SMA-CT 3001.01R01

SEISMIC AND STRESS ANALYSIS OF HIGH PRESSURE CORE SPRAY SUCTION LINE PIPING SYSTEM FOR LACROSSE BOILING WATER REACTOR (LACBWR)

Prepared for

DAIRYLAND POWER COOPERATIVE

February 1985

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This work has been performed in accordance with SMA-CT Quality Assurance Manual which meets the requirements set forth in 10 CFR part 50 Appendix B and ANSI N45.2.

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CERTIFICATION OF SEISMIC AND STRESS ANALYSIS OF HIGH PRESSURE CORE SPRAY SUCTION LINE PIPING SYSTEM DAIRYLAND POWER COOPERATIVE

I, the undersigned, being a registered Professional Engineer in the States of Connecticut and California, competent in the ASME Code stress analysis of piping systems, have performed the stress analysis of LACBWR High Pressure Core Spray Suction Line Piping System and certify that to the best of my knowledge, the stress report presented herein is in compliance with the criteria set forth in this report.

Certified by Iqbal Husain Date August 10, 1984
I. Husain

STATE OF CONNECTICUT IQBAL HUSAIN No. 12201 REGISTERED PROFESSIONAL ENGINEER

Revision: 1 Certified by: Iqbal Husain Date: February 15, 85

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1	2/14/85	Add Addendum 1	Discrepancies between As-analyzed and as-built Configurations

Approval Iqbal Husain

SMA

TABLE OF CONTENTS

Section	Title	Page
1	INTRODUCTION	1-1
2	DESCRIPTION OF PIPING SYSTEM	2-1
3	APPLICABLE CODES, STANDARDS AND SPECIFICATIONS . .	3-1
4	LOADING CONDITION	4-1
5	LOAD COMBINATIONS AND ACCEPTANCE CRITERIA	5-1
	5.1 Design Considerations and Design Loadings . .	5-1
	5.2 Service Loading Combinations	5-1
6	PIPING ANALYSIS	6-1
	6.1 Nupipe Analytical Procedures	6-1
	6.1.1 Static Analysis	6-1
	6.1.2 Dynamic Analysis	6-2
	6.1.2.1 Mathematical Model	6-2
	6.1.2.2 Natural Frequencies and Mode Shapes	6-3
	6.1.2.3 Dynamic Response	6-3
	6.1.2.4 Response Spectrum Superposition	6-4
	6.1.3 Piping Stress Analysis	6-5
7	RESULTS OF ANALYSIS	7-1
	7.1 HPCS Suction Line 1	7-1
	7.2 HPCS Suction Line 2	7-2
	7.3 Pipe Support Evaluation	7-3
8	CONCLUSIONS	8-1
9	REFERENCES	9-1
	ADDENDUNDUM I - Evaluation of Discrepancies Discovered Between As-Analyzed and As-Built Configurations. .	⚠
	APPENDICES	

LIST OF FIGURES

		Page
1-1	HPCS Suction Line 1 Horizontal Spectra.........	1-4
1-2	HPCS Suction Line 1 Vertical Spectra	1-5
1-3	HPCS Suction Line 2 Horizontal Spectra.........	1-6
1-4	HPCS Suction Line 2 Vertical Spectra	1-7
2-1	HPCS Suction Line 1 Schematic Sketch	2-3
2-2	HPCS Suction Line 2 Schematic Sketch	2-4
2-3 to 2-6	HPCS Suction Line Supports	2-5 to 2-8
4-1 to 4-3	HPCS Suction Line 1-X,Y and Z Spectra	4-3 to 4-5
4-4 to 4-6	HPCS Suction Line 2-X,Y and Z Spectra	4-6 to 4-8
6-1	HPCS Suction Line 1 NUPIPE Mathematical Model..	6-10
6-2	HPCS Suction Line 2 NUPIPE Mathematical Model..	6-11
6-3	HPCS Suction Line 1 NUPIPE Computer Plot	6-12
6-4	HPCS Suction Line 2 NUPIPE Computer Plot	6-13
7-1 to 7-4	HPCS Suction Lines Class 1 Stress Analysis Results	7-7 to 7-10

LIST OF TABLES

7-1	HPCS Suction Line 1 Modal Frequencies and Modal Mass Fraction	7-5
7-2	HPCS Suction Line 2 Modal Frequencies and Modal Mass Fraction	7-6

1. INTRODUCTION

Seismic and stress analysis of the High Pressure Core Spray (HPCS) suction piping and support system of the La Crosse Boiling Water Reactor (LACBWR) have been performed to verify the adequacy of the "as-built" HPCS piping system to withstand a seismic event. The High Pressure Core Spray System of the LACBWR plant is the principal emergency core cooling system. It is designed to provide emergency coolant spray to the reactor core in the event that reactor water level drops accidentally.

Seismic and stress analyses of the LACBWR HPCS piping system were performed and design of the additional seismic supports were prepared by Nuclear Energy Services, Inc. (Reference 1 and 2) using the seismic criteria and spectra developed by Gulf United Nuclear Fuels Corporation (Reference 3). However, under Systematic Evaluation Program (SEP), the seismic hazard at the LACBWR site has been reevaluated, using current methodology and site specific response spectra. The applicable response spectra developed by EG&G under the SEP program (Reference 4) exceed the original design spectra as indicated in Figures 1-1 through 1-4. In order to assure adequacy of the LACBWR HPCS piping system to withstand the higher postulated seismic excitation, Structural Mechanics Associate of Connecticut Inc. (SMA-CT) has analyzed the HPCS piping system using the current ASME Code and licensing criteria. The revised analysis is based on the "as-built" configuration of the piping and support systems and include the stiffness characteristic of the piping supports. This report presents the results of the seismic and stress analysis conducted to verify the adequacy of the HPCS Suction piping and support systems. The HPCS disnharge piping analysis is presented in separate report.

The HPCS piping and their support systems have been evaluated in accordance with the applicable requirements for Class 1 piping and component supports stipulated in the ASME Boiler and Presuure Vessel Code, Section III, Division 1, "Nuclear Power Plant Components", 1983 (Reference 5) and USNRC Standard Review Plan 3.9.3 "ASME Code Class 1,2, and 3 Components, Component Supports, and Core Support and Structures;" 1981 (Reference 6).

The seismic and stress analyses for the HPCS piping systems have been performed using the NUPIPE computer code (Reference 7), which is widely used code in the nuclear industry. The piping geometry input data (coordinates, diameter, wall thickness and weights), and the pressure and thermal loads have been taken from the piping isometric drawings (Reference 8), specifications (Reference 9), Nuclear Energy Services, Inc. reports (Reference 1,10, and 11) and the "as-built" field verification data (Reference 12). The seismic analysis has been performed using the response spectrum modal superposition method of dynamic analysis including a correction to account for the effects of non-participating mass. The seismic responses have been calculated using the applicable spectra associated with the damping values given in NRC Regulatory Guide 1.61 (Reference 13). The combination of modes and spatial earthquake components are based on requirments of NRC Regulatory Guide 1.92 (Reference 14). The stress analysis and acceptance criteria are in accordance with the design requirement of ASME Code and NRC Standard Review Plan 3.9.3.

Section 2.0 of this report describes the description of the piping systems. Applicable Codes, standards and specification, are given in Section 3.0, while Section 4.0 describes the loading criteria. The acceptance criteria given in the Section 5.0 are consistent with licensing criteria as specified in ASME Code,

and current NRC Regulatory Guides and the Standard Review Plan. The analytical methods for the static, dynamic and stress analysis are given in Section 6.0. Section 7.0 summarizes the results and conclusions of the analysis.

The results of the analysis indicate that the HPCS suction piping systems and their supports meet the acceptance criteria. Therefore, it has been concluded that the HPCS suction piping and support system meet the intent of current licensing criteria.

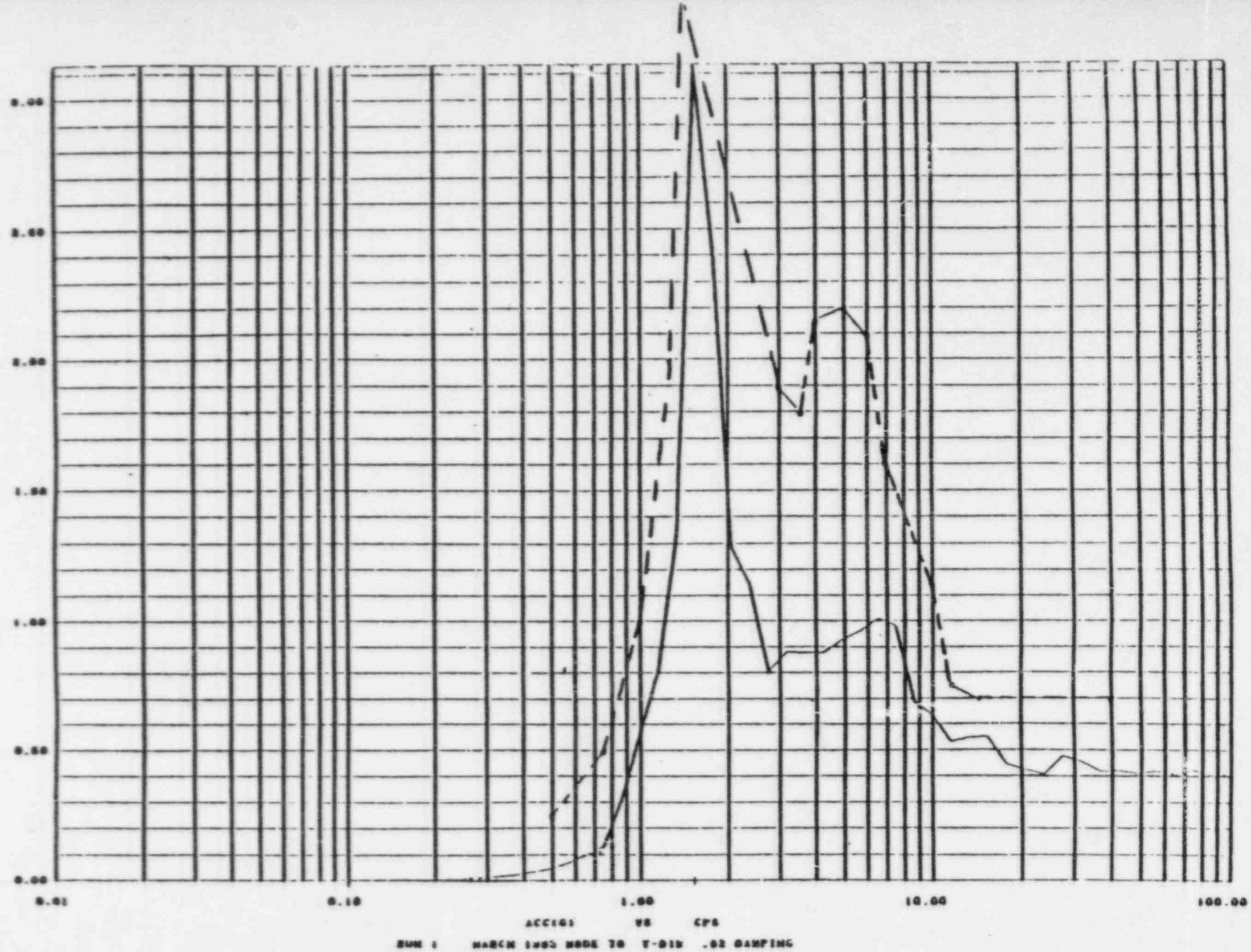


FIGURE B-1. HPCS SUCTION LINE 1 HORIZONTAL SPECTRA
(FIGURE 1-1)

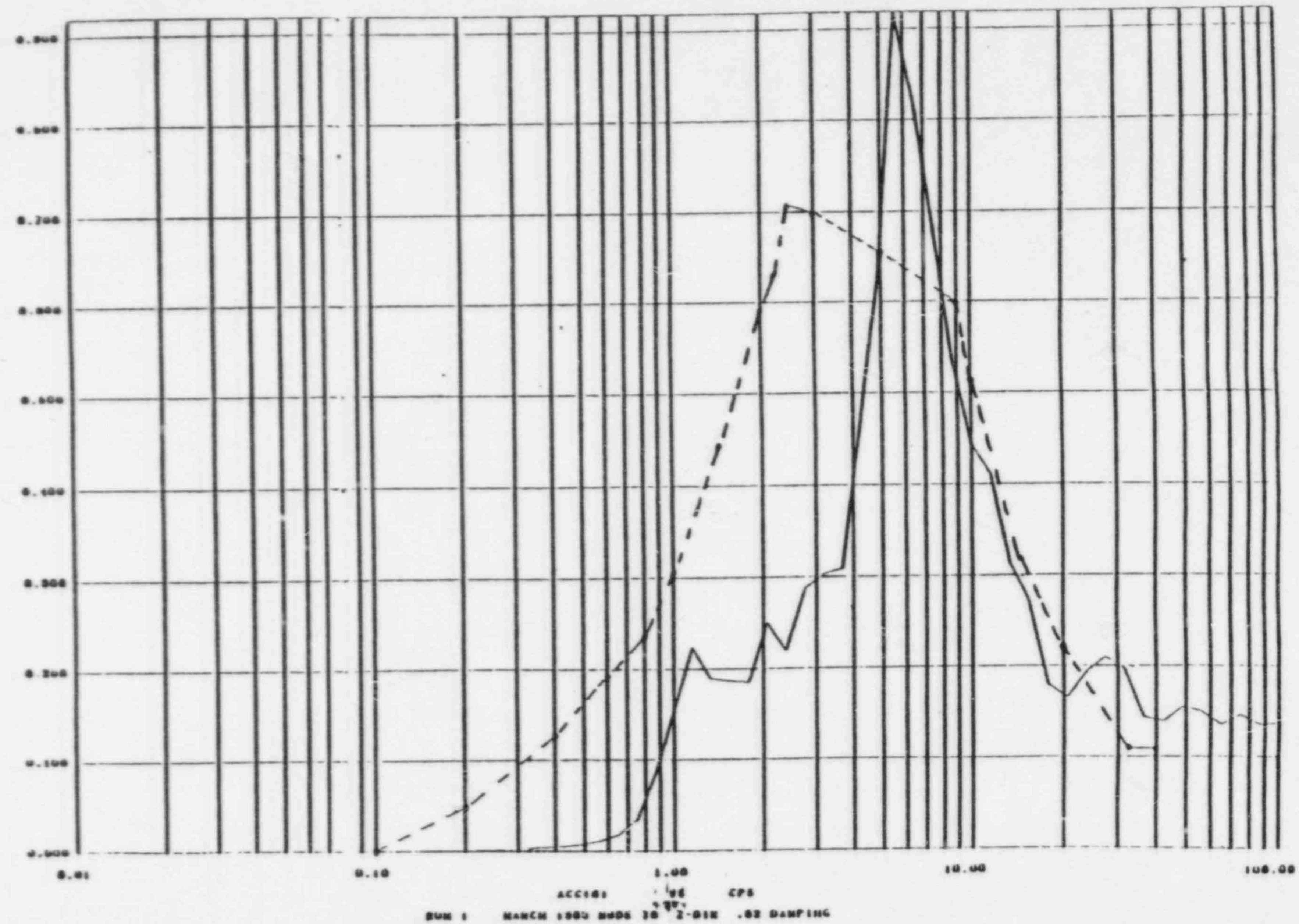


FIGURE B-2. HPCS SUCTION LINE 1 VERTICAL SPECTRA
(FIGURE 1-2)

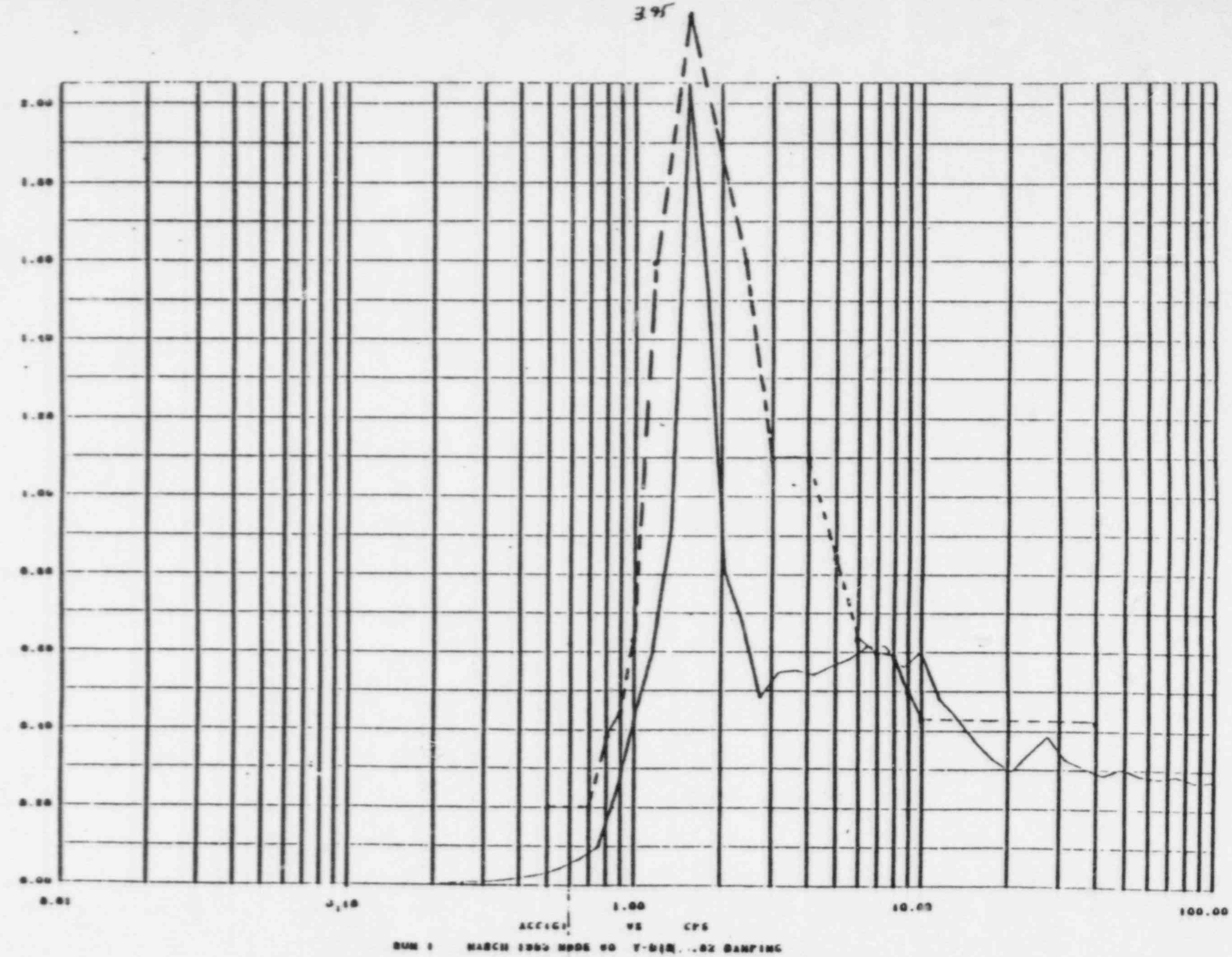


FIGURE B-3. HPCS SUCTION LINE 2 HORIZONTAL SPECTRA
(FIGURE 1-3)

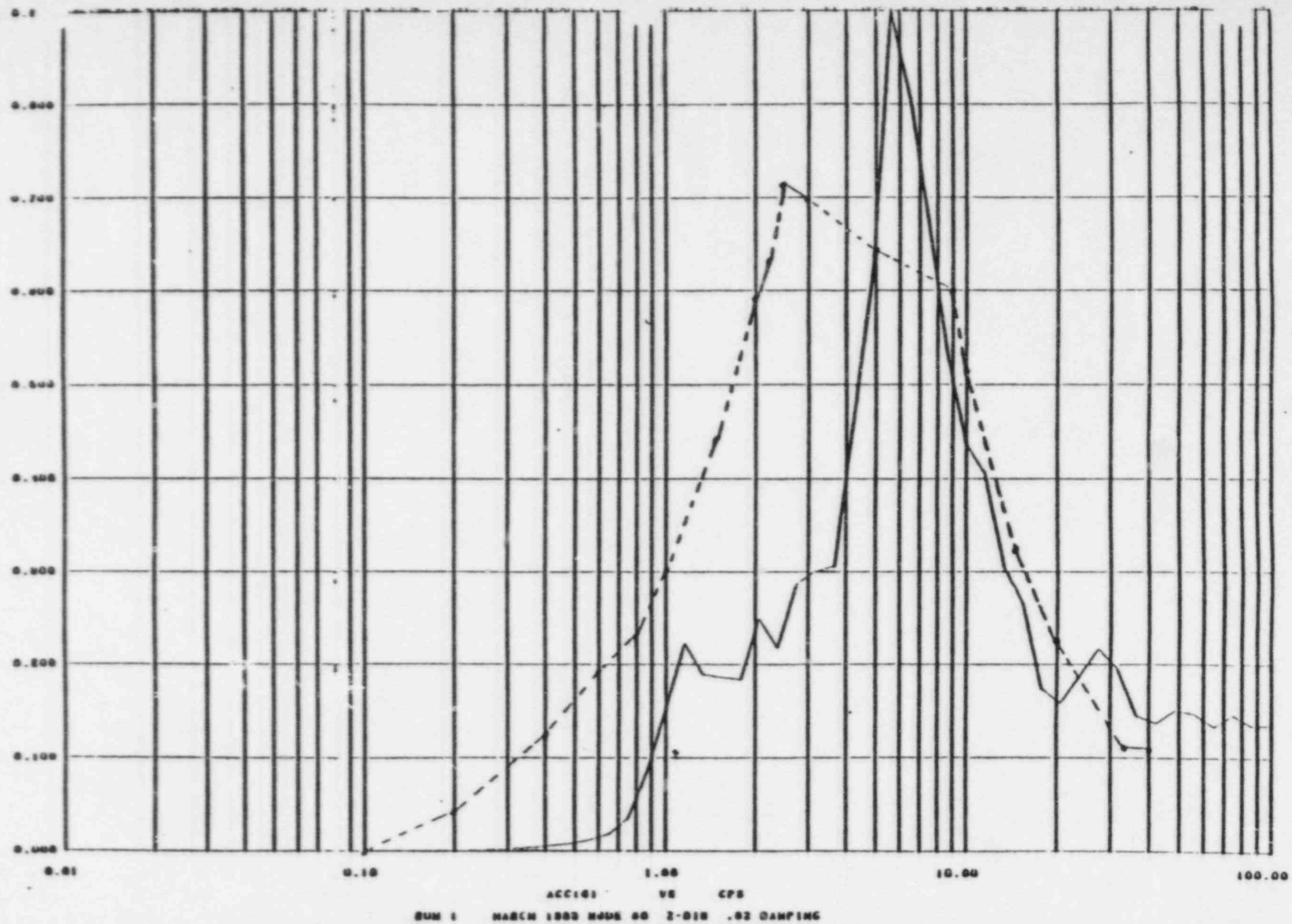


FIGURE B-4. HPCS SUCTION LINE 2 VERTICAL SPECTRA
(FIGURE 1-4)

2. DESCRIPTION OF PIPING SYSTEM

The High Pressure Core Spray (HPCS) system of the LACBWR power plant is the principal emergency core cooling system. It is designed to provide an emergency coolant spray to the reactor core in the event that reactor water level drops accidentally. this is done either by means of high pressure water injection under high reactor pressure conditions or by direct gravity feed of water from the overhead storage tank to the core spray header under low reactor pressure conditions.

In order to simplify the seismic and stress anlyses of the long and complex HPCS piping system, the HPCS piping system has been divided into two sections. The first consisting generally of the suction piping which runs from the over head storage tank to the HPCS pumps and the second consisting of the discharge piping which runs from the HPCS pumps to the core spray header inlet. The HPCS suction line is further simplified by dividing it into two sections as shown in Figures 2-1 and 2-2. HPCS Suction line 1 shown in Figure 2-1 consist of 4" schedule 40S stainless steel piping from the overhead storage tank to node no. 19 near the 4"x3" reducer. A portion of the 4" fuel storage well flooding line connected at node no. 18 is included in the analysis of HPCS line 1. The HPCS suction line 2 shown in Figure 2-2 begins at node no. 19 and consist of schedule 40S stainless steel piping up to HPCS pumps A and B. Rigid anchors at node nos. 40 and 79 have been provided to isolate the HPCS suction line 2 from sodium pentaborate and high pressure service water piping system.

