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SUBJECT: Forwards "Effect of Horizontal Flexibility of Annulus Structure on Seismic Qualification of Attached Piping & Supports." Study resolves SSER 20,Open item 2, "24 Hertz Cutoff Frequency."

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J. O. SCHUYLER
VICE PRESIDENT
NUCLEAR POWER GENERATION

March 16, 1984

PGandE Letter No.: DCL-84-101

Mr. George W. Knighton, Chief
Licensing Branch No. 3
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Docket No. 50-275, OL-DPR-76
Diablo Canyon Unit 1
Closeout of SSER 20, Open Item 2 - 20 Hertz Cutoff Frequency

Dear Mr. Knighton:

At a meeting with PGandE on December 6, 1983, the NRC Staff requested further documented confirmation of conclusions presented in PGandE submittals dated December 28, 1982, September 9, 1983 and October 12, 1983. These submittals related to Safety Evaluation Report Supplement No. 20 (SSER 20) concerning the appropriateness of the 20 Hertz criteria for the horizontal response of the annulus structure. Specifically, the NRC Staff requested that studies be performed to investigate the effect of Hosgri response spectra frequency content between 20 Hertz and 33 Hertz on piping supported by the more amplified sections of the annulus steel structure.

Enclosed is a report entitled "Effect of Horizontal Flexibility of the Annulus Structure on the Seismic Qualification of Attached Piping and Supports." This study further demonstrates that the frequency content of the Hosgri response spectra in the 20 to 33 Hertz range does not have a significant influence on the piping systems supported from the annulus structure. Therefore, PGandE concludes that the original design basis for piping supported by the annulus structure is reasonable and appropriate. PGandE believes that this information resolves SSER 20 Open Item 2.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

J O Schuyler

cc: D. G. Eisenhut
H. E. Schierling
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ENCLOSURE

EFFECT OF HORIZONTAL FLEXIBILITY OF THE ANNULUS STRUCTURE ON THE SEISMIC QUALIFICATION OF ATTACHED PIPING AND SUPPORTS

1.0 INTRODUCTION

In full accordance with the FSAR, the methodology for seismic qualification of the piping supported from the containment annulus structure for the DE and DDE used horizontal response spectra from the interior concrete and vertical ground response spectra without additional amplification. In the horizontal direction, this is equivalent to considering the motion of the annulus structure and the interior concrete to be essentially the same. Similarly, in the vertical direction, this is equivalent to considering the motion of the annulus structure and the ground to be the same. These assumptions were considered reasonable because the annulus structure is a relatively narrow, diagonally-braced steel frame supported directly from the concrete crane wall in the horizontal direction, and the requirements for vertical amplification had not been developed in the industry at the time the DE/DDE criteria were established.

During the Hosgri review, the NRC Staff requested that vertical amplification of the annulus steel be considered explicitly. Other aspects of the Hosgri criteria remained the same with respect to the structural models used for the original DE/DDE analysis. This includes the assumption that the annulus steel horizontal motion is the same as the internal concrete structures. For the motion of the annulus structure to remain essentially the same as the interior concrete, additional bracing members were added to the annulus structure by the Diablo Canyon Project (DCP) to increase the frequency of the horizontal modes. The lowest frequency has been increased above 20 Hz.

Stiffening the structures to the 20 Hz level was consistent with the DE/DDE modeling requirements. In SSER 18, the NRC Staff requested that further studies be performed to investigate the effect of the Hosgri spectra frequency content between 20 Hz and 33 Hz on piping systems supported by the annulus steel.

The purpose of this study is to assess the significance of the annulus structure modes between 20 and 33 Hz on piping and supports. This is accomplished by including these modes in calculating the horizontal response of the annulus structure and then performing a more detailed analysis of sample piping runs and their associated supports.

The results of this study indicate that inclusion of the frequency content between 20 and 33 Hz does not significantly affect the piping design, and that adequate margins exist to maintain qualification of the piping systems for design basis loading conditions as required by the FSAR and Hosgri Report.

2.0 DESCRIPTION OF STUDY

The study consisted of several steps which are summarized below:

1) A horizontal analysis of annulus structure at elevation 106, including all modes of the interior concrete and annulus structure up to 33 Hz, was performed using time-history methodology and 7% damping.

2) Two representative piping runs from the most active zone around elevation 106 were selected.

3) The piping systems and supports were analyzed for the loads predicted by the following methods for defining the seismic motions. The analyses were based on an "uncoupled" analytical technique between the piping and the annulus structure.

Method A

The envelope of in-structure response spectra for 2% damping was obtained from the actual support points on the individual piping runs. These envelopes were broadened using the Hosgri criteria.

Method B

This method is the same as Method A except that variable damping was used, as recommended by Pressure Vessel Research Committee (PVRC, Reference 1). The PVRC recommends use of 5% damping for modes with frequencies of 10 Hz or less, 2% damping for modes with frequencies of 20 Hz or greater, and damping varying linearly between these limits for modes with frequencies between 10 and 20 Hz.

Method C

The acceleration time-history components were used producing the highest acceleration in the north-south (N-S), east-west (E-W), and vertical direction at any support point of the individual piping lines. All modes of the piping systems were assumed to have 2% damping.

Method D

This method is the same as Method B except that the variable damping was used as recommended by the PVRC.

Uniform support motion was assumed for all cases. Since this type of motion description represents a worst case, the results are conservative.

3.0 SELECTION OF PIPING SEGMENTS

In making the selection of the piping segments for detailed analysis, the intent was to select representative and possible worst case segments. The variation of horizontal acceleration with height was considered which increases approximately linearly from the base. The piping systems supported from elevation 140 were not considered most susceptible to the

response of the steel framing in the 20 to 33 Hz range, since most of the supports at this elevation are attached directly to a very stiff concrete slab. As shown in Figures 5 and 6, there is more piping supported at elevation 106 than at any other elevation. (The hexagonal symbols on these figures represent support locations.) Elevation 106 was selected over elevations 101 and 117 since elevation 106 has the largest number of supports and because the percent amplification of the interior concrete motion by the horizontal frame at elevations 101, 106, and 117 are approximately the same. Since the major interest was the influence of the increased amplification resulting from the horizontal flexibility of the annulus structure (which can be conveniently measured by the percent amplification), the conclusions drawn from the analysis at elevation 106 are applicable to the other elevations. This is discussed further in Section 6.

The selection of the piping segments was also influenced by variation in the horizontal response around the annulus structure. The variation of the horizontal acceleration is shown in Figures 7 and 8. In these figures, a datum of 0.6g has been used. By comparing the pipe segment locations in Figures 9 and 10 with the zones of high amplification, it is obvious that the segments selected are located in the zones of highest amplification.

Once the annulus area with the largest increase in acceleration (and therefore largest spectra changes) was determined, this area was studied at the plant site. This onsite review determined that there were only a few Class I lines passing through this area. All lines were less than eight inches in diameter and the general geometry of all lines was similar, as they all run parallel to the tangential beams in the area. In order to best determine the influence of the spectral content above 20 Hz, the two lines chosen for this study were those limited primarily to the area of the study. Based on these factors, the segments selected were a four-inch safety injection system line and a three-inch component cooling water system line.

4.0 SEISMIC ANALYSIS OF ANNULUS STRUCTURE

The annulus structure was analyzed using the ground acceleration time-histories as input to determine the Hosgri seismic response at the attachment points of the piping systems. The model used to determine the horizontal response consisted of the interior concrete stick model coupled with the annulus structure at elevation 106. The masses of the central stick, Figures 1 and 2, representing the interior concrete at elevation 140 and below were offset 5% from their geometric centers to represent torsional input to the annulus structure. The effect of the concrete above elevation 140 on the torsional response at elevation 106 is negligible. In the qualification analysis of the piping system previously performed by the DCP, the translational and rotational components of the piping support motion were determined separately from the analyses of the interior concrete, and then combined prior to the piping analysis. The combination of rotation and translation consisted of converting the rotation into translation based on the distance of an individual support from the geometric center of the containment and assuming the annulus structure to be rigid. With the annulus structure and the interior concrete analyzed using a coupled model, the combination of translational and rotational components of motion was performed within the structural analysis. In this analysis, all the modes of the interior concrete and the annulus structure up to 33 Hz were considered.

The horizontal model of the annulus structure included all the primary members which are the radial and tangential beams and the diagonal bracing. Most of the secondary framing members, which are provided primarily to facilitate pipe supports, were not included because their contribution to the horizontal stiffness is insignificant. Discrete masses representing the annulus structure and supported items were located in the model at the intersection of framing members, or joints.

The vertical response spectra were obtained from the analysis and modeling techniques reported in the Diablo Canyon Unit 1, Design Verification Program, Phase I Final Report (Reference 2). The

vertical analysis utilized independent models to represent the various radial frames. Two of the typical frames and models are shown in Figures 3 and 4. The behavior of the tangential beams are represented by the single mass oscillators.

5.0 DESCRIPTION OF PIPING SEGMENT ANALYSES

Two piping segments were analyzed in the annulus area at elevation 106 with the greatest increase in response spectra. The first segment, 6-101, is a four-inch line in the safety injection system. This line runs from a containment penetration around the containment annulus to a structural anchor (see Figure 11). This pipe segment has 25 rigid supports, one snubber, and two anchors in the annulus area. It has 13 modes of vibration below 33 Hz with a fundamental frequency of 11 Hz (see Table 5.1 for periods and participation factors).

The second segment, 4A-111, is a three-inch line in the component cooling water system running from Reactor Coolant Pump 1-1 in the containment interior through the crane wall to a structural anchor in the annulus (see Figure 12). This segment has eight rigid supports and three snubbers in the annulus area and two rigid supports and four snubbers in the containment interior. It has 17 modes of vibration below 33 Hz with a fundamental frequency of 4Hz (see Table 5.2 for periods and participation factors).

5.1 Description of Response Spectra

The response spectra at the individual support points of each piping segment are shown in Figures 13 to 18. Envelope response spectra were developed from these in additon to the response spectra from the "off direction." For example, the N-S envelope response spectra were obtained by combining the N-S response spectra from the N-S earthquake component with the N-S response spectra from the E-W component by the SRSS method. A comparison of 2% envelope Hosgri response spectra used

to qualify these segments and the response spectra developed for this study are provided in Figures 19 through 22. This comparison shows that the horizontal response spectra, Figures 19 and 21, used for qualification of the piping segments are exceeded by the response spectra which include the flexibility of the annulus structure, the curve labeled "Study." This is most pronounced in the period range 0.03 to 0.06 seconds or 16 to 30 Hz. Outside this range, the horizontal study curves are only slightly larger than the design response spectra. A comparison of the vertical response spectra, Figures 20 and 22, shows that the main peak of the design curve is higher than the study curve. This occurs because the design response spectra includes the response of all beams in the general area; whereas the study response spectra includes only the response of the specific beams to which the piping system is attached. Except in the vicinity of the main peak, the vertical curves are approximately the same.

5.2 Piping Analysis Performed

Two response spectra and four acceleration time-history analyses were performed for each piping segment. The response spectra analysis used a broadened envelope response spectra. One response spectrum analysis used 2% damping for all modes, and the other analysis used the PVRC-recommended variable damping. For all response spectra analyses, the E-W and N-S spectra were enveloped. Two analyses were then made with this envelope; one in the N-S direction simultaneously with the vertical, and another in the E-W direction simultaneously with the vertical, in accordance with DCP procedures. In both cases, the results from the horizontal and vertical components were combined on an absolute sum basis. The larger result from either run was used to calculate stresses for piping and supports.

The four time-history analyses consisted of the following:

1) The support point for the given piping segment with the greatest

acceleration in the E-W direction was used to define the acceleration time-history in the E-W direction for every piping support point. This resulted in the most severe response spectra. The same approach was used to select the N-S and the vertical time-histories. In this analysis, the damping of all piping modes was 2%.

2) The time-histories and damping in (1) were used, but the input integration time step was reduced to shift the peaks of the response spectra to higher frequencies, thus simulating curve broadening provided in the response spectra.

3) The time-histories in (1) where used, but the input integration time step was increased to simulate the curve broadening on the low frequency side as provided in response spectra.

4) The time-histories in (1) were used with the variable damping recommended by the PVRC.

In all cases the N-S time-history was used simultaneously with the vertical, and the E-W time-history was used simultaneously with the vertical. The larger results from these two analyses was then used to calculate stresses in the piping and supports.

6.0 RESULTS FOR PIPING AND SUPPORTS

The following Hosgri load combinations were used for stress evaluation on all calculations, which is consistent with the FSAR.

Pipe Stress = WT + P + HE

Support Loads = DL + $(HE^2 + SAM^2)^{\frac{1}{2}}$ + TH or THA*

[MISC2000]

Where:

WT	=	dead weight stress
P	=	pressure stress
HE	=	Hosgri stress or load
DL	=	dead weight load
TH	=	normal thermal loads
THA	=	accident thermal loads
SAM	=	seismic anchor movement loads

*Higher of THA or TH (only used for concrete expansion loads.)

The pipe stresses have been evaluated for the above load combinations and in all cases, the stresses are well below the allowable stresses for the ANSI B31.1 code. The stresses were checked for all six seismic motion descriptions given in Section 5.2. The largest ratio of actual stress to allowable stress at any location is 0.55.

A comparison of Hosgri loads used in the seismic qualification of the supports and the loads obtained from various analyses performed as part of this study is provided in Tables 6.1.1 and 6.1.2. These tables also show which load combination controls the support design. As indicated by the last column in these tables, the Hosgri load combination does not control all support designs. It should be noted that in some cases, the load predicted by one of the analyses performed in this study exceed the Hosgri original load, but the DDE load combination still controls. The qualification of the support would, therefore, be unaffected. This indicates that inclusion of the horizontal flexibility of the annulus structure increases the support loads less than the conservatism inherent in the DDE criteria and methodology.

The qualification of the supports is summarized in Tables 6.1.3 and 6.1.4. In determining the stress ratios, the largest support load from any of the six study cases was used. As indicated by the stress ratios, all the

supports remain qualified. In fact, the majority of the supports are not controlled by the load combinations containing the Hosgri loads. The load combinations containing the DE and DDE loads are more demanding for two reasons. First, the DE and DDE loads are calculated on a very conservative bases since damping is assumed to be 0.5%. Second, the allowable stresses for the DE and DDE events are less than or equal to those for the Hosgri load combinations. The piping supports on other piping segments supported by the annulus structure will show a similar trend; i.e., many pipe supports are controlled by the DE and DDE load combinations.

