Florida Power
CORPORATION
Crystal River Unit 3
Docket No. 50-302

April 16, 1993
3F0493-09

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Subject: Generic Letter 87-02, Supplement 1
Verification of Seismic Adequacy of Equipment in Older Operating Nuclear Plants

References: A. Generic Letter 87-02, Supplement 1, dated May 22, 1992 (3N0592-20)
B. FPC to NRC letter, dated September 4, 1992 (3F0992-02)
C. Generic Letter 88-20, Supplement 4, dated June 28, 1991 (3N0691-23)

Dear Sir:

The Seismic Qualification Utility Group (SQUG) developed the Generic Implementation Procedure (GIP) for seismic verification of selected nuclear plant equipment. In Generic Letter 87-02, Supplement 1 (Reference A), the NRC Staff issued a final Supplemental Safety Evaluation Report on Revision 2 of the GIP. That letter requested Florida Power Corporation (FPC) provide a description of FPC's plans for resolution of Unresolved Safety Issue A-46 (USI A-46) for Crystal River 3. FPC's response (Reference B) described FPC's plans for resolution of USI A-46 and other plans to establish a formal seismic design basis program applicable to safety related equipment. That response also addressed the portions of the Individual Plant Examination for External Events (IPEEE) (Reference C) related to seismic issues.

This letter provides a status report update for each of the elements of the seismic upgrade program.

USI A-46 AND IPEEE SEISMIC RESOLUTION

In Reference B, FPC committed to the development of a plant specific procedure, based on the GIP, for verification of the seismic adequacy of the safe shutdown equipment installed at CR-3. This procedure will be used in a plant walk-down to resolve USI A-46 and IPEEE seismic for Crystal River 3.

A025 1/1

Training

In support of that commitment, FPC has sent 3 engineers to the Safe Shutdown Equipment Selection Training Course and 2 engineers to the Walkdown Training Course. Additional engineers will attend the Walkdown Training Course in 1993. This schedule is consistent with FPC's commitment to perform the plant walkdown in 1995.

Safe Shutdown Equipment List

FPC has prepared a preliminary Safe Shutdown Equipment List (SSEL) using the procedure in the GIP. The marked up flow drawings, which the procedure requires to be generated, have received a preliminary review by plant operations. This activity is on schedule.

Seismic Program Team

FPC has assembled a Seismic Program Team to develop the plant specific procedure to be used to walk down Crystal River 3. The Team includes FPC engineers and two consultants (Paul Smith and Harry Johnson) with broad seismic expertise and a long involvement with SQUG and the GIP methodology. The Team also includes the structural engineers from the architect/engineer for CR-3 (Gilbert/Commonwealth) who were responsible for the structural design of the mechanical systems and the anchorage of equipment. The Team has been charged with determining which portions of the GIP are important to a low seismic site and which portions are relevant only to the moderate and high seismic plants that the GIP is intended to envelop, and, therefore, are not necessary for a low seismic plant. These portions will then be modified or eliminated in the CR-3 plant specific procedure. The Team will also document the justification for these departures from the approved methodology, as required by the GIP.

Preliminary Scoping Walkdown

A preliminary scoping walkdown was performed by the Team. The purpose of this walkdown was to look for features unique to the CR-3 design that might be important in the development of the plant specific walkdown procedure.

Plant Specific Procedure

A review of the GIP has been performed to determine which elements of the procedure are important for a low seismic risk site. The major objective was to identify those cost effective portions of the procedure that assure the greatest possible confidence in the seismic ruggedness of CR-3. Some of the remaining portions of the GIP were determined to be overly detailed or complex for a low seismic site. These portions will be simplified to produce a more cost beneficial approach. The remaining portions will be eliminated completely.

The review was two tiered. Major portions of the GIP were evaluated for applicability at a low seismic site. In addition, individual caveats were evaluated for applicability. The objective was to pre-screen the procedure for requirements

that were not significant for a plant with a safe shutdown earthquake (SSE) of only 0.1g.

The detailed justification for significant changes from the GIP is now being prepared. This justification will be submitted along with the procedure by June 30, 1993 as committed to by FPC in Reference B.

A brief summary of the major changes from the GIP is as follows:

- An evaluation of cabinets will replace the evaluation of individual relays. No specific relay review will be performed.
- The GIP guidance will be exceeded in one aspect. All safety related relay cabinets (not just those containing essential relays) will be evaluated for GIP caveats such as anchorage stiffness and connection of adjacent cabinets.
- The original seismic design criteria for raceways are conservative. An evaluation of the original criteria, with a confirming walkdown to verify the actual construction of the raceways, found that the raceways are inherently seismically rugged for a plant with a 0.1g SSE.
- The evaluation of seismic demand versus seismic capacity for all SSEL equipment will be separated from the plant specific procedure. It will be demonstrated that the SQUG spectra bound all CR-3 spectra such that further evaluation of individual components is not necessary.
- Some of the caveats will be modified or eliminated based on their relevance at a low seismic site.
- The screening guidelines for evaluation of equipment anchorage will simplified substantially.

Other exceptions to the GIP

Other exceptions to the GIP were identified during the preparation of the SSEL. Most of these relate to the single failure requirement in the GIP. These exceptions will be individually documented in FPC's subsequent submittal(s).

IPEEE seismic scope not included in A-46

FPC recognizes there are additional tasks suggested for the scope of IPEEE seismic, beyond the GIP or the CR-3 plant specific procedure. This scope difference is minimal for a reduced scope IPEEE plant such as CR-3. FPC believes that the additional tasks would not produce any meaningful results. The additional structures, systems and components are either inherently seismically rugged for a 0.1g SSE plant, or any possible vulnerability will be generic enough to be detected through the CR-3 plant specific procedure. This assumption will be reexamined following completion of the plant specific walkdown procedure to assure it remains valid.

Conclusion

FPC firmly believes a full GIP walkdown of Crystal River 3 is not cost beneficial. Even the proposed plant specific procedure would not meet the criteria for being imposed as a backfit. We believe FPC's plant specific program is an appropriate response to the NRC concerns documented in USI A-46 and Generic Letter 88-20, Supplement 4. We believe it will enhance the safety and seismic ruggedness of Crystal River 3 by examining the potential seismic vulnerabilities in a cost effective manner.

