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ENCLOSURE

SEISMIC ANALYSIS OF CONTAINMENT FAN COOLER UNITS.......

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(21 PAGES)

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FLORIDA POWER & LIGHT COMPANY

Regulatory

File Cy

August 30, 1976
L-76-314

Office of Nuclear Reactor Regulation
Attn: Dennis L. Ziemann, Chief
Operating Reactors Branch #2
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Ziemann:

Re: St. Lucie Unit No. 1 (Docket No. 50-335)
Seismic Analysis of Containment Fan Cooler Units

Enclosed herewith is the document entitled "Seismic Analysis Report of the St. Lucie Unit 1 Fan Coolers." This document supplies information regarding the analytical techniques which were employed in the seismic analysis of the containment fan cooler units at St. Lucie Unit No. 1.

We are submitting this information in accordance with our commitment made in my letter of June 30, 1976 (L-76-243) and referred to in the Staff's Safety Analysis supporting Amendment No. 6 to the St. Lucie Unit 1 Operating License.

Very truly yours,

Robert E. Uhrig
Robert E. Uhrig
Vice President

REU/NR/hlc
Attachment

cc: Norman C. Moseley, Region II
Jack R. Newman, Esq.

10903

SEISMIC ANALYSIS REPORT
OF THE
ST. LUCIE UNIT 1 FAN COOLERS

REC'D BY
TELECOPIER
FPL - PWR PLT ENG
FROM:
DATE: AUG 27 1976
TIME: 5:00
REC'D BY:

by

C.-N. Lin
H. S. LaPay
J. Parello
G. A. Balcfunas

APPROVED BY:
G. J. Bohm, Acting Manager
Structural Technology

Westinghouse Electric Corporation

August 1976

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SECTION 1

INTRODUCTION

This analysis was performed to verify the structural integrity and operability of the St. Lucie - Unit 1 reactor containment fan coolers when subjected to seismic loads. It was found from the seismic analysis that the reactor containment fan coolers conform to the St. Lucie - Unit 1 seismic criteria.

Presented in this document are the results from the seismic analysis demonstrating the seismic structural adequacy and operability of the St. Lucie-Unit 1 fan coolers. Also, given is a discussion of the analytical methods employed, a description of the input used, and a description of the fan cooler structural system.

DESCRIPTION OF FAN GENERAL ASSEMBLY

The general assembly (Fig.1 Schematic Dwg.) consists of fan assembly, motor base, and heat exchanger assembly. The motor is mounted on top of motor heat exchanger assembly which is bolted to fan assembly. The complete assembly is welded to the floor foundation. The specific details are discussed below.

The fan assembly consists of rotor assembly, housing assembly, bearing base, inlet, spherical roller bearings, and inlet flange ring. Housing assembly is made of welded steel plates and consists of side sheets and scroll. The rotor consists of centrifugal airfoil bladed wheel assembly and the shaft. The wheel assembly is pressed on the shaft and is also retained on the shaft by two 3/4-10 set screws. The spherical roller bearings are mounted on the rotor assembly and bolted to the bearing base assembly. The rotor assembly is connected to the motor with a flexible coupling. The bearing base is fabricated using welded steel construction. The inlet is of all welded steel construction and is used to guide air into the wheel assembly.

The motor base is of all welded construction and compartmented so that hot air is blown over the heat exchanger and returned to cool the motor which is bolted on top of the base. The motor heat exchanger is bolted to the welded steel mounting frame inside the motor base.

