ENCLOSURE 3

San Onofre Nuclear Generating Station
Unit 1

RESPONSES TO NRC REQUEST FOR INFORMATION, TURBINE BUILDING RESPONSE SPECTRA

Submittal to:

Nuclear Regulatory Commission

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IMPELL CORPORATION

REPORT APPROVAL COVER SHEET

Client: SOUTHERN CALIFORNIA EDISON

Project: SONGS-1 Job Number: 0310-054-1355

Report Title: Responses to NRC Request for Information, Turbine Building Response Spectra

Report Number: 01-0310-1451 Rev. 0

The work described in this Report was performed in accordance with the Impell Quality Assurance Program. The signatures below verify the accuracy of this Report and its compliance with applicable quality assurance requirements.

Prepared By: Miguel A. Manrique Date 7/25/85

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REVISION RECORD

Rev. No.	Prepared	Reviewed	Approved	Approval Date	Revision

RESPONSES TO NRC REQUEST FOR INFORMATION

SSI ANALYSIS OF SONGS-1 TURBINE BUILDING

NRC REQUEST NO.1:

Provide summary of differences, if any, between Test Problem solutions provided previously and current methods. In particular, this is applicable to current Turbine Building response spectra correction factors and original FLORA methodology.

SCE RESPONSE:

In the solution of NRC test problem III (Reference 1), the "improved" wide-band option in program FLORA was used. This option accurately computes response spectral values for cases when the frequencies of the structure are close to the frequencies at which a spectral value is calculated (i.e., for "tuned" systems).

A computer program (program FACTOR) was written for the computation of the correction factors, applied to the Turbine Building spectra. The program FACTOR uses the basic methodology in program FLORA with the simplifying assumption of detuning between the structural frequencies and the requested spectral frequencies. This assumption is acceptable because we are not interested in the absolute value of the spectral response (since we have all the spectral values from the time histories) but are solely interested in the ratio of spectral values calculated by consistent formulations. It will be shown in "SCE response to NRC Request No. 2," of this report that the calculation of this ratio is independent of the method used to compute spectral ordinates.

NRC REQUEST NO. 2:

Use FLORA narrow-band methodology to calculate correction factors at two spectral points at two independent Turbine Building nodes and compare with analysis values.

SCE RESPONSE:

The objective of this request is to validate the method for computation of the correction factors used for the Turbine Building response spectra. The correction factors were calculated using the program FACTOR. The methodology used for the computation of these correction factors will be validated by computing the correction factors using the program FLORA. The NRC has approved the use of FLORA for SONGS-1 LTS evaluations. Furthermore, for purposes of the requested validation, the same test program used for the validation of FLORA will be used (Reference 1). Correction factors will be calculated using both the wide-band and the narrow-band FLORA options to generate spectra.

The model used for the analysis is shown in Figure 2.1. This is a fixed-base model provided by the NRC for FLORA verification purposes (NRC-test problem III, Reference 1). The modal properties (frequencies, mode shapes) generated for the test problem were used for the computation of the correction factors.

The design response spectrum (Modified Housner) and the response spectrum corresponding to the time history (North-South direction) for 4 percent damping were used as input. Both the design and the time history spectra are shown in Figure 2.2. The structural composite modal damping ratios were also assumed to be 4 percent for all modes. The analyses were performed using the structure's modal properties and the two input spectra. The procedure consists of evaluating the spectral ordinates for each input spectrum and taking the ratio of the results. The ratio of the spectral value obtained using the design spectrum to the spectral value obtained using the time history's spectrum gives the "correction factor." Correction factors were evaluated for the following cases:

1) Using the methodology in program FACTOR

2) Using the FLORA wide-band approach

3) Using the FLORA narrow-band approach

Spectral values were computed at two nodes (node 4 and 11) in the model and at a total of 26 frequencies, including the fundamental structural frequency (5.26 Hz). Consistent with the application used used for the Turbine Building, the mass of the secondary system is zero (EM=0), i.e., primary-secondary system interaction is not considered.

RESULTS:

Table 2.1 shows a comparison of the correction factors. For each frequency and each node, the percentage difference between the correction factor calculated using FACTOR and FLORA are calculated as follows:

$$\text{\% difference FACTOR VS. FLORA (Wide-Band)} = \left[\frac{\text{Correction factor using FACTOR}}{\text{Correction factor using FLORA (Wide-Band)}} - 1\right] \times 100$$

$$\text{\% difference FACTOR VS. FLORA (Narrow-Band)} = \left[\frac{\text{Correction factor using FACTOR}}{\text{Correction factor using FLORA (Narrow-Band)}} - 1\right] \times 100$$

Table 2.1 shows that the method used to calculate the correction factors implemented in the Turbine Building spectra are similar to those calculated with FLORA using either the wide- or the narrow-band options. In Table 2.1, a positive percentage difference indicates that the values calculated by FACTOR are conservative, i.e., less reduction is applied to the time history's spectra. As shown in the Table 2.1, the largest differences between FACTOR and FLORA are positive, thus conservative.

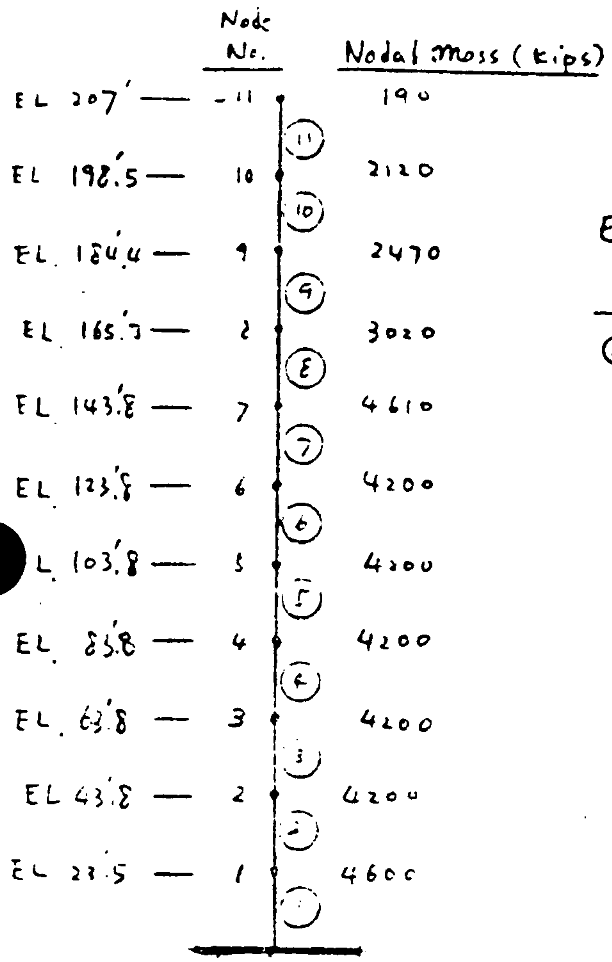
CONCLUSION:

The methodology used for the development of correction factors applied for the Turbine Building response spectra is correct and conservative.

TABLE 2.1
COMPARISON OF CORRECTION FACTORS

Frequency (cps.)	Node 4 FACTOR VS FLORA (Wide-Band) (%)	Node 4 FACTOR VS FLORA (Narrow-Band) (%)	Node 11 FACTOR VS FLORA (Wide-Band) (%)	Node 11 FACTOR VS FLORA (Narrow-Band) (%)
0.3	0.0	-8.6	0.0	-8.6
0.4	0.0	0.0	0.0	0.0
0.7	0.0	17.3	1.1	17.3
1.0	0.0	1.4	-1.4	2.9
1.5	-1.2	1.3	0.0	0.0
2.0	0.0	0.0	-1.3	0.0
2.5	1.1	-3.3	0.0	-4.4
3.0	0.0	2.6	0.0	2.6
3.5	0.0	-1.2	0.0	-2.4
4.0	0.0	0.0	1.3	1.3
4.5	0.0	2.5	0.0	2.5
5.0	1.3	1.3	1.3	1.3
5.26	1.3	0.0	1.3	-1.2
5.5	1.2	-1.2	0.0	-2.4
6.0	1.2	-2.4	1.2	-3.4
6.5	1.2	-1.2	1.2	-2.3
7.0	0.0	-1.2	0.0	-2.3
7.5	0.0	-1.2	0.0	-2.4
8.0	-1.2	0.0	-1.2	-3.5
9.0	0.0	1.2	0.0	-2.3
10.0	0.0	1.2	0.0	-1.2
12.0	0.0	1.2	0.0	-2.3
15.0	1.2	5.1	1.2	3.8
20.0	3.7	0.0	2.5	-1.2
25.0	2.5	0.0	3.7	-1.2
30.0	7.4	3.6	12.5	2.3

Structure Description

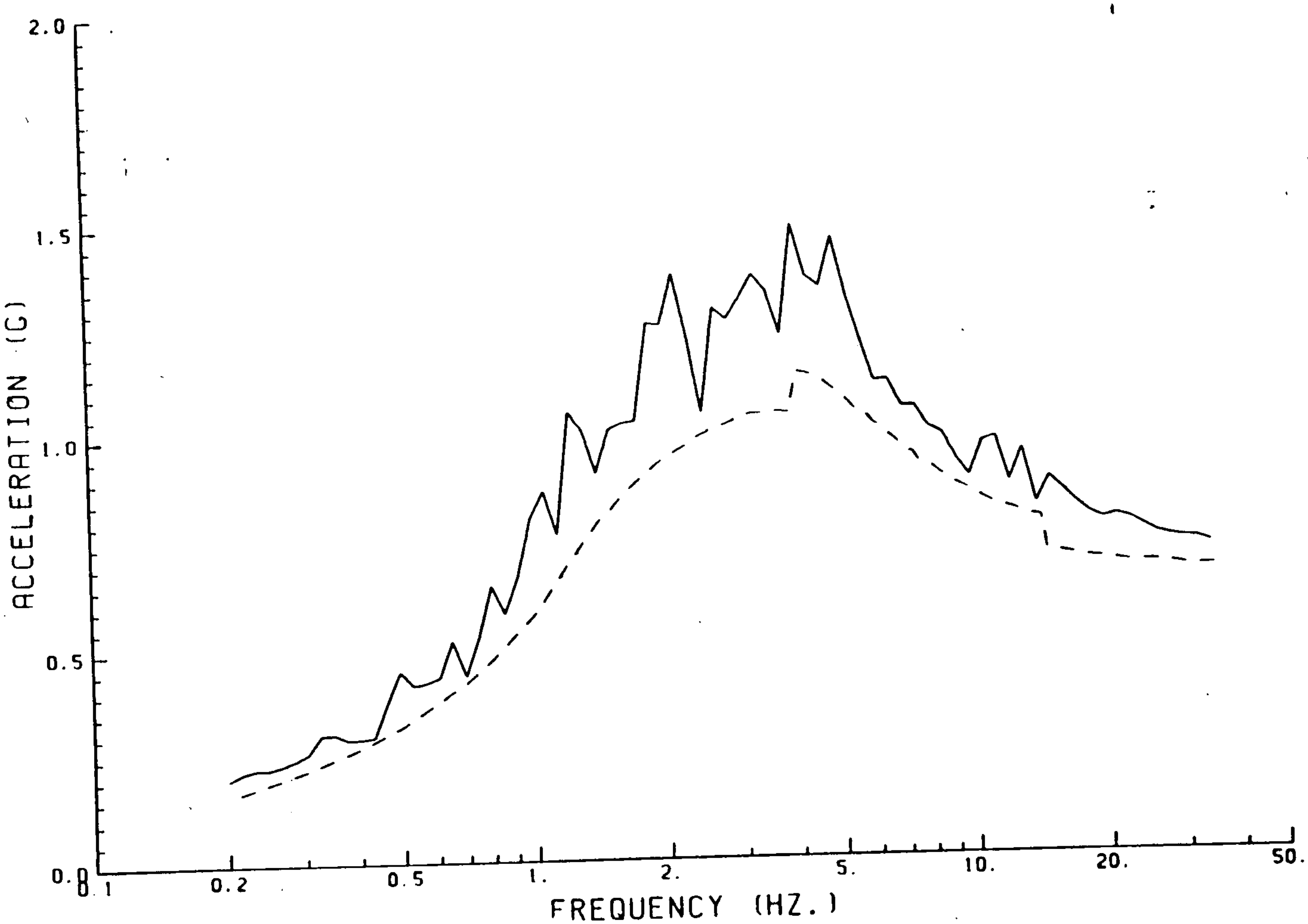


The structure has 11 massless beams. Their properties are as follows:

Element no.	Section area (ft^2)	shear area (ft^2)	moment of inertia (ft^4)
① ~ ⑦	1400	700	2.8×10^6
⑧	990	500	1.9×10^6
⑨	990	500	1.5×10^6
⑩	990	500	0.8×10^6
⑪	990	500	0.2×10^6

STRUCTURAL MODEL FOR NRC TEST PROBLEM III
(REFERENCE 1)

FIGURE 2.1



SCE-SONGS1
DESIGN (DASHED LINE) VERSUS ENVELOPE (SOLID LINE) SPECTRA
NORTH-SOUTH DIRECTION
4 PERCENT DAMPING

FIGURE 2.2

NRC REQUEST NO. 3:

Provide comparison of Turbine Building floor response spectra with previous Bechtel spectra at two locations.

SCE RESPONSE:

Raw response spectra, for 2% damping, generated by Impell and those generated by Bechtel are provided for the following locations:

1) Nodes 580, 586 and 610 in Area 2, North Extension, Elev. 42.0' for North-South Direction.

2) Nodes 29, 71 and 86 in Area 6, West Heater Platform, Elev. 35.0' for East-West and Vertical directions.

Table 3.1 lists the spectra being transmitted.

TABLE 3.1

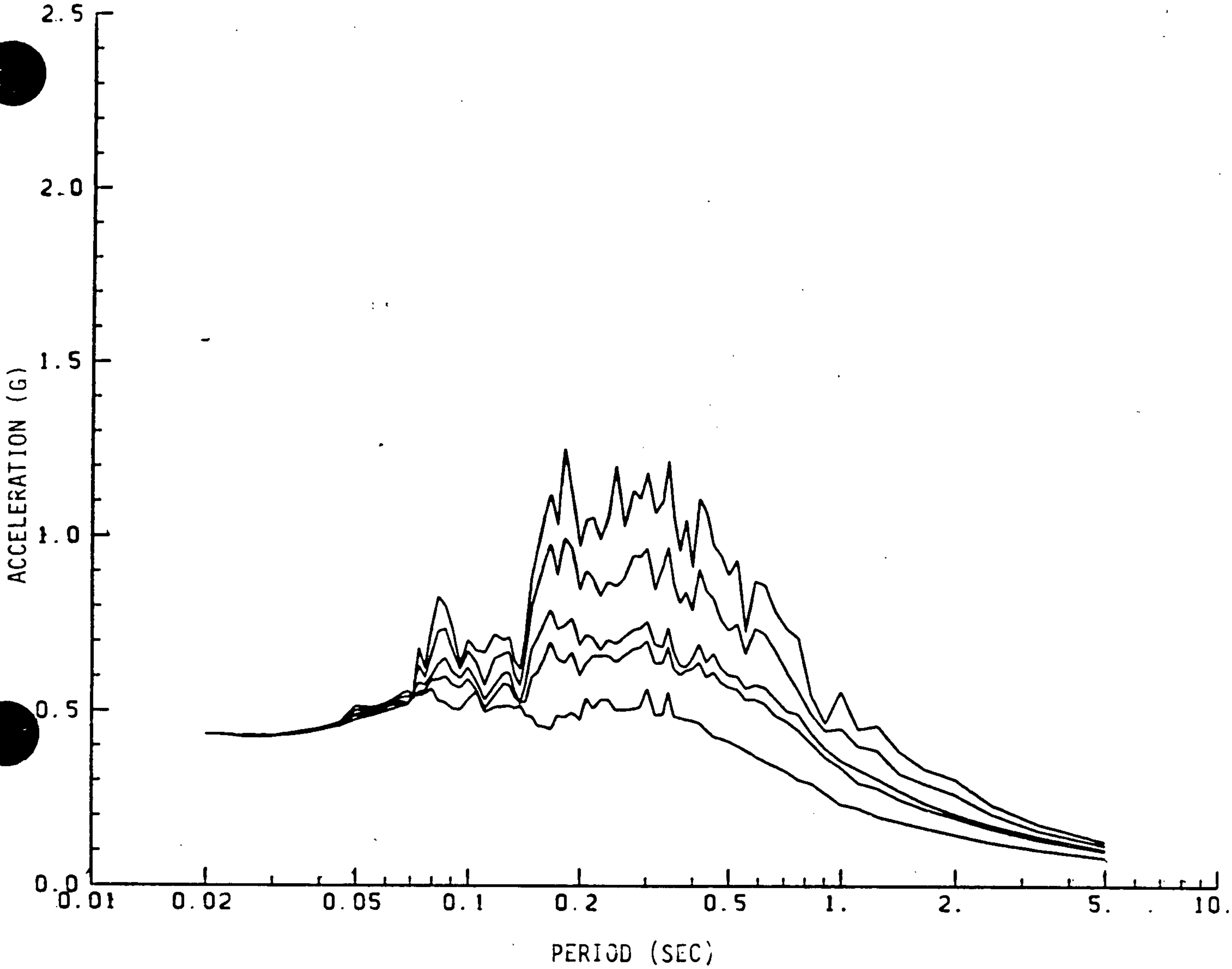
COMPARISON OF IMPELL AND BECHTEL RAW SPECTRA

Note:	For Figures 1 to 18, all spectra are for the analysis case of in-situ soil, and the crane located at the south end of the Turbine Building.
Figure 1	Impell Raw Spectra. Turbine Building. West Heater Platform. East West (Y) Direction. Area 6. Elevation 35.5 Feet. 2,3,5,7,15% damping. Node 29.
Figure 2	Impell Raw Spectra. Turbine Building. West Heater Platform. East West (Y) Direction. Area 6. Elevation 35.5 Feet. 2,3,5,7,15% damping. Node 71.
Figure 3	Impell Raw Spectra. Turbine Building. West Heater Platform. East West (Y) Direction. Area 6. Elevation 35.5 Feet. 2,3,5,7,15% damping. Node 86.
Figure 4	Impell Raw Spectra. Turbine Building. West Heater Platform. Vertical (Z) Direction. Area 6. Elevation 35.5 Feet. 2,3,5,7,15% damping. Node 29.
Figure 5	Impell Raw Spectra. Turbine Building. West Heater Platform. Vertical (Z) Direction. Area 6. Elevation 35.5 Feet. 2,3,5,7,15% damping. Node 71.
Figure 6	Impell Raw Spectra. Turbine Building. West Heater Platform. Vertical (Z) Direction. Area 6. Elevation 35.5 Feet. 2,3,5,7,15% damping. Node 86.
Figure 7	Impell Raw Spectra. Turbine Building. North Extension. North South (X) Direction. Area 2. Elevation 42.0 Feet. 2,3,5,7,15% damping. Node 580.
Figure 8	Impell Raw Spectra. Turbine Building. North Extension. North South (X) Direction. Area 2. Elevation 42.0 Feet. 2,3,5,7,15% damping. Node 586.
Figure 9	Impell Raw Spectra. Turbine Building. North Extension. North South (X) Direction. Area 2. Elevation 42.0 Feet. 2,3,5,7,15% damping. Node 610.
Figure 10	Bechtel Raw and Enveloped Spectra. Turbine Building. West Heater Platform. East West (Y) Direction. Area 6. Elevation 35.5 Feet. 2% damping. Node 29.

TABLE 3.1 (Continued)

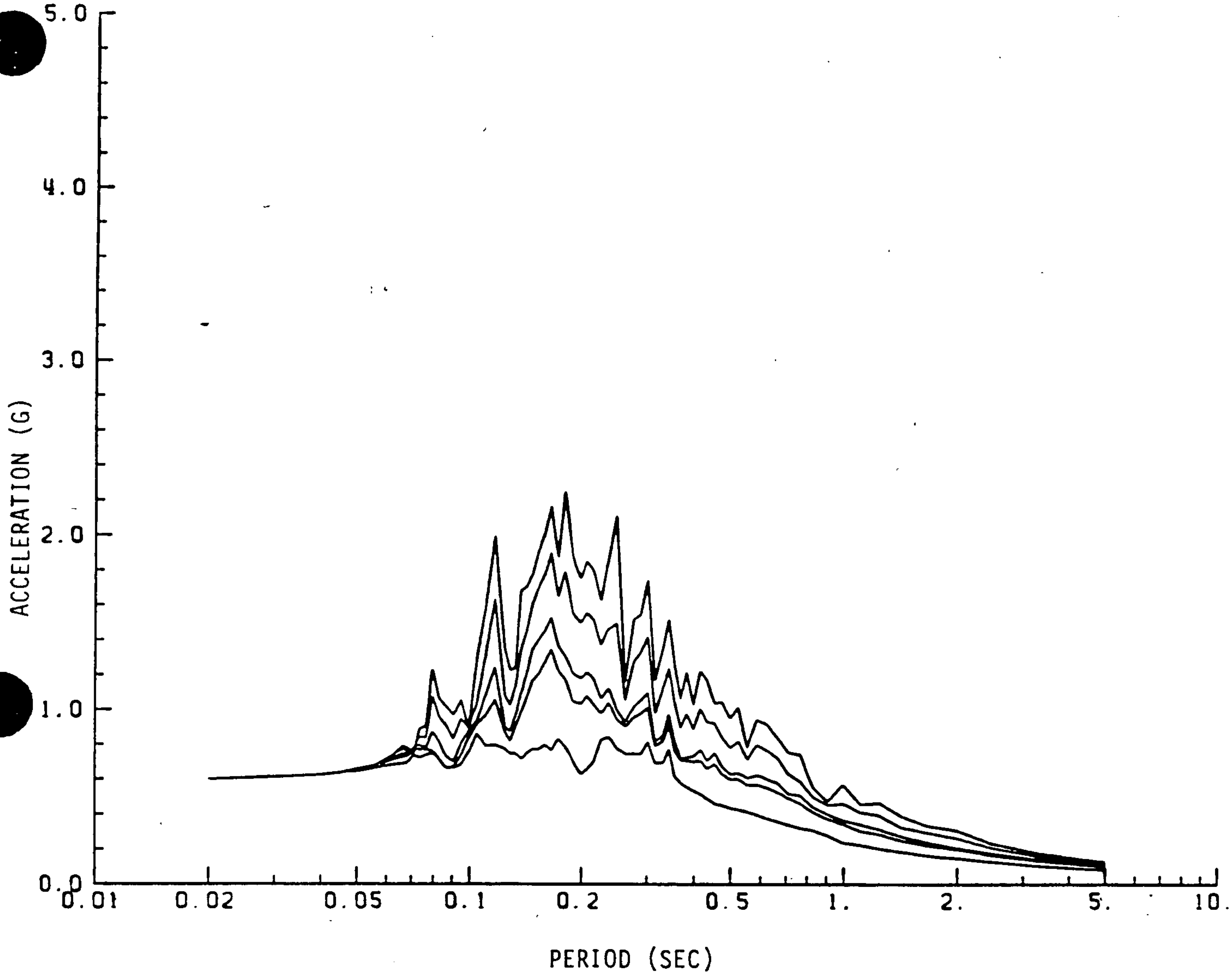
COMPARISON OF IMPELL AND BECHTEL RAW SPECTRA

