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In the Matter of:

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON FLUID DYNAMICS

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON

FLUID DYNAMICS

Bellevue Hotel
Riviera Room
505 Geary Boulevard
San Francisco, California

Friday,
September 25, 1961

The Subcommittee met, pursuant to adjournment, at 8:30 a.m.

BEFORE: DR. M. PLESSET, Chairman

ACRS MEMBERS PRESENT:

MR. J. EBERSOLE

DR. D. WARD

ACRS CONSULTANTS PRESENT:

DR. T. THEOFANOUS

DR. I. CATTON

DR. Z. ZUDANS

DR. S. BUSH

DR. J. LIENHARD

ACRS STAFF PRESENT:

MR. P. BOEHNERT, Designated Federal Employee

NRC STAFF PRESENT:

MR. J. KUDRICK

MR. M. FIELDS

DR. W. BUTLER

mc 1

PROCEEDINGS

8:30 a.m.

CHAIRMAN PLESSET (presiding): Well, let's reconvene and continue the discussion that we were having yesterday.

Dr. Bush raised a question to which I don't think an adequate answer was given. And I think this is brought up again by him and Mr. Ebersole.

We've heard a lot about the possible damage to the grill and the floor, and so on, but more important is the possible damage to important equipment that's being supported there.

Now I don't think we got an answer to that. Of course the really important equipment has to do with capability of shutdown. So could you say a word about that, Jack? Has that been looked at carefully? Or whoever has looked at it. We don't care about the walks or the floor. It's the equipment that's important. Will it fall down in the pool? Will it get amaged?

MR. KUDRICK: We have just become aware of the degree of the problem rather recently, so we really haven't delved into exactly what equipment is located on the grill as opposed to the concrete, and what type of damage would occur if the loads were exceeded on the grating.

We have asked that question to Mississippi Power and Light, and I believe they are looking at it. I don't know if they have any additional comments that they'd like to share

mc 2

with the Committee right now or not.

The question is what type of equipment is located on or around the grating of Grand Gulf.

CHAIRMAN PLESSET: Come up and use the mike. We want to get this on the record.

What we want to know is will this equipment survive?

MR. RICHARDSON: John Richardson, Mississippi Power and Light.

On the hydraulic control unit floor, the grating portion is primarily instrument control racks, some piping and valves, control hydraulic system, the hydraulic units for the flow control valve for recirc system. But primarily the instrumentation and control racks are on that floor.

And the panels and racks are designed for the impact loads.

CHAIRMAN PLESSET: Well, yes, go ahead. This sounds like very important information, and it's not clear to me that you can tell us with assurance that it would survive. What assurance can you give us?

You want to add to that, Frank?

DR. BUSH: Well, I'll let him answer that. I have a more general question. I'd like to rephrase what I said yesterday. And I'll wait until we get this in.

CHAIRMAN PLESSET: All right.

Go ahead.

mc 3

MR. RICHARDSON: Okay. I'm not prepared right now to tell you specific requirements. I can find those, the requirements that we've imposed on that equipment, the design criteria for the hydrodynamic loads.

CHAIRMAN PLESSET: Go ahead.

MR. EBERSOLE: You say that the equipment has been designed for the impact loads. Was the equipment put there originally with the thought in mind that there wouldn't be any impact and such things, and now you have sort of patched it over by putting barriers or something up?

MR. RICHARDSON: I don't --

MR. EBERSOLE: Why does the equipment have to be within range of damage of something like that? Why can't it be moved to a safer place, free from all the worries about the variability of these things like foam velocity and impact load?

MR. RICHARDSON: I don't know the exact history of why it was put in that area, and if it was designed there without knowledge of the fact that, you know, there would be the impact loads, etcetera.

I wasn't around then. Maybe GE could address the philosophy behind that.

CHAIRMAN PLESSET: Okay.

MR. SMITH: My name's Al Smith, from General Electric.

One of the reasons that the instrumentation is

4

located at that area is to maintain the proper criteria for the instrument line slope, and given that penetrations exist in certain areas, there isn't much flexibility in moving the instrumentation to another area. So that was one of the major criteria, and it doesn't allow us too much flexibility.

Some of the instrumentation, essential instrumentation, has been removed from some of the racks and put out of this area of impingement. There remains however some instrumentation and some racks that we could not move because of the slope criteria, and so therefore other ofrms of protection have been looked into, such as deflector shields, that type of thing.

MR. EBERSOLE: Well, the instrumentation can be broadly put into two classes: Those that shutdown the reactor in the minutes lock shutdown, and so they can be damaged or whatever after that; and those that have to sustain some active function by being energized or otherwise actively supporting the operation.

This latter class is the critical class, the ones that have to go on and on and on. The first can sometimes do whatever it has to do, and then be considered as having performed its function, and be subsequently damaged. Is it the second kind that we're worried about here?

MR. SMITH: We are concerned with the type that must perform its action or monitoring function during a LOCA and post-LOCA.

MR. EBERSOLE: Post-LOCA.

CHAIRMAN PLESSET: Spence?

DR. BUSH: Yes. Let me rephrase my concern or my interest at least more generally.

We're talking of a spectrum of loads. I would classify some of them as being relatively inconsequential, but I would say there are a few others that are significant and are still under negotiation, so they have a fair possibility of moving up in value.

I have a concern that again can be divided in two parts, once we stablize what loads are to be used.

The first is will the loads have an adverse effect on structures. Now if a load simply cracks concrete, and you haven't lost the functional capability of equipment that's sitting on the concrete, because this is a folded condition, I can't get too concerned.

However, if there are loads that will either damage platforms and in the process essentially have a high probability of rendering certain equipment non-functional, then I think that's very important.

I think we have to look at it on the basis that under dynamic loads and a one-shot folded condition, we do a realistic analysis for those conditions and establish the response of the struvtures themselves, and in the process, if that response is adverse, we have to look and see at the next step, does it result in the damage of equipment -- and in equipment, I include piping, etcetera -- that have to provide a vital function with regard to the shutdown, shutting down the reactor or folding it down.

That's really the bottom line. And we can talk all we want to about loads. But our concern, ultimately, should be can that unit be -- assuming we have such and such an accident -- can it be held down, and so we minimize any further effects? And that I think is what we have to address here.

Now I won't get into the argument of whether some of the loads are realistic or not. That's another matter. But I think once there's a decision made on it, then the analysis has to be on the basis of those particular loads. And I don't think it's been done.

CHAIRMAN PLESSET: Well, I don't think we can get an answer to these questions. But as you can see, they're really vital ones. We don't care about the concrete walks or the grills. But we do very much -- we are very much concerned with these matters that have just been brought up.

I think of course we have got to know what the loads are before we can tell whether the instrumentation will survive. But we'd like to see this thing emphasized in the study.

Okay?

MR. KUDRICK: We definitely share your concern.

CHAIRMAN PLESSET: All right. Yes, I'm sure. Thank

7

you.

And we'll go back to the regular agenda. Jack, you want to take over?

DR. BUTLER: Let me just add one point on that.

I don't believe we have yet crossed that threshold of giving up on the grates. We're still working to make sure that the grates stay in place.

We will be looking into the effect of -- if these loads in fact exceed the capability of the grate, then what are the consequences? But we are still looking towards assuring that the loads are within the capability of the grates.

CHAIRMAN PLESSET: Okay, that's all right. We don't mind that. Fine, thank you.

DR. ZUDANS: Along those same lines, just a couple of remarks?

CHAIRMAN PLESSET: Okay, not too long, because I think they've got the idea.

Go ahead.

DR. ZUDANS: It's just an addition to the same thing.

I think it would be important to calibrate these loads in terms of their importance. Some of the loads have no potential of damaging anything, the others do.

And that's what one would like to see.

CHAIRMAN PLESSET: Yes, okay.

Jack, back to you.

MR. KUDRICK: To continue on with our scheduled agenda, I would like to introduce Dr. George Bienkowski, who will be presenting the structures of submerged structure drag loads on both the generic aspect as well as Grand Gulf specifically.

He is a Consultant from Princeton, and has worked in this particular area for both the Is and IIs.

DR. BIENKOWSKI: Good morning.

(Pause.)

I thought I would put up a slide just giving an overview, which I think summarizes partly my feeling on the subject. There is not a lot of controversy left in this area. I think the reasons are fairly clear why.

One is that I think unlike some other issues such as CO and chugging, where the phenomena themselves are not clearly understood, one can have a lot of controversy about what data one should use and so forth.

Now clearly submerged structure loads associated with CO and chugging have those same questions associated with them. But as far as the issue of how does one compute forces on an object, given a flow field, there are still some questions assoiated with maybe what kind of flow field one should be taking data from, but the the phenomenon is at least reasonably well understood. So I think that eliminates some of the potential controlversy.

For those of you familiar with the Mark I and Mark II history on this, I think it's a little bit -- Mark III has some advantage here that one looks at the pool, it's relatively less cluttered in the area of submerged structures that could suffer due to LOCA bubbles and so forth.

The other part is that we also have had the history of the various concerns on Mark I and Mark II, which have been batted around back and forth. So we don't have to fight those battles again.

And thirdly, there is actually some experiemental data in the Mark III type geometry which can be used at least as a benchmarking verification of theoretical calculations.

Somewhat arbitrarily, submerged structure loads are -- well, not arbitraily. They are divided into LOCA and SRV loads. But then within the LOCA load, the chronology is clearly just a somewhat arbitrary division of what phenomena take place, and the names have gone into the record as such and we will stick with them.

There's something called water jet loads, which basically we are talking about the clearing of the water through the vent, up the vent clearing, followed by air bubble loads which presumably take the pool all the way up to the riser, fall back loads, when the pool falls back down after the air has all come out of the drywell, condensation oscillation loads and chugging loads. And finally for SRV, there's still a distinction to made between water jet loads and quencher bubble and so on. So I will try to treat these subjects in that order, although it may be clear that some of these divisions are somewhat arbitrary, such as clearly the division between water jets and bubble loads is somewhat arbitrary, because in the actual phenomenon it just goes from one to the other and also clearly as the amount of air and steam mixture changes gradually, rather than a sudden change from all air to all steam.

The first subject, on the water jets, the thing that makes this sort of a non-issue for Mark III is that if one takes the most conservative calculations from experiemental data, one can at least designate a region of influence, a zone of influence, in which one wouldexpect not necessarily that there is no jet mode associated with flow field induced by the jet, but that those those flow fields induced by the jet are smaller within that region of influence than will be the subsequent loads due to the flow field induced by the bubble growth, once the air starts coming out of the vent.

So one can designate a certain region of influence, and ask: Are there any structures in that region of influence? I will try to use this approach the data approached. The basis, in this case the experiments are the Mark III one-third scale experiments which tend to indicate a separate structure relatively close to the vent in the path directly of the jet. The loads are generally substantially bounded by the subsequent air clearing and the step loads. The theory of the very conservative bounds was this Moody jet model, which tends to predict a much, much higher penetration of the jet than other experiments have measured.

Well, the conclusion is essentially there are no structures in Mark II for which jet load is not bounded by the bubble load. I don't know whether it's worth showing the next two slides, which just show if one takes such a very conservative estimate of the zone of influence, you can see that most of the structures are near the opposite wall from the vents and therefore would not be impacted by the jets directly.

The only structures that have some -- I mean if one takes a conservative estimate of something -- well, basically the zone of influence shown on the slide, one sees that SRV quencher arms could potentially be in -- parts of the quencher arms could potentially be in the zone of influence. GE has done some calculations showing what -- taking I believe the Moody jet model calculations for that and showing that the calculation that they use for LOCA air bubble bounded substantially with the forces that you'd even predict from that.

So the conclusion is that one does not need to worry about the jet load.

MR. EBERSOLE: Pardon me just a minute.

Is there sufficient time delay in the starting of some of those heavy pumps to insure that they uptake some substantial void fraction and thereby will bind themselves? If there's a time delay, of course it's all right. I'm not sure what that is.

DR. BIENKOWSKI: I'm not sure what you're referring to.

MR. EBERSOLE: Okay.

There's some very large pumps that take suction on the pool.

DR. BIENKOWSKI: Yes?

MR. EBERSOLE: If they were to start instantaneously, they would be in the direct path of these large air bubbles and they would ingest that, and then lose their NPSH function and cease to function.

I hope that's not the case. The pump uptakes --

MR. KUDRICK: Yes. They're on the outside wall. The penetration that we're talking about here is nowhere near the end of the wall.

MR. EBERSOLE: We have no concern about air uptake of the pump suction.

MR. KUDRICK: No we do not.

MR. EBERSOLE: Thank you.

DR. BIENKOWSKI: I assume you are referring to the subsequent air bubble, not to the water jet, because the water jet is still working.

MR. EBERSOLE: I am, yes.

DR. BIENKOWSKI: Okay.

13

The normal division for the next load is to talk about the LOCA air bubble. And the approach is to consider spherical, essentially radial, bubble growth. That is clearly not an exact representation of what is going on, because clearly the flow as it was coming -- the jet that was coming out -- has initial induced velocities in the pool, so the bubble would not be spherical.

However, the experimental evidence shows that the -- especially since eventually there is a factor of two, multiplier applied to the thing -- and it bounds the spherical calculations.

The pool boundar-es and the flow field is considered using the method of images that has been in the other Mark Is and Mark IIs. The multiplier of two is applied to account -- rather than to couple for the LOCA, rather than to couple the bubble motion, the rise of the bubble -- I assume due to bouyancy -- together with the volume increase of the bubble due to charging of the bubble, the simple factor of two is applied to the calculations done for a stationary bubble, and some evidence is presented that this is conservative.

This was indeed one of the questions and concerns that I have expressed, and I will mention something about it in a moment.

Once the bubble calculation is done for each particular structure, an equivalent local uniform flow field approximation is made, local acceleration and standard drag is then computed for each segment on the structure in the same way it was done for Mark Is and Mark IIs.

The basis, again, is primarily theoretical, with some experimental confirmation.

The conclusions are that there is not much difference in this from the Mark Is and Mark IIs, so the issues that have all been discussed there need to be discussed in the same way. The Mark III, people have agreed essentially, that some of those detailed issues, like what drag coefficients to use, whether one must consider standard drag or only acceleration drag, should be done on the same basis.

So unless somebody has some specific questions, I will not discuss those nitty-gritties.

The one new thing was the multiplier for bubble motion. And the question was: Is that a conservative bound to account for a bubble motion? Well, if one looks at the induced flow field due to the volume expansion, together with the induced flow field due to motion, the one thing that immediately strike ones is that, sure enough, at some peak it may be true that the motion term can add no more than double the load, but clearly the time-history of the bubble rise is different from the time-history of expansion. Clearly, by simply multiplying the bubble expansion by a factor of two, one gets

15

a significantly different time-history.

And so then the issue was: Is it necessary to apply these loads dynamically to the structure, or does one really basically have a quasi-static application?

If it was to be dynamic, then one might indeed worry about the different time-history. If it's quasi-static, then clearly it's a non-issue, because it's really the largest load that's going to matter.

And so I have asked some information, and received essentially the information for all of the strucutres of concern. The -- I guess it should be omega-sub-n rather than w-sub-n -- but the natural frequency of the structures times the characteristic time for the bubble growth is generally substantially larger than one for all of the structures of concern, and therefore, the load to the structures essentially is quasi-statically applied. And so as long as the factor of two bounds the peak load, there should be no worry about the different time-history.

DR. CATTON: Before you leave that, Jesse, how much air intake can these pumps handle.

MR. EBERSOLE: I wouldn't want to say very much.

DR. CATTON: because following the clearing of the bubble out of the pool, all that violent motion, there are small bubbles everywhere, and it takes several seconds for them to clear.

16

MR. EBERSOLE: Well, it depends on the pump design. Some pumps can take up a few cubic inches of air, and stop. And other pumps can ingest large amounts.

And I don't know. It depends on the individual pump.

DR. CATTON: I don't think it's a non-problem, without looking at it.

CHAIRMAN PLESSET: Well, I think if you're down to very small bubbles, it won;t matter.

DR. CATTON: Well, they're not all that small.

CHAIRMAN PLESSET: Well, if they are big, then of course it's a question.

DR. CATTON: Well, you've just blown a big bubble in this pool, and it just stirs everything up. And it takes a little while to quiet down.

CHAIRMAN PLESSET: That's true.

But it takes some time for them to vibrate to the pump suction. And in that time, they can disappear, or get very small. That's their idea.

DR. LIENHARD: In fact, in modeling experiments, you see the pool whipped up into a froth that goes quite far down, yes.

CHAIRMAN PLESSET: That's right.

DR. CATTON: But the question is not that there's a lot of froth, but how long does it last and how long do the

17

bubbles stay significant.

DR. LIENHARD: Or does it get near the pump intake.

CHAIRMAN PLESSET: Yes.

DR. LIENHARD: I believe it does. I'm not certain.

DR. CATTON: The jets that come from the --

CHAIRMAN PLESSET: Let this man -- we're just talking -- let him say something that contributes.

DR. CATTON: I just want to get the concern on the record.

CHAIRMAN PLESSET: It's on.

MR. HUCIK: My name is Steve Hucik.

In general, the ECCS pumps have about a 30-second delay to come up to full speed before they run and inject, so there's a delay time of about 30 seconds before they are called upon to actually pull suction and start.

That's sufficient time to have the pool swell phenomena calm down by the time they then take suction and start to inject.

MR. EBERSOLE: As I recall, the pumps are called upon to perform their thing instantly, and if AC power is available, they attempt to do that once the valves clear.

MR. HUCIK: But that takes about 30 seconds.

MR. EBERSOLE: Is that a positive number, of about a half a minute?

MR. HUCIK: It takes about 30 seconds to come up to full flow.

MR. EBERSOLE: Are the LOCA temperature calculations based on the 30-second rise time to full flow?

MR. HUCIK: I believe so.

MR. EBERSOLE: I thought in the past it's been 10 seconds.

MR. HUCIK: No.

MR. EBERSOLE: And that really was an allowance for the diesels to start.

MR. HUCIK: Ten seconds for the diesels to come up to speed, 30 seconds for the pumps to be available.

MR. EBERSOLE: Well, thank you.

DR. LIENHARD: But you're not going to get air into the pump intake during the pool swell period?

MR. HUCIK: No, no.

DR. LIENHARD: You'll get air into the pump intake after the pool swell is finished, and you've started churning things around, mixing. I think that's the problem, isn't it?

MR. EBERSOLE: Well, if it exists 30 seconds, it's a potential problem.

CHAIRMAN PLESSET: Well, I think the 30-second kind of relieves my anxiety. It was a good question, but I think -- Are you satisfied.

MR. EBERSOLE: If it's 30 seconds, it seems to me that's a long time.

CHAIRMAN PLESSET: Oh, yes, that's quite a while.

19

MR. EBERSOLE: And it seems to contradict the local calculations, but maybe that's been changed.

CHAIRMAN PLESSET: Well, I thought that that was also addressed. Has that been --

MR. EBERSOLE: No pull for 30 seconds on the flooding pumps.

Is that correct? No pull on the field for 30 seconds?

MR. HUCIK: I believe in the calculational models, there is no credit taken for flow up to 30 seconds, before they come up to power.

DR. LIENHARD: That doesn't mean a pump has really come on.

CHAIRMAN PLESSET: Please continue.

DR. BIENKOWSI: It's clear what we've been talking about now is substantially beyond the time I've been considering, and I don't have that in the slides and what I handed out.

But this is at least the calculation on the rising bubble, and you can see the time-scale here is less than a second. So we're talking about the LOCA bubble here, we're talking about a much shorter time-scale.

And the concern I was expressing essentially was that the factor of two multiplier may indeed apply to the the peak acceleration, but it would certainly be a different time-history

20

but because of the fact that the time-scale here is of the order of a second, natural frequencies of the order of 10, 12, and above, the load is essentially quasi-statically applied to the structure.

The fallback loads, which seem to happen after the pool has risen to its maximum height and is coming back down, the calculation is based on a freefall of the slug of water from 20 feet high, which gives a velocity of something like 35 feet per second. One of the issues -- the GESSAR suggested that essentially standard drag alone be calculated at that velocity, based on an appropriate drag coefficient.

The question was I guess whether the -- is it always true that the acceleration drag force is negligible compared to the standard drag force. It clearly depends on the size of the structure.

One can essentially make a simple calculation and show that effectively, for this kind of assumption, the acceleration force over the drag force is proportional to the size of the structure divided by twice the freefall height. And it's fairly clear that all structures will be substantially smaller, so the standard drag calculation is sufficient.

DR. THEOFANOUS: Can I ask a question?

DR. BIENKOWSKI: Sure.

DR. THEOFANOUS: Associated process with that is the generation of waves in the pool. So if you look at some bounding situations where maybe you have more area on one side, you generate the higher swell on the other side, then with the fallback maybe generate a circumferential wave. And do you look into those waves and the effects on structures?

DR. BIENKOWSKI: I have not personally looked at it in connection with Mark III.

I think those kinds of things had been discussed previously with Mark II. Just my own guy feeling and reaction, I suspect that these initial forces associated with very highly accelerated pool rise and so forth would be substantially higher than anything you would get from the sloshing.

DR. THEOFANOUS: Yes, but the times are different, and the time-scale of the forces is different, and that depends on what kind of structure you are talking about, and how sensitive it is to different kinds of loads.

But here we have substantially higher shelves. They go up to 18-20 feet. And I think somebody ought to look at that. I'm not saying it is a problem, but somebody ought to look at it.

DR. BIENKOWSKI: Okay. If you believe that the one-third area scale is at least somewhat of a representation of the real thing, the data I recollect from seeing those tests of submerged structures, once they -- for the submerged structures now I'm talking about -- once the air bubble load is over, the data you see looks like hash.

DR. THEOFANOUS: But that's not the point.

22

Because in these experiments, you're only talking about at most three cells. And here we're wide circumferential variations. The wave would be propogating along the circumference of the pool. And you can see that in the experiments.

DR. BIENKOWSKI: Yes, yes.

Those waves would clearly be lower frequency rather than higher frequency.

DR. THEOFANOUS: Yes, right.

DR. LIENHARD: You can do it in your head. It's just the velocity is the square root of gH. It's a deep water wave. Just do it in your head.

DR. THEOFANOUS: What are you saying?

Are you speaking to me?

DR. LIENHARD: Yes.

I'm not answering your question. I'm saying it's just a deep water wave, and it has a velocity of square root of gH. And just do it in your head.

DR. THEOFANOUS: So what?

DR. LIENHARD: It's a very low frequency.

DR. THEOFANOUS: I'm aware it's low frequency.

DR. BIENKOWSKI: If it's low frequency, then are you worrying about exciting some sort of specific mode in the structure, or are you worried -- I mean if it's low frequency, presumably then it means it going to be essentially quasi-static in most of the structures.

23 And if it's quasi-static, then the question is is its amplitude comparable to amplitudes we're already considering. And I think again one can conclude that the amplitudes are much smaller.

If it has to do with wave heights, and the velocity induced on that, clearly 20-foot fallback is a lot higher than any wave heights one would expect in the waves thereafter.

DR. THEOFANOUS: Well, I don't want to pursue that. But I still think that somebody ought to look at the numbers for some bounding cases of waves propogating alongside in this manner.

CHAIRMAN PLESSET: Let me just say I think there was a slip. They're not deep water waves. They're shallow water waves.

You said the square root of gH. I think that's for shallow water waves.

No, it's shallow water. But let's not belabor the point.

DR. THEOFANOUS: Are you saying that the waves will be small-sized waves?

CHAIRMAN PLESSET: No, no.

I was just saying that it's a shallow water wave. The wavelength could be anything.

DR. BIENKOWSKI: Okay.

After the pool swell, and a significant amount of the air has come out of the drywell and primarily steam is coming through, the next division of the oscillating condensation has traditionally been called condensation oscillations.

The approach here has been to essentially use the same basic methodology for the calculation of the forces, but clearly one must now put in some information on what the volume source strengths are of the oscillating bubbles or interfaces at the vent exit.

The source strengths are -- clearly have to come from some experimental evidence, and that comes from the same evidence that was used for the boundary load calculations for CO. The flow field, again, uses the method of images, uniform equivalent flow field.

The question then arose as to whether acceleration drag alone needs to be inserted. It turns out that for the kind of sources one gets, there is more -- it is relatively low amplitude oscillations at some reasonable frequencies, so for typical structures, one ideed would expect that the acceleration forces -- or you might call them acoustic loads on the structures -- would be more significant than would be the standard drag proportional to U-squared. The issue that was raised, that was asked to be addressed, was to quantify this in some way and to essentially say under what conditions, since it clearly depends on both the distance from the source and size of the structure, under what conditions is the standard drag negligible. And as a matter of fact, I guess I did not include that in a slide either, because I wasn't sure whether it was something that would be considered proprietary or not. But I don't believe it's labeled proprietary, so I can show it.