DESIGN BASIS EARTHQUAKE AND DAMPING

In Reference B FPC also committed to review the licensing basis earthquake magnitude to determine if safety can be enhanced by changing to a more appropriate Safe Shutdown Earthquake (SSE). FPC also committed to evaluate the benefits of updating from a 2 dimensional to 3 dimensional earthquake. This would be more consistent with current engineering and licensing practice. Finally, FPC committed to review the current licensing basis damping coefficients to determine if it would be more appropriate to use higher or lower values for some components or structures.

FPC has completed these reviews with the assistance of the expert members of the Seismic Program Team. As a result of these reviews FPC has concluded that a change to the current SSE magnitude is not advantageous at this time. A change to a larger SSE was rejected because of the large operational and economic impact compared to the very low probability that the current SSE level would be exceeded. Pursuing an exemption request allowing a lower magnitude SSE was rejected due to the delay it would cause in the implementation of the seismic design basis program, and the resolution of USI A-46 and IPEEE seismic.

The experience of two other utilities that had made a change from a 2D to 3D earthquake was evaluated. It was concluded that the complexity and level of effort required to make such a change was considerably greater than had been anticipated and the cost far exceeded the benefits. Therefore, we will not pursue this change.

A change in licensing basis damping values was discussed with the expert members of the Seismic Program Team. From these discussions we learned that it would not be appropriate to change damping values without also changing the design basis SSE spectrum. Because of the difficulties associated with such changes, as described above, this option was also rejected.

FLOOR SPECTRA

FPC committed to review the current design basis floor spectra to determine if they contain a minimal, sufficient, or an excessive degree of conservatism. This review has not yet begun.

NON-SEISMIC OVER SEISMIC

FPC also committed to review the current "falldown" criteria for non-safety related piping, conduit, cable trays, ductwork, lighting, suspended ceilings, and equipment.

The current guidance was put in place in 1984 and has created inconsistencies in the plant with items installed before that. Preliminary discussions have been held among the FPC staff and consultants regarding changes to the guidance. No conclusions have been reached as of this date.

SEISMIC QUALIFICATION AND OPERABILITY

FPC indicated that the seismic program development would consider alternative means of demonstrating seismic qualification. FPC will also provide clarification of how seismic qualification relates to Technical Specification OPERABILITY.

As an alternative for demonstrating seismic qualification, FPC will likely change the licensing basis for CR-3 to provide for the use of the GIP to demonstrate the seismic adequacy of applicable equipment. This change will not be made until after the USI A-46/IPEEE seismic actions have been completed. FPC also will pursue better definition of the relationship between operability and seismic qualification through an expansion to the guidance provided in Generic Letter 91-18.

FLOOR SPECTRA

The Attachment to this letter contains the detailed information as to what procedures and criteria were used to generate the in-structure response spectra to be used for USI A-46 and IPEEE seismic, as requested in Supplement 1 to Generic Letter 87-02. The ground and floor response spectra are also included for information.

We would be pleased to meet with the NRC Staff to discuss our planned program in more detail.

Sincerely,

P. M. Beard, Jr.
Senior Vice President
Nuclear Operations

PMB/AEF:

ATTACHMENT

xc: Regional Administrator, Region II
NRR Project Manager
Senior Resident Inspector

Attachment "A"

Description of the Generation Methods used to develop 5% SSE Floor Response Curves

DESCRIPTION OF THE GENERATION METHODS

1. BIGGS METHOD

A generalized procedure was developed in Reference [1] for direct generation of floor response spectra for seismic design and analysis of structural systems in nuclear power plants. A detailed description of this procedure (Hereafter, called Biggs Method) is presented in Reference [9]. This procedure is well understood, utilized and accepted in the industry.

In the original seismic design of CR3 [2], DYNAL computer program was utilized to obtain the modal data (natural frequencies, mode shapes, and participation factors) for the lumped-mass models of the Seismic Category I structures. Afterthat, the procedure developed by Biggs was used to generate floor response spectra. Biggs method was implemented by using the G/C's in-house FLORMO computer program.

The necessary input to FLORMO computer program is:

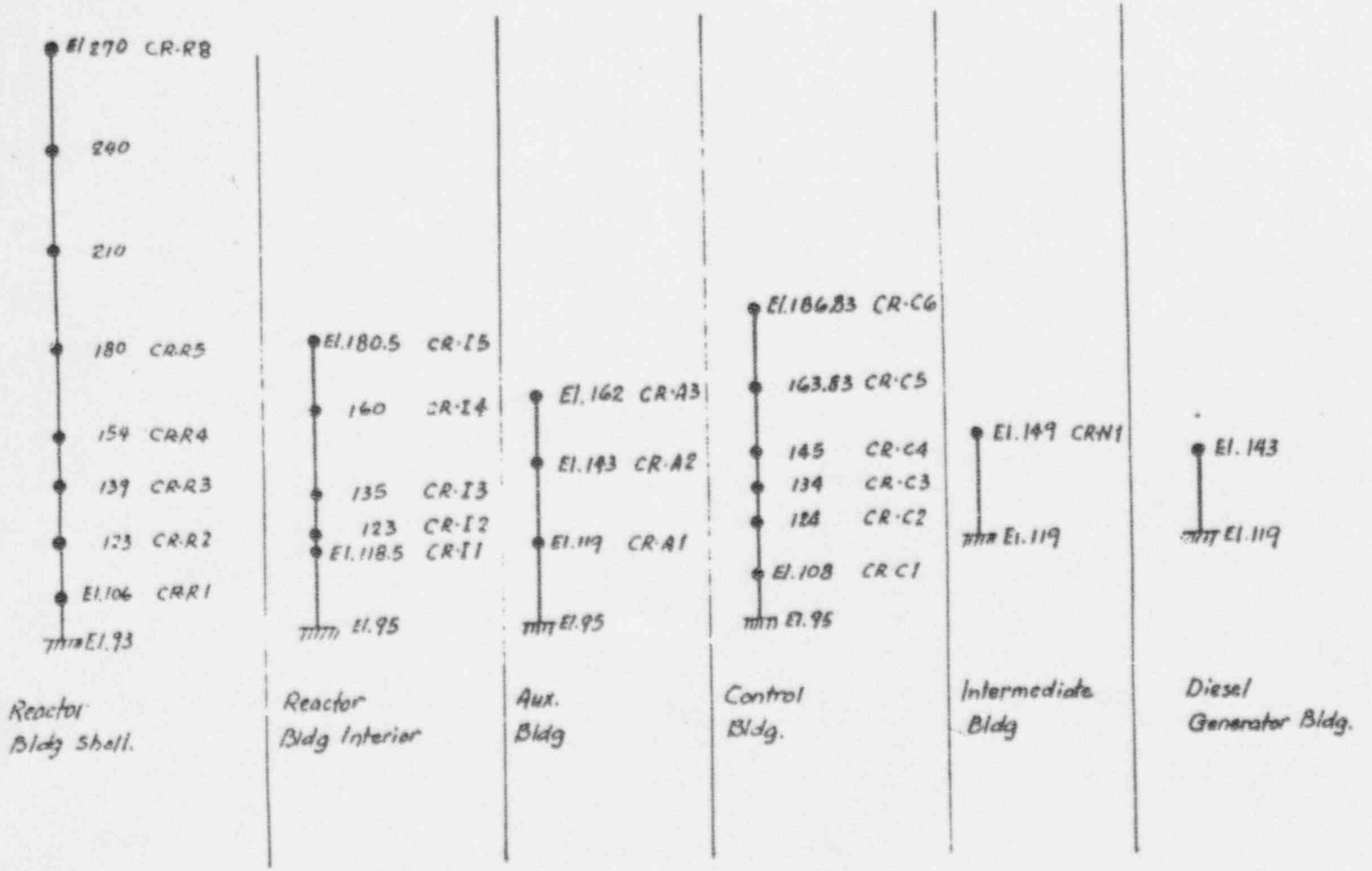
- Ground response spectra corresponding to equipment damping value.
- Biggs curve # 1 corresponding to the equipment and structural damping values. This is provided in Reference [9] for certain damping values. For other damping values, linear interpolation or extrapolation is adequate.
- Biggs curve # 2 corresponding to the structural damping value. This is provided in Reference [9] for certain damping values. For other damping values, linear interpolation or extrapolation is adequate.
- Natural frequencies of structure, mode shapes, modal participation factors and modal accelerations.

