MPR ASSOCIATES, INC.

OYSTER CREEK NUCLEAR GENERATING STATION

SEISMIC REANALYSIS OF LIQUID POISON SYSTEM PIPING

MPR-780

Prepared for:

GPU Nuclear
Parsippany, New Jersey

December 1983

1050 CONNECTICUT AVENUE N.W. WASHINGTON, D.C. 20036 202-659-2320

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I. INTRODUCTION

A. Purpose

This report presents the results of a seismic reanalysis of the Oyster Creek liquid poison system piping outside containment. The seismic reanalysis of the liquid poison system piping was performed in response to Section 4.11(1) of NUREG-0822 (Integrated Plant Safety Assessment - Systematic Evaluation Program - Oyster Creek Nuclear Generating Station) which requested in part that licensee (GPU Nuclear/JCP&L) perform seismic reanalysis of two randomly selected small diameter piping systems to demonstrate the adequacy of the original piping and piping support design. The other piping system selected for seismic reanalysis is the core spray system piping. Results of the seismic reanalysis of the core spray piping are presented in MPR Report MPR-777.

The Oyster Creek Facility Description and Safety Analysis Report (FDSAR) applied earthquake design requirements to two classes of systems and structures: Class I for the more critical equipment required for safe shutdown and Class II for other equipment essential to operation, but not required for shutdown. The liquid poison system was classified as Class I - Critical Equipment (Page V-3-6 of the FDSAR) under this method.

This classification is not equivalent to one resulting from the more recent classification methods contained in ANSI/ANS-52.1-1978, Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants, and the 1980 Edition (including Summer 1981 Addenda) of the ASME Code. In accordance with ANSI/ANS-52.1-1978, the liquid poison system piping is ASME Class 1 piping from the reactor vessel to the second isolation check valve, which is the first check valve outside containment. The remaining piping is ASME Class 2 piping. In accordance with the 1980 Edition (including Summer 1981 Addenda) of the ASME Code, Section III, Subarticle NB-3630, Class 1 piping (Subsection NB) may be analyzed to Class 2 requirements (Subsection NC) provided certain fatigue criteria are met. The liquid poison piping meets these fatigue criteria.

Therefore, the seismic reanalysis of the liquid poison system piping outside containment was performed in accordance with the requirements of the 1980 Edition (including Summer 1981 Addenda) of the ASME Code, Section III, Subsection NC for Class 2 Components. The

1980 Edition (including Summer 1981 Addenda) of the ASME Code was used in the seismic reanalysis of the liquid poison system piping since the equations required for evaluation by this Code are available using an up-to-date computer program, PIPESD. Showing that the liquid poison system piping meets the applicable requirements of the 1980 Edition (including Summer 1981 Addenda) of the ASME Code is considered confirmation of the adequacy of the original piping and piping support design.

II. SUMMARY AND CONCLUSIONS

A. Summary

The liquid poison system piping outside containment was reanalyzed for load combinations including operating basis earthquake (OBE) and safe shutdown earthquake (SSE) in accordance with the requirements of the 1980 Edition (including Summer 1981 Addenda) of the ASME Code, Section III, Subsection NC. Results of these analyses are summarized below.

1. Liquid Poison System Piping Stresses

Results of stress analyses for the liquid poison system piping are presented in Tables II-1 and II-2. Table II-1 presents stresses at the highest stressed locations of the liquid poison system piping due to each load component, i.e., internal pressure, deadweight, and seismic loads during OBE and SSE conditions. Table II-2 tabulates the ratio of the maximum calculated stresses in the liquid poison system piping to the applicable ASME Code allowables. Load combinations including OBE are evaluated to Level B Service Limits. Load combinations including SSE are evaluated to Level C Service Limits. Use of Level C Service

Limits is conservative for SSE load combinations since Level D Service Limits were used and accepted for piping reanalyses in the Systematic Evaluation Program. As shown in Table II-2, all calculated stresses are below the ASME Code allowable values.

B. Conclusion

Based on the results of analyses presented in this report and summarized in Tables II-1 and II-2, the liquid poison system piping outside containment meets the seismic stress analysis requirements of the 1980 Edition (including Summer 1981 Addenda) of the ASME Code, Section III, Subsection NC for Class 2 Components. This confirms the adequacy of the original piping and piping support design.

Table II-1

STRESS ANALYSIS RESULTS FOR INDIVIDUAL LOAD COMPONENTS

Liquid Poison System Piping Outside Containment

Location (Note 1)	Piping Component	Pressure Stress (psi)	Deadweight Stress (psi)	Occassional Load Stress (psi)	
				OBE	SSE
Pump Discharge Line From Containment to Explosive Valves					
132	Soc. Weld Elbow	2969	62	13582	21858
152	Soc. Weld Elbow	2969	405	14815	23842
158	Containment Penetration	2969	175	8518	13719
Pump Discharge Line From Explosive Valves to Pumps					
234	Check Valve	2969	3916	3658	6000
250	Soc. Weld Tee	2969	5936	3558	6008
402	Soc. Weld Elbow	2296	5474	5786	9463
404	Soc. Weld Elbow	2296	5461	5363	8772
466	Safety Relief Valve	2296	7514	4006	6596
Pump Suction Line					
36	Test Tank Penetration	391	1587	480	981
162	Valve	275	1034	99	203

Notes:

(1) Location numbers are shown in Figures IV-1, IV-2, and IV-3.

Table II-2

SUMMARY OF STRESS ANALYSIS RESULTS
ASME CODE SECTION III, SUBSECTION NC
FOR CLASS 2 COMPONENTS

Liquid Poison System Piping Outside Containment

Location (Note 1)	Piping Component	Equation (9) Stress Ratio[2]	
		OBE	SSE
Pump Discharge Line From Containment to Explosive Valves			
132	Soc. Weld Elbow	0.74	0.74
152	Soc. Weld Elbow	0.81	0.80
158	Containment Penetration	0.52	0.50
Pump Discharge Line From Explosive Valves to Pumps			
234	Check Valve	0.47	0.38
250	Soc. Weld Tee	0.55	0.44
402	Soc. Weld Elbow	0.60	0.51
404	Soc. Weld Elbow	0.58	0.49
466	Safety Relief Valve	0.61	0.49
Pump Suction Line			
36	Test Tank Penetration	0.11	0.09
162	Valve	0.06	0.05

Notes:

(1) Location numbers are shown in Figures IV-1, IV-2, and IV-3.

(2) Equation (9) is given in Section III of this report. Allowable stress ratio is 1.0.

III. DESIGN REQUIREMENTS

A. Applicable Codes

The liquid poison system piping outside containment was originally furnished in accordance with the requirements of the 1955 Edition of the American Standard Code for Pressure Piping, ASA B31.1. The number and location of the seismic restraints were determined using a chart method (Bergen-Paterson Piping Support Catalog No. 66, pp. 79-103).. In this report, the seismic reanalysis of the liquid poison system piping will be in accordance with the requirements of the 1980 Edition (including Summer 1981 Addenda) of the ASME Code, Section III, Subsection NC for Class 2 Components.

B. Materials

1.	All Piping	SA-312 Type 316 SST or SA-376 Type 316 SST
2.	Socket Weld Fittings	SA-182 Type F316 SST

C. Drawings

1.	Piping	General Physics Corp. Drawing JCP-19435, Rev. 3. Burns & Roe Drawings 2149, Rev. 3. ISO M0177, Rev. 0. ISO M0178, Rev. 0.

2. Piping Supports — Bergen-Paterson Drawings

331, Rev. 1	337, Rev. 1
331A, Rev. 0	337A, Rev. 0
331B, Rev. 0	406, Rev. 1
332, Rev. 1	406A, Rev. 0
333, Rev. 1	406B, Rev. 0
334, Rev. 1	407, Rev. 1
335, Rev. 1	407A, Rev. 0
336, Rev. 0	410C, Rev. 0
336A, Rev. 0	410D, Rev. 0
336B, Rev. 0	

D. Loads

The design and operating loads for the liquid poison system piping are summarized below.

1. Internal Pressure Loads

Po: Design internal pressure load from the reactor vessel safe end to the check valve.

Pa: Liquid poison pump actuation pressure load.

2. Deadweight Loads

D: Deadweight load of the piping, including the weight of water in the pipe, and the weight of the valves.

3. Seismic Loads

E: Loads generated by operating basis earthquake (OBE).

E': Loads generated by safe shutdown earthquake (SSE).

4. Thermal Loads

To: Thermal effects and loads generated during normal plant operation.

E. Acceptance Criteria

1. Internal Pressure, Deadweight, and Seismic Loads

The stresses due to load combinations including the OBE shall meet the requirements of Equation (9) of the ASME Code, Section III, Subsection NC.

$$\frac{P_{max} D_o}{4 t_n} + 0.75i \frac{M_A + M_B}{Z} \leq 1.2 \text{ Sh}$$

The stresses due to load combinations including the SSE shall also meet the requirements of Equation (9), except the allowable stress for this condition shall be 1.8 Sh.

The above equation is identical to the equation used in the PIPESD computer program (Version 6.2), based on the 1974 ASME Code.

2. Definition of Terms

D_o = Outside diameter of pipe, in.

t_n = Nominal wall thickness, in.

Z = Section Modulus of pipe, in^3.

i = Stress intensification factor.

P_{max} = Peak pressure, psi (design pressure used).

M_A = Resultant moment loading on cross section due to weight and other sustained loads, in-lb.

M_B = Resultant moment loading on cross section due to occasional loads such as earthquake.

Sh = Basic material allowable stress at maximum (hot) temperature.

3. Allowable Stress Intensity Limits

The design temperature of the liquid poison system piping outside containment is 150°F. The material allowable stresses are obtained from Appendix I of Section III of the ASME Code.

Material	Sh, psi 150°F
SA-312 Type 316 SST	18,800
SA-376 Type 316 SST	18,800
SA-182 Type F316 SST	18,800

IV. DESCRIPTION OF ANALYSES

This section of the report describes the analyses that were performed on the liquid poison system piping. The detailed calculations are given in Appendices A through E. Microfiche of the computer output data is given in Appendix F.

A. Model

The liquid poison system piping was evaluated using the finite element computer program PIPESD, Version 6.2. A total of three finite element models were used to model the liquid poison system piping outside containment. The finite element models are shown in Figures IV-1, IV-2 and IV-3. Joint coordinates and support locations are summarized in Appendix A.

1. Spring Supports

The springs hangers indicated in Figure IV-1 were modeled by specifying the preload and spring stiffness. The cold spring preloads used in the liquid poison system piping analyses are tabulated below and are based on data from the spring hanger drawings listed in Section III.C.2 of this report. (In the PIPESD seismic stress analyses, the cold spring preloads were reduced by the loss in spring load due to anchor displacements of the pipe end at the containment penetration during heatup of the containment from cold shutdown to normal operating temperature as determined from the spring hanger relaxation analyses.)

Spring Designation (Note 1)	Cold Spring Preload (lbs)	Loss In Preload Due to Thermal Expansion (lbs)	Spring Preload for Analysis (lbs)	Spring Stiffness (lb/in)
NP-1-H2	32.0	-6.1	25.9	26.7
NP-1-H3	69.0	-1.2	67.8	26.7

Notes:

(1) Spring designations refer to General Physics Corp. Drawing JCP-19435.

2. Valves

As shown in Figures IV-1, IV-2, and IV-3, the liquid poison system piping models contain 20 valves. The valve weights and the distances from the valve c.g. to the centerline of the pipe that were used in the analyses are tabulated in Table IV-1.

3. Material and Section Properties

Material properties for the liquid poison system piping are given in Appendix B and summarized below. All liquid poison system piping materials are Type 316 stainless steel. For stress analysis purposes all material properties were evaluated at a temperature of 70°F for the portion of the liquid poison system piping outside containment. (Note: Material allowable stresses were taken at the design temperature of 150°F.)

- Modulus of Elasticity -- 28.30×10^6 psi
- Coefficient of Thermal expansion -- 8.42×10^{-6} in/in/°F
- Poisson's Ratio -- 0.3

Pipe section properties for the liquid poison system piping are calculated in Appendix B and tabulated in Table IV-2.

B. Loads

The liquid poison system piping was evaluated for the following loads.

1. Internal Pressure Load, P_a

Liquid Poison Injection

P_a = 1250 psig reactor vessel to pump discharge

= 150 psig pump suction to poison storage tank

2. Deadweight, D

The deadweight consists of weight of the liquid poison system piping, including weight of fluid in the pipe, and valve weights. The total weights of the liquid poison piping runs are tabulated below.

	Total Piping System Weight (lbs)
Containment to Explosive Valves	395
Explosive Valves to Pump Discharge	1145
Pump Suction to Poison Storage Tank	849

3. Thermal Load, T_o

The thermal load results from the displacement of the pipe anchor at the containment penetration during heatup of the containment to normal operating temperature. The thermal load is based on the assumed conditions shown on the following table. The calculation of the anchor displacement for the assumed conditions is given in Appendix C.

Thermal Load Case	Drywell Temperature (°F)	Pipe Temperature Outside Containment (°F) (Note 1)
Normal Operating Conditions	135.0	70.0

NOTES:

(1) Reference temperature for pipe thermal expansion = 70°F. Pipe temperature outside containment is 70°F.

The thermal load (i.e., the forces and moments in the liquid poison system piping due to thermal expansion of the pipe and anchor displacements) is not evaluated explicitly in Equation (9) of the ASME Code, Section III, Subsection NC. However, the anchor displacement affects the deadweight stresses in that it reduces the springs hanger loads during normal operating conditions as discussed in Section IV.A.2 of this report. The stresses in Equation (9) due to deadweight are determined for the reduced spring hanger loads during normal operating conditions.

4. Seismic Loads, OBE and SSE

Seismic analysis was performed using the response spectra method. Seismic loads consist of the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE). Seismic loads are defined by horizontal and vertical response spectra as shown in Figures IV-4 and IV-5 for the OBE and Figures IV-6 and IV-7 for the SSE. The response spectra shown on these figures are based on the response spectra generated by Lawrence Livermore Laboratories in the revised Appendix B of NUREG/CR-1981.

Damping values of 1% for OBE and 2% for SSE were used, in accordance with USNRC Regulatory Guide 1.61. Response spectra obtained from NUREG/CR-1981 were extrapolated to obtain values at 1% and 2% damping. The response spectra given in Figures IV-4 through IV-7 envelope the extrapolated response spectra from elevations of 38'-3" to 95'-3" of the reactor building in accordance with Section 3.7.3 of the Standard Review Plan, (NUREG-0800).

The horizontal and vertical response spectra for the OBE and SSE conditions were multiplied by 0.165/0.22, based on a zero period acceleration (ZPA) at the ground of 0.165g's for Oyster Creek versus the ZPA at the ground of 0.22g's used in NUREG/CR-1981. Calculations of the enveloped response spectra are given in Appendix D.

C. Analyses

The seismic analysis of the liquid poison system discharge line from the containment penetration to the explosive valves is performed in two PIPESD computer runs: one spring hanger relaxation run and one stress analysis run. Analyses of the discharge line from the explosive valves to the pumps and the pump suction line were performed in one PIPESD computer run per model: a stress analysis run since there are no spring hangers on these lines.

1. <u>Spring Hanger Relaxation Analyses</u>

   The spring hanger relaxation analyses determine the loss in spring preload due to the anchor displacement at the containment penetration during heatup of the containment from cold shutdown (70°F) to normal operating temperature (135°F). Results of the spring hanger relaxation analyses are given in Appendix E and tabulated in Section IV.A.1 of this report.

2. <u>Seismic Stress Analyses</u>

   The seismic stress analyses determine the stresses in the liquid poison system piping due to the combination of internal pressure, deadweight, and seismic loads (OBE and SSE). Results of seismic stress analyses are given in Appendix E and summarized in Section II of this report. Deadweight stresses are evaluated at the reduced spring hanger loads determined from the spring hanger relaxation analyses. Stresses are calculated in accordance with Equation (9) of the ASME Code, Section III, Subsection NC. Load combinations including OBE are evaluated to Level B Service Limits. Load combinations including SSE are evaluated to Level C Service Limits.

Computer output for the seismic stress analyses are given in Appendix F.

Table IV-1

LIQUID POISON SYSTEM PIPING VALVE PROPERTIES

Designation (Note 1)	Valve Type	Valve Weight (lbs)	Valve C.G. to Centerline of Pipe (inch)
Pump Discharge Line - Containment to Explosive Valves			
V-19-16	1-1/2" Check	20.0	2.0
V-19-25	1-1/2" Gate	100.0	10.0
Pump Discharge Line - Explosive Valves to Pumps			
V-19-7	1-1/2" Gate	100.0	10.0
V-19-8	1-1/2" Gate	100.0	10.0
V-19-37	1-1/2" Check	20.0	2.0
V-19-38	1-1/2" Check	20.0	2.0
V-19-36	1-1/2" Globe	24.0	5.0
V-19-35	1-1/2" Globe	24.0	5.0
V-19-41	1" Globe	16.0	5.0
V-19-23	1-1/2" Globe	45.0	8.0 at 45°
V-19-44	1-1/2" Explosive	40.0	NA
V-19-45	1-1/2" Explosive	40.0	NA
V-19-42	1"x2" Pressure Relief	40.0	5.0
V-19-43	1"x2" Pressure Relief	40.0	5.0
Pump Suction Line			
V-19-4	2-1/2" Gate	95.0	10.0
V-19-11	2-1/2" Gate	95.0	10.0
V-19-10	2-1/2" Check	55.0	3.0
V-19-5	2-1/2" Gate	95.0	10.0
V-19-6	2-1/2" Gate	95.0	10.0
V-19-9	1" Globe	16.0	5.0

Notes:

(1) Valve designations refer to Burns and Roe Valve List Drawing 2075 and General Electric Drawing 148F723.

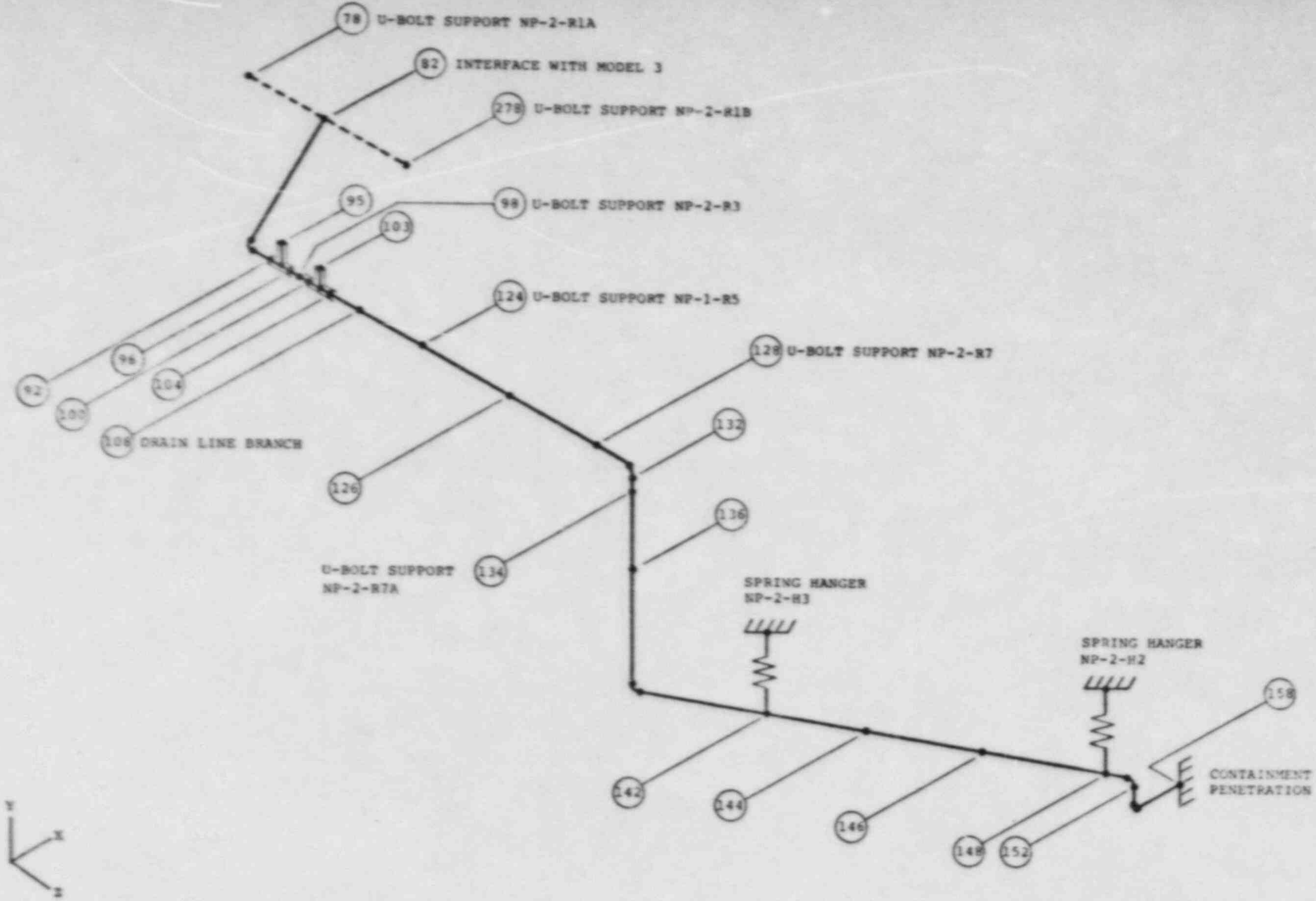
Table IV-2

LIQUID POISON SYSTEM PIPING SECTION PROPERTIES

Component	O.D. (inch)	t (inch)	Weight (lb/in) (Note 1)
1-inch Sch 80	1.315	0.179	0.207
1-inch Socket Weld Elbow	1.392	0.179	0.223
1-inch Socket Weld Sleeve	1.722	0.196	0.316
1-1/2-inch Sch 80	1.900	0.200	0.366
1-1/2-inch Socket Weld Elbow	1.995	0.200	0.391
1-1/2-inch Socket Weld Sleeve	2.351	0.218	0.517
2-inch Sch 80	2.375	0.218	0.525
2-inch Socket Weld Elbow	2.448	0.218	0.559
2-inch Socket Weld Sleeve	2.882	0.238	0.723
2-1/2-inch Sch 80 Pipe	2.875	0.276	0.791
1-1/2-inch Welded Flange	7.000	2.750	10.455

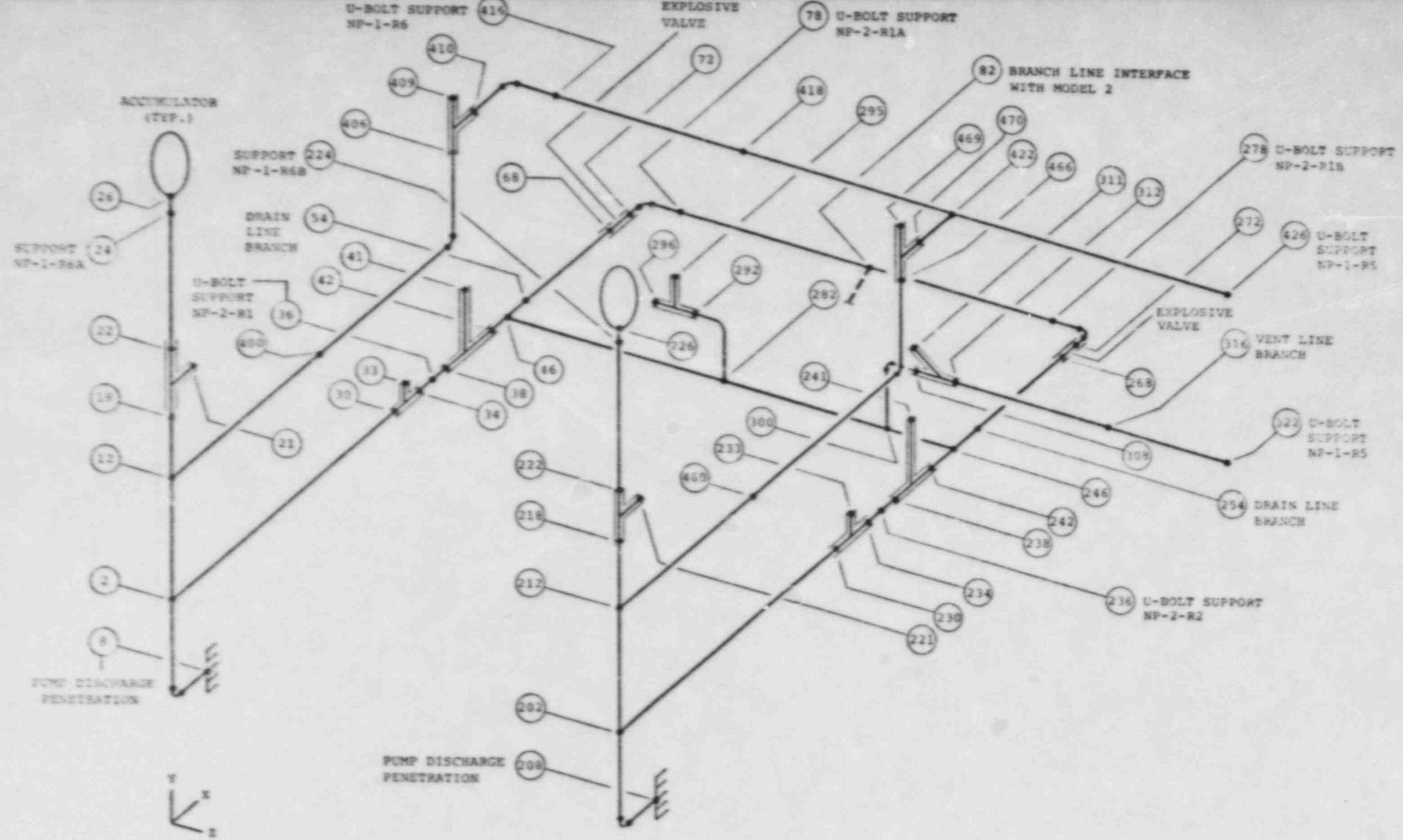
Notes:

(1) Includes weight of fluid in pipe.