The calculation was made just for what essentially the boundary between -- for what structures standard drag is or is not important. And it's essentially an equation relating the size of the structure versus the distance from the wall.

And it turns out that the only one worry that might be of importance is the RHR, a couple of RHR lines, and indeed I believe the new revision mentions that for those structures the standard drag will have to be computed. It ought to be a minor point. It's going to be only a relatively small correction.

The only thing that at least in my mind still is not -- I cannot give you a total conclusion on it yet, because we are still passing information back and forth on this issue, so I will have to leave a question mark at the end of this one, is having to do with chugging loads.

Okay, again the source strength clearly must come from an empirical data base. And it is the same data base as for the boundary chugging loads. However, there cleary is an important distinction here, and that is that when one is computing boundary loads, one can take some credit for the fact that one does not expect all chugs to be maximum strength everywhere around the boundary.

And so one can take some credit for the fact that one then does not have to compute a total symmetric load with all chugs at maximum strength, and synchronized, and so forth.

Whereas when one is talking about submerged structure loads, there is always the possibility that it's precisely the maximum chug that's going to occur through the whole LOCA occurs right next to the particular structure that you're considering, so clearly one has to use somewhat different criteria for deciding whether a source strength is conservative or not.

And that's the one remaining issue that we're still discussing, as to whether it is or is not.

Okay, in this particular case, rather than computing the whole flow field and going through all the details, a sort of an approximate acoustic model is taken for all the chugs propogating through the pool and arriving at the strucutres.

It actually turns out that what is eventually done is that conservative assumptios are made that simply all of the chugs that could reach a particular structure from different neighboring vents within the duration of the chug are taken as being all totally synchronized. So no advantage is taken of the dephasing or arrival times of the various pulses at the structure.

27

Then what is done is just the force is taken proportional to the pressure difference one would compute from such pulses. And that clearly has some questions that could be asked about it. But what is done, again to be conservative, is rather than taking the pressure gradient that would exist at the structure, due to the pulse arriving at that structure, the full pressure difference across the pulse is taken across the whole structure.

Now that sounds conservative. And indeed, if you look at the conclusions, it turns out that if you just ask what is that pressure gradient, taking the whole pressure difference across the structure, compared to the pressure gradient that you'd get for the pulse arriving at the structure for the largest structure that exists in the pool, you find out that you get a factor of 2.54.

Well, that sounds like enough conservatism to not worry about anything else, except for the fact that we all know that if I have a pressure gradient existing in a flow field, and I put a structure in it, the actual force that I get is not proportional -- is not just equal to essentially the pressure difference across the structure, if the structure hadn't been there -- but there is a hydrodynamic mass effect which, for a cylindrical structure, is about two. And it is around two here because in spite of the fact that its acoustic propogation is taken into account, on a scale of the structures themselves, the flow field, the induced flow field, is essentially incompressible.

So it turns out that there is an adequate conservatism for the calculation associated with taking the pressure gradients and so forth, provided the source strength is still conservative.

There is additional conservatism -- and this is the part that's the hardest to put your finger one -- associated with the fact that no phasing is taken between these pulses arriving at the structure. And secondly, that all of the pulses, all of the pressure gradients, are assumed to act in the same direction. In other words, no geometric consideration is taken that the pressure pulses are coming from different directions to the structure.

However, these conservatisms are difficult to quantify. And it is precisely the issue that still exists is are those conservatisms sufficient to compensate for any potential lack of conservatism in the interpretation of the date base of deducing the source strength.

And at this stage, I am not prepared to say yes or no yet.

On the SRV, there is -- I guess partly as a result of the history having to do with the Ram's-head type design, one worried about the water jet coming from the quencher. It's clear that it's a kind of a misnomer for a quencher, because clearly there are a lot of little jets coming out of the quencher holes which coalesce into larger areas of sphere of flow around each of the quenchers, which then presumably penetrate some distance until the air starts coming out of the quencher.

We can still call it a water jet if we like. The experimental evidence on that, however, suggested that that effect is limited to some region which is something like a sphere of influence around each quencher.

And the conclusion is essentially that there is no structure within that region for each quencher, and therefore one doesn't have to worry about that part of the load.

The bubble loads -- the methodology is essentially similar to either LOCA or CO methodology. Again, the only issue is where do I put the bubbles, and what their strengths are.

The strengths come from a conservative estimate of what -- I mean one can obviously -- There are four bubbles taken, coming in between each of the quencher arms, and clearly one can take a conservative estimate of the pressure and the size based on the volume of the air that would come through and the initial conditions with which one would start.

In this particular case, however, since these bubbles are smaller than a LOCA bubble and there's actually an oscillation involved in the rise of these bubbles, the calculation includes both the oscillations and the trajectory. And then an equivalent uniform flow field is computed, each structure location, and standard and acceleration drags are taken. And the various issues associated with using the conservative bounds on the drag coefficients to account for ascillating flow and so forth have all been agreed to.

The only issue that came to my mind was the question of phasing of the four bubbles at a single quencher, since clearly if one does the calculation totally in phase, one would expect that there would be -- I mean certain loads, let's say on the quenchers themselves, might exactly cancel out and one would get no asymmetric load.

So the question was asked: What evidence is there that these are in phase? And clearly, like everything in any experiment, the things are not totally in phase, but the amount of phase difference and amplitude difference in the four bubbles around the quencher are sufficiently small that one does not expect that load to be significant compared to all of the other loads that have to be computed on the quencher.

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DR. BIENKOWSKI: Well, that's all I have, unless there are any questions. I have some slides in connection with the chugging source strength if there are questions.

(No response.)

Okay, thank you.

CHAIRMAN PLESSET: Are there any questions?

(No response.)

I guess not.

MR. KUDRICK: I suggest that we continue on with our agenda now.

CHAIRMAN PLESSET: All right.

MR. KUDRICK: We have two remaining areas of consideration associated with local pool dynamic load. They are thermal stratification and its effects, as well as flow-structure interaction.

Dr. Economus, of Brookhaven National Laboratory, will present those areas.

DR. ECONOMUS: Good morning.

As pointed out by Dr. Theofanous yesterday, there are two aspects to this non-issue, one of which has to do with the concern in designing the structure for thermal stress. The other one, that has to do with long-term heat-up, is not the one that I am going to deal with today.

Okay, in order for the AE to design the structure to accomodate thermal stresses he needs some definition of a

32

temperature gradient. Experiments indicate that you do have a vertical temperature gradient. The one that GE has provided -- the basis for it is the one-third scale area PSTF tests. Mel showed you that profile yesterday; it increases upward at -- the specification as an overall delta-t of around 60 degrees Fahrenheit. And, it was developed by the finite cell energy deposition application to the experiment.

DR. CATTON: That also includes the mixing process, doesn't it?

DR. ECONOMUS: I beg your pardon?

DR. CATTON: The mixing process plays a r in what that temperature gradient is.

DR. ECONOMUS: Well, sure. What they did was take the measured profiles and sort of divvy-up the pool into five cells, as a matter of fact, and estimate how energy would be deposited on that basis, on the background of temperature flow.

MR. EBERSOLE: I believe Dr. Catton is talking about mixing as it is enhanced by the pump operation, are you not?

DR. CATTON: Well, no, the pump operation would tend destroy the thermal gradient.

MR. EBERSOLE: All right.

DR. CATTON: The fact that they have just used scaling --

MR. EBERSOLE: This is early on, that you are talking about.

33

DR. CATTON: Different geometric scaling may decrease the thermal gradient.

DR. ECONOMUS: Sure.

DR. CATTON: Have you looked at that?

DR. ECONOMUS: Well, one of the concerns -- which the next slide will address -- of course, is exactly that issue.

The one point that, I guess, Mel didn't mention yesterday when he showed the profile is that the profile varies with time, consistent with the global temperatures in the pool.

The concern, of course, as Dr. Catton points out, is how applicable is the one-third scale data for the prototype. And, also, another question is: what sort of effect of break size may we expect?

The way GE resolved these concerns was to do a series of numerical calculations using the RELAP code. Most specifically, to address the question of distorted scale, as to what that would do to the profile.

DR. CATTON: For natural convection in that particular geometry using the RELAP code is nonsense.

Just a comment.

CHAIRMAN PLESSET: Well, that's a strong comment.

DR. ECONOMUS: We will have to take that comment into account

DR. CATTON: I can expand on that if you want.

DR. ECONOMUS: Well, sure.

34

DR. CATTON: It's a natural convection problem and the RELAP code is not set up to solve that kind of a problem.

It's not a trivial problem. You have very high Rayleigh numbers, you have turbulence resulting from the convection process, you have stratification that wipes these things out, and the RELAP code is not a code that was designed to look at that kind of a problem.

DR. ECONOMUS: Well, the confirmation proceeded as follows: they modeled the actual number of facilities and generated profiles for the actual one-third scale blowdown, and first demonstrated that RELAP was doing a reasonable job of predicting the profile.

DR. THEOFANOUS: Which RELAP was that?

DR. ECONOMUS: Well, Steve could give us the number. I don't remember it at this point.

STEVE HUCIK: It was RELAP 4.

CHAIRMAN PLESSET: RELAP 4, MOD 5.

DR. THEOFANOUS: Thank you.

DR. ECONOMUS: The first step was to generate some predictions for the actual one-third scale area tests. The predictions look reasonable.

Then, having satisfied oneself that the thing does a reasonable job in the one-third scale, they proceeded to make predictions for a full scale PSTF, and an actual Mark III

35

238 plant. What they showed primarily was that the scale had a very slight effect on the slope form.

DR. CATTON: I'm not sure that with RELAP you can show much of anything in that problem.

DR. ECONOMUS: Okay, we'll have to take that into account.

DR. CATTON: They are very tough to model using computer codes because of the coupling between the energy equation and the momentum equation.

RELAP was just not designed to be that kind of a code, and I would be very surprised if it were to solve the problem, without a lot of empirical adjustment.

DR. ECONOMUS: Well, as I say, presumably --

DR. CATTON: I think that's enough.

DR. ECONOMUS: That's enough, okay.

Well, in any case, basically the comparisons that they show us with the actual measurements, we concluded that the RELAP code does a reasonable job of modeling the profile, and quantitatively the calculations for Mark III showed that the overall delta-t, which is specified -- namely, that 60 degrees Fahrenheit that I showed you earlier -- is conservative, because the RELAP prediction is only 56 degrees.

DR. THEOFANOUS: Does that mean that the Staff accepts this?

DR. ECONOMUS: At the present time the Staff's posi-

36

tion is that that temperature profile is acceptable for use in the design of the structure.

DR. THEOFANOUS: On the basis of this RELAP calculation, that's the basis you used to accept it?

DR. ECONOMUS: On the basis of comparison of tests as well.

DR. THEOFANOUS: So, you used the RELAP to take those tests up to full scale. So, you are really using RELAP as the basis of your thinking?

DR. ECONOMUS: Yes.

DR. THEOFANOUS: Because you believe it has acceptable meaning.

DR. ECONOMUS: It was benchmarked against actual experiments as a first step.

DR. CATTON: It was benchmarked against the one-third scale tests, which have skewed geometry.

I think you first have to address the question of the skewed geometry from the natural circulation that is taking place in the pool.

DR. ECONOMUS: Well, I don't understand.

Do you mean that when applied to the one-third area scale geometry -- I mean, the actual geometry that was --

DR. CATTON: As indicated earlier, that one-third scale -- or one-ninth scale -- makes the whole problem more one-dimensional. That makes it kind of like a chimney.

So, if anything I suppose you are going to get more stratification as you extend that wall out, because you have got more room for that hot fluid to flow out across the surface and be stratified.

Until you address that, somehow -- the effects of the scaling -- you can't use the code for a different scale.

DR. THEOFANOUS: Well, you know, from my point of view, I'm sure you used the facilities and you used certain constants -- which facilities' momentum and energy -- to do the calculations. And, you fixed those numbers so that you can predict the one-third scale.

And, again, even if they work in a one-third scale, nothing tells you that they can be used in a larger scale. There are many problems.

DR. CATTON: They don't have a second-order term in RELAP, so they don't have diffuse energy.

DR. THEOFANOUS: They must have something, otherwise it would --

DR. CATTON: I don't know where.

MR. TOWNSEND: Hal Townsend from General Electric.

Let me make one comment about the distorted scaling. We did measure temperatures in the one-ninth scale as well. As we go from the one-third scale to the one-ninth scale we are getting progressively narrower and more chimney-like.

We saw that the temperature gradients were greater

38

in the one-ninth scale and it indicated more stratification than we have in the one-third scale.

So, it has a very superficial extrapolation and you would expect smaller gradients in the full scale, I believe, independent of what you do with RELAP, or that type of thing.

DR. CATTON: Well, if you have got other arguments they might be acceptable. But, RELAP is a one-dimensional code.

MR. TOWNSEND: Yes, I don't dispute that.

CHAIRMAN PLESSET: Well, I don't think that we need to go into RELAP anymore. It's pretty well trampled on, I think.

But, I think that -- the idea that I get out of all of this is that there are a certain amount of problems, okay?

Do you agree with that?

DR. ECONOMUS: Yes, I do.

MR. FIELDS: You know, in the Mark III pool there are a lot of pump suction devices; there is a lot of mixing in there.

CHAIRMAN PLESSET: There is another question about this.

MR. EBERSOLE: I suspect that a more critical problem is the rapidity with which the pool liner -- it is lined, is it not?

DR. ECONOMUS: Yes.

39

MR. EBERSOLE: It heats up relative to the concrete; the concrete stays in place, in essence, and the liner tries to crawl out of there. At the points of anchorage it will tear itself unless you design specifically for that purpose and create leaks exactly when you don't want them to occur.

I would be interested in your showing that the rapidity of the heat-up of the pool has not caused the liner to depart from the concrete at the anchor points and develop leaking points all along its side.

DR. BUSH: But, even if it does it, it doesn't matter that much, Jesse, from a safety point of view.

I admit that it causes a gap in the heat transfer process.

MR. EBERSOLE: No, what it is is radioactive fluid, now, that has a leakage past two atmospheres.

DR. BUSH: You are assuming that the concrete, by definition, is going to leak, and I don't agree with that.

MR. EBERSOLE: Oh, that's okay, yes.

If you agree that the concrete is inadequate --

DR. BUSH: I agree that the tanks that are not lined are weak.

MR. EBERSOLE: Dr. Bush is right. Unless we have established the leakage I have no problem.

DR. ZUDANS: But, even if this temperature would be twice as much -- for twenty feet height distribution -- you

40

would have no structural effects.

MR. EBERSOLE: Well, the steel moves very fast relative to the concrete.

DR. ZUDANS: It starts from the bottom. The bottom is at the same temperature as the side, and it regularly heats up as you go up, and that's within some fifteen of twenty feet. The gradient is insignificant.

MR. EBERSOLE: I'm not talking about the gradient. I'm talking about the absolute mixed temperature of the water versus that of the concrete at the steel/concrete interface.

If the water, that suddenly gets up to near 200 degrees, leaks I have no gradient problem. It's the gradient into the concrete out of the steel.

CHAIRMAN PLESSET: Right.

But, I think that Spence has a good point --

MR. EBERSOLE: Yes.

CHAIRMAN PLESSET: -- that the concrete itself will work, even if it does separate.

MR. EBERSOLE: If it can stand cracks and still retain the function.

DR. ZUDANS: How can it separate? It's backward compression if it gets hotter.

MR. EBERSOLE: I don't think the concrete -- is the concrete designed as a membrane to hold leakage? Doesn't it have seals in certain places where leakage could come out at

41

steel-to-concrete interfaces?

I didn't know that the concrete was actually a vapor containment shell.

MR. KUDRICK: The liner is in place for that --

MR. EBERSOLE: For that purpose.

MR. KUDRICK: However, if the liner were not there, it's not obvious that you would have any leakage.

MR. FIELDS: The concrete surrounding the suppression pool is seven to eight feet thick.

MR. EBERSOLE: Yes, but that would be no good if there were a gap.

MR. FIELDS: Right.

(Pause.)

CHAIRMAN PLESSET: Are you finished?

DR. ECONOMUS: I'm finished with thermal stratification.

CHAIRMAN PLESSET: Okay.

DR. ECONOMUS: Jack, should I go on to FSI?

MR. KUDRICK: Yes, just continue on.

DR. ECONOMUS: Well, let me try another non-issue and see how far I get.

Once again, there are two aspects to this issue. One is the one that is highlighted by that question: has there been any FSI effect on the measurements that were obtained which introduce non-conservatisms?

42

The other question has to do with: does the AE correctly account for FSI when he does his structural evaluation?

On the basis of what has transpired before, in Mark I and Mark II, I believe that the answer is that they do account for that by added masses, and so on. I believe that the AEs recognize at this point that they have to properly model the presence of the water on the boundary.

So, we are addressing this issue here. Once again, the approach to demonstrate that the FSI is either negligible or did not introduce non-conservatism, or was to use numerical modeling, to demonstrate that. A variety of models were used and predictions were generated for all three scales, all three facilities.

The general conclusion was that it had very little effect and that when it does have an effect, the effect is to add conservatism to the load specification.

As I said, they used different numerical modeling; for the one-ninth and one-third scale tests they used NASTRAN.

How do you feel about NASTRAN?

DR. CATTON: You will have to ask Zenon about NASTRAN.

DR. ECONOMUS: That's all right.

(Laughter.)

In general, the NASTRAN code showed that there is --

that very little FSI should be expected in those facilities.

43 DR. ZUDANS: It's such a heavy structure.

DR. ECONOMUS: Yes, it's -- well, it turned out -- I'm preceding myself a little bit here -- the full scale facility had the south wall -- the south wall is a drywell wall?

(Affirmative response from a person in the audience.)

The south wall was somewhat flexible, but that flexibility introduced conservatism.

In any case, the conclusion is that there is very little effect and they tend to introduce conservatism.

For the full scale facility, as I said, they use different methods. They used the 2-degree-of-freedom model and also three-dimensional compressible finite element model, and they examined the transfer functions, and so on. And, again, they showed that -- they tended to overestimate FSI effects, in that they were important or non-conservative.

I just have one example of the sort of thing that one sees when comparing this acoustic model -- that I just talked about -- with the actual measurements. You see there is very little FSI indicated on the basemat or the north wall, or containment wall. But, a significant effect on the drywell wall. And, the solid profile is the actual forcing function tha is used in defining the loads.

CHAIRMAN PLESSET: Thank you, Dr. Economus.

MR. KUDRICK: That concludes our prepared presentation in LOCA-related pool dynamic loads.

44 Since we're going so well, I've been told we can proceed into the area of SRVs.

And I would like to introduce Nelson Su, who is the Task Manager on Task Action Plan A39, who is responsible for the SRV-related loads for Mark III.

(Pause.)

DR. SU: Good morning.

Just to introduce myself, I am the Task Manager for Task Action Plan A39, which deals with SRV-related pool dynamic loads for Mark I, II and III.

We have had opportunity to discuss this subject with the subcommittees in the past several years. Therefore, I will just quickly provide you an overview of what we have done, and the current status of our review of Mark III SRV loads.

First of all, I would like to provide you the background of the SRV-related issues. In 1975, GE proposed the use of the X-quenchers. This quencher device was a modified version of the KWUs X-quenchers. The modification includes the lengths of arms and the number of holes in each arm.

The whole pattern is identical with the KWUs X-quencher. As you know, the KWUs had performed the rest of the scale test and incline test on these particular devices. Based on this date base, GE developed a methology to predict

45

loads for the GE version of the X-quenchers. As a result of the reviews on GE's methodology, we concluded that GE's proposed methodology is conservative and acceptable. Subsequent inplant tests, both in Caorso and the one I'm going to talk about -- Kuosheng Nuclear Power Plant SRV test -- to confirm that.

Therefore, we issued acceptance criteria in 197 The acceptance criteria include the GE proposed methodology. In one area, with regard to multiple activations, we imposed a very conservative assumption, that is, a bubble oscillating in phase, to be used.

We also encouraged the load cases should be analyzed to demonstrate the piping equipment and structures to accomodate these load cases.

Since we issued our acceptance criteria in 1976, GE proposed three key area of modifications -- or you can say exceptions -- to our acceptance criteria.

The first one is so-called low-low set logic. The second one is load reduction factors, based on the Caorso inplant tests. The third one is the bubble phasing, to be determined by Monte Carlo's approach.

DR. CATTON: What is low-low set logic?

DR. SU: Yes, I will go briefly into the descriptions. I am not prepared to go in detail into discussion in these particular areas. Low-low set logic is a system designed

46

to limit the number of SRVs to not more than one. The German experiment shows SRV-subsequent activation results in higher loads than the first activation. And they proposed that only one valve will pump subsequently. On that basis, the piping equipment and containement structures were determined on that basis. Subsequent to that time, GE found some mistake in their analysis.

If we pump more than one, as high as ten, in order to maintain that design load, GE proposed a so-called low-low set logic, which means they will alow some of the valves to continue to maintain open, after the first activation. So the valve released the energy to the pool, and adds to the primary system below the set point. Some of the valves will close, but some of them will continue to open. This will reduce the primary system as such, and if the pressure rises again, they will pump only one.

Recently, we have completed a review on this particular system, in conjunction with the Grand Gulf review.

As I say, I'm not prepared to discuss this in detail, but I will answer any questions the members of the subcommittee may have.

Yes?

DR. BUSH: That gets to be a very interesting code problem, because it sounds to me now as if the reliability of this circuit response is going to be very critical. You can

47

either -- you could go one of two ways: In theory, you could hold open and get a control blowdown, but in practice it might be a continuing one.

Or the other possibility is, depending on what type of circuitry, that you can't get an adequate blowdown.

DR. SU: Well, I am not the right person to give you detail. I always say the staff and the instrumentation and the electrical system have reviewed it, and some single failure may result more than once. The most is two.

And we also requested risk and probabilities, the assessments branch, to review the probability of this type of failure.

And the conclusion would be it ranged from 10^{-3} to 10^{-6}. Now when I come to the discussions on the Taiwan Power Company implant test to show, suppose this happens, a single failure -- although the low probability -- has happened from that point of view would not be substantial. This will be bound by the design load.

Does that satisfy you, Dr. Bush?

DR. BUSH: Well, I'm just thinking that I believe that this deviates enough from the code that states might not accept it.

So any utility that has them better check with their states.

DR. SU: Okay. I will take your comments.

Dr. Economus from BNL will discuss in more detail the second item and the third item.

48 Our current status has no open items for GESSAR dockets, virtually its generic applications for all the Mark III containment.

The result of staff evaluations of the Mark III SRV load will be included in a new report. The draft of NUREG 0802, entitled "Safety Relief Valves," our evaluation report, Mark II and IIIs containment, is scheduled to be issued for management's comments and concurrence by November, 1981.

With respect to the performance of cross-quenchers, the draft of NUREG 0783 entitled "Suppression Pool Temperature Limits for BWR Containments" was issued to ACRS for comment.

I talked to the ACRS staff, Mr. Paul Boehnert. I was told they have received no comment.

On that basis, we proceeded to issue our final form of the NUREG 0783. By issuance of NUREG 0783 and 0802, we will complete our evaluations on this particular issue. In fact, we will complete the Task Action Plan A39 by that time.

My next topic of my presentation today may be more interesting. I will talk about the recent SRV inplant test conducted in the Kuosheng Nuclear Power Stations.

First I will provide you general information regarding the Kuosheng Nuclear Power Station.

49

Kuosheng Nuclear Power Station is located near the northern tip of Taiwan. It is a twin unit, which means the shell; a number of buildings, including the control room. Each unit is rated at 985 megawatts.

The first unit started construction in September, 1974. The work was completed in January, 1981, probably a little more than six years from the time construction started to the time of fuel loading.

Both units are BWR 6/Mark III containment. The first unit was operating at 60 per cent power in August, 1981, at the time performing the SRV test. This would be actually the first BWR 6/Mark III in the world.

The second unit is scheduled to have fuel loading by the second quarter of 1982.

This cross-sectional view of the Kuosheng Nuclear Power Plant primary containment, as you can see, is a reinforced concrete Mark III containment. It is essentially the same type of containment for the Grand Gulf. In fact, the Bechtel Corporation is the architectual engineer for both the Kuosheng Nuclear Power Plant and Grand Gulf.

