ENCLOSURE 2

DIABLO CANYON

SPECIFICATION FOR SEISMIC REVIEW OF MAJOR STRUCTURES FOR 7.5M HOSGRI EARTHQUAKE

FEBRUARY 2, 1977

REVISED FEBRUARY 8, 1977

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SPECIFICATION FOR SEISMIC REVIEW OF

MAJOR STRUCTURES FOR 7.5M HOSGRI EARTHQUAKE

CONTENTS

FIGURES

1. Basic Approach

This specification delineates criteria to be used in reviewing the major Diablo Canyon structures for response to the postulated 7.5M Hosgri earthquake. The structures considered and their seismic classifications are:

(a) Containment Structure (Class I)
(b) Auxiliary Building (Class I)
(c) Turbine Building (Class II)
(d) Intake Structure (Class II)

The basic approach to be used in this review calls for use of the same analysis procedures and criteria which were used and accepted at the time of the original DDE analyses, but with the following specific changes each as clarified in the following pages:

(a) use the new 7.5M Hosgri spectra
(b) use Reg. Guide 1.61 dampings
(c) use actual material properties
(d) allow ductility in certain cases
(e) use of fixed based mathematical models permitted (V_s > 3500 fps)
(f) use accidental torsion or equivalent (in addition to geometric torsion)
(g) use vertical response analysis or equivalent
(h) use modified smoothing of the new raw floor spectra
(i) combine horizontal and vertical responses on 3-component SRSS basis or equivalent

The purpose of this specification is to delineate criteria only and not to specify that seismic reviews be accomplished by complete reanalyses. Such reviews may be possible with brief generic approaches, whenever they can be shown to satisfy the basic criteria, in lieu of more lengthy, complete reanalyses.

Where the criteria and procedures used in the 7.5M Hosgri seismic review depart in any significant way from present NRC approved approaches, parametric and other studies will be simultaneously performed.

2. Seismic Inputs to Structures

A. Horizontal. The free-field horizontal response spectra for the site are the Blume[1] and Newmark[2] spectra shown on Figures 1 and 9, respectively, with 0.75g peak ground acceleration (PGA) values. These spectra conservatively define the 7.5M Hosgri motions in the free-field. In the presence of structures having large, relatively rigid foundations in plan, these free-field motions can be expected to have reduced effective inputs to structures. These effective inputs are summarized in Table A and given on Figures 2 through 8 (Blume) and 10 through 16 (Newmark). The effective inputs have been derived by spatial averaging of accelerations across the foundations of each structure by the tau filtering procedure. In no case shall the effective responses in structures be less than those produced by the use of Newmark's criteria.

TABLE A - tau and PGA Values

Structure	tau	Blume PGA	Newmark PGA
Containment	.040	.67g	.60g
Auxiliary Bldg.	.052	.63g	.55g
Turbine Bldg.	.080/.067*	.54g	.50g*
Intake	.040	.67g	.60g

* Newmark PGA corresponds to a maximum tau = .067

B. Vertical. The 7.5M Hosgri vertical response spectra will be the free-field (tau = 0) Blume and Newmark translational spectra with amplitudes scaled two-thirds. Peak vertical acceleration is 0.50g. The Blume and Newmark vertical spectra are given on Figures 17 and 18 and on Figures 19 and 20, respectively.

C. Damping and Ductility. In conjunction with use of the Blume and Newmark 7.5M Hosgri spectra, damping and ductility to be used are indicated in Table B.

TABLE B - Damping and Ductility[a]

Structure	Damping	Blume Ductility	Newmark Ductility	
Containment	7%	1.3[b]	1.0[b]	
Auxiliary Bldg.	7%	1.3[b]	1.0[b]	
			Class I	Non-Class I
Turbine Bldg.	7%	c	1.0[b]	c
Intake	7%	c	1.0[b]	c,d

a. Ductilities are on story basis; however, floor response spectra will, in general, be computed on an elastic analysis basis.

b. Under normal conditions Newmark ductility is 1.0 maximum; however, NRC will consider special cases where supporting evidence justifies its use. Blume ductility for Class I structures is 1.3, and will be used only in specific situations.

c. Concrete 1.3; steel 3, with up to 6 locally.

d. Or as may be required to demonstrate that function of Design Class I equipment will not be adversely affected.

3. <u>Material Properties</u>

For the determination of the strength and stiffness of structures under the 7.5M Hosgri motions, actual material properties as determined by properly substantiated test results will be used. These values more realistically characterize the actual properties of materials used in the Diablo Canyon structures than would be derived from the specified minimums used in design. Detailed strength values and substantiating data will be submitted in a separate report.

A. <u>Concrete</u>. The compressive strength of concrete, f'_c, will be taken as the average of the 28-day or 60-day test values, depending on the original curing period specification. The substantial additional margin of strength associated with the gain in compressive strength by aging will not be considered.

B. <u>Steel</u>. Both reinforcing and structural steel yield strengths, f_y, will be taken as the average of actual test values. In no case will the yield strength value used in strength computations be taken as greater than 70-percent of the corresponding average ultimate strength value.

4. Analysis Procedures

A. Class I Structures. Analyses of the Class I Containment Structure and Auxiliary Building will utilize the same mathematical models and analysis procedures as used in the DDE analyses, excepting the following:

(1) mathematical model stiffness properties will reflect the increased material properties;

(2) in conjunction with use of the structure-specific inputs resulting from spatial averaging of accelerations, models will have fixed bases without soil-structure interaction;

(3) 7-percent damping will be used;

(4) vertical response will be determined by dynamic analysis;

(5) individual responses to the two horizontal and one vertical components will be combined on the SRSS basis unless it can be shown that the absolute sum combination of individual responses due to one horizontal and the vertical components is essentially equivalent;

(6) the seismic inputs of the second horizontal component in the 3-component SRSS procedure is generally recognized as being less than the first; however for conservatism both components will be taken as equal.

(7) accidental torsion will be included by consideration of an additional eccentricity in the mathematical models of 5-percent of the building dimension in direction perpendicular to the applied loads or 7-percent if torsional results are computed independently and combined by SRSS basis with translational results, whichever is greater, or an equivalent amount for buildings without rigid floor diaphragms;

(8) ductility, when applied in accordance with Table B, is to be by reduction of the elastic response by approximate procedures.

B. <u>Class II Structures</u>. Analyses of the Class II Turbine Building and Intake Structure will utilize the same seismic inputs as for the Class I structures because both of these structures contain limited amounts of Class I equipment.

(1) <u>Turbine Building</u> response will be determined by both linear elastic and nonlinear inelastic methods. Except for the use of nonlinear analysis procedures, the analysis procedures will be similar to those for the Class I structures. The inelastic response to the Hosgri motions must be such that ductilities in steel bracing and framing do not exceed 3 on a story basis or 6 locally. Ductilities in concrete shear walls will be limited to 1.3, and to 6 in reinforcing steel. Because of the configuration of the building, longitudinal and transverse analyses will be uncoupled. Torsion will be considered in the models, and an accidental torsion will be applied as an equivalent 5-percent eccentricity. The possibility of impingement between the Turbine Building structure and the Turbine Pedestal will be considered in the response calculations, with the assumption that limited (controlled) local structural damage, such as concrete chipping or spalling, is permissible provided the overall safety of the structures or the Class I equipment is not impaired.

Where nonlinear methods are employed, the lower bound of material strength shall be used but the ductility in bracing shall not exceed 3. In generating the floor response spectra for Class I equipment, two analyses shall be made, elastic and inelastic, the latter using the lower bound of material strength. The final floor response spectrum shall be the envelope of the two spectra.

(2) <u>Intake Structure</u> contains the Class I Auxiliary Salt-water Pumps. Thus, the structure must be shown to avoid collapse which would impair the safety of the pumps and prevent their receiving an adequate supply of water. Response of this structure to the

Hosgri motions will be determined similar to that for the Class I structures. Where stresses calculated on an elastic basis exceed allowable values, more detailed investigations will be made, including consideration of behavior in the inelastic range to verify that the Hosgri motions will be resisted without structural collapse and that an adequate supply of water is maintained.

5. Smoothing Raw Hosgri Floor Response Spectra

The following smoothing procedure is to be used on the new, raw 7.5M Hosgri floor spectra generated by the time-history method. It is based on appropriate consideration of the effects of new structural strengths and mathematical model properties. Peak spectral amplitudes, associated with the structural modes of vibration, will be widened and smoothed as follows:

A. High Frequency Side of any Peak. In conjunction with use of the structure-specific inputs resulting from spatial averaging of accelerations, use 5-percent period broadening to smooth spectra. Consideration of higher structural stiffnesses associated with the estimated actual concrete strengths and the use of fixed-base mathematical models eliminates the need for more conservative smoothing in this situation. New stiffness properties are virtually the highest values expected and further shifts of spectra spikes toward higher frequencies are essentially precluded.

B. Low Frequency Side of any Peak. Use 15-percent period broadening to account for possible softening of material and soil stiffness properties under extreme seismic motions and corresponding high stresses. Smooth lesser Hosgri peaks and valleys by free-hand averaging as for the original DDE analyses.

Representative floor response spectra, computed by the time-history approach, will be reviewed against similar spectra computed by approximate procedures, not involving time-history computations. Peak spectral ordinates will not be clipped 10-percent, as in the

DDE analyses, except in special cases where the very conservative effects of a smoothing without peak clippings will be reviewed on an individual basis.

6. Time-History Motions

For purposes of floor response spectra computations and time-history response analyses, several artificial horizontal acceleration time histories have been developed. Each time history closely matches a smooth 7.5M Hosgri response spectrum and models the expected amplitude, frequency content, and duration characteristics. Figures 21 through 24 (Blume) and 25 through 28 (Newmark) show the various time histories for the free-field and each of the major structures.

7. Acceptance Criteria

Allowable stresses in structural steel and reinforced concrete elements will be based on actual material properties in lieu of the specified minimum values used in the original DDC structural design.

A) Class I Structures. For the Class I structures, allowable stresses will be based on those codes and standards listed in the FSAR unless otherwise noted.

B) Class II Structures. For purposes of evaluating the seismic adequacy of the Class II structures, the following criteria are to be used:

(1) Load Combinations. Dead, actual acting live, and 7.5M Hosgri earthquake loads will be combined as follows.

$$U = D + L' + EQ$$

where

U = total load to be resisted

D = dead weight load

L' = actual live load, if any, acting on element considered

EQ = total combined seismic loads due to both horizontal and vertical inputs

(2) Allowable Stresses (Ultimate Strength Design Basis)

Element	Code *
Concrete shear walls	SEAOC (1974), Section 3(C)
Reinforced concrete elements	ACI 318-73
Structural steel	AISC 7th Edition, Part II

(3) Ductility. Lateral forcing resisting elements will be allowed inelastic deformations according to those indicated in Table B. For these elements, the allowable stress limitations of item B above need not apply.

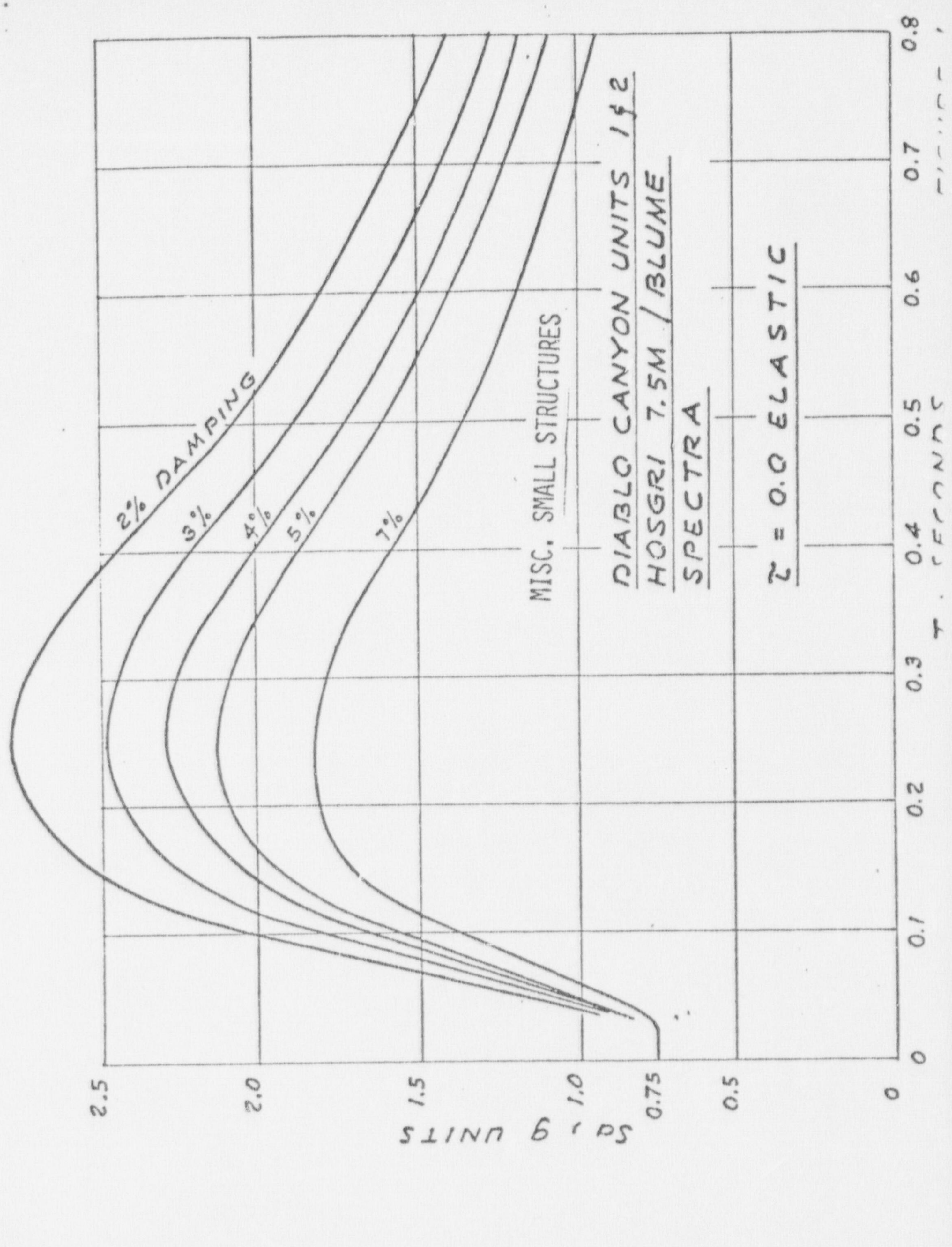
* FURTHER DISCUSSIONS WITH THE STAFF ARE NECESSARY IF SEOAC IS TO BE USED INSTEAD OF ACI 318-73

8. References

1. URS/John A. Blume & Associates, Engineers, "Diablo Canyon, Hosgri 7.5M Blume & Newmark Spectra Plots," report to PG&E, September 22, 1976.

2. Newmark, Nathan M., "A Rationale for Development of Design Spectra for Diablo Canyon Reactor Facility," a report to the U.S. Nuclear Regulatory Commission, September 3, 1976.

3. "Recommended Lateral Force Requirements and Commentary," Seismology Committee, Structural Engineers Association of California, 1974.



