Attachment 2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 2 3 1980

MEMORANDUM FOR: D. Crutchfield, Acting Chief
Systematic Evaluation Program Branch

THRU: James P. Knight, Assistant Director for Components and Structures Engineering, DE

FROM: Robert E. Jackson, Chief
Geosciences Branch, DE

SUBJECT: INITIAL REVIEW AND RECOMMENDATIONS FOR SITE SPECIFIC SPECTRA AT SEP SITES

We have been working for the past two years with the SEP Branch and their consultants in order to provide preliminary recommendations regarding site specific spectra to be used in the SEP for evaluation of the seismic design adequacy of the selected plants.

The Branch recommendations are attached, however, it should be noted that they are subject to the limitations described in the sections entitled "Purpose and Scope" and "Recommendations." These recommendations were prepared by Dr. Leon Reiter based primarily on documents submitted in the Site Specific Spectra Program. We expect that our evaluation of items still forthcoming in the Site Specific Spectra Program may result in the following:

1. It is likely that there will be further changes in the return periods associated with the recommended spectra for the various sites. These return periods will still be able to be described as "of the order of 1000 or 10,000 years", which is the present description of the spectra and the level implicitly accepted by NRC in recent licensing decisions.

2. There will be no major change in the relative levels of seismic hazard between sites.

3. There will be little or no change in the "deterministic" comparisons for the various site used to evaluate the acceptability of the spectra recommended in the attached review.

4. There is a preliminary indication that a reduction in spectra at intermediate and low frequencies may be called for at rock sites (Dresden, Ginna, Haddam Neck and Millstone). Probabilistic predictions of peak velocities at these sites may also be affected.

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While it is difficult to predict the outcome of an innovative program that is still in progress it is our best estimate, based on the above, that this subsequent evaluation will not result in very large changes in spectra recommended for use in the evaluation of the SEP.

We recommend that you utilize these spectra in your reanalysis of the SEP facilities. We further recommend that a minimum spectra be established as discussed in the report. This recommendation is based on the innovative nature of the Site Specific Spectra Program and the need for continued review and maturation of the program. The site specific spectra provided are generally less than would result from a literal application of Appendix A to 10 CFR and the current Standard Review Plan throughout the frequency range of interest for nuclear power plants.

Since follow up work and sensitivity studies are continuing, we will monitor progress and provide a final recommendation in December 1980 upon completion and review of these elements of the program.

Robert E. Jackson

Robert E. Jackson, Chief
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Enclosure:
As stated

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Initial Review and Recommendations for Site Specific Spectra at SEP Sites

Purpose and Scope

This review presents initial recommendations for Site Specific Spectra to be used in the reevaluation of SEP plants. It is based upon review of the following items.

(1) Draft Seismic Hazard Analysis: TERA - Lawrence Livermore Laboratory (LLL), 3 volumes, August 1979.

(2) Peer Review Comments to above reports, Individual comments by Dr. O. Nuttli, Dr. L. Sykes, Dr. D. Veneziano Dr. A. Ang, (LLL Review Board); Fugro, URS Blume Assoc., Dr. A. Cornell, Mr. R. Holt, Commonwealth Edison (licensee sponsored reviews); Dr. L. Abramson (NRC, Applied Statistics Branch) Fall-Winter 1979.

(3) Response to Peer Review Site Specific Spectra Project (SSSP), TERA, May 1980.

(4) Draft Seismic Hazard Analysis: SSSP Sensitivity Results, TERA-LLL, May 1980.

(5) Attenuation Panel Feb. 1980, and comments on the panel meeting by Dr. O. Nuttli, Dr. M. Trifunac, Dr. R. McGuire, Dr. N. Donovan.

(6) Letter Report evaluation of Attenuation Panel by TERA, April 4, 1980.

(7) Letter Reports on Ossippee Attenuation Model by TERA, May 22, May 29, 1980

(8) Interim Summary of assessment of conservatisms by TERA, May 30, 1980.

(9) Evaluation of Ossippee Attenuation Models and alternatives by LLL, May 23, 1980.

(10) Seismic Hazard Evaluation for SEP plants (Draft) N. M. Newmark (May 30, 1980).

In addition to these documents there have been many discussions and telephone conversations with individuals at TERA, LLL, reviewers, attenuation panel members and Drs. Newmark and Hall.

Following is a list of other items and reviews which will be forthcoming and could have an impact upon the results.

1. Review of the Draft Seismic Hazard Analysis by the USGS.
2. Additional Review and comments by Drs. Newmark and Hall.
3. Review of all submissions by the licensees on their recommendations for site specific spectra (several have been reviewed).
4. Comparison of SSSP results with other eastern U. S. hazard analyses.
5. Feedback meeting with original expert group.
6. Recommendation from TERA-LLL and possible reanalysis based upon utilization of input from sensitivity results, attenuation panel and feedback meeting.

Recommendations

It is recommended that the following spectra presented in the Sensitivity Results (May 1980) be used as site specific free field spectra.

Eastern U. S. (Yankee Rowe, Connecticut Yankee, Millstone, Ginna, Oyster Creek) - "1000 year" spectra assuming no background and Ossippee Attenuation.

Central U. S. (Dresden, Palisades, LaCrosse, Big Rock Point) - "1000 yr" spectra assuming no background and Gupta-Nuttli Attenuation.

These spectra account for gross site conditions (soil or rock) and do not take into account any specific conditions which may result in amplification (LaCrosse, Yankee Rowe, Palisades).

It is also recommended that a minimum be established for which no spectra be allowed to go below. It is suggested that this minimum be the median (50th percentile) representation of real spectra for a magnitude 5.3 earthquake. This minimum exceeds the "1000" yr spectra for Big Rock Point, LaCrosse and Palisades at frequencies greater than 2 to 3 Hz.

The rationale for these recommendations are discussed below.

General Comments

The SSSP was conceived as a multi-method approach for determining site specific spectra (Bernreuter, 1979). It encompassed probabilistic approaches at predicting peak acceleration, peak velocities and uniform hazard spectra for different return periods and a empirical approach which includes calculation of 50th and 84th percentile spectra from ensembles of real data at different magnitudes, site conditions and distance ranges. The probabilistic approach utilized is basically that suggested by Cornell (1968) which has been modified to formally incorporate "expert" judgements. This approach is explained in detail in the documents referenced above and in Part 1 of the Executive Summary by TERA Corp.

The difference between so called "deterministic" approaches (for example, that found in the Standard Review Plan*) and probabilistic approaches are described below. In the deterministic approach (Figure 1) local (fault) and regional

*Although this approach is commonly called "deterministic" it is better described as "judgemental-empirical." A true deterministic approach would involve using the principles of physics to calculate ground motion due to a rupturing fault.

(tectonic province) source regions are specified geometrically (Step 1). The largest earthquake associated with each source is then defined from historical seismicity and/or geological estimates, and it is assumed to occur at a location in each source closest to the site in consideration (Step 2). The resultant ground motion (usually peak acceleration) at the site from each of these sources is then estimated utilizing magnitude-acceleration or intensity-acceleration relationships (Step 3). The largest of these is then considered the controlling ground motion and it determines the assumed earthquake loading at the site (Step 4). In the current NRC practice this earthquake loading (Safe Shutdown Earthquake) usually is peak acceleration used to anchor the standardized Regulatory Guide 1.60 spectrum. This method does not take into account the frequency of earthquake occurrence and allows no description of uncertainty.

In the probabilistic approach described in Figure 2, earthquake sources are determined (Step 1) as in the deterministic approach. Historical seismicity is then used to determine an earthquake recurrence model for each source (Step 2). This model is usually determined from a linear regression analysis relating earthquake size (magnitude or intensity) to frequency of occurrence. These recurrence models are terminated at the largest earthquake expected from each source. Most probabilistic models assume that earthquake occurrence follows a Poisson process or that these earthquakes occur randomly with respect to time and space within a given source. The ground motion (peak or spectral parameter) at the site from the different earthquakes at different distances is estimated using a set of magnitude (or intensity) - ground motion relationships that explicitly incorporate the dispersion of the data about such relationships (Step 3). Finally, integrating the effect of different size earthquakes from different locations in different sources with the recurrence information from Step 2, the probabilities that given levels of ground motion will not be exceeded within given time periods are calculated (Step 4).

The deterministic approach is strongly controlled by the choice of input parameters (source configuration, intensity-acceleration relationship, response spectra etc.). Sizeable changes in characterizationof safe shutdown earthquakes for Nuclear Power Plants in the past 5 to 10 years have resulted from staff adoption of the Regulatory Guide 1.60 spectrum and the Trifunac-Brady (1975) intensity-acceleration relationship. Probabilistic prediction can also be driven by the choice of input parameters. In the eastern U. S. these input parameters or their statistical representation cannot in many cases be unambiguously derived from the existing data. The innovative approach of the SSSP was to canvas expert opinion as to what the choice of these input parameters were, what range they might be expected to assume and what credibility could be attached to them. Each experts input was treated separately, spectra were computed for each expert at each site than a trial synthesis was performed combining all the experts at each site based upon their own self-ranking. The input parameters covered four areas: (1) the configuration of seismic source zones in the central and eastern U. S. (2) the largest earthquake expected in each of these zones (3) the earthquake activity rate and recurrence statistics associated with each zone and (4) methods for predicting ground motion in the eastern and central U. S. from an earthquake of a given size at a given distance.

Responses were received from 10 of the 14 expert polled. (The questionnaires were lengthy and required several days to answer in a comprehensive manner). These responses were almost exclusively directed at the first three areas. The significant lack of response in areas of ground motion made it necessary for TERA-LLL to develop its own ground motion determination scheme. Additional approaches were presented in the sensitivity results and an additional special "Attenuation Panel" was convened to discuss this difficult problem.

In addition to the ground motion problem, the extensive peer review conducted for the initial draft report identified other problem areas. The most significant of these were related to the way each expert's zonation was treated and the assumed dispersion of the data. These subjects were also treated in the sensitivity studies mentioned above. Specific discussions on each of these problem areas follow.

