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

MAR 27 1985

MEMORANDUM FOR: C. Grimes, Chief
Integrated Assessment Branch
Division of Licensing

THRU: Robert J. Bosnak, Acting Assistant Director for
Components & Structures Engineering
Division of Engineering

FROM: Stephan J. Brocoum, Acting Chief
Geosciences Branch
Division of Engineering

SUBJECT: MAINE YANKEE NUCLEAR POWER PLANT SEISMIC REANALYSIS
GROUND MOTION

Attached is the Geosciences Branch's recommendation for the ground motion characterization to be used in the seismic reanalysis of Maine Yankee Nuclear Power Station. This recommendation is based on staff review of reports submitted by the licensee, research reports in the scientific literature, and results of NRC sponsored research.

Our recommendation is that the appropriate characterization of the ground motion to be used in the reanalysis of Maine Yankee Nuclear Power Station is a NUREG/CR-0098 response spectrum obtained by using the 50th percentile amplification factors and having a high frequency anchor acceleration of 0.18g. While this ground motion characterization is not necessarily the one which we would recommend if a new plant were being licensed in the vicinity, it is consistent with the approach taken in defining reanalysis spectra for SEP plants. It should be considered within the context of structural and mechanical performance of plant structures, components and equipment such that the integrated level of desired conservatism is obtained.

This review was performed by Robert L. Rothman, Seismologist and Richard B. McMullen, Geologist, of the Geosciences Branch.

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Richard B McMullen
for Stephan J. Brocoum, Acting Chief
Geosciences Branch
Division of Engineering

Attachment:
As stated

cc: See next page

#7

MAR 27 1985

cc: K. Heitner
T. Cheng
P. Y. Chen
J. Miller
J. Knight
T. Sullivan
GSB Staff

Maine Yankee Nuclear Power Station Seismic Reanalysis Ground Motion

Introduction

The Geosciences Branch has been reviewing the seismology and geology of the northeastern United States and southeastern Canada over the past few years to determine an appropriate ground motion for use in the reanalysis of the Maine Yankee Nuclear Power Station (MYNPS). Among the materials considered in the review are reports submitted by the licensee, Maine Yankee Atomic Power Company, research reports in the scientific literature, and the results of NRC sponsored research. Based on this review the staff concludes that the appropriate characterization of the ground motion to be used in the reanalysis of MYNPS is a NUREG/CR-0098 response spectrum obtained by using the 50th percentile amplification factors and having a high frequency anchor acceleration of 0.18g (0.18g NUREG).

Background

The Maine Yankee Nuclear Power Station is located near Wiscasset, Maine. The plant was designed and constructed in the 1960's and early 1970's. The design basis earthquake (now called the safe shutdown earthquake (SSE)) is a horizontal ground acceleration of 0.10g. This value was established based on the recommendation of the U. S. Coast and Geodetic Survey, which acted as site reviewer for the AEC. This horizontal acceleration was used to anchor the Housner design response spectrum.

In 1979 MYNPS was one of five nuclear power plants which the NRC ordered to shutdown because of an incorrect analysis of safety-related piping. In reviewing the seismic design bases for these plants the NRC staff found that because of relatively lower design acceleration and higher local seismicity, the Maine Yankee site had an apparently higher risk of exceeding its design basis than many other nuclear plants. An examination of probabilistic seismic hazard studies existing at that time indicated that the chance of ground motion exceeding the intensity associated with the design may be on the order of 10^{-2} per year.

On April 17, 1979, during the shutdown, an earthquake of approximately magnitude 4 and at least 30 aftershocks occurred about 10 kilometers west of the MYNPS site. Although these events had no adverse effect on the plant they did serve to reinforce the staff's conclusion that the plant is located in an area where felt earthquakes can and do occur, and seismic design considerations are important. Because of these factors the staff determined that it would be prudent to reexamine the seismic design basis for MYNPS.

On January 9, 1982 an earthquake of approximately magnitude 5 3/4 occurred in central New Brunswick, Canada. The earthquake is the largest event known to have occurred in the New England-Piedmont tectonic province which has not been associated with a particular tectonic structure or seismogenic zone. Although the licensee does not agree, it is the staff's position that the MYNPS is in the New England-Piedmont tectonic province. Appendix A to 10 CFR Part 100 (Seismic and Geologic Siting Criteria for Nuclear Power Plants) requires that

in determining the SSE in current licensing actions, the largest reported earthquake in a tectonic province which cannot reasonably be related to tectonic structure should be assumed to occur near the site.

Utility Sponsored Studies

As a result of the above factors the staff held a meeting with the Maine Yankee Atomic Power Company on May 7, 1982. At this meeting the staff expressed its concerns about the seismic hazard and seismic design adequacy of MYNPS. In a letter dated June 21, 1982 the licensee committed to among other things:

1) Develop suitable site specific response spectra (SSRS) along the general lines of 10 CFR Part 100 Appendix A methods.
2) Develop suitable ground response spectra by probabilistic methods.
3) Select appropriate input for use in analysis of plant structures, systems and components.
4) Update and augment the geologic and seismic data and models which were used in establishing the plant's licensing bases.

The licensee stated that if the analyses indicate deficiencies, they will be corrected and that a more general objective of this program is to demonstrate that the plants seismic capability is generally consistent to that of other New England plants.

The licensee has submitted several reports on studies it and its consultants have performed with respect to this program. Those related to seismology and geology are:

1) Maine Yankee Seismic Hazard Analysis, June 1983
2) Seismological and Geological Studies Miramichi Area, New Brunswick and Central New Hampshire, August 1983.
3) Draft Report, Update of Geology and Seismology for the Maine Yankee Nuclear Power Station, Wiscasset, Maine, April 1984.
4) Update of Geology and Seismology for the Maine Yankee Nuclear Power Station, Wiscasset, Maine, July 1984.
5) Sensitivity of Seismic Hazard Results at Maine Yankee to LLNL Study Assumptions on Attenuation and Seismicity, September 1984.
6) Geological and Seismological Studies Millstone Nuclear Power Station - Unit 3 Response to NRC Information Requests Q230.4, Q230.6 and Q230.7, October 1984.
7) Review and Comment on NUREG/CR-3756 "Seismic Hazard Characterization of the Eastern United States: Methodology and Interim Results for Ten Sites", December 1984.

At a meeting between the staff and the licensee on May 10, 1983 the licensee reported on the progress in its design review. Probabilistically determined uniform hazard spectra with exceedance probabilities of 10^{-2}, 10^{-3} and 10^{-4} per year were presented. The licensee proposed the use of a Regulatory Guide 1.60 spectrum with a high frequency anchor of 0.1g for the seismic reanalysis of MYNPS. The justification for the use of this ground motion characterization was the licensee's claim that it falls between the exceedance probabilities of 10^{-3} and 10^{-4} per year on their uniform hazard spectra plot.

In the June 1983 report the licensee presented its seismic hazard study for the MYNPS site. The objectives of this study were to develop a seismic hazard analysis for use as the basis for estimates of the seismic capability of the MYNPS and to develop response spectra for the site representing the 10^{-2}, 10^{-3}, and 10^{-4} annual probabilities of exceedance. To accomplish this, several hypotheses about eastern U. S. seismicity were analyzed and weighted. The study employed both historic and zonation methods of seismic hazard analysis. The peak ground acceleration (PGA) and peak velocities from the two methods were averaged to get integrated PGA and velocity values. The numerical results were summarized as:

1) The median estimate of the 10^{-2} peak ground acceleration and spectral velocity are 0.03g and 1.4 in/sec, respectively.
2) The median estimate of the 10^{-3} peak ground acceleration and spectral velocity are 0.11g and 5.2 in/sec, respectively.
3) The median estimate of the 10^{-4} peak ground acceleration and spectral velocity are 0.25g and 14 in/sec, respectively.

