EVENING SESSION

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON EXTREME EXTERNAL PHENOMENA

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Nuclear Regulatory Commission
Room 1046
1717 H Street, N. W.
Washington, D. C.

Wednesday, June 4, 1980

The Committee met, pursuant to notice, at 8:30 a.m.

BEFORE:

DR. DAVID OKRENT, Presiding

DR. STEPHEN LAWROSKI

DR. DADE W. MOELLER

RICHARD P. SAVIO

HAROLD W. LEWIS

JESSE EBERSOLE

JEREMIAH J. RAY

W. LIPINSKI

ALSO PRESENT:

E. LUCO

J. MAXWELL

B. PAGE

DR. I. ZUDANS

G. THOMPSON

M. D. TRIFUNAC

R. MATTSON

D. ROSS

ZECH

(Slide)

Now, usually professional judgment is always incorporated in any analysis i a rather informal way. A bunch of people sit around a table and pick a stress drop or they look at epicenter maps, and they say, well, the future load has got to come from -- there are many complex issues. There is a way of incorporating expert opinion into the analysis.

This technology is called expert opinion solicitation, and it has quite a precedent on a number of relatively significant projects. For example, the USGS has for the last year funded internally a research project to assess the seismic hazard in the San Francisco Bay area and at cities around the New Madrid region, and that project formerly required expert opinion from geologists and seismologists.

Their opinions were synthesized and integrated into the hazard analysis. The USGS has also for a long time had an expert opinion based project assessing the oil and gas reserves of the United States, and they do this in a questionnaire sort of format.

They send out a questionnaire to each of their branch offices asking the geologists there to provide point estimates of what holdings they think are undiscovered in their region, and these things are synthesized again back in Denver, and basic policy decisions are made on that basis.

The Bureau of Reclamation instituted a study as part of the Auburn Dam Project, looking at the seismic hazards. That, too, was based on expert judgment or expert opinion. Finally, the Department of Energy has used experts in assessing the safety of underground depositories for high level nuclear waste with a design life of one million years, clearly something that requires substantial expert opinion.

All these projects have formally incorporated expert opinion.

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Now, I am not a social scientist; I am an engir ›r. So it was with a lot of thought that we began considering soliciting expert opinion for this project. Things that we considered were the complexity of the problem, the sparsity of the data, and the uncertainty.

It was on that basis that we decided -- it turned out to be a keystone of the project -- to solicit the expert opinion from two groups of people thus far. I will go through some of the details.

The first and most important group whose opinions we solicited were a group of ten seismologists. There is a variety of ways that one can solicit expert opinion or judgment, and which of these a person picks depends upon the schedule and the budget and various things like that.

A very straightforward approach is a questionnaire approach, if it is properly done, and this is what we elected for this project. We developed a questionnaire and we sent it out to ten well-known seismologists. I will review them and their credentials in a moment.

It was a carefully considered questionnaire, designed first of all to make it as simple as possible for them to answer it and to have scientific appeal to keep their attention during the question and answer process. We included in the questionnaire a question booklet. There were 50 questions we asked, and I will give you some examples in a moment.

We provided each of these individuals with a data base, and we acknowledged that it was one of many, and that if they had their own data, they should feel free to use it; that if they qualified ours, at least we presented it in a form that they could extract substantial information from very quickly.

It included quite a few maps, and I will give you examples of those in a moment. We gave them an answer booklet on which they submitted their answers, and the answer booklet provided them with numerous aids like probability paper and transparencies and things like that.

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Selecting the experts was carefully done. We spent quite a lot of time looking at all the candidates who were available, and I would say that we considered, either formally or informally, virtually every well-known seismologist in the eastern United States.

In the end, as a function of the person's availability more than anything else, we came down to selecting these ten experts. Their selection was in part driven by trying to find a cross-representation, so they come from various organizations, universities and industry. The original design was to include USGS, but they would not participate.

There are specific credentials. The names will be familiar to most of you. The one thing they all have in common is being well-published and well-recognized for various aspects of earthquakes in the eastern United States. Their background spans a spectrum from classical seismology and observational seismology to theoretical seismology; and to that extent we got a particularly diverse group.

Something that many of you will probably be asking right now -- and I will tell you I am going to be talking quite a bit about it -- is what we did with each of these answer booklets, and in particular, if we ranked these experts. I will tell you about that. But let me say that a key to the project was anonymity.

We have calculated results based on each of these experts' judgment, but the answers are indexed in a way that a person cannot go back and figure out which expert's opinion reflects which response sector. So anonymity was rather a key to the openness that we experi nced from the experts on this project.

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The questionnaire had five parts to it. The first part was on zonation, and I give you here an example of -- in fact, it turned out to be the first question in the questionnaire. We did everything we could to minimize introducing a bias, to eliminate introducing a bias into our question process. We tried not to preconceive anything.

So, for example, we did provide some maps, and I will show them to you in a moment. But we asked the experts to consider these maps, to weigh them, but to add other zones, to subtract our zones, to modify our zones in any way they felt was appropriate, and to indicate their degree of belief in each of the zones, both ours and theirs.

This introduced an interesting aspect to the problem. If a project attempts to do anything, it is to characterize and carry along all of the uncertainty of any seismic assessment. It attempted to do this quite honestly. The fact that we have asked each expert for his opinion as to the zonation of future earthquakes around, for example, New Madrid, and he comes back acknowleding our zones and adding some of his own, basically allows us to do an analysis with what you might call fuzzy boundaries. That is, we do not have to say that future earthquakes around New Madrid are going to be restricted to a very specific geometry on a probabilistic basis.

The analysis accounts for the likelihood that earthquakes could migrate up the Wabash Valley, or it equivalently accounts for the fact that future earthquakes might be tightly constrained to a very local structure like the New Madrid area.

So in that sense, I think this is one very good example of honestly dealing with the uncertainty. I think you will be interested in the way that this uncertainty manifested itself in the results.

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The answers we got back were rather startling to us at first in the way they honestly characterized the uncertainty in zonation. What I would like to show you here are some overlays of this zonation. What I show you here is a transparency that has been slightly modified, and that generated by Hadley and Devine. It is a USGS map of the United States. I do not know if you can see it well here, but there are various shades of zones.

There is a dark-bounded zone and a light-bounded zone. These represent a possible zonation for the eastern

United States, specifically designed to stimulate their thought process, not to encourage them to endorse it.

Every question we asked them that referenced this map, we reminded them of that. We provided them this and asked them to modify the map in ways they thought might be appropriate.

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So, for example, here is one expert's response. This happens to be Expert 3. He rather substantially modified our maps, as we expected. He filled in a couple of zones around Piedmont. He extended New Madrid. He looked at the northern boundary and modified it and modified Charleston quite a bit. Associated with this, he assigned a degree of belief to each of these zones, again giving us the ability to shade the zonation, not let it just be black and white inside a particular region or outside.

That is only one. That is Expert 3. If I add a few more experts to this map, you will begin to see a spider web develops of results that perhaps do not leave one too encouraged as to how this process might end, in that it is a very explicit indication of the uncertainty in zonation.

One expert, for example, has accepted the fact that all earthquakes in the eastern United States should be unconstrained, that they can migrate up and down the coast. That has been included in this analysis.

Other experts say that the Charleston area ought to be tightly constrained, and therefore both interpretations are presented on these maps and therefore will be carrying through the analysis. But certainly one would get the feeling, looking at this, that when uncertainty is formally included in an analysis, the results will be unacceptable, too high or something.

It was very interesting what happened.

DR. TRIFUNAC: I think it is a little bit off.

DR. OKRENT: Otherwise, somebody moved the Charleston earthquake. It didn't include Charleston any more.

(Laughter.)

MR. WIGHT: I believe that was the zone the expert provided. In many cases you will see where a person has, based on some other evidence, come up with different zones.

DR. SIESS: Is it 16 you are talking about?

MR. WIGHT: I think it is 24.

(Slide)

DR. SIESS: Does there seem to be agreement in the open spaces? I don't see anybody putting a circle around Chicago.

MR. WIGHT: Not on this map, but I tell you what: I will get your attention even more and add a few more of these.

(Slide)

There is one more, but it is not too important. You can see, with regard to your question, the central United States, a variety of alternatives have been presented for, in some cases conventional, and in other cases not widely accepted. Michigan is a zone that has been specified by one or two experts and not by any of the others. I think various experts accounted for it explicitly in including it or not including it.

There were earthquakes that occurred up there during 1906 related to mining activity where you see no zones. The questioning and the answers we got explicitly accounted for the fact that there should be a background zone of seismicity. There are regions of diffuse, perhaps low-level seismicity which one cannot treat with precision that one can treat Charleston or New Madrid or the Cape Ann regions.

So there were earthquakes accommodated by the experts and included in our analysis where you do not see regions specified by them. Now, when I used the term "fuzzy boundaries" earlier, I was not trying to make a pun; but you can certainly see that for some of the well-known regions there are fuzzy boundaries as specified by these experts.

We used this information in two ways. We used it to form the analysis. We treated it in two ways. First of all, we accounted for the fact that the experts' degree of belief in the various zones allowed for the fact that earthquakes could occur outside the region specified by them. Therefore, for completeness and as part of a trial run of this, we specified for each source region a background zone.

There was an overall regional background zone that I referred to earlier, but for each source region, there is a source region base background zone that represented the envelope of all the experts' specifications. The earthquakes that were allowed to occur out in that zonal background region were determined by the degree of belief each expert had in his zones and ours.

Of course, earthquakes were considered to be constant in, for example, the New Madrid region; that basically we were talking about how earthquakes were allowed to migrate.

DR. SIESS: I missed a point earlier. Were those zones that you had and they put on different intensity zones, or was that part of it?

MR. WIGHT: That was part of it. They were not different intensity zones. They were zones in which the experts felt future seismicity would be uniform without at this point specifying the level of uniformity.

DR. SIESS: But in some way related to past seismicity, presumably.

MR. WIGHT: Possibly, but not necessarily. We explicitly asked the experts, and I called it out in an earlier Vu-graph, to include all indirect information they felt was appropriate in that assessment which might be seismic gap related or geophysically related, such as the arch structure under the central United States.

In a moment I will talk about the seismicity models appropriate for each of these regions.

(Slide)

The next part of the questionnaire asked the experts to deal with a maximum possible earthquake they feel could occur in each of the regions, both their region, the one we specified and we provided to them -- we certainly did not specify -- and their region, the one that they answered back to us with.

Second, we did everything possible to minimize potential biases in our solicitation. So, for example, we gave every expert the option to provide answers in the sized scale he felt comfortable with, whether it was modified intensity, local magnitude or whatever.

As it turned out, all experts responded in terms of bodyweight magnitude or modified Mercale intensity. It was split 50-50. There were five each way.

Here is an explicit call, an appeal to the fact that since we are trying to assess future seismicity, we want the experts to appeal to all appropriate information.

Now, there is an entire technology dedicated to solicitation of expert opinion, and we capitalized on this to the extent possible. One of the basic ground rules of any solicitation technique is to try to ask questions redundantly to check the experts. That can accomplish two things. It can provide an absolute check that one might use in a ranking scheme. We did not do that.

It can also keep the expert thinking. When he realizes, perhaps, that he is being asked the same question two different ways, he will be a little more careful in his answering process. It might reveal a dimension of the question that he had not thought of before.

For example, one question that we asked the experts was a very indirect redundant question: which of the two time periods, 150 and 1000 years -- within the next ten years, the largest that occurs in the zone -- now would you change your answer from the previous question? It is a very, very simple way to look at the answer to that and assess it.

It turned out fifty questions are quite a few, and the experts only had about three days to answer these questions. So that I am not sure that they actually had the time or the interest to go back over these questions.

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(Slide.)

Seismicity models, this turns to the question that we had earlier as to the level of activity appropriate to each of these source regions. This was the third part of the questionnaire.

We asked the experts to evaluate the quality and completeness of the recorded earthquake data base to represent future activity in each of those regions. By completeness, I mean, of course the fact that large earthquakes of, say, intensity IX, X, XI, or XII, are presumably complete over a long period of time, probably 2, 3, or 400 years.

Whereas, intensity V, VI, VII earthquakes are complete due to population bias or not being experienced or are complete over a much shorter period of time.

We ask questions here, and in all other parts of the questionnaire at many different levels. One level question was always a model level.

For example, it is conventionally held that earthquakes -- that the distributions -- size distribution of earthquakes in a given source region, or even on a fault should be logarithmically linear. We wanted to make sure that we were not just assuming somehting for the experts.

So, we asked that question. Do you believe that is the case? In fact, they all said, yes, with some caveats occasionally. They all agreed with that model assumption.

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DR. OKRENT: Excuse me. We hava about 19 minutes, including questions.

MR. WIGHT: Thank you. Good. There are other questions, again designed to check the consistency of the answers.

(Slide.)

The fourth part of the questionnaire dealt with attenuation models, or ground motion models. We included this for completeness. As it turns out, the ten experts did not themselves feel equally qualified to address this part of the questionnaire. This resulted in organization of a separate group of poeple.

We had the same theme. This part of the questionnaire, as in earlier parts, asking the model base questions, asking very important questions for us using analysis, trying to define consistency.

(Slide.)

Here, I refer in this vu-graph to an August 1979 model and results that we developed. We developed these ourselves based on incomplete answers on experts on attenuation, based on that we organized a separate group of people, separate panel of people to review earthquake ground motion models for the eastern United States.

Dr. Trifunac was on that panel, as were several other people. Dr. Nuttli from St. Louis, and several others. Let me say a few words about the ground motion model that we are currently

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using.

The project was not complete. We have yet to inplement some of the implications of our attenuation panel, but certain of the recommendations are embodied in what I will talk about right now.

(Slide.)

It is a very difficult question to answer how one should go about constructing a ground motion model for the eastern United States. It was apparent to virtually everybody that in some way that model should be built on a large intensity data base that we have from the eastern United States, in fact, the model that we developed explicitly. developed explicitly

So, I show you here -- these are normalized to the epicentral intensity attenuation models. Three of these derive from actual earthquakes. One of which was derived rather theoretically by Professor Nuttli.

There are other earthquake attenuation models available. I'm not presenting them here. In all cases, and in particular, the ones I have not presented here, there is question as to the effect of lower intensity values driving the result over influencing the model at other distances.

These three are derived from actual earthquakes. The Charleston, with a large intensity X very carefully analyzed. These two others were smaller earthquakes, intensity VII or VII-VIII.

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This one right here is a separate model developed, in part, using impirical data, but also theoretical consideration by Otto Nuttli.

What we have done is we have used this intensity attentuation model along with a ground motion model derived from the western United States stong ground motion data relating site intensity to spectral coordinates.

When we combine these things, we end up with a spectral coordinate attenuation relationship, a true ground motion attenuation model.

(Slide.)

I would like to very briefly compare that resulting model with a very very limited strong ground motion data that is available from the central United States. There have been three earthquakes, two prime shocks and an after shock, that triggered strong ground motion instrumentation in the New Madrid region.

They were 4.5 and a 5 recorded at various distances. The data is shown here. What I also show here is our theoretically impirically based model from $M_b =4$ and $M_b =5$. I think you can see that the results are consistent.

We no way claim good agreement, but it is as good as any modelling I have seen using strong ground motion data. We have another level comparison. Some of the recordings our here were digitized by Bob Hermann at St. Louis University.

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Response factors were calculated. I would like to compare our predicted response spectrum with those actual recordings in this vu-graph. They were recorded at New Madrid and at Tiptonville at about 130 kilometers.

This was from and M_b =5 event. What I show in the solid line here is our model response factor. Again, the agreement is acceptable.

(Slide.)

What I have been talking about in the last few vu-graphs is, you might say, the fiftieth percentile, or the median ground motion attenuation model. As this vu-graph indicates, they are clearly scattered about those median estimators that should be accounted for in any honest probabilistic analysis.

We have accounted for that. We carried a value of acceleration dispersion through the analysis. I would just like to say a few words about that particular issue.

As it turns out, acceleration dispersion is the most important parameter in this seismic hazard analysis. It is more influential than any other parameter in the analysis, or more influential than the spider webs or the maximum earthquake or the seismicity models.

So, it is rather a keystone issue. Just a few quick words about it. If one calculates, assuming a log normal distribution, and even that assumption can be qeustioned, but if

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the assumption is incorrect, it is not incorrect by a gross amount. If one calculates distribution properties of a log normal distribution of acceleration from a single earthquake, and we now have three or four that we can do this for, you find that the natural logarithm acceleration has a value of about .35.

If you take all the data from the western United States, combine it all, and do a progressional analysis and infer a distribution, that distribution will have a much larger log normal character, about .65.

DR. TRIVUNAC: How do you get .65?

MR. WIGHT: The calculated data base. It is derived from a data base that is itself restrictive, for sure. It is a Cal Tech data base that represents magnitudes, 4.5 to about 6.5 over a distance ranged from about 30 kilometers to 150 to 200.

DR. TRIVUNAC: I still don't understand what corresponds to this .35. That is what I am asking.

MR. WIGHT: Yes, the .35 would be derived from the 1975 Imperial Valley, or the San Fernando; a single earthquake, its distribution of acceleration.

DR. TRIVUNAC: It is too large.

MR. WIGHT: It is a natural log scale. This is .65 That is the issue, sorry. Now, time is running out on me. I have quite a few more slides. There is one important point here that this is derived from the western United States data.

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We use data like this with intensity attenuation to derive an eastern model. Now, there is large uncertainty in how intensity attenuates from eastern United States. If one formally combines the errors in that intensity attenuation model with the errors in this ground motion model, one formally does that assuming that the components are independent.

You come out with a natural logarithmic value of about .9. This has been done by many people, including most recently, Alan Cornell. So, there is the issue. There is the range of values that dispersion could take.

(Slide.)

Considerations one might apply in picking a given value -- and we have sensitivity on the value we prefer -- but considerations would be first of all reasonable agreement with ground motion model, the median estimator with the available data in the central United States.

Actually, very good agreement with a separate model, but I have not talked about it. I don't have a vu-graph on it. That is derived by Otto Nuttli, a theoretically based acceleration attenuation model.

Finally, a judgmental account name for the fact that the load at a given site, say Dresden, is -- results from earthquakes of a rather narrow range of magnitude, and a very specific fault type, or focal mechanism with a rather narrow travel path variation.

Whereas, the entire data base covers, let's say, all magnitude earthquakes and all travel paths at a given site specific application. The range of those variables should tighten.

We account for that. In fact, our preferred value for the log normal dispersion for the eastern United States is about .6.

I will show you some of those. I will show you the sensitivity of the result about that value.

(Slide.)

What did we do with the answers from the questionnaire and these attenuation models? Well, we took each expert, each expert provided us his zones. He acknowledged our zones in varying degrees. He provided us with seismicity models, maximum earthquakes.

We coupled that information with our ground motion model and we calculated the resulting exposure at each site for each expert.

What I show here -- it is a reduced version. You will see more later -- is the response -- a sweep of response spectra did result from that analysis. In this case, there are all ten of them represented here. One for each expert.

There are a couple of interesting things that I would like to call your attention to, but the most important one is the acceleration along this access.

(Indicating.)

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If you look at your handouts, you will see that the spread from MIN to MAX among the experts is about a factor of two.

Certainly in the high frequency, a little bit more in the long period. That is about the range of values that the actual strong motion data in the western United States suggesting that if we applied this technique to the western United States, we would be as good as the data.

I would not be so quick as to imply that, but it is a point.

DR. OKRENT: I'm sorry. What is the significance of the factor of two on high frequency?

MR. WIGHT: Well, the range of actual strong motion values availabe from the western United States sits within about a factor of two.

DR. OKRENT: What were the constraints that went into this calcuation? Was each expert talking about a certain magnitude earthquake, or a certain intensity earthquake, or a certain return frequency earthquake, or just what?

MR. WIGHT: This is a 10^{-3}.

DR. OKRENT: 10^{-3}, thank you. They agreed within a factor of two?

MR. WIGHT: A factor of two.

DR. OKRENT: Your experts are different than my experts.

(Laughter.)

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MR. WIGHT: But that is the case. But to specifically --

DR. OKRENT: We don't get that agreement in this room after they have talked for hours, the staff and the applicant.

(Laughter.)

Go ahead.

MR. WIGHT: That is basically it. It is a whole process -- it is the whole process. It is very very involved treating each expert individually. We are doing analysis on 14 spectral events, such that we can predict this response spectra, but the other thing I call your attention to that is related to the factor of two is if you remember the diversity of opinion on zonation, you might have expected to see a much wider of variation and predicted response factor.

This, I think, turned out to be for us the most interesting and important conclusion from the study, that that expert opinion was diverse, but it tended to self-cancel.

The opinion was, of course, of three or four components. If an expert, for example, left the Charleston earthquake run up and down the east coast; he tried to do something else which happened to be an earthquake occurrence model that competed against that Charleston migration, or maybe the size of that Charleston earthquake in the future, or something like that.

So, they tended to self-cancel.

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That resulted in ten spectra for each site. Now, what do we do with that? Well, we could -- we could put a distribution on it.

We played around with that and looked for the fiftieth percentile of it. There are a number of things that we could do, a mode or a median.

In fact, it was at this point that we included the self-ranking results. We asked each expert to rank himself in some detail. It may have been the hardest question we asked. We asked him to rank himself in virtually every question that he answered.

What we did is that when we performed the seismic hazard analysis, we could see where the load was coming from for the 10^{-3} spectra.

For example, we could see what earthquakes from which regions dominated the results. What we had the opportunity to do then, what we in fact did was to go back and see how each expert felt about himself for that region or for those regions.

It turned out this is frequency dependent. The high frequency spectral ordinants come from rather nearby earthquakes. The long term come from distant events.

So, an expert self-ranked for a different spectrum will change as a function of frequency when we got into it, and how he ranked each question.

DR. OKRENT: Do you have a spread among the experts mm12

for their one in 10,000 or the one in a million year earthquakes?

MR. WIGHT: We would never do a million.

DR. OKRENT: THe largest.

MR. WIGHT: You mean earthquake size or spectra?

DR. OKRENT: You said there was a factor of two on acceleration among your experts for the one in 1000 year earthqu .

MR. WIGHT: Yes.

DR. OKRENT: What was the spread for the one in 10,000 or one in 100,000 or one in a million year earthquake? Do you have that?

MR. WIGHT: To answer your question, we had thus far in our preliminary results reported spectra. This synthesis I am going to talk about right here is fairly involved. So, we could not do it at 100, 120, 150 years and so on.

So, we only did three return periods, 200, 1000, and 4000 years. We have other results available from which we can infer. So, my answer is restricted to those three return periods. Going from 1000 to 4000 years. The spread did increase. I do not recall just how much.

It was not overly dramatic, if my recollection is correct.

DR. OKRENT: I think part of the problem is the limited range of your return frequency. I think if you had gone to what could happen at a frequency less than one in 10,000, people start developing rather different opinions.

DR. TRIFUNAC: It depends on distribution.

DR. OKRENT: Exactly.

MR. WIGHT: And their perception.

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DR. TRIVUNAC: No, no, no. But nobody knows that anyway. So --

MR. WIGHT: That is true. We have considered the character of this distribution. It has been the topic of some debate, in fact. It does drive the results more than anything else. It is something that Otto Nuttli can think about, but neither he nor any of the other experts are qualified to address.

I know that the data base is expanding rapidly enough from these recent events that it is possible that we will be able to make more refined statements, but there is always going to be a limit.

I certainly acknowledge that. I would say right now our limit in return period is a gradation. I think the tails of the distribution begin, in my opinion, to unduly influence the results over return periods of about 4000 years.

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Let me say a word about synthesis.

I did not clock myself, but --

DR. OKRENT: you have used about an hour. I think at this point if you have some principle results to report, you should in the next couple of minutes.

MR. WIGHT: Okay, fine.

Just to wrap up the methodology very quickly, we actually performed a synthesis using the self-ranking results that I described earlier, and as it turns out, the synthesis comes very close to sort of a mode of the distribution of spectral ordinants.

So it is a rather formal and elegant way to do what, it turns out, might have been done for this case at least more directly, more simply.

But it is a formal accounting of the experts' self worth in particular areas.

(Slide)

I have a variety of results, and they are contained in the handout. You can overlay them yourself and see the sensitivty of the various parameters. As I said before, the zonation, the maximum magnitude event, the relative frequency of different size events in a source region were not particularly significant parameters. The ground motion model turned out to be the most significant, and within that model, our value of dispersion, the distribution of spectral evidence turned out to be far and away the most important.

I would like to just show you -- let me just show you without -- let me show you, for example, as I said, we believe that a natural logarithm value that is appropriate for analysis is about .6. One can theoretically justify something as high as .9 and just leaving everything else the same.

And looking at the results, whether it is .6 or .9, both are within the range of acceptability. You can produce factors of two or more difference in acceleration at 10^{-3} and if you go up in the return period, that difference increases very, very rapidly.

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I would say in summary then that the most significant finding of this project are, first, that the attenuation model, as I said several times, is very, very important, more important than we realized ourselves, that the range of expert derived results in the eastern United States for this project thus far -- and it is still in progress -- is not much greater than was predicted for a range of values for the western United States.

And finally, the diversity of expert judgments tends to self-cancel.

That will do it.

Any questions?

VOICE: What do you mean by self-cancel as opposed to cancel?

MR. WIGHT: They tend to compete against each other. In other words, if I could use the word "conservative" just for illustration, if relative to the other experts an expert is conservative in the way he answered one part of the questionnaire, he will be in a relative sense non-conservative in the way he answered other parts of the question.

DR. OKRENT: Dr. Luco?

DR. LUCO: Have you compared the shape of the spectra you obtained with the spectra obtained by the deterministic or empirical approach?

MR. WIGHT: That has been done. Most of that work has been done by Lawrence Livermore, and I think it will be addressed by Leon Reiter.

DR. LUCO: The thrust of my question is the following: by using this probabilistic technique, you attain an aggregate spectra. It does not correspond to a physical earthquake.

MR. WIGHT: Absolutely true. That is an important point.

DR. LUCO: In the process of calculations later on, one would have to use time history that will match the spectra, and that time history will not have a physical meaning.

MR. WIGHT: This is a very important point, one that I tried to develop early on; that the probabilistic results are a certain perspective of the hazard. The 10^{-3} spectral ordinants come from at least two classes of earthquakes; the high frequency

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come from relatively nearby earthquake, whereas the long term spectral ordinants come from long distance earthquakes.

The implication might be, if used for design, that chose earthquakes have occurred simultaneously.

DR. LUCO: So the problem is that if these spectra are significantly different from observed spectra, then one would have to take a probabilistic approach all the way to be consistent and not to use response spectra at all, but go into core spectra dn do the whole analysis, including the structure that way, not in the time domain, without some considerations -- spearate considerations.

MR. WIGHT: I agree with you completely.

DR. LUCO: One could do that only if the analysis is linear.

MR. LEVIN: Dr. Luco, one of the things we are looking at and Larry mentioned it, one of the advantages of this approach is to look at the contribution from different source zones. So you could cull out the Dresden site, the contribution coming from New Madrid versus the more immediate area around the site.

And what we would like to do is look at maybe the conservatism associated with that, let's say, uniform hazard spectra, run structural analyses for earthquakes which should, let's say, be more typical from a distant source zone or an earthquake which may be more local.

So it is something we are pursuing.

DR. OKRENT: Thank you.

Maybe we should take a seven minute break since it has been a couple of hours.

(Recess)

DR. OKRENT: The meeting wilo reconvene and we will begin as soon as the next speaker is ready.

DR. REITER: My name is Leon Reiter. I am a geologist with the Seismology Branch of NRC, and what I would like to talk about now is I will show you our initial attempts to utilize the study just discussed, which is not only part of task action plan A-40, but we are interestedin attempting to utilize it with respect to the systematic evaluation program.

(Slide)

This is a hard slide to see, but this is a map of the eastern United States, and the red dots represent the nine sites in the eastern United States which were looked at in the systematic evaluation program.

The contours represent contours of seismicity, numbers of earthquakes, and this is a map which was part of a series produced by Hadley and Devine.

Again, these represent controus of a certain number of earthquakes per unit and varies with unit of time. So these are areas of higher numbers of earthquakes.

These are the sites across: Dresden 1 and 2; Palisades, Big Rock Point, Yankee Row, Millstone, and Oyster Creek.

MR. MAXWELL: What was the lowest intensity on there, do you remember?

DR. REITER: It is very small print; I cannot tell you. I really cannot tell you.

Our initial recommendation that we proposed for use in the scientific spectra program are as follows.

(Slide)

That we use the so-called 1000 year synthesis; two, that we use a model based on attentuation from the Ossippee earthquake for the northeastern sites; and that we use a model based on the Gupta-Nuttli attenuation for the United States sites.

As you see, there are some problems we are still working on which may affect this. But these are our recommendations as of now.

We also feel that there should be a minimum flaw for all spectra, and this flaw is a median representation of a nearby magnitude 5.3 earthquake, as determined from western data and the so-called 1000 year spectra fall below the minimum at three sites. That is at Palisades, LaCrosse and Big Rock Point.

And finally we have not specific site amplification conditions. They have not been fully assessed at three sites: LaCrosse, Yankee Rowe, and Palisades.

DR. OKRENT: Are you going to tell us why you think those are suitable to use?

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DR. REITER: Yes, I will go into this, and I will compare how these results compare with other methods that perhaps people are more familiar with, and in fact that was one of the ways we chose them.

To give you an idea of the kind of document we reviewed, we had an initial three volumes from TERA-Livermore. Then we had peer review comments that were submitted in the fall and the winter.

There was a licensee review, comments from Blume, Fugro, and Commonwealth Edison, Holt, and Allen Cornell. The applied statistics branch in NRC also reviewed it.

TERA responded to that review with a document, and as a result of that, TERA conducted a series of sensitivity results which came out in March -- May 1980.

Specific problems were identified in terms of attenuation;an attenuation panel was convened, and TERA evaluated that panel.

(Slide)

At the time this slide was made we had not yet received reviews and comments by Newmark and Hall. We had just received a draft copy of that. Perhaps you might read a few comments from that if you are interested; a draft seismic review analysis by the USGS.

We got an indication that they had completed their review. We have been informed very generally on the telephone that we expect to get this shortly.

We expect to review all the submittals that the licensees have submitted; we have reviewed some of them. THere are still others which we have to look at.

TERA-Livermore will compare the results with other hazard analysis for similar sites to see how their analysis compared to other sites.

We are going to get -- and I think ..e just received -- an LLL report on attenuation recommendations. There is projected a meeting in June of the original expert group to get feedback to sort of see how they react to the initial assumptions or they might want to change some of the assumptions or have a look at the results.

And finally, we are going to get some recommendations as to whether, on the basis of all the proceedings, we should do the re-analysis on those results.

So we expect to see some of these partially done. Most of these have not tet been received.

(Slide)

So the review I am presenting is based essentially on the materials shown in these previous slides and is not yet included in the material just shown now.

As a result of presentations, and our own general review, and review by the various panels, several problems have been identified, and we have suggested several ways -- the staff has suggested several ways of resolving the problem. One, as was indicated, the problem of ground motion attenuation determination -- and I think as it was pointed out, the original group of experts really, except for several, did not answer that question. And the way -- the resolution of this problem was to convene a separate attenuation panel and to try and fill out and get their input and get their feelings on some of the problems that were raised.

As a result, we believe that the way to proceed at this point would be to use the Ossippee and Gupta-Nuttli models for the northeastern and the central United States.

Again, we are at the present time clarifying some issues about the way the regression was done in the Ossippee model.

DR. TRIFUNAC: Can I ask a question now or later?

DR. REITER: Whenever you want.

DR. TRIFUNAC: Ossippee and the Gupta-Nuttli model are specific models. I mean, they are specific regression models. Why do you prefer that versus using it as it is directly? For example, Anderson is doing that.

Here, there is no assumption whatsoever; what is the advantage of being so specific?

DR. REITER: I am not quite sure what you mean.

DR. TRIFUNAC: Anderson has a paper in the Bulletin where he shows how to do the same thing, not putting specifically the

dsp10

attenuation, but using all the available data, distribution of that data.

So there is assumption there; it is just all the data used simultaneously.

DR. REITER: I cannot answer that. We find when we look at these things that there are always lots of assumptions built in. TERA-Livermore looked at several models, regional models of attenuation -- of intensity.

DR. TRIFUNAC: THis is why I am asking the questions: how good is this model? It does use assumptions and the other thing I mentioned does not use assumptions.

DR. REITER: I find that hard to believe, that there are no assumptions.

But let's continue.

DR. TRIFUNAC: Okay.

DR. REITER: Zonation here -- the problem here is it was difficult to reflect the experts' confidence in source zone earthquake occurrence. A problem arose. You have many, many different configurations. People have different kinds of confidence in the accounting method of how you deal with this. And the one suggested technique that TERA did intially was to assume what is called a background zone, which was the union or the envelope of all the zones of everything in a particular area; they took everybody's zones for New Madrid, and we drew an envelope around it and called it a background.

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And after you distributed all the possibilities assigned by a particular exp- -t -- accounting for the earthquake, there is alway- something l-ft over.

And + original idea was to use that background and envelope as a source for those earthquakes. It was pointed out in some of the reviews that this in some ways is trying to get the various experts, and assuming that one expert's opinion is going to be tied to the next expert's opinion.

It violated the idea of independence between experts. As a result of this, TERA-Livermore created another model which assumed absolutely no background. It represents the other extreme and their resolution was to -- we felt that both assumptions were extreme; they could not be defended and given at this point.

We felt that somewhere in between there were intermediate assumptions that would be the correct ones. We think there is probably -- if we were smart enough and had enough money and enough computer time, if we had that, we could devise a way to get at the proper expression of this.

DR. OKRENT: What do you by "correct"?

DR. REITER: By correct I -an that which we think -- what I think fits what the people are trying to tell us.

DR. OKRENT: I guess this is a good time for me to recite an experience that occurred in connection with using expert opinion for omponent failure rate for the reactor safety study.

In one area, they did not have data, but they did have experts who could give estimates on failure rate, and they gave median and 90 and 10 percent or 95 and 5 percent confidence bounds and so forth.

This is what was used in WASH-1400. And some years later when there was some data available from one or more plants and people reviewed this, on a few occasion they found that the data not only did not agree with the median but it did not fall within the 5 and 95 percent bounds.

So while I appreciate the problem you have -- and I am not against using experts -- I think at some point you have to step back and ask yourself how much do I press forward refining the input.

Let me just leave it at that point.

DR. REITER: Okay. I think what you are saying is correct. We are trying to aim at here what we think is the correct way or the way to model what the experts are telling us. It turns out in this case the difference between the extremes is that -- the order of 5, 10, or 15 percent, maybe 20 percent, and we felt that computationally that might be a way to do what they want.

But it may be at least, given what we have now -- we felt it would be computationally prohibitive to do that. And given all those assumptions, at least the staff felt that an appropriate way to proceed would be to go and do something intermediate

dsp13

between that.

The next problem, as Larry pointed out, was the dispersion of data, how we define strata without an appropriate data base, and we felt an assumption that the data would be somewhere similar to that in the west. And the western data -- the ensemble of western data falls somewhere between point sigma, between .6 and .7. We felt we should use .7 with a cutoff at three sigma.

The synthesis of expert results -- there are various ways of synthesizing results, and TERA has estimated that essentially the way they did it -- although it may not be the only or best way to do it -- would not be significantly different from other ways of doing it.

(Slide)

So again we integrated these recommendations. We performed an evaluation of the sensitivity of the results and did dispersion changes and we found -- this is a matter of disappointment -- we had computations at sigma 19 plus 2 sigma but not background.

By very simple estimates we came to the conclusion that this is equivalent to an intermediate background of sigma equals .7 plus or minus 3 signma.

It was a tradeoff between the sigma and the background, and again it was a matter -- we were dealing with a matter of 5 to 20 percent.

(Slide)

So if some error is made and there might be some model dependence, it is not going to be anything like 50 or 100 percent; it is on the order of several -- maybe 5 percent. That is not to say further refinement cannot really attack this problem and come up with a more accurate estimate.

We then attempt to look at this and try to specifically add what we thought the conservatisms and nonconservatisms were and here is a list of some of them and there might be some more. But conservatisms, generally it is felt that there is a strong motion data set because of the interest. There is general bias toward higher values and paritcularly at large distances.

Engineers are generally interested in earthquakes of strong ground shaking and generally not interested in those which are very little.

Another conservatism was the very assumption of randomness in the source zone; again, the assumption is that within any particular source zone or tectonic province or seismotectonic province, that the earthquakes are occurring randomly within any part of that, and we feel that in zones of moderate or low seismicity this is a conservative estimate.

We do think that eventually earthquakes can be related to geologic and tectonic features, and eventually these will be tied down and that we will eventually -- it will eventually result in a conservative estimate for those areas of low seismicity.

Generally, the way the whole thing was done -- the way each expert was asked to utilize and define his uncertainty, the conservative part was tail dominant.

Finally, it has been pointed out that large earthquakes attenuate faster than small earthquakes. So nonconservatisms were, one, mixing true field and basement strong motion records. Generally, as has been pointed out, that if you look at the small buildings and large buildings, generally if you look at large buildings, you get lower peak acceleration in the low and high frequencies.

And we are essentially -- the data base -- they are mixed together and they are assumed to be three fields. We think that might be a possible source of conservatism.

And finally the spectra really, although they are assigned to a return period, they really represent more than -- a chance of more than once being exceeded in the return period, the 1000 year return period, the chance of only being seen once in 1000 years, once or more in 1000 years.

And by some estimates by TERA, we think this is not really that significant once you go beyond the chance of exceeding -- the chance of being seen three or four or five times is really very small.

DR. OKRENT: Why is it a conservatism that the conservative part of uncertainty dominates?

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DR. REITER: The way it was modeled; for example, the B values. The B values were modeled such that -- the B value is recurrence rate, and it was modeled such that people said, what is the -- what is that slope, and the slope was taken to pivot about a point such that the largest -- the low -- the pivot point was in the smaller earthquakes, while the largest earthquakes, you had a larger spread than you have for the intermediate or smaller sized earthquake. And that was just an artifact of the way the people did it.

DR. TRIFUNAC: I do not understand it.

end 3

DR. REITER: Is the best estimate or B value, and the slope is, let's say, .57. There are other slopes and there are various ways of looking at that. One of the various ways of looking at it was such that -- this is the zone, or the large-size earthquakes, the part contributing very largely to the risk. These are very sensitive because of their pivoting back here. These are very sensitive.

DR. OKRENT: But the pivoting is done at a smaller earthquake because that is where you have data, presumably.

DR. REITER: You have some data there but you have more data back there. If you do pivoting, there is a larger amount.

DR. OKRENT: How can you say that? It depends on how you draw those lines. I could pivot it around anything and still have a very narrow cone. In other words, I could have pivoted at the far left and still have so narrow a cone. At the far right end I fell way within what you have drawn.

DR. REITER: If you pivoted back here, then the greatest effect is going to be over here no matter what the size.

DR. OKRENT: The statement that you have is that the conservative part or the uncertainty dominates, and I agree; but if the uncertainty goes a factor 10 in each direction around some value when you do an expected -- it will shift in the direction of the larger value. Is that what you are saying?

DR. REITER: I am saying that the way the conservatism, the way the uncertaint. as modeled -- and I don't know if there is a better way to do it -- but the way that it was modeled is such that it tends to give very large results or very large changes, perhaps, conservative changes with regard to the largest earthquakes in this particular case.

I think, speaking with the people at TERA on some other cases we have done, maybe there is no better way to do it; but that is the way it resulted. I guess part of it is also in the thought that the tail-end distribution is very important and are controlling a lot of the hazards.

Part of it is also the way that was modeled. I do not know if there is a better way to do that. We are not trying at this point to attach a specific value on each one of these. We are just trying to get a general picture. It is our judgment that the conservatisms that we are seeing are really more conservative, and the so-called 1000-year spectra real.y reflect longer return periods.

For example, TERA recently did some finer calculations, and it is their belief that this so-called 1000-year spectra may represent something like a 5000-year spectra. We don't necessarily agree with that. What we do know, and this perhaps goes to what you said before -- in my experience in the NRC in the last four years, and I was not privy to the Greenwood hearings, but in the Branch there has been an implicit acceptance of return periods on the order of 1000 or 10,000 years, not between 1000 and 10,000, but on that order.

What I mean by that, I mean by that people ask what was the return period of the SSE at the site, and the answer was given: well, looking at all kinds of estimates, 1000 years, 5000 years, 10,000 years. That seemed to be implicitly accepted. It was not explictly accepted but was implicitly accepted.

DR. OKRENT: In my opinion, that is accepted the same way reactors at Indian Point are accepted: they are there. In other words, now it is a thought. There were a lot of decisions made on earthquakes, in fact, in the sixties when people were thinking the frequencies were much smaller. I cited at Greenwood when we were first getting a number, it was thought that it was much smaller than the numbers you gave, and that was already thought to be a big number.

By the time the staff, I guess, felt it was in the range you said, they already had, I don't know, 100 sites under their belly, as it were. And it was difficult, I guess, to say other than this is what we approved.

DR. REITER: I think what you are saying is that what we really need is an explicit statement for what is an acceptable level of hazardous site. You are right. But I think at this point in the review, attempting to do that would be biting off much too much. At this point we are just going to proceed as to what has been implicitly accepted in the past.

But you are right, there was no implicit saying that we have run some kind of calculations and we decided that the 5,698th year earthquake is the correct one.

DR. OKRENT: By the way, I could have told you that this was the conclusion, that is, 1 to 10,000, based on the survey I did and knowing who my experts were and what results they gave. In fact, the median that I got from them was in the vicinity of a little more frequent than 1 in 10,000.

DR. REITER: I want to make sure. I am not saying exactly. It could be 11,000 or 12,000. It could be 900.

DR. OKRENT: It will vary.

DR. REITER: We feel that the recommended spectra fit within this description, and it is not an explicit statement. It is back-dooring it. But at this point I don't know any better way to go.

Most importantly, we think that these spectra, whatever their exact return period is, represent generally equivalent hazards from site to site. Look at Yankee Rowe. We look at Big Rock Point or Dresden. We think that those spectra, those thousand-year spectra, whatever they are, represent essentially equivalent hazards.

That is very nice, but the next question is is there any other way of looking at what is coming up.

(Slide)

We attempted to do what we call a deterministic -- yet I think what has really been described is empirical --deterministic is really a much more physical modeling of the earthquake. In this point what we did was, one, assume seismic zoning forms to have purpose; and second, use the largest historical earthquake.

Then the third step was to deviate a little bit, where instead of going to the standard way which is laid out -- the most acceptable way in the standard review plan -- instead of going to Trifunac and Brady and using the trend of the mean, we decided to use NUREG-CR-0098 of Newmark and Hall.

In order to get at the peak acceleration and peak velocity, we compiled as much information as we could about prediction and acceleration for earthquakes in the United States, and it is empirical based on various earthquakes.

Then we took an appropriate group of those and averaged those to get a particular peak acceleration or peak velocity. So I want to repeat it exactly like the way we do it in the standard review plan. However, instead of looking at the trend of the mean, or Trifunac and Brady, we used NUREG-CR-0098 and these acceleration velocities.

I will show you the impact of using Reg Guide 160 and the mean of Trifunac and Brady.

(Slide)

When we do this we get the following numbers. These are for the so-called thousand year peak acceleration. Here is the so-called deterministic acceleration. Deterministic accelerations generally are the same, .12,.13. The differences, this is the eastern United States, and this is the central United States.

The 1000-year ranged from .08g at Big Rock Point to .8g at Haddam Neck, and generally the sites in the eastern United States of high peak acceleration are greater than those in the central part of the United States, and I will show a map of seismicity.

I think there is a logic behind this. I think it really reflects in a gross way, perhaps more than a gross way, what the seismicity is about.

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I just want to say that most of these values are above the peak. Half of them are above, or five of them are above, and four of them are at or below. If you look at the velocities, the 1000-year ranged from 11 centimeters per second to 22 centimeters per second, while the deterministic ranged from 9 to 20.

The so-called deterministic are below the 1000 year, excent at Dresden where it is a little bit higher. That is due to the influence of the New Madrid zone.

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How do we get this? Please excuse this. You cannot see this.

Here again, here is the seismicity. These are the contours of equal seismicity. The eastern sites and northeastern sites are the areas of high seismicity. The central sites are in areas of lower seismicity. Essentially what we are seeing is the ability of a site-specific spectra to pick this up.

We use a deterministic spectra, and then we get the same for Haddam Neck and Big Rock Point; and indeed, you could possibly get higher for Big Rock Point than Haddam Neck. I think what we are seeing here is the ability of this program to pick up the reflection in the seismicity.

The so-called tectonic province approach in Appendix A says go out and find a tectonic province and your largest maximum earthquake, and assume concurrence at the site. It doesn't take into account the fact that you have lots of earthquakes over here but very few earthquakes over here (indicating).

I think what we are seeing is the sensitivity aspects. So generally, the 1000-year, the peaks are more conservative with deterministic. They represent real differences in seismicity and perceived hazard. If we look at the spectra, I will give you two examples of the spectra.

Here is Haddam Neck. This red line represents the probabilistic spectra or the 1000-year spectra from using the Ossippee earthquake, one we think at this point we should use. The 50th and 84th percentile represent the spectra derived from peak acceleration and peak velocity, amplified using Newmark and Hall's amplification factors.

Generally we see that for Haddam Neck the 1000-year spectra falls at about the 84 percentile level. If we go to look at Big Rock Point, the other end of the spectra, we see that generally we fall below the 50th percentile. Again, this is a reflection of the fact that while the probabilistic spectra are sensitive to perceptions about seismicity and seismic hazard, the 84th percentile are completely upside down and geared to an approach which says use an actual historic earthquake in a tectonic province.

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So generally, if we look at all the spectra -- and I can show you all of them, they are in the handout -- in the central U.S. it is 1000-year spectra and they are at or below the deterministic spectra, while the eastern spectra, the 1000-year spectra, are at the 84th percentile deterministic. In the deterministic approach followed before, practically all the acceleration and velocities were below the probabilistic.

Now we see when we use the spectral amplification, that that factor is taken up in the so-called empirical or deterministic approach. The conservatism is embodied in the assumed spectral amplication, whether it be Reg. Guide 1.60 or the spectral amplification factors of Newmark and Hall.

If we compare this to Reg. Guide 1.60, then here we have sites in the eastern United States. Here is Reg. Guide 1.60, anchored at .1g., Reg. Guide 1.60 anchored at .2g for the eastern part of the United States. For the eastern part of the United States or the northeastern part of the United States, the spectra are generally above .1g.

If we went out and used the tectonic province approach, every one of these sites would be at somewhere between .13 and .2, depending upon what was the interpretation at that time, who the reviewer was, and the amount of conservatism it was felt could be put into this.

If you want to look at it in terms of strict application of a standard review plan without any sort of modificaton, then you would get a band which would go something like that (indicating).

If you look at the central part of the United States, we see that now the spectra fall generally either at or below .1g. Again, if we went using Trifunac and Brady and Reg. Guide 1.60, again the spectra would fall somewhere in this band. The reason in the eastern United States they fall above and in the central United States they fall below, again we think is really an expression of the perceived seismic hazard by the experts and, we think, by the seismological community in general.

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Again, this is just repeating what I said before. In Reg. Guide 1.60 -- it was conservatively derived. Although the peak acceleration, .13, was less than most of the probabilistic acceleration, the conservatism in that approach is very much embodied in the kinds of spectra used, and that was Reg. Guide 1.60.

That is why it is very important not to only talk about a minimum g value, what acceleration, but how it is being used. If I took a group of spectra -- I would get determinations half of Reg. Guide 1.60. At some time in the future when we discuss peak accelerations, please make it an integral part of the whole review process and do not treat it separately from everything else.

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Another thing that was done is we asked Lawrence

Livermore to go out and look at real earthquake data from the western U.S., the idea being that at least in the nearby regions, less than 25 kilometers, factors such as attenuation will not be pronounced between east and west.

There are some other things that could cause it, source differences, but generally you might be looking at the same level. Here what we have done is presented the spectra for rock sites for a magnitude 5.3 plus or minus .5 event, from western data. The reason we did that is that Nuttli associates magnitude 5.3 with about intensity 7, and intensity 7 seems to be about the level of earthquake that seems to occur in many parts of the eastern United States, and may, indeed, be really at this point independent of location. Maybe this kind of earthquake can occur in any part of the eastern United States.

Here have the 50th percentile, and we see the 84 percentile, and we see that for the rock site, the data falls either at the 84th percentile or somewhere between them. I might add the large spread is in many ways due to the fact that because you do not have many earthquakes at one magnitude or distance, you have to take earthquake over a large magnitude range at a distance range from 0 to 25 kilometers. There is a lot of spread in that, so you get a very large dispersion.

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If you look at soil sites, then we see again the spectra fall between, except for three 3000-year spectra, Palisades, La Crosse and Big Rock Point, at periods around .2 or .3 seconds. Although we believe that these spectra represent true relative risk or relative hazard, we believe that it is prudent, because of what we know, what we think we don't know about intensity 7 earthquakes, that we establish this median as the minimum below which we do not allow any of the spectra to fall.

DR. OKRENT: Would you tell me what the 50 percent curve is again and how it is generated?

DR. REITER: We asked Lawrence Livermore to go out and get all the records they could, the western United States, Italy and other sites, for various magnitude ranges. One was magnitude 5.3. They went out and we said, let's look at all the soil sites we have. There is approximately -- I don't have the numbers here -- I think it was around 13 or 14 sets of records, which is 28 components, and that is the data. That is what it is.

DR. OKRENT: What did they do then?

DR REITER: Then they just computed, assuming a log normal distribution, computed the 50th percentile or median, and the mean plus 1.

DR. OKRENT: And this places the earthquake where with respect to the site?

DR. REITER: This set looks at all data you have nearby the source, and nearby is defined as distances less than 25 to 27 kilometers.

DR. OKRENT: So if the data happen to come from points that were 20 to 25 kilometers --

DR. REITER: There was no correction made. There is a reason for that, and part of the reason for that is that I guess we are dealing in the western United States, where we have surface rupturing and explicit -- faulting near the surface with perhaps a very sharp fall-off as you go away from that rupture. And you might say there might be significant difference between 8 kilometers and 5 kilometers or 10 kilometers.

We did see this in the Imperial Valley, but in the eastern part of the United States there has been no surface faulting. Earthquakes occur at depths at 10 or 15 kilometers. Generally the maximum intensity occurs over an area which may go out to 20 kilometers. That was the driving point behind it. That way we got earthquakes in the eastern United States.

Nuttli, for instance, puts the maximum intensity zone at around 20 kilometers. That was the driving factor, the observed maximum intensity, and the facts that eastern earthquakes are occurring at a depth greater than western earthquakes. Clearly, if we have lots of data, we could do the kind of refinement that this could allow. But the point, again, that we are tryinn here is an attempt to go out in the real world and take a look at where these spectra fall.

This was the approach that we did in Sequoyah, where we used a magnitude 5.8.

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So again, we find in these computations that generally six sites fall between the 50th and 84th percentile, while three fall less than the 50th percentile. We think it is an obvious answer: that Palisades, La Crosse and Big Rock Point are in Michigan and Wisconsin and represent areas of low seismicity.

By establishing a uniform standard, you are not taking into account relative differences. But we feel at this point, however, that we need such a minimum standard, and it is our recommendation that we use the median of the 50th percentile. We recommending using a 1000-year spectra except where they would go below that 50th percentile. That is our conclusion.

DR. OKRENT: Okay. I guess I myself would find it hard to know why the combination you have proposed is suitable for evaluating the seismic design of these plans or plants to be constructured or so forth, without having some way of translating this to the seismic contribution to risk.

We had a considerable go-round with the NRC staff on ATWS, which is still not ne essarily at an end, in trying to deal with probabilities of events there. It was certainly relevant to the thinking. What is the probability of having some accident as the -- caused by the original event.

If we cannot go from your 1000-year event to some chance of an accident, and also if you do not tell us what is the 10,000-year earthquake and the 100,000-year earthquake, and what is the chance that this will cau:e an accident, it represents a more detailed examination of the information but not necessarily any more plausible way to judge that we have an adequate design.

DR. REITER: Well, we will discuss that later, but I think you are right. I mean I don't agree with your conclusion, but I think your idea that really the way to do this would be to use it with an integrated risk assessment. Indeed, perhaps when he results of the SSMRP come out, we may be able to use those. Perhaps two years down the road, we will be able to involve an integrated risk assessment.

At this point, however, I think we have to make a decision on what is the best way to go. I want to point out on the question of the 1000-year earthquake, we don't believe that the only thing we can say is based on our assessment. It is in the general ballpark. Then we go out and take a look at it and look at other methods. That is the way that we are scaling. We are determining that that is the proper way to go. We do not think we can pin that probability down exactly.

DR. OKRENT: Let me complicate your life a little bit, then, this way. I do not really are whether it is a 1000 or 3000 or 5000-year earthquake. I do not think you are selling the 10,000-year one. If you are, let me know.

DR. REITER: I am selling it as something on the order of a 1000 or 10,000. It could very well be the 10,000-year earthquake.

DR. OKRENT: It is conceivable that you could have two sites where at the -- I will use a median number. At the 5000-year earthquake you see a substantial difference by your method of analysis, and 50 percent or more, let's say, in important seismic design parameters.

These same sites, if you went to the experts and you asked them what is the 50,000-year earthquake, they might not have any basis for distinguishing between the two. It could be that when you did the risk analysis, that the principal risk came from the earthquakes more like the 50,000-year one than the 5000-year one, whatever it is, in which case you might have thought, gee, Site A, La Crosse or whatever it is, could really have a much less design basis based on the 5000 or 1000 or whatever it is; and yet, if you look beyond, they should not have a different design basis because, in fact, you are using this margin to handle these less frequent earthquakes, and that is really what is important.

So I am saying, in fact, in my opinion, dealing with only the one design basis, the one for which you try to design the plant, which if you have done it right, in principal you should not even have an accident, it is only half of the picture, as it were. And if you don't have a basis for estimating what is the earthquake, ten times less frequent or maybe even one hundred times less frequent, you could, in fact, end up with a poor decision.

DR. REITER: I think I want to reemphasize again that we are using the probabilistic method here as a relative tool. The general level of that probability is not determined by the exact calculation but by several factors. One of them is the general level of the implicit acceptance of risk. That is only one part of it.

The other parts are how it fits with respect to other methods we use. The principal use for us at this point is the relative method to let us get at the ways that we can be consistent at Big Rock Point and not require the same for both.

DR. OKRENT: You did not hear what I said. What I said is this relative one could in principal give you the wrong answer. Where you think you are really doing something on a relative basis and allowing for the differences, if you have a way of evaluating the risk and if, in fact, these do not fall off at the same rate as you go to lower probabilities but they tend to reach a plateau, then, in fact, you may have arrived at an erroneous conclusion. That is what I am saying.

DR. REITER: You are telling me you want to look at other risk levels to really get a better picture.

DR. OKRENT: I think if you don't, you will arrive at an erroneous conclusion.

DR. REITER: Given the options we have now in terms of what we are capable of doing, I do not see any way at this point of doing that. We have to make a decision at this point how to proceed, and I think that perhaps it is not the complete picture. I think you have to look at those kinds of things.

But given what we have now, I think this is a logical way to proceed, and I think it is a better way to proceed than a method which gives me the same numbers everywhere throughout all those sites, even though the seismicity is different. That is the key question.

I really think the best way to do this thing is say, hey, we want the 30,000, 100,000-year earthquake, we want to do integrated risk assessment, and let's see what happens. Maybe it is a 50,000-year earthquake. Maybe it is a 100,000-year earthquake. As I think you said, what are the challenges at various levels? But we do not have all those abilities now, and I do not think at this point today we have the capabilities of computing those numbers.

What we are attempting to do here is a strategy to deal with that information we have with the work that is done and attempt to come to a conclusion which we think, although it may not be the best decision, perhaps is more rational than the decision that we could make without this. That is the trust of what we were trying to get at.

t5 flws er t4

Baml

DR. SIESS: In your determination for the explicit risk, what year did you go back to?

DR. REITER: I said I had been onthe staff for four years.

DR. SIESS: If I look at Dresden, for example, you come up with .134, an acceptable -- corresponding to an acceptable risk. Why would I not be justified in concluding that .2 was the acceptable value? That is about what Dresden 2 and 3 were designed for.

DR. REITER: You could do that. That procedure, which said, "Let's take the largest earthquake which is intensity VII-VIII, and let's go to the Trifunac and Brady mean."

DR. SIESS: We have been doing that for so long now that certainly almost all of the reactors that have been built since the SEP plants have been on that basis.

DR. REITER: Right.

DR. SIESS: Which is an implicit level of risk and an implicit level of acceptance of a somewhat higher -- lower risk than you got for the early plants.

DR. REITER: I will make one comment and then Howard can continue on, because he is going to discuss the individual designs on each plant.

What I am saying here is that when those numbers were looked at, those levels, whether it be .13 or .2, and the number varies, when people did the calculations, the general numbers that people were coming up with looking at the risk maps, the growth calculations were on the order of 10^{-3}, 10^{-4}.

I am not saying that represented -- .2 represents the real risk. There was an implicit acceptance of those numbers.

MR. LEVIN: Dr. Siess, one thing you are correct in as far as Dresden 2 and 3 are concerned, the original PGAs were .2 Gs. However, the response spectra was anchored to that value. I mean, you really look at it across the frequency bound, as an example.

That although the spectra that Leon is proposing have, let's say, lower PGAs than the .2. If you look at it across the frequency band, the spectras start to look very similar. So, I think what we have to do is get away from looking at the peak accelerations and look at the engineering frequency range of interest.

DR. SIESS: If someone would take Dresden 1 and analyze it for the same spectrum that was used for Dresden 2 and 3 and show that it was just about as good, I would get a great deal of comfort from that.

MR. LEVIN: That is exactly what we intend to do.

DR. SIESS: My assumption would be that these SEP plants were not as good as those plants built later. I think they did accept a lower risk in those days because we were not as aware of earthquakes.

I would be -- I would be a little bit surprised if btm3

we did not.

DR. REITER: Perhaps at this point, Howard could present a comparison of what the actual designs were.

DR. OKRENT: Let me add a point pursuant to your last comment. I think, in fact, you do not have to have the benefit of everything we hope that Livermore will provide us via the SSMRP program to have important additional information.

I think if you are going to go to the trouble of trying to get this probabilistic treatment, and do it at the -- you estimate it at the 1000 and 4000 year interval, I think, in fact, you should try to see what you get at some higer return periods because that is relevant information to your decision-making.

If there is some reason to question whether they fall off at the same rate, or whatever, or reach a plateau, that should influence you decision as to whether the differences that you see at what they normally call the 1000 year period is really valid or not.

Do you see what I am saying?

DR. REITER: I understand what you are saying.

DR.OKRENT: It sounds to me like you could be tooled up to get some insight into that area.

DR. REITER: Larry, did you attempt to do longer return periods? Did you observe a general trend when you did the longer return periods?

bfm4

MR. WIGHT: No, we really did not calculate any spectra and longer return periods than 4000. We did look at individual experts' results.

My recollection is that for return periods up to about 10,000, we did not look at anything beyond that; that the same trands we saw at 1000 continue. That is the central U.S. appear to be proportionally less hazardous than the eastern U.S. sites.

(Slide.)

MR. LEVIN: My name is Howard Levin. I promise you I will be brief. This vu-graph summarizes the original FSAR seismic input that was used in the original design of the eleven SEP plants. The plants are listed in order of their vintage.

Dresden was the earliest and proceeding to Palisades. The most evident thing is that the first four plants used either uniform building code, or in two cases, there is actually no consideration of seismic design -- of a seismic input value in the design.

I would like to point out that that was consistent with the buidling code provisions of the day for plants located in that region.

(Slide.)

In a few minutes, I will be showing examples of the original design spectra with the NRC proposed site specific spectra. In addition to spectra, which may be considered today as representing current criteria along with other spectra, which various SEP licensees have proposed for use in the SEP evaluation.

Before I get into that, I think I would like to summarize for you what the results would yield. In a nutshell, there are three facilities, Dresden 2, Plaisades, and Oyster Creek, where the site specific spectra across the entire frequency range or lower than the original FSAR seismic input.

There are two facilities, Ginna and Mill, where the site specific input is higher, but we are projecting very minor impact into that.

Then there are five plants where the site specific spectra are considered to be significantly higher than the FSAR values. For four of those plants, it is because there was a very nominal consideration originally.

At San Onofre, although it was not considered in the context of hte Lawrence Livermore TERA project and our evaluation there was a decision. We might talk about this at some other time where .67 G spectra was proposed for continuing reevaluation.

We are projecting an impact there.

(Slide.)

DR. OKRENT: Do you have those figures listed anywhere?

MR. LEVIN: You have --

DR. SIESS: Which were higher, which were lower?

MR. LEVIN: I did not list those, but if you like, I can.

DR. SIESS: I would appreciate it.

m6

MR. LEVIN: Okay. The three plants in the lower were Dresden 2, Plaisades, and Oyster Creek.

DR. SIESS: Okay.

MR. LEVIN: The two plants which were higher were Ginna and Millstone. The five plants were Humboldt, Big Rock Point, La Crosse, Yankee Rowe, and Dresden 1.

This slide is interesting because I have plotted here original seismic input from two plants. They are located in the same site, Dresden 1 and 2. However, you can see the original input was substantially different.

The red line here is the site specific spectra codes by the NRC staff. The dashed green line is the original .2 G response spectra. The blue line is a spectra which is a .2 G Reg Guide 1.60 spectra, whcih we might consider if this were a CP, which we were licensing today.

It may turn out that way. This is the original spectra, equivalent UBC kind of criteria that Dresden 1 was designed for. This yellow line is the proposal by Commonwealth Edison to use in reevaluation.

It was a site specific response spectra developed by FUGRO. The interesting thing here as far as the Dresden reevaluation that was talked about this morning is the original Housner spectra is very close to that, which we are proposing.

It just so happens that that works out very conveniently for Dresden. I can go through site by site, but maybe before I

bfm7

do that to see how much of this you would like to see, I can go through what we feel the anticipated impact of each site for the individual spectra.

(Slide.)

In the left hand column is the facility name, the original FSAR, the seismic input. This is the PGA that comes out of the NRC proposed spectra. I hesitated to put that on the slide because I do not want to focus attention on the PGAs, but it's just there as a reference.

In the structural area -- I think the right hand portion of this chart is consistent with the conclusions we gave this morning. It is more specific on a plant specific basis, how we intend things to go.

In the structural area, for the most part, we anticipate either no impact or minor impact. In the one case, we already know there are major impacts on the structural area. That is due to a very unique situation at the Yankee Rowe plant, in the way that the reactor internals are supported on concrete -- steel-encased concrete legs. Since they were not designed for greater loads, there is a problem.

They will require stiffening, or reenforcing. The mechnaical area for the most part -- these are for the group one plants, the later vintage plants we anticipate relatively minor impact. The group two plants we anticipate major impacts, primarily because pipe supports and things of that nature will have to be provided in piping.

I might add as far as other mechanical components, such as pumps, as an example, we don't anticipate great impact primarily because other things control the design of a pump and the way it was founded on its pedastal, such as thermal hydraulic lifts.

Due to this kind of consideration, you find that items of that nature can be found to have seismic resistance capability. Virtually every plant in the electrical area we are anticipating major impact.

We have already identified the concern with the anchorage and support. I believe it is going to be a very difficult road ahead in demonstrating the functional capability of the equipment. As some of the members of our team pointed out, our assessment has been largely judgmental. I think that in the next few years the industry and the staff will be involved in great detail in the electrical area, demonstrating functionability.

Now, Mr. Chairman, if you would like to go thorugh other examples of other sites, I presented them in the handout. We can go through them. If there are any that you are interested in, we can put them up on the screen, similar to that Dresden chart.

MR. EBERSOLE: Before you do that, is it fair to say that in the lower group up there, because you are going to have major impact on electrical, is it merely becausc ou are going to -- have to do some work that you would have done even if you did not change the earthquake spectra?

MR. LEVIN: That is true.

MR. EBERSOLE: It is a process of clearn-up?

MR. LEVIN: We have, as we indicated, a tremendous documentation problem.

MR. EBERSOLE: I mean, if you did not change the earthquake spectra at all, you would have a problem looking at the seismic confidence?

MR. LEVIN: I think that is true in that area because, let's say, for two plants or for, let's say, a total of seven plants it has been somewhat of an escalation, but that is what is driving that conclusion.

MR. EBERSOLE: Okay.

MR. RAY: Will you impose a mangitude for which the restraints must be capable by .1 or .2 G?

MR. LEVIN: That will be determined through -- what we intend to do is take the suggested ground spectra and recompute structural response spectra and the equipment will have to be reevaluated for those spectra.

MR. RAY: You mean the same spectra that you are evaluating structural and mechanical on?

MR. LEVIN: We will go into the structure and get an in-strucure response spectra. That is what we will use.

MR. RAY: Then the qualification of the electrical installations to support the ability to safety shut down the plant and initiate emergency cooling RHR in one is going to be improved or at least improved?

MR. LEVEIN: I hope we will improve it. That's right.

MR. RAY: I've beendiscouraged because I did not get the slightest inkling up to this point that that was going to be the case.

In fact, Mr. Ebersole asked a question at the outset whether or not any considerations would be brought to bear on electrical facilities.

My impression was there was a negative answer. Maybe I misunderstood.

MR. EBERSOLE: What you have just shown is contradictory to one of the first questions I asked up there, where you had a statement earlier on. Let's see, who made that? Mr. Bagchi.

The slide showed developmental methods and so forth. My question was did that mean you were going to conduct a general examination for potential deficiencies and identification of those systems that had to be seismically competent, would the scope include reidentification of functional systems which would now need to be identified as being functionally adequate?

The answer was, no, you weren't going to do that. Here, this says you are.

MR. BAGCHI: I am trying to return that -- I am trying to answer that question. I was discussing task action plant A-40.

bfm11

What you are hearing now is a discussion on systematic evaluation programs. Systematic evaluation programs goes out, looks at specific plants; the ten or eleven older plants. That program certainly is charged with looking at those specific plants.

MR. EBERSOLE: They will carry the seismic reassessment load?

MR. BAGCHI: Yes.

MR. EBERSOLE: That took the load off your back in the seismic area because they are going to carry it, right?