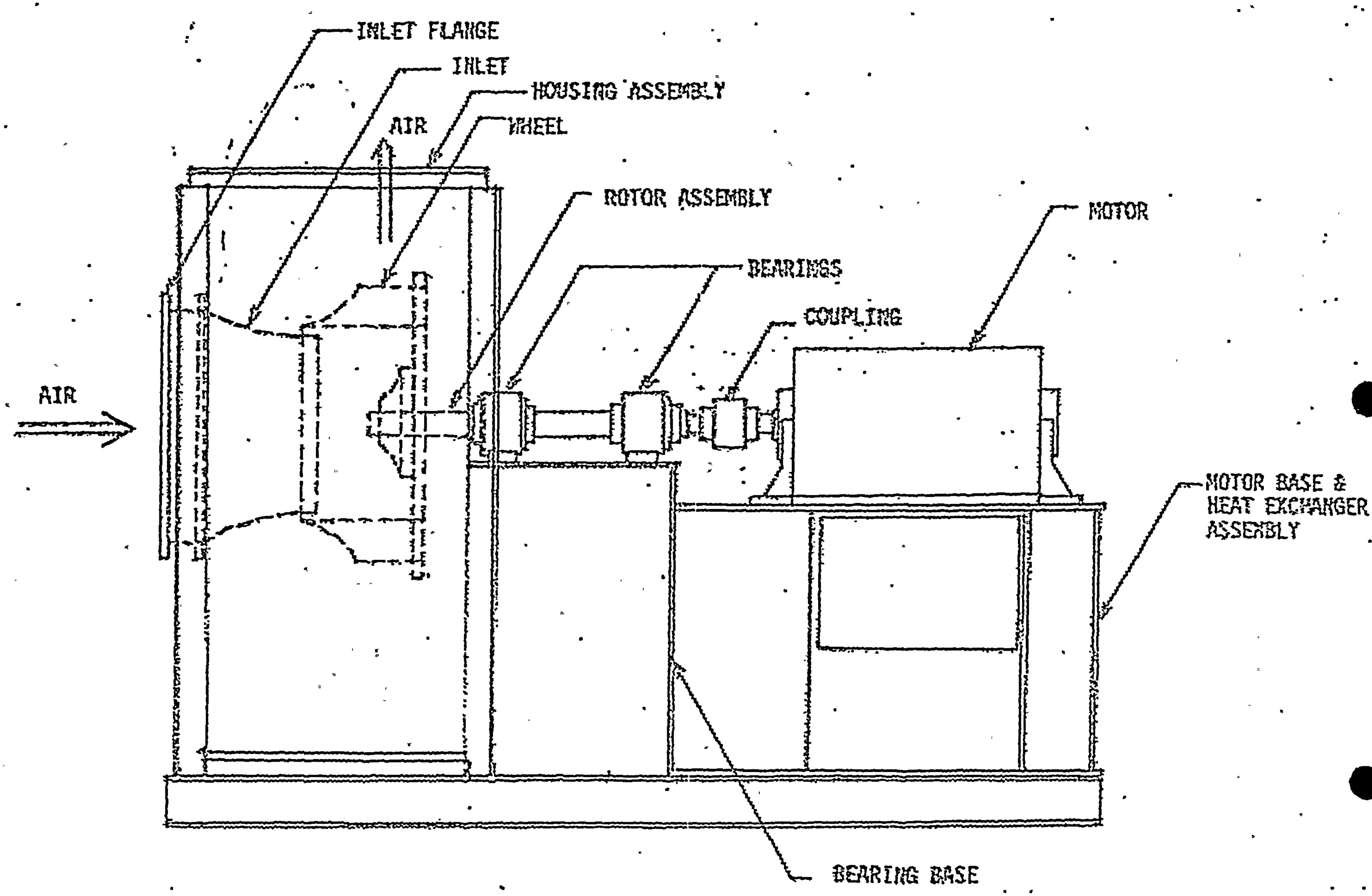

FIGURE 1: Schematic Representation of the Fan General Assembly

SECTION 3

ANALYTICAL METHODS AND CRITERIA

As described in the previous section, there is no interaction between the fan and motor rotors of the fan cooler structure because each rotor has its own fixed bearing and the shafts are connected through a flexible coupling. Based on this fact, the fan and motor were independently analyzed.

Drawings for the reactor containment fan cooler were used to determine the general assembly, dimensions, and properties of components.

The structure was modeled as spring mass systems and the natural frequencies were computed to determine the behavior of the components during seismic excitation. As explained in Section 4, the amplification levels are determined based on the floor response spectra. It was determined that the frequencies associated with the fan motor system including coils and coil banks have frequencies in the region of zero amplifications. Therefore, the seismic analysis was performed using equivalent static loads.

Stresses and deflections were calculated using elastic relations for the worst combination of operating loads, horizontal seismic (DBE), vertical seismic (DBE), and accident pressure (coils and coil banks).

Limit values used were in accordance with the elastic provisions in Part I (fan cooler structural components) AISC-69 and ASME Sec. VIII, Pressure Vessels Specifications (coil tube and fin material). No analysis was made for the OBE since it was shown that the DBE stress levels are within OBE elastic limits as defined in the criteria documents above.

Operability of the fan cooler during seismic event is ensured after establishing that the stresses are within elastic limits and that the deflections are limited and will remain within allowable values of the operating clearances.

SECTION 4

INPUT DESCRIPTION

The seismic design values used in the calculations were obtained from the floor response spectra included in the EBASCO specification containment fan coolers No. FLO-8770.775, dated May 26, 1971, Section 18.

Shown in Figures 2 to 7 are the floor response spectra for OBE. Figures 2 and 3 are vertical floor response spectra for 0.5% and 1% equipment damping values, respectively. Figures 4 and 5 are horizontal floor response spectra for 0.5% and 1% equipment damping values, respectively, at reactor building elevation 60. Figures 6 and 7 are horizontal floor response spectra for 0.5% and 1% equipment damping values, respectively, at reactor building elevation 44.

As shown in Figures 2 to 7, the response spectral peaks are at and above 0.30 second period. Less than or equal to 0.05 second period which includes all natural frequencies calculated for the assembly, the response spectral values have converged to the floor acceleration values. Consequently, the assembly can be considered as rigid for the floor response spectra shown in Figures 2 to 7. However, for the purpose of conservatism, static accelerations of 0.6g and 0.4g for horizontal and vertical directions, respectively, have been chosen as the OBE input to the assembly.

To obtain the maximum hypothetical earthquake (DBE) values, the above values were multiplied by 2. The following DBE acceleration values were used:

VERTICAL SEISMIC	HORIZONTAL SEISMIC	
	Elev. 44'	Elev. 60'
0.8g	1.2g	1.2g

The vertical and horizontal seismic loads were applied simultaneously to allow for the worst possible conditions. In addition, the coils were subjected to a differential pressure of 2 psi to represent the blowdown transient pressure difference.