Specific Comments

Ground Motion Determination

The problem is to quantitatively predict ground motion east of the Rockies when there is practically no strong motion data recorded in this region. The existing data base (most Western U. S.) was recorded in areas where seismic wave attenuation and, to some extent, seismic sources are different. A method must be developed to predict this motion theoretically or make use of the historical (non-instrumental) felt reports from the eastern U. S. in conjunction with strong ground-motion data from the western U. S. The initial results (August 1979) utilized felt reports from the well-documented Southern Illinois Earthquake of 1968 and the assumption that ground motion associated with a given felt effect (site intensity) and epicentral distance will be the same in both east and west. The sensitivity studies (May 1980) examined the affects of assuming that the ground motion associated with a given felt effect and given earthquake size will be the same for both east and west. The studies accomplished this result for three felt-effect predictions; the 1968 Southern Illinois Earthquake, the 1940 Ossippee New Hampshire earthquake, and a modification of the Gupta-Nuttli (1976) relation based upon several central U. S. earthquakes. While the attenuation panel had mixed feelings there seemed to be some preference for this latter assumption. In conjunction with the sensitivity studies, the existing data set was also modified to prevent undue dependence upon a single earthquake and to eliminate strong motion records that were believed to represent only part of the actual shaking. In addition, studies of several other earthquake suggested a difference in attenuation of ground motion between the northeastern and central U. S. At distances greater than 100 kilometers, the affects of shaking appear less attenuated in the central U. S. when compared with that in the northeast. As a result of these considerations, we recommend that the 1980 model based upon the Ossippee earthquake be used as a basis for determining ground motion in the northeastern U. S.; while the 1980 model based upon the Gupta-Nuttli relationship be used as a basis for determining ground motion in the central U. S. The Ossippee attenuation was calculated several ways. In the original SSSP Sensitivity Results (May 1980) an average distance was first computed for each intensity level and then a regression was performed treating distance as the independent parameter and site intensity as the dependent parameter. A significant difference was observed when the averaging was omitted and the regression performed directly on the data (TERA Letter Reports, May 22 and May 29, 1980). It is not immediately clear which approach is more appropriate. Conceptually it appears better to avoid the averaging step. We feel, however, that at this time the original technique using the averaging step should be used. The reasons for this are (LLL Letter, May 23, 1980): (1) This method is analagous to that used by Gupta and Nuttli (1976) to derive their attenuation relationship. (2) the second method would predict ground motion significantly less at most distances than that proposed by the theoretical model of Nuttli (1979) while the original method falls much closer to his model.

The attenuation panel recommended greater use of such theoretical relationships for determining ground motion. Initial calculations show that when these theoretical relationships are incorporated into SSSP methodology peak accelerations for return periods of 1000 years appear to be similar to the Gupta-Nuttli and original Ossippee attenuations. While some small differences between central and northeastern attenuation can be expected we feel that at this time, reliance upon results produced utilizing a particular regression technique on one earthquake in the northeast which are significantly less than theoretical and empirical results for the central U. S. is imprudent. Clearly, however, determination of a proper attenuation relationship is an area that requires additional work.

Zoning

The initial treatment of experts input to configuration and credibility of seismic source zones allowed for the existence of a background zone consisting of the union (enevelope) of all the experts zones in a particular region. The extent to which this background zone was used depended upon the experts general level of belief (credibility) in the existence of these zones. As a result, this leads to tying one expert's results to others and the allowance of specific numbers of the larger earthquakes normally associated with a seismic zone being allowed to occur anywhere within the background. Various reviewers criticized this approach and some alternatives were suggested. The sensitivity studies computed spectra based upon the opposite extreme i.e. the assumption that each expert had 100% belief in his zone and no background need exist. These two computations bound the problem.

For SEP sites, the latter assumption results in a reduction in estimated seismic hazard. If a site were located in the middle of an active seismic zone such as New Madrid the assumption of no background would result in an increase in estimated seismic hazard. There are many arguments that may be made as to how this problem may be treated correctly. It seems clear that neither extreme is correct and some better way of accounting for credibility is warranted. TERA-LLL has argued that a true representation of credibility in such a complex problem may be very cumbersome computationally and prohibitively expensive. It is our recommendation that, barring such a computation spectra intermediate between these two assumptions be used at this time. As shown below the actual difference between spectra computed using the two extreme assumptions is not large and any error in estimating the intermediate spectra will not have a significant effect.

Dispersion of Data

In The August 1979 report the dispersion assumed about the final ground motion prediction was assumed to be log normal with σ=0.9 (base e). In addition the distribution was truncated at $\pm 2\sigma$. This size of the dispersion was determined combining dispersions normally encountered in determining site intensity from earthquake size (epicentral intensity) and in converting this intensity to ground motion. These individual dispersions can be considered as due to randomness found in nature. Several reviewers argued however that treating these errors as independent and disregarding their cross correlation is overly conservative and that it increases the total dispersion beyond that resulting from true randomness. Where ground motion records due exist, e.g. Western U. S., the dispersion associated with ground motion from a given size of earthquake can usually be described with σ=0.6 to 0.7. Data points do not normally extend out beyond limits of $\pm 3\sigma$. These criticisms are considered valid and its recommended that the dispersion defined as σ=0.7, truncated at $\pm 3\sigma$ be accepted. Extension of the truncation point beyond 3σ will not have a significant effect upon the results.

Synthesis Curves

Some alternate methods were suggested to synthesize the results of the various expert judgements. The SSSP utilizes a self-ranking system. In the opinion of TERA Corporation, alternate methods would not have a significant effect upon the synthesized curves. By inspection it appears that the synthesis curves represent a median or somewhat higher than median representation of the individual spectra computed for each expert. It is recommended that this synthesis be used to describe the hazard.

Integration of Recommendations

In the sensitivity studies, uniform hazard spectra are presented for all the ground motion models recommended above, i.e. Ossippee (1980 model) for northeastern sites and Gupta-Nuttli (1980) for central U. S. sites.

All spectra are computed assuming no background and σ=0.9 $\pm$ 2σ truncation. These spectra are approximately equal to the recommended spectra of σ=0.7 $\pm$ 3σ truncation with a zoning assumption intermediate between a background and no background because: 1) The decrease in peak accelerations and peak velocities computed for representative individual experts from σ=0.9 ($\pm$ 2σ) to σ= 0.7 ($\pm$ 3σ) is on the average about 7 to 10% for the Gupta-Nuttli and Ossippee attenuations; (2) the increase in peak accelerations and peak velocities from no background to background is on the average about 15 to 20% for the August 1979 attenuation (the only comparison available). Although there is some preliminary indication of attenuation model dependence for the background-no background comparison these approximations are considered adequate given the precision of the spectra and the size of the differences.

Adequacy and Conservatism of the Recommended Spectra

While the "1000 year" spectra are recommended it is not possible to state with any certainty that the true return period (inverse of annual risk of exceedence) is 1000 years. Generally these estimates are believed to be conservative for the following reasons.

1. Strong motion data sets are in many ways biased toward high values. Non-triggered instruments or low-level records receive little attention. This is also true at great distances and for longer periods where noise may be contributing significantly to observed motion.
2. The assumption that earthquakes occur randomly within a given seismic source zone is conservative for large zones of low to moderate level seismicity such as those around most SEP sites. While the sources of central and eastern U. S. earthquakes remain hidden, most seismologists conclude that damaging earthquakes will eventually be associated with specific faults.
3. The uniform spectra represent composite risk from different source zones which may effect different frequency ranges. Under certain situations, exceeding the spectra at different frequencies implies the simultaneous occurrence of earthquakes in more than one source zone.
4. The assumption that intensities from large earthquakes attenuate at the same rate as intensities from small earthquakes is conservative.

Some non-conservative aspects of this and other studies are:

1. The strong-motion data set used mixes accelerograms recorded in the true free field with those recorded in the basements of buildings. Many engineers feel that the effect of large foundations in these buildings is to reduce high frequency motion.
2. The probabilistic spectra represent the chance of being exceeded more than once in a given return period. The probability of being exceeded twice or more, however, is small when compared to the probability of being exceeded only once.

Based upon consideration of all of the above and their estimated relative weights, we consider the true return period associated with these spectra to be longer than 1000 years. TERA in a recent reassessment of conservatism (Letter, May 30, 1980) concludes that those spectra presented in the Sensitivity Results as "1000 year spectra" can be conservatively represented as 5000 to 10,000 year loads. Additional work will better define what the return periods are. At the present time however, we believe that there is no way of indicating what these true return periods are or establishing rigourously defined confidence limits. In the past there has been implicit acceptance of design spectra that were assumed to have return periods of the order of 1000 or 10,000 years. It is our judgement that these spectra fall within this description.

The most important quality of these spectra is that, although no great confidence can be attached to the absolute probabilities (i.e. return periods), the systematic incorporation of expert opinion and uncertainty and the wide ranging sensitivity tests indicate greater stability when estimating relative hazard probabilities at these levels of ground motion. This would apply to estimating the equivalent levels of probabilities of exceedence at different sites and small relative differences in probabilities of exceedence at the same site. Thus, while we are not sure that the "1000 year spectra" really represent 1000, 5000 or 10,000 year return periods at all the sites we have greater confidence that they represent approximately equivalent levels of hazard whatever the true return period is. This is based in large part upon the relative consistency of effects associated with the sensitivity tests (SSSP Sensitivity Results, May 1980) and the synthsizing of wide ranges of expert judgement with respect to each region.

Comparison of Spectra with "Deterministic" Procedures

In order to further evaluate the adequacy and reasonableness of the recommended design spectra several comparisons with non-probabilistic techniques were performed.

Comparison with spectra determined using the tectonic province approach (Appendix A). In this approach (Figure 1) the largest historical earthquake that has occurred in the host province is assumed to occur near the plant while the largest historical earthquakes in adjacent provinces are assumed to occur in these provinces at locations closest to the site. The ground motion at the site from these earthquakes is estimated and this determines the seismic input to design. Tectonic province boundaries and earthquake sizes were estimated based upon recent licensing decisions. The configuration of the New Madrid Zone was also used assuming the more recent suggestions of Nuttli and Herrmann (1978). The assumptions for each site are listed in Table 1. Earthquake size is also given in terms of magnitude (m_b) and these are based upon recent individual determinations of the magnitudes from intensity data and the general relationship proposed by Nuttli and Herrmann (1978).

Utilizing these events, a series of theoretical and empirical equations were used to predict the peak accelerations and velocities at each site. In order to deal with differences in these equations, selected results representing the most appropriate theoretical and empirical relationships were averaged to arrive at final estimates of peak acceleration and velocity. Table 2 shows the controlling (largest) peaks estimated at each site. These are compared with the peak accelerations and velocities associated with the recommended uniform hazard (probabilistic) spectra.

The uniform hazard peak accelerations reach or exceed the deterministic peak accelerations at all sites except Palisades, LaCrosse and Big Rock Point. This is a reflection of the fact that these 3 sites lie in areas of low seismicity and estimated seismic hazard in the central stable region. The uniform hazard peak velocities exceed the deterministic peak velocities except at Dresden where it is less. This is a reflection of the fact that probabilistic techniques take into account larger than historical earthquakes. Sensitivity studies show that these have the largest effect upon peak velocities. This is reflected in the deterministic procedure for Dresden where the proximity of the New Madrid zone has a significant impact. In general it can be said that the 1000 year uniform hazard peaks bracket the deterministic peaks. Differences between the two sets of values result from the ability of the uniform hazard approach to overcome the artificial constraints often posed by the "tectonic province" approach. Thus, while the tectonic province approach would require Big Rock Point and Haddam Neck to utilize similar seismic input for design purposes, the probabilistic methodology takes into account the real difference in seismicity and perceived earthquake hazard at these sites.

The deterministic peak accelerations and velocities are converted to response spectra using the amplification factors suggested by Newmark and Hall in NUREG CR-0098. Figs. 3 thru 11 compare the recommended uniform hazard spectra with 50th and 84th percentile deterministic spectra. In the central U.S. the recommended spectra generally fall below or at the 50th percentile. In the eastern United States the uniform hazard spectra are approximately equivalent to the 84th percentile deterministic spectra. While the deterministic peaks are generally lower than the predicted peaks, use of the 84th percentile amplification factors usually more than compensate for the differences. Again the uniform hazard spectra more adequately reflect perceived relative hazard. The "tectonic province" approach can be made to achieve conservatism in this case by utilizing conservative amplification factors.