Biggs method is used in the generation of the 5% SSE floor response curves for future application in the resolution Unresolved Safety Issue A-46. In order to account for uncertainty in the structural frequency calculations, the peaks of the floor response spectra will be broadened.

The following pages show the lumped mass models of the Auxiliary and Control buildings, SSE ground response spectra (plot and digitized values), structural damping values, and Biggs curves

FLORIDA POWER CORP.
CRYSTAL RIVER PLANT UNIT 3

Response Spectrum for CR3 Equipment Stress Analysis



MPH

4203

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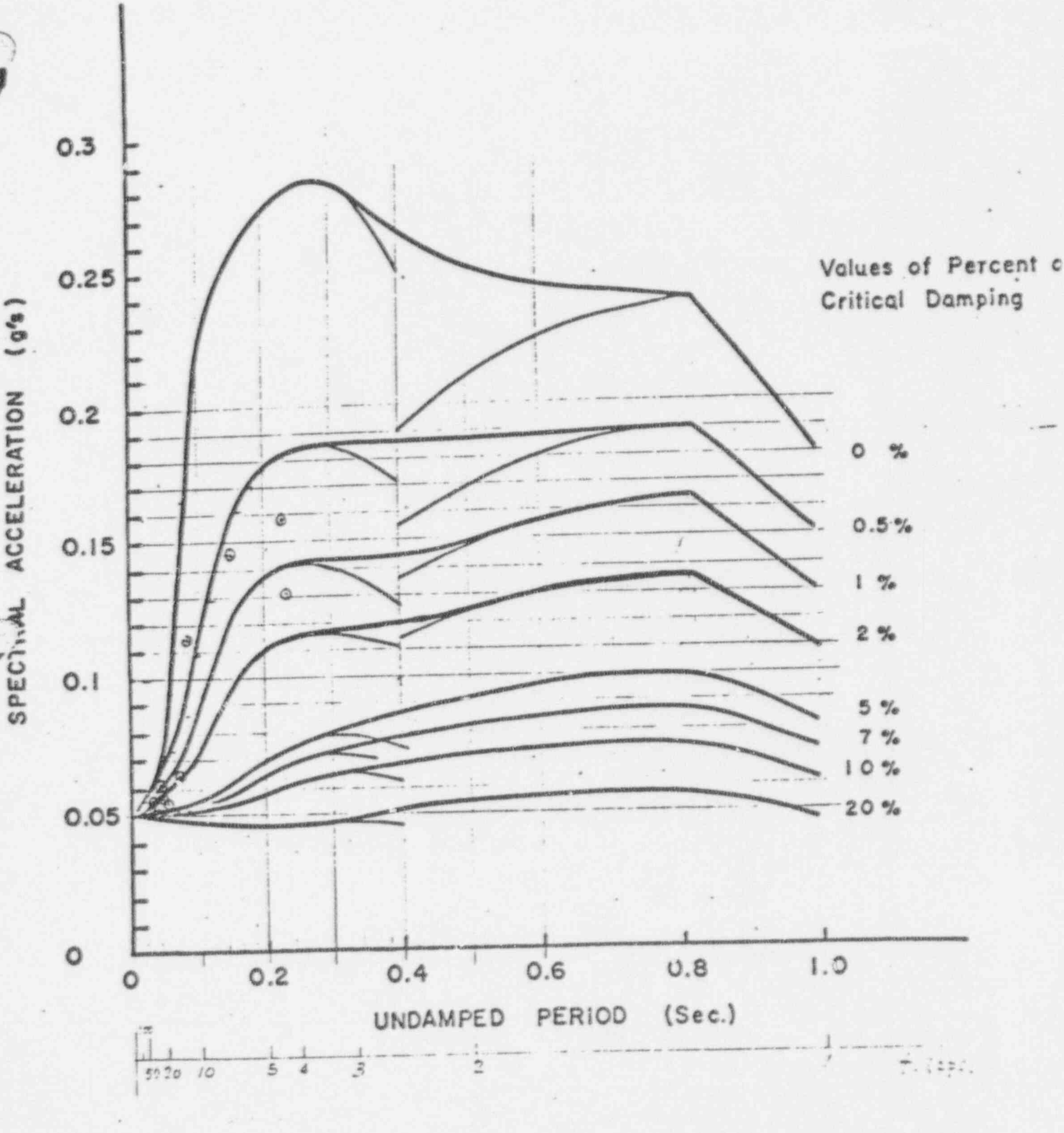