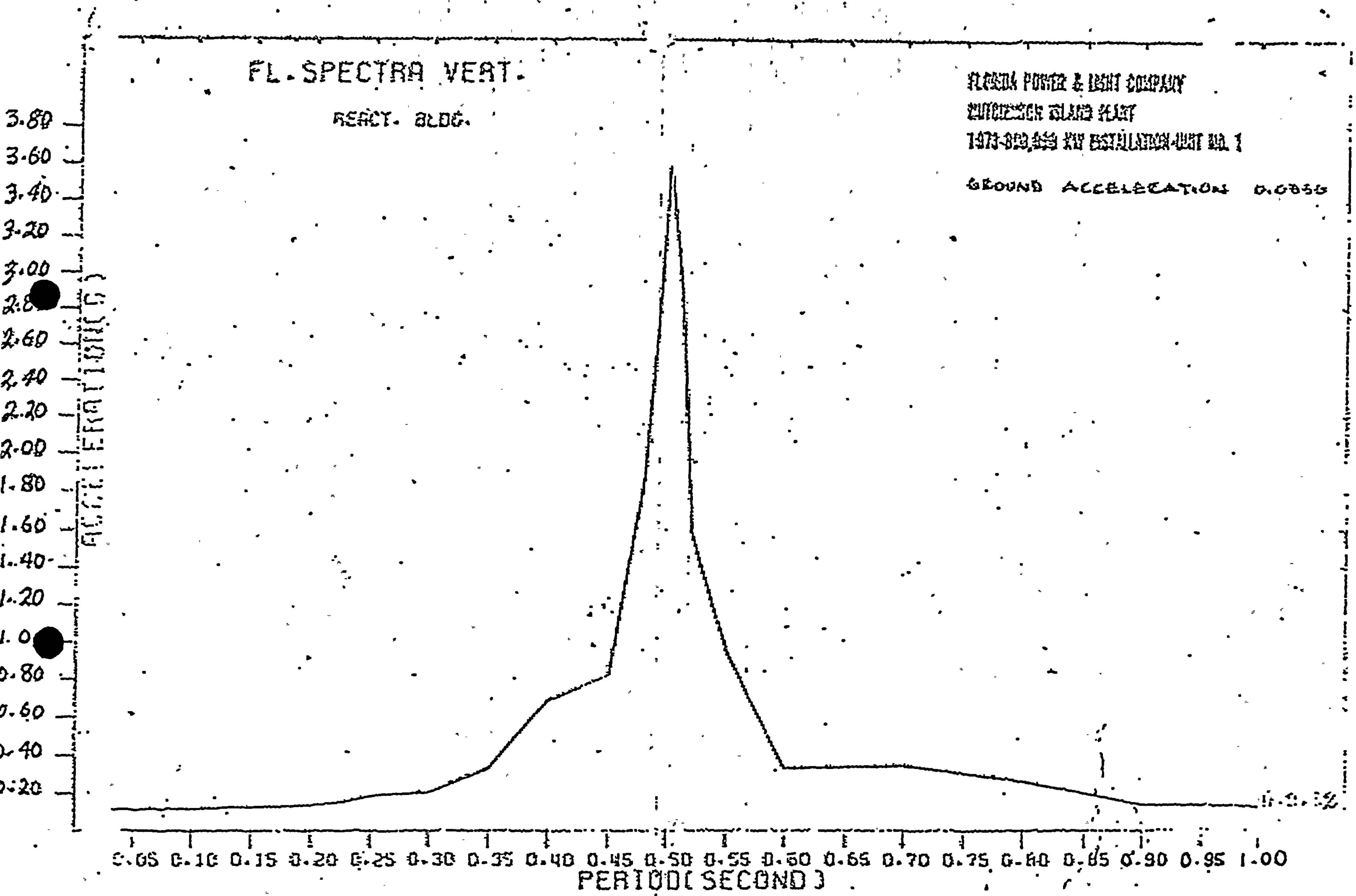

FIGURE 2: Floor Response Spectra for Vertical Direction, OBE and 0.5% Damping

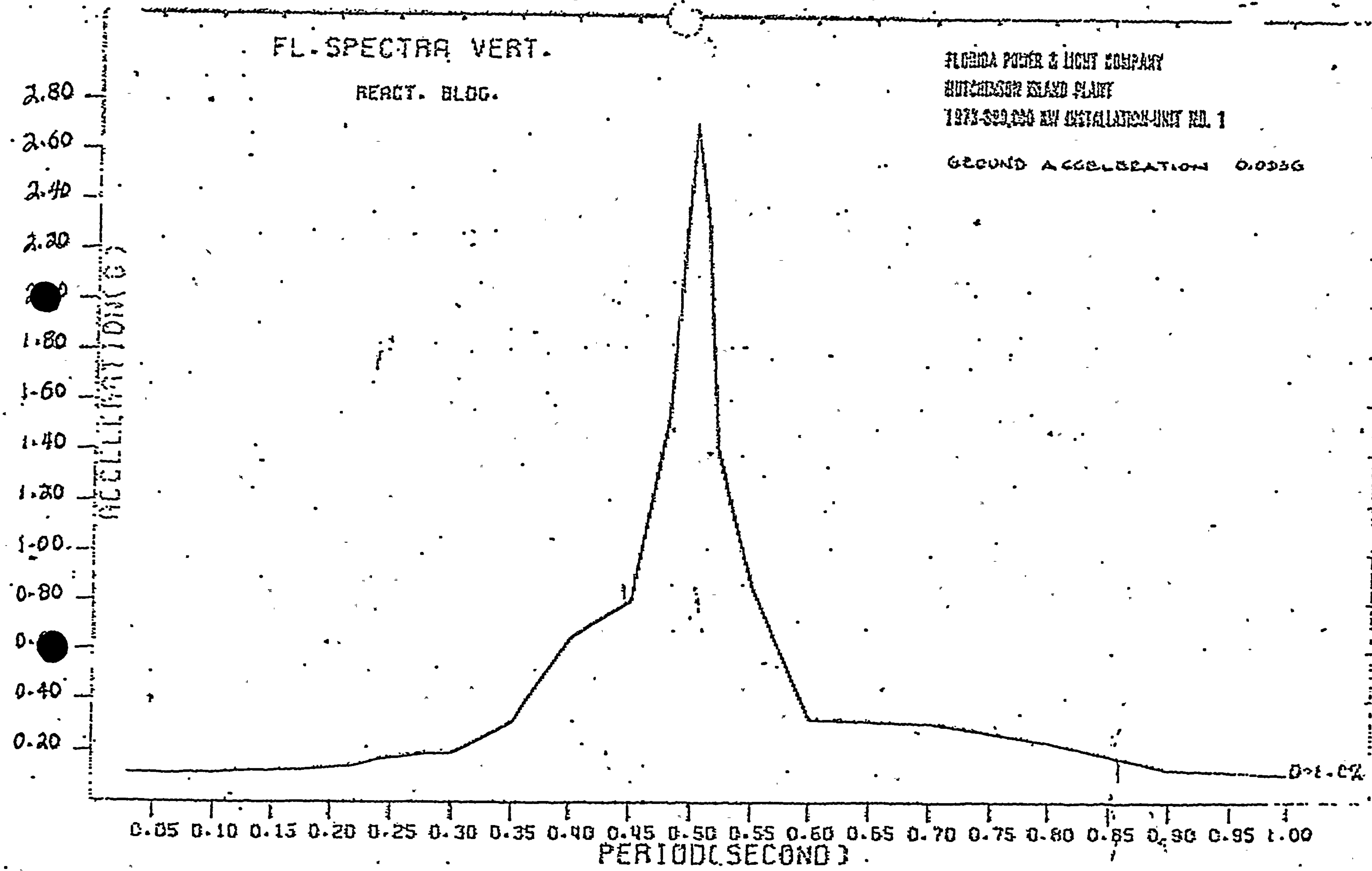

