COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH LYTLE CREEK SEPT 12,1970 ALLEN RANCH S85E RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
ALLEN RANCH - 4% DAMPING

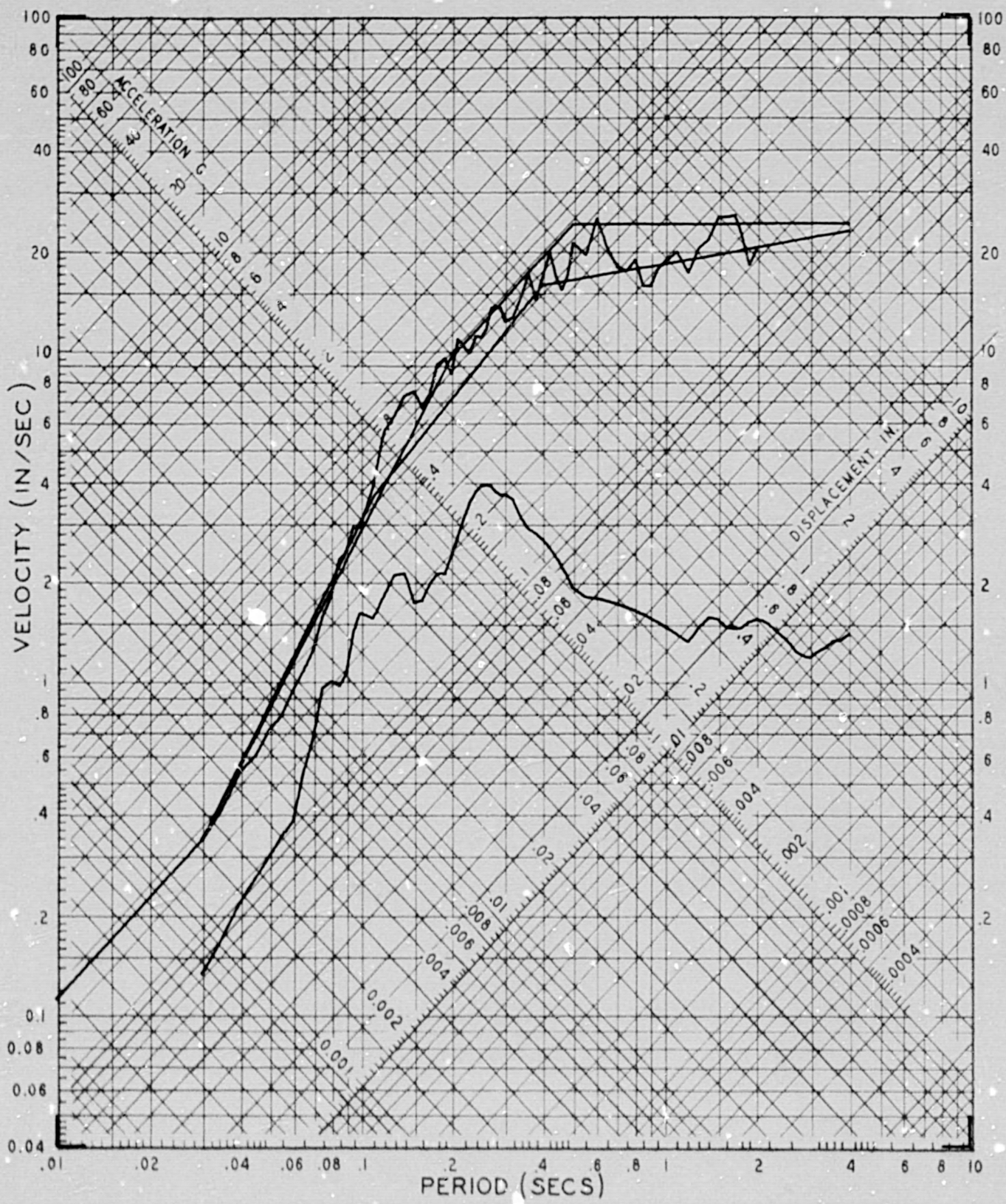

FIGURE B-15

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH LYTLE CREEK SEPT 12,1970 ALLEN RANCH S85E RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR -5% DAMPING
BELLEFONTE - 7% DAMPING
ALLEN RANCH - 7% DAMPING

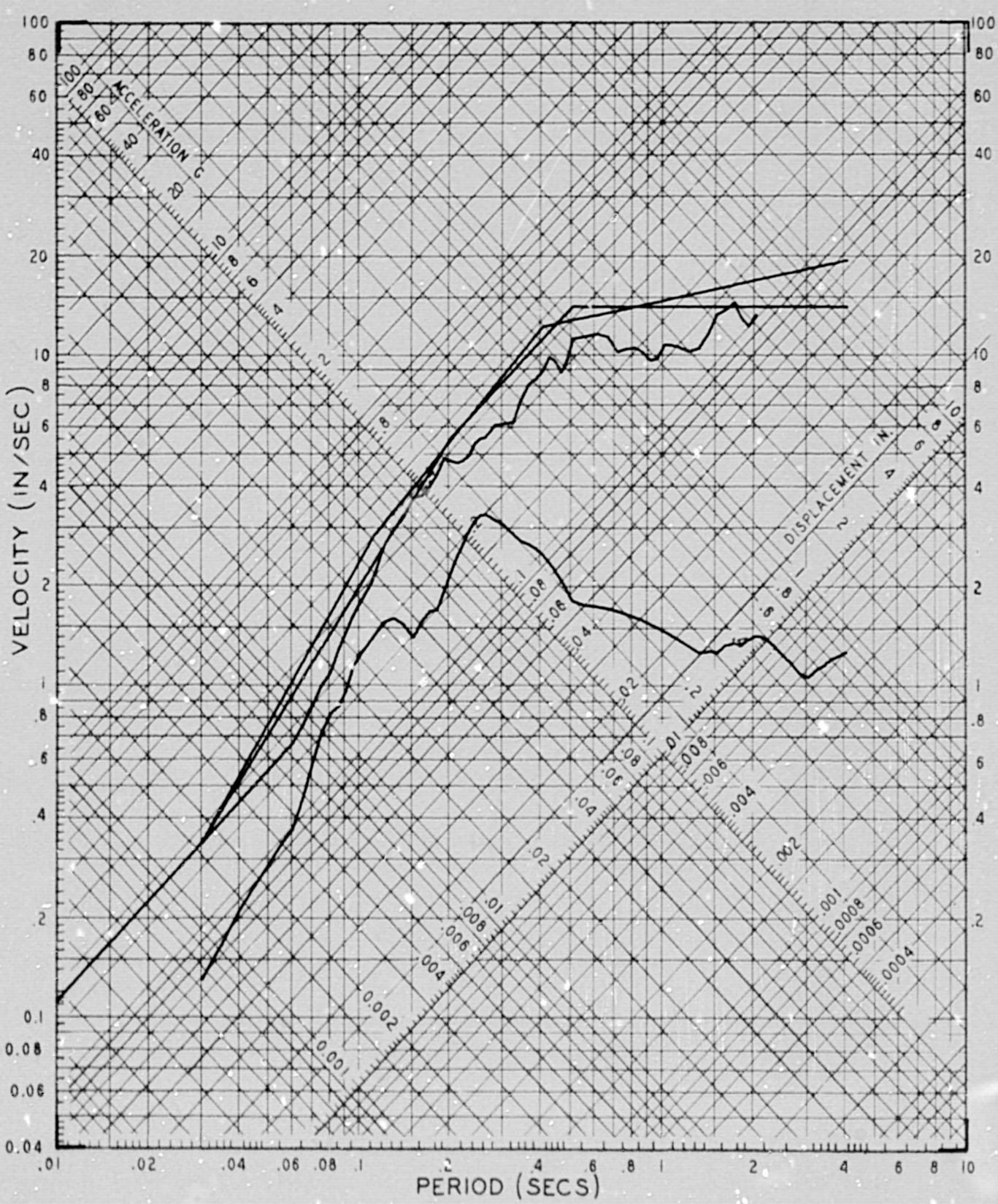

FIGURE B-16

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH LYTLE CREEK SEPT 12,1970 DEVILS CANYON SOOE RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
DEVILS CANYON - 4% DAMPING

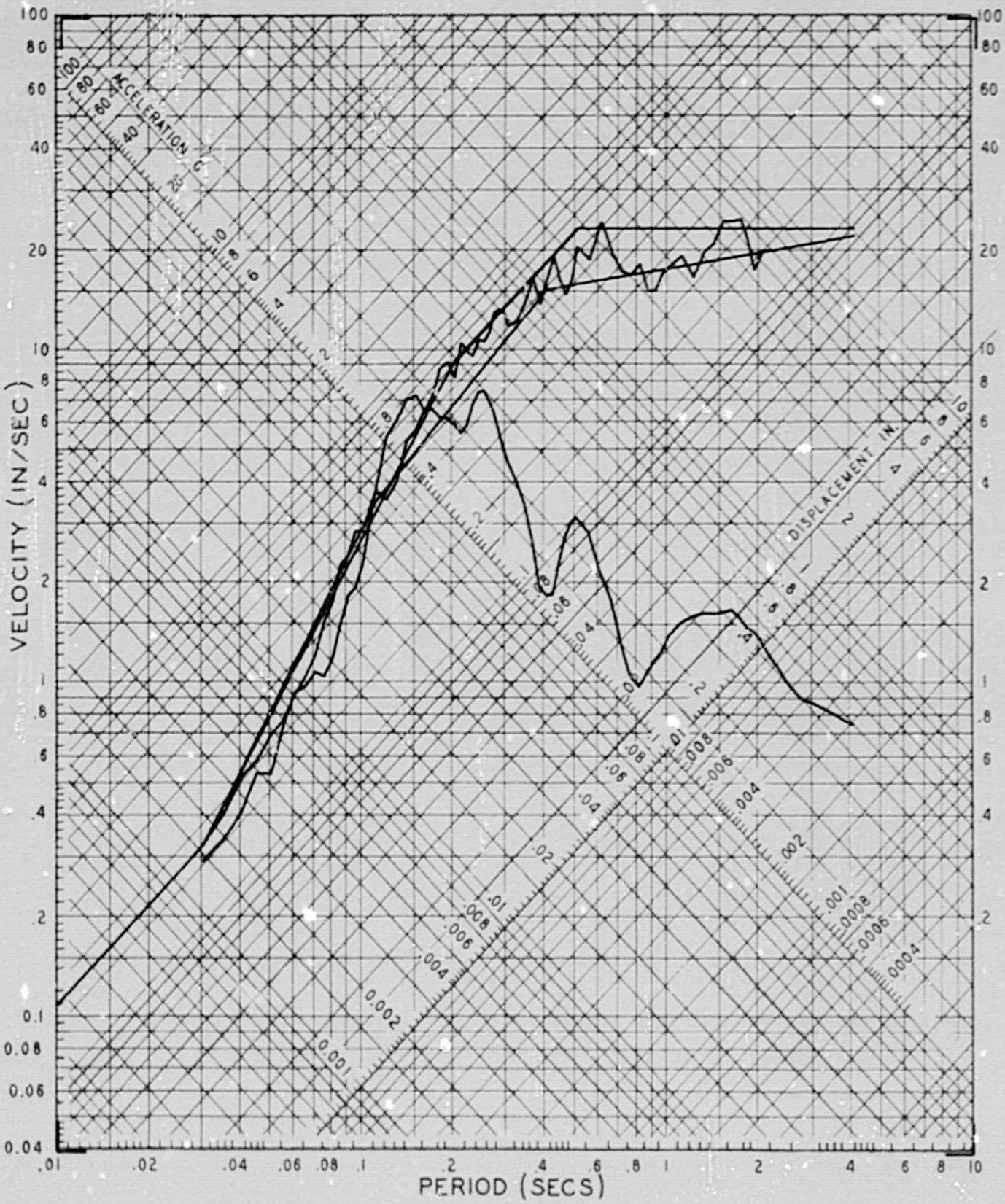

FIGURE B-17

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH LYTLE CREEK SEPT 12,1970 DEVILS CANYON SOOE RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
DEVILS CANYON - 7% DAMPING

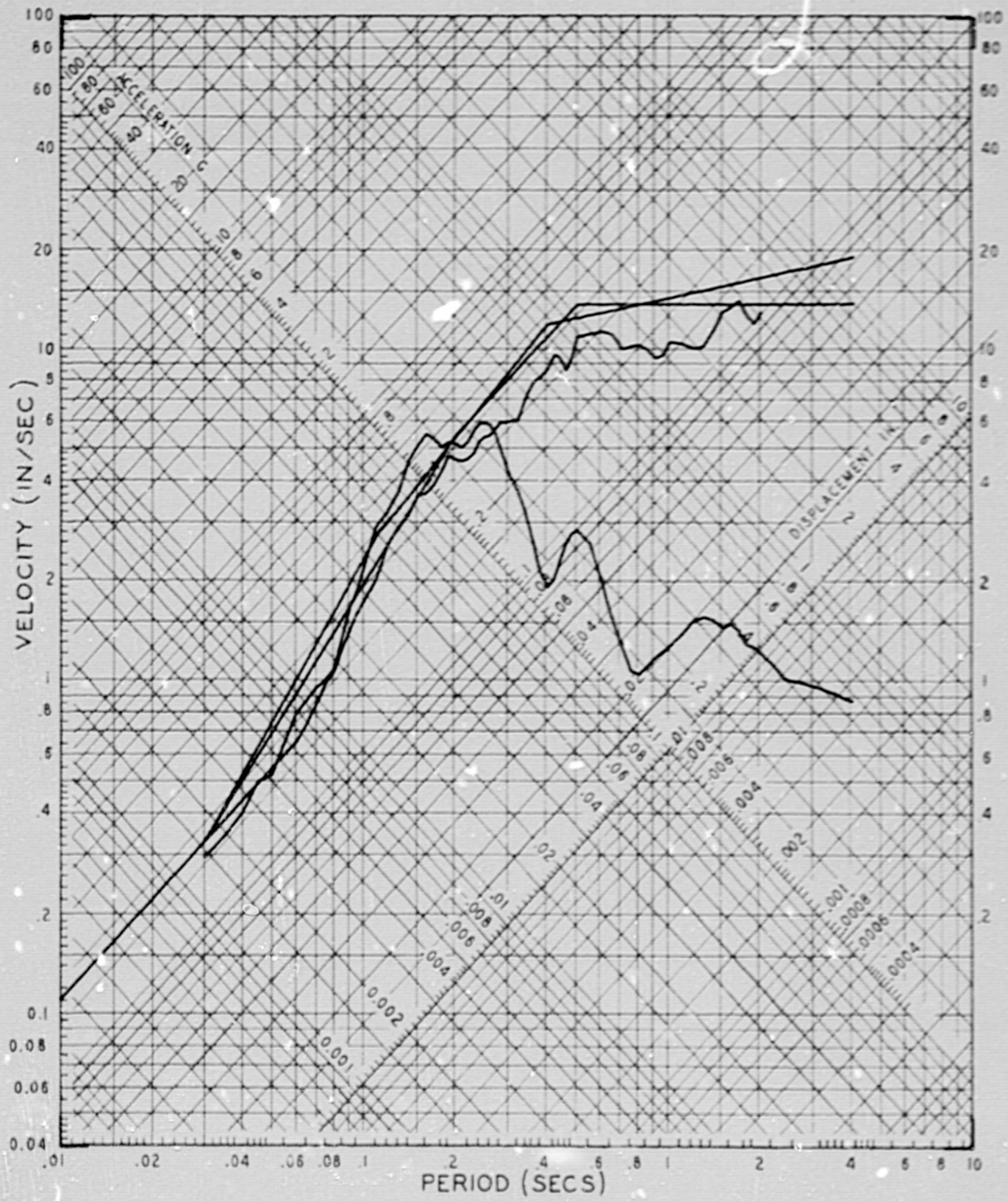

FIGURE B-18

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH LYTLE CREEK SEPT 12,1970 DEVILS CANYON S90E RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
DEVILS CANYON - 4% DAMPING

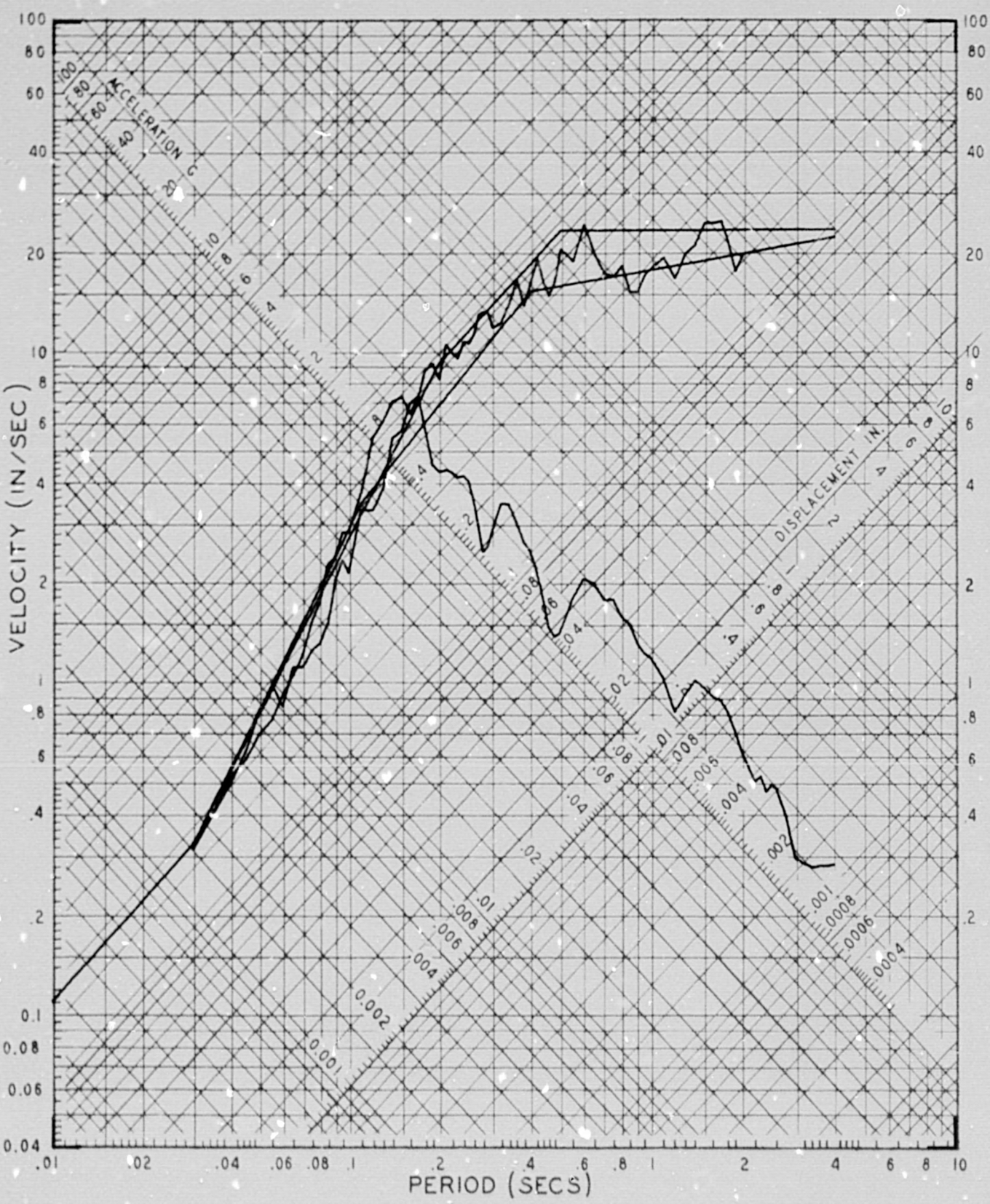

FIGURE B-19

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH LYTLE CREEK SEPT 12,1970 DEVILS CANYON S90E RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
DEVILS CANYON - 7% DAMPING

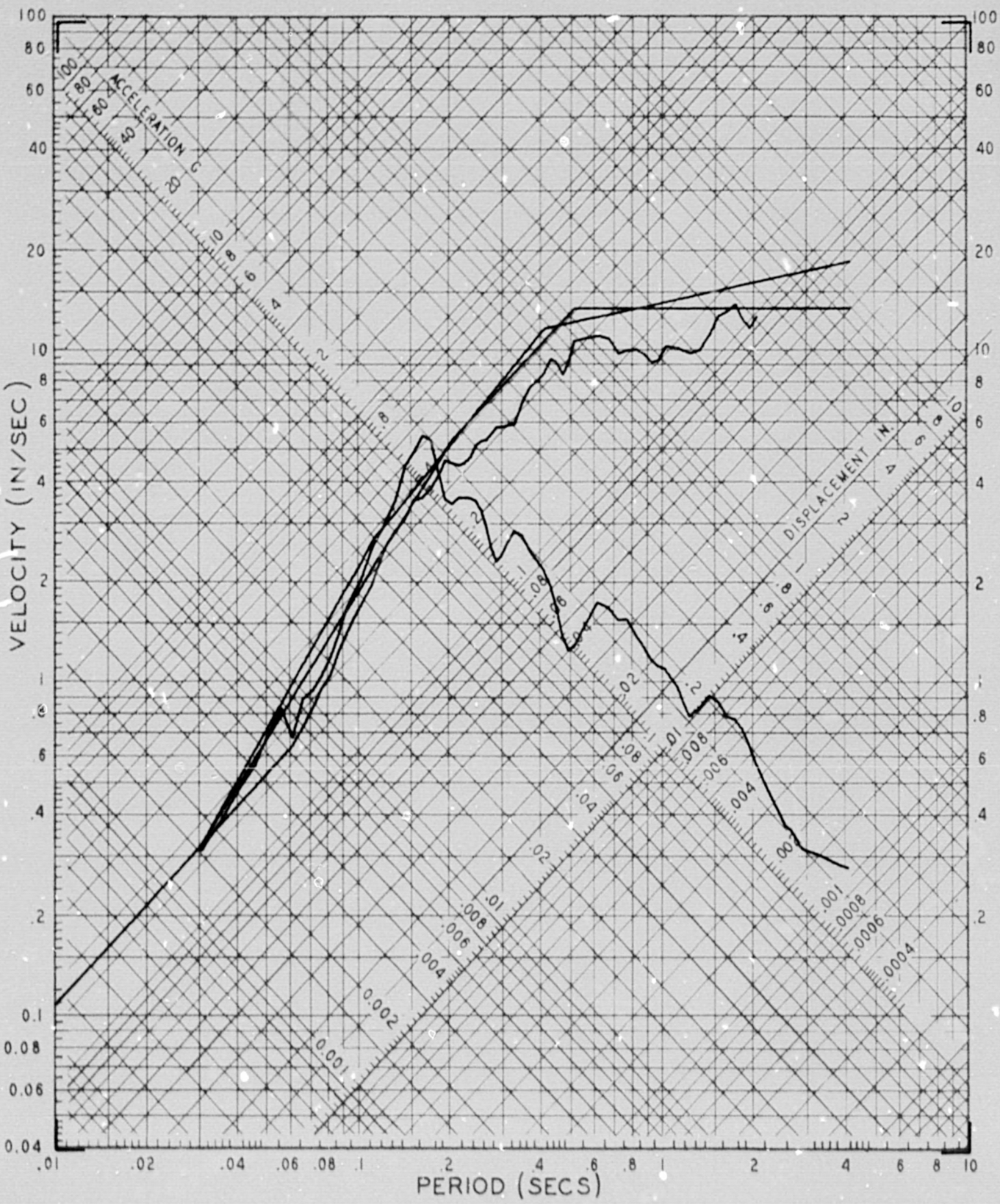

FIGURE B-20

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH OROVILLE AUG 1,1975 OROVILLE DAM N37E RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
OROVILLE DAM - 4% DAMPING

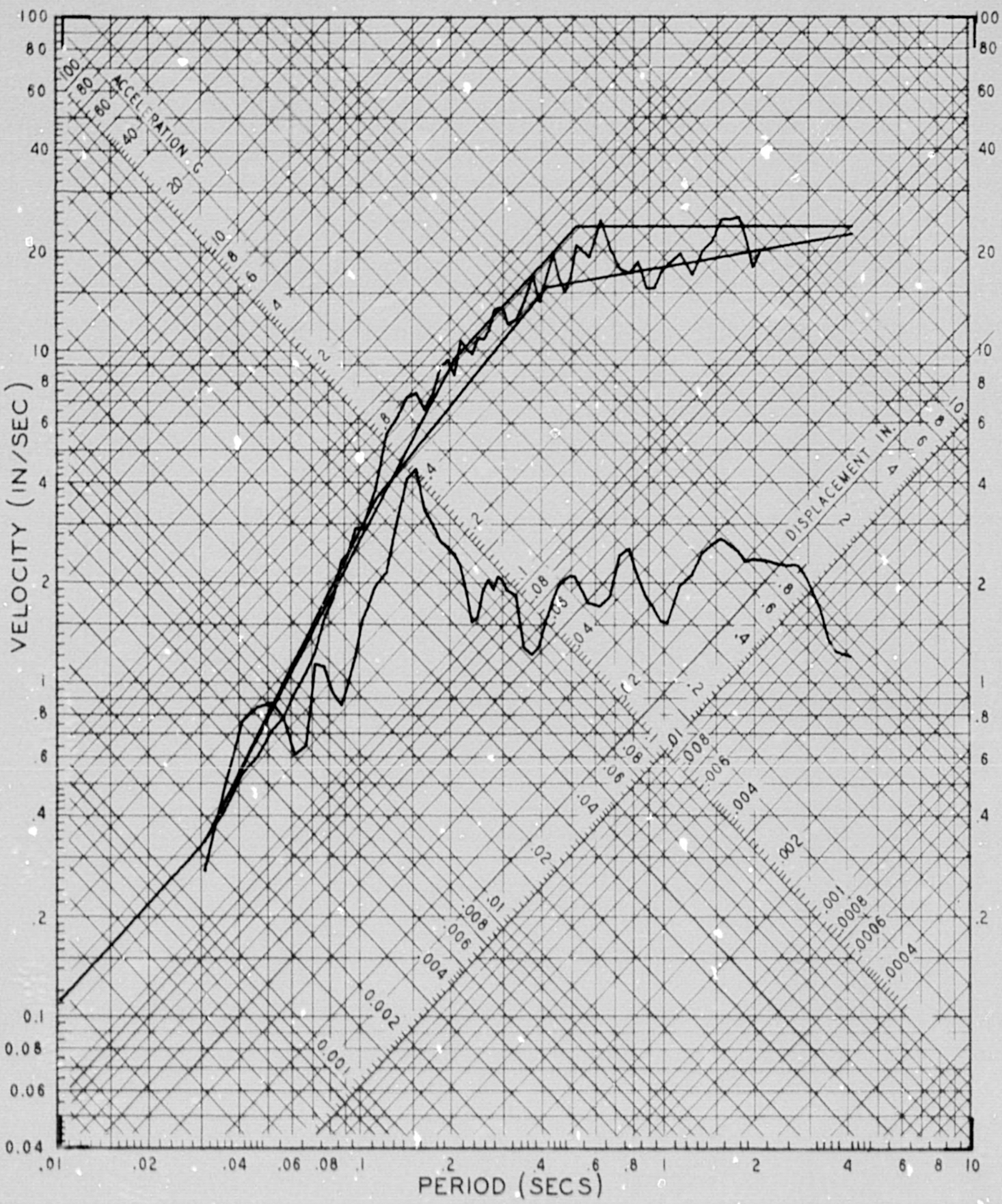

FIGURE B-21

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH OROVILLE AUG 1,1975 OROVILLE DAM N37E RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
OROVILLE DAM - 7% DAMPING

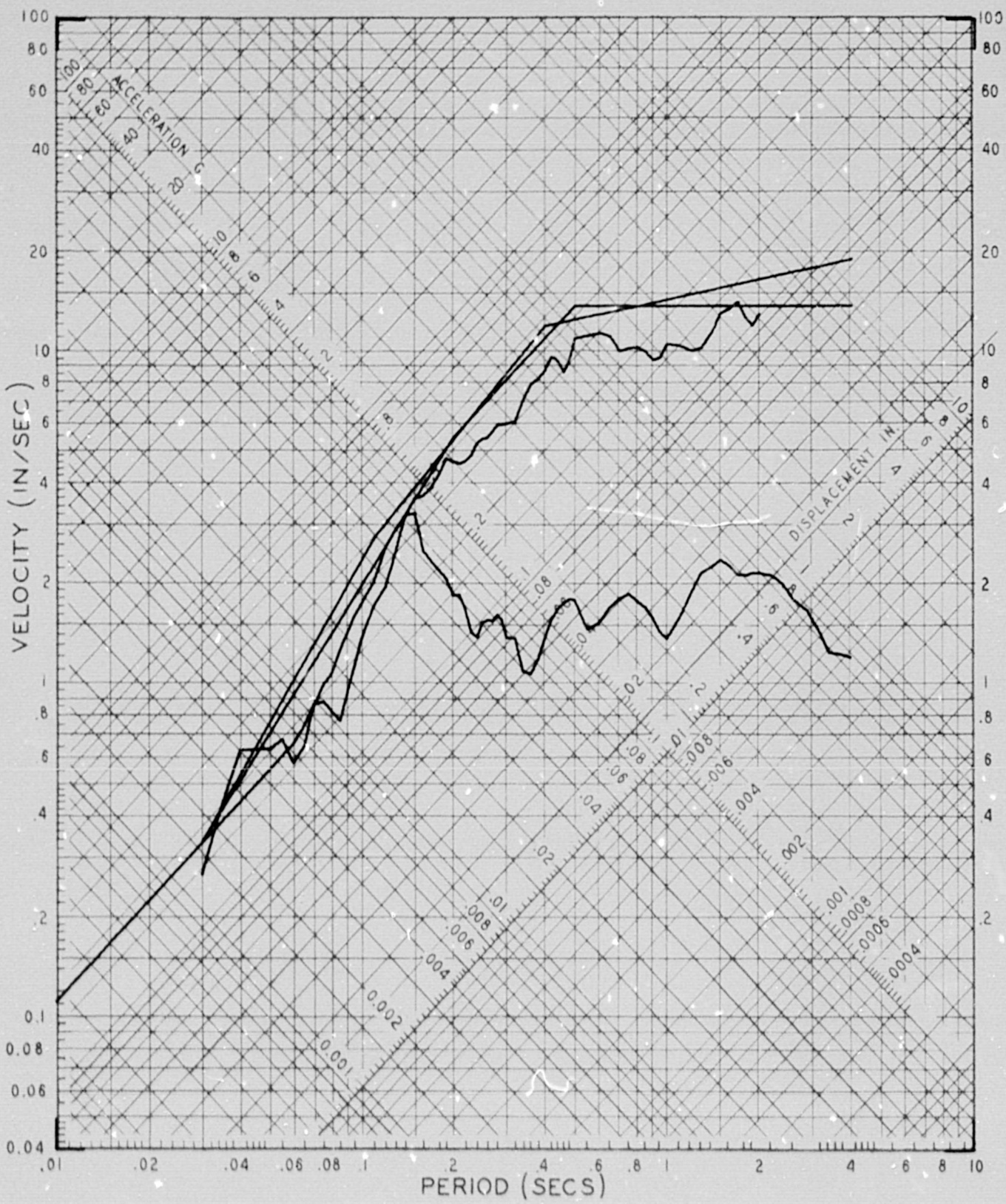

FIGURE B-22

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH OROVILLE AUG 1,1975 OROVILLE DAM N53W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
OROVILLE DAM - 4% DAMPING

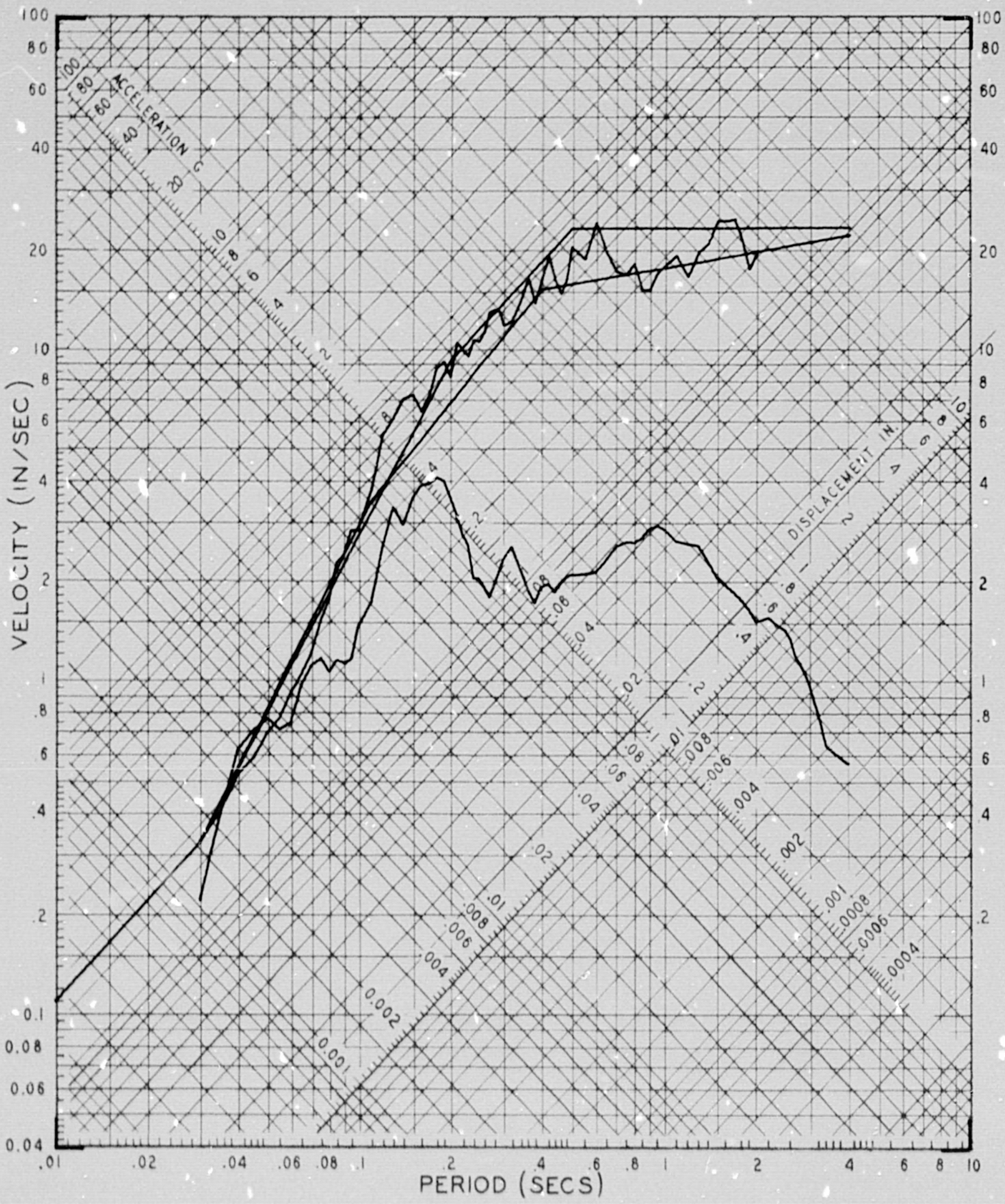

FIGURE B-23

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH OROVILLE AUG 1,1975 OROVILLE DAM N53W RECORD

SEQUOYAH - 5%DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
OROVILLE DAM - 7% DAMPING

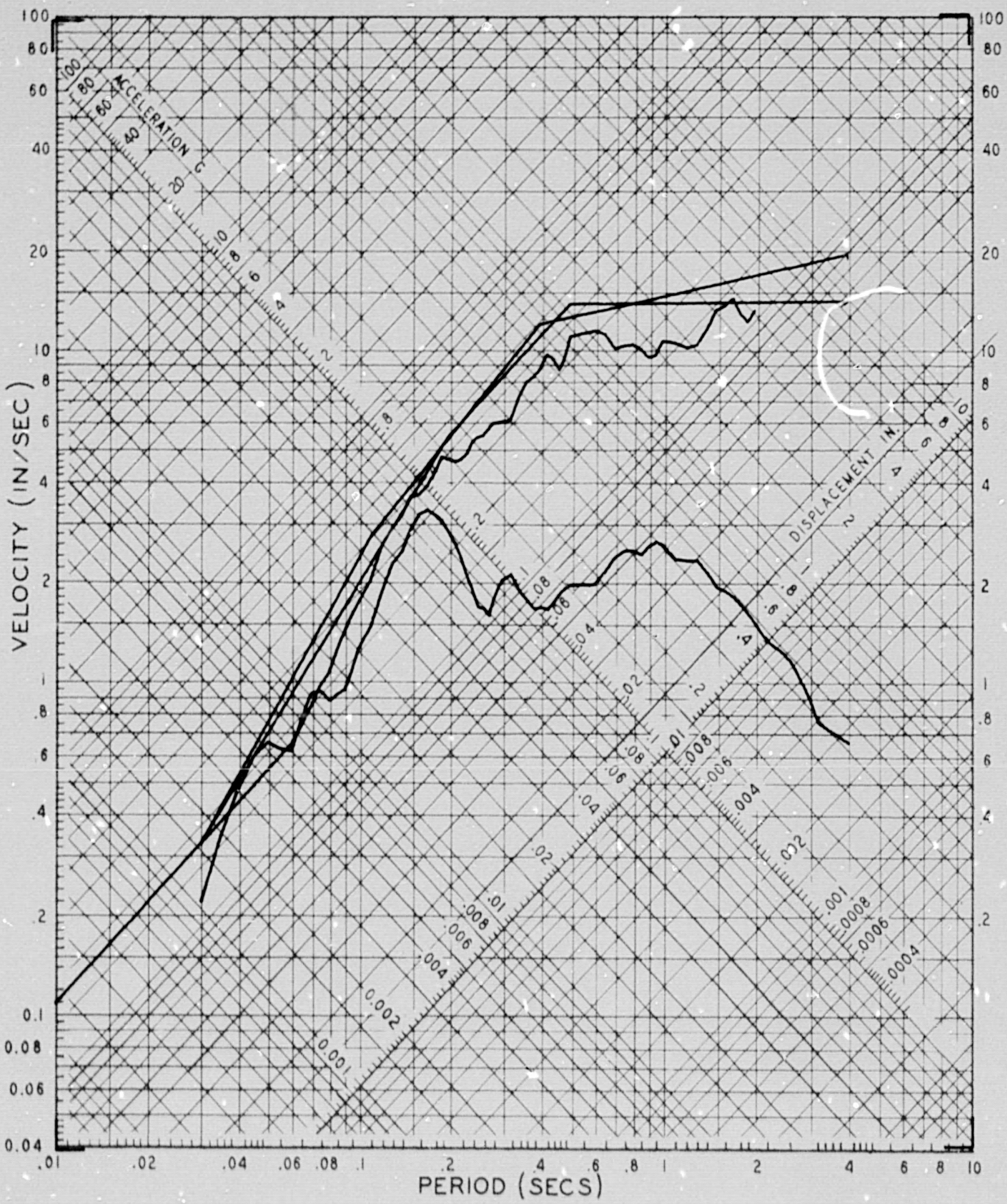

FIGURE B-24

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 6,1976 TOLMEZZO (038) N-S RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
TOLMEZZO (038) - 4% DAMPING

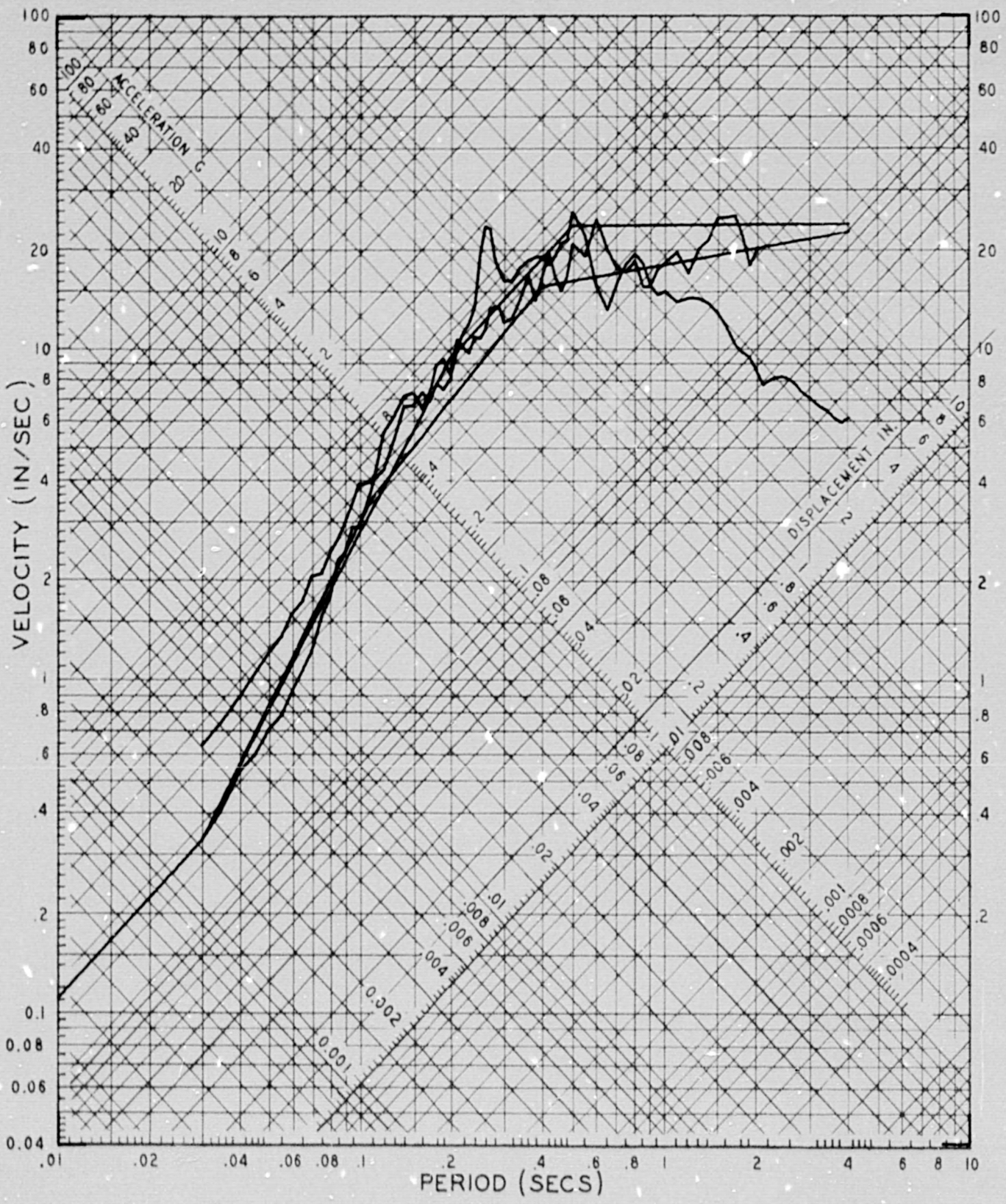

FIGURE B-25

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 6,1976 TOLMEZZO (038) N-S RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
TOLMEZZO (038) - 7% DAMPING

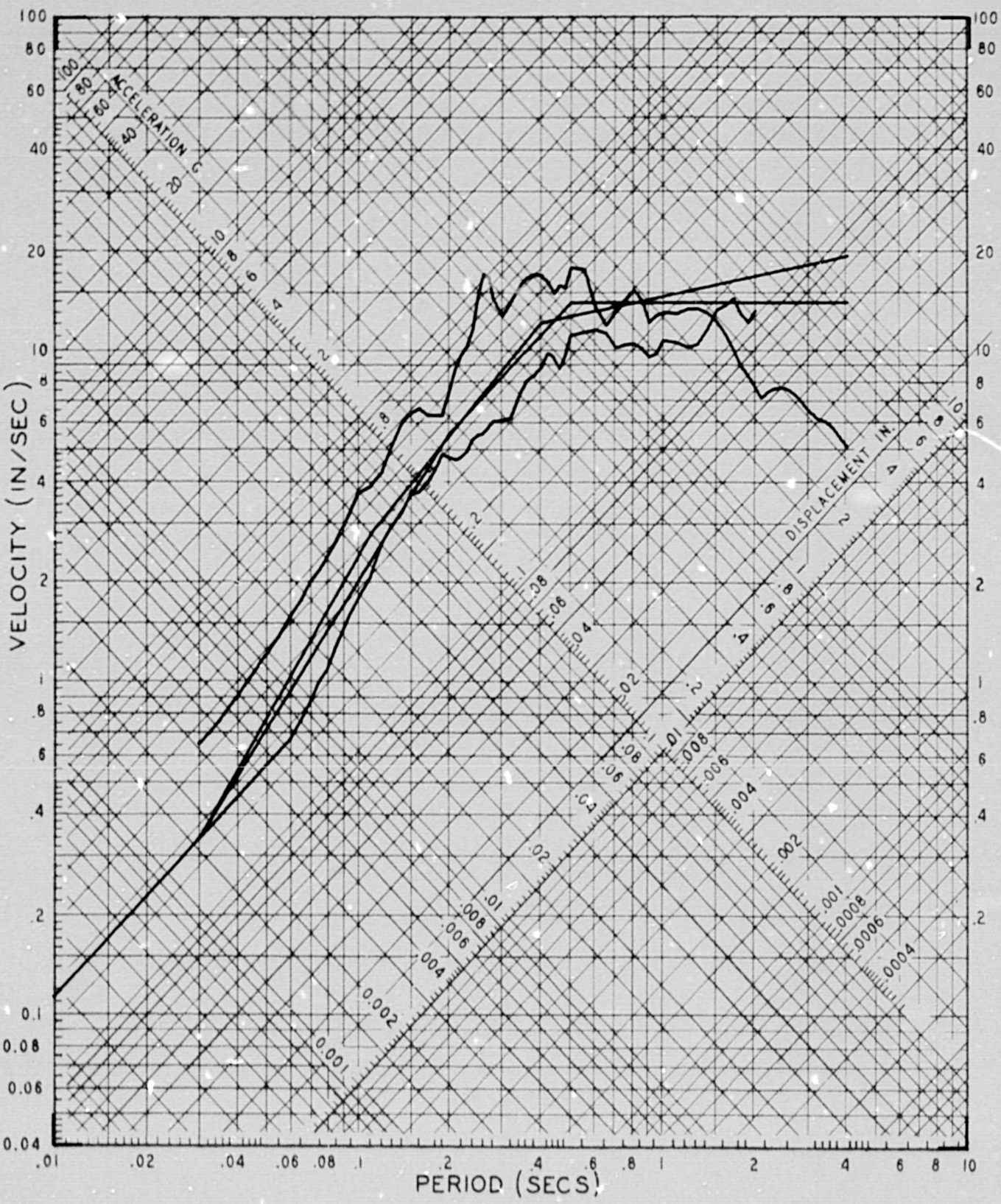

FIGURE B-26

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 6,1976 TOLMEZZO (038) E-W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
TOLMEZZO (038) - 4% DAMPING

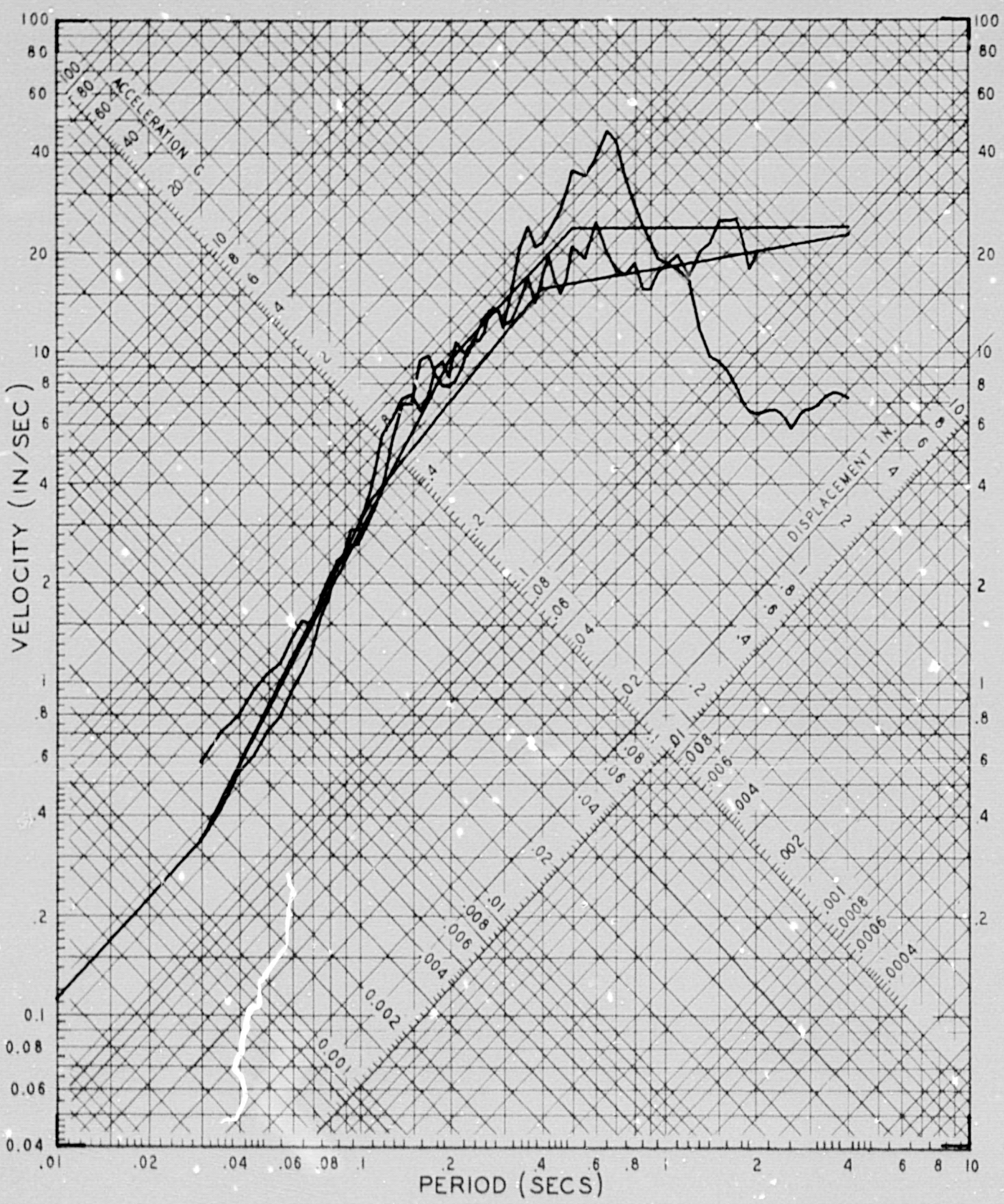

FIGURE B-27

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 6,1976 TOLMEZZO (038) E-W RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
TOLMEZZO (038) - 7% DAMPING

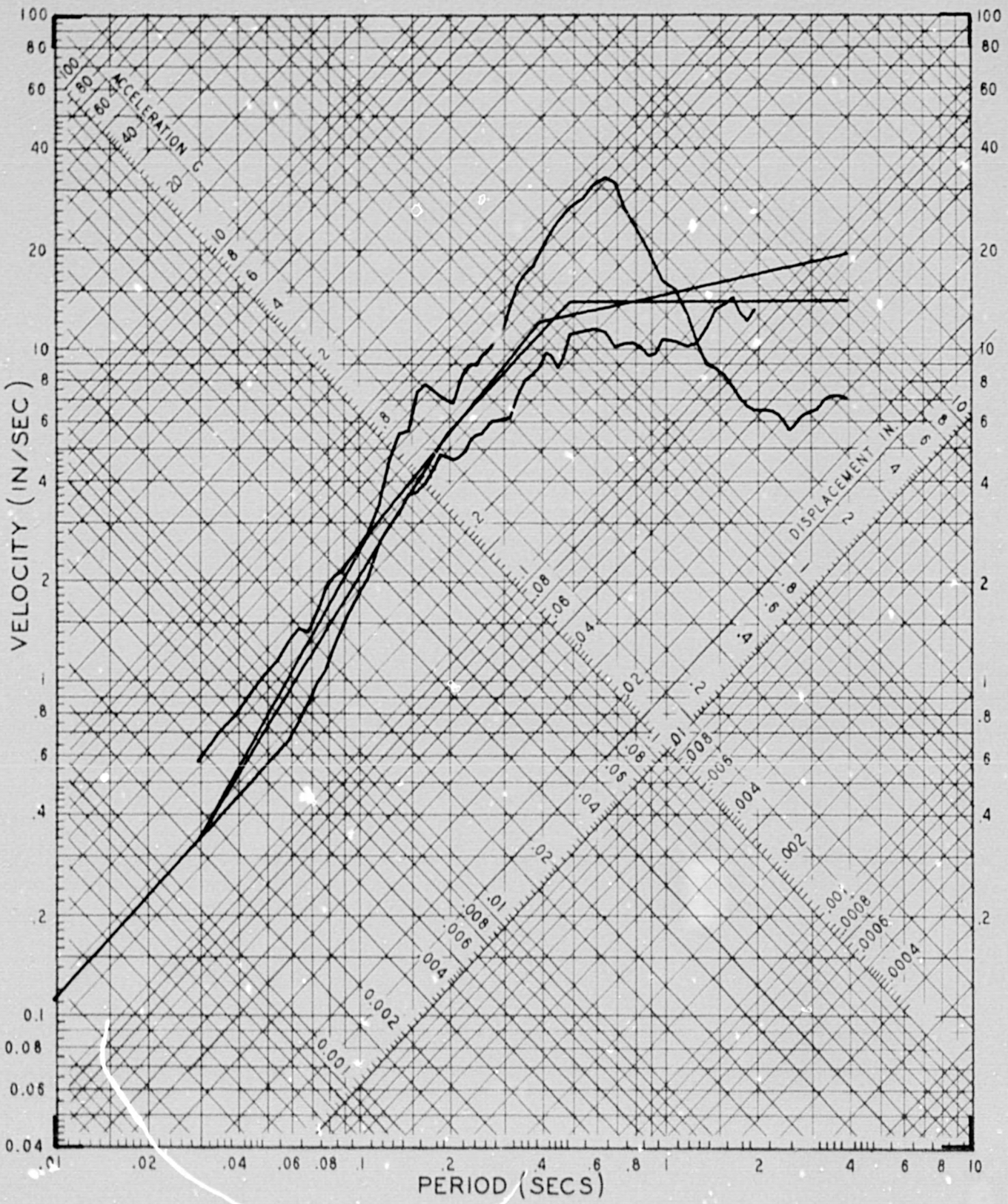

FIGURE B-28

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 9,1976 TOLMEZZO (054) N-S RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
TOLMEZZO (054) - 4% DAMPING

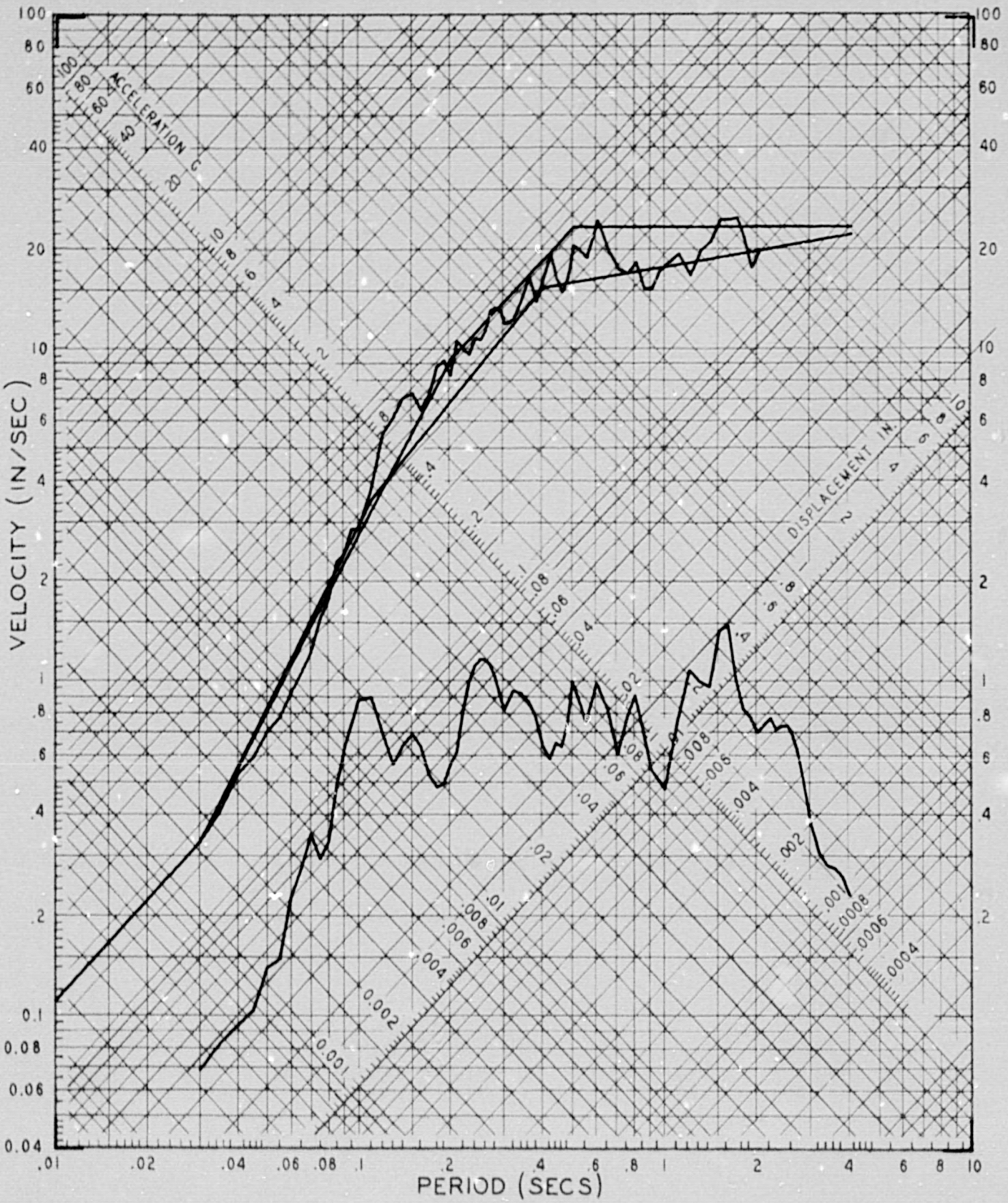

FIGURE B-29

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 9,1976 TOLMEZZO (054) N-S RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
TOLMEZZO (054) - 7% DAMPING

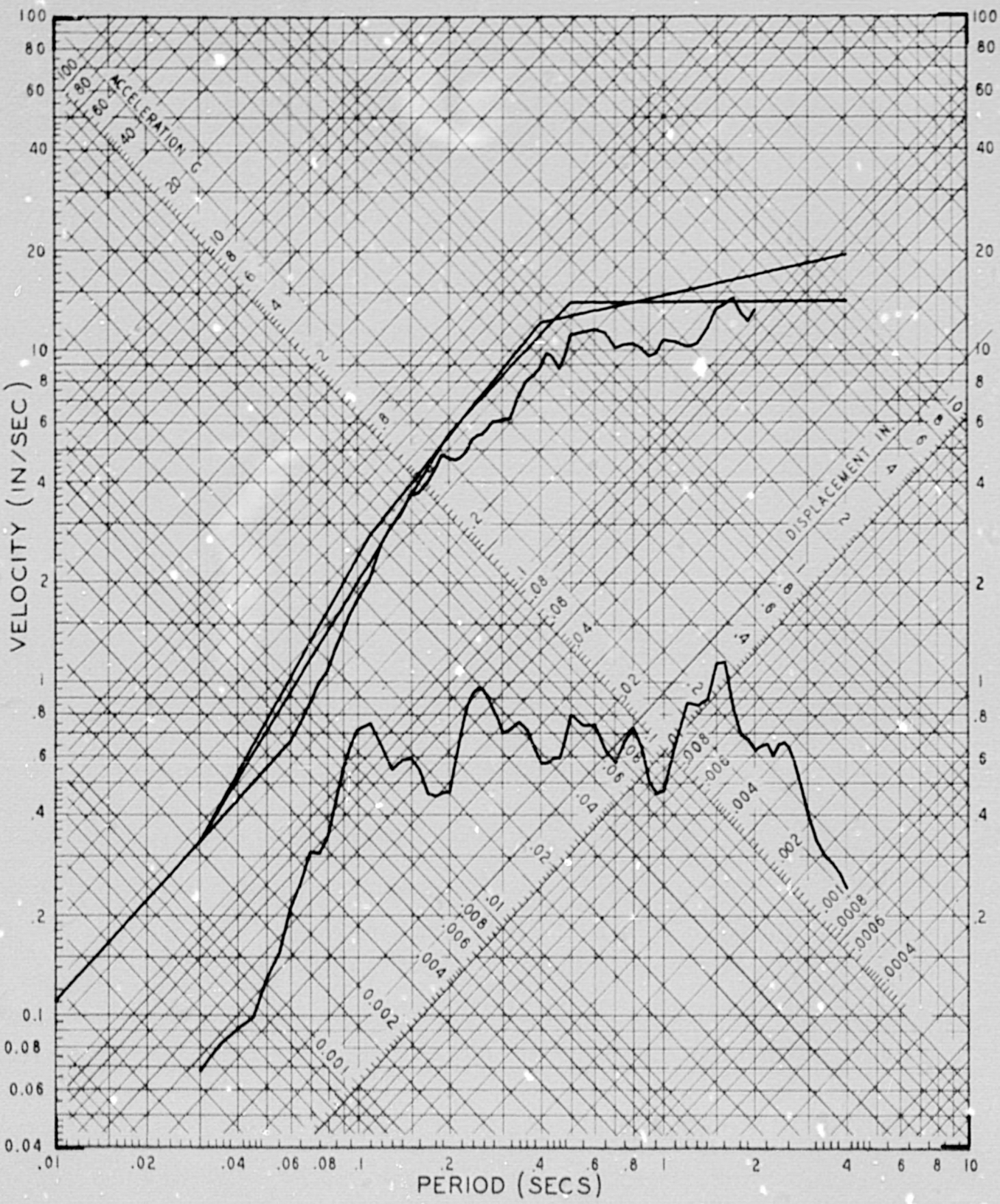

FIGURE B-30

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 9,1976 TOLMEZZO (054) E-W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
TOLMEZZO (054) - 4% DAMPING

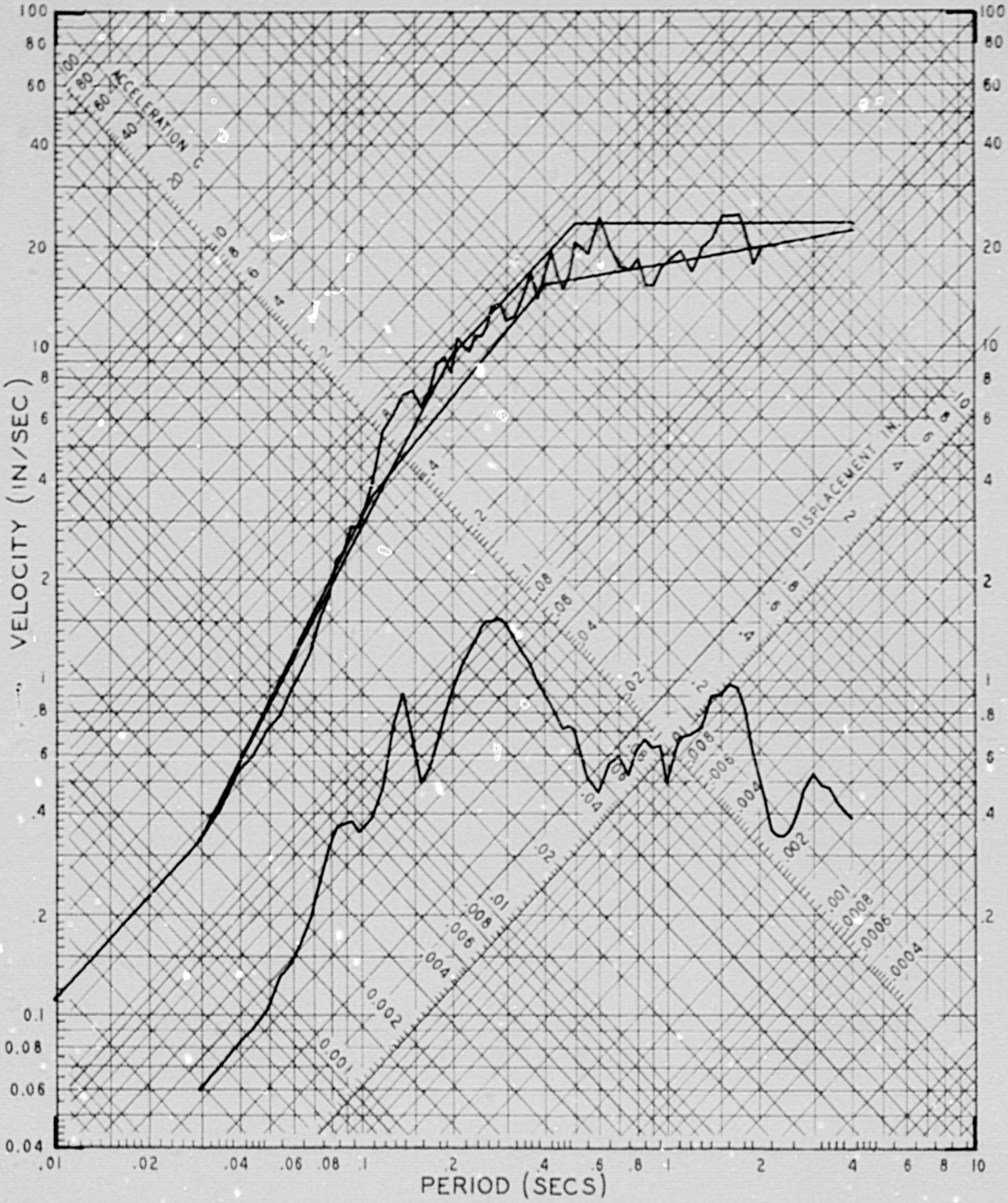

FIGURE B-31

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 9,1976 TOLMEZZO (054) E-W RECORD

SEQUOYAH - 5%DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7%DAMPING
TOLMEZZO (054) - 7% DAMPING

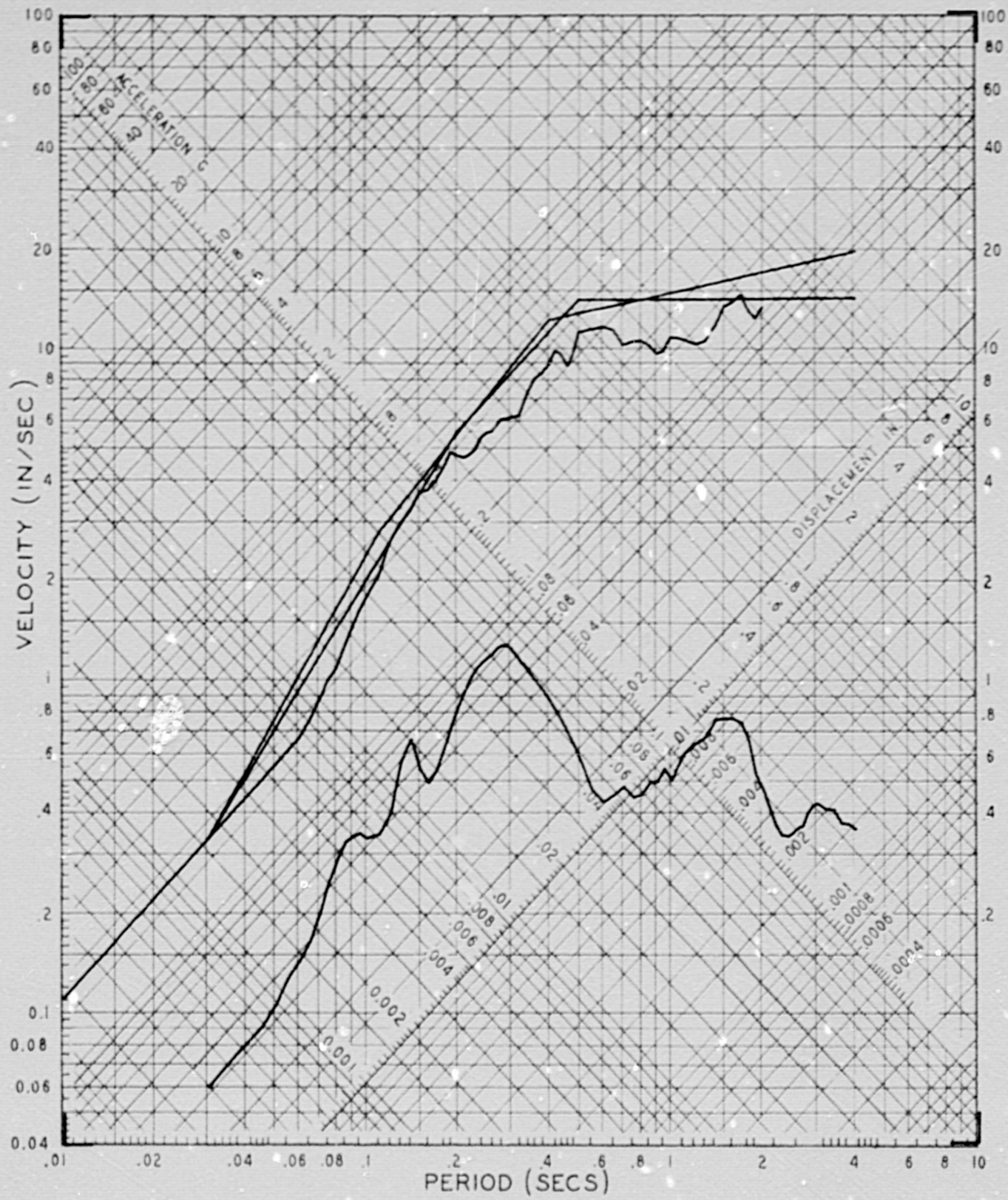

FIGURE B-32

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 11, 1976 TOLMEZZO (063) N-S RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
TOLMEZZO (063) - 4% DAMPING

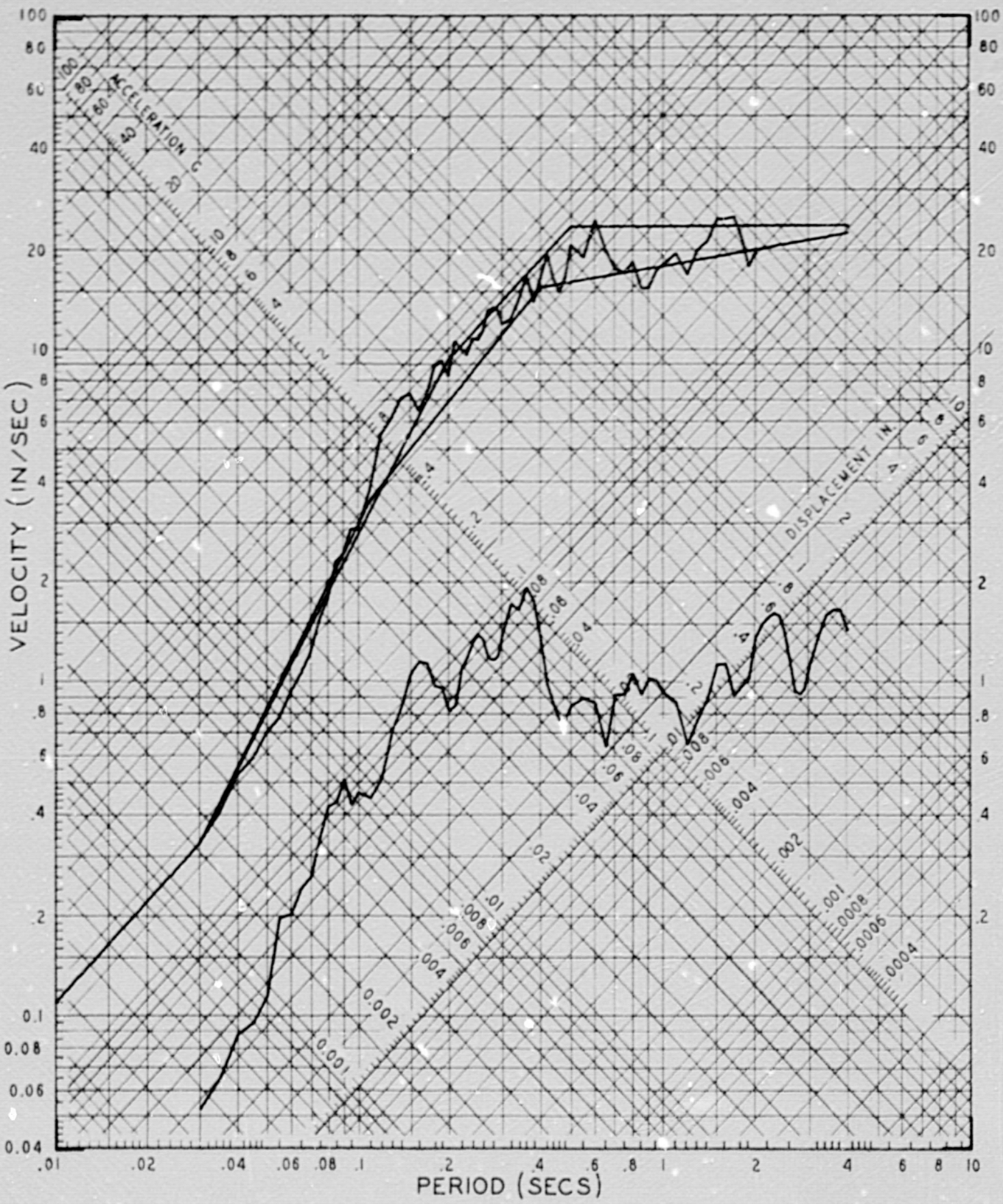

FIGURE B-33

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 11, 1976 TOLMEZZO (063) N-S RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
TOLMEZZO (063) - 7% DAMPING

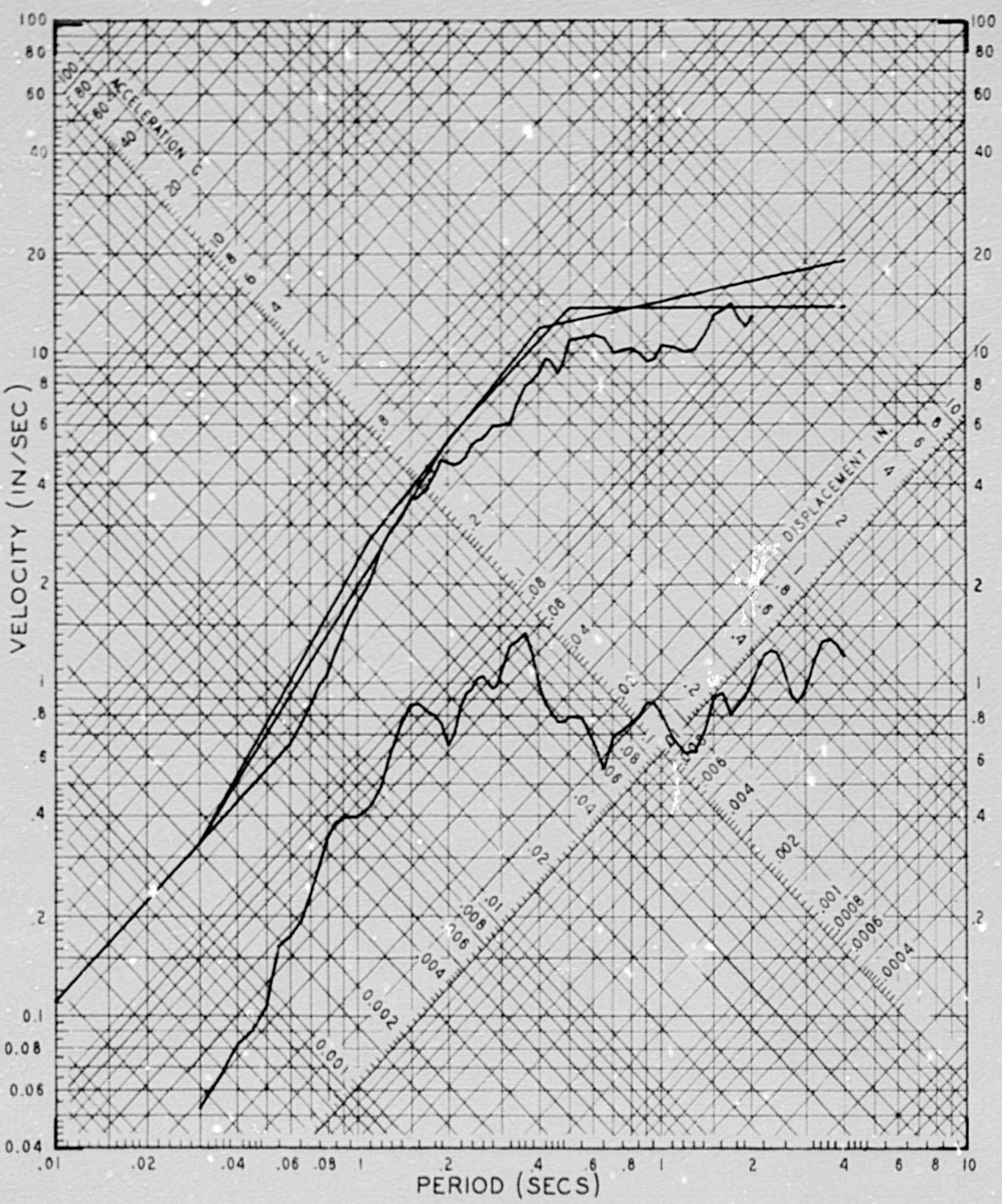

FIGURE B-34

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 11,1976 TOLMEZZO (063) E-W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
TOLMEZZO (063) - 4% DAMPING

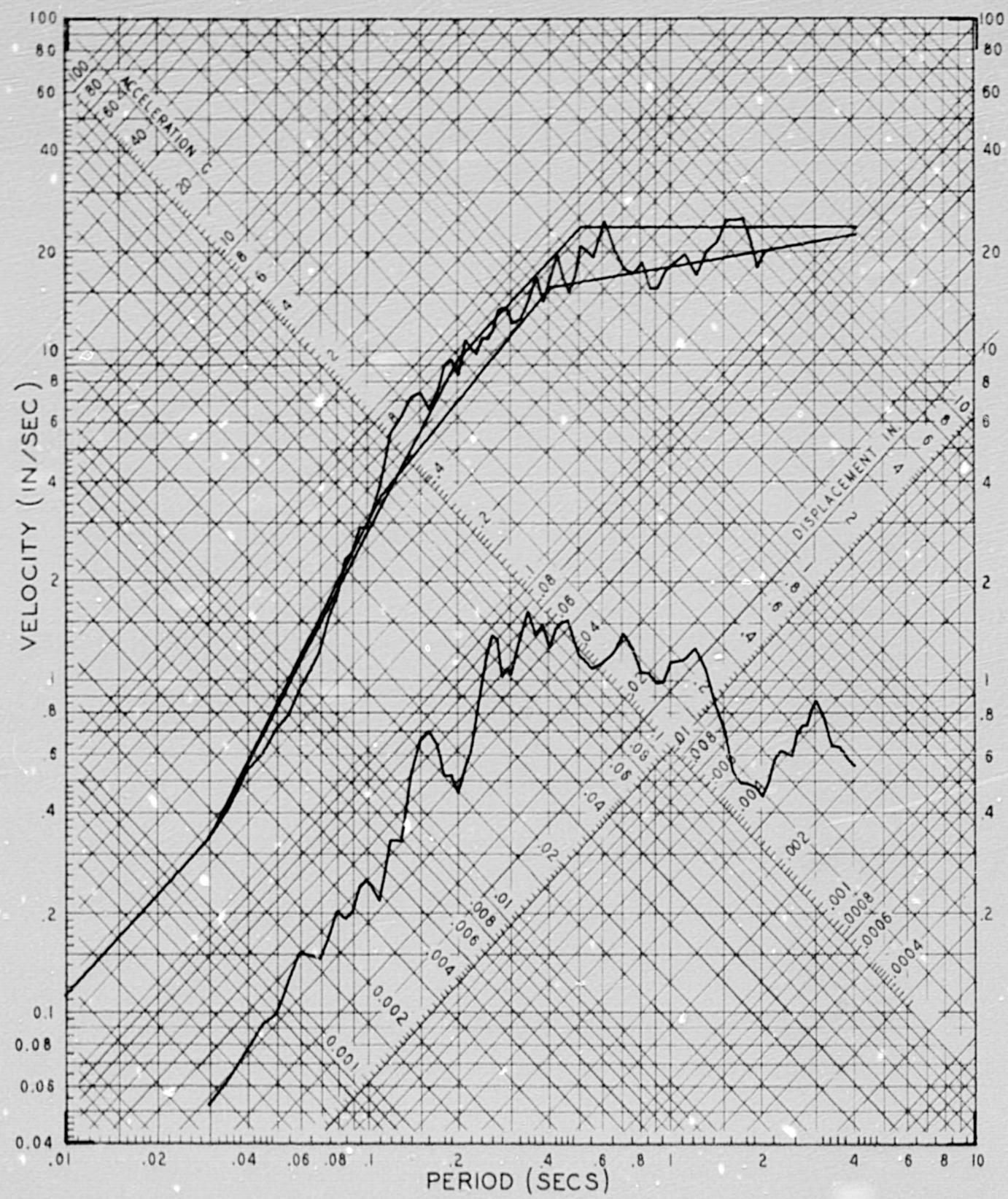

FIGURE B-35

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI MAY 11, 1976 TOLMEZZO (063) E-W RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
TOLMEZZO (063) - 7% DAMPING

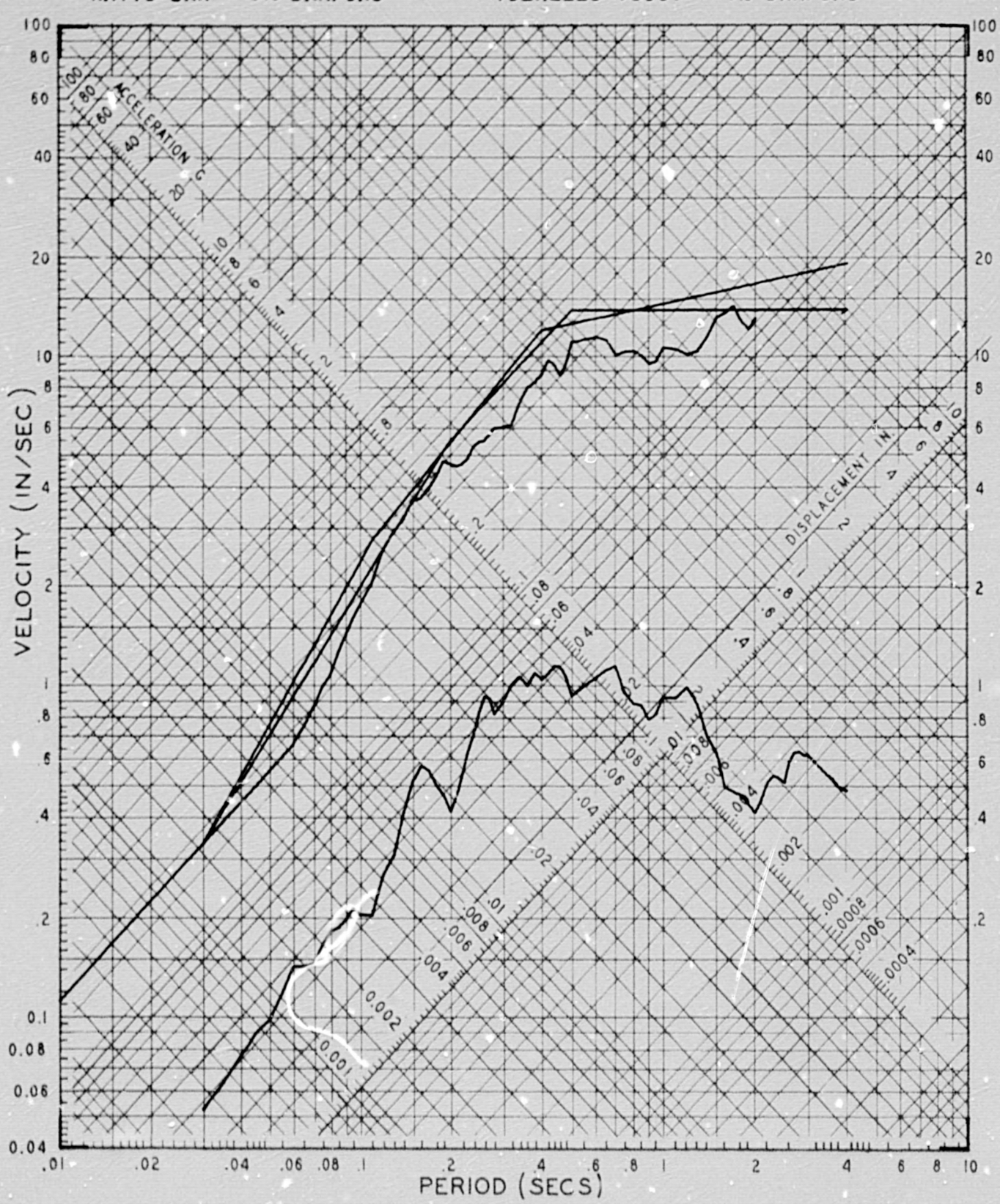

FIGURE B-36

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:31 S.ROCCO (132) N-S RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
S.ROCCO (132) - 4% DAMPING

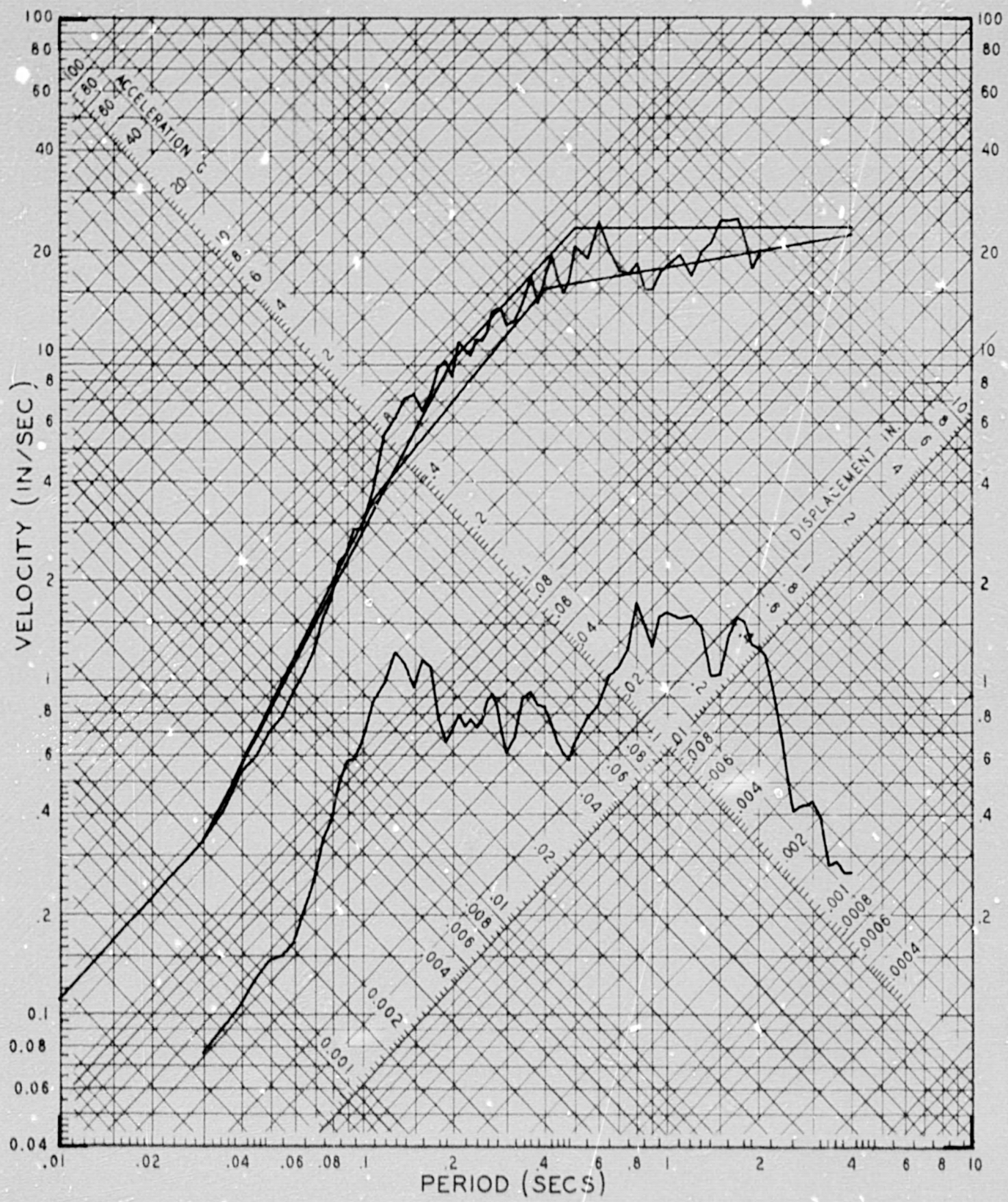

FIGURE B-37

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:31 S.ROCCO (132) N-S RECORD

SEQUOYAH – 5% DAMPING
WATTS BAR – 5% DAMPING
BELLEFONTE – 7% DAMPING
S.ROCCO (132) – 7% DAMPING

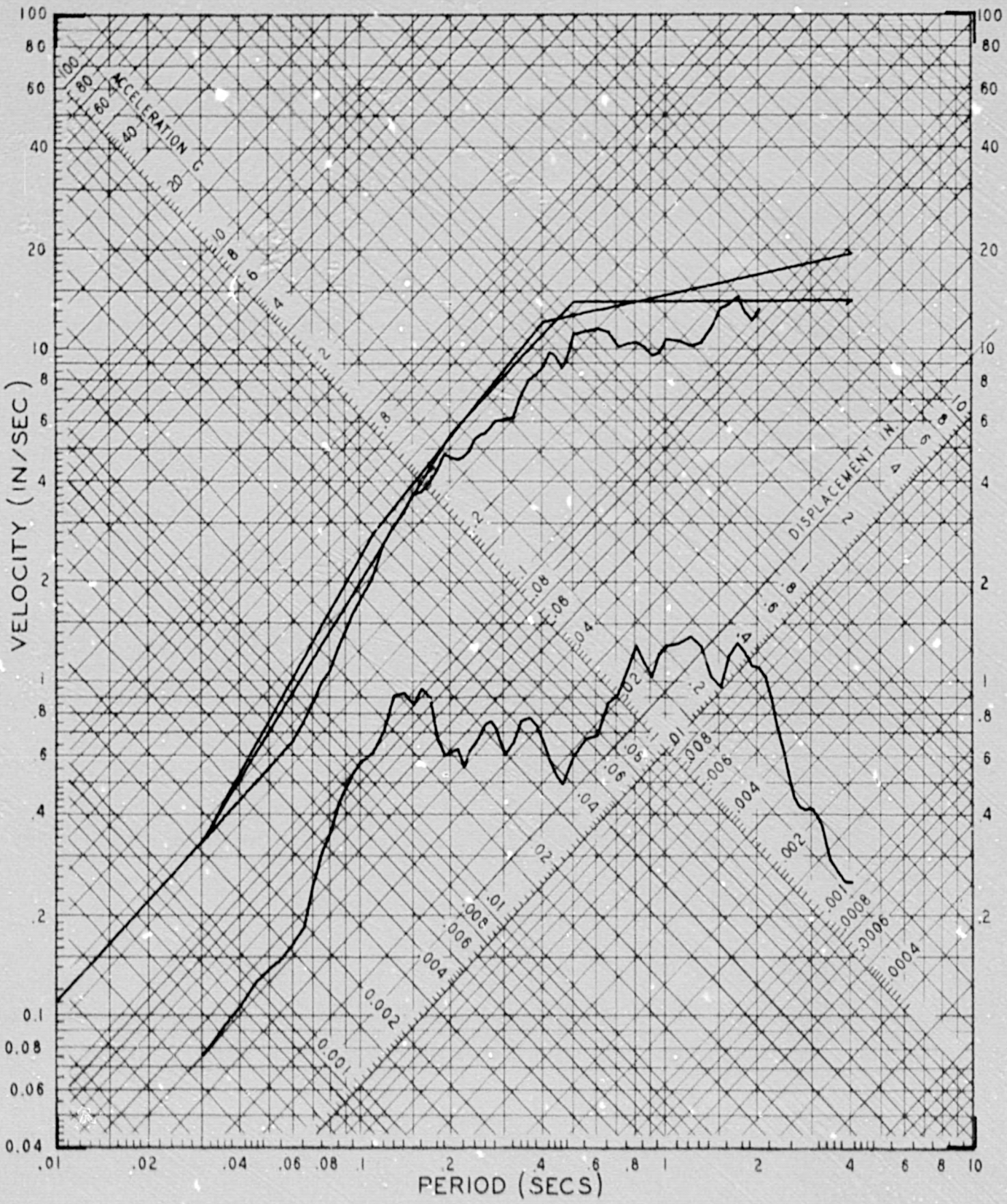

FIGURE B-38

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:31 S.ROCCO (132) E-W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4%DAMPING
S.ROCCO (132) - 4% DAMPING

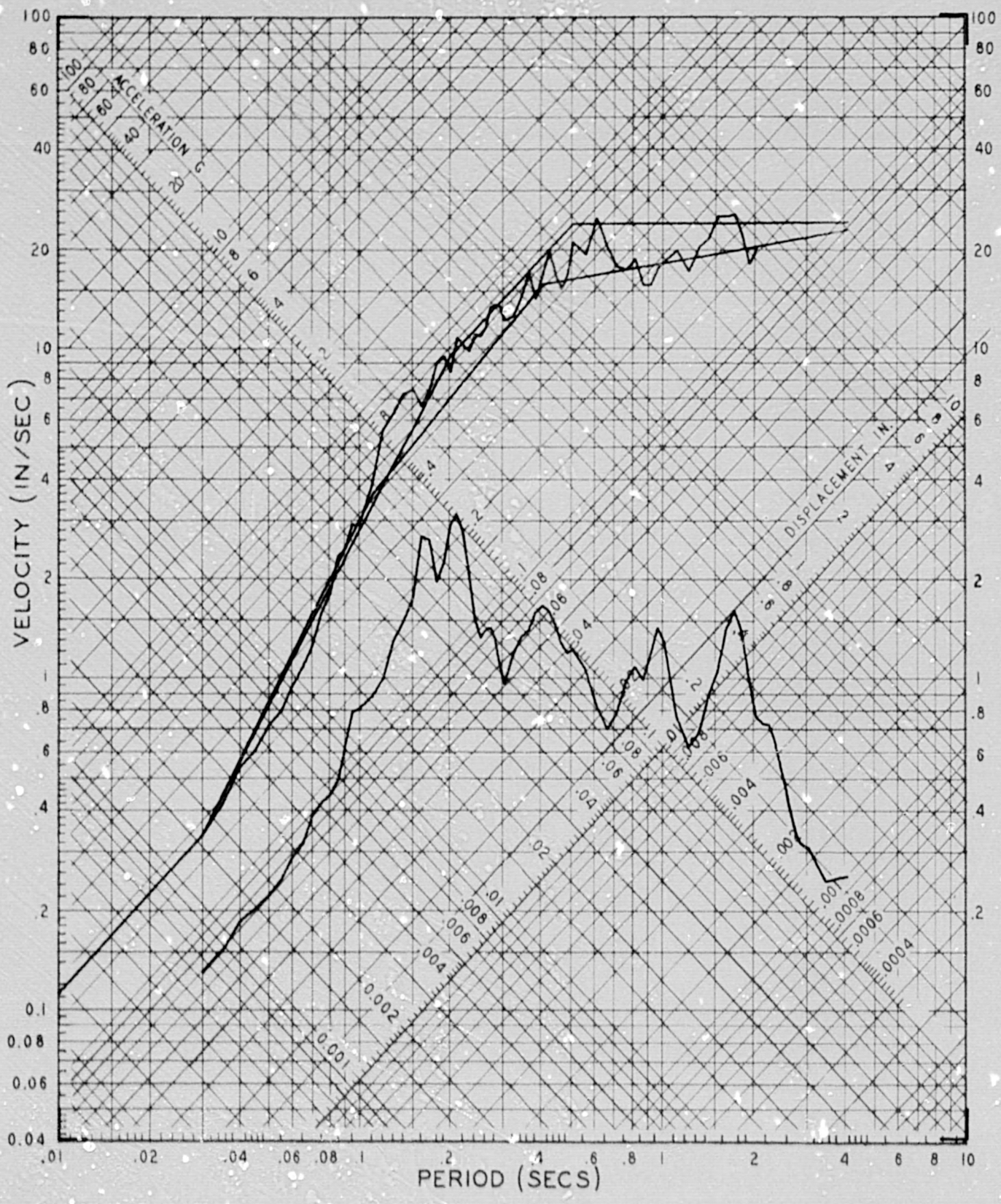

FIGURE B-39

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:31 S.ROCCO (132) E-W RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
S.ROCCO (132) - 7% DAMPING

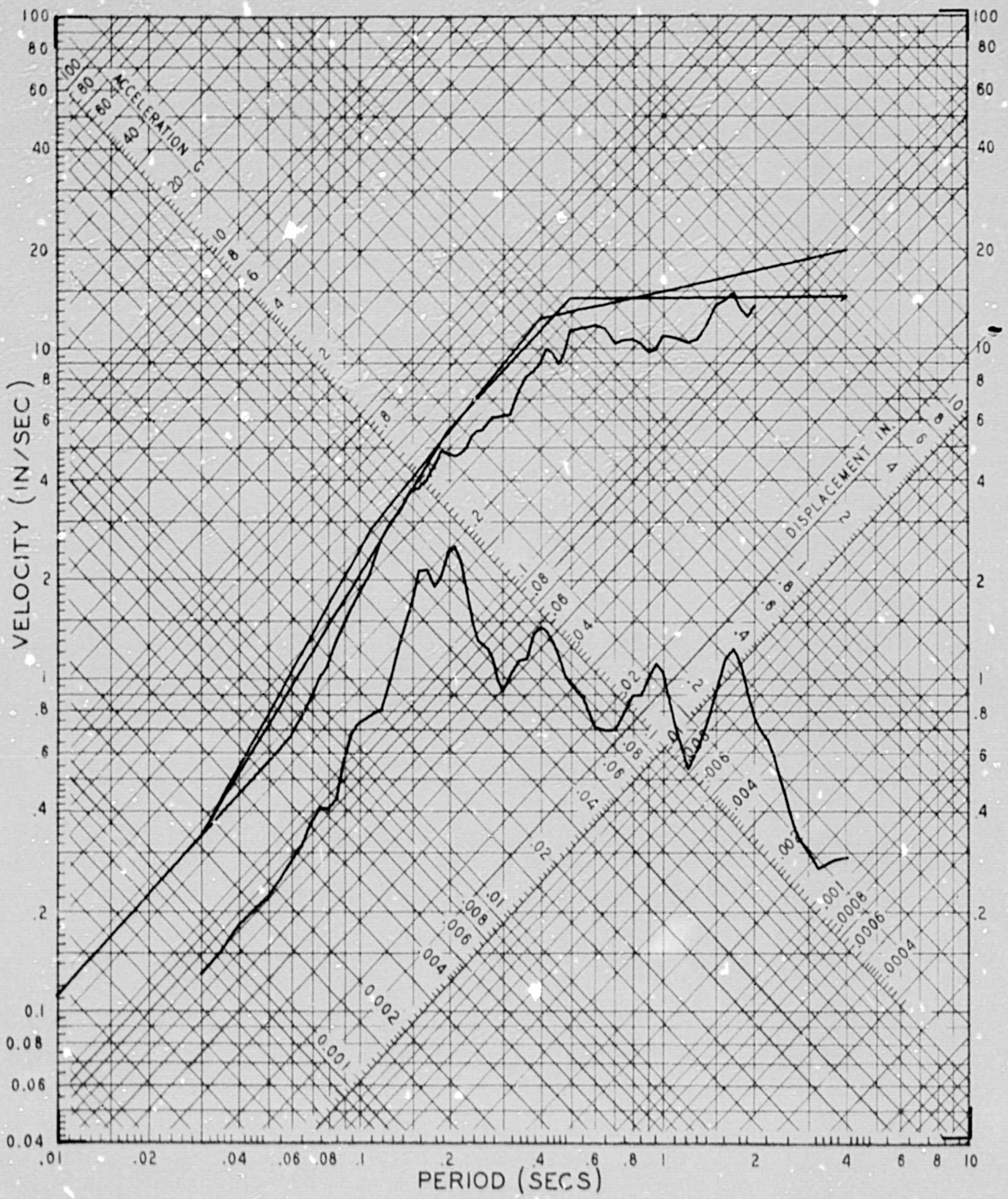

FIGURE B-40

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:35 S.ROCCO (139) N-S RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
S.ROCCO (139) - 4% DAMPING

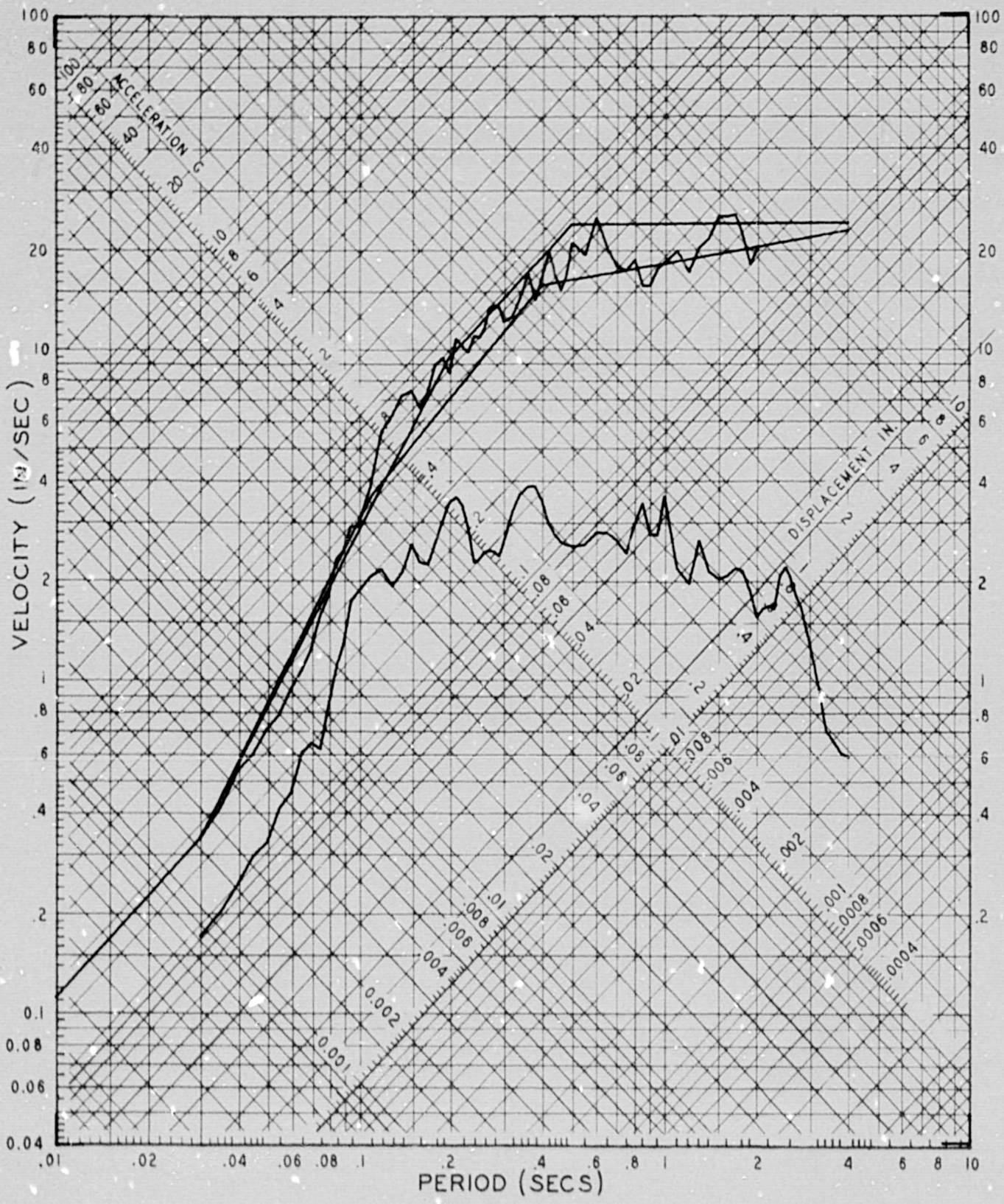

FIGURE B-41

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:35 S.ROCCO (139) E-W RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
S.ROCCO (139) - 7% DAMPING

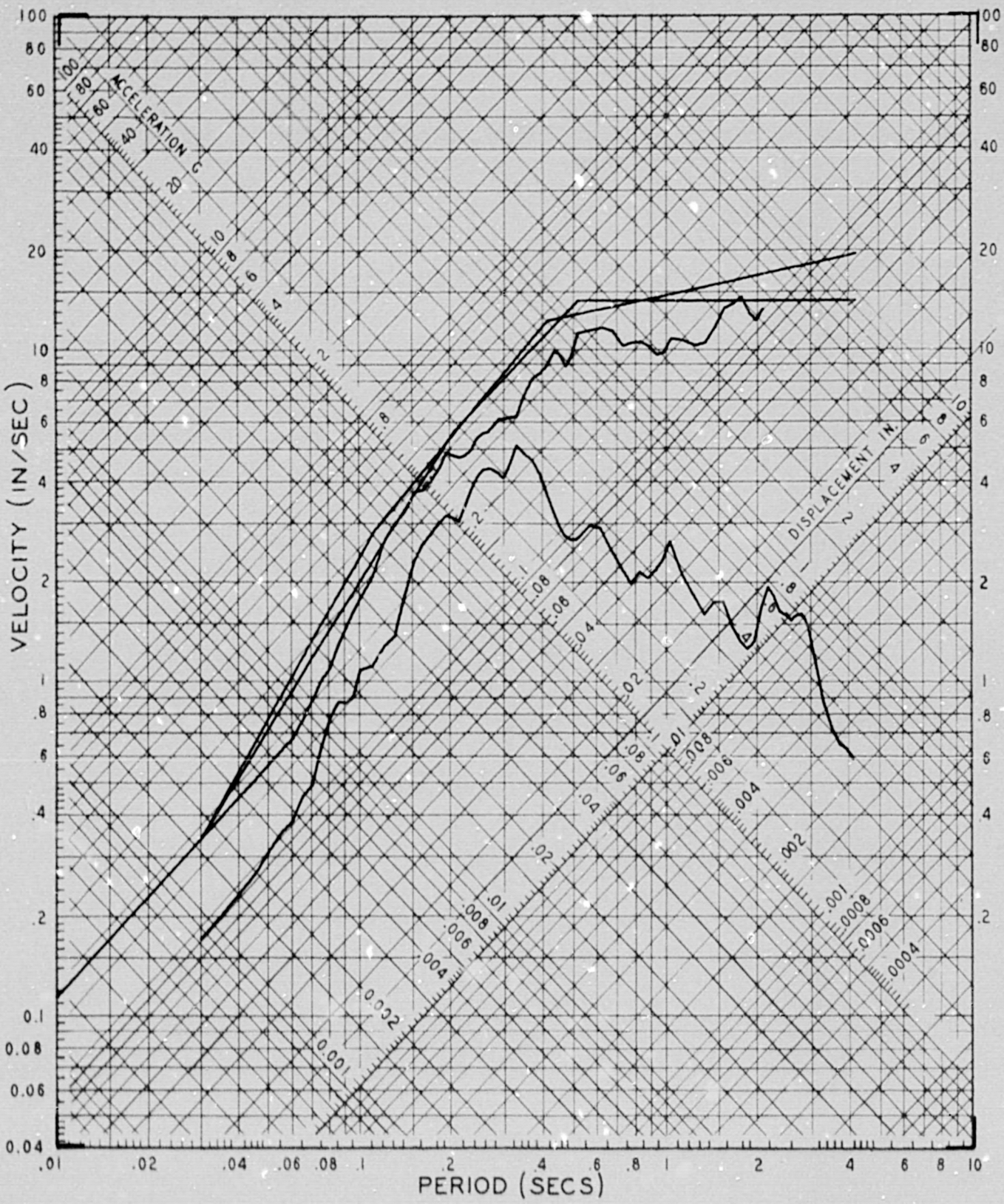

FIGURE B-42

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:35 S.ROCCO (139) E-W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
S.ROCCO (139) - 4% DAMPING

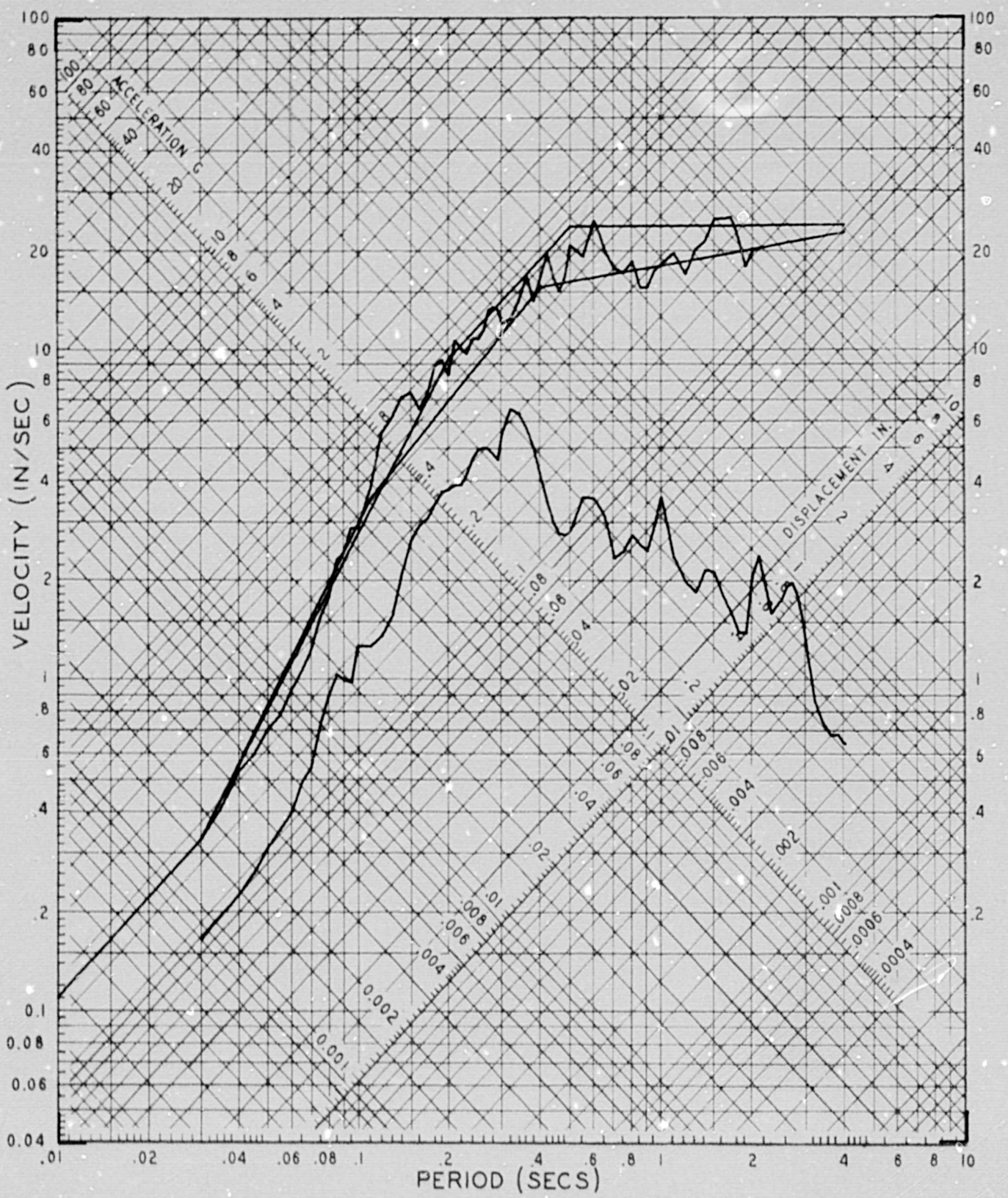

FIGURE B-43

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 11,1976 16:35 S.ROCCO (139) N-S RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
S.ROCCO (139) - 7% DAMPING

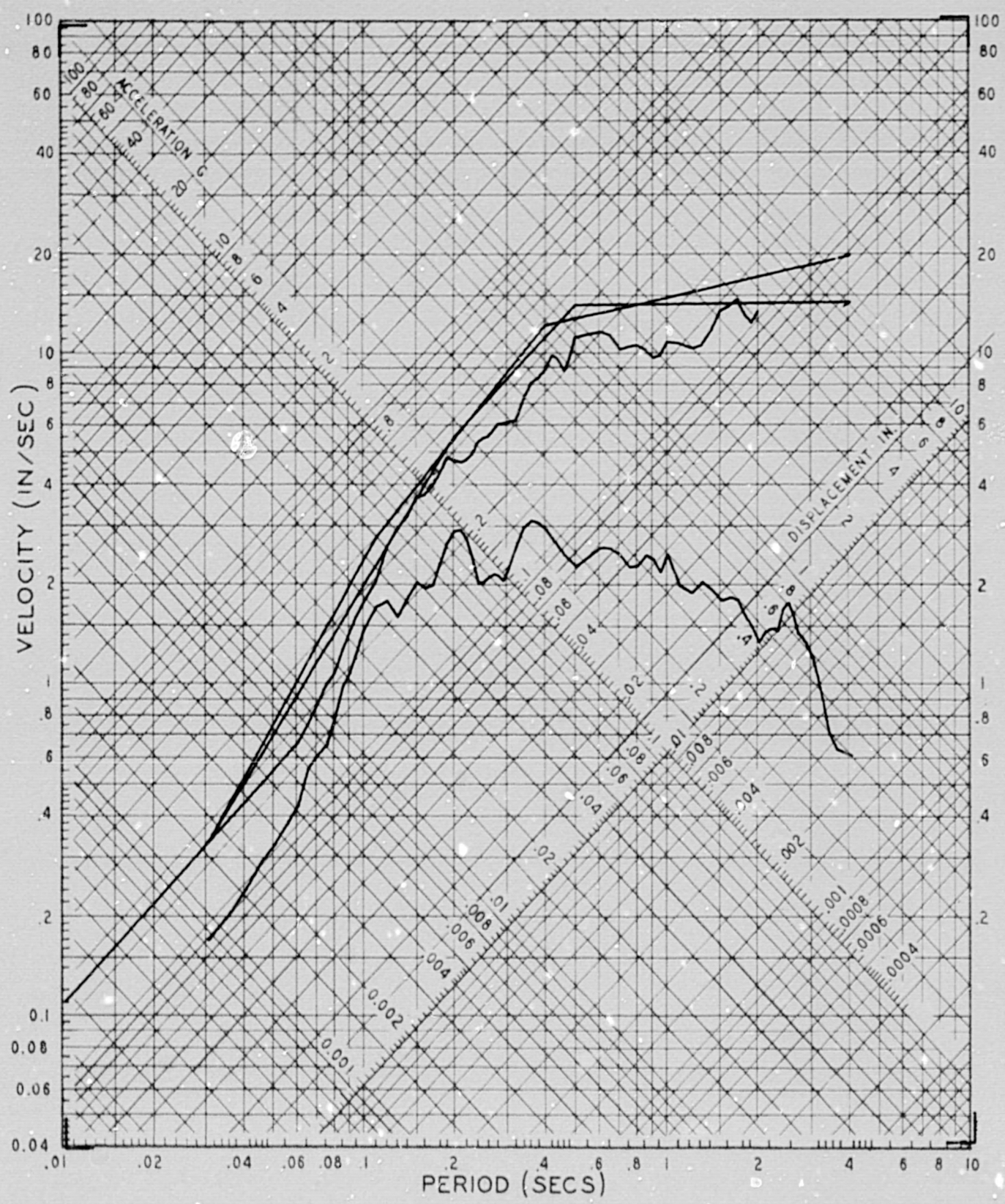

FIGURE B-44

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 03:15 S.ROCCO (153) N-S RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
S.ROCCO (153) - 4% DAMPING

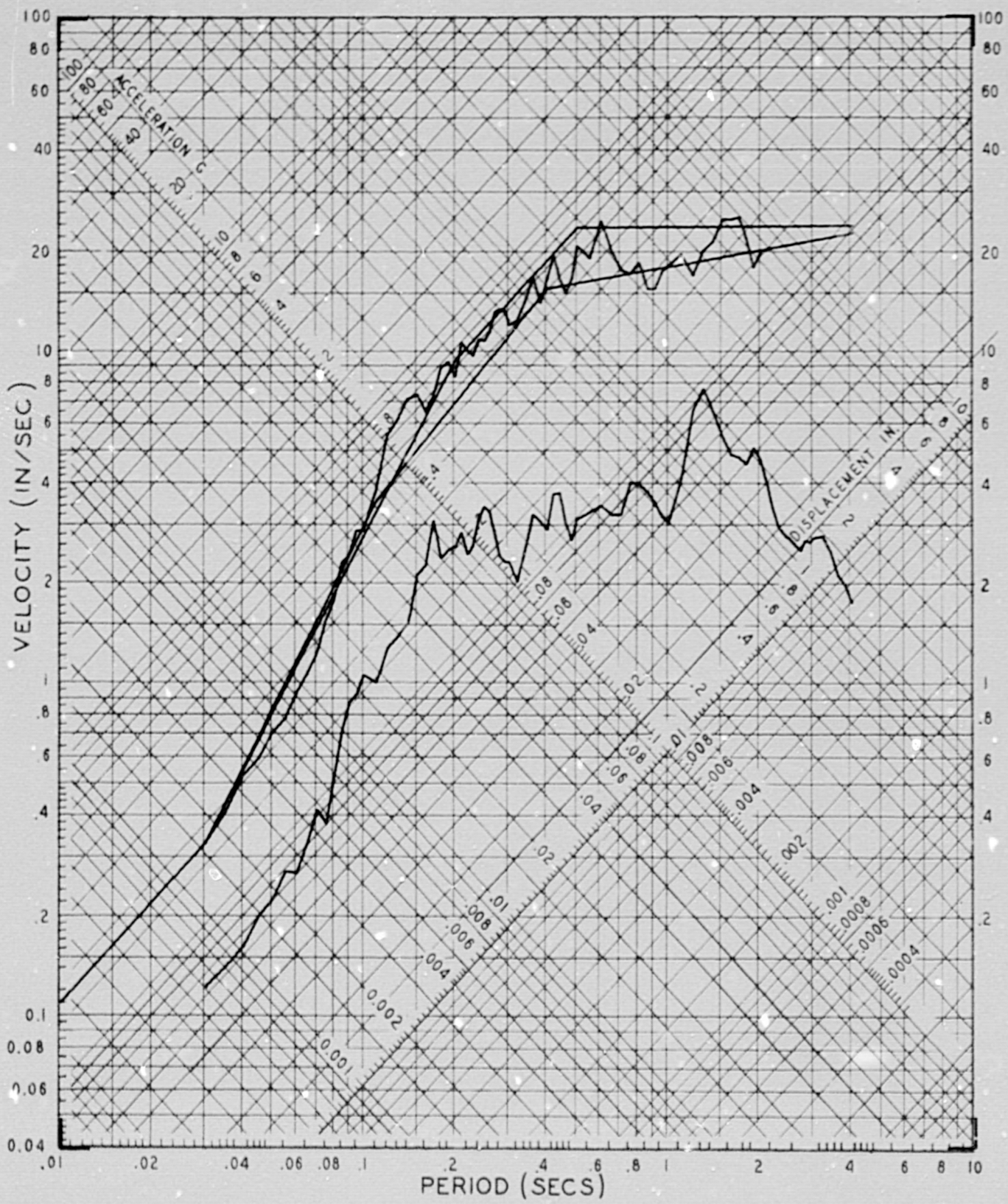

FIGURE B-45

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 03:15 S.ROCCO (153) N-S RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
S.ROCCO (153) - 7% DAMPING

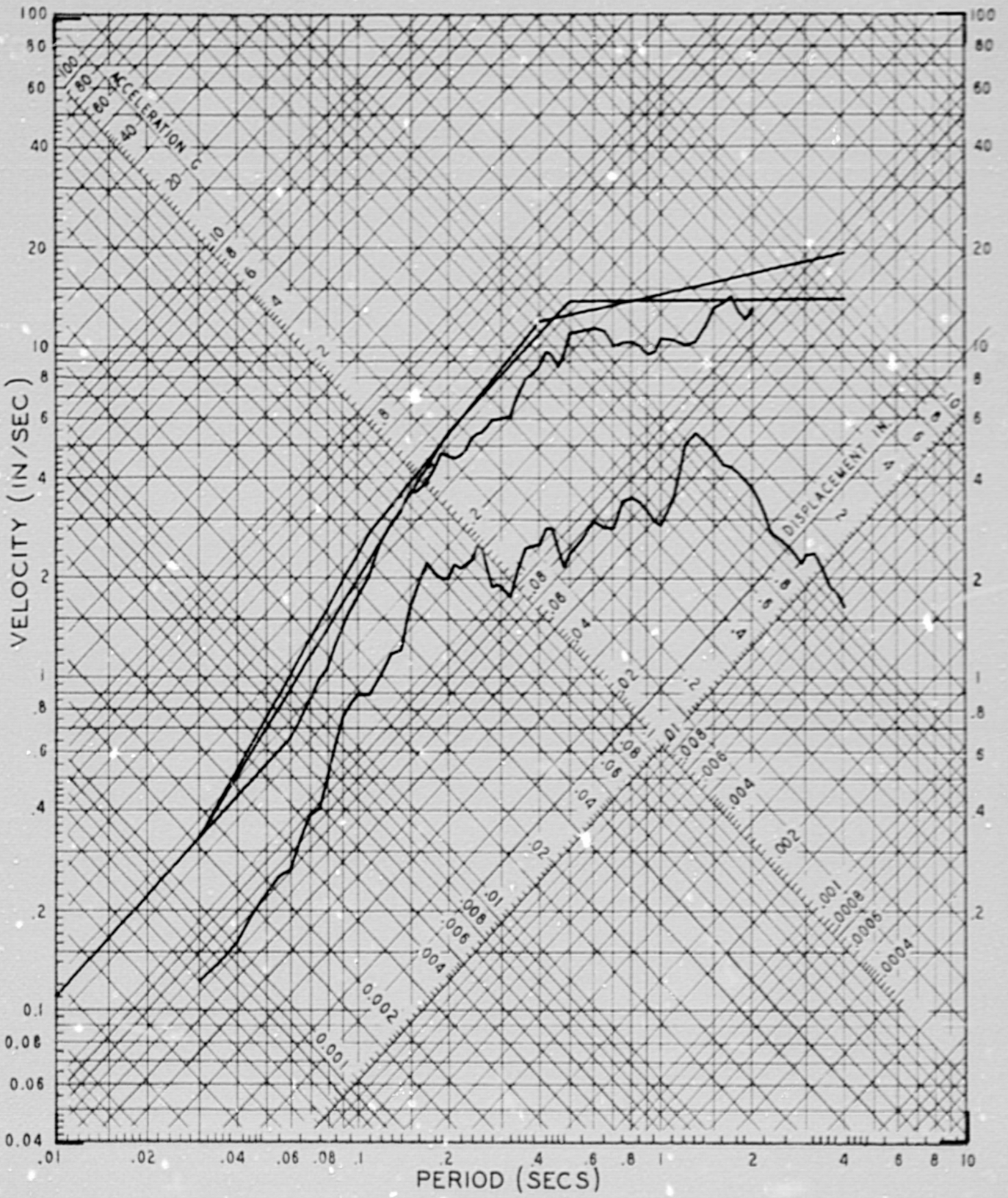

FIGURE B-46

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 03:15 S.ROCCO (153) E-W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
S.ROCCO (153) - 4% DAMPING

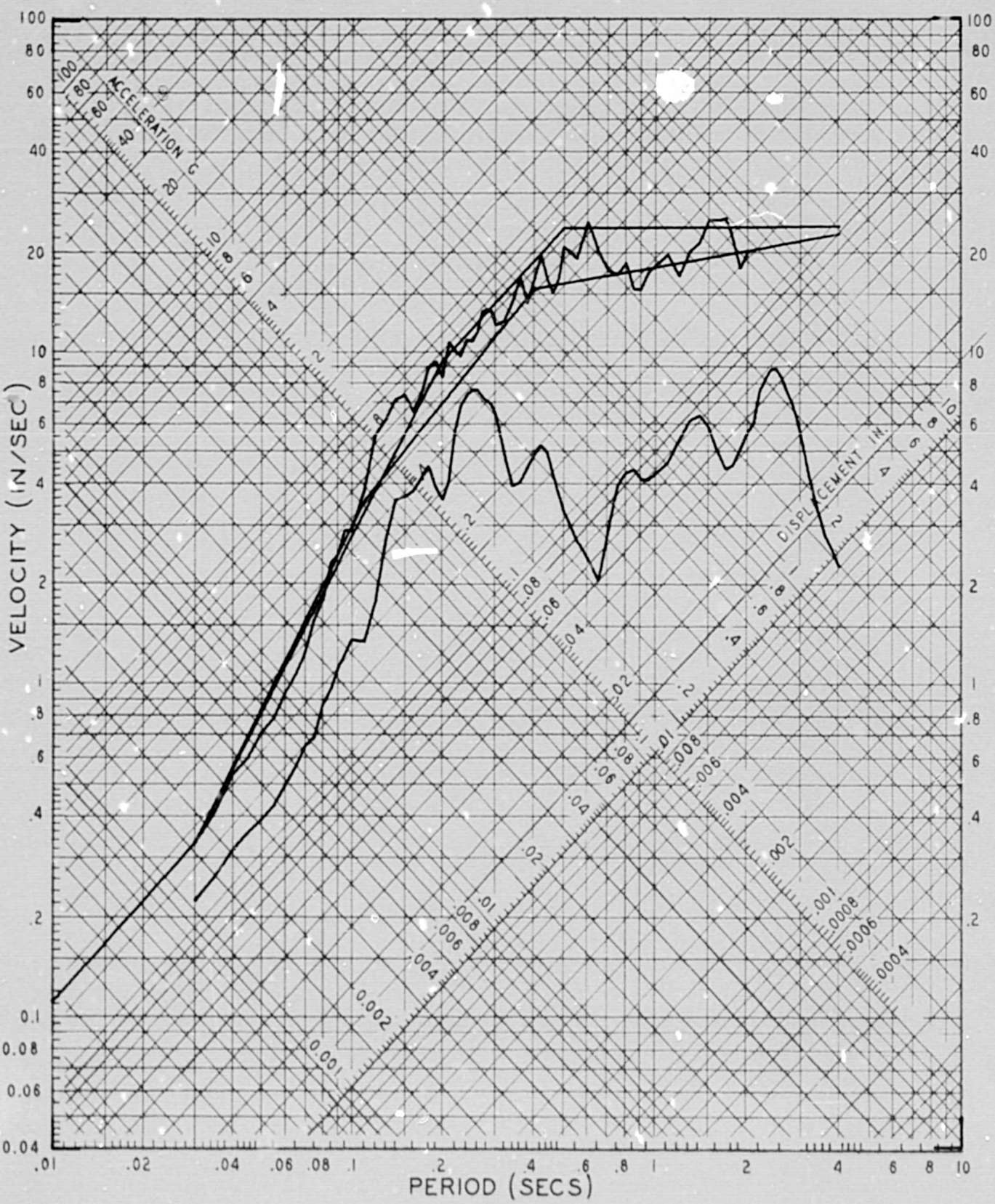

FIGURE B-47

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 03:15 S.ROCCO (153) E-W RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
S.ROCCO (153) - 7% DAMPING

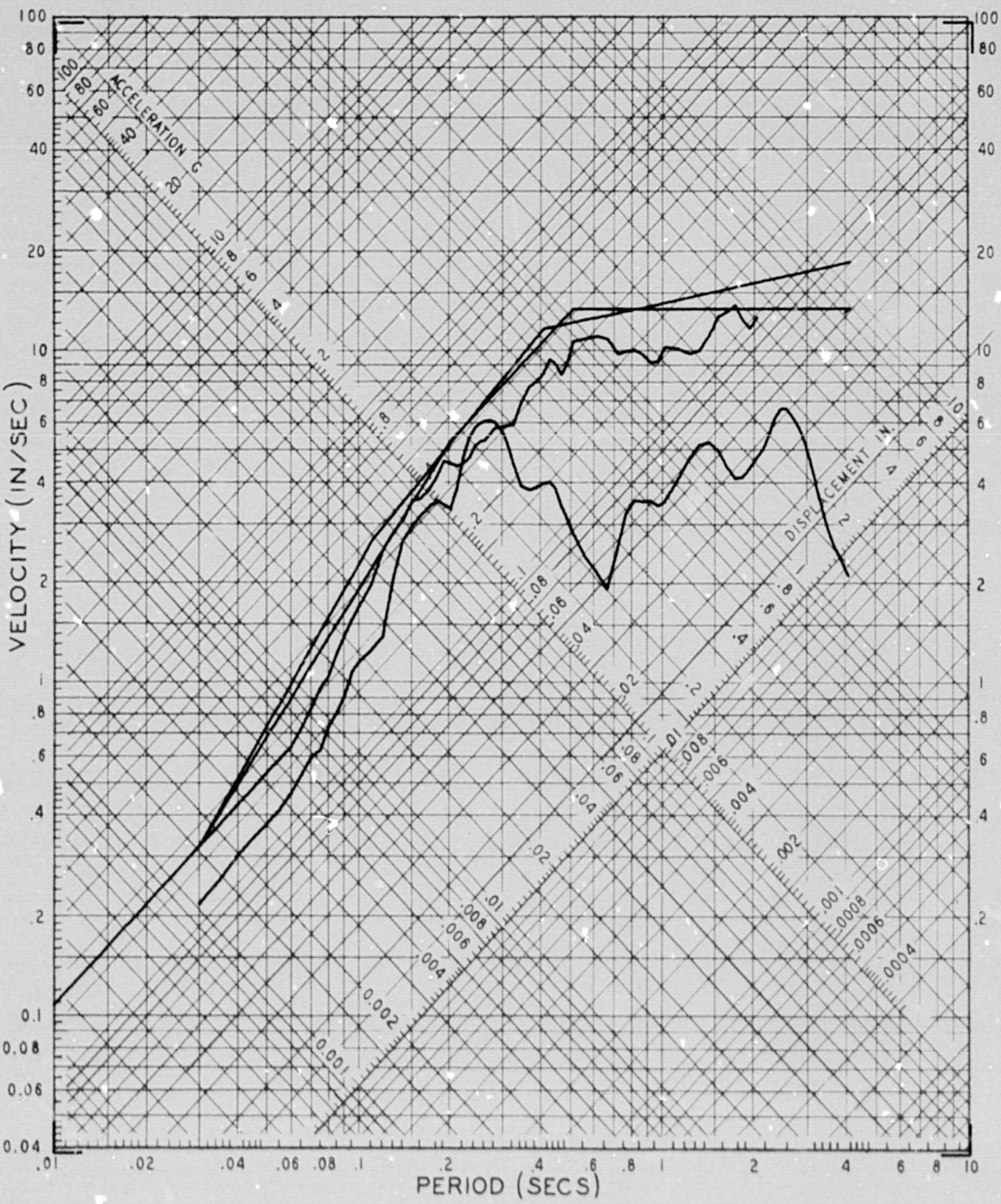

FIGURE B-48

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 09:21 S.ROCCO (169) N-S RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
S.ROCCO (169) - 4% DAMPING

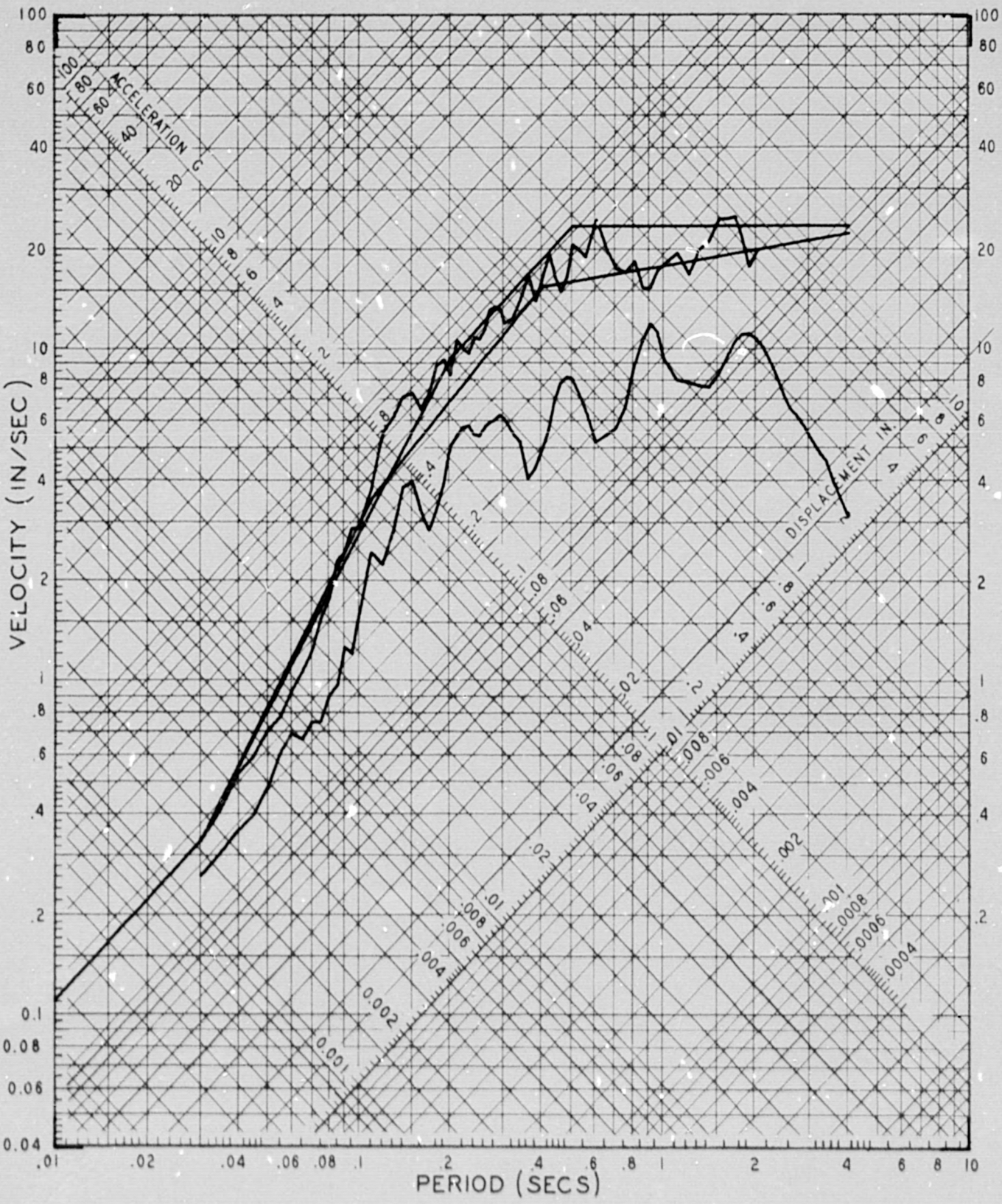

FIGURE B-49

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 09:21 S.ROCCO (169) N-S RECORD

SEQUOYAH -5% DAMPING
WATTS BAR -5% DAMPING
BELLEFONTE - 7% DAMPING
S.ROCCO (169) - 7% DAMPING

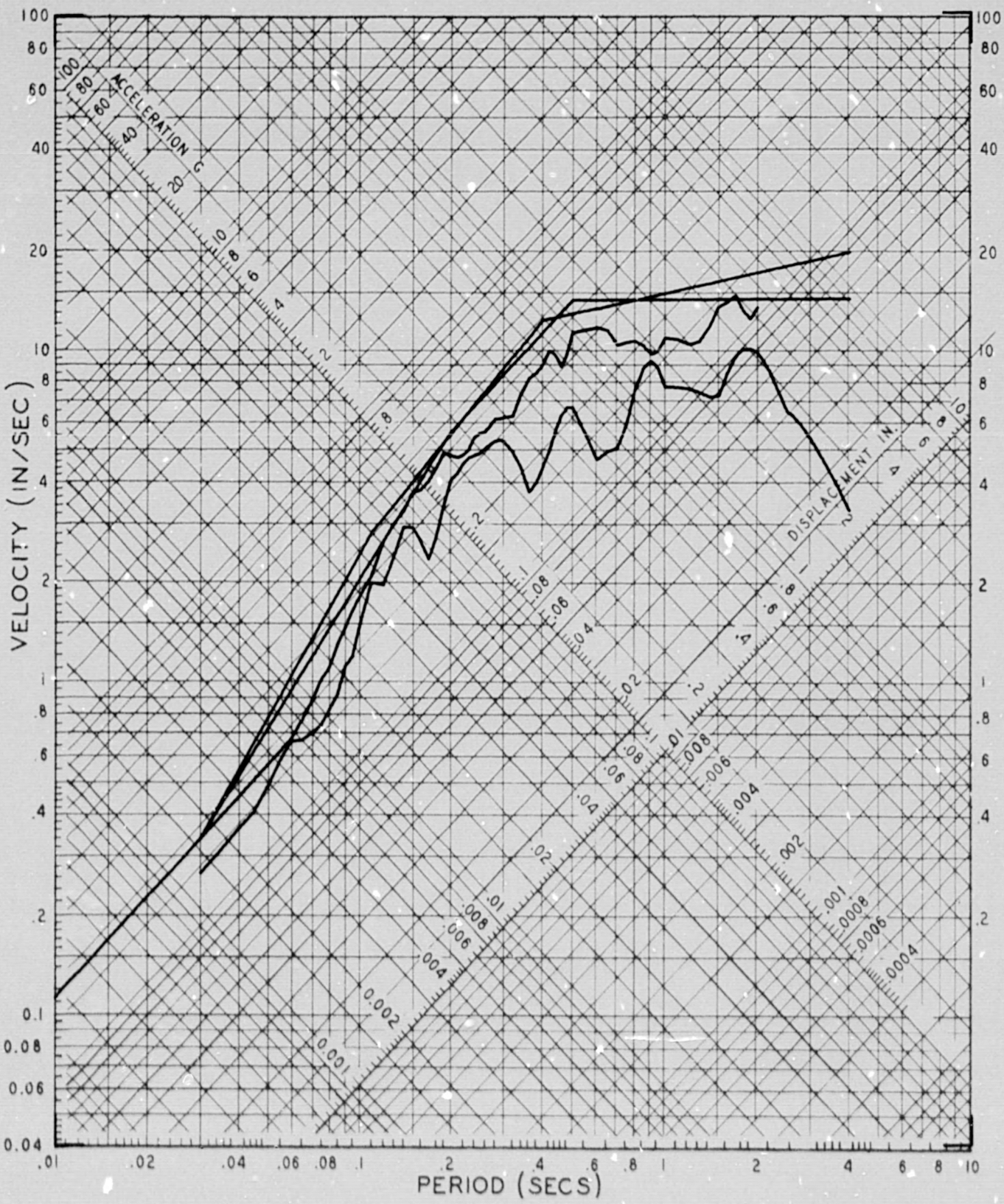

FIGURE B-50

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 09:21 S.ROCCO (169) E-W RECORD

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
S.ROCCO (169) - 4% DAMPING

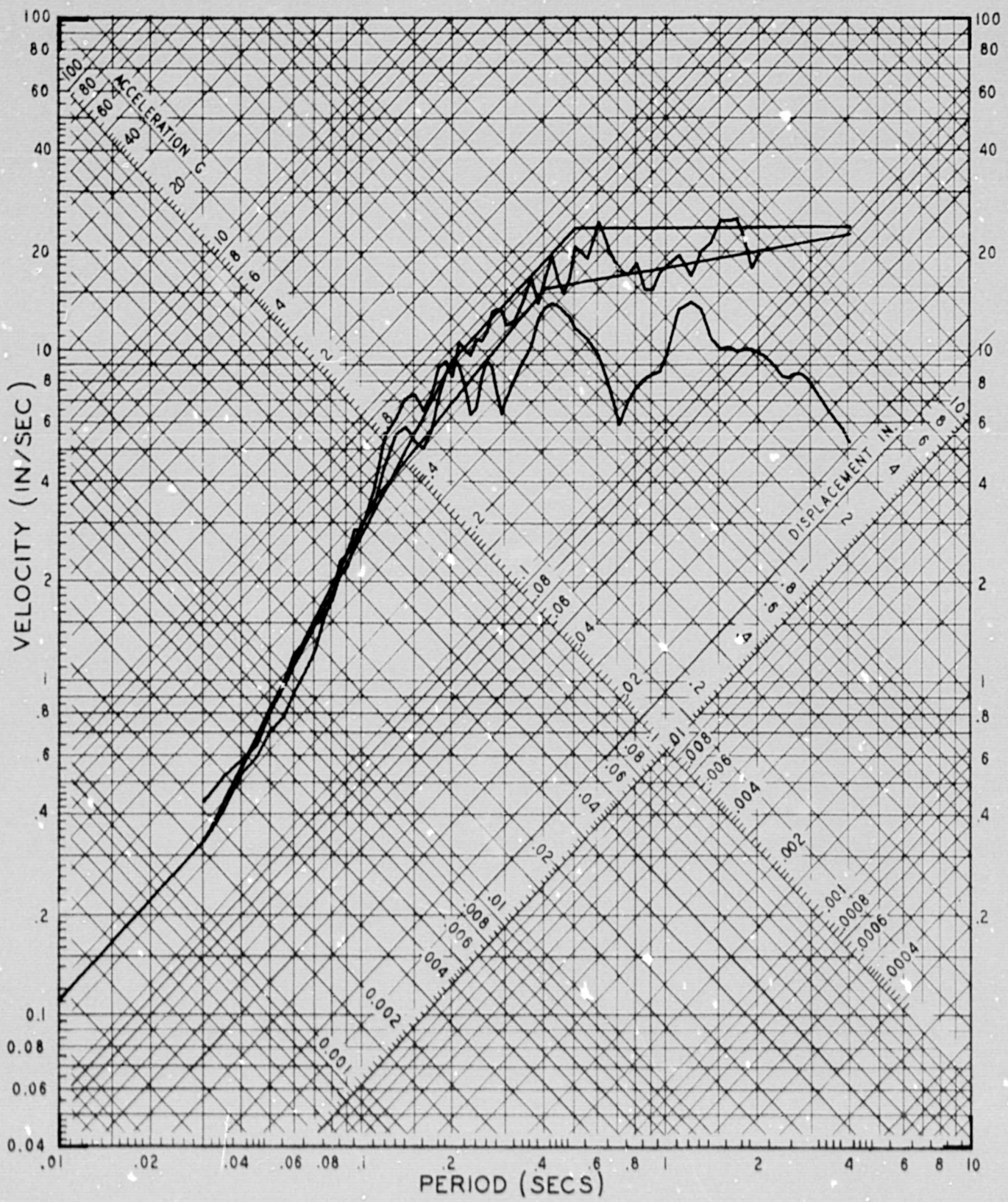

FIGURE B-51

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH FRIULI SEPT 15,1976 09:21 S.ROCCO (169) E-W RECORD

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
S.ROCCO (169) - 7% DAMPING

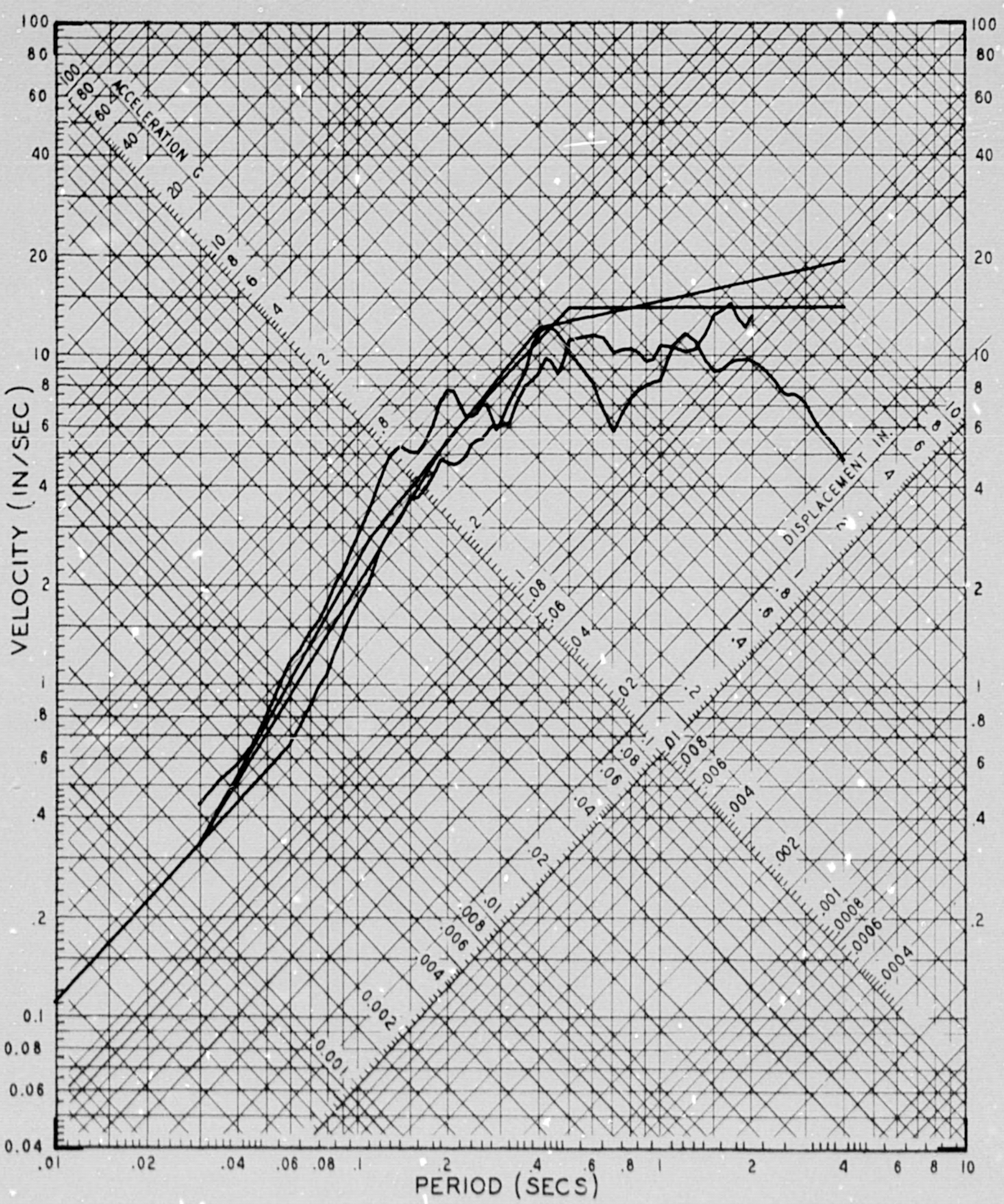

FIGURE B-52

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH MEAN OF SIX UNITED STATES EARTHQUAKES

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
US MEAN - 4% DAMPING

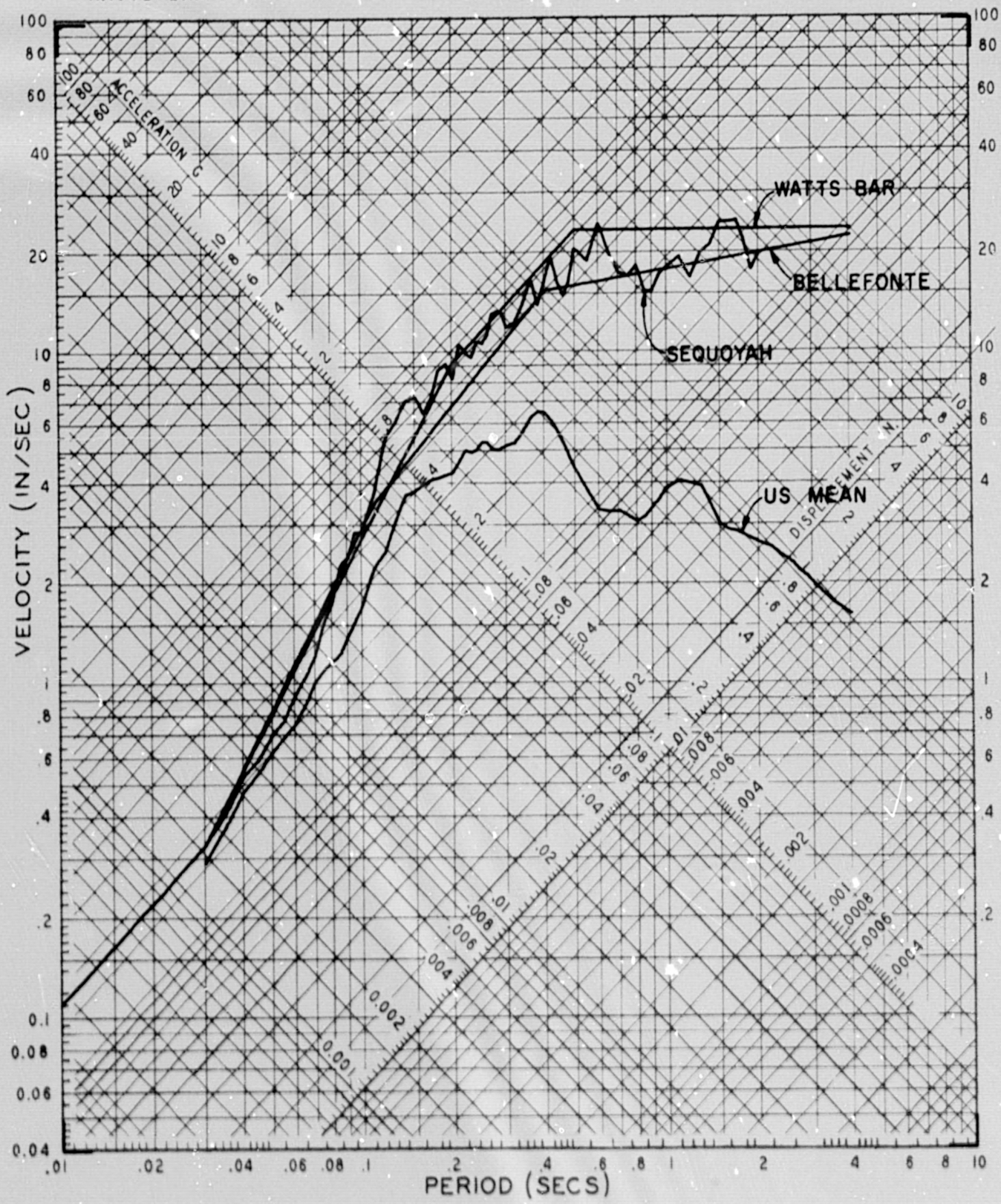

FIGURE B-53

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH MEAN OF SIX UNITED STATES EARTHQUAKES

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
US MEAN - 7% DAMPING

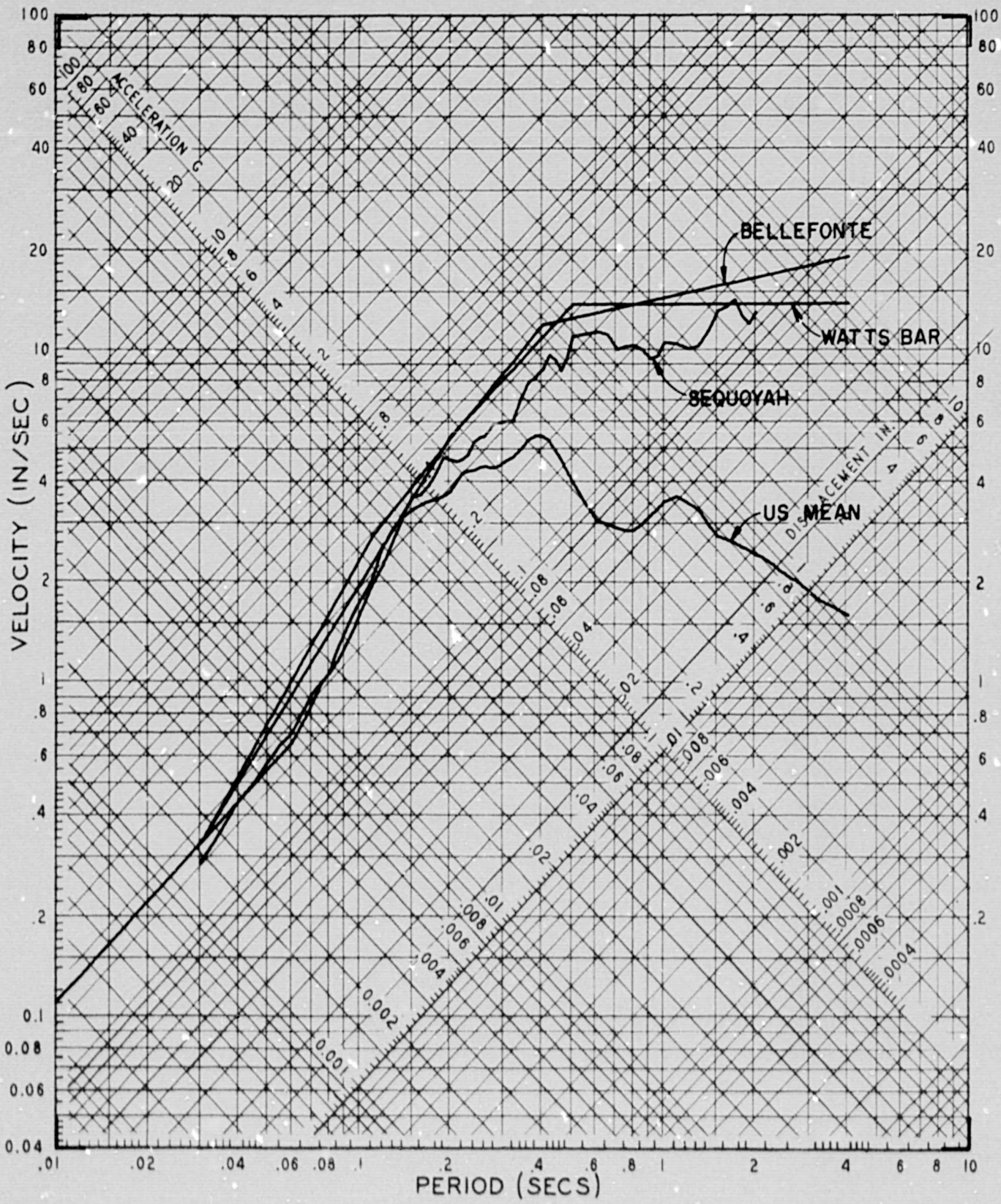

FIGURE B-54

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH MEAN OF SEVEN FRIULI ITALY EARTHQUAKES

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
ITALY MEAN - 4% DAMPING

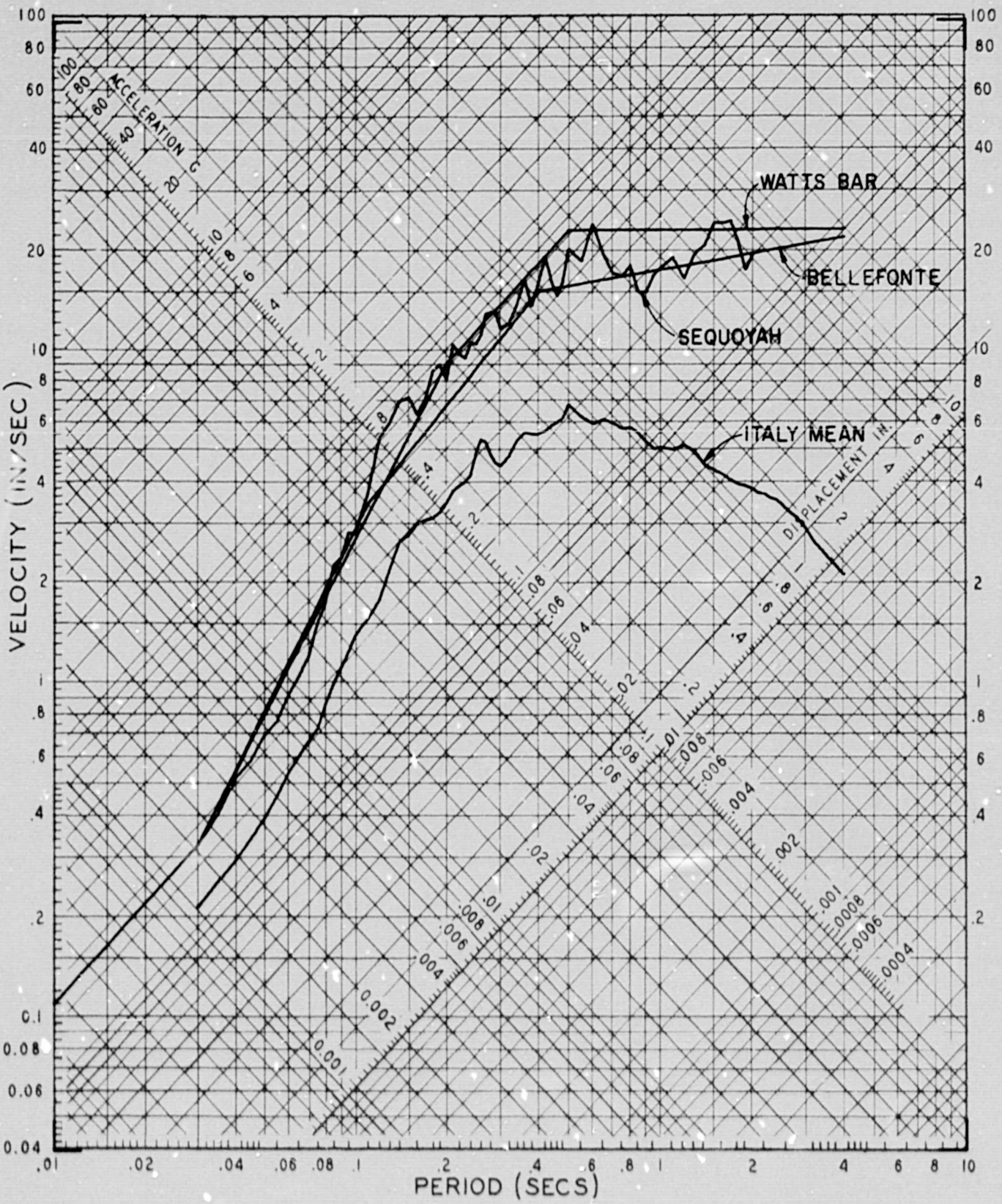

FIGURE B-55

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH MEAN OF SEVEN FRIULI ITALY EARTHQUAKES

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
ITALY MEAN - 7% DAMPING

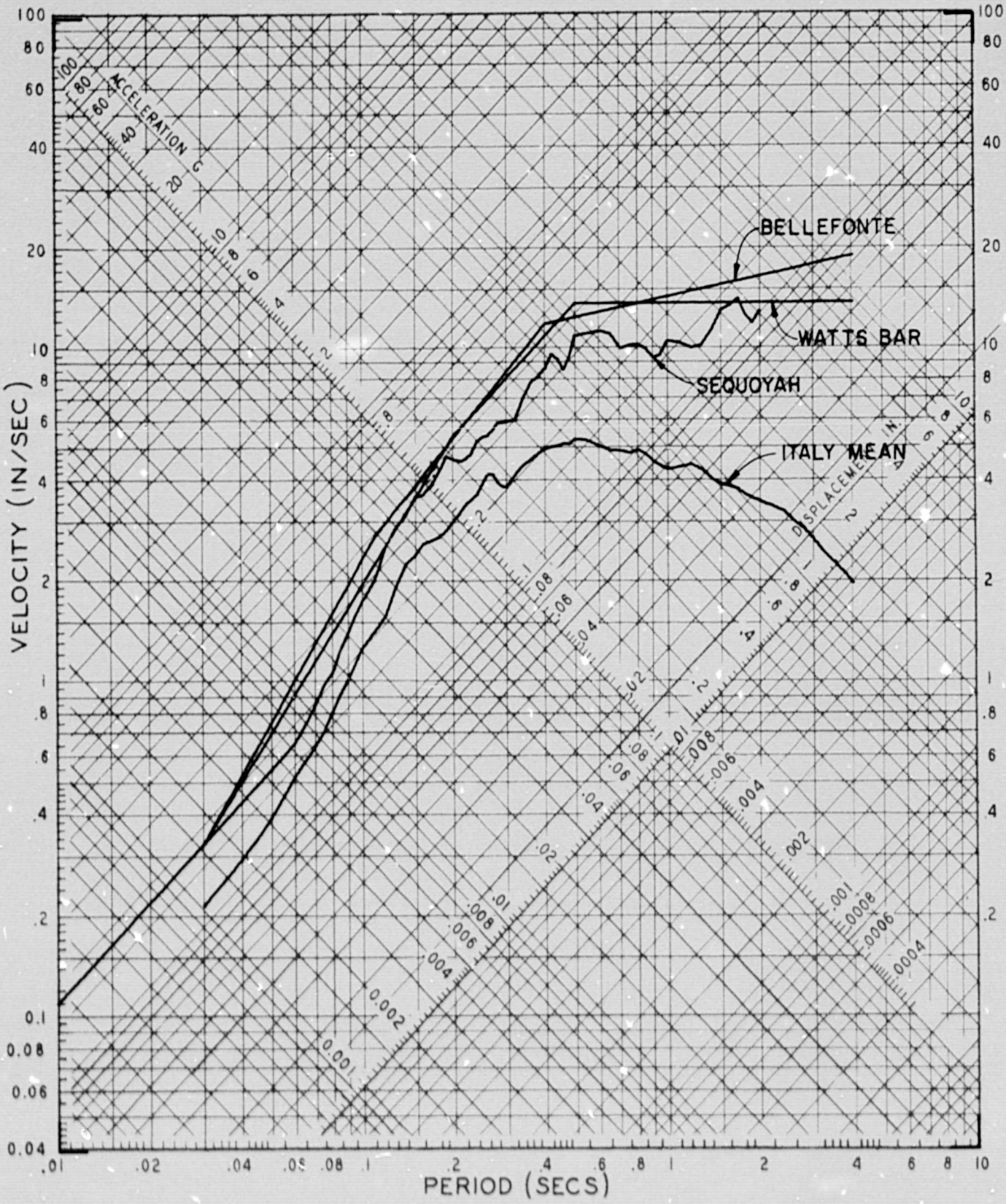

FIGURE B-56

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH MEAN OF THIRTEEN US AND ITALY EARTHQUAKES

SEQUOYAH - 1% DAMPING
WATTS BAR - 1% DAMPING
BELLEFONTE - 4% DAMPING
US & ITALY MEAN - 4% DAMPING

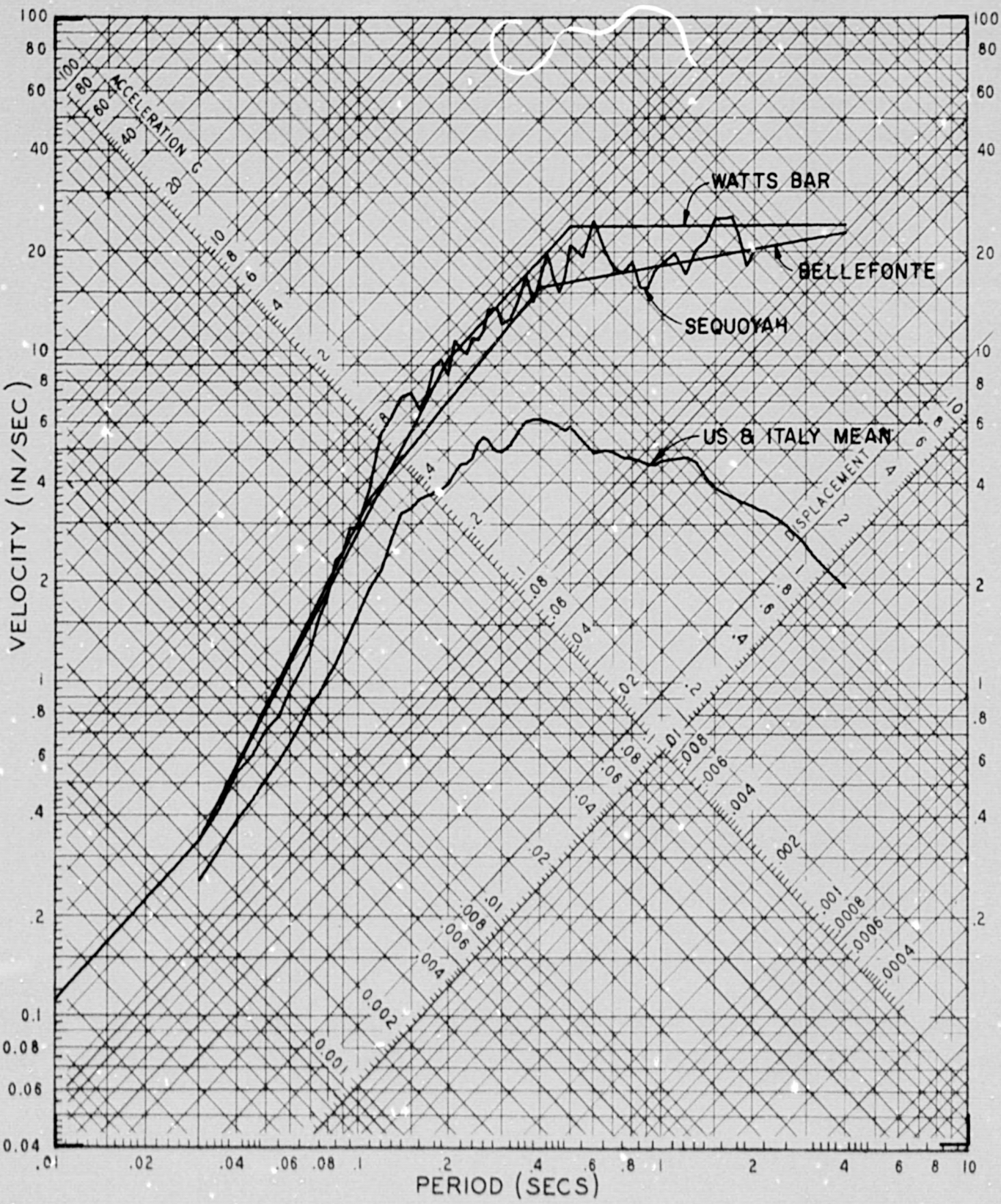

FIGURE B-57

COMPARISON OF SEQUOYAH, WATTS BAR, AND BELLEFONTE NUCLEAR PLANTS TOP OF ROCK DESIGN SPECTRA WITH MEAN OF THIRTEEN US AND ITALY EARTHQUAKES

SEQUOYAH - 5% DAMPING
WATTS BAR - 5% DAMPING
BELLEFONTE - 7% DAMPING
US & ITALY MEAN - 7% DAMPING

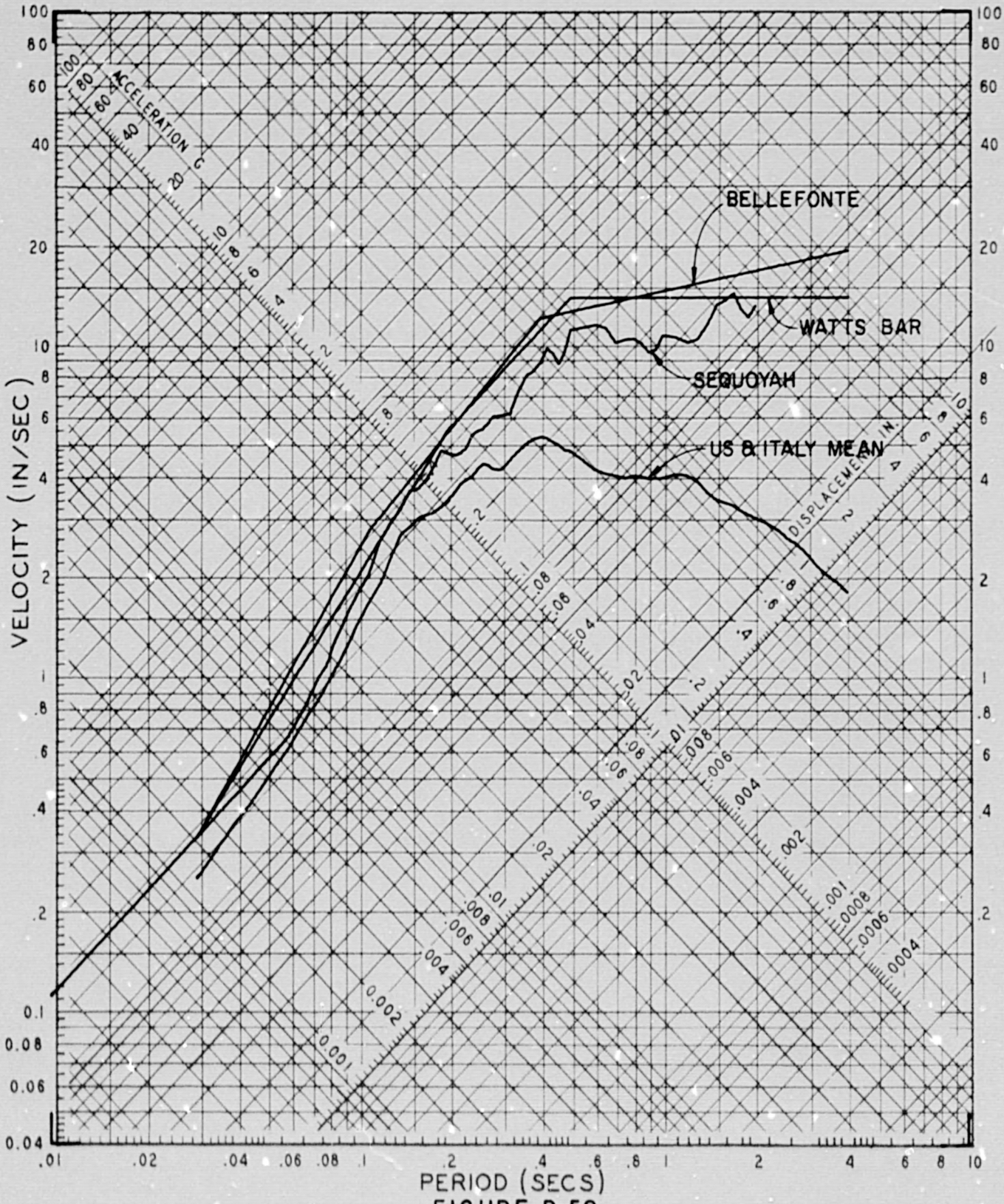

FIGURE B-58

"Thus it happens that even in Cornwall itself, the major destructive effects are distributed along a central zone or strip rather than over the whole city. A belt through the central portion is known to be underlain by marine clays and associated silts and this is the part of the city that was most affected by the earthquake.

"The same principle is recognized over the whole area of disturbance. Although certain cemeteries, for example, are so badly affected that a majority of the monuments show displacement, there are in the immediate vicinity other cemeteries, but on different quality of ground, which show very little destructive effect of any kind. The same observation applies to buildings and the same would be true of larger installations such as engineering works if there had been such works in place.

"The difficulty in drawing the area more definitely is the fact, as already explained, that surface disturbance depends largely on the quality of the overburden,--the looser the material the more easily disturbed it is; and this difference is prominently shown in the different parts of the area under observation. Virtually all badly disturbed or violently shaken or much damaged buildings or other structures are located on either loose silty outwash or silt-clay marine deposits. No buildings or other structures located on heavy glacial till were destroyed or badly damaged.

"The most striking differences of behavior may be observed in neighboring cemeteries. Those located on the loose marine deposits are badly wrecked within the area indicated, whereas those located on comparatively compact till have suffered little damage. That is true over the whole area and makes it somewhat difficult to compare different parts of the region one with another and to draw boundaries accurately.

"In Cornwall itself, which appears to have been violently shaken, there are three cemeteries located on comparatively loose silty and sandy clays and all three show many dislocated monuments, whereas one cemetery located just on the east margin of the village is virtually not damaged at all. When this discrepancy was noticed and the ground was inspected further, it was found that this cemetery was located on ground of entirely different quality from the others."

three plants are located on rock sites. The rock foundations are very competent (shear wave velocities of 6000 fps or greater). Considering the different damping ratios used at Sequoyah versus the regulatory guide, the response spectra at Sequoyah are about equivalent to a regulatory guide spectrum anchored at 0.15 g. Figure 12 is a comparison of the response spectrum used to arrive at the design specifications for concrete structures at Sequoyah and the NRC Regulatory Guide spectrum; the Sequoyah spectrum is based on 5% damping while the Regulatory Guide allows 7% damping. Figure 13 is a similar comparison for steel structures; the Sequoyah design spectrum being based on 1% damping while the Regulatory Guide calls for 4% damping.

This discussion is appropriate to sites which are sufficiently far from the earthquake fault such that the near source, very high frequency accelerations have dissipated. Little recorded data for the near-field is available; to our knowledge, pairs of acceleration in the near-field are not available at all.

Newmark[10] notes: "Peak values of ground motion may be assigned to the various magnitudes of earthquake, especially in the near vicinity of the surface expression of the fault or at the epicenter. However, these motions are in general considerably greater than smaller motions which occur many more times in an earthquake. Design Earthquake response spectra are based on "effective" values of the earthquake intensities of accelerations, velocities and displacements, which occur several times during the earthquake, rather than isolated peak values of instrumental reading. The earthquake hazards selected for design are about 1/2 to 1/3 the expected isolated peak instrument readings."