The Schematic of the piping systems shown in Figure 2-1 and 2-2 includes major pipe dimensions, elevations, anchor points and support locations. The piping arrangement, has been taken from drawings of Reference 8. Piping properties are based on

information given in the piping specification (Reference 9) and are summarized in Appendix A. The location of pipe support systems and their structural stiffness charecteristics are based on informations given in References1, 10, & 11, and those obtained/verified by Dairyland Power Co-Operative engineers from a field inspection dated February 1 through 4, 1983 (Reference 12). The support structural characteristic are shown in Figures 2-3 through 2-6. The support stiffnesses are summarized in Appendix A.

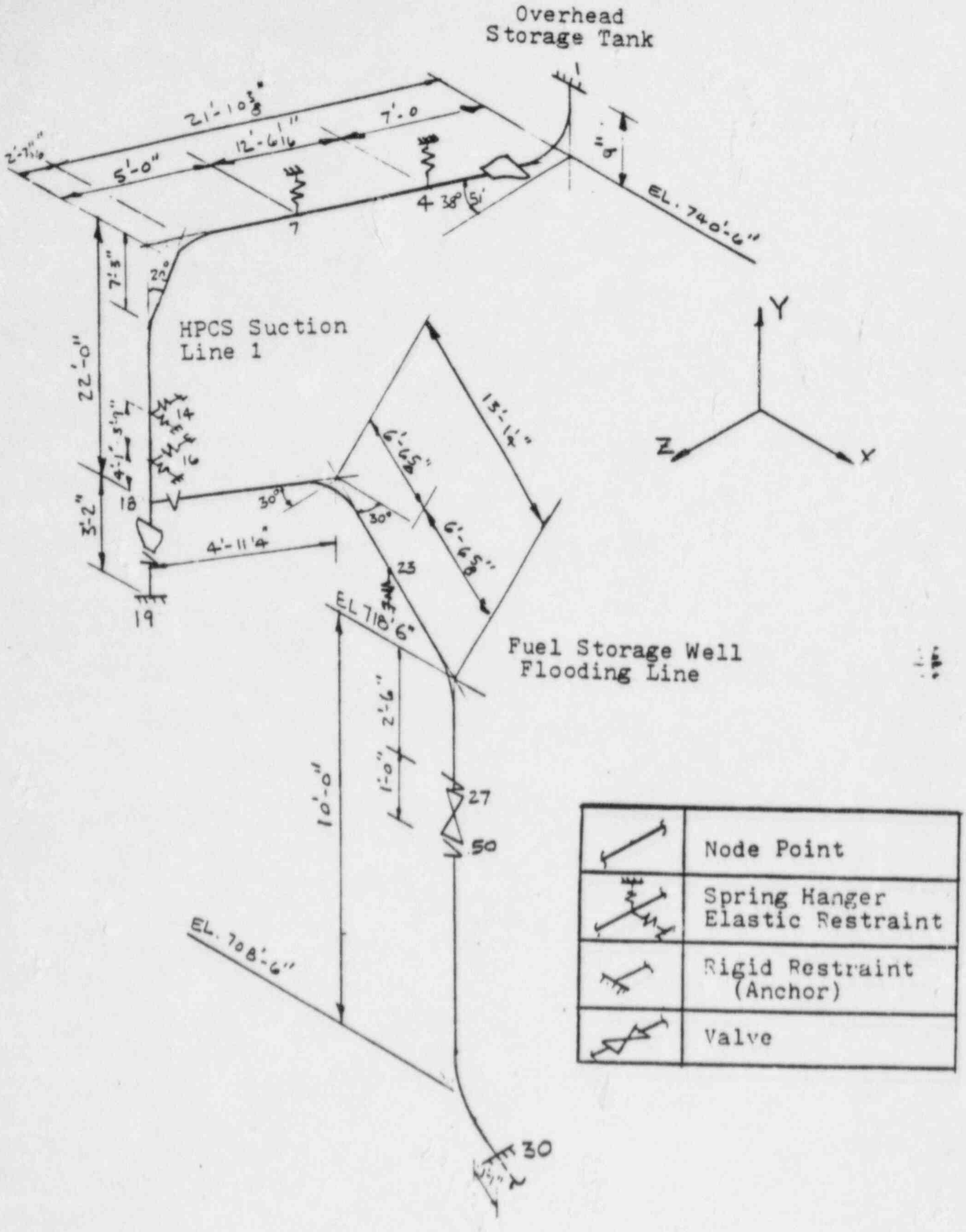


FIGURE 2-1 HPCS SUCTION LINE 1

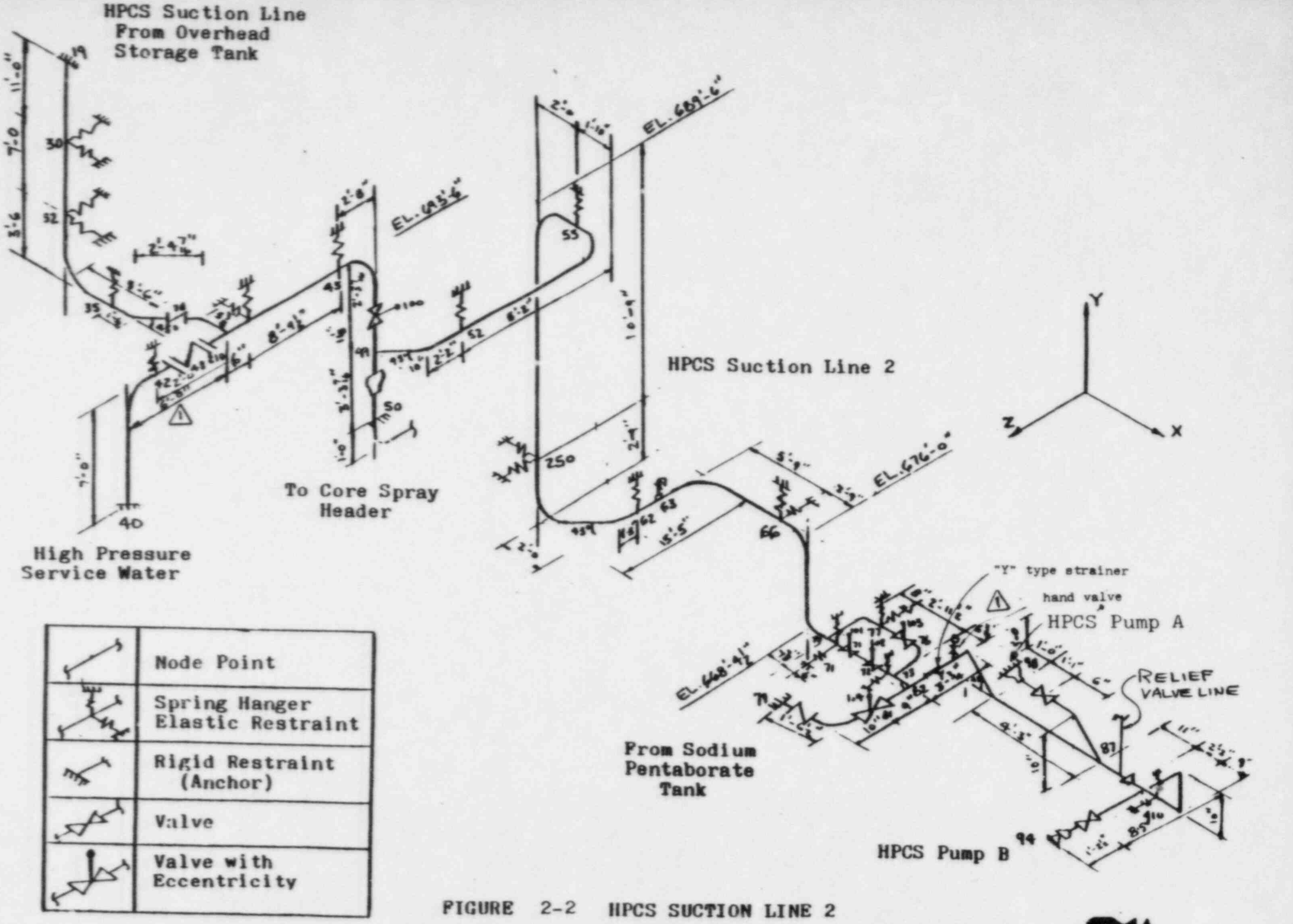


FIGURE 2-2 HPCS SUCTION LINE 2

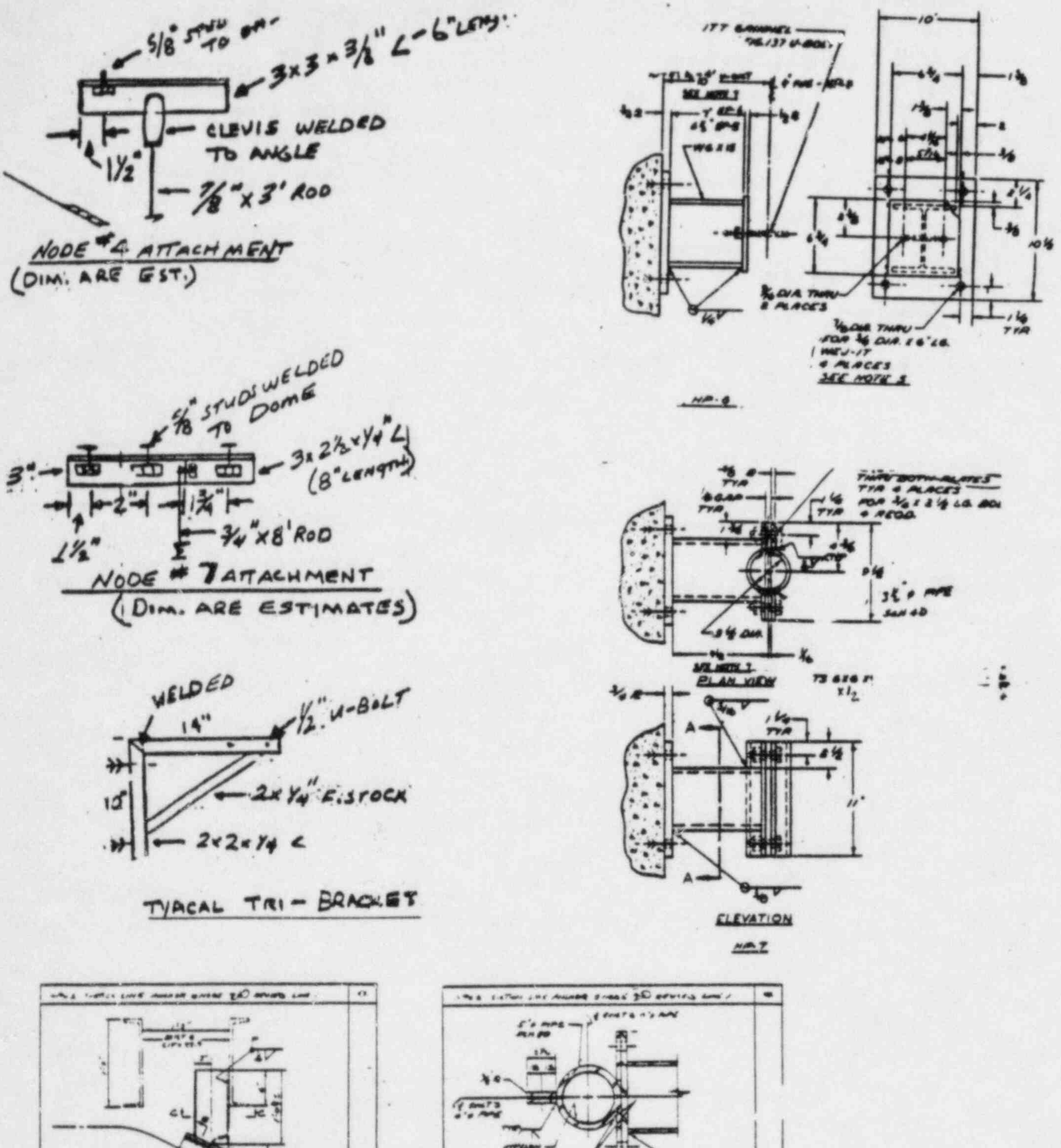


FIGURE 2-3 HPCS SUCTION LINE SUPPORTS

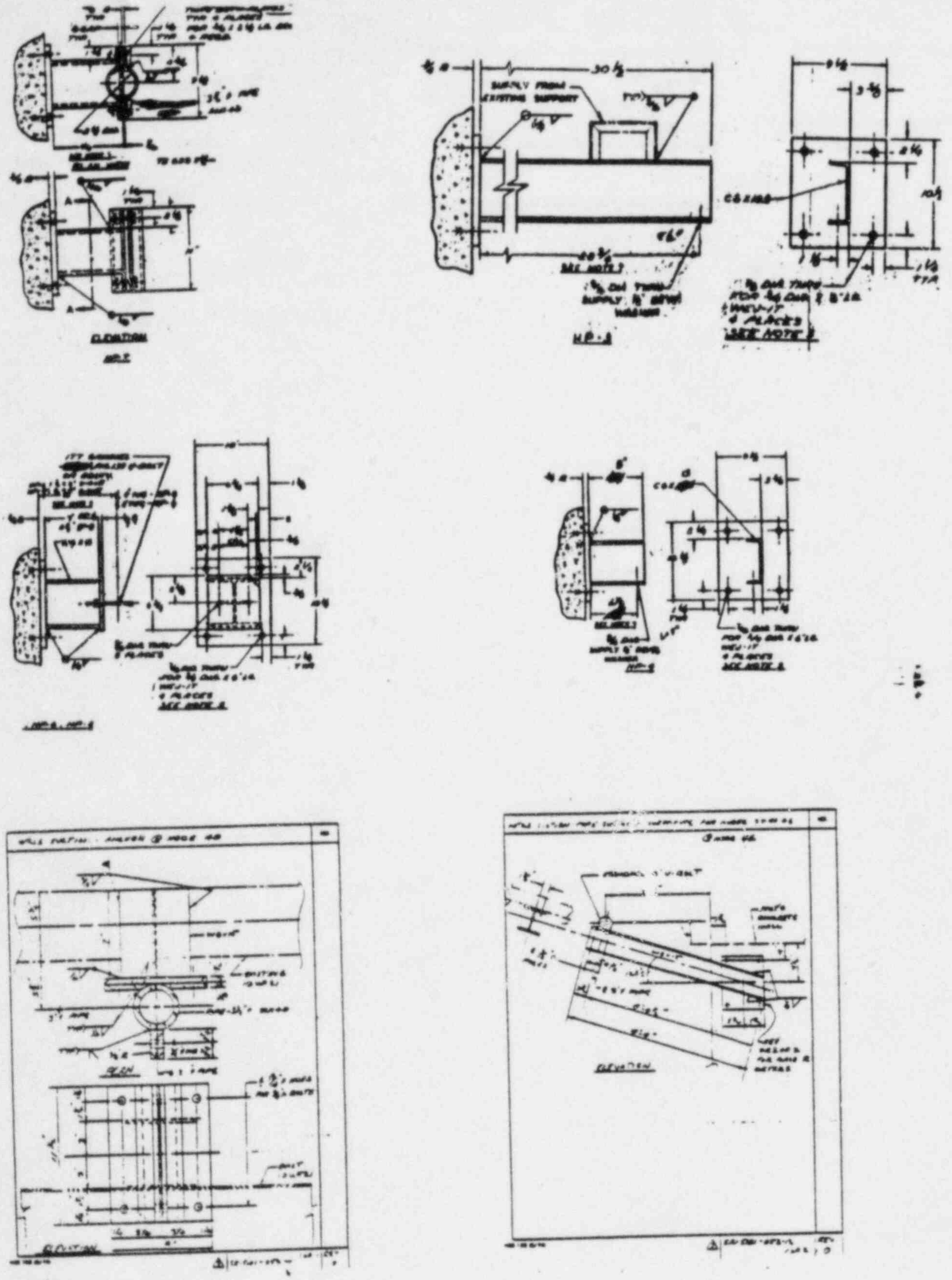


FIGURE 2-4 HPCS SUCTION LINE SUPPORTS

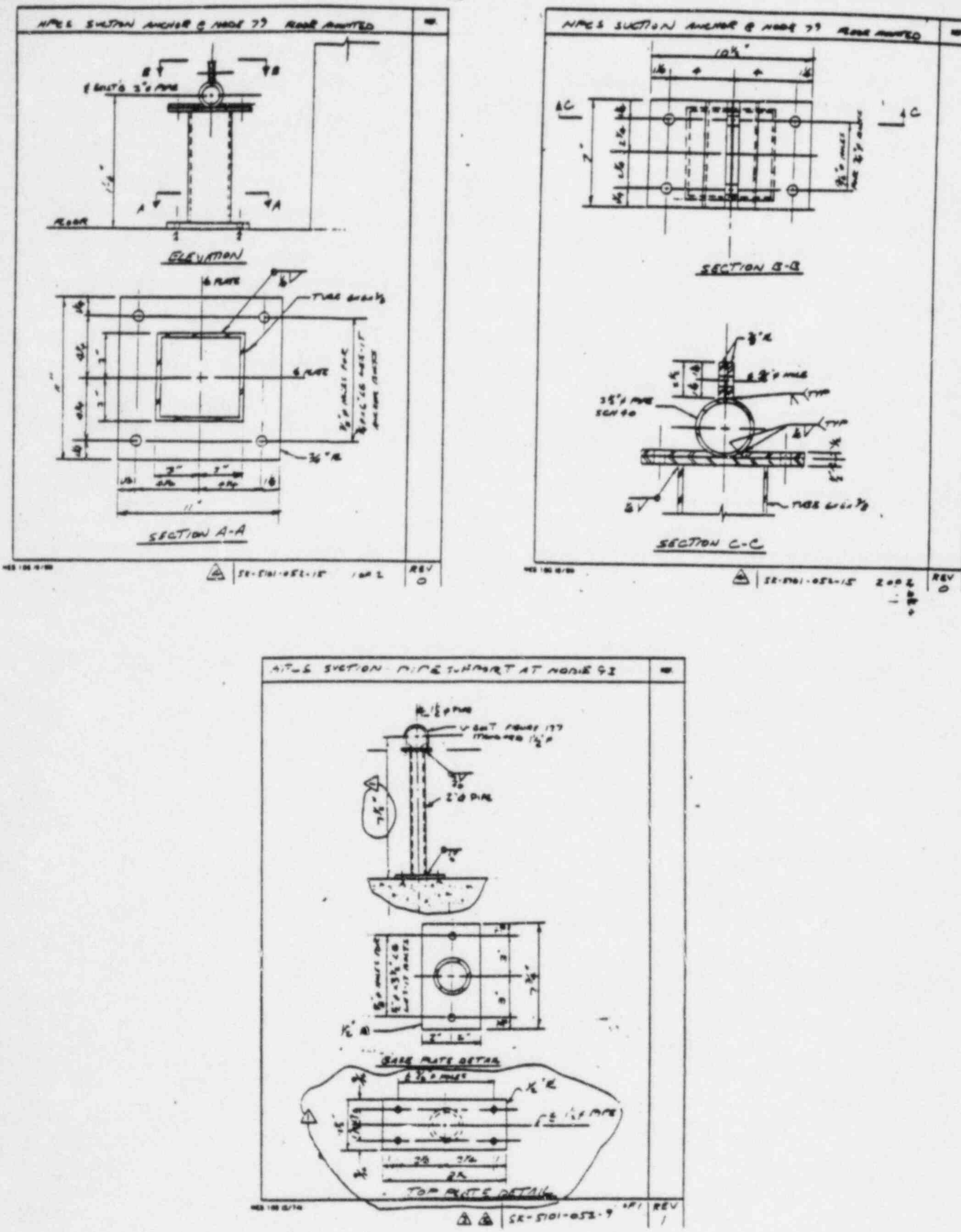
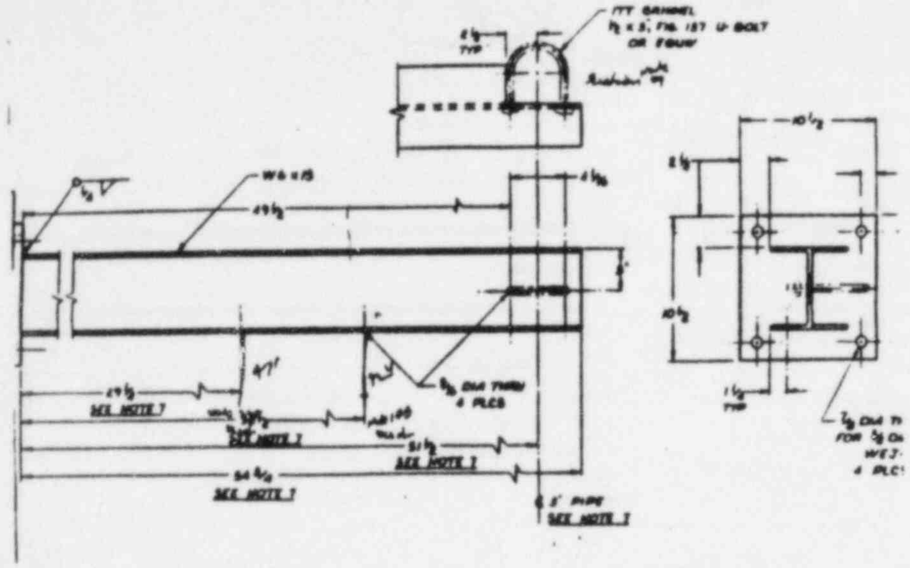
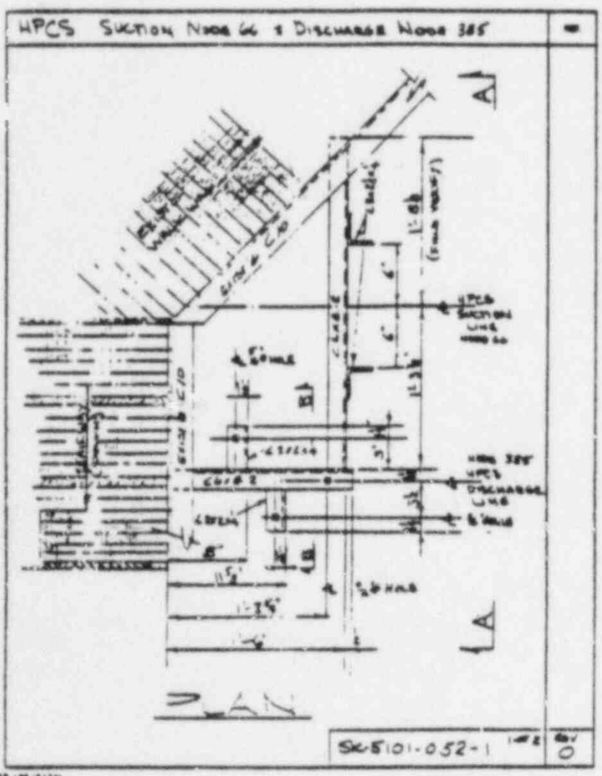
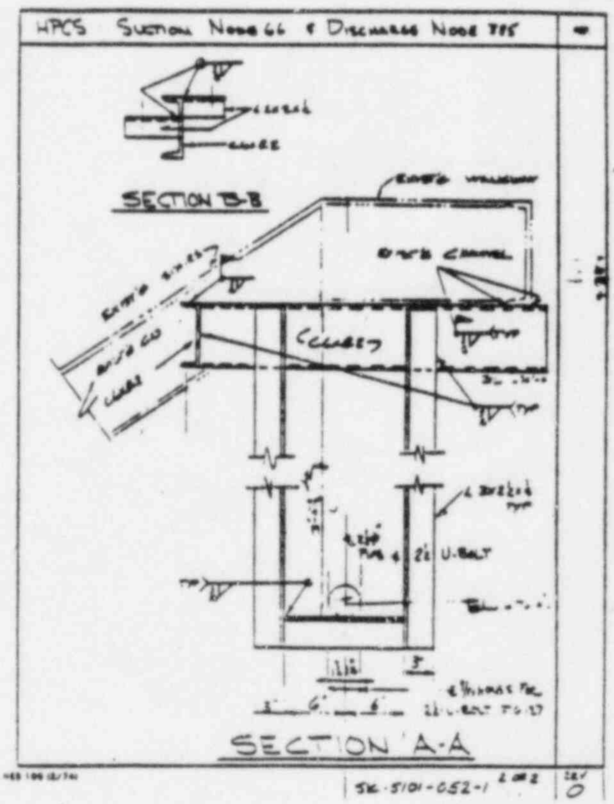


FIGURE 2-5 HPCS SUCTION LINE SUPPORTS







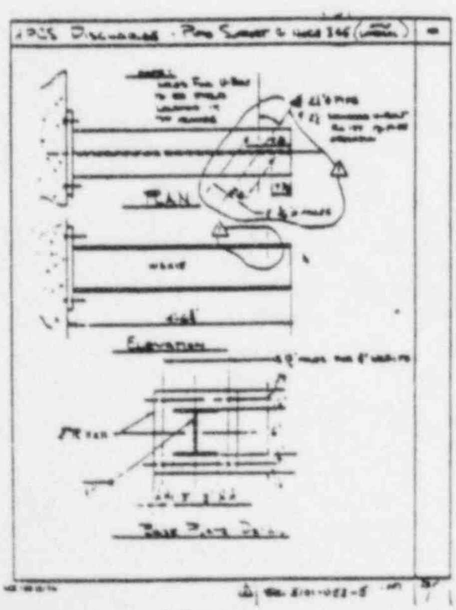


FIGURE 2-6 HPCS SUCTION LINE SUPPORTS

3. APPLICABLE CODES, STANDARDS AND SPECIFICATIONS

The HPCS piping and support systems have been analyzed using applicable methodology and acceptance criteria consistent with current ASME Code and Regulatory requirements.

