50-286 INDIAN POINT 3 , PASNY

PROCEDURES & CRITERIA FOR GENERATION OF IN-STRUCTURE RESPONSE SPECTRA (Attachment 2)

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ATTACHMENT 2 TO JPN-92-053

PROCEDURES AND CRITERIA FOR GENERATION OF IN-STRUCTURE RESPONSE SPECTRA

NEW YORK POWER AUTHORITY
JAMES A. FITZPATRICK NUCLEAR POWER PLANT
DOCKET NO. 50-333
DPR-59

PROCEDURES AND CRITERIA FOR GENERATION OF IN-STRUCTURE RESPONSE SPECTRA

JAMES A. FITZPATRICK NUCLEAR POWER PLANT

NEW YORK POWER AUTHORITY

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STONE & WEBSTER ENGINEERING CORPORATION
NEW YORK, NEW YORK

PROCEDURES AND CRITERIA FOR GENERATION OF IN-STRUCTURE RESPONSE SPECTRA

JAMES A. FITZPATRICK NUCLEAR POWER PLANT

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1.0 INTRODUCTION

The purpose of this report is to provide detailed information concerning the procedures and criteria used to generate the in-structure response spectra for the James A. FitzPatrick Nuclear Power Plant. This information is provided as an integral part of the response to the NRC "Supplement No. 1 to Generic Letter (GL) 87-02 that transmits Supplemental Safety Evaluation Report No. 2 (SSER No. 2) on SQUG Generic Implementation Procedure, Revision 2, as corrected on February 14, 1992 (GIP-2)".

The in-structure response spectra proposed for use in the Unresolved Safety Issue (USI) A-46 evaluation are those developed for the original design, and will be used as the conservative, design, in-structure response spectra for implementation using Method B of GIP-2. Method A of GIP-2, comparison of seismic capacity with ground response spectra, will be used when applicable.

2.0 GEOLOGICAL AND SEISMOLOGICAL CONDITIONS AROUND THE SITE

The James A. FitzPatrick nuclear power plant lies within the Erie - Ontario lowland physiographic province and in the northern part of the Appalachian Basin geologic province. The Appalachian Basin is characterized by few deformation features. The two minor geologic features which were found during construction have no effect on the design or safety of the plant. All structures of the plant are founded directly upon competent sandstone bedrock.

The regional study of seismicity and tectonics indicates that no significant earthquake ground motion is expected at the site during the design life of the plant. The site region exhibits very low seismicity. Earthquake activity within 50 miles of the site has been infrequent and minor, epicentral intensity smaller than Modified Mercalli Intensity III (MM). No earthquake damage has resulted from this activity. The earthquake closest to the site, which resulted in any damage at the epicenter, occurred near Lowville, New York, approximately 50 miles east northeast of the site. Some minor earthquake activity, not directly associated with any known geologic structure, has occurred in the vicinity of Buffalo, New York, to the west of the site in 1857, 1879, 1944, 1946 and 1962. The lack of a well defined relationship between seismicity and geologic structure required a conservative assessment of the design values for vibratory ground motion at the site based on the delineation of tectonic provinces as required by Appendix A to 10 CFR 100.

There are two structurally restrictive areas of repeated earthquake activity within 200 miles of the site that are significant to seismic assessment. These are: 1) The concentration of activity near Massena, New York which generated a maximum event of intensity equal to VIII (MM) in 1944; and 2) seismicity associated with the Clarendon Linden fault near Attica, New York, the largest of which was the August 12, 1929 shock of intensity equal to VII - VIII (MM). A recurrence of the 1944 Massena earthquake on the Gloucester fault at a minimum distance of about 109 miles would cause intensity V (MM) at the site. It is significant that structures in the epicentral area founded on rock or dense compact soils did not sustain any appreciable damage. The greatest damage in the epicentral area was suffered by structures founded on outwash sands, silt and clays. A recurrence of the 1929 Attica event would be felt at the site with intensity V (MM).

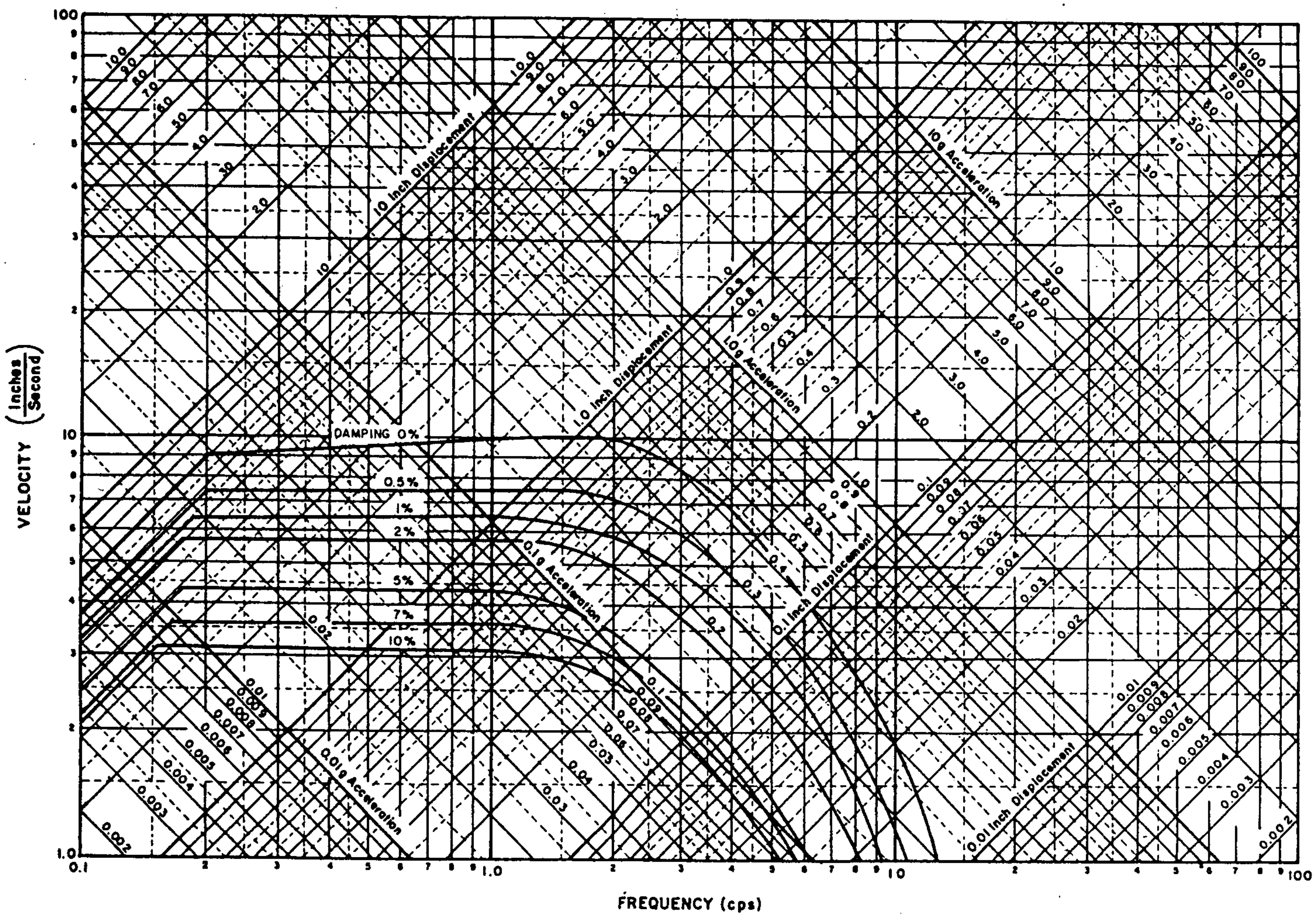
An intensity IX (MM) event, in the St. Lawrence Valley would be attenuated to slightly more than V (MM) at the site. Effects at the site from large distant shocks such as Charleston, S.C. earthquake of 1886 or the New Madrid events of 1811/1812 would be minimal. The only additional consideration for seismic design is the random activity in the site region which cannot be associated with specific geologic structures. Within the site tectonic province, historical occurrence of shocks of VI (MM) or less have not been associated with any known geologic structure. Therefore, the maximum earthquake potential at the site must be represented by the random occurrence of an intensity VI (MM) shock, a level of ground motion larger than the cases discussed above.

A geophysical survey was done in 1968 for the James A. FitzPatrick site. Reported compressional wave velocities range from 3367 to 4600 m/sec (11,046 to 15,093 ft/sec). Shear wave velocities range in value from 1694 to 2445 m/sec (5,559 to 8,020 ft/sec). Young's modulus, shear modulus and Poisson's ratio were calculated from these values. The average values of Young's modulus and shear modulus are 4.2×10^6 and 1.6×10^6 psi respectively.

3.0 GROUND RESPONSE SPECTRA

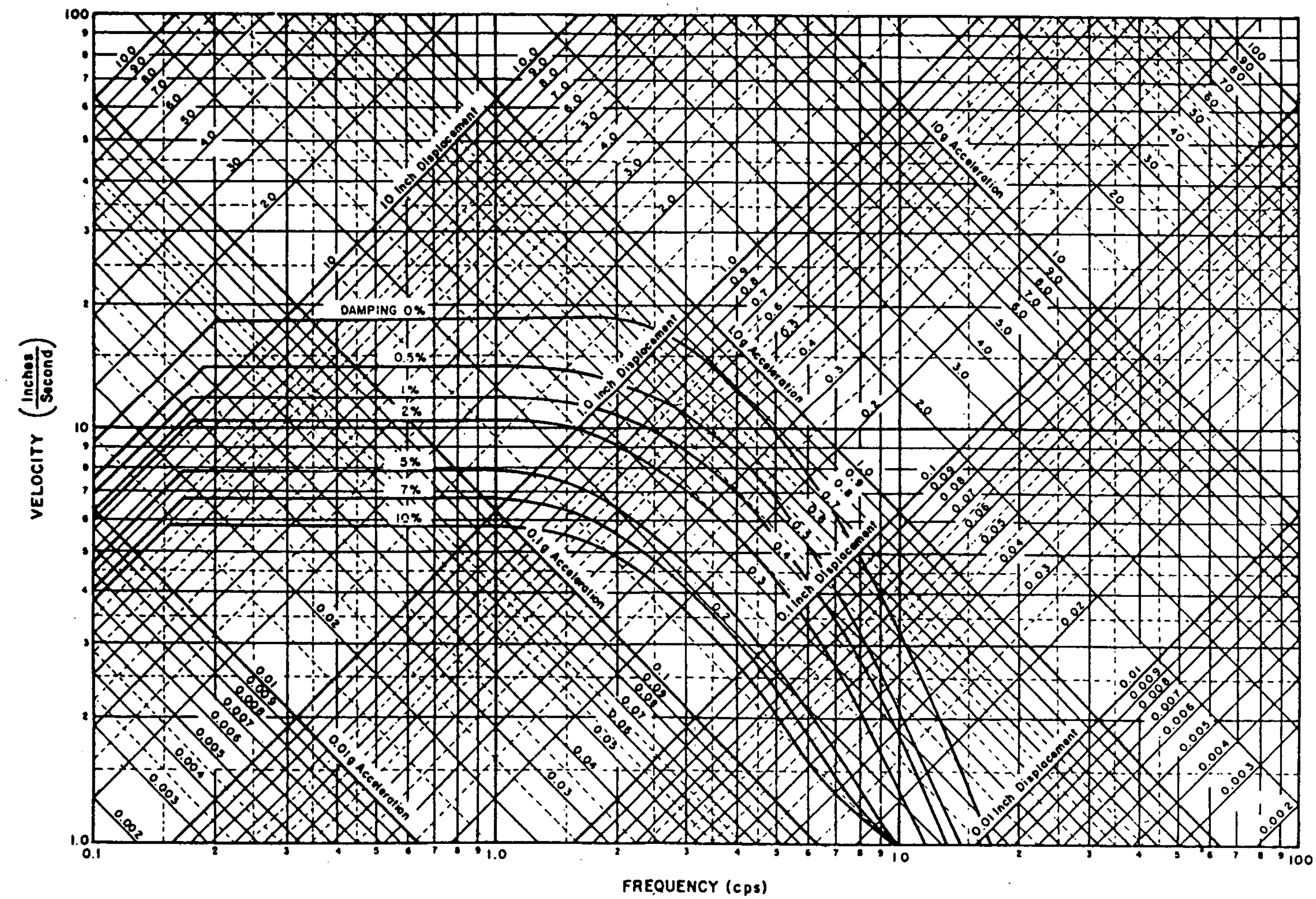
It was concluded in the FSAR that the maximum ground surface acceleration resulting from any historical events in the entire region has been no more than 0.05 g at the site. The historical record would indicate that the Seismic Class I structures of the plant could be designed for an Operating Basis Earthquake (OBE) of 0.05 g horizontal ground acceleration and a Design Basis Earthquake (DBE) of 0.10 g horizontal ground acceleration as all structures are founded on or within competent bedrock. However, to be conservative, the OBE was assumed to correspond to horizontal ground acceleration of 0.08 g and DBE was assumed to correspond to horizontal ground acceleration of 0.15 g. Ground response spectra were generated by normalizing the Housner response spectra at "zero period" to 0.08 g and 0.15 g for the OBE and DBE, respectively and are shown in Figures 3.0-1 and -2 (Figures 2.6-1 and -2, UFSAR).

The DBE ground response spectra with a zero period acceleration of 0.15 g should effectively envelope ground response resulting from the occurrence of the events near the site or distant events such as those in the St. Lawrence Valley.



JAMES A. FITZPATRICK		FSAR UPDATE
OPERATING BASIS EARTHQUAKE RESPONSE SPECTRA - 0.08g		
REV. 0	JULY, 1982	FIGURE NO. 2.6-1

FIG. 3.0-1 OPERATING BASIS EARTHQUAKE - GROUND RESPONSE SPECTRA



JAMES A. FITZPATRICK		FSAR UPDATE
DESIGN BASIS EARTHQUAKE RESPONSE SPECTRA 0.15g		
REV. 0	JULY, 1982	FIGURE NO. 2.6-2

FIG. 3.0-2 DESIGN BASIS EARTHQUAKE - GROUND RESPONSE SPECTRA

4.0 BUILDING ANALYSIS

4.1 General

The seismic response of the building structure was analyzed using the response spectrum approach. Since the buildings are founded on bedrock with shear wave velocity exceeding 5500 ft/sec, any soil-structure interaction effect was considered negligible. Therefore, soil-structure interaction analysis is not required. The free field ground response spectra, Figs. 3.0-1 and -2, were utilized as the response spectra at the base of the structures.

Basically the plant consists of two building complexes: 1) the reactor building housing the reactor pressure vessel, primary shield wall, drywell and the suppression chamber, and 2) the turbine building complex which includes the turbine building, administration building, radwaste building, screenwell pumphouse and emergency diesel generator building. These structures were modeled as beam elements. The masses of walls, floors and equipment were lumped discretely at floor elevations and other major structural discontinuities. Computer programs were utilized to generate the mass and stiffness/flexibility matrices, and to calculate the natural frequencies, mode shapes, participation factors, modal accelerations, and finally, building accelerations and displacements.