MR. BAGCHI: Yes, sir.

MR. EBERSOLE: Thank you.

DR. SIESS: Would you put the San Onofre slide up?

MR. LEVIN: I might add, Dr. Siess, that this was not established to any of the considerations that you have heard today by Livermore and TERA.

DR. SIESS: There is not one on there for the design basis. You have 67 --

MR. LEVIN: I have .67 plotted. The original design basis was .5 G Housner spectra.

DR. SIESS: Has it en reexamined for .67?

MR. LEVIN: A portion of the reactor that has the reactor coolant loop. The -- that item has been evaluated already. In certain cases, modifications have been made. The support of the steam generators have been modified.

bfm12

DR. SIESS: In each case where you put the FSAR design basis, the coefficient is what?

MR. LEVIN: As far as this, I have not attempted to --

DR. SIESS: Not on this one, on the others.

MR. LEVIN: On each of them I have plotted -- here, I plotted all two percent, so you can compare them. The others I have compared straight five percent.

If we were doing the evaluation, we would use appropriate damping values.

DR. SIESS: They are not strictly comparable. For example, on Dresden, where we show the .2 G Housner and the five percent for D-2, D-2 might have been using three percent. Something lower than --

MR. LEVIN: Let me make a specific example. Dresden used five percent for concrete, originally, okay? If we want to compare, let's say, our site -- and we were using between seven and ten percent, okay.

If we wanted to compare, we would not compare -- this is five versus five. We would now compare the original five percent to our site specific at seven and ten.

DR. SIESS: Forgetting site specific now, compate D-2 and D-3. What were they using for concrete?

MR. LEVIN: They were using five percent. In our reevaluation, we are proposing seven to ten depending on the stress levels.

bfm13

DR. SIESS: Five percent for concrete -- Reg Guide 1.61 says five percent.

MR. LEVIN: It says seven percent.

DR. SIESS: They designed for five percent?

MR. LEVIN: That is correct.

DR. SIESS: So, if I compare their .2 G Housner, five percent with Reg Guide 1.60 at seven percent, I will get --

MR. LEVIN: You might get the difference between what they did and what we require in current criteria today.

DR. SIESS: It is smaller than I get --

MR. LEVIN: The objective of this slide was to illustrate any kind of damping.

DR. SIESS: You cannot draw a response spectra independent of damping?

MR. LEVIN: It depends.

DR. SIESS: Independent of theory?

MR. EBERSOLE: Would you put that table back up there again, please, just a second?

end t5

er flw t6

DR. SIESS: Whether or not those damping factors are the real ones, they are different. There is a real one for the plant.

MR. EBERSOLE: On the last two columns on the r ght there where you show major and minor impacts on the el ctrical, this pertains to the ten SEP facilities in the seismic context, right?

MR. LEVIN: That is correct.

MR. EBERSOLE: That is only ten. How many which are not SEP plants which are going to be impacted by seismic upgrading?

MR. LEVIN: By site-specific spectra, let's say?

MR. EBERSOLE: Yes. In other words, there are a lot more plants that are going to have some major and minor activities when you apply the new seismic criteria, right?

MR. LEVIN: I guess from our perspective now, and I think I indicated this morning, I think seismic design criteria evolve most significantly throughout this period. So by the time you start looking at a plant like Millstone, the way it was looked at was very similar to plants which are -- as far as operating plants in the middle vintage.

MR. EBERSOLE: You do not expect every impact --

MR. LEVIN: I cannot conclude that if you did a site-specific evaluation at other sites, that you would not find, let's say, in some frequency ranges, spectra ordinants which were higner. But based upon this look -- okay, I cannot say this with 100 percent certainty -- I would anticipate that you would be able to deal with that unless you were located in an area of unusual -- either for one reason or another, the original seismic input was particularly low for one reason or another, and things that happened over the years --

MR. EBERSOLE: I am getting back to the point that even if you did not adjust the site-specific -- seismic criteria at all, in the process of reviewing and cleaning up the plant, they are going to be more than those involved, than these on the SEP list.

DR. SIESS: He is talking about qualification of electric.

MR. EBERSOLE: Right.

MR. LEVIN: I believe that that will ultimately be for all operating plants.

MR. EBERSOLE: Yes, beyond the SEP group.

DR. SIESS: It is already being addressed.

MR. LEVIN: I would not personally advocate going through a detailed evaluation as we have in SEPs for all operating reactors. I think what we should attempt to do is look at the areas which appear to be wink links, maybe electrical, and look at them. I don't think it is justified to go through the whole thing.

MR. EBERSOLE: This is a guide for where to look on the others.

MR. LEVIN: That was the intent of the program.

DR. OKRENT: Is there any thinking that Yankee Rowe and La Crosse are small areas at remote sites, and Oyster Creek and Millstone are medium to largest reactors at relatively more populated sites?

MR. LEVIN: I know what you are getting at. You know, I cannot say it is explicitly addressed in a quantitative sense. If you ılly took a probabilistic base study such as TERA-Livermore have proposed, one could certainly, let's say, incorporate the effects of population density and things like that in evaluating the total risk. I think it is qualitatively adjusting the review.

DR. OKRENT: At some point the Commission is going to have to decide what it thinks should be backfit and what need not, and I would assume that we are getting to a point where it is not based on the assumption all reactors are equal, because I think the Commission is departing from that currently in connection with three large reactors at highly populated sites.

It may be, for example, that if what you are proposing based on some of these considerations is adequate for Millstone and Oyster Creek, or example, you could decide you could accept something less for Yankee Rowe and La

Crosse, just as an example.

MR. LEVIN: I am not sure if I know how to do that.

DR. SIESS: Was Humboldt Bay originally in the SEP list?

MR. LEVIN: Not in the original list as I knew it.

MR. BAGCHI: It was certainly on the list originally, but it was shut down for considerations of faulting, so it was automatically eliminated.

MR. LEVIN: The two basic criteria are, one, they wanted to get the old plants in. There were various plants where there were full-time operating license conversions, and one of the objectives of the SEP is to convert those licenses.

MR. KNIGHT: Along those lines, management has been directed to start factoring those considerations into our priorities, so that very definitely, a larger plant, if you will, in a population center or some places of denser population would be given priority both in terms of attention and backfit, as compared to some of the smaller plants or plants in a lower population area.

That philosophy is woven rather tightly, for our part.

DR. OKRENT: I cannot tell. At the moment what I see is the result of an effort to try to evaluate these all on some consistent basis, and in fact, it may well be that this is as consistent a basis as you have for evaluating these sites with regard to the probability of the "1000-year earthquake."

I am not sure how the decision will be made as to what need to be modified. That could be automatically that whatever flows from the result of this is what you do. That sort of would be the simplest. But it might not necessarily represent the most judicious expenditure of resources.

MR. KNIGHT: In fact, at this point we don't know either.

MR. EBERSOLE: Could it take the shape of not qualifying engineers, equipment at all, but just get the --

MR. LEVIN: Maybe I could say a few words on that because that, in fact, was brought up as a possibility in SEP. I think the philosophy went as follows: if you look at the rafter coolant pressure boundary in detail and you felt it was well bunkered and you are very confident about it, and the seismic event was not going to cause an accident, then why would you need it?

But I think the current thinking on the staff is that the seismic event is not likely to cause a full double-ended break out of LOCA, but there is a possibility because of other unknowns that you may get a small break. So we did not want the ECCS equipment to be laying on the ground, and we wanted it available.

So I think the thinking changed and we felt that we had to look at engineering safety features.

DR. SIESS: Is that list in chronological order?

MR. LEVIN: In order of their CP.

DR SIESS: In order of their construction permit?

MR. LEVIN: Yes. Basically, it goes from --

DR. OKRENT: I guess we better go on, Mr. Levin Thank you.

MR. LEVIN: The reason we use CP is that CP is probably more indicative of the criteria at the time that the OL --

DR. OKRENT: Dr. Smith, if I understand correctly, you are going to go through recommendations. I think that maybe we should take them one at a time and see if there are more specific or important comments that members or consultants want to bring up now.

I guess we will ask that people write in comments on this and other things that they feel are relevant.

DR. SMITH: Thank you. My name is Paul Smith. I am with Lawrence Livermore Laboratory. Dave Coats is the project manager on this particular project. He is the person most capable of making the presentation, but due to a conflict, he was unable to be present and asked me to make this presentation.

(Slide)

The purpose of the study is to evaluate the current state of the art of seismic engineering and to recommend changes to the existing NRC seismic design criteria where appropriate. The recommendations are intended to provide short-term improvements.

The recommendations were based on the following sources: reports on the A-40 program; expertise of the core members and consultants -- there were a number of consultants outside the laboratory and we teamed for this project, and there were core people that Livermore identified for this project; and the literature; and coming on the heels of the SSSP or the Site-specific Spectra Project; and the intensive activity we have seen in the last couple of hours or three.

I have to advise you that those reports are not available at the time of the recommendations produced in this project, so using Leon's term, this recommendation here and the SSSP project are virtually what we have. We were aware of its going on but we did not have the results.

L(Slide)

A final report has been submitted covering the Phase I portion of the project. This report includes recommendations in the areas of ground motion and soil structure interactions, structures, equipment and components and testing. As was mentioned earlier, the report is due out as a NUREG this week, I believe.

This is what it looks like, but this is not the NUREG. This is another version of it. It is Contract Report 1161.

(Slide)

We will have a brief summary of the recommendations in the report. For ground motion we recommended replacement of Reg. Guide 1.60 spectra with the Newmark-Hall spectra. This was very similar to what I believe Leon called his deterministic approach. His alternative to the SSSP was the Newmark-Hall spectra, and this was our recommendation at that time. This allows for some site specificity. It can use velocity and displacement values to construct site spectra as opposed to just peak acceleration.

The other difference in the spectra is that the vertical is two-thirds the horizontal for all frequencies. This slight complication between the horizontal and the vertical in R.G. 1.60 is not put into the Newmark-Hall study.

(Slide)

Various additions and clarifications to the standard review plan were made, and I believe Dr. Zudans asked the question earlier. There is a marked-up copy of the standard review -- the recommendations from Livermore as to the changes that should be made in the standard review plan that I believe the staff members have mentioned earlier today. These by no means have been accepted by the staff, but Livermore was asked to provide marked-up recommendations directly on the SEP, but in different areas, identification of primary review areas. This would be tectonic provinces, correlation of earthquake with tectonic provinces capable faulting, maximum earthquake. And subordinate areas would be things like regional geology, seismicity, site geology, site amplification and fault characteristics, redefining the safe shutdown earthquake.

I cannot quote Appendix A exactly, but it had some words like it was the maximum potential earthquake, and the redefinition called for in our recommendation was to define it as the peak ground acceleration for use in seismic design for that site. I am not trying to say that it is any maximum event.

Clarification of historical and instrumental earthquake data reporting requirements and recommendations relating to the determination of appropriate SSE.

DR. OKRENT: What was your recommendation there, and what was the basis for it?

DR. SMITH: Which one, the last one?

DR. OKRENT: Yes.

DR. SMITH: I made a note of a couple here. When the province approach was used, the mean was to be selected for the SSE, and when you had well-defined --these are just two examples. It was a fairly long laundry list. Where you did have well-defined structure such as in the West Coast, where you use that you define the site SSE value which used the mean plus one standard deviation.

That was a couple of examples.

DR. OKRENT: Do I recall somewhere a recommendation concerning return frequency to correspond to an SSE?

DR. SMITH: There was no recommendation as to what it should be in this report. There was a recommendation as to what the values or response is when you calculate using present methods, what the response values, what probability of exceedance they should have.

It was conditional on the SSE value being on the order of 10^{-3}. It was not a recommendation as to what the SSE should be, but the recommendation was that you should -- given the SSE, there be a 10^{-1} probability of exceeding the values you select for use in seismic design.

So the peak ground acceleration does not tie everything down. You still have the spectra with quite a bit of freedom yet. We attempted to make a recommendation as to what the objective of the seismic analysis should be, and that was our recommendation.

Further recommendations were the use of multiple time histories for analysis and design, and we had recommendations on both synthetic and real and minimum number of time histories that should be used. This comes out of a concern many people have expressed of the quality of the results when you use just a single time history. So we recommended more than that

Once you make that kind of recommendation, then you can do a number of other things and just calculate design responses using multiple analysis with variation of parameters, as opposed to the way we do it, which was just an easy step once you accepted more than one time history.

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MR. PAGE: Are you going back over these points later in your talk?

DR. SMITH: I hadn't planned to, no.

MR. PAGE: I would like to go back to redefining the safe shutdown earthquake. I think that is important. I think in a paper Carl Step authored for Livermore studies, he pointed out the difference between a controlling earthquake which may be a distant one and the earthquake that is felt at the site.

There may have been some confusion in the past in making those two things one and the same. Because in the case of the SSE, probably it should be the ground motion at the site. An earthquake is not the same anywhere on earth except at the source.

It is different everywhere it goes. What you want to know is what it is going to be like at the site. Even there, there is a problem. I think it will have to be dealt with. That is whether the earthquake is supposed to be on a nearby rock and then translated into something on soil.

If the plant is going to be built on soil or whether it is going to be free field, or whether it is going to be right at the grass roots, or at a depth of five meters, ten meters, or what.

So, I think that probably applicants should have some guidance here. Maybe some latitude. Maybe they could choose between two or three equivalent approaches for dealing with a

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safe shutdown earthquake. These approaches, I guess, would have to be approved by the staff. You see, it gets pretty complicated because you are working in a three dimensional framework.

DR. SMITH: MY recollection is that recommendation did come from Carl.

MR. JACKSON: I would make one comment. We have Appendix A to Part 100. We hope there will be modifications to it.

Again, we would argue the time to do that and make those changes is with that modification. Anything that we would like to do as a staff we cannot always do, nor can the applicant because of the regulations.

(Slide.)

DR. SMITH: We recommended that if you are going to do non-linear analysis, that you use only real time histories and not consider synthetic.

If you did the multiple analyses with variation of parameters, you are under no obligation to go out for the examination of floor spectra.

DR. OKRENT: Do I recall somewhere in your report for the recommendation of more peak broadening that is currently used, or is that not in your report?

DR. SMITH: The effect of a recommendation of this type is that you would typically in the results we are seeing, which are by no means exhausted, you would lower the peaks and raise the valleys.

It is not just broadening. You are reducing the peak value and raising the valleys to end up with more of a smooth spectra, more broad band type full structure spectra.

DR. OKRENT: In that regard, I understand that there are some results that came out of the HDR tests which suggest, at least to John O'Brien, that one might need more peak broadening in full response spectra than ten or fifteen percent.

Could you help me a little bit to understand? Is there some general conclusion among the staff one way or the other that we should have more peak broadening, or are there differences of opinion? Where does this all seem to come down now?

MR. O BRIEN: Can I talk from here?

DR. OKRENT: It would be easier to hear you if you could get by a microphone.

MR. O BRIEN: I guess the issue is that the peaks in the full response spectra occur at the location of the frequencies of the supporting structures. In typical analysis that is provided in the support of a license, we use linear analysis which gives a very discreet frequency.

It is broadened ten or fifteen percent because that is viewed as the ignorant factor on our ability to predict frequencies.

When we look at the data, we learn that the ignorance factor might be 100 percent. If it is on a soil site or perhaps

50 percent if we sharpen our pencils as best we can.

If you look at the predictions of frequencies of buildings, you see firstly that they shift. They shift depending on the level of excitation. So, the analyst that does the equipment loads in a nuclear power plant calculates a single frequency, then broadens it ten or fifteen percent.

That does not appear to be consistent with our knowledge. In support of this, I have used the HDR data, but I have also used refernce studies by several consultants that worked for DOE.

As a matter of fact, I talked with Paul about this and some staff people. My perception is we are just looking at it and entertaining this as a thought. Paul partially responded to this in A-40.

Anyway, by spreading the full response spectra energy over a wider beam, but he does that through a different route. He does that on justifications based on time histories, not on justifications based on ignorance or on structural parameters or structural frequencies.

DR. SMITH: It is both. It is predominantly the ignorance of frequencies.

DR. OKRENT: Mr. Trifunac?

DR. TRIFUNAC: I would like to make a comment related to this frequency. We did a lot of studies but we never had enough support to study them. The studies were focussing on the recordded motions in buildings primarily in Los Angeles during the San Fernando earthquake.

We did a multiple filter analysis to see whether predominant frequency of the overall system would be a function of time; depending on the building. On the soils and on the building, we found that the frequency during that -- apparent frequency.

So, this is not the fundamental frequency. It is a frequency that you see during vibration. That can go down as much as 50 percent. Okay. This was not in all buildings, but in quite a few, it wold go down 30, 40, 50 percent.

Then, curiously enough, after the earthquake it went up again. We do not know exactly what the explanation for that effect might be, but I thought it might be worthwhile to mention it.

It is definitely so much. Okay? But I don't know exactly why.

DR. SMITH: I don't think the problem is resolved by any means. I would suggest that you keep at least two factors separate in your mind in considering it. One is shift, which may occur in frequencies, as just mentioned. The other one would be ignorance of what the frequency is in your policy as to a design requirement might be different for those two kinds of things.

For example, for the shift part, you might be willing to conced that by the time the structure sees an earthquake of SSE size, the shifting would be predominantly done. That is a type of earthquake that you are most interested in evaluating the safety for.

So, you might not consider that shift so vigorously as some other.

DR. TRIFUNAC: The numbers, I said, are variations during excitation. So, if you have the estimate of the frequency of the building in the very first part of earthquake shaking, it is so much; using strong shaking, it could be down 30, 40, 50 percent.

This assumes that you know the frequency before the earthquake with 100 percent certainty. So, if you are doing the analysis for the future case, the overal uncertainty, of course, is much bigger than the numbers I gave.

DR. OKRENT: It is not clear to me whether the multiple time history approach would pick up John's concern if en each case you analyzed a piece of equipment or a structure the same way.

Would it show the cover -- would it show what is suggested by the [illegible] efforts?

MR. O'BRIEN: If you have a 5 hertz single degree of freedom system and you are excited at 8 hertz, it will move at 8 hertz. What I thought Paul was doing by considering as suite of time history was spreading predominant energy over a

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wide band.

You will always get a residence at the natural frequency. So, you couls say there are two contributors to depressing the peaks in the full response spectra and elevating the valleys.

Perhaps the minor one is the energy content of the excitation, or the input, or the earthquake. The major one, however, is the first, what you might call low amplitude frequency of the structure. There is some problem in estimating that, a very small amplitude frequency.

Then, on top of that, there is a shift which we don't know about. It is usually a downward shift. so, as Dr. Trifunac just noted, there are two possible errors in locating very sharp peaks which, heretofore is the only kind of full response spectra we have seen, very sharp peaks with all the resident energy located at -- by the way, that resident energy is the soil modes.

We all know the grave uncertainties there where essentially all the deformation is in the soil and the structure is moving as a rigid body.

So, we have, first of all, great ignorance on the low amplitude frequencies. On tope of that, we have additional uncertainties due to the shift in frequencies as the motion increases during the earthquake.

If you think about design, this spreads the energy out because initially the equipment is going to respond at the low resident frequency. Then it is going to shift as the earthquake amplitude increases.

The only way to cope with that, I think to assure that you do not experience failure at the low amplitude -- it is possible, by the way. It could fail more readily at the low amplitude than at the higher amplitude because the frequency is shifting in an unfavorable way.

So, the only way to deal with the whole earthquake is to spread it out, I think.

DR. SMITH: I think all of the concerns that I have herd are covered by our recommendation which is the 10^{-1} in multiple analysis, because we do not spell out the precise policy or effects that you should account for.

I mean, this is one point where you are getting into kind of a probabilistic analysis. You ultimately have to accept the fact that you have some probability exceedance. We recommended an acceptable probability of exceedance, but not set high to get it.

DR. TRIFUNAC: The multiple analysis conceptually may not have enough broadening to include like repeated analysis. In my look at analysis of this parameter or that parameter in the system, but that is only the degree by which we know to model the system.

These changes we see during large earthquakes or moderately large earthquakes are in addition beyond that.

My guess would be is if you did half a dozen analyses you would have a distribution of results which is indicative of having, say, very low amplitude of vibration test of a building, and compare that with the calculation, or somebody else does the calculation.

You have those uncertainties, but the fact is that there is a definite change of the apparent frequency with which the whole thing is going. Not the building only, but the whole thing as a function of time during the earthquake.

DR. SMITH: You rapidly get into the whole question of the sense in which linear analyses are appropriate and/or "equivalent."

In the type of scenario you lay out, you could get a different "modal frequency" for each second of excitation, perhaps if a building is responding in a manner that you suggest.

So, you know the question is what do you do about it. We have made a recommendation which is a very precise and how you achieve it is something else, again. It is a target.

I think it is a good example of a target, that if it is okay -- I don't know if it is completely okay -- it is of the recommendation.

But from that target, an awful lot of decision is going to be made.

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MR. ZUDANS: Paul, could you refresh my memory? When you did the multiple time history analysis, you then directed towards the envelope spectra of these analyses. To each history, there is a correspondence to certain response spectra for every point in the system.

You did some spectra-selected in some fashion, which I want to find out how the results, how are these different? Each one will have a sharp peak.

That may be at a different location. Now if you took those response spectra from each of the histories and then envelope them and say that this is the spectra that you will use; then I could see that you broadened the peaks.

If you did something else, you would not broaden, because it is still a linear analysis, still a sharp distinct peak. How was it done? I do not recall.

DR. SMITH: Number one, we specifically recommended against enveloping. That is specific in the report to recommend against that practice. The 10^{-1} or mean standard deviation of spectra from a number of analyses will be broadened because each one, depending on how many you do, will be at a different frequency.

The end result of that will be a broadened spectra.

MR. ZUDANS: Each one has a broadened peak?

DR. SMITH: That is correct. The end result of that type of calculation will be -- the distribution that went into mll

the uncertainty, that distribution is symmetric.

Then that broadened peak, say, for the first mode will be at the same frequency that your one analysis might have assumed. The end result of the 10^{-1} requirement or mean plus the standard deviation requirement will be a broader or suiter type spectrum.

MR. ZUDANS: It will appear, then, one will have to see by some fairly comprehensive examples as to what kind of broadening you really get, because the broadening requirement is real.

I do not see how you can drop it unless this process produces enough broadening to justify what we have seen.

DR. SMITH: You rapidly get into probabilistic analysis in this type of scenario. You have to understand what your objective is and what it is not.

If your objective is to envelope everything in sight, then I'm not sure that --

MR. ZUDANS: My problem is this: That I know the only peak that I can get is shock by my analysis. So, if I have a spectra, then I will do everything possible to get outside of that peak with my analysis, because my analysis will show a single point.

So, if I do not broaden it, I do not need to cheat very much to get out of trouble.

DR. SMITH: Okay. People are designing supports to be

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in valleys.

MR. ZUDANS: That's right. That's right. I would do that too. There is nothing illegal about it. All I need to do is mis-design a little bit and I'm out.

Supposing I made this little bit adjustment, which may come out not right, a little bit of a mistake. Also, your spectra is a little bit off because it could vary 50 percent -- as much as 50 percent what I hear.

So, I think that broadening cannot be written off that easily.

DR. OKRENT: This looks like a topic of some interest. I'm glad I asked Mr. O'Brien to discuss it. Let's go on.

DR. SMITH: In the area of soil structure interaction, we recommended [illegible] ement of some words which are not too significant. The direct solution is equivalent to the one-step substructure direct solution approach, substructure is --

MR. ZUDANS: I have a question. What you call substructure is really the continuum method, right?

DR. SMITH: Yes.

MR. ZUDANS: Where would you put the classic type of solutions?

DR. SMITH: Classic would be a substructure. I don't think it isintended that every substructure is --

MR. ZUDANS: Substructure is really just a numerical technique. It does not have much to do with what what kind of theory there is behind it. So, it is a continuum approach that you are talking about.

I could do it without substructure too.

DR. SMITH: I think that is fine. For one reason or another, some people felt it was important to use different terms than the ones that have been used.

MR. ZUDANS: As long as I understand. Call it anything you want as long as I am sure that is what you mean.

DR. SMITH: Yes, that is it.

(Slide.)

The advantages, disadvantages, and methodology associated with both methods, direct solution, and substructure were identified as a couple of examples here.

I have the direct solution has the capability, for example, of addressing the secondary, non-linearity aspects that some people think you should.

Others do not. A substructure approach, at least, has some capabilities that exist. For example, classic can address the three dimensional aspects of the problem. All of them are limited to linear analysis.

Recommendations were made regarding the non-linear soil behavior. For the present in design, we recommended that you approximate the non-linear soil behavior using linear techniques and spend your money rather on sensitivity studies, or bonding solutions as opposed to -- in other words we are recommending that you not require non-linear analyses for design purposes in nuclear power plant construction.

There were some limitations identified about shear modulus and hysteretic soil damping. Again, here the multiple time history analysis with parameter variations enters into all these type of calculations.

We made a recommendation on slanted soil layering from the presentation earlier, I saw it was not too unlike it. Incidentally, the report that we saw at the beginning of the A-40 block on soil structure interaction was one of the reports we had at our disposal for these recommendations.

(Slide.)

The response spect um input motion or time histories for the soil structure interaction analyses are to be specified at the preservice or foundation rock as opposed to some point in between.

In a position some time ago, it may be the one in the standard review plan at this time. It specified the so-called control elevation at the foundation of the structures. So, this recommendation was to clarify that.

Models and analytical techniques for deconvolution must be consistent with the free field and soil structure interaction computations. As we saw, some discussion of problems with deconvolutions discussed earlier, this would specifically recommend that you, for example, not use SHAKE with FLUSH, two

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codes that have been used for analyses in the past.

These are not consistent formulations of the dynamics. SHAKE should not be used as FLUSH. FLUSH, I believe, has a deconvolution option in it. That option is more appropriate for a FLUSH analysis.

This is kind of a game. A game that you are playing here in the absence of having all the information you would like, you are forced to accpet the seismic input, defined in some way other than you would like.

So, the two analyses should be consistent with one another. Additional studies are required on the amount and location of acceleration reduction due to embedment effect. In my recollection, this is the most controversial area that the team ran into.

They could not agree, so we recommended that there be additional study on this recommendation in the present standard review plan.

There is the so-called 60 percent rule. That is acceptable. We did not make such a recommendation, but further made a recommendation that further study be done on this issue.

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(Slide)

DR. SMITH: We are late. I will try to hit some high points, some detailed recommendations. We did make the recommendation to adopt the new values of damping, which are the ones out of, I believe it is, NUREG 0098, and these are the same ones, I believe, that are being used on the SEP. But those two recommendations are happenstance, to my understanding.

DR. ZUDANS: Just a brief remark. Those two specify stress levels

DR. SMITH: That is correct.

DR. ZUDANS: Is that what you intended to do?

DR. SMITH: It is intended to make the recommendation that damping be dependent on stress level, and I am sorry about that.

DR. ZUDANS: That is all right.

DR. SMITH: We were encouraged to make recommendations without regard to acting for licensing people. That is not our job. So we made the recommendations that we felt made sense.

DR. ZUDANS: Don't misunderstand. It is okay, the recommendations

DR. SMITH: That is correct.

(Slide)

I believe the present standard review plan does not allow direct generation methods, and I cannot quote the exact words, but it requires, say, that the time history method be used for unconservative in-structure spectra. We recommended both in time history and direct methods, and I think the reason we could make such a recommendation is these methods have been developed significantly since the ones back at the time that the standard review plan was developed.

A lot of this is a result of the concern of manipulation of synthetic time histories; and if you are lowering the peaks and raising the valleys, and the valleys are possibly unconservative relative to the recommendations being made, it could have some unconservatism.

Maybe a very important point is we have a number of different kinds of recommendations for different points on parametric studies, and they are much easier to make and more economical with the direct generation methods than with time history. I think, unfortunately for some of us who do non-linear analysis, we must for some time period accept linear methods.

And it is not necessarily the case that they come up with results that are inconsistent with a good design. You do not have to do, you know, from first principles non-linear analyses to come up with good design. But we have a technology problem here, and we are encouraging, and this is consistent with the multiple analysis, the 10 requirement, and 10^{-1} or mean plus standard deviation of .84. We do not distinguish between this.

DR. OKRENT: Would you elaborate a little bit on that recommendation? What do you mean by that? And then I will ask you why that number after you tell me exactly what it means, in your opinion.

DR. SMITH: First, what it means is it is conditional on an earthquake with a peak acceleration equal to the SSE occurring. So you are analyzing your system, your structure or what have you for earthquakes with a peak acceleration equal to the SSE value, and so that 10^{-1} or .84 exceedance probability are conditional on that event. So this is really roughly comparable to the very basis for, say, RG 1.60 where that was applied at the beginning, and here we are applying it, can be applied at any stage that you like.

DR. OKRENT: That is .84 probability, not exceeding what, now, as you are stating it?

DR. SMITH: Let me state it another way, since I am not so sure that that reads right. The value that you select for a design should have a 10^{-1} probability of exceedance. You needn't charge a value larger.

DR. TRIFUNAC: It is the opposite.

DR. SMITH: That is what I think I am telling, what the recommendation is.

DR. OKRENT: Tell me what you think the

recommendation is.

DR. SMITH: You should choose a value, say, of floor spectra. You are going to develop in-structure floor spectra now in the design of some piece of equipment, perhaps. The value that you select for that floor spectra should have a 10^{-1} probability of being exceeded, conditional that you derive --

DR. OKRENT: Exceeded by what? You say exceeded by a real earthquake by one of your postulated time histories, and is it exceeded with some range or at any single frequency?

DR. SMITH: At any single frequency. The value has a proabability of 10^{-1}.

DR. OKRENT: At each and every frequency?

DR. SMITH: Yes. That corresponds roughly to mean plus one standard deviation.

DR. OKRENT: In other words, suppose I took my frequency band -- I don't know whether I would do it logarithmically or linearally. Let's simply say I take it from .01 to 25. Can I exceed it between 1 and 2 hertz over that whole range, or maybe 1 in 3 hertz, and by a large amount, and still have met this criterion, if everywhere else it is below?

DR. SMITH: No.

DR. OKRENT: That is what I am asking you. What do you mean by this --

DR. SMITH: In this case it is frequency by frequency point. So the value of the response vector that you set up at 1 hertz, for example, or any frequency, should have a 10 percent probability of being exceeded.

DR. OKRENT: Being exceeded.by what?

DR. ZUDANS: It says here on page 6 it would be exceeded if an SSE occurs with a given acceleration.

DR. OKRENT: Everyone has been telling me -

DR. ZUDANS: Page 6 is missing. That is why I didn't understand.

DR. OKRENT: What does the word "SSE" now mean when you are using it? It is not really specified by --

DR. SMITH: If earthquakes with a peak acceleration equal to the SSE occur, by specifying only the peak acceleration you have not made much of a specification at all. You see, you tell me what you feel th appropriate time history is. Let's think in terms of the time history method of analysis, say for a structure and in-structure spectra, and you select the time histories, earthquakes, whatever, that you feel are appropriate for use in your analysis, and you do your analysis with whatever frills that you like insofar as uncertainty and the like, and you will get different spectra.

You have seen plots from some of our results. It is quite noisy, really. Now, if you look at any given frequency, you can think in terms of the distribution that you car characterize by, for example, the mean standard deviation, by the very spectral values.

DR. OKRENT: Excuse me. So you are saying in terms of some previously specified family, of shapes of acceleration versus time or whatever previously specified for that family, the probability should be 84 percent, the non-exceedance. Is this what it is you are saying?

DR. SMITH: That is right. The frequency point by frequency point.

DR. ZUDANS: Do you live with just those seven histories that you suggest we use and pick from them?

DR. SMITH: At a minimum of seven.

DR. ZUDANS: Okay. You are really looking at the distribution of response spectra value at that point.

DR. SMITH: In reality you have a distribution, you have an uncertainty associated if you are looking at in-structure spectra, an uncertainty associated with any coordinate at any different frequency, and we say the value you should use for design corresponds to some upper limit there but it is not the envelope.

DR. LUCO: May I ask a favor?

DR. TRIFUNAC: I would appreciate it if you would erase 84 percent and put average put standard deviation, because I think this is what you mean. I tried to point out to a lot of people that the normal distribution is violated in every structural response, almost every structural response in the whole package.

The second significant figure is really -- just call it average plus standard deviation. Everyone will agree.

DR. SMITH: That will be the case in the report. Dr. Zudans, you find a contradiction.

DR. TRIFUNAC: This is standard deviation if it is log normal, but not if it is not log normal.

DR. SMITH: Your point is well taken.

DR. ZUDANS: Do you make any recommendations which I did not see? How do you pick the seven or more history?

DR. SMITH: No.

DR. ZUDANS: So they run the same history seven times?

DR. SMITH: No.

DR. LUCO: I do not understand. When you refer to time histories, if you are going to use a probabilistic approach, you are not going to use time histories. You are going to use spectral density or something like that. The whole idea in there is to get away from time histories.

DR. SMITH: Okay. I do not necessarily agree. You could go either approach, but I think in a previous slide we recommended that you use other time history methods or direct methods which are equivalent to those. What you have to do and what you do do, I do not know. I understand the point. I understand where you are coming from. I don't necessarily accept it as a given.

People may have for some period of time much more -- I mean we are going from, say, a stage in this technology where we do one-time history analysis to where we are going to do something else. Maybe the appropriate intermediate state is to do more than one-time history analysis preparatory to something else.

DR. ZUDANS: All of your recommendations are based on the deterministic.

DR. SMITH: I believe -- whichever one it was -- it said that equal acceptability should be given to time history methods or to direct methods, which are essentially power spectral density methods. We understand, but I have not seen analyses, that it is simpler and easier to reflect the uncertainties in the model properties. I mean that was. We can go find it if you cannot find it there. That was a recommendation that either approach be used.

DR. LUCO: I think their problem is how do you define probabilistic methods? Are you trying to do a Monte Carlo type of thing?

DR. SMITH: you can think in terms of if you do multiple time history analysis, that it is Monte Carlo, but I don't think you need think in terms of randomly selecting the parameters that you use for your parameters, which would be a brute force type of Monte Carlo. There are other methods. With that type of an approach, it takes a very long time to get to the extremes. It takes a number of trials to get to the extremes of whatever particular distribution that you are using. You need not restrict your thinking to that kind of straightforward brute force Monte Carlo. But I would not argue with the use of the term "Monte Carlo" for what we proposed.

DR. LUCO: Could I ask other questions?

DR. SMITH: I don't want to interrupt, but I think the bottom line is that there is concern on a couple of issues. One is single time histories, and two is uncertainty of various kinds. We recommended that it be addressed in some way. If it is addressed in some other way as a result of whoever's deliberations, that is fine with us; but it needs to be addressed, I think, a little differently than it has been.

DR. TRIFUNAC: I think you would avoid a lot of troubles and a lot of questions if you did not talk about time histories, if you just said probabilistic approach with a transfer function characterization of what you want to do, floor response spectra or particular motion or something in that way. Don't use the floor spectral approach. You don't have those, either. And again, that opens a can of worms.

But if you just said the probabilistic approach with the transfer function, the methodology used to get the end result, you are opening a lot of doors and you are not restricting anything, and I think you are saying exactly what you want to say, just in a different way.

DR. SMITH: Fine. Unfortunately, the report will not be changed. I hear what you are saying. I think, on one hand, if people were and are familiar with what they can do with time history analyses and understand some of the limitations and some of the benefits, then I think it makes sense from a technological standpoint, if not, perhaps, a strictly technical standpoint, to move with one set. Maybe you don't use it in design but maybe you use these as checking methods on the methods you might propose.

But I do not disagree with that, and I hope that that is the sense of our recommendation. Maybe I should get it out here. Either approach is acceptable. We did not say power spectral density, but we said direct methods, nd that is exactly what you are suggesting, direct methods.

DR. OKRENT: Dr. Luco had another question.

DR. LUCO: My question has to do with the integration of the different recommendations. You have recommendations on the soil structure interaction and so on, but they must be compatible. For instance, on the part dealing with design spectrum, the concept of an effected acceleration is still there. For structures with large foundations you could use an effected acceleration.

Now, if you are going to use soil structure interaction, any effect of scattering by foundation and so on will be immediately incorporated, so it will not make any sense to have that effective acceleration.

DR. SMITH: I agree. I was not the only person making the recommendations.

DR. LUCO: If you are not going to do soil structure interaction analyses, still you would have to explain what do you mean by effected acceleration. Is it to account for the soil structure interaction effects and results doing a complete analysis? If that is so, then the question of damping comes.

The new proposed values for damping are fairly large based on information, which is affected by the effects of the soil. So I would be willing to use those large values if soil structure interaction effects were not considered and if the soil properties were similar to the soil properties where the data was obtained. In addition, the structures would have to be similar. But if you are going to use soil structure interaction which is going to use additional damping, you could not use those large damping values.

So I think there is a need to integrate all of these recommendations. Also, at the very beginning you have recommendation of using the Newmark-Hall procedure, in which you start from peak velocity, peak acceleration. Then you multiply by some factors and you use the mean plus one standard deviation spectra.

But later on you say that peak acceleration -- and this is on page 18, recommendation 6(a) -- you equate that mean plus one standard deviation or spectra -- the value of that spectrum at high frequencies with the peak acceleration.

DR. SMITH: I do not have you version of the report. Is that in the section on the SSE? I cannot speak to that recommendation except that is what it is. It was confusing to me and I questioned it a couple of times, and that is what came back from the various consultants involved in that.

I think that was one where I made a comment on one of my earlier slides that the mean plus one standard deviation --zero period acceleration was to be used in those cases where you had a tectonic structure well-defined, such as in the West, and you use the mean in other cases. At least that is the sense of the recommendation But I can't really speak to it.

DR. ZUDANS: That is correct.

DR. SMITH: So that does refer to the peak acceleration. That is my understanding, yes. But that was just the recommendation on the value of peak acceleration that should be selected going to that sort of process as opposed to a mean value. I don't know whether I would say it is more or less conservative vis-a-vis the East or how it would stand vis-a-vis the 3/4 g at Diablo Canyon. I have no idea.

DR. LUCO: The way it is written there, it is not clear, at least to me, how this would be done.

DR. SMITH: There does remain a great deal of work to be done for any of the recommendations that are accepted to be cast in the form of standard review plans, if that is to be done, and clarification of the types can be made at that time, I think. This is precisely one of the purposes of having a meeting of this type.

DR. LUCO: The recommendation has to do with tortion, and I believe a 5 percent eccentricity is proposed there.

DR. SMITH: I believe it is in addition to any actual. I would have to look it up. I believe that is the recommendation.

DR. LUCO: But that, again -- you would use that only if you did not consider inclined waves. But if you do consider more general type of excitation, that will produce tortion, so you do not want to add that to an additional eccentricity.

DR. ZUDANS: That would only be possible if he did not use that, the first method, he did not do that. I think that is what he is implying.

DR. SMITH: I do not recall a discussion centering on an alternative type you suggest. You are speaking to the question of tortion itself regardless of whether the soil structure interaction method that you used had the capability of inducing tortion by virtue of its capability.

DR. LUCO: I will agree with that recommendation if you are going to consider only vertical waves. But if somebody decides to try to consider a more general seismic excitation, they should not be penalized twice with respect to tortion.

DR. SMITH: There was another way of questioning it which I questioned, that effect can be treated in the parameter variations. But my view did not win out.

DR. LUCO: I am assuming actual eccentricities should be reflected.

DR. OKRENT: Paul, maybe you ought to flash on -- I think you have two or three more Vu-graphs, and see if there are specific comments there. If possible, I would like to finish this topic in five or ten minutes.

DR. SMITH: I think we can do that. There was only one major topic to cover, and that is this one, recommendations made that the SRP should require more testing for seismic design to increase confidence in analytical methods, and also to get some idea of failure levels.

DR. OKRENT: On the previous one, you said something about the OBE. Could you put that one up?

DR. SMITH: Oh, yes. That was the number of operating basis earthquakes recommended to be at two, whereas I believe the present requirement is five. This was just the judgment of the group.

DR. OKRENT: Five, you said?

DR. SMITH: I believe the present requirement in those cases where you have this kind of -- if you want to call it low cycle fatigue -- they require five operating basis earthquakes.

DR. OKRENT: Okay.

DR. TRIFUNAK: The previous Vu-graph --

DR. SMITH: I guess that is kind of a justification for it from some persons. Look at the data. The OBE acceleration is more than 90 percent non-exceedance probability during a 50-year life. That was the basis for the recommendation. This was felt to be more than you needed.

DR. OKRENT: On the last point, if you get the SSE, how do you figure after-shocks in there, or don't you?

DR. SMITH: I amk not aware that much is done along those lines.

DR. OKRENT: They will be larger than your OBE or like your OBE. It will come after instead of before. It is all right.

(Slide)

I want to mention at this point here that there was a reg. guide and standard review plan on this, and that concludes the presentation.

DR. OKRENT: Are there any other comments now?

As I indicated earlier, I think we would like to have the consultants provide us with comments in those areas in which, to use one of the other speaker's words, they feel either expert or -- those are his words, now my words -- where they would like to make a comment, whether they feel expert or not.

NRC
6/4

dsp r&t
tape 9

DR. SIESS: You had better define "expert."

DR. OKRENT: I said, I gave you a different basis. If you want to make the comment, that is sufficient reason. You do not have to feel --

MR. THOMPSON: Your expertise --

DR. SIESS: Well --

DR. OKRENT: Somehow we drifted back to the original agenda. I cannot understand how.

(Laughter)

DR. ZUDANS: If you had not changed the agenda originally, we would not be here.

(Laughter)

DR. OKRENT: There is supposed to be one more discussion on budget, which I guess would have to be a closed session, which we would start on right away in terms of what your latest figures are.

So I would propose we would take a seven or eight minute break and then go into a closed session to talk about your latest figures. And Dick, you can arrange it with the reporter.

(Thereupon, at 9:00 p.m., the the meeting in the above-entitled matter was recessed to go into executive session.)

end 9
end job

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

____

in the matter of: ACRS - Subcommittee on Extreme External Phenomena

Date of Proceeding: June 4, 1980

Docket Number: ____________________

Place of Proceeding: Washington, D. C.

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

David S. Parker

Official Reporter (Typed)

[signature]

Official Reporter (Signature)

6/14/86
Tape 1, Site
(Level) I.

NRC SYSTEMATIC EVALUATION PROGRAM

SEISMIC REVIEW

- PROGRAM OVERVIEW - HOWARD A. LEVIN (NRC)
- BASES FOR SEP RE-EVALUATION/DRESDEN 2 OVERVIEW
  - WILLIAM J. HALL (U. OF ILL.)
- DRESDEN 2 STRUCTURAL RE-EVALUATION - ROBERT P. KENNEDY (SMA)
- DRESDEN 2 MECHANICAL/ELECTRICAL RE-EVALUATION
  - JOHN D. STEVENSON (WOODWARD-CLYDE)

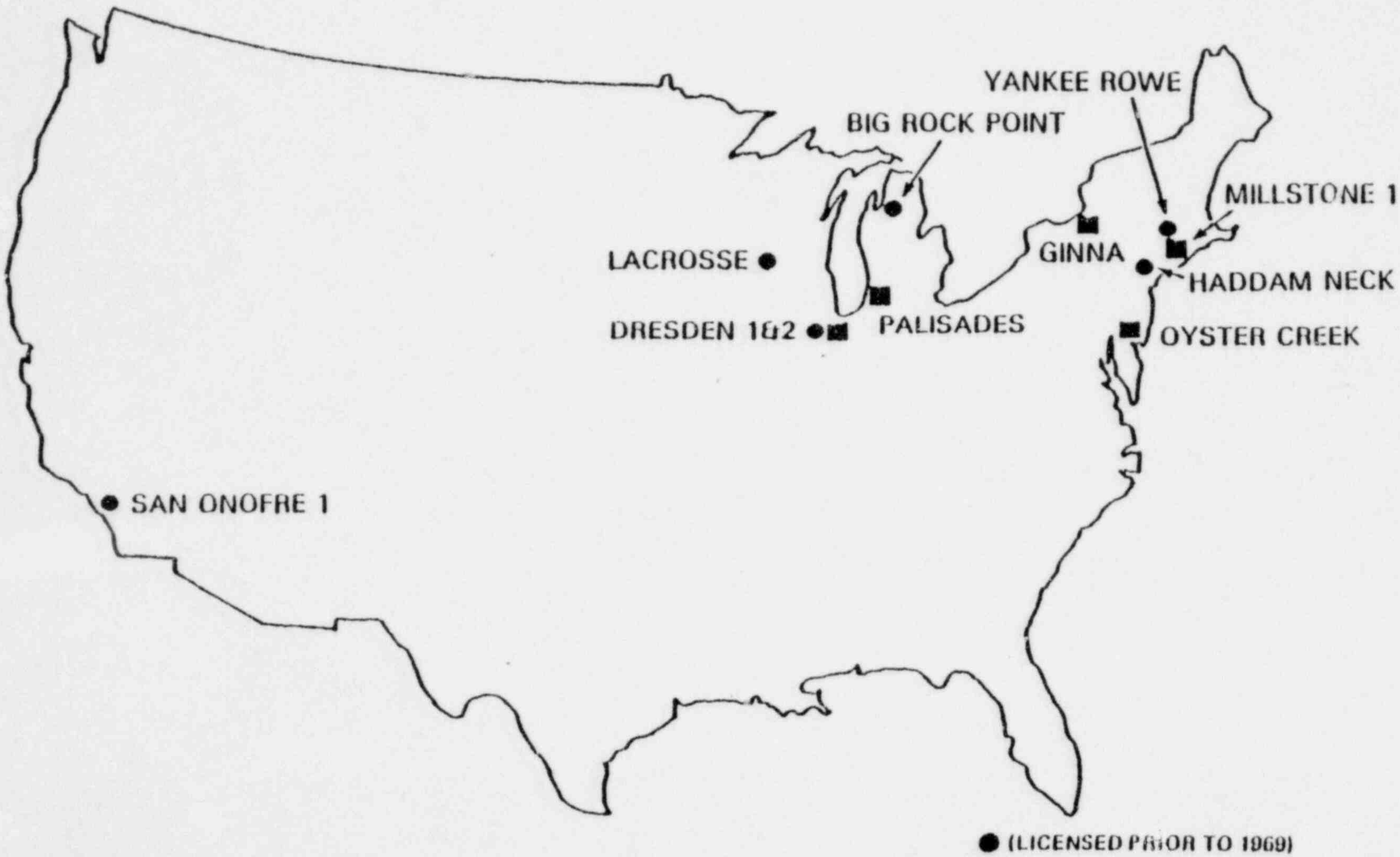
NRC SYSTEMATIC EVALUATION PROGRAM

SEISMIC REVIEW

PROGRAM OVERVIEW

- INTRODUCTION
- GENERAL PHILOSOPHY
- OVERVIEW OF REVIEW PROCEDURE
- SEISMIC HAZARD DETERMINATION
- PRELIMINARY CONCLUSIONS
- ANCHORAGE AND SUPPORT OF SAFETY-RELATED ELECTRICAL EQUIPMENT

PLANTS FOR PHASE II REVIEW



PERTINENT FACILITY DATA AND SEP SEISMIC REVIEW GROUP CATEGORIZATION

FACILITY	LOCATION	NOTICE OF CONSTRUCTION PERMIT HEARING	REACTOR TYPE	CAPACITY MWe	SEP SEISMIC REVIEW GROUP
DRESDEN 1	MORRIS, IL	5/4/56 CP ISSUED	BWR	200	2
YANKEE ROWE	ROWE, MA	9/4/57	PWR	175	2
BIG ROCK PT.	CHARLEVOIS, MI	2/19/60	BWR	75	2
LACROSSE	GENOA, WI	12/21/62	BWR	50	2
SAN ONOFRE 1	SAN CLEMENTE, CA	10/16/63	PWR	430	2
HADDAM NECK	EAST HADDAM, CN	2/29/64	PWR	575	2
OYSTER CREEK	FORKED RIVER, NJ	12/23/64	BWR	640	1
DRESDEN 2	MORRIS, IL	10/25/65	BWR	809	1
GINNA	ONTARIO, NY	3/3/66	PWR	490	1
MILLSTONE 1	WATERFORD, CN	3/18/66	BWR	652	1
PALISADES	SOUTH HAVEN, MI	1/19/67	PWR	700	1

GENERAL PHILOSOPHY

- GOALS
  - OVERALL SAFETY ASSESSMENT
  - COMPARISON TO CURRENT CRITERIA
- CONCEPTS
  - RECOGNITION OF INHERENT RESISTANCE CAPABILITY
  - UTILIZATION OF REALISTIC METHODS FOR DETERMINATION OF SEISMIC HAZARD AND EVALUATION OF RESISTANCE CAPABILITY
  - DETERMINATION IF PLANT MEETS "INTENT" OF CURRENT CRITERIA
  - CONSIDER BACKFITTING IN ACCORDANCE WITH 10 CFR 50.109
- PRIORITIES
  - REACTOR COOLANT PRESSURE BOUNDARY
  - SAFE SHUTDOWN SYSTEMS
  - ENGINEERED SAFETY FEATURES

SEP SEISMIC REVIEW PROCEDURES

- GROUP 1 - NRC STAFF/CONSULTANT REVIEW OF EXISTING INFORMATION WITH SUPPLEMENTAL EVALUATIONS BY REVIEW TEAM FOR SPOT CHECKING AND CONFIRMATION OF JUDGMENTS

- GROUP 2 - NRC STAFF/CONSULTANT REVIEW OF NEW LICENSEE SEISMIC DESIGN EVALUATIONS WITH SUPPLEMENTAL EVALUATIONS BY REVIEW TEAM FOR SPOT CHECKING

ROLES OF SEP SEISMIC REVIEW PERSONNEL

. SENIOR SEISMIC REVIEW TEAM (SSRT)

N. M. NEWMARK, CHAIRMAN (NMN)
W. J. HALL, VICE CHAIRMAN (U. OF ILL.)
R. P. KENNEDY, (SMA)
J. D. STEVENSON, (WC)
F. J. TOKARZ, (LLL)

- RECOMMENDS REVIEW CRITERIA AND PROCEDURES
- DEMONSTRATES REVIEW APPROACH FOR DRESDEN 2
- PROVIDES OVERSIGHT FOR SRT REVIEWS
- PARTICIPATES AT SITE VISITS
- PROVIDES CONSULTATION ON SPECIAL PROBLEMS

. SEISMIC REVIEW TEAMS (SRT)

- NRC STAFF, LLL PERSONNEL AND SUBCONTRACTORS
- IMPLEMENTS SEP SEISMIC REVIEW PROGRAM
- CONDUCTS SITE VISITS
- CONDUCTS CONFIRMATORY EVALUATIONS
- REVIEWS LICENSEE SUBMITTALS
- DOCUMENTS RESULTS
- RESOLVES ALL OPEN ISSUES

GROUP 1 REVIEW APPROACH

- DEVELOP REVIEW PROCEDURE/BASES FOR RE-EVALUATION (NUREG/CR-0098)
- IDENTIFICATION OF CATEGORY 1 ITEMS
- DOCKET REVIEW
- REVIEW OF SUMMARIZED INFORMATION FROM LICENSEE, A-E, NSSS AND VENDOR FILES
- SITE VISITS
- REVIEW OF DETAILED INFORMATION FROM LICENSEE, A-E, NSSS AND VENDOR FILES
- DEVELOP SIMPLIFIED CONTEMPORARY MODELS (E.G. TO ESTIMATE 3-D EFFECTS VS ORIGINAL 2-D)
- CONDUCT SCREENING ANALYSES/EVALUATIONS (E.G. TO CONFIRM REVIEW TEAM JUDGMENTS)
  - STRUCTURAL RESPONSE
  - IN-STRUCTURE SPECTRA
  - EVALUATE SELECTED PIPING/EQUIPMENT
- COMPARE WITH PERFORMANCE CRITERIA
- IDENTIFY POTENTIAL DEVIATIONS
- RESOLVE OPEN ISSUES
- DOCUMENT RESULTS (CONSULTANT REPORTS, SER)

SCHEDULE

GROUP 1 PLANTS

	DRAFT CONSULTANT REPORT	FINAL CONSULTANT REPORT
DRESDEN 2	7/79 C	4/80 C
GINNA	6/80 T	9/80 T
PALISADES	6/80 T	10/80 T
OYSTER CREEK	7/80 T	11/80 T
MILLSTONE 1	9/80 T	12/80 T

GROUP 2 REVIEW APPROACH

. DEVELOP REVIEW PROCEDURE/BASES FOR RE-EVALUATION (NUREG/CR-0098)

. IDENTIFICATION OF CATEGORY 1 ITEMS

. DOCKET REVIEW

. REVIEW OF INFORMATION FROM LICENSEE, A-E, NSSS AND VENDOR FILES

. DEVELOP ACTION PLAN FOR RE-EVALUATION (LICENSEE)

. NRC REVIEW OF LICENSEE'S PLAN

. LICENSEE CONDUCTS EVALUATION

. NRC REVIEW OF LICENSEE'S SUBMITTALS

  - SCREENING EVALUATIONS BY NRC REVIEW TEAM

. COMPARE WITH PERFORMANCE CRITERIA

. IDENTIFY POTENTIAL DEVIATIONS

. RESOLVE OPEN ISSUES

. DOCUMENT RESULTS (CONSULTANT REPORTS, SER)

SCHEDULE

GROUP 2 PLANTS SEISMIC MILESTONES

A.	ACTION PLAN/CRITERIA DOCUMENT COMPLETE	JULY 1, 1980
B.	ANALYSIS AND EVALUATION OF REACTOR BUILDING AND RCPB COMPLETE (SUPPLEMENTAL REPORT, INCL. ACTION PLAN FOR ANY MODIFICATIONS)	20 WEEKS
C.	ANALYSIS OF OTHER CAT. 1 BUILDINGS COMPLETE (FLOOR SPECTRA, RESPONSE PROFILES)	24
D.	ANALYSIS AND EVALUATION OF SAFE SHUT-DOWN SYSTEMS COMPLETE (PIPING, ANCHORAGE OF MECHANICAL/ELECTRICAL EQUIPMENT) (REPORT, WITH ACTION PLAN FOR ANY MODIFICATIONS)	40
E.	STRUCTURAL EVALUATIONS OF (C) ABOVE COMPLETE (REPORT, WITH ACTION PLAN FOR ANY MODIFICATIONS)	40
F.	ANALYSIS AND EVALUATION OF ECCS/ES SYSTEMS COMPLETE (PIPING, ANCHORAGE OF MECHANICAL/ELECTRICAL EQUIPMENT)	48
G.	EVALUATION OF MECHANICAL/ELECTRICAL EQUIPMENT COMPLETE (INCL. OPERABILITY)	64
H.	LICENSEE SUBMITS FINAL REPORTS (WITH ACTION PLAN FOR ANY MODIFICATIONS)	JANUARY 1, 1982

SCHEDULE (CON'T)

I. NRC REVIEW COMPLETE — APRIL 1, 1982

J. ALL FACILITY MODIFICATIONS COMPLETE — JANUARY 1, 1983

SEP SEISMIC REVIEW ACCOMPLISHMENTS

. COMPLETED AND DOCUMENTED DOCKET REVIEWS ON ALL 11 PLANTS

. COMPLETED DRESDEN 2 SEISMIC REVIEW - NUREG/CR-0891

. COMPLETED STRUCTURAL RE-ANALYSIS INCLUDING IN-STRUCTURE SPECTRA FOR GINNA, PALISADES, OYSTER CREEK (MILLSTONE 1 - IN PROGRESS)

. EQUIPMENT QUALIFICATION REVIEWS NEARING COMPLETION FOR GINNA, PALISADES AND OYSTER CREEK

. DEVELOPMENT OF RE-EVALUATION PROGRAM FOR GROUP 2 PLANTS/REVIEW OF LICENSEE SCOPING EVALUATIONS (E.G. YANKEE ROWE, LACROSSE, DRESDEN 1, ETC.)

. REVIEW OF SAN ONOFRE 1 RE-EVALUATION PROGRAM RESULTS

. LACROSSE LIQUEFACTION SHOW CAUSE ORDER

. SUPPORT OF IE EQUIPMENT/I&E INFORMATION NOTICE 80-21

. SITE SPECIFIC SPECTRA PROJECT

DETERMINATION OF SEISMIC HAZARD

. VARIOUS DETERMINISTIC AND PROBABILISTIC TECHNIQUES UNDER CONSIDERATION

- LLL/TERA CORP. SITE SPECIFIC SPECTRA METHODOLOGIES
- SEP LICENSEE SITE SPECIFIC PROGRAM
- OTHER PREDICTIVE TECHNIQUES

. GOALS

- RECOGNITION OF UNCERTAINTY
- UNIFORM AND CONSISTENT TREATMENT FROM SITE TO SITE
- REALISTIC, BUT NOT OVERLY CONSERVATIVE METHODOLOGY
- DEFENSIBLE BASES FOR DECISION

. PRELIMINARY NRC DECISION IS IMMINENT

PRELIMINARY CONCLUSIONS

- STRUCTURAL

  GROUP 1 - ADEQUATE

  GROUP 2 - MAY REQUIRE UPGRADING

- MECHANICAL AND PIPING

  GROUP 1 - ADEQUATE WITH SOME EXCEPTIONS

  GROUP 2 - SUBSTANTIAL UPGRADING WILL BE REQUIRED

- ELECTRICAL

  GROUP 1 AND 2

  A) FUNCTIONAL QUALIFICATION DOCUMENTATION LACKING

  B) ANCHORAGES AND SUPPORTS MAY REQUIRE UPGRADING

ANCHORAGE AND SUPPORT OF SAFETY-RELATED ELECTRICAL EQUIPMENT

PROBLEM

. DEFICIENCIES IDENTIFIED DURING SITE VISITS TO 6 LATER SEP PLANTS

- EQUIPMENT WAS SUPPORTED IN NON-UNIFORM MANNER
- SOME EQUIPMENT LACKED POSITIVE ANCHORAGE
- ANCHORAGE OF SOME EQUIPMENT APPEARED NOT TO BE ENGINEERED
- SUPPORT OF INTERNAL EQUIPMENT POTENTIALLY INADEQUATE
- POTENTIAL INTERACTION OF NON-SEISMIC ITEMS WITH CATEGORY I EQUIPMENT (DOLLEYS, DUCTWORK, ETC.)