The smallest stress ratio for supports summarized in Tables 6.1.3 and 6.1.4 resulting from the Hosgri load combination is 1.71. The supports can accommodate an additional substantial increase in the horizontal response. This is particularly true in view of the apparent significant increase in horizontal response spectra shown in Figures 19 and 21. As shown by the comparison of design qualification loads with loads obtained from this study, the only supports which appear to experience a significant increase in loads, greater than 35%, were the anchors (the supports in Tables 6.1.1 and 6.1.2 which have six force components). In fact, there were only four nonanchor supports which experienced an increase above 25%. Some components of anchor forces experience substantial increases, but the qualification of the anchors is not affected. The design of anchors is in general quite conservative.

The trends that have been observed for these two piping segments can be extended to other elevations within the annulus structure. As indicated in previous submittals, the load combinations involving Hosgri do not control the design of all pipe supports. In fact, as shown by this study, the majority are not controlled by these load combinations. The higher modes of vibration (modes in the 20 to 33 Hz range) make a minor contribution to the global response of the piping system. This is confirmed by support reactions experiencing only minor changes when the percent changes in the response spectra in some frequency ranges might suggest a far greater percent change in response.

Although the effect of specific differences in response spectra at other elevations were not investigated in this study, it is expected that any increased acceleration at other elevations would be adequately covered by the margin in existing stress ratios as documented by this study at elevation 106.

7.0 CONCLUSIONS

Two piping segments have been analyzed for several descriptions of seismic motion which includes certain additional horizontal amplification of the annulus structure not included in the design qualification of the piping and supports. Results from this study indicate that support loads are not significantly affected by modes in the 20 to 33 Hz range. All supports in the study remained qualified considering the additional horizontal amplification from the annulus structure. The change in the individual support loads ranged from a decrease of 15% to an increase of 35% with only 4 supports out of 33 experiencing an increase over 25%. Some components of anchor loads increased by a larger percentage but all remained qualified.

The study shows that the Hosgri load combination generally does not control the design of the pipe supports. This minimizes the importance of the frequency content of the Hosgri response spectra in the 20 to 33 Hz range. These results show the original design basis to be reasonable and appropriate for evaluating piping systems subjected to the postulated Hosgri event.

The support loads predicted in this study still contain additional conservatisms since a number of effects have not been quantified. One effect which was not quantified was the dynamic coupling between the annulus steel framing and the supported piping. If this effect were included, the supports loads would be reduced from these obtained in the time-history analysis. Other conservative effects which have not been quantified in this study were discussed in PGandE's previous submittal of December 28, 1982.

8.0 REFERENCES

1) PVRC Technical Committee on Piping Systems of the Pressure Vessel Research Committee, Progress Report on Damping Valves, 1983.

2) Diablo Canyon Unit 1, Design Verification Program, Phase I Final Report.

[MISC2000]

TABLE 5.1 PERIOD AND PARTICIPATION FACTORS FOR LINE 6-101

PARTICIPATION FACTORS

MODE	PERIOD	X-DIRECTION	Y-DIRECTION	Z-DIRECTION
1	.0908	.89080	-.01086	.17442
2	.0578	-.10708	.13329	-.26275
3	.0431	-.06327	.06173	-.02030
4	.0428	-.07932	-.20358	-.40741
5	.0407	-.24038	.10873	.04659
6	.0389	-.20916	.22514	.11156
7	.0388	-.42455	-.12517	.16651
8	.0374	-.00029	.38522	-.00460
9	.0361	-.04032	.03530	.22138
10	.0358	.21598	-.11986	-.31623
11	.0324	.51898	-.02346	.06457
12	.0306	.00151	.74912	.08541
13	.0305	-.46914	.04342	.61553

TABLE 5.2 PERIOD AND PARTICIPATION FACTORS FOR LINE 4A-111

		PARTICIPATION FACTORS		
MODE	PERIOD	X-DIRECTION	Y-DIRECTION	Z-DIRECTION
1	.2521	.89559	.01203	.60924
2	.2129	.60589	.09215	−.66374
3	.1712	.44074	.04331	-1.16827
4	.0993	.47908	−.00364	.44075
5	.0809	−.42519	.04938	−.08214
6	.0694	−.01749	−.06080	.09059
7	.0663	.26375	.07494	−.22628
8	.0545	.32228	−.05874	−.30191
9	.0536	−.13116	.21659	−.17589
10	.0459	.02649	−.34890	−.00773
11	.0451	.38408	−.06961	.21463
12	.0391	−.02174	.64152	−.47570
13	.0386	−.14137	−.97639	−.65092
14	.0374	.17661	−.25420	.12966
15	.0362	.48256	.07214	.57853
16	.0326	.04934	−.37509	.05369
17	.0306	.35814	−.34097	.48651

TABLE 6.1.1

6-101 SUPPORT LOADS - HOSGRI[1]

SUPPORT	DIR	QUALIFICATION LOAD	NEW RS,2%	NEW RS,2-5%	TH,2%	TH,2% CONDENSED	TH,2% EXPANDED	TH, 2-5%	GOVERNING COMBINATION
40-22R	Y	247[2]	210	210	193	227	231	193	DDE
40-22R	H	255	251	251	233	247	227	233	DDE
40-21R	Y	228	194	194	172	204	207	172	DDE
40-21R	H	171	168	168	133	179	139	133	DDE
40-20R	Y	149	130	130	116	135	122	116	DDE
10-44SL	H	932	916	916	877	1007	878	877	DDE
40-19R	Y	241	209	209	228	257	250	228	DDE
40-19R	H	273	268	268	196	264	236	196	DDE
56N-112R	Y	250	213	213	202	239	235	202	DDE
56N-112R	H	273	269	269	207	238	232	207	DDE
56N-111R	Y	187	159	159	138	150	144	138	DDE
56N-111R	H	225	221	221	166	175	166	166	DDE
56N-110R	Y	159	136	136	125	157	153	124	HOSGRI
56N-109R	Y	211	180	180	162	188	173	162	DDE
56N-109R	H	182	191	191	149	198	150	149	DDE
56N-108R	Y	255	217	217	200	252	222	201	DDE
56N-108R	H	189	185	185	197	211	187	197	DDE
56N-107R	Y	200	178	172	171	244	210	171	DDE
56N-107R	H	293	288	288	314	352	311	314	DDE
56N-106R	Y	197	169	168	167	226	189	167	DDE
56N-106R	H	165	162	162	160	169	153	160	DDE
56N-105R	Y	277	263	237	265	372	323	260	DDE
56N-105R	H	3184	3251	2436	1786	3081	2922	1515	DDE

TABLE 6.1.1
6-101 SUPPORT LOADS - HOSGRI
(continued)

SUPPORT	DIR	QUALIFICATION LOAD	NEW RS,2%	NEW RS,2-5%	TH,2%	TH, 2% CONDENSED	TH, 2% EXPANDED	TH, 2-5%	GOVERNING COMBINATION
56N-48R	H	1300	1277	1277	944	1093	1087	944	DDE
56N-48R	H	3561	3587	2648	2294	3559	3291	1988	DDE
56N-104R	Y	701	696	506	399	745	685	335	DDE
	FA	629	618	618	369	430	359	369	DDE
	FB	117	100	100	87	96	92	87	DDE
40-23A	FC	87	85	85	389	467	454	389	DDE
	MA	62[3]	59	58	98	132	92	98	DDE
	MB	165	175	175	146	175	149	146	DDE
	MC	286	223	223	125	149	126	125	DDE
	FA	663	660	473	535	716	733	496	DDE
	FB	569	568	411	418	621	563	369	DDE
Pent.77	FC	189	212	211	150	212	178	150	DDE
	MA	211	233	232	151	222	179	151	DDE
	MB	894	979	972	555	891	761	547	DDE
	MC	816	824	624	598	898	789	529	DDE

[1]Explanation of load column heading
a) Qualification load - the load obtained from previous Hosgri analysis based on original design criteria. Comparison between controlling demand and allowable loads is given in Table 6.1.3 and 6.1.4 via stress ratios.
b) New RS, 2% - Response spectra including the horizontal flexibility of the annulus structure was used to determine the support loads. Damping of 2% was used for all modes.
c) New RS, 2-5% - same as (b) except variable damping was used.
d) TH,2% - Time-history analysis including the horizontal flexibility of the annulus structure was used to determine the support loads. Damping of 2% was used for all modes.
e) TH,2% Condensed - The input integration time step was reduced to simulate curve broadening on the high frequency side of the corresponding response spectra.
f) TH,2%, Expanded - The input integration time step was increased to simulate curve broading on the low frequency side of the corresponding response spectra.
g) Same as (d) except variable damping was used.

[2]Reaction forces are given in pounds.

[3]Reaction moments are given in inch-pounds.

[MISC2000]

TABLE 6.1.2

4A-111 SUPPORT LOADS - HOSGRI[1]

SUPPORT	DIR	QUALIFICATION LOAD	NEW RS	NEW RS	TH,2%	TH, 2% CONDENSED	TH, 2% EXPANDED	TH, 2-5%	GOVERNING COMBINATION
10-55SL	Y	759[2]	878	576	822	858	744	536	DE
10-70SL	Z	965	1135	658	1202	943	1100	782	DDE
10-56SL	H	624	712	473	751	626	581	525	DDE
10-57SL	Y	962	1149	836	908	927	920	587	HOSGRI
51-5R	Y	1054	1389	1284	724	855	722	623	HOSGRI
51-5R	H	470	567	334	438	550	522	334	HOSGRI
41-34R	Y	1436	1697	988	1807	1490	1681	1181	DDE
41-35R	Y	641	757	452	643	607	664	436	HOSGRI
10-144SL	H	998	1043	680	685	1113	810	512	DDE
41-37R	Y	390	460	310	365	375	361	316	DDE
41-39A	Y	173	180	168	206	205	151	171	DDE
41-40R	Y	92	81	74	102	90	89	103	DDE
10-92SL	H	1086	1161	804	782	1184	939	673	DDE
41-41R	Y	119	95	95	108	84	94	107	HOSGRI
10-58SL	H	641	807	743	387	451	327	343	HOSGRI
41-42R	Y	129	102	102	126	107	108	126	HOSGRI
RCP #1-1	FA	409	495	279	337	416	426	240	DE
	FB	170	197	122	160	143	171	111	DE
	FC	180	213	140	272	253	312	193	DE
	MA	557[3]	640	389	1157	1182	1442	798	DE
	MB	1705	2099	1683	1879	2394	1958	1338	DE
	MC	1456	1700	1034	636	646	737	459	DE

TABLE 6.1.2

4A-111 SUPPORT LOADS - HOSGRI
(continued)

SUPPORT	DIR	QUALIFICATION LOAD	NEW RS	NEW RS	TH,2%	TH, 2% CONDENSED	TH, 2% EXPANDED	TH, 2-5%	GOVERNING COMBINATION
57N-101A	FA	956	949	1003	1162	1257	1115	926	DDE
	FB	81	75	75	90	83	75	90	
	FC	320	433	425	141	117	141	126	
	MA	3527	4435	4077	2201	2351	1836	1893	
	MB	11881	15921	15501	5593	6497	4748	4725	
	MC	2215	2442	2442	2048	2079	1677	2055	

[1]Explanation of load column heading

a) Qualification load - the load obtained from previous Hosgri analysis based on original design criteria. Comparison between controlling demand and allowable loads is given in Table 6.1.3 and 6.1.4 via stress ratios.

b) New RS, 2% - Response spectra including the horizontal flexibility of the annulus structure was used to determine the support loads. Damping of 2% was used for all modes.

c) New RS, 2-5% - same as (b) except variable damping was used.

d) TH,2% - Time-history analysis including the horizontal flexibility of the annulus structure was used to determine the support loads. Damping of 2% was used for all modes.

e) TH,2% Condensed - The input integration time step was reduced to simulate curve broadening on the high frequency side of the corresponding response spectra.

f) TH,2%, Expanded - The input integration time step was increased to simulate curve broading on the low frequency side of the corresponding response spectra.

g) Same as (d) except variable damping was used.

[2]Reaction forces are given in pounds.

[3]Reaction moments are given in inch-pounds.

TABLE 6.1.3

SUMMARY OF SUPPORT QUALIFICATION

FOR PIPING SEGMENT 6-101

SUPPORT NO.	CRITICAL ITEM	STRESS RATIO[1]	GOVERNING LOADS & COMMENTS
40-22R	Frame	8.94	DDE
40-21R	Weld	1.18	DDE
40-20R	Frame	26.0(26+)[2]	Hosgri
10-44SL	Weld	1.35	DDE
40-19R	Frame	1.5	DDE
56N-112R	Weld	1.01	DDE
56N-111R	Weld	1.03	DDE
56N-110R	Frame	2.5(2.5)	Hosgri
56N-109R	Weld	1.03	DDE
56N-108R	Frame	1.5	DDE
56N-107R	Frame	1.25	DDE
56N-106R	Frame	2.88	DDE
56N-105R	Frame	1.11	DDE
56N-48R	Weld	1.22	DDE
56N-104R	Frame	1.3	DDE
40-23A	Weld	1.27	DDE
57N-104V	-	-	Spring

[1]Ratio of FSAR allowable stress to acutal demand.

[2]The number in parenthesis is the previous stress ratio.