4.2 Reactor Building

The reactor building has a common foundation mat resting on bedrock and supporting the reactor pressure vessel, primary shield wall, drywell, suppression chamber and the building enclosure (secondary containment) as shown in Fig. 4.2-1 (UFSAR Fig. No. 12.3-7). All these structures, except the suppression chamber, were included in the mathematical model of the reactor building. Although the suppression chamber was analyzed independently, as discussed in Section 4.4, its mass was included in the model and lumped with the reactor building masses.

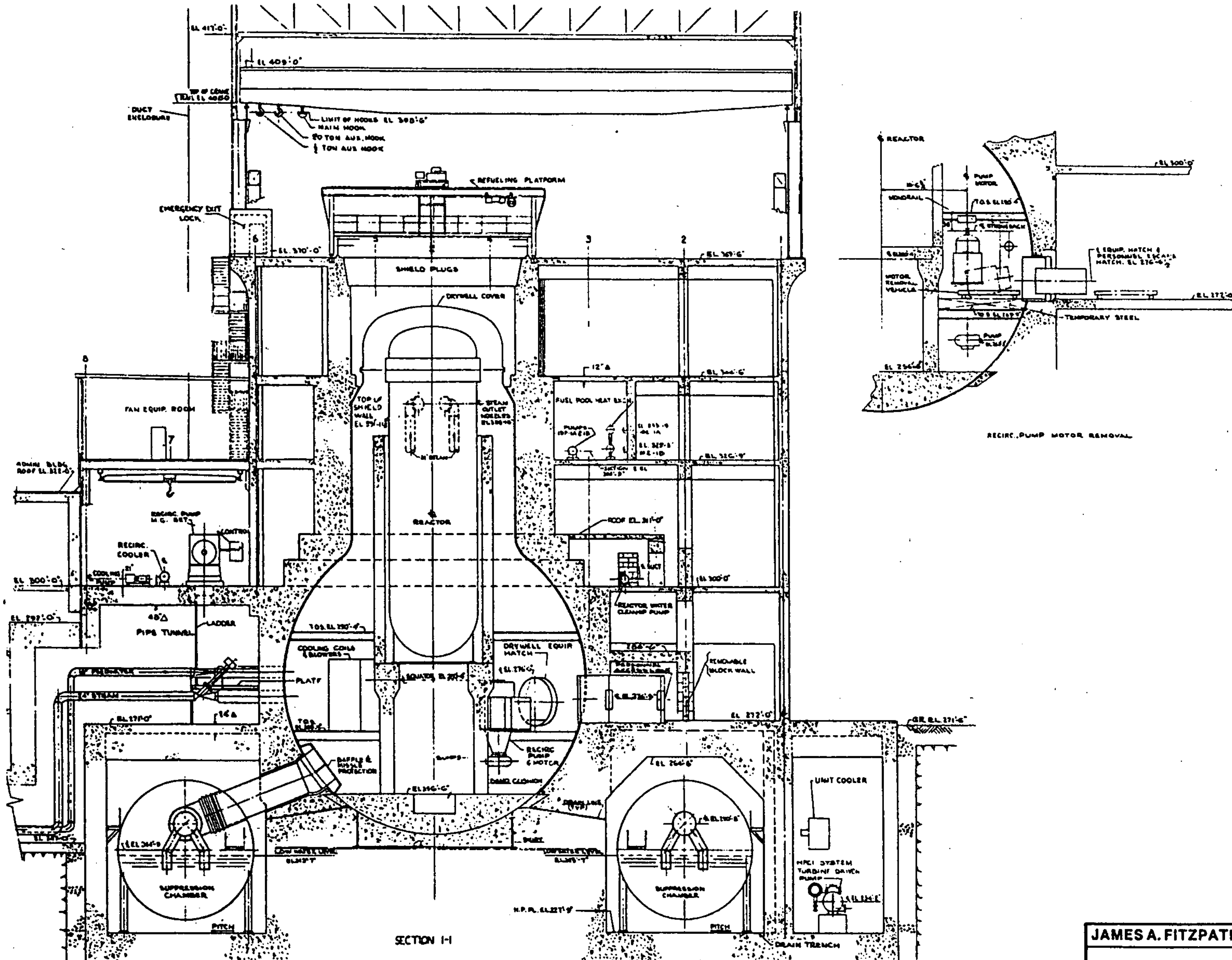
The structural seismic response analysis was finalized in 1972 (Reference 6.3). The structures were modeled with two-dimensional beam elements. The basic model had 37 lumped masses representing the major structures. It was expanded to 89 lumped masses to include the refined modeling of the reactor pressure vessel and its internals as provided by General Electric Co., the NSSS manufacturer. As shown in Fig. 4.2-2 (Fig. No. 12.5-1, UFSAR) the drywell is connected to the reactor building by shear lugs represented by the element 22-26. Elements 25-26, 16-20 and 10-11 represent the structural connections between the drywell and the primary shield wall. Elements 25-29 and 13-14 simulate the reactor vessel stabilizer system and skirt respectively. A study was made and concluded that a single mathematical model was acceptable to represent the dynamic characteristics of the building in both east-west and north-south directions.

The bedrock was represented by translational springs, vertical and horizontal, calculated based on an equivalent circular base. Rocking springs were not considered, since the rocking stiffness of bedrock was judged to be extremely rigid.

The stiffness matrix and its static condensation of the mathematical model were calculated by STARDYNE program. Using these as the input data, a free vibration analysis was performed. The analysis was performed for horizontal and vertical motions independently, assuming that the two motions were decoupled from each other. Tables 4.2-1 and 4.2-2 show the natural frequencies and their participation factors for the horizontal and vertical vibrations respectively. Table 4.2-3 delineates the mode shapes of the first twenty modes for the horizontal model.

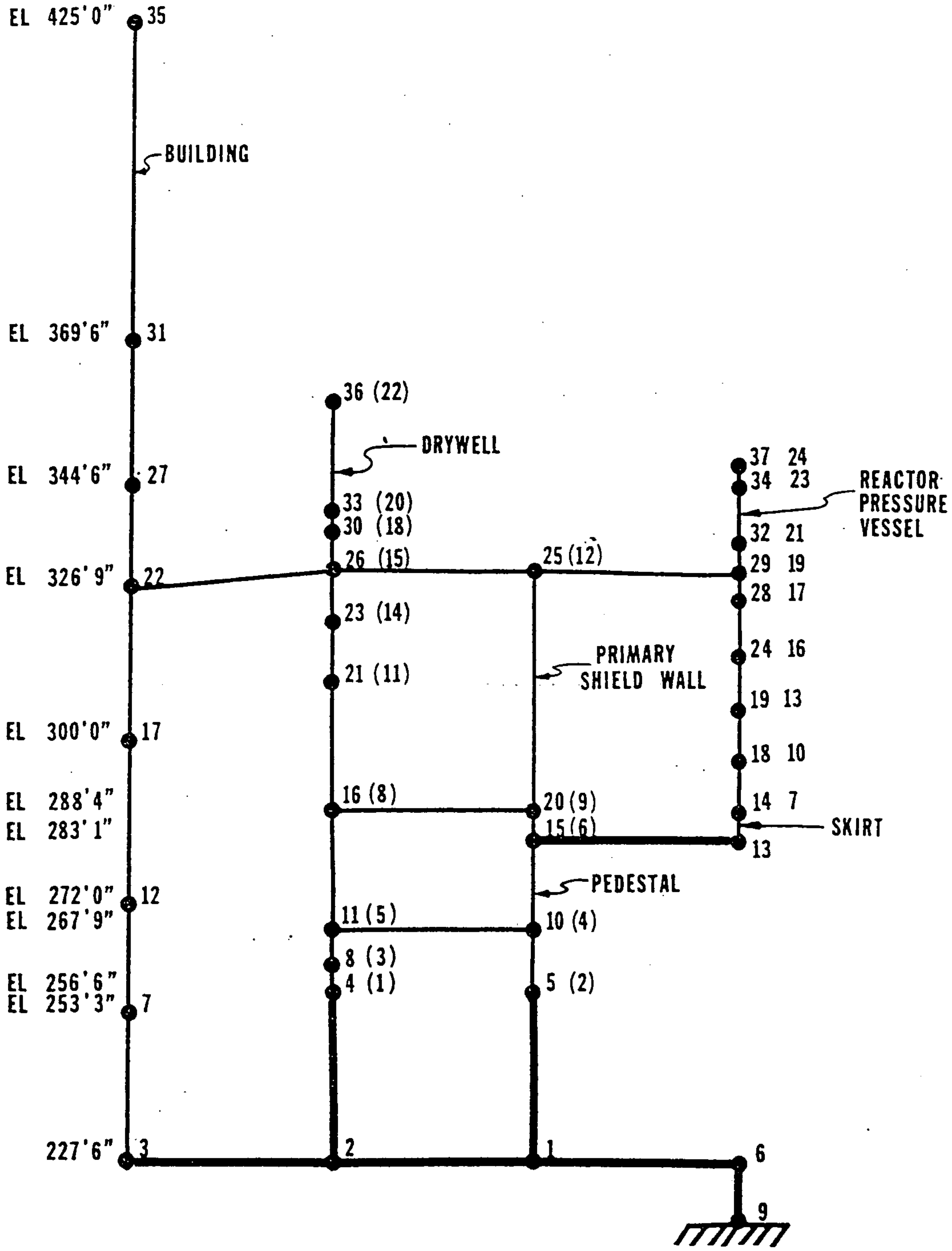
Damping values for the DBE were defined as 5% and 3% of the critical damping for concrete and steel structures respectively. Since the reactor building mathematical model is a composite of concrete and steel structures, a weighted average damping value was calculated for each mode based on the relative strain energy of each individual structural element. For example, the damping value for the first two modes of the horizontal motion was calculated as 3%, and for the third and fourth modes 3.5%.

Tables 4.2-4 and 4.2-5 show the modal accelerations at various elevations for the first twenty (20) modes for horizontal motion and fifteen (15) modes for vertical motion respectively. The total seismic acceleration at a specific location was calculated as the square root of the sum of the squares of all significant modal accelerations at that location.



JAMES A. FITZPATRICK		FSAR UPDATE
REACTOR BUILDING CROSS SECTION 1-1		
REV. 0	JULY, 1982	FIGURE NO. 12.3-7

FIG. 4.2-1 REACTOR BUILDING CROSS SECTION



JAMES A. FITZPATRICK		FSAR UPDATE
MODEL FOR DYNAMIC ANALYSIS OF REACTOR BUILDING		
REV. 0	JULY, 1982	FIGURE NO. 12.5-1

FIG. 4.2-2 REACTOR BUILDING MATHEMATICAL MODEL

TABLE 4.2-1 REACTOR BUILDING
NATURAL FREQUENCIES AND PARTICIPATION FACTORS
HORIZONTAL MODEL

MODE	FREQUENCY (HZ)	PARTICIPATION FACTOR
1	2.33	-1.605
2	3.60	-2.153
3	3.77	-1.531
4	5.04	-2.806
5	5.69	-6.214
6	5.78	-6.393
7	8.87	-0.194
8	12.85	-1.901
9	14.84	-1.234
10	16.40	-0.111
11	17.14	-0.026
12	18.67	-0.700
13	21.01	-0.052
14	23.00	-1.112
15	25.13	-2.828
16	26.40	-1.695
17	28.23	-0.166
18	31.32	0.052
19	33.95	-4.619
20	34.03	-4.666

TABLE 4.2-2 REACTOR BUILDING

NATURAL FREQUENCIES AND PARTICIPATION FACTORS
VERTICAL MODEL

MODE	FREQUENCY (HZ)	PARTICIPATION FACTOR
1	10.74	1.837
2	18.73	2.256
3	21.48	-1.982
4	32.43	-0.001
5	35.69	0.614
6	37.91	-0.343
7	40.66	-0.407
8	52.39	0.007
9	57.86	0.019
10	59.61	-0.032
11	72.53	0.002
12	73.11	0.014
13	78.25	0.037
14	81.74	-0.013
15	87.23	-0.016

TABLE 4.2-3 REACTOR BUILDING

MODE SHAPES OF HORIZONTAL MODEL

	ELEVATION (FEET)									
MODES	REACTOR BUILDING				DRYWELL		PSW		R.P.V	
	272.0	326.8	369.5	425.0	278.0	351.0	284.0	330.8	298.9	337.5
1	.0016	.0050	.0083	1.0000	.0010	.0062	.0013	.0048	.0023	.0052
2	.0007	.0020	.0024	-.0031	.0004	.0048	.0091	.0080	.0240	.0364
3	.0000	.0001	.0001	-.0001	.0000	.0000	.0008	.0002	.0009	-.0002
4	.0001	.0003	.0003	-.0002	.0001	.0003	.0016	.0006	.0021	.0006
5	.0088	.0225	.0295	-.0163	.0051	.291	.0154	.0274	.0279	.0508
6	.0576	.1438	.1959	-.1069	.0337	.1847	.0572	.1595	.1010	.2276
7	.0082	.0199	.0327	-.0141	.0071	-.0383	-.1823	-.1301	-.3832	-.8156
8	.0115	-.0026	-.0160	.0093	.0113	-.0633	.3672	.1143	.2112	-.6022
9	.5102	.0063	-.4918	.4004	.1248	-.0681	-.1761	-.1166	-.1401	.2876
10	.0008	.0001	-.0002	.0003	-.0002	.0020	-.0164	-.0143	.0001	.0202
11	.0007	.0000	.0006	-.0010	.0001	-.0019	-.0166	-.0246	.0023	-.0198
12	.0162	-.0165	-.0137	-.5733	.0017	-.0222	.0053	-.0246	.0080	.0048
13	.0002	-.0003	.0010	.0011	.0001	-.0009	.0017	-.0262	.0293	-.0013
14	.0031	-.0099	.0192	.0112	.0043	-.0276	.1173	-.3416	.2719	-.1032
15	.0010	-.0029	.0042	.0016	.0007	-.0037	.0164	-.0347	.0112	-.0029
16	.0479	-.1140	.1471	.0432	.0092	-.0986	-.0197	-.0003	-.2609	.1547
17	.0102	-.0165	.0193	.0052	.0019	-.0797	-.1567	.3189	.4675	-.2987
18	.0003	-.0002	.0002	.0000	.0000	-.0032	.0064	.0237	.0394	-.0119
19	-.0076	.0168	-.0176	-.0030	-.0204	.0243	.0026	.0281	-.0135	.0097
20	.0079	.0175	-.0184	-.0031	.0224	.0192	.0035	.0191	.0130	-.0108