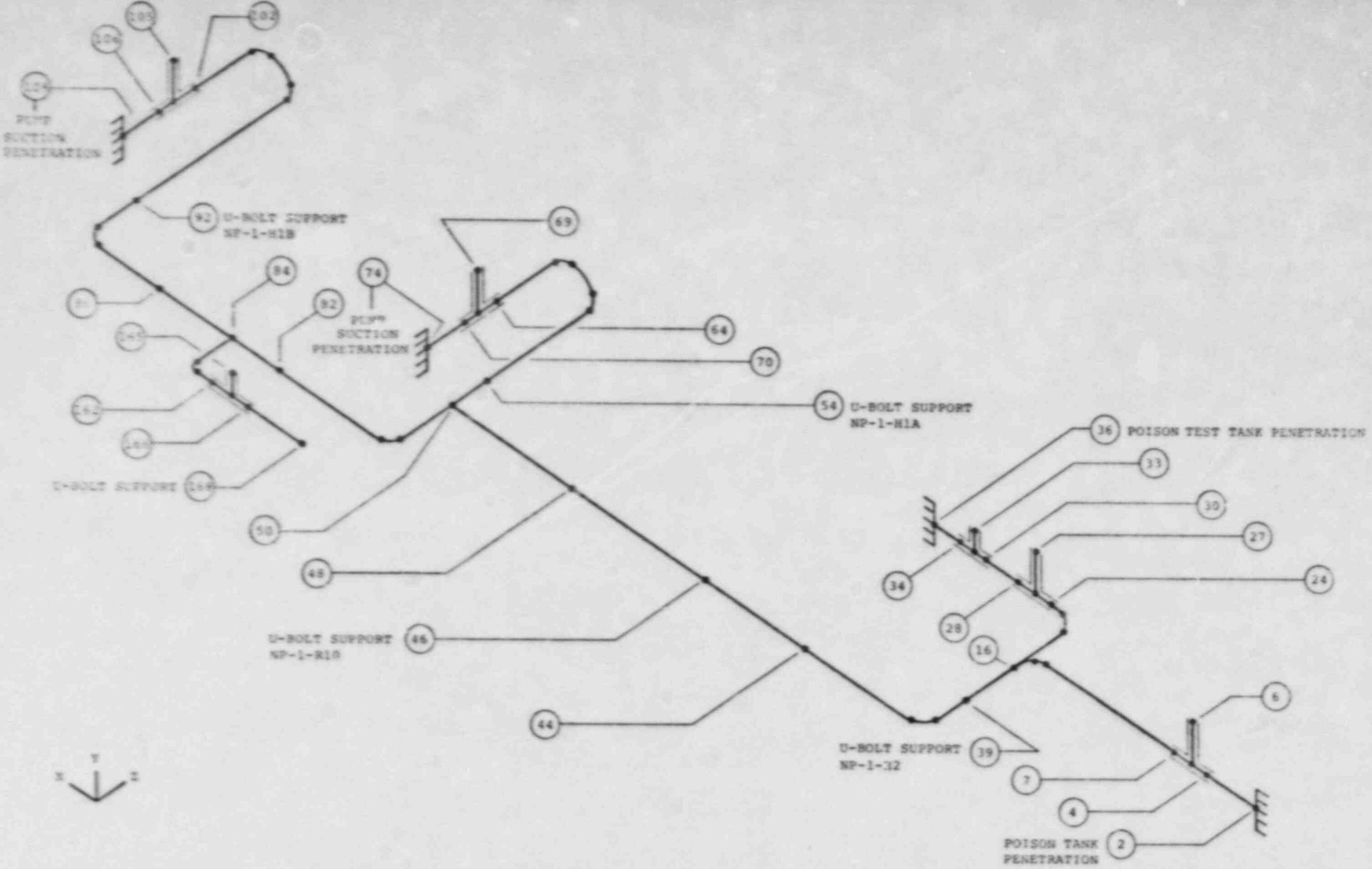
PUMP DISCHARGE LINE—CONTAINMENT TO EXPLOSIVE VALVES

FIGURE IV-1



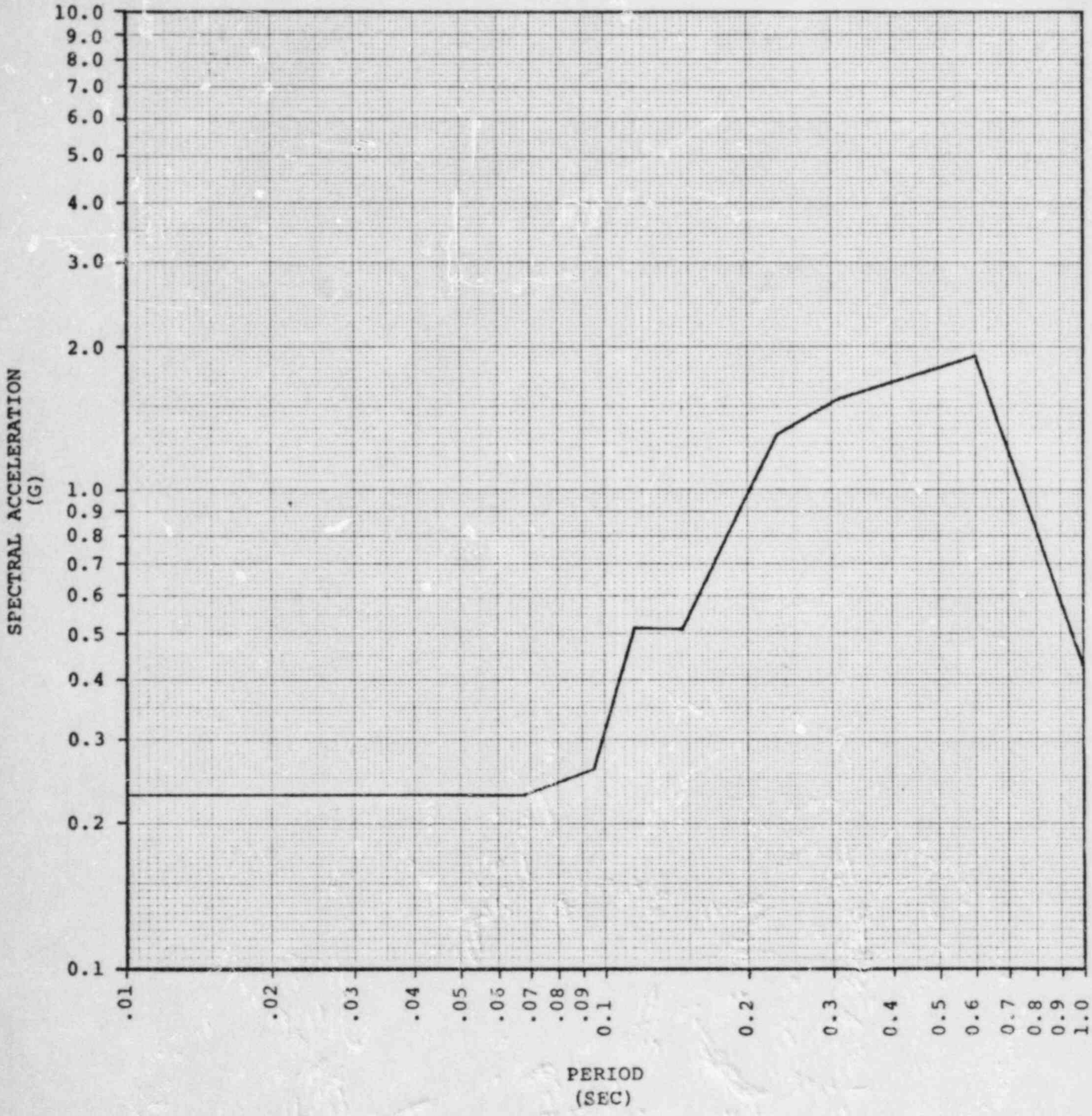
PUMP DISCHARGE LINE—EXPLOSIVE VALVES TO PUMPS

FIGURE IV-2



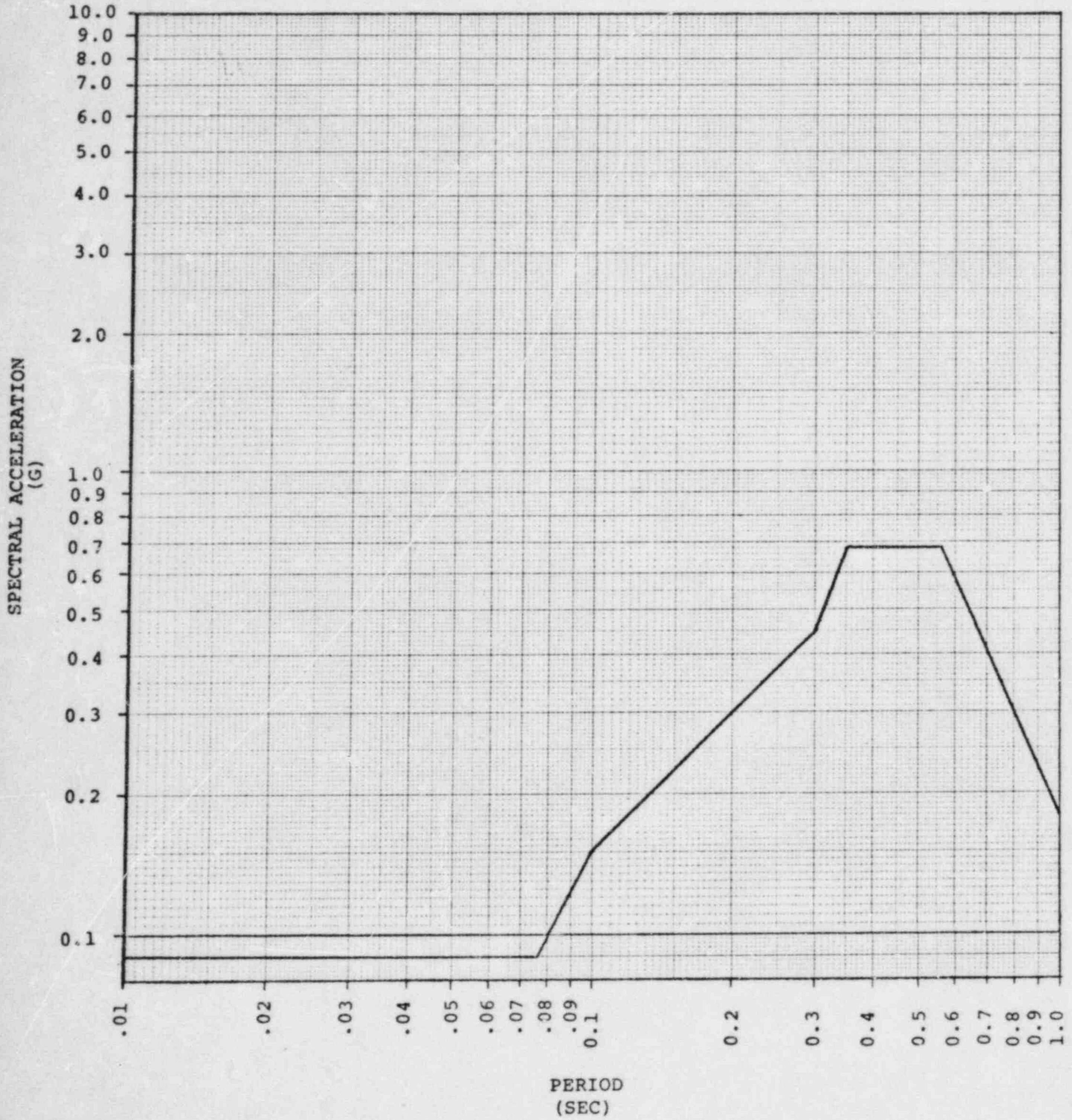
PUMP SUCTION LINE

FIGURE IV-3



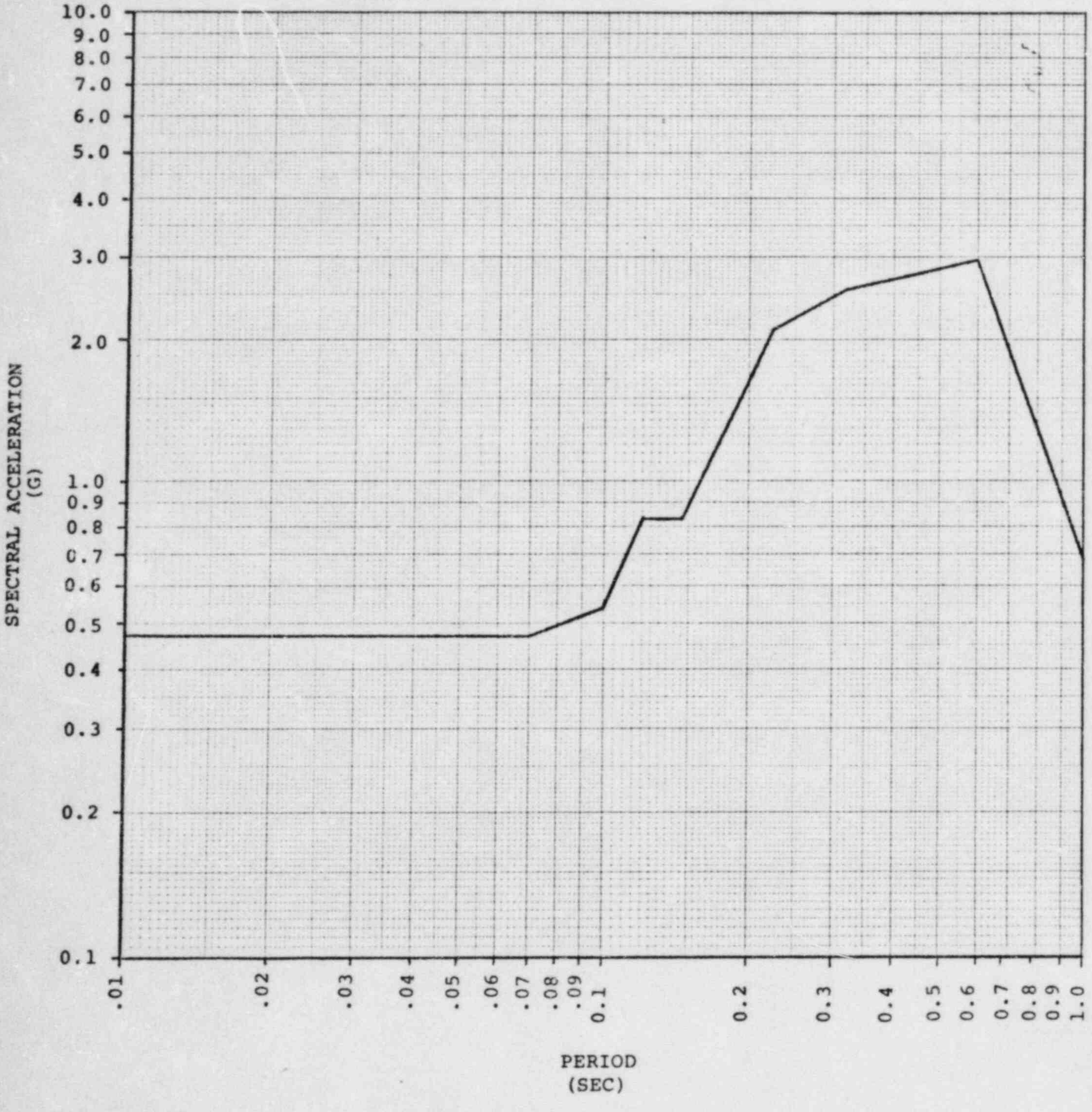
OPERATING BASIS EARTHQUAKE
CORE SPRAY PIPING HORIZONTAL RESPONSE
SPECTRA AT 1% DAMPING

FIGURE IV-4



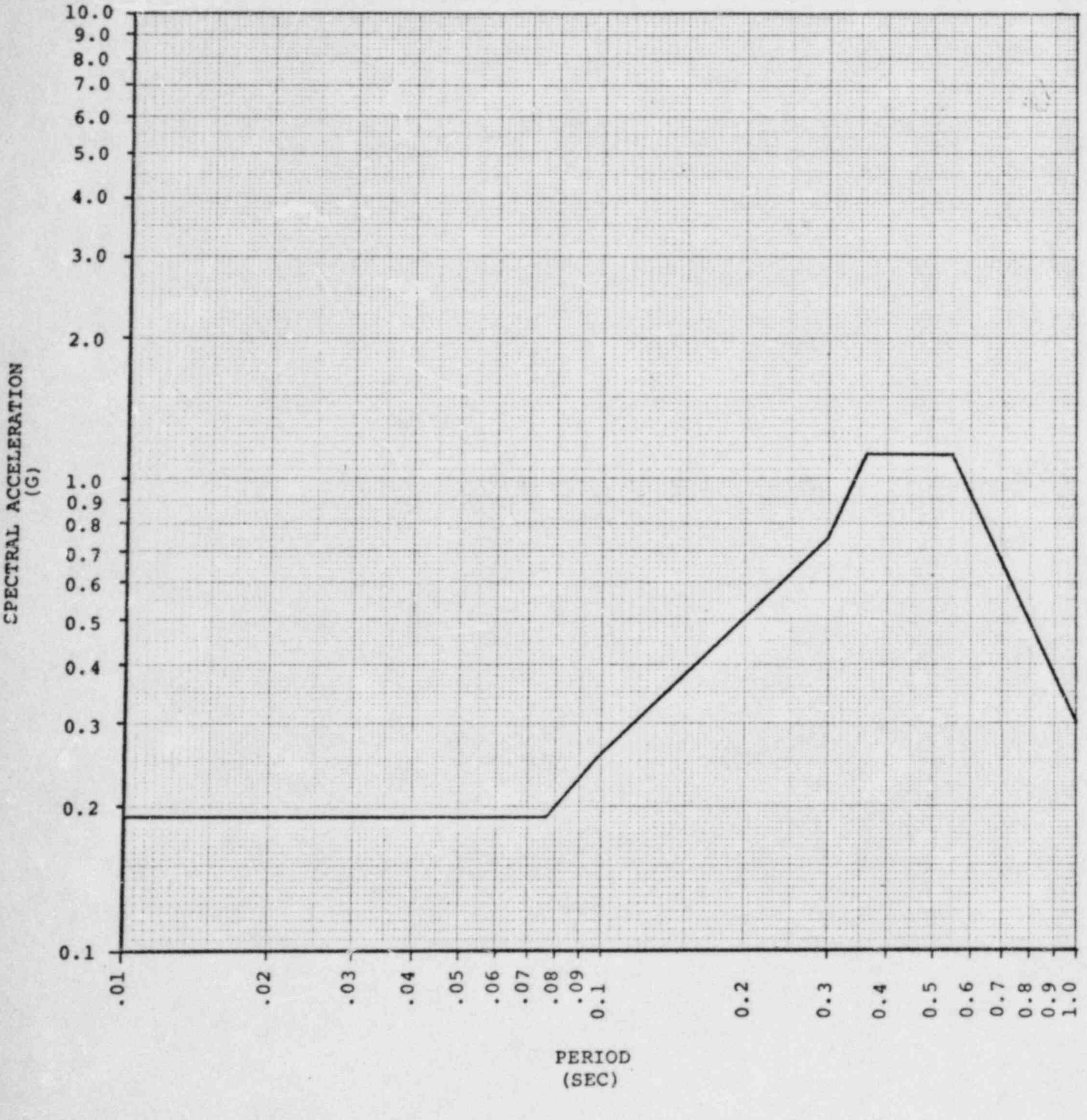
OPERATING BASIS EARTHQUAKE
CORE SPRAY PIPING VERTICAL RESPONSE
SPECTRA AT 1% DAMPING

FIGURE IV-5



SAFE SHUTDOWN EARTHQUAKE
CORE SPRAY PIPING HORIZONTAL RESPONSE
SPECTRA AT 2% DAMPING

FIGURE IV-6



SAFE SHUTDOWN EARTHQUAKE
CORE SPRAY PIPING VERTICAL RESPONSE
SPECTRA AT 2% DAMPING

FIGURE IV- 7

V. APPENDICES

APPENDIX A

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Title: PIPING CONFIGURATION	Calculated by: [signature]	Date: 11/28/83
	Checked by: [signature]	Date: 12/1/83
	Reviewed by: [signature]	Date: 12-1-83
Project: SEP PIPING 83-03		Page 1 of 31

PURPOSE

The following calculation documents the geometry used in the piping models of the liquid poison system piping outside containment at Oyster Creek.

