ATTACHMENT 2

JPN-85-60

dated

NEW YORK POWER AUTHORITY
James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333

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TECHNICAL REPORT

TR-5321-2
REVISION 1

MARK I CONTAINMENT PROGRAM

**PLANT-UNIQUE ANALYSIS REPORT
OF THE
TORUS ATTACHED PIPING
FOR
JAMES A. FITZPATRICK
NUCLEAR POWER STATION**

NOVEMBER 1984

DSR # 24777

ENGINEERING SERVICES

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July 9, 1985
5321-186

Mr. Leon Guaquil
Director
Project Engineering - BWR
New York Power Authority
123 Main Street
White Plains, NY 10601

Subject: **JAFNPP Torus Program - Final Piping Report TR-5321-2, Revision 1, "Mark 1 Containment Program, Plant Unique Analysis Report for the Torus Attached Piping for JAFNPP," dated November 1984**

Dear Leon:

There are two minor errors in the subject report that have been brought to our attention by Mr. P. Okas of your staff. They are:

1. On page 59, the node listed as 370 should be 70.

2. On page 62, there is no indication for penetration x 212, node pt. 26 to show if it was modified or not. It was not modified and an "X" should appear in that column to indicate so.

These are both typographical errors that have no affect on the technical results or conclusions. Because of that, we will not be changing the report unless a revision is done for some other reason.

Should you have any questions, please contact us.

Very truly yours,

TELEDYNE ENGINEERING SERVICES

C. H. Berks for NSC

Nicholas S. Celia
Manager, Engineering

NSC:slg
cc: P. Okas (NYPA)

NEW YORK POWER AUTHORITY
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TECHNICAL REPORT TR-5321-2
REVISION 1

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PLANT-UNIQUE ANALYSIS REPORT OF THE TORUS ATTACHED PIPING FOR JAMES A. FITZPATRICK NUCLEAR POWER PLANT

NOVEMBER 1984

TELEDYNE ENGINEERING SERVICES
130 SECOND AVENUE
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RECORD OF REVISIONS

REVISION	PAGE	DESCRIPTION
1	Cover and Title	Add Revision 1 and change date from May 1984 to November 1984.
	10	In equation (1) change "1.85_n" to $1.8\ S_h$". Also change "...load combinations (15), (1) and (2)..." to "...load combinations (14), (15), (2), and (1)...".
	19	Support PFSK-831, Y-Rigid, change "X" yes modified to "X" No modified and remove "Support Reinforced".
	41	Section 3.3.5, change "..., equal to the total TAP motion..." to "..., equal to twice the TAP motion...".
	49	Section 3.5, fifth bullet, change "Relocate 10" condensate line" to "Resupport 10" condensate line".
	52-54	Table 3-3, Branch Line Pipe Stresses, change all maximum stress values to reflect updated analysis.
	58	Support PFSK-2107, change Node number from 745 to 245.
		Support PFSK-2477, change Node number from 169 to 160.
	60	Node 85, change Spring to PFSK-1854 and add Spring under type of support.
		Node 715, change Support number from PFSK-1986 to PFSK-1982
		Support PFSK-2567, change Node number from 386 to 385.
		Support PFSK-2446, change Node number from 750 to 250.
	62	Support PFSK-1049, change Snubber to Spring.
		Support PFSK-2223, change Node number from 186 to 190.

RECORD OF REVISIONS (cont.)

REVISION	PAGE	DESCRIPTION
	64	X-226, Node 100, change H23-62 to PFSK-983.
		Support PFSK-1994, change Node number from 318 to 300.
		X-227, Node 125, remove H14-27.

Note: Revision 1 changes are a result of incorporating NRC review comments which are documented in TR-5321-1, Revision 1, and to incorpoate updated analysis results as well as to correct typographical errors.

ABSTRACT

The work summarized in this report was undertaken as part of the Mark 1 Containment Long Term Program. It includes the evaluation of all piping systems that are attached to the suppression pool (torus).

These piping systems include both Main Steam Safety Relief lines and piping attached to the torus shell.

Mark 1 induced loads, as well as original design loads, are included in the evaluation. Necessary modifications have been completed and are summarized here.

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FIGURES AND TABLES

1.0 GENERAL

The purpose of the Mark 1 Containment Program is to evaluate the effects of hydrodynamic loads resulting from a loss of coolant accident and/or an SRV discharge on the torus structure.

Teledyne report TR-5321-1 (Reference 1) reported the effects of Mark 1 loads on the FitzPatrick torus structure, support system and internals. This second report completes the work on the program by considering the effects of the Mark 1 loads on the piping systems attached to the torus. Both the main steam relief lines and the piping connected to the torus shell are considered. Also included is the evaluation of piping penetrations, supports and active components.

A summary of modifications made as a result of this analysis is included.

The report is separated into two major categories, one that deals with main steam relief lines (SRV piping) and one that deals with piping attached to the torus shell (TAP). Each of these sections is written to stand alone and includes a discussion of methods and results.

2.0 SRV PIPING ANALYSIS

There are eleven main steam relief (SRV) lines at FitzPatrick. These lines connect to the main steam lines in the drywell, extend down the main vents and penetrate the main vent into the torus (Figures 2-1 and 2-2). These lines penetrate the main vent pipe at the vent header intersection, run horizontally inside the vent header impact deflector, and enter the pool vertically over the ring girders. (Figures 2-3 and 2-4).

Analysis results for the discharge end of the SRV lines were previously reported in Reference 1. This referenced report includes SRV piping in the torus airspace, the submerged part of the SRV line, the tee-quencher and the quencher support beam. This report will cover the remaining portion of the line, which includes:

- The main vent penetration.
- The SRV piping between the penetration and the main steam line.
- SRV pipe supports between the penetration and main steam lines.

The analysis of SRV piping in this report accounts for the fact that some modifications have previously been made to these lines. These modifications are described in the Reference 1 report and consist of the addition of tee-quenchers and support beams (Figure 2-4) and the addition of one ten-inch vacuum breaker on each SRV line.

2.1 Applicable Codes and Criteria

The SRV piping and pipe support analysis was performed in accordance with Section III of the ASME Code, 1977 Edition, including Summer 1977 Addenda (Reference 2).

In cases where modifications to SRV line supports were required, they were designed in accordance with Section III of the ASME Code (Reference 2).

Load combinations and stress levels were evaluated in accordance with Table 5-5 of the Mark 1 Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide (Reference 5). Table 5-5 is reproduced in this report as Table 1.

2.2 SRV Loads

The Mark 1 Program defined several new SRV line conditions. These conditions resulted from different drywell and torus conditions and produced several different reflood heights and discharge pressures. The load cases considered are listed in Table 2-1.

The analysis and evaluation in this report considers all these SRV cases as well as seismic, weight, thermal and pressure effects.

The specific loads considered in this analysis include:

- Gas clearing (blowdown) loads.
- Water clearing discharge loads.
- Submerged structure drag on the SRV line, quencher and support due to pool motion.
- Thermal expansion of SRV line.
- Thermal expansion of containment structure.
- Seismic.
- Weight.
- Internal Pressure.

Calculational methods developed as a part of the Mark 1 generic program were used to the extent that they apply.

2.2.1 SRV Gas Clearing Loads

Sudden pressurization of the SRV line, due to rapid opening of the safety relief valve, causes unbalanced dynamic forces on the SRV

piping. These forces progress through the system as pressure waves, whose speed and amplitude depend upon the particular line conditions being considered; the various SRV cases are listed in Table 2-1.

TES has evaluated the stresses resulting in various SRV piping systems, due to the cases listed in Table 2-1, and has concluded that SRV Case A1.2 is the bounding case for gas clearing loads. Case A1.2 is a first actuation after an SBA/IBA break and is characterized by increased gas density in the line before valve actuation. This increased density is a consequence of increased drywell pressure which affects the internal line pressure and density through the vacuum breakers. This increased density produces higher thrust forces than the lower density cases. This load case was run for each of the eleven SRV lines.

The calculation of loads resulting from Case A1.2, as well as all other SRV cases, was based upon use of the "Computer Code RVFOR-04" (Reference 7), which is the property of General Electric Company.

Case A1.2 was run for each of the eleven SRV lines at Fitz-Patrick. Gas clearing loads associated with this case were used for all SRV cases and, therfore, produced conservative results for normal actuation, as well as other cases. In cases where this conservative condition exceeded the lower allowables associated with normal SRV actuation, Case A1.1 was also calculated.

2.2.2 SRV Water Clearing Loads

Water clearing loads are produced in the SRV line as water accelerates under line pressure and is forced around the elbows at the quencher end of the line. These forces are very sensitive to reflood height, which varies for several of the second actuation cases.

Maximum line reflood and water clearing are clearly associated with SRV Case C3.3. Case C3.3 is the second actuation after an IBA/SBA break with steam in the drywell. The high reflood is a consequence of

additional steam entering the line through the vacuum breaker after the first actuation (rather than air).

The high water clearing loads that result from this condition affect the torus end of the SRV line, including the piping in the main vent. It has a negligible effect on piping loads in the drywell.

Water clearing for FitzPatrick was calculated for SRV Case C3.3, using G.E. programs RVRIZ and RVFOR-04 (References 7 & 14). These programs were run for the longest and the shortest SRV lines and maximum worst case water clearing loads were used on all eleven lines. (These lines are identical inside the torus, except some lines are mirror images of others). The second valve actuation was assumed to occur at the point of maximum reflood.

Water clearing loads associated with SRV Case C3.3 bound all other cases and were used for all SRV analysis conditions.

2.2.3 Pool Drag Loads

The torus end of the SRV line, including the tee-quencher and quencher support beam, are submerged in the torus pool. These components are subject to drag loads due to pool motion from the following loads:

Pool Swell - Jet Loads
- Bubble Loads

Condensation Oscillation -
- Source Induced Drag
- Fluid Structure Interaction (FSI) Drag

Chugging - Source Induced Drag
- FSI Drag

SRV Discharge - Drag from Adjacent Quenchers (as applicable)

The drag loads associated with these events were calculated in the earlier part of the program and the methods are reported in Reference

1. At that time, the data drag loads were used to determine stresses in the SRV piping in the torus, the quencher and the support beam; these were all reported in Reference 1. The same drag load information was used as a part of this analysis to help determine stress in the penetration, and the SRV line and supports in the main vent pipe.

2.2.4 Thermal Expansion

Two different load conditions were considered for thermal expansion stress.

The first assumed that the entire SRV line was at its maximum operating temperature (350^{0}). It included maximum thermal motion of the connection at the main steam line and assumed the drywell and torus were at ambient.

The second case was like the first except the main vent pipe was assumed to be at 340^{0}F. This has the effect of moving the penetration in the main vent pipe relative to the torus and quencher.

2.2.5 Weight, Pressure and Seismic

Weight, pressure and seismic loads were also considered in the analysis. The seismic analysis was based on different spectra for OBE and SSE response. Total seismic response was determined by the SRSS combination of each of the three response directions, in accordance with the FSAR.

Seismic end effects were considered for this analysis, but judged to be negligible.

A typical horizontal spectra is illustrated in Figure 2-6. These seismic spectra were developed according to the procedure outlined in FSAR Section 12.5.4.

2.3 SRV Analysis Method

2.3.1 Piping Analysis

2.3.1.1 Computer Model

Analysis of all SRV load cases was performed using computer models of the piping systems and the STARDYNE computer code (Reference 15). A typical computer model is illustrated in Figure 2-5.

Features of the model include:

- Modeling of the main steam line with each SRV line.
- Representation of the stiffness of the main vent penetration by a set of six attachment springs, developed by computer analysis of the penetration area.
- Full representation of the tee-quencher and quencher support beam in the piping model.
- Full representation of the brackets between the quencher and support beam which allow free torsional rotation of the quencher arms.
- Two percent damping used for time history analysis.

2.3.1.2 Piping Analysis Method

Analysis for SRV discharge cases was done by imposing individual time histories for water and gas clearing loads at each bend

and elbow in the system and performing the dynamic analysis. Bounding analysis was performed for these cases by combining gas clearing loads from SRV Case A1.2 with water clearing loads from SRV Case C3.3 into a single load condition. This conservative combination was used to bound all discharge cases, including normal actuations. Different line-unique loads were applied to each of the eleven SRV lines for gas clearing; water clearing is the same for all lines and equals the maximum load for the longest line.

Damping for these time history analyses was taken at 2% of critical and calculational time increments for the solution were taken at .0025 seconds. All response frequencies to 50 Hz were considered in the solution.

Seismic analysis was done using the same model and static analysis. The seismic spectra were applied in the vertical and two horizontal directions and the results were combined by SRSS. Separate spectra were used for OBE and SSE analysis.

Analysis for thermal and weight conditions was done using static analysis. Calculations for internal pressure were done by hand.

2.3.2 Pipe Supports Analysis

Analysis for SRV piping supports was done using both hand and computer analysis. The STAAD computer program was used for the analysis of complex supports (Reference 16).

The support analysis included the attachment weld to the supporting steel. In cases where there was a question regarding the ability of the support steel to carry the new loads, the steel was also analyzed.

In addition to the SRV line supports in the drywell, there are eleven supports in the main vent pipes.

Analysis of these supports included a detailed evaluation of the stresses in the main vent wall, near the support. These stresses were calculated using a Bijlaard analysis (Reference 8) in combination with intensified free-shell stresses due to vent header loads. Free shell stresses were taken from work done in Reference 1 using the computer model illustrated in Figure 2-7 of this report (Figure 4-4 in Reference 1).

Support analysis was done to the ASME Code Section III, Subsection NF (Reference 2).

2.3.3 SRV Main Vent Penetration Analysis

The SRV line penetrations of the vent pipe are illustrated in Figure 2-3. Analysis of these penetrations was done using a Bijlaard analysis (Reference 8), to determine local penetration stresses due to SRV line loads. These local stresses were added to intensified free shell stresses which occur in the vent pipe due to vent header loads. These were calculated using the finite element model illustrated in Figure 2-7. Development of these free shell stresses and a description of the model are given in Reference 1, Section 4.

2.4 Evaluation and Results (SRV)

2.4.1 General

Combinations of the previous analysis cases were done to allow evaluation of the results in accordance with Table 1. This table lists a total of 27 different load combinations; of these, 13 include an SRV event.

This evaluation is concerned with piping and supports from the main steam line to the vent pipe penetration; evaluation of piping and supports inside the torus is reported in Reference 1. This separation is important to the selection of the controlling load combinations that follow.

The results of a conservative load case (described below) were evaluated against level B allowables, without use of increased allowables, as allowed in Table 1. Where this load combination produced unacceptable results, less conservative combinations were evaluated, as described below.

Thermal loads were considered differently for piping and supports as discussed below.

2.4.2 SRV Pipe Stresses

Initial evaluation of SRV pipe stress was done as described in Section 2.4.1 above; that is:

$$P + DW + \sqrt{(SSE)^2 + (Blowdown)^2} \leq 1.2\ S_h$$

In cases where this conservative condition could not be met, the following four cases were evaluated:

(1) $P + DW + \sqrt{(OBE)^2 + (Blowdown)^2} \leq 1.8\ S_h$

(2) $P + DW + \sqrt{(SSE)^2 + (Blowdown)^2} \leq 1.8\ S_h$

(3) $P + DW + OBE = 1.2\ S_h$

(4) $P + DW + Blowdown = 1.2\ S_h$

These four cases represent load combinations (14), (15), (1) and (2) in Table 1, and are still conservative. No further reduction in conservatism was necessary to qualify the SRV piping.

Thermal expansion stresses were evaluated for piping as a separate load condition, using ASME Section III, Subsection NC Code Equation 10.

Results of SRV pipe stress evaluation are listed in Table 2-2.

2.4.3 SRV Pipe Supports

SRV pipe supports were evaluated in accordance with the ASME Code, Section III, Subsection NF (Reference 2).

A worst-case load condition was developed to include:

- The conservative A1.2/C3.3 blowdown case.
- SSE seismic.
- Worst case thermal load.
- Deadweight.

Seismic and blowdown were combined by SRSS and added to the other loads. Allowable stress for this condition was maintained below yield to assure that pipe stress would not be effected by support motion. This stress criteria is consistent with the Case 15 allowables from Table 1.

Results of pipe support analysis are listed in Table 2-3.

2.4.4 Support Steel for SRV Supports

Evaluation of drywell support steel for SRV supports was done in accordance with Subsection NF of the ASME Code, (Reference 2), as required.

Evaluation of local stress in the main vent pipe wall was done using the same method described for the SRV penetration except evaluation for the Nozzle Piping Transition, paragraph NE-3227.5 is not required. This evaluation was performed for all main vent supports.

Controlling stresses for the main vent pipe wall are:

PRIMARY STRESS

(Local Membrane Shell Stress Intensity)

	Controlling Load Case	Calculated Stress	Allowable Stress
Support	Case 15 (Table 1)	22,486	28,900 (1.5 S_{mc})

SECONDARY STRESS

(Primary and Secondary Stress Intensity)

Support	Case 15	63,366	69,900

2.4.5 SRV Penetration

Stresses in the main vent pipe penetration area were evaluated in accordance with subsection NE of The ASME code, using the following paragraphs:

NE-3221.2	Local Membrane Stress Intensity
NE-3221.3	Primary General or Local Membrane plus Primary Bending Stress Intensity
NE-3221.4	Primary plus Secondary Stress Intensity
NE-3221.5	Analysis for Cyclic Operation
NE-3227.5	Nozzle Piping Transition (for vertical lines only)

Fatigue evaluation of the penetration (paragraph NE-3221.5) showed that the maximum load could be cycled on the penetrations for at least 7500 cycles without exceeding code allowables. The major load component in this case is SRV Case C3.3, which can only occur for a few cycles (less than 50). Normal SRV actuations produce substantially less load for up to 4500 effective stress cycles (Reference 9). Since the 7500 cycles of maximum load bounds both of these by such a large margin and since no other significant loads are imposed on the line, the penetration was assumed acceptable for fatigue without further evaluation.

Controlling stresses in the SRV penetration follow:

PRIMARY STRESS
(Local Membrane Shell Stress Intensity)

Controlling Load Case	Calculated Stress	Allowable Stress
Case 15 (Table 1)	8,370	28,900 (1.5 S_{mc})

SECONDARY STRESS
(Primary plus Secondary Stress Intensity)

Controlling Load Case	Calculated Stress	Allowable Stress
Case 15	58,966	69,900 (3.0 S_{mi})

2.4.6 Valves

Evaluation of the SRV valves was done on the basis of stresses in the adjacent piping for the combined load cases. Pipe stresses meeting level B criteria were considered adequate to insure proper operation of the device (Reference 5, Section 5.5).

Results of the valve evaluation are listed in Table 2-4.

2.4.7 Fatigue Evaluation

Fatigue evaluation of SRV lines was undertaken as a generic Mark 1 Program effort, using bounding assumptions. This effort is described and reported in Reference 9, and concludes that fatigue will not be a problem for Mark 1 SRV lines; this includes the SRV lines at FitzPatrick. No further plant-unique analysis is necessary.

Fatigue evaluation of the SRV penetration is discussed in Paragraph 2.4.5.

2.5 Summary of SRV Line Modifications

Modifications to the SRV lines at FitzPatrick included the following changes:

- Installation of tee-quencher discharge devices and quencher supports on all eleven lines (Figure 2-4).
- Installation of one ten-inch vacuum breaker on each SRV line.
- Modification to supports and supporting steel in the drywell as listed in Table 2-3.