The following design Codes, Regulatory Guides, Standard Review Plan criteria and specifications have been used in the seismic and stress analysis of Class I piping and support systems.

1. ASME Boiler and Pressure Vessel Code Section III, Subsection NB Class I Components, 1983 Edition.

2. Standard Review Plan 3.9.3 "ASME Code Class 1 2 and 3 Components, Component Supports and Core Support Structure".

3. USNRC Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants", October, 1973.

4. USNRC Regulatory Guide 1.92 "Combination of Modes and Spatial Components in Seismic Response Analysis", Revision 1, February, 1976.

5. Sargent and Lundy Engineers, "Specification for Piping System La Crosse Boiling Water Reactor", LACBWR #256.

6. Allis-Chalmers, "La Crosse Boiling Water Reactor Safeguards Report Volume I and II, LACBWR #283, dated August, 1967.

4. LOADING CONDITION

Appendix A to the Standard Review Plan 3.9.3 and ASME Code Subsection NB provide guidance in the selection of acceptable design and service stress limits associated with various loadings and combinations there of, resulting from plant and system operating conditions and design basis events, and natural phenomenon. Based upon these guidance, the following applicable loading conditions have been considered in the analysis.

Design and Operating Pressures.

Piping design pressures are taken from the LACBWR piping specification (Reference 9) and are 100 psig for both the HPCS Suction line 1 and 2. Operating pressures for the HPCS Suction lines are based on the LACBWR Safeguards Report (Reference 15). These are 100 psig for both the HPCS Suction line 1 and 2.

Dead Weight and Sustained Mechanical Loads.

The dead weight of the piping system is calculated considering the piping to be insulated and filled with water. Sustained mechanical loads considered in the analysis includes the weight of the valves and valve operators. The uniformly distributed piping weights and the concentrated weight are given in Appendix A.

Thermal Load

The HPCS suction piping system is basically a cold line containing room temperature water from the overhead storage tank. Thermal expansion stresses are calculated assuming the design temperature of 120°F to be the normal operating condition. Thermal discontinuity and thermal gradient secondary bending stress are negligible at this temperature and are therefore, not considered in the analysis.

Seismic Loading

The piping anchors and supports are subjected to seismic accelerations as defined by the appropriate response spectrum for each of the two horizontal and the vertical directions. The 2% damped, peak-broadened Safe Shutdown Earthquake (SSE) Spectra associated with the Containment Building at an elevation of 752 feet (Reference 4) are used for the HPCS Suction line 1. These spectra shown in Figure 4-1 through 4-3 are conservative for all elevations of the HPCS Suction line 1. Similarly, the 2% damped, peak broadened SSE spectra associated with the Containment Building at an elevation of 701 feet are used for the HPCS Suction line 2. These spectra shown in Figure 4-4 through 4-6 are conservative for all elevations of the HPCS suction line 2. The digitized seismic spectra are presented in Appendix A.

The relative seismic anchor movements between the various pipe support and anchor points are calculated from the low frequency displacement response obtained from the Containment Building response spectra. The relative seismic anchor movements used in the analysis are presented in Appendix A.

For load combinations including Operating Basis Earthquake (OBE), the SSE response results are conservatively multiplied by a factor of 0.5.

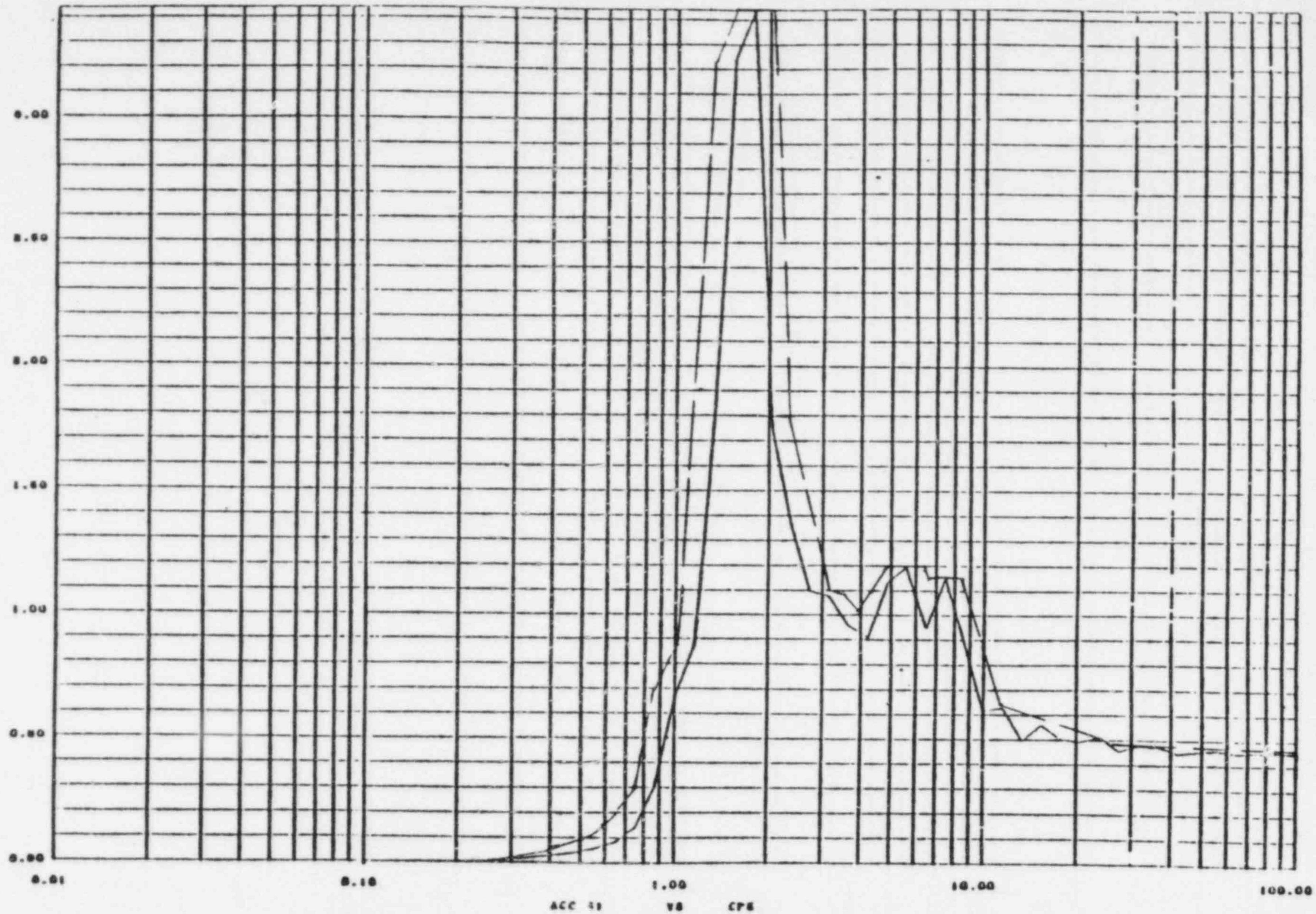


Figure 59. Node 70 (elev. 752 ft.) X-Dir. Spectra .02 Damping

FIGURE 4-1 For Suction Line No. 1

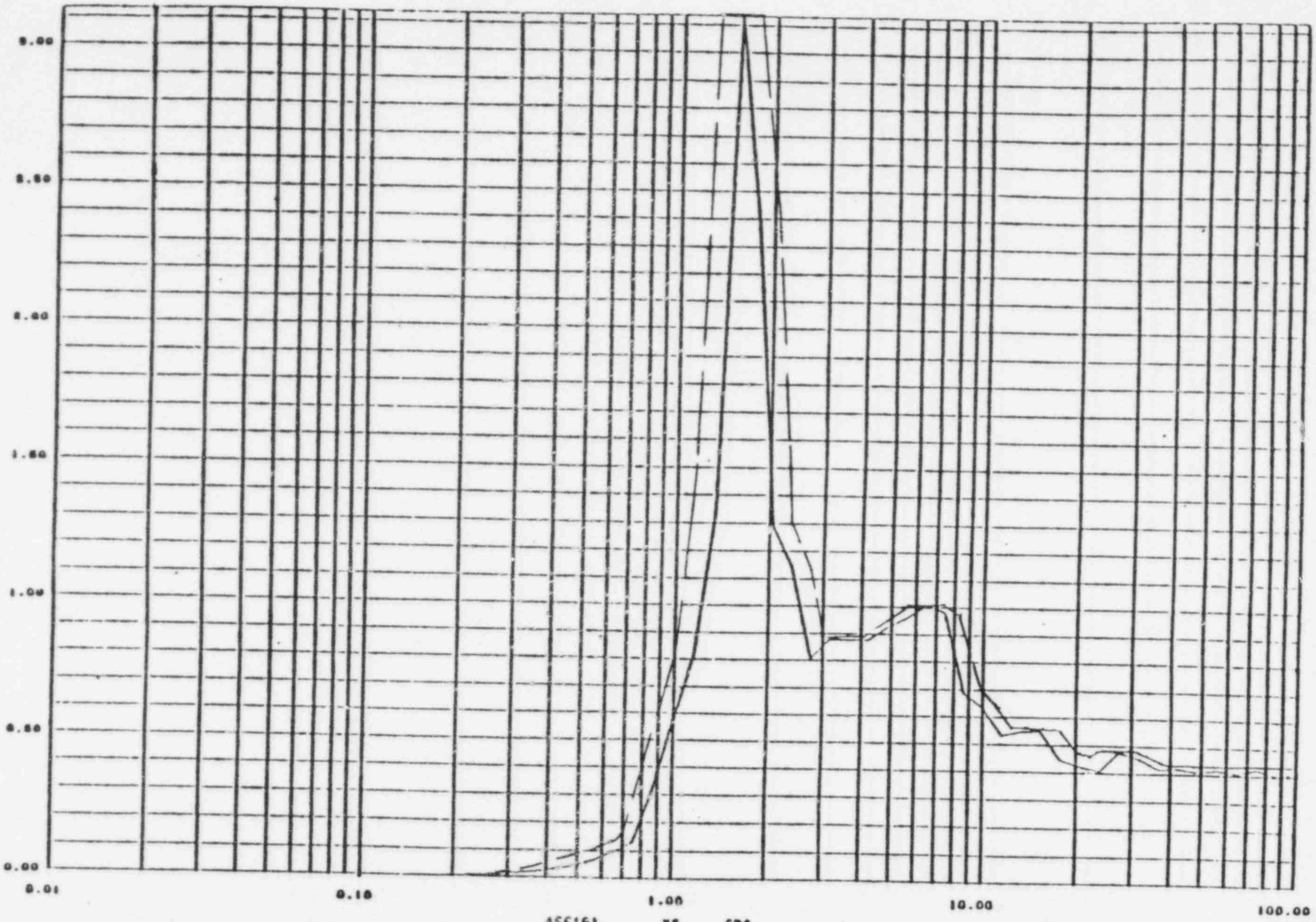


Figure 60. Node 70 (elev. 752 ft.) Y-Dir. Spectra .02 Damping

FIGURE 4-2 for Suction Line No. 1

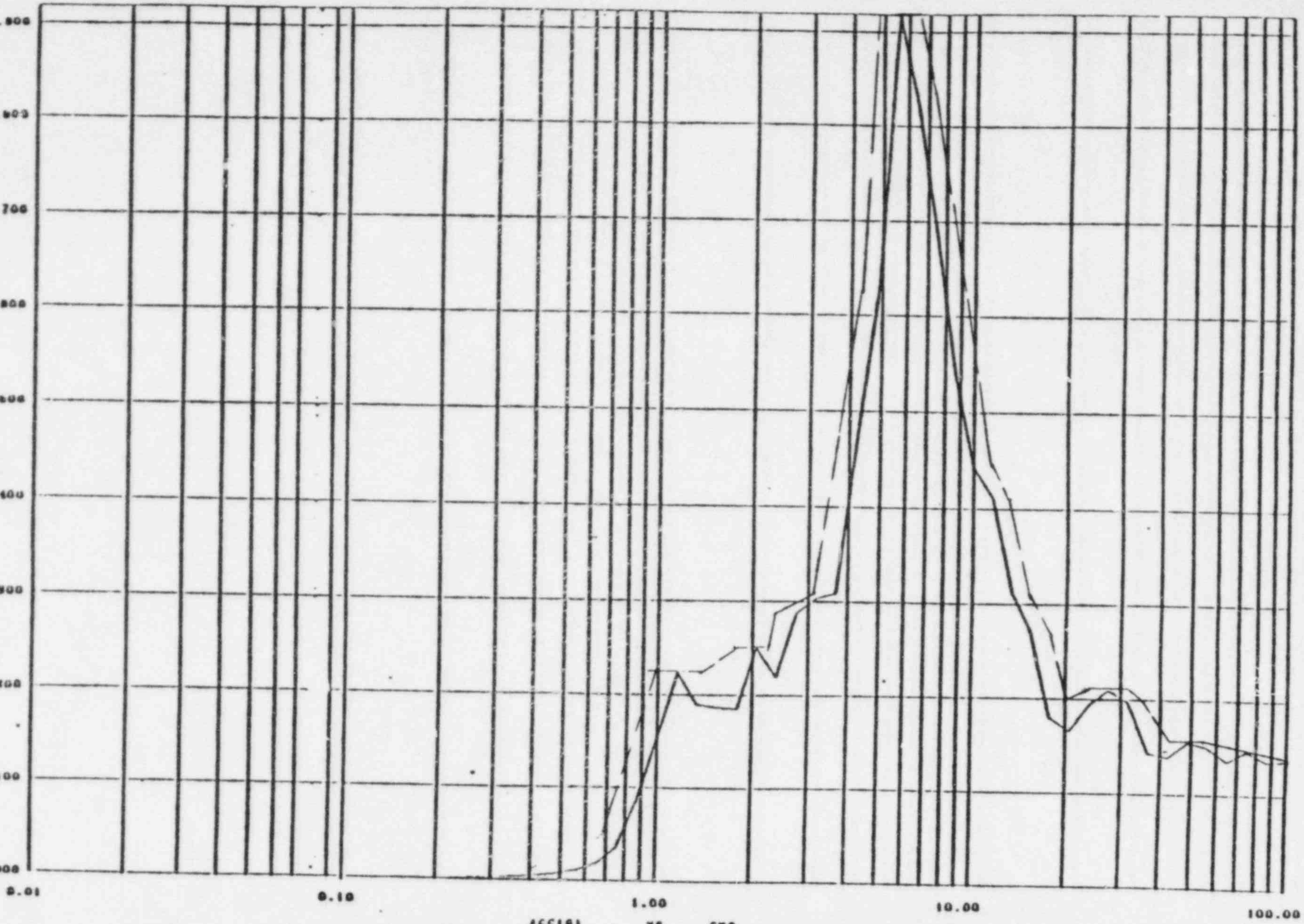


Figure 61. Node 70 (elev. 752 ft.) Z-Dir. Spectra .02 Damping

FIGURE 4-3 For Suction Line No. 1

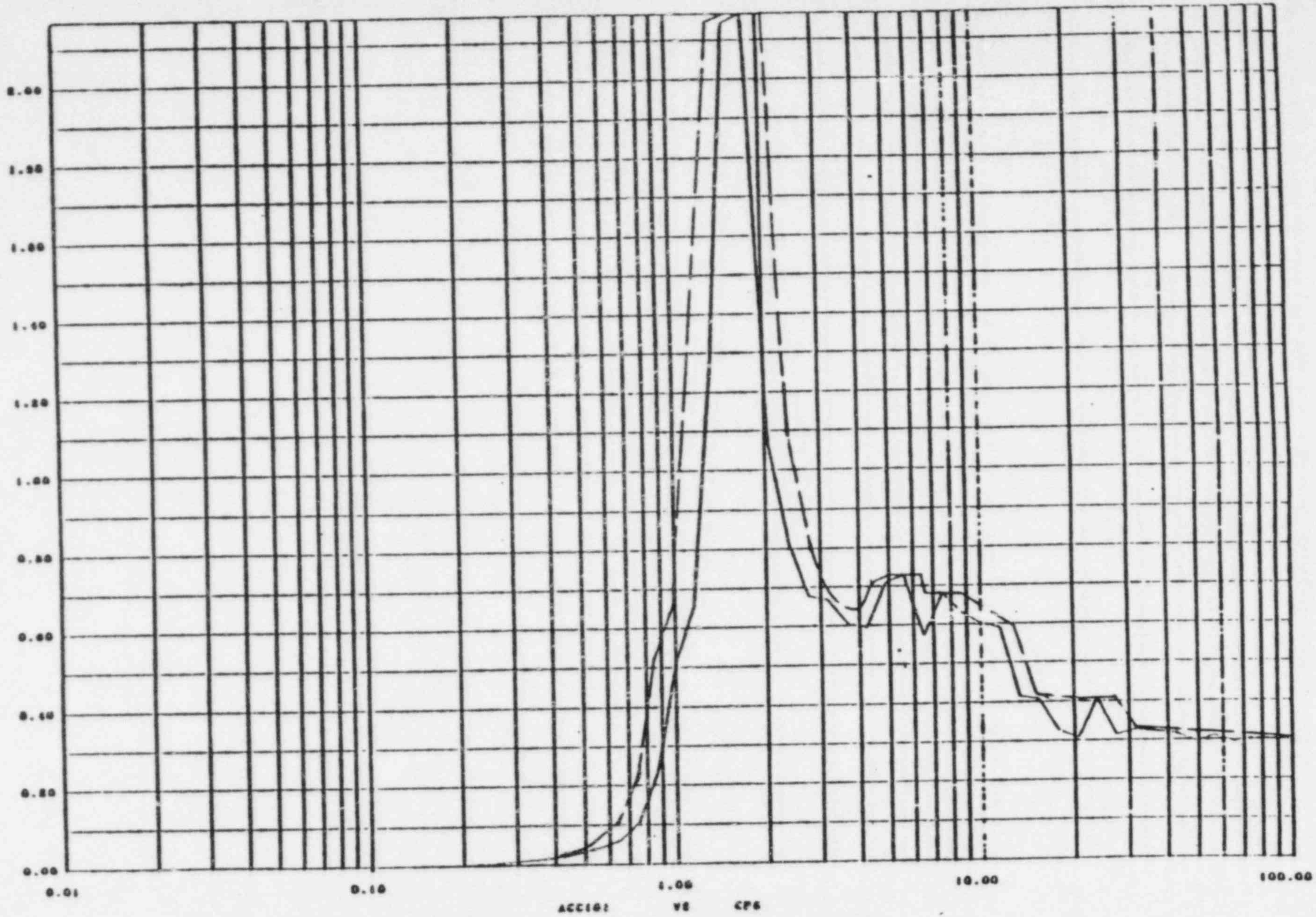


Figure 47. Node 60 (elev. 701 ft.) X-Dir. Spectra .02 Damping

FIGURE 4-4 For Suction Line No. 2

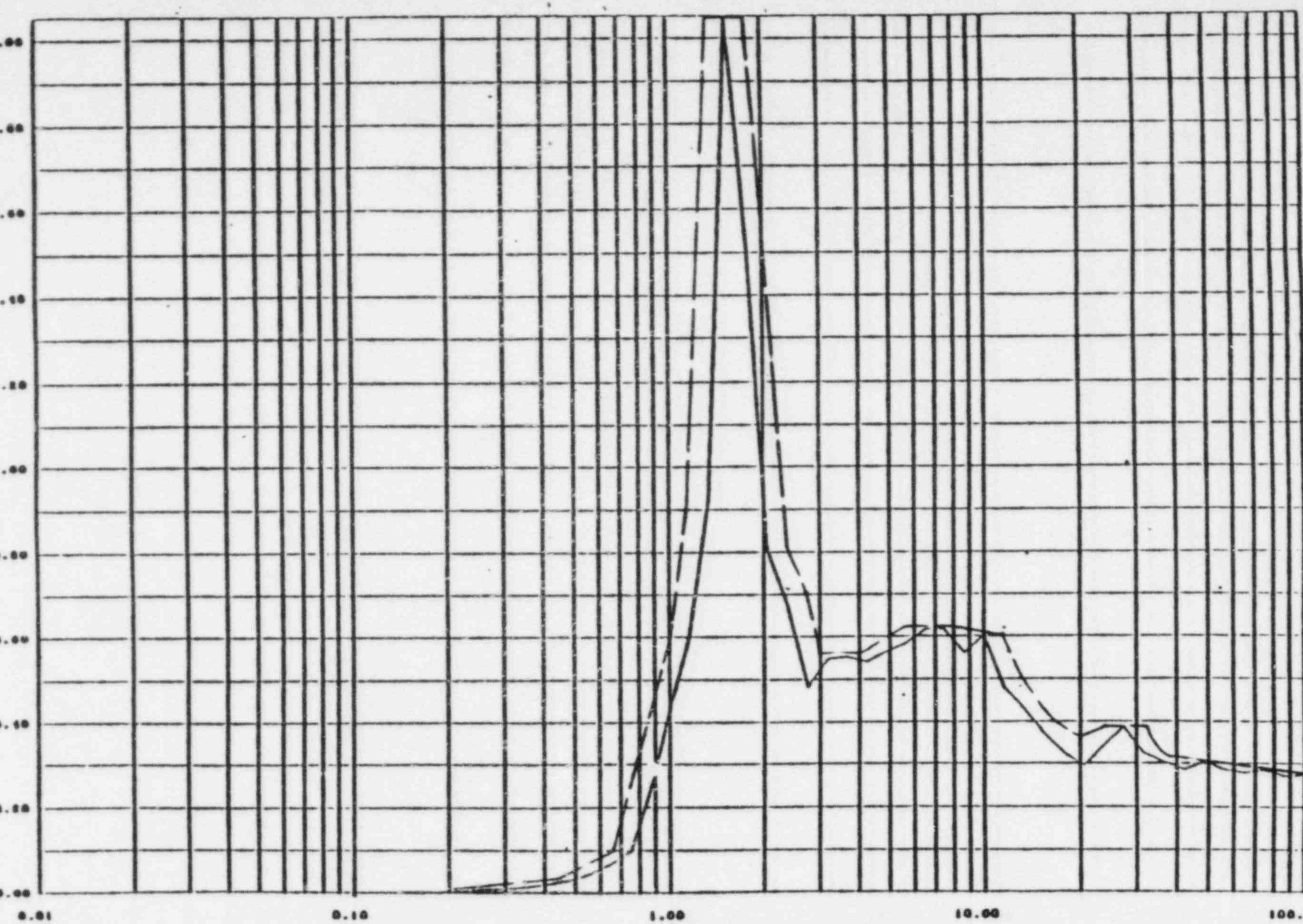


Figure 48. Node 60 (elev. 701 ft.) Y-Dir. Spectra .02 Damping

FIGURE 4-5 For Suction Line No. 2

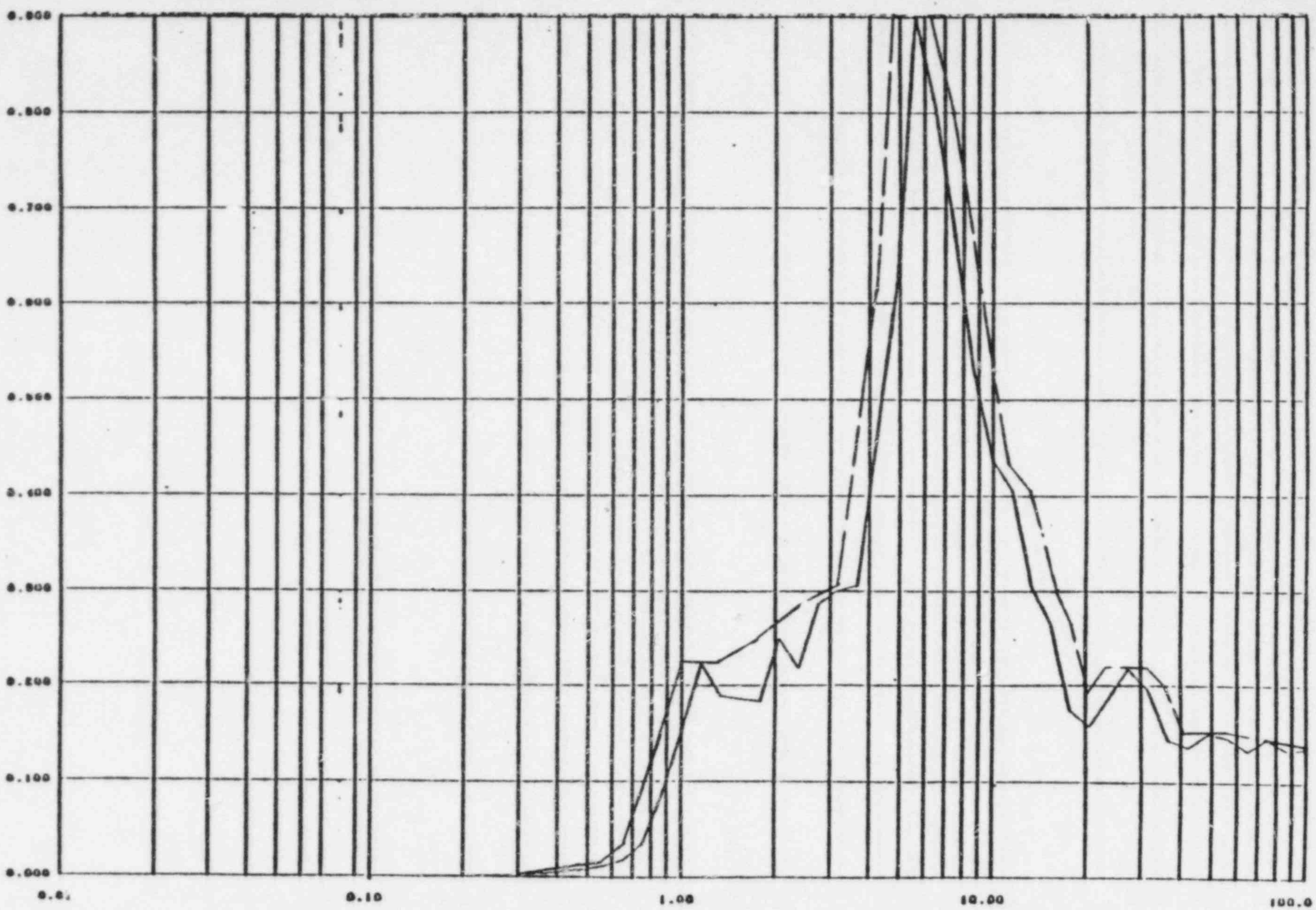


Figure 49. Node 60 (elev. 701 ft.) Z-Dir. Spectra .02 Damping

FIGURE 4-6 For Suction Line No. 2

5. LOAD. COMBINATIONS AND ACCEPTANCE CRITERIA

The requirements for load combinations and stress acceptance criteria for a Class I piping system are given in NRC Standard Review Plan 3.9.3 (Reference 6) and Subsection NB3600 of Section III of the ASME Code. These requirements are summarized below.