ANCHORAGE AND SUPPORT OF SAFETY-RELATED ELECTRICAL EQUIPMENT

. EXAMPLES OF EQUIPMENT FOUND WITHOUT POSITIVE ANCHORAGE

- STATION SERVICE TRANSFORMERS (4160V-480V)
- DC TO AC INVERTERS
- BATTERIES (EMERGENCY DIESEL GENERATOR, DIESEL FIRE PUMP, STATION)
- MOTOR CONTROL CENTERS
- CONTROL PANELS (MG SET, AIR COMPRESSOR, CONTROL ROOM)
- INSTRUMENT RACKS
- BATTERY ROOM MAIN BREAKERS AND DISTRIBUTION PANELS
- SWITCH GEAR

ANCHORAGE AND SUPPORT OF SAFETY-RELATED ELECTRICAL EQUIPMENT

NRC ACTION

. LETTERS SENT TO ALL SEP LICENSEES ON JANUARY 1, 1980

- INSPECT ALL SAFETY-RELATED ELECTRICAL EQUIPMENT FOR POSITIVE ANCHORAGE WITHIN 60 DAYS
- EVALUATE THE ADEQUACY OF THE ANCHORAGE AND SUPPORT SYSTEM
- CORRECT DEFICIENCIES BY SEPTEMBER 1, 1980

. I&E INFORMATION NOTICE NO. 80-21 SENT TO ALL ORs ON MAY 16, 1980

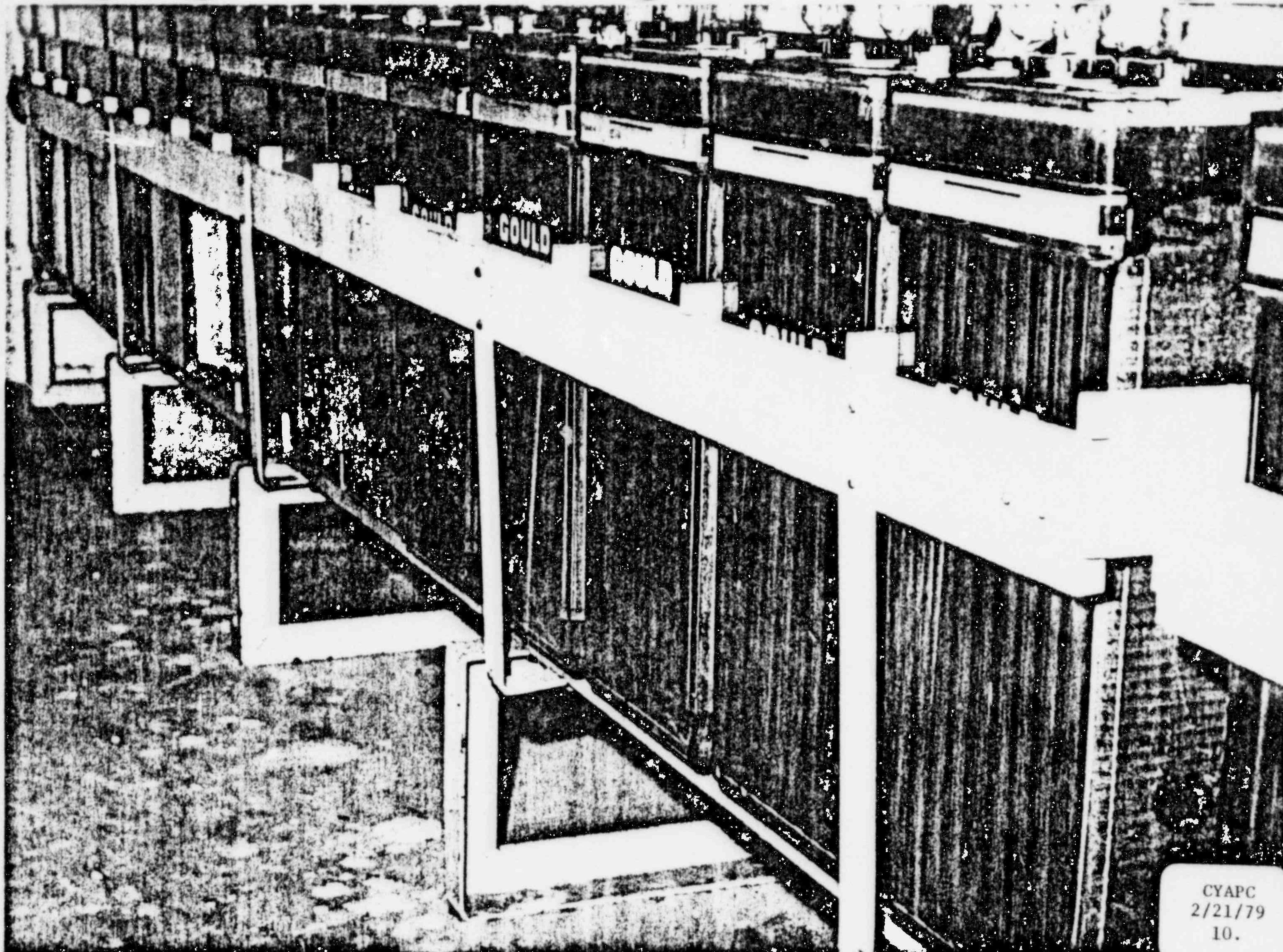
ANCHORAGE AND SUPPORT OF SAFETY-RELATED ELECTRICAL EQUIPMENT

SHORT TERM RESOLUTION

- EQUIPMENT IDENTIFIED WITHOUT POSITIVE ANCHORAGE HAS BEEN FIXED OR WILL BE FIXED PRIOR TO START-UP FROM CURRENT OUTAGES WITH EXCEPTION OF THE BIG ROCK POINT PLANT WHERE FIXES WILL BE COMPLETED DURING UPCOMING SEPTEMBER/OCTOBER OUTAGE

LONG TERM RESOLUTION

- LICENSEES ARE IN THE PROCESS OF EVALUATING THE ADEQUACY OF ALL ANCHORAGES AND SUPPORTS
- TARGET DATE - SEPTEMBER 1, 1980



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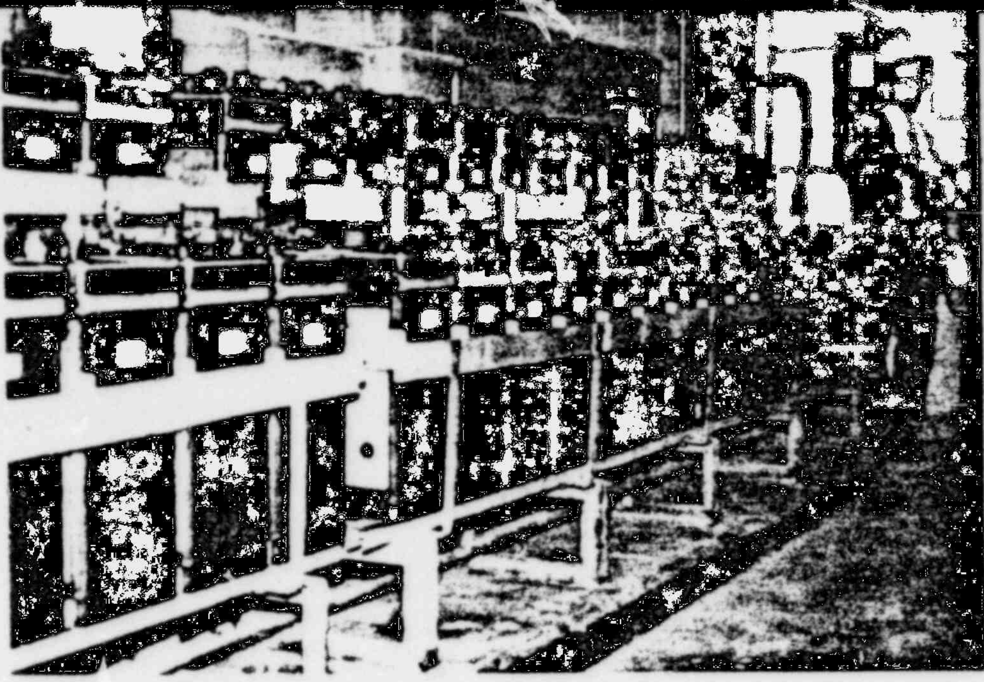

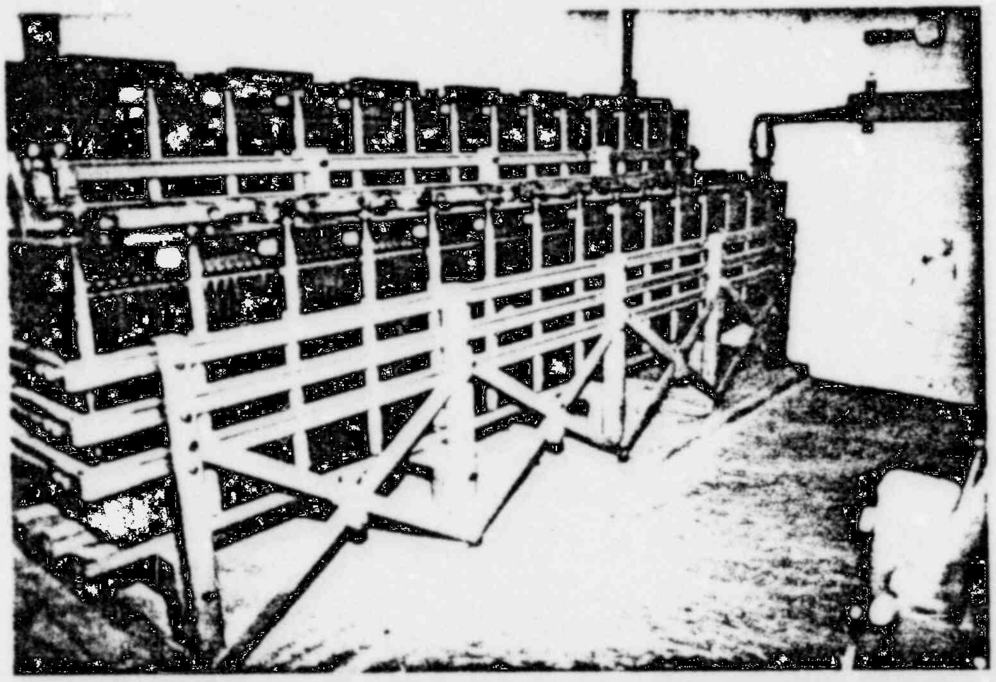

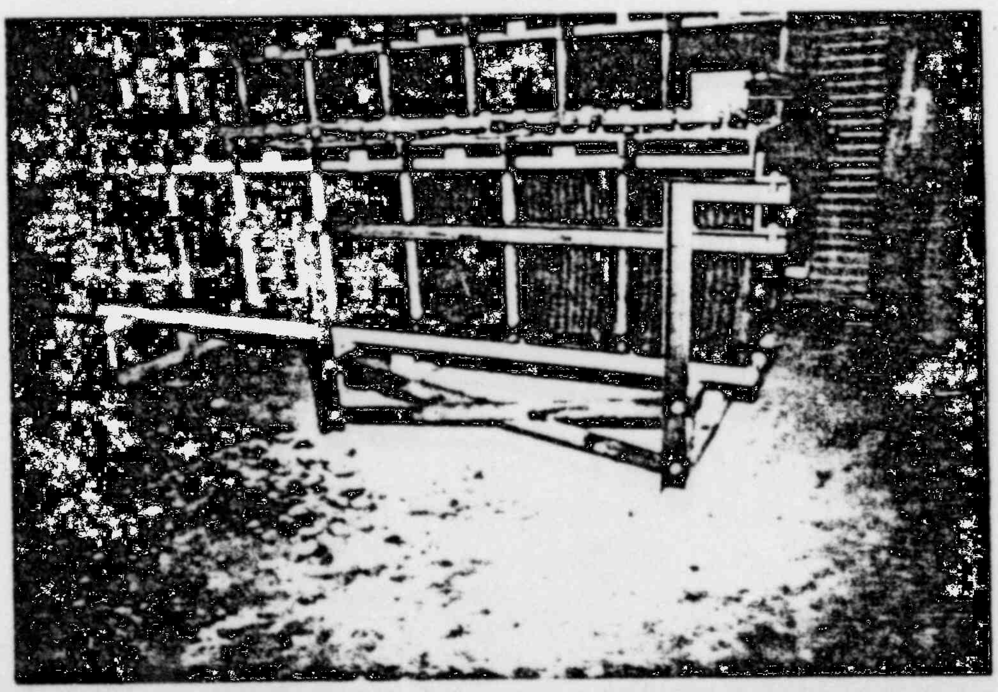

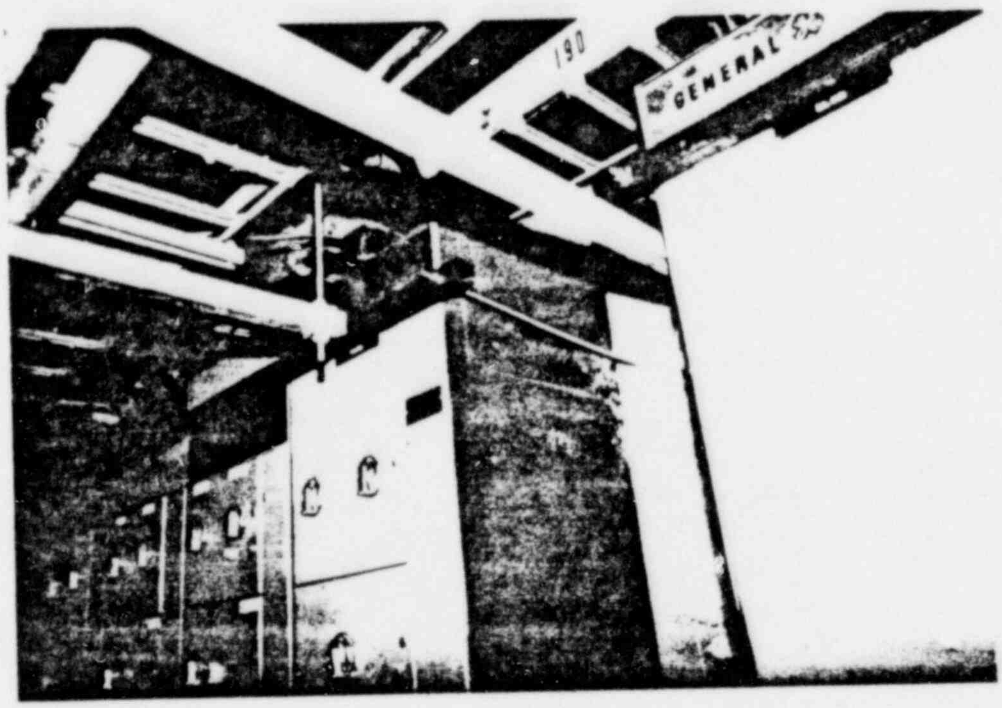
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GENERAL

ORIGINAL SEISMIC INPUT

SITE	SEISMIC INPUT
DRESDEN 1	0.025 - 0.033g UBC (STATIC)
YANKEE ROWE	NONE (110mph WIND)
BIG ROCK POINT	0.025 - 0.05g UBC (STATIC)
LACROSSE	NONE
SAN ONOFRE 1	0.5g HOUSNER (STATIC)
HADDAM NECK	0.17g HOUSNER
OYSTER CREEK	0.22g HOUSNER
DRESDEN 2	0.2g HOUSNER
GINNA	0.2g HOUSNER
MILLSTONE 1	0.17g HOUSNER
PALISADES	0.2g HOUSNER

SEP SITE SPECIFIC SPECTRA PROJECT

FUNDING

	FY 78	FY 79	FY 80
FUNDING (NRR/RES)	120^K ($20^K/100^K$)	230^K ($0^K/230^K$)	290^K ($290^K/0^K$)
EXPENDITURES	75^K	308^K	205^K[1]
CARRYOVER/ DEFICIT	45^K	-33^K	-120^K[2]

SUMMARY

TOTAL PROJECTED EXPENDITURES	760^K (50^K GETR)
BREAKDOWN	430^K NRR/330^K RES

NOTES: 1. YTD (END OF APRIL)
2. PROJECTED

SEP SEISMIC REVIEW FUNDING

	FY 79	FY 80	FY 81
FUNDING	600K	500K	300K[3]
EXPENDITURES	445K	385K[2]	-
CARRYOVER	155K[1]	0[3]	-

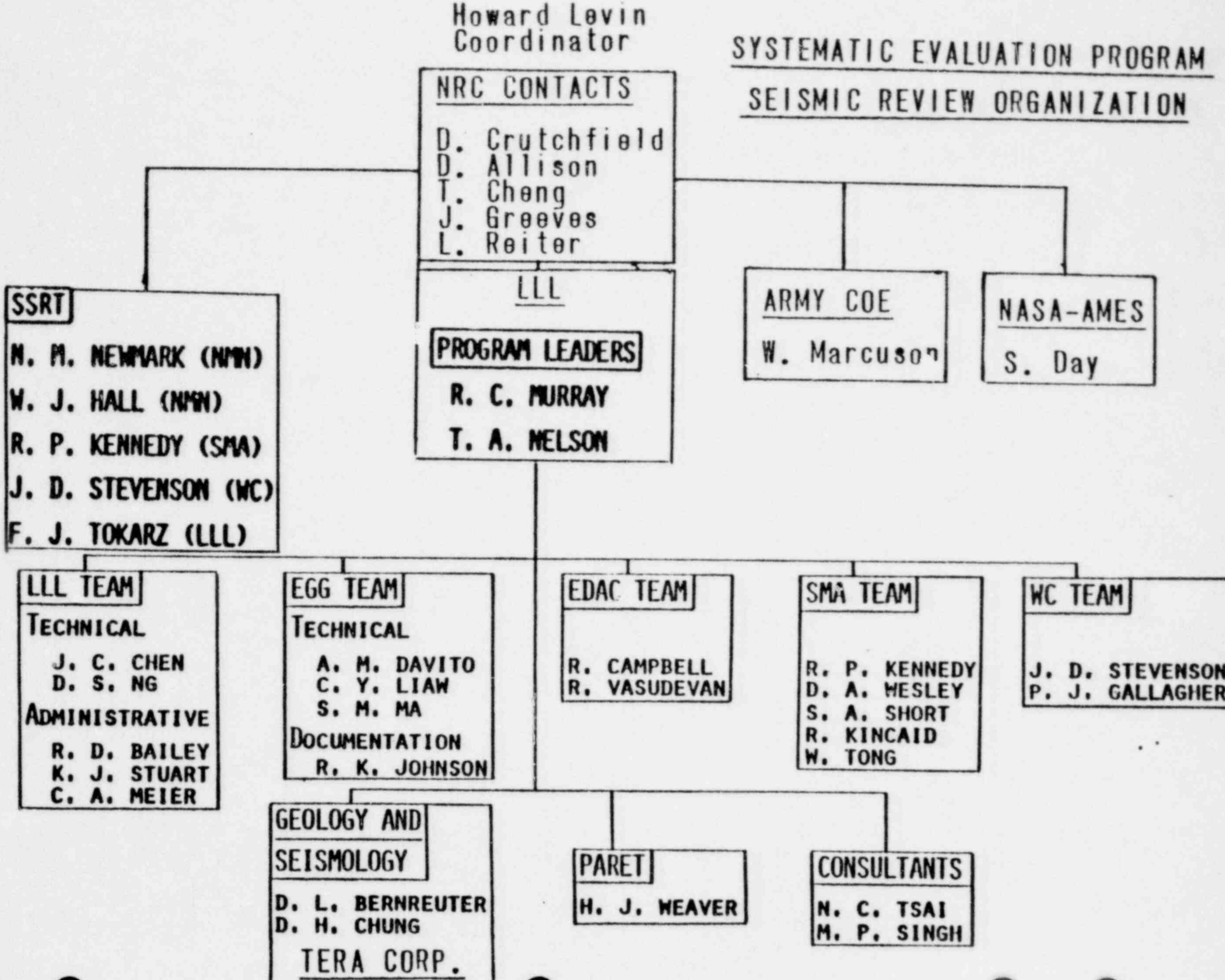
SUMMARY

TOTAL PROJECTED EXPENDITURES 1245K

NOTES:
1. TRANSFERRED TO SSSP
2. YTD (END OF APRIL)
3. PROJECTED

SYSTEMATIC EVALUATION PROGRAM

SEISMIC REVIEW ORGANIZATION



BASES FOR REEVALUATION

- CRITERIA DOCUMENTED IN NUREG/CR-0098 BY N. M. NEWMARK AND W. J. HALL, "DEVELOPMENT OF CRITERIA FOR SEISMIC REVIEW OF SELECTED NUCLEAR POWER PLANTS"

1. SELECTION OF EARTHQUAKE HAZARD
2. DESIGN SEISMIC LOADINGS
3. SOIL-STRUCTURE INTERACTION
4. DAMPING AND ENERGY ABSORPTION
5. METHODS OF DYNAMIC ANALYSIS
6. REVIEW ANALYSIS AND DESIGN PROCEDURES
7. SPECIAL TOPICS (e.g.,BURIED PIPING, TANKS, EQUIPMENT QUALIFICATION)

SUMMARY OF STRUCTURAL DAMPING VALUES
RECOMMENDED FOR SEP VS R.G. 1.61

PERCENTAGE
(CRITICAL DAMPING)

STRESS LEVEL	TYPE AND CONDITION OF STRUCTURE	SEP RECOMMENDATION[1]	REGULATORY GUIDE 1.61
WORKING STRESS, NO MORE THAN ABOUT 1/2 YIELD POINT	A. VITAL PIPING	1 TO 2	1 TO 2
	B. WELDED STEEL, PRESTRESSED CONCRETE, WELL REINFORCED CONCRETE (ONLY SLIGHT CRACKING)	2 TO 3	2
	C. REINFORCED CONCRETE WITH CONSIDERABLE CRACKING	3 TO 5	4
	D. BOLTED AND/OR RIVETED STEEL	5 TO 7	4
AT OR JUST BELOW YIELD POINT	A. VITAL PIPING	2 TO 3	2 TO 3
	B. WELDED STEEL, PRESTRESSED CONCRETE (WITHOUT COMPLETE LOSS OF PRESTRESS)	5 TO 7	4
	C. PRESTRESSED CONCRETE WITH NO PRESTRESS LEFT	7 TO 10	5
	D. REINFORCED CONCRETE	7 TO 10	7
	E. BOLTED AND/OR RIVETED STEEL, WOOD STRUCTURES, WITH BOLTED JOINTS	10 TO 15	7
	F. CABLE TRAYS	10[2]	-
	G. EQUIPMENT	7[2]	-

REF. - 1. N. M. NEWMARK, W. J. HALL, "DEVELOPMENT OF CRITERIA FOR SEISMIC REVIEW OF SELECTED NUCLEAR POWER PLANTS," NUREG/CR-0098 (MAY 1978).

2. J. D. STEVENSON, "STRUCTURAL DAMPING VALUES AS A FUNCTION OF DYNAMIC RESPONSE STRESS AND DEFORMATION LEVELS," PAPER K11/1, 5TH INTERNATIONAL CONFERENCE ON STRUCTURAL MECHANICS IN REACTOR TECHNOLOGY (AUGUST 1979).

PROPOSED SEISMIC DESIGN CLASSIFICATION AND DUCTILITY FACTORS RECOMMENDED FOR SEP[1]

CLASS	DESCRIPTION	DUCTILITY FACTOR
I-S	EQUIPMENT, INSTRUMENTS, OR COMPONENTS PERFORMING VITAL FUNCTIONS THAT MUST REMAIN OPERATIVE DURING AND AFTER EARTHQUAKES; STRUCTURES THAT MUST REMAIN ELASTIC OR NEARLY ELASTIC; FACILITIES PERFORMING A VITAL SAFETY-RELATED FUNCTION THAT MUST REMAIN FUNCTIONAL WITHOUT REPAIR.	1 TO 1.3
I	ITEMS THAT MUST REMAIN OPERATIVE AFTER AN EARTHQUAKE BUT NEED NOT OPERATE DURING THE EVENT; STRUCTURES THAT CAN DEFORM SLIGHTLY IN THE INELASTIC RANGE; FACILITIES THAT ARE VITAL BUT WHOSE SERVICE CAN BE INTERRUPTED UNTIL MINOR REPAIRS ARE MADE.	1.3 TO 2
II	FACILITIES, STRUCTURES, EQUIPMENT, INSTRUMENTS, OR COMPONENTS THAT CAN DEFORM INELASTICALLY TO A MODERATE EXTENT WITHOUT UNACCEPTABLE LOSS OF FUNCTION; STRUCTURES HOUSING ITEMS OF CLASS I OR I-S THAT MUST NOT BE PERMITTED TO CAUSE DAMAGE TO SUCH ITEMS BY EXCESSIVE DEFORMATION OF THE STRUCTURE.	2 TO 3
III	ALL OTHER ITEMS WHICH ARE USUALLY GOVERNED BY ORDINARY SEISMIC DESIGN CODES; STRUCTURES REQUIRING SEISMIC RESISTANCE IN ORDER TO BE REPAIRABLE AFTER AN EARTHQUAKE. (DEPENDING ON MATERIAL, TYPE OF CONSTRUCTION, DESIGN OF DETAILS, AND CONTROL OF QUALITY).	3 TO 8

REF. - 1. N. M. NEWMARK, W. J. HALL, "DEVELOPMENT OF CRITERIA FOR SEISMIC REVIEW OF SELECTED NUCLEAR POWER PLANTS," NUREG/CR-0098 (MAY 1978).

DETERMINATION OF THE SEISMIC HAZARD

- LLL/TERA CORP. SITE SPECIFIC SPECTRA METHODOLOGIES

  - MULTI FACETED APPROACH FOR DETERMINING SITE SPECIFIC SPECTRA AND SEISMIC HAZARD

    1. DIRECT AVERAGING OF RESPONSE SPECTRA FROM APPROPRIATE GROUPS OF EARTHQUAKES

    2. SCALING APPROPRIATE REAL SPECTRA TO PREDICTED PEAK ACCELERATION VALUES AT THE SITE FOR VARIOUS RISK LEVELS

    3. USING THE NEWMARK-HALL APPROACH TO SCALE RESPONSE SPECTRA TO PEAK ACCELERATIONS AND VELOCITIES FOR VARIOUS RISK LEVELS

    4. USING UNIFORM RISK TECHNIQUES TO SCALE SPECTRAL ORDINATES AS A FUNCTION OF ANNUAL RISK OF EXCEEDENCE

- SEP LICENSEE SITE SPECIFIC PROGRAM

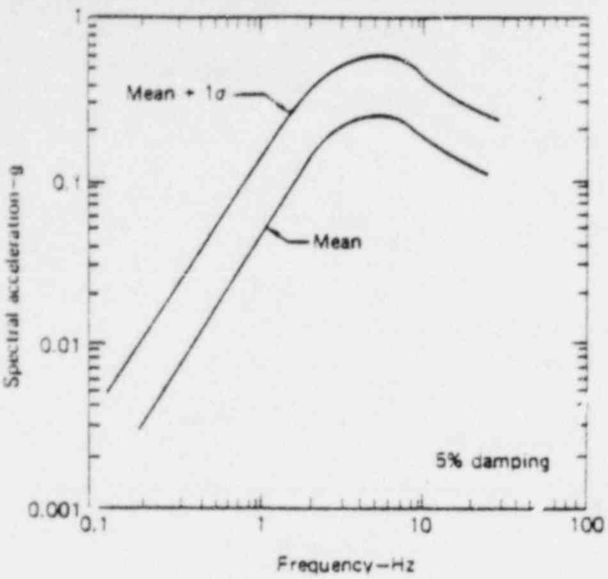


FIG. 1 Real spectra

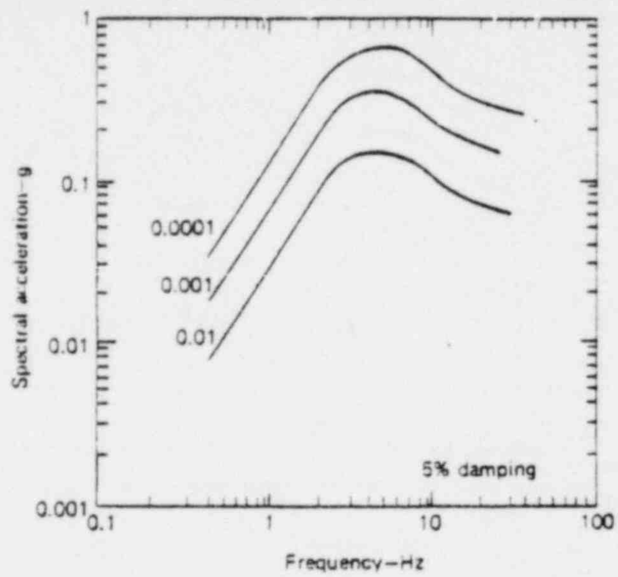


FIG. 2 Real spectra scaled to peak accelerations

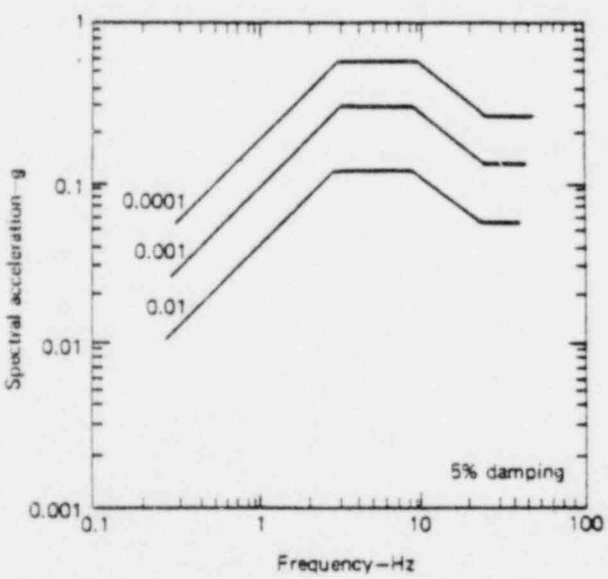


FIG. 3 Newmark-Hall spectra scaled to peak accelerations

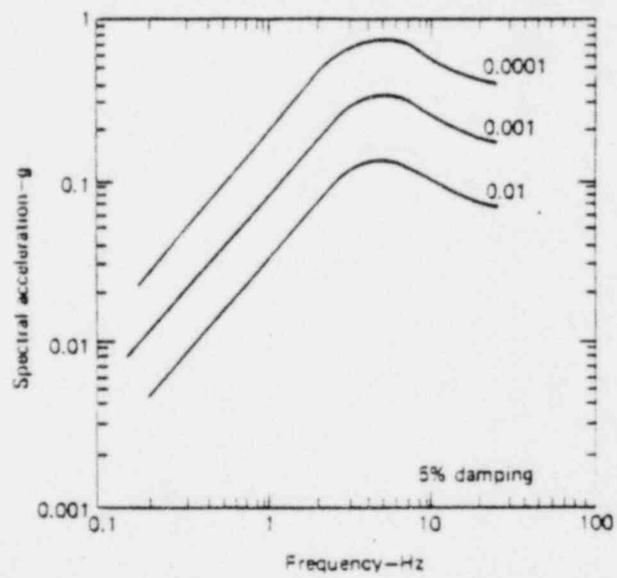


FIG. 4 Uniform hazard spectra

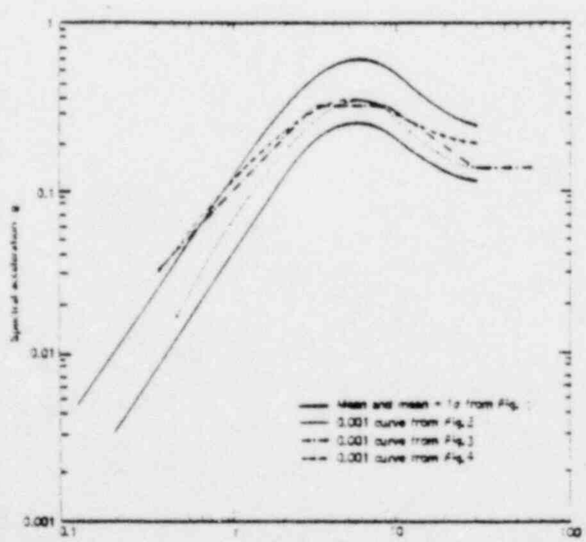


FIG. 5 Comparison of spectra from FIGS. 1-4

PROBABILISTIC SEISMIC RISK ANALYSIS METHODOLOGIES

- PROS

  1. EXPLICIT TRACKING OF PARAMETERS FOR SENSITIVITY OF THEIR VARIANCE (ABILITY TO DEAL WITH UNCERTAINTY)

  2. QUANTIFICATION OF PREDICTED RISK IN CONSISTENT AND UNIFORM MANNER

  3. ESTIMATION OF RELATIVE RISK FROM ONE HAZARD OR DESIGN LEVEL TO ANOTHER

  4. LIMITED EVALUATION OF NECESSARY RESISTANCE IN TERMS OF OVERALL RISK GOALS

- CONS

  1. LIMITED DATA BASES

  2. DIFFICULTIES IN DEVELOPING CORRECT STATISTICAL METHODS (ABILITY TO DEAL WITH BOTH RANDOM AND SYSTEMATIC ERRORS)

BASES FOR SEP RE-EVALUATION

and

OVERVIEW OF DRESDEN 2 CONCLUSIONS

By W. J. Hall and N. M. Newmark

Prepared for meeting of A.C.R.S. Subcommittee on Extreme External Phenomena, June 4, 1980

BASES FOR SEP RE-EVALUATION

Introduction

A history of the development of the SEP program and the status of the review studies underway have been presented by Mr. Howard Levin of NRC. We shall not attempt to restate these important details here but shall confine our comments to a short overview of the philosophy underlying the SEP seismic review and evaluation.

The Senior Seismic Review Team which was assembled to assist and provide overall consultation in the areas of criteria development, analysis and technical evaluation, consists of N. M. Newmark, Chairman, W. J. Hall, R. P. Kennedy, J. D. Stevenson, and F. J. Tokarz. We wish to acknowledge here the excellent technical support provided by the cognizant NRC and LLL staff and their subcontractors. In the case of the Dresden 2 study, these individuals are identifired on page xix of Ref. 2.

General Philosophy and Approach Pertaining to the Review Process

In October 1977 the Nuclear Regulatory Commission approved initiation of Phase II of the Systematic Evaluation Program (SEP) which consists of a plant-specific reassessment of the safety of eleven older operating nuclear plants. Many of the early nuclear facilities were designed and constructed during the time when seismic design procedures for such specialized systems were just beginning to be developed. As such it is recognized that in many cases these plants were designed to criteria that are different from those used for more recent plants, in some cases less rigorous and in some cases more rigorous.

In the case of nuclear facilities, safety for seismic excitation does imply that certain elements and components of the system must continue to remain functional. However, resistance to seismic motions does not mean complete absence of permanent deformation in all cases. Structures, piping, and equipment may deform into the inelastic range, and some elements and components may even be permitted to suffer damage, provided that the entire system can continue to achieve and to maintain afterward a safe shutdown condition. On the other hand some items may be required to have limited deformation even in the elastic range in order to achieve the desired criteria. Hence the safety criteria for an existing facility differ for the various elements and components of the system.

It should be apparent in such a case that the review is considerably different in scope and depth from current construction permit and operating license reviews, because it is designed to focus only on pertinent matters of significance in a manner sufficient to identify safety issues and to provide an integrated and balanced approach to backfit considerations in accordance with 10CFR 50.109. This regulation specifies that backfitting will be required only if substantial, additional protection can be demonstrated for the public health and safety. Such a determination requires an assessment of broad safety issues considering the various systems interactions in the context of overall plant safety. Thus the review concept in the case of older nuclear plants is not envisioned as one based upon demonstrating compliance with specific criteria in the Standard Review Plan or Regulatory Guides, since individual criteria do not generally control broad safety issues. However, current licensing criteria are utilized with respect to the level of design they dictate, and as baselines from which to measure relative safety margins to support broader integrated assessment.

As used in the previous paragraph, the term "relative" is not to be construed as evaluation based on the norm of current criteria, standards, and procedures, but instead in the light of knowledge that led to such a level of design. It would be unreasonable to assume that an older plant would consist of structures, equipment, components, and systems that would meet current criteria in every instance; even so, those items that do not meet current criteria may be entirely adequate in the sense of meeting acceptable safety and reliability criteria. Therefore, the seismic resistance capability of a facility is compared in a qualitative fashion to that dictated by the "intent" of today's licensing criteria with the objective of assessing the levels of safety and reliability.

In the case of nuclear plants the review focuses specifically on the following:

(a) an assessment of the integrity of the reactor coolant pressure boundary, and

(b) an evaluation of the capability of essential structures, systems and components required to safely shut down the plant and maintain it in a safe shutdown condition (including removal of residual heat) during and after a postulated seismic disturbance.

Obviously all structures, piping and equipment cannot be examined or inspected in detail, but the close study of one subgroup of equipment can be used in many cases to infer capability of other safety-related systems; a positive finding (albeit judgmental) with respect to the reactor coolant system and safe shutdown systems, for example, could be interpreted to imply adequate assurance of seismic resistance for the other systems on the premise they are designed similarly.

The Review Process

The review process for a reactor facility normally consists of two general tasks, one pertaining to detailed review of the existing plant in the light of applicable review criteria and the other involving detailed design and analysis studies to develop the desired (and possible) upgrading of the seismic resistance.

The detailed review normally encompasses inspection of the plant, review of existing documentation (reports, plans, and calculations) as appropriate, determination of existing material properties, and identification of those systems which realistically and economically are amenable to upgrading. As a part of this review it may be desirable to carry out a risk analysis to help provide a basis for the decisions that must be made as to the desirability and advantages of carrying out the upgrading.

In many cases it is economically, if not physically, impossible to carry out significant seismic upgrading improvements. In those cases where it is possible and economical, it is desirable to take advantage of the latest concepts pertaining to development of seismic resistance. Thus in the evaluation of an existing facility, and in the subsequent detailed design studies for physical upgrading of structural or mechanical systems, it is possible (and desirable) to take into account the modest amount of nonlinear behavior that can be permitted in many portions of such systems without significant decrease in the margin of safety against safe shutdown or containment.

Last, but by no means least, is the observation that the inherent seismic resistance of well designed and constructed systems is usually much greater than that commonly assumed, largely because nonlinear behavior is mobilized to limit the imposed forces and accompanying deformations. In such systems where the resistance is nondegrading for reasonable deformations, the requirements for retrofitting may be nonexistent or at most minimal. General guidelines for seismic review of nuclear facilities were presented by the authors recently in Ref. 1, and includes consideration of such items as the general philosophy and approach pertaining to the review process, selection of the earthquake hazard for review and design, design seismic loadings, soil-structure interaction, damping and energy absorption, methods of dynamic analysis, and review analysis and design procedures.

Evaluation

On the basis of the re-evaluation studies made as a part of the foregoing studies, an overall evaluation (judgmental assessment) of the adequacy of the critical structures and representative equipment items and systems to function properly during and following the SSE hazard is made. Such an evaluation takes into account judgmental or factual assessment of the margin of safety, as the case may be, and consideration of the adequacy of individual items in a system in terms of overall system performance. Also, specific comments pertaining to upgrading or retrofitting are made when appropriate.

DRESDEN 2 EVALUATION

Introduction

A summary of the Dresden 2 re-evaluation efforts is presented in Ref. 2 in considerable detail. Some brief overview comments are given in the following sections; these comments will receive elaboration in the subsequent presentations on structures to be given by Dr. R. P. Kennedy, and on equipment and distribution systems to be given by Dr. J. D. Stevenson.

Hazard

On the basis of tne original seismic investigation, and the re-evaluation by the NRC as a part of the SEP program, the SSRT decided to use an SSE characterized by 0.2 g zero period horizontal ground acceleration and R. G. 1.60 spectra for the re-evaluation. Vertical effects, in accordance with the current NRC criteria, were also considered. Preliminary review of the site specific response spectra suggests that for Dresden 2 the spectra may be anchored to a value slightly less than 0.2g. Obviously this comparison, only one of many, suggests that the margin of safety may be even greater than those reported in Ref. 2.

Structures

The first task in examining structures is to summarize the nature and makeup of the structures that are to be examined in the light of knowledge about original design criteria and information on the as-constructed plant. Also required is a summary of design analysis approaches employed, including loading combinations, stress and deformation criteria, and controlling response calculations.

The re-evaluation of Dresden 2 considered such factors as

(1) response spectra, damping and nonlinear behavior,

(2) analysis models

(3) normal, seismic and accident loads,

(4) forces, stresses and deformations, and

(5) relative deformaion.

In order to gain insight into certain factors, some analysis was undertaken, as will be described by Dr. Kennedy.

Equipment and Distribution Systems

Of particular importance in the re-evaluation process is the assessment of the adequacy of critical mechanical and electrical equipment, and fluid- and electrical-distribution systems. The re-evaluation centers on those items or systems essential to meeting the general criteria described earlier.

A major task of the re-evaluation process is to identify the critical safety related systems and the criteria originally used for procurement and seismic qualification of equipment. For such systems selected, representative items or systems were identified on the basis of (a) physical inspection of the facility (where specific items were identified as appearing possibly to have nearly lower bound seismic resistance), and (b) representative sampling.

After system or item identification, and after ascertaining the nature of the seismic criteria used during procurement or qualification, the re-evaluation effort involves a detailed assessment of the original design in the light of current knowledge about equipment vulnerability to seismic excitation. Specifically the evaluation involves consideration of the following items.

(a) Seismic qualification procedures

(b) Seismic criteria (including floor response spectra, dynamic coupling, and damping)

(c) Force, stress and deformation criteria

(d) Anchorage of equipment

These topics, and the findings as they pertain to Dresden 2, will be addressed by Dr. J. D. Stevenson.

Concluding Evaluation and Assessment - Dresden 2

The summary and conclusions pertaining to the Dresden 2 re-assessment are lengthy and the essence of the details will be given in the presentations that follow. The overall general assessment appearing on pages 10-12 of Ref. 2 is reproduced below.

"Based on the combined experience and judgment of the members of the SSRT, the reviews and spot checks of the original design analyses, recent revisions and amendments to these analyses, comparisons with similar items of equipment and components in other more recently designed reactors and in line with our recommendations contained herein, it is our conclusion that:

1) The structures and structural elements of the Dresden 2 facility are adequate to resist an earthquake with an SSE value of acceleration of 0.2 g, subject to confirmation as noted on p. 8.**

2) The piping in the facility is adequate to resist an earthquake with an SSE value of 0.2 g with acceptable inelastic deformation as controlled by current piping design codes.

   However, we have not reviewed in detail the as-built piping supports to determine if they are fully in accord with the design criteria. We recommend that the as-built spacing of pipe support design using lateral-deflection and force-evaluation curves be checked to ensure that the spacing is consistent with attaining a piping frequency

** The p. 8 citation refers to the adequacy of sway rods and their bracing for the torus shell and columns.

greater than two times the building frequency as stated in the design criteria.

3) Based upon the examination of selected mechanical and electrical equipment that in our judgment represents a lower bound with respect to seismic fragility, we believe that the equipment in the facility is adequate to resist an SSE earthquake consistent with 0.20 g, and, subject to satisfying several points discussed below, should remain functional. This conclusion is based upon consideration of modern criteria involving floor response spectra, especially at upper levels of the structures where amplified motions might be expected, and with the realization that the uncertainity bound for the seismic resistance of equipment is broad. It is felt that the margins of resistance against damage to equipment are probably less than specified by current criteria, but it is our assessment that the possible damage should not impair functional capability. We recognize that less rigorous design and qualification criteria existed when the equipment was manufactured, and there was also less attention paid in the design of equipment supports.

   The above conclusions are predicated on the following additional points:

   - That all safety-related electrical equipment in the plant are checked to ensure that adequate engineered anchorage exists. "Engineered anchorage" means that the anchorage has been determined to be adequate by analysis or tests employing design procedures (load, stress and deformation limits, materials, fabrication procedures and quality acceptance) in accordance with a recognized structural design code.

- That the remaining items listed in Section 2.3** are evaluated and upgraded if required, including the specified design modifications documented in Ref. 60.
- That a general reconnaissance of the plant be made to identify and upgrade, if necessary, any overhead or suspended items, and items on rollers or capable of sliding or overturning that could dislodge, fall, or displace during an earthquake and impair capability of the plant to shut down safely. This applies to temporary as well as permanently installed items.

4) With regard to seismic criteria, the functional reliability of electrical equipment and, to a lesser degree, that of mechanical equipment are among the most difficult items to evaluate. In recent years, shake-table tests of generic, or specific prototype-equipment systems, or both, are conducted to confirm their reliability. Alternatively, analyses are made where modeling is possible and rational.

   Because much of the electrical and mechanical equipment is expected to function in an active manner during its lifetime (as contrasted to the passive function of structural systems or elements) it is to be expected that failures, especially in some classes of equipment, will occur from time to time under normal operation. Realization of this situation is one reason that redundancy of safety systems is normally required, thereby reducing reliance upon a single system in the event of a seismic disturbance that might by chance render a piece of equipment inoperable, especially if it has been functioning for an extended period of time.

** These items will be identified by Dr. J. D. Stevenson in his presentation.

With appreciation of the state of the art of equipment qualification at the time of the Dresden 2 design, and as carried out and reported in generic testing (see Chapter 6), and on the basis of years of experience by members of the SSRT with respect to functioning of equipment, not only in earthquakes throughout the world but also under military requirements, it is our opinion, in the case of Dresden 2, that there is strong reason to believe that the systems required for safe shutdown will remain functional under the design hazard. This conclusion is predicated upon the consideration that there are degrees of redundancy in safety systems and components within a given safety system to avoid dependence on any one component or system, and on the premise that a comprehensive equipment maintenance program is carried out."

REFERENCES

1. Newmark, N. M. and Hall, W. J., "Development of Criteria For Seismic Review of Selected Nuclear Power Plants," U. S. Nuclear Regulatory Commission Report NUREG/CR-0098, Sept. 1977, 49 p.

2. Newmark, N. M., Hall, W. J., Kennedy, R. P., Stevenson, J. D., and Tokarz, F. J., "Seismic Review of Dresden Nuclear Power Station -- Unit 2 -- for the Systematic Evaluation Program," U. S. Nuclear Regulatory Commission Report NUREG/CR-0891, April 1980, 181 p.

SYSTEMATIC EVALUATION PROGRAM

RE-EVALUATION OF THE SEISMIC ADEQUACY OF STRUCTURES

OBJECTIVES

- DEVELOP CRITERIA AND EVALUATION CONCEPTS FOR COMPREHENSIVE REVIEW
- ESTIMATE THE SEISMIC SAFETY RELATIVE TO CURRENT CRITERIA
- RECOMMEND GENERALLY ANY REQUIRED MODIFICATIONS TO BRING THE PLANTS TO ACCEPTABLE LEVELS OF CAPABILITY IF THEY ARE NOT ALREADY AT SUCH LEVELS

SEP STRUCTURES CRITERIA
DRESDEN UNIT 2

EVALUATE THE EFFECTS OF:

	DESIGN	SEP
• EARTHQUAKE INPUT	0.2G HOUSNER	0.2G R.G. 1.60
• DIRECTIONAL COMBINATIONS	ONE HORIZ. & VERT.	SIMULTANEOUS 3-D
• DAMPING	LOW	MEDIAN CENTERED
• DUCTILITY	ELASTIC	LIMITED INELASTIC ALLOWED
• MODELLING	2-D	3-D INCL. TORSION
• FLOOR RESPONSE SPECTRA	GROUND SPECTRA OR SIMILAR PLANT SPECTRA	CURRENT CRITERIA

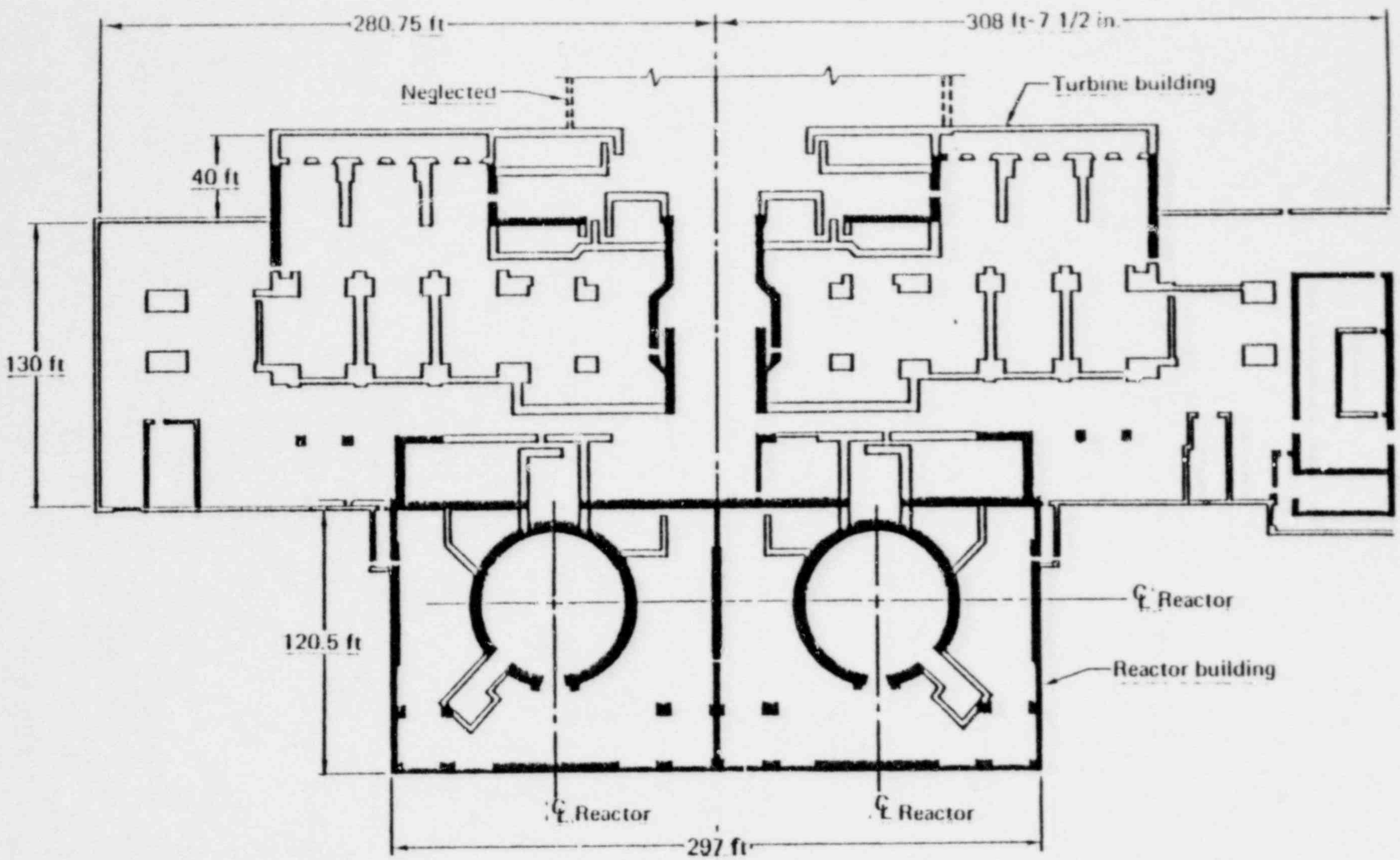


FIG. 4-5a. Reactor and turbine buildings--plan view (Source: Ref. 15).

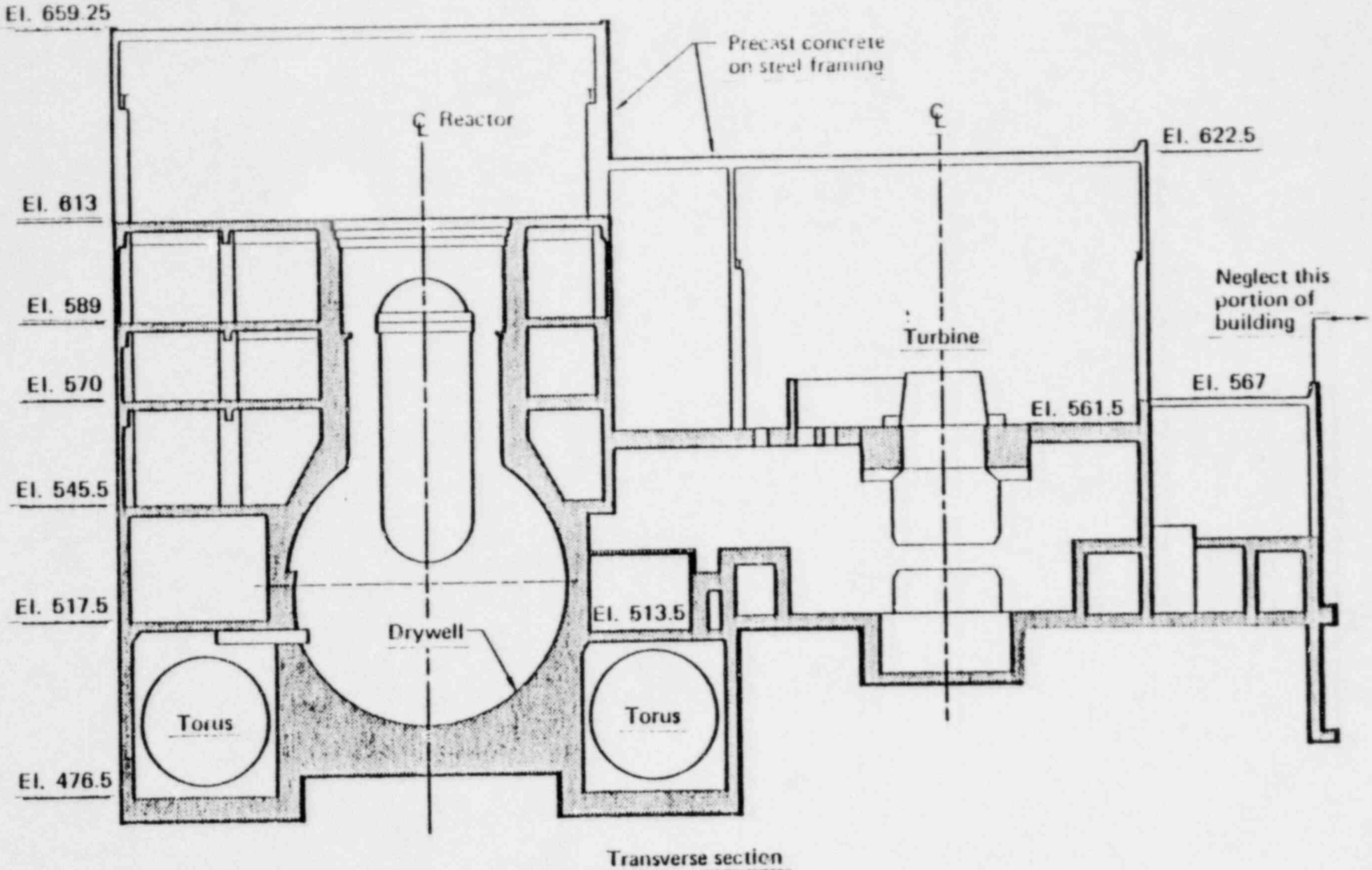


FIG. 4-5b. Reactor and turbine buildings--transverse section (Source: Ref. 7).

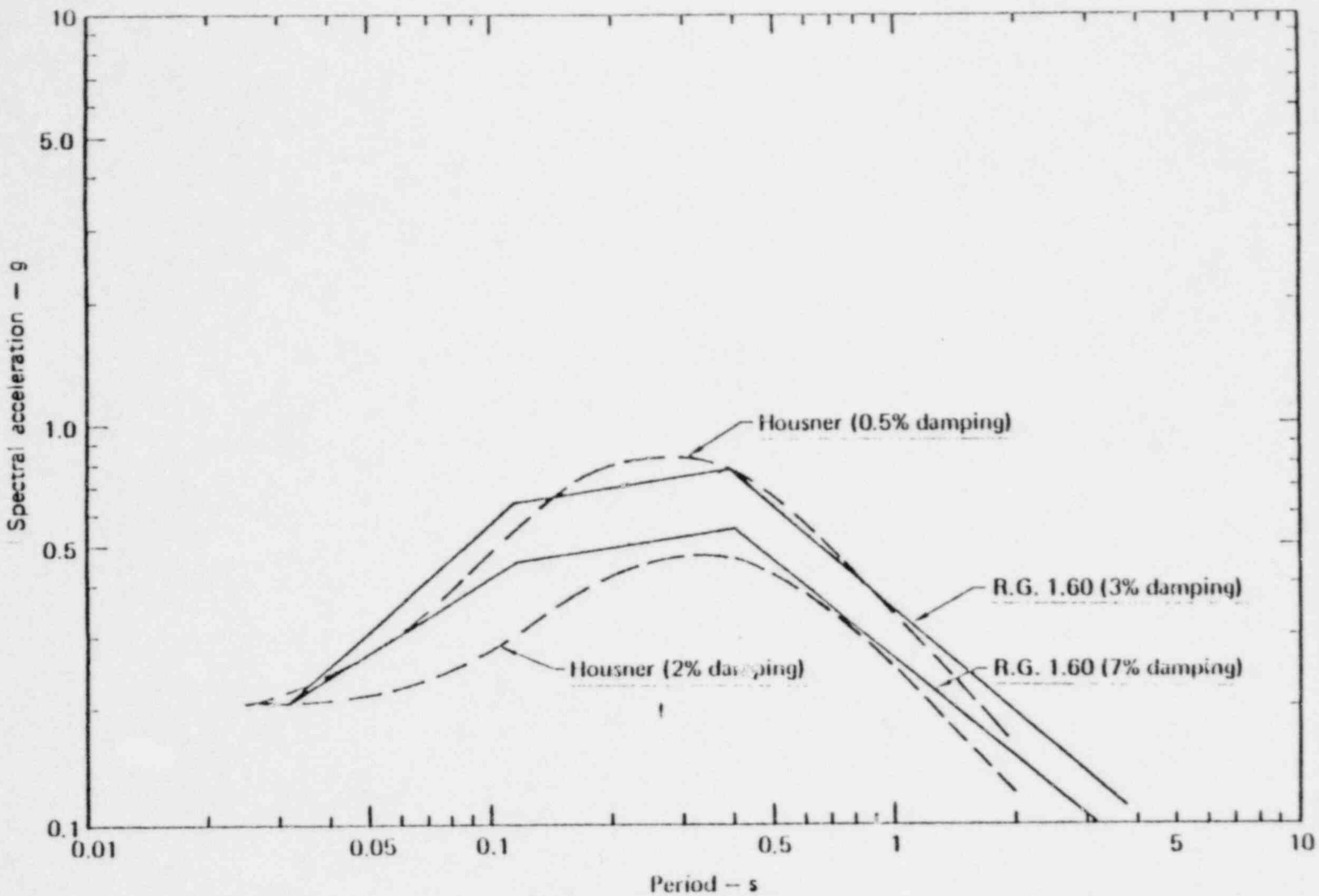


FIG. 5-2. Comparison of original Housner response spectra to R.G. 1.60 spectra for base-slab-mounted piping and equipment.

TABLE 5-1. Original and currently recommended damping values.

	Percent of critical damping		
Structure or component	Dresden 2	R.G. 1.61[6] (SSE)	NUREG/CR-0098[4] (Yield levels)
Reinforced concrete	5	7	7 to 10
Steel frame	2	4 or 7	10 to 15
Welded assemblies	1	4	5 to 7
Bolted and riveted assy.	2	7	10 to 15
Vital piping	0.5	2 or 3	2 to 3

TABLE 4. PROPOSED SEISMIC DESIGN CLASSIFICATION

CLASS	DESCRIPTION
I-S	Equipment, instruments, or components performing vital functions that must remain operative during and after earthquakes; Structures that must remain elastic or nearly elastic; Facilities performing a vital safety-related function that must remain functional without repair. Ductility factor = 1 to 1.3.
I	Items that must remain operative after an earthquake but need not operate during the event; Structures that can deform slightly in the inelastic range; Facilities that are vital but whose service can be interrupted until minor repairs are made. Ductility factor = 1.3 to 2.
II	Facilities, structures, equipment, instruments, or components that can deform inelastically to a moderate extent without unacceptable loss of function; Structures housing items of Class I or I-S that must not be permitted to cause damage to such items by excessive deformation of the structure. Ductility factor = 2 to 3.
III	All other items which are usually governed by ordinary seismic design codes; Structures requiring seismic resistance in order to be repairable after an earthquake. Ductility factor = 3 to 8, depending on material, type of construction, design of details, and control of quality.

APPLICATION OF SEP CRITERIA
DRESDEN UNIT 2

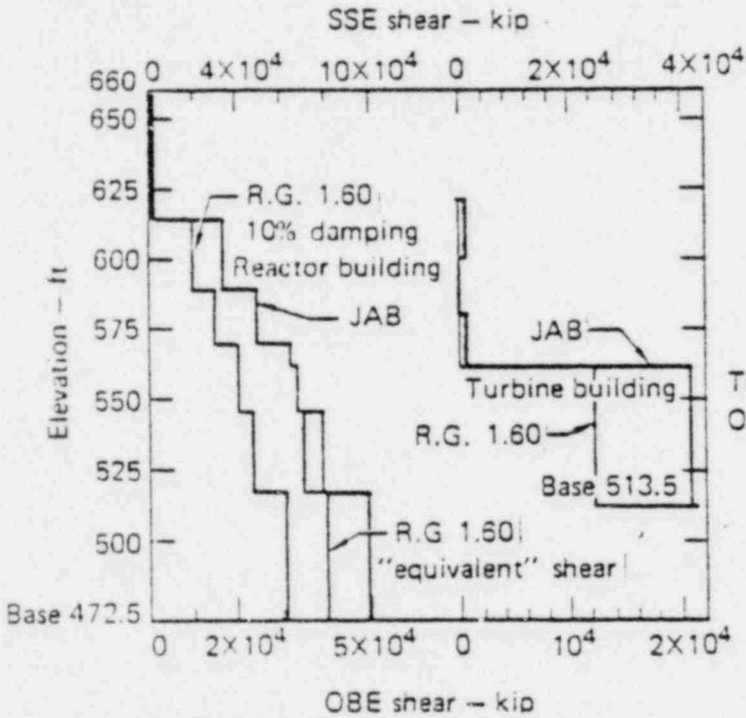
- COMPARISON OF DESIGN LOADS WITH THOSE FROM CURRENT METHODS USING EXISTING OR SIMPLIFIED MODELS

  - CURRENT LOADS LESS THAN DESIGN LOADS - STRUCTURE ASSUMED ACCEPTABLE

  - CURRENT LOADS GREATER THAN DESIGN LOADS - COMPARED ON THE BASIS OF LOAD RATIOS SUCH THAT ALLOWABLE DUCTILITY NOT EXCEEDED

- LIMITED STRESS ANALYSIS CONDUCTED IF DESIGN LOADS NOT AVAILABLE OR IF LOAD RATIOS EXCESSIVE

- FLOOR RESPONSE SPECTRA DEVELOPED BASED ON CURRENT CRITERIA



Axial force – kip

Member	(JAB 5%)	(R.G. 1.60 10%)
Turb. bldg. roof	4102	4490
Operating floor	1910	6439

FIG. 5-3. Reactor and turbine building shear distributions under N-S excitation from R.G. 1.60 and JAB analyses.

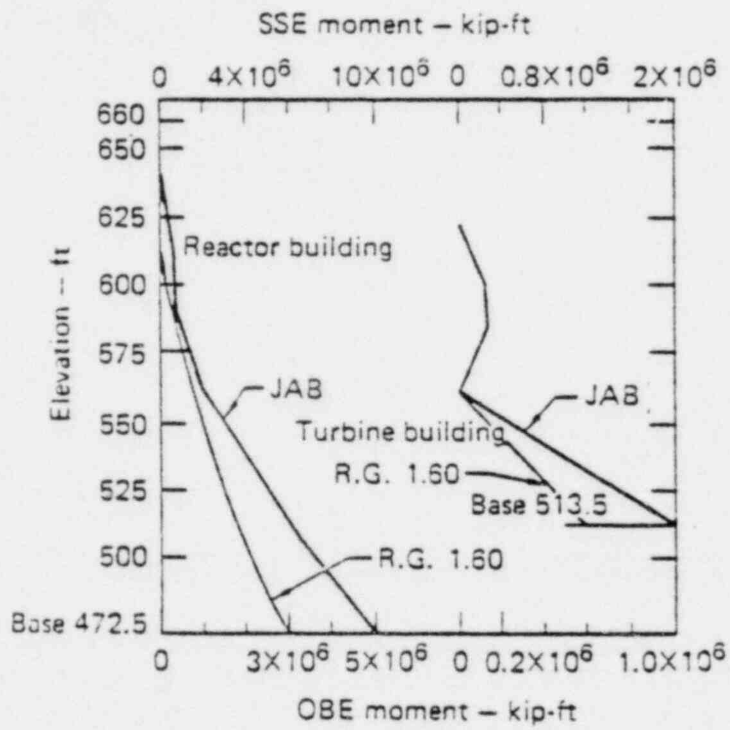
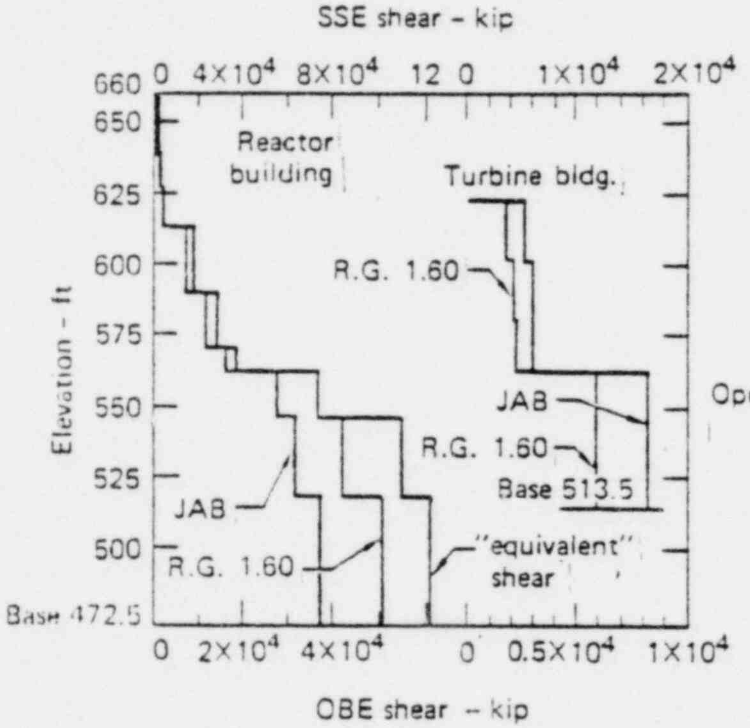


FIG. 5-4. Reactor-turbine building moment distributions under N-S excitation from R.G. 1.60 and JAB analyses.



Shear force — kip

Member	(JAB 5%)	(R.G. 1.60 10%)
Operating floor	22,500	37,690

FIG. 5-6. Reactor and turbine building shear distributions under E-W excitation from R.G. 1.60 and JAB analyses.

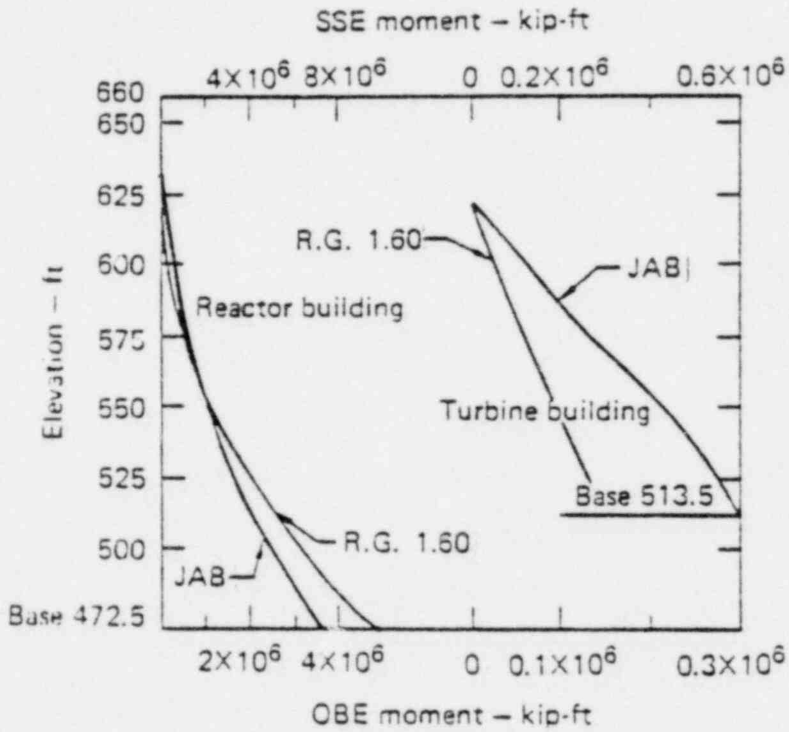


FIG. 5-7. Reactor-turbine building moment distributions under E-W excitation from R.G. 1.60 and JAB analyses.

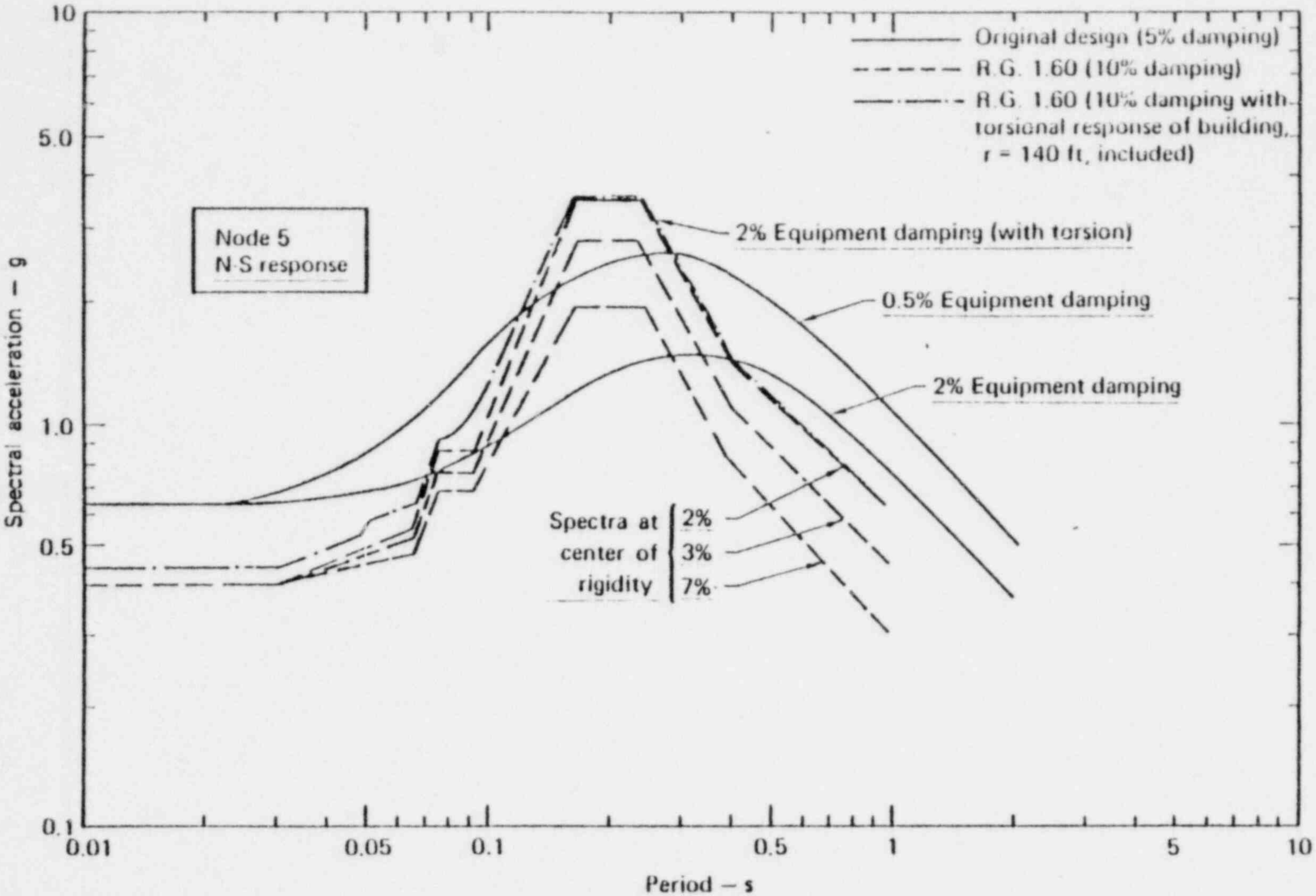


FIG. 5-12. Comparison of original amplified ground response spectra to floor spectra developed from R.G. 1.60 spectra, with and without torsional response included. Curves are for node 5 under N-S excitation.