These were used with the median amplification factors from NUREG/CR-0098 to generate uniform hazard spectra. This report does not make a comparison between the seismic design basis for MYNPS and the probabilistic estimates, and it does not recommend how the results of the probabilistic hazard study should be used to determine a ground motion for use in a reanalysis of the plant.

In the August 1983 report the licensee presented seismologic, geologic and geophysical information obtained from the review of the scientific literature

as well as some information collected in field surveys in the New Brunswick earthquake epicentral area. The conclusions of the report with respect to the New Brunswick earthquake are:

a. Prior to the 1982 earthquakes, central New Brunswick had experienced a level of seismicity sufficiently high to be included in a zone 2 on the seismic map of the National Building Code of Canada. (Zone 2 is defined as a zone having a peak acceleration of between 0.03g and 0.06g with a probability of exceedance of 0.01 per year). Considering the epicentral uncertainty of some of the larger historical events and the occurrence in 1977 of smaller, but better located, shocks near the 1982 seismic activity, the existence of a significant seismic source is probable. The occurrence of the 1982 sequence, including a 5.7 m_{blg} main shock within this area, was therefore no surprise to seismologists familiar with the data.

b. The presence of gravity and aeromagnetic anomalies in the exact epicentral area and a number of adjacent major faults strongly suggest the existence of a tectonic structure within the central Miramichi Anticlinorium.

c. The close spatial association of the hypocenters of the larger earthquakes of January, March, and June 1982 with the inferred boundaries of that structure, supports the theory of a causal relationship. On this basis, the 1982 New Brunswick activity can be constrained to its tectonic domain, and thus has no direct implication for the New England power plants.

In the April 1984 draft report and the July 1984 report the licensee presented an update of the geology and seismology of the New England region. These reports reference mainly existing literature rather than specific utility

sponsored studies and discussed generally regional geology and seismology. The reports postulate that the Maine Yankee site is in the Coastal Anticlinorium tectonic province and that the maximum historical earthquake in this province had a Modified Mercalli intensity of VI. Based on this, mean and median response spectral estimates were presented based on recordings of earthquakes in the magnitude range of 4.5 to 5.5.

In the September 1984 report the utility presented a critique of the Lawrence Livermore National Laboratory (LLNL) report "Seismic Hazard Characterization of the Eastern United States: Methodology and Interim Results for Ten Sites" (NUREG/CR-3756). The purpose of the report was to examine the seismic hazard results produced in the LLNL report for Maine Yankee and to assess their dependence and sensitivity to various assumptions made in the LLNL study. The licensee's main points are: the attenuation estimates used by LLNL are conservative, the seismic activity rates are overestimated and the use of a lower bound magnitude of 3.75 by LLNL is overly conservative because damage to engineered structures and equipment is not known for earthquakes less than magnitude 5. The main conclusion of the report is that accounting for the effects of the LLNL assumptions implies significant reduction in the calculated hazard at Maine Yankee from the hazard published in the LLNL report.

In October 1984 the licensee submitted a three volume report entitled "Geological and Seismological Studies Millstone Nuclear Power Station-Unit 3 Response to NRC Information Requests Q230.4, Q230.6 and Q230.7" to be added to the MYNPS docket for NRC review. This report provides a compilation of the data collected in the epicentral region of the 1982 New Brunswick earthquake

and a comparison of that region to the Millstone site region, including a comparison of the seismicity in both areas.

In the December 1984 report the licensee presented an additional evaluation of the seismic hazard results for the MYNPS in the LLNL study (NUREG/CR-3756). The report identified several factors which the licensee believes results in overly conservative hazard estimates for all ten sites in the LLNL study and some factors, such as attenuation models and seismicity parameters, which primarily effect the Maine Yankee hazard estimation.

Staff Review

The staff has reviewed and considered the licensee's reports as part of its program to develop a ground motion estimation appropriate for the seismic reanalysis of MYNPS.

In reviewing the seismic design basis for older operating nuclear power plants under the Systematic Evaluation Program (SEP) the NRC staff used a multi-method approach for determining site specific spectra. This encompassed probabilistic methodology for determining uniform hazard spectra for various return periods and empirical methodology which included calculating seismic response spectra from ensembles of real earthquake data. In determining the ground motion to be used for the seismic reanalysis of the Maine Yankee Nuclear Power Station the staff has undertaken to utilize the concepts of the SEP to arrive at a reasonable estimate. A conclusion in the seismic hazard review for SEP was that "the recommended spectra can be generally associated with the higher end of the range of implicitly assumed seismic hazard that has been found

acceptable using current criteria" (NUREG-0967). Under the SEP, recommended site specific spectra for sites in the eastern U. S. had return periods on the order of 1000 or 10,000 years. This is the level which has been implicitly accepted by the NRC in recent licensing decisions. In the program to determine the appropriate characterization of the ground motion to be used in the seismic reanalysis of MYNPS, the staff used a general approach similar to that developed under the SEP. This involved the iterative use of both deterministic-empirical and probabilistic techniques to arrive at a ground motion characterization which is based on real earthquake data.

In licensing decisions relating to New England since about 1976 the NRC staff has recognized the New England-Piedmont tectonic province as a single entity. Maine Yankee Nuclear Power Station is located in this tectonic province, which is a region of very complex geology and tectonic history. On January 9, 1982 a body-wave magnitude 5 3/4 earthquake occurred in south central New Brunswick, Canada, in the New England-Piedmont tectonic province. In reports submitted by the licensee, data were presented to attempt to demonstrate a correlation of the New Brunswick earthquake to definable tectonic structure. This postulated tectonic structure is defined by the applicant as a fault bounded, apparently counterclockwise rotated crustal block, approximately 1650 km^2 in area. The boundaries of this crustal block include the Catamaran fault to the south, a steep gravity gradient to the west, brittle faults to the north, and northwest trending gravity gradients to the east. It is the staff's position that the evidence for the crustal block along the boundaries given is not conclusive. The Catamaran fault is a reasonable southern boundary; it appears to have the proper right lateral strike slip motion to fit the model. The mylonitic zones,

brittle faults, and cleavage on the west could indicate a western boundary. However, rotation along discontinuous brittle faults which appear to be normal faults (see licensee's October 1984 report Figure 3-1A) to the north, and along northwest trending gravity gradients to the east, which may or may not indicate faulting, are not sufficient evidence for rotational tectonics. In addition, the licensee has not demonstrated how this block is uniquely structured to cause a localization of seismicity in the New Brunswick region. The Millstone applicant also presented seismological and geological information from the epicentral area to show a possible relationship of seismicity to specific structure. The staff concluded that the evidence was insufficient to demonstrate a relationship of the earthquakes to tectonic structure within the epicentral area and to show that the proposed structures are unique to the area. (Millstone Unit 3 OL SER, NUREG-1031). Because of the complexity of the New England-Piedmont tectonic province geology and our current inability to relate earthquake occurrence to geology in the eastern United States, the staff has taken the position, for purposes of reviewing nuclear power plant sites, that areas of higher seismicity in the northeastern U. S. should be considered as having the potential for an earthquake of approximately magnitude 5 3/4 (Millstone 3 OL SER, NUREG-1031; Limerick 1 and 2 OL, SER, NUREG-0991; Hope Creek OL SER, NUREG-1048). The coastal area of Maine, in which MYNPS is located, appears to be an area of relatively higher seismicity when compared to other areas in the New England-Piedmont tectonic province. In view of this and the occurrence of the magnitude 4, 1979 earthquake and its aftershocks within 10 km of the site it is appropriate to consider the possible occurrence of an

earthquake of approximately magnitude 5 3/4 near the site in the seismic reanalysis of the Maine Yankee Nuclear Power Station.

