Attachment 4

Prairie Island Nuclear Generating Plant Earthquake Analysis:

Reactor-Auxiliary-Turbine Building Response Acceleration Spectra

John A. Blume & Associates Report JAB-PS-04

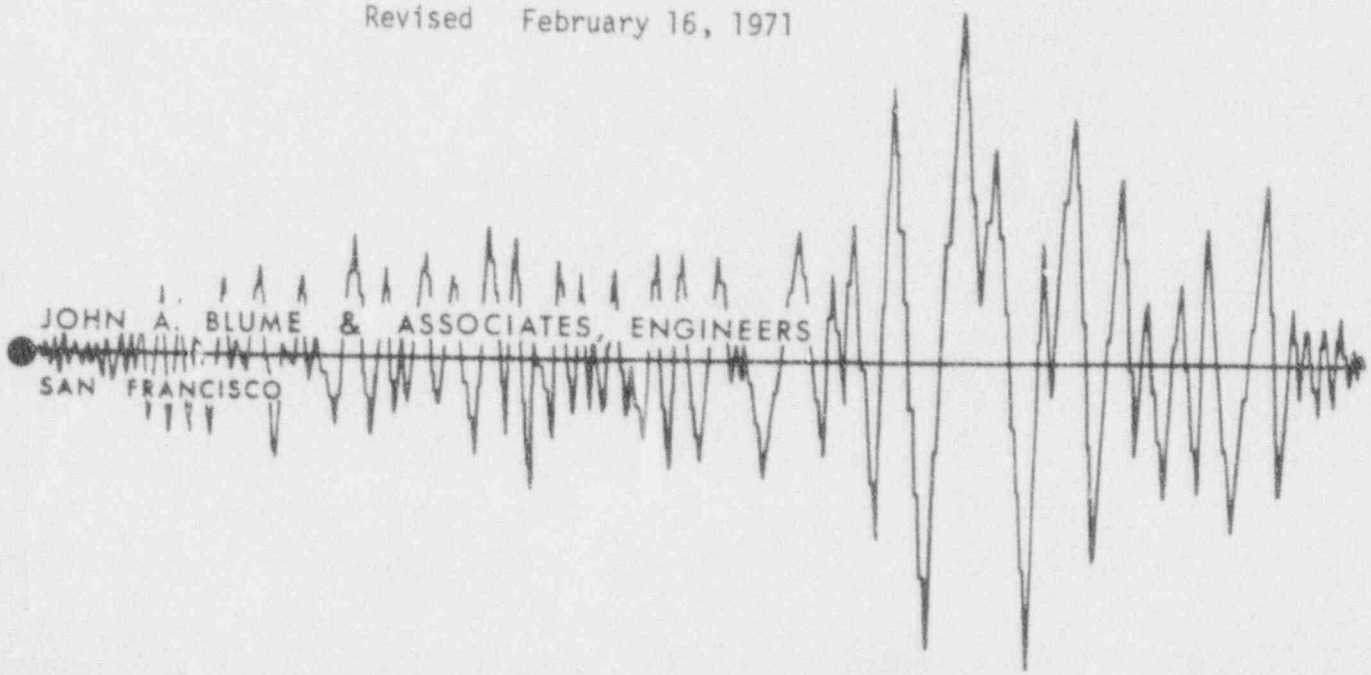
February 16, 1971

Pioneer Service & Engineering Co.

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

Earthquake Analysis:
Reactor-Auxiliary-Turbine Building
Response Acceleration Spectra

Revised February 16, 1971



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1 Spectra for Mass Points 17-19, 17A-19A modified September 16, 1969.

2 Spectra for Screenhouse added December 2, 1969.

3 Spectrum for Mass Points 17, 17A (Damping Ratio = 0.05) added January 2, 1970.

FIGURES

(Follow Tables)

FIGURES

(Continued)

FIGURES

(Continued)

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
EARTHQUAKE ANALYSIS:
REACTOR-AUXILIARY-TURBINE BUILDING
RESPONSE ACCELERATION SPECTRA

INTRODUCTION

This report presents the response acceleration spectra for selected floors of the Auxiliary and Turbine Buildings and selected mass point elevations of the Shield Building, Containment Vessel, and Reactor Support Structure. Also included are spectra for the Screenhouse. The response acceleration spectra are based on the design criteria stated below and on an earlier report on the Prairie Island Plant.[1]*

Horizontal response acceleration spectra for earthquakes acting in north-south and in east-west directions are presented. Vertical response acceleration spectra due to vertical earthquake accelerations are also presented. The spectra for accelerations in the horizontal direction have been developed for damping values of 0.5 percent and 1.0 percent of critical damping, and the spectra for accelerations in the vertical direction have been developed for damping values of 0.5, 1.0, 2.0 and 5.0 percent of critical damping. These response spectra are for use in the seismic analysis and design of critical equipment and piping located at the specified floors and mass point elevations.

The presented spectra can be used directly in the analysis of equipment that can be idealized as single-degree-of-freedom systems; the use of the spectra can be extended to multi-degree-of-freedom systems, such as piping systems, by dynamic analysis techniques.

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* References are listed in Appendix A.

DESIGN CRITERIA

The earthquake ground acceleration time-history developed for this analysis was based on the ground response acceleration spectra presented in Reference 2. The results of the analyses presented in this report are for the Design Earthquake (0.06g). Values for the Maximum Credible Earthquake (0.12g) can be obtained by doubling the presented results.

MATHEMATICAL MODEL

The mathematical model used for determination of response in the horizontal directions has been described in detail earlier[1] and is reproduced in this report in Figures 1, 2, and 3. Mass points and their elevations are shown in Figure 3.

The structure was also modeled for response in the vertical direction. The structures of the Prairie Island Plant have very short periods in the vertical direction. Therefore, the structure was modeled as a single-degree-of-freedom system. The spring in this system represented the vertical deformation of the soil under the structure and the mass was that of the entire structure.

ANALYTICAL PROCEDURE

The mathematical model (Figures 1, 2, and 3) was subjected to the developed ground acceleration time-history acting in the north-south and in the east-west directions, and the time-history of horizontal acceleration at each mass point of the mathematical model was generated. Using the generated acceleration time-histories at selected mass points, the response acceleration spectra for the desired damping values were calculated. The response in the vertical direction was similarly determined using the developed horizontal ground acceleration time-history normalized to 0.04g. The method used to calculate the response

acceleration spectra was based on established methods of response analysis[3] which were modified to permit a computer solution of the calculations.

DISCUSSION OF RESULTS

Horizontal Translational Accelerations

Response acceleration spectra for accelerations in the horizontal direction and for an earthquake in either the north-south or the east-west direction are presented in Figures 4 through 25 and Tables 3 through 24 for the specified mass points and damping ratios. These spectra are for translational accelerations at the centers of mass of the individual structures and must be adjusted for the effects of torsional accelerations as discussed below.

The response acceleration spectra obtained at various points in the structure showed that the response is primarily due to deformation of the foundations and that the responses due to earthquakes acting in the north-south and east-west directions were not significantly different. Therefore, the spectra were combined for the two earthquake directions to facilitate their application in the seismic design and analysis of critical equipment and piping. For example, the spectra shown in Figure 4 can be used for Mass Points 4 and 4A for the earthquake acting in the north-south or east-west direction for damping ratios of 0.005 and 0.010 (0.5% and 1.0% of critical damping, respectively).

Horizontal Torsional Accelerations

Response acceleration spectra for torsional accelerations were also developed. As was the case of the translational accelerations, the spectra for the torsional accelerations showed peaks in the vicinity of the torsional period of vibration of the foundations soils and the spectra were not significantly different for the earthquake in the north-south and east-west directions.

The total acceleration at any point within a structure is the sum of the translational acceleration and the acceleration due to rotation (torsion). The acceleration due to rotation at any point within the structure is obtained by multiplying the rotational (torsional) acceleration at the center of mass by the distance from the center of mass to the given point.

To account for torsional accelerations and, at the same time, to simplify the seismic design and analysis procedures, the factors in Table 1 were developed. The translational accelerations must be multiplied by the factors in Table 1 to determine the total spectral acceleration at the point of support of the equipment or piping. This total acceleration then includes the contribution from both the translational and rotational (torsional) accelerations.

The factors in Table 1 are a function of the natural period of vibration of the item under consideration, the damping ratio applicable to the item, and the distance parameter, R. R is the radial distance in feet (in plan) from the center of mass of the building floor to the point of support of the equipment or piping. The values of these factors can be interpolated linearly for values of R not shown. The locations of centers of mass and rigidity are presented in Table 2.

Vertical Accelerations

Response acceleration spectra for vertical accelerations are presented in Figure 25 and Table 25 for damping ratios of 0.005, 0.010, 0.020, and 0.050. Vertical accelerations are to be assumed to act simultaneously with the horizontal accelerations.

The vertical response acceleration spectra apply only to those items of piping or equipment that are supported on structures of the Reactor-Auxiliary-Turbine Building that have very low periods in the vertical direction. Structures that have these low periods

in the vertical direction are the Shield Building, Containment Vessel, Reactor Support Structure, Turbine Support Structure, and the walls and columns of the Auxiliary and Turbine Buildings. Slabs and beams of the Auxiliary and Turbine Buildings should be analyzed to determine if their periods of vibration in the vertical direction are low. If the periods are not low, the vertical response acceleration spectra may have to be increased to account for the vertical response of the slabs or beams before the vertical spectra are used in the seismic analysis and design of piping or equipment mounted on the slabs and beams.

SUMMARY

The response acceleration spectra are to be used as follows: (1) Determine the floor or mass point elevation at which the equipment or piping in question is located; (2) Compute the period(s) of vibration of the equipment or piping; (3) Select the translational response acceleration from the appropriate spectrum for the desired damping ratio (0.005 for piping and 0.010 for equipment); (4) Increase this translational acceleration to account for torsional accelerations by multiplying the translational accelerations by the factors in Table 1; and (5) Determine the vertical response acceleration from the appropriate spectrum. These final values are the response accelerations which are to be used in the seismic design of the piping or equipment in question. Examples of the application of this procedure is presented in Appendices B and C.

RECOMMENDATIONS

The presented response acceleration spectra show that equipment or piping having periods of vibration in the vicinity of translational, torsional, and vertical periods of vibration of the foundations will have to be designed for high accelerations. If possible, the mass and stiffness characteristics of items having

such periods should be altered to reduce those accelerations. In the use of the presented spectra in the seismic design and analysis of piping and equipment, it should be recognized that it is not always possible to precisely compute the periods of vibration of such items. Therefore, those items having periods that are on the steep slopes of the response spectra should be treated in either of the two following ways. First, modify the stiffness or mass characteristics such that the periods are not in the ranges of the slopes, or, second, use the peak spectral acceleration in the design of the item.

Equipment or piping located at a particular mass point should be designed using the spectra presented for that mass point and for the appropriate damping value. The translational spectral acceleration value should be multiplied by the appropriate factors presented in Table 1 to account for torsional accelerations. Vertical acceleration acting simultaneously with the horizontal acceleration should be used in the design. No increase in the allowable stresses for short term loading is recommended for Class I items.

The results presented in this report are for the Design Earthquake (0.06g). Values for the Maximum Credible Earthquake (0.12g) can be obtained by doubling the presented results.

Spectra for the Screenhouse are presented in Figures 27 and 28 and Tables 26 and 27.

TABLE 1

FACTORS FOR TORSIONAL ACCELERATIONS

Damping Ratio = 0.010 and 0.005

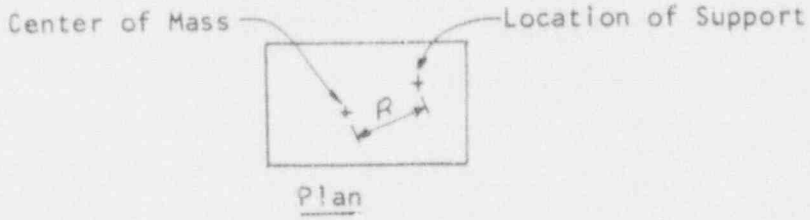
Mass Points	Period Range (seconds)	R = 100' (See Note 1)	R = 50'	R = 25'
4, 4A	0.00 - 0.08	1.08	1.04	1.02
9, 9A	0.09 - 0.12	1.24	1.12	1.06
10, 10A	0.13 - 0.21	1.10	1.05	1.03
	0.22 - 0.27	1.40	1.20	1.10
	0.28 - 0.32	1.10	1.05	1.03
	0.33 - 2.00	1.08	1.04	1.02
6, 6A	0.00 - 0.08	1.10	1.05	1.03
	0.09 - 0.12	1.40	1.20	1.10
	0.13 - 0.22	1.14	1.07	1.04
	0.23 - 0.27	1.36	1.18	1.09
	0.28 - 0.30	1.14	1.07	1.04
	0.31 - 0.36	1.18	1.09	1.05
	0.37 - 2.00	1.08	1.04	1.02
14, 14A	0.00 - 0.08	1.10	1.05	1.03
15, 15A	0.09 - 0.12	1.40	1.20	1.10
	0.13 - 0.22	1.10	1.05	1.03
	0.23 - 0.27	1.36	1.18	1.09
	0.28 - 0.36	1.16	1.08	1.04
	0.37 - 2.00	1.08	1.04	1.02
16-20	0.00 - 0.09	1.08	1.04	1.02
16A-20A	0.10 - 0.13	1.16	1.08	1.04
32, 42	0.14 - 0.20	1.12	1.06	1.03
33, 33A	0.21 - 0.26	1.20	1.10	1.05
	0.27 - 0.46	1.08	1.04	1.02
	0.47 - 0.50	1.16	1.08	1.04
	0.51 - 2.00	1.08	1.04	1.02

Note: Table continued on next page.

TABLE 1 (Cont'd)

Mass Points	Period Range (seconds)	R = 100' (See Note 1)	R = 50'	R = 25'
28, 29	0.00 -0.07	1.20	1.10	1.05
	0.08 -0.14	1.85	1.43	1.21
	0.15 -0.21	1.21	1.11	1.05
	0.22 -0.40	1.12	1.06	1.03
	0.41 -0.52	1.12	1.06	1.03
	0.53 -2.00	1.08	1.04	1.01
30, 24	0.00 -0.04	1.09	1.05	1.02
	0.05 -0.13	1.73	1.37	1.18
	0.14 -0.28	1.42	1.21	1.11
	0.29 -0.40	1.10	1.05	1.03
	0.41 -0.52	1.10	1.05	1.03
	0.53 -2.00	1.08	1.04	1.02
31, 25	0.00 -0.17	1.08	1.04	1.02
	0.18 -0.28	1.37	1.19	1.09
	0.29 -0.42	1.08	1.04	1.02
	0.43 -0.52	1.14	1.07	1.04
	0.53 -2.00	1.08	1.04	1.02
41	0.00 -0.13	1.30	1.15	1.08
	0.14 -0.20	1.10	1.05	1.03
	0.21 -0.30	1.31	1.16	1.08
	0.31 -0.45	1.08	1.04	1.02
	0.46 -0.65	1.12	1.06	1.03
	0.66 -2.00	1.08	1.04	1.02

Note 1. R is the radial distance in feet (in plan) from the center of mass of the building floor to the point of support of equipment or piping (see Sketch).



Plan

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TABLE 2*

SUMMARY OF LOCATIONS OF CENTERS OF MASS AND RIGIDITY

Structure	Mass Point	Center of Mass [1]		Center of Rigidity [1]	
		X	Y	X	Y
Shield Building, Unit 1	1-8	335.5	250.0	335.5	250.0
Shield Building, Unit 2	1A-8A	104.5	250.0	104.5	250.0
Containment Vessel, Unit 1	9-16	335.5	250.0	335.5	250.0
Containment Vessel, Unit 2	9A-16A	104.5	250.0	104.5	250.0
Reactor Support Structure, Unit 1	17-19	335.5	250.0	335.5	250.0
Reactor Support Structure, Unit 2	17A-19A	104.5	250.0	104.5	250.0
Reactor Building Foundation, Unit 1	20	335.5	250.0	---	---
Reactor Building Foundation, Unit 2	20A	104.5	250.0	---	---
Auxiliary Building Roof, South Part	21	220.0	303.2	220.0	345.0
Fuel Tank Area	22	220.0	288.0	220.0	288.0
	23	220.0	288.0	220.0	288.0
	24	220.0	285.0	220.0	285.0
	25	220.0	285.0	220.0	285.0
Auxiliary Building Roof, North Part	26	220.0	219.8	220.0	178.0

Note: Table continued on next page.

*Reprint of Table 4 from Reference 1

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TABLE 2*

SUMMARY OF LOCATIONS OF CENTERS OF MASS AND RIGIDITY

(Continued)

Structure	Mass Point	Center of Mass[1]		Center of Rigidity[1]	
		X	Y	X	Y
Auxiliary Building	27	220.0	93.8	221.9	126.0
	28	220.0	167.8	220.0	144.9
	29	227.9	174.4	221.9	157.9
	30	229.7	163.0	251.7	168.4
	31	238.8	169.5	239.8	139.5
Auxiliary Building - Fuel Tank Area Foundation	32	231.3	148.8	---	---
Turbine Support, Unit 1	33-35	330.5	61.5	330.5	61.5
Turbine Support, Unit 2	33A-35A	109.5	61.5	109.5	61.5
Turbine Support Foundation, Unit 1	36	330.5	61.5	---	---
Turbine Support Foundation, Unit 2	36A	109.5	61.5	---	---
Turbine Building	37	220.0	28.0	220.0	0.0
	38	220.0	0.0	220.0	0.0
	39	220.0	0.0	220.0	0.0
	40	220.0	15.9	220.0	0.0
	41	220.0	15.7	220.0	0.0
Turbine Building Foundation	42	220.0	10.0	---	---
Entire Structure, base rotation about a vertical axis	--	223.8	190.4	---	---

1) Measured in feet from the intersection of column lines A and 17. The plus-x direction is east of column line 17 and the plus-y direction is south of column line A.

*Reprint of Table 4 from Reference 1

TABLE 3

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 4, 4A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.145	0.145	0.575	1.040	0.840
0.025	0.155	0.155	0.600	0.920	0.760
0.050	0.165	0.165	0.625	0.600	0.520
0.075	0.172	0.172	0.650	0.460	0.420
0.100	0.180	0.180	0.675	0.400	0.360
0.125	0.190	0.190	0.700	0.330	0.310
0.150	0.200	0.195	0.725	0.290	0.280
0.175	0.213	0.205	0.750	0.255	0.255
0.200	0.230	0.220	0.775	0.235	0.235
0.225	0.255	0.240	0.800	0.215	0.215
0.250	0.300	0.275	0.825	0.200	0.200
0.275	0.360	0.320	0.850	0.185	0.185
0.300	0.480	0.400	0.875	0.173	0.173
0.325	0.920	0.600	0.900	0.165	0.165
0.350	1.480	1.080	0.925	0.160	0.160
0.375	1.350	1.510	0.950	0.156	0.156
0.400	2.000	1.570	0.975	0.153	0.153
0.425	2.150	1.585	1.000	0.150	0.150
0.450	2.150	1.580	1.250	0.120	0.120
0.475	2.000	1.565	1.500	0.100	0.100
0.500	1.960	1.480	1.750	0.070	0.070
0.525	1.400	0.960	2.000	0.040	0.040
0.550	1.100	0.890			

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TABLE 4

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 6, 6A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010
0.000	0.080	0.080
0.025	0.085	0.085
0.050	0.093	0.090
0.075	0.105	0.095
0.100	0.112	0.100
0.125	0.115	0.102
0.150	0.120	0.105
0.175	0.130	0.120
0.200	0.165	0.145
0.225	0.220	0.180
0.250	0.290	0.235
0.275	0.340	0.280
0.300	0.375	0.315
0.325	0.390	0.325
0.350	0.400	0.335
0.375	0.440	0.360
0.400	0.480	0.400
0.425	0.560	0.480
0.450	0.710	0.560
0.475	0.920	0.720
0.490	0.940	0.765
0.500	0.930	0.760
0.525	0.850	0.700
0.550	0.700	0.615
0.575	0.640	0.560
0.600	0.560	0.440
0.625	0.400	0.360
0.650	0.340	0.300
0.675	0.300	0.260
0.700	0.250	0.230
0.725	0.220	0.200
0.750	0.185	0.180
0.775	0.160	0.160
0.800	0.145	0.145
0.825	0.135	0.135
0.850	0.121	0.121
0.875	0.120	0.120
0.900	0.120	0.120
0.925	0.120	0.120
0.950	0.119	0.119
0.975	0.118	0.118
1.000	0.117	0.117
1.250	0.095	0.095
1.500	0.080	0.080
1.750	0.060	0.060
2.000	0.040	0.040

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TABLE 5

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 9, 9A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.180	0.180	0.525	1.760	1.320
0.025	0.190	0.190	0.550	1.170	0.980
0.050	0.200	0.200	0.575	1.120	0.920
0.075	0.215	0.215	0.600	1.000	0.840
0.100	0.240	0.235	0.625	0.640	0.560
0.125	0.275	0.260	0.650	0.520	0.480
0.138	0.300	0.280	0.675	0.440	0.410
0.150	0.340	0.310	0.700	0.390	0 360
0.168	0.335	0.305	0.725	0.340	0.320
0.175	0.295	0.270	0.750	0.300	0.290
0.188	0.280	0.265	0.775	0.270	0.260
0.200	0.290	0.270	0.800	0.245	0.240
0.225	0.320	0.300	0.825	0.225	0.225
0.250	0.400	0.360	0.850	0.210	0.210
0.275	0.530	0.480	0.875	0.190	0.190
0.300	0.720	0.630	0.900	0.180	0.180
0.325	1.160	0.880	0.925	0.175	0.175
0.350	2.200	1.600	0.950	0.172	0.172
0.363	0.440	1.960	0.975	0.169	0.169
0.375	2.470	2.000	1.000	0.165	0.165
0.400	2.485	2.040	1.250	0.140	0.140
0.425	2.490	2.050	1.500	0.110	0.110
0.450	2.488	2.050	1.750	0.080	0.080
0.475	2.480	2.040	2.000	0.055	0.055
0.500	2.420	2.000			

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TABLE 6

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 10, 10A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.150	0.150	0.500	2.080	1.720
0.025	0.160	0.160	0.525	1.080	0.960
0.050	0.170	0.170	0.550	1.015	0.880
0.075	0.190	0.180	0.575	0.970	0.830
0.100	0.215	0.200	0.600	0.800	0.640
0.125	0.240	0.230	0.625	0.520	0.480
0.138	0.280	0.255	0.650	0.440	0.400
0.150	0.315	0.270	0.675	0.380	0.350
0.163	0.300	0.260	0.700	0.320	0.310
0.175	0.260	0.240	0.725	0.280	0.280
0.188	0.240	0.235	0.750	0.245	0.245
0 200	0.245	0.240	0.775	0.225	0.225
0.225	0.275	0.255	0.800	0.212	0.212
0.250	0.320	0.300	0.825	0.205	0.205
0.275	0.400	0.365	0.850	0.190	0.190
0.300	0.520	0.460	0.875	0.180	0.180
0.325	0.800	0.640	0.900	0.172	0.172
0.350	1.720	1.400	0.925	0.168	0.168
0.363	2.040	1.640	0.950	0.163	0.163
0.375	2.090	1.740	0.975	0.161	0.161
0.400	2.140	1.785	1.000	0.160	0.160
0.425	2.150	1.800	1.250	0.130	0.130
0.450	2.140	1.790	1.500	0.100	0.100
0.475	2.125	1.770	1.750	0.070	0.070
			2.000	0.040	0.040