Summary

Figure 1 illustrates the geometry of the liquid poison piping discharge line from containment to explosive valves (model 2). Table 1 contains the coordinates of the piping model nodes. Figure 2 illustrates the geometry of the liquid poison piping discharge line from explosive valves to pump discharge (model 3). Table 2 contains the coordinates of the piping model nodes. Figure 3 illustrates the geometry of the liquid poison piping pump suction line from pump suction to liquid poison tank. tank. Table 3 contains the coordinates of the piping model nodes.

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Title: PIPING CONFIGURATION	Calculated by: MJK	Date: 11/28/83
	Checked by: RWC	Date: 12/1/83
	Reviewed by: JT	Date: 12-1-83
Project: 83-03		Page 2 of 31

Reference Drawings

Burns & Roe: 2149, MO 177, MO 178

General Physics: JCP-19435

BERGEN - PATTERSON: 331, 331A, 331B, 332, 333, 334, 335, 336, 336A, 336B, 337, 337A, 406, 406A, 406B, 407, 407A, 410C, 410D

Reference Specifications

Burns & Roe Spec S-2299-60-C
Valve List Dwg. 2075

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TABLE I

POISON PIPING DISCHARGE LINE OUTSIDE CONTAINMENT – from CONTAINMENT TO EXPLOSIVE VALVES (MODEL 2)

RUN ID #	NODE NUMBER	X	Y	Z
1	78	121.500	0.0	6.0
1	80	121.500	0.0	30.75
1	82	121.500	0.0	33.0
1	84	121.500	0.0	35.25
1	86	119.909	-1.591	33.0
1	278	121.500	0.000	59.000
1	88	87.591	-33.909	33.0
1	521	86.884	-34.616	33.0
1	522	86.259	-35.241	33.366
1	523	86.000	-35.500	34.25
1	90	86.000	-35.500	35.25
1	92	86.000	-35.500	36.000
1	94	86.000	-35.500	42000
1	95	86.000	-25.500	42.000
1	96	86.000	-35.500	48.000
1	98	86.000	-35.500	49.000
1	100	86.000	-35.500	51.500
1	102	86.000	-35.500	55.000
1	103	86.000	-33.500	55.000
1	104	86.000	-35.500	58.500
1	106	86.000	-35.500	68.750
1	108	86.000	-35.500	71.000
1	110	86.000	-37.750	71.000

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Title: PIPING CONFIGURATION

Calculated by: MK Date: 11/28/83
Checked by: PEVC Date: 12/1/83
Reviewed by: JJ Date: 12-1-83

Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
1	112	86.000	-35.500	73.250
1	114	86.000	-35.500	80.250
1	116	86.000	-35.500	81.750
1	118	86.000	-35.500	87.000
1	120	86.000	-35.500	92.250
1	122	86.000	-35.500	93.750
1	124	86.000	-35.500	109.000
1	126	86.000	-35.500	153.000
1	128	86.000	-35.500	197.000
1	130	86.000	-35.500	210.750
1	531	86.000	-35.500	211.750
1	532	86.000	-35.866	212.634
1	533	86.000	-36.750	213.00
1	132	86.000	-37.750	213.000
1	134	86.000	-38.125	213.000
1	136	86.000	-79.500	213.000
1	138	86.000	-121.250	213.000
1	541	86.000	-122.250	213.000
1	542	86.183	-123.134	213.317
1	543	86.625	-123.500	214.086
1	140	87.125	-123.500	214.949
1	142	110.000	-123.500	254.569
1	144	132.000	-123.500	292.674
1	146	154.000	-123.500	330.780
1	148	176.000	-123.500	368.885
1	150	177.875	-123.500	372.132
1	551	178.375	-123.500	372.998
1	552	178.817	-123.866	373.764
1	553	179.000	-124.750	374.081

MPR ASSOCIATES, INC.
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Title: PIPING CONFIGURATION

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Project: 83-03

RUN I.D. #	NODE NUMBER	X	Y	Z
1	152	179.000	-125.750	374.081
1	154	179.000	-133.25	374.081
1	561	179.000	-134.25	374.081
1	562	179.317	-135.134	373.898
1	563	180.083	-135.500	373.456
1	156	180.949	-135.500	372.956
1	158	186.794	-135.500	369.581

Element Definition (MODEL 2)

Run # 1

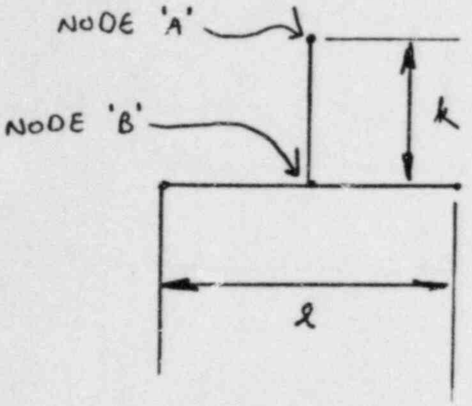
Straight members - PIPE

member #	NODES	member #	NODES	member #	NODES
1S	78-80	17S	104-106	33S	136-138
2S	80-82	18S	106-108	34S	138-541
3S	82-84	19S	108-110	35S	140-142
4S	82-86	20S	108-112	36S	142-144
5S	84-278	21S	112-114	37S	144-146
6S	86-88	22S	114-116	38S	146-148
7S	88-521	23S	116-118	39S	148-150
8S	90-92	24S	118-120	40S	150-551
9S	92-94	25S	120-122	41S	152-154
10S	94-95	26S	122-124	42S	154-561
11S	94-96	27S	124-126	43S	156-158
12S	96-98	28S	126-128	44S	523-90
13S	98-100	29S	128-130	45S	533-132
14S	100-102	30S	130-531	46S	543-140
15S	102-103	31S	132-134	47S	553-152
16S	102-104	32S	134-136	48S	563-156

Curved members - PIPE

member #	NODES	member #	NODES	member #	NODES
1C	521-522	5C	541-542	9C	561-562
2C	522-523	6C	542-543	10C	562-563
3C	531-532	7C	551-552		
4C	532-533	8C	552-553		

VALVE GEOMETRY - MODEL 2



Valve Designation	NODE A	NODE B	l (in)	k (in)	Valve weight (lb)
V-19-16	103	102	7.0	2.0	20.0
V-19-25	95	94	12.0	10.0	100.0
flow meter	NA	118	9.0	0.0	25.0

Support Locations and Geometry - Model 2

HANGER Supports

SPRING HANGER DESIGNATION	NODE	SPRING CONSTANT (lb/in)	Cold Preload (lb)
NP-2-H3	142	26.7	69.0
NP-2-H2	148	26.7	32.0

ANCHORS AND SEISMIC RESTRAINTS

SUPPORT LOCATION (NODE)	TRANSLATION			ROTATION			TYPE OF SUPPORT
	X	Y	Z	X	Y	Z	
78	X	X					U-Bolt Restraint -
78			X				(Note 1)
98	X	X					U-Bolt Restraint
124	X	X					U-Bolt Restraint
128	X	X					U-Bolt Restraint
134	X		X				U-Bolt Restraint
158	X	X	X	X	X	X	Containment Penetration
278	X	X					U-Bolt Restraint
278			X				(Note 1)

Notes:

(1) A stiffness of 1018 lb/in. in the z direction is used at nodes 78 and 278 to model the transition to Model 3.

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TABLE 2

POISON PIPING DISCHARGE LINE OUTSIDE CONTAINMENT - FROM EXPLOSIVE VALVES TO LIQUID POISON PUMPS. (MODEL 3)

RUN ID #	NODE NUMBER	X	Y	Z
1	2	0.0	0.0	0.0
1	4	0.0	2.250	0.0
1	5	0.0	-2.250	0.0
1	6	0.0	-12.750	0.0
1	501	0.0	-13.750	0.0
1	502	0.366	-14.634	0.0
1	503	1.250	-15.000	0.0
1	7	2.25	-15.000	0.0
1	8	9.000	-15.000	0.0
1	10	0.0	16.250	0.0
1	12	0.0	18.500	0.0
1	14	0.0	20.750	0.0
1	16	2.25	18.500	0.0
1	18	0.0	29.000	0.0
1	20	0.0	32.500	0.0
1	21	5.000	32.500	0.0
1	22	0.0	36.000	0.0
1	24	0.0	51.500	0.0
1	26	0.0	60.875	0.0
1	28	2.25	0.0	0.0
1	29	28.0	0.0	0.0
1	30	56.0	0.0	0.0
1	32	59.5	0.0	0.0
1	33	59.5	2.000	0.0

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Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
1	34	63.000	0.0	0.0
1	36	66.000	0.0	0.0
1	38	69.000	0.0	0.0
1	40	75.000	0.0	0.0
1	41	75.000	10.0	0.0
1	42	81.000	0.0	0.0
1	44	83.750	0.0	0.0
1	46	86.000	0.0	0.0
1	48	86.000	0.0	2.25
1	50	88.250	0.0	0.0
1	52	89.250	0.0	0.0
1	54	91.500	0.0	0.0
1	56	93.750	0.0	0.0
1	58	91.500	-2.25	0.0
1	60	97.000	0.0	0.0
1	62	100.000	0.0	0.0
1	64	103.000	0.0	0.0
1	66	106.000	0.0	0.0
1	68	111.000	0.0	0.0
1	70	114.000	0.0	0.0
1	72	117.000	0.0	0.0
1	74	119.250	0.0	0.0
1	511	120.250	0.0	0.0
1	512	121.134	0.0	0.366
1	513	121.500	0.0	1.250
1	76	121.500	0.0	2.250
1	78	121.500	0.0	6.000
1	80	121.500	0.0	30.750

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Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
1	82	121.500	0.0	33.000
1	84	121.500	0.0	35.250
1	86	119.909	-1.591	33.000
1	278	121.500	0.0	59.000
1	280	86.000	0.0	29.750
1	202	0.0	0.0	66.000
1	204	0.0	2.250	66.000
1	205	0.0	-2.250	66.000
1	206	0.0	-12.750	66.000
1	601	0.0	-13.750	66.000
1	602	0.366	-14.634	66.000
1	603	1.250	-15.000	66.000
1	207	2.250	-15,000	66.000
1	208	9.000	-15.000	66.000
1	210	0.0	16.250	66.000
1	212	0.0	18.500	66.000
1	214	0.0	20.750	66.000
1	216	2.250	18.500	66.000
1	218	0.0	29.000	66.000
1	220	0.0	32.500	66.000
1	221	5.000	32.500	66.000
1	222	0.0	36.000	66.000
1	224	0.0	51.500	66.000
1	226	0.0	60.875	66.000
1	228	2.250	0.0	66.000
1	229	28.000	0.0	66.000
1	230	56.000	0.0	66.000

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Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
1	232	59.500	0.0	66.000
1	233	59.500	2.0	66.000
1	234	63.000	0.0	66.000
1	236	66.000	0.0	66.000
1	238	69.000	0.0	66.000
1	240	75.000	0.0	66.000
1	241	75.000	10.000	66.000
1	242	81.000	0.0	66.000
1	244	83.750	0.0	66.000
1	246	86.000	0.0	66.000
1	248	86.000	0.0	63.750
1	250	88.250	0.0	66.000
1	252	89.250	0.0	66.000
1	254	91.500	0.0	66.000
1	256	93.750	0.0	66.000
1	258	91.500	-2.250	66.000
1	260	97.000	0.0	66.000
1	262	100.000	0.0	66.000
1	264	103.000	0.0	66.000
1	266	106.000	0.0	66.000
1	268	111.000	0.0	66.000
1	270	114.000	0.0	66.000
1	272	117.000	0.0	66.000
1	274	119.250	0.0	66.000
1	611	120.250	0.0	66.000
1	612	121.134	0.0	65.634
1	613	121.500	0.0	64.750
1	276	121.500	0.0	63.750

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Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
1	278	121.500	0.0	59.000
1	299	86.000	0.0	53.750
1	300	86.000	0.0	56.000
1	302	86.000	0.0	58.750
1	304	86.000	1.630	56.000
1	280	86.000	0.0	29.750
1	282	86.000	0.0	32.000
1	284	86.000	0.0	34.250
1	286	86.000	2.250	32.000
1	288	86.000	7.120	32.000
1	621	86.000	7.870	32.000
1	622	86.000	8.492	31.742
1	623	86.000	8.750	31.120
1	290	86.000	8.750	30.370
1	292	86.000	8.750	27.000
1	294	86.000	8.750	24.500
1	295	86.000	13.750	24.500
1	296	86.000	8.750	22.000
1	298	86.000	8.750	18.000
1	400	36.000	18.500	0.0
1	402	70.370	18.500	0.0
1	691	71.120	18.500	0.0
1	692	71.742	18.758	0.0
1	693	72.000	19.380	0.0
1	404	72.000	20.130	0.0
1	406	72.000	29.500	0.0
1 & 2	408	72.000	35.500	0.0
1	409	72.000	40.500	0.0

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Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
2	410	78.000	35.500	0.0
2	412	83.000	35.500	0.0
2	701	84.500	35.500	0.0
2	702	85.561	35.500	0.439
2	703	86.000	35.500	1.500
2	414	86.000	35.500	3.000
2	416	86.000	35.500	11.000
2	418	86.000	35.500	38.500
2	420	86.000	35.500	63.000
2	422	86.000	35.500	66.000
2	424	86.00	35.500	69.000
2	472	83.000	35.500	66.000
1	460	36.00	18.500	66.000
1	462	70.370	18.500	66.000
1	741	71.120	18.500	66.000
1	742	71.742	18.758	66.000
1	743	72.000	19.380	66.000
1	464	72.000	20.130	66.000
1	466	72.000	29.500	66.000
1 & 2	468	72.000	35.500	66.000
1	469	72.000	40.500	66.000
2	470	78.000	35.500	66.000
2	472	83.000	35.500	66.000
2	426	86.000	35.500	107.000
1	306	86.000	8.370	56.000
1	631	86.000	8.750	56.000
1	632	86.000	9.634	56.366
1	633	86.000	10.000	57.250

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RUN ID #	NODE NUMBER	X	Y	Z
1	307	86.000	10.000	57.630
1	308	86.000	10.000	59.500
1 & 2	310	86.000	10.000	64.000
1	311	86.000	15.657	58.343
2	312	86.000	10.000	68.500
2	314	86.000	10.000	87.370
2	316	86.000	10.000	89.000
2	318	86.000	10.000	90.630
2	320	84.370	10.000	89.000
2	322	86.000	10.000	107.000

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Element Definition (MODEL 3)

Run # 1

Straight members – PIPE

member #	NODES	member #	NODES	member #	NODES
1S	2-4	26S	40-41	51S	84-278
2S	2-5	27S	40-42	52S	202-204
3S	2-28	28S	42-44	53S	202-205
4S	4-10	29S	44-46	54S	202-228
5S	5-6	30S	46-48	55S	204-210
6S	6-501	31S	46-50	56S	205-206
7S	7-8	32S	48-280	57S	206-601
8S	10-12	33S	50-52	58S	207-208
9S	12-14	34S	52-54	59S	210-212
10S	12-16	35S	54-56	60S	212-214
11S	14-18	36S	54-58	61S	212-216
12S	16-400	37S	56-60	62S	214-218
13S	18-20	38S	60-62	63S	216-460
14S	20-21	39S	62-64	64S	218-220
15S	20-22	40S	64-66	65S	220-221
16S	22-24	41S	66-68	66S	220-222
17S	24-26	42S	68-70	67S	222-224
18S	28-29	43S	70-72	68S	224-226
19S	29-30	44S	72-74	69S	228-229
20S	30-32	45S	74-511	70S	229-230
21S	32-33	46S	76-78	71S	230-232
22S	32-34	47S	78-80	72S	232-233
23S	34-36	48S	80-82	73S	232-234
24S	36-38	49S	82-84	74S	234-236
25S	38-40	50S	82-86	75S	236-238

Run #1

Straight members – PIPE (cont)

Member #	NODES	Member #	NODES	Member #	NODES
76S	238-240	96S	274-611	116S	310-311
77S	240-241	97S	276-278	117S	400-402
78S	240-242	98S	282-280	118S	402-691
79S	242-244	99S	282-286	119S	404-406
80S	244-246	100S	284-282	120S	406-408
81S	246-248	101S	286-288	121S	408-409
82S	246-250	102S	288-621	122S	422-472
83S	248-302	103S	290-292	123S	460-462
84S	250-252	104S	292-294	124S	462-741
85S	252-254	105S	294-295	125S	464-466
86S	254-256	106S	294-296	126S	466-468
87S	254-258	107S	296-298	127S	468-469
88S	256-260	108S	299-284	128S	503-7
89S	260-262	109S	300-299	129S	513-76
90S	262-264	110S	300-304	130S	603-207
91S	264-266	111S	302-300	131S	613-276
92S	266-268	112S	304-306	132S	623-290
93S	268-270	113S	306-631	133S	633-307
94S	270-272	114S	307-308	134S	693-404
95S	272-274	115S	308-310	135S	743-464

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RUN #1

Curved members – PIPE

member #	NODES	member #	NODES	member #	NODES
1C	501 - 502	7C	611 - 612	13C	691 - 692
2C	502 - 503	8C	612 - 613	14C	692 - 693
3C	511 - 512	9C	621 - 622	15C	741 - 742
4C	512 - 513	10C	622 - 623	16C	742 - 743
5C	601 - 602	11C	631 - 632		
6C	602 - 603	12C	632 - 633		

RUN # 2

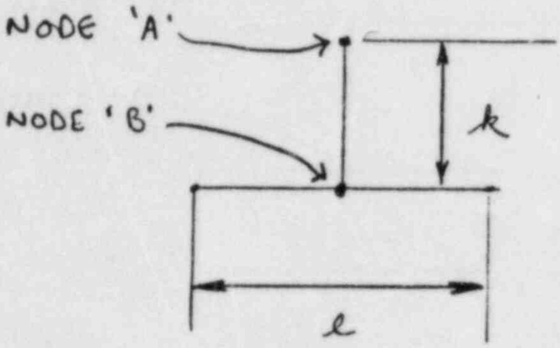
Straight Members – PIPE

member #	NODES	member #	NODES	member #	NODES
136S	310 - 312	142S	408 - 410	148S	420 - 422
137S	312 - 314	143S	410 - 412	149S	422 - 424
138S	314 - 316	144S	412 - 701	150S	424 - 426
139S	316 - 318	145S	414 - 416	151S	468 - 470
140S	316 - 320	146S	416 - 418	152S	470 - 472
141S	318 - 322	147S	418 - 420	153S	703 - 414

Curved members – PIPE

member #	NODES
17C	701 - 702
18C	702 - 703

VALVE GEOMETRY - MODEL 3



VALVE DESIGNATION	NODE A	NODE B	l (IN)	k (IN.)	VALVE WEIGHT (lb.)
V-19-35	221	220	7.0	5.0	24.0
V-19-36	21	20	7.0	5.0	24.0
V-19-7	41	40	12.0	10.0	100.0
V-19-8	241	240	12.0	10.0	100.0
V-19-37	233	232	7.0	2.0	20.0
V-19-38	33	32	7.0	2.0	20.0
V-19-41	295	294	5.0	5.0	16.0
V-19-23	311	310	9.0	8.0 @45°	45.0
V-19-42	409	408	12.0	5.0	40.0
V-19-43	469	468	12.0	5.0	40.0

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Project: 83-03

VALVE GEOMETRY - MODEL 3 (CONT.)

VALVE DESIGNATION	NODE		l (in.)	k (in.)	VALVE WEIGHT (lb.)
	A	B			
V-19-44	NA	70	6.0	0.0	40.0
V-19-45	NA	270	6.0	0.0	40.0
Accumulator	NA	26	NA	0.0	65.0
Accumulator	NA	226	NA	0.0	65.0

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Project: 83-03

Support Locations and Geometry - Model 3

ANCHORS AND SEISMIC RESTRAINTS

SUPPORT LOCATION (NODE	TRANSLATION			ROTATION			TYPE OF SUPPORT
	X	Y	Z	X	Y	Z	
8	X	X	X	X	X	X	PUMP ANCHOR
24	X		X				LATERAL SEISMIC RESTRAINT
36		X	X				U-Bolt Restraint
78	X	X					U-Bolt Restraint
208	X	X	X	X	X	X	Pump Anchor
224	X		X				LATERAL SEISMIC RESTRAINT
236		X	X				U-Bolt Restraint
278	X	X					U-Bolt Restraint
322	X	X					U-Bolt Restraint
416 *	X	X					U-Bolt Restraint
426	X	X					U-Bolt Restraint

* Note: IN computer run POISON 5, restraint WAS inadvertantly provided in the yz directions rather than the xy directions. The piping system is restrained at this location in the z direction by the NP-1-R4 U-Bolt AND the poison tank Anchor, so this restraint is not inaccurate. The lack of a restraint in the y direction may cause stresses to be larger than one would expect with a restrained pipe. The resulting analysis is therefore conservative.