In this review the staff has used both deterministic studies and probabilistic studies to arrive at a reasonable estimate of the ground motion to be used in the reanalysis. Several standard response spectral shapes anchored at various peak accelerations in the range 0.10g to 0.25g were compared to empirical site specific response spectra and probabilistic seismic hazard spectra for MYNPS to get an appropriate response spectrum for the reanalysis. As a means of assessing the MYNPS reanalysis estimates relative to the other plants, the ratio of the reanalysis estimates to the LLNL 1000 year 50th percentile probabilistic spectrum for MYNPS were compared to ratios of the seismic design spectra of the other plants to their probabilistic spectra.

A current staff practice in deterministically evaluating the adequacy of the seismic design basis of nuclear power plants is to use appropriate empirical site specific response spectra. In this method the design response spectrum is evaluated by comparison to a site specific spectrum which is obtained from the statistical analysis of a suite of appropriate strong ground motion spectra. The selection of the data to be used in generating the site specific spectrum is based on the magnitude of the earthquake, the geology of the recording site and the distance from the recording site to the earthquake source. In regard to Maine Yankee, appropriate parameters are magnitude of about 5 3/4, distance of less than about 25 kilometers and recording sites founded on rock.

The staff has available three site specific spectra for earthquakes of magnitude 5.8 and one spectrum for magnitude 6.0 developed from recordings at

rock sites. These spectra are the LLNL magnitude 5.8 spectrum developed for the site specific spectra project as part of the SEP, the Tennessee Valley Authority's (TVA) magnitude 5.8 rock spectrum developed for Sequoyah, the Weston Geophysics Corporation (WGC) site specific spectrum developed for Seabrook (magnitude 5.8) and the LLNL magnitude 6.0 spectrum developed for Seabrook.

In arriving at a response spectrum appropriate for use in the seismic reanalysis of the Maine Yankee Nuclear Power Station the staff has compared the four site specific spectra listed above with several standard spectral shapes anchored at high frequency with a suite of peak ground acceleration values. The spectral shapes considered were Housner, Regulatory Guide 1.60, NUREG/CR-0098 50th percentile and NUREG/CR-0098 84th percentile. The peak ground acceleration levels considered ranged from 0.1g to 0.25g.

The current staff practice in licensing reviews of nuclear power plants is to use the 84th percentile spectral level of site specific spectra as the criteria for judging the adequacy of seismic design. This level is based on past practice as exemplified in criteria such as the Regulatory Guide 1.60 response spectrum and recommended revisions to the Standard Review Plan that deal with site specific spectra. In the SEP review the staff considered probabilistic spectra which when compared with deterministically derived NUREG/CR-0098 criteria range from less than the 50th percentile to greater than the 84th percentile. In all cases, however, a 50th percentile site specific spectrum was used as a minimum below which recommended spectra were not allowed to fall. As a result of the comparisons the staff has found that the spectrum which is

consistent with the approach taken in SEP is the spectrum obtained by using the 50th percentile amplification factors from NUREG/CR-0098 with a high frequency anchor of 0.18g (0.18g NUREG).

Two types of comparisons were performed, deterministic and probabilistic. Deterministic comparisons are shown in Figures 1, 2, 3 and 4. These are plots of the 50th and 84th percentile spectral levels of the LLNL magnitude 5.8 SEP site specific spectrum, the TVA magnitude 5.8 Sequoyah site specific spectrum, the WGC magnitude 5.8 Seabrook site specific spectrum and the LLNL magnitude 6.0 Seabrook site specific spectrum, respectively. Each figure also contains the 0.18g NUREG spectrum for comparison. For the three magnitude 5.8 SSRS (Figures 1, 2, 3) the 0.18g NUREG spectrum exceeds the 84th percentile SSRS at longer periods and is exceeded by the 84th percentile at shorter periods. The 84th percentile of the magnitude 6.0 SSRS essentially exceeds the 0.18g NUREG spectrum at all periods. In all cases the 0.18g NUREG spectrum exceeds the 50th percentile SSRS.

The staff has used probabilistic estimates of earthquake hazard to address the adequacy of the seismic designs of nuclear power plants in a confirmatory manner or as a means of assessing relative levels of hazard. Because of the large uncertainty inherent in probabilistic earthquake hazard estimates for the eastern U. S., the staff has used them in a relative rather than an absolute manner. For example in assessing the relative difference in hazard among sites.

There have been two recent probabilistic seismic hazard estimates performed for the Maine Yankee site. One by the licensee to justify its proposed reanalysis basis (0.1g Regulatory Guide 1.60), and the other by LLNL as part of the Probabilistic Assessment of the Seismic Hazard for Eastern U. S. Nuclear Power Plant Sites project (NUREG/CR-3756). A comparison of the licensee's uniform hazard spectra and their proposed reanalysis spectrum (0.1g Regulatory Guide 1.60) revealed that at periods less than about 0.25 seconds (frequencies greater than 4 hertz) the 0.1g Regulatory Guide spectrum falls between the exceedence probabilities of 10^{-2} and 10^{-3} per year.

Maine Yankee is among the first ten sites evaluated under the LLNL project. In making comparisons of the seismic design bases of these ten sites to the initial probabilistic earthquake hazard calculated by LLNL (NUREG/CR-3756) we find that for Maine Yankee the ratio of the design basis (0.1g Housner) to the probabilistic hazard is significantly lower than those of the other nine sites. The probabilistic earthquake hazard representation used in the comparisons, the 50th percentile 1000 year return period, was selected because this representation is common to both the LLNL study and the licensee study and was a reference level used in the SEP spectra. The spectra called 1000 year return period may not actually represent that absolute level. They may represent longer or shorter return periods because of the uncertainties in the probabilistic methods. However, they should be relatively consistent from site to site. Figure 5 contains plots of the ratios of the design spectrum to the LLNL 50th percentile 1000 year probabilistic spectrum for each of the ten sites and also the ratio of the 0.18g NUREG response spectrum to the 50th percentile 1000 LLNL spectrum for Maine Yankee. The ratio of the Maine Yankee design

basis spectrum to the LLNL 50th percentile 1000 year spectrum is about 0.4 in the period range 0.04 to 1 second. Three of the other sites have ratios of 0.8 to 1.0 over parts of this period range and the other six sites have ratios greater than one over the entire period range. The ratio of the 0.18g NUREG spectrum to the LLNL 50th percentile 1000 year spectrum is about 0.8 to 0.95 over the period range 0.04 to 1 second. This is thus at the low end of the range of ratios calculated for the other nine sites.

The licensee has argued that the initial LLNL probabilistic estimates are overly conservative and biased in certain aspects to overestimate Maine Yankees seismic hazard. The staff has used the LLNL probabilistic estimates along with those of the utility to arrive at an appropriate reanalysis spectrum. The LLNL studies provide the capability to compare the MYNPS hazard to that at other eastern sites where the same methods were used. This allows for judgments similar to those in the SEP. The seismicity panel and the ground motion panel in the LLNL program were made up of 14 and 5 experts, respectively. These panel members are among the most knowledgeable seismologists on the subject of eastern U. S. earthquakes. Groups with broad ranges of knowledge were used as means of minimizing the effects of possible individual bias.

Subsequent to the publication of the initial results, LLNL reconvened its expert panels and calculated new results which are presently in draft form. The staff is reviewing this draft report. It appears that the absolute hazard estimation for each of the sites has been reduced. However, the relative

hazard among the sites has not changed significantly even though the attenuation relations, which the licensee claimed were biased, had been modified. Figure 6 contains a plot of the ratios of the design spectra to the latest LLNL 50th percentile 1000 year probabilistic spectra for each of the ten sites and also the ratio of the 0.18 NUREG response spectrum to the 50th percentile 1000 year LLNL spectrum for Maine Yankee. The ratio of the Maine Yankee design basis spectrum to the LLNL 50th percentile 1000 spectrum is still the lowest of all ten sites. The ratio of the 0.18g NUREG response spectrum to the LLNL probabilistic spectrum for Maine Yankee is about 1 or greater and at the lower end of the ratios for all ten sites. Figure 7 is a plot of the licensee's 1000 year uniform hazard spectrum for Maine Yankee and the latest LLNL 1000 year 50th percentile spectrum. These probabilistic estimates are approximately equal for periods greater than 0.35 seconds. At shorter periods the LLNL spectrum exceeds the licensee's spectrum somewhat.