Figure 11	Bechtel Raw and Enveloped Spectra. Turbine Building. West Heater Platform. East West (Y) Direction. Area 6. Elevation 35.5 Feet. 2% damping. Node 71.
Figure 12	Bechtel Raw and Enveloped Spectra. Turbine Building. West Heater Platform. East West (Y) Direction. Area 6. Elevation 35.5 Feet. 2% damping. Node 86.
Figure 13	Bechtel Raw and Enveloped Spectra. Turbine Building. West Heater Platform. Vertical (Z) Direction. Area 6. Elevation 35.5 Feet. 2% damping. Node 29.
Figure 14	Bechtel Raw and Enveloped Spectra. Turbine Building. West Heater Platform. Vertical (Z) Direction. Area 6. Elevation 35.5 Feet. 2% damping. Node 71.
Figure 15	Bechtel Raw and Enveloped Spectra. Turbine Building. West Heater Platform. Vertical (Z) Direction. Area 6. Elevation 35.5 Feet. 2% damping. Node 86.
Figure 16	Bechtel Raw and Enveloped Spectra. Turbine Building. North Extension. North South (X) Direction. Area 2. Elevation 42.0 Feet. 2% damping. Node 580.
Figure 17	Bechtel Raw and Enveloped Spectra. Turbine Building. North Extension. North South (X) Direction. Area 2. Elevation 42.0 Feet. 2% damping. Node 586.
Figure 18	Bechtel Raw and Enveloped Spectra. Turbine Building. North Extension. North South Direction. Area 2. Elevation 42.0 Feet. 2% damping. Node 610.



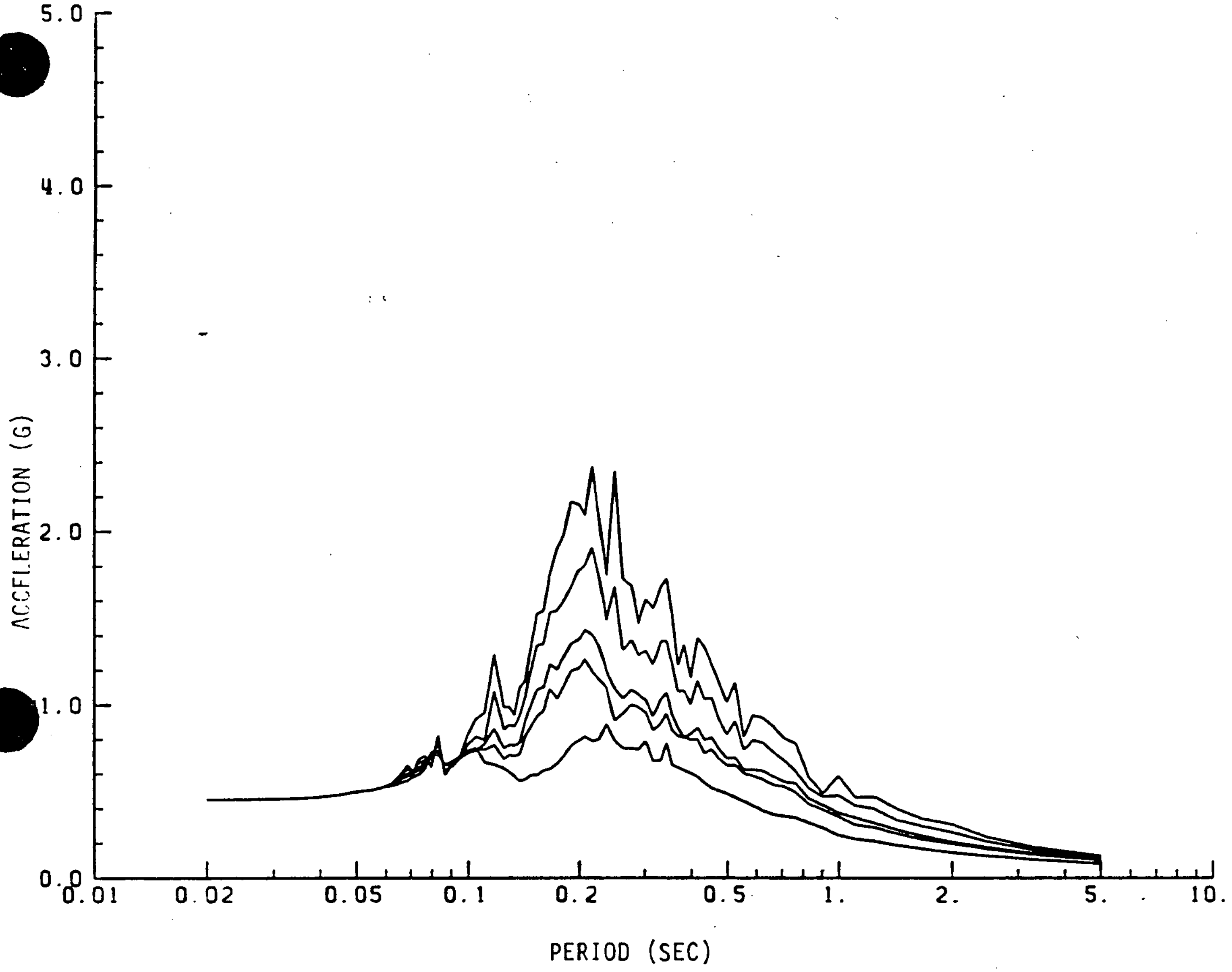
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 29 Y-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 1



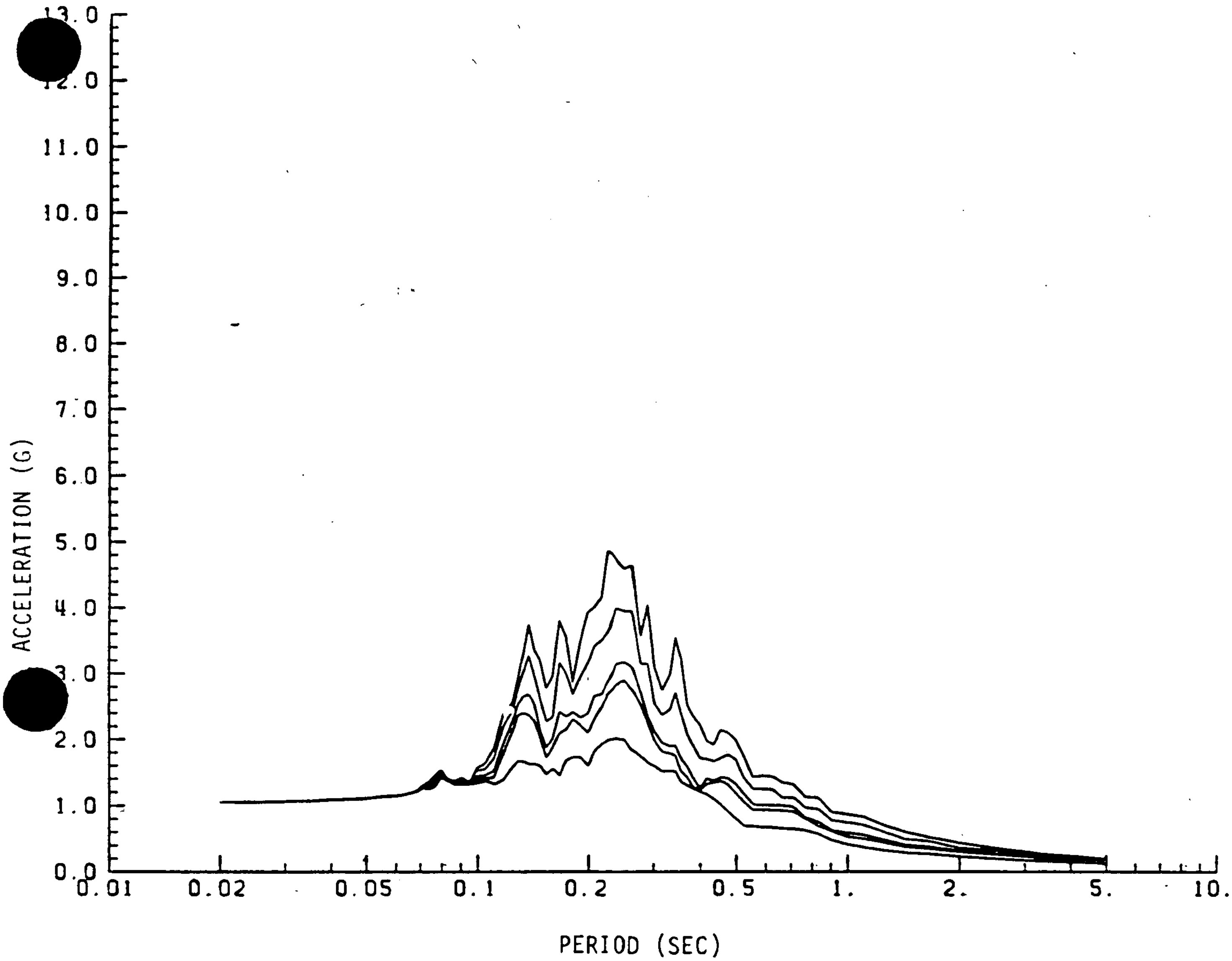
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 71 Y-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 2