TABLE 2-1

SRV LOAD CASE/INITIAL CONDITIONS

Design Initial Condition		Any One Valve	ADS* Valves	Multiple Valves
	1 NOC*., First Act.	A1.1		A3.1
A	2 SBA/IBA,* First Act.	A1.2	A2.2	A3.2
	3 DBA,* First Act.[1]	A1.3		
	1 NOC, Subsequent Act.			C3.1
C	2 SBA/IBA, Sub. Act. Air in SRV/DL			C3.2
	3 SBA/IBA, Sub. Act. Steam in SRV/DL			C3.3

(1) This actuation is assumed to occur coincidently with the pool swell event. Although SRV actuations can occur later in the DBA accident, the resulting air loading on the torus shell is negligible since the air and water initially in the line will be cleared as the drywell to wetwell ΔP increases during the DBA transient.

* ADS = Automatic Depressurization System

NOC = Normal Operating Condition

SBA = Small Break Accident

IBA = Intermediate Break Accident

DBA = Design Basis Accident

TABLE 2-2

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SRV PIPE STRESS

SRV Line	Max. Stress Location	Line Size & Sch. @ Max. Stress Pt.	Maximum Stress	Allowable Stress
10" SSV-302-1A	171	10" Sch. 40	19,695	22,500
10" SSV-302-1B	292	10" Sch. 40	17,542	18,000
10" SSV-302-1C	362	10" Sch. 40	19,460	22,500
10" SSV-302-1D	670	10" Sch. 40	17,122	18,000
10" SSV-302-1E	886	10" Sch. 40	17,355	18,000
10" SSV-302-1F	665	10" Sch. 40	19,461	22,500
10" SSV-302-1G	125	10" Sch. 40	22,383	22,500
10" SSV-302-1H	138	10" Sch. 40	17,990	18,000
10" SSV-302-1J	803	10" Sch. 40	20,438	22,500
10" SSV-302-1K	358	10" Sch. 40	21,743	22,500
10" SSV-302-1L	341	10" Sch. 40	21,144	22,500

TABLE 2-3

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SRV PIPE SUPPORT MODIFICATIONS

SRV Line	Piping Node #	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
A	125	PFSK-1298	Y-Rigid	X		Support Reinforced
	124	PFSK-1286	X-Snubber		X	
	195	H29-180	Spring	X		Replace Spring Can
	145	PFSK-829	Y-Rigid	X		Support Reinforced
	132	PFSK-1291	X-Rigid		X	
	115	H29-177	Spring	X		Reset Existing Spring
	160	New Support	Lateral Rigid	X		Add New Support
	119	New Support	Axial Snubber	X		Add New Snubbers
B	219	H29-163	Spring	X		Reset Existing Spring
	545	PFSK-1236	X-Snubber	X		Remove Support Steel
	225	H29-164	Y,Z-Rigid	X		Support Reinforced
	232	PFSK-870	X,Y-Rigid	X		Support Reinforced
	242	H29-166	Spring	X		Reset Existing Spring Can
	530	PFSK-1237	X-Snubber		X	
	247	H29-167	Y-Rigid		X	

TABLE 2-3 (CONTINUED)

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SRV PIPE SUPPORT MODIFICATIONS

SRV Line	Piping Node #	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
C	155	PFSK-822	Y-Rigid	X		Replace Rigid Struts
	270	PFSK-1427	X-Rigid		X	
	286	H29-196	Spring	X		Replace Spring Can
	300	PFSK-832	Y-Rigid	X		Support Reinforced
	345	New Support	Rigid	X		New Support Added
D	496	PFSK-1255	Y-Snubber	X		Replace Snubber
	500	H29-154	X,Z-Rigid	X		Support Reinforced
	550	H29-153	Spring	X		Replace Spring Can
	570	H29-155	Spring		X	
	575	PFSK-1263A	Snubber	X		Replace Snubber
	580	H29-156	Y-Rigid		X	
	590	H29-157	Y-Rigid		X	
	604	PFSK-1256A	Strut	X		Replace Existing Snubber
	625	H29-158	X,Y-Rigid	X		Support Redesigned
	650	PFSK-826	Y-Rigid		X	
	685	New Support	Rigid	X		Add New Support

TABLE 2-3 (CONTINUED)

FITZPATRICK

SRV PIPE SUPPORT MODIFICATIONS

SRV Line	Piping Node #	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
E	760	H29-190	X,Y-Rigid	X		Support Redesigned
	815	PFSK-1289	X-Rigid	X		Support Redesigned
	841	PFSK-740	Spring	X		Replace Spring Can
	860	PFSK-831	Y-Rigid		X	
	905	New Support	Rigid	X		New Support Added
F	374	New Support	Snubber	X		Support Added
	395	H29-182	Spring		X	
	430	PFSK-1926	Snubber		X	
	445	H29-216	Rigid		X	
	460	H29-183	Spring	X		Reset Existing Spring
	461	PFSK-1238	Snubber		X	
	471	H29-184	X,Y-Rigid		X	
	505	H29-185	Spring	X		Replace Spring Can
	512	PFSK-1251	Snubber		X	
	513	H29-186	Y-Rigid		X	

TABLE 2-3 (CONTINUED)

FITZPATRICK

SRV PIPE SUPPORT MODIFICATIONS

SRV Line	Piping Node #	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
F (continued)	550	PFSK-200	Y-Rigid	X		Support Redesigned
	635	New Support	Rigid	X		Support Added
	590	PFSK-830	Y-Rigid		X	
G	134	New Support	Snubber	X		Support Added
	165	H29-160	Y-Rigid	X		Support Redesigned
	206	H29-215	Z-Rigid	X		Support Redesigned
	210	PFSK-1907	Snubber	X		Replace Snubber
	230	PFSK-827	Y-Rigid	X		Support Reinforced
	275	New Support	Rigid	X		Support Added
H	113	H29-198	Spring	X		Reset Existing Spring
	117	PFSK-1299	Y-Rigid	X		Support Reinforced
	123	PFSK-1290	X-Rigid	X		Support Redesigned
	130	PFSK-741	Spring	X		Replace Spring Can
	132	PFSK-833	Rigid	X		Support Reinforced
	142	New Support	Rigid	X		Add New Support
	159	PFSK-1287	Snubber		X	
	500	New Support	Snubber	X		Add New Support

TABLE 2-3 (CONTINUED)

FITZPATRICK

SRV PIPE SUPPORT MODIFICATIONS

SRV Line	Piping Node #	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
J	208	New Support	Snubber	X		Add New Support
	800	H29-203	Spring	X		Reset Existing Spring
	801	PFSK-1275	Snubber		X	
	216	H29-204	Y,Z-Rigid	X		Support Reinforced
	218	PFSK-1886	Snubber		X	
	228	H29-205	Spring	X		Replace Spring Can
	235	H29-206 New Support	X,Z-Rigid Y-Rigid	X		Support Redesigned
	243	H29-207	Spring	X		Replace Spring Can
	248	PFSK-1258 H29-208	X,Y-Rigid		X	
	294	H29-209	Spring		X	
	257	H29-210	Spring	X		Reset Existing Spring
	249	PFSK-1268	Snubber		X	
	295	PFSK-1267B	Snubber		X	
	818	PFSK-1267A	Snubber		X	
	296	H29-211	Y-Rigid		X	

TABLE 2-3 (CONTINUED)

FITZPATRICK

SRV PIPE SUPPORT MODIFICATIONS

SRV Line	Piping Node #	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
J (continued)	264	H29-212	Spring	X		Reset Existing Spring
	269	H29-213	X,Y-Rigid	X		Add Weld
	270	PFSK-1259	Snubber		X	
	275	PFSK-834	Y-Rigid		X	
	284	New Support	Rigid	X		Add New Support
K	319	PFSK-1135A	Y-Rigid	X		Support Redesigned
	338	PFSK-1135B	X,Z-Rigid	X		Support Redesigned
	314	New Support	Y-Snubber	X		Add New Support
	328	New Support	X,Z-Snubber	X		Add New Support
	361	PFSK-1135C	Rigid	X		Support Reinforced
	377	New Support	Rigid	X		Add New Support
L	320	PFSK-1156	Y-Rigid	X		Support Reinforced
	331	PFSK-1158	X,Z-Rigid	X		Support Redesigned
	346	PFSK-1159	Y-Rigid	X		Support Reinforced
	357	New Support	Snubber	X		New Support Added

TABLE 2-3 (CONTINUED)

FITZPATRICK

SRV PIPE SUPPORT MODIFICATIONS

SRV Line	Piping Node #	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
L (continued)	371	New Support	Snubber	X		New Support Added
	372	New Support	Snubber	X		New Support Added
	374	New Support	Snubber	X		New Support Added
	376	New Support	Snubber	X		New Support Added
	377	New Support	Snubber	X		New Support Added

TABLE 2-4

FITZPATRICK

SRV VALVE EVALUATION

Component Designation	Component Type	SRV System	Pipe Stress	Allowable Pipe Stress
02RV/71A	SRV	SRV A	2710	18000
3"-VCF-3A	3"Check	SRV A	3364	18000
02-VB-1	10" Check	SRV A	6157	18000
02RV/71B	SRV	SRV B	1414	18000
3"-VCF-30A	3" Check	SRV B	3862	18000
02-VB-2	10" Check	SRV B	4882	18000
02RV/71C	SRV	SRV C	3170	18000
3"-VCF-30A	3" Check	SRV C	8568	18000
02-VB-3	10" Check	SRV C	6072	18000
02RV/71D	SRV	SRV D	3092	18000
3"-VCF-30A	3" Check	SRV D	9250	18000
02-VB-4	10" Check	SRV D	5450	
02RV/71E	SRV	SRV E	2880	18000
3"-VCF-30A	3" Check	SRV E	5502	18000
02-VB-5	10" Check	SRV E	6170	18000
02RV/71F	SRV	SRV F	3155	18000
3"-VCF-30A	3" Check	SRV F	5593	18000
02-VB-6	10" Check	SRV F	5902	18000
02RV/71G	SRV	SRV G	3248	18000
3"-VCF-30A	3" Check	SRV G	4747	18000
02-VB-7	10" Check	SRV G	6180	18000
02RV/71H	SRV	SRV H	2955	18000
3"-VCF-30A	3" Check	SRV H	3570	18000
02-VB-8	10" Check	SRV H	5558	18000
02RV/71J	SRV	SRV J	2634	18000
3"-VCF-30A	3" Check	SRV J	9050	18000
02-VB-9	10" Check	SRV J	5336	18000
02RV/71K	SRV	SRV K	2870	18000
3"-VCF-30A	3" Check	SRV K	5050	18000
02-VB-10	10" Check	SRV K	6656	18000
02RV/71L	SRV	SRV L	2904	18000
3"-VCF-30A	3" Check	SRV L	7846	18000
02-VB-11	10" Check	SRV L	5462	18000

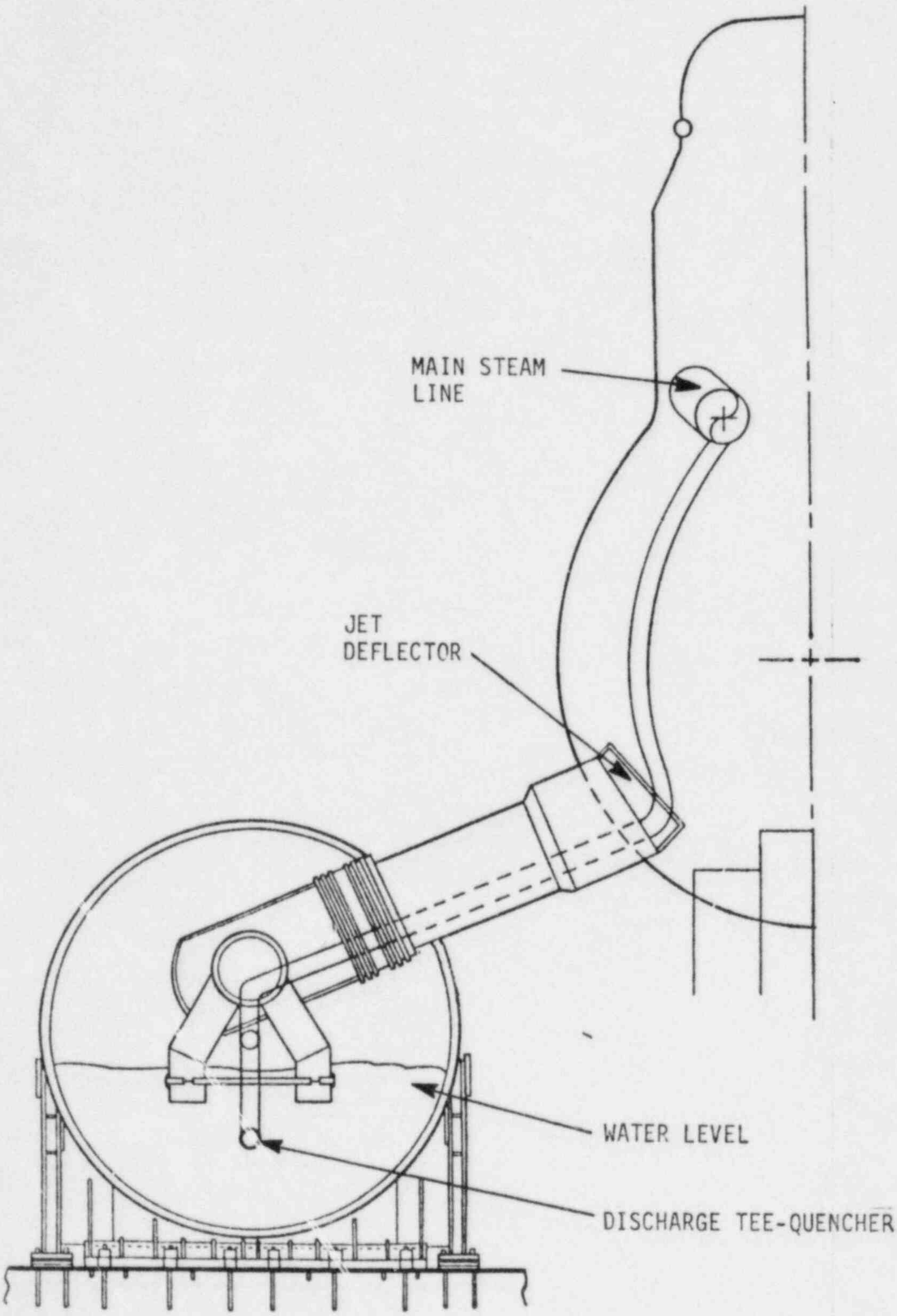


FIGURE 2-1 SRV LINE ROUTING-TYPICAL

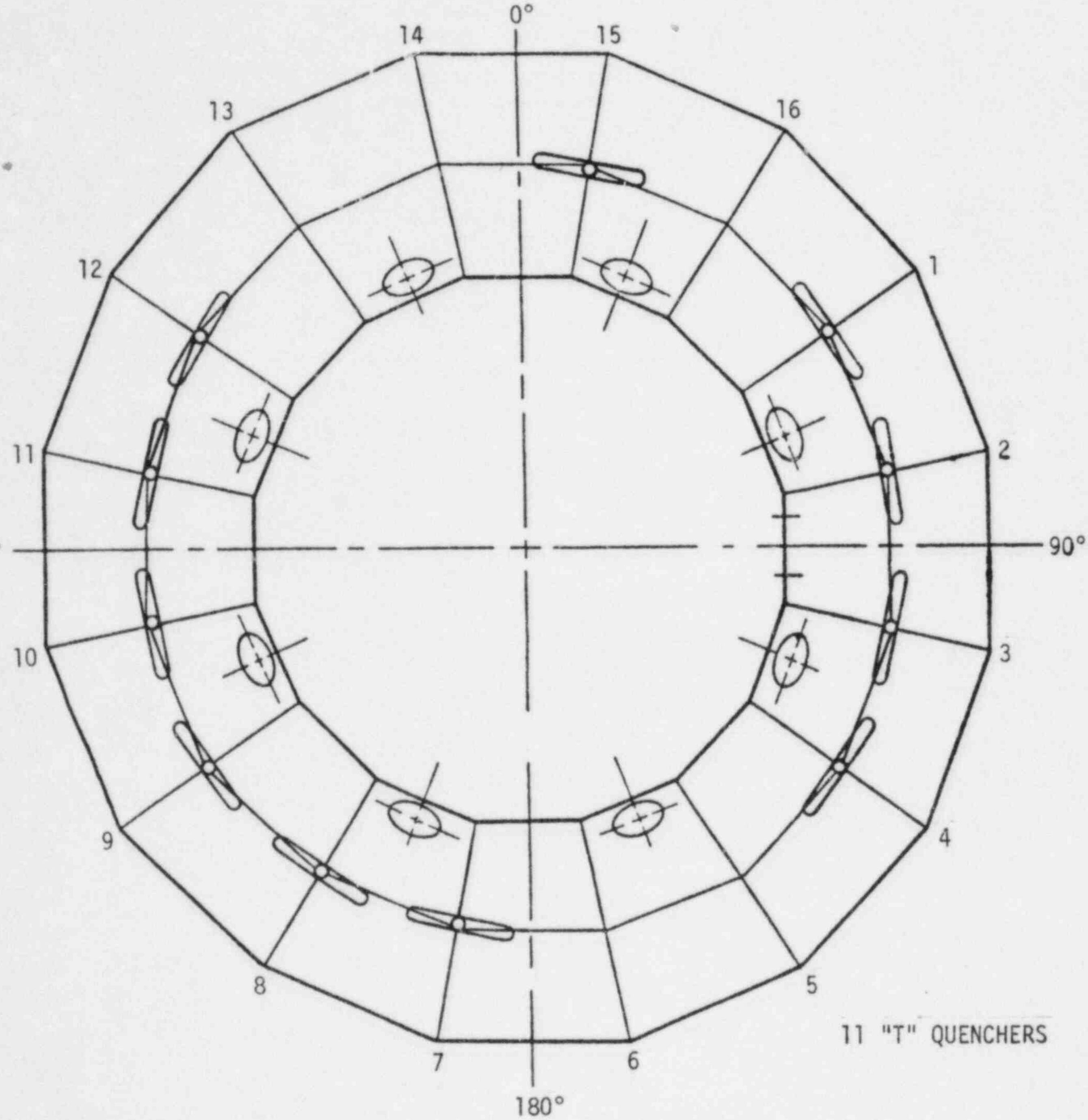
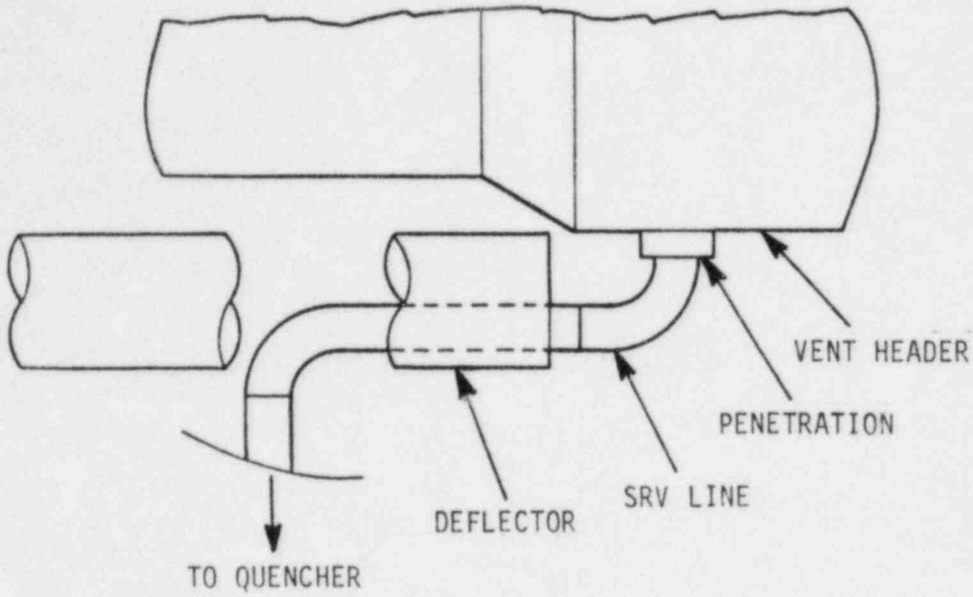