5.1 Design Considerations and Design Loadings.

The primary stress intensity, resulting from design pressure shall satisfy the requirement of equation 1 of the ASME Code.

5.2 Service Loading Combinations.

Service Level A Stress Limit

The piping system shall meet a service limit not greater than Level A when subjected to sustained loads resulting from normal plant/system operation. This requirement is satisfied by limiting the primary stress intensity due to pressure and sustained loads calculated using equation 9 of the ASME Code to 1.5 times the allowable design stress intensity, S_m , at design temperature.

Service Level B Stress Limit

The piping system shall meet a service limit not greater than Level B when subjected to the appropriate combination of loadings resulting from (1) sustained loads, (2) specified plant/system operating transients (SOT) and (3) the Operating Basis Earthquake (OBE) The requirement for Service level B is satisfied by limiting the primary stress due to applicable service level B loadings as calculated by equation 9 of the ASME Code to 1.8 S_m or 1.5 S_y which ever is smaller. In addition the primary plus secondary stress intensity range resulting from the combined effects of linear thermal expansion linear thermal gradient and discontinuity, operating pressure

thermal anchor movement calculated in accordance with equation 10 of the ASME Code must be less than 3 Sm. In the event equation 10 is not satisfied, the piping component may still be acceptable provided the requirement of a simplified elastic-plastic discontinuity analysis (NB-3653.6) are met.

Service Level C Stress Limit

The piping system shall meet a service limit not greater than Level C when subjected to the appropriate loadings resulting from (1) sustained loads and (2) the design basis pipe break event (not specified in this analysis)

Service Level D Stress Limit

The piping system shall meet a service limit not greater than Level D when subjected to the appropriate combination of loadings resulting from (1) sustained load (2) LOCA; and (3) The Safe Shutdown Earthquake (SSE). The requirement for Service level D is satisfied by limiting the primary stress due to applicable service level D loadings as calculated by equation 9 of the ASME Code to $2.4S_m$ or $0.7S_u$ which ever is smaller.

6. PIPING ANALYSIS

6.1 NUPIPE ANALYTICAL PROCEDURES

The basic method of anlysis used in NUPIPE is the finite element stiffness method. In accordance with this method, the continiuous piping is mathematically idealized as an assembly of elastic structural members connecting discrete nodal points. Nodal points are placed in such a manner as to isolate particular types of piping elements, such as straight runs of pipe, elbows, valves, etc., for which force-deformation characteristics can be categorized. Nodal points are also placed at all discontinuities, such as piping supports, concentrated weights, branch lines, and changes in cross-section. System loads such as weights, equivaent thermal forces, and earthquake inertia forces are applied at the nodal points. Stiffness charateristics of the interconnecting members are related to the effective shear area and moment of inertia of the pipe. The stiffness of piping elbows and certain branch connectors is modified to account for local deformation effects by the flexibility factors suggested in the ASME Section III Code. Figures 6-1 through 6-4 shows the NUPIPE mathematical model and computer plots of the HPCS suction line 1 and 2 piping systems.

6.1.1 Static Analysis

The static equation of equilibrium for the idealized system may be written in matrix form, as follows:

$$KU = P - Q \qquad (6\text{-}1)$$

where:

K = stiffness matrix for assembled system
U = nodal displacement vector
P = external forces, weights, etc.
Q = equivalent thermal forcea = $\int AE\alpha \, T dL$

The nodal unknown displacements are obtained in NUPIPE by solving these simultaneous using the Gauss method. The nodal displacements are then applied to the individual members, and member stiffness used to find internal forces. The nodal displacements at support locations is used along with the support stiffness to determine support reactions.

6.1.2 Dynamic Analysis

6.1.2.1 Mathematical Model

For dynamic analysis, the mathematical model is described as a lumped mass, multi-degree of freedom model. The distributed piping mass is lumped at the system nodal points. The equation of equilibrium for the system is:

$$M\ddot{U} + C\dot{U} + KU = F \qquad (6\text{-}2)$$

where:

- M = mass matrix for assembled system.
- C = damping matrix for assembled system
- $\ddot{U}$ = nodal acceleration vector = $\ddot{U}(t)$
- $\dot{U}$ = nodal velocity vector = $\dot{U}(t)$
- U = nodal displacement vector
- F = applied dynamic force = $F(t)$ = $M\ddot{U}_g$ for earthquake
- $\ddot{U}_g$ = support acceleration = $\ddot{U}_g(t)$

This equation is solved for the system dynamic response as follows. First, the frequencies and mode shapes are obtained by removing the forcing and damping terms from Equation 6-2 and solving. Next, the natural mode shapes are used to affect an orthogonal transformation of Equation 6-2, yielding a series of indepdndent equation of motion uncoupled in the system modes. Then, the uncoupled equations are solved by the response spectrum method to obtain system response in each mode, and the individual modal results

are then combined in accordance with Regulatory Guide 1.92 (Reference 5) to determine the total system dynamic response. The mathematical formulation of these steps are as follow:

6.1.2.2 Natural Frequencies and Mode Shapes

The eigenvalues (natural angular frequencies ω_n) and the eigenvectors (mode shapes ϕ_n) for each of the natural modes are calculated by solving the frequency equation.

$$\left[K - \omega_n^2 M\right] \left\{\phi_n\right\} = \left\{0\right\} \qquad (6\text{-}3)$$

where:

ω_n = natural frequency in n^{th} mode
K = stiffness matrix
M = mass matrix
ϕ_n = mode shape vector in n^{th} mode
0 = null vector

The eigenvalues and eigenvectors are obtained in NUPIPE using the Householder- QR algorithm (NUPIPE -11M) or subspace iteration (NUPIPE-11L).

6.1.2.3 Dynamic Response

Pre and post-multiplication of Equation 6-2 by $[\phi]$, the square matrix of mode shape vectors, constitutes an orthogonal transformation, from which the uncoupled equations of motion shown below are obtained.

$$\ddot{Y}_n + 2\omega_n \lambda_n \dot{Y}_n + \omega_n^2 Y_n = P_n \qquad (6\text{-}4)$$

where:

Y_n = generalized (modal) displacement coordinate for the n^{th} mode ($U_n = \phi_n Y_n$)

λ_n = damping ratio for the n^{th} mode expressed as percent of critical damping

P_n = generalized force for the n^{th} mode = $\phi_n^T F$

Solution to these differential equations is obtained by the method of response spectrum superposition.

6.1.2.4 Response Spectrum Superposition

Based on this method, the maximum generalized acceleration for each mode is given by:

$$\ddot{Y}_{n_{max}} = \left(\sum_{j=x,y,z}\left(R_{nj}\ Sa_{nj}\right)^2\right)^{1/2} \Big/ M_n \qquad (6\text{-}5)$$

where:

$\ddot{Y}_{n\ max}$ = maximum generalized coordinate acceleration response

Sa_{nj} = spectral acceleration for n^{th} mode in in J-direction (from response spectrum data input)

R_{nj} = Mode participation factor for n^{th} mode in J-direction

M_n = modal mass for the n^{th} mode = $\left(\phi_n^T M\phi\right)$

The maximum internal inertia forces are given by:

$F_{in\ max} = M_i \ddot{Y}_{n\ max} \phi_{in}$ = maximum inertia force at nodal mass point i in the n^{th} mode

These inertia forces are calculated for each of the system natural modes, and applied as static forces in the same manner as the weight or equivalent thermal forces, to find internal forces in each mode. Total system response is then obtained by combining the individual modal response values in accordance with regulatory guide 1.92. The effects of higher modes (Frequency $>$33 Hz) is automatically considered by applying static loads in proportion to the non-participating mass times the zero period acceleration. The combined seismic response of the three spatial component of the earthquake is obtained by taking the square-root-of-the-sum-of-the-squares of the corresponding maximum response value due to the three components calculated independently (Regulatory Guide 1.92).

6.1.3 Piping Stress Analysis

The modeling of the various piping problems using the NUPIPE computer code was conducted in a manner consistent with the data available from the piping isometric drawings, the support detail drawings, and the NES design analyses. Care was taken to accurately model the mass and stiffness characteristics of the various systems. Particular care was taken to properly model the mass eccentricities associated with the operators of motor operated, air operated, and hand operated valves as well as smaller eccentricities associated with other non- axisymmetric valves.

The formula used to evaluate the primary secondary stress intensity levels and fatigue analysis for Class 1 piping systems is taken from Subsection NB-3600, Section III, ASME Boiler and pressure Vessel Code. These formulas are given below.

Pressure Design Check

The minimum rquired pipe wall thickness (t_m) is computed from

$$t_m = \frac{PD_o}{2(S_m + yP)} \quad \text{---------------------(Eqn.1)}$$

where:

P = Internal design pressure

D_o= Outside diameter of pipe

S_m= Maximum allowable stress in material at the design temperature

y = 0.4

Primary Stress Intensity Check

The primary stress intensity is computed from and limited by the following:

$$B_1 \frac{PD_o}{2t} + B_2 \frac{D_o}{2I} M_i = 1.5S_m \quad \text{-----------------(Eqn.9)}$$

where:

B_1, B_2 = Primary stress indices for the specific piping component being investigated.

t = Nominal wall thickness of piping component

I = Moment of inertia

M_i = Resultant moment loading from loads caused by (1) weight, (2) earthquake, and (3) other mechanical loads (one-half the range, excluding anchor movement effects).

P, D_o, S_m = as in Eqn.1

Primary Plus Secondary Stress Intensity Range Check

The primary plus secondary stress intensity range is computed from and limited by the following:

$$S_n = C_1\left(\frac{P_o D_o}{2t}\right) + C_2\left(\frac{D_o}{2I}\right) M_i + \left[\frac{1}{2(1-v)} \quad E\alpha\, \Delta T_1\right]^{*} + C_3 E_{ab} \left|\alpha_a \bar{T} - \alpha_b \bar{T}_b\right| \leq 3S_m \text{ - (Eqn. 10)}$$

where:

C_1, C_2, C_3 = Secondary stress indices for the specific piping component being investigated.

P_o = Range of operating pressure

M_i = Range of moment loading resulting from thermal expansion, anchor movements from any cause, seismic effects, and other mechanical loads.

V = Poison ratio = 0.3

* = This term is omitted in the summer, 1979 revision of the ASME Code. Version 1.5 of NUPIPE reflects this change.

$E\alpha$ = Modules of elasticity (E) times the mean coefficient of thermal expansion (α)

ΔT_1 = Range of absolute value (without regard to sign) of the temperature difference between the temperature of the outside surface (T_o) and the temperature of the inside surface (T_i) of the piping component, assuming moment-generating equivalent linear temperatur distribution.

E_{ab} = Average modulus of elasticity of the two parts of the gross discontinuity.

α_a = Mean coefficient of expansion on side "a" of a gross discontinuity such as a branch-to-run, flange-to-pipe, or socket-fitting-to-pipe gross discontinuity.

T_a = Range of average temperature minus the room temperature on side "a" of a gross discontinuity.

α_b = Mean coefficient of expansion on side "b" of a gross discontinuity.

T_b = Range of average temperature minus the room temperature on side "b" of a gross discontinuity.

D_o, t, I = As above.

Peak Stress Intensity Range

In peak stress intensity range is calculated, for later use in the fatigue evaluation, as follows:

$$S_p = K_1C_1\left(\frac{P_oD_o}{2t}\right) + K_2C_2\left(\frac{D_o}{2I}\right)M_i + \frac{1}{2(1-v)}\ K_3E\alpha\left|\Delta T_1\right|$$

$$+ K_3C_3E_{ab}\left|\alpha_a\bar{T}_a-\alpha_b\bar{T}_b\right| + \frac{1}{1-v}\ E\alpha\left|\Delta T_2\right| \text{---(Eqn. 11)}$$

where:

K_1, K_2, K_3, = Local stress indices for the specific piping component being investigated.

ΔT_2 = Range of absolute value (without regard to sign) for that portion of the nonlinear thermal gradient through the wall thickness not included in ΔT_1 of (Eqn.10)

Elastic-Plastic Discontinuity Analysis

Where the primary plus secondary stress intensity range, calculated by equation (10), does not fall within the elastic range (3Sm), the following formula (simplified elastic-plastic discontinuity analysis) are evaluated.

$$S_e = C_2\left(\frac{D_o}{2I}\right)M_i \leq 3S_m \text{------------------------(Eqn. 12)}$$

where:

S_e = Expansion stress

C_2 = Secondary stress index for specific piping component being investigated.

M_i = Range of moment loading resulting from thermal expansion and anchor movements.

Limit of primary plus secondary membrane, plus bending stress

intensity, excluding thermal expansion stresses:

$$C_1\left(\frac{P_oD_o}{2t}\right) + C_2\left(\frac{D_oM_i}{2I}\right) + C_3^1E_{ab}\left|\alpha_aT_a - \alpha_bT_b\right| \leq 3S_m \text{------(Eqn. 13)}$$

where:

C_1, C_2 = Secondary stress indices for the specific component under investigation.

C_3^1 = Stress index value for the specific component under investigation.

Both equation (12) and equation (13) must be satisfied before equation (14) is used.

Fatigue Evaluation

Fatigue criteria are satisfied by limiting the usage factor. The uasage factor is defined as the ratio of the number of system cycles between two load conditions to the number of cycles allowable for the alternating stress range between these conditions. This ratio is identified as $U = n_n/N_n$ in subaricle NB3222.4 of the ASME , section III code. The number of cycles allowable is taken from a curve provided in appendix I of the ASME Code and which is contained in NUPIPE. The alternating stress is calculated from:

$$S_{alt} = \tfrac{1}{2}K_eS_p \text{ -------------------(Eqn.14)}$$

where:

S_{alt} = Alternating stress intensity

K_e = Factor used to compensate for reduction in cycle life in plastic cycling.

