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OFFICIAL TRANSCRIPT OF PROCEEDINGS

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Advisory Committee on Reactor Safeguards

Title: Subcommittee Meeting on ABB CE Standard
Plant Designs

Docket No.

LOCATION: Bethesda, Maryland

DATE: Tuesday, March 8, 1994

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UNITED STATES NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

DATE: March 8, 1994

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NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETING ON ABB CE STANDARD PLANT DESIGNS

Nuclear Regulatory Commission
7920 Norfolk Avenue
Room P-110
Bethesda, Maryland

Tuesday, March 8, 1994

8:30 a.m.

ACRS MEMBERS PRESENT:

J. CARROLL, CHAIRMAN
P. DAVIS
C. MICHELSON
I. CATTON
T. KRESS
W. LINDBLAD
R. SEALE
C. WYLIE
D. COE, COGNIZANT ACRS STAFF MEMBER

PROCEEDINGS

[8:30 a.m.]

MR. CARROLL: The meeting will now come to order. This is a meeting of the Advisory Subcommittee on the ABB-CE standard plant designs system 80+. I'm Jay Carroll, subcommittee chair. The ACRS members in attendance are Pete Davis, Carlyle Michelson, Ivan Catton, Tom Kress, Bill Lindblad, Bob Seale, and Charile Wylie.

MR. COE: Charlie came to the meeting this time. You sure know how to pick meetings to be sick from.

MR. WYLIE: That is strategic planning.

MR. CARROLL: The purpose of this meeting is for the subcommittee to continue its review of the System 80+ standard plant design. Mr. Doug Coe is the cognizant ACRS staff member for the meeting. The rules for participation in today's meeting have been announced as part of the notice of this meeting, previously published in the Federal Register on February 23, 1994, and as modified March 1, 1994.

MR. FRANOVICH: That means we extended the meeting by one day from the earlier notice. What does that mean?

MR. CARROLL: A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. It is requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she can be readily heard. We have received no written comments or requests to make oral statements.

A couple of items. Doug is progressing with making arrangements for our subcommittee to make a fact-finding visit to Palo Verde on St. Patrick's Day, right?

MR. COE: Right.

MR. CARROLL: Okay, everybody wear their green. I wanted to -- during today's meeting, we're going to try to -- or today and tomorrow's meeting, we're going to try and cover factors 2, 3 and 19. Originally, we were only going to concern ourselves with the seismic structural aspects of Chapter 2 and 3, but since tomorrow became available to us, the intent is to cover the entirety of those two chapters. I'd like to ask the staff what progress has been made in the finalizing of the chapters that we have looked at at our past meetings so that we can take a look at them in final forms.

MR. FRANOVICH: This is Mike Franovich from NRR projects. The FSER was issued by the Commission on the third. The FSER contains no open items and eight confirmatory items. We will need to make arrangements as to how we want to deliver a copy of the FSER to each of the members. I did bring down a courtesy copy for today for references should anyone need to look at a bound copy. I did send an extra copy to Doug Coe yesterday. So, you can assess that later how we want to handle sending each of the members a copy.

MR. CARROLL: Why don't we just sent it?

MR. FRANOVICH: Well, it's currently in reproduction.

MR. CARROLL: Oh, I see. When do you think it will be ready?

MR. FRANOVICH: Later this week.

MR. ARCHISAL: This is Ralph Archisal from the staff. Just one comment on your question. When things have been through the tech editor and get them to you, the Chapters 8, 9, 11, and 16 that you will get with this version have been through the technical editor and have basically final form content. The rest of the chapters we will have, like you know, we will give you the other chapters, but those chapters will basically be finished.

MR. CARROLL: Okay, now, with respect to the chapters you identified as being complete, were there any substantial changes made to them? One of the commitments we have from you is that --

MR. ARCHISAL: When there were technical editor comments, they were strictly editorial, no technical content was changed.

MR. CARROLL: Okay. We'll do an audit of that and see if we agree with it.

MR. ARCHISAL: I should note that the sections for today, Chapters 2, 3, and 19, there were portions that were technically changed, namely 19, in the shutdown risk area. For chapters 3, I believe, and 2, to the best of my knowledge, I don't believe there's been anything technically changed.

MR. CARROLL: Well, in 19 there were also some missing pieces.

MR. ARCHISAL: Yes.

MR. CARROLL: And I assume those have been --

MR. ARCHISAL: We tried to fill those holes in the report, draft version.

MR. CARROLL: Bill?

MR. LINDBLAD: Mr. Chairman, we in the last few weeks have been working with some individual pages dated February '94. Is that what we're talking about? Those were the most recent ones that have been now technically edited and ready to go?

MR. CROM: What you've been reading, we still had additional changes and the chapters you've been reading for this meeting have not received technical editor comments yet, so they will be changed again in the future for technical editor comments. Also, the OGC review has not been done yet, and we may get additional changes out of that. I guess our previous arrangement was after the technical area comments were incorporated, we would give you those chapters and noting significant changes. We will still have to do that even for these chapters you're going to hear about today.

MR. LINDBLAD: So, to help me in my communications with CE-ABB today, have they seen your drafts?

MR. CROM: No, they have not seen a copy of the report.

MR. LINDBLAD: Okay, thank you.

MR. DAVIS: Mr. Chairman, a quick question. This may come later, but on page 235 of Chapter 19, there's reference made to a new amendment that will be coming out that will update the analysis of the steam generator tube rupture, and will show an increase in risk of about a factor of two. I got a little confused because it looks like that's already been submitted as part of the document that we got at PRA. Do you know what I'm talking about.

MR. FRANOVICH: This is Mike Franovich again. I believe you're talking about the design alternatives evaluation which is 19.4. That section, the draft was written with the idea that Amendment U would nave contained those changes to the release classes for two ruptures. That was premature and that did not come in Amendment U but will come in Amendment V, but the numbers reflected in the report in the following report are accurate.

MR. DAVIS: So, you have another amendment coming?

MR. FRANOVICH: That is correct. Amendment B should be coming sometime in the April time frame.

MR. CARROLL: Is that expected to be the last amendment?

MR. FRANOVICH: I suspect that -- well, ABB is in a better position to answer that, but there will probably have to be an amendment after that to incorporate ACRS comments sometime in June.

MR. CARROLL: Does anyone else have any general sort of questions before we move into the chapters?

MR. LINDBLAD: Mr. Chairman, as I look over the proposed agenda for today, they appear to be mostly presentations by the applicant. Is the staff going to have a presentation of their review at some point?

MR. CARROLL: No, the way we've been doing this, Bill, is Combustion has been making presentations on these topics, and it turns into sort of a free-for-all where we ask questions in combustion or questions of the staff about their FSER during the course of the discussion on the particular chapter. It's not that structured. Somehow it didn't get there.

Okay, if nobody else has anything, let's turn it over to Charlie to lead off. Charlie Brinkman?

MR. BRINKMAN: Good morning. I'm Charlie Brinkman, director of nuclear systems licensing at ABB Combustion Engineering. I just want to say a couple of words before we get into the technical presentation. I wanted to announce what you already heard, that we did -- Dr. Murley signed out the FSER. He signed it out on his last day in office, as a matter of fact, on February 28, which was right on the schedule that the staff had set about a year ago. I want to express publicly our appreciation for the staff's effort, along with the effort by the ABB-CE team which culminated in that. I think it was just a super accomplishment.

I want to also express our appreciation for the fact the ACRS is giving us such a focused review to meet the schedule that we're on which the next major milestone after the advance copy of the FSER, is to achieve the final issue of the FSER in June, which means that we need an ACRS letter in June. We are very much appreciative of your effort, and we've attempted to be responsive. We have responded in writing to the questions that were left over from the December meeting and before the February meeting, and we covered many of those, and I understand on today's agenda time is set aside to cover those for Mr. Wylie.

Then we've also responded in writing to the questions that were left over from the February meeting prior to this meeting, and I believe there's time on the agenda tomorrow to discuss those.

MR. CARROLL: Those responses are in your packages, and as you get time today, you might want to glance through them so that when you get to that on the agenda, you're ready to say whether you agree or disagree and if you have any questions on the responses.

[Slide.]

MR. BRINKMAN. Despite your remarks about the structure of the meeting, you can see that the staff is here in force to stand by their FSER, and I wanted to let you know that the ABB-CE team is as well. I won't read all these names, but you can see that behind you here, we have a staff of our experts. We hope to be responsive to all of your inquiries today.

MR. CARROLL: Now, if it comes down to a vote on some issue, you can't count on those guys.

MR. BRINKMAN: Finally here is today's agenda as we see it, and if there's no further questions about that, I'd like to introduce Lyle Gerdes of ABB-CE who has been heading up the structural design of System 80+.

MR. GERDES: Thank you. I'm Lyle Gerdes, senior consultant at ABB Combustion Engineering in the mechanical engineering group. I've been with Combustion Engineering for over 20 years, primarily in the area of seismic and structural design. Today I would like to briefly cover some of the site parameters that we've considered, the seismic design, and highlight the structural design efforts.

First, some of the site parameters. For external floods, the grade elevation, finish grade elevation for reference is 90 foot, 9 inches. Our maximum ground water level is two feet below grade, and the probable maximum flood level is one foot below grade. Some of the design features that are incorporated in the structural design are concrete construction joints are sealed with water stops, external penetrations below grade are sealed, doors and accesses are at least one foot off grade level.

MR. CARROLL: What does that second bullet mean in terms of the pressure rating of the seals? What is assumed in terms of hydrostatic rate?

MR. GERDES: The pressure rating of the seals, Todd, do you have an answer on that?

MR. OSWALD: This is Todd Oswald with engineering services. The pressure rating of the seals will be for the static head of the water when the penetration enters the structure.

MR. CARROLL: So it assumes a flood, an external flood, for example?

MR. GERDES: External flood design level is one foot below grade.

MR. OSWALD: It's Todd Oswald again. Yes, that does assume that external flood level.

MR. MICHELSON: Is that actually said in the word somewhere I can read? Later on if you could tell me where I can read the pressure rating on this.

MR. OSWALD: That is not specifically stated.

MR. MICHELSON: Doesn't it have to be specifically stated if it's going to be a reality? You can tell us whatever you think, but what it is it really going to be when the COL starts the design?

MR. OSWALD: I'll have to review exactly how it is stated.

MR. MICHELSON: Did the staff ever check into that to see if they were satisfied with what the SSAR says? We pursued this a long time on APWR, so I thought this would be an immediately available answer.

MR. BAGCHI: A slight perimeter is a discriminating factor.

MR. MICHELSON: The flood will always be one foot below grade maximum. I don't care what the site is. This is what you are designing for. That sets the hydrostatic pressure of the seal. The only question is there somewhere in the SSAR that says that the seals will be rated for that hydrostatic pressure?

MR. BAGCHI: It is not specifically addressed in the SSAR.

MR. MICHELSON: Do you think it should be, and if not, why not?

MR. BAGCHI: I will take your recommendation and we will look at that.

MR. LINDBLAD: Mr. Gertes, your next line you were going to say doors are at least one foot above grade. So certainly you have no tracks leading in and out of the building, is that right? How do you accomplish rails that might be there? Is there a slope that matches?

MR. GERDES: Yes, there are slopes. There are no rails leading in below one foot above grade.

MR. LINDBLAD: So, what kind of slope is it over the one foot rise?

MR. GERDES: I don't have --

MR. LINDBLAD: Local, or is grade a general backrow description, or is there a micro-dimension of grade immediately outside the doors and access?

MR. OSWALD: This is Todd Oswald of Duke Engineering and Services. It will be a local grade in that area because in general all the way around the plant, we want to keep that one foot elevation as much as possible. It will be a local grade.

MR. LINDBLAD: And so there will not be a step at doors and accesses, but there will be a local grade sloping up to the door threshold, is that right?

MR. OSWALD: There may be a step at doors and access. Normally you have about a seven inch rise in a step, so there would probably be a step, yes.

MR. LINDBLAD: But where do have wheeled vehicles going in and out?

MR. OSWALD: There would be a local ramp.

MR. LINDBLAD: Thank you.

MR. CARROLL: I'm not sure this is the right place to ask this question, but I came across numerous references to a magic plus 70 feet in the context of the divisional separation is solid up to plus 70 feet. I never could quite figure out what was magic about plus 70 feet. I got the sense that that was as high as you could --

MR. CROM: This is Tom Crom from Duke Engineering. I've got a presentation later that will address that.

MR. CARROLL: All right, thank you. We'll wait for that. Okay.

MR. LINDBLAD: I have a question later on precipitation. Is this the right place?

MR. GERDES: I believe this would be the right place.

MR. LINDBLAD: In your CDM site envelope, you identified that there's a certain maximum precip, but you limit it to roof design. Is there some reason that it's limited to roof design? Are there other places that are designed for less or more maximum precip rates?

MR. GERDES: Any area where precipitation would influence the design, it will be designed for this maximum precipitation. The roofs, I believe, are identified specifically because this is where you may have a water buildup.

MR. LINDBLAD: So, it's the roof structure as well as drainage from the roof?

MR. GERDES: The drainage, yes, is designed for this maximum precipitation.

MR. LINDBLAD: And how about the local ground level drainage, storm water drainage? I'm trying to understand why was there a limitation in the site envelope description for roof design.

MR. OSWALD: This is Todd Oswald, Duke Engineering Services. That was not intentional just to limit it to just the roof design. Any of your hydrologic issues would have to be addressed with the site drainage system. That's somewhat of a site specific thing, the elevations, et cetera at the site. It was intended to -- I guess that was just addressing the structural issues at that point where you were reading that.

MR. LINDBLAD: It was supposed to explain what the relevance was in that particular page rather than to be a limit, is that what you are saying?

MR. OSWALD: That is correct.

MR. LINDBLAD: Thank you.

MR. CARROLL: If you could explain where that probable maximum flood is.

MR. GERDES: The probable maximum flood, that is designed or addressed, and I can't recall the specific document.

MR. OSWALD: This is Todd Oswald, Duke Engineering and Service. That's an ANSI standard definition. I can't recall exactly what the details of that ANSI standard, how they define it right now. It is a value addressed. I feel it is a large number of years, I cannot recall, 100,000, a very large, 100,000 years or so. It's a very large number.

MR. BAGCHI: This is Goutam Bagchi. Our extended review plan, Section 2.4, addressed that, and based on that, the standard review plan was upgraded, and you really have to look at the details of the definition of probable maximum. It is probablistically based, however, it is a physical limit as to how intense the precipitation can be. It is based on that.

MR. CARROLL: What happened in the Mississippi Valley envelope? Have you looked at that?

MR. GERDES: We have not specifically looked at the floods of the Mississippi Valley and how that would affect it. That would be site specific, the specific location.

MR. BAGCHI: That is the reason why we have this. It could be higher in some places.

MR. CARROLL: But would the experience in the past year have been enveloped by your standard review plan?

MR. BAGCHI: This is B&D, very local intense precipitation. It has not been exceeded last year. At the Cooper site there was flooding, which exceeded the SSAR stated, I believe the one million year flood. It was exceeded.

MR. MICHELSON: If you experience the maximum precipitation and there are a number of possible reasons for it not draining, what is the maximum loading before you start getting into an overflow through scuppers or something of that sort? Or do you depend upon the drain to keep the roof from collapsing?

MR. OSWALD: This is Todd Oswald, Duke Engineering and Services. The nuclear island structure does not have the parapets or anything to contain the water.

MR. MICHELSON: There appears to be a flat roof, then, but there are no parapets?

MR. OSWALD: That's correct. Well, there would be a very slight slope to the roof. We'd want to eliminate any ponding.

MR. MICHELSON: Okay.

MR. LINDBLAD: While we are on that subject, for snow load, you have a curved containment outer shell, is that right?

MR. OSWALD: That is correct. The shield building is curved. It is a spherical dome shaped.

MR. LINDBLAD: Is it assumed that the snow adheres to the rounded roof of the containment or that it drifts off onto the remainder of the deck of the rounding flat roof?

MR. OSWALD: The snow loading, I cannot address that right now.

MR. MICHELSON: What ice load do you design for then? What is your ice loading?

MR. LINDBLAD: Fifty pounds per square foot. That is the snow load.

MR. OSWALD: The snow load was designated as 50 pounds, that is correct.

MR. MICHELSON: Ice can get extremely thick in some parts of the country, several inches, in fact. This may come within the realms of the 50 pounds per square inch -- per square foot.

MR. BAGCHI: This leaves the impression that the roof design has substantial margin. We have looked at the margins. I just wanted to address something about the flood level. Mr. Michelson, you pointed out whether or not there is any requirement about the seal itself. There is not. However, there is a requirement that there be no opening, no opening below that level.

MR. MICHELSON: You mean no penetration of the outer walls?

MR. BAGCHI: No penetrations.

MR. CARROLL: Yes, but I can do that with cellophane.

MR. MICHELSON: The opening has to be sealed in concrete.

MR. LINDBLAD: Certainly construction joints will be below grade. They will have to be as tight as other places to avoid seepage, and as a practical -- from normal seepage, but certainly the flood, they will have to have a higher design, construction joints for one.

MR. CARROLL: Goutan, you just finished saying there were no external penetrations below?

MR. BAGCHI: Yes, in Chapter 3.4-2, that's the page number, amendment two, I guess. It says, "No exterior access openings will be lower than one foot above the grade elevation."

MR. CARROLL: Access?

MR. MICHELSON: What is an access opening?

MR. LINDBLAD: A door or a window.

MR. CARROLL: Certainly there are piping

penetrations into the buildings.

MR. BAGCHI: Yes, there will be service water --

MR. CARROLL: Those are the seals we are talking about.

MR. BAGCHI: It is a level of detail we have not gone into. This is not an unusual construction. It is a normal design for a nuclear power plant.

MR. MICHELSON: But you have to put the requirements in. You don't have to put the design in. This is an interface now, and it has to have interface requirements. The requirement is it's got to withstand a hydrostatic pressure.

MR. BAGCHI: The important thing is there is no free large open area below the grade. I need to make that point.

MR. MICHELSON: You have 30-inch water pipes coming through.

MR. BAGCHI: But that's not a 30-inch opening.

MR. CARROLL: Okay, let's move ahead.

MR. GERDES: When in tornado design --

MR. CARROLL: Question. How come I don't find any reference throughout the entire report to hurricanes? Is it enveloped with wind and tornado parameters? We do have hurricanes in the vicinity of nuclear power plants once in awhile. Ask the guys at Turkey Point.

MR. BAGCHI: Mr. Carroll, I really have to say that this is based on our regulation. General design criteria addresses tornado, not hurricane necessarily. So, my experience has been that tornado winds envelopes the hurricane winds.

MR. CARROLL: Okay. That's fine with me. I was just curious about that.

MR. OSWALD: I think that was a PRA assumption also.

MR. GERDES: Extreme wind, basic wind speed designed for 100 miles per hour for a tornado. Maximum wind speed of 330 miles per hour, which 260 miles per hour rotational speed, translational velocity of 70 miles per hour.

MR. MICHELSON: Excuse me. If you are designing for 330, then why do you even need to mention 110? What am I missing?

MR. OSWALD: This is Todd Oswald, Duke Engineering and Services. They have different --

MR. LINDBLAD: Stress criteria.

MR. OSWALD: The factors --

MR. MICHELSON: I'm only trying to relate it to the previous answer that says the hurricane is bounded by the tornado. Then why isn't the 110 bounded by the --

MR. OSWALD: Again, the tornado comes into a different load combination.

MR. MICHELSON: We'd better talk about hurricanes some more to see how they are handled. They're more than 110 miles per hour.

MR. BAGCHI: Tornado is not combined with earthquake, but the wind has to be.

MR. MICHELSON: You are combining 110 mile an hour wind with an earthquake.

MR. BAGCHI: Yes, sir.

MR. MICHELSON: What about a hurricane with the earthquake?

MR. OSWALD: The hurricane would be combined with a tornado combination.

MR. FRANOVICH: It is a coincidence that the translational speed and velocity add up to the maximum one speed?

MR. GERDES: No, that is not coincidence.

MR. FRANOVICH: That is pretty bad arithmetic because these are dectors instead of the --

MR. GERDES: A maximum differential pressure for the tornado is 2.4 psi. The rate of pressure dropped 1.7 psi per second, and the mission Spectra tornado -- the missiles are a spectrum of missile -- are in accordance with the standard review plan, Section 3.5.1.4 for missile spectra two.

MR. MICHELSON: My big recollection is that we used a three point differential. Has that been changed to 3.4 by the staff?

MR. BAGCHI: 360 Mile an hour that went with the 3 psi.

MR. MICHELSON: You dropped it to 330, and you can drop the pressure. Okay.

MR. LINDBLAD: Mr. Bagchi, while you are standing there, as I read the SER material in draft, I see a reference to ABB-CE as meeting Reg. Guide 1.76, but it is not clear to me that that is Reg. Guide 1.76 as modified by the letter of March 25, 1988, or without the modification.

MR. BAGCHI: Let me say that he's from the staff. The tornado wind speed in Reg. Guide 1.76 is 360. The letter that you referenced was 330. In the SECY 93-87, we accepted 300. ABWR is using 300 miles per hour, and ABB-CE is using 330, which is the letter.

MR. LINDBLAD: I'm reading words that say design to effect tornado effects in accordance with the interim staff position in Reg. Guide 1.76, is that correct?

MR. SNODDERLY: That is correct. That was a letter that modified the original Reg. Guide 176. So, it started with 360 miles per hour, and then that letter changed to 300, and then the SECY changed it to 300. ABB-CE has the intermediate value of 330. We have accepted, as of SECY 93-87, that it's lower than the 330 miles per hour.

MR. LINDBLAD: I understand that, and I'm reading words, and it says, in accordance with Reg. Guide 1.76, and it does not say as modified by the letter.

MR. SNODDERLY: It is the interim position is what the letter was. The letter defined an interim position on Reg. Guide 176.

MR. LINDBLAD: I suggest you read what you have written here and ask the question.

MR. CARROLL: When you do ask the staff about specific words, I think it is helpful to them to tell them page number and paragraph.

MR. LINDBLAD: Thank you, Mr. Chairman, I will.

[Slide.]

MR. GERDES: The design features structures for the wind and tornado, the seismic category one structures are designed for the associated loading. The exterior walls and roof are also designed as tornado missile barrier. The dampers are qualifying due to tornado differential pressures.

MR. CARROLL: You say the exterior walls, that includes doorways and so forth in exterior walls?

MR. GERDES: Yes.

MR. CARROLL: Windows?

MR. OSWALD: This is Todd Oswald, Duke Engineering and Services. The doorways would be protected by labyrinths over the interior side.

MR. MICHELSON: I was thinking more of the differential, not penetrations by missile, but rather the differential pressure blowing the door out.

MR. OSWALD: Yes, the doors would have to be evaluated --

MR. MICHELSON: Is it specified somewhere that that is a design requirement, that the doors take the maximum differential on the tornado?

MR. OSWALD: Yes, it is specified that the exterior, the roof and the walls, are designed for that.

MR. MICHELSON: I found that. I did not find the doors. That's my question. Is it specified that the doors be able to withstand the pressure?

MR. OSWALD: It is not specifically stated that the doors will be designed --

MR. LINDBLAD: And the ventilation systems.

MR. MICHELSON: There are a number of things they didn't say. They just talk about the walls.

MR. LINDBLAD: I think we're talking to the wall man.

MR. MICHELSON: We're talking to the concrete men, not the ventilation man or the door man and so forth. Clearly before we are done, I would expect to find specifications for this sort of thing. Just a few words. Without it, I have no assurance of how it would be designed.

MR. GERDES: It is a requirement that the detailed design meet the site parameters.

MR. MICHELSON: We're not questioning the site parameter. We're questioning your design. When you say the walls are designed for it, fine, I accept that. How about the doors, are they designed for it? And there, you remain silent. And any other penetrations, ventilation penetrations and so forth, you just remain silent. I assume they are, and before I'm done, I'm sure they will be, but it is not so as stated yes.

MR. RITTERBUSH: We will be glad to add an appropriate sentence.

MR. MICHELSON: That's all it takes.

MR. CARROLL: What dampers are you talking about in the last bullet?

MR. CROM: This is Tom Crom. Basically, the dampers we are talking about are on any of the HVAC intakes, the ductwork and the damper that would be manually closed during a tornado warning would be qualified to the 2.4 psi differential pressure.

MR. MICHELSON: In terms of the non-safety ventilation systems where you may shut them down and then they close, well, those dampers meet the differential.

MR. CROM: Any of the openings, even if it was non-safety ventilation, if it is required to protect the interior of the building, we'll have dampers and we'll be qualified to 2.4.

MR. MICHELSON: It will say somewhere in the essay or before we're done.

MR. CROM: I think every one of the NVAC flow diagrams has an indication of where the dampers are. There is a note that says they are qualified for the tornado differential pressure.

MR. CARROLL: And you say the tornados in the vicinity, operating procedures will say to close these dampers.

MR. CROM: Yes. This is similar to the MacGuire and Catawba sites. So, if you actually have the tornado that is spotted in the line of site, you are required to manually isolate those dampers. You also qualify all of the interior structures for the maximum differential pressure that can be obtained, should the operators fail to isolate, which I believe is at about .5 psi differential pressure. One of the things I like about this design compared to Maguire and Catawba is we don't have any block walls. Block walls are one of the biggest problem of qualification, but this is all concrete reinforced walls, so there is not the problems that we have seen at Maguire in Catawba.

MR. MICHELSON: But the problem you unit into is the differentials are such that they become missiles, and then maybe the adjacent safety related equipment. You've got to worry about more than just the walls.

MR. CROM: You are correct. The doors would be qualified for the same differential pressure.

MR. LINDBLAD: What is the design requirement for structures other than seismic category one?

MR. CURTIS: The rad waste building, the turbine generator building are designed for the earthquake in accordance with seismic category one criteria. That in itself will give inherent strength to withstand typical wind speeds if they are made out of reinforced concrete. Is that right? If they are made out of reinforced concrete, and they will be are you saying?

MR. OSWALD: This is Todd Oswald, Duke Engineering and Services. The rad waste building will be made out of reinforced concrete. The turbine building is a seismic category two structure which will not be reinforced concrete. It will be a steel frame structure.

MR. LINDBLAD: And so will the siding come off in a tornado or not?

MR. OSWALD: The siding could come off in a tornado.

MR. CARROLL: And end up in the switch year.

MR. LINDBLAD: And the diesel generator -- excuse me, you have a combustion gas turbine as well as that, correct?

MR. OSWALD: That is correct.

MR. LINDBLAD: And is that in a separate structure?

MR. OSWALD: It is in a stand alone structure.

MR. LINDBLAD: It has dampers with its air intake? Will it be operable in a tornado?

MR. STAMM: This is Steve Stamm. The gas turbine is not designed for the tornado. There is no current requirement for it to be designed for a tornado, and therefore, operation is not guaranteed during or immediately after. The building is designed with rugged construction on the order of 100 mile an hour winds. It is an enclosure. If it were to come off, it probably would not actually damage the internals itself. The non-category one buildings that are -- the criteria as far as safety for those buildings is that any potential impact for the failure of those buildings by the design basis, earthquake or tornado will not cause a failure of a category one structure.

MR. LINDBLAD: When we were talking about dampers, did I understand that we said that dampers would close during tornados?

MR. STAMM: That is for category one buildings but not for non-safety.

MR. LINDBLAD: What about for diesel generator air intake?

MR. CROM: The dampers on the diesel generator air intake are not closed. The building and the interior structures are designed for the differential pressure.

MR. CARROLL: But that is not true of the combustion gas turbine, I take it?

MR. OSWALD: That is correct. That is not true of the combustion and gas turbine.

MR. GERDES: The combustion gas turbine is a non-seismic category one turbine and structure.

[Slide.]

MR. GERDES: Missile protection. Primarily, the first step in missile protection is to minimize the source of missiles by equipment design features that prevent the generation of such missiles.

MR. CARROLL: How do you do that?

MR. GERDES: Rugged design features on valves to keep the operators from becoming missiles.

MR. LINDBLAD: But you do not require that the turbine building not have siding, is that correct?

MR. GERDES: I did not understand the question.

MR. LINDBLAD: When you say minimize, one could interpret that to mean that the turbine generator superstructure should be reinforced concrete.

MR. GERDES: The turbine generator building is a non-seismic category one structure. There is no need to preclude that from happening. If there is a missile that occurs due to siding from blowing off, it must be demonstrated that it does not impact a seismic category one function.

MR. LINDBLAD: Are you saying this requirement in this first item, it says minimize the sources of missiles only applies to categories? Actually, excuse me, seismic category one buildings?

MR. GERDES: Primarily to category one buildings, structures, equipment and systems.

MR. LINDBLAD: I would think that the greatest threat to seismic category one buildings would be missiles from non-seismic category one buildings.

MR. GERDES: I believe probably just as large of a threat may be from equipment that cannot be secured that may be in the yard, and that is where you get your missile spectra and what you design your structures for.

MR. LINDBLAD: Is there a description of this in your submittal that I can look at during the lunch hour?

MR. OSWALD: This is Todd Oswald, Duke Engineering and Services. We have identified in Section 3-4 the missile spectra that we are designing for --

MR. LINDBLAD: I understand that, but I mean the design rule that you're proposing to minimize.

MR. OSWALD: These are in section 3-4 of the CSAR, the items that are on the presentation.

MR. GERDES: Better wording there may reduce the potential for the sources of missiles because you cannot necessarily minimize all sources of missiles. There are always other features that can be established or taken, but they would not be cost effective, and that is especially true with non-category one structures and equipment.

MR. CARROLL: There has been a long experience in start-up testing of people taking siding off of buildings as a result of testing of the atmospheric dump system, or whatever you call it, on a combustion plant. Have you taken that into account in the design of the siding of the turbine building?

MR. GERDES: The turbine building has not been completely designed. We have established some design criteria for that.

MR. CROM: This is Tom Crom. I believe you are not talking about safety related. I think you're talking about non-safety. This particular design, all the 55 percent bypass goes directly to condenser and not to atmosphere.

MR. CARROLL: Oh, that's right on this design.

That's right, okay. The only point I would make is that it seems like in every one of those instances, there is something magic about pieces of siding that go up several hundred feet in the air. They want to glide down into your switchyard. I have seen that.

MR. GERDES: Along with the minimizing or maybe again reducing the potential for the sources of the missiles, accomplished largely the orient or physically separate potential missile sources away from safety related equipment components to the extent it's practical. The use of protective shields and barriers near the source of potential missiles, and not be reasonably avoided by other methods is hardening of safety related equipment and components to withstand the potential missiles in the areas of the components.

[Slide.]

MR. GERDES: For internally generated missiles, we have redundant safety systems that are physically separated by divisional walls outside the containment. Missile barriers are used both inside and outside containment were required.

MR. MICHELSON: Let me ask you a question on your first bullet. How many systems do you have? Two divisional or four divisional arrangement?

MR. GERDES: Two divisional.

MR. MICHELSON: It's just two divisional. Okay, so there's one divisional wall --

MR. GERDES: One divisional wall, yes.

MR. MICHELSON: Because there's another wall showing, but only one divisional wall. So, it's really a two division system.

MR. GERDES: That's correct.

MR. MICHELSON: Thank you.

MR. LINDBLAD: For the benefit of the other members, I was confused as we looked at these missile coils that Mr. Curtis is presenting, I thought we're still on wind and tornado, and he apparently, as I look a the CSAR report, we're talking about all kinds of missiles, and so that's why I was confused on that. Thank you.

MR. GERDES: I may have switched gears on you without strict identification. I'm sorry about that. We also identified some of the features on some of the pumps, motors, valves, that helped reduce the potential of missiles and the design of the equipment.

[Slide.]

MR. GERDES: Pressure vessels, pressure relief devices, the minimize the potential of vessels. Turbine missiles, the probability of less than one time ten to the minus four events per year, by maintenance considerations, inspections over speed protection. Also, the orientation of the turbine generator which later on in my presentation I will identify or show the orientation of the turbine generator building with the nuclear island missile path.

MR. CARROLL: On this general subject, I'm looking at the FSAR page 39, and it talks about missiles that are not likely. There is the induction type which are relatively slow speeds, and I don't know what that means, and are not prone to overspeed. Well, of course, they are not, but the device they are driving can certainly drive the motor to overspeed conditions under certain circumstances, backflow through a pump or whatever can do that do you. So, I guess I've seen this staff statement in other places, and I objected to it last time I saw it, probably in ABWR, and I continue to object to it because I don't think it's correct.

Also on that page, beginning of the next paragraph, it says ABB-CE states that no missiles were postulated for valves because all valve stems are divided with a back seat or shoulder that is larger than the valve bonnet opening. Is that true of gate valves? That sounds -- is that true of load valves? That sounds like a gate valve sort of statement to me.

MR. BORCHARDT: I would have to look at that.

MR. CARROLL: Please do, and also someplace else, you were talking about the turbine. I found a fairly positive statement that missiles from the turbine because of orientation cannot cause any damage to safety related equipment, and that simply is not true. The orientation reduced the probability, but it does not eliminate it. I will have to tell you where that statement is. Someplace later or, you have got it right. In one section, you make the flat statement that you cannot have damage from turbine missiles.

MR. LINDBLAD: I thought Mr. Gerdes said he was going to deal with the orientation.

MR. GERDES: I'll have later on in the structural presentation. Just show me the orientation.

MR. CARROLL: I'm sure that's right. Okay, keep going.

MR. MICHELSON: On the question of backseating, I have some of the same difficulty because I could not find a requirement that they use backseated valves. It only says well, there is usually a backseated valve and a shoulder, whatever, that's fine, but there's no requirement to use backseated valves.

Now, if you put it in as a requirement, then I buy the argument. Otherwise, I don't. Valves can be bought with or without back seats. You can buy them either way.

MR. LINDBLAD: I have the impression that what we are listening to are proven engineering design issues that tend to reduce the frequency of missiles rather than eliminate missiles. I do not think they are making a case that the plant does not have to be designed for internally generated missiles.

MR. MICHELSON: I was only saying that if you're going to claim the you do not have valve stemmed missiles because you've got back seats, that has to be a design requirements. It is part of your safety evaluation. You evaluated them out because you have backseated valves, but there's no requirement for it.

MR. OSWALD: This i Todd Oswald, Duke Engineering and Services. They are evaluated out when they are actually eliminated. In some cases, they are eliminated. You would have to account for that. We are not saying that every valve will -- is not a potential missile hazard. As Mr. Lindblad was saying, we are not eliminating valves.

MR. MICHELSON: You're designing a plant today where you do not design it to put in bounding requirements so that the future designer will validate essentially your safety evaluation. You've got to evaluate safety today, not --

MR. CARROLL: It sounds like the staff and CE do not agree. The staff's statement is that CE states that no missiles are postulated from valves because all valve stems were provided with a back seat or shoulder. You're saying that it's not true.

MR. OSWALD: This is Todd Oswald, Duke Engineering and Services. I will have to see how we have got it stated in there. It sounds like we need to investigate that.

MR. MICHELSON: It's only a matter of making it clear. If they are backseated, there is no problem. If they're not, you have to say something, and the staff has to decide it's okay.

MR. LINDBLAD: He says back seat and shoulder, and frequently the disk, I think, is what they are crediting as being the shoulder.

MR. MICHELSON: Not when you break the stem. You break the stem, it is a missile. It ejects out. If you do not have a -- some people call it a back seat and some people call it a shoulder. I think they're one and the same, but all the experts may tell me I'm wrong.

MR. LINDBLAD: I think the case arises when you're looking at relief valves, spring loaded relief valves. Do they or do they not have a back seating? Generally, they don't have a back seat on the spring operated.

MR. CARROLL: This says all valves. It does not eliminate --

MR. MICHELSON: I found their wording in the SAR fuzzy.

MR. LINDBLAD: Could I ask, is it thought that the valve stem is the only source of missiles from a valve, or will bonnet holds be missiles?

MR. OSWALD: This is Todd Oswald. There could be the potential for bonnets becoming missiles also.

MR. LINDBLAD: Then why are no missiles postulated from valves?

MR. CARROLL: I don't think he made that statement. It is the staff.

MR. LINDBLAD: I am reading the staff's report.

MR. CARROLL: Which Combustion has not even seen.

MR. MICHELSON: I thought I had read the combustion portion in Section 3.6 and then another argument as to why there were no bonnet missiles. Go back and read your own stuff. Come back next time and tell us.

MR. CARROLL: The staff knows where all of this started, page 339, at the middle of the page.

MR. FRANOVICH: Yes, sir, we have noted.

MR. LINDBLAD: The combustion materials on 3.5-3.

MR. CARROLL: Moving on.

MR. GERDES: Externally generated missiles. Again, I believe we have covered that.

[Slide.[

MR. GERDES: Missiles are a part of the design basis for the category one structures. I don't plan on going into any detail on the radiological dilution factors other than to identify what those factors are for our design basis. Exclusionary area boundaries, 5/10 of a mile. Population is on two miles, and the dilution factors given for the time periods.

MR. LINDBLAD: There was some confusion in my review of the CSAR design specification material as to what the EAB boundary was, a half-mile or 500 meters. Can you clear that up?

MR. GERDES: There is a discrepancy, and it is taken to .0 in Section 2-3, I believe. The information in the 2-3 is the correct -- the half mile and the two mile is correct, and what has been used in the Amendment V to Table 2.0 will be corrected.

MR. CARROLL: How are these dilution factors used?

MR. GERDES: I'm not an expert in this area. I will turn to Mr. Ritterbush.

MR. CATTON: When you specify that dilution factor, are you placing requirements on the site?

MR. RITTERBUSH: Yes.

MR. CATTON: The site has to have more dilution factor or what? You don't use it, the proposed site?

MR. LINDBLAD: The building orientation is also included. The structures are factored into that, the materials, the building weight, you think, correct?

MR. RITTERBUS": It depends on the particular Pi over Q and the analysis being formed, but the bottom line is that the parameters have to confirm it.

MR. CARROLL: So, if you found a site that did not quite make it, it would require a COL applicant to ask for a change in the rule. Remove his boundaries. This is correct, isn't it? Franovich, this COL applicant will have to seek an exemption and re-analyze for the higher Pi over Q.

MR. CARROLL: I see the heading up there. Bill, do you want to make some preliminary remarks about this section? I notice that we have gotten --

MR. LINDBLAD: Mr. Gertes is going to cover it, describe it, but I would like to take notice that Mr. Carroll, chairman of the subcommittee did provide to me the minutes of a meeting that was held three years ago, almost to the day, the same materials. So, actually, reviewing some of the material covered three years ago has solved many of my questions that I will be asking questions about, has it changed since three years ago.

MR. CARROLL: Let's ask that question right now.

MR. GERDES: There are some changes. I will identify that as a go through. I believe the primary change from what I presented three years ago to what I will be presenting today is three years ago, we were only using one control motion at a hypothetical rock outcrop for the basis of the System 80+ design. Since then, we have added two additional emotions. One, regulatory guide 1.6, defined spectral shape, define ant, the ground surface, and also a second spectral shape defined at a hypothetical outcrop, and I will show those shortly.

MR. LINDBLAD: I would like for you to make your presentation, but I would like to highlight the issues that have changed in the last three years, and could I ask a question? When we are talking about these projects being designed in the safety category, one area for Part 3-AG, ground acceleration, does that mean that if a flight is selected that is in an area of low seismicity, then the .3 G acceleration will be retained in all of the structures as marginal, or does that mean that the SSE will be something less and will be permitted to perhaps reduce the amount of reinforcing steel in it.

The .3 G ground motion will be repaying for the category one structures that have been defined for the design certification. There may be able to use the site specific ground site parameters with that .3 G earthquake.

MR. LINDBLAD: Does that apply across the board?

MR. GERDES: Not across the board.

MR. BAGCHI: Yes, Mr. Lindblad, this is Goutam Bagchi. I just wanted to point out to you that the cinder design offering that contains all of the category one structures, primarily the nuclear island and a few other non-nuclear structures. They are signed for a .3 G. The structure is standard. However, the equipment, piping, all of those things, are laid up on a trial basis, on a sampling basis? Those are subject to changes years in the actual site parameter, whatever will response better. That's what they can use.

MR. LINDBLAD: Well, are we saying that the reactor coolant piping as going to be designed for .3 G with the safety reliance problem, not is that what it is?

MR. BAGCHI: They have looked at all of the piping inside the containment for a leak before break. They have given us an analysis that envelops all of the site conditions presumably, and they have given us an analysis that envelopes all of the site conditions, presumably covering all of the site characteristics, you have determined that it is feasible to make that design, and I suspect you're right. They can be designed on the basis of site specific response of the building.

MR. GERDES: I might bring out, though, that the main loop piping would not change. The requirements for that are primarily due to pressure requirements more than the seismic requirements. So, there would be no reduction in size of main loop at piping.

MR. LINDBLAD: I would expect that inquiries would be the area. Why don't you proceed, Mr. Curtis?

MR. BAGCHI: Okay. The general seismic design basis for the system 80+ is the select design parameters that would envelope the majority of potential nuclear science. You should both current and anticipated, you would have both current and anticipated regulatory guidance. The envelope of the site conditions -- Lindblad -- would you like to explain on what the participated regulatory guidance has.

MR. GERDES: This primarily was from a carryover when we started the program and is one of the reasons that in some of the controlled emotions, we have included significant amount of higher frequency content in those control emotions than what are in the regulatory Guide 1.60. Since that time, there has been a lot of work in the industry, demonstrating that those high frequency content may not be damaging to either the equipment or structures. That is an area that is believe is being looked at, I believe, both by the staff and industry. We have included additional high frequency content in the design of our structures over and above current regulatory requirements.

MR. LINDBLAD: So, as I understand what you're talking about now really applies only to soil structure interaction issues. Is that correct? When you speak of anticipated regulator guidance, you're talking about how vibratory motion is communicated from the soil to the structure.

MR. GERDES: The definition of the control motion and how it is then factored into this whole structure interaction analyses and, of course, that affects the response of your structures for equipment component design also.

MR. LINDBLAD: But you're not talking about stress criteria and the component design.

MR. GERDES: No, at this time I'm not talking about that.

MR. CATTON: Your peak ground acceleration, is that in all directions?

MR. GERDES: The peak ground acceleration of .3 G, as you will see a little bit later on, our three control motions, the Reg. Guide 1.60 is .3 G, in all three directions. The two control motions that are designed at a hypothetical rock outcrop, the vertical is two-thirds of the horizontal at the hypothetical rock outcrop. When you convolute through the soil layers, though, at the foundation of the structures, the vertical motion is on the equal type magnitude as to what the horizontal is.

MR. CARROLL: How would a thermal hydraulic guy know that? Is that because you're from Los Angeles?

MR. CATTON: There are some interesting stories about the vertical acceleration. Even though low, it resonates with the automobile. In some cases, the cars literally jumped up the garage door.

MR. LINDBLAD: Mr. Gerdes, at some time as you go through this, I will want to talk about soil liquefaction. Do you have a slide on that at some time?

MR. GERDES: I do not have a slide on soil liquefaction. Each potential site will have to be evaluated and will have to be demonstrated by the COL applicant, that they do not have the potential for liquefaction at that site. That is a COL item in the SAR.

MR. LINDBLAD: Is it identified what criteria will be used to determine satisfaction there?

MR. BAGCHI: They would use site specific SSE to determine no liquefaction potential.

MR. LINDBLAD: Why is that appropriate, Mr. Bagchi? It effects the nuclear island.

MR. BAGCHI: We said that there will be some sites where no liquefaction potential at .3 G is almost impossible to achieve, Southern Florida, for example.

MR. LINDBLAD: Is that a good argument from a safety point of view?

MR. BAGCHI: From a safety point of view, we have assured no liquefaction potential. Therefore, the structure as built is not subjected to that kind of hazard.

MR. LINDBLAD: I'm sorry, I misunderstood what you said previously. What did you say about some sites?

MR. BAGCHI: In the FSAR, particularly the site parameter, we make it very clear that no soil liquefaction potential is to be determined based on site specific SSE.

MR. LINDBLAD: Which will be equal to our less than .3 G.

MR. BAGCHI: 1.5 G in Florida, that is what we would accept.

MR. LINDBLAD: And so while the nuclear island is designed for --

MR. BAGCHI: Substantial margin to .3 G, and then has been demonstrated to have a margin of another two on top of that.

MR. LINDBLAD: But the foundation soil under the structure would not have the same margins.

MR. BAGCHI: That is correct.

MR. CARROLL: So you are basically saying that South Florida is ruled out for this design?

MR. BAGCHI: No, sir, no. I am saying that this design is perfectly acceptable. However, the potential for soil liquefaction would be evaluated on the basis of the site specific earthquake. Remember, not site specific soil properties, but site specific earthquake is the hazard the site has.

MR. LINDBLAD: What are you saying, is Florida known for having high ground water elevation, but also a low seismicity, and so the combination of low seismicity and high ground water level might be compensatory.

MR. CARROLL: Yes, I've got you.

MR. GERDES: One of the areas that I want to briefly cover are the selection of the design control motions that I have referred to. The selection of the soil profiles, the development of the models that we used in the dynamic analysis, the analysis itself, and then the definition of some of the typical input for structural subsystems, equipment design analysis and qualification.

[Slide.]

MR. GERDES: The control motion definition. Again, this is, as I pointed out before, one of the areas that has changed from the three years ago. The CMS1, 2, and in the next slide I will show 3. What that refers to is our use of the word CMS for control motion spectrum. Three years ago, what I presented was strictly what we now call control motion spectrum 2. Since that time, we've added CMS 1, which is U.S. NRC Regulatory Guide 1.60. It is defined at the surface in Freefield plant site. Horizontal peak ground acceleration of .3 G and also vertical peak ground acceleration of .3 G.

CMS 2 which I will show shortly is what was presented three years ago, enriched in high frequency content. It is defined at a hypothetical rock outcrop. For those of you who may not be familiar with that term, I also have an overhead that I will show that horizontal peak ground acceleration at the outcrop. The outcrop is .3 of G. The vertical peak ground acceleration is .2 G.

[Slide.]

MR. GERDES: CMS 3 is based on NUREG CR-0098, spectral shape. It has been enhanced somewhat to include additional high frequency content. It also is defined in a rock outcrop horizontal peak ground acceleration of .3 G, vertical peak ground acceleration of .2 G.

MR. LINDBLAD: Mr. Gerdes, these changes going from one control motion to three, do I understand that they are a result of working with the staff on the staff's concerns?

MR. GERDES: We have worked with the staff on this. There were concerns, I think, not only by maybe a few members of the staff but also members within the industry that use of a design control motion that only the one control motion that is different from that that has been used, the Regulatory Guide 1.60 shape for all of the newer plants. It may be more difficult to convince some individuals that use of the one control motion at a rock outcrop may or may not cover a similar .3 G reg guide 1.60

shape. We worked very closely with the staff in this entire seismic design program.

MR. LINDBLAD: So that the refinement over the past year is not to narrow your conservatism but to broaden the envelope of conservatism covering this. Is that what I understand?

MR. GERDES: This really has broadened the envelope and it gives us much more confidence that we have a design that can be sited in most any potential nuclear site. Although it is only being certified for sites for .3 G earthquake, as I was told later, the capacity is there, that the same design would be adequate for sites of a much higher ground motion.

MR. LINDBLAD: So while that has broadened your commercial attractiveness, it has also introduced additional margin into the safety characteristics, is that correct?

MR. GERDES: It may have added some additional margin from a margin on structural design and potential cost. I would say that margin is not that great.

MR. LINDBLAD: So probably you are dealing with the same forces within the structure as you had before but you just have a broader soil description.

MR. GERDES: That is generally true, yes.

MR. LINDBLAD: Thank you.

[Slide.]

MR. GERDES: Again, in the definition of where these control motions are defined, the CMS 1, which is Regulatory Guide 1.60 is defined and the free field surface for the CMS 2 and CMS 3. We find them as a hypothetical rock outcrop. Those motions actually come out through the soil layers, and this is why I say, when we look at the actual motions as a spectra at the base of the foundation or the surface, even though we apply the motions of the rock outcrop and the vertical at that point of application is two-thirds of the horizontal, that the response, when it comes through the soil at the base mat or the free field, those levels of input that the plant sees are approximately equal in the horizontal and vertical directions for the CMS 2 and CMS 3 control motions.

MR. CATTON: Maybe you can help me understand a little bit. In Los Angeles when the earthquake took place, a rock outcropping was maybe six or seven miles from the epicenter. That was one of the places that they had the highest accelerations. That was in Tarzana, and a nursery, not kid nursery, but plant nursery, and yet here I see that it is reduced for the rock outcropping.

MR. BAGCHI: We will be talking to you and a few other members of your committee about the Tarzana stations recordings and so on. I do have a copy of the CDM reports. It was 1.8 G, 1.2 vertical, as I recall. As I recall, the vertical was still a little lower than the horizontal.

MR. CATTON: Those numbers were almost the highest I found in the San Fernando Valley.

MR. BAGCHI: Yes, it was the best experiment that one could ever imagine to get their hands on.

MR. CATTON: It was quite a ways away, in between the accelerations for lower. Anyway, we're going to talk about it.

MR. LINDBLAD: Can I ask you a question about the slide that you had there? Right where your fingers are?

MR. GERDES: Sure.

MR. LINDBLAD: Right where your fingers are, the left-hand side of the figure, you used the word P-wave and vertical analysis. I'm sorry, is the vertical analysis limited to just -- I understand P-wave to be a characteristic of the original seismic effort, but it doesn't shared ware motions introduce a vertical component?

MR. GERDES: I will let Scott's office address that. He can do a better job of that than I can.

MR. BORCHARDT: In the horizontal motion analysis, the P-wave vertically propagating has been assumed in the soil analysis. In an additional study with heat lines, they produced both horizontal and vertical motion. It has been conducted and shown that the response spectra are not different, not much different than the spectra when the vertical propagating SP-wave assumption has been used. The vertical propagation for SP-waves is pretty commonly done in the industry to come up with the surface motion.

MR. LINDBLAD: I was surprised to see the word P-wave on the figure. How does the P-wave enter into the soil structure interaction?

MR. BAGCHI: For the convolution of the rock outcrop motion to the surface, a P-wave is used because it has different characteristics than the SV-wave, and that is also vertically propagating from the rock outcrop to the top of the surface.

MR. LINDBLAD: Thank you.

[Slide.]

MR. GERDES: This is an overview of the three control motions. The CMS 1, we find at the free field service. CMS 2, which was the control motion that we used, which I presented three years ago. You can see it as greatly enhanced in the higher frequency content. CMS 3, also defined at the rock outcrop, which in the lower frequency range is identical to NUREG 0098. There is additional high frequency content that we have included above 8 or 9 Hertz, above the 0098 requirements.

MR. LINDBLAD: Mr. Gertes, later as we talk about activities of an operating plant or if a possible OBD experience operating basis earthquake experience, there is a reference to a CAV value, absolute velocity factor of 1.6. Can you tell me roughly what the plant is designed for compared to a CAV value of .16?

MR. CARROLL: And before that, tell me what CAV value is because I flagged it.

MR. BAGCHI: I believe we have members of the audience that have a better definition.

MR. KENNEDY: Several years ago, industry threw EPRI -- attempted to find out if there was any single ground motion characteristic that could correlate best with damage to engineered structures, and by that, I mean structures that, do you have a lateral load carrying system, sheer walls, brace frame and anchored equipment. It was found that there were several candidates that seemed to work best. Peak ground acceleration didn't work very well. Spectral acceleration in the two to 10 Hertz range worked pretty well. A term called areas intensity which is just the integration of acceleration BT over the full duration of the time history worked pretty well. It was found the one that worked best was the one we have following the CAV, cumulative absolute velocity. It's simply the integral of acceleration, absolute value of acceleration BT. That just keeps adding up velocity, and so it keeps accumulating velocity. It's purely an empirical study that shows that that worked. It has a reasonable descriptor of the onset of damage to engineering facilities and anchored equipment, even though that equipment did not have seismic design.

MR. LINBLAD: Were you going to respond to my question, as to what the design control motions have in the way of CAV value?

MR. KENNEDY: Basically, they have CAV values very much above this threshold value. I am not sure we ever bothered even calculating what they have. They would be at least two or three times this controlled one. The reason why the CAV is used as a descriptor from a damage standpoint is, we have found that low magnitude earthquakes like a magnitude four earthquake can have very high acceleration for very short durations. The very short duration just doesn't create damage.

The time histories being used for the evaluation of CE System 80 have long durations. I don't know, do you have a viewgraph that shows the time histories?

MR. BAGCHI: I believe I do.

MR. KENNEDY: They are durations of strong ground motion, in the neighborhood of ten seconds. This CAV value was used to eliminate from consideration ground motions with durations of less than one to two seconds. They will have a much lower cumulative absolute velocity that would be integrated over the time. They just don't build up to shorter time.

This one will have a very much larger CAV than those CAV limits. I don't know the number.

MR. BAGCHI: I just want reinforce Dr. Kennedy's statement. Recall please, that the OBE value for this plant is 1.0G and the CAV value of .16 will be one of the discriminators. The other one would be the spector of acceleration of two to ten hertz that has to be less than .2G.

I believe that with respect to the CAV value of 1.6G second this plant would have the capability of at least three times that for the SSE.

MR. LINBLAD: Thank you.

MR. CARROLL: As an aside, when the technical editor goes through this will he pick up things like all of a sudden we start talking about CAV values on page 318, with no explanation as to what it means?

MR. FRANOVICH: That is the responsibility of the project manager. When we get comments back from the technical editor and as we go through those comments, we will also be looking for technical continuity.

MR. CARROLL: You would agree with me, that some explanation of what a CAV value is should be provided?

MR. FRANOVICH: I would agree with that.

MR. CARROLL: The next item on page 318 the reference is made to the CAM shall be determined in accordance with EPRI report such and such. Is that a typo? Should that have been CAV?

MR. TERAD: That should be CAV.

MR. DAVIS: You thought that we had switched constant air monitors?

MR. CARROLL: I never have understood this seismic stuff.

[Slides.]

MR. GERDES: The next overhead I have is identical to what I presented three years ago. It basically identifies with the generation the control motion spector of two, the lower frequency range we based our shape on NUREG 0098 for 24 inches per second per G velocity. We also looked at and evaluated some information that was available at that time for estimated spectral content for Eastern North America, knowing the fact that there was effort to identify some of this high frequency content that was non-damaging to structures and equipment and believing that, and knowing the fact that if we took into account all of that high frequency content, we would have to greatly enhance the models that we used to really respond to those high frequencies which we did not believe were appropriate for design.

We decided to follow the NUREG 0098 shape in the lower area and pick up a large portion of that high frequency content say, in the ten to 25 hertz region, and then come down to the EPA value. This is identical to what I presented three years ago.

The spectral shape for the horizontal by itself, CMS2 vertical component again defined at the hypothetical rock outcrop, is two-thirds of the horizontal.

[Slides.]

MR. GERDES: I will just go through these very quickly. All of the spectral shapes for all three control motions and also the spectra generated from the artificial ground motions that were used in the design are shown in the SAR. I just show a few of these in the overheads.

Also, the power spectral densities of all three control motions were generated and are included in the SAR material. I have shown here only the correlation of the power spectral density for the CMS1, the Reg Guide 1.606 with the target spectral which is provided in the Standard Review plan Section 371, Appendix A.

MR. CARROLL: This is a probably a good time, before we get into the soil, to take our mid-morning break, isn't it?

MR. GERDES: Okay, that's fine.

MR. CARROLL: Let's return at 10:20.

[Brief recess.]

MR. CARROLL: Let's reconvene. Even though we have a formidable pile of stuff here, I have been assured that we can get through it in a big hurry, right?

MR. GERDES: I will, if I am not stopped. The material that I will be presenting next was given three years ago with little or no change. The generic soil sites that were considered, we looked at categories that we divided into A, B, C and D.

Category A, actually we have soil on the sides. The nuclear island is bounded right on the bed rock. We also looked at soil conditions where the rock was 100, 200, 300 feet below the soil surface.

I will just show one or two of the actual assigned shield wave velocities. This is case one, where the plant is bounded on the rock with soil on the sides. Sheer wave velocity varying from about 1,800 feet per second to 2,200 feet per second. The rock itself is assumed to be 5,000 feet per second.

We selected the soil profiles to try to cover and envelope potential site conditions. In doing so, we looked at various site conditions, layering, so we could get significant impedance mismatches. We actually did obtain a lot of amplification as the motions were propagated through the soil layers. The actual soil profiles were selected when we were looking only at the CMS2 control motion. We compared then, the outer surface spectra with not only the spectral shape of the control motion at the hypothetical outcrop but also with the Regulatory Guide 1.60 spectral shape which is defined at the free field.

If you look at later at your leisure the different soil profiles, the numbering, some of them you will see numbered like 3.5 or 1.5. The point five's come in because from the original set of soil profiles we looked at the spectra at the free field and compared them with the control motion and the Reg Guide 1.60 spectra in areas where we thought we had holes in there that we maybe did not have appropriate soil profile to get amplification that would challenge the structure equipment in those frequency ranges. We went back and added some soil profiles.

As you can see, the range of the soil -- the spectra at the free field from the use of control motion, CMS2 as a rock outcrop, provides amplifications and soil motions at the free field surface much greater than the Regulatory Guide 1.60 and/or the control motion that was defined at the outcrop.

It also showed the ground motion envelope of spectra at the ground surface from the CMS3. Primarily I wanted to show this because we added CMS3 control motion. One of the reasons we added it was primarily to pick up some additional low frequency content and amplification, although there is very few structures or components that really have that low a frequency content. There are some. We wanted to make sure that our overall design envelope adequately covered the low frequency range.

[Slides.]

MR. GERDES: The next two spectra shapes are actually just an envelope then of the free field surface spectra at the site location which, again, based on spectral that I showed just previously, are much greater than the Reg Guide 1.60 requirement by itself. I might add, this is really a lower bound envelope of spectra. If you are looking at spectra within a structure that you use for qualification of equipment you take an upper bound so that you envelope all of the spectra for qualification of equipment.

This is really a lower bound such that if you look at the spectra shape from all of the motions that we looked at they actually envelope above. Similarly, the vertical direction.

MR. CARROLL: So, what does this tell me about Reg Guide 1.60, that it is not conservative?

MR. GERDES: No, I would not say it is not conservative. I would say it is a spectral shape that is refined with a broad range of amplifications across a broad band. When you apply the other control motions at the rock outcrop and propagate them through each of the soil conditions, you get larger amplifications at specific frequencies that relate to those soil properties, as would occur in any real plant site.

I would not say that Reg Guide 1.60 is not conservative. In fact, I would say Regulatory Guide 1.60 is still a conservative design. Any specific earthquake is not going to have frequency content across that entire band.

[Slides.]

MR. GERDES: For the site conditions that we looked at then, although this has been chopped out, adequately covered shear soils with shear wave velocity from as low as 500 feet per second and upward, we chopped it off at 3,500 feet per second. Actually, if you look at the profiles we assumed 5,000 feet per second in our evaluation. This is not a limit here. It extends both down and to the right.

Just so you do not believe that there is an inconsistency between our shear wave velocity that we are showing here and shear wave velocity that was shown in the site parameters in Table 2.0, we identify a best estimate minimum shear wave velocity of 700 feet per second for our seismic analyses to account for variation in soil properties and uncertainties in our analyses. We have included cases as low as 500 feet per second.

[Slides.]

MR. GERDES: Again, the next two overheads that I have, I presented three years ago showing variation of shear range of properties that were presented by Seed and Idriss, and the conservative relationship selected for this project. If you have any specific questions on these Dr. Idriss is here, present, for any detail.

MR. LINBLAD: It would be a shame not to use him.

MR. GERDES: Variation of damping ratio is the same way. The range that was published, we used the lower value as a conservative bound in our analyses.

[Slides.]

MR. GERDES: The next information that I presented three years ago, the model development, the individual stick models that were used for various portions of the structure actually were developed initially finite element models were prepared for the structure for floor by floor bases. Properties for each floor level were determined, and then using those we developed stick models. This happens to be the stick model for the internal structure.

Similarly in your package there is a stick model for the shield building. For the steel containment we could not adequately obtain, or at least in our mind we could not adequately get both frequency and mode shape captured in a stick model. We actually used what looks like a fairly detailed but yet a relatively crude finite element model, so that we got better representation of the containment shell.

Likewise, to account for interaction effects between the major components of the reactor coolant system and the internal structure, both from a mass and a stiffness effect, we included a simplified representation of the reactor coolant system in our model, steam generators, interconnected hot leg piping, 42 inch piping, very stiff reactor vessel modeled into the structural model that was used in the soil structure interaction analyses.

MR. CARROLL: The people who were developing these models were given the right drawings? There is no image problems here?

MR. GERDES: No, they were the right drawings. A schematic representation of the nuclear island model -- and I point out, this is just a schematic representation, the soil structure and interaction analysis -- we have the layered soil media. We have the representative stick models of the shield building, the internal structure steel containment vessel and NSSS. Also, representations on the other structure portions of the nuclear island which we called the annex building, which I will show later on in more detail.

These are just two representative sticks shown in the schematic representation.

MR. DAVIS: Excuse me. I noticed in the previous slide you do not seem to have the pressure represented. Is that a non-factor in these analyses?

MR. GERDES: The mass is represented in the structure from a structural aspect, the soil structure response aspect. The stiffness effects have no real effect on the response of the structure. The mass of the pressurizer is included, the same as the mass of the reactor coolant pumps, are included in the models.

MR. CATTON: How well do you have to characterize the soil media to do an analysis like that?

MR. GERDES: You mean, the specific layering and depth of layers in the soil structure interaction analysis?

MR. CATTON: I guess you have to do an analysis like that, and you have to know the soil compressibility.

MR. DERMITZAKIS: As far as characterizing the layers, thicknesses vary from two and one-half feet to about ten feet per layer and there are multiple layers, depending on the depth of the site from surface to bed rock.

MR. CATTON: What do you do? Do you input the characteristics into the analysis?

MR. DERMITZAKIS: It's mass density, vertical velocity, horizontal velocity and material damping.

MR. CATTON: What do you do if one of these layers is in there at an angle?

MR. BAGCHI: I think you did not get a satisfactory answer to your question. It is a generic design. There is no site. You have to rely on parametric variation, what causes changes in the structural forces in moments ard things like that, and full response. Those were looked at very carefully by the staff.

The representation of the soil is important. But looking at what kinds of variations of different kinds of layers and their properties is important to the structural response. That is what guided their analysis and consideration of different kinds of soil conditions.

MR. CATTON: My question wasn't that specific. I was trying to understand how they do the calculations.

MR. BAGCHI: This is a generic site, generic basis.

MR. CATTON: You have to make some assumptions then?

MR. BAGCHI: Yes, sir.

MR. CATTON: Do they assume it's uniform?

MR. BAGCHI: They are assumed to be uniform.

MR. CATTON: Now, if this is anything like acoustics, there's a possibility of focusing. Do they worry about that or do you just put in a factor, or what?

MR. BAGCHI: Focusing would be related to the site aspect, not just under the area under the foundation itself.

It is defined in terms of the hazard for the site.

MR. CATTON: I understand that. I am just trying to get a picture of how they do it. When somebody comes in and is going to build a plant, are there going to be certain requirements in what they do to evaluate the goodness or badness of the model?

MR. BAGCHI: Absolutely. That is site specific. Not goodness of the model.

MR. CATTON: But the fact that the modeling is done with a uniform soil characteristic in some depth of the rock, are they going to make sure that whatever was done is adequate by doing --

MR. BAGCHI: There is a detailed flow chart that says how the site specific site has to be found acceptable. Maybe Lyle could give you that.

MR. GERDES: Also, for the models that I showed were for the nuclear island which of course is the most detailed dynamic model. Also, for other category one structures the diesel fuel storage structure component cooling water structure which are in the vicinity of the nuclear island, we used two-dimensional models that we could capture and account for the interaction of the nuclear island to the soil to the other category one structures.

So that, the response of the other category one structures do account for the interaction affects from the nuclear island.

MR. CARROLL: You jogged my memory when you mentioned diesel fuel oil storage. Where is the oil for the gas turbine stored? Is that in the same storage or different

MR. GERDES: That is in a separate storage that would be in the vicinity of the gas turbine building.

MR. CARROLL: What is its seismic requirements?

MR. GERDES: I cannot answer if we have identified specific seismic requirements for that.

MR. LINBLAD: Is it buried or above ground, which?

MR. CARROLL: I think it is buried.

MR. LINBLAD: Then liquefaction is a bigger problem than anything else. Don't worry about it if it is buried.

MR. GERDES: I believe we will have to get back to you on that question.

[Slides.]

MR. GERDES: In the dynamic analysis soil structure interaction analysis the computer program used was the SASSI computer program. Again, that is a state of the art soil structure interaction analysis code. To the best of my knowledge it is the soil structure interaction code that is being used by all three vendors for advanced nuclear design.

MR. CATTON: Is the diesel storage above ground?

MR. GERDES: The diesel fuel storage structure is essentially below ground.

MR. MICHELSON: Below ground?

MR. CROM: It is a sunken building. Seventeen feet is the base.

MR. MICHELSON: A sunken grade building.

MR. CROM: The mat of the building is 17 feet below grade.

MR. MICHELSON: Is it completely covered with dirt, the building, the structure?

MR. CROM: No, the building comes up.

MR. MICHELSON: A hole in the ground, and you put the building in the hole. You do not berm it back up again.

MR. CROM: Yes. In other words, it is regraded. We don't just leave a trench around the building.

MR. MICHELSON: Is it completely covered when you are done?

MR. CROM: The building comes up above the grade level.

MR. MICHELSON: How far?

MR. CROM: I will have to look at the dimensions. It's in the SAR.

MR. MICHELSON: I didn't find it on the site plan.

MR. GERDES: I may have figures later on in the presentation that deals essentially with what those distances are.

MR. CARROLL: I just opened to it. You have not numbered your figures. I cannot tell Carl where to go.

MR. MICHELSON: I am looking at Volume 1.

MR. CARROLL: I am looking at a figure in the package.

MR. GERDES: I will get you that figure later, unless you have a specific question on it for this portion of the presentation.

MR. CATTON: It looks like it's all concrete, too.

MR. GERDES: Yes.

MR. LINBLAD: Yes, it is.

MR. CARROLL: Let's move on.

[Slides.]

MR. GERDES: Again, the general design process and amplification of the control margins for the process itself, some of which I have gone over already. The development of the model including the definition of the soil properties, definition of the control motion. This happens to be CMS1 which is designed right at the free field soil surface. The output from the dynamic analysis then are acceleration, velocities, loads, placements that are used as input for the structural subsystem and equipment analysis.

The CMS2 and 3 application is very similar as far as exactly the same in the development of the model. As pointed out before, the control motions that we find in the hypothetical rock outcrop propagated up through the soil area through the free field -- again, that free field motion is used as input at the free field surface in the SASSI computer analysis.

Next, I will just show some of the typical response spectra. There are a number of them in your package. I am not going to show them all. For each of the control motions for each of the three directions analyses were performed for each of the soil conditions. This happens to be response at the top of the basemat for the Regulatory Guide 1.60 control motion, east/west direction. As you can see, the response of the structure for each of the identified soil profiles is quite different.

Of course, for the design purposes the envelope that is used for design, the dash line, if you have any question on that, the dash line represents the case for a fixed base analysis where the control motion was applied directly to the base of the structure.

MR. LINBLAD: What is your expected period of the building?

MR. GERDES: That varies, from structure to structure.

MR. LINBLAD: For the nuclear island.

MR. DERMITZAKIS: The overall nuclear island from fundamental frequencies, about 700.

MR. LINBLAD: Thank you.

MR. CARROLL: Now, we have north, south, east and west for each case. Wouldn't it make a difference how the equipment was oriented? I see you get a different spectrum with north/south versus east/west. How do you know what direction the earthquake is coming from?

MR. GERDES: Well, the difference in response to a large extent is the fact that your structures are not symmetrical. They are going to respond differently in the different directions.

MR. CARROLL: The free field --

MR. GERDES: Essentially the same.

MR. CARROLL: Essentially the same, all the way around. It's just the way the building --

MR. GERDES: They are statistically independent but they envelope the same design spectra.

MR. CARROLL: I got you.

[Slides.]

MR. GERDES: In the interest of time, unless there is a question, I will not go through the next set of spectra that I have in the package. They are just similar, just sets of spectra for different locations for the various directions.

You get past the individual spectra, I have the envelope spectra for some selected locations. This happens to be the elevation in the control room, north/south direction. This is an envelope of response for the analyses from all of the site profiles for all three control motions.

[Slides.]

MR. GERDES: Similarly, east/west direction. Again as you can see, the responses are somewhat different. It's primarily the fact that the structures are not symmetrical in the two directions. Again, I will not show them all. This happens to be similar envelope of spectra. This is in the interior structure of the containment at elevation 146.

This happens to be response spectra for the diesel fuel storage structure, elevation 78, north/south direction, five percent damping. Again, I showed the envelope spectra for the other two.

MR. CARROLL: The fuel tanks themselves survived.

MR. GERDES: Yes.

[Slides.]

MR. GERDES: Next, I will not expect you to be able to read this. There is in the package, this.

MR. CATTON: With these kinds of analyses, how much resolution do you get with respect to inside the building for example? The reason I ask is, we were just experiencing an earthquake as you well know. What I found very interesting was, inside the structure there were local load points where, apparently there as shaking. The amplitudes were much different than anywhere else.

In this very fine structure one of the people that everybody here knows, David Okrent, his office was devastated and the offices on either side were just fine. That means the resolution of about 15 or 20 feet.

MR. LINBLAD: He stacks his books higher than everybody else.

MR. GERDES: The spectra that I am showing are envelope spectra at different floor elevations which, of course, the structures are fairly rigid in the plane of the floors. For any equipment that would be located on wall panels you would have to do a more detailed analysis of that or at least an evaluation for that piece of equipment and take into account the flexibility of that wall panel with the natural frequency and response characteristics where, if they are in the amplified region.

MR. CATTON: If you look at a floor for example, if this was a floor, you look for node points within it, or you just move the whole floor as a rigid rectangular surface.

MR. GERDES: In the plane of the floor it responds rigidly. We also look at floor flexibility for the floor direction.

MR. ESFANDOR: Generally, the corner offices seem to have more damage. In generating the infrastructure the extremes of the floor elevation, because the response was also included and added, extremes of the structure already incorporated.

MR. GERDES: Keep in mind, these structures are extremely rugged structures, compared to office buildings that you may be looking at and evaluating in the recent California earthquakes.

MR. LINBLAD: I think I have seen similar reports as to what you were talking about. I think the thing to recognize is that librarians find that after they have anchored the bookcases the bookcases survive very well but all of the books are on the floor. The same thing is going to happen. We are here talking about anchored equipment rather than loose equipment.

MR. CATTON: I understand the difference. In this particular case his bookcases were probably anchored better than most. They ripped right out of the wall. For some reason his office is about midway along one wall. I don't know whether it was because the kinds of deformation that the building underwent that happened to be some kind of a node point or midway between two node points, so that he got the maximum amplitude which was quite a variation within the single level of the building.

MR. GERDES: I guarantee you, it was not designed to the same criteria that we are designing to.

MR. CATTON: I know that. Still, the resolution I think -- the question is not --

MR. GERDES: That's why I say, when you get into detailed design and specific equipment that may be located where you have vertical floor flexibility or where you may have amplification due to wall panels, it has to be evenly weighted.

MR. CATTON: Another example was in one of the overpasses. Right in the center of the overpass it was almost two G's vertical. That was due to flexibility. The overpass is a very rigid structure.

MR. GERDES: The site acceptance criteria which was referred to earlier, first of all, for any specific site it --

MR. CARROLL: This is the flowchart that Goutom mentioned.

MR. GERDES: Yes. For any specific site the applicant will have to define the site characteristics. The site evaluations that are required of past plants will still be required for certified plants. We have two different arms shown down here, one for a rock site and one for a soil site.

Based on the site characteristics the applicant will have to develop site specific spectra, either at the rock or at the free field surface at the site location. For a rock site you would compare the site specific rock spectra to the envelope, CMS1, CMS2, CMS3 spectra. That is because of the System 80 plus for rock sites has been evaluated with each of these three control motions being applied directly through the base of the structure.

For a specific soil site you would compare the site specific surface spectra and the horizontal directions and vertical directions to the envelope of the CMS1, 2 and 3 surface spectra. In either case, the rock site or the soil site, if that comparison shows that the site specific spectra are enveloped for what was used in the design of System 80 plus. The site is enveloped by the System 80 plus envelope that has been used. Design System 80 plus is certified for that site. It is true, for either a rock site or a soil site.

If they are not totally enveloped the evaluation is done by comparing responses to the site specific requirements to some selected locations which are defined in CSAR Section 2.5. If there are no amplifications more than ten percent over the design envelope then the System 80 plus design is adequate.

If it exceeds by more than ten percent at any location then the site is not enveloped by the System 80 plus design. That does not mean that the System 80 plus design may not be adequate for that site. Definitely, a site specific evaluation would have to be performed to show that the structure's components are adequate for that site.

[Slides.]

MR. GERDES: Next, it may be a little bit out of order from what the schedule identifies. This concludes the portion that I had on the seismic. I believe Dave Finnicum has arrived. I believe this is the appropriate portion for him to present on briefly, what was performed for a seismic margin assessment, before we go into some of the structural designs.

MR. CARROLL: That would be fine.

MR. FINNICUM: My name is Dave Finnicum. I am the probabilistic risk assessment project manager for System 80 Plus. I have been with CE since 1975, and have been involved in the reliability risk assessment of nuclear power plants throughout all of that time. My work experience began in 1969 in the aerospace industry, where I was also involved in reliability and risk assessment.

[Slides.]

MR. FINNICUM: What I am going to talk about is the seismic margins assessment performed for System 80 Plus.

Basically, we started out working -- we did a probabilistic seismic margins assessment rather than the EPRI standard approach. We started out by using our Level 1 fault tree models, and modifying them to add in seismic value of components and structures and components within the model.

We then looked at the structures to identify structural values that could affect our equipment. From that, we developed a list of seismic equipment for which we would need fragility information.

We then constructed our seismic event trees. The seismic event tree started out with a hierarchy tree based on the NUREG CR-4840 methodology which is the NUREG 1150 external events evaluation. We started with the most severe element as the highest on the hierarchy and working to essentially a transient. Then, for each of the elements on that hierarchy tree we developed a standard event tree for use with our fault tree models.

What we then did is constructed the overall fault tree, consisting of our representation of the seismic event tree for the initiator, and used the fault tree linking to get the cutsets for that core damage sequence for seismic event. During this portion we essentially set the failure rate for seismic events at .01, just so that we could generate cutsets.

At this point in time the HCLPF values our high confidence/low probability of failure values were generated for the structures in System 80 Plus and the components for which we had seismic failures in the models. The values were calculated using the EPRI CDFM methodology. They were calculated using a review level earthquake of .6G and using the modified 0098 spectral shape.

The structural response curve that was shown here was used as a basis for calculation of our HCLPF values. The base case we did was the CMS2 control motion for the rock side. We also did comparison analysis for selected other spectra in the soil cases.

[Slides.]

MR. FINNICUM: Once we had the HCLPF value for the components and structures we pulled these into the cutsets we had generated from the fault tree models to generate the HCLPF values at the cutset level and at the core damage sequence level, and finally at the plant level. In this case we were using the MIN-MAX approach. In this case the HCLPF for a sequence cutset is defined to be the maximum of the HCLPF of the components within that sequence.

For an overall sequence the HCLPF for that sequence is the minimum of the HCLPF for all of its cutsets. Finally, the HCLPF for the plant is the minimum of all of the sequence HCLPF's. We also had cutsets containing both seismic failures and random failures. These were tracked separately. What the fixed cutset shows is the probability of handling a lower plant HCLPF should a selected set of random failures also occur.

[Slides.]

MR. FINNICUM: Basically, the results we were able to demonstrate is a plant HCLPF of 0.73G for the CMS3 site, which was the limiting site. This is as compared to the goal of 0.5G which is 1.67 times the design basis earthquake. The dominant contributor in the model was seismically induced sliding and overturning of the containment shell which was assumed to result directly in core damage.

The second dominant seismic sequence was a LOCA in excess of ECCS capability with an HCLPF of 0.86G. In this case it was assumed that a seismically induced failure of the steam generator supports would result in failing of the RCS cooling piping and lead to a LOCA that was not mitigated, and also leading directly to core damage.

MR LINBLAD: Was there any indication in the scenarios that you developed that an earthquake would cause some instability in the neutron flux of the reactor itself?

MR. FINNICUM: No, we did not look at that.

MR. LINBLAD: You did not look at it, or you rejected it?

MR. FINNICUM: We modeled the ATWS. We did not model the neutron instability.

MR. CATTON: Why would you ask that, because you shake the internals?

MR. LINBLAD: I asked that, because I had seen something in the staff's proposal SER following an OBE experience to watch the reactor flux and I was troubled by that, wondering whether the designer thought it could happen.

MR. CATTON: I believe the staff is going to address that question.

MR. BAGCHI: I can offer one reason for that. We were looking at both OBE inspection of the plant. As a matter of fact, in Japan it was experienced in a BWR. Whether or not it is feasible in a BWR, I think not.

MR. CARROLL: While we are still on this one, what you are referring to is on page 3-20 -- it jumped out at me, too. It does state that a check of the reactor's stability should be made.

MR. LINBLAD: It wasn't clear to me whether this was following the earthquake or in the course of the earthquake. Could I ask the staff if that is what was intended?

MR. BAGCHI: I am sorry sir, one more time.

MR. LINBLAD: The references to a plant inspection and the added staff comment on top of what the EPRI report called for was that the control room should watch the flux monitors, neutron monitors, to see if there was an instability present, to see that they were stable.

My question is, does this happen during the shaking of the earthquake or following the earthquake, when the plant inspection is being done.

MR. BAGCHI: We were trying to cover the incident that might happen following the earthquake. In an actual event what happened was, the reactor was shutdown as a result of this additional flux.

MR. LINBLAD: Did we know it was the flux, or erhaps the instrumentation?

MR. BAGCHI: We knew it was not instrumentation. We asked that.

MR. LINBLAD: The intention is to examine the meters, not during the earthquake but following the earthquake.

MR. BAGCHI: That is correct.

MR. CARROLL: Why did this particular reactor scram, presumably because of high flux? What caused the high flux?

MR. BAGCHI: Earthquake, as a contributor, is what is speculated. Nobody knows the real reasons.

MR. CARROLL: Did you look around?

MR. BAGCHI: No. It must have been splashing water inside the vessel, but who knows where the LOCA was.

MR. CARROLL: You probably know what the level was with instrumentation.

MR. BAGCHI: Instantaneously.

MR. CATTON: It is difficult to imagine sloshing inside.

MR. LINBLAD: Mr. Bagchi, when you speak of the neutron flux being stable, do you mean it in the sense of oscillations or just at the same level as before the earthquake?

MR. BAGCHI: Oscillations, any indication that the core is not stable.

MR. LINBLAD: Stable, in the sense of oscillation of radial or axial --

MR. BAGCHI: Yes.

MR. LINBLAD: Thank you.

MR. MICHELSON: I have a seismic question. Are we designing or selecting sites that have a potential for ground movement? By that, I mean ground cracking or whatever?

MR. BAGCHI: I think in the parameters it is excluded.

MR. MICHELSON: You do not take a site where there can be any relative motion of the earth?

MR. BAGCHI: Yes, sir.

MR. LINBLAD: That is called vibration.

MR. MICHELSON: Let me tell you what I am worried about, and then I will tell you it is a non-problem. We are going to use a gravity feed from the fuel oil tanks out in the yard to the diesel engines, and that is going to be a small pipe, and inch and one-half or something, probably not very big. It could be six inches. That is a big pipe. I thought it would be smaller than that.

The gravity line will not be buried in the ground?

MR. BAGCHI: The pipe will not be buried in the ground by itself. It goes through a tunnel.

MR. MICHELSON: No.

MR. CROM: It's described in the diesel fuel section, and it will be in a tunnel.

MR. MICHELSON: You need to correct your drawing.

MR. CROM: It does not appear in the drawing because the locations would be site specific.

MR. MICHELSON: I just looked at it on the drawing. It shows on the drawing to the tank building.

MR. BAGCHI: I can share with you what we did. The staff review asked these questions, and it turned out that the piping design criteria for interior piping is supposed to conclude the effects. If there is any deterioration of the soil causing a change between two anchor points that is included in design.

MR. MICHELSON: I guess I cannot tell positively. It just says that it is going to exit in structures underground -- exits and entrance will be adjusted.

MR. BAGCHI: The System 80 requirement will not allow them to put the pipe --

MR. MICHELSON: I am asking for this design.

MR. BAGCHI: Yes, sir.

MR. MICHELSON: I can find out somewhere by reading it? I would not find it out with this drawing.

MR. CROM: I believe it is in the diesel fuel oil section.

MR. MICHELSON: I am looking at the plant drawing.

MR. CROM: I understand. It's not in the structure section, it's in the system, Chapter 9.

MR. MICHELSON: If there is a chase it ought to be shown as a structure interfacing with the building. It does not.

RITTERBUSCH: We will help you either find it, and if it is not clear we will make it clear.

MR. MICHELSON: You ought to make the drawing clear, as well.

MR. CARROLL: You had a question.

MR. DAVIS: I forgot what it was. On page 19.57 the statement that you made is that you did not change the operator error rates in your seismic margin assessment to account for the increased stress, the potentially increased stress during a seismic event. Do you think this would make a difference, if you had tried to account for that? Did you do a sensitivity study on human error rates as part of this analysis?

The reason I ask is, there has been some recent activity in that area and some are trying to account for detrimental effect on human errors due to the seismic event itself.

MR. FINNICUM: No, I did not do a sensitivity analysis on that. I have recently heard of these studies where I believe the treatment is to increase the operator error rate by an order of magnitude. In the basic plant HCLPF it would not be effective. Again, this is purely seismic contribution. In the mixed cutsets it would not affect the HCLPF portions. We did not look at that per se. It could be looked at.

MR. DAVIS: Thank you.

MR. CARROLL: Moving on.

MR. LINBLAD: Thank you.

MR. GERDES: In the structural design I have some figures that I will show later. The seismic category one nuclear island structures are divided up. Although it is really one integral building we address it as two separate areas. In the reactor building itself are the major components and there are the steel containment building, shield buildings, the subsphere area and the containment internal structures. Nuclear annex, again, some of the major areas is CVCS maintenance areas, fuel area, diesel generator area, emergency feedwater, main steam valve and control areas.

Non-nuclear island, structure seismic category one, station service water pump structure was not part of the certified design. It is site dependent. We have identified in the SAR some design criteria, the diesel fuel storage structure, component cooling water, heat exchanger structure and tunnel, and buried cable tunnels and conduit banks.

Seismic category two structures, rad waste building, turbine building, outdoor tank --

MR. LINBLAD: What has to be preserved with the buried cable tunnel?

MR. GERDES: The tunnel itself has to maintain structural integrity.

MR. LINBLAD: And, water tight integrity?

MR. GERDES: It cannot be flooded; am I correct?

MR. OSWALD: That is correct. It is also particularly for missile protection, the tunnels, where you would have two related cables particularly going out to the auxillary structures off the main nuclear island.

MR. LINBLAD: I am trying to picture the seismic for the cable tunnel aside from the site missile damage. You say it is mostly missile protection.

MR. OSWALD: That is correct.

MR. CARROLL: What is a conduit bank?

MR. OSWALD: Just like a cable tunnel, you may have conduit running through there instead of just cables.

MR. LINBLAD: You are saying that all vaults have concrete covers rather than checker plate; is that basically right?

MR. OSWALD: For seismic category one conduit bank or cable tunnel it would be concrete.

MR. MICHELSON: I could not find them on drawings. Maybe there are drawings that show them. Are these at grade level and below, or are they very deep? Are they various elevations below grade?

MR. TOKELSON: Generally, they are buried underground.

MR. MICHELSON: That's okay, to get from one structure to another. But you are saying then, they never go any deeper than a couple of feet underground?

MR. TOKELSON: Generally, that's true.

MR. MICHELSON: Then, go down to the 50 foot elevation before they enter the building.

MR. OSWALD: There are some conduit banks, cable conduit banks, that are attached to the nuclear island structure. The intention of those tunnels are to route cable between structures and to get cable outside of the nuclear island. They go down. They stop at elevation 70. They don't go down to 50 right now on the design.

MR. MICHELSON: They are still going 20 feet underground.

MR. OSWALD: That is correct. They are vertical at that point, and are attached to the nuclear island.

MR. MICHELSON: You have penetrations for the nuclear island? That's where I would like to know that those penetrations are qualified for emergencies which can happen. Any tunnel can spring a leak and it could be totally flooded. You have no assurance that you can keep the water out of both sides. You assume one side could become flooded.

MR. OSWALD: These tunnels are an integral part of the nuclear island themselves.

MR. MICHELSON: How can they be, when they go out to the structures that are many feet away?

MR. OSWALD: Once they reach the elevation where they would go out, that is correct.

MR. MICHELSON: If you wanted to evaluate the safety of these interconnecting tunnels one has to have enough knowledge of them to know where they are and so forth. Is that anywhere in the SSAR? Can I find these tunnel routings and elevations somewhere?

MR. GERDES: That tunnel routing would be somewhat site specific.

MR. MICHELSON: Let me just say, the routing at the interface with the seismic category one structure, that would not be site specific unless you are also changing it with the site. That is a different animal. You have to have an interface.

MR. STAMM: I don't think we specifically show the tunnels. There is no question, they obviously need to be designed to hydraulic pressure based on the design site parameters that we talked about. Given the connections although not specifically, they have to be flexible to allow for differential movement plus the hydraulic pressure.

MR. MICHELSON: And, to deal with the non-seismic piping that might be in there. Depending on the particular tunnel, if there is not seismic piping, penetration can still happen.

MR. STAMM: That is correct.

MR. MICHELSON: There has to be no motion to prevent penetration. I don't find these words anywhere. Tell me where they are, and I will read them.

MR. STAMM: We will see if we can come up with references. I am not sure they are all there.

MR. LINBLAD: While you are there responding to this, we were talking earlier about a site with high groundwater in it. There is a requirement by the staff that the site be de-watered with a safety grade de-watering system. Does that include sumps as well, deep sumps to de-water.

MR. GERDES: We are not aware that there is a requirement for a de-watering system. In fact, we have no requirement for a de-watering system.

MR. LINBLAD: I am sorry, I misspoke. I will look and see what I thought I understood.

MR. CARROLL: I thought I read it in the same place somewhere, Bill.

MR. LINBLAD: I will look at the reference and bring it up later in the day.

MR. GERDES: Some of the major codes and standards for the category one structures, concrete ACI 349 supplemented by 318.

MR. MICHELSON: Excuse me. One more thing I did not get to on the previous slide. You talked about the component cooling water heat exchanger structure. Do we know where that tunnel is? That has some big energy piping in it, I assume. The pumping station is someplace with the nuclear island.

MR. GERDES: Again, specifically, there is not a specific location.

MR. MICHELSON: Do you know what elevation it comes into the building?

MR. OSWALD: That tunnel is specifically identified on the drawings. That is one of the items that goes down and runs vertically.

MR. MICHELSON: Outside the nuclear island? It shows where it interfaces with the nuclear island?

MR. OSWALD: It shows where it interfaces with the vertical shaft into the nuclear island. I don't believe you will find the horizontal run out to the component cooling water structure itself on these drawings.

MR. MICHELSON: I am in total ignorance, so at the next break you can tell me what you are talking about.

MR. GERDES: Again, to identify some of the major codes and standards used for the concrete and structural design. Also, locations for loads and load combination requirements.

[Slides.]

MR. GERDES: The number of pictures depicting the nuclear island structures, again, these are all in the SAR. Before, when I referred to the reactor building, this portion of the building here, this is the subsphere shield building steel containment internal structures. Integrated with that is the surrounding structures which we often refer to as the nuclear annex which, again, has specific maintenance areas, control room areas. These are identified on the drawings and the SAR.

MR. MICHELSON: With the control room you go down to what you call the final instrument equipment room, roughly at the 50 foot elevation? I see no flood barriers protecting it from the balance of the nuclear island. Are there some, but I just don't see them. I see the three hour fire barrier.

MR. CROM: There are barriers, and I will show them to you in my presentation for internal floods.