FIGURE 3: Floor Response Spectra for Vertical Direction, OBE and 1% Damping

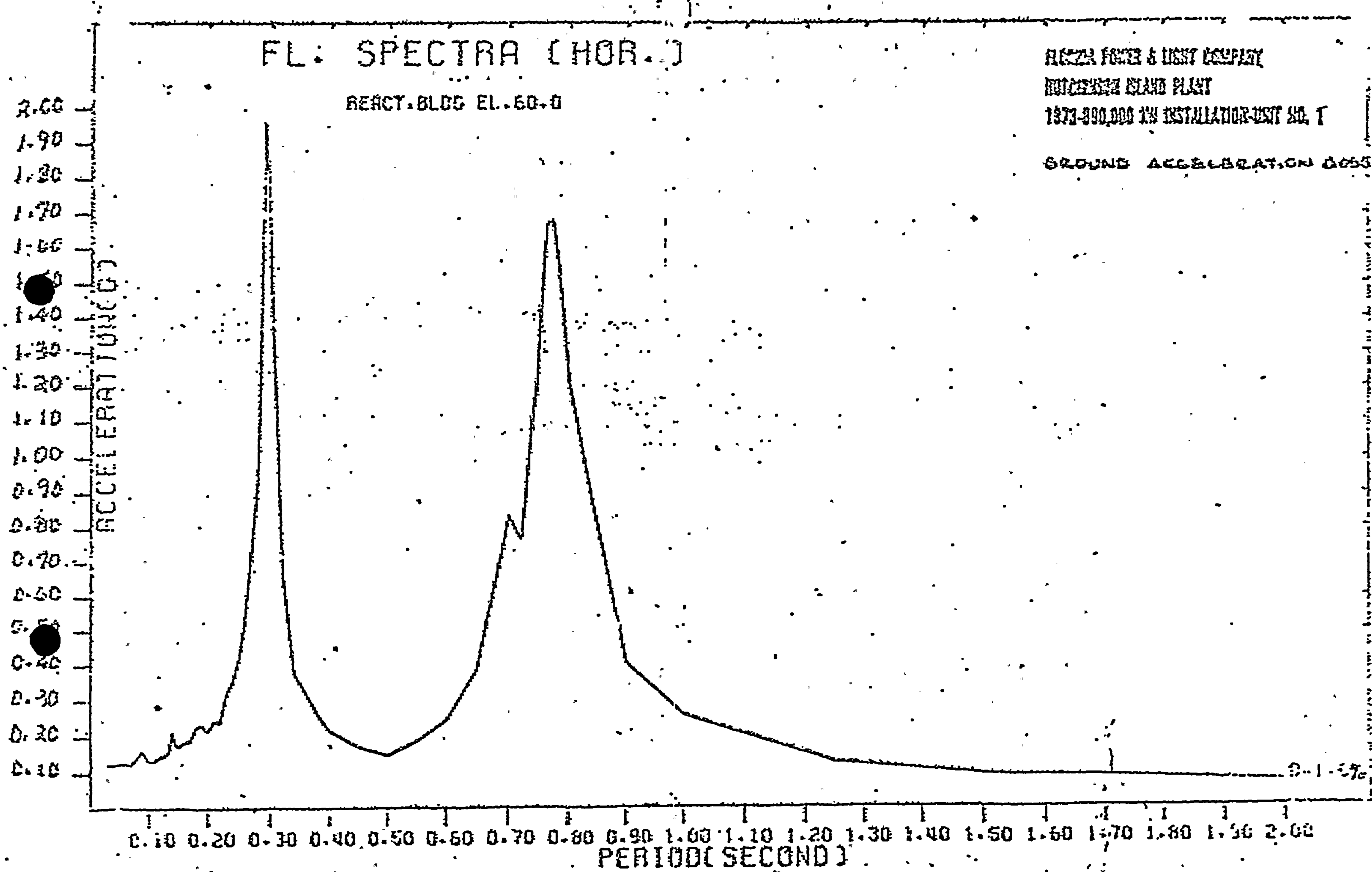

FIGURE 4: Floor Response Spectra for Horizontal