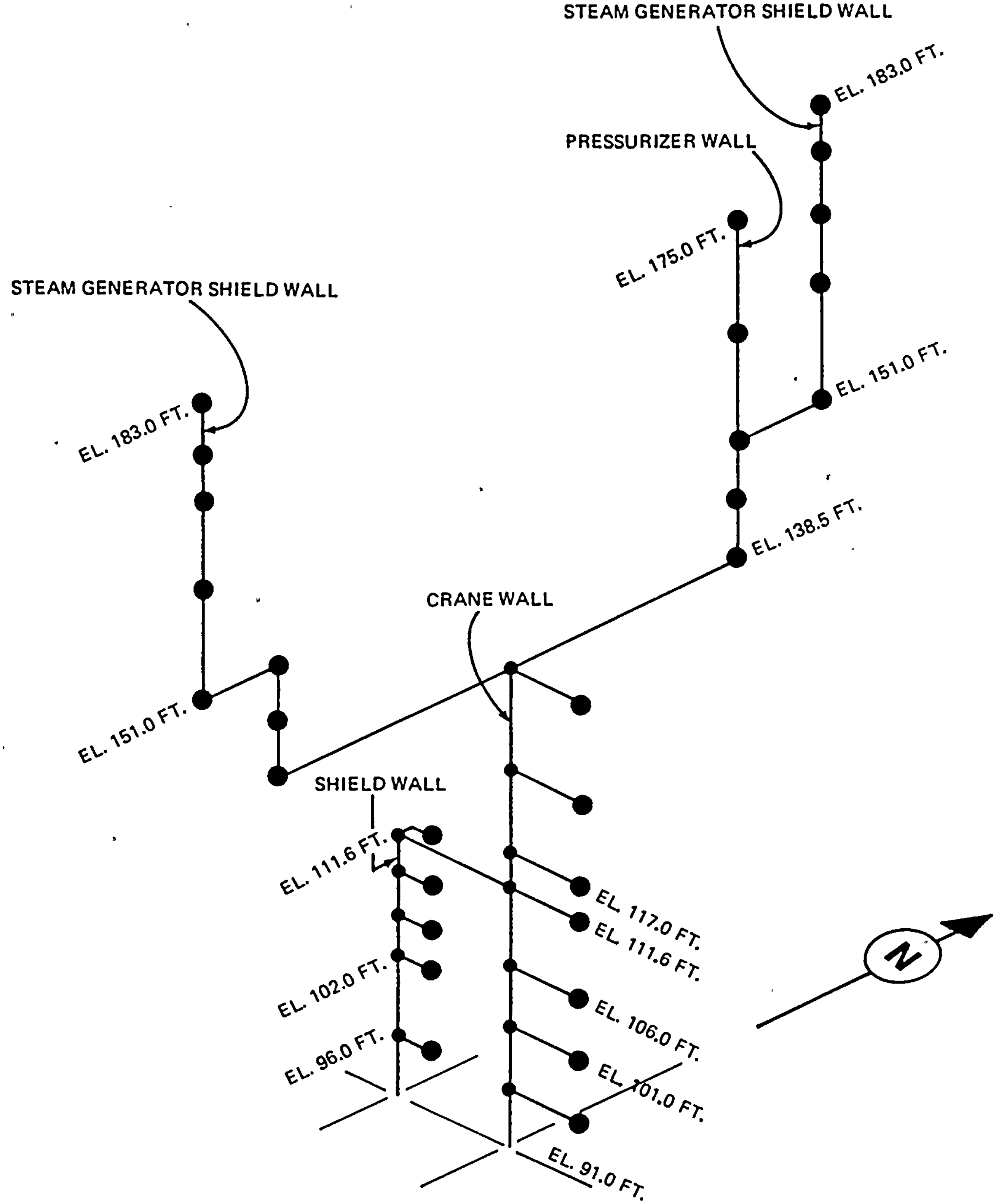
TABLE 6.1.4

SUMMARY OF SUPPORT QUALIFICATION
FOR PIPING SEGMENT 4A-111

SUPPORT NO.	CRITICAL ITEM	STRESS RATIO[1]	GOVERNING LOADS & COMMENTS
10-55SL	Snubber	1.72	DE
10-70SL	Snubber	1.40	DDE
10-56SL	Snubber	2.47	DDE
10-57SL	Snubber	1.71(2.02)[2]	Hosgri
51-5R	Clamp	3.65	DDE
41-34R	Frame	2.2	DDE,Hosgri
41-35R	Weld	1.93(2.28)	Hosgri
10-144SL	Snubber	3.4	DDE
41-37R	Frame	1.45	DDE, multiple pipe support. Controlled by other piping.
41-39A	Weld	1.17	DDE, multiple pipe support. Controlled by other piping.
41-40R	Weld	1.16	DDE
10-92SL	Plate	1.33	DDE
41-41R	Weld	1.2	DDE, multiple pipe support. Controlled by other piping.
10-58SL	Snubber	2.68(3.2)	Hosgri
41-42R	Frame	4.58	Hosgri
51-3V	-	-	Spring
51-4V	-	-	Spring
57N-101A	Weld	1.85	DDE

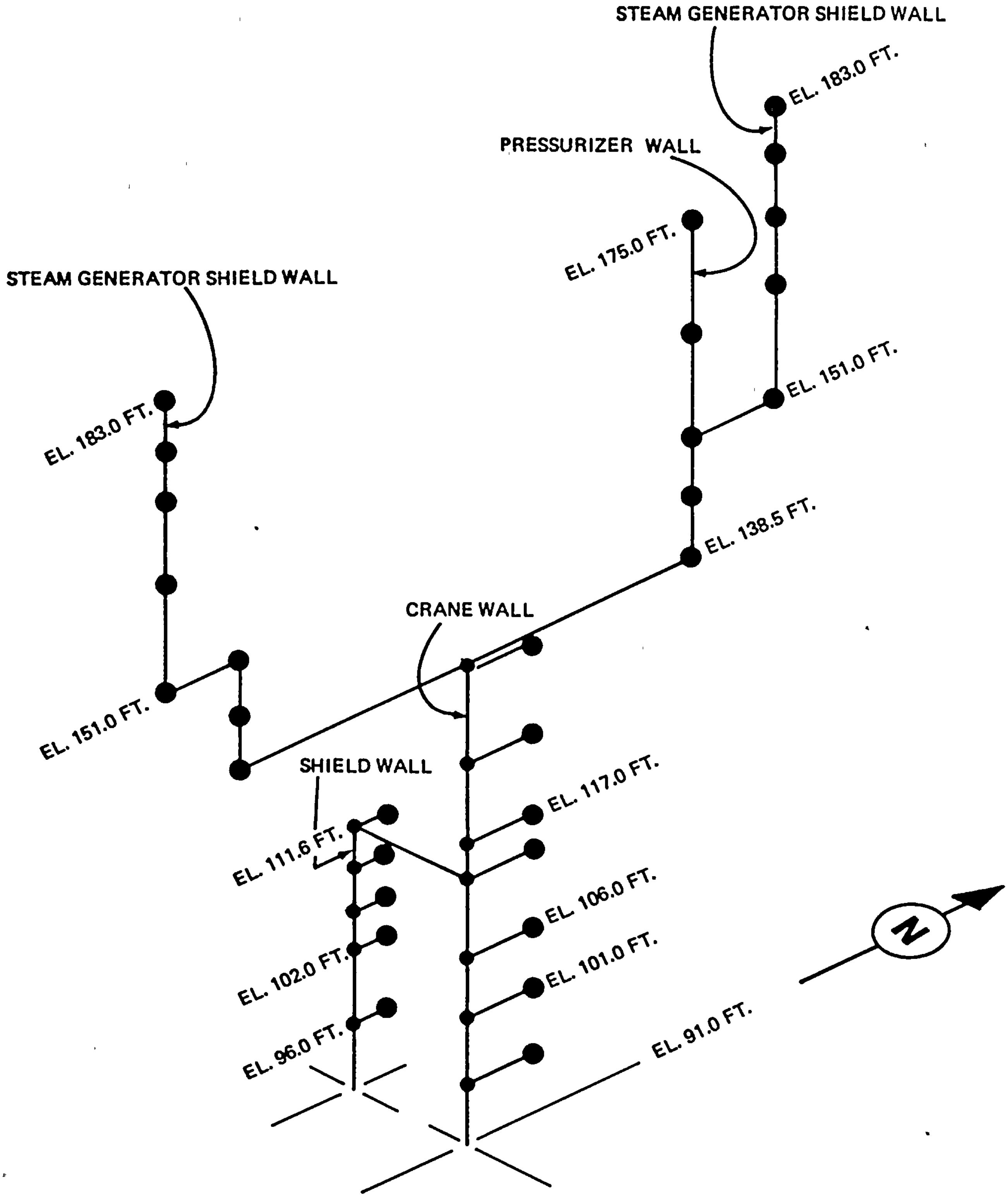
[1]Ratio of FSAR allowable stress to acutal demand.

[2]The number in parenthesis is the previous stress ratio.