El Centro (2% Damping)
Oakland City Hall (2% Damping)

DES... ...ERATION SPECTRA
...RIVER UNIT 3

FIGURE 2-28

(FSAR)

CRYSTAL RIVER UNIT 3 FLORIDA POWER CORP.	MADE M P H CHK'D. SQ CF	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.	
Ground Response Spectrum	CF DFN. ENG.	4203-078 WORK ORDER	SIZE DRAWING REV
Interpeted from "FSAR Fig. 2-28"	REV. CH. APP. DATE	June 7 '1973	

T	f	Damping = .005	ft/sec²	Damping .02		Damping .05	ft/sec²
0.0		.05 g	1.61	.05 g	1.61	.05 g	1.61
.01	100.0	.0525	1.691	.051	1.642	.0505	1.626
.02	50.0	.0555	1.787	.0525	1.691	.051	1.642
.03	33.33	.059	1.9				
.04	25.0	.063	2.029	.057	1.835		
.05	20.0	.067	2.157				
.06	16.67	.073	2.351	.062	[illegible]	.0525	1.691
.07	14.29	.079	2.544				
.08	12.5	.086	2.769	.067	2.157		
.09	11.11	.096	3.091				
.10	10.0	.109	3.51	.074	2.383	.056	1.303
.11	9.09	.118	3.8				
.12	8.33	.129	4.154	.083	[illegible]		
.13	7.69	.138	4.444				
.14	7.14	.146	[illegible]	.092	[illegible]	.061	1.964
.15	6.67	.156	5.023				
.16	6.25	.161	5.184	.101	3.252		
.17	5.88	.166	5.345				
.18	5.56	.170 g	5.474	.107	3.445		
.19	5.26	.174	5.603				
.20	5.0	.1765	[illegible]	.110 g	3.542	.07	2.254
.21	4.76	.1790 .178	[illegible]				
.22	4.55	.181	5.828	.113	3.639		
.23	4.35	.182	5.860				
.24	4.17	.183	5.893	.115	3.703		
.25	4.0	.184	5.925				
.26	3.85	.1845	5.941	.116	3.735		
.27	3.702	.185	5.957				
.28	3.57	.1855	5.973	.117	3.767		
.29	3.45	.1865	6.005				
.30	3.33			.117	3.767	.08	2.576
.40	2.5	.1870		.120	[illegible]	.087	2.801
.50	2.0	[illegible]		.125	[illegible]	.090	2.962
.60	1.667	[illegible]		.131	[illegible]	.097	3.123
.70	1.43	[illegible]		.134	[illegible]	.100	3.22
.80						.100	3.22
.82	1.22	.1870	[illegible]	.136	[illegible]	.099	3.188
.90						.09	3.027
1.0	1.0	.151 g	[illegible]	.110 g	3.542	.082	2.640
2.0	0.5	.075		.055		.040	

FLORIDA POWER CORPORATION CRYSTAL RIVER PLANT UNIT No. 3	MADE	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.		
	CHK'D.			
	EQ. CF.			
FLOOR RESPONSE SPECTRUM	CF. DFN.	4203-078		
	ENG. MPH	WORK ORDER	SIZE DRAWING	REV.
	REV. CH. APP. DATE	July 1973		

DAMPING FACTOR :-

See FSAR P.5-41, 42

Reactor Bldg Shell	2%
Concrete Support Structure (Inside Reactor Bldg)	2%
Structural Steel	
Bolted	2.5%
Welded	1.0%
Piping	0.5%
Other Concrete Structure	5.0%

Gilbert Associates, Inc.
Reading, Pennsylvania

ANALYSIS/CALCULATION

SUBJECT		CISID		PAGE ___ OF ___ PAGES
REV. 0	1	2	3	
MICROFILMED				
ORIGINATOR S. Hoffa	R. Chang			
DATE Oct 22, 1980	Oct 7, 1992			

Bigg's Curve # 1

PERIOD, T	5% Structure Damping				
	$\beta_e = 2\%$	$\beta_e = 4\%$	$\beta_e = 7\%$	$\beta_e = 3\%$	$\beta_e = 5\%$
0.	1.0	1.0	1.0	1.0	1.0
0.10	1.1	1.1	1.1	1.1	1.1
0.20	1.2	1.2	1.2	1.2	1.2
0.30	1.4	1.4	1.4	1.4	1.4
0.40	1.75	1.75	1.75	1.75	1.75
0.50	2.0	2.0	2.0	2.0	2.0
0.60	2.4	2.4	2.4	2.4	2.4
0.70	3.2	3.0	2.8	3.1	2.93
0.80	4.15	3.8	3.3	3.975	3.63
0.90	5.6	5.3	4.0	5.45	4.87
0.96	6.99	6.4	4.4	6.7	5.73
0.98	7.8	7.0	4.7	7.4	6.23
1.00	8.0	7.2	4.8	7.6	6.4
1.02	7.8	7.0	4.6	7.4	6.2
1.05	7.0	6.2	4.3	6.6	5.57
1.10	5.8	5.2	3.9	5.5	4.77
1.15	4.9	4.5	3.5	4.7	4.17
1.20	4.0	3.9	3.2	3.95	3.67
1.30	3.0	3.0	2.8	3.0	2.93
1.40	2.4	2.4	2.4	2.4	2.4
1.50	2.2	2.2	2.2	2.2	2.2
1.60	2.0	2.0	2.0	2.0	2.0

2. POWER METHOD

Response spectrum is a plot of the maximum response (displacement, velocity, acceleration or any other response quantity of interest) to a specified input excitation for all possible Singe-Degree-Of-Freedom Systems that are characterized by given natural frequency and damping ratio. For a given damping ratio, the abscissa of the response spectrum is the natural frequency and the ordinate is the maximum response. Response spectrum is used to predict, with a satisfactory engineering accuracy, the maximum effect of exciting a simple system with a prescribed loading function. In addition to the natural frequency and damping ratio, response spectrum depends on load type, load duration, peak amplitude, rate of increase of load to its peak amplitude, load spectral composition and so on.