= 1.0 for $S_n \leq 3S_m$

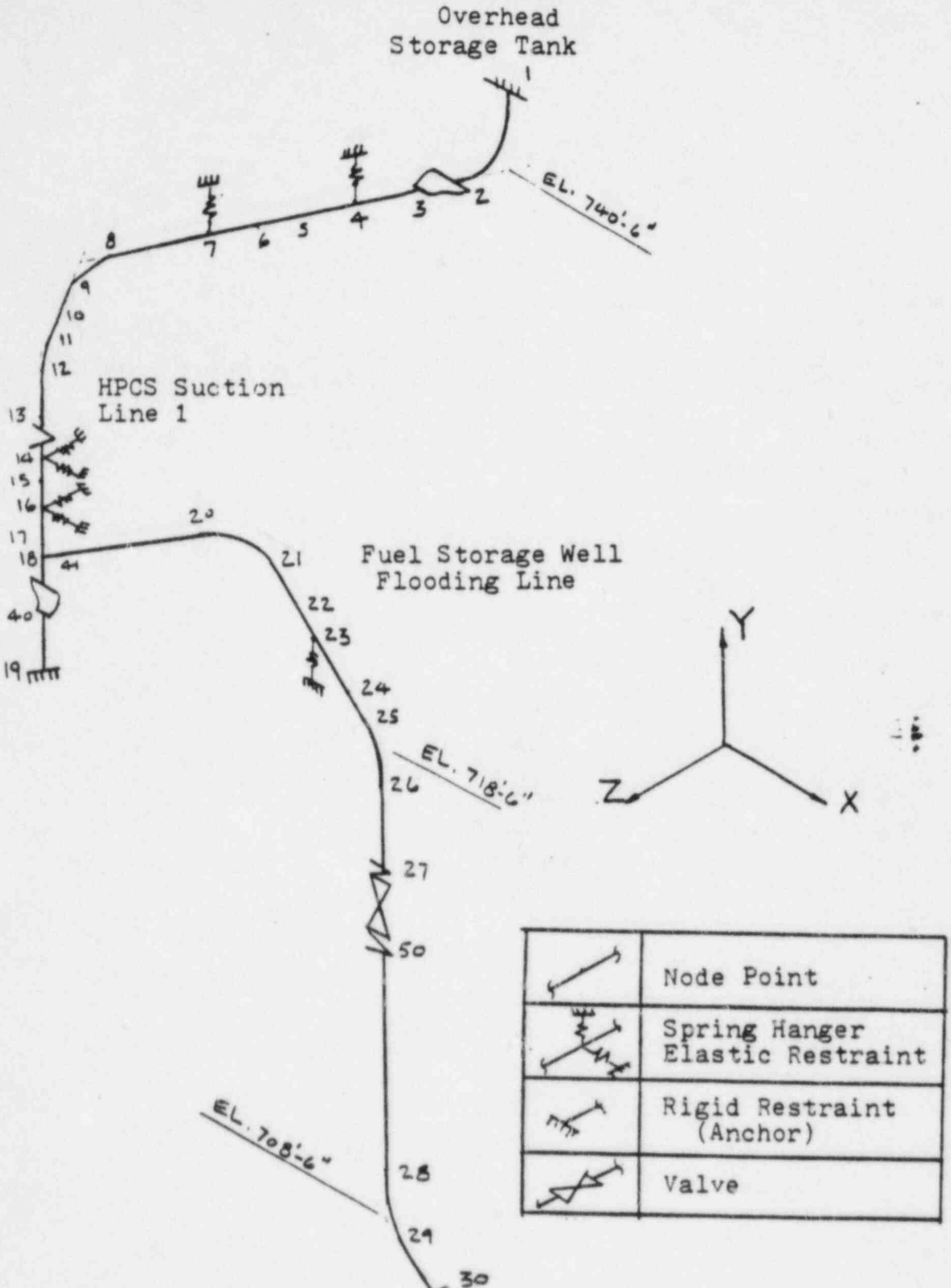


FIGURE 6.1 HPCS SUCTION LINE 1
NUPIPE MATHEMATICAL MODEL

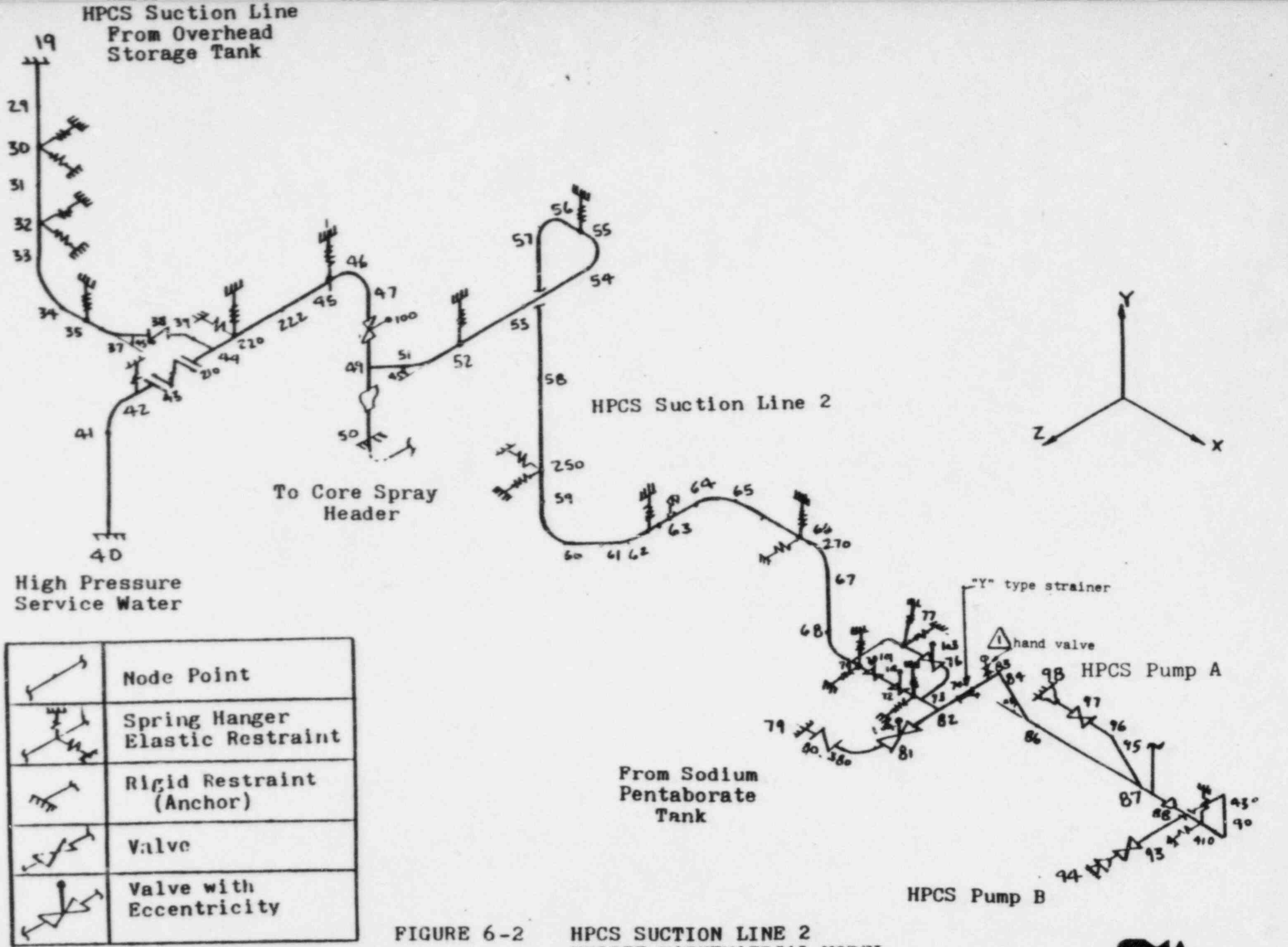


FIGURE 6-2 HPCS SUCTION LINE 2
NUPIPE MATHEMATICAL MODEL

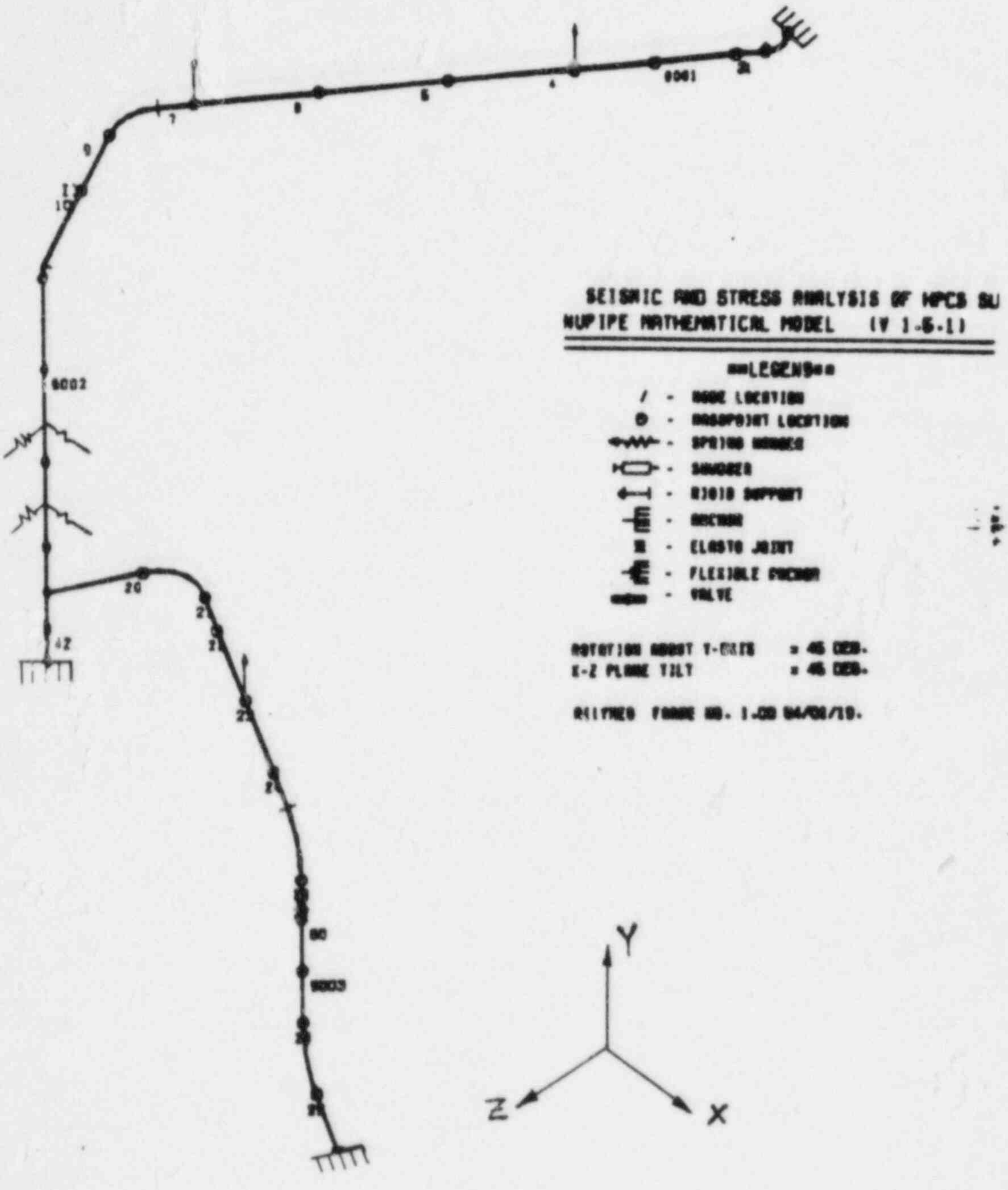


FIGURE 6-3 HPCS SUCTION LINE 1
NUPIPE COMPUTER PLOT

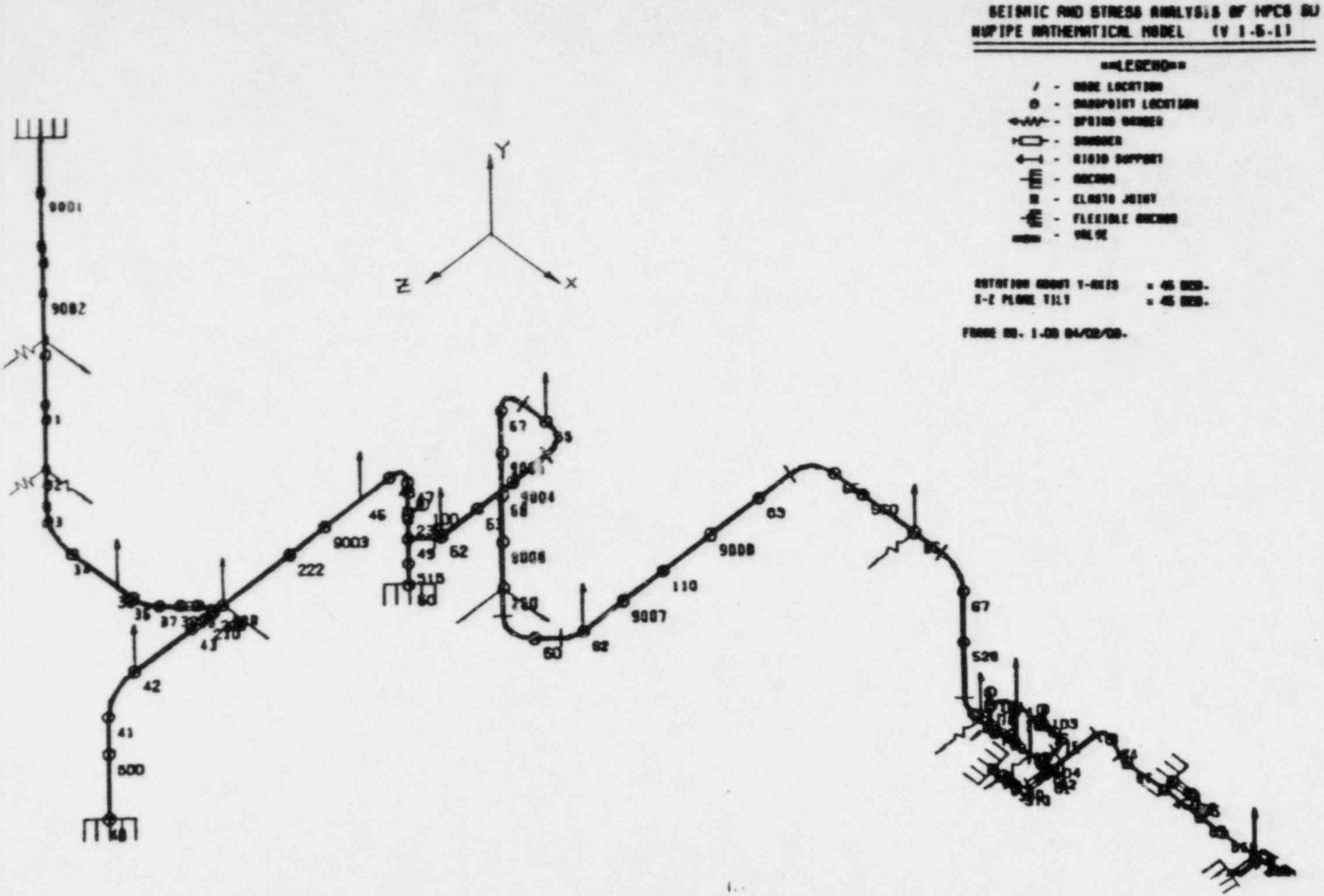


FIGURE 6-4 HPCS SUCTION LINE 2
NUPIPE COMPUTER PLOT

7. RESULTS OF ANALYSIS

The detail results of seismic and stress analysis of LACBWR High Pressure Core Spray Suction Piping systems are contained in Reference 16.

Appendix A contain the NUPIPE input data such as pipe mass and section properties, pipe supports stiffnesses, concentrated weights, digitized seismic spectra, and seismic anchor movements. Appendix B contain the support reaction loads due to various load cases and accelerationsdue to seismic load.

7.1 HPCS SUCTION LINE 1

The modal analysis of HPCS Suction Line 1 indicates 13 natural frequencies of vibration exist below the rigid response frequency of 38 H_z. These are shown in Table 7-1 together with the modal participating mass fractions for each mode. The fundamental frequency of 3.12 Hz represents the x-direction horizontal displacement at node 8. The most important mode in terms of mass participation is mode 3 (8.32 Hz) which represents the x-direction horizontal displacement of HPCS Suction Line 1 at Node 25. The maximum deflection due to the SSE seismic inertia loading is 1.08 inches at Node 8. For a flexible piping system this deflection is acceptable. The maximum seismic acceleration is 1.44 G at Node 8.

Figure 7-1 through 7-2 represents Class 1 piping stress analysis results together with the Code allowable stress values for HPCS Suction Line 1. The maximum primary stress intensity of 11.37 ksi, resulting from Service Level D load combination which included SSE Seismic event occurs at Node 1 (HPCS Suction Line 1/over head storage tank inter face) is considerably smaller than the Code allowable stress intensity of 48.0 ksi. The maximum primary plus secondary stress intensity of 36.19ksi due to Service Level D load combination which included SSE Seismic event occurs at Node 18 is smaller than

the Code allowable stress intensity of 60 ksi. The maximum allowable number of stress cycles based on the maximum alternating stress intensity of 18.52 ksi at Node 18 and Figure 1-9.2 of ASME Code Section III Appendices, is in excess of 10^6 cycles.

The above analysis indicates that the HPCS Suction Line 1 is adequate to sustain the effects of the SSE seismic event. The evaluation of the piping support is included in section 7.3.

7.2 HPCS SUCTION LINE 2

The pertinent natural frequencies, of the lower 20 modes of vibration of the HPCS Suction Line 2 together with the modal paticipating mass fractions for each mode are given in Table 7-2. The fundamental frequency of 3.26 Hz represents the x-direction horizontal displacement at Nodes 55,56. The most important mode in terms of mass participation is mode 4 (8.59 Hz) which represents the horizontal displacement of HPCS Suction Line 2 at Node 46. The effects of higher modes (>25.4 Hz) is adequately accounted for in the NUPIPE program by applying static loads in proportion to the non-participating mass times the zero period acceleration. The maximum deflection due to the SSE seismic inertia loading is 0.67 inches in horizontal x-direction at Node 55. For a flexible piping system this deflection is acceptable. The maximum combined SSE seismic acceleration is 1.63 G at Node 64. Therefore valves in the HPCS Suction Lines should be seismically qualified at 1.63 G acceleration level.

Figure 7-3 and 7-4 represents Class 1 piping stress analysis results together with the Code allowable stress values for HPCS Suction Line 2 The maximum primary intensity of 15.33 ksi, resulting from Service Level D load combination which included SSE seismic event occurs at Node 70 and is considerably smaller than the Code allowable stress intensity of 48.0 ksi. The maximum primary plus secondary stress intensity of 32.93 ksi due to Service Level D load combination which included SSE seismic event occurs at Node 70 is smaller than the Code allowable stress intensity of 60.0 ksi. The maximum allowable number

of stress cycles based on the maximum alternating stress intensity of 37.36 ksi at Node 49 and Figure 1-9.2 of ASME Code Section III Appendices is 9×10^4 cycles.

The above analysis indicates that the HPCS Suction Line 2 is adequate to sustain the effects of the SSE seismic event. The evaluation of the piping support is included in Section 7.3.

7.3 PIPE SUPPORT EVALUATION

The pipe supports for HPCS Suction Lines were evaluated for the Services Level D (faulted condition) load combination consisting of:

DW + TE $\pm$ SSE (inertia) $\pm$ SSE (SAM)

where:

DW = Deadweight

TE = Thermal expansion including thermal anchor dispalcement

SSE(inertia) = Safe Shutdown Earthquake inertia loads

SSE (SAM) = SSE Seismic Anchor Movements

This combination is conservative since it conservatively assumes that the maximum support reaction loads due to thermal expansion, SSE inertia loads and SSE seismic anchor movements occurs simultaneously. The resultant support force and movement so obtained was then compared with the similar loads used by Nuclear Energy Services (NES) on the pipe support evaluation/design.

Where the above comparison indicated that the NES design/evaluation reaction loads exceeded the SMA faulted condition loads, no further evaluation of the support was conducted noting that safety margin

greater than 1.0 must exist by definition. Conversely, for those supports for which the SMA reaction loads exceeded the NES reaction loads, the support design was verified either by comparing the available margin of safety to the increase in the loads or by detail structural calculations.

The evaluation of the HPCS Suction Line 1 and 2 pipe supports indicated that the supports are adequate to sustain the effects of the SSE event.

TABLE 7-1

HPCS SUCTION LINE 1
MODAL FREQUENCIES AND MODAL MASS FRACTION

SPECTRAL ACCELERATION VALUES

MODE	FREQ.	PERIOD	X(G)	Y(G)	Z(G)
1	3.1172	.320795	1.0779	.3087	.8800
2	4.5631	.219148	1.1126	.7516	.9198
3	8.3220	.120164	1.1500	.7523	.9776
4	9.6598	.103522	1.0017	.6250	.7499
5	16.7410	.059734	.5926	.2884	.5500
6	17.6274	.056730	.5637	.2730	.5500
7	20.4475	.048906	.5555	.2011	.4991
8	22.2345	.044975	.5377	.2056	.4647
9	26.1607	.038225	.4984	.2100	.4800
10	27.2218	.036735	.4896	.2100	.4800
11	28.1925	.035470	[illegible]	.2100	.4800
12	29.9915	.033343	.4874	.2100	.4800
13	38.4720	.025993	.4800	.1876	.4713

MODAL MASS FRACTION

MODE	X	Y	Z
1	.1726E+00	.6390E-06	.1122E+00
2	.1526E-02	.4644E-03	.2579E+00
3	.2779E+00	.3257E-02	.1242E-01
4	.5588E-02	.4349E-03	.7453E-04
5	.4884E-05	.1273E+00	.3324E-08
6	.5165E-01	.4494E-03	.3137E-01
7	.1803E-01	.1530E-01	.1278E-02
8	.3552E-01	.1463E-01	.3956E-01
9	.4971E-02	.1119E+00	.5544E-04
10	.1202E-01	.4710E-01	.1859E-01
11	.7270E-01	.3260E-04	.8159E-01
12	.2241E-02	.1443E-03	.1152E-03
13	.7830E-01	.3074E-02	.1582E-02
TOTAL SUM	.7331E+00	.3244E+00	.5567E+00

MAXIMUM RIGID BODY FACTOR = MAX(1-SUM(L(I) * PHI(I))

X	Y	Z
.1000E+01	.1183E+01	.1000E+01

TABLE 7-2

HPCS SUCTION LINE 2
MODAL FREQUENCIES AND MODAL MASS FRACTION

INTERPOLATED SPECTRAL ACCELERATION VALUES FOR SPECTRUM 1

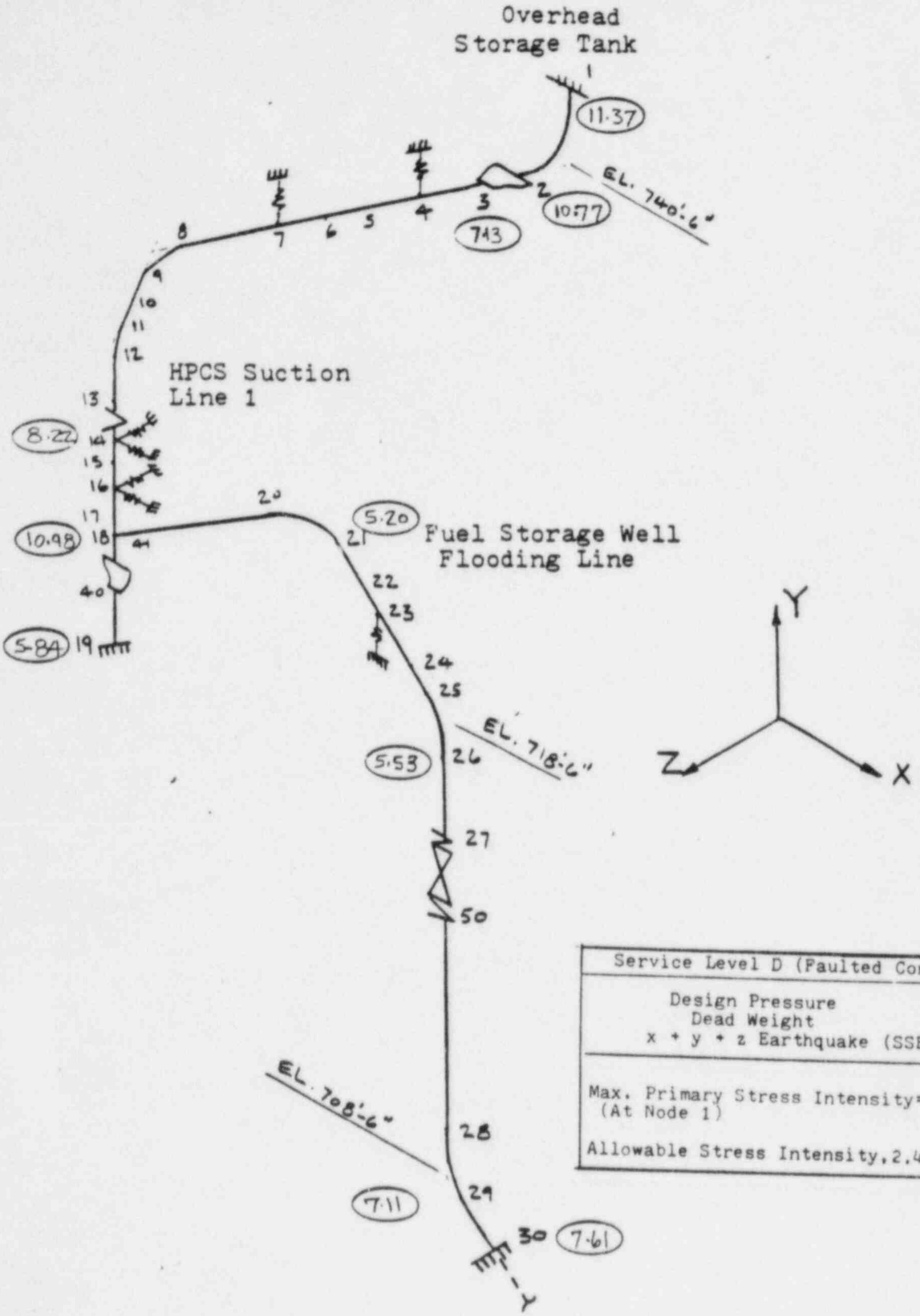
MODE	FREQ.	PERIOD	X(G)	Y(G)	Z(G)
1	3.2556	0.307160	0.6686	0.3076	0.6359
2	5.0719	0.197163	0.7300	0.9000	0.5972
3	7.4833	0.133630	0.6800	0.8014	0.6160
4	8.5865	0.116463	0.6800	0.6722	0.6160
5	8.9670	0.111520	0.6749	0.6274	0.6145
6	10.1282	0.098735	0.6589	0.5288	0.6078
7	11.6097	0.086135	0.6385	0.4283	0.5927
8	11.9935	0.083379	0.6332	0.4222	0.5671
9	13.5287	0.073917	0.6120	0.3951	0.4876
10	13.5579	0.073756	0.6116	0.3939	0.4867
11	14.8584	0.067302	0.5419	0.3439	0.4563
12	15.2293	0.065663	0.4949	0.3296	0.4475
13	16.1038	0.062100	0.4100	0.2984	0.4278
14	18.2340	0.054843	0.4100	0.2643	0.3893
15	18.7798	0.053251	0.4100	0.2480	0.3833
16	21.8109	0.045850	0.4100	0.2091	0.3791
17	22.0358	0.045381	0.4100	0.2100	0.3801
18	23.2240	0.043059	0.4100	0.2161	0.3861
19	24.9694	0.040049	0.4100	0.2200	0.3900
20	25.3810	0.039399	0.4100	0.2200	0.3900

MODAL MASS FRACTION -

MODE	X	Y	Z
1	0.5292E-01	0.3741E-02	0.5743E-03
2	0.1021E+00	0.2099E-02	0.5181E-02
3	0.5242E-01	0.1954E-02	0.1241E-03
4	0.1710E-02	0.3802E-02	0.1820E+00
5	0.3041E-03	0.4136E-02	0.2866E-01
6	0.2869E-01	0.6524E-04	0.4592E-01
7	0.9276E-03	0.2227E-02	0.1397E+00
8	0.1043E-01	0.1034E-01	0.3128E-02
9	0.5086E-01	0.5661E-02	0.3040E-01
10	0.6557E-01	0.1062E-01	0.2984E-01
11	0.3200E-05	0.1144E-03	0.4667E-02
12	0.4059E-01	0.3212E-05	0.3196E-06
13	0.1070E+00	0.5648E-05	0.2532E-04
14	0.1019E-03	0.2466E-02	0.4856E-01
15	0.1184E-02	0.2584E-01	0.1492E-01
16	0.2684E-02	0.1292E-04	0.8333E-02
17	0.4966E-03	0.1738E-04	0.2559E-02
18	0.7278E-01	0.2452E-05	0.1496E-01
19	0.2942E-03	0.4772E-02	0.1495E-02
20	0.1627E-01	0.7943E-02	0.2329E-02
TOTAL SUM	0.6871E+00	0.1204E+00	0.5626E+00

MAXIMUM RIGID BODY FACTOR = MAX(1-SUM(L(I) * PHI(I))

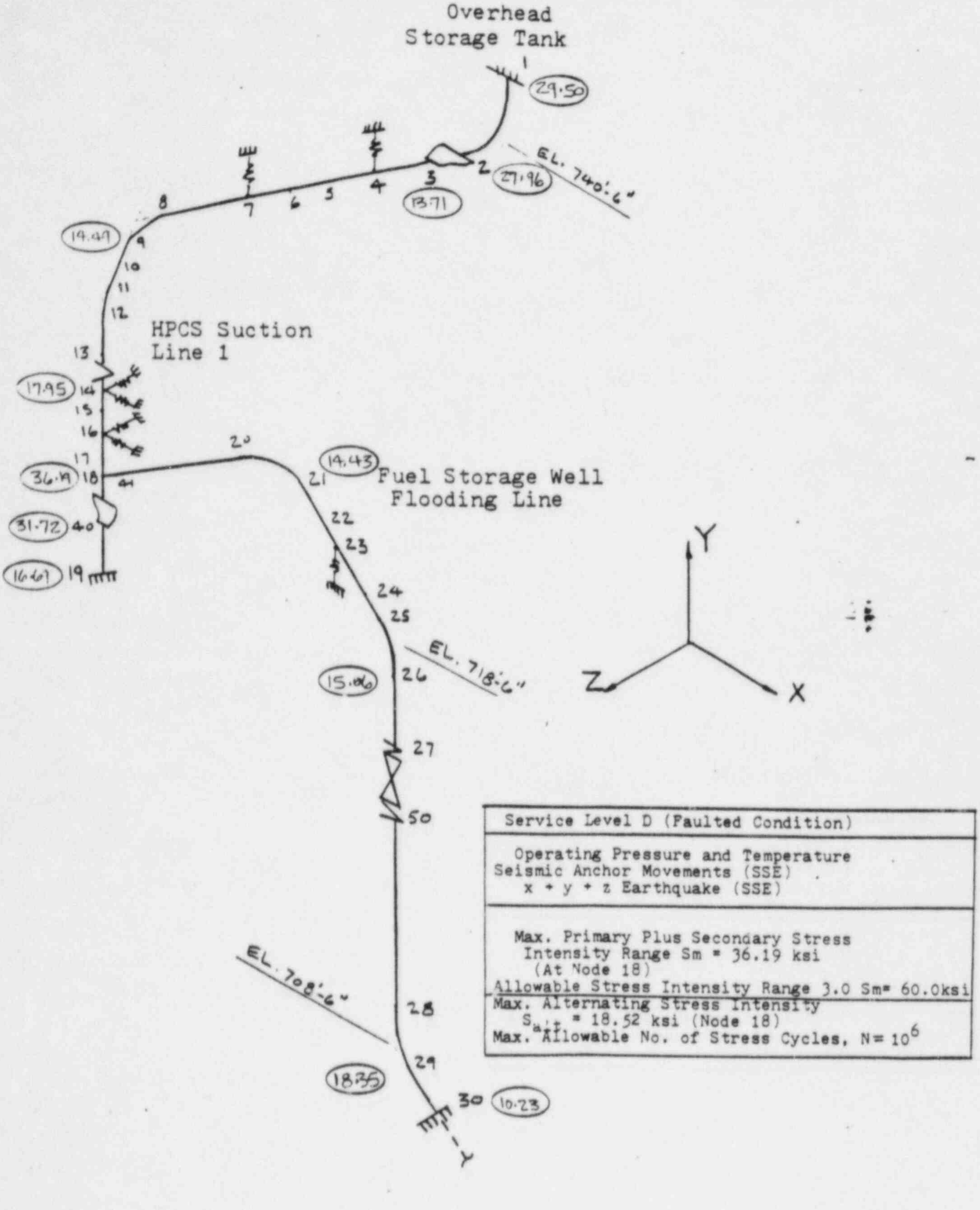
X	Y	Z
0.1017E+01	0.1190E+01	0.1109E+01



Service Level D (Faulted Conditions)
Design Pressure Dead Weight x + y + z Earthquake (SSE)
Max. Primary Stress Intensity = 11.37 ksi (At Node 1) Allowable Stress Intensity, 2.4 S_m = 48.0ksi