MR. MICHELSON: The drawing is not quite right.

MR. CROM: It is shown on elevation 50, the flood barrier between --

MR. MICHELSON: That is elevation at 50 in the drawing.

MR. CROM: You need to look at the plant elevation. I will show it to you during my presentation.

MR. MICHELSON: I will take your word for it, for the moment.

[Slides.]

MR. GERDES: This is the plant elevation at the top of the basemat.

MR. MICHELSON: That's not elevation at 50. Now, I guess you are going to show me where the flood barriers are or somebody else will.

MR. GERDES: Tom is going to address this in his presentation.

MR. MICHELSON: There is another thing there identified there as the divisional walls. As near as I can tell, that goes straight down the middle of the building more or less. That is the only wall you call a divisional wall?

MR. GERDES: This is the divisional wall, correct.

MR. MICHELSON: Whenever I hear somebody talking about the divisional wall it is just that wall; is that correct?

MR. GERDES: Yes.

MR. MICHELSON: Essentially, this is a two division plant with a barrier between the two divisions.

MR. GERDES: Yes.

MR. CATTON: What about the north/south line?

MR. MICHELSON: They don't count that.

MR. CATTON: It isn't a containment --

MR. CROM: Mr. Michelson, you say it is two divisional. However, the additional redundancy -- and, again, I will got into it in my presentation.

MR. MICHELSON: I appreciate there is redundancy within the two divisions. But for flooding purposes it is two divisions.

MR. CROM: It can be treated both ways, and I will go into that in my presentation.

MR. MICHELSON: There's more to it than meets the eye here.

MR. GERDES: Again, what I have here are just the figures that are in the SAR. This happens to be a nuclear island structure plant at the operating floor. As identified earlier in my presentation, the purpose of this overhead is strictly to identify the location and orientation of the turbine building itself with respect to the nuclear island structure, and the identification of the low trajectory turbine missile path.

MR. MICHELSON: How much differential motion do you expect to be in the turbine building nuclear island, and the same question for the rad waste building. You show the six inch gap. You expect differential motion?

MR. GERDES: You always have a small amount of differential motion that will be dependent on the specific site itself. These are very rigid structures. The motion itself, I don't have that number. It has been calculated.

MR. MICHELSON: Particularly for the rad waste building, if you are getting differential motion how do you protect the piping that is going through the walls?

MR. GERDES: That is accounted for, and that is part of the piping design criteria. You account for the differential motion.

MR. MICHELSON: Is there some kind of a flexible penetration. There is too short of a distance to put a flexible pipe in. It has to be some sort of a flexible penetration. I couldn't find any discussion. We need a discussion of how the penetrations -- if you don't have any motion great. But, I suspect you do.

MR. STAMM: I think I can answer that. The piping is not designed -- what we have is design criteria. The differential motion goes into the design criteria. There are two basic ways of taking that up which are to design the system with sufficient flexibility or put in some kind of expansion connection. That would be done on a case by case basis.

The six inches was selected because we have a very high confidence that would conservatively envelope any motion of the two buildings.

MR. MICHELSON: It will keep the buildings from having a problem, but that does not necessarily take care of the piping. I assume the six inch gap can have groundwater in it. It's not a water excluded area. Unless there is a spec that says this gap will actually have a damper on it, you can't get any water in it and so forth. Is this a water excluded area, or can groundwater be in the gap between the buildings.

MR. STAMM: The six inch gap itself is not watertight. However, the pipe tunnels where we would have pipe tunnels going from one building to another, would be watertight connections.

MR. MICHELSON: Those tunnels had better take the relative building motion. It's hard to build a tunnel between two concrete walls that can withstand the differential motions. You can get the flavor of my concern, and I hope the staff does.

MR. BAGCHI: Mr. Michelson, we have asked for details of a tunnel design. It did not yet show up in the SSAR. We expect it to show up. The dynamic pressure on the tunnel walls is going to be very substantial. Also, the criteria actually calls for a combination of actual motion to relative motion.

MR. MICHELSON: I did not find it, but when we get it we can talk about it.

MR. CARROLL: Back to the turbine missile drawing. You have a favorable orientation. Would you agree with the staff's statement, that with respect to the reactor building the turbine system is created so that any possible turbine missile will not strike the reactor building, any postulated?

MR. GERDES: Any reasonably postulated turbine missile has a reasonable possibility of occurring. I would not say that -- you could not hypothesize that there could be some missile coming out of the turbine.

MR. LINBLAD: Mr. Gerdes, your description of the turbine missile path is limited to low trajectory. Is there some other missile path, other than the low trajectory missile path?

MR. GERDES: I believe that is the only one. I am not a turbine expert.

MR. LINBLAD: Why is the descriptor required on the drawing? It suggests to me that there must be a high trajectory turbine missile path.

MR. CARROLL: Poor choice of terminology.

MR. GERDES: Turbine missile path.

MR. LINBLAD: I think maybe that's the proper terminology. That's what I am trying to understand.

MR. DAVIS: Is it because there's not any equipment in the high trajectory path?

MR. LINBLAD: What goes up must come down.

MR. DAVIS: You are suggesting damage on re-entry, but it will be out, away from the building, won't it?

MR. LINBLAD: Never mind.

MR. CARROLL: The staff statement that I was concerned about is on page 3-41.

MR. FRANOVICH: Yes, the staff has noted that.

[Slides.]

MR. GERDES: Likewise, the purpose of this overview is to show the orientation of the rad waste building, again, with the nuclear island structures.

MR. LINBLAD: Is there any requirement that this structure not fall within the turbine missile path of the previous -- you only show the relationship of the nuclear island.

MR. GERDES: The turbine building is over here. The turbine missile paths are over in this area.

MR. LINBLAD: Thank you.

[Slides.]

MR. GERDES: In your package you have a view of the component building water heat exchanger structure, the diesel fuel storage structure. There was a question regarding the embedment. It does not give a dimension of the above ground here, but you can get a general interpretation of the portion that was embedded and the portion that is above ground.

MR. CARROLL: About half in and half out. The equipment room is for the transfer pumps.

MR. STAMM: The equipment room is for the supply pumps, off flow from the tank and ventilation equipment.

MR. GERDES: The equipment room itself is non-seismic category one. The rest of the stuff here is seismic category one, the rest of the structure.

MR. STAMM: Also, recirculation and the cleanup loop.

MR. CARROLL: You are going to provide us with some information on the fuel storage for the combustion gas turbine.

MR. GERDES: Yes, we will. The analysis of the structure, it uses static finite element model in general, for the nuclear island. For seismic you use equivalent static methods using the dynamic analysis results. These results include the effect of structure to structure and soil to structure interaction. Also, apply other global loads, mass of destruction equipment, tornado, wind, large pipe rupture, large fluid masses.

From the large global finite element models we use local models to perform the more detailed analyses to account for local effect. This is out of plane bending effects. The schematic of the nuclear island finite element model that was developed for applying global loads was to get a loading for the structural elements.

[Slides.]

MR. GERDES: The results from the seismic results from the seismic analysis, the maximum accelerations were applied to this finite element model to determine loads throughout the structure. We also compared the overall base shears and moments on this structure with the total base shear end moment, when you sum up the base shears and moments from each of the stick elements from the dynamic analysis model.

We have a minimum conservatism of about 30 percent over maximum shears of moments that were developed from any of the soil cases from the dynamic analysis. We have an additional conservative factor of about 35 percent built in. For some soil cases it's greater than that.

MR. LINBLAD: Mr. Gerdes, this is quite a massive foundation involved in this. But as I understand your description, you have not taken any advantage of considerations that are sometimes called incoherences or chill effects; is that right?

MR. DERMITZAKIS: Incoherence effects were considered and was the parametric study concerning inclined waves as the source of the seismic motion. Therefore, using inclined waves in one part of the structure is different than the part of the structure at the right end. The structure response spectra showed very little difference when they were developed using the computed motion.

MR. LINBLAD: Let me ask my question a different way. You have not reduced peak ground accelerations into the building by virtue of incoherence assumptions.

Mr. DERMITZAKIS: No.

MR. LINBLAD: Thank you.

[Slides.]

MR. GERDES: In addition to obtaining the overall structural loads and load requirements we also selected certain areas which we performed detailed design. In the nuclear island we selected 13 structural areas for detailed design. We also evaluated all of the shear walls, that they could adequately or were adequately sized to accommodate the required loadings.

Non-nuclear island, we looked in detail at diesel fuel storage structure.

MR. CARROLL: But not the tunnel?

MR. GERDES: Component cooling water heat exchangers and tunnel. We only looked in detail at one tunnel cross section.

MR. CARROLL: Do you think that envelopes the tunnel, for example, for the diesel fuel storage?

MR. GERDES: Again, we are not performing detailed design of all of the structures for certification. We are selecting what we determined to be critical areas to evaluate so that when the final detailed design is performed the arrangement and size of the structures were adequate.

MR. CARROLL: The COL holder will have to do a detailed analysis of the tunnel connecting the diesel fuel storage to the --

MR. GERDES: The COL applicant will have to perform the detailed design of all of the structures. He has to meet the design criteria that have been identified for certification in the SAR.

MR. CARROLL: Can I find design criteria for the tunnel, connecting the diesel fuel storage to the nuclear island?

MR. GERDES: Yes, there are design criteria.

MR. CARROLL: I will find that if I look in the right place in the SAR?

MR. GERDES: Right. Also, there is an Appendix in Section 3.8 dedicated to the design criteria for seismic category structures, Appendix 3.8(a) that has all of the criteria for seismic category one steel and concrete requirements.

MR. CATTON: When you treat the seismic input is wave length a consideration? The distance between the peaks, is that a consideration?

MR. GERDES: That was the incoherence argument.

MR. CATTON: But whether you can reduce the impact would depend on the wave length.

MR. LINBLAD: I think Mr. Kennedy wants to respond to that.

MR. KENNEDY: In the design the ground motion is assumed to be vertically propagating, so it arose at all times in the foundation at the same time. For the design process there is no statistical incoherence of the ground motion. There is no horizontal spatial variation in the ground motion.

Wave length is an important parameter in the design analyses, in arriving at the size of the finite elements for the soil structure interaction analysis. They must be small enough so that they properly propagate the waves that you are trying to propagate.

I do want to correct, we did the margin review. We did take credit for statistical incoherence of the ground motion in coming up with the HCLPF margin numbers. We did not take credit for that in the design.

MR. CATTON: What about horizontal propagation?

MR. KENNEDY: As Stavros indicated, there were some parameter studies done in which we put waves in at an inclined angle. We convinced ourselves that putting the vertically propagating waves in gave us floor spectra, that we looked at all of these sites and enveloped the results. The design analysis all worked with vertically propagating waves.

MR. CATTON: What is the wave? I don't have that number right here. I can go back and calculate it.

MR. GERDES: It depends on each soil case.

MR. IDRISS: The question is, what is the wave length. The wave length would depend on the velocity of the material and on the frequency you are looking at.

MR. CATTON: I understand that.

MR. IDRISS: Typically we have velocities from 500 to 3,500 and frequencies of interest are around -- we take about 1,000 feet per second. We have about eight hertz, 1,250 feet, 135 feet. That is sort of the middle range.

MR. CATTON: It is about the same order as the building size. That's where the analysis would get really interesting.

MR. IDRISS: It is more conservative. If you go the vertically propagating wave every point there is not incoherence.

MR. CATTON: I would have thought that worse case would be that one -- acceleration is oscillation. You get an upward acceleration and then it is downward.

MR. IDRISS: We were looking at the horizontal. The translation is reduced. We create some other modes.

MR. CATTON: When you look at the vertical the wave length is the same order as the building. One edge of the building is downward and the other is upward.

MR. IDRISS: Then, you are looking at the vertical. That's what you see with the line wave.

MR. CATTON: The wave length is on the order of 125 feet. Wouldn't that see the different edges of the building being sort of ratcheted up and down.

MR. IDRISS: The base is being oscillated. There is no change across the base. As the propagate to the model they are automatically accommodating these differences.

MR. CATTON: I understand from the viewgraphs we just saw, I understand the finite element and how you treat the building. I also thought that a lot of this is quite different when the wave lengths are of the same order. The wave length is the order of 100 feet and the building -- I have to worry about each edge of the building being hit out of phase. Wouldn't that cause a problem?

MR. IDRISS: The wave length that goes through -- however, the wave itself is hitting the side is influenced by the wave that is underneath, which is around five times bigger. Therefore, the wave length is five times longer. That is why the incoherence was not that important. The passage of the wave -- the earthquake is some distance away. The waves comes to the site first through the higher velocity medium and then it propagates to the site.

The effect of the incoherence is actually more controlled by the vertical velocity, which was a minimum of 5,000 and as high as 8,000, in which case the wave length is much higher. That would be about 5,000, again, using the eight hertz about four or 500 feet.

MR. CATTON: The wave length -- the building size, the ratio is about five.

MR. IDRISS: On that order.

MR. KENNEDY: There are a couple of facts here. If we are worrying about variation of ground motion from location to location there is variation of the ground motion between two locations rather close together. There are two causes. One, is the inclined nature of the waves coming to the site so that they arrive at each of these spots at a slightly different time. That has a horizontal wave speed that is up at the very high velocity that Idriss just mentioned, 5,000 feet per second. We can see that from differential range.

Another source is just the statistical variation of the wave pass, the specific locations. We find that really starts affecting the ground motion rather substantially above about ten hertz. It has very little effect on ground motion less than about ten hertz.

The effect of this ground motion, if it comes to our building, it will bring about inertial effects which are the big effects. The worst way to bring this ground motion in is such that it is seeing the same motion at the same time. That's why we typically with the vertically propagating wave models it's because the entire basemat is subjected to the exact same motion, that will tend to give you the highest inertial effects.

You will get from spatial variation in the ground motion, you will get twisting of the basemat. That will reduce the overall translation of this one LOCA region to respond more, but the overall will respond less. Similarly, for vertical if you have got wave passage effects are incoherent you will get some rocking. Your overall vertical uplift -- accelerations will be less. You will actually lower the inertial effects.

You will create some differential displacement effects that you are mentioning. These buildings are very stiff basemats to accommodate that kind of an effect. The studies that have been done on these types of buildings indicate the most severe design conditions come when you treat it as a vertically propagating wave.

MR. CATTON: Thank you.

MR. CARROLL: Since I have you two up here, I would like to ask a question. Is there anything that has so far come out on the misnamed Northridge Earthquake, the impact on how it should be designing nuclear power plants from a seismic point of view?

MR. IDRISS: We are collecting a lot of information. We are collecting a lot of information regarding ground motions and behavior of specific structures. As far as the ground motions, that's where we have gotten the most information so far.

The indications are that the level of safety is somewhat higher than would have been expected in similar size earthquakes, similar in nature earthquakes. This is the third major threat we have had in Southern California in the last ten years. It is not unheard of to have -- the nature of the ground motion appears to be a little more energetic than we would have expected, not as high as some people have been speculating. I think it is more like 20 percent.

What effect would that have on a nuclear plant constructed based on these attributes, is really nothing. This hypothesizes a motion. It says we are going to design for that motion and that motion if it is exceeded, then you have do something else. So far on any future plant, it has no effect, because you will be putting the plant in a site where you expect a certain level of shaking.

For what we look at in terms of future ground motions at a specific site there is an effect. How big of an effect, I think it is premature to say. We only look at peak accelerations. The full spectrum, which is what we should all look at, only ten recordings have been digitized. There is not enough information yet to really make any conclusions.

I have looked at those ten. There is one that has a surprise -- in Santa Monica. There are ones that have been digitized. As far as the damage that has occurred I think lessons we have learned before for the bridges or the sheer failure occurs and things like that as far as buildings, I understand some steel structures have suffered damage.

Again, I am going to the areas that are really not my field, for liquefaction. Where we would expect that it did occur -- on top of that it really does not affect this particular situation.

MR. KENNEDY: In the structures area, I think that there are several things that are being learned that will affect all kinds of design. One is, now that we have a large computer power and can do dynamic analyses and sophisticated analyses of buildings, maybe we have taken too much advantage of that and shaved out too much of the margin in the design of at least some of our competitive designs that go into California.

You see, all old designs that have massive shear walls, massive brace frames, come through very well. Modern designs that do not have such massive shear walls and such massive brace frames have not done as well. Maybe we have to raise the design loads, because we now know how to do the analysis better. I do not think that really affects nucle power plants because they do have the massive shear walls and the massive brace frames.

I think the other issue that has come out of the

Northridge Earthquake is, there is some indication of damage to the steel structures that was not expected prior to that earthquake. It looks like, because of those damages, it is logical to have expected the damage. I don't think we did expect it. I think we are going to have to spend more attention on the design of connection details in steel structures. There is indications that welded and other types of connection details did not perform as well as expected.

MR. CARROLL: We learned quite a bit from the Sylmar earthquake, the one that caused all of the damage at the Sylmar converter station, things like control room and false ceilings falling down and things like that. How did that converter station come through this?

MR. IDRISS: There are three things that are affected very heavily during Sylmar. I will comment on a couple of them. One was the dam, it had a major landslide. That was replaced by a new dam, well compacted dam. It performed extremely well. It moved about three inches, the San Fernando Dam. The old dam which was left in place and for flood control did have liquefaction all over again and moved about a foot, and so did the upper dam. The Genson filtration plant which was next door, suffered a lot of damage in 1971 and has since been somewhat fixed. It suffered some movement but not as much as 1971.

The third area was the Sylmar substation. I understand there was a great deal of damage there.

MR. KENNEDY: I have not been to the Sylmar converter station. I have talked to people who have been there, and I have been told that the damage is the same kind of damage that happened in the 1971 San Fernando earthquake. It was very extensive damage. I think switchyards are vulnerable.

MR. CARROLL: I can understand the mercury filled rectifiers having some problems, but how about the more prosaic things like control room ceilings?

MR. KENNEDY: We still have ceilings coming down in earthquakes. I do not know whether that happened at Sylmar but I know of several places where hung ceilings came down. It still is an issue that needs to be considered in nuclear power plants, safety wiring of the hung ceilings. I think any modern nuclear power plant is doing that.

MR. LINBLAD: Let's be sure that on the record, Sylmar is recognized to be a unique type of substation involving direct current transmission rather than the normal alternating current transmission, and has totally different equipment in place.

MR. IDRISS: The Sylmar hospital suffered a great deal of damage. It was redesigned in the 1970's to a significant higher level of shaking. It has actually steel shear walls in fact, and suffered practically no structural damage. It did have some problems with its sprinkler system.

MR. ESFANDOR: We did have a chance to go to the Sylmar station after the earthquake. The structural system itself, the control room in general, did very well. There was a tremendous amount of damage in the surroundings. The steel structure supporting that were perfectly braced, resulting from the fire earthquake. They all did well. Other than the ceramic damage, everything else was architecturally sound.

MR. CARROLL: The control room ceiling did not come down this time?

MR. ESFANDOR: I did not see the control room. Looking from the glass, it looked like it was okay.

MR. IDRISS: The Pacoima dam is northeast of the substation. It is an arched dam, sitting in a very steep valley. The recording in 1971 was in one of the abutments which looks something like this. I wish I knew that we were going to make this discussion. I had a picture taken shortly after the earthquake.

The new one is one and one-half -- I was talking about the Pacoima dam which is an arch concrete dam. On the abutment which is very steep, that is where they had the recording in 1971, which was recorded G. It is recorded at this same location at about one and one-half G. Down at the base of the dam now they have a recording of about one-half G.

Also, there is a station downstream about one-half a mile or so downstream. It's almost a free field station. There is a recording. They have about 18 channels recording. It is fully instrumented. I don't pay much attention to the structural elements. There was a 2.3G at the crest of the dam itself.

MR. CARROLL: Thank you. That was very interesting. Mr. Gerdes, I don't understand why you aren't able to finish on schedule. You were to be finished by 12:00. How much more time do you have?

MR. GERDES: I think we can go through the rest of the structural work in ten or 15 minutes.

MR. CARROLL: Let's do that.

[Slides.]

MR. GERDES: There were some mentions of the structures that were identified which may have been appropriate for some of the category one structures. But for the nuclear island the dimensions are something like 434 feet by 326 feet, so we have a very large massive structure here, much larger than the dimensions that were identified when we were talking about wave lengths.

[Slides.]

MR. GERDES: I identified a number of areas that we looked at and performed detailed design, and determined what the rebar requirements were. The primary purpose of this was to identify and confirm that the arrangement which we had defined in our arrangements were really adequate to withstand the envelope of design loads that we were subjecting it to. When we got to the detailed design of the [illegible] structures we would not find out that we needed to inc[illegible] the size of the shear walls significantly that would change the dynamic response to the structures.

These areas are identified in the package. They are also identified and discussed in more detail in Appendix 3.8(b). Unless there are specific questions that you might have, I am just going to go on over the rest of the identification on these areas.

For certain other areas we define design requirements and interface requirements that we didn't do detailed design, rad waste building, turbine building, station service building, auxillary, dikes, station service water pump structure. These design requirements are identified in Appendix 3.8(a), as identified earlier.

[Slides.]

MR. GERDES: A very detailed analysis was performed for the spherical steel containment vessel. The description of this vessel, the type, it is a steel sphere, SA 537 Class 2, diameter of 200 feet, one and three-quarter inch thickness with a two inch band at the transition region where it goes into the concrete, a volume of 3.34 times ten to the sixth cubic feet.

The codes and standards that were considered in the detailed design of this vessel are identified in general as very typical codes and standards. Design conditions, we looked at normal operating, temperature 110 degrees fahrenheit, inadvertent containment actuation which is the condition that is critical for buckling consideration, 100 negative pressure vacuum of 2 psi.

MR. LINBLAD: I would like to understand what that means.

MR. GERDES: The two pound vacuum condition, what exists before the containment spray actuation. Or, is it the result of -- that is a result of the containment spray actuation. I might add, in the buckling analyses this was considered in conjunction with the seismic event.

MR. LINBLAD: What are the initial conditions prior to the containment spray actuation?

MR. GERDES: Essentially normal operating conditions.

MR. LINBLAD: How much steam in the structures?

MR. GERDES: I don't really have that.

MR. LINBLAD: What is the partial pressure of steam at that time?

MR. OSWALD: I am not sure of the numbers. Actual value came out to be something like 1.81 psig. We rounded up to two, for the structural analysis.

MR. LINBLAD: How much steam is being condensed?

MR. OSWALD: I am not sure, without the details of that analysis.

MR. CATTON: Is it just cool down of the air, because the spray water is cold?

MR. CARROLL: No.

MR. LINBLAD: I would think that if you had a steam leak and you have lived with that and vented off some of the air, that your partial pressure of steam will have grown.

MR. CARROLL: Is there anything that limits the negative pressure to two psi?

MR. LINBLAD: Are there vacuum breakers on the containment?

MR. GERDES: No, there are not.

MR. CARPENTINO: If I understood the question, the negative pressure is determined by assuming that the containment is at 100 percent relative humidity to begin with and low pressure. You inadvertently turn on maximum spray flow rate at the coldest temperature that you can have the spray water temperature, at two psi.

MR. LINBLAD: It is a partial temperature at 110 degrees fahrenheit.

MR. CARPENTINO: Yes. I seem to have created an equilibrium.

MR. CATTON: So, why is the final temperature 110 degrees?

MR. OSWALD: The 110 degrees was used for the containment material properties. The containment steel itself could not have developed much of a uniform temperature much beyond what it was operating at. This was structural analysis and not the thermodynamic analysis for the design basis accident that you are looking at here.

MR. CATTON: For your calculation of the minus two, the environment temperature would be whatever the spray temperature is; is that what you did?

MR. OSWALD: The containment material properties were used for 110 degrees.

MR. CATTON: I am trying to understand what you did to get the minus five. Did you cool the containment air to the spray temperature, and that's what is the pressure?

MR. CARPENTINO: The thermodynamic analysis started out at the high temperature, high relative humidity.

MR. LINBLAD: What temperature was that prior to the actuation?

MR. CARPENTINO: I think it was 110. I have to check that. I do not know for sure.

MR. CATTON: What is the pressure when it is in equilibrium with the spray? Is that where you get the minus two?

MR. CARPENTINO: Yes. We run it out until the pressure is in equilibrium. We have taken the pressure as far as it is going.

MR. CATTON: The only question is then, is 110 appropriate.

MR. OSWALD: Again, the 110 was for material properties from the containment materials. I think in Chapter 6 and subsequent meetings here the design basis chapter, that maybe you will be enlightened.

MR. LINBLAD: We need a tech spec environmental temperature, yes.

MR. GERDES: Pressure 53 psi.

MR. CARROLL: That is LOCA.

MR. GERDES: Either LOCA or steam line, I am not sure which was controlling there. Each was about the same for the steam line break.

MR. CARROLL: You have conveniently skipped over the last item.

[Slides.]

MR. GERDES: The containment was also evaluated for postulated combustible gas loading.

MR. OSWALD: That was a 10 CFR 50.44, 50.34 analysis. On other note, the 76.5 psi was added. In our analysis we added a 76.5 with the 53 and evaluated a containment response at about 129.

MR. LINBLAD: At what service level?

MR. OSWALD: We looked at service level C stresses.

MR. LINBLAD: Thank you.

MR. CATTON: The design basis temperature of 290 degrees F, that's LOCA, isn't it?

MR. OSWALD: That is correct.

MR. CATTON: Actually, steam line break determines this 290 degrees is an average volume temperature, is that correct?

MR. OSWALD: That is correct.

MR. CATTON: There will be significant stratification at the top that is going to be quite a bit higher temperature than down at the bottom. How do you accommodate that in your analysis?

MR. BAGCHI: I think this is best left for the severe accident.

MR. CATTON: This is not a severe accident.

MR. BAGCHI: I understand that.

MR. CARROLL: It is covered in Chapter 19.

MR. BAGCHI: That is the best place to ask for these types of questions. That's when people are prepared to give you some answers that are going to be meaningful.

MR. CARROLL: You are happy to wait?

MR. CATTON: I am not happy, but I will wait. This is a stratification that exists and it can be significant.

MR. CARROLL: I know that.

MR. BAGCHI: As a structural engineer, let me understand what your concern is. What is the stratification going to do to the structure?

MR. CATTON: What it is going to do is, you have temperature variation from the bottom to the top.

MR. BAGCHI: Understood.

MR. CATTON: The thermal stresses --

MR. BAGCHI: We have not looked at that explicitly. That does not give me any concern. This, combined with the pressure, is fine for the capability of the -- we are talking about temperature stresses that are secondary stresses. Even over the less large surface --

MR. CATTON: Don't get mad at me. This is my business.

MR. BAGCHI: As a structural engineer, I don't understand.

MR. CATTON: In Quench River when they did the analysis of the steel shell it turned out that this was a problem. Stratification from bottom to top could be a problem. If the average temperature is 290 degrees -- I don't know how much stratification --

MR. BAGCHI: The biggest concern would be at the joint where the steel is coming down into the concrete, where you have a significant change in geometry. The stresses were looked at for that discontinuity.

MR. CATTON: Just to make sure --

MR. BAGCHI: The thermal stress was not covered.

MR. CATTON: When you do your thermal stress analysis you do not vary the temperature from the basemat to the top of the dome?

MR. BAGCHI: We do not. We account for a condition --

MR. CATTON: Let me continue the question. You had 150 degree temperature variations from the basemat to the top of the dome. Would that give you a headache?

MR. BAGCHI: I don't think so.

MR. CATTON: Does anybody know?

MR. DAVIS: They look at temperatures as high as 500 F in severe accidents.

MR. CATTON: That does not give them a problem?

MR. BAGCHI: No, sir.

MR. CATTON: I don't know if the variation in temperature --

MR. BAGCHI: The buckling problem, that was looked at very carefully. The results were corroborated.

MR. CATTON: I will ask again, when we get to severe accidents.

MR. CARROLL: I bet you will.

MR. GERDES: The analyses discussed test condition, design condition, ASME service level conditions, stability, ultimate capacity, combustible gas loading and also the sliding and overturning, potential sliding and overturning of the steel shell.

[Slides.]

MR. GERDES: Just some indication of the three dimensional finite element model, the steel dome that was used in the analyses. The remaining slides that I have present the loading categories, the load combinations allowable, maximum calculated stresses. These results are identified in Section 3.8 of the SAR. The description of the analyses is thoroughly defined in that section.

Unless there are any other questions, that finishes my presentation.

MR. CARROLL: Are there any further questions for Mr. Gerdes?

MR. DAVIS: Mr. Chairman, let me ask you something real quick. There is a reference in Chapter 19 to the FSER to an Appendix 19, which is purported to be a listing of all of the issues that have come up in the staff's review. I could not find that in the material that was sent to me.

MR. FRANOVICH: The final version does have Appendix 19(a). It is only related to PRA questions identified in the DSER. It has made it into the final version, not the version that you received.

MR. DAVIS: Would it be possible for me to get a copy of that?

MR. FRANOVICH: Certainly.

MR. CARROLL: Anything else?

[No response.]

MR. CARROLL: Let's recess until 1:25.

[Whereupon, at 12:25 the Subcommittee recessed, to reconvene at 1:25 p.m., this same day.]

AFTERNOON SESSION

[1:32 p.m.]

MR. CARROLL: Let's reconvene.

For this afternoon, I guess we're going to first take up some pending -- some questions that I have had pending because the staff has got people down here that are able to respond to them and we can let them go back to work after we get through that.

Then we're going to take up leak-before-break. And at that point, then pick up severe accidents and try, in particular, deal with issues Ivan's interested in, since he's not going to be here tomorrow.

And we'll pick up flood, in-service testing and high energy line breaks at some point either late this afternoon or tomorrow.

MR. COE: I think we can do it late this afternoon because the staff does not come back until tomorrow.

MR. CARROLL: Is that right?

MR. COE: The sections of Chapters 2 and 3 that are non-seismic, the staff will not be back until tomorrow morning for.

MR. FRANOVICH: That's correct. Tomorrow morning. Compliance System Branch will be here.

MR. CARROLL: So you are not prepared to deal with leak-before-break this afternoon?

MR. FRANOVICH: No. I think we are.

MR. CARROLL: Oh, okay.

MR. FRANOVICH: Mr. Bagchi is still here, so --

MR. CARROLL: Yes. Okay. But not flood, in-service testing or high energy lines?

MR. FRANOVICH: No. That will be tomorrow morning.

MR. CARROLL: Tomorrow morning.

MR. DAVIS: Well, when are we going to get to the important part, the PRA? Doesn't sound like you've left any time for that, Mr.

MR. CARROLL: Tomorrow.

MR. LINDBLAD: We're talking about deterministic schedule and he's talking about his probabilistic schedule.

MR. CARROLL: It will happen at 8:35 tomorrow morning.

MR. LINDBLAD: Probabilistically.

MR. CARROLL: Probabilistically.

Okay. Are we all -- everybody happy with the way we've ordered things?

Okay? All right. Ivan's questions.

MR. CATTON: Is that what you just gave me?

MR. CARROLL: Yes.

MR. CATTON: I guess the first one was the SER --

COURT REPORTER: Microphone, please.

MR. CARROLL: Mike. Go ahead.

MR. CATTON: The first question dealt with the SER on the codes being used by combustion. I have it. I haven't had a chance to look at it.

The second is the three-dimensional studies done at Oak Ridge on temperature distributions in the vessel wall. And the staff says it is presently reviewing the thermohydraulic and structural integrity aspects of thermal stratification for plume generation. Can't ask for any more than that.

MR. CARROLL: Now tell me what you're looking at so I can follow.

MR. CATTON: Well, it's something that Doug gave me. It says "NRC Staff Responses to ACR's questions on the System 80 Plus Standard Plant Design.

MR. CARROLL: Do I have this, Doug?

MR. CATTON: And there are basically two questions.

MR. CARROLL: Oh, okay.

MR. CATTON: The first question was about the paper presented at the SMER conference by the people from Oak Ridge, and the second was the SER's for the torque code. The CETOPD code and there's something -- CEN139AP statistical combination of uncertainties. I have the SER. I'll take a look at it. At least I think that's what I have.

MR. CARROLL: And that was the --

MR. CATTON: September 14th, 1976.

MR. CARROLL: How long would it take you, Ivan, to go through what they've written here so we could --

MR. CATTON: I don't know. I think --

MR. CARROLL: -- let the staff go home.

MR. CATTON: Why don't you let them go home then. If I come upon something we can communicate it to them. How does that sound?

MR. FRANOVICH: That's fine on the SER's for the three topical reports. We don't have Reactor Systems Branch people here today anyway. I was going to say there was one question on the 60-year design life. We do have several people here waiting to respond. I realize that wasn't your question.

MR. CATTON: There was one other thing before they take the microphone away from me, and that's this question about the ATHOS code that they use for steam generators.

We're having problems getting a copy of the models and correlation document. I think it's -- I wrote it down here.

The one I would like to see is referenced somewhere. Every report that's three volumes there's a co-user, a -- I forget what they are, but one of the deals with the models of correlations or the basis for the ATHOS code. I would like to see that.

I would like to see that. Does the staff rely on that in any way?

MR. FRANOVICH: No. The ATHOS code was not used for to make a safety decision for steam generator II ruptures. There was provided -- some information was provided in part of the steam generator II rupture analysis but the topical reports from EPRI were not submitted on the document list to my knowledge.

MR. CATTON: Then I'm not going to be able to see it, so I'll ask you another question then. How did you deal with the critical velocity that leads to fluid elastic instabilities?

What did you do? It's a different steam generator.

MR. FRANOVICH: Again, we don't have the appropriate people to discuss that, but we didn't review ATHOS code in any detail.

MR. CATTON: I understand that answer.

MR. FRANOVICH: We had a different emphasis on a review. Rather than two ruptures and looking at thermohydraulic performance on the secondary, we looked at it from the SECY paper position which was more of reducing the likelihood of containment bypass. And there are a number of design features offered on system 80 plus to reduce the likelihood of containment bypass.

MR. CATTON: Maybe we're not talking the same language. The question of fluid elastic instability leading to tube ruptures is what I would like to address. Now, if it's an existing steam generator, that's one thing. But as I understand it, the CE system steam generator is different.

How did you conclude that that's not a problem or did you even look at it?

MR. BAGCHI: This is Goutam Bagchi. I can only offer you one insight. We had a staff meeting yesterday and the Materials Branch folks told me that they don't use ATHOS code at all. And best of my knowledge, the Plant Systems folks don't use it at all either. But there is a circulation ratio of 3.7 for this system 80 plus as opposed to 3.0 for Palo Verde. So there is high recirculation.

So the kinds of problems that have been encountered in Palo Verde are not likely to occur in System 80 plus. But beyond that, I just --

MR. CATTON: Well, you just said the recirculation ratio is higher?

MR. BAGCHI: Higher.

MR. CATTON: That means the cross-flow through the tubes is higher. If that's the case, then you could well move closer to the critical velocity. So I don't think I could come to the same conclusion that you just did.

MR. BAGCHI: Critical velocity for the tube vibration, you mean?

MR. CATTON: That's right.

MR. BAGCHI: Well, I was addressing another problem. The problem I was addressing is crack buildup and cracking of the tubes as a result of that.

MR. CATTON: A couple of the problems that have been experienced have been the result of fluid elastic instability.

MR. DAVIS: Are you talking about one rupture leading to several or --

MR. CATTON: Well, the first thing is -- see, there's a threshold and the threshold is a critical velocity. What happens is the amplitude of the tube vibrations grows very slowly as you increase the cross flow or increase the recirculation ratio. But there's a big knee in the curve and it turns up very dramatically at some specific critical velocity.

MR. BAGCHI: I would like to answer that.

MR. CATTON: I would like to know what that critical velocity is for the CE steam generator. And then I would like to know what the actual velocity is to decide how much margin you have.

MR. BAGCHI: I will find out about the critical velocity and what the natural frequency is.

MR. CATTON: When I asked CE this question they told me that the ATHOS code was used. If the ATHOS code was used to evaluate that, I'd like to see it. But if you didn't evaluate it. I think you ought to.

MR. BAGCHI: No. We did not evaluate the ATHOS code.

MR. DAVIS: Ivan, are you talking about -- I'm sorry. I'm not understanding this -- increased likelihood of steam generator rupture --

MR. CATTON: Yes.

MR. DAVIS: -- or propagation of rupture to other tubes?

MR. CATTON: Well, I think you have to take it one at a time. There is a question of propagation. And I think if you take a look at the Bahamas incident, you'll see that there's whole bunch of tubes broken but that was a result, I think, of one of them whipping around once it had broken.

MR. DAVIS: CE makes the argument in the PRA, if I read it right, that one tube is limiting and that if you get more than that you're better off because you need to get the pressure of the primary down if you lose high pressure injection.

MR. CATTON: I don't know.

MR. DAVIS: But that might not be related to this.

MR. CARROLL: Does combustion having any comments on this?

MR. FRANOVICH: Yes.

MR. CATTON: What I don't understand is the strong concern that the fluid elastic stability tube rupture engendered in Japan and almost the lack of interest here.

MR. RITTERBUSCH: There is no lack of interest. This is Stan Ritterbusch, ABB.

There is no lack of interest on the part of ABB on steam generator performance and especially the secondary site thermohydraulics. We use version 2 of the ATHOS code. We do have the documentation. It's not proprietary. It's our understanding that the results are very, very close to those that you would obtain with version 3, which is, I believe, the current state-of-the-art documented by EPRI.

MR. CARROLL: Well, you say it's not proprietary, Stan? Why can't Ivan get a copy of it?

MR. RITTERBUSCH: It's my understanding that a copy of the ETHOS 2 code documentation can be purchased from EPRI.

MR. CATTON: You got to be kidding. You're expecting me to buy it? They usually put prices on those things of $100,000 or more.

MR. RITTERBUSCH: No. I didn't --

MR. CATTON: Have you looked at the prices inside the cover of the EPRI documents?

MR. RITTERBUSCH: No, not at all. What we can do, when our people from Chattanooga come April 5th and 6th we can bring the two volumes and we can get the details sorted out at that time.

MR. CATTON: All right.

MR. LINDBLAD: For less than $100,000.

MR. CATTON: Some of the prices on that inside cover will just blow your socks off.

Yes. I'd like to see it. I would like to have it in advance, but if I can't, I can't, I guess.

MR. CARROLL: Is there some way Ivan could get it in advance?

MR. RITTERBUSCH: He could come to Chattanooga.

MR. CATTON: Is there's some other way I could get it in advance?

MR. CARROLL: Apparently not.

MR. RITTERBUSCH: I'll find out. If we had more than one copy of the documentation, of course. We've got one set. We'll check into it and work something out.

MR. CARROLL: I guess there's huge copyright stamp on the side of the cover also.

MR. RITTERBUSCH: That's correct.

MR. CARROLL: Okay. So we've dealt with the

Catton questions.

MR. CATTON: Sort of.

MR. CARROLL: Sort of. For the time being.

Now, did I understand from the staff that you have people here that can address the 60-year design life that would like to go off and do something useful?

MR. FRANOVICH: There is written response to that one, but -- that one particular question. But we also have other people available from Plant Systems Branch to discuss any other questions you may have on that response.

MR. CARROLL: Well, what I'm looking for is -- are there people that could answer the questions and then go back to work that we could release if -- or are they going to be here anyway?

MR. LINDBLAD: Are you trying to reinvent government here?

MR. FRANOVICH: No. I think they were planning on staying here for only about another hour. Go through leak-before-break and depart. So, --

MR. CARROLL: Okay. Well, let's -- so what are the -- leak-before-break is one topic. What else are there here --

MR. FRANOVICH: That's basically it. After that we get into severe accidents and they -- as far as I know, they won't be here.

MR. CARROLL: Okay. But they're -- how about the 60-year life thing that you brought up?

MR. FRANOVICH: That's why I was recommending that if we can take a look at the response, if the response needs any further clarification, we could discuss that now.

MR. CARROLL: Okay. Charlie, are you happy with the response?

MR. WYLIE: Well, yes. I read the response. I don't have any problem with what the staff has written. My question really is the applicant in that there are bits and pieces of what the applicant, the COL applicant, has to do to achieve 60-year design life program control, I call it.

EPRI, in the URD outlined what they thought was an acceptable program for management of a 60-year design life by the COL holder and it seems to me that there ought to be identified in the COL license information section, wherever that is. And in the interface requirements it brings this together to assure that the applicant set up such a program similar to what EPRI has described.

MR. RITTERBUSCH: I guess that -- Stan Ritterbusch, again. I think that question was directed at the applicant, so I'd like to try and respond.

The work that we present in CESSAR/DC for design certification is that work necessary to show compliance with regulations and the standard review plan and so on and so forth. We are familiar with the EPRI/URD requirements. We provide in the System 80 plus design those design features that we think will enable us to comply with the EPRI/URD requirement and where it's important for safety reasons, we provide certain specifications in CESSAR/DC.

But what I'm really getting to is that the details of the life management plan and the maintenance plans are part of commercial proposals and work that would be accomplished in the final stages of plant design and plant procurement.

MR. WYLIE: Well, to maintain a plant with its design basis requires that you manage -- and I don't argue what you say in your chapters about how you're going to do it. It sounds acceptable. They're scattered throughout the SSAR. But it only appears reasonable that you identify it to the COL applicant and then place a requirement that he has to set up such a plant and pull these things together to maintain this throughout the life of the plant.

It has to be done early. He can't wait until later to do it.

MR. RITTERBUSCH: I agree that there's information throughout the SSAR, but most of it is summarized in the design reliability assurance program, so that is the focal point for all the reliability and maintenance type requirements and interfaces. And in fact, I believe there is an action item that the COL applicant look at our product from our reliability assurance program.

MR. WYLIE: Oh, I understand that. But --

MR. CARROLL: It's in here.

MR. RITTERBUSCH: Yes, it's in there. This is the same thing.

MR. WYLIE: What's the reluctance to saying in the COL license information section, whatever that is, or the interface requirement, that a COL applicant has to establish a design life control program.

MR. RITTERBUSCH: Well, I mean, it could be done, but we established an agreement with NRC staff some groundrules or consideration for definition of what would go on the COL applicant list and what goes on that list are items that are important to the staff's safety conclusion. And further more, items that are well defined enough so that a COL applicant can turn to the various sections of CESSAR/DC and find out the specific details of what he needs to do.

If is something open-ended such as a maintenance program, which is really in the utility's purview and not ours, then we would not provide a lot of detailed specifications on that program.

MR. CARROLL: Well, Charlie, you're talking about a life management program.

MR. WYLIE: That's correct.

MR. CARROLL: And there is a COL applicant commitment or action item or whatever for the reliability assurance program. Is that not right? And doesn't that take care of, Charlie, life management?

MR. WYLIE: Is that identified as a COL action item?

MR. CARROLL: The RAP?

MR. WYLIE: D-RAP, particularly.

MR. CARROLL: What about O-RAP or D-RAP?

MR. RITTERBUSCH: Yes. D-RAP is our method of providing input to O-RAP.

MR. CARROLL: And that is a COL applicant action item?

MR. RITTERBUSCH: That's correct.

MR. CARROLL: Well, so, is it a semantics problem? You're calling it a life management program and they're talking --

MR. WYLIE: No. I don't think so. I don't think so. Maybe we need to study this more, but it seems like to me that it's not specifically identified that the COL applicant can set up a program to do what I said.

MR. RITTERBUSCH: I would agree that D-RAP does not resolve what Mr. Wylie is asking here today. I guess what I'm saying is that it wasn't our intent to address all of the EPRI/URD requirements in CESSAR/DC. In fact, what happens for commercial proposals is the URD requirements are referenced in proposals and then we have to demonstrate our compliance with the URD requirement.

So it's through the commercial proposal process that we pick up items that are not specifically covered in the safety related documentation, such as we have in CESSAR/DC.

MR. WYLIE: Well, I've read pretty much -- I think I've read most of it where you say what actions are required to maintain the design life of components and replace them and so forth. That's in the SSAR. But it seems to me that there should be something said regarding license -- COL license information or interface requirements. That they establish a plan that pulls all this stuff together.

MR. RITTERBUSCH: One thing we can do is add to our D-RAP program a statement that would indicate that the utility must look at the EPRI/URD. I could not obligate the utility to do anything, so it would essentially be a reminder, a pointer to the utility. But I think it would be outside our scope to require that the utility have such programs.

MR. WYLIE: Well, that would be satisfactory, I would think. It's really a flag saying you've got to do it. And then it is incumbent on the staff then to look to see whether they've done it or not.

If you're going to maintain the design basis throughout the life of the plant, you've got to have some management of the agent.

MR. RITTERBUSCH: We believe -- well, I guess we have to ask what is the design basis figure referring to. If it's a safety related design basis, NRC staff has made sure that we've taken care of that. And that goes for the D-RAP program.

MR. WYLIE: But only if you maintain that plant and replace items when they're needed to be replaced and you refurbish items when they need to be replaced and so forth. You say you're going to do that all the way here.

MR. RITTERBUSCH: Correct.

MR. WYLIE: And that places that burden on the COL holder. I don't see the reluctance to say he's going to do it.

MR. CARROLL: The reluctance is that combustion can't really speak for the COL.

MR. WYLIE: But they do it all the way through here. They say the COL holder will do this and thus and such all the way through here.

MR. RITTERBUSCH: We can separate a little bit from the way we've been doing COL action items and we can say that the COL applicant needs to go look at the EPRI/URD and determine whether they want to -- the details of how they want to implement these programs. But it's not really anything more than a flag.

MR. WYLIE: I think it would be worth a flag to alert them and to alert the staff that 15-20 years from they that they go back and look at this thing. They just don't do that.

MR. RITTERBUSCH: Possibly -- we can add a flag. That's easy. So I'll make some words and we'll propose a statement somewhere in our documentation.

MR. CARROLL: Okay. All right. Shall we move on to leak-before-break?

MR. MICHELSON: Before you move on, we were discussing some of these questions but not others.

MR. CARROLL: Only because in one case Ivan's not going to be here --

MR. MICHELSON: The others are going to be covered later.

MR. CARROLL: -- tomorrow.

MR. MICHELSON: Well, there's one that I'd like to ask about now then.

MR. CARROLL: All right.

MR. MICHELSON: That's the use of water for oil fires.

MR. CATTON: And the response we got was they had called the University of Maryland and --

MR. CARROLL: Couldn't find the report.

MR. CATTON: Well, there isn't a report. The work is underway by Quintieri for us.

MR. CARROLL: If you talked to him, he should have been able to tell you that.

MR. CROM: This is Tom Crom. We talked to both Dr. Quintieri and Dr. Milke and they did not -- at least did not give us any insight on the work that was being done.

MR. MICHELSON: They didn't claim it wasn't being done?

MR. CROM: No, no they did not.

MR. MICHELSON: I thought the inference was in the reply they didn't even talk about it.

MR. CROM: Yes. Maybe we misunderstood you. We thought there was paper that was already out.

MR. CATTON: No, there's not a paper out. But they were doing the work. Jim Quintieri --

MR. CARROLL: Received the actual funding.

MR. CATTON: Yes. And he has done a study of use of water on diesel oil fires. He's came to some rather negative conclusions. Now he's supposed to bring that to us what -- in May?

MR. MICHELSON: We're unaware of any paper being developed the way your answer says. I don't believe that

that's possible.

MR. CATTON: Well, your answer isn't right.

MR. MICHELSON: It cannot be right.

MR. CROM: We talked to Dr. quintieri. He did not lead us that he was working on anything. We can take that response out of there and we can talk after he comes to his conclusion, and we can talk about it later.

MR. MICHELSON: Let's check his billing.

MR. CATTON: Yes. That's right. If he hasn't done anything, I'd really like to know about it.

MR. MICHELSON: He has some preliminary results, but his preliminary results don't look too good.

MR. CROM: When we find out what his results are, we'll be glad to address each one.

MR. CATTON: Maybe somebody from CE would like to attend our subcommittee meeting when we address these issues.

MR. RITTERBUSCH: I guess I can find from Doug Coe when that is?

MR. CATTON: Yes. Or from Dudley.

MR. COE: Well, right now it's being considered for May 10th, but I'm not sure that that's the date.

MR. CATTON: We wanted it to be May 10th but I guess there are some people who are having schedule problems, so we're not quite sure.

MR. RITTERBUSCH: I'm a little uncomfortable with the way that was left. We will -- I mean, we have a schedule and I'm not sure whether ongoing work -- you know, if results come in in June or July or whenever. I'm a little uncomfortable with saying that our review is -- or implying that our review may be open until the results of that program.

MR. CATTON: Well, if their conclusion were looking good, I wouldn't worry about it. But the thing is you're being informed now that the use of water on a diesel oil fire looks like it's a problem. So I think you know about it now.

MR. CARROLL: That is tier 1 material isn't it, Stan? So it could be -- I mean, you're not talking about something that's --

MR. RITTERBUSCH: But you're also supposed to be making a final safety determination, too, and until you've got some of these things settled it's very difficult to make it. You can't make it without knowing the answer.

MR. CARROLL: Well, there are alternatives.

MR. MICHELSON: Well, leave it an open item in our letter. That's another alternative.

MR. LINDBLAD: But we also have to hear Dr. Quintieri's concern. Right now it's not articulated it all.

MR. CATTON: All I have is preliminary

information.

MR. LINDBLAD: So we really need to hear.

MR. CATTON: And we will hear in May.

MR. CARROLL: Well, just hypothetically, if it was August --

MR. CATTON: We'd switch to another means of fire suppression.

MR. LINDBLAD: Why?

MR. CATTON: If water doesn't work.

MR. LINDBLAD: What if we just don't care one way or the other until August?

MR. MICHELSON: Then we have to decide.

MR. CARROLL: How will we deal with it, Ivan?

MR. LINDBLAD: I mean, your remark really does not have any explanation.

MR. CATTON: Why it may not be any good?

MR. LINDBLAD: Yes. I mean, Dr. Quintieri doesn't judge for us.

MR. CATTON: No, he doesn't.

MR. LINDBLAD: The suitability of the --

MR. CATTON: That's fine. Fine. I agree. I'm just indicating that preliminary calculations have shown that there may be a problem. And that means that you have to take a good look at it. And I'm not sure it's our job to take a look at it.

MR. LINDBLAD: I guess I'd like to see what the problem is before --

MR. CATTON: I guess the problem is the generation of steam and then the steam condensing. I don't recollect all of the details.

MR. RITTERBUSCH: I would like to add a comment. I just want to be very clear that we believe that the proper method of fire protection for this design is the water suppression system as described. And we would like the review closed out on that basis. If it turns out that there is some new research result that comes in at some future time NRC staff is well capable of bringing that to the attention to people holding an FDA. There's a process to be gone through if new issues arise.

MR. MICHELSON: No, not really, unless you want to make it a Commission action. We've got finality when we issue the certificate. That's final.

MR. CARROLL: When do we write our letter?

MR. CATTON: June 2.

MR. RITTERBUSCH: June. Yes.

MR. CATTON: And as far as our letter is concerned, we have time.

MR. DAVIS: Does the fire protection system meet NRC requirements the way it's now designed?

MR. CATTON: Yes.

MR. DAVIS: Oh, it does?

MR. CARROLL: Well, there are a lot of plants out there that use water for the diesel oil fire. We're getting them but --

MR. MICHELSON: We also question whether water was the right -- you know, on the ABWR it's --

MR. DAVIS: You mean foam.

MR. MICHELSON: Foam. Yes. But water was questioned there and that's what first got us started, because we said, well, you know, maybe someone said water was the only way.

MR. CATTON: I guess there's just a complete lack of analysis in this area. It's just follow the guidelines that basically were generated 50 years to, 60 years ago.

MR. LINDBLAD: The analysis may be weak but there's a lot of experience, isn't there?

MR. CROM: This is Tom Crom. Let me addess that a little bit. We have not talked about fire protection. We will April 5th and 6th. We are not using a methodology from 50 years ago. We are not using combustible loading. We are proposing using linear heat rate analysis, new fire methodologies, new computer codes that have been generated most recently from the University of Maryland and so forth.

We're not talking about using any of the combustible loaded calculations. We're going to use linear heat rate type analysis.

MR. CARROLL: Okay. So I guess we'll just let this play out. We'll be hearing more about fire protection next month. So let's get on with leak-before-breaks.

MR. MICHELSON: Well, before we do that, have we covered everything on this item then or can we bring up the rest of it later.

MR. CARROLL: The fire protection?

MR. MICHELSON: Yes. I have a couple of questions on it as well.

MR. CATTON: I thnk if it's on the fire protection area I'd like to hear it.

MR. CARROLL: Okay. Do it, Carl.

MR. MICHELSON: Yes. This isn't very long.

On the bottom of page 50, the last couple of lines, it says that the generator is air cooled and it's going to have a NEMA 125A, whatever that is -- or NEMA 1.25.A.

MR. CROM: That's the requirement for it to be drip proof.

MR. MICHELSON: Yes. I'm not acquainted with that particular number, NEMA enclosure, but I ask you just one question. Is that enclosure rated with the generator operating? In other words, can it draw its normal cooling air through in a real fog and still work?

MR. CROM: Not for long-term. Our response on it earlier is that most fires in the diesel generator room will occur with operators are there and the detection will be done and be put out by manual means.

MR. MICHELSON: But I think you probably missed was the thrust of the question to begin with, and it didn't get articulated here very well in the statement of the question. And that is, the concern was this is a non-seismic fire protection scheme and what happens if it inadvertently actuates. And then it gets into the question of the seismic qualification of the nozzles and so forth. And then we wonder, well, maybe the equipment is well protected to begin with.

And you said yes, it was drip proof and so forth and I wondered what that really meant. So you went back and checked and I don't think this kind of enclosure will handle it.

MR. CROM: You're right. It will only protect for short-term.

MR. MICHELSON: A very short-term.

MR. CROM: But the thing that we discussed in our response is most fires, operators will be present because any time the diesel generator is being tested or if it's running, there will be operators at the local control panel.

MR. MICHELSON: If you have a fire at that time then you start addressing it and you presumably do it all in a timely fashion. But if a fire is in that compartment, I never had any question about the viability of the generator. I assume it's probably --

MR. CROM: Yes. The previous response on the seismic was that the probability is extremely low that there will be an inadvertent actuation since we are using pre-action sprinklers and that the piping is seismically rugged.

MR. MICHELSON: And then the argument about the pre-action is when we started getting into this whole question, well, is that the way to address an oil fire.

MR. CROM: That's correct.

MR. MICHELSON: The real experts that I've talked to say no, that isn't the way you address it, even if you want to use water. You don't do it one sprinkler at a time on an oil fire. You've got to do a whole area. And that's where you get into these arguments.

I've looked at this thing for 20 years now and I've talked to a lot of utilities, including Duke and so forth back before your day, perhaps. And each utility had their own way, their own experts, and they knew that was the only way to do it.

MR. CROM: Let me -- if it's okay, I'd like to address this next meeting. I'm going to bring the fellow that has done all the Duke plants from McGuire, Catawba and

Iconi from day one.

MR. MICHELSON: Were they all done with water?

MR. CROM: No. The older plants did not. They used gaseous systems and those have been outlawed based on halon type systems.

MR. MICHELSON: No. They used CO2, I think.

MR. CROM: Yes. That's correct. CO2. That's correct.

MR. MICHELSON: That's not outlawed.

MR. CROM: Yes. But they've had a lot of instances in McGuire plants where we have taken people out on stretchers because those have inadvertently gone off.

MR. MICHELSON: You've got CO2 in your spreading rooms and so forth I think you have, too, don't you?

MR. CROM: That's correct. It's not a pleasant sight when you see those people coming out.

MR. MICHELSON: It's got a risk. It's got a risk. So do oil fires have a risk.

Okay.

MR. CARROLL: Is that all your questions on fires?

MR. MICHELSON: That's all.

MR. CARROLL: Okay. Mr. leak-before-break, it's all yours.

MR. PECK: My name is Daniel Peck. I am the Director of Mechanical Engineering at ABB Combustion

Engineering at Windsor, Connecticut. I'm going to summarize the application of leak before a break on the System 80 plus piping.

System 80 plus has used the traditional LBB method on five different pipes, all of which are inside containment. What is perhaps not traditional about the leak-before-break that we have done is that the lines are not yet built.

In the past, leak-before-break has always been applied to existing piping or piping that was under construction. What I will be showing you is how we have defined a set of requirements for the System 80 plus piping designer to assure that the as-designed and as-built piping will in fact satisfy traditional LBB criteria.

MR. MICHELSON: Just to make sure I understand, clearly this is inside of containment. Are you proposing to apply it all presently outside of containment?

MR. PECK: No, sir.

MR. MICHELSON: How about the penetration lines such as main steam and feed water which are both inside and outside of containment? Are you applying it outside of containment there?

MR. PECK: Inside only,.

MR. MICHELSON: What do you do about the zone between isolation valves and high energy lines?

MR. PECK: There is an anchor at each of the lines where it penetrates the containment so that the effects are indeed physically limited to inside containment.

MR. MICHELSON: You essentially, if I understand the SAR correctly, have essentially said there are no breaks in these penetration lines between the isolation valves and that it's sort of even better than leak-before-break. It will not even break.

MR. PECK: That is the subject for tomorrow's high energy line break.

MR. RITTERBUSCH: Briefly, those pipes have guard pipes on them.

MR. MICHELSON: Everyone will be guarded? Main steam?

MR. RITTERBUSCH: I'm going to wait until our representative get back, but I think so. High energy lines have the guard pipes.

MR. MICHELSON: Okay. That will do it.

[Slide.]

MR. PECK: Here's what I'm going to tell you. I would like to discuss which pipes we have applied leak-before-break on System 80, what we use it for, what is the basis for choosing the lines that have LBB, how we have demonstrated LBB in the impact on System 80 plus of the LBB.

MR. CARROLL: And then when you finish all that you're going to tell us what you told us.

MR. PECK: That is the Army way.

These are the five lines.

[Slide.]

MR. PECK: The main coolant lip piping. There are two 42 inch lot legs, four pump discharge legs. These are 30 inch. Four pump suction legs, also 30 inch. These are carbon steel with stainless steel cladding.

Surge line, 12 inch of stainless steel. There are two 16 inch shutdown cooling lines of stainless steel, four direct vessel injection lines, 12 inches stainless and the four main steam lines, 28 inch carbon steel, the inside containment portions of these lines.

The next set of --

MR. MICHELSON: The feed water line will not have leak-before-break?

MR. PECK: The feed water line will not have leak-before-break applied to it.

MR. CARROLL: Did I learn somewhere that you were leaving the option open to the COL holder to apply it outside of containment?

MR. RITTERBUSCH: We are not aware of any such option.

MR. PECK: We have not made that statement except as it may generally apply to all licensees.

Brief schematic of the main coolant loop. I think you're all familiar with that, but you can see the hot legs, the pump discharge legs and the suction legs, pump suction legs.

[Slide.]

MR. PECK: This is a schematic of the surge line. It runs from one of the hot legs around the steam generator over to the pressurizer.

MR. CARROLL: With a sloped line?

MR. PECK: It has a sloped line. This is the direct vessel line to our four direct vessel injection lines. They directly inject into the reactor vessel annulus. They run over to where they split for the safety injection tank and run over to the containment penetration for the high pressure safety injection.

This is the shutdown coolant piping.

[Slide]

MR. PECK: There are two shutdown cooling lines, one off of each, the bottom of the hot leg out through containment.

MR. MICHELSON: Does your leak-before-break start right at the interface with the primary containment?

MR. PECK: Yes. There is a anchor here at the shield building.

MR. MICHELSON: That is outside of primary containment.

MR. PECK: There is ballast attachment to the primary containment over to the anchor.

MR. MICHELSON: And so it starts at the anchor?

MR. PECK: It is anchor to anchor. The rules for leak-before-break is anchor to anchor. The other end is where it attaches to the main pipe.

MR. MICHELSON: I just did not see the penetration design. It looked like there was a pipe anchored.

MR. PECK: It does not show.

And then finally we have the main steam piping. There are two steam lines off of each steam generator. This shows one steam generator. And again, there is an anchor at the shield building with billow seals to the primary containment. So it is the portion from the anchor at the shield building to the top of the generator, the steam line that we are applying leak-before-break.

[Slide]

MR. PECK: What do we use it for? Leak-before-break is used to eliminate dynamic load events, postulated pipe breaks. It does not eliminate containment pressure temperature effects of design basis pipe breaks. It does not eliminate emergency core cooling system requirements and does not eliminate environmental qualification requirements of design basis pipe breaks.

So it's only used for the dynamic load effects.

MR. CARROLL: So you have not taken advantage of it to lengthen the time it takes for the emergency diesel generators to come up?

MR. PECK: No.

MR. CARROLL: Why not?

MR. PECK: We only use it for dynamic load effects because those are the regulations. The current regulations make this distinction between what it is applied to and what it is not applied to.

[Slide]

MR. PECK: The basis for the choice of these lines is that first, we must show that they are qualified because they are not susceptible to any of these types of effects: water hammer, creep, erosion, corrosion, fatigue or environmental conditions.

So we start first with a set of pipes that are not susceptible to these effects. Then we must show that they satisfy various evaluation criteria with margins that are prescribed. A margin of 10 on leak detection capability; a margin of 2 on crack length; and a margin of square root of 2 on loads.

These are all prescribed in the standard or traditional NRC requirements for leak-before-break. New Reg 1061 Volume 3.

MR. LINDBLAD: What is your leak detection rate and can it be masked by other --

MR. PECK: The leak detection rate is the standard leak detection rate in accordance with New Reg 1.45, one gallon per minute sump monitoring for the primary system. We also monitor the condensate cooler for the effect of condensation for steam that might be in the atmosphere of the containment.

I will show you a little more in detail.

This slide just gives a numerical statement of the acceptance criteria. We must postulate a crack length which will leak 10 times the leak detection system capability, so it is a one gallon per minute leak detection system. Then we have postulated a 10 gallon per minute crack, leak size, leakage crack size, and then we show that that crack size is less than critical crack size, for a square root of 2 times the maximum loads.

And also twice that crack length is less than critical crack length for the maximum loads. Maximum loads, for example SSE.

The process we used for System 80 plus piping was first to confirm that piping system satisfies the qualifications, not susceptible to those various phenomena. Then we defined LBB acceptance criteria based on parametric studies for use by the piping designers.

The method that we've developed requires definition of only the pipe size and the material. Material properties and pipe size. The routing of the pipe is not defined in order to come up with the acceptance criteria. The piping designer will then define the pipe routing and demonstrate that he meets the acceptance criteria.

We have demonstrated that we meet these criteria for each of the five pipes with preliminary designs of each of the pipes. The main loop pipe is not preliminary but the other piping, the branch line piping, is not final designed at this time. But we have demonstrated that there is a design which will satisfy the LBB criteria for each of the piping.

MR. LINDBLAD: Is the final piping designer permitted to call for welded lugs on your piping?

MR. PECK: For example, for support hangars?

MR. LINDBLAD: Yes.

MR. PECK: I guess that would be a standard piping design feature.

MR. LINDBLAD: So your evaluation has included all kinds of restraints on the piping?

MR. PECK: It is considered standard piping design, nothing in particular. No lug per se because it is not a final design at this time.

MR. MICHELSON: But you're keeping stress levels down to some criteria which I assume is buried in the second bullet.

MR. PECK: The requirement are basically ASME code requirements. If you start putting too many lugs in the wrong places --

MR. LINDBLAD: You will get stress intensifications.

MR. PECK: But the normal design will catch you on that. This would not cause any change in your normal design practice and I will show you the type of acceptance criteria.

The final design only needs to confirm the material properties are within the parameters that were used to develop the acceptance criteria. We also included in CESSAR the methods for developing the criteria in case the piping designer chooses to go with a different material than what we assumed. Maybe a better material comes along and he would like to use it. Well, the method for developing the LBB acceptance criteria are built into the CESSAR so that he can develop those criteria for the new material property.

If he chooses the material property that we use the parametric study, he merely needs to show the material properties fall within the range that we selected. And then he, of course, has to check the as-built design for the actual loads that are in the piping.

MR. LINDBLAD: Piping frequently includes valves. In your discussion do they include valves and bonnets?

MR. PECK: Valves are not treated per se in LBB. They're simply part of the piping run.

MR. LINDBLAD: And so are they covered by the same ASME criteria and stress intensification?

MR. PECK: Yes. They would be covered by ASME code for normal design. But there is no special breakout criteria for the valves on LBB.

MR. LINDBLAD: Let's say valve stems. Are they covered by ASME code requirements?

MR. PECK: I'd have to say it's an ASME valve. That's all I could say.

MR. MICHELSON: They don't cover the stems but they cover the gates even though those aren't --

MR. PECK: This is an example of the acceptance criteria that we have developed. The example I have chosen is one of the figures that is in CESSAR. All the pipes and all of the materials that we have used are in CESSAR. And what is plotted here is for the surge line, a TIG weld for SSE load versus normal operating load.

So as the piping designer does his design and he's showing that he's meeting all the other ASME code stress requirements, he then goes into this chart and says, what is my normal operating load at the point of evaluation for LBB and what is my SSE load at that location.

If he is below the line he has passed LBB, so built into this chart are all of the requirements for the different margins on load and crack length. One of these lines is the margin load. The other line is the margin on crack length. And so as long as he's below both of those lines then he knows his design has passed LBB for that particular pipe for that particular material.

Now what has been the impact on the design for System 80 plus of using the LBB? Well, you know System 80 plus is based on System 80, which is implemented at Palo Verde. Palo Verde was originally designed assuming pipe breaks in the main loop and before they got their operating license we went through the leak-before-break and we demonstrated that the main loop pipes passed leak-before-break for Palo Verde. They were able to then remove pipe whip restraints and things like that.

But when we passed the LBB, removed the pipe whip restraints, we did not change anything else in the plant. The basic System 80 plus design main loop retains all the size and strength that the System 80 had, so we've not withdrawn any margin for showing that we pass leak-before-break.

Rather, what we've done is used that margin for additional seismic margin because now the System 80 plus is a higher seismic design requirement.

Most of the things are sized as big as they are for stiffness for seismic considerations. We have not removed any strength. We have removed pipe whip restraints and features that are only there for pipe break effects.

And of course, we have also eliminated a lot of analysis for various effects of dynamic loads, blow down loads, subcompartment loads, jet impingement loads. There's a lot of analysis that is not required to be done.

Which kind of brings us to the bottom line of why do we want to do this anyway?

[Slide]

MR. PECK: What are the benefits of leak-before-break? Especially on the branch line piping we believe that it has improved reliability of the system by not requiring very close fitting pipe whip restraints. A lot more accessibility for in-service inspection and maintenance.

Reduced personnel exposure because you do not have to go in and inspect pipe whip restraints. You can also have reduced personnel exposure because you have more access for inspection of things that you do have to look at.

Obviously reduced construction and time and cost; very important to the owner.

And there will be reduced refueling times because we are now able to -- we don't have to have wide open spaces for a blow down and reactor cavity pressurizations so we can put in a permanent fuel seal and have a faster refueling time.

This again is important to the owner.

MR. LINDBLAD: Did I not recall that one of the reasons for the reactor cavity annulus being open was to get ventilation air past the insulation, reactor insulation, for recooling and the like? What does the concrete get to without --

MR. PECK: Well, there are cooling passages designed into the concrete to bypass around the perimeter pool seal, so you trade one thing for another. So we have now had to design in air passages for cooling.

MR. LINDBLAD: That you would not have had before.

MR. PECK: Yes, yes. But the benefit is that you don't have to remove and replace that seal and you have a quicker refueling time. So it's a tradeoff.

MR. LINDBLAD: But you have to plug the air passages.

MR. PECK: No. The air passages would be in the seal so you could close the seal off with hatches or they could be through the concrete. That is kind of a design detail that has to be worked out, or both.

Questions?

MR. CARROLL: I have a question of the staff, I guess. I am looking at page 3A-74 and I find the incredible statement that carbon steel main steel lines have a successful and expensive operating history. Thousands of years of nuclear P and BWR's and fossil power plants.

Now it really bothers me that the staff doesn't understand that we for the last 60 years use superheated steam in fossil power plants and you don't use carbon steel.

That doesn't give me a lot of confidence that they know what they're doing when they tell me a lot of other things that I understand less well than that.

MR. TARAO: In the '50s, yes it is true in the fossil plants the design for the main steam line increases temperature from about 600 to 1100 degrees Fahrenheit.

MR. CARROLL: 1930, maybe?

MR. TARAO: That is a little before my time.

MR. CARROLL: Yes. 1930 they were using 1000 degree superheated, 1000 degree reheat in a plant that I'm very familiar with.

MR. TARAO: My understand is around the '50s. But there were many plants that had main steam lines that ran at a 600 degree Fahrenheit that used carbon steel piping. And some of those plants are still operating today. And there have been no failures in the carbon steel piping for the plants that run at 600 degree Fahrenheit. That's all we're trying to say. There were fossil plants that ran at about the same temperatures as nuclear plants, 600 degrees.

MR. CARROLL: No, there weren't. All fossil plants used superheat. Using superheat started in the '30s.

MR. TARAO: The reheat piping always ran at 600 degree.

MR. CARROLL: No.

MR. TARAO: Those are carbon steel. Those have good operating experience with carbon steel piping. Now we said main steam and I scill hold that there were main steam piping designed to 600 degrees Fahrenheit before the '50s.

MR. CARROLL: I think that may be true of the sugar mill industry where they used saturated steam, but it certainly is not true of utilities. They have been using superheat since the '30s. Believe me.

MR. TARAO: The discussion in the paragraph dealt with erosion corrosion, first of all. And the point that we're trying to discuss at that point was the use of carbon steel is probably the best material for erosion corrosion at this time. We don't want to go do a crow molly type of material for the main steam piping.

MR. CARROLL: All I want you to do, David, is get rid of the reference to main steam piping when you talk about fossil fuel plants. I mean, I agree with what you're saying. It's just that it was not used for main steam piping. Saturated steam.

MR. TARAO: All right. We will take out the fossil plants, if you don't like fossil plants.

MR. MICHELSON: Well, it's simply not true. Do it for your own protection, not because we don't like it.

MR. CARROLL: Any other questions or comments for either the staff on combustion or leak-before-break?

MR. LINDBLAD: He was going to tell me more about the leak detection system and how it might be masked by other leaks in the plant.

MR. CARROLL: Yes, he was.

MR. PECK: Here's a chart that shows the process that you go through with a PWR to determine what is happening if you're looking for leaks.

[Slide]

MR. PECK: You determine the leakage from the containment sump and cooler condensate monitoring. Those are two places where you collect water that might accumulate inside the containment. One is the sump and one is condensate from the cooler.

If it is less than one gallon per minute, then no action is required. If it is not less than one gallon per minute, if it is greater than one gallon per minute, then you subtract identified leakage and you may have a non-leakage source.

There's some valve on some drinking fountain somewhere that you're going to fix next time you get to it when you're shut down for some other reason. It is not a safety line but you know what it is. It's identified leakage. I don't know.

Subtract identified leakage from the total and you see whether you have less than one gallon per minute. If not, then you perform a water inventory balance on the primary system and determine how much of this leakage is coming from the primary system.

MR. LINDBLAD: How long does that take?

MR. PECK: Every 72 hours and it takes some portion of the shifts to do. Generally it is done at night when the plant is stable.

Is it about four hours? About four hours to do an inventory balance.

Now, if the unidentified leakage is less than one gallon per minute and still no action, if it is greater than one gallon per minute then you correct for steam generator tube leakage if you have known leakage from primary to secondary side. You would be able to quantify that and you can subtract that.

If you do all of that and you still are not less than one gallon per minute, then there is tech spec that says you must determine whether you've got integrity in your reactor coolant pressure boundary. And if you don't, you have to shut down by tech spec limit.

The tech spec limit is basically one gallon per minute on the primary side.

MR. LINDBLAD: I gather from this that this a process that could conceivably take one or two days to really go through the chart.

MR. PECK: I don't think so.

MR. LINDBLAD: In any case, can you tell me how fast cracks would grow of concern.

MR. PECK: It would probably take about a thousand years and I'm not kidding. Several lifetimes.

MR. LINDBLAD: We are talking about a crack that has already begun to leak.

MR. PECK: Yes. You'd have to have a crack leaking. And these cracks, in size, are something like 15 to 20 inches long in order to leak at this 10 gallon per minute design number. Very large cracks.

MR. LINDBLAD: How long before it would run at that rate?

MR. PECK: It could sit there for several times 60 years, go up and down the full life of the plant, all cycles, and wouldn't grow appreciably.

MR. LINDBLAD: Thank you.

MR. CARROLL: That is not in our package. Could you give that to Doug so he can make copies for us?

MR. PECK: Yes. I have an extra copy.

MR. CARROLL: Anything more on the issue of leak-before-break? All right.

I guess we are now on the subject of severe accidents.

MR. MICHELSON: High energy and low energy --

MR. CARROLL: Tomorrow or late this afternoon.

MR. MICHELSON: After everybody else has gone?

MR. CARROLL: I'll be here.

[Pause.]

MR. SCHNEIDER: My name is Ray Schneider. I am a consultant for severe accidents analysis at ABCE for both PRA and Fluid System Groups for the deterministic severe accidents. I've worked in the area of thermohydraulics for about 25 years, 20 of which have been at Combustion Engineering. And for the past 15 years I've been involved with beyond design basis events in severe accident activities for CE operational plants and events BRW's.

MR. CARROLL: We will try not to hold the fact that you've spent a career in hydraulics against you.

MR. SCHNEIDER: I appreciate that. I do deal with BRW people as well.

So we are going to be talking about severe accident analysis performed at CE for a number of different applications.

We perform severe accident analysis primarily to -- with the intent of demonstrating compliance with SECY 93-087 issues and 10 CFR 50.34(f) post TMI requirements. In addition, severe accident analysis has been used to support the level 2 quantification for the PRA.

We are mainly going to focus this morning on the deterministic issues and the issues associated with SECY 93-087 and the URD, the EPRI utility requirements document.

MR. LINDBLAD: Do we have a quorum on hydrogen control if Ivan is not at the table? Okay.

MR. SCHNEIDER: We're going to be addressing a number of the SECY issues. The first one we're going to get on the agenda is hydrogen control and then another issue which is high pressure core melt ejection. Mitigation of steam explosions was not a separate SECY issue but it was within the SECY discussions, so we pulled that out as an individual item to discuss.

Mitigation of core concrete interactions will be discussed, and then we will discuss overall containment performance with a primary emphasis on overpressure failure because we will be discussing containment performance all along as we go through the other phenomena.

And at this point we're going to review some information in terms of what the PRA came out with in terms of containment capability, and then we're going to talk about instrumentation and equipment survivability during severe accidents.

[Slide]

MR. SCHNEIDER: Okay. The purpose of the System 80 plus response to SECY 93-087 is to demonstrate -- to limit the containment concentration to less than 10 volume percent in containment. Demonstrate the ability of containment to accommodate the consequences of 100 percent oxidation of the fuel clad. And tacit in all of this is reducing the capacity for containment failures in general and early containment failures in particular.

System 80 plus has a lot of features which contribute to our ability to meet these goals, one of the most important of which is the large containment volume. It's approximately 3.4 or 3.3 for million cubic feet. It ensures that even without hydrogen control features the maximum uniform concentration in the containment will be less than 13 volume percent, which is -- you know, given 100 percent oxidation of the fuel clad, which is a relatively low level for that amount of oxidation. And we feel this gives us substantial margins to issues associated with detonations and its easily capable of handling deflagration of that level.

Hydrogen mitigation systems are included as well with a pressure relief dampers associated with the IRWST and these will function to provide additional confidence to preclude hydrogen detonations within the containment.

Containment arrangement promotes natural circulation and mixing. We'll discuss that in a minute. And we have very few in-containment enclosures but those enclosures that we have are vented to prevent local accumulations of hydrogen.

MR. CARROLL: What happens to the 13 percent if I oxidize all of the zirc?

MR. SCHNEIDER: It would go up by about 2 percent. If you oxidize every bit of zirc in the core because we have zirc alloy grids and guider tubes that would go up to 15 percent.

[Slide]

MR. DAVIS: How do the IRWST pressure relief dampers affect -- how does that aid in hydrogen mitigation?

MR. SCHNEIDER: It prevents collection, minimizes the collection of hydrogen in the IRWST. It prevents level pocketing. You want to make sure you get -- we have a direct flow path from the -- from our rapid depressurization system into the IRWST. So it is possible for that to be the initial release point for hydrogen. You want to make sure you have the ability to vent the IRWST.

MR. CARROLL: What operates the dampers?

MR. SCHNEIDER: By directional pressure, any directional pressure above a few PSi will open it. What will open it is the steaming and the IRWST.

MR. CARROLL: And that is the only way out, the IRWST?

MR. KRESS: Did consideration of hydrogen concentration go into selection of the volume of your containment at all?

MR. SCHNEIDER: Absolutely. That was the primary consideration early on. The reason it comes out as 13 percent is because the way the old regulations are interested is that 13 percent would be the maximum level for 100 percent clad and that was the guidance at that point when the containment was designed.

MR. KRESS: How much bigger would it be if that were 10 percent?

MR. SCHNEIDER: Maybe about --

MR. CARROLL: Go ahead, Ray, finish your sentence. I wanted to add something to your answer.

MR. SCHNEIDER: It would be proportional, another million cubic feet possibly.

MR. RITTERBUSCH: What I wanted to indicate was that the containment size is also impacted by construction practices and experience. So we knew what previous containments were and we did not want to go too far above that. So there was some judgment that we wanted to stay reasonably close to the spherical designs that had already been constructed.

MR. SCHNEIDER: I did not mean to imply that it was the driving consideration.

We've also done a few things in the containment that we feel make it relatively capable of mixing. What we have essentially done is have like -- basically have the steam generators, cavities or tunnels work as a chimney in effect. We've also noticed that all the hydrogen sources are located -- well, actually all the hydrogen or steam sources would be located well low in the containment and basically directed out the steam generator tunnels.

We've surrounded the whole RCS and most of the containment with a crane wall which is generally solid except at the very bottom. And essentially to promote a recirculation pattern to allow some degree of mixing in general in the containment.

MR. KRESS: Are those lines drawn on there a result of some calculation or just an artist's conception?

MR. SCHNEIDER: Both. This is an artist's conception. We have since done calculations which indicate that this is the most likely dominant path. It is not the only pathway. All the steam -- and this is not the only flow path and it's not the only way steam can circulate or the only way that steam and hydrogen can circulate throughout the containment. But from the analyses we have done it looks like the most logical. It seems to confirm what we would naturally believe in how we intend to design it.

Part of it is because you have all of your heat sources basically located in the steam generator region. And so we have some confirmatory kinds of calculations, but we do not want to count on the calculations. Basically it is the design that we think promotes it.

MR. LINDBLAD: Are you saying that there is a heat transfer to the containment shell at the top of the crane there? I understand how you add heat. I don't understand how you lose heat in the downcomer.

MR. SCHNEIDER: It's not so much that you lose it in the downcomer. What's going to drive it is the relatively hot steam that is coming out of the RCS at the bottom. And ultimately that will drive its way up and you will still have a more dense mixture. The outside, it will be a little cooler because you're losing energy as you go further up. You are going to have a small delta P.

MR. LINDBLAD: It seems like it would come to equilibrium in a little while unless you're pulling a lot of heat out of the containment shell. Is there ventilation between the shell and the shield building?

MR. SCHNEIDER: There is heat transfer between the shell and the shield building. It is not specifically ventilated. It can be but you are not counting on ventilation for it. What you're counting on -- that's not even counting on. But one thing that will occur is the lag between the fact that the steel shell remain cooler for a certain period of time as you're heating up. So it will serve as a condensing source for some time and cool the mixture.

MR. KRESS: At the time that you are generating significant amounts of hydrogen you really don't have any steam left.

MR. SCHNEIDER: Your whole containment is full of steam at that time.

MR. KRESS: Most of it is condensed by then. If you look at the calculations, by the time you are generating all of that hydrogen that come out you basically condense most of the steam already.

So I was wondering if this was the result. That's why I asked the question about those patterns. Were they the result of the calculation that looked at the conditions that existed -- well, when the hydrogen is being generated in severe accident.

MR. SCHNEIDER: You're not going to condense the steam unless you have the sprays. So you're saying when you have the sprays on? If you have the sprays on, then the whole system is going to be a well mixed system anyway. It's going to be -- you know, you're not going to be able to maintain -- it only takes a few PSI delta P to drive these flows through the containment. And if you have the sprays going you're going to mix up the containment pretty well.

This is kind of a conceptualization if you don't have the sprays going.

You're not going to condense the steam without the sprays.

MR. LINDBLAD: As I understand you have not modeled it or analyzed it to satisfy yourself that it will occur; is that right? It is intuition more than analysis.

MR. SCHNEIDER: We have done multiple, multi-nodal analysis with MAAP-4 like up to 25 nodes and we have taken great care to make sure that we don't have any unusual currents that will artificially mix the system.

MR. LINDBLAD: And that shows the circulation?

MR. SCHNEIDER: It shows as a pattern that you can get. This is one of the patterns for a period of time. As I say, it is not the only pattern but it is one of the dominant patterns that we could expect to see and that seems to be confirmed.

What the analyses do confirm, though, is well mixing, regardless of what the patterns are.

MR. CATTON: I don't know anything about MAAP-4, but when you look at this particular configuration you can sort of imagine that the steam generator is heating the surroundings and that would cause a flow of hot steam air or whatever up into the top region. You would almost block the recirculation.

And it seems to me when that occurs you would be getting recirculation back through from outside. You show your arrows coming down around the shell and it isn't. It seems to me that you're going to heat up the upper part and you're going to get recirculation out to the outside.

MR. SCHNEIDER: Well, we don't -- I don't know what is going to maintain the driving head. The hot gases collect up in the top and they slowly will fill, coming down around the outside.

MR. KRESS: Basically, MAAP is incapable of calculating that and I wondered if you had some other calculation that showed that.

MR. SCHNEIDER: MAAP-4 is totally incapable of calculating. MAAP-4 has a generalized containment model. We do not use MAAP-4 containment. We use the generalized containment feature that was developed as an enhancement to MAAP-4 which is very much in the same way contained, or maybe we use the 25 node model to represent the system, including the IRWST. I actually have a picture of it.

MR. CATTON: The support for the crane is essentially in impervious wall. Isn't that correct?

MR. SCHNEIDER: Right. Yes.

MR. CATTON: I bet what you would get is recirculation within those walls with some leakage to the outside.

MR. CARROLL: It is not an impervious wall.

MR. CATTON: For the most part it is.

MR. SCHNEIDER: What we believe we've found is that very, very small delta P's are sufficient to cause sufficient mixing such that regardless of the direction at any given time we don't see very much than a few PSI or a few degrees difference in the upper portions of the containment.

We do see differences here and we see differences here and we may see differences in this region and in the cavity, but we don't see differences in this general region.

MR. CATTON: I have a little bit of trouble with that.

MR. DAVIS: How important is the assumption on your subsequent severe accident calculations?

MR. SCHNEIDER: Not at all.

MR. DAVIS: That's what I thought. So let's move right along.

MR. CATTON: It maybe they're going to put things in to control --

MR. DAVIS: They've got 80 igniters.

MR. CARROLL: Forty redundant igniters is what they have. They have 80 total.

MR. DAVIS: At 40 locations.

[Slide]

MR. SCHNEIDER: We will show you the figures. We have 80 igniters strategically located within the containment to a set of criteria. Virtually every major area is covered with igniters and we have multiple levels on the key areas along the main where we expect the dominant flows. Like the steam generator tunnel has multiple levels of burning because you're going to have most of the steam going up, most of the hydrogen going up and we want to make sure you catch it.

We have two redundant electrical trains. The igniters and cables will be designed to basically survive their own operation, survive hydrogen burns. I believe they are category one seismic. They are not going to fall down on you and they will operate through seismic events.

High expected system availability. They have diverse powering through offsite power emergency diesels, combustion turbine as well as batteries.

MR. DAVIS: Are these batteries their own or are these the station batteries?

MR. SCHNEIDER: Basically there is the division battery dedicated to have power to the igniters, so it is guaranteed they will have power to them.

MR. DAVIS: I'm looking at the loss of offsite power sequence where the batteries last about eight hours. And then you would lose igniters after that time also?

MR. SCHNEIDER: It depends upon the number of igniters you power. It will last for the life, the duration of the batteries, yes.

MR. CARROLL: You have an option as to how many you power?

MR. SCHNEIDER: Yes. You can control that, I believe, from -- if you have to from the panels, I think.

Tom?

MR. RITTERBUSCH: I think there's one thing we need to bring out at some point in this discussion, Ray, and that is that the priorities for using the igniters. We really rely on the combustion turbine to provide the power.

Tom wants to take over here.

MR. CROM: Yes. There are several power sources for the igniters. The first one, of course, is offsite power if it is available.

Second, the next one would be the diesel generators. The third source would then be the combustion turbine and finally would be the batteries.

Now we power these off the division batteries, not the channel batteries and we size these batteries to basically take the five starts of the diesel generator before the air supply runs out -- starting air supply runs out.

And then on top of that, size it for the eight hours for the hydrogen igniters. So that the batteries are sized for both the five starts of the diesel generator and for powering the igniters, the minimum set, which I believe is 17 for each division for eight hours.

MR. CARROLL: It is out of place but since you're up there, tell me why I need batteries to run the auxiliary feed water?

MR. CROM: Why do you need them?

MR. CARROLL: Yes.

MR. CROM: It depends on what kind of governor you end up getting. That is correct. Basically it would be for speed control. Now, you could get a mechanical hydraulic governor but that would run wide open unless you sent an operator down there to adjust the speed. But then he wouldn't know what a steam generator level is.

The more critical thing would be the steam generator level because he wouldn't know where to control the speed of the turbine.

MR. CARROLL: It would make a more reliable system.

MR. CROM: The old mechanical hydraulic control error on speed control and they are somewhat questionable if they are safety related. And the came out with electronic hydraulic.

Now what would be ideal is if you had a combination, but I don't know the manufacturer that supplies one yet. But you could have some sort of adjustable electronic device on mechanical hydraulic governor that would control it off of them rather than just electro hydraulic.

MR. CARROLL: Why not just put a little generator on the turbine and make its own electricity?

That was just -- I thought that was the answer but, okay. Move along.

MR. CROM: In addition, the igniters are part of the technical specifications with surveillance and operability requirements and they are included in the reliability assurance program, so they have a high degree of reliability to be available.

[Slide]

MR. CROM: The igniter system design considers three basic functions: system maintainability where we want to make sure that the igniters can be located where they can be reached and replaced so that operation of the system does not become an undue burden to the utility. Redundancy and reliability, as you said. And we have the batteries like that and placement criteria.

[Slide]

MR. CROM: And part of that is based on insights from experimentation as well.

The maintainability requirements will basically have a system that is sufficient, but with no more igniters than absolutely necessary to perform its function, and primarily that is an operability issue and maintainability issue for the utilities igniters to be located with the reasonable expectation of maintainability and surveillance so they can actually check them to make sure the equipment is functioning and replace the igniters when necessary, if necessary.

Redundancy comes in two ways. One is through power but the other is also through the way we locate the igniters. Typically the igniters are located with multiple levels of burning and dominant flow paths. But actually it's not just dominant. It's also secondary flow paths as well. Pairs of igniters cover similar regions. Igniter pairs are powered by independent power sources so there is a high reliability of the system functioning to be able to do its job.

MR. KRESS: When you say to cover similar regions, do you mean pairs of igniters in the same regions?

MR. SCHNEIDER: Sometimes they can be located in close proximity but other times it may just be that we would have one located on the north region of the containment and maybe the other one on the south, so if you lose one, if it is an open region you will have the other one in a slightly different location as long as the region is open.

MR. LINDBLAD: Help me a little bit. These are basically hot wires, is that correct?

MR. SCHNEIDER: These are glow plugs.

MR. LINDBLAD: They generate heat or are they in the chimney, so they develop circulation through a chimney?

MR. SCHNEIDER: Most of these igniters are in the steam generator flow path actually so they are naturally in that tunnel because that's where we predict to be the dominant flow path through the system. Otherwise they are located throughout the containment. There are no other closed or chimney areas in the containment.

So in terms of the placement criteria, we have looked at the containment in multidimensionals and we had like two dimensional or three dimensional drawings drawn up and we located what we believe to be the potential flow paths to the containment. Along all dominant and secondary flow paths we placed igniters, which basically resulted in igniters being placed virtually in every region that even resembled an enclosure.