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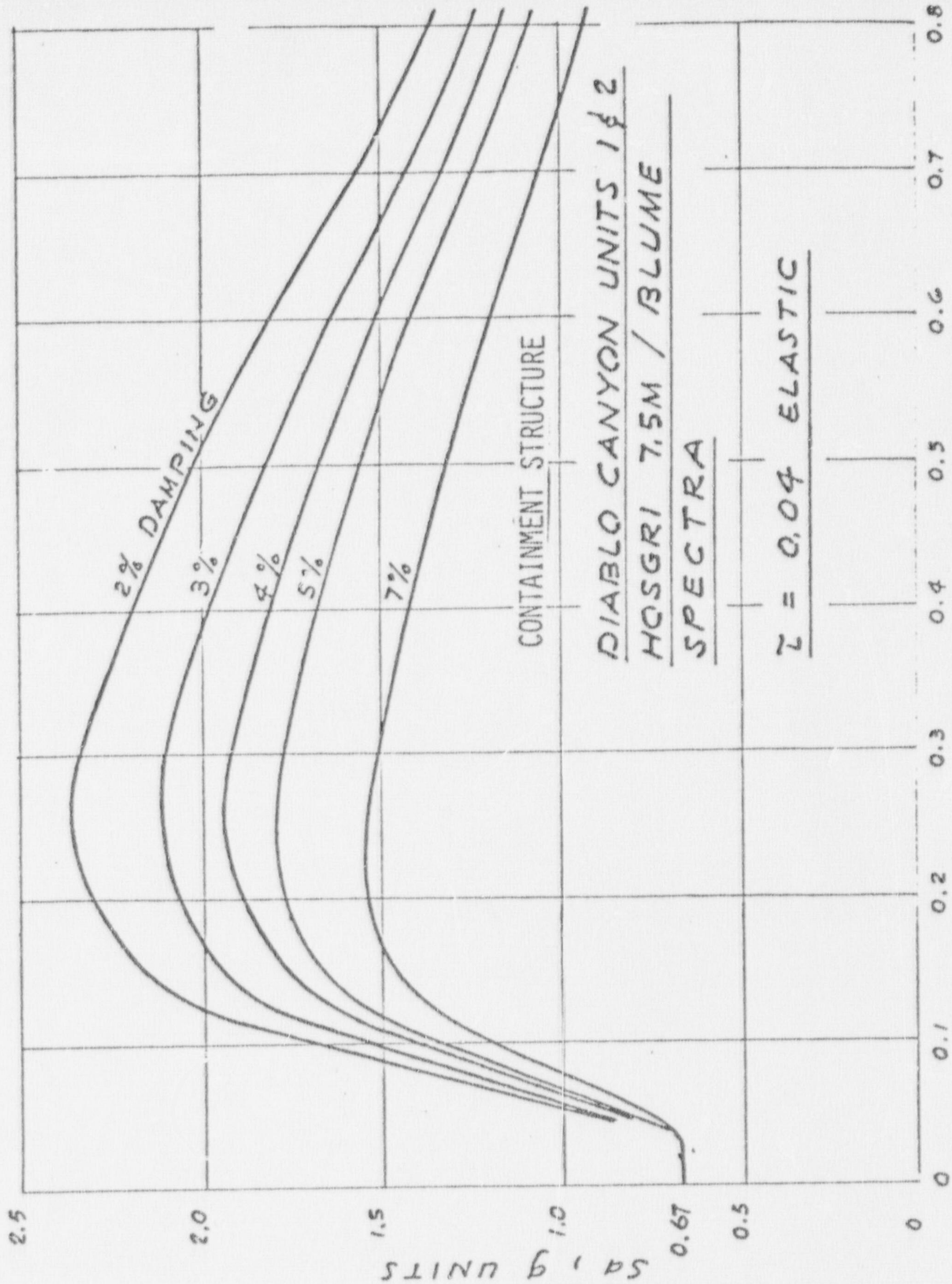

FIGURE 2

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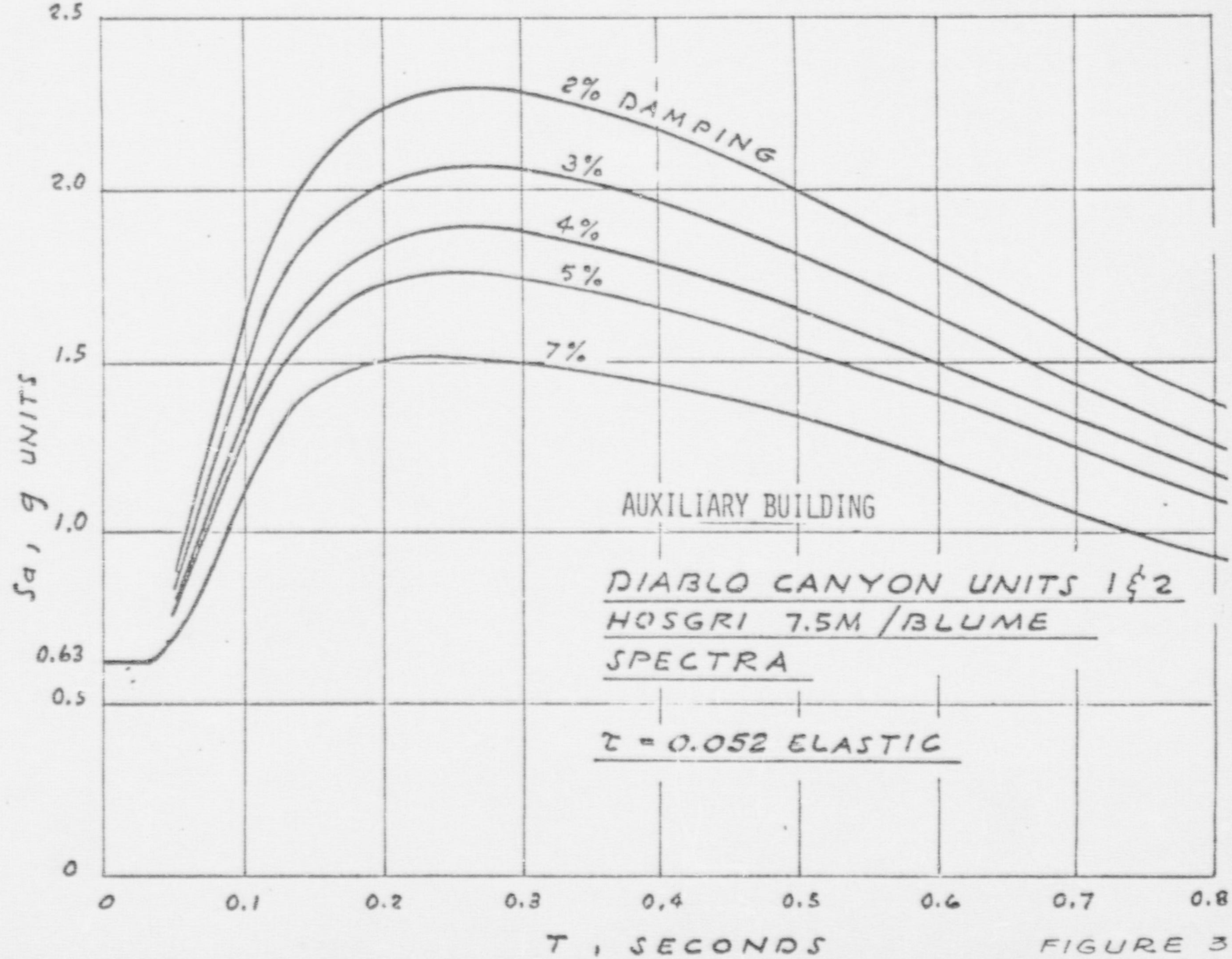
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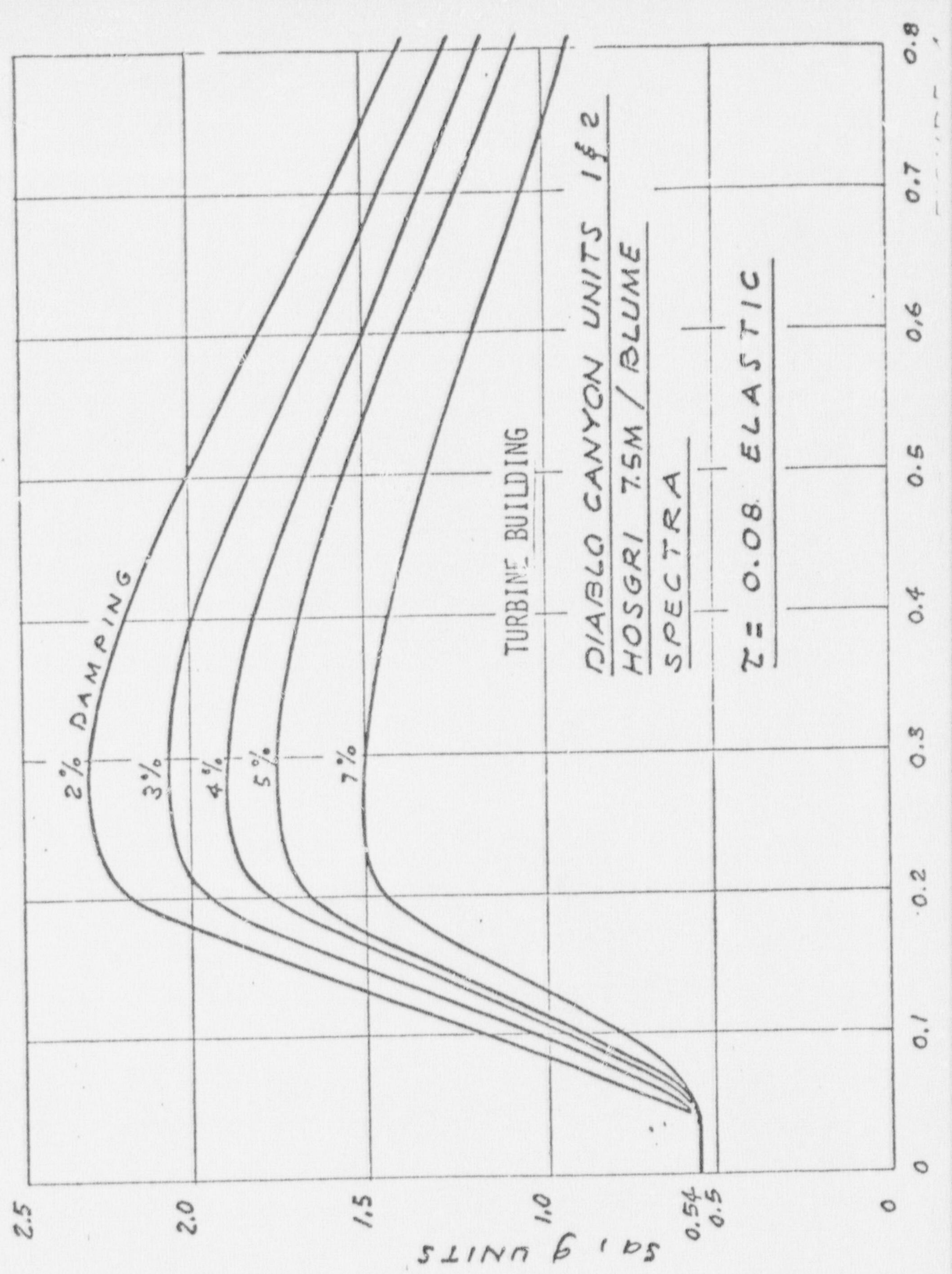
1.5
1.0
0.63
0.5
0
Sa, g UNITS
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
T, SECONDS
2% DAMPING
3%
4%
5%
7%
AUXILIARY BUILDING
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / BLUME
SPECTRA
τ = 0.052 ELASTIC

FIGURE 3


DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / BLUME
SPECTRA
T = 0.08 ELASTIC
TURBINE BUILDING
2% DAMPING
3%
4%
5%
7%
Sa, g UNITS
2.5
2.0
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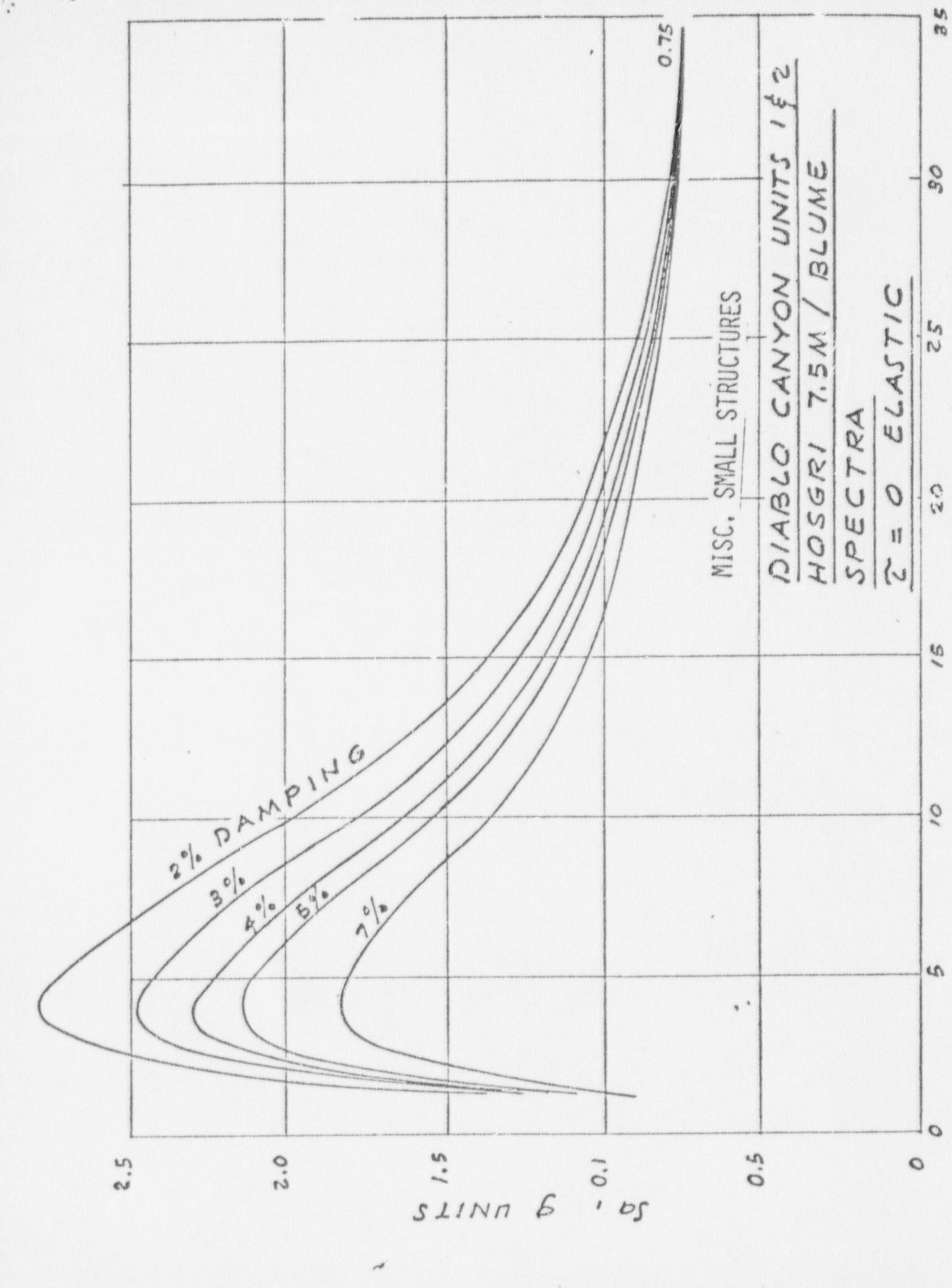
0.7
0.8