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TABLE 7

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 14, 14A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.070	0.070	0.575	0.540	0.440
0.025	0.070	0.070	0.600	0.440	0.380
0.050	0.075	0.075	0.625	0.380	0.320
0.075	0.080	0.080	0.650	0.320	0.280
0.100	0.085	0.085	0.675	0.280	0.240
0.125	0.100	0.095	0.700	0.240	0.200
0.150	0.120	0.105	0.725	0.205	0.175
0.175	0.150	0.125	0.750	0.180	0.160
0.200	0.200	0.165	0.775	0.165	0.150
0.225	0.260	0.215	0.800	0.146	0.146
0.250	0.345	0.300	0.825	0.143	0.143
0.275	0.440	0.375	0.850	0.140	0.140
0.300	0.540	0.440	0.875	0.136	0.136
0.325	0.575	0.485	0.900	0.133	0.133
0.350	0.560	0.480	0.925	0.130	0.130
0.375	0.450	0.400	0.950	0.127	0.127
0.400	0.335	0.300	0.975	0.124	0.124
0.425	0.350	0.320	1.000	0.121	0.121
0.450	0.480	0.420	1.250	0.100	0.100
0.475	0.840	0.640	1.500	0.080	0.080
0.500	0.880	0.660	0.750	0.060	0.060
0.525	0.840	0.590	2.000	0.040	0.040
0.550	0.660	0.520			

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TABLE 8

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 15, 15A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.060	0.060	0.550	0.520	0.420
0.025	0.065	0.065	0.575	0.450	0.360
0.050	0.070	0.070	0.600	0.400	0.320
0.075	0.080	0.080	0.625	0.340	0.270
0.100	0.085	0.085	0.650	0.290	0.240
0.125	0.095	0.095	0.675	0.250	0.210
0.150	0.105	0.105	0.700	0.220	0.180
0.175	0.140	0.130	0.725	0.200	0.160
0.200	0.185	0.170	0.750	0.180	0.155
0.225	0.270	0.240	0.775	0.165	0.148
0.250	0.400	0.340	0.800	0.155	0.140
0.275	0.560	0.440	0.825	0.145	0.137
0.300	0.720	0.600	0.850	0.140	0.134
0.325	0.840	0.660	0.875	0.131	0.131
0.338	0.880	0.700	0.900	0.128	0.128
0.350	0.885	0.705	0.925	0.126	0.126
0.363	0.880	0.700	0.950	0.124	0.124
0.375	0.800	0.630	0.975	0.122	0.122
0.400	0.440	0.380	1.000	0.120	0.120
0.425	0.420	0.360	1.250	0.100	0.100
0.450	0.480	0.390	1.500	0.080	0.080
0.475	0.580	0.500	1.750	0.060	0.060
0.500	0.615	0.520	2.000	0.040	0.040
0.525	0.570	0.480			

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TABLE 9

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 16, 16A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.060	0.060	0.550	0.420	0.325
0.025	0.070	0.060	0.575	0.380	0.295
0.050	0.085	0.067	0.600	0.340	0.270
0.075	0.095	0.075	0.625	0.300	0.250
0.100	0.105	0.090	0.650	0.252	0.230
0.125	0.115	0.105	0.675	0.230	0.210
0.150	0.130	0.125	0.700	0.210	0.195
0.175	0.160	0.155	0.725	0.190	0.180
0.200	0.220	0.220	0.750	0.175	0.165
0.225	0.340	0.300	0.775	0.165	0.150
0.250	0.490	0.410	0.800	0.148	0.140
0.275	0.650	0.560	0.825	0.142	0.131
0.300	0.880	0.735	0.850	0.136	0.122
0.325	1.170	0.950	0.875	0.131	0.116
0.338	1.400	1.030	0.900	0.126	0.112
0.350	1.440	1.045	0.925	0.121	0.109
0.368	1.435	1.040	0.950	0.117	0.107
0.375	1.350	1.000	0.975	0.113	0.105
0.400	0.970	0.720	1.000	0.110	0.103
0.425	0.800	0.580	1.250	0.100	0.100
0.450	0.680	0.500	1.500	0.080	0.080
0.475	0.600	0.440	1.750	0.060	0.060
0.500	0.530	0.395	2.000	0.040	0.040
0.525	0.470	0.350			

TABLE 10

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 17, 17A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.150	0.120	0.500	0.650	0.550
0.025	0.180	0.150	0.525	0.510	0.450
0.038	0.225	0.180	0.550	0.420	0.380
0.050	0.450	0.300	0.575	0.380	0.320
0.063	0.630	0.540	0.600	0.340	0.280
0.075	0.640	0.550	0.625	0.300	0.255
0.088	0.630	0.540	0.650	0.270	0.230
0.100	0.450	0.400	0.675	0.230	0.210
0.113	0.270	0.220	0.700	0.210	0.195
0.125	0.250	0.210	0.725	0.190	0.180
0.150	0.270	0.250	0.750	0.175	0.165
0.175	0.400	0.350	0.775	0.165	0.150
0.200	0.600	0.450	0.800	0.150	0.145
0.225	0.850	0.650	0.825	0.147	0.147
0.250	1.150	0.900	0.850	0.143	0.143
0.275	1.600	1.280	0.875	0.132	0.132
0.300	2.050	1.700	0.900	0.127	0.127
0.325	2.600	2.220	0.925	0.125	0.125
0.338	2.775	2.250	0.950	0.118	0.107
0.350	2.790	2.265	0.975	0.113	0.113
0.363	2.790	2.255	1.000	0.110	0.110
0.375	2.770	2.240	1.250	0.100	0.100
0.400	2.300	1.850	1.500	0.080	0.080
0.425	1.750	1.400	1.750	0.060	0.060
0.450	1.290	0.900	2.000	0.040	0.040
0.475	0.850	0.670			

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TABLE 10A

RESPONSE ACCELERATION SPECTRA TABULATION
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION
MASS POINT 17, 17A
DAMPING RATIO = 0.05

PERIOD SEC.	SPECTRAL ACCEL G UNITS	PERIOD SEC.	SPECTRAL ACCEL G UNITS
0.000	0.150	0.550	0.250
0.025	0.160	0.575	0.230
0.050	0.190	0.600	0.205
0.063	0.235	0.625	0.190
0.075	0.340	0.650	0.170
0.088	0.375	0.675	0.160
0.100	0.340	0.700	0.150
0.125	0.215	0.725	0.135
0.150	0.220	0.750	0.130
0.175	0.240	0.775	0.120
0.200	0.280	0.800	0.110
0.225	0.380	0.825	0.105
0.250	0.490	0.850	0.100
0.262	0.545	0.875	0.095
0.275	0.630	0.900	0.090
0.288	0.730	0.923	0.085
0.300	0.840	0.950	0.082
0.312	0.880	0.975	0.080
0.325	0.888	1.000	0.075
0.350	0.892	1.100	0.065
0.375	0.888	1.200	0.060
0.388	0.838	1.300	0.058
0.400	0.860	1.400	0.050
0.412	0.700	1.500	0.045
0.425	0.625	1.600	0.043
0.450	0.500	1.700	0.042
0.475	0.400	1.800	0.041
0.500	0.330	1.900	0.041
0.525	0.285	2.000	0.041

TABLE 11

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 18, 18A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.100	0.100	0.525	0.470	0.390
0.025	0.150	0.130	0.550	0.420	0.330
0.050	0.250	0.020	0.575	0.380	0.295
0.063	0.460	0.400	0.600	0.340	0.270
0.075	0.480	0.410	0.625	0.300	0.250
0.088	0.460	0.400	0.650	0.260	[illegible]
0.100	0.250	0.200	0.675	0.230	[illegible]
0.113	0.190	0.180	0.700	0.210	[illegible]
0.125	0.180	0.179	0.725	0.190	0.180
0.150	0.220	0.200	0.750	0.175	0.162
0.175	0.280	0.260	0.775	0.165	0.150
0.200	0.450	0.360	0.800	0.150	0.147
0.225	0.650	0.500	0.825	0.147	0.145
0.250	0.900	0.700	0.850	0.143	0.143
0.275	1.200	0.950	0.875	0.132	0.132
0.300	1.600	1.300	0.900	0.127	0.127
0.325	2.100	1.200	0.925	0.125	0.125
0.338	2.370	1.820	0.950	0.118	0.118
0.350	2.390	1.840	0.975	0.113	0.113
0.363	2.385	1.840	1.000	0.110	0.110
0.375	2.350	1.820	1.250	0.100	0.100
0.400	1.850	1.400	1.500	0.080	0.080
0.425	1.300	0.960	1.750	0.060	0.060
0.450	0.850	0.700	2.000	0.040	0.040
0.475	0.640	0.550			
0.500	0.540	0.450			

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TABLE 12

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 19, 19A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.070	0.070	0.525	0.470	0.350
0.025	0.110	0.100	0.550	0.420	0.325
0.050	0.180	0.150	0.575	0.380	0.295
0.615	0.260	0.240	0.600	0.340	0.270
0.075	0.290	0.260	0.625	0.300	0.250
0.088	0.260	0.240	0.650	0.270	0.230
0.100	0.180	0.150	0.675	0.230	0.210
0.125	0.155	0.130	0.700	0.210	0.195
0.150	0.180	0.150	0.725	0.190	0.180
0.175	0.220	0 200	0.750	0.175	0.165
0.200	0.300	0.220	0.775	0.165	0.150
0.225	0.470	0.380	0.800	0.150	0.145
0.250	0.670	0.530	0.825	0.147	0.145
0.275	0.915	0.730	0.850	0.143	0.143
0.300	1.250	1.000	0.875	0.132	0.320
0.325	1.650	1.300	0.900	0.127	0.127
0.338	1.870	1.450	0.925	0.125	0.125
0.350	1.900	1.470	0.950	0.113	0.113
0.363	1.903	1.475	0.975	0.111	0.111
0.375	1.890	1.460	1.000	0.110	0.110
0.400	1.300	1.050	1.250	0.100	0.100
0.425	0.870	0.700	1.500	0.080	0.080
0.450	0.680	0.550	1.750	0.060	0.060
0.475	0.600	0.440	2.000	0.040	0.040
0.500	0.530	0.395			

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TABLE 13

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S DIRECTION

MASS POINT 21

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.200	0.200	0.750	0.190	0.190
0.025	0.202	0.202	0.775	0.180	0.180
0.050	0.205	0.205	0.800	0.170	0.170
0.075	0.215	0.215	0.850	0.155	0.155
0.100	0.230	0.230	0.900	0.140	0.140
0.125	0.260	0.260	1.000	0.125	0.125
0.150	0.300	0.300	1.250	0.110	0.110
0.175	0.340	0.340	1.500	0.105	0.105
0.200	0.400	0.400	1.750	0.100	0.100
0.225	0.600	0.600	2.000	0.095	0.095
0.238	0.750	0.750			
0.250	0.800	0.800			
0.275	1.200	1.200			
0.300	2.400	2.400			
0.325	3.500	2.700			
0.338	3.580	2.750			
0.350	3.600	2.790			
0.363	3.595	2.795			
0.375	3.550	2.745			
0.388	3.450	2.660			
0.400	3.200	2.500			
0.413	2.200	2.200			
0.425	1.200	1.200			
0.450	0.800	0.800			
0.475	0.615	0.615			
0.500	0.505	0.505			
0.525	0.430	0.430			
0.550	0.395	0.395			
0.575	0.330	0.330			
0.600	0.305	0.305			
0.625	0.280	0.280			
0.650	0.245	0.245			
0.675	0.220	0.220			
0.700	0.205	0.205			
0.725	0.200	0.200			

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TABLE 14

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN E-W DIRECTION

MASS POINT 21

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010
0.000	0.280	0.280
0.025	0.295	0.295
0.050	0.315	0.315
0.075	0.335	0.335
0.100	0.350	0.350
0.125	0.370	0.370
0.150	0.390	0.390
0.175	0.410	0.410
0.200	0.440	0.440
0.225	0.500	0.500
0.250	0.800	0.800
0.275	0.900	0.900
0.300	1.000	1.000
0.313	1.200	1.200
0.325	2.000	2.000
0.338	3.300	3.300
0.350	4.400	3.600
0.363	4.450	3.670
0.375	4.460	3.700
0.386	4.440	3.690
0.400	4.400	3.640
0.413	3.500	3.500
0.425	2.500	2.500
0.450	1.500	1.500
0.475	1.120	1.120
0.500	0.910	0.910
0.525	0.795	0.795
0.550	0.690	0.690
0.575	0.600	0.600
0.600	0.520	0.520
0.625	0.450	0.450
0.650	0.395	0.395
0.675	0.340	0.340
0.700	0.300	0.300
0.725	0.260	0.260
0.750	0.220	0.220
0.775	0.200	0.200
0.800	0.190	0.190
0.850	0.187	0.187
0.900	0.180	0.180
0.950	0.170	0.170
1.000	0.160	0.160
1.250	0.130	0.130
1.500	0.105	0.105
1.750	0.075	0.075
2.000	0.050	0.050

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TABLE 15

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 24

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.070	0.070	0.550	0.440	0.355
0.025	0.080	0.080	0.575	0.400	0.320
0.050	0.100	0.095	0.600	0.350	0.285
0.075	0.130	0.110	0.625	0.295	0.255
0.100	0.150	0.135	0.650	0.260	0.220
0.125	0.165	0.140	0.675	0.230	0.200
0.150	0.170	0.145	0.700	0.200	0.120
0.175	0.180	0.150	0.725	0.175	0.160
0.200	0.205	0.165	0.750	0.160	0.155
0.225	0.320	0.240	0.775	0.150	0.150
0.250	0.560	0.440	0.800	0.147	0.147
0.275	0.680	0.560	0.825	0.144	0.144
0.300	0.800	0.650	0.850	0.141	0.141
0.313	0.840	0.700	0.875	0.139	0.139
0.325	1.200	0.900	0.900	0.136	0.136
0.338	1.600	1.220	0.925	0.133	0.133
0.350	1.625	1.250	0.950	0.130	0.130
0.375	1.635	1.250	0.975	0.128	0.128
0.400	1.590	1.235	1.000	0.125	0.125
0.413	0.900	0.900	1.250	0.107	0.107
0.425	0.640	0.600	1.500	0.085	0.085
0.450	0.580	0.510	1.750	0.062	0.062
0.475	0.540	0.450	2.000	0.040	0.040
0.500	0.500	0.400			
0.525	0.420	0.375			

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TABLE 15

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 25

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.060	0.060	0.550	0.410	0.370
0.025	0.070	0.070	0.575	0.385	0.345
0.050	0.080	0.080	0.600	0.345	0.285
0.075	0.090	0.090	0.625	0.310	0.250
0.100	0.100	0.100	0.650	0.240	0.220
0.125	0.120	0.110	0.675	0.200	0.200
0.150	0.135	0.125	0.700	0.175	0.175
0.175	0.150	0.140	0.725	0.165	0.165
0.200	0.180	0.160	0.750	0.160	0.160
0.225	0.240	0.210	0.775	0.156	0.156
0.250	0.400	0.340	0.800	0.152	0.152
0.275	0.600	0.500	0.825	0.149	0.149
0.300	0.820	0.660	0.850	0.146	0.146
0.325	0.920	0.790	0.875	0.142	0.142
0.338	1.480	1.080	0.900	0.139	0.139
0.350	1.520	1.170	0.925	0.135	0.136
0.375	1.520	1.180	0.950	0.134	0.134
0.400	1.500	1.160	0.975	0.132	0.132
0.425	0.600	0.560	1.000	0.130	0.130
0.450	0.500	0.460	1.250	0.107	0.107
0.475	0.460	0.415	1.500	0.085	0.085
0.500	0.435	0.385	1.750	0.062	0.062
0.525	0.410	0.370	2.000	0.040	0.040

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TABLE 17

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 28

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.080	0.080	0.500	0.600	0.520
0.025	0.090	0.090	0.525	0.540	0.470
0.050	0.115	0.110	0.550	0.480	0.415
0.075	0.180	0.160	0.575	0.430	0.370
0.088	0.265	0.230	0.600	0.370	0.325
0.100	0.255	0.220	0.625	0.320	0.280
0.125	0.185	0.175	0.650	0.270	0.250
0.150	0.180	0.170	0.675	0.235	0.220
0.175	0.195	0.180	0.700	0.205	0.195
0.200	0.230	0.200	0.725	0.185	0.180
0.225	0.300	0.300	0.750	0.170	0.170
0.238	0.710	0.710	0.775	0.160	0.160
0.250	0.900	0.740	0.800	0.155	0.155
0.275	0.970	0.780	0.825	0.150	0.150
0.300	1.000	0.830	0.850	0.146	0.146
0.313	1.040	0.900	0.875	0.142	0.142
0.325	1.600	1.200	0.900	0.139	0.139
0.338	1.980	1.560	0.925	0.136	0.136
0.350	2.030	1.595	0.950	0.134	0.134
0.375	2.050	1.605	0.975	0.132	0.132
0.400	2.035	1.580	1.000	0.130	0.130
0.413	2.000	1.200	1.250	0.107	0.107
0.425	1.360	0.760	1.500	0.085	0.085
0.438	0.820	0.720	1.750	0.062	0.062
0.450	0.760	0.640	2.000	0.040	0.040
0.475	0.670	0.575			

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TABLE 18

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 29

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.070	0.070	0.525	0.520	0.445
0.025	0.080	0.080	0.550	0.475	0.400
0.050	0.095	0.095	0.575	0.415	0.360
0.075	0.135	0.120	0.600	0.365	0.320
0.088	0.200	0.175	0.625	0.310	0.280
0.100	0.220	0.180	0.650	0.260	0.250
0.125	0.180	0.160	0.675	0.230	0.220
0.150	0.170	0.160	0.700	0.200	0.190
0.175	0.175	0.165	0.725	0.175	0.170
0.200	0.200	0.185	0.750	0.160	0.160
0.225	0.250	0.250	0.775	0.157	0.157
0.238	0.520	0.520	0.800	0.154	0.154
0.250	0.700	0.580	0.825	0.151	0.151
0.275	0.760	0.640	0.850	0.148	0.148
0.300	0.800	0.700	0.875	0.145	0.145
0.313	0.840	0.760	0.900	0.142	0.142
0.325	1.160	1.000	0.925	0.139	0.139
0.338	1.560	1.360	0.950	0.136	0.136
0.350	1.880	1.440	0.975	0.133	0.133
0.375	1.895	1.455	1.000	0.130	0.130
0.400	1.875	1.440	1.250	0.107	0.107
0.425	0.920	0.720	1.500	0.085	0.085
0.450	0.690	0.600	1.750	0.062	0.062
0.475	0.620	0.535	2.000	0.040	0.040
0.500	0.570	0.490			

March 14, 1969

TABLE 19

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 30

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.061	0.061	0.550	0.440	0.355
0.025	0.080	0.080	0.575	0.400	0.320
0.050	0.100	0.095	0.600	0.350	0.285
0.075	0.130	0.110	0.625	0.295	0.255
0.100	0.150	0.135	0.650	0.260	0.220
0.125	0.165	0.140	0.675	0.230	0.200
0.150	0.170	0.145	0.700	0.200	0.120
0.175	0.180	0.150	0.725	0.175	0.160
0.200	0.205	0.165	0.750	0.160	0.155
0.225	0.320	0.240	0.775	0.150	0.150
0.250	0.560	0.440	0.800	0.147	0.147
0.275	0.680	0.560	0.825	0.144	0.144
0.300	0.800	0.650	0.850	0.141	0.141
0.313	0.840	0.700	0.875	0.139	0.139
0.325	1.200	0.900	0.900	0.136	0.136
0.338	1.600	1.220	0.925	0.133	0.133
0.350	1.625	1.250	0.950	0.130	0.130
0.375	1.635	1.250	0.975	0.128	0.128
0.400	1.590	1.235	1.000	0.125	0.125
0.413	0.900	0.900	1.250	0.107	0.107
0.425	0.640	0.600	1.500	0.085	0.085
0.450	0.580	0.510	1.750	0.062	0.062
0.475	0.540	0.450	2.000	0.040	0.040
0.500	0.500	0.400			
0.525	0.420	0.375			

March 14, 1969

TABLE 20

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 31

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.060	0.060	0.550	0.410	0.370
0.025	0.070	0.070	0.575	0.365	0.345
0.050	0.080	0.080	0.600	0.345	0.285
0.075	0.090	0.090	0.625	0.310	0.250
0.100	0.100	0.100	0.650	0.240	0.220
0.125	0.120	0.110	0.675	0.200	0.200
0.150	0.135	0.125	0.700	0.175	0.175
0.175	0.150	0.140	0.725	0.165	0.165
0.200	0.180	0.160	0.750	0.160	0.160
0.225	0.240	0.210	0.775	0.156	0.156
0.250	0.400	0.340	0.800	0.152	0.152
0.275	0.600	0.500	0.825	0.149	0.149
0.300	0.820	0.660	0.850	0.146	0.146
0.325	0.920	0.790	0.875	0.142	0.142
0.338	1.480	1.080	0.900	0.139	0.139
0.350	1.520	1.170	0.925	0.136	0.136
0.375	1.520	1.180	0.950	0.134	0.134
0.400	1.500	1.160	0.975	0.132	0.132
0.425	0.600	0.560	1.000	0.130	0.130
0.450	0.500	0.460	1.250	0.107	0.107
0.475	0.460	0.415	1.500	0.085	0.085
0.500	0.435	0.385	1.750	0.062	0.062
0.525	0.410	0.370	2.000	0.040	0.040

March 14, 1969

TABLE 21

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S DIRECTION

MASS POINT 33, 33A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.110	0.110	0.625	0.225	0.200
0.025	0.130	0.130	0.650	0.195	0.175
0.050	0.150	0.150	0.675	0.170	0.160
0.075	0.180	0.180	0.700	0.155	0.150
0.100	0.220	0.210	0.725	0.145	0.145
0.125	0.300	0.270	0.750	0.142	0.142
0.150	0.620	0.530	0.775	0.140	0.140
0.163	0.680	0.550	0.800	0.138	0.138
0.175	0.500	0.370	0.825	0.135	0.135
0.200	0.330	0.270	0.850	0.133	0.133
0.225	0.350	0.300	0.875	0.130	0.130
0.250	0.500	0.450	0.900	0.128	0.128
0.275	0.600	0.550	0.925	0.126	0.126
0.300	0.800	0.700	0.950	0.124	0.124
0.325	1.450	1.300	0.975	0.122	0.122
0.350	2.050	1.725	1.000	0.120	0.120
0.363	2.075	1.700	1.250	0.100	0.100
0.375	1.600	1.250	1.500	0.074	0.074
0.400	1.100	0.900	1.750	0.053	0.053
0.425	0.850	0.650	2.000	0.033	0.033
0.450	0.630	0.540			
0.475	0.550	0.450			
0.500	0.460	0.380			
0.525	0.400	0.330			
0.550	0.350	0.295			
0.575	0.300	0.255			
0.600	0.260	0.225			

March 14, 1969

TABLE 22

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN E-W DIRECTION

MASS POINT 33, 33A

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.120	0.120	0.625	0.180	0.170
0.025	0.120	0.120	0.650	0.170	0.150
0.050	0.150	0.150	0.675	0.155	0.145
0.075	0.210	0.210	0.700	0.145	0.140
0.088	0.350	0.350	0.725	0.135	0.135
0.100	0.950	0.600	0.750	0.130	0.130
0.113	0.955	0.670	0.775	0.128	0.128
0.125	0.600	0.450	0.800	0.126	0.126
0.138	0.410	0.320	0.825	0.124	0.124
0.150	0.400	0.315	0.850	0.122	0.122
0.175	0.440	0.350	0.875	0.120	0.120
0.200	0.550	0.470	0.900	0.118	0.118
0.225	1.200	1.000	0.925	0.116	0.116
0.238	1.550	1.300	0.950	0.114	0.114
0.250	1.580	1.290	0.975	0.112	0.112
0.275	0.650	0.550	1.000	0.110	0.110
0.300	0.500	0.400	1.250	0.090	0.090
0.325	0.425	0.350	1.500	0.070	0.070
0.350	0.420	0.360	1.750	0.050	0.050
0.375	0.500	0.420	2.000	0.030	0.030
0.400	0.745	0.580			
0.425	0.600	0.470			
0.450	0.460	0.380			
0.475	0.400	0.320			
0.500	0.330	0.280			
0.525	0.290	0.250			
0.550	0.250	0.220			
0.575	0.225	0.200			
0.600	0.200	0.175			