A comparison of the 0.18g NUREG spectrum with the licensee's uniform hazard spectra, Figure 8, indicates that the 0.18g NUREG spectrum would have an annual probability of exceedance between 10^{-3} and 10^{-4}. A similar comparison of the 0.18g spectrum with the latest LLNL Maine Yankee hazard spectra, Figure 9, indicates that the 0.18g NUREG spectrum would have a return period of between 1,000 and 10,000 years.

Considering the uncertainties involved in absolute probabilistic earthquake hazard estimates, the difference in results at the 10^{-3} (1000 year return period) level between the LLNL and the utility's study appear to be relatively small. Although future absolute estimates could differ from those presented,

we find little basis to believe that there will be any significant changes in the relatively hazard at MYNPS as compared to other nuclear power plant sites.

Conclusion

The staff's position, based on the deterministic estimates and the probabilistic studies, is that the appropriate basis for the seismic reanalysis of the Maine Yankee Nuclear Power Station is a spectrum obtained using the 50th percentile amplification factors in NUREG/CR-0098 and a peak acceleration of 0.18g. This position is in accord with the conclusion in the seismic hazard review for SEP that "the recommended spectra can be generally associated with the higher end of the range of implicitly assumed seismic hazard that has been found acceptable using current criteria." While this spectrum is not necessarily the one which we would recommend if a new plant were being licensed in the vicinity, it is consistent with the approach taken in defining reanal sis spectra for SEP plants. It should be considered within the context of structural and mechanical performance of plant structures, components and equipment such that the integrated level of desired conservatism is obtained.

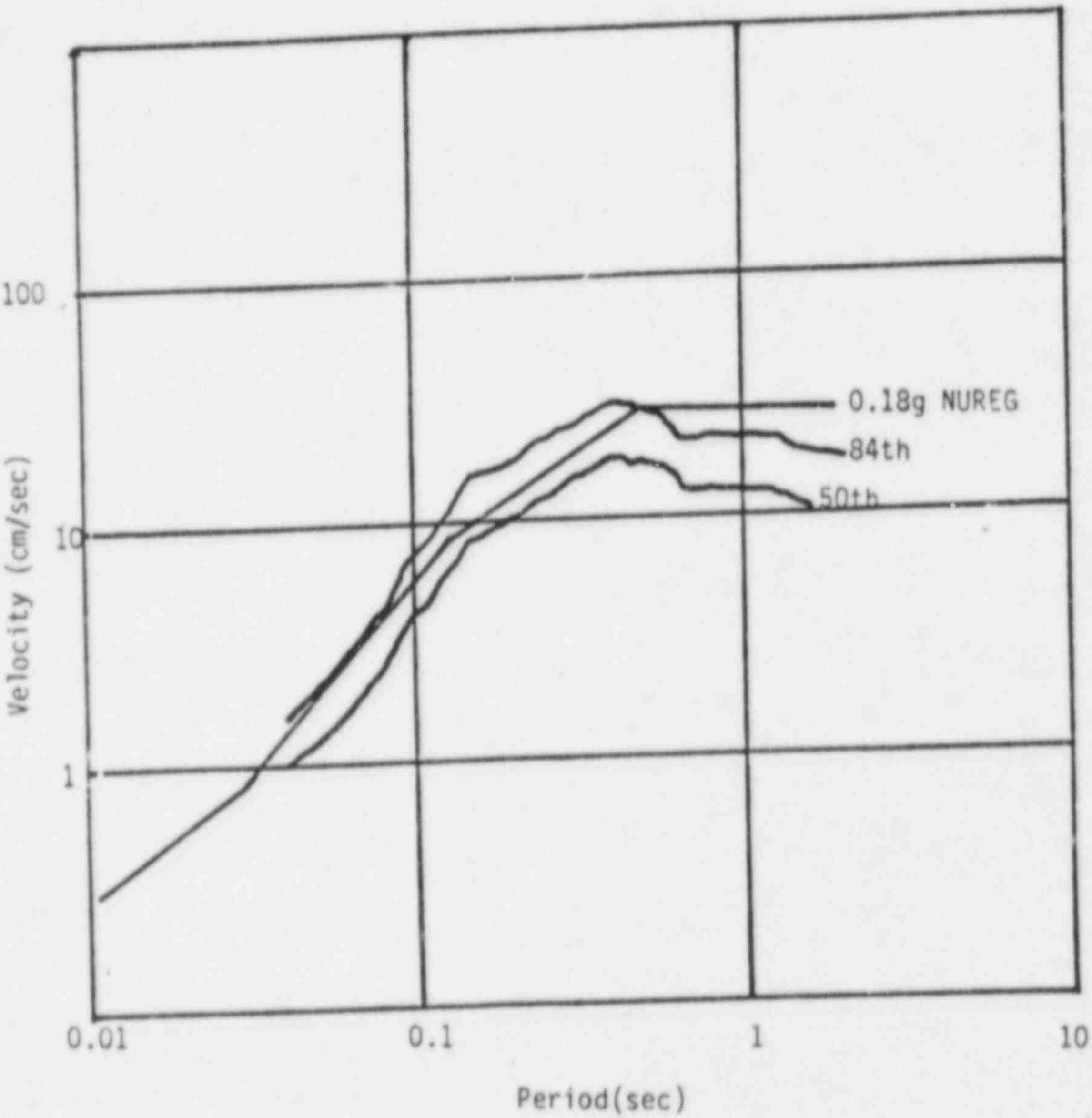

FIGURE 1. LLNL magnitude 5.8 SEP SSRS 50th and 84th percentile spectra, and 0.18 g NUREG/CR-0098 50th percentile amplification factors spectrum.