MISC. SMALL STRUCTURES
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / BLUME
SPECTRA
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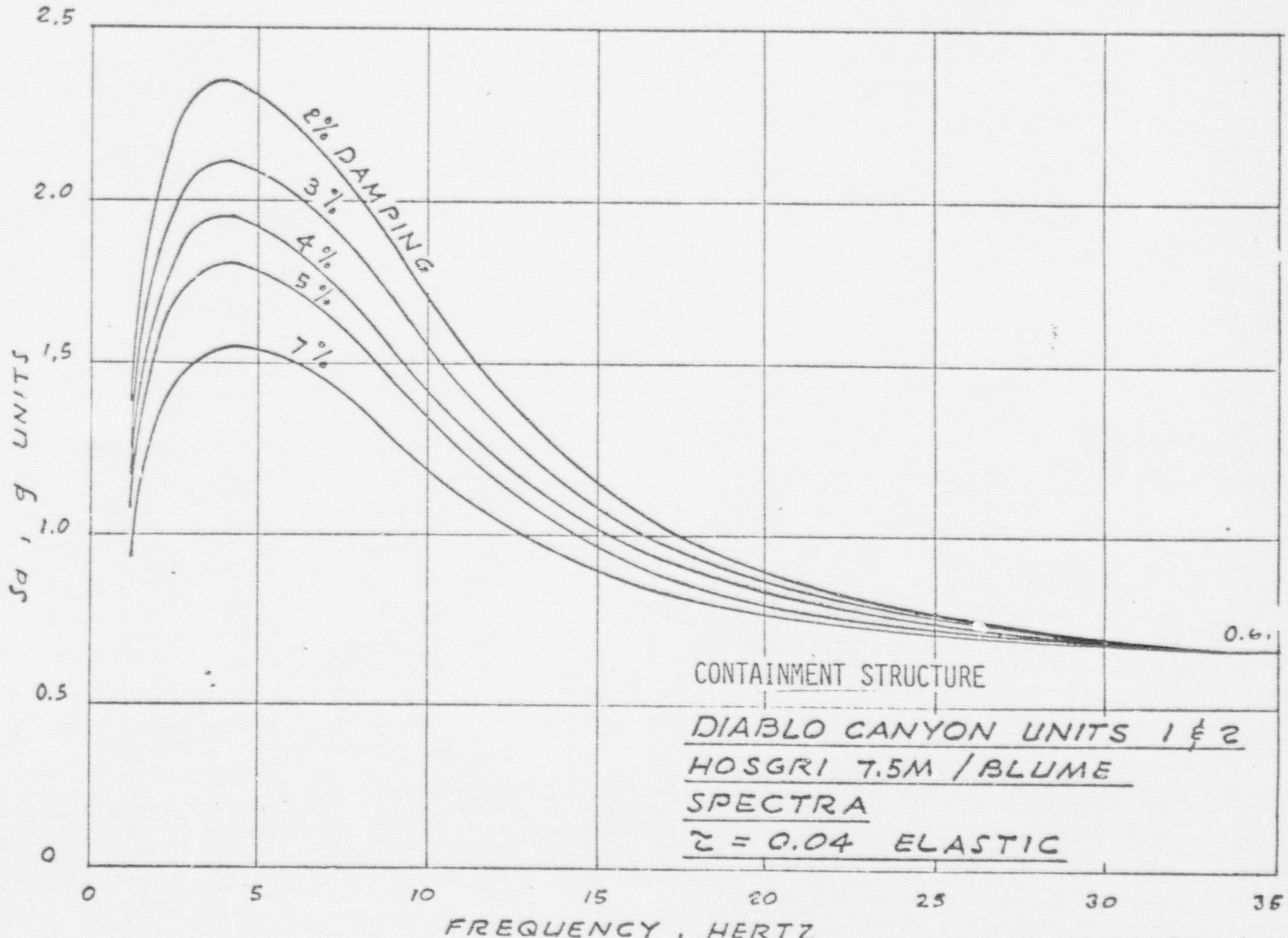
4%
5%
7%
0.75
Sa, g UNITS
FREQUENCY, HERTZ

FIGURE 5



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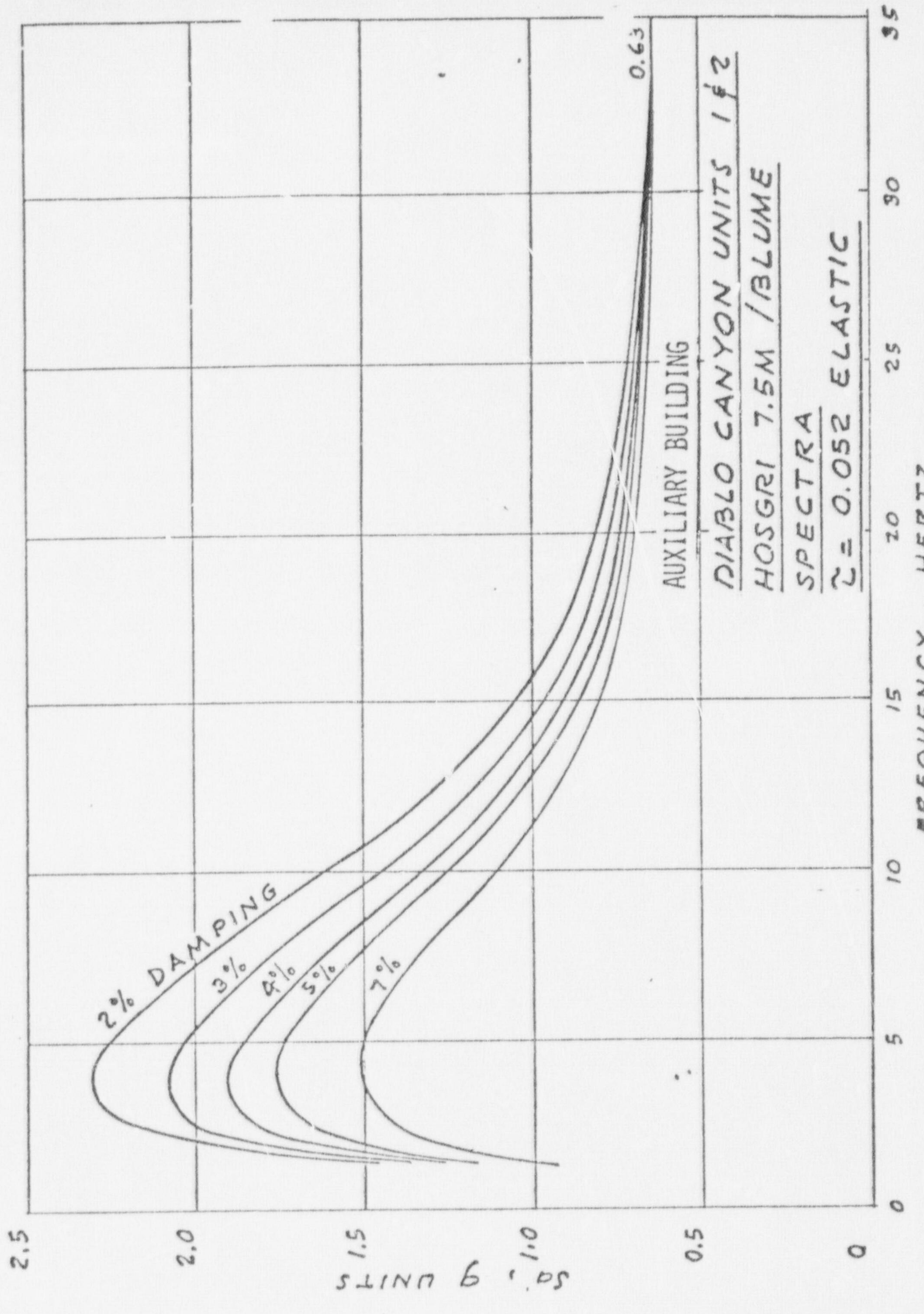
2.0
1.5
1.0
0.5
0
Sa , g UNITS
0
5
10
15
20
25
30
35
FREQUENCY , HERTZ
2% DAMPING
3%
4%
5%
7%
0.6.
CONTAINMENT STRUCTURE
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / BLUME
SPECTRA
τ = 0.04 ELASTIC

FIGURE 6


AUXILIARY BUILDING
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / BLUME
SPECTRA
ζ = 0.052 ELASTIC
2% DAMPING
3%
4%
5%
7%
0.63
FREQUENCY, HERTZ
Sa, g UNITS
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5
10
15
20
25
30
35
0.5
1.0
1.5
2.0
2.5

FIGURE 7

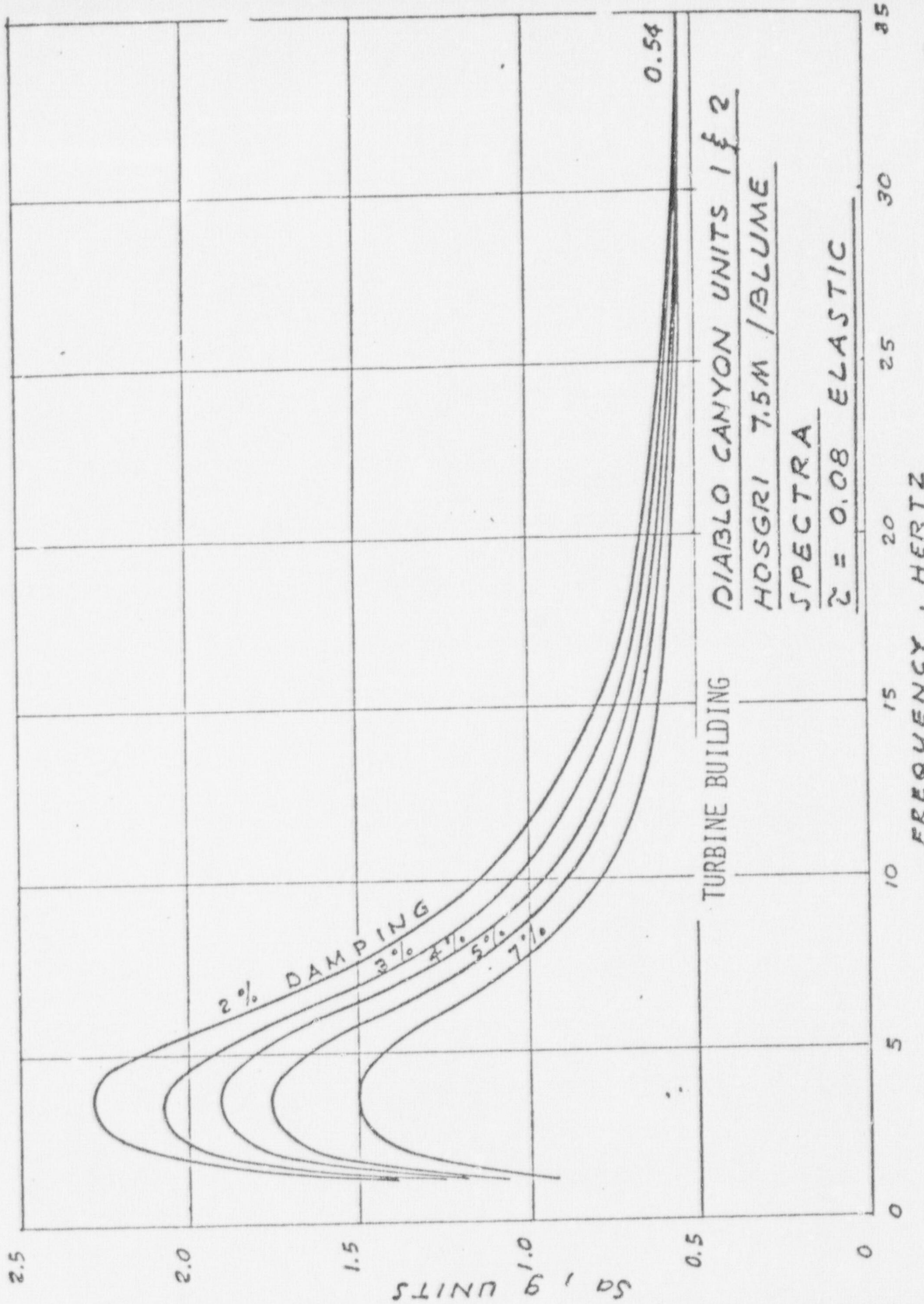
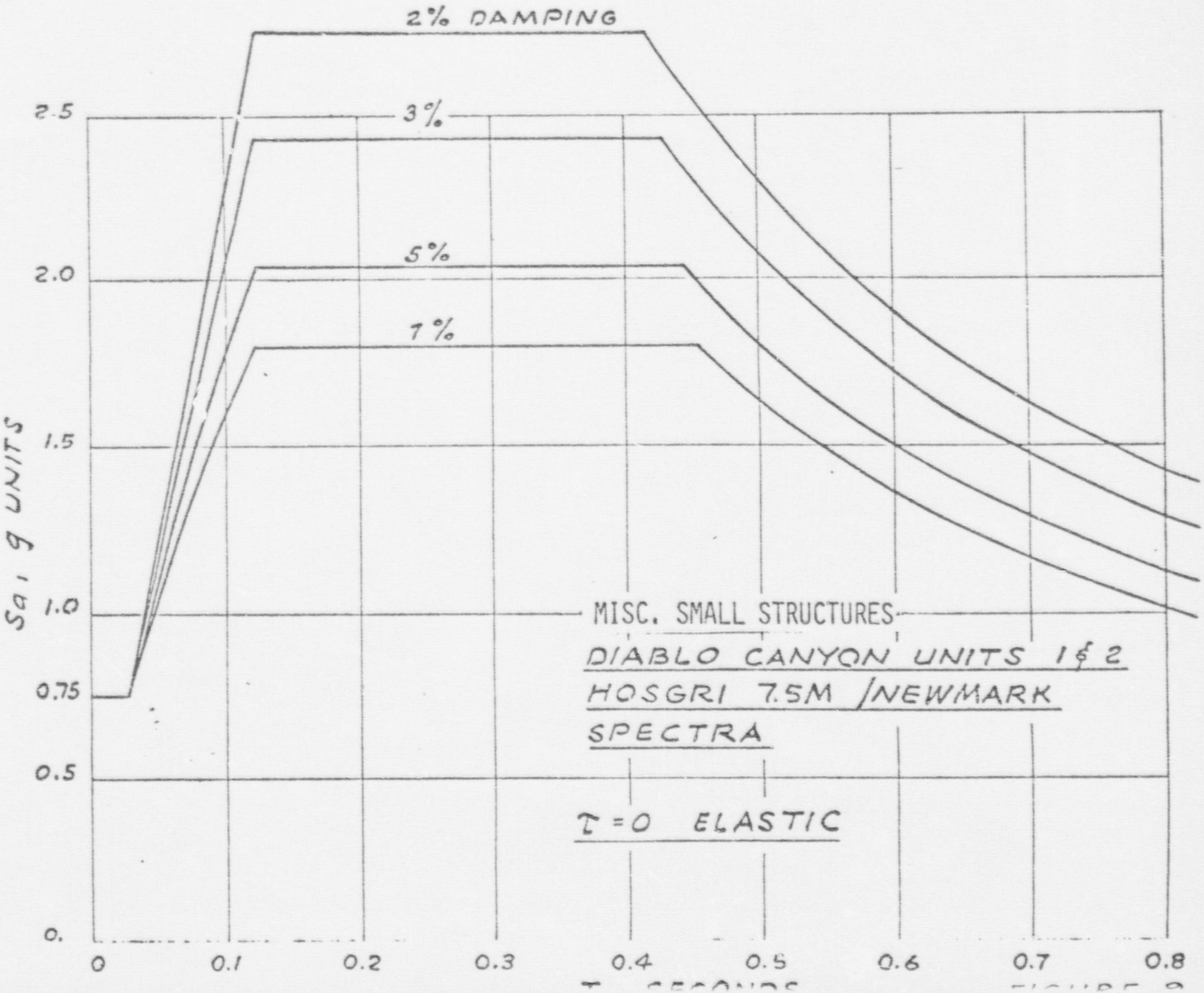

DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / BLUME
SPECTRA
τ = 0.08 ELASTIC
TURBINE BUILDING
2 % DAMPING
3 %
4 %
5 %
7 %
0.54
Sa , g UNITS
0
0.5
1.0
1.5
2.0
2.5
FREQUENCY , HERTZ
0
5
10
15
20
25
30
35

FIGURE 8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5%
7%
Sa, g UNITS
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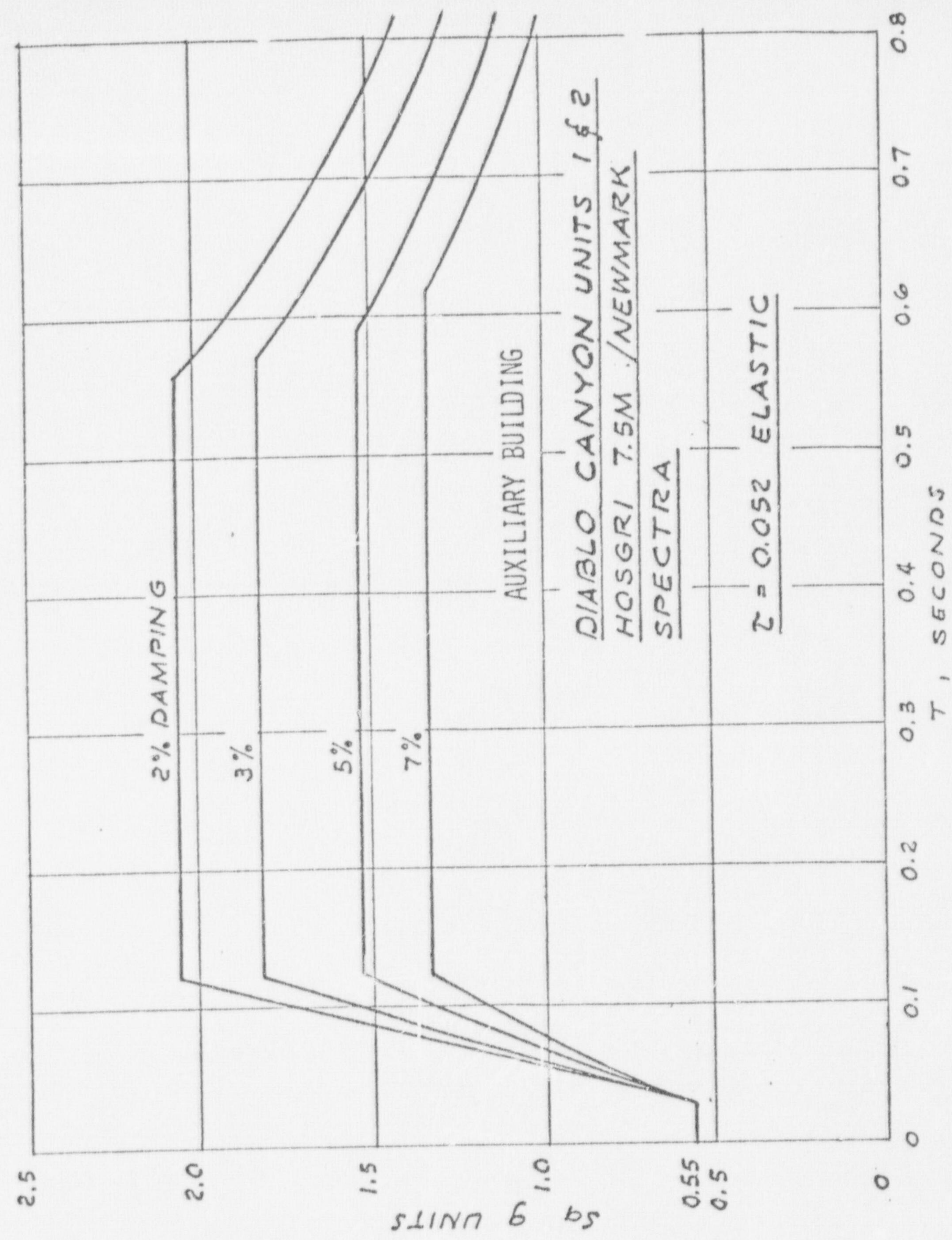
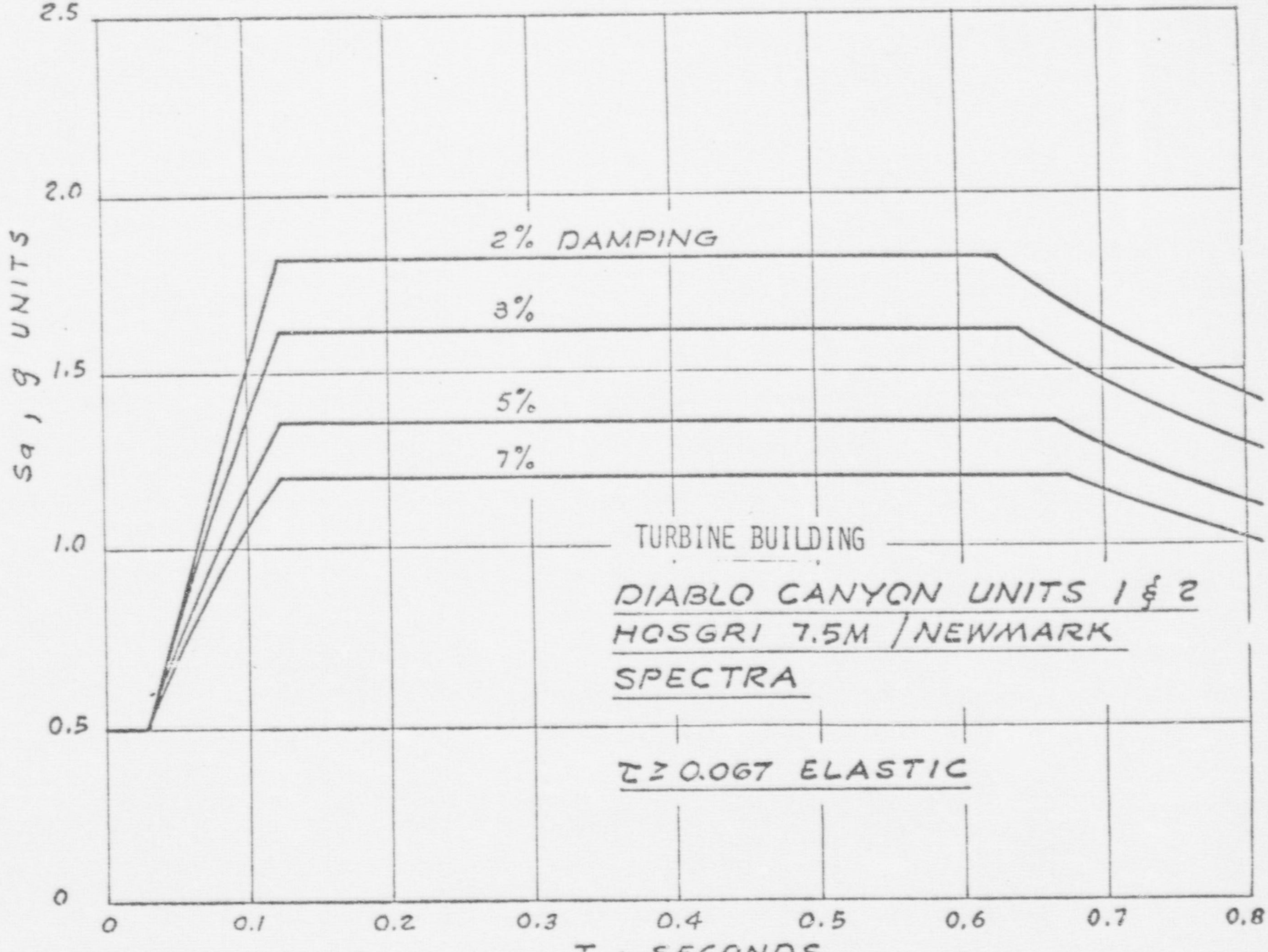
2.0
1.5
1.0
0.75
0.5
0.
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
MISC. SMALL STRUCTURES
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / NEWMARK
SPECTRA
τ = 0 ELASTIC



DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / NEWMARK
SPECTRA
AUXILIARY BUILDING
τ = 0.052 ELASTIC
2% DAMPING
3%
5%
7%
Sa g UNITS
2.5
2.0
1.5
1.0
0.55
0.5
0
T, SECONDS
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

FIGURE 11



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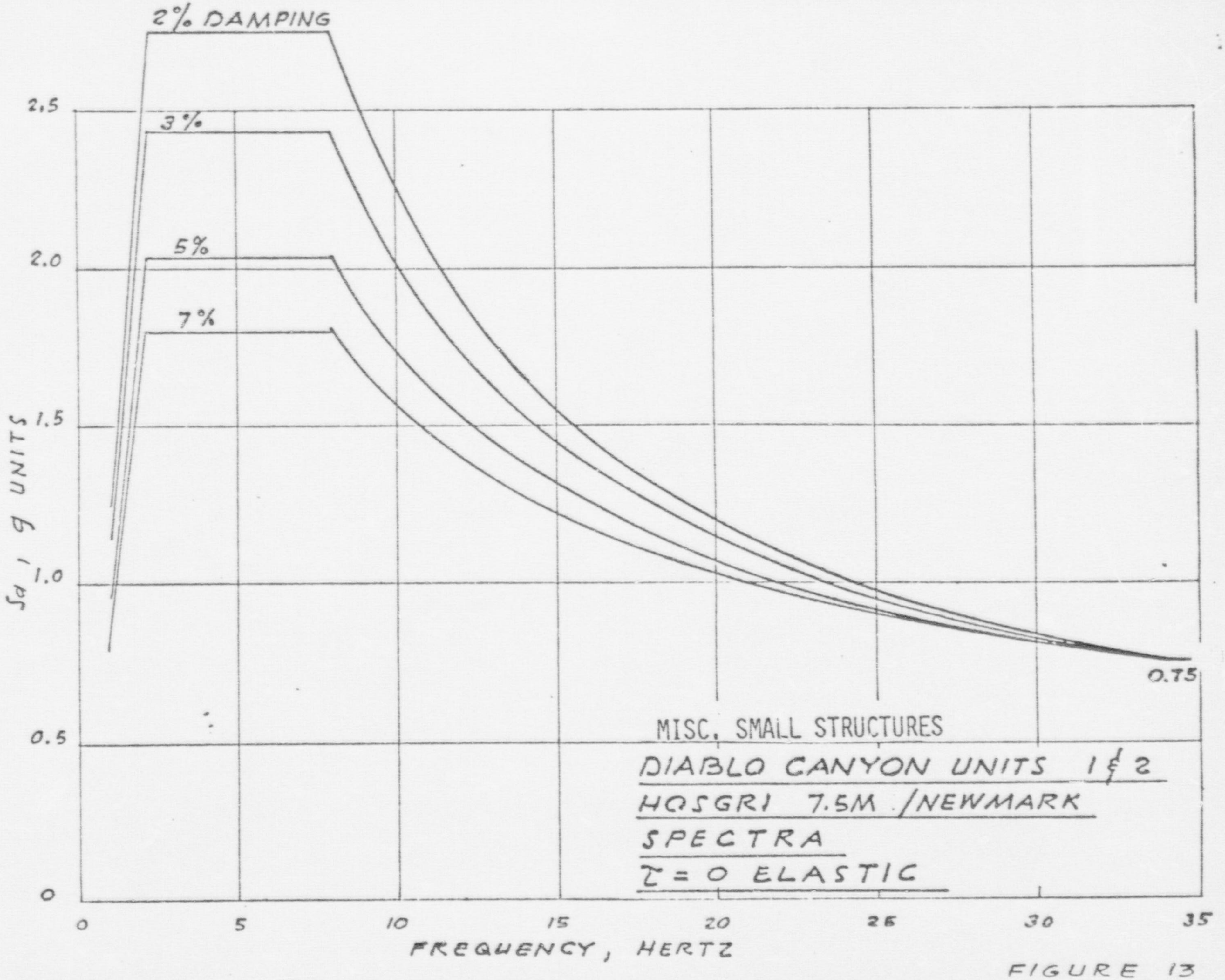
0
Sa, g UNITS
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
T, SECONDS
2% DAMPING
3%
5%
7%
TURBINE BUILDING
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / NEWMARK
SPECTRA
τ ≥ 0.067 ELASTIC

FIGURE 12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5%
7%
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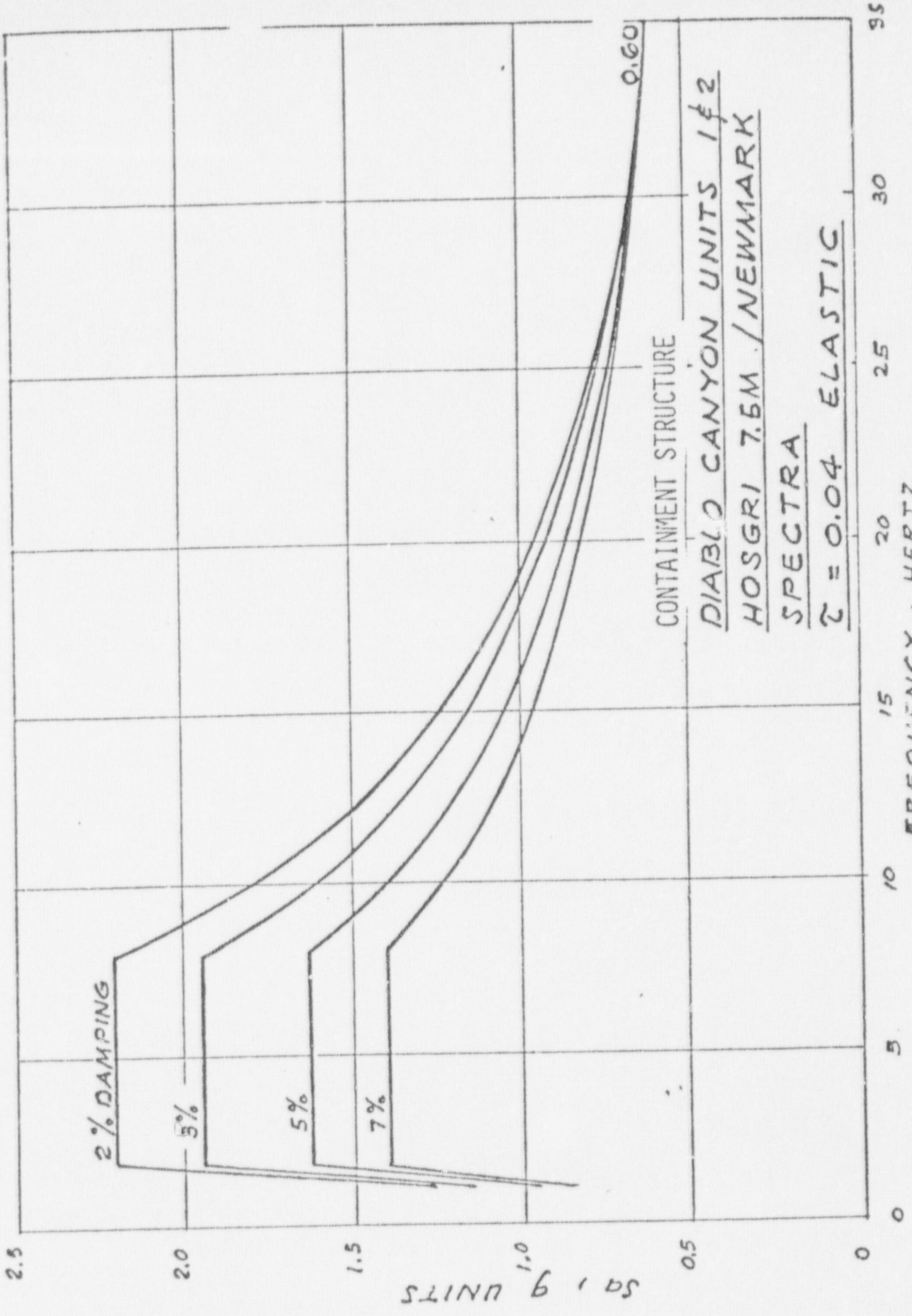
1.0
0.5
0
Sa, g UNITS
0
5
10
15
20
25
30
35
FREQUENCY, HERTZ
0.75
MISC. SMALL STRUCTURES
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M /NEWMARK
SPECTRA
τ = 0 ELASTIC

