	28.01	37.34
			PRIMARY MEMBRANE+ PRIMARY BENDING	25.67	28.01	37.34
RAMSHEAD SADDLE PLATE	SA-516 Gr. 70	S = 17.5	PRIMARY MEMBRANE	17.50	21.00	26.25
			LOCAL PRIMARY MEMBRANE	26.25	31.50	39.38
			PRIMARY MEMBRANE+ PRIMARY BENDING	26.25	31.50	39.38
SUPPORTS						
QUENCHER SUPPORT BEAM	SA-333 Gr. 6	S_y = 32.92 S_u = 60.00	TENSILE	19.75	26.34	39.51
			BENDING	19.75	26.34	39.51
			COMPRESSIVE	17.78	20.80	20.80
			INTERACTION	1.00	1.00	1.00
QUENCHER ARM SUPPORT PLATES	SA-537 Cl. 2	S_y = 54.66 S_u = 80.00	BENDING	32.80	43.62	55.99
			COMPRESSIVE	15.64	20.07	20.07
			COMBINED	1.00	1.00	1.00
SRV PIPING SUPPORT STRUTS	SA-106 Gr. B	S_y = 32.92 S_u = 60.00	TENSILE	19.75	26.34	39.51
			BENDING	19.75	26.34	39.51
			COMPRESSIVE	18.61	21.66	21.66
			INTERACTION	1.00	1.00	1.00
WELDS						
SADDLE PLATE TO RAMSHEAD	SA-403 Type WPW316L	S = 15.56	PRIMARY	13.32	18.17	24.22

5-3.4 Methods of Analysis

This section describes the methods of analysis used to evaluate the wetwell SRV piping, T-quenchers, and supports for the effects of the governing loads as presented in Section 5-3.2.1. The methodology used to evaluate the SRV piping, T-quenchers and supports is discussed in Section 5-3.4.1. The methodology used to evaluate the local effects at the ramshead is discussed in Section 5-3.4.2. The approach used to address fatigue effects is presented in Section 5-3.4.3.

5-3.4.1 Analysis for Major Loads

The wetwell SRV piping, T-quenchers, and supports are evaluated for the effects of the loads discussed in Section 5-3.2.1 using a beam-type finite element computer model. Due to the similarity of the SRV line routings in the wetwell, a single analytical model is utilized to represent a typical system. The analytical model, shown in Figure 5-3.4-2, includes the SRV line in the wetwell from the vent pipe penetration (VPP) to the ramshead assembly, the quencher arms, the quencher support beam and the associated connecting members. This model is included in the vent system 1/16 segment analytical model described in Section 3-2.4. The 1/16 model is shown in Figure 5-3.4-1.

The local stiffness effects at the VPP and at the ramshead are included in the beam model by using stiffness matrix elements. The stiffness matrix element at the VPP is described in Section 3-2.4.1. The stiffness matrix element at the ramshead is developed using the finite element model of the ramshead assembly shown in Figure 5-3.4-3 and described in Section 5-3.4.2. The ramshead stiffness matrix element connects the SRV piping to the T-quencher arms and is connected to the suppression chamber by pin plates attached to the mitered joint ring girder. Support conditions at the SRV piping and T-quencher support locations on the suppression chamber and vent system are explicitly included in the analytical model.

For stiffness evaluation, corrosion allowance of 1/8 inch and 1/16 inch are subtracted from the material thicknesses or diameters of the T-quencher supports and SRV supports respectively. Mass properties used in the model are based on the nominal dimensions and densities of the materials used to construct the SRV line, T-quencher, and T-quencher supports. The water mass contained within the SRV line and T-quencher arms is lumped along the submerged component lengths in three directions. Additional hydrodynamic mass is lumped along the submerged member lengths of the SRV piping, T-quenchers and supports in the lateral directions, to account for the effective water mass which acts with these structures during dynamic loadings.