Figures 12 and 13 show the uniform spectra compared to Reg. Guide 1.60 spectra anchored at 0.1 and 0.2g. Following suggested Standard Review Plan procedures for new plants that is utilizing the trend of the means of Trifunac and Brady (1975) to anchor the Reg. Guide 1.60 spectra, would result in design spectra anchored at between 0.12 and 0.20g. The specific acceleration used would depend in large part upon the applicants submittal and the reviewer's conservatism. For the central U. S. the recommended spectra are mostly below the Reg. Guide spectrum anchored at 0.1g while for eastern U. S. the recommended spectra are at or above the Reg. Guide spectrum anchored at 0.1g. The average recommended spectrum would be roughly equivalent to the Reg. Guide 1.60 Spectrum anchored at a peak acceleration of about 0.1g. The observation that the average peak acceleration associated with the recommended spectra (Table 2) is about 0.15g illustrates the often discussed conservatism of the Reg. Guide spectrum. It was conservatively derived from earthquakes of different sizes recorded at different distances and different site conditions.

Comparison with Real Spectra

A more applicable comparison can be found in Figures 14 and 15. Here the recommended spectra are compared to the 50th and 84th Percentile levels of ensembles of response spectra derived from strong motion records recorded at nearby distances (usually 27 km or less) from earthquakes of magnitude

5.3 ± 0.5 in the western U. S. and Italy. At these distances differences in regional attenuation are not pronounced. At periods less than 0.3-0.5 seconds the recommenced spectra fall in between the 50th and 84th percentile except for Palisades, LaCrossse and Big Rock Point which are slightly below the 50th Percentile. Differences again can be related to real differences in earth quake hazard.

There can be some concern however in that the recommended spectra may fall below some minimum level of ground motion from a nearby magnitude 5.3 (Intensity VII). While Intensity VIII or larger earthquakes have been restricted in historical time in the central and eastern U.S. to five or six locations, Intensity VII earthquakes have occurred in sufficient numbers and at sufficient locations such that we believe that they could occur anywhere in the U.S. at varying levels of certainty. It is prudent therefore to establish such a minimum level although a direct uniform hazard assessment would more accurately reflect relative earthquake hazard. It is recommended that this minimum be set at the 50th percentile of the plotted real spectra. While the 84th percentile has been used in deterministic techniques it is not suggested that it be used as a minimum since it is more a reflection of the dispersion of data resulting from the magnitude and distance range needed to gather an adequate number of records for statistical treatment.

As indicated above use of the 50th Percentile would have a small effect upon LaCrosse, Palisades and Big Rock Point.

Conclusions

Based upon review of the indicated documents and the comparison with "deterministic" procedures mentioned above, we believe that the site-specific uniform hazard response spectra suggested represent an adequate level of free field ground motion for use in the reevaluation of the SEP plants. The varying levels of these spectra more accurately reflect true variations in real seismic hazard than those derived utilizing the "deterministic" tectonic province approach. We also believe that it is prudent to establish some minimum level below which no spectra be allowed to fall. It is recommended that this be the 50th percentile of real data from a nearby magnitude 5.3 earthquake as shown in the comparative plots. Utilization of this minimum would have a small effect upon Palisades, LaCrosse and Big Rock Point. These spectra do not take into account specific site amplification factors that may be present at LaCrosse, Palisades or Yankee Rowe nor do they reflect consideration of additional studies still ongoing in the SSSP program. Those spectra presented were computed for 5% damping.

Table 1

Controlling Earthquakes used in the Tectonic Province Approach

Site	Local Earthquake (Host Province) (Average Epicentral Distance 10-15 km)	Distant Earthquakes (other than Host Provinces
Yankee Rowe	mb 5.3 (Intensity VII)	mb6.0 (Intensity VIII) from White Mt. zone (80 km)
Haddam Neck	mb 5.3 (Intensity VII)	mb 6.0 (Intensity VIII) from White Mt. Zone (130 km)
Millstone	mb5.3 (Intensity VII)	mb 6.0 (Intensity VIII) from White Mt. Zone (140 km)
Oyster Creek	mb 5.3 (Intensity VII)	mb 6.0 (Intensity VIII) from White Mt. Zone (375 km) mb 5.8 (Intensity VIII) from Southern Valley and Ridge (550 km)
Ginna	mb5.3 (Intensity VII-VIII)	mb 5.75 (Intensity VIII) from Clarenden-Linden Fault (55 km)
Dresden	mb 5.3 (Intensity VII-VIII)	mb 7.5 (Intensity XI-XII)from New Madrid Zone (280 km) *mb6.7 (Intensity X) from Wabash Zone (200 km)
Palisades	mb5.3 (Intensity VII-VIII)	mb7.5 (Intensity XI-XII) from New Madrid Zone (315 km) *mb6.7 (Intensity X) from Wabash Zone (300 km)
LaCrosse	mb5.3 (Intensity VII-VIII)	mb7.5 (Intensity XI-XII from New Madrid Zone (600 km) *mb6.7 (Intensity X) from Wabash Zone (530 km)
Big Rock Pt.	mb5.3 (Intensity VII-VIII)	mb7.5 (Intensity XI-XII) from New Madrid Zone (760 km) *mb6.7 (Intensity X) from Wabash Zone (650 km)

*Controlling event based upon Nuttli and Herrmann (1978) interpretation of Mississippi Embayment Seismic Zoning.

Table 2

Comparison of Predicted Peak Accelerations and Velocities Based upon Probabilistic* and Deterministic** Techniques

	Site	Peak Acceleration (cm/sec^2) Probabilistic	Peak Acceleration (cm/sec^2) Deterministic	Peak Velocity (cm/sec) Probabilistic	Peak Velocity (cm/sec) Deterministic
1.	Yankee Rowe	195	123	22	11
2.	Hadden Neck	202	123	20	9
3.	MIllstone	184	123	18	9
4.	Oyster Creek	161	123	18	9
5.	Ginna	169	132	17	10
6.	Dresden	124	132	16	20
7.	Palisades	102	132	15	12
8.	LaCrosse	91	132	14	9
9.	Big Rock Point	81	132	11	9

*Probabilistic values are those associated with TERA-LLL's synthesis for the 1000 yr return period. Attenuation model used for sites 1-5 was 1980 Ossippee for sites 6-9 1980 Gupta-Nuttli. While explicit values assumed no background and a dispersion of σ=0.9 + 2 σ This is estimated to be equivalent to intermediate background and a dispersion of σ=0.7, $\pm$ 3 σ.

**Deterministic values were computed using Table 1 and averages of results from the following suites of predictive equations.

Local Events - all sites, suite (a)
Distant Events - northeastern sites (1,2,3,4), Suite (b),
central sites (6,7,8,9) Suite (c)
intermediate site (5) Suite (a).

The suites of equations are:

a. Herrmann (personal communication, 1980), TERA-LLL Aug, 1979, TERA-LLL 1980 Ossippee, TERA-LLL 1980 Gupta-Nuttli.
b. Herrmann (personal communication, 1980), TERA-LLL 1980 Ossippee
c. Herrmann (personal communication, 1980), TERA-LLL Aug. 1979, TERA-LLL 1980 Gupta-Nuttli.