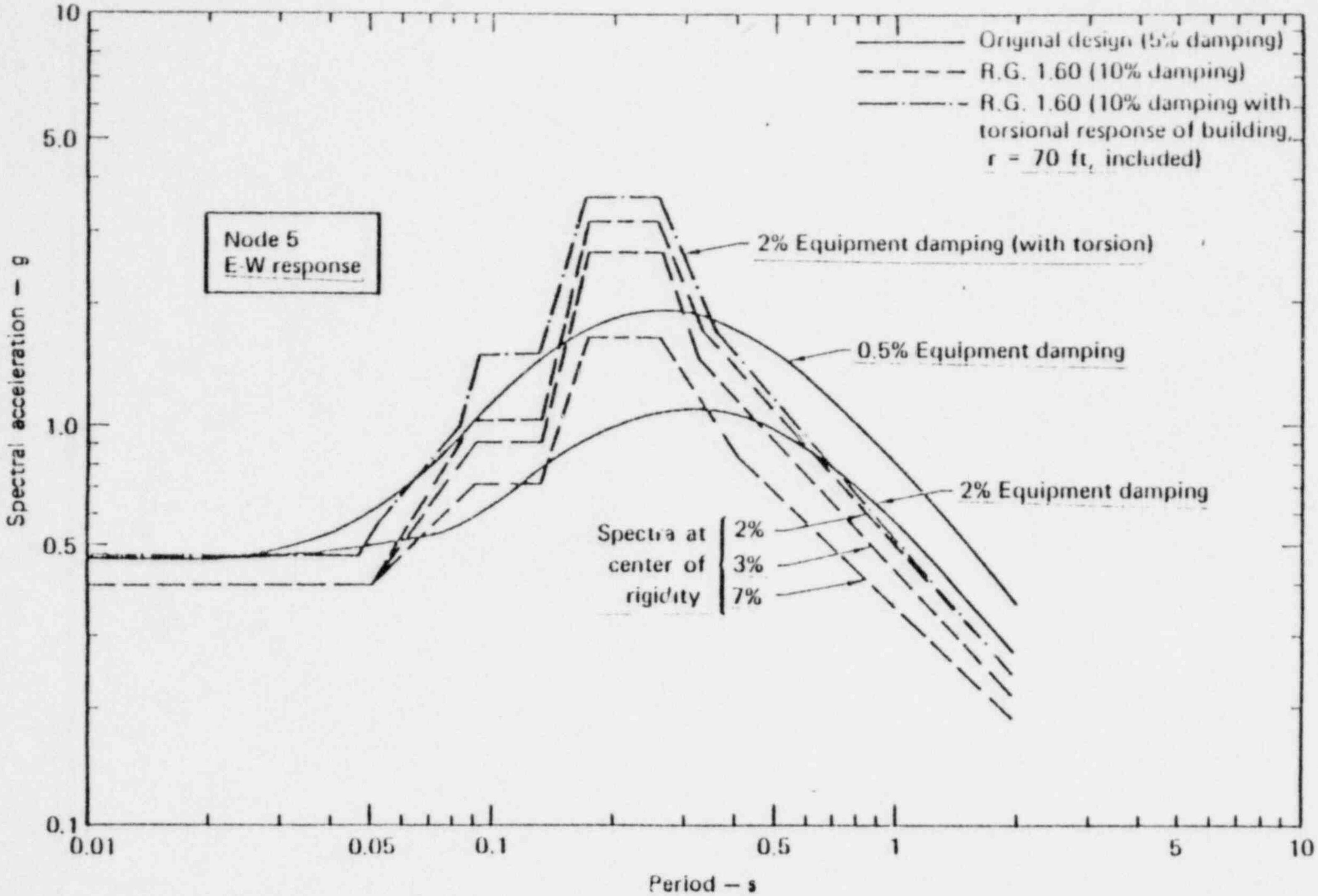


FIG. 5-13. Comparison of original amplified ground response spectra to R.G. 1.60 spectra, with and without torsional response included. Curves are for node 5 under E-W excitation.

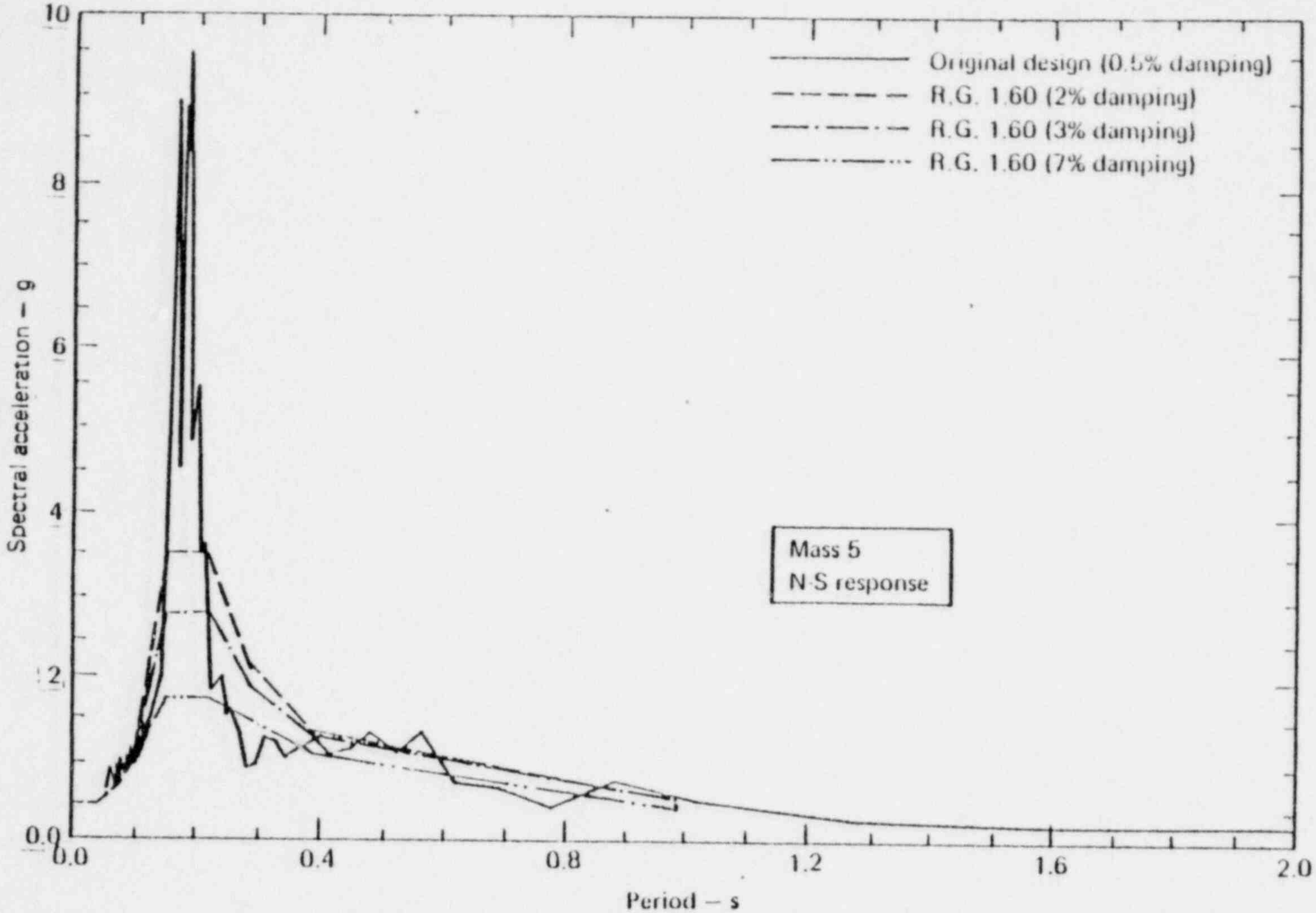


FIG. 5-20. Comparison of original design spectrum (Brown's Ferry) for feedwater and main-steam piping to R.G. 1.60 spectra with 2, 3, and 7% damping. Spectra are for mass 5 under N-S excitation.

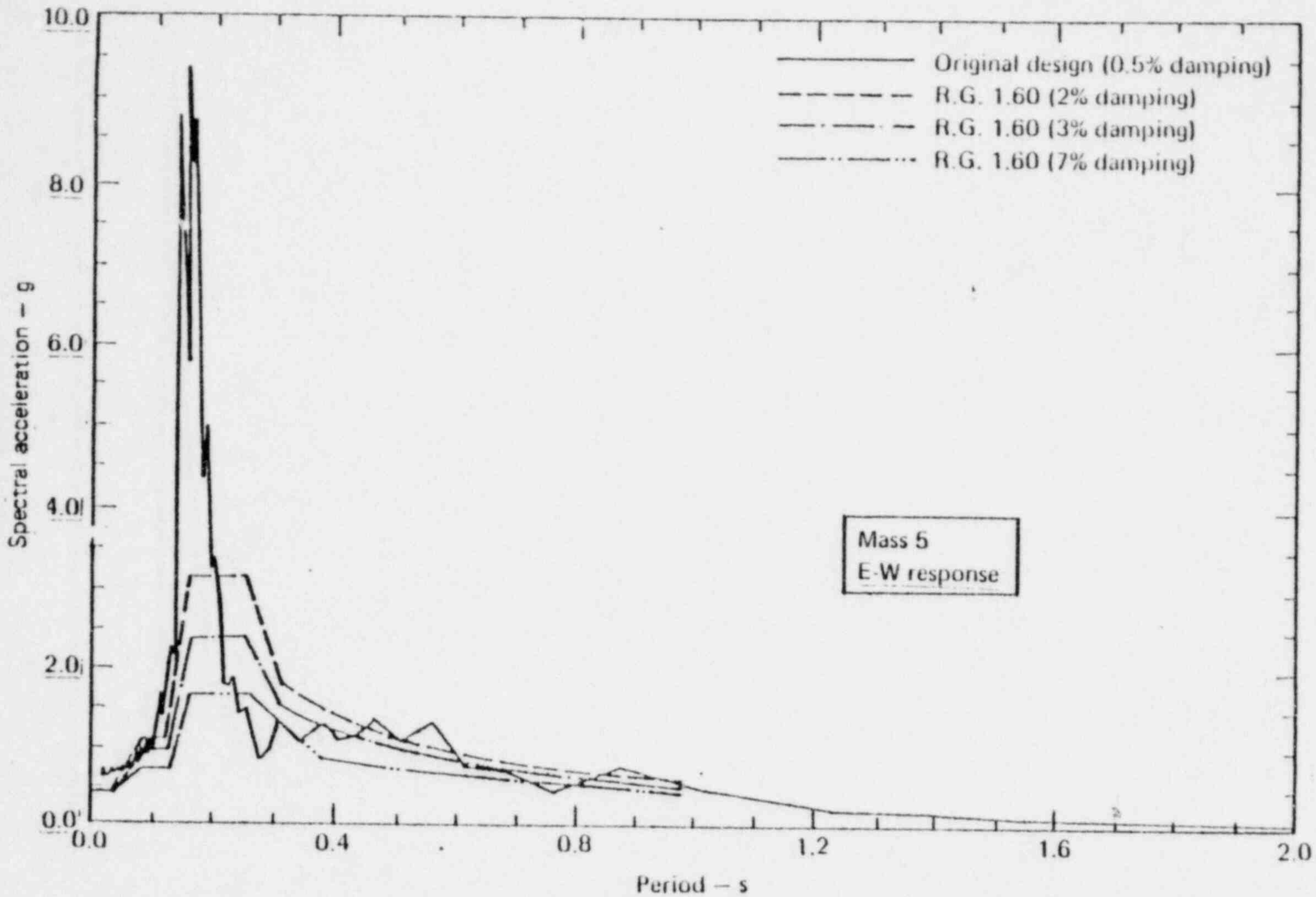


Fig. 5-21. Comparison of original design spectrum (Brown's Ferry) for feedwater and main-steam piping to R.G. 1.60 spectra with 2, 3, and 7% damping. Spectra are for mass 5 under E-W excitation.

CONCLUSIONS

DRESDEN UNIT 2 STRUCTURES

- REACTOR AND TURBINE BUILDINGS - STRUCTURE ADEQUATE
  - NO INELASTICITY IN EXCESS OF ALLOWABLE UNDER SEP CRITERIA
- DRYWELL - STRUCTURE ADEQUATE
  - SEP LOADS EXCEED DESIGN LOADS BUT SEISMIC STRESSES LOW
- SUPPRESSION CHAMBER - STRUCTURE ADEQUATE ASSUMING NO NON-DUCTILE FAILURE MODES
  - SEISMIC STRESSES GENERALLY LOW COMPARED TO DEADWEIGHT AND POOL DYNAMIC LOAD STRESSES WHICH ARE BEING EVALUATED IN A SEPARATE PROGRAM
  - DETAILS OF TORUS BRACING SYSTEM WERE NOT AVAILABLE
- VENT STACK - STRUCTURE ADEQUATE
  - SEP LOADS EXCEED DESIGN LOADS BUT SEISMIC STRESSES LOW

SYSTEMATIC EVALUATION PROGRAM

RE-EVALUATION OF THE SEISMIC ADEQUACY OF MECHANICAL/ ELECTRICAL EQUIPMENT AND PIPING

J. D. STEVENSON

TABLE 4-4. Summary of original load combinations and allowable stress.

Primary containment (including penetrations)	Allowable stress
a. $D^a + P^b + H^d + T^e + E^f$	ASME, Sec. III, Class B, without the usual increase for seismic loading.
b. $D + P + R^c + H + T + E$	Same as above, except local yielding is permitted in the area of the jet force where the shell is backed up by concrete. In areas not backed up by concrete, primary local membrane stresses at the jet force do not exceed 0.9 × yield point of the material at 300°F.
c. $D + P + R + H + T + E'^g$	Primary membrane stresses, in general, do not exceed the yield point of material. If the total stress exceeded yield point, an analysis was made to determine that the energy absorption capacity exceeded the energy input from the earthquake. The same criteria as in (b), above, are applied to the effect of jet forces for this loading condition.
<u>Reactor building and all other Class I structures</u>	
a. $D + R + E$	Normal allowable code stresses (AISC for structural steel, ACI for reinforced concrete). The customary increase design stresses, when earthquake loads are considered, is not permitted.
b. $D + R + E'$	Stresses are limited to the minimum yield point as a general case. However, in a few cases, stresses may exceed yield point. In this case, an analysis, using the limit-design approach, is made to determine the energy absorption capacity, which should exceed the energy input. This method is discussed in Ref. 9. The resulting distortion is limited to assure no loss of function and adequate factor of safety against collapse.

TABLE 4-4. Cont'd.

Primary containment (including penetrations)	Allowable stress
Reactor primary vessel supports	
a. D + H + E	Stresses remain within code allowable levels without the usual increase for earthquake loadings (AISC for structural steel, ACI for reinforced concrete).
b. D + H + R + E	Stresses do not exceed: • 150% of AISC allowable levels for structural steel • 90% of yield stress for reinforcing bars • 85% of ultimate stress for concrete.
c. D + H + E'	No functional failure. Usually, stresses do not exceed the yield point of the material for steel or the ultimate strength of the concrete. If these limits are exceeded, energy absorption capacity is determined and compared to the energy input from the earthquake. The design ensures that energy absorption capacity exceeds energy input.
Reactor primary vessel internals	
a. D + E	Stresses that result from the maximum possible combination of loadings encountered in operational conditions are within the stress criteria of ASME, Sec. III, Class A Vessel.
b. D + E'	The secondary and primary plus secondary stresses are examined on a rational basis taking into account elastic and plastic strains. These strains are limited to preclude failure by deformation that would compromise any of the engineered safeguards or prevent safe shutdown of the reactor.

TABLE 4-4. Cont'd.

Primary containment (including penetrations)	Allowable stress	
c. P + D	Primary stresses are within the stress criteria of ASME, Sec. III, Class A. The secondary and primary plus secondary stresses are examined on a rational basis taking into account elastic and plastic strains. These strains are limited to preclude failure by deformation that would compromise any of the engineered safeguards or prevent safe shutdown of the reactor.	
Emergency core cooling systems (ECCS)		
a. D + T + H + E	Stresses remain within code allowable levels.	
	Component	Code
	Piping	ASA B 31.1 (1955) plus code cases.
	Pumps	ASME, Sec. III, Class C.
	Shell side	ASME, Sec. III, Class C and TEMA C.
	Tube side	ASME, Sec. VIII, TEMA C.
b. D + T + H + E'	Same as (c) above.	

[a]D = Dead load of structure and equipment plus any other permanent loads contributing stress, such as soil or hydrostatic loads or operating pressures and live loads expected to be present when the plant is operating.

[b]P = Pressure due to loss-of-coolant accident.

[c]R = Jet force or pressure on structure due to rupture of any one pipe.

[d]H = Force on structure due to thermal expansion of pipes under operation condition.

[e]T = Thermal loads on containment due to loss-of-coolant accident.

[f]E = Design earthquake load.

[g]E' = Maximum earthquake load.

TABLE 6-3. Comparison of original and current structural behavior criteria for determining seismic design adequacy of passive mechanical and electrical equipment and distribution systems.

Component	Original criteria (0.1 g input)	Current criteria (0.2 g input)	
Vessels, pumps and valves	$S_{m_{all}} \le 0.33\ S_u$ and $0.67\ S_y$ ASME III Class A $S_{all} \le 0.25\ S_y$ and $0.63\ S_y$ ASME III Class C	$S_{m_{all}} \le 0.7\ S_u$ and $1.6\ S_y$ $S_{m_{all}} \le 0.67 S_u$ and $1.33\ S_y$ $\sigma_{m_{all}} \le 0.5\ S_u$ and $1.25\ S_y$ $\sigma_{m_{all}} \le 0.5\ S_u$ and $1.25\ S_y$	ASME III Class 1 (Table F 1322.2.1) ASME III Class 2 (NC 3217) ASME III Class 2 (NC 3321) ASME III Class 3 (ND 3321)
Piping	$S_{all} \le 0.3\ S_u$ and $0.75\ S_y$ B31.1	$S_{m_{all}} \le 1.0\ S_u$ and $2.0\ S_y$ $S_h \le 0.6\ S_u$ and $1.5\ S_y$	ASME III Class 1 (Table F 1322.2.1) ASME III Class 2 and Class 3 (NC 3611.2)
Tanks	$S_{all} \le 0.25\ S_u$ and $0.63\ S_y$ API 620 or API 650	No ASME III Class 1 $\sigma_{m_{all}} \le 0.5\ S_u$ and $1.25\ S_y$	ASME III Class 2 and Class [illegible] (NC 3821)
Electrical equipment	----------	$S_{all} \le 1.0\ S_y$	
Cable trays	----------	$S_{all} \le 1.0\ S_y$	
Supports for ASME components	----------	$S_{all} \le 0.7\ S_u$ or $1.2\ S_y$	For ASME Section III plate and shell supports and Appendix XVII for bolting.
Other supports	----------	$S_{all} \le 1.0\ S_y$	ASME Section III and Appendix XVII for bolting

(5)

TABLE 6-1. Mechanical and electrical components selected by the SSRT for seismic evaluation and the basis for selection.

Item No.	Description	Reason for selection
	<u>Mechanical Components</u>	
1	Control rod drive control units and associated hydraulic tubing	The supports of this item appear to be of relatively low frequency; hence, significant seismic response is possible. Specific provisions for carrying seismically induced loads are not apparent from visual inspection.
2	Shutdown heat exchanger	This item is supported by two saddles that do not appear to be seismically restrained. Concern was expressed about the saddles ability to carry required seismic loads, particularly in the longitudinal direction.
3	Isolation condenser	This horizontal heat exchanger is supported by three saddles, but the concerns are the same as those expressed for Item 2.
4	Motor-operated valves	A general concern with respect to motor-operated valves, particularly for lines 4 in. or less in diameter, is that the relatively large eccentric mass of the motor will cause excessive stresses in the attached piping, if the valves are not externally supported.
	<u>Electrical component</u>	
5	Battery rack	The battery rack for the 250- and 125-V batteries use wooden cell braces. The bracing required to develop lateral load capacity did not appear sufficient to carry the seismic load.

TABLE 6-2. Mechanical and electrical components selected by the SSRT for seismic evaluation based on licensee query, and reasons for selection.

Item No.	Description	Reason for selection
	Mechanical Components	
1	Pump--horizontal, high-pressure coolant injection (HPCI)	Pumps supplied to Dresden 2 had no specified, well-defined code-design requirements that included support and anchor-bolt stress requirements.
2	Pump--vertical, low-pressure coolant injection (LPCI)	Same as Item 1. Also, experience has shown that the suction intake and column support legs of vertical pumps tend to be highly stressed by seismic loads.
3	Liquid control tank	Anchor-bolt system for in-structure flat-bottom tanks that are flexible may be overstressed if tank and fluid contents were assumed rigid in the original analysis.
4	Reactor vessel and core supports	Items are particularly critical to insure reactor coolant system integrity.
5	Recirculation pump	Item is particularly critical to insure reactor coolant system integrity.
6	Piping systems:	
6a	Recirculation system	Typical of large, dynamically analyzed pipe systems in Dresden 2, and is particularly critical to insure reactor coolant system integrity.
6b	LPCI system pump suction seismic analysis	Typical of large, statically analyzed pipe systems in Dresden 2.
6c	Quad Cities typical piping run test Probe #1	Typical of small, standard layout pipe systems in Dresden 2.

7

TABLE 6-2. Cont'd.

Item No.	Description	Reason for selection
	Electrical components	
7	Motor control centers--250 V, dc	Typical seismic-qualified electrical equipment.
8	440 V, ac	Same as Item 7. Also, items were supplied by a different vendor.
9	Switch gear	Same as Item 7.
10	Transformer--440 V	Same as Item 7.
11	Control room electrical panels	The control panels appear adequately anchored at the base. However, there appear to be many components cantilevered off of the front panel, and the lack of front panel stiffness may permit significant seismic response of the panel, resulting in high acceleration of the attached components.
12	Electrical cable raceways	The cable tray support systems did not appear to have positive lateral restraint and load carrying capacity.

6.2 SEISMIC INPUT AND ANALYTICAL PROCEDURES

6.2.1 Original Seismic Input

The seismic design input for mechanical equipment and piping are given in Sec. 5.6.

For electrical components, the static type of analysis was apparently used, with design acceleration levels typically limited to 0.2 g.[38] For electrical distribution cable pans, it also appears that a static type of analysis was considered with design acceleration listed as 0.2 g.[39]

8

SEISMIC INPUT MOTION FOR EQUIPMENT AND PIPING

- MODAL SUPERPOSITION USING FLOOR RESPONSE SPECTRA
- EQUIVALENT STATIC ANALYSIS
- LATERAL-DEFLECTION AND FORCE-EVALUATION CURVES

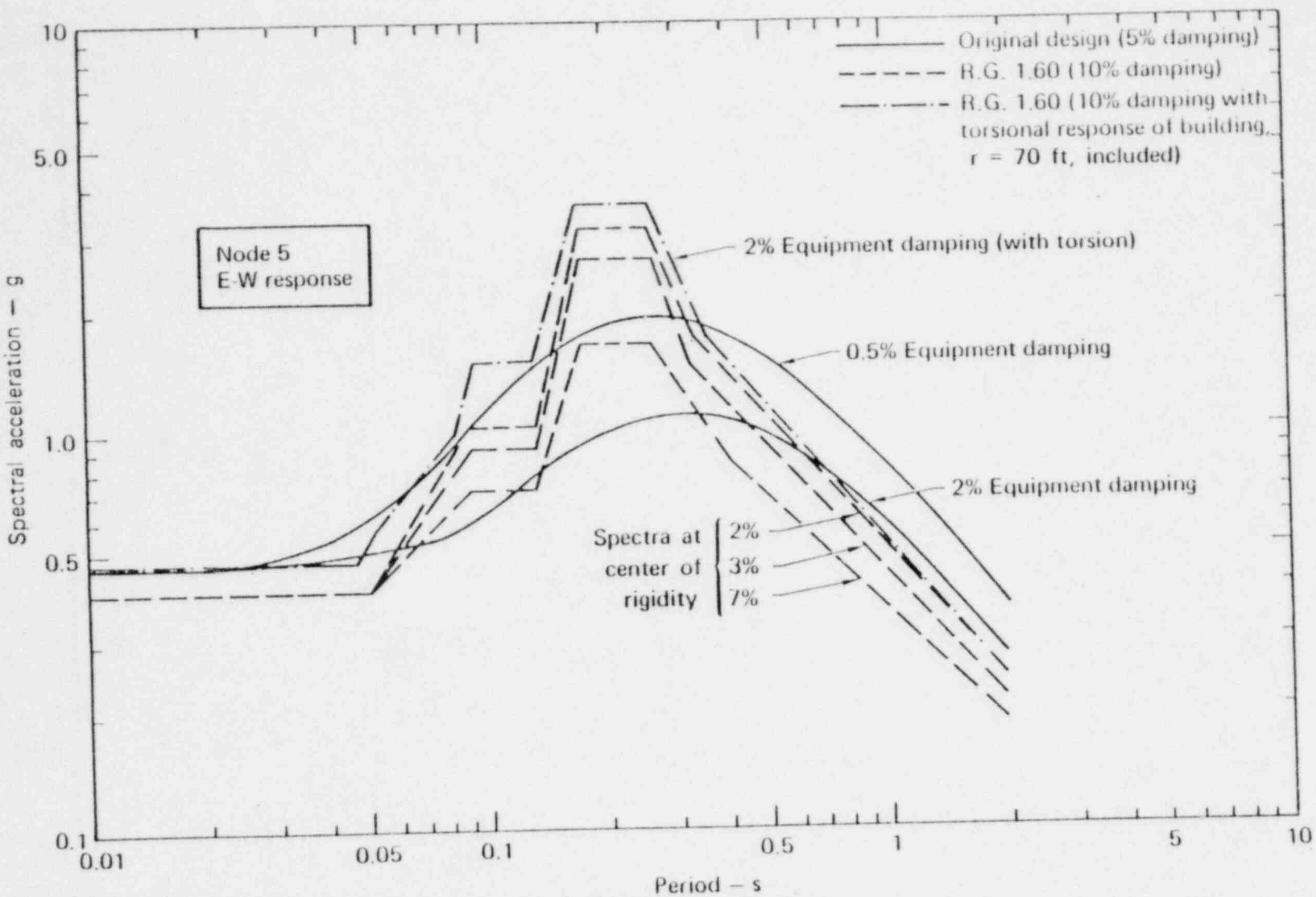


FIG. 5-13. Comparison of original amplified ground response spectra to floor spectra developed from R.G. 1.60 spectra, with and without torsional response included. Curves are for node 5 under E-W excitation.

TABLE 7

COMPARISON OF AVAILABLE NUCLEAR STATION EXPERIMENTALLY MEASURED DAMPING AND REGULATORY REQUIREMENTS AND RECOMMENDATIONS

I. Best Estimate or Mean Value Damping Values

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Reactor System Piping	3.4	2.0	8.1	2.0	10.0	3.0	3.0	12.7	16.2
Mechanical Components	3.8	3.0	5.7	2.0	6.5	4.0	7.0	7.7	9.1
Concrete Structures	5.2	5.0	7.5	4.0	13.9	7.0	10.0	18.7	25.0

Notes:

Column Headings:

(1) Average of Measured Data for Stress Levels at or less than 0.1 Yield for Components and Piping and 0.25 Yield for concrete from Table B.1.

(2) Suggested Newmark and Hall Values at Approximately 0.5 Yield (Ref. 7).

(3) Measured Damping Values Normalized to 0.5 Yield Stress Using Procedures Shown in Appendix B.

(4) Regulatory Guide 1.61 Values for Stress Levels of Approximately 0.67 Yield (OBE).

(5) Measured Damping Values Normalized to 0.67 Yield Stress Using Procedures Shown in Appendix B.

(6) Regulatory Guide 1.61 Values for Stress Levels of Approximately 0.90 Yield (SSE).

(7) Suggested Newmark and Hall Values at Approximately 0.9 Yield (Ref. 7).

(8) Measured Damping Values Normalized to 0.9 Yield Stress (Faulted: Buildings; Emergency: Component Supports).

(9) Measured Damping Values Normalized to 1.2 Yield Stress (Faulted: Component Supports).

TABLE 6-6. SSRT conclusions regarding equipment reviewed for seismic design adequacy of Dresden 2.

Item	Description	Conclusion and recommendation
1.	Control rod drive units and associated hydraulic tubing supports	Design adequacy of the tubing and its support system in 0.2 g SSE seismic event should be demonstrated by analysis.
2.	Shutdown heat exchanger	O.K.
3.	Isolation condenser	O.K.
4.	Motor-operated valves	Generic analysis showing motor-operated valves on lines <4 in. should be performed to show resulting stresses are less than 10% of Condition B allowable stresses (~1800 psi). Otherwise, stresses induced by valve eccentricity should be introduced into piping analysis to verify design adequacy or provide a procedure whereby all motor valves <4 in. be externally supported.
5.	Horizontal pump (HPCI)	O.K.
6.	Vertical pump (LPCI)	O.K.
7.	Liquid control tank	O.K.
8.	Reactor vessel and internal shroud support	Definitive seismic input to reactor supports is not available. Available calculations are incomplete but indicate that the reactor vessel and shroud supports are capable of carrying approximately 0.6 g. A more detailed evaluation is recommended.
9.	Recirculation pump	A detailed evaluation of the pump and supports is recommended to quantify the safety margin.

TABLE 6-6. Cont'd.

Item	Description	Conclusion and recommendation
10.	Piping:[a] a. Recirculation system b. LPCI System, pump suction c. Typical piping run example #1	O.K. in general. However, verification is recommended to assure seismic support spacings of pipe give fundamental frequencies $\geq$ 2 times building fundamental frequency for pipe support design using the lateral-deflection and forc -evaluation curves. Otherwise, design stresses in these supports may not meet current behavior limits.
11.	Electrical equipment - general	The support or anchorage of electrical equipment including control panels, instrument racks, switch gear, transformers, motor control centers, etc., do not appear, in general, to have been engineered. Positive anchorage of such components appears to have been decided in the field without any specified material, design, fabrication, or inspection requirements. Supports or anchorage for electrical components should undergo a general engineering review to assure design adequacy.
12.	Battery racks	The racks, with the exception of the wooden lateral cell bracing, appear O.K. Wooden cell braces should be replaced or strengthened to carry full seismic inertial loads.
13.	Instrumentation and control room panels	O.K. if existing test results can be said to be applicable to panels and instrumentation actually installed in Dresden 2 and modifications suggested by that report have been made.
14.	Motor control centers 250 V, dc	O.K. for El. 517.5 ft and below and up to support El. 545 ft if no fundamental cabinet frequencies below 9.0 Hz, and if existing test results are applicable to control centers in Dresden 2. No control centers are located above El. 538 ft.

[a]Seismic design adequacy of steam and feedwater systems has been determined from review of Ref. 18 and 20.

TABLE 6-6. Cont'd.

Item	Description	Conclusion and recommendation
15.	Motor control centers 480 V, ac	Centers have not been qualified at frequencies below 5 to 7.5 Hz. Additional testing or analysis should be performed to determine that there are no resonance frequencies below 5 Hz. Also, test results supplied should be specified as being applicable to motor control centers in Dresden 2.
16.	Switch gear	Test results verifying design adequacy similar to those developed for items 12, 13, and 14 will be required.
17.	Transformer	O.K.
18.	Cable trays (pans)	The trays or pans themselves are O.K., but the supports of the trays or pans, consisting primarily of 0.5-in.-diameter threaded rod, do not appear to have adequate lateral load capacity. Additional analysis or test verification is needed to establish lateral load capacity of the supports seismic design adequacy for the applicable response spectra in Chapter 5.

SEISMIC CAPACITY OF PIPING

DESIGNED TO ANSI B31.1 - 1967

Everett Rodabaugh

June 4, 1980

SCOPE OF DISCUSSION

Piping Made of Ductile Material

Examples: A106 Gr.B at 70 F and up

A312 Type 304

Not cast iron

Welds

Welds acceptable per ANSI B31.1

CAUSES OF PIPING FAILURES

(1) Corrosion/Erosion
Stress Corrosion Cracking

(2) Vibration
Mechanically induced, e.g. pipe attached to reciprocating pump
Fluid flow induced; e.g., pressure pulses from pump or turbine

(3) Fluid Flow Hammer
Water hammer
Steam hammer
Slug flow

(4) External Damage
Support failure
Truck runs into pipe or support
Excavator hits buried pipe
Fire
Landslide

(5) Thermal Fatigue

(6) Fatigue due to restraint of thermal expansion

(7) Earthquake

ANSI B31.1-1967 ALLOWABLE STRESS, S_h

A106 Grade B Carbon Steel (No Change in 1973, 1977)

Temp, °F	S_h psi	$\frac{S_h}{S_y}$	$\frac{S_h}{S_u}$
100	15,000	0.429	0.250
200	↓	0.470	↓
400	↓	0.500	↓
550	↓	0.554	↓

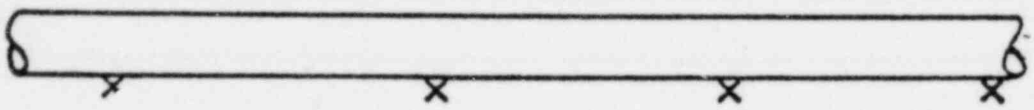
A312 Type 304 Austenitic Stainless Steel

Temp, °F	S_h, psi	$\frac{S_h}{S_y}$	$\frac{S_h}{S_u}$
100	18,750	0.625	0.250
200	16,550	0.662	0.233
400	14,950	0.722	0.232
550	14,450	0.769	0.228

S_y = minimum expected yield strength

S_u = minimum expected ultimate strength

STRAIGHT PIPE, SUPPORTED SO THAT
WEIGHT STRESS = 1500 psi

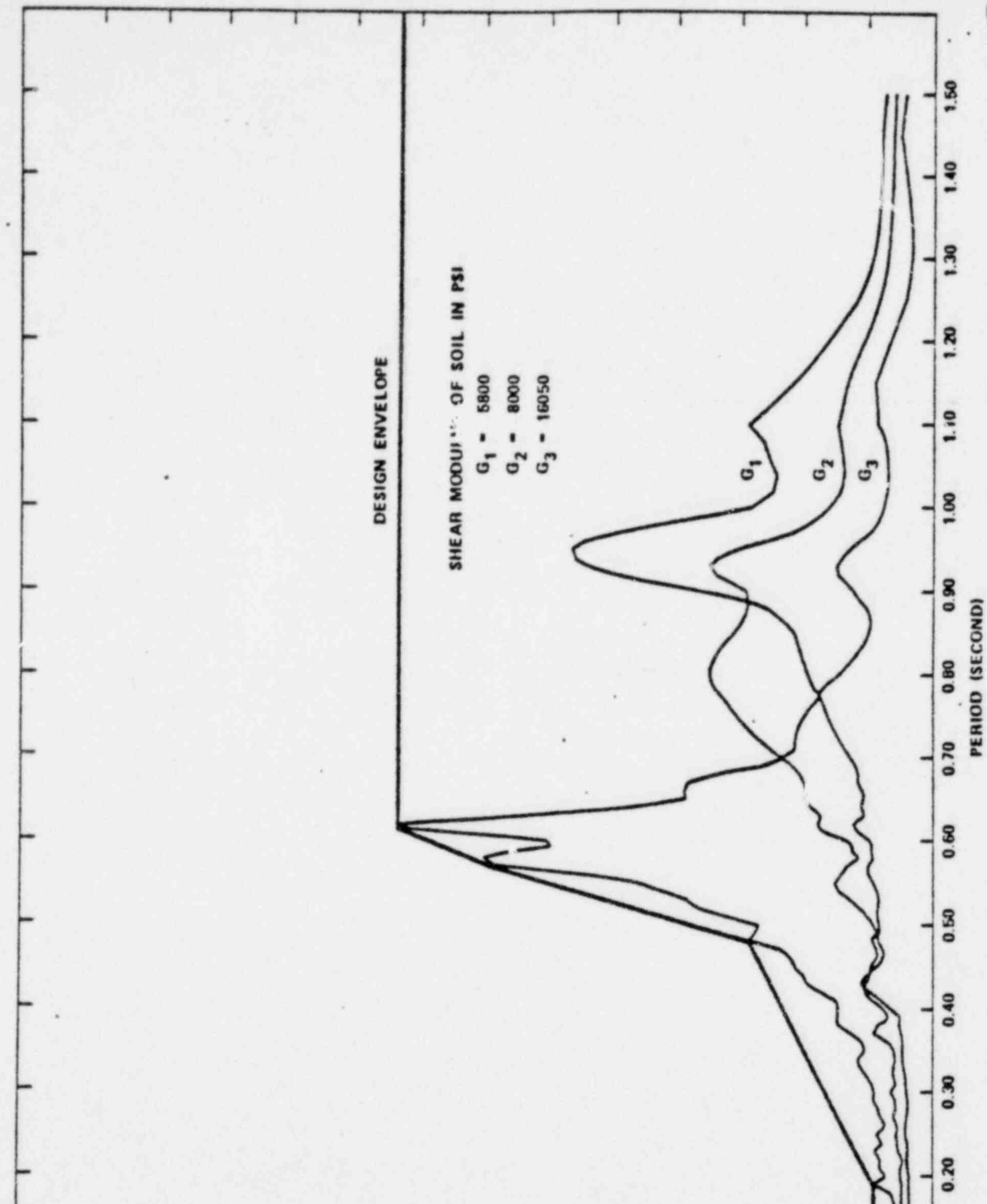


Seismic g-load	Margin on Limit Moment	
	SA 106 Grade B	SA 312 Type 304
0	3.03	2.08
1	2.76	1.93
2	2.53	1.79
3	2.33	1.68
4	2.17	1.58

Limit Moment is the highest moment the pipe can withstand with a small amount of plastic deformation.

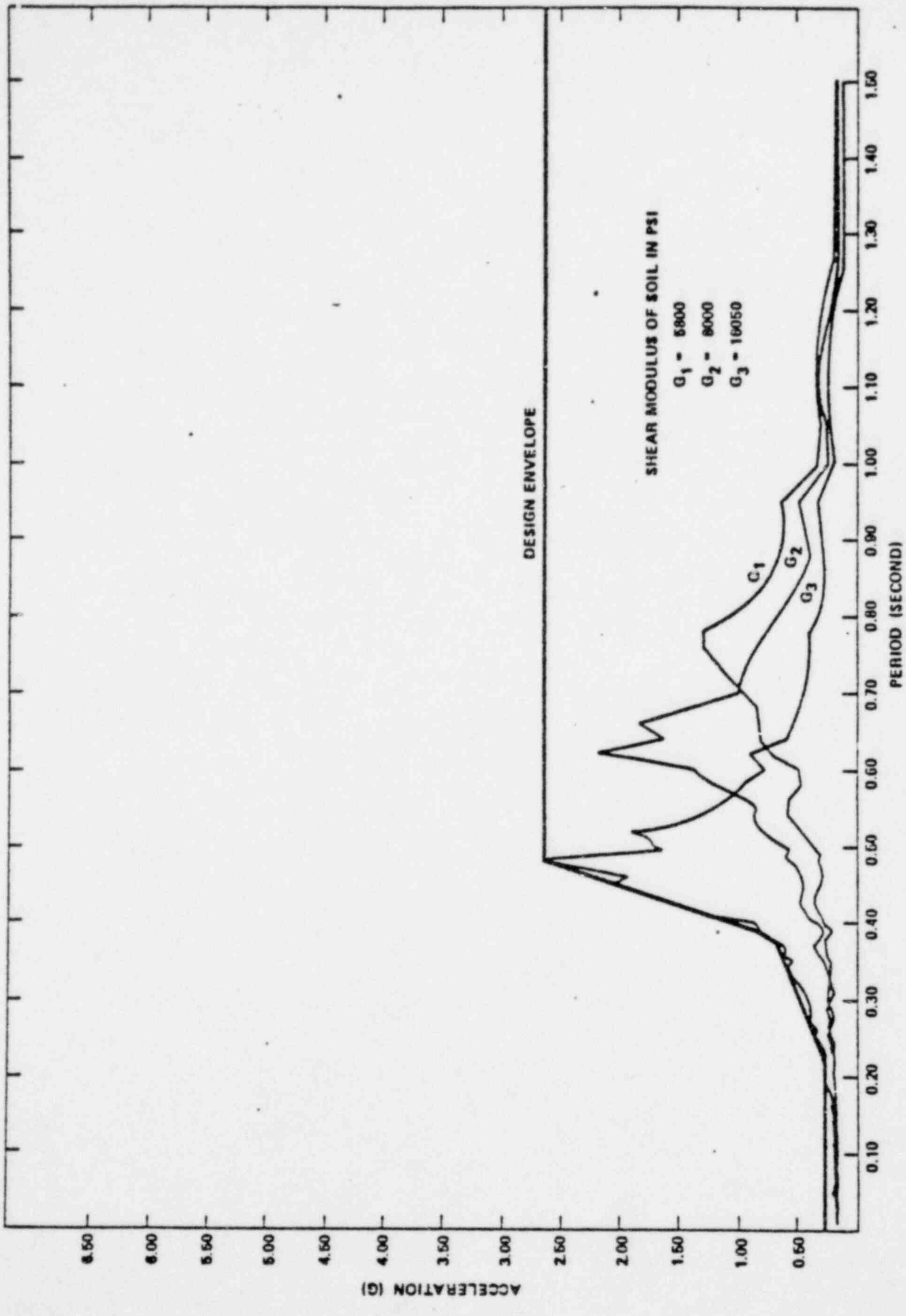
First mode frequency of pipe supported to restrict weight stress to 1500 psi is in the range of 9 to 13 Hz.

(5)

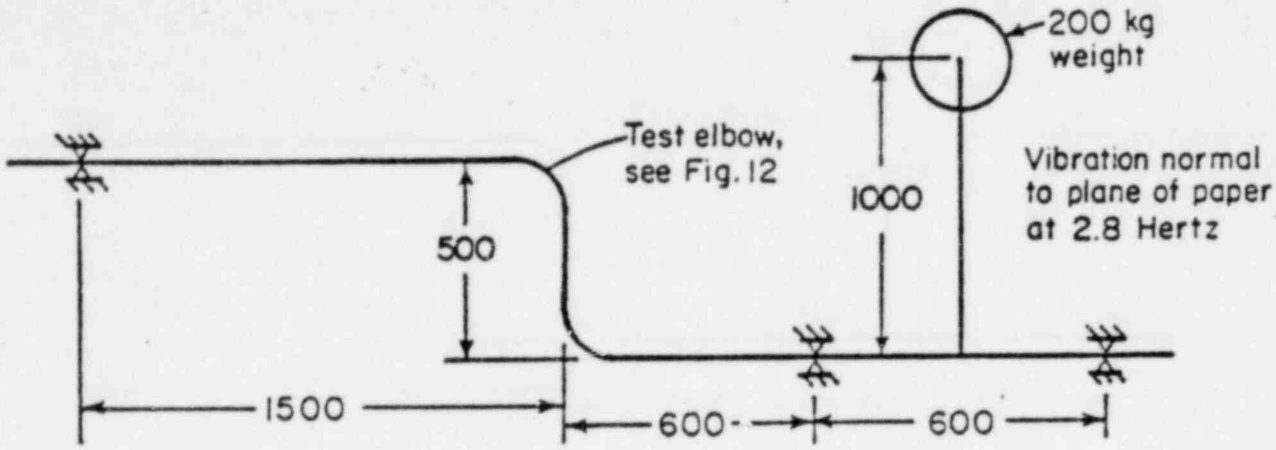


LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	FLOOR SPECTRA E-W SSE 1% INTERNAL STRUCTURE ELEV. + 46 FT. MSL	Figure 3.7–12

(6)

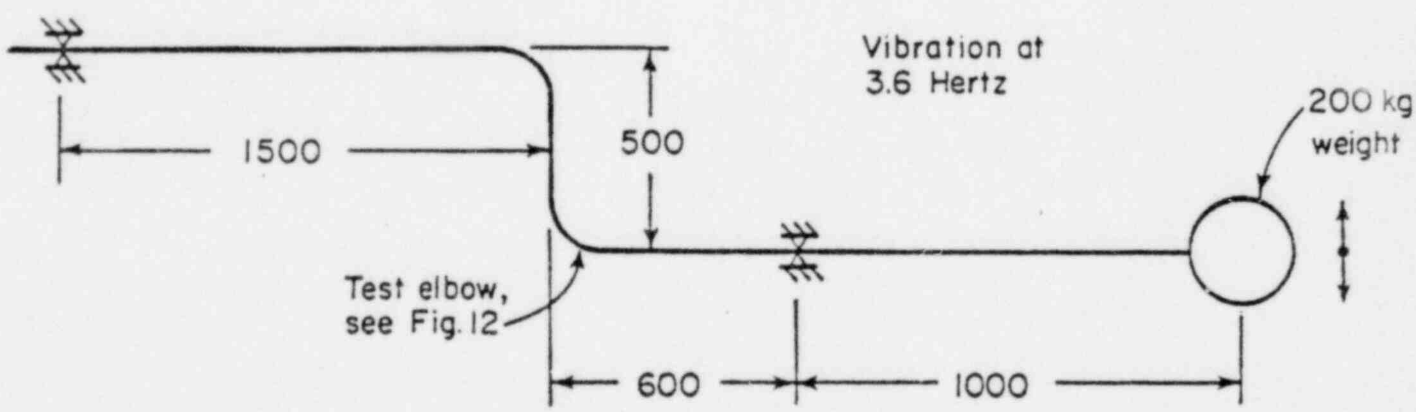


LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	FLOOR SPECTRA VERTICAL SSE 1% INTERNAL STRUCTURE ELEV. + 46 FT. MSL	Figure 3.7-17



a. Model 1 (3 units tested)

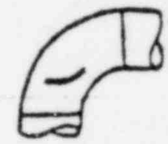
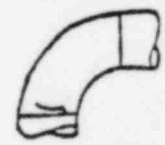
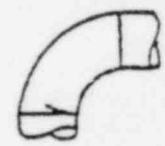
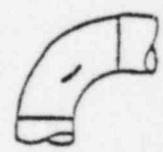
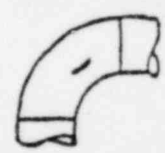
Dimensions in millimeters.



b. Model 2 (2 units tested)

SCHEMATIC OF REF. (24) VIBRATION INDUCED
LOADING TESTS ON ELBOWS

SUMMARY OF FATIGUE TEST RESULTS, REF (24)

Ref. No.	Moment (±) in-lb	Type of Moment	$\frac{PD}{2t}$ ksi	Cycles To Failure[(a)]	Failure Location and Extent (b)
(24)1	39900 $\frac{S_a}{S_h} = 5.5$	$\pm M_y$	0	157	
(24)2	53100 $\frac{S_a}{S_h} = 7.3$	$\pm M_y$	19.8	140	
(24)3	56700 $\frac{S_a}{S_h} = 7.9$	$\pm M_y$	18.9	108	
(24)4	43800 $\frac{S_a}{S_h} = 6.1$	$\pm M_z$	16.5	231	
(24)5	45000 $\frac{S_a}{S_h} = 6.2$	$\pm M_z$	17.3	340	

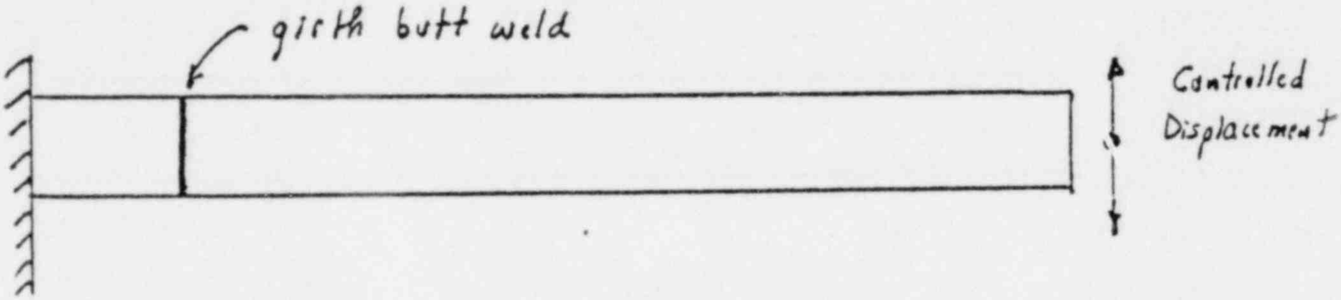
(a) Failure was defined as a crack thru-the-wall as evidenced by leakage.

(b) See Figure 12 for elbow dimensions. Elbows were made of stainless steel like SA312 TP304

D_o = 89.1 mm outside diameter
t = 3.0 mm wall thickness
R = 114.3 mm bend radius

$S_a = i\ (M/Z)$ = ANSI B31.1 calculated stress amplitude

Fatigue Test - Girth Butt Weld



FATIGUE TESTS, TYPICAL GIRTH BUTT WELDS

Material	Test Temp, F	S_r, ksi	S_r/S_h	N_t	P, psi
A106-B	100	44	2.9	400,000	0
	100	60	4.0	50,000	0
	100	90	6.0	3,000	0
	550	58	3.9	36,000	0
	550	102	6.8	7,500	2200
304	550	64	4.4	14,900	0
	550	94	6.5	2,900	0
	550	96	6.6	7,700	1050

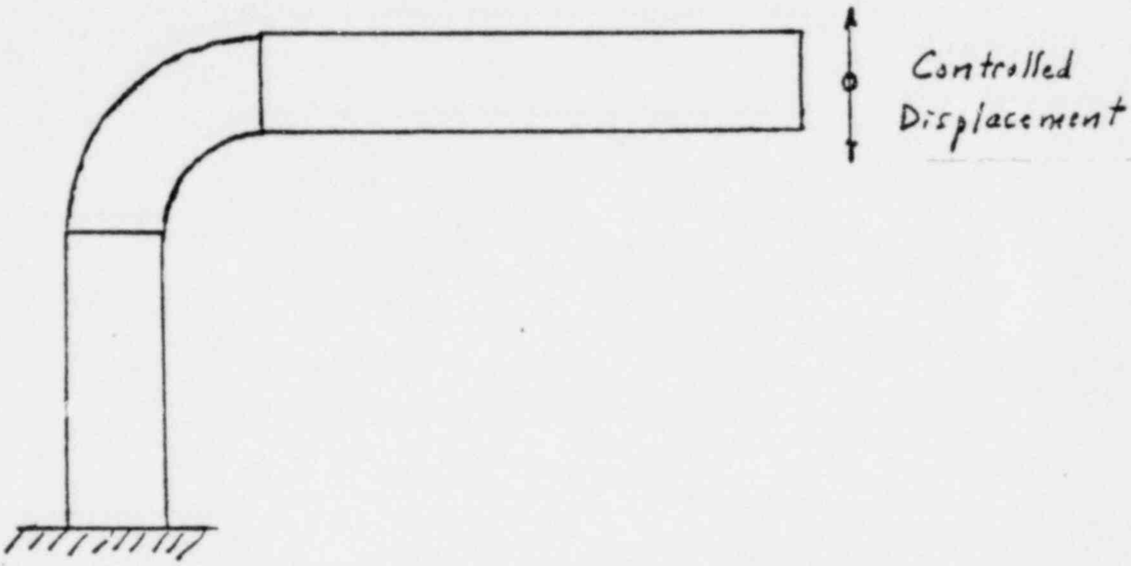
S_r = nominal (M/Z) stress range corresponding to applied displacement

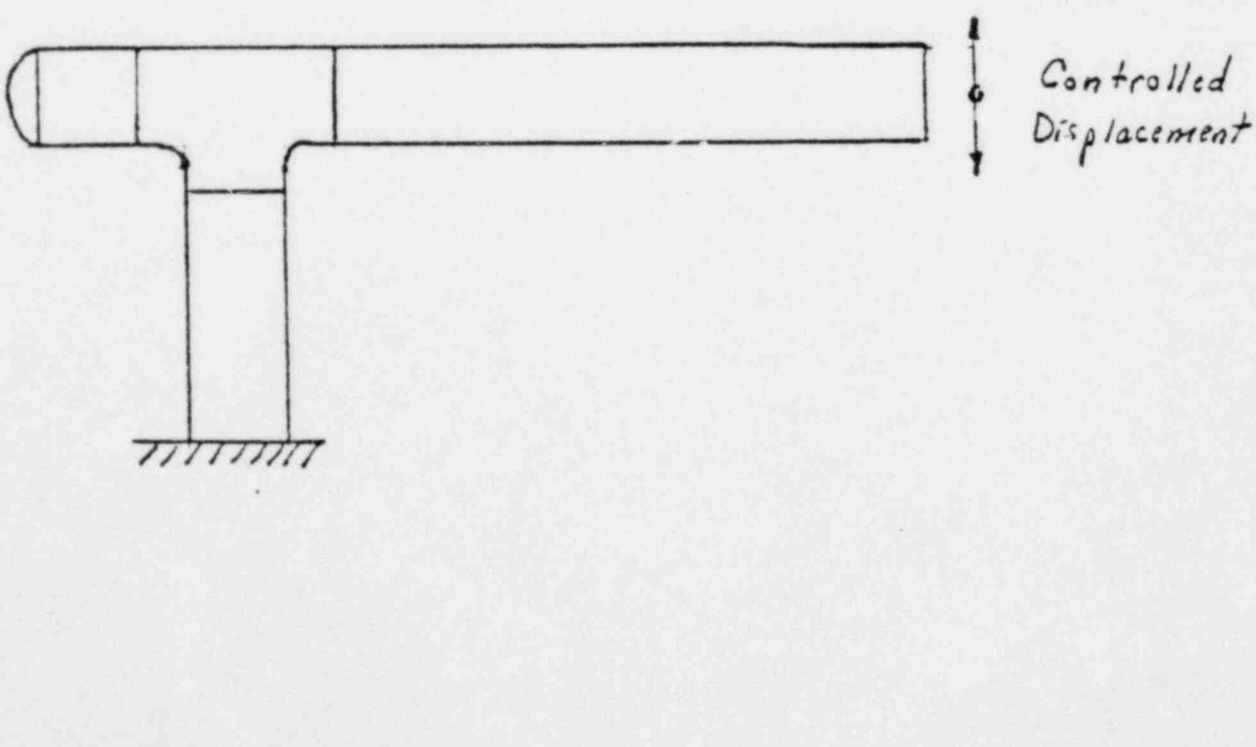
S_h = ANSI B31.1 allowable stress

N_t = cycles-to-failure (thru-wall crack, leak)

P = static internal pressure

Fatigue Test - Elbows & Tees





FATIGUE TESTS, ELBOWS & TEES

Fitting	Material	Test Temp., F	S_r ksi	S_r/S_h	N_t	P
Elbow	A106-B	100	30	2.0	10^6	0
		100	77	5.1	20,000	0
		100	250	17.1	300	0
		550	128	8.5	26,000	0
		100	126	8.4	6,800	1050
	304	100	100	5.3	4,500	0
		550	125	8.6	1,900	0
		100	131	7.0	910	1050
Tee	A106-B	100	28	1.9	500,000	0
	"	100	145	9.7	900	0
	304	100	116	6.2	4,600	0

S_r = stress range, = iM/Z_b, i = stress intensification factor

S_h = ANSI B31.1 allowable stress

N_t = cycles-to-failure (through-wall crack, leak)

P = static internal pressure

(13)

SUMMARY

- Piping made of ductile materials apparently was not damaged in severe earthquakes.
- ANSI B31.1 - 1967 stress limits, in conjunction with normal piping practice of support spacings, provides high assurance that such piping will not be damaged by earthquakes.
- Experimental data shows the high strength of piping components, relative to allowable stresses in ANSI B31.1 - 1967.

(14)

CHECKS ON EXISTING PLANTS

WITH PIPING TO ANSI B31.1 - 1967

- Review existing "floor response spectra" for guidance.

- Check adequacy of existing supports. In a few cases, it may be an appropriate precautionary measure to provide supplemental supporting; e.g., where present supports do not sufficiently restrict lateral or upward movement.

DIABLO CANYON

SYSTEMS INTERACTION PROGRAM

Cecil Graham

BACKGROUND

- Developed as result of discussions concerning failure of non-seismic Category I piping at 11/5/79 TMI-2 Accident Implications ACRS Subcommittee meeting
- Program considers seismically-induced interactions between non-seismically-qualified equipment and safety-related equipment
- Requirement documented in Task II.C.3 of NUREG-0660

PROGRAM

- Initial Office Activities - Identification of target equipment, identification according to location in existing fire zones, preparation of detailed criteria
- Field Walkdown Activities - Confirming walkdown, interaction walkdown, intercompartmental walkdown
- Technical Evaluation - Of unacceptable conditions identified during field walkdown
- Modifications - As required as result of technical evaluation
- Independent Audit - Program audit to be performed by PG&E's Quality Assurance Department
- Independent Review Board - Independent of PG&E, will monitor program and report findings to Manager, Nuclear Projects

SIB REVIEW

- Interdisciplinary Review Team - Several members of SIB, members of MEB, consultant
- In-House Review - Organization, methodology, criteria, documentation as described in PG&E's submittals
- Onsite Audit - Documentation, records, walkdown activities, independent audit

SCHEDULE

- PG&E Submittals - May 7, 1980 and May 27, 1980
- SIP Onsite Audit - June 17-19, 1980
- SER Supplement - Early August 1980
- ACRS Subcommittee Meeting - Mid to late August 1980
- ACRS Meeting - September 1980

Ls Graves

BACKGROUND OF RHR POSITION

1. JOINT POSITION - DTR/DPM - FEBRUARY 1974
2. APPEALS BY WESTINGHOUSE & GENERAL ELECTRIC & STAFF REEVALUATION
3. STAFF POSITION TO WESTINGHOUSE AND GENERAL ELECTRIC - NOVEMBER 1975
4. RRRC APPROVAL OF BTP RSB 5-1 - JUNE 1976
5. WESTINGHOUSE PRESENTATION AND STAFF EVALUATION
6. RRRC APPROVAL OF REVISED BTP RSB 5-1 - JANUARY 1978
7. ACRS MEETING ON REG. GUIDE 1.139 - MARCH 1978
8. REG. GUIDE 1.139 ISSUED FOR PUBLIC COMMENT - MAY 1978
9. PRESENTATION TO ACRS IN FEB. 1979
10. TMI-2 - MARCH 1979
11. REVISION TO R. G. 1.139 TO REFLECT TMI-2 - 1979
12. PRESENTATION OF REVISED R.G. 1.139 TO ACRS IN APRIL 1980
13. REVISED R.G. 1.139 ISSUED FOR PUBLIC COMMENT BY JULY 1980

DESIGN REQUIREMENTS OF BTP RSB 5-1 FOR NEW PLANTS

I. FUNCTIONAL REQUIREMENT FOR TAKING TO COLD SHUTDOWN

A. CABABILITY USING ONLY SAFETY-GRADE SYSTEMS

B. CAPABILITY WITH EITHER ONLY ONSITE OR ONLY OFFSITE POWER AND WITH SINGLE FAILURE (LIMITED ACTION OUTSIDE CR TO MEET SF).

C. REASONABLE TIME FOR COOLDOWN ASSUMING MOST LIMITING SF AND ONLY OFFSITE OR ONLY ONSITE POWER.

II. RHR ISOLATION

III. RHR PRESSURE RELIEF

IV. PUMP PROTECTION

V. TEST REQUIREMENT

A. FOR PWR'S, TEST PLUS ANALYSIS TO CONFIRM ADEQUATE MIXING AND COOLING UNDER NATURAL CIRCULATION.

VI. OPERATIONAL PROCEDURE

A. MEET R.G. 1.33. FOR PWR'S, INCLUDE SPECIFIC PROCEDURES AND INFORMATION FOR COOLDOWN UNDER NATURAL CIRCULATION.

VII. AUXILIARY FEEDWATER SUPPLY

A. SEISMIC CATEGORY I SUPPLY FOR AUXILIARY FW FOR AT LEAST 4 HOURS AT HOT SHUTDOWN PLUS COOLDOWN TO RHR CUT-IN BASED ON LONGEST TIME FOR ONLY ONSITE OR ONLY OFFSITE POWER & ASSUMED SINGLE FAILURE.

PROCESSES IN GOING FROM HOT STANDBY TO COLD SHUTDOWN

1. CIRCULATION OF REACTOR COOLANT

2. DEPRESSURIZATION DURING COOLDOWN

3. BORATION DURING COOLDOWN

4. HEAT REMOVAL DURING COOLDOWN

CIRCULATION OF REACTOR COOLANT DURING SHUTDOWN

A. REASONS FOR FUNCTION

1. MIXING
2. UNIFORM COOLING OF LOOPS
3. REDUCE VESSEL STRESS

B. ACHIEVEMENT OF FUNCTION

1. OFFSITE POWER -- RCS PUMPS
2. LOSS OF OFFSITE POWER -- NATURAL CIRCULATION

C. COOLDOWN UNDER NATURAL CIRCULATION

1. FACTORS AFFECTING FLOW RATE
2. NATURAL CIRCULATION TESTS
3. NATURAL CIRCULATION AND MIXING
4. NATURAL CIRCULATION AND COOLING--VESSEL STRESSES
5. NATURAL CIRCULATION AND RHR OPERATION

D. EFFECTS OF SEISMIC EVENTS -- LOOP -- DUMP VALVE CONTROL

E. EFFECTS OF SINGLE FAILURE -- DUMP VALVE -- MECHANICAL FAILURE

DEPRESSURIZATION DURING COOLDOWN

A. REASONS FOR FUNCTION -- 2250 PSIA TO 400 PSIA

B. ACHIEVEMENT OF FUNCTION

1. OFFSITE POWER -- NORMAL PRESSURIZER SPRAY
2. LOSS OF OFFSITE POWER -- AUXILIARY PRESSURIZER SPRAY

C. DEPRESSURIZATION WITH NATURAL CIRCULATION (AUXILIARY SPRAY)

D. EFFECT OF SEISMIC EVENT (INSTRUMENT AIR AND AUXILIARY SPRAY)

E. EFFECT OF SINGLE FAILURE (LINE BLOCKAGE OR DIVERSION OF AUXILIARY SPRAY)

F. ALTERNATE METHODS

1. PRESSURIZER LEVEL
2. POWER-OPERATED PRESSURIZER RELIEF VALVES
3. NORMAL HEAT LOSS?

BORATION DURING COOLDOWN

A. REASON FOR FUNCTION -- EOL -- 0 TO 1400 PPM BORON

B. ACHIEVEMENT OF FUNCTION
   1. OFFSITE POWER
   2. LOSS OF OFFSITE POWER

C. BORATION UNDER NATURAL CIRCULATION
   1. MIXING PROBLEM
   2. TEST REQUIREMENT

D. EFFECT OF SEISMIC EVENT
   1. LOSS OF INSTRUMENT AIR (LETDOWN, CHARGING, MEASUREMENT)
   2. NONSEISMIC EQUIPMENT
   3. ATMOSPHERIC DUMP VALVES

E. EFFECTS OF SINGLE FAILURE (LETDOWN, CHARGING)

F. ALTERNATE METHODS
   1. NO LETDOWN -- PRESSURIZER LEVEL -- CONTRACTION

HEAT REMOVAL DURING COOLDOWN

A. REASON FOR FUNCTION

1. DECAY HEAT

2. SENSIBLE HEAT

B. ACHIEVEMENT OF FUNCTION

1. WITH OFFSITE POWER

2. LOSS OF OFFSITE POWER

C. HEAT REMOVAL UNDER NATURAL CIRCULATION

1. STEAM DUMP VALVE CAPACITY AND RHR CUT-IN T

2. AUXILIARY FEEDWATER SUPPLY REQUIREMENTS

PLANT CLASS	IMPLEMENTATION
1 - ALL PLANTS (CUSTOM OR STANDARD) FOR WHICH CP OR PDA APPLICATIONS ARE DOCKETED ON OR AFTER JANUARY 1, 1978.	FULL
2 - ALL PLANTS (CUSTOM OR STANDARD) FOR WHICH CP OR PDA APPLICATIONS ARE DOCKETED BEFORE JANUARY 1, 1978 AND FOR WHICH AN OL ISSUANCE IS EXPECTED ON OR AFTER JANUARY 1, 1979.	PARTIAL AS PER TABLE 2
3 - ALL OPERATING REACTORS AND ALL OTHER PLANTS (CUSTOM OR STANDARD) FOR WHICH ISSUANCE OF THE OL IS EXPECTED BEFORE JANUARY 1, 1979.	TO BE DETERMINED BY IE/DOR REVIEW

PARTIAL COMPLIANCE WITH BTP RSB 5-1 FOR PWR CLASS 2 PLANTS

A. FUNCTIONAL REQUIREMENTS

1. SINGLE DROP LINE FROM RHR	COMPLIANCE WILL NOT BE REQUIRED IF IT CAN BE SHOWN THAT CORRECTION FOR SINGLE FAILURE BY MANUAL ACTIONS INSIDE OR OUTSIDE OF CONTAINMENT OR RETURN TO HOT STANDBY UNTIL MANUAL ACTIONS (OR REPAIRS) ARE FOUND TO BE ACCEPTABLE FOR THE INDIVIDUAL PLANT.
2. PORTIONS OF SYSTEMS INVOLVED IN DEPRESSURIZATION AND BORATION	COMPLIANCE WILL NOT BE REQUIRED IF (A) DEPENDENCE ON MANUAL ACTIONS INSIDE CONTAINMENT AFTER SSE OR SINGLE FAILURE OR (B) REMAINING AT HOT STANDBY UNTIL MANUAL ACTIONS OR REPAIRS ARE COMPLETE ARE FOUND TO BE ACCEPTABLE FOR THE INDIVIDUAL PLANT.
3. STEAM DUMP VALVES (INVOLVED IN HEAT REMOVAL AND RCS CIRCULATION)	SEE SLIDE 17
4. TIME FOR COOLDOWN	36 HOURS TO RHR CUT-IN POINT

B.	NATURAL CIRCULATION TEST AND ANALYSIS	COMPLIANCE REQUIRED
C.	OPERATIONAL PROCEDURES	COMPLIANCE REQUIRED
D.	AUXILIARY FEEDWATER SUPPLY	COMPLIANCE NOT REQUIRED IF IT CAN BE SHOWN THAT ADEQUATE ALTERNATE SEISMIC CATEGORY I SOURCE IS AVAILABLE".

1. ALL CLASS 2 PLANTS SHOULD EITHER:

   A. PROVIDE REMOTE MANUAL OPERATION OF THE DUMP VALVES FROM THE CONTROL ROOM USING ONLY SAFETY-GRADE MECHANICAL AND ELECTRICAL SYSTEMS, OR

   B. DEMONSTRATE BY OPERATIONAL TESTING THAT CONTROLLED SAFE PLANT COOLDOWN CAN BE ACCOMPLISHED BY MANUAL OPERATION OF THE DUMP VALVES. THE CRITERIA THAT SHOULD BE MET IN ACCEPTING MANUAL OPERATION OF THE DUMP VALVES IN LIEU OF MEETING 1.A. ABOVE SHOULD BE:

      I. THE APPLICANT SHOULD DEMONSTRATE THAT THE PLANT CAN BE MAINTAINED IN A SAFE HOT STANDBY CONDITION, ASSUMING LOSS OF OFFSITE POWER, WITHOUT RELIANCE ON DUMP VALVE MANUAL OPERATION FOR AT LEAST ONE HALF HOUR FOLLOWING REACTOR SHUTDOWN.