TABLE 4.2-4 REACTOR BUILDING
MODAL ACCELERATIONS (g) - HORIZONTAL DBE

Mode	Elevation (feet)									
	Reactor Bldg				Primary Shield Wall		RPV		Drywell	
	425	369.5	326.8	272	330.8	284.2	337.5	298.8	351.8	278
1	-0.401	-0.003	-0.002	-0.001	-0.002	-0.001	-0.002	-0.001	-0.002	0
2	0.002	-0.001	-0.001	0	-0.005	-0.006	-0.022	-0.014	-0.003	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	-0.001	0	-0.001	0	0
5	0.018	-0.033	0.025	-0.010	-0.031	-0.017	0.057	-0.031	-0.033	-0.006
6	0.137	-0.250	-0.190	-0.074	-0.204	-0.073	-0.291	-0.129	-0.236	-0.043
7	0.001	-0.002	-0.001	-0.001	0.008	0.011	0.051	0.024	0.002	0
8	-0.004	0.006	0.001	-0.005	-0.046	-0.147	0.240	-0.084	0.025	-0.004
9	-0.074	0.089	-0.001	-0.094	0.022	0.033	-0.053	0.026	0.013	-0.023
10	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
12	0.060	0.001	0.002	-0.002	0.003	-0.001	-0.001	-0.001	0.002	0
13	0	0	0	0	0	0	0	0	0	0
14	-0.002	-0.003	0.002	-0.001	0.057	-0.020	0.017	-0.045	0.005	-0.001
15	-0.001	-0.002	0.001	0	0.015	-0.007	0.001	-0.005	0.002	0
16	-0.012	-0.037	0.029	-0.012	0	0.005	-0.039	0.066	0.025	-0.002
17	0	0	0	0	-0.008	0.004	0.007	-0.012	0.002	0
18	0	0	0	0	0	0	0	0	0	0
19	0.002	0.012	-0.012	0.005	-0.020	-0.002	-0.007	0.009	-0.017	-0.014
20	0.002	0.013	-0.012	0.006	-0.013	-0.002	0.008	-0.009	-0.018	-0.016

TABLE 4.2-5 REACTOR BUILDING

MODAL ACCELERATIONS (g) - VERTICAL DBE

Mode	Elevation (feet)									
	Reactor Bldg				Primary Shield Wall		RPV		Drywell	
	425	369.5	326.8	272	330.9	294.1	337.5	298.8	351.8	278
1	0.184	0.167	0.150	0.091	0.074	0.064	0.073	0.070	0.055	0.052
2	-0.062	-0.045	-0.032	0.009	0.226	0.136	0.216	0.192	0.035	0.028
3	-0.048	-0.031	-0.019	0.015	-0.198	-0.097	-0.187	-0.160	0.036	0.027
4	0	0	0	0	0	0	0	0	0	0
5	0.061	0.004	-0.003	-0.006	-0.003	0	-0.002	-0.001	0.031	0.011
6	0.004	0	0	0	0	0	0	0	-0.034	-0.010
7	-0.041	0.007	0.003	-0.008	-0.003	0.001	-0.002	-0.001	-0.026	-0.006
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0.002	-0.001	0.001	0	0	0
10	0.003	-0.003	0.002	-0.002	0.003	-0.002	0.002	0	-0.001	0
11	0	0	0	0	0	0	0	0	0	0
12	-0.001	-0.001	0.001	0	0	0	0	0	-0.001	0
13	0	0	0	0	0	0	0	0	0.004	-0.002
14	0	0	0	0.001	0	0	0	0	0.001	-0.001
15	0	0	0	0	0	0	0	0	0	0

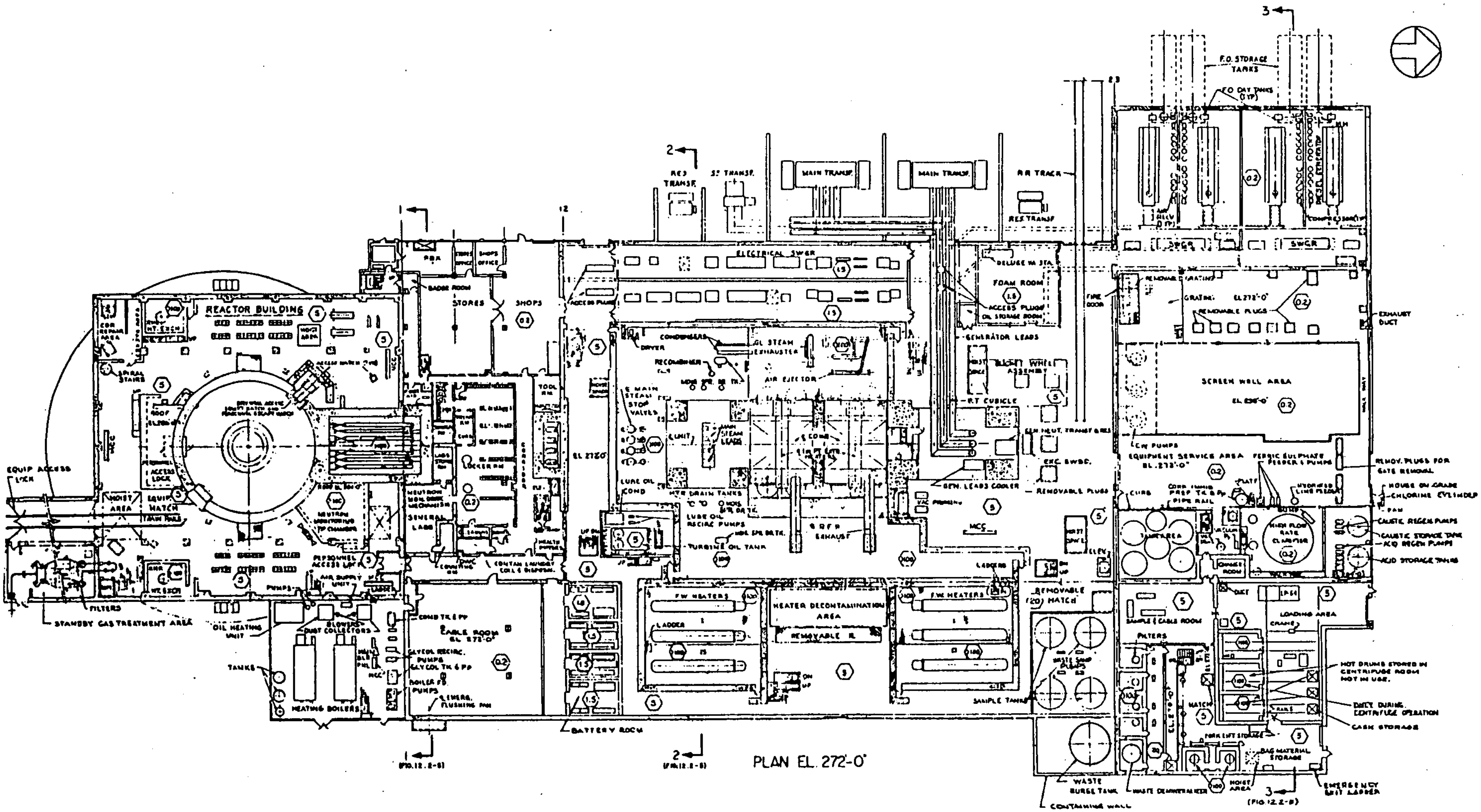
4.3 Turbine Building Complex

The Turbine Building Complex includes the Turbine Building, Administration Building, Radwaste Building, Screenwell-Pump House and Emergency Diesel Generator Building as shown in Figures 4.3-1 and -2 (UFSAR Fig. Nos. 12.2-3 and -5). The seismic analysis of this complex was performed in 1970 (Reference 6.4). A mathematical model was developed to closely represent the structural members, i.e., concrete walls and floors. The model had 63 joints and 125 three-dimensional beam members. The masses of the walls, floors and equipment were lumped at eleven locations, approximately at the center of gravity of the assigned elements. Each mass had two horizontal translational dynamic degrees of freedom and one rotational dynamic degree of freedom about the vertical axis. The model was assumed fixed at the base, a reasonable assumption for the bedrock foundation with a shear wave velocity exceeding 5500 ft/sec. The schematic mathematical model is shown in Fig. 4.3-3.

ICES-STRUDL computer program was used to develop the flexibility matrix of this dynamic system with thirty-three degrees of freedom. Using this flexibility matrix and the mass matrix of the eleven lumped masses, a free vibration analysis was performed. The results are tabulated in Tables 4.3-1 and 4.3-2. Table 4.3-1 shows the natural frequencies and participation factors of the first sixteen (16) modes. Table 4.3-2 identifies the mode shapes at three major elevations. The mode shapes were normalized in such a way that the values at EL. 372' in the north-south direction were always unity.

Modal accelerations were calculated based on the ground response spectra with 2% and 5% damping values for OBE and DBE respectively. Table 4.3-3 shows the modal accelerations at three major elevations for the first sixteen (16) modes. The cross coupling effect of the two horizontal motions was considered in the analysis. The modal accelerations given in Table 4.3-3 are those in the direction of the defined motion. The rotational accelerations were considered in the calculation of the total seismic acceleration for locations away from the location of the lumped mass.

The vertical earthquake was assumed to be decoupled from the horizontal. It was analyzed independently with a simplified model, assuming only vertical dynamic degree of freedom at the masses. Table 4.3-4 shows the frequencies and participation factors of the first five modes.



DESIGN DOSE RATE MREM/HR	HOURS/WEEK OCCUPANCY
>100	NOT NORMALLY ACCESSIBLE
100	CONTROLLED INFREQUENT ACCESSIBILITY
20	1-5
5	20
1.5	50-67
0.2	CONTINUOUS

JAMES A. FITZPATRICK FSAR UPDATE

BUILDING ACCESS PLAN EL. 272 FT.-0 IN.