FIGURE 2-2 SRV LINE ARRANGEMENT-TORUS



DETAIL "A"

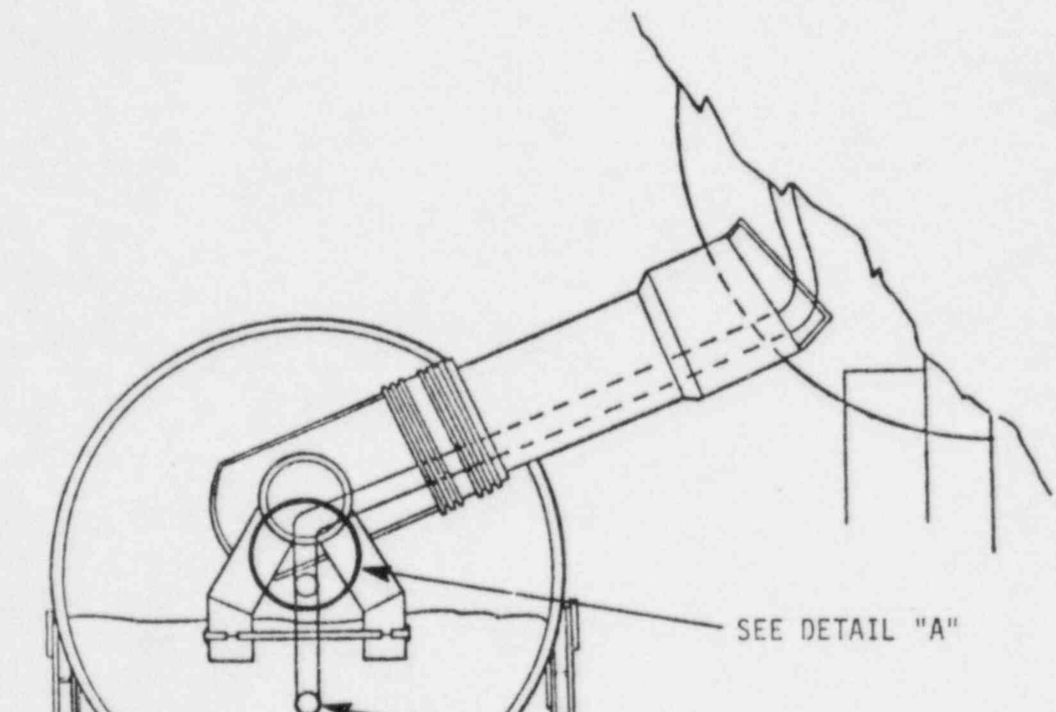


FIGURE 2-3 SRV LINE ROUTING-TYPICAL

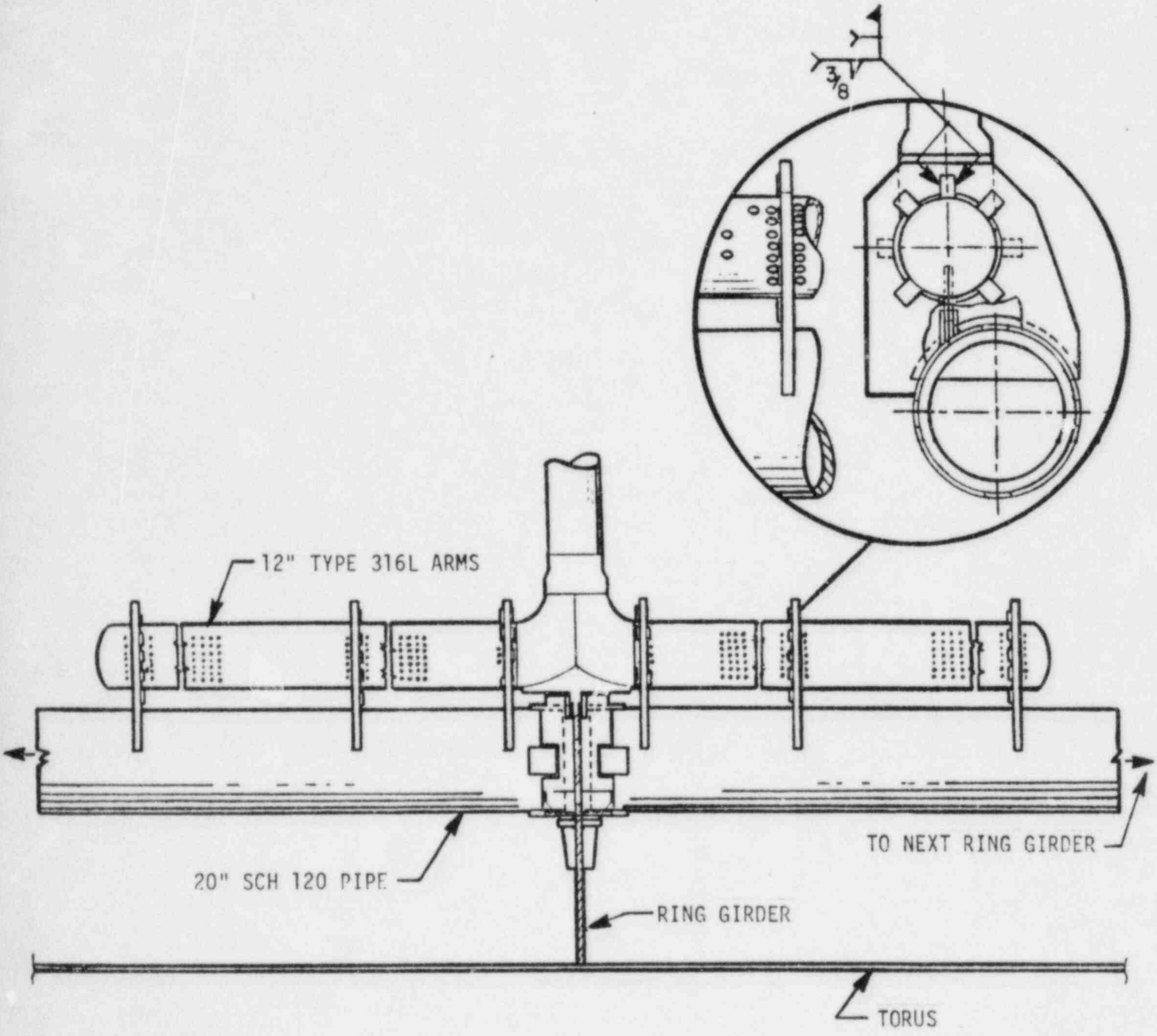


FIGURE 2-4 SRV TEE-QUENCHER & SUPPORT

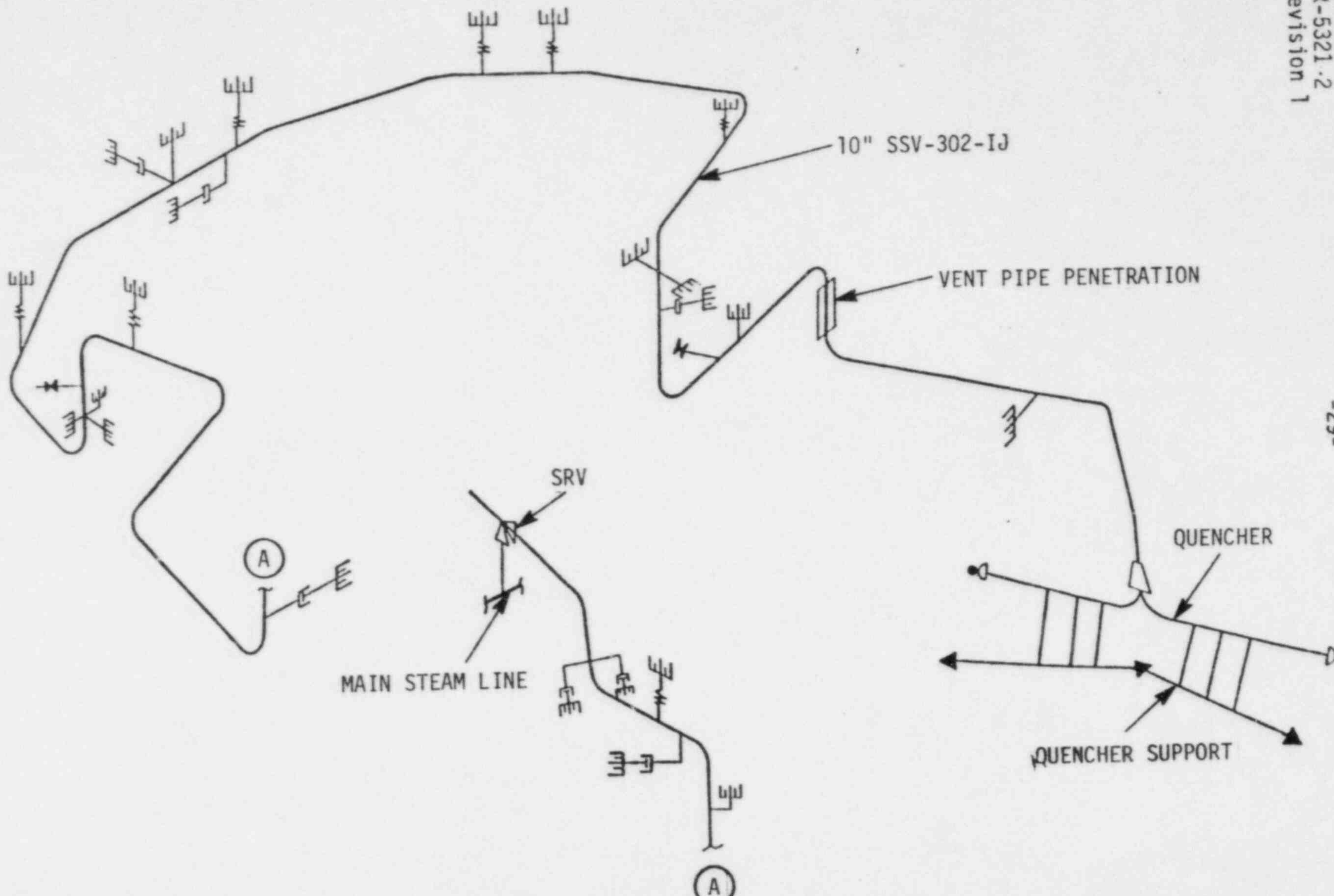


FIGURE 2-5 SRV PIPING MODEL, TYPICAL

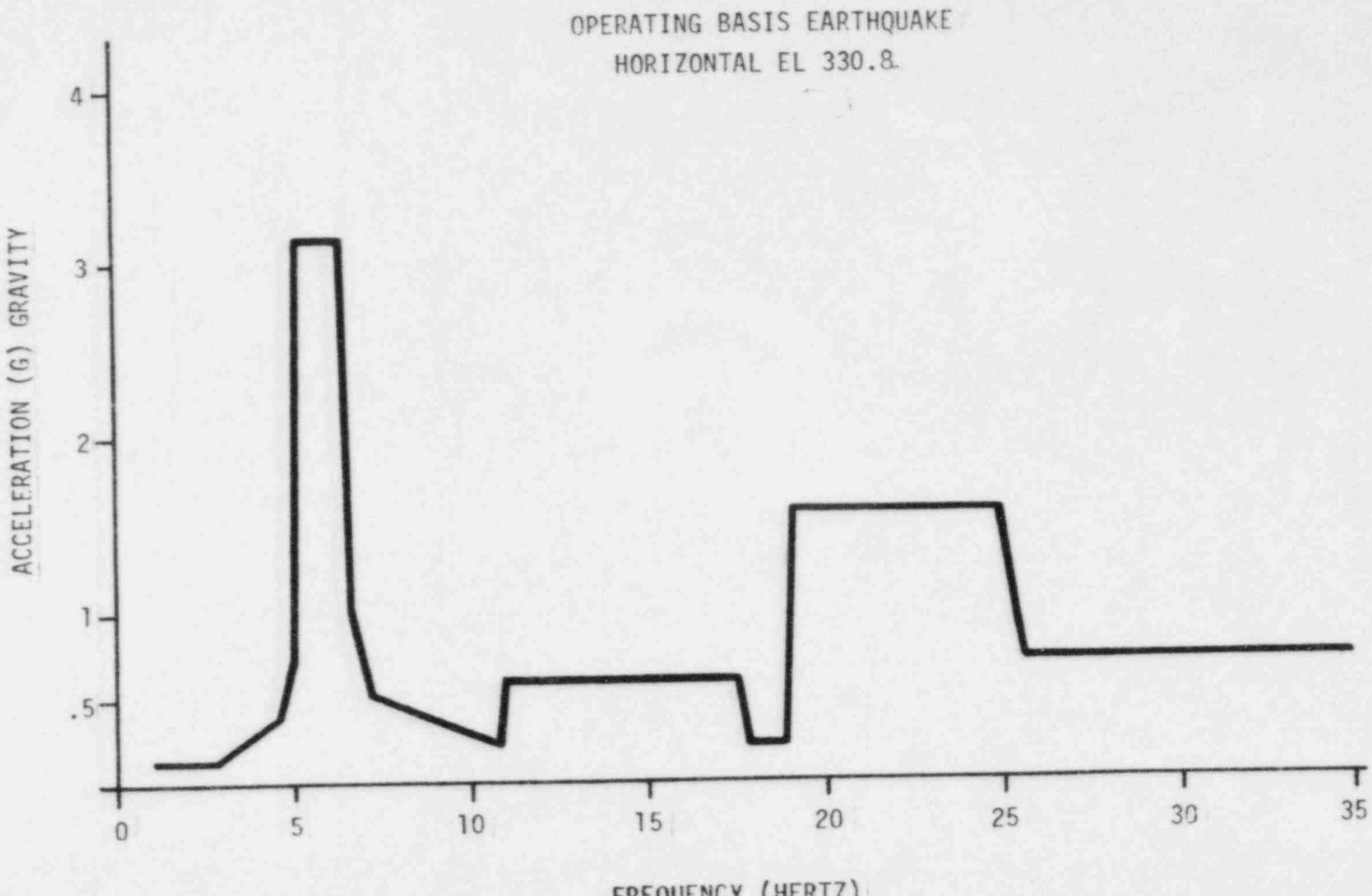


FIGURE 2-6 SRV SEISMIC SPECTRA, TYPICAL

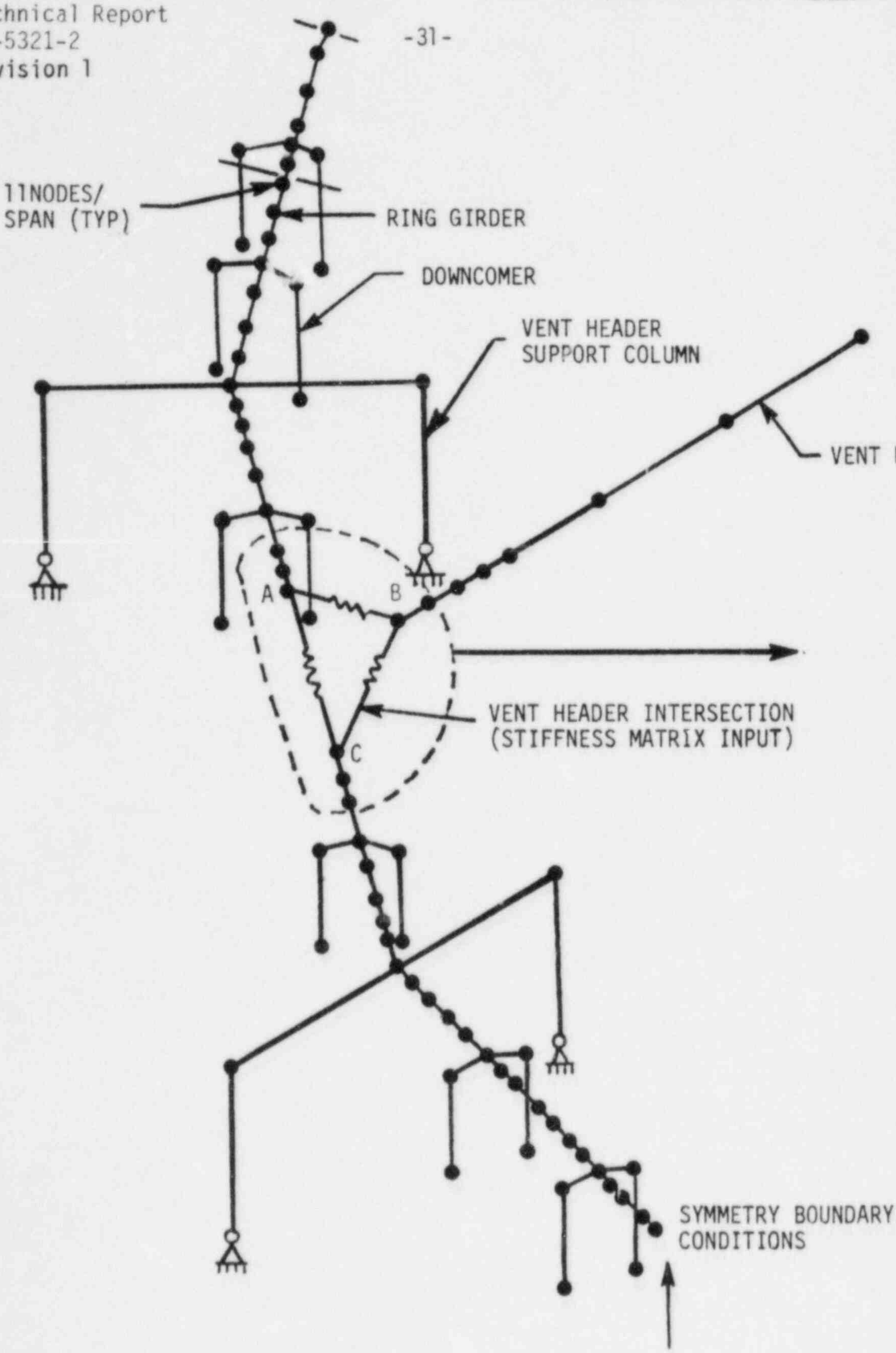


FIGURE 2-7 VENT SYSTEM MODEL

3.0 TORUS ATTACHED PIPING (TAP)

The torus at FitzPatrick has 17 piping systems attached to its outer shell. These systems connect to 29 penetrations and are listed in Tables 3-1 and 3-2, and Figure 3-8c. Analysis of the large diameter attached piping systems included all piping from the torus to the first anchor. Small diameter piping was analyzed to the first anchor or a distance where the torus loads could be considered negligible.

Also considered in this analysis are:

- Branch piping connected to TAP systems.
- Torus penetration stresses.
- Piping inside the torus attached to TAP systems.
- Pump and valve loads.
- All pipe support and anchor loads.

The analysis method is different for large bore TAP systems (above four-inch diameter) and small bore systems (four-inch and below), as discussed in the following text.

Different organizations were involved in these analyses. TES performed piping analysis for torus dynamic loads for all systems. Stone & Webster* had recently completed weight, thermal and seismic analysis for the same lines as a part of Bulletin 79-14 work; these results were used for these loads (Reference 18). In cases where a line had to be resupported, or where Stone & Webster analysis was not available, TES analyzed for all loads. All piping supports were analyzed to the new combined loads by TES.

This report includes descriptions and results for all analysis.

3.1 Applicable Codes and Criteria

Analysis and modifications to TAP piping and supports were in accordance with the following codes:

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*Stone & Webster Co., New York, NY

Piping Analysis

TES Analysis - ASME Section III, 1977 Edition (Reference 2) and B31.1 1967 Edition (Reference 17).