Direction, OBE and 1% Damping
Elev. 60

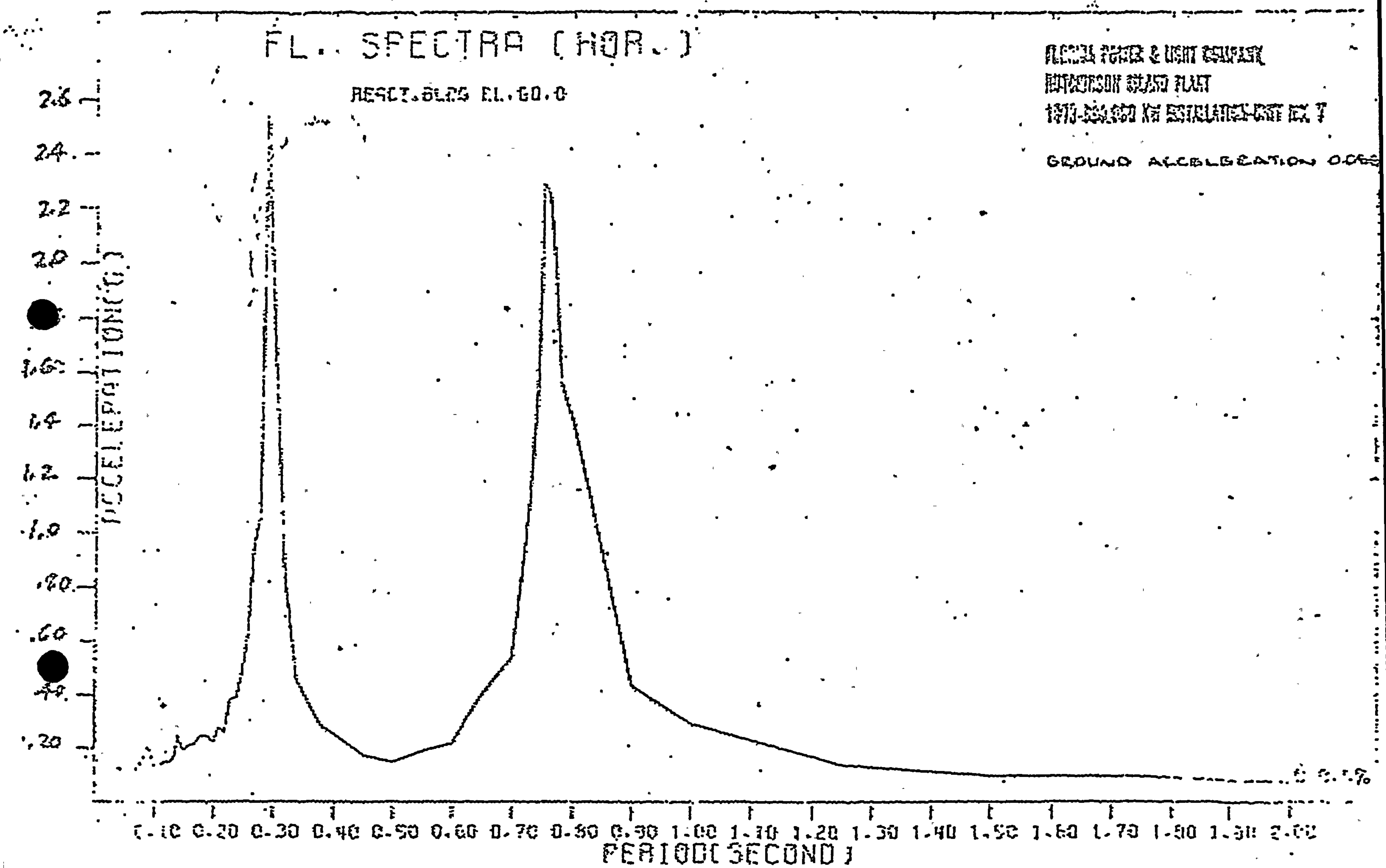

FIGURE 5: Floor Response Spectra for Horizontal Direction, OBE and 0.5% Damping
Elev. 60