In the vicinity and above the hydrogen sources we specifically provided hydrogen igniters so that they could be as close to the source as possible as well as multiple levels above that.

MR. KRESS: How did you determine dominant and secondary flow paths?

MR. SCHNEIDER: Basically the dominant flow path is where you are going to have the stem generator tunnel. There are not that many paths and we will go through the figures in a minute. There are not that many paths through the containment. It is a relatively channeled flow, with the major flow path being up through the steam generator, steam generator tunnels, and since that is the source of where your pipe breaks are likely to be, that is the source of where your hydrogen is likely to be released from. That is basically the source of the IRWST events. It seems to be the most logical place to do multilevel burning.

By the time that you got to the very top of the steam generator, you had a very good chance of having burnt all of the hydrogen, and then we will have two or three regions above that to cover it as you go to the upper regions of the containment. We wanted to make sure that they were far enough below solid surfaces so that the burning could be as effective as possible. If you put them too far up against the solid surfaces, the burns are not going to be very effective.

We tried to locate them, except for possibly in the dome in about a 50,000 cubic foot region which the experimental data indicates, based on event, you can handle about one igniter has been demonstrated to handle 75,000 cubic feet, something of that general order.

MR. CATTON: I see no mention of doorways. There is a school of thought that says you do not want to put an igniter in a downstream side.

MR. SCHNEIDER: I don't have any doorways.

MR. CATTON: I just mean a place where you have a contraption in the flow. Let's go through the pictures.

MR. SCHNEIDER: Let's go through the pictures. The containment is not like what you're used to seeing in the German designs. I think that there is not -- let's go through the figures. We will get to that right now as a matter of fact. There is about 11 slides.

The first slide will show the overall view of at least one elevation cut through the containment, just to give you an idea of reference levels, and then there are five slides which basically are planar cuts at the various levels looking down on the containment, and then we have multidimensional cuts which are cut generally around this location in the containment, and as you look through all of it I think you can get a feel for where you might expect flow to be and why we feel reasonably confident with the placement of the igniters.

[Slide]

MR. SCHNEIDER: Going from the bottom up, if we look on the two dimensional plane, and we may have to go back and forth with these to get a feel for where everything is, but let's get an idea of the placement and the way the system is structured. Going from the bottom up, this is a cut basically taken in the cavity region, just the cavity itself. The reactor vessel is placed here. We're looking down the rafter cavity toward this chamber would be here. You do not see the breach hatcher in this junction, and igniters are placed basically in that region to cover potential for post-vessel breach.

MR. CARROLL: Toward the breach chamber? This is DCH.

MR. SCHNEIDER: No, it is a phenomenon toward the breach chamber. It's a physical structure in the next section. It is not really -- it is. It is a debris accumulation chamber.

[Slide.]

MR. SCHNEIDER: As we move up the containment, this is basically a cut through the containment where you have the cavity region with a planar cut through it and the IRWST surrounding it. The spargers are located in this general region with the piping. Spargers go down and it covers a large fraction of the IRWST and igniters are located along the walls in order to maintain easy accessibility and maintainability in mounting of the igniters, and they will be located well above, or at least above the water level.

[Slide]

MR. SCHNEIDER: This represents the first floor of the containment, so now as you are marching up, you have a cut in item three which is right across the 91'9" elevation.

[Slide]

MR. SCHNEIDER: This is basically the -- what you call -- basically it is the first floor, what you call basement floor, whatever. The steam generator tunnels are found in this general region. The IRWST events are also provided in that general region to the underneath, within the steam generated tunnel.

We have not really an enclosure but a room -- it is an enclosure -- a room for the let-down heat exchanger and both of these have ended on the top.

[Slide]

MR. SCHNEIDER: Each of these rooms have igniters of their own should they somehow become a preferential source of hydrogen accumulation, which we believe to be unlikely.

The exit from the cavity is right out here. Igniters are located by either side of the cavity except this represents the lower elevation of the crane wall. This represents the only -- one of the few elevations where you have a penetration through the crane wall itself. At about the seven foot elevation above this, the walls will stop and these will come to be manways that you walk into and these would represent the only way for flow to get back in.

[Slide]

MR. SCHNEIDER: We move up to the next floor, which is 115 elevation. The steam generator tunnel, this is located in here. It's not shown but it is graded in a steam generator tunnel areas. This is primarily solid, with the exception of, I believe, a solid with the exception of this area, which has, I think, a grade, and maybe this area, which has a grade. So there is not a lot of bypass flow that you would expect in these regions. Most of the flow is going to come here and enter and exit in these regions.

This represents the pressurizer enclosure, which has its own separate igniters associated with it. This represents the outer region of the annulus. This is primarily solid with flow holes along the side, and some additional grades may be over there.

[Slide]

MR. SCHNEIDER: This covers the remainder of the containment. It is basically opened all the way down from the 257 elevation all the way down to the 156. Again, the steam generator tunnel coming straight up, the pressurizer enclosure would be closed on the top and have relatively a decent size venting or vents or exit holes along the sides.

Igniters are located where it would vent. Again, igniters located again in the steam generator tunnel heavily ignited in that region. This represents the missile shield for the steam lines and igniters are located above that elevation but there's not a enclosure underneath. It is basically a missile shield.

MR. CATTON: So you put your igniters near the exit from the chamber on the outside?

MR. SCHNEIDER: I believe this was on the inside and the outside. We have some on the outside and a handful on the inside so it is covered in both regions.

MR. CATTON: If I remember right, wasn't there a description that you put it inside because of the concern about the jetting that was observed at Frankfurt?

MR. SCHNEIDER: These are located inside the enclosure and there is one located outside the enclosure as well.

MR. CATTON: The one that is outside is near the vent for that compartment. Shouldn't that one be on the inside?

MR. SCHNEIDER: It is a pressurizer compartment. The only way that one is ever going to see a hydrogen accumulation is if you have the actual break in the pressurizer itself, so we felt that that was kind of a low enough probability. We really were not concerned about that being a major contributor. It's the only pipe there. It is an unlikely pipe to go.

MR. CATTON: Is there anywhere else where you can put it outside the compartment where the hydrogen is generated?

MR. SCHNEIDER: There were no other compartments that even resembled enclosures like this one, and again, looking straight down, you see nothing else except relatively open areas and this being the -- let's see. This is probably, has to be the crane wall, the outer side here.

MR. DAVIS: How much of the surge line for the pressurizer is in that compartment, Dave, remember?

MR. SCHNEIDER: Just the entrance section. There is a lot of residual piping because if you look, if you just basically look at this location to the RCS, the surge line has got to come off of the hot leg, which is probably here. So it goes underneath this area and then there is a small -- not really enclosure area but there is a small concrete section where the pipe will turn up, so very little of it is actually in this enclosure.

There is some of it located well down in the section where the piping will move in, but the area where it comes in is not nearly as closed as it is in the top.

MR. DAVIS: The only reason I'm asking, even though the accident may not be initiated by a surge line break, that surge line by some calculations is expected to fail due to over temperature and hot gases recirculating through the pressurizer.

MR. CARROLL: In the leak-for-break presentation, there was a schematic piping schematic that gives you some sense of that.

MR. DAVIS: There is not much of that in that compartment, I guess.

MR. SCHNEIDER: I believe we have igniters placed where the search line is located. Let's see if we can see that.

MR. DAVIS: It does not sound like a problem. Why don't you go ahead.

MR. LINDBLAD: I must have missed something. Why is there a solid roof over the pressurizer?

MR. SCHNEIDER: The pressurizer, because probably a missile shield, I would guess. That is about the only reason I can think that we have one.

Tom, solid roof?

MR. CROM: Yes, I believe the solid roof is for the missile protection for the PROVs and things like that on top of the pressurizer.

MR. LINDBLAD: But the pressurizer room is vented for line breaks?

MR. CROM: Yes, it is vented on the top.

MR. LINDBLAD: It is vented toward the top?

MR. SCHNEIDER: Towards the top.

MR. CROM: Not on the top. It is towards the top on the sides.

MR. LINDBLAD: Thank you.

[Slide]

MR. SCHNEIDER: Now we have basically a similar set if you want to go through the containment three dimensionally. This is basically again the cut through the lower containment IRWST areas showing the surge lines as you see the surge line piping that goes all the way down, and it has holes up and down the sparger.

MR. CARROLL: Do you have enough sense of this, Ivan, or do you want to go through the three dimensionals?

MR. CATTON: I like the three dimensional much better than the flat ones.

MR. CARROLL: But do you have enough sense about what they are doing to allow us to skip them?

MR. CATTON: I can just go through these myself, I guess. How many more do you have?

MR. SCHNEIDER: About four more. If you want to look at it yourselves, feel free to do so. It is here at your disposal. The NRC felt very strongly that this gave them a good feel for the containment and we think it gives us a good feel also.

MR. CARROLL: I almost suggested that we start with the three dimensional but I didn't want to interrupt you.

MR. CATTON: I think it would have been better to have started with them.

MR. SCHNEIDER: That's what the NRC said also.

MR. CATTON: And you would use shading too.

MR. SCHNEIDER: As you can see, you can see the guardings and the steam generator tunnel and basically minimum access areas on the side. You can see where the access for the staircase is and the like. The exits for the cavity is here, two big louvered doors on each side. Here is your let-down heat exchanger -- it is vented on top. I do not see the vent in this picture. It could be an older picture.

There is a staircase opening and this is one of the few ways that you can enter the second floor from the outside of the crane wall on this side and this side, so these are actually doorways into the crane wall but that is about it.

[Slide]

MR. SCHNEIDER: And again, the pressurizer cut-through. The venting of the pressurizer is right here on either side and that represents the vent and you would have a solid wall here. It is just another view of pretty much the same thing showing relatively limited access on the non-dominant flow paths.

[Slide]

MR. SCHNEIDER: This is just another view of pretty much the same thing. Again, the mavic area. That is your cavity exit. And again, steam generator tunnels. Again, limited access except through the steam generator department.

[Slide]

MR. SCHNEIDER: And then finally this just gives you a layout of the piping, not the search line piping but at least the piping for the discharge of the IRWST of the safety depressurization system.

[Slide]

MR. SCHNEIDER: So we have tried to address this issue. We believe pragmatically by trying to make sure that we have covered all of the dominant regions we believe we have put enough igniters in to control any kind of hydrogen concentration and having a large enough volume we believe helps us so that our initials right to begin with is not very significant.

Having very few enclosures prevents the possibility of substantial accumulation, and having, we think, the chimney kind of effects we think is going to help us in potential mixing. We have also looked at the issue in the event the igniter system does not function. We looked at limiting burns at 13 volume percent to see if they were concerned, and even at 13 volume percent, we -- actually we don't exceed by quite some margin the ASME "C" levels.

[Slide]

MR. SCHNEIDER: We did do some contrimatory work and I do not want to get into this in any depth. We did not rely on this for analyses, but we did do some, as I said, multinodal map calculations with a generalized containment model. We took tremendous amounts of care. We were heightened to the sensitivity of the poor performance of MAP, generalized models on gas in predicting HDR.

We felt that if we worked at it and modeled as precisely and as carefully as possible so as to minimize any unnecessary flows that we would be able to get a rough idea as to what might happen when we modeled the igniter system, so the first part of the effort, a substantial part of the effort was placed into getting a system that did absolutely nothing, where nothing happened to it, and that is not easy.

When you deal with small delta Ps, you can actually get very easily flows going through the system because your nodes and flow paths do not quite match up, and if you are not very careful, you get artificial flows. So we took a lot of care not to get those artificial flows.

Then in addition we played a game scene. What we noticed that HDR was that if you injected from an upper region, you got stratified flow above the region you ejected but not below. What we did was artificially increase the volume of the cavity to about the size of the first major node above the cavity. We looked at the concentrations in those two regions, and in injecting that -- and if you had a design like that, we actually did convince ourselves and we had -- unfortunately I don't have a slide of it. We actually showed that you would get a concentration of nearly zero in the cavity, with a very high concentration above.

Then we started doing the analyses, and so we have a feel that at least the model itself is not going to kill us from the outset. There is a lot of effects that we understand the models cannot do and we are not relying heavily on them but we are locking for some insights. Is the containment going to be generally not well mixed, and if we take care in at it, we've got the feeling that it was going to be generally well mixed.

We looked for gradients and the biggest gradient would be the ones associated with possibly the steam generator tunnels, all along its pathway, and possibly if you have a direct injection into IRWST and expect some gradient there. But on the whole there was nothing that gave us the feeling that there was any concern.

The system looked like it would operate very effectively. The models for the igniters were independently verified by past tests on maps, so we're reasonably comfortable with what we came up with. It was nothing that really -- after you ended up looking at all the results, there was nothing that did not -- that violated our intuition.

MR. KRESS: Refresh my memory. Map for containment model is a control volume model with lump rounders in it?

MR. SCHNEIDER: Yes.

MR. KRESS: So when you divided your containment up into nodes or volumes, were those boundary lines represented? Did they represent real solid volumes or were they phantom lines drawn just for wherever you wanted a node?

MR. SCHNEIDER: We took great care to do it as physically accurate as possible. We were concerned if we did not come up with a decent analysis we could not believe the results at all. Now we believe we can believe the results a little. We have like 25 nodes and 37 junctions.

MR. KRESS: They represent 25 separate regions that have walls?

MR. SCHNEIDER: I'll give you a feel. Not all of them represent walls. We broke the dome up into a handful of regions but mostly they did not.

The other thing is, I have to be careful. You know, I am saying map four because it is most familiar. But there are detail differences between what we actually did and what map four actually has, and what map four may becoming in the future. So the work was done by Mark Hatton and his people. To a great extent they took their version of the generalized containment model.

I personally believe is superior to the one on map four but it is basically very similar. The care taken in modeling it basically is important, and as you can see, we have the steam generator regions. We do have lower compartments based on floor levels. We modeled the IRWST as a multiple three node region with not very much mixing here, but where we allowed the spargers to be credited, the floor regions for the annular compartment, pressurizer compartment, so we tried to do a decent job to get a feel for what was going on.

As I said, it confirmed what we kind of suspected. If in the long term hydrogen concentrations can be maintained four or five percent, maybe five, six, seven percent, at any rate in that range. And I guess that's truly about it.

There are also 37 heat sinks. They divided up the heat sinks in order to not put too much energy in any one area and not kind of artificially generate a thermal plume.

MR. HATTON: And you say that you have checked to see that map four would reproduce some of the results from HDR?

MR. SCHNEIDER: No. What we did is we did --

MR. CATTON: My recollection is that the lump perimeter was poor. You needed to do something.

What did you do that is more?

MR. SCHNEIDER: I think what we did that is more is that at the beginning we took great pains to make sure that we did not get artificial mixing. Ten to the minus fifth, delta p's. If you were not very careful exactly how you lined up all of these junctions, you artificially created a density-driven flow just by modeling.

We took great pains to make sure that you do not generate density driven close through the modeling process, so we think the difference is the care taken in modeling, and part of the reason is we knew they had a problem before. They may not have been as sensitive to it when they do a blind experiment, so as a result and the concern, we decided that we were not going to use this if you could not get at least something that represented a good steady state.

MR. CATTON: What I don't understand is how do you know you got it when you didn't make any comparisons?

MR. SCHNEIDER: We felt comfortable we can reproduce.

MR. CATTON: Is this because you feel that you are better than anyone else who does it? They were all pretty much a failure.

MR. SCHNEIDER: We understand that.

MR. CATTON: The only code that did any good like the one at Los Alamos. ATM? I don't remember the name of it, but the one that came out at Los Alamos. HMS. That's right. The HMS code was one of the few that did well.

MR. SCHNEIDER: There are a few other things. HDR is a much more complicated facility.

MR. CATTON: I understand. That's why it is a good test.

MR. SCHNEIDER: We were not trying to necessarily test out the code. We figured the question would be, how do you know that you -- how can you prove that this code will predict stratification? We wanted to convince ourselves that if we modeled it properly and if we did something that looked like an HDR-type thing in our facility, we would indeed predict the large stratification and indeed we did.

So we felt that since we could predict

stratification if it occurred, if it did not occur, we're going under the assumption that the models aren't good enough to give us an idea of the level of mixing. There's not much more we can push to. This is only for confirmation. We did not rely strongly on it but felt it was something we should do to convince ourselves -- basically to address some issues that have come up in the past ACRS meetings and we felt that this was a reasonable way of doing it at a reasonable level of effort.

We did not feel comparison to HDR was required. We wanted to make sure that if stratification could occur in our facility that we could predict it.

MR. CATTON: So what you did was use judgment instead. Not necessarily bad if your judgment is good.

MR. KRESS: Did you take essentially the same containment model and vary the nodal structure to see if you got different answers?

MR. SCHNEIDER: Yes, this is probably -- well, we took -- we did a lot of modeling early on in the process to make sure we did not get artificial mixing. The first test that we performed basically mixed everything. They ultimately traced that down to the fact that the nodes were not lining up perfectly. After maybe about a month they were able to get the nodes to line up such that if you let the model sit and do absolutely nothing to it, nothing happened.

Now that may seem like a small thing but sometimes that is real difficult. We got the thing to basically sit there and be perfectly stable, and then at that point that would be the point that we would start doing the initializations. Otherwise you ended up with very small differences that can drive these flows substantially.

Then we artificially increased the cavity region to about the size of the upper compartment region, and since we were not getting much stratification with such a small cavity, we said, what happens if I make that very big? If I make that very big, which is something that a simulator and HDR type thing, we had a large region above and below it, we did indeed get quite substantial stratification.

MR. CATTON: When you do one of these calculations, do you start with a type of stratification one might expect if it is a LOCA type sequence? There is stratification in the containment before you start. I gather than answer is no.

MR. SCHNEIDER: I'm trying to understand why you think there should be a lot of stratification with respect to a LOCA.

MR. CATTON: That's what they experienced in HDR. It was very hot on top and it stayed very hot.

MR. SCHNEIDER: These are relatively open containments. It is somewhat alien or different for me to think about these things being very different, having very nonuniform behaviors because what drives, what normally drives the LOCA is the fact that your containment is pretty much a saturation. The only way you would make it hot is to have some super-heated regions at some point, and since there is no way of getting super-heated steam in a LOCA transient, there's got to be something unique about the way HRD did it to get super heat, or maybe something unique about -- maybe the structure where they were able to condense or something at the bottom, but normally it is different. It is not something that --

MR. CATTON: There are whole lots of tests they run to show that the top part of the containment getting extremely hot relative to the bottom.

MR. KRESS: When you ran the test --

MR. CATTON: High temperatures in one place relative to another.

MR. KRESS: When you run the calculations, this is an integral calculation with a full sequence, so it will generate its own thermo-hydraulics, its own initial conditions. You are asking, had it stratified before. If it was, it would have calculated it, is the point.

MR. CATTON: I think the only saving grace is 80 igniters.

MR. KRESS: That helps.

MR. SCHNEIDER: That was the brunt of it. This is only here for -- well, maybe it should be here, whatever.

MR. CARROLL: We would like the slide you have been talking about, since it is not in your package. While we are still on hydrogen control, as long as you are putting 80 igniters in, why aren't you putting in the auto-catalytic gadgets also?

MR. SCHNEIDER: They are not seismically qualified. They act too slowly. We are not sure of their performance. We are not 100 percent sure anyone would accept them if we put them in.

MR. CARROLL: I like those answers. The other thing you need --

MR. CROM: You need to look at the size of what you're proposing. These things are like five by five by three foot boxes and we are talking the same lumber here that we would need of those in the amount of space, and just everything else. The other thing is the testing. What we read on them is it does not look real beneficial there either.

MR. CATTON: A couple of us attended a meeting in Germany. They came to the conclusion that the catalytic reactors are what should be used and that igniters were too speculative, particularly the possibility of deflagration being initiated. Nobody -- they were not too concerned about detonation because they felt the highly variable environment that detonation would not occur but deflagration could, and that if you did not place the igniters properly, you could initiate it.

I believe they're going to recommend that the catalytic reactors be used and igniters -- there is still question as to whether they should be used or not.

MR. SCHNEIDER: That might be the right decision for the German plants. They are more compartmentalized. They have areas that could propagate flows in with accelerations. It is not that we disagree with their judgment. We do not think it is the right thing for our plant.

MR. CARROLL: Add to your list the good German catalytic converter on my Porsche has disintegrated and it's going to cost me $1,200 to get a new one.

[Laughter]

MR. CARROLL: The next topic is the limiting burn pressure. So that is sort of separate, I guess? Why don't we take our break at this point and pick that up when we come back? Ten minutes.

[Recess.]

MR. CARROLL: Let's reconvene.

MR. SCHNEIDER: As the last part of the hydrogen analysis, what we wanted to demonstrate is if we had the 13 volume percent uniformly accumulated within the containment, that the resulting deflagration from that would still be well below the containment service level C limits. So we calculated the hydrogen pressure based on AICC and we burned from the maximum flammable condition for the containment to get the maximum initial --

MR. CATTON: How much steam did you have in it?

MR. SCHNEIDER: That's what we'll do next. What we did is we started off with a 13 volume percent dry, relatively dry, with a couple of weight percent, couple of volume percent steam, and then started to add steam into the mixture, so we had a constant hydrogen mix, but the volume percent dropped, and this is the flammability line.

We calculated the combustion pressure, which is on this scale, as a function of the steam concentration, the hydrogen volume concentration. Either percent, or 10 to the minus 2. Both of these might apply. We went down the regime of adding steam to the mixture and then calculated the AICC pressure.

Even as we go beyond the no combustion point where you go beyond flammability -- when you get to about six, maybe seven volume percent, you start getting into the incomplete combustion range. We still assumed AICC and then we still took it even, and as you get to just beyond the no combustion point, the final pressure for volume percent mixture in this containment is 100 psi with C, 140 psi.

We have, we feel, a substantial margin for that. That is a reasonably limiting evaluation, we believe, so our conclusion was the assessment of the post-burn containment performance indicates that the system 80 design features successfully mitigate the severe accident threat.

MR. CARROLL: Now Ivan, why don't you take a look at the topics in the next slide here. One of the first ones also. And I assume you're ready to talk about any of them?

MR. SCHNEIDER: Yes.

MR. CARROLL: Why don't we pick the ones you would like to hear this afternoon, Ivan?

MR. CATTON: What about all of them? Why don't you just start and go.

MR. CARROLL: I don't know if we can get all of them in. It's five minutes to four. Steam explosions?

MR. CATTON: I would like to see the excess steam explosions, core concrete interactions.

MR. SCHNEIDER: Ex-vessel steam explosions. I put excess. It should have been ex-vessel. Ex-vessel steam explosions we treated probablistically. We don't have a deterministic treatment of in-vessel steam explosions. We've reviewed basically what was done by the SERG, as did the steam explosion review group that concluded that that was applicable.

We used that set for values of probability of containment failure and we had a multiple probability of containment failure depending on the low pressure versus one conducted at high pressure. We propagated it into the PRA.

MR. CATTON: It is a steam explosion review group. That's been 10 or 15 years ago.

MR. SCHNEIDER: It's been some time but it was supporting new reg 1150. Maybe about eight years ago.

MR. CATTON: It was quite a ways, quite a while ago.

MR. CARROLL: The staff did something more recent.

MR. SCHNEIDER: We did also look at the German risk report. I guess --

MR. CATTON: I'm not sure the Germans believe their risk report. At Karlsruhe there are 32 people who are working in this area of steam explosions, and it is not so much that you blow the lid off but you also have the possibility of knocking the lower end off, and then the acceleration of the vessel rocket.

What have you done about this? You just put the number and put it into your PRA?

MR. SCHNEIDER: Right now we don't have, we don't feel that the in-vessel steam explosion is a credible containment threat. It is in the PRA at something like 10 to the minus --

MR. CATTON: There is more to the in-vessel steam explosion than the Alpha mode failure of your containment, and you could argue that that probability is low, but that is basically all that this particular group address.

MR. SCHNEIDER: Right.

MR. CATTON: But there are other things. There was a momentary surge and pressure in the lower cavity. You could argue that your cavity is much bigger and it would be nice if you did it, and there is also the thrust that you would have on the vessel if you ruptured and whether or not your supports could take it. Have you done all these things?

MR. SCHNEIDER: Partially. We looked at rocket failure as a separate issue.

MR. CATTON: And you concluded that it is strong enough to handle?

MR. SCHNEIDER: Yes. Basically rocket failure -- we did not look at the full failure of the lower head. We looked at the failure of a typical lower head failure for a lower head level plant.

MR. CATTON: That is a hole the size of my thumb.

MR. SCHNEIDER: It is a hole a couple of feet. We looked at 20 square feet and based on 20 square feet we were able to indicate the thrust without it being that great. We used the German calculations using RELAP for their upper thrust and scaled it down for our areas.

MR. CATTON: What does RELAP calculate thrust?

MR. SCHNEIDER: Basically they calculated the impulse of a lower head falling off in order to estimate the loadings on their support structure in one of their containment analyses, and what we did was basically use their data with their prediction, scaled it for our particular areas, looked generally at what our supports were.

We have very messy hot links that generally could take and the clove legs and kind of came to the conclusion that it is still going to be -- even with a 20 square foot hole in the bottom, and I believe that is the number we used. I have to double check that. It is unlikely that there's going to be any substantial -- that you're going to be able to lift a million pound vessel 100 feet. The kinetic energy just was not there.

MR. CATTON: What about the momentary pressure spike in the lower cavity?

MR. SCHNEIDER: Our cavity is very robust. It will handle well over 100 pounds. We did do a full failure of the lower -- of the cavity and the cavity pressure is going to be -- I've got to be careful about the numbers. We did the analysis. The cavity pressure for a steam-driven release is a lot lower than you would have gotten traditional for the blow-down of steam-water mixture, which they used to analyze the massive double-ended bricks for. This cavity is bigger and stronger than any cavity that we have designed in the past.

So I believe we looked at it. It has been an issue that I have not looked at for a long time because it was kind of dismissed because we had substantial margin. I was even considering maybe taking it out because nobody seemed to have any interest in it, but we did actually some compartment pressure analysis of a break in the lower head of the -- a break in the lower head of the vessel, pressurizing the cavity and because of the large vent, the large volume, we're okay. I don't think there is a problem.

The modeling is in CESSAR.

MR. DAVIS: I think part of the argument that I got out of the PRA was that you do not have very many high pressure mount sequences because you have got a safety grade depressurization system, and for a lot of cases you go through an aggressive cooldown of the primary system when you start getting into problems. So there's very low probability of a high pressure melt sequence, isn't that true?

MR. SCHNEIDER: Yes, that is true. You run into a problem when you talk phenomena versus probablistic risk. I wear both hats. He asked me if it's a phenomenon problem. I will tell you what the phenomenon is, but probablistially it has risk significance.

MR. CATTON: If both sides go away then it's really low-risk, and that's what would be nice to hear too.

MR. DAVIS: Okay.

MR. CARROLL: It doesn't sound to me like what this stuff says about in-vessel steam explosions, beginning on page 19-169 really reflects the current state of the art.

MR. LINDBLAD: Fossil plants again?

MR. CARROLL: They're hanging their hat on NUREG-1116, and this CSNI meeting in January, which you say people are now re-thinking. January '93.

MR. CATTON: That was not the meeting I was talking about. That is not the one that the gentleman up here referred to. It was something called a severe accident review group that formed. I thought it was 10 years ago, that concluded that it was very low probability. It was a bunch of people like me who didn't know anything about steam explosions.

MR. CARROLL: That is what NUREG 1116 is about.

MR. SNODDERLY: I was one of the contributors. Really what we have hung our hat on is, as Dr. Catton said, it sort of took place about 10 years ago and then there was another meeting that was attended by one of the contractors for the ACRS, members of research NRR, and from experts from all over the world. It headed by Professor Theofanos.

MR. CATTON: That was the meeting at Santa Barbara and the conclusions there were not very conclusive.

MR. SNODDERLY: I would agree, but one point that did come out was that there would be limited, not mass involvement, because if you go to the next paragraph we melt mass involvement because of the structures in the lower head, i.e., the CIC guide tubes in the lower baffle plate would break up the melt mass, and because of the limited melt mass would limit the size of the in-vessel steam explosions.

That is one of the conclusions we drew, and one of the things that we are really basing our conclusion on.

MR. CATTON: How come I don't have a chapter 19?

MR. CARROLL: You've got one at home.

MR. CATTON: Oh, that's that big, thick --

MR. CARROLL: Do you want to read your words from mine and see what you think of them?

MR. SNODDERLY: That would be the last paragraph right before section -- right before ex-vessel steam explosions.

MR. CATTON: What led them in Germany to sort of revitalize this concern and to put so much resources into it? Do you know?

MR. SNODDERLY: I believe that would maybe be the beta experiment.

MR. CATTON: The beta experiment certainly helped because there it showed how you could get total mass involvement.

MR. SNODDERLY: And I think that there was a pressurization because of a limited vent area that caused -- that caused it to force back.

MR. CATTON: Correct me if I'm wrong, Tom. Didn't we hear that what happened is that somehow melt got into the water and pressurized where the water was outside of the region where everything was supposed to be occurring, and that pressure then drove the water into the melt?

MR. SNODDERLY: And kept it in that confined geometry.

MR. CATTON: It was just driving the water into it that caused the problem. How can we preclude that in other circumstances?

MR. SNODDERLY: I personally don't think that we're going to have that because of the limited vent area, forcing the water back.

MR. CATTON: Look at Three Mile Island, where you almost melted through into the annulus. Then it begins to sort of look like the beta experiment. Anyway, I don't personally think the alpha mode is a concern, and if they have evaluated these other things, the only question then is the 20 square feet. How do you come to 20 square feet as the area that you used?

MR. SCHNEIDER: Well, our best estimate was something on the order of one, and we did some kind of a log normal type of fit down to full vessel size and I think we took it -- I've got to go back. I think it is just standard deviation. We decided to go to the upper end but it just did not generate enough thrust.

MR. CATTON: Okay. I don't need to hear any more.

MR. CARROLL: Okay. Well, do you like what the staff has said? Do you think that is appropriate language for an FSER?

MR. CATTON: I have not seen this in NUREG 1116. Oh, that is the SERG report. Well, the fact that they refer to that report makes me a little nervous.

MR. BARRETT: I am Richard Barrett with NRR staff. I guess our thinking was that in the original 90-016 we really did not address steam explosions, and I think probably that was because of the low importance they had in NUREG 1150. After we started the reviews, we recognized that this could be a problem and we went back and revisited it, based on the SERG report, and Mike Snodderly attended the meting in Santa Barbara and his report on what the conclusions were was that if we were going to deal with this issue, we would gain a lot more by concentrating on the ex-vessel. That seemed to be the consensus of the experts.

MR. CATTON: The last part where they talk about the structure in-core instrument tube guides that is below the core plate probably does more to eliminate a large steam explosion in that region than anything else because we heard about that too. Apparently some experiments have been done and you have a lot of metal tubes and so forth that makes it somewhat incoherent and that reduces the peak. I guess we go to ex-vessel.

MR. SCHNEIDER: Okay, I'm happy.

[Slide]

MR. SCHNEIDER: The purpose of ex-vessel steam explosion studies was, one, again, to comply with the goal to minimize early containment failures. It was not any specific goal in ex-vessel steam explosions and addressed the observations made in some of the NUREG 1150 containment performance analysis, and can induce a containment failure possibly via failure penetrations.

[Slide]

MR. SCHNEIDER: So we attack this on multiple fronts, and actually resulted in a lot of design analysis, and actually even some design improvements, if you will, for severe accidents. Basically, if you remember the cavity design, it is this huge cavity that sits at the relative bottom. Maybe let me pull up the figure again, with a massive amount of concrete around it.

We just have a couple of views of it. This is the lower portion of the cavity. The cavity is the region inside here, including some of the stuff going up to there, so it is a pretty massive structure.

MR. CATTON: How thick is the concrete?

MR. SCHNEIDER: About 10 feet.

[Slide]

MR. OSWALD: It is six foot at the thinnest portions at the very sidewalls. It is six foot at the thinnest.

MR. DAVIS: You're talking about a steam explosion which results when the molten core exits the vessel and enteres the cavity.

MR. SCHNEIDER: Yes.

MR. DAVIS: Which may or may not have water in it.

MR. CARROLL: Which is supposed to have water in it.

MR. DAVIS: No, because that is a manual system and they can either wait or they can put it in afterwards. And if this is a problem, they can put it in -- isn't that correct? It is a manual system. Your accident management strategy can put it in before and after.

MR. SCHNEIDER: Right now we are comfortable with putting it in -- because of the structural design and we will talk about that in detail. We are not really concerned about a steam explosion. Basically the bottom line is you can damage the cavity, virtually eliminate the bottom portion of the cavity and there's enough cantilever support and re-bar shear that will still hold up the vessel so that at the moment we think there is enough robustness in the design.

MR. CARROLL: Your strategy would be to flood the cavity where there is indication that you have core melting?

MR. DAVIS: But you have the flexibility to adjust that?

MR. SCHNEIDER: Yes. Should a different interpretation ever become available, we can, which is a unique feature of the system 80-plus design.

MR. CATTON: So you plan to try to save the vessel, to turn the vessel into a crucible with flooding?

MR. DAVIS: The flood will not get up to the vessel.

MR. SCHNEIDER: It is basically just to break the core room up and to cool the core itself. Unfortunately, in the process of going through the earliest slide to get the containment picture, I misplaced the slide I was just showing you so I will have to read it to you. The system-

80 plus reactor vessel can be supported without the presence of a lower cavity wall, and in addition we have corbels, and let's see if I can use the picture up here.

MR. CARROLL: You've got a better one further on. We tend to do that to people. This is a test.

[Laughter.]

MR. SCHNEIDER: We have corbels, which are pretty massive, and reinforced with re-bar at the top and bottom. The only reason they are reinforced at the bottom is for the steam explosion loading, and basically it is a reasonably massive structure. This contained impulse loads pretty close to psi seconds, which is pretty high, like 1,000 psi loading over a period of time.

If we fail the lower cavity, this is all gone, there is enough residual re-bar shear strength to maintain this in a cantilevered mode and hold up the reactor vessel.

MR. CATTON: What was the impulse again?

MR. SCHNEIDER: The corbels itself can take close to 4.6 psi seconds. The walls are not quite as robust and we will talk about that in a minute. But should you fail the walls, you still have enough strength in the re-bar on -- that's from the adjacent structure to maintain integrity of the -- or main support of the reactor vessel so that you're not going to be pulling. This is not going to be moving so far out of its location that it will pull penetrations out of the containment.

MR. CATTON: Where did the 4.6 come from?

MR. SCHNEIDER: We did detailed structural analyses.

MR. CATTON: You have the structure there and then you ask yourself.

MR. SCHNEIDER: I'm telling you what the structures can take.

MR. CATTON: There are lots of tools available to do calculations once you have made some assumptions as to what the impulse might be. Have you done that?

MR. SCHNEIDER: In a manner of speaking. We decided that the state of the art was fine, but what we felt is we could get a good handle by using basically the depth charge impulse loadings with equivalent TNT energy transformation, so we did basically a similar thing for NUREG 1150. Basically we used the cold underwater explosion impulse and determined, based on so many pounds of corium, with such superheat and conversion efficiencies, what the size impulses would you get propagated as a spherical basically depth charge.

MR. CATTON: I understand how to do that part. It's just the energy conversion. When you put the .03 did -- what was the impulse?

MR. SCHNEIDER: It depends on the mass. We can talk about that. Basically what we concluded was, based on a .03, and I will have that in the next slide and we can talk about it a little more if you wish, will survive a one-half PSIA, which is equivalent to a 10,000 pound mass participation at three percent.

MR. KRESS: How much total mass is in the core?

MR. SCHNEIDER: The core has a total mass of about 350,000 pounds. So, it is not a large fraction of the total,mass, but remember the explosion is only going to be a millisecond phenomena and so that you're not going to have a lot of mass at any given time.

MR. CATTON: It turns out that it is going to be longer than a millisecond.

MR. SCHNEIDER: Of that order, you're not going to have a lot of mass that is going to be able to accumulate in a short amount of time. A lot of it is going to lose super heat, plus a lot of it is going to be contained within the mass itself. Not all of it is going to participate. Be that as it may, 10,000 pounds can participate and your cavity still stands with best estimate analysis. We looked at this probabilistically. That is basically the level at which we can withstand. This is kind of a demonstration that we can withstand that much.

MR. CATTON: Did the Staff do any calculations? They did for ABWR. Did they do it for this also?

MR. SNODDERLY: Yes, we did.

MR. CATTON: What kind of mass did you assume?

MR. SNODDERLY: I can get that in one second.

MR. CATTON: Did you use the Texas Code again?

MR. SNODDERLY: Yes.

MR. CATTON: Tom, I think we're going to have to take a look at that Texas Code.

MR. SNODDERLY: We assumed a melt composition of 5,000 kilograms of UO2, 13,000 kilograms or zirconium, and 28,000 kilograms of steel molten. Then what we did was for the best estimate case we assumed a three centimeter single penetration failure of essentially one instrument and we got loadings that showed you would not fail the cavity walls.

Now, we did some sensitivity studies on that and we boosted it up to eight penetrations failed for one penetration of -- essentially of going through three centimeters diameter to about seven centimeters diameter. It showed that it would exceed the capacity of the cavity walls at the finis portion that Todd Oswald mentioned, that six foot region.

But because calculations done by Duke showed that you could fail that cavity wall and still support the structure and the connecting penetrations and preserve containment integrity, we felt that that was acceptable.

MR. KRESS: Did the significance of the number of penetrations failed that is because Texas treats this as a jet going into the water?

MR. SNODDERLY: Yes, sir, a gravity pour.

MR. BEHBAHANI: Ali Moni, from Accident Evaluation Branch. You can also have high mass injections if you have higher pressure in the reactor vessels. So, in addition to gravity flow, you can have higher velocity flow.

MR. CATTON: How much corium did you say or zirc that was in the mixture? 5,000 tons of UO2, 13,000 kilograms of something.

MR. SNODDERLY: It was conservatively kilograms. 13,000 kilograms of zirconium, 28,700 kilograms of steel.

MR. CATTON: 28,000 of steel. Now, in Texas, how do they treat the zirc? Do they react it?

MR. SNODDERLY: We would have to get that for you. This report right now is in draft form. We expect it is also being reviewed by two other reviewers, Mike Cordini of the University of Wisconsin and another professor at Georgia Tech.

MR. CATTON: Who at Georgia Tech, Abdul Kalik?

MR. SNODDERLY: Once we get that final report we will put in on the docket and submit it to the ACRS and then we can, hopefully, answer any questions you have. I believe the zirconium is molten. It is just treated as molten zirconium.

MR. CATTON: It looks like it makes up at least 30 percent of your mix. So the temperature of the zirconium is going to be very important.

MR. SNODDERLY: We also did sensitivity studies on the temperature of the melt. We had it with 100 degrees super heat in the base case in one of the sensitivity studies. We did it with 200 degrees super heat. So 2,800 degrees and 3,000 degrees.

MR. CATTON: What did you take as a water temperature in the cavity?

MR. BEHBAHANI: 363.

MR. CATTON: Was it saturated?

MR. SNODDERLY: Just beyond saturated.

MR. CATTON: Because it is very interesting as you change the water temperature the possibility of the zirconium entering in in a real rapid way goes up. You actually get a sharp transition and the rate of reaction curve as you increase the water temperature.

MR. KRESS: You increase energetics as you go down in the subcooling.

MR. CATTON: It is a trade off. You reduce the temperature of the energetics from the thermal interaction get more exciting but you damp the chemistry, and somewhere in the middle it gets really exciting. I think, Tom, we should take some time and take a look at what they've done because we keep hearing about the Texas Code as the tool of choice for the Staff.

MR. SNODDERLY: Dr. Catton, one other point of interest might be that those initial conditions that we chose were based on the Levi analyses.

MR. CATTON: The who analyses?

MR. SNODDERLY: Levi. And then what we did was -- what our contractor did then was scale that for the System 80+.

MR. CATTON: So you assumed 40 to 60 percent or something of the core was molten?

MR. SNODDERLY: Right.

MR. CATTON: Then you broke a hole in it, a small hole?

MR. SNODDERLY: That's right, then entered into five and half meters of water, which would be the most water that you could have. Really it can to me what you really gain from this code, or at least what I gained as far as an insight, is the sensitivity to number of penetrations, the amount of melt mass involvement, and number two the deficit of the pool.

So if you lower the pool from five and a half meters to four and a half meters, you have a significant drop in loadings, and then from four and a half to three and a half. So it is very sensitive to pool depth.

That is really I think why we did the analysis was to get some feel of the loadings. By no means do we think that these are the exact loadings. These are what I would term ballpark kind of figures to see how -- we have a good feeling for how much the walls would handle.

We were trying to get a feel for what type of loaders we were going to be talking about and I think we accomplished that with this. I think this was the best tool that we felt was available at the time and that we had access to.

MR. CATTON: You understand that no two code gurus agree?

MR. SNODDERLY: No, sir. That is why also we are having the Office of Research. They are running the IFCI Code.

MR. CATTON: Which code?

MR. SNODDERLY: That was the code that I believe that was developed by Sandia National Laboratory, and we have not gotten those. I have not personally seen those results yet but that will be interesting to see, how those codes compare.

MR. CATTON: One of the reasons I asked this because the numerics in the Texas Code preclude the development of the strong shocks. So, really, whether the results are any good depends on whether it is a shock loading or just the sort of pressure rise that is maintained for some small period of time.

MR. SNODDERLY: I believe the Texas Code is based on the experiments that were done by Cordini at Wisconsin and I believe one of those did involve a shock wave so that he is attempting to model shock waves with this code.

MR. CATTON: That is something we should discuss when we take a look at the code.

MR. KRESS: How did the results of your calculation compare with this 10,000 pounds of mass at .03 conversion efficiency? Was it higher, lower, close to it?

MR. SNODDERLY: The mass would be -- we got similar loadings but for much less mass. Ours were more conservative.

MR. KRESS: Which is implied that .03 might be wrong or something.

MR. SNODDERLY: Yes, that would be my conclusion. But I just want to end with one point. These calculations are done purely. These are secondary calculations. We really drew our safety conclusion on the fact that even if the cavity wall is destroyed, the reactor vessel and the containment integrity will be preserved, and that was the safety finding.

Now, we also did the supplementary calculations because these tools were available and we felt that it was a good idea. But the safety finding is that FCI is not a problem because even if the cavity wall fails, the reactor vessel can be supported by the surrounding structures, and I think you got a good feel for that from the picture that you saw with the thick walls and the wind walls extending to the ends of containment. That is where most of the load is going to be taken.

MR. KRESS: Is that a judgment call or was that based on calculations also, that the support was really there?

MR. SCHNEIDER: DC calculations with ACII standards without the conservatism. So best estimate ACI-349.

MR. CARROLL: Now, how big a steam explosion is needed to do in the corbels?

MR. SCHNEIDER: Huge. Corbels -- we have reinforced the corbels as a result of the initial analyses. We have put additional rebar in. It is about three times as strong. It takes an impulse about three times as strong as the cavity wall. We're dealing with something about four and a half PSI impulse which is probably -- I don't have a number here. I think you're dealing with something closer to maybe 30, 40 thousand pounds, 50 thousand pounds, something in that general range. It is a lot bigger. There is a substantial difference.

The corbels are not going to be fully immersed for the things. They may not be fully loaded.

MR. LINDBLAD: What percentage of steel roll is in the corbels? Are they asked to respond ductilely? Or is there more steel in there than concrete?

MR. SCHNEIDER: No, there is -- I don't know if we went above any normal type or reinforcing. The reinforcement was kind of normal. What they normally don't do is they normally would not reinforce the lower portion of a concrete structure if they don't expect loads on it, and since now they may expect loads on it they reinforced it to withstand loadings.

MR. LINDBLAD: Two way loads, loads up and down? All right.

MR. KRESS: But the entire safety case for this rests on the fact that you're not going to fail those corbels and you're going to hold the vessel up with them. Based on the fact that there is some level of steam explosion that won't fail. It seems to me like it is a still a little loose there. You have to get a technical basis for how big of a steam explosion you really expect, how big a steam explosion or fail the corbels, and compare those two. I suspect you have done that but it is a little loose to me right now.

MR. SCHNEIDER: Our best estimate hole size failure to estimate the mass involved in the event, our best estimate hole size failure is approximately a square foot, and that is kind of based on more or less like a TMI bulge with about a foot in diameter or something. So that with a square foot -- with a square foot hole your ending up with approximately I think 10,000 pounds of mass going down about 15 feet. So, if you assume that that amount of mass all interacts at once, that is kind of a rough way of estimating the mass at any given time.

MR. CARROLL: You've also got a backup position and that is do not flood first.

MR. SCHNEIDER: Yes.

MR. KRESS: I don't know if that is a backup position or not because you've made the decision to flood first. On what basis was that decision made? You know it seems to me like if it didn't matter whether you flooded first or later you would always decide to flood later. You must have decided that there was a reason.

MR. CARROLL: If I was not worried about steam explosions, I would always flood first.

MR. KRESS: But if you're worried about --

MR. CATTON: What you could do is put a limited amount of water in first. Let the steam explosion take place and then put the rest. That way you could control the magnitude impulse.

MR. CARROLL: Which steam explosion?

MR. LINDBLAD: How long would you wait for the steam explosion to happen?

MR. CARROLL: And how long would you wait for Number 2 to happen?

MR. DAVIS: Let me ask you this, what if the corbels fail?

MR. SCHNEIDER: There are a whole bunch of multilayers of things which we did not credit because we felt comfortable. But the thing is that other considerations.

[Slide.]

MR. SCHNEIDER: These things we did not do details on. You do have additional support. We really do have a relatively thick hot leg, which is almost as a structural member.

So, there is always the potential of just having a thing bend and sag without major motions. Even if you fail the reactor vessel, the steam generator rotational bulk prevent very much -- the steam generator keys will prevent very much rotation of much of the adjacent piping.

So, we're not going to expect significant displacement of this location of piping in the RCS, and even if you do, it is more likely to fail the piping inside containment than at the penetration because the penetrations are reinforced. The first level is the cavity is not going to fail. If it does, it can still possible be supported by this.

Even if it does, the piping may not get enough rotation because piping failure -- even if the piping fails, it is more likely to fail in containment. We did treat it probabilistically also where we actually overestimated. We did not credit any of this stuff, overestimated the impact, and the way it turns out this is probably one of our most dominant containment failures only because we conservatively treated what might be viewed as a potential. But probabilistically we are created the fact that maybe through some unforeseen reason there is a small probability of this actually occurring. So it does turn out to be a contributor.

We have looked at it in a continuous spectrum of various positions. We think that this is about as robust of steam explosion you're going to get. We think it is pretty good.

MR. CARROLL: Now, in our review of ABWR, they have, of course, do not flood until they get melt in the cavity. They also made quite a point of the fact that it would be an extremely low probability that there would be water in the cavity because of the designer of their plant from any other source. Can you say the same thing?

MR. SCHNEIDER: Yes. All of our water will go into the hold up volume, which will, basically, feed back into the IRWST, and if you do not open those valves, it is not going to get into the cavity. You need to flood the valves to get in.

MR. CARROLL: So you're backup of not flooding first is viable in that sense. Okay.

MR. CATTON: I guess if you flooded it, you sort of take care of the core concrete interaction.

MR. SCHNEIDER: We believe so.

MR. BARRETT: I would like to point out that the Staff's review of this severe accidents was based on preflooding. One of the concerns we would have if there was not preflooding would be the operability of those valves following steam explosions in excessive events.

MR. KRESS: You may not have that option.

MR. BARRETT: Our finding if the option were still open that they may have a dry cavity, we would want to take a second look at that.

MR. CARROLL: Do you have a response to that or do you agree?

MR. SCHNEIDER: I agree. We do plan on preflooding and we have not. We don't have any current plans of not flooding the cavity. We think it is a more realistic and pragmatic approach. We are not at all sure how much we would want to drive the design because the potential of steam explosions at this stage of knowledge and considering the robustness of the design. If you were ever getting into that situation, I think right now I think most people feel that you would rather break up the debris and be able to cool it as before you started attacking and eating away your concrete.

MR. CARROLL: If you can put the steam and explosion issue to bed, I totally agree.

MR. SCHNEIDER: As I said, we believe that with the multiple levels we have reasonable confidence that it is a really low likelihood that steam explosion will fail this containment in a realistic sense. How do you put realistic into severe accidents?

MR. CARROLL: Tom, you keep saying this is something that we will have to put on notice to look at? Is this a combustion list or is this a more general list?

MR. CATTON: In my view, it is a more general list because this is the second time we have heard that this particular code has been used for coming to some conclusion about steam explosions. So I think Tom's Severe Accident Subcommittee ought to hear about it.

MR. CARROLL: Cordini, of course, was with up in Portland.

MR. CATTON: But Cordini is the one who developed the code.

MR. CARROLL: He told us quite a bit about it at that time.

MR. CATTON: Not really.

MR. CARROLL: All right. So if you had to cast a vote today, are you happy with the situation of X vessel steam explosions that combustion has portrayed?

MR. CATTON: My reaction is that it is probably okay because it is so robust.

MR. KRESS: But that case has not been made clear that it is okay.

MR. CATTON: If I had to cast a vote as I stand right here, that is where I would come down. I certainly would like to have the two calculations that you refer to in front of me. What is the maximum possible impulse that you could expect? What is the impulse that this thing could withstand? What is the expected impulse so that you sort of look at the numbers?

Now, they're talking 4.6 psi seconds is what the corbels can withstand. Right off the top, I don't know if that is a big number or a little number. I would have to look at some of the calculations.

MR. KRESS: I think that is a big number.

MR. SCHNEIDER: A thousand pounds for five milliseconds.

MR. CATTON: It depends on who you're doing business with. But in Pascal seconds or something or others. I think they have made a better case than I have heard for any other system.

MR. KRESS: I think the Staff has made a relatively good case based on Texas because the real questions you end up with is what is the efficiency of the conversion and how much mass is involved, and there is no real way to attack that a priori. But with a code like Texas it gives you a little handle on that. We need to look at the physics involved.

MR. CATTON: With a code like Texas has this jet injected into the pool. So it means it is a rate limited process where it is adding into the pool. And there are lot of cases that we both know about --

MR. KRESS: It is a delayed explosion. Explosion and you have to worry about that thing.

MR. CATTON: That's fine. There are also assumptions that go into it. The assumptions are the globular sizes before the steam explosion, the globular sizes are fragments after the shock has passed it --

MR. KRESS: That is not an assumption that part. That is calculated. There is a globular size before that is calculated.

MR. CATTON: They are both input. They are not calculated. I would sure like to see how they do that. There ain't nobody that knows.

MR. CARROLL: We need to get you to the mike if you're going to be on the record.

MR. CATTON: This is a shock passing across a droplet and I don't think anybody knows how to do that really well.

MR. BEHBAHANI: The fragmentation formula was based upon Corotas experiments at Israel, and too much of the Corotas experiments they have fragmentation based on that. As you said, there are some constants in there that you have to play around with and they match up those constants such that they get matched up. They result in the Corotas experiments.

MR. CATTON: That is one set of experiments, one set of materials. There are lot of parameters, diameters for and after the heat before and after, there is chemistry, there is all these things.

MR. KRESS: That is why I say it is still pretty loose.

MR. CATTON: That's right.

MR. CARROLL: Okay. Have you've concluded?

MR. SCHNEIDER: I will.

MR. CARROLL: He sat down.

[Laughter.]

MR. SCHNEIDER: It is our belief, based on the robustness of the design, that X vessel steam explosions will not compromise our V support and, consequently, don't pose a significant risk of containment failure. As I said, it is treated probabilistically. It is included in our PRA with a higher level of capability for failing than we actually -- than we necessarily believe. But it is there. It does show up.

[Slide.]

MR. CARROLL: So, you're going to talk about that when we talk about PRA when you have your other hat on?

MR. SCHNEIDER: Dave, is going to talk about the stuff with the other hat. A lot of it depends on how the compositions go.

MR. CARROLL: This is the next point you wanted to hear about, Ivan?

MR. CARROLL: I think so.

MR. SCHNEIDER: Let's get the cover slide. The goal here was to provide coolability of the corium debris in the reactor cavity as a physical system and we have the cavity flood system protecting the containment pressure boundary, which is going to be the lower shell, the lower portion of the shell, and the applicable guidance is provided a means to flood the reactor cavity, protect the steel shell with concrete, have a large floor area for potential corium spreading, and demonstrate that you have about a day for containment integrity even with core concrete attack for a probable scenario.

The design features applicable to this are relatively large cavity floor area which limits the average for uniform depth to approximately ten inches.

MR. CARROLL: How does that relate to the utility requirements document?

MR. SCHNEIDER: It is a little less. It is a slightly less than .02.

MR. CARROLL: 80 percent of it?

MR. SCHNEIDER: It is about 80 percent of it. THe cavity flooding system is capable of flooding the reactor cavity to approximately 11 feet, and again, the water is expected to fragment, cool and scrub the debris. Cavity floor is constructed with a minimum of three feet of limestone based concrete, either limestone common sand or if they choose, it is pure limestone. But because the cavity is so -- because the system is so large we're not really worried about the carbon dioxide content of this because it is a better resistance. It better resists erosion to protect the containment shell.

We have robust upper cavity design. So, again, erosion of the lower pedestal is not a major concern. The additional 15 feet of concrete remains as a barrier below the shell before you get to the floor.

MR. DAVIS: What kind of concrete is that?

MR. SCHNEIDER: That is not specified. That could be whatever the COL applicant decides.

MR. DAVIS: If it were limestone, would you still not have a problem with CO2?

MR. SCHNEIDER: At that point we wouldn't. But at that point, it is not going to matter. There is still a lot of volume. What we find is the sequences that go that deep -- that would go that deep into the containment is generally because you have lack of water. If you don't have the water, you're not going to be able to pressurize the containment substantially by just adding CO2 even if you add I would say tens of thousands or twenty thousand pounds of just CO2 contribution.

MR. DAVIS: I thought when we were looking at the ABWR there was a difference between the Staff's evaluation and some of the Brookhaven reviews that I looked at, and as I recall in the Brookhaven review, even with water over the mount there was still substantial erosion of the concrete.

MR. SCHNEIDER: There was erosion of the concrete. It does not prevent it. A lot of it depends on -- we will get into the modeling versus the morphology.

MR. CATTON: It was a big difference because with the ABWR the molten materials are on top of the concrete and then the water comes in and it crusts. What they're doing is they're putting the water first so it fragments. Then the question becomes one of dry out. But this thing is only ten -- what did you say, that it was ten inches deep?

Refraction is 40 percent, so maybe it is 20 inches deep with its rubble bed if you have water over it. So what they have done is they are assuring that they the quench stuff, which is a lot different than what GE is doing. With the ABWR you can not be sure. I think they are sure.

MR. SCHNEIDER: Not only that --

MR. CATTON: Reasonably sure.

MR. SCHNEIDER: We have also analyzed it as if it didn't. We have decided that because of the uncertainties in the calculations and some questions that we basically based the 24 hours on a layered non-debris bed.

MR. CATTON: Human error. You may open it up too late.

MR. SCHNEIDER: Okay. Whatever.

MR. CATTON: When it is ten inches from the bottom of the cavity, how much of the core is that?

MR. SCHNEIDER: 100 percent.

MR. CARROLL: The 11 feet is still below the bottom of the vessel.

MR. SCHNEIDER: Yes.

MR. CARROLL: How much? Do you know? A couple of feet?

MR. SCHNEIDER: About --

MR. CARROLL: I see a 63 up at the narrow end there.

MR. SCHNEIDER: Basically, it goes to maybe it is a little more than 11. Maybe it is 13 or 14. Basically, what will happen the IRWST level will drop a little bit. It will go to maybe a foot or so below the bottom of the vessel, maybe two feet below the bottom of the vessel, something on that order.

MR. CATTON: Did you consider flooding up over the lower end?

MR. SCHNEIDER: For the instrument that designs, they don't. It was considered. Stan, do you want to handle that?

MR. RITTERBUSCH: It was not seriously considered. We understood that as an option when we were designing the volume of the IRWST and we made a decision to keep the maximum level well below the reactor vessel from the beginning. One of the things we considered was inadvertent operation. We did not want the water touching the vessel, you know, for inadvertent operation.

MR. CARROLL: You would probably have to buy a new vessel if you did that.

MR. CATTON: At Indian Point they flooded the cavity and didn't even know it.

MR. KRESS: You said you did some calculations where you assumed the debris was not coolable.

MR. CATTON: That is what he is going to tell us about.

MR. KRESS: Did that include some scrubbing calculations of the pool for the fission products as they went up through it?

MR. SCHNEIDER: We treated that as a separate issue on fission product removal. We handled it differently as part of the PRA, and these are, basically, deterministic calculations done to estimate maximum climbings of erosion and nothing else.

MR. KRESS: You used the MAAP Code for that?

MR. SCHNEIDER: No, we did not believe MAAP was the appropriate tool of choice for this. What we felt wasn't going with the state of the art best tool around. We used CORCON Mod 3. MAAP cannot be forced to give a layered behavior I don't believe and we wanted to make sure that we, because of all the sensitivity in the base, that we treated the thing as a layered debris.

Basically, the cavity -- you probably have a good view of it at this point -- relatively large surface area with a core debris chamber at this point. Below there is about five feet of concrete in the central region going to about three feet in this general region. There is another picture, another view in a minute.

The elevation for the bottom of the basement is about 40. It is about 22 feet total before you actually get to the soil.

MR. CATTON: Is that an open area where it says elevation 50?

MR. SCHNEIDER: This is the SI Pump Room. In the PRA we did consider the possibility of ingression into it. You do not get enough radial erosion without PRA types of assumptions.

[Slide.]

MR. SCHNEIDER: This is a top view of the cavity. This is the sump -- the sump different from what you may have seen for the other designs. The sump is very shallow. It is only a foot deep. It still has 3.2 feet of concrete below the bottom of the sump to the steel shell.

MR. DAVIS: What are the ICI plates that you talked about in the PRA?

MR. SCHNEIDER: The instrumentation tubes coming out the bottom and core instruments. They get pulled out the bottom of the vessel.

MR. CARROLL: GE dealt with the sump by I guess putting in some restrictions so that you would get the melt freezing before it got into the sump.

MR. SCHNEIDER: We were happy we didn't have to do that. We dealt with the sump by having a very shallow sump and having enough concrete below so that their sump was deeper and with very little concrete below it. Plus, it is basaltic. It goes quicker.

So we had actually ANL do calculations where they simulated the sump kind of effect and where they simulated the base effect using CORCON Mod 3, and even the sump calculation in that small region, subsequently about 16 square feet. But even in the small region it did not get to the shell position for over 24 hours based on CORCON Mod 3 calculations with a slightly increase corium build up in the sump region.

Had we gone -- we had toyed with the idea of going with a basaltic design here and we were toying with freezing type of designs and taps and covers. We don't have to do that.

[Slide.]

MR. SCHNEIDER: But we did specific limestone so that gives us the added nodule. We wanted to demonstrate that with minimum debris coolability -- so even with water on the debris with minimum debris coolability the cavity erosion would not reach the embedded containment shell for about 24 hours. We had to impose analytical restrictions, which were primarily imposed by the NRC in terms of trying to force a MACE type of environment on us.

So the initial attack at the lower shell implies containment failure. We think that is a conservative assumption to begin with, but that is, basically, the goal. Only concrete above the steel shell is credited and no credit for debris fragmentation. So, the debris morphology was not favorable to heat transfer.

[Slide.]

MR. SCHNEIDER: The tools selected for this analysis was CORCON Mod 3. I don't have the list but it is one of the -- it has at least some degree of pedigree as a national lab tool. It has followed the history of core concrete experiments for years. It is the Mod 3 version of it. It is capable of "realistically" considering the limiting case of layered morphologies where you can have layered melts and the changing of layers. It considers all of the exodermic reactions and all of the chemical processes that go along with it

We did analysis for both flat cavity floor and sump regions. The analyses was done by ANL consultants. We assume the vessel breech occurs three hours following reactor trip, which is very early, like you're following a large LOCA without SI. 100 percent of the core inventory is deposited on the cavity floor. We credited decay energy released due to volatiles into the corium mixture. We assumed that there was zirc oxidation going on while in the vessel and as it passed through the water. So we assumed 75 percent of that zirc alloy oxides into the concrete.

MR. KRESS: Would you vary that number as a sensitivity calculation?

MR. SCHNEIDER: I don't believe so.

MR. KRESS: That is a real dragger for core concrete interactions. How much of that zirc is unoxidized?

MR. SCHNEIDER: We're dumping it in with the pool of water above it. The question was steam explosion are that virtually all of it will oxidize. The question with -- I'm sorry. The question with how much oxidation and hydrogen generation is virtually all going to oxidize. But, basically, we're not oxidizing all of it. There is still a good amount not oxidized.

It will affect the course of the event, probably several hours. But I would not expect it to be the redominant and it this point because it is not like you can make it zero. The credible number you are dealing with has got to be at least 50 to 75 or maybe 50 to 100.

MR. KRESS: Or to be conservative, maybe 25.

MR. SCHNEIDER: We believe we are conservative enough by having the layered debris bed 100 percent on the core in three hours.

MR. KRESS: You're right. It is conservatism.

MR. SCHNEIDER: With those calculations the time it takes to actually erode the three feet of concrete was 30 hours for the flat area, 3.2 feet of concrete, which is the sump depth, 24 hours.

[Slide.]

MR. SCHNEIDER: So, we feel reasonably comfortable with that level of assumptions that we need the -- that we've demonstrated the ability of System 80+ to provide the 24 hours of containment integrity called for in SECY 93-087. That's it. Not a big story.

MR. DAVIS: In this case, even if you erode to the containment shell, what would happen?

MR. SCHNEIDER: Nothing.

MR. DAVIS: There is no release path. You've got another 15 feet below that.

MR. SCHNEIDER: We did make a conservative assumption for some of the transients probabilistically to assume that you can erode about eight feet or so radially into the pump room. But we expect really the main trajectory to be down. There will be radial erosion, but we think it is really going to be unlikely it is going to migrate all the way over to the pump room. But we do consider it as part of the PRA.

MR. DAVIS: Thank you.

MR. CATTON: I'm happy.

MR. SCHNEIDER: It is quarter to. Any particular topic?

MR. CATTON: I guess containment performance is next. You might as well work your way on through.

MR. SCHNEIDER: Okay.

MR. KRESS: Well, you might want to go back to the DCH. We skipped it. Let's go back to the DCH.

MR. LINDBLAD: That is not very long.

MR. SCHNEIDER: No, it is not long.

[Pause.]

MR. SCHNEIDER: Prevention of direct containment heating. Again, the purpose is to comply with the utility requirement document guidance, to minimize the potential for events leading to high pressure melt ejection, and minimize the potential for direct containment heating. Along with that, it is complying with specific guidance of 93-087 to provide a reliable depressurization system and to provide a cavity design feature to decrease the amount of ejected core debris that reaches the upper containment.

[Slide.]

MR. SCHNEIDER: The relative design features that tie into this is a rapid depressurization system, which is a manually operated system that will the operator for the Control Room to depressurize the RCS in advance of vessel breach. Our reactor cavity design, which you have seen a few times already, with a large convoluted reactor cavity vent and a debris accumulation chamber, and even when you get out of that, the HVAC provides a nice accumulation position for debris also.

Cavity flood system, which is clearly, if it is operationable, you would expect that to do a really good job of quenching a lot of the debris when that is operationable and the large containment volume again has a capability of withstanding large pressure, will give you more mass and more capability to withstand pressure increases or energy inputs.

MR. CARROLL: Why do you feel comfortable with a manual initiation of the depressurization system? Historically, on boiling water reactors at least, that has always been an automatically initiated system.

MR. DAVIS: Which the operator can override, of course.

MR. RITTERBUSCH: One of the primary considerations was the unreliability of inadvertent openings during normal operation.

[Slide.]

MR. CARROLL: I guess one other feature we did not talk about when we talked about high region that again is an operator action is the notion that the containment can be vented through the hydrogen purge valves unfiltered.

MR. SCHNEIDER: We do not view that as a hydrogen issue. It is more that we used a hydrogen recombiner lines for venting. It is more of an overpressure capability.

MR. CARROLL: That be as it may, how do you feel about -- who is going to make that decision?

MR. SCHNEIDER: Well, we, basically, do not feel that anyone should make that decision. We do not think -- it is not part of our strategy. It is there should the utility decide on using it at their own discretion. It is not something that we embed within our accident management guidance and it is not something that we would necessarily recommend. But it is a capability that is there. We were asked to show that it is there and we did.

MR. CARROLL: It makes me nervous.

MR. CATTON: It is unfiltered. That does kind of make me nervous.

MR. SEALE: It gives the governor the option, doesn't it?

MR. CARROLL: He isn't going to open it.

MR. LINDBLAD: Are you going to show us the large convoluted reactor cavity vent on this picture?

MR. SCHNEIDER: Yes, I think so.

MR. DAVIS: Before you do that, I have another question on the safety system, and maybe this is a question for tomorrow. But I notice on page 19.4-24 you say that the safety depressurization system could be used for the small LOCAs with failure at the safety injection system, but it was not considered in the PRA.

MR. SCHNEIDER: Dave is standing up already. He wants to answer that.

MR. CARROLL: They did not say it. The Staff said that. Oh, it is in the PRA also in Volume 17.

MR. DAVIS: That would be the preferred method to do it rather than using aggressive cool down method that they do consider in the PRA, but I may be missing something.

MR. FINNICUM: This is Dan Finnicum with ABB. In the Level 1 portions, the safety depressurization valves are used for the feed and bleed cooling portion and the small break LOCA analysis. With opening up the safety depressurization valve, there was a concern that by introducing essentially a medium break LOCA there that the loss of inventory back to the IRWST might not cover the core before we were able to bring the pressure down fast enough to get the RHR pumps on.

MR. DAVIS: So the procedures call for aggressive secondary cooling rather than use of the safety depressurization system?

MR. FINNICUM: Yes. That is in the function of recovery area. That does not include the rapid depressurization for that scenario.

MR. DAVIS: Thank you.

MR. SCHNEIDER: The way the cavity is designed is that corium leaving the vessel has a few options. It can up, fail the pool seal, and out, or the other path is going through the tunnel where the inertia we expect to carry a lot of the debris into this general area where it would be hopefully be trapped. It can turn up. Then it has to turn on to go up a staircase, and then once it goes up the staircase, you go against the solid closed roof with louvered vents.

So, it ultimately blows out the vents and then turns in either direction and then you, basically, on an area where you're isolated from the above floors. So, whatever you have done, if you don't trap it here you're going to, basically, lose most of the energy and you're going to trap it right around this area even if you trap it in this region of the containment. So, you're not going to have very much DCH contribution.

While we do say that the entrainment -- we expect very low entrainment from this geometry. We have actually analyzed it with considerably higher levels of entrainment than we expect. So --

MR. LINDBLAD: What is convoluted about it?

MR. SCHNEIDER: It is a multiple path where we have a lot of changes in directions, a lot of recirculation potential flows. There is another breaker flow out here which could have the recirculation in the instrument area, which has a very high pressure seal table which will not fail.

It just gives you a lot of pathways where the debris has to turn, and you're trying to pull very dense material which has its own inertia going in all different directions through all of these turns and we feel it is not going to be able to follow very effectively and get any place near the upper containment or get much even outside this HVAC room.

MR. LINDBLAD: You describe it as being large as well. You mean it is lengthy or that it has a big cross section?

MR. SCHNEIDER: Big volume. The volume is generally large. The pressures will not be -- will not necessarily build up very large pressures inside because it has a high volumetric. I guess I don't remember the exact volume but it is relative to existing cavities. It is a lot bigger. I think it is over 10,000 cubic feet.

[Slide.]

MR. SCHNEIDER: We have also decided that -- again, to demonstrate its capability deterministically, we played some conservative games. We looked at single and two celled models, direct containment heating models, which generally take the corium and either mix in one region or two regions, depending on the assumptions. We assume the splits are -- we assumed that the -- we didn't credit the rapid depressurization systems so we had the corium at high. We had the vessel, which we breached at high pressure. We only marginally credited debris retention.

So we assumed that any of the debris -- 50 percent of the debris disbursed went directly into the upper containment and 60 percent of the instantaneous corium mass was injected, which is a high fraction of the corium, on the upper end of the NUREG-1150, the injection -- core amount injections following vessel breach curves.

When we did it we did it two different ways and both of them concluded that the shell stresses -- the pressures would be well below Service Level "C" allowables, even given this set of conservative assumptions. We also did something similar probabilistically where we looked at a whole spectrum of potential cases where we varied most of these parameters and several more parameters across the board and came to the conclusion of a very low conditional probability of containment failure given high pressure. High pressure is not going to be a high probability state following prior vessel breach. So, we are reasonably confident this is going to be a noncontributor to containment damage.

MR. CATTON: You did these estimations with a cavity filled with water?

MR. SCHNEIDER: No. We're assuming the cavity, if it was filled with water, the cavity would quench it because there is so much water down there. We did it assuming it the cavity was dry. If there was water in the cavity --

MR. CATTON: I'm trying to remember what the results with Sandia study were and I don't, whether water was food or bad.

MR. SCHNEIDER: I spoke to Pilchy yesterday I guess for a different reason. He is a believer that a lot of water is good. A little bit of water could be a problem, but he is not even sure of that. So his feeling would be that -- and I don't want to quote him, but I think the Sandia people will tell you a lot of water in the cavity is going to be good. We're talking about 60,000 gallons.

What that does is it gives us the steam explosion problem. You have to balance. So, you just basically transfer one issue to another.

MR. CATTON: When you did your steam explosion calculation, did you put 2,500 psi behind the jet?

MR. SCHNEIDER: We did ours based on total best.

MR. CATTON: That's right. The Staff, you put 2,500 pounds behind the jet.

MR. SNODDERLY: No, we didn't.

MR. CATTON: That would be an interesting calculation, wouldn't it?

MR. SNODDERLY: I don't know if the Texas Code could handle that. We could investigate that to see if it could.

MR. CATTON: It would be interesting to see what you get.

MR. SCHNEIDER: What we did --

MR. CATTON: I understand that.

MR. SCHNEIDER: Okay.

MR. CATTON: As long as we're using words like bounding and things like that, we ought to have, indeed, the bounding calculation.

MR. DAVIS: This could go on forever, Ivan.

MR. CATTON: Then don't use the words bounding.

MR. DAVIS: These are low probability.

MR. CATTON: Don't use the word bounding.

MR. SCHNEIDER: A low probability -- we selected a low probability conditions. I apologize.

MR. CARROLL: Or it is low probability until it happens.

MR. DAVIS: Then it still can be low.

[Slide.]

MR. SCHNEIDER: Do you want any further discussion on direct containment heating or shall I move on?

MR. CATTON: Not I.

MR. CARROLL: Okay. Now, what do you want to talk about, Ivan?

MR. CATTON: The next thing on the list is containment performance.

MR. CARROLL: All right.

[Slide.]

MR. CATTON: Now, we're back on track now.

[Discussion off the record.]

MR. SCHNEIDER: The number and system may break down after the next disk. The containment integrity was addressed from reliability and overpressure failure. The goals here were to demonstrate high containment reliability, which Dave will talk a little bit more about and I have some small information from that here, and with sprays unavailable to demonstrate that containment will maintain its role as a reliable leak point barrier for approximately 24 hours under the more likely severe accident challenges. I believe that is pretty much the wording in SECY 93-087.

[Slide.]

MR. SCHNEIDER: Again, the applicable features are highly reliable. Redundant containment spray system, fast running backup pumps via shutdown cooling system so that we can, if need be, realign if we lose a containment spray pump, realign the pump through the shutdown cooling system.

We have redundant power supplies, off site power, emergencies diesels, and combustion turbine. We have a large containment volume which is very useful to mitigating the pressurized -- the rate of pressurized.

There is alternative pressure control cooling capabilities.

[Slide.]

MR. SCHNEIDER: We have non-class E-1 fan coolers, which are available. We have external spray capability, which will extend the time for pressure control to get other systems online and we have vent capability via purge line. But these are all low probability systems.

MR. CARROLL: The fan coolers are environmentally qualified?

MR. SCHNEIDER: No. It is more just to show that they are there. They are not environmentally qualified specifically. But there is a lot of transients where it if you lose power, you still may not have very severe environments and they still may be able to perform a function. What they are is oversized typically. So, while they are basically HVAC for ventilation fan coolers, they have been kind of designed so they can, after a certain amount of time, function as a diesel containment heat removal system.

MR. CARROLL: Where our famous perch line unfiltered vents?

MR. SCHNEIDER: It is there if you need it to hold the pressure in something. If you are anticipating containment failure and you should decide for some reason that you want to vent because you cannot get any of your other systems back online to control pressure, it is there and it will, basically, level the pressure off at 80 to 100 pounds.

MR. CARROLL: What are they big enough for?

MR. SCHNEIDER: It will level pressures off at about 80 to 100 pounds after about 24 hours. It is not going to, basically --

MR. CARROLL: Because it is fairly small.

MR. SCHNEIDER: These are small.

MR. CATTON: Do these go up through the plant vent? Are they monitored?

MR. SCHNEIDER: I don't recall.

MR. CROM: This vent that we are talking about is really an alternative for hydrogen purge. It purges into the annulus. The only way that it would be filtered and typically designed even on current plants is if your hydrogen recombiners fail. You would purge in the annulus and then your annulus ventilation would then do the clean up and the mixing in the secondary containment, and that would be going out the plant if the system is operational.

MR. LINDBLAD: I would think your radiation instrumentation would be saturated from direct shine as well. It would be pretty hard to keep that operable.

MR. SCHNEIDER: There has been no credit taken of this capability at all in any of the analyses. It is just kind of showing it for completeness.

MR. CARROLL: I think if it was my plant I'd find some three inch pipe caps and weld them on.

[Laughter.]

[Slide.]

MR. SCHNEIDER: There was a point that this was a strong NRC interest that we have the ability.

MR. CARROLL: There is a requirement that you have to have a means of penetrating the containment on ABWR, isn't that right?

MR. RITTERBUSCH: We are taking an exception from that regulation.

MR. CARROLL: You're using this as an argument that says you --

MR. RITTERBUSCH: No.

MR. CARROLL: You're just taking an exception?

MR. RITTERBUSCH: It is creased within the diameter.

MR. CARROLL: The Staff has agreed to the exception?

MR. BARRETT: We have not specifically focused on that exception, but I think that it would be agreeable. Our basic finding regarding pressurization is that we believe that it will be quite a long time before you challenge the pressure capability of this containment, even in a case -- the one that Ray analyzed -- namely, the one with no sprays. I think the worst case we analyzed was the 56 hours to reach Service Level "C."

We don't exclusively deal with what happens after that in our FSER, but I think that the way we feel about it is that by that time there will be plenty of help available and the capability of regaining some form of heat removal, such as internal sprays, which in addition to heat removal will also give you fission product removal.

So, from our perspective, this vent does not come close to playing the important role that the containment overpressure protection system plays for the PWR. Even in the BWR, we allow the -- in the ABWR we allow General Electric to take exception to the rule because the ABWR containment overpressure protection system is not a three foot vent.

MR. DAVIS: As I recall, it is ten inch.

MR. BARRETT: That's correct. So, I don't see any reason why we would have any objection whatsoever to seeing you taking an exception to this rule. This vent, from our perspective, would be perhaps for some period of time long after you've regained control of the container to take measures to perhaps vent some hydrogen, perhaps vent some small amounts of atmosphere.

MR. CARROLL: But the three foot hatch in the containment does not necessarily imply three foot vent. It is a number picked out of the air years ago, isn't i?.

MR. BARRETT: That is correct, and it was simply to allow the option. We are allowing ABWR to take exception to that based on the calcs. I don't see any problem with ABB taking the exception because, basically, their control mechanism is the very large volume of the containment.

[Slide.]

MR. SCHNEIDER: So, we've performed some deterministic analysis to show the minimum time of containment failures is more than 24 hours. Here we used MAAP.3. We feel this is applicable for this application, which basically is a large energy balance. We went to our spectrum of severe accident transients within it. We did not credit spray operation and we based containment failure on ASME Service Level "C" stresses.

MR. KRESS: Could I ask the Staff if they intend to audit those calculations with MELCOR or contain or something like?

MR. SNODDERLY: Yes. We have contracted

Brookhaven to perform analyses using MELCOR. To date, they have done six run for six sequences. They have analyzed small break and mean break LOCAs; steam generator tube ruptures with one and two and five tubes, station blackout, wet and dry cavity; and the LOCA sequences, wet and dry cavity.

Those timings appear to be -- it would be fair to portray them in reasonable agreement. We are not seeing anything unusual in the times. That was our QA check.

MR. KRESS: Thank you.

MR. SCHNEIDER: Our results showed containment failure times greater than approximately than 24 hours for some limiting cases. I think I was eliminating large LOCAs with actuation of the cavity flood system. So you always had enough steam getting into the containment to pressure you.

MR. DAVIS: Excuse me. There is a statement in Volume 23, page 19.9-4. You've got a case where the containment failed by overpressurization after 41 hours. Is this the same calculation that you're talking about here?

MR. SCHNEIDER: I don't know. 19.9?

MR. DAVIS: Yes. Dash 4.

MR. FINNICUM: That was --

MR. DAVIS: It is close enough.

MR. FINNICUM: That was an early calculation done with a Level 1 PRA where we were looking primarily at containment failure before a core melt where we had safety injection. Essentially, the RCS was intact, but we had no containment heat removal. It was a MAAP calculation. It was in the range of about 40 to 41 hours.

MR. DAVIS: Thank you.

MR. SCHNEIDER: This is the one were you fail containment before you melted the core so that the core melt would occur after. That way, subsequently, was a very low probability, much lower probability.

[Slide.]

MR. SCHNEIDER: I will make a few PRA comments because the SECY 93-087 has a containment integrity goal and unless you want to wait until for the PRA presentation tomorrow --

MR. TYREL: Is this better with it? Dave thinks so. Okay.

MR. FINNICUM: I will present the same information.

MR. SCHNEIDER: So you want to drop this one? No, okay.

[Slide.]

MR. SCHNEIDER: The overall conclusion is that the containment meets the deterministic goals for overpressure failures of the 24 hours and Dave will demonstrate tomorrow that it is robust with respect to a severe accident, it has a high probability of maintaining containment integrity following severe core damage event, and the resultant CCFPs, conditional containment failure probability, are consistent with the stated goals of SECY 93-087. That completes the PRA presentation.

I guess the last section would be equipment instrumentation and survivability.

MR. CARROLL: Do you want a break about now?

MR. DAVIS: How long will this take?

MR. SCHNEIDER: Without any questions, it shouldn't take too long.

[Laughter.]

MR. SCHNEIDER: I will leave it up to you fellows. You can go want to go on through or not.

MR. CARROLL: I was thinking of adjourning for the day and picking up tomorrow.

[Discussion off the record.]

MR. CARROLL: Would it help anybody to finish up today in terms of who has to be in here in the morning? You and Mike would like us to finish up?

MR. BARRETT: If possible, yes.

MR. CARROLL: Then let's do it. All right, let's do it.

MR. SCHNEIDER: Equipment survivability. The goals that comply with SECY 93-087 and the additional requirements of 10 CFR 50.34 requirements. They require that we define the instrumentation equipment for achieving and maintaining a safe shutdown and maintaining containment integrity, to define the minimum SECY that applies to that, demonstrate the high confidence that the instrumentation will survive severe accident conditions for a period needed to perform its functions, and as a subset consider the effect of 100 percent oxidization of fuel cladding on equipment survivability.

In order to establish environments, we reviewed events progressions for in vessel recoverable and unrecoverable event sequences.

[Slide.]

MR. SCHNEIDER: To a large extent we used -- we would use snap and judgment in order to estimate the behaviors, define minimum equipment set for achieving and maintaining a safe shutdowns on the conditions when your lower head is going to remain intact so you can have a recoverable sequence, define minimum equipment set for maintaining integrity should your vessel lower head fail in addition, and use analytical experimental methods to establish local severe accident environment, and then we compared the severe accident environments with the EQ envelope in establish supplementary guidelines to guarantee equipment survivability.

[Slide.]

MR. SCHNEIDER: The next couple of pages are lists of equipment. For the instrumentation required for severe accident mitigation and prevention we divided it into categories of instrumentation that is useful prior and instrumentation that is more important post-vessel breach or are more important in both sequences.

The UHJTC stands for the unheeded junction thermal couple, which is located in the upper head of our design, which is part of our reactor vessel level monitoring system. What this essentially does is it is able to give you a load of reliable and high confidence survivable temperature measurement capability for the reactor vessel following recovery.

RCS or pressurizer pressure were intended to give you some indication of the plan pressure for recoverable sequences. SI flow injection clearly make sure you're getting water, emergency feedwater flow to make sure that it can remove heat through the steam generators. Same thing with the steam generator water level, IRWST water level, to make sure that you're not dumping the stuff outside of containment basically, and again, hydrogen monitor to control what is happening with the hydrogen radiation monitoring, mostly of later interests to determine if you want to take any actions with regard to high radiation levels and containment pressure, again, which is a useful parameter to determine the closeness of potential overpressure failures.

We have on the list containment temperature, which is helpful, but we kind of view it as nonessential and it was not given the some of the same stringent requirements as the rest of this equipment, and containment spray flow, which you need to make sure that your spray is functioning.

MR. KRESS: Could I ask if you had some sort of criteria that you used to make the judgement as to which instruments and devices were required for this?

MR. SCHNEIDER: In '79, I was involved with ICC NUREG-737 responses for adequate core cooling instrumentation. So, clearly, based on that review, we kind of felt like the operator is going to need in order to control -- in order to control the plant -- we wanted to make sure is, basically, he has the ability to get feedwater or some inventory source in both pressure and SI flow, provide those guidance because if your pressure is too high you can't get your SI flow in.

So, these, basically, give you some guidance of inventory into the vessel. This provides you the energy balance for heat removal. So, you need these two to make sure that you're getting energy out.

The HJPC gives you an idea of the level of super heat you might have in the vessel. This, basically, just supplies the level of the inventory. So, what we're basically looking for is tracking where the water is, where it is going to go, and what it is doing.

MR. DAVIS: What instrument does he use to decide if he floods the cavity or not?

MR. SCHNEIDER: This is actually post that. The ICCI instrumentation is a much more extensive list. This is a subset of that. That list you would use the core rates of thermal couple or a combination of the full RVLMS, reactor vessel monitoring system.

This is a minor subset of only a system where you have substantial core uncovering. You know you are in the core damage sequence, and this is what you need if you can potentially recover it. You may have gotten to the point where you have melted your core exit thermal couples at this point. You may have gotten to the point where some of the RVLMS thermal couples may be gone. This is the minimum set --

MR. CARROLL: By then you have already flooded the cavity.

MR. SCHNEIDER: Yes, we flooded the cavity. Right. So, this is a subset of that much larger set of instruments. I got carried away there.

MR. KRESS: I'm not sure I'm still clear on this. If I look at this list and ask the question, if those things are not -- that do not survive the severe accident conditions, am I in trouble?

MR. SCHNEIDER: No. Regulation requires that we provide -- 10 CFR 50.34(F) requires that we define this set of instrumentation. We let the operators know what -- the applicant know what instruments are going to be useful. We take special precautions to see that they survive.

What the operator is going to do is he is going to take any available water source and try to get it in. So he is going to try to start his HPCIs. Regardless of what the pressure says, he is going to try to pump it in.

If he cannot get it in, he can tell that pretty easily by the way the HPCIs are going to run. If the HPCIs are not running or if his SI is not running, it is not going to do him much good. Same thing with the emergency feedwater. It is not so much measured in the flaw. You want to know that your emergency feedwater system is functioning. Those things help get confidence, but you do all the same actions.

The operator would naturally get emergency feedwater to the steam generators. He would naturally try to get as much inventory as he can into the RCS. So by and large, he is going to do all of these things functionally regardless of what the instrumentation says. But it is good to know if the instrumentation is there, it may minimize any confusion that he has in doing his action. It may help guide it. It may reduce the stress, do all these other things.

But, in essence, if he loses this, does he lose the farm? Lose the equipment -- if he loses the equipment he loses the farm. If he loses the instrumentation, he can still survive.

MR. KRESS: So if I search through the PRA event tree and look for places where these devices would impact on the sequence reaction, I would not be able to find them?

MR. SCHNEIDER: For one good reason. We do not credit this in vessel recovery in the PRA.

MR. KRESS: That takes care of the top five.

MR. SCHNEIDER: All of these then are -- the only reason that you need the hydrogen monitor is, basically, to know what hydrogen concentration you have. You have your igniter systems on. If the igniters weren't working, it is going to do its job. You need containment pressure only to do venting. We don't credit venting --

MR. KRESS: But you turn on the hydrogen monitors manually. Is it based on that reading?

MR. SCHNEIDER: Right now it is going to based on the core exit thermal couple exceeding 700 degrees well before.

MR. KRESS: So they're already on.

MR. SCHNEIDER: Yes.

MR. BARRETT: If I could just add a word, in addition to the criteria that ABB articulated for choosing these instruments, we requested that they include additional instruments for the simple reason that we felt that in an advanced reactor, if there were an accident at that vessel we did not feel that we should be blind, that there should be some minimum set of information that would be available to those people trying to manage the accident both on site and also for the purpose of taking protective measures. So if there is not a clear nexus to some of these instruments to specific operator actions or accident management accidents. They are there simply because we thought it was prudent.

MR. LINDBLAD: But some of these locations, some of these parameters will have local values rather than distributed single values. You're only asking for a single measurement of the containment temperature. Is that right?

MR. SCHNEIDER: We only have two in the whole containment normally Right?

MR. LINDBLAD: But you would expect that there would be many different temperatures inside the containment after a severe accident.

MR. SCHNEIDER: If you had control of the containment and your sprays are operating and everything is going fine, you really would. If things are going very right, the pressure is up, your temperatures are really reading high, there may be a distribution. But that will give the operator the idea that the sprays are not on and the containment is not functioning as it should. The goal is to control or turn the event. Everything tells the timing for evacuation.

MR. LINDBLAD: Then you can sense the temperature by feeling the outside of the shell, putting a thermal couple on the outside of the shell rather than on the inside, and that would be a good averaging of containment temperature.

[Slide.]

MR. SCHNEIDER: Again, the equipment that he needs has much the same logical. The equipment you want is that which will provide inventory, remove heat, and in essence, we also have -- okay, for recovery the event. In order to respond to the event the rapid depressurization system which is actuated early and will function prior to vessel breach the cavity flooding system, which is intended to be actuated early, the hydrogen mitigation system --

MR. CARROLL: Is there a significance to the arrows with the bent top?

MR. SCHNEIDER: Those are runs. Those are notes for actuated and performs function early. Sorry about that. Hydrogen mitigation system -- containment penetration integrity is an individual item that we called out as trying to attempt to make sure that that is going to survive as long as reasonable. Containment spray system is a critical system and the shutdown cooling system primarily is a back up to the containment spray system, not so much as the shutdown cooling system function itself.

MR. CATTON: How do you decide what the environmental conditions are that the penetration has to deal with?

MR. SCHNEIDER: What we have basically done is use MAAP analyses to get a rough idea of the global temperatures we're going to expect in the containment.

MR. CATTON: That is more than global temperatures, isn't it? You have to do the same thing? Did you use something like MAAP.4?

MR. SCHNEIDER: We used that to get a feel for the general temperature gradients because remember this is on the outside of the region. The penetrations are going to be in the annular regions where we really don't expect to have a very large -- the higher temperatures. The higher temperatures we expect mostly inside, if we're going to have them, inside the crane wall.

MR. CATTON: I thought your circulation patterns showed the hot gases rising right up to the top coming down around the other side? You can't have it both ways.

MR. SCHNEIDER: We don't get large gradients. The only high temperatures we have noticed are those inside the tunnels themselves, and outside the gradients are not that substantial.

MR. CATTON: What about the top of the dome?

MR. SCHNEIDER: It does not show as being a lot different.

MR. CATTON: That is because you're using MAAP.4. You've got to be using a finite difference code if you want to put the penetrations up there that will do you some good or if you put penetrations that survive. You're going to have to know what the temperature distribution is.

MR. SCHNEIDER: What we're trying to count on is one, the robustness of the penetrations themselves and the fact that most of these penetrations are inside and outside containment.