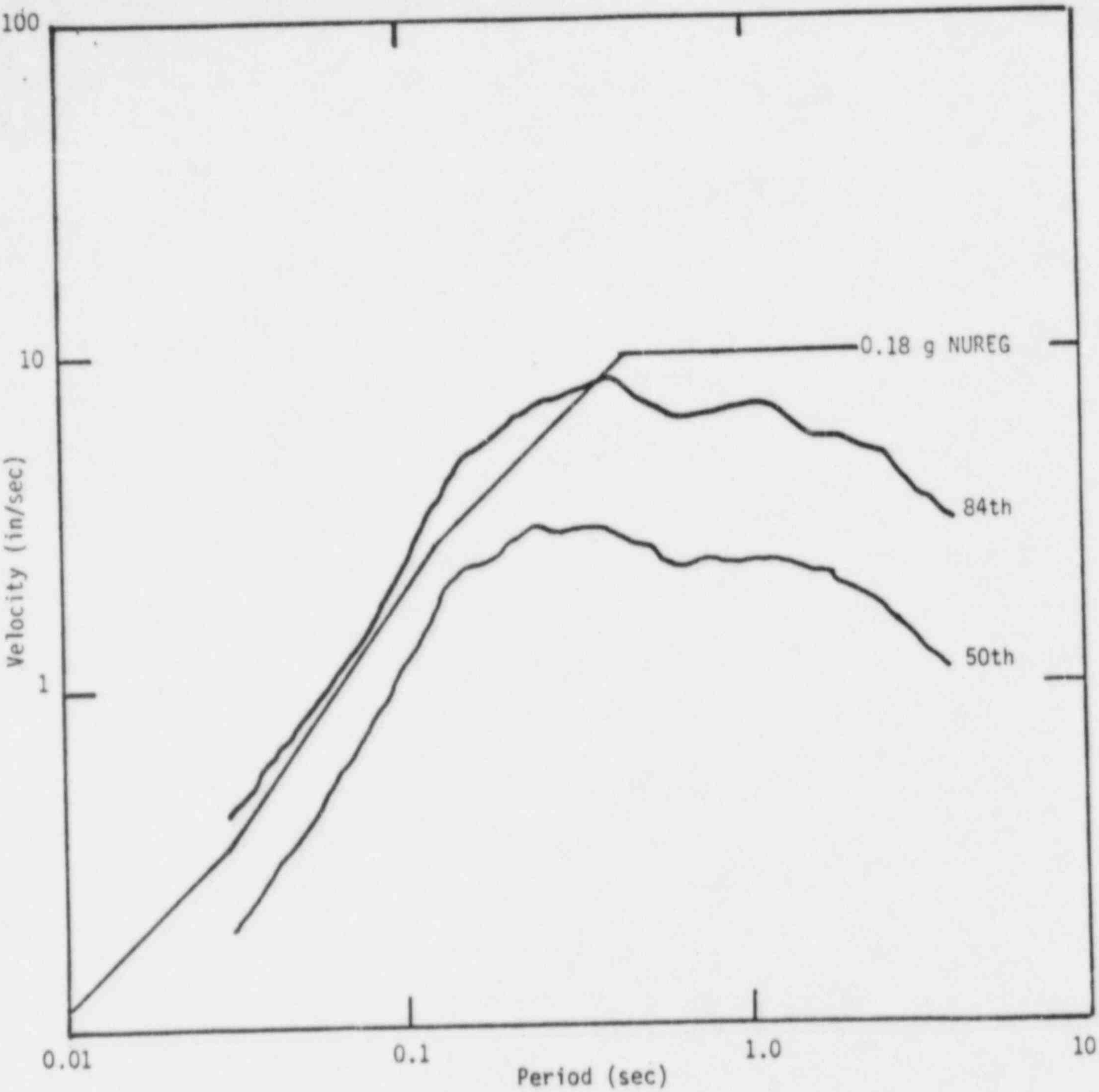

FIGURE 2. TVA magnitude 5.8 Sequoyah SSRS 50th and 84th percentiles, and 0.18g NUREG/CR-0098 50th percentile amplification factors spectrum.

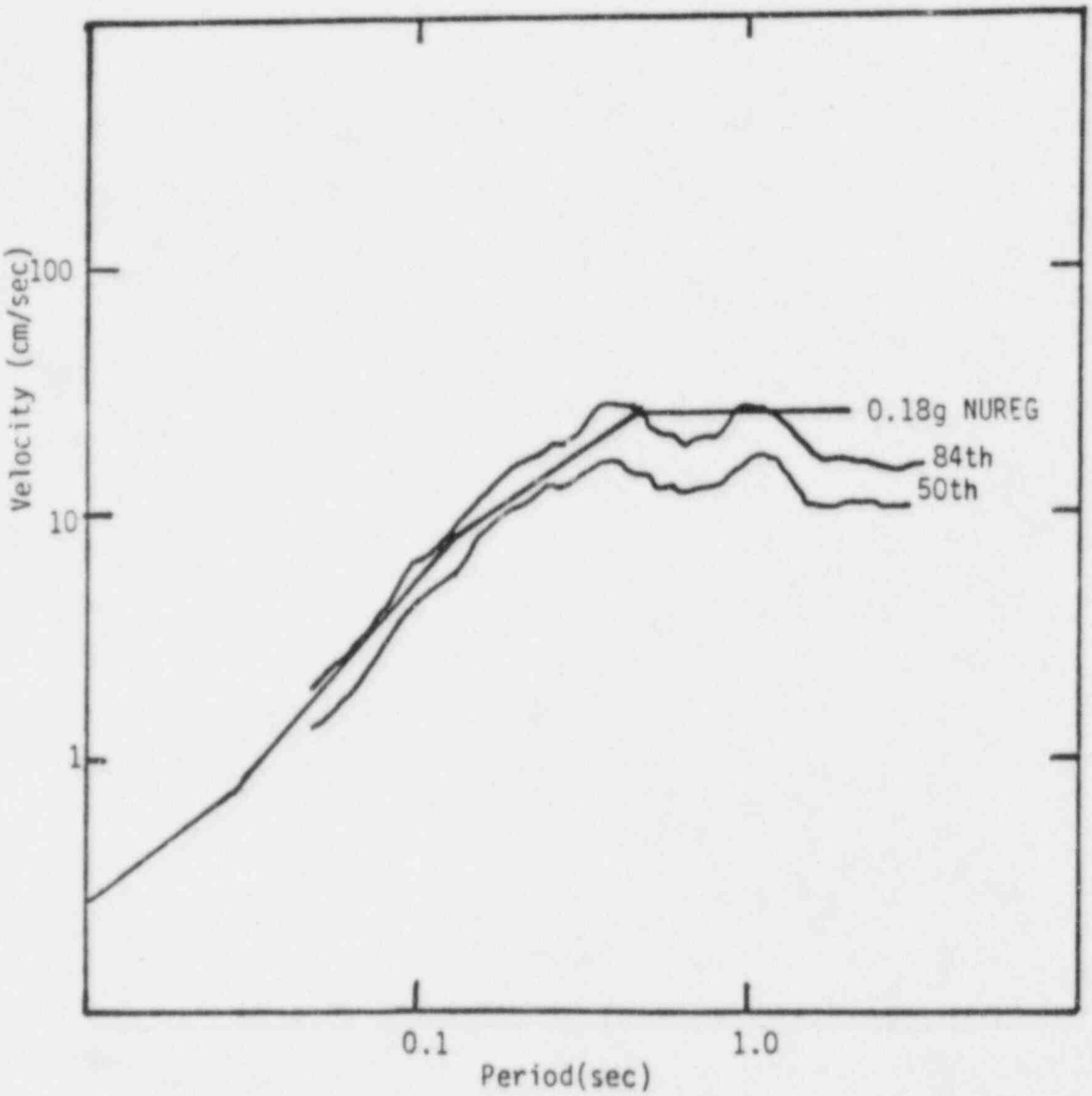

FIGURE 3. Weston Geophysical Corporation magnitude 5.8 Seabrook SSRS 50th and 84th percentiles, and 0.18g NUREG/CR-0098 50th percentile amplification factors spectrum.