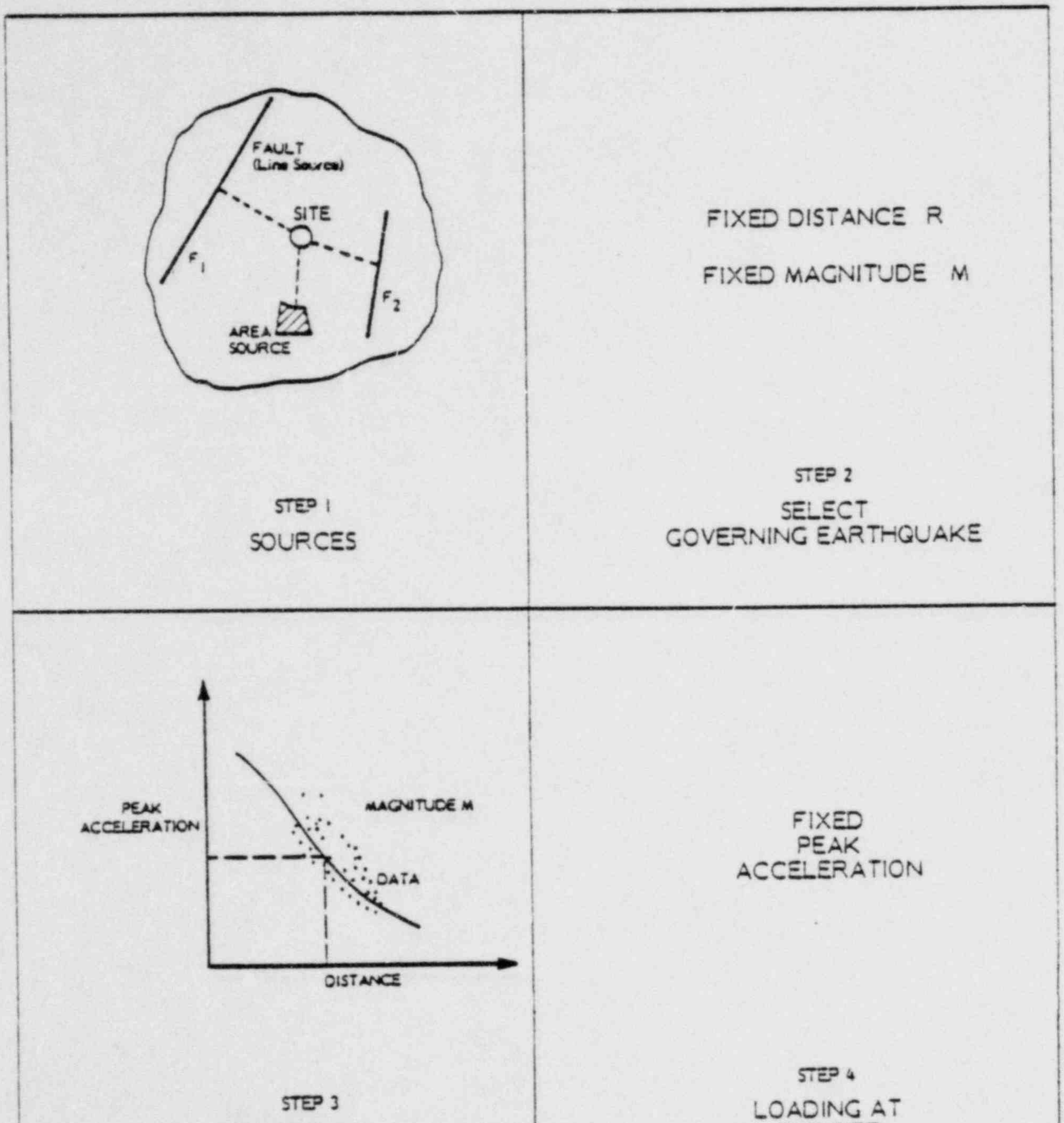


FIGURE 1

DETERMINISTIC APPROACH
TO LOADING AT THE SITE

TERA CORPORATION

Dec. 8, 1978

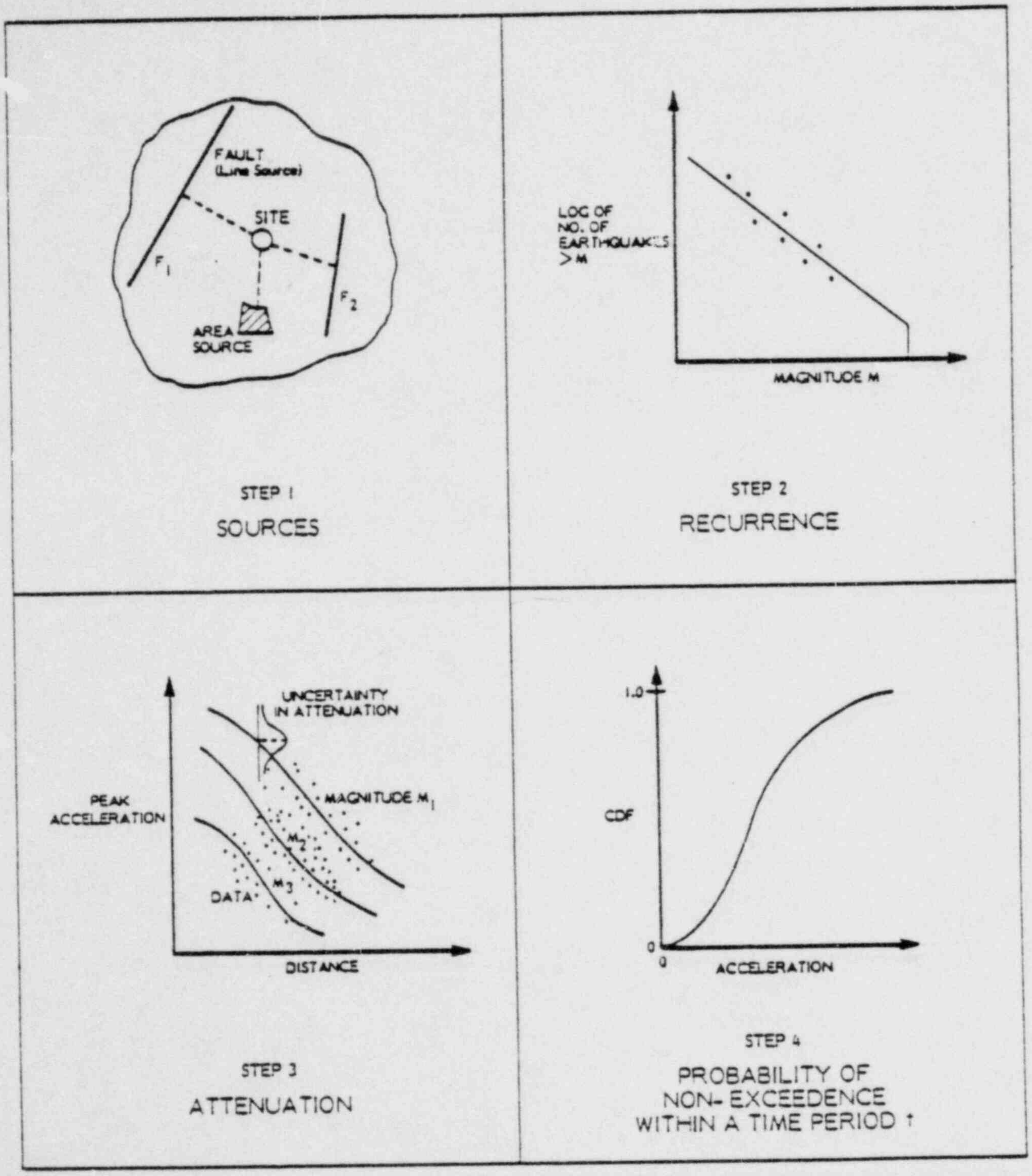
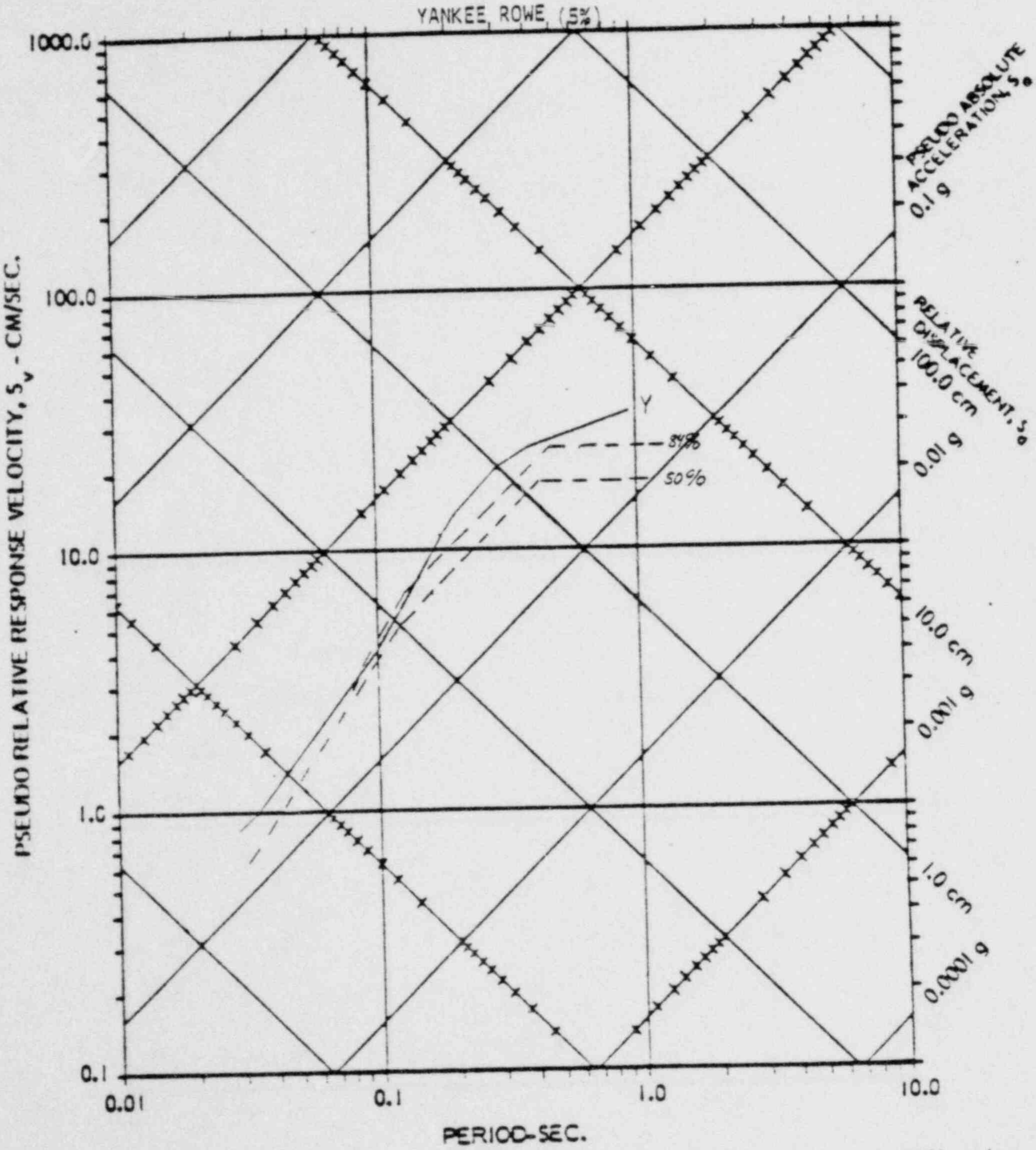


FIGURE 2

CURRENT APPROACH TO HAZARD MAPPING FOR PEAK VALUES

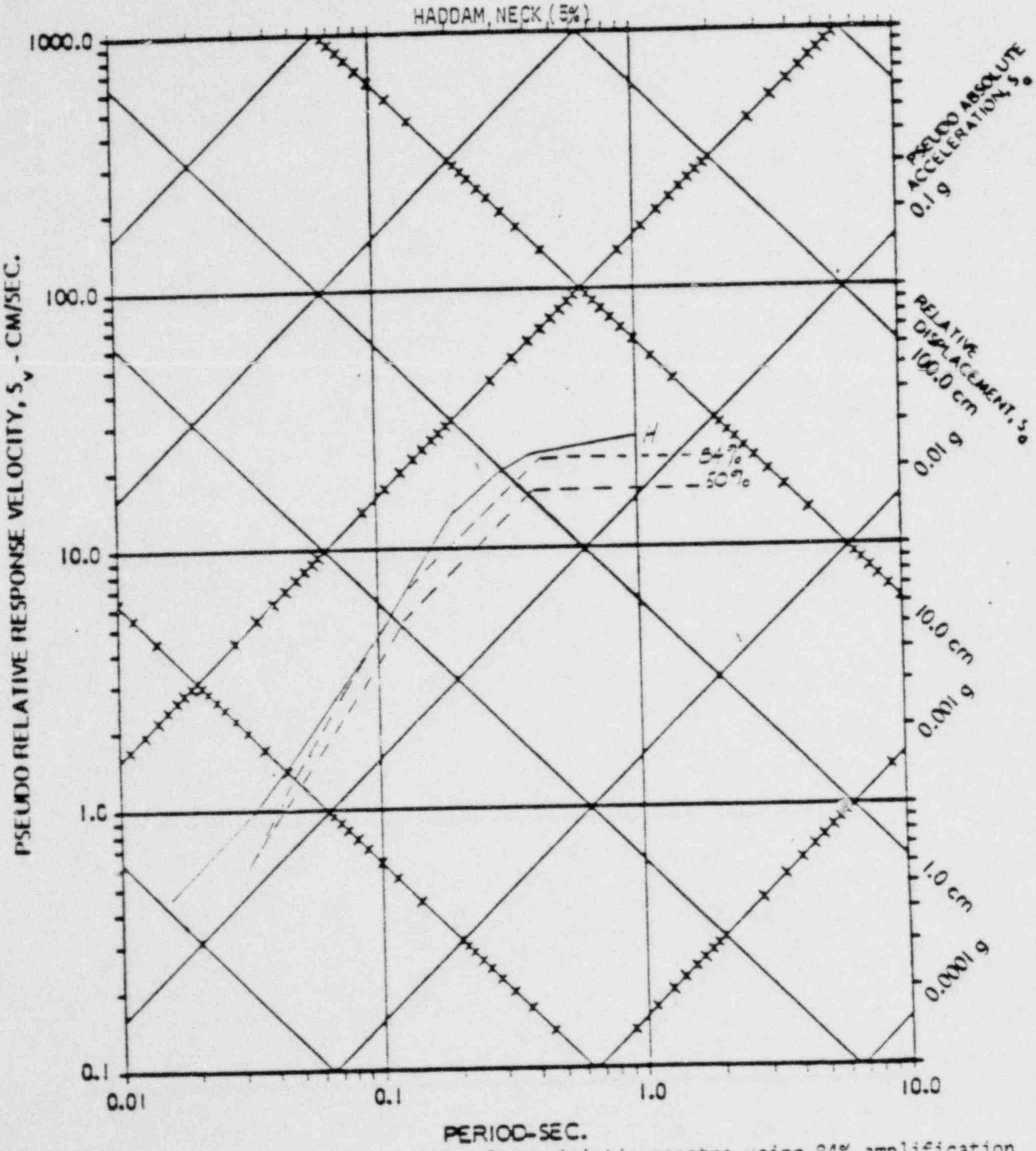


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

Y - Recommended probabilistic spectra.