REV. 0 JULY, 1982 FIGURE NO. 12.2-3

FIG. 4.3-1 TURBINE BUILDING COMPLEX - PLAN

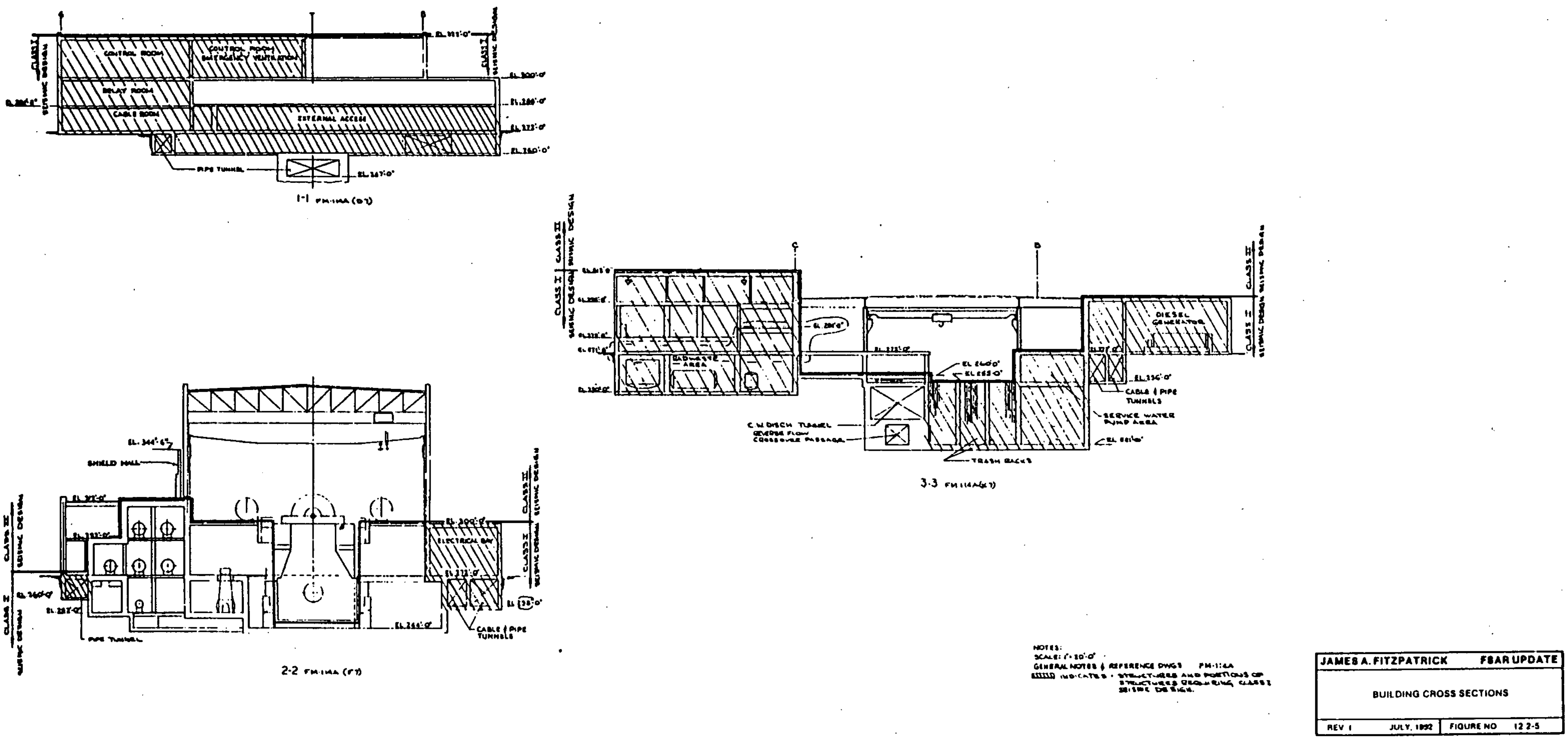


FIG. 4.3-2 TURBINE BUILDING COMPLEX - CROSS SECTIONS

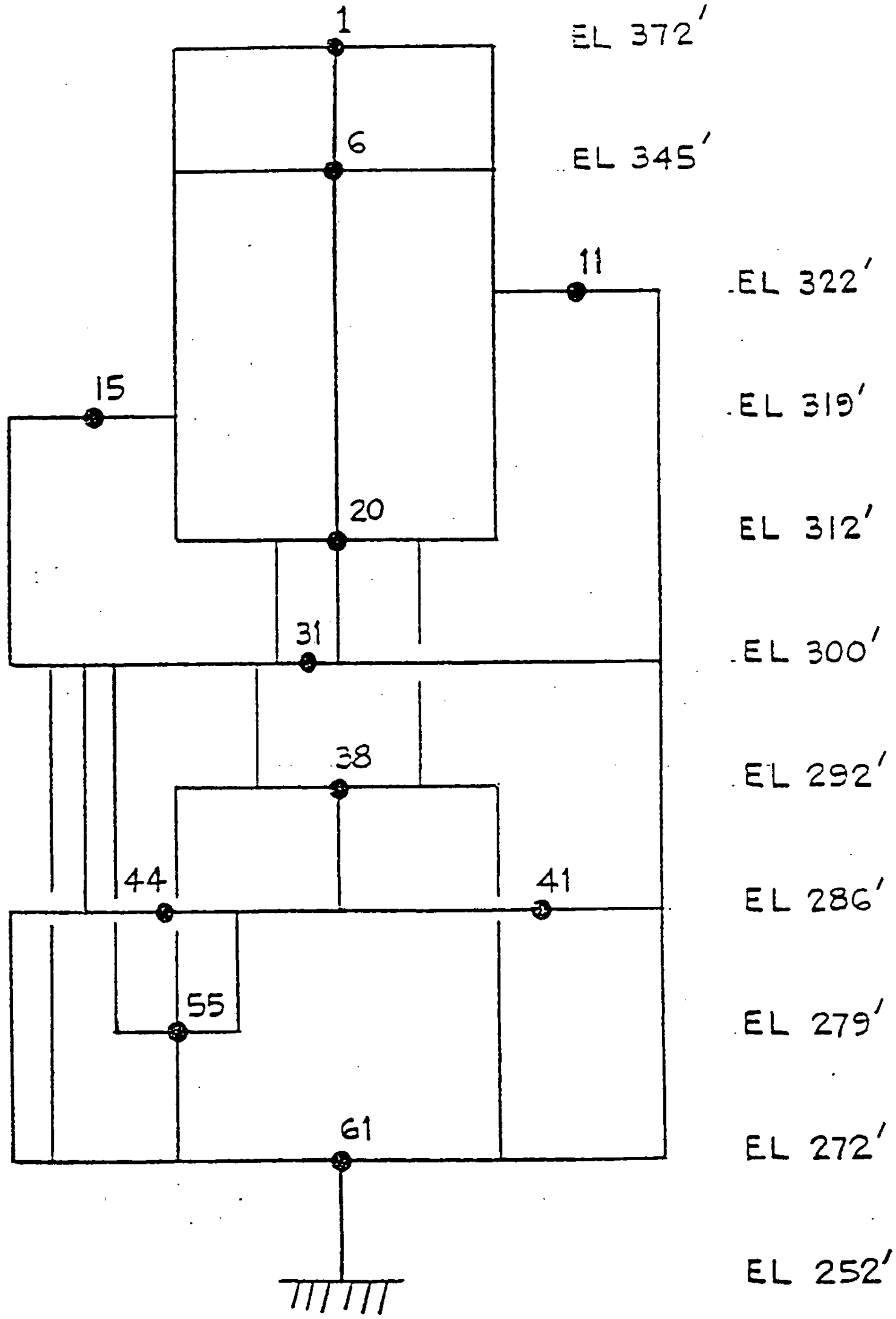


FIG. 4.3-3 TURBINE BUILDING COMPLEX - MATHEMATICAL MODEL

TABLE 4.3-1 TURBINE BUILDING COMPLEX

NATURAL FREQUENCIES AND PARTICIPATION FACTORS - HORIZONTAL MODEL

MODES	FREQ (HZ)	P.F. (NS)	P.F. (EW)
1	7.98	0.011	-0.003
2	8.73	0.039	0.282
3	9.68	2.839	-0.048
4	11.06	0.019	-0.217
5	12.43	-1.721	-0.372
6	13.28	-0.106	0.049
7	13.85	-0.124	0.312
8	18.60	-0.001	0.001
9	20.78	-0.009	-0.002
10	22.95	0.007	-0.007
11	25.90	-0.002	0.008
12	27.55	-0.007	0.001
13	29.39	0.008	-0.006
14	30.95	0.019	-0.006
15	32.24	0.004	0.001
16	32.98	0.025	0.009

TABLE 4.3-2 TURBINE BUILDING COMPLEX

MODE SHAPES

MODES	EL. 372'		EL. 300'		EL 272'	
	NS	EW	NS	EW	NS	EW
1	1.00	0.74	0.22	-0.08	0.060	-0.017
2	1.00	8.13	0.31	1.28	-0.005	0.38
3	1.00	-0.12	0.16	0.005	0.027	0.002
4	1.00	3.00	-0.17	-2.03	0.11	-0.63
5	1.00	-0.070	-0.29	-0.064	-0.063	-0.034
6	1.00	5.04	-0.59	0.085	-0.060	0.088
7	1.00	-3.23	-0.78	1.15	-0.11	0.55
8	1.00	1.73	-5.33	0.74	-0.32	1.97
9	1.00	-0.074	-7.78	-5.84	-3.27	0.30
10	1.00	-1.75	-5.01	0.40	2.46	-3.78
11	1.00	11.59	1.50	-12.52	-10.46	40.12
12	1.00	-1.97	-0.80	-11.84	2.62	5.16
13	1.00	1.99	2.88	5.80	4.34	-5.56
14	1.00	1.30	-4.49	5.93	5.62	-2.47
15	1.00	-0.88	-4.62	-10.70	2.59	-1.07
16	1.00	0.19	-2.20	-3.69	19.94	6.72

TABLE 4.3-3 TURBINE BUILDING COMPLEX

MODAL ACCELERATIONS(g) - DBE

MODES	EL. 372'		EL. 300'		EL 272'	
	NS	EW	NS	EW	NS	EW
1	0.0019	-0.0004	0.0004	0.00005	0.0001	0.00001
2	0.0063	0.3731	0.0020	0.0586	-.00003	0.0174
3	0.4349	0.0009	0.0683	-0.00004	0.0118	-0.00002
4	0.0028	-0.0976	-0.0005	0.0661	0.0003	0.0204
5	-0.2582	0.0039	0.0753	0.0036	0.0162	0.0019
6	-0.0159	0.0373	0.0094	0.0006	0.0010	0.0007
7	-0.0185	-0.1511	0.0145	0.0538	0.0020	0.0259
8	-0.0001	0.0003	0.0008	0.0001	0.00005	0.0004
9	-0.0014	0.00003	0.0109	0.0020	0.0046	-0.0001
10	0.0011	0.0019	-0.0053	-0.0004	0.0026	0.0041
11	-0.0003	0.0141	-0.0004	-0.0153	0.0031	0.0489
12	0.0011	-0.0002	-0.0008	-0.0011	0.0028	0.0005
13	0.0011	-0.0017	0.0033	-0.0050	0.0050	0.0048
14	0.0029	-0.0013	-0.0130	-0.0057	0.0162	0.0024
15	0.0006	-0.0001	-0.0028	-0.0016	0.0016	-0.0002
16	0.0037	0.0003	-0.0083	-0.0052	0.075	0.0095

TABLE 4.3-4 TURBINE BUILDING COMPLEX

NATURAL FREQUENCIES AND PARTICIPATION FACTORS - VERTICAL MODEL

MODES	FREQ (HZ)	P.F.
1	15.82	1.21
2	47.69	-0.280
3	76.05	.182
4	79.17	-0.099
5	97.06	-0.014

4.4 Suppression Chamber

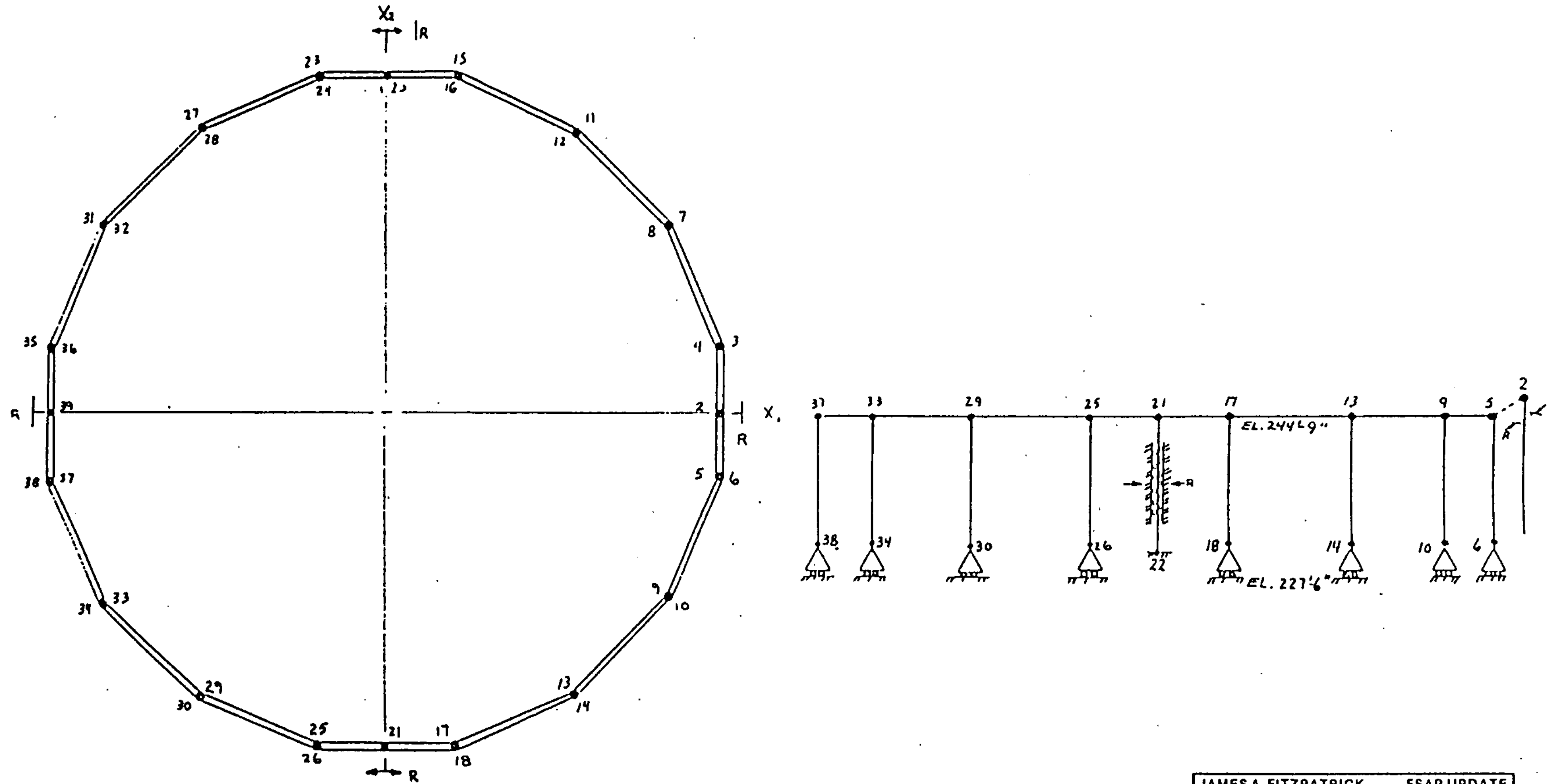
The suppression chamber is a toroidal steel structure supported by sixteen (16) vertical saddles spaced around the circumference of the torus. The saddle base plates are free to slide in order to allow thermal expansion. Four seismic ties equally spaced around the circumference were installed to provide restraint against horizontal seismic inertia forces. These ties were designed to resist seismic forces in the direction tangential to the circumference. Therefore, any axisymmetrical expansion due to temperature and pressure will not be restricted.

Eight vent pipes form the only connection between the drywell and the suppression chamber. Because expansion joints are provided in these vent pipes to allow for differential movement, any dynamic coupling between the drywell and suppression chamber was assumed to be negligible. Also, because the foundation mat rests directly on bedrock, there should be no significant structural interaction between the suppression chamber and the reactor building. Therefore, the torus structure was analyzed as an independent structural system decoupled from the reactor building (Reference 6.5).

The mathematical model of the suppression chamber includes the torus, the saddles supports and the seismic ties. The torus is represented by three-dimensional beam elements. Figure 4.4-1 (Fig. No. 12.5-2, UFSAR) shows the mathematical model, which has 40 nodes and 20 discrete masses. The mass includes the weight of water inside the torus. For the OBE case, the torus is considered half full of water (normal), while it is assumed full for the DBE case.

The analysis was finalized in 1972. The free vibration analysis was performed using the computer program STARDYNE. Tables 4.4-1 and 4.4-2 show the natural frequencies of the suppression chamber half full and full of water respectively. The mode shapes for these two cases are shown in Tables 4.4-3, 4.4-4, 4.4-5 and 4.4-6.

Modal accelerations were calculated from the ground response spectra with a damping value of 0.5% for both OBE and DBE. This is extremely conservative. A damping value of 3% for the suppression chamber would be considered reasonable and in compliance with NRC/Regulatory Guide 1.61 (damping value for equipment and large-diameter piping systems). Tables 4.4-7 and 4.4-8 show the modal accelerations for all significant modes at various locations.



JAMES A. FITZPATRICK		FSAR UPDATE
MODEL FOR DYNAMIC ANALYSIS OF SUPPRESSION CHAMBER		
REV. 0	JULY, 1982	FIGURE NO. 12.5-2

FIG. 4.4-1 SUPPRESSION CHAMBER MATHEMATICAL MODEL

TABLE 4.4-1 SUPPRESSION CHAMBER - HALF FULL

NATURAL FREQUENCIES AND PARTICIPATION FACTORS

MODE	FREQUENCY (HZ)	NS	EW
1	6.100	0.0	0.0
2	10.834	0.0	1.2328
3	10.834	1.2328	0.0
4	16.110	0.0	0.0
5	17.121	0.0	0.0
6	17.58	0.0	0.5831
7	17.58	-.5831	0.0
8	18.794	0.0	0.0
9	21.046	0.0	0.0
10	26.673	-0.0327	-.1437
11	26.673	-.1437	0.0327
12	30.573	0.0	0.0
13	33.176	0.0	0.0
14	33.363	0.0232	0.3698
15	33.363	0.3698	-0.0232
18/19	39.93	0.4342/-0.0063	-0.0063/-0.4342
22/23	57.30	0.0/0.3413	0.3413/0.0
26/27	60.62	0.0/-0.2175	-0.2175/0.0
30/31	85.29	0.2386/0.0	0.0/0.2386
34/35	88.77	0/-0.1645	0.1645/0.0

TABLE 4.4-2 SUPPRESSION CHAMBER - FULL

NATURAL FREQUENCIES AND PARTICIPATION FACTORS

MODE	FREQUENCY (HZ)	NS	EW
1	4.280	0.0	0.0
2	7.602	1.2317	-0.0456
3	7.602	0.0456	1.2317
4	11.300	0.0	0.0
5	11.992	0.0	0.0
6	12.315	0.0	-0.5828
7	12.315	0.5828	0.0
8	13.177	0.0	0.0
9	14.755	0.0	0.0
10	18.705	0.0	-0.1506
11	18.705	-0.1506	0.0
12	21.418	0.0	0.0
13	23.246	0.0	0.0
14	23.383	-0.1288	0.4056
15	23.383	0.4056	0.1288
18	28.036	-0.0880	0.4246
19	28.036	-0.4246	-0.0880
22/23	40.169	0/0.3406	0.3406/0.0
26/27	42.521	0/-0.2167	-0.2167/0.0
30/31	59.929	0/0.2394	0.2394/0.0
34/35	62.333	0/-0.1661	0.1661/0.0