Several types of analysis techniques are used to determine system response to the major loads acting on the wetwell SRV piping, T-quenchers, and supports. These techniques include time-history, equivalent static, and static analysis procedures. The time-history analyses are performed utilizing a modal superposition technique with 2% critical damping. For the equivalent static analyses, a frequency analysis of the beam model is first performed in which all structural modes in the range of 0 to 100 hertz are extracted. Conservative values of dynamic amplification factors are then developed and applied to the individual dynamic loads.

The beam model results are also used to develop loads for use in evaluating local stresses in the ramshead. Beam end loads are taken from the beam model and applied to the finite element model of the ramshead shown in Figure 5-3.4-3. Additional information relating to the ramshead stress evaluation is provided in Section 5-3.4.2.

The specific treatment of each load in each load category identified in Section 5-3.2.1 is discussed in the following paragraphs.

1. Dead Weight Loads

    a. Dead Weight (DW) Loads: A static analysis is performed for a unit vertical acceleration applied to the weight of steel and the weight of the water contained inside the SRV line and T-quencher arms.

b. Dead Weight (DW_T) Loads: Load Case 1a is used in the analysis in lieu of this load case due to the negligible effect of the additional water weight contained in the SRV piping above the suppression pool.

2. Seismic Loads

a. OBE Inertia (OBE_I) Loads: A static analysis is performed for a 0.26g horizontal and 0.27g vertical acceleration applied to the combined weight of steel and water in the analytical model. These accelerations are taken from the seismic response spectra at the dominant structural frequencies.

b. OBE Displacement (OBE_D) Loads: A static analysis is performed for the horizontal and vertical relative displacements at the SRV piping, T-quencher, and support attachment points on the suppression chamber and vent system.

c. SSE Inertia (SSE_I) Loads: A static analysis is performed for a 0.28g horizontal and 0.48g vertical acceleration applied to the combined weight of steel and water in the analytical model. These accelerations are taken from the seismic response spectra at the dominant structural frequencies.

d. SSE Displacement (SSE_D) Loads: A static analysis is performed for the horizontal and vertical relative displacements at the SRV piping, T-quencher, and support attachment points on the suppression chamber and vent system.

The methodology used to combine spatial components in the seismic analysis is defined in NRC Regulatory Guide 1.92, Revision 1 (Reference 7). The seismic analysis is performed independently for each of the two horizontal directions and for the vertical direction. The resulting peak responses obtained for each of the three directions are combined by SRSS.

3. Pressure and Temperature Loads

a. Pressure Loads: The effects of maximum pressure (P_o) and design pressure (P) on the wetwell SRV piping and T-quencher are evaluated utilizing the techniques described in Subsection ND-3650 of the ASME Code, Section III (Reference 6). The values of P_o and P used in the analysis are listed in Table 5-3.2-2.

b. Temperature (TE1, TE2) Loads: A static analysis is performed for the TE1 and TE2 temperatures cases defined in Table 5-3.2-2. The temperature loads are applied uniformly to the wetwell SRV piping, T-quencher arms, and T-quencher support components.

An additional static analysis is performed for the effects of the thermal anchor movements of the vent system and suppression chamber at the attachments of the SRV piping, T-quenchers and supports.

4. Safety Relief Valve Discharge Loads

a. SRV Discharge Thrust (RV1) Loads: An equivalent static analysis is performed for an envelop of the SRV discharge thrust load cases shown in Table 5-3.2-3 which produces maximum stresses in the wetwell SRV piping and T-quencher. The values of the loads shown include dynamic load factors computed using first principles.

b. SRV T-quencher discharge (QAB) Loads:

o T-Quencher and End Cap Thrust Loads: An equivalent static analysis is performed for the thrust loads shown in Table 5-3.2-5. The values of the loads shown include a dynamic load factor (DLF) which is computed using first principles.

o Air Bubble Drag Loads: An equivalent static analysis of the wetwell SRV piping, T-quenchers and supports is performed to evaluate the acceleration drag and standard drag forces imparted to submerged portions of the structures. The applied equivalent static loads include a DLF of 3.0 if the natural frequency of the structure is below 20 hz and 2.0 if the natural frequency is above 20 hz. The DLF values have been established based on test results as discussed in Section 1-4.2.4.