Figure 3

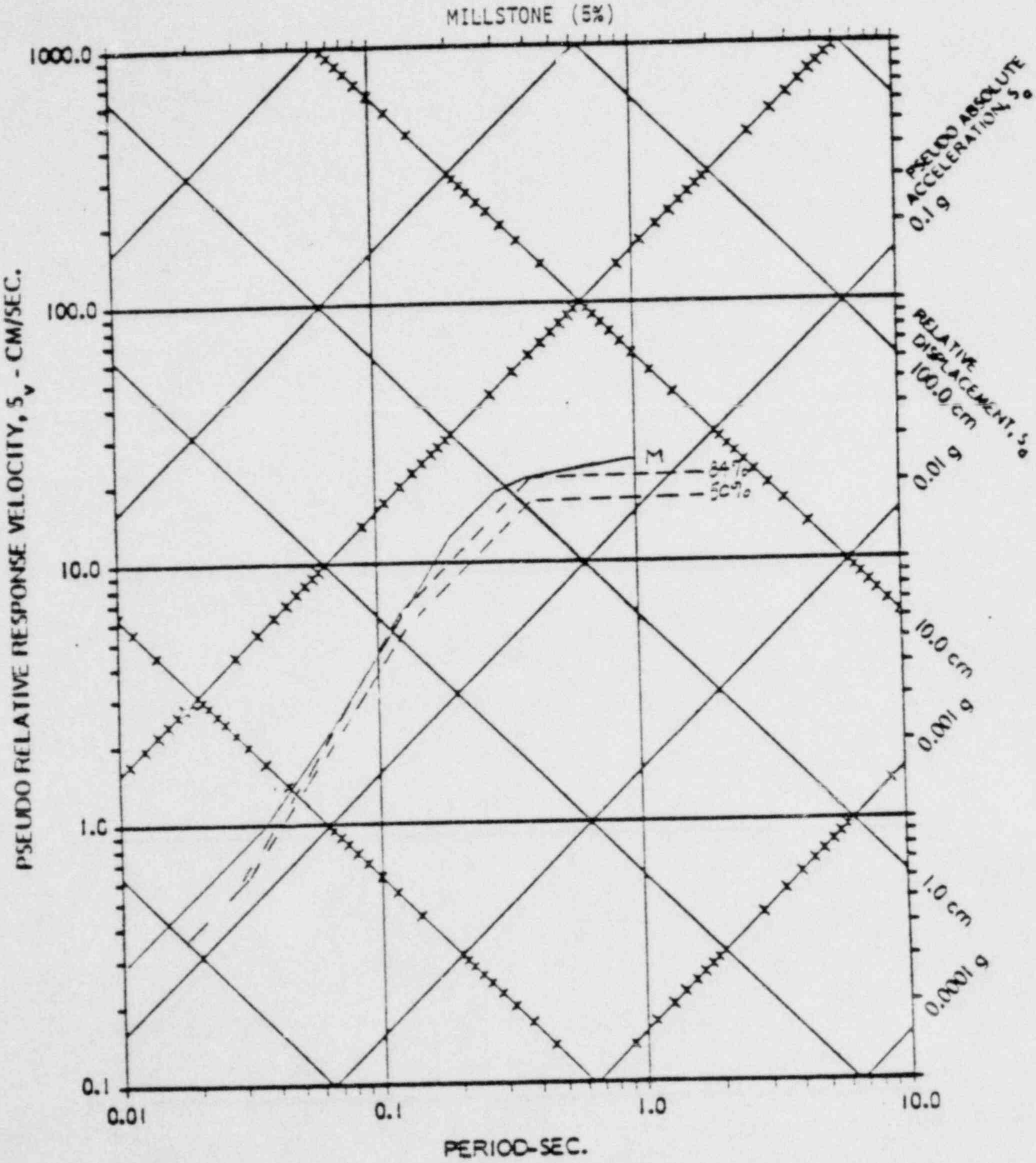


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spestra using 50% amplification factor from NUREG CR - 0098.

H - Recommended probabilistic spectra.

Figure 4

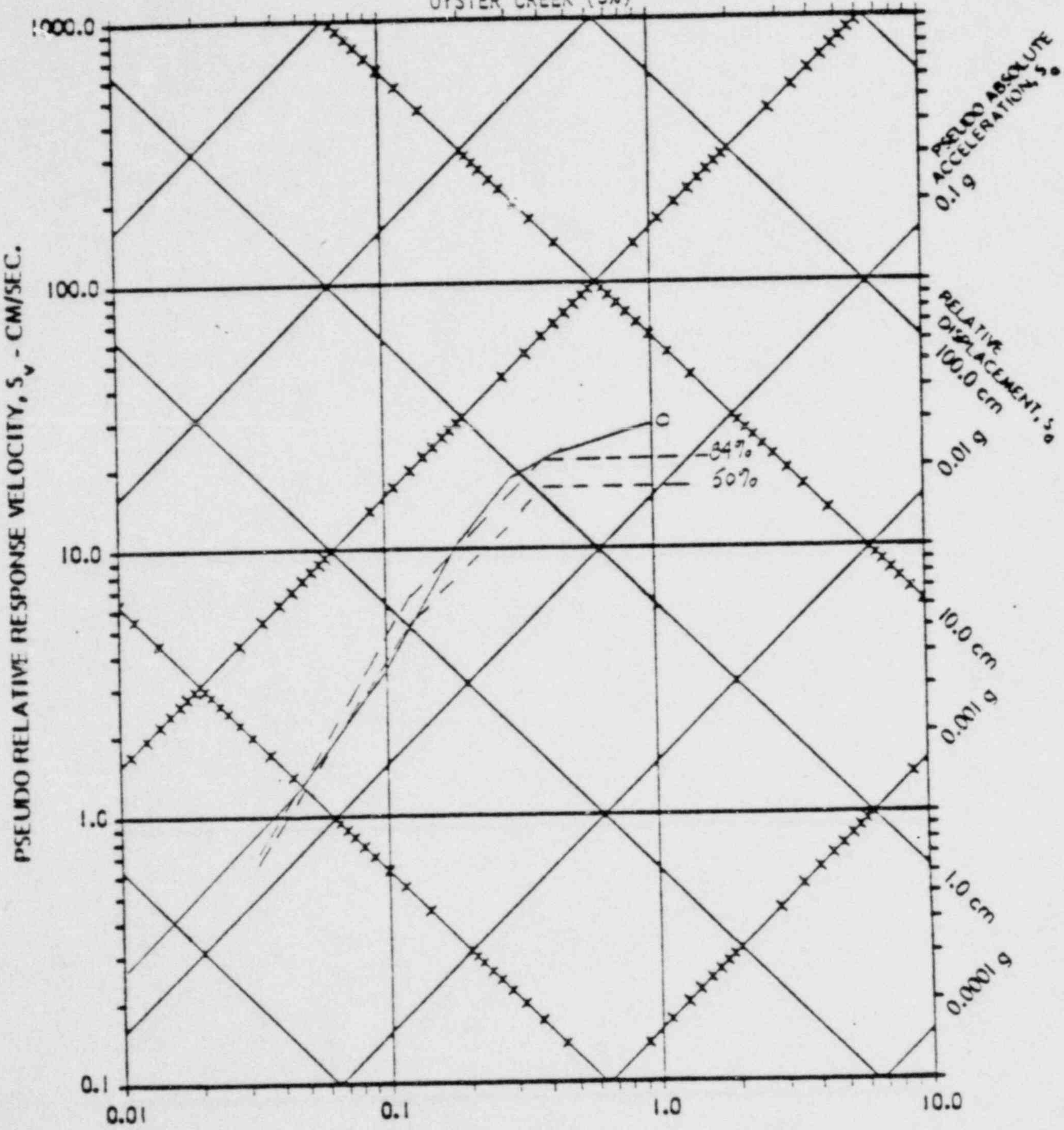


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 50% amplification factor from NUREG CR - 0098.

M - Recommended probabilistic spectra.

Figure 5

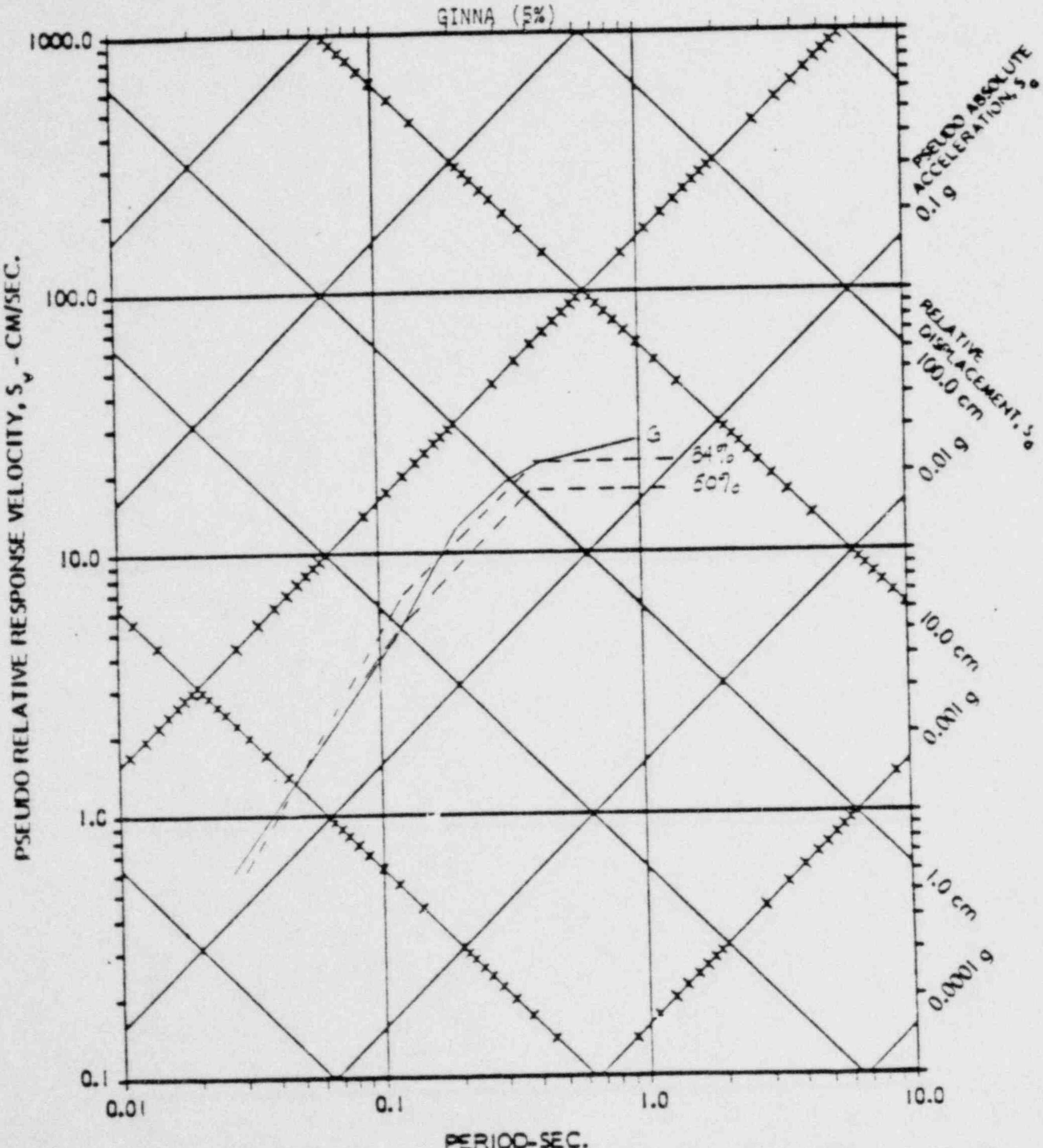


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 50% amplification factor from NUREG CR - 0098.