S & W Analysis - (Bulletin 79-14), B31.1 1967 Edition (Reference 17 & 18).

Support Analysis

All TAP and branch supports - ASME Section III, 1977 Edition, and including NRC Bulletin 79-02 requirements (Reference 3).

Load combinations and stress levels were evaluated in accordance with Table 5-5 of the Mark 1 Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide (Reference 5). Table 5-5 is reproduced in this report as Table 1.

Damping for all time history piping analysis was taken at 2% of critical for lines equal to or less than 12 inches in diameter, and 3% for larger lines. Seismic analysis used 2% damped spectra.

3.2 TAP Loads

Loads applied to TAP systems include:

Mark 1 Loads

Shell motion due to pool swell.
Shell motion due to SRV line discharge.
Shell motion due to condensation oscillation.
Shell motion due to chugging.
Pool drag and impact loads on internal piping.

and

Original Design Loads

Deadweight.
Thermal expansion.
Seismic.

The Mark 1 loads, due to shell motion, were calculated based on plant unique shell response data developed during an earlier phase of this program and reported in the PUA report, Reference 1. Drag loads on internal piping were developed using generic methods from the Mark 1 Program as a part of this piping analysis work. These loads are described more fully in the Mark 1 Load Definition Report (Reference 10).

Analysis for seismic response was based on FSAR spectra.

3.2.1 Shell Motion Due to Pool Swell

TAP input loads, due to shell motion during pool swell, were based on data developed during the Plant Unique Analysis for the shell (Reference 1). The PUA shell analysis provided time history response information in five degrees of freedom for every point on the shell where large bore TAP was connected. This data consisted of three translations and two out of plane rotations (no torsion). Data for small bore piping was based on conservative bounding of the large bore data. Attachment points for large bore piping are illustrated in Figures 3-8a, 3-8b and 3-8c.

Data available from the plant unique shell analysis consists of time history displacements and rotations. These were converted to equivalent time history forces as described in paragraph 3.3.6.1.

A typical pool swell force time history is illustrated in Figure 3-1.

3.2.2 Shell Motion Due to DBA Condensation Oscillation

The DBA condensation oscillation load definition is given in Reference 11 as a set of spectral pressures, from 1-50 Hz. Shell response due to this loading was calculated by applying each frequency in this band to the torus shell model shown in Figure 3-7 and calculating response for each sinusoidal excitation. (This work was done earlier to allow calculation of shell stress for Reference 1). Shell response was calculated for frequencies up to 32 Hz; frequencies above 32 Hz were considered negligible as discussed in Appendix 2.

Shell responses for each of these frequency components were combined into an equivalent time history using random phasing of the individual components. Amplitudes of this equivalent time history were then increased by a factor of 1.15 to allow for the in-phase response of the four peak frequency components. See Reference 12 for a further discussion of the factor and component phasing.

This method of combining frequency components and generating an equivalent shell response time history was repeated for each TAP penetration for large bore piping. Responses for small bore piping were based on conservative bounding of the large bore data.

A typical DBA CO shell response is illustrated in Figure 3-2.

3.2.3 Shell Motion Due to Chugging

Shell response during chugging was defined separately for pre-chug and post chug loads.

Pre-chug is a sinusoidal pressure load equal to ± 2 psi on the torus shell; this load can occur at any frequency between 6.9 and 9.5 Hz

(Reference 10). Shell response for pre-chug was calculated by applying a continuous ± 2 psi sine pressure to the large torus model (Figure 3-7) in the specified frequency range. Maximum shell response in this range occurred at 9.5 Hz. This was considered as one of the inputs to TAP.

Post chug is specified as a spectrum of pressures from 1-50 Hz. Shell response was calculated for each 1 Hz component in this spectrum, then all 50 components were combined into an equivalent time history using random phasing of all components. Amplitudes of this time history loading were multiplied by 1.15 to account for the fact that some elements of the spectrum are not randomly phased. Further discussion of this factor can be found in Reference 6. The resulting pressure time history was applied to the model in Figure 3-7 to calculate shell response.

3.2.4 Shell Motion Due to SRV Line Discharge

TAP input loads, due to shell motion during SRV line discharge, were based on data developed for the PUA shell analysis (Reference 1). This shell analysis was the result of a finite element analysis that was calibrated with in-plant SRV test data, as described in Reference 1. The data resulting from the shell analysis were time histories and were used to provide time history input functions for the TAP.

Section 5.2 in the Load Definition Report (Reference 10) requires that we allow for a ± 25 percent shift in the SRV frequency for discharge through a cold line, and a ± 40 percent shift for discharge through a hot line. This was considered by examining the response modes and frequencies of the TAP piping systems and then making adjustments within the specified ranges to force worst case input-response frequency pairing.

The strongest torus shell response during SRV actuation is the result of simultaneous actuation of several SRV lines. These cases were considered by adding the shell pressures due to the individual actuations by absolute summation.

A typical shell response due to SRV actuation is illustrated in Figure 3-3.

3.2.5 Loads on Internal Piping

Most of the large TAP systems extend into the torus. In the case of suction lines, the internal portions usually consist of a pipe fitting and strainer. For return lines, longer sections of pipe, up to approximately 20 feet, extend into the torus.

The internal portions of these systems are subjected to submerged structure drag if they are in the pool; or pool impact, if they are above the water level. In either case, the appropriate Mark 1 loads were calculated and considered during the piping evaluation.

Loads for piping in the pool and above the pool were calculated in accordance with the methods of the Load Definition Report (Reference 10), NUREG 0661 (Reference 11) and Appendix 1 of Reference 1. All loads were considered, including:

<u>For Submerged Piping</u>:

- CO Source and FSI Drag.
- Post Chug Source and FSI Drag.
- Pre-chug Drag.
- SRV Bubble and Jet Loads.
- Pool Swell Bubble Drag.
- Pool Swell Fallback.

<u>For Structures Above the Pool</u>:

- Pool Swell Water Impact and Drag.
- Froth.
- Fallback.

A typical submerged structure load spectrum is shown in Figure 3-4. This spectrum includes CO and CH source and FSI drag.

3.2.6 Deadweight, Thermal and Seismic Analysis

Analysis for all TAP systems was also done for deadweight, thermal and seismic conditions.

Thermal analysis was performed at the original design thermal conditions. Thermal displacement of the penetration was determined from the maximum operating temperature of the torus and applied for all cases.

Seismic analysis was done using the spectra from the FSAR. The enveloped OBE spectra for a typical line is shown in Figure 3-5.

3.3 TAP Analysis Method

The method for TAP pipe stress analysis varied for each of the following cases:

- Large bore piping (over 4" diameter).
- Small bore piping systems (4" and less), which could be reduced to single degree-of-freedom approximations.
- Small bore piping which could not be reduced to single dof systems.
- Branch piping off of TAP systems.

Analysis of supports, anchors and torus penetrations did not vary and was the same for all types of piping systems.

3.3.1 Representation of Torus Shell for Piping Analysis

Because the larger TAP systems are stiff and heavy when compared to the torus shell, it is important that the piping computer model

allows for dynamic interaction between the piping and the torus. This was done for all TAP piping systems by including a set of ground springs in the piping model to represent the torus connection, as illustrated in Figure 3-6. Five ground springs were used to represent the torus shell; these represented stiffnesses associated with the three translations of the shell and the two out of plane moments on the shell. Torsional pipe loads were considered negligible.

The stiffness values of the ground springs were calculated by applying unit loads and moments to the large shell finite element model of the torus illustrated in Figure 3-7. Different attachment stiffnesses were calculated for each pipe penetration location, and then applied to the appropriate piping system model.

3.3.2 Piping Analysis Method - Large Bore Systems

Analysis of all large bore piping systems was done using finite element models of each system. These models included ground springs to represent the torus and also included piping inside the torus.

All analysis on these models was done using the STARDYNE computer code (Reference 15). Time history dynamic analysis used damping values of 2% of critical for all lines with 12 inch diameter or less, and 3% for larger lines; OBE seismic used a 2% damped spectra. Analysis on these models included:

- Zero and Full ΔP Pool Swell Motion and Drag Loads.
- Post Chug Shell Motion and Drag Loads.
- DBA CO Shell Motion and Drag Loads.
- SRV Shell Motion and Drag Loads.
- Deadweight.
- Seismic.
- Thermal.

Pre-chug was considered as a separate load condition, but it was determined that it would always be bounded by DBA CO. On that basis, pre-chug loads were not run for each TAP system.

All TAP response due to shell motion was done using time history analysis. Response due to drag loads on internal piping was calculated by harmonic analysis for the spectral loads and hand analysis for transients. The effects of both shell motion and internal loadings were considered for all points in the piping system.

Pipe stress due to welded support attachments was considered by separate analysis and included in the pipe stress evaluation.

3.3.3 Piping Analysis Method - Complex Small Bore Systems

Analysis of small bore piping systems that could not be reduced to single degree of freedom systems were treated identically to large bore systems, except for the loads considered. For these systems, the loads considered included:

- DBA CO.
- Deadweight.
- Seismic.
- Thermal.

Consideration of Mark 1 dynamic loads was limited to DBA CO, based on experience with large bore piping analysis for five Mark 1 plants. This experience showed that all high stressed lines were controlled by DBA CO, except in a few special cases. Appendix 1 discusses this further.

3.3.4 Piping Analysis Method - Simple Small Bore Systems

Small bore piping systems that could be reduced to single mass approximations were analyzed using hand analysis. Torus shell stiffness

was included in these models to the extent that it affected first mode response, as a minimum. Higher modes were considered if they fell within the range of the input load. Typically, these systems consisted of a short length of pipe, terminating in a valve or tubing.

Shell input to these systems (for Mark 1 loads) was formatted in the frequency domain to provide an input spectrum. This spectral data was used in combination with the hand analysis to calculate response levels.

Loads considered for simple small bore systems were the same as for the more complex small bore systems, including seismic, weight and thermal, if applicable.

3.3.5 Piping Analysis Method - Branch Piping

Branch piping connected to TAP systems was modelled with the TAP systems if the ratio of their bending stiffness was greater than approximately 1:40.

Branch piping too flexible to meet this ratio was considered by separate analysis. These systems were analyzed statically by placing a displacement at the connection point, equal to twice the TAP motion at the connection point. (except deadweight deflections, which were considered negligible). The entire branch line was modelled for these analyses.

3.3.6 Piping Analysis - Load Input for Computer Models

3.3.6.1 Mark 1 Loads Due to Shell Motion

Shell motion, due to internal Mark 1 loads, is due to pressures across broad areas of the shell, as opposed to concentrated forces at the penetration. Because of this, the interactive effects of piping

and shell should include allowance for local shell compliance in the force input to the piping system. The method of load input for TAP accounts for this. The method is illustrated in Figure 3-6.

The steps involved are:

- Extract displacement time history from large computer model for a shell without an attached TAP system. (Reference 1 and Figure 3-7).
- Determine local shell stiffness from large computer model (Reference 1 and Figure 3-7).
- Determine an equivalent force time history at the penetration by multiplying displacement by stiffness.
- Apply the force time history to the TAP as shown in Figure 3-6.

The use of forces, rather than displacements to drive the model, is necessary to accurately account for the inertial interaction of the piping, since the available shell response data is for an unloaded shell (no piping). Use of forces as input will allow displacements at the penetration to increase or decrease in reaction to the inertial forces from the piping.

3.3.6.2 Submerged Drag Loads on Internal TAP

Drag loads on internal piping during CO, CH, SRV and pool swell were evaluated using the same TAP piping models that were used for shell induced, seismic and other loads. Internal drag loadings were run as separate cases, with worst-case orientations, and then combined with other loadings to determine pipe stress, support loads and penetration stress. The effects of drag load on both internal and external parts of the TAP system were calculated and included in all evaluations.

Loads were applied to the piping and evaluated by the following methods:

- Pool Swell Drag - Static Analysis x 2.
- Pool Swell Fallback - Static Analysis x 1.
- Pool Swell Impact - Static Analysis x 2.
- Pool Swell Froth - Static Analysis x 2.
- CO Drag - Dynamic Analysis (Spectrum).
- Post Chug Drag - Dynamic Analysis (Spectrum).
- SRV Drag - Static Analysis x 1.
- Pre-chug - Bounded by DBA CO.

Piping response to CO and post chug drag were evaluated using dynamic analysis. These spectra, including their FSI components, were then enveloped to form a single spectrum that was used in this analysis. Each frequency component in this spectrum was then applied to the CG of the submerged internal piping as a harmonic forcing function. The load in the pipe was calculated at a point just inside the penetration, in each of six degrees-of-freedom. These single-frequency piping loads were then combined into a single load at that point by absolute sum of the four largest components added to the SRSS of the balance. This was done for each degree of freedom. (The basis for this method of combining individual frequency components is discussed in Reference 12). The loads calculated in the pipe were then applied to the system as static loads; and pipe stress, penetration stress, and support loads were determined. A typical combined spectrum is illustrated in Figure 3-4.

TAP analysis for other loads noted above, was done by applying the appropriate load to the CG of the affected area and performing static analysis.

3.3.7 TAP Penetration Analysis

Analysis of torus penetrations included the following loads:

- Loads from piping response due to shell motion (Mark 1 loads).
- Loads due to submerged drag and/or pool impact, on internal sections of TAP, as applicable.
- Loads from weight, seismic and thermal conditions on the attached piping.
- Shell loads which exist due to the Mark 1 and other loads, independent of piping (from Reference 1).

The calculation of stress from the loads was done using a Bijlaard analysis (Reference 8) to account for local penetration stress due to piping loads. These stresses were combined with free shell stresses in that area, intensified to account for the discontinuity. Free shell stress was taken from earlier containment analysis, as reported in Reference 1. Penetration stresses were calculated for each load in each degree of freedom. Stresses resulting from this analysis were combined to form the load cases defined in the PUAAG (Reference 8 and Table 1).

Stress in the piping within the limits of reinforcement was calculated by combining the stress in the pipe with the local shell stresses by absolute summation. This was also evaluated for each degree of freedom and each of the PUAAG load cases (Table 1).

3.3.8 Analysis Method for Piping Supports

Analysis was done for all piping supports for all TAP and branch systems. Calculations were made using both hand and computer analysis, depending on the complexity of the individual support. Evaluation of baseplates and anchor bolts was included, using the current procedures devel-

oped in response to NRC Bulletin 79-02 (Reference 3). The STAAD computer program was used in most cases where computer analysis of supports was done (Reference 16).

3.3.9 Vacuum Breaker Analysis

The torus TAP systems include a portion of the vacuum relief system which connect the main vent pipe to the the torus airspace, and which include the wetwell-to-drywell vacuum breakers. Analysis of these vacuum breakers was not within the scope of the Mark 1 Containment Program, but is addressed in Reference 13.

3.3.10 Active Components

Active components on TAP systems include ten pumps and 68 valves, excluding the 11 vacuum breakers. Acceptability of these components was assured by limiting stresses at these locations, as described in the evaluation section. No analysis was necessary on these components.

3.4 Evaluation and Results

3.4.1 General

Combinations of the previous analysis cases were done to allow evaluation of results in accordance with Table 5-5 of Reference 5. (Table 1 in this report.) This table lists a total of 27 load cases for both essential and non-essential piping systems. For purposes of this evaluation, all TAP systems are classified as essential.

The 27 load cases shown in Table 1 were reduced, by conservative bounding, to the cases listed below:

	Case No. (Table 1)	Major Load(s)	Allowable (Eq. 9)
1	2	SRV (C3.1) + OBE	1.2 S_h
2	16	Zero Δ P	2.4 S_h
3	21	DBA CO/CH + SSE	2.4 S_h
4	25	Pool Swell + SRV (A1.3)	2.4 S_h
5	15	Post Chug + SRV	2.4 S_h

In these cases, the seismic stresses were combined with the absolute sum of the Mark 1 dynamic loads by the the SRSS method.

3.4.2 Piping Stress - Large Bore Systems

Stress in all large bore TAP systems was combined and evaluated in accordance with Section III of the ASME code for the five cases listed in Paragraph 3.4.1. These evaluations included the effects of local pipe stresses due to welded attachments at supports. Fatigue was considered as explained in Paragraph 3.4.5 & 3.4.6.

The large bore TAP systems are listed in Table 3-1 along with the maximum stress for the controlling load combination.

3.4.3 Pipe Stress - Small Bore TAP Systems

Evaluation of small bore TAP systems was the same as for large bore systems, except that the only Mark 1 dynamic load considered was DBA CO. This approach was based on experience gained in large bore analysis and is discussed further in Appendix 1.

Small bore systems are listed in Table 3-2.

3.4.4 Pumps and Valves

Evaluation of pumps and valves was done based on stresses in the adjacent piping. Pipe stresses meeting Level B criteria were considered adequate to assure proper operation of the pumps or valve. (Reference 5, Section 5.5).

Results of the pump and valve evaluation are listed in Table 3-4.

3.4.5 Piping Fatigue Evaluation

Consideration of the fatigue effects of cyclic loading is reported in Reference 9 for bounding Mark 1 plants. This reference defines bounding conditions and concludes that the stress levels and cycles involved in these systems will not produce a fatigue problem. The conclusions are applicable to the FitzPatrick Plant. No further plant unique evaluation was done to address fatigue considerations for piping. Fatigue for the penetration is considered below.

3.4.6 Torus Shell Penetration Evaluation

Evaluation of torus penetration stresses considered loads from the external and internal piping, as well as the loads that exist in the shell, due to the same event(s). Shell stress away from penetrations is reported in Reference 1.

Stresses in the penetration area were evaluated in accordance with subsectin NE of The ASME code, using the following paragraphs:

NE-3221.2 Local Membrane Stress Intensity

NE-3221.3 Primary General or Local Membrane plus Primary Bending Stress Intensity

NE-3221.4 Primary plus Secondary Stress Intensity

NE-3221.5 Analysis for Cyclic Operation

NE-3227.5 Nozzle Piping Transition

Fatigue evaluation of the penetration (paragraph NE-3221.5) showed that the maximum load could be cycled on each penetration for at least 10,000 cycles without exceeding code allowables. The major loads that form these load combinations are pool swell (1 cycle), DBA.CO (900 cycles), and SRV Case C3.3 (50 cycles). Other loads; normal SRV actuation, IBA CO, and chugging, can produce up to 10,000 cycles, but only at greatly reduced stress levels. Based on this, the 10,000 cycles at maximum stress represents a conservative level of evaluation and the TAP shell penetrations are considered acceptable for fatigue.

Controlling stresses in the TAP penetrations are listed in Table 3-6. Additional information of number of cycles for each condition can be found in Reference 9.

3.4.7 Piping Supports

All piping supports on the TAP systems were evaluated for the same load combinations as the piping (Table 1).

Evaluation was done in accordance with ASME, Section III, Division I, Subsection NF, 1977 with 1978 Summer Addenda and included the following criteria:

- Expansion type anchor bolts and baseplates were evaluated in accordance with Bulletin 79-02 criteria (Reference 3).

- No stresses in pipe supports were allowed to exceed yield, regardless of pipe stress allowables.

A listing of pipe supports and modifications is given in Table 3-5.

3.5 Summary of TAP Modifications

Modifications to torus attached piping systems consisted of support changes, as well as modifications to internal piping.

Modifications to internal piping included shortening some lines to reduce submergence and drag loads; rerouting one line and supporting it from the ring girder and resupporting one other. The following modifications were made; these are illustrated in Reference 1:

- Reroute RHR line and support from ring girder.
- Reinforce spray header supports on the ring girders.
- Modify HPCI line.
- Relocate RCIC line 8".
- Resupport 10" condensate line.

Modifications to external piping consisted of support and support steel modifications as summarized in Table 3-5 of this report.

TABLE 3-1

FITZPATRICK

LARGE BORE TAP RESULTS

System Name	Penetration Number	Line Size & Schedule	Controlling Load Case	Maximum Stress	Allowable Stress
Vacuum Relief Line	X-202A/F	30" Std.	Seismic & SRV	24,029	27,000
Vacuum Relief Line	X-202B/G	30" Std.	DBA CO	27,926	36,000
Reactor Building Normal Vent	X-205	20" Sch. 10	Seismic & SRV	21,415	27,000
RHR Discharge	X-210A & X-211A	24" Std.	DBA CO	31,961	36,000
RHR Discharge	X-210B & X-211B	24" Std.	DBA CO	35,073	36,000
RCIC Turbine Exhaust	X-212	8" Sch. 40 (Std)	DBA CO	32,608	36,000
Drain	X-213A/B	3" Sch. 40 (Std)	DBA CO	31,195	36,000
HPCI Turbine Exhaust	X-214	20 Sch. 10	DBA CO	21,139	36,000
Vent Purge Outlet	X-220	20" Sch. 10	SRV	11,633	27,000
RCIC Pump Suction	X-224	6" Sch. 40 (Std)	SRV + PS2	25,146	36,000
RHR Pump Suction	X-225A	20" Sch. 10	SRV + PS2	26,407	36,000
RHR Pump Suction	X-225B	20" Sch. 10	DBA CO	35,643	36,000
HPCI Pump Suction	X-226	16" Std.	PS1	29,480	36,000
Core Spray Pump Suction	X-227A	16" Std.	DBA CO	33,381	36,000
Core Spray Pump Suction	X-227B	16" Std.	PS1	33,746	36,000
Condensate Drain	X-228	10" Sch. 40 (Std)	SRV + PS2	29,447	36,000

TABLE 3-2

FITZPATRICK

SMALL BORE TAP RESULTS

System Name	Penetration Number	Line Size & Schedule	Type of Analysis	Maximum Stress	Allowable Stress	Max. Stress Location
Oxygen Analyzer	X-203B	1" Sch. 80	Computer	11,110	36,000	Node 1
Liquid Level Indicator	X-206A,B,C,D	1" Sch. 80	Computer	25,738	36,000	Node 1
23	X-217	2" Sch. 80	Computer	25,545	36,000	Node 28
Vacuum Pump Discharge	X-221	2" Sch. 80	Computer	19,538	36,000	Node 24
Condensate Drain	X-222	2" Sch. 80	Computer	18,162	36,000	Node 58

TABLE 3-3

FITZPATRICK

BRANCH LINE PIPE STRESSES

Branch Line Designation	TAP System	TAP Penetration	Branch Line Dia./Sch.	Maximum Stress	Allowable Stress
1" W25-152-18	HPCI Pump Suction	X-226	1" Sch. 80 (XS)	10,455	36,000
3/4" Vent	HPCI Pump Suction	X-226	3/4" Sch. 80 (XS)	(1)	
1" W23-152-22A	Core Spray Pump Suction	X-227A	1" Sch. 80 (XS)	(2)	
2" W23-152-16A	Core Spray Pump Suction	X-227A	2" Sch. 80 (XS)	12,700	37,500
2" W23-152-17A	Core Spray Pump Suction	X-227A	2" Sch. 80 (XS)	12,700	37,500
1" W23-152-22B	Core Spray Pump Suction	X-227B	1" Sch. 80 (XS)	(2)	
2" W23-152-16B	Core Spray Pump Suction	X-227B	2" Sch. 80 (XS)	12,700	37,500
2" W23-152-17B	Core Spray Pump Suction	X-227B	2" Sch. 80 (XS)	12,700	37,500
1" WD-152-48	HPCI Turbine Exhaust	X-214	1" Sch. 80 (XS)	15,748	36,000
3/4" Drain	RCIC Pump Suction	X-224	3/4" Sch. 80 (XS)	(4)	
3/4" Vent	RCIC Pump Suction	X-224	3/4" Sch. 80 (XS)	(4)	
3/4" Drain	RCIC Pump Suction	X-224	3/4" Sch. 80 (XS)	(3)	
2" W22-152-11	RCIC Pump Suction	X-224	2" Sch. 80 (XS)	(3)	
1" W20-302-110	RCIC Pump Suction	X-224	1" Sch. 80 (XS)	(1)	
1½" Drain	RHR Pump Suction	X-225A	1½" Sch. 80 (XS)	(2)	

TABLE 3-3 (CONTINUED)

FITZPATRICK

BRANCH LINE PIPE STRESSES

Branch Line Designation	TAP System	TAP Penetration	Branch Line Dia./Sch.	Maximum Stress	Allowable Stress
1½" Drain	RHR Pump Suction	X-225B	1½" Sch. 80 (XS)	(2)	
1½" W20-152-46B	RHR Pump Suction	X-225B	1½" Sch. 80 (XS)	8,840	36,000
1½" W20-152-124B	RHR Pump Suction	X-225B	1½" Sch. 80 (XS)	(3)	
1" W20-152-45B	RHR Pump Suction	X-225B	1" Sch. 80 (XS)	6,200	36,000
4" W20-152-41B	RHR Discharge	X-210B & X-211B	4" Sch. 40 (Std)	6,572	36,000
4" W20-302-19B	RHR Discharge	X-210B & X-211B	4" Sch. 40 (Std)	31,482	36,000
3" W23-152-7B	RHR Discharge	X-210B & X-211B	3" Sch. 40 (Std)	7,147	36,000
1" W23-302-29B	RHR Discharge	X-210B & X-211B	1" Sch. 80 (XS)	2,317	27,000
3" W23-302-6B	RHR Discharge	X-210B & X-211B	3" Sch. 40 (Std)	(1)	
4" W20-302-35	RHR Discharge	X-210B & X-211B	4" Sch. 40 (Std)	12,761	18,000
1½" AS-302-55B	RHR Discharge	X-210B & X-211B	1½" Sch. 80 (XS)	2,543	27,000
2" AS-302-55B	RHR Discharge	X-210B & X-211B	2" Sch. 80 (XS)	20,132	27,000
1½" SLP-152-51	RCIC Turbine Exhaust	X-212	1½" Sch. 80 (XS)	4,392	27,000
1" SLP-152-25	RCIC Turbine Exhaust	X-212	1" Sch. 80 (XS)	(4)	
2" SLP-152-49	HPCI Turbine Exhaust	X-214	2" Sch. 80 (XS)	4,006	27,000

TABLE 3-3 (CONTINUED)

FITZPATRICK

BRANCH LINE PIPE STRESSES

Branch Line Designation	TAP System	TAP Penetration	Branch Line Dia./Sch.	Maximum Stress	Allowable Stress
4" W20-152-41A	RHR Discharge	X-210A & X-211A	4" Sch. 40 (Std)	6,572	36,000
3" W22-152-16	RHR Discharge	X-210A & X-211A	3" Sch. 40 (Std)	499	27,000
2" W22-152-15	RHR Discharge	X-210A & X-211A	2" Sch. 80 (XS)	11,976	27,000
4" W20-152-40A	RHR Discharge	X-210A & X-211A	4" Sch. 40 (Std)	32,110	36,000
3" W23-152-7A	RHR Discharge	X-210A & X-211A	3" Sch. 40 (Std)	7,147	36,000
1½" W23-302-10A	RHR Discharge	X-210A & X-211A	1½" Sch. 80 (XS)	12,700	37,500
1" W23-302-29A	RHR Discharge	X-210A & X-211A	1" Sch. 80 (XS)	3,586	18,000
3" W23-302-6A	RHR Discharge	X-210A & X-211A	3" Sch. 40 (Std)	(1)	
4" WLP-302-123	RHR Discharge	X-210A & X-211A	4" Sch. 40 (Std)	15,491	18,000
2" AS-302-55A	RHR Discharge	X-210A & X-211A	2" Sch. 80 (XS)	20,122	27,000
4" W25-152-16	RHR Discharge	X-210B & X-211B	4" Sch. 40 (Std)	33,750	36,000
1 1/2" AS-302-55A	RHR Discharge	X-210B & X-211B	1 1/2" Sch. 80 (XS)	2,543	27,000
1 1/2" W23-302-10B	RHR Discharge	X-210B & X-211B	1 1/2" Sch. 80 (XS)	12,700	37,500

Notes: (1) Beyond Scope of Mark I Analysis.
(2) Piping Frequency greater than 50 Hz.
(3) Total combined displacement of less than 1/16" at branch line connection.
(4) Mark I stresses at branch line connection are less than 10% of allowable.

TABLE 3-4

FITZPATRICK

PUMP AND VALVE EVALUATION

Component Designation	Component Type	TAP System	TAP Penetration	Max. Pipe Stress at Component	Allowable Pipe Stress
VB-1	Valve	Primary Cont. Vacuum Brkr. Pip.	X-202A,F	11,771	18,000
VGW-15A	Gate Valve	Condensate Drain Line	X-228	8,927	18,000
VGW-15AN	Gate Valve	Steam Line & Vent From RCIC Pump	X-212	14,575	18,000
VCW-15AN	Check Valve			14,320	18,000
VCW-15AN	Check Valve			16,799	18,000
13-TU-12	RCIC Turbine			8,680	18,000
MOV-7B	Mtr. Oper. Valve	Core Spray Pump Suction (East Lead)	X-227B	4,097	18,000
14P-1B	Core Spray Pump			15,190	18,000
VGW-15AN	Gate Valve			2,965	18,000
3" Globe Valve	Globe Valve	Drain Line	X-213A/B	10,796	18,000
1" Globe Valve	Globe Valve			1,459	18,000
27AOV-117	Air Oper. Valve	Air Piping	X-205	13,483	18,000
270AOV-118	Air Oper. Valve			12,537	18,000
VB-2	Valve	Primary Cont. Vacuum Breaker Piping	X-202B,G	13,294	18,000
AOV-101A	Air Oper. Valve			3,444	18,000
AOV-101B	Air Oper. Valve			3,471	8,000
VB-6	Valve			1,163	1[illegible],000
VB-7	Valve			1,171	18,000
VGW-15AN	Gate Valve	Steam Line & Vent HPCI Pump	X-214	11,587	18,000
VCW-15AN	Check Valve			10,488	18,000
VCW-15AN	Check Valve			9,870	18,000
23TU-2	HPCI Turbine			664	18,000

TELEDYNE ENGINEERING SERVICES

TABLE 3-4 (CONTINUED)

FITZPATRICK

PUMP AND VALVE EVALUATION

Component Designation	Component Type	TAP System	TAP Penetration	Max. Pipe Stress at Component	Allowable Pipe Stress
MOV-151A	Mtr. Oper. Valve	RHR Piping	X-225A	7,611	18,000
MOV-13A	Mtr. Oper. Valve			6,031	18,000
MOV-15A	Mtr. Oper. Valve			4,555	18,000
MOV-13C	Mtr. Oper. Valve			8,038	18,000
MOV-15C	Mtr. Oper. Valve			4,223	18,000
10P-3C	Pump			11,929	18,000
10P-3A	Pump			11,720	18,000
27AOV-116	Air Oper. Valve	Air Cooling	X-220	5,726	18,000
27AOV-115	Air Oper. Valve			6,158	18,000
MOV-58	Mtr. Oper. Valve	HPCI Piping	X-226	10,647	18,000
VCW-15AN	Check Valve			3,266	18,000
MOV-57	Mtr. Oper. Valve			4,186	18,000
23P-1	Booster Pump			13,453	18,000
MOV-17	Mtr. Oper. Valve			8,279	18,000
VCW-15AN	Check Valve			4,376	18,000
MOV-41	Mtr. Oper. Valve	Suction Line to RCIC Pump	X-224	13,308	18,000
VCW-15AN	Check Valve			3,863	18,000
MOV-39	Mtr. Oper. Valve			6,824	18,000
VGW-15AN	Gate Valve			5,171	18,000
13P-1	RCIC Pump			3,351	18,000
VCW-15AN	Check Valve			2,806	18,000
MOV-18	Mtr. Oper. Valve			2,872	18,000
MOV-36	Mtr. Oper. Valve			79*	18,000
AOV-71A	Air Oper. Valve			5*	18,000
MOV-21A	Mtr. Oper. Valve			14*	18,000

*Mark 1 dynamic stress only - values remote from torus - wt, thermal, & seismic not available

TABLE 3-4 (CONTINUED)

FITZPATRICK

PUMP AND VALVE EVALUATION

Component Designation	Component Type	TAP System	TAP Penetration	Max. Pipe Stress at Component	Allowable Pipe Stress
MOV-151B	Mtr. Oper. Valve	RHR Piping	X-225B	8,498	18,000
MOV-13B	Mtr. Oper. Valve			12,663	18,000
10P-3B	Pump Suction			11,423	18,000
MOV-13D	Mtr. Oper. Valve			8,798	18,000
10P-3D	Pump Suction			8,824	18,000
MOV-15D	Mtr. Oper. Valve			5,167	18,000
MOV-15B	Mtr. Oper. Valve			7,871	18,000
MOV-34A	Mtr. Oper. Valve	RHR Discharge	X-210A/	9,400	18,000
MOV-39A	Mtr. Oper. Valve	Spray Header	X-211A	7,190	18,000
MOV-26A	Mtr. Oper. Valve			6,935	18,000
VCW-30AN	Check Valve			5,136	18,000
14P-1A	Core Spray Pump			6,281	18,000
MOV-27A	Mtr. Oper. Valve			11,162	18,000
MOV-25A	Mtr. Oper. Valve			9,695	18,000
MOV-38A	Mtr. Oper. Valve			2,719	18,000
MOV-34B	Mtr. Oper. Valve	RHR Discharge	X-210B/	13,263	18,000
MOV-39B	Mtr. Oper. Valve	Spray Header	X-211B	6,636	18,000
MOV-26B	Mtr. Oper. Valve			12,308	18,000
12" Valve	Check Valve			5,136	18,000
14P-1B	Core Spray Pump			6,281	18,000
MOV-26B	Mtr. Oper. Valve			5,096	18,000
MOV-31B	Mtr. Oper. Valve			7,827	18,000
MOV-27B	Mtr. Oper. Valve			10,168	18,000
MOV-25B	Mtr. Oper. Valve			14,880	18,000
MOV-38B	Mtr. Oper. Valve			1,332	18,000
MOV-7A	Mtr. Oper. Valve	Core Spray	X-227A	5,747	18,000
14P-1A	Core Spray Pump	Pump Suction		13,163	18,000
VGW-15AN	Gate Valve	(West Lead)		3,214	18,000
VCW-15AN	Check Valve			2,759	18,000

TABLE 3-5

TAP PIPE SUPPORTS

Pipe System Penetration	Node	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
210B/	240	H10-52A	Rigid		X	
211B	190	PFSK-1949	Snubber		X	
	210	PFSK-1953	Snubber		X	
	715	PFSK-1956	Rigid	X		Support Reinforced
	75	PFSK-2074	Rigid	X		Clips Added
	245	PFSK-2107	Snubber		X	
	780	PFSK-2220	Rigid		X	
	775	PFSK-2225	Rigid		X	
	440	PFSK-2265	Snubber		X	
	445	PFSK-2392	Snubber		X	
	105	PFSK-2437	Rigid	X		Support Redesigned
	755	PFSK-2457	Rigid		X	
	160	PFSK-2477	Snubber		X	
	720	PFSK-2487	Rigid		X	
	306	PFSK-2534	Snubber		X	
	251	PFSK-2558	Snubber		X	
	308	PFSK-2535	Snubber		X	
	175	PFSK-2570	Rigid		X	
	205	PFSK-2573	Rigid	X		Clips Added
	156	PFSK-2042	Snubber		X	
	133/126	PFSK-2047	Snubber		X	
	337	PFSK-2052	Rigid		X	
	605	PFSK-2161	Rigid		X	
	607	PFSK-2582	Rigid		X	
	610	PFSK-2597	Rigid		X	
	616	PFSK-2548	Rigid		X	
	640	PFSK-2397	Anchor		X	
	275	PFSK-2434	Rigid		X	

TABLE 3-5 (CONTINUED)

TAP PIPE SUPPORTS

Pipe System Penetration	Node	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
X-225A	107	PFSK-2404	Spring		X	
	80	PFSK-2470 (D.P. 80)	Y Rigid	X		Support Redesigned
	83	PFSK-2471 (D.P. 83)	Snubber	X		Support Reinforced
	330	PFSK-2513	Spring		X	
	325	PFSK-2560	Rigid		X	
	81	PFSK-2237	Snubber		X	
	245	H10-7	Spring		X	
	275	H10-7A	Spring		X	
	145	H10-8	Spring		X	
	400	H10-13A	Spring		X	
	300	PFSK-624	Spring		X	
	370	PFSK-1855	Spring		X	
	358	PFSK-1971	Snubber	X		Support Redesigned
	415	PFSK-2053	Rigid	X		Support Redesigned
	390	PFSK-2084	Rigid		X	
	335	PFSK-2110	Rigid		X	
	355	PFSK-2129	Snubber	X		Baseplate Stiffened
	50	PFSK-2238	Rigid	X		Support Redesigned
	372	PFSK-2285	Rigid	X		Shim Plate Added
	81	PFSK-2337	Snubber		X	
	420	PFSK-2387	Anchor		X	
X-225B	450	H10-15			X	
	415	H10-16	Rigid	X		Rod Replaced With Struts
	320	H10-21A	Spring		X	
	145	H10-23	Spring		X	
	290	H10-22	Spring		X	
	570	PFSK-770	Rigid		X	
	650	PFSK-1003	Spring		X	
	535	PFSK-1005	Spring		X	
	725	PFSK-2302	Anchor		X	

TABLE 3-5 (CONTINUED)

TAP PIPE SUPPORTS

Pipe System Penetration	Node	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
X-225B (continued)	85	PFSK-1854	Spring		X	
	615	PFSK-1923	Rigid		X	
	675	PFSK-1934	Rigid		X	
	98	PFSK-1936	Snubber	X		Snubber Replaced by Greater Capacity Snubber
	715	PFSK-1982	Rigid		X	
	95	PFSK-2009	Rigid	X		Rigid Support Replaced by Strut
	365	PFSK 941	Rigid		X	
	360	PFSK-2020	Spring		X	
	96	PFSK-2072	Snubber	X		Replace Base Plate and Anchor Bolts
	380	PFSK-2077	Spring		X	
	480	PFSK-2078	Rigid		X	
	386	PFSK-2112	Snubber			
	435	PFSK-2134	Spring		X	
	590	PFSK-2149	Spring		X	
	530/532	PFSK-2187	Rigid		X	
	488	PFSK-2260	Rigid		X	
	695	PFSK-2281	Rigid		X	
	500	PFSK-2387	Anchor		X	
	575	PFSK-2456	Snubber		X	
	585	PFSK-2468	Rigid		X	
	690	PFSK-2489	Rigid		X	
	385	PFSK-2567	Snubber	X		Support Redesigned
	65	PFSK-2270	Rigid	X		Support Redesigned
X-210A/211A	345	PFSK-2343	Snubber		X	
	625	PFSK-2398	Rigid		X	
	250	PFSK-2446	Snubber		X	
	655	PFSK-2449	Rigid		X	
	181	PFSK-2502	Snubber		X	
	340	PFSK-2509	Snubber	X		Snubber Replaced by Greater Capacity Snubber

TABLE 3-5 (CONTINUED)