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TABLE 3

POISON PIPING SUCTION LINE OUTSIDE CONTAINMENT (MODEL 4)

RUN ID #	NODE NUMBER	X	Y	Z
1	2	0.0	0.0	0.0
1	4	8.995	-.290	0.0
1	5	13.993	-.451	0.0
1	6	14.315	9.544	0.0
1	7	18.990	-.613	0.0
1	8	31.000	-1.000	0.0
1	201	47.606	-1.536	0.0
1	400	49.032	-1.868	0.0
1	202	50.221	-2.719	0.0
1	14	52.030	-4.649	0.0
1	16	54.000	-6.750	0.0
1	18	54.000	-6.750	3.000
1	38	54.000	-6.750	-3.000
1	211	54.000	-6.750	10.250
1	410	55.098	-6.750	12.902
1	212	57.750	-6.750	14.000
1	24	58.000	-6.750	14.000
1	26	63.000	-6.750	14.000
1	27	63.000	3.25	14.000
1	28	68.000	-6.750	14.000
1	30	72.000	-6.750	14.000
1	32	76.500	-6.750	14.000
1	33	76.500	-3.750	14.000
1	34	81.00	-6.750	14.000
1	36	85.000	-6.750	14.000

Title: PIPING CONFIGURATION
Calculated by: MJK Date: 11/28/83
Checked by: [illegible] Date: 12/1/83
Reviewed by: JJ Date: 12-1-83

Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
1	39	54.000	-6.750	-9.000
1	221	54.000	-6.750	-15.250
1	415	55.097	-6.800	-17.902
1	222	57.746	-6.920	-19.000
1	44	77.975	-7.836	-19.000
1	46	101.951	-8.922	-19.000
1	48	126.925	-10.053	-19.000
1	49	156.015	-11.370	-19.000
1	50	158.892	-11.500	-19.000
1	52	158.892	-11.500	-16.000
1	76	158.892	-11.500	-22.00
1	54	158.892	-11.500	-9.000
1	231	158.892	-11.500	11.250
1	420	159.761	-10.829	13.902
1	232	161.860	-9.208	15.010
1	241	163.048	-8.292	15.000
1	440	165.147	-6.671	13.902
1	242	166.016	-6.000	11.250
1	64	166.016	-6.000	0.0
1	68	166.016	-6.000	-5.000
1	69	166.016	4.000	-5.000
1	70	166.016	-6.000	-10.000
1	74	166.016	-6.000	-15.750
1	251	158.892	-11.500	-27.250
1	450	159.990	-11.508	-29.902
1	252	162.642	-11.528	-31.000
1	82	182.891	-11.682	-31.000
1	150	189.891	-11.735	-31.000
1	84	192.891	-11.758	-31.000
1	152	195.891	-11.780	-31.000

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Title: PIPING CONFIGURATION
Calculated by: [illegible] Date: 11/28/83
Checked by: [illegible] Date: 12/1/83
Reviewed by: [illegible] Date: 12-1-83

Project: 83-03

RUN ID #	NODE NUMBER	X	Y	Z
1	86	208.891	-11.879	-31.000
1	156	192.891	-11.750	-33.250
1	261	221.142	-11.972	-31.000
1	460	223.793	-11.992	-29.902
1	262	224.892	-12.000	-27.750
1	92	224.890	-12.000	-13.000
1	271	224.892	-12.000	11.250
1	470	225.710	-11.268	13.902
1	272	227.687	-9.500	15.000
1	281	228.803	-8.500	15.000
1	480	230.779	-6.732	13.902
1	282	231.598	-6.000	11.250
1	102	231.598	-6.000	0.0
1	104	231.598	-6.000	-5.000
1	105	231.598	4.000	-5.000
1	106	231.598	-6.000	-10.000
1	108	231.598	-6.000	-15.750
1	158	192.891	-11.750	-38.250
1	291	192.891	-11.758	-39.120
1	490	192.633	-11.758	-39.742
1	292	192.011	-11.758	-40.000
1	160	191.261	-11.758	-40.000
1	162	186.891	-11.758	-40.000
1&2	164	183.891	-11.758	-40.000
1	165	183.891	-6.758	-40.000
2	166	180.891	-11.758	-40.000
2	168	168.891	-11.758	-40.000

Element Definition (MODEL 4)

Run # 1

Straight members – PIPE

member #	NODES	member #	NODES	member #	NODES
1S	2-4	21S	44-46	41S	104-106
2S	4-5	22S	46-48	42S	106-108
3S	5-6	23S	48-49	43S	150-84
4S	5-7	24S	49-50	44S	152-86
5S	7-8	25S	50-52	45S	156-158
6S	8-201	26S	50-76	46S	158-291
7S	14-16	27S	52-54	47S	160-162
8S	16-18	28S	54-231	48S	162-164
9S	16-38	29S	64-68	49S	164-165
10S	18-211	30S	68-69	50S	202-14
11S	24-26	31S	68-70	51S	212-24
12S	26-27	32S	70-74	52S	222-44
13S	26-28	33S	76-251	53S	232-241
14S	28-30	34S	82-150	54S	242-64
15S	30-32	35S	84-152	55S	252-82
16S	32-33	36S	84-156	56S	262-92
17S	32-34	37S	86-261	57S	272-281
18S	34-36	38S	92-271	58S	282-102
19S	38-39	39S	102-104	59S	292-160
20S	39-221	40S	104-105		

Title: PIPING CONFIGURATION
Calculated by: [illegible] Date: 11/28/83
Checked by: [illegible] Date: 12/1/83
Reviewed by: [illegible] Date: 12-1-83

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Run # 1

Curved members – PIPE

member #	NODES	Member #	NODES	Member #	NODES
1C	201-400	8C	271-470	15C	440-242
2C	211-410	9C	281-480	16C	450-252
3C	221-415	10C	291-490	17C	460-262
4C	231-420	11C	400-202	18C	470-272
5C	241-440	12C	410-212	19C	480-282
6C	251-450	13C	415-222	20C	490-292
7C	261-460	14C	420-232		

Run # 2

Straight members – PIPE

Member #	NODES
60S	164-166
61S	166-168

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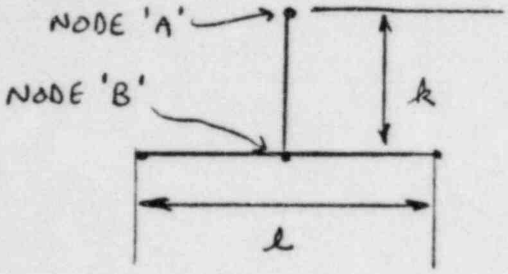
Reviewed by: [illegible] | Date: 12-1-83

Project: 83-03

VALVE GEOMETRY - MODEL 4



VALVE DESIGNATION	NODE A	NODE B	l (in.)	k (in)	VALVE Weight (lb.)
V-19-4	6	5	10.0	10.0	95.0
V-19-11	27	26	10.0	10.0	95.0
V-19-10	33	32	9.0	3.0	55.0
V-19-5	69	68	10.0	10.0	95.0
V-19-6	105	104	10.0	10.0	95.0
V-19-9	165	164	6.0	5.0	16.0

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Calculated by: [illegible] Date: 11/28/83
Checked by: [illegible] Date: 12/1/83
Reviewed by: [illegible] Date: 12-1-83

Project: 83-03

Support Locations AND Geometry - Model 4

ANCHORS AND SEISMIC RESTRAINTS

Support Location (NODE)	TRANSLATION			ROTATION			TYPE of SUPPORT
	X	Y	Z	X	Y	Z	
2	X	X	X	X	X	X	POISON TANK ANCHOR
36	X	X	X	X	X	X	TEST TANK ANCHOR
39	X	X					U-Bolt RESTRAINT
46		X	X				U-Bolt RESTRAINT
54	X	X					U-Bolt RESTRAINT
74	X	X	X	X	X	X	PUMP ANCHOR
92	X	X					U-Bolt RESTRAINT
108	X	X	X	X	X	X	PUMP ANCHOR
168		X	X				U-Bolt RESTRAINT

APPENDIX B

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title:	MATERIAL AND PHYSICAL PROPERTIES - Models 2 & 3	Calculated by: [signature]	Date: 9/13/83
		Checked by: [signature]	Date: 10/4/[illegible]
		Reviewed by: [signature]	Date: 12-1-83
Project:	SEP PIPING 83-03		Page 1 of 19

PURPOSE

The following calculation documents the material and physical properties used in the piping model of the liquid poison system pump discharge line outside containment.

References

(1) BR Spec. S-2299-60-C

(2) ANSI B16.11 - 1966

(3) ASME Code, Sec III Appendices, 1980 Ed.

Summary

Model 3

Pipe ID #	Material ID #	OD (IN.)	thickness (IN.)	weight per unit length (lb/in)
1	1	1.315	0.179	0.207
2	1	1.722	0.196	0.316
3	1	1.392	0.179	0.223
4	1	1.900	0.200	0.366
5	1	2.351	0.218	0.517
6	1	1.995	0.200	0.391
7	1	2.375	0.218	0.525
8	1	2.882	0.238	0.723
9	1	2.488	0.218	0.559
10	1	7.00	2.75	10.455

Model 2

Pipe ID #	Material ID #	OD (IN.)	thickness (IN.)	weight per unit length
4	1	1.900	0.200	0.366
5	1	2.351	0.218	0.517
6	1	1.995	0.200	0.391
10	1	7.00	2.75	10.455

Material I.D. No.	Modulus of Elasticity	Poissan's Ratio	Coefficient of thermal expansion	Sh
1	28.30×10^{6} PSI	0.3	8.42×10^{-6} in/in °F	18800 PSI

PIPE IDENTIFICATION #1

MATERIAL IDENTIFICATION #1

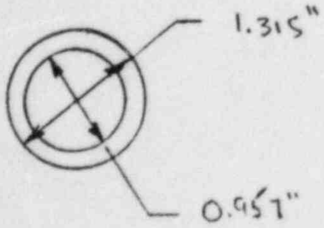
OUTSIDE DIAMETER AND THICKNESS

O.D. = 1.315"

I.D. = 0.957"

t = 0.179"

1" Sch 80 PIPE
Ref: Burns & Roe Spec. 5-2299-60-C
CRANE TECH PAPER #410



Weight per unit length (full of water)

PIPE weight = $A \cdot \rho_{st} = \frac{\pi}{4}(1.315^2 - 0.957^2) \cdot .283 = 0.181$ lb/in

water weight = $A \cdot \rho_w \cdot \frac{\pi}{4}(0.957^2) \cdot 0.0361 = 0.026$ lb/in

TOTAL weight per unit length = 0.207 lb/in

Title: Material & Physical Prop Model 3 & 4
Calculated by: MVK Date: 9/13/83
Checked by: RNC Date: 10/?/83
Reviewed by: TT Date: 12-1-83

Project: 83-03

PIPE IDENTIFICATION # 2

MATERIAL IDENTIFICATION # 1

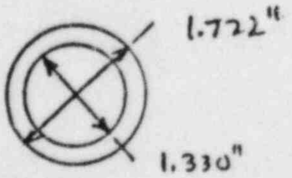
Outside Diameter AND THICKNESS

O.D. - 1.722"

I.O = 1.330"

t = 0.196

1" soc. weld sleeve PIPE PROPERTIES
Ref: ANSI B16.11-1966



See figures 1 & 2

Weight per unit length (full of water)

PIPE weight = $A \cdot \rho_{st} = \frac{\pi}{4}(1.722^2 - 1.330^2) \cdot .283$ = .266 lb/in

WAter weight = $A \cdot \rho_w = \frac{\pi}{4}(1.330^2) \cdot 0.0361$ = 0.050 lb/in

TOTAL weight per unit length = 0.316 lb/in

PIPE IDENTIFICATION # 3

MATERIAL IDENTIFICATION #: 1

OUTSIDE DIAMETER AND THICKNESS

OD = 1.392"

ID = 1.034"

t = 0.179"

1" soc. weld elbow
Pipe Properties
Ref: ANSI B16.11-1966

See Figure 1

Weight per unit length (full of water)

Pipe weight = $A \cdot \rho_{st} = \frac{\pi}{4}(1.392^2 - 1.034^2) \cdot .283 = 0.193$ lb/in

water weight = $A \cdot \rho_w = \frac{\pi}{4}(1.034^2) \cdot 0.0361 = 0.030$ lb/in

TOTAL WEIGHT per unit length = 0.223 lb/in

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Title: Material & Physical Prop Model 2 & 3
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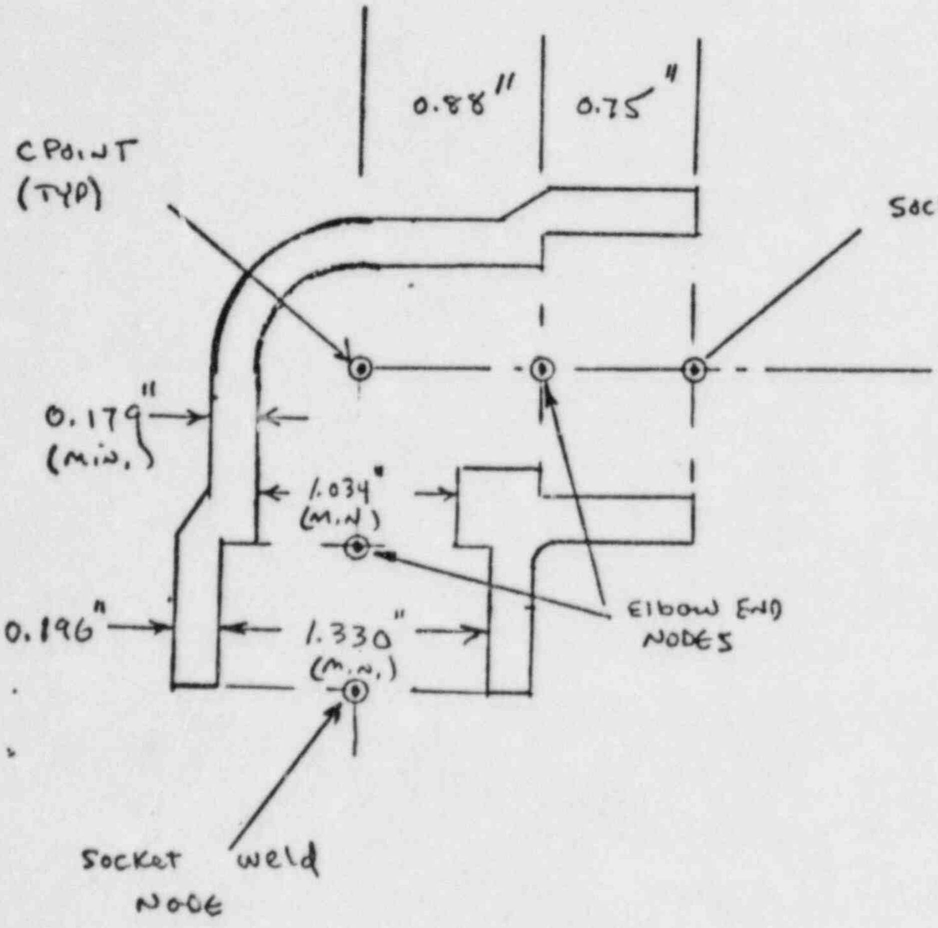
Checked by: [illegible] Date: [illegible]
Reviewed by: [illegible] Date: 12-1-83

Project: 83-03

Figure 1.

1" Socket Weld 90° Elbow ANSI B16.11-1966



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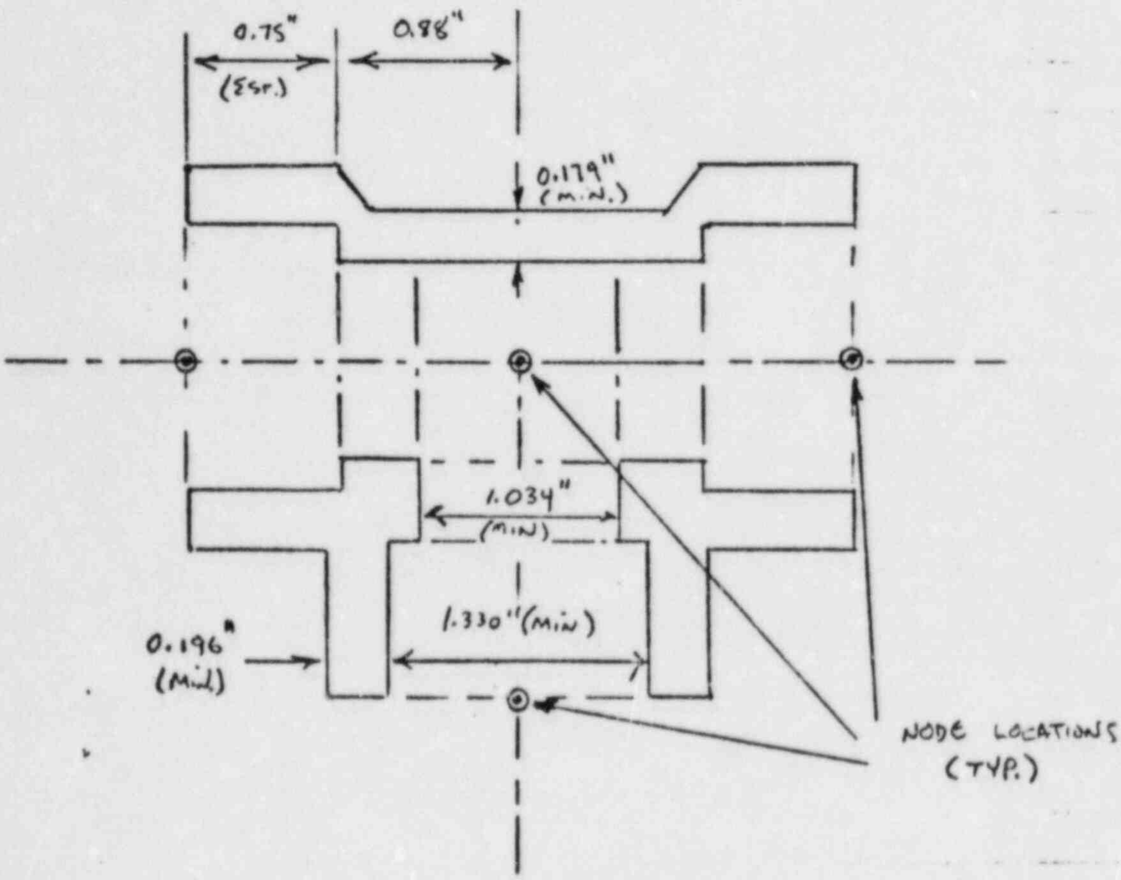
Title: Material & Physical Prop Model 2 & 3	Calculated by:	Date: 9/13/83
	Checked by:	Date: 10/4/83
	Reviewed by: JJ	Date: 12-1-83

Project: 83-03

Figure 2.

1" x 1" x 1" Socket Weld TEE ANSI B16.11-1966



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Title: Material & Physical Prop Model 2 & 3 | Calculated by: MJK | Date: 9/13/83
Checked by: PNC | Date: 10/4/83
Reviewed by: JJ | Date: 12-16-83

Project: 83-03

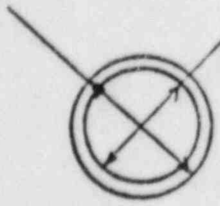
PIPE IDENTIFICATION # 4

MATERIAL IDENTIFICATION #1

OUTSIDE DIAMETER & THICKNESS:

Ref: BURNS & ROE SPECIFICATION S-2299-60-C
CRANE TECH PAPER # 410

PIPE SIZE 1½" NOMINAL SCH. 80



t = .200"

WEIGHT PER UNIT LENGTH (full of WATER):

PIPE WEIGHT – $A \times \rho_{ST} = \frac{\pi}{4}(1.9^2 - 1.5^2) \cdot .283 = 0.302$ lb/in

WATER WEIGHT – $A \times \rho_W = \frac{\pi}{4}(1.5^2) \cdot 0.0361 = 6.3 \times 10^{-2}$ lb/in

TOTAL WT PER UNIT LENGTH = .366 lb/in

PIPE IDENTIFICATION # 5

MATERIAL IDENTIFICATION # 1

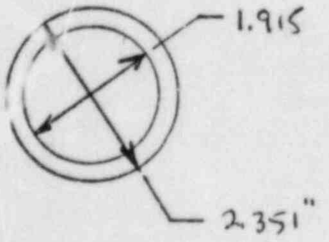
<u>OUTSIDE DIAMETER AND THICKNESS</u>

O.D. = 2.351"

I.D = 1.915"

t = 0.218"

1½" soc. weld sleeve pipe properties Ref ANSI B16.11 -1966



See Figures 3 & 4

Weight per unit length (full of water)

Pipe weight = $A\rho_{st} = \frac{\pi}{4}(2.351^2 - 1.915^2)\cdot .283 = 0.413$ lb/in.

water weight = $A\rho_w = \frac{\pi}{4}(1.915^2)\cdot 0.0361 = 0.104$ lb/in.

Total weight per unit length = 0.517 lb/in.

PIPE IDENTIFICATION # 6

MATERIAL IDENTIFICATION # 1

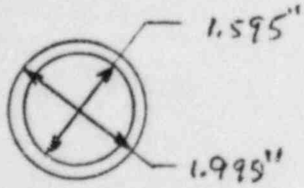
OUTSIDE DIAMETER AND THICKNESS

O.D = 1.995"

ID = 1.595"

t = 0.200"

1½" Soc. weld elbow
PIPE PROPERTIES
Ref. ANSI B16.11 -1966



See figure 4

Weight per unit length (full of water)

Pipe Weight = $A \cdot \rho_{st} = \frac{\pi}{4}(1.995^2 - 1.595^2) \cdot .283 = 0.319$ lb/in

water weight = $A \cdot \rho_w = \frac{\pi}{4}(1.595^2) \cdot 0.0361 = 7.21 \times 10^{-2}$ lb/in

Total Weight per unit length = .391 lb/in

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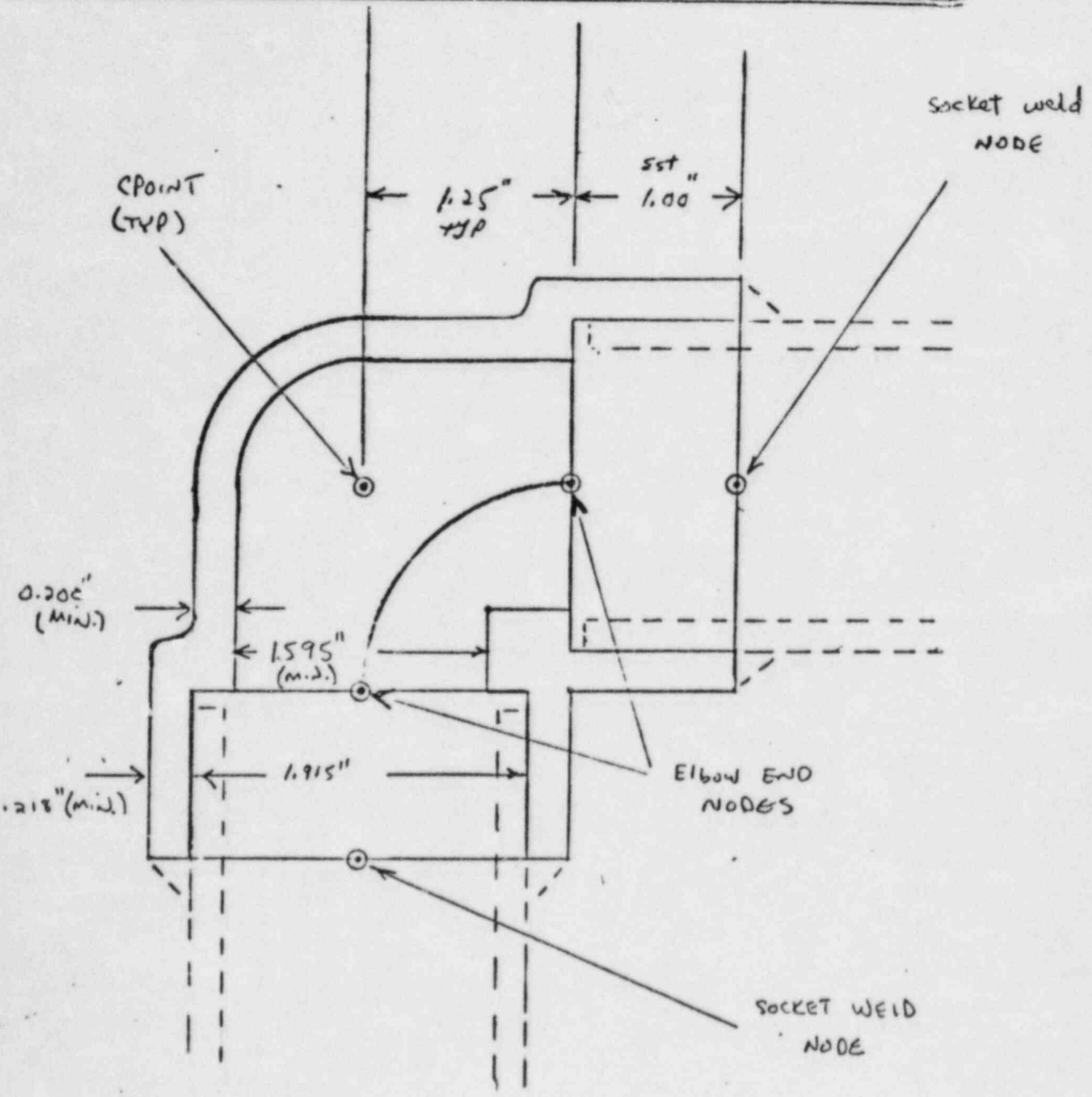
Reviewed by: [illegible] | Date: 12-1-83

Project: 83-03

Figure 3.