MR. CATTON: Don't you have to demonstrate the robustness of the penetrations?

MR. SCHNEIDER: Sandia has done a real good job of testing a whole series of penetrations. For example, EPA, electrical penetrations assemblies, can withstand something in the order of 700 degrees on the inside for 10 hours.

That is well above anything we could ever expect mainly because what holds it is all of the interior seals fails but the exterior fails hold.

Our air locks will have seals on both sides. The O rings seals around main equipment hatches, a double O ring design, has been tested to handle about 600 and some odd degrees before failure. We are dealing with temperatures that we feel are in the 300 to 350 range before we get to containment failure. So for the majority of the sequences we are dealing with, we are well below most of these levels. The EPA thing I misstated. It is like about eight days at 700 degrees.

So there is a general robustness of the equipment. We don't have all of the details of exactly what environment it is going to be in, but remember there is thermal lag associated with these large penetrations themselves. Thermal lag -- the penetrations have large steel pieces of steel, the physical process.

MR. CATTON: That triggers another nerve.

MR. SCHNEIDER: Just the physical process, the time delay associated with heating up massive amounts of steel penetrations. So, we are reasonably comfortable that based on the existing design the penetrations will last -- you're probably going to fail the overpressure -- will fail the containment before you fail the penetrations.

So we are not uncomfortable --

MR. CATTON: Is there anything you're worried about just above the steam generators?

MR. SCHNEIDER: No. The penetrations -- there is no penetrations in the upper region.

MR. CATTON: At all?

MR. SCHNEIDER: No. The only thing you would have -- the highest you could get is the main steam line, which has like metal bellow penetrations, and those are not going to be very susceptible to temperature transients.

MR. CATTON: If you have nothing up there, then stratification will not be a problem.

MR. DAVIS: It will be good for it. It puts the temperature where you don't have a problem.

MR. SEALE: You will have all of the high energy up there.

MR. DAVIS: The mixing assumption is conservative.

MR. CATTON: That's true, but you've got to be careful, especially if you're buying or selling, Pete.

[Slide.]

MR. SCHNEIDER: What we did do is that we felt that we could not just look at global effects. We tried to get a rational logic for looking at the potential for local effects which are driven, we felt, more by combustion processes. We felt local effects might occur near igniters and near hydrogen sources. Global effects would be driven by convected processes. We assume that is going to govern the bulk of the containment. So, we do take some credit for local effects. But we do not do detailed local calculations.

[Slide.]

MR. SCHNEIDER: What we did do though is we tried to do whatever we could to reduce the effect of local environments on the instrumentation. So the goal was to, basically, move the instrumentation -- well as is naturally the case, most of the instrumentation is located away from where we would expect the hottest environments. As a matter of fact, most of the sensors and cabling really starts from the point outside the crane wall.

So, we wanted to rely primarily on instrument equipment and instruments with transmitters located as far away as possible from the hydrogen sources based on the HCOG data, which was the Hydrogen Control Owners Group.

GE did a compartmentalized test with igniters. Based on their data, they indicated that about one and a quarter scale feet away from their igniters the environment could be considered global. But within that region you can get locally higher temperatures.

So we put a placement restriction that the scale value would be five feet. So, we put the placement restriction that within ten feet of all igniters we have to remove equipment and cables to be at least ten feet from igniters.

The other thing is that we did not want for a potential diffusion flame. We did not want the equipment to directly see a continuously burning flame. So we gave an instruction that for those pieces of the equipment that will be in the direct line of sight of igniters that we feel thermally shield, radiatively shield the equipment and the cables.

For post VB sequences most of the equipment -- after you reach the vessel, post vessel breach sequences, the bulk of the equipment relied on for mitigation is primarily located outside the containment, which has no local effects at all.

[Slide.]

MR. SCHNEIDER: Global environments were to be expected away from igniters. For any containment instrumentation, global environments were primarily were established with MAAP.3(b). We did uniform modeling, basically, with the generalized model. You see, we did that with the hydrogen.

MR. CATTON: You cannot use a code like MAAP.3 for this. It is a displacement process. The hot materials are going to rise up and displace downward. That is not the way those codes work.

For example, I could have absolutely uniform pressure across the top, about midway between the deck and the crane wall, absolutely uniform pressure, and I will have movement of the air and the hot stuff will rise up to the top, slowly displace down. MAAP does not do that.

MR. SCHNEIDER: It does not do the right phenomena but there are no hot sources to drive any annulus where the equipment is located.

MR. CATTON: What is the MAAP Code doing? It is giving you delta P to make it work.

MR. SCHNEIDER: It has a delta P.

MR. CATTON: And the delta P is phony.

MR. SCHNEIDER: Yes, to some extent. What it does tell you is what is what is driving this is the absolute steam in the containment will drive the saturation pressure generally of the containment as long as you don't have the super heater --

MR. CATTON: You don't a code for that.

MR. SCHNEIDER: I'm not saying you need a code. We used MAAP for estimating the global effect and the primary effect of the energy balance. Hence, as we approach containment failure, containment failure is going to be a saturated steam environment at about 350 degrees F. At about 350 pounds or something of that order. So we don't feel the code was critical but we used that for timing and when we had a reference they want to see a calculation of it, and so it does a good job.

MR. CATTON: If they want to see a calculation then you will give them one.

MR. SCHNEIDER: It is their right. We didn't do anything wrong. It makes sense.

MR. CATTON: If you stick in there to determine environmental conditions that are bothersome when it is followed by MAAP.

MR. SCHNEIDER: Okay.

MR. CATTON: If you want environmental conditions you have to do it another way. If you want to know what they are throughout the containment. The only thing that MAAP will do probably correctly is the pressure because you just dump everything in.

MR. SCHNEIDER: That's all what I really needed. It has the pressure right. It has about the right mass of water and saturation, which is the reasonable assumption, is going to have about the right temperature. You're not going to expect -- it is not going to do it into detail. Maybe I will be 20 or 30 degrees off. The regions where this equipment it is probably going to be off in a good direction. The equipment is located away from the energy sources and down low.

MR. CATTON: I would buy that.

MR. CARROLL: You picked on him, Ivan, for doing a calculation because the Staff wanted one. Not that part GE and the pool swell issue --

[Laughter.]

MR. CATTON: It is not over yet.

MR. SCHNEIDER: So, basically, we view these as global energy balances basically. What we found is within the first 24 hours the containment provided some degree of flooding without even sprays. One maintained a pressure below about 90 psia and maintained temperatures about 330 degrees F. At containment failure the temperature is expected to be below 350 and below 140 psia. The design basis --

MR. CATTON: How sensitive is containment failure to the temperature of 350?

MR. SCHNEIDER: Not at all. That is, basically, the saturation condition. It is not a steel shell temperature. It is more that when I get this pressure I'm going to get about that temperature. The equipment is mainly a temperature --

MR. CATTON: If I had, for example, 250 degrees on the bottom and 550 up on the top, would the failure pressure be different?

MR. SCHNEIDER: Of containment?

MR. CATTON: I don't know how to get a measure of that. We know that the temperature in the containment is not going to be uniformed. It is going to be hotter up in the top than it is in the bottom. If you're calculating an average value of 350, what is the maximum?

MR. SCHNEIDER: It is about 340 on the bottom, maybe 360 or someplace on the top. You cannot get very large differences.

MR. CATTON: Why?

MR. SCHNEIDER: Because you have the large delta P differences. That is driven -- but the same thing because what drives the delta P is the mass of water and the pressure of steam. So if you had those differences, delta P, you would have those driving poles to move them around.

MR. CATTON: Somehow I don't understand.

MR. LINDBLAD: Not if the top is hot and the bottom is cold.

MR. CATTON: It is going to return to motion.

MR. SCHNEIDER: Remember, the steel shell is layers everything. It is the coolest portion. How are you going to get the top to, basically, get the super heated steam, super heated steam on the top?

MR. LINDBLAD: With radiation. Radiant energy.

MR. SCHNEIDER: All the corium is located in the cavity covered with water.

MR. CATTON: Well, that is certainly true. So what you are doing is --

MR. SCHNEIDER: Basically, a steaming calculation.

MR. CATTON: It is strictly a steaming calculation.

MR. SCHNEIDER: It is more elaborate, but that is essentially what it amounts to.

MR. CATTON: I have to buy that if the source of the hot steam is put on the bottom and it is like my coffee pot.

MR. CARROLL: As long as there is water in it.

MR. CATTON: As long as there is water in it.

MR. SCHNEIDER: We wanted to look at the distribution of the senses to see what is going to be affected by what. The only thing inside the crane wall would be the thermal couple that comes right out of the top of the upper head, and that is only has -- basically, that can survive very high temperatures, and the cabling is only exposed to the crane walls, but only the upper portion of the crane wall. So, it shouldn't be in that bad of shape.

Everything else is located outside the crane wall for sensors. Most of the stuff is also located in the subsphere. For the radiation monitor we have something located in the outside of the crane wall. But it is also backed up by the post-accident sampling system, which is located in the subsphere itself.

MR. LINDBLAD: What is the subsphere?

MR. SCHNEIDER: The portion of the containment building that is located below the sphere but because we use up all the available space in the -- it has a common basement and there are rooms below.

MR. CATTON: It is not in containment.

MR. CROM: It is not in containment. The subsphere is where all of the ECCS pumps are located, which is under --

MR. CATTON: You mean below the sphere?

MR. CROM: That is correct.

MR. CARROLL: Sub -- submarine.

MR. SEALE: Subnormal.

[Laughter.]

[Slide.]

MR. SCHNEIDER: Again, in terms of the equipment, the only equipment located inside the crane wall is going to be that which is going to be actuated early or has been environmentally qualified to survive the burns. Most of the residual equipment will be located outside the crane wall.

Some pieces have now -- for the containment spray system, the only thing inside the crane wall containment are the containment spray headers, which should not be subject to much of the loading containment penetrations both inside and outside the crane wall, inside and outside the containment.

So, by and large, a large fraction of what we are expecting to survive will survive by virtue of its location, not being in the containment. The remainder of it will survive because it is going to be reasonably well qualified by the design basis itself, plus special restrictions on placement.

In addition, it is located in one of the most favorable positions on the other side of the crane wall. So we think that there is a high confidence that the equipment will be available to be called upon should the operator ever need it for the situations.

MR. LINDBLAD: When you were showing the hydrogen mitigation system, both sensors and cables, how many sensor locations do you have.

MR. SCHNEIDER: 80. Oh, sensors locations, no. Sensors are outside of containment. They are what two? They are on the recombiner. They are on the recombiner skid.

MR. CROM: I believe it is two but I do not recall right off hand.

MR. LINDBLAD: So most of is cabling for the igniters.

MR. SCHNEIDER: Oh, yes. It is cabling.

MR. LINDBLAD: Thank you.

MR. SCHNEIDER: The result of a thermal environment, we believe that the equipment instruments required for achieving and maintaining a safe shutdown will have a high confidence of surviving a recoverable severe accident and equipment sensors, transmitters, and cables located outside the containment will just survive virtually any severe accident. That is really the story.

MR. CARROLL: Any questions.

MR. DAVIS: I have a quick one. It is related to some previous discussion about the containment. One of the down sides of having such a huge steel shell as a containment means you get a substantial thermal expansion as the containment starts to heat up and the growth can be quite large.

There is a discussion in Volume 24 about the shell growth as the temperature increases and this opens up a leak in pads between the penetrations and the shell. But it was not clear to me how that was accounted for in the analysis. Do you have some leak grade versus temperature analysis that you were using for the risk assessment?

MR. SCHNEIDER: The reason I went to Service Level "C" for the minimum yield stresses, we keep the containment in the elastic range. Once it gets into the plastic range we are assuming it will start to fail probabilistically, and the only way that it is treated in the PRA would be to be treated by having material property variation on the modules of elasticity on the shell and the yield point stress -- the yield point stress. So, that has a variation in it based on the material property.

Once you go past yield, once you go into the yield portion of the curve, we have not credited any strained hardening. We assume that will grow. That will be a failure because we do not have the detailed drawings that we show that we can prove that it won't.

MR. LINDBLAD: It sounds like you're talking about pressure dilution rather than temperature expansion. Is that correct?

MR. SCHNEIDER: Any kind of separation. We look at the whole temperature range. I think what he was -- the concern was that once you get above a certain stress, you can have --

MR. LINDBLAD: Why would there be any different stress with the temperature expansion if the shell is free to expand and the stress intensity will remain the same?

MR. SCHNEIDER: I think he was quoting from a section referring to the pressure. Am I misinterpreting something?

MR. DAVIS: It was more of a temperature problem as I read it and what I could not find out is how does the leak rate vary as the temperature increases during a severe accident?

MR. SCHNEIDER: It really should not. Until you get beyond yield, you will not have any problem.

MR. DAVIS: This says that the leak pads will open up between the penetration and the shell as the shell temperature increases.

MR. CARROLL: I think those are preexisting leakage paths.

MR. KRESS: Generally, if you have a percent volume per day, you don't know where it is. You can ration the area change and assume that that leakage goes with the area change.

MR. DAVIS: What was done on the PRA on leak rate versus temperature?

MR. SCHNEIDER: Dan?

EVENING SESSION

MR. FINNICUM: When we looked at the PRA up to the temperature that they were assumed to fail, we did not look at any leak change in leak rate at that temperature. It was then assumed to be catastrophic failure.

MR. DAVIS: What was that temperature?

MR. FINNICUM: About 400 degrees, something like that.

MR. SCHNEIDER: It is really not a temperature. We used 350 degrees for -- that's right -- 350 degrees for the failure yield stress to establish where the failure of the yield stress would be, the temperature associated with it. 350 degrees, which is, basically, the equivalent temperature you would expect in containment on a global basis and steaming to give you about the same pressure loading to correspond to failure.

MR. DAVIS: The leak rate is still the same at that temperature?

MR. SCHNEIDER: We did not do anything on that.

MR. CARROLL: Okay. Any other questions? All right, Doug would have us deal with Ivan's part.

MR. CATTON: I'd like to take a look at the questions and I think there are some -- that Chad should take a look at them. I'm not sure if I asked the questions or not, but if I did I asked them so that Chad could listen to the answers. It had to do with copper and a few other things.

For the most part, I have no problem with their answers. I guess in the one case -- that was Oak Ridge? That was for the Staff.

MR. COE: The three dimensional analysis study.

MR. CATTON: Let me quickly go through these. There was a question about the core vibrations and they indicated their velocities are lower. So there is no problem. I don't have any problem with that. We have those that are still sort of open with -- I would like to see the models of correlation document.

MR. CARROLL: I did notice that they used a Zuber correlation.

MR. CATTON: Then it has to be good.

MR. COE: Page 40?

MR. CATTON: Page 40. Page 40 was the criteria to size the lower grid flow points. It sounds good to me.

MR. LINDBLAD: I have a question about that later.

MR. CATTON: Explain the differences between SCU&D&B convolution methods? I guess I'm just bothered by the use of the convoluted method. I read through it and it sounds like they are using the sum of the squares or something, thermal couples. They address some issues that I recall from years ago so I have no problem with that. Where is the next one?

MR. COE: 47.

MR. CATTON: Page -- ABBCE regarding improvement in reactor vessel improvement. I think Shack should take a look at that.

MR. CARROLL: Does Shack know what you learned in Germany?

MR. CATTON: Probably not. But if he could read the trip report. I was referring to another trip report and actually this here part of the trip to Germany is back here. Charlie -- it is not fair to ask him.

Let's see. The last one is post-action radiation monitors. I don't think I asked that question. The answer sounds okay to me.

MR. CARROLL: I will figure out whether I asked it.

MR. CATTON: How does the answer sound to you?

MR. CARROLL: I have not read it again. I read it once.

MR. KRESS: What is your problem with convolution? It is a tried and try --

MR. CATTON: Convoluted and nobody can understand what it is. I'm happy with the answers.

MR. COE: The Staff also responded to your question regarding the three dimensional analysis studies done at Oak Ridge that might indicate a less margin. You looked at that too?

MR. CATTON: Yes.

MR. CARROLL: Okay. Do we have any more business? We should go on the record, stay on the record for --

MR. LINDBLAD: I move that we recess.

MR. CARROLL: Then we are in recess.

[Whereupon, at 6:06 p.m., the meeting in the above-entitled matter was adjourned.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

NAME OF PROCEEDING: ACRS ABB CE Plant Design

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Barbara Whitlock

Official Reporter
Ann Riley & Associates, Ltd.

INTRODUCTORY STATEMENT BY THE
ABB-CE STANDARD PLANT DESIGNS
SUBCOMMITTEE CHAIRMAN

MARCH 8, 1994
BETHESDA, MARYLAND

The meeting will now come to order. This is a meeting of the Advisory Subcommittee on ABB-CE Standard Plant Designs. I am Jay Carroll, Subcommittee Chairman.

The ACRS Members in attendance are: I. Catton, P. Davis, T. Kress, W. Lindblad, C. Michelson, R. Seale, and C. Wylie.

The purpose of this meeting is for the Subcommittee to continue its review of the ABB-CE System 80+ Standard Plant Design.

Mr. Doug Coe is the cognizant ACRS Staff Member for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on February 23, 1994 as modified March 1, 1994.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice. It is requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she can be readily heard.

We have received no written comments or requests to make oral statements from members of the public.

(Chairman's Comments - if any)

We will proceed with the meeting and I invite Mr. Charles Brinkman of ABB-CE to begin the presentations.

ABB Combustion Engineering
System 80+™ Standard Plant

Chapter 3 Design of Structures, Components, Equipment, and Systems

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Leak-Before-Break
Technology Application
ACRS March 8, 1994

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System 80+ Standard Plant Leak Before Break

- What pipes have LBB applied in System 80+?
- What is LBB used for?
- What is the basis for choosing lines for LBB?
- How is LBB demonstrated for System 80+?
- What is the impact of LBB on System 80+?

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System 80+ Standard Plant Leak Before Break Applications

- Main coolant loop piping
  - 2 hot legs (42" carbon steel)
  - 4 pump discharge legs (30" carbon steel)
  - 4 pump suction legs(30" carbon steel)
- Surge line (12" stainless steel)
- 2 shutdown cooling lines (16" stainless steel)
- 4 direct vessel injection lines (12" stainless steel)
- 4 main steam lines (28" carbon steel)

Note: All lines are inside containment

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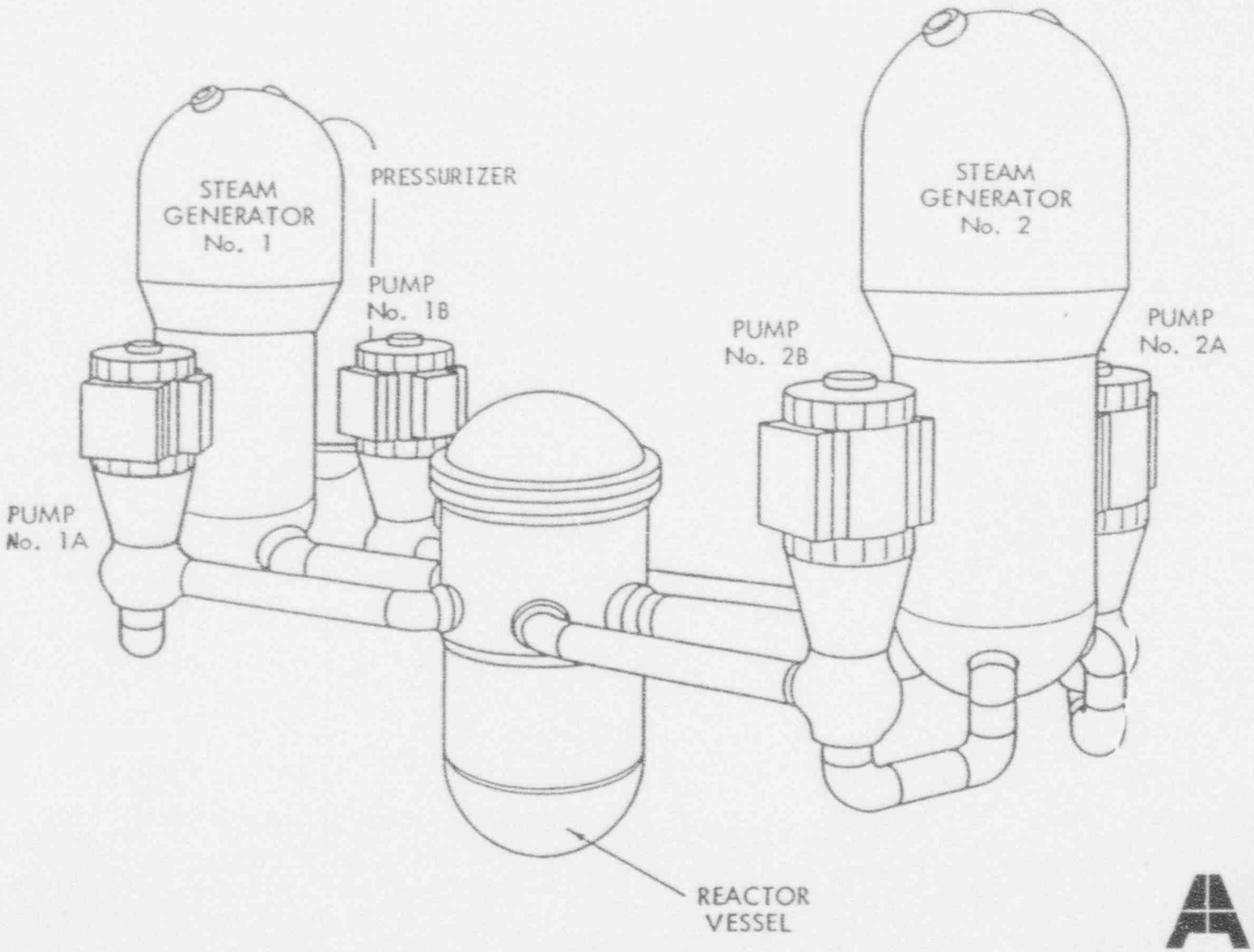
System 80+ Standard Plant
Isometric View of Reactor Coolant System



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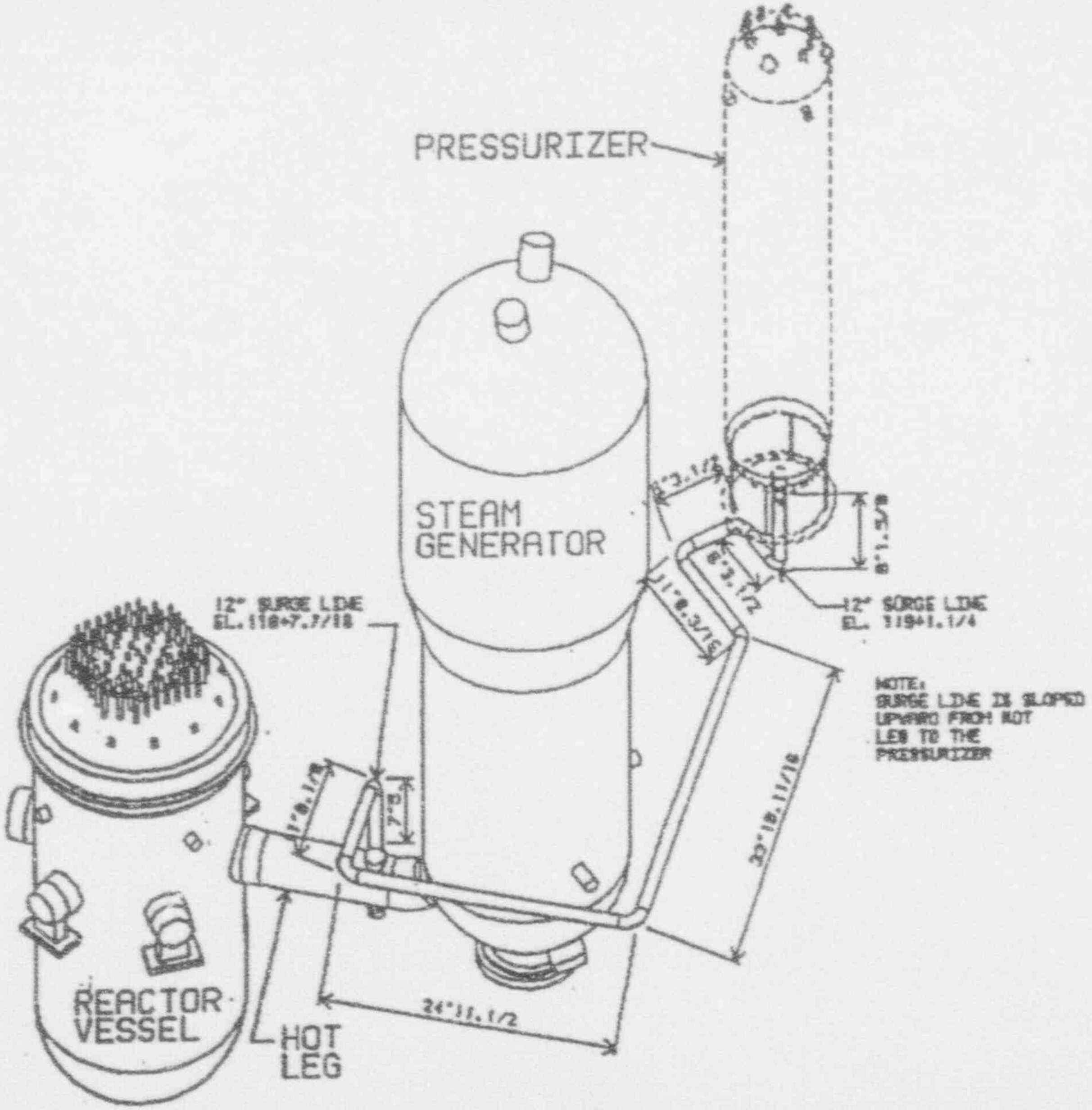
System 80+ Standard Plant
Surge Line



NOTE:
SURGE LINE IS SLOPED
UPWARD FROM HOT
LEG TO THE
PRESSURIZER

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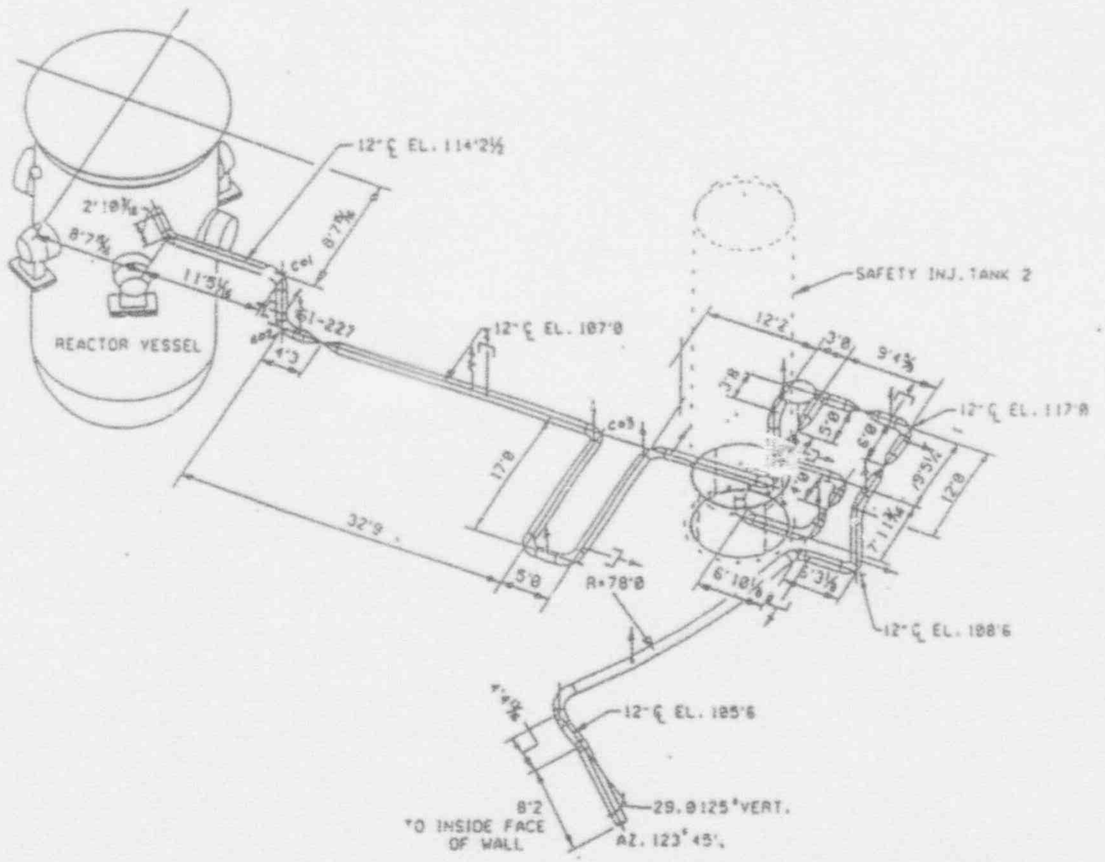
System 80+ Standard Plant
Direct Vessel Injection Line



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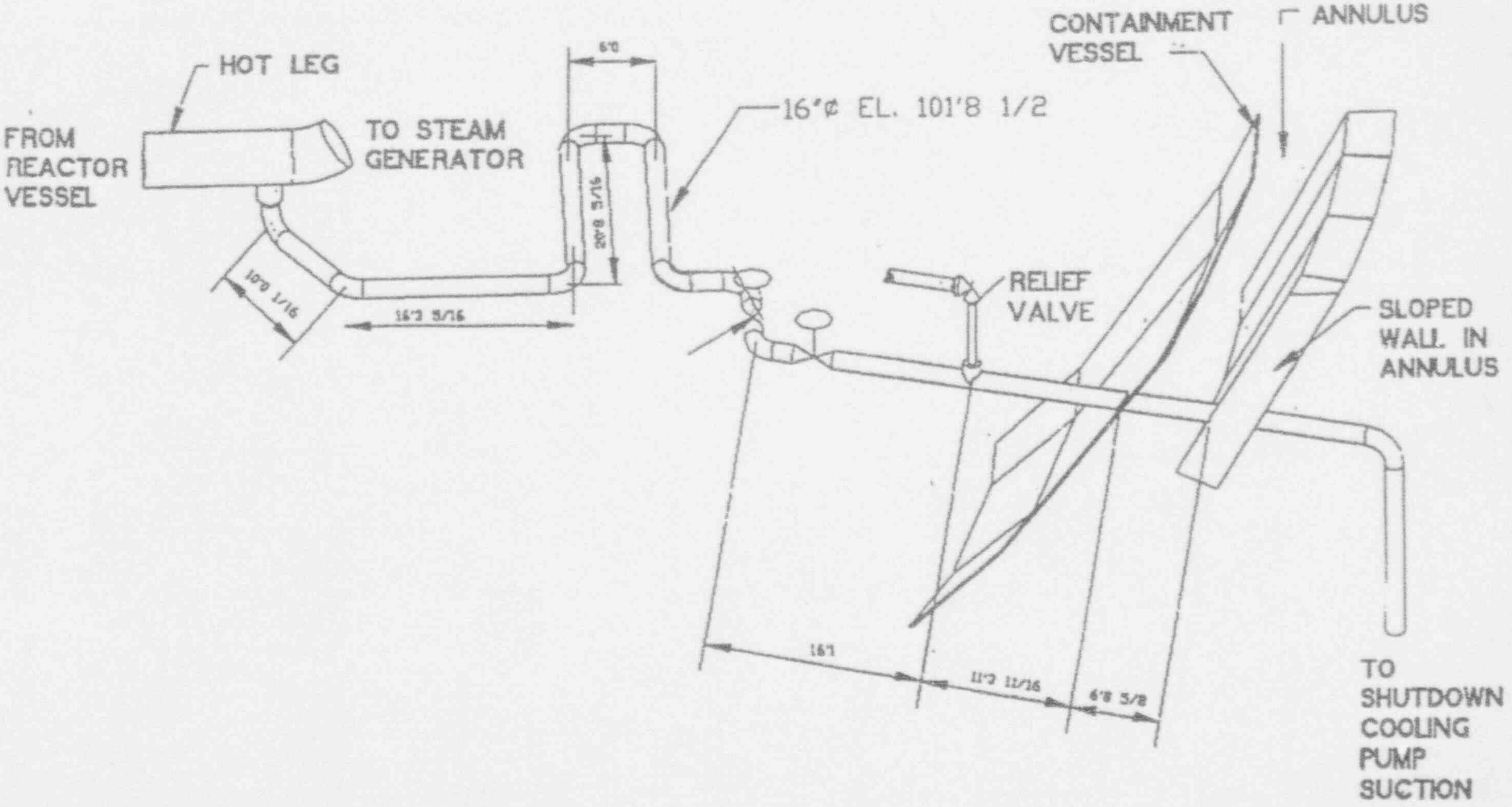
System 80+ Standard Plant Shutdown Cooling Piping



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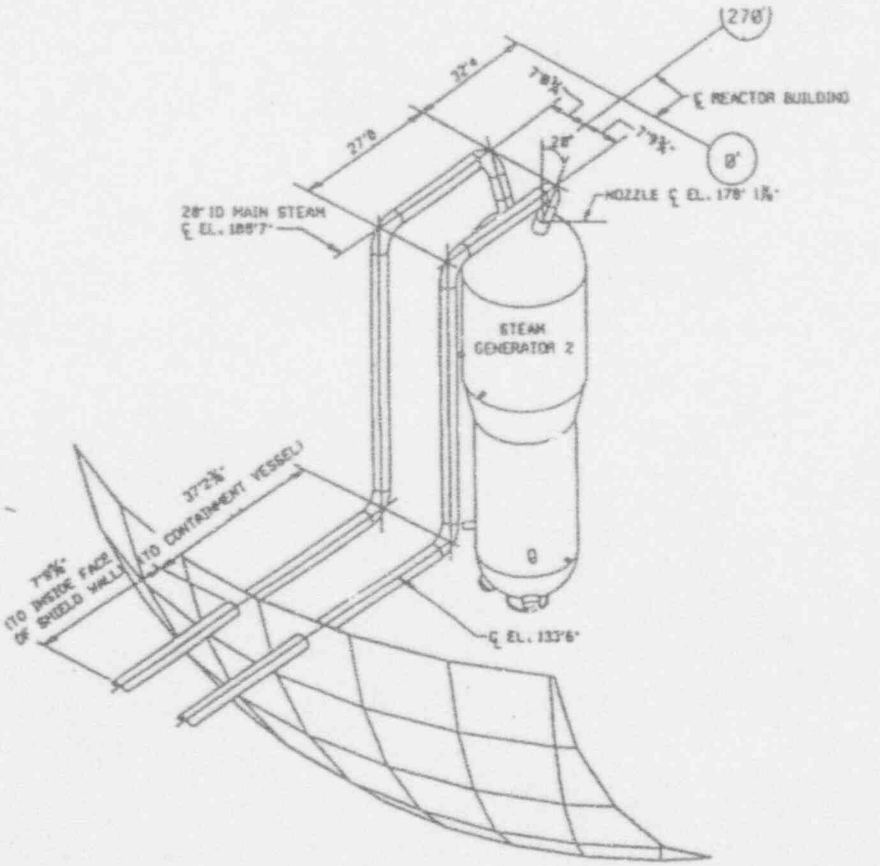
System 80+ Standard Plant
Main Steam Piping



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System 80+ Standard Plant
Leak Before Break Applicability

- LBB analysis used to justify elimination of dynamic load effects of design basis pipe breaks (DBPBs).

- LBB analysis does <u>not</u> eliminate:
  - Containment pressure-temperature effects of DBPBs.
  - Emergency core cooling system requirements for effects of DBPBs.
  - Environmental qualification requirements for effects of DBPBs.

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System 80+ Standard Plant
Choice of Application Piping

Basis for choice of lines for LBB

- Qualified based on not being susceptible to:
  - Waterhammer
  - Creep
  - Erosion
  - Corrosion
  - Fatigue
  - Environmental Conditions

- Satisfies LBB evaluation criteria:
  - Margin of 10 on leak detection rate
  - Margin of 2 on crack length
  - Margin of $\sqrt{2}$ on loads

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System 80+ Standard Plant LBB Acceptance Criteria

$L < L_c$ for $\sqrt{2}$ x maximum loads

$2L < L_c$ for maximum loads

where:

- L = Crack length which would leak 10 times the leak detection system sensitivity at normal operating conditions.
- Lc = Critical crack length

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System 80+ Standard Plant Evaluation Process

- Confirm piping system satisfies qualifications for applicability of LBB.
- Define LBB acceptance criteria based on parametric studies for use by piping designers.(Method Requires definition of only pipe size and materials.)
- Demonstrate capability to design to LBB acceptance criteria by complete preliminary design of System 80+ piping.
- Confirmation of material properties and final as-built design will be performed at construction stage.

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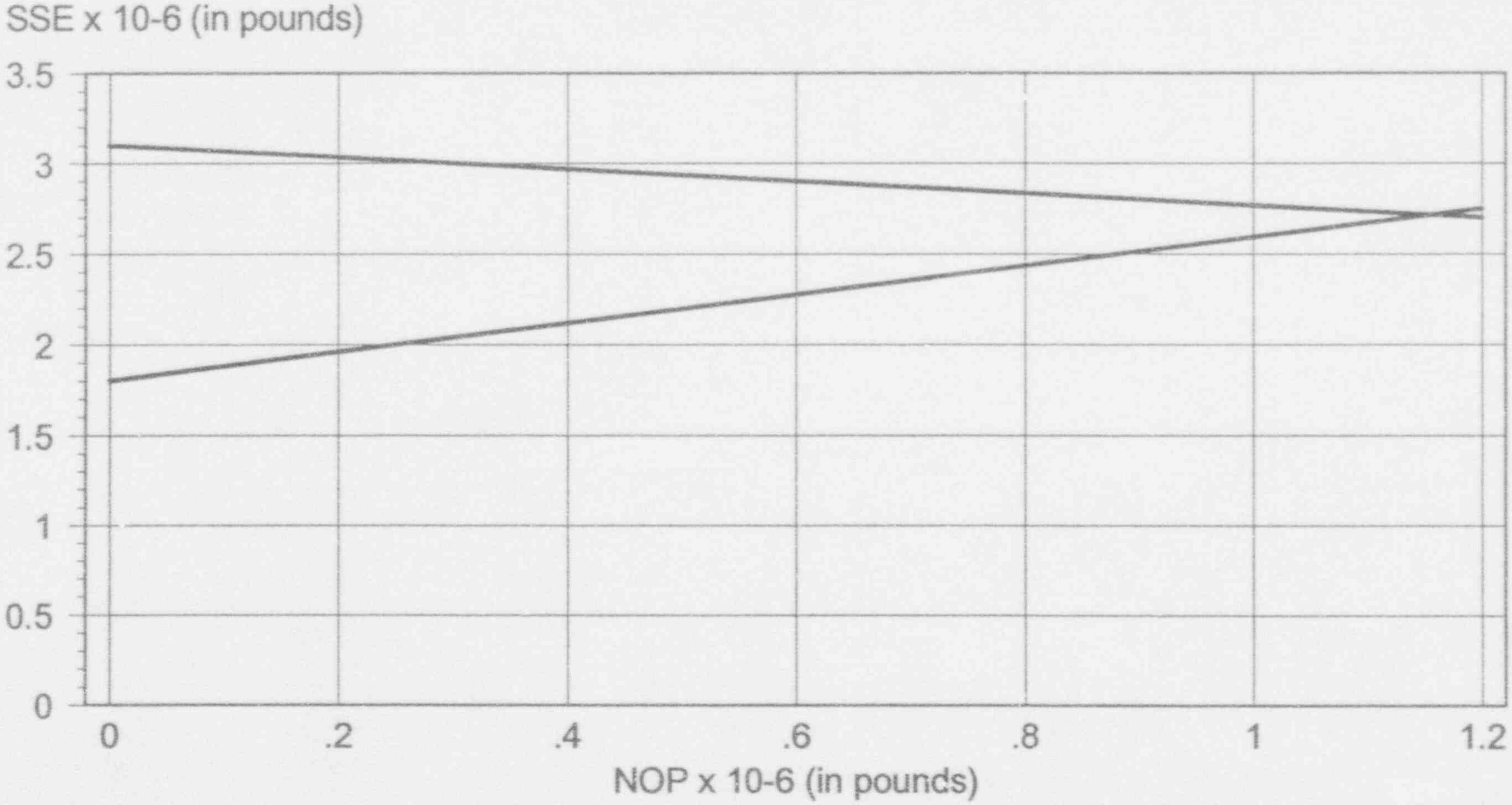
System 80+ Standard Plant LBB Piping Evaluation Diagram

ALWR Surge Line (TIG), A_c= .02 in^2



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System 80+ Standard Plant
LBB Impact on Design

- System 80 (implemented at Palo Verde Units 1,2 & 3) was originally designed and built to withstand dynamic effects of design basis pipe breaks.
- LBB analyses justified removal of pipe restraints for main loop pipes.
- Inherent capability to withstand dynamic effects is maintained in System 80+ design.
- Unused capability provides additional seismic design margin.

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System 80+ Standard Plant
Leak Before Break Benefits

- Improved reliability of piping system due to elimination of restraint structures which may restrain normal thermal expansion.
- Improved accessibility for in-service inspection and maintenance of piping and equipment in vicinity.
- Reduced personnel exposure due to improved accessibility and no need to inspect and maintain restraints.
- Reduced construction time and costs.
- Reduced refueling times and less personnel exposure due to ability to install a permanent pool seal over reactor cavity annulus.

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ABB Combustion Engineering System 80+™ Standard Plant

Section 19.11 "Severe Accident Analysis"

Raymond E. Schneider

ACRS ABB-CE Standard Plant Designs Subcommittee
March 8-9, 1994

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System 80+ Standard Plant

System 80+ Severe Accident Analysis

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System 80+ Standard Plant Goals of Severe Accident Analyses

- Purpose:
  - Demonstrate compliance with regulatory issues defined in SECY-93-087 and 10CFR50.34 (f)
  - Support PRA Level II quantification

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System 80+ Standard Plant
SECY-93-087 Severe Accident Issues

- Hydrogen control
- Prevention of high-pressure core melt ejection (and direct containment heating)
- Mitigation of ex-vessel steam explosions
- Mitigation of core-concrete interactions
- Containment performance (overpressure failure)
- Instrumentation and equipment survivability

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System 80+ Standard Plant

Hydrogen Control

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System 80+ Standard Plant Hydrogen Control

- Purpose:
  - Limit uniform containment hydrogen concentration to <10 volume percent
  - Demonstrate ability of containment to accommodate the consequences of 100% oxidation of the fuel clad
  - Reduce potential for containment failures

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System 80+ Standard Plant Hydrogen Control

- Design Features:
  - Large containment volume (3.4 million ft^3) ensures that, even without hydrogen control features, the maximum hydrogen concentration is less than 13%.
  - Hydrogen mitigation system including igniters and IRWST pressure relief dampers function to preclude hydrogen detonation within the containment.
  - Containment arrangement promotes natural circulation and mixing
  - "In Containment" enclosures vented to prevent local hydrogen accumulation

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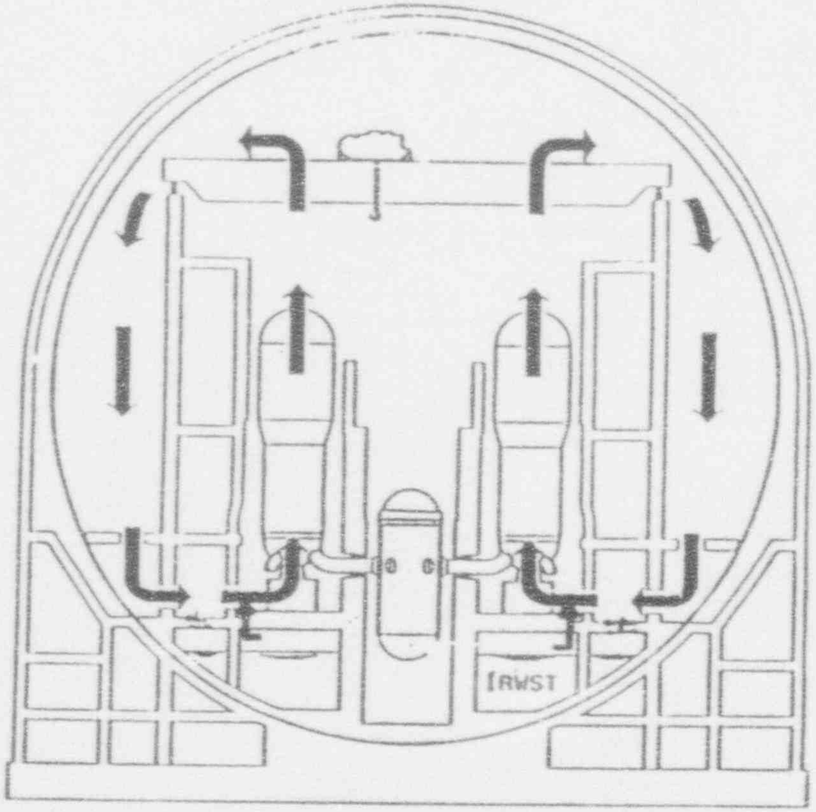
System 80+ Standard Plant Hydrogen Control



Dominant Post Accident Natural Circulation Pattern for System 80+

ABB

RAK SRS4 3/1/94

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System 80+ Standard Plant

Hydrogen Mitigation System (HMS)

- 80 Igniters
  - Strategically located within the containment
  - Two redundant electrical trains

- Igniters and cables designed to survive
  - Hydrogen burns
  - Seismic events

- High expected system availability
  - Powered by diverse power sources including offsite power, emergency diesels, combustion turbine and batteries
  - Technical specifications address surveillance and operability
  - Included in Reliability Assurance Program

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System 80+ Standard Plant
Hydrogen Igniter Placement Criteria

- Igniter system design considers
  - System maintainability
  - redundancy/reliability
  - Placement criteria

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System 80+ Standard Plant

Detailed Hydrogen Igniter Placement / Design Criteria

- System maintainability requirements
    - No more igniters to be included in system than necessary
    - Igniters located with reasonable expectation of maintainability and surveillance

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System 80+ Standard Plant

Detailed Hydrogen Igniter Placement / Design Criteria

- Redundancy and system reliability objectives require
  - Multiple levels of burning in dominant flow paths
  - Pairs of igniters to cover similar regions
  - Igniter pairs powered via independent power sources

- Placement criteria requires igniter to be placed
  - Along all dominant and secondary flowpaths
  - In vicinity and above hydrogen sources
  - In all compartments
  - About 10 feet below solid surfaces
  - So as to control hydrogen in volumes of 50,000 cu. ft. except in dome

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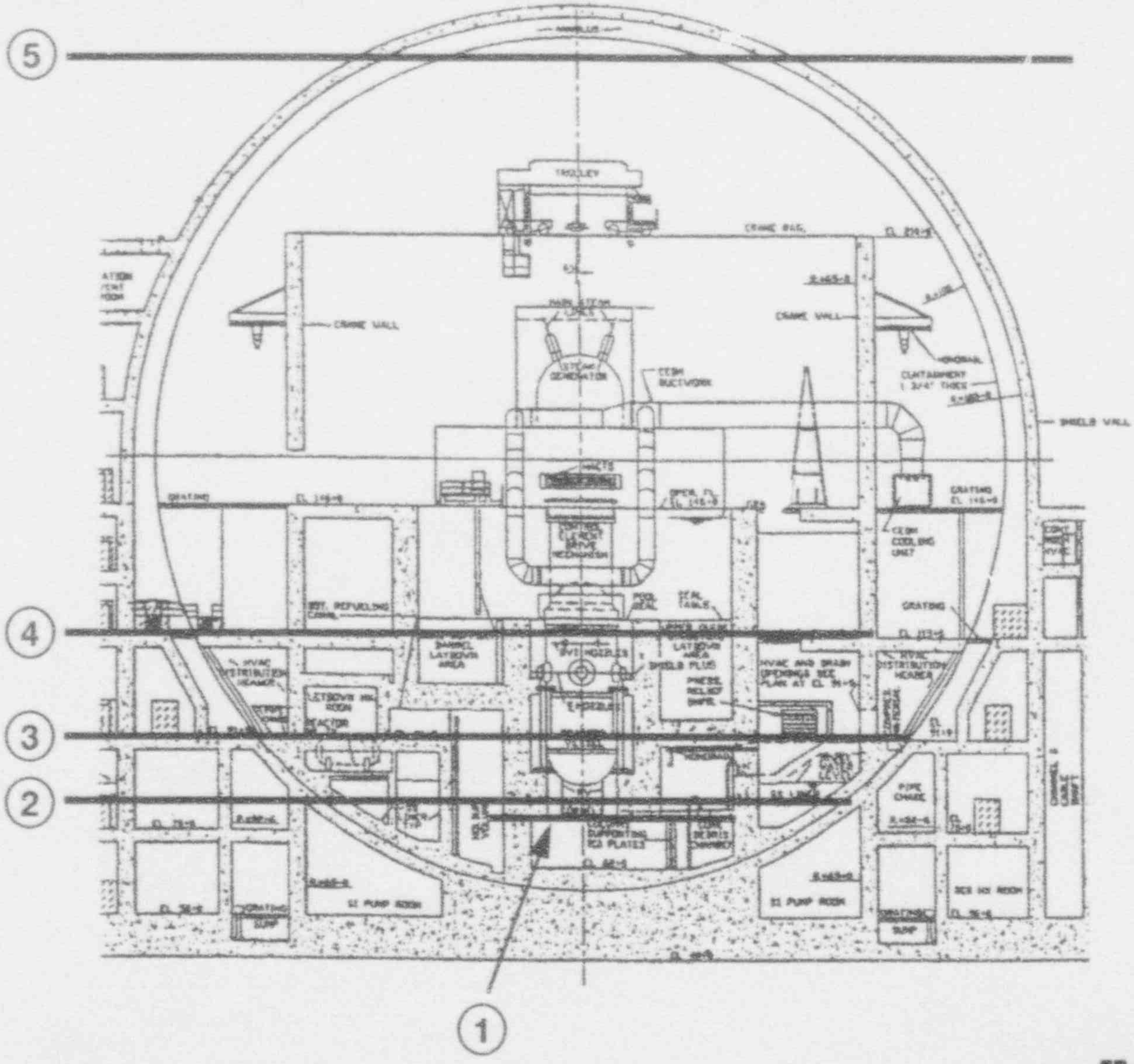
System 80+ Standard Plant Hydrogen Igniter Placement/Layout



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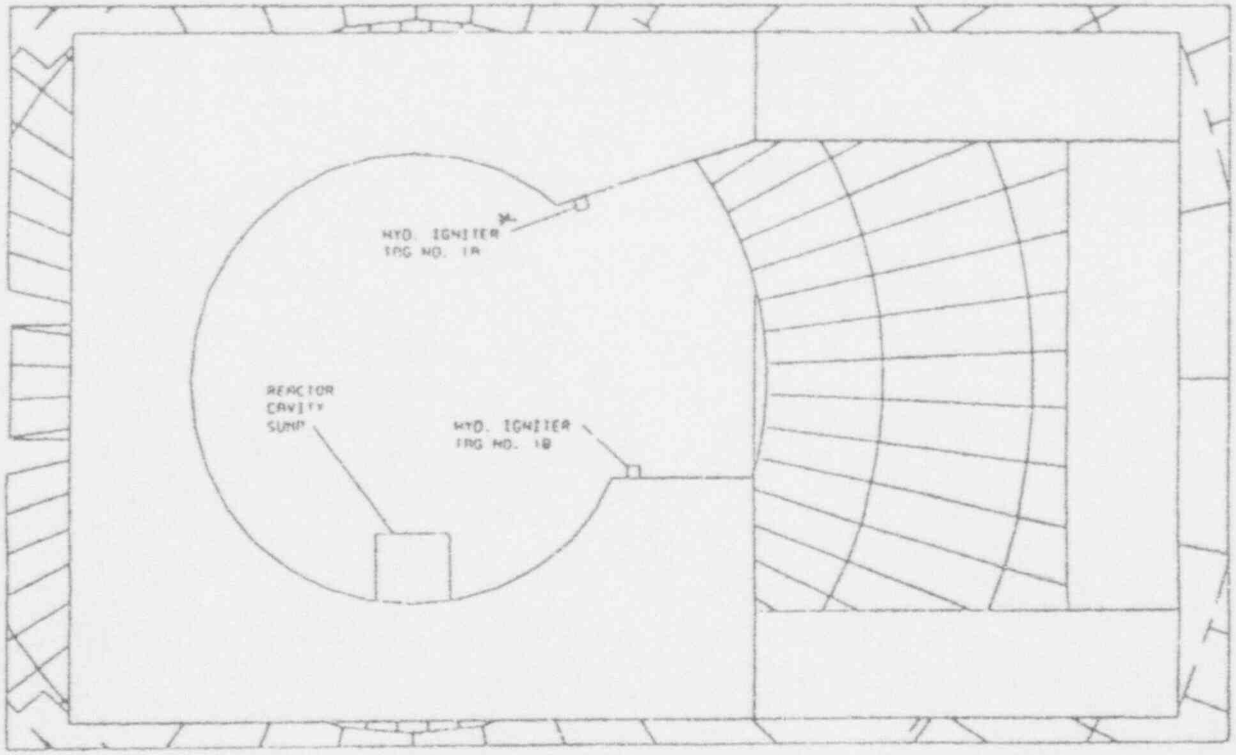
System 80+ Standard Plant
Hydrogen Igniter Placement/Layout



Plan View of Reactor Cavity

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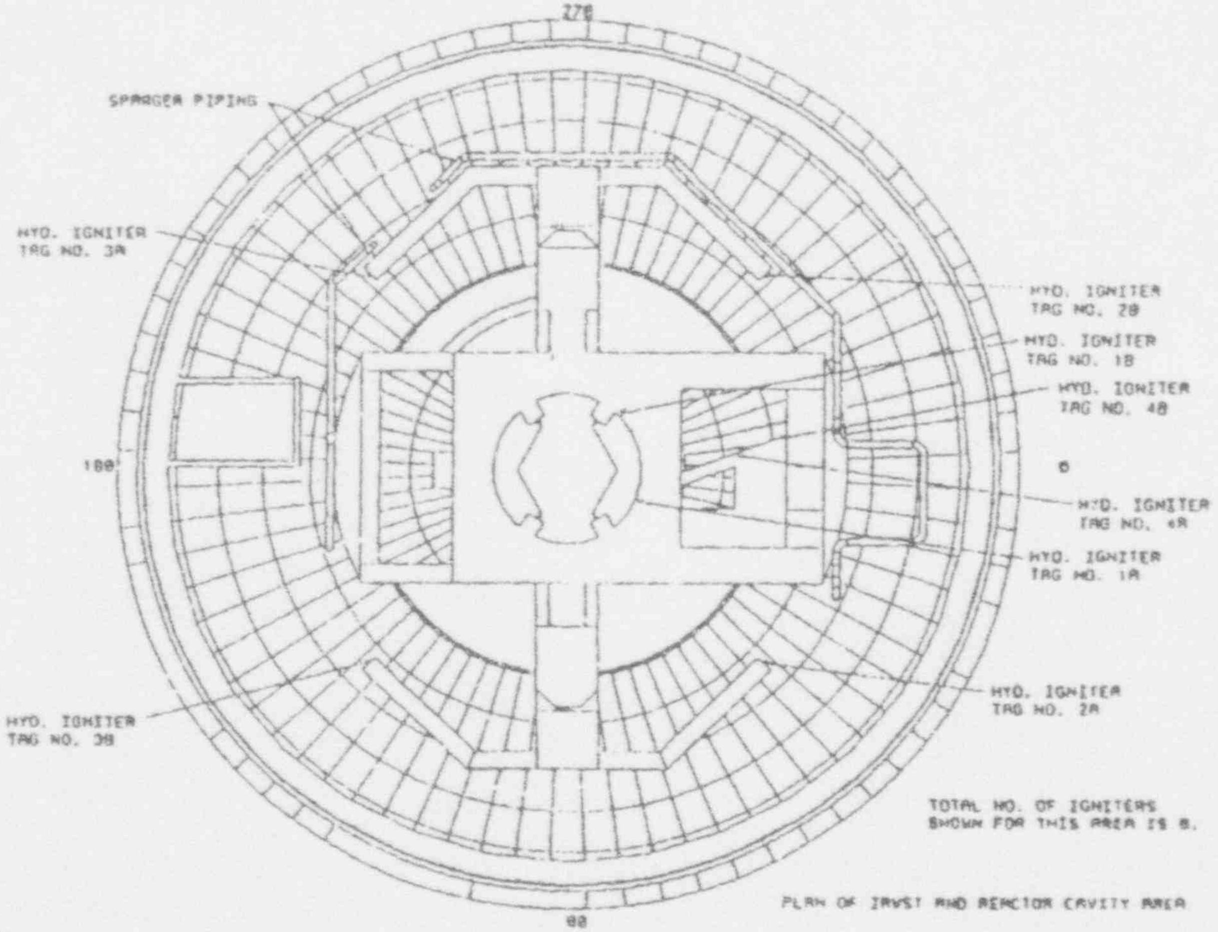
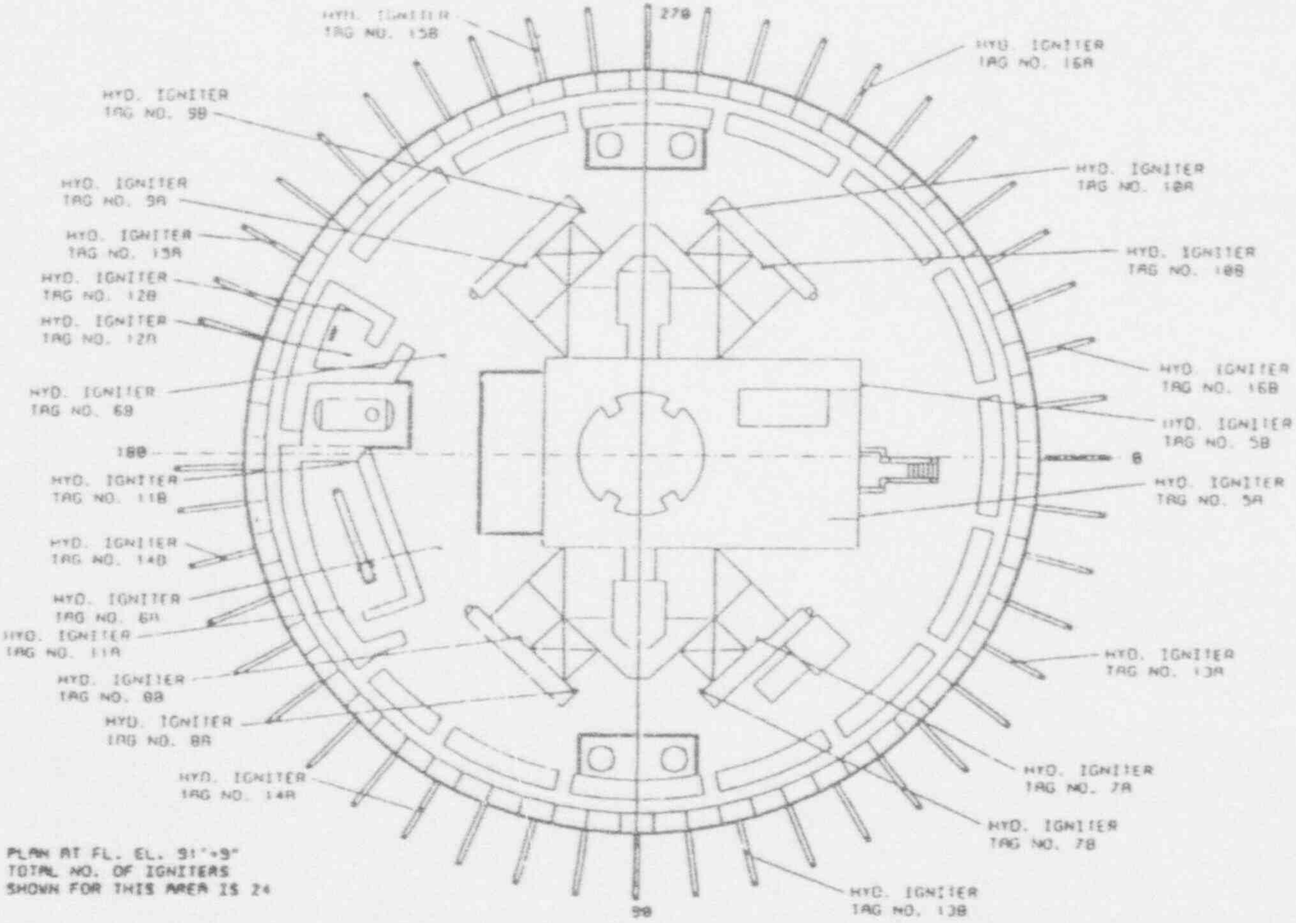
System 80+ Standard Plant Hydrogen Igniter Placement/Layout



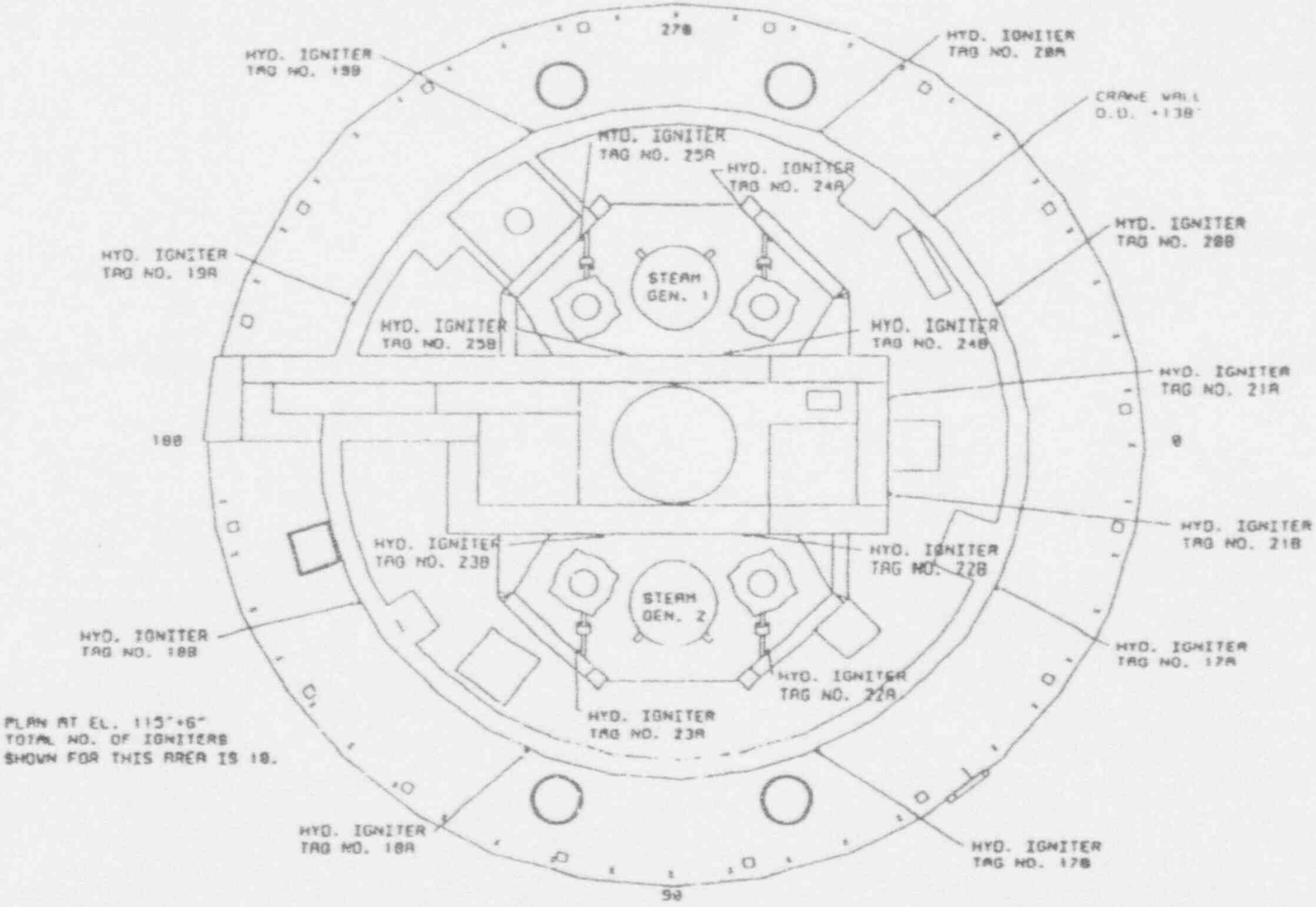
Plan View of Reactor Cavity and IRWST

System 80+ Standard Plant
Hydrogen Igniter Placement/Layout



Plan View at El. 91'+9"

System 80+ Standard Plant
Hydrogen Igniter Placement/Layout



Plan View at El. 115'+6"

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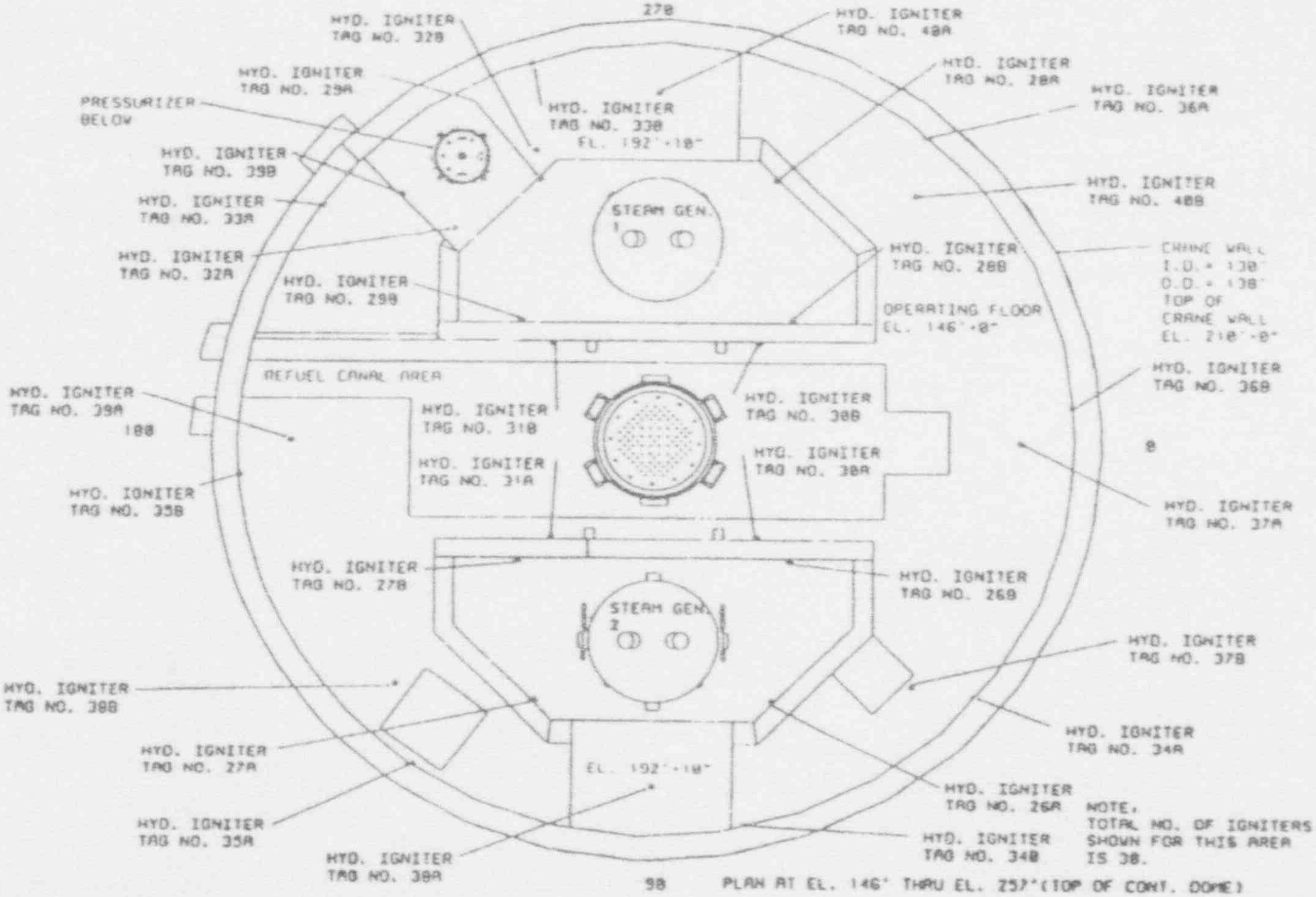
System 80+ Standard Plant
Hydrogen Igniter Placement/Layout

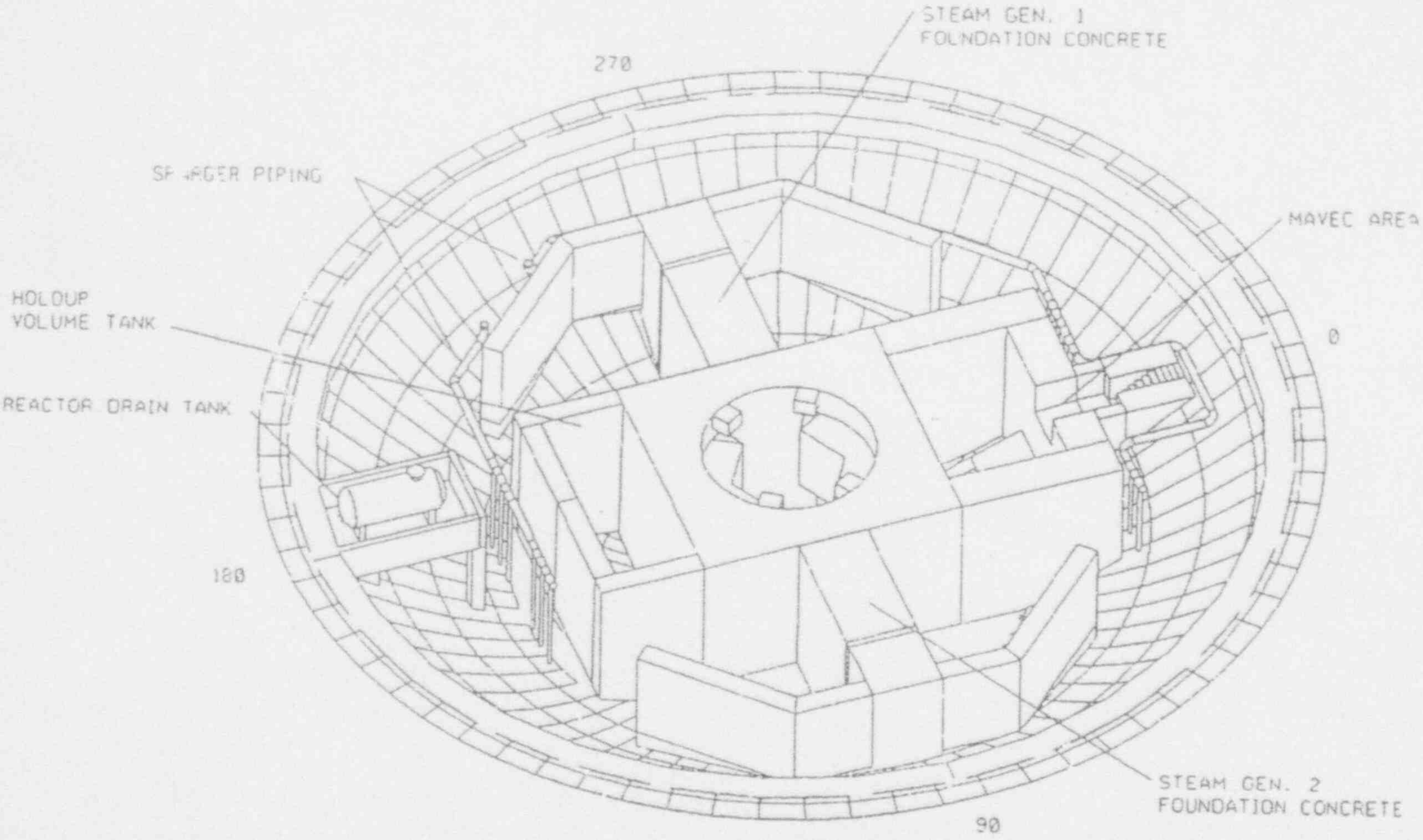


NOTE,
TOTAL NO. OF IGNITERS
SHOWN FOR THIS AREA
IS 38.

PLAN AT EL. 146' THRU EL. 257' (TOP OF CONT. DOME)

Plan View El. 257' through 146'

System 80+ Standard Plant
Three Dimensional Plant Layout



VIEW OF IRWST AREA
"LID" AT FL. EL. 91'+9"
HAS BEEN REMOVED FOR CLARITY

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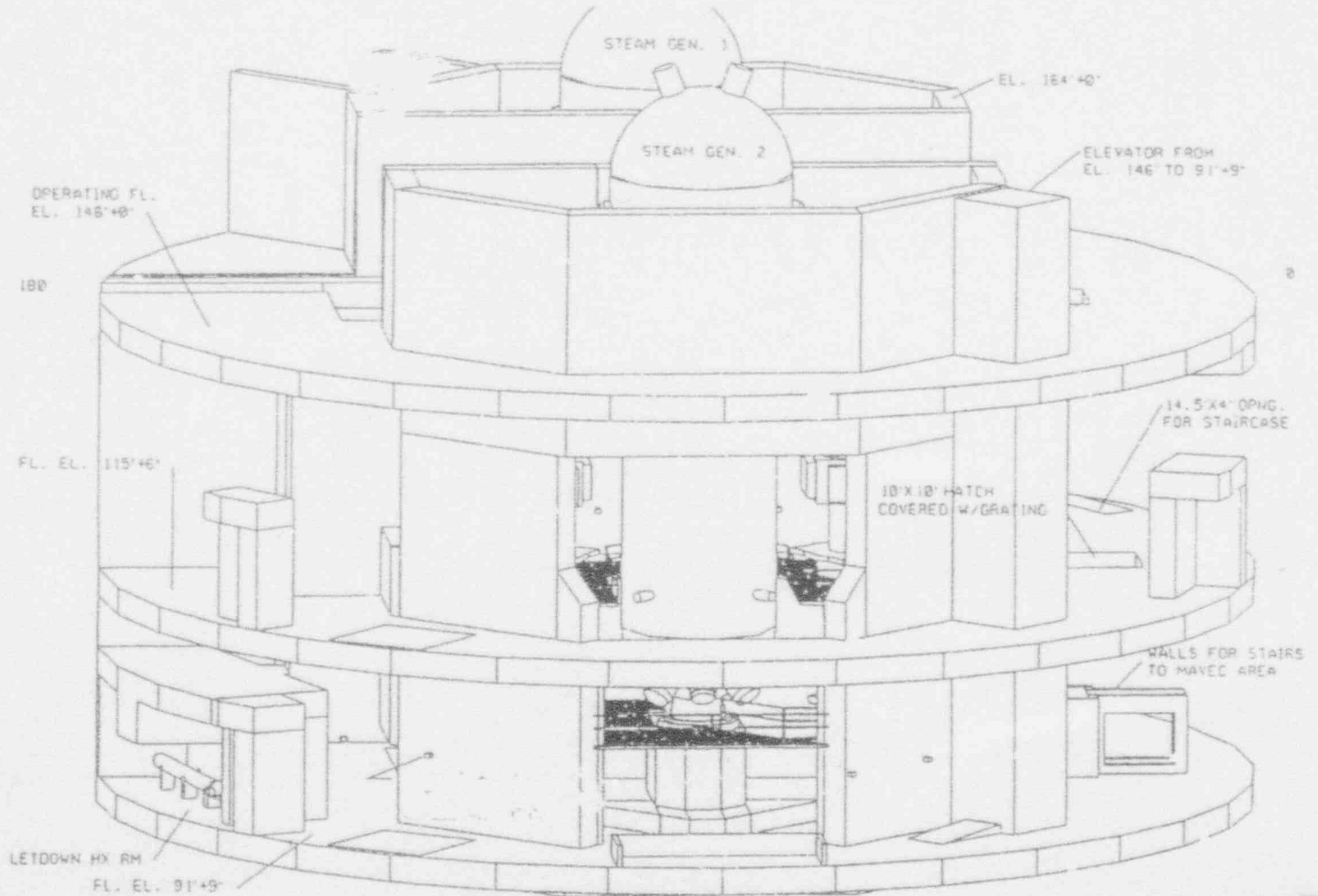
System 80+ Standard Plant
Three Dimensional Plant Layout



VIEW LOOKING NORTH (TOWARDS 270 DEG)
BETWEEN EL. 91'+9" AND 165'+0"
CRANE WALL HAS BEEN REMOVED FOR CLARITY

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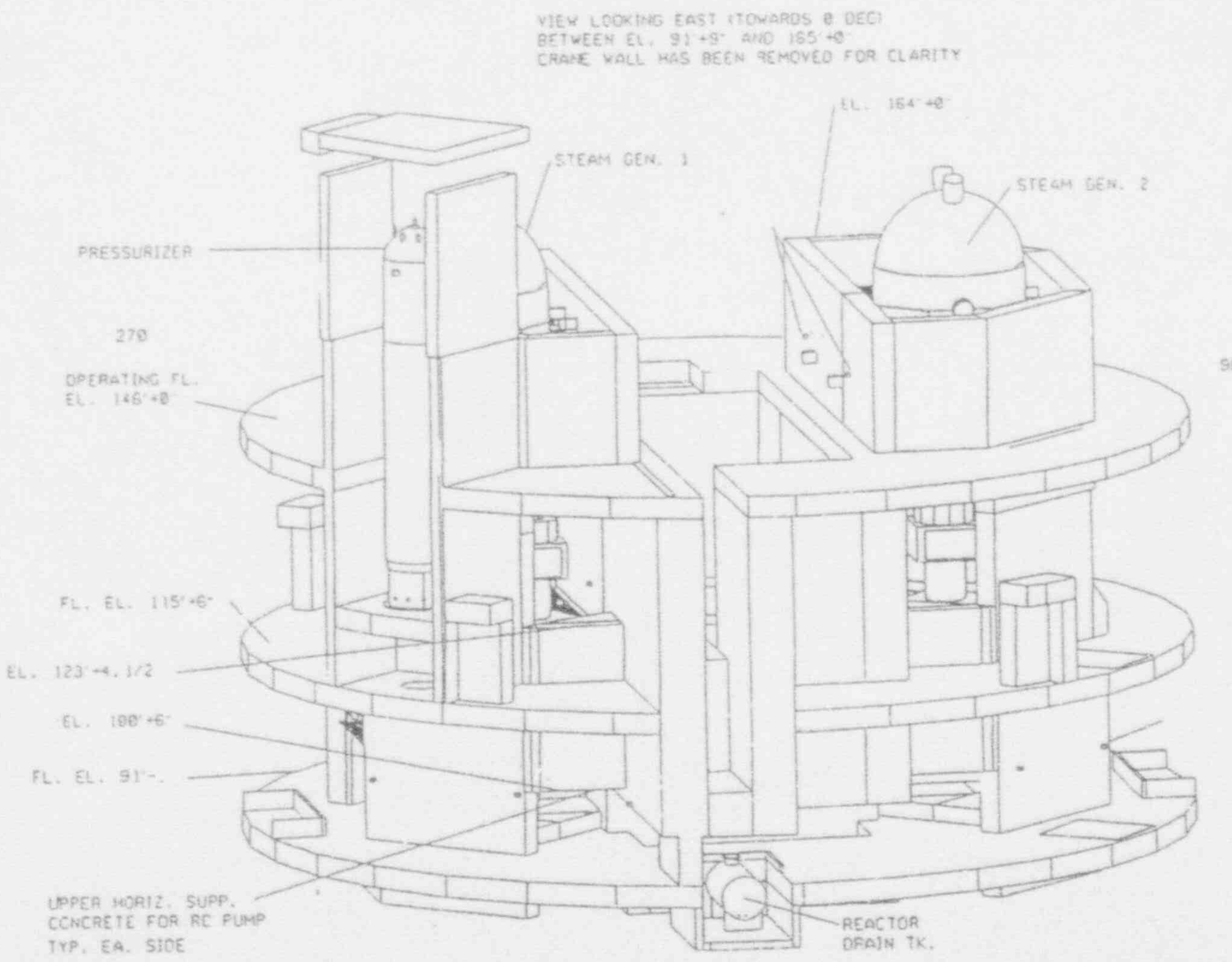
System 80+ Standard Plant
Three Dimensional Plant Layout



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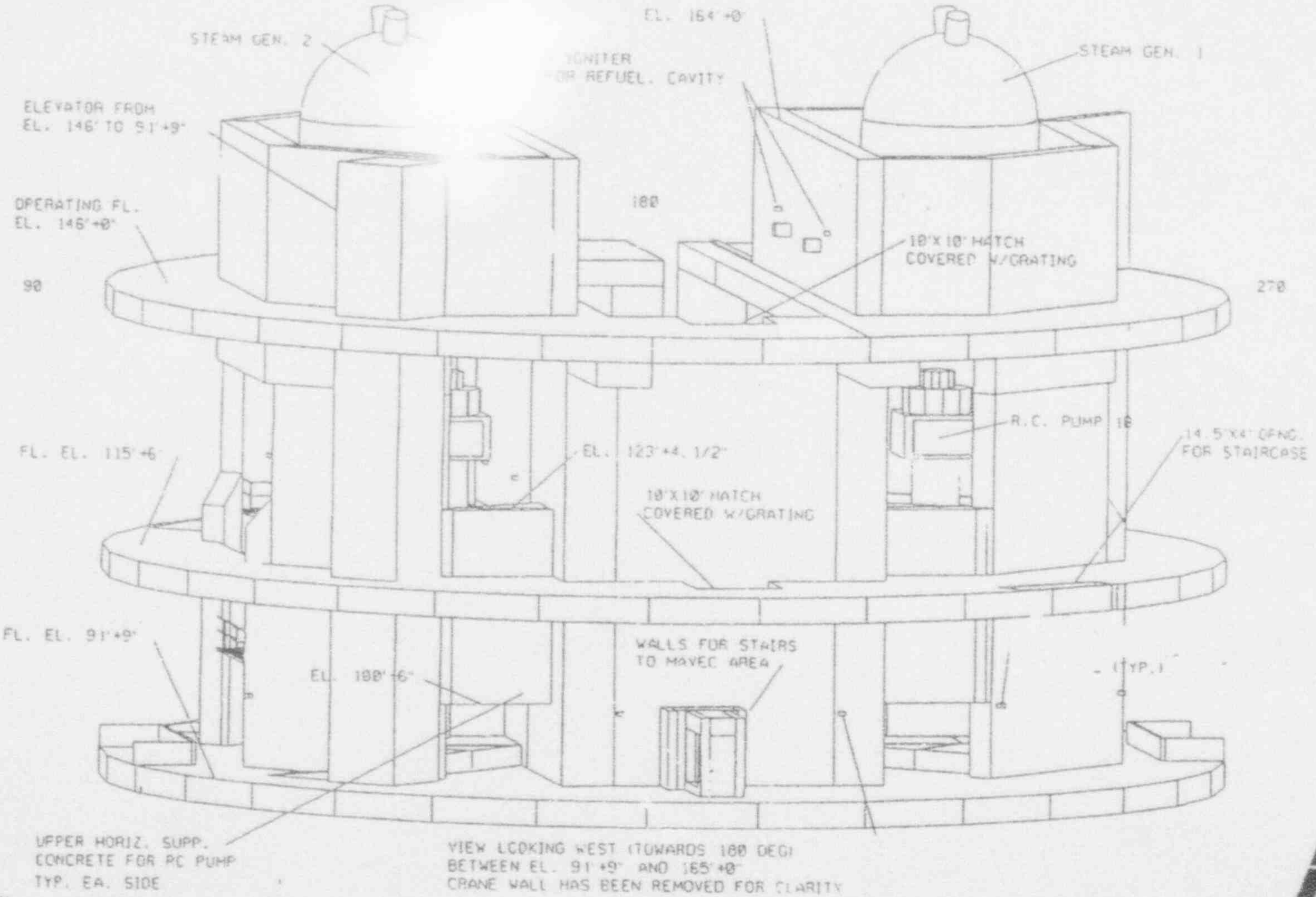
System 80+ Standard Plant
Three Dimensional Plant Layout



VIEW LOOKING WEST (TOWARDS 180 DEG)
BETWEEN EL. 91'+9" AND 165'+0"
CRANE WALL HAS BEEN REMOVED FOR CLARITY

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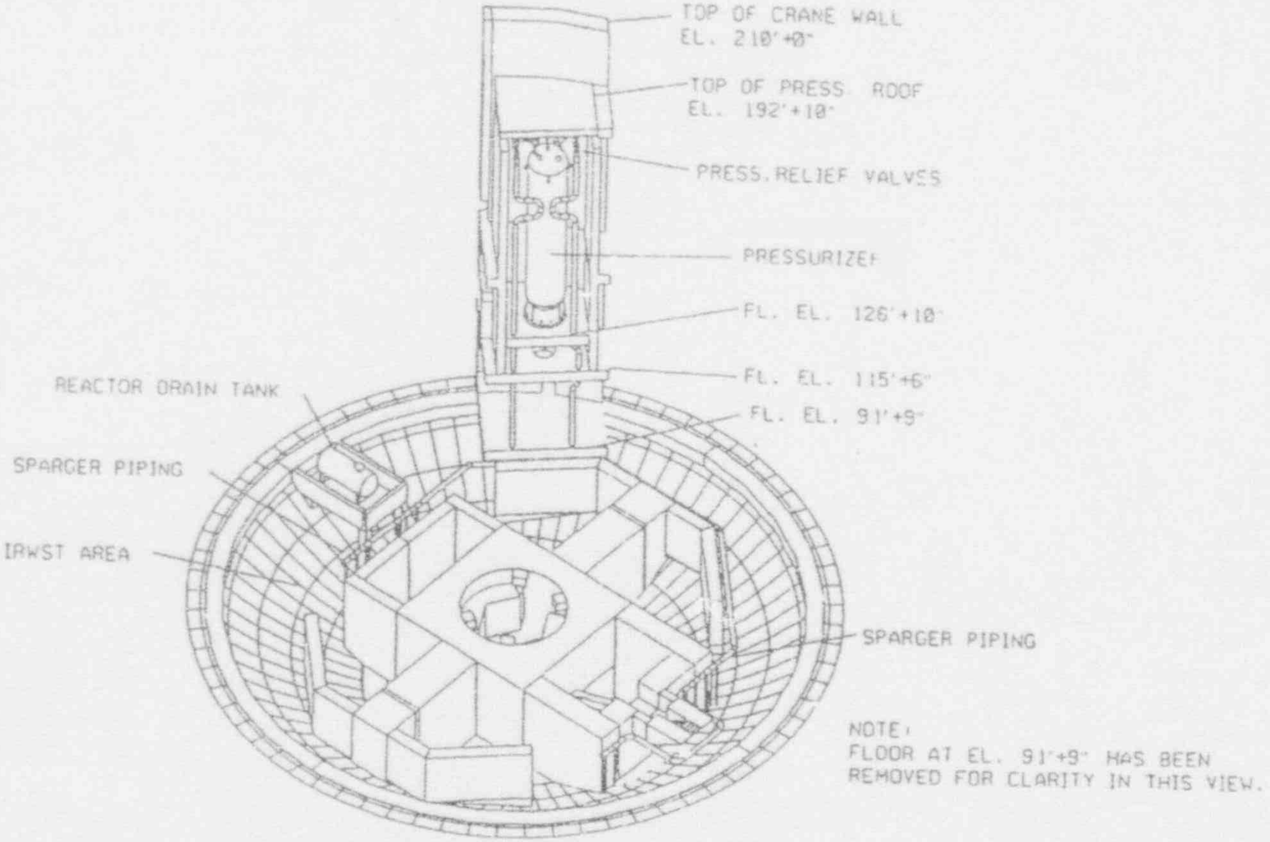
System 80+ Standard Plant
Three Dimensional Plant Layout



NOTE:
FLOOR AT EL. 91'+9" HAS BEEN
REMOVED FOR CLARITY IN THIS VIEW.