As I understand, the Kuosheng Nuclear Power Plant was following the Grand Gulf. Then by now, it is way ahead of the Grand Gulf.

As I mentioned previously, Kuosheng Nuclear Power is the first BWR 6/Mark III containment in the world. Taiwan

Power Company, under the supervision of the Atomic Energy Council for the Republic of China, decided to perform SRV inplant tests. The object of the test was to confirm SRV loads for piping, equipment and structures.

Second, the result of the test will provide a data base for the structure model. Now as I understand it, the Bechtel Corporation will use this data to generate so-called low reduction factors for their structural response model.

The third objective is to provide a data the X-quenchers' thermal performance, namely in pool mixing. By these data, they will be able to demonstrate the GE cross-quenchers at the Kuosheng Nuclear Power Plant will meet the pool temperature limits.

I may want to make a note. Taiwan Power Company and the NRC counterparts followed closely what we have been doing here.

Now this slide shows a plan view of the suppression pools. The Kuosheng Nuclear Power Plant has 16 quenchers, with seven of them designated as ADS. That is the pressure sensor, as you can see it. The low-low set SRVs, that's the one identified V8. This one is V8.

This is a cross section of the suppression pools, where the quenchers are and the quencher supports. You can see they're very richly supported to the wall with an almost solid steel block, supported to the drywell wall.

As you see, there are also a number of the pressure sensors around to measure the pressure attenuation effect.

51 The inplant test was started on August 22nd, 1981, and completed on August 28th, 1981, roughly eight days, 24 hours around the clock.

The total number of the tests was 32. The instrumentation you can see here appeared to as more than adequate just for the purpose of confirmation. They have 128 accelerometers located inside the containment building and outside the containment building on the select equipment and piping system. They have the pressure sensors around the pools, in the vertical direction and the horizontal direction, which measures the pressure attenuation.

They also have pressure sensors located in the piping. Strain gauges here, and a quencher support. They have 22 thermocouples at this point to aid the normal flow temperatures monitoring system.

The test included the single-valve first activation, which means they popped the valve to simulate normal operating conditions. And they had single-valve consecutive activations, which means they first pop the valves and instead of waiting, say two hours, for the next text, they wait on a range less than one minute, and then pop. At that time, the line would be in the high temperature condition, because of the heat from the prvious activation.

52

The test also included two adjacent valves' activation, to demonstrate the asymmetric loads on the containment. Now the four valve test was primarily to provide a data base for the structural response model.

Finally, they had three extended blowdown tests. One without RHR -- the pool stands still. Second, with the RHR in operation one hour before the SRV was activated. The third test was with RHR put in operation five minutes after the SRV was activated.

Yes, sir?

DR. BUSH: You said there were three extended tests. That means there were 29 of them divided, I presume, among the first four -- the single valve first, the single valve consecutive, the adjacents and the four valves.

Exactly how mnay were run on those?

DR. SU: For the single valves first activation, the test on the V8 and V5 each one I believe was four, in order to provide some statistical significance.

DR. BUSH: Is that eight in all?

DR. SU: Yes.

I can't be exact. Just the rough ideas.

DR. BUSH: Yes, right.

DR. BUSH: How about the others?

DR. SU: Excuse me for one moment. Consecutive saturations will be 12. Was 12 and the ------ involved was 3.

DR. BUSH: It was 6 for the SRV?

DR. SU: Right.

DR. BUSH: So that from a structural response point of view there were a fair number of tests under that four valve ---?

DR. SU: Yes.

DR. BUSH: Thank you.

MR. EBERSOLE: May I ask a question? In your general valve design you've got 16 valves. You've got by-pass of some capacity, I don't know.

Presumably when you have a turbine trip and your by-pass fails, you're going to get most of these valves, aren't you, at once?

DR. SU: That's right.

MR. EBERSOLE: Not once, you get them all?

DR. SU: Not once, at different set points.

MR. EBERSOLE: But they'll come up and will they all be functional for the full power turbine trip without by-pass?

DR. SU: I don't ------.

MR. EBERSOLE: What's the capacity of the by-pass?

DR. SU: I don't recall. I would say probably 10%.

MR. EBERSOLE: And what's the capacity in terms of full steam flow of these 16 valves?

DR. SU: Each one is designed for 7%.

MR. EBERSOLE: 7%?

DR. SU: Right.

MR. EBERSOLE: So it's 70% -- no, well over 100%?

DR. SU: Yes.

MR. EBERSOLE: That's a notable difference between some twr's that I know and yours.

DR. SU: I believe so. They have acquired margins.

MR. EBERSOLE: Does this help you out with that one?

DR. SU: I don't know.

MR. EBERSOLE: If you can -- them all at once.

DR. SU: I try to stay away ---.

In 1980's NRC and AC's, the Republic of China and Taiwan Power Company reached informal agreement for the NRC participation in -- SRV and plant tests.

Primarily the NRC staff would provide technical assistance in exchange for access to the data.

You may know or not, the total cost of the test was reported around $5 million dollars, U.S. dollars.

In mid-1980, the staff review and comment on the test plan, subsequently the staff was invited to witness the test.

The NRC teams, during the test includes myself, and three consultants from RES, because the original set-up was with the research people.

And since I happened to be working in this area, so I was to get involved.

During the test, the NRC staff participated in review of the test results to determine whether the next test can proceed.

That means to see any surprise or any test result that showed to exceed the design barrier to make a decision or recommendation to the management whether to stop or change the program.

We also provided technical guidelines for the test programs.

I would like to mention the participation includes the G.E.'s, Bechtel, the NRC and some observers from Italy and the Mississippi Power and Light Company.

The tests were conducted by Nutech and Wyle Labs. Well, I have to apologize. I will not be able to provide you the test results in specific terms because at this point, it's still not clear how the Taiwan Power Company will handle the test data. They may regard that as company proprietary information, and will have limit the

the release of the data, or they won't make it public.

Because of this situation, I will present to you in the general term, instead of the specific number.

One -- shows in the slides, the test results show a substantial data scattering. It's not, I would say, it's not as good as CAORSO data in terms of repeatability. What reason caused that, to wait until we have an opportunity to evaluate the data.

In general, the test results show the strain gauge measurement are very small in comparison with the expected value.

When I say the very small it means only a fraction of the expected value.

The accelerations measurement -- they are also very -- I would say -- small, not as small as the strain gauge to compare. I still have significant margin.

The test results show you have significant acceleration in pool region. Now, this, I put a note that it requires further investigation because the accelerators, the way they set up may pick up the motion of the pool in addition to the building response.

In the same relative location, inside a pool, and outside a pool or say outside containments, very close similar locations, the one inside the pools measures almost a factor of 6 or 8 higher than the one measures outside the pool.

MR. EBERSOLE: The acceleration of what part, please?

DR. SU: The building.

MR. EBERSOLE: The building.

DR. SU: ----- the building because it's a small distance. I don't know but I really suspect the building --- would cause such a big difference.

MR. EBERSOLE: That was measured with a maximum of four valves discharging?

DR. SU: No, sir. Single valves.

MR. EBERSOLE: Would you expect a substantial increase, added increase with all 16 working?

DR. SU: I would say so. Keep this in mind. The so-called expected values I mean for the single valve --- the pressure measurements in general are within their expected values. Some exceed as I note in my slide.

Now what this one really means in terms of design is not clear from the on-site data. I will categorize that as localized loads because you have to look at the overall in terms of global pressures on the containment.

The last slide really reflects what I said previously, on the low-low set logic.

Now, the test result shows no significant pressure increase from consecutive acceleration.

This is somewhat contradictory to the German data. Dr. Zudans, the questions there on the subsequent accelerations there, I believe the Germans' test may have very small vacuum breakers in comparison with what was used in Mark III and also Mark II and Mark I. We made some before on Mark I -- also shows no signficant pressure increase from subsequent accelerations.

Let me back up a little bit to the Low-low set logic.

If a single values so occurs on the low-low set logic will result ----- subsequently instead of single one.

On this, the basis, this would be bound by the design case. All 16 pums or even ---.

DR. ZUDANS: Would you show where those vacuum breakers were located on this plant?

DR. SU: Locate inside the dry wells.

DR. ZUDANS: You have a sketch there.

DR. SU: Although it is a schematic diagram, it's very close, to where they locate each one. They won't really show the vacuum breaker locations -- what I see is in the unit 2 is locate around this region, pretty close to the discharge.

DR. ZUDANS: So if it would get stuck open it would pressurize the dry well without --

DR. SU: You say in terms of --there you become small on break.

DR. ZUDANS: That's right.

And that's what confused me because in the G.E. report they said they are located in such a way that that cannot happen and obviously that's not true.

DR. SU: Well, I really don't know the section you quote.

I would say it would not happen -- not in terms of stuck open, in terms of stuck closed because they have two vacuum breakers in series so that is a simple flip-flop. You want to stop close after both of them fail and the CAORSO test with one of the valves closed, intentionally to test what the consequence and the results shows how much change because the capacity of the valves ---, I believe the dangers.

MR. EBERSOLE: The item that you have on the four valve test which shows significant acceleration on the crane girder, I don't believe you went over that.

Do you mean the crane girder at the top of the --

DR. SU: All the way at the top, yes sir.

MR. EBERSOLE: Was that just due to building resonance or --

DR. SU: Not clear to me. All I have heard is ---- on-site at the analysis and very quick look and I was --- keep this one in mind, if we have the opportunity to participate the evaluation of the data.

MR. EBERSOLE: Would you throw the smaller cross-section up on the board a moment please?

The other picture you have.

DR. SU: Okay.

MR. EBERSOLE: I notice you extended the guard pipe on the SRV discharge line right down to the 45° line. Why did you do that? I don't believe the G.E. design does that.

DR. SU: I really can't answer that, sir. Because the nuclear power plant designed that way. I believe the use of the GESSAR, just up to the point there was --- and you can see the ----, the design, different from what we have or what you will see in this country, for instance, Grand Gulf. The floors are different. The guard pipe I see ---- different.

MR. EBERSOLE: Has the staff noticed any difference between the Taiwan plant and the Grand Gulf plant. The issue to bring out is the significant engineering difference from a safety viewpoint.

MR. FIELDS: For the SRV loads or in general.

MR. EBERSOLE: In general.

MR. FIELDS: I don't think we've really done any detailed comparison in that fashion. The only reason we have looked at the differences that could effect the SRV loads is because we may be using their test data.

MR. EBERSOLE: For instance, are the instruments located in the same place? Do they have the same catwalk?

MR. FIELDS: Maybe G.E. could answer that.

MR. HUCIK: I think the general design of Koshang is similar to the all standard Mark IIIs so that the HCU floor and that sort of thing is pretty much designed in general.

There are several plant unique features for all plants.

MR. EBERSOLE: I didn't notice the grating.

MR. HUCIK: It's there.

MR. EBERSOLE: It is?

MR. HUCIK: Yes.

That may be another Mickey Mouse cartoon -- it may be only showing a certain section where it maybe is concrete but they do have the grating also.

MR. EBERSOLE: Do you know then if there is no particular engineering significant difference that you know of from a safety context?

MR. HUCIK: No, not that I can think of.

MR. EBERSOLE: Thank you.

MR. FIELDS: The SRV supports are different.

10

MR. EBERSOLE: I saw that.

DR. SU: The final item from the test results for the pool mixing -- the total discharge times was 9 minutes for each test and the bulk to local temperature difference is 19°F without RHR and decrease to 9°F with RHR operating one hour before SRV was actuated.

The highest temperatures that were measured is around the quenchers and they compare with the bulk temperatures about 30 minutes after the closures of SRV.

I came out -- I have to mention this. That is the number I came out--not really officially Taiwan Power Company's number.

DR. BUSH: Did they start with ambient temperatures in the pool? For these tests, essentially?

DR. SU: I would say essentially about 90° to start with. It really cannot cool down further. The ocean temperature is about 87°.

I have to put a note on my presentations. The results and my conclusions, I have to emphasize, my presentations and the test results and conclusions of the test results were based on a very preliminary assessment of the on-site data. With that note, I will mention the nuclear the ---- nuclear power plants have fulfilled the objective of the SRV test. In general, the structural model way over predicts the piping equipment

11

and building response, with respect to the forcing functions. The methodologies for predicting the pressures is marginal in terms of maximum pressures. That's the way, here note, I have to investigate in terms of global pressures, because the ---, the methodologies provide a very conservative pressure attenuation, the effect.

The other conclusions, the forcing functions, is the consecutive actuations, the methodologies over-predict most of the cases.

The final terms regarding the applicability of the test result is -- you notice, the methodologies marginally predict the forcing functions and I really cannot make -- distinguish the conclusions before a detailed investigation we make.

However, the thermal mixings, I believe, the -- and SRV tests will provide a good data base for all the Mark III plants.

MR. EBERSOLE: Can I ask you a question about these tests in a little bit different aspect.

Were the people inside the containment when you ran the test?

DR. SU: Yes, I was there. I put my ears against the containment walls and the sections, the quencher discharging and I really don't feel much the building response.

MR. EBERSOLE: Well, normally you don't have people inside the containment -- about how many? Do you know?

DR. SU: Inside the containment, I don't believe they do.

MR. EBERSOLE: Won't they be maintaining some of the instruments in there?

DR. SU: No, no.

MR. EBERSOLE: There's normal maintenance in the building.

MR. FIELDS: There's normal maintenance in the building.

DR. SU: No, I have to say, not inside the containment. I was outside the containment.

MR. EBERSOLE: You were outside the containment.

DR. SU: In fact, the -- when they performed the last series of tests, 4 valve test, the plant superintendent request some of his staff went inside the containment to get a feel.

MR. FIELDS: Did he go in?

DR. SU: No, no, the plant superintendent --.

MR. EBERSOLE: I think the older the better because I'm getting around to a radioactive dose question.

With an old core and its ultimate limit of damage, before you have to take it out, because of -- defects, 13 when you experience a turbine trip you get many of these valves discharged.

The steam will stop in the suppression pool but the available gases will come up to be breathed by the occupants.

What dose will he get?

DR. SU: I really can't answer your question.

DR. BUSH: I don't think they're permitted to be in there, are they?

MR. EBERSOLE: You're working in there.

DR. BUSH: You're working in there?

CHAIRMAN PLESSET: I think we have a volunteer from G.E.

MR. HUCIK: One of the G.E. personnel did go in with the Tripower people during that one acuation. He said the noise level was barely audible above the normal plant noise.

The radiation levels that were measured during all of the SRV tests were well below the limits that the Republic of China AEC asked for.

MR. EBERSOLE: It has no relevance to my question. I'm talking about with an old and worn out core and a full turbine trip.

MR. HUCIK: I would imagine one could scale up those readings to get a feeling of --

MR. EBERSOLE: I think it would be necessary that we have an estimate of radiation dose in keeping with our other requirements.

CHAIRMAN PLESSET: I think we have more comment here. Mississippi Light?

MR. RICHARDSON: John Richardson, Mississippi Power and Light.

There are two things. I don't remember the exact source terms that were used but G.E. did do calculations based on normal occupancy, times and duration of time to get out of the containment during those consequences and I don't remember, like I said, what the source terms were, but there is a NEDO report and G.E. could probably find out the number or we could find out the number, which gives those calculations.

In addition, we were asked by the staff for some numbers on the dose rates to an operator or a maintenance man if he was in the containment under certain conditions and we did respond and give those dose rates and I don't have them on the top of my head but that issue has been looked and addressed.

CHAIRMAN PLESSET: Then we'll get it. Thank you.

DR. BUSH: Referring to your last item, I presume your conclusion is based on the fact that you had thermal mixing for just a very short time. I mean, if you are talking about an extended period --

DR. SU: No, ---. The Mark III containment, the shell can take such the temperature difference, that would be very conservative.

DR. BUSH: One other question. On your -- model over-predicting, of course, you've got two aspects of it and I presume Bechtel will address both forcing functions and also the conservatism in the damping factors would certainly be a very important thing and they are generally very conservative.

If you look if one combines them, perhaps one can understand the over-predicting.

DR. SU: I believe so. We have some discussion on the Mark I before. Sometime they over-predict by a factor of 10.

CHAIRMAN PLESSET: Do they have ignitors in the containment at the plant?

DR. SU: I don't think so.

CHAIRMAN PLESSET: I didn't think they would. Okay.

DR. SU: They didn't take the fast speed pictures.

MR. FIELDS: Are those the hydrogen guiders?

DR. SU: Oh, hydrogen guiders, I don't believe so.

16

DR. BUSH: I'm sorry. I misunderstood.

CHAIRMAN PLESSET: I'm sorry. Yes.

DR. ZUDANS: Did you say the structural model of the piping equipment and building response -- did they have the analysis before for these systems to compare to measurements?

DR. SU: Yes.

DR. ZUDANS: And the forcing function in the analysis was the forcing function as specified by G.E. and not the one that was observed in experiment?

DR. SU: The question -- yes. Based on G.E.'s predicted values.

DR. THEOFANOUS: I noticed in the NUREG report that you mentioned earlier that makes reference to this test. I got the impression by reading the report that the experimental data were somewhat different, of course, lower than what you expected, but I got the impression that you attribute that to imperfect knowledge of the actual experimental conditions of the reactor.

I was wondering if I got the correct impression, number one, and number two, if that is the case, what were the amounts and why there were such amounts that limit the comparability between what one would calculate and what one measured?

DR. SU: The in-plant test was required -- at the we issued the acceptance criterias in 1976, at the time the quenchers, there was developing and we don't know much about it. Since then, a number of in-plant tests have been performed. If you want me to make a judgement at this point, I would say the requirements on the in-plant test would be much in a narrow scope to have now. We specify in NUREG-0763 essentially we call for that.

CHAIRMAN PLESSET: Thank you, Mr. Su. It was a very interesting presentation.

MR. EBERSOLE: May I ask one more question that is relevant to the safety of the system.

In your design do you also lose water in the suppression pool to a central region under the core and you have to make it up with an elevated pool supply?

DR. SU: That is not my design.

CHAIRMAN PLESSET: It's not his. It's NRC's.

MR. EBERSOLE: In that design.

DR. SU: I believe so. As I say, it very much borrows the old way of doing here. It may have small deviations.

MR. EBERSOLE: In essence, they have to make up the water after certain loss --- from an elevated pool exactly as Mississippi Power and Light does.

DR. SU: I would say so, sir.

DR. BUSH: May I ask a quick question?

DR. SU: Yes, sir.

DR. BUSH: You have NUREG-0763 released and you mentioned the other two reports.

Do these three complete A-39?

DR. SU: Yes, sir.

DR. BUSH: Or are there others I'm not aware of?

DR. SU: That's the three reports in conjunction with NUREG-0661 for the Mark I. That will complete the A-39.

DR. BUSH: I'd like to second Dr. Plesset's comments. I thought this was a very well presented and very interesting discussion.

DR. SU: Thank you very much.

CHAIRMAN PLESSET: Yes, very much so.

Let's take a ten minute break at this point.

(Whereupon, a ten minute break was taken.)

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CHAIRMAN PLESSET: Let's reconvene and I believe that Dr. Economus comes on again. Is that right, Jack?

MR. KUDRICK: That's correct.

CHAIRMAN PLESSET: If he's ready.

(Pause)

DR. ECONOMUS: This is slightly -- the presentation will be slightly different than the way it is shown in the agenda, I think, but it is not too important.

I'm going to describe what is referred to as the GE cross quencher load methodology to be distinquished from the bubble phasing aspects of the methodology. The application for this methodology is for structural design, again, to be distinguished from piping and equipment evaluation.

It is a dynamic pressure loading which is applied directly to the wetted boundaries. It uses and idealized pressure signature which is -- you could characterize as a damped Rayleigh bubble. The- this wave form is totally characterized by specficiation of a peak pressure amplitude and a dominant bubble frequency. The latter is arbitrarily arranged from five to twelve hertz and the peak pressure amplitude is derives from a algorithm or an equation which is a function of plant parameters and the initial conditios -- operating conditions.

It evolved from a regression analysis of small scale,large scale and in plant test data which were performed by a foreign licensee. Namely, the Germans.

It -- as I say, it is a regression analysis of the data and it uses -- It uses a 95-95 confidence level margin. Aside from the features of the pressure signature, some of the other features are the spacial distribution. There is a two quencher arm radius plateau. In other words, any boundaries which are intersected by sphere of radius 2R, twice the quencher arm, maintain the maximum pressure. Beyond that point, there is a one over R attenuation, coupled with what is called a line of sight cut off. In other words, if the line projected from the quencher arm to a boundary intersects another boundary, the pressure is set equal to zero beyond that point and all of this applies below a certain point in the pool. That point being a 75 percent depth.

Above that point, there is a linear decay to zero at the pool surface. Now, for this methodology which is for structural design, the way multiple valve effects are treated is to assume there are synchronized bubble ossicilations and to SRSS the individual contributions with a cutoff at the peak pressure amplitude.

Of course, part of that methodology is a specification of a variety of load cases. The load cases that are considered are first actuation at low pool temperature -- this is of a single valve. A subsequent actuation at an elevated pool temperature, two adjacent valves, first actuation at low temperature, ten valves, one low and the next high set point group -- again, at low pool temperature. ADS valves, a first actuation at elevated pool temperature and all valves first actuation at low pool temperature.

Now, this figure simply shows how the wave form looks. As you can see, all features of it are defined. This figure shows POP. It's the same as PPE. Once you define POP in the DBF, this signature is completely defined.

Now, this methodology as Nelson pointed out earlier was originally accepted by the NRC by in 1976. Since that time, as the result of the data base made available by the Caorso tests, GE proposed some modification of the methodology.

Specifically, they proposed that it was appropriate to reduce the peak pressure amplitude by 20 percent for first actuations and 35 percent for subsequent actuations. We are -- This says Staff Review in Progress. That's true. We haven't completly finished taking our positions. In fact we received formal information at this meeting here from GE which we're going to be reviewing.

The issues that came up in the course of our review were really only three and we really consider them minor. In first developing -- in first justifying the reductions, we felt that they used the load trend with line volume that the original methodology had in non conservative manner.

We also found that when applying the same reduction to the under pressure that there was an incorrect application of the reduction made and also there was a vaccuum breaker effect which was observed during the Caorso tests which was not accounted for. I can talk about that in some detail, if you want, a little later.

In any case, there is complete agreement on these issues between the staff and General Electric and we expect and I would say that we have a solution on all of them. Primarily because after taking these reductions, there still remains sufficent margin to account for correct interpretation of the Caorso data base.

I can sort of indicate the extent of that margin with this bar chart that General Electric has provided us. This shows how one takes the Caorso measured data, adjust it to account for various differences between a standard plant and the GESSAR plant conditions and shows how far up you would have to go based on Caorso to get the 95-95 confidence level and this is compared with what the new modified GESSAR design would be. So, as you see there is substantial margin still between the -- what you would infer from the Caorso data and what the design uses.

Now, I have to point out that this calculation for modifying the Caorso data has already taken account of our concern with regard to the line volume effect, but not our concern with respect to the vaccuum breaker effect.

I'm going to show a proprietary slide here, which is not in your handout to indicate that when you account for that concern, you do increase what you would extrapolate from the Caorso data somewhat if you look at the value there. You see it turned out to be like 13.2, whereas without properly accounting for the vacuum breaker effect, you would project 11.7. Still a substantial margin remains and after all we don't consider that as a concern.

DR. CATTON: What is the vacuum breaker effect?

DR. ECONOMUS: Well, okay, specifically what was observed at Caorso was that -- well, the bulk of the tests -- I would say that 90 percent of the tests were done with so-called Valve A, which had a prototypical pair of vacuum breakers, but one of them was blocked and as I say, essentially all the data base came from a valve with only one operating vacuum breaker.

A limited number of tests were done with Valve U, which essentially had the same line volume. Geometrically, they were pretty similar. The only difference was when they actuated Valve U, both vacuum breakers were operating. What was observed was that there was a substantial increase in subsequent actuation loads with Valve U.

We speculate that this is a vacuum breaker effect, to wit, by having both vacuum breakers operating you let enough air in to crank up the loads.

The parameters that control such actuations are very complicated. They depend on what your initial water leg is, how much air content there is, etcetera.

DR. CATTON: Time between actuations.

DR. ECONOMUS: Oh, sure, absolutely, but as I say, I mean, everything else being nominally the same, Valve U tended to show significantly higher loads -- subsequent actuation loads than Valve A.

(Pause)

Now, that sort of covers --

DR. ZUDANS: I have a question.

DR. ECONOMUS: Yes.

DR. ZUDANS: In this sort of Valve U , was the subsequent actuations were associated with higher loads than the first association on the same valve?