      II. THE APPLICANT SHOULD DEMONSTRATE THAT AN OPERATOR HAS GOOD ACCESS TO THE DUMP VALVE, CAN SAFELY OPERATE IT MANUALLY, AND CAN COMMUNICATE WITH THE CONTROL ROOM.

      III. THE APPLICANT SHOULD INCLUDE IN THE PLANT TEST PROGRAM A TEST THAT VERIFIES THE ABILITY TO ACHIEVE SAFE PLANT COOLDOWN USING MANUAL DUMP VALVE OPERATION.

REVIEW OF AUXILIARY FEEDWATER SYSTEMS NOT DESIGNED TO SEISMIC CATEGORY I

- STATEMENT OF CONCERN
- SCOPE OF REVIEW
- REVIEW APPROACH
- REVIEW STEPS
- PLANT APPLICATION
- EXPECTED RESULTS

STATEMENT OF CONCERN

IN MANY PLANTS THE AUXILIARY FEEDWATER SYSTEM WAS NOT DESIGNED TO SEISMIC CATEGORY I CRITERIA (REGULATORY GUIDE 1.29).

THE SAFETY IMPLICATION OF THIS FACT NEEDS TO BE REVIEWED AND APPROPRIATE LICENSING ACTIONS NEED TO BE FORMULATED.

SCOPE OF REVIEW

1. IDENTIFY THOSE PWR PLANTS AND THOSE SPECIFIC PIECES OF EQUIPMENT IN THE AUXILIARY FEEDWATER SYSTEM WHICH WERE NOT DESIGNED TO SEISMIC CATEGORY I CRITERIA.

2. EVALUATE THE IMPORTANCE TO SAFETY.

3. RECOMMEND APPROPRIATE LICENSING ACTION.

REVIEW APPROACH

- RISK ANALYSIS BASED ON "SEPARATED SEISMIC SAFETY ANALYSIS" (TO ESTIMATE THE PROBABILITY OF A CORE MELT AND AN EARLY FAILURE OF CONTAINMENT)

- TWO STEP PROCESS IN WHICH THE

    PROBABILITY OF A GIVEN VALUE OF GENERAL ACCELERATION (G)

  IS COMBINED WITH THE

    PROBABILITY OF A SYSTEM FAILURE AT THAT VALUE OF GROUND ACCELERATION (G)

  TO DETERMINE THE TOTAL PROBABILITY OF A SYSTEM FAILURE AS A RESULT OF A SEISMIC EVENT.

REVIEW STEPS

1. DETERMINE APPROPRIATE GROUPINGS OF PLANTS BY AUXILIARY FEEDWATER SYSTEM DESIGN.
2. DEFINE LEVEL OF DETAIL FOR DESCRIPTION OF THE AUXILIARY FEEDWATER SYSTEM (SYSTEM LEVEL OR COMPARTMENT LEVEL)
3. DETERMINE THE PROBABILITY OF A GIVEN GROUND ACCELERATION (G) AS A FUNCTION OF (G)
4. DETERMINE THE APPROPRIATE METHOD OF TREATING SYSTEM REDUNDANCY
5. DEFINE THE "SAFETY FACTORS" TO BE USED TO DESCRIBE EACH COMPONENT OR SYSTEM
6. CONSTRUCT AN AUXILIARY FEEDWATER SYSTEM FAULT TREE FOR EACH PLANT OR FOR GROUPS OF PLANTS

7. ADD APPROPRIATE ALTERNATIVE DECAY HEAT REMOVAL PATHS TO THE FAULT TREE
8. PERFORM THE RISK ANALYSIS FOR EACH PLANT OR GROUP OF PLANTS
9. DEFINE CRITERIA FOR: SHORT TERM ACTIONS: LONG TERM (TWO TO THREE YEARS) STUDY AND LONG TERM ACCEPTABILITY
10. HAVE EACH UTILITY VERIFY THE ACCURACY OF THE DESIGN INFORMATION AND THE APPROPRIATENESS OF THE PLANT GROUPINGS

- PROBABILITY OF A GIVEN GROUND ACCELERATION (G) AS A FUNCTION OF (G)

AVAILABLE INFORMATION:

- COULTER (1973) (USED IN WASH-1400)
- ALGEMISSER (1969)
- HSIEH, OKRENT, APOSTOLAKIS (1975)

- PROBABILITY OF A SYSTEM OR COMPONENT FAILURE AS A FUNCTION OF GROUND ACCELERATION

AVAILABLE INFORMATION:

- NEWMARK (1975) USED IN WASH-1400
- CORNELL AND NEWMARK (1978)
- HSIEH AND OKRENT (1976) (UCLA-ENG-76113)
- NRC STAFF - ENGINEERING BRANCHES AND SEP
- NRC CONTRACTORS (BNL)
- DIABLO CANYON STUDIES (PG&E)

20X

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

MAY 20 1980

MEMORANDUM FOR: Malcolm L. Ernst
Assistant Director for Technology

FROM: Roger J. Mattson
Director, Division of Safety Technology

SUBJECT: SEISMIC QUALIFICATION OF PWR AUXILIARY FEEDWATER SYSTEMS

Background

In the past year, several reviews of auxiliary feedwater systems (AFWS) have been conducted. All of them were stimulated, at least in part, by the TMI accident. The most important of those reviews was the analysis of AFWS reliability for operating plants with reactors supplied by Westinghouse or Combustion Engineering. It was performed by PAS last summer and a number of equipment backfit requirements for AFWS were subsequently issued by NRR. Comparable work is now in progress by operating B&W reactor licensees and near term OL applicants (see TMI Action Plan, Item II.E.1.1).

In the course of these AFWS reviews it has been generally understood that some of the systems meet the standard Review Plan (SRP) criteria (i.e., the AFWS is safety grade) and some do not (i.e., those AFWS designed and approved before issuance of the SRP or the development of the criteria it contains). With the completion of the reliability analyses and associated backfitting, all AFWS will be of demonstratable reliability and comparable capability, but not all AFWS will necessarily be "safety grade," and, more importantly, not all will be designed to seismic category 1, as currently required by the SRP.

The lack of seismic qualification for auxiliary feedwater systems has been of concern for some months (e.g., see enclosed memo of November 27, 1979 from Mattson to Ross on the ACRS concern with seismic qualification of AFWS and subsequent memo from Ross to ACRS (Okrent) on December 28, 1979). Our response to this concern, at least up to now, has been that those PWRs that have AFWS without seismic qualifications generally have alternative methods of decay heat removal that are seismically qualified (e.g. high pressure ECCS). This has led to a secondary concern for the veracity of these alternative decay heat removal techniques; e.g., would feed and bleed cooling of the core work and for how long, and were operators trained and otherwise prepared to use it?

Following this line of logic, the staff and ACRS began discussions earlier this year of feed and bleed cooling capability for PWRs. Subsequently, the ACRS, in commenting on the TMI Action Plan, noted in effect that the staff's approach to decay heat removal reliability was piecemeal. The Action Plan steering group agreed and within the past month broadened item II.E.3.3 in the plan (NUREG-0660) to provide a more general approach to the problem.

About the same time, the staff task force on the transient response of B&W plants finished its report (NUREG-0667). It contained four specific recommendations on AFWS design. It also contained a recommendation to study further the need for seismic qualifications of AFWS.

Also about the same time, the director of AEOD expressed concern with the general question of decay heat removal reliability (see enclosed memo of April 24, 1980 from Michelson to Mattson). The AEOD concern also brings into this general area of uncertainty the proposed regulatory guide 1.139. Mr. Michelson has also pointed out in a personal communication that the general concern is not just reliability and capability of cold shut down heat removal, but also hot shutdown and other intermediate decay heat removal states.

The Problem

Action Items II.E.3.2 and II.E.3.3 of NUREG-0660 are probably sufficient to treat the overall concern with reliability of the decay heat removal capability for PWRs, with the exception of the seismic qualification question. That is, these actions will not specifically answer the question of whether the decay heat removal capability in some operating plants, approximately 10 in number, is of sufficient seismic capability.

Assignment

1) Study the logic and rationale of the actions planned for addressing AFWS and decay heat removal reliability in general (TMI Action Plan). Develop a specific rationale and approach for dealing with the question of AFWS seismic qualifications. 2) For those plants that do not have an AFWS designed to seismic Category I requirements, develop guidance to the Division of Licensing (DOL) so they can make a decision whether or not there is a basis for continued operation for the two to three year period that will be required to study all of the decay heat removal alternatives in accordance with Task Action Plan II.E.3.3.

The guidance should emphasize the information needed to make a judgment on safety, but it should include consideration of the question of conformance to the applicable Commission regulation, e.g. GDC 2 and 34. The guidance should include evaluation of other systems that can remove decay heat. If such systems exist and are seismic Category I in design, and if the use of the system does not introduce other safety problems (e.g. vessel integrity with bleed and feed), this might be judged to be sufficient decay heat removal capability.

For plants without an alternate seismic Category I decay heat removal system, the guidance should identify the information needed to make a sound judgment (possibly supported by probabilistic analyses) on the basis for continued operation.

Comments on the overall approach in the Action Plan and a recommendation for NRR action on the specific problem of seismic qualifications of AFWS should be provided by DST to the Director of NRR in sufficient time for his input to be factored in and a report made to the Commission (Information Paper) by June 15, 1980.

Imput to accomplish this assignment should be sought from SEP branch in Division of Licensing and from the Divisions of Engineering and Systems Integration.

The Division of Systems Integration has identified 10 operating PWRs that do not have AFWS with seismic qualification. The exact number of plants should be confirmed. The enclosed memorandum from the director of DSI shows the results of preliminary studies to confirm that all of these plants have alternative methods of varying capacity and qualifications for removing decay heat in the event of loss of all feedwater.

Roger J. Mattson

Roger J. Mattson, Director
Division of Safety Technology

Enclosures:
1. Memo RJMattson to DFRoss
   dtd 11/27/79
2. Memo DFRoss to DOkrent
   dtd 12/28/79
3. Memo CMichelson to RJMattson
   dtd 4/24/80
4. Memo DRoss to RMattson
   dtd 5/12/80 w/Attach 5 only

cc: H. Denton
E. Case
D. Eisenhut
R. Vollmer
D. Ross
S. Hanauer
C. Michelson
R. Fraley
R. Baer

Rouattson

November 27, 1979

MEMORANDUM FOR: Denwood F. Ross
Bulletins and Orders Task Force

FROM: Roger J. Mattson, Director
Division of Systems Safety

SUBJECT: ACRS QUESTIONS

I was asked two questions at the November 5 TMI-2 Implications Subcommittee meeting that require written response to Dr. Okrent. They were:

1. Why does NRC not require automatic closing of the block valve upstream of the PORV on U.S. PWRs, like the FRG design?

2. What is the staff decision and basis for seismic qualification of AFW water source?

I think the Bulletins and Orders Task Force addressed these two issues, at least indirectly, but I don't know of the outcome, if any. Please advise whether your folks can get an answer off to Dr. Okrent or whether I should assign the work within DSS.

Original signed by
Roger J. Mattson

Roger J. Mattson, Director
Division of Systems Safety

OFFICE ▶	DSS					
SURNAME ▶	RJMattson:ts					
DATE ▶	11/27/79					

ENCL 1

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

Docket No. 50-320

DEC 28 1979

MEMORANDUM FOR: D. Okrent

FROM: D. F. Ross, Jr., Acting Director, Division of Project Management

SUBJECT: TMI-2 IMPLICATIONS

Enclosed are responses to two questions you raised during the TMI-2 Subcommittee meeting on November 5, 1979. These answers cover the extent to which the staff has considered these issues at this time.

D. F. Ross, Jr., Acting Director
Division of Project Management
Office of Nuclear Reactor Regulation

Enclosure:
Responses to Questions

cc: R. Mattson
D. Crutchfield
T. Novak
P. Matthews
G. Mazetis
S. Israel

Contact: Sandy Israel, NRR
49-27591

ENCL 2

NRC Staff Responses

1. Why does NRC not require automatic closing of the block valve upstream of the PORV on U.S PWRs, like the FRG design?

Response

The automatic closing of the block valve was considered by the Bulletins and Orders Task Force and was included in the generic PWR reports which are to be issued. The staff recommends that, in order to improve PORV reliability, licensees should design and install a control system which provides interaction between the PORV and block valve to prevent a small break LOCA in the event of a failure of a PORV to close. One such design would cause the block valve to close after the PORV opens on high pressure, and subsequently, the reactor coolant system pressure decays below the PORV reset pressure. This system would be provided with an override so that pressure relief could be accommodated at lower pressures, if required. We believe that the implementation of this system must be carefully evaluated to ensure that failure of this system would not decrease overall safety by intensifying plant transients and accidents.

2. What is the staff decision and basis for seismic qualification of AFW water source?

Response

For the reliability review of the AFW systems of W and C-E operating plants, performed by Bulletins and Orders Task Force, the review teams used the criterion that the AFW system should have a seismic Category I water source or a water source with seismic design equivalent to the seismic design of the plant auxiliary feedwater system accepted at the time of licensing the plant. Basically, this decision assured that the water source has seismic capability at least as good as the rest of the AFW system. Most of the plants reviewed except for some SEP plants have AFW systems and associated water sources which have capability to withstand a seismic event ranging in intensity from seismic Category I to the seismic intensity required at the time of licensing the plant. For the SEP plants, the seismic design requirements of AFW system, including the water sources will be reevaluated as part of SEP reevaluation of the plant seismic requirements.

As noted in NUREG-0560, several of the operating B&W plants do not have a seismically qualified AFW water source. The staff has not reached a decision on whether to upgrade these plants; however, the affected plants have an alternate means of removing decay heat without relying on AFW. B&W submitted analyses of small break LOCAs in May 1979 which showed that adequate core cooling could be obtained with only the HPI pumps (shutoff pressure >2500 psi) operating in the event of total loss of feedwater. The operator would have 20 minutes to initiate this alternate cooling mode. Emergency operating procedures at the B&W plants have been modified to direct the operator to use HPI if the normal heat sink is unavailable.

Not Davis Besse

For plants under construction, we require a seismic Category I water source in accordance with Standard Review Plan Section 10.4.9.

The following are specific bases for this decision:

1. General Design Criterion 2 requires that "structures, systems and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes..." and further that "the design bases for these structures, systems and components shall reflect...(2) appropriate combinations of the effects of normal and accident conditions with the effects of natural phenomena, and (3) the importance of the safety functions to be performed."

   Since a seismic event of any significance would likely result in a loss of offsite power and a loss of main feed flow, the auxiliary feedwater system would be necessary to remove decay heat from the reactor. If there were no qualified source of water for the auxiliary feedwater system, the system could not function as designed to remove decay heat. Therefore, it follows that a seismically qualified source of water must be available since the AFW system would be the only system available for decay heat removal at operating temperatures and pressures.

2. Standard Review Plan 10.4.9 refers to GDC 2 Regulatory Guide 1.29 and states that, "In conjunction with a seismic Category I water source, the AFW system functions as an emergency system for the removal of heat from

the primary system when the main feedwater system is not available for emergency conditions...." Since the main feedwater system would not be available following any significant seismic event, it follows that a seismically qualified AFW system and water source must be available.

MEMORANDUM FOR: Roger Mattson, Director
Division of Systems Safety

FROM: Carl Michelson, Director
Office for Analysis and Evaluation
of Operational Data

SUBJECT: NRC ACTION PLANS DEVELOPED AS A RESULT OF TMI-2 ACCIDENT - DRAFT 3, TASK II.E.3 DECAY HEAT REMOVAL

AEOD has briefly examined the issue of BOP water systems required for normal plant operation and for decay heat removal. This was triggered by the February 26, 1980 Crystal River event in which the plant did not go on to RHR for several days due to bearing failures (memo attached), and San Onofre's cooling pump failure (3/10/80, LER 80-006).

AEOD notes that on the Crystal River Plant, the Nuclear Services closed cycle cooling system, NSCCCS, (which serves to cool motor bearings for all of the reactor coolant pumps and provides water to both the turbine driven and the motor driven auxiliary feedwater pumps, reactor building ventilation system, etc.) appears to be capable of withstanding single active failures, but cannot withstand a single passive failure (rupture of an 18" line would disable the entire NSCCCS-Florida Power Corporation drawing FD-302-601, rev. 26, 3/28/79).

The interaction between the NSCCCS and the AFW and the reactor building ventilation system was also presented by RES (J. Murphy) as part of the IREP study at the 4/11/80 meeting of the ACRS Subcommittee on sensitivity of B&W plants.

AEOD believes that the reliability of DHR systems should be reviewed and, where necessary, upgraded on an expedited basis. The NRC Action Plan (Draft 3 - Section B2) calls for NRR to perform a "generic study to assess the capability and reliability of shutdown heat removal systems...." by August 1982; this appears to be too late.

Based upon NRR's 2 or 3 day site audits of the SEP plants regarding the plants' safe shutdown capabilities, it is apparent that brief audits of the DHR capabilities of each operating plant can readily pinpoint weak spots of the systems and that action can and should be taken to fix the obvious deficiencies rather than waiting two years for generic probabilistic assessments each of which, at best, are applicable to only a few plants. The crash program which was undertaken by NRC to assess the reliability of AFW systems shortly after TMI showed that such audits can be performed quickly, and can be significant in improving reactor safety.

ENCL 3

Regarding Section B.4 of Task II.E.3 (Revision 1 of Regulatory Guide 1.139 "Guidance for Residual Heat Removal to Achieve and Maintain Cold Shutdown"), AEOD notes that Draft 2, Proposed Revision 1 to Regulatory Guide 1.139 - transmitted from SD (Arlotto) to ACRS (Fraley) March 7, 1980 - addresses only new plants, and that older plants will be reviewed against the guide "on a case-by-case basis." AEOD is concerned that there is an immediate need for assuring reliable residual heat removal capabilities in existing plants with safety grade equipment. AEOD believes that the requirements for residual heat removal capabilities of the older plants should be specifically addressed in the proposed revision to Regulatory Guide 1.139.

/s/

Carl Michelson, Director
Office for Analysis and Evaluation
of Operational Data

Attachment:
Memo, H. Ornstein to C. Michelson
dated March 20, 1980

cc w/attachment:
R. Bernero
H. Denton
D. Eisenhut
F. Rowsome

Distribution:
Central File
AEOD Reading File
AEOD Chron. File
HOrnstein, AEOD
CMichelson, AEOD

OFFICE	AEOD	AEOD			
SURNAME	HOrnstein:gt	CMichelson			
DATE	4/ /80	4/ /80			

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

MAR 20 1980

MEMORANDUM FOR: Carl Michelson, Director
Office for Analysis and Evaluation of
Operational Data

FROM: Harold L. Ornstein
Office for Analysis and Evaluation of
Operational Data

SUBJECT: CRYSTAL RIVER NUCLEAR POWER PLANT DECAY HEAT CLOSED
CYCLE COOLING WATER PUMPS/DCP-1A AND DCP-1B

I have pulled together the following information:

The NRC requires surveillance testing of these pumps every 30 days. Pump DCP-1A tested satisfactorily on 2/6/80. Above and beyond the inservice inspection program required by NRC, Florida Power Corporation has an outside consultant (C&S Maintenance Consultants) conduct a plant-wide overall vibration maintenance program.

On 2/13/80, one week after DCP-1A passed the NRC required surveillance test, C&S found the pump motor vibration to have a 1.4 mil displacement (1.0 mil alert is required, 1.5 mil action is required). A C&S report, dated 2/15/80, noted the increased displacement and indicated that it was not at a point of concern, and advised FPC that the pump should be watched for increases in vibration and/or temperature.

On 2/26/80, at 8:00AM, C&S retested the motor and found it to be out of spec (4.7mil) and in need of immediate repairs. The vibration was attributed to the motor bearing closest to the coupling. A work request was written up noting the fact that this is a tech spec priority item (72-hour action status). The fact that DCP-1A was inoperable was not relayed to the control room personnel until after the incident, partially due to system inertia and the plant evacuation. (A meeting between the shift supervisor and the maintenance planners/coordinators to go over the pump repair did not take place until after reactor trip. The question of communication between operations and maintenance personnel regarding declaring vital equipment out of service needs to be addressed - is this a problem at many other plants vs. just Crystal River vs. just an isolated event at Crystal River?)

The [illegible] was changed on the morning of 2/27/80; however, excessive vibration was still recorded (displacement of 1.1 mil). Because of this vibration, the motor bearing on the opposite side of the motor was then changed. Changing the second bearing brought the displacement down to 0.68 mil which was [illegible] alert range, but still outside the normal operating range of about 0.5 mil. Subsequently, FPC broke down the coupling, found that one end of the coupling [illegible] lubricated, and that it "had bad teeth which were somewhat corroded"; most probably due to improper lubrication. The coupling was then replaced and the pump/motor were realigned. C&S ran vibration tests on the pump/motor on 3/28/80 and readings were within normal ranges (displacement was 0.3 mil).

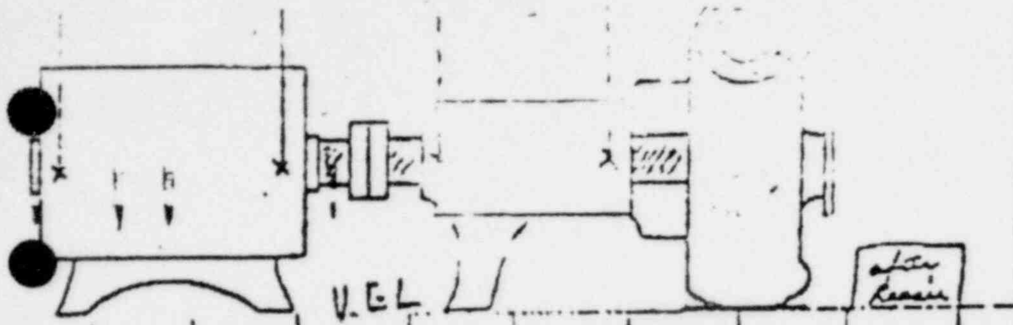
The redundant decay heat closed cycle cooling system pump, DCP-1B, was examined, and the pump and motor were found to be out of alignment. There was grease in the coupling; however, the grease showed signs of degradation (loss of "slickness"). It was concluded that the degradation arose from misalignment which caused the heating of the grease and excessive wear.

The coupling does not have any grease cup or simple provisions for lubrication. In order to grease the coupling, it must be disassembled. FPC (G. Claar - shop supervisor) informed me that FPC was of the impression that the DCP couplings were not permanently lubricated. FPC had found that the plant equipment lubrication list (which was put together with the assistance of Gulf Atomic) had omitted the couplings on DCP-1A and 1B. As a result, FPC was planning to check the couplings during the next refueling outage for lubrication. I&E (Ashenden) was informed that, as a result of their recent experience with DCP-1A and 1B, FPC is now planning to implement a plant-wide program for alignment and coupling lubrication.

The lubrication problem on the decay heat closed cycle cooling system pumps, the unexpected failure, and the resultant delay in going to cold shutdown highlight the vulnerability of nuclear power plants to inadequate lubrication. The NRC does not appear to have adequate visibility of lubrication and maintenance on vital pumps and other critical equipment. Inadequate lubrication and alignment checks and the "incipient common mode failures" of the decay heat closed cycle cooling water pumps, DCP-1A and 1B, at the time of the 2/26/80 Crystal River incident, are viewed as potential accident precursors which should be addressed immediately.

Harold L. Ornstein
Office for Analysis and Evaluation
of Operational Data

Enclosures:
1. C&S Maintenance Consultants' Data Sheet
2. Florida Power Work Request



MAINTENANCE CONSULT[illegible]

plant

machine

P.M. PROGRAM

[illegible]		1-13	12-12	1-2-80	2-13	2-26	2-27	2-27	2-28	2-28
[illegible]		CCN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A	H	.10	.07	.04	.14	.48	.14	.04	.04	.04
	V	.07	.11	.05	.08	.18	.09	.02	.05	.05
	A	.10	.06	.06	.09	.15	.04	.02	.04	.05
B	H	.09	.06	.03	.16	.60	.14	.05	.05	.05
	V	.09	.07	.06	.09	.16	.09	.04	.05	.06
	A	.09	.06	.08	.07	.17	.05	.03	.04	.05
C	H	.10	.11	.08	.13	.17	after	after	.11	.11
	V	.05	.08	.09	.08	.10	1st brg	2nd brg	.06	.05
	A	.05	.06	.05	.07	.10	change	change	.07	.08
D	H	.08	.12	.06	.07	.12	on	on.	.08	.10
	V	.07	.08	.06	.07	.10	motor	motor	.09	.10
	A	.07	.07	.06	[illegible]	.10			.07	.06

[illegible]		[illegible]	12-12	1-2-80	2-13	2-26	09:18 hrs	16:44 hrs	07:29 hrs	08:20 hrs
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A	H	.50	.20	.20	1.0	3.7	.98	.46	.21	.16
	V	.21	.16	.19	.30	1.2	.20	.29	.16	.15
	A	.25	.20	.21	.38	.88	.14	.30	.19	.17
B	H	1.0	.27	.23	1.42	1.7	1.1	.68	.30	.30
	V	.25	.75	.30	.36	1.0	.29	.45	.26	.26
	A	.17	.16	.27	.36	.76	.55	.29	.19	.20
C	H	.3[illegible]	[illegible]	.30	.46	1.0			.34	.30
	V	[illegible]	.27	.12	.19	.52			.16	.14
	A	[illegible]	.17	.20	.20	.32			.18	.19
D	H	[illegible]	[illegible]	.30	.74	.52			.16	.16
	V	[illegible]	[illegible]	.16	.14	.28			.10	.13
	A	[illegible]	[illegible]	.15	.20	.34			.18	.19

COMMENTS

ELEC ...

CONDITION, CAUSE AND METHOD ...

... OUT OF SPEC VIBRATION

... BEARINGS POSSIBLY BAD

... S VIBRANALYSIS READINGS, ... IN/SEC (...

4.7 MILS (... NORMAL)

A.I. ...

G.E. 100 HP. ~~4160 V~~ 480 V DRIVE END BRG No. 631_

OPP END BRG. No. 6314

RELATED DOCUMENTS: MAR NO. | PROC'D. NO. | WR NO.

ORIGINATOR: H GOFORTH, JR. DATE: 2/26/80 TIME: 1100

RESPONSIBLE SUPVR: R.A. Brown DATE: 2-26-80

PART II — EVALUATION OF WORK REQUIRED

NUCLEAR SAFETY RELATED: YES [✓] QC REQ'D NO [ ]

PRIORITY CODE: [✓] 1 TECH. SPEC. OR SECURITY ITEM [ ] 2 SCHEDULE [ ] 3 OUTAGE

PROCEDURE REQUIRED:	POST. MAINT. TEST:	CLEARANCE	RWP / ...	FPWP REQ'D	NDE REQUIRED:
YES [ ] NO [✓]	YES [✓] NO [ ]	YES [✓] NO [ ]	YES [✓] NO [ ]	YES [ ] NO [✓]	YES [ ] NO [✓]
LIST ~~SP-344~~ SP 340	LIST	NO: 02-75	NO: 79-56	NO:	LIST

QUALITY ITEM: YES [✓] QC REQ'D NO [ ]

CHARGE ACCOUNT NO.: 530.00

WORK INSTRUCTIONS: Repair as Required

MANHOUR ASSESSMENT: NO. OF MEN: 2 NO. OF HOURS: 7

EVALUATED BY: [signature] DATE: 2-26-80 WORK REQUEST TO SUPERVISOR: [signature]

PART III — WORK PERFORMED DESCRIPTION:

DESCRIBE WORK AS PERFORMED: REMOVED INBOARD ENDBELL AND BEARING RTH 3 HRS. Removed outboard Endbell and replaced bearing 2 men 1.5 hr. 3 men hrs [illegible] take to [illegible] disassemble reassemble return bump for rotation [illegible] 2 men 6 hrs 12 [illegible] [illegible] Coupling [illegible]

SHIFT SUPERVISOR [signature] DATE: 2-26-80

MANHOUR ACCOUNTING: NO. OF MEN: 2 NO. OF HOURS: 11 TOTAL MANHOURS: 22

COMPLETED BY: [signature] M Bailey DATE: 28 Feb. 80

RESPONSIBLE SUPVR. DATE:

№ 09516

PART IV — CORRECTIVE ACTION

CORRECTIVE ACTION: YES [■] NO [ ]

DESCRIBE INVESTIGATION / ACTION TAKEN:

INITIALS/DATE

WORK REVIEW COMPLETION: (PLAN. COORD.) DATE: | WORK VERIFIED BY: (QC INSP.) DATE:

RESPONSIBLE SUPT.: DATE: | COMPLIANCE ENG.: DATE: | PLANT MANAGER: DATE:

...S
...C...
...2555

May 12, 1980

Note to: R. Mattson
R. Tedesco
R. Veer
J. Knight
P. Check

From: D. Ross, Jr.

Subject: QUALIFIED AFW SYSTEM

We are to discuss at 11:00A.M. (5/13/80) at Roger's office relative merits of qualified AFW vs. qualified feed and bleed, given that an SSE has occurred at a PWR. This discussion will include:

1) the ACRS transcript of 5/80 wherein NUREG-0667 was discussed (copy attached);

2) page 7-25 (para. d) of NUREG-0667 (copy attached);

3) page 2-4 (para. 2.2(1)) of NUREG-0667 (copy attached);

4) pages 21-29 inclusive of 4/21/80 briefing to Commission on NUREG-0667 (copy attached)

5) A summary table on seismic standards of some plants.

The purpose of the meeting is to develop an NRR Office position on whether AFW systems should be Seismic Class I (including backfits) or, whether F&B is an acceptable alternate to safe shutdown, given an SSE.

DR

D. F. Ross, Jr.

Attachments:
As stated

Encl 4

ATTACHMENT 5

ALTERNATE PATH DECAY HEAT REMOVAL
CAPABILITY FOR PLANTS WITH NON-SEISMIC I AFW SYSTEMS

[illegible]	VENDOR	# LOOPS	THERMAL POWER MWth	HPI SHUTOFF HEAD, psig	CHARGING FLOW @ S.V.	REMOVE D.H. BEFORE CORE UNCOVERY	F&B BY** DEPRESS. TO HPI ACTV.	COMMENTS
[illegible]*	W	2	1300	1485	180 gpm	Yes	?	Charging flow predicted to remove all deca heat after ~16 Unknown if char pumps are on diesels or are seismic. Plant can possibly ... by PORV depres to HPI setpoin.
[illegible]	W	4	1825	2948	?	Yes	Psbl. Alt.	
[illegible]	W	3	1347	2600	?	Yes	Psbly	No MSIV; Main F on AFW; OBE
[illegible]*	W	4	600	844	99 gpm	Yes	1 AFW pump	Charging flow predicted to remove all dec heat after ~7 Unknown if charging pumps are on diesels are seismic I. Due to low SI s off head, quest able if depress to HPI actuatio possible.
[illegible]	CE	2	2530	1257	133 gpm	No	Maybe	Charging flow insufficient to remove all decay heat befo core uncovery.

PLANT	VENDOR	# LOOPS	THERMAL POWER MWth	HPI SHUTOFF HEAD, psig	CHARGING FLOW @ S.V.	REMOVE D.H. BEFORE CORE UNCOVERY	F&B BY** DEPRESS. TO HPI ACTV.	COMMENTS
PALISADES (continued)								Plant can possibly [illegible] by PORV depressurizati to HPI setpoin Turbine pump = paper qual.
[illegible]	B&W	2	2568	~3000	~400 gpm	Yes	-	
[illegible]	B&W	2	2452	~2800	~400 gpm	Yes	-	
[illegible]	B&W	2	2568	~3000	~400 gpm	Yes	-	

[illegible]/7/80
[illegible] Sheron
[illegible] PLANT
[illegible] SURE ABT SEISMICITY

DATA SOURCE:

NUREG-0635
NUREG-0560
NUREG-0611

#X
6/4/80

INFORMATION PERTAINING TO SEISMIC SCRAM

SEISMIC SCRAM FOR REACTORS:

POWER REACTORS IN JAPAN

SOME RESEARCH REACTORS AND ONE POWER REACTOR IN U.S.A.

JAPANESE PRACTICE:

SCRAM VALUE:

GREATER OF:

1/3 DESIGN STATIC COEFFICIENT

2/3 DYNAMIC RESPONSE ACCELERATION AT THE LOCATION OF INSTALLATION

INFORMATION PERTAINING TO SEISMIC SCRAM

JAPANESE EXPERIENCE:

TYPICAL MAXIMUM DESIGN ACCELERATIONS AT BEDROCK:

1) TSUGARA - 250 GALS
2) MIHAMA - 300 GALS
3) FUKUSHIMA - 180 GALS
4) TAKAHAMA - 270 GALS
5) SHIMANE - 200 GALS
6) HAMAOKA - 300 GALS
7) GENKAI - 180 GALS
8) IKATA - 200 GALS

SENDAI EARTHQUAKE, 1980:

FUKUSHIMA: 0.125g

PLANT OPERATED THROUGH THE EVENT WITH ONLY MINOR DAMAGE TO CERAMIC INSULATORS LOCATED IN THE SWITCH YARD.

XI
6/4/80

PROPOSED SUBCOMMITTEE POSITION

THAT NUCLEAR POWER PLANTS BE REQUIRED TO BE EQUIPPED WITH SEISMIC SCRAM SET AT THE OBE LEVEL. THE SUBCOMMITTEE BELEIVES THAT THIS WOULD PROVIDE THE FOLLOWING ADVANTAGES:

(1) PROVIDE A TRIP WHICH WOULD ANTICIPATE THE PEAK FORCES ASSOCIATED WITH AN EARTHQUAKE IN EXCESS OF THE OBE AND WOULD ALLOW TIME FOR SCRAM AND SOME DECAY HEAT REMOVAL BEFORE THE SYSTEMS AND STRUCTURES, WHICH ARE NOT DESIGNED TO SEISMIC - CATEGORY 1 CRITERIA , ARE SUBJECTED TO FORCES IN EXCESS OF THE OBE.

(2) WOULD ALLOW OPERATION OF THE PLANT AND POWER SUPPLY TO THE GRID WITHIN THE GUIDELINES OF THE CURRENT REGULATORY CRITERIA.

(3) REDUCE SPURIOUS SCRAMS TO AN ACCEPTABLE LEVEL.

MEETING OF ACRS SUBCOMMITTEE

ON

EXTREME EXTERNAL PHENOMENA

GOUTAM BAGCHI

JUNE 4, 1980

XII
6/4/80
Tape 14

TASK ACTION PLAN (TAP) A-40

SEISMIC DESIGN CRITERIA - SHORT TERM PROGRAM

OBJECTIVES:

DEVELOP CAPABILITY TO EVALUATE ADEQUACY OF SEISMIC DESIGN OF OPERATING REACTORS AND PLANTS UNDER CONSTRUCTION

DEVELOP METHODS TO QUANTITATIVELY ASSESS THE OVERALL ADEQUACY OF SEISMIC DESIGN FOR NUCLEAR PLANTS IN GENERAL

REVISE CURRENT SEISMIC DESIGN CRITERIA IF APPROPRIATE

TASK ACTION PLAN (TAP) A-40

APPROACH:

PHASE 1 - RESPONSE OF STRUCTURES, SYSTEMS, AND COMPONENTS

- QUANTIFICATION OF SEISMIC CONSERVATISMS
- ELASTO-PLASTIC SEISMIC ANALYSIS
- SITE SPECIFIC SPECTRA
- NONLINEAR STRUCTURAL DYNAMIC ANALYSIS
- SOIL-STRUCTURE INTERACTION
- REVIEW AND EVALUATE RESULTS OF PHASE 1 STUDY

PHASE 2 - SEISMIC INPUT DEFINITION

- STUDY OF EARTHQUAKE SOURCE MODELING
- ANALYSIS OF NEARFIELD GROUND MOTION
- REVIEW AND EVALUATE RESULTS OF PHASE 2 STUDY

TASK ACTION PLAN A-40

CURRENT STATUS

PHASE 1

CONTRACTOR REPORT ON RECOMMENDED CHANGES TO DESIGN CRITERIA COMPLETED.

CONTRACTOR REPORT ON CHANGES TO REGULATORY GUIDES & STANDARD REVIEW PLANS COMPLETED.

REGULATORY GUIDES - 1.60, 1.61, 1.92, 1.122 AND
STANDARD REVIEW PLANS - SECTIONS 2.5.2, 3.7.1, 3.7.2 AND 3.7.3

PHASE 2

STUDIES ON SOURCE MODELING ARE ON SCHEDULE.

STUDIES ON NEAR-FIELD GROUND MOTION ARE EXPECTED TO BE COMPLETED ON SCHEDULE.

#XIII
6/4/80
Tape 15
+16

SITE SPECIFIC SPECTRUM PROJECT

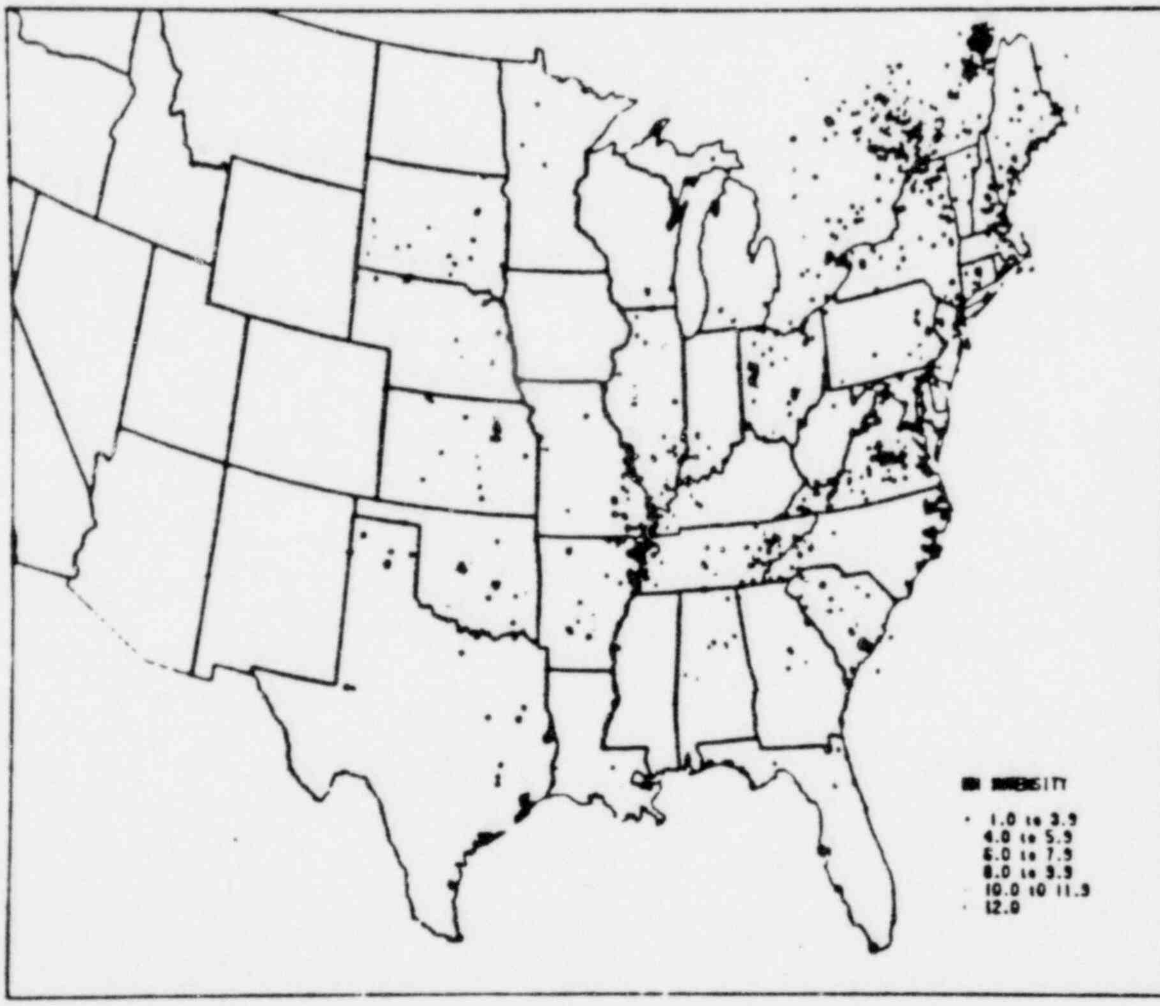
PROGRAM REVIEW

JUNE 4, 1980

LARRY WIGHT

DON BERNREUTER, L^3 PROJECT MANAGER

Our objective was to integrate all relevant and available data with seismic hazard models to estimate the seismic hazard at the SEP sites.



Since the relevant and available data is sparce, we formally incorporated the judgements of ten recognized experts into the analysis.

We structured the overall program for maximum benefit to the NRC.

CREDIBILITY

- Probabilistic methodology employed was well accepted but nevertheless state of the art.

ACCURACY

- Technique was favorably compared against other available methodologies.

QUALITY

- Specialized external experts involved during development and review of key components.

H. Shah (Stanford)	Prob. Analysis
G. Baecher (MIT)	Subjective Probs.
T. McEvilly (U. Cal.)	Seismology
D. Veneziano (MIT)	Probability

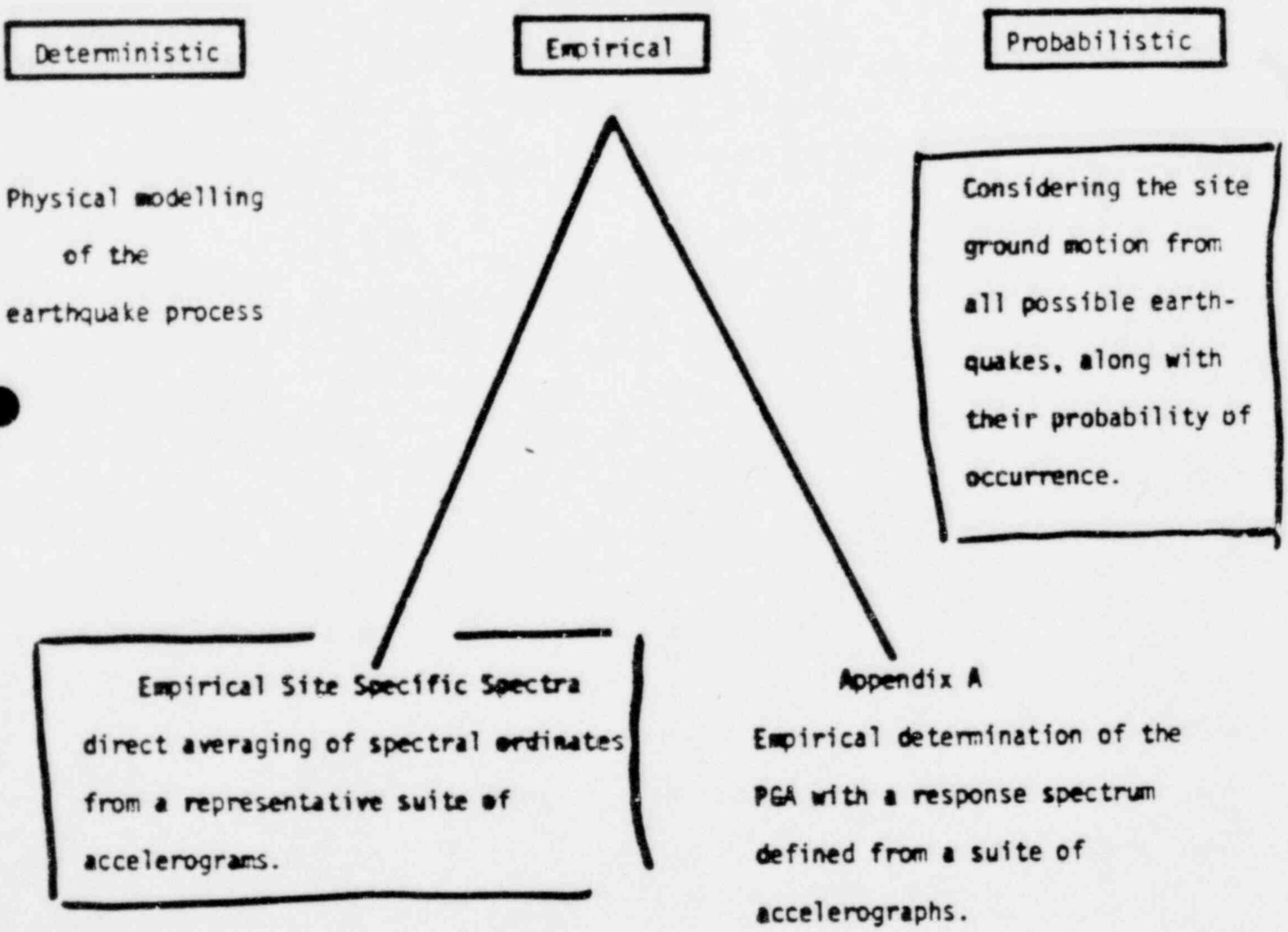
RELEVANCE

- Entire program was peer reviewed by prestigious panel of experts:

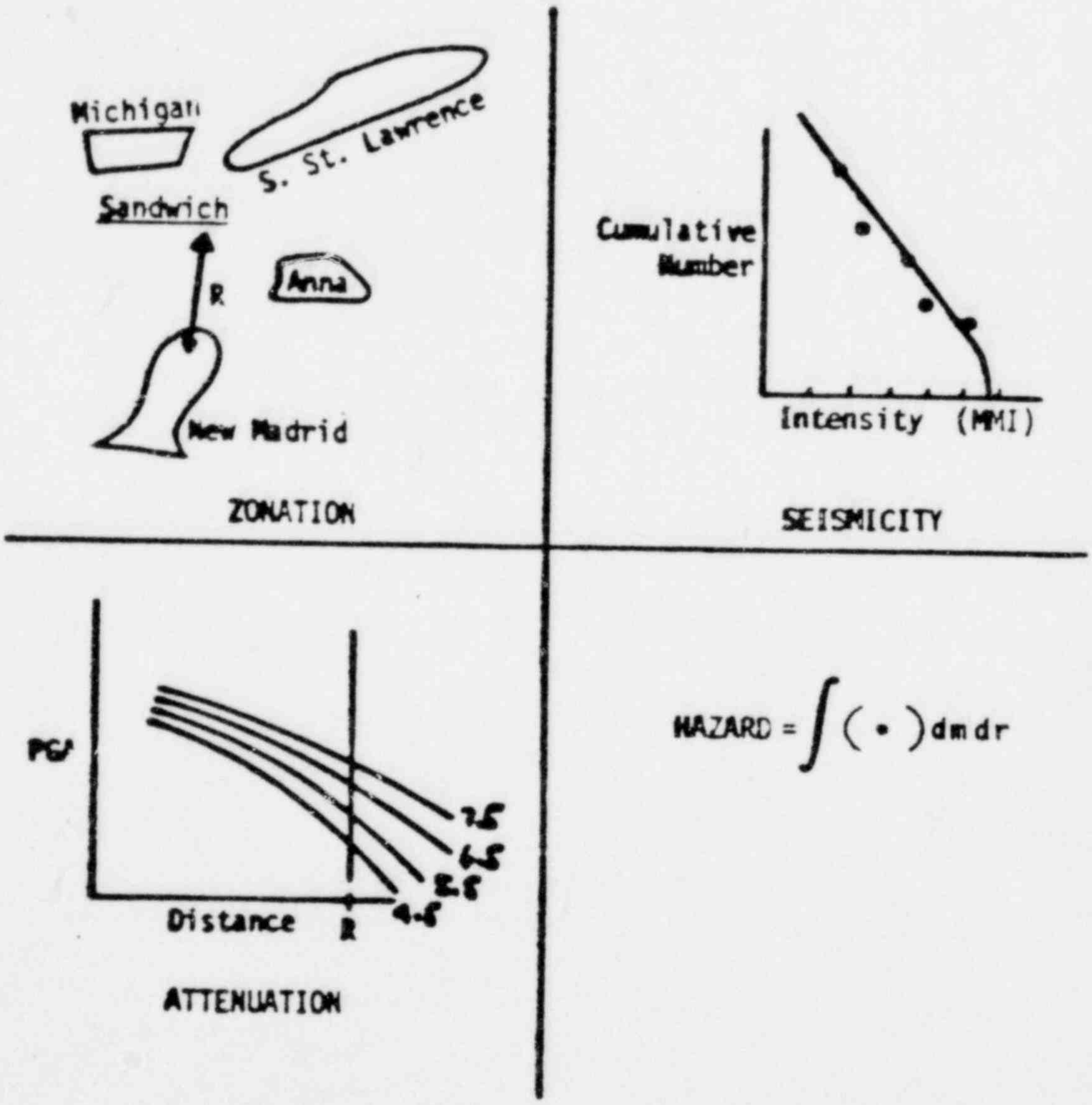
Professor Nuttli	(St. Louis)
Professor Sykes	(Columbia)
Professor Ang	(U. Ill.)
Professor Veneziano	(MIT)

TERA CORPORATION

In designing the approach for this project, we sought techniques that were complementary to Appendix A.



Every seismic hazard analysis consists of four distinct steps:



The different analysis techniques deal with these steps in very different ways.

Each of these techniques represent a different perspective of the seismic hazard, each with its own objective and limitations.

The results are best used to compare the relative hazard between sites.

Deterministic	Empirical	Probabilistic
Objectives		
Specific size & location.	Average over slight range of sizes & locations.	Average over all sizes & locations accounting for probability of occurrence.
Advantages		
Allows predictions beyond available data.	Simple & direct; a single answer.	Allows trade off between hazard and other factors; age, inventory, dispersibility, population, and structural resistance.
Disadvantages		
Complexity of physical model.	Hypothesized design situation; usually limited data.	Tails of probability distributions can dominate results.

The results from any seismic hazard analysis are only as good as the analysts' experience and judgement.

Deterministic

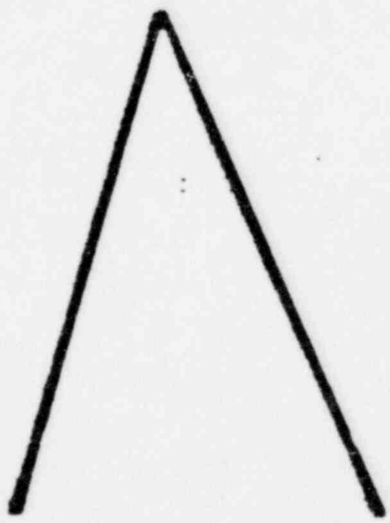
Empirical

Probabilistic

Fault rupture kinematics

postulated stress drop

postulated moment.



Zonation

Size distribution
(seismicity)

Time variation prop-
erties (Poisson)

Attenuation

Magnitude and distance

interval for averaging

Zonation

maximum MMI

site MMI or acceleration

- Professional judgement is always incorporated (usually informally) in any technical analysis.

Many issues are sufficiently complex and of such importance that <u>formal</u> use of professional judgement is required.

- Called expert opinion solicitation, such techniques have been used on several important projects.

USGS	Seismic Hazard
USGS	Oil & Gas Estimates
USBR	Seismicity Study at Auburn Dam
DOE	Waste Isolation Safety Analysis Program

The use of professional judgement, as required in any analysis technique, was formally incorporated into our program.

- to ensure most credible and accurate input
- t^ ensure direct Peer Review
- to evaluate consequences of judgement differences

In consideration of the

- complexity of issues
- number of issues
- schedule
- budget

we implemented the questionnaire approach.

We designed the questioning process to be as thorough, efficient, and precise as possible.

MAPS

The seismological experts who participated in this project represented a cross-section of the scientific community.

Many were considered; few were chosen, based upon:

- *organizational affiliation*
- *technical strengths*
- *availability*

Professor Gilbert A. Bollinger

Dr. Edward Chiburis

Dr. Michael A. Chinnery

Professor Robert B. Herrmann

Mr. Richard J. Holt

Professor Otto Nuttli

Dr. Paul W. Pomeroy

Professor Ronald Street

Professor Marc Sbar

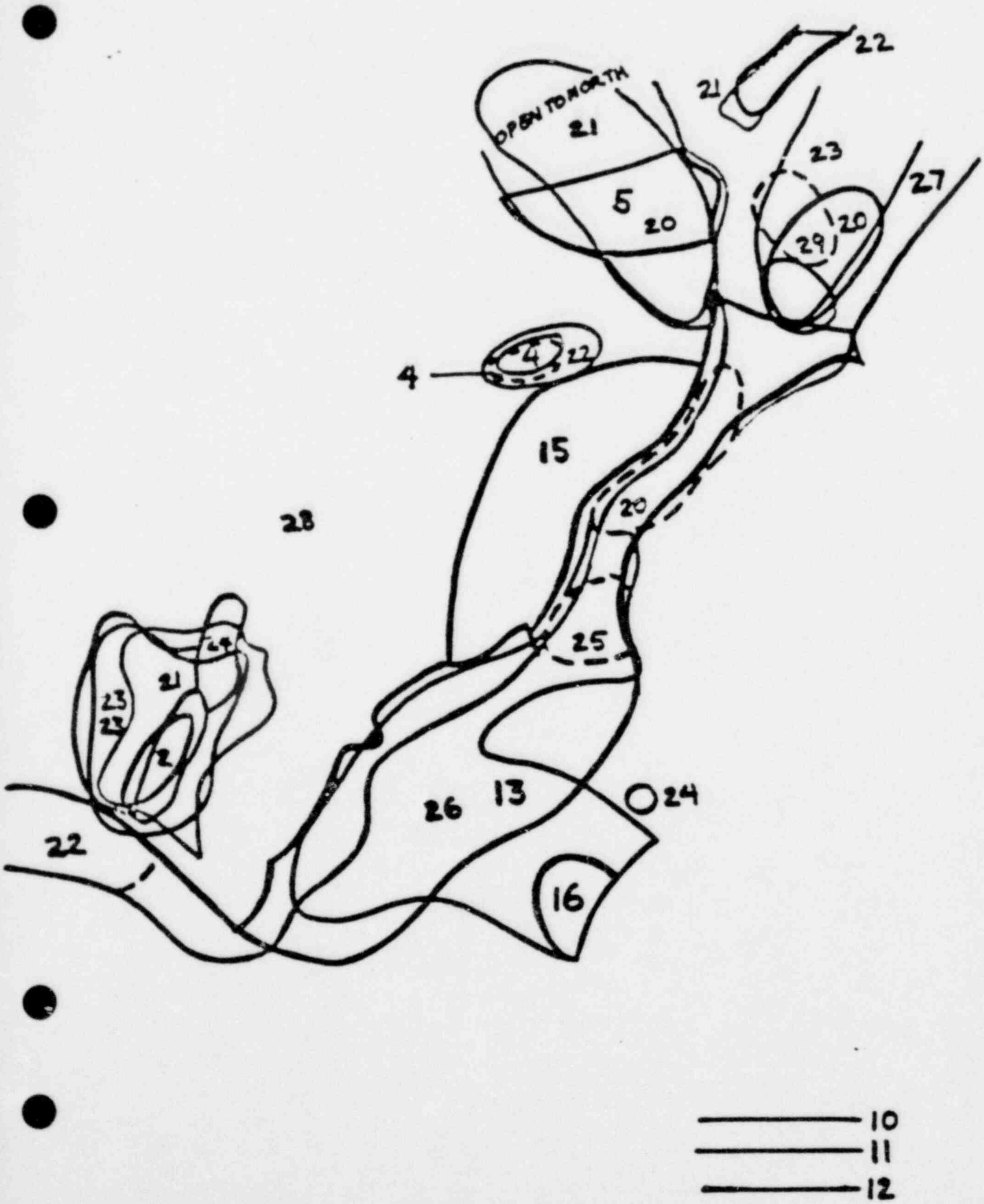
Professor Nafi Toksoz

ZONATION

I-1 Please carefully review the source zones specified in Figures 1 and 2 of the answer booklet. Feel free to modify, combine, add or delete zones where necessary. Indicate, preferably with colored pencils, what seismic source regions you feel are appropriate for Eastern United States. Indicate only those regions that in your mind are very reasonable. We ask you to speculate on less likely source regions and local tectonic structures in following questions.

You should also summarize your zonation on Table I-1 where we ask you to label each of your zones and to also assign, as a percentage, your "degree of belief" in all of the seismic source regions, both yours and the zones in Figures 1 and 2. Zero credibility or "degree of belief" corresponds to zero percent.

We illustrate a possible response to this question in Table 2. Note in particular how the percentage credibility need not add to 100% for each source zone. This is how you may indicate that there is a chance for a zone to be considered independently or simply as a part of the background seismicity. For example, in Table 2 the answer indicates that there is a 70% chance that the seismicity of Upper Keweenaw, Michigan, defines an independent zone and a 30% chance that this seismicity simply belongs to the background seismicity of the Central Stable Region.