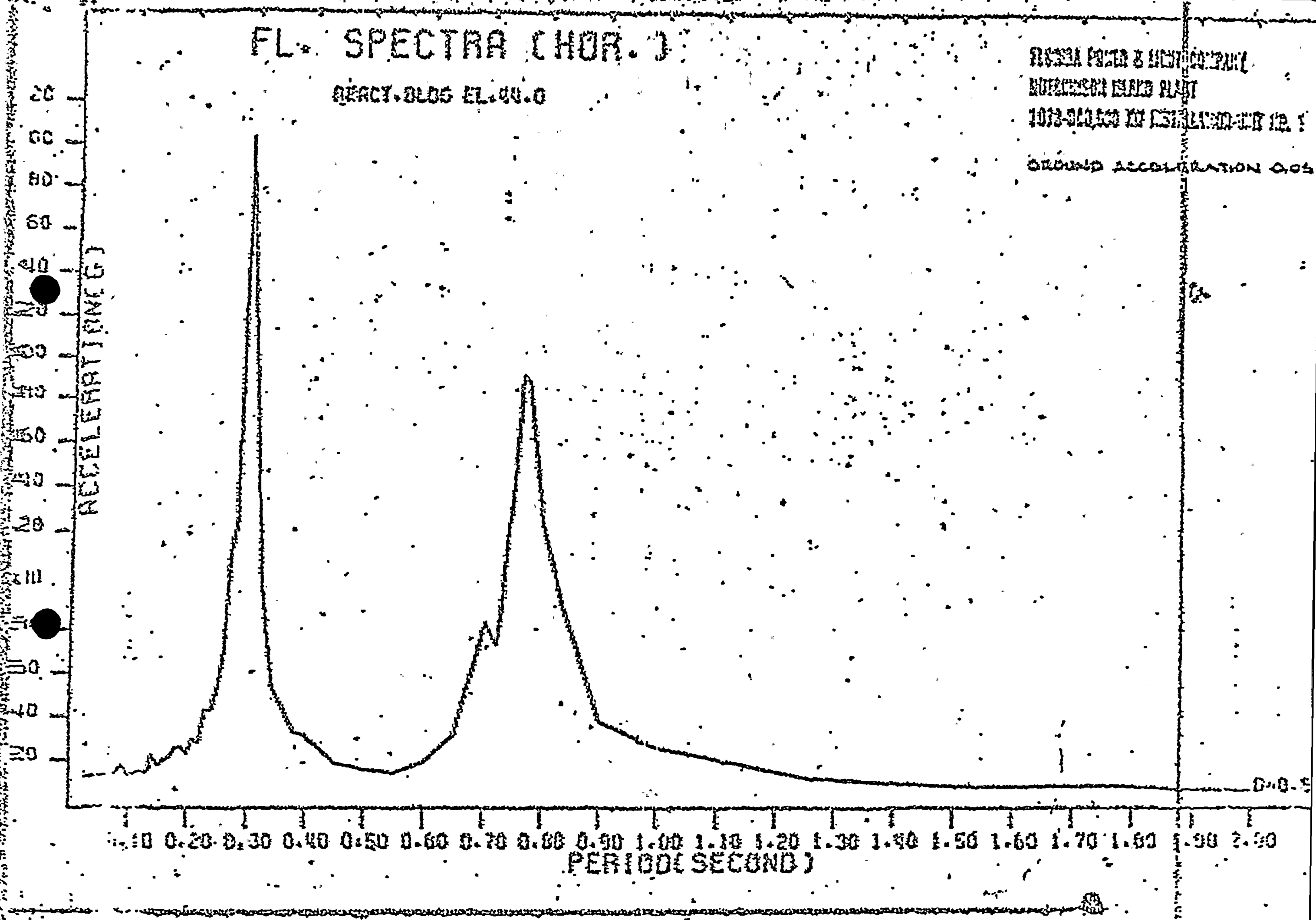

FIGURE 6: Floor Response Spectra for Horizontal Direction, OBE and 0.5% Damping
Elev. 44