DR. ECONOMUS: Well, actually the ratio between first and subsequent of Valve U was in both in proportion and absolute sense higher. The first actuations of Valve U were somewhat lower than the first actuations with Valve A.

And the subsequent actuations with Valve U were higher than the subsequent actuations with Valve A.

DR. ZUDANS: But the Valve U, by itself, first and subsequent.

DR. ECONOMUS: That ratio was higher than Valve A.

DR. ZUDANS: That's interesting. With the more air, that would be contrary to waht --

DR. SU: I just want to make a note. Caorso has a much larger air -- inside a line comparing with the -- would be. The effect is very difficult to determine.

DR. ECONOMUS: I would certainly agree with. It's a very complicated process and it depends on conditions inside the line when you do a subsequent actuation, it is highly variable.

DR. ZUDANS: Does anyone have a precise physical understanding why in Caorso there subsequent actuation is higher than the first actuation?

DR. ECONOMUS: My speculation is that what you wound up with is a situation with a hot pipe and lots of air. In other words, more air than in the --

DR. ZUDANS: First actuation?

DR. ECONOMUS: Not in the first actuation, but in the subsequent actuation with Valve A with only vacuum breaker operating.

DR. ZUDANS: No, no. Looking at the same line.

DR. ECONOMUS: Yes.

DR. ZUDANS: You have a first actuation and a subsequent actuation.

DR. ECONOMUS: Yes, sir.

DR. ZUDANS: In the first actuation, I assume that the water level is right where the pool level is --

DR. ECONOMUS: Nominal water level and cold pipe.

DR. ZUDANS: -- and you had the same area in there. And cold pipe.

DR. ECONOMUS: Yes.

DR. ZUDANS: In the second case, you had a hot pipe and the same water level, presumably?

DR. ECONOMUS: I think that's correct, yes.

DR. ZUDANS: And actually less air volume in there -- less mass, because it was hotter.

DR. ECONOMUS: That's true, because the pipe was hotter, yes.

DR. ZUDANS: Why would that show high load. That's a physical difficulty to understand.

DR. ECONOMUS: The mechanism is suppose to be that the steam that is driving what air you have in there out -- when the pipe is cold, more of it condenses and you don't have as much of a drive to compress the air in the pipe. That's sort of the qualitative mechanism that we expect. Gives rise to higher subsequent actuation loads.

It's a complicated process.

DR. BUSH: May I ask one question?

DR. ECONOMUS: Yes.

DR. BUSH: Vacuum breakers come in a lot of sizes. In Caorso, what was the throat size?

DR. ECONOMUS: We've gone through that. It's a ten inch.

Now, I'm going to the subject that is listed here in the agenda. Namely, the multiple phasing -- multiple valve bubble phasing of it. I tried to make the distinction earlier and I repeat this again. This feature of the proposed methodology is to be used to do the piping system and the equipment response evaluation. The motiviation is that when you make the synchronise bubble assumption that you're exciting the structure with an overly conservative forcing function and GE approach is to demonstrate quantitatively how much you can reduce that by Monte Carlo simulation so that you can develop, still a conservative, but a more realistic estimate of what the excitation is.

Now, some features of the methodology and of course since it is a probabalistic one, you have to decide what are your random variables. The ones that were selected by General Electric were the reactor pressure rise rate which triggers the valves at different times as opposed to simultaneously, because of the different set points.

They choose the valve set point tolerance as a random variable. They choose valve opening time as a random variable. They choose the dominant bubble frequency as a random variable.

Now, for each of the variables if you've decided a random, you have to specify the probability density function. General Electric derives these for PRR from operating experience and plant transient analysis. For the valve set point tolerance, the GAussian distribution is used. And note, it needs to be made here. The testability feature that is employed in Mark III SRV controls preclude the drifting of nominal set points between groups. So that the potential for randomly actuating groups simultaneously is sort of precluded by only using the set point tolerance as a random variable.

Valve opening time, the density function is derived from shop tests and the density function for the dominant bubble frequency comes from foreign in plant test data.

The confidence level for the load specification fifty-nine Monte Carlo trials are used to generate it and a 95-95 confidence level is claimed. For design a total of as many as nine is used to actually excite the structure and the way the nine are selected from the total fifty-nine is by examining the spectral peaks and vertical and overturning moments to assure that you have some sort of a envelope of the fifty-nine trials.

Those are the features of the methodology -- some of the features of the methodology. Other features -- there is one Rinko. The DBF probability density function is shifted to account for differences in line volume. It is reasonably well established that the bubble frequency is a function of line volume and that is taken into account in the methodology deterministically.

In this methodology, the contributions from different valves are now added algebraically. Since the credit is -- The SR assess was sort of an indirect way of getting some credit for randomness or phasing, now you phase them in a probabilistic fashion. Now, you superimpose the loads algebraically.

All the other features, the pressure signature, the peak to peak amplitude, the special distribution, the load cases are essentially as they were for the original methodology.

Staff evaluation -- We've looked at each of the individual ingredients of the methodology and we can't say that we're completely satisfied that each and everyone of them is a precise -- is totally validated.

Some examples -- The probability density function for DBF, we feel, is not really prototypical, for example, of the -- of what was exhibited by the Caorso data. In particular, the mean frequency and the standard deviation in Caorso was significantly different than the one that was employed by this methodology. We can speculate on why there are those differences.

Also, another example of where we couldn't quite agree with General Electric about the methodology is the claimed 95-95 confidence level. That can only be claimed if you were to use all fifty-nine trials for design. Therefore, we don't agree with General Electric about that.

Nevertheless, if you consider the methodology in its entirety, we feel that the result is acceptable. We've satisfied ourselves that this is so based on series of sensitivity studies that we asked them to make with respect to chaning the probability density functions and the standard deviations and so on to demonstrate that the final results were not too sensitive for that. But primarily, our conclusion that the methodology is acceptable is based on an actual application of the methodology to a multiple valve test conducted in the Caorso plant.

I will show one of the typical results that show there is a considerable conservatism. Then, of course, pending the actual execution of the Grand Gulf inplant tests, we will have further confirmation that the methodology is acceptable.

Now, let me just show you a couple of examples of the conservatism which are demonstrated when it's applied to an actual test result. This is what has been predicted by the the multiple SRV methodology for the conditions of -- for the conditions that existed in one of the four valve Caorso tests.

In this case, the only random parameters are the valve opening time and the dominant bubble frequency, because first of all, we knew precisely when the signal to open the valves was -- occurred and therefore we knew exactly -- that was a deterministic input. The only parameters that are random here, as I'll repeat, is the valve opening time and the bubble frequency.

As you can see, the margin is -- well, it varies from almost a factor of 100 down in the frequency range with the bubble -- where we expect the bubble to really be active to a factor of two out at high frequency. The margin of course is not so great at high frequency, but we're not really concerned with this, because chugging loads would take over at this end anyway.

One final comparison of that sort --

DR. THEOFANOUS: What do you attribute this discrepancy? Is there is something that you can attribute it to?

DR. ECONOMUS: The large margin?

DR. THEOFANOUS: Yes.

DR. ECONOMUS: Even when you phase, you still have very high pressure amplitudes that would be used. I mean, the PPA that you used for the conditions of the Caorso tests are significantly higher than what actually occurred.

The nature of the wave form that concentrates lots of power --

DR. THEOFANOUS: To you contribute to the methodology or to the input of the methodology?

DR. ECONOMUS: No, we've cut the inputs to the methodology out as far as possible. As I say, they're only getting credit for slight differences in bubble frequency and slight differences for valve opening time. Primarily, it's the methodology itself.

Just one final figure that is sort of like this, but what it does is show a comparison of what the envelope looks for all fifty-nine trials and in fact, I thought I'd show the upper bound of the fifty-nine trials and the lower bound of the fifty-nine trials compared with the measurements.

When it was presented, there was some wag, was it you, Terry? Maybe not. He said, well maybe a reasonable specification is a lower bound of our Monte Carlo simulation which, of course, we didn't go along with.

That concludes --

VOICE: That says something for bounding techniques.

DR. ZUDANS: This of course refers to a specific point.

DR. ECONOMUS: Yes, as I stated. A selected point on a wetwel.

DR. ZUDANS: Are you sure that there are no other points where the picture is the worst?

DR. ECONOMUS: I'm pretty sure. They showed us -- several tests, several sensors.

CHAIRMAN PLESSET: Have you completed your presentation?

DR. ECONOMUS: Yes, sir, if there are no other questions.

CHAIRMAN PLESSET: Yes, let's continue.

MR. KUDRICK: That basically concludes our planned presentation on the dynamic individual loads for both LOCA and SRV and now what we would like to do is share with the subcommittee on what changes have been made to plants other than Grand Gulf since the issuance of the CP to give you some idea of the type of modifications that are being made in the plants out in the field. Other than Grand Gulf.

Grand Gulf, you heard of the modifications that you made yesterday.

MR. FIELDS: We felt that the ACRS would be interested in knowing what modifications the various plants have made in the design of their plants, because of the refinement of the load definitions in the pool dynamic load area, since the issuance of the CP for Grand Gulf and the PDA for GESSAR.

Basically, the objective of this presentation is to show the extent of plant modifications and the methods we selected for plants. Two plants at the OL stage and two plants at the CP stage.

The four plants are Clinton, River Bend, Black Fox, Allens Creek.

We'll just start first with Clinton along with Perry,the most advanced Mark III in the United States except for Grand Gulf.

Clinton said that the suppression pool liner was strengthened. This is basically because of the SRV negative bubble load. There were some general modifications at the HCU floor because of the pool swell loads. The equipment moved from grating on to concrete where ever possible. Piping under the HCU floor was moved as high as possible to get out of the solid water impact zone. A lot of the SRE piping and supports were modified and also the ECCS suction strainers and supports that are in the suppression pool were redesigned because of submerged structure loads.

The polar crane girder and brackets were redesigned, basically because of the higher frequency content in the load definition. Primarily from the SRV actuation. There was a lot of gentle upgrading of piping, pipe supports, snubbers and etcetera. Again, because of the higher frequency content of the load definition.

CHAIRMAN PLESSET: Where is this plant located?

MR. FIELD: Clinton? Illinois. It sounds familiar. Decatur, Illinois.

DR. ZUDANS: The quencher itself is still supported either laterally only or vertically only and no two supports.

MR. FIELDS: I don't believe that it's supported in two directions, is it Nelson? Basically, how is the SRV supported at Clinton?

DR. ZUDANS: Not the SRV, --

MR. FIELDS: The quencher.

So, his response is basically that it is supported both laterially and vertically.

DR. ZUDANS: Okay.

DR. BUSH: I presume that by general upgrading of piping and pipe supports, that means that they've added a lot more supports --

MR. FIELDS: Yes.

DR. BUSH: I'm not sure that I define that as upgrading. It's negative upgrading.

MR. FIELDS: There is two ways of looking --

River Bend, the other operating plant we looked at added steel hoops and stiffeners to the outside of the free standing steel containment up to the elevation of the suppression pool service to make basically stiffen the steel containment and they have decided recently that that wasn't quite enough. They're going to fill the annulus etween the concrete shield building and steel containment with concrete to a level of five feet above the suppression pool surface.

Basically a generic approach is being taken on all of the free standing steel shell Mark III containments.

DR. BUSH: Depending on how they did the first one, you could actually reduce the reliability of that system.

MR. FIELDS: Hopefully. The problem with making the containment so rigid that you have no -- for the SRV loads, then you have problems with the seismic loads. The two would have to be traded off.

Black Fox is of course the SP and therefore is not become construction. The design changes are on paper only. They have modified the stud patterns on the weir wall because of the chugging loads in the top vent. They're considering adding stiffners to the free standing steel containment and they will fill the annulus between the concrete shield building and the steel containment to the same level as the other plants.

The other plant I contacted was Allens Creek. This was basically done verbally last week, because it really wasn't too much time to get too much information.

Allens Creek -- again they're adding vertical stiffners in the suppression pool region. They modified their -- design from an elipsodial to a hemispherical design because of the higher frequency content of the design loads and they have relocated all piping out of the solid inpact area. That's the zero to 18 feet above the initial suppression pool temperature -- suppression pool level.

DR. THEOFANOUS: Which dome is that?

MR. FIELDS: This is the containment dome. It's a free standing containment dome. The previous design was an elipsodial design and as it was described to me, the way the middle of the dome wall responds to high frequency loads, is more pronounced in an elipsodial design than it is for a hemispherical design.

Another method would be to add stiffeners to the dome instead of changing the dome design. They decided to go in this direction. I'm pretty sure they're -- I'm not sure if Allens Creek is filling the annulus with concrete or not.

DR. ZUDANS: That was generically done, I understood yesterday from GE.

MR. FIELDS: GE is definitely doing it on the stride package which is basically the Heartsville. This would be an individual decision made by the architect/engineer.

In summary, the Staff feels that the load requirements do not require major design modifications and major should be defined that modifications can be made late in the construction of the plant. It doesn't require stream delays in the plant construction.

That's about it for this presentation.

There is a comment was that Perry should make a presentation on their modifications. I have talked briefly with them. They're basically doing the same thing that the other plants are. If the staff would be interested, perhaps someone from Perry could talk to you.

Is there someone from Perry who could make a brief impromptu discussion?

(Pause)

MR. VATH: My name is Carl Vath from Gilbert Associates in the Perry Project.

CHAIRMAN PLESSET: Where is that located?

MR. VATH: Perry is located about 20 miles northeast of Cleveland, Ohio.

CHAIRMAN PLESSET: Thank you.

MR. VATH: We are a free standing steel containment. We've added fill concrete between the containment and shielf building, roughly five feet above the suppression pool upper elevation. We have moved a lot of equipment out of the bulk pool swell area. There is still some equipment there.

We have had to heavily strengthen the platform supports and attachment points to the drywell and have significant redesign on the two lower platforms effected by pool swell itself.

We've had extensive modification and equipment qualification due to high responses because of timing, the full effect of the fix and reduction of the appropriate containment ringing problem or excitation of the containment. We had a timing problem there in being able to take the full reduction on the equipment qualification, but -- so we've had some equipment mods and some very significant amounts of piping support redesign and support additions.

DR. EBERSOLE: I want to go back on the general topic of equipment modifications to point out that our concern is basically what happens to equipment rather than structures. Of course, if the structures fall and carry equipment with them, than that's structure involvement, or rather equipment involvement.

I'd also like to recall an earlier remark that I made that while we're looking at jet and dynamic loads -- this equipment list re-examined the interior of the drywell with such aspects as blast loads on the -- gravity -- recalling that the dry tubing is necessary to insert the rods at the LOCA because the primary pressure is going down extremely rapidly. You don't have the auxillary pressure to help you in completing this problem.

The accumulator will put you in if you retain the pipe, that is, because of the residual pressure having placed a lower operating pressure in the reactor.

But, if you look very carefully, and I looked at this -- you find that the jump shifts certain piping in subcontainment makes you suspicious of where LOCA breaks might occur and carry away substantial number of the drag pipes as well as perhaps --

There is also the matter of other instrumentation in the drywell which might bare further examination and aspect of the same kind load that we're looking at down in the suppression pool.

MR. VATH: To address that is to really not address it. Jet impingement loads have been designed for it. I'm not prepared to discuss any jet impingement loads outside of hydrodynamic effects which is the main purpose of the meeting.

MR. EBERSOLE: This hydrodynamic effects of course is the concern of other parties.

MR. VATH: Correct. Rephrase that to, quote, new loads. Pool swell and SRV is the only thing --

MR. EBERSOLE: It would be the equipment load and dynamic effects inside the drywell.

MR. VATH: Right. And we have a very significant amoung of analysis and design on that, but I'm not prepared to discuss this.

MR. RICHARDSON: John Richardson, Mississippi Power and Light. The effects that you're asking about, Mr. Ebersole are required to be evaluated by the mechanical engineering branch specifically, jet impingement, the blast effects, etcetera and you're required to protect essential equipment. Those effects and the analysis are discussed, I think, in section 3.6 of the final safety analysis report.

MR. EBERSOLE: Those reports are so brief that one can only gather -- supporting data to show how well you analyse these affects.

MR. RICHARDSON: Well, we've got the data that was used inthe analysis in our files.

MR. EBERSOLE: Particularly the area in the vacinity of the -- land piping where the quadrant of the control drive was located. I would be particularly interested in your presentation of that area.

MR. RICHARDSON: I remember that area specifically we have looked at and the analysis was under taken. As far as how much supporting information we have, I'm not sure. We can look into that. But those affects are evaluated by the mechanical engineering branch and they have basically accepted what we have done today.

CHAIRMAN PLESSET: Thank you. Is there any further presentation on this line, Jack?

MR. KUDRICK: Not in the area of design modifications. The subcommittee did hear the Grand Gulf discussion in this particular area yesterday. So that concludes our area relative to containment modifications. If you desire, we can continue on.

CHAIRMAN PLESSET: Sure.

MR. KUDRICK: The next topic on the agenda is a description of the inplant SRV test as proposed by Grand Gulf.

CHAIRMAN PLESSET: We were going to get a presentation from GE on general plant design?

MR. FIELDS: Well, that is what I did.

CHAIRMAN PLESSET: Does GE back you?

MR. FIELDS: GE wouldn't do it.

(Laughter)

MR. JOHNSON: My name is McKinley Johnson, project engineer with Mississippi Power and Light Company on the Grand Gulf project.

What I would like to discuss with you this morning is the inplant testing program that we presently have scheduled at Grand Gulf. Very briefly the background of that program and a brief discussion and description of the test itself -- the pressure measurements that we expect to take -- the accelerometer measurements that we expect to take. What schedule this work will be performed under and also our conclusions relative to the test that we are presently planning.

(Pause)

With regard to background, the NRC has indicated in a review of the GESSAR 238 plant that verification of quencher loads would be required by the first plant -- the

GESSAR Nuclear Island design. They also indicated that prototypical tests would be required for each type of containment structure that is still in concrete.

As was discussed this morning, Kuosheng has recently completed inplant testing with the objective of demonstrating significant reductions in structural response and therefore reducing loads to piping equipment.

The Kuosheng and the Grand Gulf plant are reinforced concrete containments and we presently have plans for inplant testing in addition we are reviewing Kuosheng data and it's applicability to Grand Gulf to determine if additional testing is required at this time.

I think the terminology of the test description that you probably heard this morning and maybe look familiar to you. We have six single valve actuation tests planned or SVA tests. We also have six consecutive valve actuations scheduled. Seven multi-valve actuations and one extended valve actuation for the thermal mixing consideration.

The instrumentation that is scheduled and I'll show you a little bit about where it is located consists of about 27 pressure sensors, 34 string gages on submerged structures and 16 temperature sensors and 41 acclerometer channels in 17 separate locations.

DR. CATTON: You have less instrumentation than the Kuosheng.

MR. JOHNSON: That's correct.

DR. CATTON: Are you basing that on the UHL of the Kuosheng test?

MR. JOHNSON: I think that the real issue there is -- the objective of the test. Their objective was more to demonstrate significant reductions in containment response for a number of load combinations throughout the plant.

Our position was one of 100 percent of containment response has been built into our design and that load input has been put into all type of equipment. So, although we're interested in what the margins are, we're more interested in just observing that there are margins as opposed to trying to quantitatively trying to describe exactly what those numbers are.

(Pause)

This slide basically demonstrates where your pressure sensors are located. It demonstrates the arrangement of the quencher in the pool. Basically, you can see pressure sensors are located on the base mat within five feet of the quencher. They are also located on the containment wall at three different elevations. Along with the asimuth of the quencher being tested.

Also -- on the drywell wall at three elevations along the asmuth of the quencher being tested.

MR. EBERSOLE: After the test, is any of these going to be left in place, because about ten times in the first year, you're going to see a whole lot of these go off at once. Do you intend to leave any of them and monitor the -- effect of all of them?

MR. JOHNSON: I do know that obviously the instrumentation in the pool will remain in the pool at least the first few --

MR. EBERSOLE: I think it might be interesting to see the full -- trip without bypass.

MR. JOHNSON: We have built into our test plan the contingency that the instrumentation will be operated during other transient testing and MSI -- closure internmenship is one of those --

This slide projects certain locations of accelerameters that are being incorporated in the test plan. There again of a lesser magnitude than the Kuosheng test. And actually, if you review the Grand Gulf test plan, these accelerameters are not even shown in that test plan. The test plan was a basically load conformatory test plan with the understanding and agreement and it was spelled out in the test plan that at any time level one or level two values are exceeded, we would evaluate the significance of that before proceeding on with the test. So these accelerameters were put in to aid us with that evaluation should any level one or level two pressures be exceeded in the test.

We tried to get a variety of elevations along the containment and drywell wall. Another criteria that we used was to try and select through review of the structural model where locations where peak response was predicted.

Also you see one in the low input to the crane and mid point of the crane. We mentioned yesterday that we made significant qualifications to that crane so we wanted to observe whether we wasted our time and efforts in that or maybe it would be really worthwhile.

(Pause)

The schedule for our evaluations calls for a fuel load, right now, on December 31st. If that occurs, we should be testing at 50 percent power in the mid April time frame which will allow for a quick look reports to be issued about June 15th and a final report on September 1.

Conclusions relative to our test at this time, is that we feel like the test program is sufficient to provide a data base so that we can evaluate the load definitions in our plant. Another conclusion and significant conservatism are about to exist in the structural model as Mr. Su pointed this morning which will result in additional safety margins.

The third item is that we will complete evaluations of Kuosheng data in early October and if appropriate, we would like to meet with the staff at that time for the purpose of deleting further testing. As I say, if it's appropriate at that time. We don't have all the data at this point.

Two other slides that I'd like to discuss very briefly. I mentioned that we're looking at the data and would like to meet with the Staff to determine if that data is applicable to us. There are some items that lead us to believe that at this time. They are in no way conclusive at this point, but I would like to at least share with you the things that we see that tell us that we should look at that.

NUREG o763, as Mr. Su mentioned this morning, basically describes in what area plants must be similar for the data from one plant to be prototypical to the other.

The first item has to do with quencher devise geometry and in general, although we need to look at much more detail, we both have exquenchers with identical arm and hold patterns on the structures.

The parameters that affect the bubble pressure would need to be similar and we feel that they are. If you go through the emperical calculations of pressures and you increase those for standard deviation and confidence factor adjustments, you'll see that the final design value for consecutive valve actuation at Grand Gulf is 18.2 as compared to 16.6 at Kuosheng.

Another items mentioned in the NUREG is steam flow per line area and the flow rates are identical with no impact on predicted pressures expected. Line diameters are also identical.

With regard to quencher pool geometry, as you can see, I made a slight change on that one yesterday. I apologize for that. And the change has been made on the handouts that were given as well. Both quenchers are located center line five feet and zero inches from the drywell wall. At Grand Gulf, the center line of the arm is located five feet zero inches from the floor. At Kuosheng, it is five feet, six inches.

The pool depth normal water level at Grand Gulf is 18 feet, 10 inches. At Kuosheng it is 19 feet, two inches.

With regard to containment characteristics, both are reinforced concrete containments -- drywell and pedestal of similar construction, platforms and floors similarly located. And as I mentioned, this data is rather preliminary. I just wanted to share with you the things that we know now that would have to be looked at in more detail.

DR. THEOFANOUS: Have you thought about making an effort of locating at least some of your instrumentation in locations exactly the same like the Caorso tests or do you have an exact one to one comparison?

MR. JOHNSON: I guess the thought process has been more of locating the instruments in exact spots that relate to the structural model for our plant. So that we would really have a comparison of test data to predict it as opposed --

DR. THEOFANOUS: I'm sure that the same time the logic went through their mind -- they were getting their instruments, so I'm not sure that they're positions were too far from where they should be. In might be worthwhile in view of this comparison that they're showing to locate your instruments, at least some of them, in exactly corresponding positions so that we can see more or less the same -- conditions to see what kind of a position we get. We might get some idea about the --

MR. JOHNSON: Are you speaking relative to Kuosheng or Caorso.

DR. THEOFANOUS: Yes.

MR. JOHNSON: Kuosheng. I understand your comment is well taken. I feel like if we go back and look you'll find that we do have the same spots, but I can't say for sure right now.

(Pause)

The last slide is just a pictorial display of what I just onthe proceeding slide show the two quenchers. The pool width at Kuosheng is 17 feet, six inches. Grand Gulf is slightly wider, 20 feet and six inches.

We discussed the five foot dimension from the drywell to the center line of the quencher on both plants. We also discussed the 18 feet, 10 inch pool depth as opposed to

19 feet, two inches.