ISO VIEW OF IRWST AREA
AND PRESSURIZER AREA

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System 80+ Standard Plant
System 80+ Hydrogen Control

- Performance Results

  - HMS ignitors and IRWST pressure relief dampers control uniform global hydrogen concentration < 10 volume percent

  - In the event HMS does not function, the limiting hydrogen burn pressure will not exceed containment pressures associated with ASME Level "C" stress allowables

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System 80+ Standard Plant HMS Performance Analysis

- Objective:
  - Provide confirmatory asessment of igniter placement and develop insights on system performance.
- Methodology:
  - Develop detailed System 80+ containment model using MAAP-4 "generalized containment model"
  - Normalize model to eliminate "phantom" flows
- Insights
  - Igniters are successful in reducing containment wide hydrogen concentration

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System 80+ Standard Plant Calculation of Limiting Burn Pressure

- Objective:
  - Demonstrate that deflagrations resulting from the combustion of hydrogen equivalent to 100% oxidation of zircaloy will not threaten containment integrity

- Methodology
  - Calculate hydrogen pressure based on AICC assumptions
  - Full range of initial conditions considered including worst credible "non inerted" burn containment condition

- Conclusion
  - Post burn containment pressure will not exceed ASME Service Level "C" stress allowables. Therefore, containment failure due to hydrogen deflagration threat not credible

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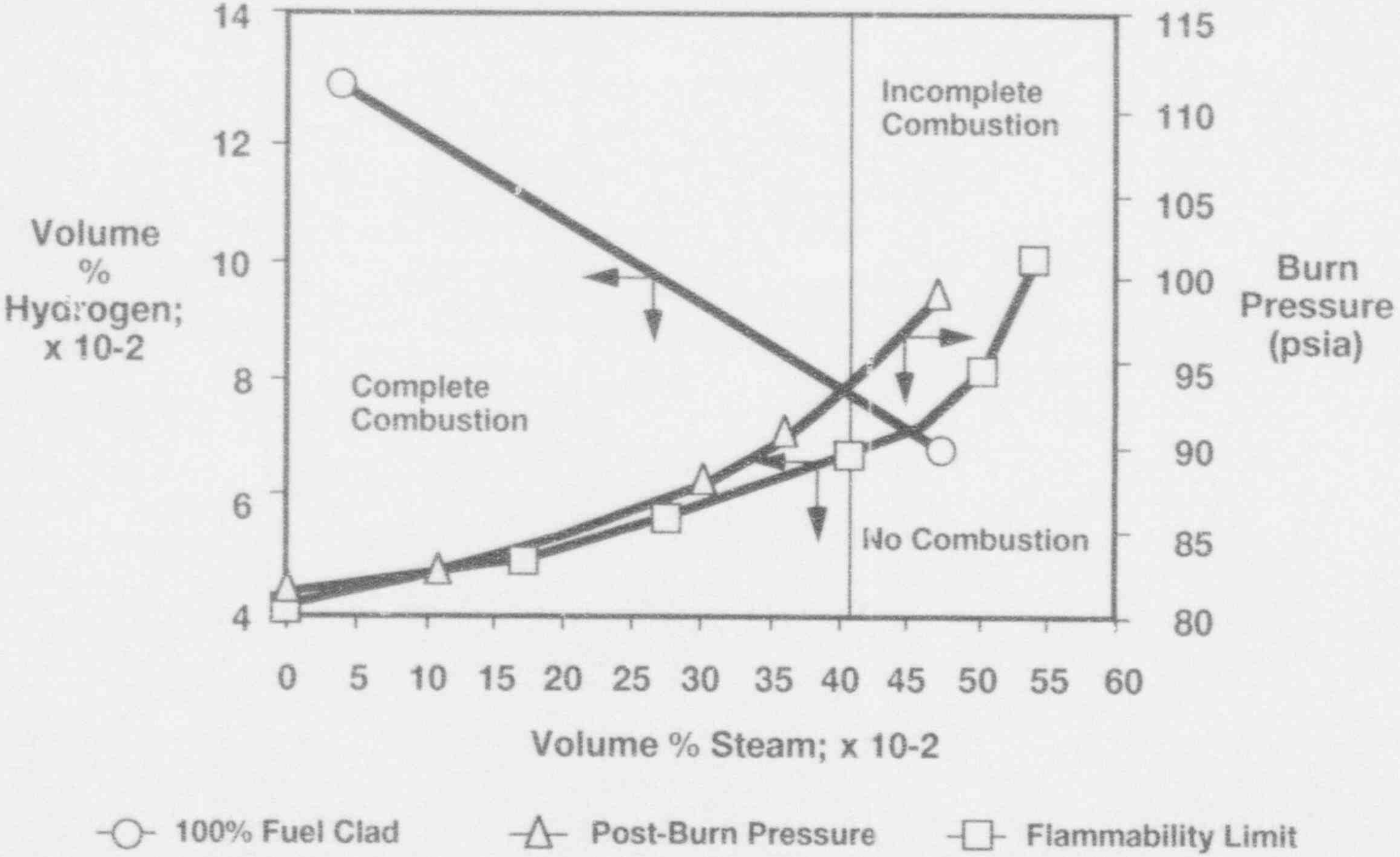
System 80+ Standard Plant
System 80+ Hydrogen Control



Containment pressure associated with AICC combustion of hydrogen produced following a hypothetical 100% oxidation of active fuel cladding
(Service Level C Pressure ~140 psia)

System 80+ Standard Plant Conclusions

- *Assessment of the post burn containment performance indicates that System 80+ design features successfully mitigate this potential severe accident threat*

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System 80+ Standard Plant
SEYC-93-087 Severe Accident Issues

- Hydrogen control
- Prevention of high-pressure core melt ejection (and direct containment heating)
- Mitigation of ex-vessel steam explosions
- Mitigation of core -concrete interactions
- Containment performance (overpressure failure)
- Instrumentation and equipment survivability

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System 80+ Standard Plant

Prevention of Direct Containment Heating/High Pressure Melt Ejection

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System 80+ Standard Plant Prevention of Direct Containment Heating

Purpose:

- Comply with ALWR Utility Requirements Document (URD) guidance to minimize potential for events leading to a high pressure melt ejection and minimize potential for direct containment heating

- Comply with specific guidance of SECY-93-087and URD:
  - Provide a reliable depressurization system
  - Provide cavity design features to decrease the amount of ejected core debris that reaches the upper containment

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System 80+ Standard Plant
High Pressure Core Melt Ejection (HPME)

Relevant Design Features for HPME Prevention / Mitigation

- Rapid Depressurization System (manually operated from the Control Room) allows for depressurization of RCS prior to vessel breach

- Reactor cavity design with a large convoluted reactor cavity vent and a core debris accumulation chamber

- Cavity Flood System

- Large containment volume

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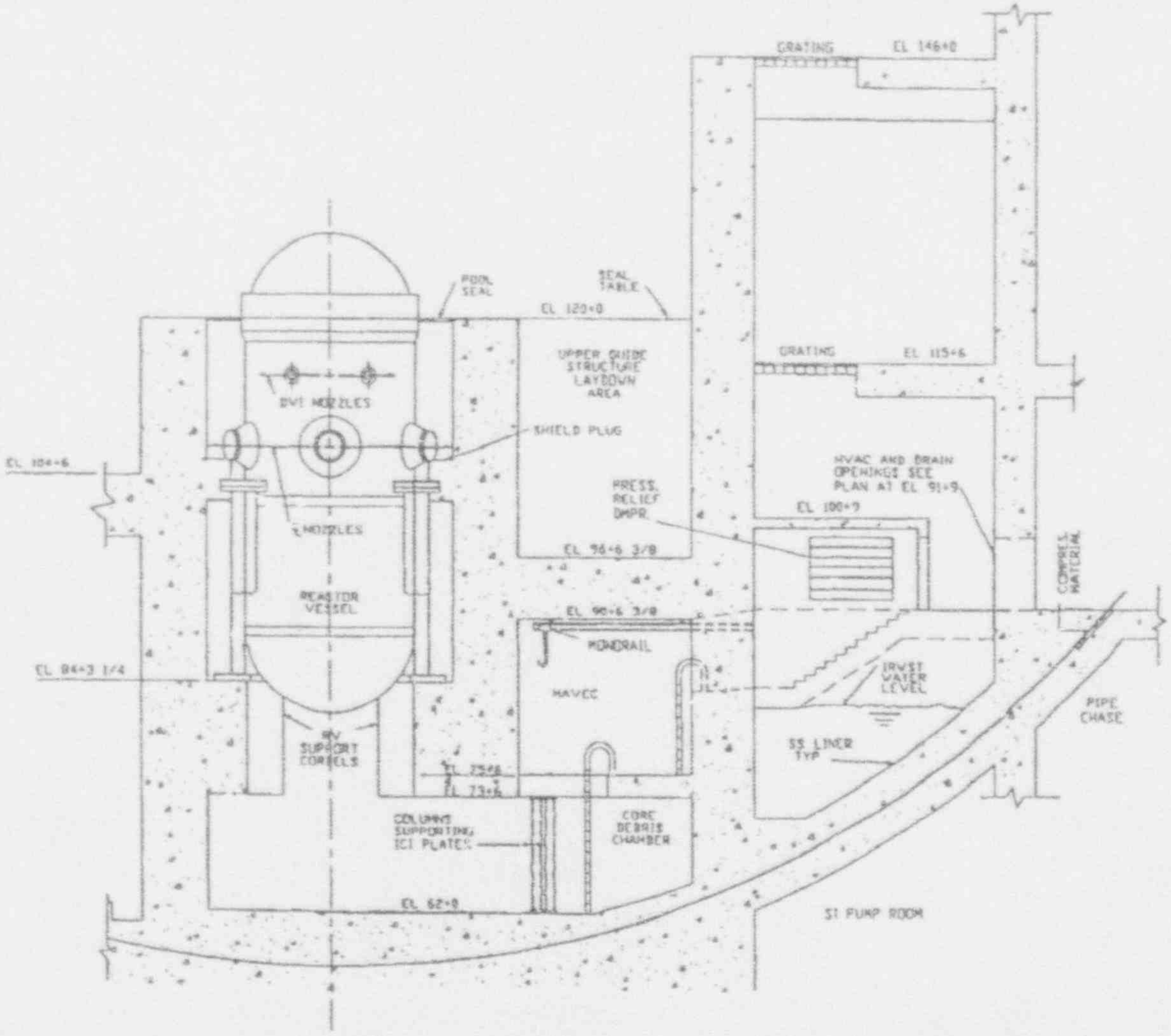
System 80+ Standard Plant
Reactor Cavity Design



Elevation View of Reactor Cavity

System 80+ Standard Plant DCH Deterministic Analyses

- Purpose: provide bounding estimates of containment pressure rise due to DCH.

- Methodology:
  - Single and two cell DCH models (similar to Pilch) employed
  - Analyses performed do not credit RDS and only marginally credit cavity debris retention characteristics of the design.

- Assumptions:
  (1) Pre-VB RCS pressure 2500 psia
  (2) 60% instantaneous corium mass ejection from the RCS
  (3) 50% dispersal into upper containment

- Result: Peak containment pressures produce shell stresses below ASME Service Level "C" allowables

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System 80+ Standard Plant Conclusion

- *As a consequence of System 80+ design features, the associated containment threat caused by high pressure melt ejection poses a negligible contribution to plant risk*

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System 80+ Standard Plant
SECY-93-087 Severe Accident Issues

- Hydrogen control
- Prevention of high-pressure core melt ejection (and direct containment heating)
- Mitigation of ex-vessel steam explosions
- Mitigation of core-concrete interactions
- Containment performance (overpressure failure)
- Instrumentation and equipment survivability

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System 80+ Standard Plant
Mitigation of Ex-Vessel Steam Explosions

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System 80+ Standard Plant
Mitigation of Ex-Vessel Steam Explosion

- Purpose
  - Comply with SECY-93-087 goal to minimize early containment failures
  - Address NUREG-1150 Containment Performance observation that Ex-Vessel Steam Explosions (EVSE) can fail the RV supporting structure and potentially induce a containment failure via failure of penetrations

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System 80+ Standard Plant
Mitigation of Ex-Vessel Steam Explosion

- Design Features
  - Robust upper cavity and corbel structural design
  - The System 80+ RV can be supported without the presence of the lower cavity wall
  - RV corbels (which support the RV) are reinforced to withstand high dynamic EVSE loadings

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System 80+ Standard Plant
Deterministic Assessment of EVSE

- Purpose: Quantify potential EVSE loadings on the reactor cavity walls following ejection of corium into a water filled reactor cavity

- Methodology:
  - Magnitude of EVSE based on TNT equivalent impulse
    - Mass of corium
    - Superheat
    - Efficiency of energy conversion process (ε≅0.015 to 0.03)

  - Structural dynamic analysis of lower cavity and corbels

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System 80+ Standard Plant
Deterministic Assessment of EVSE

- Results
  - EVSE Loads will not fail cavity walls provided Corium mass involved in a single explosion < 10,000 lbm
  - Structural analyses demonstrate that sufficient vertical shear would be available in connecting rebar to support the RV even if the lower reactor cavity wall is eliminated
  - Reinforcing the RV corbels ensures survival of lower supports from direct impact loadings

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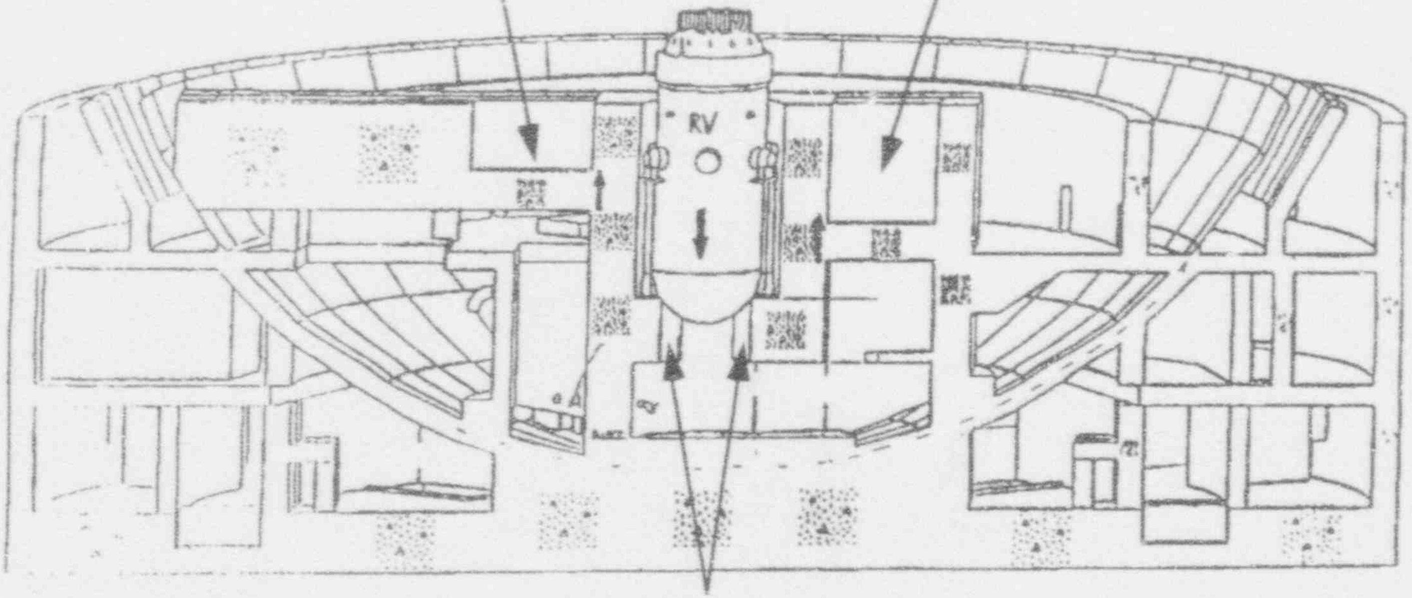
System 80+: Mitigation of Ex-Vessel Steam Explosions

Deterministic Assessment



Core support barrel laydown area

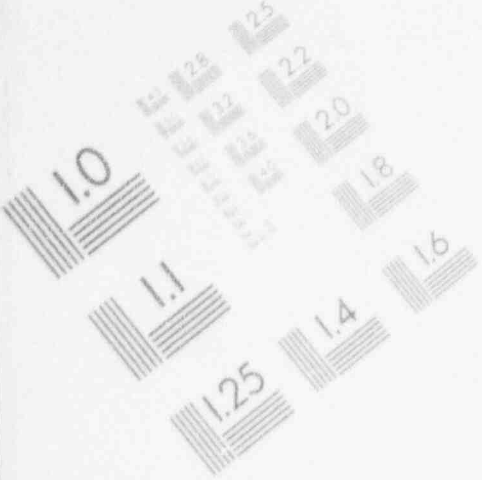
UGS Laydown Area

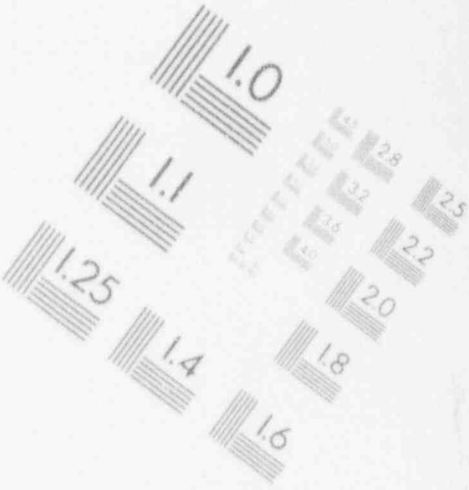
Corbel

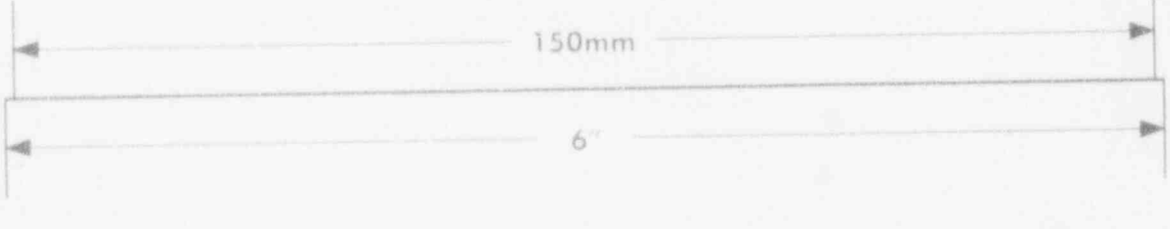
Load paths for RV support following loss of lower reactor cavity walls

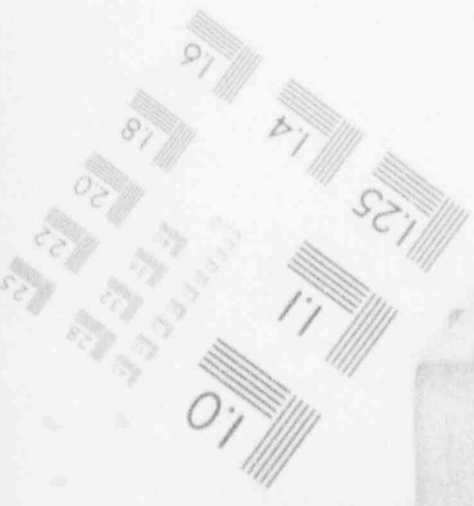
1

IMAGE EVALUATION TEST TARGET (MT-3)









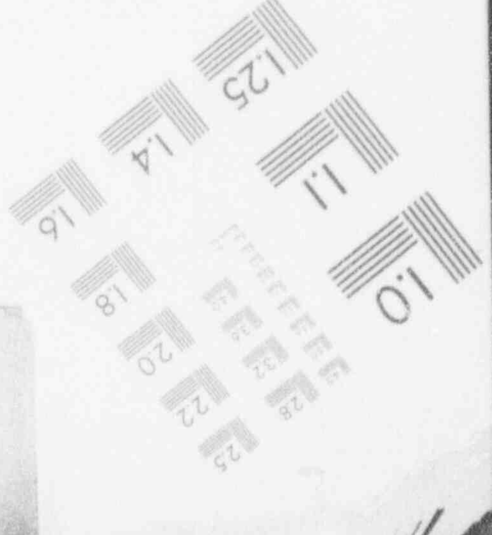


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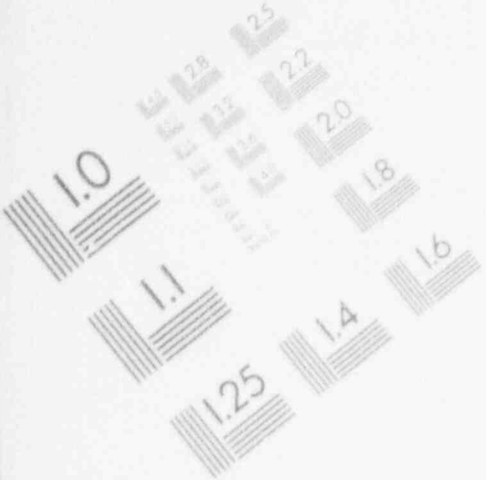
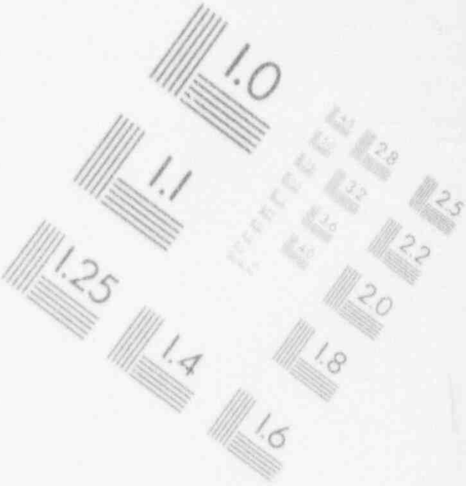
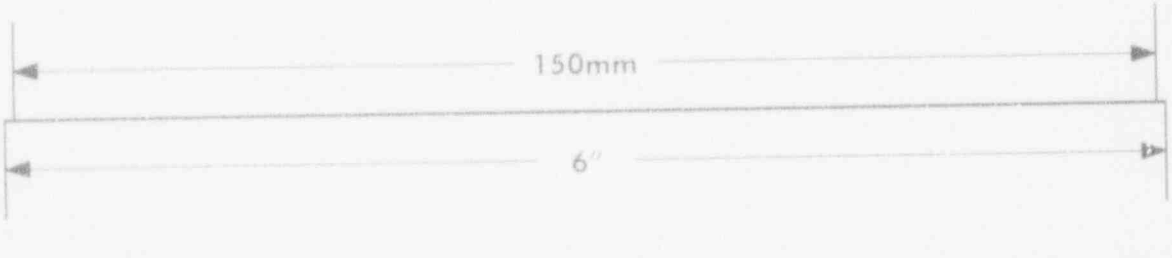
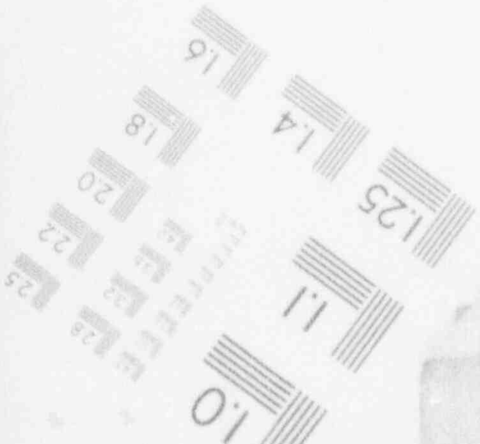
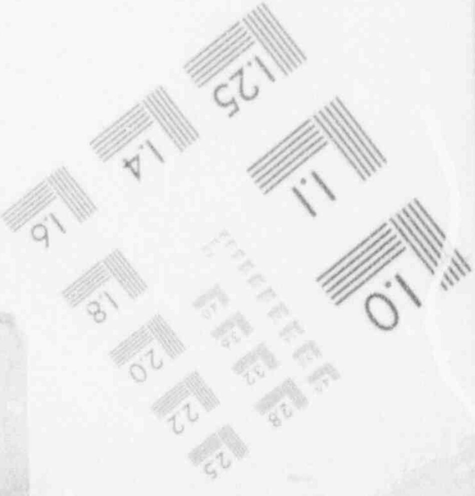
IMAGE EVALUATION
TEST TARGET (MT-3)











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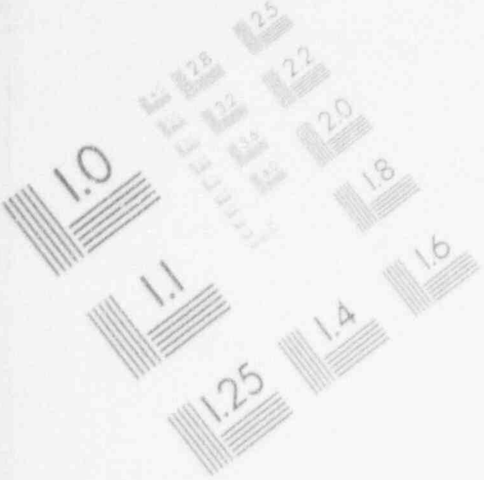

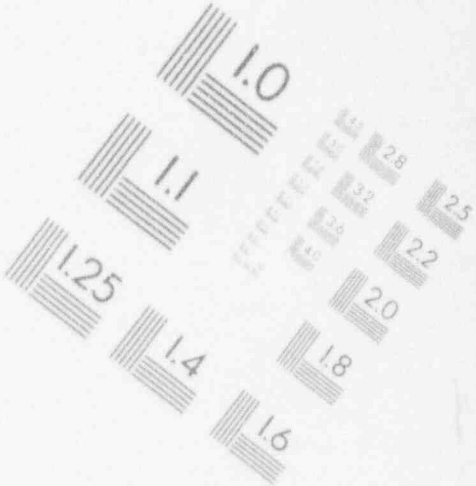

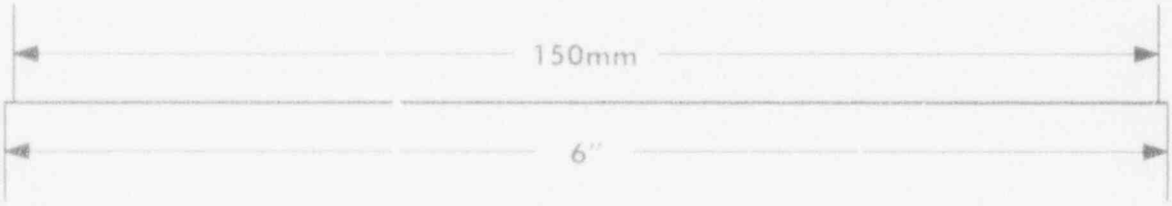

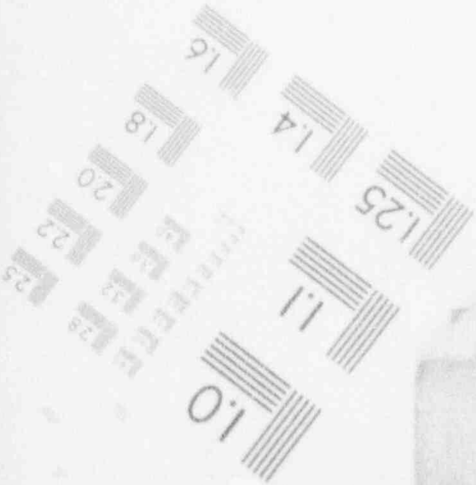

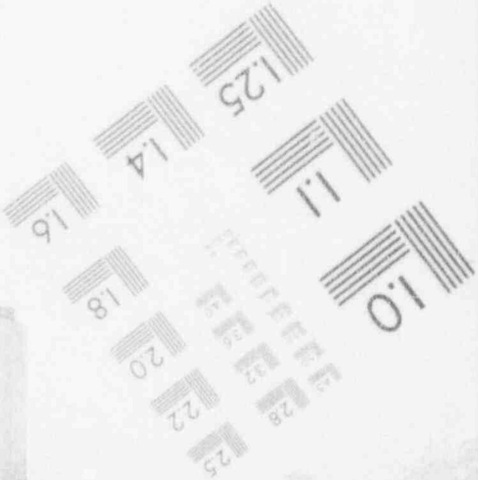

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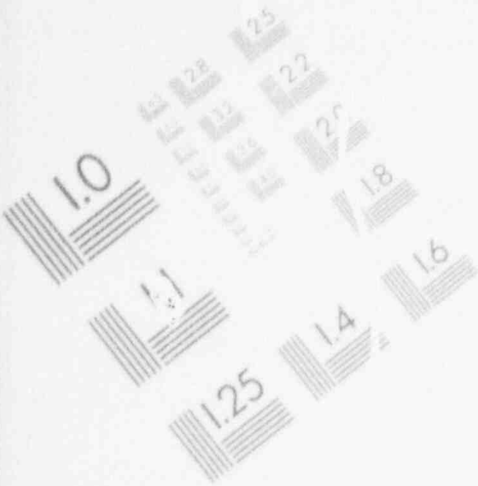
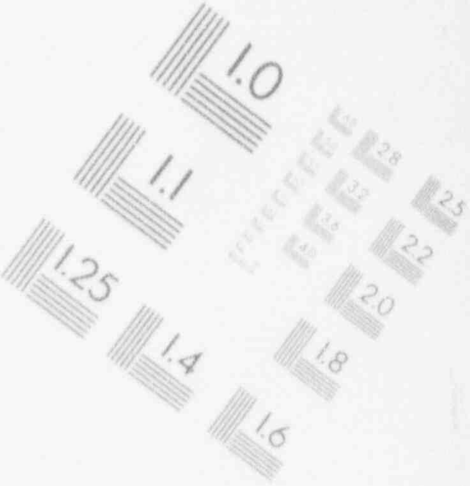
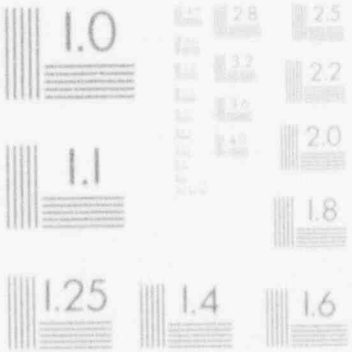
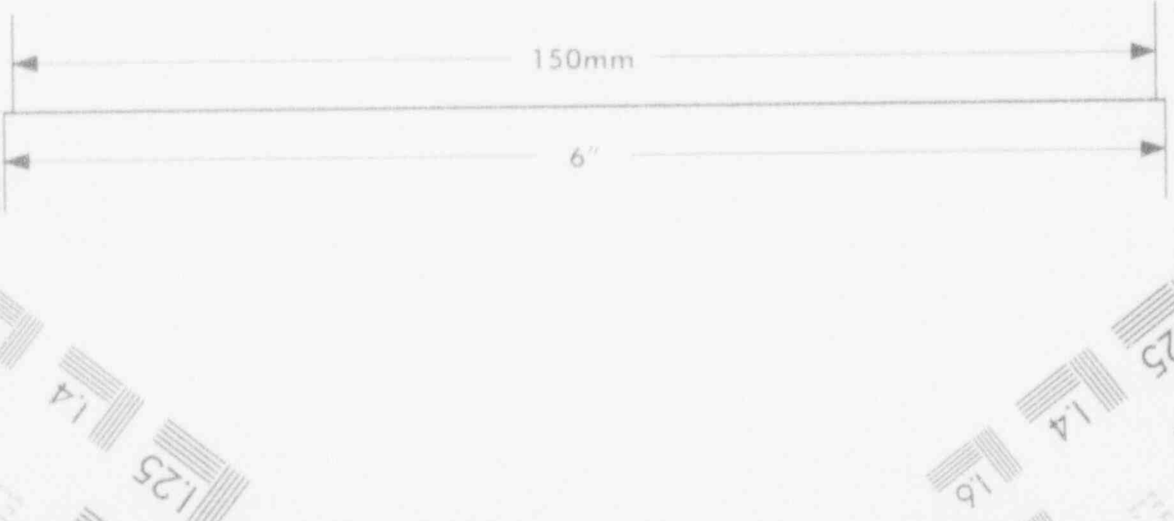
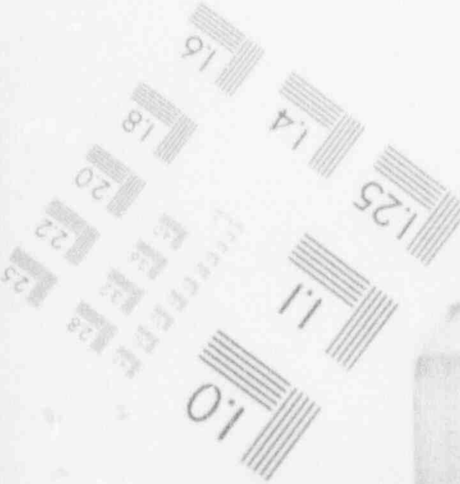
IMAGE EVALUATION
TEST TARGET (MT-3)

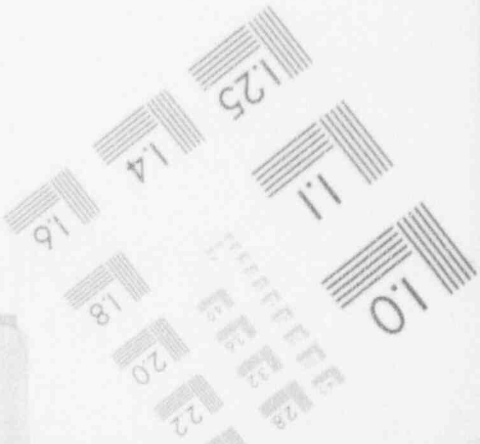












System 80+ Standard Plant
Deterministic Assessment of EVSE

- Other considerations (not credited in deterministic assessment)
  - Additional support to the RV can be provided by the 2 hot legs and 4 cold leg pipes
  - SG keys prevent significant rotation of SG therefore loss of support of RV will not result in a significant dislocation of piping connected to RCS or the SG
  - RCS displacements are more likely to fail piping within the containment then at the containment penetrations.

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System 80+ Standard Plant Deterministic Assessment of ESVE

- *Conclusions*

  - *Ex-Vessel steam explosions in the System 80+ reactor cavity will not compromise RV support and consequently do not pose a significant risk of containment failure*

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System 80+ Standard Plant SECY-93-087 Severe Accident Issues

- Hydrogen control
- Prevention of high-pressure core melt ejection (and direct containment heating)
- Mitigation of ex-vessel steam explosions
- Mitigation of core-concrete interactions
- Containment performance (overpressure failure)
- Instrumentation and equipment survivability

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System 80+ Standard Plant
Mitigation of Core Concrete Interactions

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System 80+ Standard Plant
Mitigation of Core Concrete Interactions

- Purpose:
  - Provide coolability of corium debris retained in the reactor cavity
  - Protect containment pressure boundary
  - Applicable guidance SECY-93-087 and ALWR URD:
    - Provide a means to flood the reactor cavity
    - Protect steel shell with concrete
    - Large floor area for corium spreading
    - One day minimum containment integrity goal

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System 80+ Standard Plant
Reactor Cavity and Basemat Design Features

- Design Features
  - Large cavity floor area (limits average corium debris depth to approximately 10 inches)
  - Cavity Flooding System capable of flooding the reactor cavity to a depth of approximately 11 feet. Water pool is expected to fragment, cool, and scrub debris
  - Cavity floor constructed with a minimum of 3 feet of limestone based concrete to resist erosion and protect containment shell
  - Robust upper cavity design can support RV following complete erosion of lower pedestal
  - Additional 15 feet of concrete below steel shell as a barrier to release of radiation to the soil

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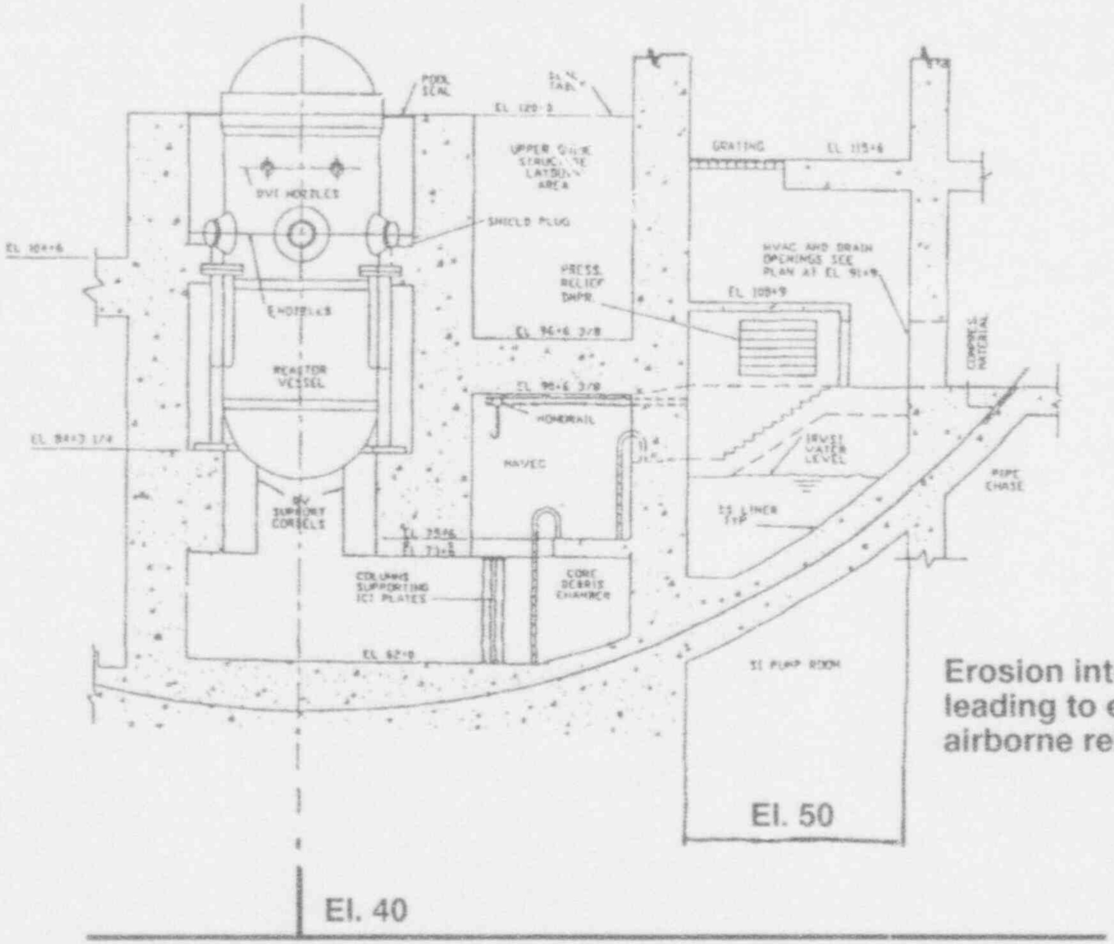
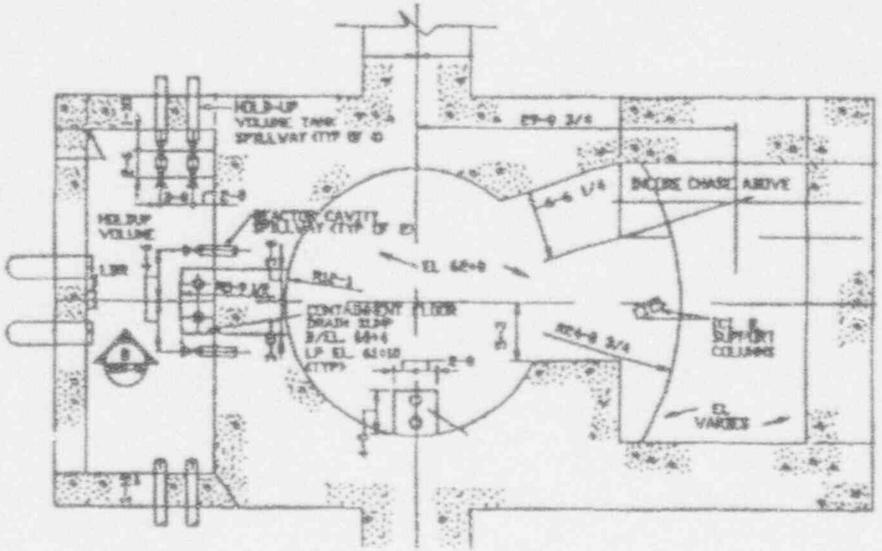
System 80+ Standard Plant Containment Basemat

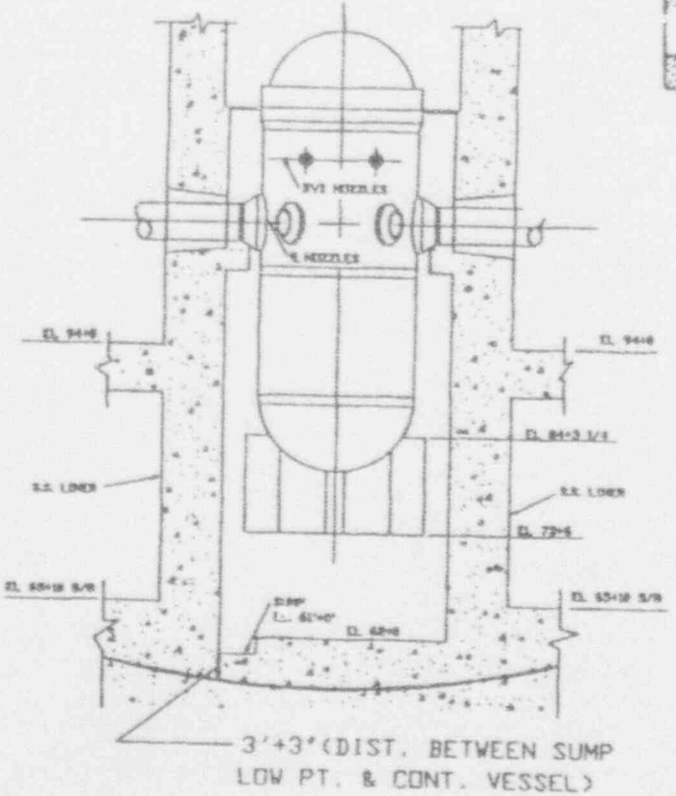


Erosion into subsphere leading to energetic airborne release

System 80+ Standard Plant Reactor Cavity Layout

Plan Approx. Elevation 70+0





Section from 90° to 270°

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System 80+ Standard Plant Deterministic Assessment of CCI

- Goal (SECY-93-087)
  - Demonstrate that with minimum debris coolability, cavity floor erosion will not reach the embedded containment shell for about 24 hours

- Imposed Analytical Restrictions
  - Initial attack of lower shell implies containment failure
  - Only concrete above steel shell credited
  - No credit for debris fragmentation. Debris morphology not favorable to heat transfer

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System 80+ Standard Plant Deterministic Assessment of CCI

- Methodology for calculation of the erosion of cavity floor
  - Tool selected for deterministic assessment was CORCON-MOD3
    - Code verified against CCI experiments
    - Capable of "realistically" considering limiting case of a layered morphology
    - Analyses considered flat cavity floor and sump regions

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System 80+ Standard Plant Deterministic Assessment of CCI

- Analytical assumptions
  - Vessel Breach (VB) occurs at 3 hours following reactor trip
  - 100% of core inventory corium deposited on the cavity floor
  - Decay energy credits prior release of volatile fission products
  - 75% of zirconium oxidized prior to concrete contact

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System 80+ Standard Plant
Deterministic Assessment of CCI

Results of Coron - MOD3 Calculations

	Time of erosion to steel shell
Cavity Flat Area	30 hrs
Sump*	24 hrs

* Erosion to 3.2 FT

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System 80+ Standard Plant Deterministic Assessment of CCI

- Conclusions
  - Assessments of concrete erosion demonstrate the ability of the System 80+ design to provide 24 hours of containment integrity.

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System 80+ Standard Plant
SECY-93-087 Severe Accident Issues

- Hydrogen control
- Prevention of high-pressure core melt ejection (and direct containment heating)
- Mitigation of ex-vessel steam explosions
- Mitigation of core-concrete interactions
- Containment performance (overpressure failure)
- Instrumentation and equipment survivability

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System 80+ Standard Plant
Containment Overpressure Failure

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System 80+ Standard Plant Containment Overpressure Failure

- Objective
  - Comply with SECY-93-087 goals:
    - Demonstrate high containment reliability
    - With sprays unavailable, demonstrate that the containment will maintain its role as a reliable, leak-tight barrier for approximately 24 hours under the more likely severe accident challenges

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System 80+ Standard Plant Containment Overpressure Failure

- Features
  - System 80+ includes a highly reliable containment heat removal system
    1. Redundant containment spray system with Class 1E backup pumps via the SCS
    2. Redundant power sources including offsite power, emergency diesels, and combustion turbine
  - Large containment volume for mitigating pressure rise

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System 80+ Standard Plant
Containment Overpressure Failure

- Alternate pressure control/cooling capabilities
  - Non-Class 1E fan coolers
  - External spray capability provides extended time for pressure control
  - Containment vent capability via purge lines

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System 80+ Standard Plant

Containment Overpressure Failure Deterministic Evaluation

Objective

- Show minimum time to containment failure of more than 24 hrs

Methodology

- Containment failure times computed using MAAP 3.0 B
- Spectrum of transients considered
- No spray operation credited
- Containment failure based on ASME Service level C stress allowables

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System 80+ Standard Plant

Containment Overpressure Failure Deterministic Evaluation

Results

- Containment failure times > 48 hours
- Limiting transients result from Large LOCA with actuation of Cavity Flooding System (CFS)

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System 80+ Standard Plant Probabilistic Aspects of Containment Failure

- PRA employed to demonstrate compliance with SECY-93-087 overall containment integrity goal
- Based on PRA the conditional containment failure probabilities (CCFPs) associated with core damage sequences were evaluated as follows:

Criteria	1-CCFP
Containment releases do not exceed DBA values for 24 hours	0.98
Containment precludes large fission product release	0.973
Containment leaktight indefinitely	0.886

- Consistent with SECY-93-087, the System 80+ containment has a high probability of maintaining containment integrity following a core damage event.

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System 80+ Standard Plant
Containment Overpressure Failure

- Conclusions
  - Containment meets the deterministic SECY-93-087 containment integrity goal for containment overpressure failures.
  - Probabilistic analyses indicate that System 80+ is robust to a spectrum of severe accidents and has a high probability of maintaining containment integrity following a severe core damage event. Resulting CCFPs are consistent with stated goals of SECY-93-087.

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System 80+ Standard Plant SECY-93-087 Severe Accident Issues

- Hydrogen control
- Prevention of high-pressure core melt ejection (and direct containment heating)
- Mitigation of ex-vessel steam explosions
- Mitigation of core-concrete interactions
- Containment performance (overpressure failure)
- Instrumentation and equipment survivability

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System 80+ Standard Plant
Instrumentation and Equipment Survivability

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System 80+ Standard Plant
Equipment Survivability

Purpose

- Comply with requirements of SECY-93-087 and 10CFR50.34(f)
    - Define instrumentation/equipment for achieving and maintaining safe shutdown and maintaining containment integrity
    - Demonstrate high confidence that the instrumentation/equipment will survive severe accident conditions for a period that is needed to perform its intended function
    - Consider effect of 100% oxidation of fuel cladding on equipment survivability

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System 80+ Standard Plant
Equipment Survivability

Methodology

- Review event progression for "in-vessel" recoverable and unrecoverable severe accident scenarios
- Define minimum equipment set for achieving and maintaining safe shutdown (vessel lower head intact)
- Define minimum equipment set for maintaining containment integrity
- Use analytical methods and experimental data to establish expected local and global severe accident environments
- Compare resulting severe accident environments with DBA EQ envelope and establish any supplementary guidance

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System 80+ Standard Plant instrumentation required for severe accident mitigation and prevention

INSTRUMENT	REQUIRED PRE-VESSEL BREACH	REQUIRED POST-VESSEL BREACH
UHJTC	✓	-
RCS PRESSURE OR PZR PRESSURE	✓	-
SI FLOW	✓	-
EFW FLOW	✓	-
SG WATER LEVEL	✓	-
IRWST WATER LEVEL	✓	✓
HYDROGEN MONITOR	✓	✓
RADIATION MONITOR	✓	✓
CONTAINMENT PRESSURE	✓	✓
CONTAINMENT TEMPERATURE	✓	✓
CS FLOW	✓	✓

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System 80+ Standard Plant equipment required for severe accident mitigation and prevention

EQUIPMENT	PRE-VESSEL BREACH	POST-VESSEL BREACH
SAFETY INJECTION SYSTEM	√	-
EMERGENCY FEEDWATER SYSTEM	√	-
CONTAINMENT ISOLATION SYSTEM	√[1]	-
RAPID DEPRESSURIZATION SYSTEM	√[1]	-
CAVITY FLOODING SYSTEM	√[1]	-
HYDROGEN MITIGATION SYSTEM	√	√
CONTAINMENT PENETRATION INTEGRITY	√	√
CONTAINMENT SPRAY SYSTEM	√	√
SHUTDOWN COOLING SYSTEM	√	√

1-ACTUATED AND PERFORMS FUNCTION PRIOR TO VB

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System 80+ Standard Plant
Definition of Severe Accident Environment

- Local vs global effects
  - Local effects
    - Driven by combustion processes
    - Near igniters
    - Near hydrogen sources
  - Global effects
    - Driven by convective processes
    - Governs bulk of containment

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System 80+ Standard Plant

Equipment Survivability Severe Accident Environment

- Consideration regarding local environmental conditions
  - Reduce effect of local environments on instrumentation / equipment
  - Rely primarily on equipment and instruments with transmitters / sensors and cables located away from potential hydrogen sources
  - Based on HCOG data all required instruments are located a minimum of 10 feet from igniters to reduce influence of local igniter burn environments
  - Instruments to be shielded from thermal radiation from active igniters
  - For post-VB sequences the bulk of equipment relied upon for accident mitigation located outside of containment

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System 80+ Standard Plant

Equipment Survivability Severe Accident Environment

- Global Environments
  - Uniform temperatures expected away from igniters and other sources of burning
  - For "In-Containment" instrumentation/equipment, global environments primarily established using MAAP 3.0B
  - Verified uniform modeling using generalized containment model

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System 80+ Standard Plant DCH Deterministic Analyses

- Purpose: provide bounding estimates of containment pressure rise due to DCH.

- Methodology:
  - Single and two cell DCH models (similar to Pilch) employed
  - Analyses performed do not credit RDS and only marginally credit cavity debris retention characteristics of the design.

- Assumptions:
  (1) Pre-VB RCS pressure 2500 psia
  (2) 60% instantaneous corium mass ejection from the RCS
  (3) 50% dispersal into upper containment

- Result: Peak containment pressures produce shell stresses below ASME Service Level C allowables

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System 80+ Standard Plant

Equipment Survivability Severe Accident Environment

- Results of Assessment of Thermal Environment
  - Equipment / instruments required for achieving and maintaining a safe shutdown have a high confidence of surviving a recovable severe accident.

Thermodynamic Parameter	Bounding Severe Accident Environment		DB EQ
	< 24 hours	At containment failure	
Temperature (F)	<330	<350	~330
Pressure (psia)	<90	<140	<90

- Equipment with sensors, transmitters and cables located outside of containment have a high confidence of surviving any severe accident

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System 80+ Standard Plant
Distribution of required sensors/cables

instrumentation	req'd post-vb	location		
		inside crane wall	ouside crane wall	subsphere
UHJTC	no	√		
RCS OR PZR Pressure Sensor	no		√	
SG Water Level	no		√	
Radiation Monitor	yes		√	√*
Containment Pressure Sensor	yes			√
Containment Temperature Sensor	yes		√	
Containment Spray Flow	yes			√
Safety Injection Flow	no			√
Emergency Feedwater Flow	no			√
IRWST Water Level	no			√
Hydrogen Monitor	yes			√

* PASS

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System 80+ Standard Plant
Distribution of required sensors/cables

instrumentation	req'd post-vb	location		
		inside crane wall	ouside crane wall	subsphere
safety injection system	no			✓
emergency feedwater system	no			✓
containment isolation system	no		✓[1]	✓
rapid depressurization system	no	✓[1]		
cavity flooding system	no	✓[1]		
hydrogen mitigation system	yes	✓[2]	✓[2]	
containment penetrations	yes		✓[3]	✓[3]
containment spray system	yes		✓[4]	✓
shutdown cooling system	yes			✓

1: actuated and completes function prior to harsh environment ; 2: designed to survive local continuous hydrogen burn

3: penetration designed to withstand severe environment ; 4: spray piping/nozzles only

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System 80+ Standard Plant

Equipment Survivability Severe Accident Environment

- Results of assessment of thermal environment
  - Equipment/instruments required for achieving and maintaining a safe shutdown have a high confidence of surviving a recoverable severe accident
  - Equipment with sensors, transmitters and cables located outside of containment have a high confidence of survivng any severe accident

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System 80+ Standard Plant Equipment Survivability

Conclusions

- System 80+ instrumentation necessary for achieving and maintaining a safe shutdown condition and maintaining containment integrity will survive exposure to a spectrum of severe accidents for sufficient period to perform its intended function

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System 80+^{TM} Standard Plant
Meeting Technical Support

ABB-CE

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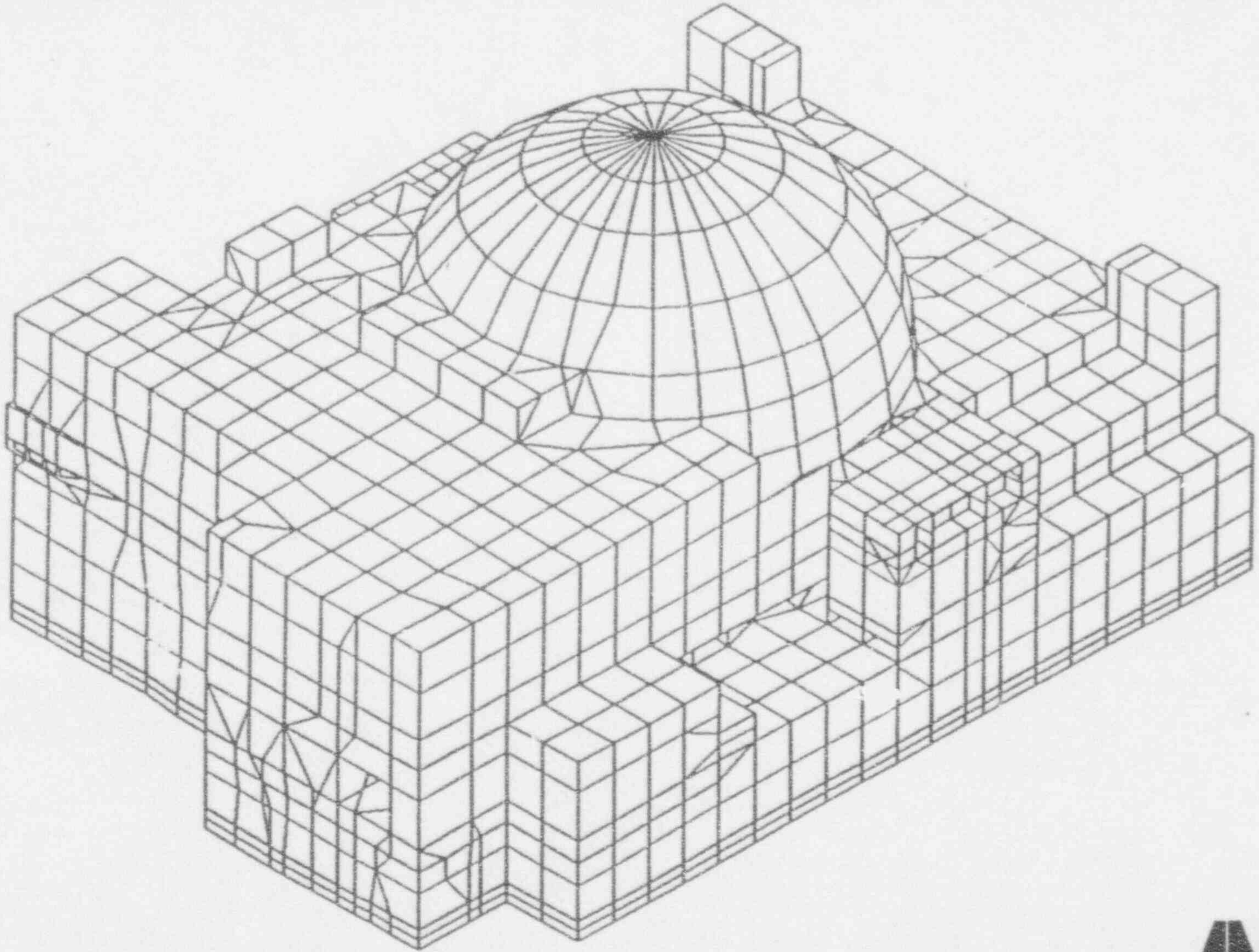
System 80+ Standard Plant Nuclear Island Finite Element Model



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System 80+ Standard Plant Structures

Detailed Design

- Nuclear Island
  - Thirteen structural areas identified for detailed design
  - All shear walls evaluated

- Non-Nuclear Island
  - Diesel fuel storage structure
  - Component cooling water heat exchanger structure and tunnel

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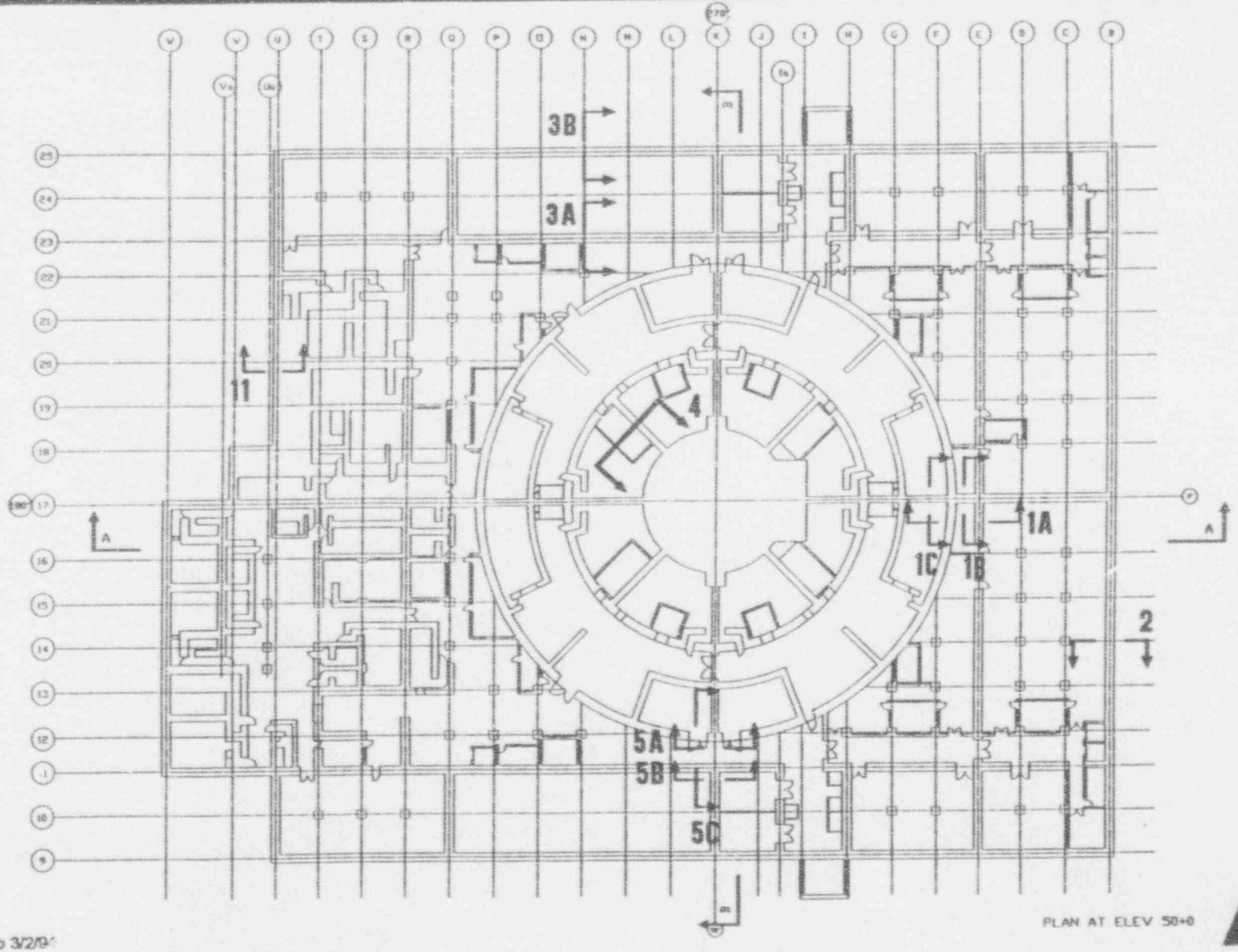
System 80+ Standard Plant
Nuclear Island - Detailed Design Areas



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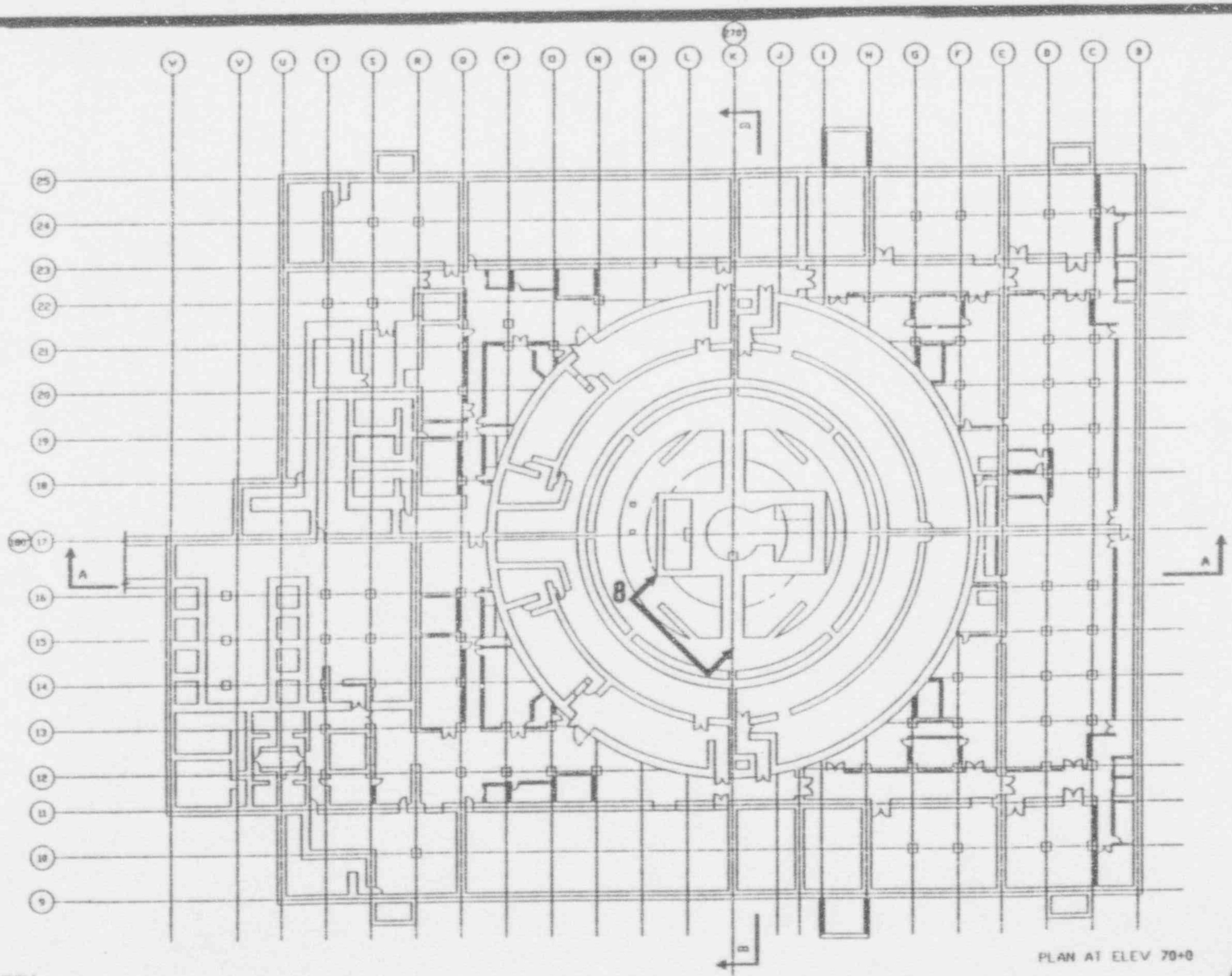
System 80+ Standard Plant
Nuclear Island - Detailed Design Areas



PLAN AT ELEV 70+0

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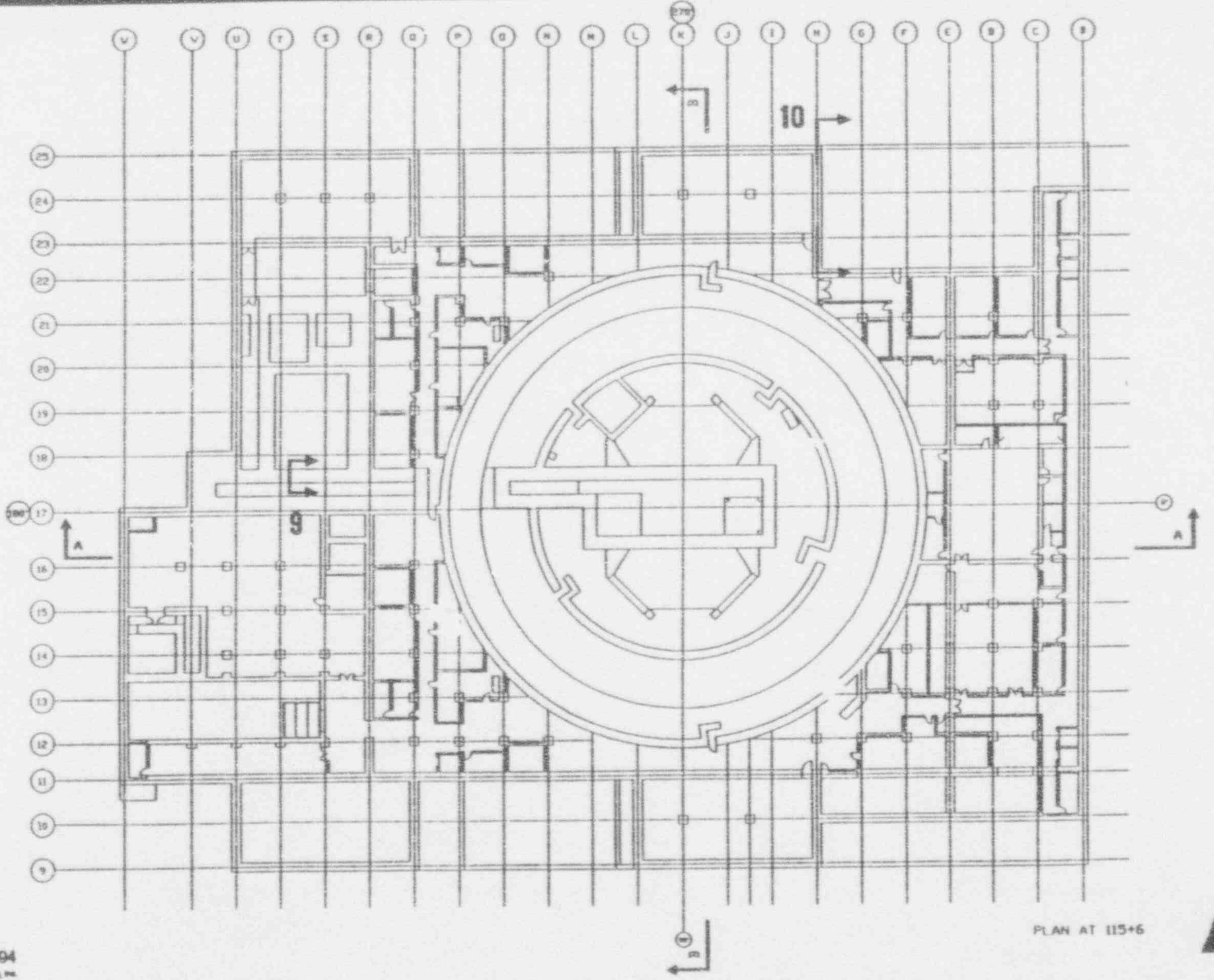
System 80+ Standard Plant
Nuclear Island - Detailed Design Areas



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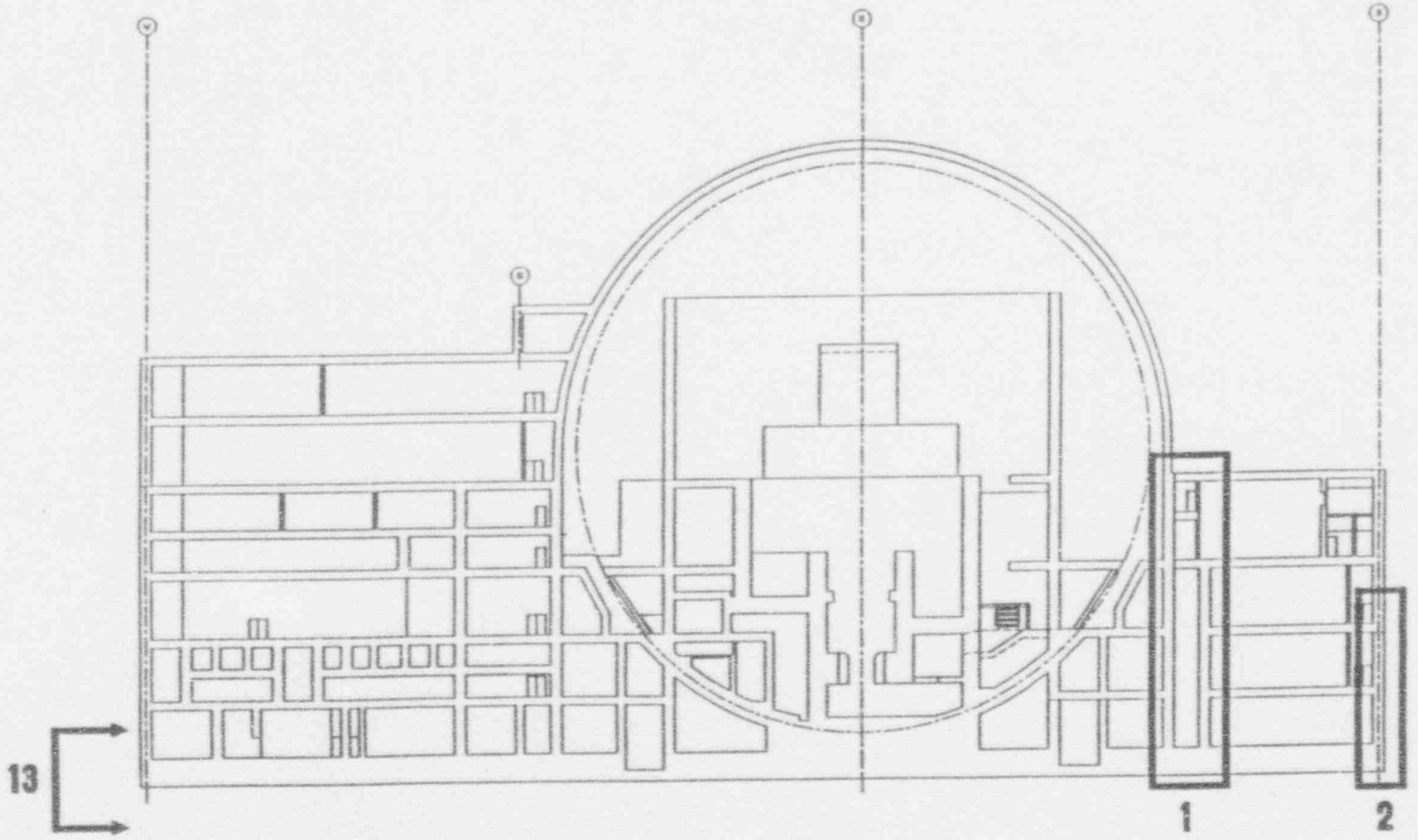
System 80+ Standard Plant
Nuclear Island - Detailed Design Areas



SECTION A-A

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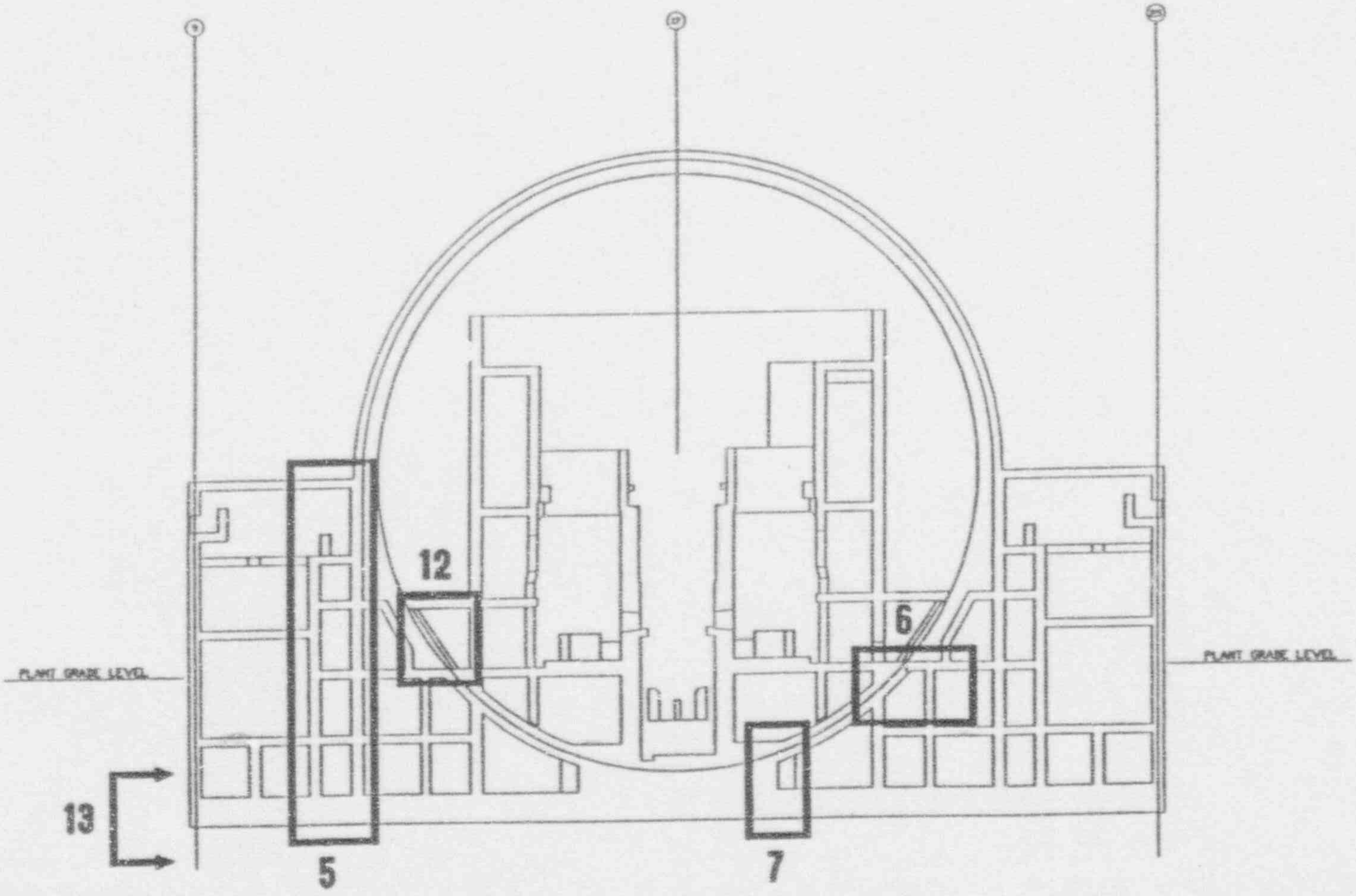
System 80+ Standard Plant
Nuclear Island - Detailed Design Areas



SECTION B-B

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System 80+ Standard Plant Structures

- Design requirements and/or interface requirements developed
  - Radwaste building
  - Turbine building
  - Station service building/ auxiliary boiler structure
  - Outdoor tank dikes
    - Boric acid, holdup and reactor makeup water
  - Station service water pump structure

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System 80+
Containment Vessel

System 80+ Standard Plant Steel Containment Vessel

Description

Type	Steel sphere
Material	SA-537, Class 2
Diameter	200 feet
Thickness	1.75 inch with two inch band at transition region near base
Free volume	3.34×10^6 cubic feet

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System 80+ Standard Plant
Steel Containment Vessel

Codes and Standards

- 10CFR50 - General Design Criteria
- 1989 ASME Boiler and Pressure Vessel Code, Section III, Subsection NE "Class MC Vessels"
- NUREG-0800 - Standard Review Plan
- Regulatory Guide 1.57
  - Design limits and loading combinations for metal primary eactor containment systems
- Regulatory Guide 1.61
  - Damping values for seismic design of nuclear power plants
- Regulatory Guide 1.84
  - Design and fabrication code case acceptability
- Regulatory Guide 1.92
  - Combining model responses and spatial components in seismic response analysis

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System 80+ Standard Plant Steel Containment Vessel

Design conditions

- Normal operating
  - Temperature: 110° F
  - Pressure: 0 psig
- Inadvertent containment spray actuation
  - Temperature: 110° F
  - Pressure: -2.0 psig (vacuum)
- Design basis
  - Temperature: 290° F
  - Pressure: 53.0 psig
- Combustible gas loading
  - Temperature: 290° F
  - Pressure: 76.5 psig

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System 80+ Standard Plant
Steel Containment Vessel

<u>Analyses</u>

- Test condition
  - Elastic three dimensional finite element analysis
- Design condition
  - Elastic three dimensional finite element analysis
- ASME service level conditions
  - Elastic three dimensional finite element analysis, except Level A which is an elastic axisymmetric finite element analysis
- Stability
  - Large deflection analyses with three dimensional finite element model
- Ultimate capacity
  - Elastic axisymmetric finite element analysis
- Combustible gas loading
  - Elastic axisymmetric finite element analysis
- Sliding & Overturning
  - Time history lumped mass stick model

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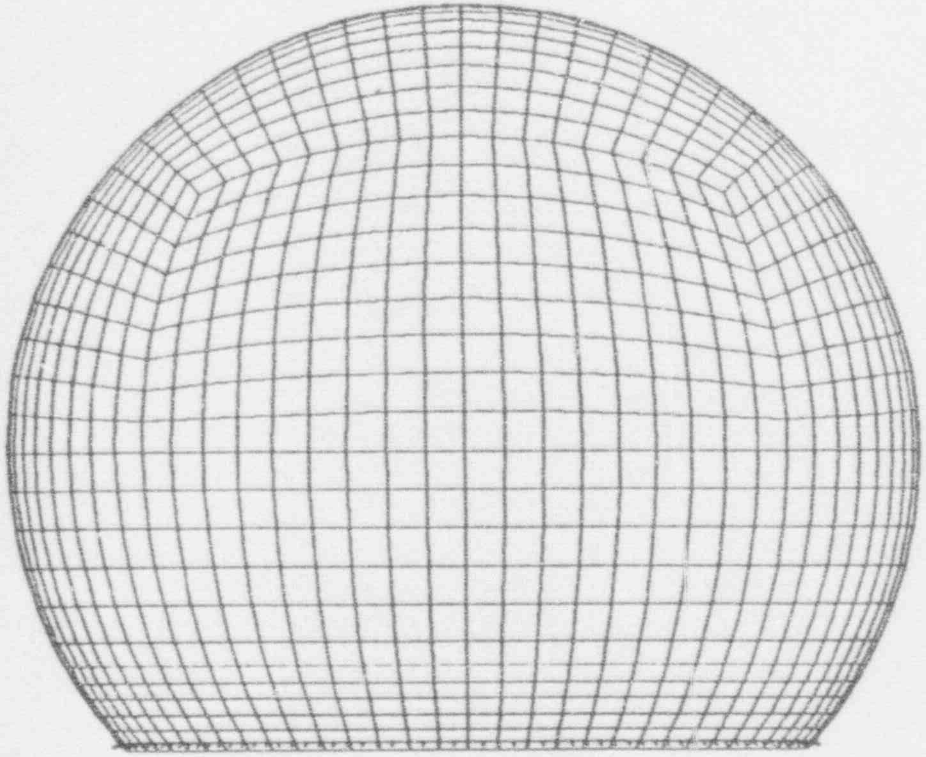
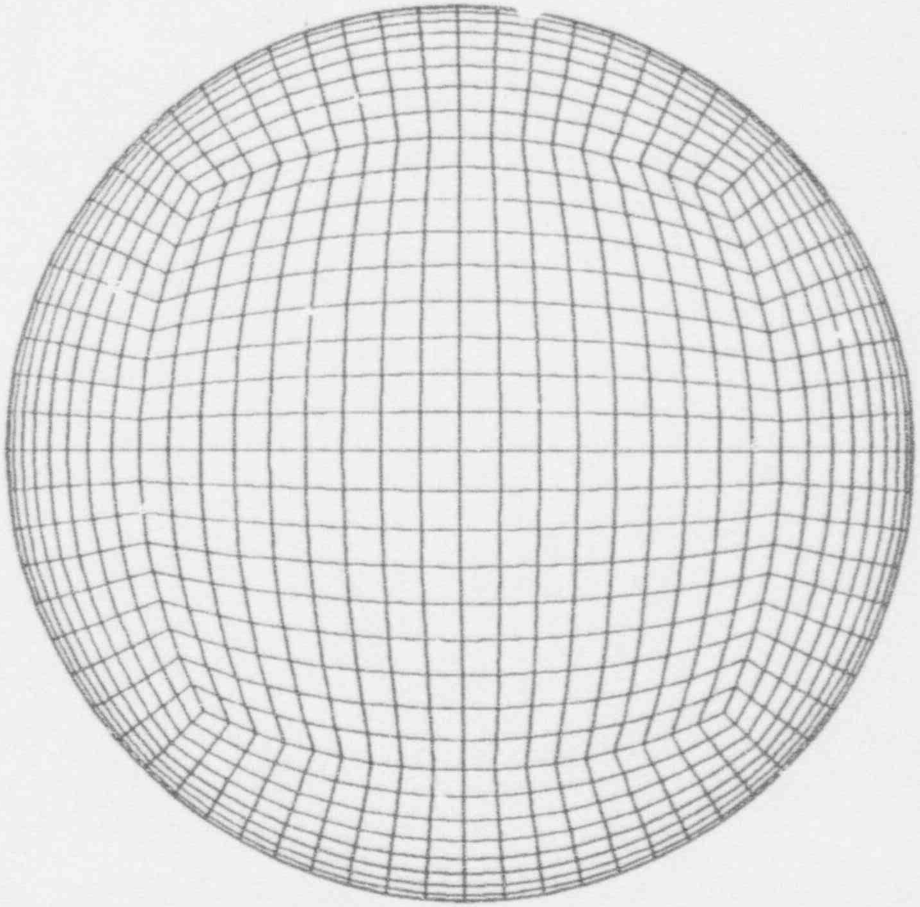
System 80+ Standard Plant
Three Dimensional Finite Element Model

Steel Containment Vessel



SIDE VIEW



TOP VIEW

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System 80+ Standard Plant Analysis Results

Steel Containment Vessel

Load Categories	Loading	Allowable Stress Intensity (ksi)		Maximum Calculated Stress Intensity (ksi)
		Limit	Value (ksi	
Test Condition	$D+L+P_t+T_t$	$0.75S_y$	44.3	22.4
Design Condition	$D+L+P_a$	$1.0S_{mc}$	22.0	20.1
Level A	$D+L+P_a$	$1.0S_{mc}$	22.0	20.1
	$D+L+P_a+T_a$	Note 1.	146.0	77.0
Level D	$D+L+P_a+E'$	S_f	47.6	31.4
Construction	$D+L+C$	$0.9S_y$	54.0	12.8
Combustible Gas	$D+L+P_a+P_g$	S_y	52.5	48.1

Notes:

1. Simplified Elastic Plastic Analyses used for secondary stress evaluation per ASME Code Section NE-3228.3

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System 80+ Standard Plant Stability Analysis Results

Steel Containment Vessel

Load Categories	Loading	Calculated Safety Factor	Required Safety Factor
Level A	$D+L+P_a+T_a$	3.0	3.0
Level C	$D+L+P_e$	2.7	2.5
Sliding and Overturning	$D+L+E'$	2.4	1.1

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System 80+ Standard Plant Ultimate Pressure Capacity

Steel Containment Vessel

Temperature (°F)	Loading	Pressure (psig)	Stress Intensity (ksi)	Yield Stress (ksi)
150	$D+L+P_u$	156	57.4	57.5
290		142	52.5	52.5
350		138	51.0	51.1
450		132	48.8	48.8

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ABB Combustion Engineering System 80+™ Standard Plant

Site Parameters, Seismic Design, Structural Design

Lyle D. Gerdes

March 8&9, 1994

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System 80+™
Site Parameters

System 80+ Standard Plant External Floods

- Site Parameters
    - Grade elevation - 90'+9" (Reference)
    - Maximum groundwater level - two feet below grade
    - Probable maximum flood (PMF) level - one foot below grade

- Design Features
    - Concrete construction joints sealed with waterstops
    - External penetrations below grade sealed
    - Doors/accesses at least one foot above grade
    - Seepage will end up in sumps in basement through floor drains

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System 80+ Standard Plant
Wind and Tornado

Site Parameters

- Extreme wind-basic wind speed 110mph

- Tornado

Maximum wind speed	330 mph
Rotational speed	260 mph
Translational velocity	70 mph
Radius	150 ft
Max. differential pressure	2.4 psi
Rate of pressure drop	1.7 psi/sec
Missile spectra	SRP 3.5.1.4 Spectra II

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System 80+ Standard Plant
Wind and Tornado

Design Features

- Design Seismic Category 1 structures for associated loading and exterior walls and roof designed as tornado missile barriers
- Dampers qualified to tornado differential pressures

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System 80+ Standard Plant Missiles

Protection

- Minimize the sources of missiles by equipment design features that prevent missile generation

- Orientation or physical separation of potential missile sources away from safety related equipment and components

- Containment of potential missiles through the use of protective shields and barriers near the source

- Hardening of safety related equipment and components to withstand missile impact where such impacts cannot be reasonably avoided by the above methods

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System 80+ Standard Plant Missiles

Internally Generated Missiles

- Redundant safety systems physically separated by divisional wall outside containment
- Missile barriers used inside and outside containment where required
- Auxiliary pumps and motors
    - Induction type, relatively slow speed, rotor contained by stator, pumps impellers contained by casing
- Emergency feedwater pumps
    - Overspeed protection (electrical and mechanical), enclosed in separate room
- Valves
    - Stems have backseat or shoulder larger than bonnet opening, MOV and manual valve stems retained by threads, operators prevent stem ejection

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System 80+ Standard Plant Missiles

Internally Generated Missiles

- Pressure Vessels
  - Moderate energy (275 psig) or less, pressure relief devices installed where necessary
- Turbine Missiles
  - Probability less than 1.0E-4 events per year by maintenance and inspections, overspeed protection, orientation

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System 80+ Standard Plant Missiles

<u>Externally Generated Missiles</u>

- **Missiles generated by natural phenomena**
  - Tornado missiles are part of the design basis for Seismic Category 1 structures, systems and components

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System 80+ Standard Plant Radiological Dilution Factors

Distance	Time Period	Dilution Factor (sec/cubic meter)
EAB (0.5 mile)	0-2 hours	1.00×10^{-3}
LPZ (2.0 miles)	0-8 hours	1.35×10^{-4}
LPZ (2.0 miles)	8-24 hours	1.00×10^{-4}
LPZ (2.0 miles)	1.4 days	5.40×10^{-5}
LPZ (2.0 miles)	4-30 days	2.20×10^{-5}