FIGURE 7-1

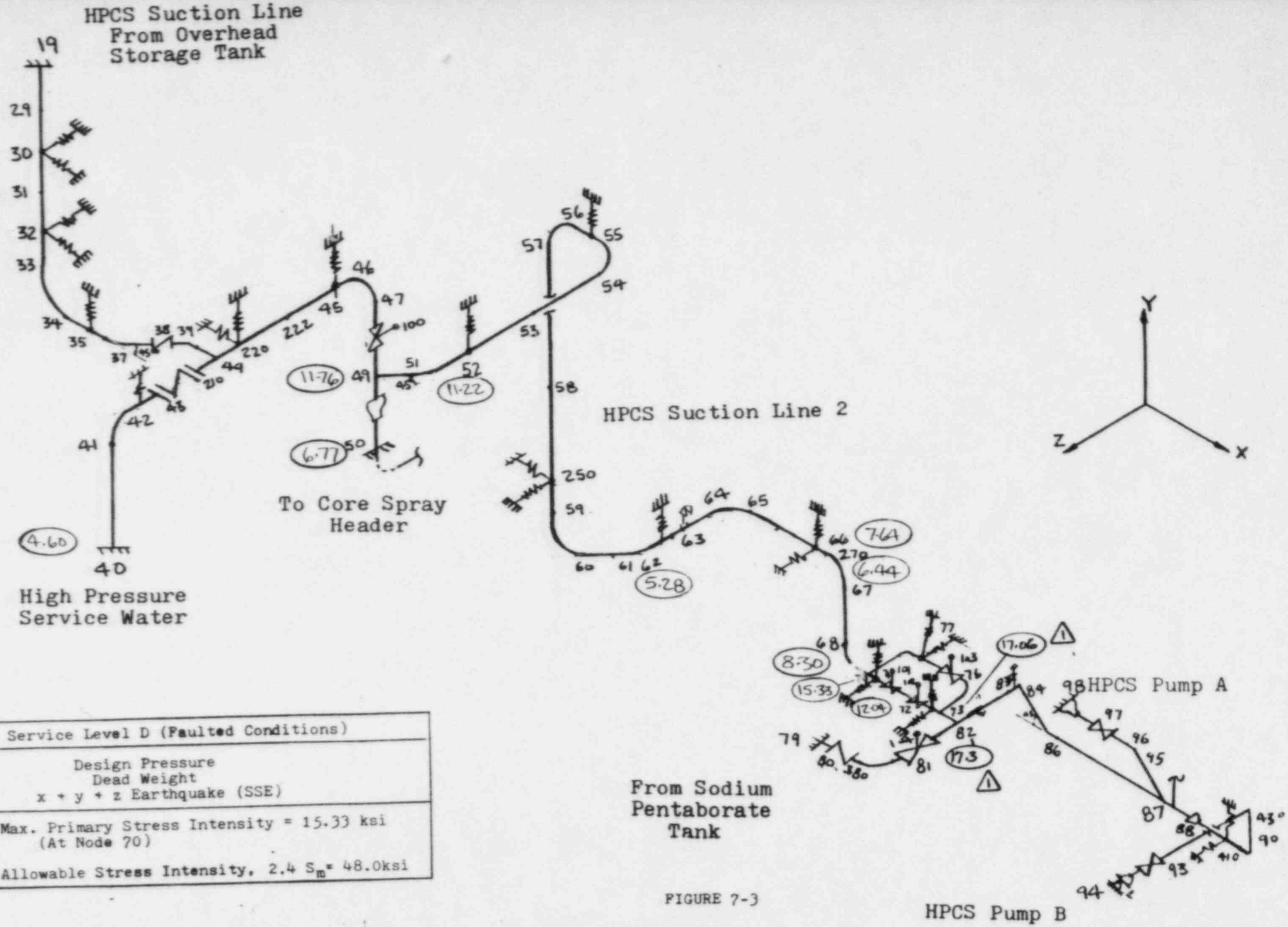
HPCS SUCTION LINE 1
Class 1 Stress Analysis
Compliance with ASME Code Equation 9



Service Level D (Faulted Condition)
Operating Pressure and Temperature Seismic Anchor Movements (SSE) x + y + z Earthquake (SSE)
Max. Primary Plus Secondary Stress Intensity Range Sm = 36.19 ksi (At Node 18) Allowable Stress Intensity Range 3.0 Sm= 60.0ksi
Max. Alternating Stress Intensity S_{alt} = 18.52 ksi (Node 18) Max. Allowable No. of Stress Cycles, N= 10^6

FIGURE 7-2

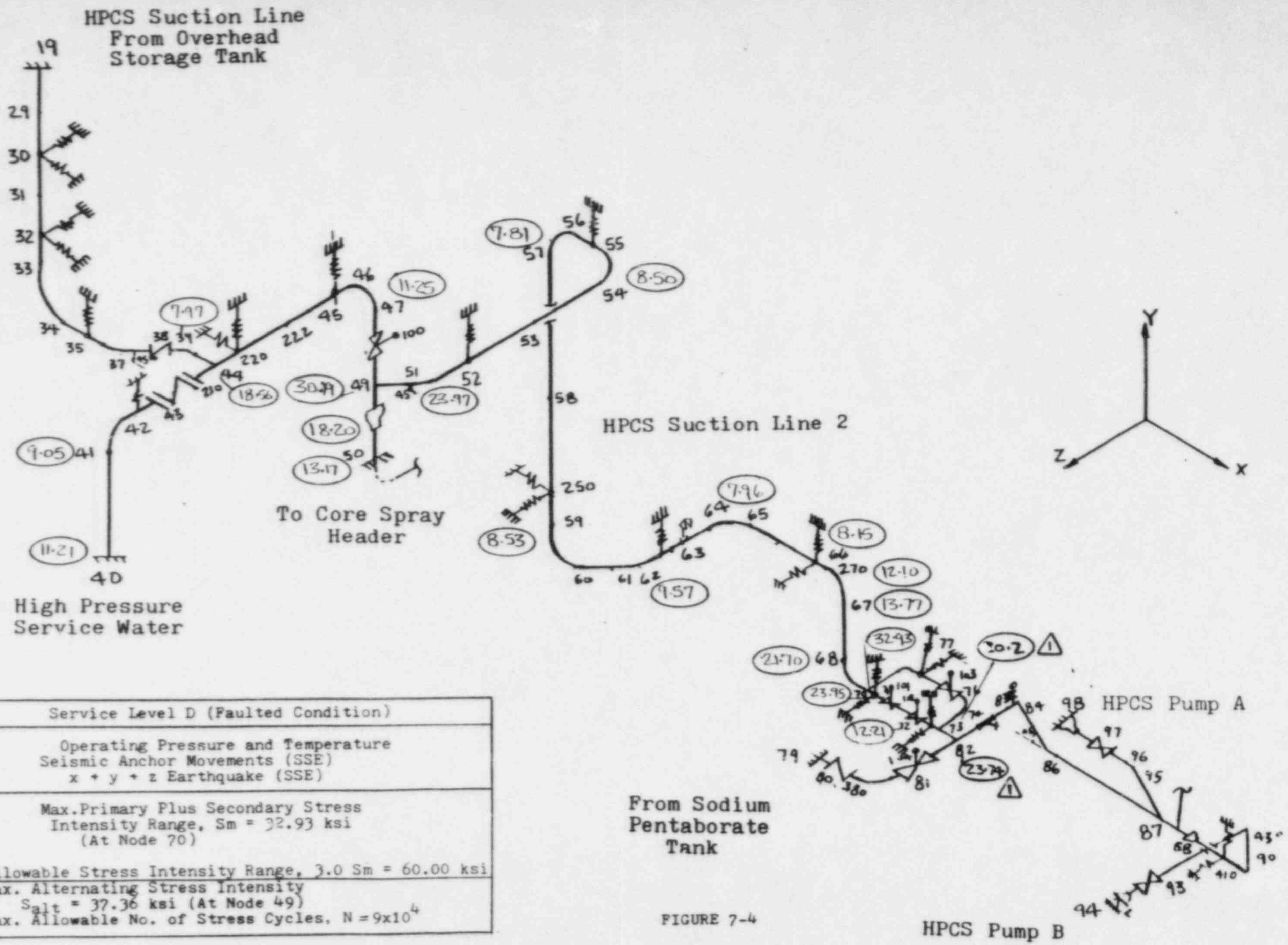
HPCS SUCTION LINE 1
Class 1 Stress Analysis
Compliance with ASME Code Equation 10



Service Level D (Faulted Conditions)
Design Pressure Dead Weight x + y + z Earthquake (SSE)
Max. Primary Stress Intensity = 15.33 ksi (At Node 70)
Allowable Stress Intensity, 2.4 S_m = 48.0ksi

FIGURE 7-3

HPCS SUCTION LINE 2
Class 1 Stress Analysis
Compliance with ASME Code Equation 9



Service Level D (Faulted Condition)
Operating Pressure and Temperature Seismic Anchor Movements (SSE) x + y + z Earthquake (SSE)
Max.Primary Plus Secondary Stress Intensity Range, Sm = 32.93 ksi (At Node 70)
Allowable Stress Intensity Range, 3.0 Sm = 60.00 ksi
Max. Alternating Stress Intensity S_{alt} = 37.36 ksi (At Node 49) Max. Allowable No. of Stress Cycles, N = 9×10^4

FIGURE 7-4

HPCS SUCTION LINE 2
Class 1 Stress Analysis
Compliance with ASME Code Equation 10

8. CONCLUSIONS

The results of the seismic and stress analysis of the HPCS Suction Lines 1 and 2 and their support system indicates the following:

1. Deflections in the piping systems due to dead weight, and the specified SSE seismic loads are nominal and acceptable.

2. The fundamental frequencies of vibration of the flexible piping systems are reasonable.

3. The maximum primary and primary plus secondary stress intensities resulting from appropriate load combinations are within the ASME Code allowable stress intensity values for Class 1 components.

4. The piping support system are adequate to withstand the normal and abnormal loads including the effects of SSE.

The acceptance criteria for the HPCS Suction piping and their support system are consistent with licensing criteria as specified in the ASME Code, current NRC Regulatory Guides and the Standard Review Plan. Therefore, it has been concluded that the HPCS Suction piping and support system meet the intent of the current licensing criteria.

9. REFERENCES

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3. Gulf United Services Report No. SS-1162 "Seismic Evaluation of the La Crosse Boiling Water Reactor;" dated January 1, 1974.

4. EG&G "LACBWR Containment Building Independent Seismic Analysis", Attechment to Letter from D.M. Crutchfield (USNRC) to F. Linder (DPC), dated October 18, 1983.

5. ASME Boiler and Pressure Vessel Code Section III, Subsection NB Class I Components, 1983 Edition.

6. USNRC Standard Review Plan 3.9.3, "ASME Code Class 1, 2, and 3 Components, Component Supports and Core Support Structure" 1981.

7. NUPIE II/TRHEAT - Piping Analysis Program, User Information Manual, Control Data Corporation, Revision K. May 25, 1983.

8. Pittsburgh Piping and Equipment Company Drawing Nos. 1087-29,-30,-42 and 35202.

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10. Nuclear Energy Services Inc. Danbury, Connecticut. Report 81A0042, "High Pressure Core Spray Suction and Discharge Pipe Supports for the La Crosse Boiling Water Reactor", Revision 4 dated March 22, 1983.

11. Nuclear Energy Services Inc. Drawing 80E0040 Rev. 0. "LACBWR Pipe Hanger Base Plates".

12. Dairyland Power Cooperative, "Field verified, as-built" informations and drawings of the HPCS Suction and Discharge System at LACBWR ", P.C. Sampson (DPC) to C. Finnan (NES), dated March 1, 1983.

13. USNRC Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants", October, 1973.

14. USNRC Regulatory Guide 1.92, "Combination of Modes and Spatial Components in Seismic Response Analysis", Revision 1, February, 1976.

15. Allis-Chalmers, "La Crosse Boiling Water Reactor Safeguard Report Volume I and II; LACBWR #283 dated August 1967.

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ADDENDUM I
EVALUATION OF DISCREPANCIES
DISCOVERED BY LACBWR RESIDENT INSPECTOR BETWEEN
AS-ANALYZED AND AS-BUILT CONFIGURATIONS

1. SUMMARY

This report, prepared for Dairyland Power Cooperative is being issued as an addendum to the original report. "Seismic and Stress Anavsis of the High Pressure Core Spray Suction Line Piping System" for LACBWR, SMA-CT Report 30001,01R00 August 1984. The purpose of this addendum is to account for discrepancies discovered by NRC resident inspector between the "as-built" configuration and the analytical model of the HPCS line, and to modify and correct the results previously provided in the original report. On the basis of a combination of both quantitative and qualitative assessments, it has been found that the margin of safetv of the as-built HPCS line, although reduced from that previouslv reported for the original model, is still adequate.

2. DISCREPACNCIES *

1. Dimensional errors exist between node 41 and 44. The shutoff valve between nodes 43 and 210 is actually a check valve.

2. A 3 inch "Y" type strainer and hand valve with pressure gage was not included in the computer model between node points 82 and 83.

3. The relief valve line from the pump discharge to suction line was not in included in the analysis.

Figures 1 and 2 shows the discrepancies. Their effects are discussed in section 3.

* Reference I-1 : DPC Letters, G. Lange to I. Husain
LAC-10278 and 10308 dated October 22, 1984
and November 13, 1984 respectively

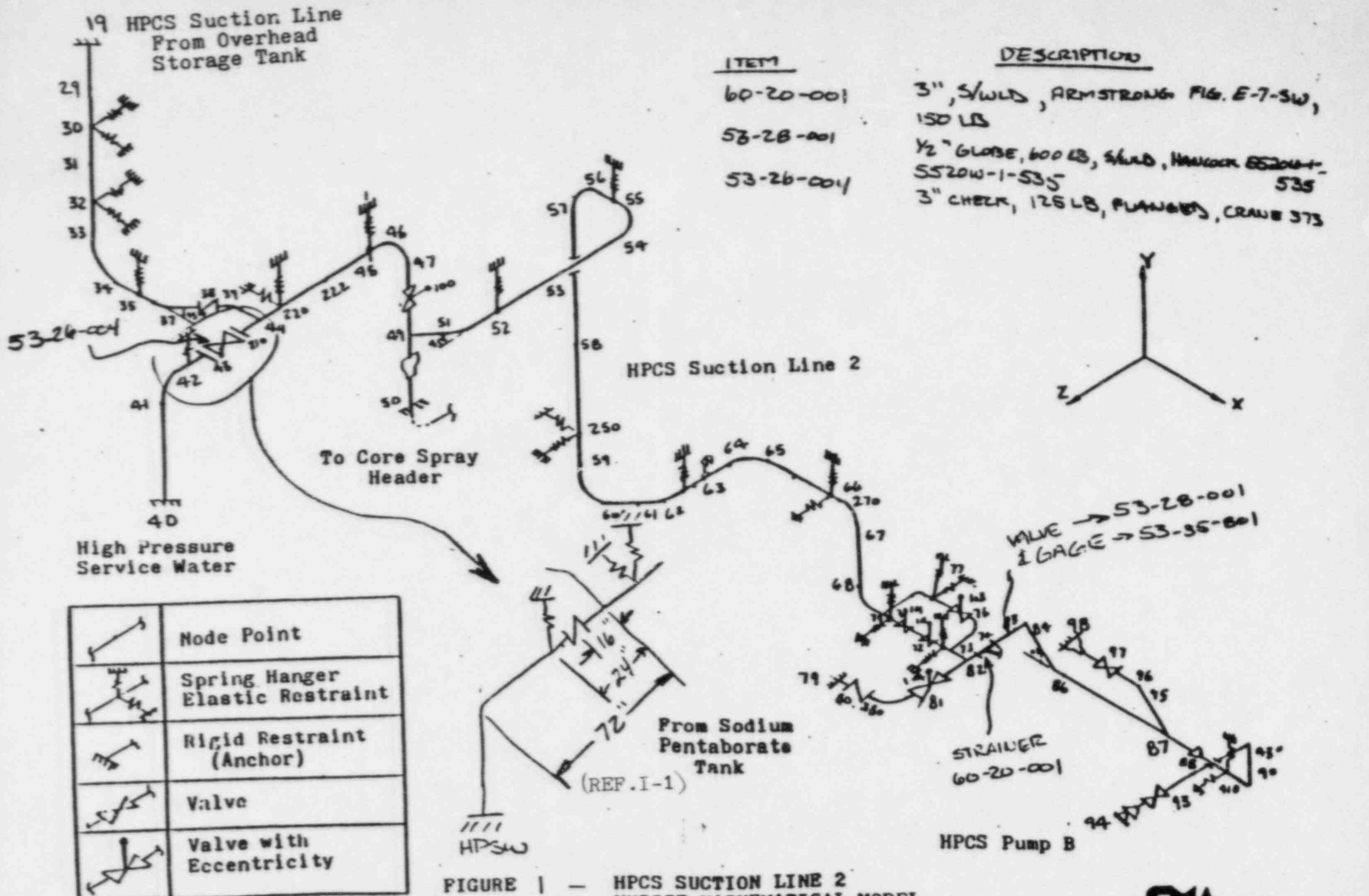
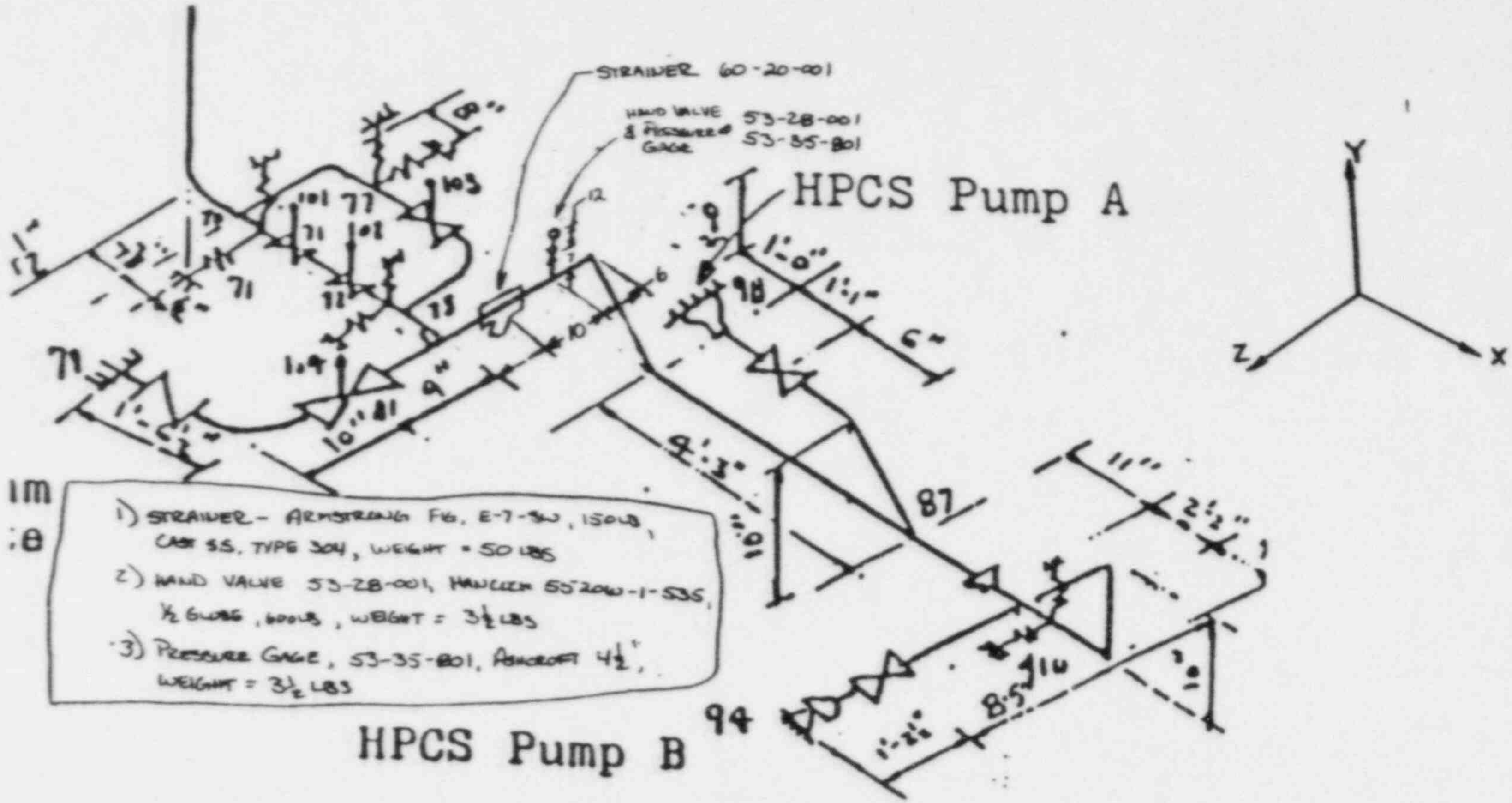


FIGURE 1 — HPCS SUCTION LINE 2 NUPIPE MATHEMATICAL MODEL

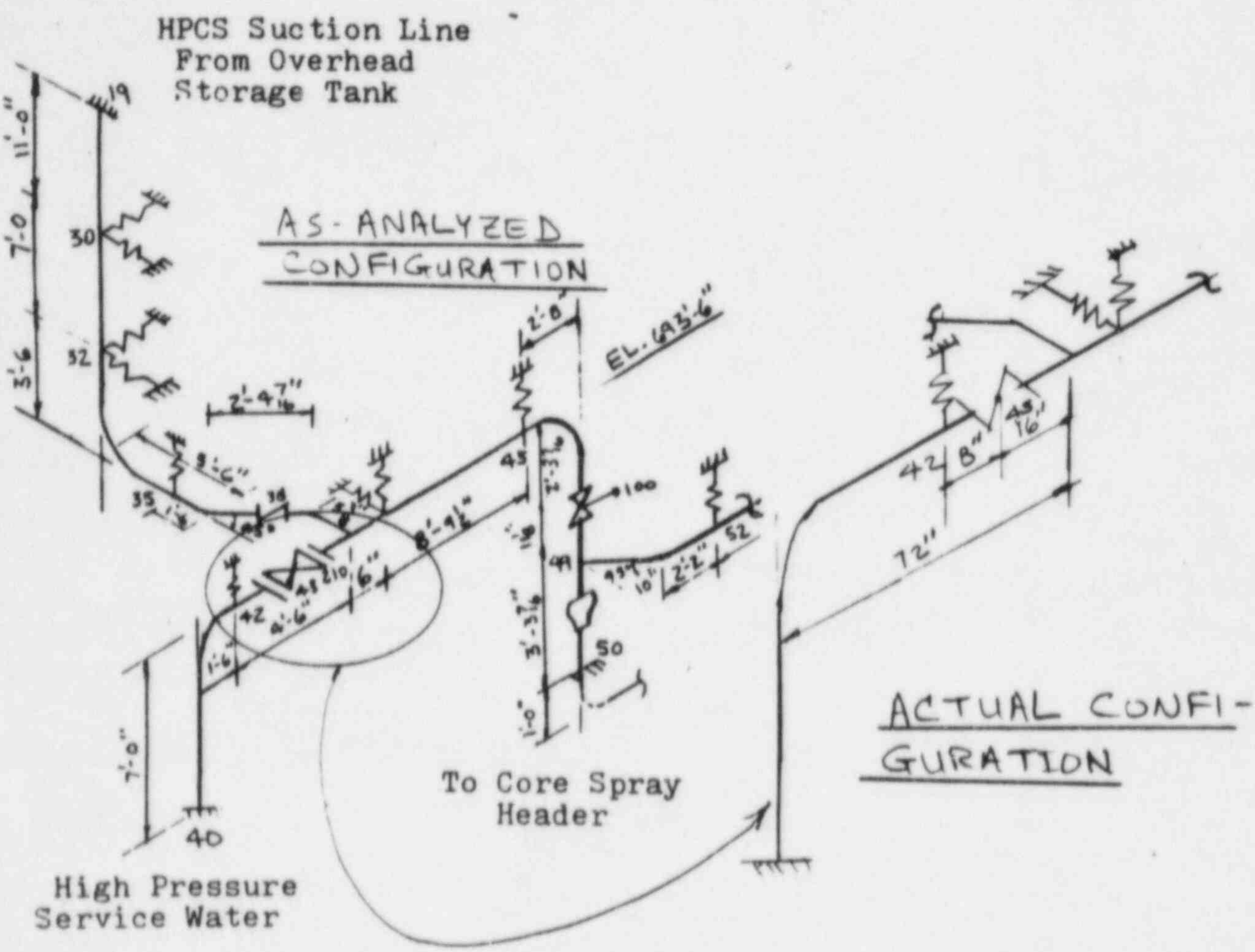


HPCS SUCTION LINE 2

FIGURE 2

(REF.I-1)

3.1 EVALUATION OF DISCREPANCY NO. 1



AS INDICATED ABOVE, THE VERTICAL SUPPORT IS MOVED CLOSER TO THE CHECK VALVE, THIS WILL REDUCE THE STRESSES IN THE PIPING SYSTEM DUE TO DEAD WEIGHT AND VERTICAL SEISMIC LOAD. THE SUPPORT REACTION LOAD WILL INCREASE HOWEVER THERE IS ENOUGH MARGIN IN THE SUPPORT DESIGN TO ACCOMODATE THE SLIGHT INCREASE IN THE REACTION LOAD.