The following is a detailed description for the derivation of the Power method:

Equation of forced motion of a SDOF system has the form:

$$y + 2 \cdot \omega_n \cdot \beta \cdot y + \omega_n^2 \cdot y = \left[\frac{1}{m}\right] \cdot F(t)$$

and its steady-state solution is [3, Page 69]:

$$y(t) := \left[\frac{1}{\omega_n^2}\right] \cdot DMF$$

Where

$$DMF := \left[\frac{\omega_n}{m}\right] \cdot \int_0^t F(\tau) \cdot e^{-\beta \cdot \omega_n \cdot (t-\tau)} \cdot \sin\left[\omega_d \cdot (t-\tau)\right] d\tau$$

and

$$\omega_d := \left[1 - \beta^2\right]^{\frac{1}{2}} \cdot \omega_n$$

The maximum displacemnt and acceleration can be written as

$$y_{max} := \left[\frac{1}{\omega_n^{2}}\right] \cdot DMF_{max}$$

$y_{max} := \omega_n^{2} \cdot y_{max}$ which leads to: $y_{max} := DMF_{max}$

For the case when the system is excited by a harmonic load of amplitude f0 and frequency Ω:

$$DMF := \left[\left[1 - r^{2}\right]^{2} + (2 \cdot \beta \cdot r)^{2}\right]^{\frac{-1}{2}}$$

Where $$r := \frac{\Omega}{\omega_n}$$

At resonance: $$DMF_{max} := \frac{1}{2 \cdot \beta \cdot \left[1 - \beta^{2}\right]^{\frac{1}{2}}}$$

$$r := \left[1 - \beta^{2}\right]^{\frac{1}{2}}$$

For low damping ratios: $DMF_{max} := (2 \cdot \beta)^{-1}$ ....(1)

$$r := 1$$

The case of harmonic loading represents an upper bound of DMF. Similary, for stationary random excitation with white spectrum:

$$S_F(\Omega) := 2 \cdot \pi \cdot S_0$$

$$S_y(\Omega) := \frac{S_0}{\left[\omega_n^2 - \Omega^2\right]^2 + 4 \cdot \beta^2 \cdot \omega_n^2 \cdot \Omega^2}$$ [4, page 75]

$$E\left[y^2\right] := \pi \cdot \frac{S_0}{2 \cdot \beta \cdot \omega_n^3}$$ [4, page 77] ....(2)

$$E\left[y^2\right] := \int_{-\infty}^{\infty} \Omega^4 \cdot S_y(\Omega)\, d\Omega$$

Equation (2) indicates that:

$$DMF_{max} := (2 \cdot \beta)^{\frac{-1}{2}}$$ ....(3)

Both Equations (1) and (3) are power law relationships.

Based on the above discussion and given two acceleration response spectra at $\beta 1$ and $\beta 2$ damping ration, assume that:

$$sa1(f) := (z\beta 1)^{p} \qquad \text{........(4)}$$

$$sa2(f) := (z\beta 2)^{p} \qquad \text{........(5)}$$

Where sa(i) is spectral acceleration at i damping ratio and z & p are constants.

The objective is to find response spectrum at $\beta 3$ damping ratio where:

$$sa3(f) := (z\beta 3)^{p} \qquad \text{........(6)}$$

Dividing Equation (5) by Equation (4) and Equation (6) by Equation (4), and then taking ln of both sides yield:

$$\ln\left[\frac{sa2(f)}{sa1(f)}\right] := p \cdot \ln\left[\frac{\beta 2}{\beta 1}\right] \qquad \text{........(7)}$$

$$\ln\left[\frac{sa3(f)}{sa1(f)}\right] := p \cdot \ln\left[\frac{\beta 3}{\beta 1}\right] \qquad \text{........(8)}$$

Dividing Equation (8) by Equation (7) gives:

$$\ln\left[\frac{sa3(f)}{sa1(f)}\right] := \epsilon \cdot \ln\left[\frac{sa2(f)}{sa1(f)}\right] \qquad \text{........(9)}$$

Where $$\epsilon := \frac{\ln\left[\frac{\beta 3}{\beta 1}\right]}{\ln\left[\frac{\beta 2}{\beta 1}\right]}$$ ....(10)

Equation (9) can be rewritten as:

$$\frac{sa3(f)}{sa1(f)} := \left[\frac{sa2(f)}{sa1(f)}\right]^{\epsilon}$$ ....(11)

Or $$\underline{sa3(f) := (sa1(f))^{1-\epsilon} \cdot (sa2(f))^{\epsilon}}$$ ....(12)

The following symbols are [illegible]d in the derivation of the POWER method:

y	displacement
$F(t)$	loading function
m	mass
ω_n	natural frequency
β	damping ratio
DMF	Dynamic Magnification Factor
ω_d	damped natural frequency
Ω	load frequency
$S_F(\Omega)$	load spectral density
$E\left[y^2\right]$	mean square response
sa	spectral acceleration

REFERENCES

(1) J. Biggs and J. Roesset, Seismic Analysis of Equipment Mounted on a Massive Structure, Department of Civil Engineering, Massachusetts Institute of Technology, 1969.

(2) G/C Calculation 4203, Revision 0, Response Spectrum for CR3 Equipment Stress Analysis, By M.P.H., 1973.

(3) M. Paz, Structural Dynamics Theory and Computation, Van Nostrand Reinhold Company, Inc., 1980.

(4) S. Crandall and W. Mark, Random Vibration in Mechanical Systems, Academic Press, 1963.

Attachment "B"

5% Damping Curves for:

Auxiliary Building, El. 143'-0"