March 14, 1969

TABLE 23

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 41

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010	Period Sec.	Damping Ratio 0.005	0.010
0.000	0.060	0.060	0.550	0.410	0.370
0.025	0.070	0.070	0.575	0.385	0.345
0.050	0.080	0.080	0.600	0.345	0.285
0.075	0.090	0.090	0.625	0.310	0.250
0.100	0.100	0.100	0.650	0.240	0.220
0.125	0.120	0.110	0.675	0.200	0.200
0.150	0.135	0.125	0.700	0.175	0.175
0.175	0.150	0.140	0.725	0.165	0.165
0.200	0.180	0.160	0.750	0.160	0.160
0.225	0.240	0.210	0.775	0.156	0.156
0.250	0.400	0.340	0.800	0.152	0.152
0.275	0.600	0.500	0.825	0.149	0.149
0.300	0.820	0.660	0.850	0.146	0.146
0.325	0.920	0.790	0.875	0.142	0.142
0.338	1.480	1.080	0.900	0.139	0.139
0.350	1.520	1.170	0.925	0.136	0.136
0.375	1.520	1.180	0.950	0.134	0.134
0.400	1.500	1.160	0.975	0.132	0.132
0.425	0.600	0.560	1.000	0.130	0.130
0.450	0.500	0.460	1.250	0.107	0.107
0.475	0.460	0.415	1.500	0.085	0.085
0.500	0.435	0.385	1.750	0.062	0.062
0.525	0.410	0.370	2.000	0.040	0.040

March 14, 1969

TABLE 24

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 20, 20A, 32, 42

DAMPING RATIO = 0.005, 0.010

Period Sec.	Damping Ratio 0.005	0.010
0.000	0.060	0.060
0.025	0.070	0.070
0.050	0.085	0.085
0.075	0.095	0.095
0.100	0.105	0.105
0.125	0.115	0.115
0.150	0.130	0.130
0.175	0.160	0.155
0.200	0.220	0.220
0.225	0.340	0.300
0.250	0.490	0.410
0.275	0.650	0.560
0.300	0.880	0.735
0.325	1.170	0.950
0.338	1.400	1.030
0.350	1.440	1.045
0.363	1.435	1.040
0.375	1.350	1.000
0.400	0.970	0.720
0.425	0.800	0.580
0.450	0.680	0.500
0.475	0.600	0.440
0.500	0.530	0.395
0.525	0.470	0.350
0.550	0.420	0.325
0.575	0.380	0.295
0.600	0.340	0.270
0.625	0.300	0.250
0.650	0.252	0.230
0.675	0.230	0.210
0.700	0.210	0.195
0.725	0.190	0.180
0.750	0.175	0.170
0.775	0.165	0.165
0.800	0.148	0.148
0.825	0.142	0.142
0.850	0.136	0.136
0.875	0.131	0.131
0.900	0.126	0.126
0.925	0.121	0.121
0.950	0.117	0.117
0.975	0.113	0.113
1.000	0.110	0.110
1.250	0.100	0.100
1.500	0.080	0.080
1.750	0.060	0.060
2.000	0.040	0.040

March 14, 1969

TABLE 25

RESPONSE ACCELERATION SPECTRA TABULATION

(VERTICAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINTS 4, 4A, 6, 6A, 9, 9A, 10, 10A,

14-20, 14A-20A, 21, 24, 25, 28-32, 33, 33A, 41, 42

DAMPING RATIO = 0.005, 0.010, 0.020, AND 0.050

Period	Damping Ratio			
Sec.	0.005	0.010	0.020	0.050
0.000	0.060	0.060	0.060	0.060
0.025	0.062	0.061	0.061	0.061
0.050	0.072	0.065	0.063	0.062
0.075	0.085	0.080	0.072	0.068
0.100	0.100	0.095	0.085	0.075
0.125	0.120	0.110	0.100	0.085
0.150	0.145	0.138	0.120	0.100
0.175	0.180	0.165	0.150	0.130
0.200	0.230	0.210	0.190	0.160
0.225	0.760	0.460	0.270	0.220
0.238	0.785	0.635	0.430	0.260
0.250	0.788	0.635	0.435	0.270
0.275	0.780	0.625	0.440	0.275
0.300	0.760	0.605	0.435	0.265
0.325	0.730	0.580	0.420	0.250
0.350	0.660	0.520	0.380	0.230
0.375	0.560	0.420	0.300	0.200
0.400	0.420	0.340	0.260	0.180
0.425	0.320	0.280	0.220	0.160
0.450	0.280	0.240	0.200	0.140
0.475	0.240	0.210	0.170	0.130
0.500	0.220	0.190	0.155	0.115
0.525	0.195	0.170	0.140	0.100
0.550	0.170	0.150	0.125	0.087
0.575	0.160	0.135	0.112	0.079
0.600	0.140	0.120	0.100	0.069
0.625	0.128	0.110	0.090	0.060
0.650	0.120	0.100	0.080	0.053
0.675	0.108	0.090	0.071	0.048
0.700	0.100	0.085	0.065	0.045
0.725	0.095	0.080	0.061	0.041
0.750	0.090	0.075	0.057	0.040
0.775	0.085	0.070	0.054	0.039
0.800	0.082	0.068	0.052	0.039
0.825	0.080	0.066	0.051	0.038
0.850	0.078	0.065	0.050	0.038
0.875	0.076	0.064	0.049	0.037
0.900	0.074	0.063	0.049	0.037
0.925	0.073	0.062	0.048	0.037
0.950	0.072	0.062	0.048	0.036
0.975	0.071	0.061	0.047	0.036
1.000	0.070	0.060	0.047	0.036
1.250	0.060	0.051	0.040	0.030
1.500	0.050	0.042	0.033	0.025
1.750	0.040	0.033	0.026	0.020
2.000	0.030	0.025	0.020	0.015

March 14, 1969

TABLE 26

RESPONSE ACCELERATION SPECTRA TABULATION

(HORIZONTAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

SCREENHOUSE

DAMPING RATIO = 0.005 AND 0.010

PERIOD SEC.	DAMPING RATIO 0.005	0.010	PERIOD SEC.	DAMPING RATIO 0.005	0.010
0.000	0.100	0.100	0.775	0.154	0.148
0.025	0.100	0.100	0.800	0.148	0.148
0.050	0.125	0.125	0.825	0.142	0.138
0.075	0.400	0.400	0.850	0.136	0.134
0.100	0.800	0.800	0.875	0.130	0.129
0.125	1.425	1.175	0.900	0.125	0.125
0.150	1.450	1.205	0.925	0.120	0.120
0.175	1.460	1.210	0.950	0.116	0.116
0.200	1.450	1.200	0.975	0.112	0.112
0.225	1.425	1.150	1.000	0.108	0.108
0.250	1.100	0.900	1.050	0.101	0.101
0.275	0.800	0.650	1.100	0.094	0.094
0.300	0.650	0.550	1.150	0.089	0.089
0.325	0.550	0.465	1.200	0.084	0.084
0.350	0.475	0.405	1.250	0.079	0.079
0.375	0.420	0.375	1.300	0.075	0.075
0.400	0.375	0.340	1.350	0.071	0.071
0.425	0.350	0.315	1.400	0.069	0.069
0.450	0.325	0.295	1.450	0.067	0.067
0.475	0.300	0.275	1.500	0.066	0.066
0.500	0.275	0.260	1.550	0.065	0.065
0.525	0.260	0.245	1.600	0.064	0.064
0.550	0.245	0.230	1.650	0.064	0.064
0.575	0.230	0.220	1.700	0.063	0.063
0.600	0.220	0.210	1.750	0.062	0.062
0.625	0.210	0.200	1.800	0.062	0.062
0.650	0.200	0.190	1.850	0.061	0.061
0.675	0.190	0.181	1.900	0.061	0.061
0.700	0.180	0.172	1.950	0.060	0.060
0.725	0.170	0.163	2.000	0.060	0.060
0.750	0.160	0.154			

TABLE 27

RESPONSE ACCELERATION SPECTRA TABULATION

(VERTICAL ACCELERATION)

EARTHQUAKE IN N-S OR E-W DIRECTION

SCREENHOUSE

DAMPING RATIO = 0.005 AND 0.010

PERIOD SEC.	DAMPING RATIO 0.005	0.010	PERIOD SEC.	DAMPING RATIO 0.005	0.010
0.000	0.100	0.100	0.775	0.122	0.120
0.025	0.100	0.100	0.800	0.116	0.115
0.050	0.110	0.110	0.825	0.110	0.110
0.075	0.160	0.160	0.850	0.104	0.104
0.100	0.220	0.220	0.875	0.099	0.099
0.125	0.320	0.300	0.900	0.095	0.095
0.150	0.440	0.330	0.925	0.090	0.090
0.175	0.520	0.420	0.950	0.086	0.086
0.200	0.540	0.430	0.975	0.082	0.082
0.225	0.545	0.433	1.000	0.078	0.078
0.250	0.532	0.415	1.050	0.072	0.072
0.275	0.510	0.380	1.100	0.066	0.066
0.300	0.460	0.350	1.150	0.060	0.060
0.325	0.410	0.320	1.200	0.055	0.055
0.350	0.375	0.300	1.250	0.051	0.051
0.375	0.335	0.280	1.300	0.048	0.048
0.400	0.305	0.265	1.350	0.045	0.045
0.425	0.280	0.250	1.400	0.042	0.042
0.450	0.255	0.239	1.450	0.040	0.040
0.475	0.235	0.220	1.500	0.038	0.038
0.500	0.218	0.210	1.550	0.037	0.037
0.525	0.202	0.197	1.600	0.036	0.036
0.550	0.190	0.185	1.650	0.035	0.035
0.575	0.180	0.176	1.700	0.034	0.034
0.600	0.172	0.168	1.750	0.033	0.033
0.625	0.163	0.160	1.800	0.032	0.032
0.650	0.155	0.152	1.850	0.031	0.031
0.675	0.147	0.145	1.900	0.031	0.031
0.700	0.140	0.138	1.950	0.030	0.030
0.725	0.136	0.135	2.000	0.030	0.030
0.750	0.128	0.127			

December 2, 1969

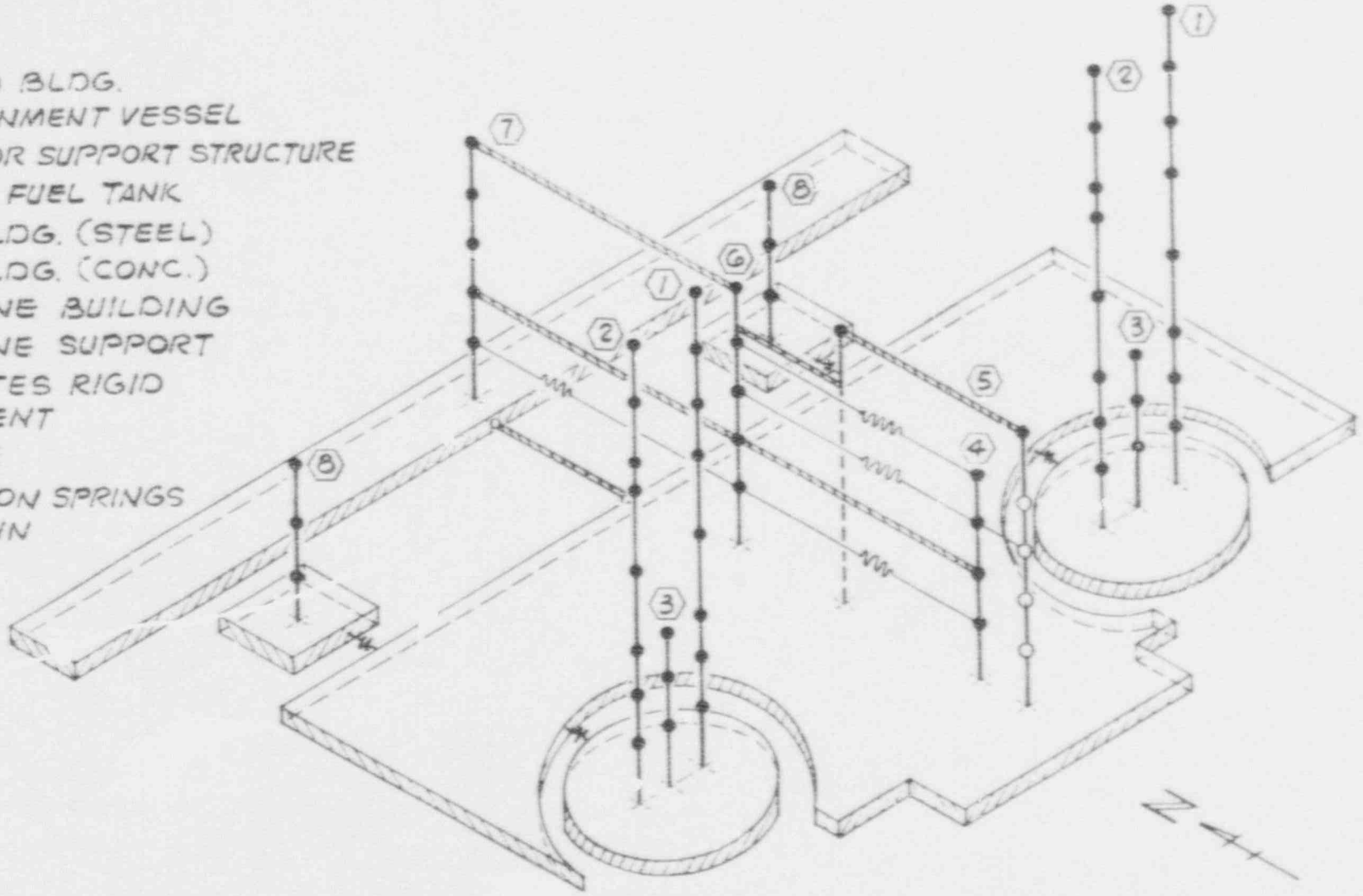
CODE:

1. SHIELD BLDG.
2. CONTAINMENT VESSEL
3. REACTOR SUPPORT STRUCTURE
4. SPENT FUEL TANK
5. AUX. BLDG. (STEEL)
6. AUX. BLDG. (CONC.)
7. TURBINE BUILDING
8. TURBINE SUPPORT

DENOTES RIGID ELEMENT

NO SCALE

FOUNDATION SPRINGS NOT SHOWN



MARCH 14, 1969

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT

MATHEMATICAL MODEL

SOUTHWEST VIEW

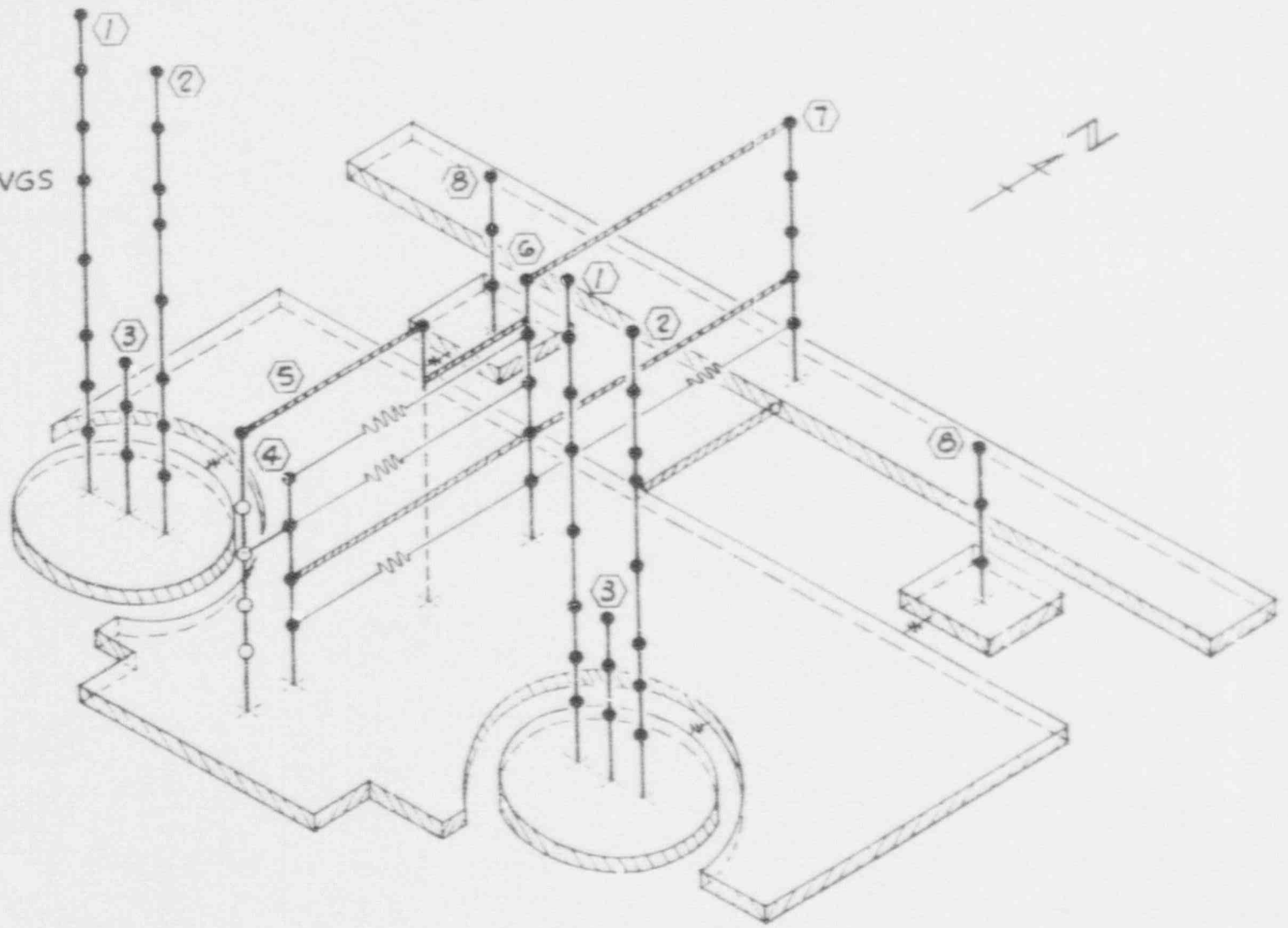
FIGURE NO. 1

NOTES:

⬡ - SEE FIGURE NO. FOR CODE

NO SCALE

FOUNDATION SPRINGS NOT SHOWN



MARCH 14, 1969

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT

MATHEMATICAL MODEL

SOUTHEAST VIEW

FIGURE NO. 2

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT
MATHEMATICAL MODEL
WEST ELEVATION