FIGURE 13


CONTAINMENT STRUCTURE
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / NEWMARK
SPECTRA
τ = 0.04 ELASTIC
2% DAMPING
3%
5%
7%
0.60
Sa, g UNITS
FREQUENCY, HERTZ
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0.5
1.0
1.5
2.0
2.5
5
10
15
20
25
30
35

FIGURE 14

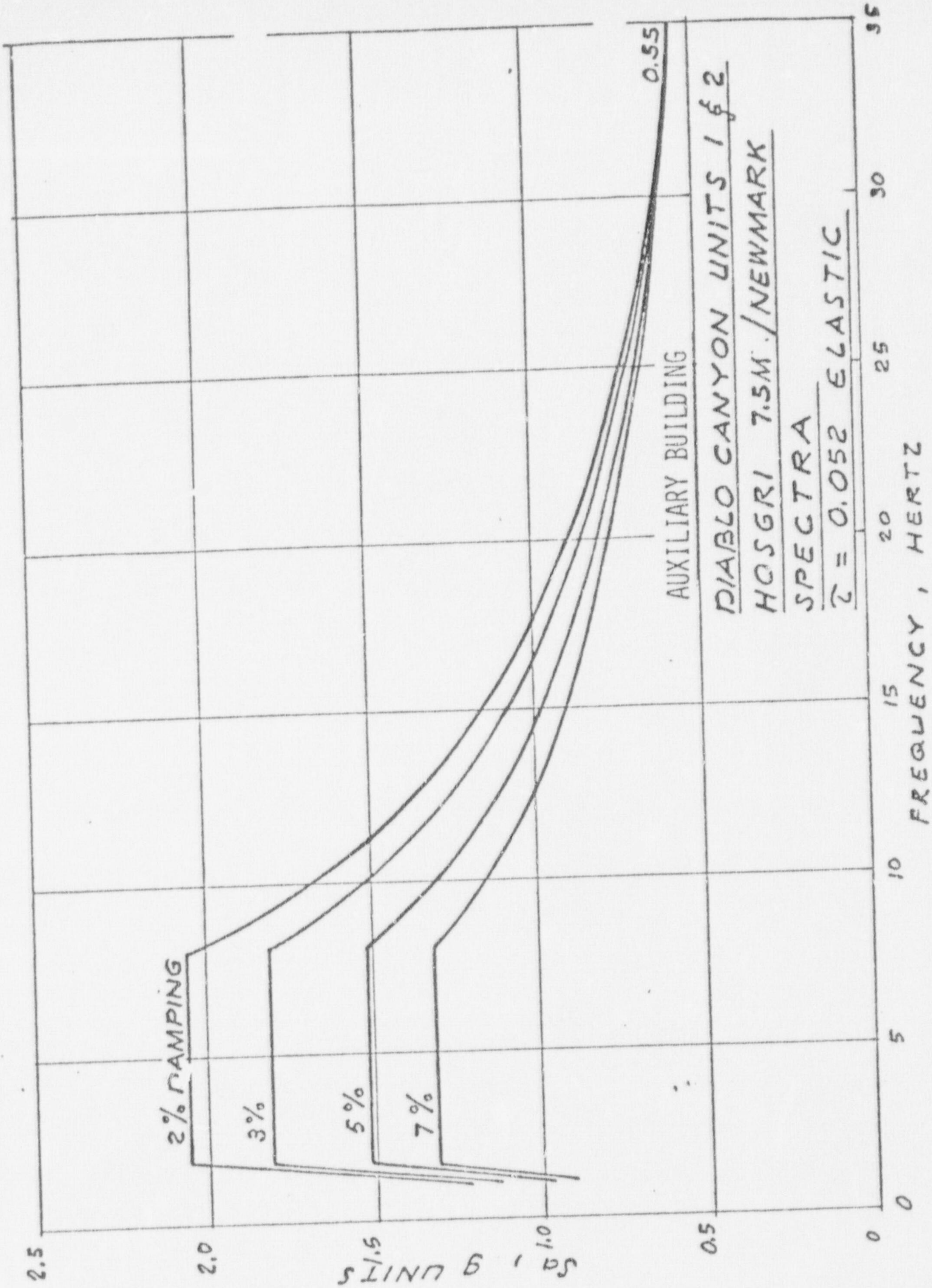

FIGURE 15

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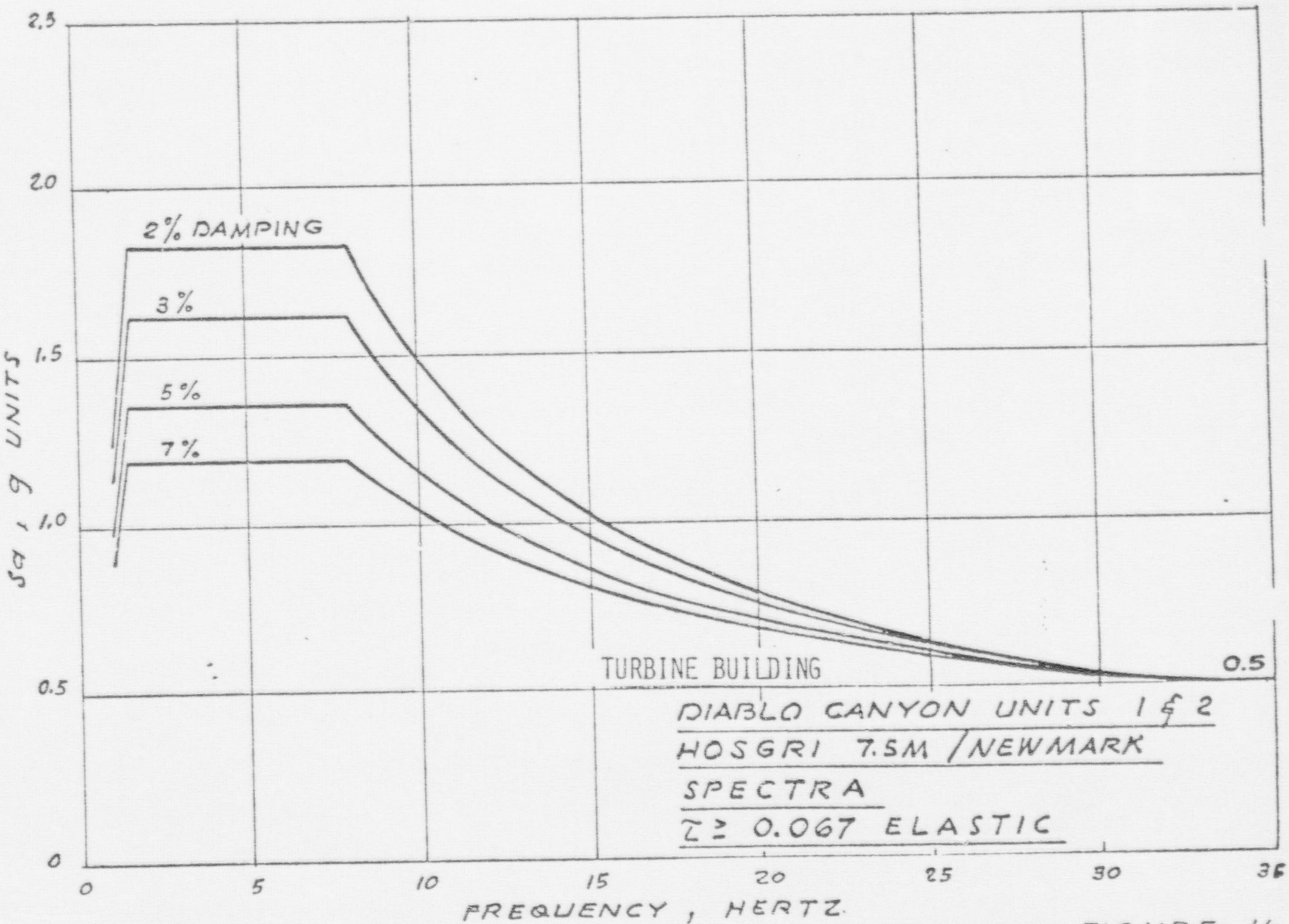

2.5
2.0
1.5
1.0
0.5
0
Sa , g UNITS
2% DAMPING
3%
5%
7%
0.5
TURBINE BUILDING
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / NEWMARK
SPECTRA
Z ≥ 0.067 ELASTIC
0
5
10
15
20
25
30
35
FREQUENCY , HERTZ

FIGURE 16

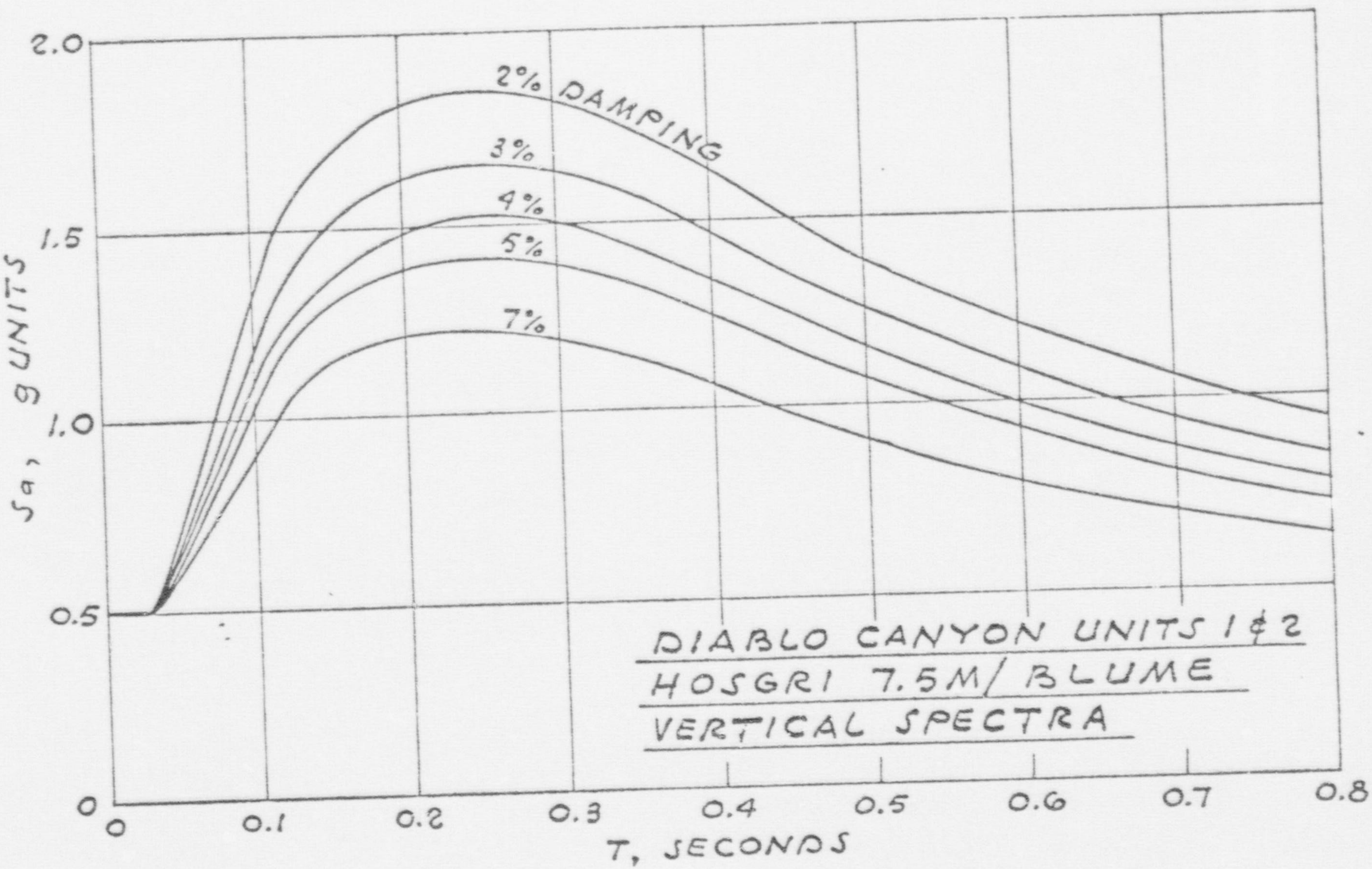
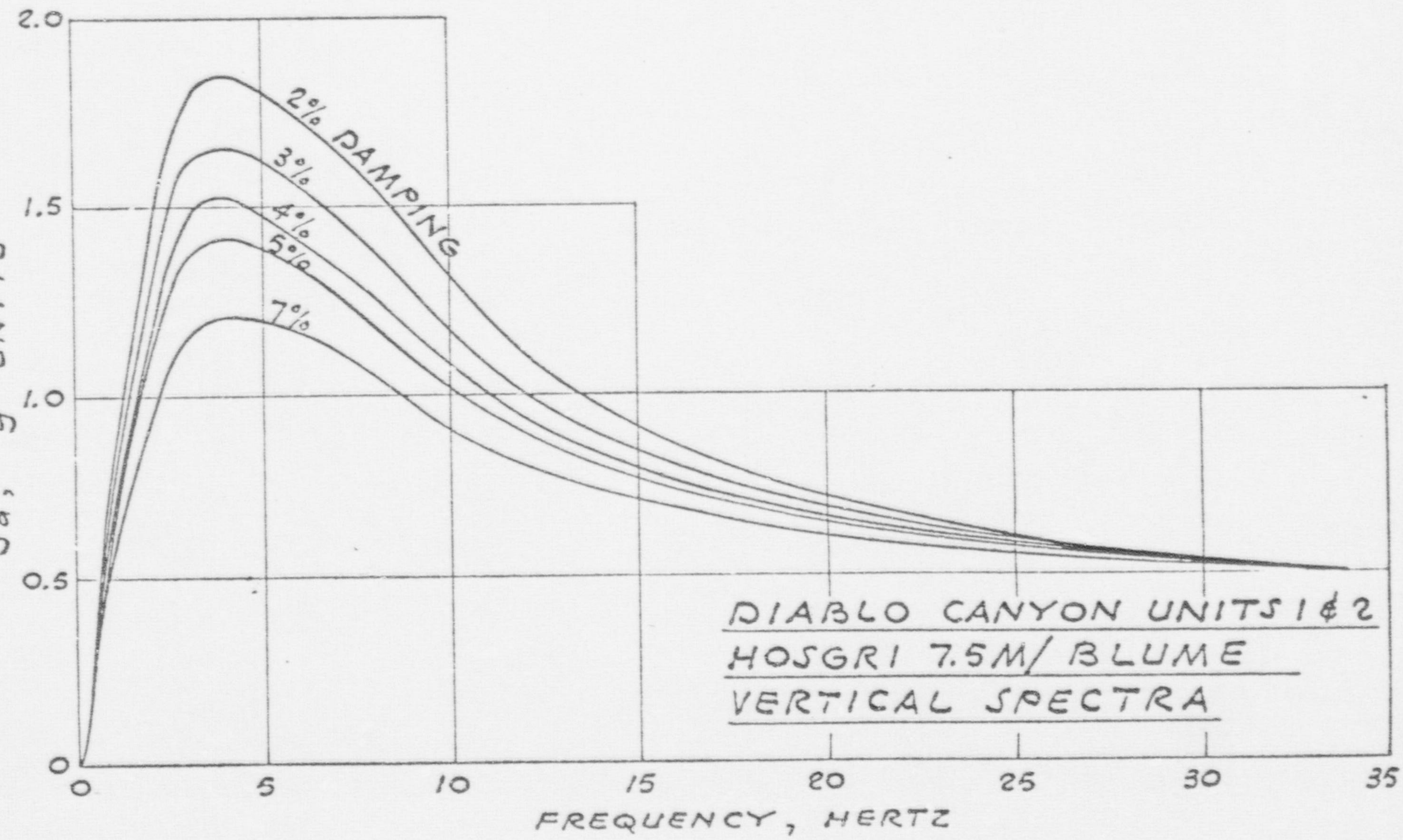