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Seismic & Structural Design

System 80+ Standard Plant Seismic Design Bases - General

- Design parameters envelope the majority of potential nuclear sites
- Both current and anticipated regulatory guidance considered
- Envelope of site conditions considered
  - Rock
  - Shallow soil
  - Deep soil
- SSE peak ground acceleration - .30G

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System 80+ Standard Plant Design Process

- Selection of design control motion(s)
- Selection of soil profiles
- Development of dynamic models
- Dynamic analysis
- Definition of input for structural, subsystem and equipment design, analysis and qualification

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Control Motion Definition

System 80+ Standard Plant Control Motion Definition

- CMS1
  - USNRC reg 1.60 spectral shape
  - Defined at surface in free field
  - Horizontal PGA = .30G
  - Vertical PGA = .30G

- CMS2
  - Enriched in high frequency content
  - Defined at rock outcrop
  - Horizontal PGA = .30G
  - Vertical PGA = .20G

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System 80+ Standard Plant Control Motion Definition

- CMS3
    - NUREG/CR-0098 spectral shape (enhanced)
    - Defined at rock outcrop
    - Horizontal PGA = .30G
    - Vertical PGA = .20G

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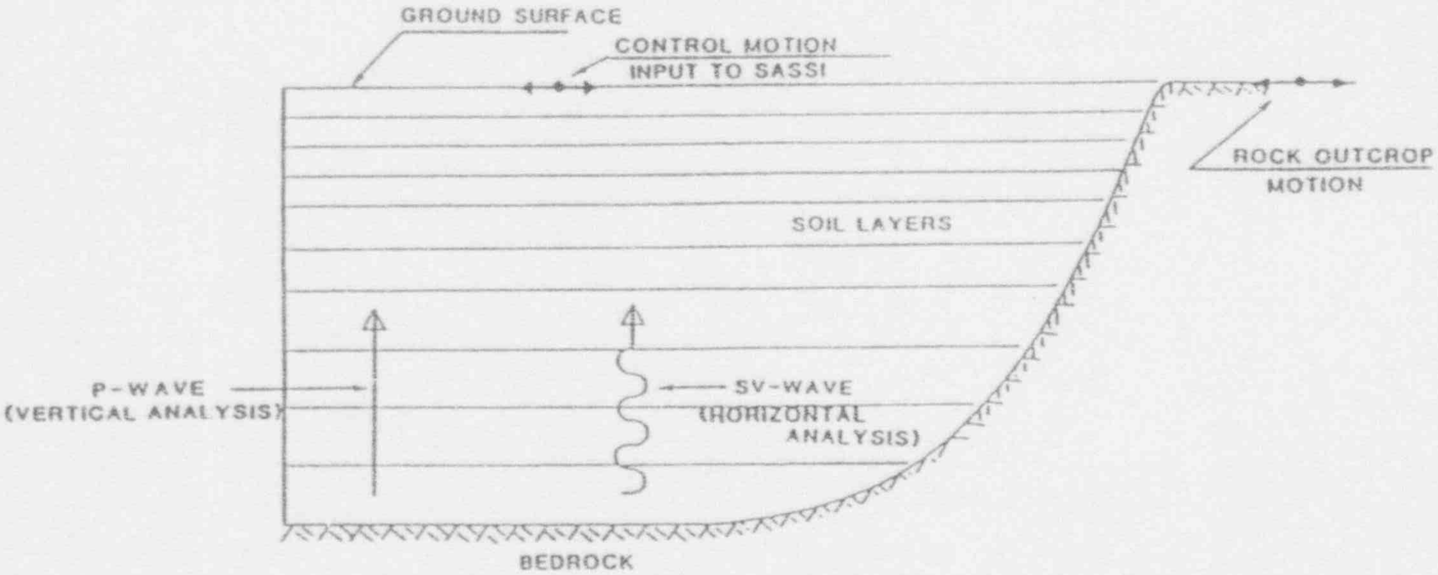
System 80+ Standard Plant
Site Response



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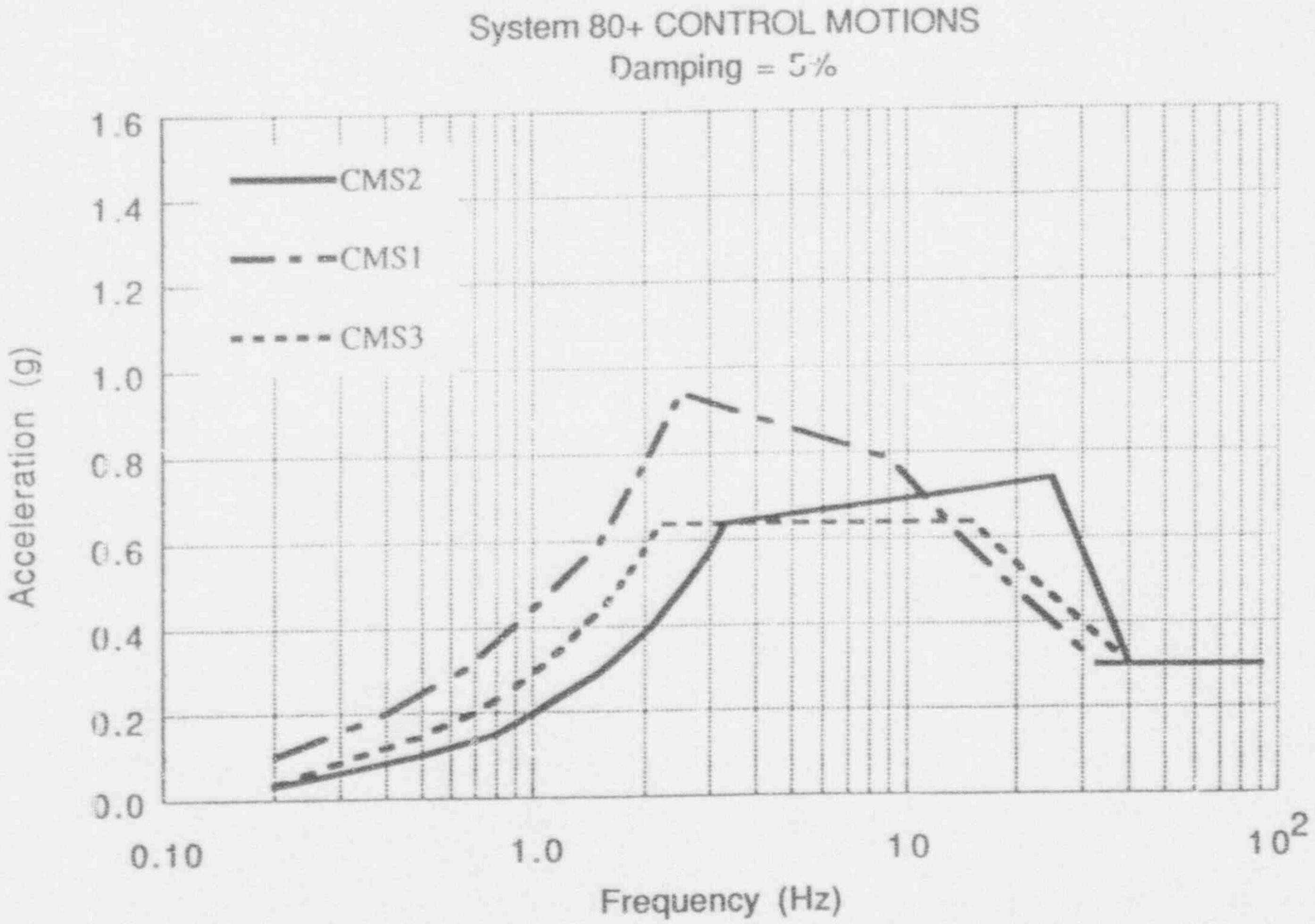
System 80+ Standard Plant
CMS1, CMS2, CMS3



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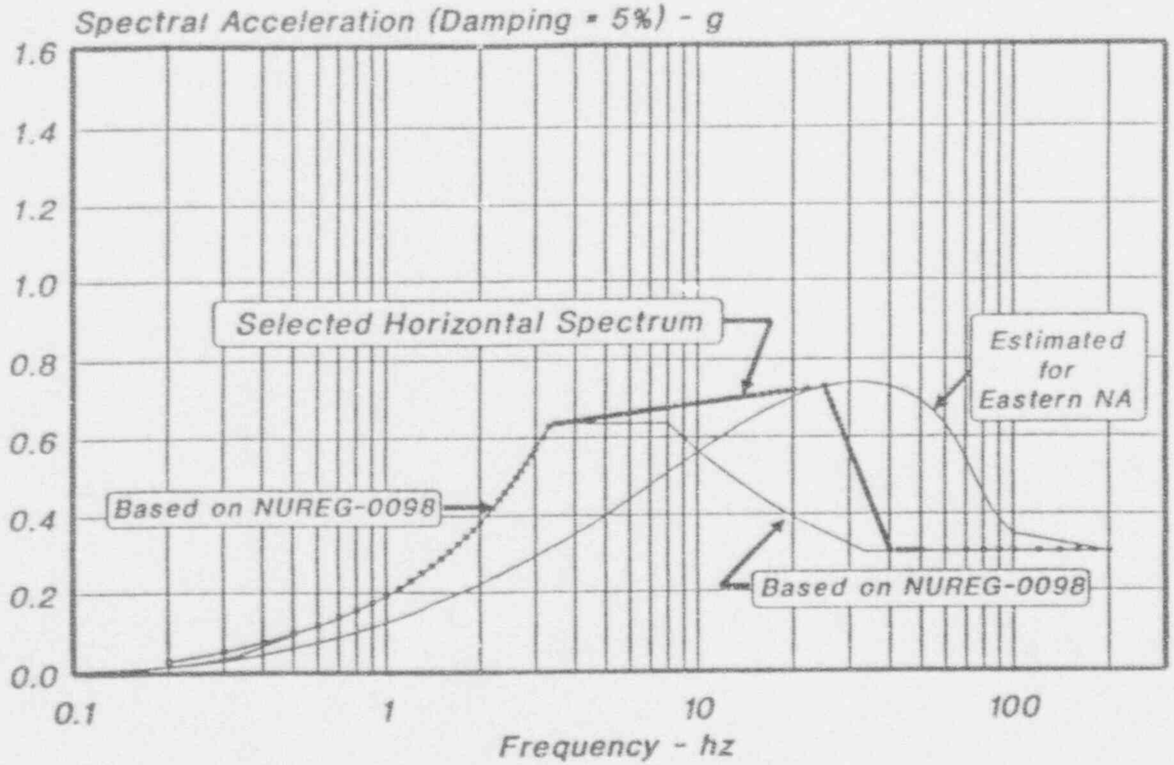
System 80+ Standard Plant Generation of Control Motion CMS2



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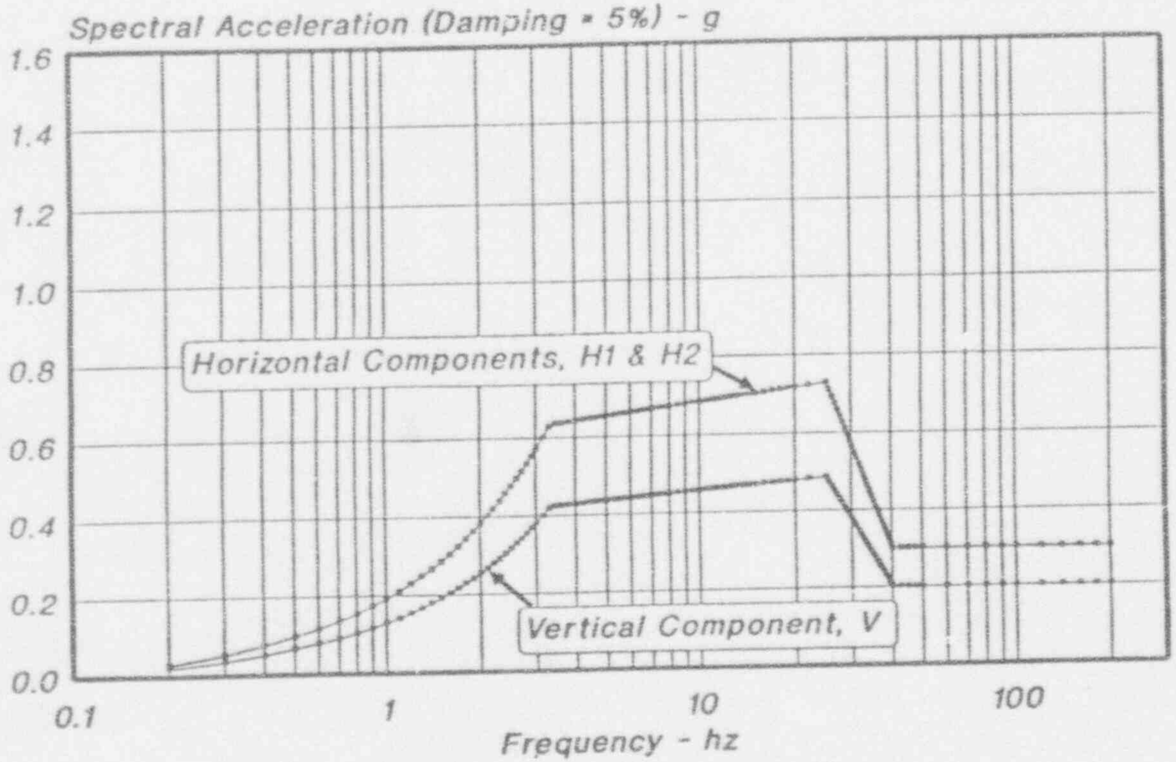
System 80+ Standard Plant
Generation of Control Motion CMS2



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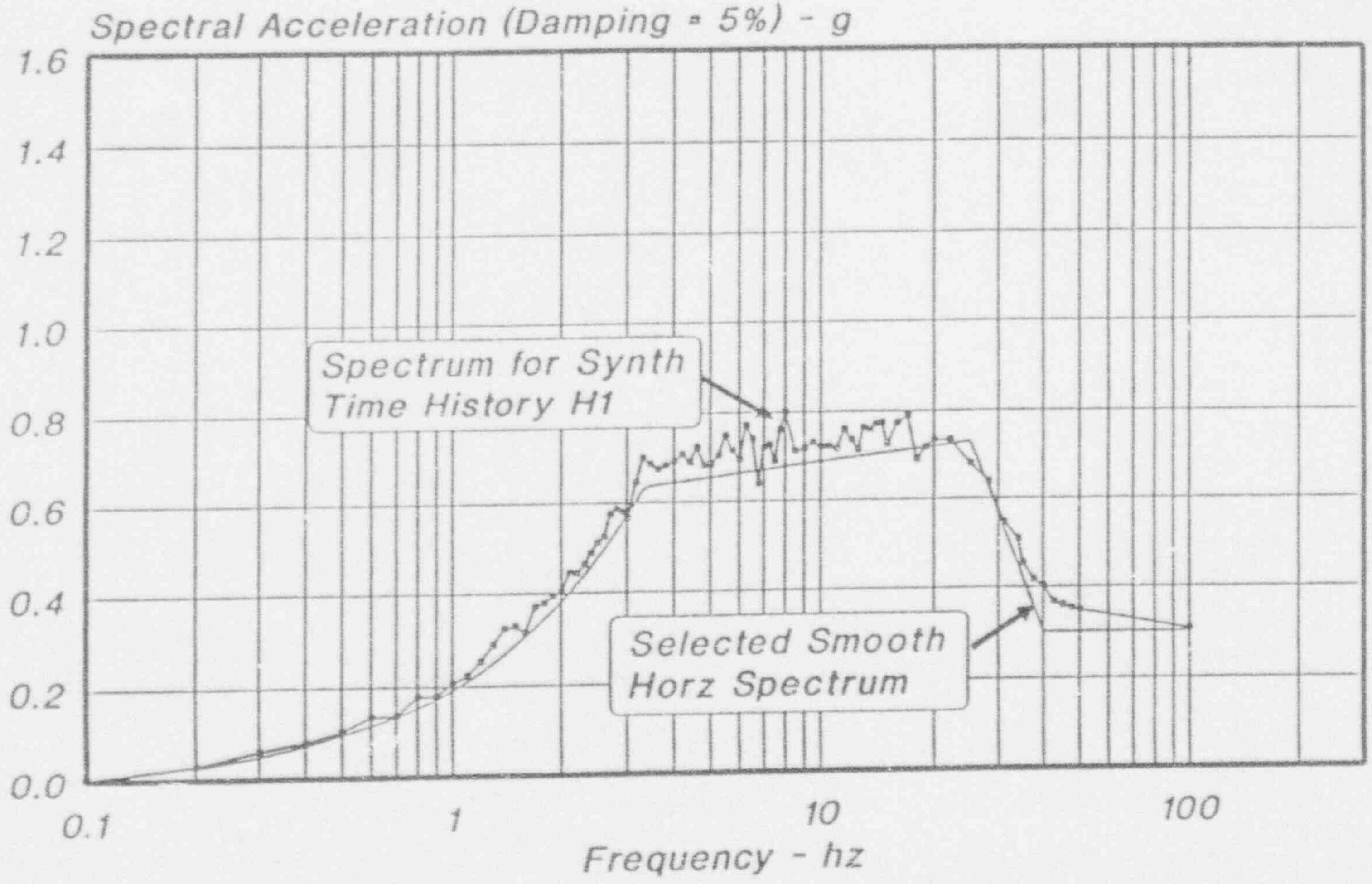
System 80+ Standard Plant
CMS2 Control Motion Spectrum - H1



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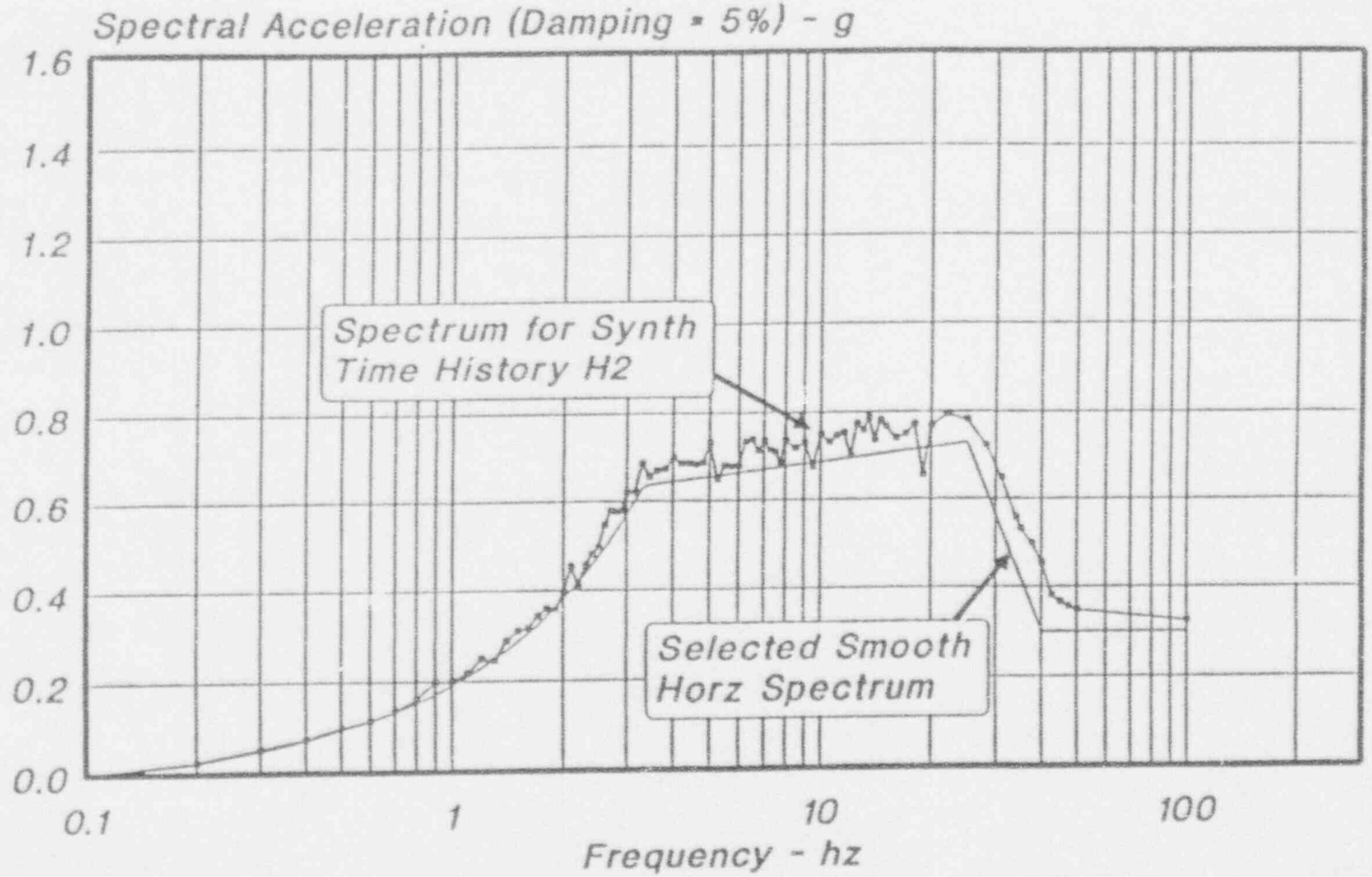
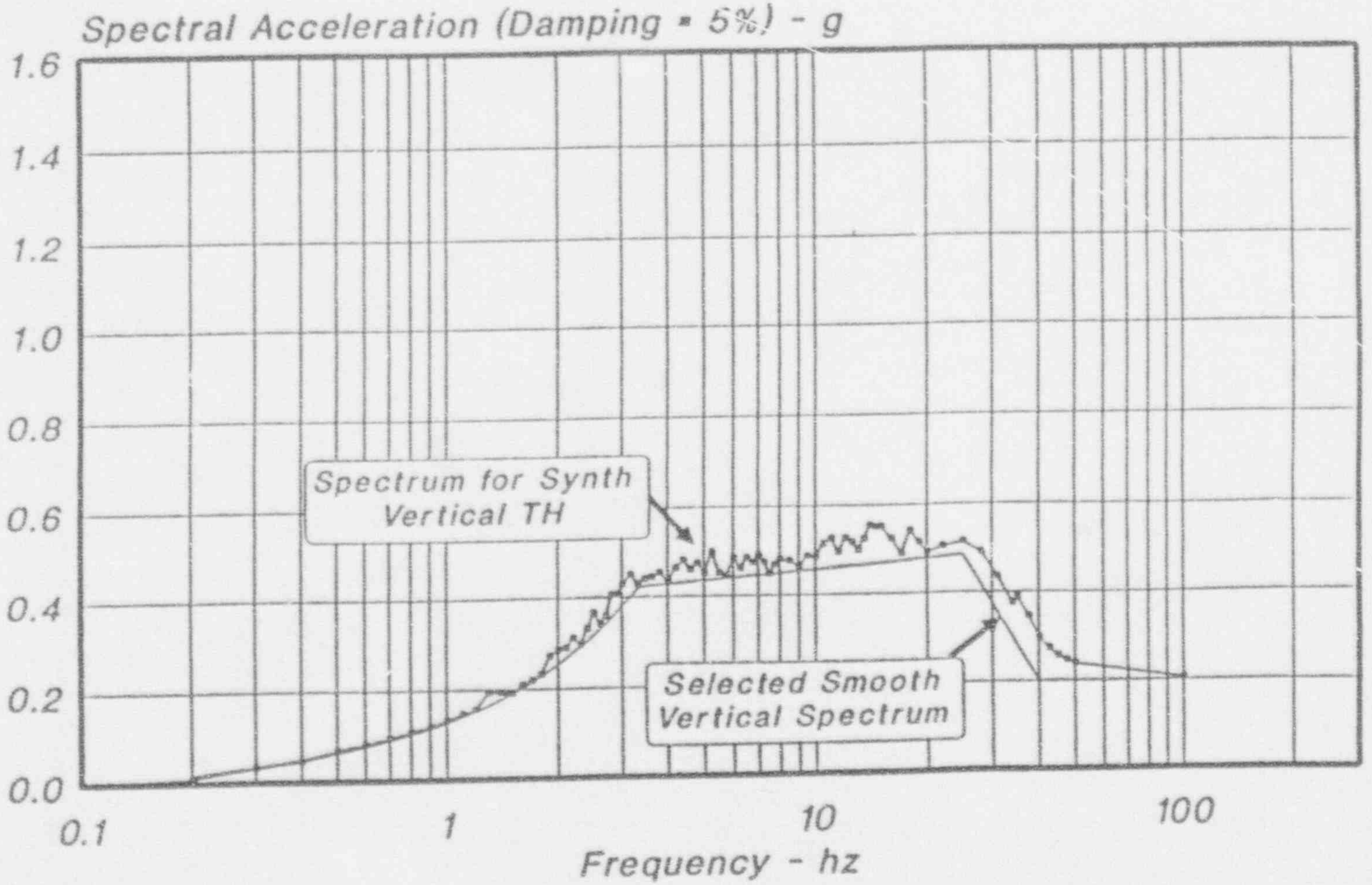
System 80+ Standard Plant
CMS2 Control Motion Spectrum - H2



System 80+ Standard Plant
CMS2 Control Motion Spectrum - V



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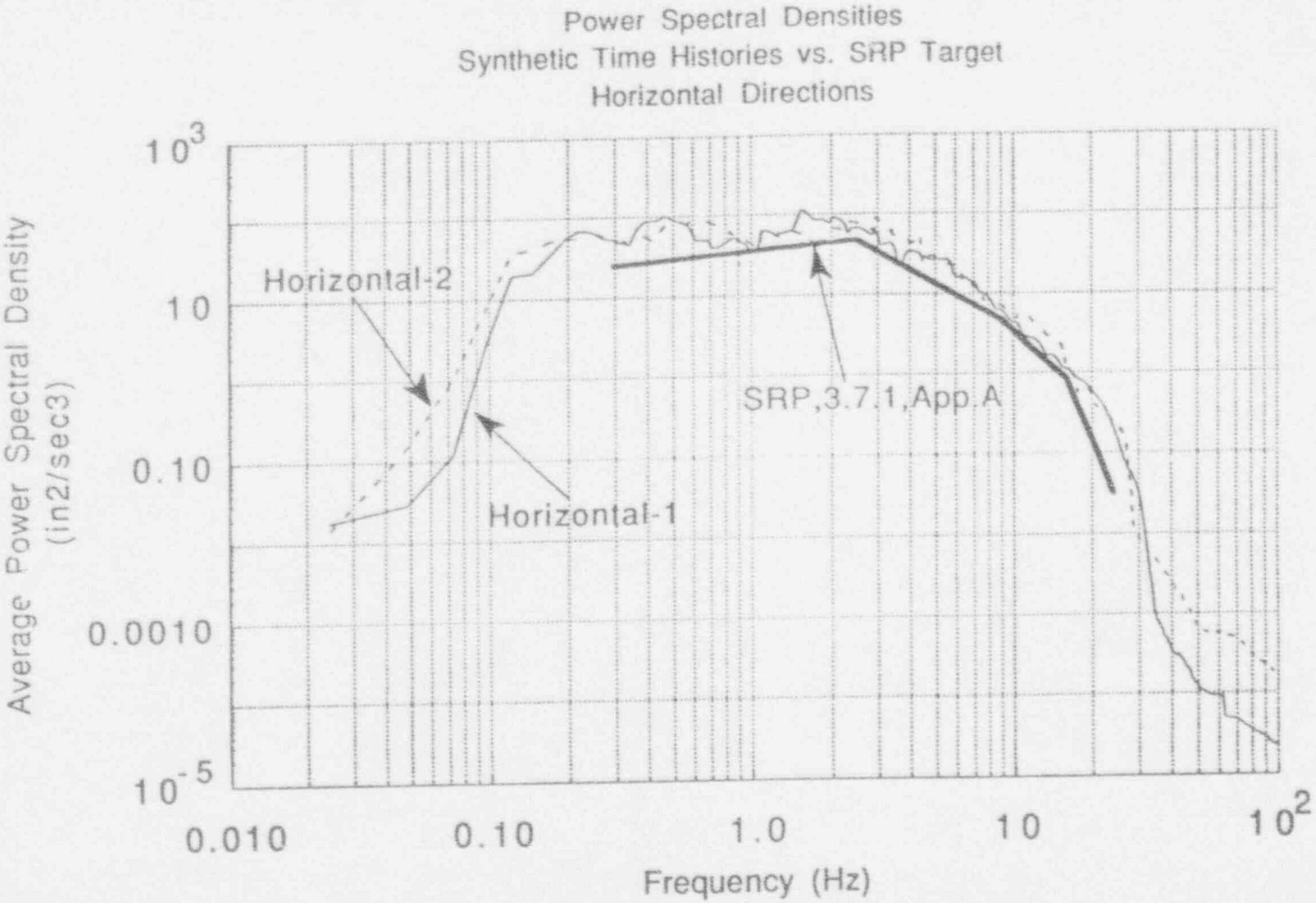
System 80+ Standard Plant
Average Power Spectral Density - CMS1



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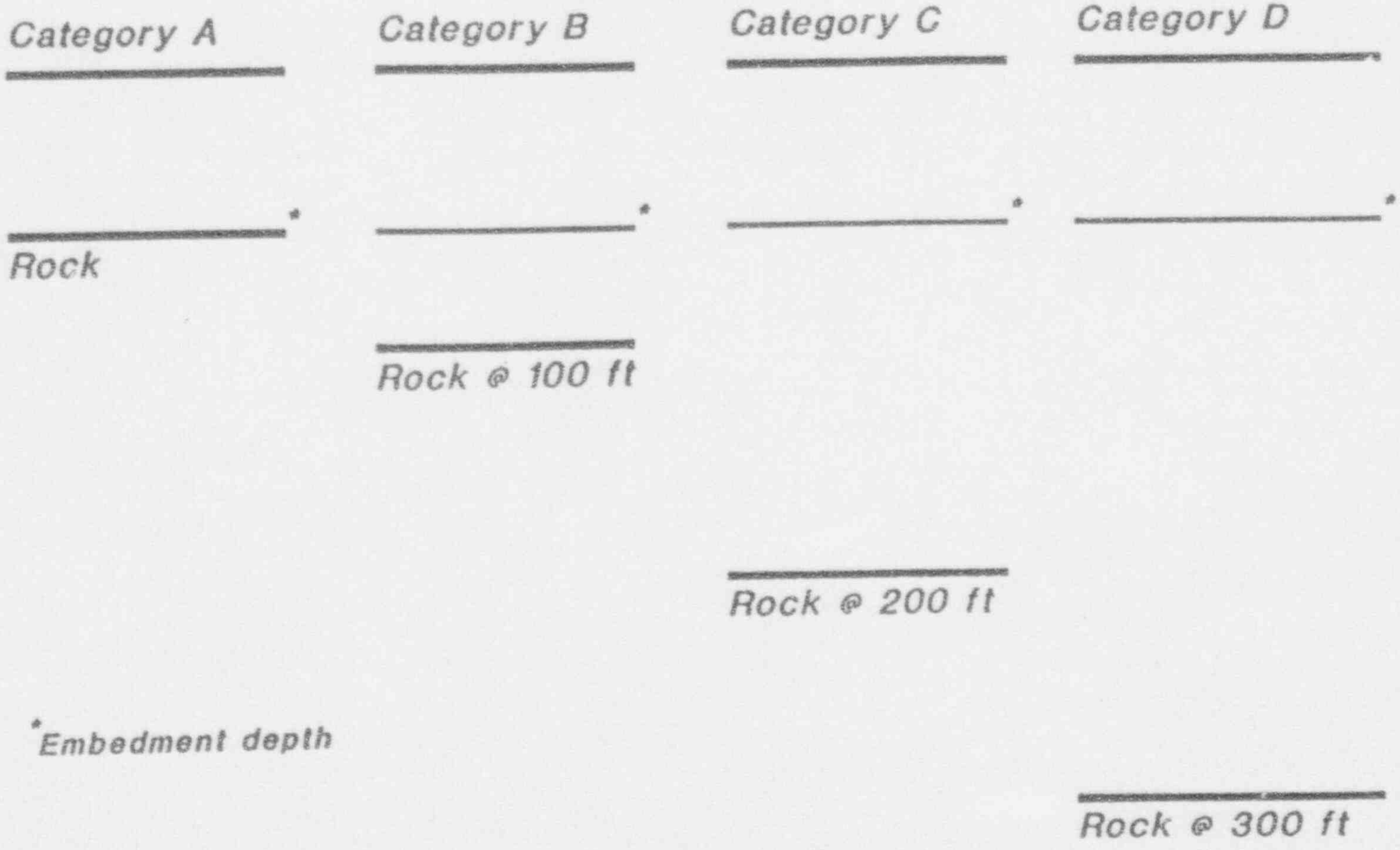
Definition of Generic Soil Profiles

System 80+ Standard Plant
Generic Soil Sites



Category A

Rock

Category B

Rock @ 100 ft

Category C

Rock @ 200 ft

Category D

Rock @ 300 ft

*Embedment depth

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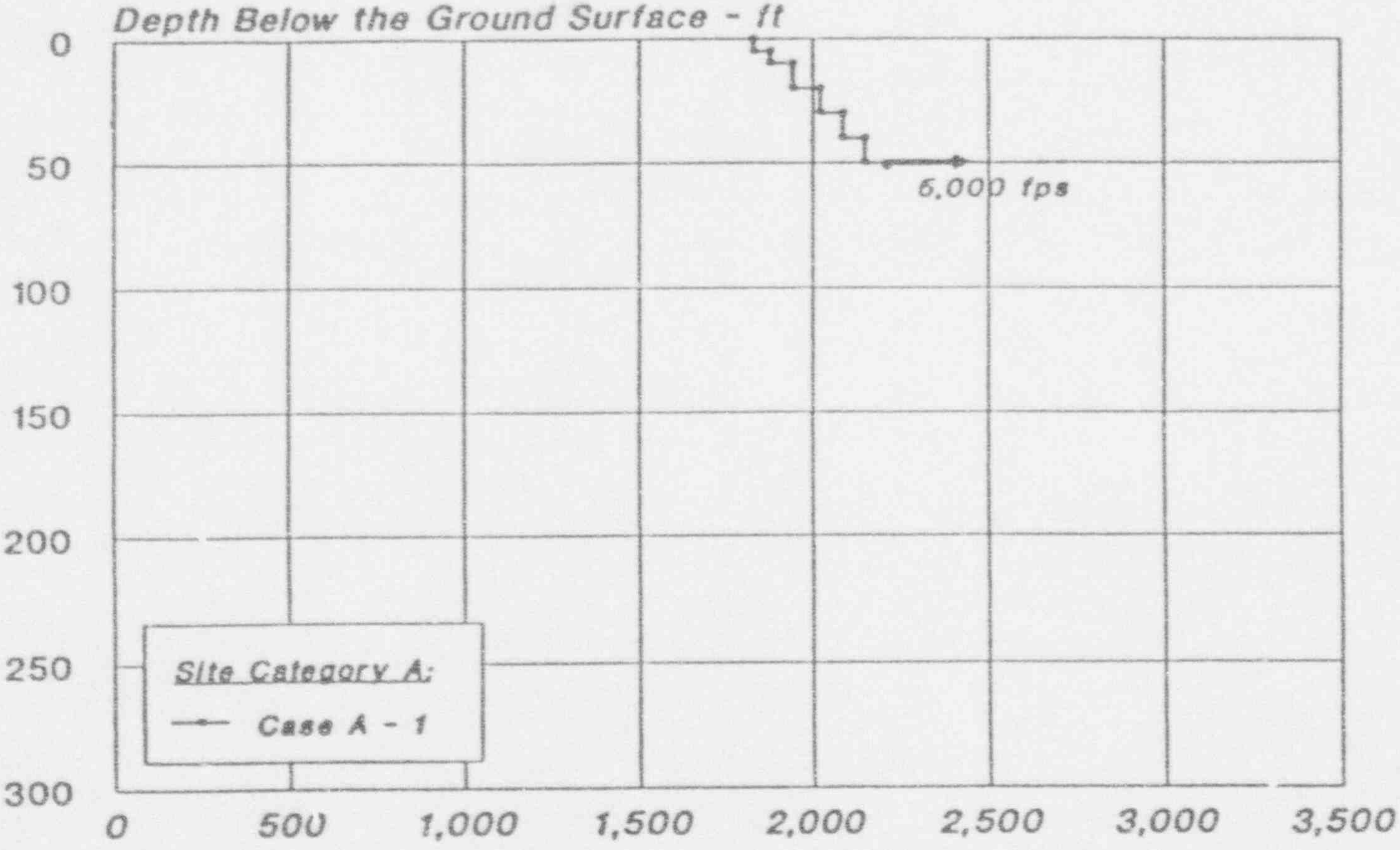
System 80+ Standard Plant
Assigned Shear Wave Velocities - A1



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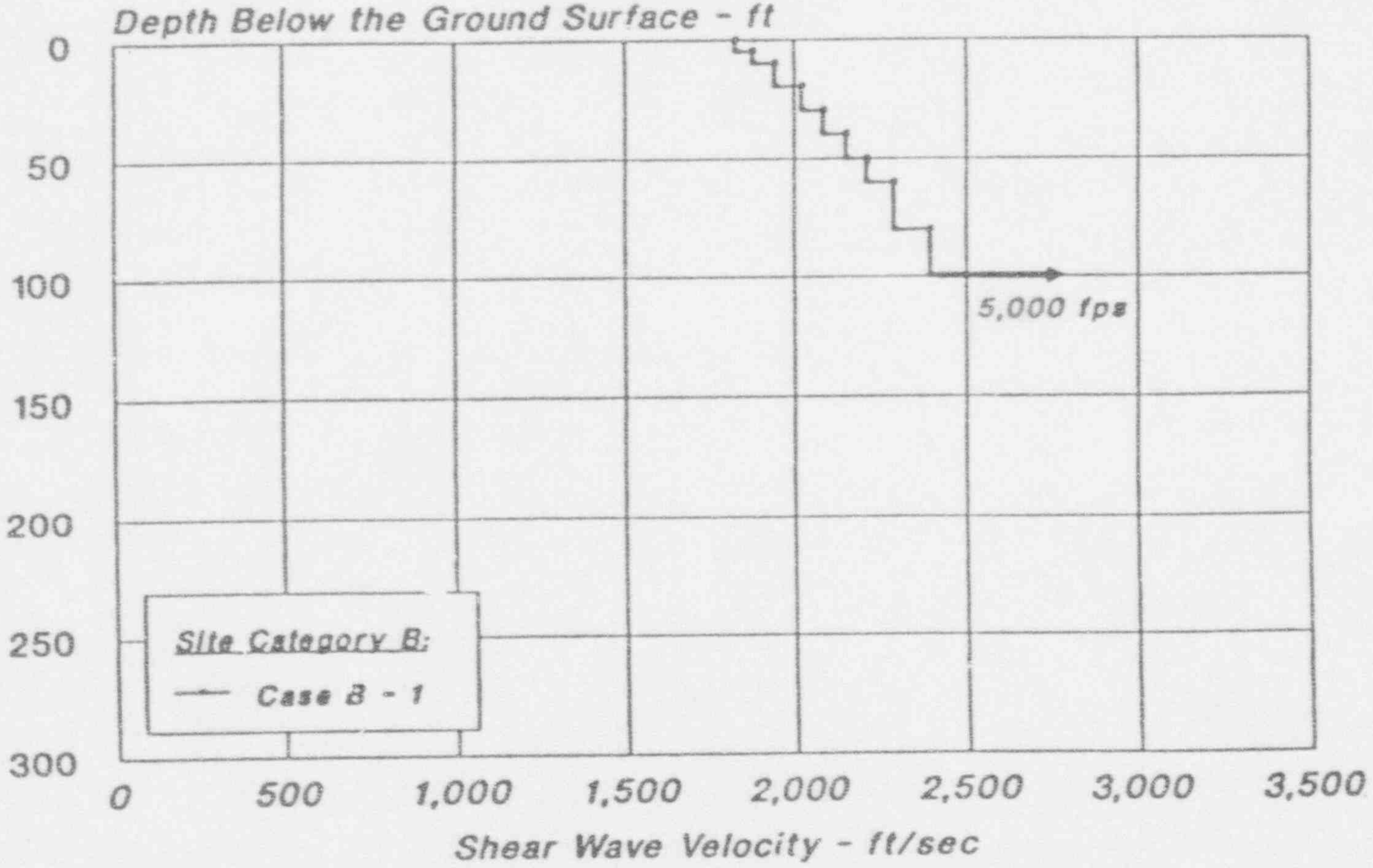
System 80+ Standard Plant
Assigned Shear Wave Velocities - B1



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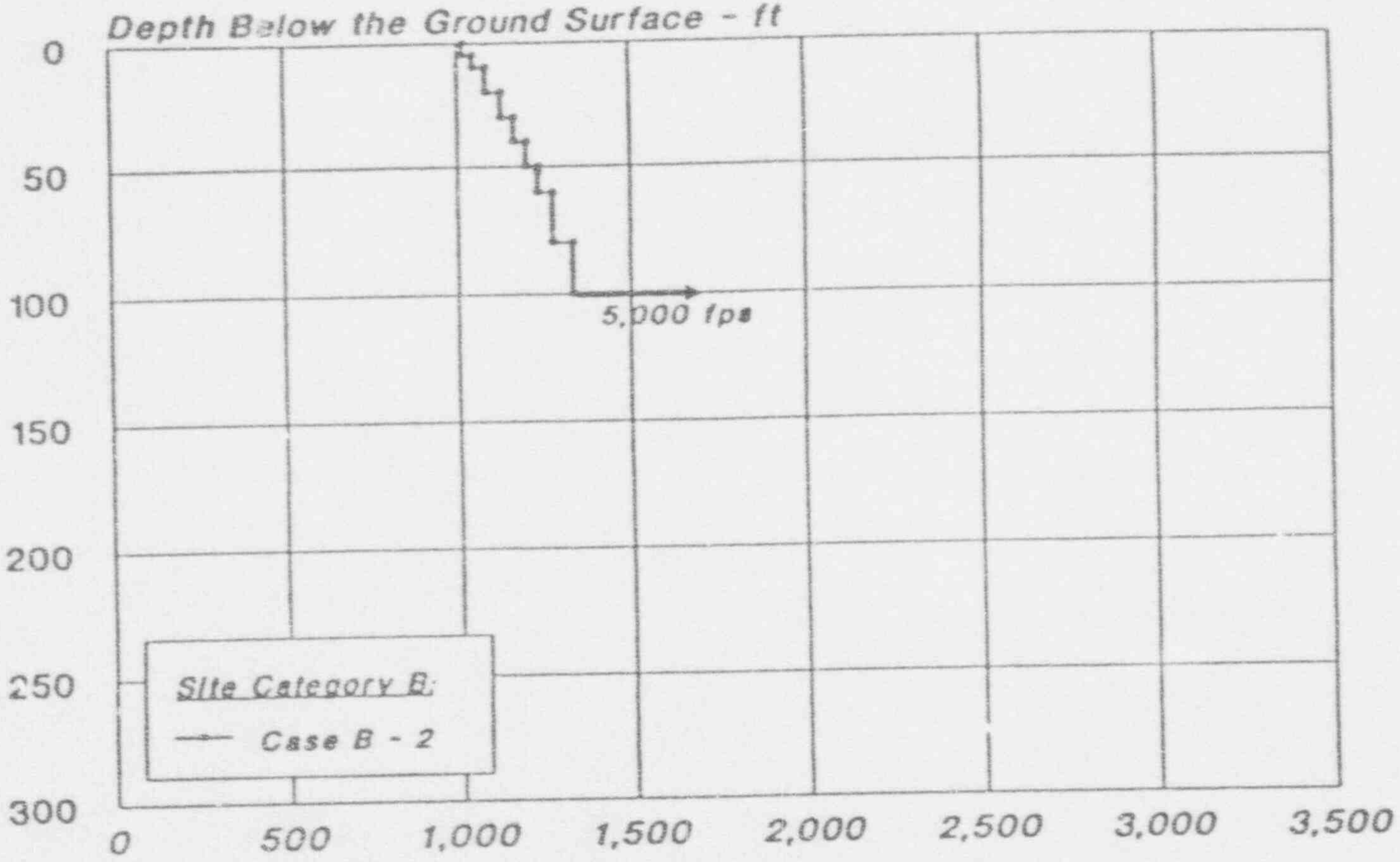
System 80+ Standard Plant
Assigned Shear Wave Velocities - B2



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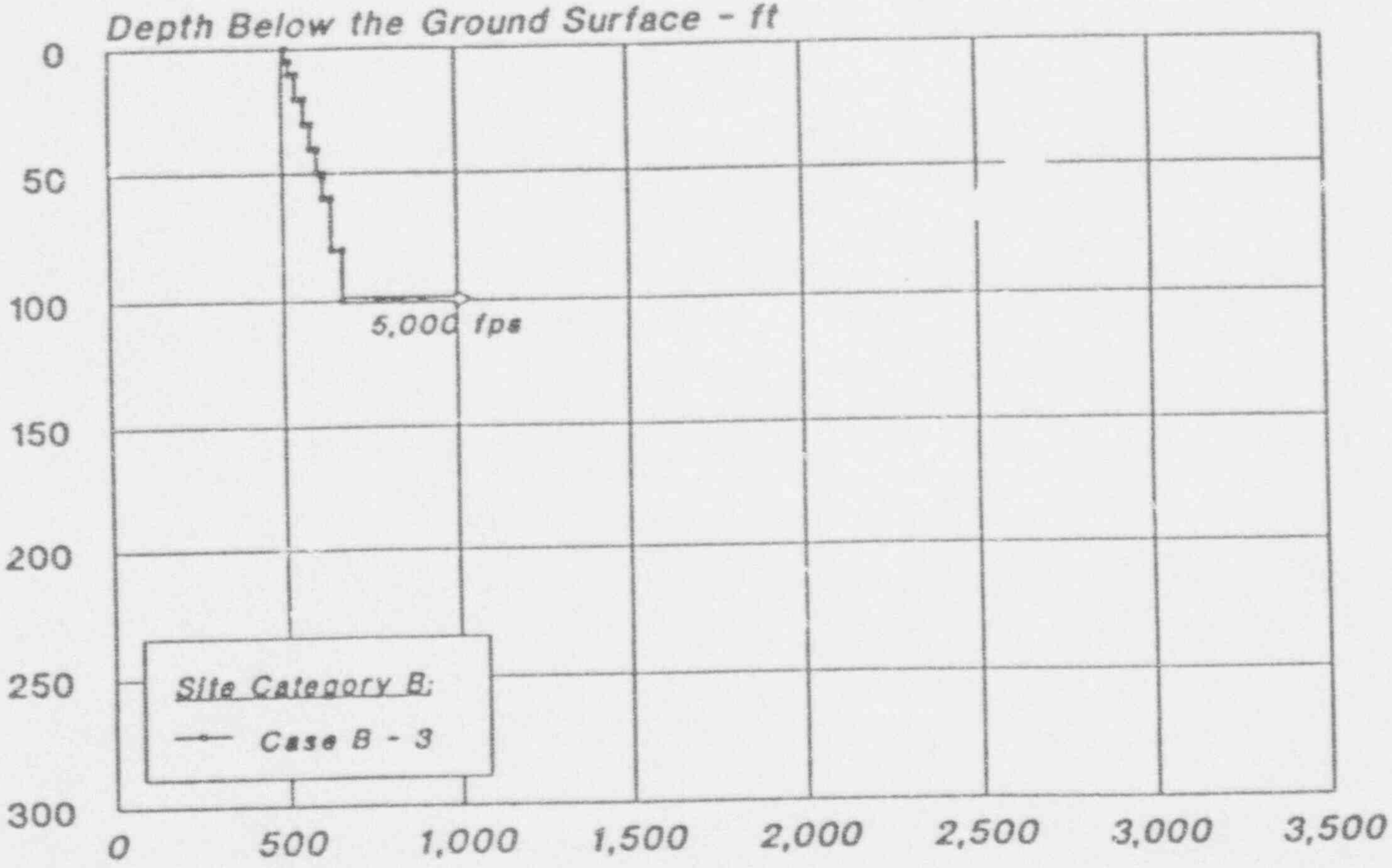
System 80+ Standard Plant
Assigned Shear Wave Velocities - B3



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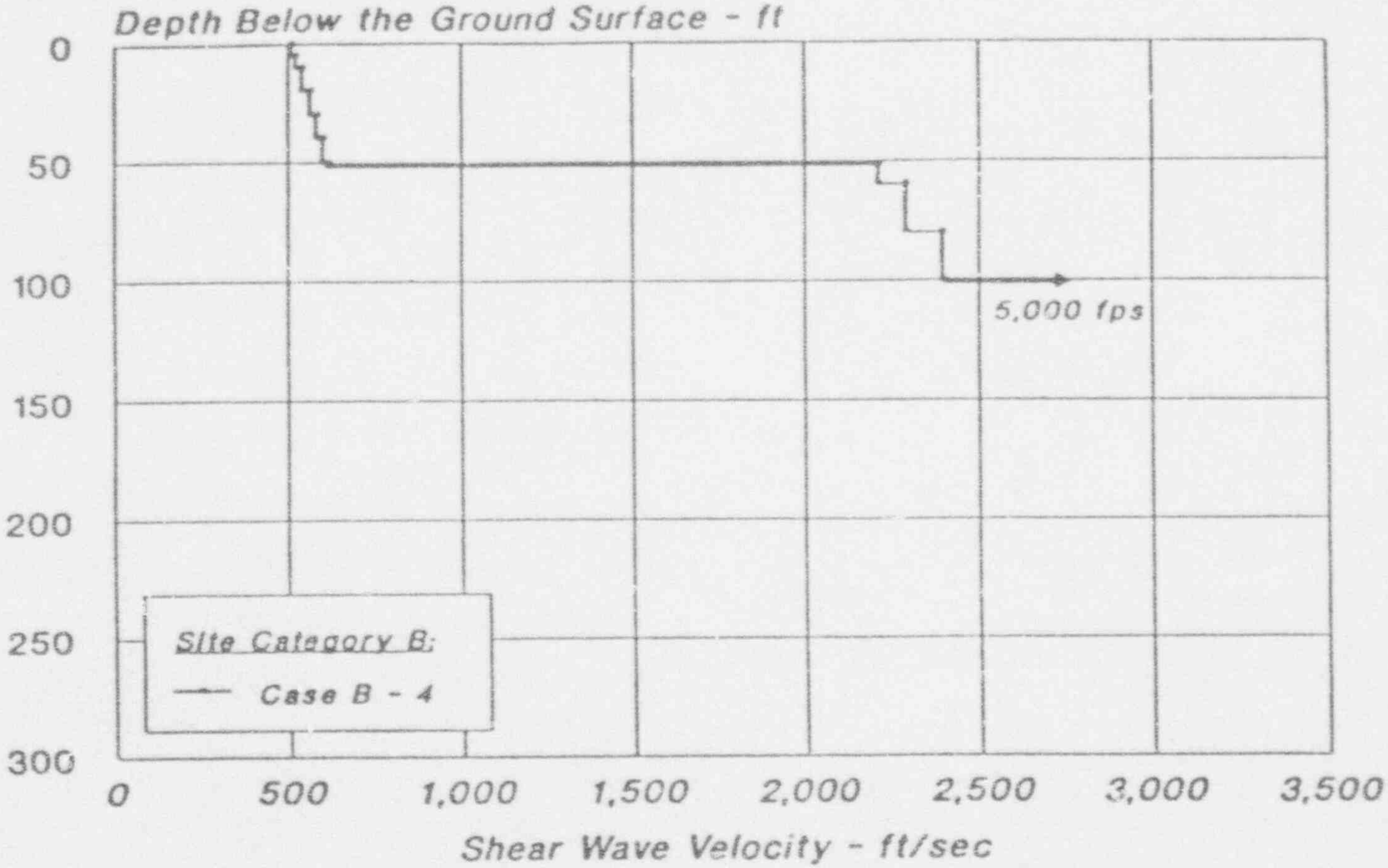
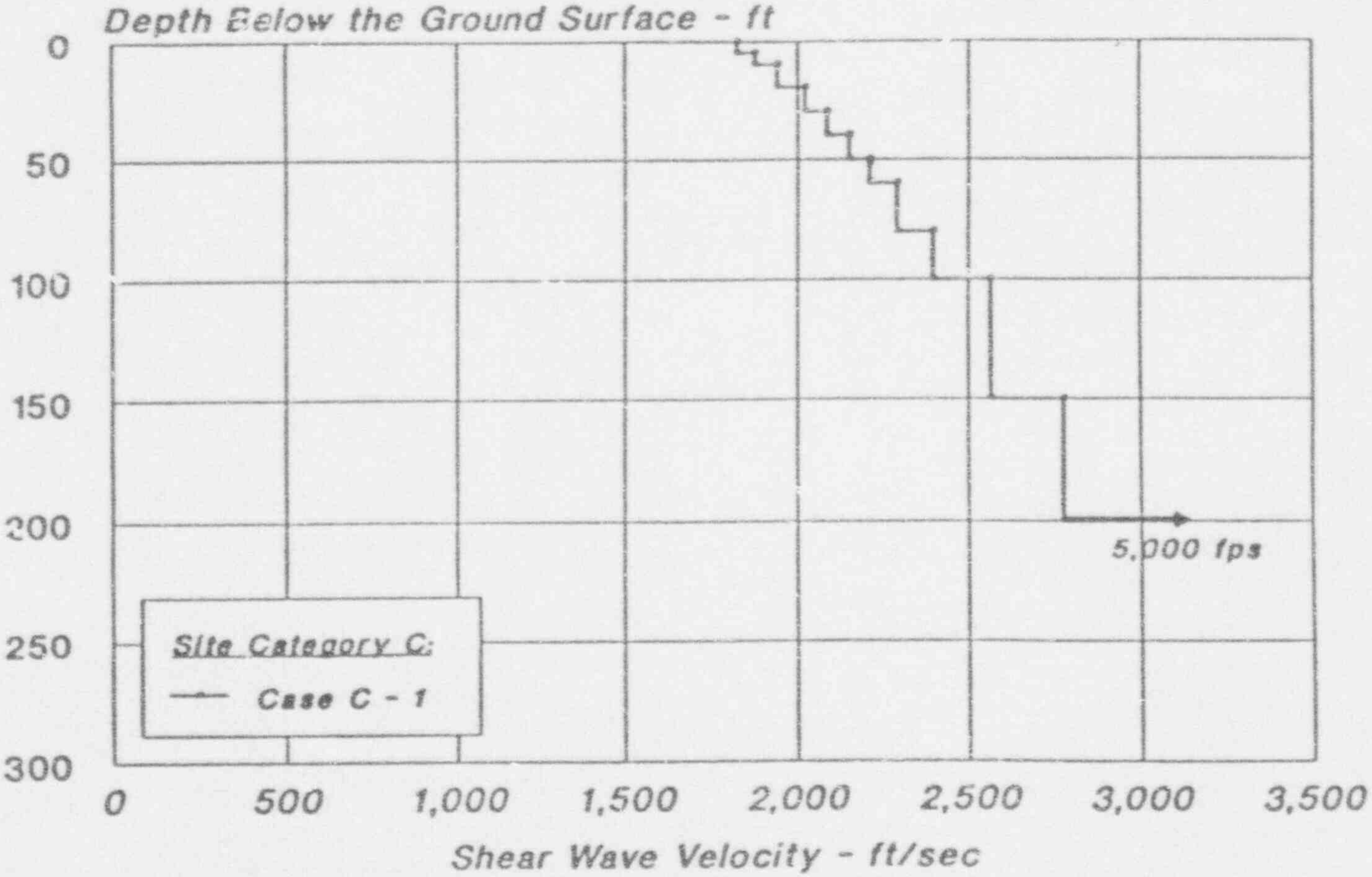
System 80+ Standard Plant
Assigned Shear Wave Velocities - B4



System 80+ Standard Plant
Assigned Shear Wave Velocities - C1



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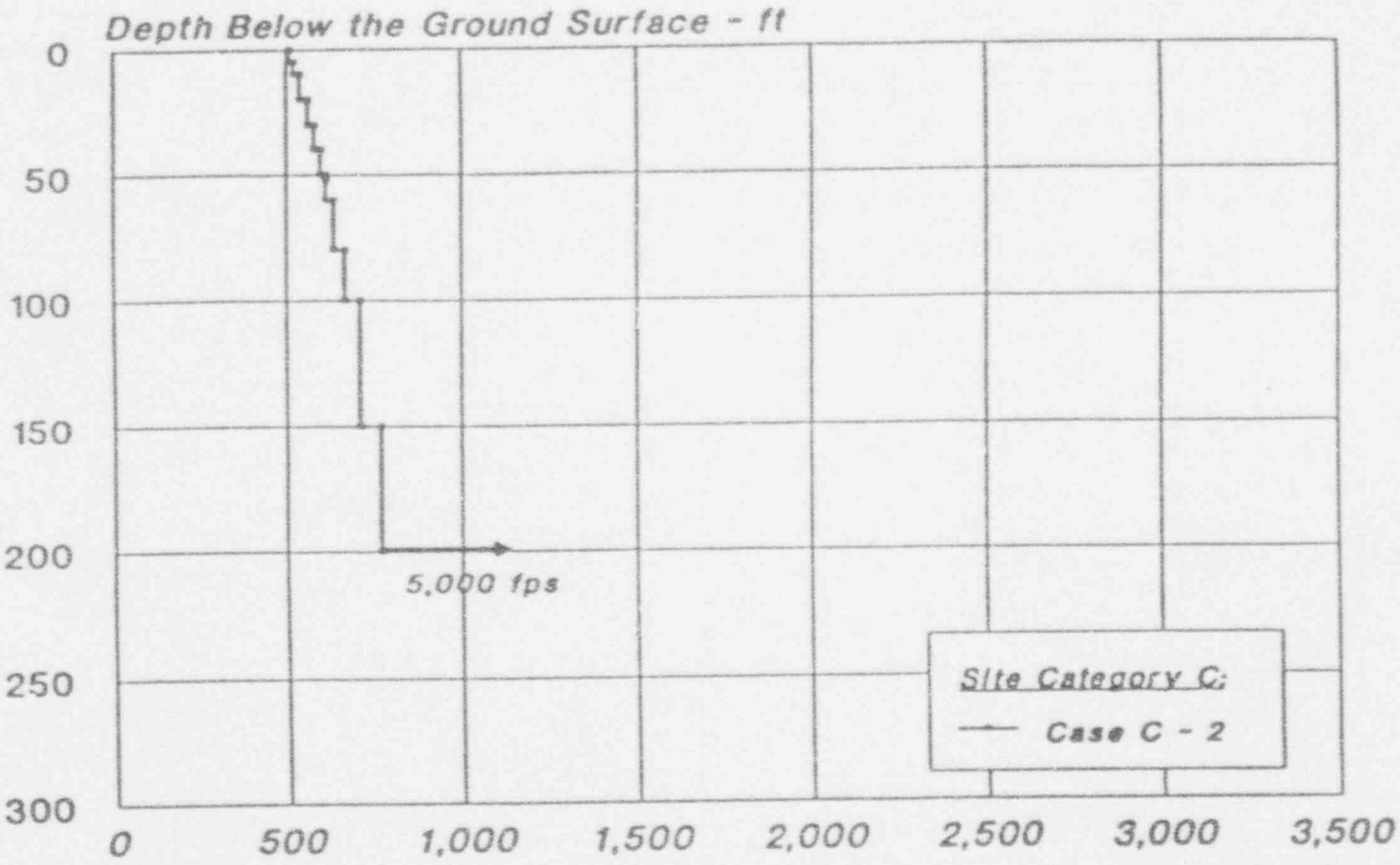
System 80+ Standard Plant
Assigned Shear Wave Velocities - C2



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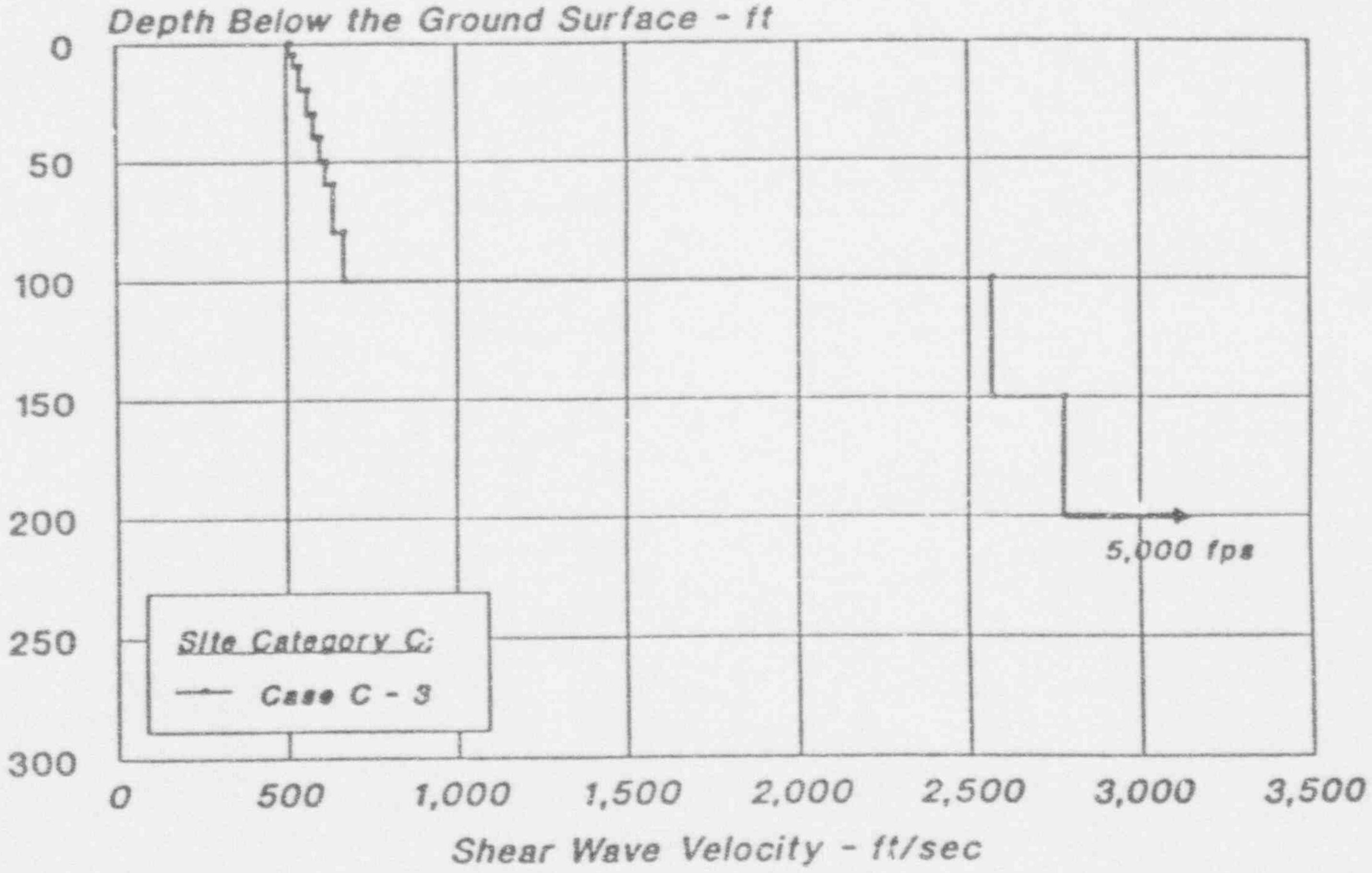
System 80+ Standard Plant
Assigned Shear Wave Velocities - C3



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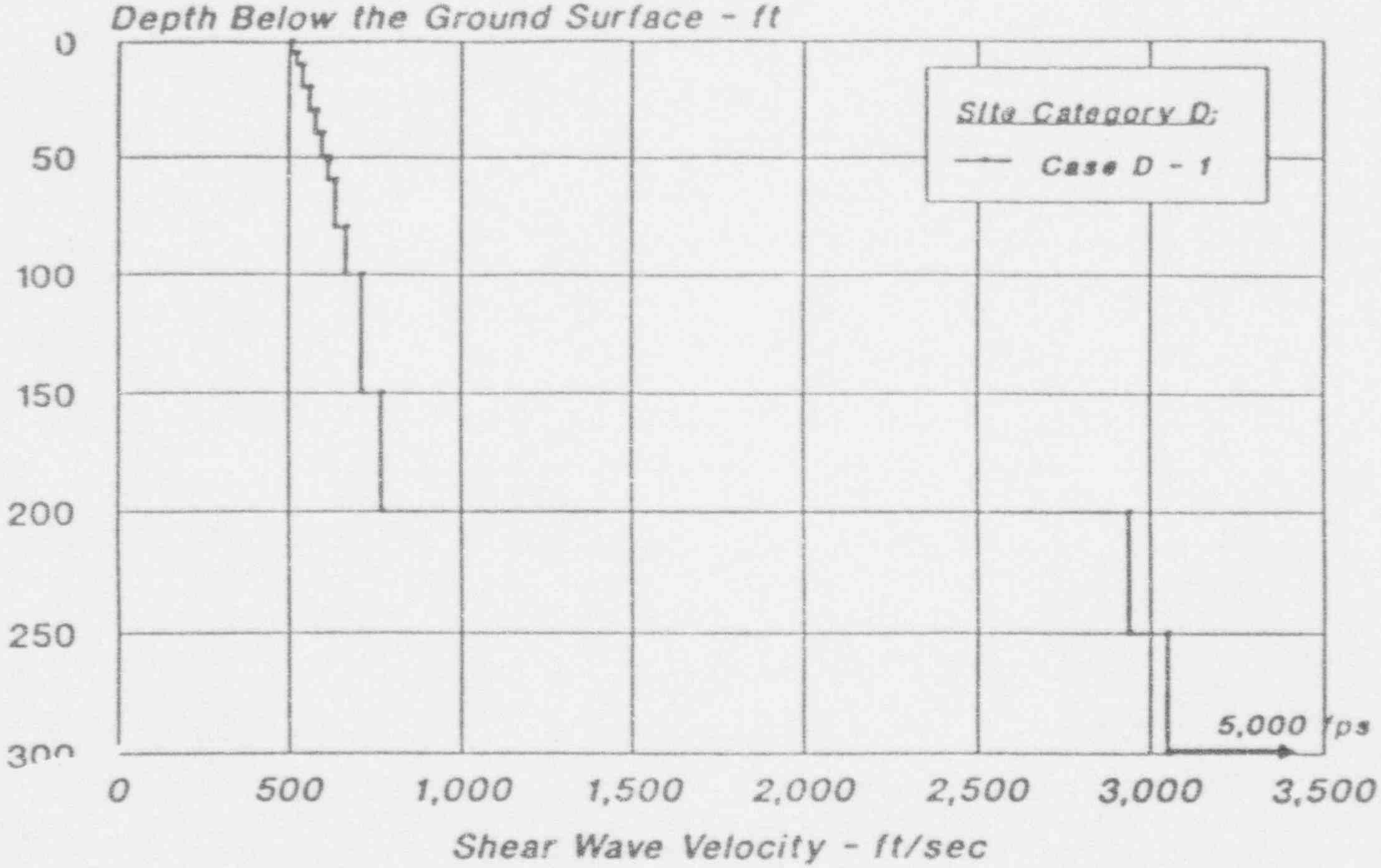
System 80+ Standard Plant Assigned Shear Wave Velocities - D1



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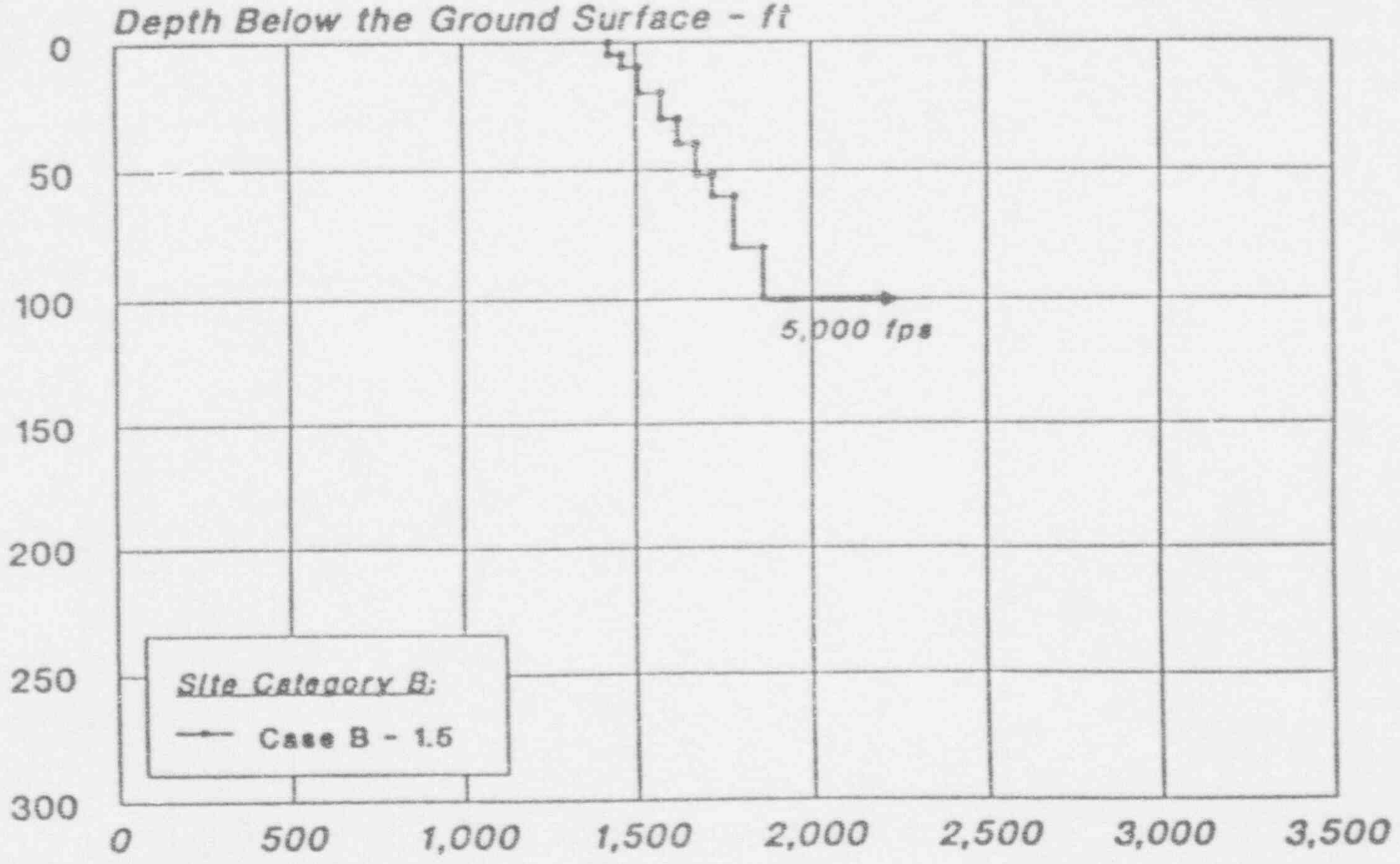
System 80+ Standard Plant
Assigned Shear Wave Velocities - B1.5



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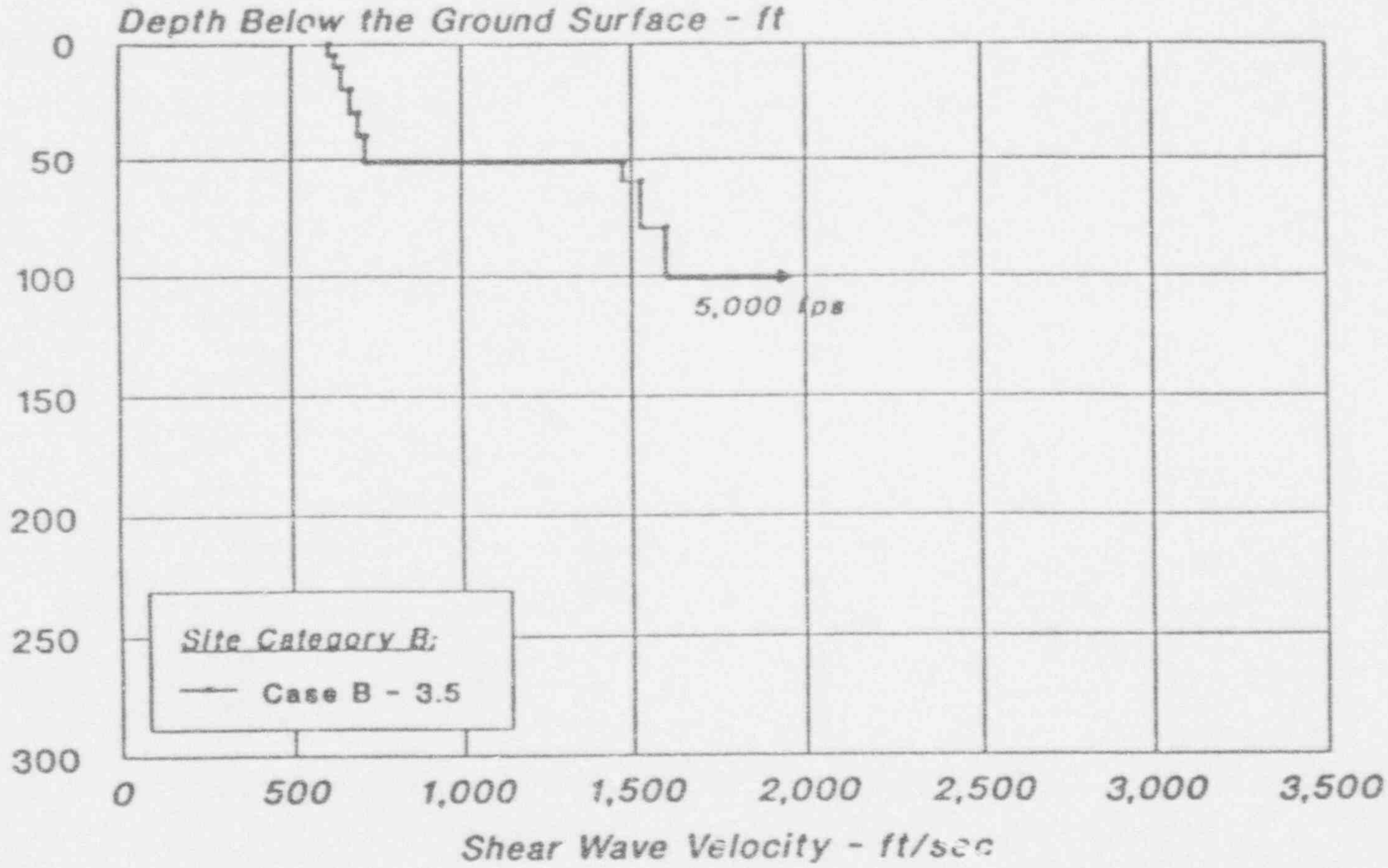
System 80+ Standard Plant
Assigned Shear Wave Velocities - B3.5



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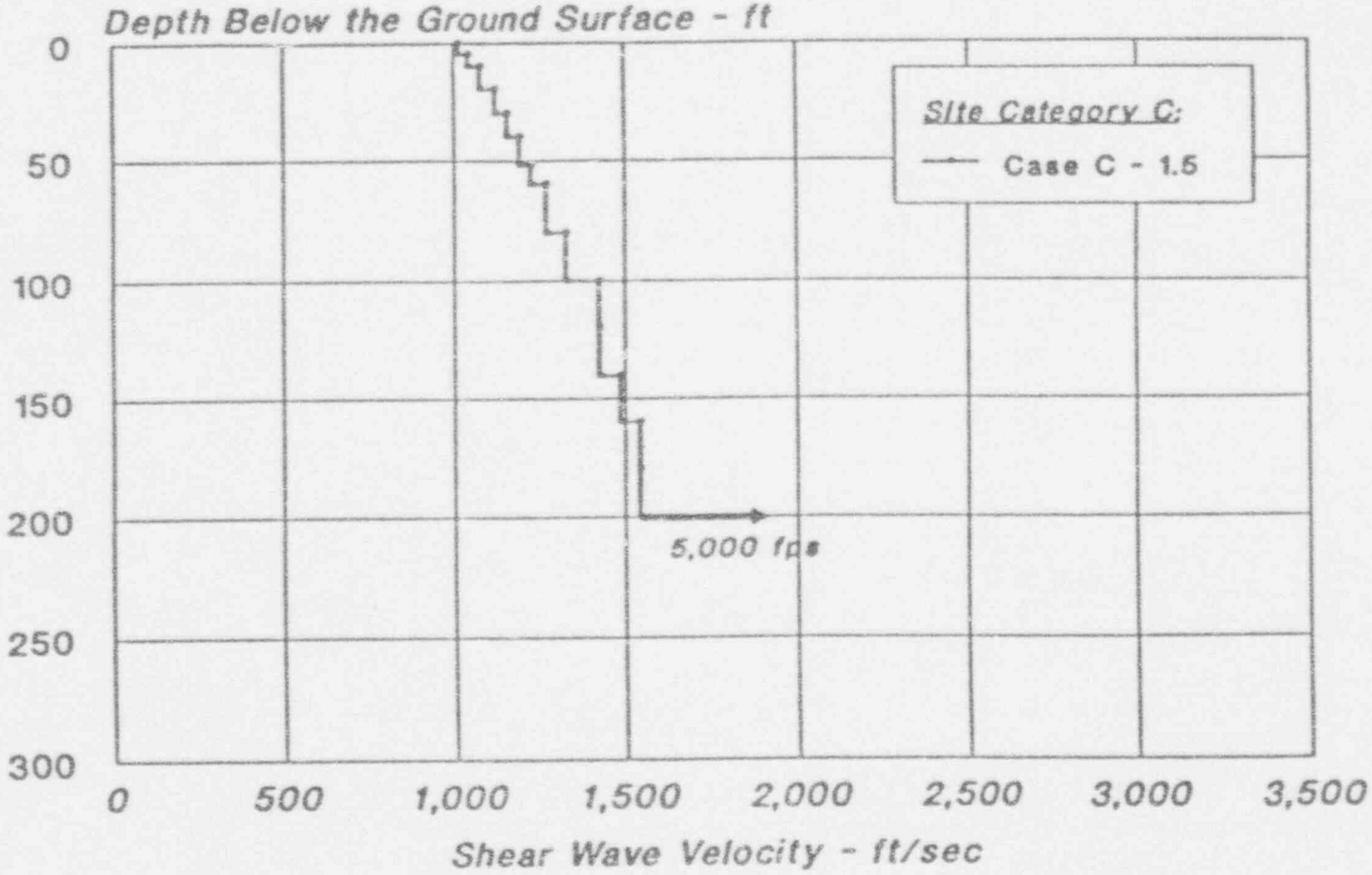
System 80+ Standard Plant
Assigned Shear Wave Velocities - C1.5



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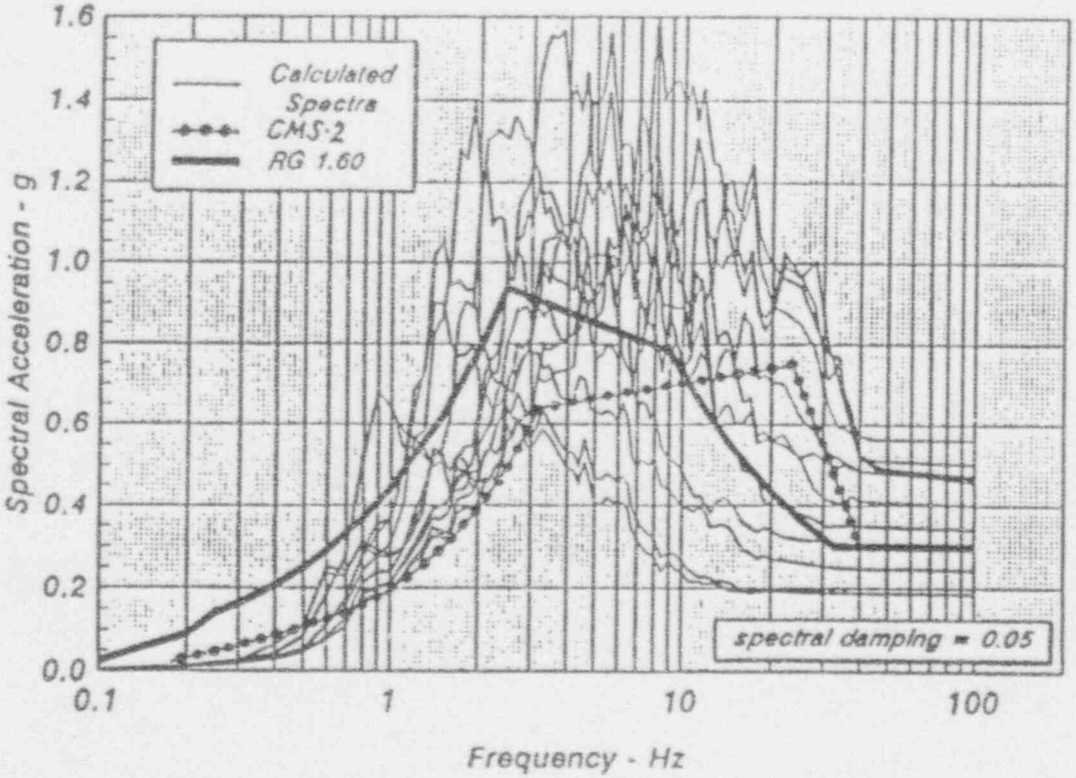
System 80+ Standard Plant CMS1 Comparison with CMS2

Horizontal Ground Surface Motions



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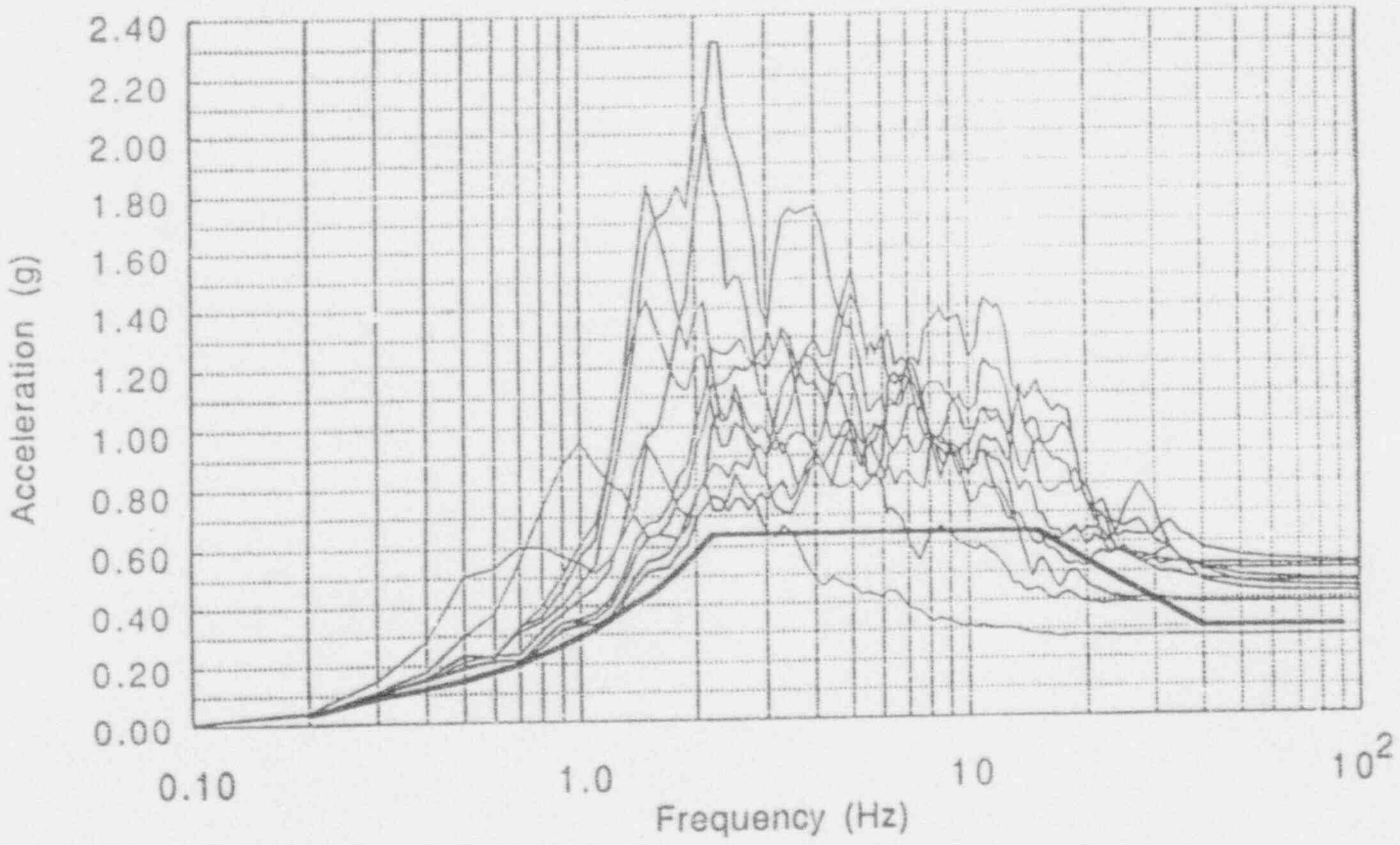
System 80+ Standard Plant Spectra at Ground Surface - CMS3, H1



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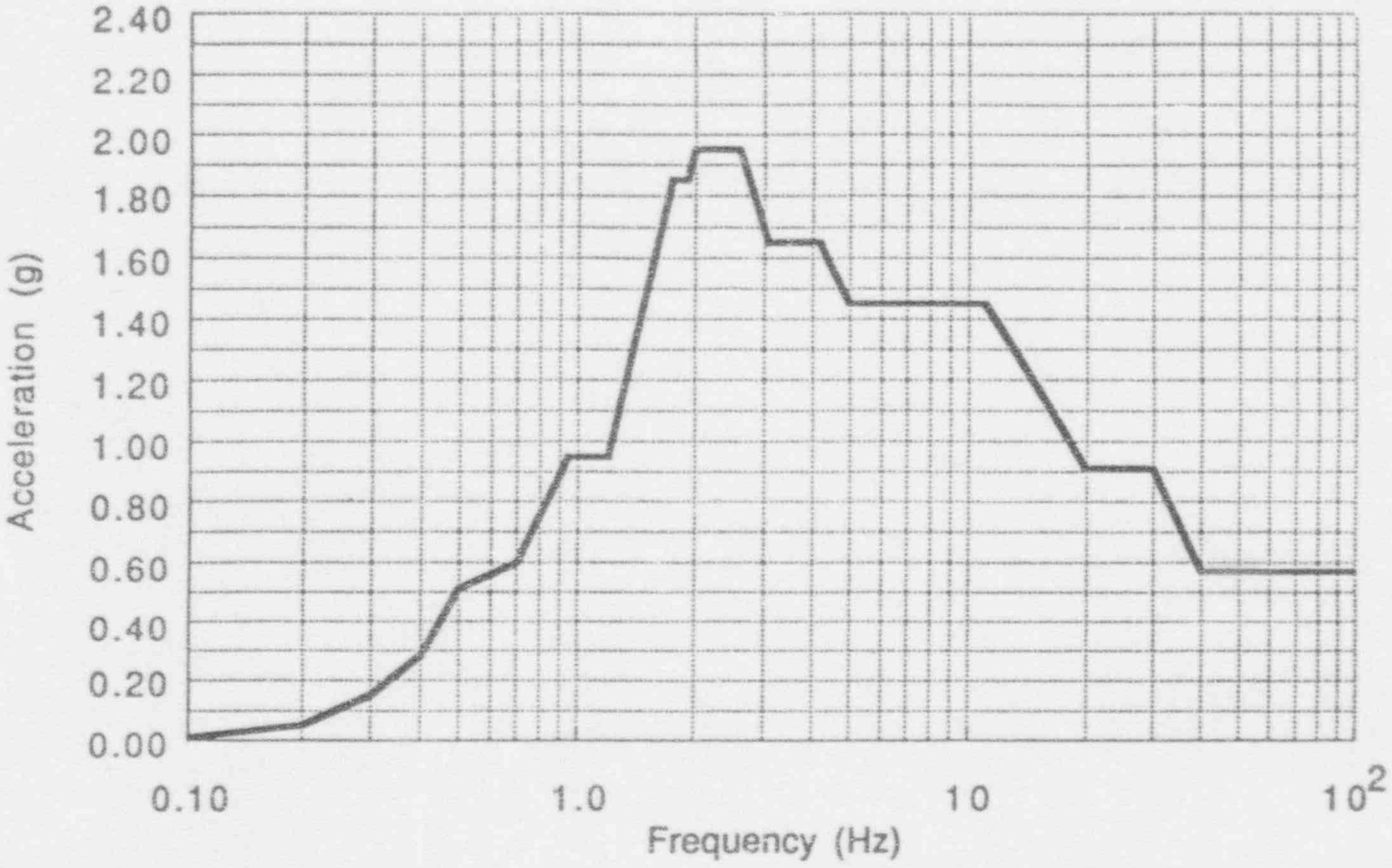
System 80+ Standard Plant