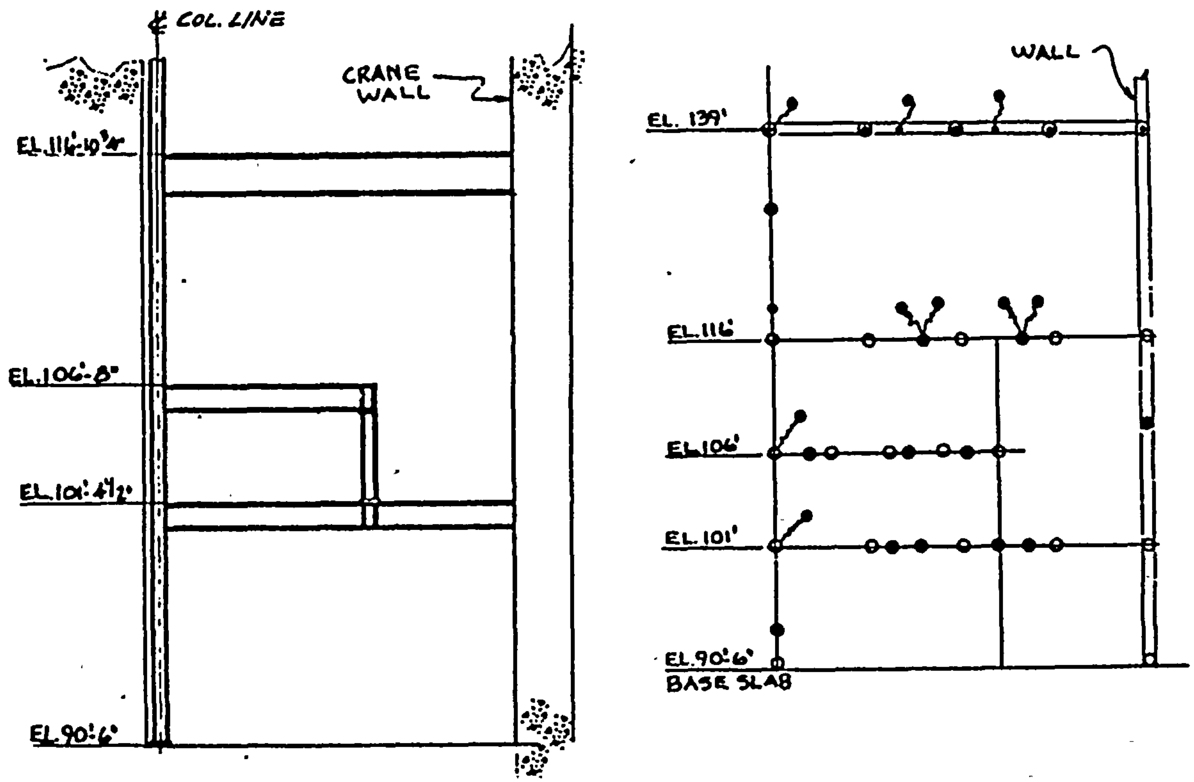
INTERIOR STRUCTURE HORIZONTAL N-S MODEL

FIGURE 1



INTERIOR STRUCTURE HORIZONTAL E-W MODEL

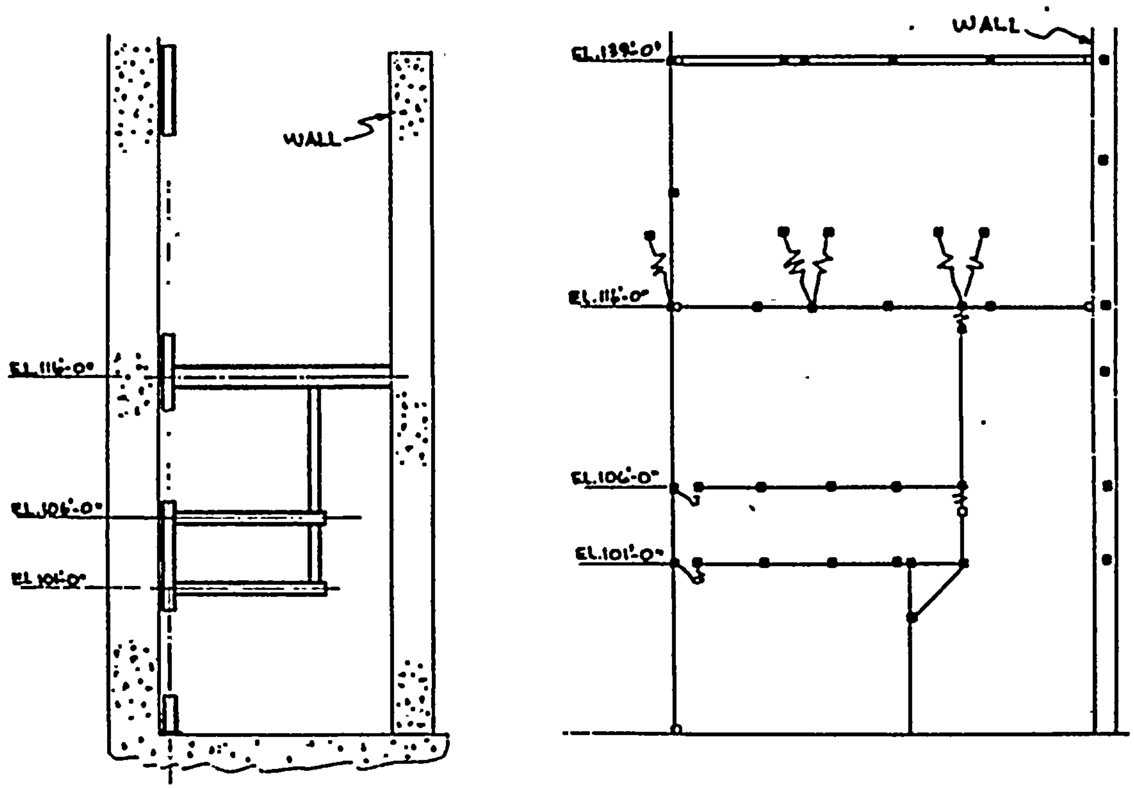
FIGURE 2



TYPICAL INDIVIDUAL FRAME ANALYSIS
FOR VERTICAL RESPONSE

COLUMN LINE 8

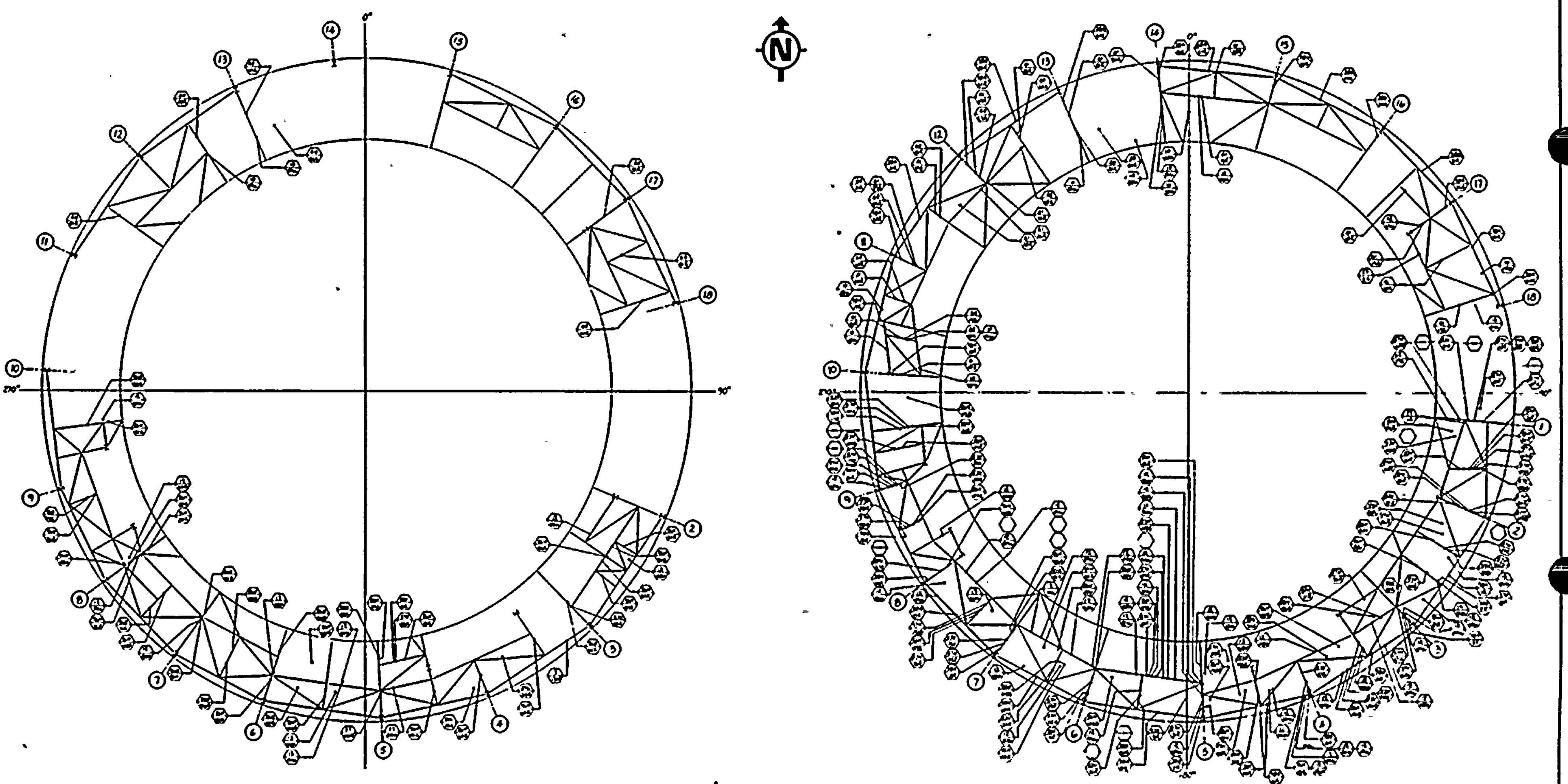
FIGURE 3



TYPICAL INDIVIDUAL FRAME ANALYSIS
FOR VERTICAL RESPONSE

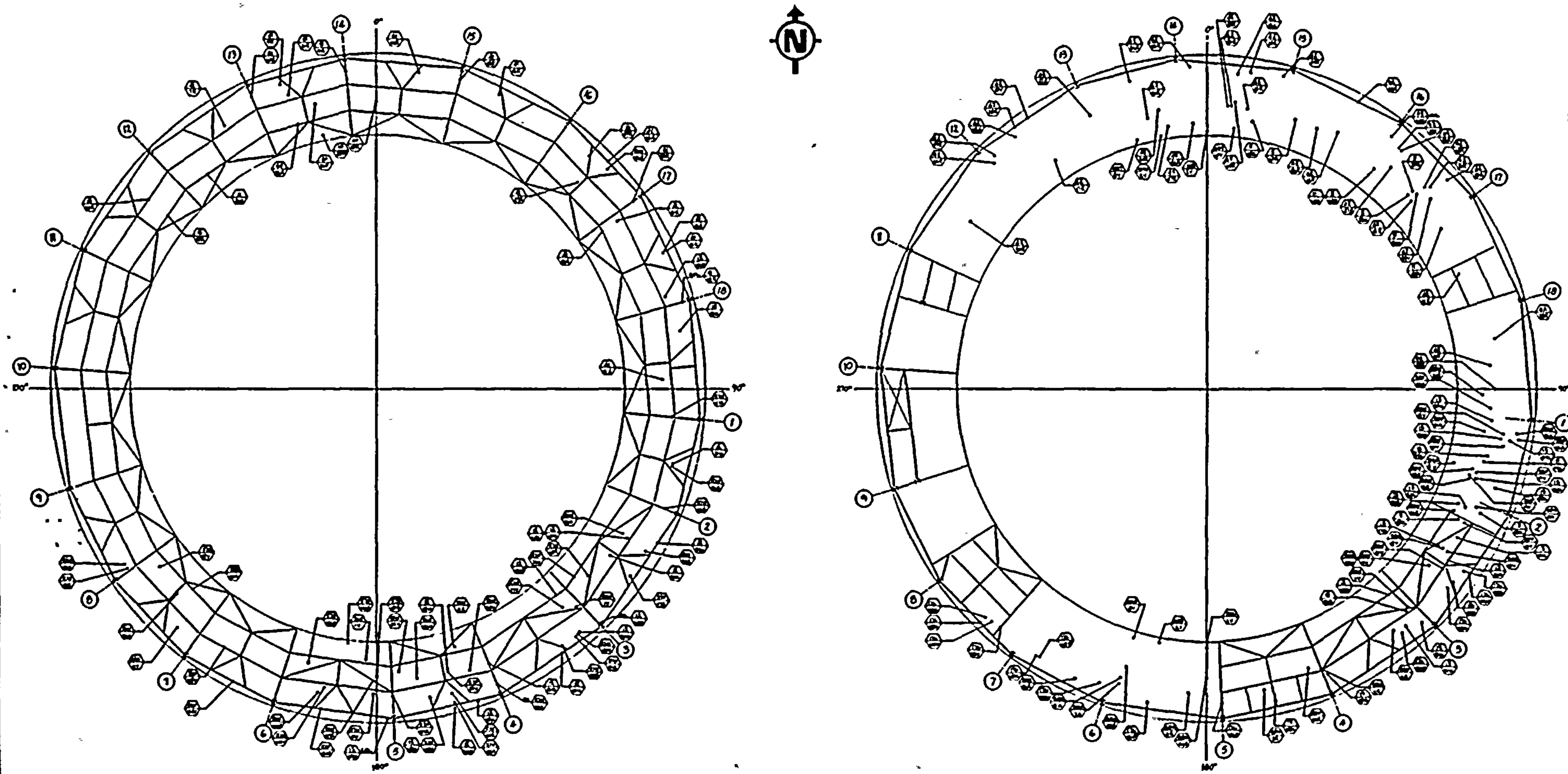
COLUMN LINE 9

FIGURE 4



LOCATION OF CLASS I PIPE SUPPORTS
AT ELEVATION 101'-4½" AND ELEVATION 106'-8"

FIGURE 5

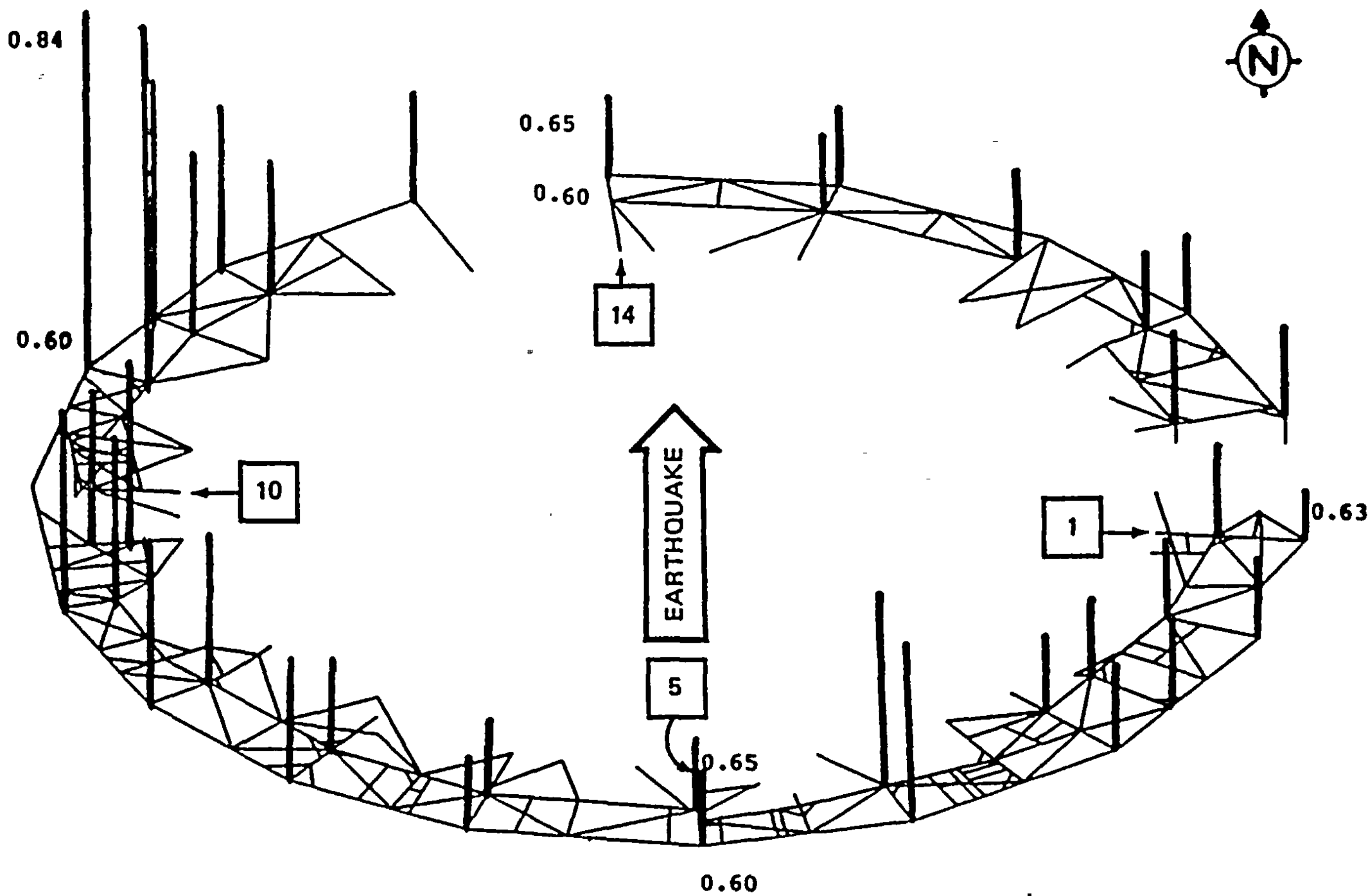


LOCATION OF CLASS I PIPE SUPPORTS
AT ELEVATION 116'-10¾" AND ELEVATION 139'-10¾"

FIGURE 6

[illegible]

DIABLO CANYON UNIT 1 ANNULUS STRUCTURE
HORIZONTAL GLOBAL DYNAMIC RESPONSE

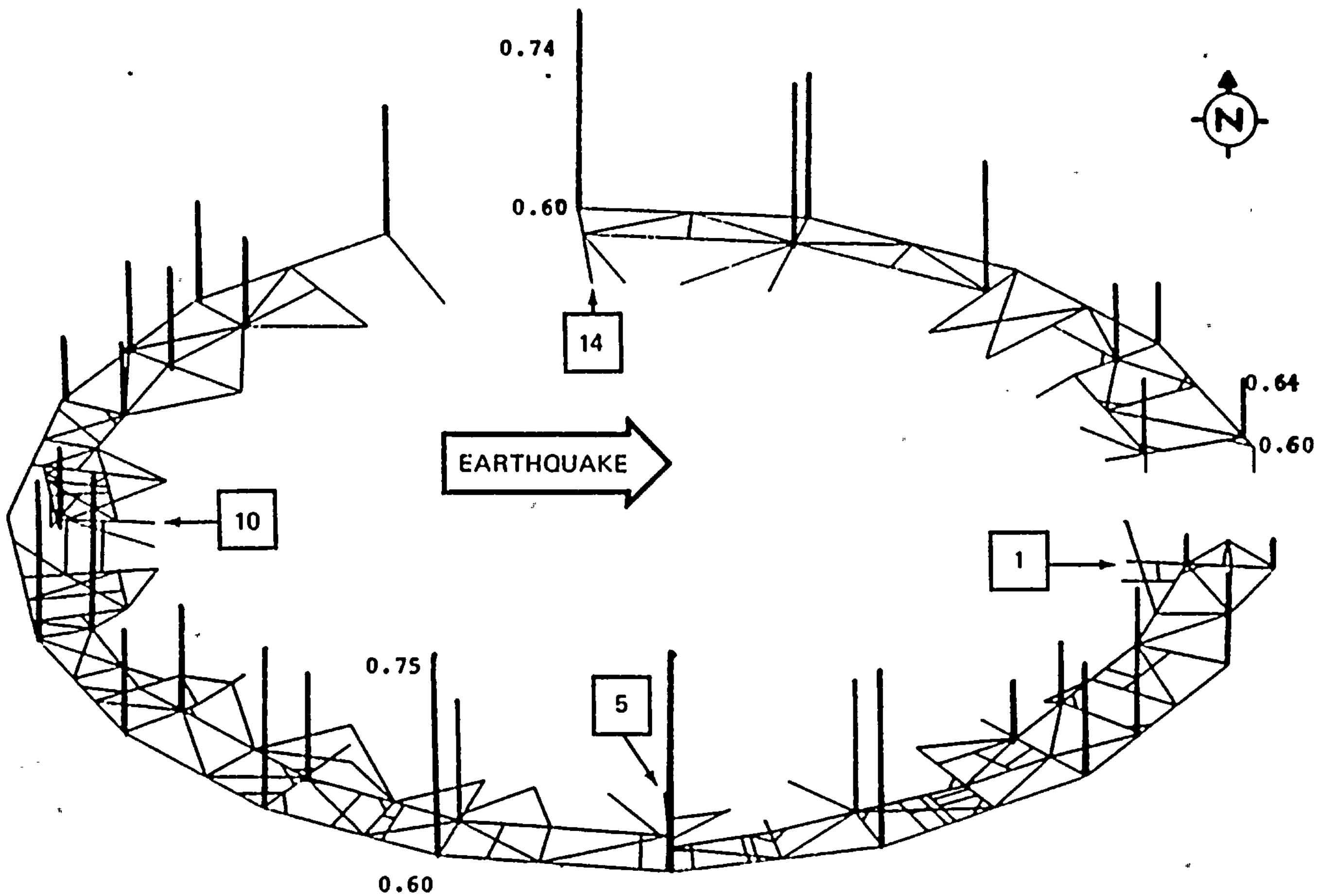


ELEVATION 106 FT.