TAP PIPE SUPPORTS

Pipe System Penetration	Node	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
X-210A/211A (continued)	685	PFSK-2518	Snubber		X	
	485	PFSK-2000	Spring		X	
	265	PFSK-2327	Rigid		X	
	269	PFSK-2317	Rigid		X	
	210	PFSK-1947	Rigid		X	
	135	PFSK-1952	Snubber		X	
	130/132	PFSK-1984	Snubber		X	
	185	PFSK-2079	Snubber		X	
	65	PFSK-2085	Rigid	X		Support Reinforced, Clips Added
	85	PFSK-2128	Rigid		X	
	170	H10-42A	Rigid		X	
	970	H10-47	Spring		X	
	615	H10-388	Snubber		X	
	800	H10-397	Spring		X	
	255	PFSK-878	Snubber		X	
	190	PFSK-944	Rigid		X	
	680	PFSK-1641	Rigid		X	
	875	PFSK-1902	Spring		X	
	126/127	PFSK-1940	Snubber		X	
	120/121	PFSK-1944	Snubber		X	
	695	PFSK-2310	Rigid		X	
	285	PFSK-2354	Anchor		X	
X-202A,F	30	H27-8	Spring		X	
X-202B,G	115	PFSK-2463	Rigid	X		Stanchion Changed to Struts
	120	PFSK-2280	Rigid	X		Stanchion Changed to Struts
	30	PFSK-1951	Rigid	X		Support Redesigned
	110	PFSK-2506	Rigid		X	

TABLE 3-5 (CONTINUED)

TAP PIPE SUPPORTS

Pipe System Penetration	Node	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
X-205	135	BFSK-519	Spring		X	
	25	BFSK-695	Rigid	X		Removal
	90	BFSK-711	Rigid		X	
	40	BFSK-982	Rigid	X		Support Redesigned
	5	BFSK-/15	Anchor		X	
	25	BFSK-696	Rigid	X		Spacers Added
X-212	255	PFSK-1914	Rigid	X		Support Redesigned
	45	PFSk-1919	Snubber	X		Support Redesigned
	45	PFSK-1921	Snubber	X		Support Redesigned
	47	PFSK-1049	Spring		X	
	26	PFSK-1963	Rigid			
	215	PFSK-2384	Rigid		X	
	225	PFSK-2385	Rigid	X		Support Reinforced
X-213A	15	New TES Support 8332	Rigid	X		Support Redesigned
X-213B	15	New TES Support 8333	Rigid	X		Support Redesigned
X-214	205	H23-1	Spring		X	
	190	PFSK-1955	Rigid		X	
	180	PFSK-1958	Rigid		X	
	115	PFSK-1987	Rigid	X		Support Redesigned
	190	PFSK-2223	Rigid	X		Support Redesigned
	90	PFSK-2247	Snubber	X		Snubber Replaced
	75	PFSK-2494	Rigid	X		Rod Replaced By Strut
X-220	110	BFSK-877	Anchor	X		Support Redesigned
	60	New TES Support 8362	Lateral Snubber	X		New Support Added
	62	New TES Support 8362	Axial Rigid	X		New Support Added

TABLE 3-5 (CONTINUED)

TAP PIPE SUPPORTS

Pipe System Penetration	Node	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
X-224	45	PFSK-840	Rigid		X	
	590	PFSK-1055	Rigid		X	
	152	PFSK-2101	Rigid		X	
	315	PFSK-2164	Rigid		X	
	58	PFSK-2218	Rigid		X	
	25	PFSK-2237	Rigid		X	
	550	PFSK-2381	Rigid		X	
	360	PFSK-2383	Rigid		X	
	660	PFSK-2465	Rigid		X	
	177	PFSK-2467	Rigid	X		Support Made Double-Acting
	183	PFSK-2473	Rigid	X		Support Made Double-Acting
	325	PFSK-2481	Anchor		X	
	295	PFSK-2538	Rigid		X	
	635	PFSK-2546	Rigid		X	
	395	H10-66A	Rigid		X	
	405	H10-66B	Rigid		X	
	153	H13-3	Rigid		X	
	134	H13-4	Spring		X	
	92	H13-19A	Rigid		X	
	74	H13-20	Rigid		X	
	52	H13-21	Spring		X	
	172	H13-48	Rigid		X	
X-226	310	PFSK-1950	Rigid		X	
	485	PFSK-1959	Rigid		X	
	465	PFSK-1995	Rigid		X	
	455	PFSK-2118	Rigid		X	
	305	PFSK-2242	Snubber		X	
	106	PFSK-2248	Snubber	X		Support Redesigned
	65	PFSK-2305	Rigid	X		Rod Hanger Changed to Strut
	300	PFSK-2500	Snubber		X	
	165	H23-30	Spring		X	
	255	H23-31	Spring		X	
	330	H23-33	Rigid		X	

TABLE 3-5 (CONTINUED)

TAP PIPE SUPPORTS

Pipe System Penetration	Node	Support Designation	Type of Support	Modified Yes	Modified No	Type of Modification
X-226 (continued)	350	H23-34	Rigid		X	
	350	H23-35	Rigid		X	
	375	H23-36	Rigid		X	
	400	H23-37	Rigid		X	
	100	PFSK-983	Rigid		X	
	106	H23-89	Snubber	X		Support Redesigned
X-227A	115	PFSK-2028	Spring		X	
	250	PFSK-2122	Rigid	X		Support Redesigned
	295	PFSK-2325	Anchor	X		Stanchion Replaced by a Smaller Stanchion
	350	PFSK-2394	Rigid	X		Support Redesigned
	90	PFSK-2418	Rigid	X		Support Redesigned
	280	PFSK-2508	Rigid		X	
	45	PFSK-2511	Rigid	X		Support Redesigned
	215	H14-8	Spring		X	
	345	H14-28	Rigid	X		Rod Replaced by Strut
	67	H14-40	Spring		X	
X-227B	275	PFSK-2323	Rigid		X	
	250	PFSK-2324	Rigid		X	
	102	PFSK-2454	Rigid	X		Stanchion Changed to Strut
	50	PFSK-2512	Rigid	X		Support Redesigned
	300	PFSK-1994	Anchor		X	
	220	H14-20	Spring		X	
	125	H14-21	Spring		X	
	75	H14-54	Spring		X	

TABLE 3-6

FITZPATRICK

TAP PENETRATION STRESS RESULTS - LARGE BORE PIPING

Penetration Number	Primary Stress: Calculated Max. Stress	Primary Stress: Allowable	Secondary Stress: Calculated Max. Stress	Secondary Stress: Allowable
X-202A & F	15,715	19,300	34,742	69,900
X-202B & G	16,200	19,300	22,642	69,900
X-205	12,939	19,300	28,646	69,900
X-210A	12,610	19,300	54,034	69,900
X-210B	12,536	19,300	56,616	69,900
X-211A	12,436	15,100	43,986	69,900
X-211B	12,436	15,100	43,986	69,900
X-212	13,728	15,100	45,137	69,900
X-213A & B	11,774	15,100	34,942	69,900
X-214	11,107	19,300	44,266	69,900
X-220	12,934	19,300	46,621	69,900
X-224	13,877	15,100	41,649	69,900
X-225A	13,828	19,300	58,526	69,900
X-225B	18,577	19,300	49,988	69,900
X-226	13,643	19,300	55,407	69,900
X-227A	13,818	19,300	57,105	69,900
X-227B	13,818	19,300	57,105	69,900
X-228	13,481	15,100	56,982	69,900