2.0
1.5
1.0
0.5
0
Sa, g UNITS
2% DAMPING
3%
4%
5%
7%
DIABLO CANYON UNITS 1 ¢ 2
HOSGRI 7.5M/ BLUME
VERTICAL SPECTRA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
T, SECONDS

FIGURE 17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1.5
1.0
0.5
0
Sa, g UNITS
2% DAMPING
3%
4%
5%
7%
0
5
10
15
20
25
30
35
FREQUENCY, HERTZ
DIABLO CANYON UNITS 1 ¢ 2
HOSGRI 7.5M/ BLUME
VERTICAL SPECTRA

FIGURE 18

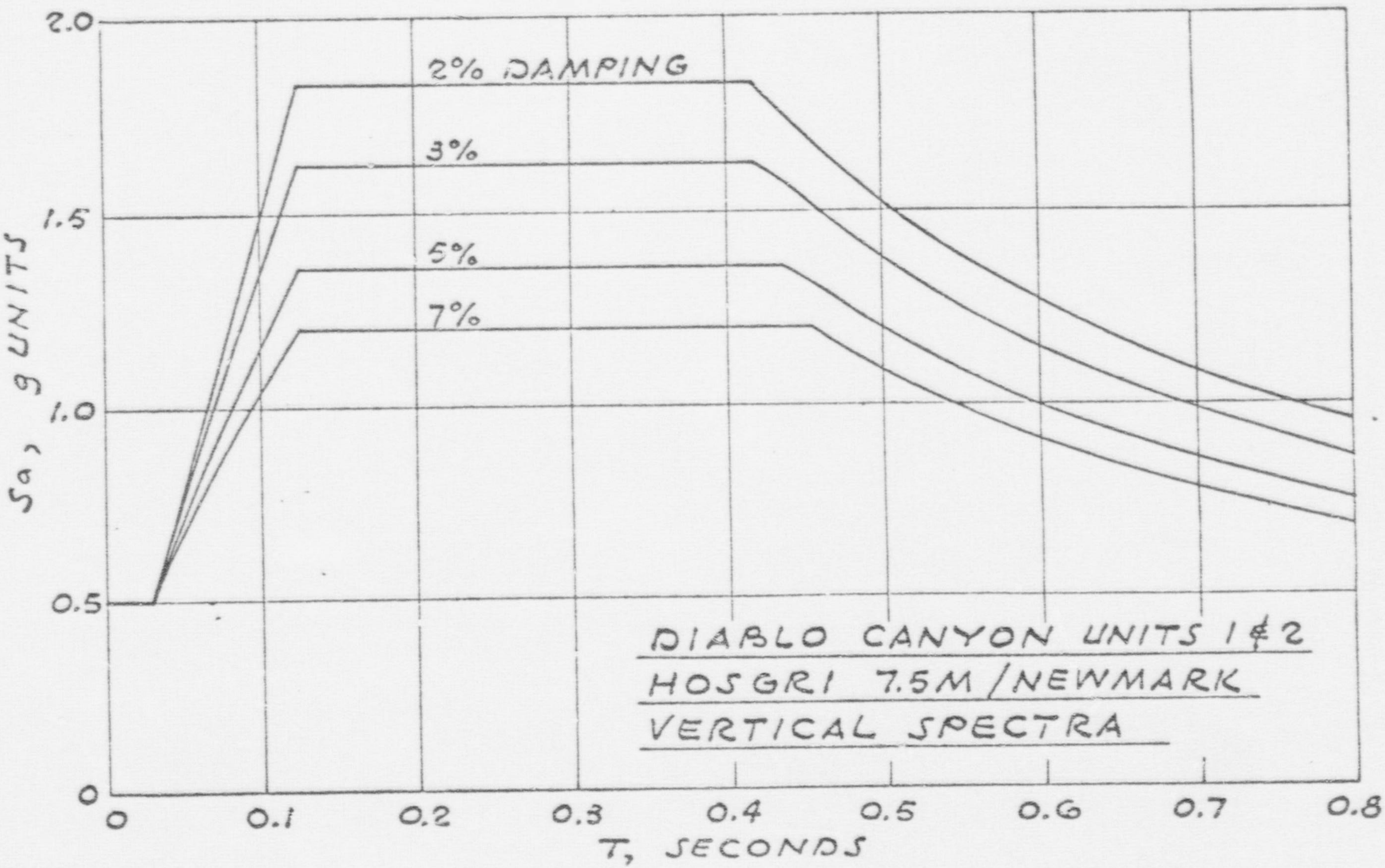
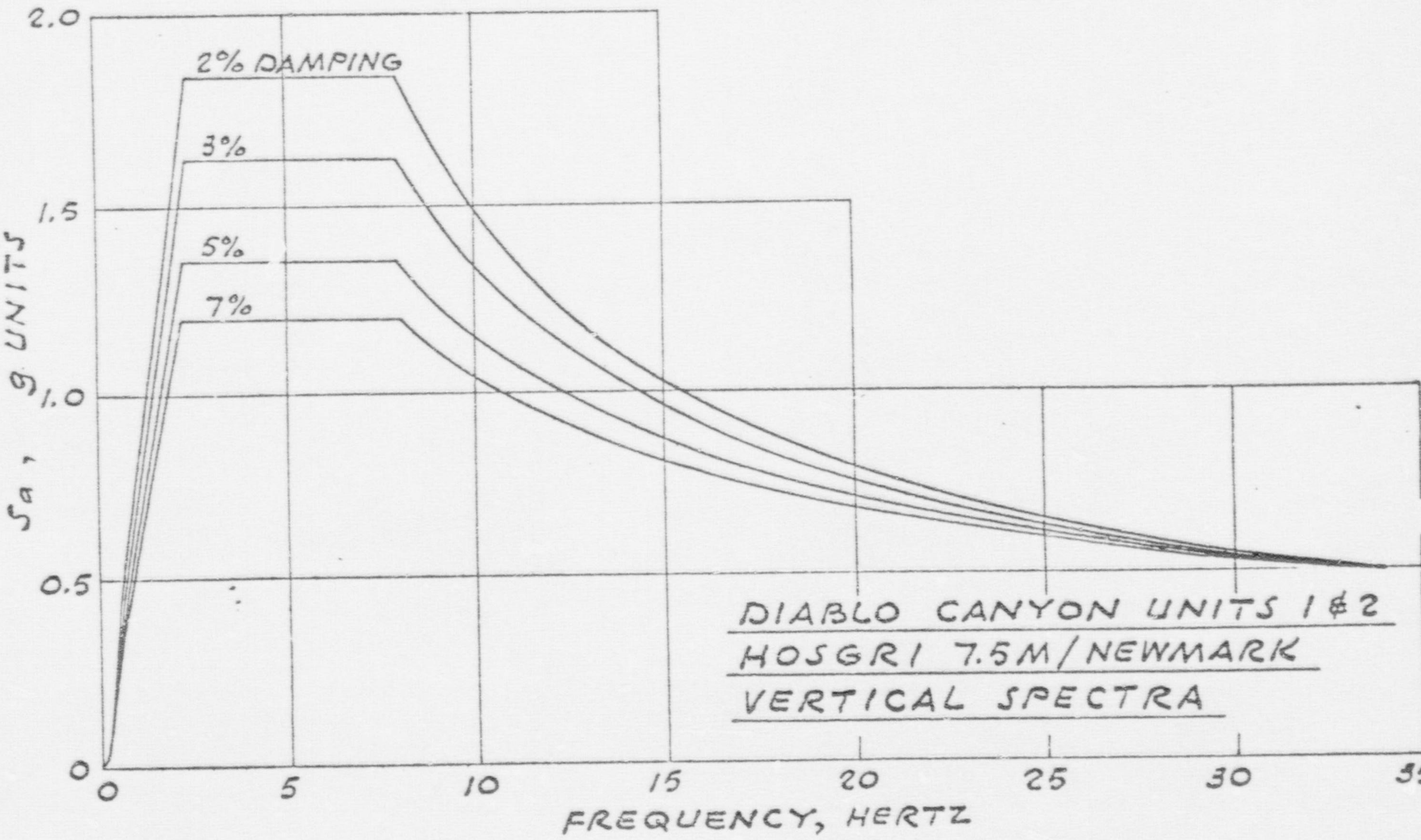
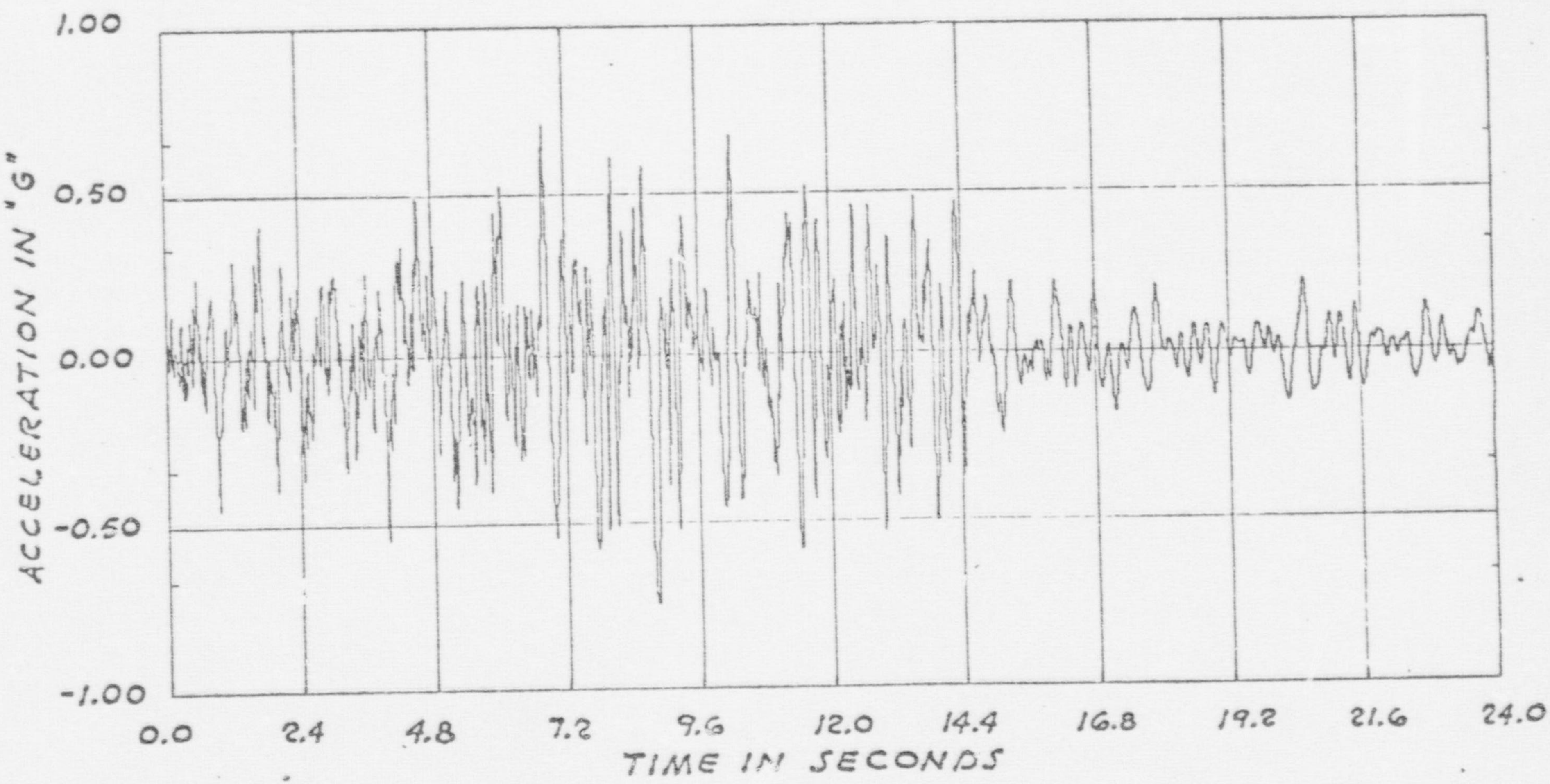

2.0
1.5
1.0
0.5
0
Sa, g UNITS
2% DAMPING
3%
5%
7%
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M / NEWMARK
VERTICAL SPECTRA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
T, SECONDS

FIGURE 19



2% DAMPING
3%
5%
7%
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M/NEWMARK
VERTICAL SPECTRA
Sa, g UNITS
FREQUENCY, HERTZ
0
0.5
1.0
1.5
2.0
5
10
15
20
25
30
35