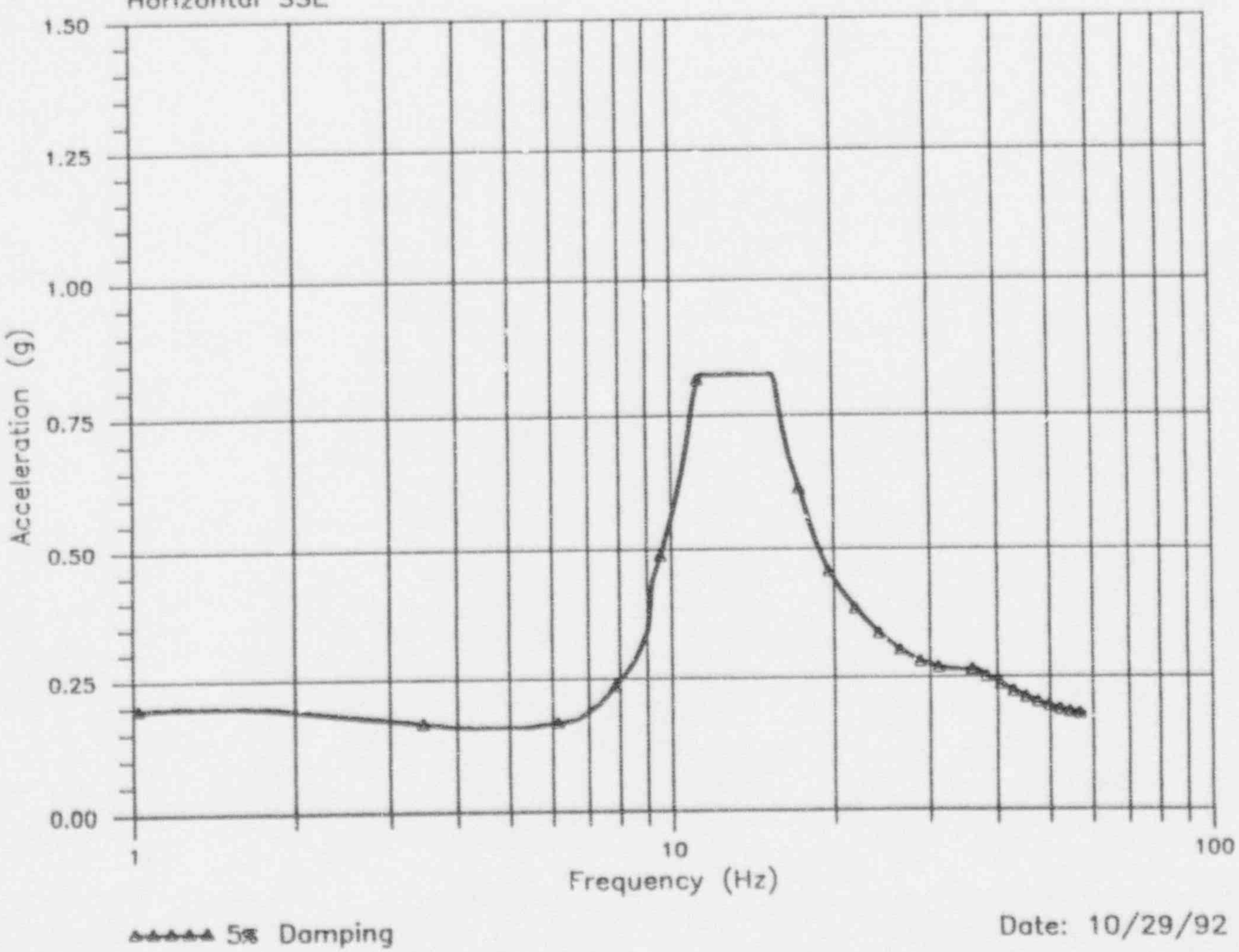
Auxiliary Building, El. 162'-0"

Control Building, El. 145'-0"

Control Building, El. 163'-10"

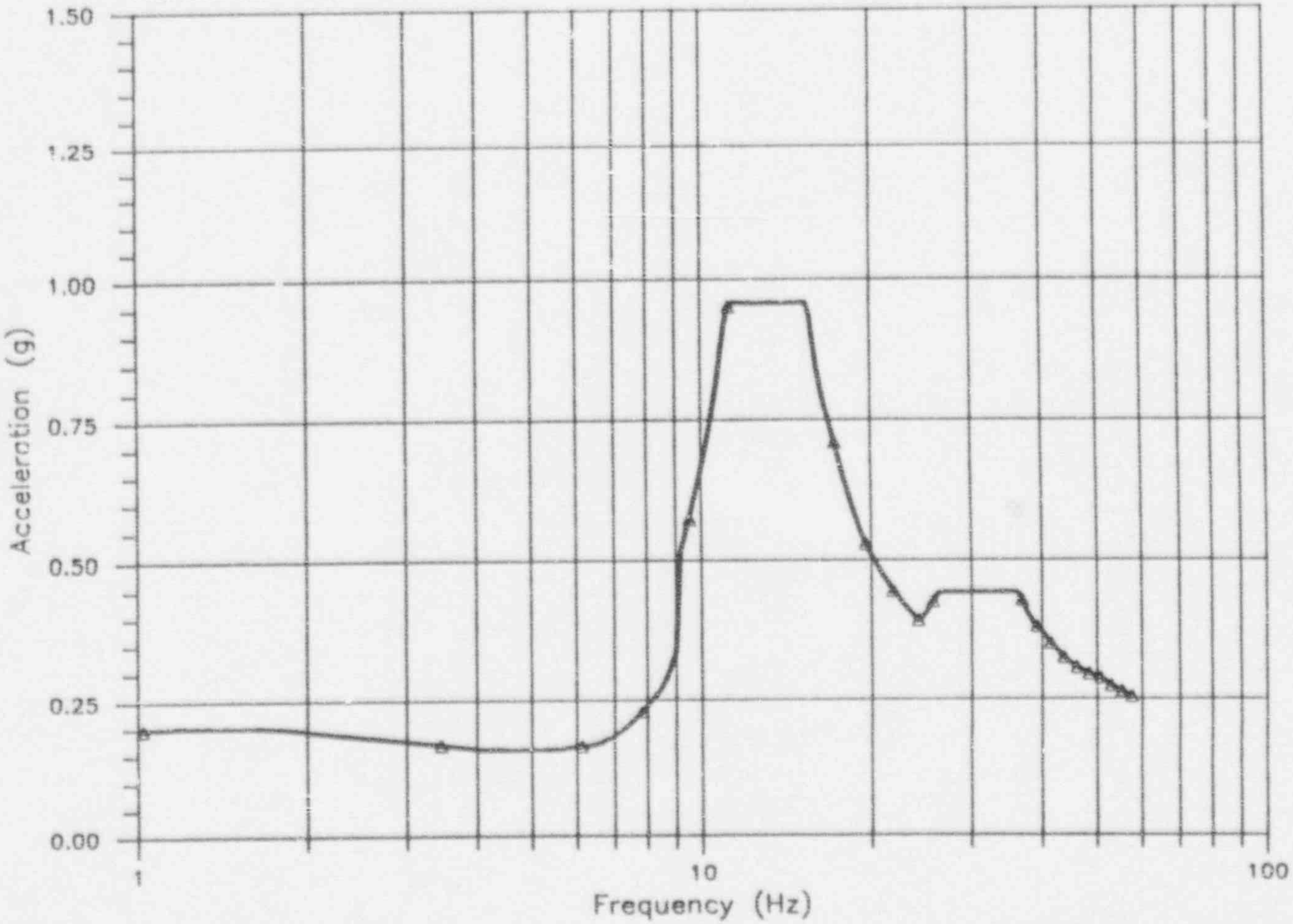
Control Building, El. 186'-10"