5. Pool Swell Loads:

   a. Pool Swell (PS) Loads:

      o Impact and Drag Loads: A transient dynamic analysis is performed for the transient pressures as discussed in the vent system analysis contained in Section 3-2.4.1.

      o Pool Fallback Loads: A transient analysis is performed for the transient pressures as discussed in the vent system analysis contained in Section 3-2.4.1.

- o Froth Impingement and Fallback Loads: A transient analysis is performed for the transient pressures as discussed in the vent system analysis contained in Section 3-2.4.1.

The analysis for Pool Swell Impact and Drag, Pool Fallback and Froth Impingement and Fallback loads is performed in a single transient analysis with appropriate load sequencing.

6. Condensation Oscillation (CO) Loads

The CO submerged structure loading is bounded by the post-chug loading and is not included in a critical load combination. Accordingly, no analysis is performed for this loading.

7. Chugging Loads

a. Pre-Chug (PCHUG) Loads: As discussed in Section 5-3.2.1, this loading is bounded by the post-chug load (Case 7b). Therefore post-chug has been used in the analyses in lieu of pre-chug.

b. Post-Chug (CHUG) Loads: The Post-Chug submerged structure loading is composed of both velocity and acceleration drag components. The drag forces are determined based on the summation of 50 harmonic loading functions. A description of the harmonic loading functions as well as the procedures used in applying the loads are discussed in Section 1-4.1.8.

An equivalent static analysis method is applied utilizing peak structural dynamic load factors. Once the amplitudes of the drag forces for the SRV piping and T-quencher components have been determined, they are converted to the analytical model coordinate system and applied as nodal forces. The torus FSI effects are also considered in performing the Post-Chug submerged structure load analyses.

8. Vent Clearing Loads

a. Vent Clearing (VCL) Loads:

- LOCA Water Jet Impingement Loads: As shown in Table 5-3.2-4, the effects of this loading on the wetwell SRV piping, T-quenchers, and supports is negligible.

- LOCA Air Bubble Drag Loads: As shown in Table 5-3.2-4, the effects of this loading on the wetwell SRV piping, T-quenchers, and supports is negligible.

9. Vent System and Torus Interaction Loads

As discussed previously, the analysis of the wetwell SRV piping, T-quenchers, and supports is included in the vent system 1/16 segment model analysis described in Section 3-2.4. In this analysis, loads are applied directly to the suppression chamber shell and vent system and thus their effects on the wetwell SRV piping, T-quenchers and supports are explicitly accounted for.

The methodology described in the preceding paragraphs results in conservative values of the SRV piping, T-quencher and support stresses for the controlling loads defined in NUREG-0661. Use of the analysis results obtained by applying this methodology leads to conservative estimates of design margins for the piping, T-quenchers and supports.

5-3.4.2 Ramshead Analysis for Local Effects

A finite element model is used to evaluate local stresses in the T-quencher ramshead assembly. The analytical model is shown in Figure 5-3.4-3. The model is also used to generate a stiffness matrix element of the ramshead assembly for use in the SRV piping, T-quencher, and supports beam model discussed in Section 5-3.4.1.

The model includes the ramshead, saddle plate, crotch plate, pin plates, stiffener plates, and the long radius elbow segments on each side of the ramshead which connect the ramshead to the T-quencher arms. For stiffness evaluation, a corrosion allowance of 1/8 inch is subtracted from the thickness of all plates except the ramshead, crotch plate and elbows which are made of stainless steel.

A local stiffness matrix is developed which expresses the stiffness of the entire ramshead assembly in terms of a few local degrees of freedom at interface points. The resulting stiffness matrix is included in the SRV piping, T-quencher and supports beam model at the corresponding interface degrees of freedom.

The loads used to evaluate stresses in the ramshead assembly are taken from the SRV piping, T-quencher and supports beam model results. The beam end loads obtained from the beam model are applied at the boundaries of the ramshead finite element model. An additional distributed load to account for internal pressure effects is also applied.