⬡ - SEE FIGURE NO. 1 FOR CODE

NO SCALE

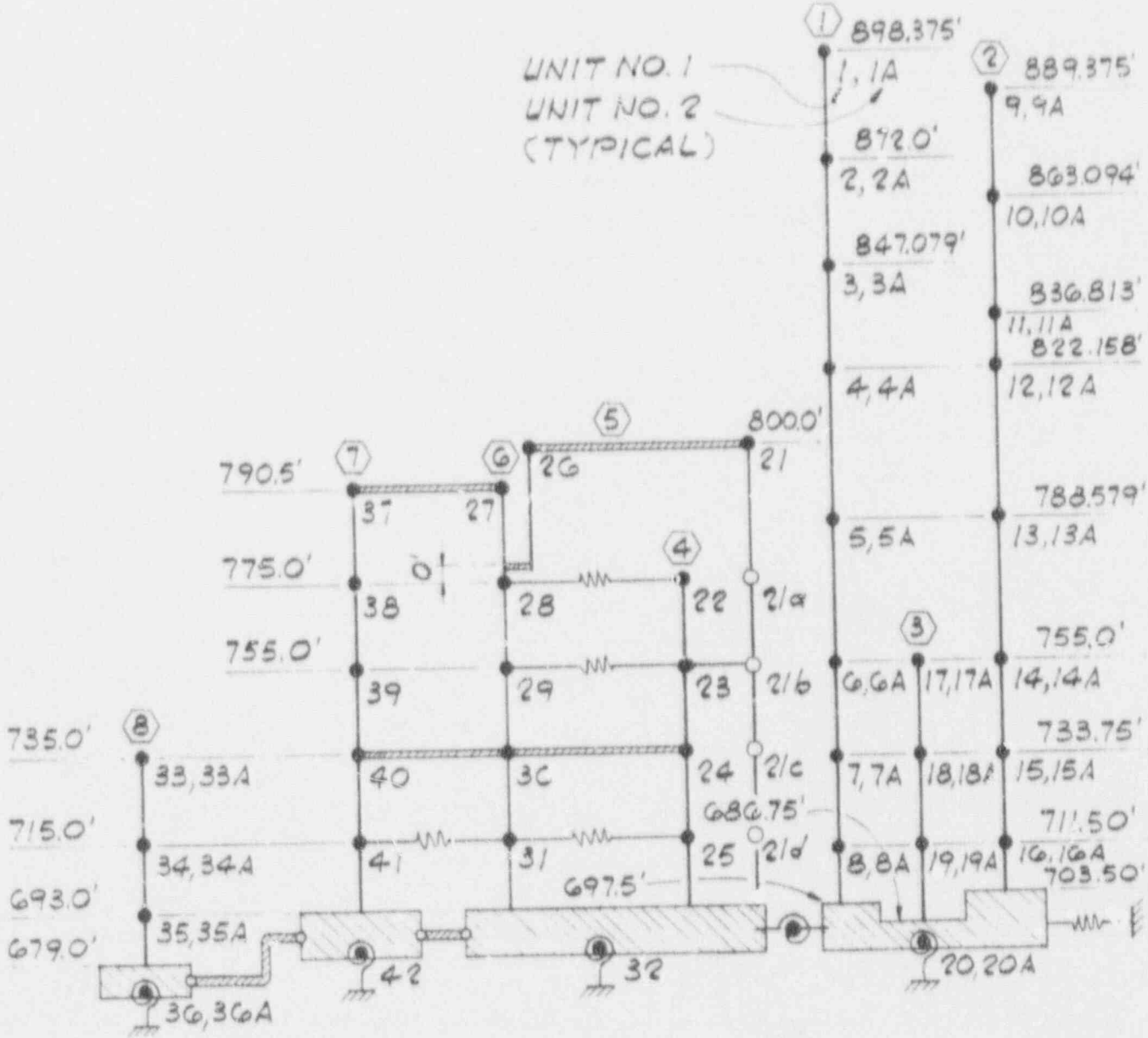


FIGURE NO. 3

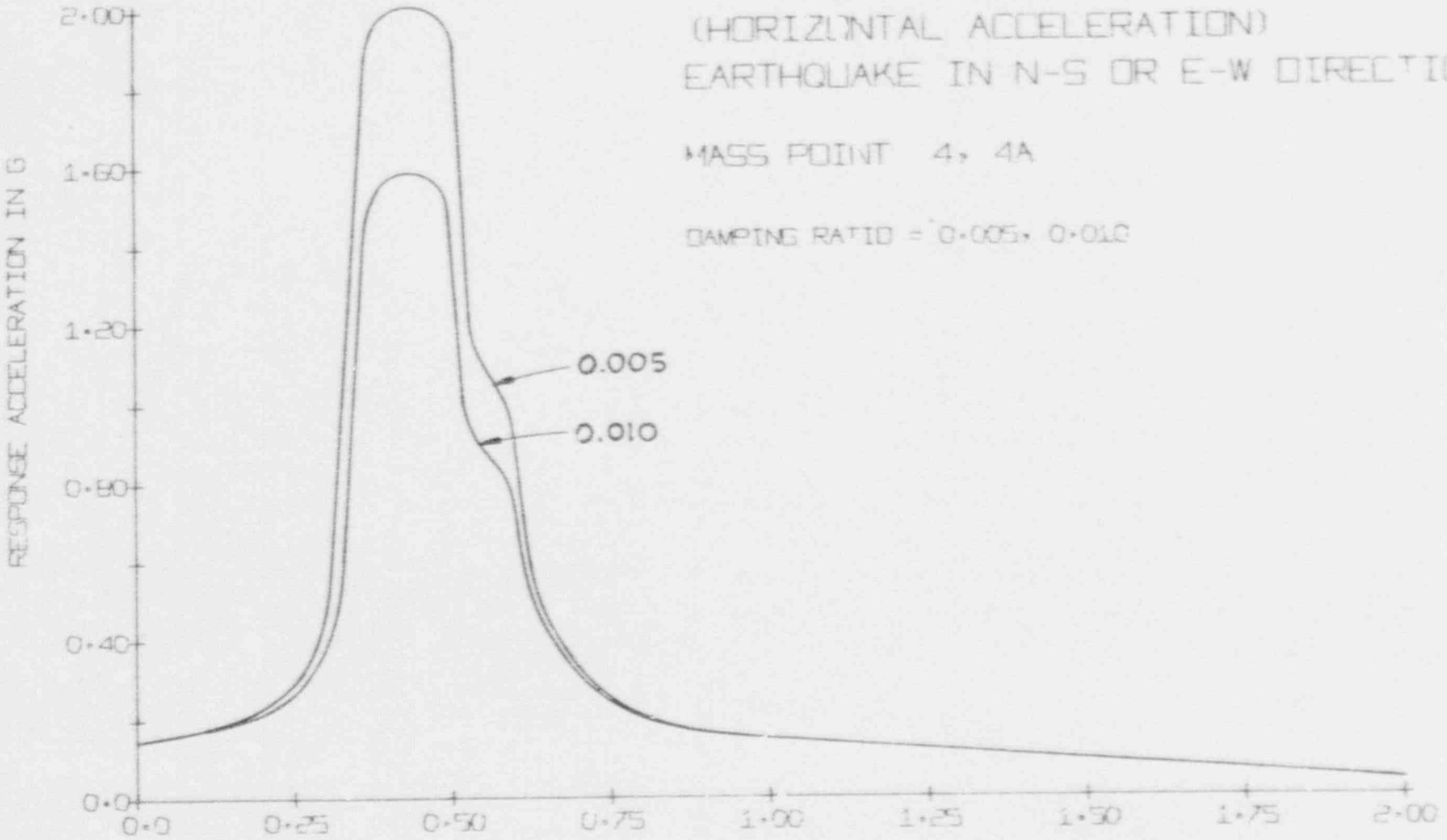
MARCH 14, 1969

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 4, 4A

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

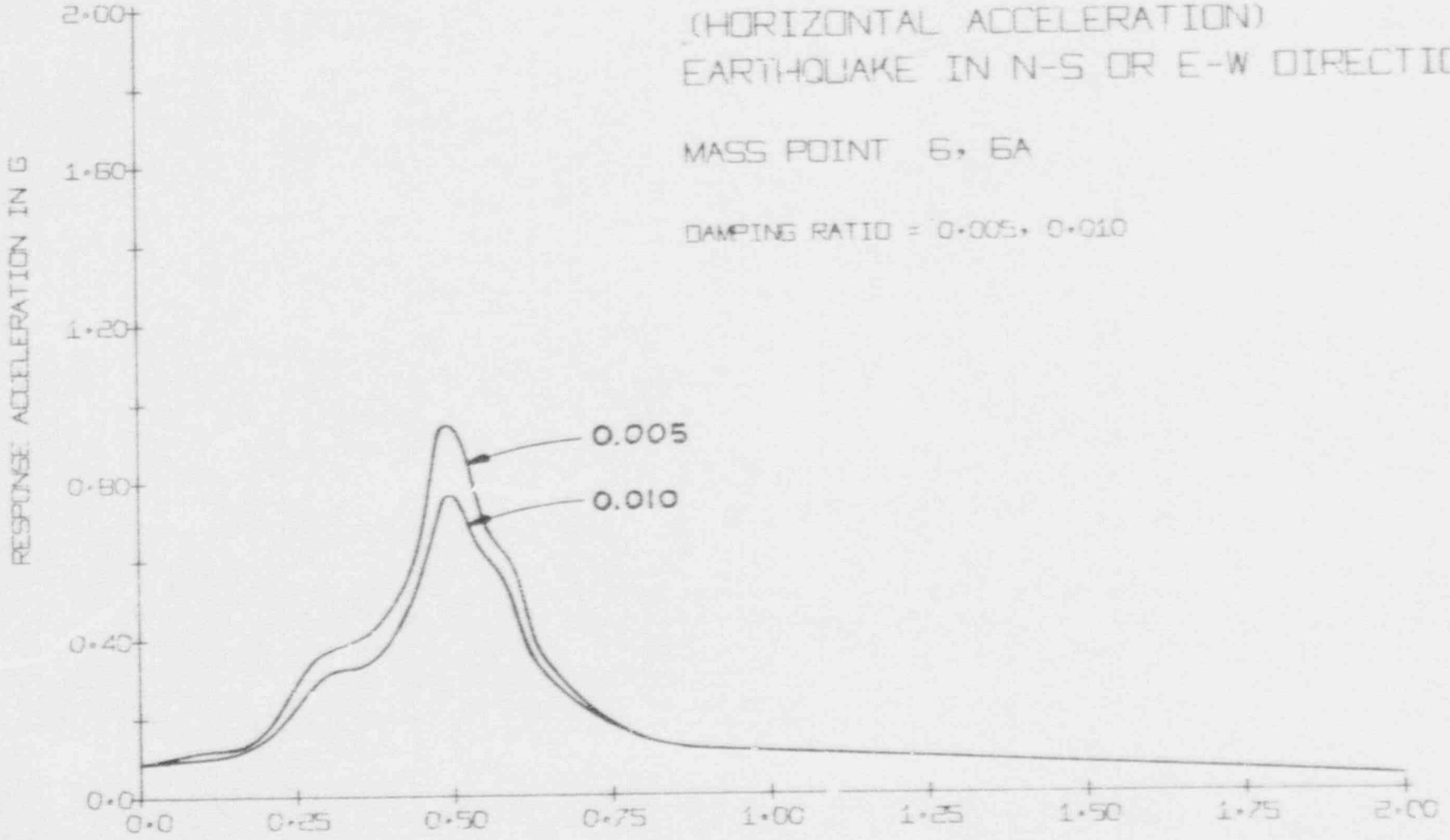
FIGURE NO. 4

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 6, 6A

DAMPING RATIO = 0.005, 0.010



MAR 15, 1969

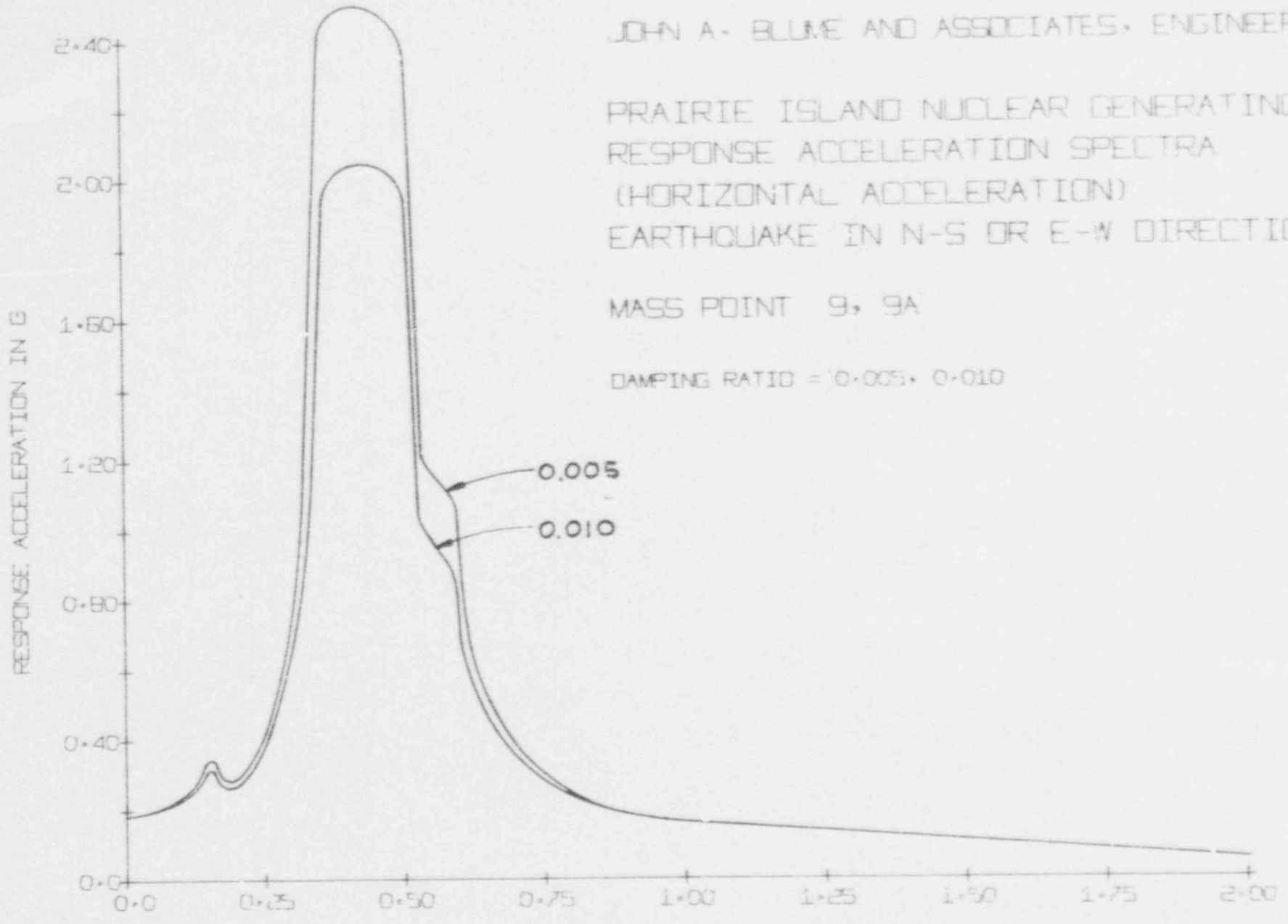
FIGURE NO. 5

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 9, 9A

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

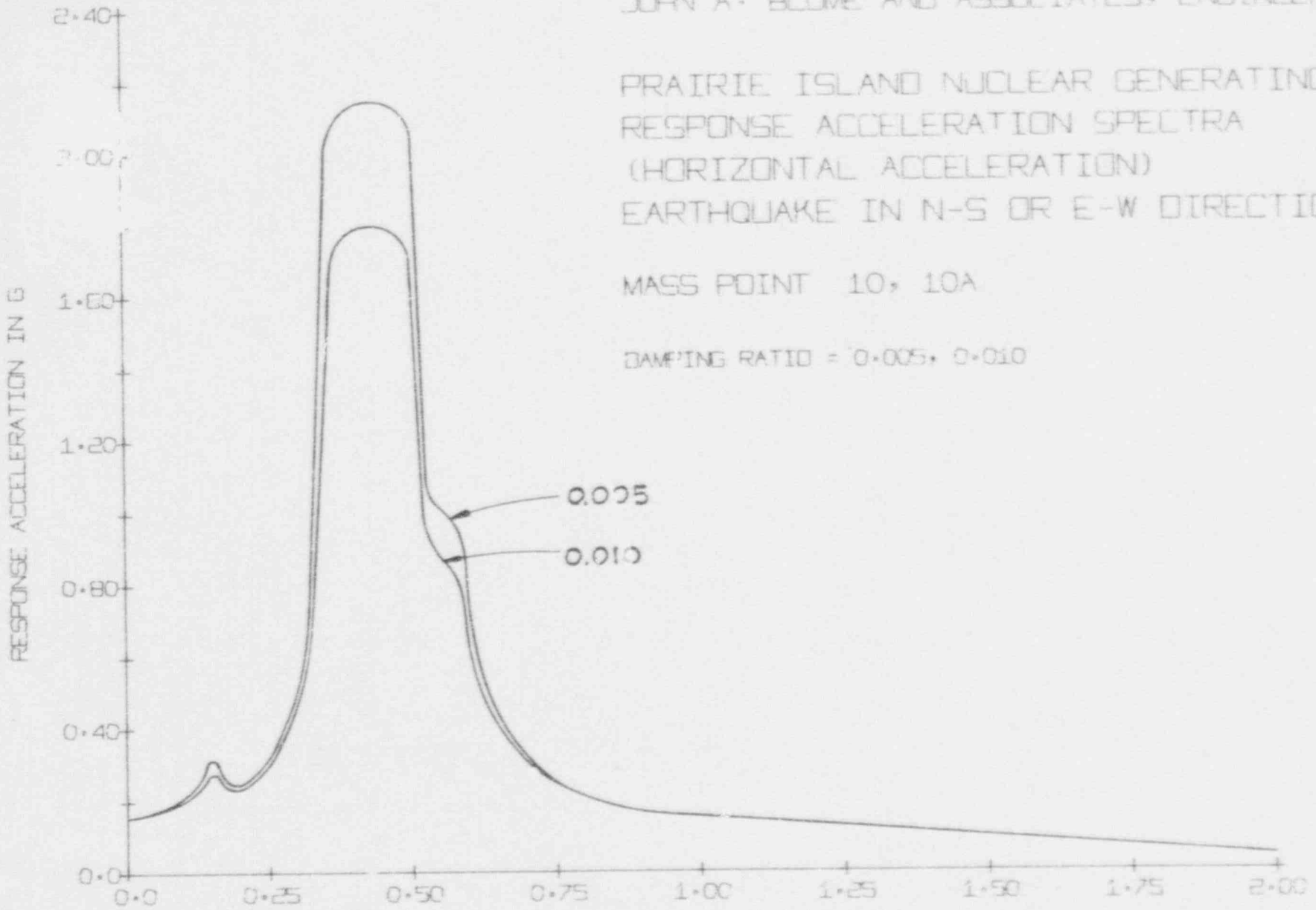
FIGURE NO. 6

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 10, 10A

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1968

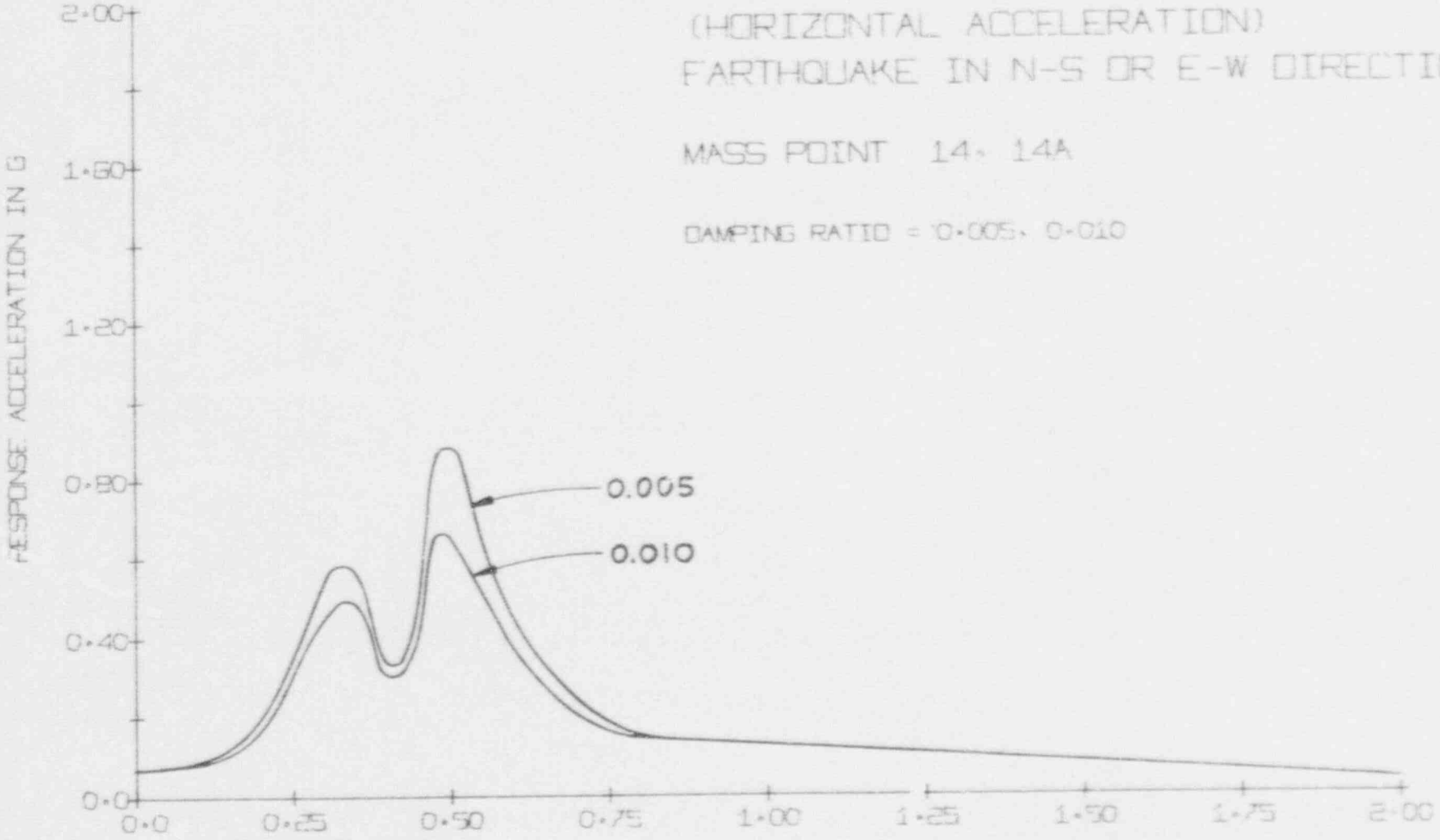