DR. CATTON: Why is that outer wall so much thicker at Kuosheng?

MR. JOHNSON: They have a higher seismic requirement at Taiwan than we have at south Mississippi. They do have a thicker containment wall. They are both reinforced concrete, but there's is thicker due to seismic considerations.

As you can see there is a slight difference in the bracing of the quenchers as well. Mr. Su commented on that. They have, I guess, a shell steel arrangement above and below the quencher arms. Ours is supported below the quencher arms.

MR. EBERSOLE: Is that 19 feet, two, I see up there for the height of the pool?

MR. JOHNSON: Yes.

MR. EBERSOLE: Than it's about six feet higher than yours.

MR. JOHNSON: Ours is 18 feet, 10 inches.

MR. EBERSOLE: Sorry, I thought it was 13.

MR. JOHNSON: No, sir. That should be 18 feet, 10 inches.

You mentioned earlier, I think, there was a question with regard to the --

MR. EBERSOLE: I see the guard pipe.

MR. JOHNSON: The guard pipe, yes, sir. I believe that is extended quite aways down into the pool to preclude the possibility of a transient and a low water level and a simultaneous break in the discharge line which would potentially bypass this --

MR. EBESOLE: I notice that your guard pipe, however, practically intersects the wall at the water line, whereas at Kuosheng, it is several feet below. The guard pipe covers that spot.

MR. JOHNSON: Yes, I think so.

DR. ZUDANS: I notice that you have a much longer unsupported length in the SRV discharge pipe line than Kuosheng. Much longer and you show something like a ball joint at the bottom of the quencher?

MR. JOHNSON: My understanding of the quencher support is that it's pretty much free standing at its base. It's not bolted down. It has obviously portable support from the floor.

DR. ZUDANS: Do you have any acclerameters where you arrow quencher B12.2 to see how that arm moves during the discharge?

MR. JOHNSON: I do not believe we do. Moses, do you know, if there are accelerameters on the discharge line itself above the quenchers?

I don't believe there is.

DR. ZUDANS: Because this is a significant different system of support .

MR. KOTOZON: My name is Paul Kotozon and -- AE for the plant. At this location right above here, we have two eight inch supports that go back to the drywell wall and to give support for any lateral loads. This is just in bearing that McKinley was discussing here. The loads were taken here. In the test there are strain gages on this support as well as strain gages onthis piping for -- loads.

DR. ZUDANS: What does this ball type of configuration mean right below the quencher? Is that a rotating joint? No, higher up.

MR. KOTOZON: Right here? That's just the bottom plate of the quencher. It's welded into this.

DR. ZUDANS: It's welded solid?

MR. KOTOZON: It's welded, yes, all the way around.

CHAIRMAN PLESSET: Any other questions.

DR. CATTON: RES was involved with the Kuosheng test. Do they have any involvements with your tests?

MR.JOHNSON: Who is this?

DR. CATTON: RES, the research office of NRC. There were two people who were at the Kuosheng test. I was wondering whether there was anybody involved from RES with your tests?

MR. JOHNSON: We have not conducted tests.

DR. CATTON: Do you plan to?

MR. JOHNSON: The test plan has been submitted to the NRC.

DR. CATTON: It seems to me that you have a well instrumented building and tests and it would just be a darn shame to not make good use of that data.

MR. JOHNSON: The instrumentation is not installed as of this date. It should be taking place in the next few months for testing.

CHAIRMAN PLESSET: What were you going to say?

MR. FIELDS: I was going to say that it was being submitted to our division for review.

CHAIRMAN PLESSET: Well, I think that what Dr. Catton was mentioning was the research was involved.

DR. CATTON: There were two people, I believe, who were --

CHAIRMAN PLESSET: They were observers. Are you suggesting that they might let Research see the instrumentation.

DR. CATTON: One of the problems is getting full scale data in order to confirm your calculation on pools. That is always a problem and we never have it. Here is a circumstance where maybe RFS got involved and put up a little bit of the money,the Grand Gulf people would cooperate and we'd get the data.

CHAIRMAN PLESSET: Dreamer.

MR. JOHNSON: It would take over five million dollars to repeat the data that was already available from Kuosheng.

DR. CATTON: I understand, but that's probably five million dollars well spent. It's a full scale system.

MR. JOHNSON: So was Kuosheng.

DR. CATTON: I understand, but it's money well spent.

CHAIRMAN PLESSET: Yes, Dave?

MR. WARD: Did I understand that after your review of he Kuosheng data you may not run this series of 14 tests that you described or you may not run additional tests. Which did you mean?

MR. JOHNSON: What we would like to have the option of doing once we reviewed the Kuosheng data is sitting down with the Staff, discussing the licensing requirements and the technical requirements of conformitory testing. And if the Kuosheng testing is available and applicable,and if our tests would just be nothing but redundant tests with redundant data, then, yes, we would like to discuss the potential for deleting our tests.

That -- I don't give you that impression that that would be an issue. I feel certain that the Staff and Grand Gulf would be able to come to an agreement on what should be done.

CHAIRMAN PLESSET: Yes, Jack?

MR. KUDRICK: I'd like to comment on that. That's in agreement with what our stated requirements are relative to inplant testing. That if other inplant tests can be demonstrated to be applicable, it can be used in place of a separate inplant test program.

CHAIRMAN PLESSET: Yes, we understand.

Thank you. We appreciate your presentation.

Jack, do you have further --

MR. KUDRICK: We have one possible addition. As a result of some of these questions concerning equipment survivability on the grating at Grand Gulf, Mississippi Power and Light has gotten some additional information that they would like to share with the Committee. It is not a co-answer, but it is certainly some additional information.

CHAIRMAN PLESSET: I think we would like to hear it.

MR. KUDRICK: John Richardson has prepared to discuss that.

MR. RICHARDSON: John Richardson with Mississippi Power and Light. THis morning you raised a question about the equipment on the grating at the hydraulic control unit floor level and as I say, this morning, it primarily consists of the -- some instrumentation and control racks, the hydraulic units for the recirculation control valve -- recirculation system flow control valve and some piping valves and equipment for the control hydraulic system -- specifically like a flow control valve station and other things associated with it.

The issue was how did we account for protecting essential instrumentation. Basically , we first identified and located all of the instrumentation which would be required to function during and after the LOCA event. First we tried to relocate that out of the pool swell region, if possible. If it was not possible to do that, then we protected the panels that the instrumentation was located on by placing deflector shields underneath the panels which are designed to handle the froth impact and drag loads.

CHAIRMAN PLESSET: Any comment?

MR. EBERSOLE: Other than some physical representation of what you did, I understand, you built deflectors. This tells me that you will still be submerged by the froth -- this instrumentation. Is there electrical apparatus which will be submerged?

MR. RICHARDSON: There is some instrumentation. All the instrumentation is from the equipment qualification standpoint, is designed for the post LOCA environmental effects.

MR. EBERSOLE: Does this include submerging?

MR. RICHARDSON: Full submergence of water, no. Just the effects of the froth spray or whatever.

MR. EBERSOLE: How do you intend to validate that this equipment can stand such an environment in situ? Are you going to go in and hose it down?

MR. RICHARDSON: We had no plans to do that, no.

MR. EBERSOLE: Why not? You're going to see it, presumably.

MR. RICHARDSON: I'm sorry --

MR. EBERSOLE: Why are you apprehensive about holding it down?

MR. RICHARDSON: Well, we just did'nt feel like from the equipment qualifications standpoint, you do an analysis and testing for the instruments.

MR. EBERSOLE: I realize that, but that always has the nagging problem of being type tested and due to the variation in field installation techniques, you never really are quite sure that a type testing advise has materialized in your actual installation and final proof of it is the in situ installation after some transients when it has actually physically moved about a little bit.

Do you follow me?

MR. RICHARDSON: Well, I understand what you're saying is that you have some -- the in situ or the installing condition may be slightly different from the testing condition.

MR. EBERSOLE: As a matter of fact, there is a problem, in I guess, the permanenticity or some such word -- the fact that an instrument mechanic may take a cover off and reinstall it. If he installs an overhand or equivalent seals like this, it may in fact, not represent the type tested model.

So there are a host of variables in this matter of instrumental reliability under hostile environmental conditions.

MR. RICHARDSON: From an installation standpoint, this equipment is necessary and there are certain requirements on how it's installed to be sure that it is not damaged in and under those effects. It's obviously a safe delay procedure for installation and quality assurance program.

MR. EBERSOLE: It is highly administrative in character.

MR. RICHARDSON: That's true. It is administrative.

MR. EBERSOLE: And let's leave it with a weakness which can only be tested really by -- tests.

I really don't know why you would be apprehensive about holding down this equipment.

MR. RICHARDSON: I think your point is well taken. I'd have to think about that a little further. Right now, we don't plan to go into the containment and start spraying our equipment down if we don't have to.

MR. EBERSOLE: That reflects a great deal of faith in the viability of your equipment, I must say.

CHAIRMAN PLESSET: Thank you about the hose.

DR. BUSH: I would also suggest looking at the LERs because if you look at it at the point of view of the maintenance errors, the list can go on for hundreds and hundreds and hundreds of items. Some of them more severe than others.

CHAIRMAN PLESSET: Jack, is all you had at the present?

MR. KUDRICK: Other than a summary.

We have talked over the last day and a half and hopefully we haven't given the impression that every area is full of problems, but we have tried to identify those areas where we still have discussions going on with both GE and Grand Gulf and we'd like to take the opportunity to summarize where we believe we are and where we think we're going in the near term future.

Mel Fields will make some comments in that area.

(Pause)

MR. FIELDS: Our initial idea was to summarize verbally, but we thought we would maybe throw up a few slides, handwritten, I'm afraid, to help clarify.

The first slide I'd like to put down is not really a summary, but a possible response to an ACRS concern on th upper pool dump. And the questions, as I understand it is one operator action is needed to initiate upper pool dump and yet questions about the time requirements needed and basically upper pool dump is automatically initiated by safety grade signals.

There are two that are used. ECCS actuation plus 30 minute delay time. ECCS actuation is of course derived from other signals of low low rack water etcetera etcetera.

The other signal that is used is low low pool level and there is no delay on that. Once that level is reached, the valves will be automatically opened to have water come from the upper pool down to the suppression pool.

Now, how reliable is this equipment? There are two sets of lines. My memory is somewhat unclear on this. But there are complete subsets. Only one of the systems is needed to assure suppression pool coverage.

The valves in these lines are powered from ESF sources. Each line has two separate valves to minimize the possibility of invert and actuation. Each valve in a particular line is powered from the same power source and the two lines have separate power sources -- you know, train A and B so you open up at least one of them concerning any single failure.

Only one line is needed to meet the flow requirements.

What they have done is that they have shown that the maximum drain from the suppression pool, from the ECCS suction lines, is matched -- actually exceeded by the flow in one line from the upper pool down to the suppression pool.

So, therefore, your level will not be any lower until after pool dump. After complete pool dump, then you have your collection of water in the dead area as your lowest level which is approximately two feet.

MR. EBERSOLE: From an environmental qualification standpoint, is this float level equipment submerged -- is it inside the suppression pool or above it or at the surface of it.

MR. FIELDS: The exact type of instrumentation that is used to measure the suppression pool level -- I don't know exactly what Grand Gulf has. It is of course -- has to meet the rigid environmental requirements. It's going to be safety grade instrumentation.

MR. EBERSOLE: Is it typically type tested? That is one of a kind and the number made.

MR. FIELDS: I don't know exactly.

CHAIRMAN PLESSET: Grand Gulf wants to respond to that.

MR. RICHARDSON: The suppression pool water level, I think, is what you're asking. Those are located outside the containment.

MR. EBERSOLE: That's a prudent thing to do.

What about the valves? Are they subject to any environmental problems?

MR. FIELDS: The valves in the lines?

MR. EBERSOLE: Yes.

MR. FIELDS: They are -- I'm not sure whether they are exposed to the drywell environment or the containment environment, but so -- they would have to be designed against containment environment which is quite a bit less severe than the drywell environment.

MR. EBERSOLE: There are individual timers part trained?

MR. FIELDS: As far as the 30 minute delay on the test actuation?

MR. EBERSOLE: Yes.

MR. FIELDS: I believe it's two complete separate trains. It has to meet the separation criteria, right?

MR. EBERSOLE: I guess the crux of the whole thing is how many instances we would have in containment where we are subject to environmental conditions which are under heavy investigation at this moment. The environmental investigation program has lagged for some ten odd years and it is just beginning to pick up and so you are all subject to what may be found in that program as it evolves.

MR. FIELDS: That's correct.

With this information presented, is there still further information that you would like to see on the upper pool dump?

MR. EBERSOLE: I don't think so.

DR. ZUDANS: What is the estimated or calculated pressure differential that promotes the expulsion of suppression pool water into the cavity? What is the delta P -- in the containment and the drywell?

MR. FIELDS: Basically, as the water is dumped into the -- vessel from the ECCS system, it spills out from the broken pipes into the bottom of the drywell. The bottom of the drywell collects dead area water and the water level rises until it reaches the top of the weir wall and then it spills into the suppression pool.

DR. ZUDANS: The other way that I'm interested in. That's how you loose suppression pool water.

MR. FIELDS: That's how you loose suppression pool water.

DR. ZUDANS: But the containment pressure gets to be higher than the drywell pressure and pushes the water through the vents --

MR. FIELDS: There are drywell vacuum breakers to equalize the pressure between the containment and the drywell that prevents this from happening.

DR. ZUDAN: -- closing suppression pool water?

MR. FIELDS: By entrapment of the suppression pool water in the area directly below the reactor vessel. That is not part of the suppression pool.

DR. ZUDAN: How did that water get there?

MR. FIELDS: Out of the broken pipe, because you pump suppression pool water into the vacuum vessel that would cool off the core. It comes out of the broken pipe and drops to the floor.

DR. ZUDANS: It's a long process. It is not instantaneous.

MR. FIELDS: It's long process, correct.

DR. CATTON: Why don't they fill that dead space up with concrete?

MR. FIELDS: I think there's a recirculation pump down there in casing and the -- it would be very difficult to get at it to have it solid concrete.

What they have done instead to put enough water in the upper pool dump to account for any loses here. It's just in the specific method.

DR. CATTON: Along with that, all the problems that are associated with having it up there that are being discussed now.

MR. FIELDS: Well, they need to have the upper pool dump, not only for the dead areas, but also to account for the -- to lesson the pool dynamic loads.

CHAIRMAN PLESSET: Is there a comment back there?

MR. EBBESON: My name is Bruce Ebbeson from Stone and Webster. I represent the River Bend plant. I'm not sure. It's not my area, but I just want to correct something. I think yesterday somebody said that all of the plants have the upper pool dump.

MR. FIELDS: All the Mark III plants.

MR. EBBESON: I'm not sure that River Bend does. And we do have concrete in that annulus.

MR. FIELDS: They do have the upper pool dump.

MR. EBBESON: I'm not sure.

MR. RICHARDSON: That's correct. River Bend has a -- where they don't loose that water. It returns back to the suppression pool.

MR. EBBESON: I'm not sure how it works. We do have the concrete in that annulus.

MR. FIELDS: The upper pool dump was basically to reduce the pool dynamic loads and if it isn't there, we'll check it out.

DR. ZUDANS: How to reduce the pool dynamic loads.

MR. FIELDS: By reducing the water level over the top vent.

DR. ZUDANS: That's all right. So, if you got the water back, you wouldn't be loosing it. If you got the water back, as I understand River Bend or someone else has, in the suppression pool, you wouldn't need that.

MR. FIELDS: The fact is that if you have an initial submergence higher than seven and a half feet from -- containments, the low definition that GE supplied for genetic Mark III containments is no longer valid.

But if you don't loose the water and you have seven and a half feet, then you may not need an upper pool dump to retain -- recover the loss fluids.

DR. ZUDAN: Now we agree.

MR. FIELDS: Yes.

CHAIRMAN PLESSET: Well, I think that maybe we can terminate this discussion, if that's agreeable with you? Are there any other comments.

MR. FIELDS: I'd like to go into, basically, the summary.

We would like to leave the ACRS with an idea of how we're going to pursue the approach for resolution of the pool dynamic loads. Now for the generic load definition, we're going to examine GE's justification for the current load definitions and where we find this current load definitions not acceptable, we're going to propose alternative acceptance criteria. We plan to do this in our draft SER, which we'll get out in December of'30.

I should make another point. We're talking about LOCA related pool dynamic loads and as Nelson Su mentioned --

DR.THEOFANOUS: You said '80.

MR. FIELDS: '81, sorry.

Nelson Su mentioned that the SRV loads will be completely finished by November. We will issue the conservative pool dynamic load for generic Mark III containments in our NUREG which is scheduled for February of '82.

Grand Gulf has a schedule problem in that this schedule for the generic is not acceptable. So, we are going to use the generic load criteria that have been found acceptable at this time by the staff and for the other load criteria, we're going to suggest a bounding approach so that we can have a quick resolution because of schedule requirements.

We would like to discuss with the ACRS the bounding approach that the Staff is currently --

For each of the loads that we still have problems with GE, the 40 feet GE specification we have problems with. We're suggesting that Grand Gulf use the bounding approach of 50 feet per second as the pool swell velocity and recalculate the drag loads in both the solid and froth zones

Show that the current impact specifications is conservative, which we have preliminary information that they can do for the solid water impact. They have done some analysis to show that the 60 feet per second is still bounded by the impact data for solid water.

For froth impact on the on the HCU floor and also the equipment on the HCU floor as the ACRS has -- is trying to highlight, we want Grand Gulf to provide a bounding specification namely 15 psi D is still under review by the Staff. We want Grand Gulf to provide a grounding specification and to show that the structure is impacted can withstand this bounding load.

I should mention that the point that we're discussing here today, we also provided to Grand Gulf and GE in a meeting last night and we expect some feedback from Grand Gulf early next week on this particular approach. Whether or not they think we can meet it.

The froth drage on the ACU floor grading is tied in with the pool swell velocity indirectly, but there are some other problems that are unique to Grand Gulf. We have asked Grand Gulf to recalculate the Delta p across the HCU floor using the Grand Gulf unique parameters.

The generic specifications, 11 psi, but because of basically the elevation of the HCU floor, we feel that this Delta P can be lower for Grand Gulf using the same conservative assumptions that we definitely find acceptable.

The biggest problem is basically we need a conservative method for transferring the Delta p into a load specification across the HCU floor grading. We have done some preliminary examination of this effect and we think that we see a way out. We think we see a method for transferring this load into a Delta P.

Now, the GE specification of using a total area of 11 psi is definitely conservative. We have no problems with that. Grand Gulf, however, cannot use that load, because they're grading swell will start --

DR. ZUDANS: It is conservative because I understood that you have a great part of that support is solid concrete surface.

MR. FIELDS: We're talking about the grating only. Grating experiences only a drag load, not an impact load. The impact load from the HCU floor is still under investigation and the approach we are taking for Grand Gulf is to try to arrive at a bounding impact for the froth on the HCU floor and then design against it.

DR. ZUDANS: Then what happens for the solid concrete portion after the impact load?

MR. FIELDS: It will fill an 11 psi drag load. 11 psi static drag load.

DR. ZUDANS: Because of the grating resistance, right?

MR. FIELDS: Because of the bottom of the upper HCU floor.

CHAIRMAN PLESSET: I'll have to explain it to Dr. Zudans.

DR. ZUDANS: No, you don't have to explain it. I understand it. I just want to make sure that the whole thing is taken into consideration.

MR. FIELDS: Again, I would like to emphasize that we feel that we difinitely have a path of resolution for the froth drag on the HCU floor gratings and of course that would ease our concerns about the equipment on the HCU floor grating.

There are a couple of areas on the condensation and chugging load specifications -- real small areas that we would like to see cleaned up. And basically for the condensation oscillation, we would like Grand Gulf to evaluate the significance of the low frequency excedients that the CO forcing function that was calculated using the 60 percent break area had.

We discussed this yesterday afternoon that the fact that this was not bounded by the CO DBA design forcing function.

Two methods come to light. One, it is possibly bounded by the pool swell design load and the low frequency which is what we're concerned about. The other is the low frequency content is not really a significant structural impact on structures and this is really really low frequency range. So, we're asking Grand Gulf to come back with a plant unique look at this particular load.

Also, the CO parameters that have significance in determination of the frequency, the mass flux, the air content and the pool temperature -- we would like Grand Gulf to assure us that the parameters at Grand Gulf, because of the slightly different design are bounded by the GE sensitivity study. Grand Gulf has a slightly larger drywell volume. They could have possibly slightly higher mass fluxes. For completeness sake, we would like them to make this particular area of review.

Chugging? There was a data point in experiments that exceeded the chugging design specification in the 30 to 40 hertz range for the weir wall. GE has told us that there is no structural significance. Grand Gulf has also told us this. It's basically just something that they had to put down in writing.

And that's all I have to say about the approach that the staff is pursing for resolution of this issue, both with GE and Grand Gulf. The full committee meeting will of course, here more about the Grand Gulf unique approach to full dynamic loads.

That's all.

MR. KUDRICK: I believe that concludes our portion of the agenda. Unless there are some individual questions still outstanding.

CHAIRMAN PLESSET: Could we get copies of this last outline?

MR. FIELDS: Sure.

CHAIRMAN PLESSET: You're planning to come into the full committee at the October meeting of the fu`l committee?

MR. FIELDS: I'm sure that you'll be asking for our presence.

CHAIRMAN PLESSET: That's on a Thursday, right?

Well, I think we'll see some of you again on October 15th and until then, we'll just adjourn.

(Whereupon, at 12:10 p.m., the meeting was adjourned.)

This is to certify that the attached proceedings before the

Nuclear Regulatory Commission

in the matter of: ACRS Subcommittee Meeting on Fluid Dynamics

Date of Proceeding: September 24, 1981

Docket Number:

Place of Proceeding: San Francisco, CA

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

Michael Connolly

Official Reporter (Typed)

Michael Connolly
API

Official Reporter (Signature)

9/12/81

ACRS FLUID DYNAMICS SUBCOMMITTEE MEETING
SEPTEMBER 24-25, 1981
SAN FRANCISCO, CA

- TENTATIVE SCHEDULE OF PRESENTATIONS -

SEPTEMBER 24, 1981	PRESENTATION+ TIME	ACTUAL TIME
I. INTRODUCTION - M. PLESSET, CHAIRMAN	10 min	8:30 am
II. NRC INTRODUCTION		
A. Background of Mark III Program J. Kudrick (NRC)	60 min	8:45 am
B. Current Status - M. Fields	30 min	9:45 am
- BREAK -	10 min	10:15 am
III. GENERAL ELECTRIC MARK III TEST FACILITY* GE (PERSONNEL)		10:25 am
A. Overview	15 min	
B. Full Scale Tests	20 min	
C. 1/3 Scale Tests	20 min	
D. 1/9 Scale Tests	20 min	
E. Data Interpretation	60 min	
F. Summary	10 min	
- LUNCH -	60 min	1:00-2:00 pm
IV. LOCA LOADS (BNL)		2:00 pm
A. Pool Swell Velocity	50 min	
B. Impact Loads	30 min	
C. Condensation Oscillatin (CO) Loads	45 min	
D. Chugging Loads	45 min	
V. RECESS		5:30 pm

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*NOTE - Portions Of This Session Will Be Closed To Protect Proprietary Information.

+Includes time for Subcommittee questions/discussion

- TENTATIVE SCHEDULE OF PRESENTATIONS -

SEPTEMBER 25, 1981		PRESENTATION+ TIME	ACTUAL TIME
VI.	RECONVENE - M. PLESSET, CHAIRMAN	5 min	8:30 am
VII.	SUBMERGED STRUCTURE LOADS (BNL)		8:40 am
	A. Jet Loads	30 min	
	B. Air Bubble Drag Loads	30 min	
VIII.	POOL THERMAL STRATIFICATION (BNL)	20 min	
IX.	FLUID STRUCTURE INTERACTION EFFECTS (BNL)	20 min	
	- BREAK -	10 min	10:30 am
X.	SAFETY-RELIEF VALVE (SRV) LOADS		10:40 am
	A. Overview - T. Su (NRC)	15 min	
	B. Tripower Mark III Inplant Tests - T. Su	30 min	
	C. Multiple Valve Bubble Phasing - C. Economus (BNL)	30 min	
	D. SRV Loads Reduction Factor - C. Economus	30 min	
	- LUNCH -	60 min	12:30-1:30 pm
XI.	MARK III CONTAINMENT MODIFICATIONS		1:30 pm
	A. General Plant Design (GE)	30 min	
	B. Grand Gulf Design (MP&L)	30 min	
XII.	GRAND GULF IN-PLANT SRV TEST PROGRAM (MP&L)	30 min	2:30 pm
XIII.	SUMMARY OF MARK III PROGRAM (NRC)	30 min	3:00 pm
XIV.	SUBCOMMITTEE DISCUSSION	30 min	3:30 pm
XV.	ADJOURN		4:00 pm

+Includes time for Subcommittee questions/discussion

MARK III CHUGGING LOADS - DESCRIPTION AND BASIS

Dynamic Pressure Fluctuation Applied Directly to Wetted Boundaries

- Weir wall.
- Top Vent.
- Drywell - Basemat - Containment Wall.