O - Recommended probabilistic spectra.

Figure 6

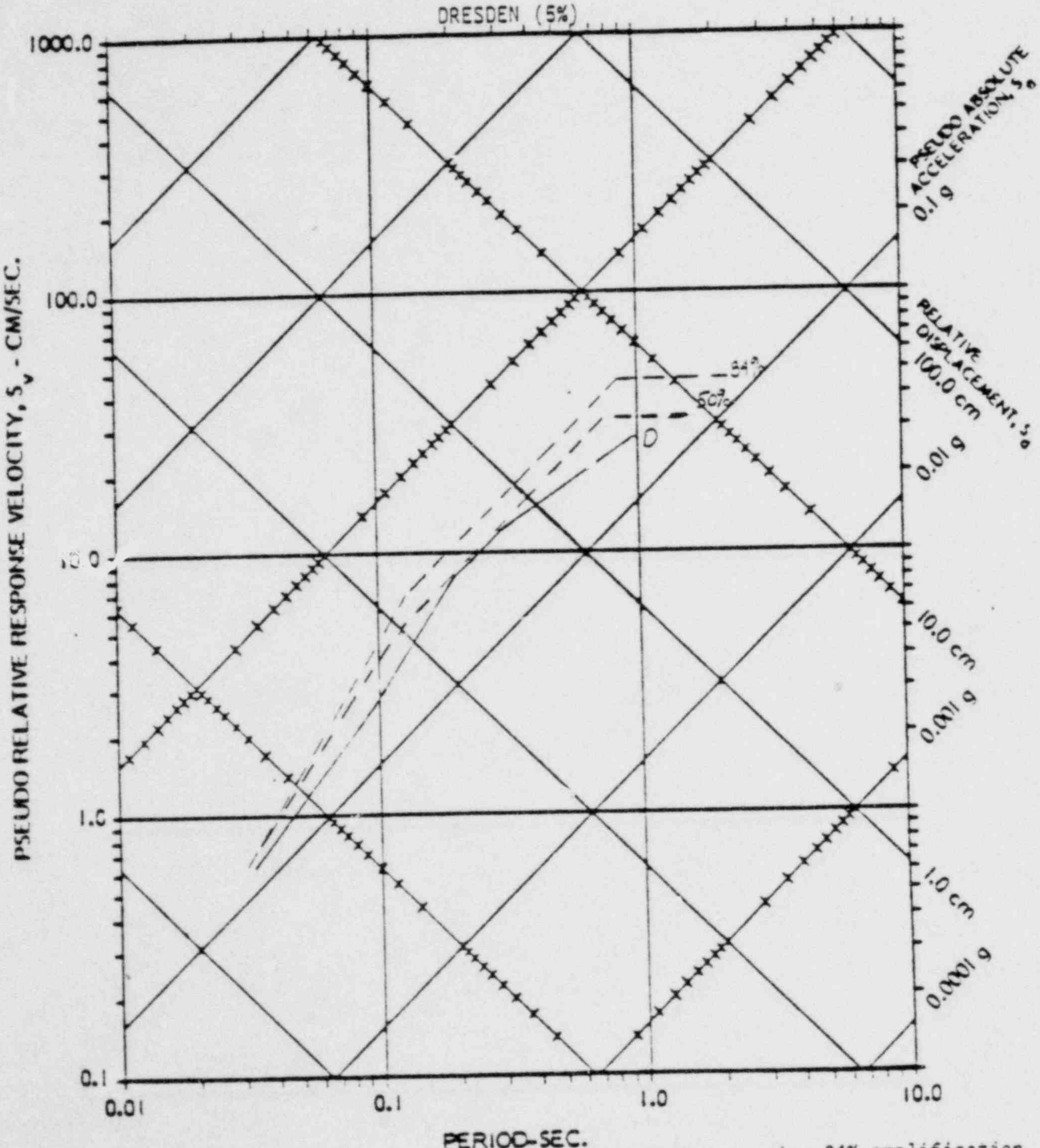


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 50% amplification factor from NUREG CR - 0098.

G - Recommended probabilistic spectra.

Figure 7

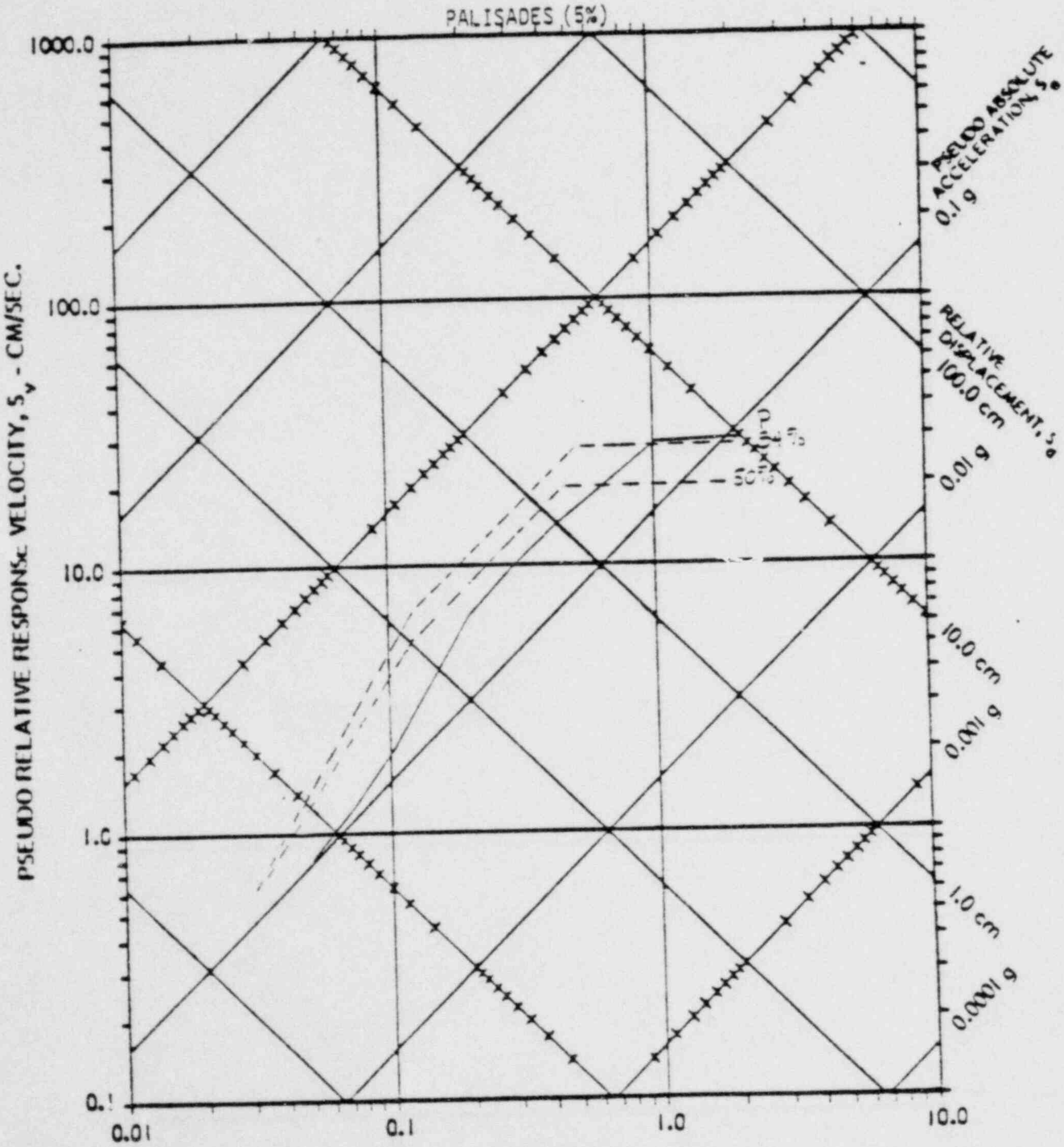


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 50% amplification factor from NUREG CR - 0098.

D - Recommended probabilistic spectra.

Figure 8

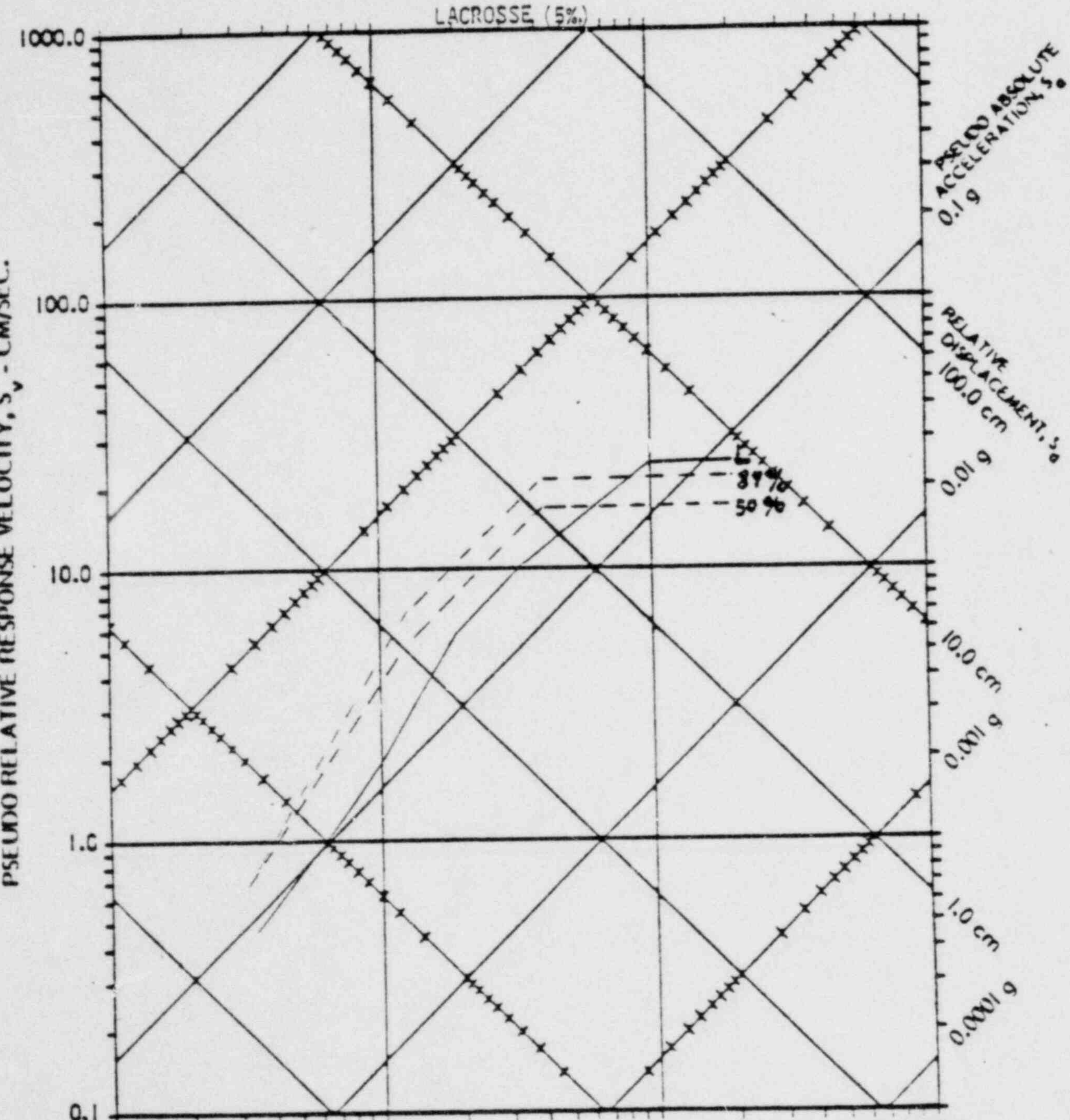


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 50% amplification factor from NUREG CR - 0098.