OPEN TO NORTH
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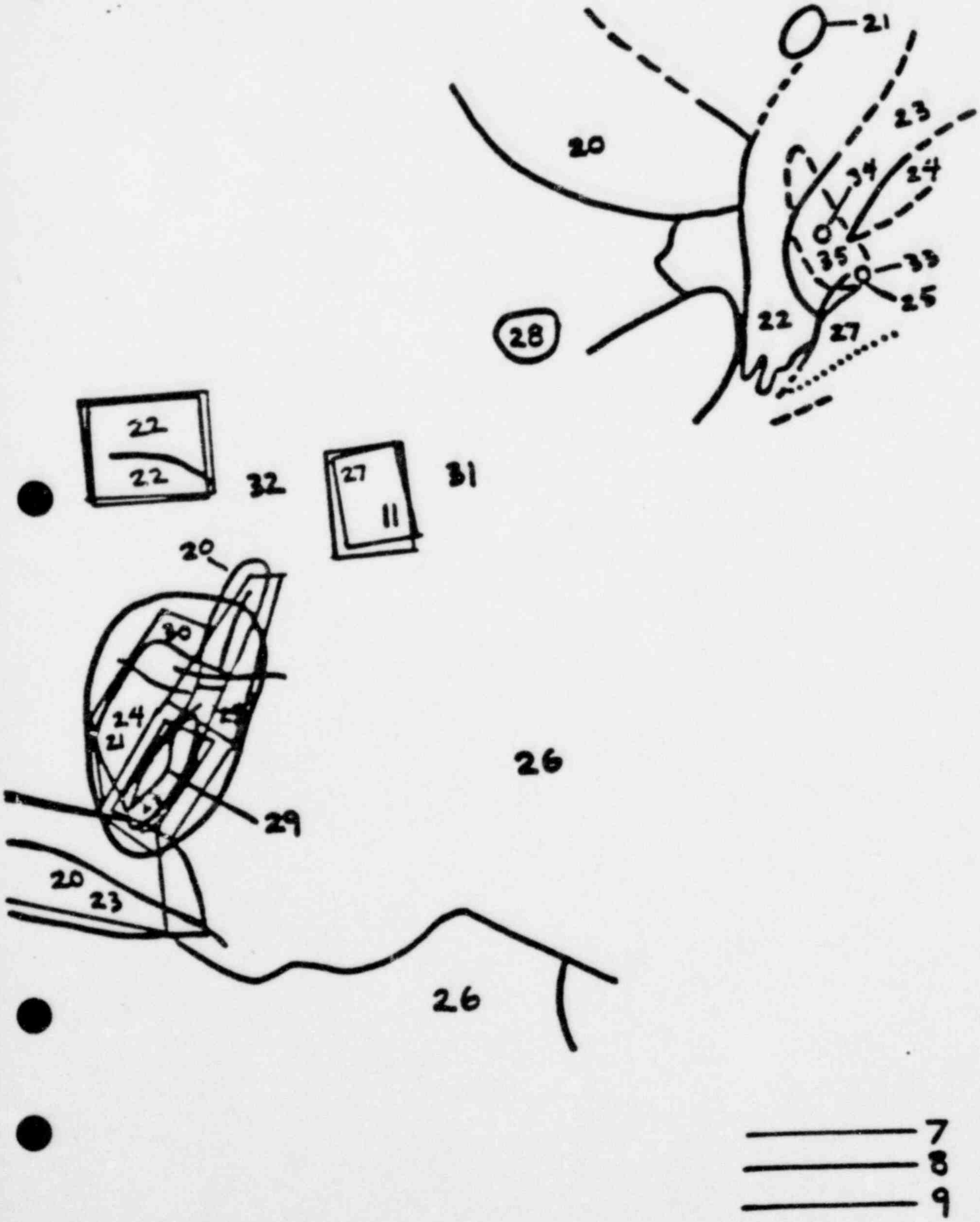
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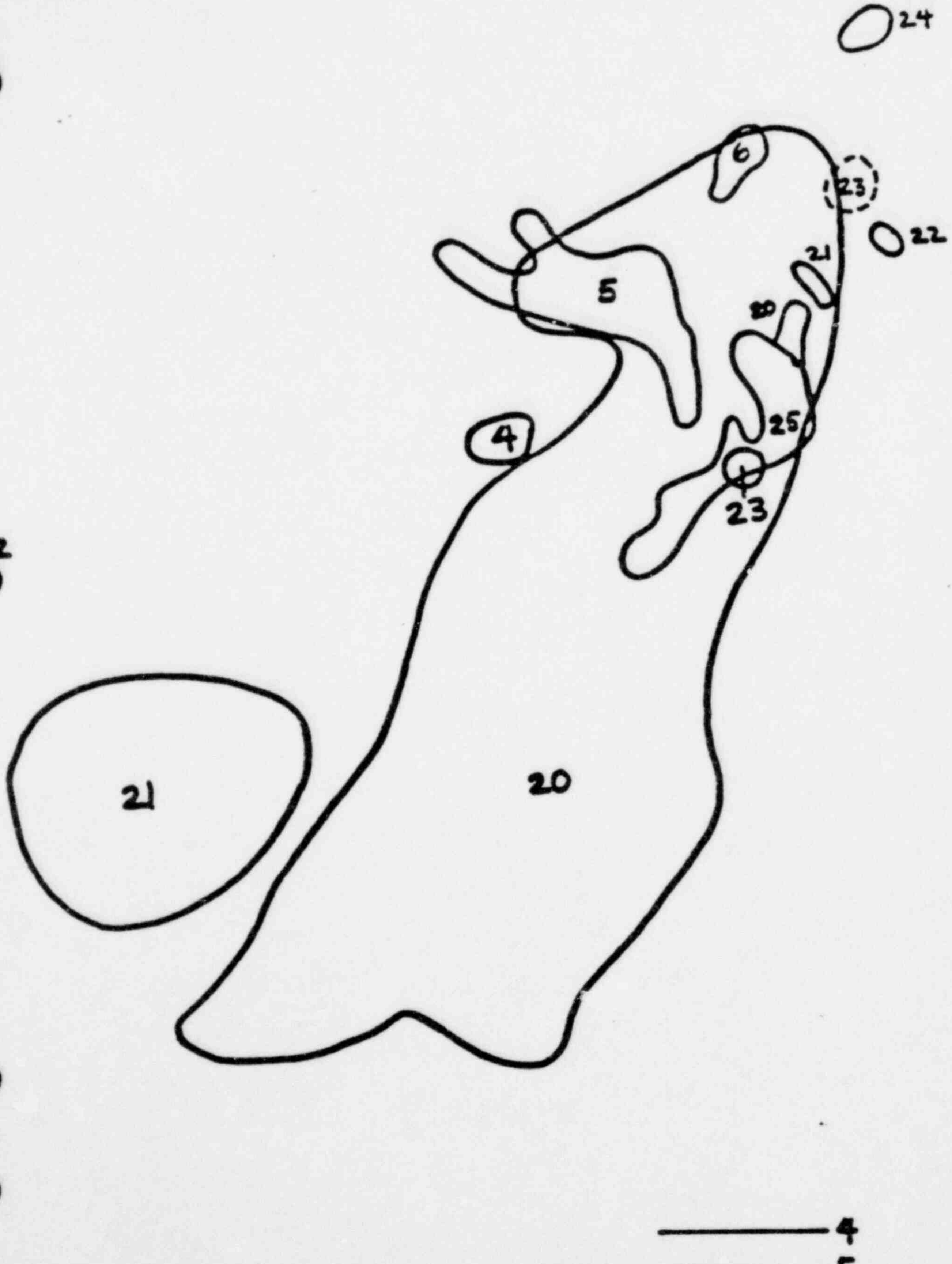
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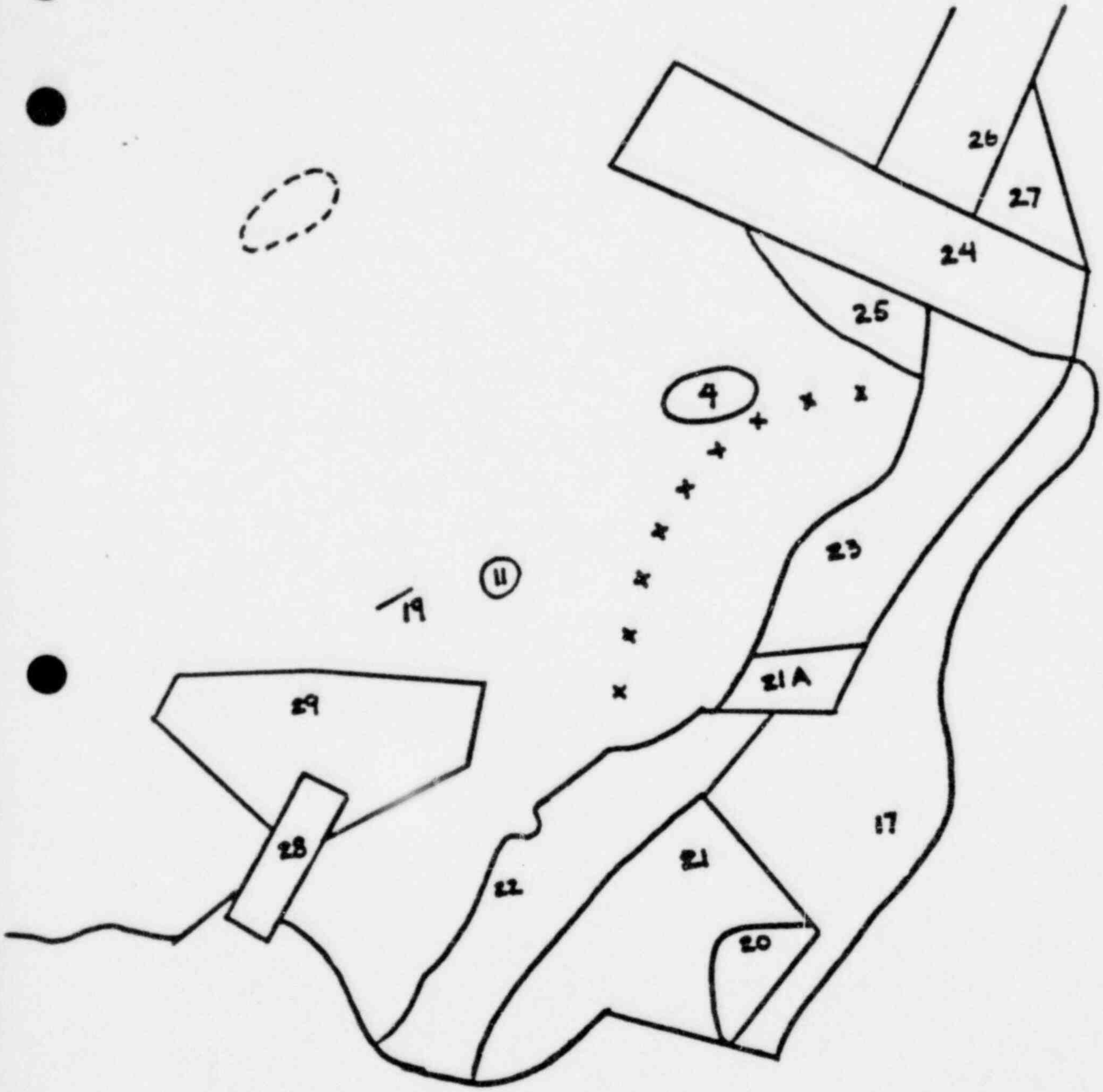

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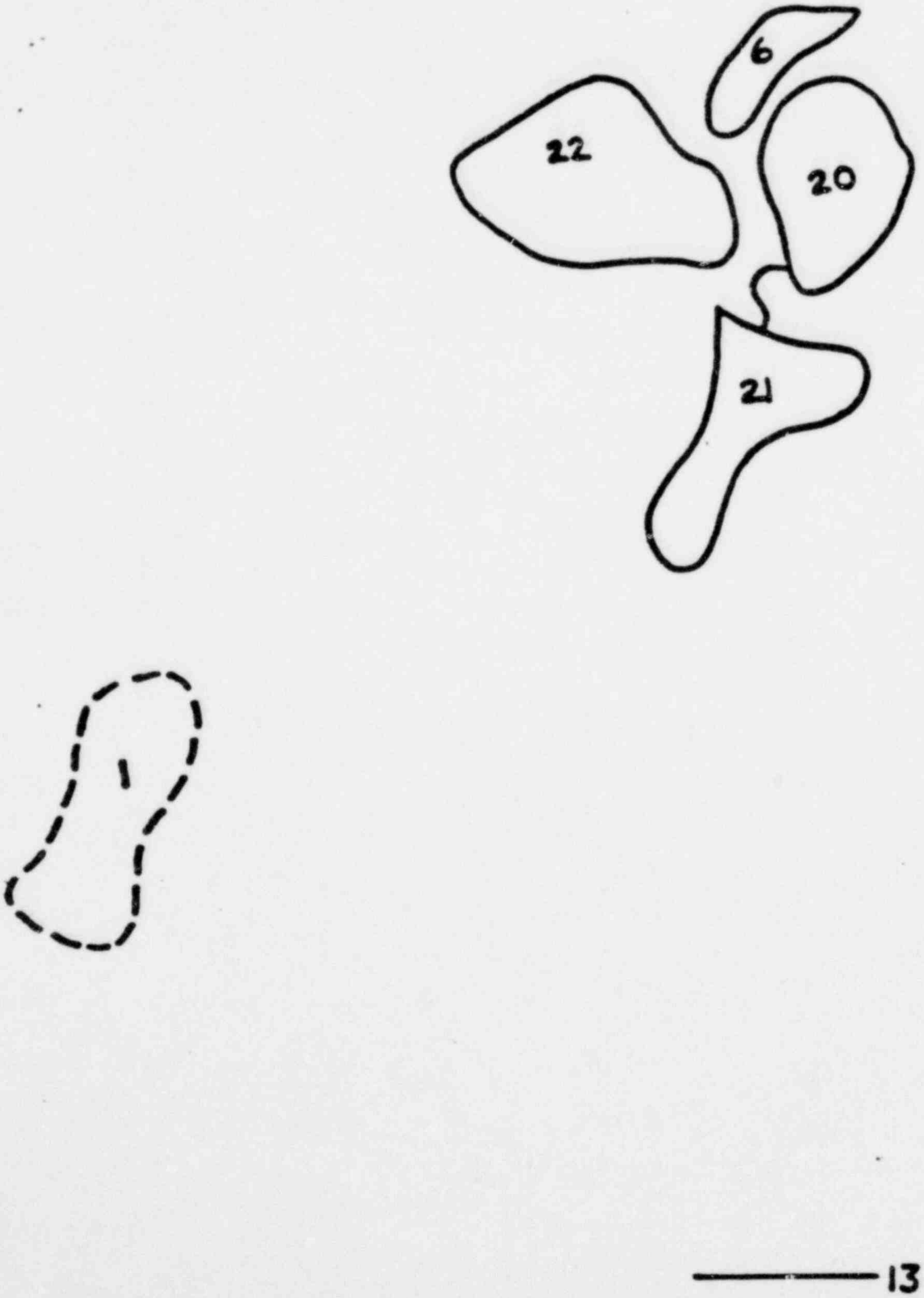
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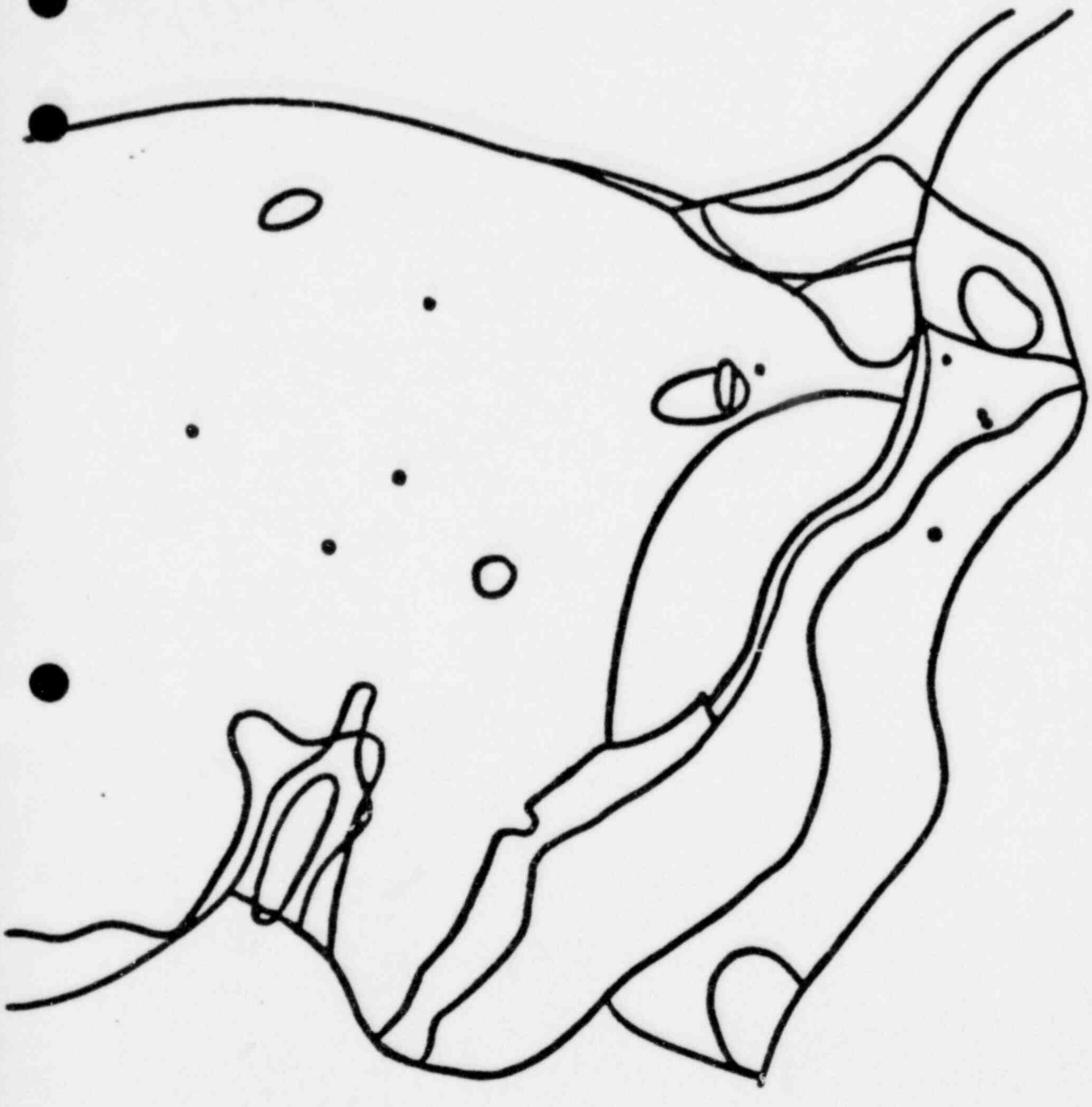
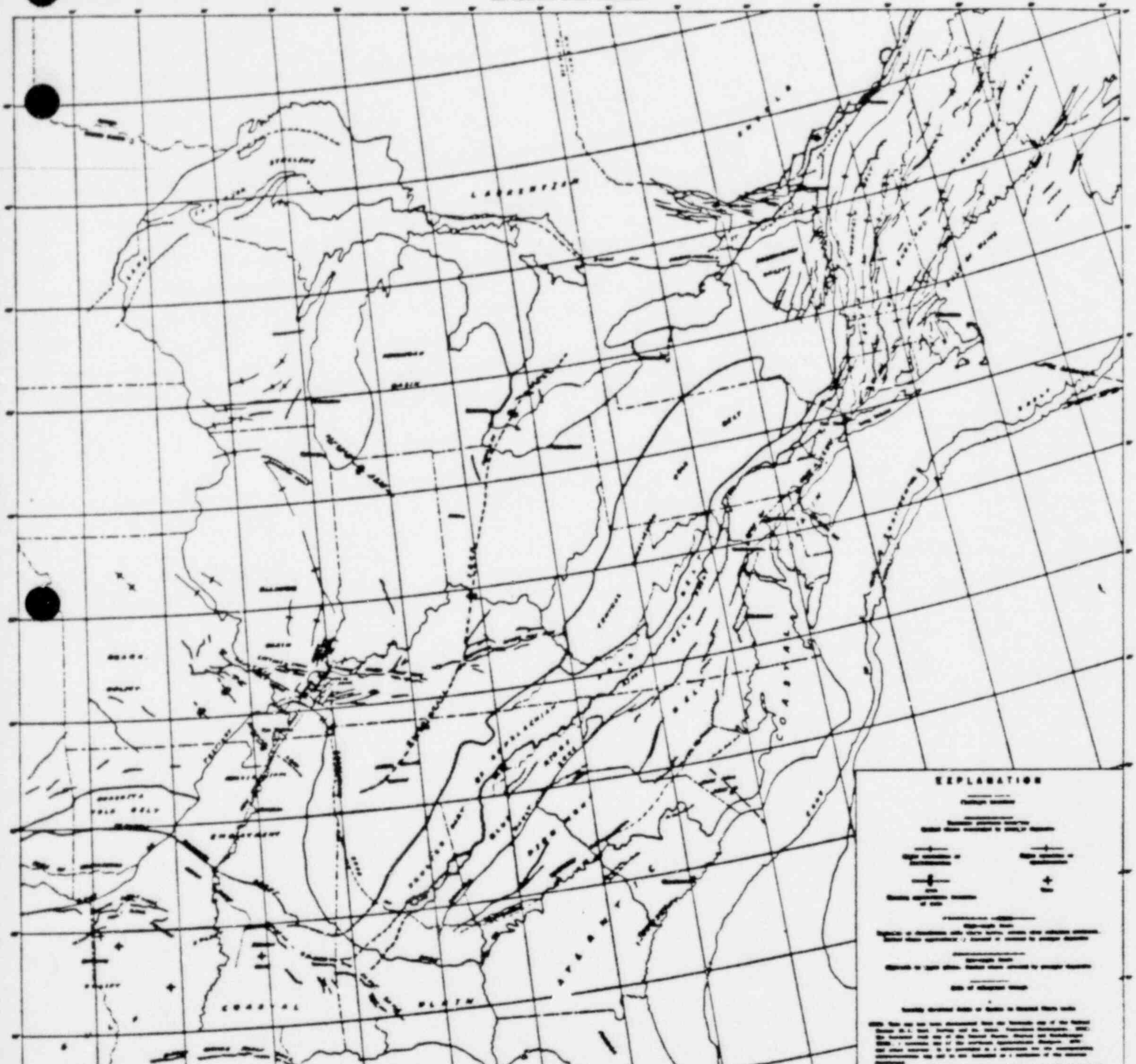




A. TECTONIC MAP

SEISMOTECTONIC MAP OF THE EASTERN UNITED STATES

By

Jarvis B. Hadley and James F. Devine

1974

18

MAXIMUM EARTHQUAKES

Although in the Eastern U. S. the earthquake sizes are commonly measured in terms of Modified Mercali Intensities (MMI), we will always refer to "size" (S) and let you choose whether you want to express your answers in terms of either magnitude or MMI.

You should base your answer not only on the recorded data, but also on your feeling as to whether the past history is a good estimator of the true state of nature and whether the future activity is likely to be similar or different from the past. This feeling can be based on any external source of information such as tectonics, theoretical studies, similarity with other regions in the world, or simply educated judgment.

2-5 For each of the two time periods, 150 years and 1,000 years, assume that within the next 10 years the upper bound estimate of the largest event actually occurs in a zone. How would this change your previous answer to 2-3?

2-10 If in the next 150 years you were told that among the several events that occurred the two largest ones were of the same size, what size would you guess they were?

SEISMICITY MODELS

Remember that you are asked to subjectively assess the future seismicity in the East based on the available data and your judgment as to the validity, quality and completeness of these data to represent the true seismicity in the East. These judgments may be based on geologic and tectonic considerations, similarities with other regions, theoretical considerations, individual studies that you have conducted or know of, or any other information that you feel has a bearing on Eastern seismicity.

3-1 Do you think that a linear relation is acceptable to describe the seismicity of seismic source zones? If not, what should the form be?

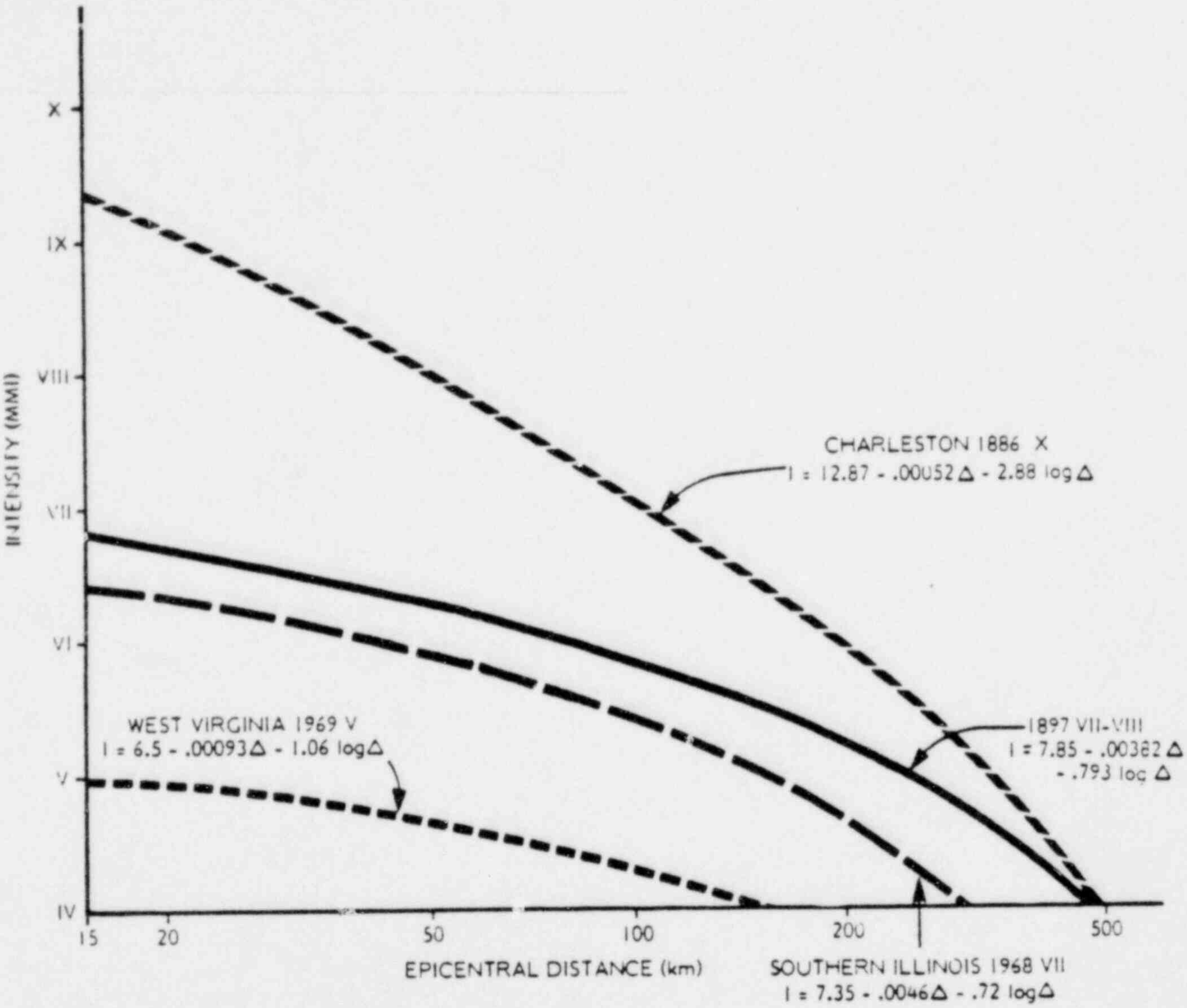
3-3 Consider a local tectonic feature which in recorded history has had a few earthquakes of relatively large size associated with it. Do you believe that the classical recurrence relationship is appropriate to describe potential activity of this feature or is another type of recurrence biased toward the large site events more appropriate?

ATTENUATION

An attractive approach to supplement the limited strong motion data in the East is to infer, based on theoretical or experimental considerations, the difference in peak acceleration and velocity ground motion between the Eastern United States (East) and the Western United States (West) and to modify correspondingly the Western attenuation relations and intensity correlations in order to make them applicable in the East. The following questions address this problem in a qualitative as well as quantitative manner.

4-1 To what degree do you feel there is evidence to substantiate the hypothesis that strong ground motion characteristics are different between the East and the West?

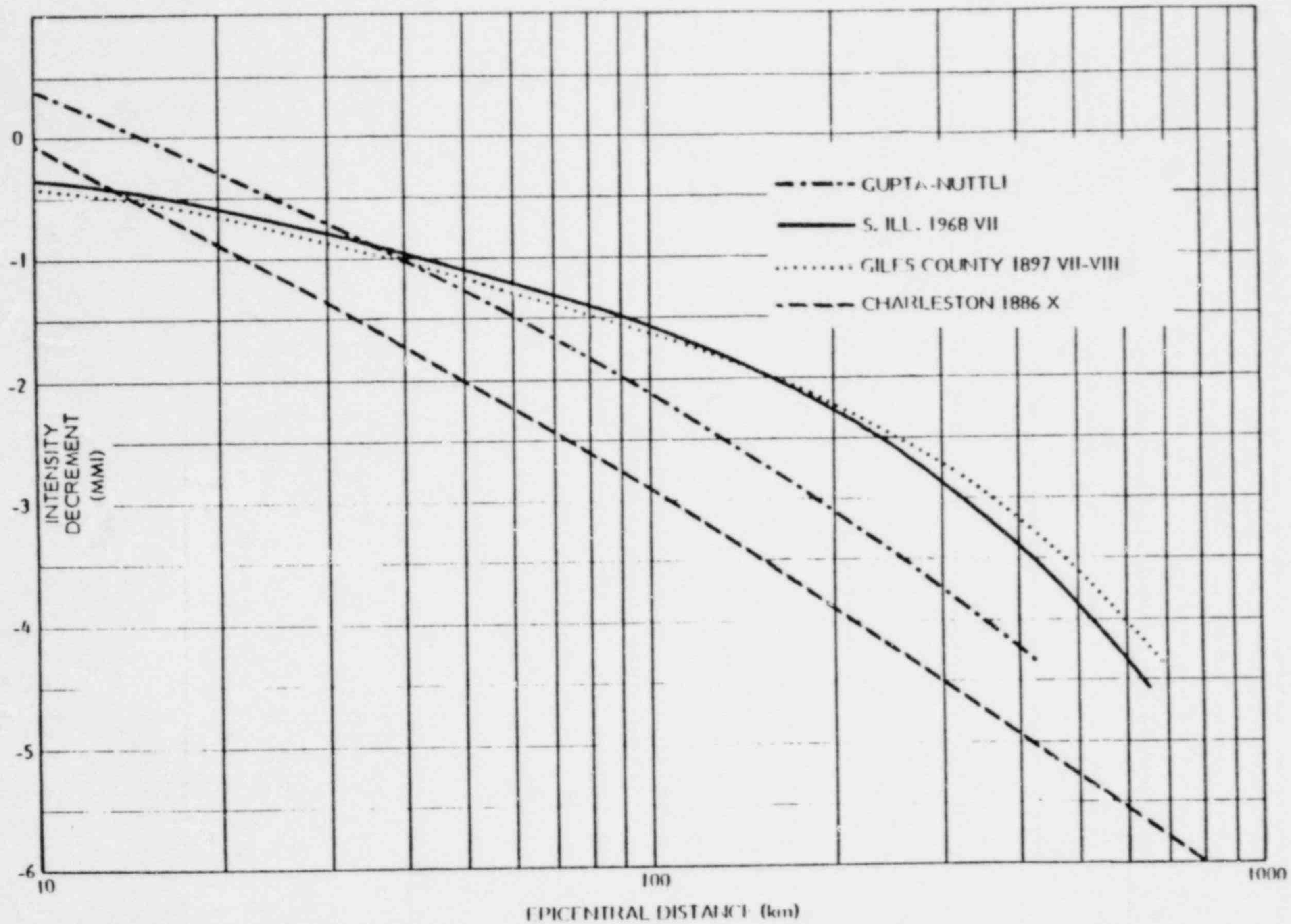
4-3 Several correlations between epicentral intensity and magnitude have been developed for different regions in the East. What correlation(s) do you think is appropriate for the source regions developed in Section 1.0? Comment in general as to the reliability of these correlations.



INTENSITY ATTENUATION RELATIONSHIPS

22

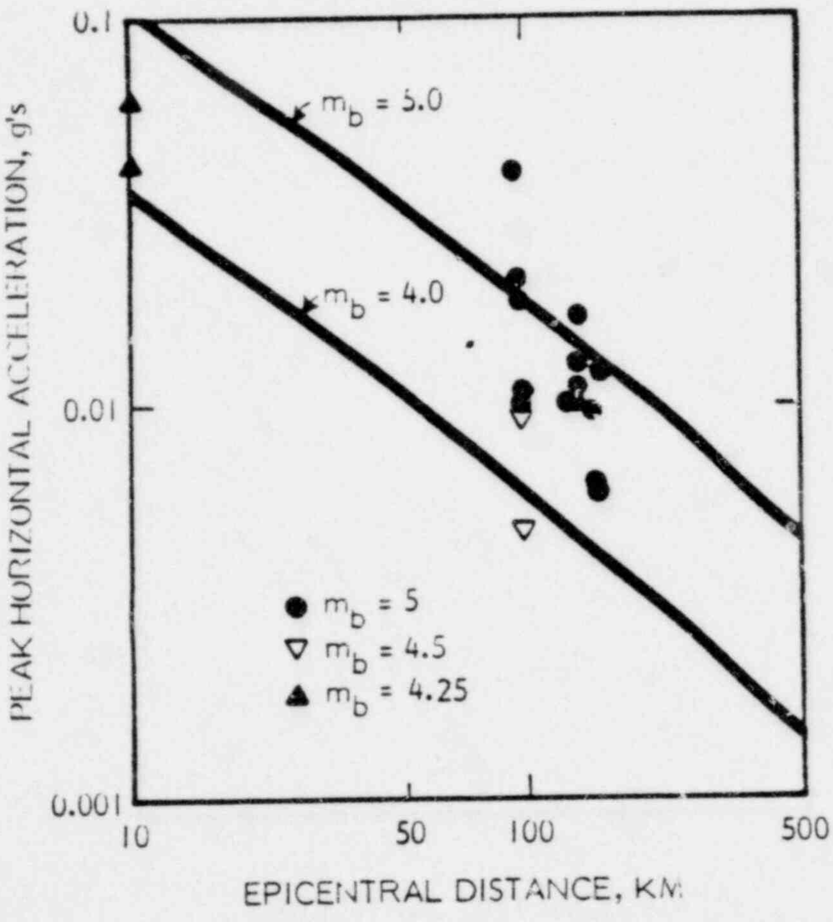
TERA CORPORATION



INTENSITY DECREMENT ATTENUATION RELATIONSHIPS

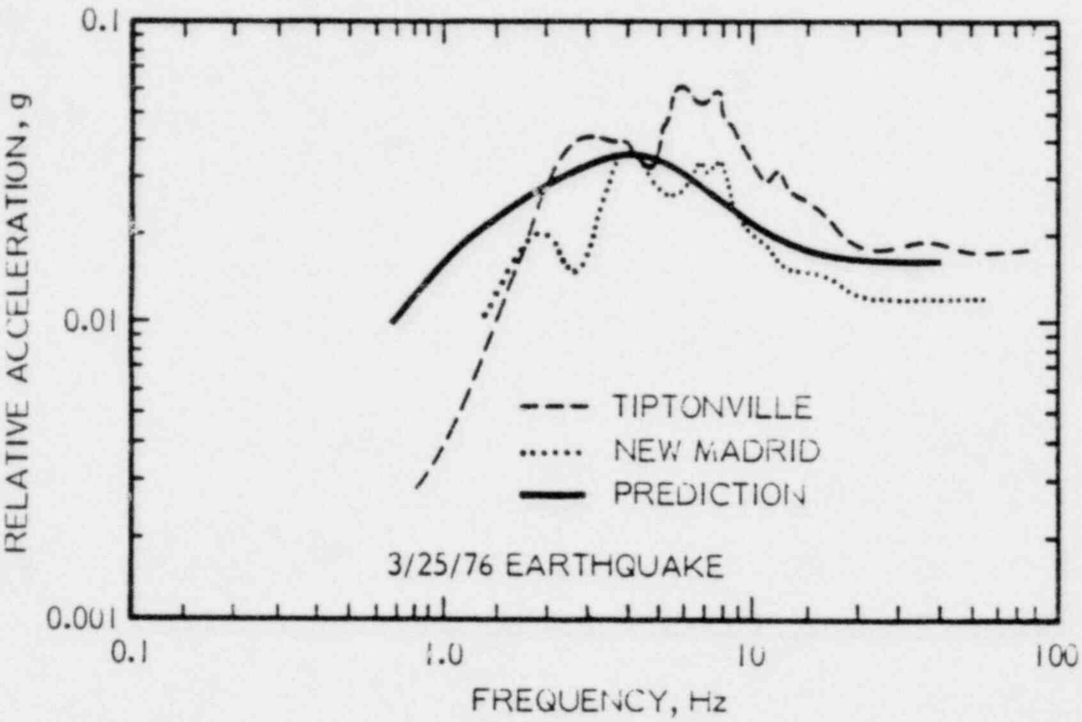
23

TERA CORPORATION



COMPARISON OF PREDICTED PEAK ACCELERATION TO AVAILABLE DATA IN CENTRAL U.S.

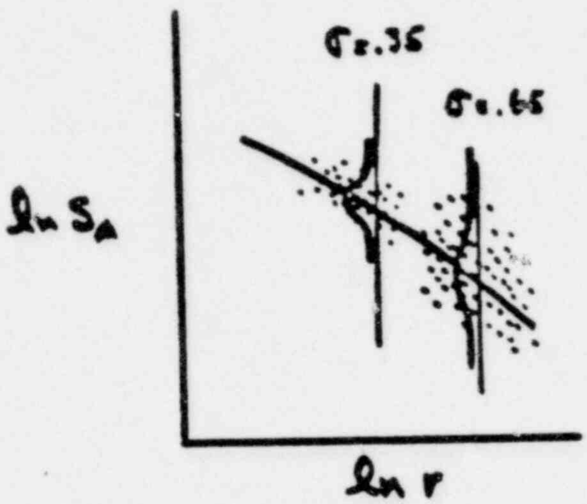
24



COMPARISON OF RESPONSE SPECTRUM PREDICTION
VERSUS STRONG MOTION DATA FOR m_b = 5 AND r = 130 KM
AND 5% DAMPING

25

Acceleration dispersion for Eastern U.S. is a very important, uncertain parameter



Attenuation data for Western U.S.

Theoretically, the use of intensity data from Eastern U.S. introduces additional statistical uncertainty

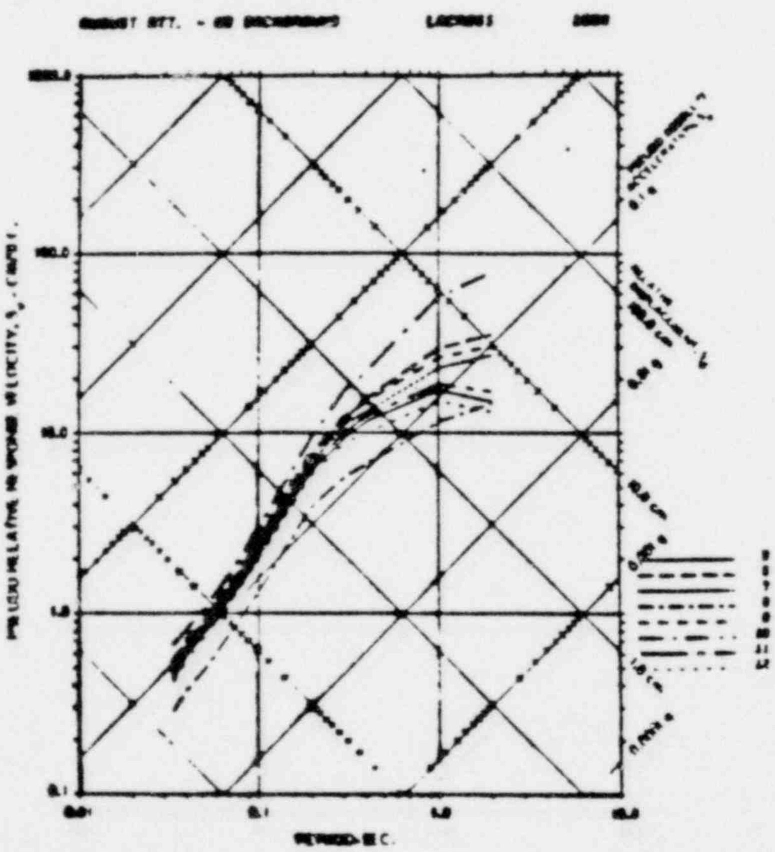
A formal combination of all these uncertainties yields σ = 0.9 (Cornell et al, 1979)

WE RELY ON JUDGEMENT AND OTHER INDEPENDENTLY DERIVED INFORMATION TO SPECIFY THE VALUE OF DISPERSION

- Reasonable agreement with available eastern U.S. acceleration data
- Good agreement with a recently derived theoretical attenuation model
- A judgemental accounting for the tightening of variables in a site-specific application

The questionnaire answer booklets quantified the judgements of ten prominent seismologists.

We calculated 10 separate site specific response spectra for each site, corresponding to each expert's judgement on zonation and seismicity models.



Digitize each source zone boundary.

Determine historical seismicity in each zone.

Quantify the "incompleteness" in seismicity for each zone.

Fit a linear seismicity model to the data in each zone, using the expert's slope.

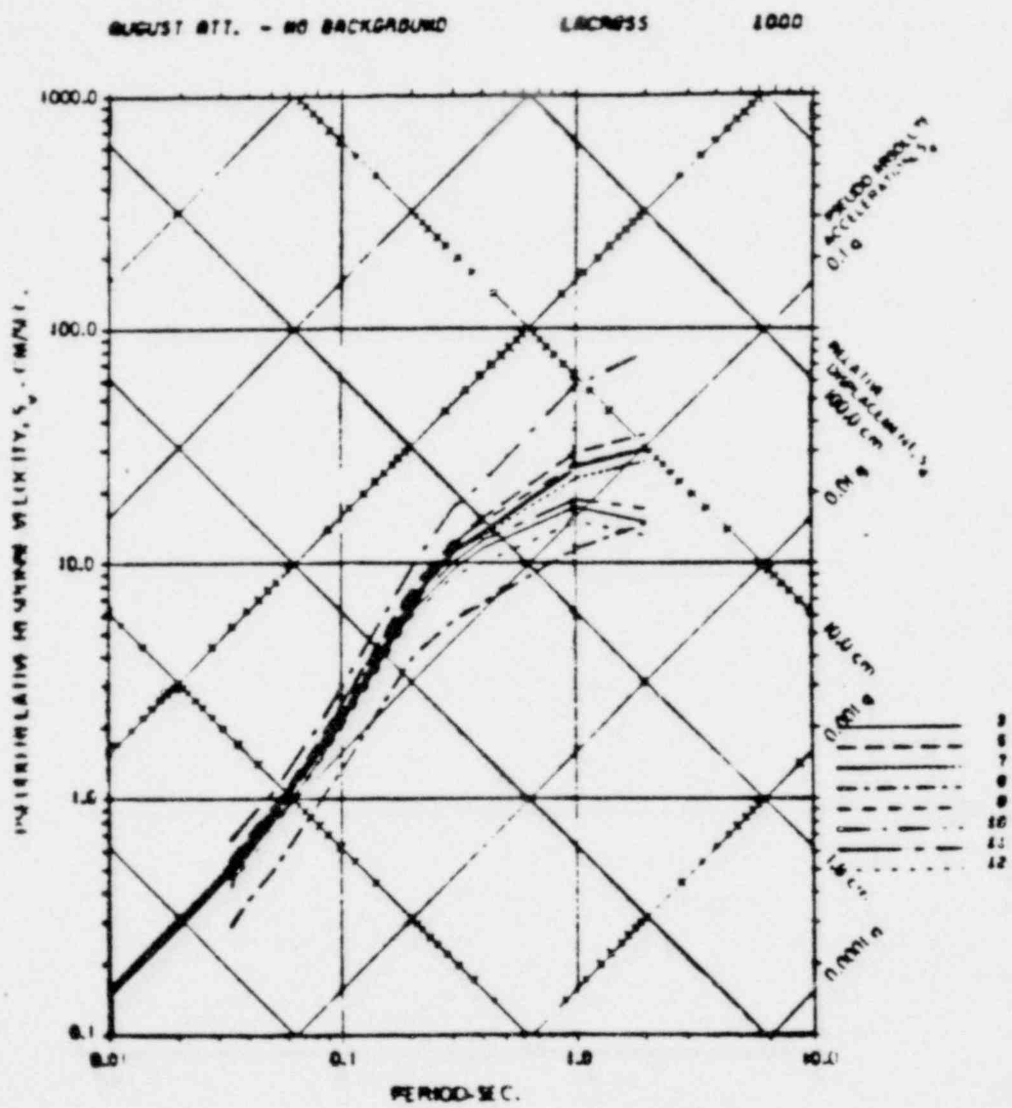
Using the zone credibilities, allocate the seismicity for each zone between the expert's regions and a general background region for the [illegible]e.

Using our attenuation model, calculate the site hazard.

SELF RANKING

When it is appropriate, a consensus or partial consensus will be reached among the experts through weighted average procedures based on self-assigned levels of confidence. In order to obtain a measure of the overall confidence you have in your answers would you please rate on a scale of 1 to 10 (10 being the highest) the confidence you have in your responses for the different sections of the questionnaire and the various source zones.

The 10 separate spectra were synthesized into a single spectrum for each site by a weighting scheme.

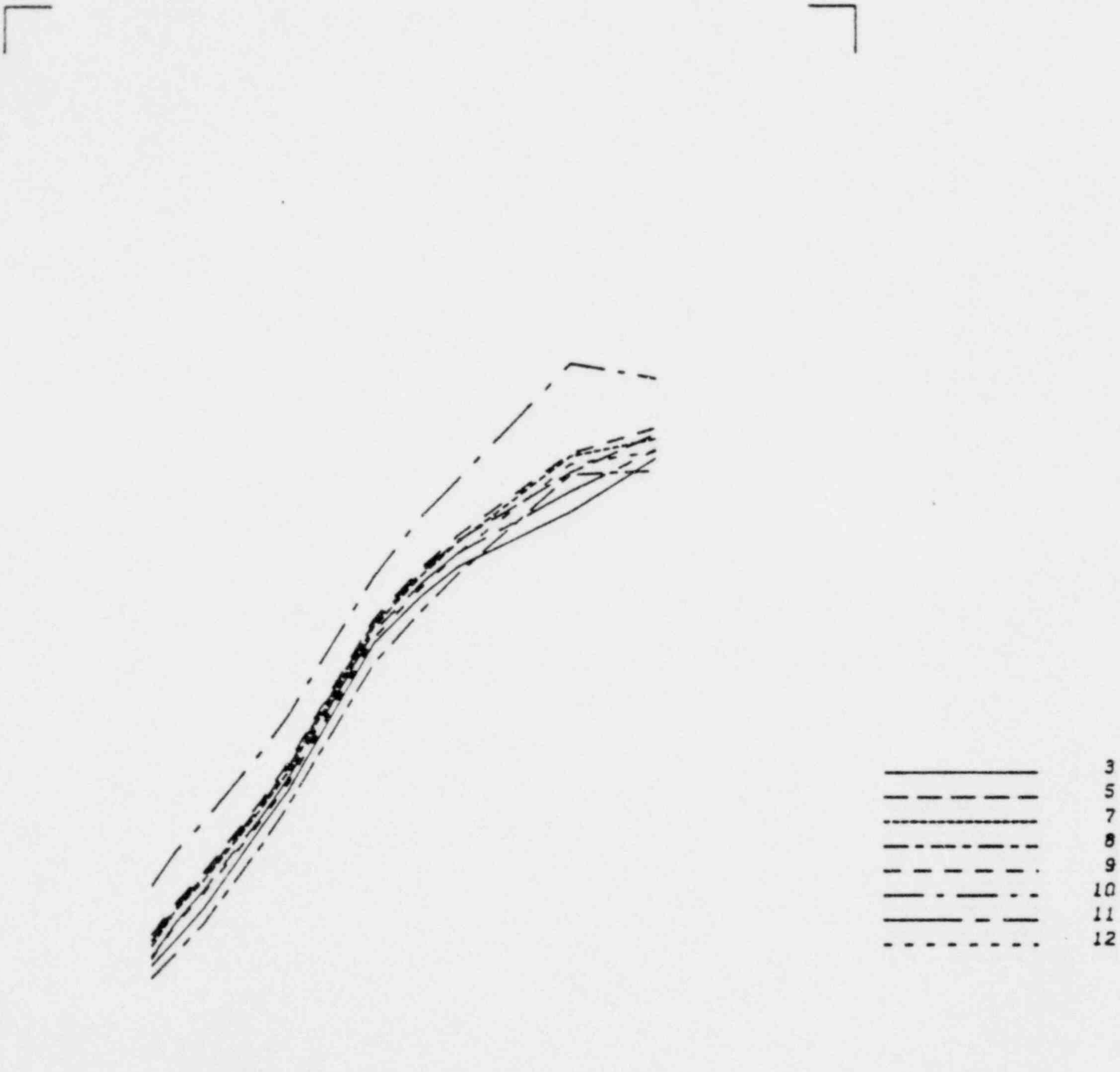


The weight for each spectral ordinate was determined from

1) *the principal source of that load*

2) *the experts' self-rank for that source*

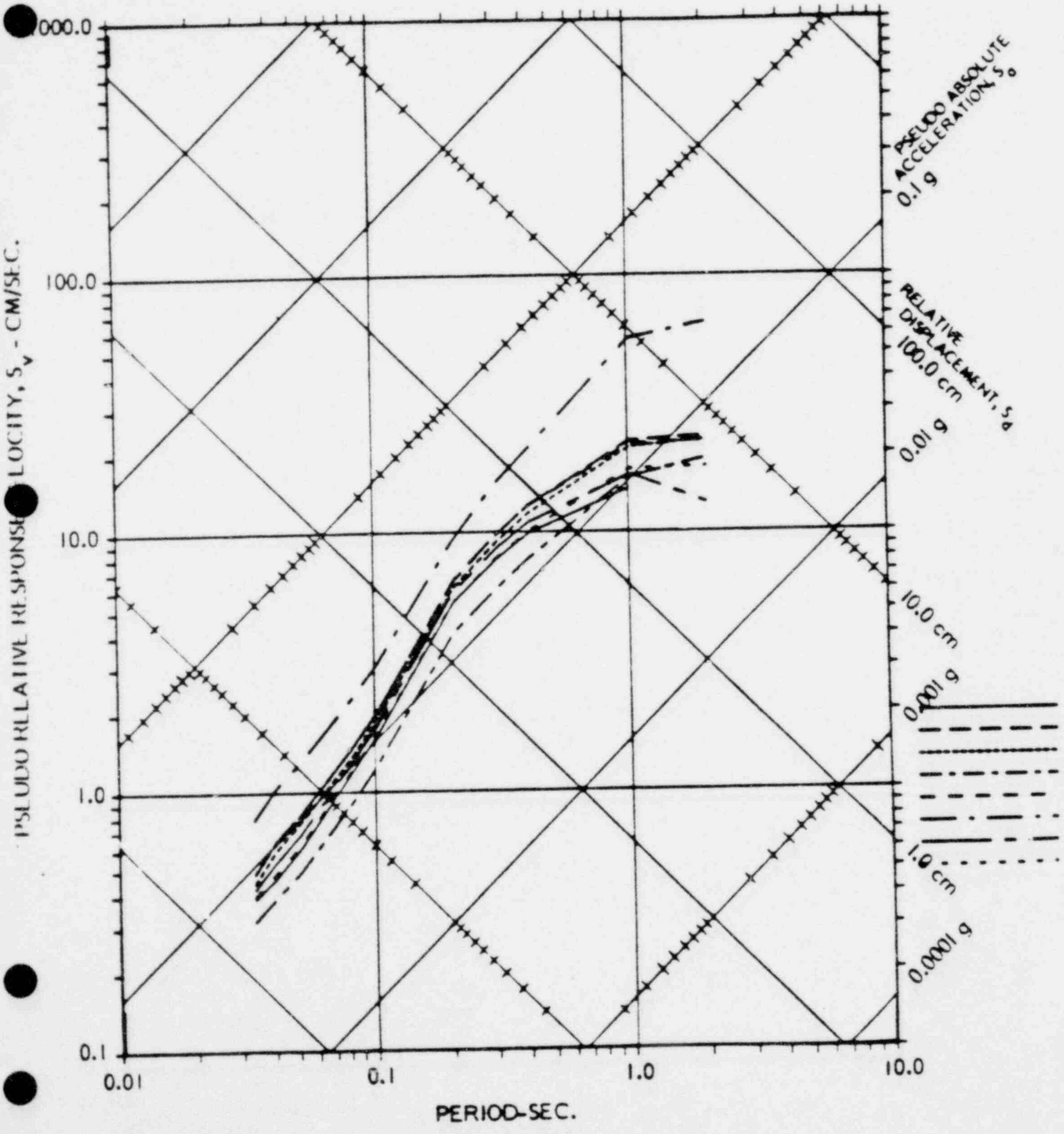
GUPTA-BACKGROUND LACROSS 1000



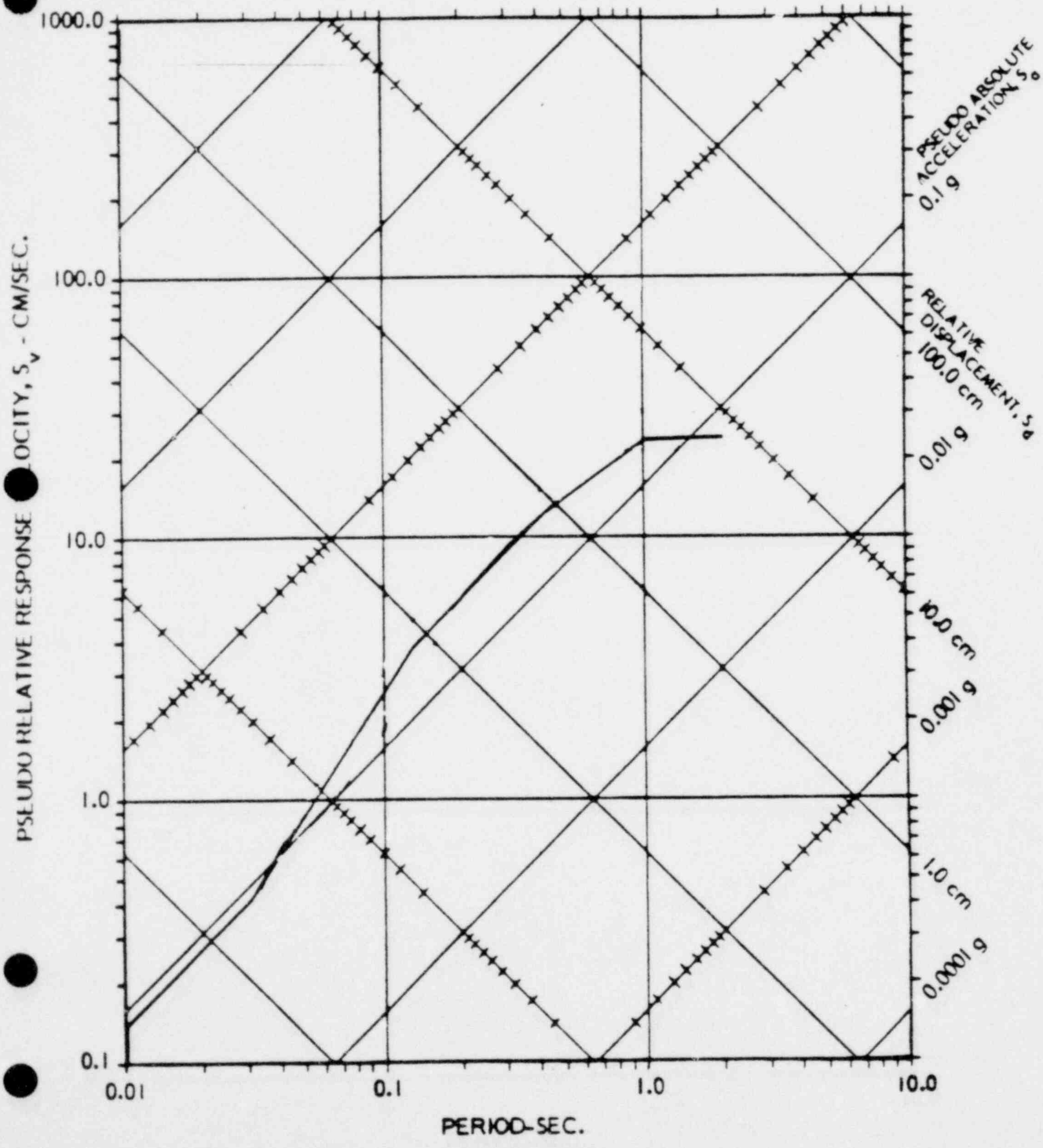
DAMPING = 5.0

05/04/80

GUPTA & NUTTLI - NO BACKGROUND LACROSS 1000



GUPTA & NUTTLI - NO BACKGROUND LACROSS 1000

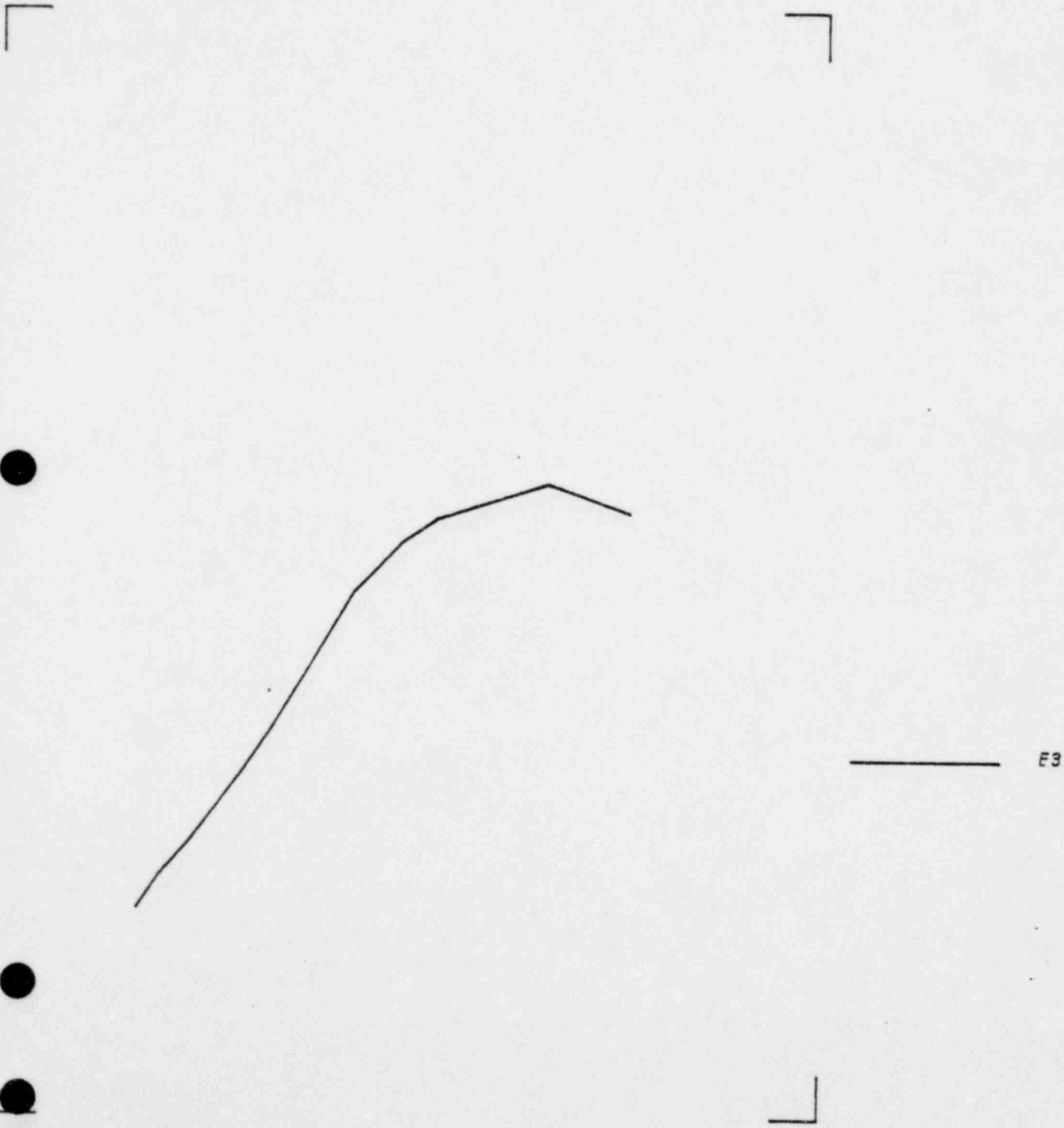


GUPTA-BACKGROUND LACROSS 1000

DAMPING = 5.0

05/04/80

3 SIGMA/0.6 EXP 3./BACKGROUND OYSTER CREEK 1000



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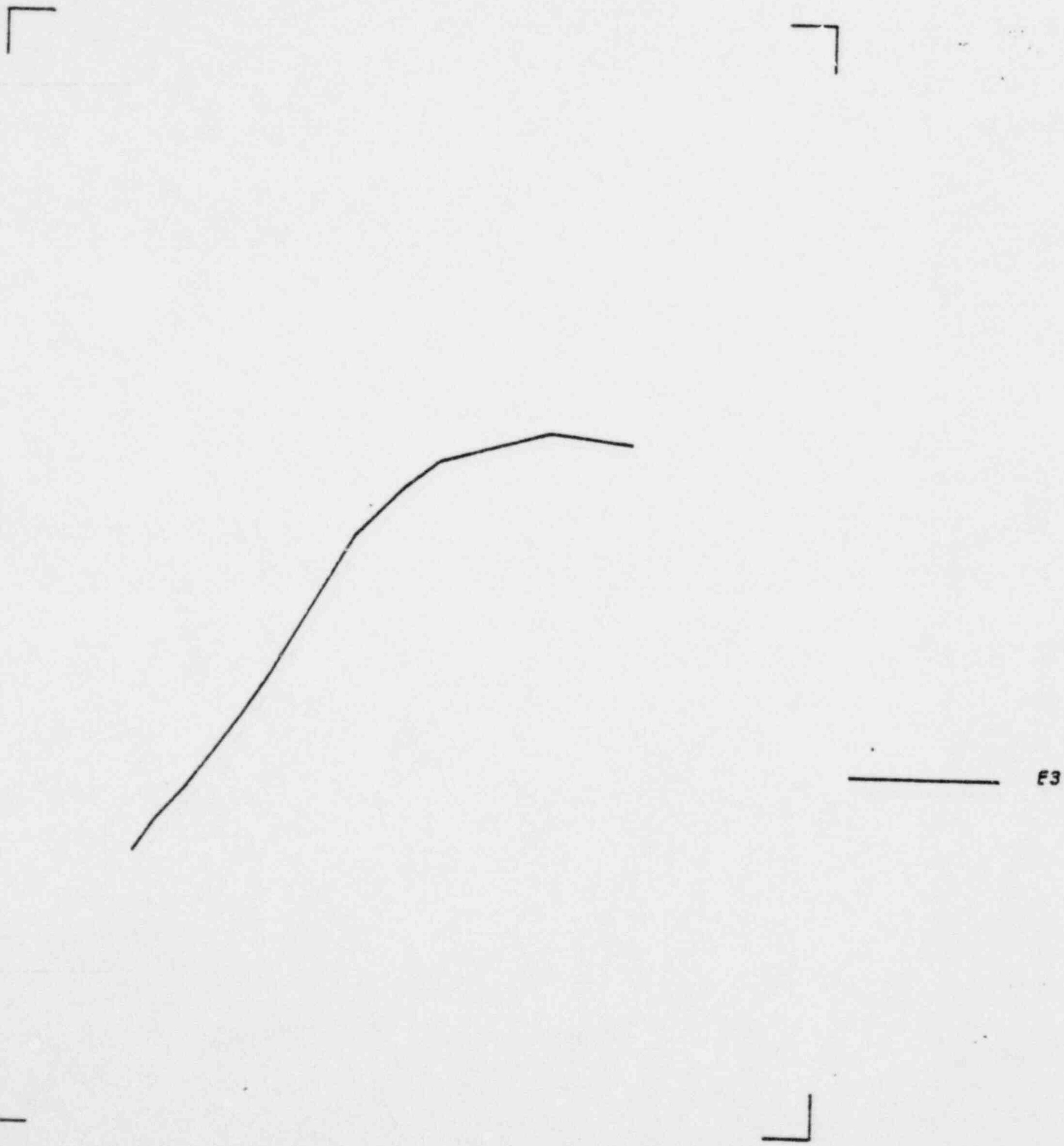
06/03/80

3 SIGMA/0.9   EXP 3/BACKGROUND   OYSTER CREEK   1000



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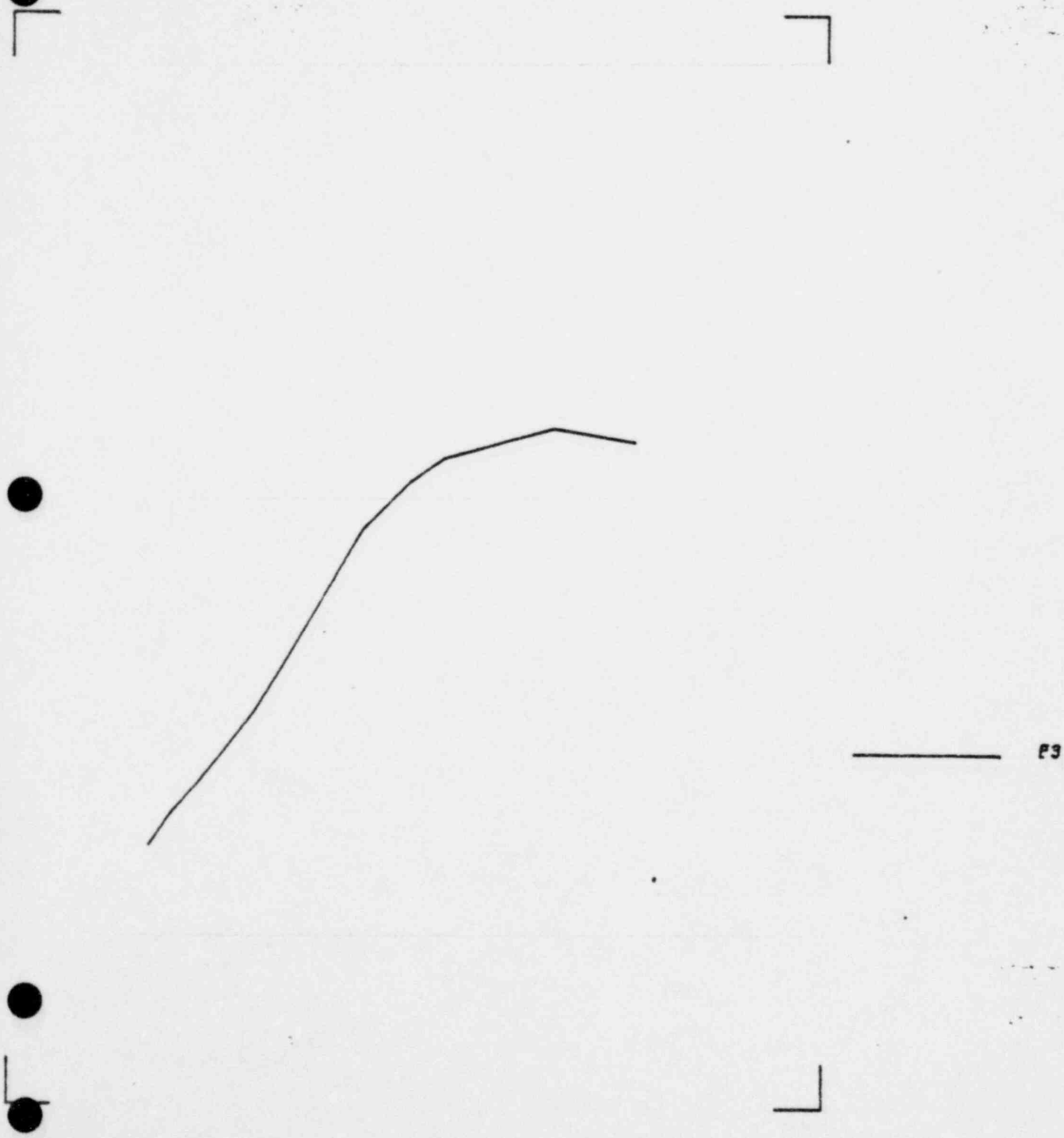
3 SIGMA/0.9 EXP 3/NO BACKGROUND OYSTER CREEK 1000



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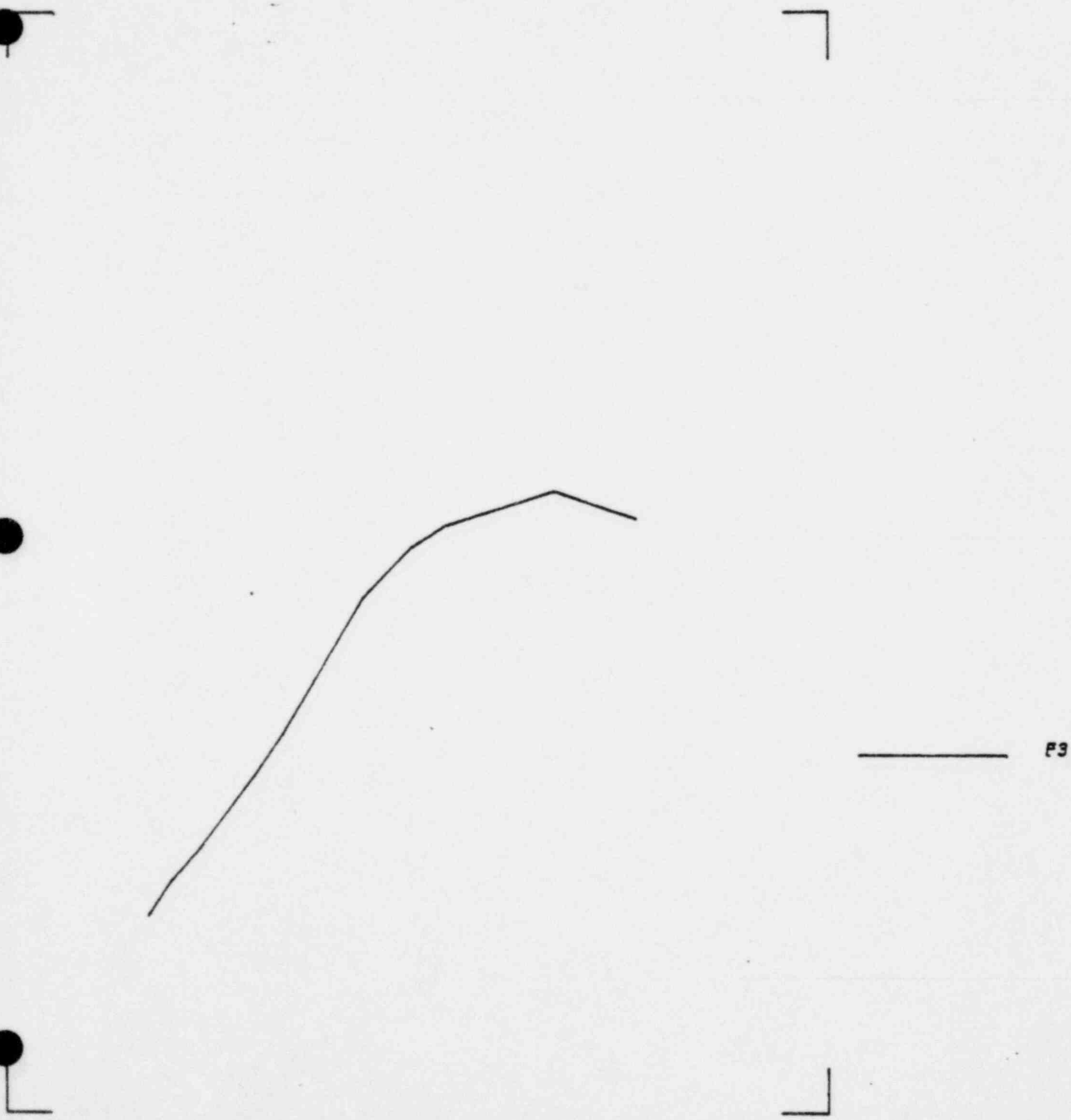
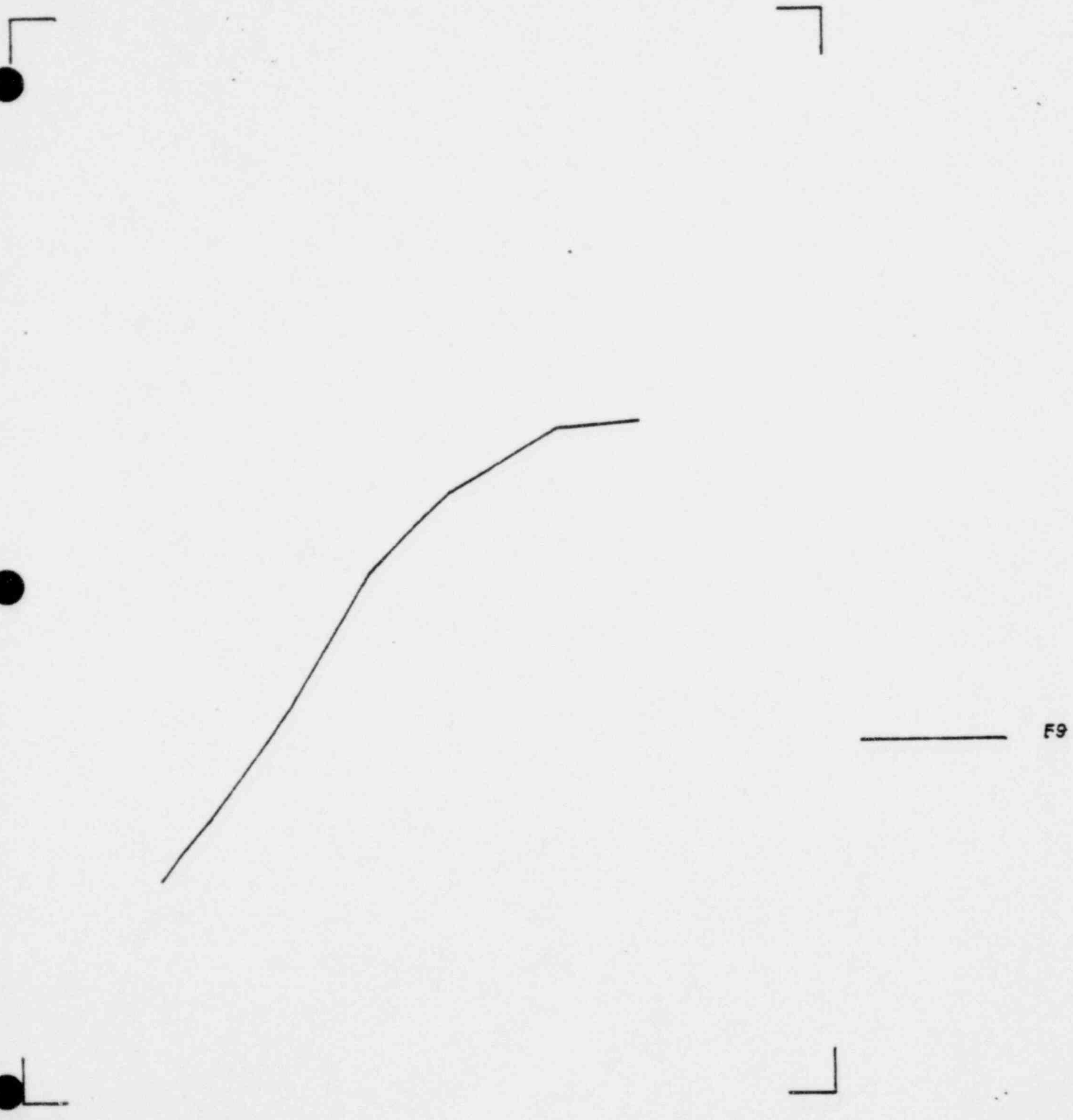
SIGMA/0.6 EXP 3/NO BACKGROUND OYSTER CREEK 1000