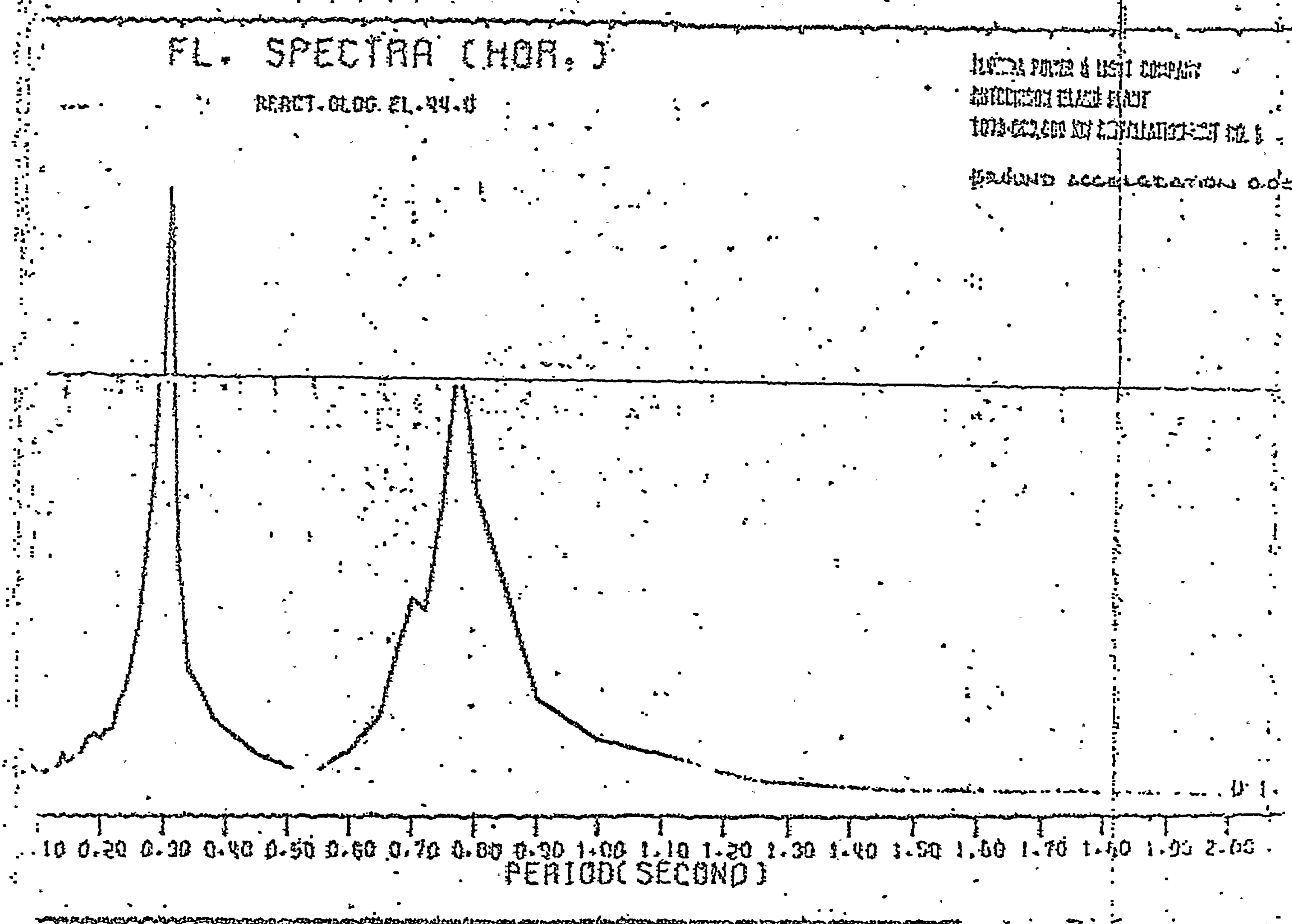

FIGURE 7: Floor Response Spectra for Horizontal Direction, OBE and 1% Damping
Elev. 44

SECTION 5

RESULTS

The fan motor system spring constants and natural frequencies were calculated. As shown in Table 1, all natural frequencies are above 20 Hz including the rotor assembly which is 24.6 Hz. These frequencies are at and above the rigid range of the floor response spectra, (Figures 2 to 7), i.e., the floor response spectra converge to the constant response values with zero amplification at and above 20 Hz (or 0.05 sec.). Because all natural frequencies are in the region of zero amplification, the fan motor system was analyzed using seismic equivalent static loads.

Shown in Table 2 are the calculated and limit behavior along with the margin of strength for different modes. DBE seismic loads were used to calculate the values in Table 2. Since the elastic limits associated with an OBE event were not exceeded when DBE seismic levels were used, it is not necessary to perform an OBE seismic analysis.

TABLE I NATURAL FREQUENCIES

ITEM	DESCRIPTION		FREQUENCY (CPS)	BEHAVIOR
1.	Bearing Base	Horizontal	106	Rigid
2.	Bearing Base	Vertical	426	Rigid
3.	Motor Base and Motor Coil	Horizontal	86.09	Rigid
4.	Motor Base with Motor & Coil	Horizontal	67.80	Rigid
5.	Rotor Assy on Brg Base & Bearings	1st	24.6	Near Rigid Region
6.	Rotor Assy on Brg Base & Bearings	2nd.	153.5*	Rigid
7.	Motor Shaft on Motor Brg. Brackets		54.65	Rigid

*Approximate - Cantilever Beam Ref.

Den Hartog, Mechanical Vibrations 4th Ed.