1½" Socket weld 90° Elbow ANSI B16.11-1966



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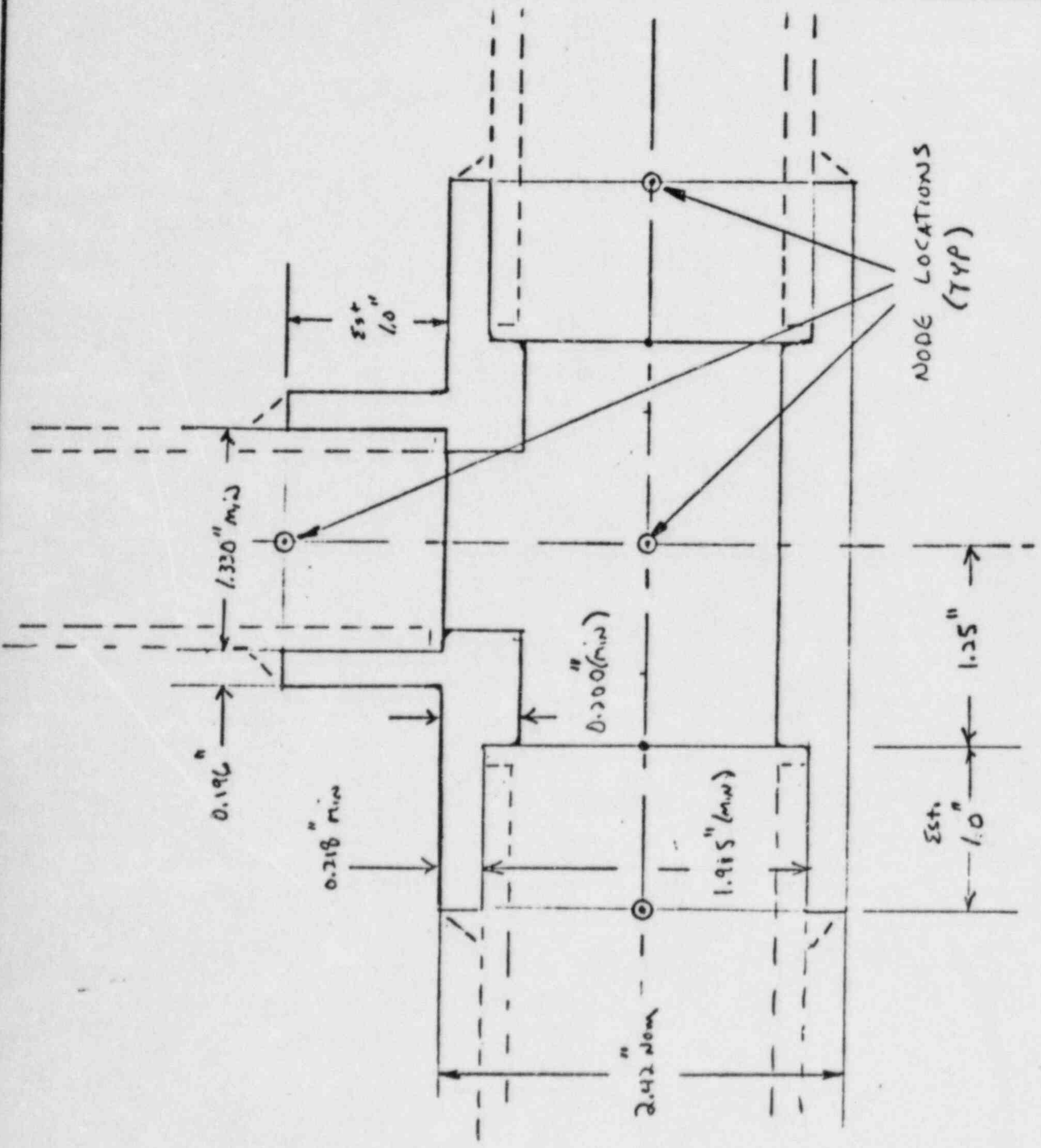
Title: Material & Physical Prop Model 253 | Calculated by: [illegible] Date: 9/13/83
Checked by: [illegible] Date: 10/3/83
Reviewed by: JJ Date: 12.1.83

Project: 83-03

Figure 4.

1½" x 1½" x 1" Socket Weld TEE ANSI B16.11-1966



Title: Material & Physical Prop Model 2 & 3
Calculated by: [illegible] Date: 9/3/83
Checked by: [illegible] Date: [illegible]
Reviewed by: [illegible] Date: 12-1-83

Project: 83-03

PIPE IDENTIFICATION # 7

MATERIAL IDENTIFICATION #1

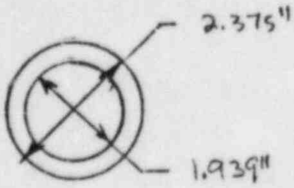
Outside Diameter and Thickness

O.D. = 2.375"

I.D. = 1.939"

t = 0.218"

2" Sch 80 Pipe
Ref: Burns & Roe Spec. 5-2299-60-C
Crane Tech Paper #410



Weight per unit length (full of water)

Pipe weight = $A \cdot \rho_{st} = \frac{\pi}{4}(2.375^2 - 1.939^2) \cdot .283 = 0.418$ lb/in

Water weight = $A \cdot \rho_w = \frac{\pi}{4}(1.939^2) \cdot 0.0361 = 0.107$ lb/in

Total weight per unit length = 0.525 lb/in

PIPE IDENTIFICATION #8

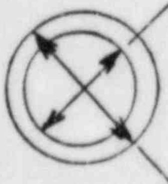
MATERIAL IDENTIFICATION #1

<u>Outside Diameter AND Thickness</u>

O.D. = 2.882"

I.D = 2.406"   2" soc. weld sleeve pipe properties

t = 0.238"   Ref. ANSI B16.11-1966



See figures 5 & 6

weight per unit length (full of water)

Pipe weight = $A \cdot \rho_{st} = \frac{\pi}{4}(2.882^2 - 2.406^2) \cdot .283 =$ 0.559 lb/in

water weight = $A \cdot \gamma_w = \frac{\pi}{4}(2.406^2) \cdot 0.0361 =$ 0.164 lb/in

Total weight per unit length = 0.723 lb/in

PIPE IDENTIFICATION #9

MATERIAL IDENTIFICATION #1

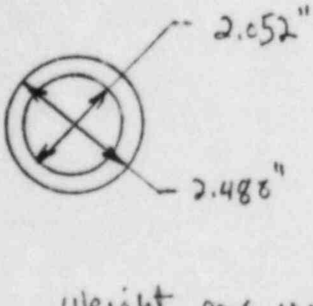
OUTSIDE DIAMETER AND THICKNESS

O.D. = 2.488"

I.D. = 2.052"

t = 0.218"

2" soc. weld elbow
PIPE PROPERTIES
Ref: ANSI B16.11-1966



See Figures 5

Weight per unit length (full of water)

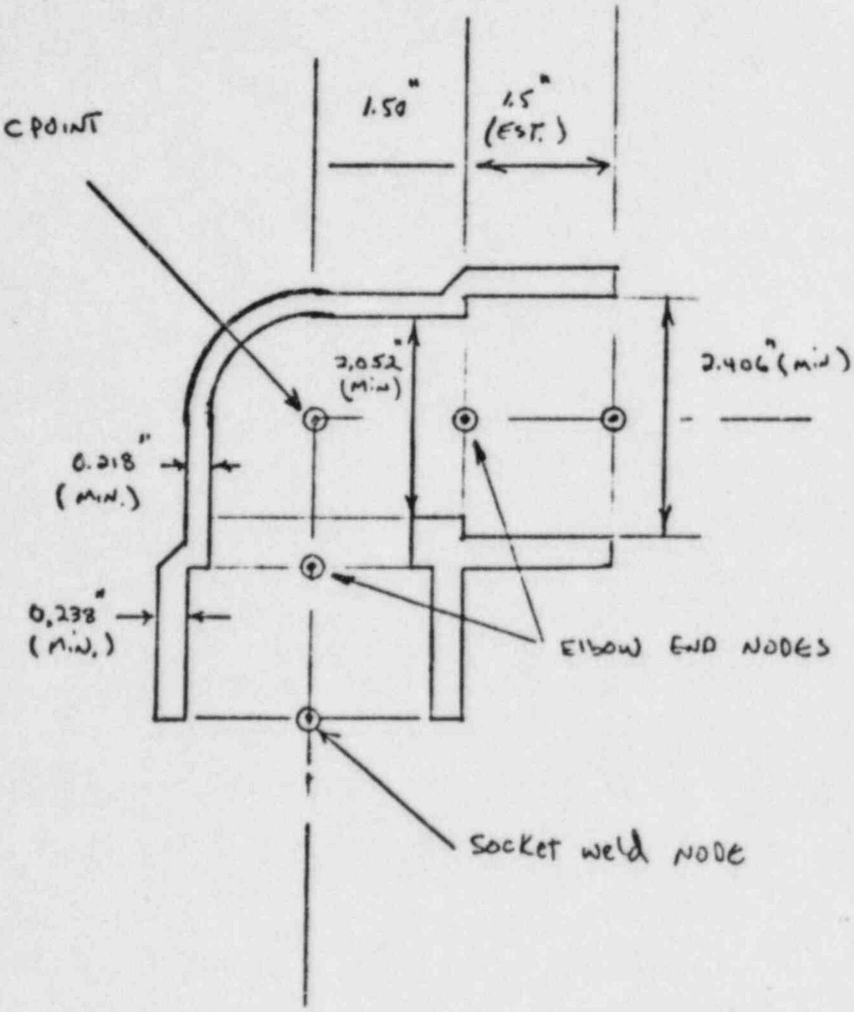
PIPE weight = $A \cdot \rho_{st} = \frac{\pi}{4}(2.488^2 - 2.052^2) \cdot 0.283 = 0.440$ lb/in.

Water weight = $A \cdot \rho_w = \frac{\pi}{4}(2.052^2) \cdot 0.0361 = 0.119$ lb/in.

TOTAL weight per unit length = 0.559 lb/in.

figure 5.

2" Socket Weld 90° Elbow ANSI B16.11-1966



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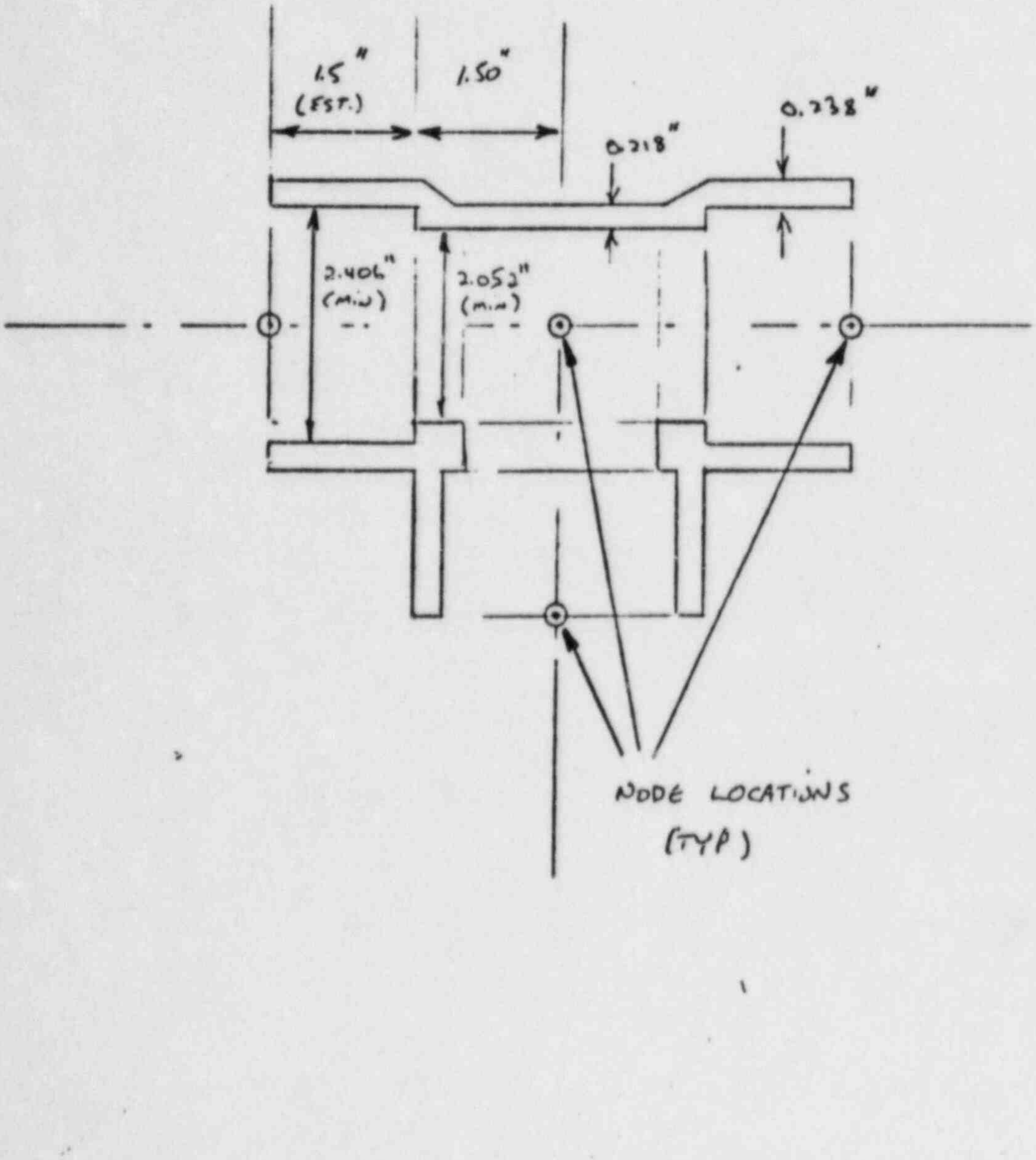
Title: Material & Physical Prop Model Z 83	Calculated by: MJK	Date: 9/13/83
	Checked by: VBC	Date: 12/1/83
	Reviewed by: JJ	Date: 12.1.83

Project: 83-03

Figure 6.

2" Socket Weld TEE ANSI B16.11-1966



PIPE IDENTIFICATION # 10

MATERIAL IDENTIFICATION #1

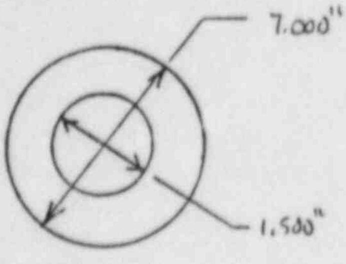
Outside Diameter AND Thickness

OD = 7.0"

ID = 1.500"

t = 2.75"

1½" Welded Flange (Soc. weld) Pipe Properties
Ref ANSI B 16.5 – 1968 P.53



Weight per unit length (full of water)

Pipe weight = $A \cdot \rho_{ST} = \frac{\pi}{4}(7.00^2 - 1.50^2) \cdot 0.283 = 10.391$ lb/in

Water weight = $A \cdot \rho_w = \frac{\pi}{4}(1.500^2) \cdot 0.0361 = 0.064$ lb/in

Total weight per unit length = 10.455 lb/in

PIPE MATERIAL

NP-2

ASTM A312 or A376, TP 316 PIPE (Sch 80)

ASTM A182 - F316, socket Weld fittings (#3000 rating)

Ref: BR Spec S-2299-60-C, p. II-11, 12

From 1980 ASME Code Appendices

16 Cr - 12 Ni - 2 Mo

α @ 70°F = 8.42×10^{-6} in/in °F
{ASME Code Sec. III AppEND. Table I-5.0}

E @ 70°F = 28.3×10^{6} PSI*
{ASME Code Sec III Append Table I-6.0}

Poisson ratio ν = .3

S_h pipe = 18.8 KSI
S_h fittings = 18.8 KSI
} Allowable Stress for use in eq (9) of Sec. III, Subsection NC, Art. NC-3653.1

{ASME Code Sec III AppEND. Table I-7.2}

Title: Material & Physical Properties - Model 4
Calculated by: [illegible] Date: 9/13/83
Checked by: [illegible] Date: [illegible]
Reviewed by: [illegible] Date: 12-1-83

Project: SEP Piping 83-03

Purpose

The following calculation documents the material and physical properties used in the piping model of the liquid poison system pump suction line outside containment.

References

(1) BR Spec S-2299-60-C

(2) ANSI B16.11-1966

(3) ASME Code, Sec III Appendices, 1980 Ed.

(4) ANSI B16.9-1978

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Material & Physical Properties Model 4 | Calculated by: [illegible] | Date: 9/13/83
Checked by: [illegible] | Date: 12/1/83
Reviewed by: [illegible] | Date: 12-1-83

Project: 83-03

Summary

Model 4

PIPE ID #	MATERIAL ID #	O.D (IN)	thickness (in.)	weight per unit length (lb/in)
1	1	2.875	0.276	0.791
2	1	1.315	0.179	0.207
3	1	1.722	0.196	0.316
4	1	1.392	0.179	0.233

MATERIAL ID. NO	MODULUS of ELASTICITY	POISSAN'S RATIO	Coefficient of thermal expansion	Sh
1	28.30×10^{6} PSI	0.3	8.42×10^{-6} in/in/°F	18,800 PSI

PIPE IDENTIFICATION # 1

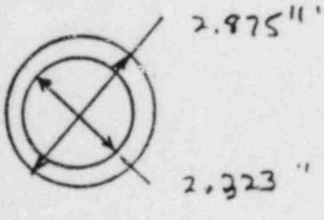
MATERIAL IDENTIFICATION # 1

OUTSIDE DIAMETER AND THICKNESS

OD = 2.875"

ID = 2.323 2 1/2" sch 80 PIPE

t = .276"



Weight per unit length (Full of water)

Pipe Weight = $A \cdot \rho_{st} = \frac{\pi}{4}(2.875^2 - 2.323^2) \cdot .283$ 0.638 lb/in

Water Weight = $A \cdot \rho_w = \frac{\pi}{4}(2.323)^2 \cdot .0361 =$ 0.153 lb/in

TOTAL Weight per unit length = 0.791 lb/in

PIPE IDENTIFICATION # 2

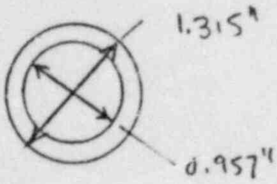
MATERIAL IDENTIFICATION # 1

OUTSIDE DIAMETER AND THICKNESS

OD = 1.315"

ID = 0.957" — 1" Sch 80 PIPE, REF: CRANE TECH PAPER # 410

t = 0.179"



Weight per unit length (full of water)

PIPE weight = $A \cdot \rho_{st} = \frac{\pi}{4}(1.315^2 - 0.957^2) \cdot .283 = 0.181$ lb/in

water weight = $A \cdot \rho_w = \frac{\pi}{4}(0.957^2) \cdot .0361 = 0.026$ lb/in

Total weight per unit length = 0.207 lb/in

PIPE IDENTIFICATION # 3

MATERIAL IDENTIFICATION # 1

<u>OUTSIDE DIAMETER AND THICKNESS</u>

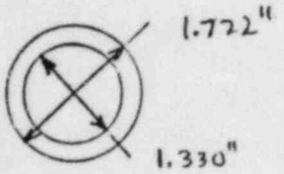
O.D. = 1.722"

I.D = 1.330"

t = 0.196

1" soc. weld sleeve
PIPE PROPERTIES
Ref: ANSI B16.11-1966

See Figure 1



Weight per unit length (full of water)

Pipe weight = $A \cdot \rho_{st} = \frac{\pi}{4}(1.722^2 - 1.330^2) \cdot .283 =$ .266 lb/in

Water weight = $A \cdot \rho_w = \frac{\pi}{4}(1.330^2) \cdot 0.0361 =$ 0.050 lb/in

Total weight per unit length = 0.316 lb/in

PIPE IDENTIFICATION # 4

MATERIAL IDENTIFICATION # 1

<u>OUTSIDE DIAMETER AND THICKNESS</u>

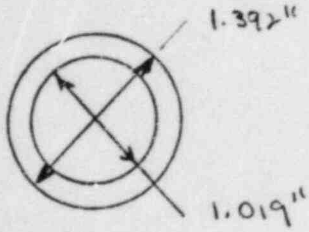
OD = 1.392"

ID = 1.034"

t = 0.179"

1" soc. weld Elbow
Pipe Properties
Ref: ANSI B16.11-1966

See figure 1



Weight per unit length (full of water)

Pipe weight = $A \cdot \rho_{st} = \frac{\pi}{4}(1.392^2 - 1.034^2) \cdot .283 = 0.193$ lb/in

water weight = $A \cdot \rho_w = \frac{\pi}{4}(1.034^2) \cdot 0.0361 = 0.030$ lb/in

TOTAL WEIGHT per unit length = 0.223 lb/in

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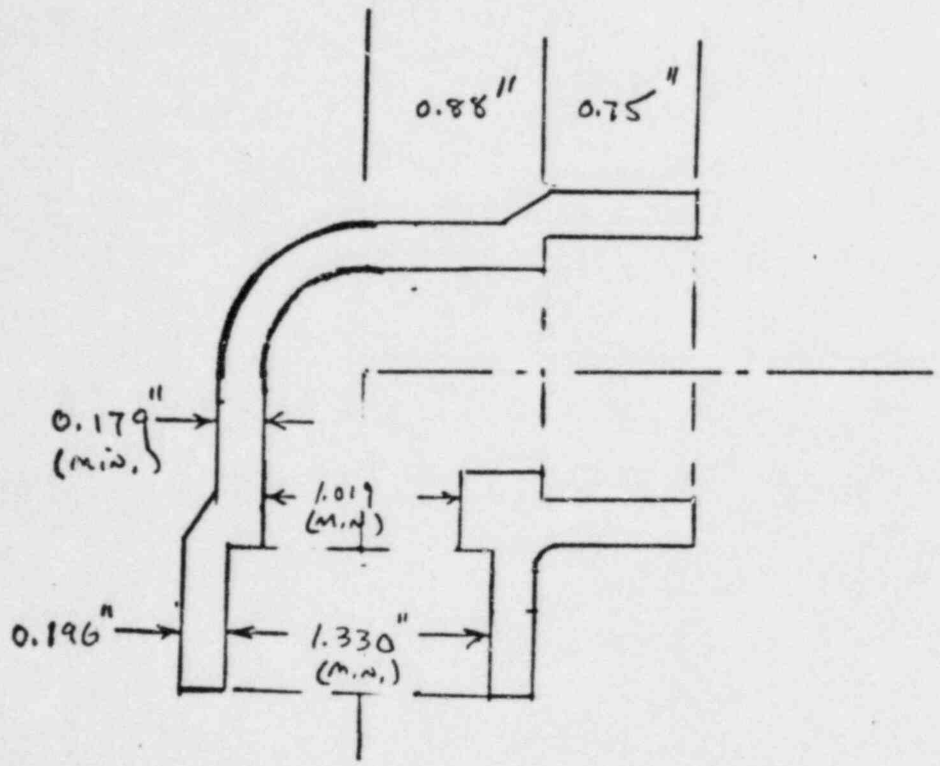
Title: Material & Physical Prop Model 4 | Calculated by: [illegible] | Date: 9/13/83
Checked by: [illegible] | Date: [illegible]
Reviewed by: [illegible] | Date: 12-1-83

Project: 83-03

Figure 1.