MAX. ACCELERATION (g's) IN N-S DIRECTION DUE TO N-S EARTHQUAKE
PLOTTED FROM DATUM LINE 0.6 g

FIGURE 7

DIABLO CANYON UNIT 1 ANNULUS STRUCTURE
HORIZONTAL GLOBAL DYNAMIC RESPONSE

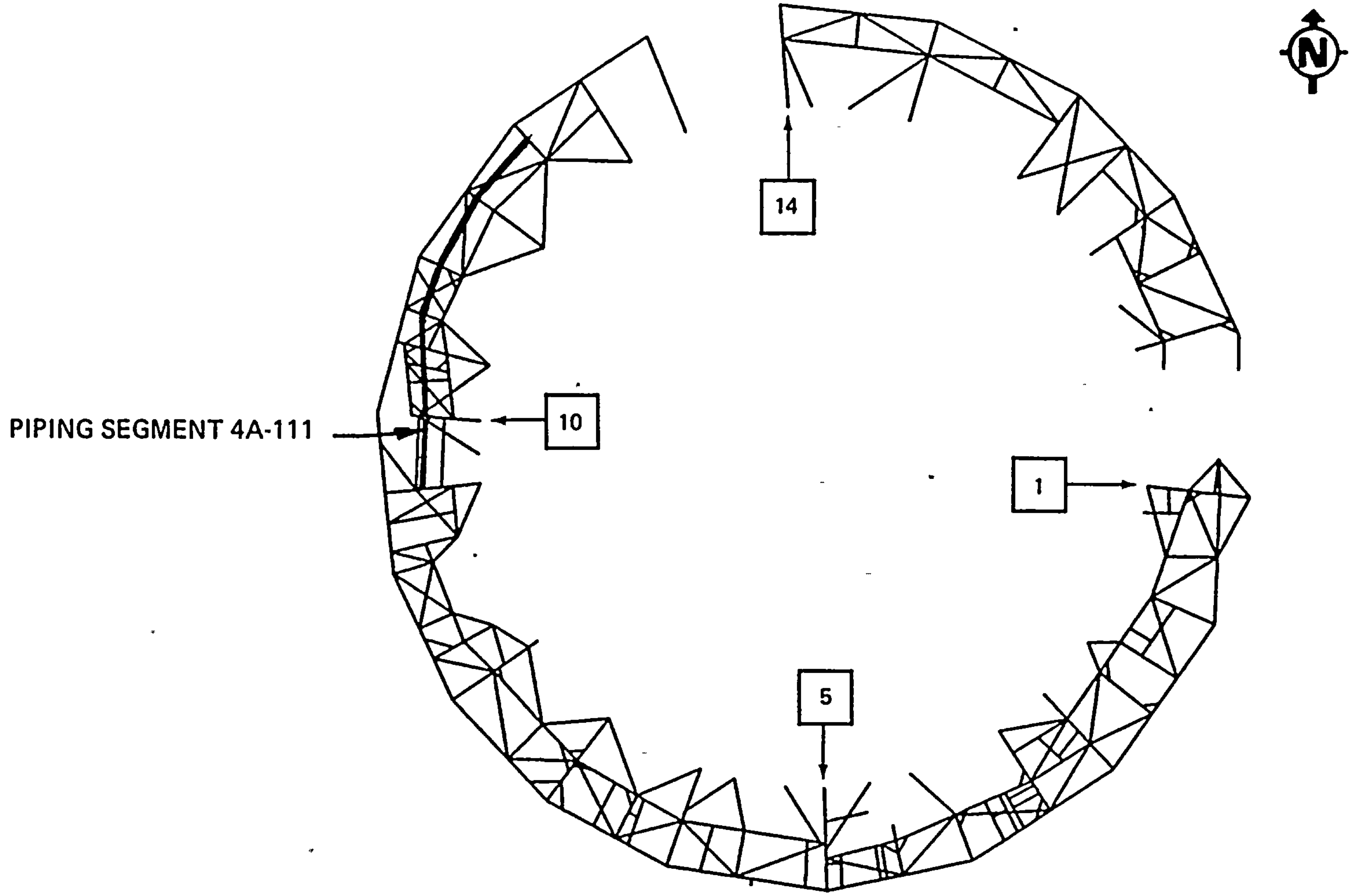


ELEVATION 106 FT.

MAX. ACCELERATION (g's) IN E-W DIRECTION DUE TO E-W EARTHQUAKE
PLOTTED FROM DATUM LINE 0.6 g

FIGURE 8

DIABLO CANYON UNIT 1 ANNULUS STRUCTURE

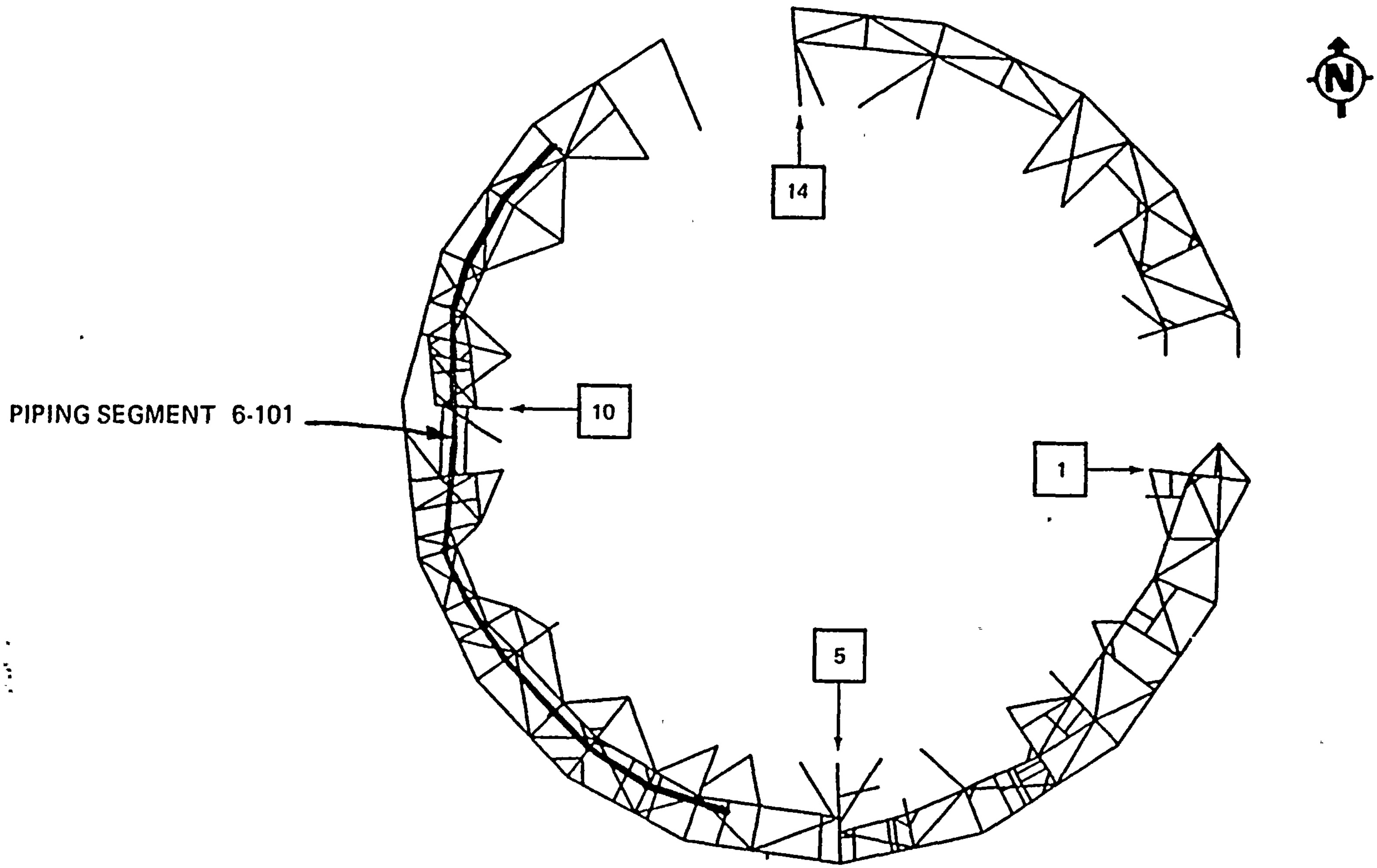


ELEVATION 106 FT.

LAYOUT OF PIPING SEGMENT 4A-111

FIGURE 9

DIABLO CANYON UNIT 1 ANNULUS STRUCTURE

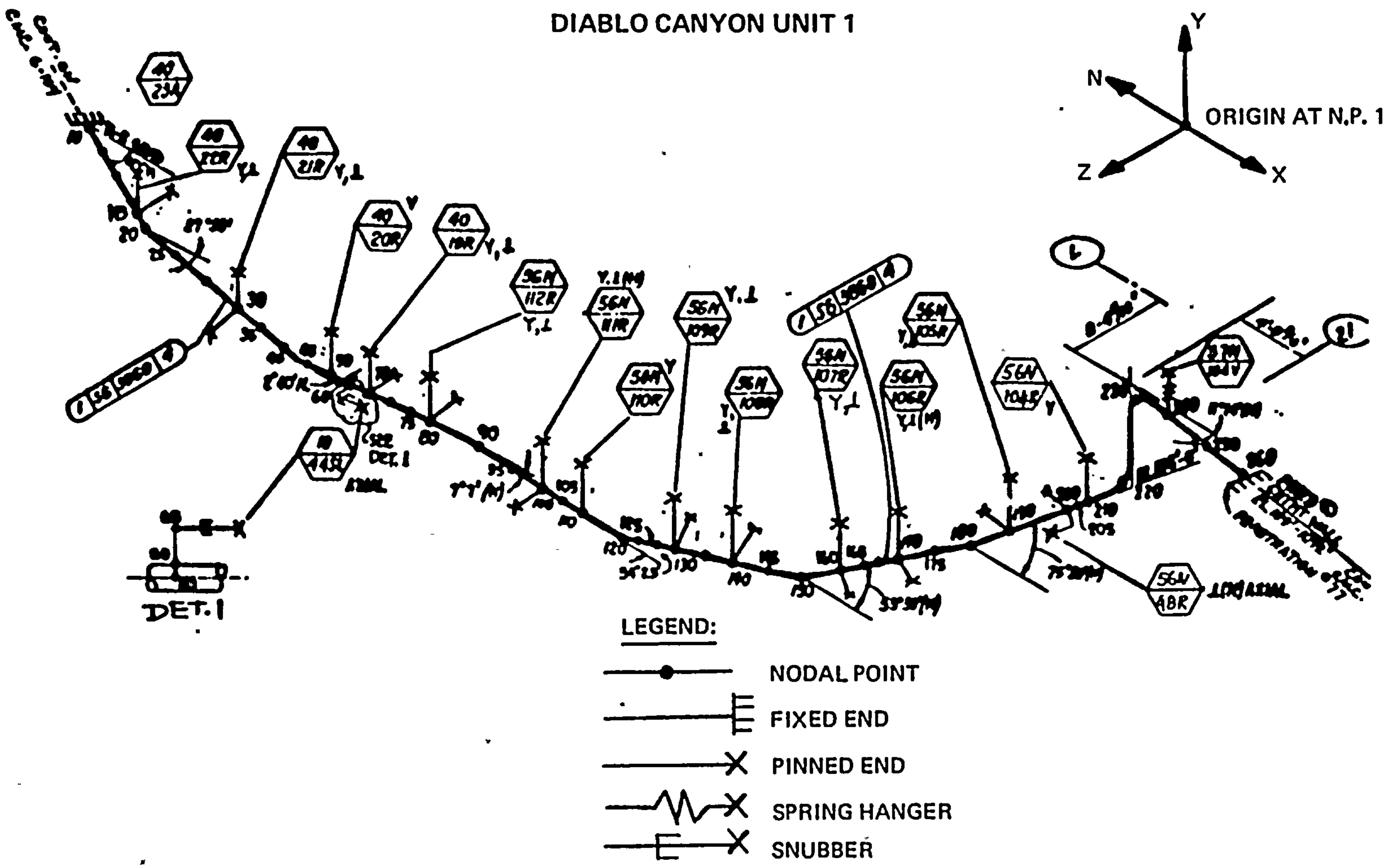


ELEVATION 106 FT.