Envelope of Free Field Surface Spectra-Horizontal



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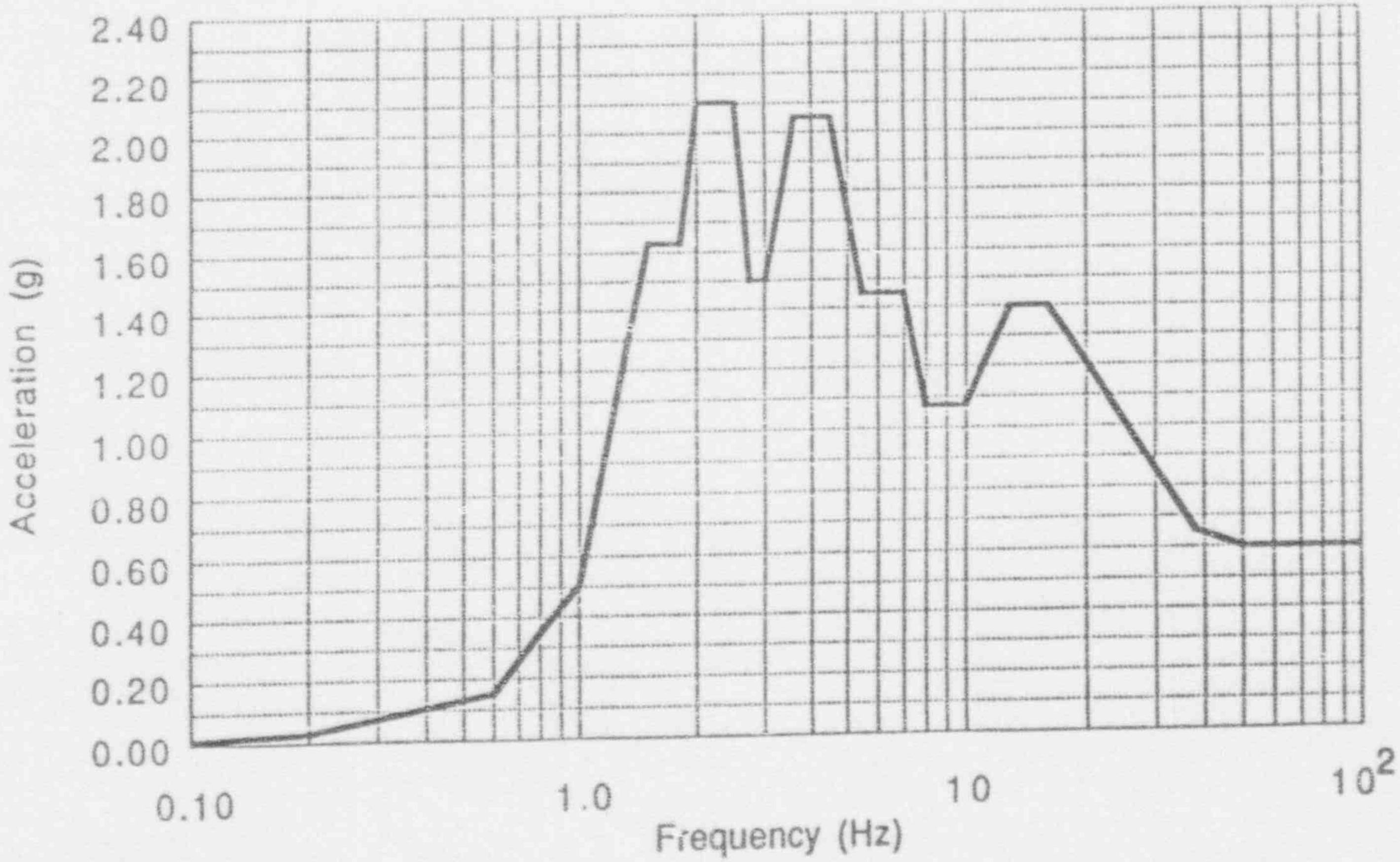
System 80+ Standard Plant
Envelope of Free Field Surface Spectra-Vertical



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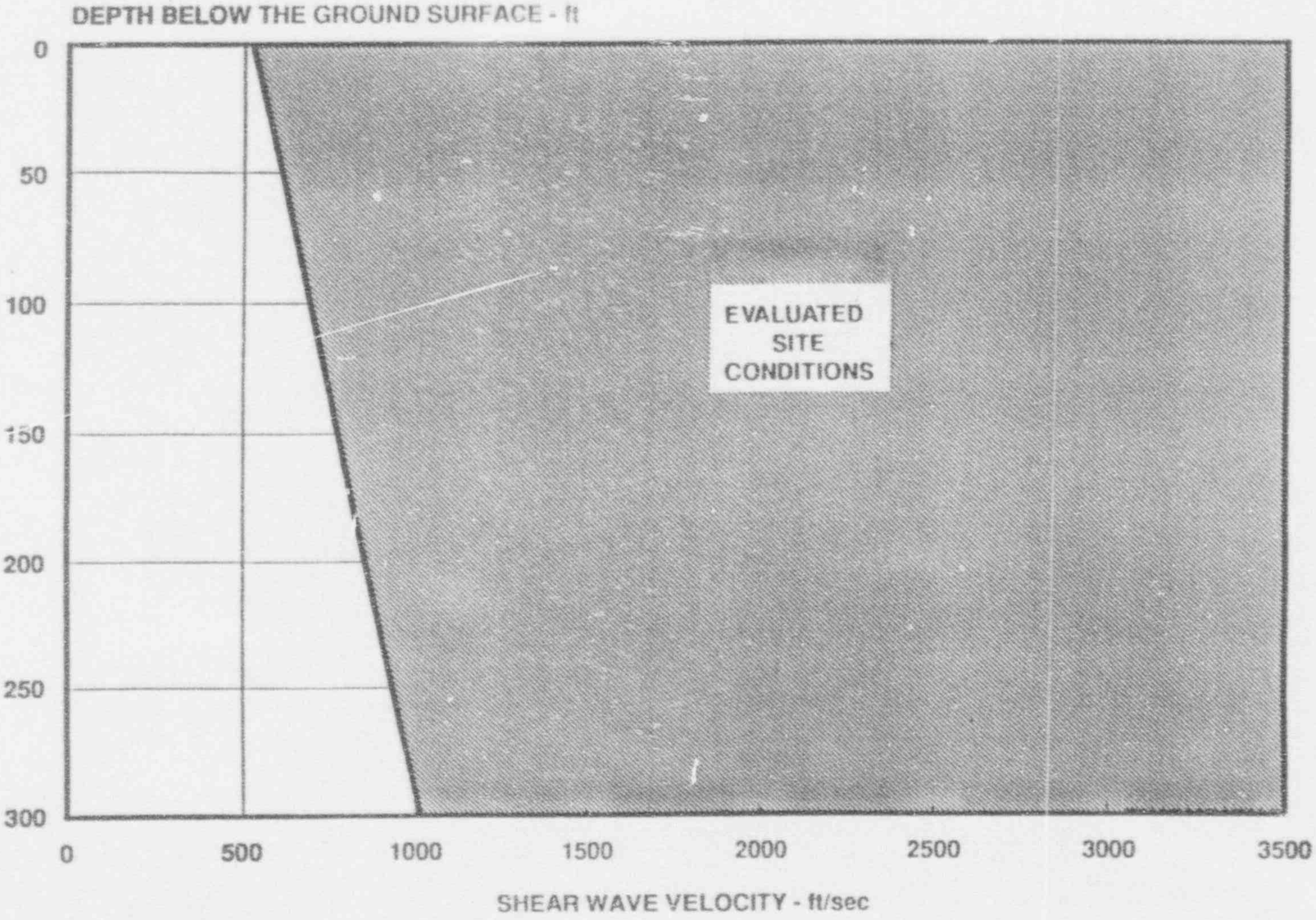
System 80+ Standard Plant

Range of Shear Wave Velocities - All Cases Considered



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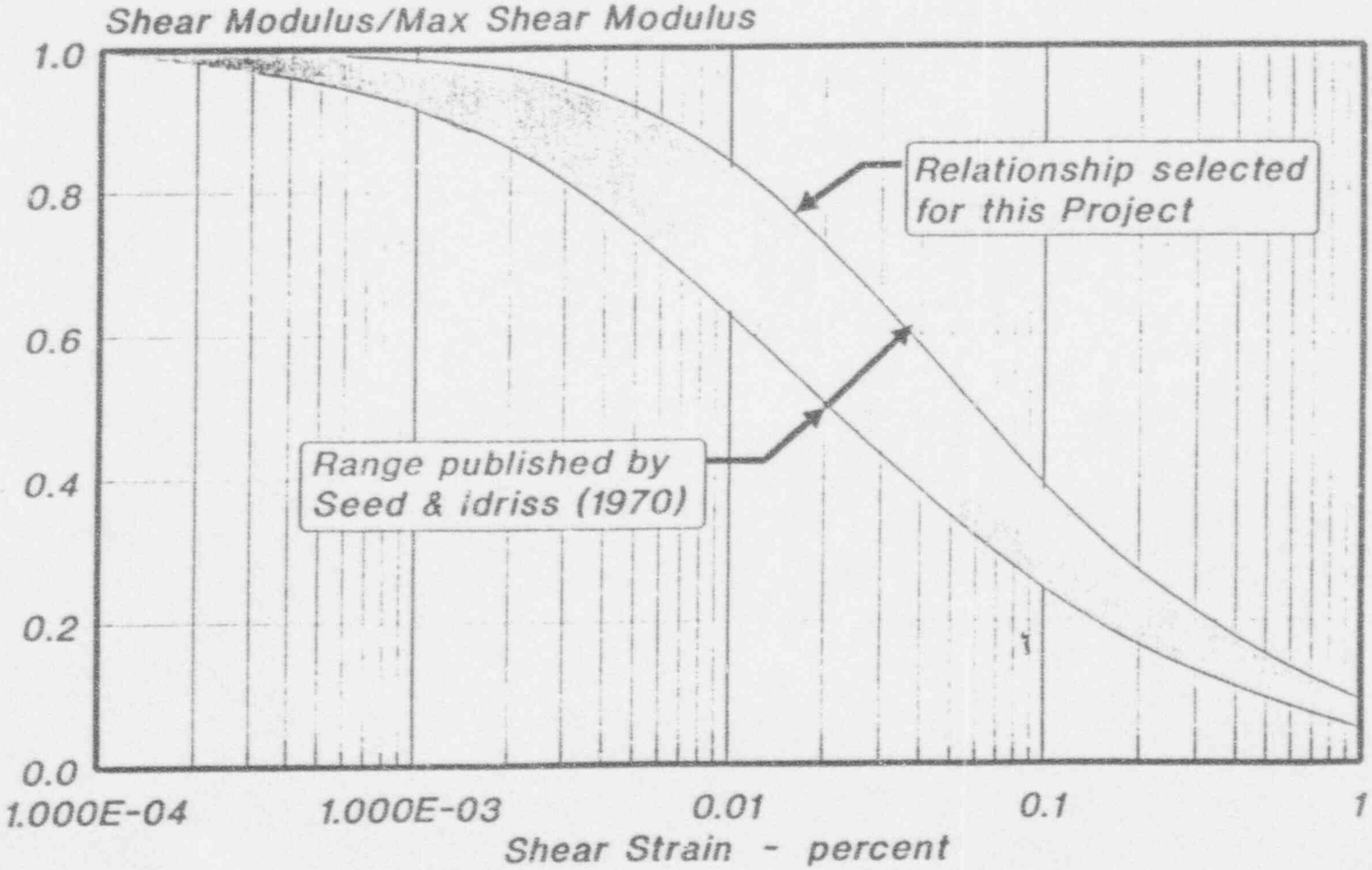
System 80+ Standard Plant
Variation of Shear Modulus



Relationship selected for this Project

Range published by Seed & idriss (1970)

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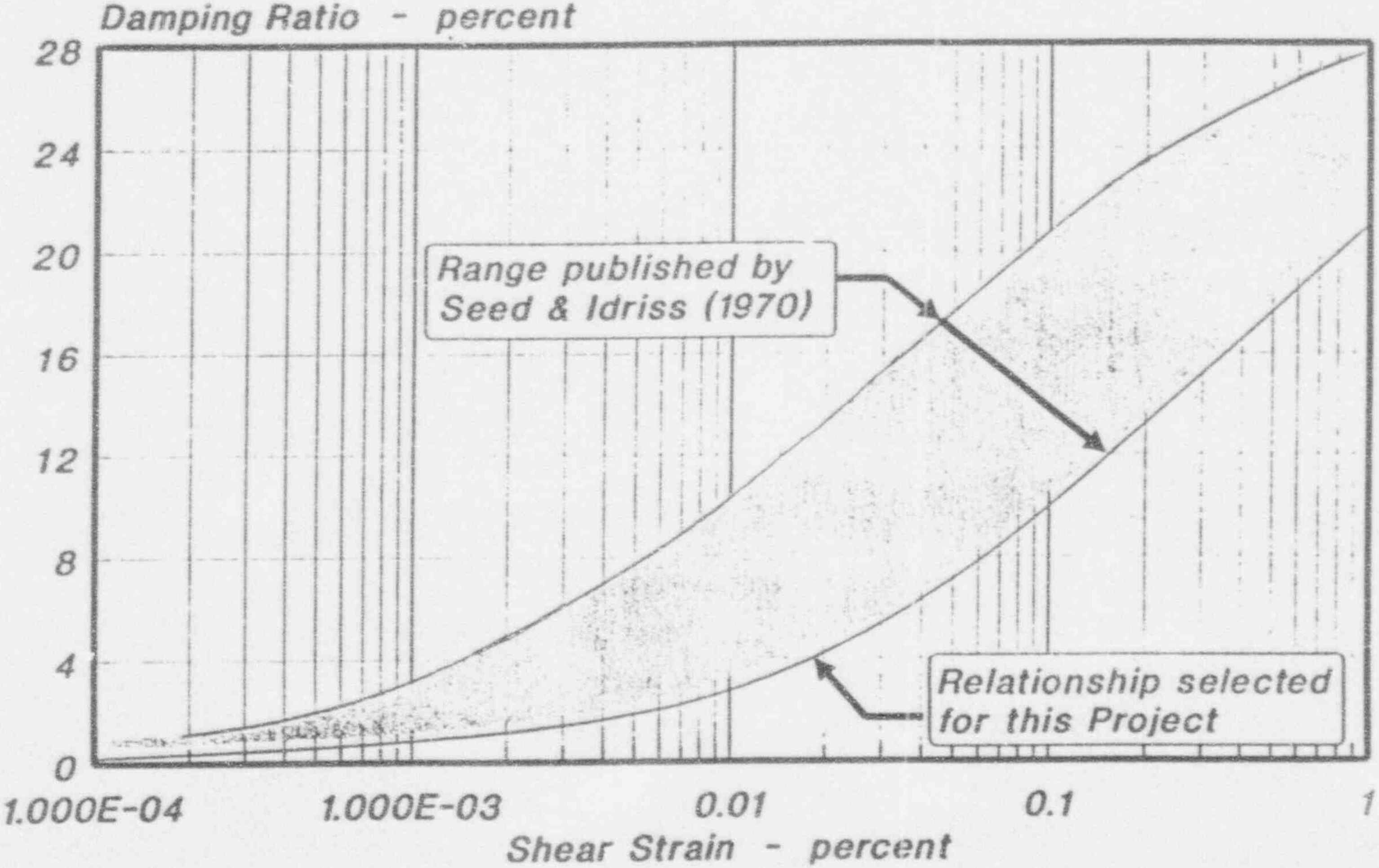
System 80+ Standard Plant
Variation of Damping Ratio



Range published by Seed & Idriss (1970)

Relationship selected for this Project

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RAK ACRS2b 3/2/94

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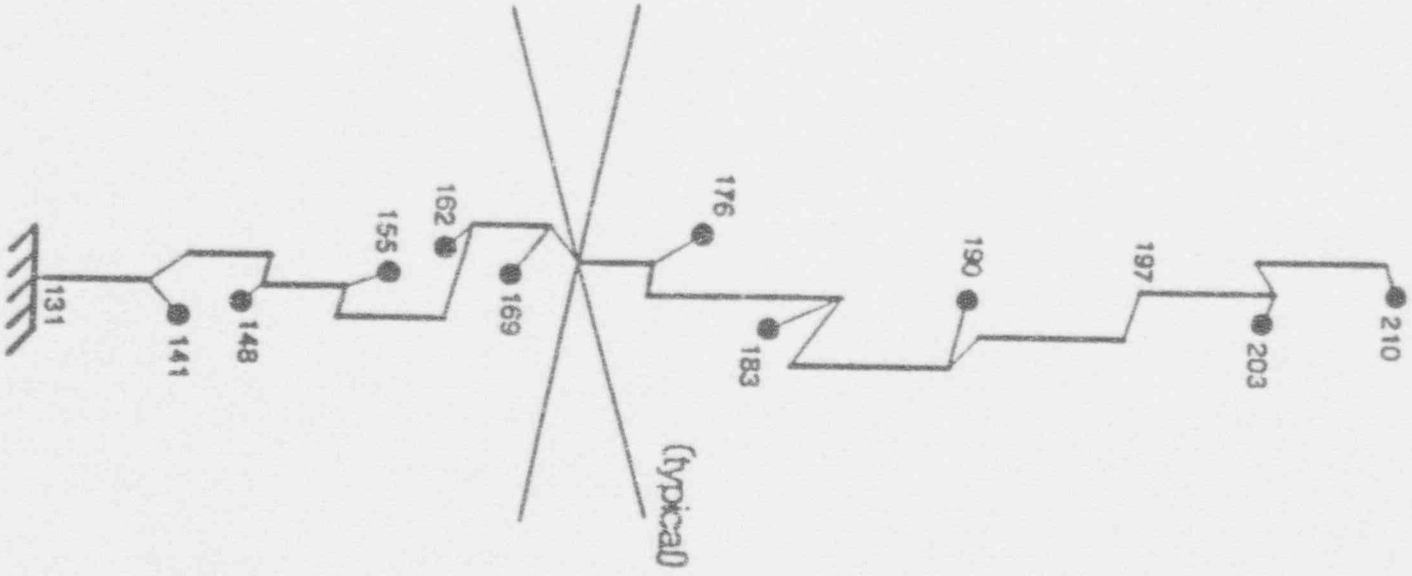
Model Development

System 80+ Standard Plant
Stick Model of Internal Structure



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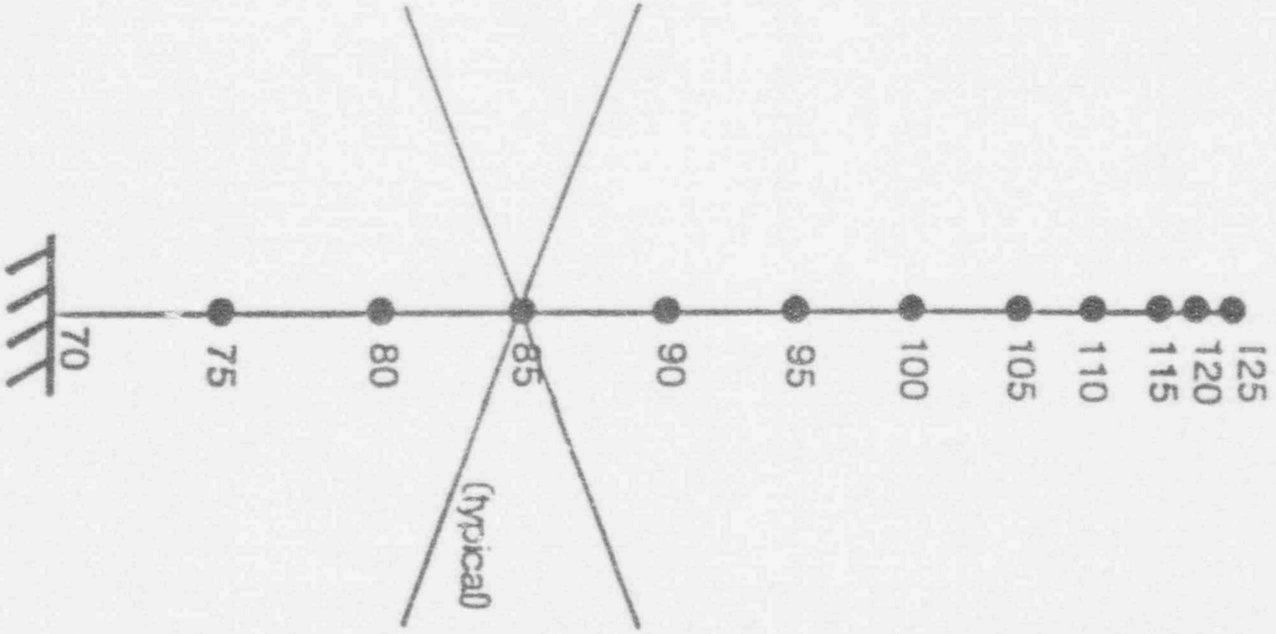
System 80+ Standard Plant
Stick Model of Shield Building



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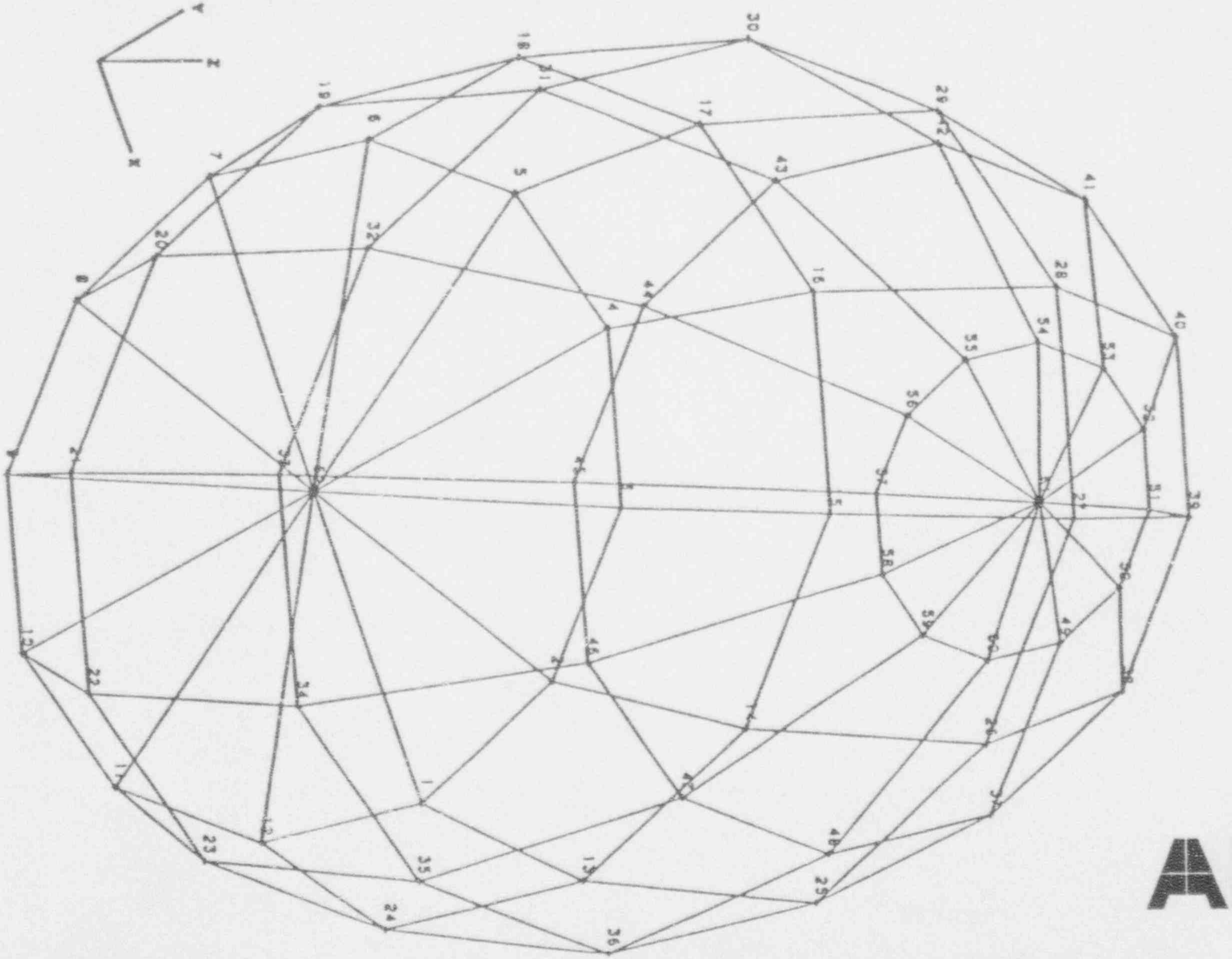
System 80+ Standard Plant
Model of Steel Containment



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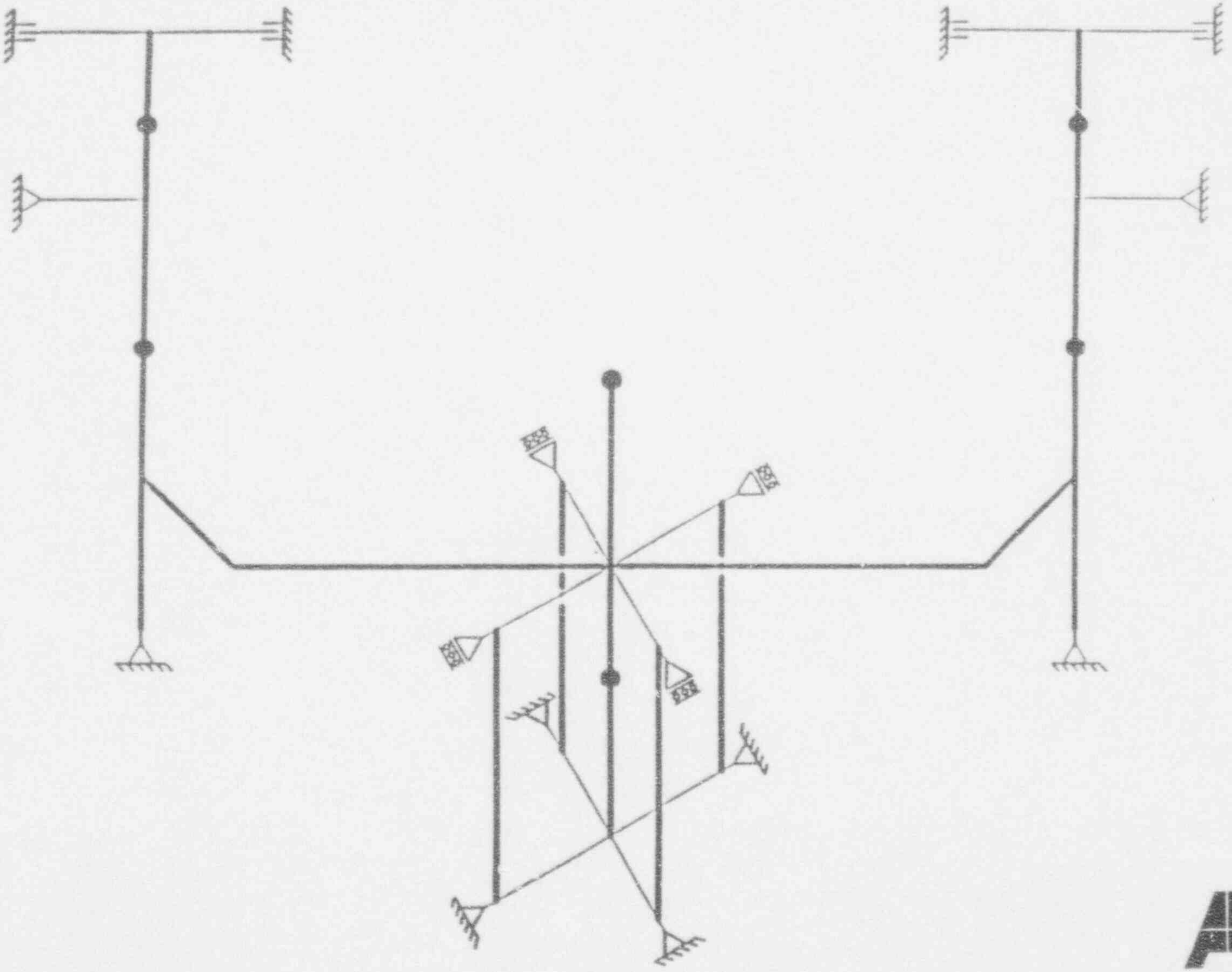
System 80+ Standard Plant
Representation of Reactor Coolant System



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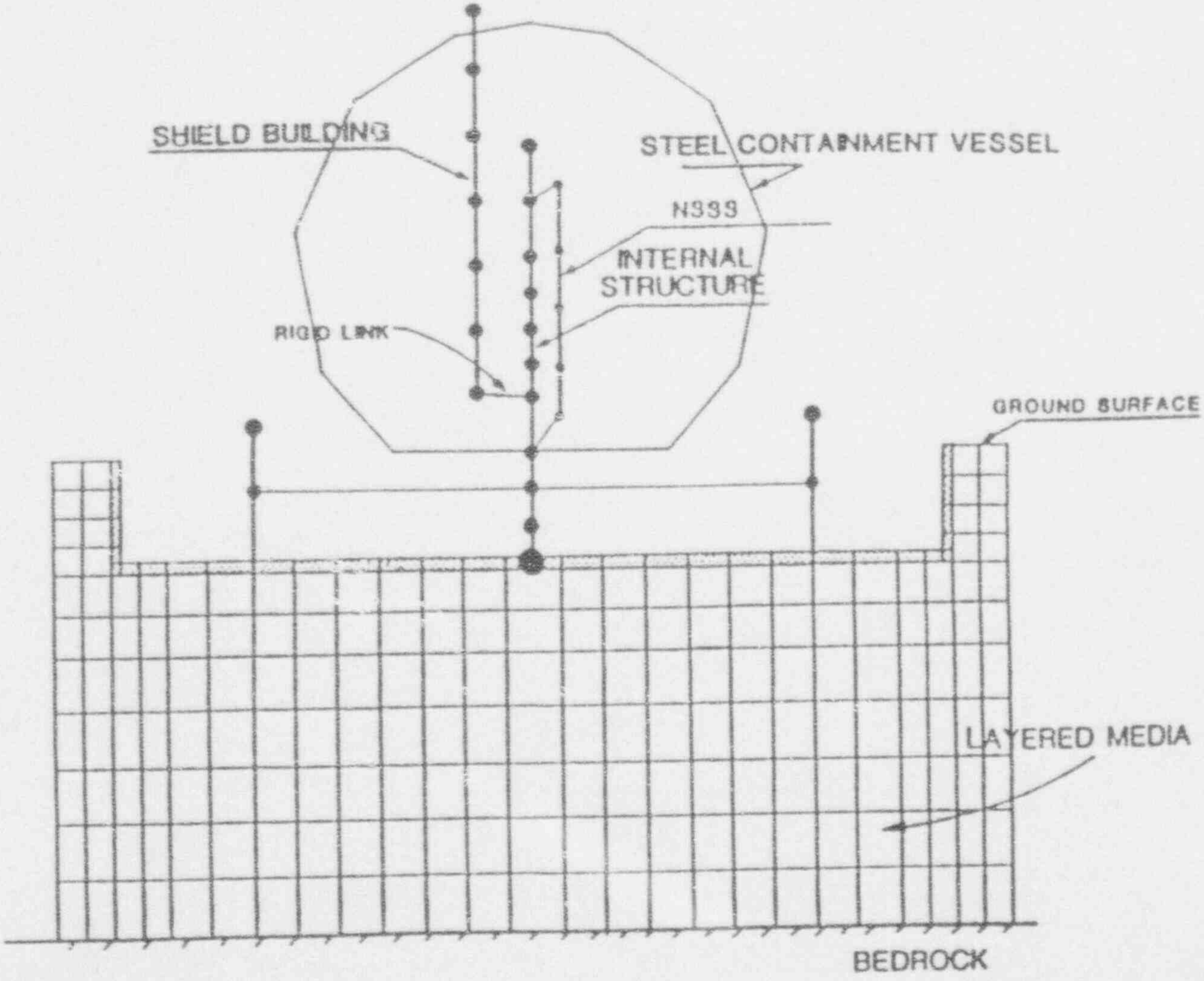
System 80+ Standard Plant
Schematic Representation of Nuclear Island Model



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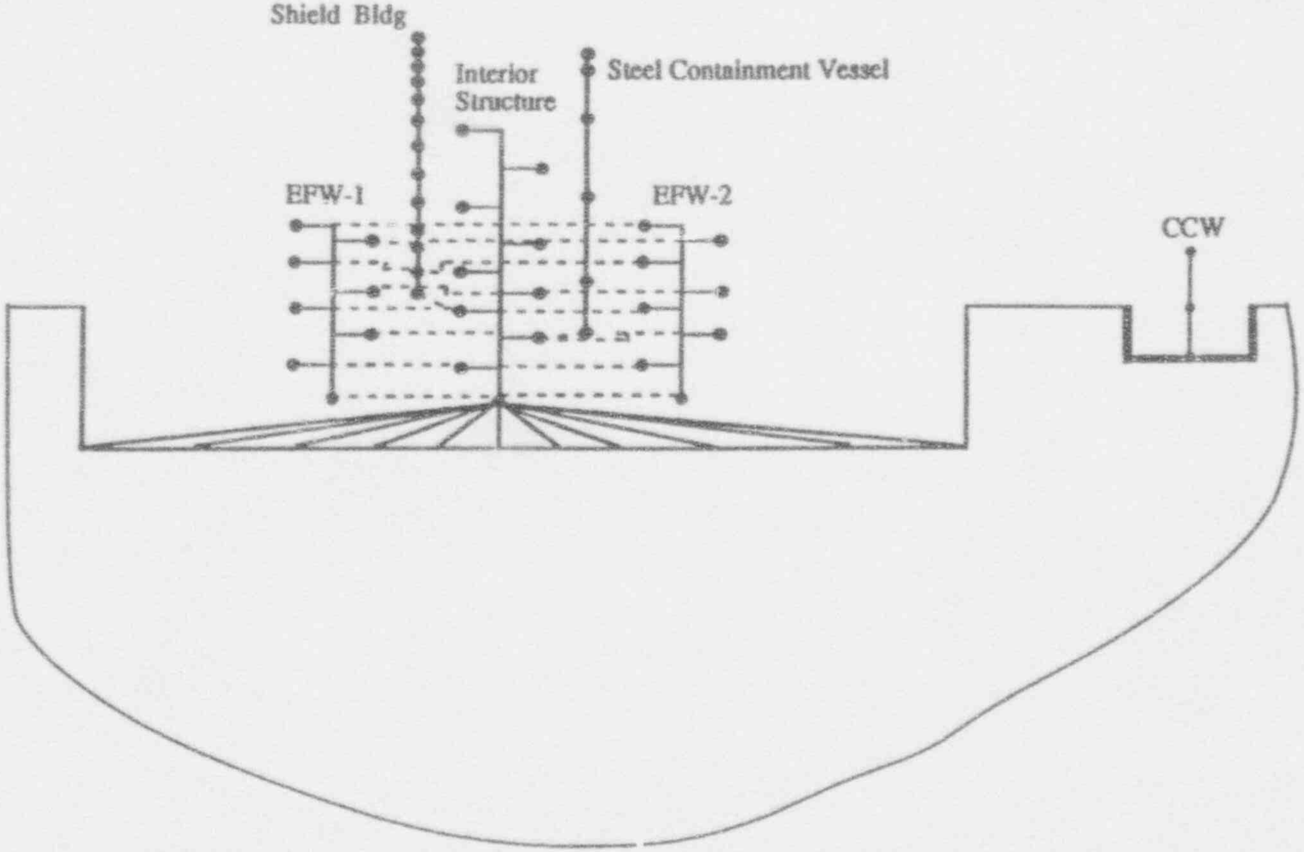
System 80+ Standard Plant
Coupled Interaction Model



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Dynamic Analysis

System 80+ Standard Plant Soil - Structure Interaction Analysis

- Computer program used:
  - SASSI (System for Analysis of Soil - Structure Interaction)

- General approach
  - Compute a site response
  - Computation of foundation independences
  - Solution of structural problem

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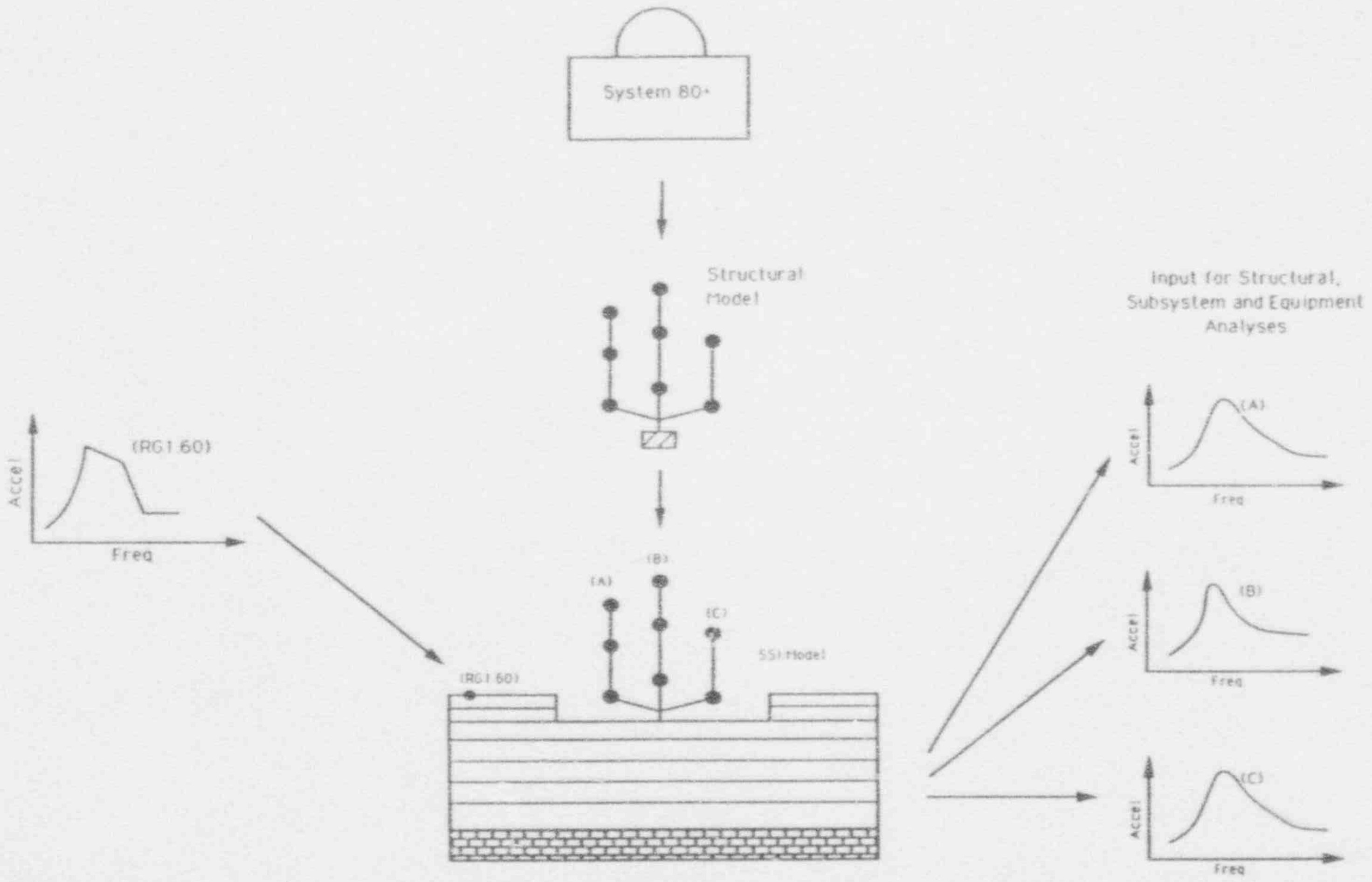
System 80+ Standard Plant
Application of Control Motions - CMS1



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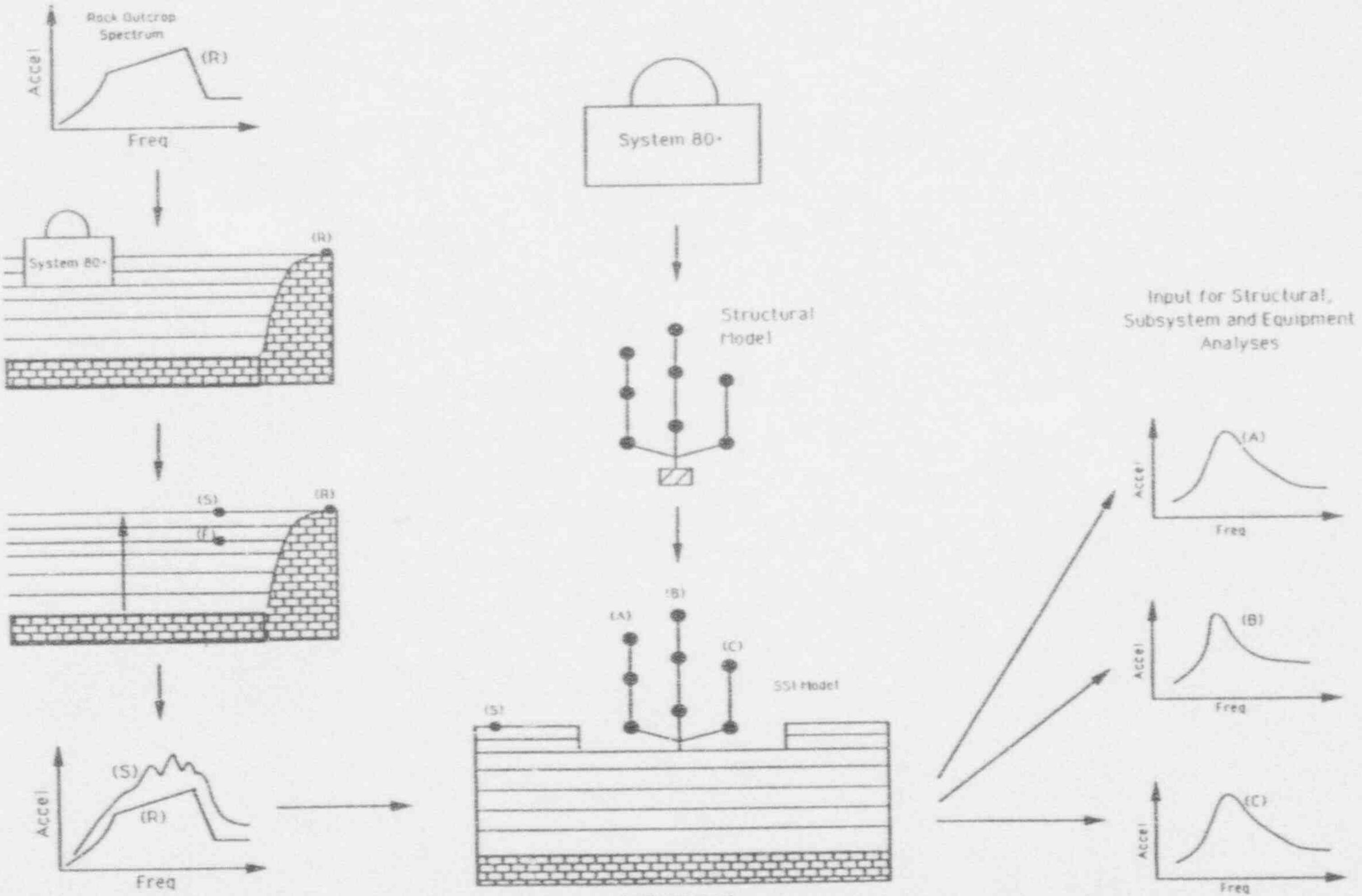
System 80+ Standard Plant
Application of Control Motions - CMS2 & CMS3



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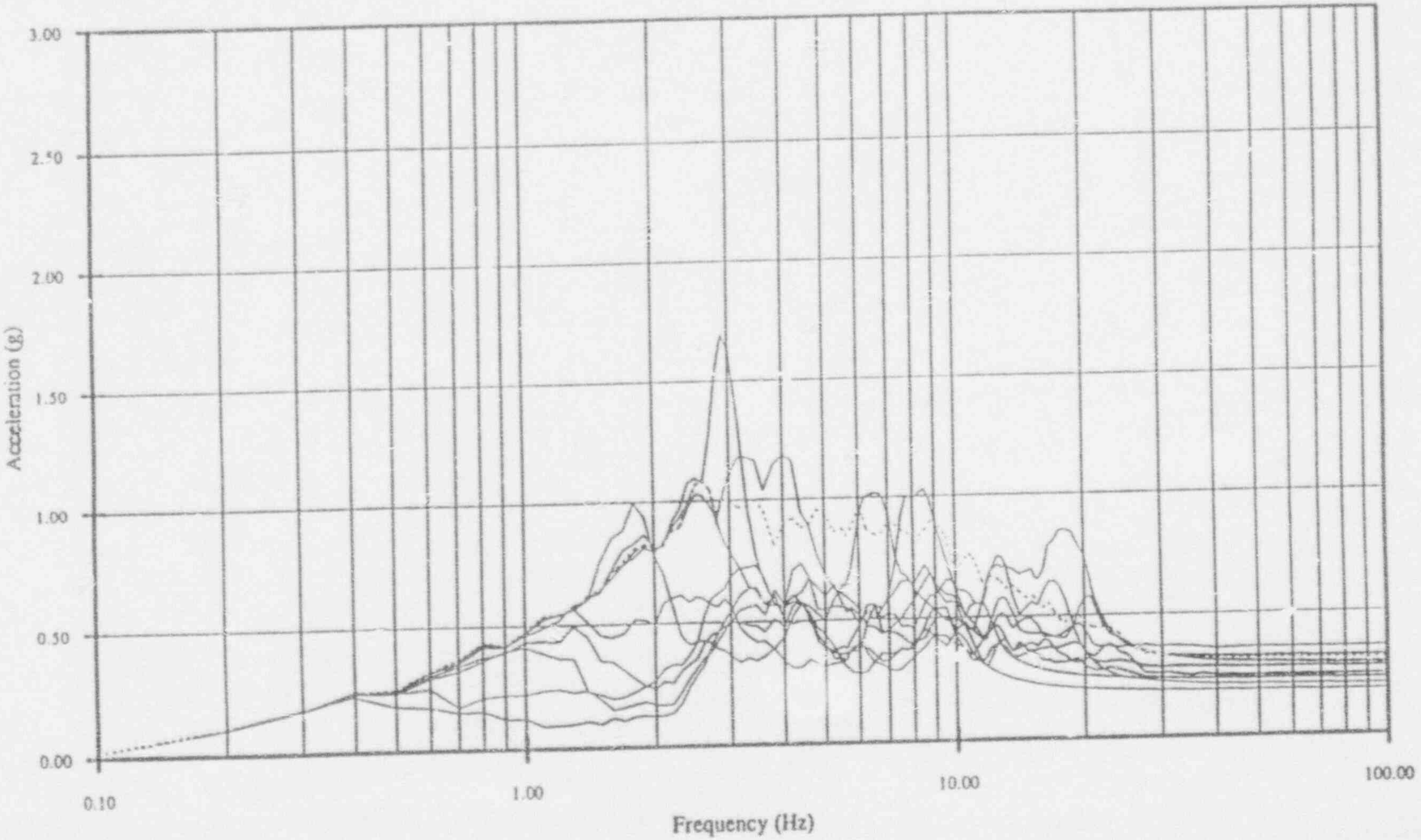
In-Structure
Response Spectra

System 80+ Standard Plant
Basemat Spectra - CMS1, E-W, 5%



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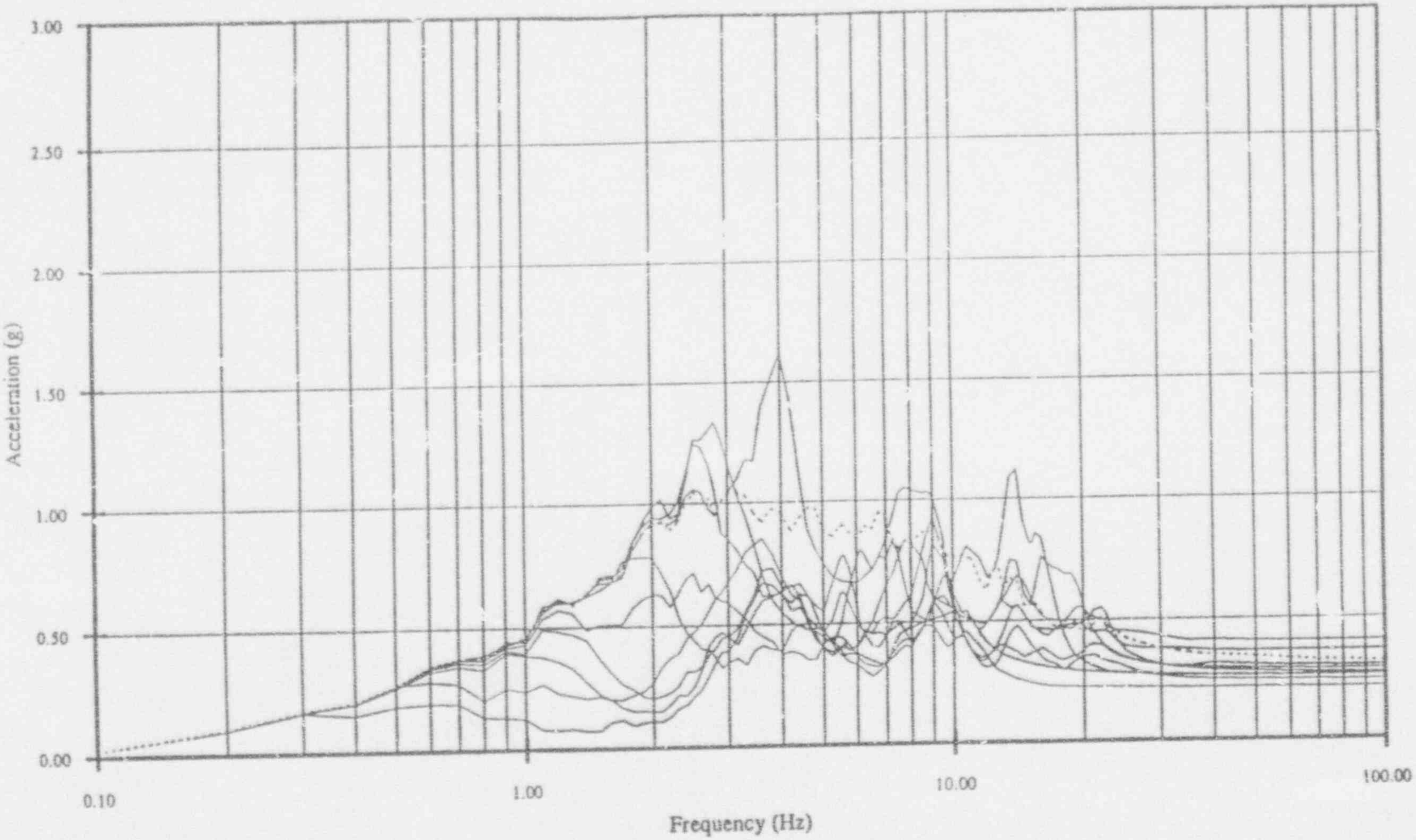
System 80+ Standard Plant
Basemat Spectra - CMS1, N-S, 5%



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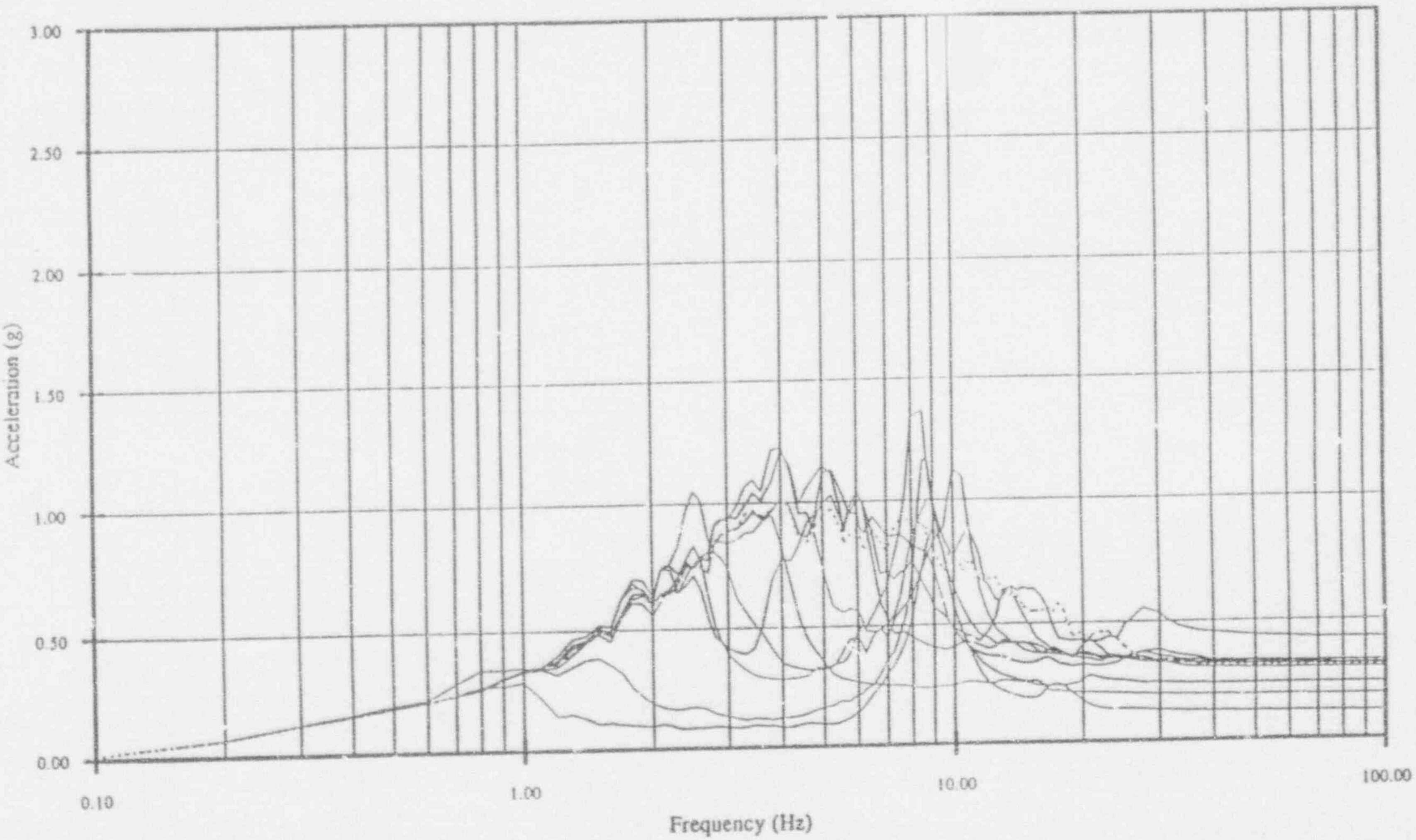
System 80+ Standard Plant
Basemat Spectra - CMS1, V, 5%



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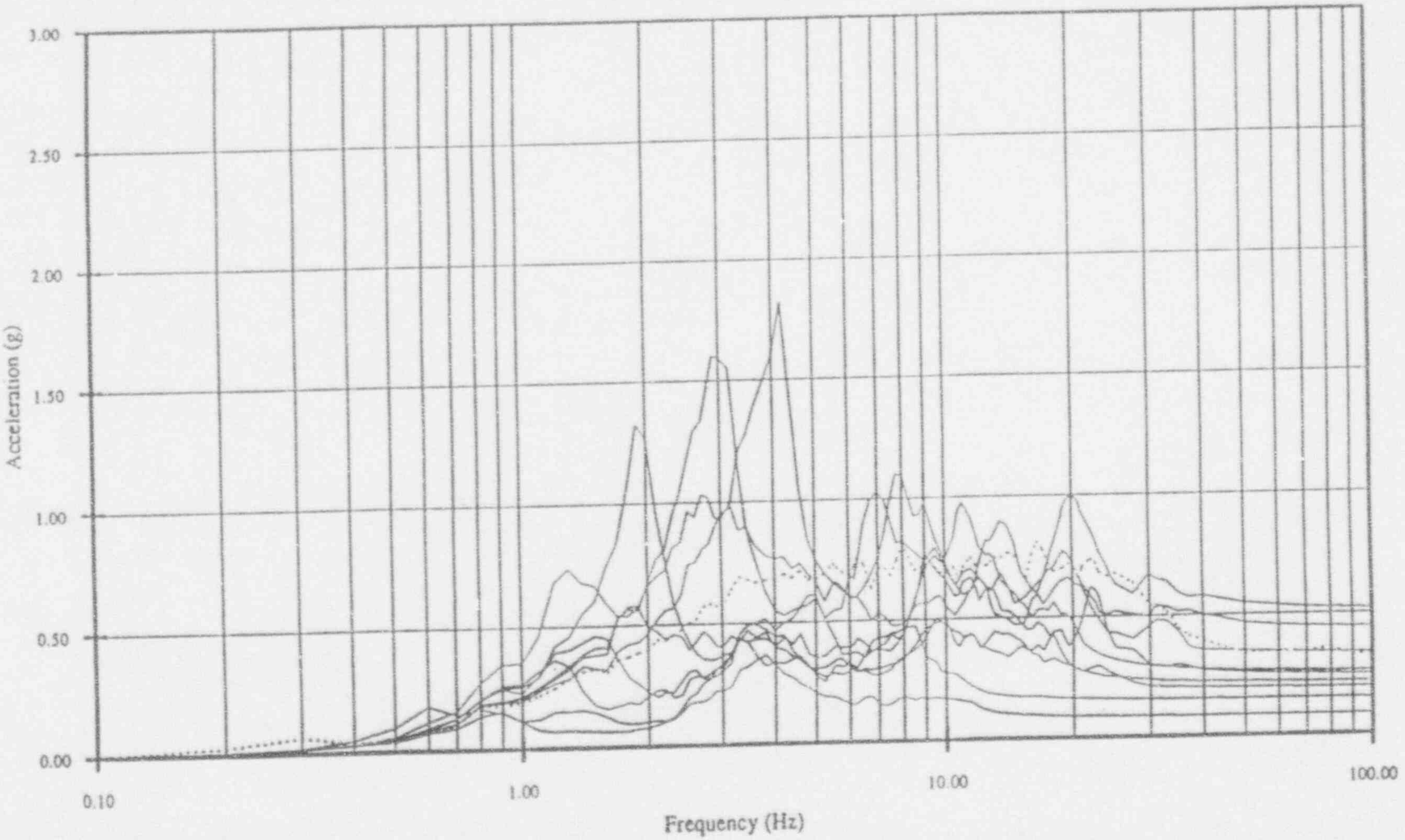
System 80+ Standard Plant
Basemat Spectra - CMS2, E-W, 5%



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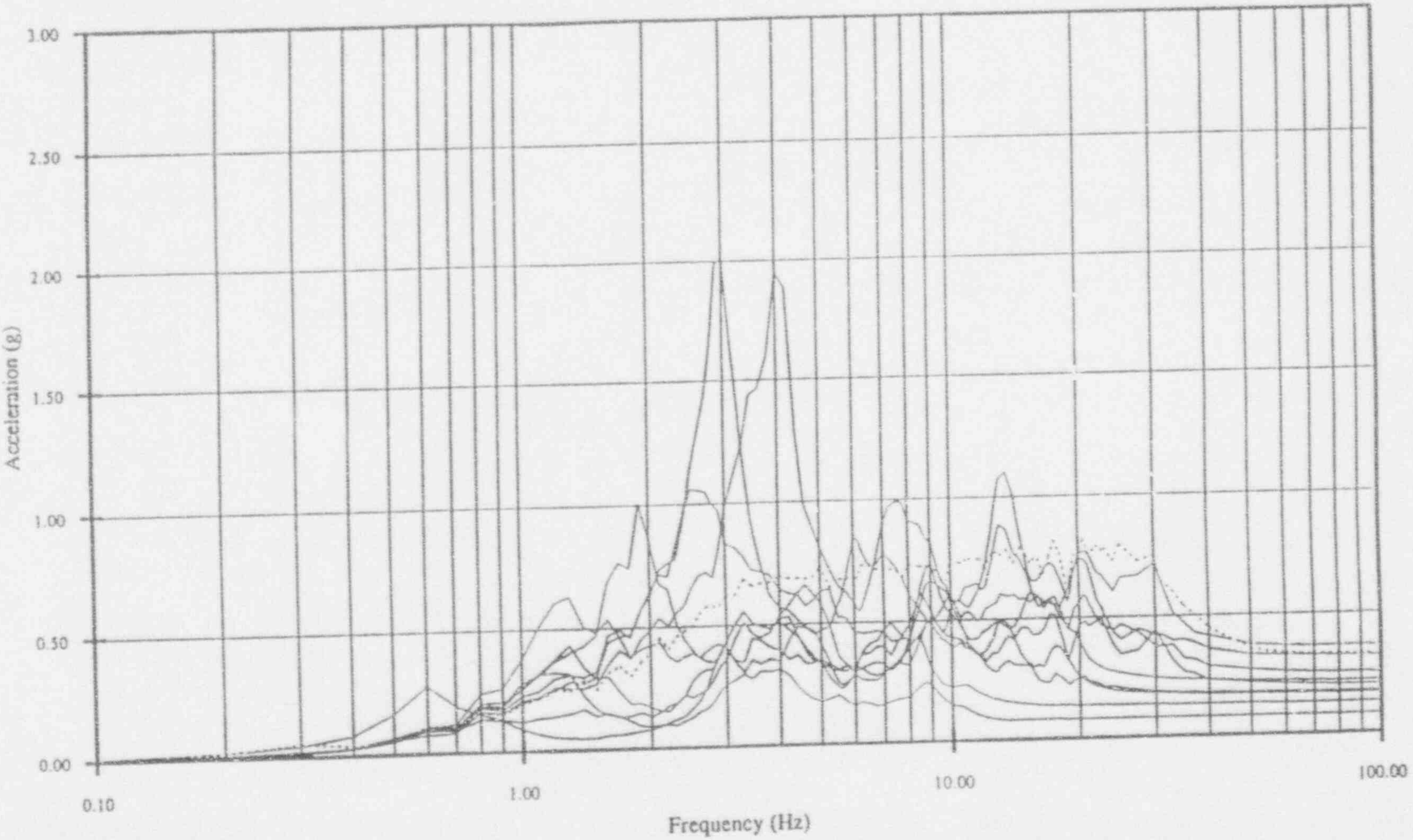
System 80+ Standard Plant
Basemat Spectra - CMS2, N-S, 5%



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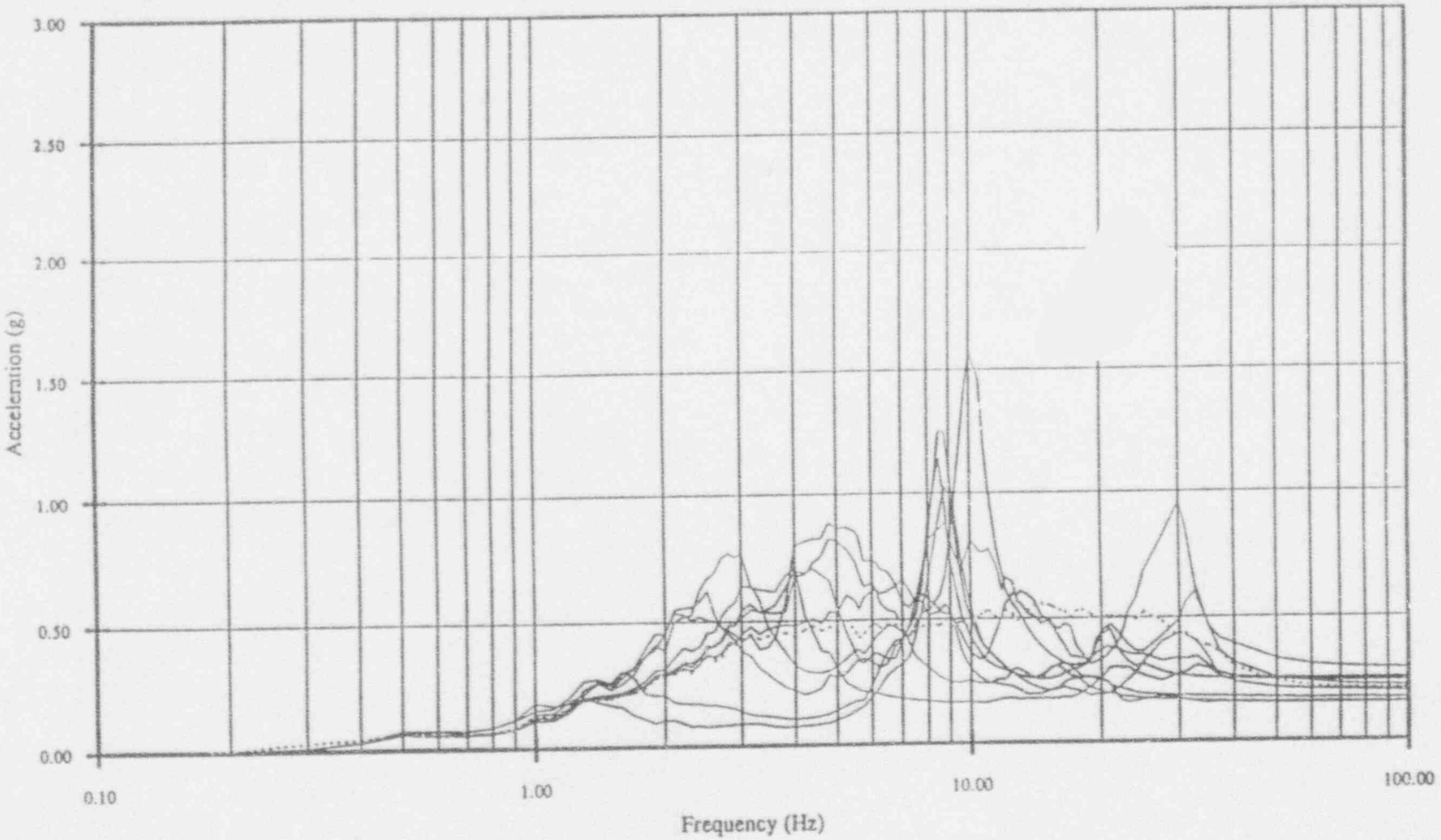
System 80+ Standard Plant
Basemat Spectra - CMS2, V, 5%



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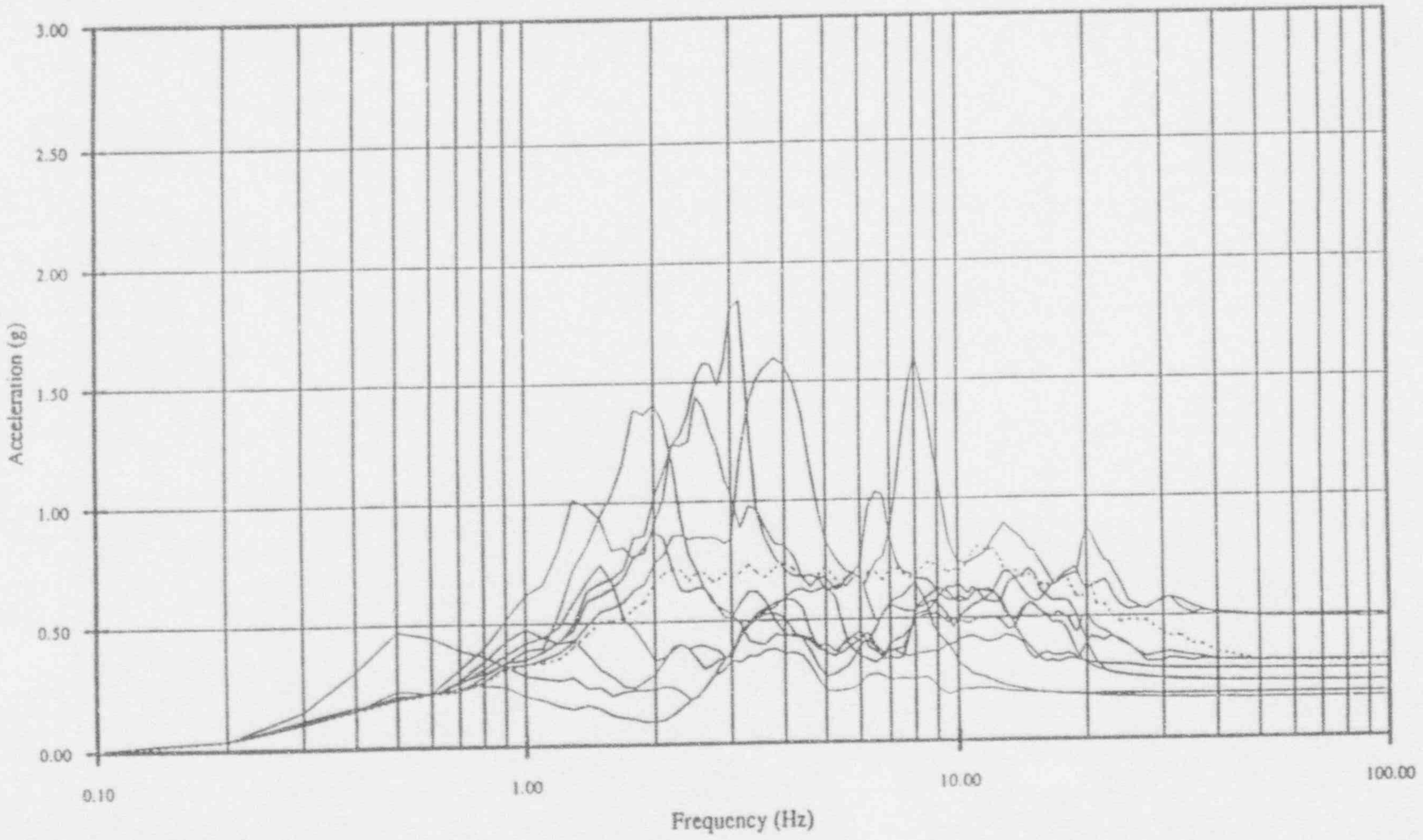
System 80+ Standard Plant
Basemat Spectra - CMS3, E-W, 5%



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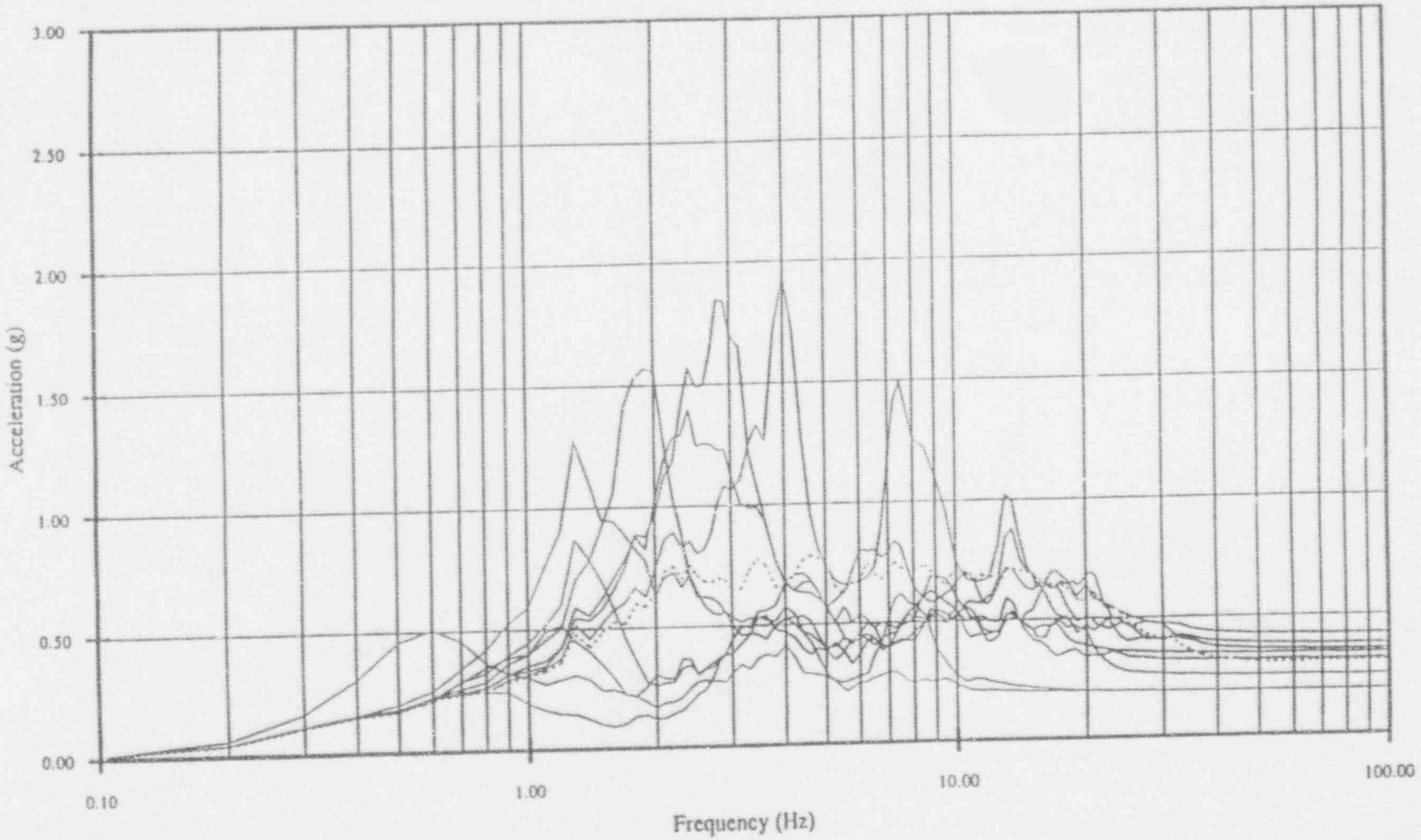
System 80+ Standard Plant
Basemat Spectra - CMS3, N-S, 5%



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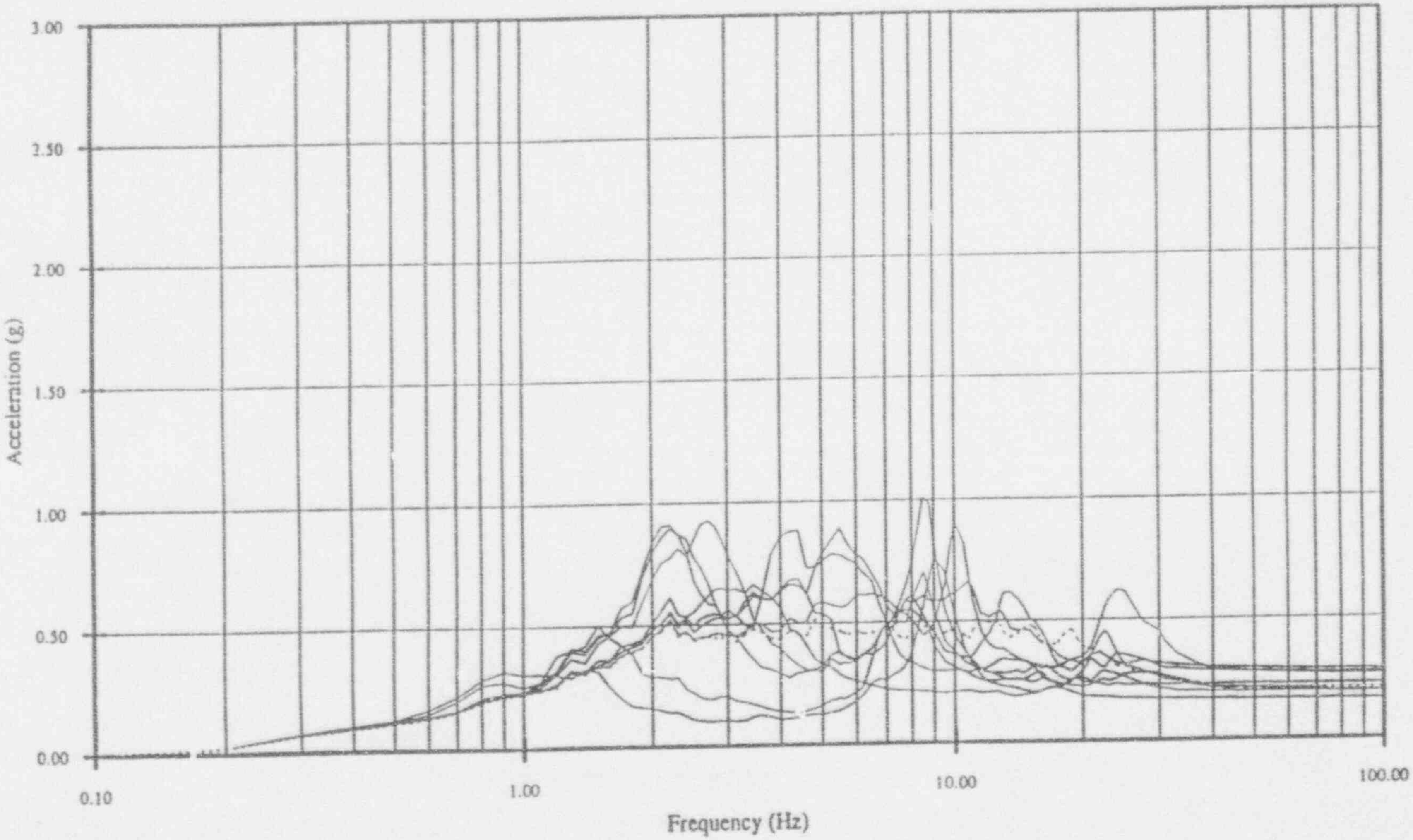
System 80+ Standard Plant
Basemat Spectra - CMS3, V, 5%



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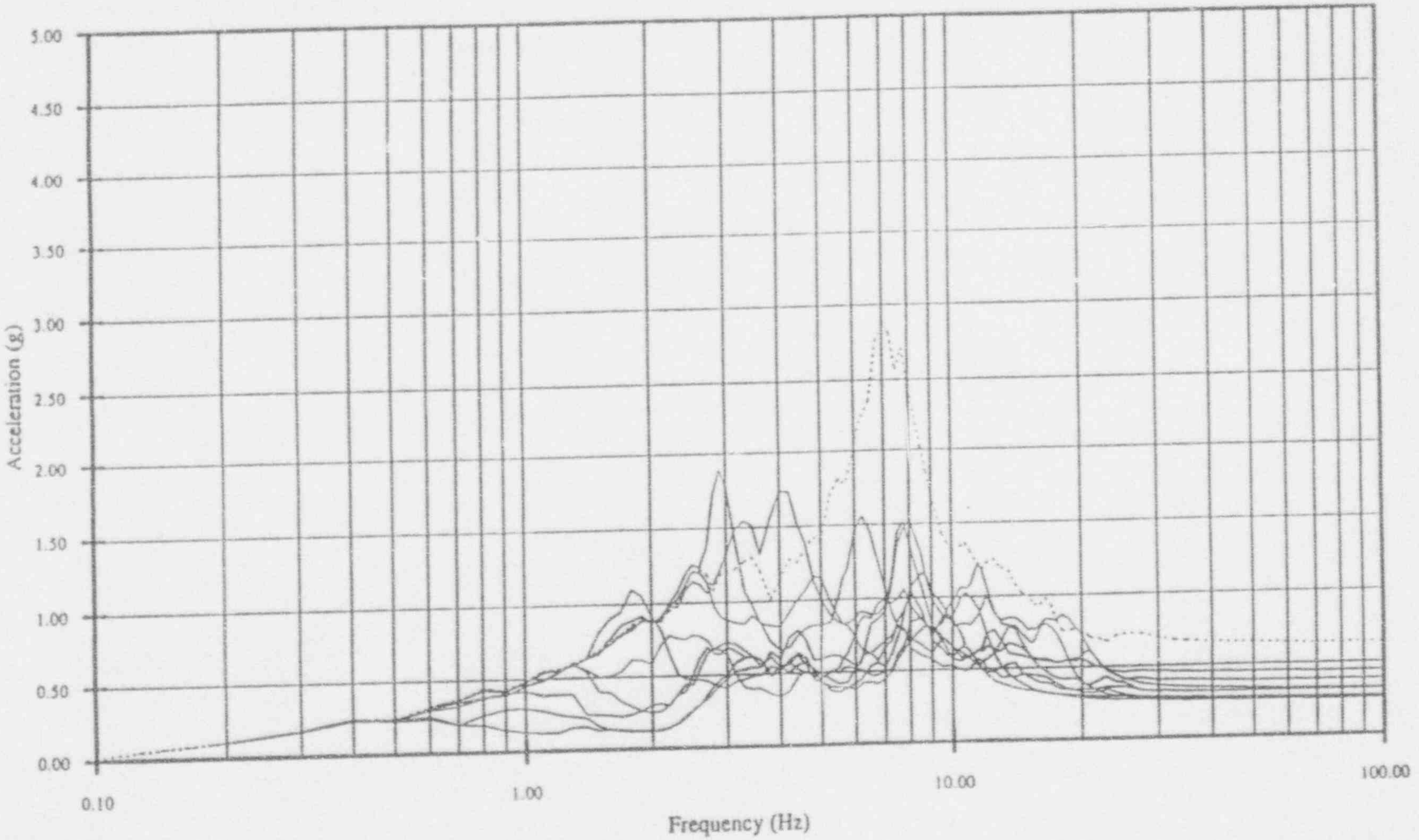
System 80+ Standard Plant
Control Room - CMS1, E-W, 5%



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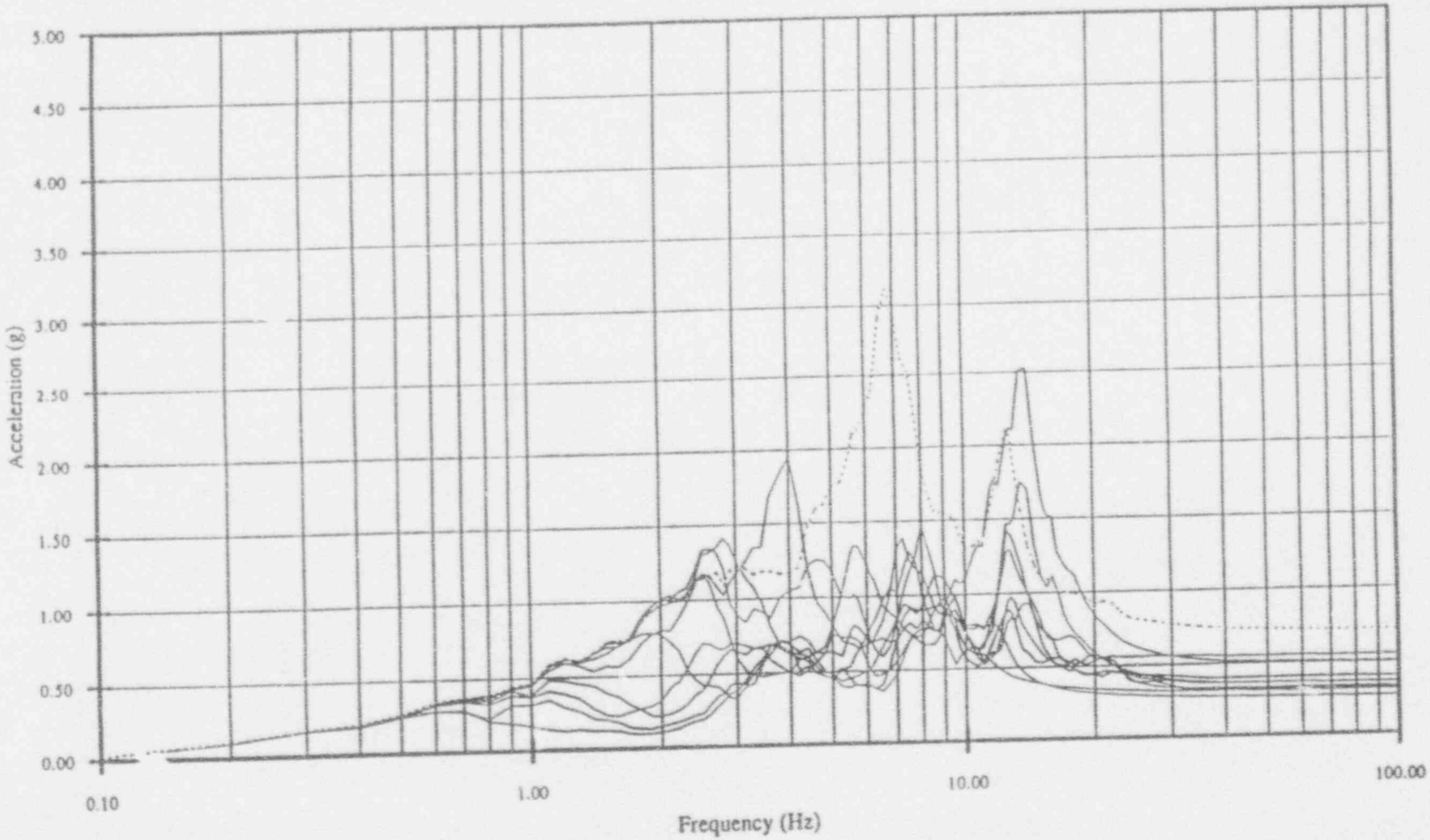
System 80+ Standard Plant
Control Room - CMS1, N-S, 5%