AS THE VALVE WEIGHT USED IN THE ANALYSIS IS CORRECT, THERE WILL BE NO EFFECT OF CHANGING THE SHUTOFF VALVE TO A CHECK VALVE.

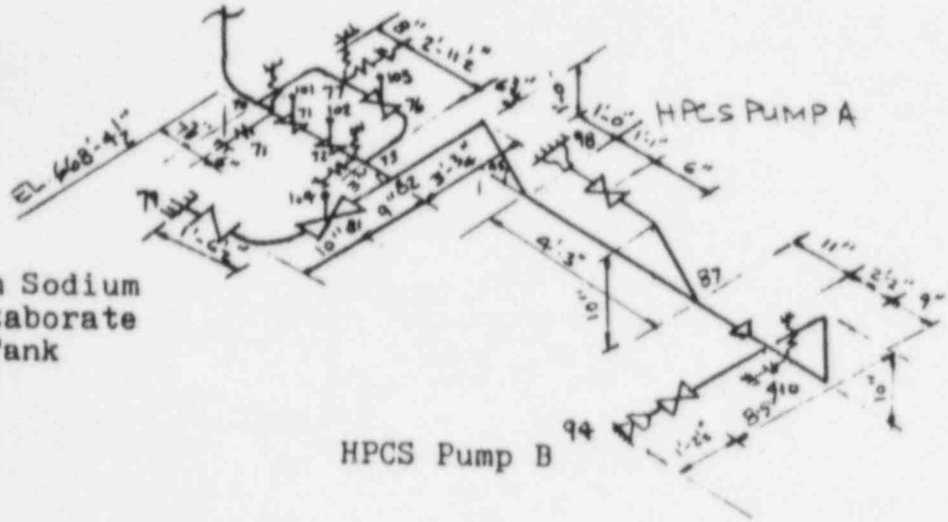
TITLE Dairyland Power Cooperative
BY I.H DATE 2/5/85
CHKD. BY ZA DATE 2/10/85

STRUCTURAL MECHANICS ASSOCIATES

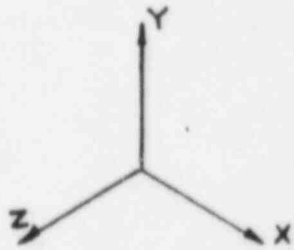
PAGE 2 OF 7 Job No. 30001.01
COMMENTS LACBWR
HPCS Piping System

3.2 EVALUATION OF DISCREPANCIES NO. 2 & 3

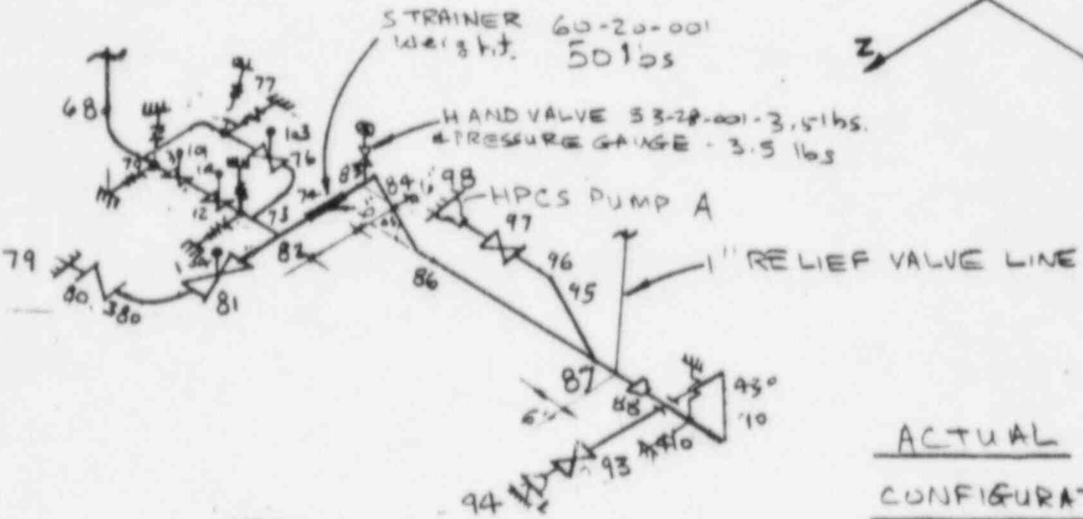
From Sodium Pentaborate Tank



AS-ANALYZED CONFIGURATION



From Sodium Pentaborate Tank



ACTUAL CONFIGURATION

HPCS SUCTION LINE 2

ANALYSIS DATA

PIPE PROPERTIES -

3" Sch 40 - $D_o = 3.5''$; Wall thickness $t = 0.216''$

Moment of Inertia $I = 3.02\ in^4$; Section Modulus $S = 1.724\ in^3$

PEAK SEISMIC ACCELERATION (APPENDIX A) FOR SSE

X-EQ.	Y-EQ.	Z-EQ.
2.17 G	0.90 G	2.05 G

FOR EQUIVALENT STATIC LOAD INCREASE THESE ACCELERATIONS BY 1.5

TRIBUTORY WEIGHT OF 1" RELIEF LINE

$$= \frac{2.5}{12}\left(\frac{75+16}{2}\right) = 9.5 \text{ lbs.}$$

METHOD OF ANALYSIS

THE MAXIMUM STRESSES IN THE PIPING SYSTEM DUE TO THE ADDITIONAL WEIGHTS OF THE STRAINER, HAND VALVE & PRESSURE GAGE AND 1" RELIEF LINE WILL BE CONSERVATIVELY CALCULATED USING THE EQUIVALENT STATIC LOAD METHOD (SECTION II. 1b. of STANDARD REVIEW PLAN 3.7.2).

MAXIMUM MOMENT DUE TO ADDITIONAL DEADWEIGHT:

VERTICAL (Y) SUPPORT IS PROVIDED AT NODE POINTS 410, 98, 73 & 79.

MAXIMUM SPAN FOR VERTICAL LOAD = PROJECTED LENGTH ON X-Z PLANE.

$$L_Y = 2'\text{-}2 + 11 + 4'\text{-}3" + 1' + 3'\text{-}0.75' + 6.75" + 3"$$
$$= 146.5 \text{ in.}$$

MAX. MOMENT FOR CONCENTRATED LOAD $M_D = \frac{PL_Y}{8}$

TOTAL CONCENTRATED LOAD = $P = 50.0 + 3.5 \times 2 + 9.5 = 66.5$ lbs

$$M_D = 66.5 \times \frac{146.5}{8} = \underline{1217.8} \text{ lbs in}$$

MAX. MOMENT DUE TO SEISMIC LOADS:

EARTHQUAKE IN X-DIRECTION -
X-SUPPORTS AT 79, 98

MAX. SPAN LENGTH FOR X-ACCELERATION = PROJECTED PIPE LENGTH ON YZ PLANE

$$L_X = 10 + 9 + 36.75 + 12 + 10 = 77.75 \text{ in}$$

X-EARTHQUAKE INERTIA LOAD = $P_X = 66.5 \times 2.17 \times 1.5$
$= 216.5$ lbs

MAX. " " MOMENT $= M_X = \frac{216.5 \times 77.75}{8}$
$= 2103.7$ lbs in

EARTHQUAKE IN Y DIRECTION;

Y SUPPORTS AT 410, 98, 73 & 79
SPAN LENGTH $L_Y = 146.5$ in.

Y-EARTHQUAKE INERTIA LOAD $= P_Y = 66.5 \times 0.9 \times 1.5$
$= 89.78$ lbs

MAX. Y " MOMENT $M_Y = \frac{89.78 \times 146.5}{8}$
$= 1644.0$ lbs in.

EARTHQUAKE IN Z-DIRECTION

Z-SUPPORTS AT NODES 410, 73 & 79
MAX SPAN LENGTH = PROJECTED PIPE LENGTH ON X-Y PLANE

$L_Z = 2'-2'' + 11'' + 4'-3'' + 1'-0'' + 6.75 + 3.0''$
$= 109.75$ in

Z EARTHQUAKE INERTIA LOAD = $P_Z = 66.5 \times 2.05 \times 1.5$
$= 204.5$ lbs in

MAX. Z " MOMENT $M_Z = \frac{204.5 \times 109.75}{8}$
$= 2805.3$ lbs in

COMBINED SEISMIC MOMENT $= M_S = (M_X^2 + M_Y^2 + M_Z^2)^{1/2}$
$M_S = \{(2103.7)^2 + (1644.0)^2 + (2805.3)^2\}^{1/2}$
$= \underline{3872.7}$ lbs in

ASME CODE STRESS CALCULATIONS

PRIMARY STRESS INTENSITY (EQUATION 9)

$$= B_2 \frac{D_o}{2I} M_i$$

M_i = MOMENT DUE TO DEAD WEIGHT + SSE
SEISMIC LOADS = 1217.8 + 3872.7
= 5090.5 lbs in.

B_2 = PRIMARY STRESS INDICES
= 2.902 FOR TEE AT NODES 73 & 82

D_o = 3.5" ; I = 3.02 in^4

∴ PRIMARY STRESS INTENSITY DUE TO ADDITIONAL LOADS $= 2.98 \times \frac{5090.5}{3.02} \times \frac{3.5}{2}$ = 8560.3 psi = 8.56 KSI

∴ Corrected Primary Stress Intensity at
Node 73 = 8.50 + 8.56 = 17.06 KSI
" 82 = 8.74 + 8.56 = 17.30 KSI

Allowable stress Intensity = $2.4 S_m$ = 48.0 KSI
> 17.30 KSI O.K

ASME CODE STRESS CALCULATIONS

PRIMARY + SECONDARY STRESS INTENSITY RANGE

(EQUATION 10)

$$S_n = C_2 \frac{D_o}{2I} M_i$$

M_i = RANGE OF MOMENT DUE TO SEISMIC LOADS
= 3872.7 lbs in

C_2 = SECONDARY STRESS INDICES
= 2.592 FOR TEE AT NODES 73, 82

∴ SECONDARY STRESS INTENSITY DUE TO ADDITIONAL SEISMIC LOADS $= 2.592 \times \frac{3872.7}{2 \times 3.02} \times 3.5$
= 5,816.4 psi = 5.82 ksi

∴ Corrected Primary + Secondary Stress Intensity at

Node 73 = 14.38 + 5.82 = 20.2 ksi

Node 82 = 17.92 + 5.82 = 23.74 ksi

Allowable Stress Intensity Range = $3S_m$ = 60.0 ksi
> 23.74 ksi O.K.

Allowable No. of Stress Cycles (Based on Max. stress Intensity Range of 32.93 ksi (> 23.74 ksi) at Node 70) will be $N = 9 \times 10^4$

TITLE Dairyland Power Cooperative		STRUCTURAL MECHANICS ASSOCIATES	PAGE 7 OF 7 Job No. 30001.01
BY I.H	DATE 2/5/85		COMMENTS LACBWR
CHKD. BY IA	DATE 2/10/85		HPCS Piping System

FIGURES 7-3 and 7-4 OF THE REPORT SMA-CT 30001.01R00 SHOULD BE REVISED AS INDICATED BELOW:

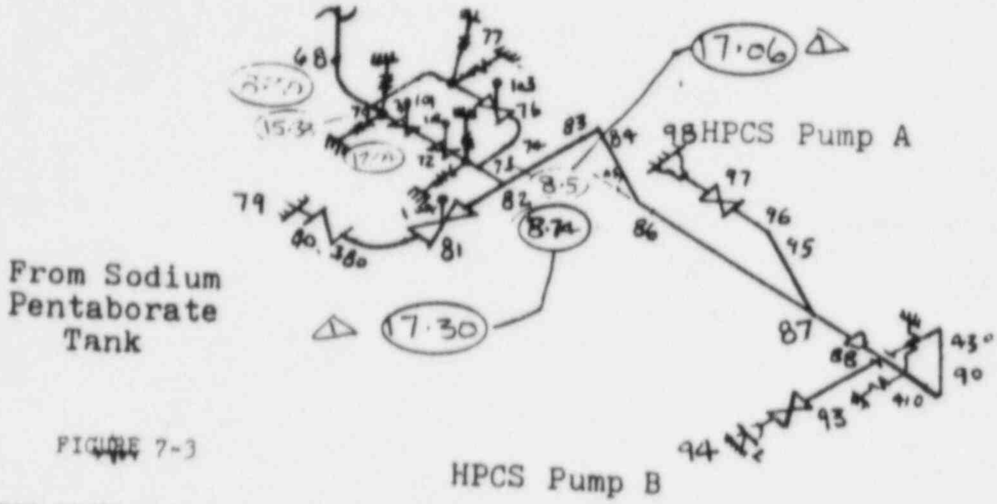


FIGURE 7-3

HPCS SUCTION LINE 2
Class 1 Stress Analysis
Compliance with ASME Code Equation 9

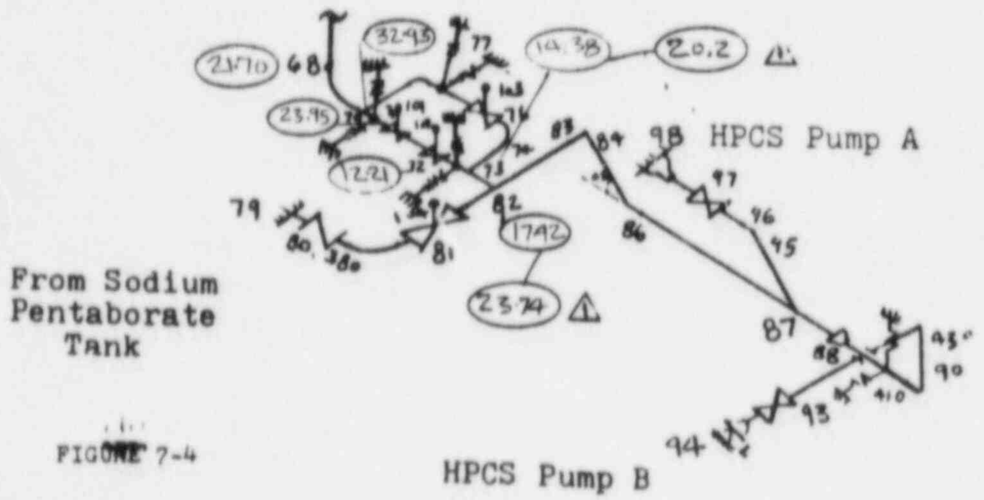


FIGURE 7-4

HPCS SUCTION LINE 2
Class 1 Stress Analysis
Compliance with ASME Code Equation 10

SUPPORT EVALUATION -

SUPPORT REACTION LOADS IN THE VICINITY OF THE STRAINER WILL INCREASE BY 72.2 lbs. HOWEVER THERE IS ADEQUATE MARGIN IN THE SUPPORT DESIGN TO ACCOMODATE SMALL INCREASE IN REACTION LOAD.

APPENDIX A

LACBWR HPCS SUCTION LINE PIPING ANALYSIS

NUPIPE ANALYTICAL INPUT DATA

HPCS SUCTION LINE 1 LACBWR

SECTION PROPERTIES

NSECT	OUTSIDE DIAMETER IN	WALL THICKNESS IN	WEIGHT LB/FT	MODULUS COLD * 1.0E-6 PSI	DESIGN PRESSURE PSI
1	6.625	.2800	33.24	26.00000	100.00
2	4.500	.2370	17.64	28.00000	100.00
3	3.500	.2160	11.88	28.30000	100.00

CONCENTRATED WEIGHTS

NODE	WEIGHT LB	NODE	WEIGHT LB	NODE	WEIGHT LB
2	5.000	27	26.500	50	26.500

EARTHQUAKE ANCHOR DISPLACEMENTS

SET NO.	NODE	TRANSLATIONAL X IN	Y IN	Z IN
1	1	.41500	0.00000	0.00000
1	14	.22600	0.00000	0.00000
1	16	.17600	0.00000	0.00000
1	19	.06600	0.00000	0.00000
2	1	0.00000	.05380	0.00000
2	4	0.00000	.05380	0.00000
2	7	0.00000	.05380	0.00000
3	1	0.00000	0.00000	.60000
3	14	0.00000	0.00000	.32700
3	16	0.00000	0.00000	.25500
3	19	0.00000	0.00000	.12700

HPCS SUCTION LINE 1 LACBWR

STATIC RESTRAINT TABLE

NODE	TYPE	STIFFNESS TRANS LB/IN ROT IN-LB/RAD	DIRECTION	SUPPORT GROUP
1	TRANS	.5628435E+12	X	1
1	TRANS	.5628435E+12	Y	1
1	TRANS	.5628435E+12	Z	1
1	ROT	.5628435E+12	X	1
1	ROT	.5628435E+12	Y	1
1	ROT	.5628435E+12	Z	1
19	TRANS	.6034312E+11	X	1
19	TRANS	.6034312E+11	Y	1
19	TRANS	.6034312E+11	Z	1
19	ROT	.6034312E+11	X	1
19	ROT	.6034312E+11	Y	1
19	ROT	.6034312E+11	Z	1
30	TRANS	.1446520E+12	X	1
30	TRANS	.1446520E+12	Y	1
30	TRANS	.1446520E+12	Z	1
30	ROT	.1446520E+12	X	1
30	ROT	.1446520E+12	Y	1
30	ROT	.1446520E+12	Z	1
4	TRANS	.4740000E+06	Y	1
7	TRANS	.1330000E+06	Y	1
14	TRANS	.1100000E+05	X	1
14	TRANS	.1169000E+05	Z	1
18	TRANS	.1170000E+05	X	1
16	TRANS	.1996800E+07	Z	1
23	TRANS	.4157000E+06	Y	1

HPCS SUCTION LINE 1 LACBWR

SEISMIC RESPONSE SPECTRA - SET 1 INTERPOLATION OPTION(LL)

X-EARTHQUAKE FREQ. HZ	X-EARTHQUAKE ACCELERATION (G)	Y-EARTHQUAKE FREQ. HZ	Y-EARTHQUAKE ACCELERATION (G)	Z-EARTHQUAKE FREQ. HZ	Z-EARTHQUAKE ACCELERATION (G)
.400	.050	.400	.010	.400	.050
.600	.150	.600	.024	.700	.150
.750	.300	.700	.050	1.000	.800
.850	.700	1.000	.230	1.200	1.400
1.000	.900	1.400	.230	1.350	3.150
1.350	3.200	1.740	.250	1.780	3.150
1.550	3.450	2.300	.250	2.300	1.300
2.050	3.450	2.400	.250	2.900	1.150
2.350	1.800	3.130	.309	3.000	.880
3.200	1.000	4.300	.620	4.000	.880
4.000	1.000	4.900	.920	5.700	1.000
5.000	1.200	6.440	.920	7.500	1.000
6.500	1.200	7.400	.840	8.600	.970
6.600	1.150	11.500	.450	9.900	.700
8.700	1.150	13.200	.410	11.500	.650
12.000	.640	15.500	.310	12.500	.550
27.000	.490	17.600	.270	17.800	.550
50.000	.470	20.000	.200	23.000	.450
100.000	.350	24.000	.210	24.000	.480
0.000	0.000	32.000	.210	31.000	.480
0.000	0.000	36.000	.200	100.000	.400
0.000	0.000	44.000	.160	0.000	0.000
0.000	0.000	58.000	.160	0.000	0.000
0.000	0.000	100.000	.135	0.000	0.000

HPCS SUCTION LINE 2 LACBWR

SECTION PROPERTIES

NSECT	OUTSIDE DIAMETER	WALL THICKNESS	WEIGHT	MODULUS COLD * 1.0E-6	DESIGN PRESSURE
	IN	IN	LB/FT	PSI	PSI
1	3.500	.2160	11.88	28.30000	100.00
2	3.500	.2160	11.88	28.30000	100.00
3	3.500	.2160	11.88	28.30000	100.00
4	3.500	.2160	11.88	28.30000	100.00
5	1.900	.1450	4.32	28.30000	100.00
6	1.900	.1450	4.32	28.30000	100.00
7	1.900	.1450	4.32	28.30000	100.00
8	2.875	.2030	8.98	28.30000	100.00
9	1.900	.1450	4.32	28.30000	100.00

CONCENTRATED WEIGHTS

NODE	WEIGHT	NODE	WEIGHT	NODE	WEIGHT
	LB		LB		LB
38	26.000	39	26.000	210	20.000
100	10.000	63	11.000	71	234.000
102	90.000	76	53.000	103	13.000
380	26.000	80	26.000	93	49.000
43	20.000	230	50.000		
101	110.000	72	214.000		
104	13.000	61	53.000		
97	49.000				

HPCS SUCTION LINE 2 LACBWR

STATIC RESTRAINT TABLE

NODE	TYPE	STIFFNESS TRANS LB/IN ROT IN-LB/RAD	DIRECTION
19	TRANS	.6034312E+11	X
19	TRANS	.6034312E+11	Y
19	TRANS	.6034312E+11	Z
19	ROT	.6034312E+11	X
19	ROT	.6034312E+11	Y
19	ROT	.6034312E+11	Z
40	TRANS	.6034312E+11	X
40	TRANS	.6034312E+11	Y
40	TRANS	.6034312E+11	Z
40	ROT	.6034312E+11	X
40	ROT	.6034312E+11	Y
40	ROT	.6034312E+11	Z
50	TRANS	.3059107E+11	X
50	TRANS	.3059107E+11	Y
50	TRANS	.3059107E+11	Z
50	ROT	.3059107E+11	X
50	ROT	.3059107E+11	Y
50	ROT	.3059107E+11	Z
79	TRANS	.6034312E+11	X
79	TRANS	.6034312E+11	Y
79	TRANS	.6034312E+11	Z
79	ROT	.6034312E+11	X
79	ROT	.6034312E+11	Y
79	ROT	.6034312E+11	Z
94	TRANS	.6197887E+10	X
94	TRANS	.6197887E+10	Y
94	TRANS	.6197887E+10	Z
94	ROT	.6197887E+10	X
94	ROT	.6197887E+10	Y
94	ROT	.6197887E+10	Z
98	TRANS	.6197887E+10	X
98	TRANS	.6197887E+10	Y
98	TRANS	.6197887E+10	Z
98	ROT	.6197887E+10	X
98	ROT	.6197887E+10	Y
98	ROT	.6197887E+10	Z
30	TRANS	.2730000E+05	X
30	TRANS	.2553000E+07	Z
32	TRANS	.1104000E+05	X
32	TRANS	.1169000E+05	Z
35	TRANS	.7910000E+05	Y
42	TRANS	.7910000E+05	Y
220	TRANS	.2683000E+05	X
220	TRANS	.4585000E+05	Y
45	TRANS	.1483000E+06	Y
52	TRANS	.6173000E+06	Y
55	TRANS	.5140000E+05	Y
250	TRANS	.6150000E+04	X
250	TRANS	.2740000E+05	Z
62	TRANS	.5123000E+05	Y
66	TRANS	.3555000E+06	Y
66	TRANS	.4000000E+04	Z
280	TRANS	.1427000E+07	Y
280	TRANS	.1170000E+05	Z
320	TRANS	.1427000E+07	Y
320	TRANS	.1170000E+05	Z
77	TRANS	.1427000E+07	Y
77	TRANS	.1170000E+05	Z
410	TRANS	.3072000E+07	Y
410	TRANS	.7770000E+05	Z

HPCS SUCTION LINE 2 LACBWR

SEISMIC RESPONSE SPECTRA - SET 1 INTERPOLATION OPTION(LL)