Loads which act on the ramshead model boundaries are applied to the finite element model through a system of radial beams. The radial beams extend from the middle surface of each of the shell elements to a corresponding node on the centerline of the shell elements, as shown in Figure 5-3.4-3. The beams have large bending stiffnesses, zero axial stiffness, and are pinned in all directions at the shell element middle surface. Boundary loads, applied to the centerline nodes, cause only membrane forces to be transferred to the shell element middle surface without causing local bending effects. Use of this boundary condition minimizes the end effects of the analytical model in the local areas of interest. The system of radial beams serves to constrain the boundary planes to remain plane during loading, which is consistent with the assumption made in small deflection beam theory.

5-3.4.3 Fatigue Evaluation

Section 4.3.3.2 of NUREG-0661 (Reference 1) requires that a fatigue evaluation of the wetwell safety relief valve discharge piping be performed for all loading conditions except pool swell.

The Mark I Owners Group prepared and submitted a generic fatigue evaluation report (Reference 9) to the NRC on November 30, 1983. The report addressed fatigue on a generic basis using actual piping analysis results from essentially all Mark I plants. The resulting cumulative usage factors are below 0.5, demonstrating that further plant unique fatigue evaluations are not warranted. Use of the generic fatigue evaluation approach has been approved as described in Reference 10. Therefore, the Hope Creek wetwell SRV piping is adequate for fatigue based on this generic evaluation.