Auxiliary Building Elev. 143.0'
Horizontal SSE



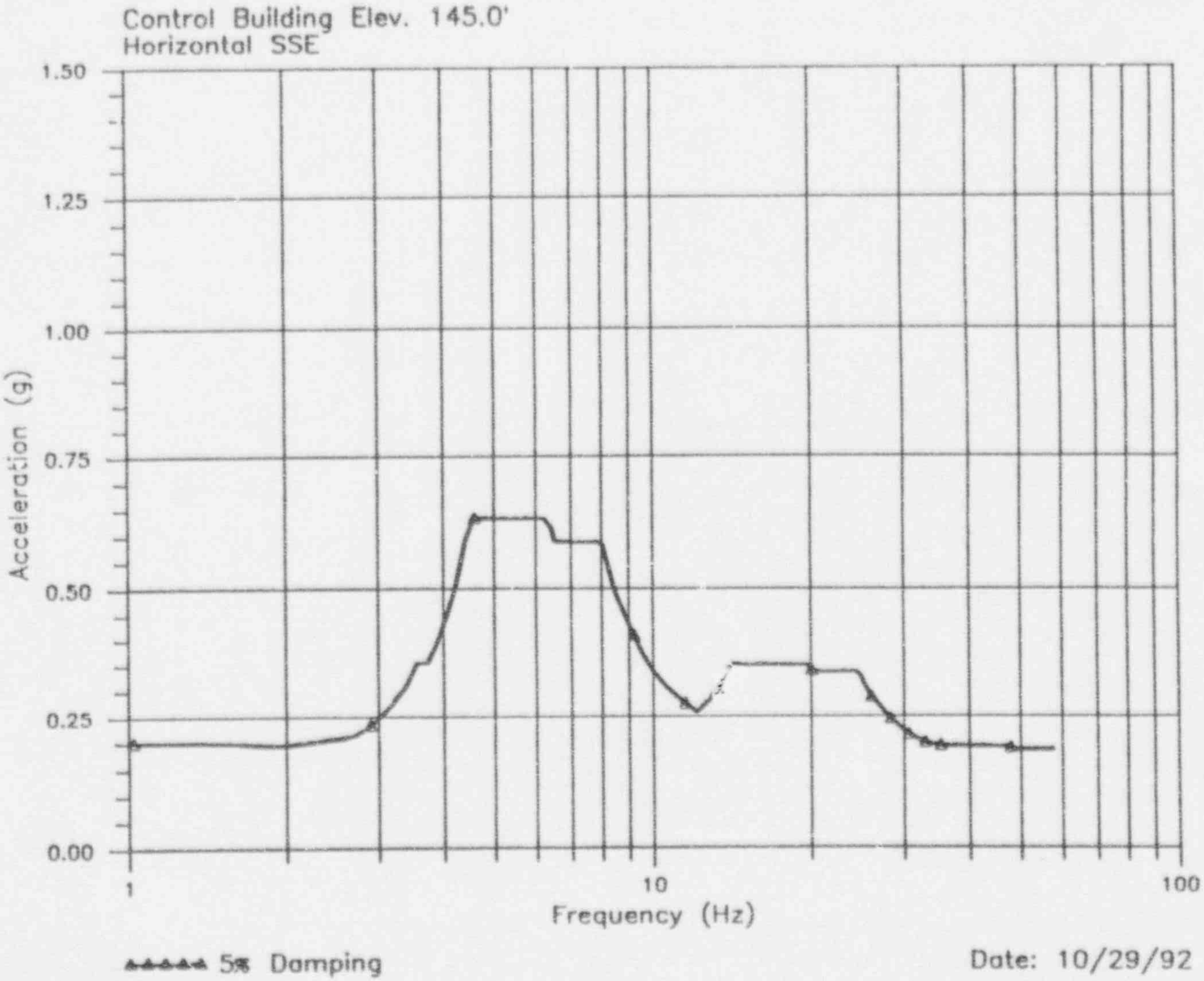
Date: 10/29/92

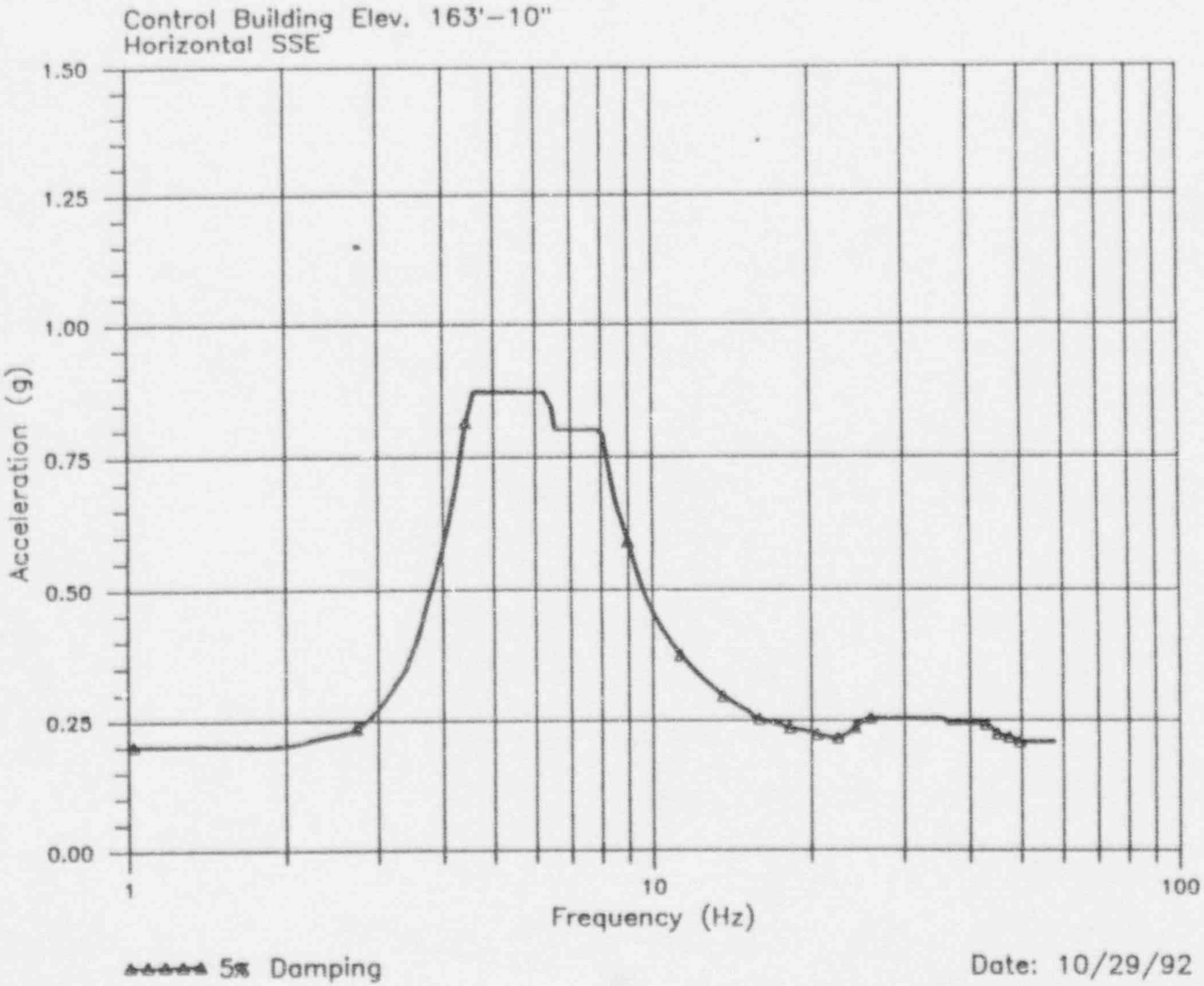
Auxiliary Building Elev. 162.0'
Horizontal SSE