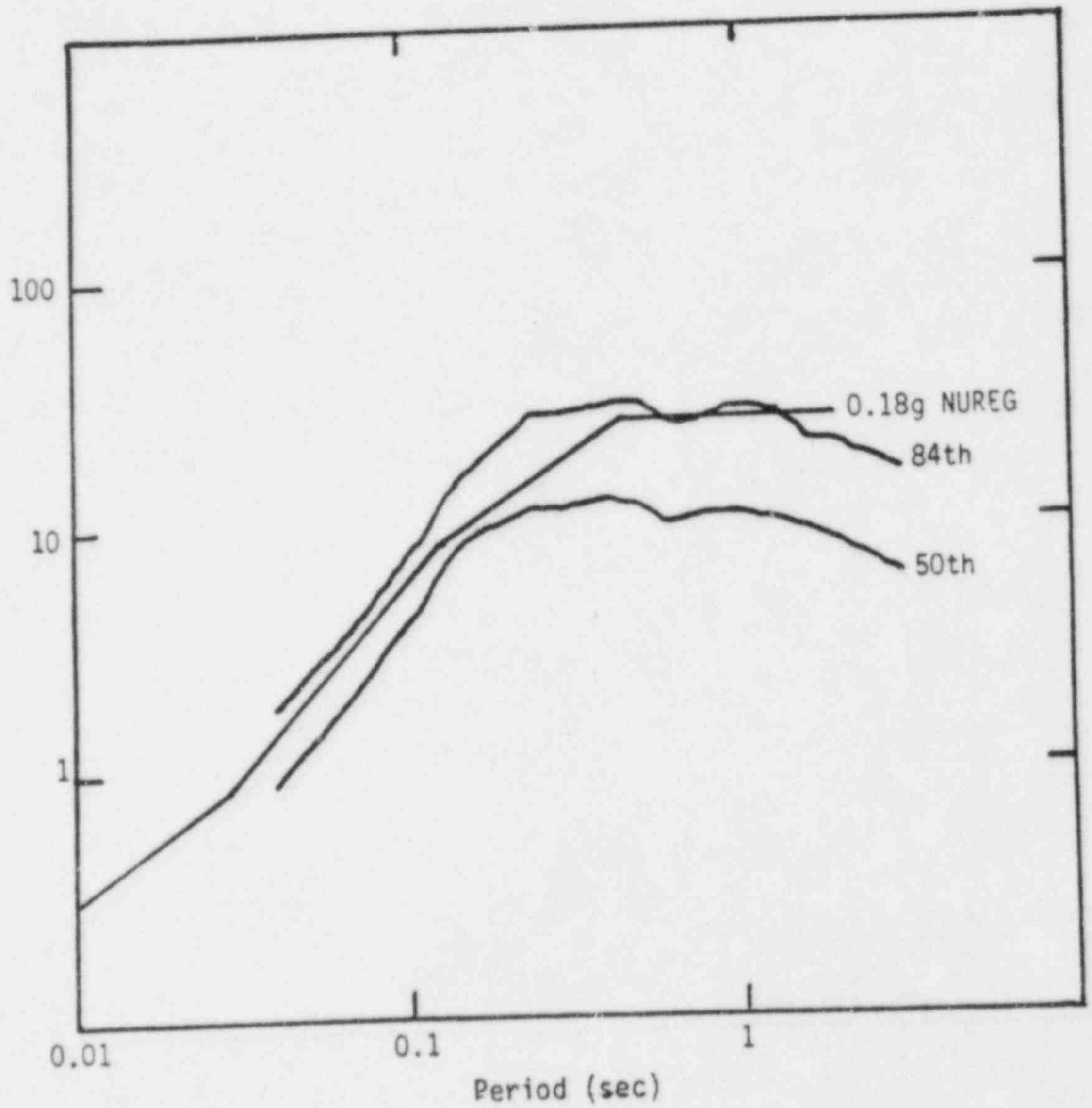

FIGURE 4. LLNL magnitude 6.0 Seabrook SSRS 50th and 84th percentiles, and 0.18g NUREG/CR-0098 50th percentile amplification factors spectrum.

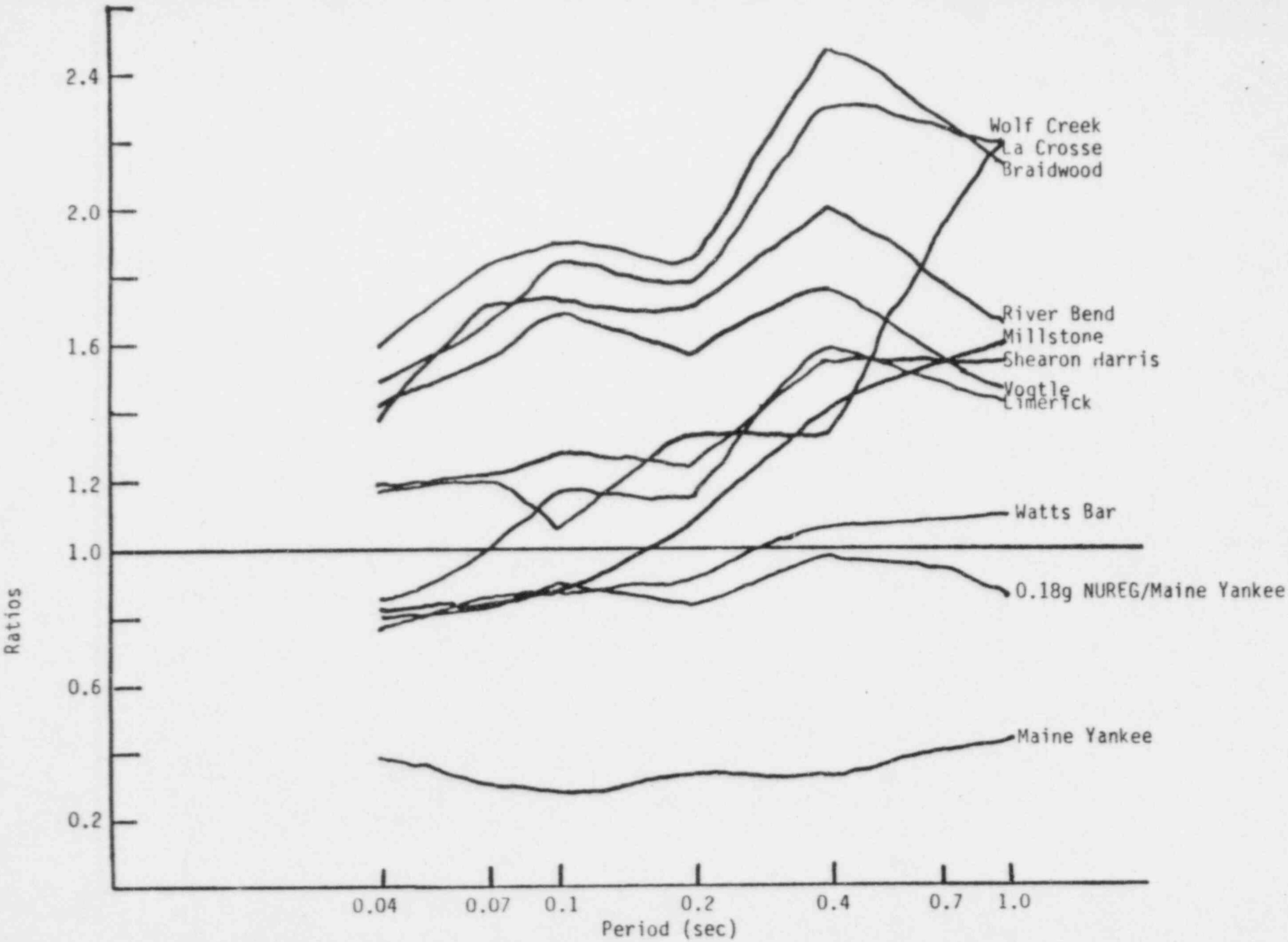

Figure 5. Ratios of design basis spectrum to LLNL(NUREG/CR-3756) 50th percentile 1000 year probabilistic spectrum for each of ten eastern U.S. sites and the ratio of 0.18g NUREG/CR-0098 50th percentile spectrum to the 50th percentile 1000 year spectrum for Maine Yankee.