1" Socket Weld 90° Elbow ANSI B16.11-1966



MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: Materials & Physical Prop Model 4 | Calculated by: MJK | Date: 9/13/83
Checked by: RAL | Date: 10/4/83
Reviewed by: JT | Date: 12-1-83

Project: 8307

PIPE material

NP-1

ASTM A312 or A376, TP316 PIPE (Sch 80)

ASTM A182-F316, socket weld fittings (#3000 rating)

Ref: BR Spec. S-2299-60-C, p. II-11, 12

from 1980 ASME Code Appendices

16Cr – 12Ni – 2Mo

α @ 70°F = 8.42×10^{-6} in/in °F
{ASME Code Sec. III Append. Table I-5.0}

E @ 70°F = 28.3×10^{6} PSI *
{ASME Code Sec III Append. Table I-6.0}

Poissan's ratio ν = .3

S_h pipe = 18.8 KSI
S_h fittings = 18.8 KSI

} Allowable stress for use in eq. (9) of Sec III, Subsection NC, Art NC-3653-1

{ASME Code Sec III Append. Table I-7.2}

APPENDIX C

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: THERMAL DISPLACEMENTS LIQUID POISON SYSTEM

Calculated by: [illegible] Date: 8/30/83
Checked by: [illegible] Date: [illegible]
Reviewed by: [illegible] Date: 12-1-83

Project: SEP - PIPING 83-03

PURPOSE:

The following calculation Determines Anchor movements for the liquid poison piping outside containment.

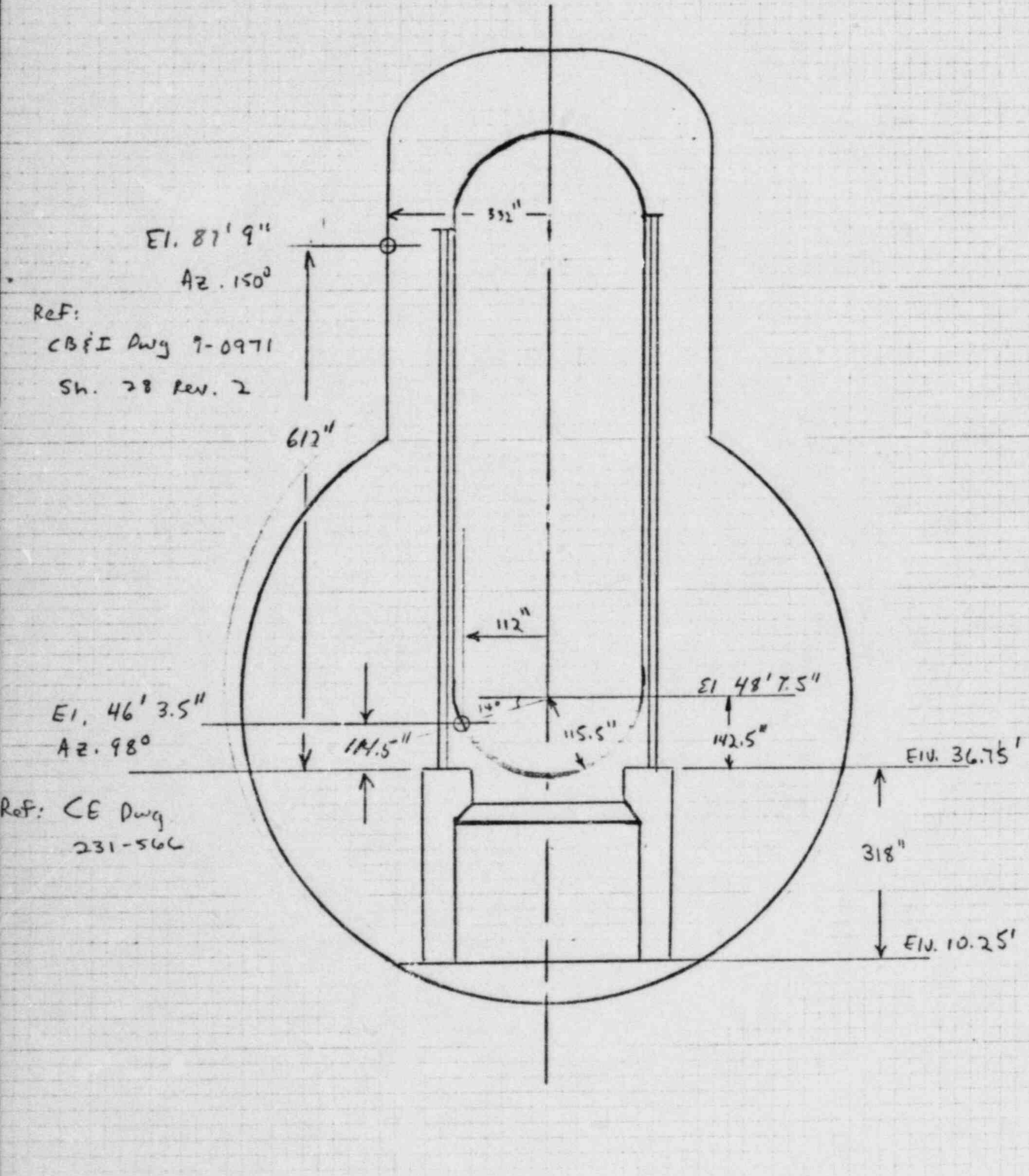
DESCRIPTION:

The piping attachments to the reactor vessel and drywell are shown in figure 1.

83-03

Calc. by MJ Kennedy 8/30/83
Chek by RW Cual 10/5/83

Figure 1.



MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: Thermal Displacements Liquid Poison System
Calculated by: [signature] Date: 8/30/83
Checked by: [initials] Date: 10/1/83
Reviewed by: [initials] Date: 12-1-83

Project: 83-03

Coefficients of Thermal Expansion

Containment – 5.86×10^{-6} in/in °F @ 135°F

Containment material – A212 B, Ref CB & I Dwg # 9-0971 SH. No. 7 Rev. 5

Equivalent material SA-516 Gr.70 (C-Mn-Si)
Mat. Group B. (Mean Value – B)

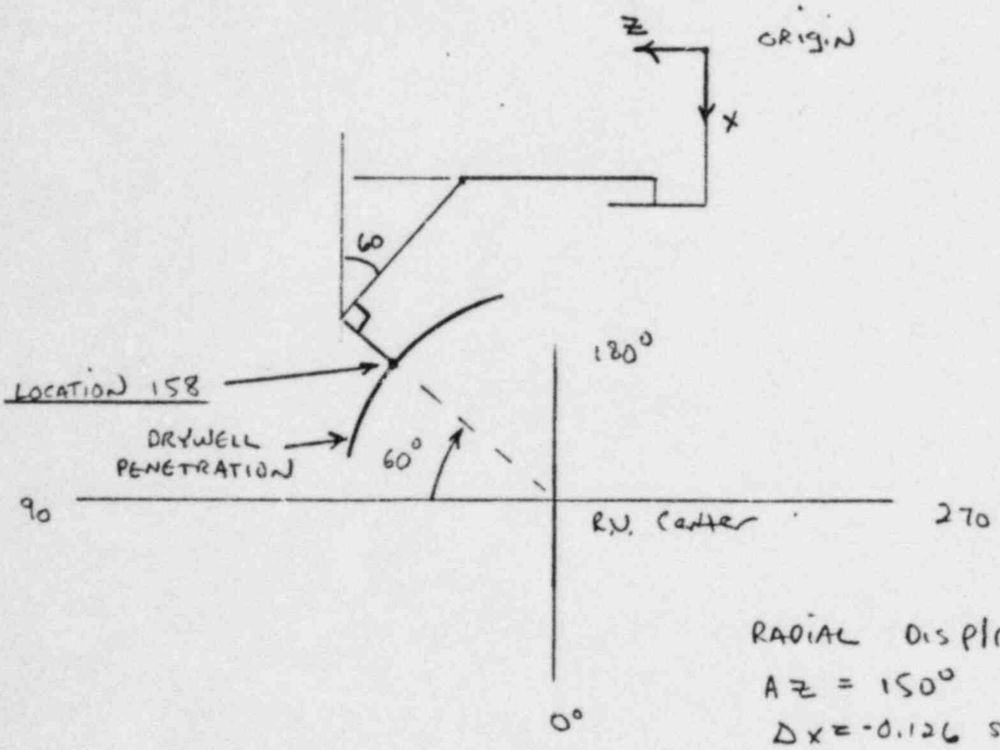
Operating Conditions Expansion Displacement Calculation

Location	α (in/in °F)	L (in.)	ΔT (°F)	d (in.)
D.W. Vertical	5.86×10^{-6}	930.0	65.0	0.354
D.W Radial		332.0	65.0	0.126

Title: Thermal Displacements Liquid Poison System	Calculated by: MJK	Date: 8/30/83
	Checked by: PNC	Date: 10/7/83
	Reviewed by: JT	Date: 10-1-83

Project: 83-03

MODEL 2



RADIAL DISPLACEMENT = 0.126"

AZ = 150°

$\Delta x = -0.126 \sin 60 = -0.109"$

$\Delta z = 0.126 \cos 60 = +0.063"$

ANCHOR DISPLACEMENTS FOR USE IN COMPUTER ANALYSIS

MODEL 2

LOCATION	x	y	z
158	-0.109	0.354	0.063

NOTE: IN PIPESD computer run POISON 2, a vertical (y) displacement of .233" WAS USED. This has a negligible effect on deadweight stresses, see Attachment A to Appendix E.

APPENDIX D

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: RESPONSE SPECTRA | Calculated by: B. Tipford | Date: 2-25-83
Checked by: M. Kennedy | Date: 2/25/83
Reviewed by: J. Johnson | Date: 2-25-83

Project: SEP PIPING
8303

PURPOSE

THE FOLLOWING CALCULATION DETERMINES THE RESPONSE SPECTRA INPUT FOR THE DESIGN BASIS EARTHQUAKE AND THE SAFE SHUTDOWN EARTHQUAKE (TWICE THE DESIGN BASIS EARTHQUAKE) FOR THE LIQUID POISON SYSTEM PIPING AT OYSTER CREEK.

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Response Spectra
Calculated by: BJ Date: 2-25-83
Checked by: MJK Date: 2/25/83
Reviewed by: JJ Date: 2-25-83

Project: 83-03

METHOD OF ANALYSIS

RESPONSE SPECTRA WILL BE USED AS INPUT TO THE FINITE ELEMENT PROGRAM "PIPESD" TO ANALYZE EARTHQUAKE EFFECTS.

RESPONSE SPECTRA COME FROM REVISED APPENDIX B OF NUREG/CR-1981*. OYSTER CREEK SITE SPECIFIC SPECTRA ARE GENERATED USING THE NUREG/CR SPECTRA SCALED TO 0.165/0.22 (0.165 g's IS ZPA AT O.C. VS. 0.22 g's USED IN NUREG/CR, PER USNRC LETTER LSO5-81-06-068 DATED 6/17/81)

RESPONSE SPECTRA IN REVISED APPENDIX B ARE FOR 2 TIMES THE DESIGN BASIS EARTHQUAKE.

* REVISED APPENDIX B RECEIVED 6/25/81, FROM LLL LETTER TO MPR (E. SCHMIDT) DATED 6/23/81, LETTER # SM-81-159.

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Response Spectra | Calculated by: BY | Date: 2-25-83
Checked by: MJK | Date: 2/25/83
Reviewed by: JJ | Date: 2-25-83

Project: 83-03

METHODS OF ANALYSIS AND ASSUMPTIONS ARE LISTED BELOW:

- MODAL RESPONSES ARE SUMMED BY THE SQUARE ROOT OF THE SUM OF THE SQUARES METHOD EXCEPT THAT CLOSELY SPACE MODES ARE SUMMED ABSOLUTELY BY THE 10% RULE SPECIFIED IN REG. GUIDE 1.92

- THREE SPATIAL COMPONENTS OF SEISMIC INPUT WILL BE USED (2 HORIZONTAL AND A VERTICAL). THE MAXIMUM CODIRECTIONAL RESPONSES WILL BE COMBINED BY THE SQUARE ROOT OF THE SUM OF THE SQUARES METHOD AS DESCRIBED IN REG-GUIDE 1.92.

- DESIGN BASIS EARTHQUAKE DAMPING = 1.0%
SAFE SHUTDOWN EARTHQUAKE DAMPING = 2.0%
(2 x's DESIGN BASIS). BASED ON REG GUIDE 1.61

- AN UPPER ROUND ENVELOPE OF ALL INDIVIDUAL RESPONSE SPECTRA WILL BE USED BASED ON STANDARD REVIEW PLAN, SECTION 3.7.3. (NUREG-0800) ELEVATIONS VARY FROM ~95' 3" (Elevation of poison pumps & storage tank) to ~46' 3" (Elevation of Reactor Vessel Nozzle). Enveloped Horizontal Spectra will be from 38' 5" to 95' 3"

- RESPONSE SPECTRA TAKEN FROM NUREG/CR-1981, USED TO ANALYZE THE SYSTEM PIPING, WILL COME FROM SPECTRA GENERATED FOR THE REACTOR BUILDING. THIS ASSUMPTION IS BASED ON THE FACT THAT STRUCTURAL SUPPORT AND LATERAL BRACING BETWEEN THE REACTOR BUILDING AND THE PRIMARY SUPPORTS (DRYWELL, BIO-SHIELD, & REACTOR VESSEL) WILL FORCE THE PRIMARY SUPPORT SYSTEMS TO MOVE WITH THE REACTOR BUILDING.

- RESPONSE SPECTRA FOR 1% AND 2% DAMPING WILL BE EXTRAPOLATED FROM THE SPECTRA PROVIDED IN NUREG/CR-1981.

- ANCHOR MOVEMENTS DURING EARTHQUAKE ANALYSIS ARE CONSIDERED NEGLIGIBLE. THIS ASSUMPTION IS BASED ON THE ANCHOR DISPLACEMENT EQUATION:

$$S_d = S_a\, g/\omega^2 \; *$$

S_d = DISPLACEMENTS
S_a = ZPA (g's)
g = ACCELERATION CONSTANT (386.4 in/sec²)
ω = NATURAL FREQUENCY OF PRIMARY SUPPORT STRUCTURE

* REFERENCE STANDARD REVIEW PLAN 3.7.3

FOR THE REACTOR VESSEL.

$T_n = 0.13$ sec

REF. - REPORT ON SEISMIC ANALYSIS OF THE R.V. FOR JCP&L "JOHN A. BLUME & ASSOCIATE ENGRS" 3/16/66.

$f_n = 1/T_n = 7.692$ cycles/sec

$\omega_n = 7.692 \text{ cycles/sec} \times \frac{2\pi}{} = 48.332$ rad/sec

$$S_a = \sqrt{S_{a_H}^2 + S_{a_H}^2 + S_{a_V}^2}$$

S_{aH} = HORIZONTAL ZPA 0.23 g's
S_{aV} = VERTICAL ZPA = 0.09 g's

S_a = .337 g's

$$S_d = \frac{0.337\,(386.4)}{(48.332)^2} = .06 \text{ in}$$

MPR ASSOCIATES, INC.

1050 Connecticut Ave., NW - Washington, DC 20036

Title: Response Spectra

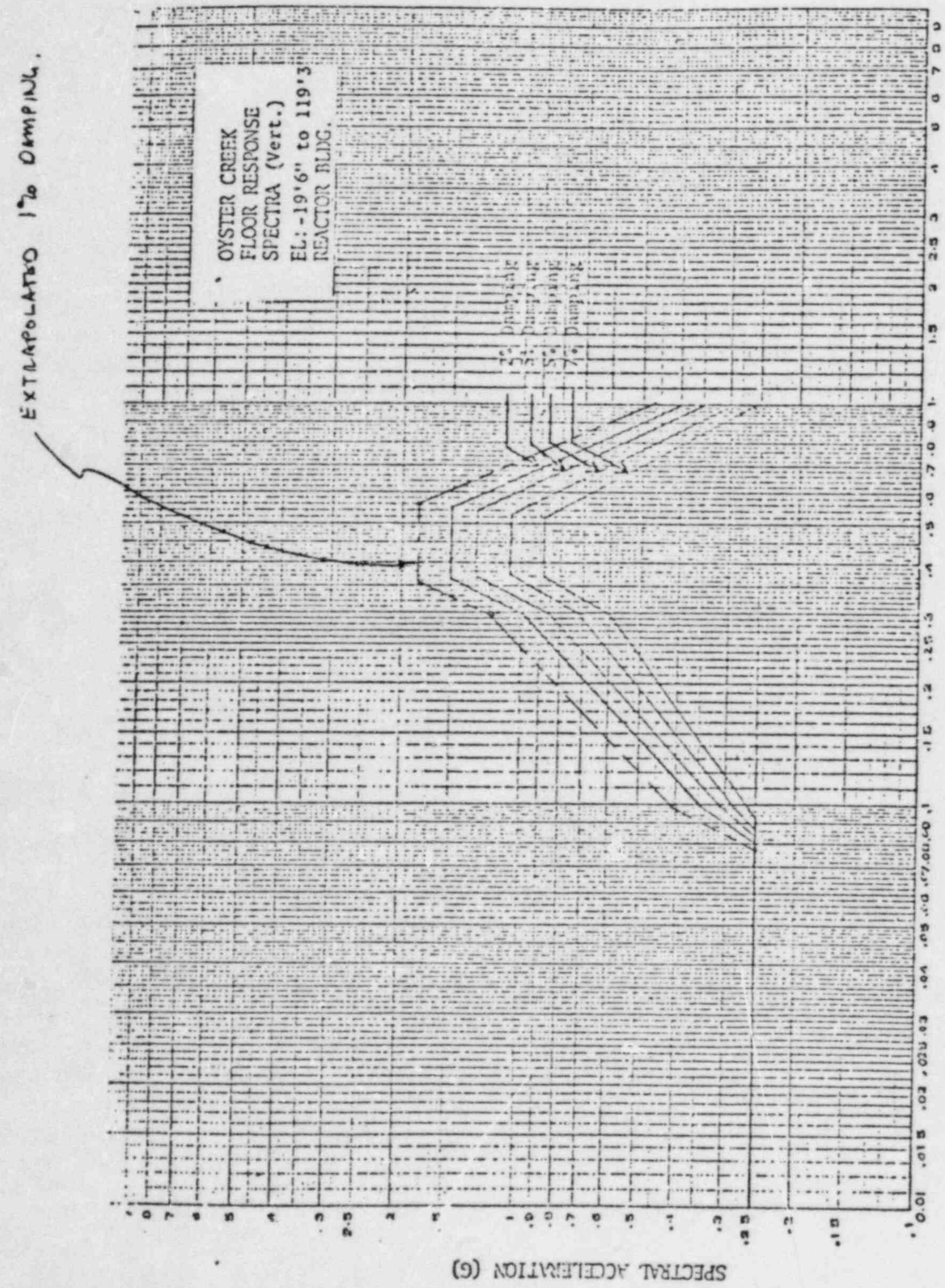
Calculated by: BJ — Date: 2-25-83

Checked by: mjr — Date: 2/25/83

Reviewed by: JJ — Date: 2-25-83

Project: 83-03

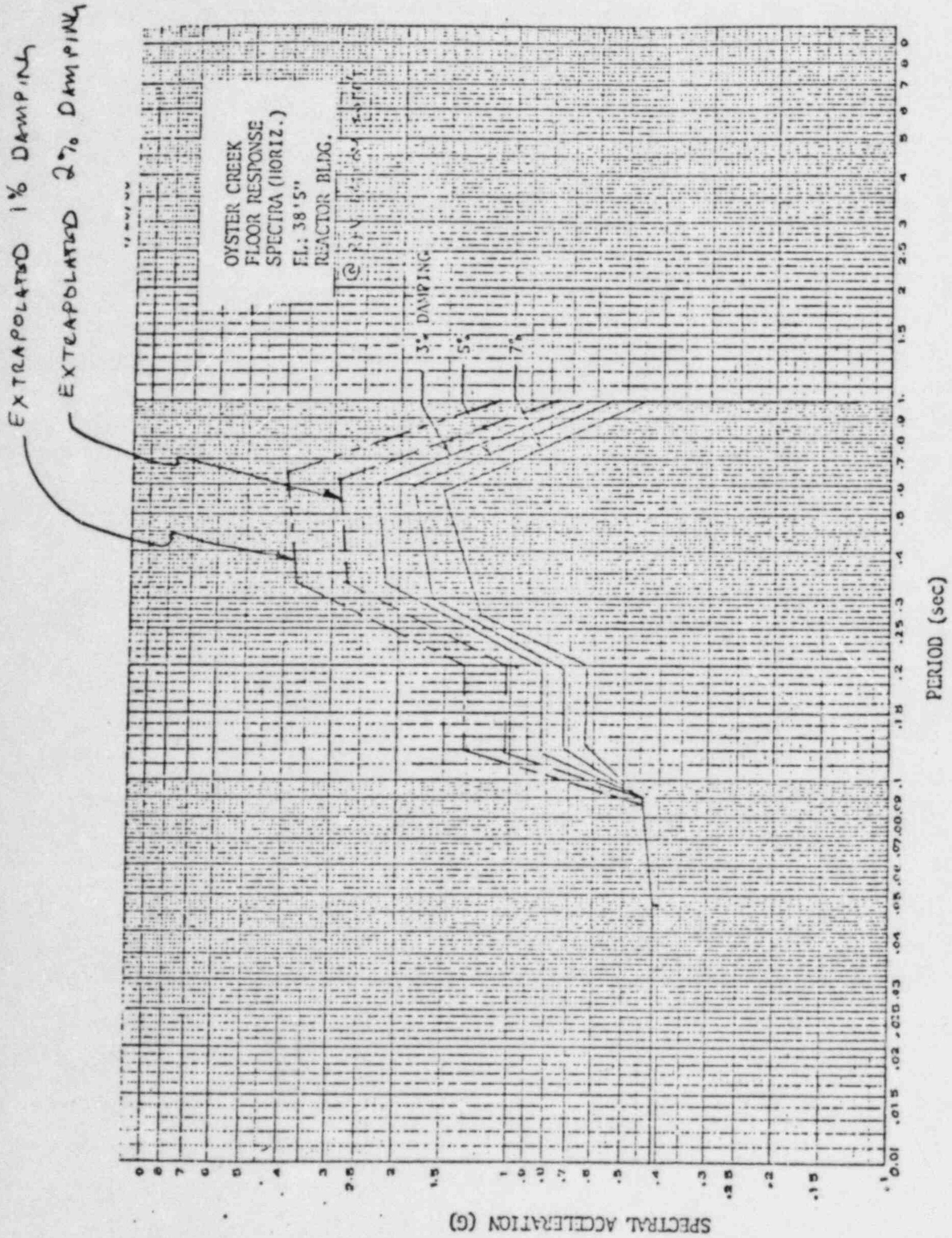
VERTICAL RESPONSE - ELV. 19'-6" TO 119'-3"



MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: Response Spectra	Calculated by: BJ	Date: 2-25-83
	Checked by: MJK	Date: 2/25/83
	Reviewed by: JJ	Date: 2-25-83
Project: 83-03		Page 7 of 15

HORIZONTAL RESPONSE – ELV 38'-5"

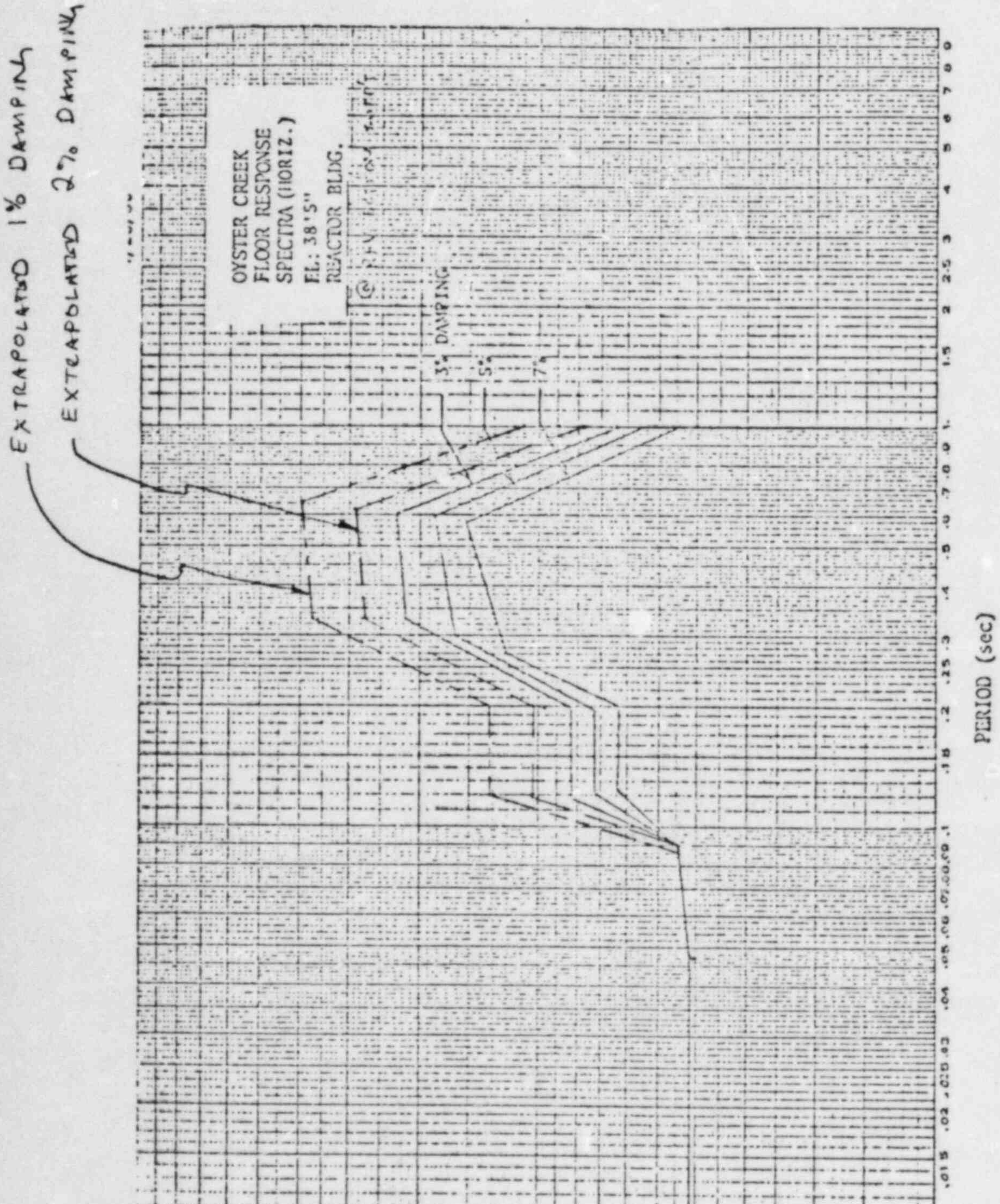


MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: Response Spectra	Calculated by: BY	Date: 2-25-83
	Checked by: [illegible]	Date: 2/25/83
	Reviewed by: JJ	Date: 2-25-83

Project: 83-03

HORIZONTAL RESPONSE - ELV. 38'-5"



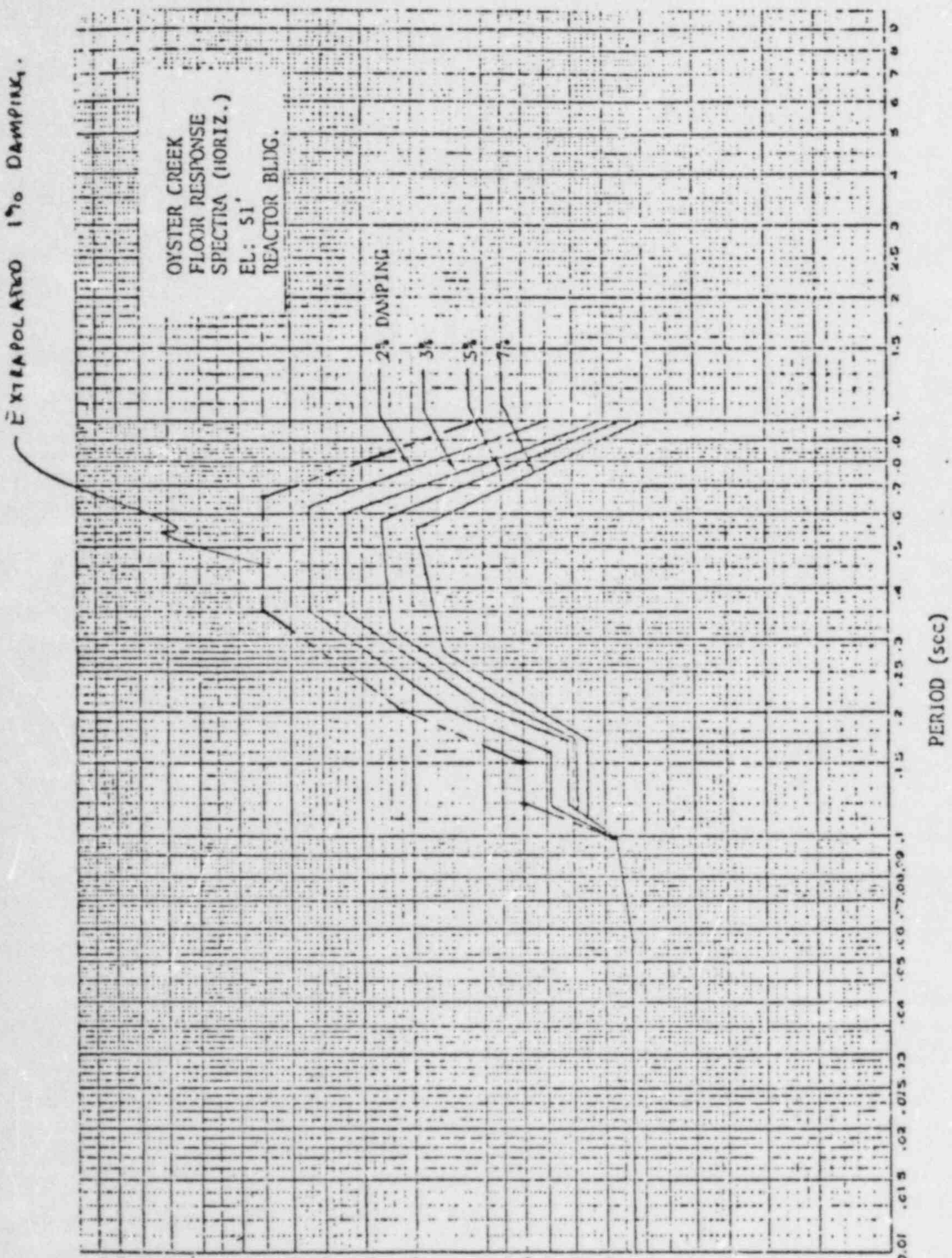
MPR ASSOCIATES, INC.

1050 Connecticut Ave., NW – Washington, DC 20036

Title: Response Spectra	**Calculated by:** BJ	**Date:** 2-25-83
	Checked by: MJK	**Date:** 2/25/83
	Reviewed by: JJ	**Date:** 2-25-83

Project: 83-03

HORIZONTAL RESPONSES – ELV. 51'

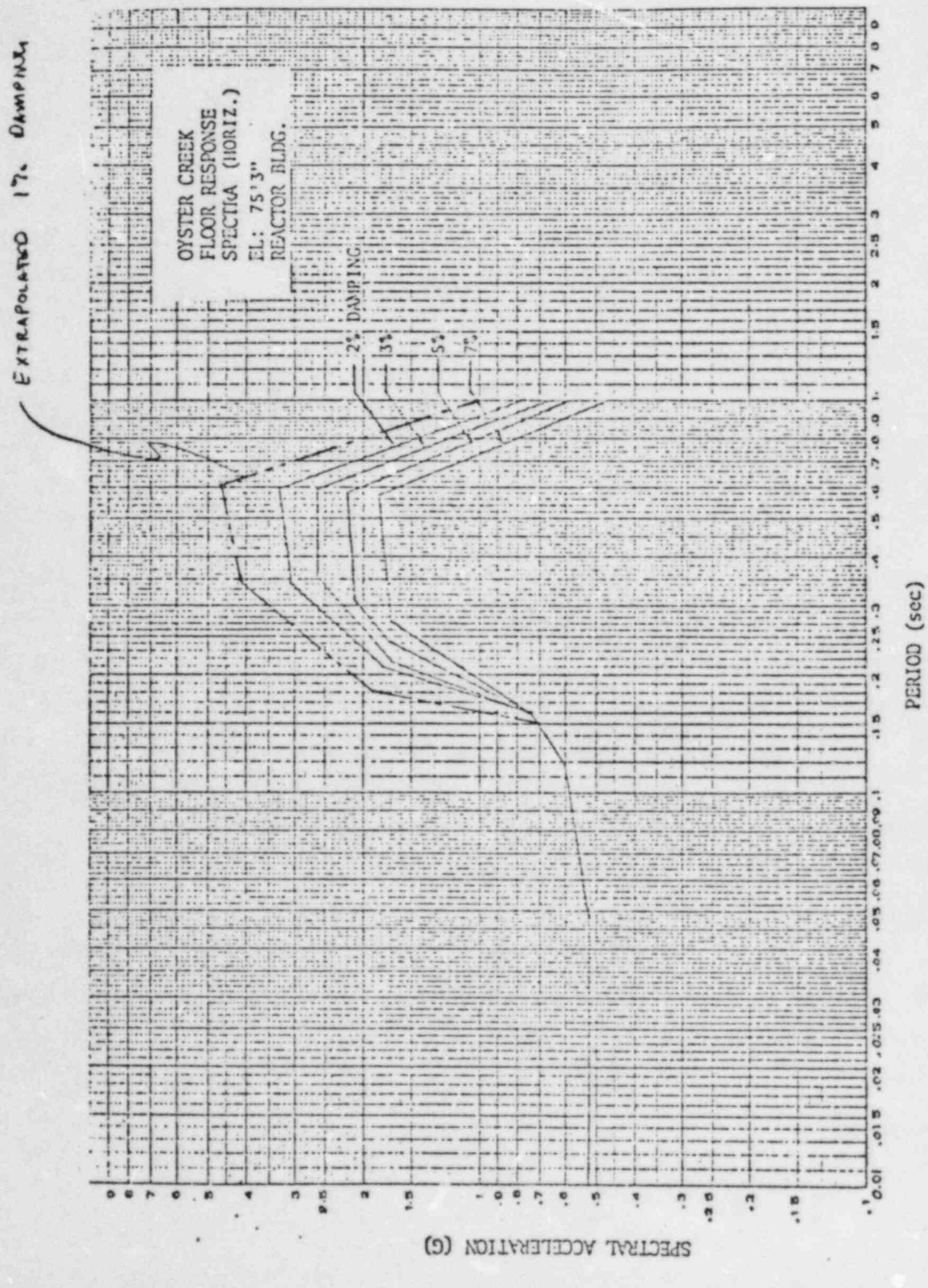


MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Response Spectra   Calculated by: BJ   Date: 2-25-83
Checked by: mjk   Date: 2/25/83
Reviewed by: JJ   Date: 2-25-83

Project: 83-03   Page 9 of 15

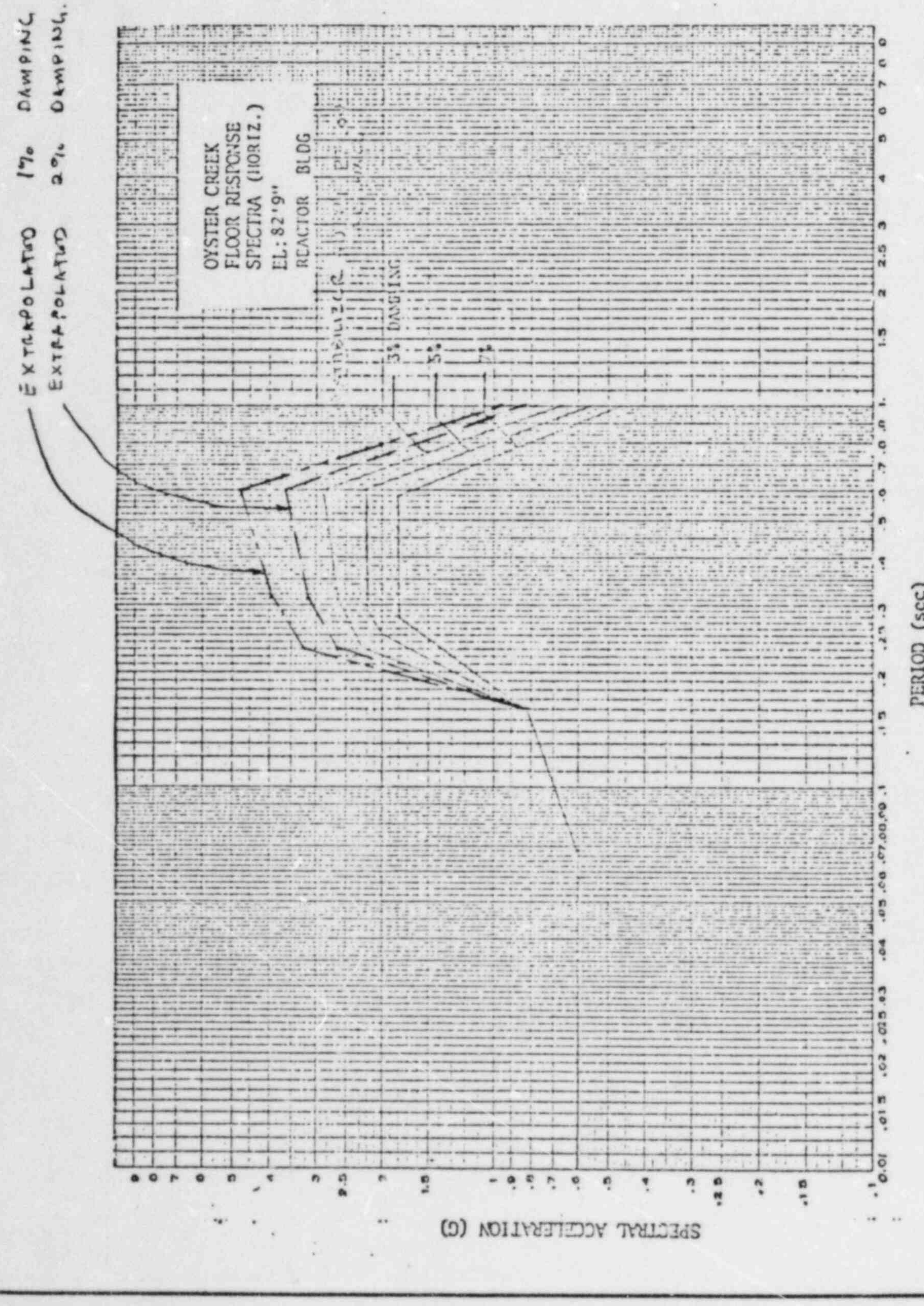
HORIZONTAL RESPONSE - ELV. 75'-3"



Title: Response Spectra	Calculated by: BJ	Date: 2-25-83
	Checked by: [illegible]	Date: 2/25/83
	Reviewed by: JJ	Date: 2-25-83

Project: 83-03

HORIZONTAL RESPONSE - ELV. 82'9"



MPR ASSOCIATES, INC.
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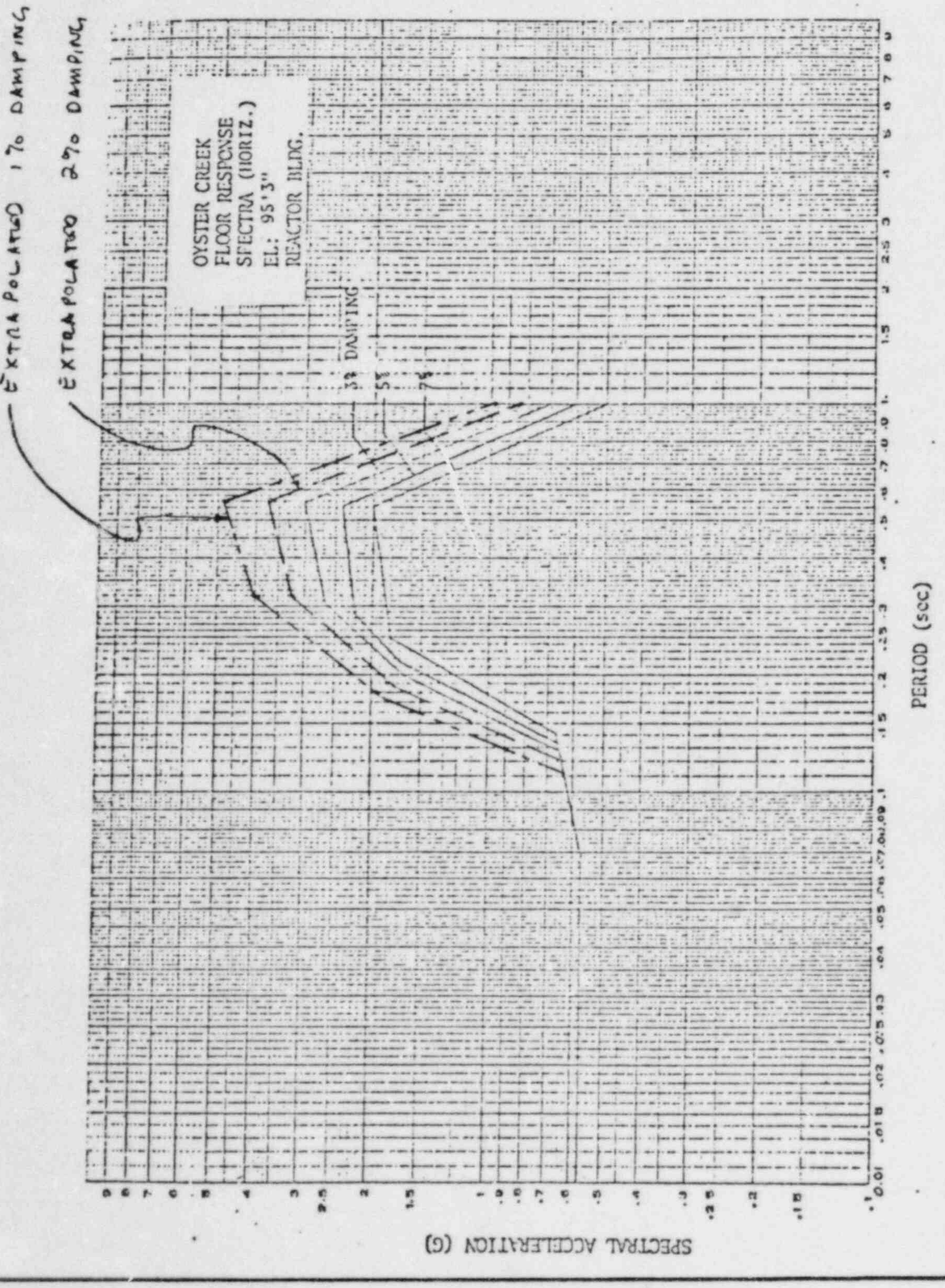
Title: Response Spectra | Calculated by: BJ | Date: 2-25-83
Checked by: [illegible] | Date: 2/25/83
Reviewed by: JJ | Date: 2-25-83

Project: 83-03

HORIZONTAL RESPONSE - ELEV. 95'-3"