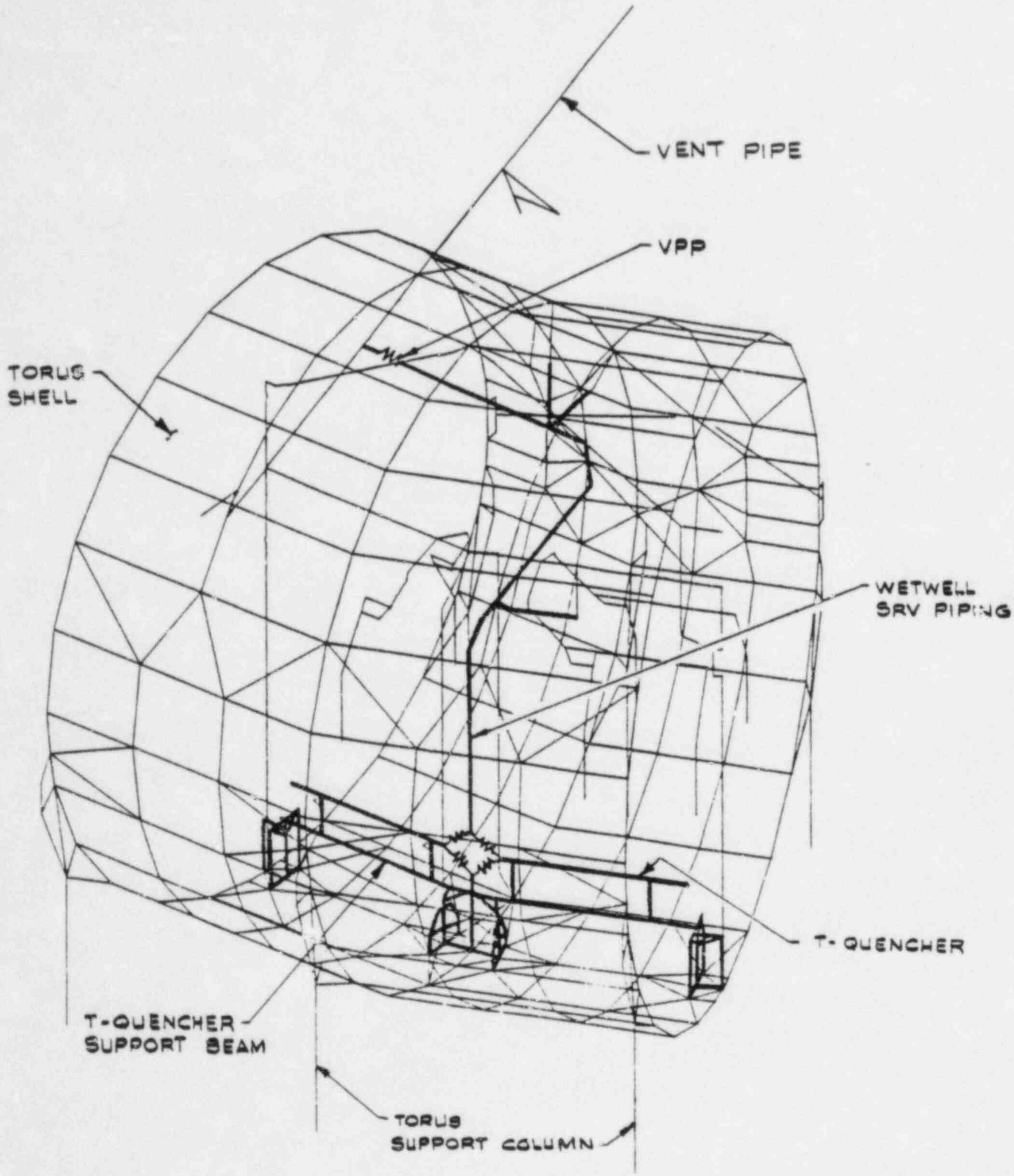


Figure 5-3.4-1

VENT SYSTEM 1/16 SEGMENT MODEL -ISOMETRIC VIEW

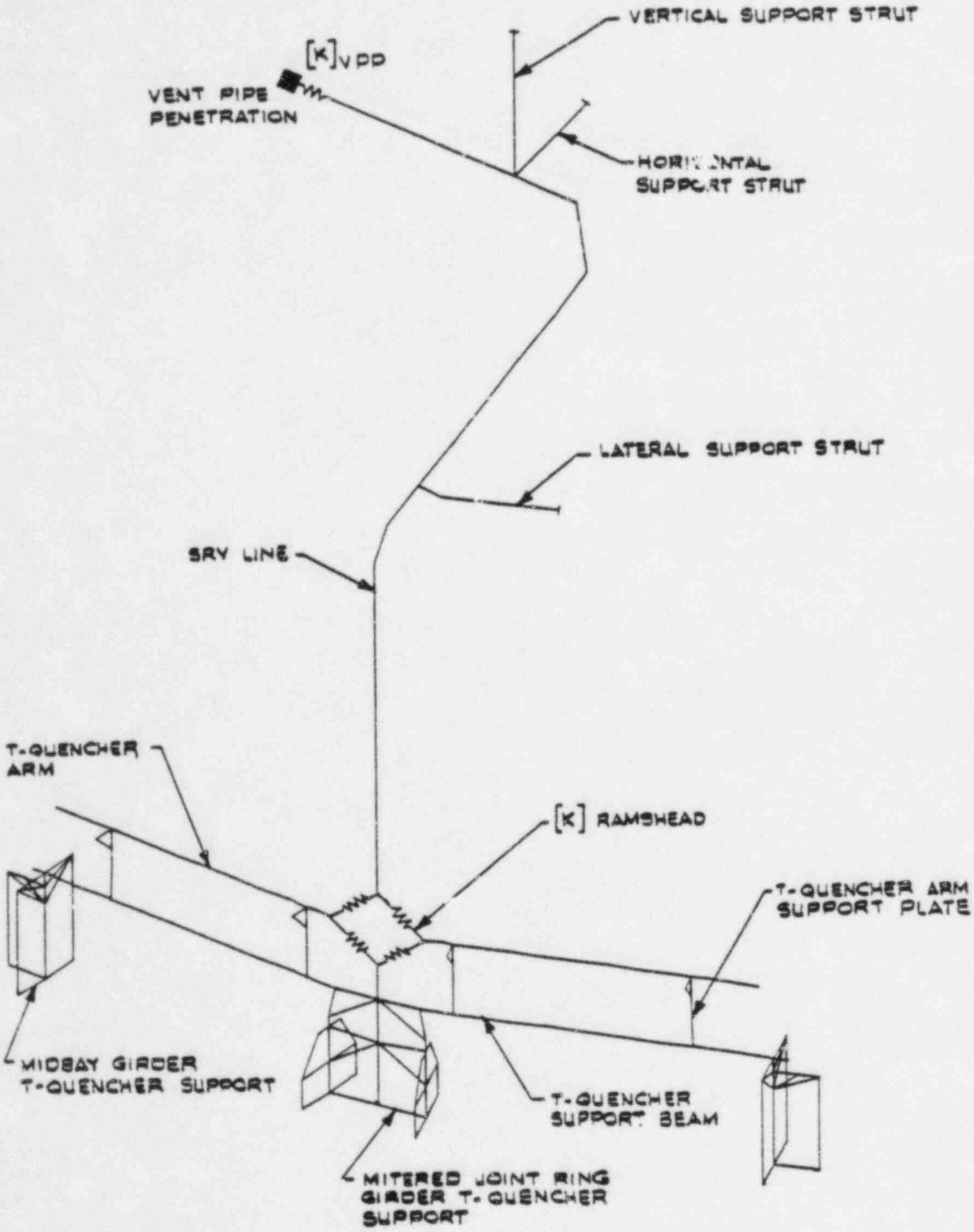


Figure 5-3.4-2

WETWELL SRV PIPING, T-QUENCHER, AND SUPPORTS

BEAM MODEL - ISOMETRIC VIEW

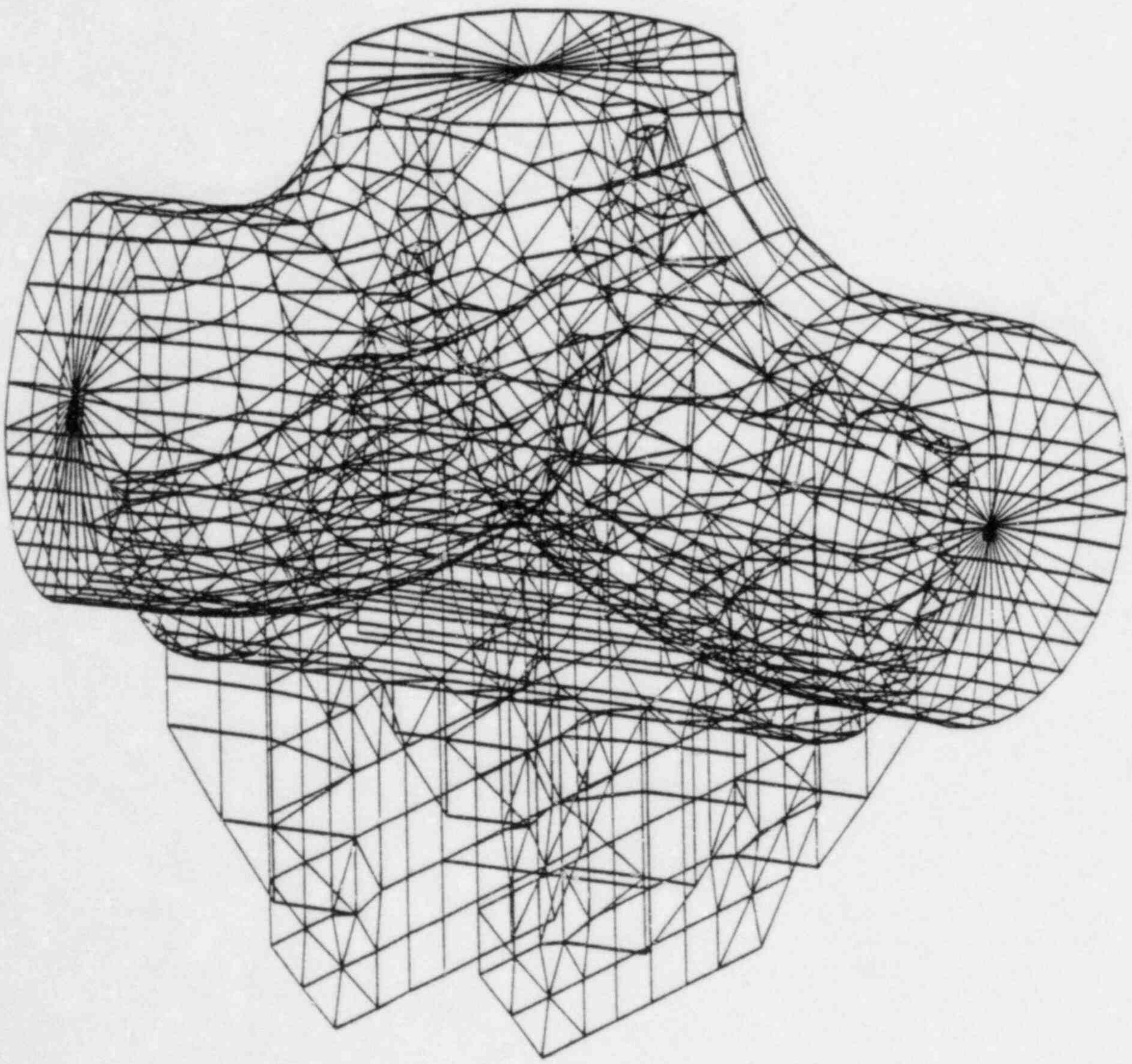


Figure 5-3.4-3

RAMSHEAD ASSEMBLY FINITE ELEMENT MODEL - ISOMETRIC VIEW

5-3.5 Analysis Results and Conclusions

The geometry, loads and load combinations, acceptance criteria, and analysis methods used in the evaluation of the Hope Creek wetwell SRV piping, T-quenchers and supports are presented and discussed in the preceding sections. The results from the evaluation of the piping, T-quenchers and supports are presented in the paragraphs and tables which follow.