FIGURE NO. 7

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 14, 14A

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

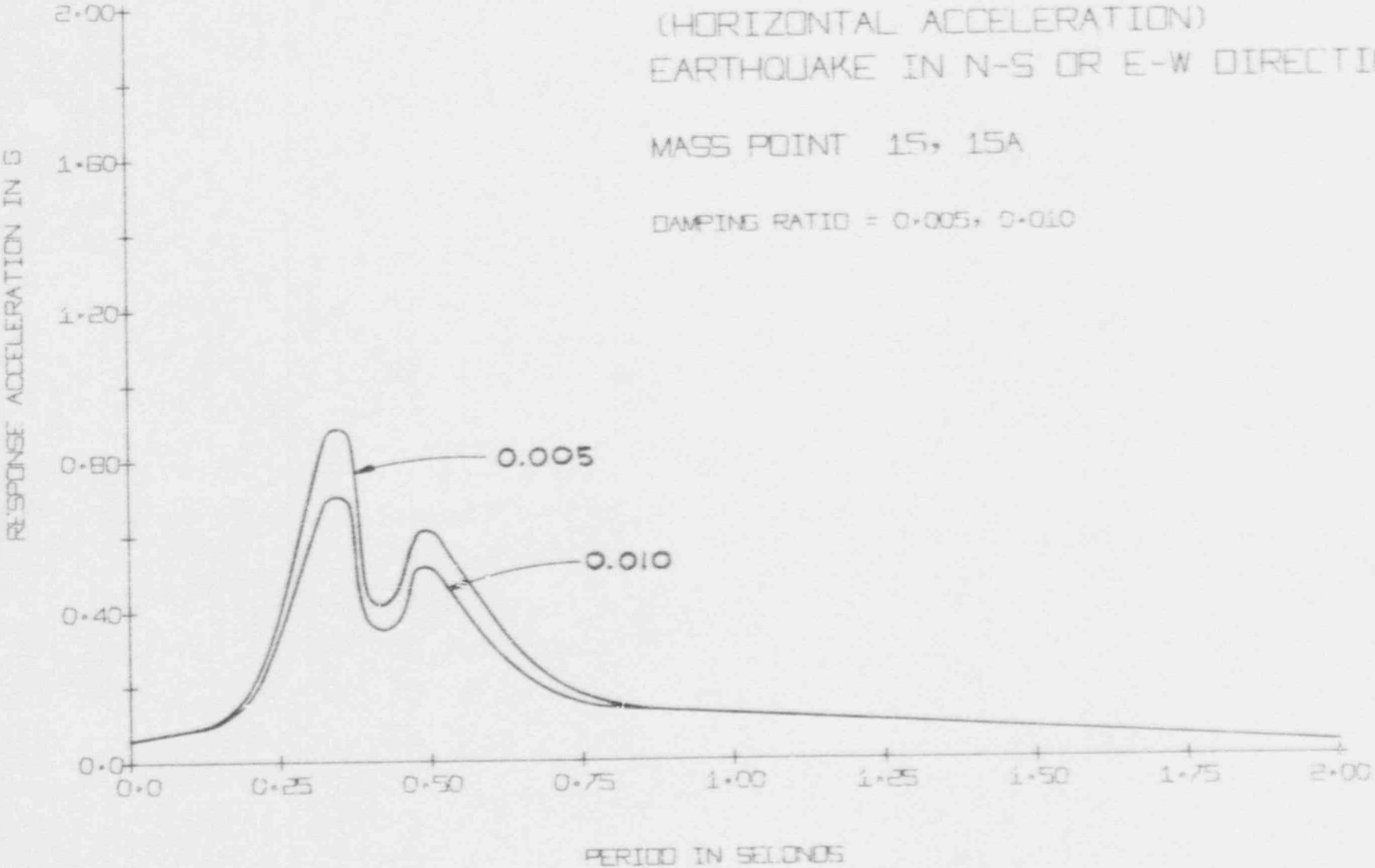
FIGURE NO. 8

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 15, 15A

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

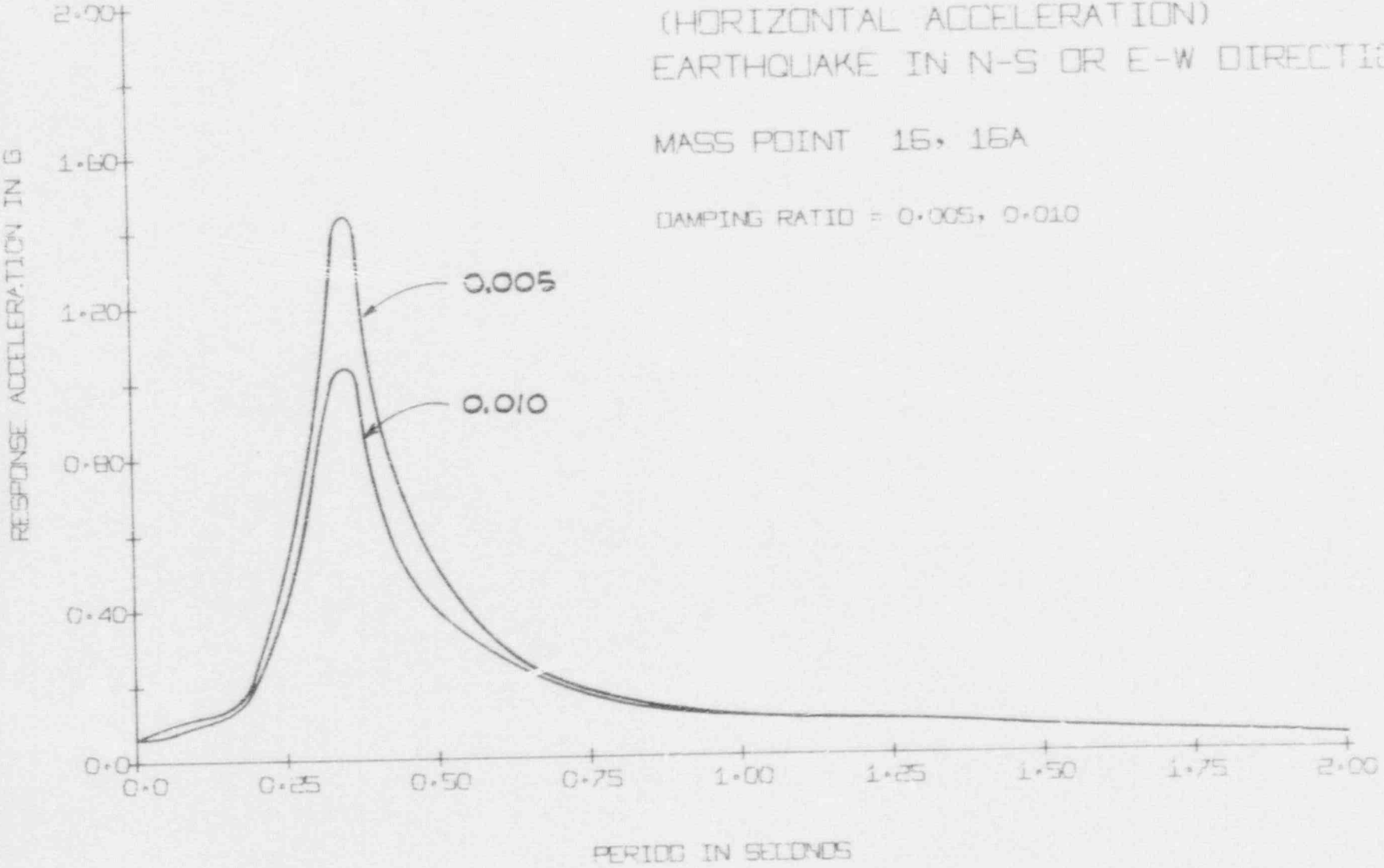
FIGURE NO. 9

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 15, 15A

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1968

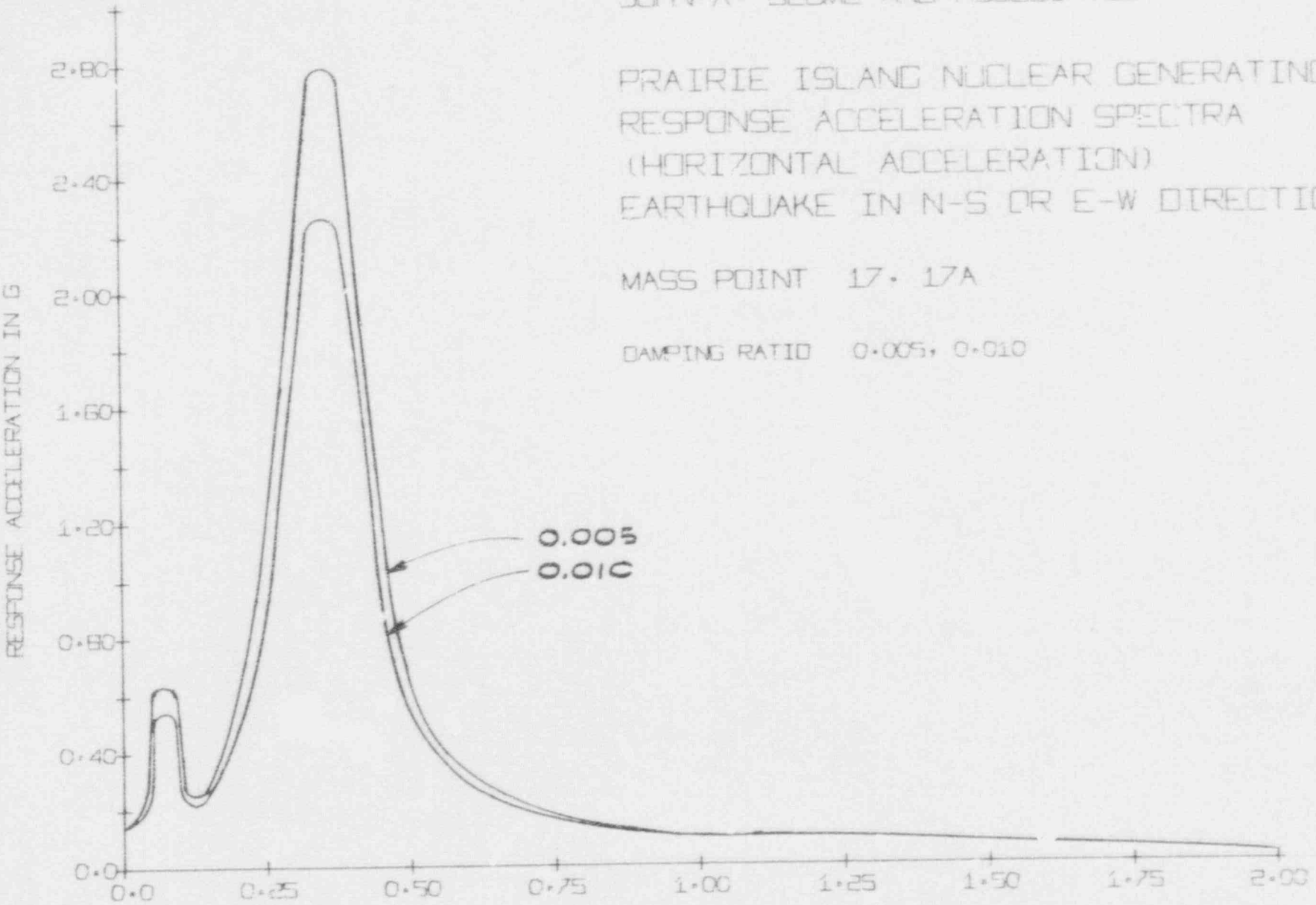
FIGURE NO. 10

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 17, 17A

DAMPING RATIO 0.005, 0.010



SEPT 15, 1969

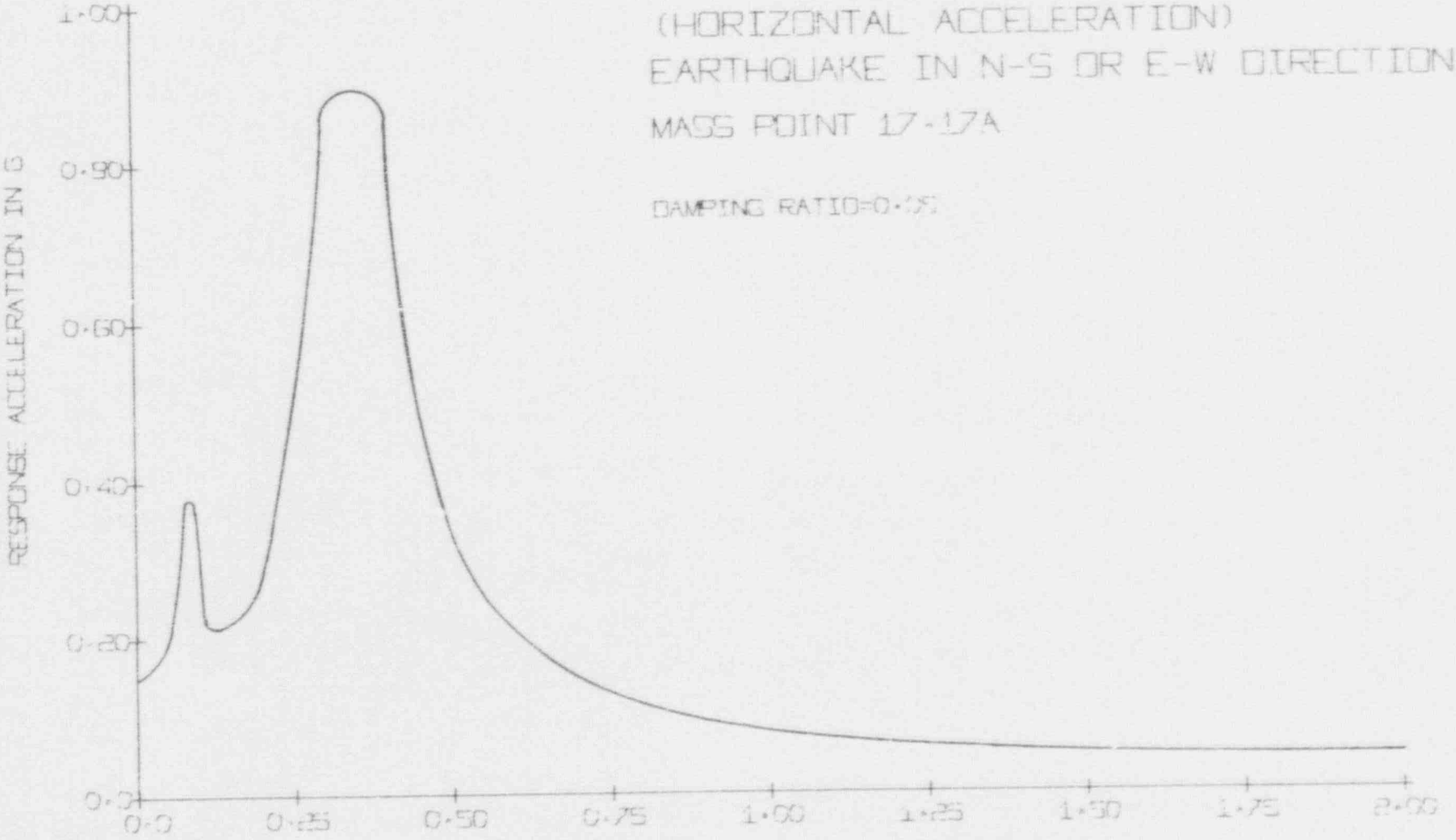
FIGURE NO. 1

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRUM
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 17-17A