LAYOUT OF PIPING SEGMENT 6-101

FIGURE 10

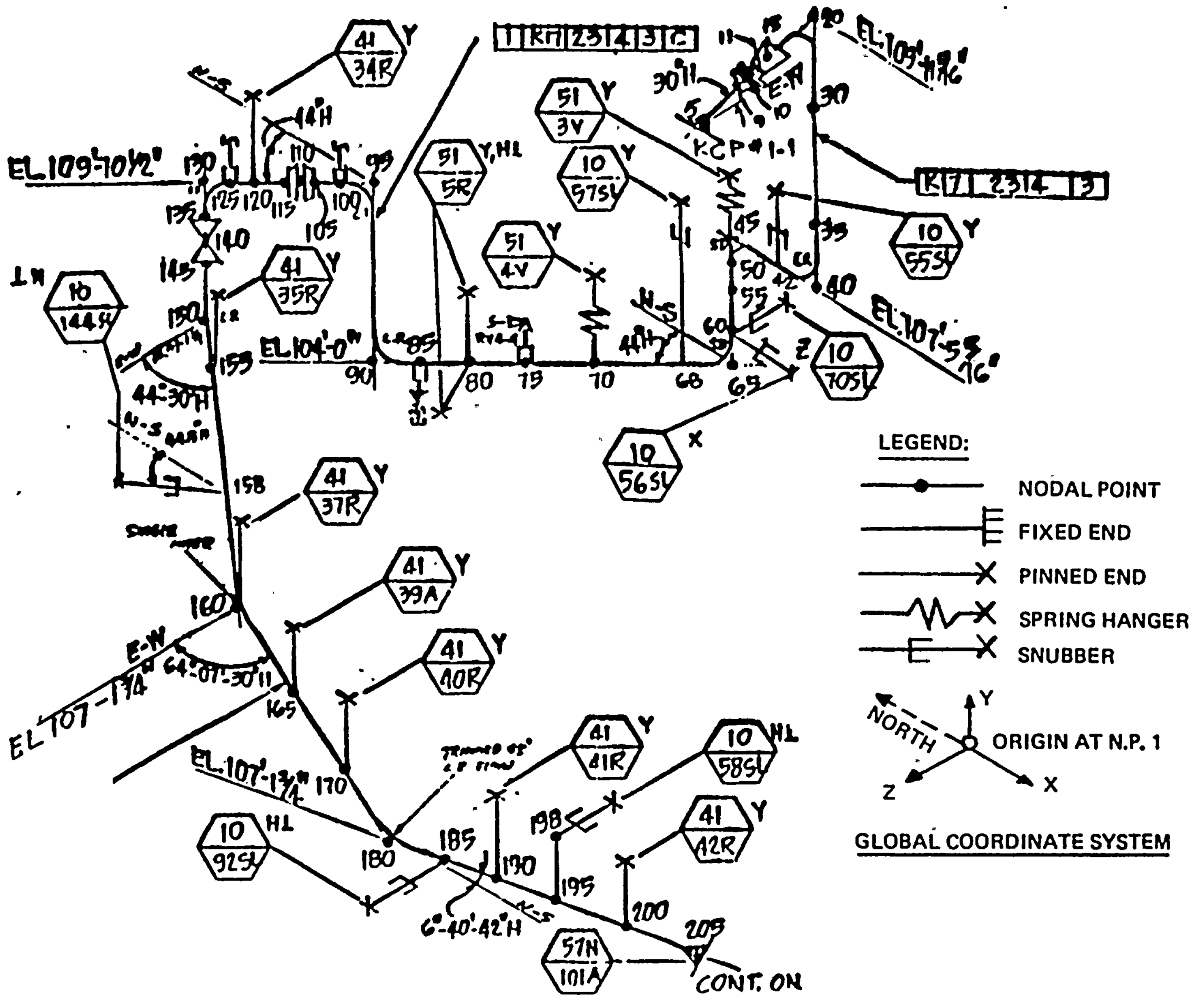
DIABLO CANYON UNIT 1



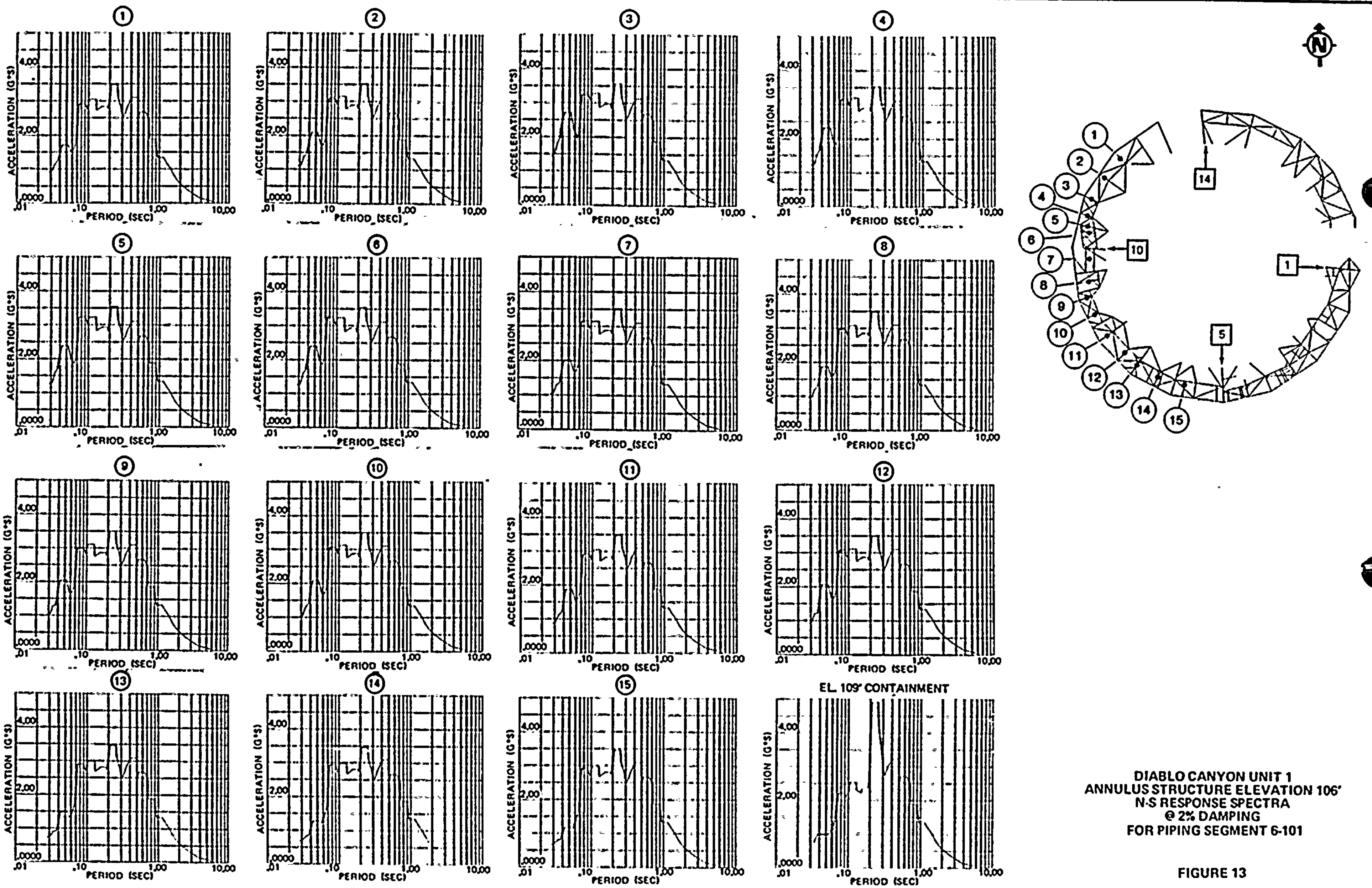
MODEL OF PIPING SEGMENT 6-101

FIGURE 11

DIABLO CANYON UNIT 1

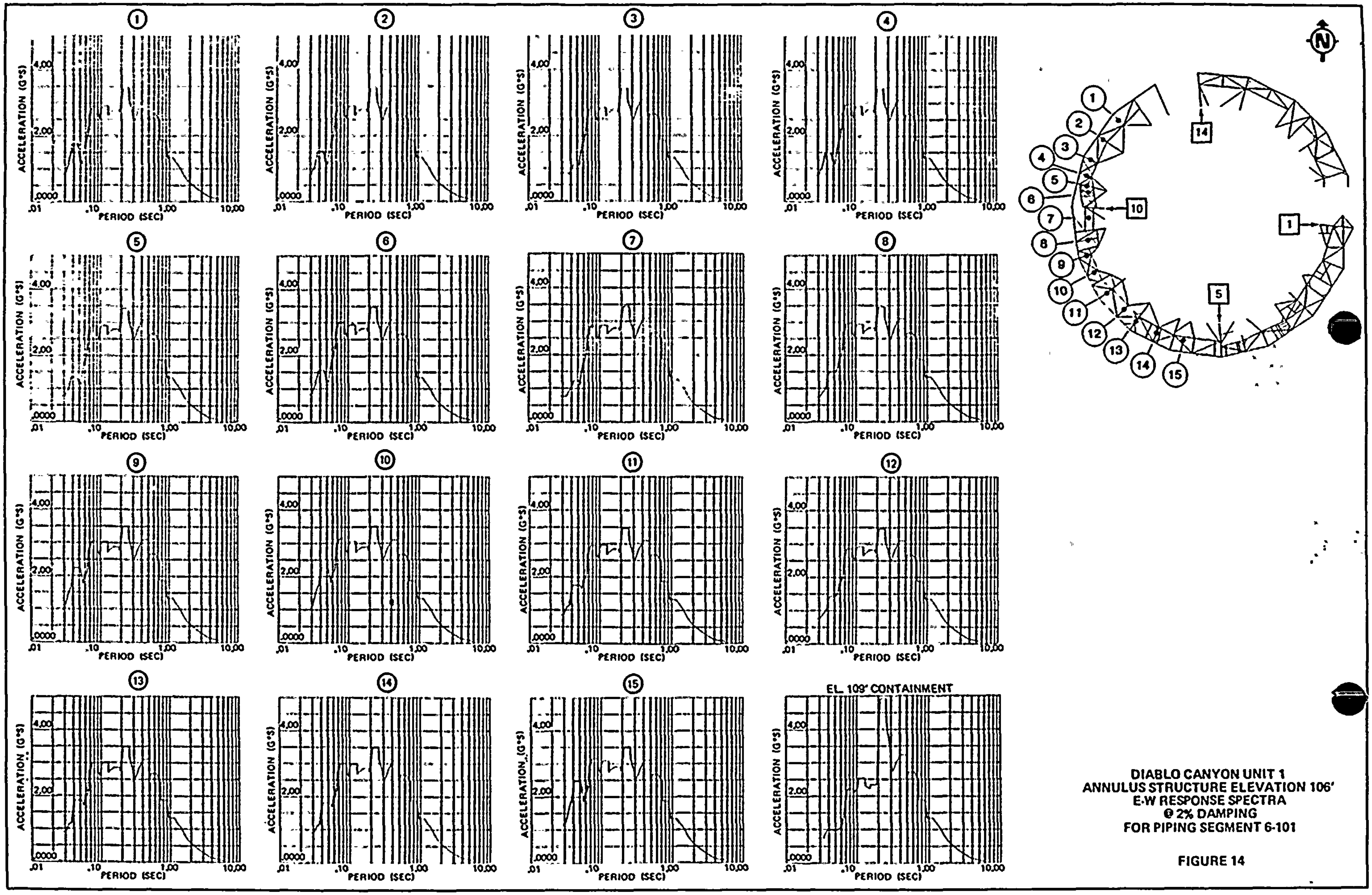


MODEL OF PIPING SEGMENT 4A-111
FIGURE 12



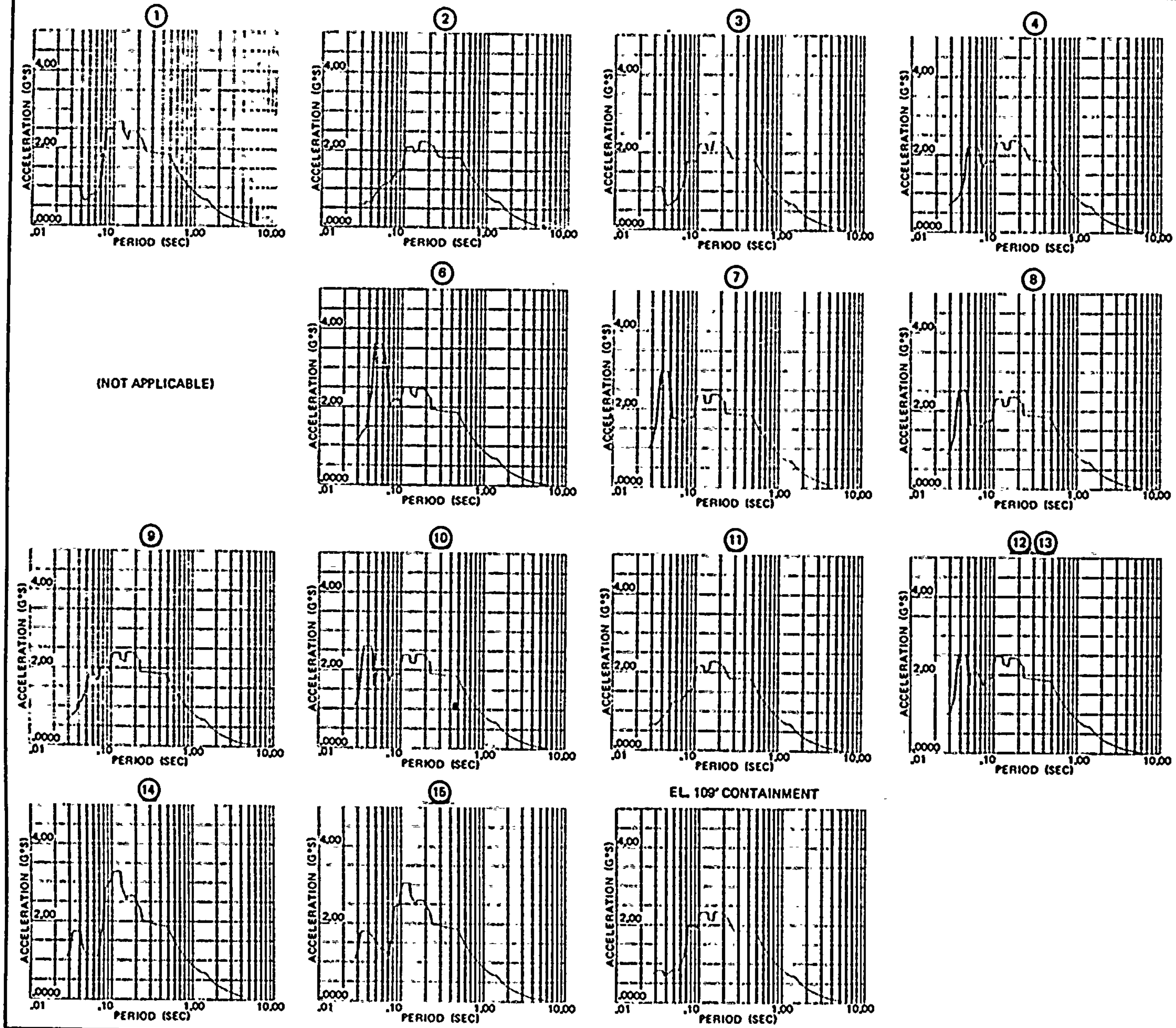
DIABLO CANYON UNIT 1
ANNULUS STRUCTURE ELEVATION 106'
N-S RESPONSE SPECTRA
@ 2% DAMPING
FOR PIPING SEGMENT 6-101