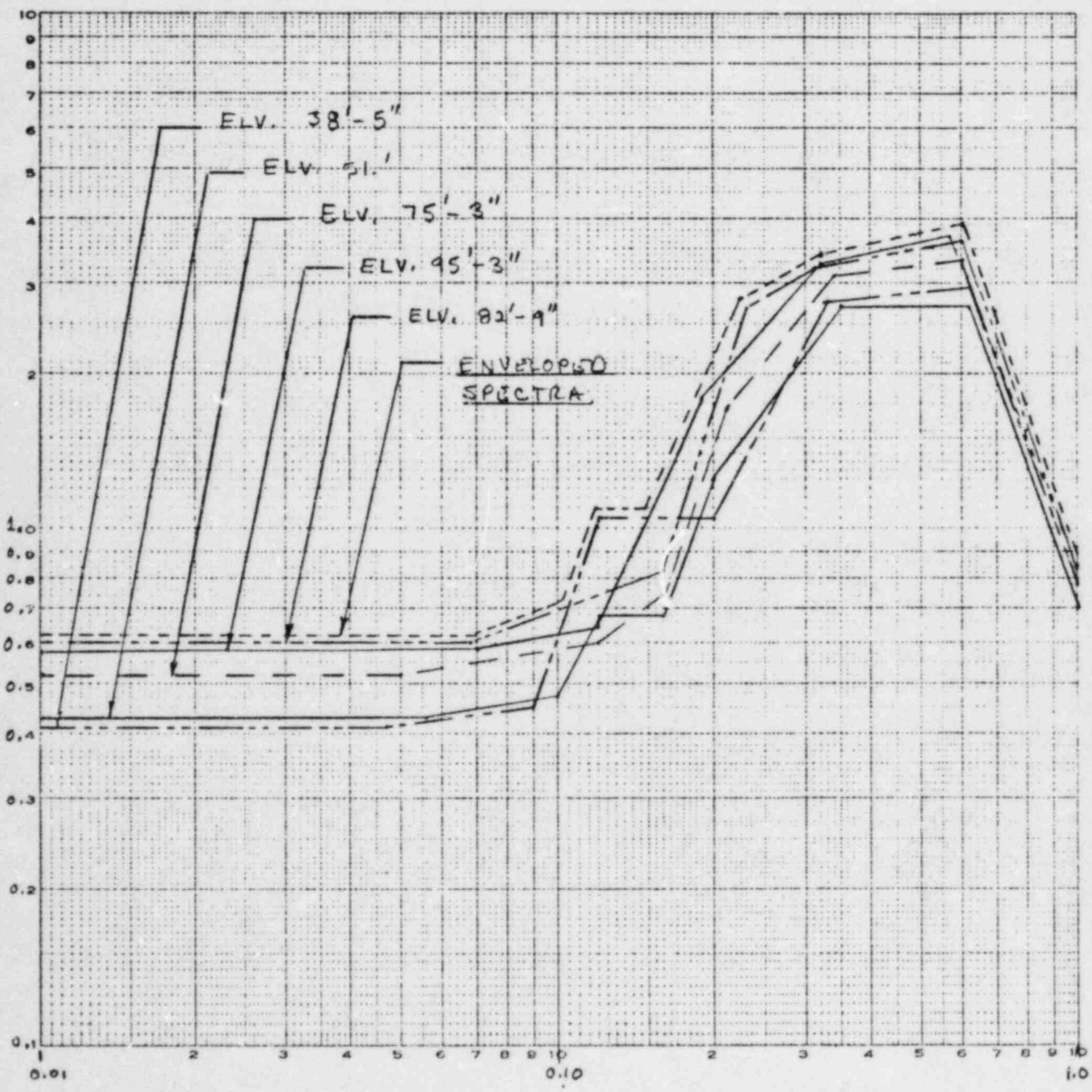


MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Response Spectra
Calculated by: BY Date: 2-25-83
Checked by: MJK Date: 2/25/83
Reviewed by: JJ Date: 2-25-83

Project: 83-03

ENVELOPE OF 2% DAMPING — ZPA = 0.22g's



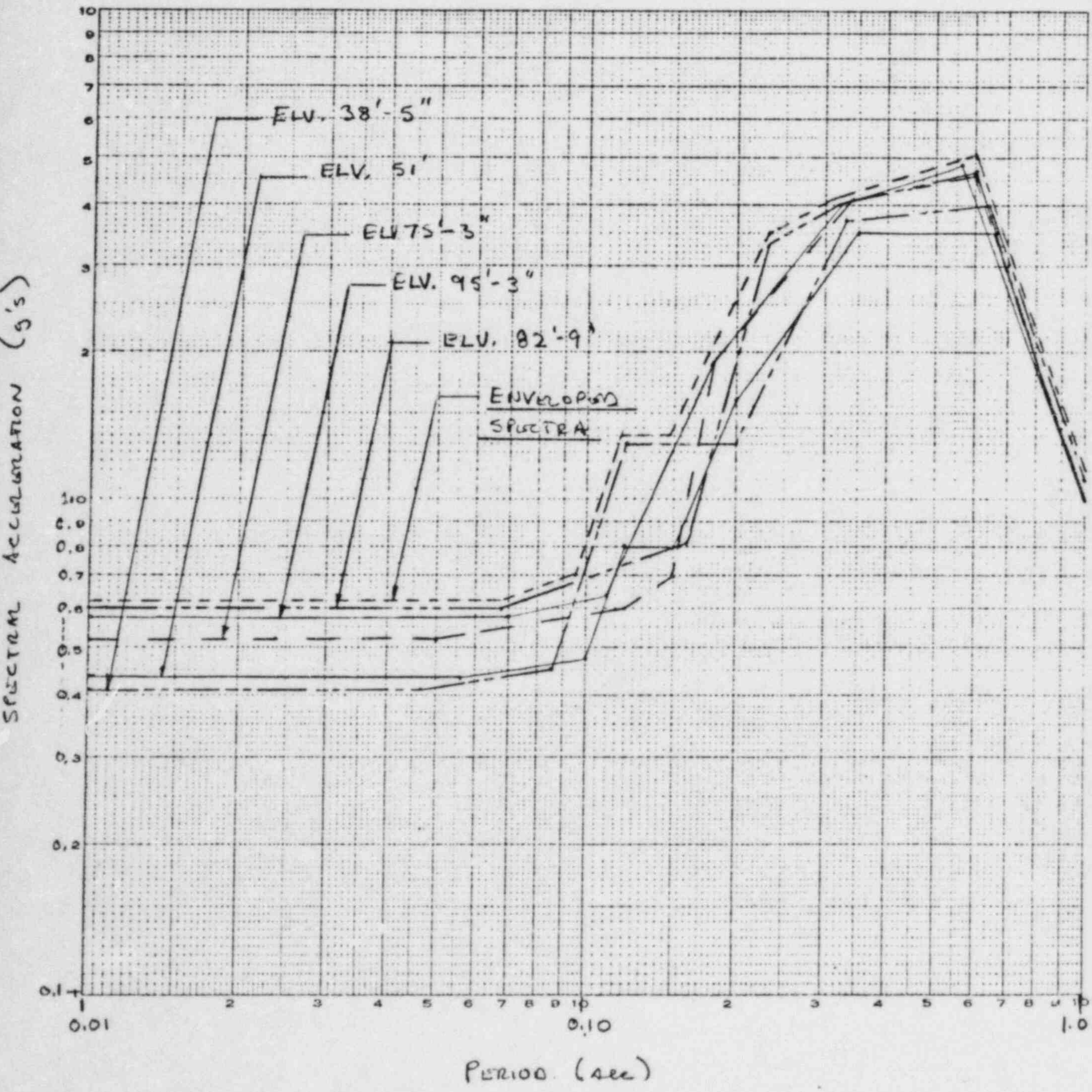
MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Response Spectra

Calculated by: BL Date: 2-25-83
Checked by: MJK Date: 2/25/83
Reviewed by: JJ Date: 2-25-83

Project: 83-03

ENVELOPE OF 1% DAMPING - ZPA = 0.22g's



MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: Response Spectra | Calculated by: BY | Date: 2-25-83
Checked by: MJE | Date: 2/25/83
Reviewed by: JJ | Date: 2-25-83

Project: 83-03

HORIZONTAL SPECTRA

1% DAMPING - ZPA = 0.22 g's
SSE

PERIOD (sec)	g's
0.001	0.62
0.068	0.62
0.095	0.70
0.115	1.35
0.145	1.35
0.230	3.50
0.310	4.10
0.600	5.10
1.0	1.15

2% DAMPING - ZPA = 0.22 g's
SSE

PERIOD (sec)	g's
0.001	0.62
0.070	0.62
0.100	0.72
0.120	1.10
0.145	1.10
0.225	2.80
0.320	3.40
0.600	3.90
1.0	0.90

VERTICAL SPECTRA

1% DAMPING - ZPA = 0.22 g's
SSE

PERIOD (sec)	g's
0.001	0.25
0.076	0.25
0.100	0.41
0.300	1.20
0.350	1.80
0.560	1.80
1.0	0.47

2% DAMPING - ZPA = 0.22 g's
SSE

PERIOD (sec)	g's
0.001	0.25
0.076	0.25
0.100	0.35
0.300	1.00
0.360	1.50
0.550	1.50
1.0	0.40

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Response Spectra
Calculated by: BJ Date: 2-25-83
Checked by: MJK Date: 2/25/83
Reviewed by: JJ Date: 2-25-83

Project: 83-03

OBE RESPONSE SPECTRA
1% DAMPING - FLOOR ZPA = 0.165 g's

HORIZONTAL SPECTRA

PERIOD (sec)	g's
0.001	0.23
0.068	0.23
0.095	0.26
0.115	0.51
0.145	0.51
0.230	1.31
0.310	1.54
0.600	1.91
1.0	0.43

VERTICAL SPECTRA

PERIOD (sec)	g's
0.001	0.09
0.076	0.09
0.100	0.15
0.300	0.45
0.350	0.68
0.560	0.68
1.0	0.18

SSE RESPONSE SPECTRA
2% DAMPING - FLOOR ZPA = 0.165 g's

HORIZONTAL SPECTRA

PERIOD (sec)	g's
0.001	0.47
0.070	0.47
0.100	0.54
0.120	0.83
0.145	0.83
0.225	2.10
0.320	2.55
0.600	2.93
1.0	0.68

VERTICAL SPECTRA

PERIOD (sec)	g's
0.001	0.19
0.076	0.19
0.100	0.26
0.300	0.75
0.360	1.13
0.550	1.13
1.0	0.30

APPENDIX E

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW – Washington, DC 20036

Title: Seismic Stress Analysis	Calculated by: [illegible]	Date: 11/28/83
	Checked by: [illegible]	Date: 12/1/83
	Reviewed by: [illegible]	Date: 12-1-83
Project: SEP - PIPING 83-03		Page 1 of 14

Purpose

The following calculation documents the load cases analyzed to determine the seismic adequacy of the poison system piping outside containment.

Method

For the piping run from the containment penetration to the explosive valves (model 2), two computer analyses are required. The first analyses determines the spring preload at operating thermal conditions (after containment penetration displacement). The second analyses evaluates the piping system to the 1980 Edition (up to and including Summer 1981 Addenda) of the ASME Code.

For the piping runs from pump discharge to the explosive valve (model 3) and from the storage tank to the pump suction (model 4), one analysis evaluates the piping to the 1980 Edition (up to and including Summer 1981 Addenda) of the ASME Code.

MPR ASSOCIATES, INC.
1050 Connecticut Ave., NW - Washington, DC 20036

Title: Seismic Stress Analysis — Calculated by: MAC — Date: 11/28/83
Checked by: RMC — Date: 12/1/83
Reviewed by: TJ — Date: 12-1-83

Project: 83-03

SPRING RELAXATION ANALYSES

Spring PRELOAD AT OPERATING THERMAL CONDITIONS

The Following table documents the spring preload at "cold" (70°F) conditions

OUTSIDE CONTAINMENT - Pump Discharge (MODEL 2)

SPRING LOCATION	SPRING TYPE	SPRING RATE (lb/in)	SPRING PRELOAD (lb.)	SPRING WORKING RANGE (lb.)
142	MS2A-2	26.7	69.0	30.0 - 90.0
148	MS2A-2	26.7	32.0	30.0 - 90.0

Ref: B&R support Dwgs 410C, 410D.

Due to anchor displacement at operating conditions, the preload of the springs decreases as the pipe displaces. This occurs in the piping run outside containment from the containment penetration to the explosive valves (model 2). This relaxation is analyzed in computer run Poison 2 (see Appendix F). The following table documents the relaxation of the spring preload due to the anchor displacements calculated in Appendix C.*

Outside Containment (Model 2)

Spring Location	Cold Spring Preload (lb.)	Cold Deadweight Spring Load (lb)	Hot Deadweight Spring Load (lb)	Operating Condition Relaxation (lb.)	Operating Condition Preload (lb.)	Working Range (lb)
142	69.0	67.4	66.2	-1.2	67.8	30.0-90.0
148	32.0	32.0	25.9	-6.1	25.9	30.0-90.0

The operating condition preload is the preload used in the deadweight run in the stress analysis.

* See Attachment A.

Stress Analyses

Applicable Code Sections

ASME BOILER AND PRESSURE VESSEL CODE, SECTION III

- Subsection NB (Class 1 Piping) for piping from the reactor vessel to the second isolation valve.
- Subsection NC (Class 2 Piping) for piping from the second isolation valve.

In accordance with NB-3630, Class 1 piping may be analyzed in accordance with the Class 2 analysis of piping systems in Subsection NC, provided the following criteria are met:

NB-3630 (d)(2)(a) Atmospheric to Service Pressure Cycle

S_m @ 135°F = 20.0 KSI

$S_a = 3 \times S_m = 60.0$ KSI

allowable number of cycles = 9000 { Ref: TAB I-9.1 ASME Code Appendices }

startup/shutdown cycles in 40 yrs ≈ 130 + 390 - 520] Assumed
130 startup/shutdown; 390 Scram to LP Hot Standby]

NB-3630 (d) (2) (b) Normal Service Pressure fluctuation

No specified pressure fluctuations

NB-3630 (d) (2) (c) Temperature Difference - Startup AND Shutdown (at containment penetration)

$135° - 70° = 65°F$

S_a for 520 cycles = 121 KSI

$E = 27.95 \times 10^{6}$ PSI
$\alpha = 8.61 \times 10^{-6}$ in/in °F

$$\frac{S_a}{2E\alpha} = \frac{121000}{2(27.95\times10^{6})(8.61\times10^{-6})} = 251 > 65$$

NB-3630 (d) (2) (d) Temperature Difference - Normal Service

No temperature change during normal service

NB-3630 (d) (2) (e) Temperature Difference - Dissimilar Materials

No dissimilar materials

Therefore, the entire piping system may be analyzed using Subsection NC rules.

Seismic Analysis under NC rules is embodied in Article NC-3652.2.

Occasional Loads, Equation (9):

$$S_{OL} = \frac{P_{MAX} D_O}{4 t_N} + 0.75 i \left(\frac{M_A + M_B}{Z} \right)$$

where

P_{MAX} = Peak Pressure (PSI)

D_O = outside diameter of pipe (in.)

t_N = nominal wall thickness (in.)

Z = section modulus of pipe (in.^{3})

i = stress intensification factor [NC-3672.2(b)]
The product of 0.75 i shall never be less than 1.0.

M_A = resultant moment loading on cross section due to weight and other sustained loads (in. lb.)

M_B = resultant moment loading on cross section due to occasional loads including earthquake (in. lb.)

Allowable Limits for S_{OL} are given in Article

<u>NC-3611.2 Stress Limits</u>:

<u>(c) (2) Level B Service Limits</u> (OBE)

$S_{OL} \leq 1.2\ S_h$

<u>(c) (3) Level C Service Limits</u> (SSE)

$S_{OL} \leq 1.8\ S_h$

where S_h = basic material allowable stress at maximum (hot) temperature (psi)

S_h / S_c = 18,800 psi for all materials

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Normal operation peak pressure load is 1250 psi from the reactor vessel to the first check valves. The peak pressure load during pump actuation is 1250 psi from the reactor vessel to the pump discharge connection. The peak pressure in the pump suction line is 150 psi.

(Ref. Burns and Roe Spec S-2299-60-C)

Sustained load moments are the result of deadweight.

Occasional load moments are determined by the response spectra method, using the response spectra contained in Appendix D. The stress analysis results for the poison system piping are contained in the following computer runs

MODEL	COMPUTER RUN
2	POISON4
3	POISON5
4	POISON6

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Project: 83-03

Microfiche of these runs are contained in Appendix F. The following tables summarize the stress analysis's results at controlling locations. Table 1 gives the calculated stress by load component. Table 2 gives the calculated stress ratio for the two service limits.

TABLE 1

POISON SYSTEM PIPING OUTSIDE CONTAINMENT
PUMP DISCHARGE LINE FROM EXPLOSIVE VALVES
TO CONTAINMENT – MODEL 2

LOCATION	PIPING COMPONENT	PRESSURE STRESS (PSI)	DEADWEIGHT STRESS (PSI)	OCCASIONAL LOAD STRESS (PSI)	
				OBE	SSE
132	Soc. weld Elbow	2969	62	13582	21858
152	Soc. weld Elbow	2969	405	14815	23842
158	CONTAINMENT PENETRATION	2969	175	8518	13719

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Project: 83-03

TABLE 1 (CONT)

POISON SYSTEM PIPING OUTSIDE CONTAINMENT

PUMP DISCHARGE LINE FROM PUMP TO

EXPLOSIVE VALVES - MODEL 3

LOCATION	PIPING COMPONENT	PRESSURE STRESS (PSI)	DEADWEIGHT STRESS (PSI)	OCCASIONAL LOAD STRESS (PSI)	
				OBE	SSE
234	CHECK VALVE	2969	3916	3658	6000
250	Soc. Weld TEE	2969	5936	3558	6008
402	Soc. Weld Elbow	2296	5474	5786	9463
404	Soc. Weld Elbow	2296	5461	5363	8772
466	Saftey Relief Valve	2296	7514	4006	6596

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Checked by: RAC | Date: 12/1/83
Reviewed by: JJ | Date: 12-1-83

Project: 83-03

TABLE 1 (cont.)

POISON SYSTEM PIPING OUTSIDE CONTAINMENT

PUMP SUCTION LINE – MODEL 4

LOCATION	PIPING COMPONENT	PRESSURE STRESS (PSI)	DEADWEIGHT STRESS (PSI)	OCCASIONAL LOAD STRESS (PSI)	
				OBE	SSE
36	TEST TANK PENETRATION	391	1587	480	981
162	Valve	275	1034	99	203

TABLE 2

POISON SYSTEM PIPING OUTSIDE CONTAINMENT

PUMP DISCHARGE LINE FROM EXPLOSIVE VALVES

TO CONTAINMENT – MODEL 2

LOCATION	PIPING COMPONENT	EQUATION (9) STRESS RATIO[1]	
		OBE	SSE
132	Soc. Weld Elbow	0.74	0.74
152	Soc. Weld Elbow	0.81	0.80
158	CONTAINMENT PENETRATION	0.52	0.50

1. Allowable Stress Ratio is 1.0.

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Project: 83-03

TABLE 2 (Cont.)

POISON SYSTEM PIPING OUTSIDE CONTAINMENT

PUMP DISCHARGE LINE FROM PUMP TO

EXPLOSIVE VALVES – MODEL 3

LOCATION	PIPING COMPONENT	EQUATION (9) STRESS RATIO [1]	
		OBE	SSE
234	CHECK VALVE	0.47	0.38
250	Soc. Weld TEE	0.55	0.44
402	Soc. Weld Elbow	0.60	0.51
404	Soc. Weld Elbow	0.58	0.49
466	SAFETY Relief Valve	0.61	0.49

1. Allowable Stress Ratio is 1.0.

TABLE 2 (cont.)

POISON SYSTEM PIPING OUTSIDE CONTAINMENT

PUMP SUCTION LINE – MODEL 4

LOCATION	PIPING COMPONENT	EQUATION (9) STRESS RATIO[1]	
		OBE	SSE
36	TEST TANK PENETRATION	0.11	0.09
162	VALVE	0.06	0.05

1. Allowable Stress Ratio is 1.0.

Title: Seismic Stress Analysis — Calculated by: MGR — Date: 11/29/83
Checked by: PML — Date: 12/1/83
Reviewed by: JJ — Date: 12-1-83

Project: 83-03

Attachment A.

The vertical displacement used in POISON2 was .233 in. The calculated displacement from Appendix C is .354 in. Therefore, the operating condition relaxation is greater and the deadweight stress is greater. Assuming the stress is increased in proportion to the increase in displacement, the stresses in tables 1 and 2 would increase as follows.

Location	Piping component	Pressure Stress (PSI)	Deadweight Stress (PSI)	Occasional Load Stress PSI OBE	Occasional Load Stress PSI SSE
132	Soc. weld Elbow	2969	94	13582	21858
152	Soc. weld Elbow	2969	615	14815	23842
158	Containment Penetration	2969	266	8518	13719

LOCATION	PIPING COMPONENT	EQUATION (9) STRESS RATIO	
		OBE	SSE
132	Soc. Weld Elbow	0.74	0.74
152	Soc. Weld Elbow	0.81	0.81
158	CONTAINMENT PENETRATION	0.52	0.50

Therefore, the results of the analysis are not affected by the difference in vertical thermal expansion displacement at the containment penetration.

APPENDIX F

MICROFICHE COMPUTER OUTPUT

COMPUTER RUN	DESCRIPTION
Poison 2	Poison System Piping Model 2 Operating Thermal Relaxation
Poison 4	Poison System Piping Model 2 ASME Code, Class 2 Seismic Stress Analysis
Poison 5	Poison System Piping Model 3 ASME Code, Class 2 Seismic Stress Analysis
Poison 6	Poison System Piping Model 4 ASME Code, Class 2 Seismic Stress Analysis

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Title: COMPUTER PROGRAM DOCUMENTATION SHEET
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Reviewed by: _____ Date: _____

Project: _____

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PROGRAM: PIPESD REVISION: 6.2

RUN BANNER: POISON 2 / JØB008W DATE: 10/7/83

INPUT PREPARED BY: MJ Kennedy DATE: 10/7/83

INPUT CHECKED BY: RW Card DATE: 12/2/83

OUTPUT REVIEWED BY: T Johnson DATE: 12-2-83

PROGRAM: PIPESD REVISION: 6.2

RUN BANNER: POISON 4 / JØB 007N DATE: 10/11/83

INPUT PREPARED BY: MJ Kennedy DATE: 10/11/83

INPUT CHECKED BY: RW Card DATE: 12/2/83

OUTPUT REVIEWED BY: T Johnson DATE: 12-2-83

PROGRAM: PIPESD REVISION: 6.2

RUN BANNER: POISON 5 / JØB 007C DATE: 10/20/83

INPUT PREPARED BY: M.J. Kennedy DATE: 10/20/83

INPUT CHECKED BY: RW Card DATE: 12/2/83

OUTPUT REVIEWED BY: T Johnson DATE: 12-2-83

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PROGRAM: PIPESD REVISION: 6.2

RUN BANNER: POISON6/JØB 008U DATE: 10/7/83

INPUT PREPARED BY: M J Kennedy DATE: 10/7/83

INPUT CHECKED BY: RW Cavard DATE: 12/2/83

OUTPUT REVIEWED PY: JJ Johnson DATE: 12-2-83

PROGRAM: REVISION:

RUN BANNER: DATE:

INPUT PREPARED BY: DATE:

INPUT CHECKED BY: DATE:

OUTPUT REVIEWED BY: DATE:

PROGRAM: REVISION:

RUN BANNER: DATE:

INPUT PREPARED BY: DATE:

INPUT CHECKED BY: DATE:

OUTPUT REVIEWED BY: DATE: