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SUBJECT: Provides info re test program at plant site to model responses to ground vibrations on cooling tower.Excerpts from ANCO Engineers,Inc rept containing calculations performed for explosive charge of 2,100 lbs,encl.

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NIAGARA MOHAWK

NIAGARA MOHAWK POWER CORPORATION/300 ERIE BOULEVARD WEST, SYRACUSE, N.Y. 13202/TELEPHONE (315) 474-1511

November 16, 1983

Director of Nuclear Reactor Regulation
Attention: Mr. Domenic B. Vassallo, Chief
Operating Reactors Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Nine Mile Point Unit 1
Docket No. 50-220
DPR-63

Dear Mr. Vassallo:

As discussed with members of your staff, Niagara Mohawk is providing information relative to a test program at the Nine Mile Point Unit 1 site to model responses to a seismic event. This will be accomplished by constructing a model of the Unit 1 Reactor Building and surrounding annulus, then simulating a seismic event with a dynamite explosion. Calculations have been performed which address the ground vibrations at the Nine Mile Point Unit 2 cooling tower (closest permanent structure) expected as a result of the test program.

Enclosed excerpts from a report performed by ANCO Engineers, Inc. contain calculations performed for an explosive charge of 2,100 pounds. The present test will use a three explosion array. The explosion charges are 2,475, 3,150 and 3,975 pounds sequentially timed to go off with a 75 millisecond delay. The ground acceleration for the 3,975 pounds charge is estimated to be 0.047g (zero period acceleration) at the cooling tower. We have investigated the probability of all charges detonating simultaneously. While we are confident this will not happen, the ground acceleration for a 9,000 pound explosion has been estimated to be 0.09g (zero period acceleration) at the cooling tower. For structural response frequencies less than 30 Hertz, the ground motions are less.

Very truly yours,

NIAGARA MOHAWK POWER CORPORATION

C. V. Mangan
Vice President
Nuclear Engineering and Licensing

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Enclosure

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Ground Motions at Nine Mile Point, Unit 2 Cooling Tower Resulting from the Main Blast Test

1.0 SUMMARY

This memorandum addresses the issue of ground vibrations at the Nine Mile Point, Unit 2 cooling tower resulting from the explosive test that is scheduled to be conducted by ANCO during June, 1983.* Five main points are discussed herein.

Based on published information that we have reviewed, expected peak ground motions at the cooling tower are

displacement <.001 in.
velocity <.1 in/s

Acceleration estimates are developed later.

Extrapolation of the Stone and Webster (SWEC) measurements, taken during ANCO's calibration shot, to the full explosive test using methods available in published literature, leads to predictions of peak motions at the cooling tower of

velocity <.03 in/s
acceleration <.03 g

The frequency content of the ground motion at the cooling tower is expected to be significantly higher than the fundamental frequency of the tower. Based on the frequency content of the motions recorded during the Calibration Tests, we estimate that the main test would produce peak displacement and acceleration at the top of the cooling tower of .0005 in. and .0003 g, respectively. This is estimated to produce stress in the cooling tower of approximately 1 lb/in^2.

We believe that realistic estimates of tower response indicate that the planned explosive tests pose no credible threat to the structure. Further, it should be noted that it is not realistic to estimate the tower's response by scaling the tower results for earthquake ground acceleration by the ratio of peak blast acceleration to peak earthquake acceleration. Both duration and frequency content will be far different, and such scaling could overestimate structure explosive test response by several orders of magnitude.

*Presently scheduled for Friday, November 18, 1983.

2.0 MOTION ESTIMATES BASED ON PUBLISHED INFORMATION

Prediction of ground motions due to explosions is an inexact science. A major uncertainty is the characterization of site properties that are treated very approximately or not at all in most motion prediction equations. It is, therefore, desirable to base predictions on test data from a site as similar as possible to the one of interest.

The preliminary explosive array design calls for three delays with the largest consisting of 2,100 lb of explosive. The motion estimates presented herein are based on 2,100 lb of explosive detonated 4,000 ft from the cooling tower. The distance was determined using the survey notes from S.J. Goves and a topographic map that was provided by NMPC.

Of the data that we reviewed, the most similar test was conducted on the Hanford Reservation in southeastern Washington in 1963 [1]. It was conducted on a Basalt site with compression wave velocities ranging from 14,000 to 20,000 ft/s. The value for the Nine Mile Point test site is about 14,000 ft/s. In the Hanford tests, one shot was done with 3,650 lb of explosive and a multiple-delay shot was done with 2,100 lb/delay. Response measurements were made at ranges of 5,000 to 20,000 ft.

From the results of these tests, the authors of the test report derived an expression to predict the peak displacement as a function of range, charge weight, and a material property constant:

$$D = \frac{K^{1/3} W^{1/3}}{r} \left(\frac{3W}{2r^2} + 7.6 \times 10^{-5} W^{1/3}\right)$$

where D = peak displacement (in.)

K = material constant (lb/in.^{2}) for the rock sites, K is taken as 600,000 lb/in.^{2}

W = charge weight (lb)

r = range (ft)

For a 2,100 lb shot at 4,000 ft, this equation predicts a peak displacement of .0003 in. One frequency spectrum plot is available for the Hanford test data. It indicates that the predominant frequency content is at about 8.25 Hz.

The displacment prediction derived from the Hanford tests is in reasonable agreement with values tabulated in a 1941 publication by the U.S. Bureau of Mines [2]. For a 2,000 lb explosion at 4,000 ft in a rock site, this document suggests a peak displacement of .0002 in.

A more recent (1966) report on quarry blasting by the U.S. Bureau of Mines [3], presents peak velocity data collected from various locations. There is considerable scatter in the data. For the proposed test parameters, a peak velocity in the range of .05-.1 in./s is predicted.

3.0 MOTION ESTIMATES BASED ON SWEC MEASUREMENTS

On 1 September 1982, ANCO conducted low-level site calibration tests at the location where the main test is to be done. SWEC made ground motion measurements at the base of the cooling tower during the calibration tests. Reported peak values of acceleration and velocity, respectively, were .003 g and .0025 in./s for shots with a maximum of 129 lb of explosive. These results can be used to predict motion due to the main test if an appropriate method can be found to extrapolate to the larger charge size.

Of the formulae that have been developed for prediction of ground motion due to explosions, nearly all can be reduced to the form

$$D = KW^nR^m$$

where D = a response quantity, e.g., displacement, velocity or acceleration

W = charge weight

R = distance to explosion (often called range)

K,n,m = experimentally determined constants

For the purpose of extrapolating from the calibration test to the main test, everything on the right side of the above equation stays the same except W. Therefore, if that form is assumed, the only additional information necessary is the value of the exponent, n. In the literature, the values of this exponent vary from .5 (Reference 4) to .8 (Reference 5),

with several references to a value around 2/3 (Reference 1 and 2) for purposes of extrapolation, the most conservative choice would be n = .8. Thus, for the 2,100 lb blast

$$\text{Peak Acceleration} = .003\ g\ \left(\frac{2{,}100\ \text{lb}}{129\ \text{lb}}\right)^{.8} = .03\ g$$

$$\approx .003\,g\left(\frac{4{,}000\ \text{lb}}{129\ \text{lb}}\right)^{.8} \approx .047\,g$$

$$= .003\,g\left(\frac{9000\ \text{lb}}{129\ \text{lb}}\right)^{.8} \approx .089\,g$$

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Similarly, peak velocity would be .03 in./s. These values are lower than those extrapolated by SWEC, and we believe them to be a very conservative estimate.

4.0 FREQUENCY CONTENT OF GROUND MOTIONS

The frequency content of the ground motion resulting from an explosion is much different than that of an earthquake. An earthquake would have significant frequency content in the range of the fundamental frequency of the cooling tower (2-3 Hz). In the case of an earthquake, there would be amplification of accelerations from the base of the cooling tower to the top, as suggested by SWEC. Explosively generated ground motion has much higher frequency content, and the cooling tower would tend to be isolated from the motion because of its low frequency.

To demonstrate the influence of frequency, we have calculated a response spectrum from one of the motion time histories that was recorded during calibration tests. This acceleration record is for a point 110 ft from the center of the explosive array in Calibration Test No. 2 (129 lb of explosive, total). The peak acceleration of the time history is 3.6 g. The time history and response spectrum are included here as Figures 1 and 2, respectively. From Figure 2, it can be seen that the peak acceleration response of a structure whose natural frequency is in the 2-4 Hz region and was at the 110 ft range, would be approximately .03 g, and the peak displacment for such a structure would be approximately .05 in.

The frequency content of the motion at 4,000 ft will not be exactly the same at 110 ft, but this can be taken as a guideline. By extrapolation of the SWEC measurements, we have estimated the peak ground acceleration at the cooling tower for the main test to be an upper bound of .03 g (see Section 3.0) or about one-hundredth of the motion used to calculate the response spectrum shown in Figure 2. Thus, for the main explosive test, we might expect the top of the cooling tower to experience relative acceleration of .0003 g and displacement relative to its base of .0005 in. We believe that, even under the most conservative criteria, this could not be judged to be potentially damaging to the cooling tower.

A rough hand-calculation, treating the cooling tower as a beam, indicates that a displacement of .001 in. at the top of the tower corresponds to a strain of 2×10^{-7} at the base. The stress in concrete at that strain level would be about 1 $lb/in.^2$.

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1. R.T. Jaske, Larrge Scale Quarry Blasting on the Hanford Reservation, Report No. HW-79614, (Hanford Atomic Products Operation, Richland, Washington, January 15, 1964).

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3. J.F. Devine, R.H. Beck, A.V.C. Meyer, and W.I. Duvall, "Effect of Charge Weight on Vibration Levels from Quarry Blasting," Bureau of Mines Report of Investigations 6774, U.S. Bureau of Mines, 1966.

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5. W.I. Duvall, C.F. johnson, A.V.C. Meyer, and J.F. Devine, "Vibrations from Instantaneous and Millisecond-Delayed Quarry Blasts," Report of Investigations 6151, U.S. Bureau of Mines.

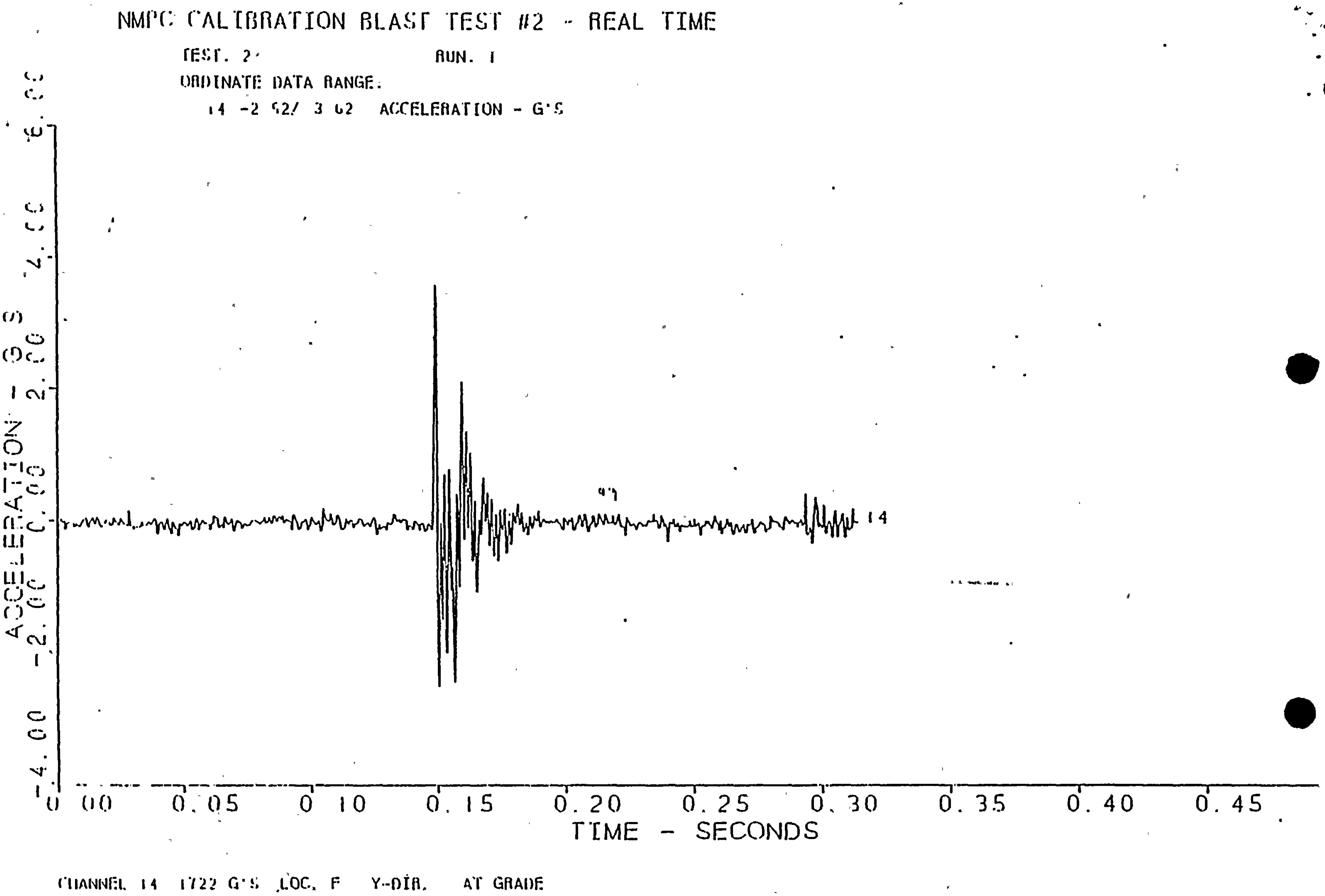

Figure 1: Ground Motion Time History Recorded 110 ft from the Center of a Planar Array Containing 129 lb of Explosive.

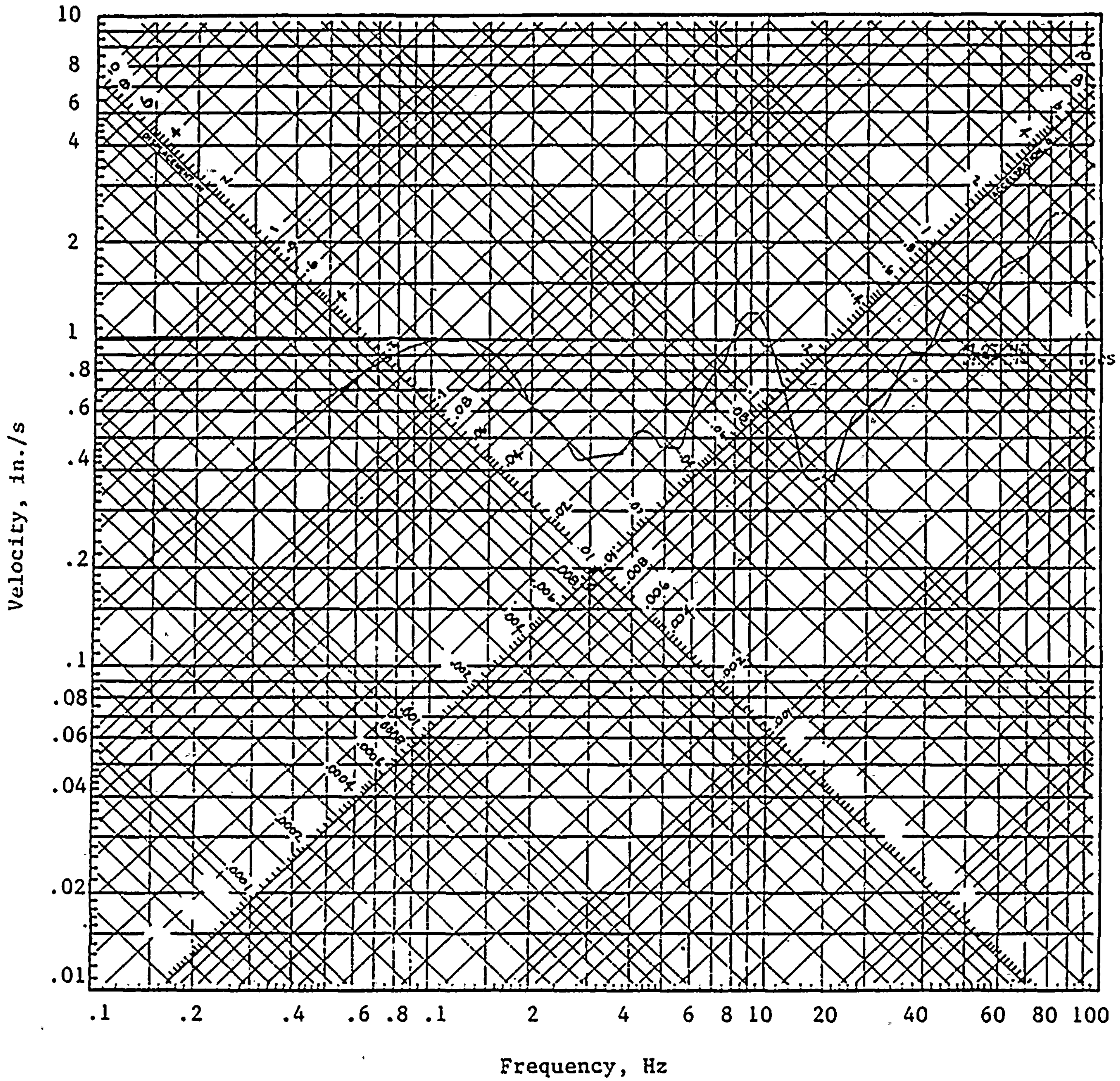

Figure 2: Response Spectrum (5% Damping) for Ground Motion Recorded 110 ft from the Center of a Planar Array Containing 129 lb of Explosive.

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