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Geological Survey

Seismic Engineering Data Report

The Imperial Valley, California Earthquake, October 15, 1979

Time Dependent Response Spectrum Plots

by

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SUMMARY

This report contains spectra plots of the response amplitudes sustained for various cycles of twenty-two strong-motion accelerograms obtained from the Imperial Valley earthquake of October 15, 1979. Table 1 lists the accelerograms and their distances to the Imperial fault (Boore and Porcella, 1980). Figure 1 is a map of the locations of the accelerograph stations and the main shock (Porcella and Matthiesen, 1979). This report complements the data report on the digitization, processing and spectral analysis of the 22 accelerograms (A. G. Brady, et al.,1980). The data from that report consisted of the uncorrected ground acceleration, corrected acceleration, velocity, displacement as well as the Fourier and response spectra; the data have been stored in two magnetic tapes which are available from Environmental Data and Information Service, N.O.A.A, Boulder, CO 80302, phone (303) 499-1000, EXT 6473.

The time-dependent spectral analysis method developed by Perez(1980), which is based on the earthquake-induced response of viscously damped linear oscillators, is applied to the 22 accelerograms. This method consists of constructing an envelope around the response of a specified oscillator, lowering a horizontal line of a given duration (1, 2, 4, 8, 16 or 32 cycles) through the envelope until its cumulative length just fits within the envelope, and then measuring the amplitude of the line. As opposed to the well known response spectrum, which keeps one spectral value representing the maximum response, this method furnishes information about other response amplitudes by keeping track of those response amplitudes that are sustained or exceeded for 1,2,4,8,16 and 32 cycles.

Of the 22 stations in this report, 12 of them form the El Centro array and are located on a relative straight line which is approximately perpendicular

to the Imperial fault. These stations range in distance from 0.6 to 22 km. When the amplitudes sustained for 1,2 and 4 cycles were expressed as percentages of maximum reponse and then were plotted against the distance to the Imperial fault, the stations of the array located furthest from the fault had in general the greatest percentage values. That is, the amplitude of the response remain closer to its maximum value for a longer period of time the further the location of the recording station. Owing to this effect of distance on the amplitudes sustained for various cycles (an example of this effect can be seen in figure 3), the array stations were separated into two groups, 6 stations which were within 8.5 km to the fault, and the other 6 stations ranging in distance 12.6 to 22 km. When the amplitudes sustained for 1 2 and 4 cycles, again expressed as percentages of maximum response, were plotted against the periods, they fell within a horizontal band of values, appearing to be relatively independent of period. In order to simplify the plotting and yet show the general relations between amplitudes sustained for 1,2,4,8,16 and 32 cycles, distance to stations and different recording orientations, the mean of the percentage value for each group of stations was used.

The raw tripartite plots, using 5 percent critical damping,for the pseudo-velocity amlplitudes sustained for 1,2,4 8,16 and 32 cycles are shown in the appendix for the 22 stations.

The Displacement of Amplitude Sustained for Given number of Cycles (SdAc)

The maximum response spectrum, an important tool in the design of earthquake resistant structures (Hudson, 1956; Merchant and Hudson, 1962), is based on the response of a single-degree-of-freedom, viscously damped linear oscillator subjected to a strong earthquake ground motion. A characteristic of each oscillator is that it acts as a narrow band filter that amplifies the input frequencies centered around the natural period of the oscillator (Trifunac, 1971). This resulting sinusoidal-like property of the response is important in the development of time dependent spectral analysis (Perez, 1973). Due to this cyclical characteristic, a valid question from the structural engineering point of view is: "How many cycles of response does a structure experience during an earthquake?". Using the response of an oscillator, one can count the number of cycles, but since the amplitude of the cyclical response varies continuously, no single amplitude is representative for all the cycles. But the following useful question can be asked: "What response amplitude is sustained for a duration equal to a given number of cycles?". To obtain this amplitude, Perez (1980) developed the following method: take the envelope of the cyclical response and lower a horizontal line through the envelope of the response until the cumulative length of the horizontal line inside the envelope is equal to the number of cycles desired. This one amplitude, designated SdAc ("Sd" normally stands for displacement response, "A" stands for amplitude sustained, and "c" refers to cycles), is then defined as the displacement response amplitude that is sustained for a given number of cycles. The values of SdAc obtained for oscillators with different natural periods generate a spectrum curve for any specific number of cycles.

In this report, 5 percent critical damping was used as in other studies of response spectra because it is representative of many structural materials.

The familiar tripartite response spectrum plots used in structural engineering are generated by making use of the sinusoidal-like nature of the response. The pseudo-velocity response (PSv) has been defined as the maximum displacement response (Sd) multipled by ω, where $\omega = 2\pi/T$, T being the natural period of the oscillator. Similarly, the pseudo-acceleration response (PSa) has been defined as the pseudo-velocity multiplied by ω (Hudson, 1956). PSv and PSa are then related to Sd by the multiplicative constants ω and ω^2 respectively and the tripartite plot can then be used to simultaneously represent the three response measurements.

Applying a similar approach, SdAc, multiplied by ω defines the pseudo-velocity amplitude sustained for a particular number of cycles and it is designated by PSvAc; the PSvAc multiplied by ω defines the pseudo-acceleration amplitude sustained for a particular number of cycles and it is designated by PSaAc. The tripartite plot ,for example, in Figure 2 was made using these definitions, the top curve representing the maximum response Sd, PSv, PSa and the six lower curves representing the response amplitudes sustained for different number of cycles of SdAc, PSvAc and PSaAc. The tripartite plots for the 66 components in the appendix were drawn for 5 percent critical damping and were calculated for durations of 1, 2, 4, 8, 16 and 32 cycles.

The plots in the appendix contained the maximum response as well as the amplitudes sustained for various cycles, so that one can visually see how the amplitude of the response decreased during the earthquake. For example, in Figure 2, El Centro array 7, 230°, the maximum PSv is about 2.80 cm/sec when the period is equal to 0.04 sec; for the same period, the PSvAc for 32 cycles is about 1.08 cm/sec. This signifies that for 32 cycles the amplitude sustained is about 39 percent of maximum response. By representing anv response amplitude sustained for any given number of cycles as a percentage of maximum response one can observe the rate at which the amplitude of the response diminished during the earthquake.

Plots of the Mean of PSvAc as a Percentage of Maximum Pseudo-velocity Response for the El Centro Array

Among the 22 accelerograms in this report, 12 were part of the El Centro array. The horizontal recorders of these 12 stations were aligned approximately parallel and transverse to the Imperial fault. Distances to the fault ranged from 0.6 km to 22 km (Boore and Porcella, 1980).

Typically, when values of PSvAc for a given number of cycles are expressed as percentages of the maximum pseudo-velocity response and then plotted against the distance to the Imperial fault(see figure 3), it appears that the greater the distance of the recording stations, the larger the percentages. Figure 3 also shows a typical trend, that the closer the recording station is to the fault, the greater the scatter of points for any one distance. Taking into account the effect that distance has on the response, the 12 stations in the El Centro array were devided into the following two groups: 1) stations 4,5,6,7,8 and 10, located within 8,5 km of the Imperial fault, and 2) stations 1,2,3,11,12 and 13, which ranged from 12.6 to 22 km from the fault. Using the six stations furthest from the fault, the values of PSvAc, expressed as percentage of maximum response, were plotted against their respective periods for 1,2 and 4 cycles. The results, seen in Figures 4 and 5 indicate that these percentages all fall within a band of values that appear to be relatively independent of period. When similar plots for both groups of stations were made using different orientations and different period ranges, the results were similar to figures 4 and 5, but again with slightly more scatter for those stations closer to the fault. Also, in all cases, the scatter of PSvAc percentage values increased as the number of cycles was increased. In order to summarise all the results in a brief form yet show the general trend seen in figures 4 and 5, for the two groups of stations, the mean value of PSvAc as a percentage of maximum response was calculated for each group of stations and are shown in figures 6 through 13. (Note that since PSv and PSa are related to Sd by the constants ω and ω^2, respectively, and since these same constants relate to PSvAc and PSaAc to SdAc, for any given oscillator, the three percentages, SdAc to Sd, PSvAc to PSv, and PSaAc to PSa reduce to the same value.)

The plots for the mean PSvAc in the upper part of figures 6 through 13 show periods ranging in value from 0.04 to 6 sec. This choice was made taking into account that the corrected ground acceleration used to generate the response was band-pass filtered for periods between 0.043 and 5.88 sec. The ramps are indicated in each plot heading. The lower part of figures 6 through 13 show in detail the plots of the mean PSvAc for the high frequency range, periods 0.04 to 1 sec. Note that for this report, the scatter of points for each of the mean PSvAc curves are not indicated in the plots. When further studies are completed, the question of scatter will be taken into account.

Owing to the fact that the three mutually orthogonal accelerometers in each station were aligned in the same direction throughout the array, each of the two groups of six stations were divided into their respective orientations: a) 230° (transverse to the fault); 140° (parallel to the fault); and c) vertical direction. The mean values for the six stations in each group and for each direction are shown in figure 6 through 11. Figure 12 is a plot for the combined 12 horizontal components for the 6 stations near the fault. Figure 13 is a plot for the combined 12 horizontal components for the six stations ranging in distance from 12.5 km to 22 km from the Imperial fault.

The response of each oscillator was calculated for the duration of the accelerogram, ranging from 37 to 39 sec. The number of cycles experienced during the earthquake were thus limited by this earthquake duration. For example, the 5 second oscillator will experience only 8 cycles during a 40 sec earthquake. Thus, in the upper plots of figures 6 through 13, the curves of the mean of PSvAc for 8, 16 and 32 cycles tend to zero when the time required for each number of cycles approaches the length of the accelerogram.

Table 2 summarizes the general trends seen in mean PSvAc curves of figures 6 through 13. The interesting characteristic of these curves is that although there is some variation in response values, they are relatively flat for the 1, 2 and 4 cycles PSvAc curves in the period range 1 to 6 sec. In the high frequency range of the response, all the curves appear to decrease slightly in value as the period is increased from 0.2 sec to 1 sec, but even in this high frequency range, the mean PSvAc curves are relatively independent of period. As an example, for periods between 1 to 6 sec, Table 2 indicates that for one cycle, for the stations in the 140° direction, response amplitudes sustained have values of about (78 ± 10) percent of maximum response for the near fault stations and amplitudes of about (83 ± 5) percent of maximum response for the more distant stations; after two cycles the response amplitudes have values of about (66 ± 11) percent of maximum response or the near fault stations and about (68 ± 8) percent for the more distant stations; for four cycles, the response of amplitudes sustained have values of about (46 ± 11) percent of maximum response for the near fault stations and about (52 ± 10) percent for the more distant stations. The variations in value for the mean percentage curve for each duration can be partially attributed to the fact that the PSvAc curves shown on the tripartite plots, especially for the longer durations, are generally not as smooth as the maximum response curves. If, instead of plotting the mean percentage for each particular period, as for example Figure 8, the mean percentage for various period ranges are plotted, then the resulting mean percentage curves tend to be much smoother, as shown in Figure

14. But note that the choice of taking the mean value of percentages is purely arbitrary and that the reason for doing any averaging at all is done with the intent of simplifying the plotting yet retaining the general information of how response amplitudes decline during an earthquake.

Summary and Comments on the Response Amplitudes Sustained for Various Cycles

The 66 plots in the appendix indicate 6 amplitude curves of the response that are sustained for some particular number of cycles (PSvAc) with the 7th top-most curve representing the maximum response (PSv). By expressing the amplitude sustained for a particular number of cycles as a percentage of maximum response, the decline in response amplitude sustained for a particular number of cycles experienced at any one station can be directly compared to the decline in amplitude experienced at any other site.

In order to simplify yet retain the general information of the behavior of response during an earthquake, using two groups of six stations from El Centro array, the mean values of the amplitudes sustained for various cycles (expressed as percentages of maximum response) were plotted for different recording orientations. The most interesting characteristics of the mean percentage curves for 1, 2 and 4 cycles, is that the amplitude sustained for these number of cycles is somewhat constant and thus relatively independent of period. Although these mean percentage curves vary, depending on period range, recording direction and distant to the fault, the following example is representative of the general trends seen in the behavior of the response: in the 140° direction, for six stations varying in distance 12.5 to 22 km, for one cycle the response amplitude sustained is about (83 ± 5) percent of maximum in the period range 1 to 6 sec; for two cycles the response sustained is about (68 ± 8) percent of maximum: for four cycles, the amplitude sustained is about (52 ± 10) percent of maximum. For this same period range and same orientation, the difference due to the effect of distance between the group of stations within 8.5 km of the Imperial fault, and the group of stations ranging in distance between 12.5 to 22 km, is that the more distant stations have their respective response sustained closer to their maximum response amplitudes, and with less scatter, than the response amplitudes for the close to fault stations (see Table 2).

Note that the analysis of the response duration generated from the recordings made in the El Centro array stations provide certain trends that give only a partial insight into the behavior of the response since only one earthquake event is used. Additional work needs to be done in order to find the effects, if any, that factors such as earthquake magnitude, soil conditions and different distances and orientations to fault have on the amplitudes of the response. Work is also needed on how to use the duration of the response in understanding building damage, and if at all possible on how to implement the response duration factor in the design of earthquake resistant buildings.

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Porcella, R. L., and Matthiesen, R. B., 1979, Preliminary summary of the U.S. Geological Survey strong-motion records from October 15 1979 Imperial Valley earthquake, U.S. Geological Survey Open-File Report 79-1654.

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Table 1 - Ground motion data

	Station Name	Distance[1] (km)	Acceleration[2] (g)	Velocity[2] (cm/s)	Displacement[2] (cm)
1.	Centro, Station 7	0.6	0.52	110	41
2.	El Centro, Station 6	1.3[1.0]	0.72	110	55
3.	El Centro, Bonds Corner	4.0	0.81	44	15
4.	El Centro, Station 8	3.8	0.64	53	29
5.	El Centro, Station 5	4.0[1.0]	0.56	87	52
6.	El Centro, Differential Array	5.1	0.51	68	34
7.	El Centro, Station 4	6.8[4.1]	0.61	78	48
8.	Brawley, Brawley Airport	8.5[3.6]	0.22	37	19
9.	Holtville, Holtville Post Office	7.5	0.26	48	25
10.	El Centro Staton 10	8.5	0.23	44	27
11.	Calexico, Fire Station	10.6	0.28	19	7.0
12.	El Centro, Station 11	12.6	0.38	39	14
13.	El Centro, Station 3	12.7[9.4]	0.27	46	18
14.	Parachute Test Site	14.0	0.20	17	9.2
15.	El Centro, Station 2	16.0[11]	0.43	31	13
16.	El Centro, Station 12	18	0.15	19	8.4
17.	Calipatria, Fire Station	23	0.13	15	6.9
18.	El Centro, Station 13	22	0.15	15	6.0
19.	El Centro, Station 1	22[15]	0.15	15	5.5
20.	Superstition Mountain	26	0.21	9.0	1.9
21.	Plaster City	32	0.066	5.8	1.8
22.	Coachella Canal Station 4	49	0.14	16	3.1

[1]Distance to slipped surface at Imperial fault. Numbers in brackets are distances to Brawley fault.

[2]Peak horizontal motion on one of two orthogomal horizontal components; vertical acceleration is larger at several stations.

Table 2 - Range of mean PSvAc amplitudes as percentages of PSv

		Distance to Imperial fault: 0.6 to 8.5 km (6 stations)		Distance to Imperial fault: 12.5 to 22 km (6 stations)	
Direction	No. of Cycles	Period range: 0.2 to 1 sec	Period range: 1 to 6 sec	Period range: 0.2 to 1 sec	Period range: 1 to 6 sec
		(%)	(%)	(%)	(%)
230°	1	78 ± 8	77 ± 10	86 ± 5	86 ± 6
	2	65 ± 7	57 ± 16	79 ± 7	74 ± 4
	4	48 ± 9	40 ± 11	68 ± 7	56 ± 13
	8	32 ± 12	- - -	52 ± 5	- - -
	16	19 ± 11	- - -	33 ± 5	- - -
	32	10 ± 7	- - -	15 ± 6	- - -
140°	1	81 ± 7	78 ± 10	85 ± 4	83 ± 5
	2	67 ± 9	66 ± 11	77 ± 6	68 ± 8
	4	51 ± 11	46 ± 11	62 ± 13	52 ± 10
	8	34 ± 12	- - -	49 ± 15	- - -
	16	20 ± 10	- - -	33 ± 10	- - -
	32	9 ± 6	- - -	15 ± 8	- - -
Vert.	1	78 ± 9	85 ± 6	86 ± 5	84 ± 6
	2	67 ± 9	70 ± 8	78 ± 8	70 ± 12
	4	48 ± 11	45 ± 15	66 ± 10	50 ± 17
	8	33 ± 13	- - -	53 ± 9	- - -
	16	18 ± 7	- - -	38 ± 8	- - -
	32	7 ± 3	- - -	23 ± 9	- - -
Horiz. (i.e., 230° and 140°)	1	79 ± 4	80 ± 7	86 ± 4	84 ± 6
	2	66 ± 5	62 ± 13	77 ± 5	71 ± 5
	4	50 ± 7	41 ± 9	65 ± 6	54 ± 9
	8	32 ± 11	- - -	51 ± 8	- - -
	16	19 ± 10	- - -	33 ± 7	- - -
	32	10 ± 7	- - -	15 ± 7	- - -

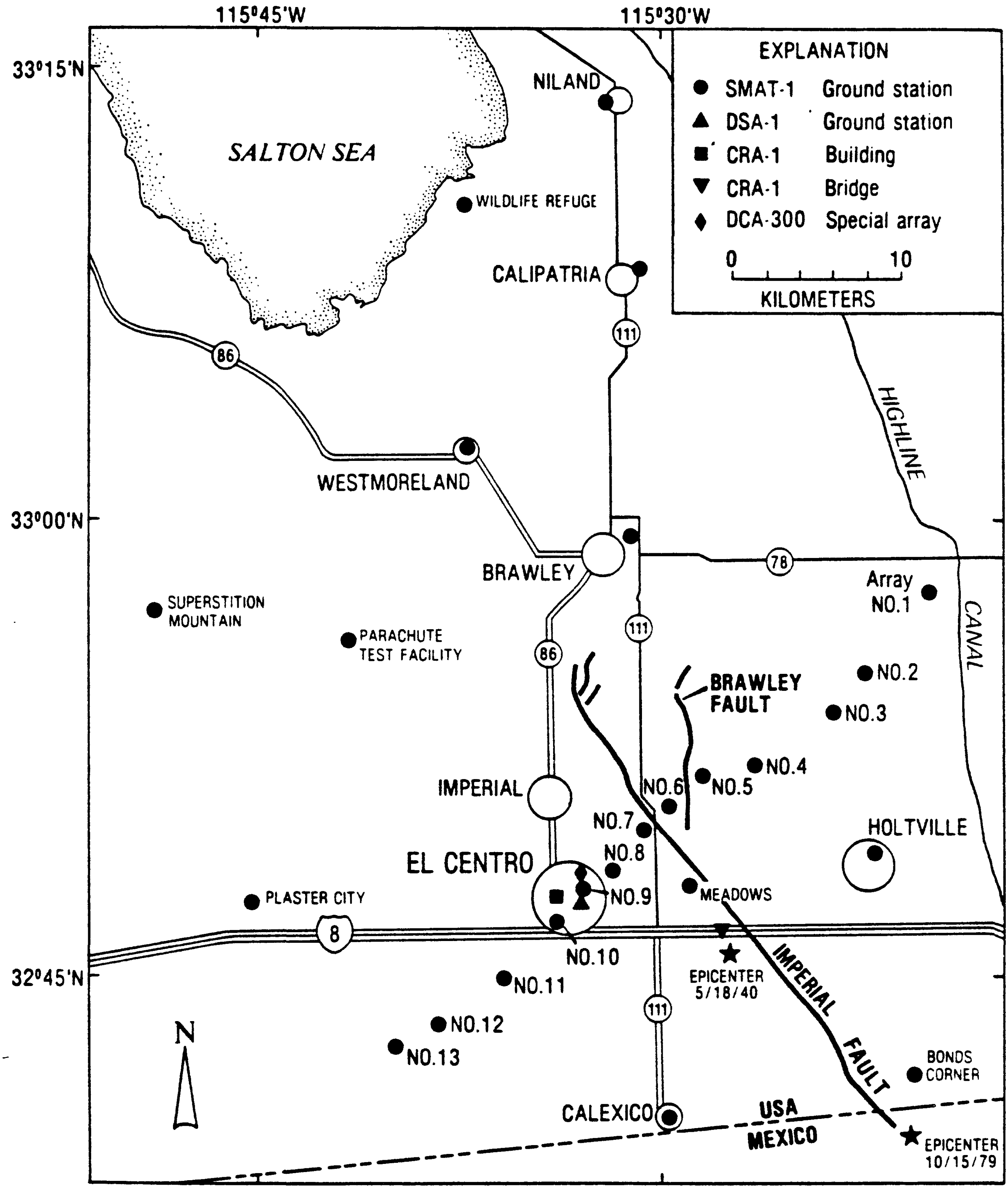


Figure 1--Strong-motion stations in the Imperial Valley, California (from Porcella and Matthiesen, 1979)

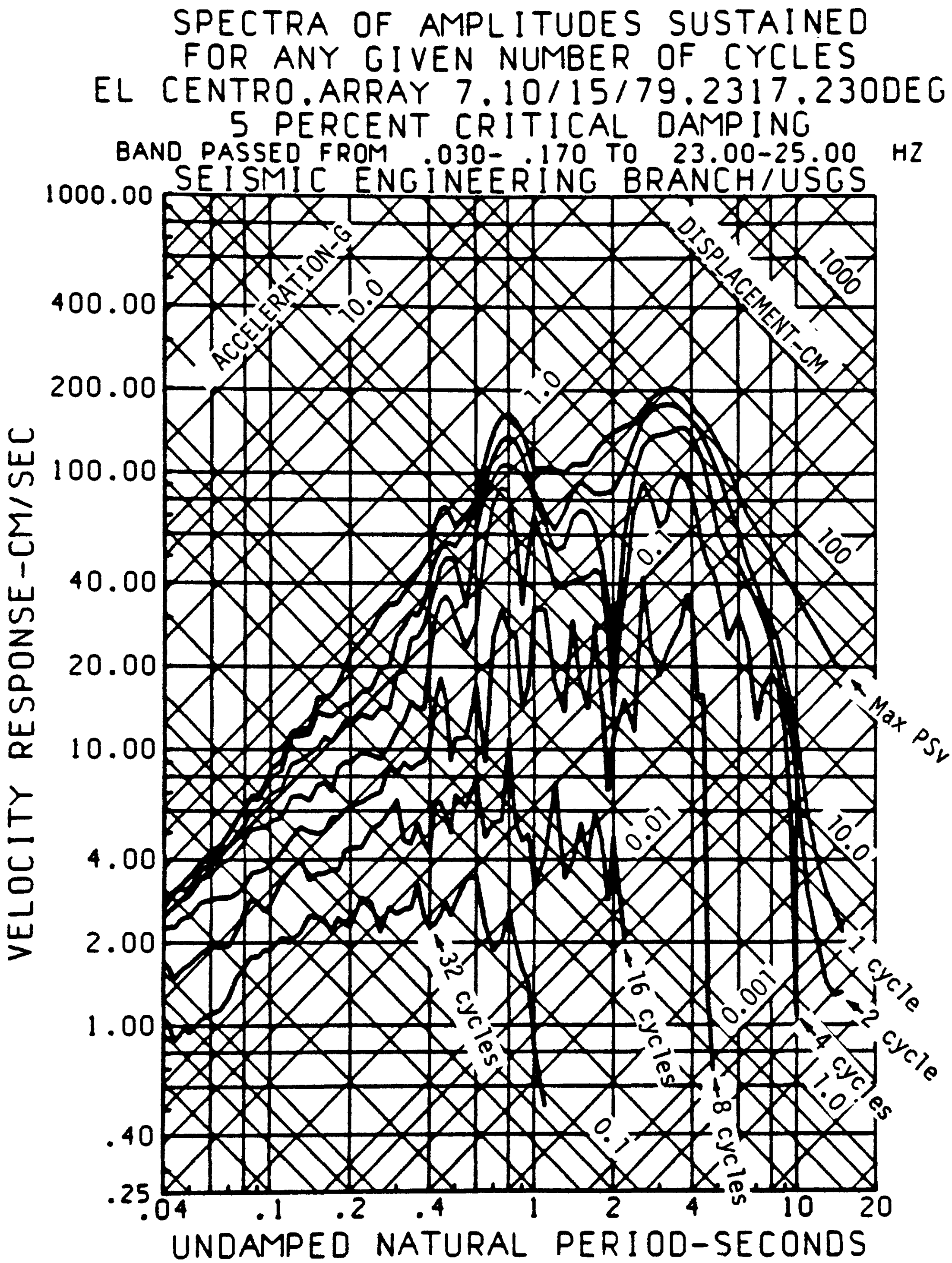


Figure 2--Amplitudes sustained for 1, 2, 4, 8, 16, and 32 cycles, El Centro, Array station 7, 10/15/79, 230 degrees.

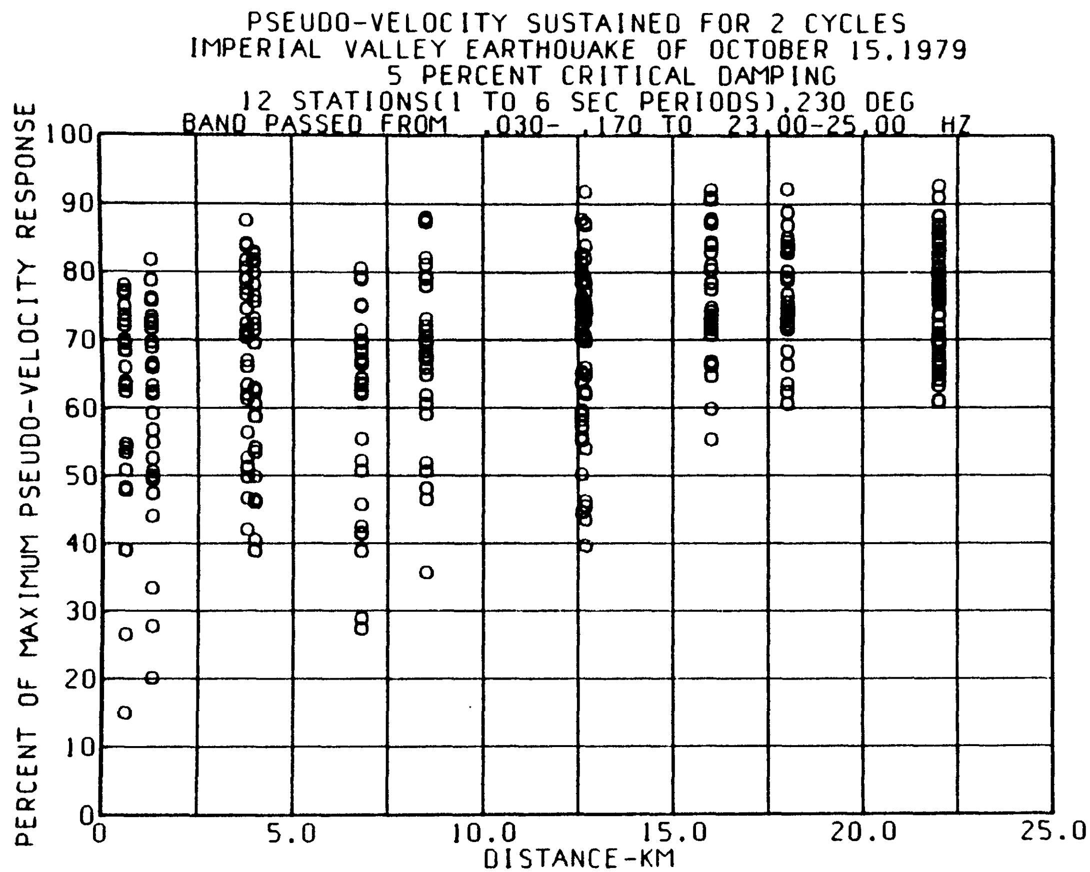


Figure 3--Pseudo-velocity amplitudes sustained for 2 cycles (expressed as percentages of maximum pseudo-velocity) for El Centro Array, 12 stations, 230 degrees direction.

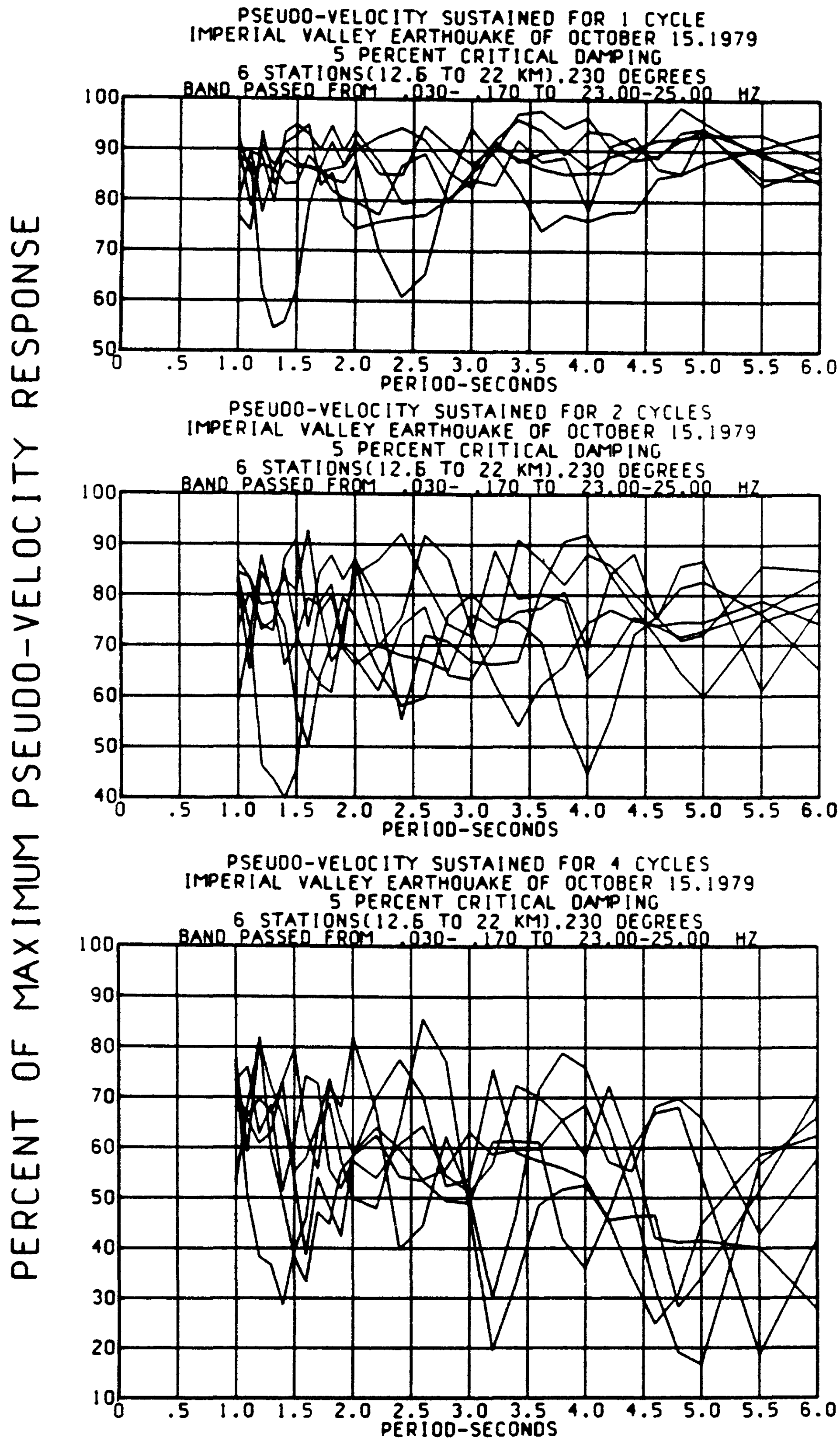


Figure 4--PSvAc for 1 cycle(top), 2 cycles(middle), and 4 cycles (bottom) expressed as percentages of PSv for El Centro Array, stations 1,2,3,11,12 and 13, 230 degrees direction, 1 to 6 second period range.

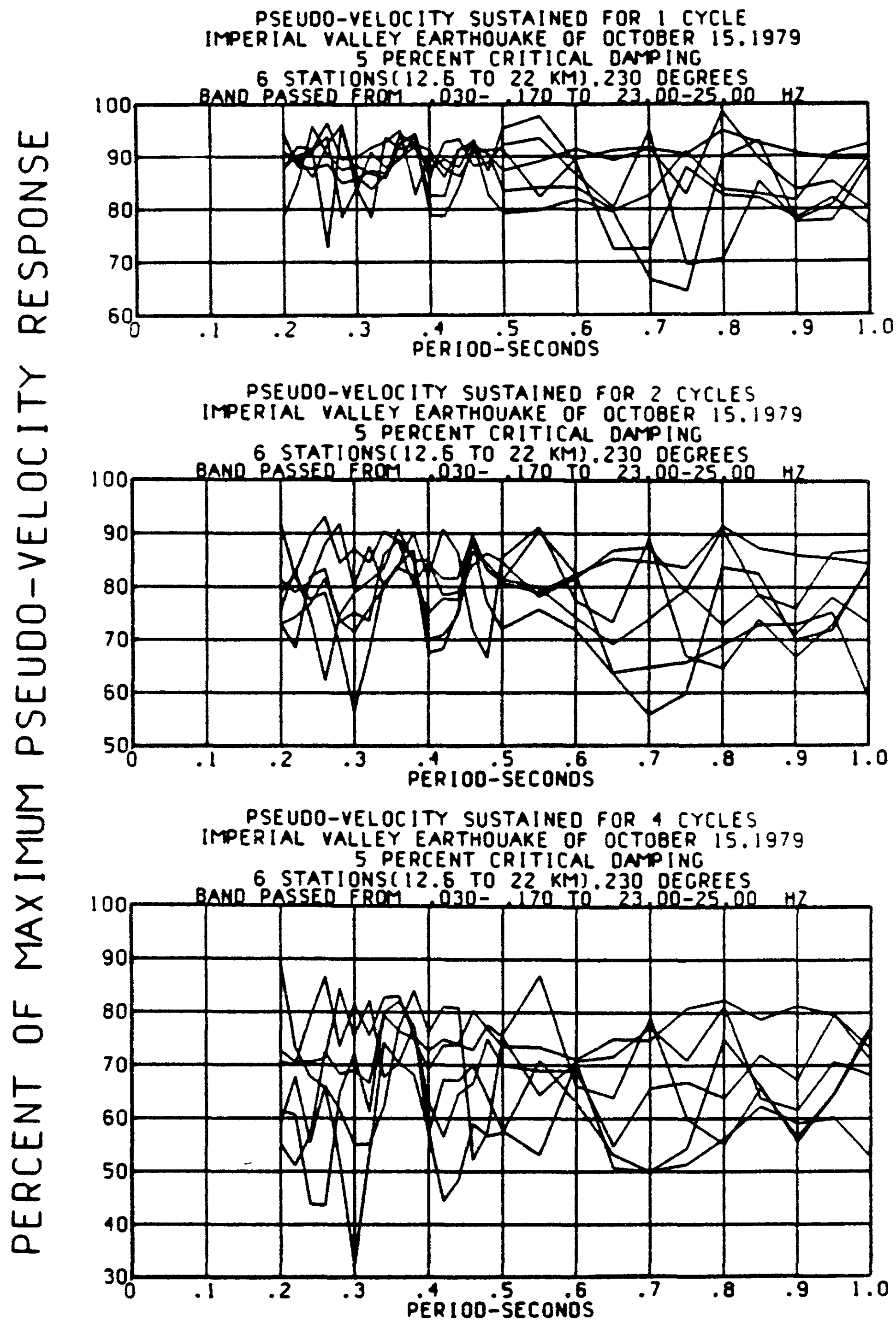
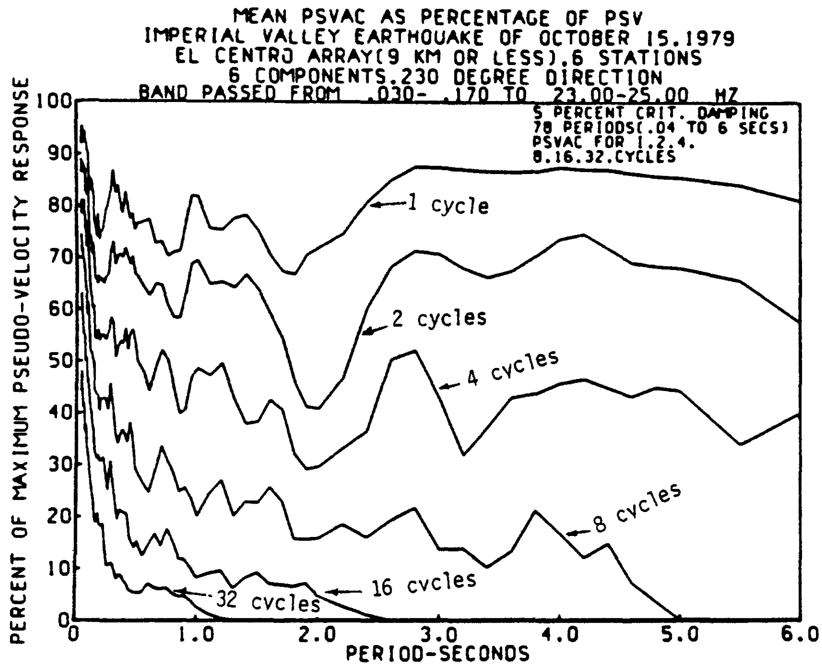
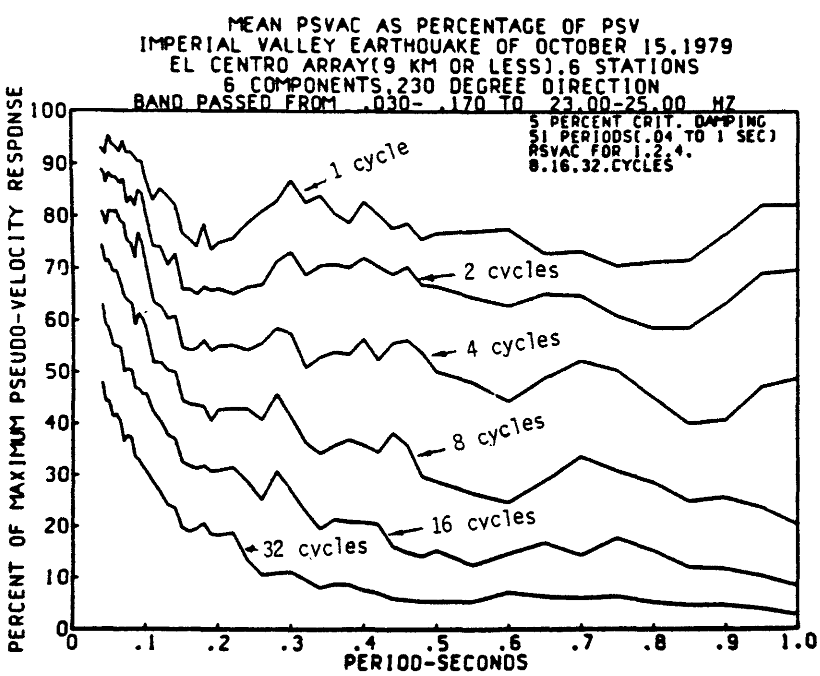


Figure 5-- PSvAc for 1 cycle(top), 2 cycles(middle), and 4 cycles (bottom) expressed as percentages of PSv for El Centro Array stations 1,2,3,11,12 and 13, 230 degrees direction, 1 to 6 second period range.





Figue 6-- Mean PSvAc for El Centro Array, stations 4,5,6,7,8 and 10 230 degrees direction.