DAMPING RATIO=0.05



January 2, 1970

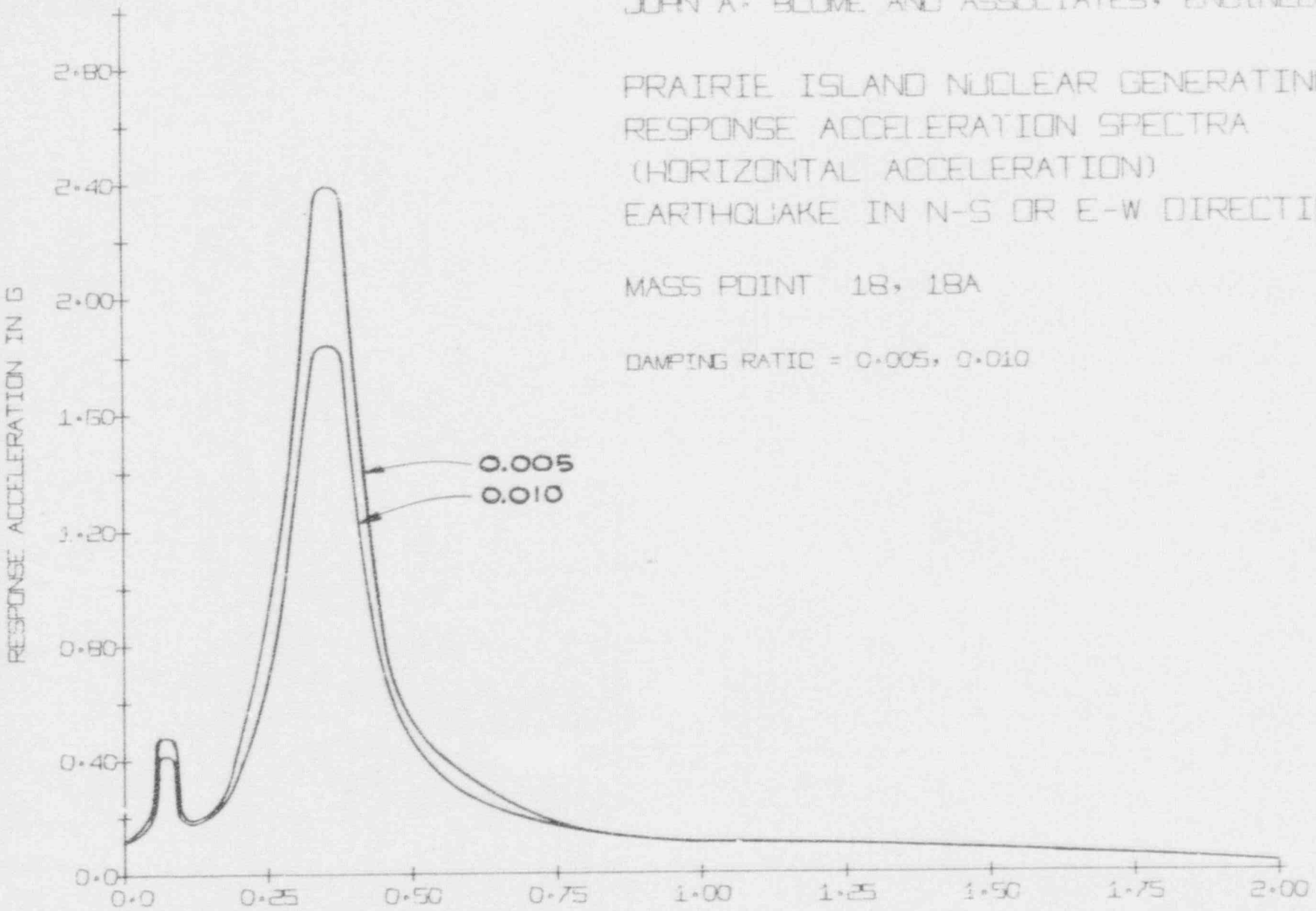
FIGURE NO. 11A

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 18, 18A

DAMPING RATIO = 0.005, 0.010



SEPT 15, 1969

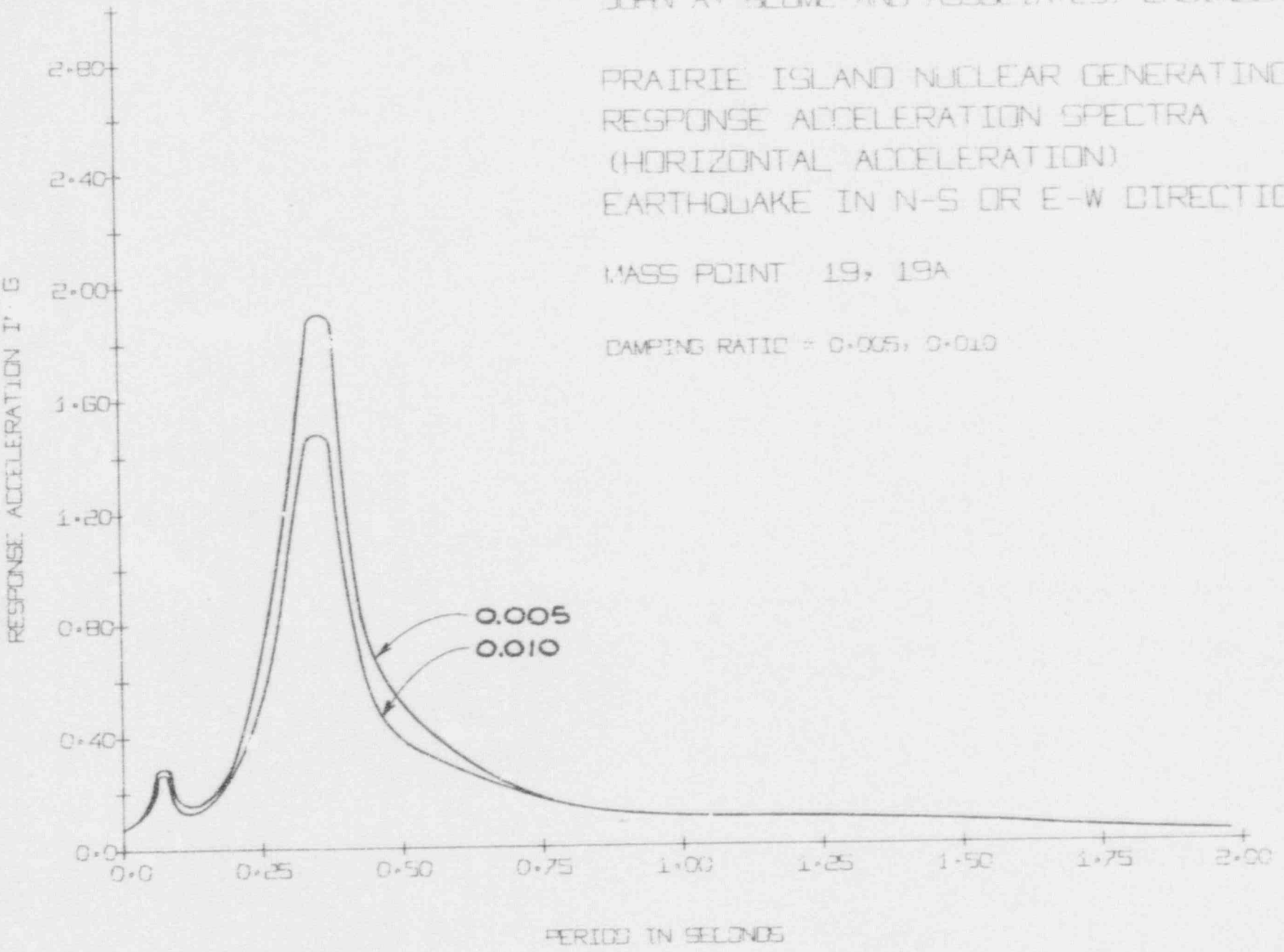
FIGURE NO. 12

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 19, 19A

DAMPING RATIO = 0.005, 0.010



SEPT 15, 1969

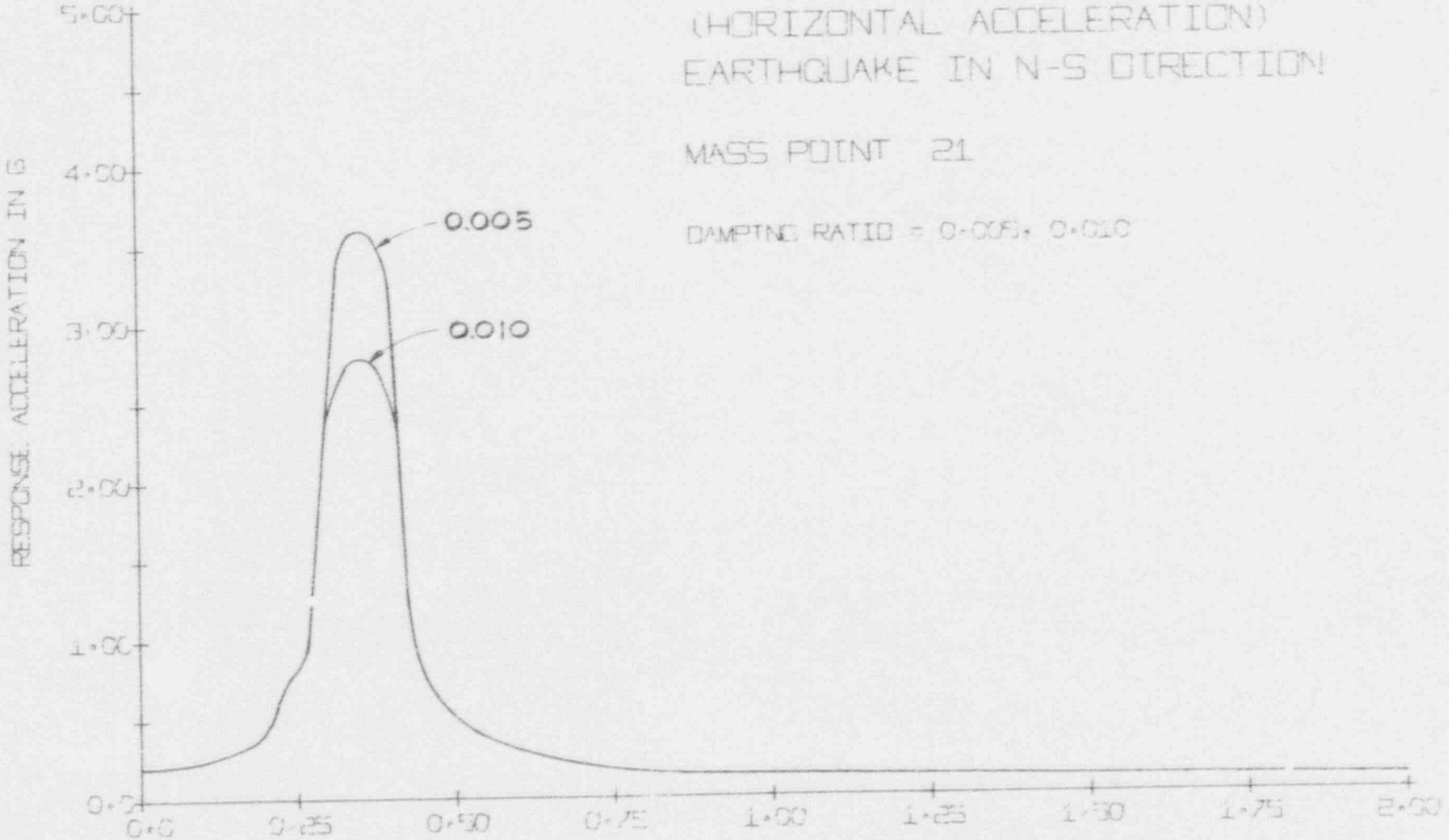
FIGURE NO. 13

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S DIRECTION

MASS POINT 21

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

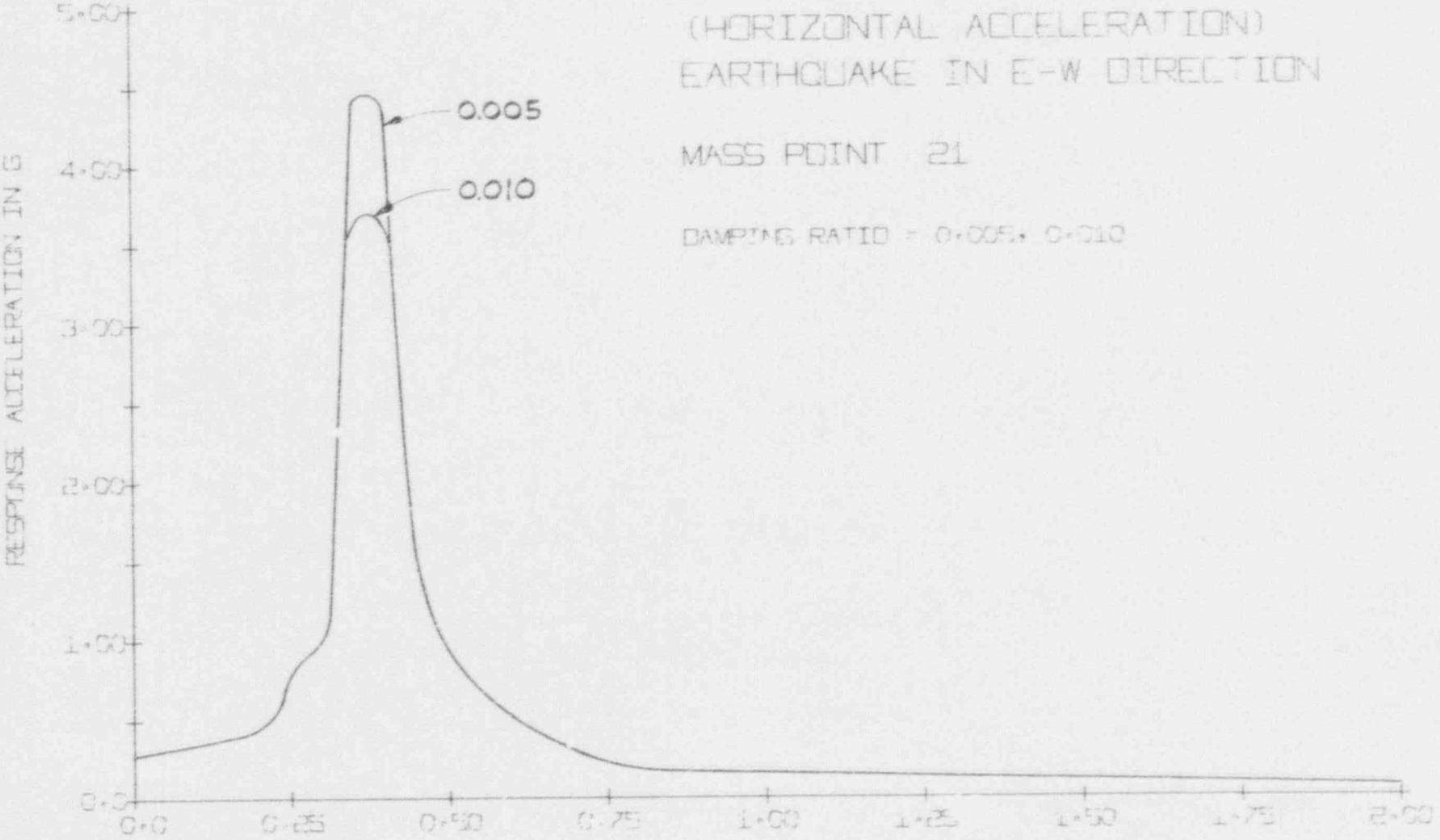
FIGURE NO. 14

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN E-W DIRECTION

MASS POINT 21

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

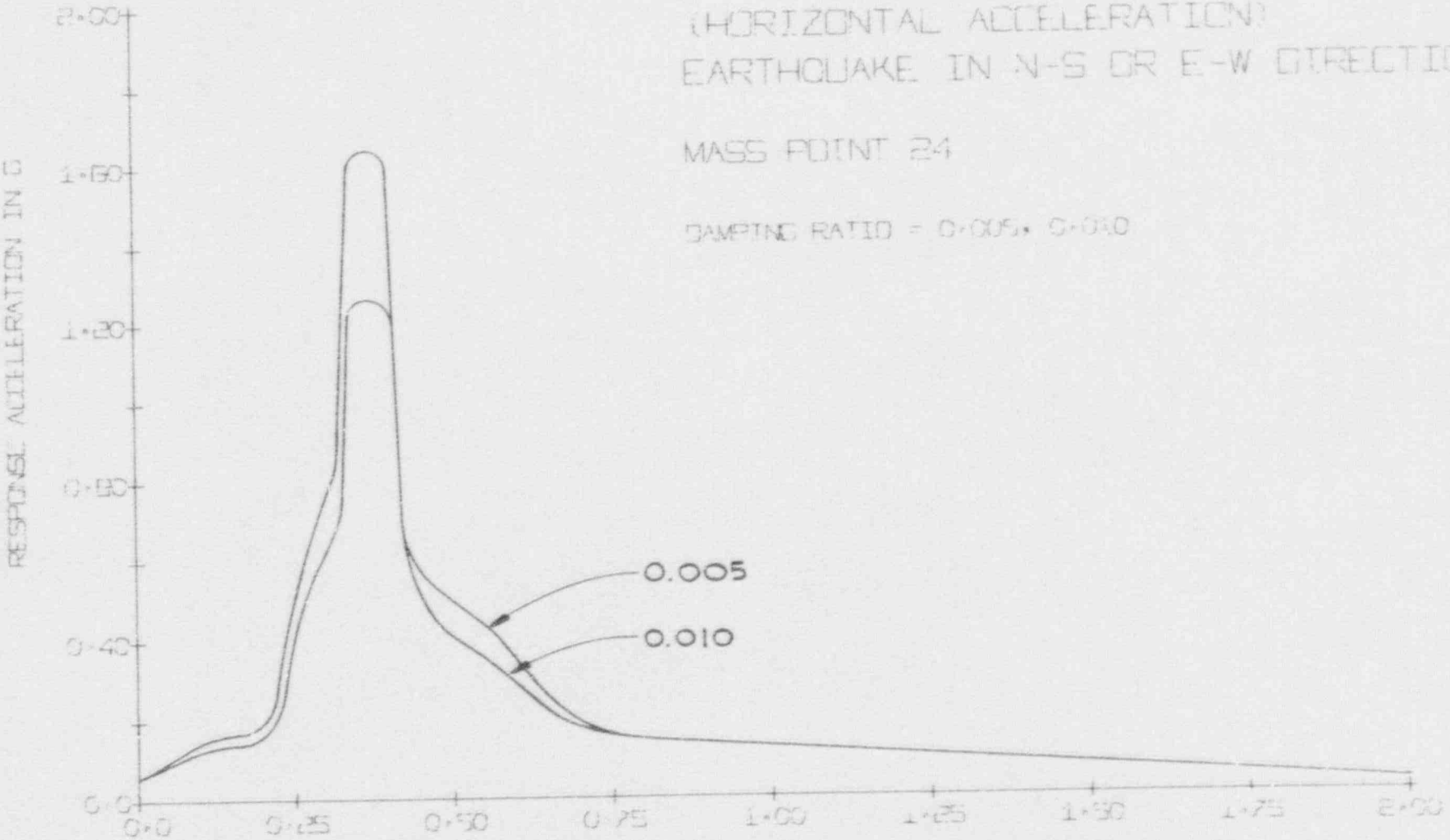
FIGURE NO. 15

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 24

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

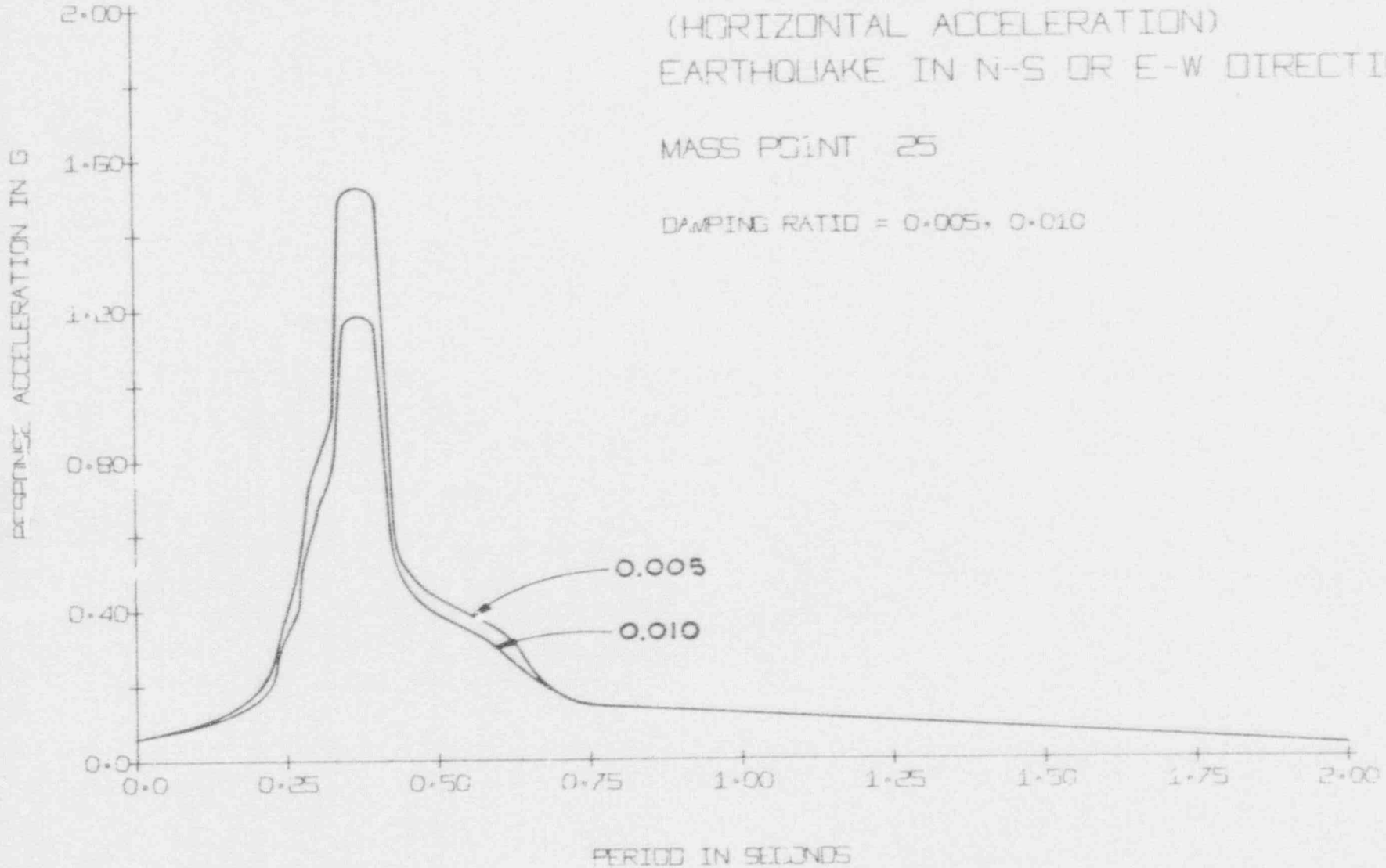
FIGURE NO. 16

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 25

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

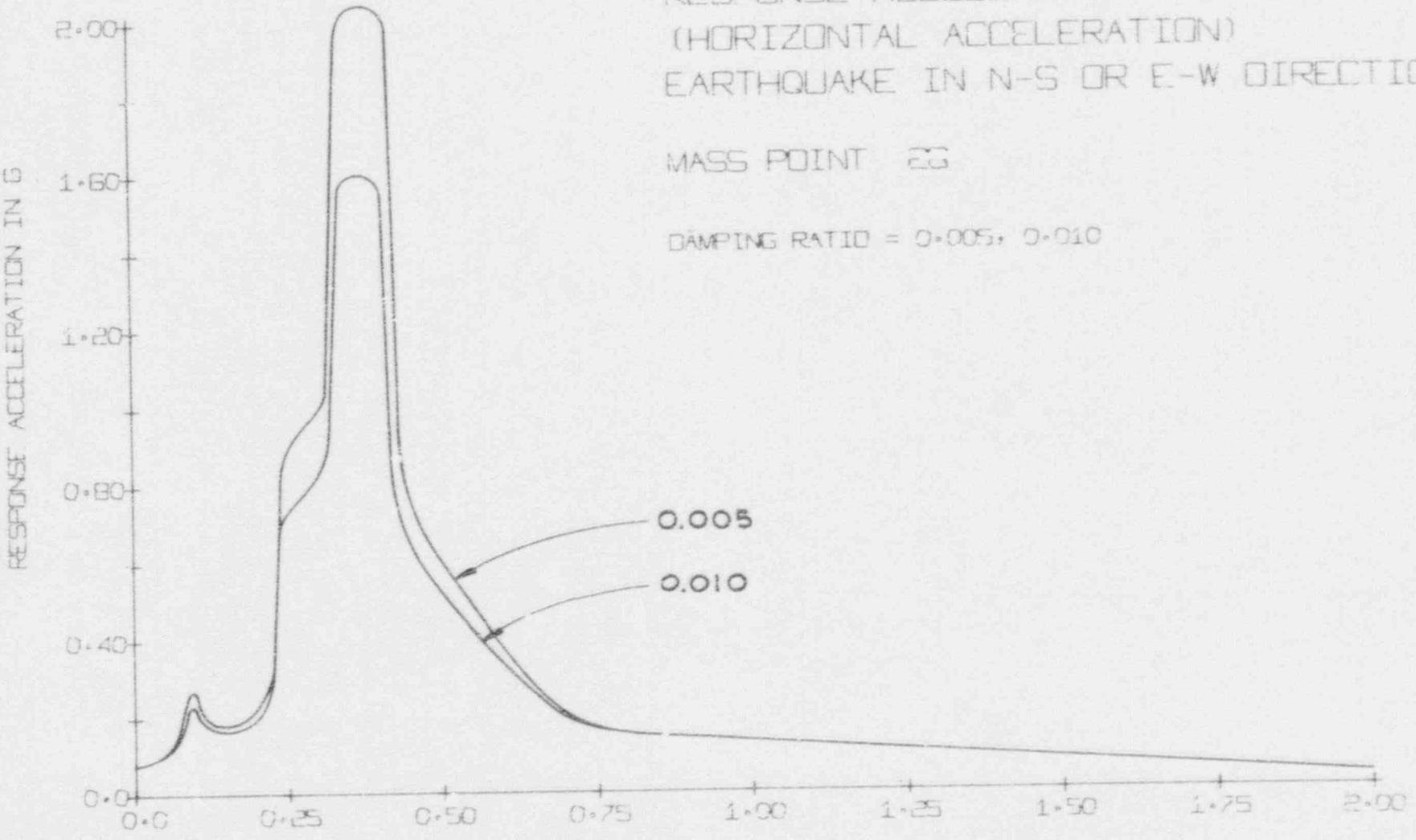
FIGURE NO. 17

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 23

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

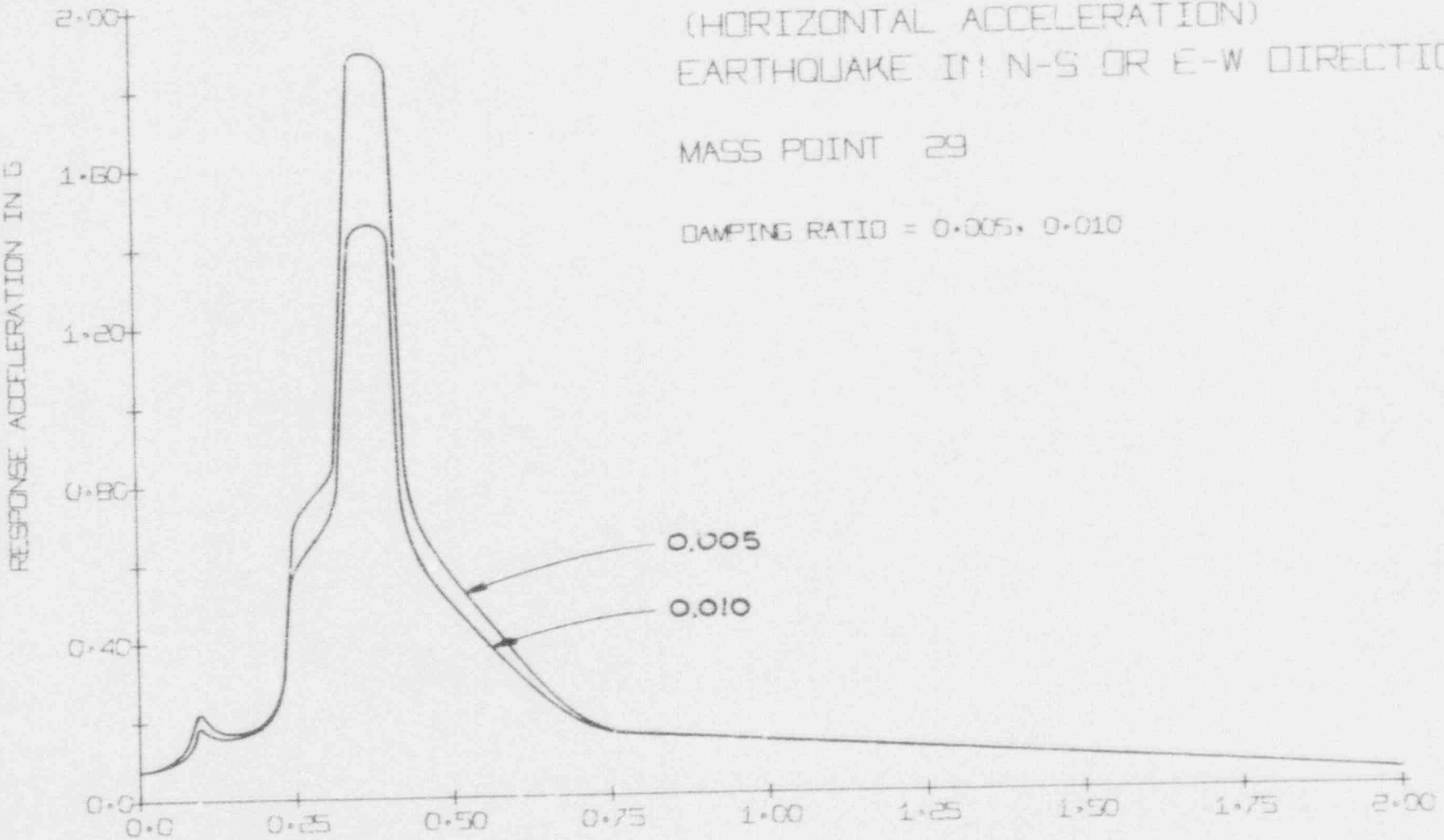
FIGURE NO. 18

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 29

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

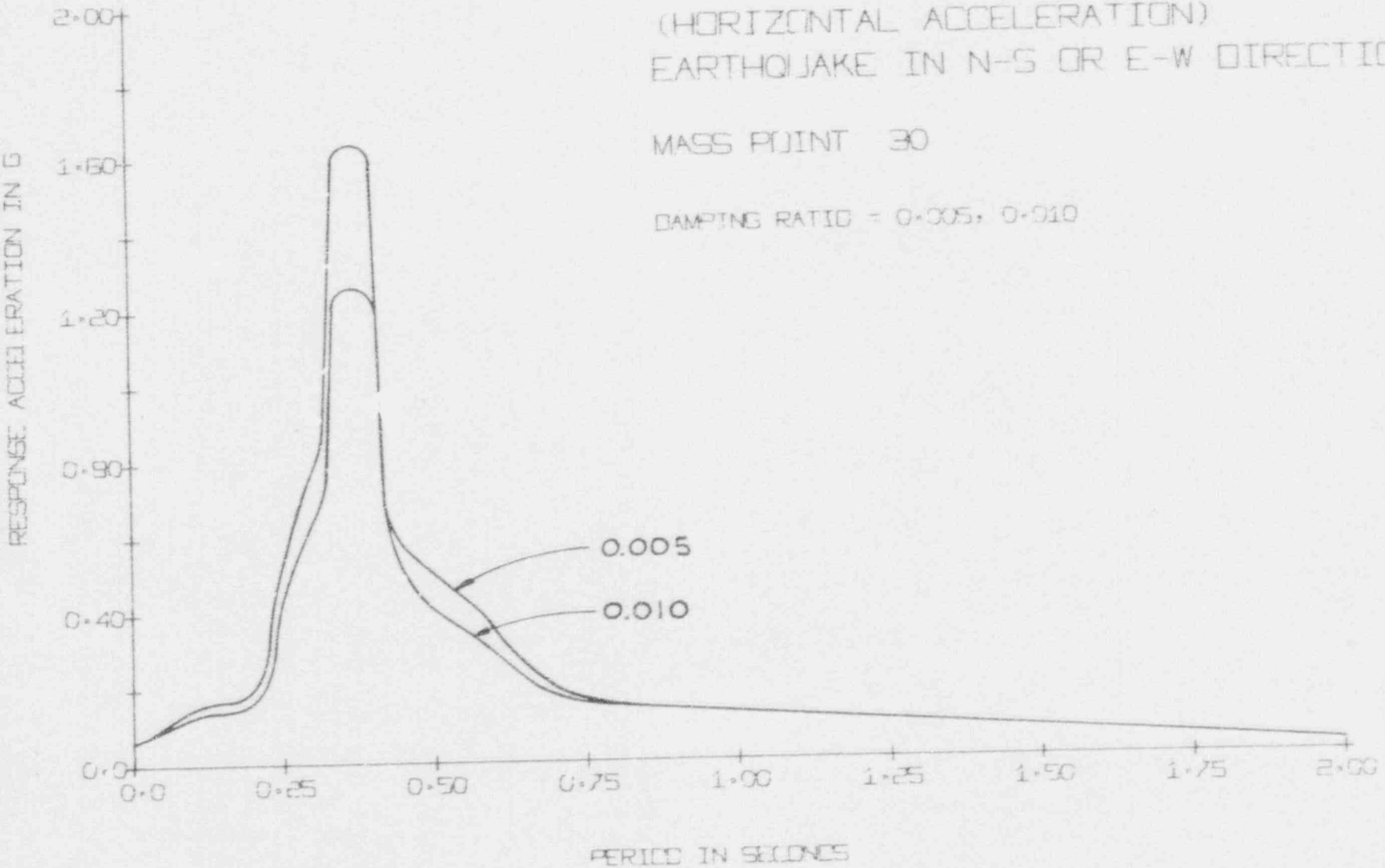
FIGURE NO. 19

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 30