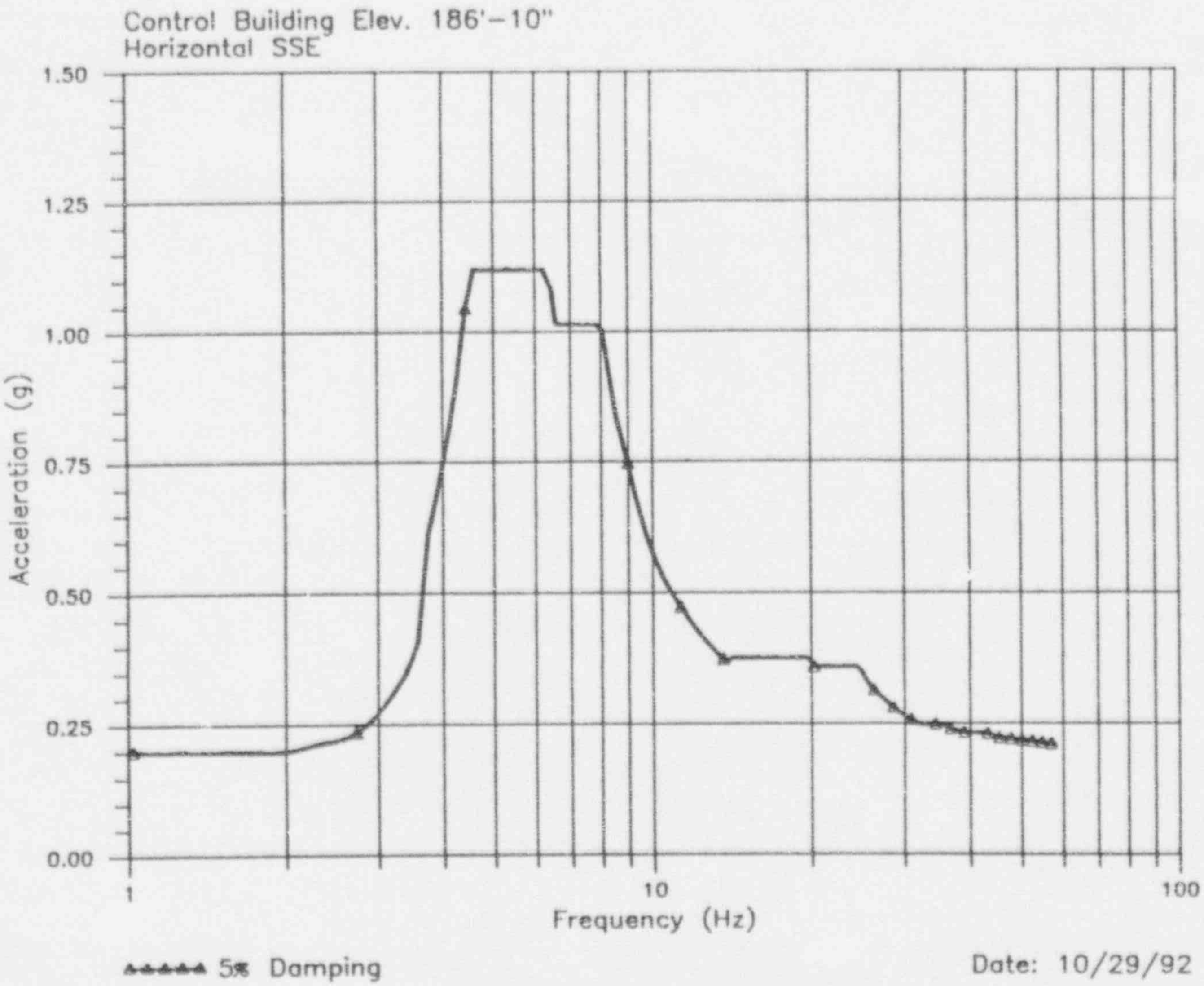


5% Damping

Date: 10/29/92


Control Building Elev. 145.0'
Horizontal SSE
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Acceleration (g)
1
10
100
Frequency (Hz)
5% Damping
Date: 10/29/92


Control Building Elev. 163'-10"
Horizontal SSE
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Acceleration (g)
1
10
100
Frequency (Hz)
5% Damping
Date: 10/29/92


Control Building Elev. 186'-10"
Horizontal SSE
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Acceleration (g)
1
10
100
Frequency (Hz)
5% Damping
Date: 10/29/92