P. 432, McGraw-Hill Book Co.

TABLE 2 - SEISMIC ANALYSIS OF REACTOR CONTAINMENT FAN COOLER

ITEM	POSTULATED FAILURE MODE DESCRIPTION	UNITS	CALCULATED BEHAVIOR	LIMIT BEHAVIOUR	MARGIN OF STRENGTH*
1	Deflection of fan wheel & housing to cause rubbing	in.	.0239	.125	5.23
2.	Wheel - Shaft Attachment	lb.	1753.	2600	1.48
3.	Max fan shaft stress - combined	psi	5046	24,800	4.28
4.	Motor coil hold down bolts (shear)	psi	5865	10000	1.70
5.	Motor coil support stress	psi	1536	22000	14.30
6.	Motor - Motor Base Bolts (tension-2 bolts)	psi	2785	20000	7.18
7.	Motor - Motor base bolts (shear-4 bolts)	psi	2228	10000	4.49
8	Motor base - Sub base bolts (tension-10 bolts)	psi	2148	20000	9.31
9.	Motor base - Sub base bolts (shear-20bolts)	psi	1300	10000	7.69
10.	Bearing bolts End brg (shear)	psi	868	10000	11.51
11.	Bearing bolts End brg (tension)	psi	736	20000	27.16
12.	Bearing bolts flg brg. (shear)	psi	1152	10000	8.67
13.	Motor coil tube stress	psi	3001	6000	2.00
14.	Motor coil end frame stress	psi	230	22000	96.0
15.	Motor coil nozzle stress	psi	1029	6000	5.83
16.	Motor rotor deflection (air gap)	in.	.00745	.0395	5.30
17.	Motor shaft stress combined	psi	4443	22000	4.95

TABLE 2 - SEISMIC ANALYSIS OF [illegible] CONTAINMENT FAN COOLER   PAGE TWO

ITEM	POSTULATED FAILURE MODE DESCRIPTION	UNITS	CALCULATED BEHAVIOUR	LIMIT BEHAVIOUR	FACTOR OF SAFETY
18.	Motor shaft stress shear	psi	4236	14500	3.42
19.	Motor Bearings frd brg B_{10}	Hr	188000**	-	--
20.	Motor Bearings flts brg B_{10}	Hr	293000**	-	-
21.	Fan Bearings frd & flts B_{10} (See FMC registered brg anal. 73618)	Hr	200,000+**	-	-
22.	Coupling	BHP	154	405	2.63
23.	Coil Bank coil tube end (shear)	psi	51.6	3406	65.97
24.	Coil Bank coil tube stress	psi	3899	5900	1.51
25.	Coil Bank coil fin stress (vert.-load)	psi	97.6	1345	13.8
26.	Coil Bank coil top & bottom plt stress	psi	1353	13200	9.75
27.	Coil Bank coil fin stress @ fin suppt	psi	598	1952	3.26
28.	Fin Support Bolts @ center (Shear)	psi	6906	10000	1.45
29.	Fin Support Bolts @ center (Shear)	psi	4577	10000	2.18
30.	Coil Top & Bottom end bolts (Shear)	psi	1433	10000	6.98
31.	Coil Header Nozzle Stress	psi	419	5900	14.05
32.	Coil - Coil Bank Frame Bolts (Shear)	psi	1298	10000	7.7

TABLE 2 - SEISMIC ANALYSIS OF REACTOR CONTAINMENT FAN COOLER-Page Three

ITEM	POSTULATED FAILURE MODE DESCRIPTION	UNITS	CALCULATED BEHAVIOUR	LIMIT BEHAVIOUR	RATIO OF LIMIT TO CALCULATED BEHAVIOR
33.	Coil Trough - Coil Bank Frame Bolts (Shear)	psi	6637	10000	1.50
34.	Coil Bank Frame - Top Bolts (Shear)	psi	5842	10000	1.71
35.	Coil Bank Frame - Bottom Bolts (Tension)	psi	10384	20000	1.93
36.	Coil Bank - Enclosure Attachment (Tension)	psi	6443	20000	3.10
37.	Coil Bank - Enclosure Attachment (shear)	psi	1326	10000	7.53
38.	Coil Bank Base - Enclosure Attachment (shear)	psi	776	10000	12.87
39.	Coil Bank Base - Enclosure Attachment (tension)	psi	1054	20000	18.97
40.	Motor Base Piping Brace	psi	4838	22000	4.55
41.	Fan Housing Ass'y Piping Brace	psi	726	22000	30.29
42.	Bearing Base Piping Brace	psi	611	22000	36.01
43.	RCFC Roof Ass'y Piping Brace	psi	3900	22000	5.64
44.	RCFC Manifold Pipe Support	psi	4892	22000	4.50
45.	RCFC Manifold "U" Clamp Stress (Shear)	psi	1770	10000	5.65
46.	RCFC Manifold Lower Pipe Support	psi	16764	22000	1.31

** Seismic Effect has No Effect on BRG Life

SECTION 6

CONCLUSIONS

Based upon the seismic analysis conducted, the fan system, cooling coils, and coil banks can more than support the maximum earthquake (DBE) loads in combination with operating and accident loads called for in the specifications. The above will remain elastic under specified maximum loads. The design, therefore, is adequate. Therefore, the St. Lucie Unit 1 reactor containment fan cooler seismic structural integrity and operability has been demonstrated to meet the St. Lucie Unit No. 1 seismic requirements.