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1963

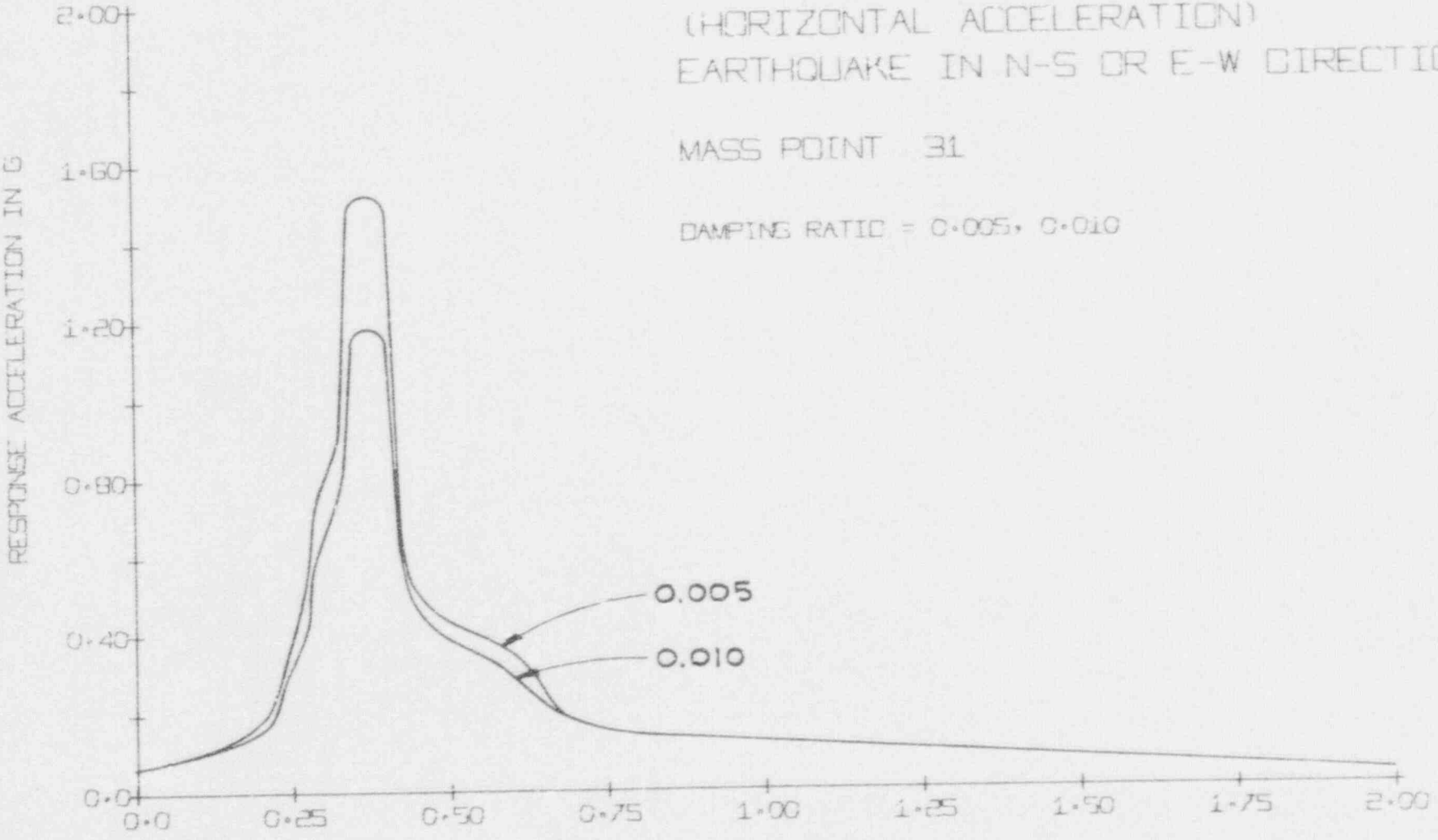
FIGURE NO. 20

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 31

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

FIGURE NO. 21

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

FAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S DIRECTION

MASS POINT 33, 33A

DAMPING RATIO = 0.005, 0.010

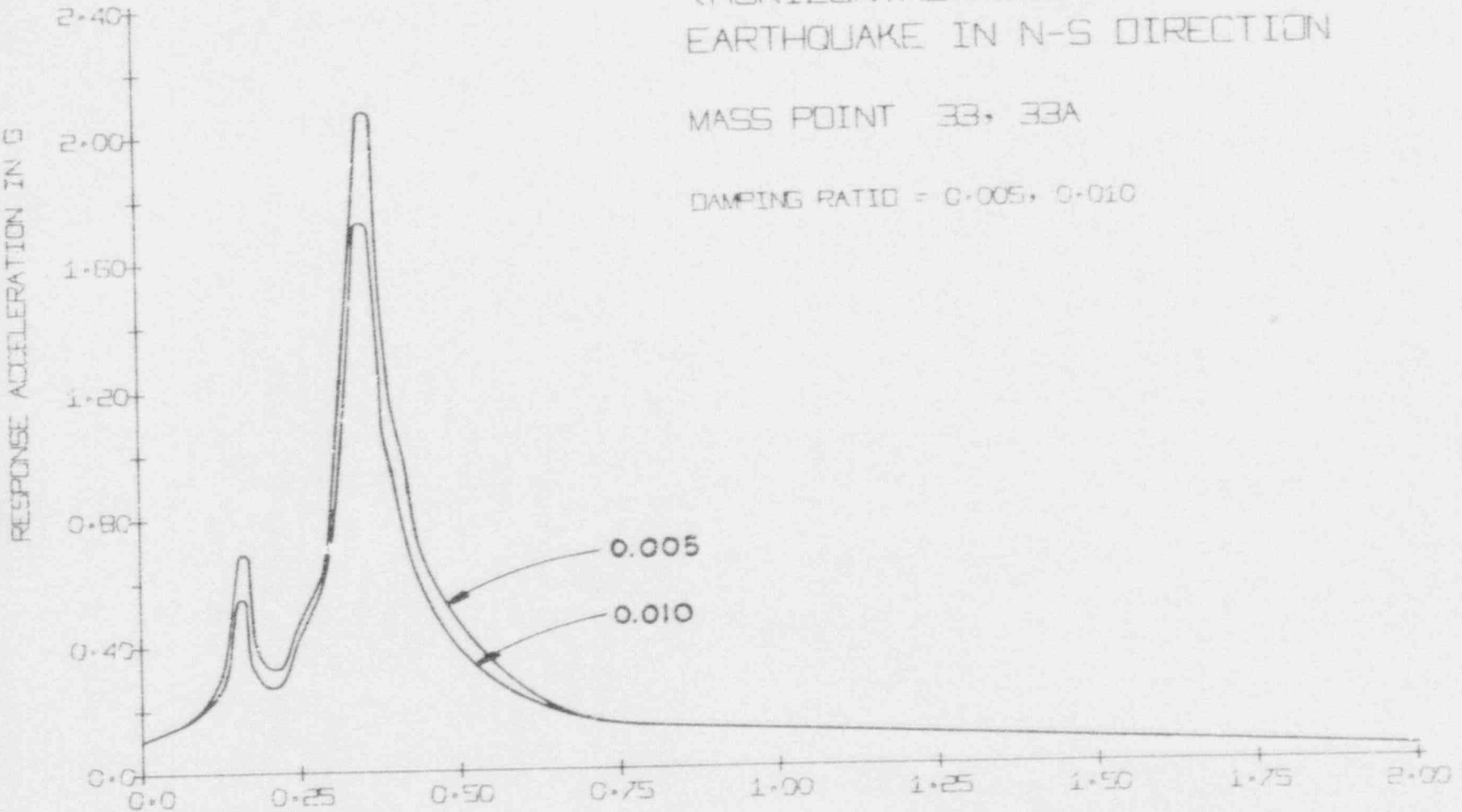


FIGURE NO. 22

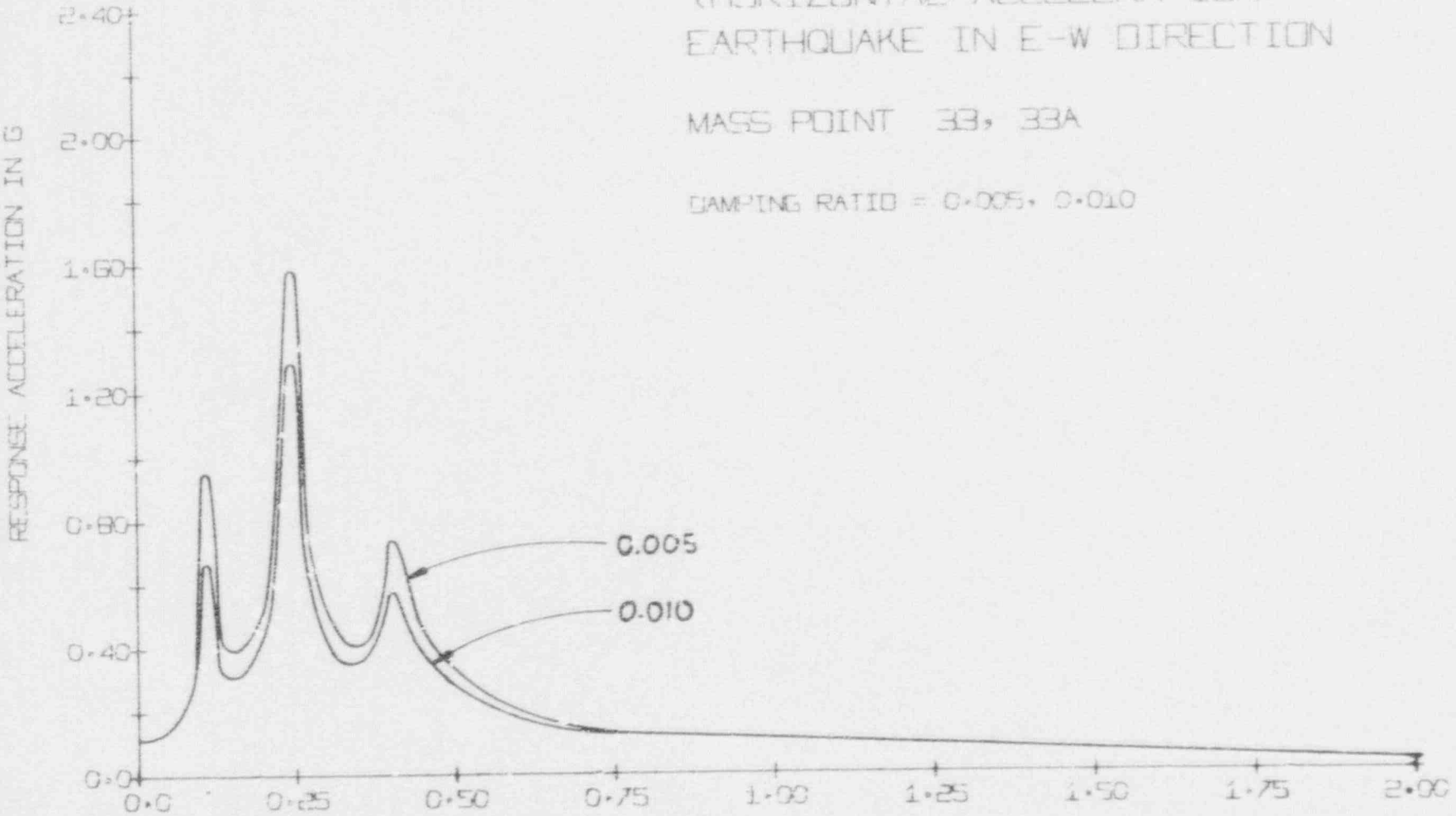
MARCH 5, 1968

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN E-W DIRECTION

MASS POINT 33, 33A

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1968

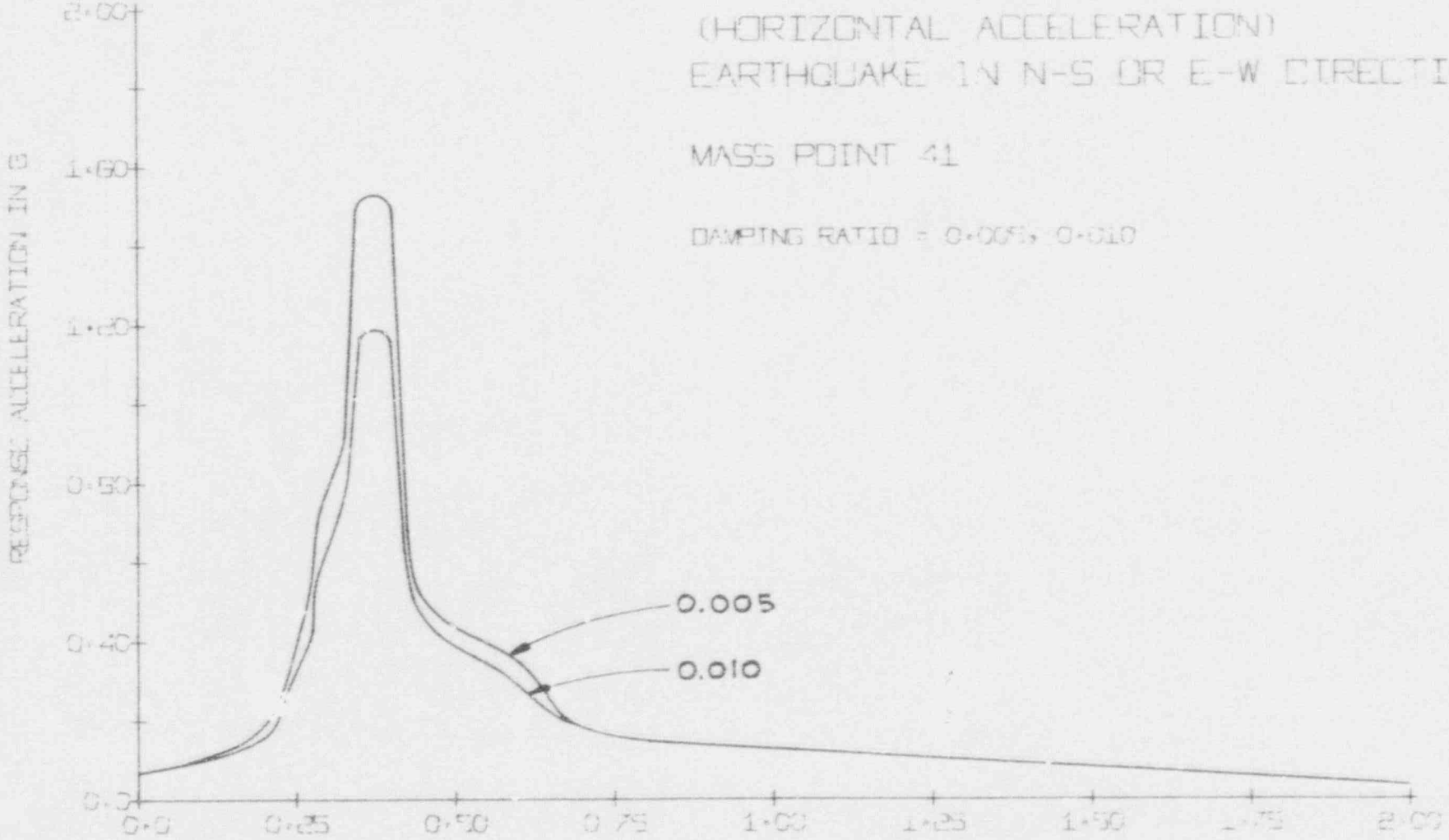
FIGURE NO. 23

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 41

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

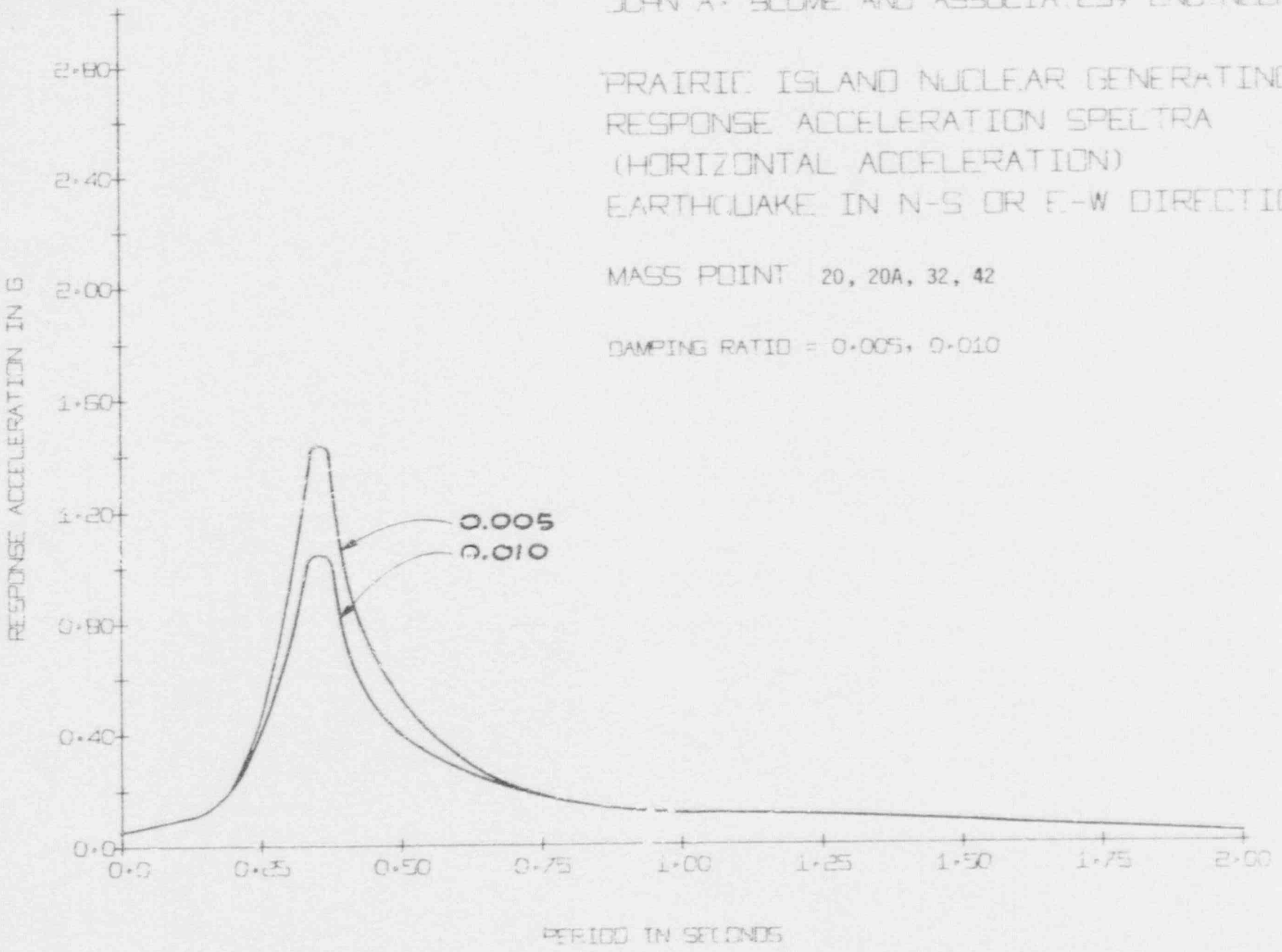
FIGURE NO. 24

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 20, 20A, 32, 42

DAMPING RATIO = 0.005, 0.010



MARCH 5, 1969

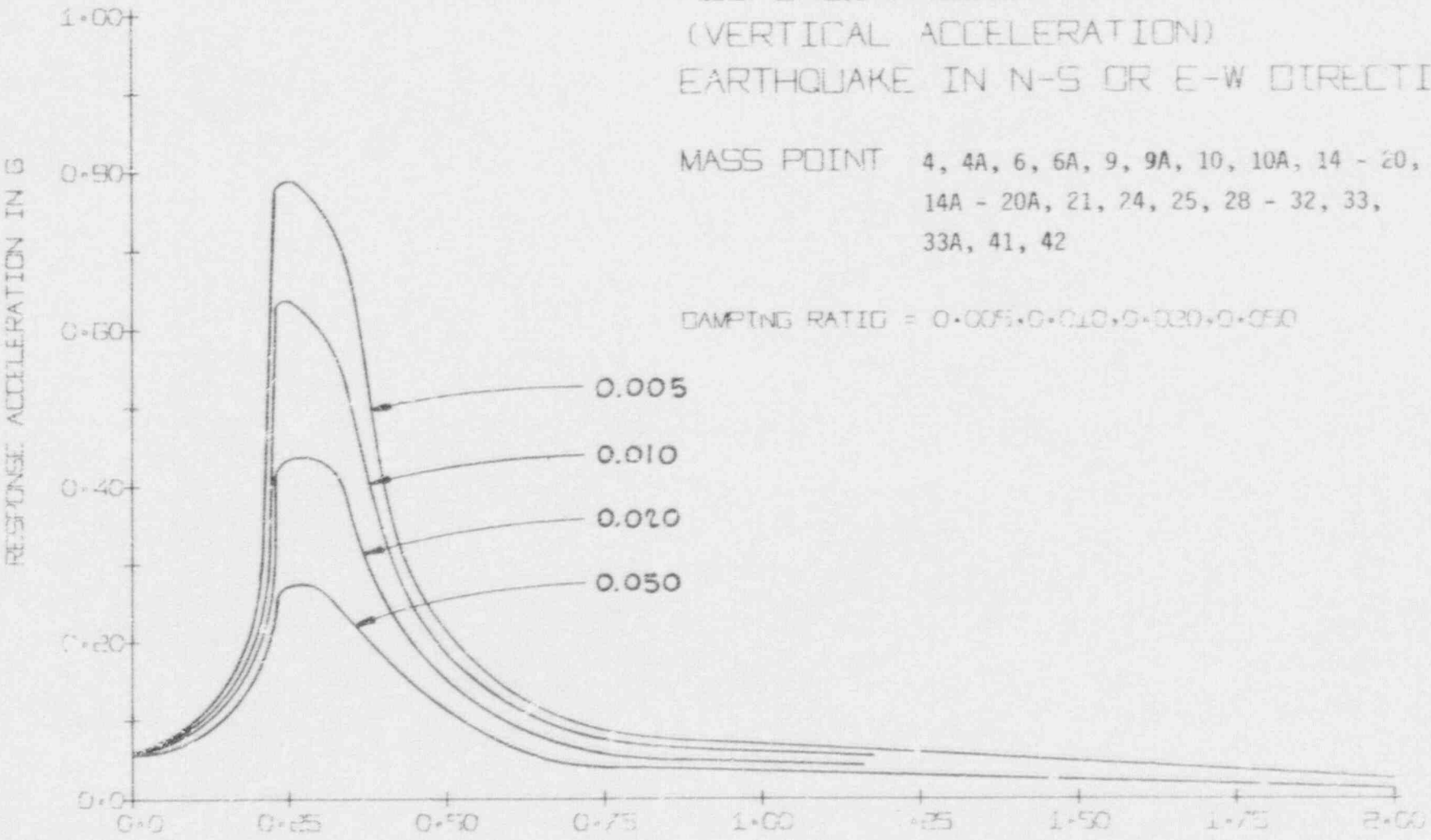
FIGURE NO. 25

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(VERTICAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

MASS POINT 4, 4A, 6, 6A, 9, 9A, 10, 10A, 14 - 20, 14A - 20A, 21, 24, 25, 28 - 32, 33, 33A, 41, 42

DAMPING RATIO = 0.005, 0.010, 0.020, 0.050



MARCH 5, 1969

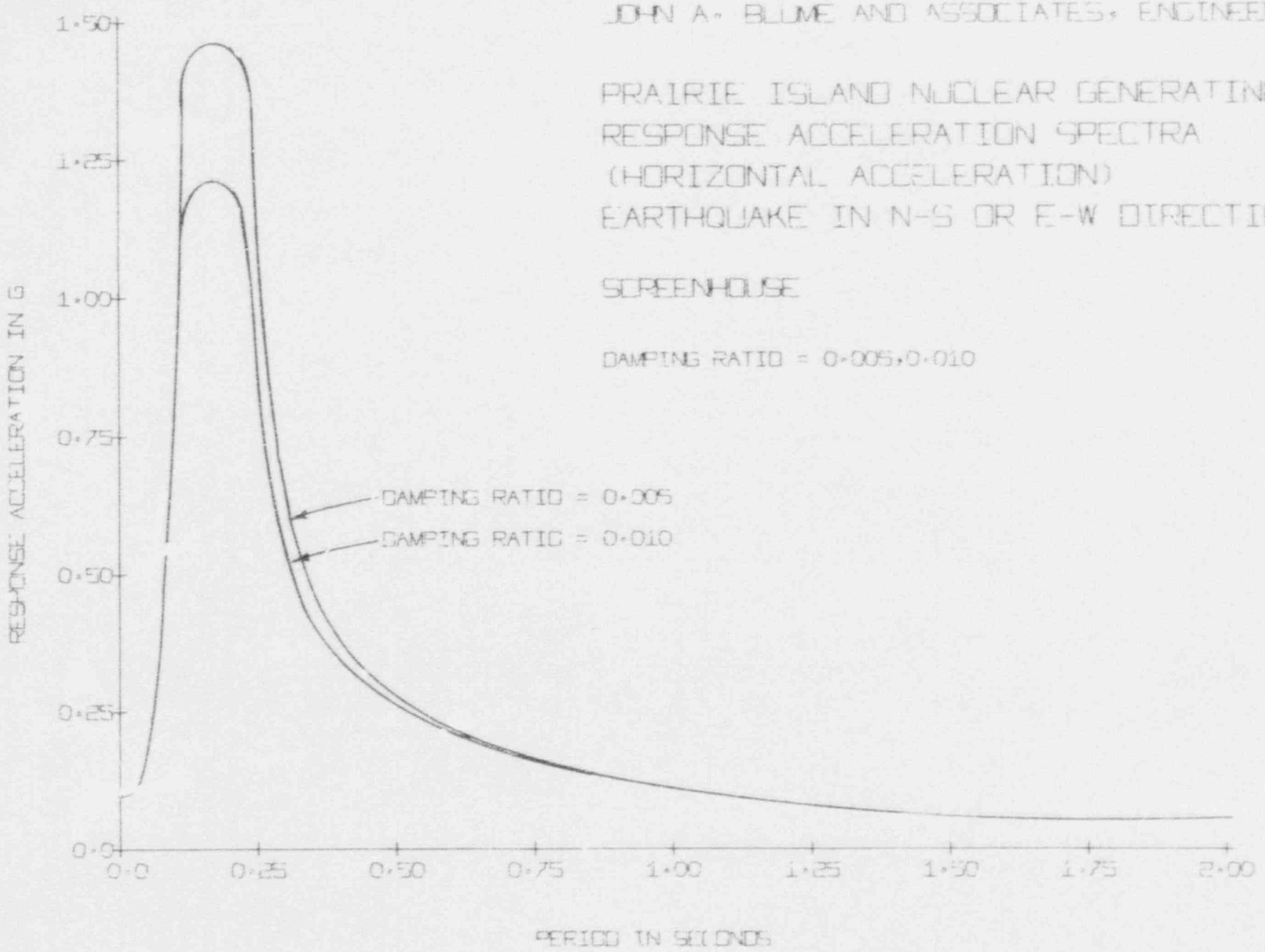
FIGURE NO. 26

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(HORIZONTAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