The maximum stresses resulting from the governing load combinations for the wetwell SRV piping and T-quenchers are presented in Table 5-2.5-1. The maximum stresses for each Service Level are listed along with the associated Code equations and allowable stress values. Maximum stresses for the ramshead, saddle plate, and piping and T-quencher supports are provided in Table 5-2.5-2.

Fatigue evaluations for the wetwell SRV piping and T-quenchers have been performed generically as described in Section 5-3.4-3. The Hope Creek wetwell SRV piping and T-quenchers are qualified for fatigue effects based on this generic evaluation.

The analysis results show that the design of the wetwell SRV piping, T-quenchers, and supports is adequate for the loads, load combinations and acceptance criteria limits specified in NUREG-0661 (Reference 1) and in the PUAAG (Reference 5).

Table 5-3.5-1

ANALYSIS RESULTS FOR WETWELL SRV PIPING AND T-QUENCHER STRESS

LOCATION	MAXIMUM STRESS (ksi)				
	DESIGN	LEVEL B	LEVEL C	LEVEL D	SECONDARY
SRV PIPING	3.51	16.24	19.19	23.88	36.80 (2)
T-QUENCHER	2.81	14.73	14.78	14.78	3.04
ASME CODE EQUATION (1)	8	9	9	9	10/11
ALLOWABLE STRESS (ksi)	15.0	18.0	27.0	36.0	22.5/37.5

Notes:

1. Equations from ASME Code, Section III, Subsection ND-3650.
2. Includes secondary displacement effects due to maximum normal operating temperature. Secondary thermal displacement effects due to one-time accident conditions are not considered.