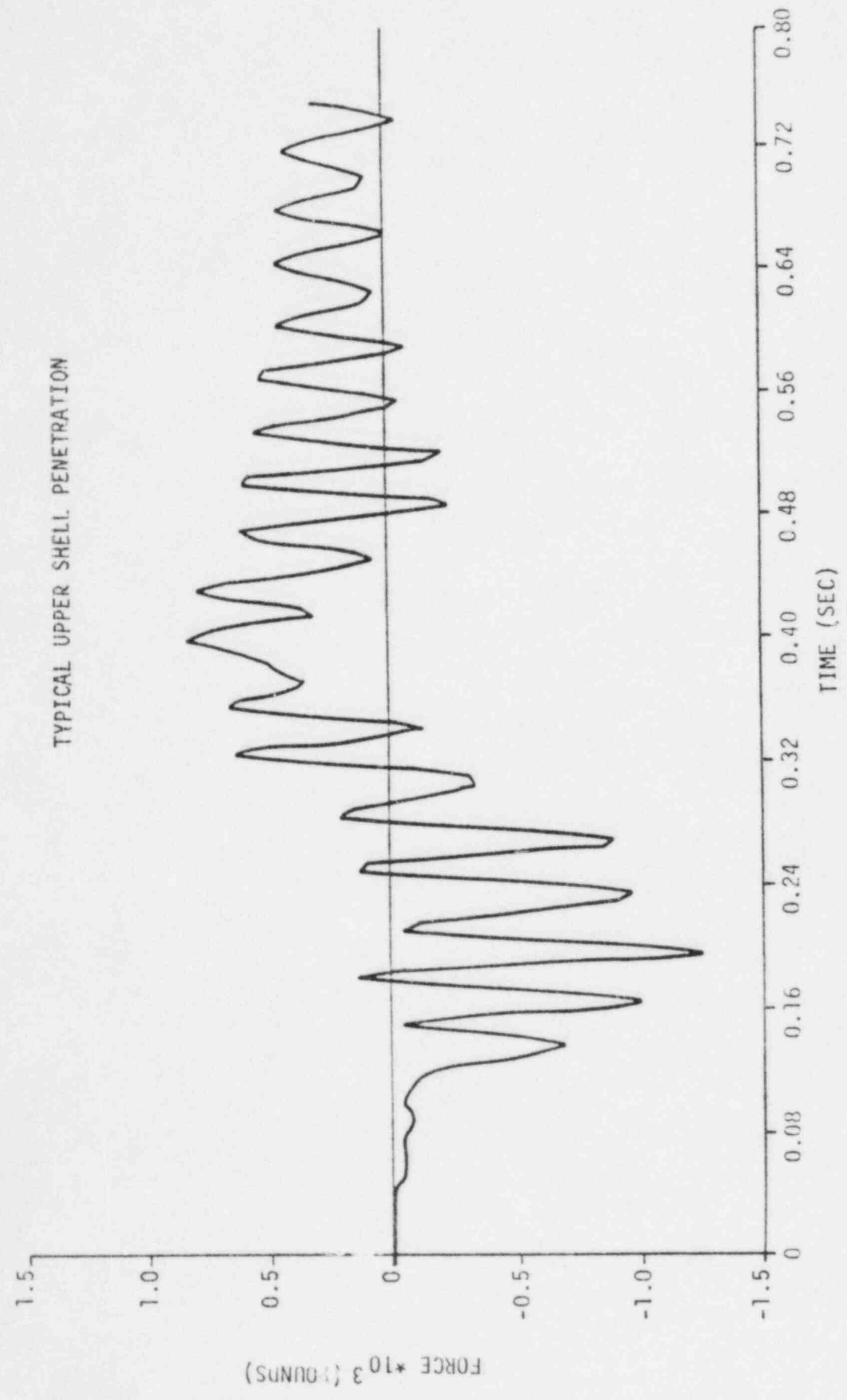


FIGURE 3-1 SHELL RESPONSE FROM POOL SWELL, TYPICAL

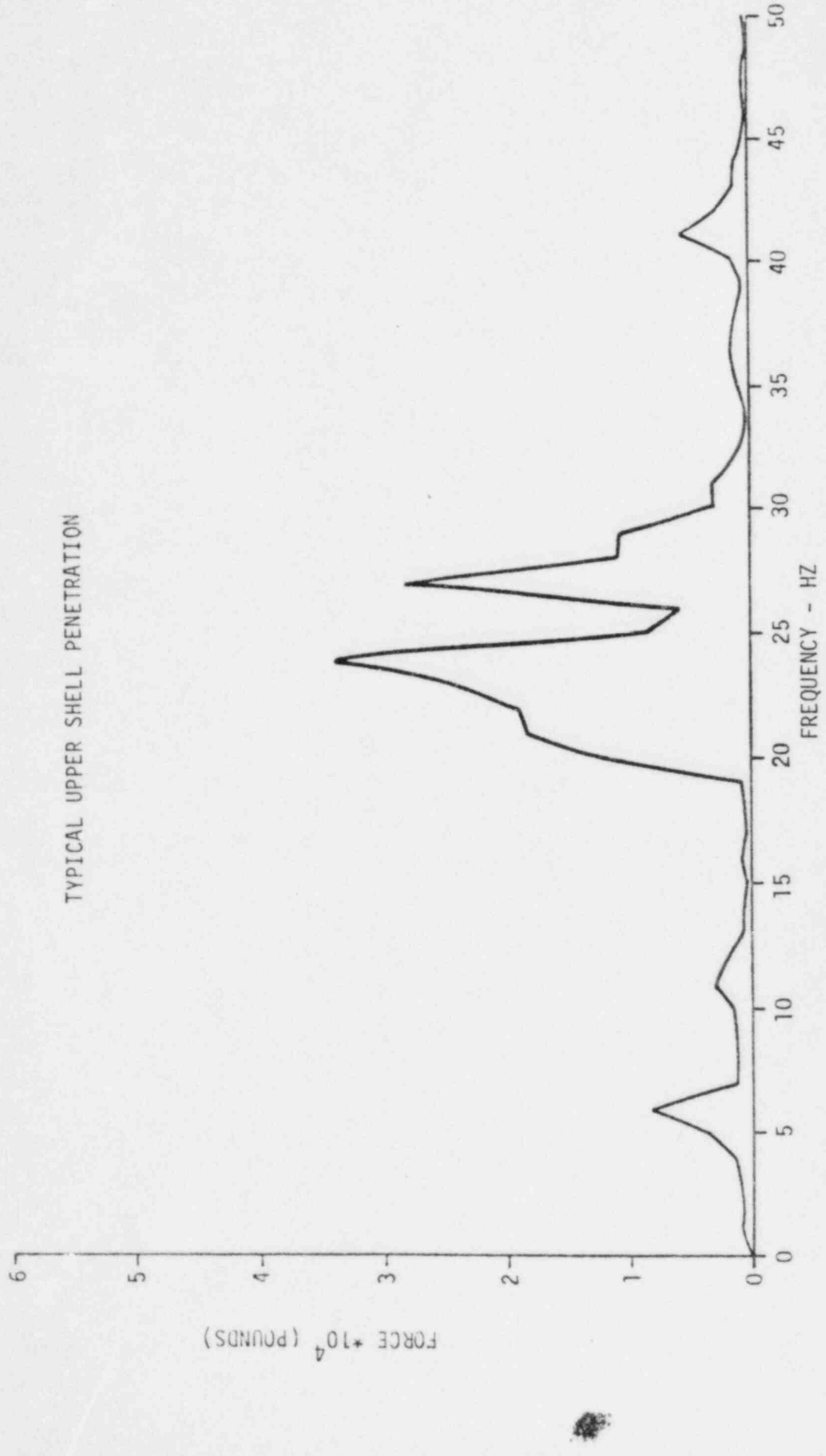


FIGURE 3-2 SHELL RESPONSE FROM CONDENSATION OSCILLATION-TYPICAL

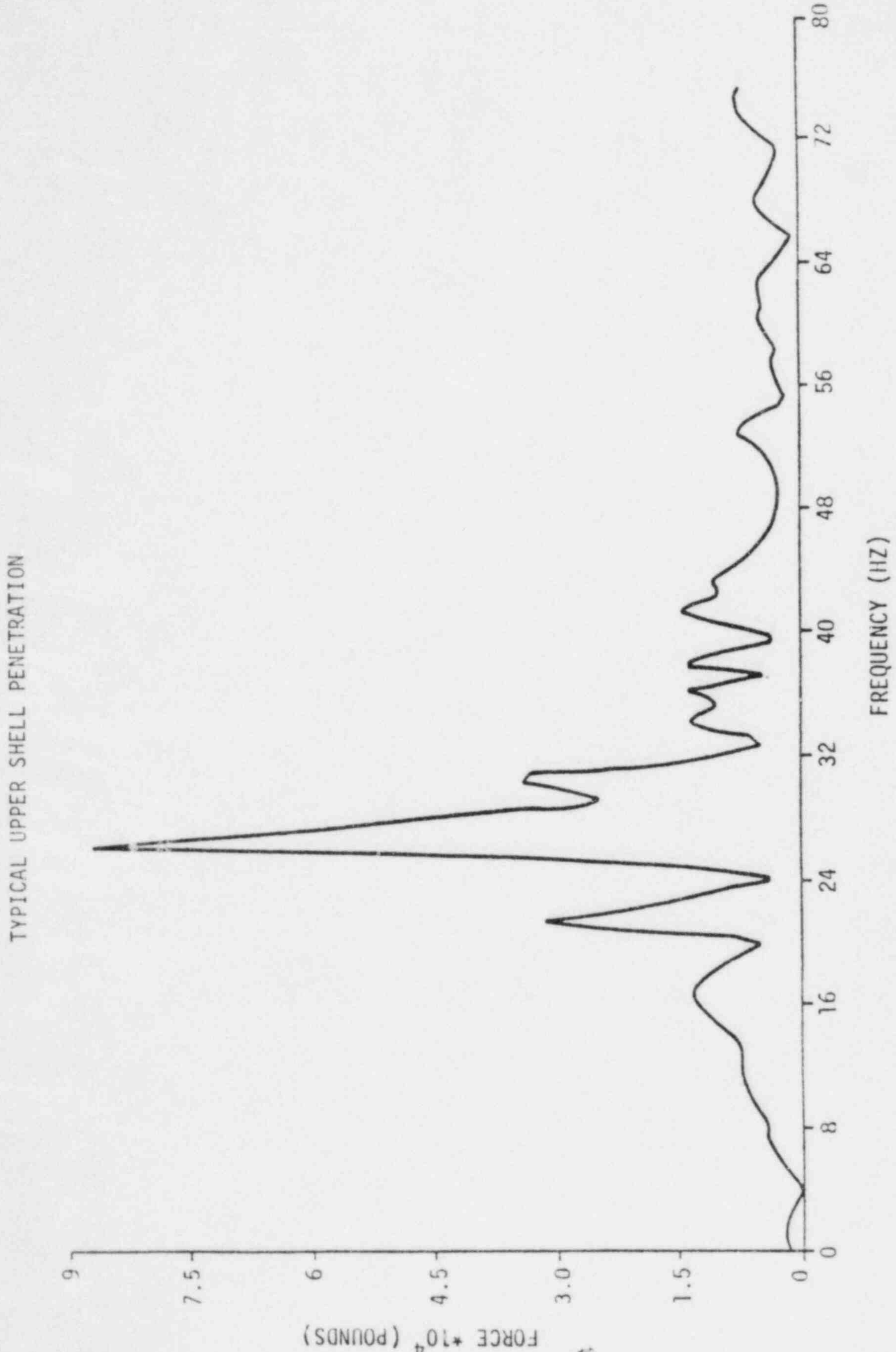


FIGURE 3-3 SHELL RESPONSE FROM SRV-TYPICAL

PENETRATION NO. X-225A & B
CONDENSATION OSCILLATION
AND POST CHUG

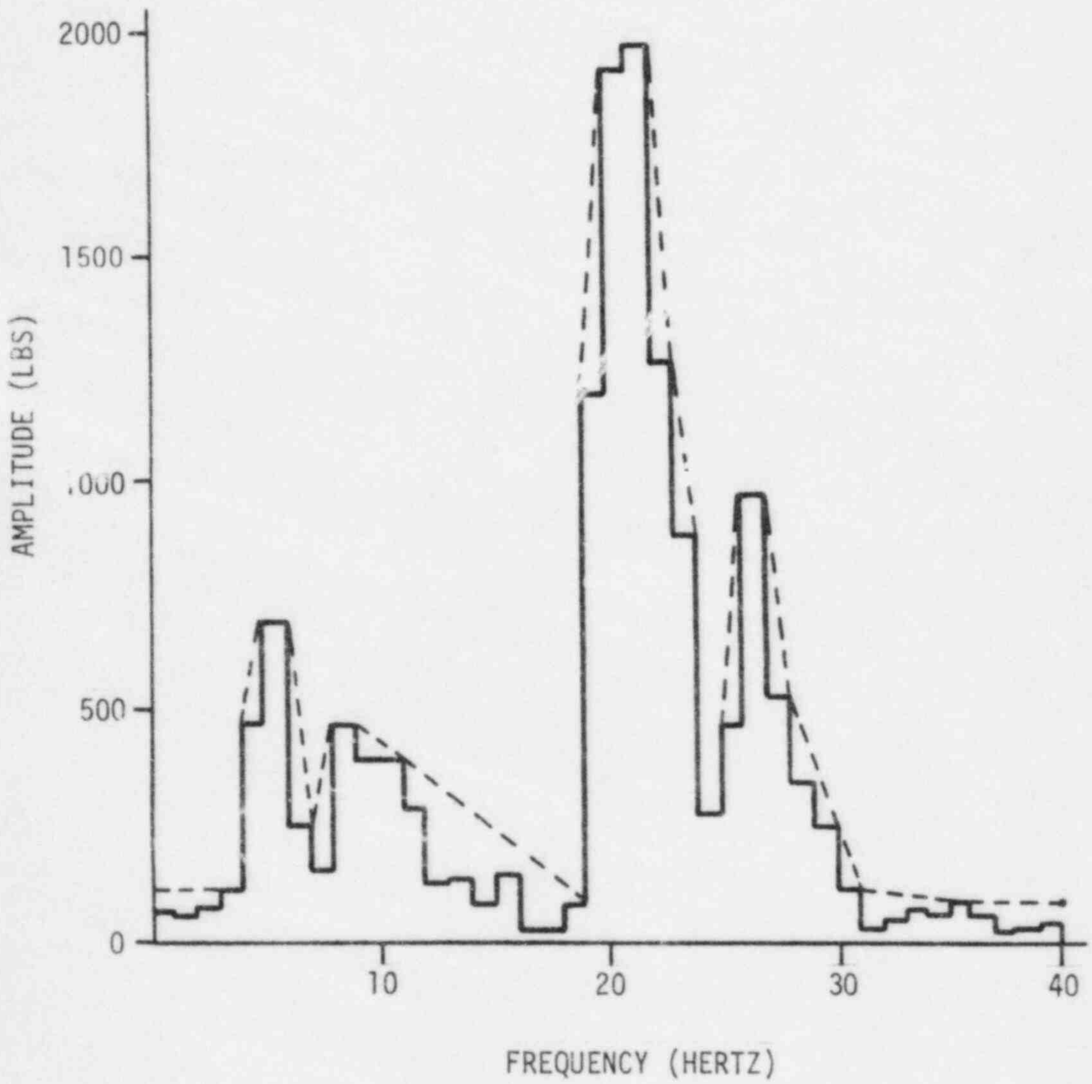


FIGURE 3-4 DRAG LOAD ON INTERNAL PIPING

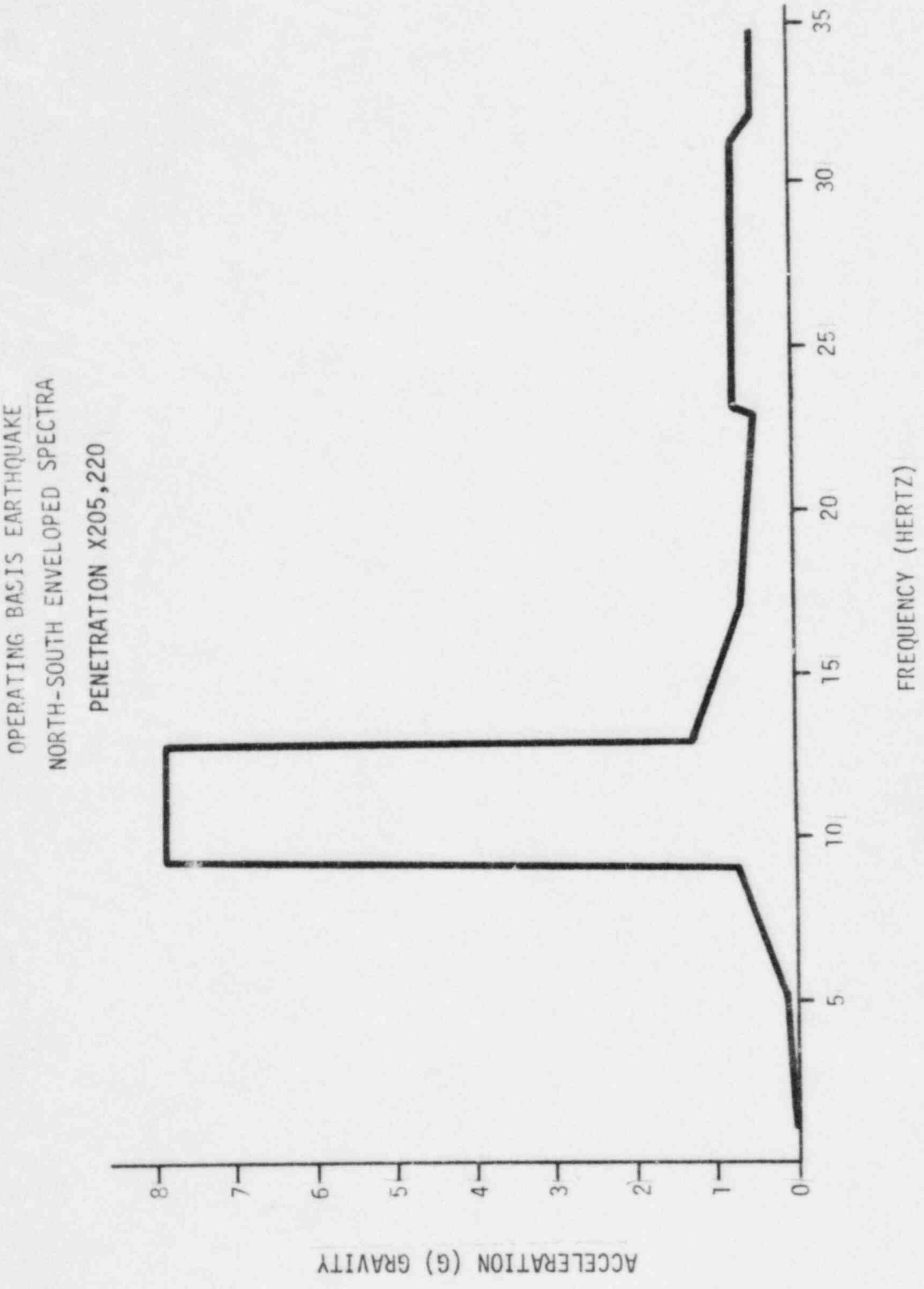


FIGURE 3-5 TAP SEISMIC SPECTRA,TYPICAL

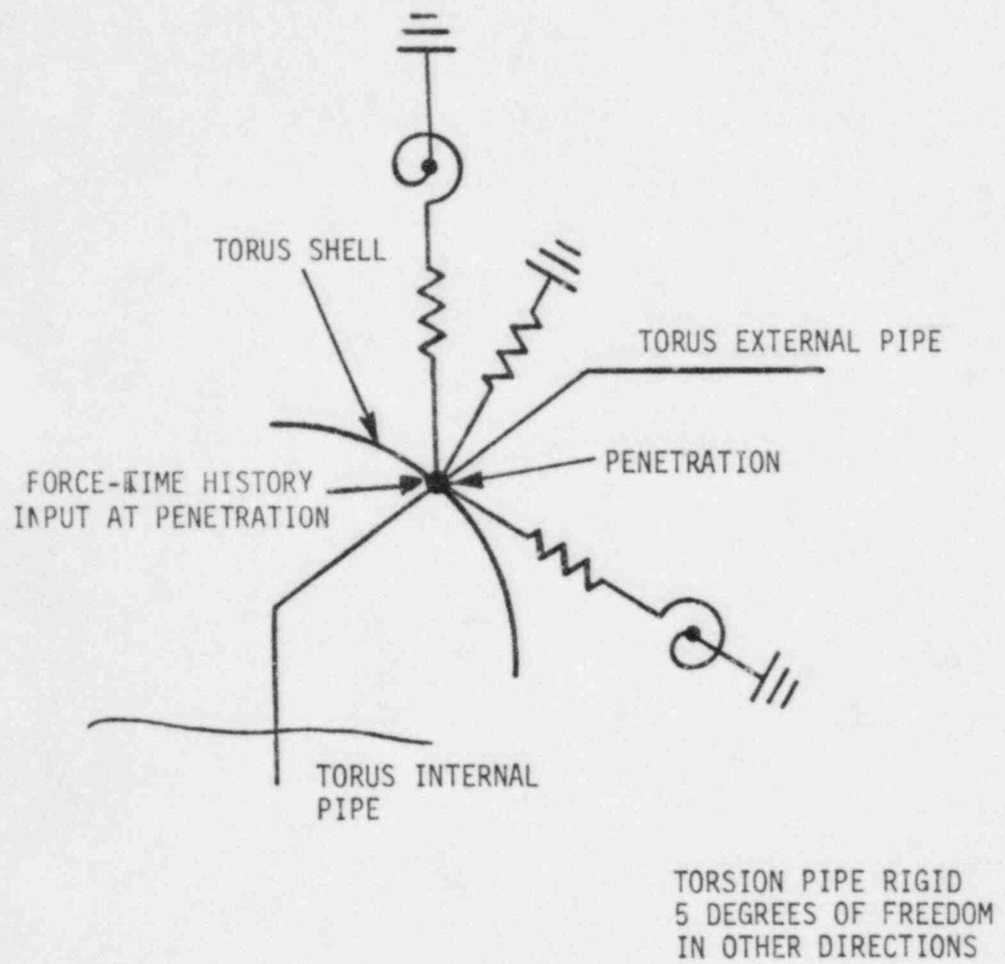
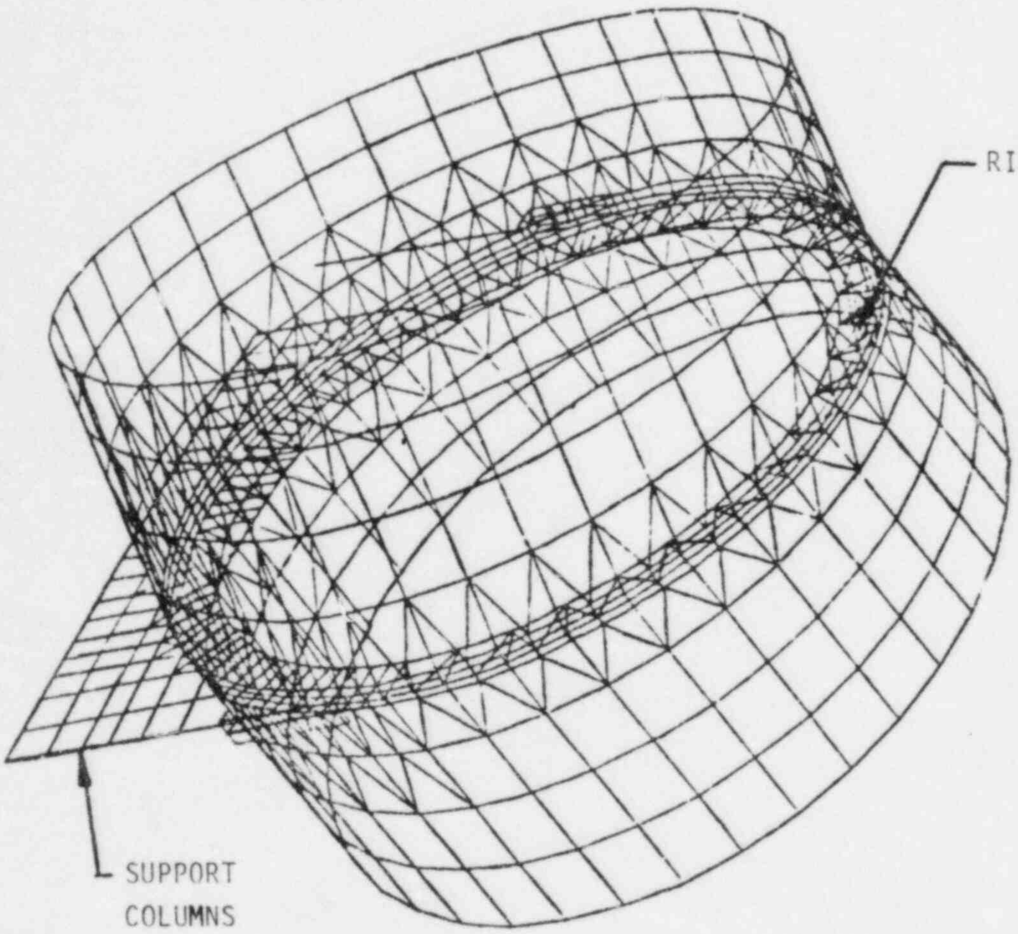
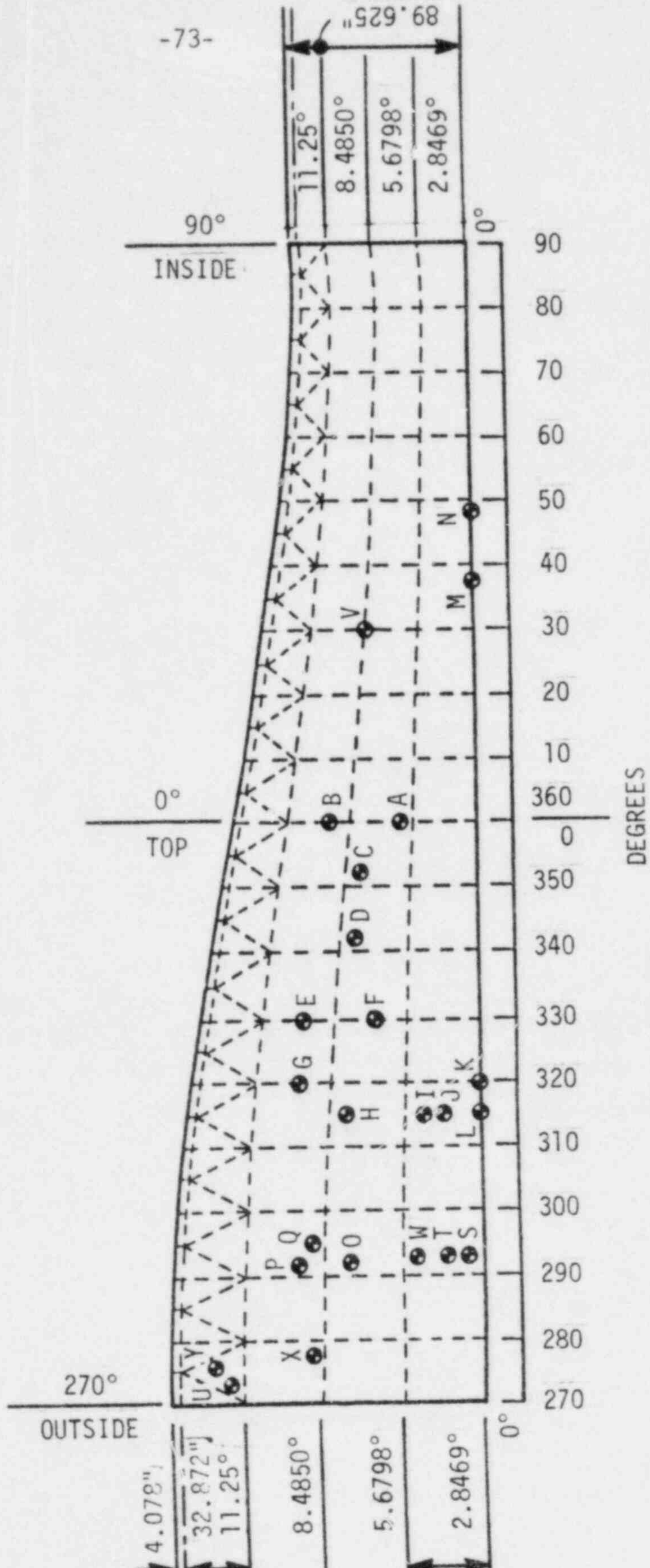


FIGURE 3-6 TAP PENETRATION REPRESENTATION (TYPICAL)



FITZPATRICK NUCLEAR PLANT

FIGURE 3-7 DETAILED SHELL MODEL

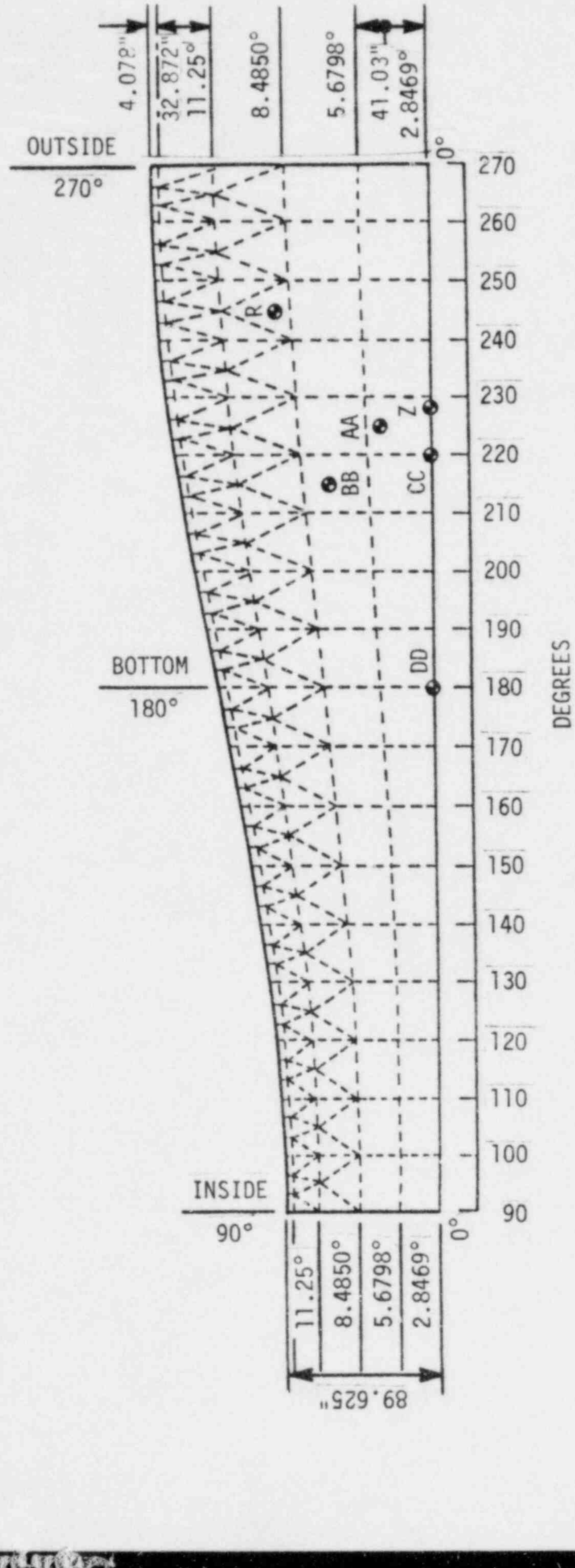


TORUS PENETRATIONS

J.A. FITZPATRICK NUCLEAR PLANT

FIGURE 3-8a TAP PENETRATION LOCATIONS

TORUS PENETRATIONS



J.A. FITZPATRICK NUCLEAR PLANT

FIGURE 3-8b TAP PENETRATION LOCATIONS

TORUS PENETRATIONS

NODE NO.	LOCATION	PENETRATION NO.	ANGLE
37	A	x220	0.00°
73	B	x205	0.00°
108	C	x202a-e	352.20°
107	D	x211a-b	340.20°
106	E	x218	330.00°
106	F	x219	330.00°
159	G	x200b	320.15°
104	H	x212	315.00°
68	I	x210a-b	315.00°
33	J	x228	315.00°
--	L	x200c	317.30°
--	M	x200a	37.60°
--	N	x201a-h	49.20°
--	O	x203a	293.00°
--	P	x203b	293.00°
--	Q	x206a/c	295.00°
--	R	206/	245.00°
--	S	x209a/c	293.00°
--	T	x209b/d	293.00°
154	U	214	273.90°
--	V	x216,x217	30.00°
--	W	x215	293.00°
101	X	x221	276.20°
155	Y	x222	276.20°
24	Z	x226	227.00°
59	AA	x225a-b	223.50°
94	BB	x224	215.00°
23	CC	x227a-b	220.00°
19	DD	x213a-b	180.00°
--	K	x231a-b	320.00°

FIGURE 3-8c TAP PENETRATION LOCATIONS

REFERENCES

1. TES Report TR-5321-1, "Mark 1 Containment Program, Plant Unique Analysis of the Torus Suppression Chamber for James A. FitzPatrick Nuclear Power Plant", dated August 11, 1983.