SCREENHOUSE

DAMPING RATIO = 0.005, 0.010



DEC. 2, 1968

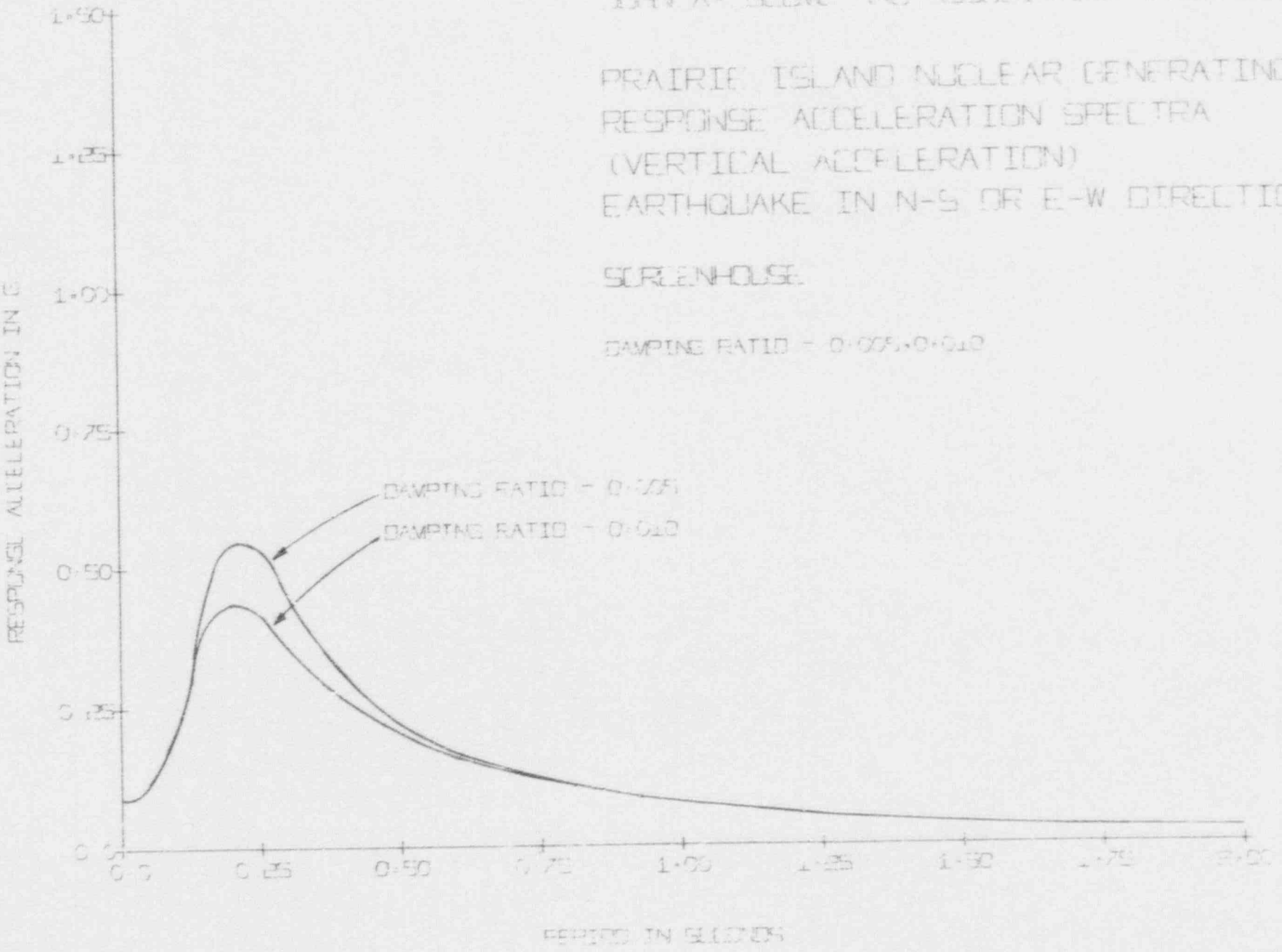
FIGURE 27

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RESPONSE ACCELERATION SPECTRA
(VERTICAL ACCELERATION)
EARTHQUAKE IN N-S OR E-W DIRECTION

SCREENHOUSE

DAMPING RATIO = 0.005, 0.010



DEC. 2, 1968

FIGURE 28

APPENDICES

A. References

B. Example of the Application of the Horizontal Response Acceleration Spectra.

C. Example of the Application of the Vertical Response Acceleration Spectra.

APPENDIX A

REFERENCES

1. Prairie Island Nuclear Generating Plant Earthquake Analysis: Reactor-Auxiliary-Turbine Building by John A. Blume & Associates, Engineers, January 22, 1971.

2. Facility Description and Safety Analyses Report, Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, Units 1 and 2.

3. Spectrum Analysis of Strong-Motion Earthquakes by J.L. Alfred, G.W. Housner, and R.R. Martel, California Institute of Technology, 1951.

APPENDIX B

EXAMPLE OF THE APPLICATION OF THE HORIZONTAL RESPONSE ACCELERATION SPECTRA

The procedure for the use of the horizontal response acceleration spectra presented in this report for the seismic analysis and design of critical equipment is illustrated in this appendix. An item of equipment that can be idealized as a single-degree-of-freedom system has been selected as an example. The example equipment, the corresponding mathematical model, and the location of the equipment in plan are shown in Figures B-1, B-2, and B-3, respectively. Note that the equipment mounted at Elevation 735.0' (mass point number 30). Assume that the weight of the equipment, W, is 28,000 pounds and the stiffness of the equipment support, K, is 126,000 pounds per inch in the horizontal direction.

The natural period of vibration of the equipment is $T = 2\pi\sqrt{W/Kg} = 0.15$ second. The horizontal translational response acceleration for the equipment can be determined to be 0.15g from Figure 20 (for a period of 0.15 second and a damping ratio of 0.01).

This translational acceleration must be increased to account for torsional accelerations. The equipment in question is located a distance R of 50 feet from the center of mass of the floor on which it is supported (Figure B-3). With this value of R, the calculated period, and a damping ratio of 0.010, the factor to account for torsion is 1.21 (Table 1).

The total horizontal acceleration for which the example equipment must be designed is then (1.21) (0.15g) = 0.18g, and the corresponding design lateral force is 0.18W = 5,040 pounds.

This horizontal force for the Design Earthquake (0.06g) is shown in Figure B-4. The lateral force for the Maximum Credible Earthquake (0.12g) is (2) (5,040) = 10,080 pounds.

The acceleration in the vertical direction can be determined in a similar manner and is not illustrated in this appendix. In most cases, many items of equipment have very short periods in the vertical direction and can therefore be designed for the peak vertical floor acceleration.

The procedures described in this appendix for single-degree-of-freedom systems can be extended to multi-degree-of-freedom systems such as piping, by the use of dynamic analysis techniques.

Refer to Appendix C for an example of the Application of vertical response acceleration spectra.

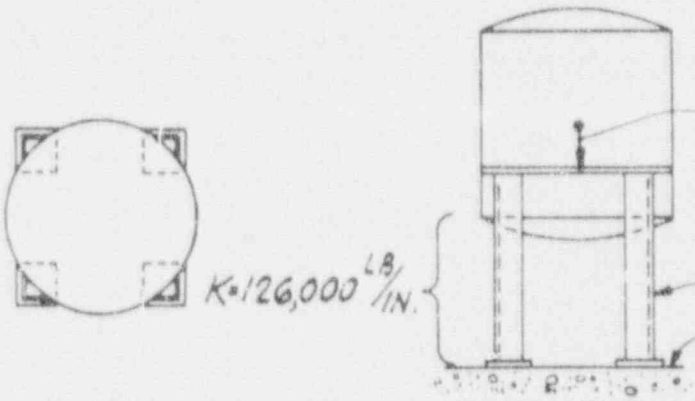


FIGURE B-1
EXAMPLE EQUIPMENT

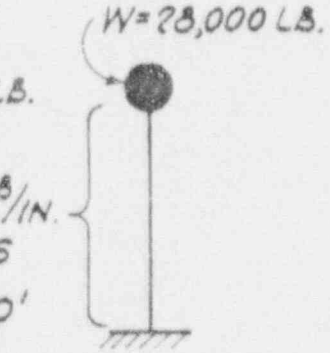
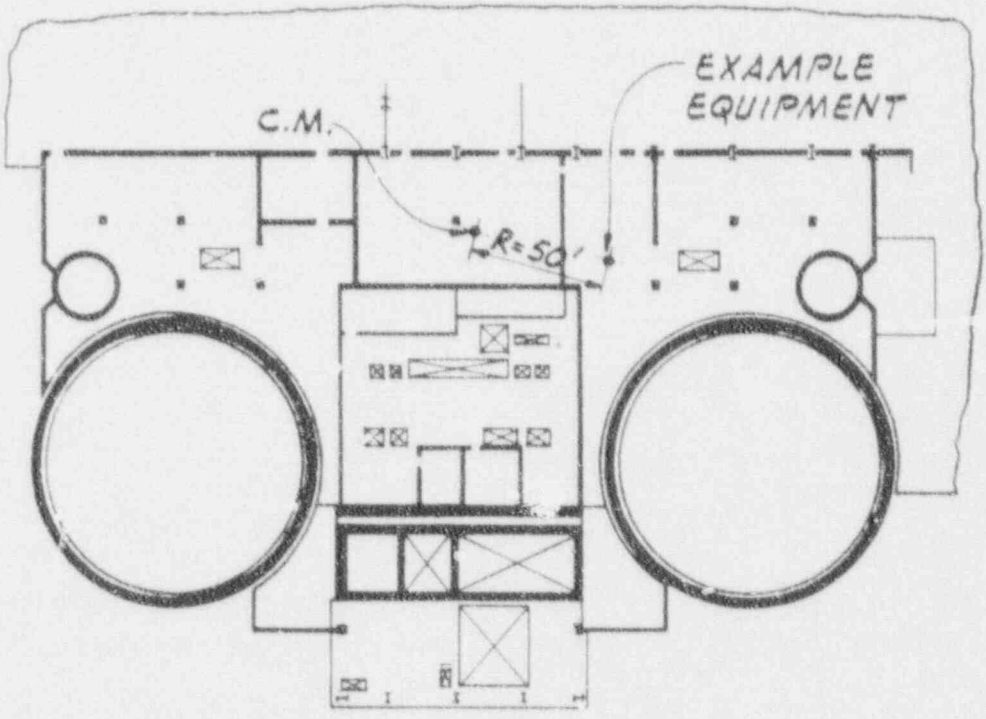


FIGURE B-2
MATHEMATICAL MODEL



PART PLAN ELEV. 735.0'

FIGURE B-3
EQUIPMENT LOCATION

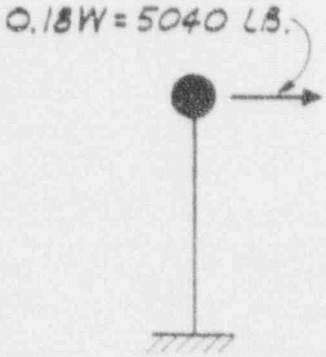


FIGURE B-4
DESIGN LATERAL FORCE

APPENDIX C

EXAMPLE OF THE APPLICATION OF THE VERTICAL RESPONSE ACCELERATION SPECTRA

The procedure for the use of the vertical response acceleration spectra presented in this report for the seismic analysis and design of critical equipment is illustrated in this appendix. Procedures are presented for equipment supported on a beam or slab and for a simple-span beam.

1. Equipment supported on a beam or slab

   a. Rigid beam or slab

      An item of equipment that can be idealized as a single-degree-of-freedom system has been selected as an example. It is assumed that the beam or slab supporting the equipment is rigid. The example equipment and corresponding mathematical model are shown in Figure C-1. The vertical acceleration spectra are applicable at the specified locations (mass points). Assume that the weight of the equipment, W, is 30,000 pounds and that the stiffness of the equipment support, K_v, is 150,000 pounds per inch in the vertical direction.

      The natural period of vibration of the equipment in the vertical direction is $T_e = 2\pi\sqrt{W/K_v g} = 0.14$ seconds. The vertical acceleration can be determined from the vertical response acceleration spectra for this period and the appropriate damping ratio. (This procedure is exactly the same as in the horizontal direction as presented in Appendix B). Assume that the vertical response acceleration was determined to be 0.12g. (Figure C-2). Then the vertical seismic load on this piece of equipment is 0.12 (W) = 3,600 pounds. The support of the equipment must then be designed for this vertical seismic load, combined with the horizontal seismic load and appropriate operating loads.

Note that in many cases (pumps, tanks, etc.), the equipment will be rigid in the vertical direction and can therefore be designed for the peak vertical floor acceleration (at T = 0.0 sec. on the vertical response spectra).

b. Flexible Beam or Slab

For this case, it is assumed that the beam or slab supporting the piece of equipment is not rigid and may amplify the input motion to the equipment. An item of equipment that can be idealized as a single-degree-of-freedom system has been selected as an example (Figure C-3). The vertical response of the piece of equipment can be estimated as follows. (The presented techniques are approximate and have been simplified so that they are more appropriate for design purposes).

Estimate the fundamental period, T_s, of the supporting beam or slab. Assume that it was determined that T_s = 0.3 sec., for example. From the vertical response acceleration spectra, select the vertical spectral acceleration, S_{av}, that corresponds to this period for the appropriate damping ratio. Assume that this value was determined to be S_{av} = 0.60g (Figure C-2). Compute the period of the equipment, T_e, by the method described in the previous section. Using the same example equipment, T_e = 0.14 seconds. Compute the T_e/T_s = 0.47. Obtain the dynamic amplification factor, DAF, from Figure C-4. The peak vertical acceleration of the equipment can be estimated as $(DAF)(S_{av})$ = (4.5)(0.60) = 2.70g and the vertical seismic load on the equipment is (2.70)(W). The supports of the equipment must be designed for this vertical load combined with horizontal seismic loads and appropriate operating loads.

2. Simple span beams on Rigid Supports

The following are simplified, approximate techniques for es-

timating the vertical response of simple span beams. The procedures apply to beams or girders with fundamental periods less than or equal to 0.5 seconds, in which case only the first mode is considered as contributing to the response of the system. The vertical response of a simple span bea with a uniform load, ω, length L, and uniform moment of inertia, I (Figure C-5) can be estimated as follows. Compute the period of the beam from $T = 0.637\left(\frac{\omega L^4}{gEI}\right)^{\frac{1}{2}}$, select the vertical response acceleration from the response spectra for this period and appropriate damping ratio. Estimate the effective seismic loading $\omega' = 0.79\, S_a \omega$. Compute seismic moments shears, etc., due to this loading by conventional procedures.

The vertical response of a simple span beam with a uniform load, ω and concentrated load, P, (Figure C-6) can be estimated as follows. Compute an equivalent load $P_e = P + \omega L/2$. Estimate the period from $T = 0.906\left(\frac{PeL^3}{gEI}\right)^{\frac{1}{2}}$, and determine the vertical acceleration from the vertical acceleration response spectra as before. Compute the effective seismic loadings $P' = S_a P$ and $\omega' = S_a$ and determine the seismic shears, moments, etc., due to this loading by conventional procedures.

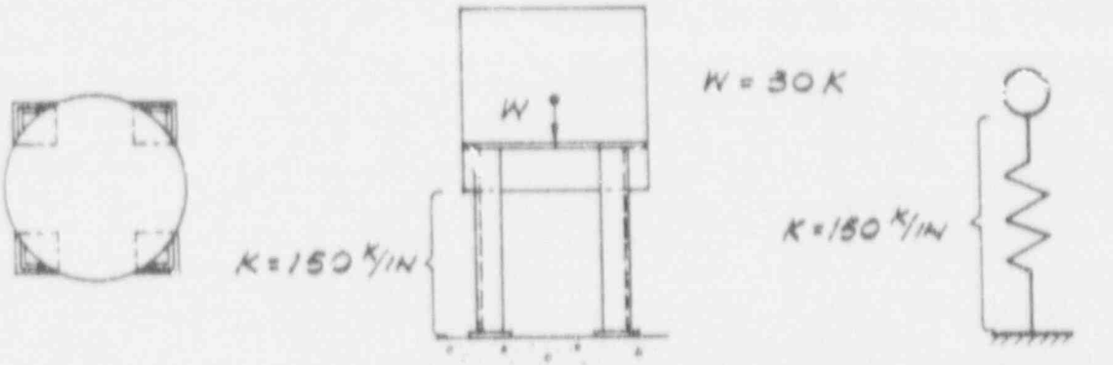


FIG. C-1 EQUIPMENT SUPPORTED ON RIGID BEAM OR SLAB

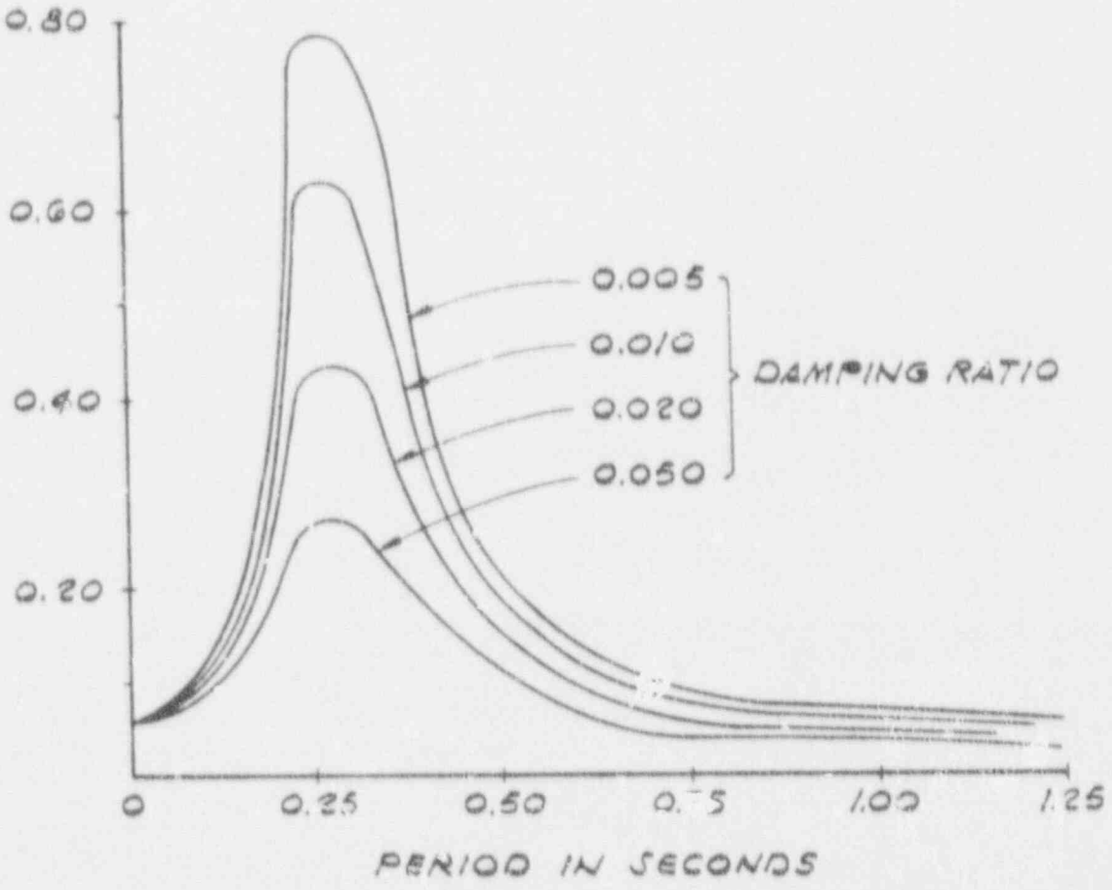


FIG. C-2 EXAMPLE VERTICAL RESPONSE ACCELERATION SPECTRA

FIG. C-3 EQUIPMENT SUPPORTED ON FLEXIBLE BEAM OR SLAB

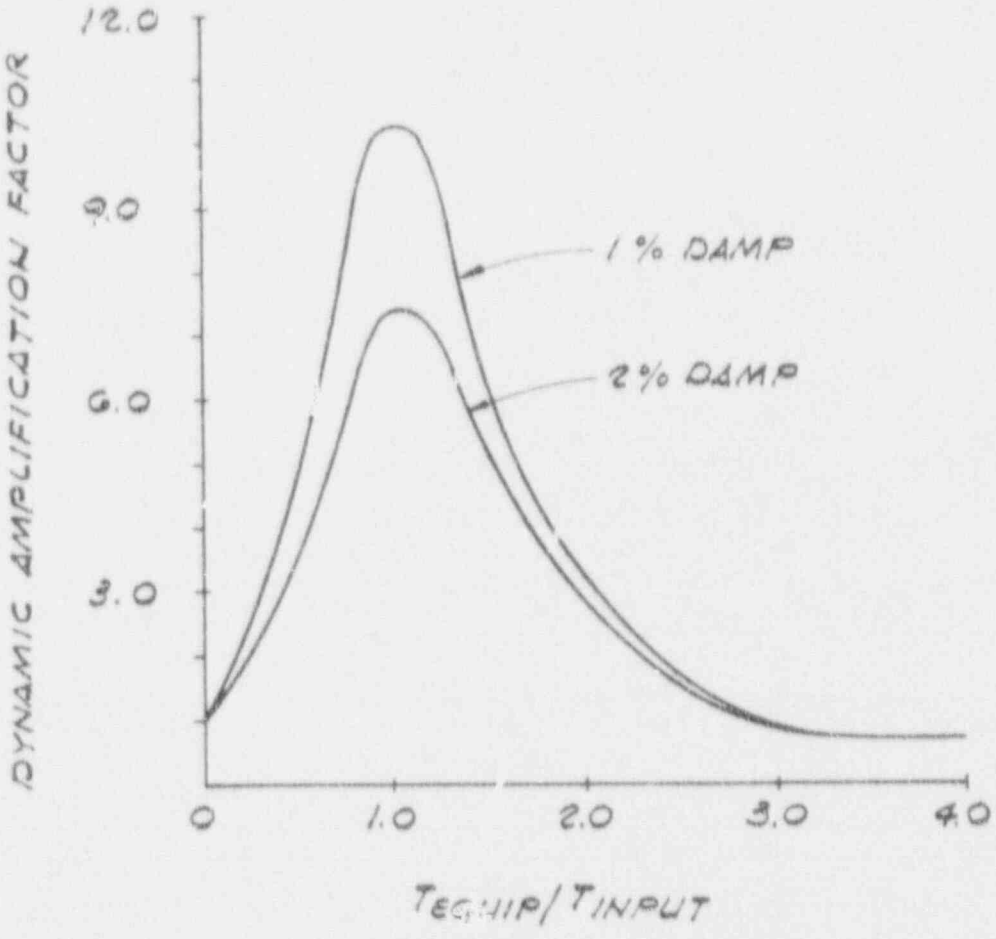


FIG. C-4 DYNAMIC AMPLIFICATION FACTOR

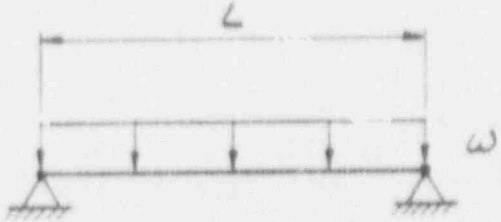


FIG. C-5 SIMPLE SPAN BEAM ON RIGID SUPPORTS WITH LOAD

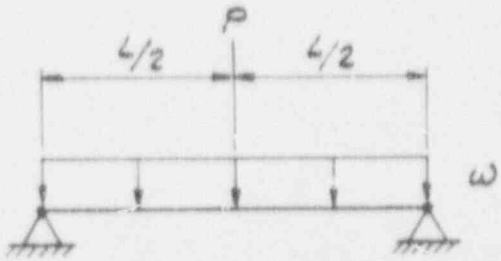


FIG. C-6 SIMPLE SPAN BEAM ON RIGID SUPPORTS WITH UNIFORM AND CONCENTRATED LOADS