P - Recommended probabilistic spectra.

Figure 9

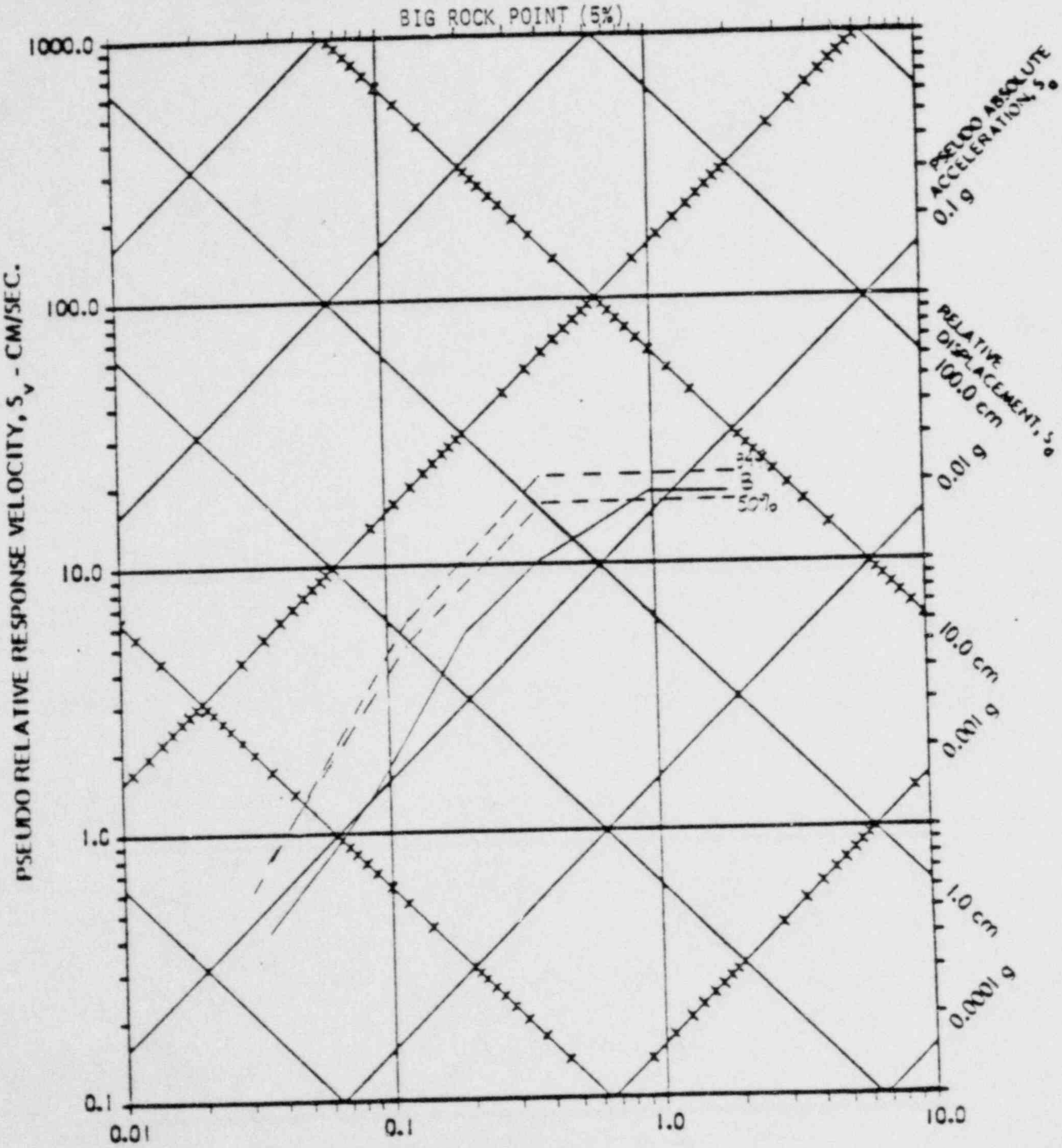


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 50% amplification factor from NUREG CR - 0098.

L - Recommended probabilistic spectra.

Figure 10



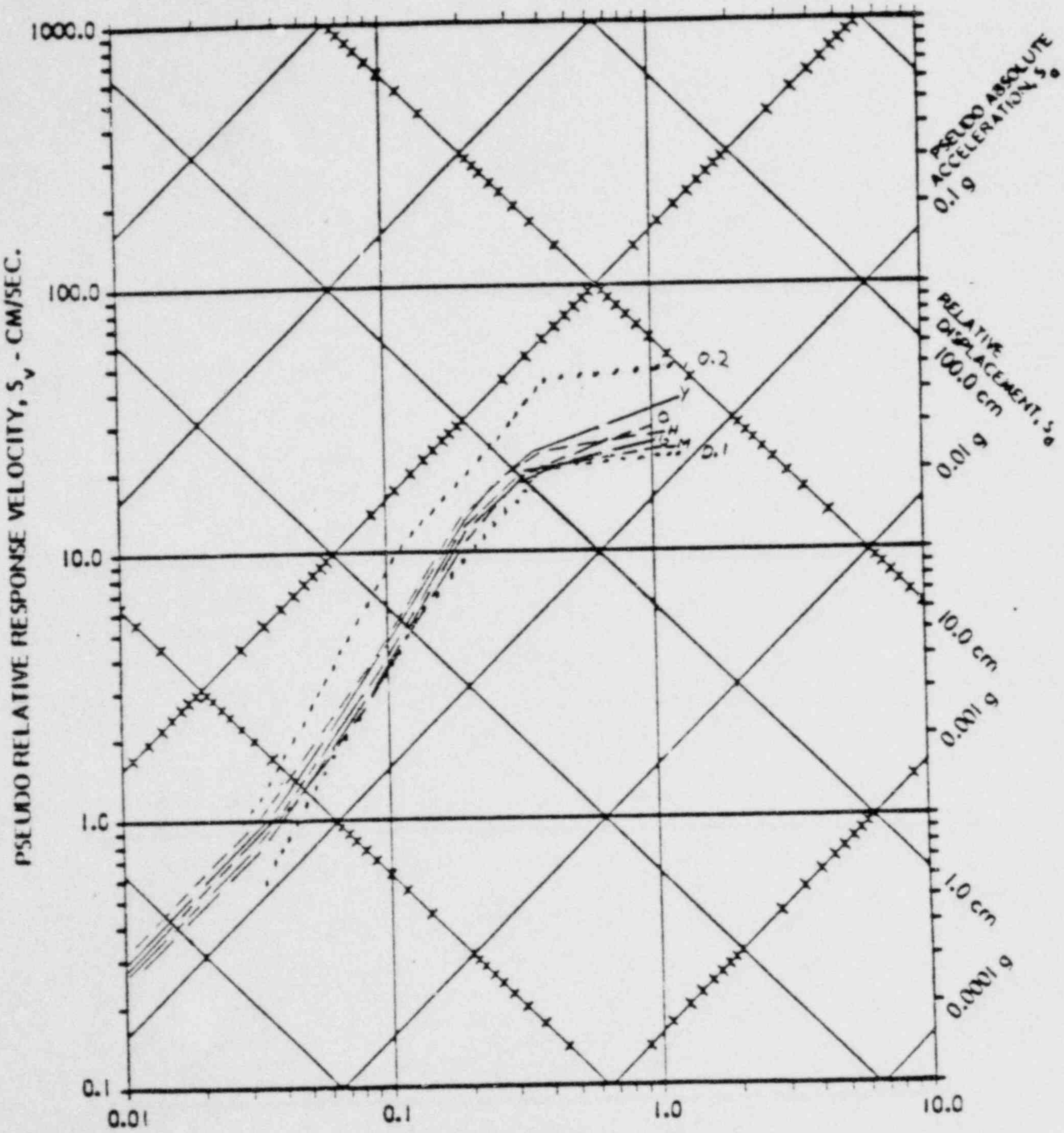
84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

50% - Deterministic spectra using 50% amplification factor from NUREG CR - 0098.

B - Recommended probabilistic spectra.