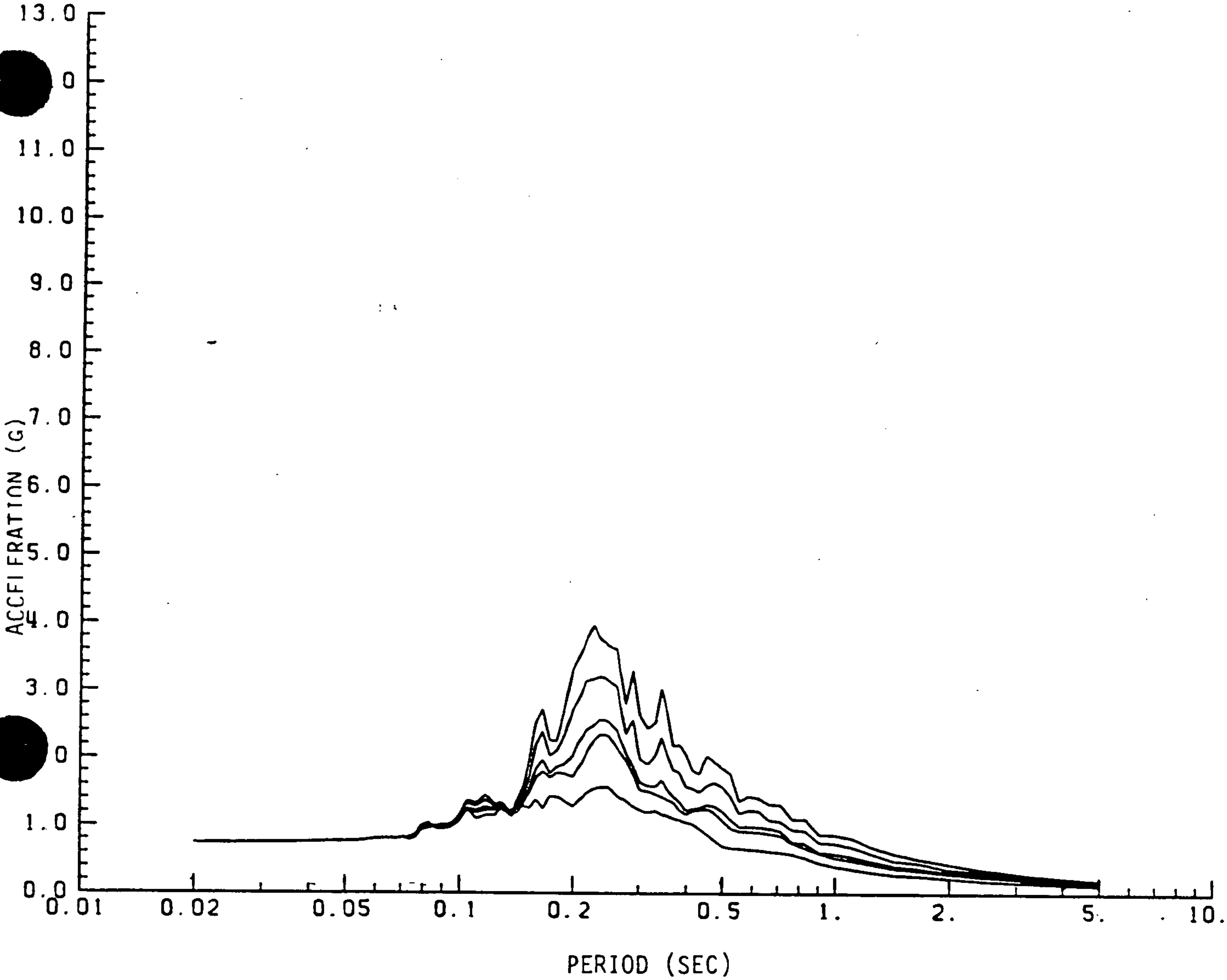
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 86 Y-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 3



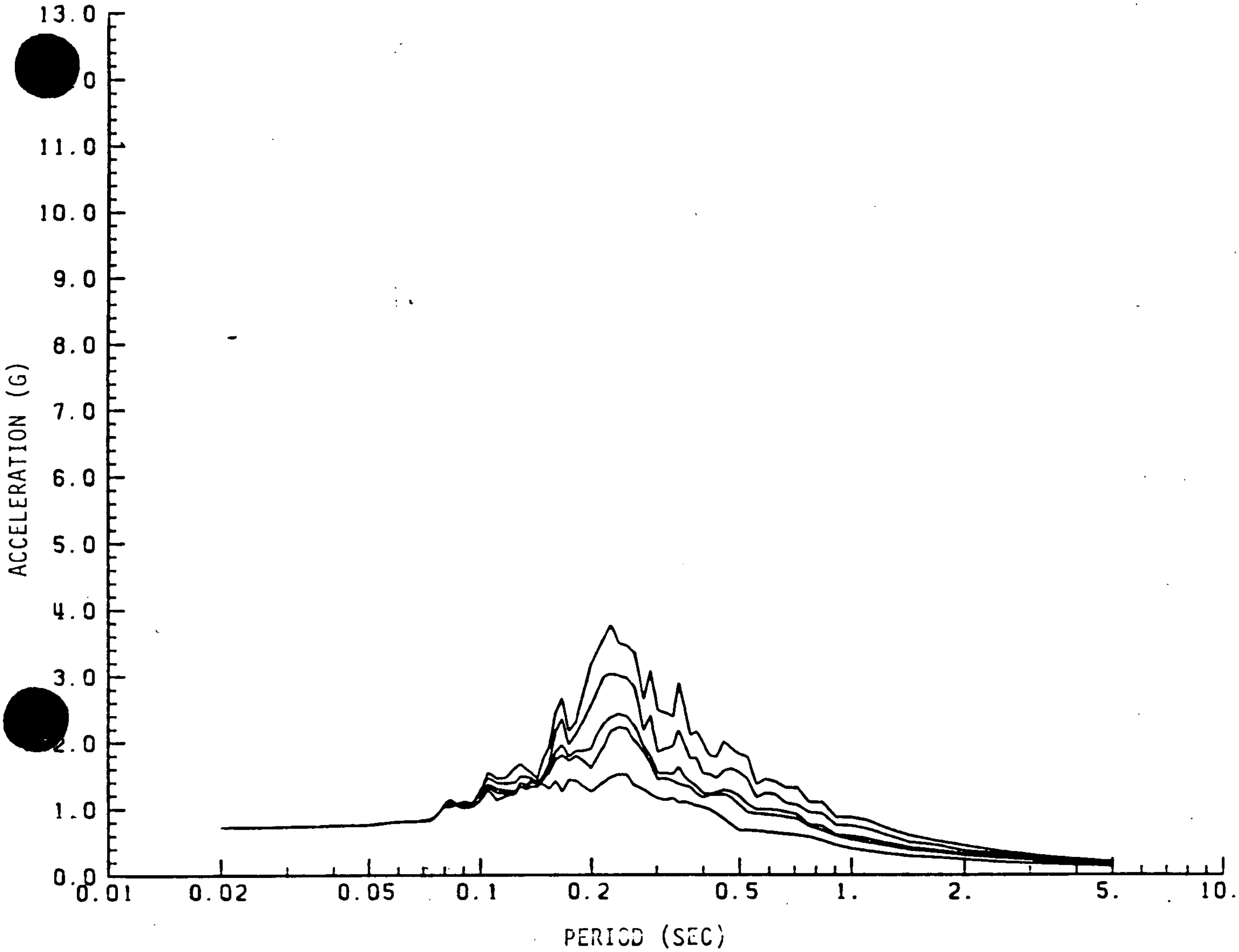
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 29 Z-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 4



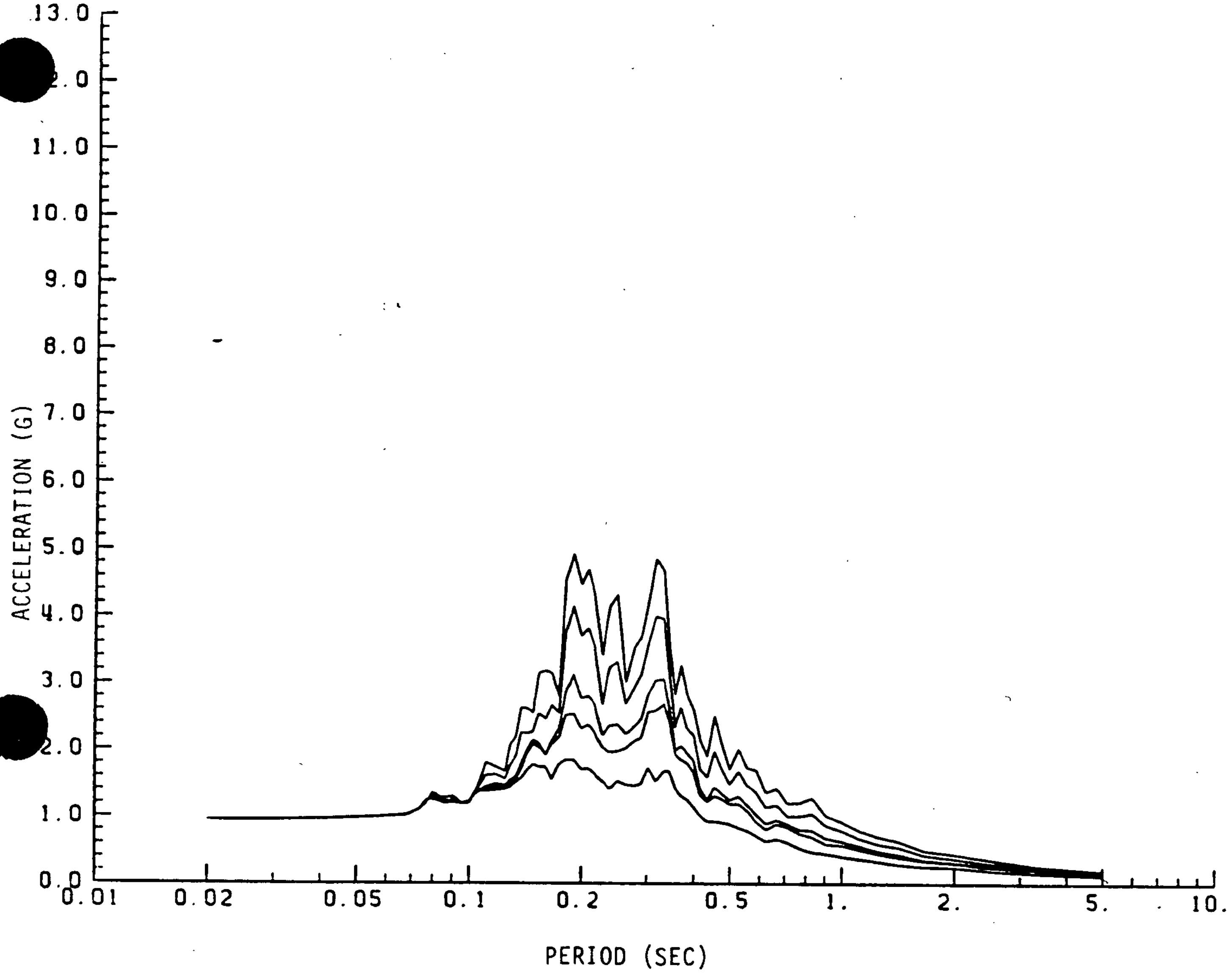
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 71 Z-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 5



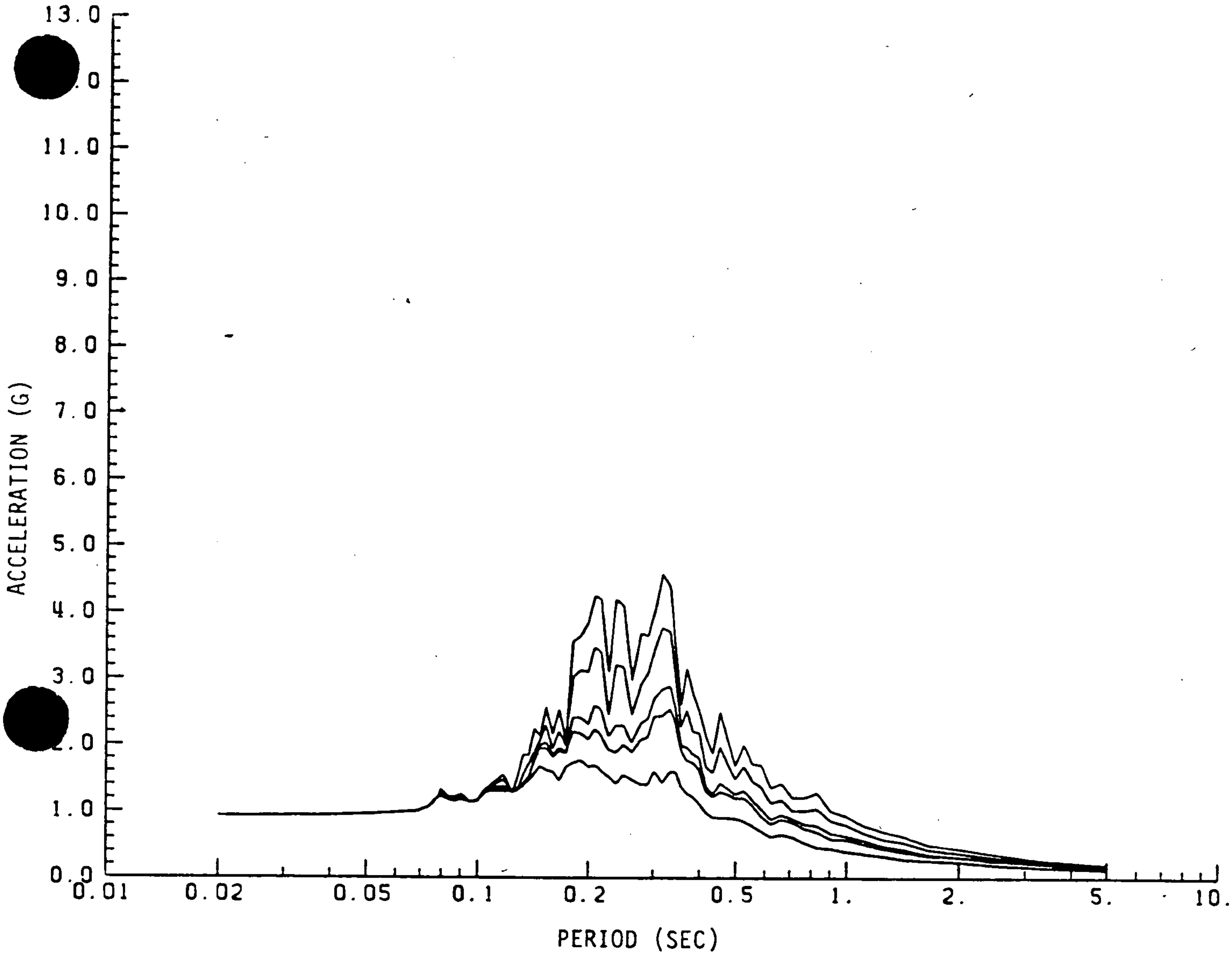
SCE - SONGS 1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 86 Z-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 6



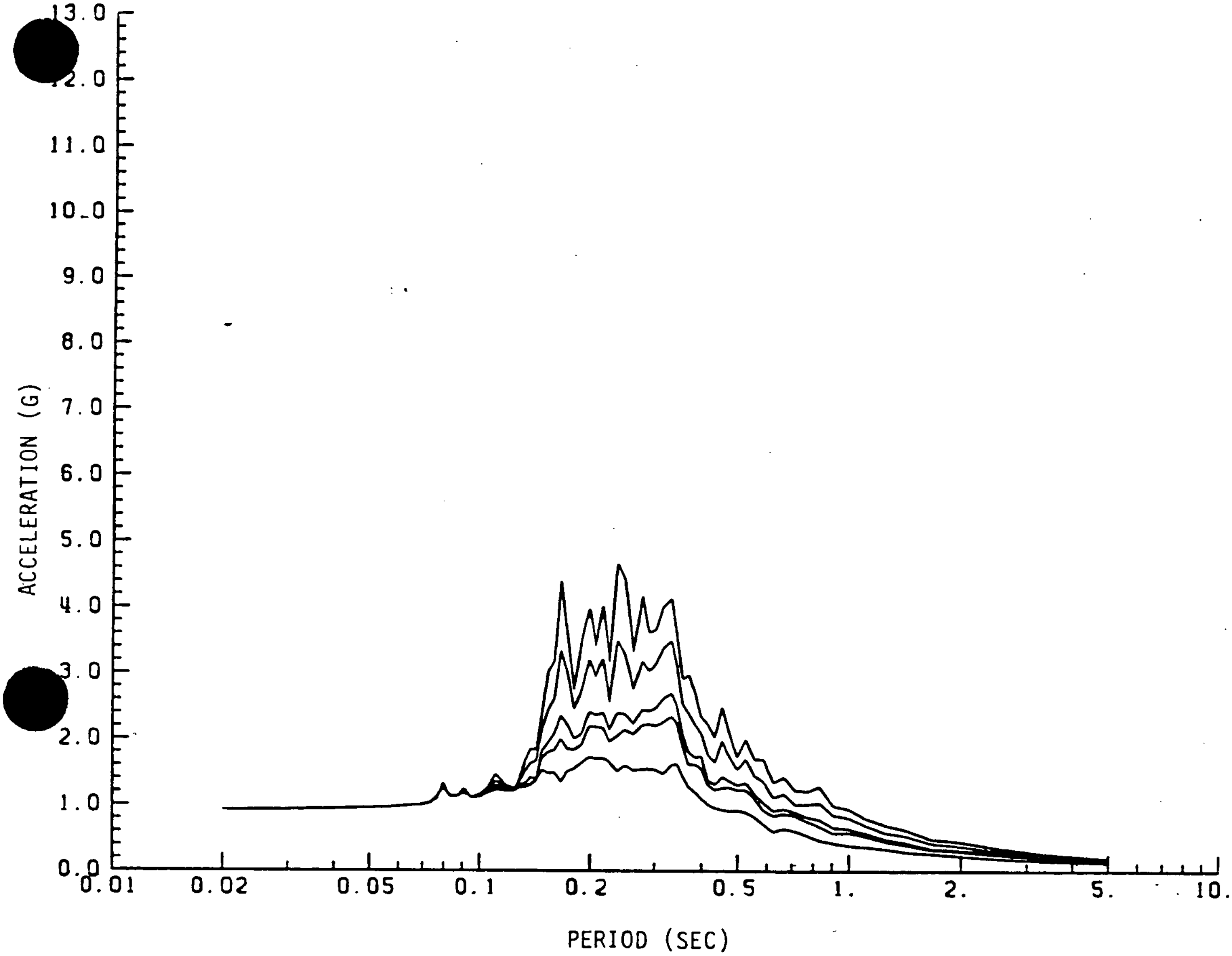
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 580 X-DIR (AREA 2 ELEVATION 42.0 FT)

FIGURE 7



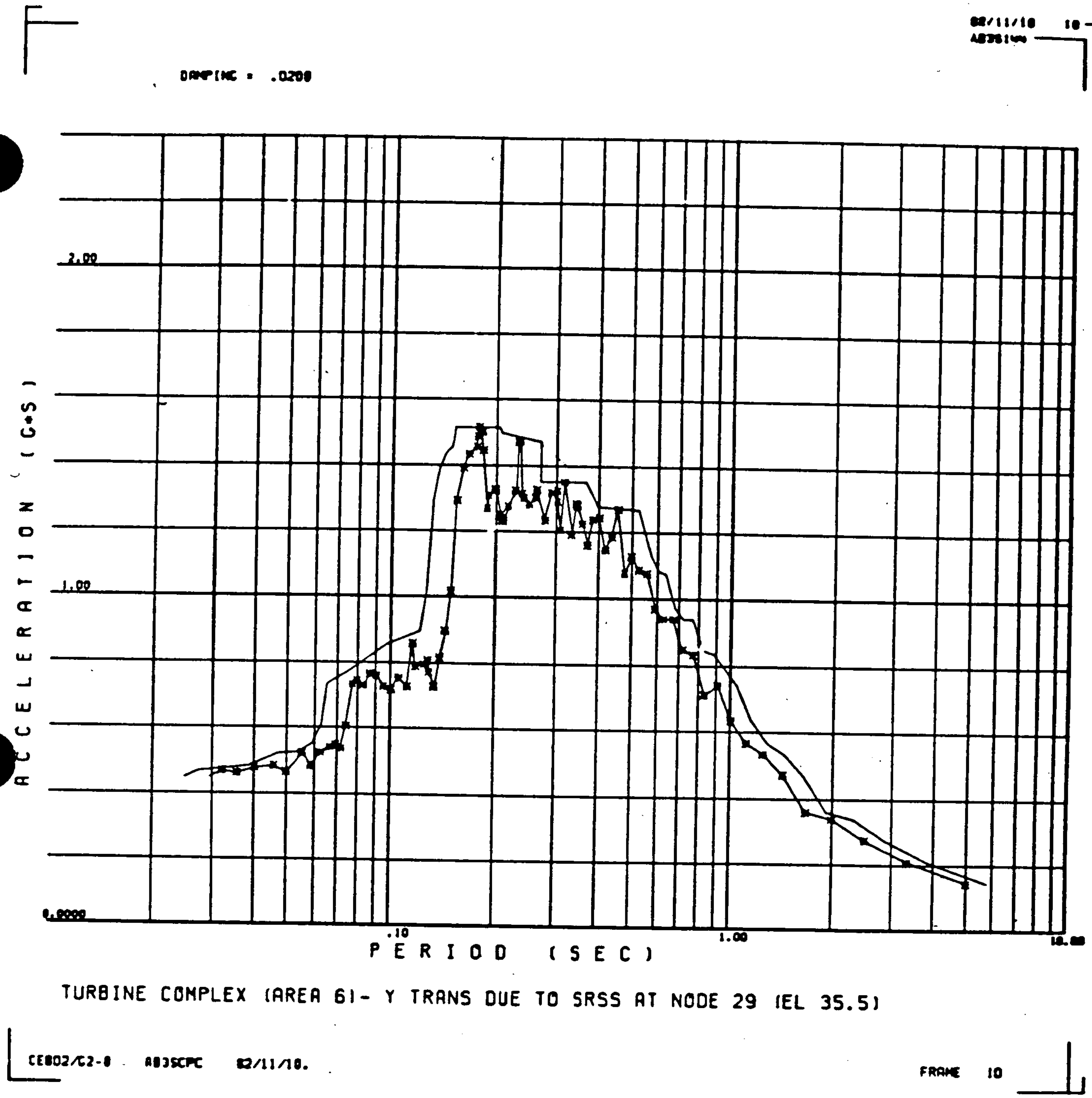
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 586 X-DIR (AREA 2 ELEVATION 42.0 FT)