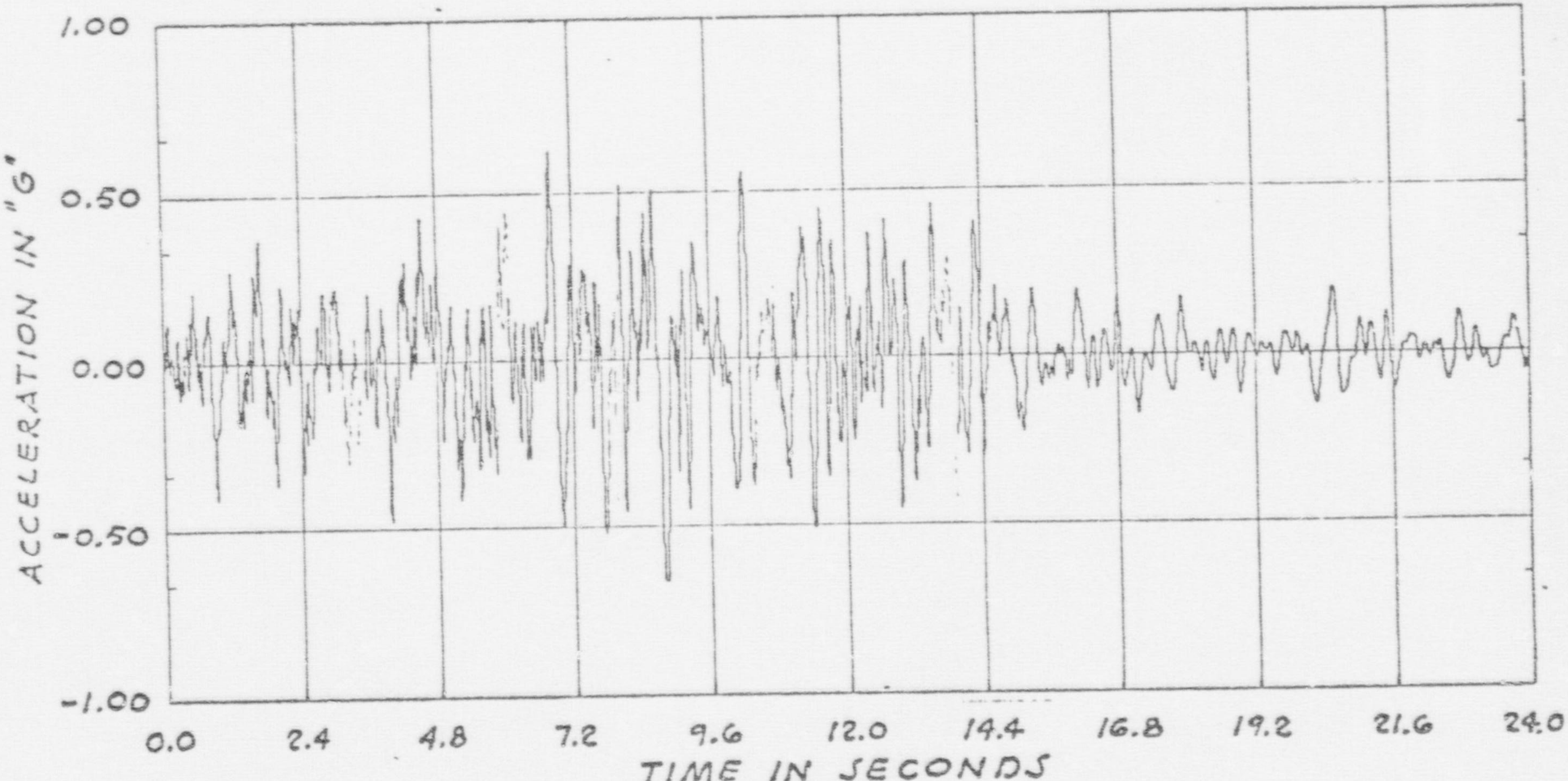
FIGURE 20



TIME HISTORY GENERATED TO MATCH 7% DAMPED HOSGRI 7.5M/BLUME RESPONSE SPECTRUM (τ = 0.00)

MISC. SMALL STRUCTURES

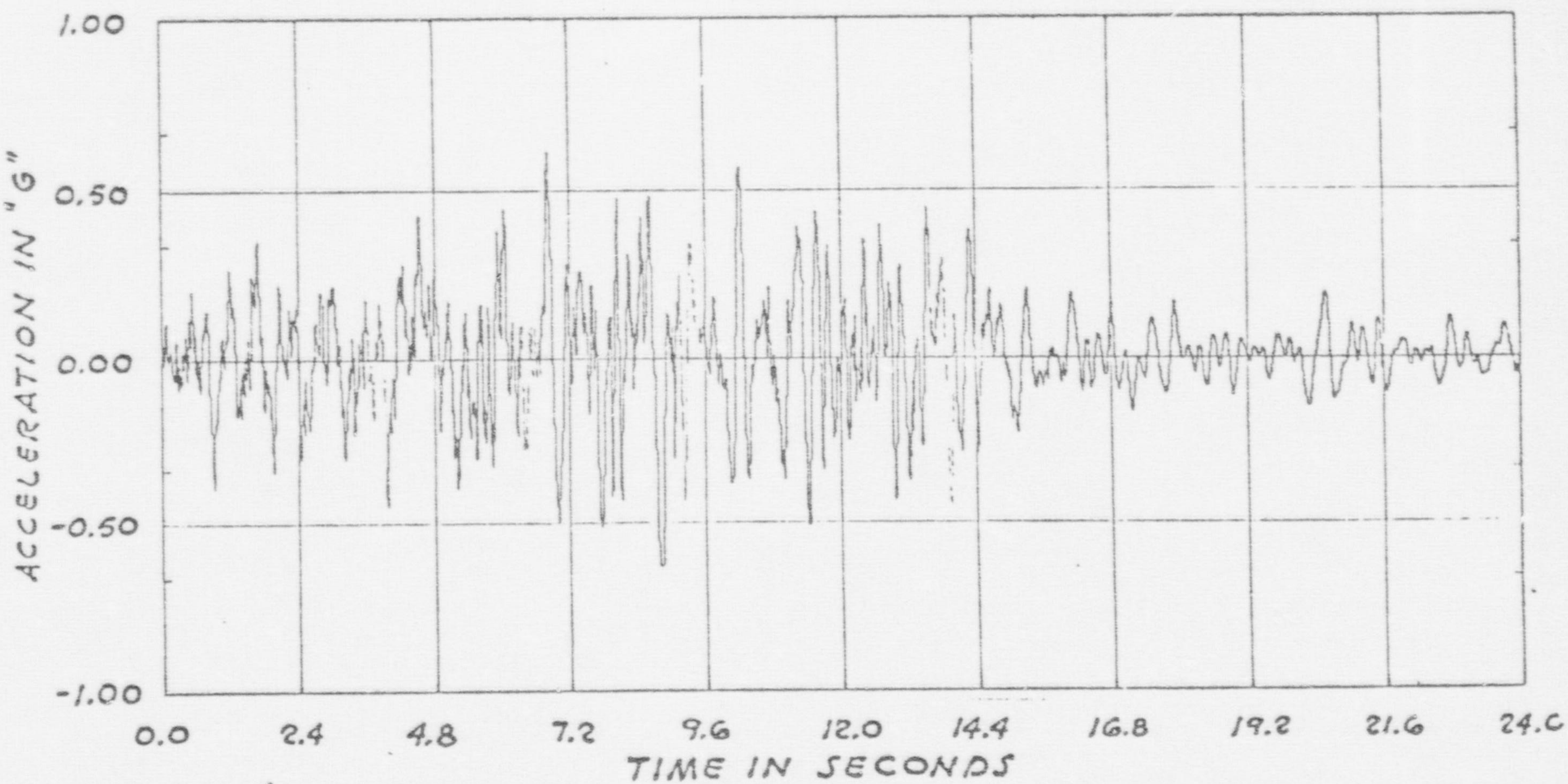
FIGURE 21



TIME HISTORY GENERATED TO MATCH 7% DAMPED HOSGRI 7.5M/BLUME RESPONSE SPECTRUM ($\tau = 0.04$)

CONTAINMENT AND INTAKE STRUCTURES

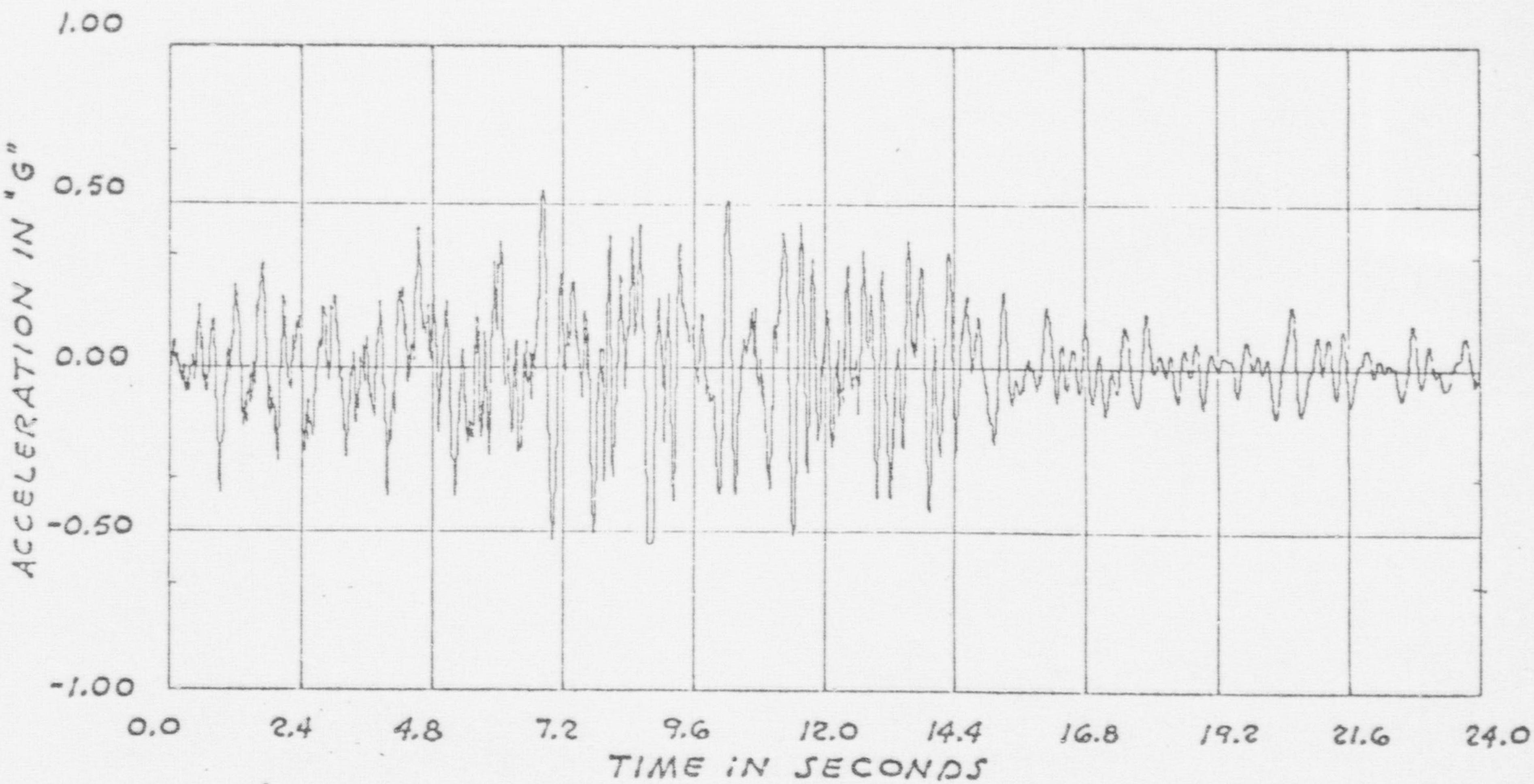
FIGURE 22



TIME HISTORY GENERATED TO MATCH 7% DAMPED HOSGRI 7.5M/BLUME RESPONSE SPECTRUM (τ=0.052)

AUXILIARY BUILDING

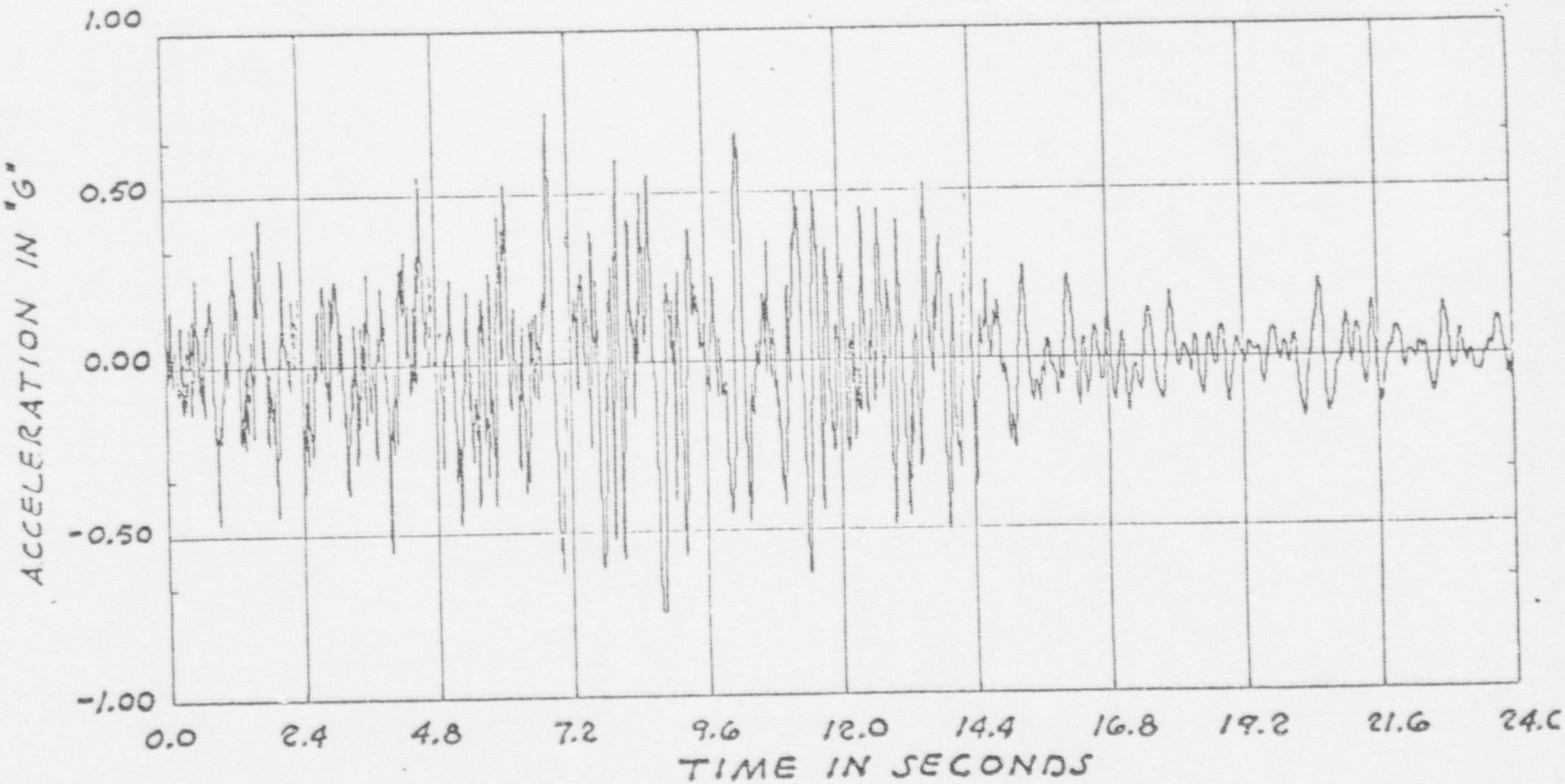
FIGURE 23



TIME HISTORY GENERATED TO MATCH 7% DAMPED HOSGRI 7.5M/BLUME RESPONSE SPECTRUM (τ = 0.080)