TABLE 4.4-3 SUPPRESSION CHAMBER - HALF FULL

MODE SHAPE - NORTH/SOUTH

MODE	NODE 2	NODE 5	NODE 9	NODE 13	NODE 17	NODE 21
3	1.000	0.9222	0.5317	0.1519	0.0629	0
7	-0.0446	-0.0694	-0.5668	-0.5805	-0.1290	0
10	0.2275	-0.5234	-0.6683	0.2443	-0.0881	0
11	1.0000	0.7899	-0.6412	-0.2763	-0.0466	0
14	-0.0082	0.6060	-0.3400	0.8273	0.3161	0
15	-0.1304	-0.1060	-0.2783	0.9038	0.2589	0
18	-0.4091	-0.0938	0.3402	0.1983	0.3014	0
23	1.0000	-0.3653	-0.0692	0.1364	0.1514	0
27	1.0000	-0.4925	0.6488	-0.5722	-0.7041	0
30	-0.0892	0.1933	-0.1134	-0.3512	1.000	0
35	-0.0968	0.2269	-0.3220	0.5282	-0.9638	0

TABLE 4.4-4 SUPPRESSION CHAMBER - HALF FULL

MODE SHAPE - EAST/WEST

MODE	NODE 2	NODE 5	NODE 9	NODE 13	NODE 17	NODE 21
2	0.	0.0629	0.1519	0.05317	0.9222	1.0
6	0.	0.1290	0.5805	0.5668	0.0694	0.0446
10	0.	-0.0801	-0.1434	-0.8672	0.4857	1.0
11	0.	-0.0593	0.3398	-0.3252	-0.8136	-0.2275
14	0.	0.2963	1.0	-0.3186	-0.0295	-0.1304
15	0.	0.2814	0.7080	-0.3026	0.6145	0.0082
19	0.	-0.3094	-0.2107	-0.3491	0.1227	0.4091
22	0.	0.1514	0.1364	-0.0692	-0.3653	1.0
26	0.	-0.7041	-0.5722	0.6488	-0.4925	1.0
31	0.	1.0	-0.3512	-0.1134	0.1933	-0.0892
34	0.	0.9638	-0.5282	0.3220	-0.2269	0.0968

TABLE 4.4-5 SUPPRESSION CHAMBER - FULL

MODE SHAPE - NORTH/SOUTH

MODE	NODE 2	NODE 5	NODE 9	NODE 13	NODE 17	NODE 21
2	1.0000	0.9129	0.5200	0.1485	0.0636	0
3	0.0370	0.2806	0.3433	0.0999	-0.0145	0
7	0.0439	0.0688	0.5672	0.5809	0.1289	0
11	1.0000	0.6370	-0.7507	-0.2060	-0.0627	0
14	0.0362	0.5274	-0.1864	0.3893	0.1766	0
15	-0.1140	0.1026	-0.3294	1.0000	0.3123	0
18	0.0825	-0.9569	0.2278	0.3736	0.2073	0
19	0.3980	0.3067	-0.3964	-0.2808	-0.3515	0
23	1.0000	-0.3684	-0.0699	0.1379	0.1523	0
27	1.0000	-0.4976	0.6477	-0.5723	-0.6996	0
31	-0.0880	0.1928	-0.1123	-0.3479	1.0000	0
35	-0.0956	0.2261	-0.3169	0.5208	-0.9631	0

TABLE 4.4-6 SUPPRESSION CHAMBER - FULL

MODE SHAPE - EAST/WEST

MODE	NODE 2	NODE 5	NODE 9	NODE 13	NODE 17	NODE 21
2	0.	-0.0191	0.0887	0.3040	0.2123	-0.0370
3	0.	0.0623	0.1555	0.5440	0.9311	1.0
7	0.	-0.1795	-0.6601	-1.0	-0.3812	0.
10	0.	-0.0626	-0.2060	-0.7507	0.6371	1.0
11	0.	-0.0734	0.2913	-0.4971	-0.6624	0.
14	0.	0.1532	0.5923	-0.1615	-0.2204	-0.1140
15	0.	0.3244	0.8948	-0.3422	0.4900	-0.0362
18	0.	0.2401	0.1092	0.2732	0.0988	-0.3980
19	0.	-0.3299	-0.4545	-0.3665	1.0	0.0825
22	0.	0.1523	0.1379	-0.0699	-0.3684	1.0
26	0.	-0.6996	-0.5723	0.6477	-0.4976	1.0
30	0.	1.0	-0.3479	-0.1123	0.1928	-0.0880
31	0.	0.9669	-0.3299	-0.1265	0.1842	0.
34	0.	0.9631	-0.5208	0.3169	-0.2261	0.0956

TABLE 4.4-7 SUPPRESSION CHAMBER

MODAL ACCELERATION(g) - DBE - NORTH/SOUTH

MODE	NODE 2	NODE 5	NODE 9	NODE 13	NODE 17	NODE 21
1	0.	0.	0.	0.	0.	0.
2	0.530	0.484	0.275	0.079	0.034	0.
3	0.001	0.005	0.007	0.002	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.007	0.011	0.088	0.090	0.020	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
11	-0.023	-0.014	0.017	0.005	0.001	0.
12	0.	0.	0.	0.	0.0	0.
13	0.	0.	0.	0.	0.0	0.
14	-0.001	-0.010	0.004	-0.008	-0.003	0.
15	-0.007	0.006	-0.020	0.061	0.019	0.
18	-0.001	0.013	-0.003	0.005	-0.003	0.
19	-0.025	-0.020	0.025	0.018	0.0224	0.
23	0.051	-0.019	-0.004	0.007	0.008	0.
27	-0.033	0.016	-0.021	0.019	0.023	0.
31	-0.003	0.007	-0.004	-0.012	0.036	0.
35	0.002	-0.006	0.008	-0.013	0.024	0.

TABLE 4.4-8 SUPPRESSION CHAMBER

MODAL ACCELERATION(g) - DBE - EAST/WEST

MODE	NODE 2	NODE 5	NODE 9	NODE 13	NODE 17	NODE 21
1	0.	0.	0.	0.	0.	0.
2	0.	0.	-0.002	-0.006	-0.004	0.001
3	0.	0.033	0.082	0.288	0.493	0.530
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.020	0.090	0.088	0.011	0.007
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.001	0.005	0.017	-0.014	-0.023
11	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
14	0.	0.009	0.036	-0.010	-0.013	-0.0071
15	0.	0.006	0.017	-0.007	0.009	-0.001
18	0.	0.015	0.007	0.017	0.006	-0.025
19	0.	0.004	0.006	0.005	-0.013	-0.001
22	0.	0.008	0.007	-0.004	-0.019	0.051
26	0.	0.023	0.019	-0.021	0.016	-0.033
30	0.	0.036	-0.012	-0.004	0.007	-0.003
34	0.	0.024	-0.013	0.008	-0.006	0.002

5.0 IN-STRUCTURE RESPONSE SPECTRA (AMPLIFIED RESPONSE SPECTRA)

5.1 Methodology

The methodology of developing amplified response spectra (in-structure response spectra) for James A. FitzPatrick Nuclear Power Plant was established in 1970. It was based on the assumption that the building would be vibrating in a pattern consisting of a series of damped sinusoidal motions with frequencies equal to the natural frequencies of the building structure when subjected to an earthquake excitation. Specifically, at a certain location of a building the vibrating motion was assumed as follows:

$$\ddot{z}(t) = \sum_{i=1}^{N} e^{-\xi \omega_i t} A_i \sin \omega_i t$$

where $\ddot{z}(t)$: the acceleration time history of a selected building location,

ξ : building structure damping value (fraction of critical damping),

ω_i : building structure natural frequency (rad/sec)-*i th* mode,

A_i : modal acceleration at the selected building location from *i th* mode, and

N : number of significant modes.

The equation of motion for a single degree of freedom system subjected to this acceleration time history is:

$$\ddot{u} + \Omega^2 u + 2\eta\Omega\dot{u} = -\ddot{z}(t)$$

where u : the relative displacement of the single degree of freedom system (equipment),

$\dot{u}$: the velocity,

$\ddot{u}$: the acceleration,

Ω : the undamped frequency (rad/sec), and

η : the damping value as a fraction of the critical damping (equipment).

The solution of this equation is:

$$u = -\frac{1}{\Omega\sqrt{1-\eta^2}}\int_0^t \ddot{z}(\tau)e^{-\eta\Omega(t-\tau)} \sin\{\Omega\sqrt{1-\eta^2}\,(t-\tau)\}\,d\tau$$

After the relative displacement, velocity and acceleration are found, the total acceleration is determined as:

$$\ddot{y} = \ddot{u} + \ddot{z}$$

A computer program (Reference 6.6) was written to generate the amplified response spectra for various locations in the aforementioned buildings. The program accepts an input of fifteen motions (15 building structure modes). For each motion a maximum acceleration was derived first. The total maximum acceleration of a specific given frequency of a single degree of freedom system (equipment) was then calculated as the square root of the sum of the squares of the maximum accelerations of the fifteen motions.

The amplified response spectra for the James A. FitzPatrick Nuclear Power Plant were generated with this approach in 1970-72. The equipment damping values were assumed 0.5% for OBE and 1% for DBE.

For the purpose of resolving USI A-46 using the implementation guidance provided in GIP-2 as supplemented by the SSER No. 2, amplified response spectra for DBE with other damping values are required. A simple approach will be used where the peak responses will be modified with the factor equal to the square root of the ratio of 1% and the appropriate damping value as follows:

$$A_\eta = A_{0.01} * (0.01/\eta)^{1/2}$$

where A_η is the modified peak response,

$A_{0.01}$ is the peak response at 1% damping, and

η is the appropriate damping value.

5.2 Reactor Building

The Amplified Response Spectra were generated for horizontal and vertical earthquakes at major floor elevations. All curves were peak-spread with +- 15% of the peak response frequencies and with vertical lines. Equipment damping was 0.5% for OBE and 1.0% for DBE. The following indicates the locations where ARS were generated.

(A) Reactor Building

Elev. 425'-0"
Elev. 369'-6"
Elev. 326'-9"
Elev. 272'-0"

(B) Drywell

Elev. 351'-9"
Elev. 278'-0"

(C) RPV Pedestal & Primary Shield Wall

Elev. 330'-9"
Elev. 284'-0"

(D) Reactor Pressure Vessel

Elev. 337'-6"
Elev. 298'-9"

Figures 5.2-1 and 5.2-2 show the amplified response spectum at elevation 326'-9" of the Reactor Building enclosure. For horizontal seismic, the two peak responses are the signatures of the dominating modal accelerations (Table 4.2-4) corresponding to 6th and 16th mode of structural frequencies. From Table 4.2-1, these natural frequencies are 5.78 Hz (or 0.173 second) and 26.40 Hz (or 0.038 second). Similarly for vertical seismic, the peak response is at 10.74 Hz (or 0.093 second), the fundamental frequency of the vertical model. The zero period accelerations (ZPA) at this elevation are 0.22g horizontally and 0.15g vertically. The amplification factors (AF), defined as the peak response divided by the floor ZPA, are as follows:

Damping	Peak Hor. Accel	Peak Vert. Accel.	AF-Hor.	AF-Vert.
1%	2.4g	1.0g	10.9	6.7
5%	1.07g	0.45g	4.9	3.0

Figures 5.2-3 and 5.2-4 show the amplified response spectrum at elevation 351'-9" of the drywell. The zero period accelerations at this elevation are 0.28g horizontally and 0.15g vertically. The amplification factors are as follows:

Damping	Peak Hor. Accel	Peak Vert. Accel.	AF-Hor.	AF-Vert.
1%	6.45g	1.05g	23	7.0
5%	2.88g	0.47g	10	3.1

Figures 5.2-5 and 5.2-6 show the amplified response spectrum at elevation 330'-9" of the primary shield wall. The zero period acceleration at this elevation are 0.30g horizontally and 0.40g vertically. The amplification factors are follows:

Damping	Peak Hor. Accel	Peak Vert. Accel.	AF-Hor.	AF-Vert.
1%	2.58g	2.45g	8.6	6.1
5%	1.15g	1.10g	3.8	2.8