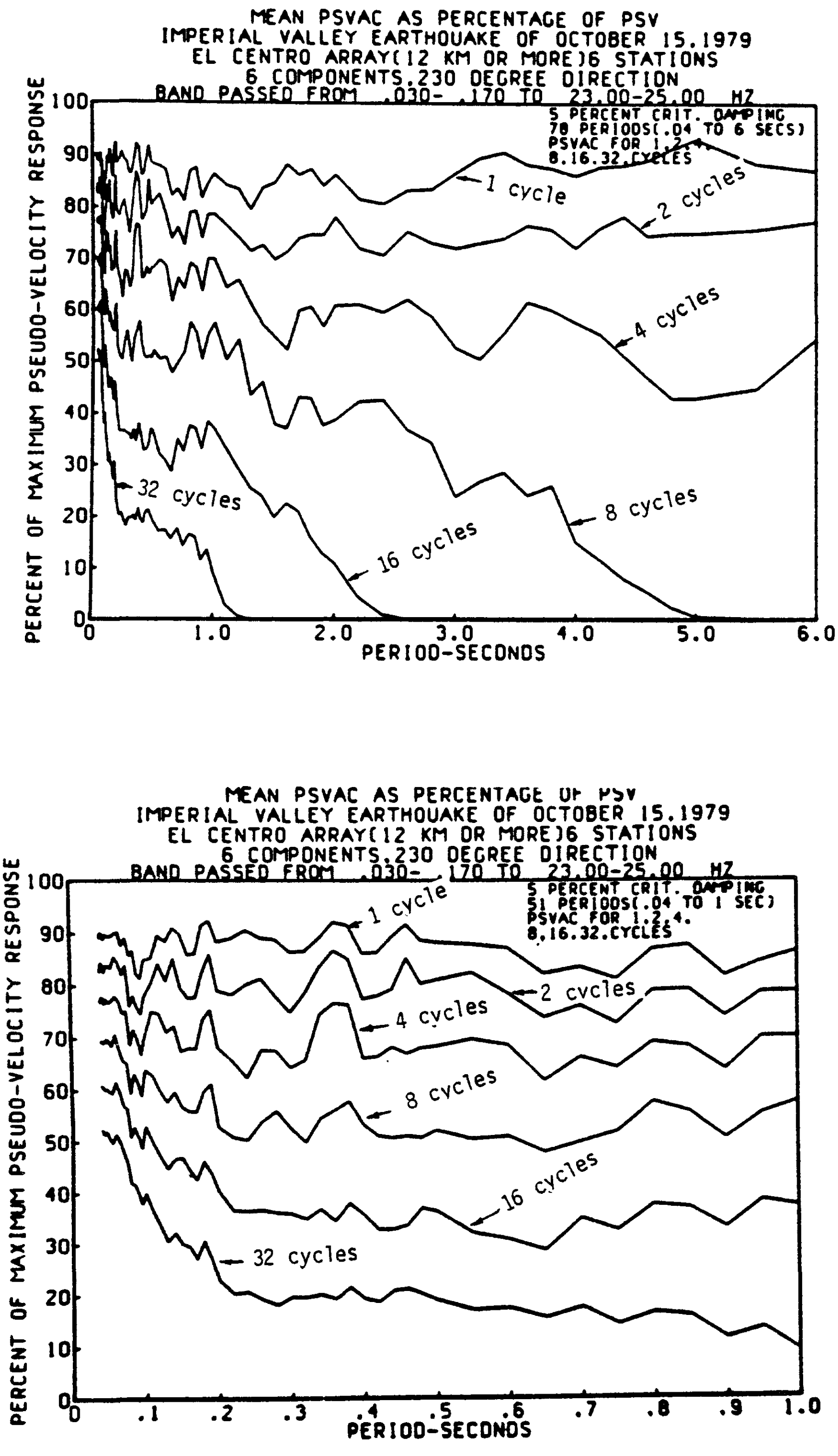
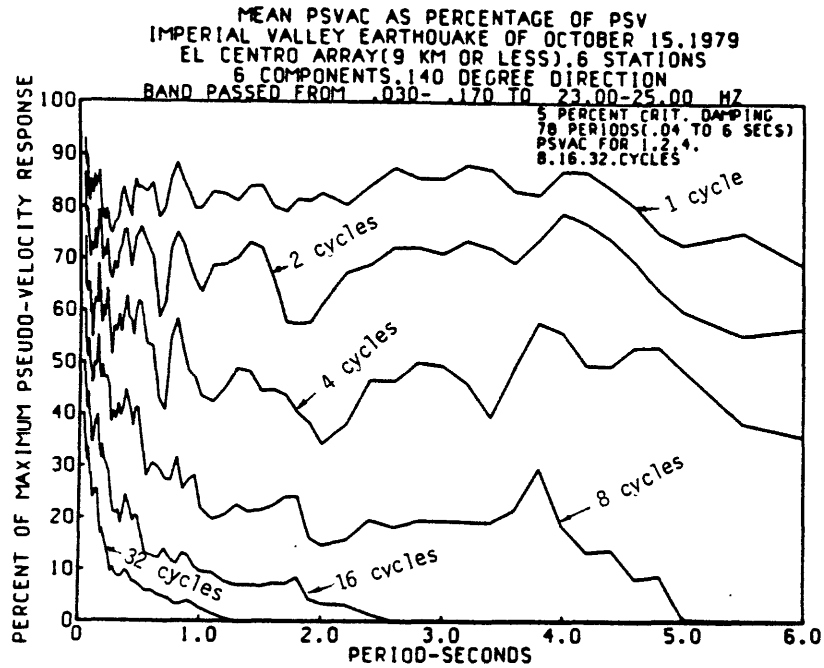


Figure 7-- Mean PSvAc for El Centro Array, stations 1,2,3,11,12 and 13, 230 degrees direction.



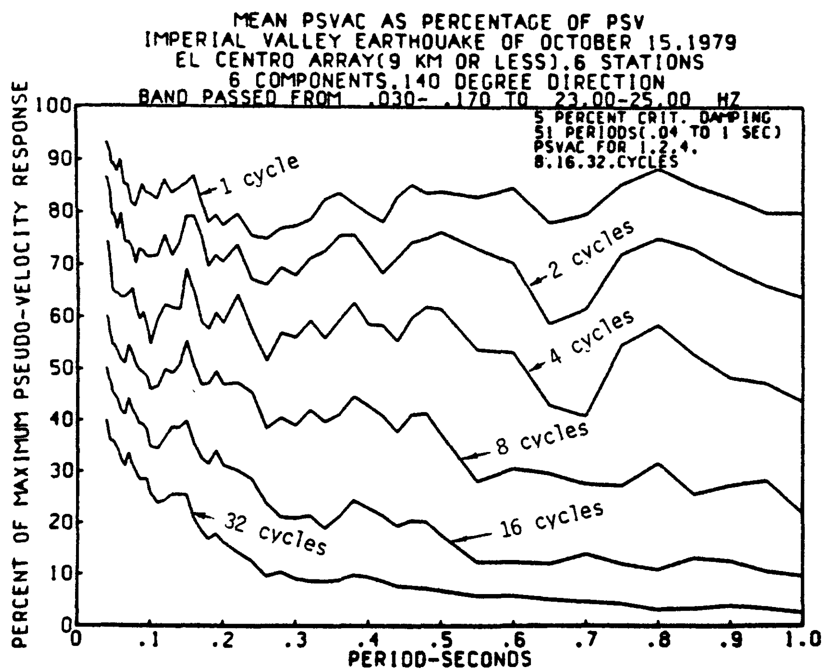
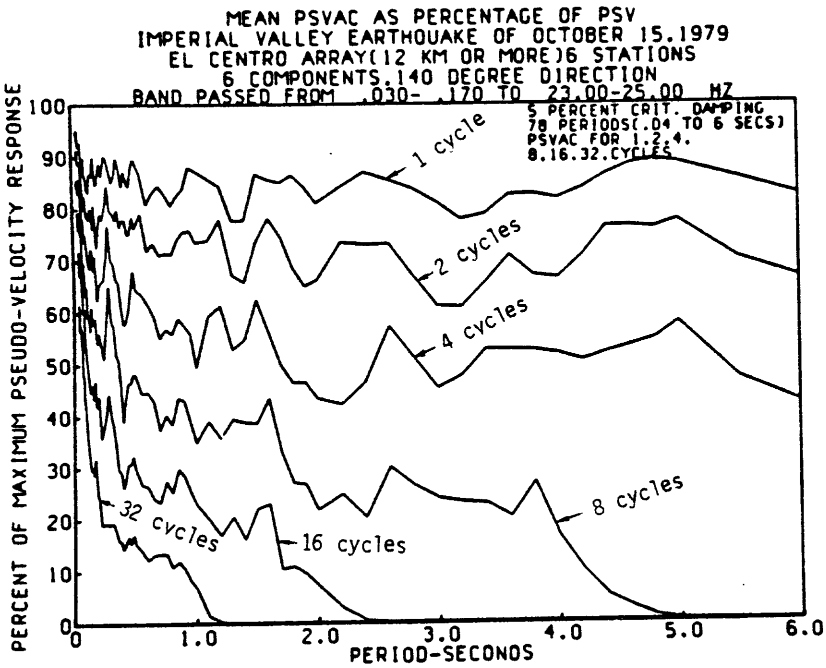


Figure 8-- Mean PSvAc for El Centro Array, stations 4,5,6,7,8 and 10, 140 degrees direction.



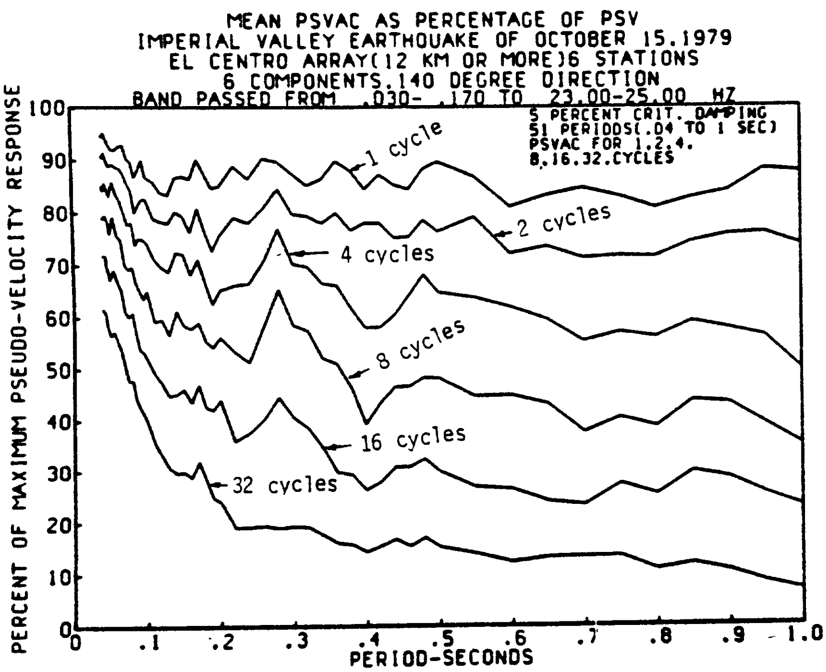
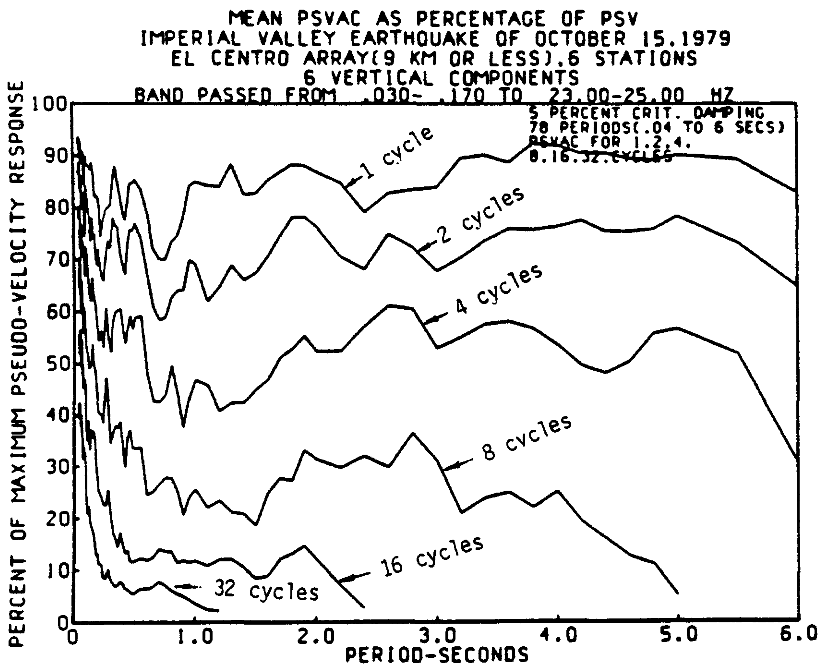


Figure 9-- Mean PSvAc for El Centro Array, stations 1,2,3,11,12 and 13, 140 degrees direction.



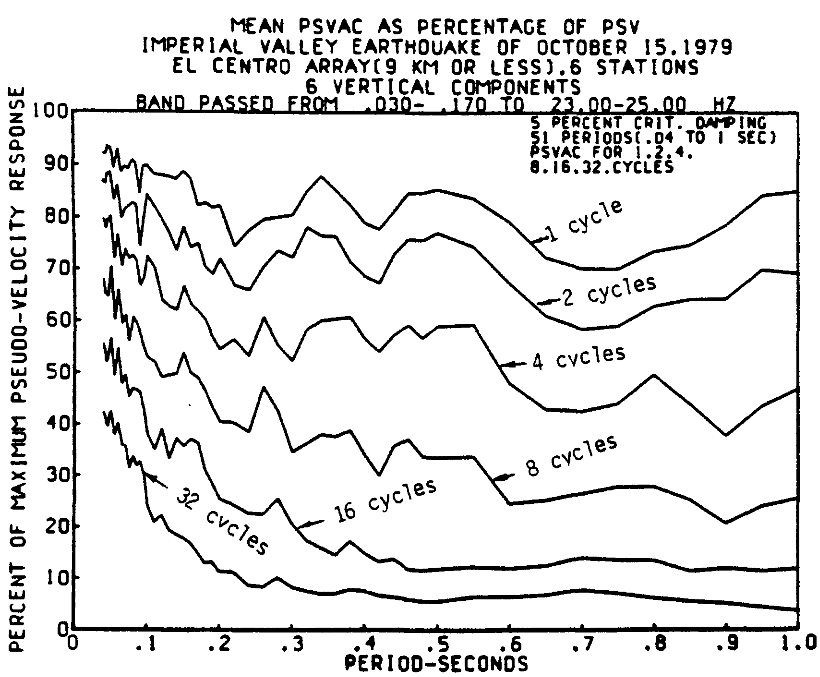
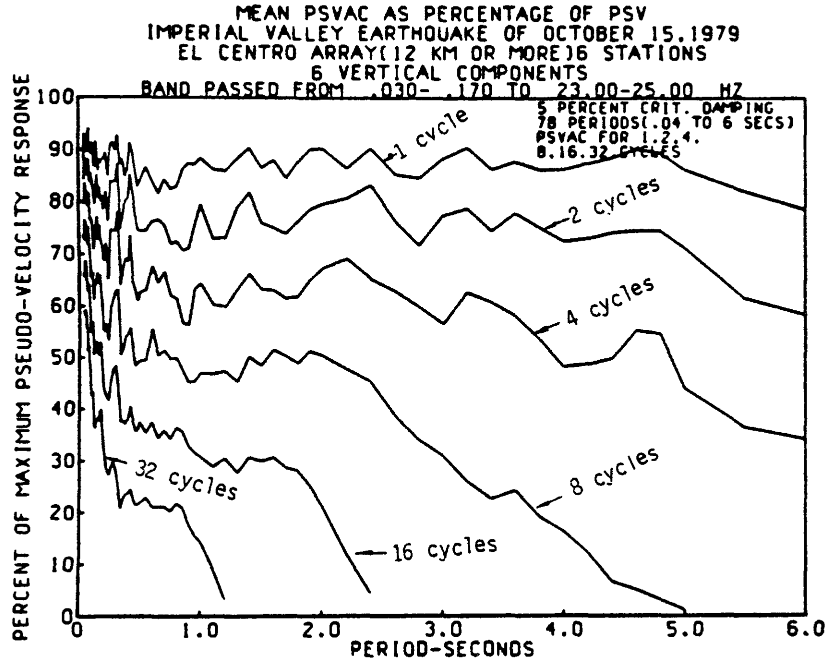


Figure 10--Mean PSvAc for El Centro Array, stations 4,5,6,7,8 and 10, vertical direction.



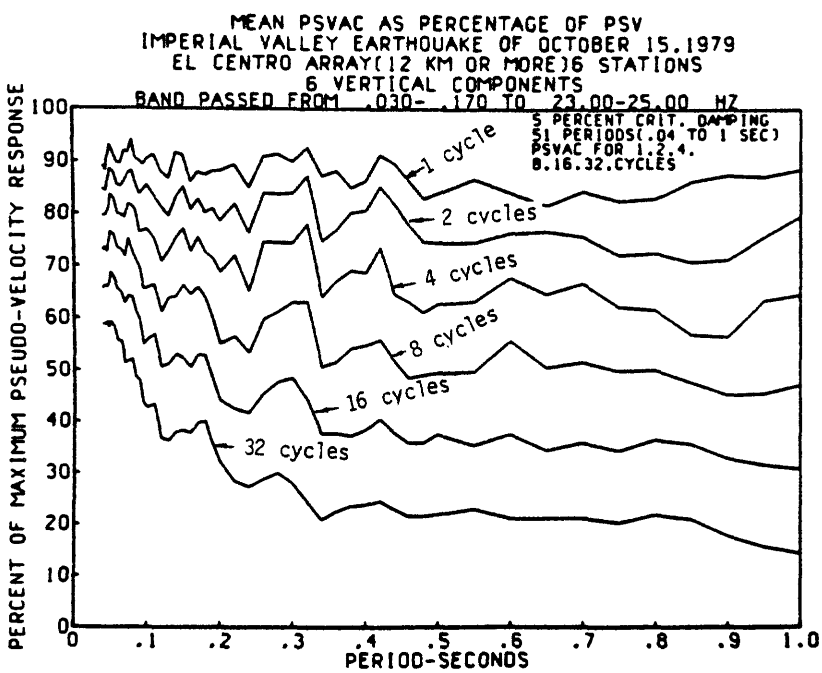


Figure 11--Mean PSvAc for El Centro Array, stations 1,2,3,11,12 and 13, vertical direction.

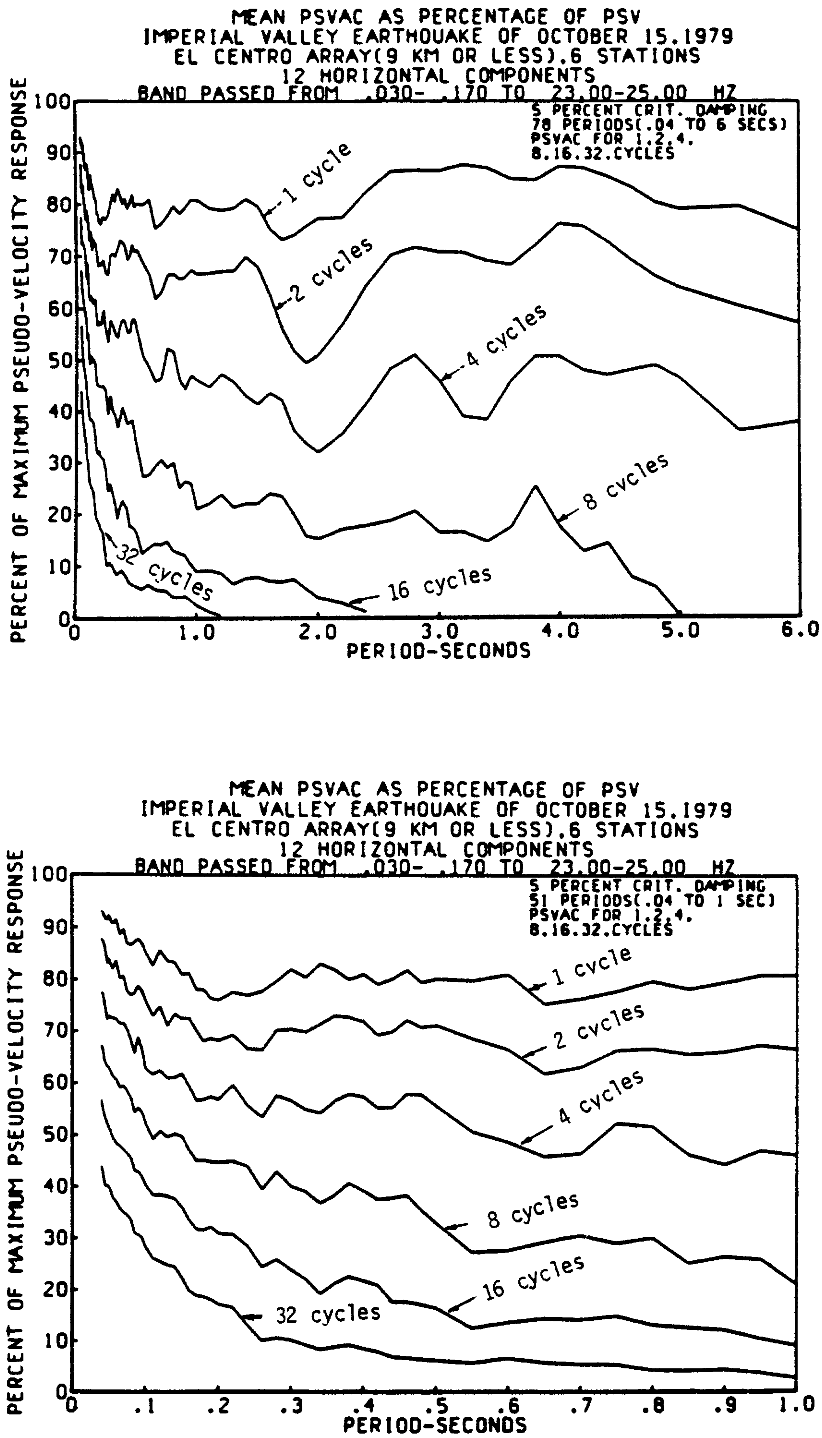
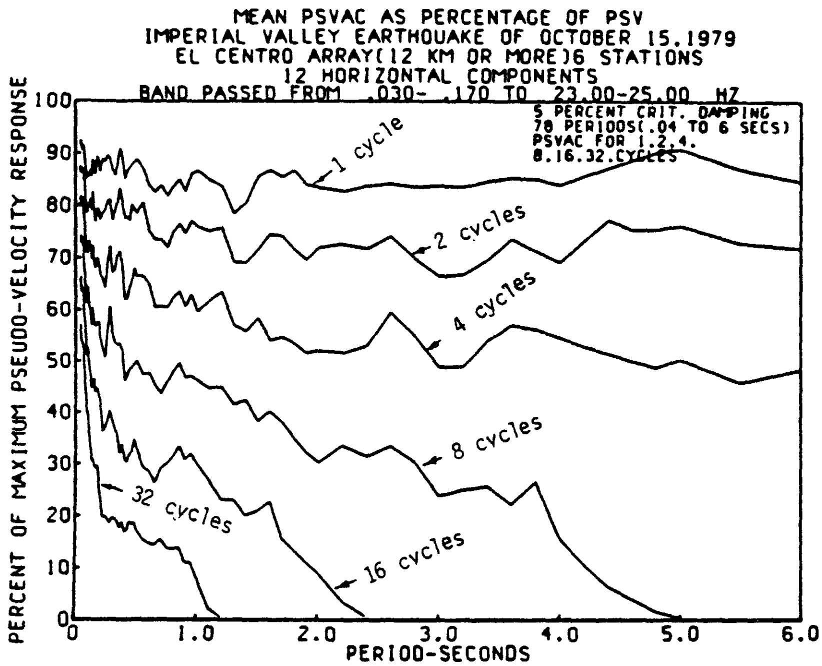


Figure 12--Mean PSvAc for El Centro Array, stations 4,5,6,7,8 and 10, 230 and 140 degrees directions.



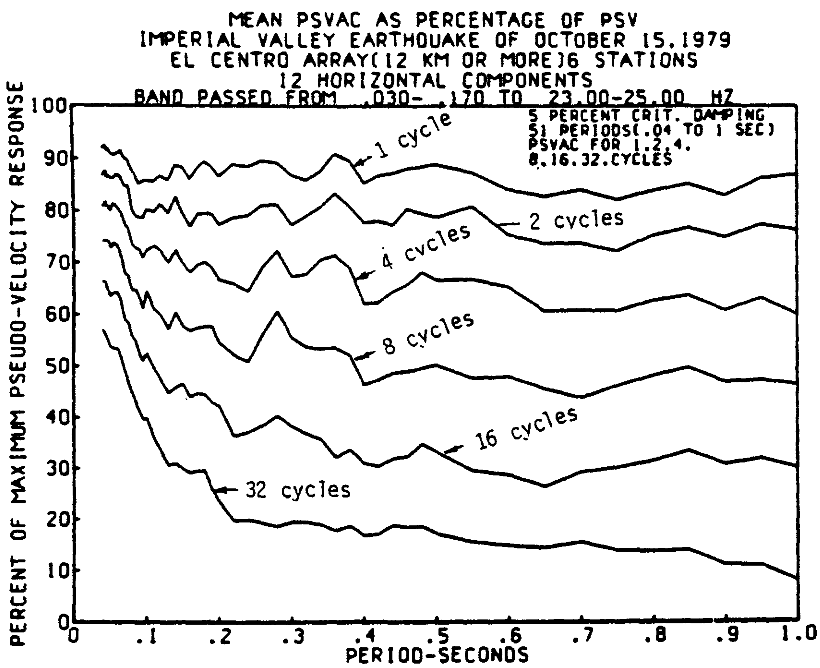


Figure 13--Mean PSvAc for El Centro Array, stations 1,2,3,11,12 and 13, 230 and 140 degrees directions.

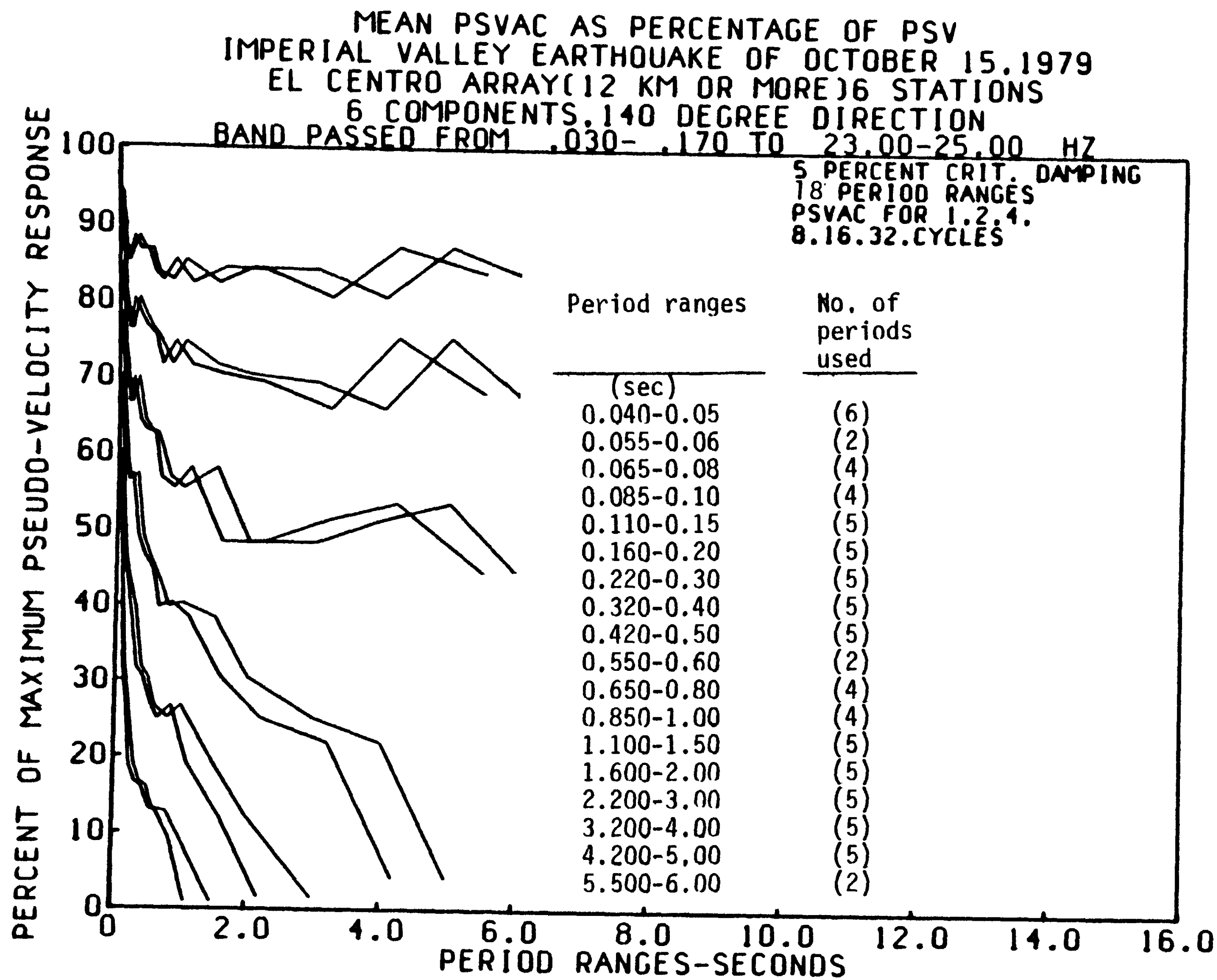
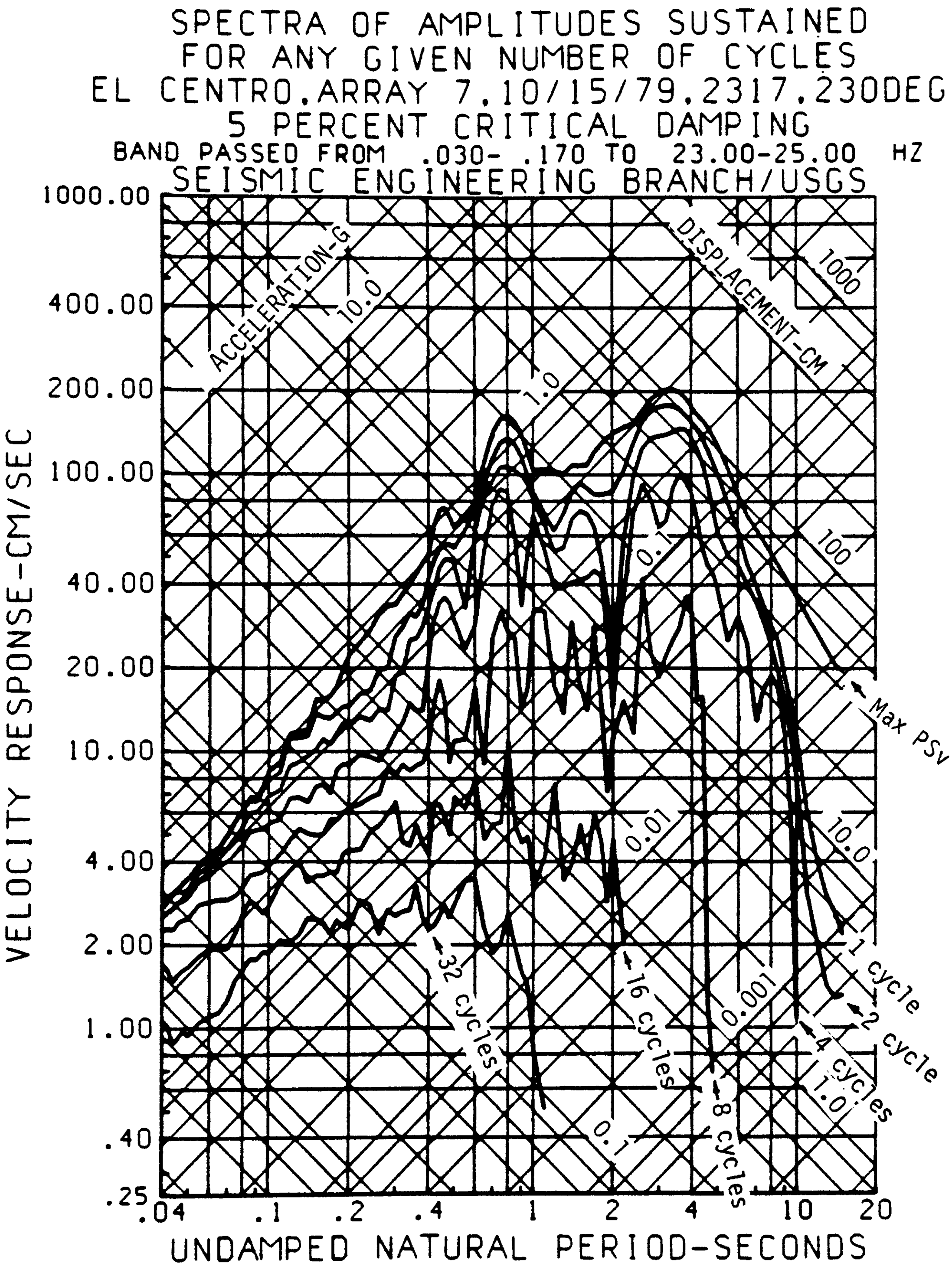


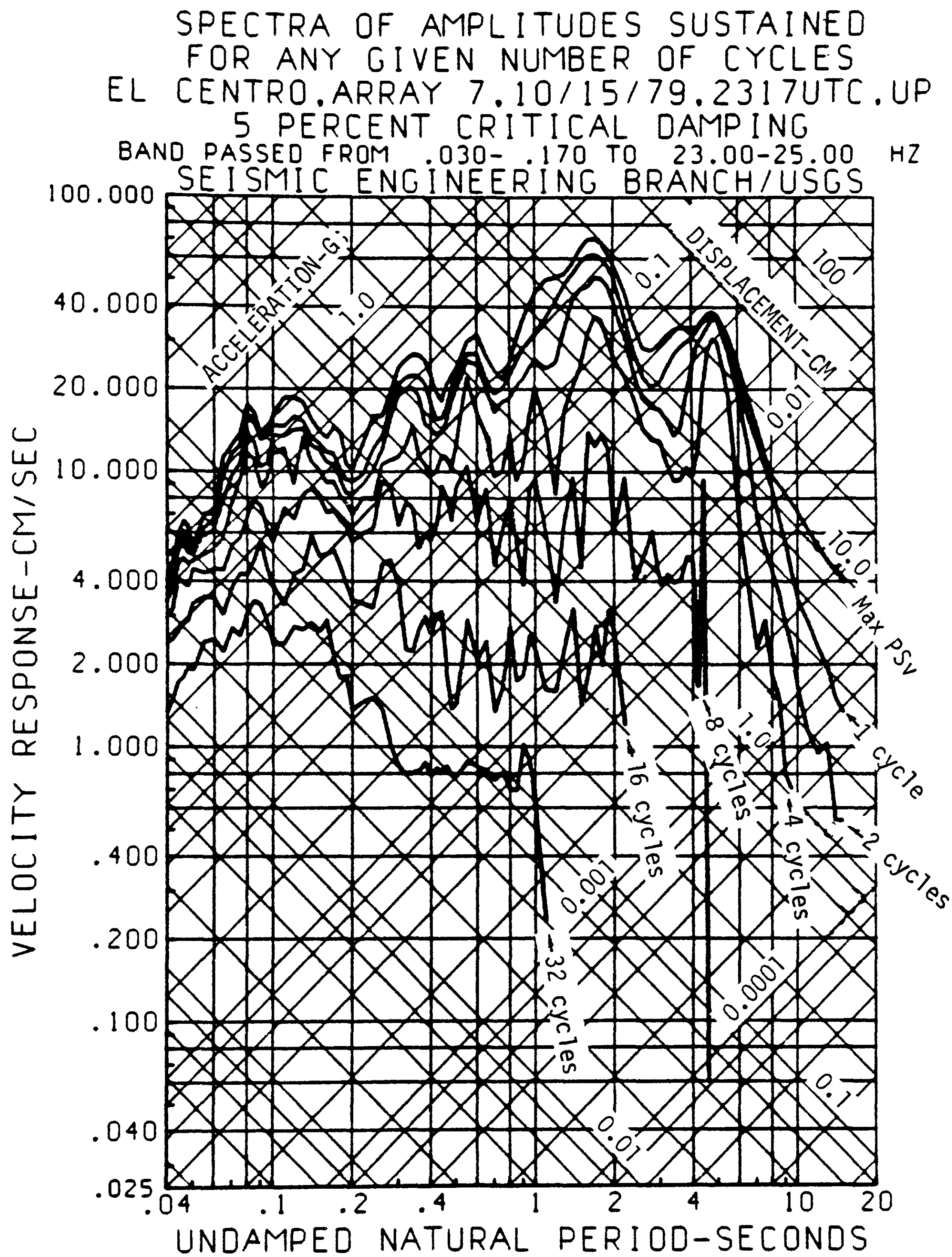
Figure 14--Mean PSvAc for various period ranges, El Centro Array, stations 1,2,3,11,12 and 13, 140 degrees direction.

Appendix

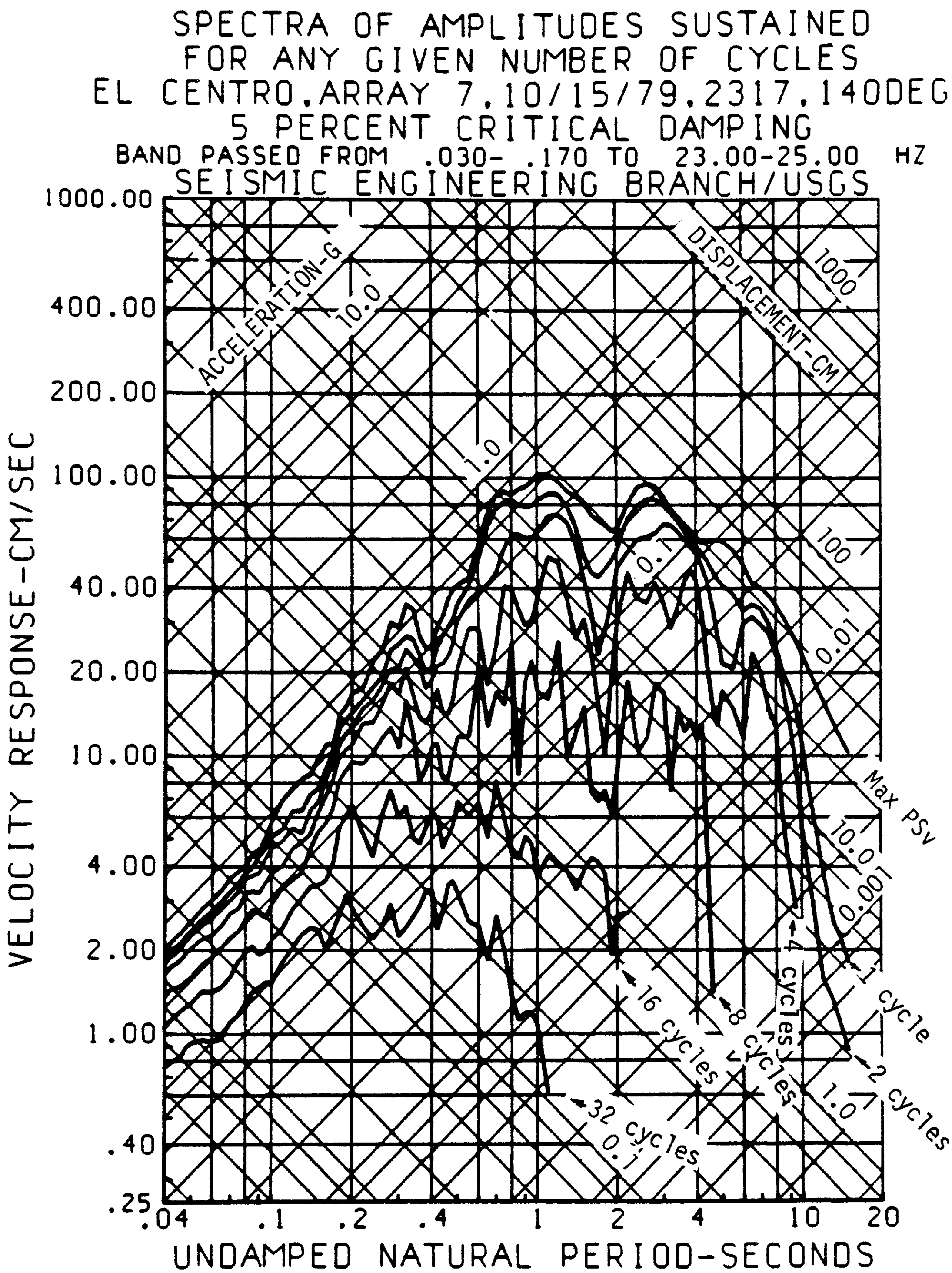
Plots:

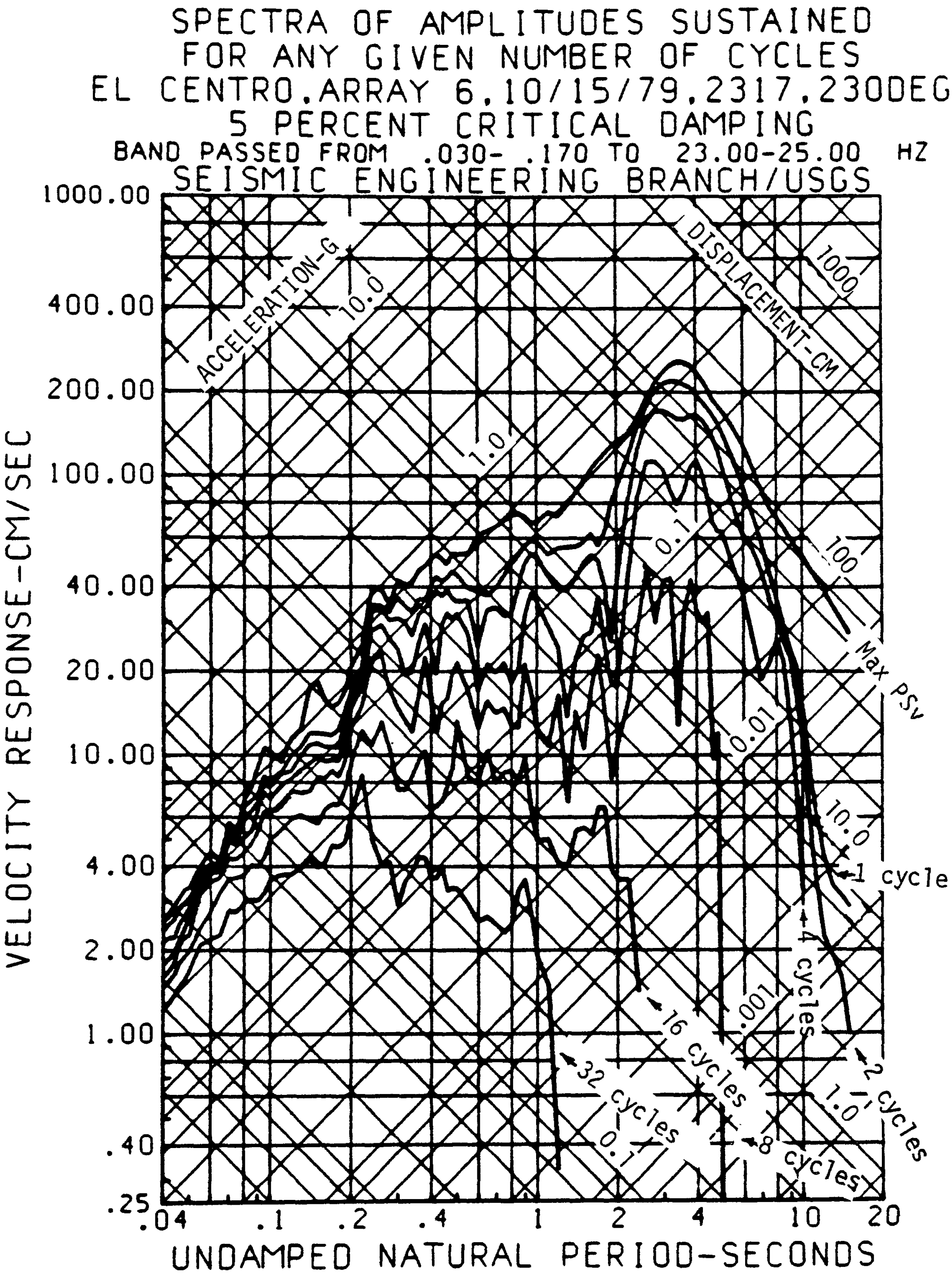
Response amplitudes sustained for a given number of cycles. The top curve represents the maximum pseudo-velocity response, the lower six curves represent the response amplitude sustained for 1,2,4,8,16 and 32 cycles. All plots were generated using 5 percent critical damping.