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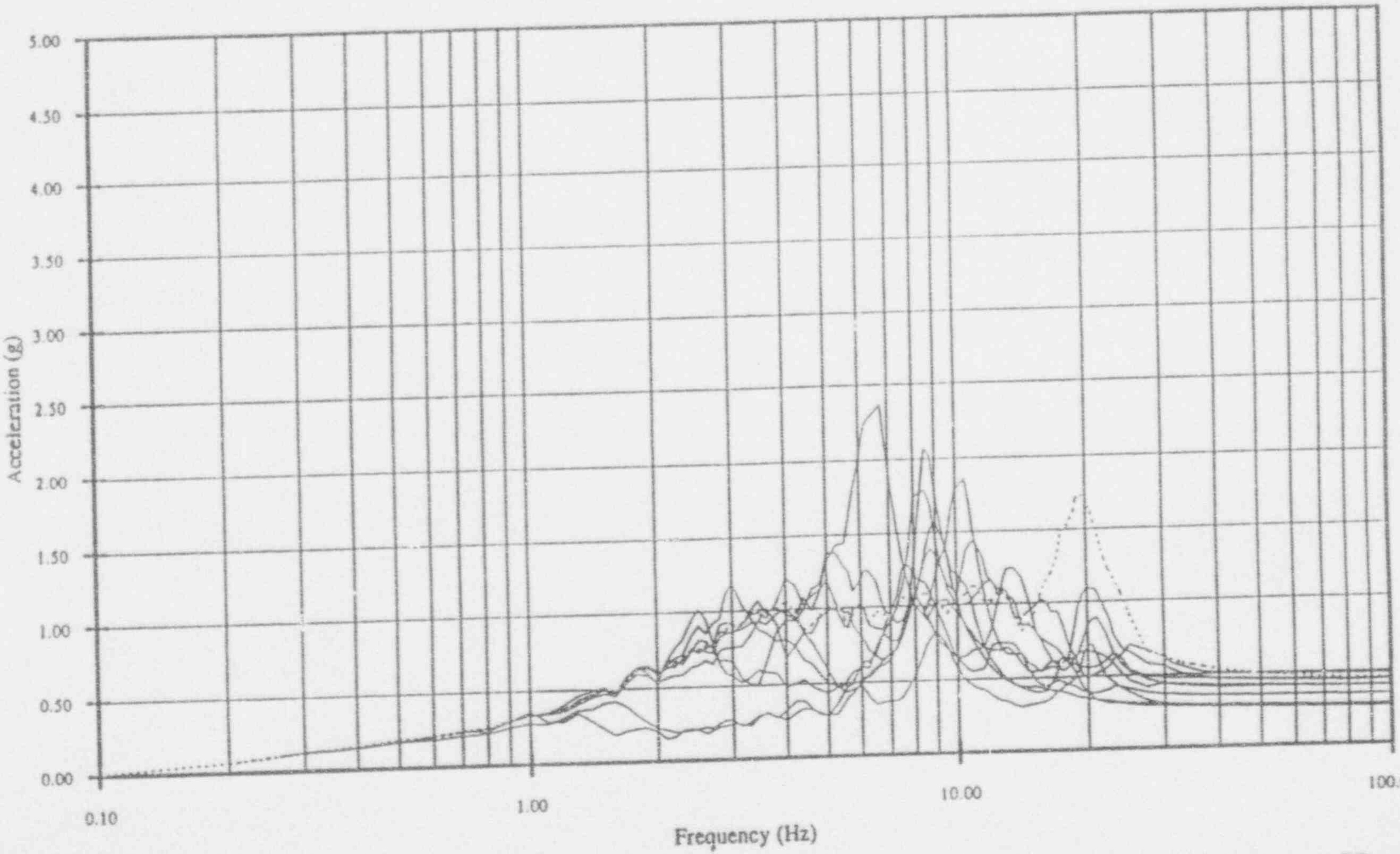
System 80+ Standard Plant
Control Room - CMS1, V, 5%



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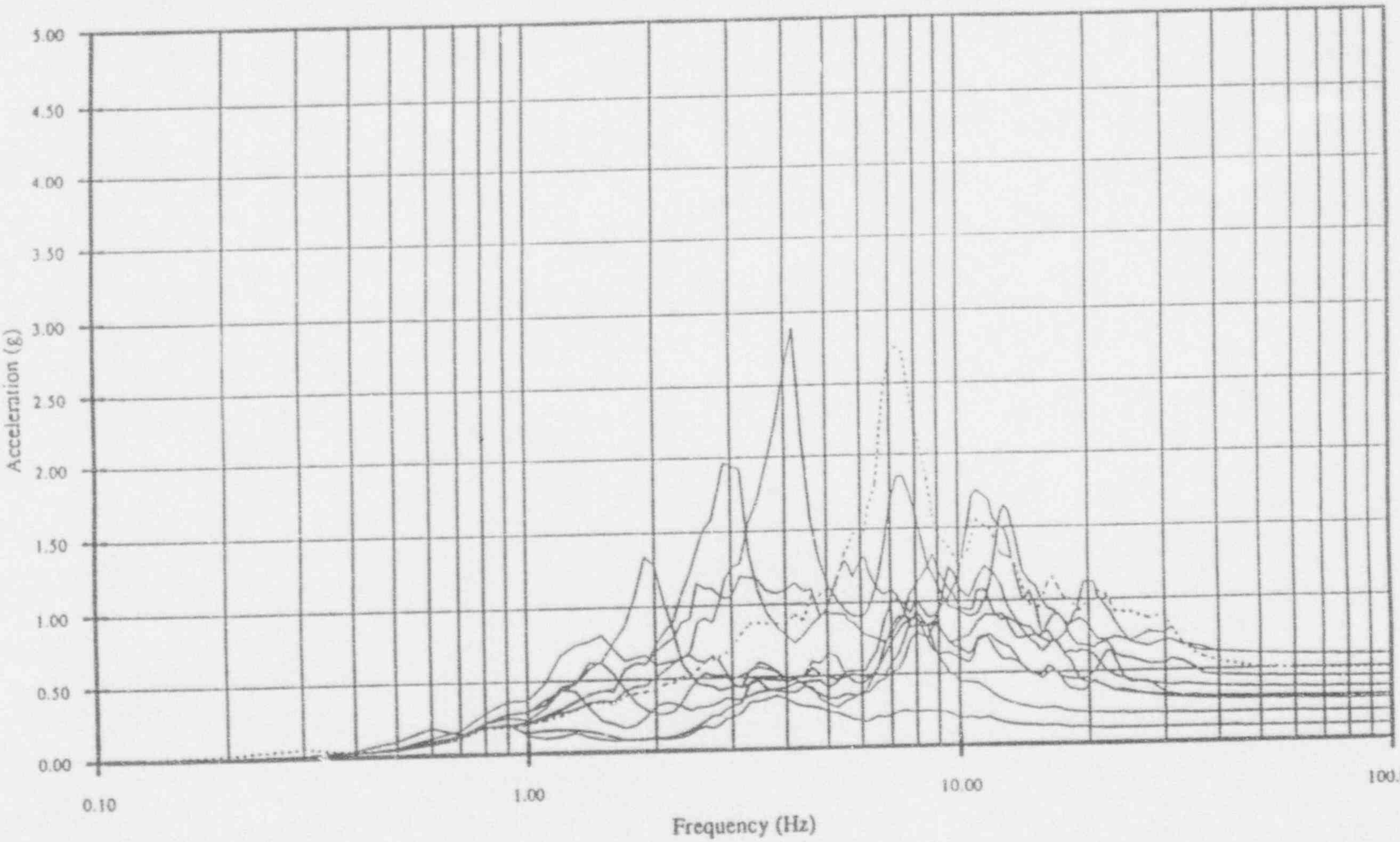
System 80+ Standard Plant
Control Room - CMS2, E-W, 5%



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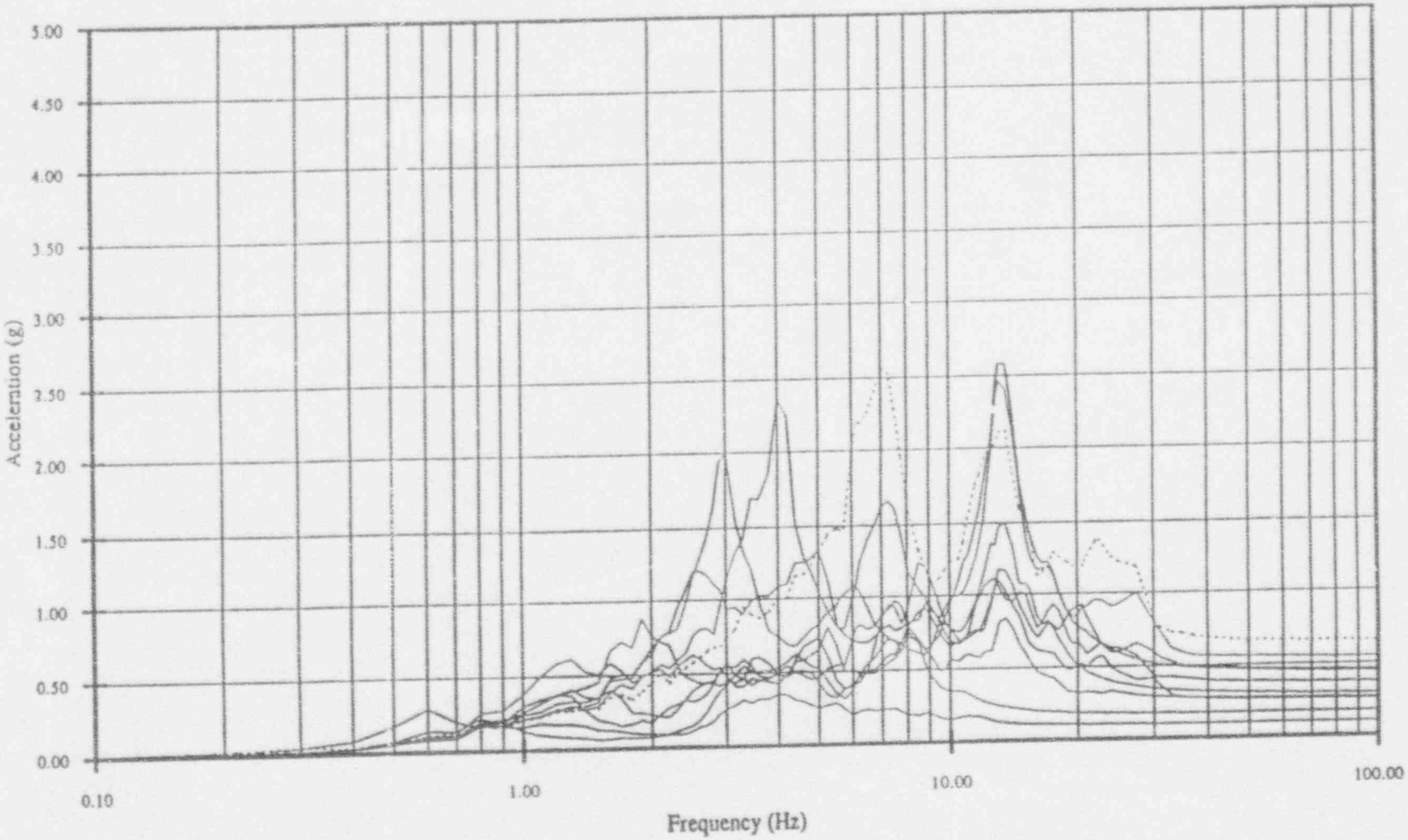
System 80+ Standard Plant Control Room - CMS2, N-S, 5%



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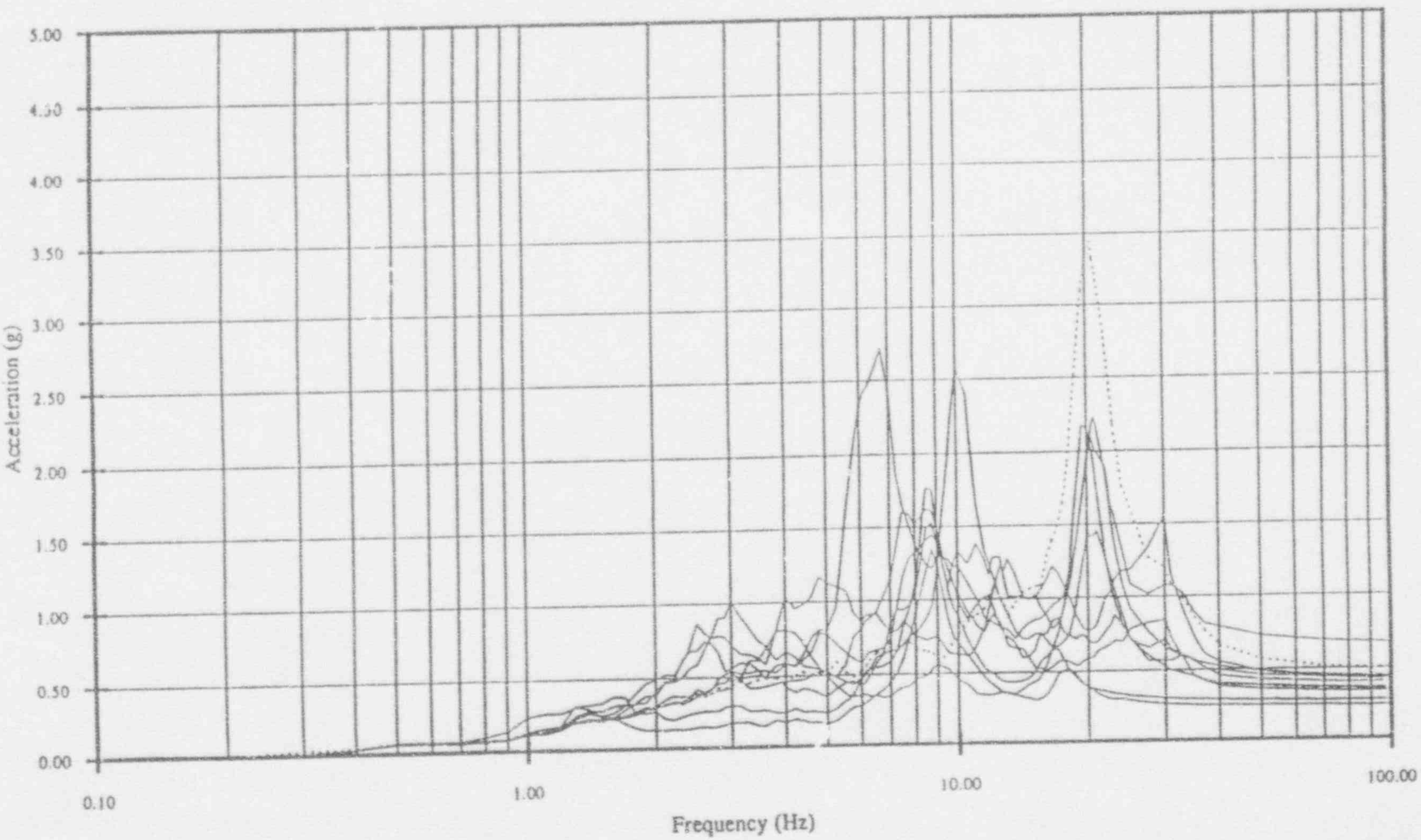
System 80+ Standard Plant
Control Room - CMS2, V, 5%



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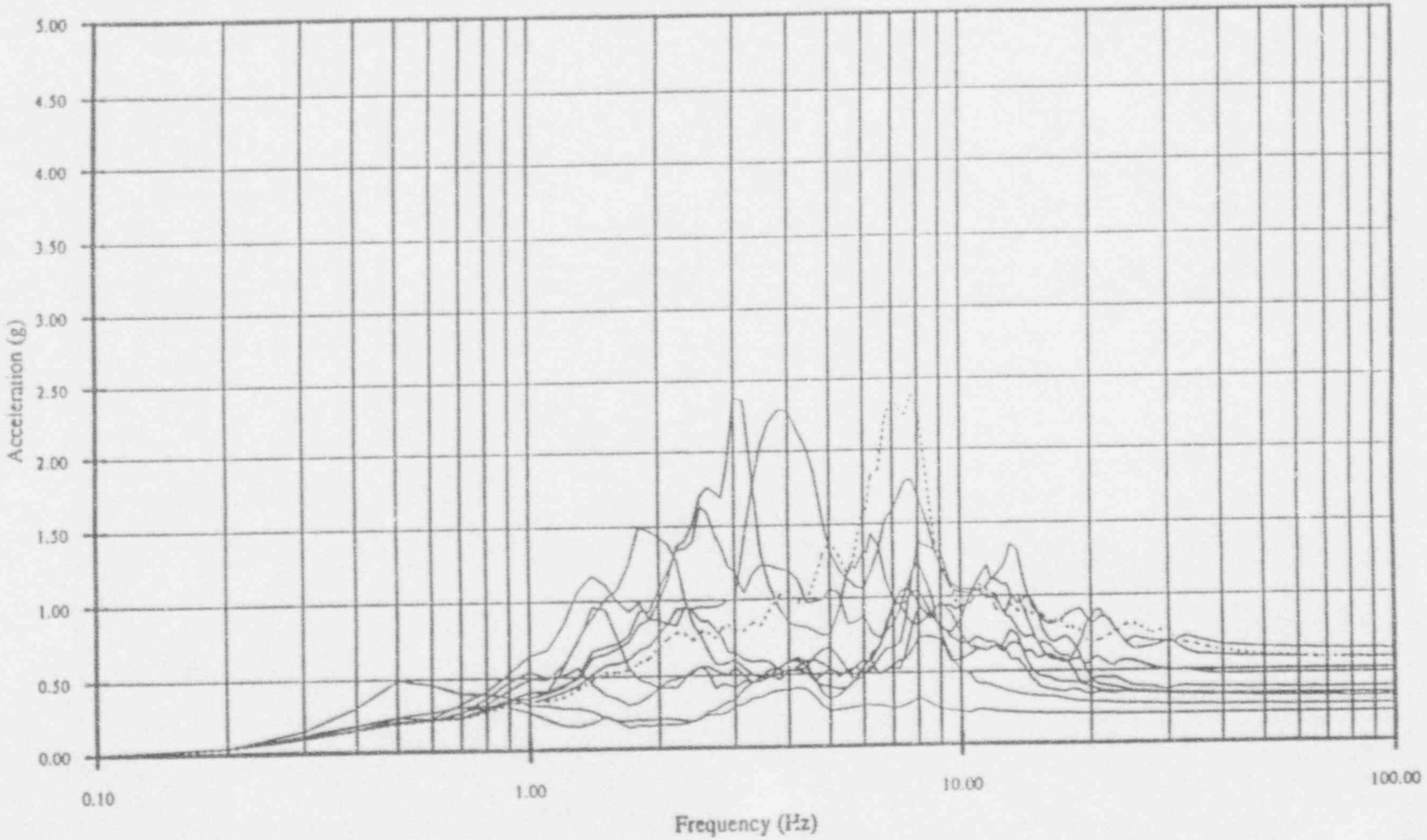
System 80+ Standard Plant
Control Room - CMS3, E-W, 5%



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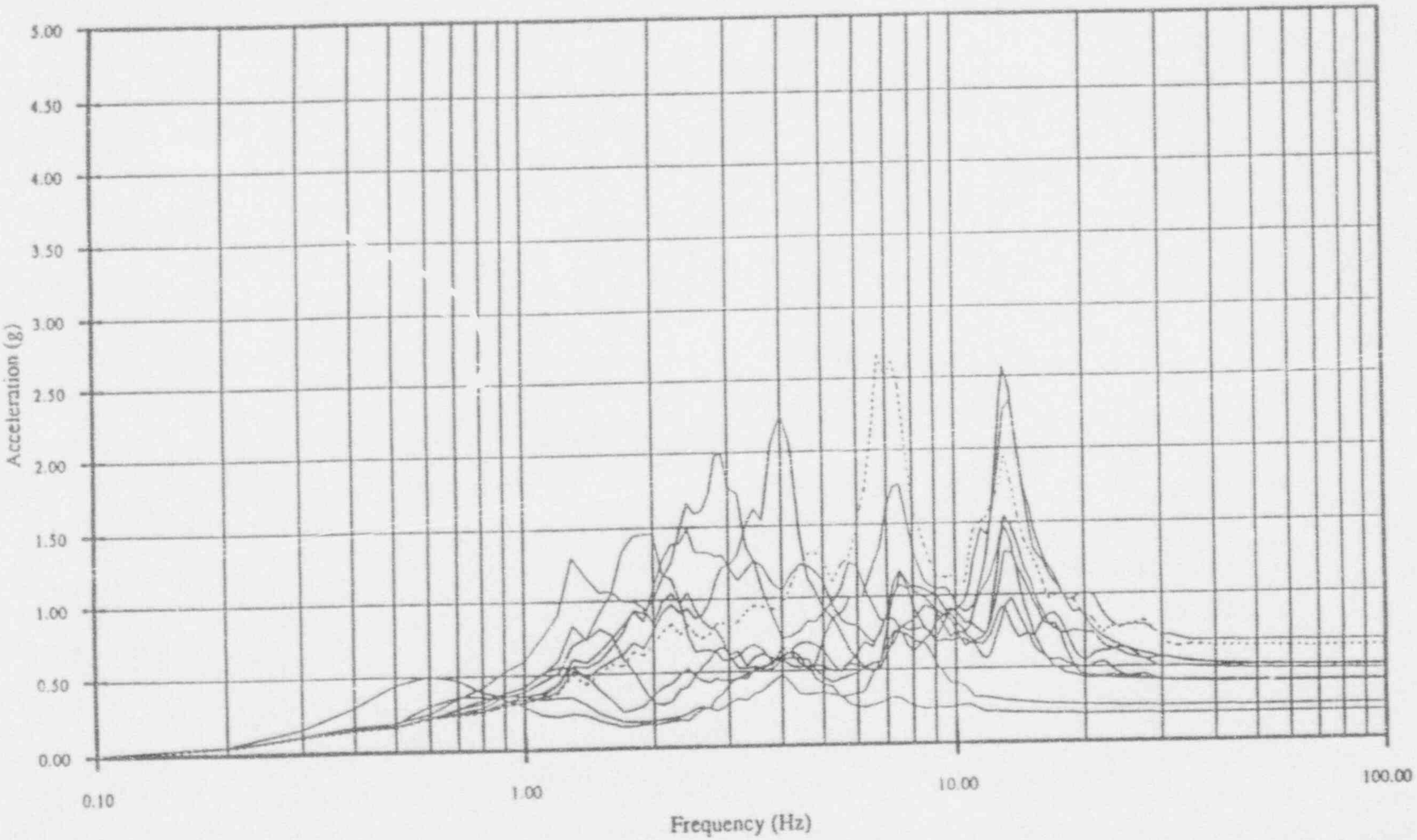
System 80+ Standard Plant
Control Room - CMS3, N-S, 5%



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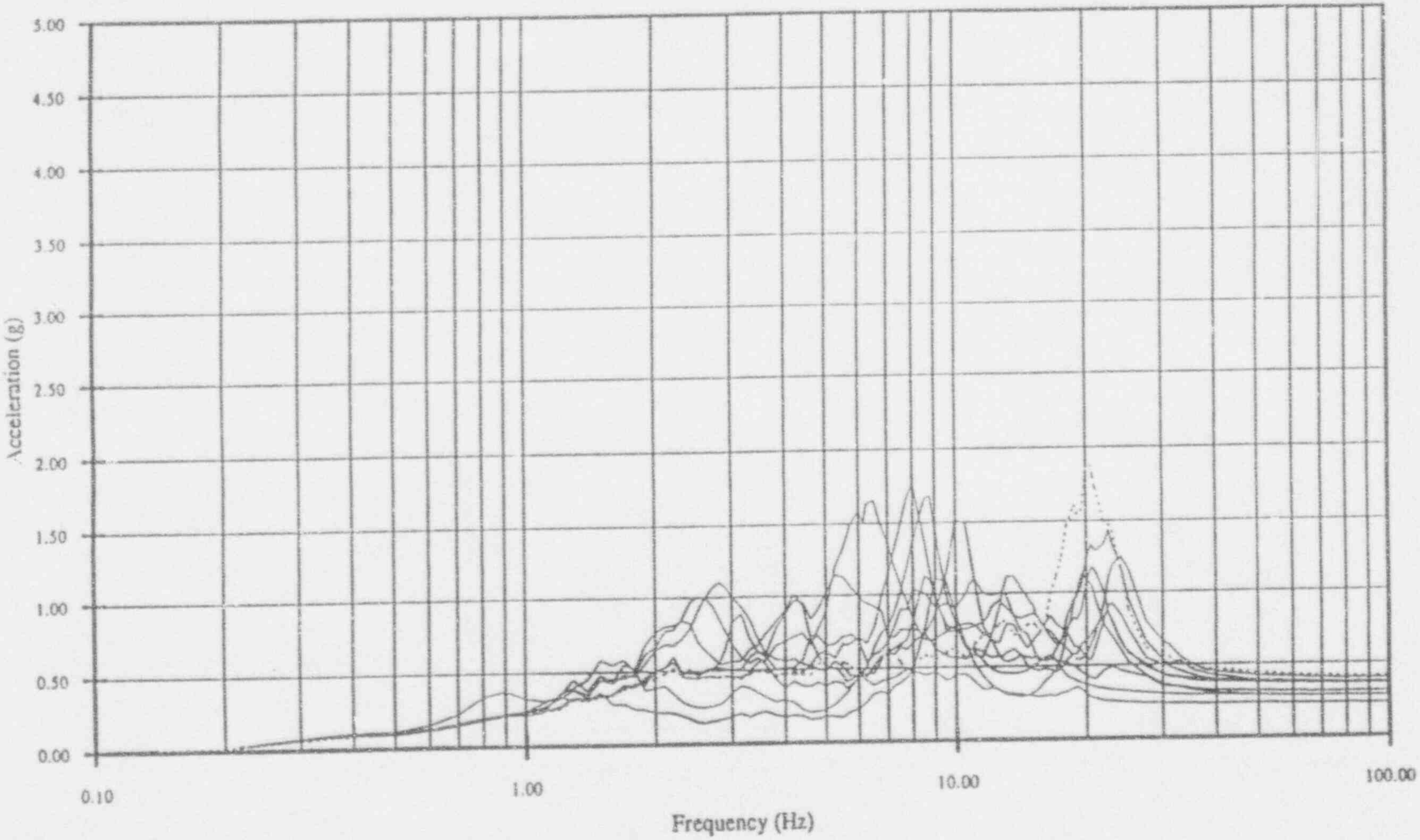
System 80+ Standard Plant Control Room - CMS3, V, 5%



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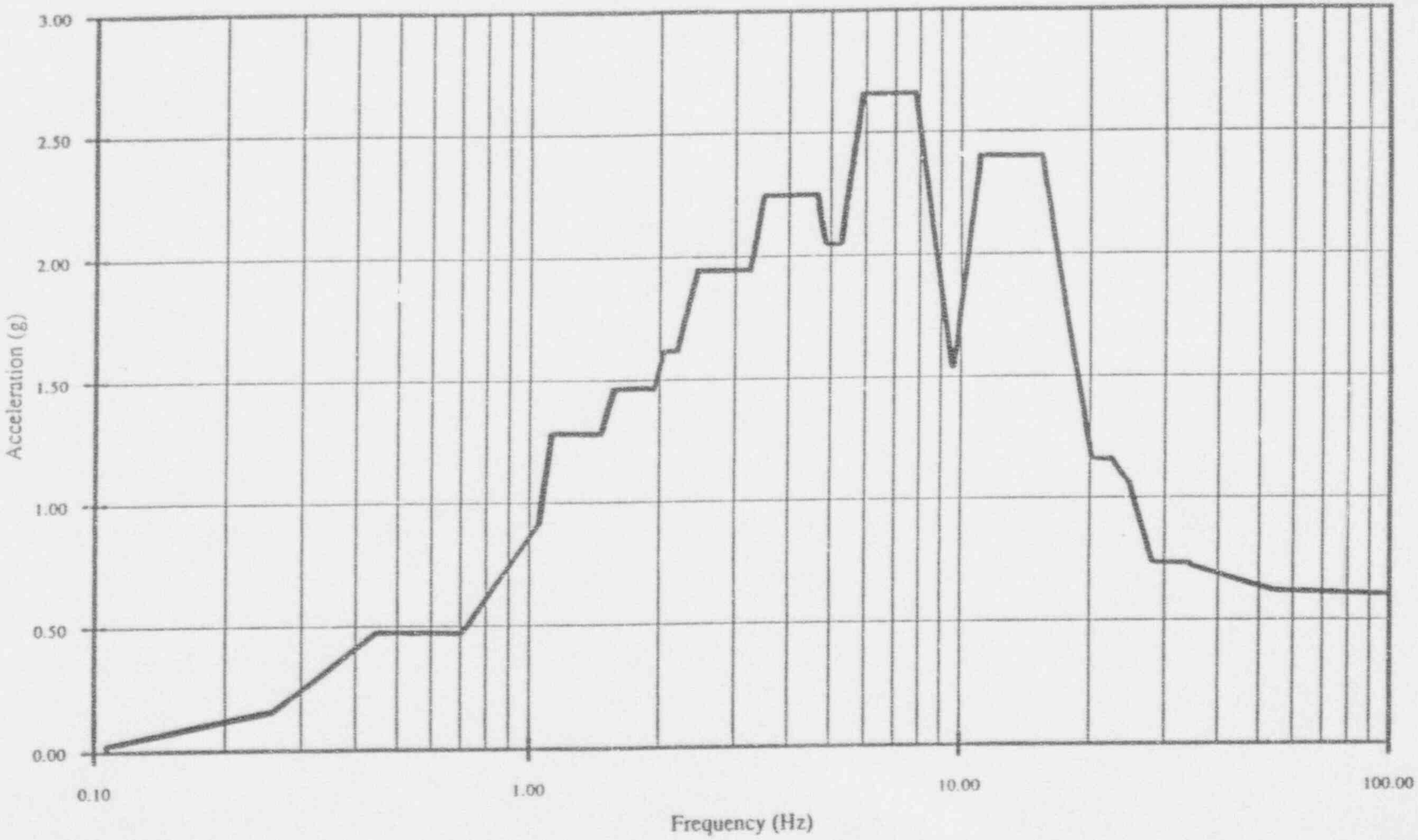
System 80+ Standard Plant
Control Room - N-S, 5%



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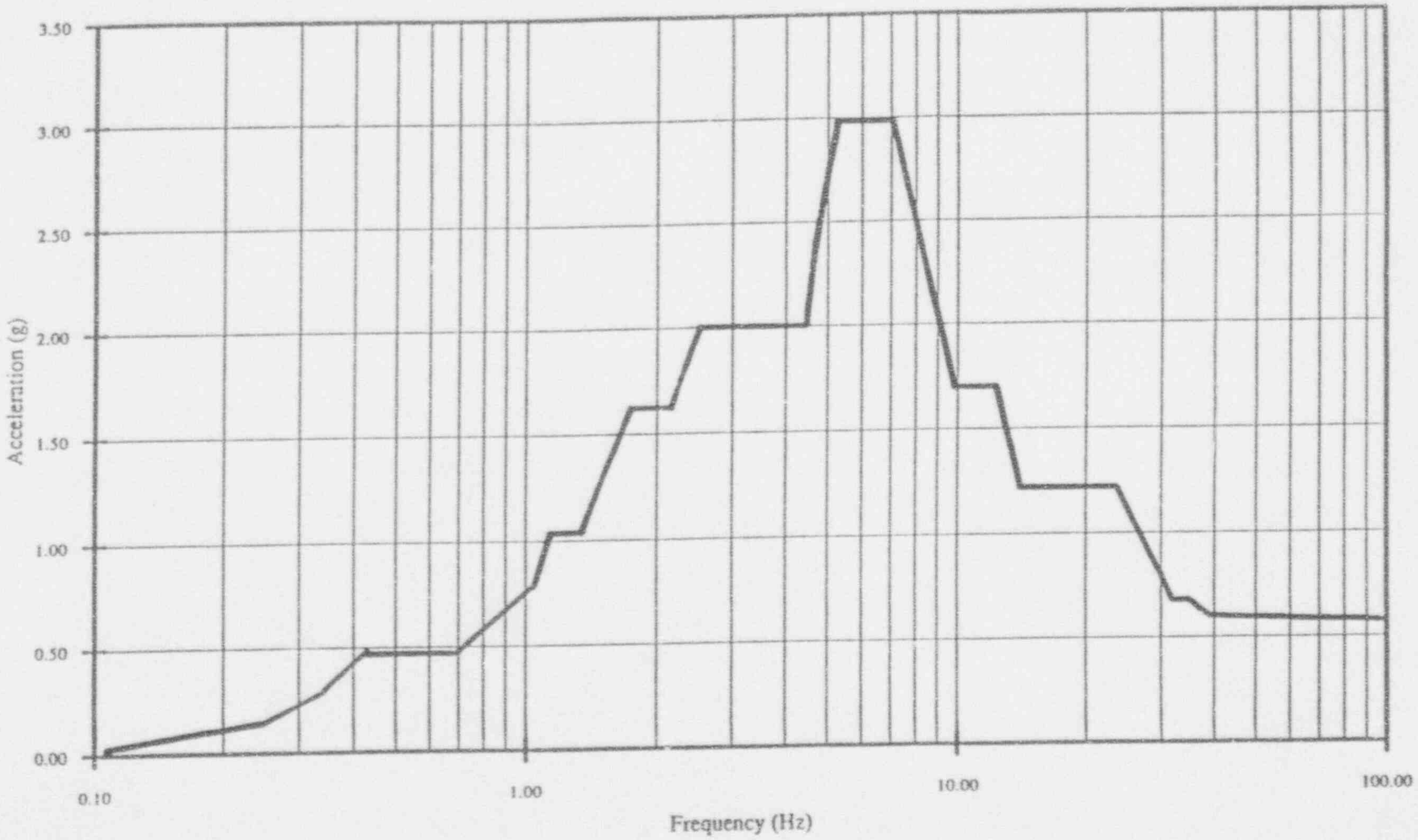
System 80+ Standard Plant Control Room - E-W, 5%



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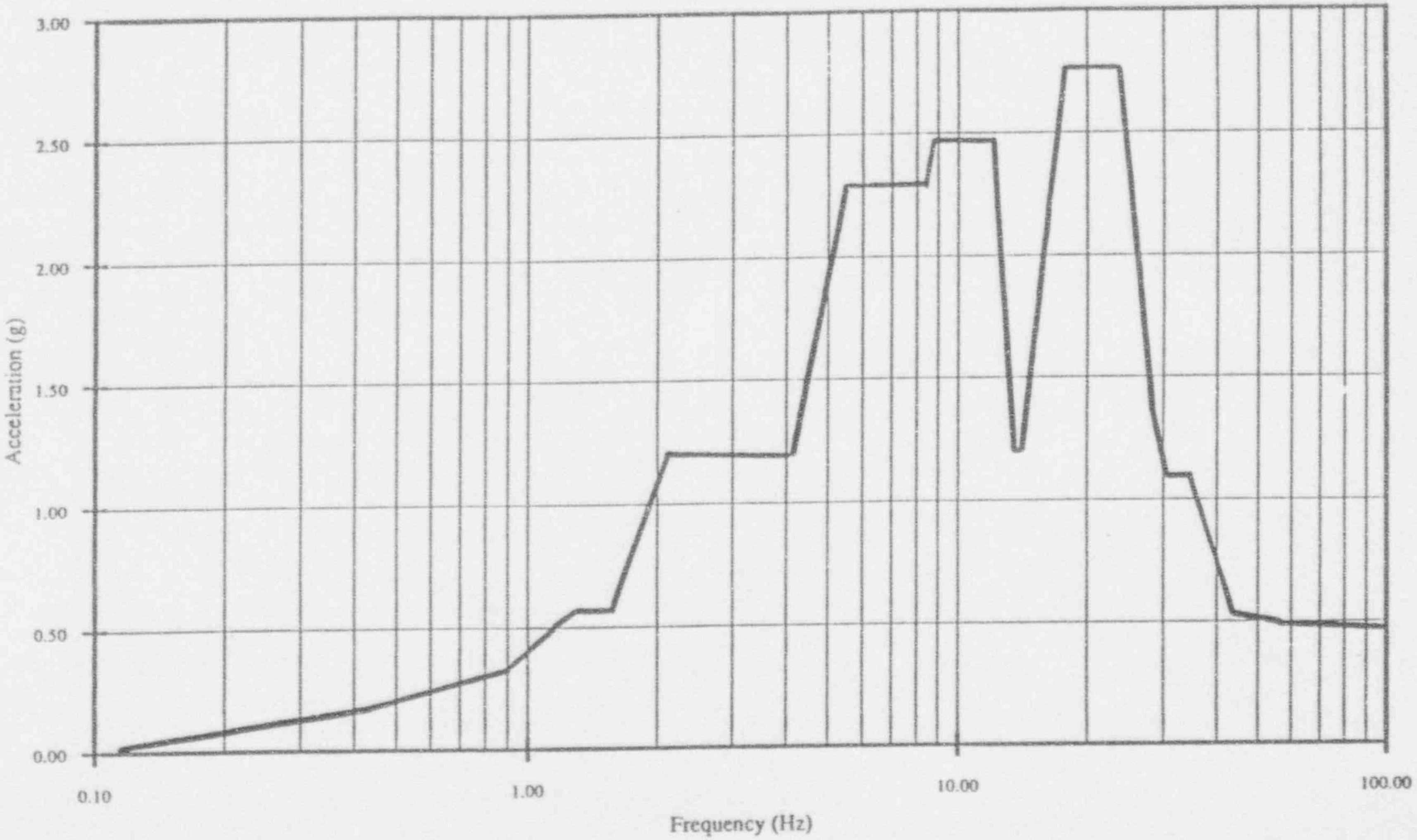
System 80+ Standard Plant
Control Room - V, 5%



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System 80+ Standard Plant
Interior Structure - Elev. 146, N-S, 5%

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System 80+ Standard Plant
Interior Structure - Elev. 146, E-W, 5%

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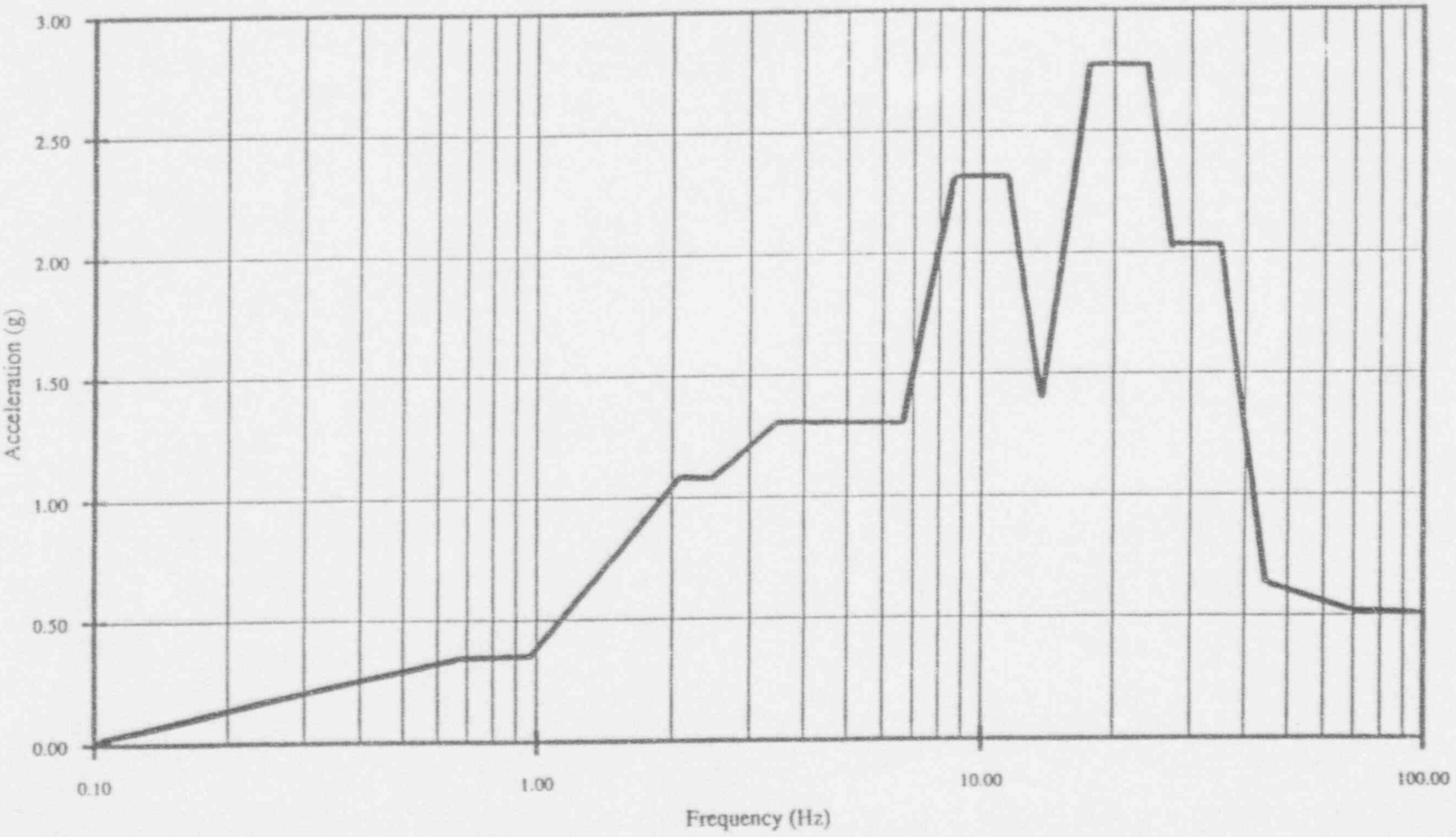
System 80+ Standard Plant
Interior Structure - Elev. 146, V, 5%



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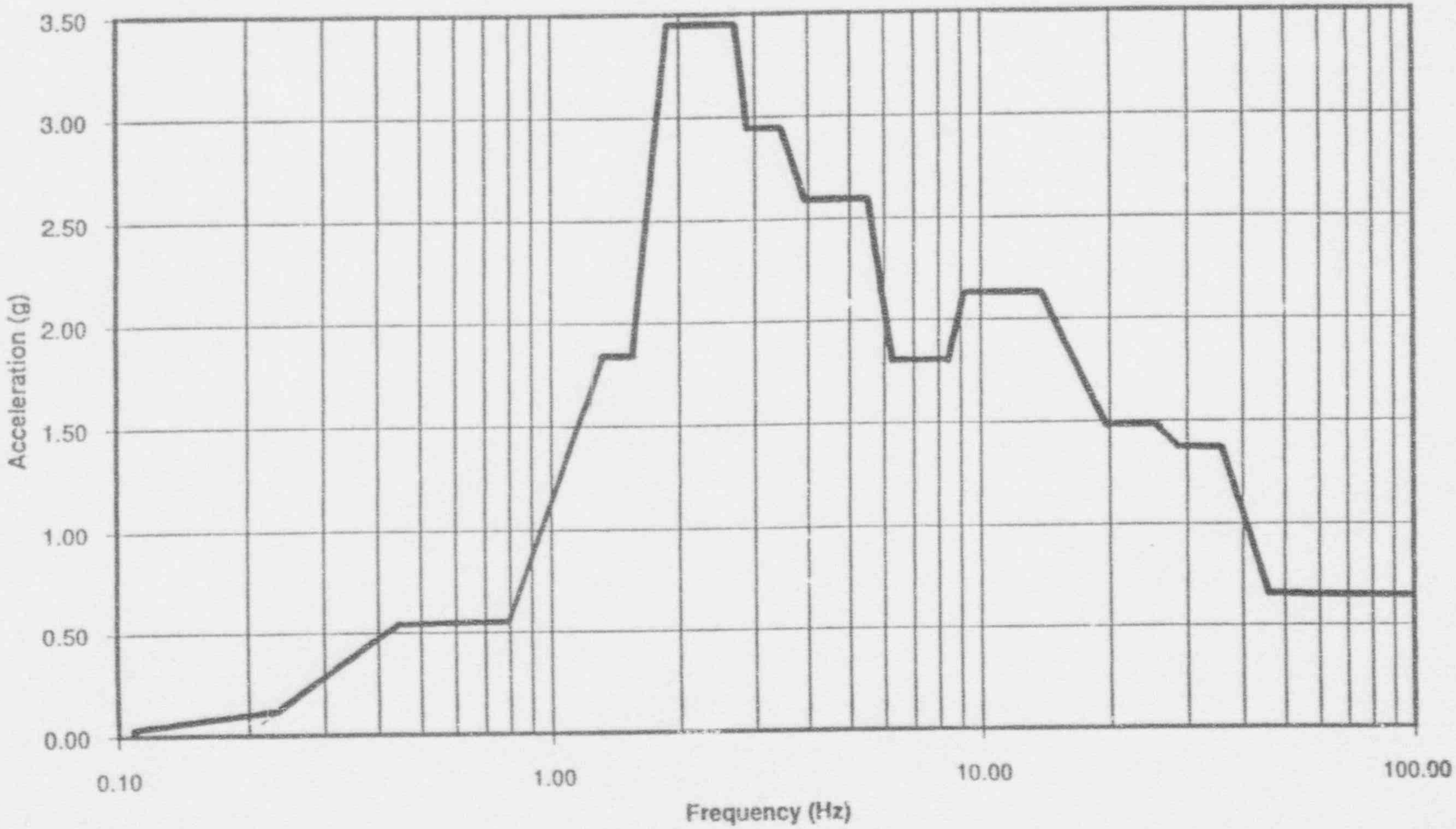
System 80+ Standard Plant
DFSS Elev. 78 - N-S, 5%



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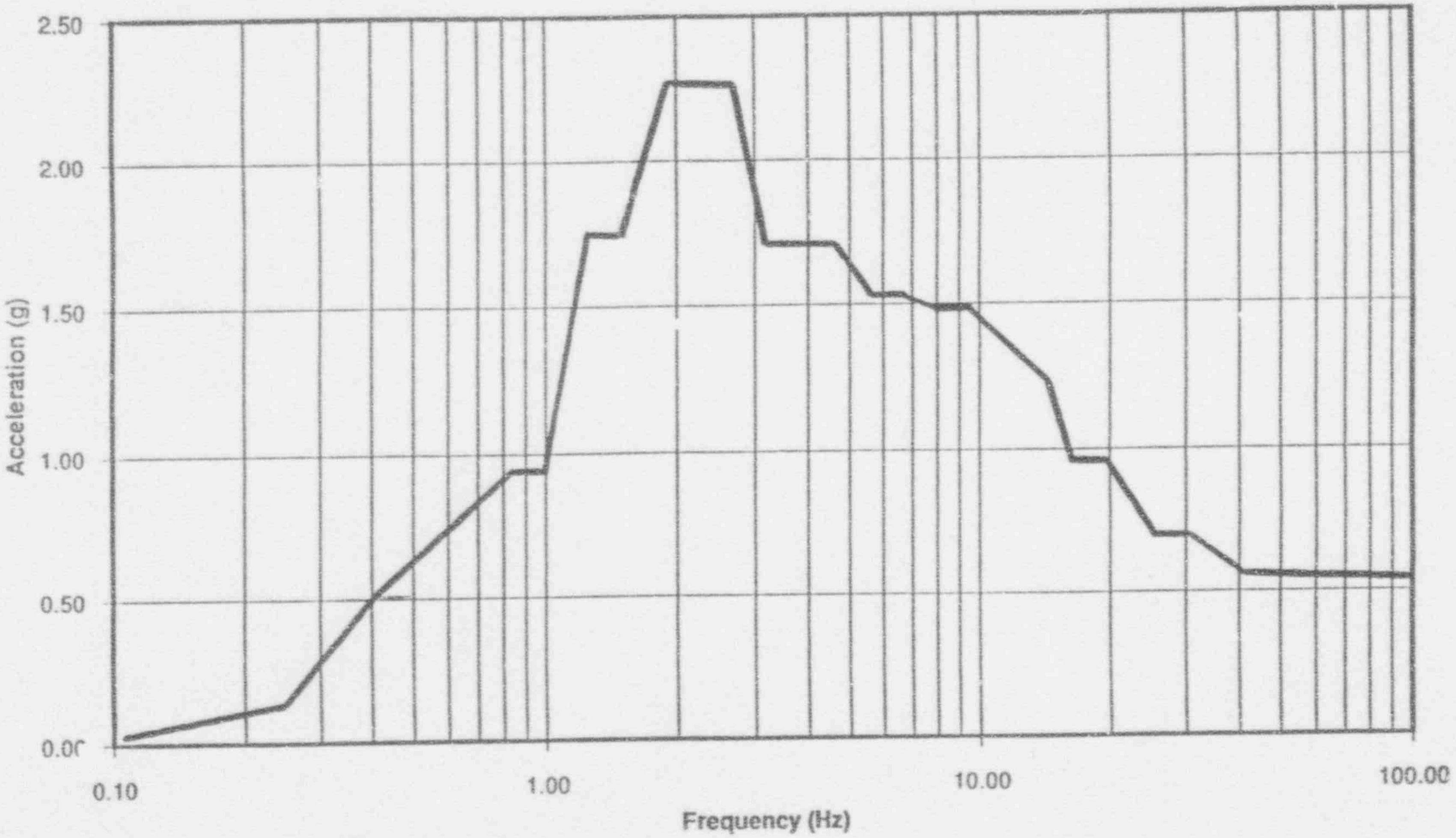
System 80+ Standard Plant
DFSS Elev. 78 - E-W, 5%



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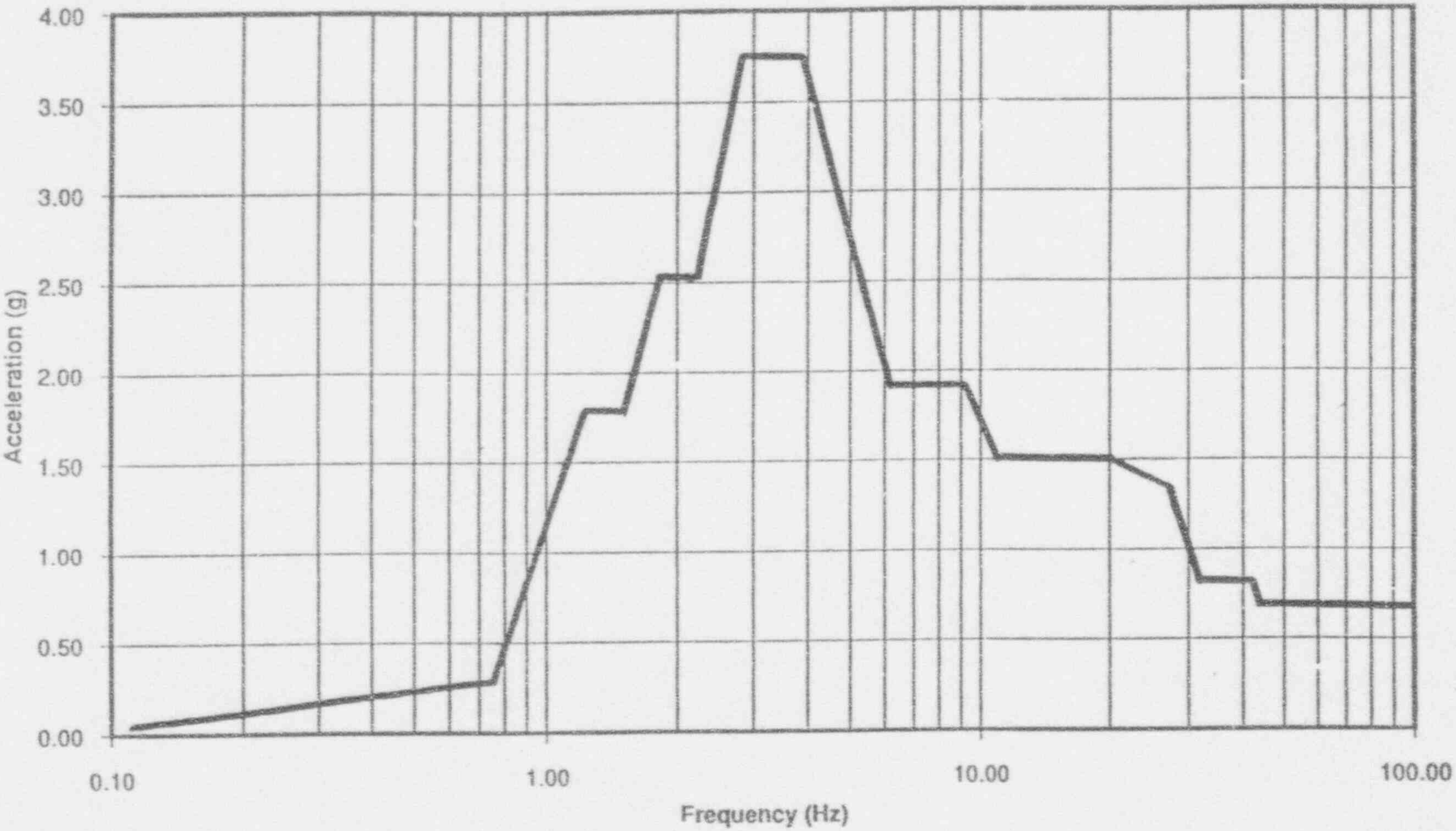
System 80+ Standard Plant DFSS Elev. 78 - V, 5%



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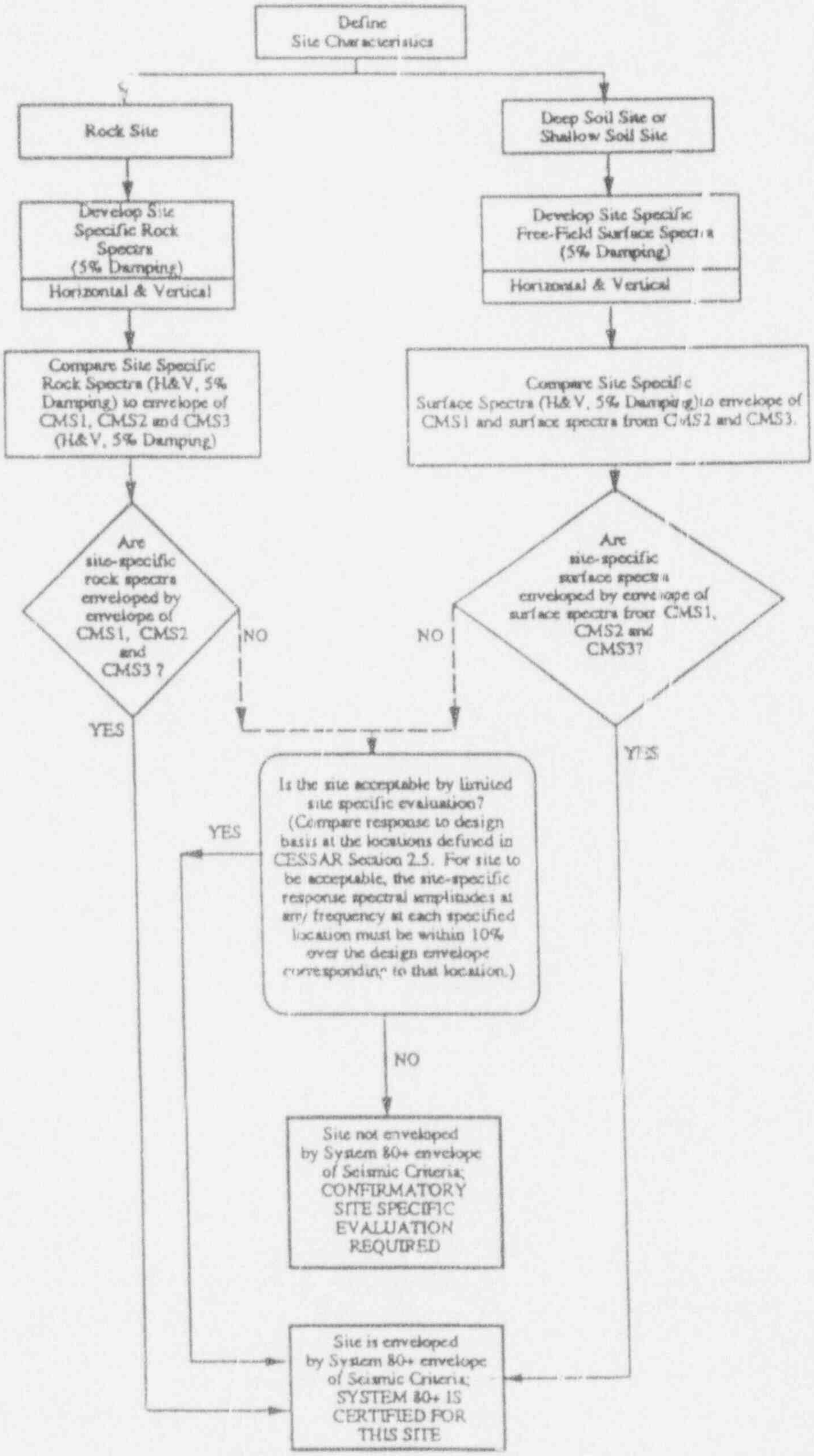
System 80+ Standard Plant
Site Acceptance Criteria for Ground Motion



Define Site Characteristics

Rock Site

Develop Site Specific Rock Spectra (5% Damping)

Horizontal & Vertical

Compare Site Specific Rock Spectra (H&V, 5% Damping) to envelope of CMS1, CMS2 and CMS3 (H&V, 5% Damping)

Are site-specific rock spectra enveloped by envelope of CMS1, CMS2 and CMS3 ?

Deep Soil Site or Shallow Soil Site

Develop Site Specific Free-Field Surface Spectra (5% Damping)

Horizontal & Vertical

Compare Site Specific Surface Spectra (H&V, 5% Damping) to envelope of CMS1 and surface spectra from CMS2 and CMS3.

Are site-specific surface spectra enveloped by envelope of surface spectra from CMS1, CMS2 and CMS3?

Is the site acceptable by limited site specific evaluation? (Compare response to design basis at the locations defined in CESSAR Section 2.5. For site to be acceptable, the site-specific response spectral amplitudes at any frequency at each specified location must be within 10% over the design envelope corresponding to that location.)

Site not enveloped by System 80+ envelope of Seismic Criteria; CONFIRMATORY SITE SPECIFIC EVALUATION REQUIRED

Site is enveloped by System 80+ envelope of Seismic Criteria; SYSTEM 80+ IS CERTIFIED FOR THIS SITE

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Seismic Margin Assessment

System 80+ Structures

System 80+ Standard Plant Nuclear Island Structures

Seismic Category 1

- Reactor Building
  - Steel containment vessel
  - Shield building
  - Subsphere
  - Containment internal structures

- Nuclear Annex
  - CVCS/Maintenance area
  - Fuel area
  - Diesel generator areas
  - EFW/ Main steam valve house areas
  - Control areas

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System 80+ Standard Plant
Non - Nuclear Island Structures

Seismic Category 1

- Station service water pump structure (site dependent)
- Diesel fuel storage structure
- Component cooling water heat exchanger structure and tunnel
- Buried cable tunnels and conduit banks

Seismic Category 2

- Radwaste building
- Turbine building
- Outdoor tank dikes

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System 80+ Standard Plant Structures

Codes and standards

- Concrete
  - ACI-349 (1990) supplemented by ACI-318 and NRC staff positions on anchor bolt design
- Steel
  - ANSI/AISC N690 (1984)

Loads and load combinations

- Concrete
  - ACI-349 (1990)
- Steel
  - ANSI/AISC N690 (1984)

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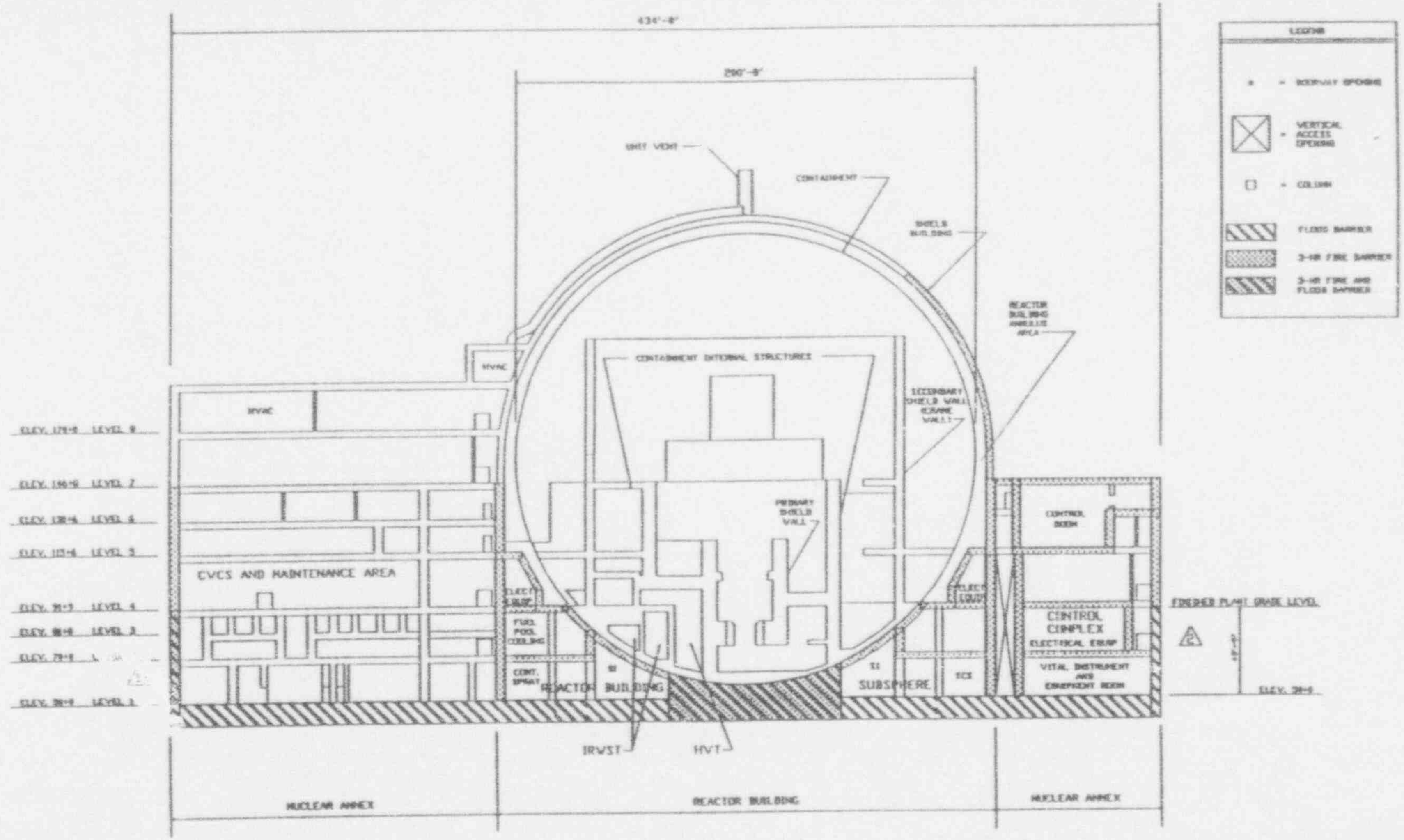
System 80+ Standard Plant
Nuclear Island Structures - Section A-A



⚠1 THE RADIOACTIVE WASTE STRUCTURE IS LOCATED ADJACENT TO THE NUCLEAR ANNEX

⚠2 THE TURBINE BUILDING IS LOCATED ADJACENT TO THE NUCLEAR ANNEX

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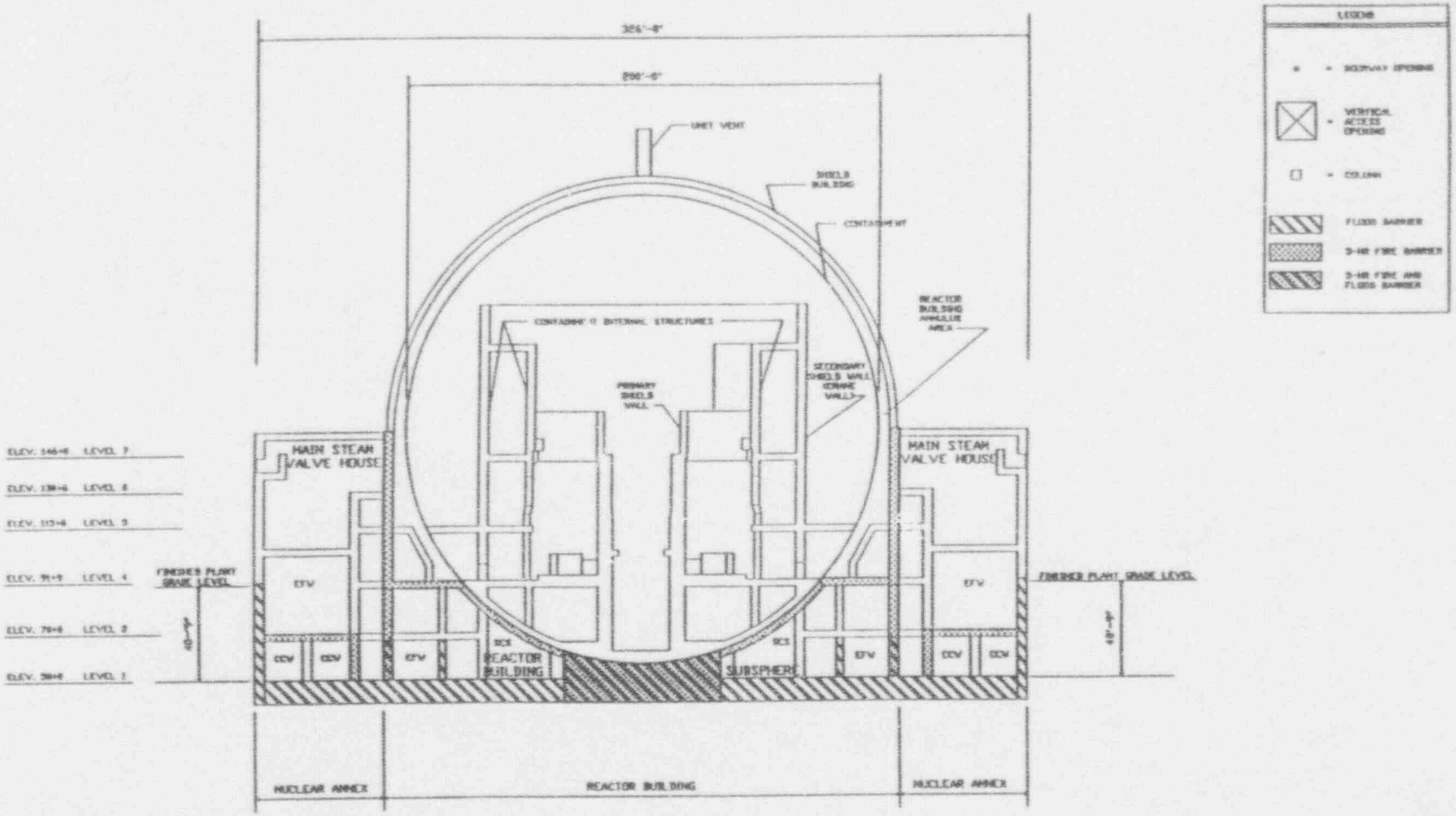
System 80+ Standard Plant
Nuclear Island Structures - Section B-B



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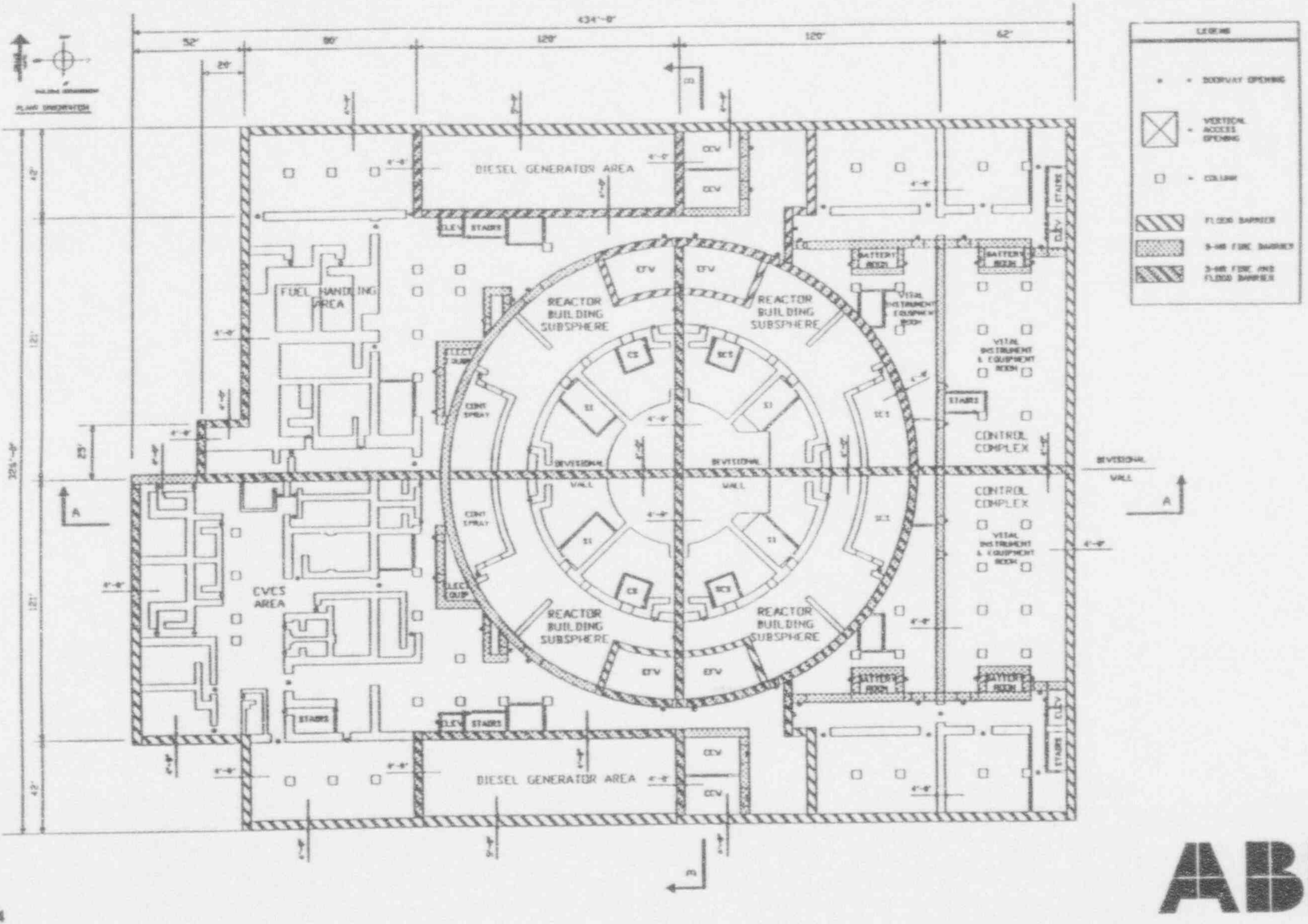
System 80+ Standard Plant

Nuclear Island Structures - Plan at Top of Basemat



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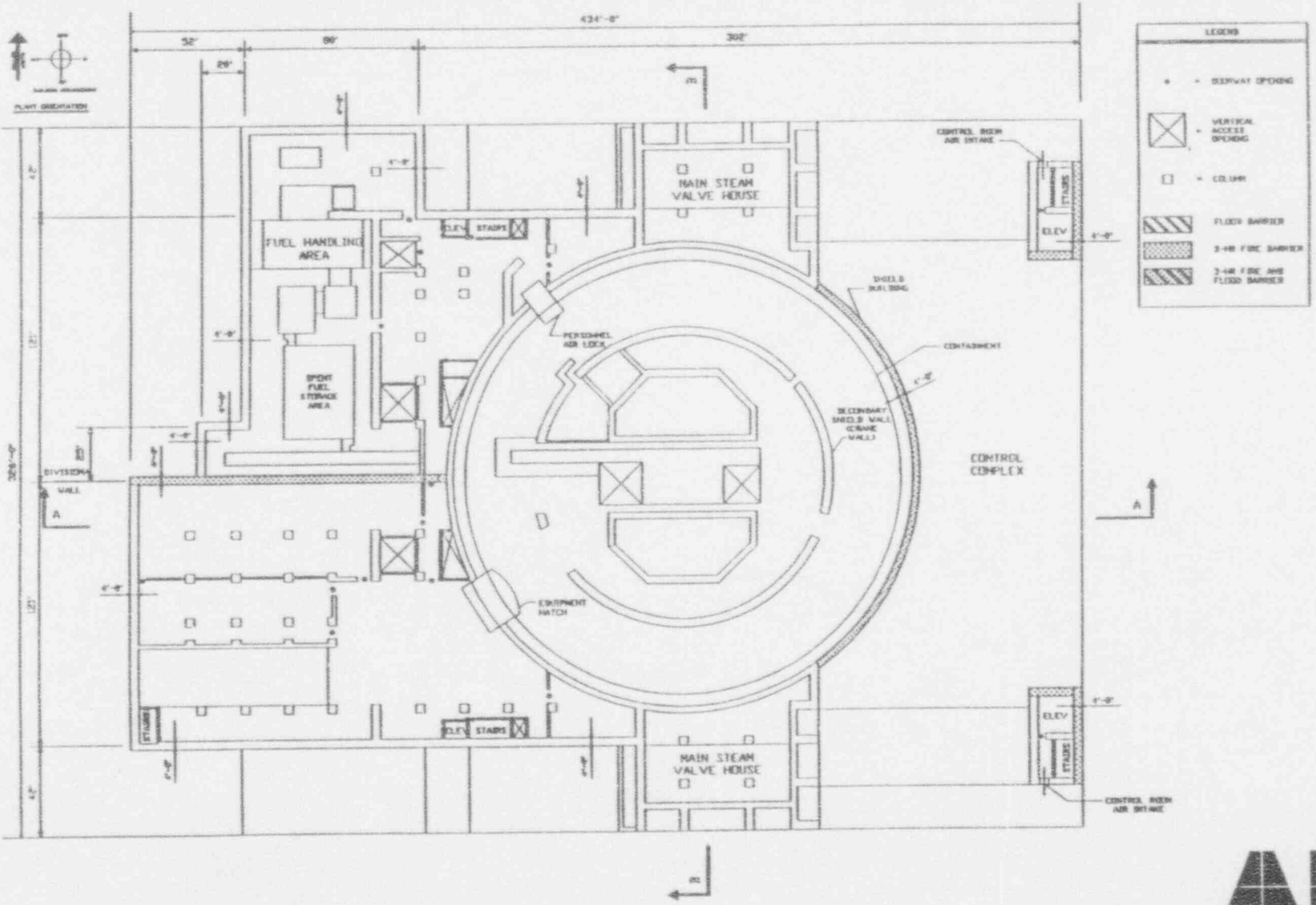
System 80+ Standard Plant

Nuclear Island Structures - Plan at Operating Floor



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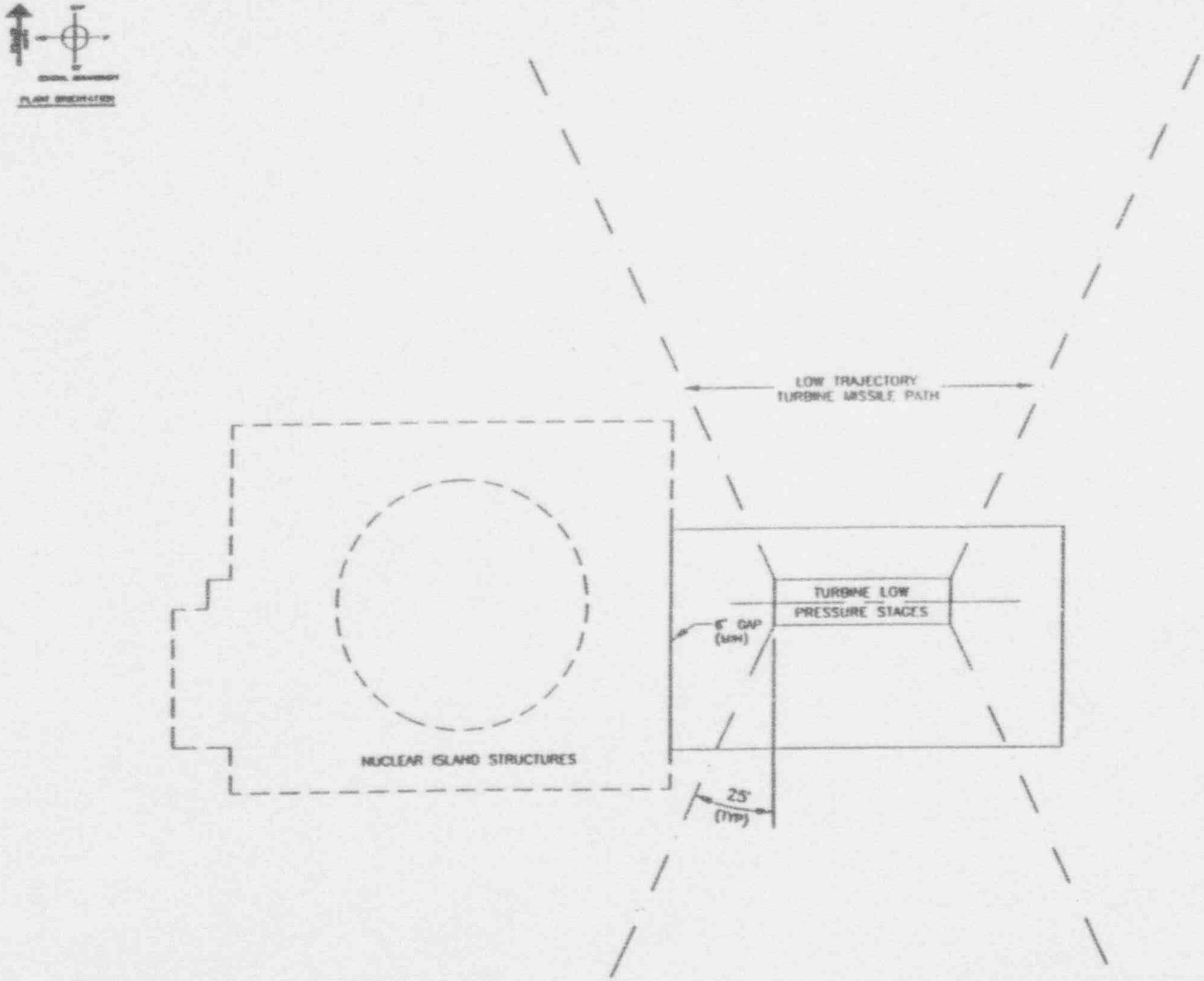
System 80+ Standard Plant
Turbine Building



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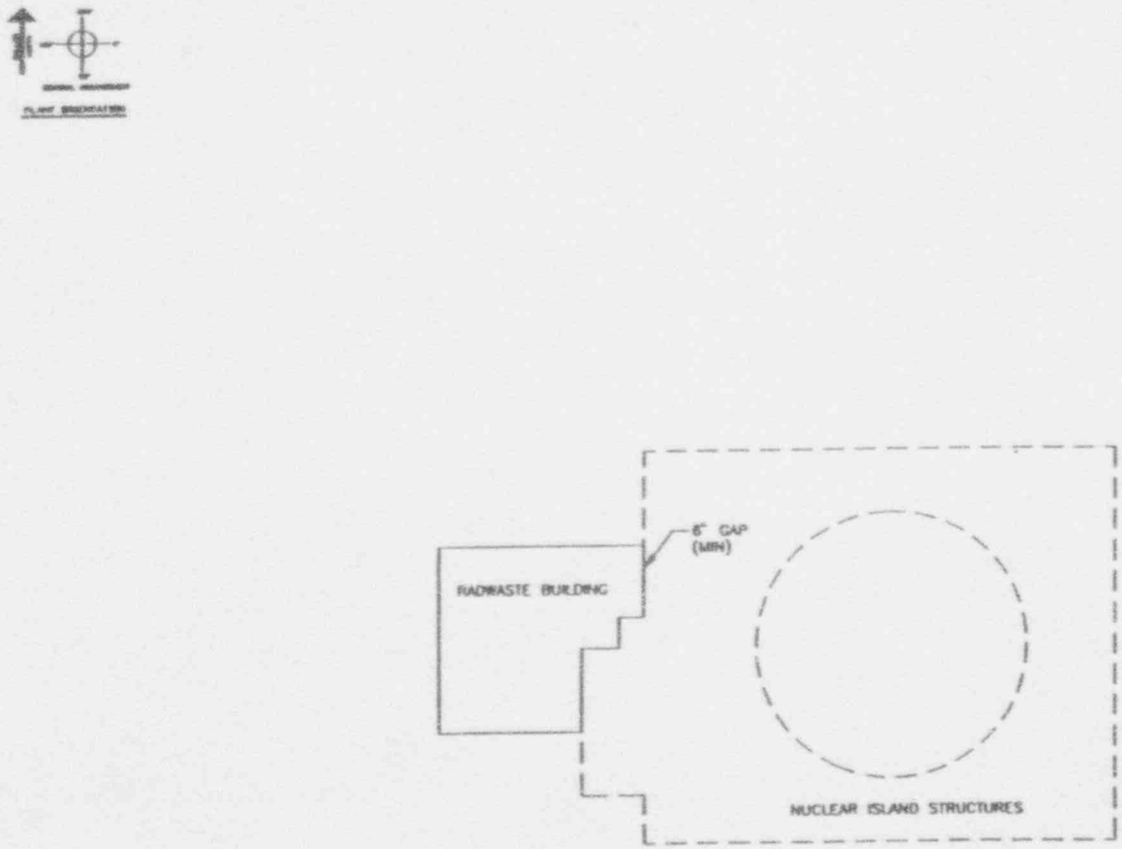
System 80+ Standard Plant
Radwaste Building



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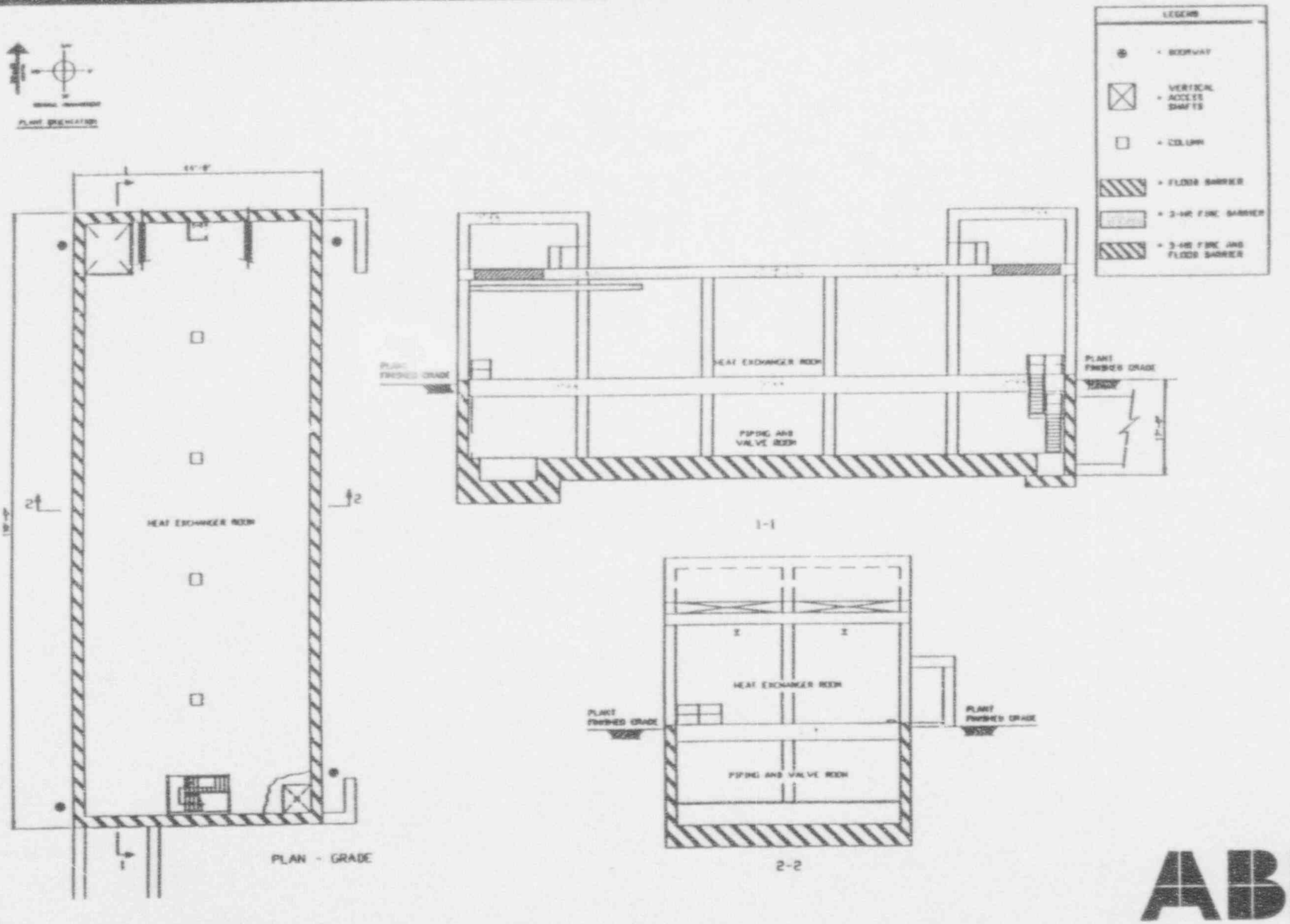
System 80+ Standard Plant
CCW Heat Exchanger Structure



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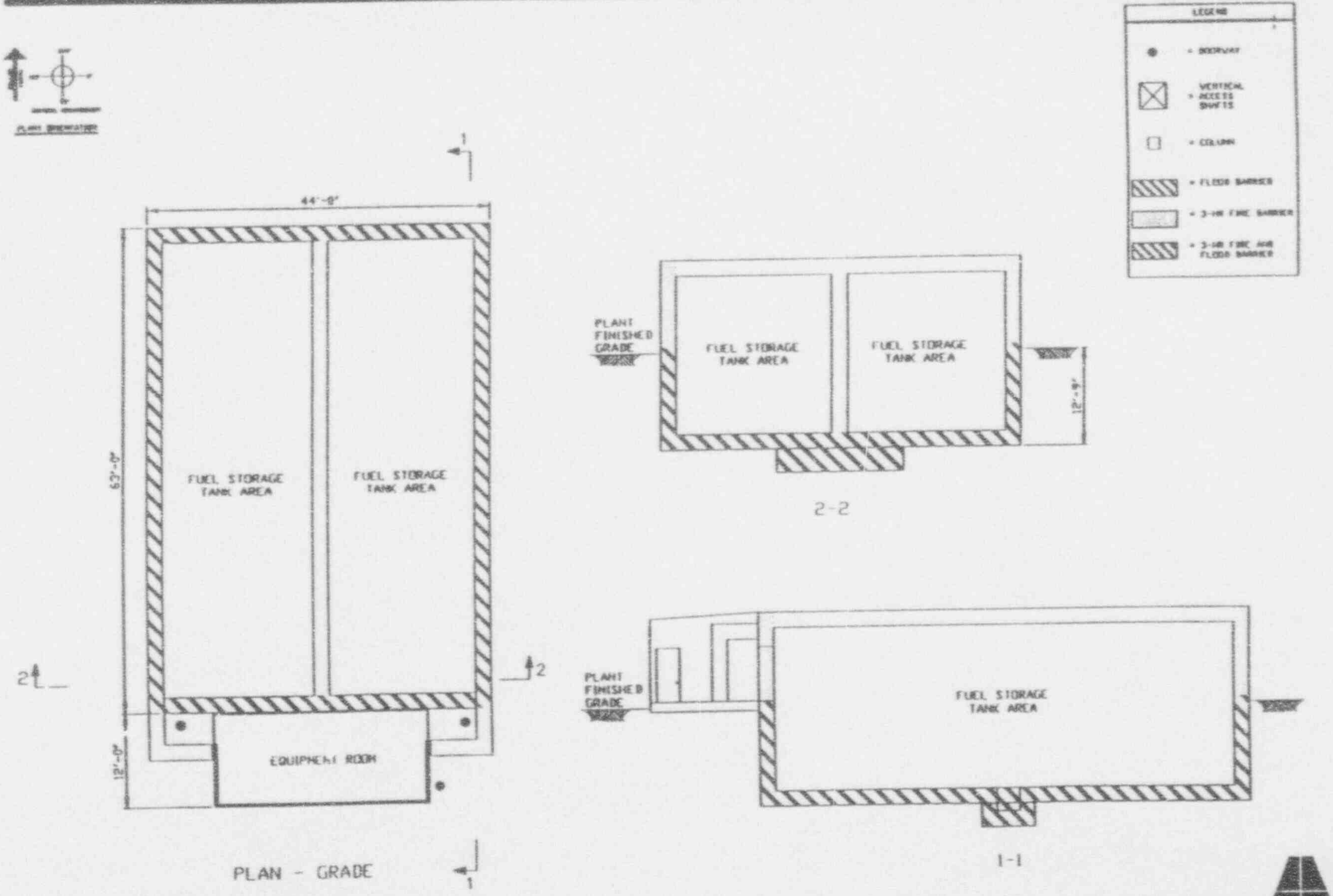
System 80+ Standard Plant
Diesel Fuel Storage Structure



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System 80+ Standard Plant Structures

Analyses

- Static finite element model
  - Seismic - Equivalent static methods using dynamic analysis results. Includes the effects of structure to structure and soil to structure interaction.
  - Other global loads - Mass of structure and equipment, tornado, wind, large pipe rupture loads, large fluid masses
- Local models
  - Local effects particularly out-of-plane loads

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