TURBINE BUILDING

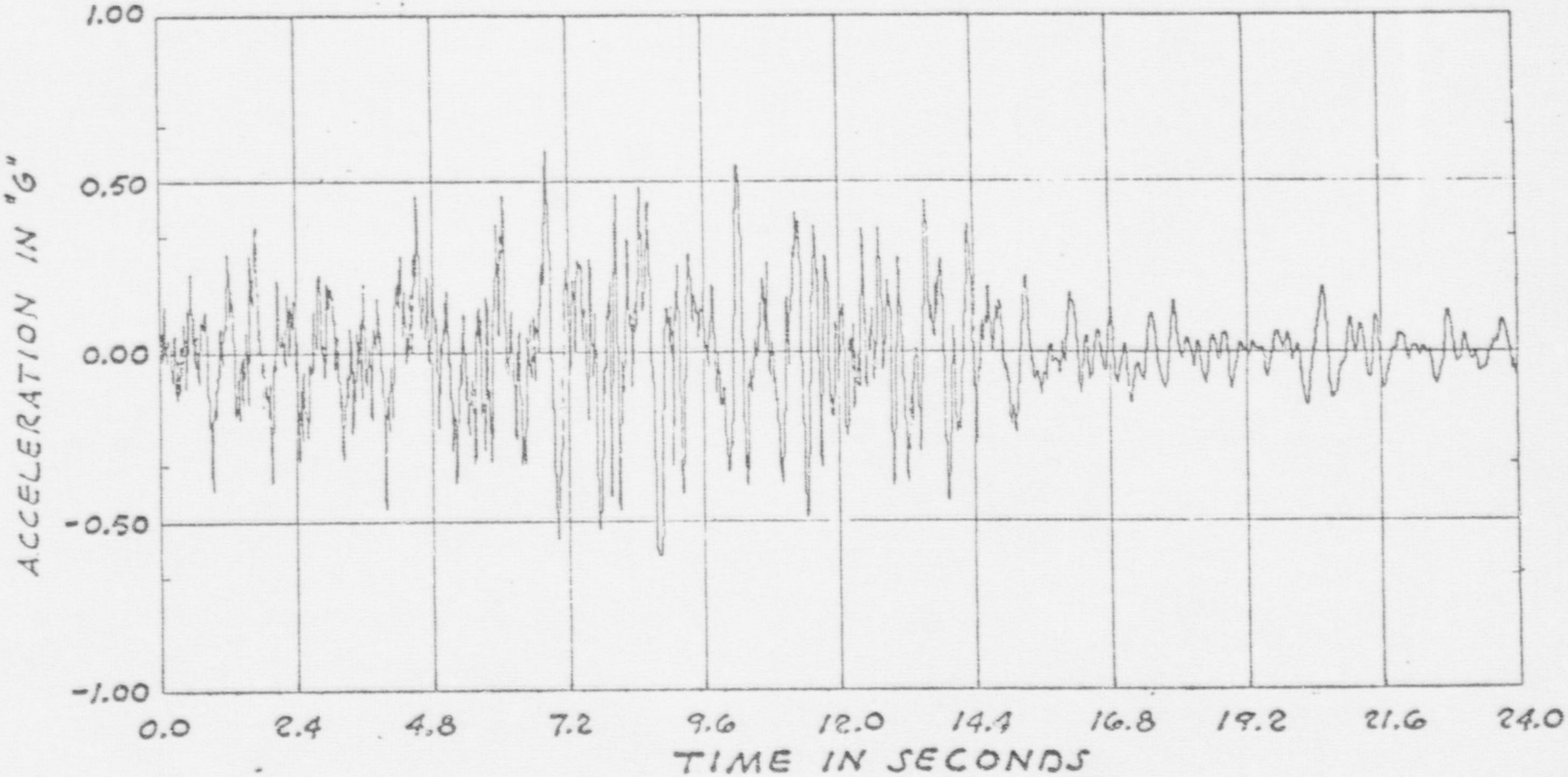
FIGURE 74



TIME HISTORY GENERATED TO MATCH 7% DAMPED HOSGRI 7.5M/NEWMARK RESPONSE SPECTRUM (τ= 0.00)

MISC. SMALL STRUCTURES

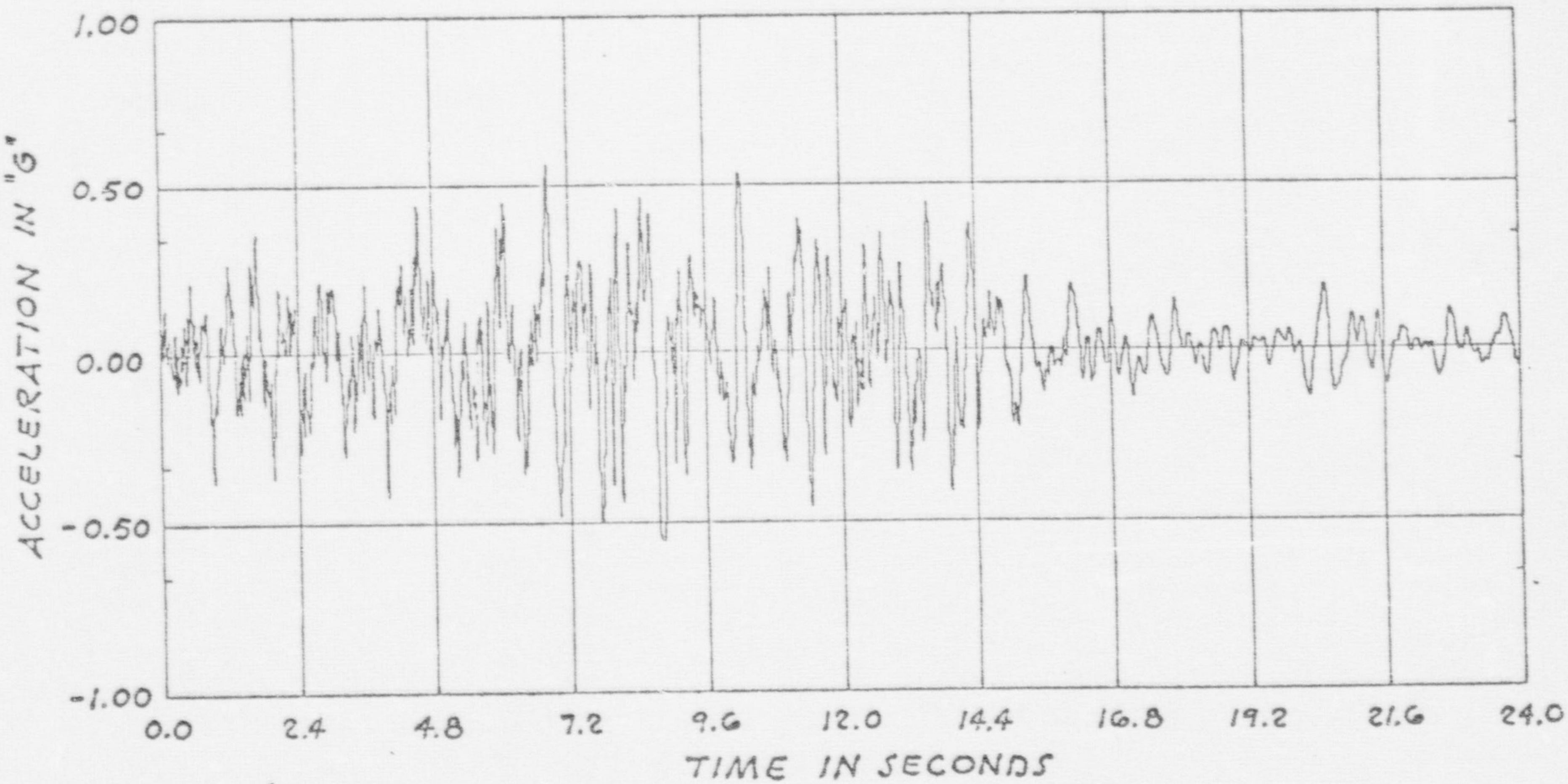
FIGURE 25



TIME HISTORY GENERATED TO MATCH 7% DAMPED
HOSGRI 7.5M/NEWMARK RESPONSE SPECTRUM ($\tau = 0.04$)

CONTAINMENT AND INTAKE STRUCTURES

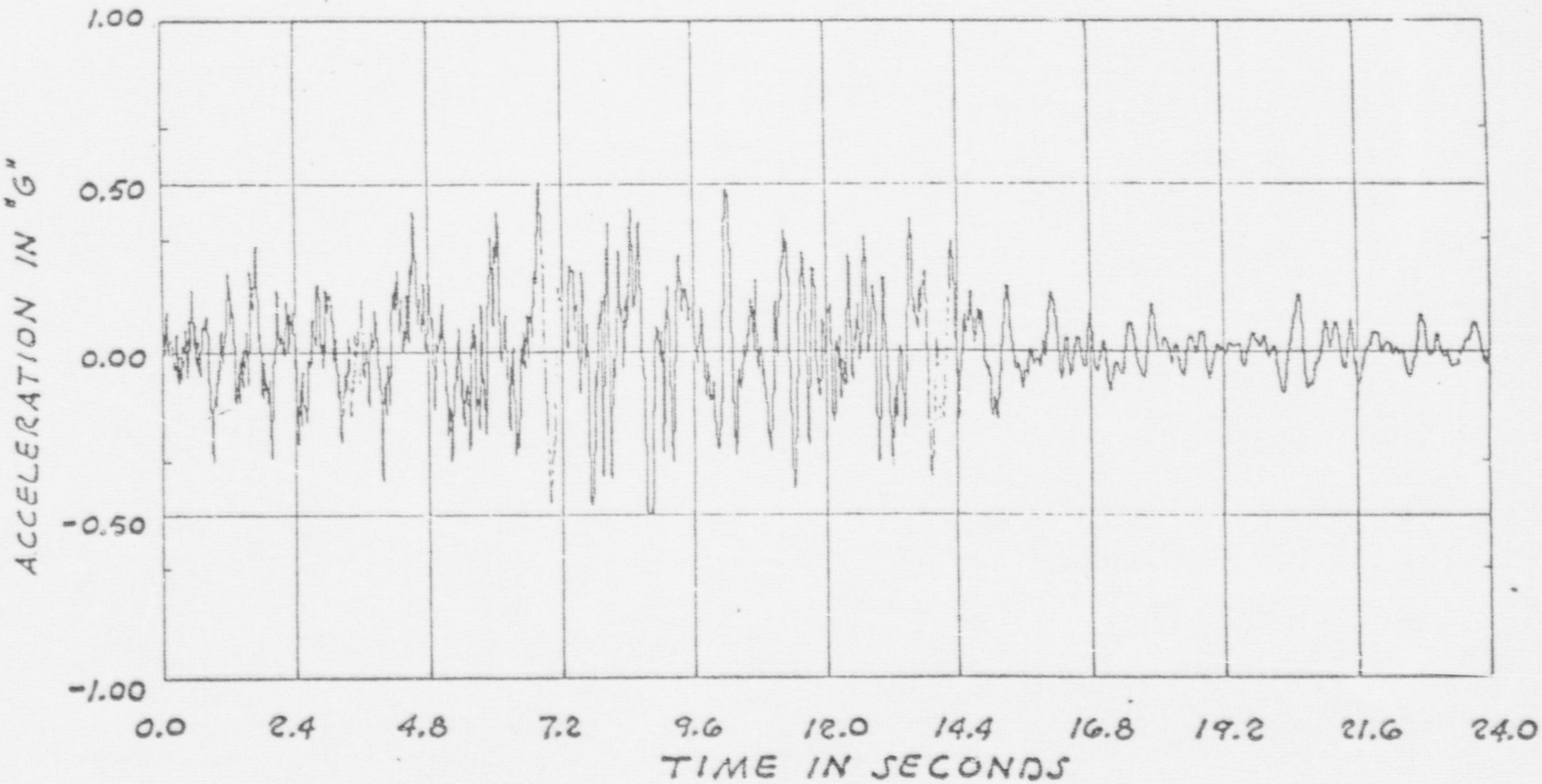
FIGURE 2[illegible]



TIME HISTORY GENERATED TO MATCH 7% DAMPED HOSGRI 7.5M/NEWMARK RESPONSE SPECTRUM (τ=0.052)

AUXILIARY BUILDING

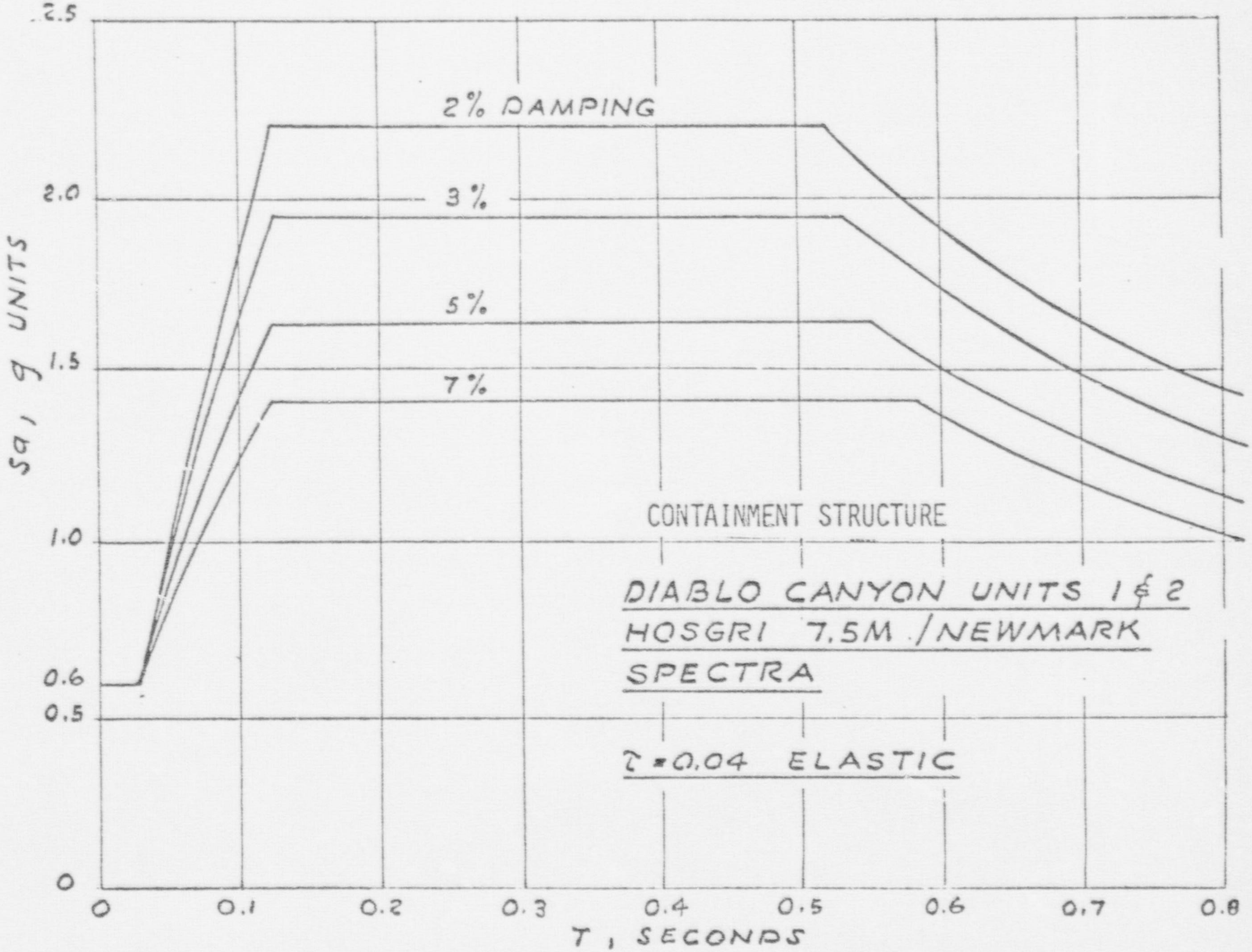
FIGURE 27



TIME HISTORY GENERATED TO MATCH 7% DAMPED
HOSGRI 7.5M/NEWMARK RESPONSE SPECTRUM (τ = 0.080)

TURBINE BUILDING

FIGURE 28



2.5
2.0
1.5
1.0
0.6
0.5
0
Sa, g UNITS
2% DAMPING
3%
5%
7%
CONTAINMENT STRUCTURE
DIABLO CANYON UNITS 1 & 2
HOSGRI 7.5M /NEWMARK
SPECTRA
τ = 0.04 ELASTIC
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
T, SECONDS

FIGURE 10