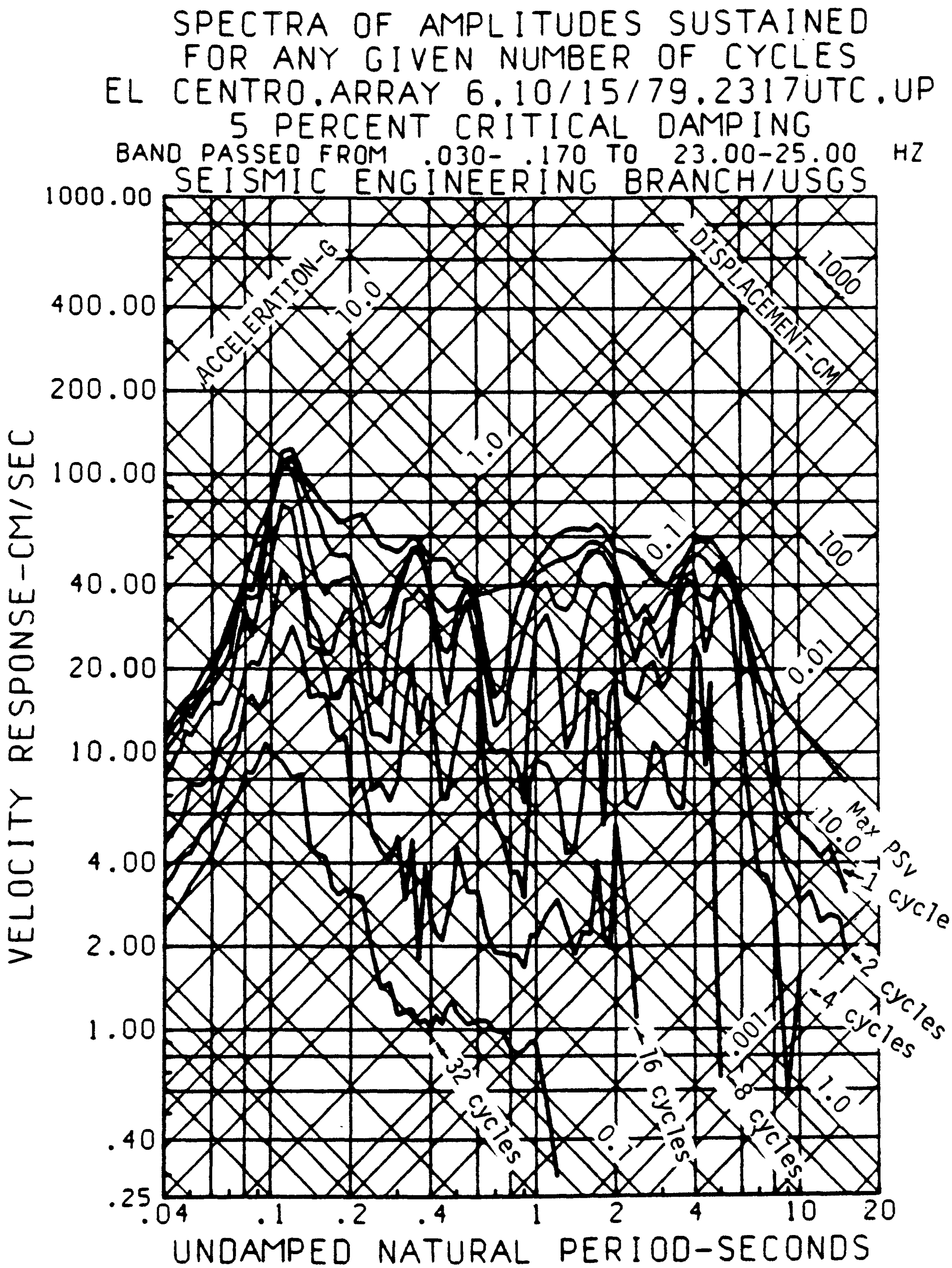

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 7,10/15/79,2317,230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycle
4 cycles
8 cycles
16 cycles
32 cycles
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.40
.25
.04
.1
.2
.4
1
2
4
10
20

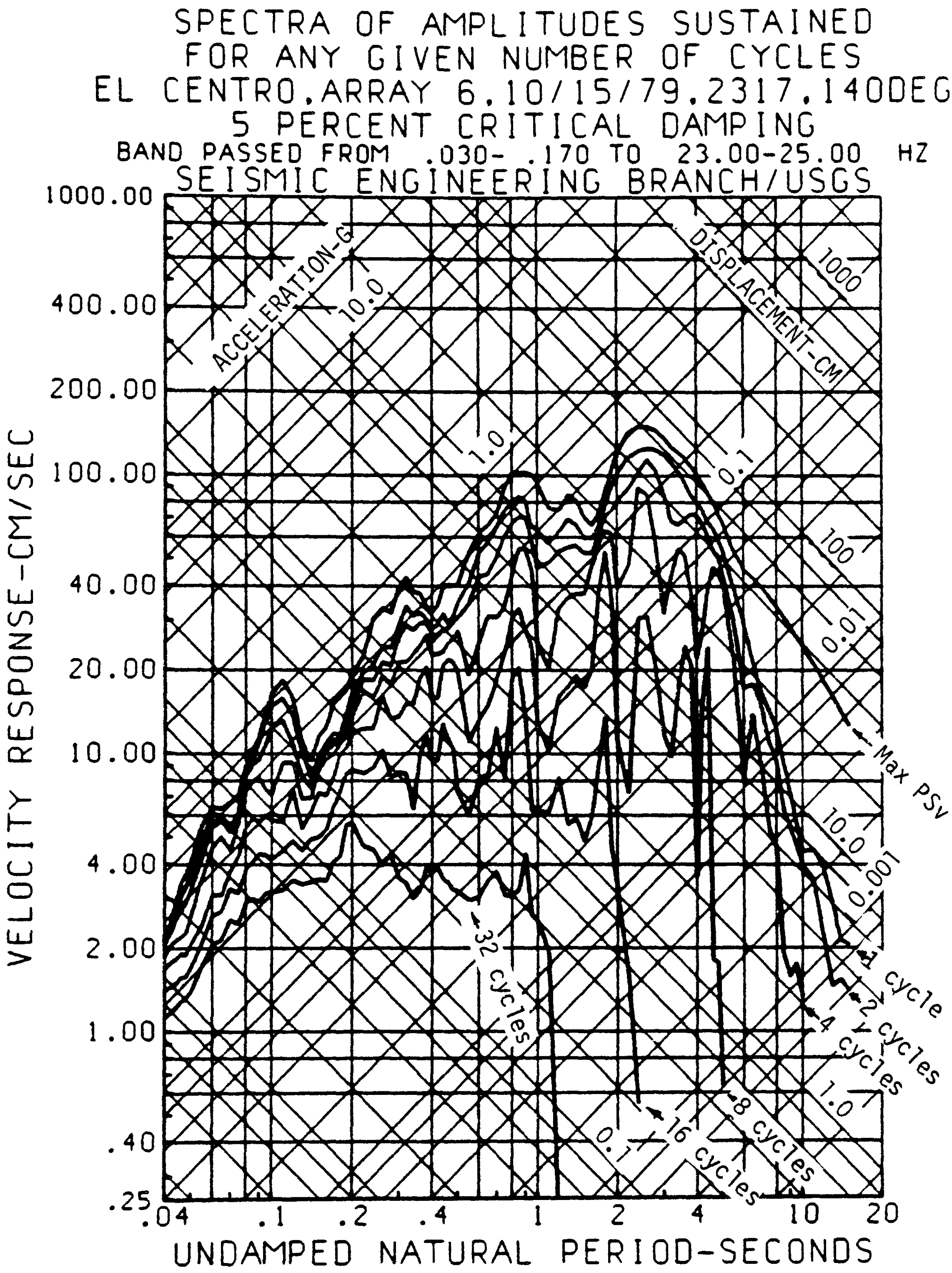


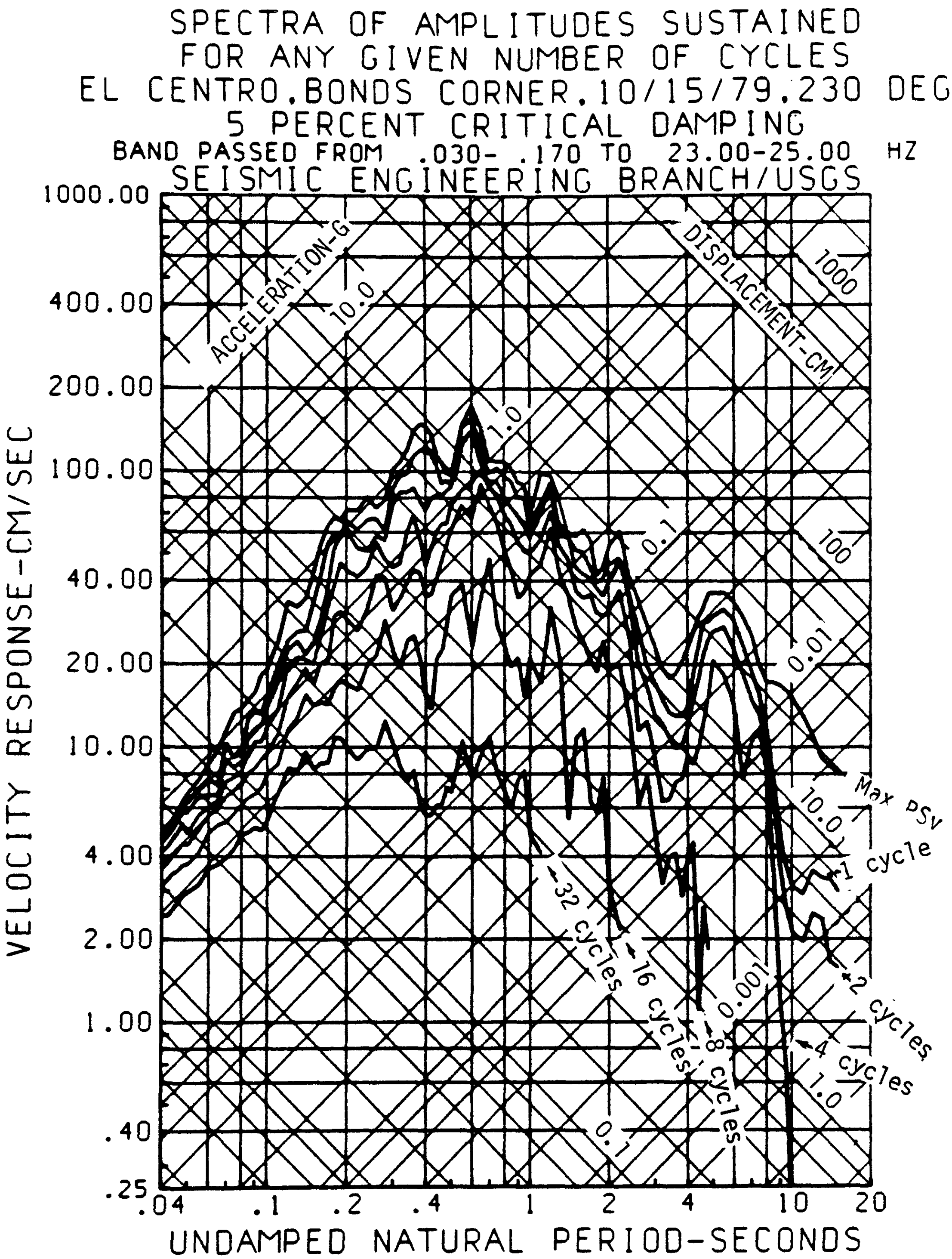
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 7,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 7,10/15/79,2317,140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.40
.25
.04
.1
.2
.4
1
2
4
10
20

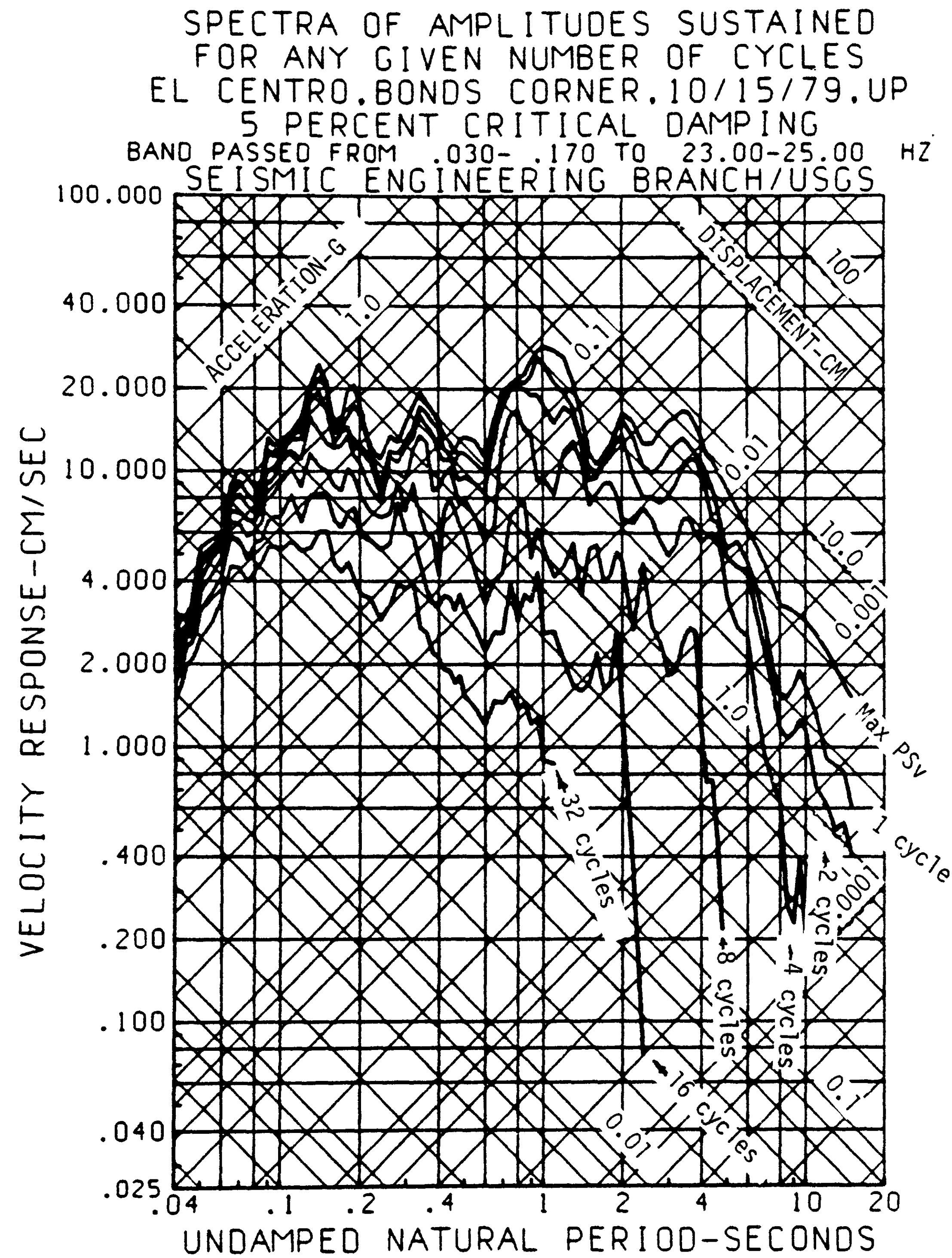

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 6,10/15/79,2317,230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.40
.25
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
10.0
1.0
0.1
0.01
.001
DISPLACEMENT-CM
1000
100
10.0
1.0
0.1
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 6,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.40
.25
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
DISPLACEMENT-CM
10.0
1.0
0.1
0.01
.001
1000
100
1.0
0.1
Max PSV
10.0
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

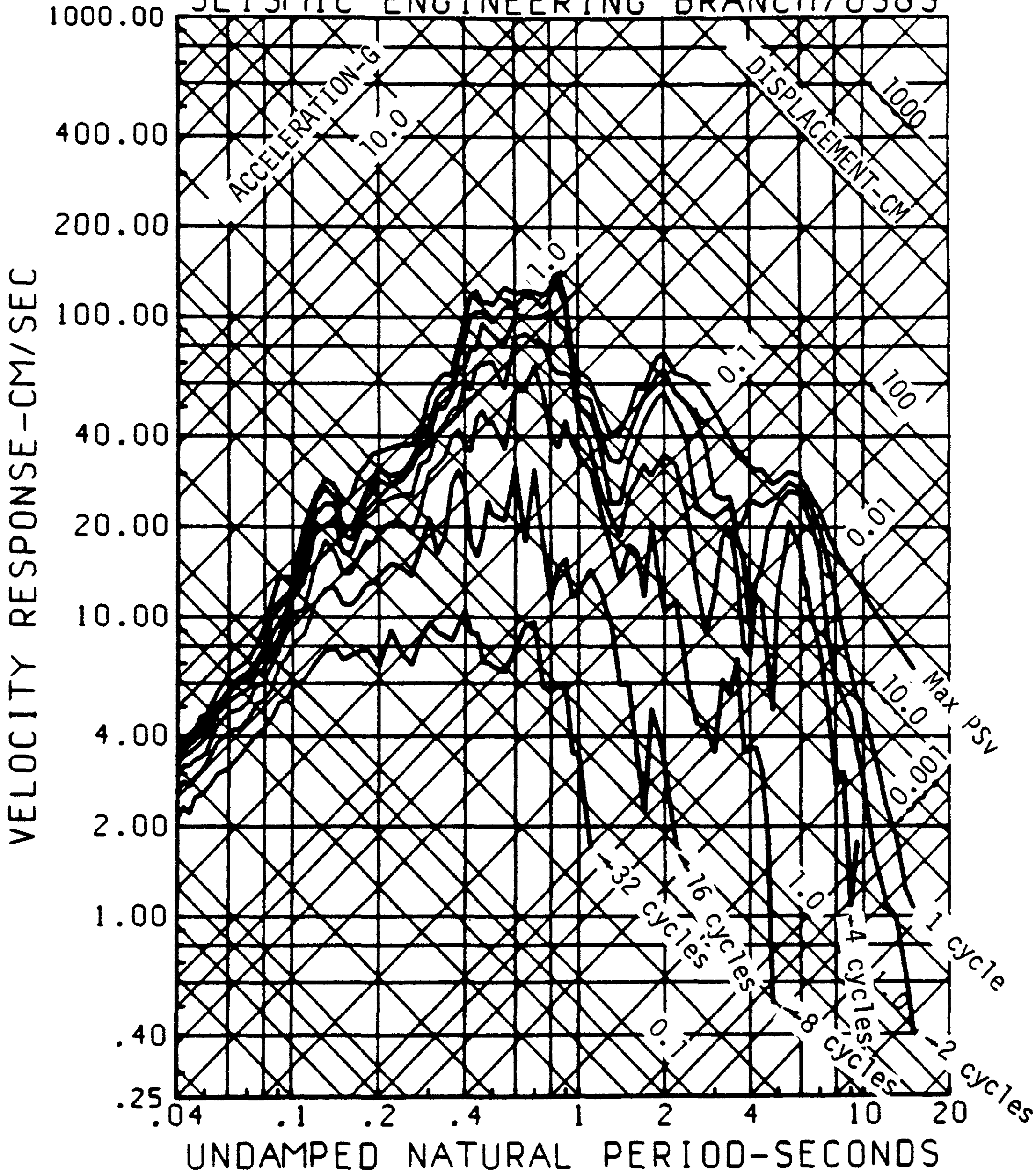

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 6,10/15/79,2317,140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

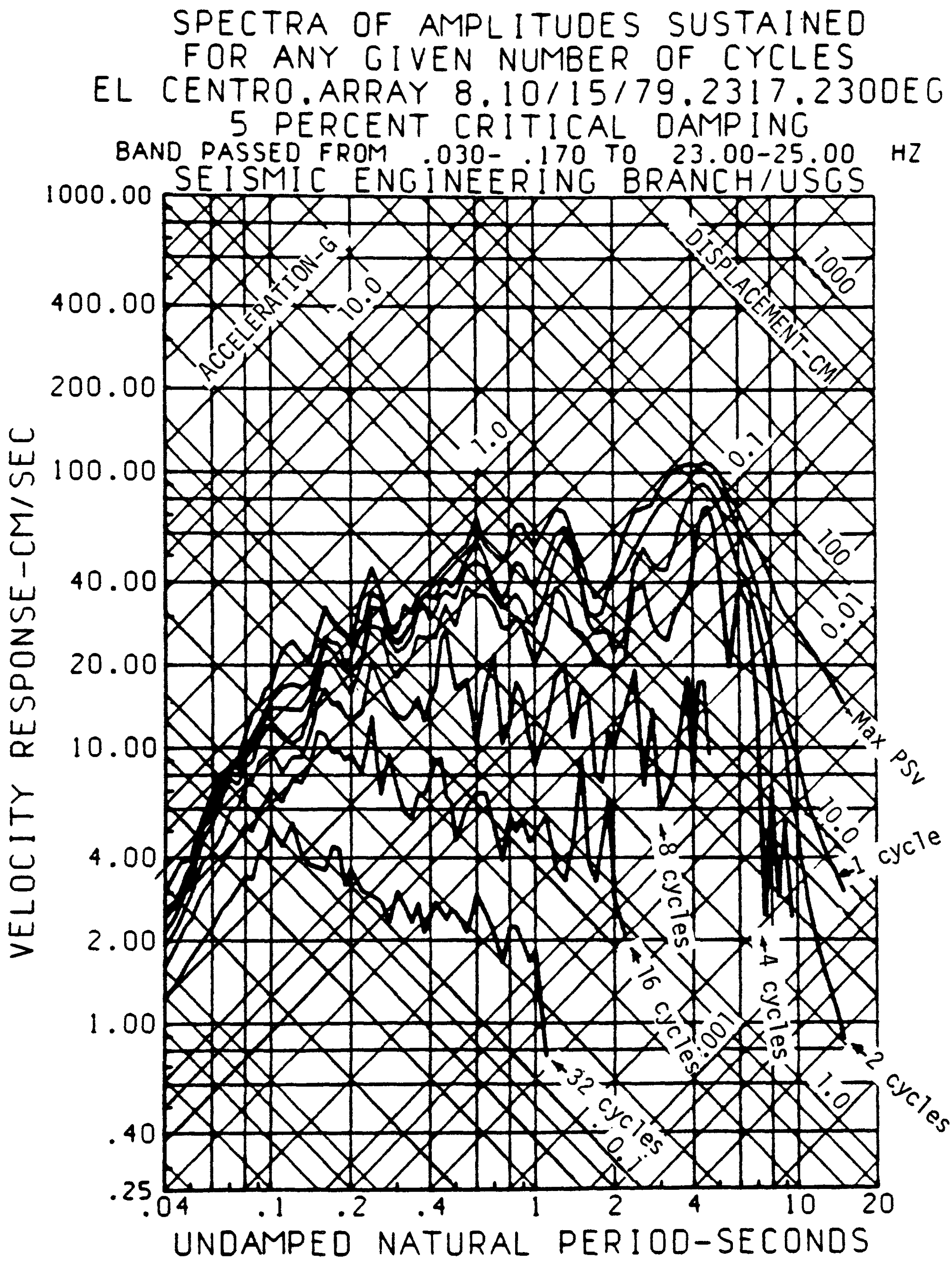


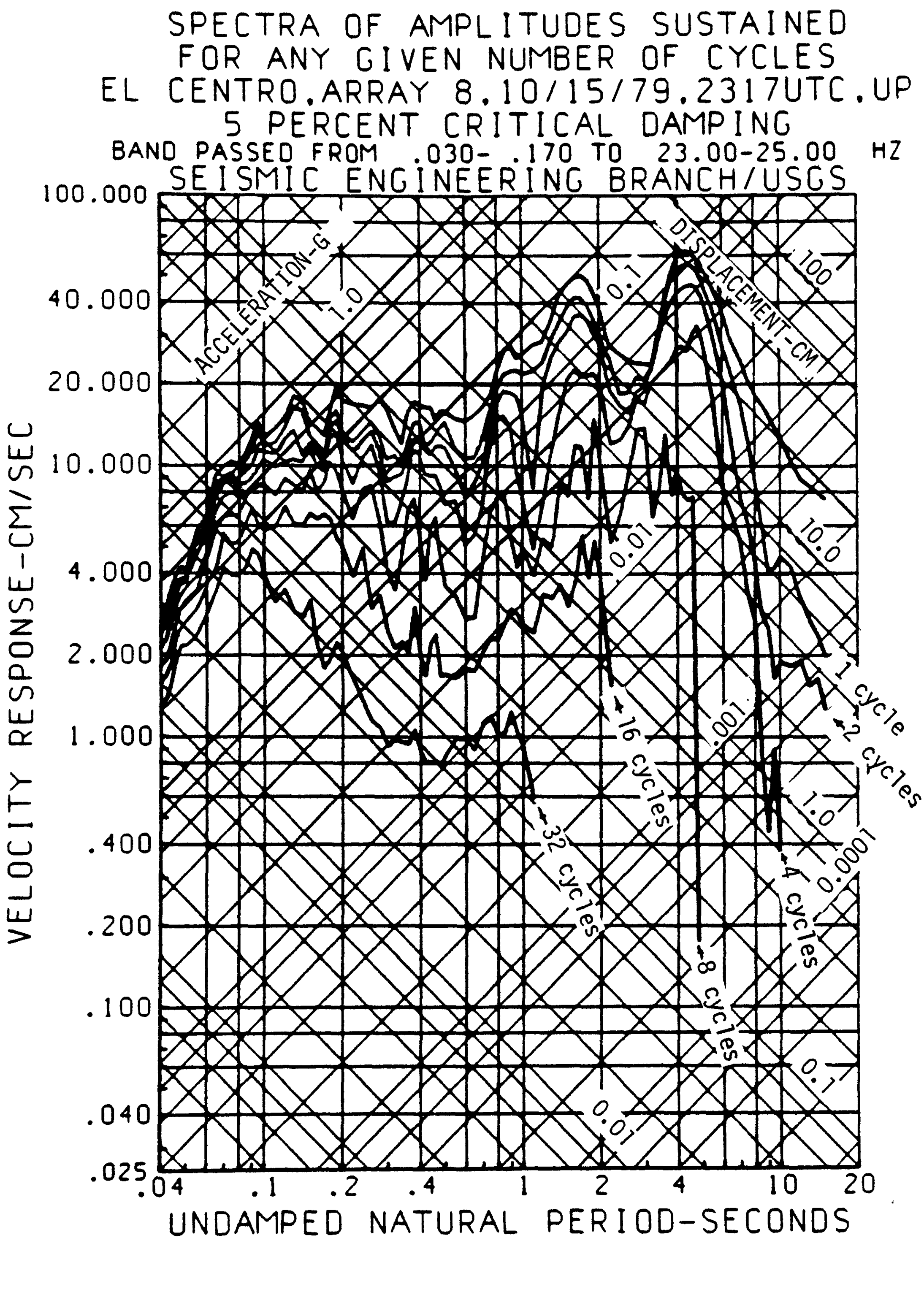
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,BONDS CORNER,10/15/79,230 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,BONDS CORNER,10/15/79,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

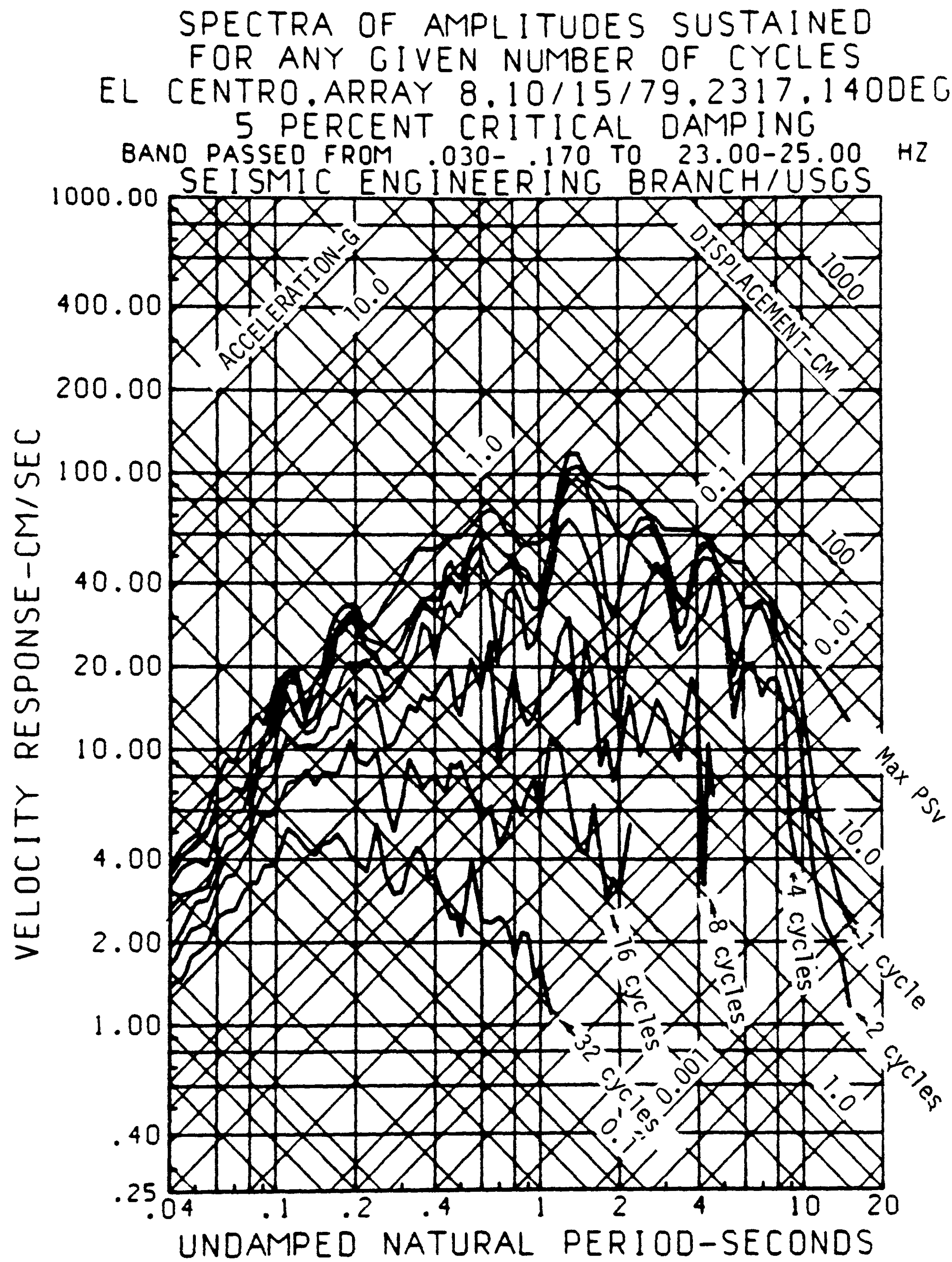
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO, BONDS CORNER, 10/15/79, 140 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

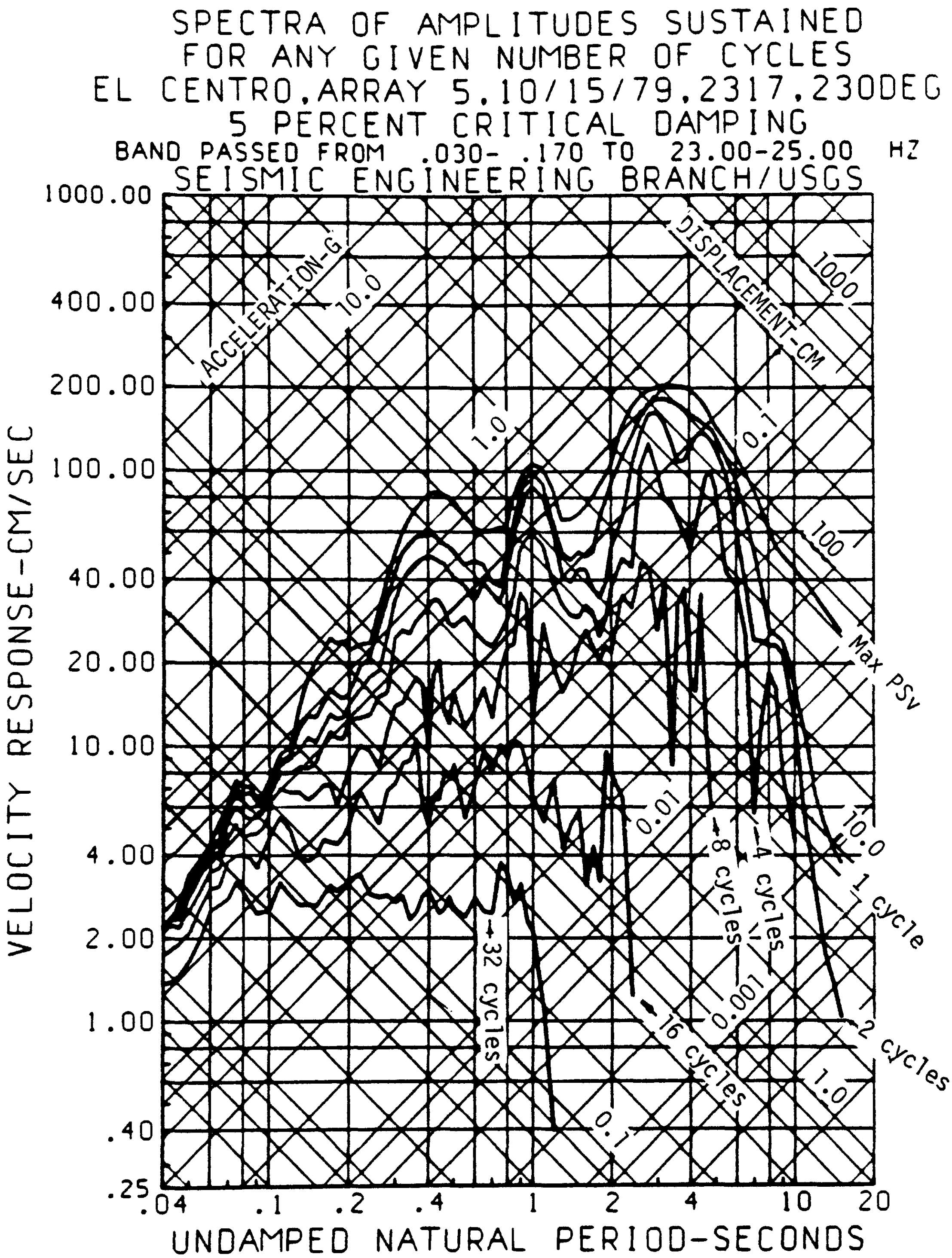



SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 8,10/15/79,2317,230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

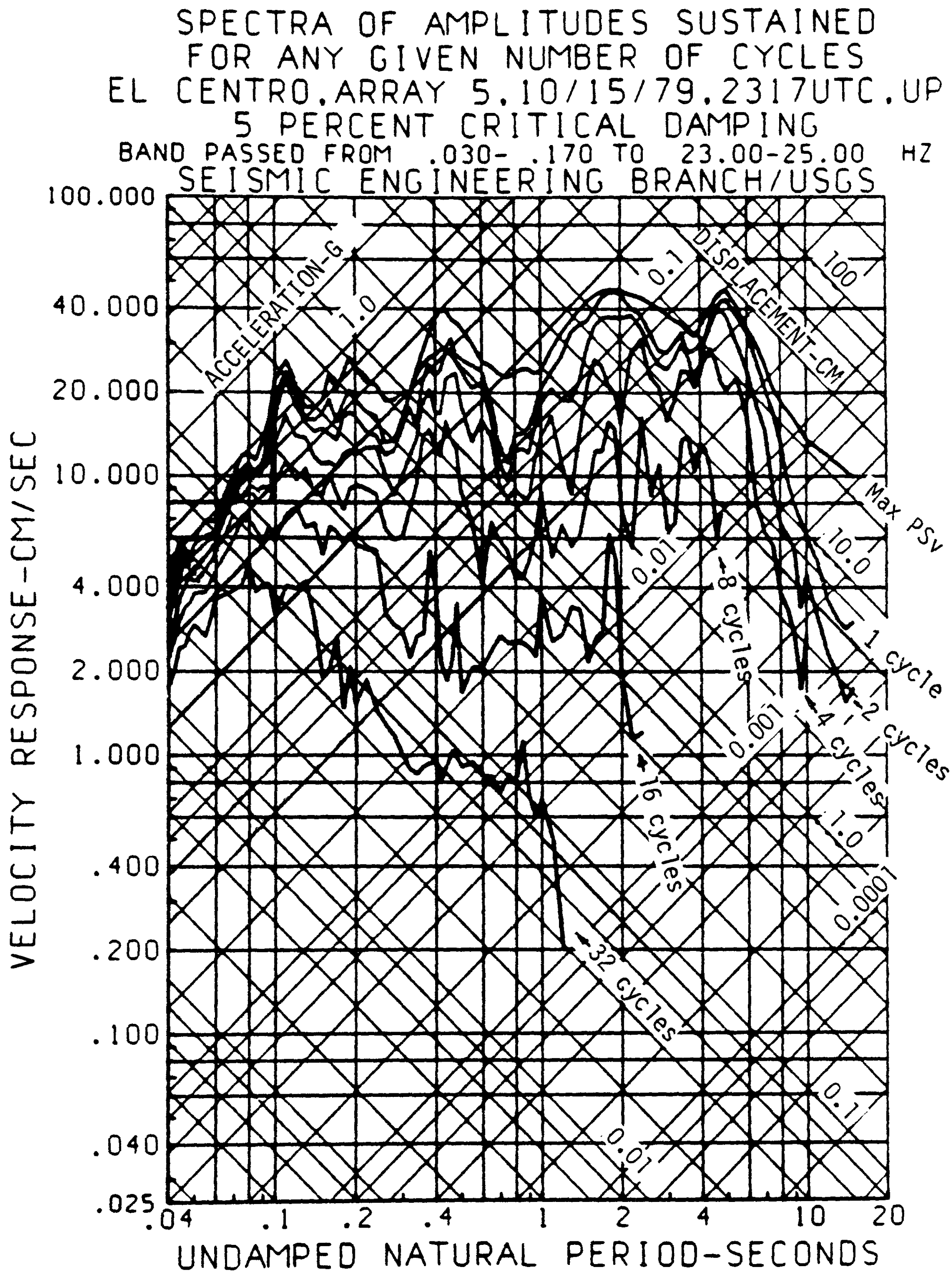


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 8,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
ACCELERATION-G
DISPLACEMENT-CM
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

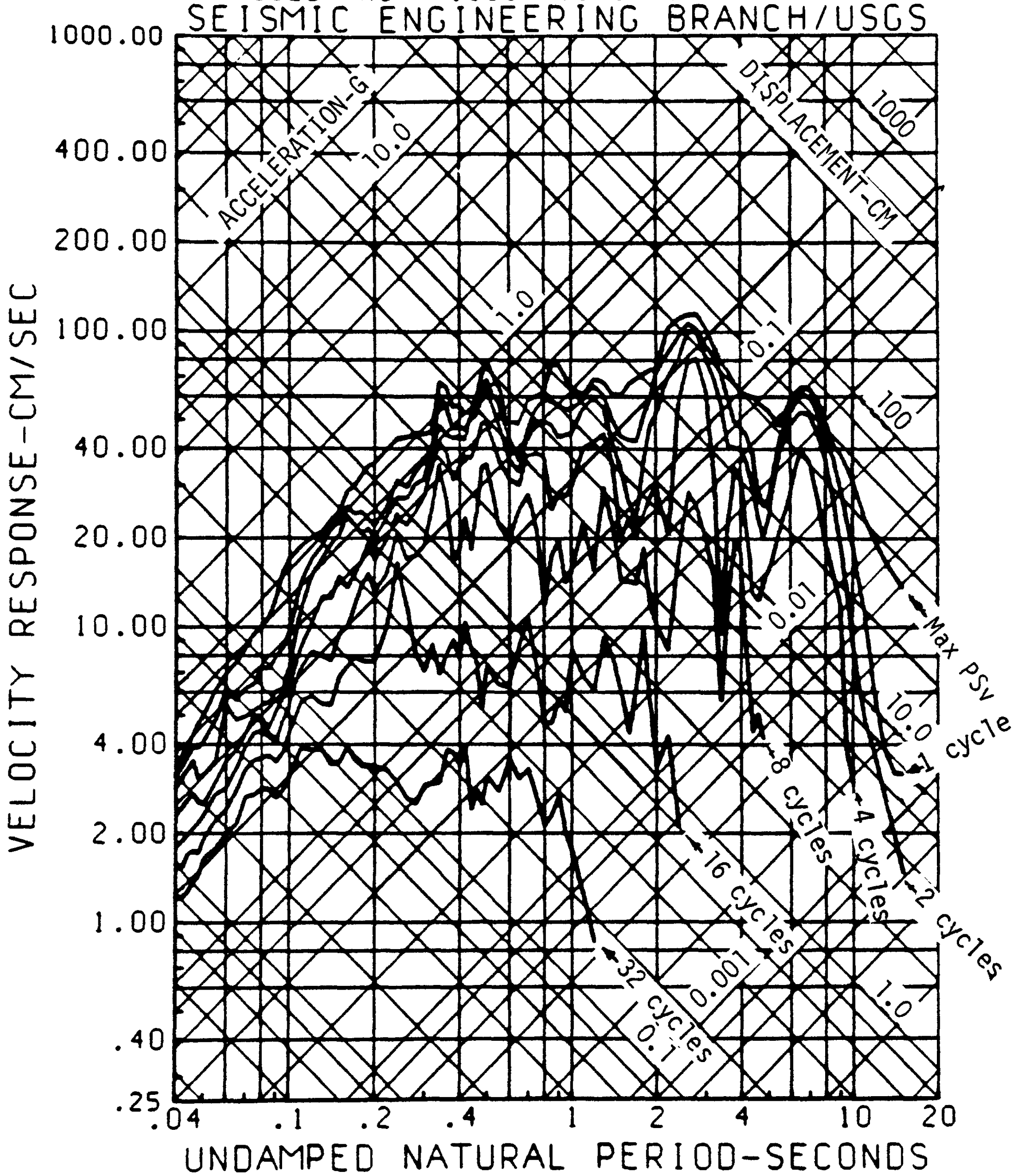

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 8,10/15/79,2317,140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

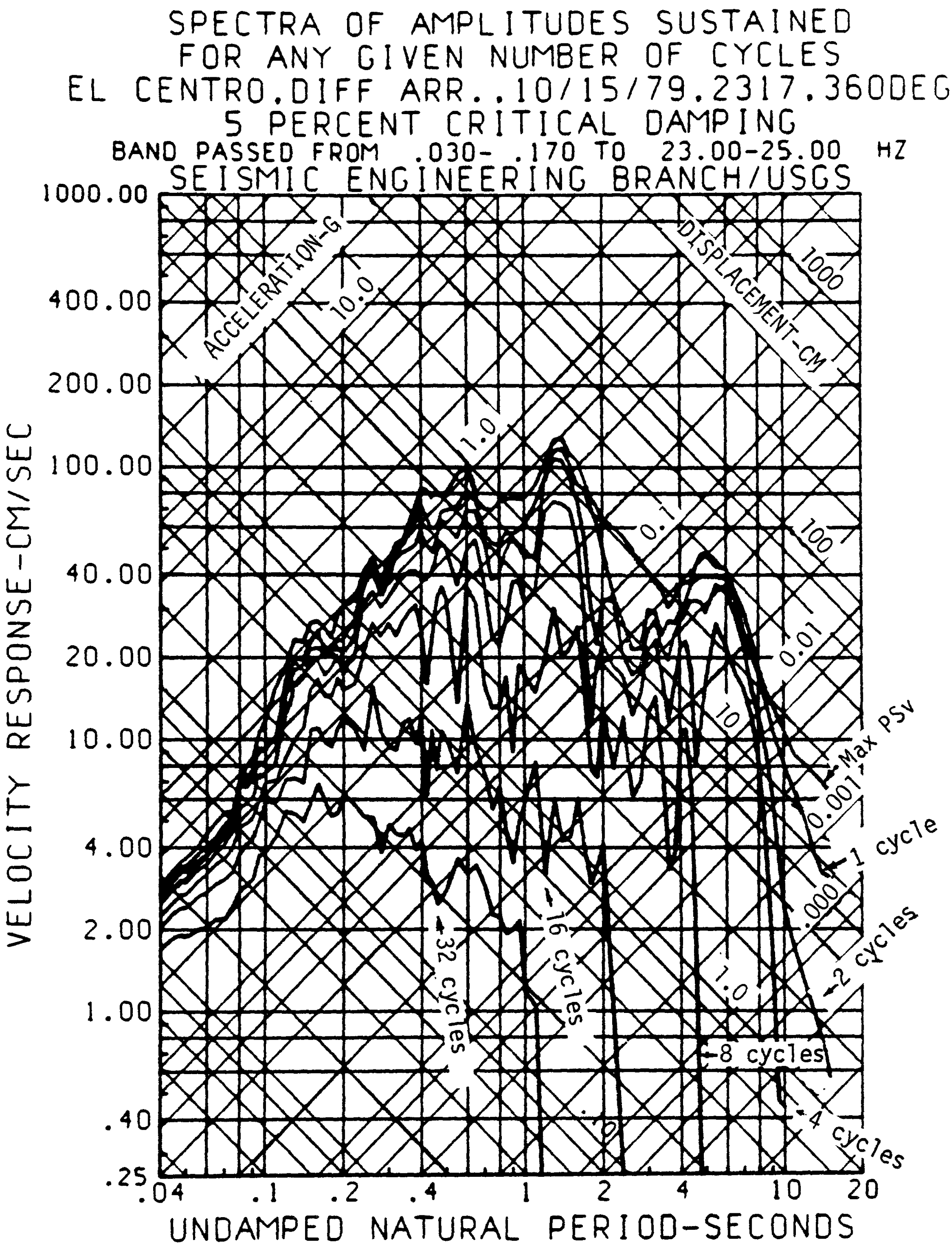


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 5,10/15/79,2317,230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 5,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 5,10/15/79,2317,140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS




SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,DIFF ARR.,10/15/79,2317,360DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
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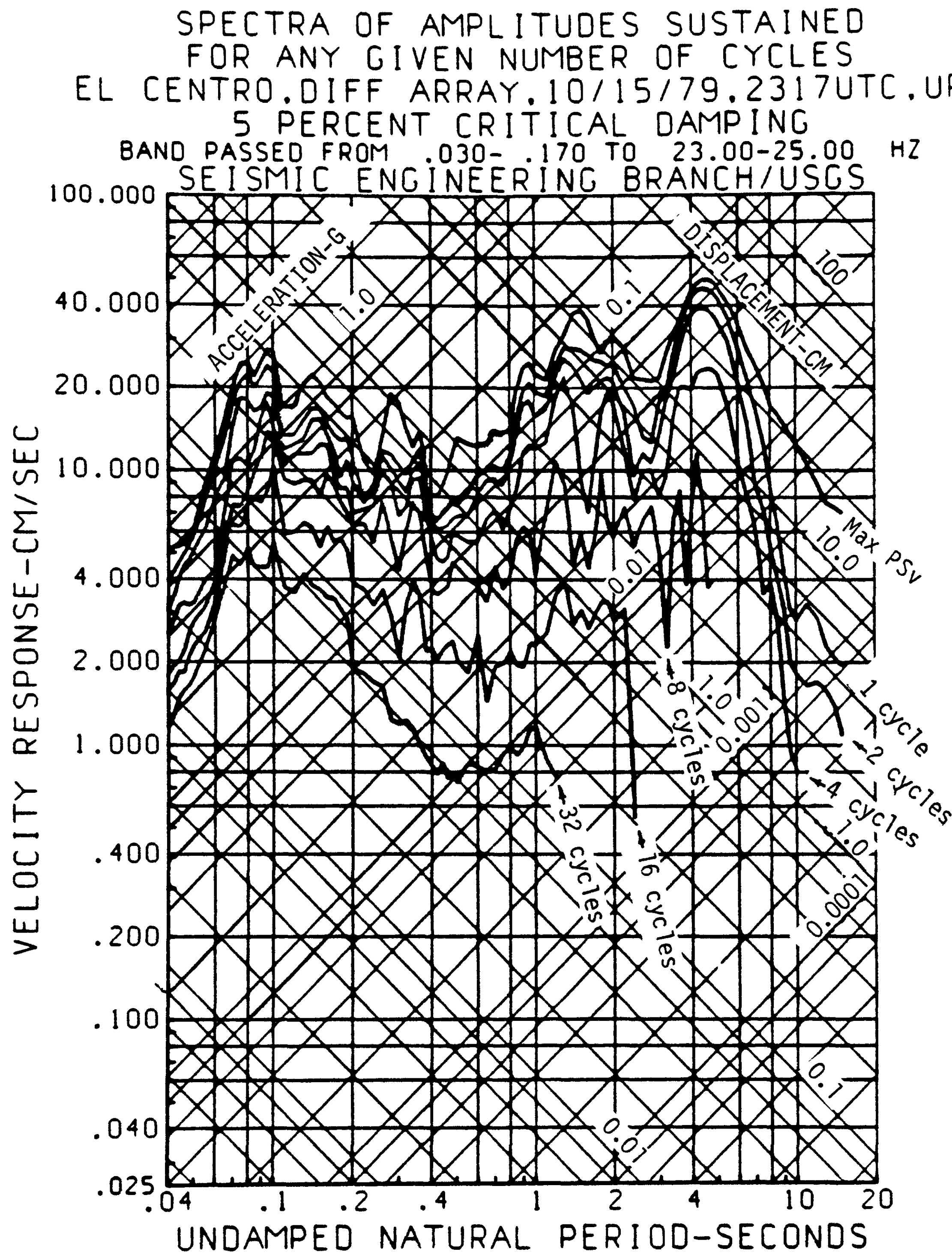
.25
.04
.1
.2
.4
1
2
4
10
20


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.DIFF ARRAY.10/15/79.2317UTC.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
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4
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20
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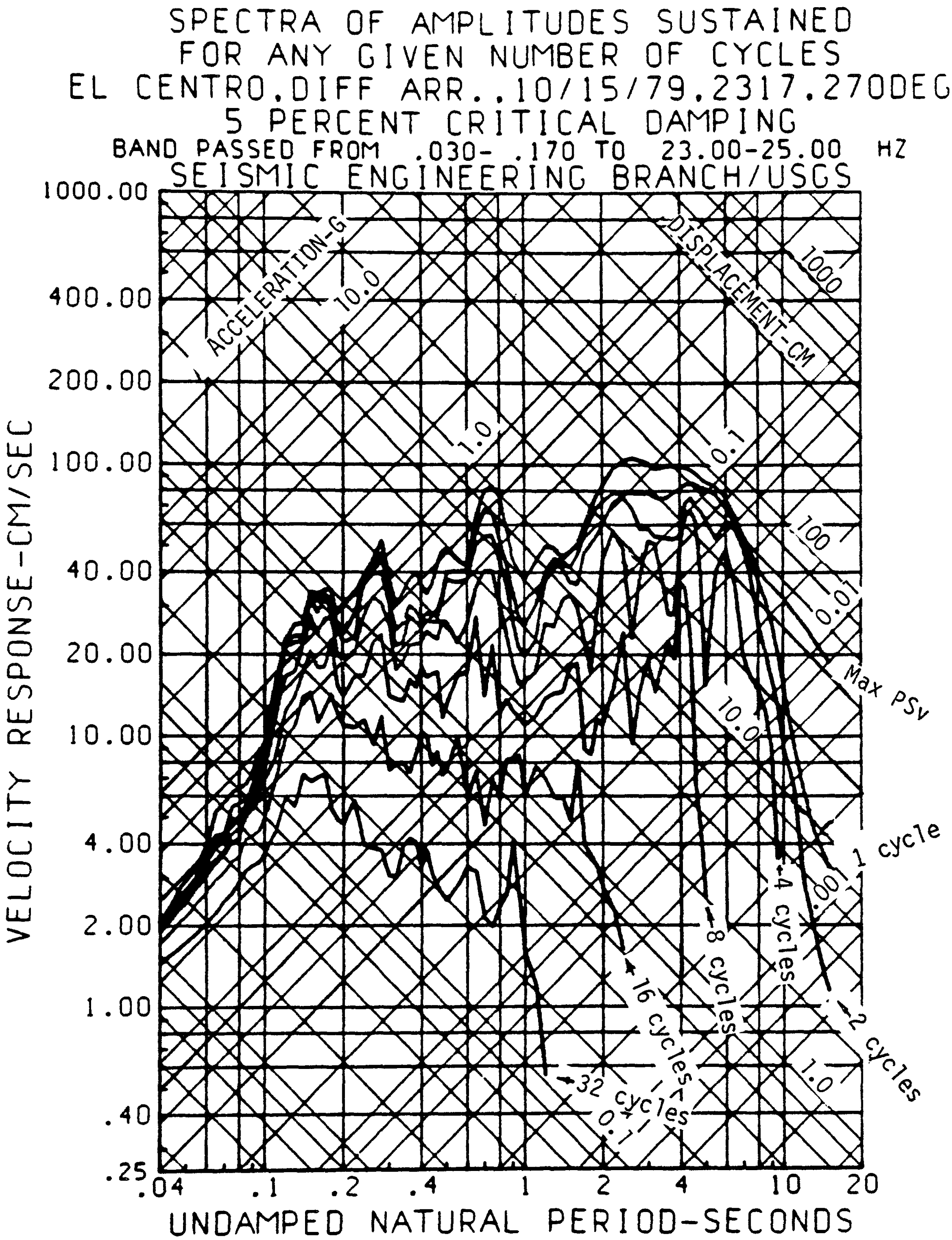
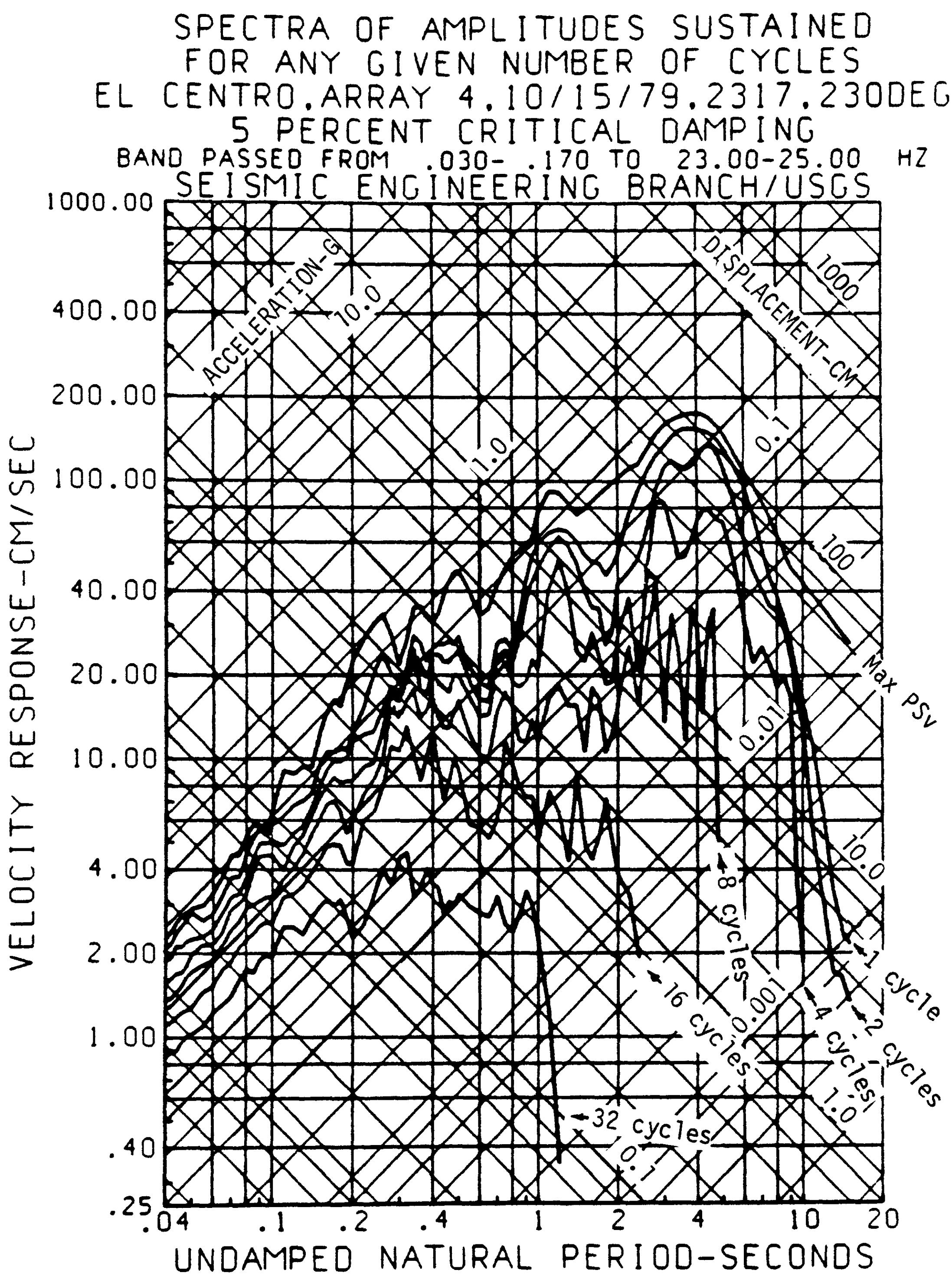
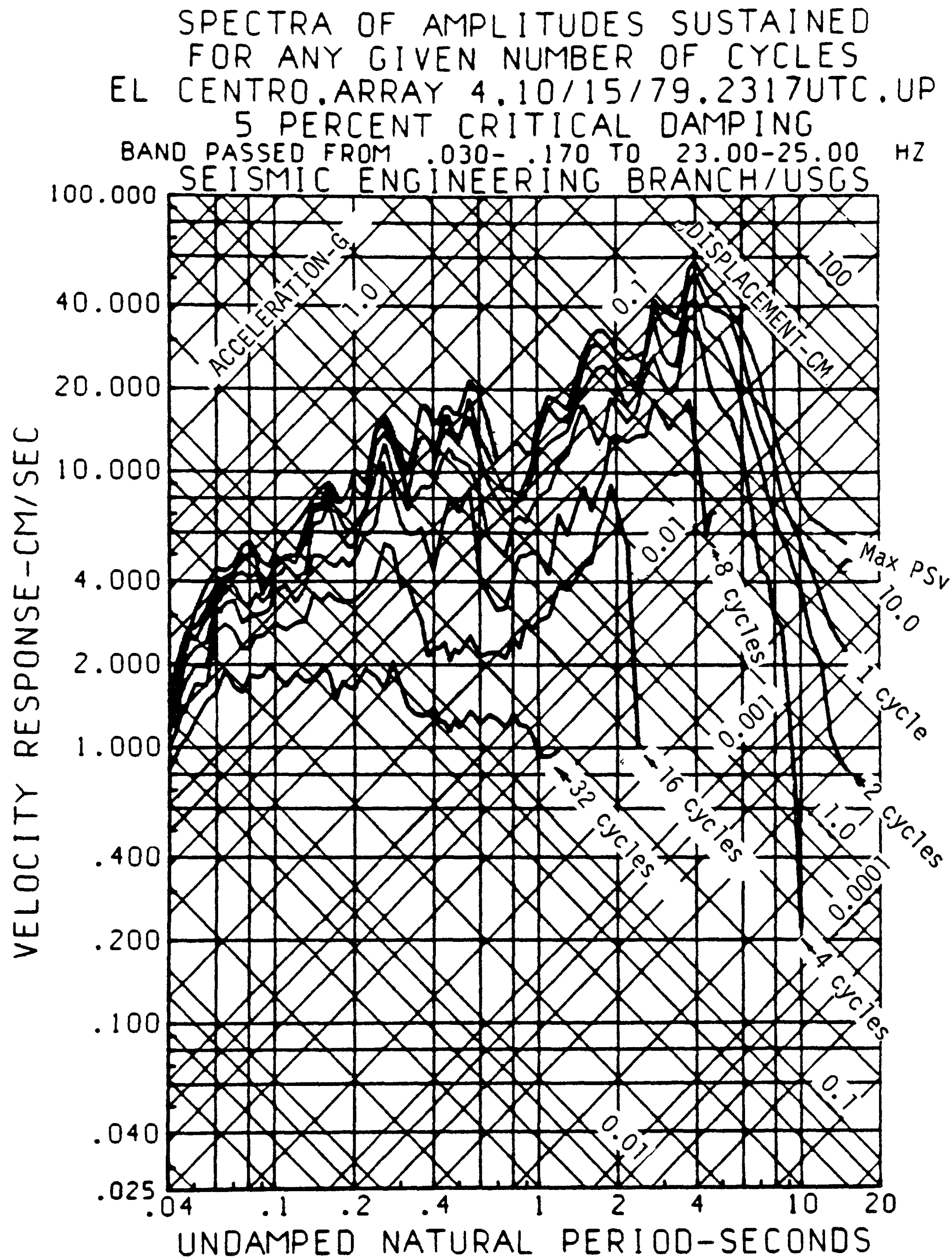
1.0
0.1
0.01
0.001
0.0001



SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,DIFF ARR.,10/15/79,2317,270DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 4,10/15/79,2317,230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
1000.00
400.00
200.00
100.00
40.00
20.00
10.00
4.00
2.00
1.00
.40
.25
.04
.1
.2
.4
1
2
4
10
20



SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 4.10/15/79.2317UTC.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
1.0
0.1
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

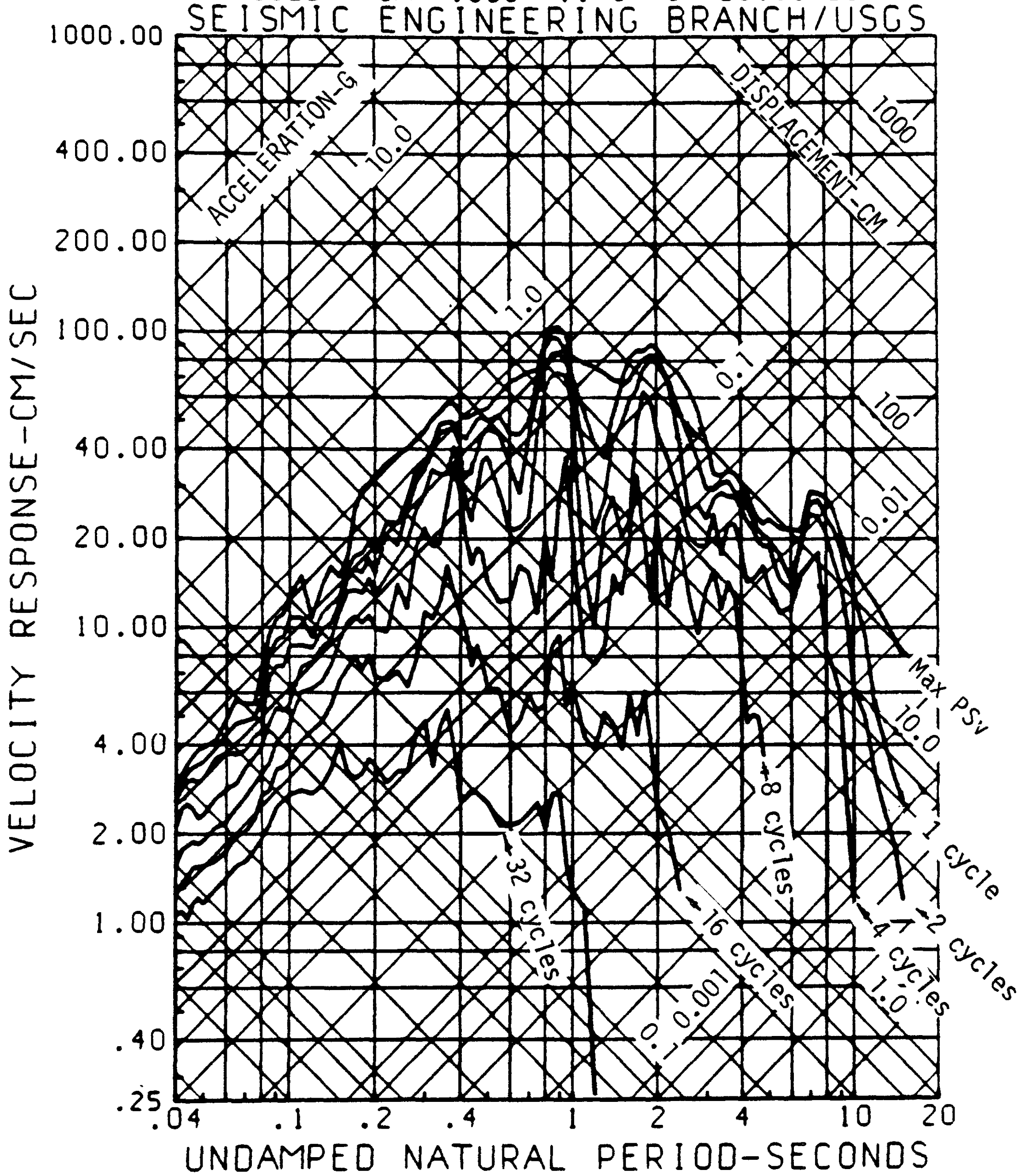
SPECTRA OF AMPLITUDES SUSTAINED FOR ANY GIVEN NUMBER OF CYCLES

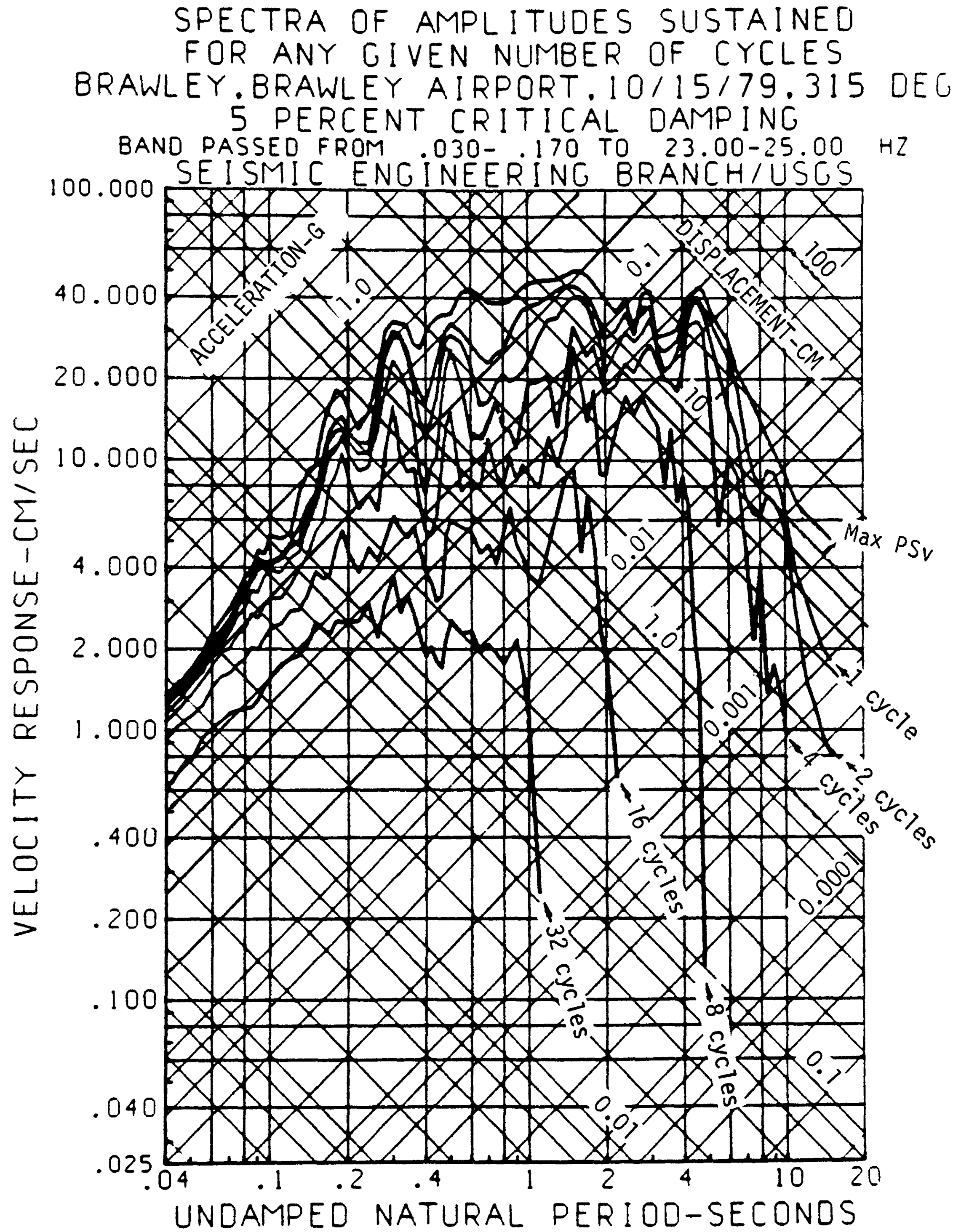
EL CENTRO,ARRAY 4,10/15/79,2317,140DEG

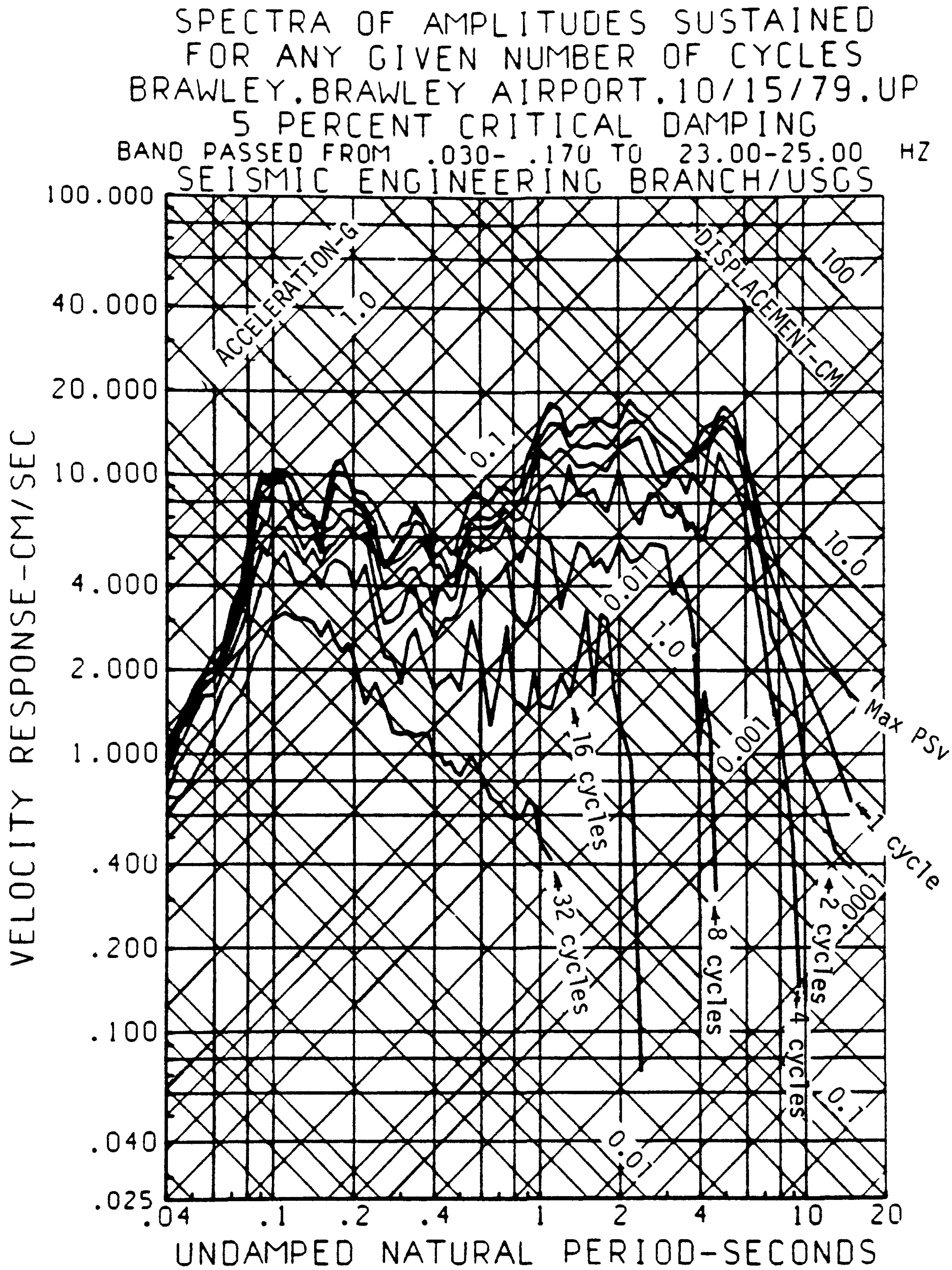
5 PERCENT CRITICAL DAMPING

BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ

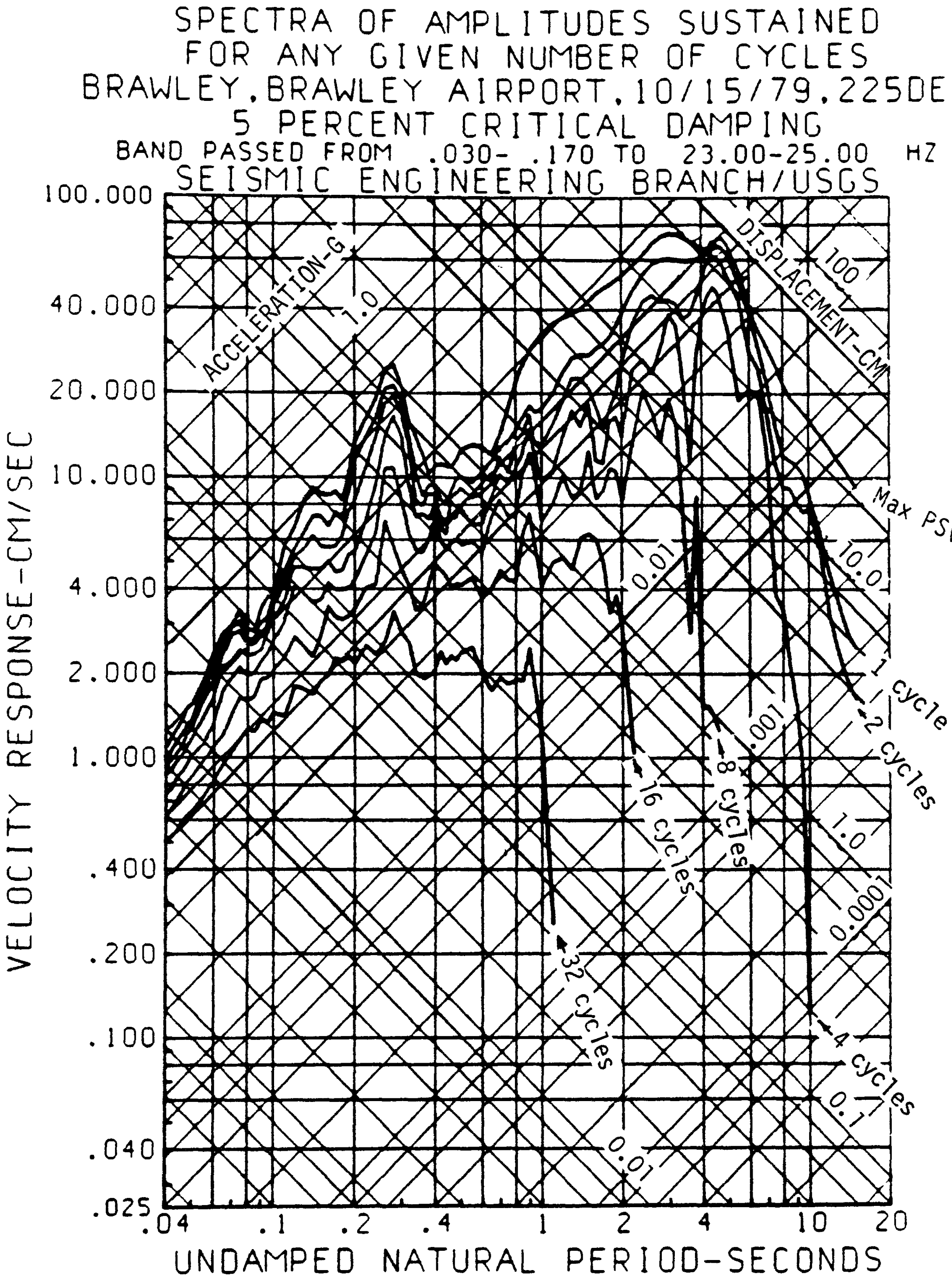
SEISMIC ENGINEERING BRANCH/USGS

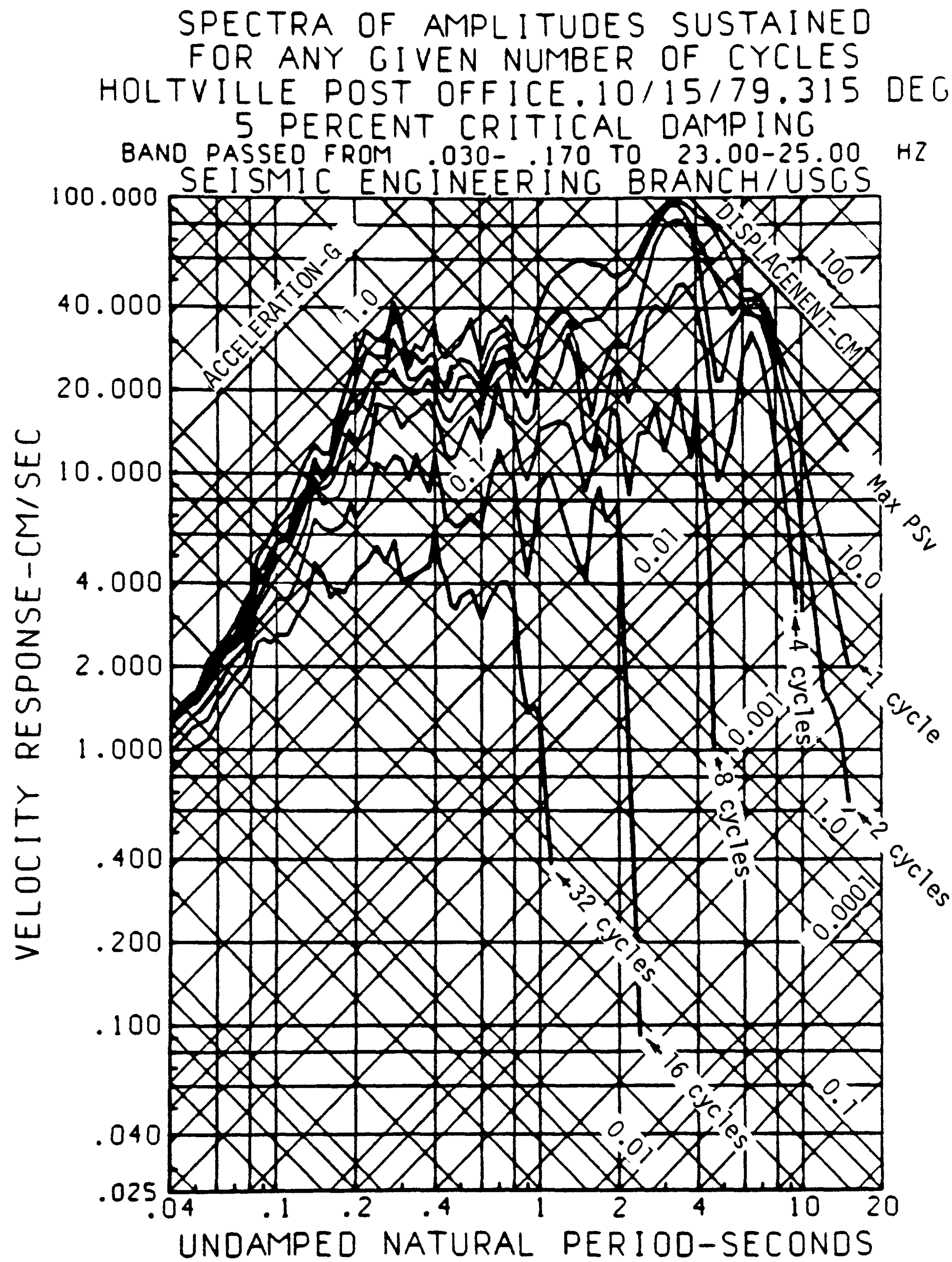



SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
BRAWLEY,BRAWLEY AIRPORT,10/15/79,315 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

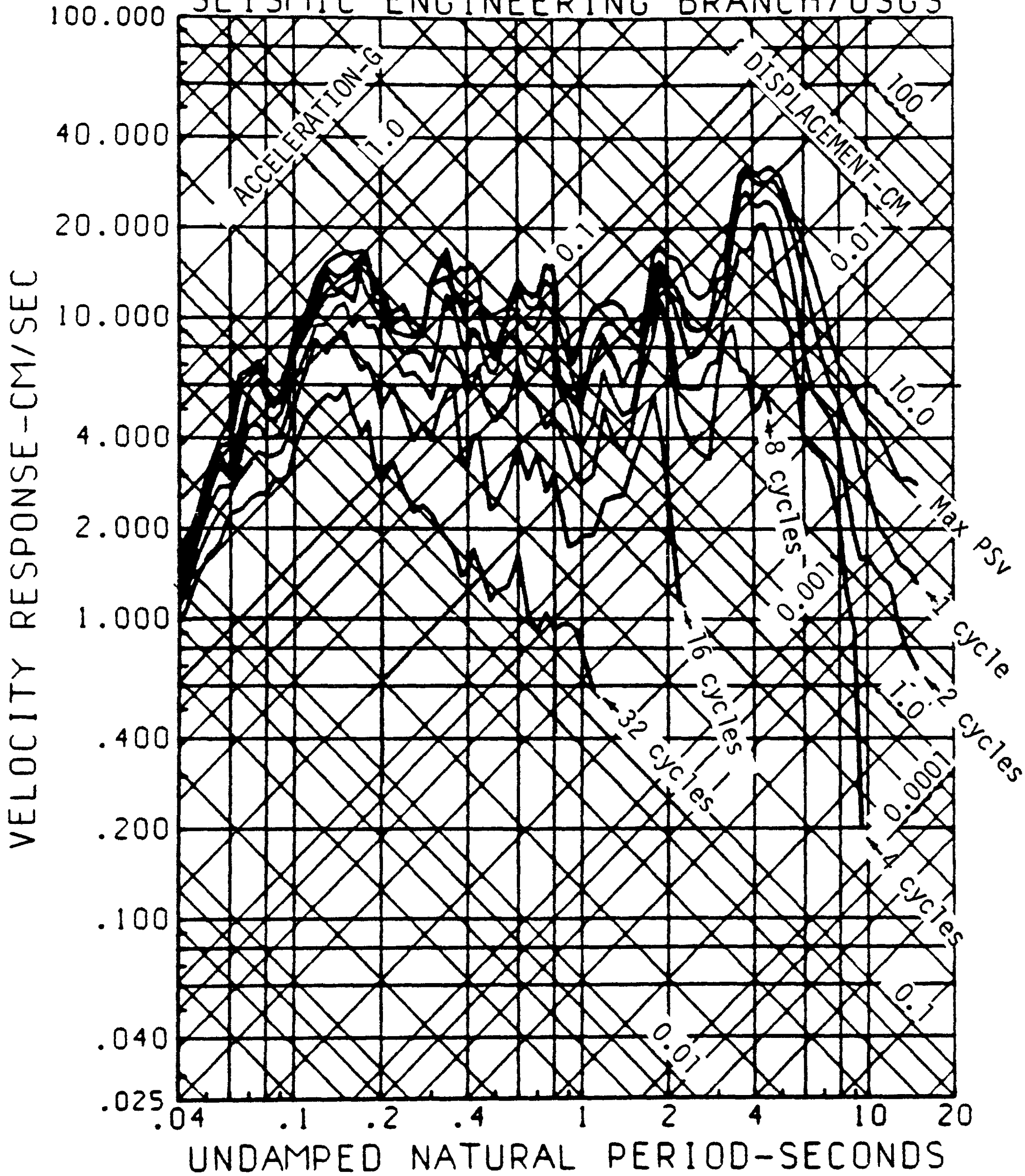


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
BRAWLEY.BRAWLEY AIRPORT.10/15/79.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

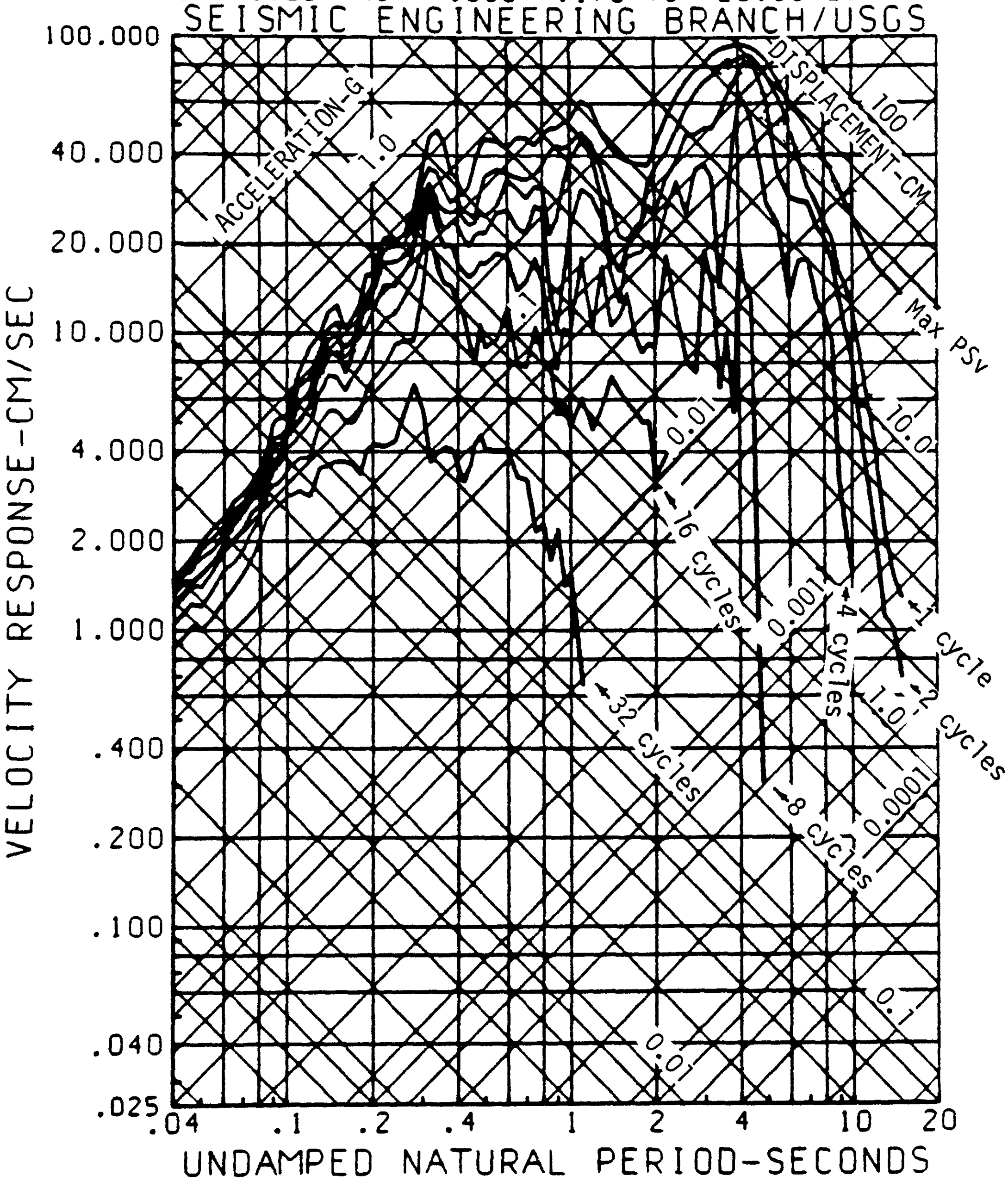

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
BRAWLEY,BRAWLEY AIRPORT,10/15/79,225DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
1.0
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
0.001
0.0001
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

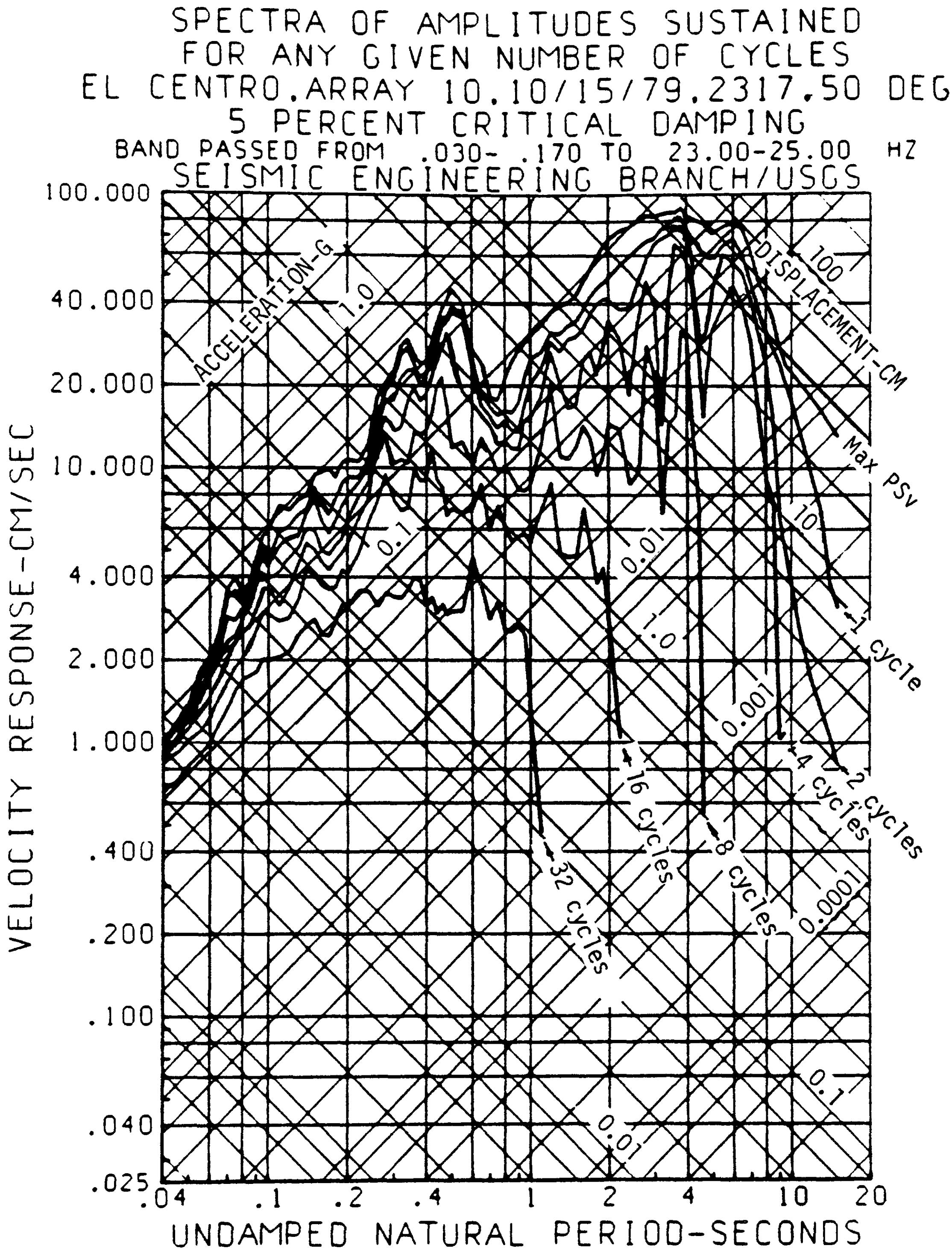

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
HOLTVILLE POST OFFICE.10/15/79.315 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20

SPECTRA OF AMPLITUDES SUSTAINED FOR ANY GIVEN NUMBER OF CYCLES
HOLTVILLE POST OFFICE.10/15/79.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

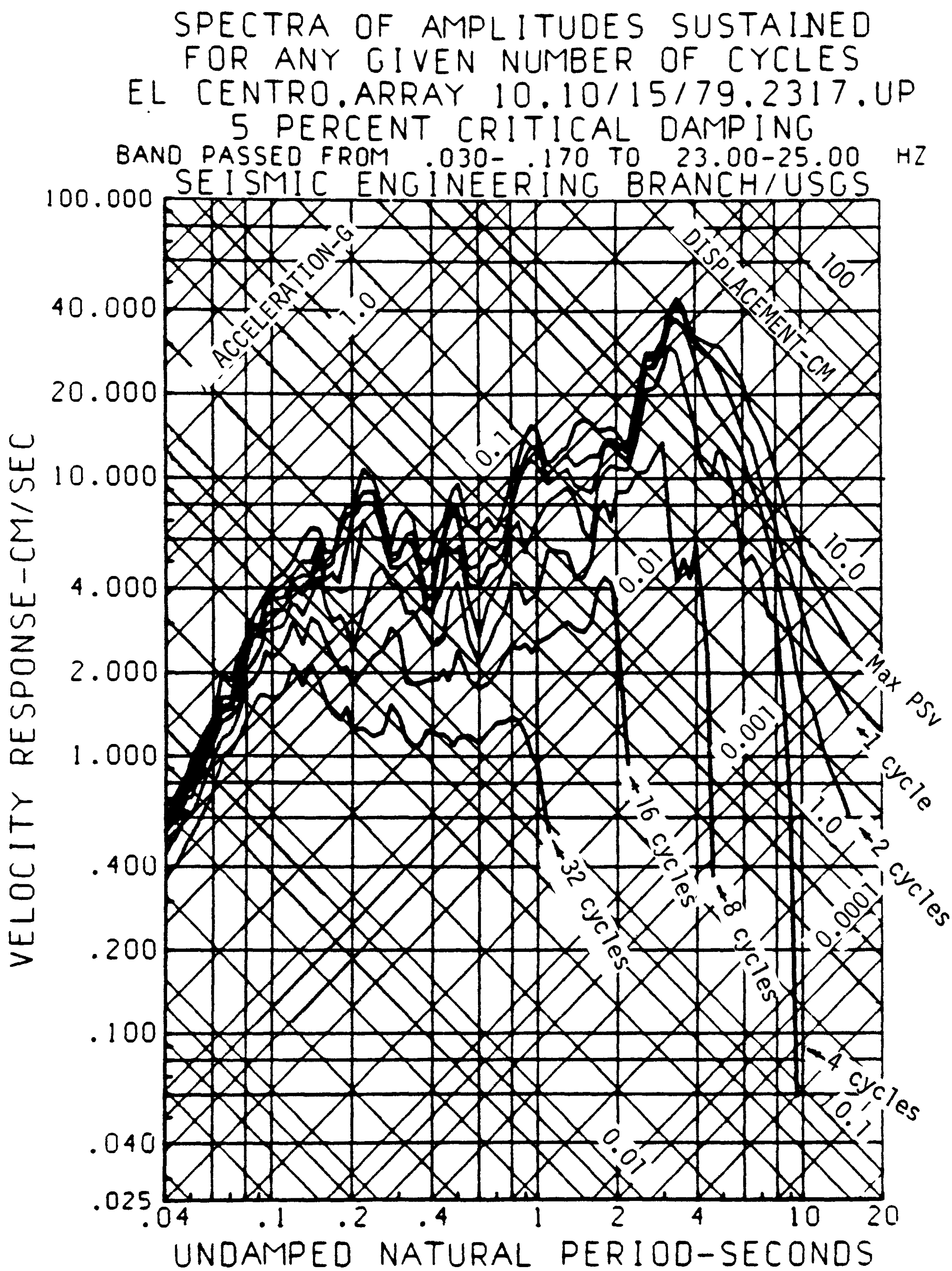


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
HOLTVILLE POST OFFICE,10/15/79,225 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

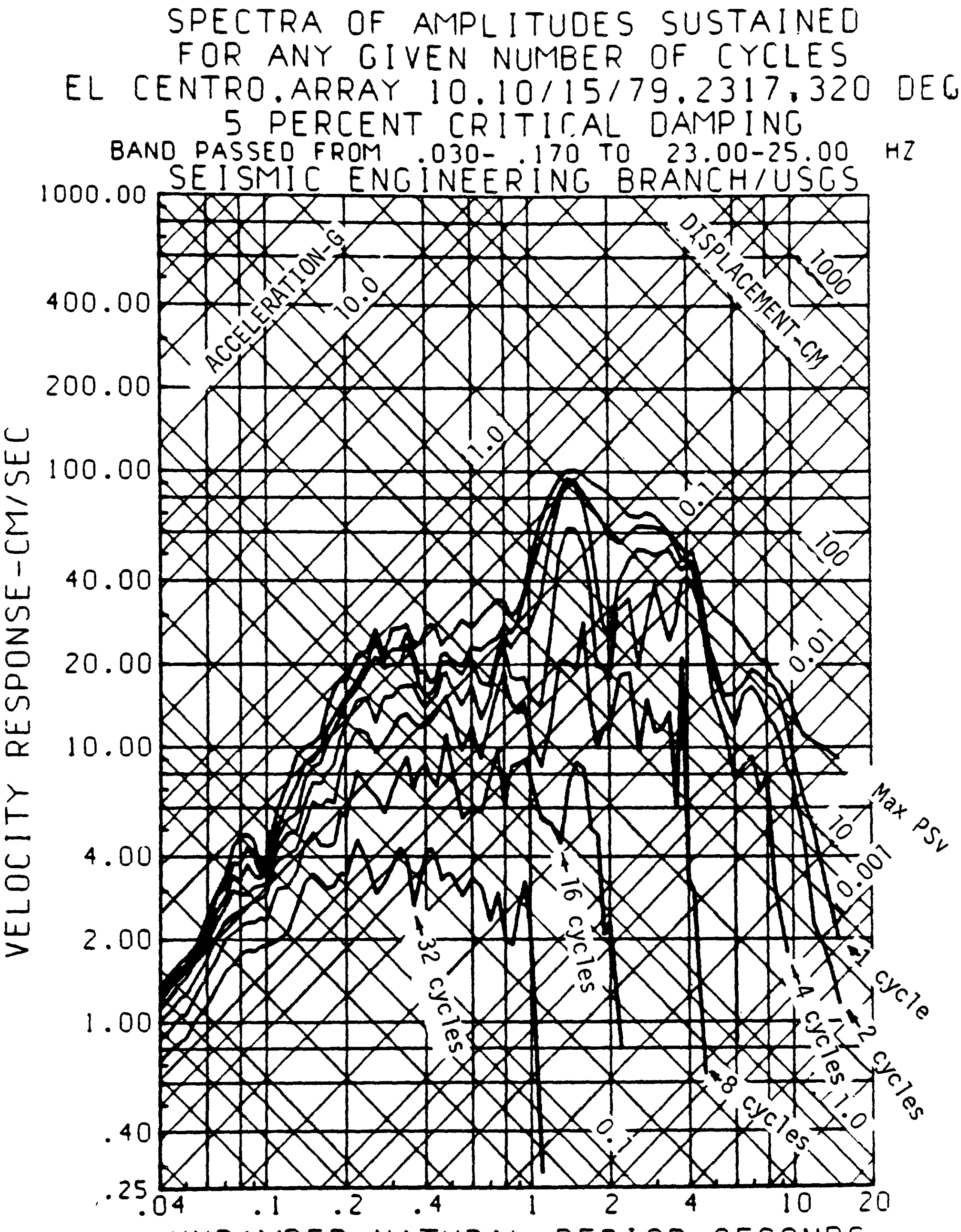


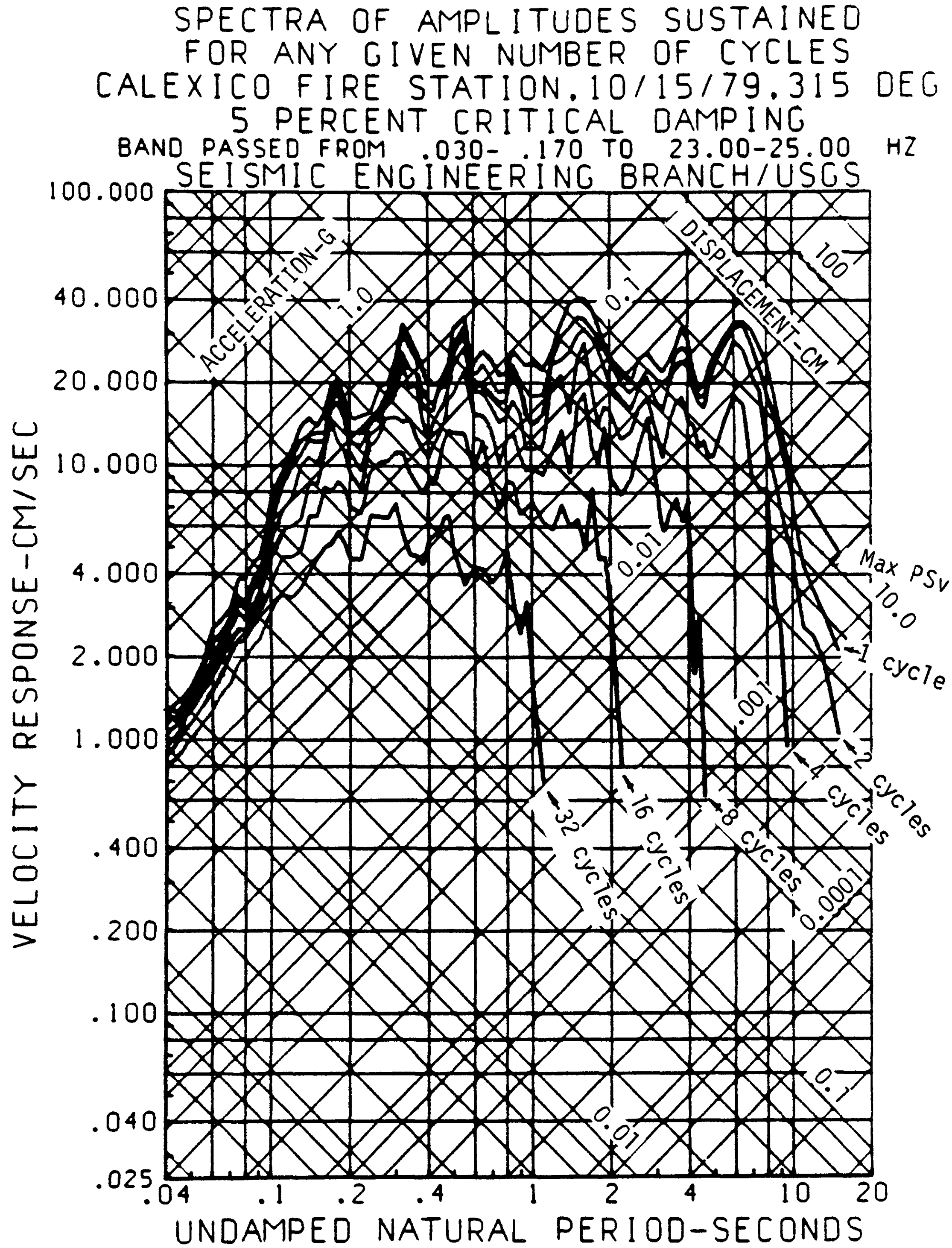


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 10,10/15/79,2317,50 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
1.0
0.1
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10
1.0
0.1
0.01
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

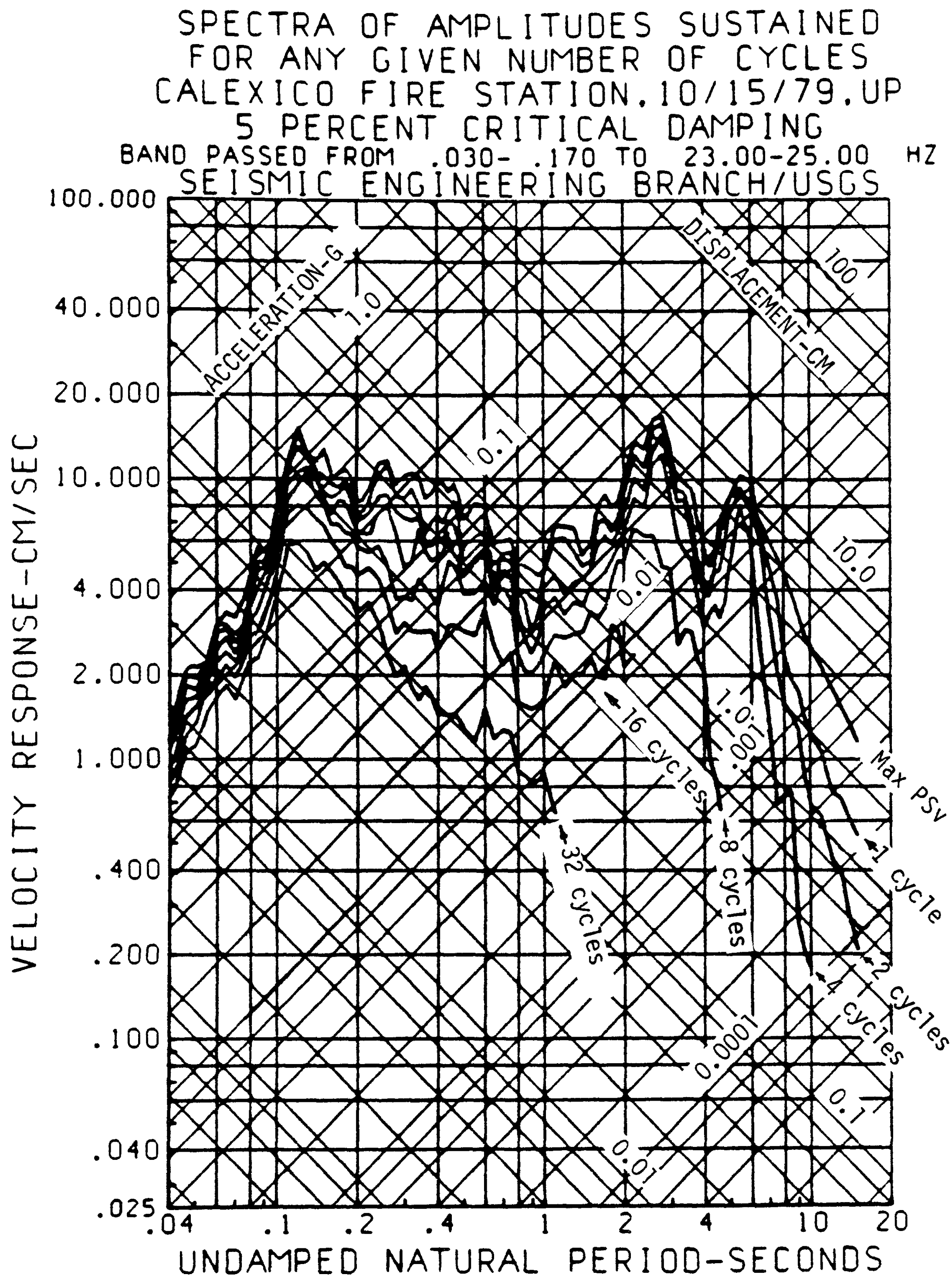


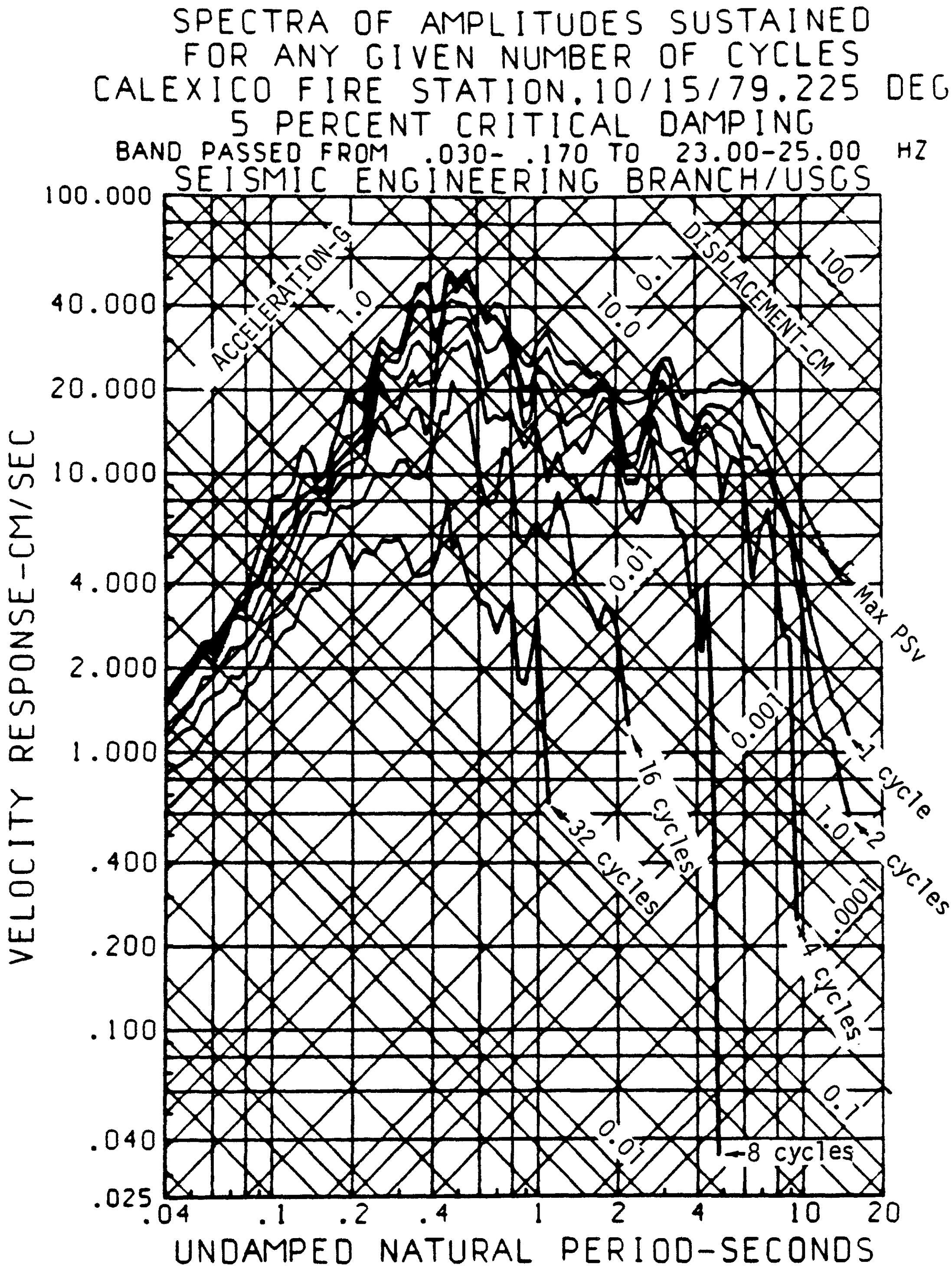
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 10.10/15/79.2317.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
ACCELERATION-G
1.0
0.1
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

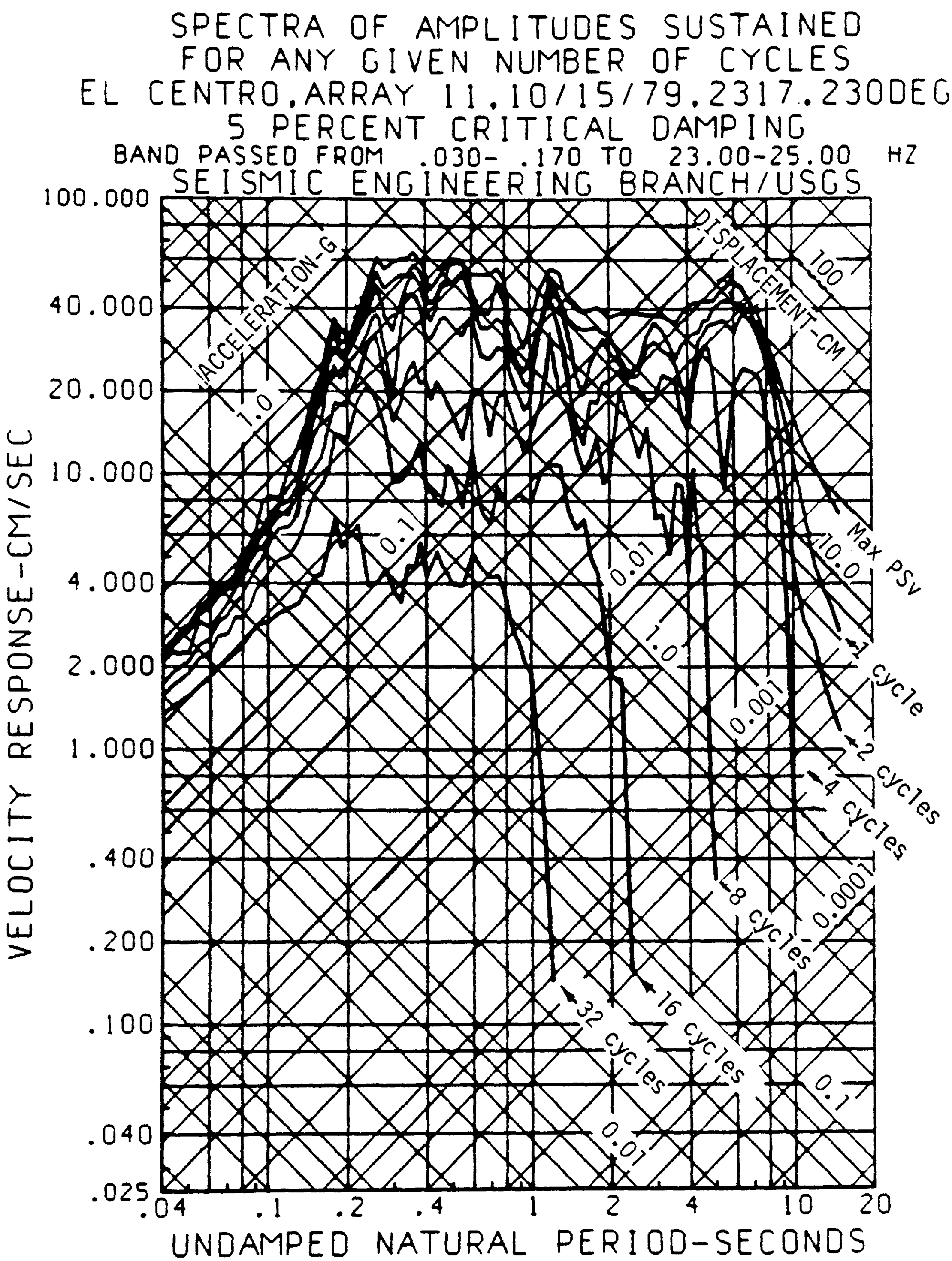

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 10.10/15/79.2317.320 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
32 cycles
16 cycles
8 cycles
4 cycles
2 cycles
1 cycle



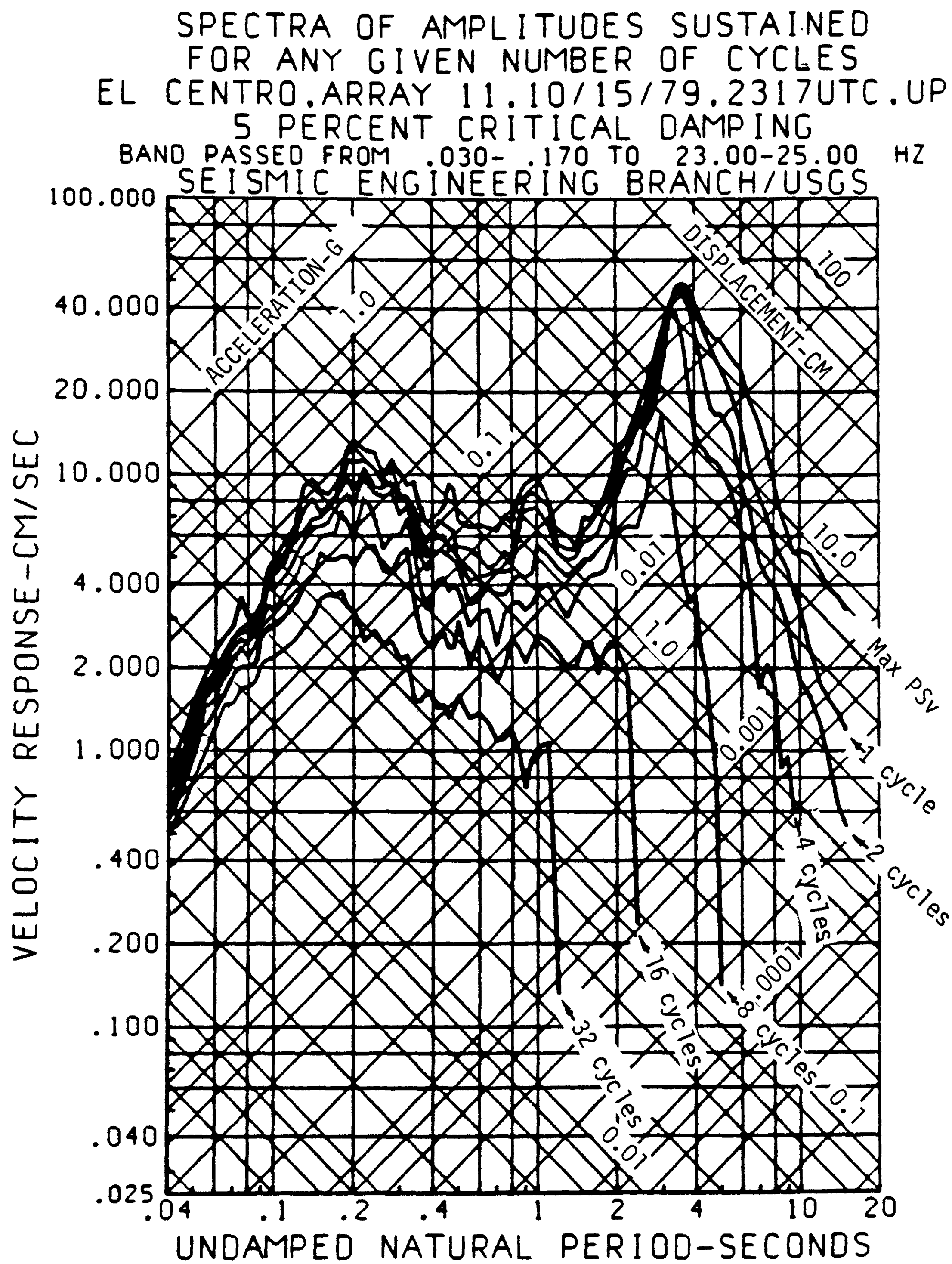
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
CALEXICO FIRE STATION,10/15/79,315 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
1.0
0.1
DISPLACEMENT-CM
100
10.0
0.01
.001
0.0001
0.1
0.01
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

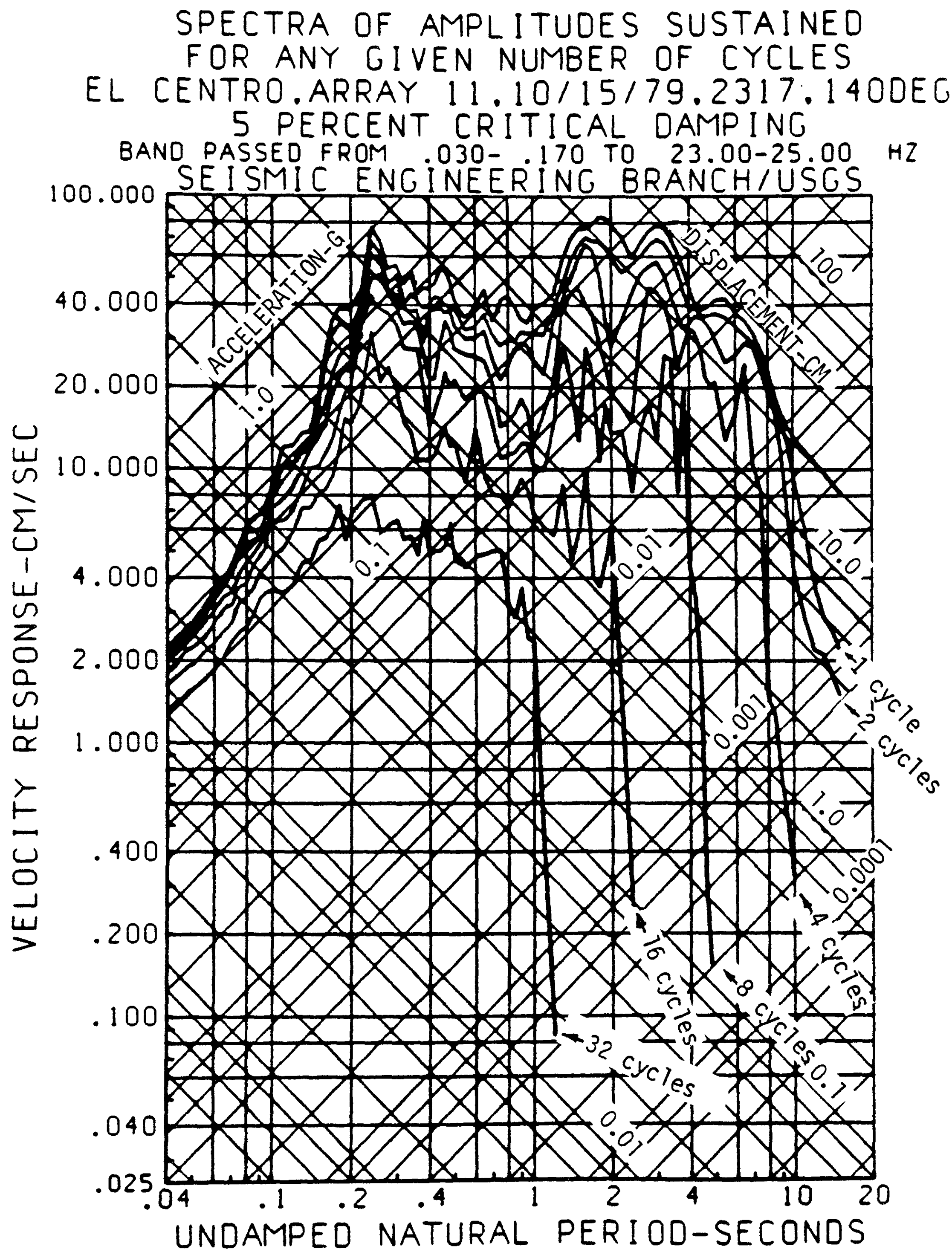

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
CALEXICO FIRE STATION,10/15/79,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
1.0
0.1
0.01
0.001
0.0001
100
10.0
1.0
0.1
0.01
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

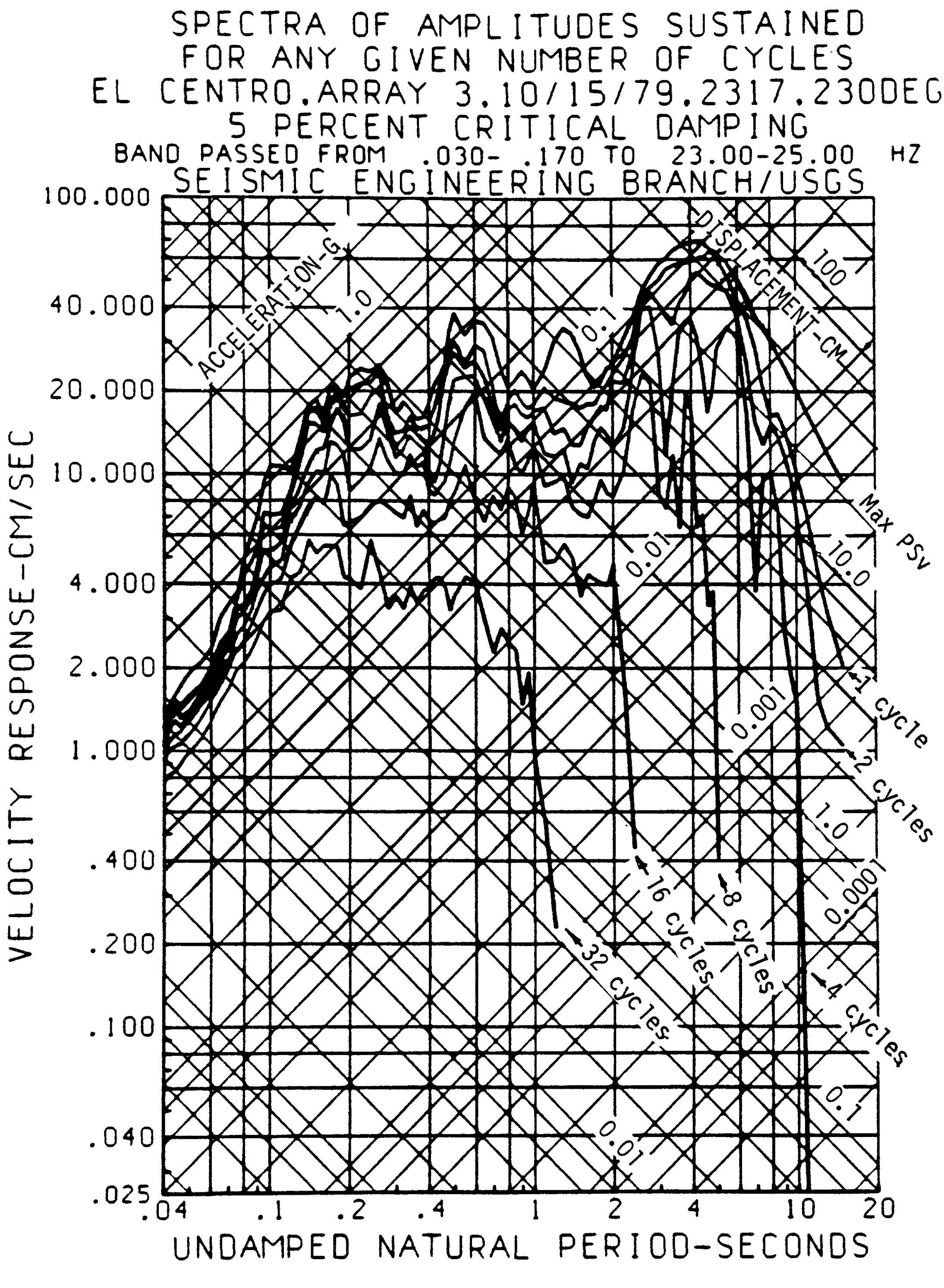

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
CALEXICO FIRE STATION,10/15/79,225 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
1.0
0.1
10.0
DISPLACEMENT-CM
100
0.01
0.001
1.0
0.0001
0.1
0.01
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles



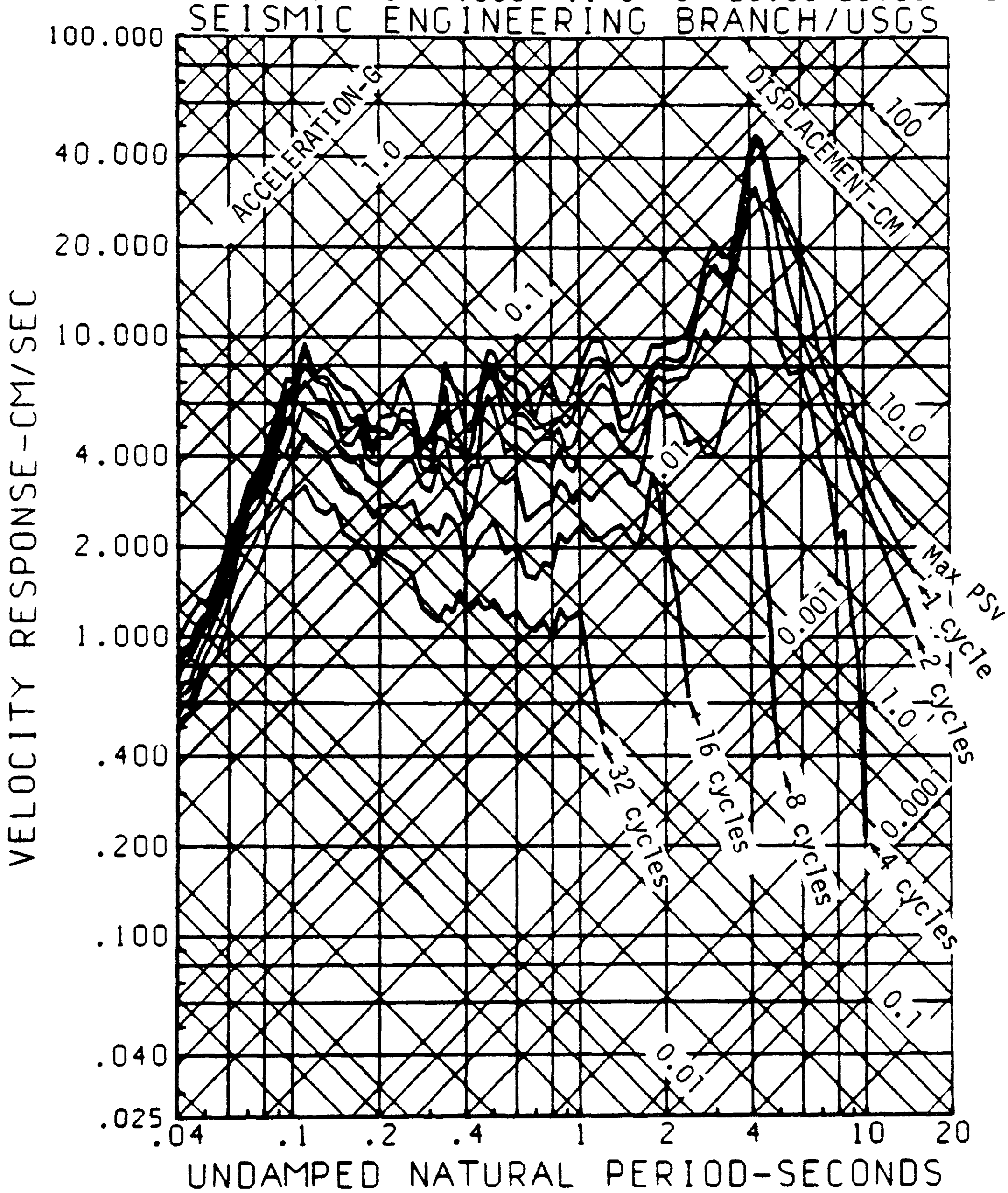
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 11,10/15/79,2317,230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20

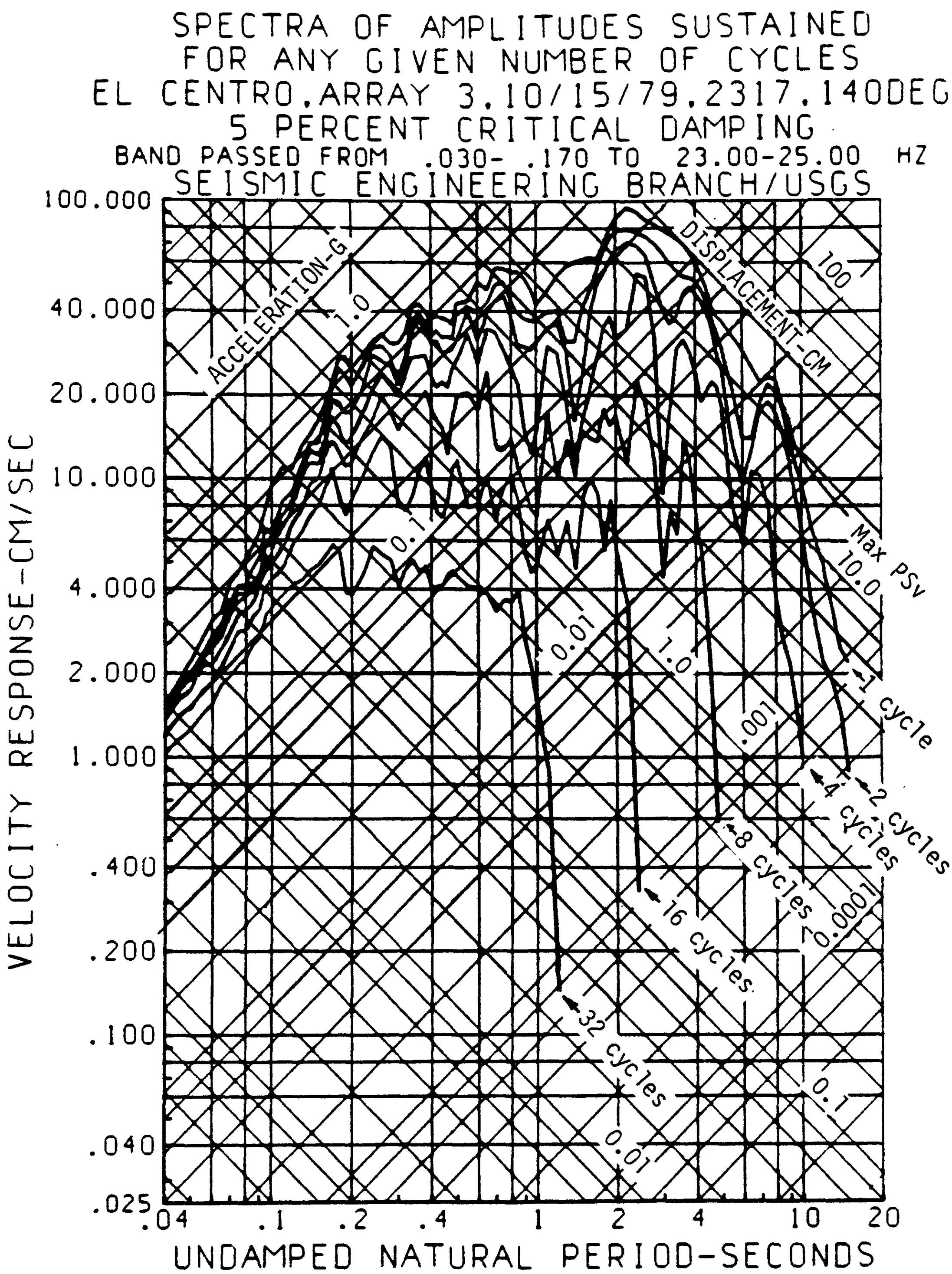

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 11.10/15/79.2317UTC.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

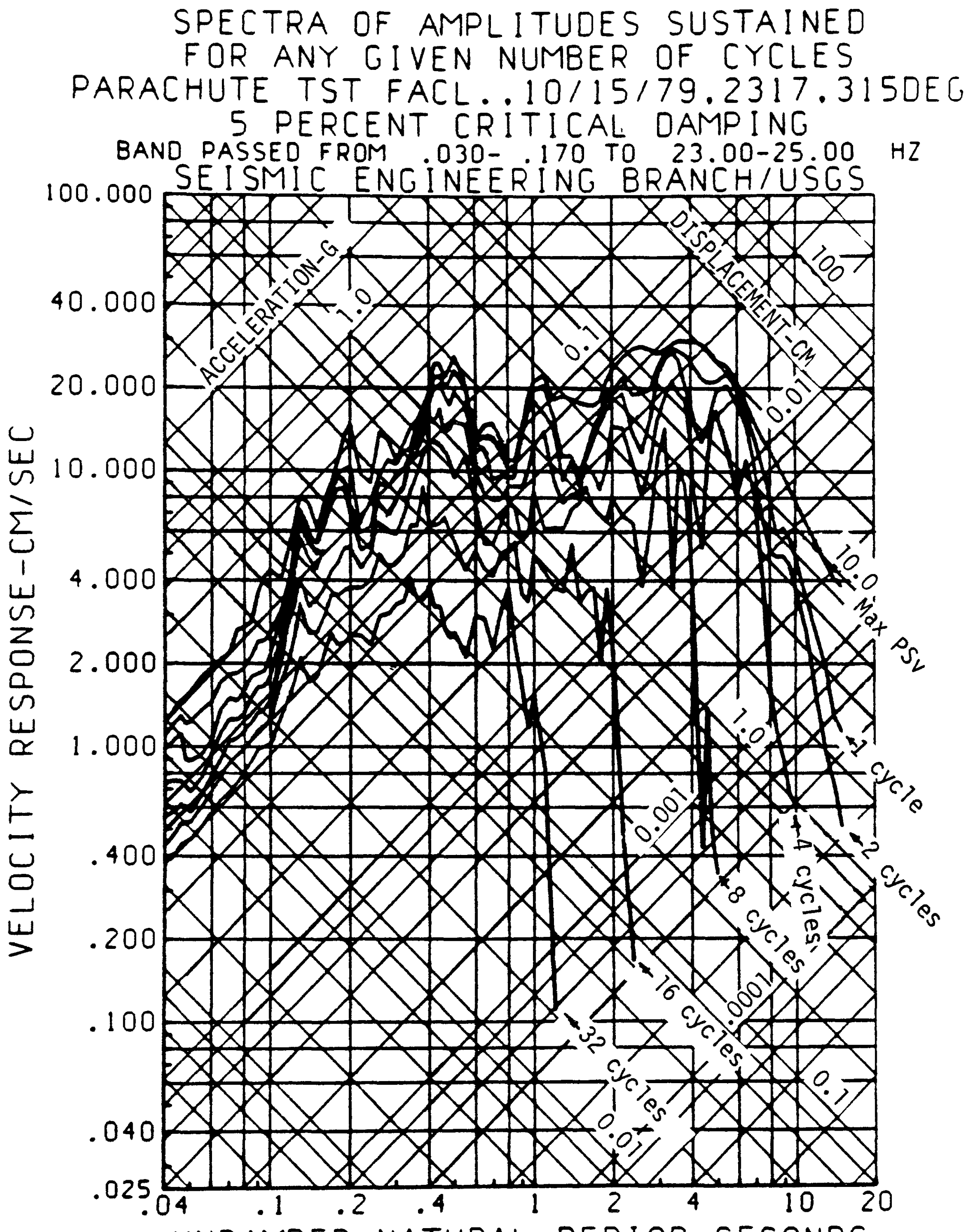

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 11,10/15/79,2317,140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
DISPLACEMENT-CM
1.0
0.1
0.01
0.001
0.0001
100
10.0
1.0
0.1
0.01
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

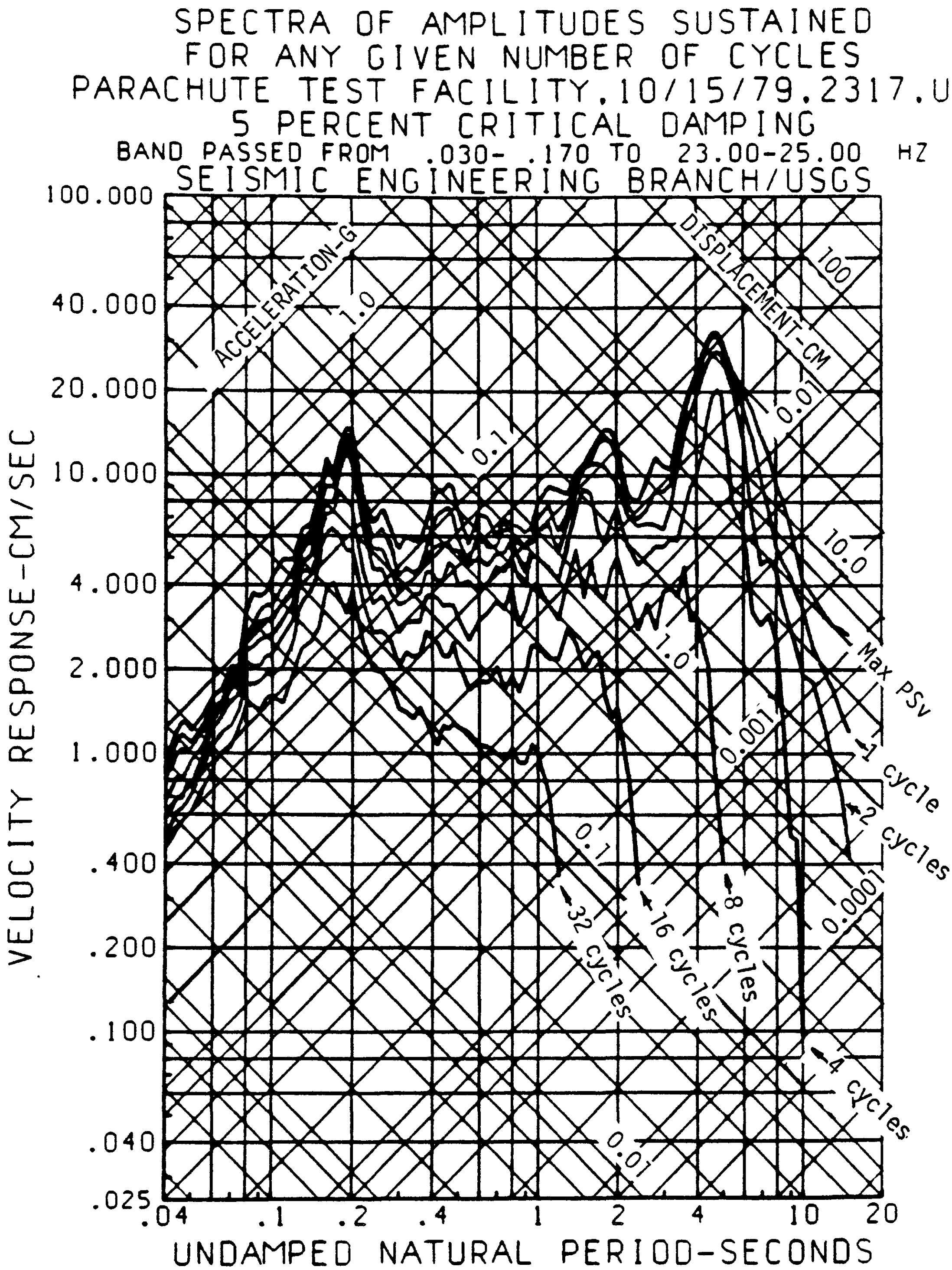

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 3.10/15/79.2317.230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
DISPLACEMENT-CM
1.0
0.1
0.01
0.001
0.0001
100
10.0
1.0
0.1
0.01
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

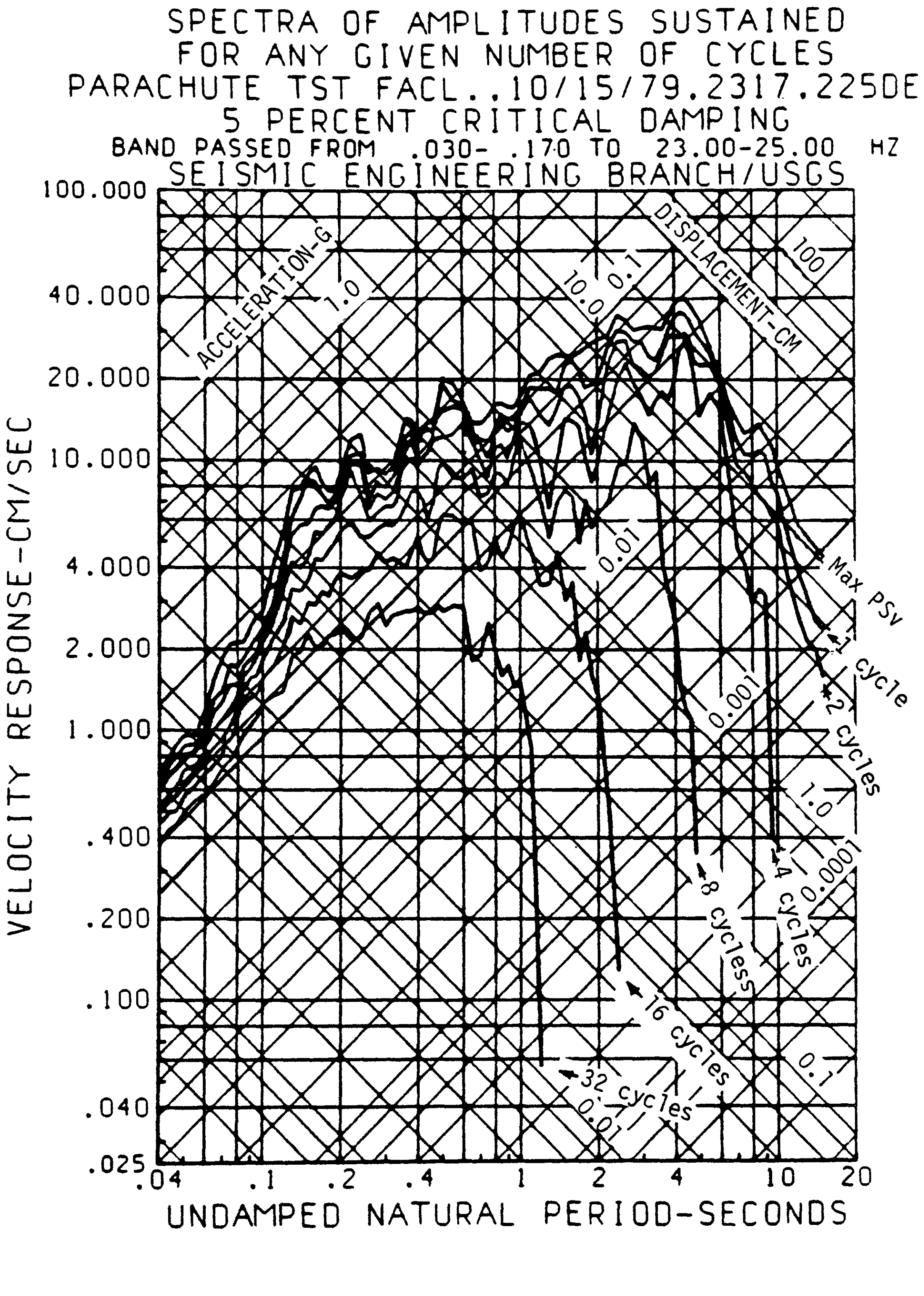
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 3,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

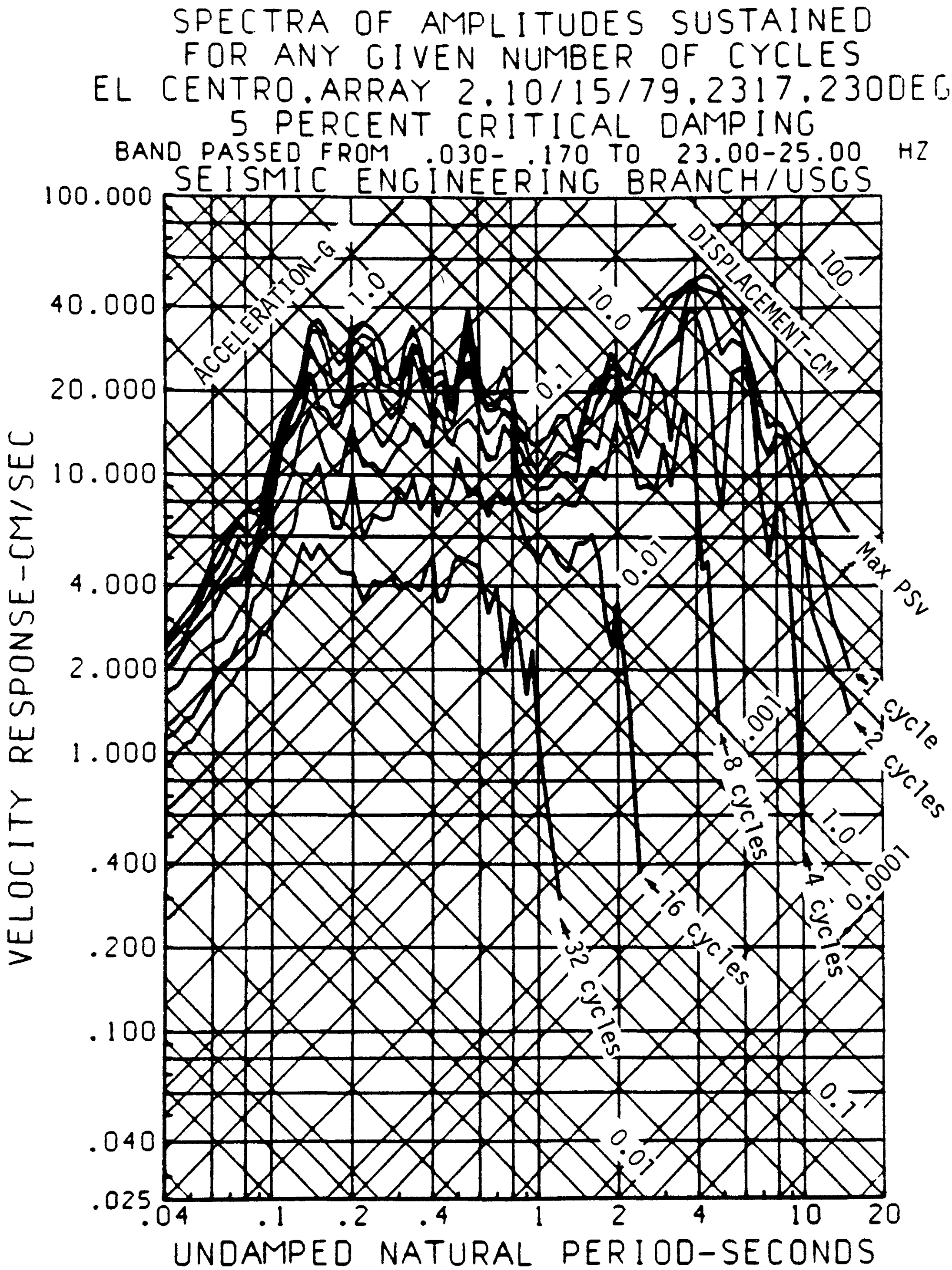


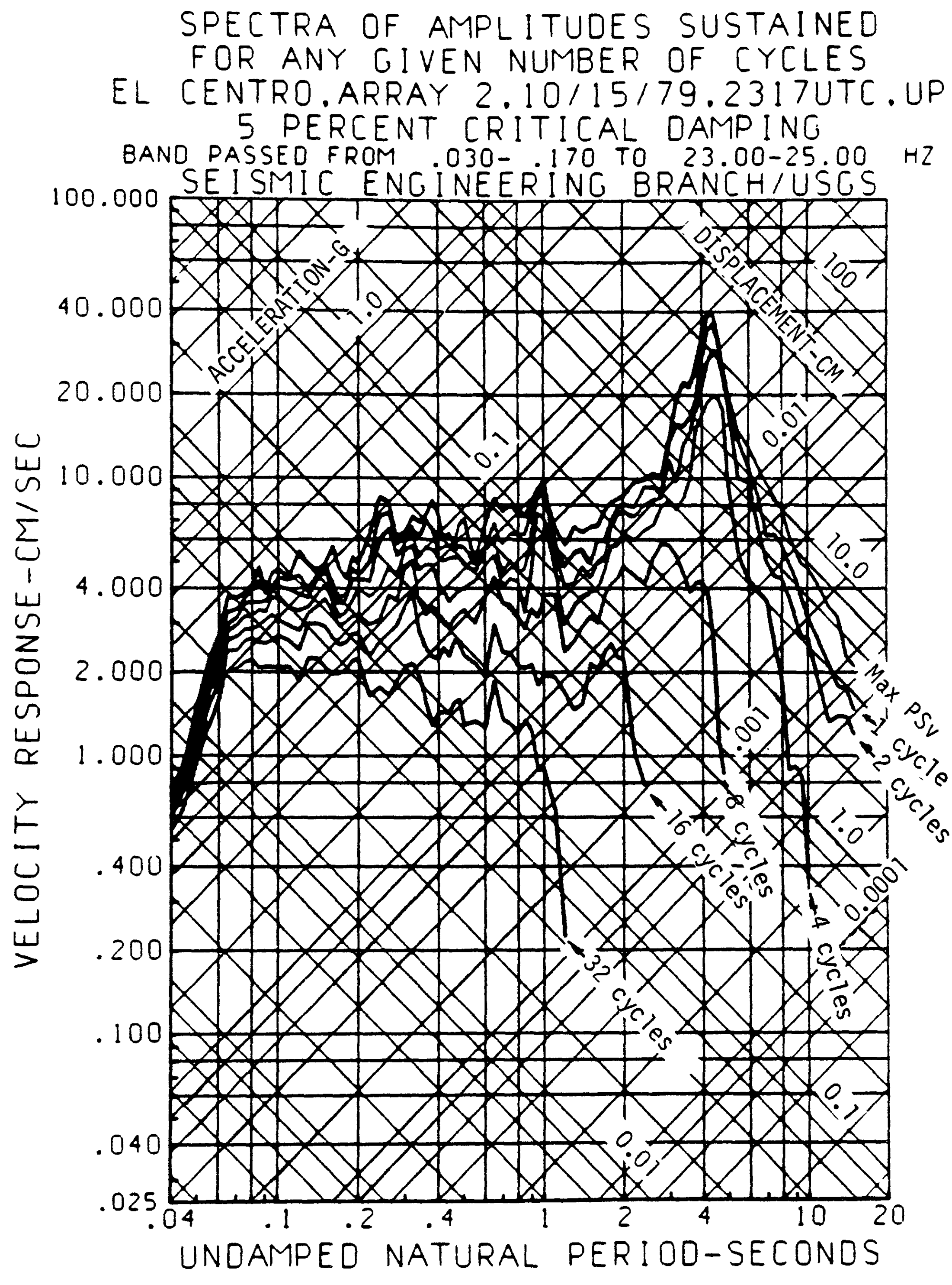

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 3,10/15/79,2317,140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
PARACHUTE TST FACL..10/15/79.2317.315DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
PARACHUTE TEST FACILITY.10/15/79.2317.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

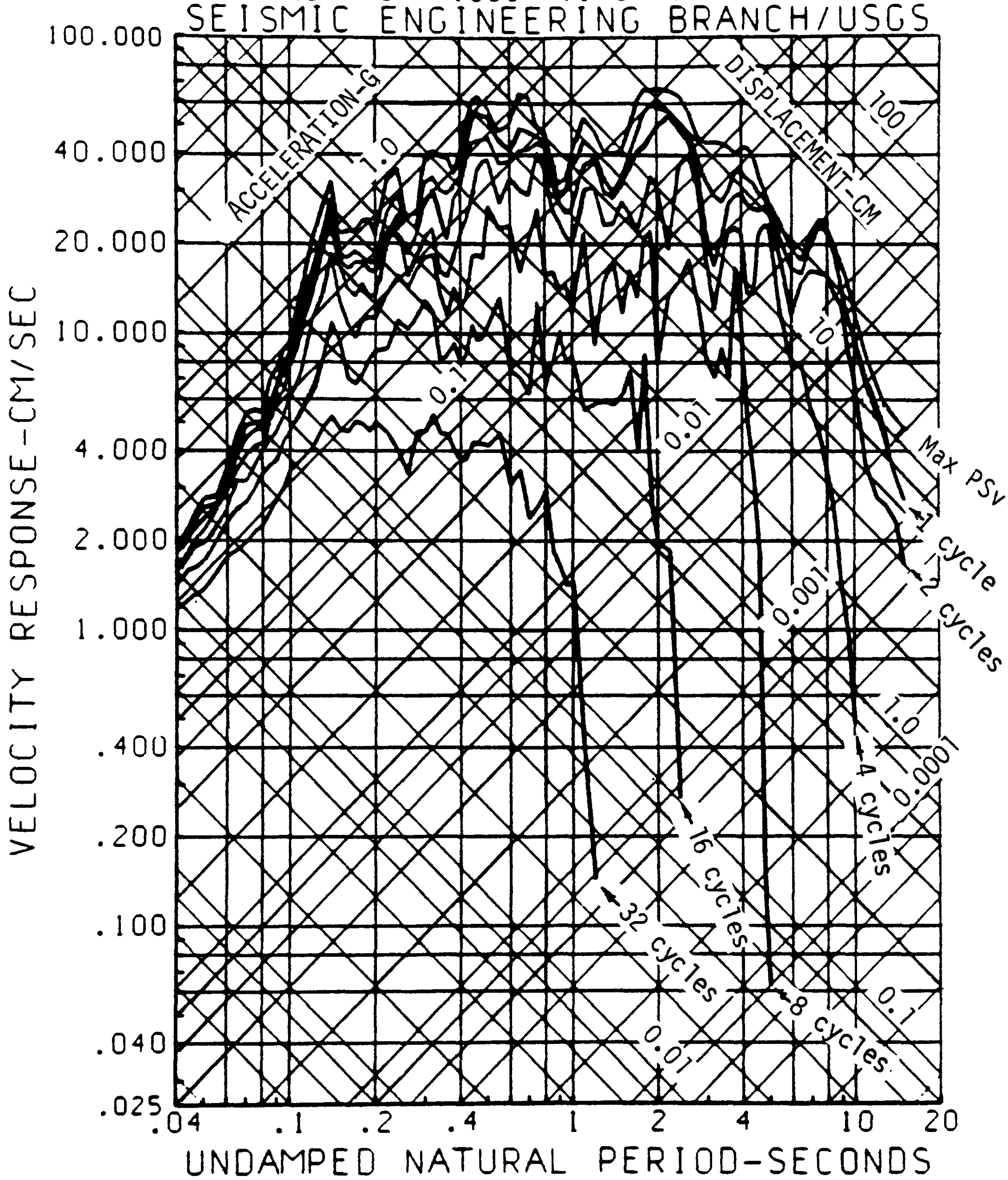

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
PARACHUTE TST FACL..10/15/79.2317.225DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

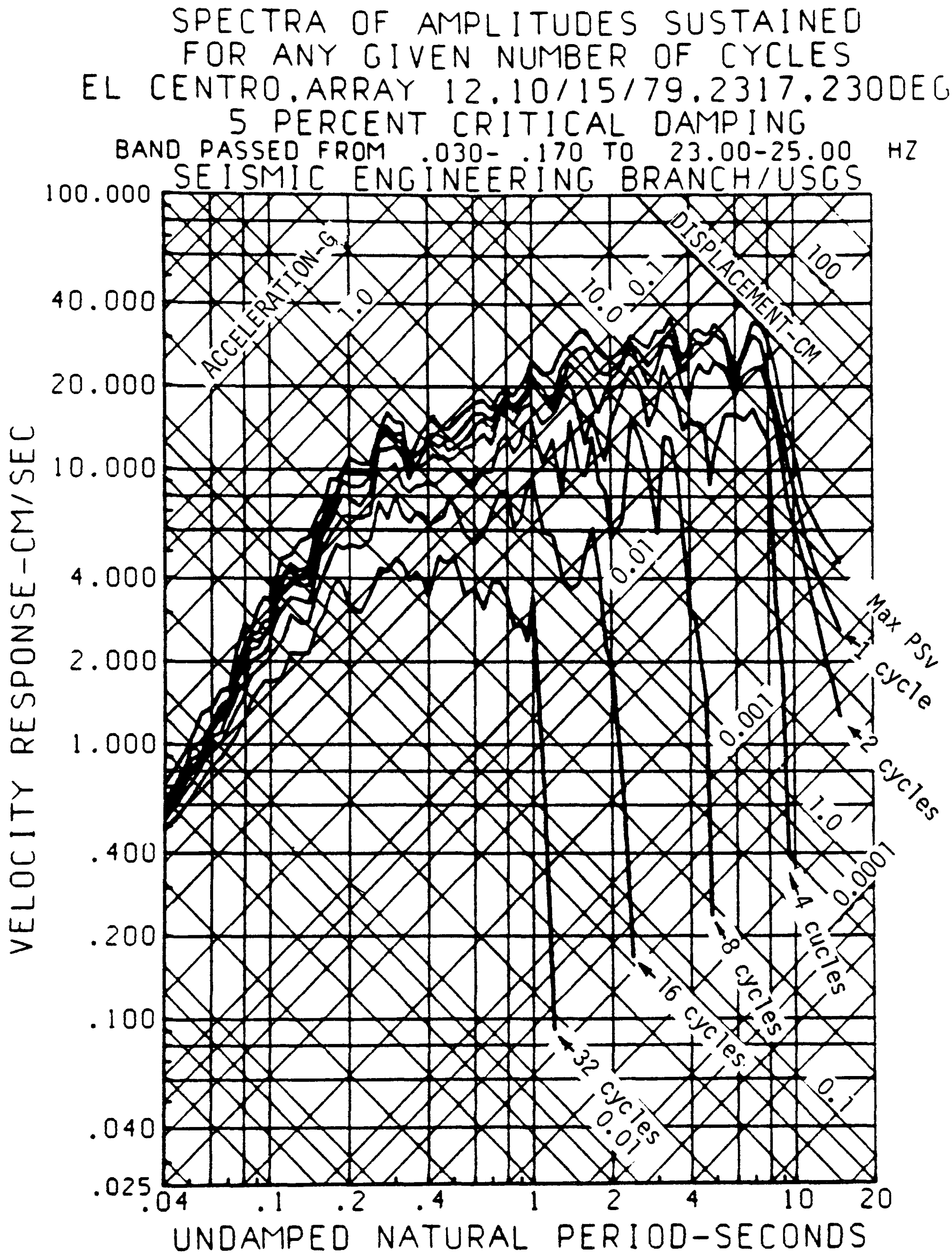

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 2.10/15/79.2317.230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles



SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 2.10/15/79.2317UTC.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
1.0
0.1
0.01
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
.001
0.0001
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 2,10/15/79,2317,140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS




SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 12,10/15/79,2317,230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
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1
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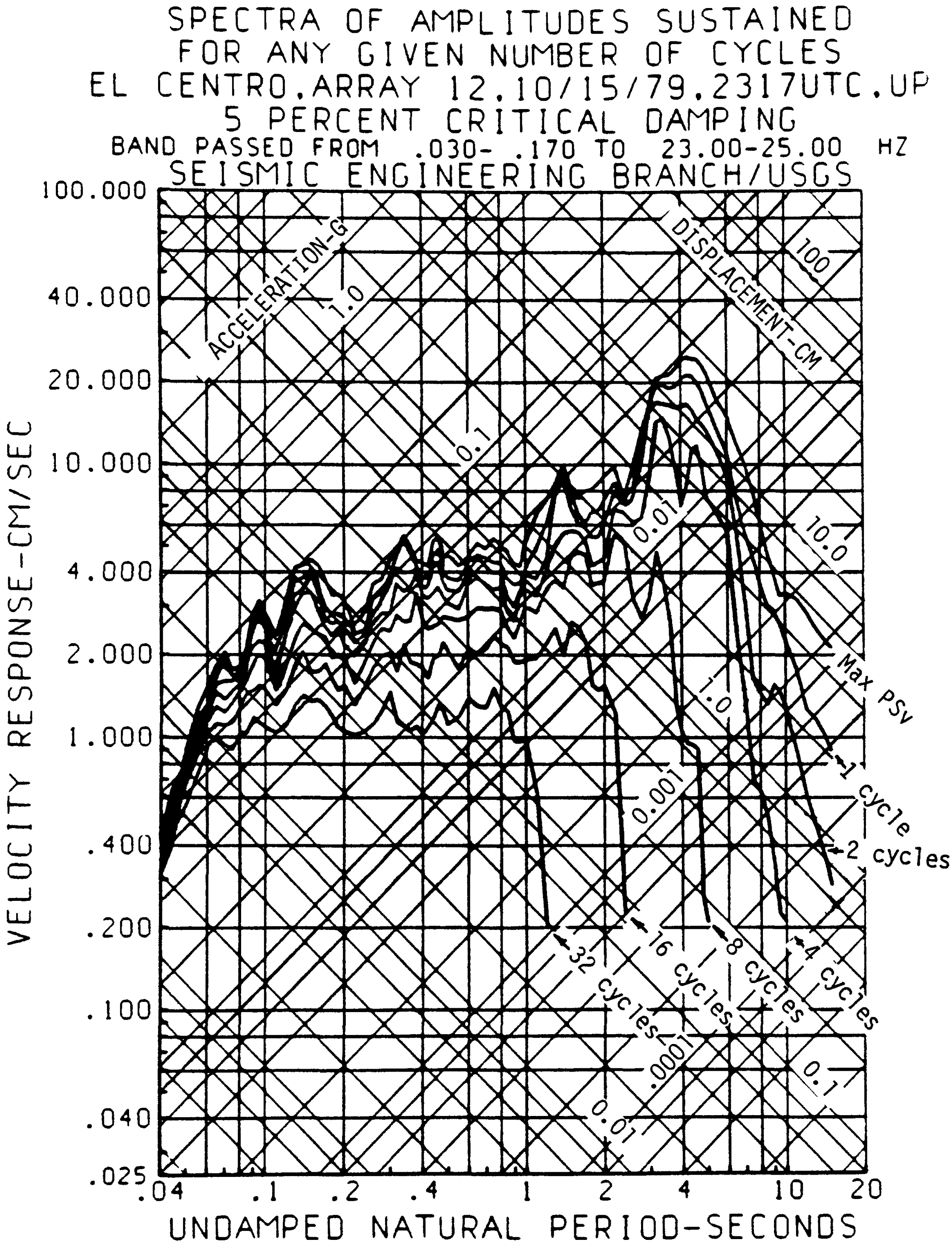
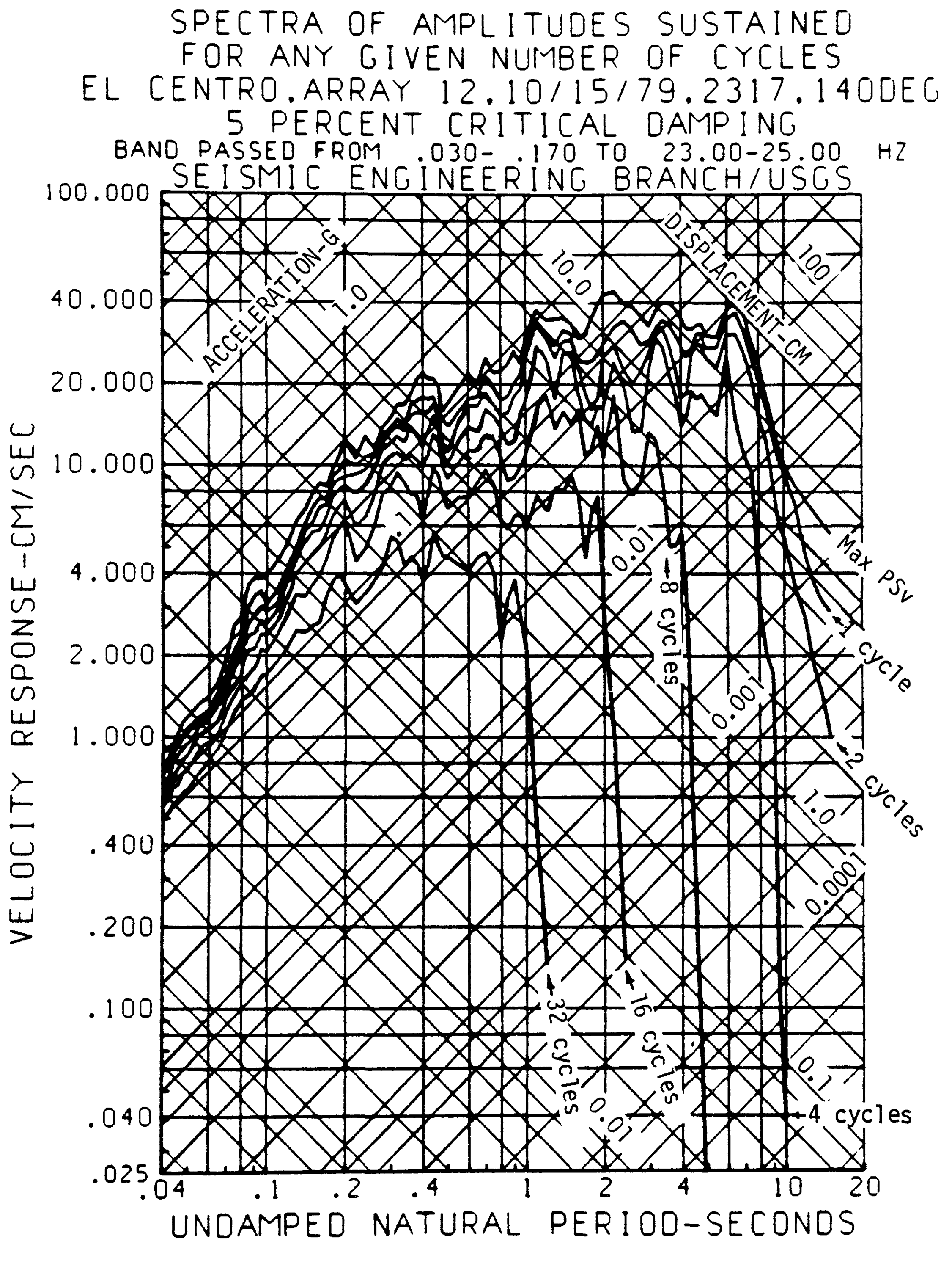
10
20


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 12,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
1.0
0.1
0.01
0.001
.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 12.10/15/79.2317.140DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
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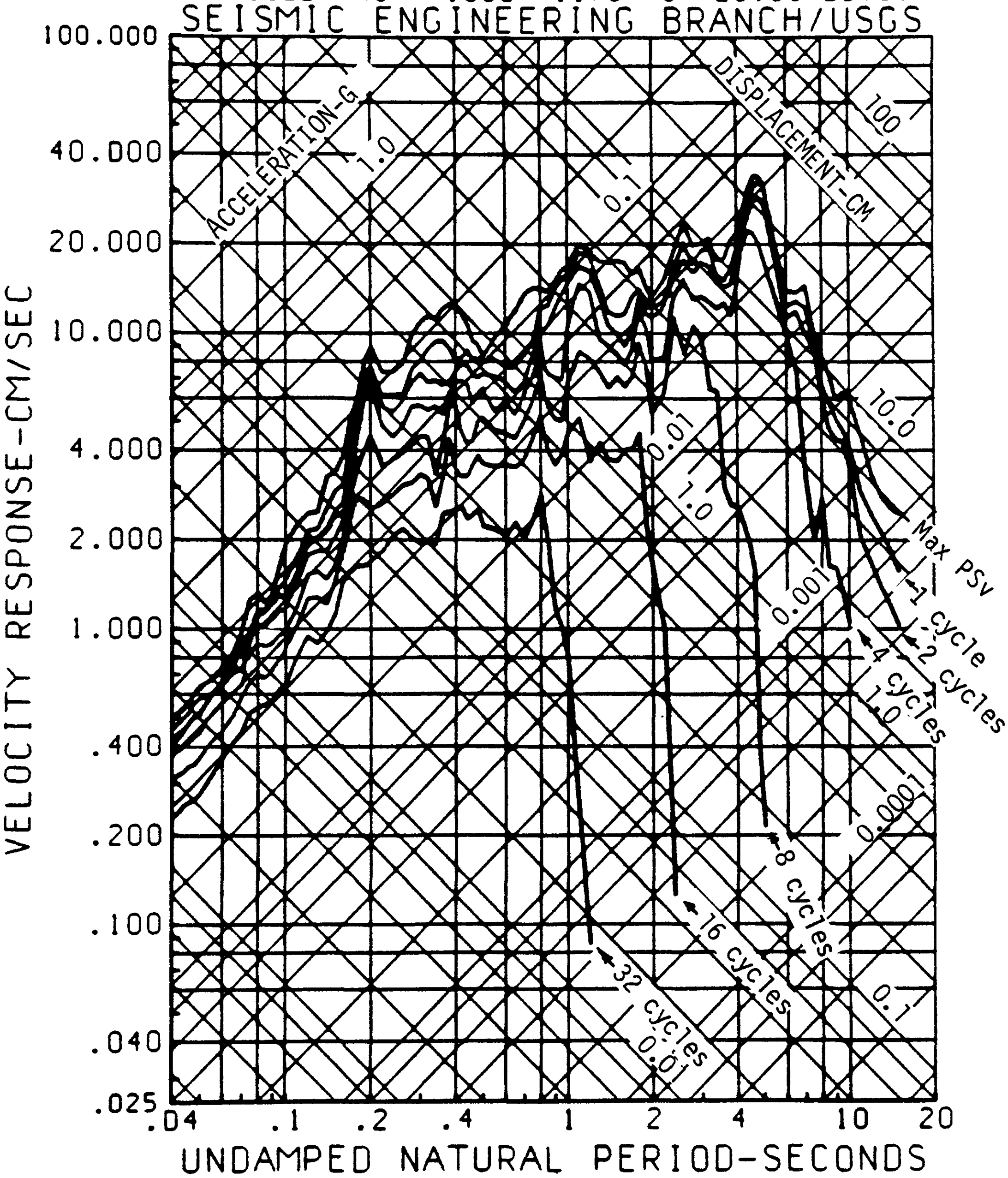
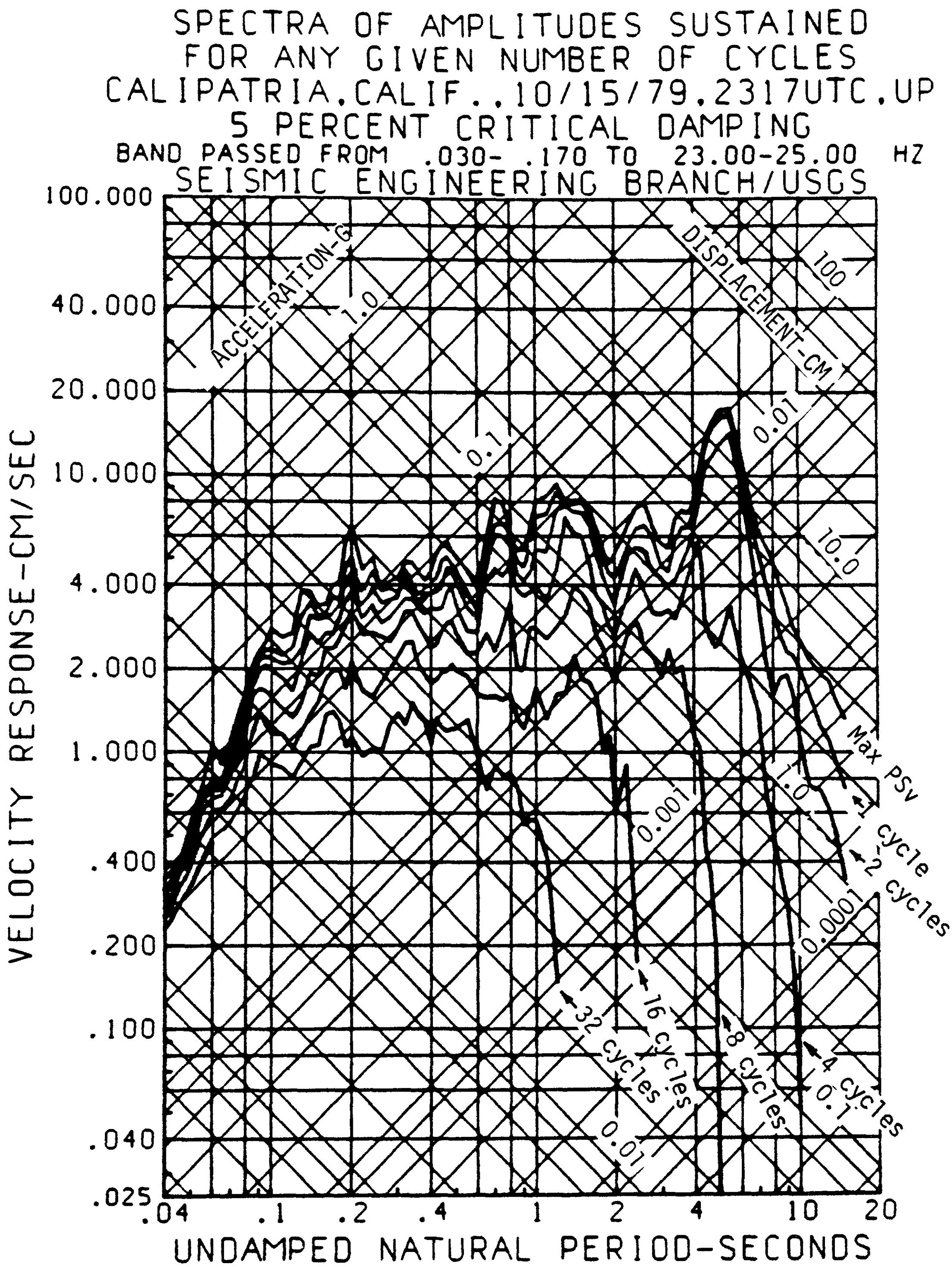
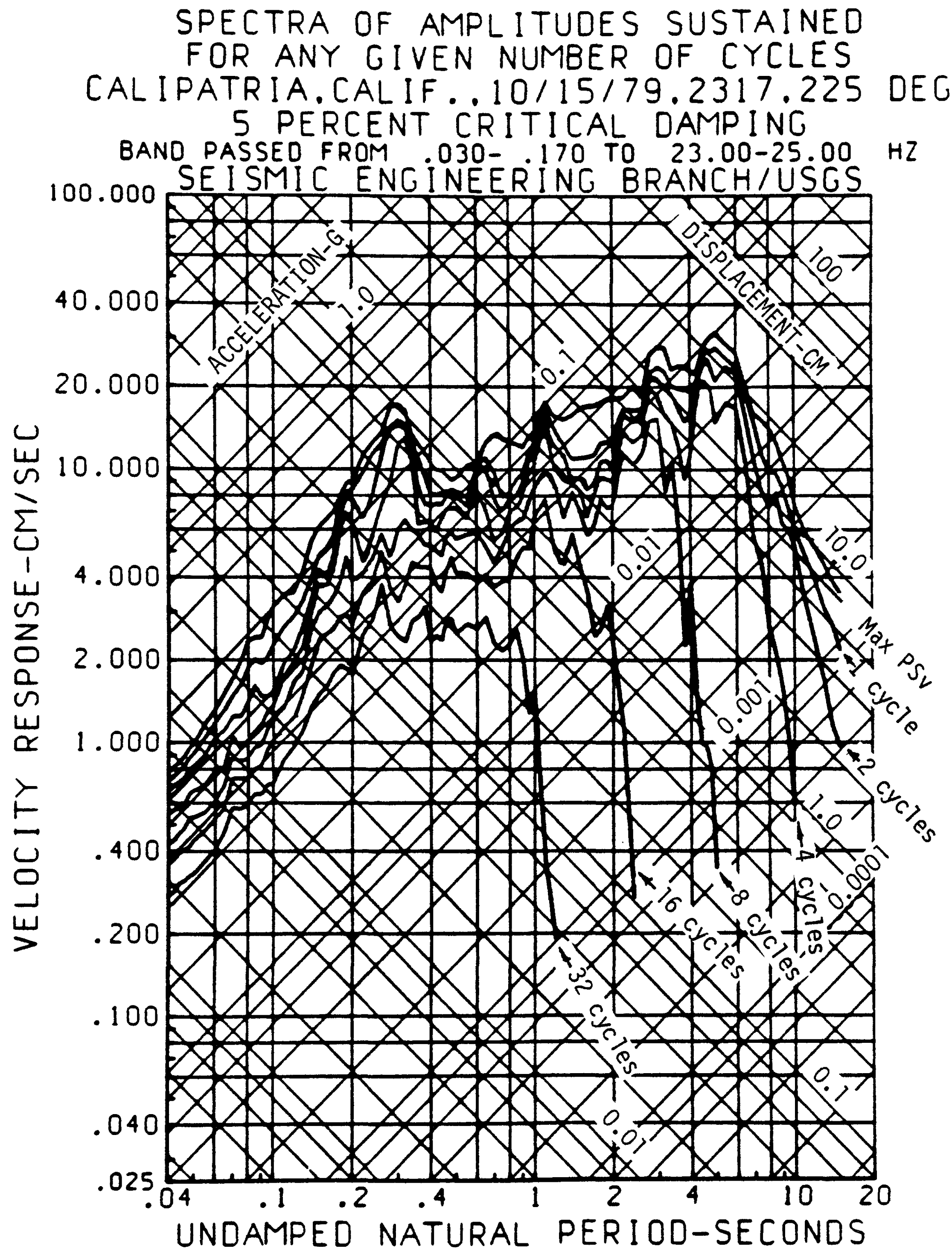
10
20

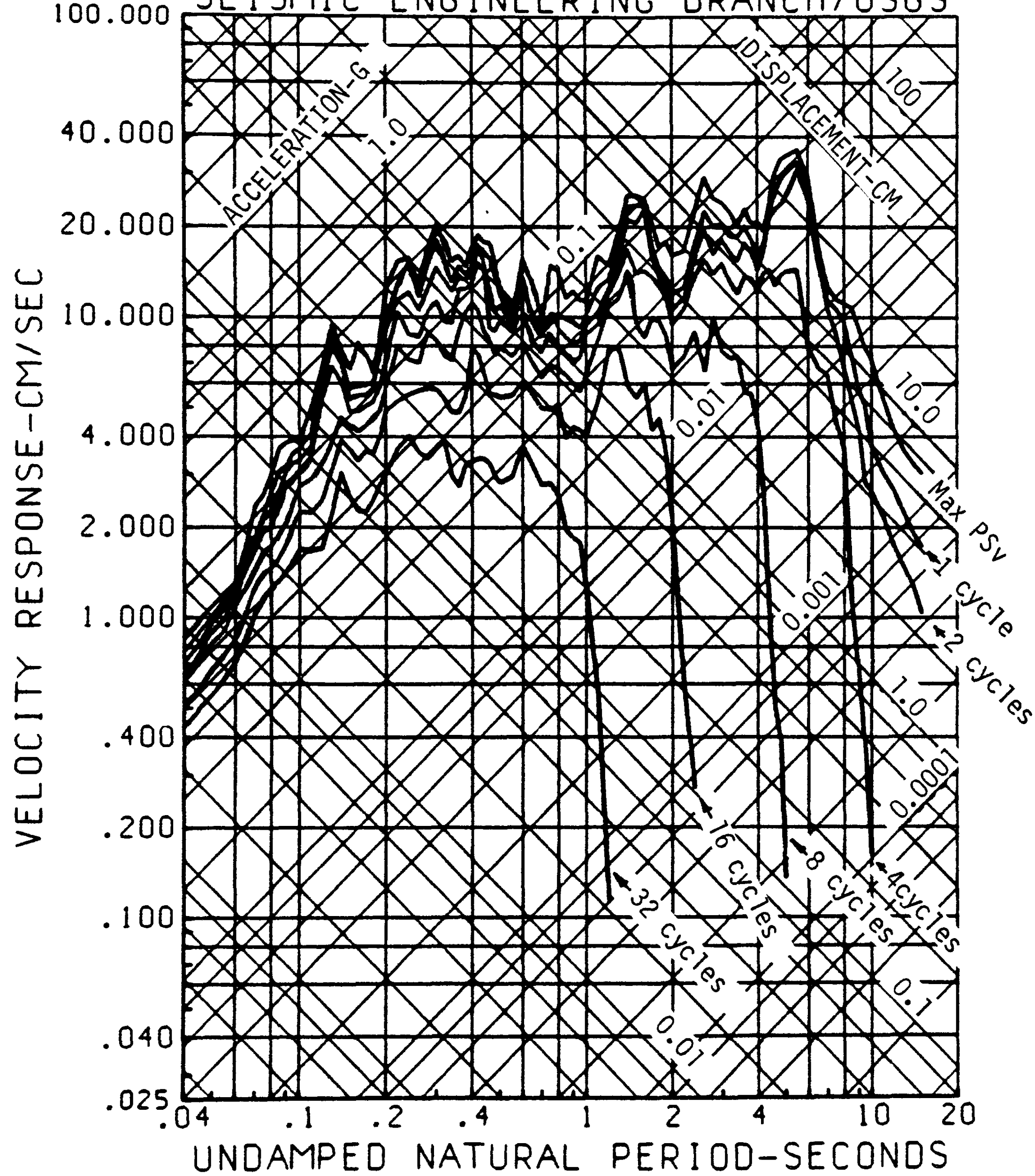
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
CALIPATRIA,CALIF.,10/15/79,2317,315 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

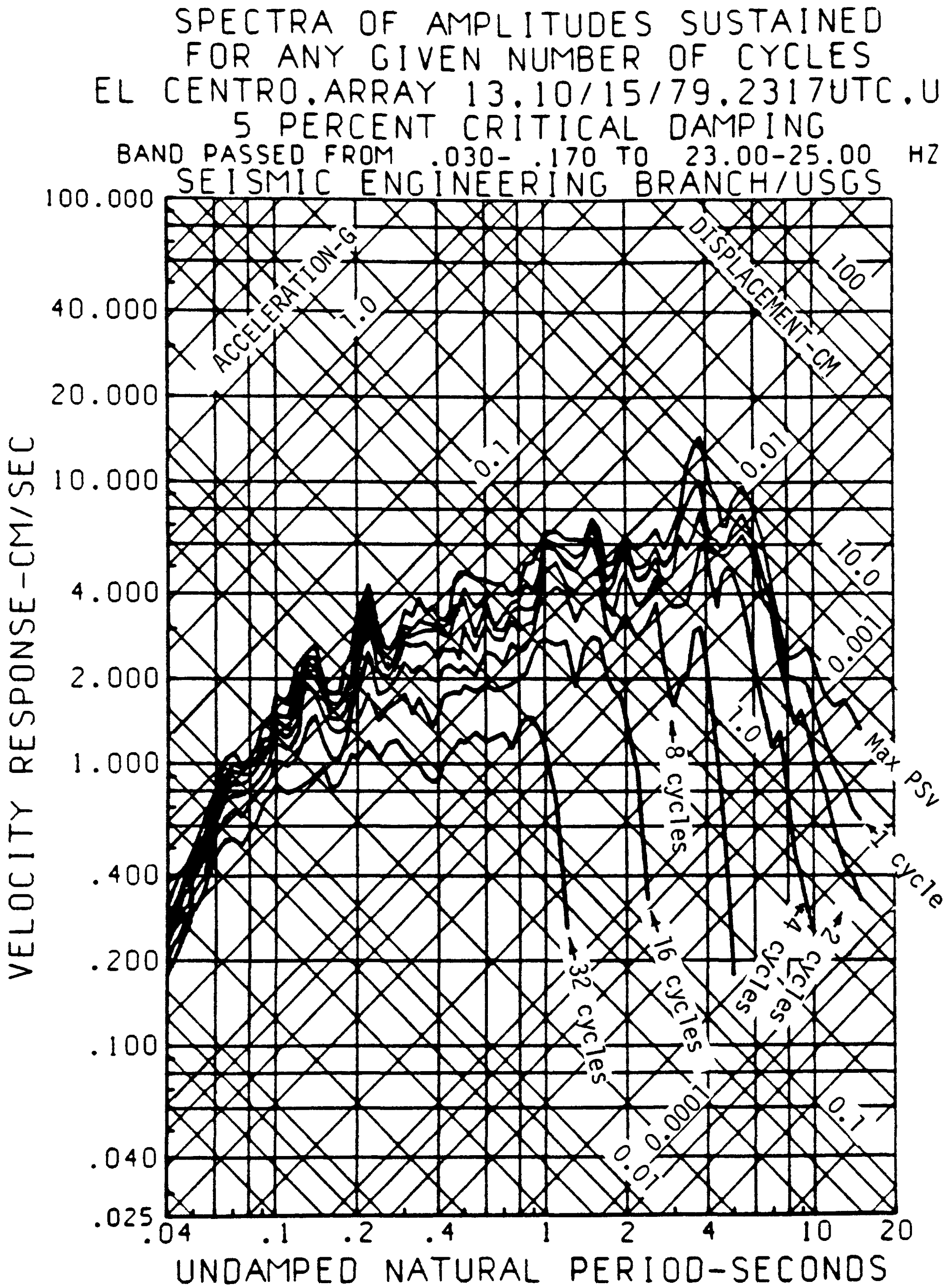



SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
CALIPATRIA,CALIF.,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
1.0
0.1
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

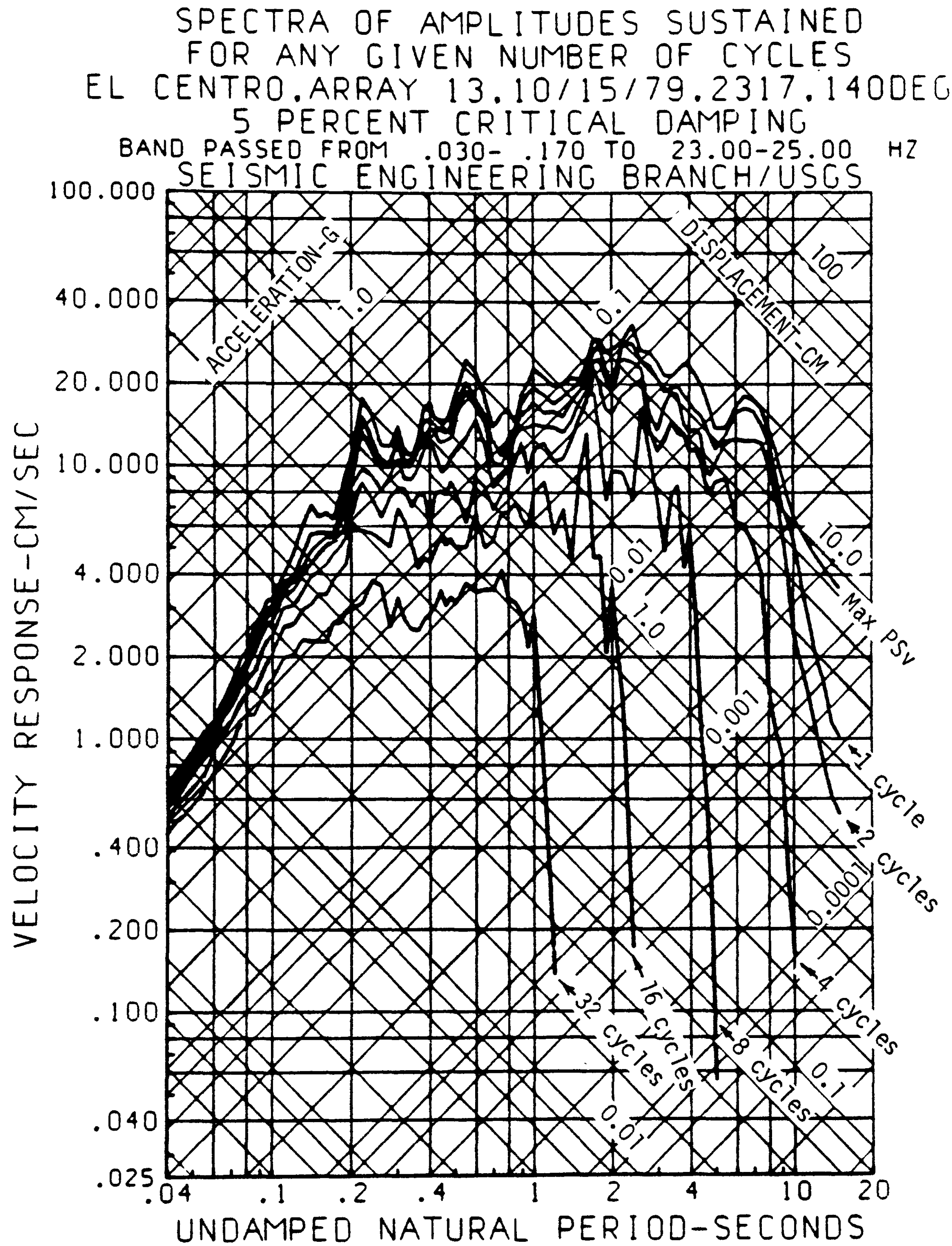

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
CALIPATRIA,CALIF.,10/15/79,2317,225 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
ACCELERATION-G
1.0
0.1
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO, ARRAY 13, 10/15/79, 2317, 230DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS





SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO.ARRAY 13.10/15/79.2317UTC.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1.0
0.1
0.01
0.001
0.0001
100
10.0
1.0
0.1
0.01
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles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FOR ANY GIVEN NUMBER OF CYCLES
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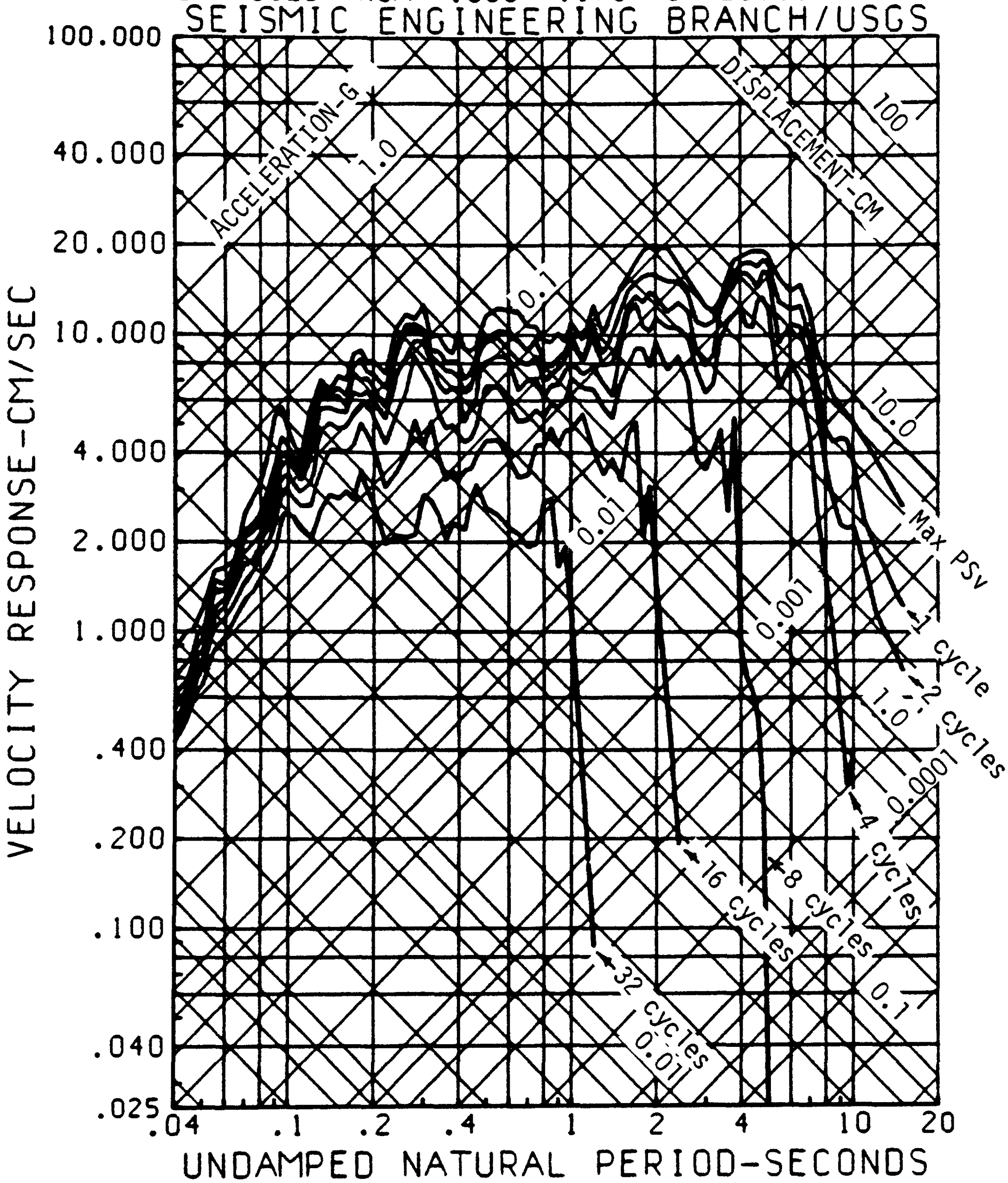
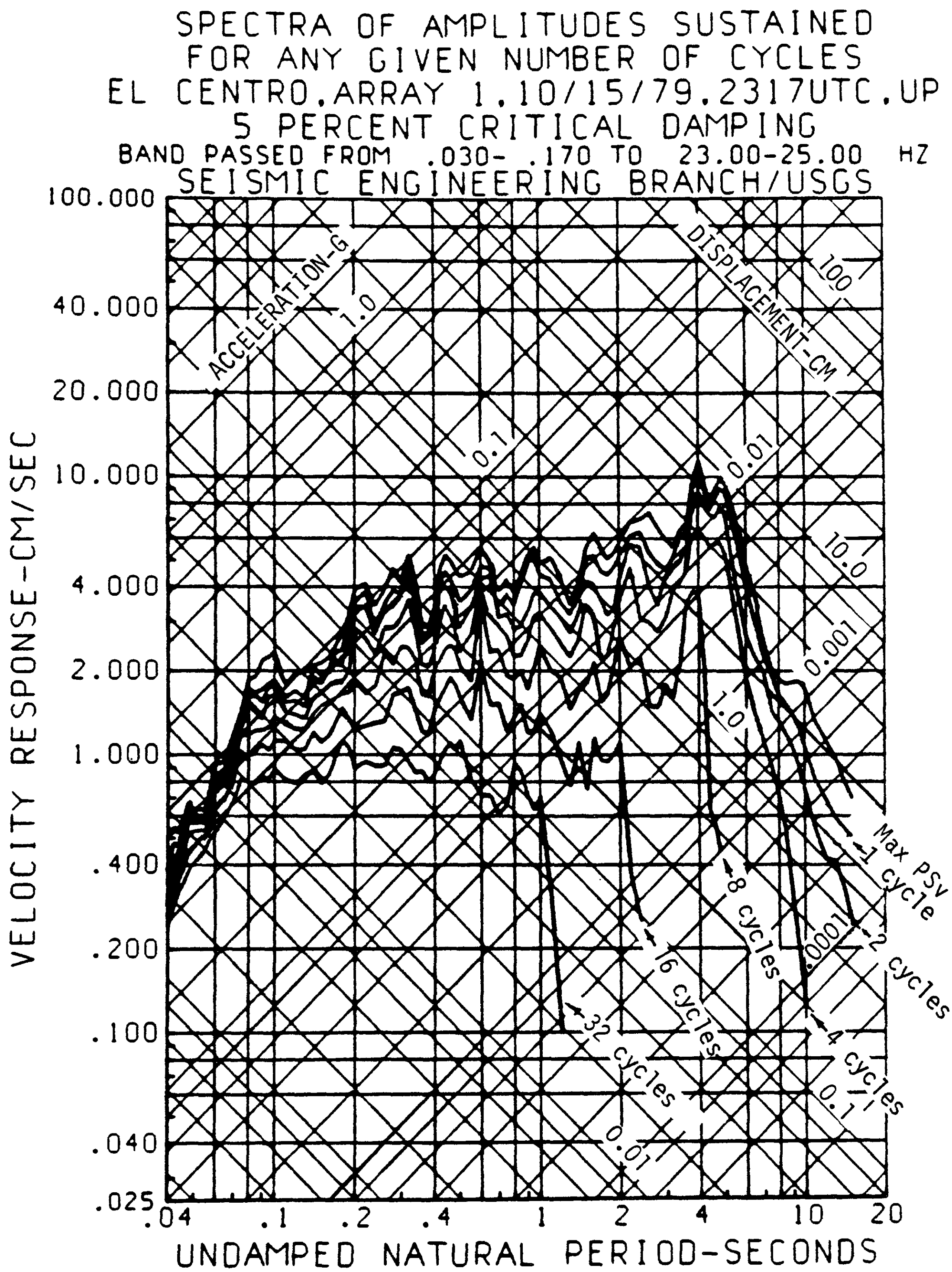
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
1.0
0.1
0.01
0.001
0.0001
100
10.0
1.0
0.1
0.01
Max PSv
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

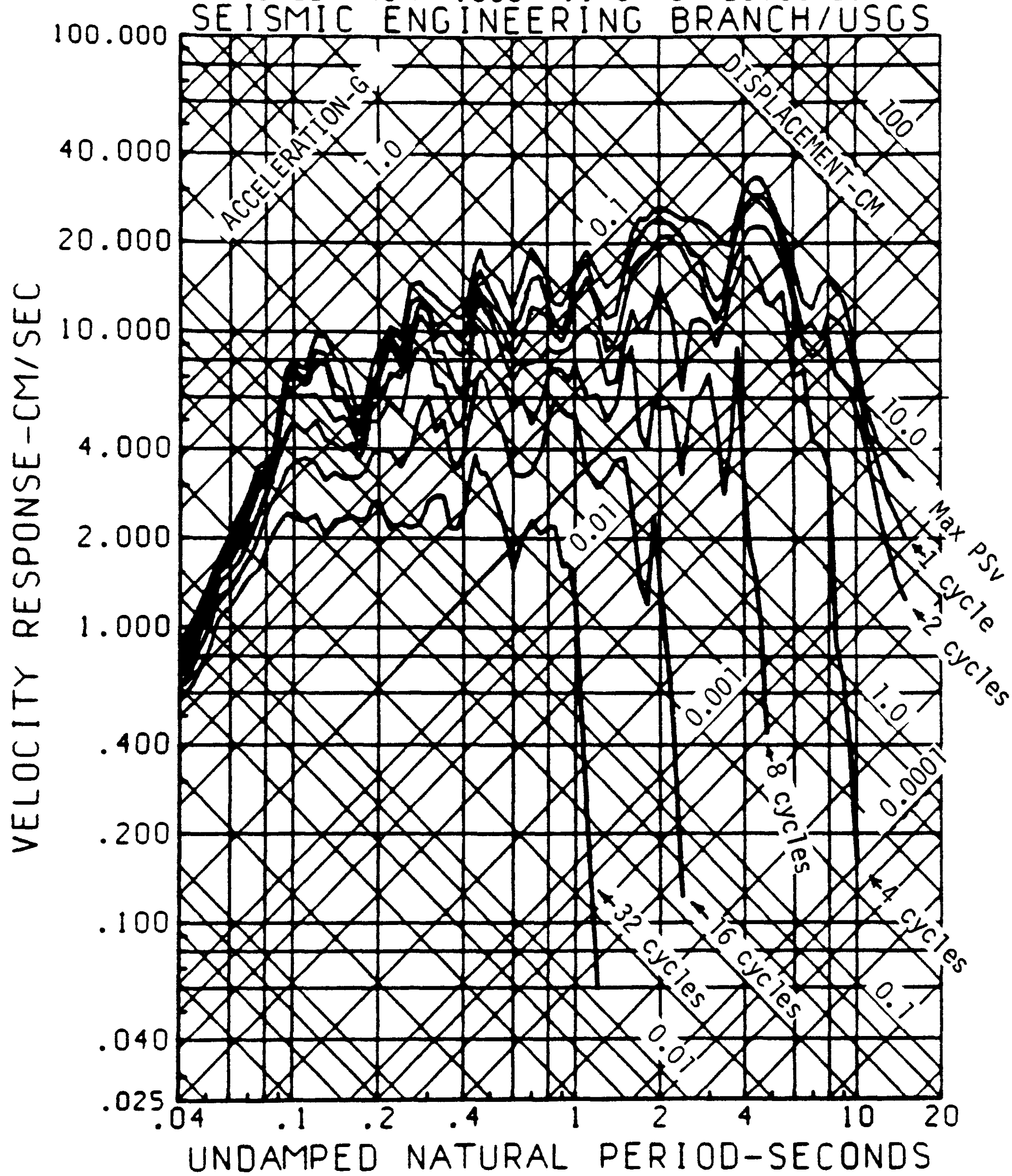
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 1,10/15/79,2317,230 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

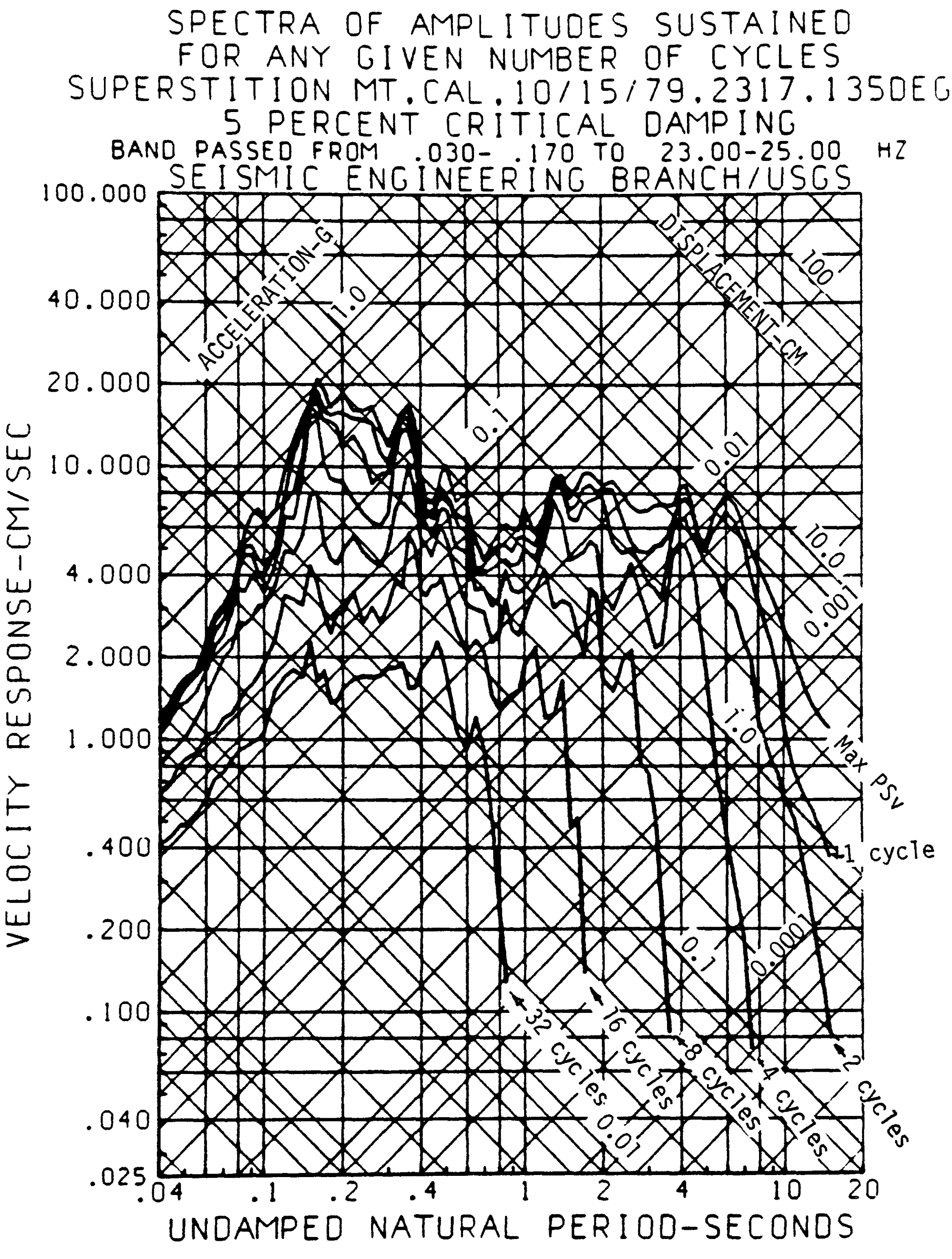


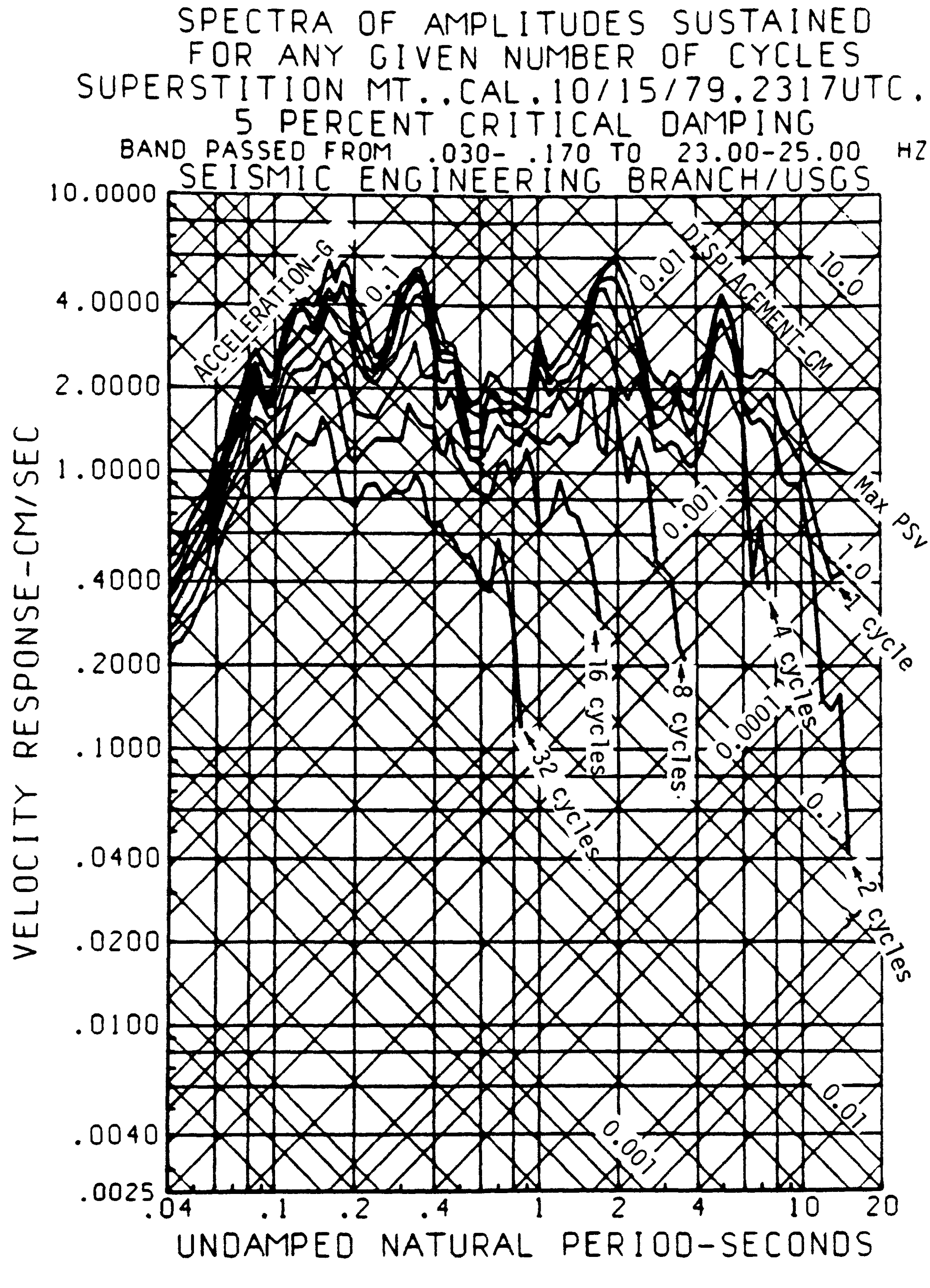


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 1,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
1.0
0.1
0.01
0.001
.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
EL CENTRO,ARRAY 1,10/15/79,2317,140 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

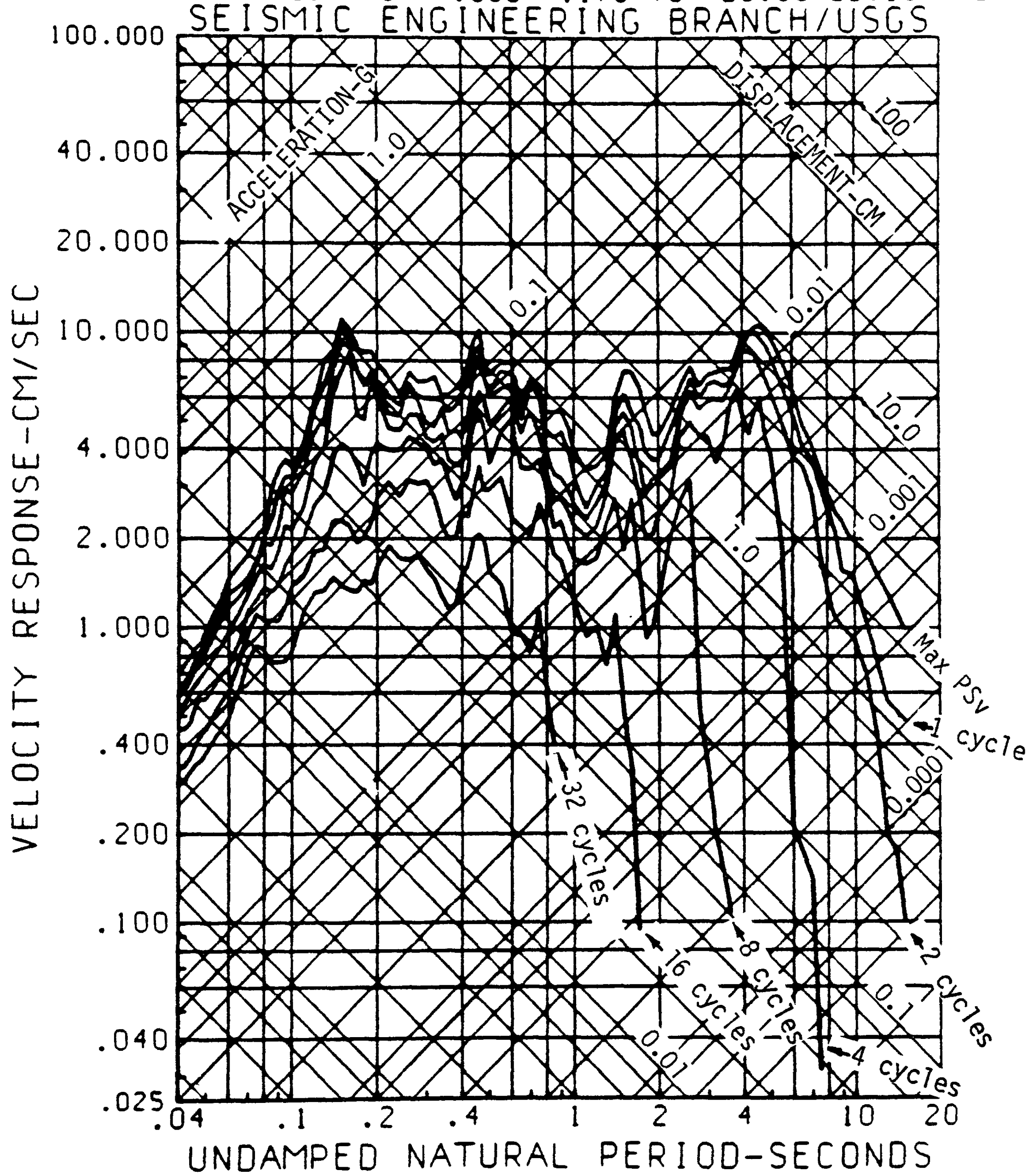


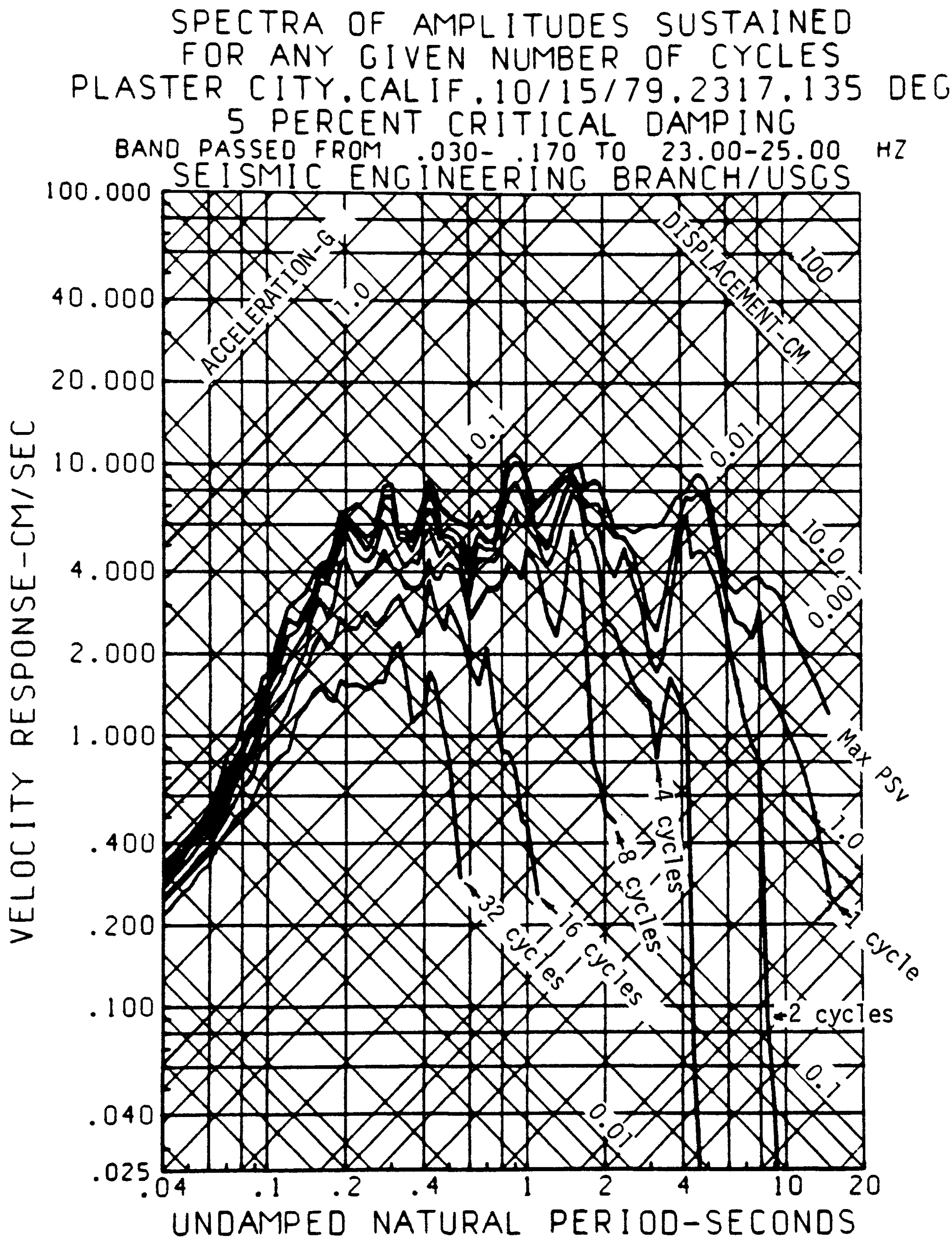

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
SUPERSTITION MT.CAL.10/15/79.2317.135DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20

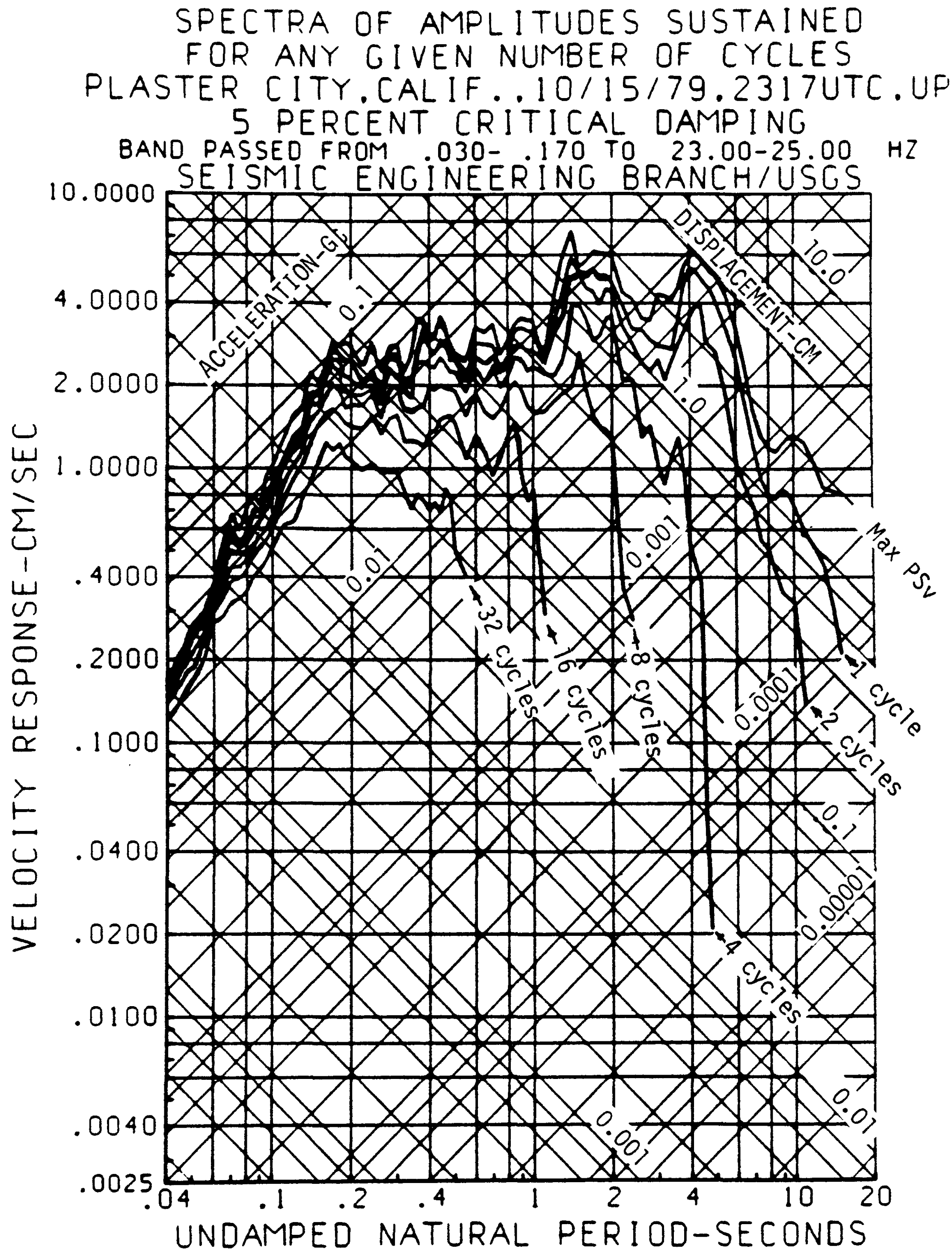


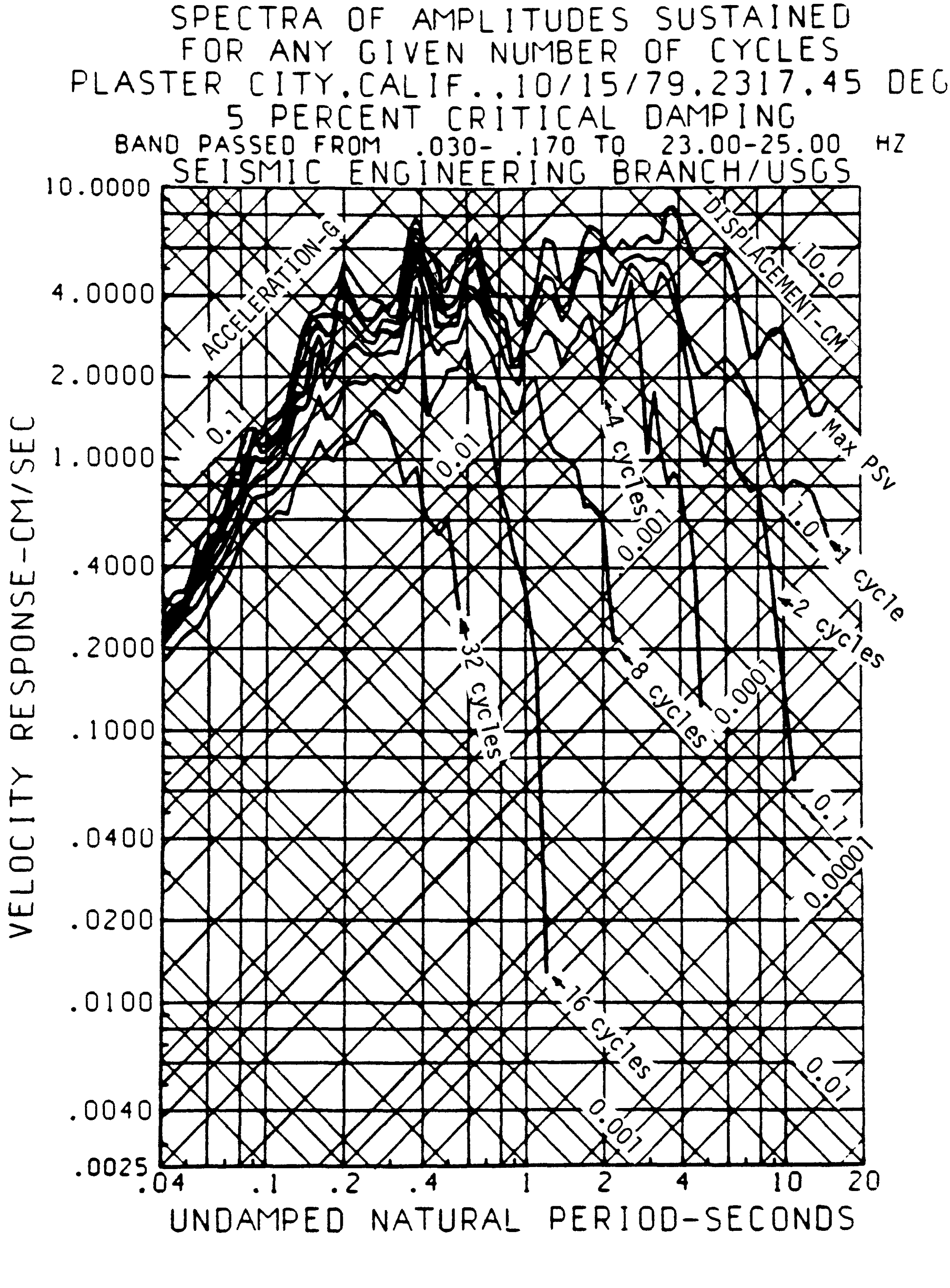
SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
SUPERSTITION MT..CAL.10/15/79.2317UTC.UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
10.0000
4.0000
2.0000
1.0000
.4000
.2000
.1000
.0400
.0200
.0100
.0040
.0025
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
0.1
0.01
10.0
0.001
1.0
0.0001
0.1
0.01
0.001
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
SUPERSTITION MT..CAL.10/15/79.2317.45DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS

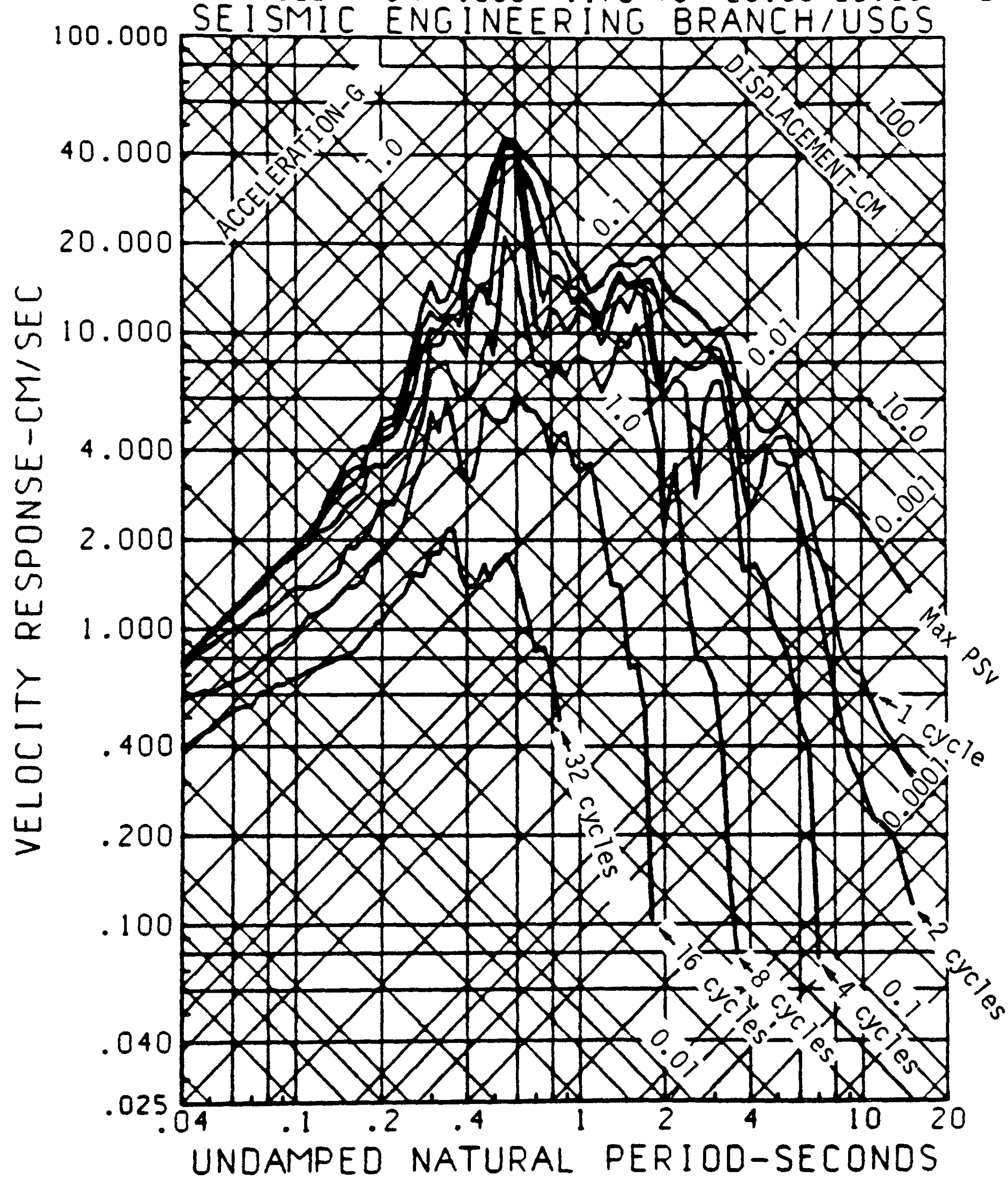


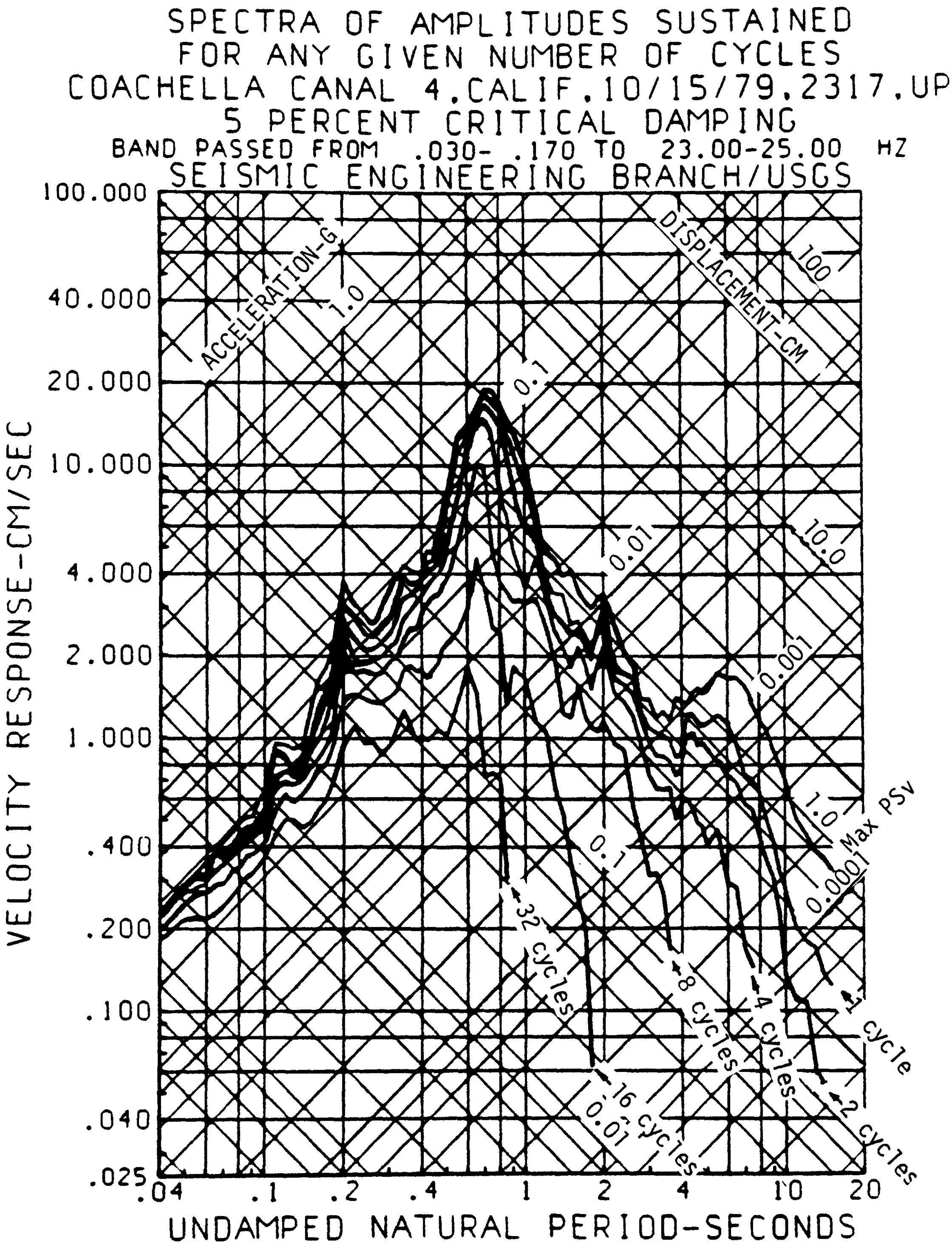

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
PLASTER CITY,CALIF,10/15/79,2317,135 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
1.0
0.1
0.01
0.001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSV
32 cycles
16 cycles
8 cycles
4 cycles
2 cycles
1 cycle

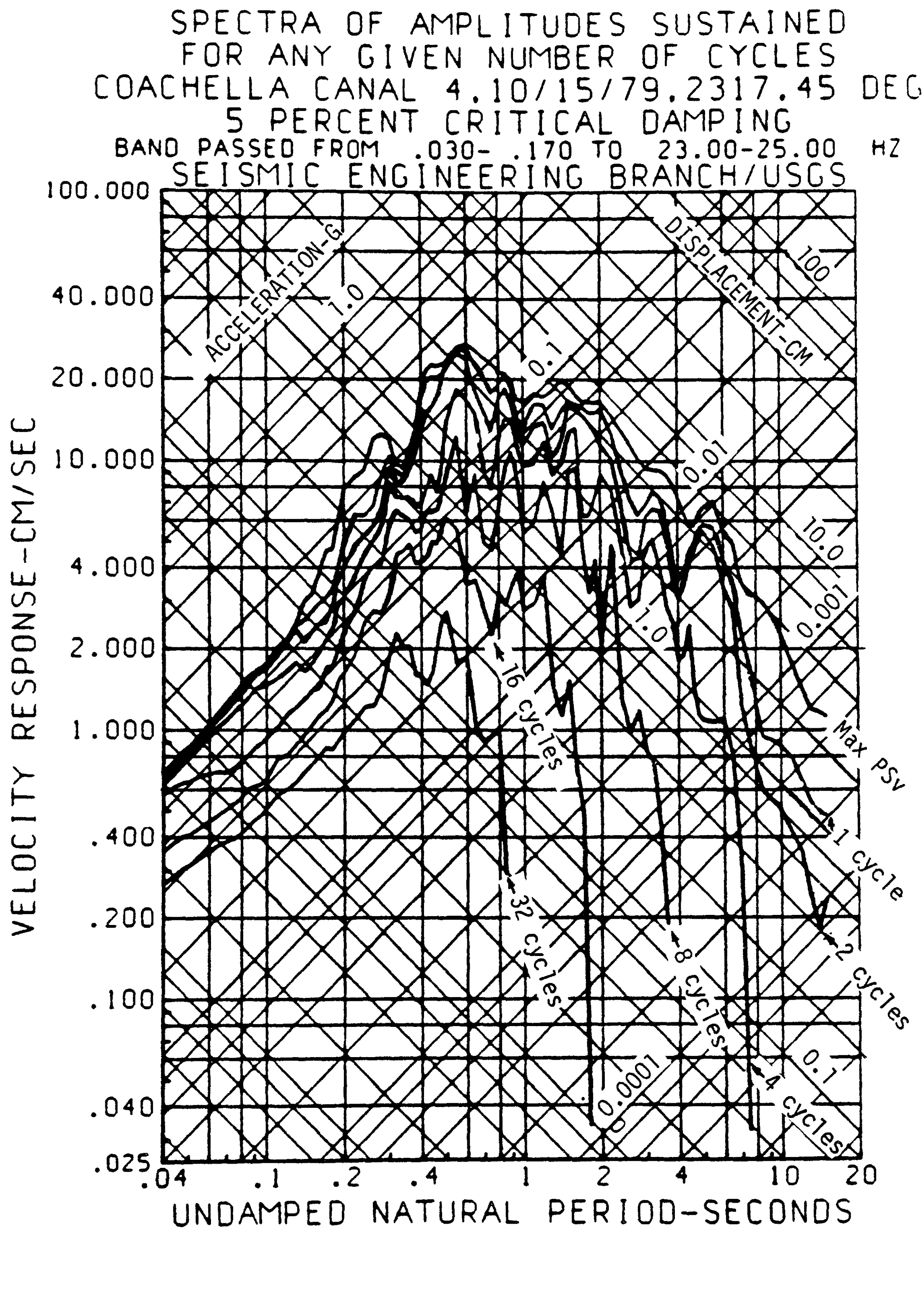

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
PLASTER CITY,CALIF.,10/15/79,2317UTC,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
10.0000
4.0000
2.0000
1.0000
.4000
.2000
.1000
.0400
.0200
.0100
.0040
.0025
.04
.1
.2
.4
1
2
4
10
20


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
PLASTER CITY,CALIF..10/15/79.2317.45 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
10.0000
4.0000
2.0000
1.0000
.4000
.2000
.1000
.0400
.0200
.0100
.0040
.0025
UNDAMPED NATURAL PERIOD-SECONDS
.04
.1
.2
.4
1
2
4
10
20
ACCELERATION-G
DISPLACEMENT-CM
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles

SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
COACHELLA CANAL 4.10/15/79.2317.135 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS




SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
COACHELLA CANAL 4,CALIF,10/15/79,2317,UP
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS
ACCELERATION-G
1.0
0.1
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
0.01
Max PSV
32 cycles
16 cycles
8 cycles
4 cycles
2 cycles
1 cycle


SPECTRA OF AMPLITUDES SUSTAINED
FOR ANY GIVEN NUMBER OF CYCLES
COACHELLA CANAL 4.10/15/79.2317.45 DEG
5 PERCENT CRITICAL DAMPING
BAND PASSED FROM .030- .170 TO 23.00-25.00 HZ
SEISMIC ENGINEERING BRANCH/USGS
VELOCITY RESPONSE-CM/SEC
100.000
40.000
20.000
10.000
4.000
2.000
1.000
.400
.200
.100
.040
.025
ACCELERATION-G
1.0
0.1
0.01
0.001
0.0001
DISPLACEMENT-CM
100
10.0
1.0
0.1
Max PSV
1 cycle
2 cycles
4 cycles
8 cycles
16 cycles
32 cycles
.04
.1
.2
.4
1
2
4
10
20
UNDAMPED NATURAL PERIOD-SECONDS