FIGURE 8



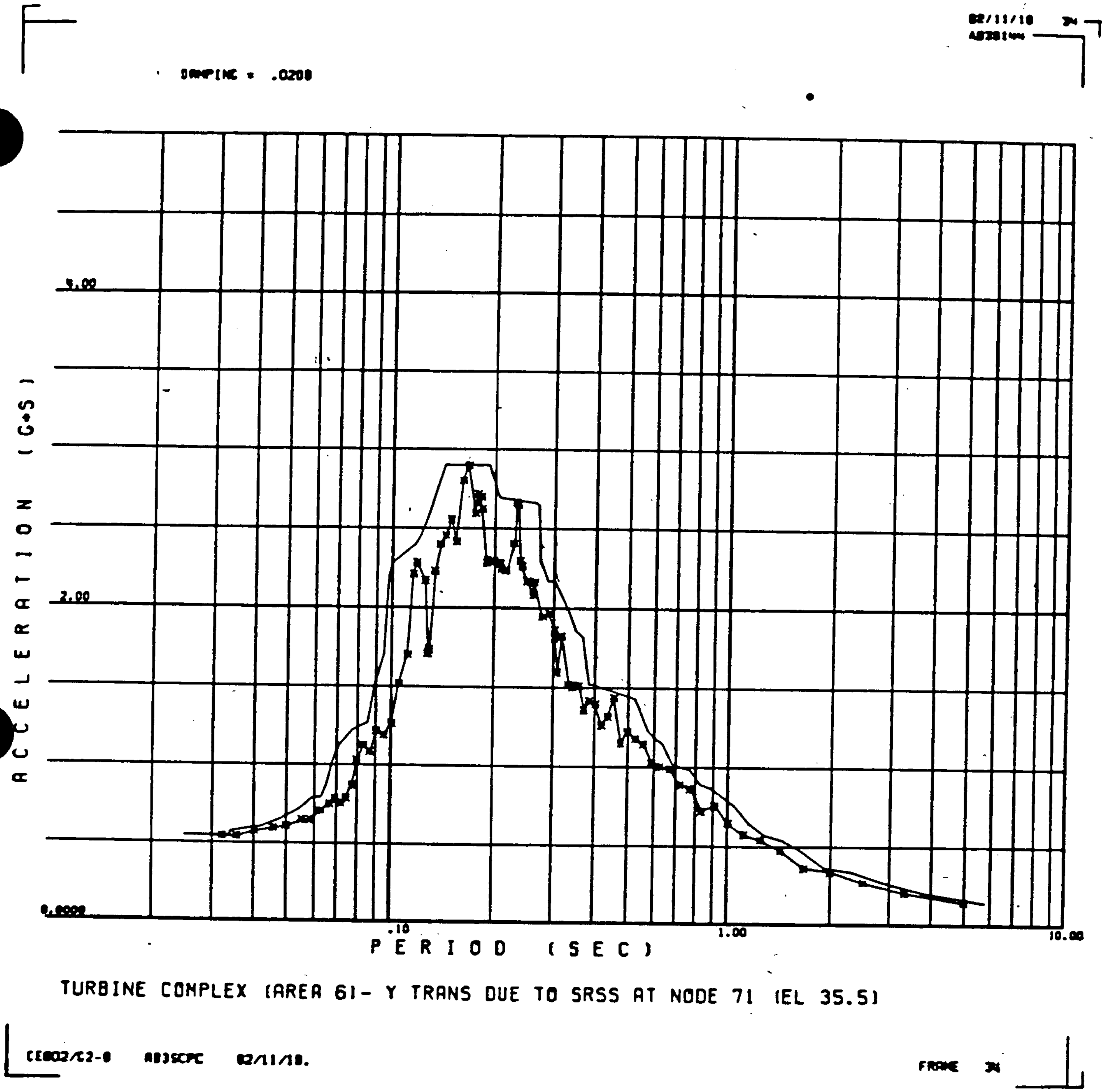
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2, 3, 5, 7, 15% DAMPING CORRECTED RESPONSE SPECTRA
NODE 610 X-DIR (AREA 2 ELEVATION 42.0 FT)

FIGURE 9



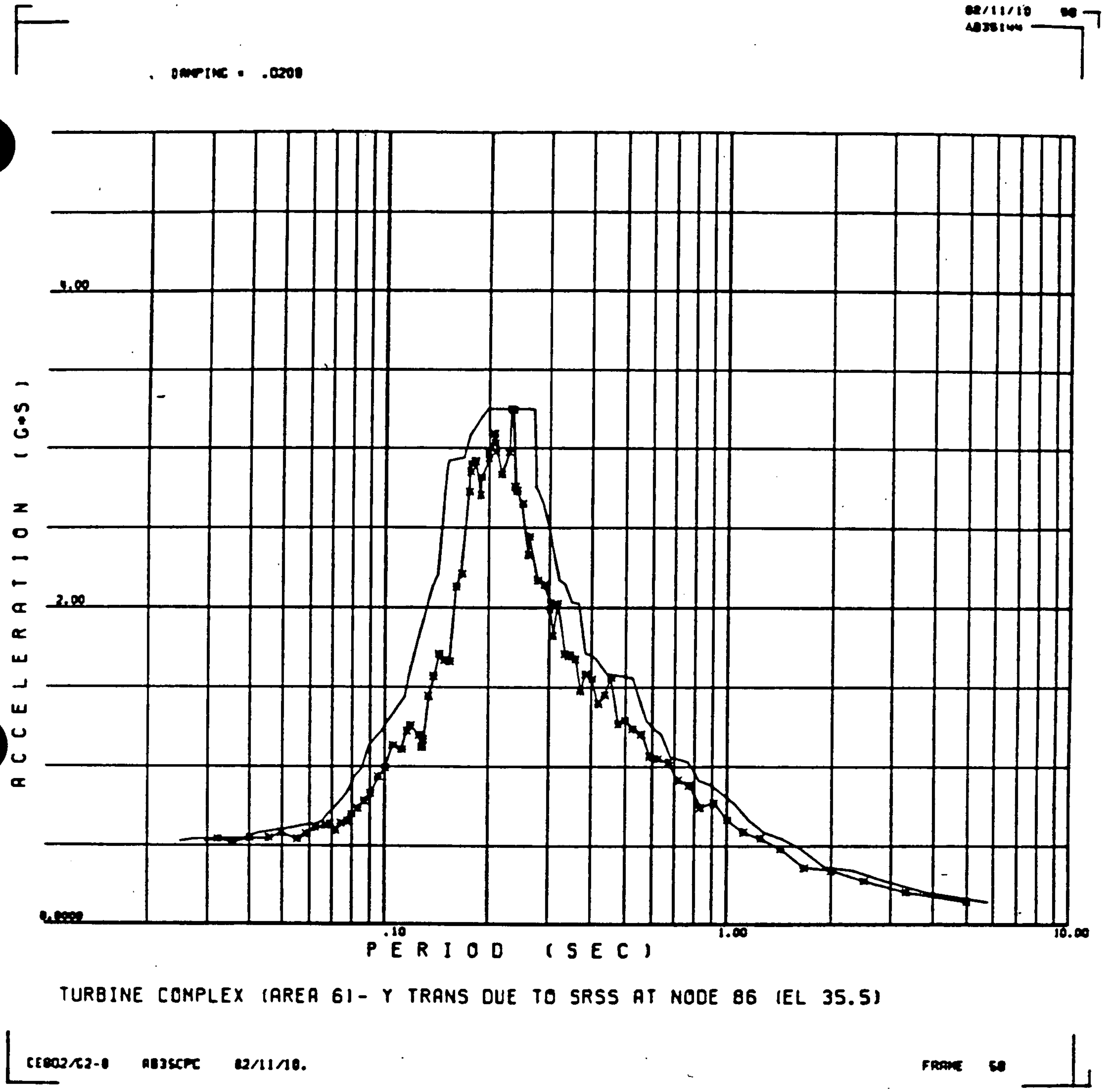
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 29 Y-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 10



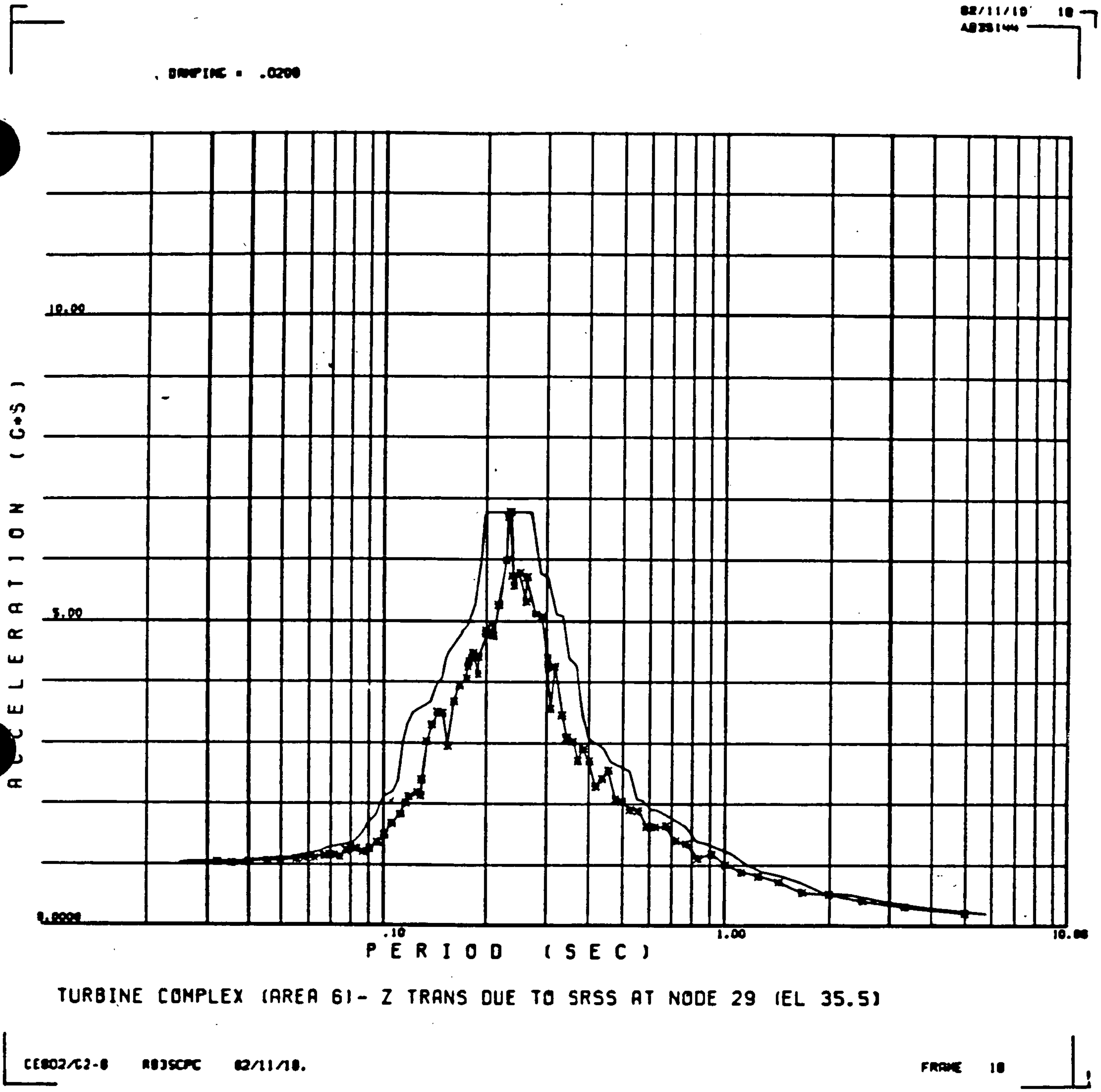
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 71 Y-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 11



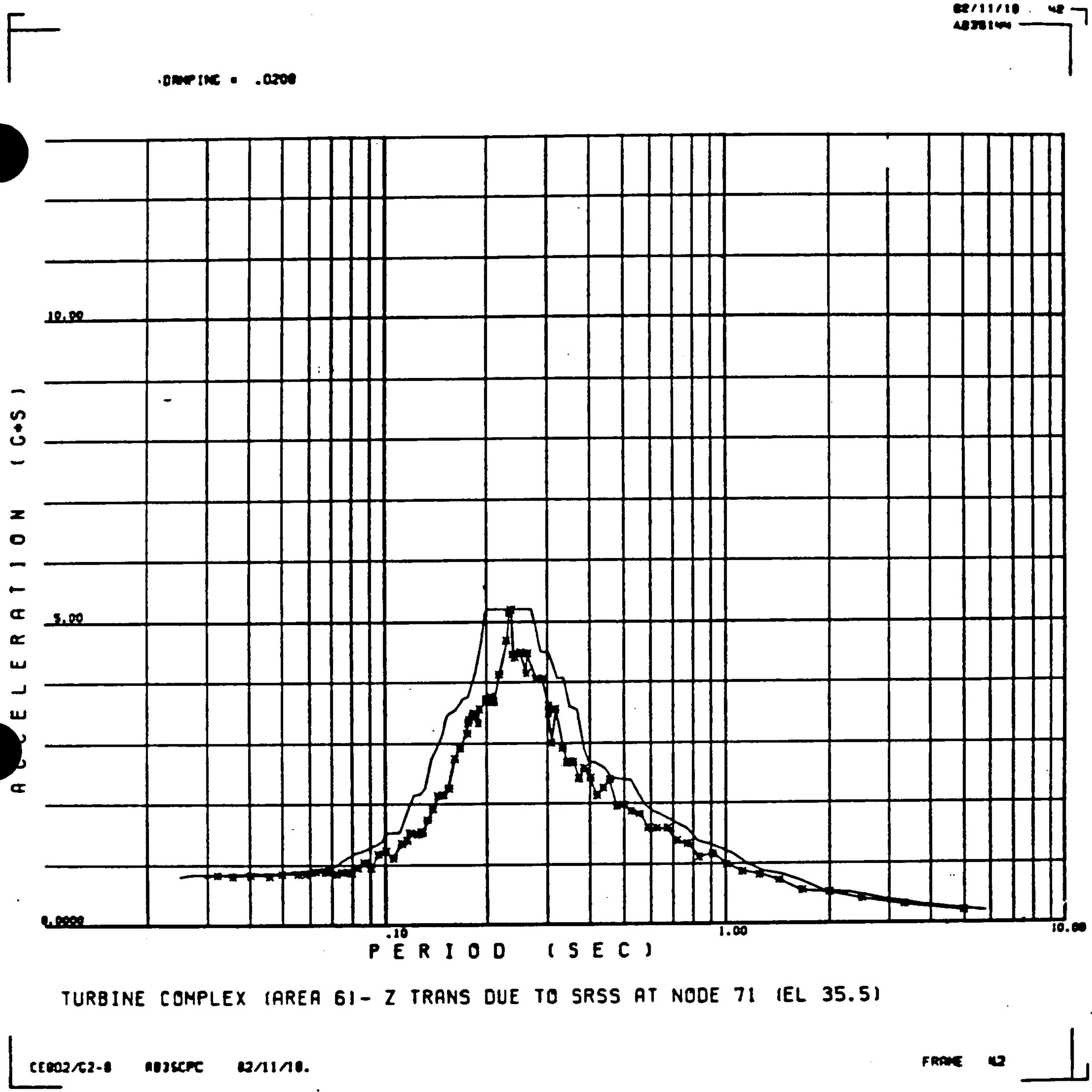
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 86 Y-DIR (AREA 6 ELEVATION 35.5)

FIGURE 12



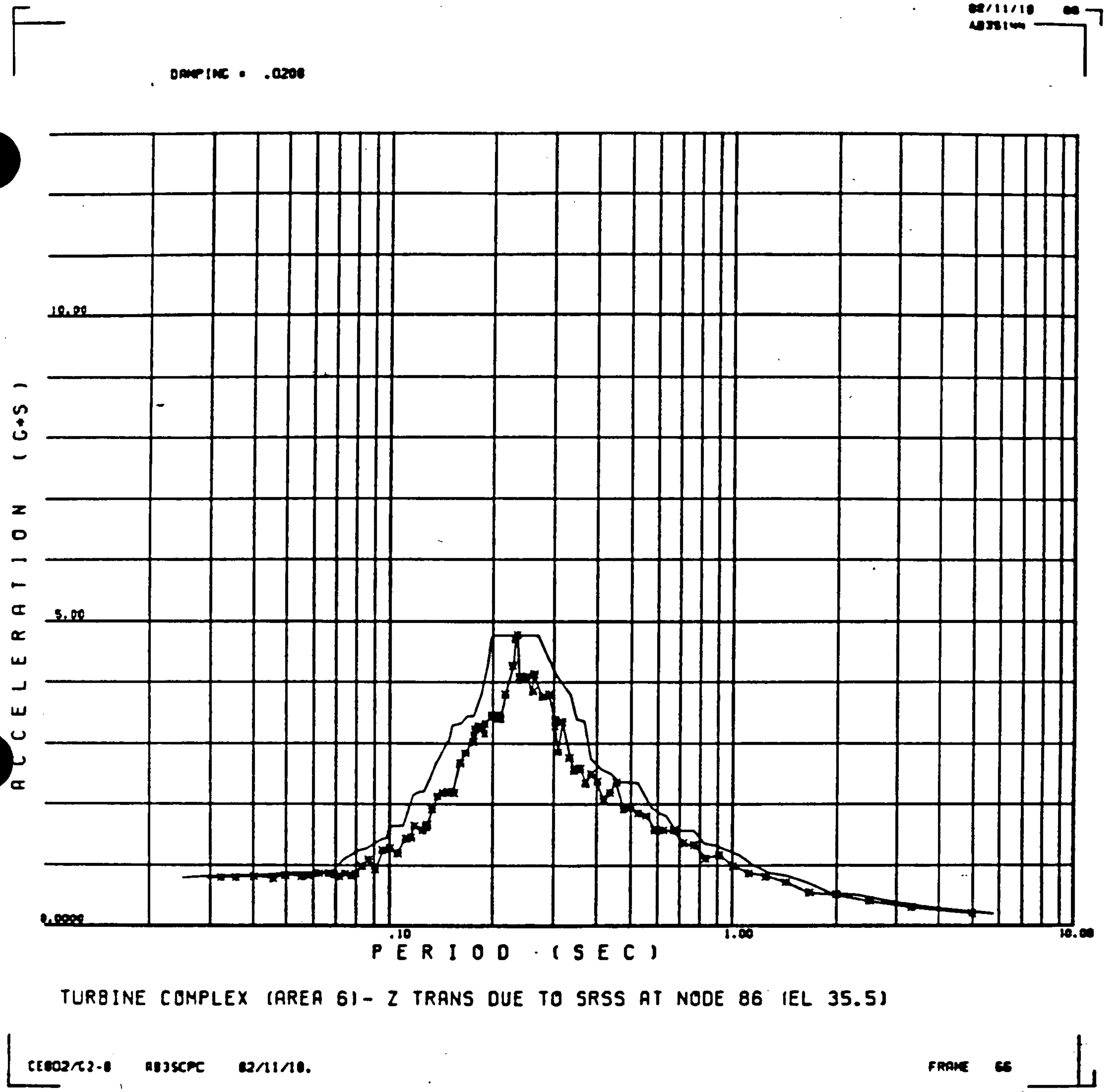
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 29 Z-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 13



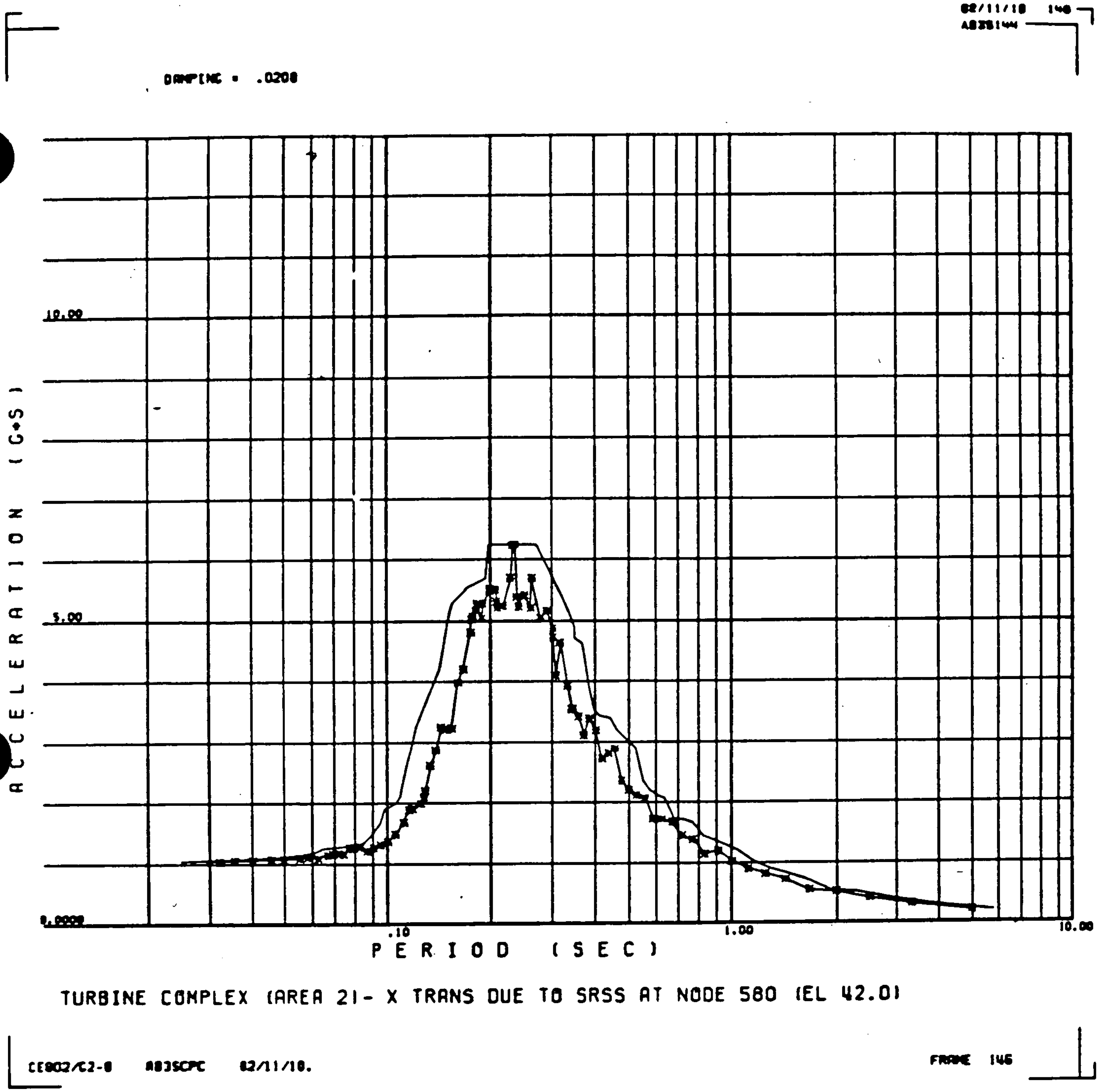
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 71 Z-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 14



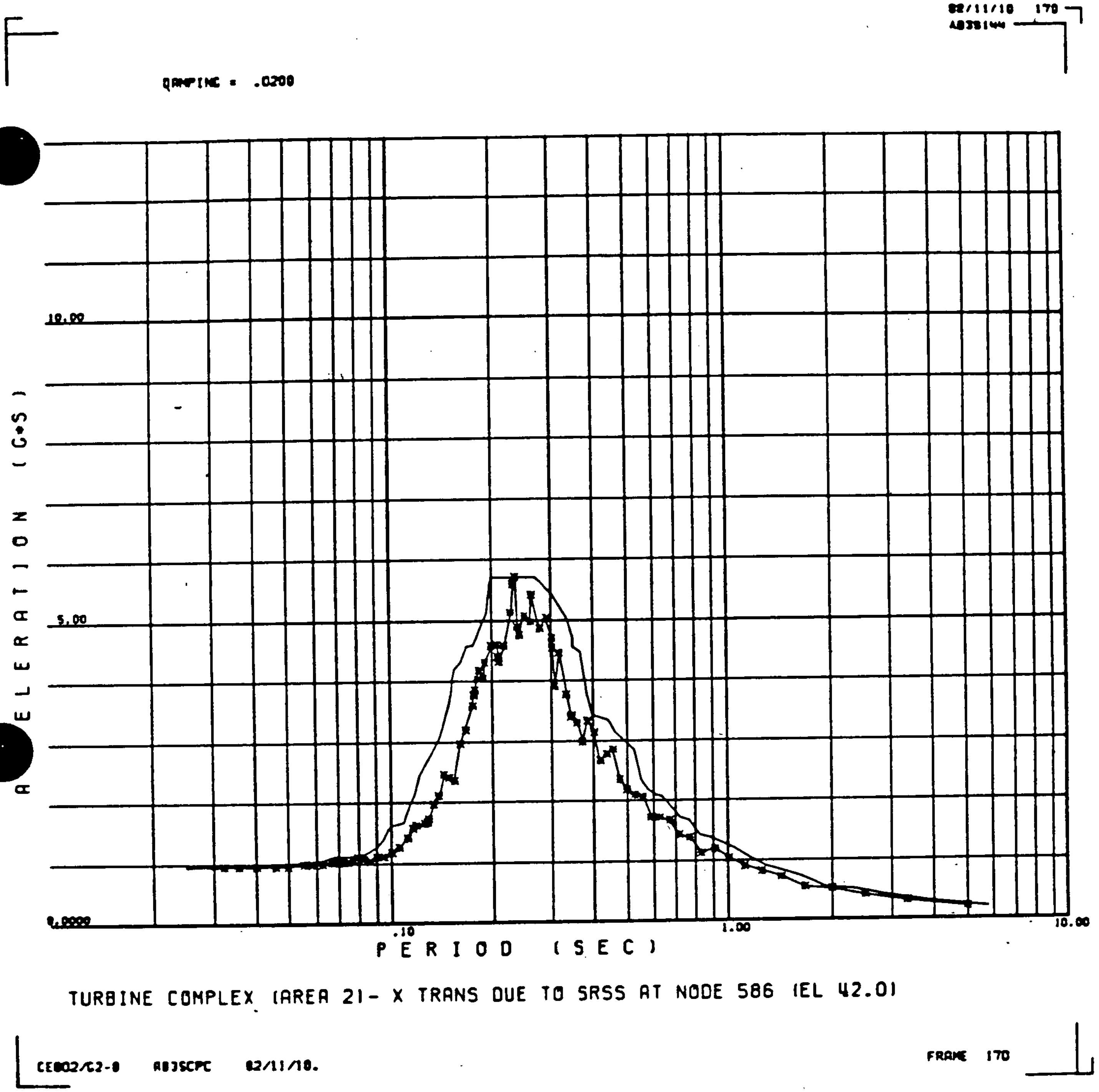
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 86 Z-DIR (AREA 6 ELEVATION 35.5 FT)

FIGURE 15



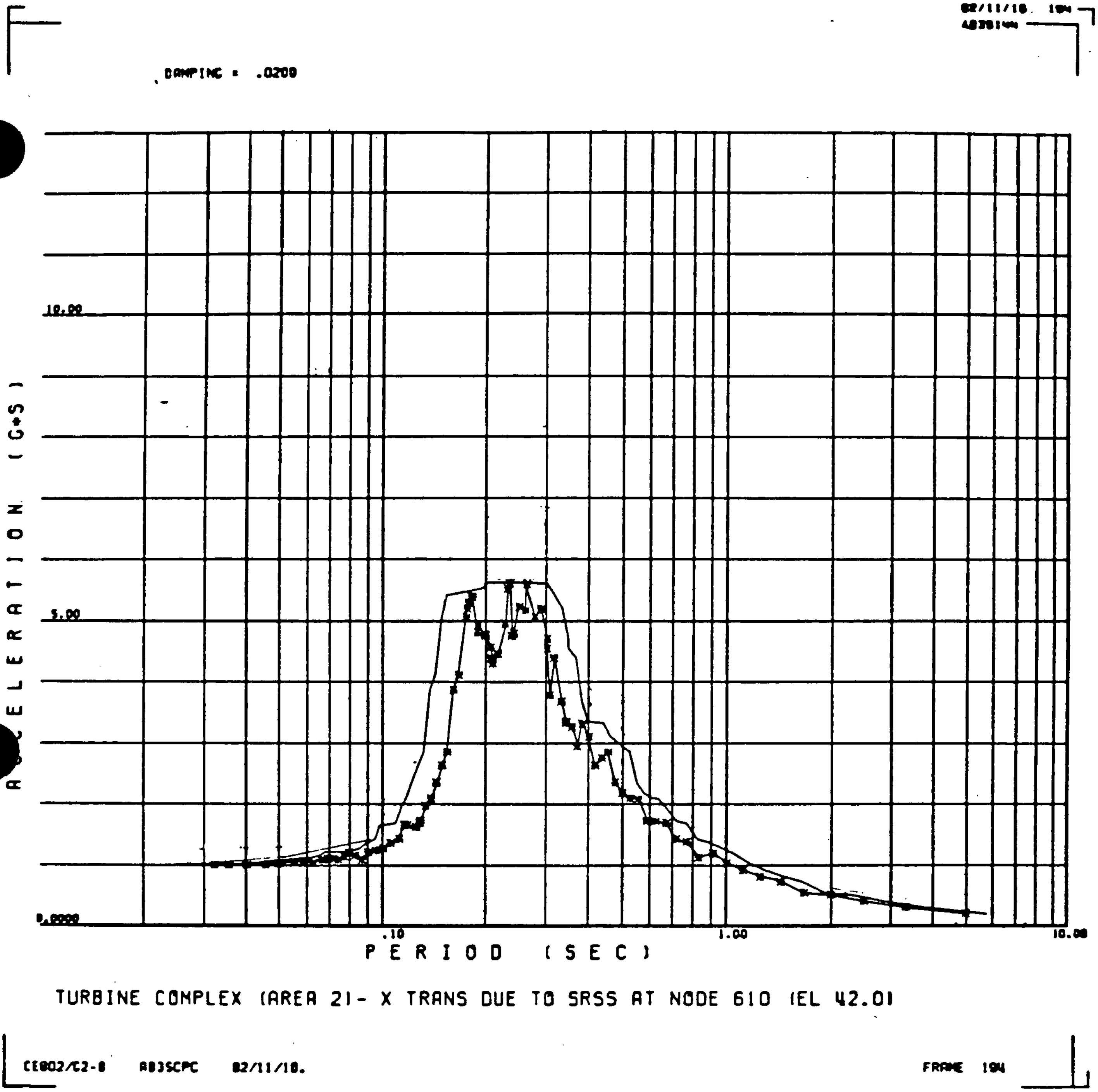
SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 580 X-DIR (AREA 2 ELEVATION 42.0 FT)

FIGURE 16



SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 586 X-DIR (AREA 2 ELEVATION 42.0 FT)

FIGURE 17



SCE - SONGS1
TURBINE BUILDING / INSITU SOIL / CRANE SOUTH
2% DAMPING RESPONSE SPECTRA (BECHTEL)
NODE 610 X-DIR (AREA 2 ELEVATION 42.0 FT)

FIGURE 18

REFERENCES

Methodology Test Problems for SONGS-1 Long Term Service Seismic Program. Impell Report No. 01-0310-1389 Revision 0, April 15, 1985. Prepared for Southern California Edison Company.

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