Idealized Pressure Wave Forms

- Prechug underpressure.
- Pressure spike/train.
- Post-chug oscillation.

Range of Duration and/or Frequency Considered.

Spatial Distribution - Bounding Fit of Measurements.

Local Loads use Peak Observed Values.

Global Loads use in-phase Chugging with Mean of Observed Values

- Top Vent and Weir (39 chugs)
- Drywell and Containment (113 chugs)

Basis - Full-Scale Single Cell Test Data

Multiple Vent Effects Examined via 1/9-scale Tests - Substantial Phasing Demonstrated.

Economus

MARK III CHUGGING LOADS - STAFF EVALUATION

SUBSTANTIAL CONSERVATISM DEMONSTRATED IN MANY AREAS. CONSERVATISM STEMS FROM:

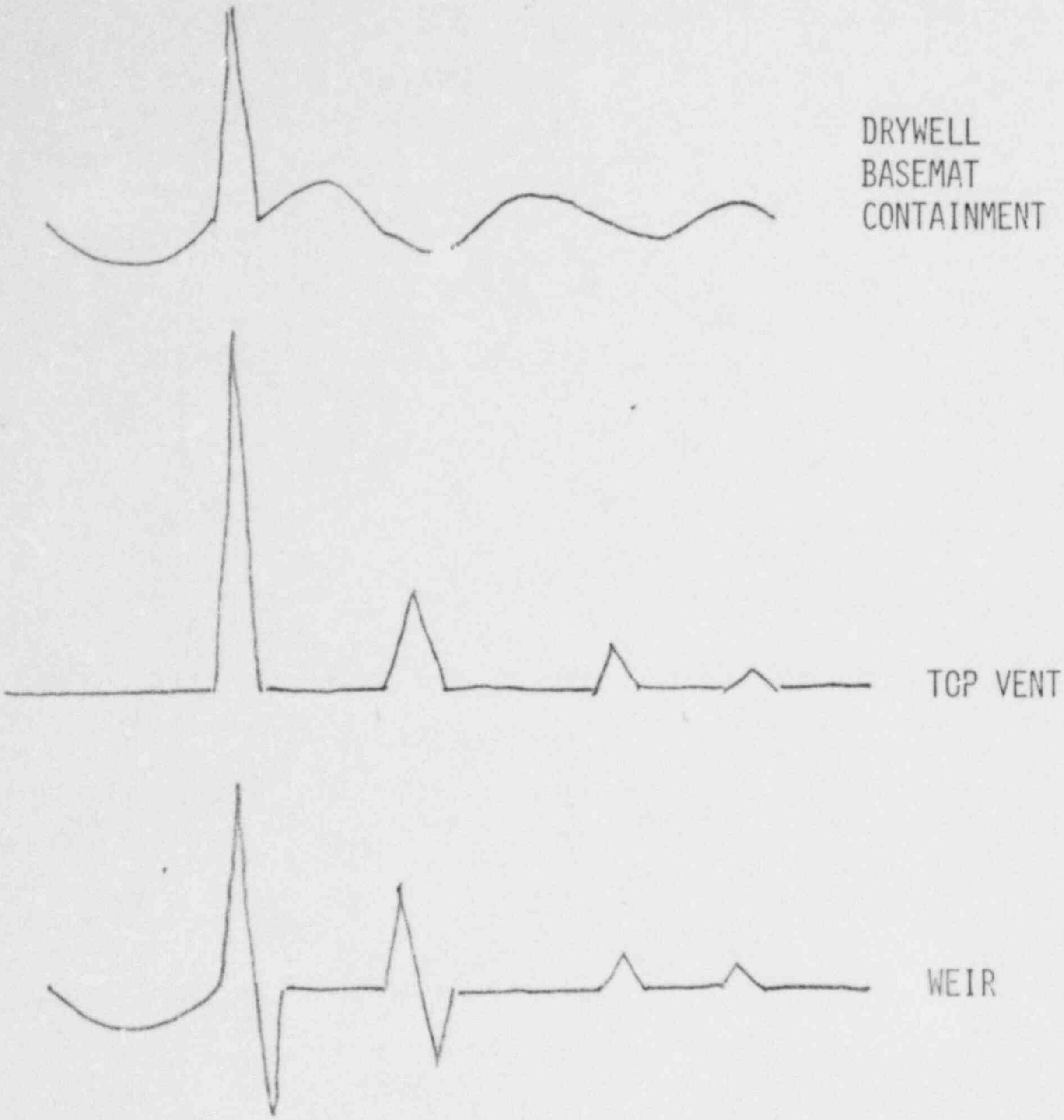
- PRESSURE WAVE FORMS - IMPULSE AMPLIFIED.
- CONSERVATIVE SELECTION OF DATA-POOL TEMPERATURE.
- LOAD APPLICATION - TOP VENT LOADS.
- SPATIAL DISTRIBUTION.
- MONTE CARLO SIMULATION SHOWS LARGE MARGIN RELATIVE TO DESIGN FOR SYMMETRIC LOAD CASE. (GLOBAL LOADS).

SOME CONCERNS:

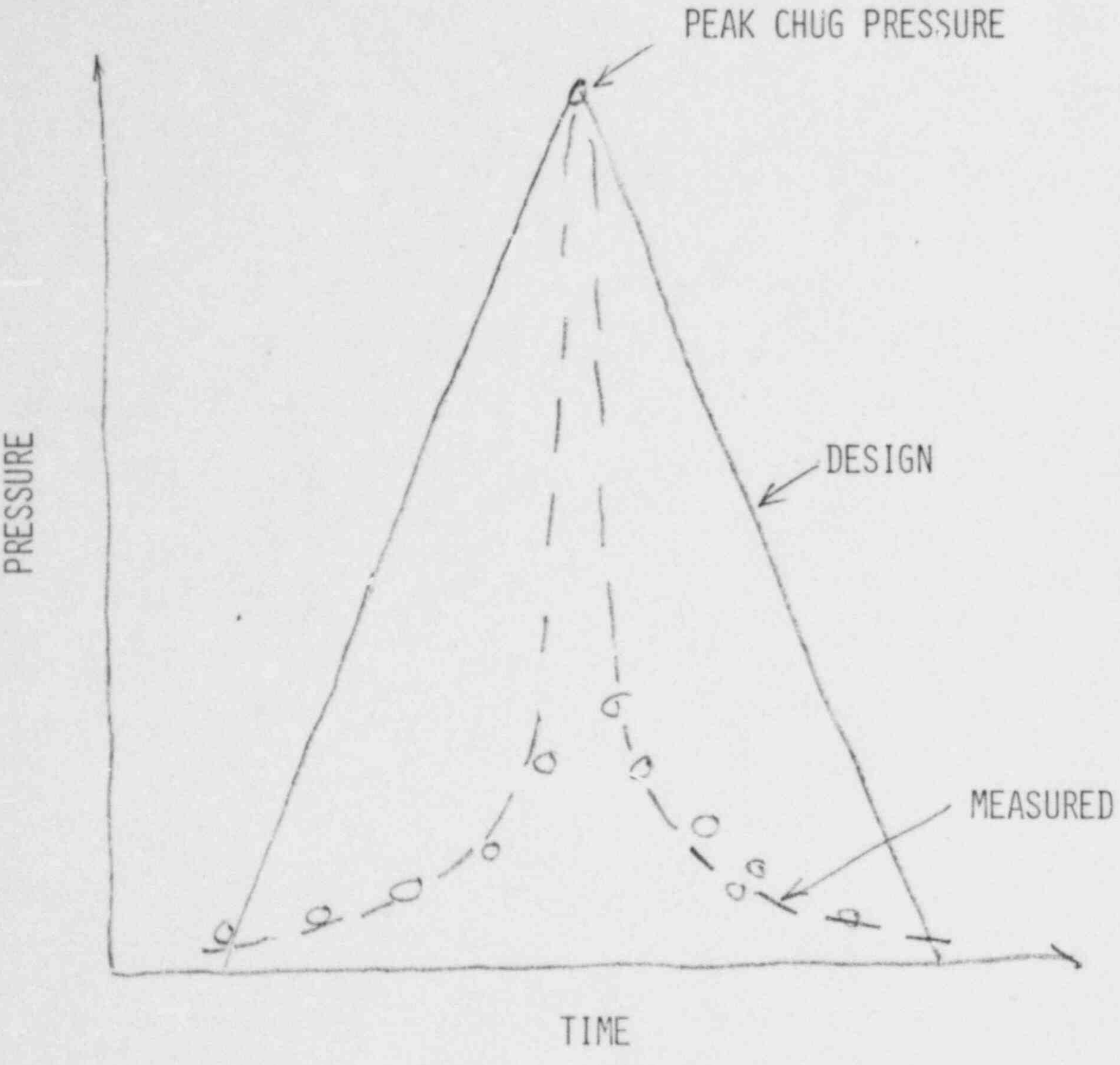
- WEIR WALL EXCEEDANCE (30-40 HZ).
- ABSENCE OF ASYMMETRIC CHUGGING LOAD.

RESOLUTION (IN PROGRESS)

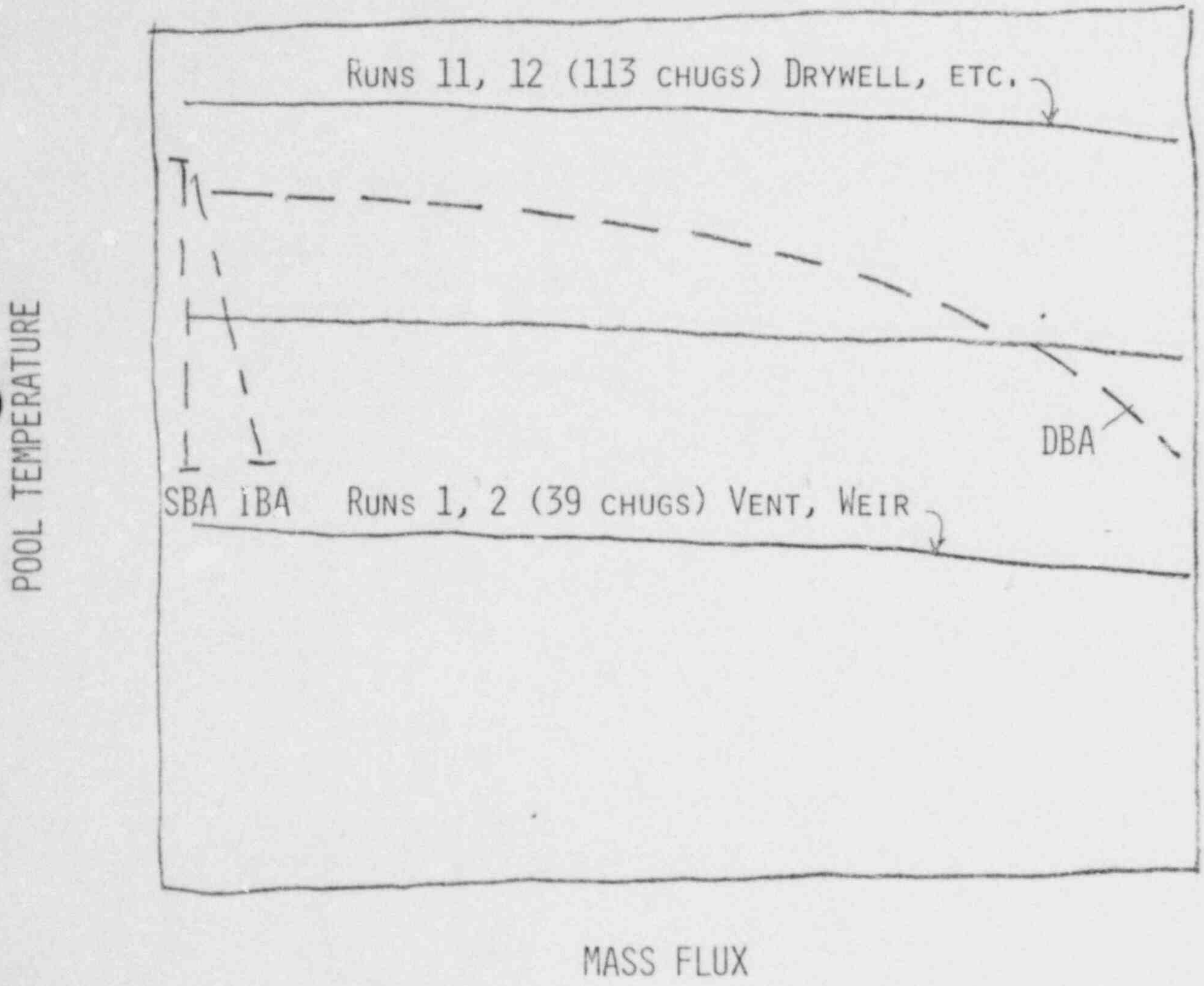
- WEIR WALL EXCEEDANCE DOES NOT HAVE STRUCTURAL SIGNIFICANCE.
- ASYMMETRIC CHUGGING LOADS IMPLIED BY MONTE CARLO SIMULATION MAY BE BOUNDED BY ASYMMETRIC POOL SWELL LOAD.