X-EARTHQUAKE FREQ. HZ	X-EARTHQUAKE ACCELERATION (G)	Y EARTHQUAKE FREQ. HZ	Y EARTHQUAKE ACCELERATION (G)	Z EARTHQUAKE FREQ. HZ	Z EARTHQUAKE ACCELERATION (G)
.400	.030	.400	.008	.350	.027
.500	.043	.500	.017	.430	.040
.650	.100	.650	.034	.500	.053
.760	.240	.750	.100	.600	.100
.870	.530	.900	.177	.780	.300
1.000	.680	1.000	.226	1.000	.600
1.400	2.150	1.320	.226	1.170	.910
1.560	2.170	1.780	.249	1.350	2.050
2.070	2.170	2.400	.280	1.790	2.050
2.300	1.300	3.300	.309	2.400	.800
2.400	1.080	3.500	.400	2.600	.550
2.800	.800	4.300	.620	2.700	.700
3.200	.670	4.800	.900	4.000	.550
4.000	.650	6.300	.900	5.500	.616
4.400	.730	7.500	.800	8.700	.616
6.500	.730	9.200	.600	11.500	.600
6.600	.680	10.100	.530	13.000	.500
8.600	.680	11.500	.430	17.250	.400
14.400	.600	13.400	.400	20.000	.370
15.900	.410	16.000	.300	24.000	.390
27.600	.410	18.500	.260	32.000	.390
31.000	.330	20.000	.200	37.000	.330
50.000	.330	24.000	.220	50.000	.300
100.000	.300	32.000	.220	100.000	.280
0.000	0.000	36.000	.200	0.000	0.000
0.000	0.000	40.000	.150	0.000	0.000
0.000	0.000	57.000	.150	0.000	0.000
0.000	0.000	100.000	.130	0.000	0.000

HPCS SUCTION LINE 2 LACBWR

EARTHQUAKE ANCHOR DISPLACEMENTS

SET NO.	NODE	X	TRANSLATIONAL Y	Z
		IN	IN	IN
1	19	.48670	0.00000	0.00000
1	30	.37400	0.00000	0.00000
1	32	.30200	0.00000	0.00000
1	40	.19200	0.00000	0.00000
1	50	.19800	0.00000	0.00000
1	220	.26500	0.00000	0.00000
1	250	.11200	0.00000	0.00000
2	19	0.00000	.02100	0.00000
2	35	0.00000	.02100	0.00000
3	19	0.00000	0.00000	.34050
3	30	0.00000	0.00000	.26100
3	32	0.00000	0.00000	.21000
3	40	0.00000	0.00000	.13400
3	50	0.00000	0.00000	.17800
3	250	0.00000	0.00000	.07800

APPENDIX B

LACBWR HPCS SUCTION LINE
PIPING ANLYSIS NUPIPE ANALYSIS RESULTS

HPCS SUCTION LINE 1 LACBWR

SUPPORT REACTIONS FOR LOAD CASE NO. 1

DEAD WEIGHT AND OTHER SUSTAINED MECHANICAL LOADS

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
1	FORCE	-1.	X COORD
1	FORCE	78.	Y COORD
1	FORCE	2.	Z COORD
1	MOMENT	-242.	X COORD
1	MOMENT	25.	Y COORD
1	MOMENT	-172.	Z COORD
19	FORCE	18.	X COORD
19	FORCE	458.	Y COORD
19	FORCE	-22.	Z COORD
19	MOMENT	-134.	X COORD
19	MOMENT	-472.	Y COORD
19	MOMENT	220.	Z COORD
30	FORCE	-15.	X COORD
30	FORCE	279.	Y COORD
30	FORCE	-6.	Z COORD
30	MOMENT	4976.	X COORD
30	MOMENT	51.	Y COORD
30	MOMENT	-2012.	Z COORD
4	FORCE	202.	Y COORD
7	FORCE	208.	Y COORD
14	FORCE	-0.	X COORD
14	FORCE	-9.	Z COORD
16	FORCE	-1.	X COORD
16	FORCE	35.	Z COORD
23	FORCE	231.	Y COORD

HPCS SUCTION LINE 1 LACBWR

SUPPORT REACTIONS FOR LOAD CASE NO. 2

THERMAL EXPANSION NORMAL OPERATING CONDITION

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
1	FORCE	-160.	X COORD
1	FORCE	-88.	Y COORD
1	FORCE	202.	Z COORD
1	MOMENT	145.	X COORD
1	MOMENT	172.	Y COORD
1	MOMENT	184.	Z COORD
19	FORCE	27.	X COORD
19	FORCE	837.	Y COORD
19	FORCE	10.	Z COORD
19	MOMENT	614.	X COORD
19	MOMENT	-1796.	Y COORD
19	MOMENT	23.	Z COORD
30	FORCE	-67.	X COORD
30	FORCE	105.	Y COORD
30	FORCE	-24.	Z COORD
30	MOMENT	2164.	X COORD
30	MOMENT	525.	Y COORD
30	MOMENT	-1158.	Z COORD
4	FORCE	214.	Y COORD
7	FORCE	-919.	Y COORD
14	FORCE	243.	X COORD
14	FORCE	-349.	Z COORD
16	FORCE	-43.	X COORD
16	FORCE	161.	Z COORD
23	FORCE	-149.	Y COORD

HPCS SUCTION LINE 1 LACBWR

SUPPORT REACTIONS FOR LOAD CASE NO. 3

HORIZONTAL X, Y, AND Z SPECTRA (SAFE SHUTDOWN EARTHQUAKE)
COMBINED RESULT FOR MODES 1 THROUGH 13
BY RMS SUMMATION FOR SPECTRUM 1

PLUS RIGID BODY PSEUDO-MODES

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
1	FORCE	219.	X COORD
1	FORCE	29.	Y COORD
1	FORCE	224.	Z COORD
1	MOMENT	3127.	X COORD
1	MOMENT	24321.	Y COORD
1	MOMENT	3638.	Z COORD
19	FORCE	242.	X COORD
19	FORCE	136.	Y COORD
19	FORCE	113.	Z COORD
19	MOMENT	1804.	X COORD
19	MOMENT	7155.	Y COORD
19	MOMENT	4867.	Z COORD
30	FORCE	169.	X COORD
30	FORCE	154.	Y COORD
30	FORCE	243.	Z COORD
30	MOMENT	10413.	X COORD
30	MOMENT	6257.	Y COORD
30	MOMENT	7752.	Z COORD
4	FORCE	50.	Y COORD
7	FORCE	82.	Y COORD
14	FORCE	492.	X COORD
14	FORCE	481.	Z COORD
16	FORCE	234.	X COORD
16	FORCE	311.	Z COORD
23	FORCE	241.	Y COORD

HPCS SUCTION LINE 1 LACBWR

SUPPORT REACTIONS FOR LOAD COMBINATION CASE NO. 9

SQUARE ROOT OF SUM OF SQUARE OF X AND Y AND Z EARTHQUAKE ANCHOR MOVEMENT

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
1	FORCE	71.	X COORD
1	FORCE	32.	Y COORD
1	FORCE	90.	Z COORD
1	MOMENT	522.	X COORD
1	MOMENT	333.	Y COORD
1	MOMENT	461.	Z COORD
19	FORCE	51.	X COORD
19	FORCE	383.	Y COORD
19	FORCE	99.	Z COORD
19	MOMENT	5904.	X COORD
19	MOMENT	1651.	Y COORD
19	MOMENT	3126.	Z COORD
30	FORCE	51.	X COORD
30	FORCE	75.	Y COORD
30	FORCE	22.	Z COORD
30	MOMENT	579.	X COORD
30	MOMENT	786.	Y COORD
30	MOMENT	1713.	Z COORD
4	FORCE	80.	Y COORD
7	FORCE	392.	Y COORD
14	FORCE	103.	X COORD
14	FORCE	169.	Z COORD
16	FORCE	97.	X COORD
16	FORCE	193.	Z COORD
23	FORCE	111.	Y COORD

HPCS SUCTION LINE 1 LACBWR

SYSTEM ACCELERATION FOR LOAD CASE NO. 3

HORIZONTAL X, Y, AND Z SPECTRA (SAFE-SHUTDOWN EARTHQUAKE)
COMBINED RESULT FOR MODES 1 THROUGH 13
BY RMS SUMMATION FOR SPECTRUM 1

PLUS RIGID BODY PSEUDO-MODES

POINT NO.	X-DIRECTION (G)	Y-DIRECTION (G)	Z-DIRECTION (G)
1	.000	.000	.000
2	.021	.017	.020
3	.040	.031	.034
31	.059	.045	.049
9001	.21[illegible]	.093	.175
4	.39[illegible]	.006	.322
5	.635	.440	.511
6	.836	.436	.675
7	1.054	.046	.849
8	1.116	.109	.899
9	1.074	.155	.866
10	.874	.094	.713
11	.745	.006	.653
12	.721	.009	.641
13	.589	.008	.546
9002	.409	.007	.376
14	.272	.006	.179
15	.269	.005	.025
16	.324	.004	.001
17	.376	.004	.110
18	.298	.003	.136
40	.160	.002	.084
42	.120	.001	.066
19	.000	.000	.000
41	.315	.024	.149
20	.771	.350	.438
21	.905	.472	.798
22	.863	.337	.907
23	.982	.005	1.028
24	1.188	.217	1.162
25	1.313	.292	1.301
26	1.295	.327	1.223
27	1.1[illegible]9	.327	1.074
50	1.055	.327	.919
9003	.739	.327	.729
28	.479	.327	.702
29	.189	.144	.327
30	.000	.000	.000

HPCS SUCTION LINE 2 LACB.P

SUPPORT REACTIONS FOR LOAD CASE NO. 1

DEAD WEIGHT AND OTHER SUSTAINED MECHANICAL LOADS

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
19	FORCE	-0.	X COORD
19	FORCE	261.	Y COORD
19	FORCE	0.	Z COORD
19	MOMENT	1.	X COORD
19	MOMENT	-22.	Y COORD
19	MOMENT	-0.	Z COORD
40	FORCE	-1.	X COORD
40	FORCE	44.	Y COORD
40	FORCE	0.	Z COORD
40	MOMENT	383.	X COORD
40	MOMENT	7.	Y COORD
40	MOMENT	46.	Z COORD
50	FORCE	29.	X COORD
50	FORCE	223.	Y COORD
50	FORCE	-2.	Z COORD
50	MOMENT	160.	X COORD
50	MOMENT	-622.	Y COORD
50	MOMENT	-842.	Z COORD
79	FORCE	-2.	X COORD
79	FORCE	20.	Y COORD
79	FORCE	-1.	Z COORD
79	MOMENT	114.	X COORD
79	MOMENT	12.	Y COORD
79	MOMENT	-9.	Z COORD
94	FORCE	-4.	X COORD
94	FORCE	37.	Y COORD
94	FORCE	2.	Z COORD
94	MOMENT	363.	X COORD
94	MOMENT	82.	Y COORD
94	MOMENT	23.	Z COORD
90	FORCE	5.	X COORD
90	FORCE	112.	Y COORD
90	FORCE	0.	Z COORD
90	MOMENT	87.	X COORD
90	MOMENT	-25.	Y COORD
90	MOMENT	1370.	Z COORD
30	FORCE	0.	X COORD
30	FORCE	-0.	Z COORD
32	FORCE	-5.	X COORD
32	FORCE	2.	Z COORD
35	FORCE	86.	Y COORD
42	FORCE	88.	Y COORD
220	FORCE	1.	X COORD
220	FORCE	150.	Y COO
45	FORCE	84.	Y COO
52	FORCE	-60.	Y COO
55	FORCE	170.	Y COO
250	FORCE	-23.	X COO
250	FORCE	-18.	Z COO
62	FORCE	205.	Y COO
66	FORCE	336.	Y COO
66	FORCE	12.	Z COO
280	FORCE	186.	Y COO
280	FORCE	-0.	Z COO
320	FORCE	657.	Y COO
320	FORCE	-1.	Z COO
77	FORCE	74.	Y COO
77	FORCE	0.	Z COO
410	FORCE	34.	Y COO
410	FORCE	-3.	Z COO

HPCS SUCTION LINE 2 LACBWR

SUPPORT REACTIONS FOR LOAD CASE NO. 2

THERMAL EXPANSION NORMAL OPERATING CONDITION

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
19	FORCE	-0.	X COORD
19	FORCE	-32.	Y COORD
19	FORCE	0.	Z COORD
19	MOMENT	12.	X COORD
19	MOMENT	-1.	Y COORD
19	MOMENT	-13.	Z COORD
40	FORCE	-2.	X COORD
40	FORCE	73.	Y COORD
40	FORCE	-14.	Z COORD
40	MOMENT	-395.	X COORD
40	MOMENT	-7.	Y COORD
40	MOMENT	140.	Z COORD
50	FORCE	0.	X COORD
50	FORCE	26.	Y COORD
50	FORCE	16.	Z COORD
50	MOMENT	400.	X COORD
50	MOMENT	13.	Y COORD
50	MOMENT	-2.	Z COORD
79	FORCE	5.	X COORD
79	FORCE	1.	Y COORD
79	FORCE	-6.	Z COORD
79	MOMENT	-2.	X COORD
79	MOMENT	3.	Y COORD
79	MOMENT	26.	Z COORD
94	FORCE	-14.	X COORD
94	FORCE	-11.	Y COORD
94	FORCE	-10.	Z COORD
94	MOMENT	166.	X COORD
94	MOMENT	256.	Y COORD
94	MOMENT	-54.	Z COORD
[illegible]	FORCE	7.	X COORD
91	FORCE	0.	Y COORD
90	FORCE	4.	Z COORD
90	MOMENT	-11.	X COORD
91	MOMENT	-49.	Y COORD
90	MOMENT	10.	Z COORD
36	FORCE	0.	X COORD
36	FORCE	2.	Z COORD
32	FORCE	22.	X COORD
32	FORCE	-5.	Z COORD
35	FORCE	46.	Y COORD
42	FORCE	-89.	Y COORD
220	FORCE	-20.	X COORD
220	FORCE	[illegible]	Y COORD
45	FORCE	-35.	Y COORD
52	FORCE	3.	Y COORD
55	FORCE	5.	Y COORD
250	FORCE	3.	X COORD
250	FORCE	-4.	Z COORD
62	FORCE	7.	Y COORD
66	FORCE	-7.	Y COORD
66	FORCE	5.	Z COORD
280	FORCE	9.	Y COORD
280	FORCE	-6.	Z COORD
320	FORCE	-4.	Y COORD
320	FORCE	4.	Z COORD
77	FORCE	-1.	Y COORD
77	FORCE	4.	Z COORD
410	FORCE	12.	Y COORD
410	FORCE	9.	Z COORD

HPCS SUCTION LINE 2 LACBWR

SUPPORT REACTIONS FOR LOAD CASE NO. 3

HORIZONTAL X, Y, AND Z SPECTRA (SAFE SHUTDOWN EARTHQUAKE)

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
19	FORCE	29.	X COORD
19	FORCE	64.	Y COORD
19	FORCE	25.	Z COORD
19	MOMENT	535.	X COORD
19	MOMENT	252.	Y COORD
19	MOMENT	649.	Z COORD
40	FORCE	44.	X COORD
40	FORCE	309.	Y COORD
40	FORCE	155.	Z COORD
40	MOMENT	6469.	X COORD
40	MOMENT	321.	Y COORD
40	MOMENT	2224.	Z COORD
50	FORCE	137.	X COORD
50	FORCE	326.	Y COORD
50	FORCE	174.	Z COORD
50	MOMENT	4130.	X COORD
50	MOMENT	2105.	Y COORD
50	MOMENT	3527.	Z COORD
79	FORCE	267.	X COORD
79	FORCE	79.	Y COORD
79	FORCE	150.	Z COORD
79	MOMENT	133.	X COORD
79	MOMENT	2973.	Y COORD
79	MOMENT	1176.	Z COORD
94	FORCE	20.	X COORD
94	FORCE	9.	Y COORD
94	FORCE	20.	Z COORD
94	MOMENT	106.	X COORD
94	MOMENT	444.	Y COORD
94	MOMENT	46.	Z COORD
90	FORCE	103.	X COORD
90	FORCE	37.	Y COORD
90	FORCE	36.	Z COORD
90	MOMENT	107.	X COORD
90	MOMENT	420.	Y COORD
90	MOMENT	360.	Z COORD
30	FORCE	47.	X COORD
30	FORCE	40.	Z COORD
32	FORCE	39.	X COORD
32	FORCE	56.	Z COORD
35	FORCE	30.	Y COORD
42	FORCE	301.	Y COORD
220	FORCE	105.	X COORD
220	FORCE	40.	Y COORD
45	FORCE	165.	Y COORD.
52	FORCE	339.	Y COORD
35	FORCE	96.	Y COORD
250	FORCE	121.	X COORD
250	FORCE	175.	Z COORD
62	FORCE	74.	Y COORD
66	FORCE	366.	Y COORD
66	FORCE	82.	Z COORD
280	FORCE	319.	Y COORD
280	FORCE	104.	Z COORD
320	FORCE	235.	Y COORD
320	FORCE	40.	Z COORD
77	FORCE	67.	Y COORD
77	FORCE	72.	Z COORD
410	FORCE	10.	Y COORD
410	FORCE	12.	Z COORD

HPCS SUCTION LINE 2 LACBWR

SUPPORT REACTIONS FOR LOAD COMBINATION CASE NO. 9

SQUARE ROOT OF SUM OF SQUARE OF X AND Y AND Z EARTHQUAKE ANCHOR MOVEMENT

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
~~19~~	~~FORCE~~	~~18.~~	~~X COORD~~
19	FORCE	66.	Y COORD
19	FORCE	13.	Z COORD
~~19~~	~~MOMENT~~	~~1362.~~	~~X COORD~~
19	MOMENT	100.	Y COORD
19	MOMENT	1919.	Z COORD
~~40~~	~~FORCE~~	~~30.~~	~~X COORD~~
40	FORCE	80.	Y COORD
40	FORCE	37.	Z COORD
~~40~~	~~MOMENT~~	~~1571.~~	~~X COORD~~
40	MOMENT	423.	Y COORD
40	MOMENT	1970.	Z COORD
~~50~~	~~FORCE~~	~~7.~~	~~X COORD~~
50	FORCE	48.	Y COORD
50	FORCE	34.	Z COORD
~~50~~	~~MOMENT~~	~~831.~~	~~X COORD~~
50	MOMENT	159.	Y COORD
50	MOMENT	270.	Z COORD
~~79~~	~~FORCE~~	~~7.~~	~~X COORD~~
79	FORCE	5.	Y COORD
79	FORCE	7.	Z COORD
~~79~~	~~MOMENT~~	~~10.~~	~~X COORD~~
79	MOMENT	144.	Y COORD
79	MOMENT	66.	Z COORD
~~94~~	~~FORCE~~	~~0.~~	~~X COORD~~
94	FORCE	0.	Y COORD
94	FORCE	0.	Z COORD
~~94~~	~~MOMENT~~	~~1.~~	~~X COORD~~
94	MOMENT	5.	Y COORD
94	MOMENT	1.	Z COORD
~~98~~	~~FORCE~~	~~2.~~	~~X COORD~~
98	FORCE	0.	Y COORD
98	FORCE	0.	Z COORD
~~98~~	~~MOMENT~~	~~2.~~	~~_ COORD~~
98	MOMENT	1.	Y COORD
98	MOMENT	0.	Z COORD
~~30~~	~~FORCE~~	~~25.~~	~~X COORD~~
30	FORCE	10.	Z COORD
32	FORCE	60.	X COORD
~~32~~	~~FORCE~~	~~15.~~	~~Z COORD~~
35	FORCE	80.	Y COORD
42	FORCE	77.	Y COORD
~~220~~	~~FORCE~~	~~20.~~	~~X COORD~~
220	FORCE	23.	Y COORD
45	FORCE	43.	Y COORD
~~52~~	~~FORCE~~	~~24.~~	~~Y COORD~~
55	FORCE	14.	Y COORD
250	FORCE	11.	X COORD
~~250~~	~~FORCE~~	~~21.~~	~~Z COORD~~
62	FORCE	11.	Y COORD
66	FORCE	13.	Y COORD
~~66~~	~~FORCE~~	~~26.~~	~~Z COORD~~
280	FORCE	13.	Y COORD
280	FORCE	3.	Z COORD
~~320~~	~~FORCE~~	~~3.~~	~~Y COORD~~
320	FORCE	2.	Z COORD
77	FORCE	6.	Y COORD
~~77~~	~~FORCE~~	~~3.~~	~~Z COORD~~
410	FORCE	0.	Y COORD
410	FORCE	0.	Z COORD

HPCS SUCTION LINE 2 LACBWR

BY RMS SUMMATION FOR SPECTRUM 1

PLUS RIGID BODY PSEUDO-MODES

POINT NO.	X-DIRECTION (G)	Y-DIRECTION (G)	Z-DIRECTION (G)
19	0.000	0.000	0.000
9001	0.002	0.000	0.020
29	0.005	0.001	0.042
9002	0.003	0.001	0.036
30	0.005	0.001	0.000
31	0.010	0.001	0.051
32	0.087	0.002	0.094
33	0.209	0.002	0.318
34	0.267	0.032	0.517
35	0.268	0.011	0.586
36	0.268	0.012	0.615
37	0.228	0.013	0.648
38	0.173	0.013	0.663
39	3.127	0.012	0.677
200	0.106	0.006	0.695
44	0.106	0.010	0.700
210	0.168	0.012	0.700
43	0.279	0.016	0.700
42	0.739	0.030	0.700
41	0.689	0.003	0.619
500	0.355	0.002	0.352
40	0.000	0.000	0.000
220	0.073	-0.008	0.700
222	0.557	0.019	0.700
9003	0.808	0.017	0.700
45	1.013	0.010	0.700
46	1.171	0.041	0.699
47	0.391	0.002	0.626
48	0.628	0.002	0.453
230	0.500	0.002	0.387
240	0.377	0.002	0.327
100	0.585	0.142	0.387
49	0.227	0.002	0.239
510	0.095	0.001	0.107
515	0.062	9.001	9.071
50	0.00[illegible]	0.000	0.006
51	0.282	0.011	0.387
52	0.310	0.004	0.318
53	0.497	0.081	0.319
9004	0.608	0.133	0.319
54	0.667	0.190	0.319
55	0.740	0.029	0.550
56	0.740	0.335	0.890
57	0.708	0.587	1.190
9005	0.670	0.587	1.033
58	0.568	0.588	0.761
9006	0.383	0.588	0.383
250	0.408	0.588	0.096
59	0.661	0.588	0.272
60	0.871	0.381	0.537
260	0.864	0.351	0.548
61	0.831	0.188	0.615
62	0.798	0.036	0.655
9007	0.810	0.479	0.655
110	0.912	0.861	0.656
9008	0.934	1.114	0.656
63	0.802	1.217	0.656
64	0.762	1.277	0.656

HPCS SUCTION LINE 2 LACBWR

65	0.792	1.002	0.575
360	0.792	0.563	0.464
66	0.792	0.010	0.383
270	0.792	0.058	0.596
67	0.745	0.035	0.760
520	0.446	0.034	0.513
68	0.238	0.034	0.284
69	0.241	0.014	0.252
70	0.241	0.009	0.243
280	0.241	0.003	0.225
71	0.241	0.010	0.178
290	0.241	0.019	0.169
300	0.240	0.019	0.140
72	0.240	0.014	0.105
310	0.239	0.007	0.068
320	0.239	0.002	0.043
73	0.238	0.009	0.048
82	0.238	0.017	0.098
101	1.212	0.010	0.931
102	0.662	0.014	0.639
74	0.343	0.042	0.040
75	0.443	0.034	0.058
330	0.443	0.029	0.065
76	0.444	0.016	0.076
103	0.464	0.016	0.100
340	0.443	0.010	0.085
77	0.443	0.001	0.133
78	0.327	0.046	0.242
81	0.202	0.012	0.098
350	0.131	0.014	0.098
104	0.216	0.012	0.117
360	0.056	0.021	0.098
370	0.002	0.018	0.053
380	0.001	0.011	0.030
80	0.001	0.004	0.011
79	0.006	0.000	0.000
390	0.273	0.069	0.098
83	0.200	0.125	0.098
84	0.134	0.126	0.061
85	0.121	0.118	0.049
400	0.093	0.102	0.023
86	0.083	0.092	0.014
450	0.082	0.051	0.031
87	0.081	0.036	0.033
88	0.081	0.066	0.030
550	0.081	0.070	0.029
410	0.081	0.000	0.002
89	0.081	0.010	0.005
90	0.076	0.009	0.008
420	0.072	0.009	0.005
430	0.072	0.009	0.005
92	0.048	0.005	0.000
93	0.030	0.003	0.000
94	0.000	0.000	0.000
95	0.040	0.036	0.020
96	0.001	0.010	0.008
97	0.001	0.007	0.007
98	0.005	0.008	[illegible]