2. ASME B&PV Code, Section III, Division 1, through Summer 1977.

3. USNRC IE Bulletin 79-02, dated November 8, 1979, (Revision 2), Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts.

4. ASME B&PV Code, Section XI, 1977 Edition, with 1978 Addenda.

5. G.E. Report NEDO-24583-1, "Mark 1 Containment Program Structural Acceptance Criteria Plant Unique Analysis Application Guide", dated October, 1979.

6. Structural Mechanics Report SMA-12101.05-R001, "Design Approach for FSTF Data for Combining Harmonic Amplitudes for Mark 1 Post-Chug Response Calculations", dated May, 1982.

7. General Electric Computer Program RVFOR-04, A Program to Compute SRV Line Clearing Forces, General Electric Company, San Jose, Calif.

8. Welding Research Council Bulletin No. 107, "Local Stresses in Spherical and Cylindrical Shells due to External Loadings", dated March, 1979.

9. General Electric Report No. MPR-751 "Mark 1 Containment Program, Augmented Class 2/3 Fatigue Evaluation Method and Results for Typical Torus Attached and SRV Piping Analysis", dated November, 1982.

10. G.E. Report NEDO-21888, Rev. 2, "Mark 1 Containment Program Load Definition Report", dated November, 1981.

REFERENCES (CONTINUED)

11. NRC "Safety Evaluation Report, Mark 1 Containment Long-Term Program", NUREG-0661, dated July, 1980.

12. Structural Mechanics Associaties Report SMA-12101.04-R002D "Response Factors Appropriate for use with CO Harmonic Response Combination Design Rules", dated March 1982.

13. NYPA Letter No. JPN-83-46, Transmittal to NRC of Vacuum Breaker Analysis Method, dated May 20, 1983.

14. General Electric Computer Program RVR1Z, A Program to Compute SRV Water Reflood, General Electric Company, San Jose, California.

15. STARDYNE, A general purpose computer program for Structural Analysis, System Developement Corporation, Santa Monica, California.

16. STAAD, A Computer Program for Frame-Structure Analysis, Research Engineers, Cherry Hill, New Jersey.

17. ASME Power Piping Code, ANSI B31.1-1977 edition.

18. USNRC IE Bulletin 79-14, "Seismic Analysis of As-Built Safety-Related Piping Systems", dated July 2, 1979.

Table 1

STRUCTURAL ACCEPTANCE CRITERIA FOR CLASS 2 AND 3 PIPING SYSTEMS

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

NOTES TO TABLE 1

1. Where drywell-to-wetwell pressure differential is normally utilized as a load mitigator, an additional evaluation shall be performed without SRV loadings, but assuming 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 up to and including the first pressure boundary isolation valve is demonstrated, including operability of that valve. If the normal plant operating condition does not employ a drywell-to-wetwell pressure differential, the listed Service Level assignments shall be applicable.

2. Normal loads (N) consist of dead loads (D).

3. As an alternative, the 1.2 S_h limit in Equation 9 of NC-3652.2 may be replaced by Level C (1.8 S_h) provided that all other limits are satisfied. Fatigue requirements are applicable to all columns with the exception of 16, 18, 19, 22, 24 and 25.

4. Footnote 3 applies, except that instead of using Level C (1.8 S_h) in Equation 9 of NC-3652.2, Level D (2.4 S_h) may be used.

5. Equation 10 of NC or ND-3650 shall be satisfied, except that fatigue requirements are not applicable to columns 16, 18, 19, 22, 24 and 25, since pool swell loadings occur only once. In addition, if operability of an active component is required to ensure containment integrity, operability of that component must be demonstrated.

APPENDIX 1

USE OF CO LOAD FOR SMALL BORE PIPING

Experience with large bore piping analysis showed that DBA condensation oscillation was usually the most severe Mark 1 load for torus attached piping. This is consistent with the continuous nature of the CO load (as opposed to the transient nature of some other Mark 1 loads) and the frequency content of CO, which is in a range of typically high piping response.

Experience on large bore piping for the first four plants completed by TES follows:

	No. of Large Bore Systems Available for Evaluation	No. Controlled by CO or Seismic*
FitzPatrick	15	14
Pilgrim	14	11
Millstone	11	9
Vermont Yankee	13	11
	53	45

Of the eight cases not controlled by CO, CO loads were very close to the maximum, as follows:

Ratio of Controlling Stress Case to CO Case

Pilgrim - .999, .953, .958
Millstone - .89, .65(1)
Vermont Yankee - .960, .53(2)
FitzPatrick - .71(3)

---

*Evaluation did not include drag loads on internal piping - small bore systems do not have internal piping.

In five of these eight cases, CO stresses are practically equal to the controlling cases. Of the other three cases (1) and (2) are special cases that do not apply to small bore piping; (3) is also a special case as discussed below.

Case (1) is a atmospheric control (vacuum breaker) line that connects at three points at the top of the torus. The multiple connections and the penetration location make this line particularly susceptible to pool swell impact on the upper shell. There is no comparable small bore system.

Case (2) is an RCIC return line which has a long internal section which is responding at a high level to shell motion. The maximum stress in this line is inside the torus. Small bore systems do not have internal piping, so this does not apply.

Case (3) showed very high seismic stress and was re-supported before Mark 1 loads were applied. Reanalysis produced low stresses for all loads (maximum combined stress was 41% of the allowable). Based on this, we conclude that the evaluation of any similar small bore line would be controlled by seismic, and therefore would be covered by our small bore analysis method.

The decision to limit analysis of small bore piping to DBA CO as the only Mark 1 load was based on the foregoing. Seismic, thermal and weight were also considered, in addition to DBA CO.

APPENDIX 2

32 Hz Cutoff for Condensation Oscillation Analysis

All condensation oscillation response of TAP systems due to torus shell motion used an input frequency cutoff of 32 Hz.

This practice began early in the TAP analysis work and was the result of a decision to cut off shell response frequencies at 32 Hz during the containment analysis. The 32 Hz cutoff for containment analysis is discussed in Appendix 2 of Reference 1, and was based on the fact that both high input energy and high modal responses occurred below that frequency. Use of the 32 Hz cutoff was shown to produce only a small error that was considered negligible. On this same basis, the 32 Hz cutoff was applied to CO analysis for TAP.

Later in the TAP analysis work, it became evident that the 32 Hz cutoff would not be realistic for post chug; input frequencies to 50 Hz were used for post chug. At this time, the decision to cut off CO frequencies at 32 Hz was reviewed. Spectra were generated for several penetrations showing the CO shell motion up to 50 Hz. Figures A4-1, A4-2, A4-3 and A4-4 illustrate typical spectra for rotation and displacement at TAP penetration points for a similar torus, analyzed by TES. These show clearly that shell response above 32 Hz is negligible for CO, and support the initial position.

FIGURE A2-1
DBA CO SHELL RESPONSE-RADIAL
(UNLOADED SHELL-NODE 37)

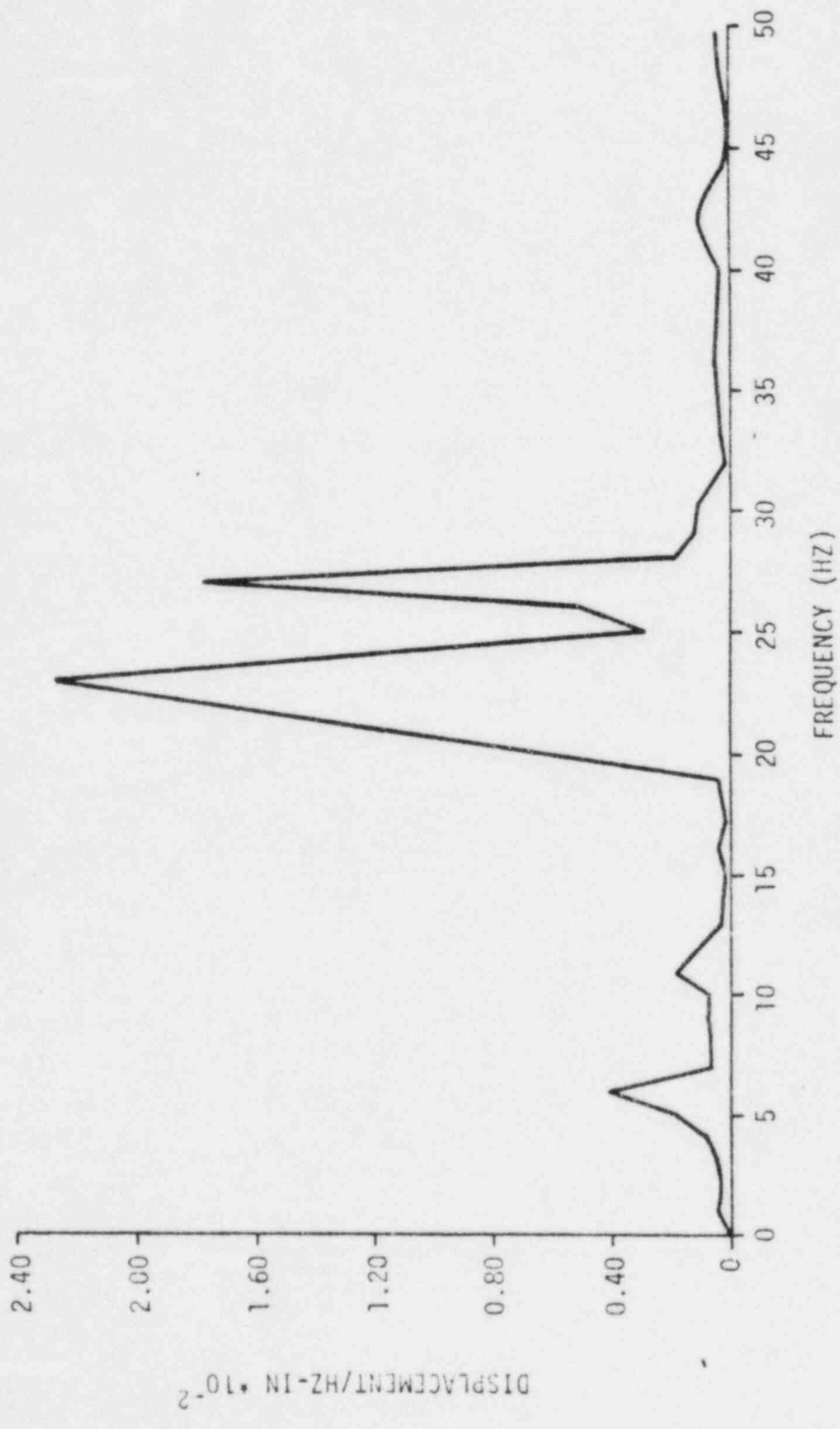


FIGURE A2-2
DBA CO SHELL RESPONSE-ROTATION
(UNLOADED SHELL-NODE 37)

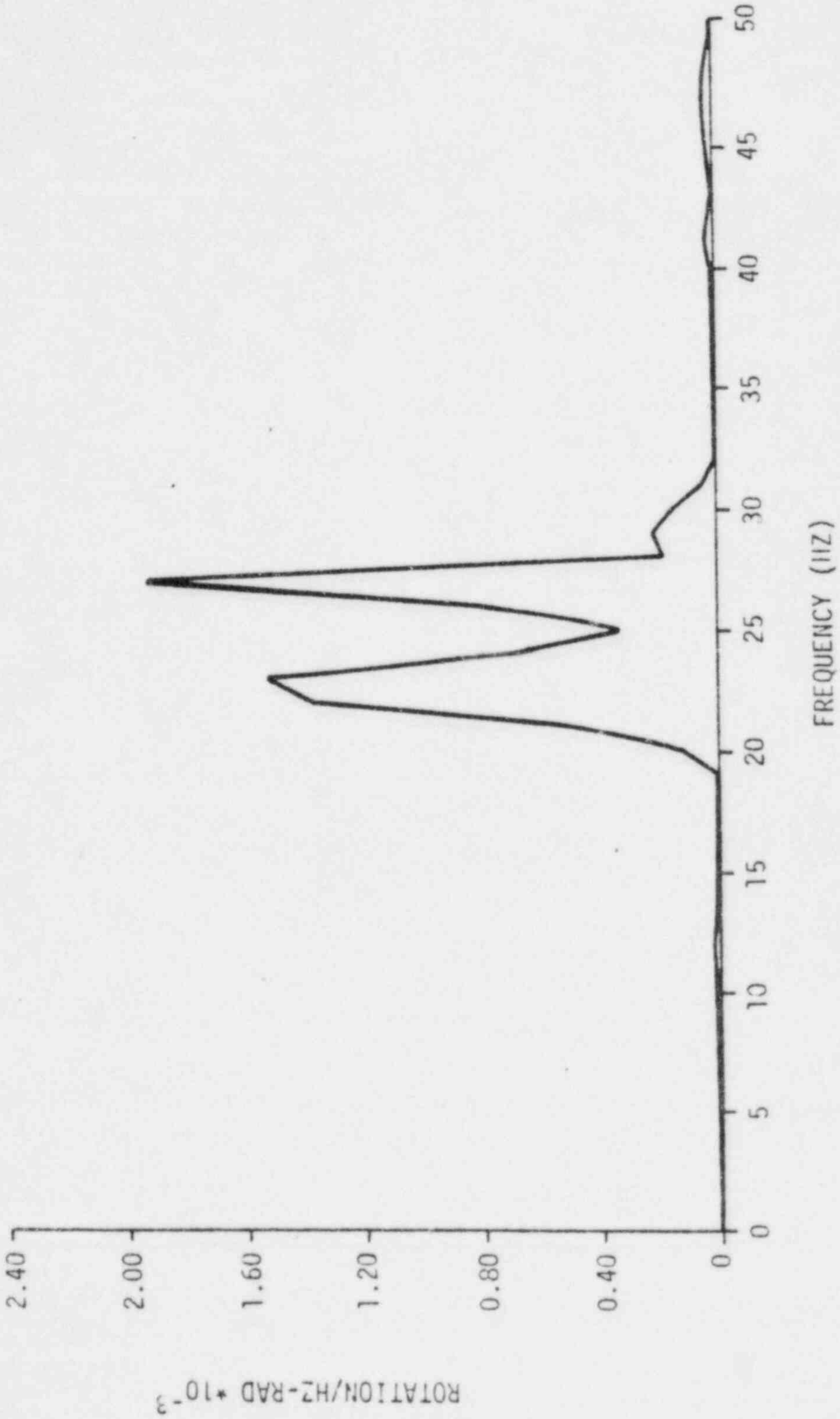


FIGURE A2-3

DBA CO SHELL RESPONSE-RADIAL

(UNLOADED SHELL-NODE 23)

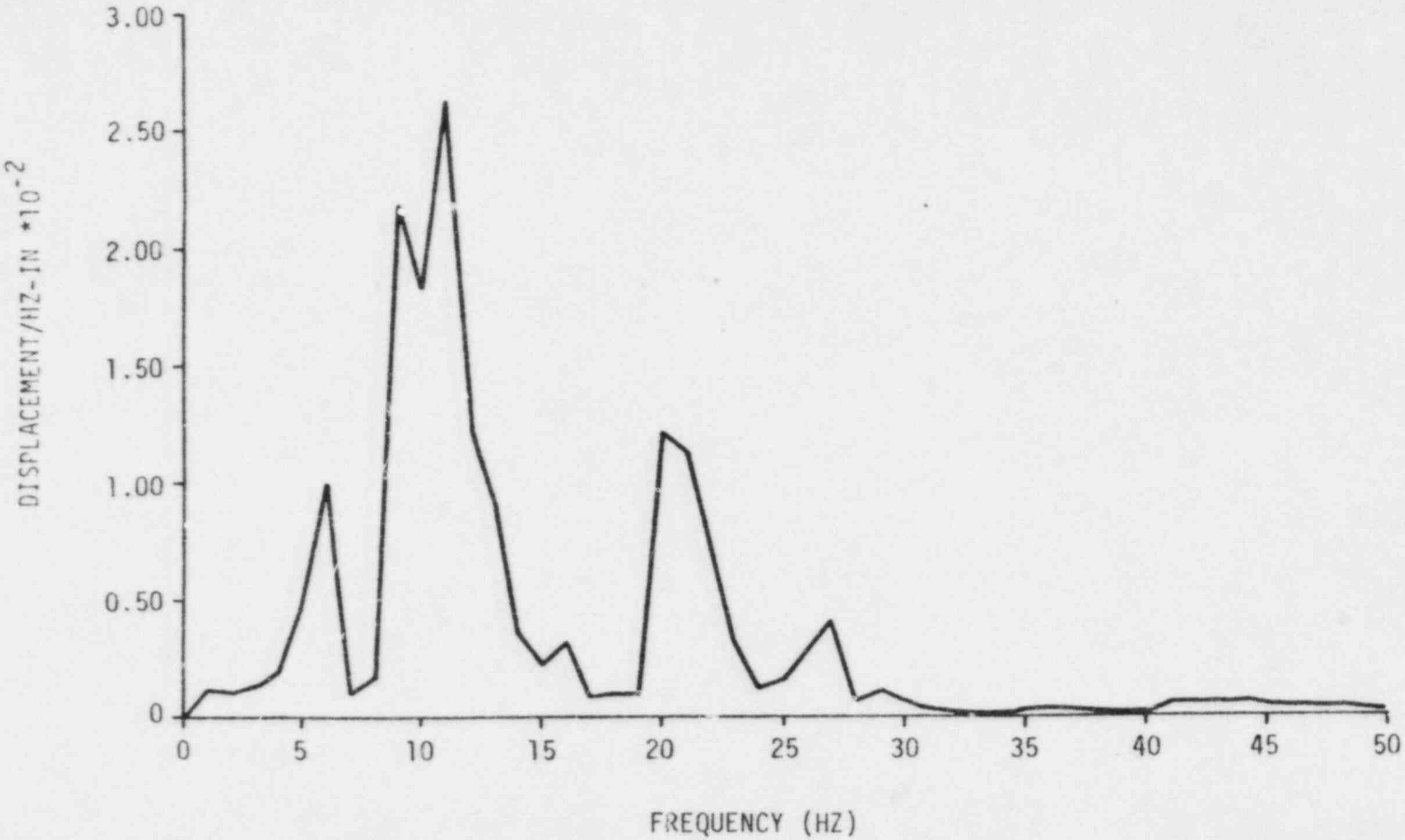


FIGURE A2-4

DBA CO SHELL RESPONSE-ROTATION

(UNLOADED SHELL-NODE 23)