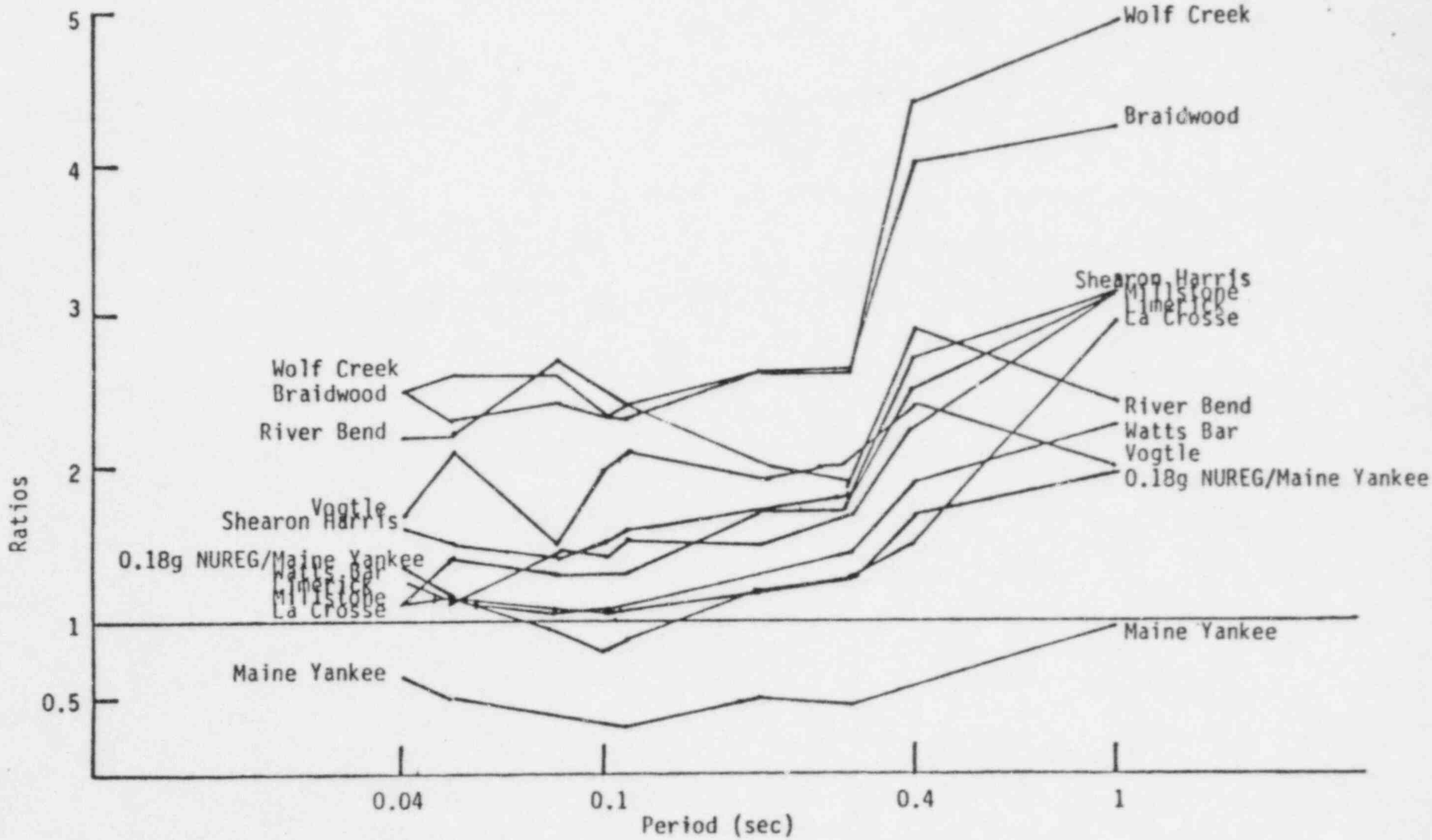

FIGURE 6. Ratios of design basis spectrum to the LLNL (latest draft) 50th percentile 1000 year probabilistic spectrum for each of the ten eastern U.S. sites and the ratio of 0.18g NUREG/CR-0098 50th percentile amplification factors spectrum to the LLNL (latest draft) 1000 year 50th percentile spectrum for Maine Yankee.

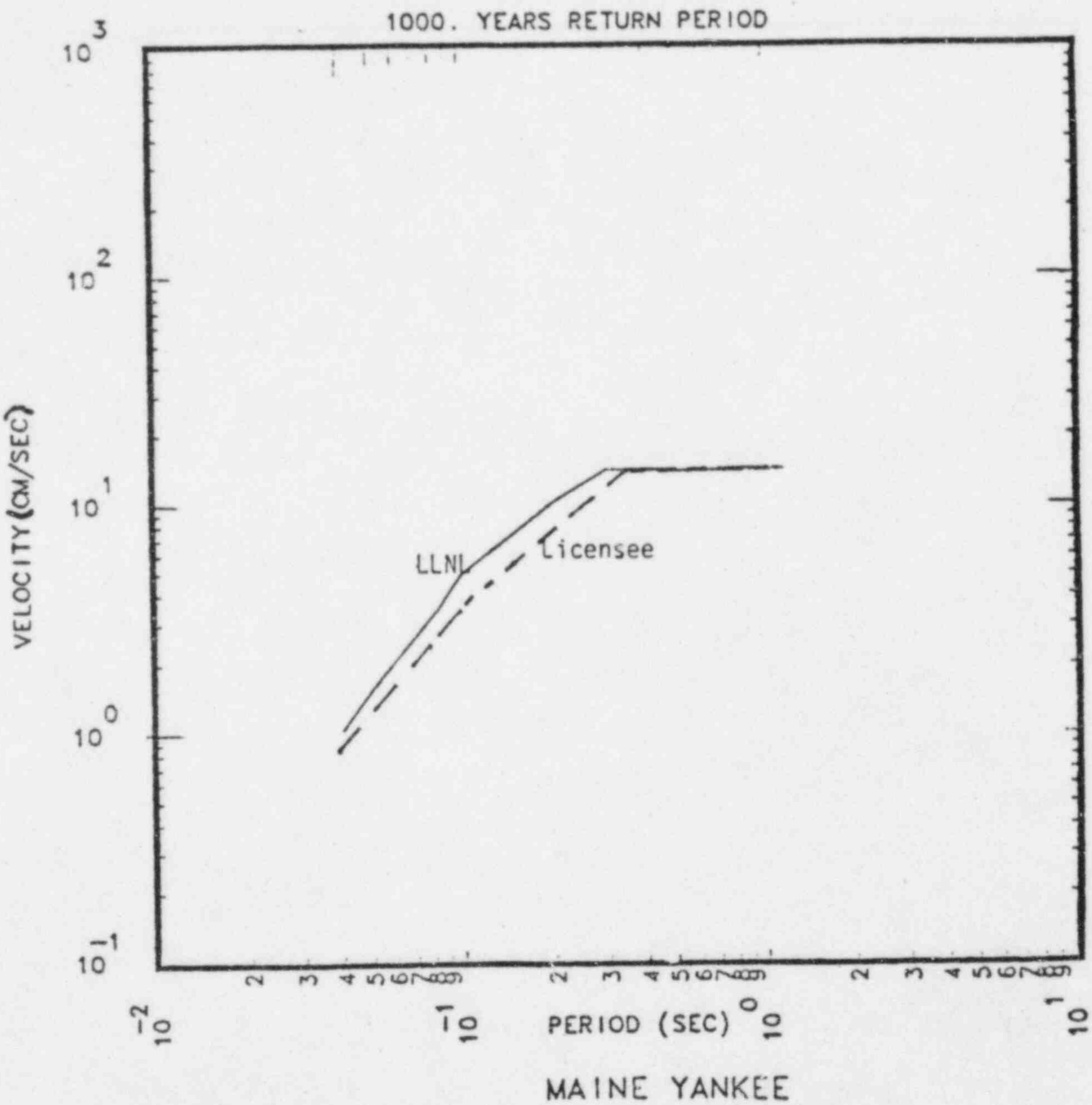

FIGURE 7. Licensee's 1000 year uniform hazard spectrum and LLNL 1000 year 50th percentile spectrum.