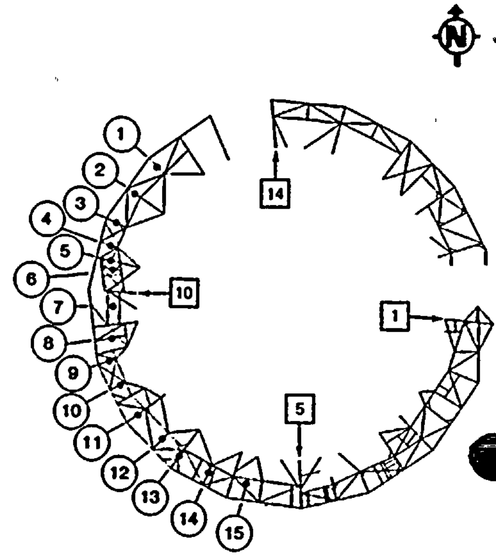
FIGURE 13



DIABLO CANYON UNIT 1
ANNULUS STRUCTURE ELEVATION 106'
E-W RESPONSE SPECTRA
@ 2% DAMPING
FOR PIPING SEGMENT 6-101

FIGURE 14

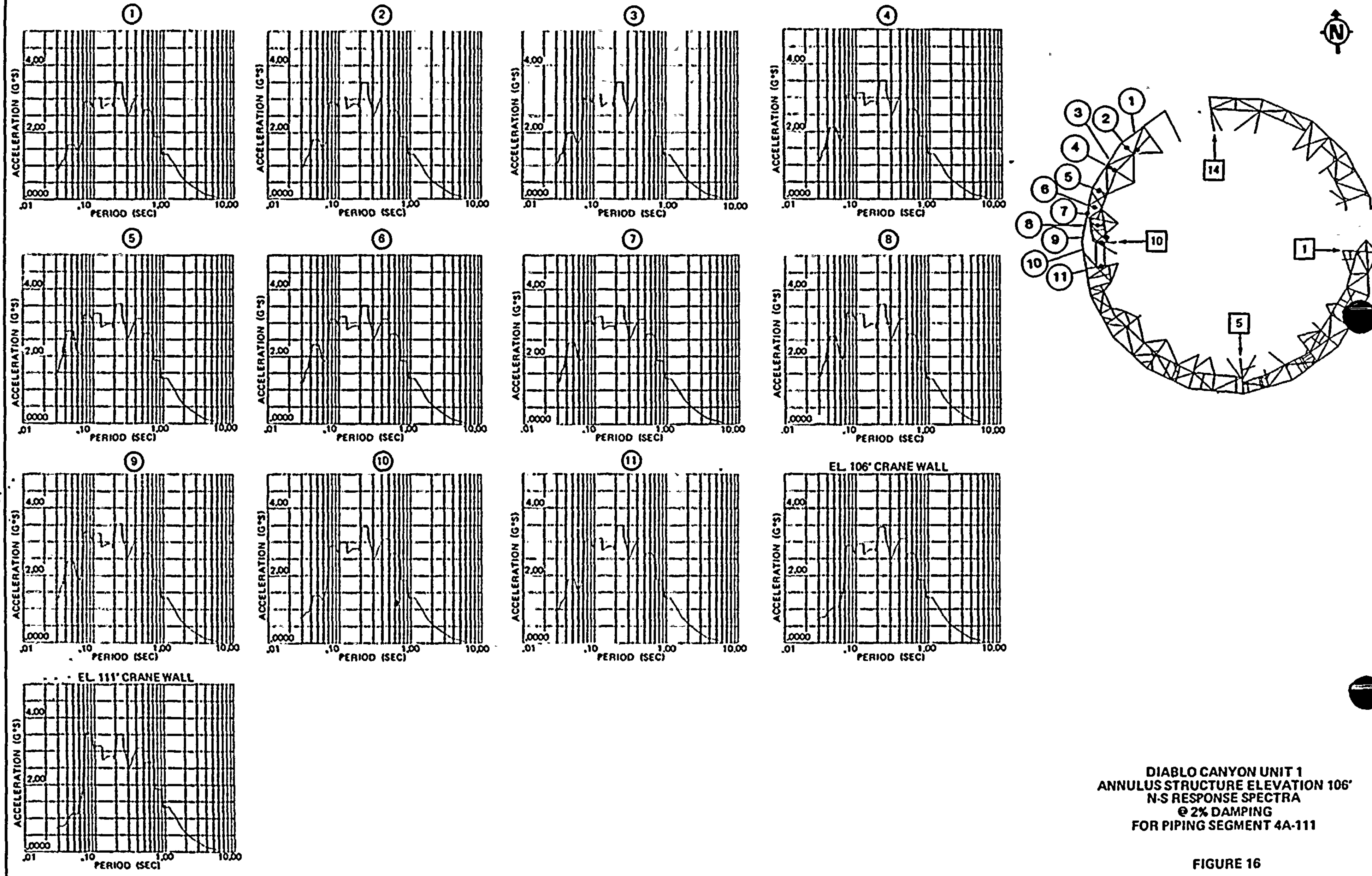




NOTE: POINT (6) IS AT CENTER OF RADIAL BEAM

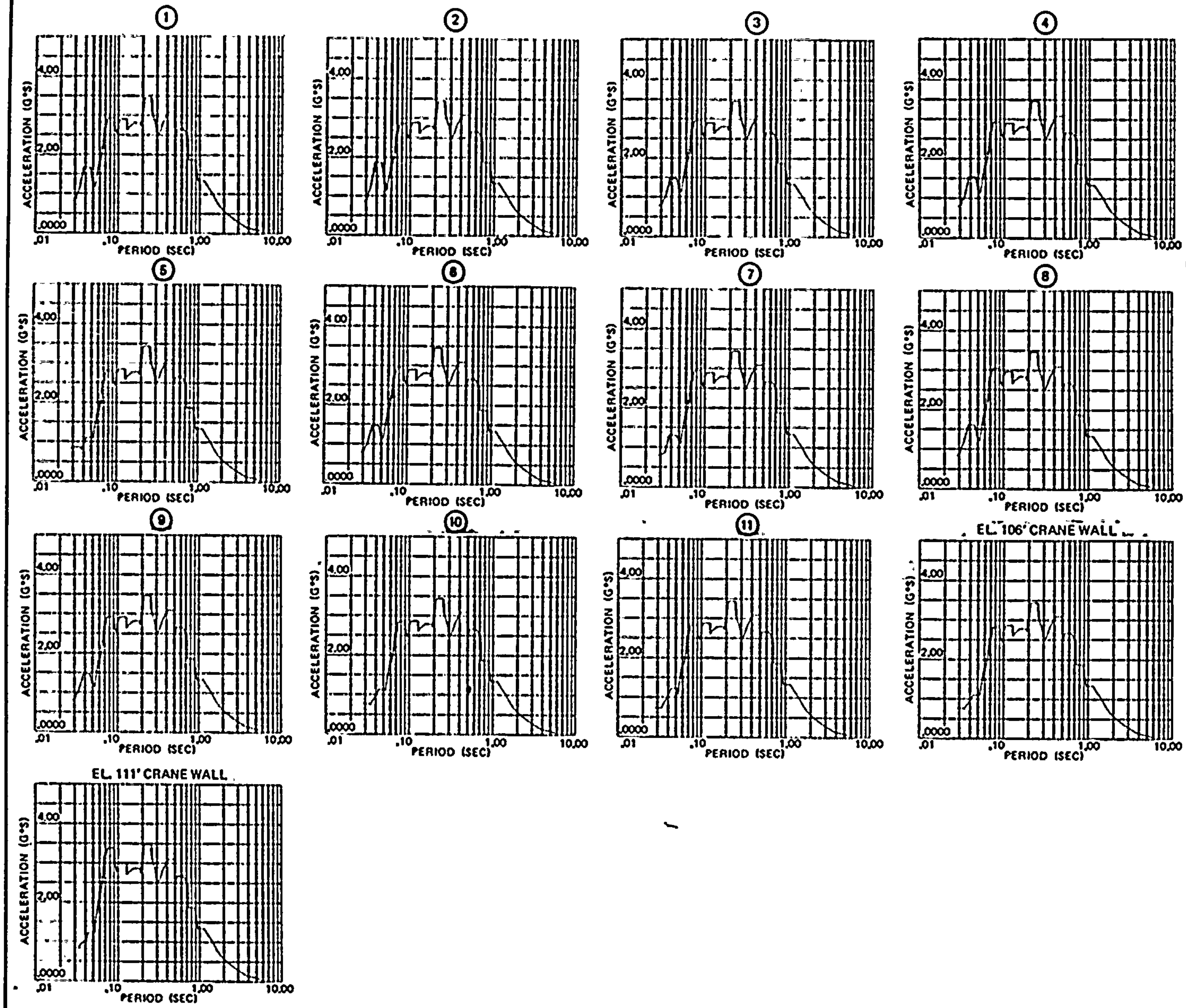
DIABLO CANYON UNIT 1
ANNULUS STRUCTURE ELEVATION 106'
VERTICAL RESPONSE SPECTRA
@ 2% DAMPING
FOR PIPING SEGMENT 6-101