Figure 11

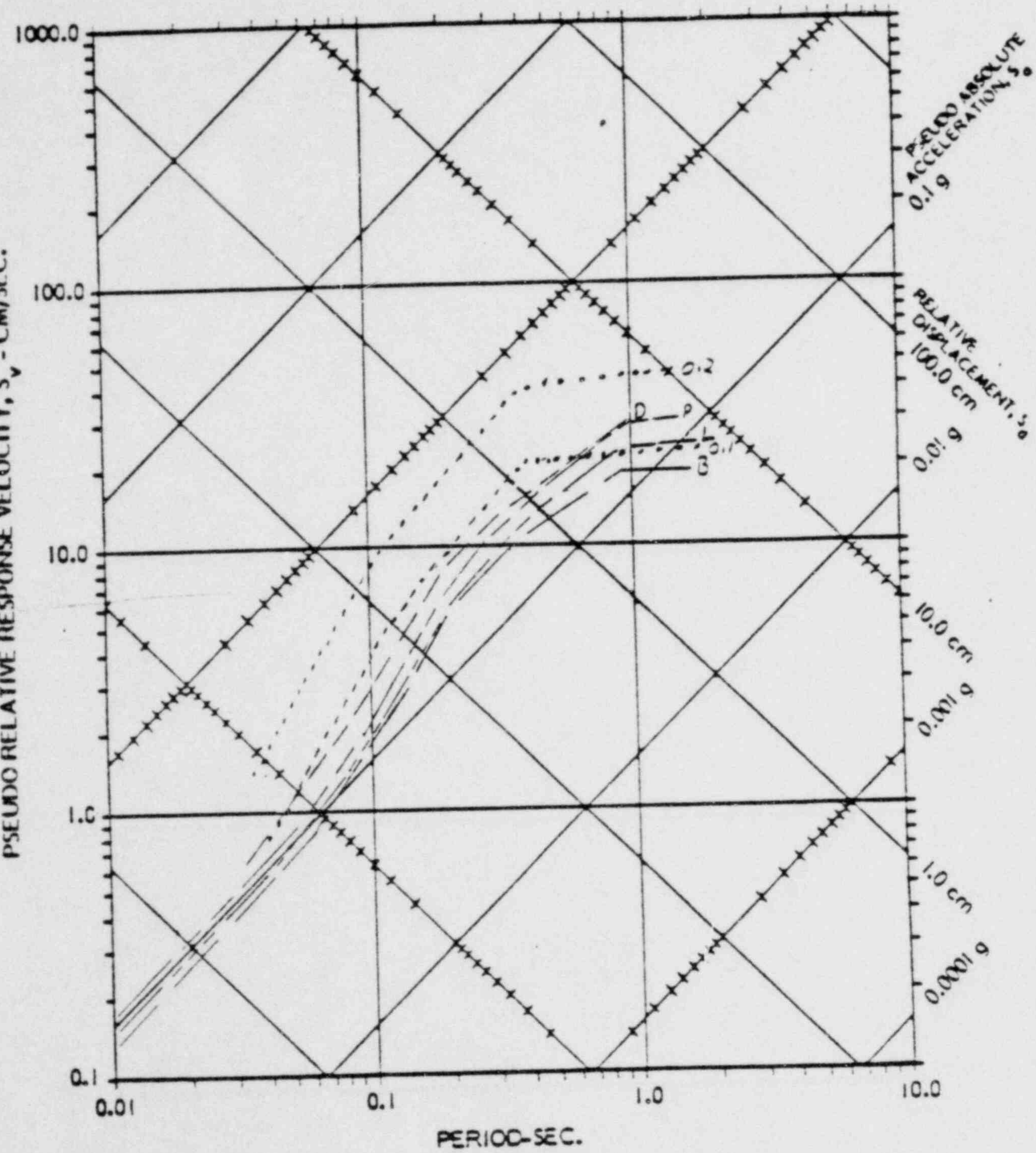
E.U.S. Recommended Probabilistic Spectra and
Regulatory Guide 1.60 Spectra



Y - Yankee Rowe
O - Oyster Creek
H - Haddam Neck
G- Ginna
M- Millstone
0.1 - R.G. 1.60 anchored at 0.1g
0.2-R.G. 1.60 anchored at 0.2g

Figure 12

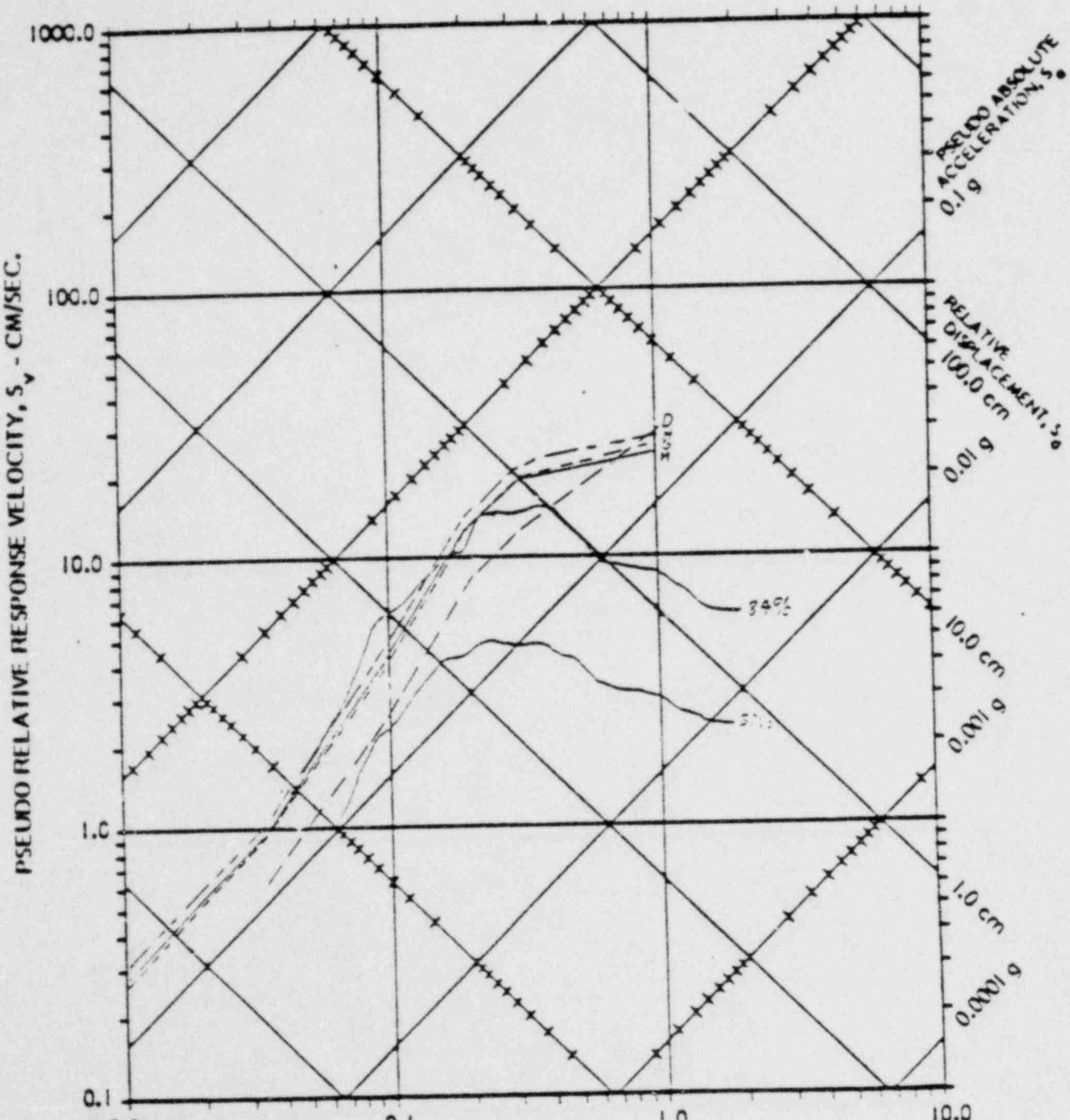
C.U.S. Recommended Probabilistic Spectra and
Regulatory Guide 1.60 Spectra



D - Dresden
P - Palisades
L - LaCrosse
B - Big Rock Point
0.1 - R.G. 1.60 anchored at 0.1g
0.2 - R.G. 1.60 anchored at 0.2g

Figure 13

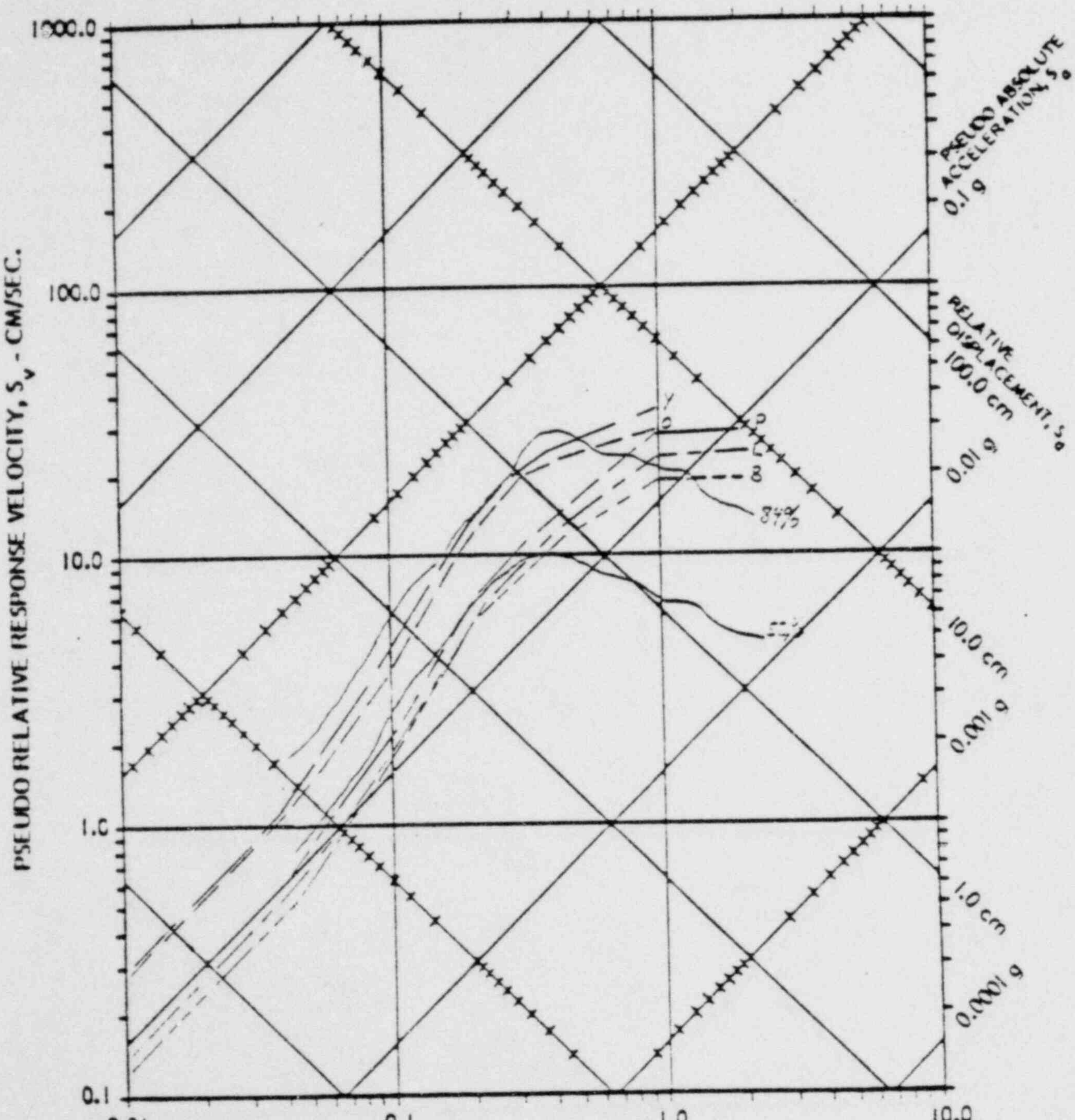
Recommended Probabilistic Spectra at Rock Sites and Recorded Spectra at Rock Sites



D-Dresden
H - Haddam Neck
G-Ginna
M-Millstone
84% - 84% spectra from nearby Mag. 5.3 ± .5 event.
50%-50% spectra from nearby Mag. 5.3 ± .5 event

Figure 14

Recommended Probabilistic Spectra at Soil Sites and
Recorded Spectra at Soil Sites



y - Yankee Rowe
O - Oyster Creek
P - Palisades
L - LaCrosse
B - Big Rock Point
84% - 84% spectra from nearby Mag. 5.3 ± .5 event
50% - 50% spectra from nearby Mag. 5.3 ± .5 event

Figure 15