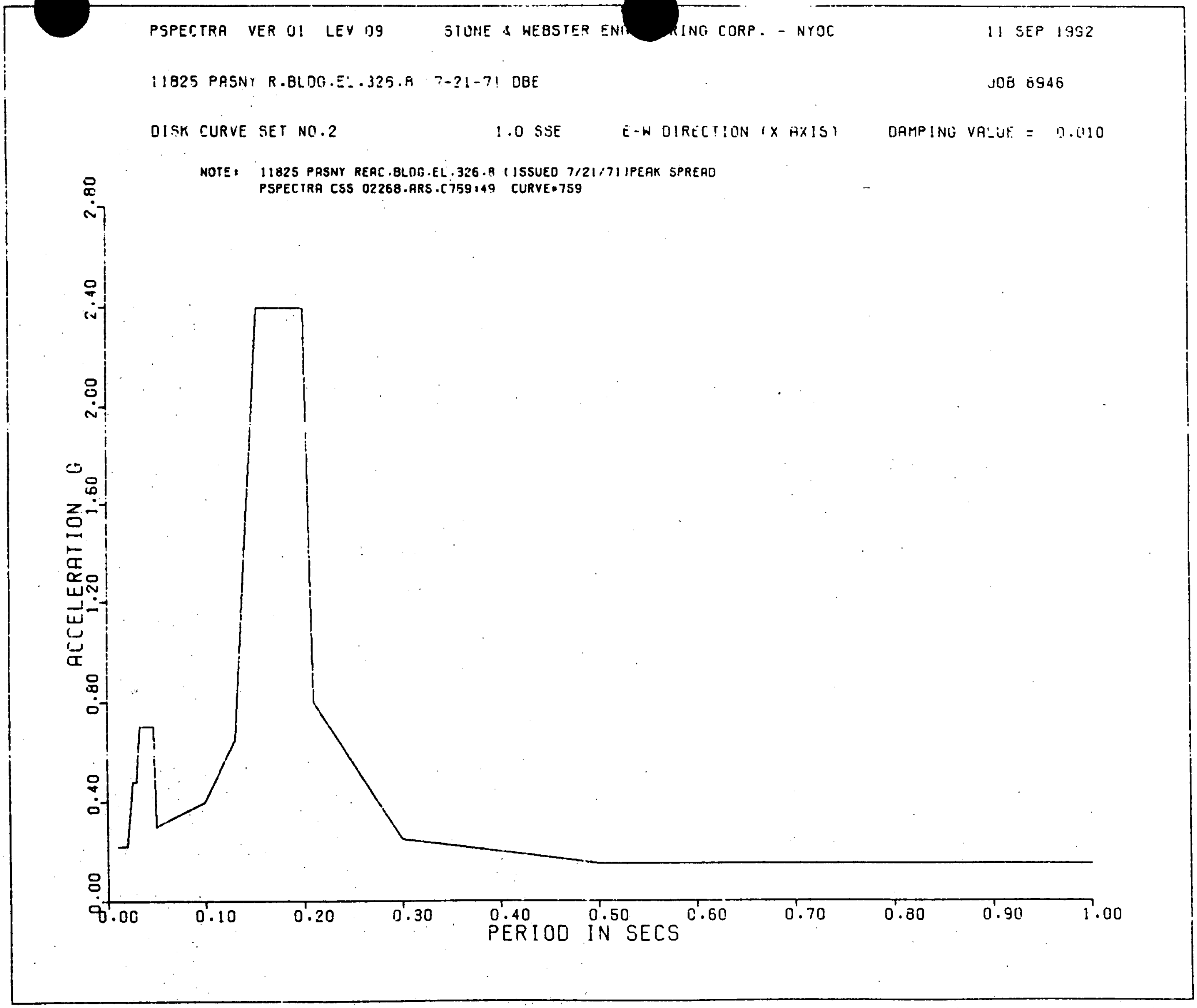


FIG. 5.2-1 REACTOR BUILDING ARS - DBE - 1% DAMPING AT EL. 326'-9", HORIZONTAL DIRECTION

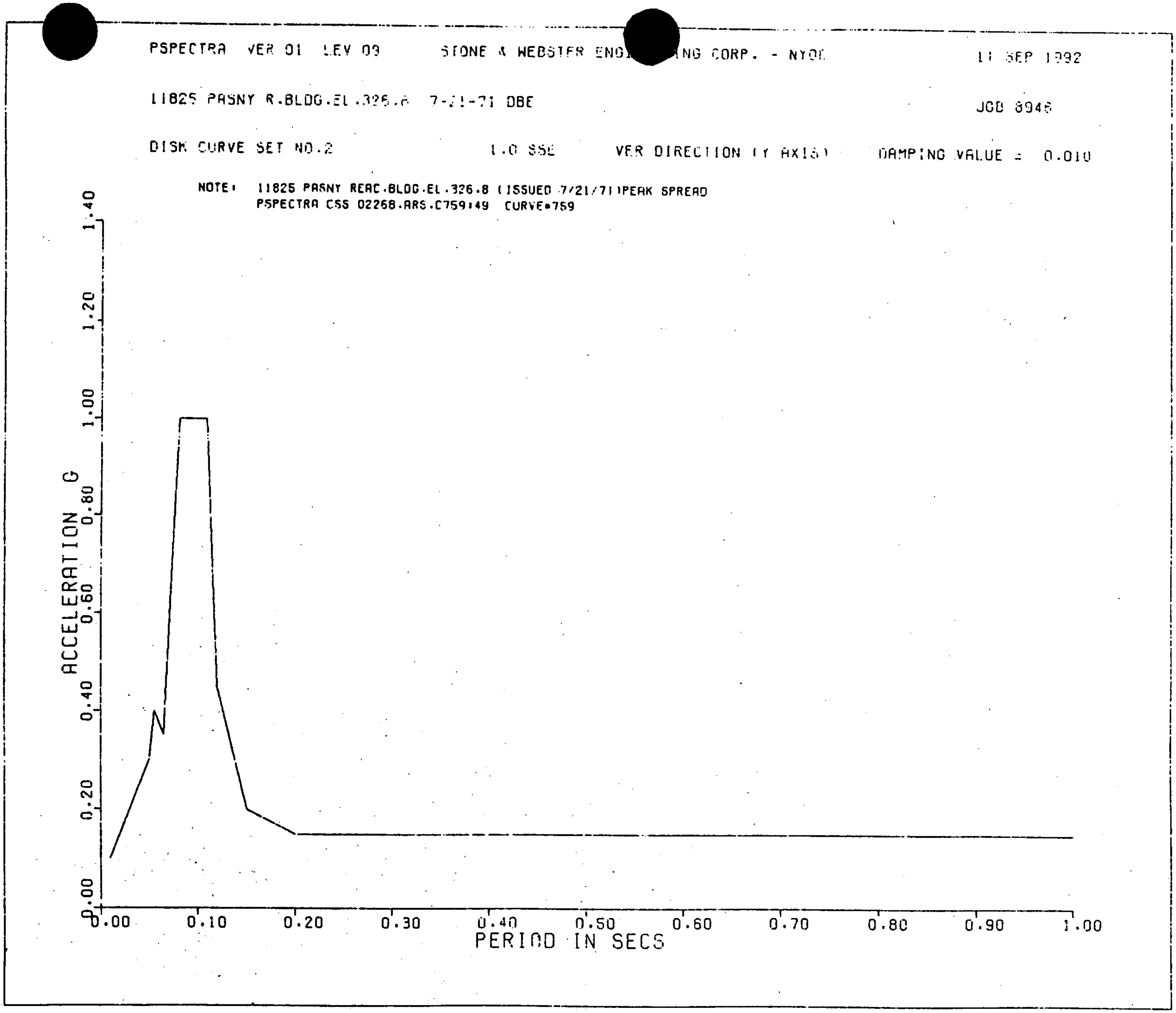


FIG. 5.2-2 REACTOR BUILDING ARS - DBE - 1% DAMPING AT EL. 326'-9", VERTICAL DIRECTION

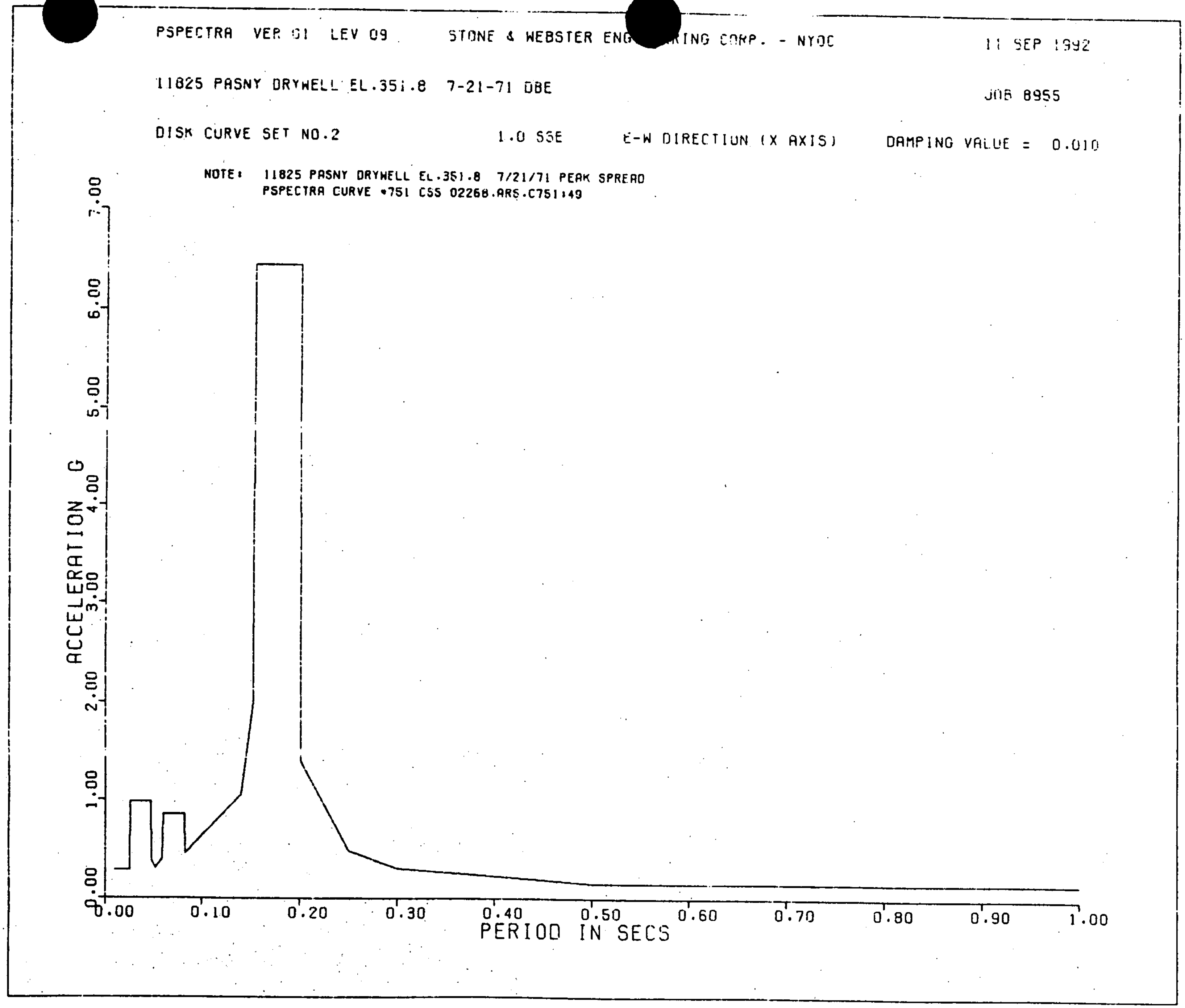


FIG. 5.2-3 DRYWELL ARS - DBE - 1% DAMPING AT EL. 351'-9", HORIZONTAL DIRECTION

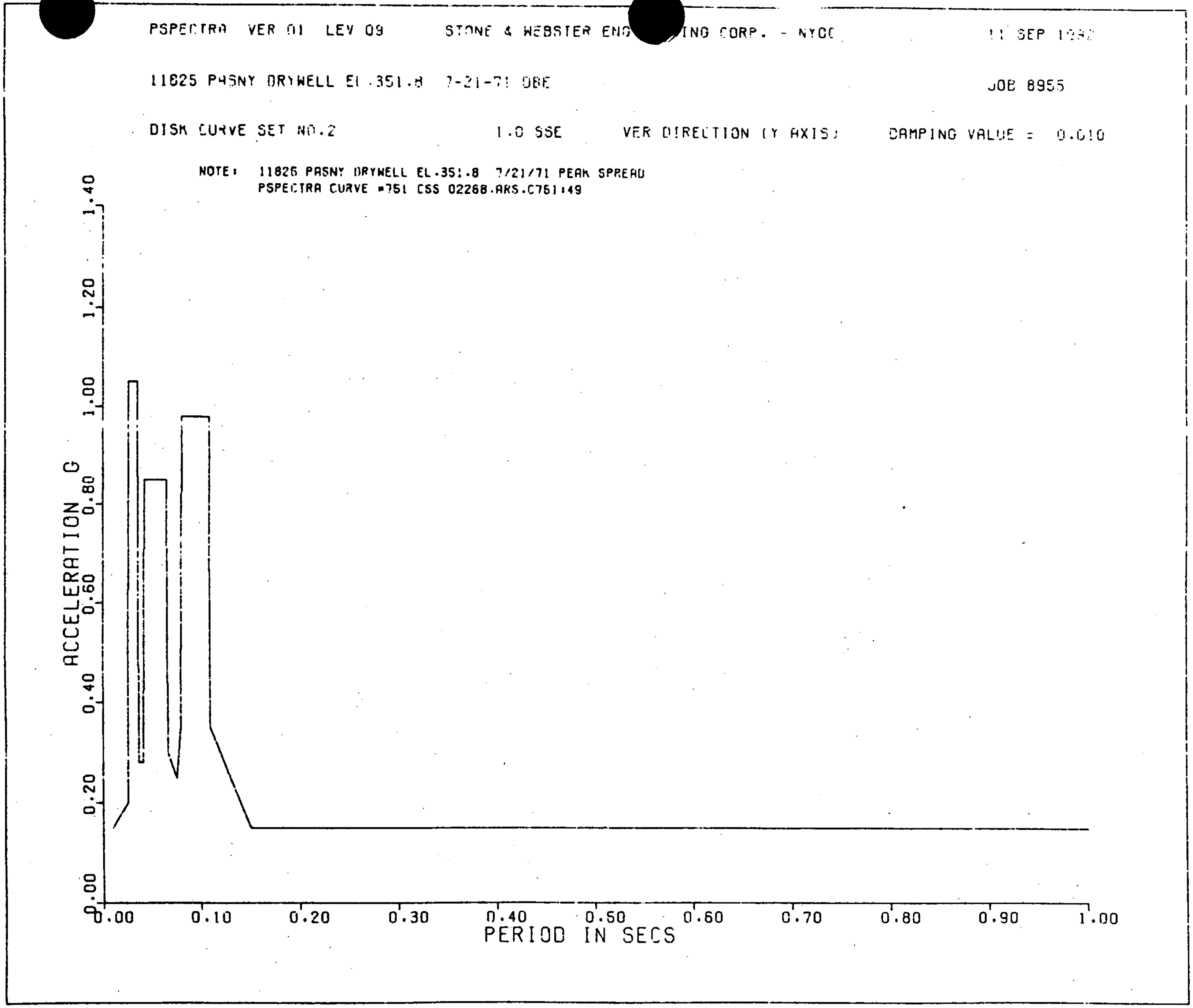


FIG. 5.2-4 DRYWELL ARS - DBE - 1% DAMPING AT EL. 351'-9", VERTICAL DIRECTION

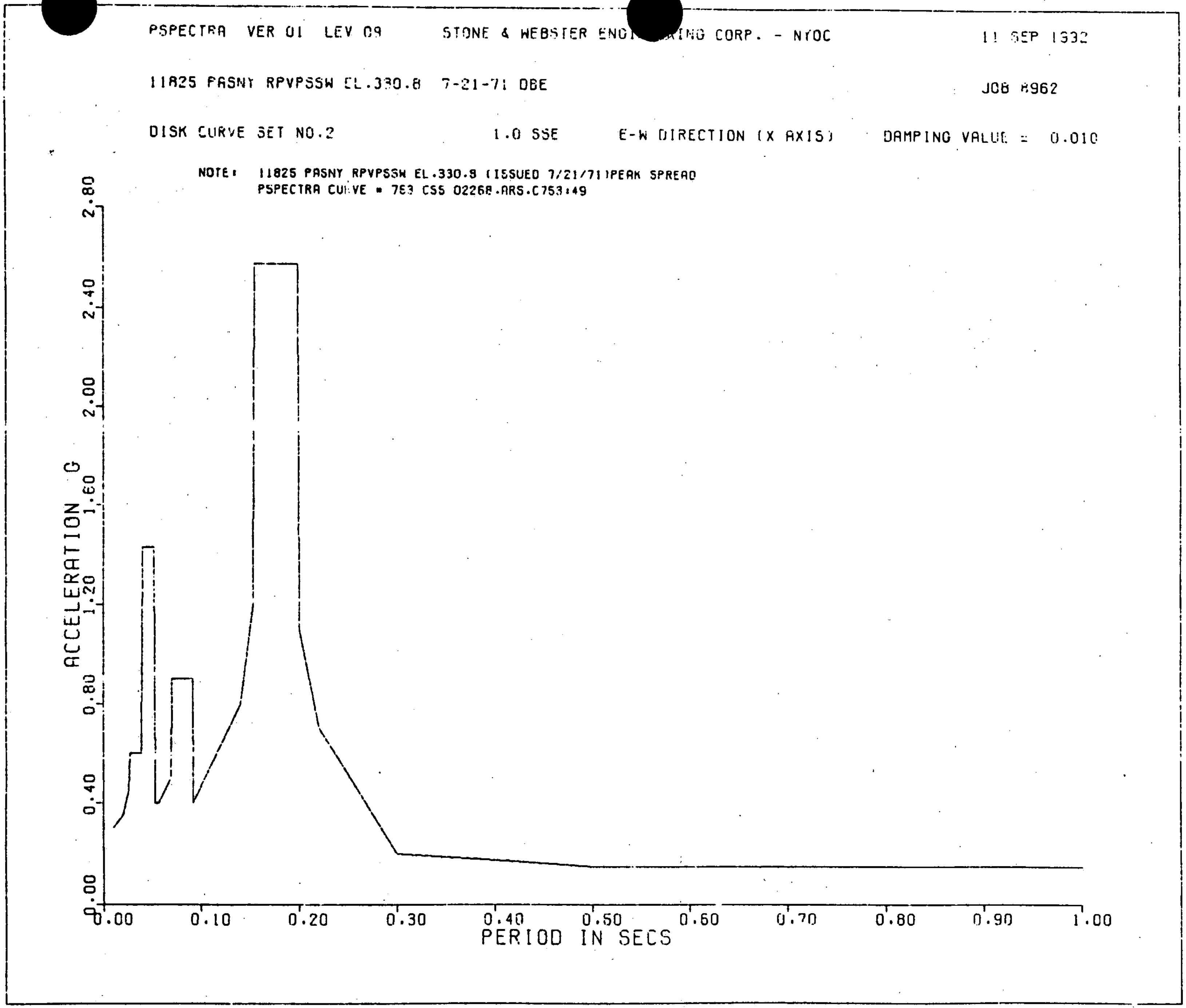


FIG. 5.2-5 PRIMARY SHIELD WALL ARS - DBE - 1% DAMPING AT EL. 330'-9",HORIZONTAL DIRECTION

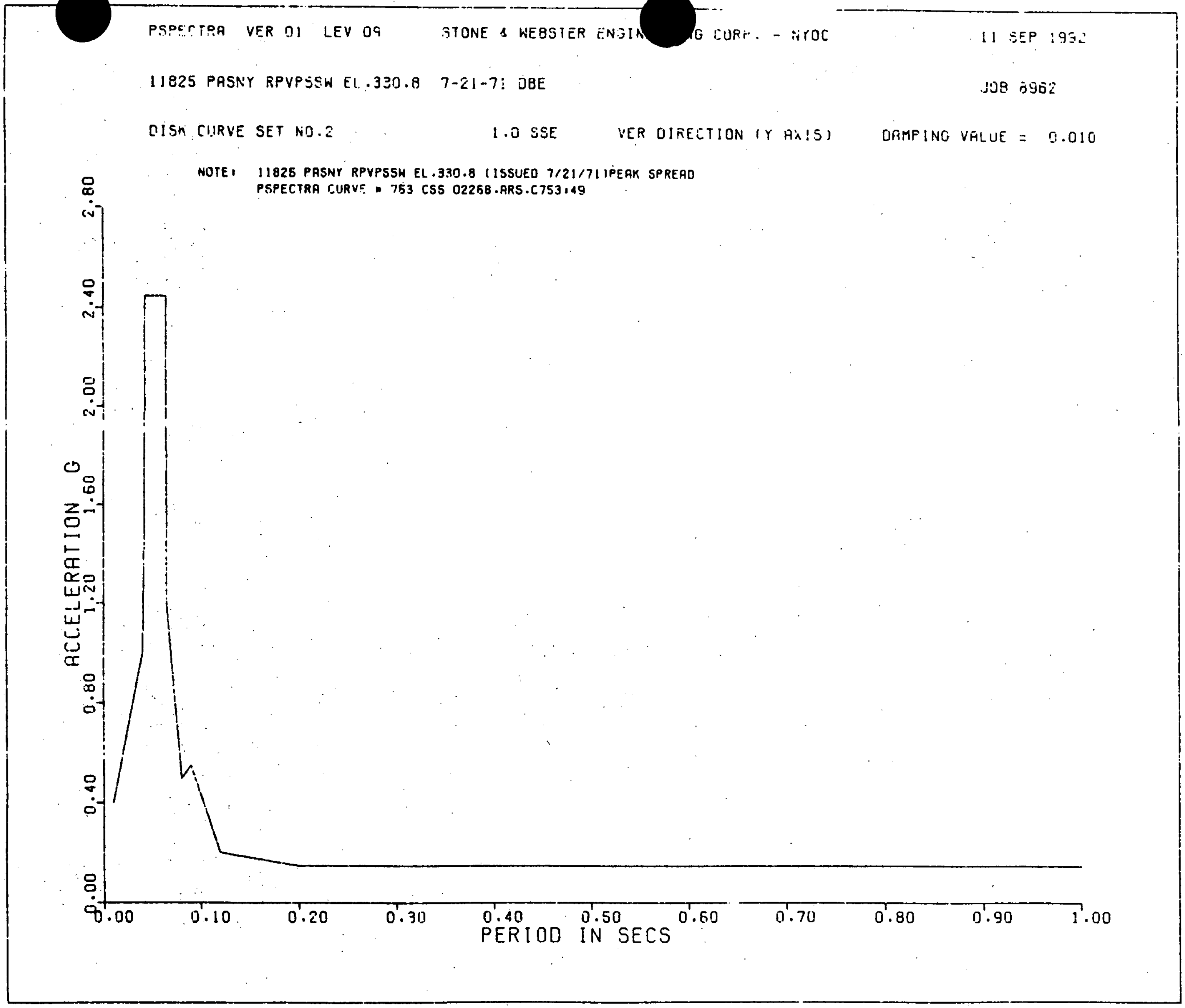


FIG. 5.2-6 PRIMARY SHIELD WALL ARS - DBE - 1% DAMPING AT EL. 330'-9", VERTICAL DIRECTION

5.3 Turbine Building Complex

Amplified response spectra were generated at four floor locations, one at elevation 300'-0" and three representative locations at elevation 272'-0" as follows:

(A) Elevation 300'-0"

at mass center

(B) Elevation 272'-0"

at location A2 South-East Turbine building and Control Room area

at location A11 North Turbine building and Diesel Generator area

at location A12 South-West Turbine building and Administration area

The translational modal accelerations at location A2, A11 and A12 are the total sum of the translational modal acceleration at mass center and the contribution from the rotational modal acceleration. Amplified Response Spectra were generated for all three directional earthquakes, E-W, N-S and vertical, and for both OBE and DBE. They were peak spread +- 15%.

Figures 5.3-1 through 5.3-3 show a typical set of amplified response spectra at location A11, elevation 272'-0" for north-south, east-west and vertical earthquakes. The zero period accelerations at this location are 0.235g in the north-south direction, 0.15g in the east-west direction, and 0.15g in the vertical direction. The amplification factors are as follows:

Damping	Peak NS	Peak EW	Peak Vert	AF-NS	AF-EW	AF-Vert
1%	1.175g	0.688g	0.95g	5.0	4.6	6.3
5%	0.525g	0.308g	0.425g	2.2	2.1	2.8