DAMPING = 5.0

06/03/80

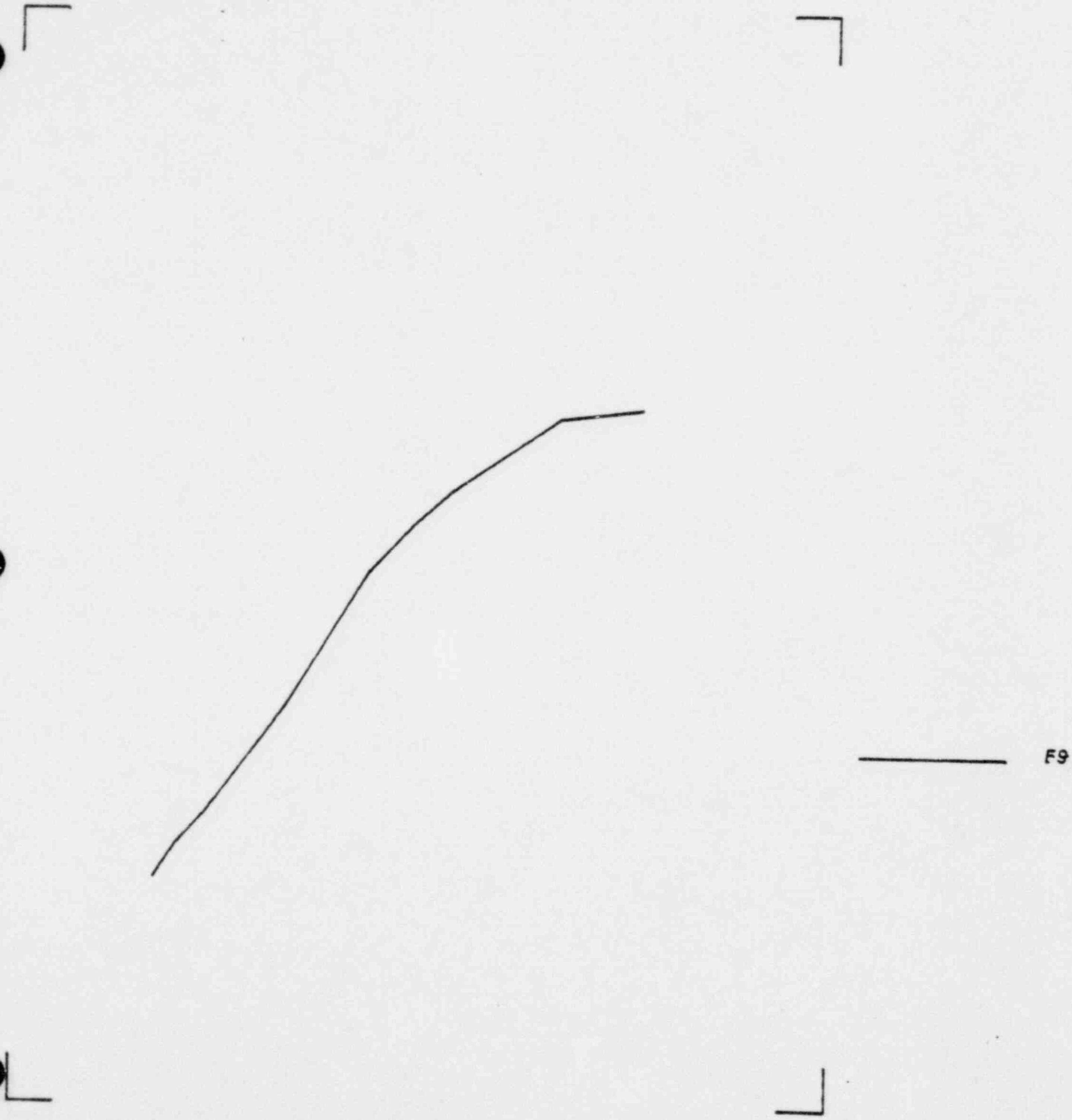
3 SIGMA/0.9   EXP 9/NO BACKGROUND LACROSS   1000



DAMPING = 5.0

06/03/80

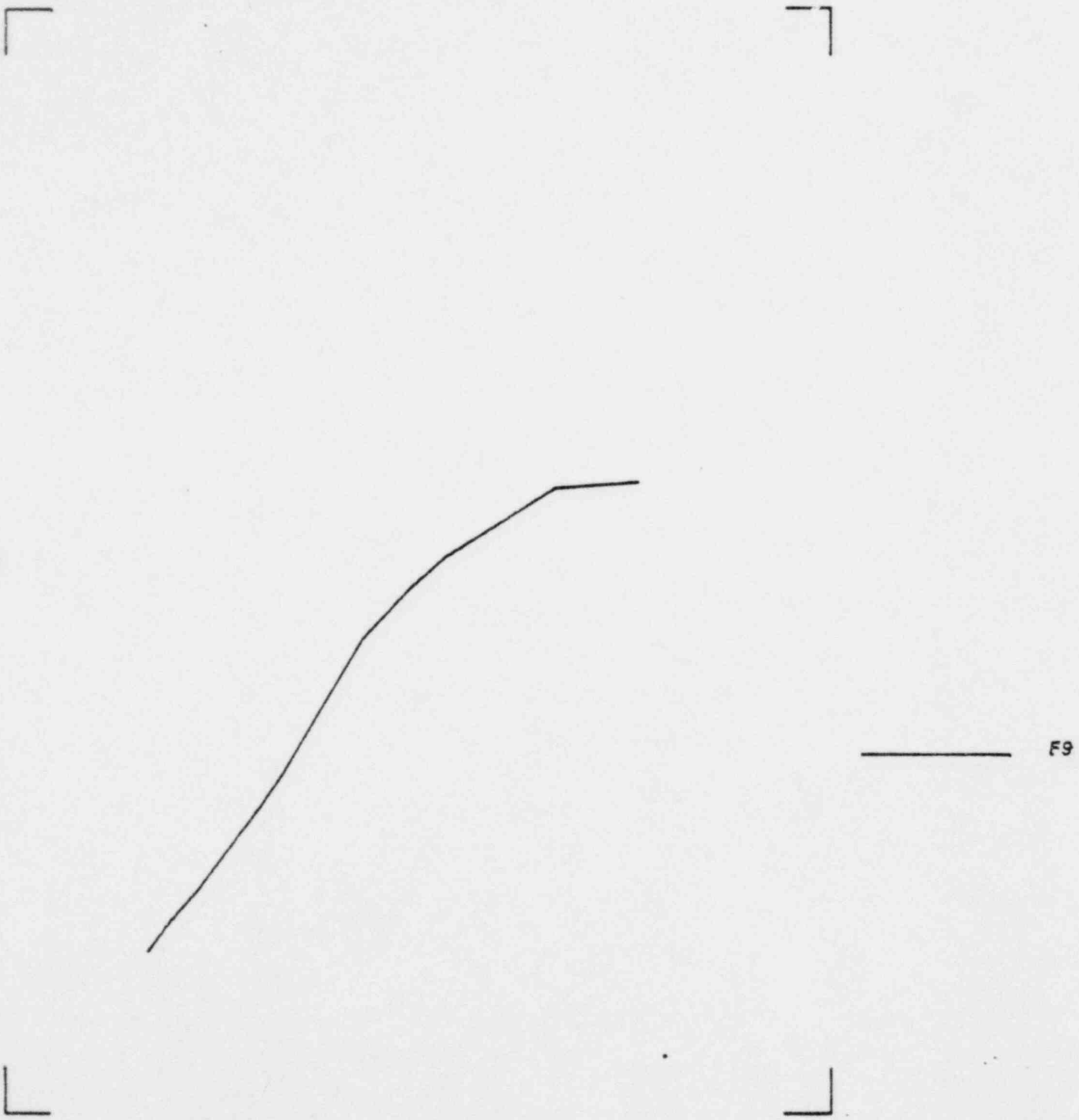
3 SIGMA/0.9 EXP 9/BACKGROUND LACROSS 1000



DAMPING = 5.0

06/03/80

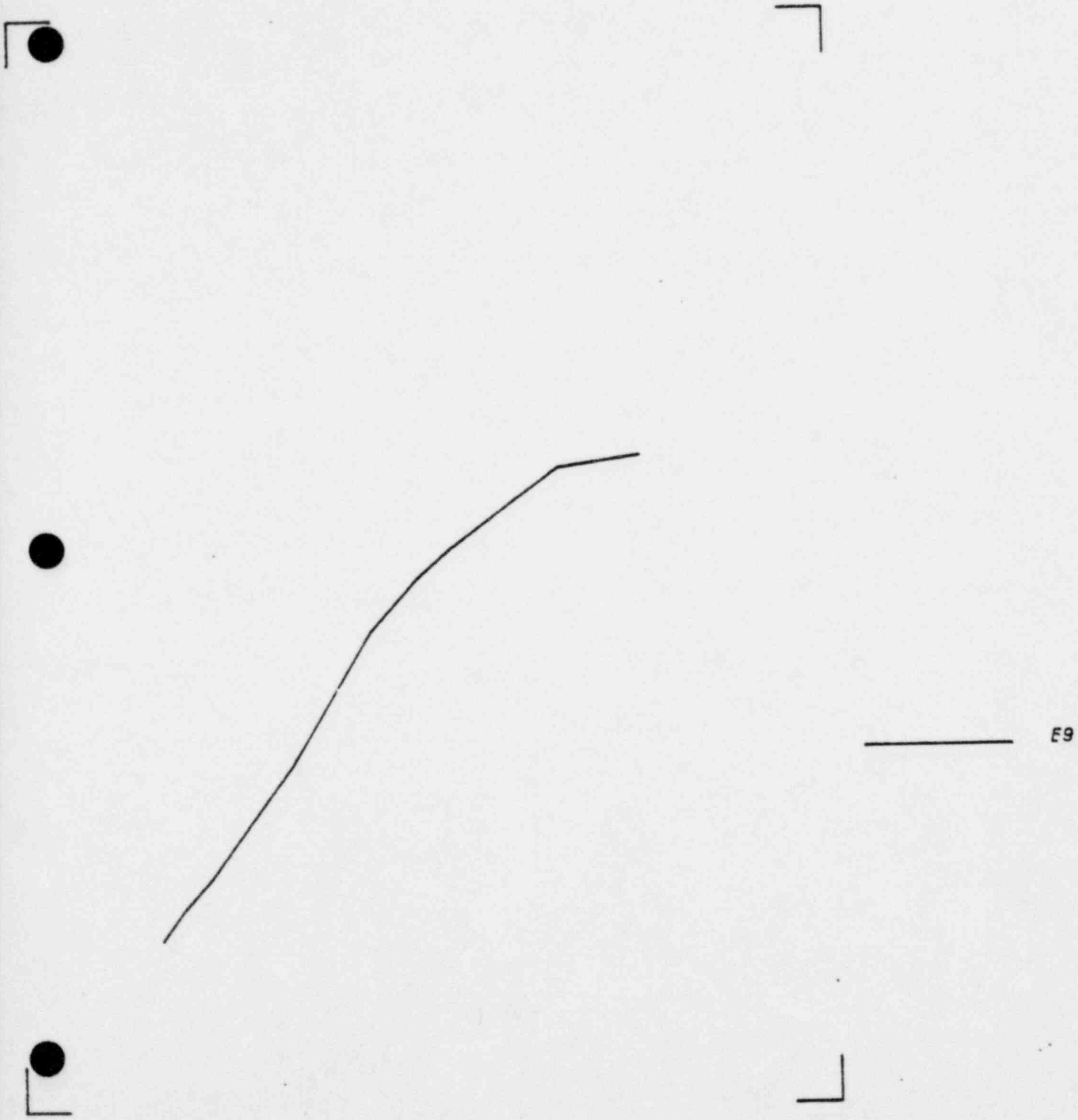
3 SIGMA/0.6 EXP 9/NO BACKGROUND LACROSS 1000



DAMPING = 5.0

06/03/80

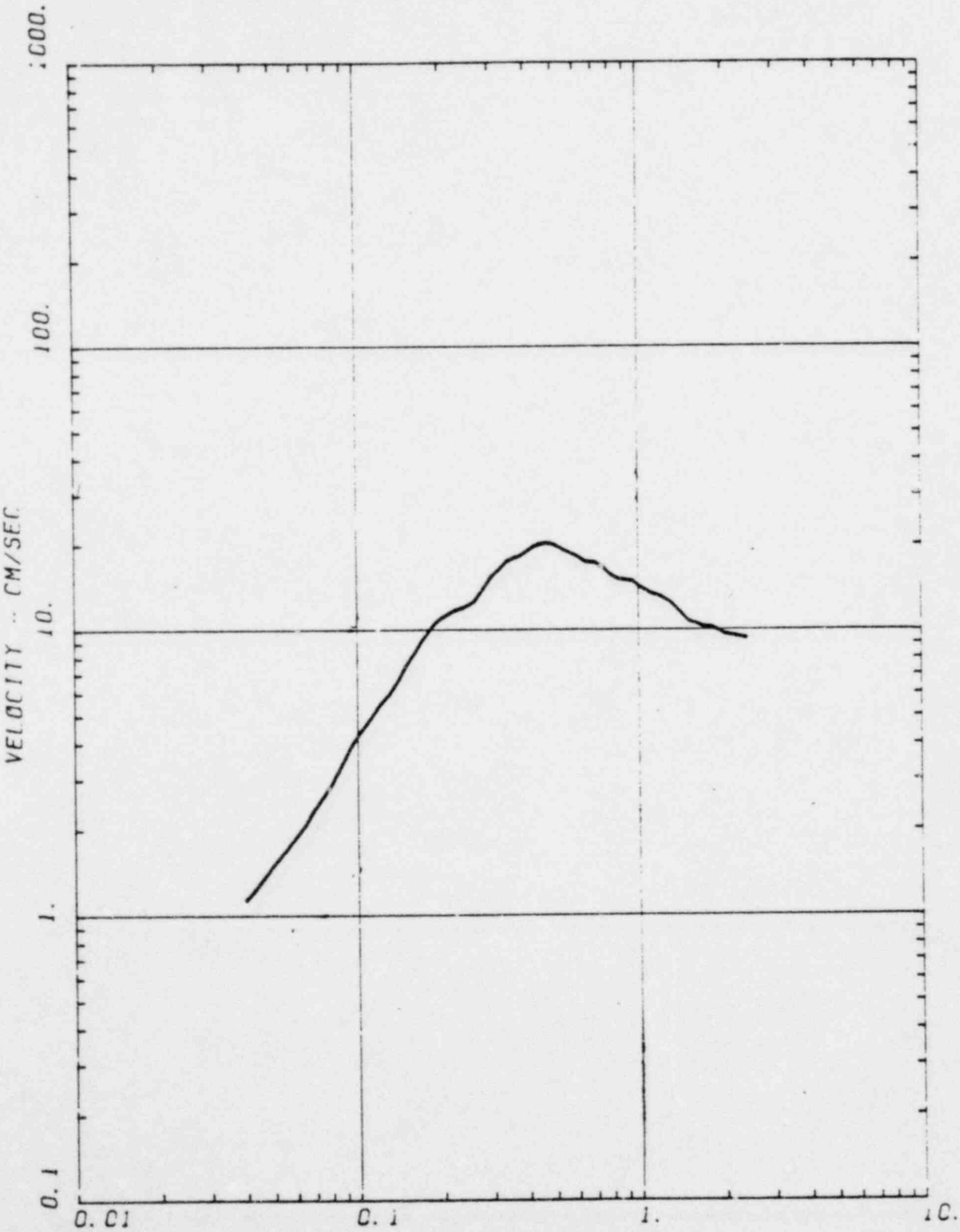
3 SIGMA/0.6 EXP 9/BACKGROUND LACROSS 1000



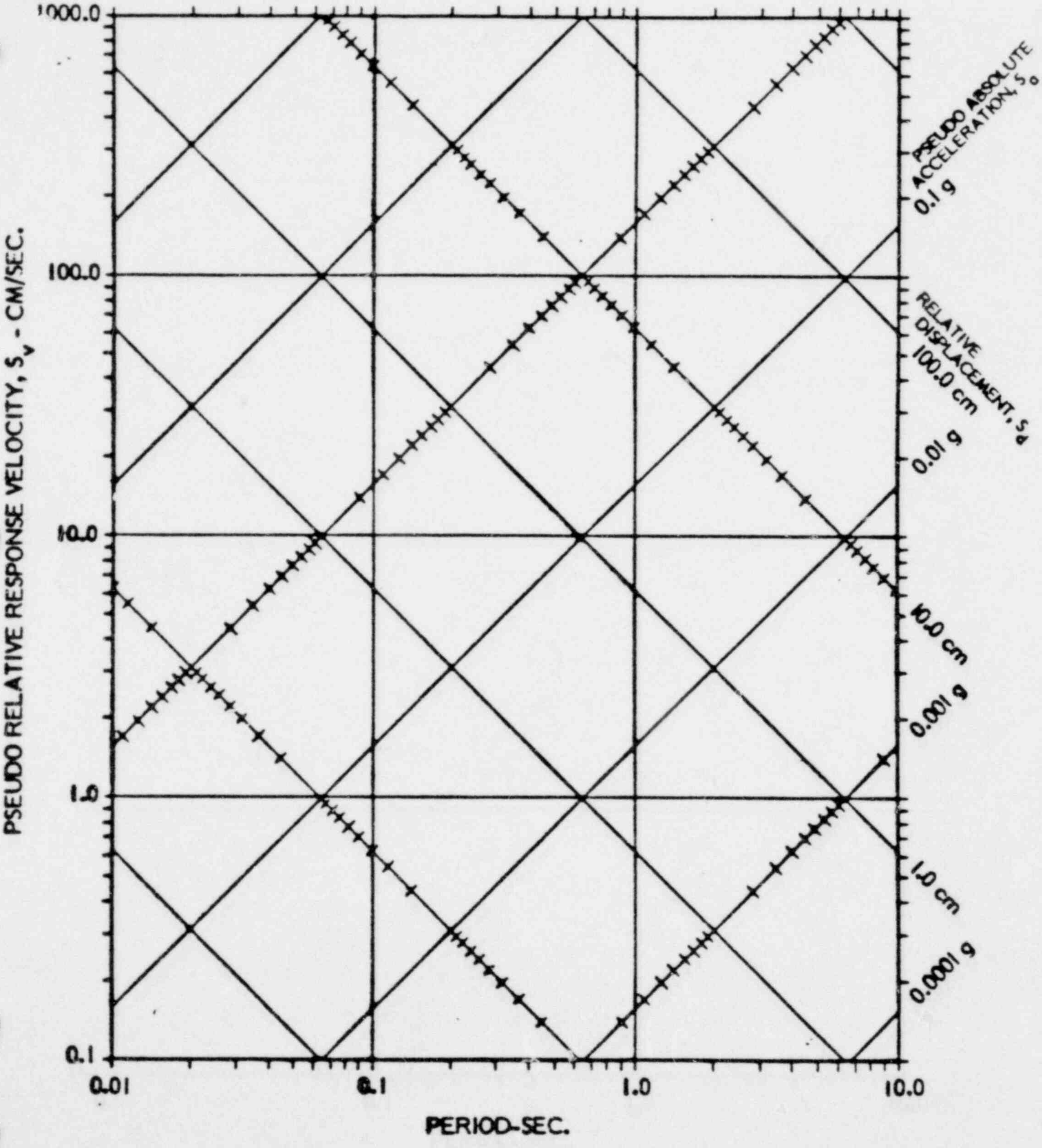
DAMPING = 5.0

06/03/80

ALL SOIL M BETWEEN 5.5 AND 6.0



28 JAN 80 DAMPING = 5.0


PSEUDO RELATIVE RESPONSE VELOCITY, S_v - CM/SEC.
1000.0
100.0
10.0
1.0
0.1
0.01
0.1
1.0
10.0
PERIOD-SEC.
PSEUDO ABSOLUTE ACCELERATION, S_a
0.1 g
RELATIVE DISPLACEMENT, S_d
100.0 cm
0.01 g
10.0 cm
0.001 g
1.0 cm
0.0001 g

The entire program was designed to formally incorporate only the expert judgement in order that each expert's opinions be accurately reflected in the results.

Because of schedule and budget constraints, certain input was developed by the project team. We have tested the results to the sensitivity of these judgements and quantified their effects.

Background model	(±10%)
"a" value in seismicity models	(±5%)
attenuation dispersion	(±20%)

The SSSP has resulted in several important findings:

- That the attenuation model, particularly the uncertainty component, is the most sensitive parameter.
- That the range of results determined in this program are not much greater than would be empirically predicted at WUS sites.
- That diversity of an experts judgements often tend to self-cancel.

STAFF PRESENTATION TO ACRS SUBCOMMITTEE ON EXTREME EXTERNAL PHENOMENA REGARDING SEISMOLOGICAL ISSUES AND APPLICATION OF SITE SPECIFIC SPECTRA PROJECT

JUNE 4, 1980

SUMMARY OF INITIAL RECOMMENDATIONS - SITE SPECIFIC SPECTRA FOR USE IN SEP

- TERA-LLL Uniform Hazard Spectra
  - "1000 year" Synthesis
  - Ossippee Attenuation - Northeastern sites
  - GUPTA-NUTTLI Attenuation - Central U. S. sites
- Minimum Floor for all Spectra
  - Median representation of nearby magnitude 5.3
  - "1000"year" spectra fall below minimum - Palisades, LaCrosse, Big Rock Point
- Specific site amplification conditions (soil column impedance contrast) not fully assessed at LaCrosse, Yankee Rowe and Palisades.

ITEMS REVIEWED BY NRC STAFF

- Draft Seismic Analysis - TERA-LLL, 3 vol. August 1979
- Peer Review Comments (Fall-Winter 1979)
  - LLL Review Team (Sykes, Nuttli, Ang, Veneziano
  - Licensee Review (Blume, Fugro, Commonwealth Edison, Holt, Cornell)
  - NRC - Applied Statistics (Abramson)
- TERA - Response to Review (March 1980)
- Sensitivity Results - TERA-LLL (March 1980)
- Attentuation Panel (Feb. 1980) and Comments on Panel (Nuttli, Trifunac, McGuire, Donovan)
- TERA Evaluation of Panel (April 1980)

ITEMS FORTHCOMING IN REVIEW

- Review and Comments by Newmark and Hall (May 1980)
- Review of Draft Seismic Analysis by USGS (May 1980)
- Review of all Licensee Submittals (Fall 1980)
- Comparison of SSSP with Other Hazard Analyses (TERA - May 1980)
- LLL Report on Attenuation Recommendations (May 1980)
- Feedback Meeting with Original Expert Group (June 1980)
- TERA-LLL Recommendations and Possible Reanalyses (Fall 1980)

DIFFERENCES IN APPROACHES

O DETERMINISTIC

- Input parameters (seismic source zones, attenuation etc.) chosen as single values
  - Output single value
- Advantages:
  - Straightforward
- Disadvantages:
  - No description of uncertainty
  - No explicit use of earthquake frequency
  - Very sensitive to simple changes in technique (adoption of Trifunac-Brady, Reg. Guide 1.60)
- Yields different levels of risk from site to site

O PROBABILISTIC

- Input parameters used with individual, statistical and exp[illegible] uncertainty
  - Out[illegible] - Range of values with chances of exceedence
- Advantages:
  - Results can be used in relative or absolute sense
  - Relatively insensitive to certain changes
  - Reflect uncertainty
  - Explicit tracking of important parameters
- Disadvantages:
  - Cumbersome
  - Controversial
  - Difficulty in choosing correct model
  - Limited data bases

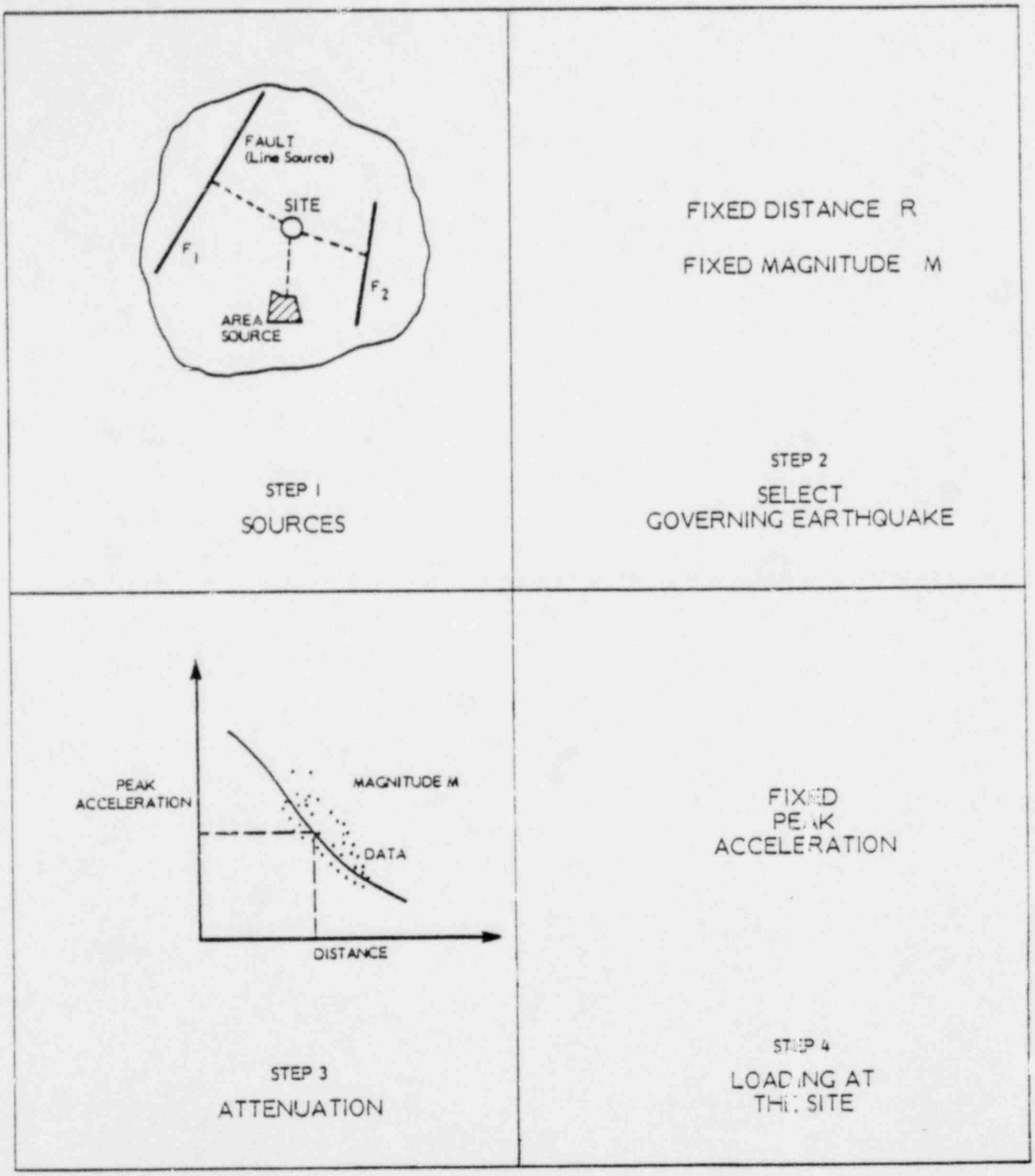


FIGURE 1

DETERMINISTIC APPROACH
TO LOADING AT THE SITE

TERA CORPORATION

Dec. 8, 1978

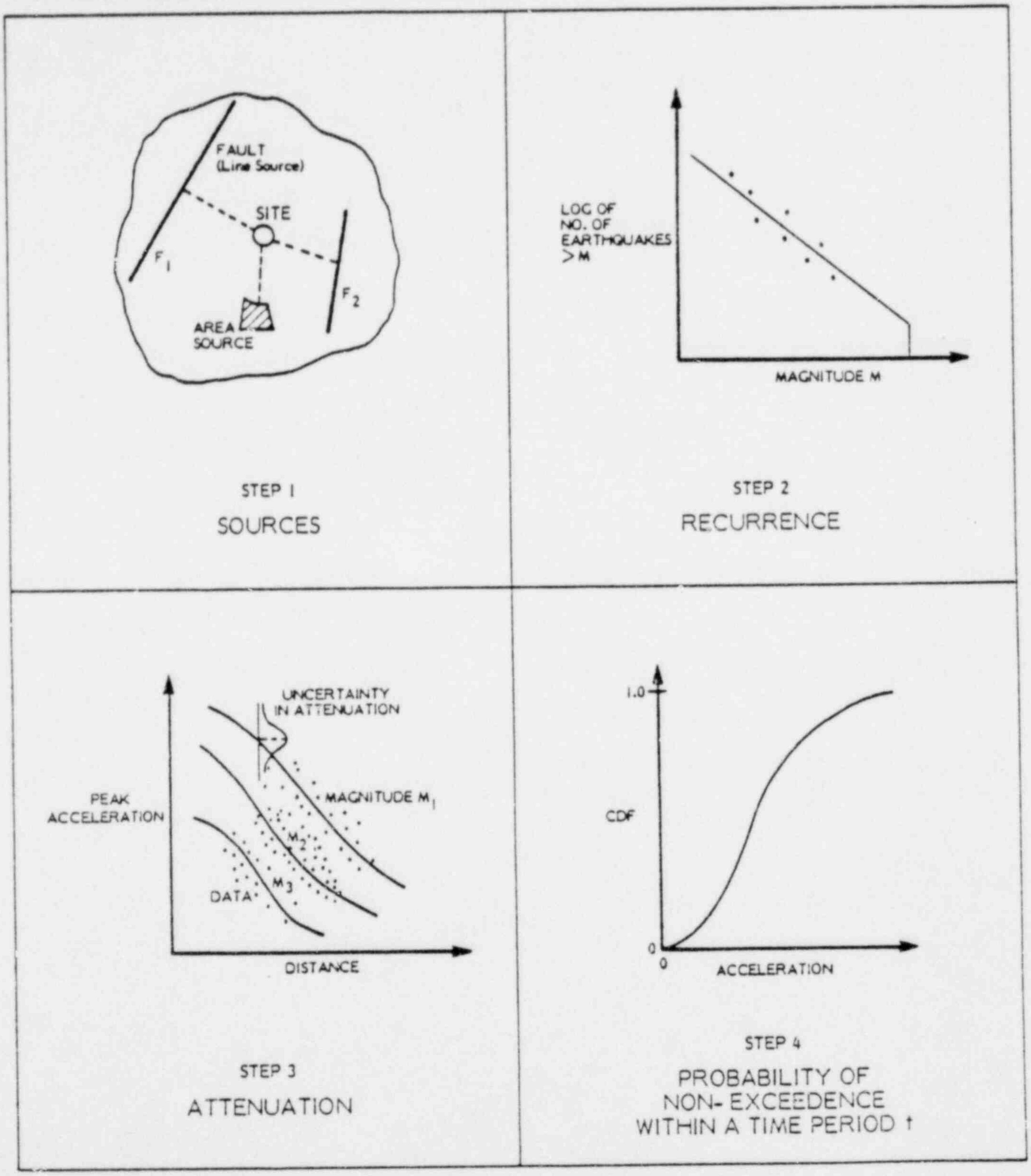


FIGURE 2

CURRENT APPROACH TO HAZARD MAPPING FOR PEAK VALUES

PROBLEMS IDENTIFIED IN REVIEW AND STAFF RESOLUTION

- GROUND MOTION ATTENUATION AND DETERMINATION
  - Problem: Insufficient expert input
  - Resolution: Separate attenuation panel (TERA-LLL)
    : Regional attenuation models (Ossippee and Gupta-Nuttli)

- ZONATION
  - Problem: Difficult to reflect experts confidence in source zones in earthquake occurrence
  - Resolution: Use spectra intermediate between extreme assumptions (background and no background)

- DISPERSION OF DATA
  - Problem: How to define scatter without appropriate data set in East
  - Resolution: Assume scatter similar to scatter of data in West
    $\ln\sigma = 0.7, \pm 3\sigma$

- SYNTHESIS OF EXPERTS RESULTS
  - Problem: Alternate method of synthesizing results
  - Resolution: TERA estimate - no significant difference

INTEGRATION OF RECOMMENDATIONS

- EVALUATE SENSITIVITY OF RESULTS TO ZONATION AND DATA DISPERSION CHANGES

- CONCLUSION - NO BACKGROUND $\sigma = 0.9, \pm 2\sigma$

  $\approx$ INTERMEDIATE BACKGROUND $\sigma = 0.7, \pm 3\sigma$

SEP SITE SPECIFIC SPECTRA PROJECT

- CONSERVATISMS
  - Strong motion data set bias toward higher values
  - Randomness in source zone
  - Possible simultaneous events in different zones
  - Conservative part of uncertainty dominates
  - Large earthquakes attenuate faster than small earthquakes

- NONCONSERVATISMS
  - Mixing true free field and basement strong motion records
  - Spectra - really more than one chance of being exceeded in return period

CONCLUSIONS

- Conservatisms more significant than unconservatisms
- "1000 year" spectra reflect longer return periods
- Implicit acceptance in past of earthquake hazard on order of 1000 or 10,000 year return period
- Recommended spectra fit within this description
- Spectra represent equivalent hazard from site to site

DETERMINISTIC TECHNIQUES FOR COMPARISON

- Assume - Seismic zoning from staff practice
- Use largest historical earthquakes
- Predict peak accelerations and velocities from average of appropriate theoretical and empirical relationships
- Convert to response spectra using NUREG CR-0098 by Newmark and Hall

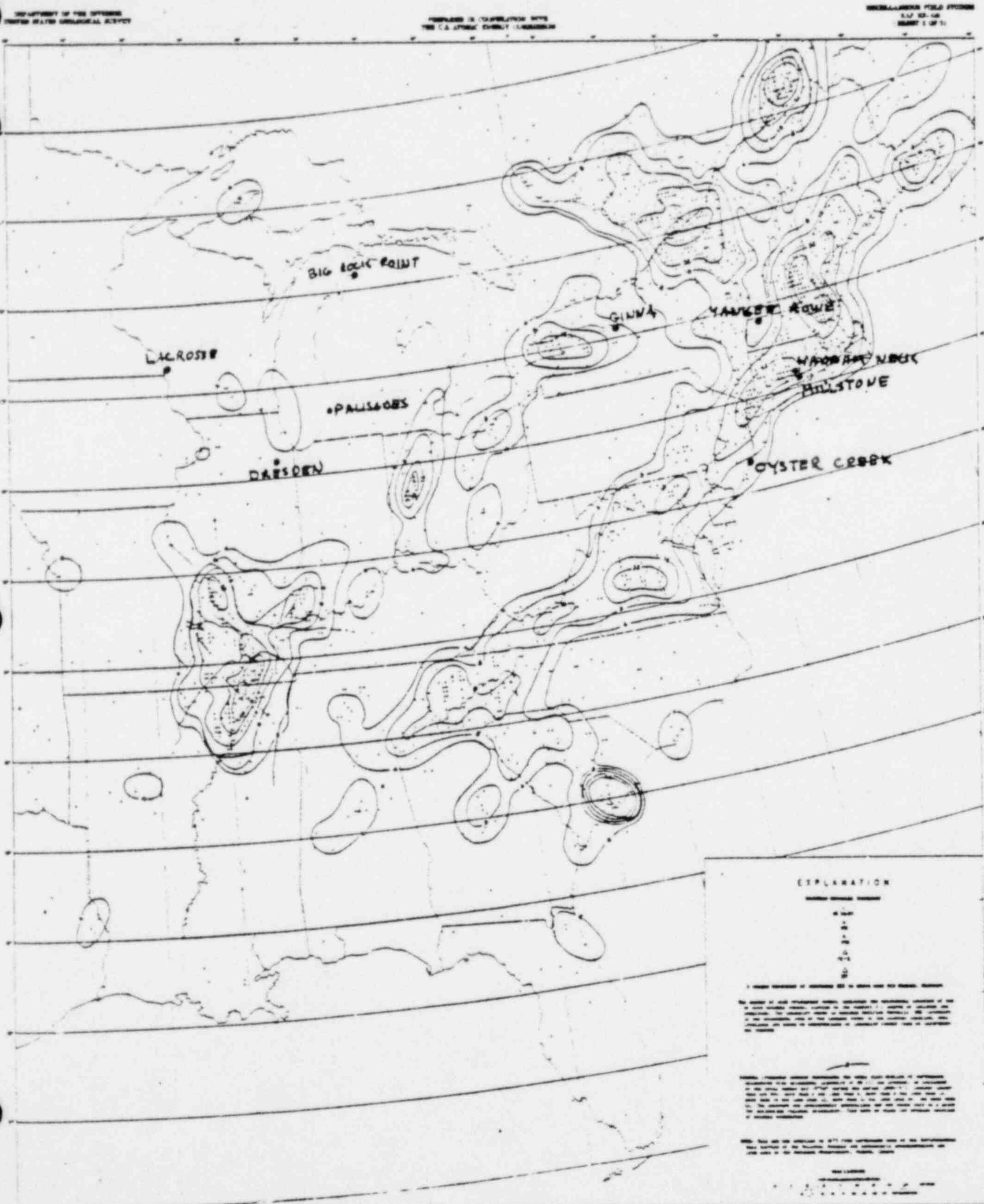
COMPARISON OF PEAK ACCELERATIONS
(cm/sec^2)

SITE	"1000 yr."	DETERMINISTIC
YANKEE ROWE	195	123
HADDAM NECK	202	123
MILLSTONE	184	123
OYSTER CREEK	161	123
GINNA	169	132
DRESDEN	124	132
PALISADES	102	132
LACROSSE	91	132
BIG ROCK POINT	81	132

COMPARISON OF PEAK VELOCITIES

(cm/sec)

SITE	"1000 yr."	DETERMINISTIC
YANKEE ROWE	22	11
HADDAM NECK	20	9
MILLSTONE	18	9
OYSTER CREEK	18	9
GINNA	17	10
DRESDEN	16	20
PALISADES	15	12
LACROSSE	14	9
BIG ROCK POINT	11	9



B. EARTHQUAKE EPICENTERS, [illegible]-1972

SEISMOTECTONIC MAP OF THE EASTERN UNITED STATES

By

Jarvis B. Hadley and James F. Devine

1974

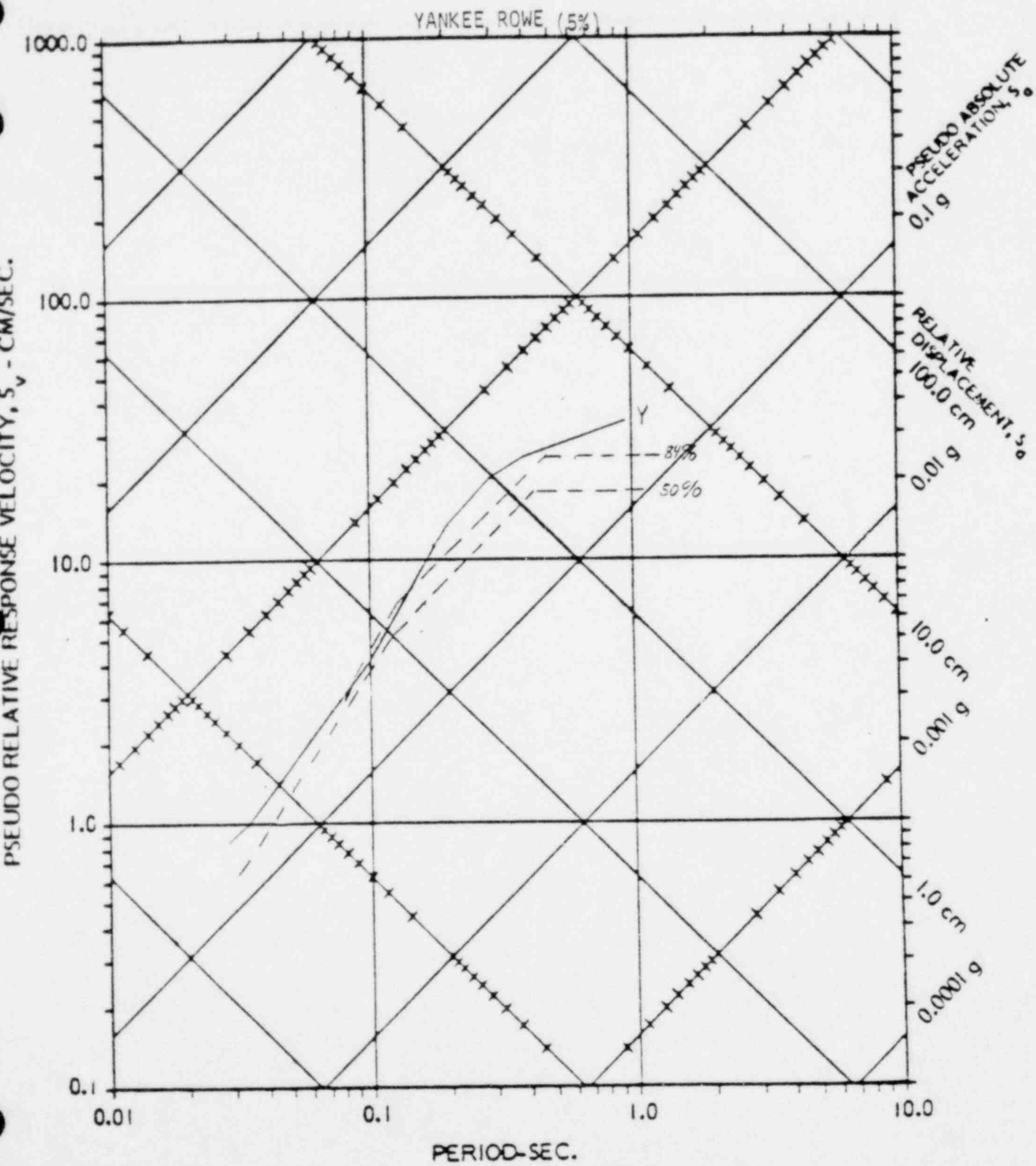
● SEP PLANTS

COMPARISON OF PEAKS

- "1000 year" generally more conservative than deterministic

- "1000 year" reflect real differences in seismicity and perceived hazard

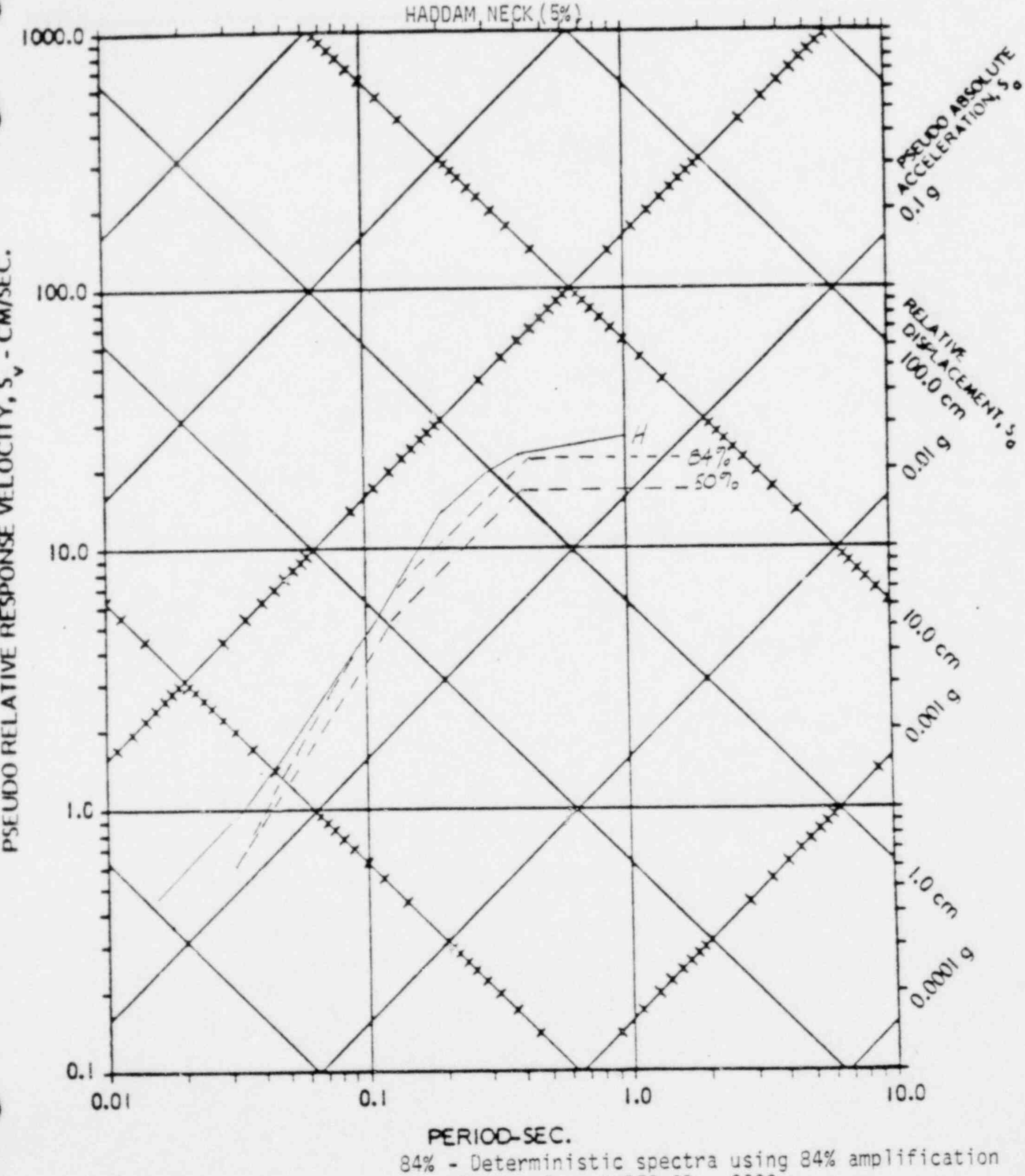
- Example of difference in approaches - Connecticut Yankee vs Big Rock Point



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.

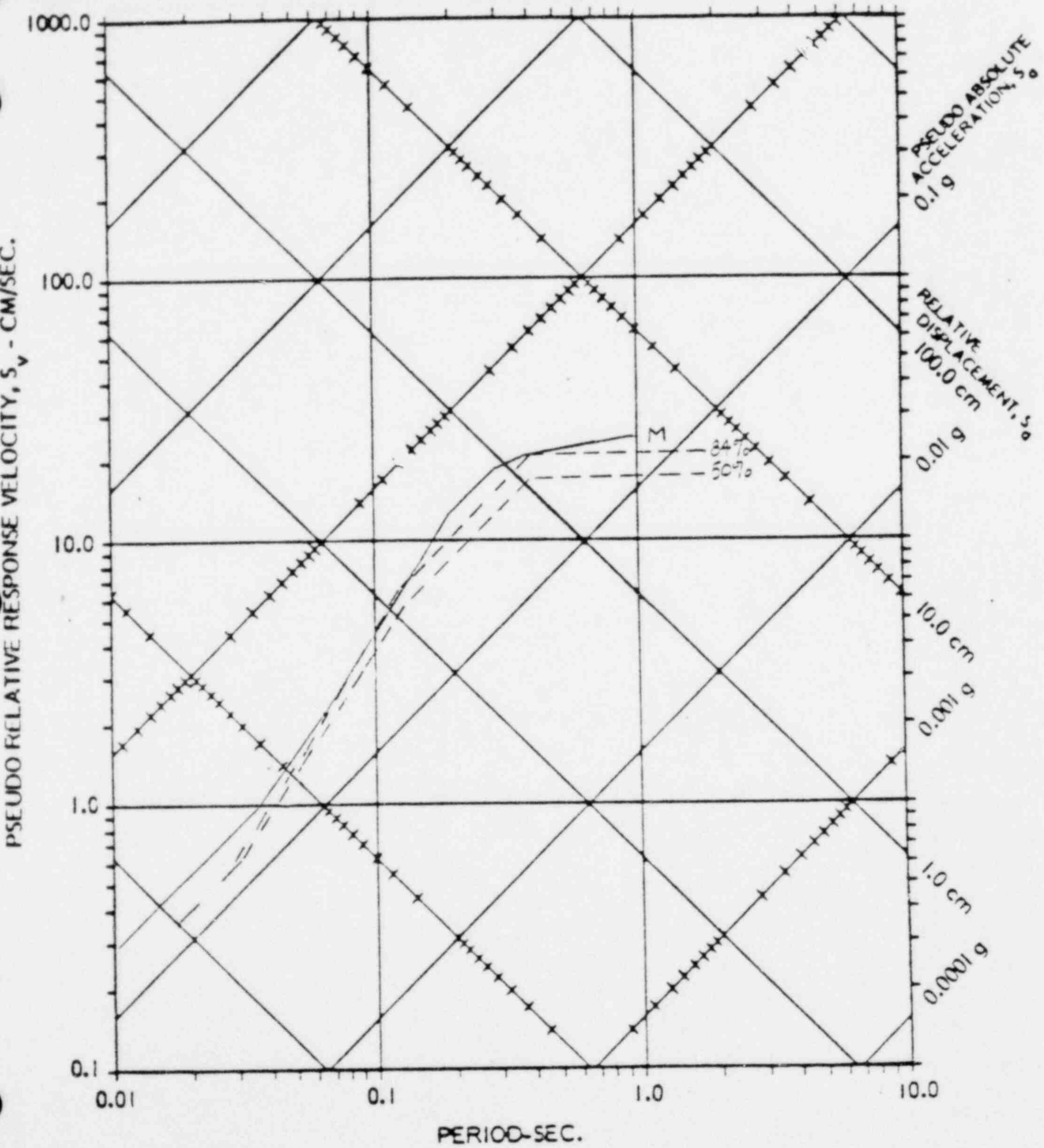


84% - Deterministic spectra using 84% amplification factor from NUREG CR - 0098.

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

H - Recommended probabilistic spectra.

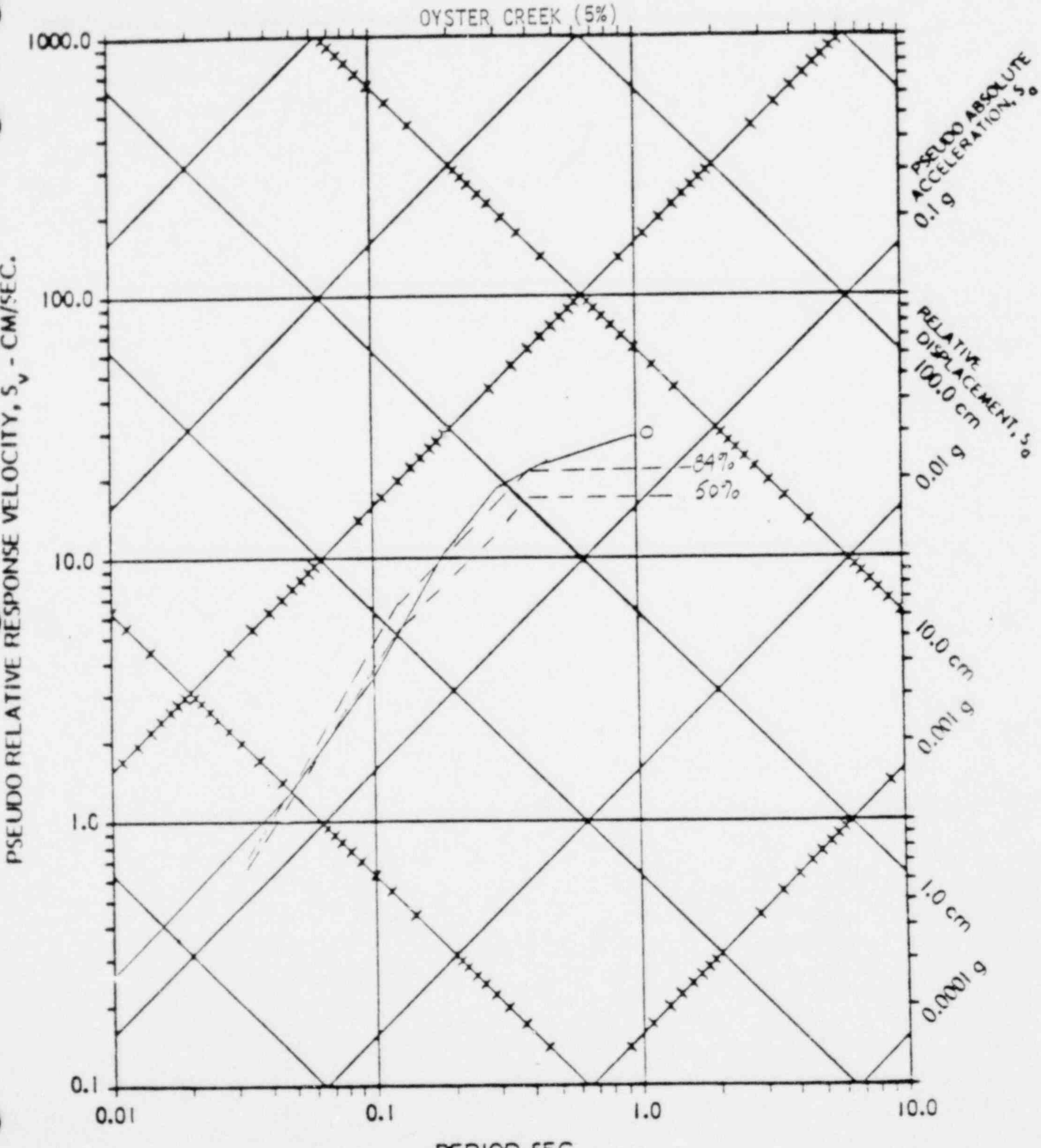
MILLSTONE (5%)



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

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

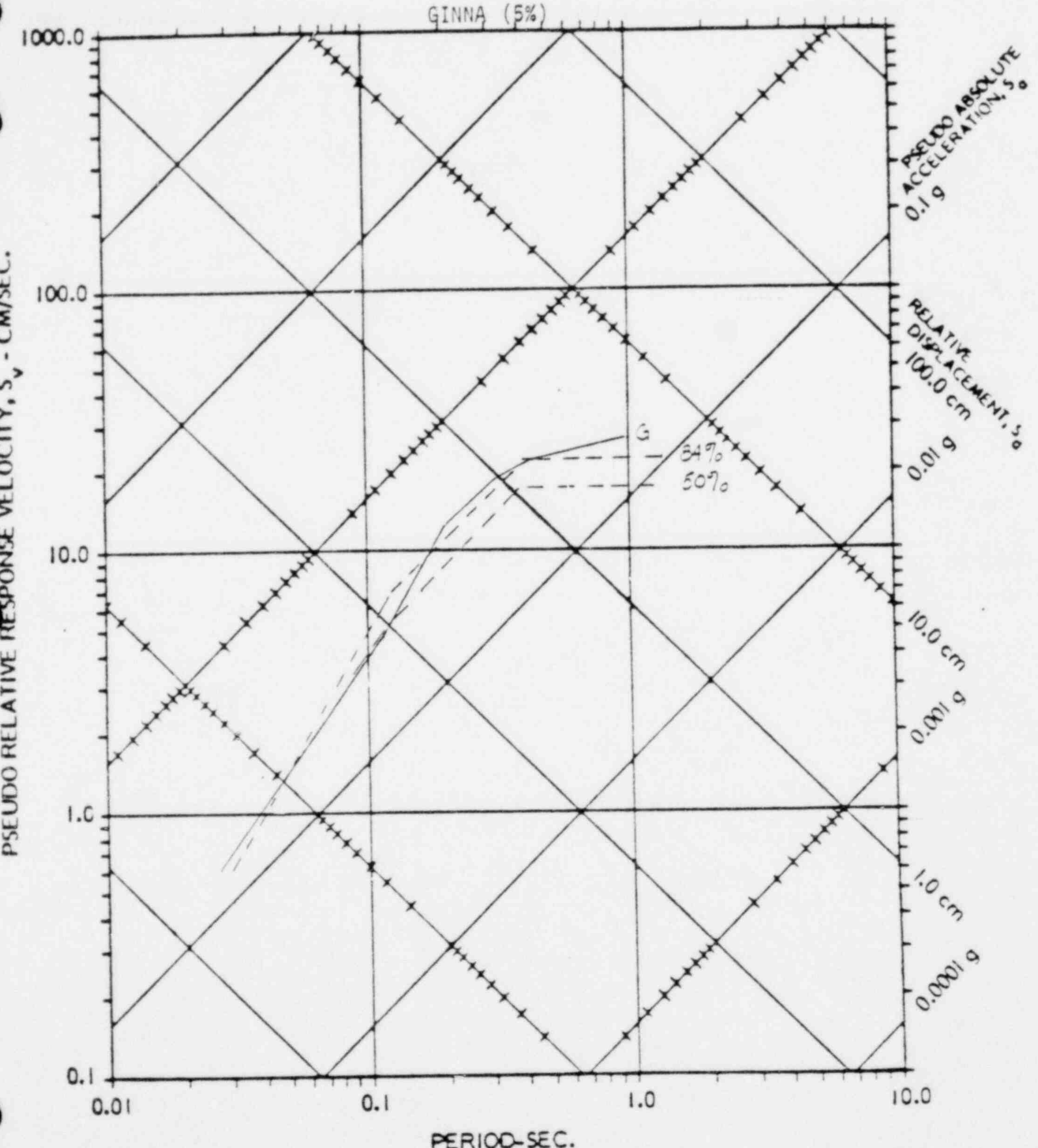
M - Recommended probabilistic spectra.



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

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

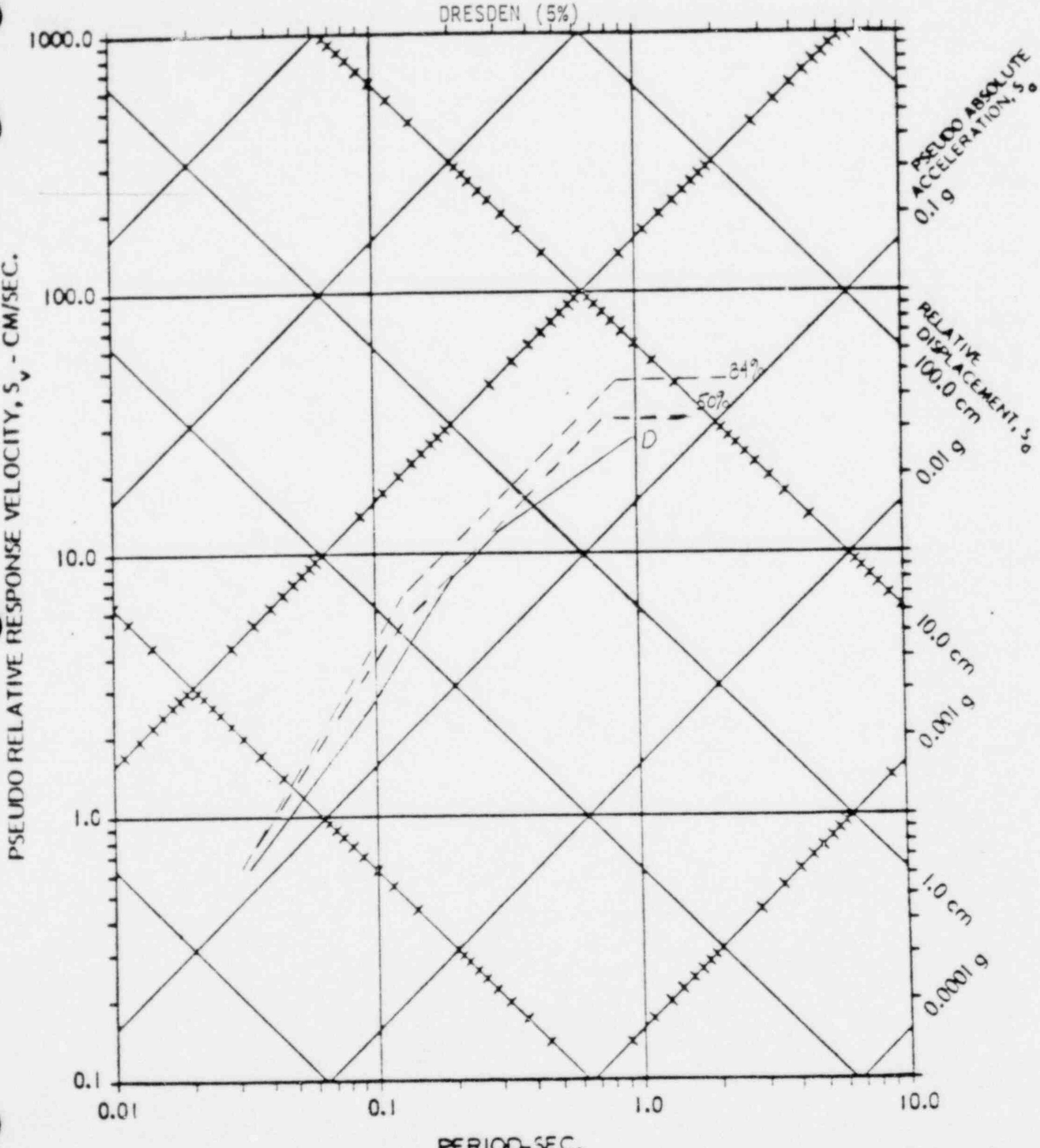
O - Recommended probabilistic spectra.



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

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

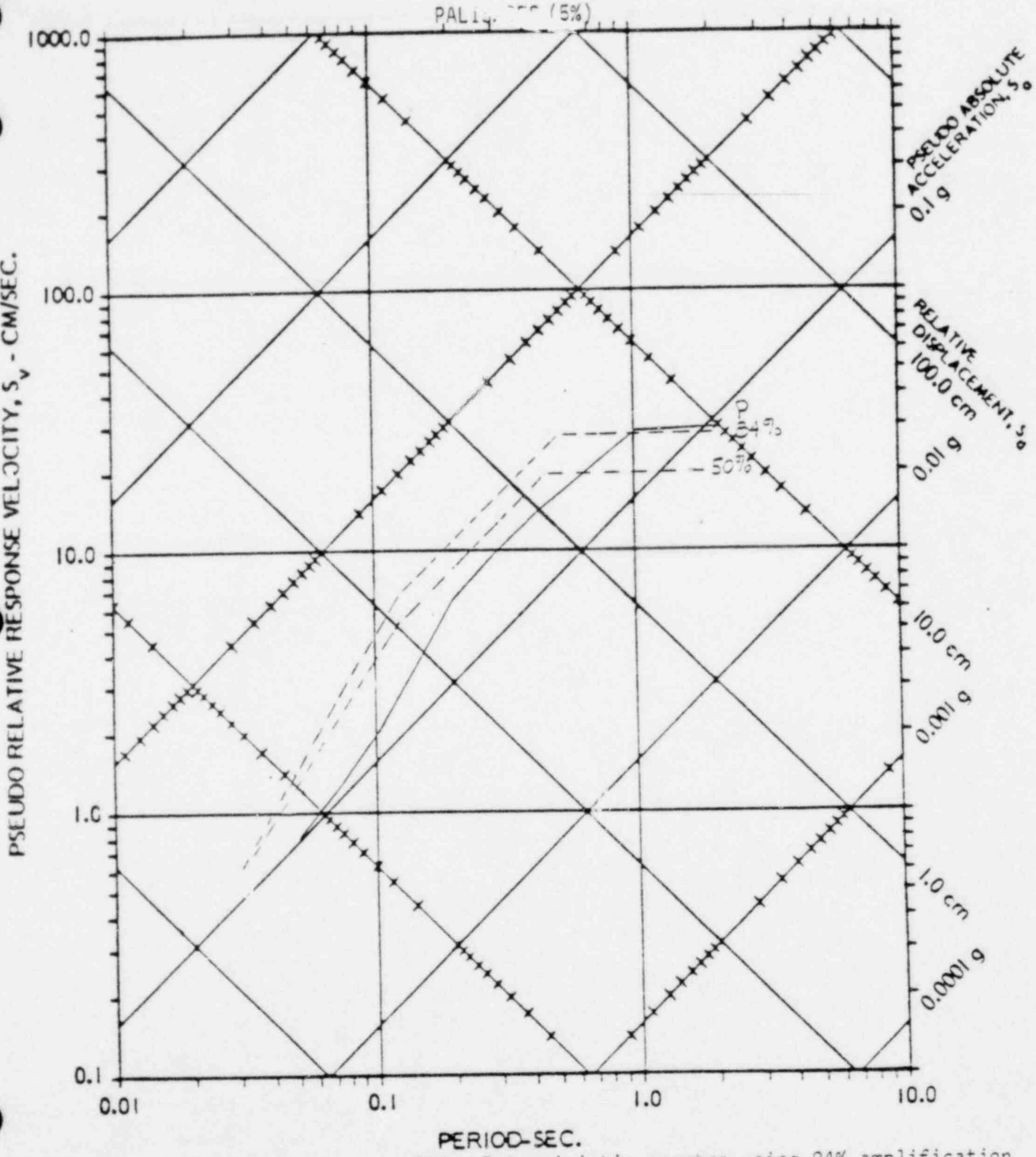
G - Recommended probabilistic spectra.