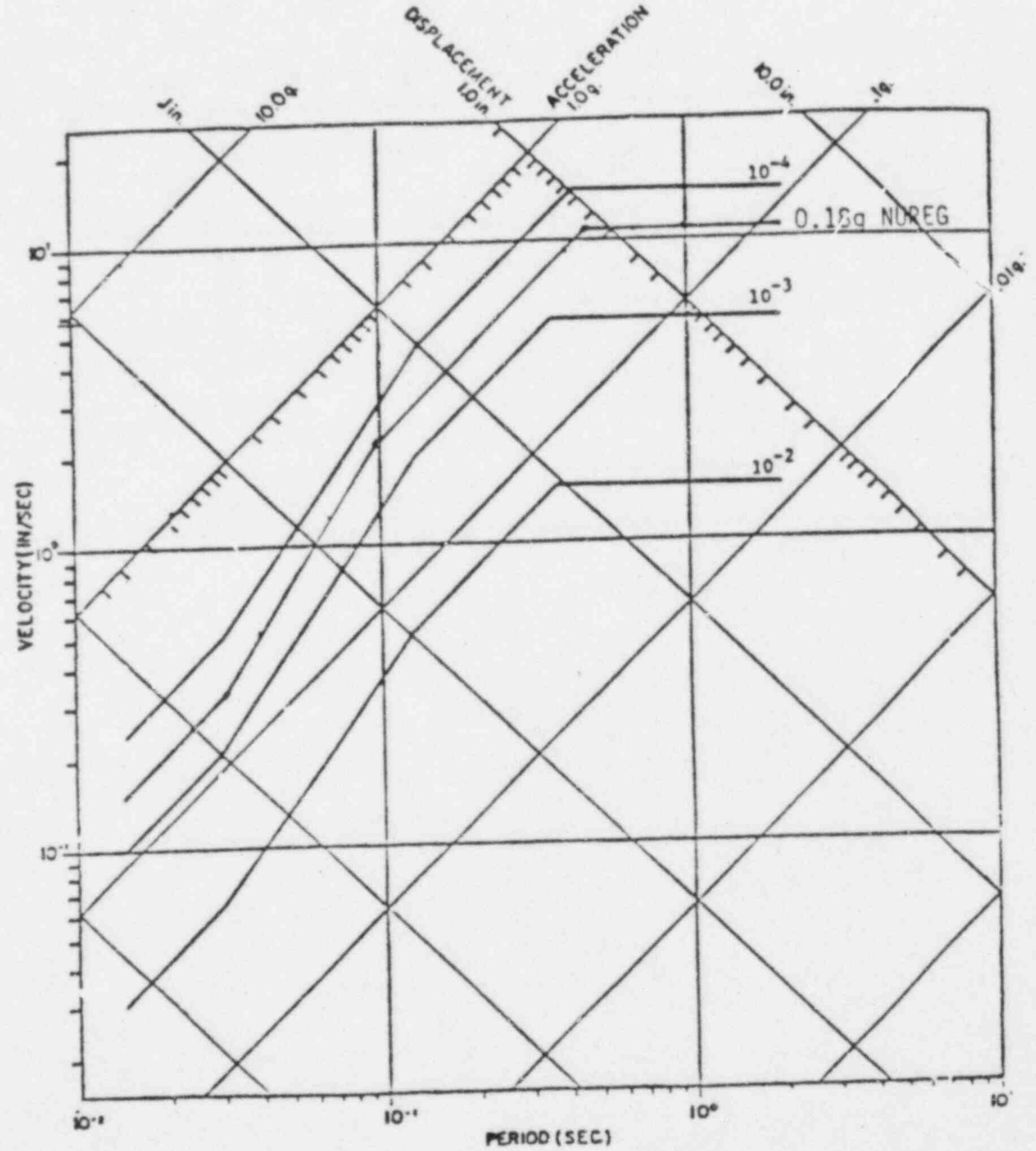

FIGURE 8. Licensee's uniform hazard spectra and 0.18g NUREG/CR-0098 50th percentile amplification factors spectrum.

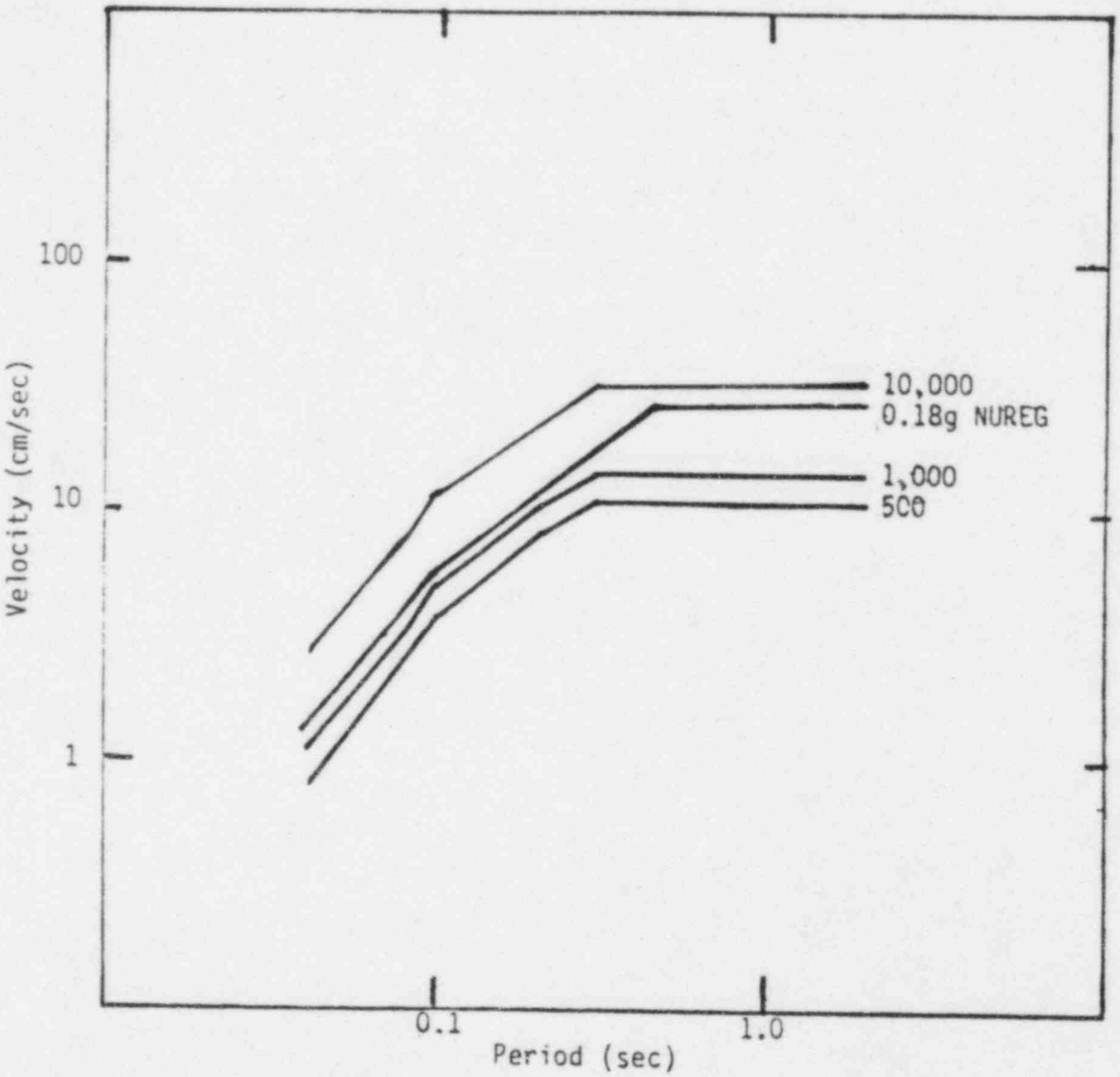

FIGURE 9. LLNL 50th percentile spectra for 500, 1,000 and 10,000 year return periods for Maine Yankee, and 0.18g NUREG/CR-0098 50th percentile amplification factors spectrum.