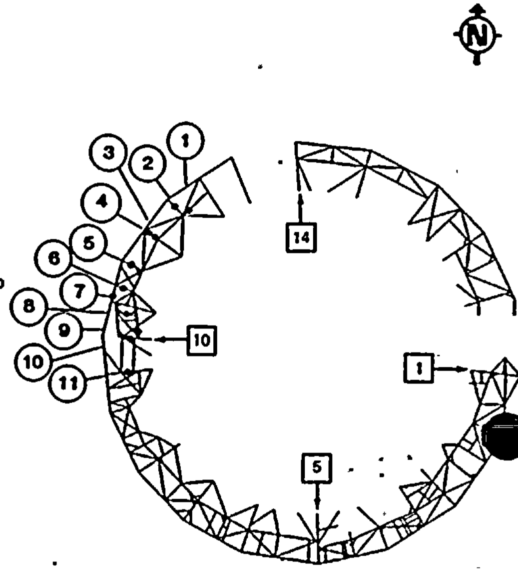
FIGURE 15



DIABLO CANYON UNIT 1
ANNULUS STRUCTURE ELEVATION 106'
N-S RESPONSE SPECTRA
@ 2% DAMPING
FOR PIPING SEGMENT 4A-111

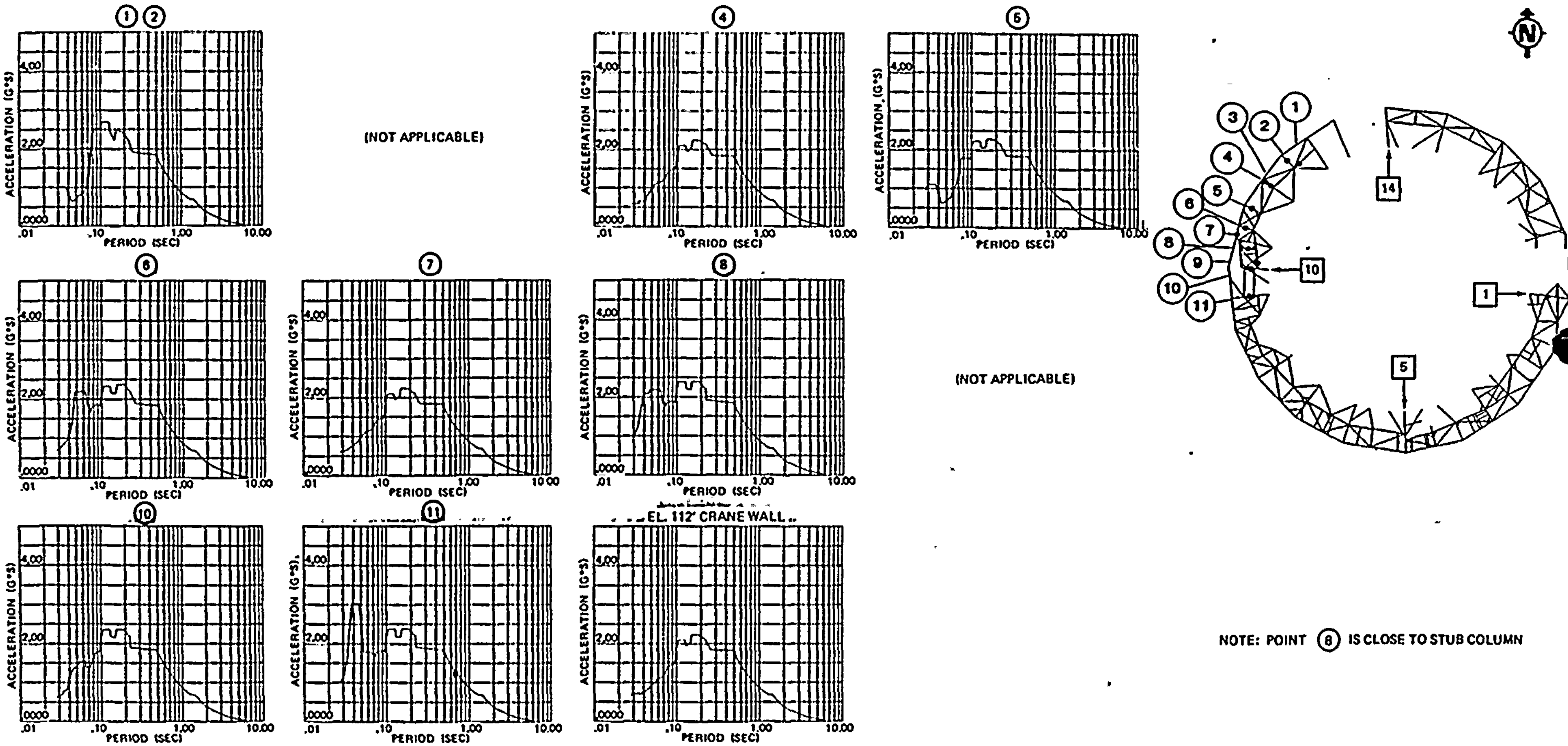
FIGURE 16





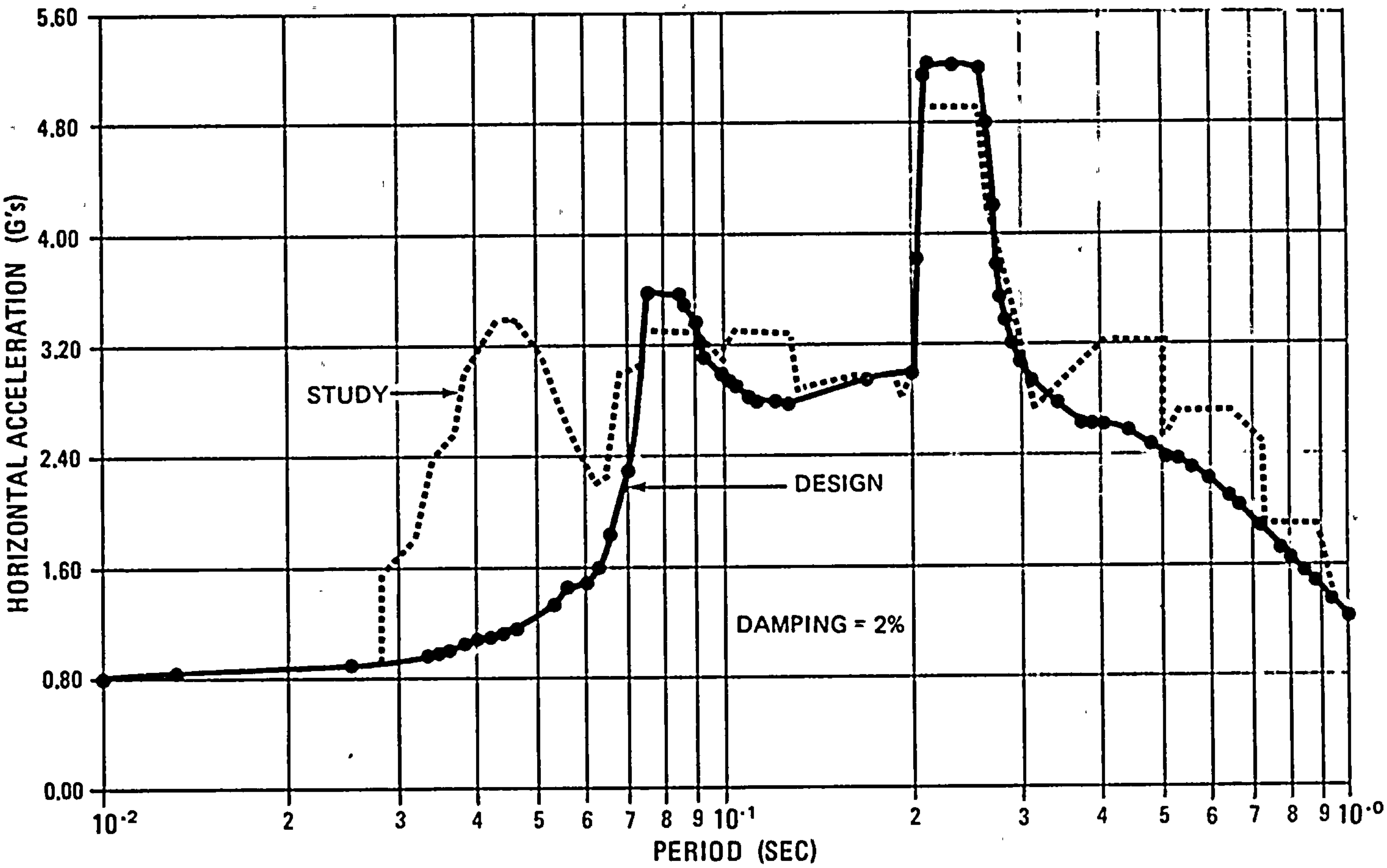
DIABLO CANYON UNIT 1
ANNULUS STRUCTURE ELEVATION 106'
E-W RESPONSE SPECTRA
@ 2% DAMPING
FOR PIPING SEGMENT 4A-111

FIGURE 17



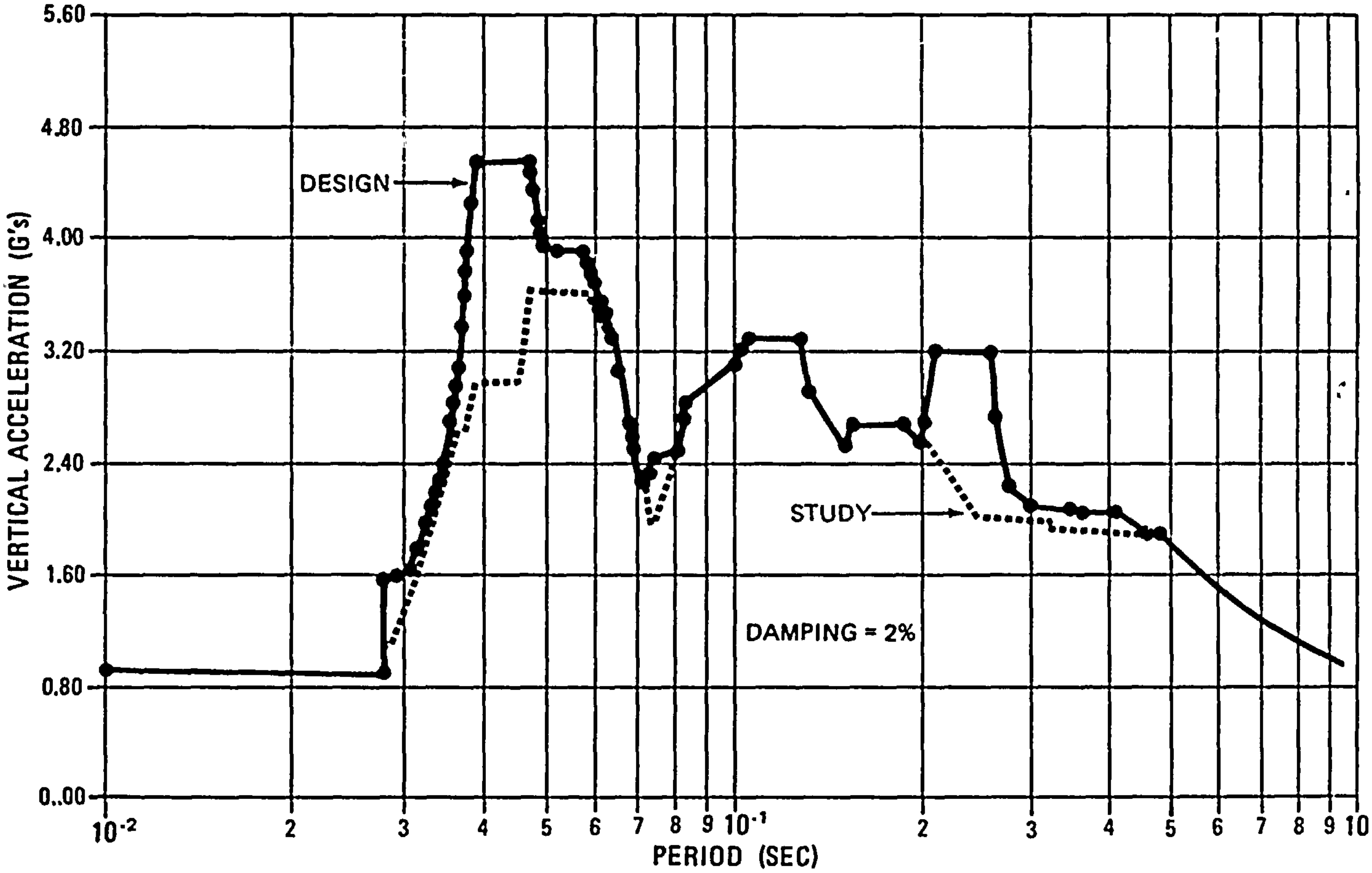
DIABLO CANYON UNIT 1
ANNULUS STRUCTURE ELEVATION 106'
VERTICAL RESPONSE SPECTRA
@ 2% DAMPING
FOR PIPING SEGMENT 4A-111

FIGURE 18



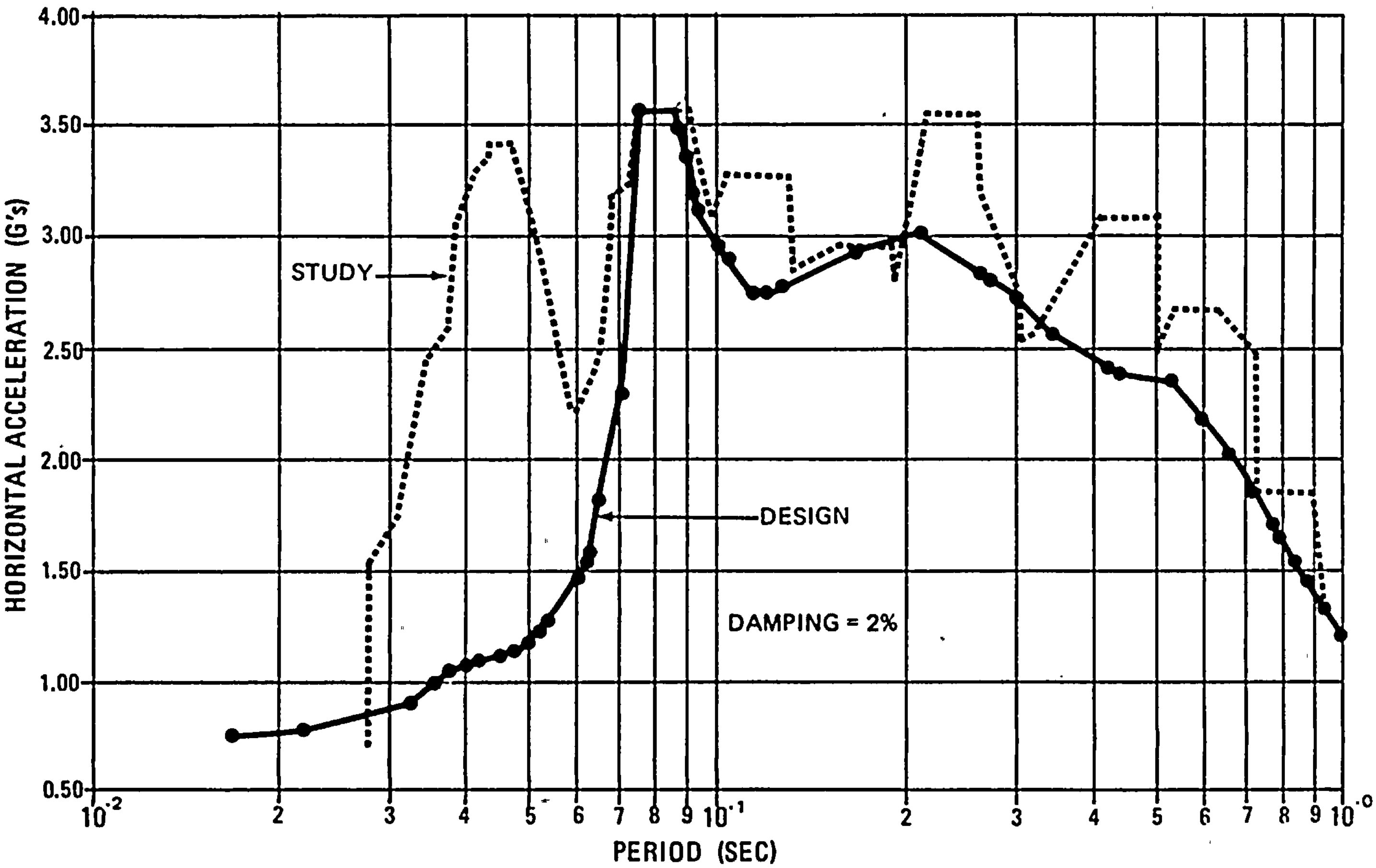
ENVELOPE HORIZONTAL HOSGRI RESPONSE SPECTRA
FOR PIPING SEGMENT 6-101

FIGURE 19



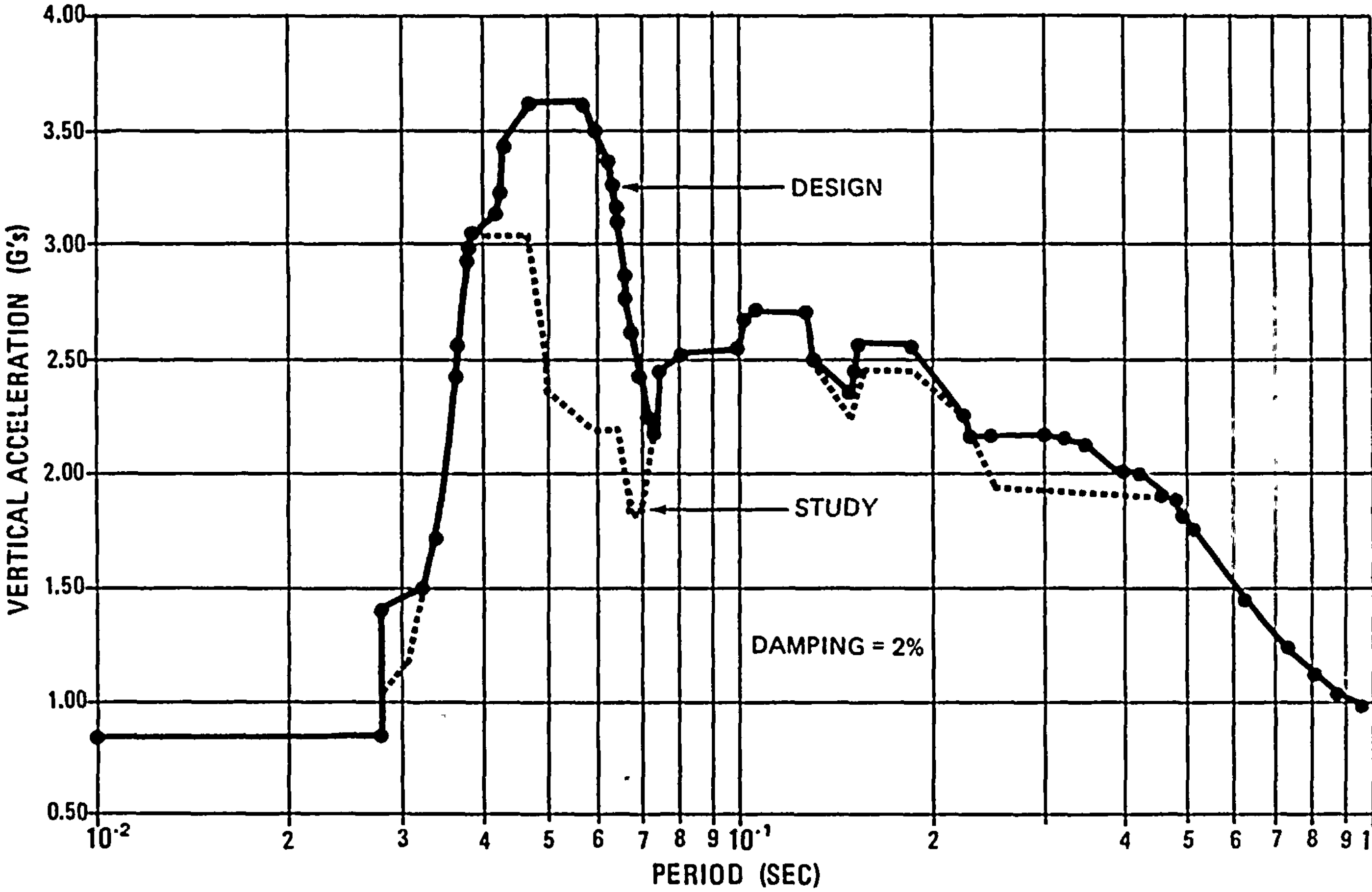
ENVELOPE VERTICAL HOSGRI RESPONSE SPECTRA
FOR PIPING SEGMENT 6-101

FIGURE 20



ENVELOPE HORIZONTAL HOSGRI RESPONSE SPECTRA
FOR PIPING SEGMENT 4A-111

FIGURE 21



ENVELOPE VERTICAL HOSGRI RESPONSE SPECTRA
FOR PIPING SEGMENT 4A-111

FIGURE 22

[illegible]