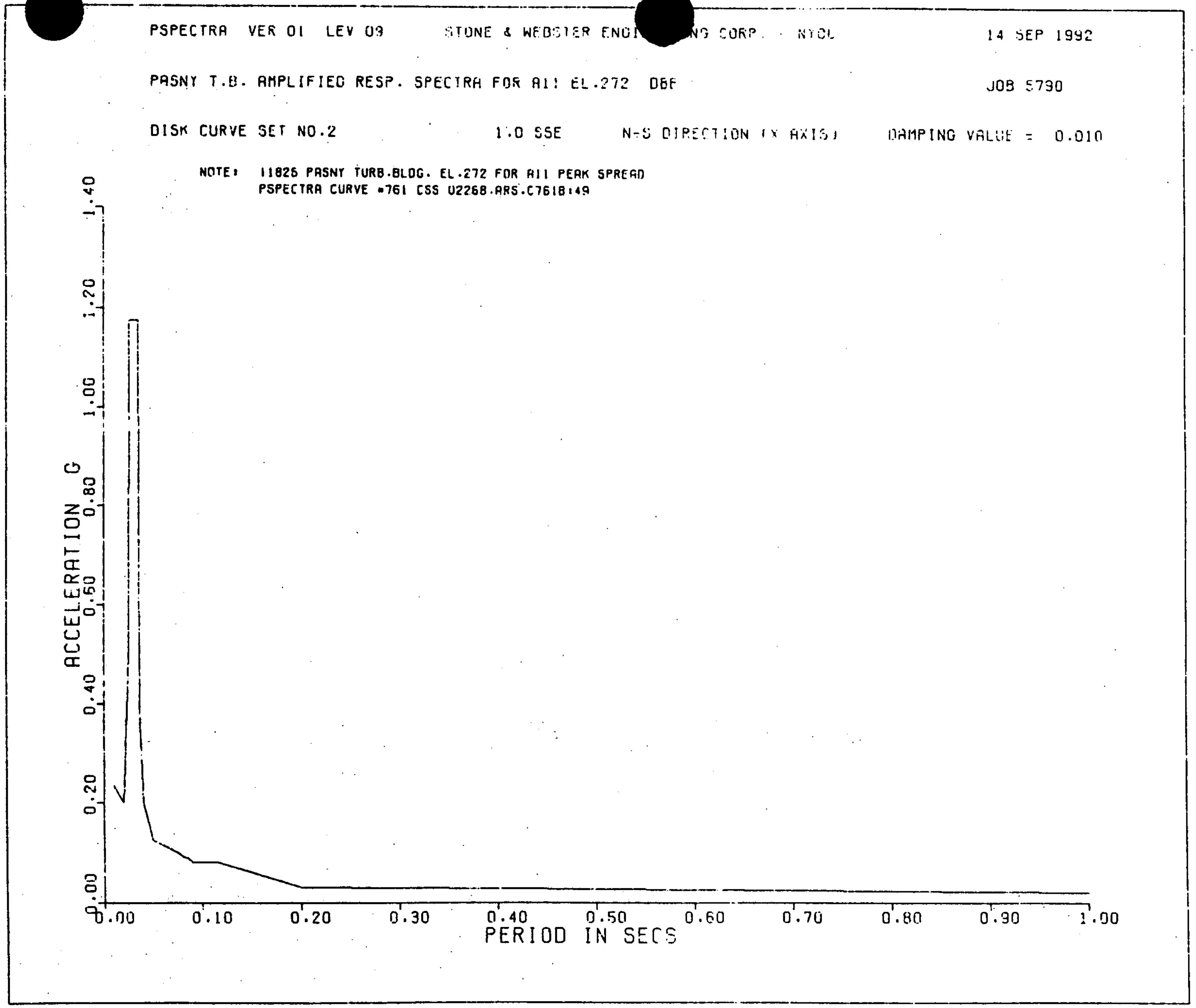


FIG. 5.3-1 TURBINE BUILDING COMPLEX ARS - DBE - 1% DAMPING AT EL. 272'
LOCATION A11 - NORTH/SOUTH

PSPECTRA VER 01 LEV 09 STONE & WEBSTER ENG NG CORP. - NYOC 14 SEP 1992

PASNY T.B. AMPLIFIED RESP. SPECTRA FOR A11 EL.272 DBE JOB 5790

DISK CURVE SET NO.2 1.0 SSE E W DIRECTION (Z AXIS) DAMPING VALUE = 0.010

NOTE: 11825 PASNY TURB.BLDG. EL.272 FOR A11 PEAK SPREAD
PSPECTRA CURVE #761 CSS 02268.ARS.C7618:49

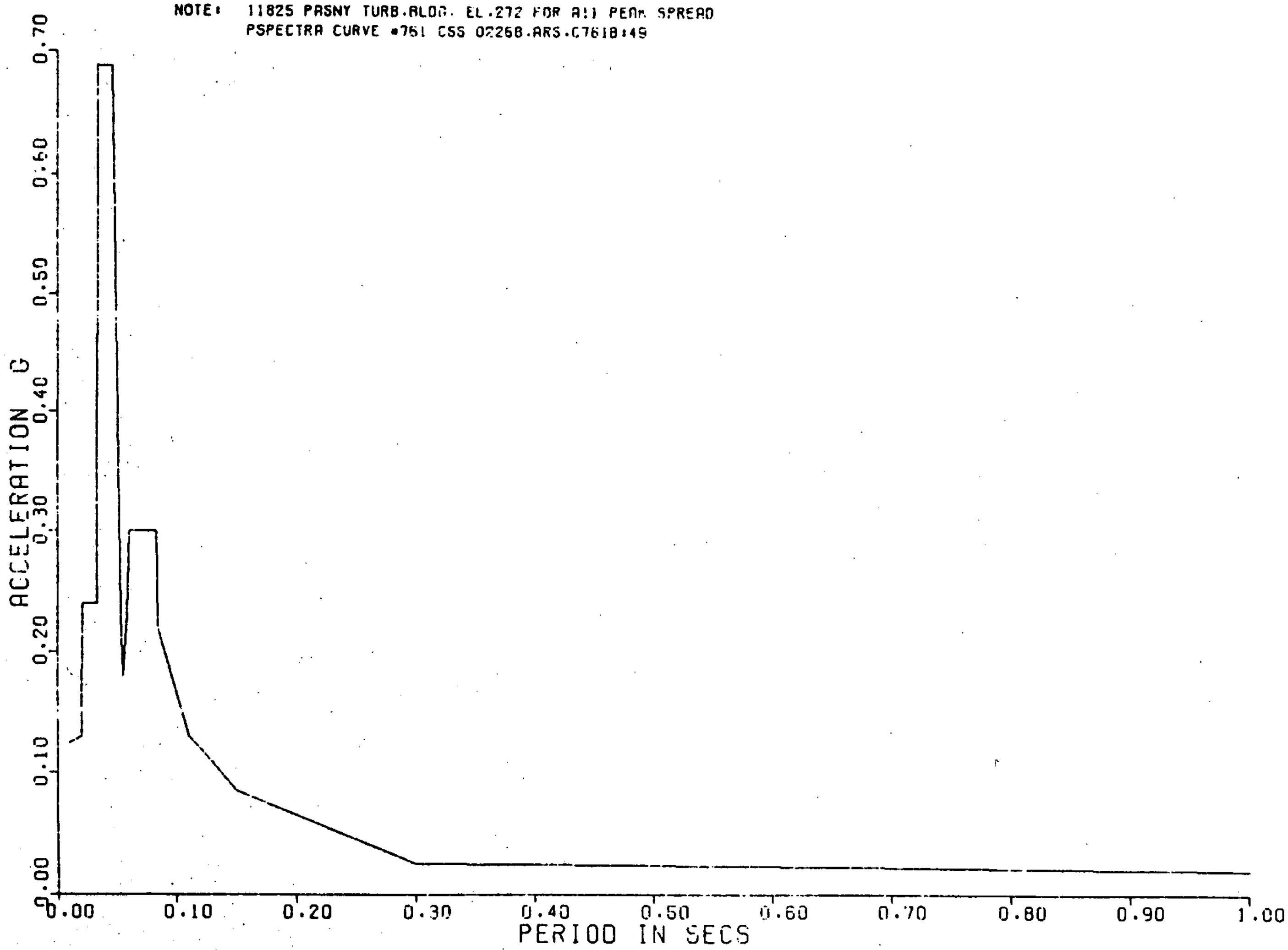


FIG. 5.3-2 TURBINE BUILDING COMPLEX ARS - DBE - 1% DAMPING AT EL. 272'
LOCATION A11 - EAST/WEST

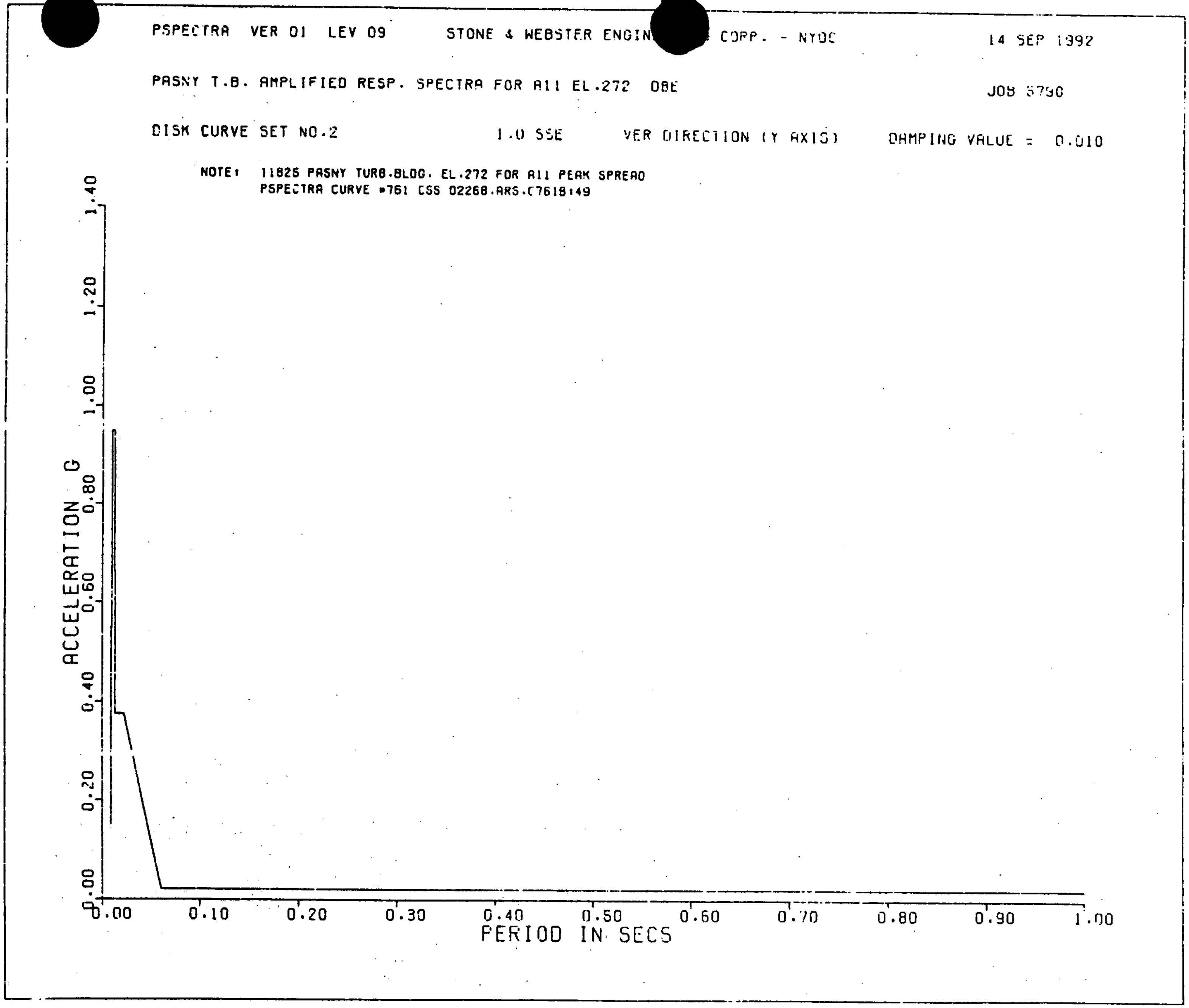


FIG. 5.3-3 TURBINE BUILDING COMPLEX ARS - DBE - 1% DAMPING AT EL. 272'
LOCATION A11 - VERTICAL DIRECTION

5.4 Suppression Chamber

Amplified response spectra were developed at various pipe penetrations at the torus shell. The modal accelerations at the penetrations were derived from linear interpolation or extrapolation from the modal accelerations at the mass points. The following is a list of penetration locations for which ARS were developed.

RHR pump suction, X225A, B	Elev. 234'-5/8"
Core spray pump suction, X227A, B	Elev. 233'-5 3/8"
Primary containment vacuum breakers	
X202A	Elev. 259'-3"
202F, G, H, I, J	Elev. 260'-4"
RHR discharge, X210A, B	Elev. 255'-2½"
X211A, B	Elev. 258'-7½"
HPCI turbine exhaust, X214	Elev. 245'-9"
HPCI pump suction, X226	Elev. 234'-8¼"
RCIC turbine exhaust, X212	Elev. 232'-1½"
RCIC pump suction, X224	Elev. 234'-6"
Reactor building normal vent, X205	Elev. 260'-6"
Vent purge outlet, X220	Elev. 260'-6"
Relief valve discharge X208A, B, E, F	Elev. 260'-4"
X208C, D, G, H	
X208I, J	

Figures 5.4-1 and 5.4-2 are a typical set of the horizontal Amplified Response Spectra at penetration X214. The peaks were spread + - 15% for analysis. Equipment damping was 0.5% for OBE and 1.0% for DBE. For N-S seismic, the major peaks occur at the frequencies corresponding to the third mode of the structural natural frequency for OBE, and second mode for DBE (Table 4.4-1 and -2). Similarly for E-W seismic, the peak response is at 10.834 Hz (second mode) for OBE and 7.62 Hz (third mode) for DBE.

The amplified response spectra were developed based on a set of modal accelerations calculated from the 0.5% damping ground response spectrum. This is extremely conservative. A damping value of 3% for DBE would be more realistic. Therefore, in addition to the peak response adjustment due to equipment damping, the peak acceleration should be further modified in accordance with the following:

accordance with the following:

$$A_{\eta} = A_{0.01} * (0.01/\eta)^{1/2} * \frac{G_{0.03}}{G_{0.005}}$$

Where $G_{0.03}$ is the amplified acceleration obtained from the ground response spectra for 3% damping at the frequency of the peak response, and $G_{0.005}$ is the amplified acceleration obtained from the ground response spectra for 0.5% damping at the same frequency.

At penetration X214 the zero period accelerations are 0.70g in the north-south direction and 0.15g in the east-west direction. The amplification factors are as follows:

Damping	Peak N-S	Peak E-W	AF-NS	AF-EW
1%	10.55g	0.72g	15.1	4.8
5%	2.52g	0.17g	3.6	1.1

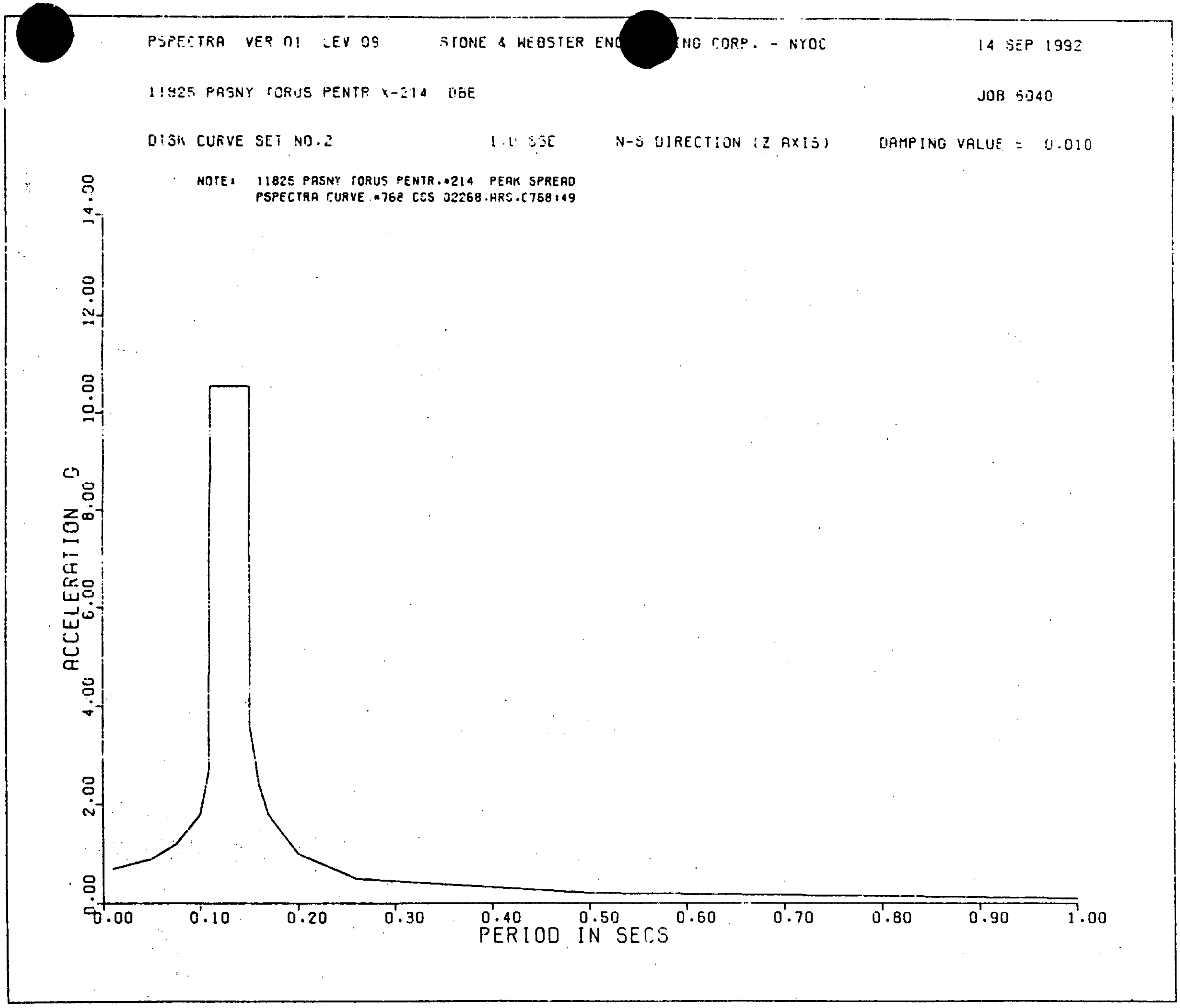


FIG. 5.4-1 SUPPRESSION CHAMBER ARS - DBE - 1% DAMPING AT PENETRATION X214 NORTH-SOUTH DIRECTION

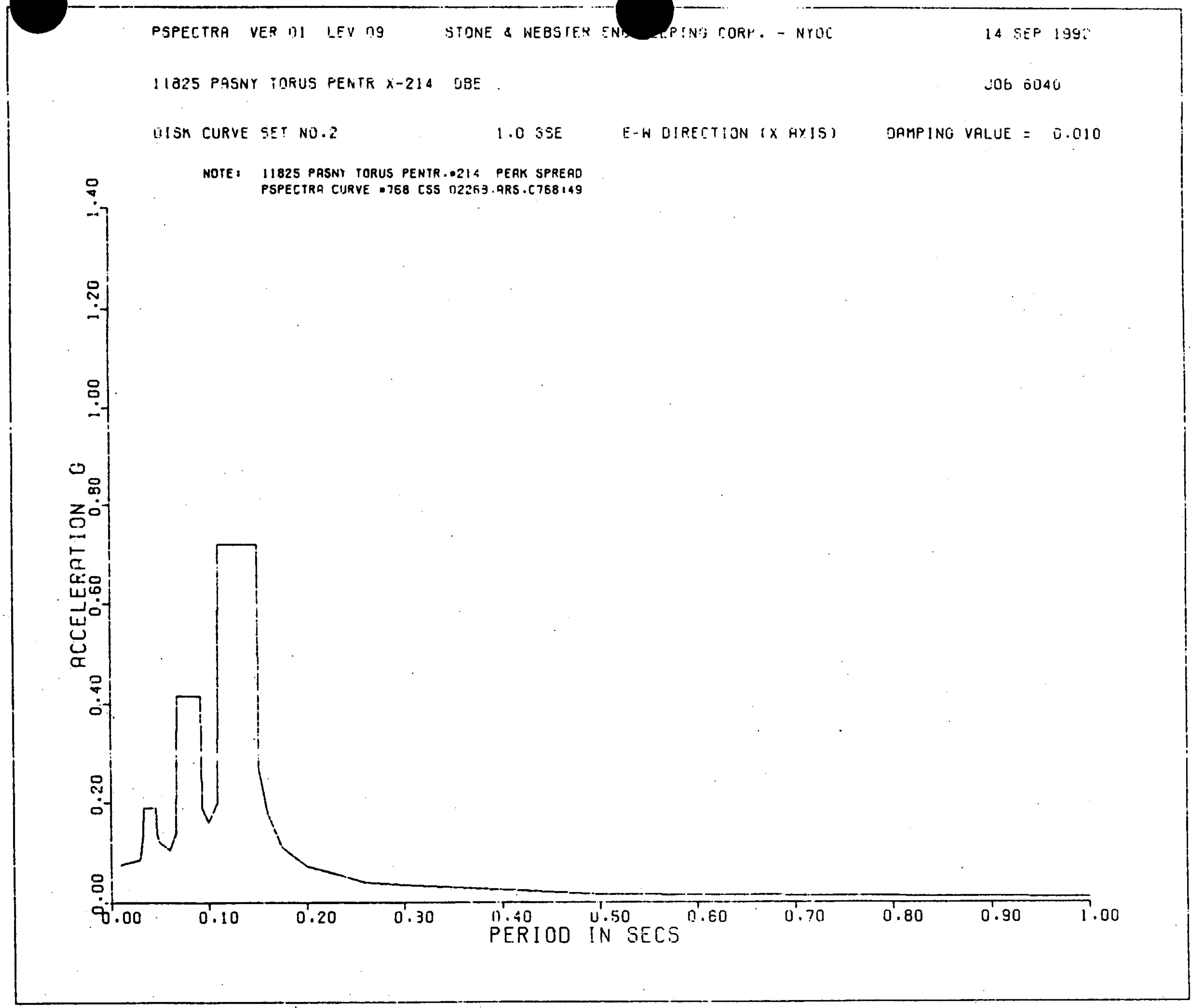


FIG. 5.4-2 SUPPRESSION CHAMBER ARS - DBE - 1% DAMPING AT PENETRATION X214 EAST-WEST DIRECTION

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SUMMARY OF SEISMIC RESPONSE
SPECTRA CHARACTERISTICS

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