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

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

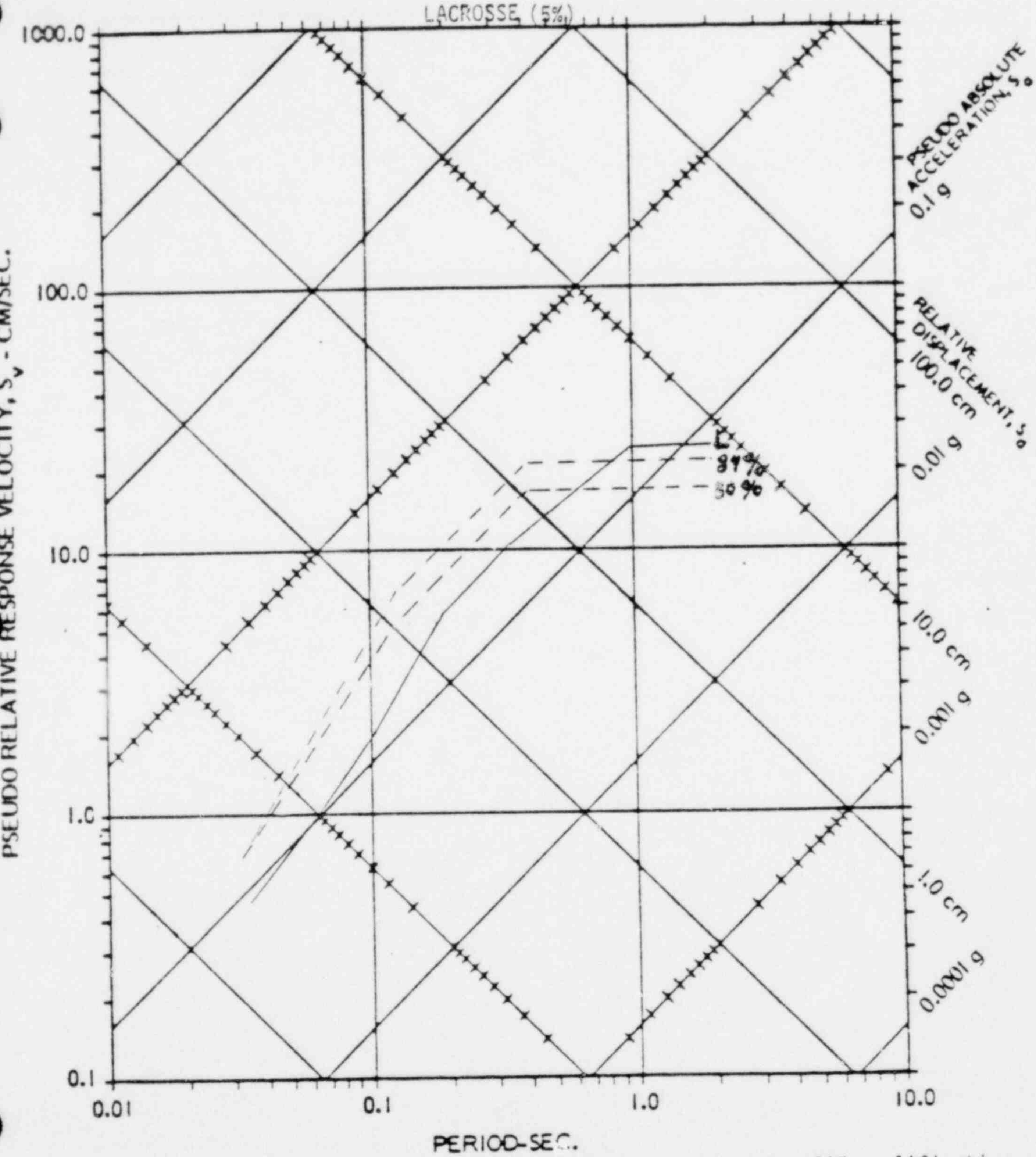
D - Recommended probabilistic spectra.



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

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

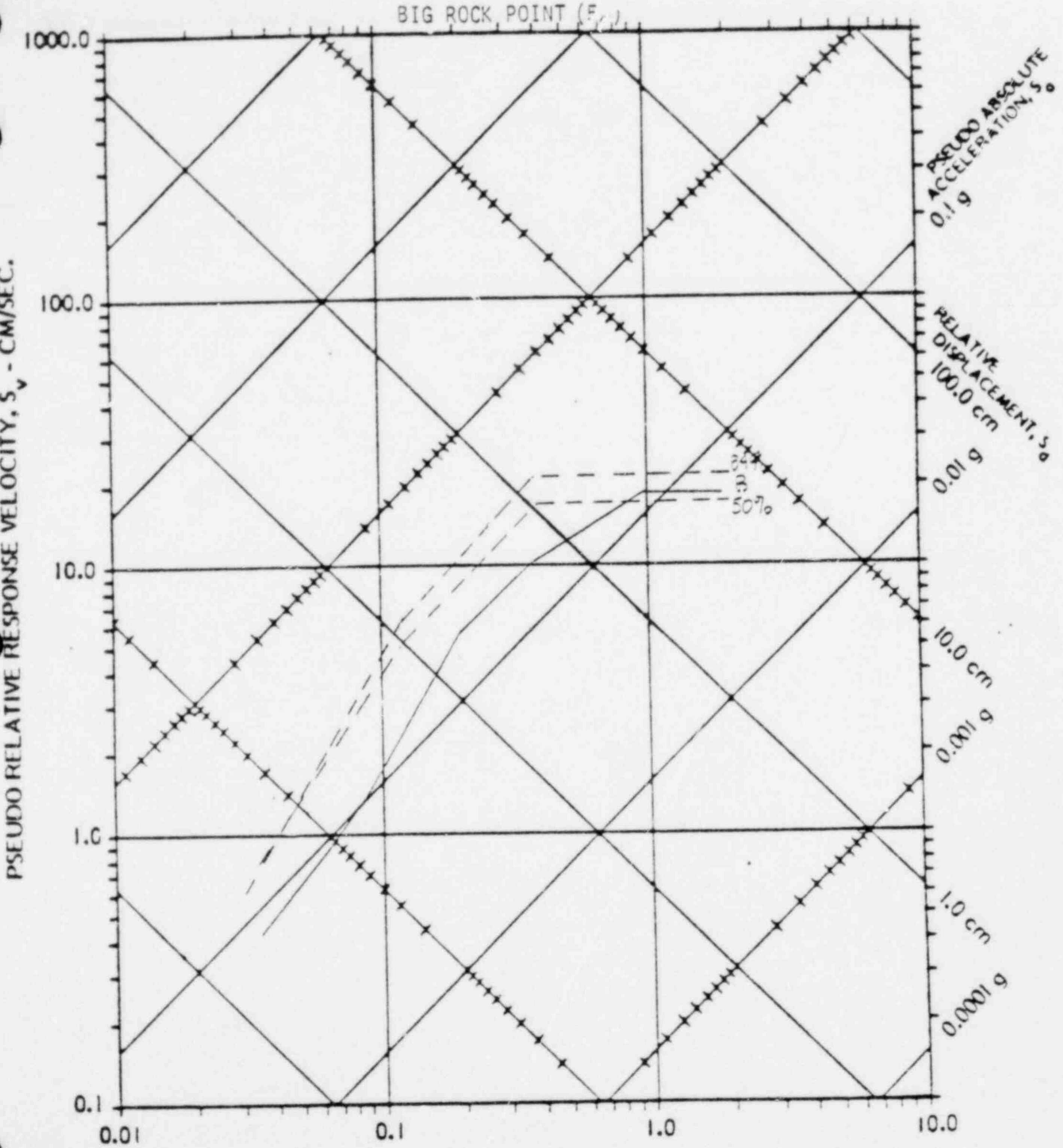
P - Recommended probabilistic spectra.



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.



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.

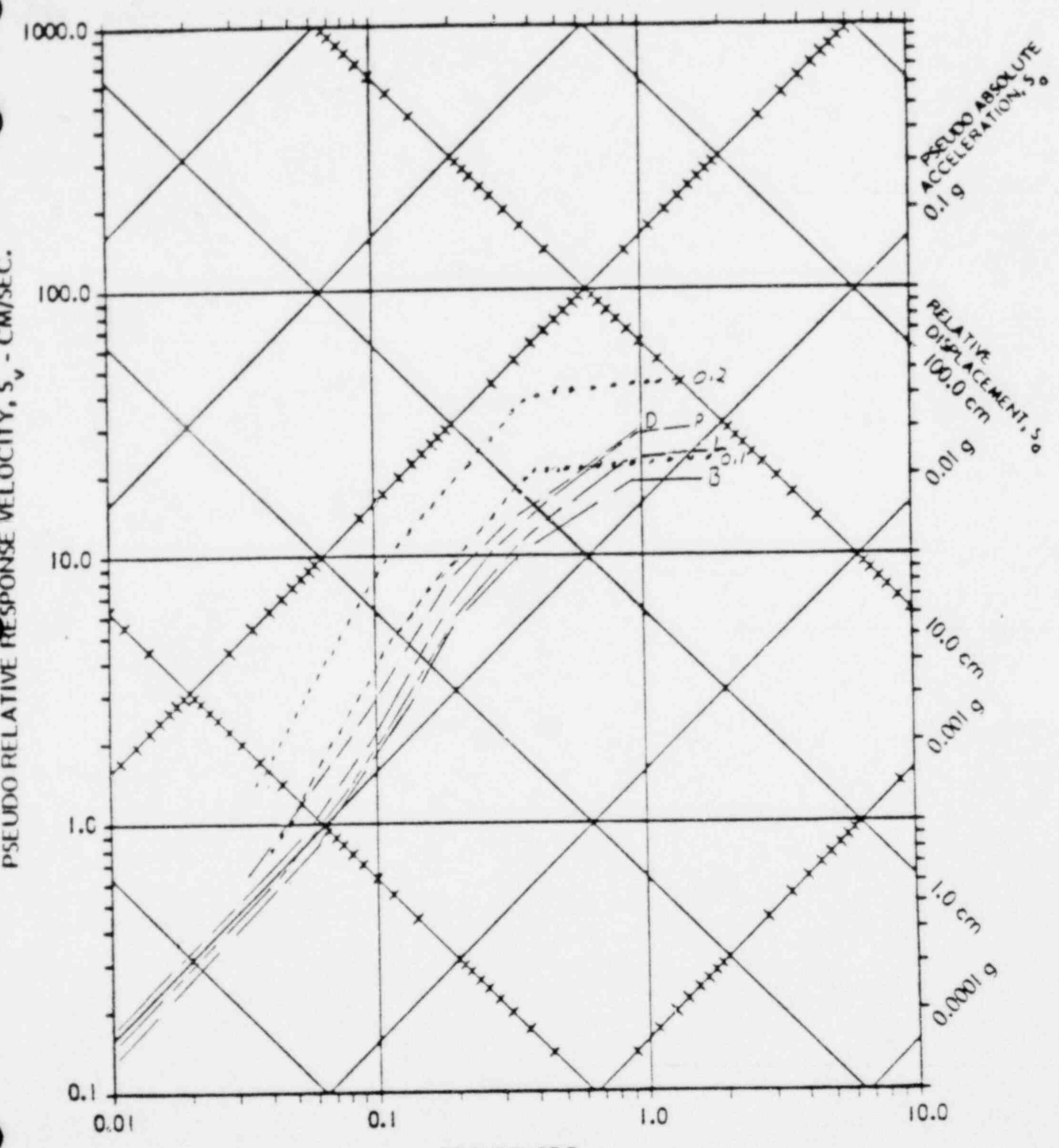
COMPARISON OF SPECTRA

- Central U. S.: "1000 year" at or below 50% deterministic

- Eastern U. S.: "1000 year" at 34% deterministic

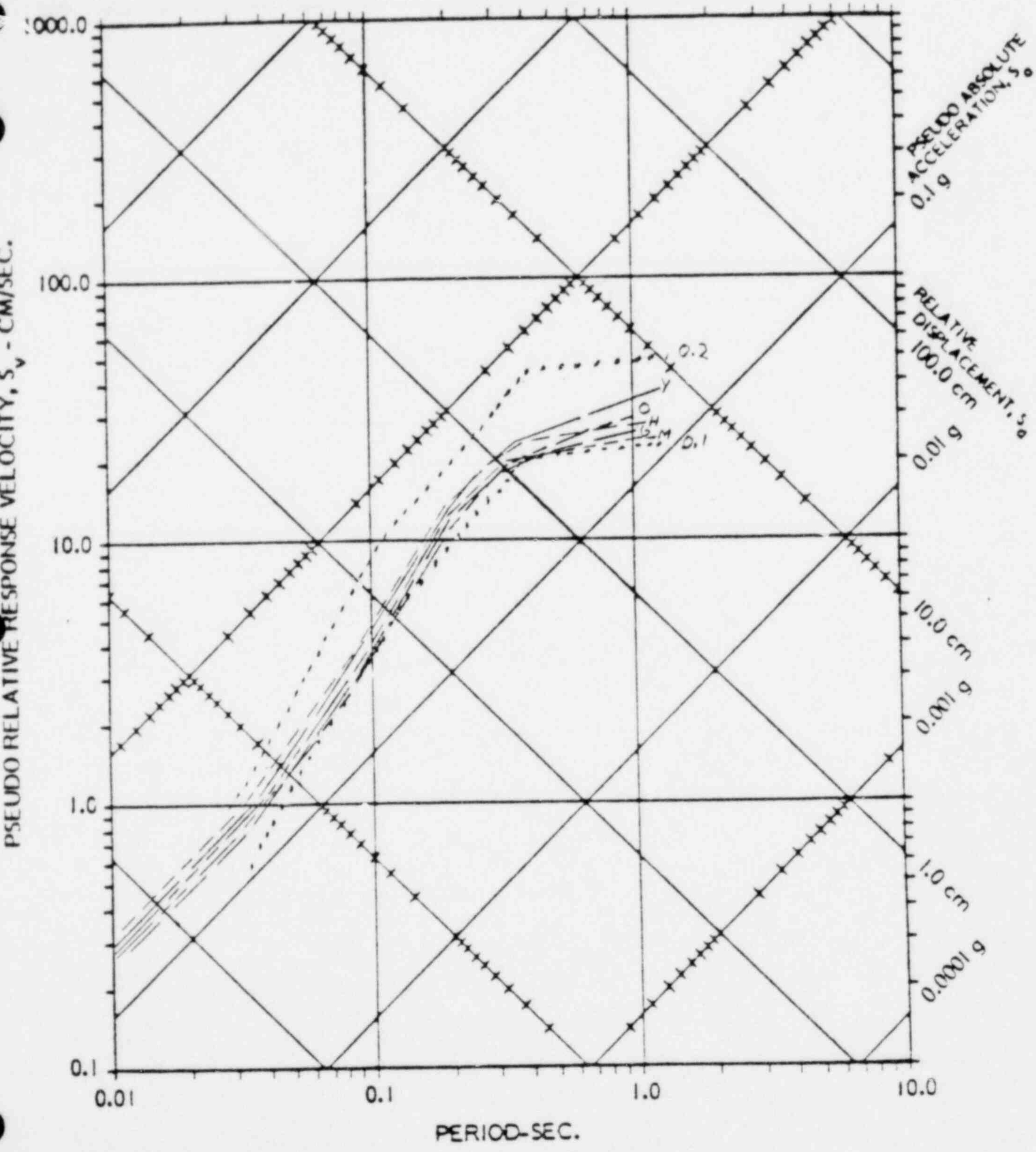
- Conservatism in deterministic approach embodied in assumed spectral amplification

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

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

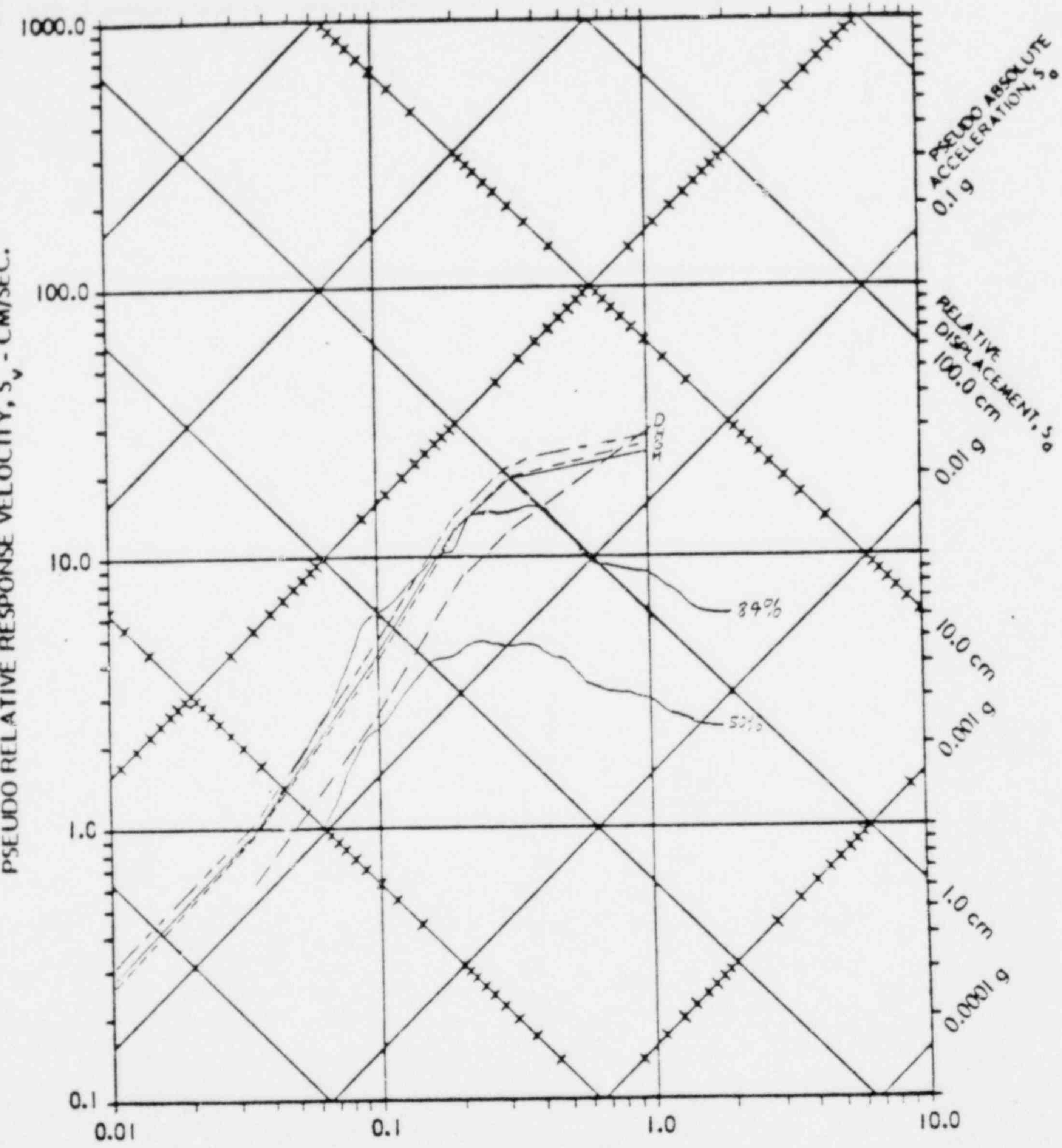
COMPARISON WITH REG. GUIDE 1.60 SPECTRA

- Central U. S.: "1000 year" spectra at or below 0.1g Reg. Guide spectra

- Eastern U. S.: "1000 year" spectra above 0.1g Reg. Guide spectra

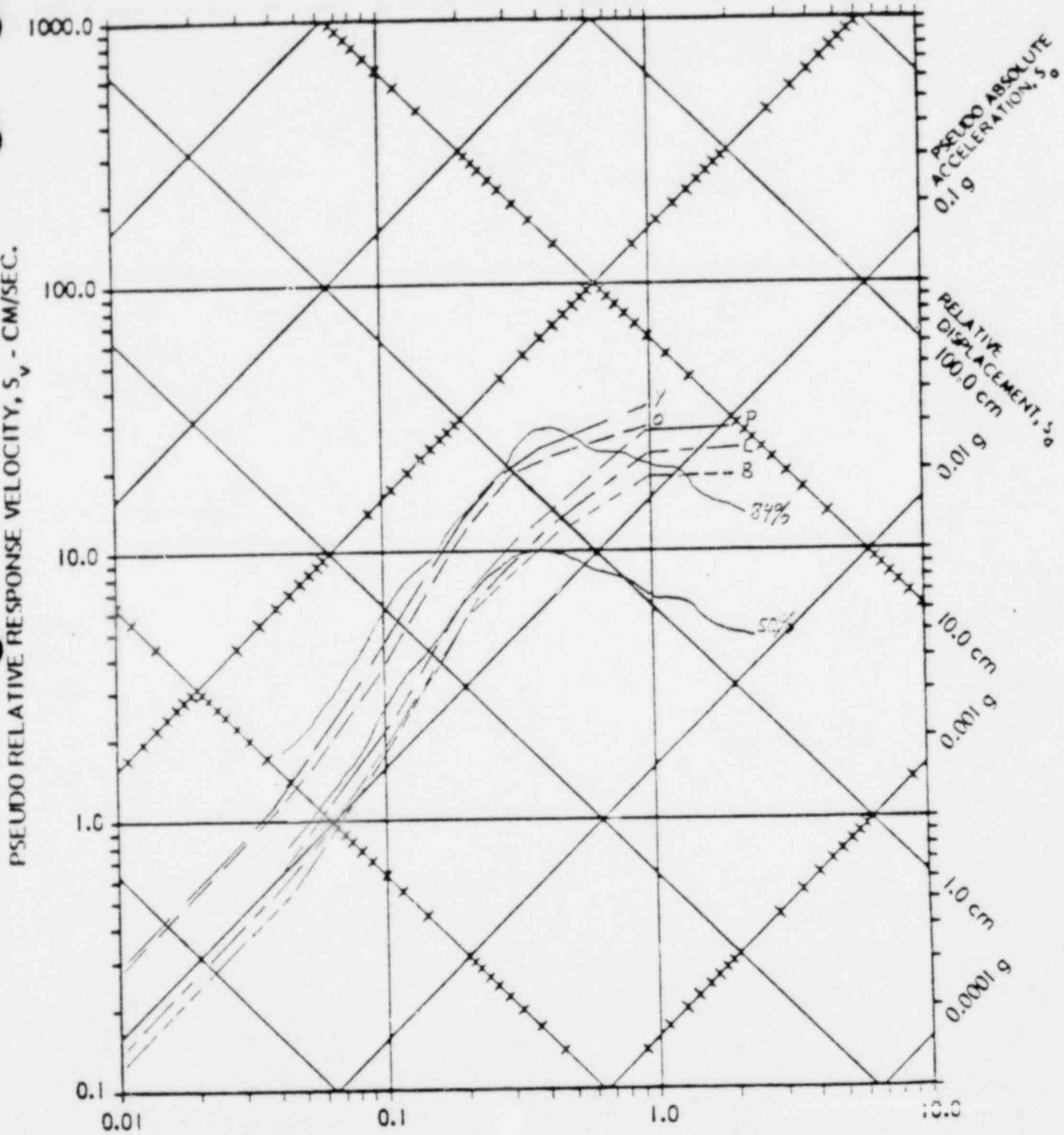
- Reg. Guide 1.60: Conservatively derived from earthquakes of different sizes, at different distances and different site conditions

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

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

COMPARISON WITH REAL SPECTRA

- Computations - 50th and 84th percentile
  - Magnitude 5.3 ± 0.5
  - Distances less than 27 km
  - Rock or soil conditions

- Results - 6 sites between 50th and 84th percentile
  - Palisades, LaCrosse, Big Rock Point less than 50th percentile

- Reasons - Michigan and Wisconsin areas of low seismicity and hazard

MINIMUM FLOOR FOR SPECTRA

- Magnitude 5.3 (intensity VII) could occur anywhere in U. S. at varying levels of certainty

- Recommendation - 50th percentile of magnitude 5.3 be mi-imum

- Impact - Small effect upon Big Rock Point, LaCrosse and Palisades

SUMMARY

IMPACT OF SSS ON SEP FACILITIES

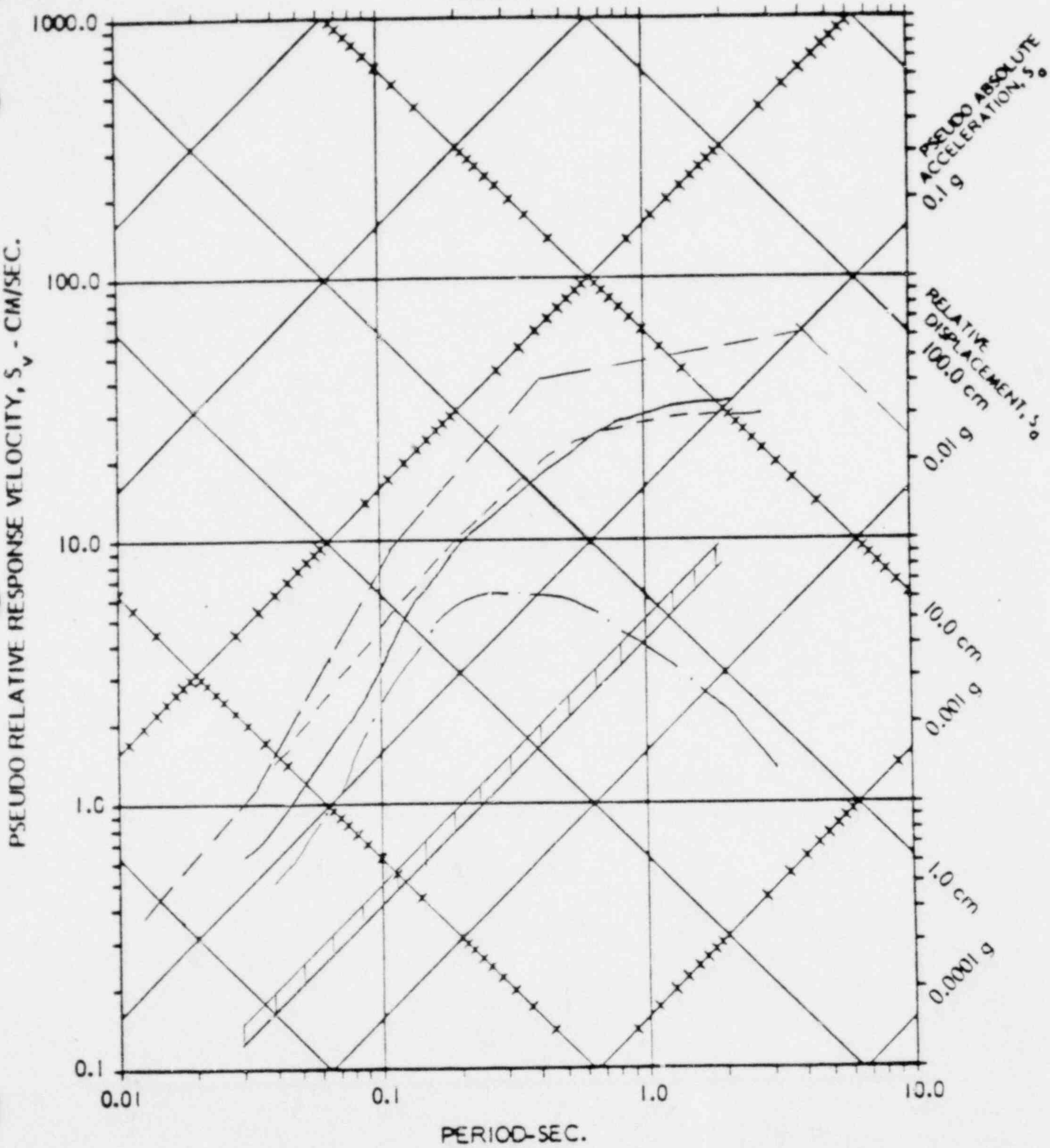
- SSS LOWER THAN FSAR SEISMIC INPUT WITH MINOR IMPACT - 3 PLANTS

- SSS HIGHER THAN FSAR SEISMIC INPUT WITH RELATIVELY MINOR IMPACT - 2 PLANTS

- SSS SIGNIFICANTLY HIGHER THAN FSAR INPUT WITH MAJOR IMPACT - 5 PLANTS

- SAN ONOFRE 1 - MAJOR IMPACT

DRESDEN 1 & 2



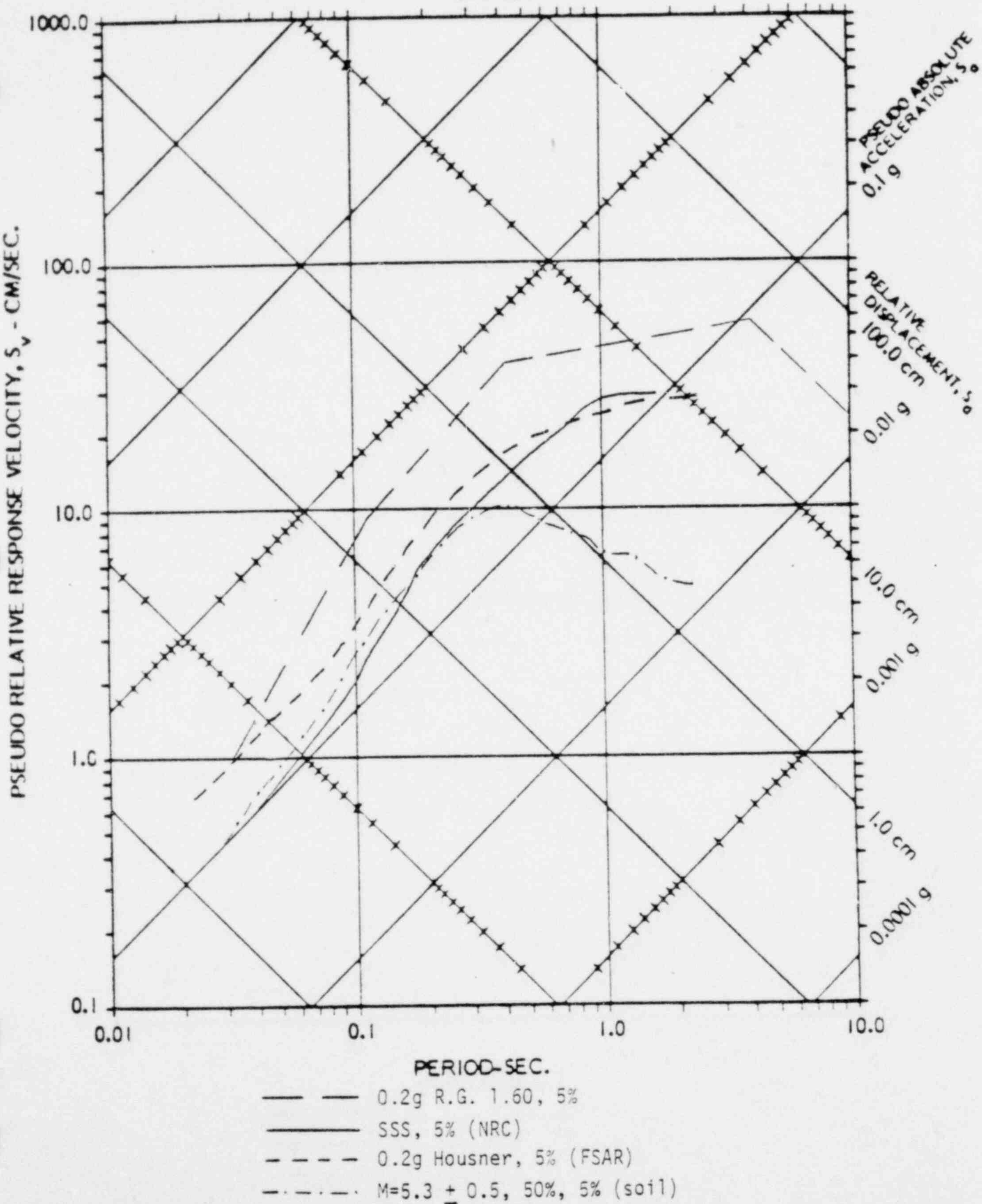
— · — 0.2g R.G. 1.60, 5%

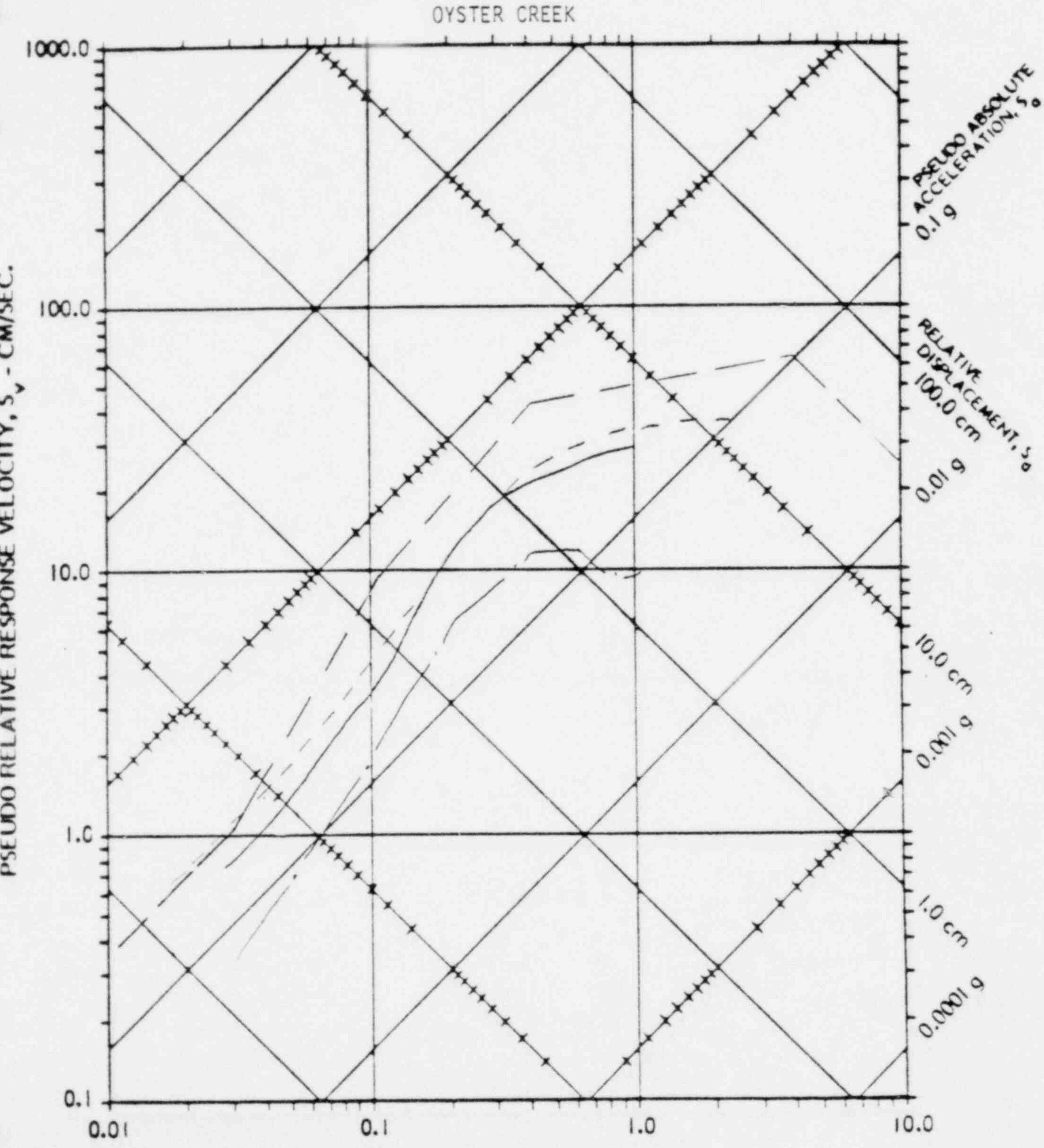
——— SSS, 5% (NRC)

– – – – 0.2g Housner, 5% (D2 FSAR), ▥ 0.025-0.03g UBC (D1 FSAR)

— · — 0.075g FUGRO SSS, 5%

PALISADES


1000.0
100.0
10.0
1.0
0.1
0.01
0.1
1.0
10.0
PSEUDO RELATIVE RESPONSE VELOCITY, S_v - CM/SEC.
PERIOD-SEC.
PSEUDO ABSOLUTE ACCELERATION, S_a
0.1 g
0.01 g
0.001 g
0.0001 g
RELATIVE DISPLACEMENT, S_d
100.0 cm
10.0 cm
1.0 cm
0.2g R.G. 1.60, 5%
SSS, 5% (NRC)
0.2g Housner, 5% (FSAR)
M=5.3 ± 0.5, 50%, 5% (soil)

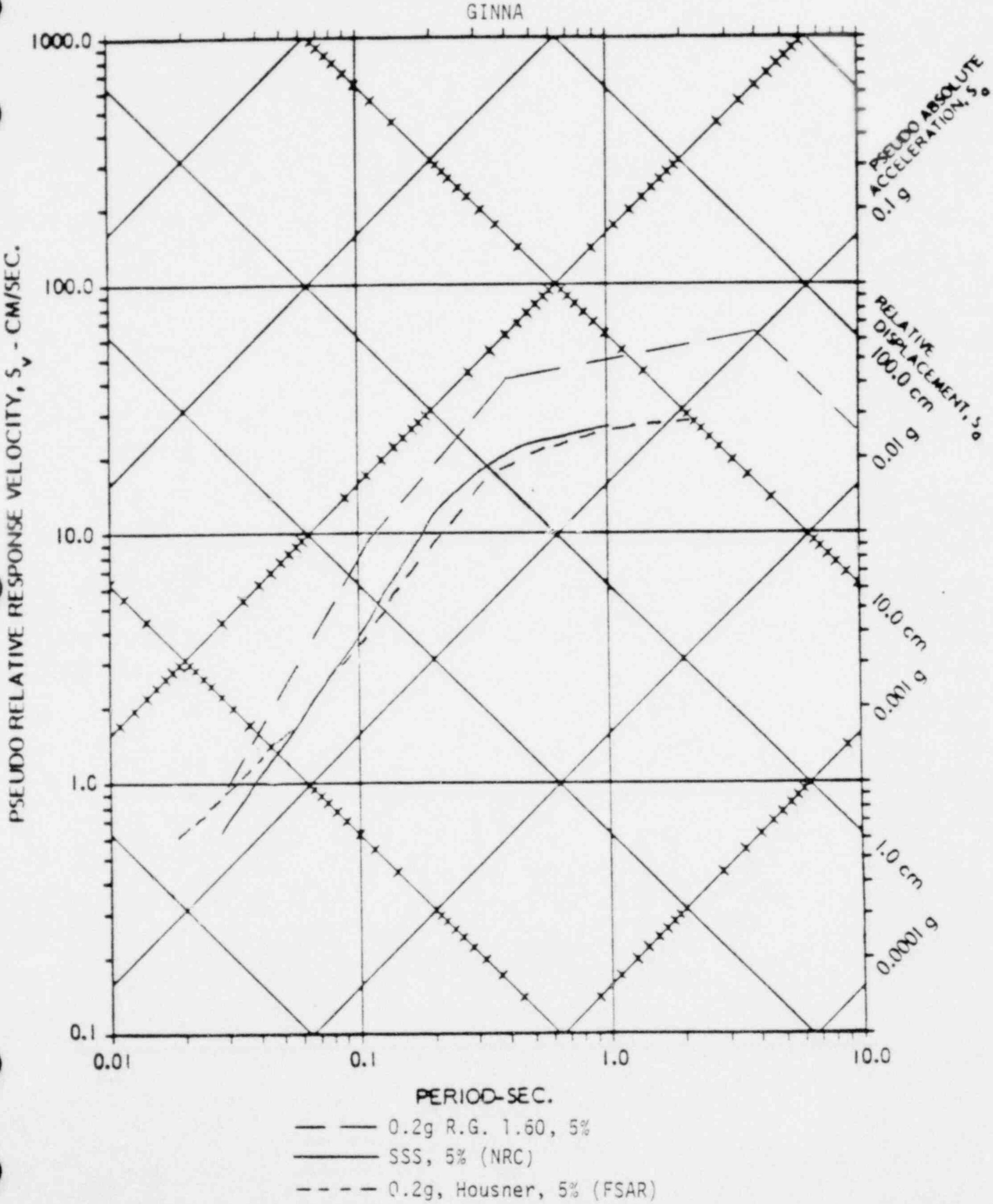


— — 0.2g R.G. 1.60, 5%

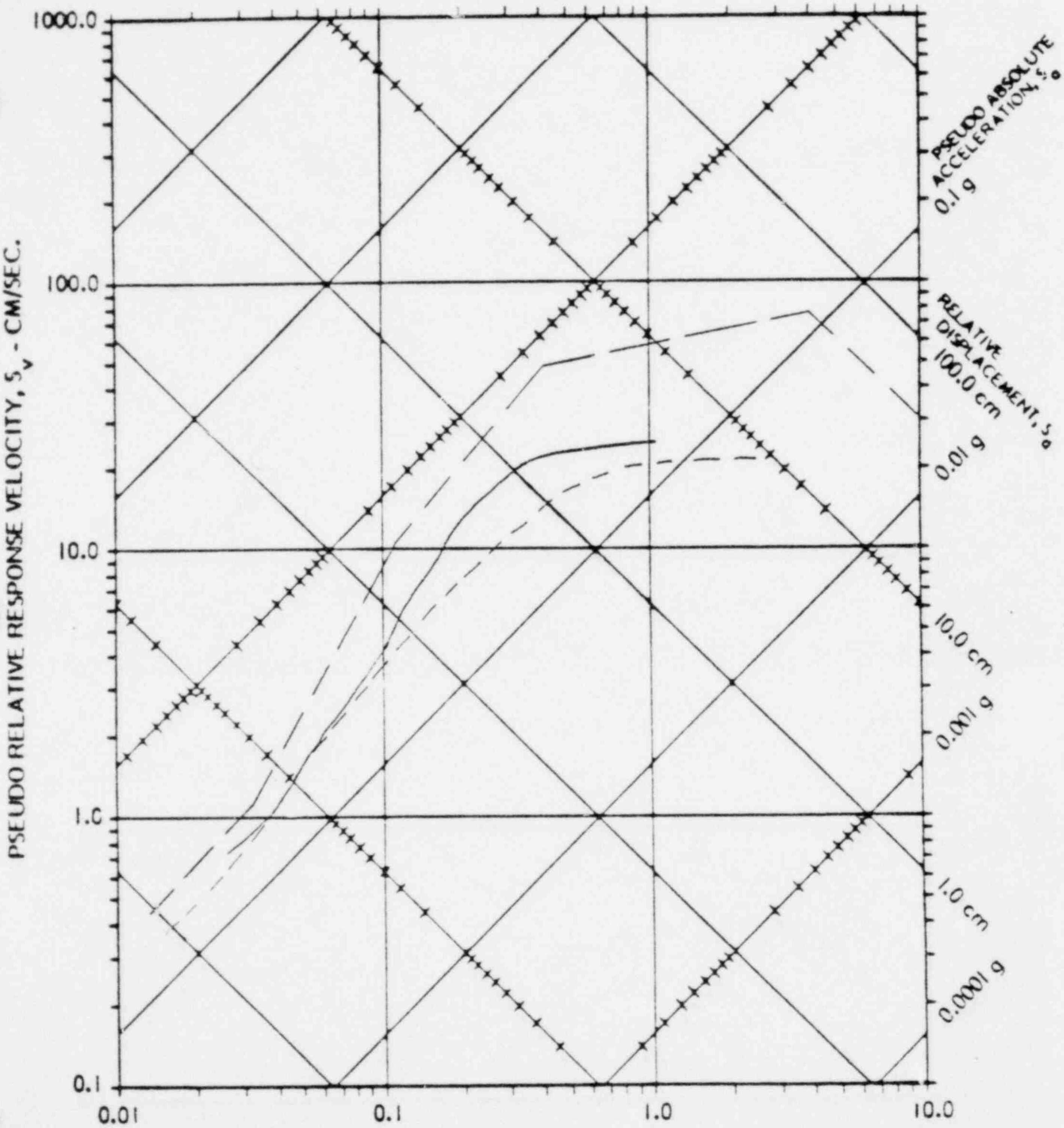
——— SSS, 5% (NRC)

– – – 0.22g, Housner, 5% (FSAR)

— · — 0.07 Blume SSS, 5%


GINNA
PSEUDO RELATIVE RESPONSE VELOCITY, S_v - CM/SEC.
1000.0
100.0
10.0
1.0
0.1
0.01
0.1
1.0
10.0
PERIOD-SEC.
PSEUDO ABSOLUTE ACCELERATION, S_a
0.1 g
0.01 g
0.001 g
0.0001 g
RELATIVE DISPLACEMENT, S_d
100.0 cm
10.0 cm
1.0 cm
0.2g R.G. 1.60, 5%
SSS, 5% (NRC)
0.2g, Housner, 5% (FSAR)

MILLSTONE 1

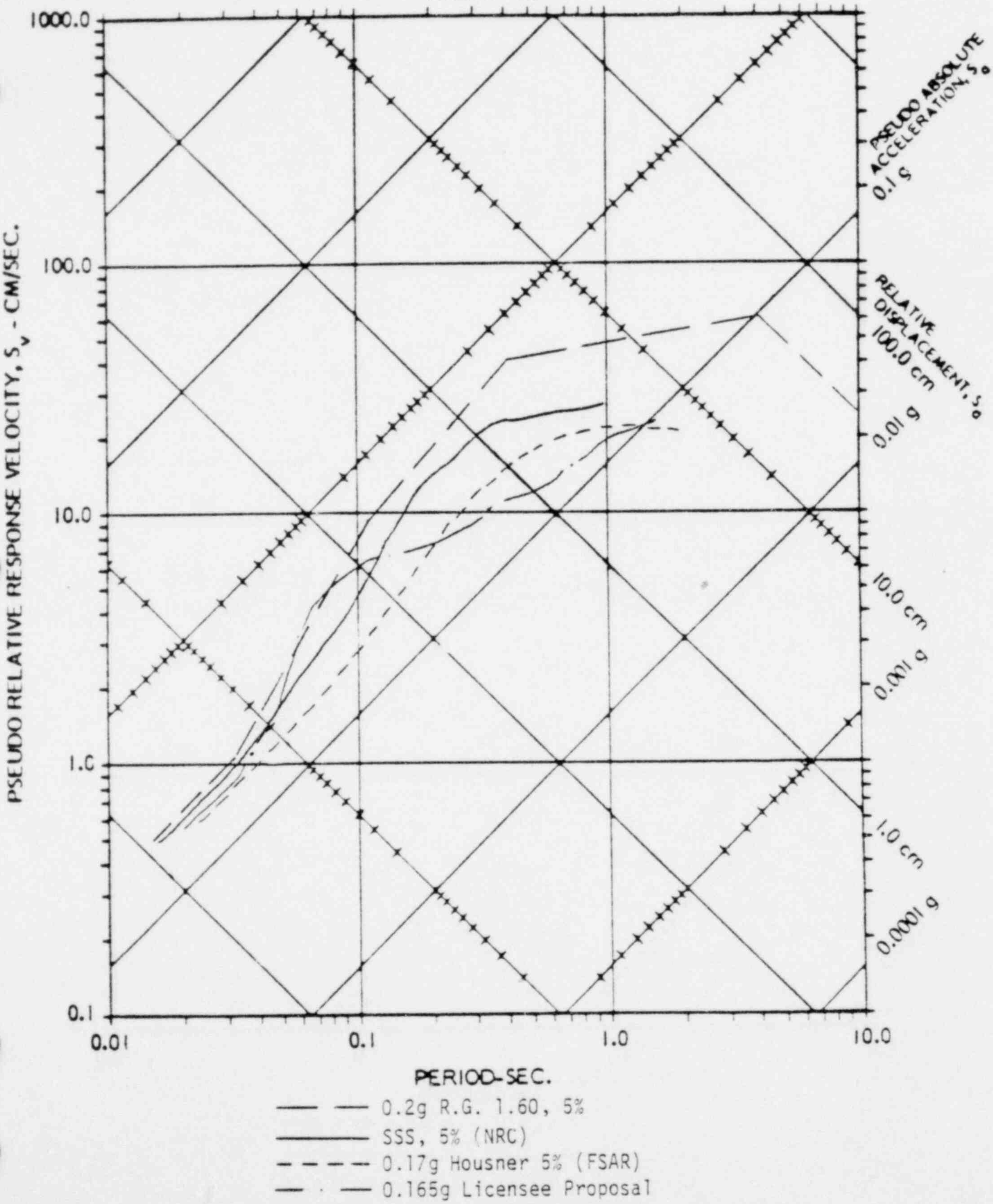


— — 0.2g R.G. 1.60, 5%

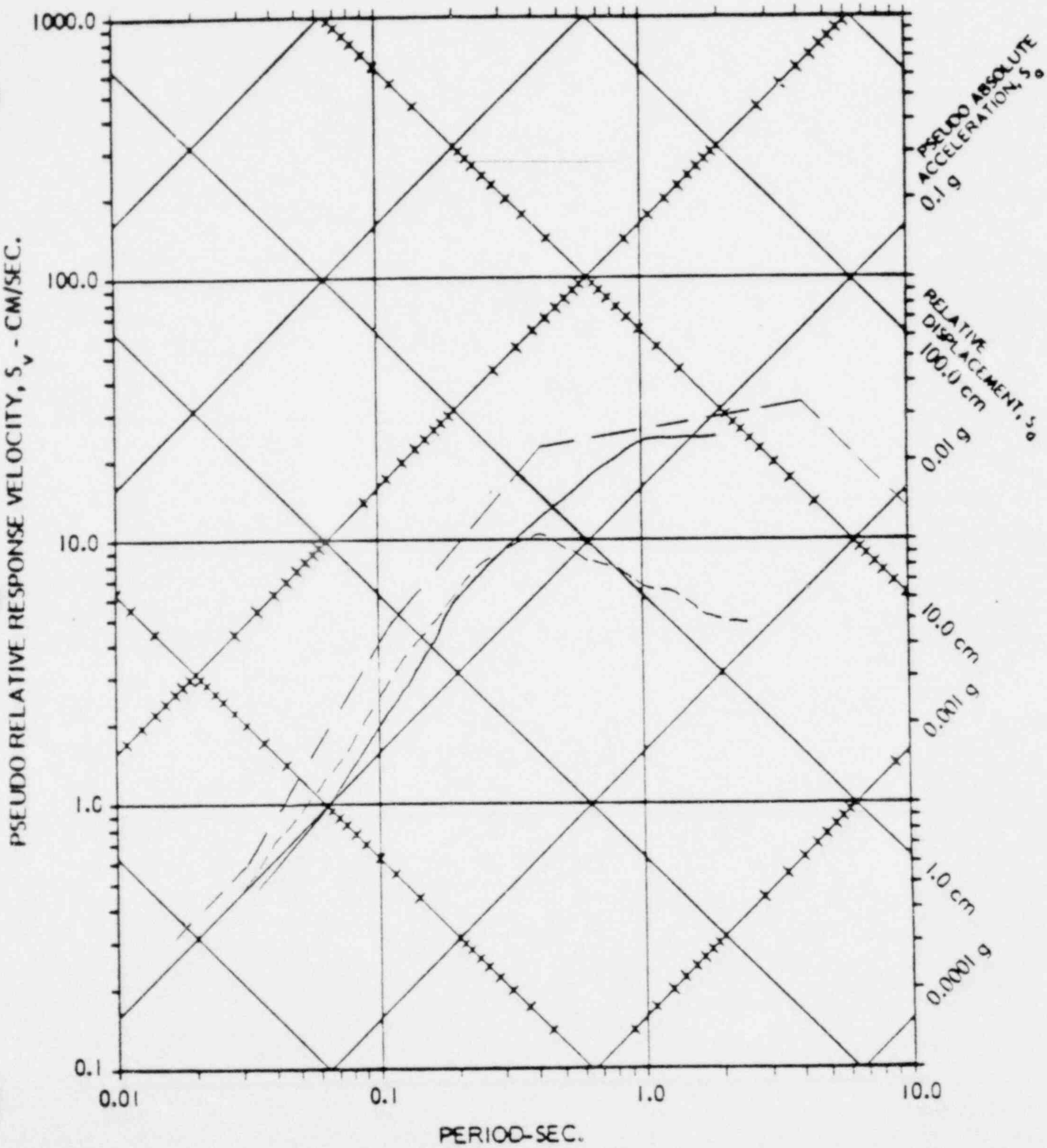
——— SSS, 5% (NRC)

– – – – 0.17 Housner, 5% (FSAR)

HADDAM NECK


1000.0
100.0
10.0
1.0
0.1
0.01
0.1
1.0
10.0
PSEUDO RELATIVE RESPONSE VELOCITY, S_v - CM/SEC.
PERIOD-SEC.
PSEUDO ABSOLUTE ACCELERATION, S_a
0.1 g
RELATIVE DISPLACEMENT, S_d
100.0 cm
0.01 g
10.0 cm
0.001 g
1.0 cm
0.0001 g
0.2g R.G. 1.60, 5%
SSS, 5% (NRC)
0.17g Housner 5% (FSAR)
0.165g Licensee Proposal

LACROSSE



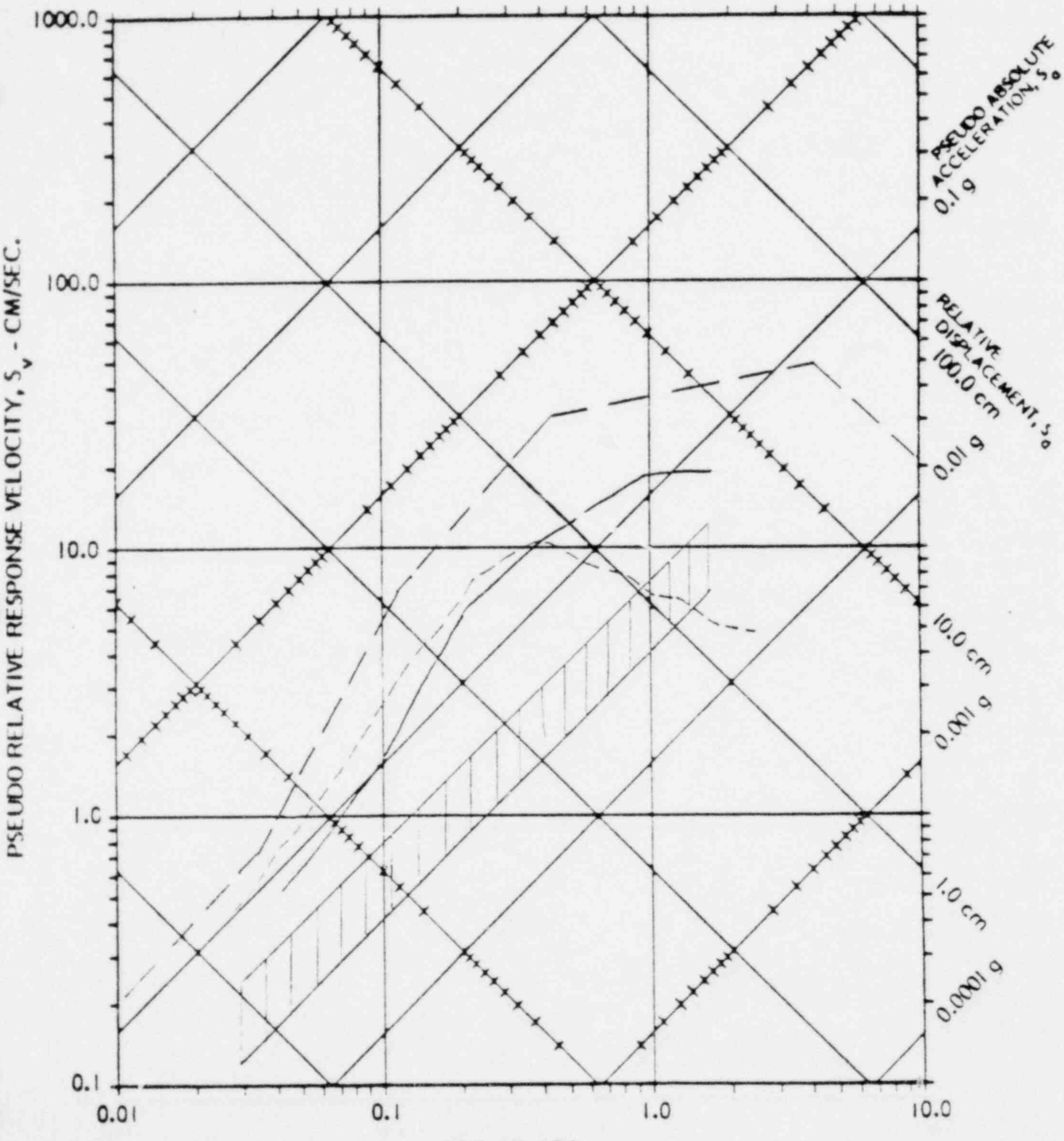
— — 0.12g R.G. 1.60, 5%

——— SSS, 5% (NRC)

No original seismic consideration

- - - - - M=5.3 ± 0.5, 50%, 5% (soil)

BIG ROCK POINT



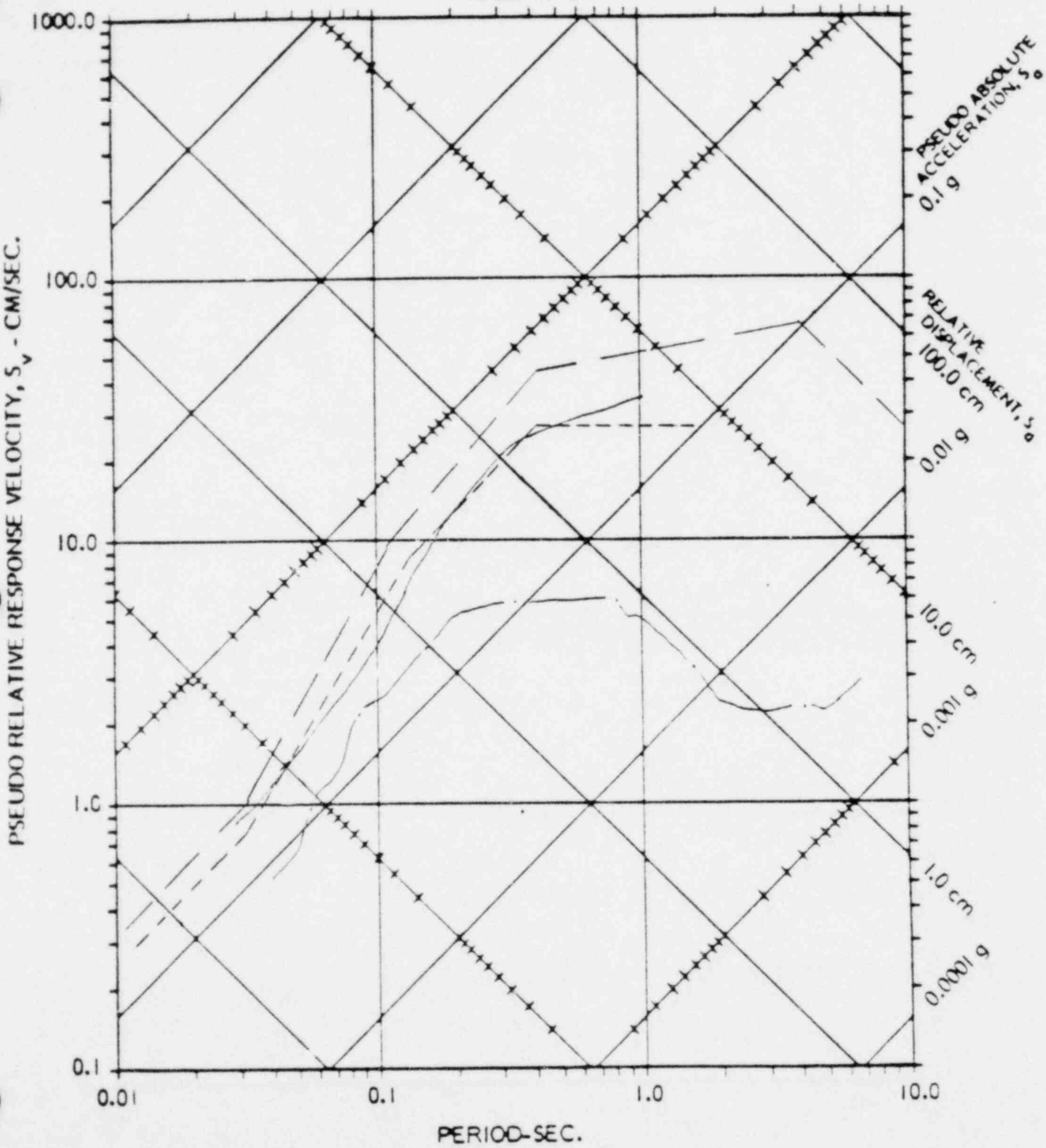
— — — 0.13g, R.G. 1.60, 5%

———— SSS, 5% (NRC)

ⅢⅢ 0.025g-0.05g UBC (Static), FSAR

- - - - - M=5.3 ± 0.5, 50%, 5% (soil)

YANKEE ROWE



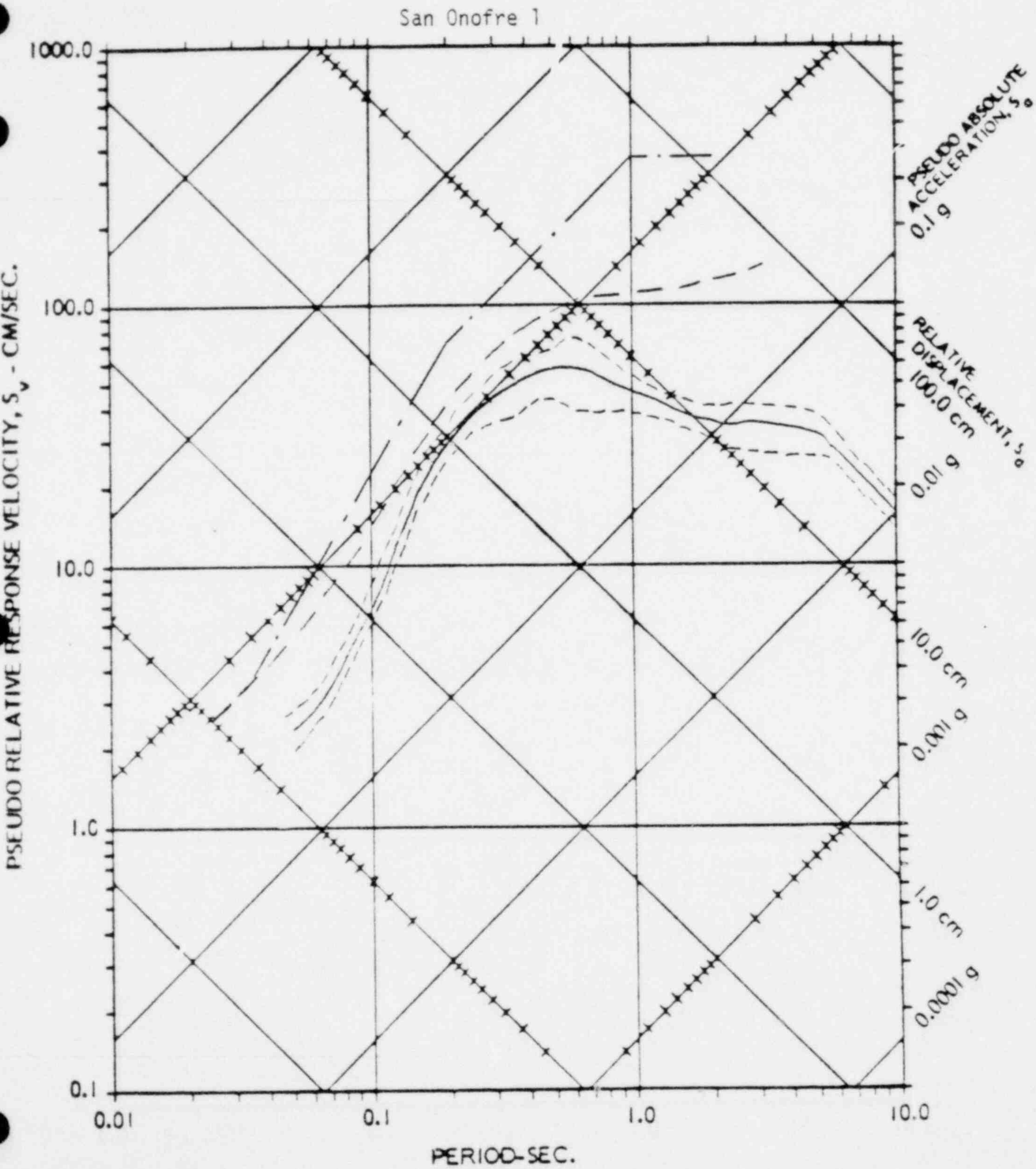
— — — 0.2g R.G. 1.60, 5%

——— SSS, 5% (NRC)

— · — Weston SSS, 4%

No original seismic consideration

------ 0.15g, 11cm/sec, 84% Newmark-Hall, 5%



—·— SONGS 2&3 DBE, 2%

——— SE SSS 2% Mean

---- SE SSS 2% Mean ± 1 sigma

— — — 0.67g 2% Housner

ANTICIPATED
IMPACT OF SITE SPECIFIC SPECTRA
ON SEP FACILITIES

FACILITY	FSAR SEISMIC INPUT	PROPOSED PEAK GROUND ACCELERATION	ANTICIPATED IMPACT STRUCTURAL	MECHANICAL	ELECTRICAL
Dresden 1	0.025-0.033g UBC (static)	0.13g	Minor	Major	Major
Yankee Rowe	None	0.20g	Major	Major	Major
Big Rock Point	0.025-0.05g UBC (static)	0.10g	Minor	Major	Major
LaCrosse	None	0.10g	Minor	Major	Major
San Onofre 1	0.5g Housner	0.67g*	Minor	Major	Major
Haddam Neck	0.17g Housner	0.21g	Minor	Major	Major
Oyster Creek	0.22g Housner	0.16g	Minor	Minor	Major
Dresden 2	0.2g Housner	0.13g	None	Minor	Major
Ginna	0.2g Housner	0.17g	None	Minor	Major
Millstone 1	0.17g Housner	0.19g	None	Minor	Major
Palisades	0.2g Housner	0.10g	None	Minor	Major

*Note: Not determined using SEP SSSP data.