IDEALIZED CHUGGING PRESSURE
WAVE FORMS

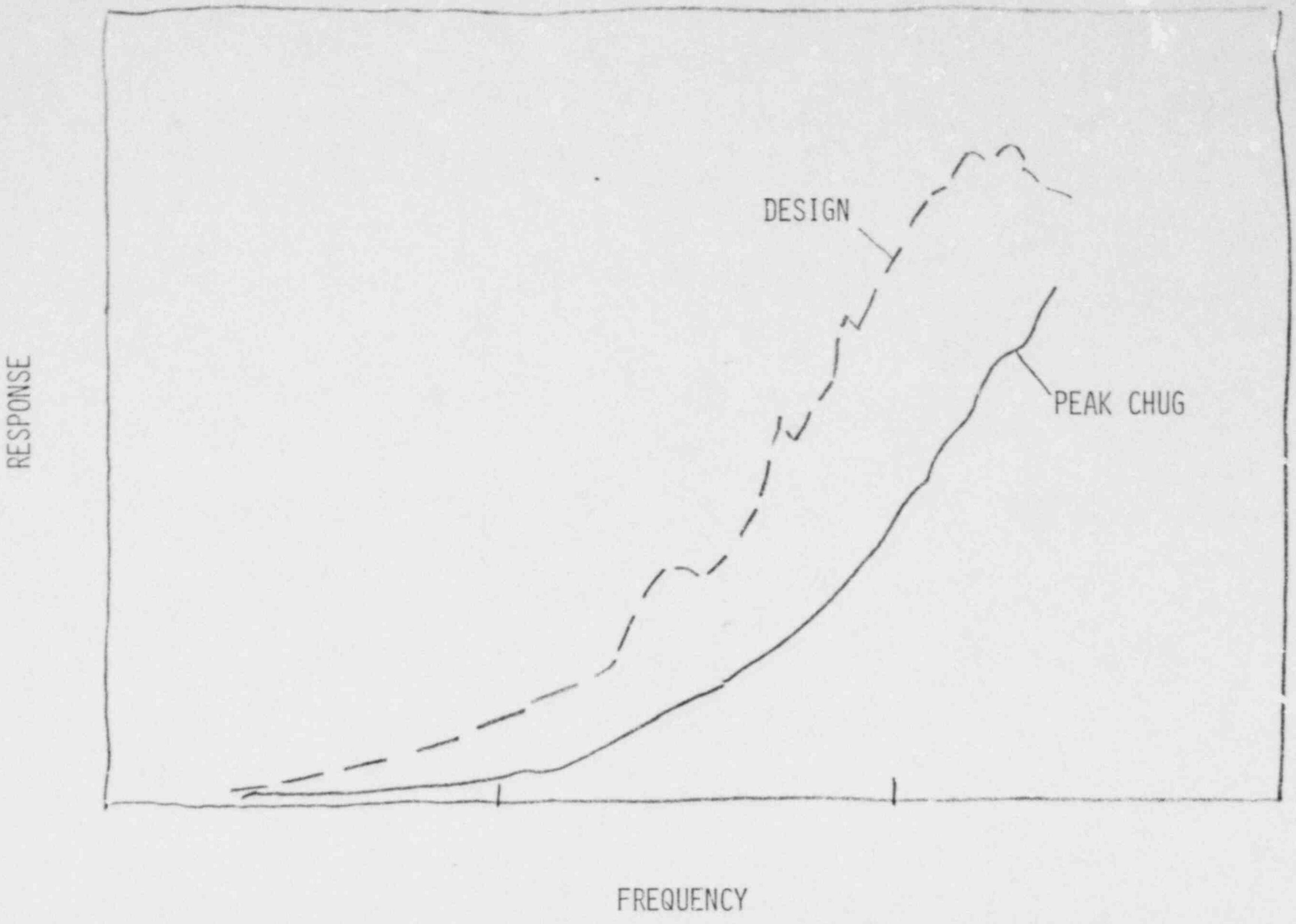


AMPLIFICATION OF IMPULSE

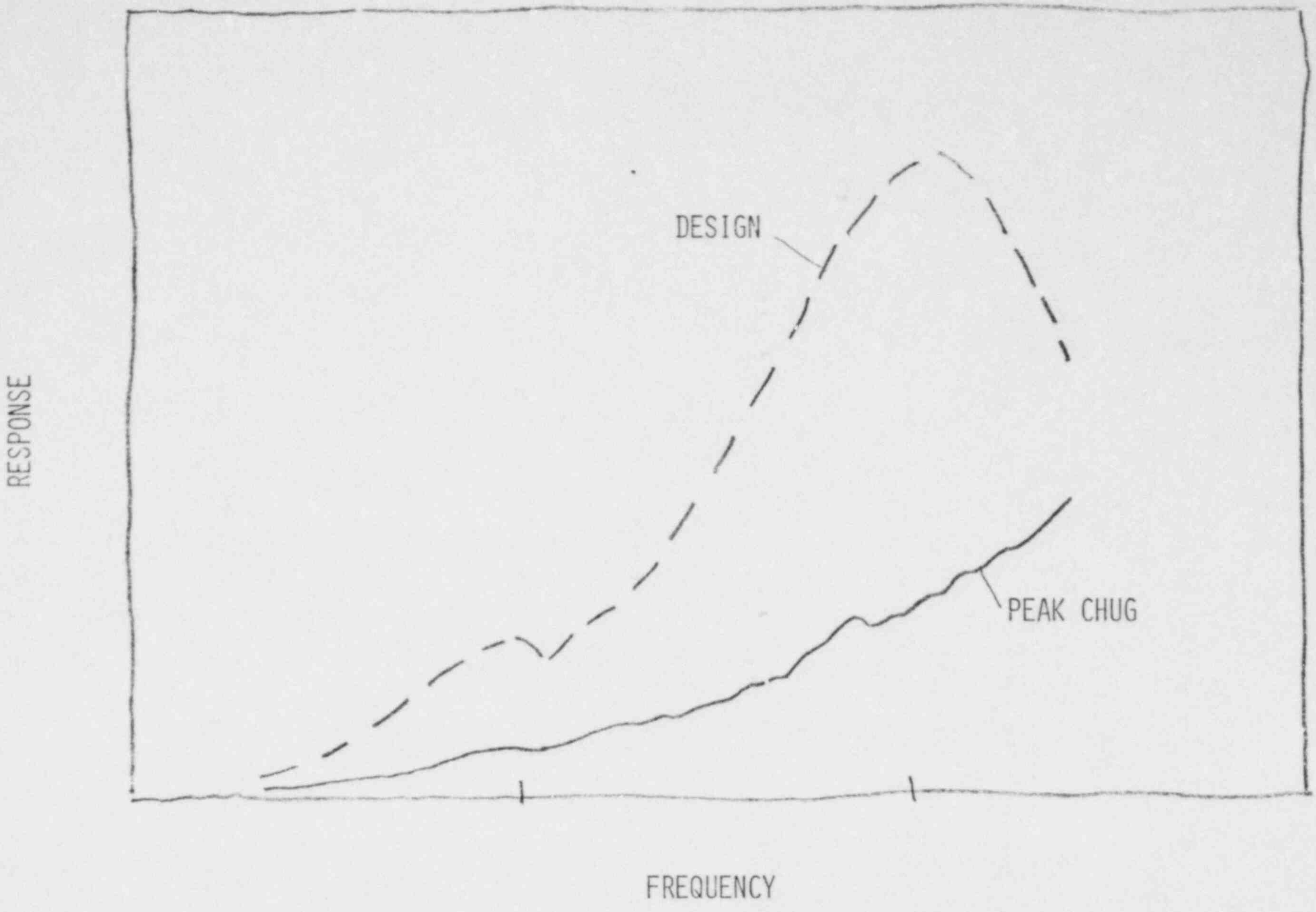


COMPARISON OF PSTF AND PROTOTYPICAL BLOWDOWN CONDITIONS FOR CHUGGING

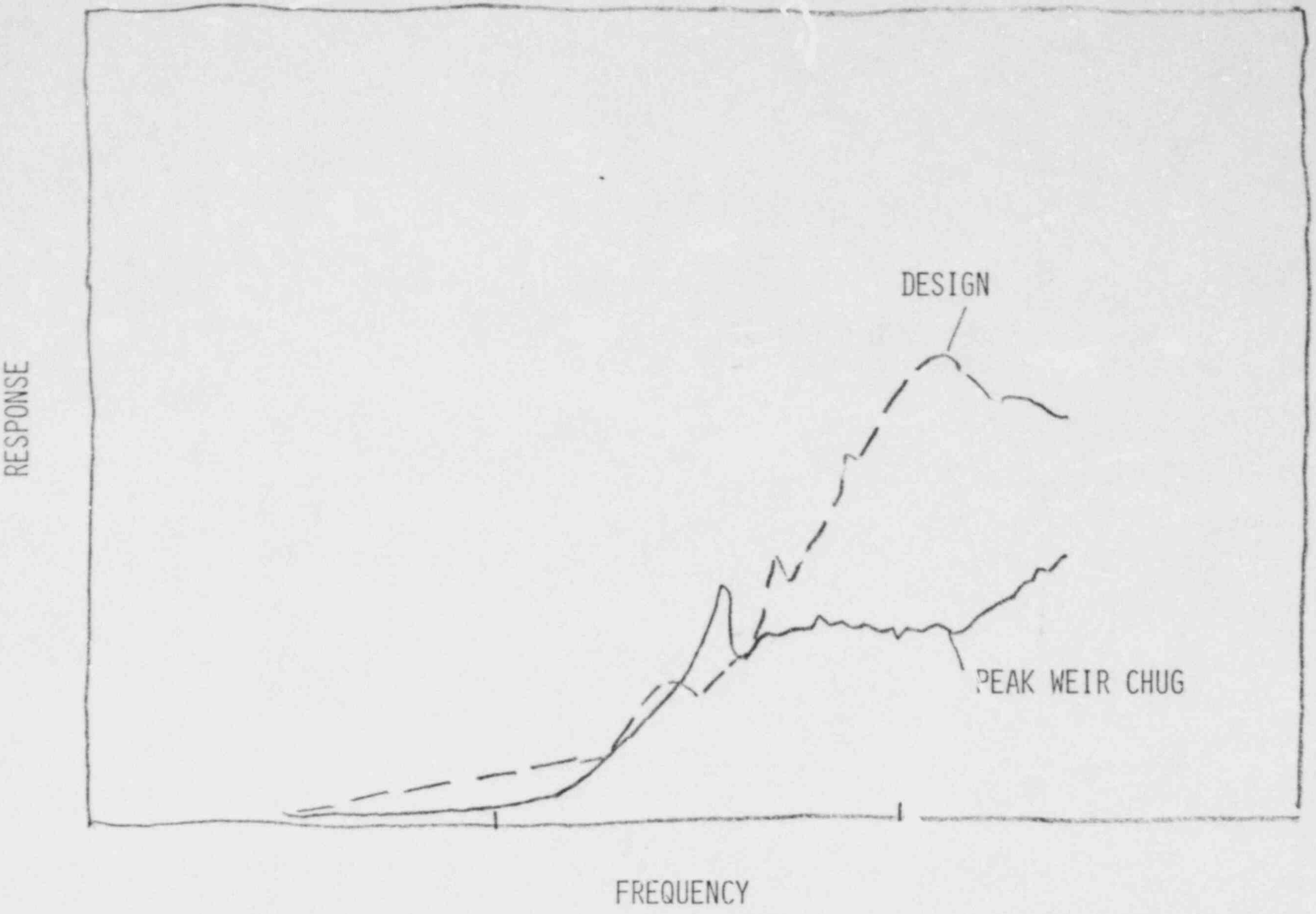
ARS COMPARISON - LOCAL TOP VENT



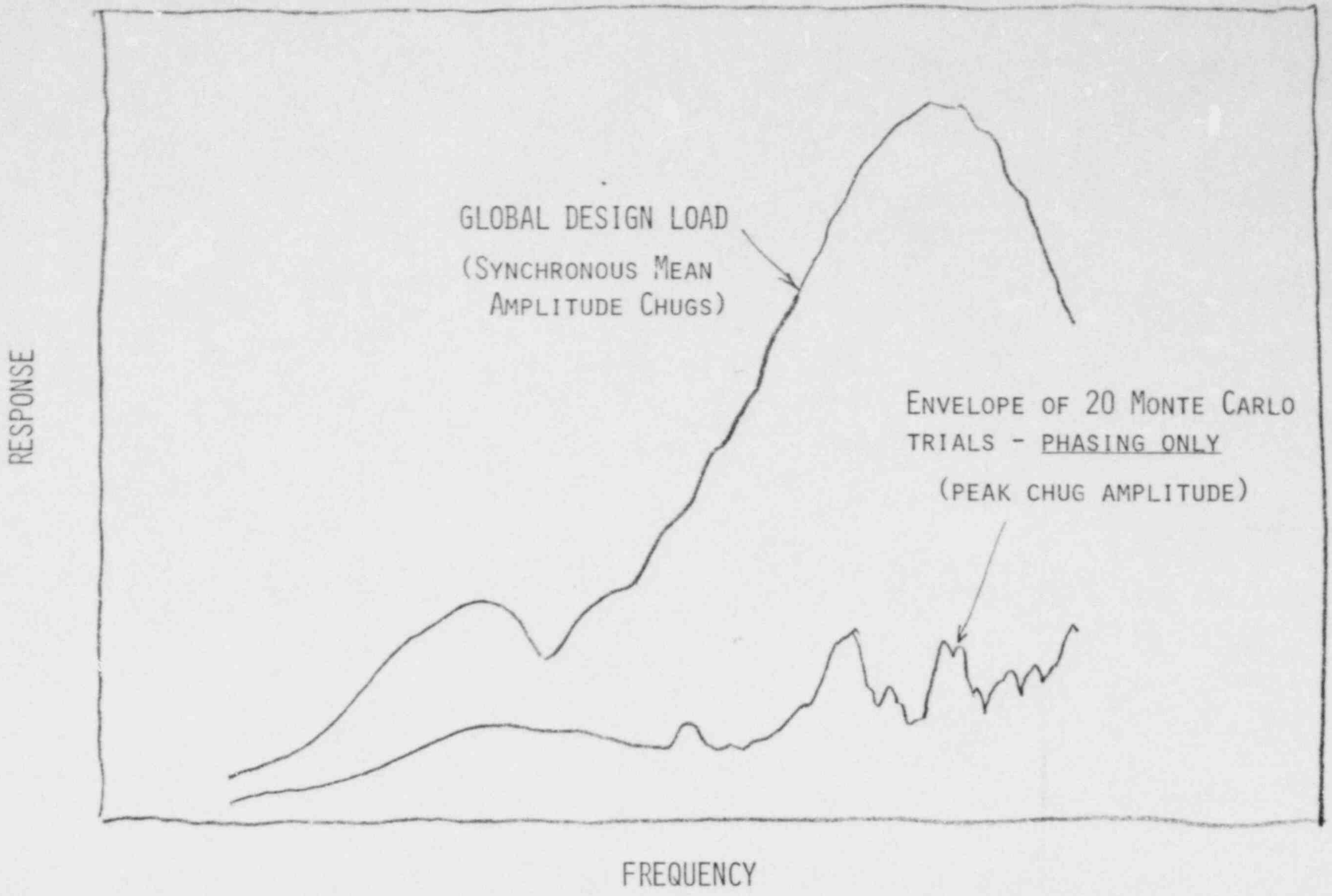
ARS COMPARISON - LOCAL DRYWELL



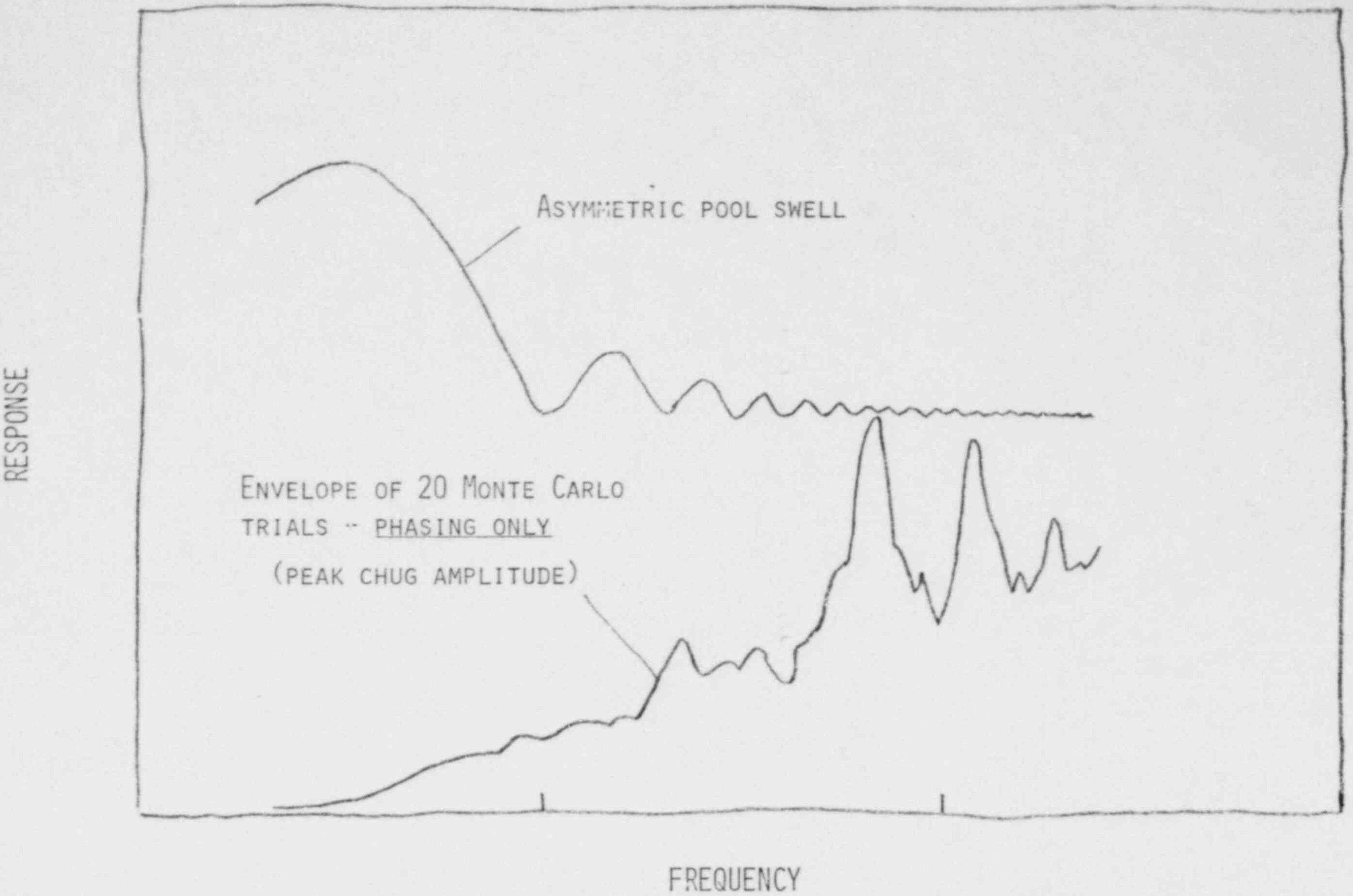
ARS COMPARISON - LOCAL WEIR



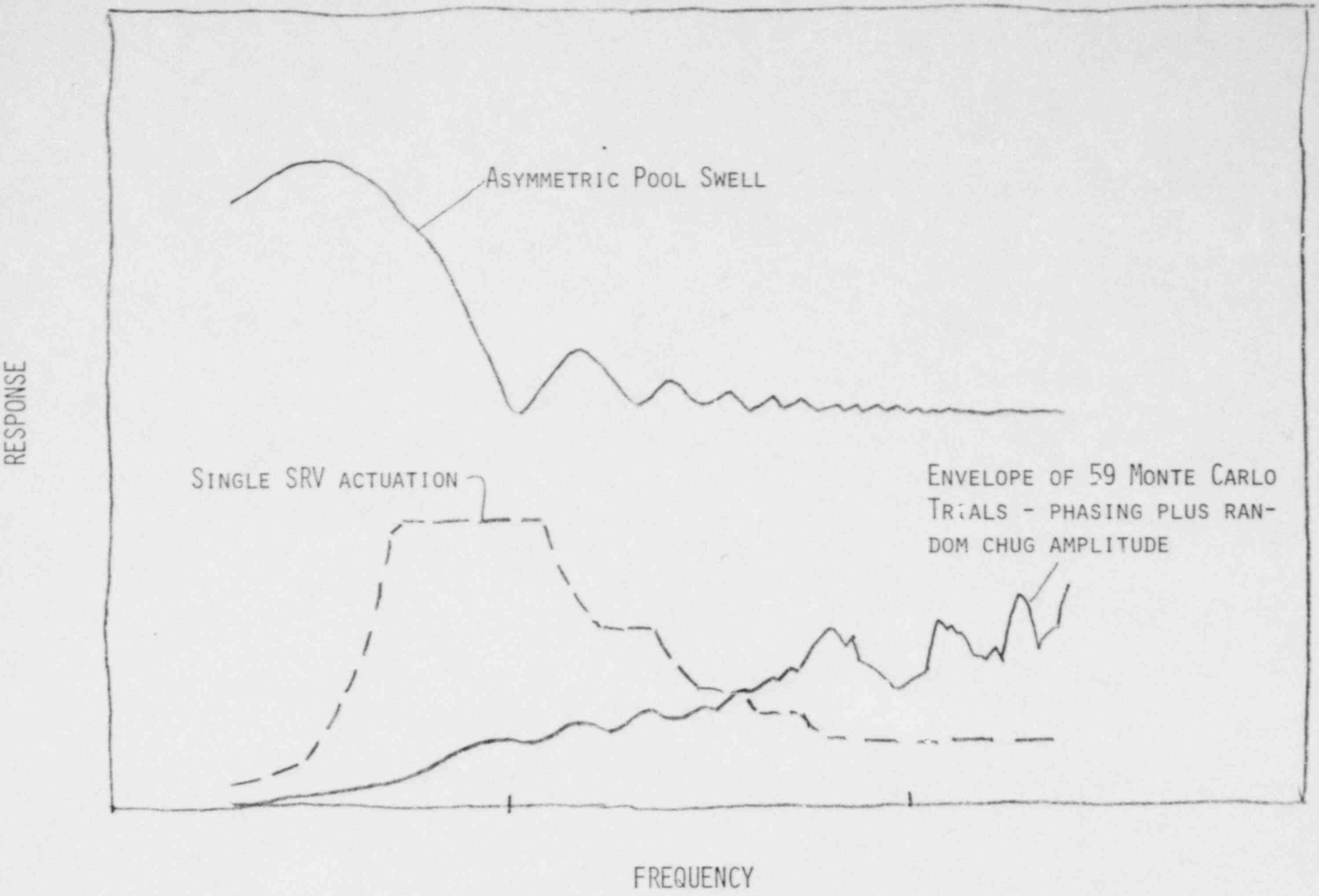
ARS COMPARISON - VERTICAL FORCE



ARS COMPARISON - M_Y



ARS COMPARISON - My



MARK III CO LOAD METHODOLOGY - DESCRIPTION

DYNAMIC PRESSURE LOADING APPLIED TO WETTED BOUNDARIES.

SOURCE (TOP VENT) PRESSURE SPECIFIED AS FUNCTION OF TIME FOR ENTIRE CO DURATION.

ATTENUATION FACTORS ESTABLISH DISTRIBUTION OF PRESSURE AWAY FROM SOURCE.

TIME DEPENDENCE ENTERS VIA TIMEWISE VARIATION OF G, C_A AND T_P.

DBA VARIATION OF G, C_A AND T_P USED FOR DESIGN.

BASIS - 1/3 SCALE PSTF TESTS.

Economou

DATA BASE FOR CO LOAD METHODOLOGY

- 1/9 AREA SCALE PSTF (3 CELLS)
  - DEMONSTRATES ABSENCE OF MULTI-VENT EFFECTS (CO SYNCHRONOUS)
  - USED FOR CONFIRMATION OF SCALING LAWS
- 1/3 AREA SCALE PSTF (SINGLE CELL)
  - MOST COMPREHENSIVE; COVERS ENTIRE RANGE OF G, C_A, T_P FOR STANDARD PLANT
  - USED TO GENERATE FUNCTIONS
    $PPA(G, C_A, T_P)$; $F(G, C_A, T_P)$
- FULL SCALE PSTF (SINGLE CELL)
  - ONLY TWO TESTS WITH USEFUL CO DATA
  - USED FOR CONFIRMATION OF SCALING LAWS

DEVELOPMENT OF CO LOAD DEFINITION

PRESSURE HISTORY IS SINUSOIDAL WITH AMPLITUDE (PPA) AND FUNDAMENTAL FREQUENCY (F) CONSIDERED TIME DEPENDENT.

REGRESSION ANALYSIS OF 1/3 AREA SCALE DATA YIELDS

$$PPA_{1/3} = f(G, C_A, T_P)$$

$$F_{1/3} = f(G, C_A, T_P)$$

SCALING LAWS USED TO CONVERT $PPA_{1/3}$, $F_{1/3}$ TO PPA_{FS}, F_{FS}.

POTENTIAL FLOW ANALYSIS DETERMINES ATTENUATION FACTORS FOR ALL SCALES.

PLANT ANALYSIS FOR DBA DETERMINES $\dot{G}(t)$, $C_A(t)$, $T_P(t)$.

THREE HARMONICS ADDED.

CO LOAD METHODOLOGY - CONFIRMATION OF ADEQUACY

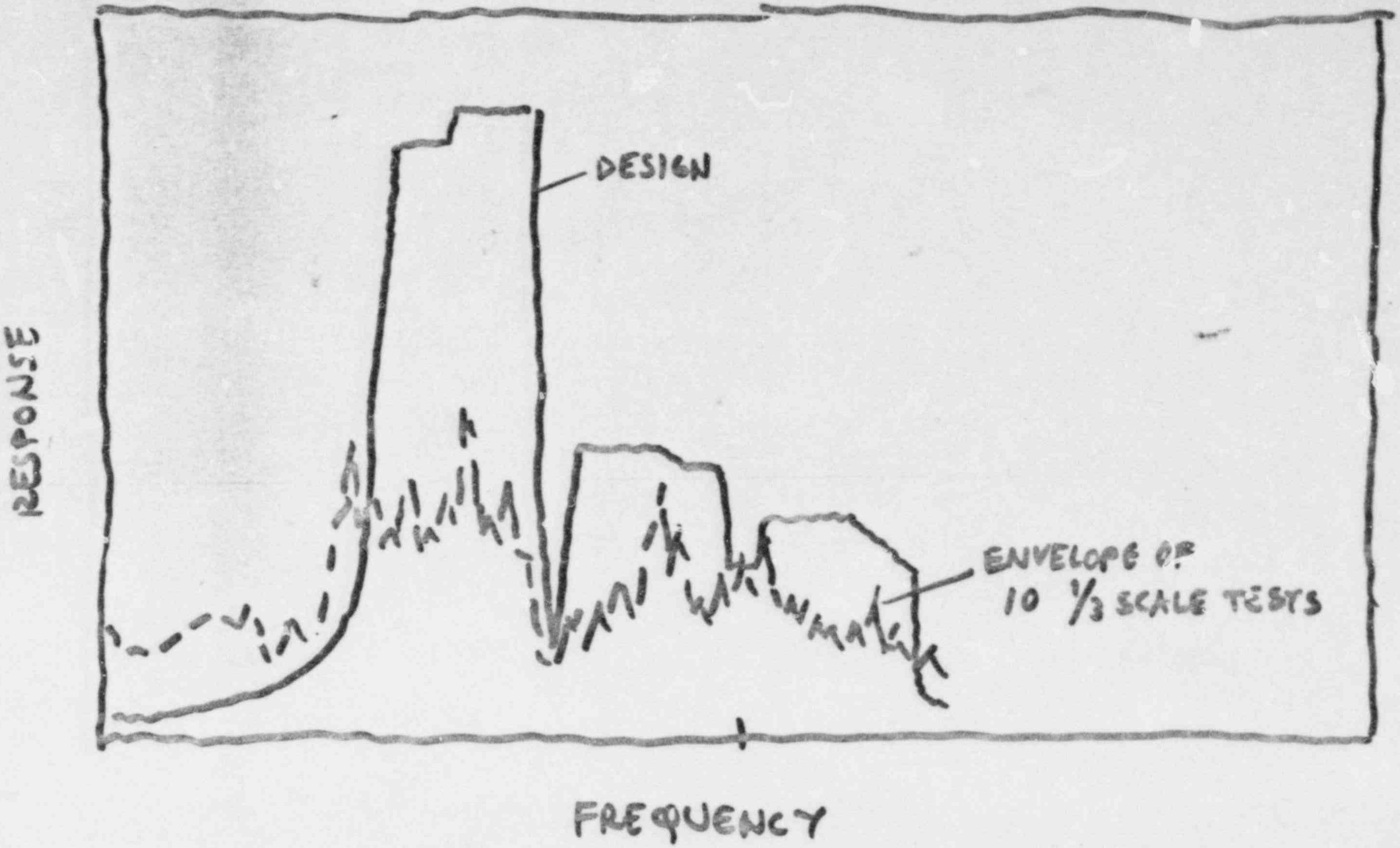
- CONCERNS
  - APPLICABILITY OF $\frac{1}{3}$ AREA SCALE TESTS FOR PROTOTYPE (SCALING LAWS)
  - BOUNDING OF ALL MEASUREMENTS
  - IS DBA "WORST" CASE ?

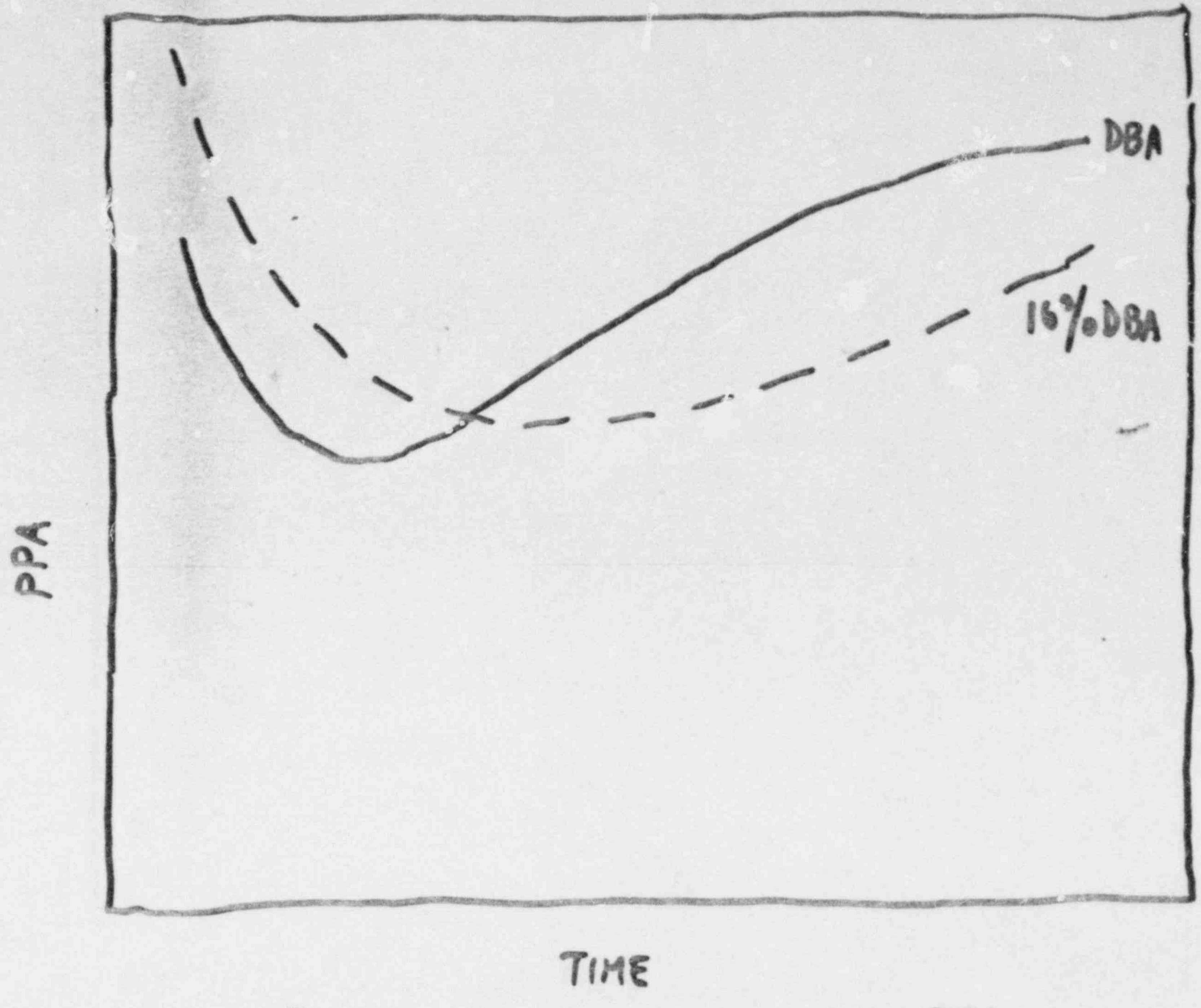
- METHOD OF APPROACH
  - APPLY METHODOLOGY AND GENERATE PREDICTIONS FOR $\frac{1}{9}$, $\frac{1}{3}$, FULL SCALE TESTS
  - COMPARE WITH ALL AVAILABLE MEASUREMENTS
    - TIME (PPA, RMS, F) AND FREQUENCY (ARS) DOMAINS
  - DEMONSTRATE BOUNDING OF ALL DATA
  - DEMONSTRATE CORRECT PREDICTION OF ALL TRENDS WITH SCALE
  - APPLY METHOD PARAMETRICALLY WITH VARIATIONS IN PLANT INITIAL CONDITIONS (C_A, T_P) AND BREAK SIZE TO SHOW STANDARD DBA IS WORST CASE

CO LOAD METHODOLOGY - RESULTS OF CONFIRMATORY STUDIES

- PREDICTIONS EXCEED MEASURED PRESSURE IN ALL CASES
  - BUT SOME UNCERTAINTY REMAINS (LACK OF COMPLETE SET OF FULL SCALE RESULTS)
- UNCERTAINTIES IN SOURCE FREQUENCY SCALING REMAIN
  - SCALING ARGUMENTS WEAK
  - EXPERIMENTAL CONFIRMATION INSUFFICIENT
  - UP TO 50% UNCERTAINTY IN PREDICTED STANDARD PLANT FREQUENCIES
- DATA EXCEEDANCES FOUND AT LOW AND HIGH FREQUENCY ENDS OF LOAD SPECIFICATION IN TERMS OF SIGNAL POWER (ARS COMPARISONS)
- SMALL BREAK SIZE RESULTS NOT COMPLETELY BOUNDED BY DESIGN LOAD (STANDARD DBA)