Table 5-3.5-2

ANALYSIS RESULTS FOR WETWELL SRV PIPING AND T-QUENCHER SUPPORT LOADS

ITEM	STRESS TYPE	LOAD COMBINATION STRESS (1), (2)								
		SERVICE LEVEL B COMBINATION			SERVICE LEVEL C COMBINATION			SERVICE LEVEL D COMBINATION		
		LOAD COMB. NO.	CALC.	CALC./ALLOW.	LOAD COMB. NO.	CALC.	CALC./ALLOW.	LOAD COMB. NO.	CALC.	CALC./ALLOW.
COMPONENTS										
RAMSHEAD ELBOW	PRIMARY MEMBRANE	B-2	17.13	1.00	C-4	19.93	0.85	D-4a	20.31	0.65
	LOCAL PRIMARY MEMBRANE	B-2	18.18	0.71	C-4	22.00	0.79	D-4a	22.34	0.60
	PRIMARY MEMBRANE + PRIMARY BENDING	B-2	19.53	0.77	C-4	23.50	0.84	D-4a	24.00	0.64
RAMSHEAD SADDLE PLATE	PRIMARY MEMBRANE	B-2	6.56	0.38	C-4	7.85	0.33	D-4a	8.00	0.31
	LOCAL PRIMARY MEMBRANE	B-2	9.02	0.34	C-4	11.02	0.35	D-4a	11.39	0.30
	PRIMARY MEMBRANE + PRIMARY BENDING	B-2	22.40	0.85	C-4	27.66	0.88	D-4a	28.21	0.72
SUPPORTS										
QUENCHER SUPPORT BEAM	TENSILE	SB-4	0.80	0.04	SC-4	2.19	0.09	SD-3a	2.24	0.06
	BENDING	SB-4	8.63	0.45	SC-4	9.97	0.39	SD-3a	10.04	0.26
	COMPRESSIVE	SB-4	0.80	0.50	SC-4	2.19	0.11	SD-3a	2.24	0.11
	INTERACTION	SB-4	9.43	0.50	SC-4	12.16	0.50	SD-3a	12.28	0.37
QUENCHER ARM SUPPORT PLATE	BENDING	SB-4	17.90	0.47	SC-4	36.23	0.70	SD-4a	36.98	0.55
	AXIAL	SB-4	0.16	0.01	SC-4	0.28	0.01	SD-4a	0.35	0.02
	COMBINED	SB-4	18.06	0.48	SC-4	36.51	0.71	SD-4a	37.33	0.57
SRV PIPING SUPPORT STRUTS	TENSILE	SB-4	9.34	0.47	SC-4	12.67	0.48	SD-4a	14.26	0.36
	BENDING	SB-4	0.05	0.00	SC-4	0.05	0.00	SD-4a	0.11	0.00
	COMPRESSIVE	SB-4	9.34	0.50	SC-4	12.67	0.59	SD-4a	14.26	0.66
	INTERACTION	SB-4	9.39	0.50	SC-4	12.72	0.59	SD-4a	14.17	0.66
WELDS										
SADDLE PLATE TO RAMSHEAD	PRIMARY	B-2	9.50	0.71	C-4	11.42	0.63	D-4a	11.67	0.48

5-4.0 LIST OF REFERENCES

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

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

3. "Mark I Containment Program Plant Unique Load Definition," Hope Creek Generating Station, Unit 1, General Electric Company, NEDO-24579-1, Revision 1, January 1982.

4. Hope Creek Generating Station, Unit 1, Final Safety Analysis Report, Public Service Electric and Gas Company, Amendment No. 2, October 1983.

5. "Mark I Containment Program Structural Acceptance Criteria Plant Unique Analysis Applications Guide," Task Number 3.1.1, General Electric Company, NEDO-24583-1, October 1979.

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

7. "Combining Modal Responses and Spatial Components in Seismic Response Analysis," USNRC, Regulatory Guide 1.92, Revision 1, February 1976.

8. Letter from Domenic B. Vassallo (NRC) to H. C. Pfefferlen (GE), "Acceptability of SRSS Method for Combining Dynamic Responses in Mark I Piping Systems," dated March 10, 1983.

9. "Mark I Containment Program Augmented Class 2/3 Fatigue Evaluation Method and Results for Typical Torus Attached and SRV Piping Systems," MPR Associates, Inc., MPR-751, November 1982.

10. Letter from D. B. Vassallo (NRC) to H.C. Pfefferlen (GE), "Evaluation of Adequacy of the Existing Mark I Downcomer Chugging Lateral Load Specification and Augmented ASME Class 2/3 Fatigue Evaluation Method for the Mark I Containment Piping Systems," dated November 9, 1983.