ARS COMPARISON





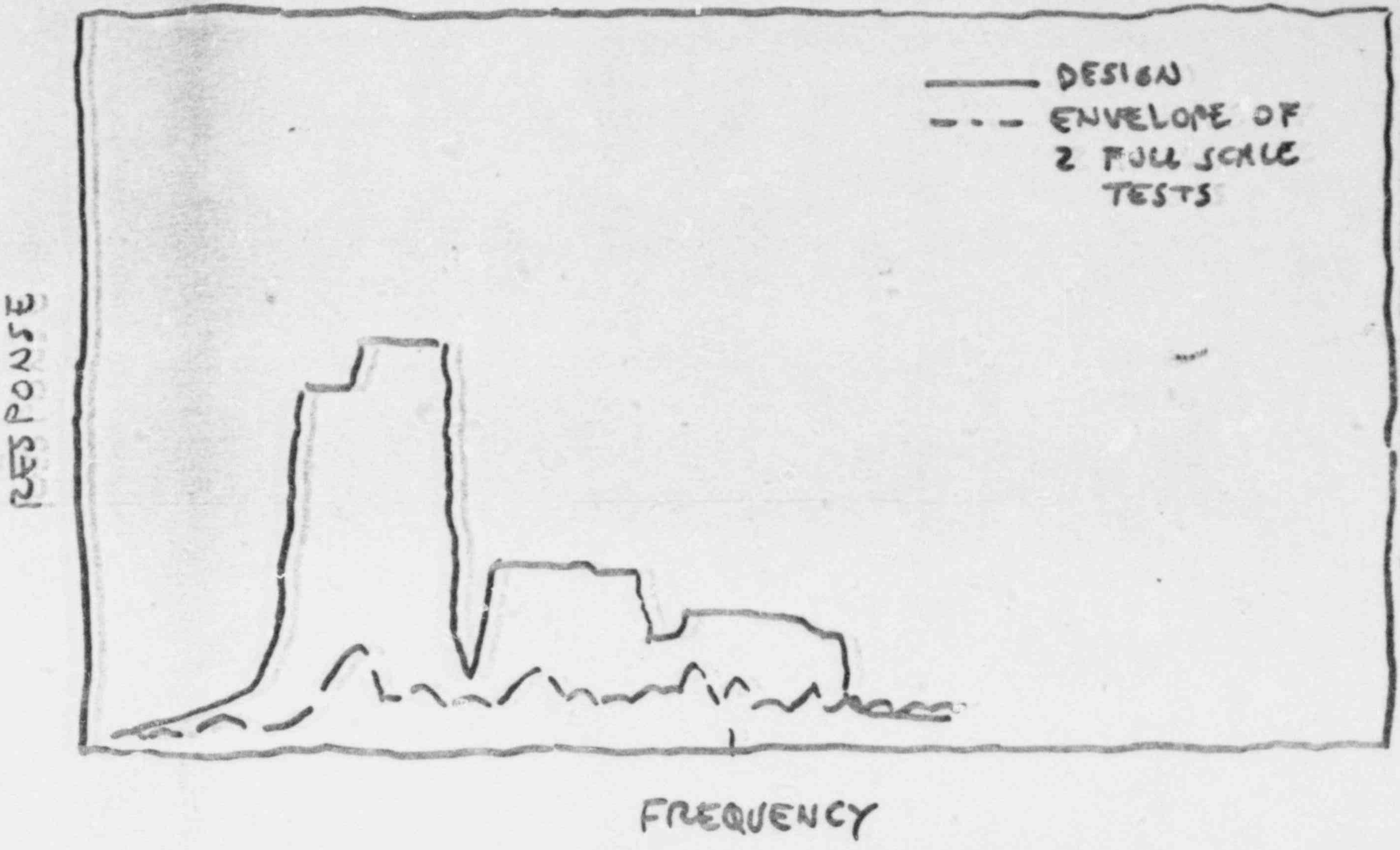
EFFECT OF BREAK SIZE ON PPA

CO LOAD METHODOLOGY

- CONCERN: LACK OF COMPLETE SET OF FULL SCALE TEST RESULTS

- RESOLUTION: ADDED CONSERVATISMS
  - THREE HARMONICS
  - AMPLIFIED ENERGY CONTENT
  - DEMONSTRATED MARGINS

ARS COMPARISON

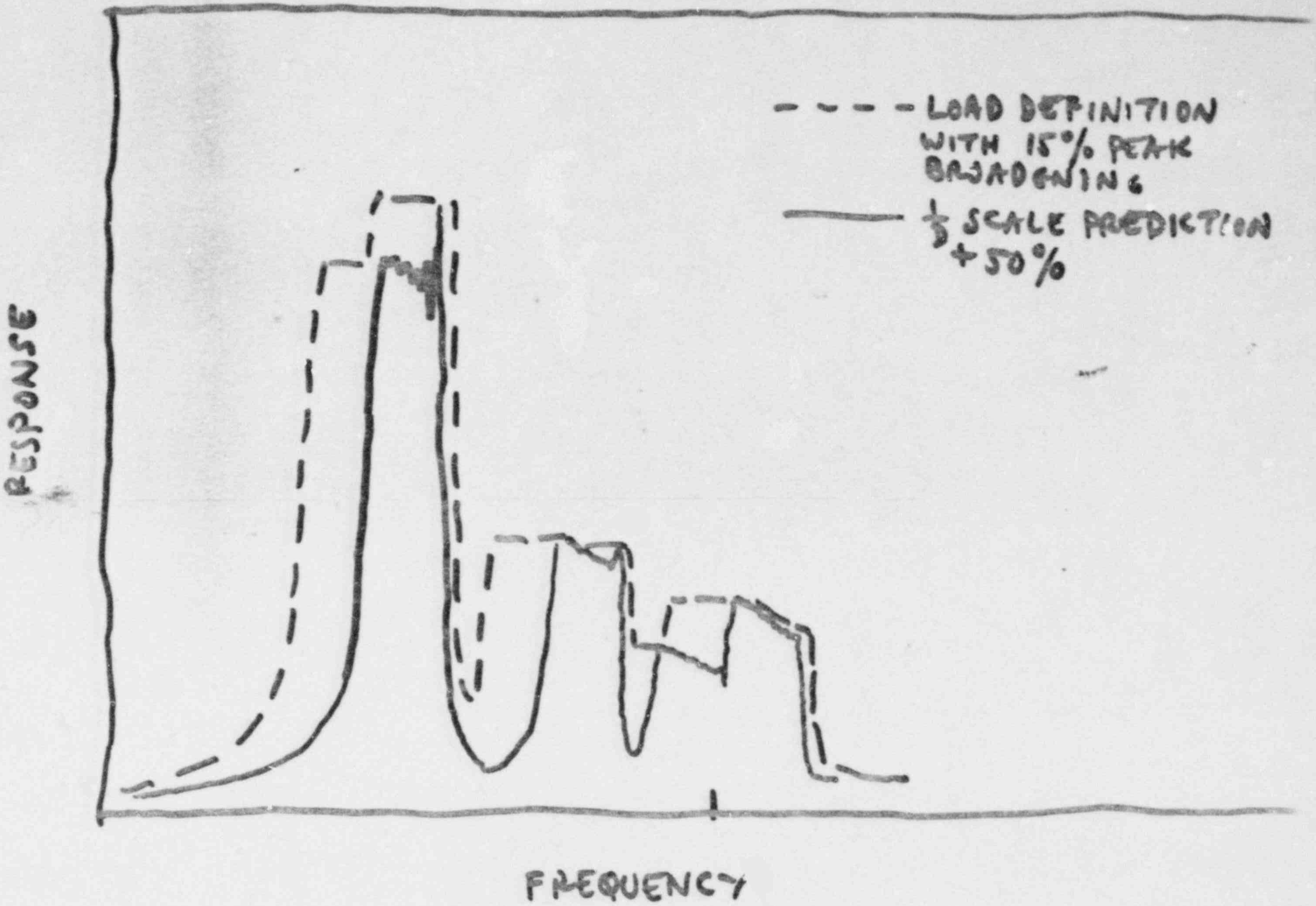


CO LOAD METHODOLOGY

- CONCERN: UNCERTAINTY IN SOURCE FREQUENCY SCALING

- POTENTIAL RESOLUTION (IN PROGRESS)
  - CO LOAD DEFINITION ARS WITH 15% PEAK BROADENING BOUNDS SCALING PREDICTION WITH 50% UNCERTAINTY
  - PEAK BROADENING DICTATED BY REGULATORY GUIDE
  - ARGUMENT HAS MERIT ONLY IF REQUISITE BROADENING IS INTENDED TO BOUND UNCERTAINTY IN FORCING FUNCTION

ARS COMPARISON



CO LOAD METHODOLOGY

CONCERN: DATA EXCEEDANCES AT LOW AND HIGH END OF FREQUENCY SPECTRUM ON ARS BASIS

- RESOLUTION (IN PROGRESS)
  - .. LOW FREQUENCIES NOT STRUCTURALLY SIGNIFICANT
  - .. HIGHER FREQUENCY LOADS BOUNDED BY CHUGGING LOAD SPECIFICATION

CO LOAD METHODOLOGY

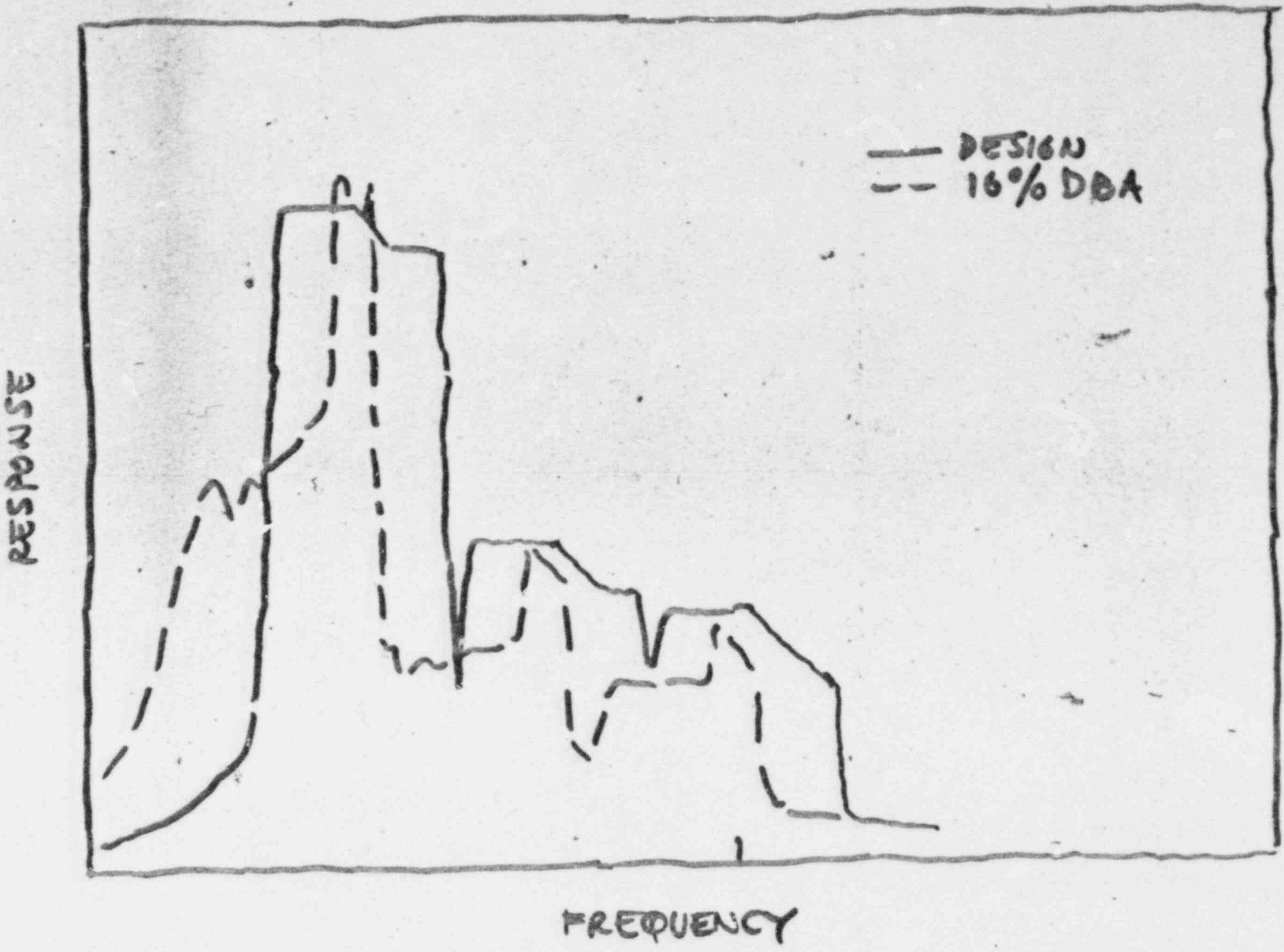
CONCERN: STANDARD DBA NOT "WORST" CASE

RESOLUTION (IN PROGRESS):

.. DESIGN WITH 15% PEAK BROADENING BOUNDS ALL CASES FOR FREQUENCIES ABOVE 3 Hz. ON ARS BASIS

.. NO STRUCTURAL SIGNIFICANCE BELOW 3Hz.

ARS COMPARISON



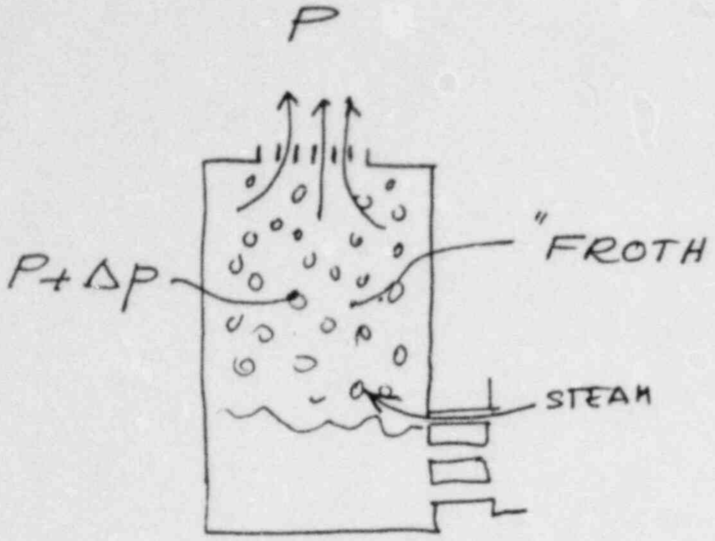
FROTH LOAD ON HCU FLOOR

A.C.R.S.

San Fransisco
24 Sept. 1981.

Ain A. Sonin

FROTH LOAD ON HCU FLOOR



POST- BREAKTHROUGH FLOW

SPECIFICATION FOR 238 PLANT :

$$\Delta p = 11 \text{ psi}$$

BASIS : A simplistic model, whose conservatism is demonstrated against 1/3-scale tests, predicts 10.8 psi.

AD HOC MODEL :

- froth flow through HCU floor modeled as homogeneous, incompressible flow with loss coefficient K.

  (K = 5 in Mark III application).

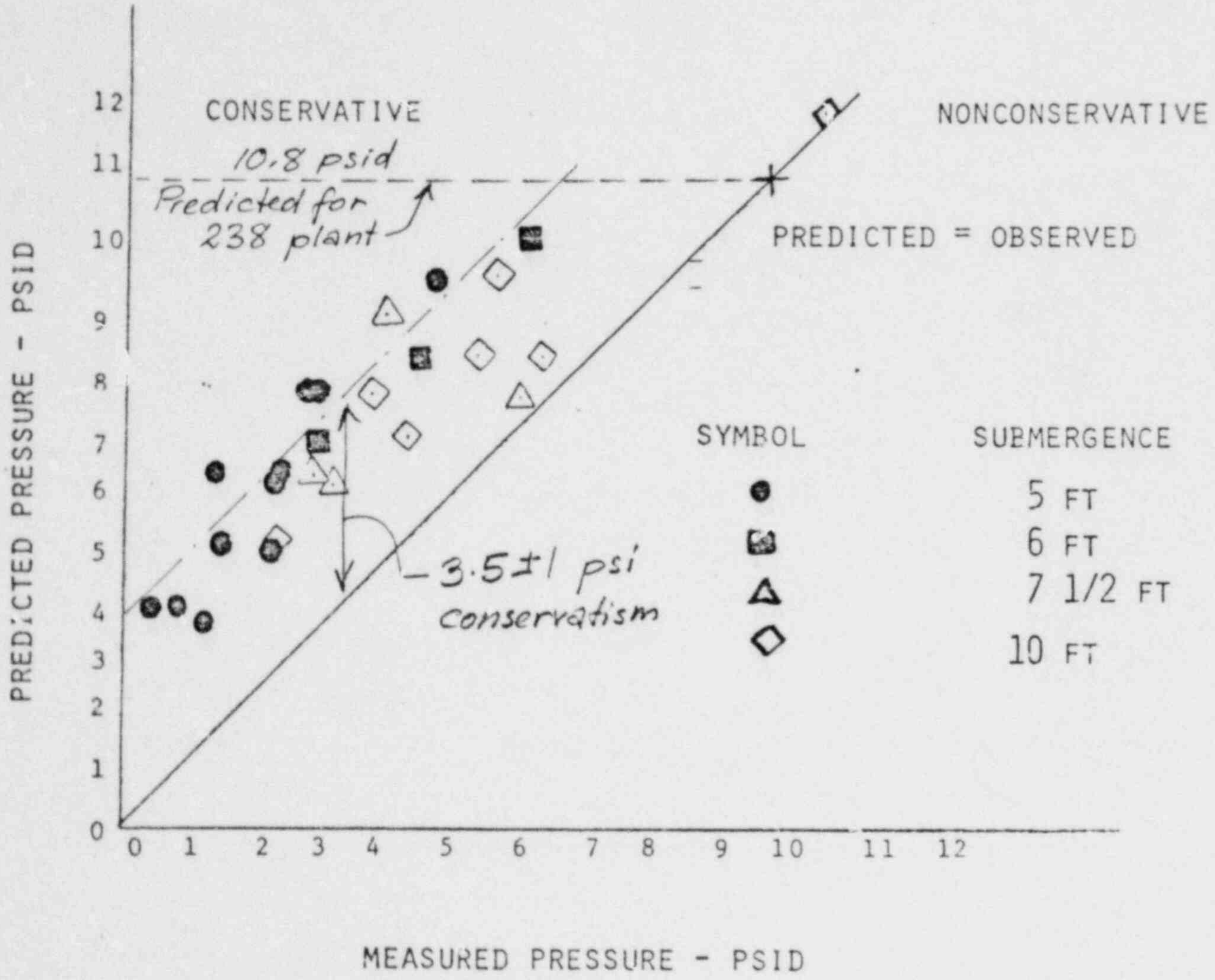
- froth density taken as constant, corresp. to assumption that all water initially above top vent mixes homogeneously with available air beneath HCU floor.

- mass balance written for wetwell region, based on inflow from vents (via a drywell model), froth outflow through HCU floor, and numerous assumptions.

- wetwell mixture is assumed to obey perfect gas equation (!), with temperature constant. This closes the problem.

Conservatisms claimed in
- froth density
- loss coefficient K
- drywell model
- etc.

COMPARISON OF MEASURED AND PREDICTED TWO PHASE PRESSURE DROP - K = 5.0



TRM05
9/15/81

For 238 plant with 25% open area.

- Model predicts $\Delta p = 10.8$ psi
- Empirical conservatism 3.5 ± 1 psi
- Other conservatism : plant has K less than 2 ; hence, expect conservatism to be greater than for 1/3-scale system.
- Possible nonconservatism ? Simplistic model, relies more on conservatism than realistic prediction. Not checked at full scale.

BASIS FOR GESSAR II BULK POOL IMPACT SPECIFICATION OF 115 PSI:

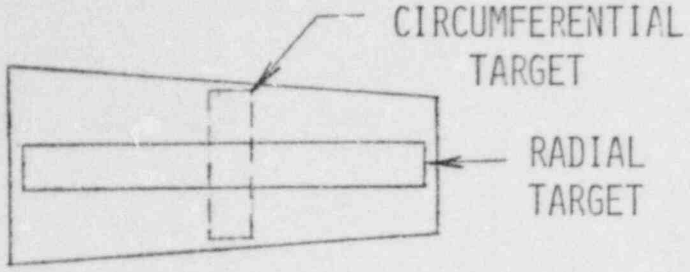
TEST SERIES/RUN	5706/4
TARGET GEOMETRY	20 INCH SQUARE PLATE
VELOCITY AT IMPACT	21 FT/SEC

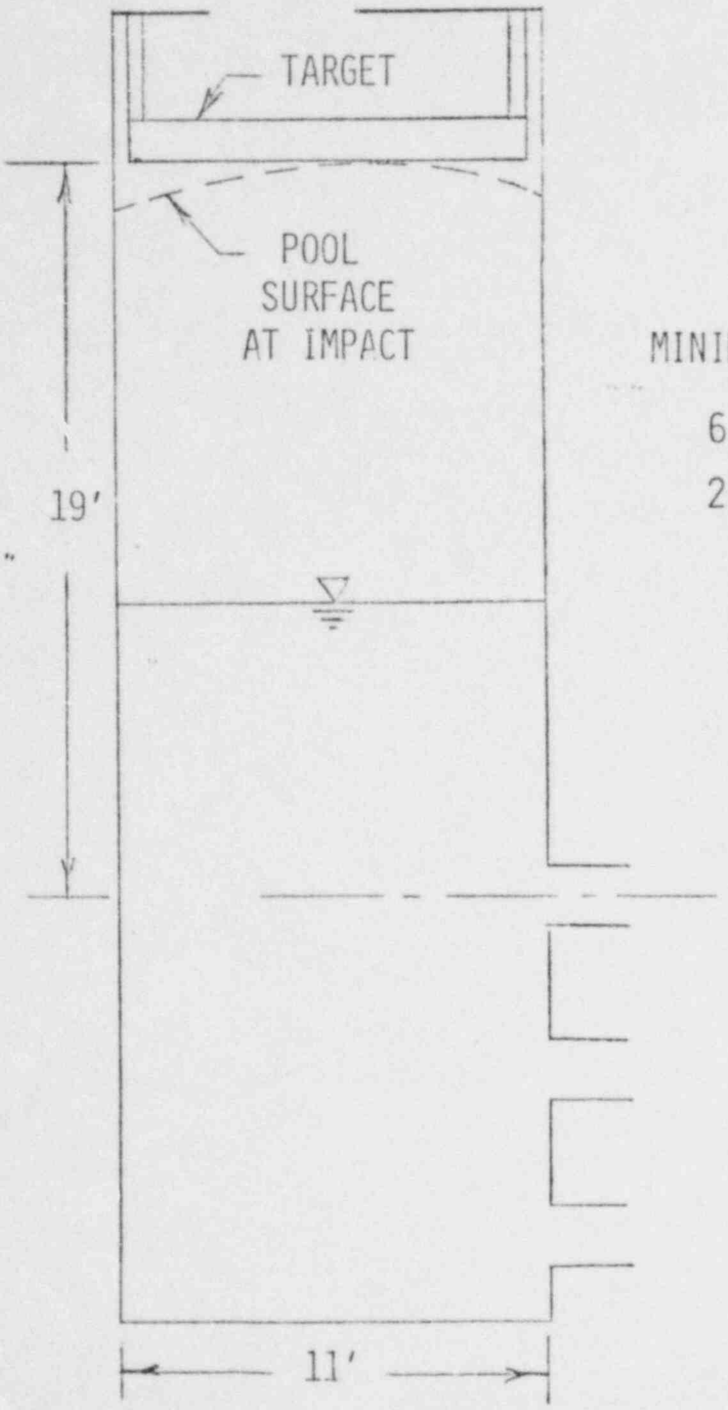
MAX. SLUG VELOCITY IN MARK III	> 40 FT/SEC

GE ANALYSIS IN RESPONSE TO NRC QUESTION NO. 4 (FIRST ROUND)

- IN ANY PARTICULAR STRUCTURE, STRESS IS PROPORTIONAL TO P_{MAX} x DLF.
- CALCULATE P_{MAX} x DLF USING GESSAR II (115 PSI, 7 MSEC).
- CALCULATE P_{MAX} x DLF USING MARK II A.C. (NUREG-0487), WITH V OF MARK III POOL AND PULSE DURATIONS APPROPRIATE FOR MARK III.
- IF GESSAR II P_{MAX} x DLF GREATER THAN MARK II P_{MAX} x DLF, SPECIFICATION IS BOUNDING.

PSTF FACILITY DURING STRUCTURES IMPACT TEST (SERIES 5805)





MINIMUM PULSE DURATIONS:

6.8 MSEC FOR RADIAL

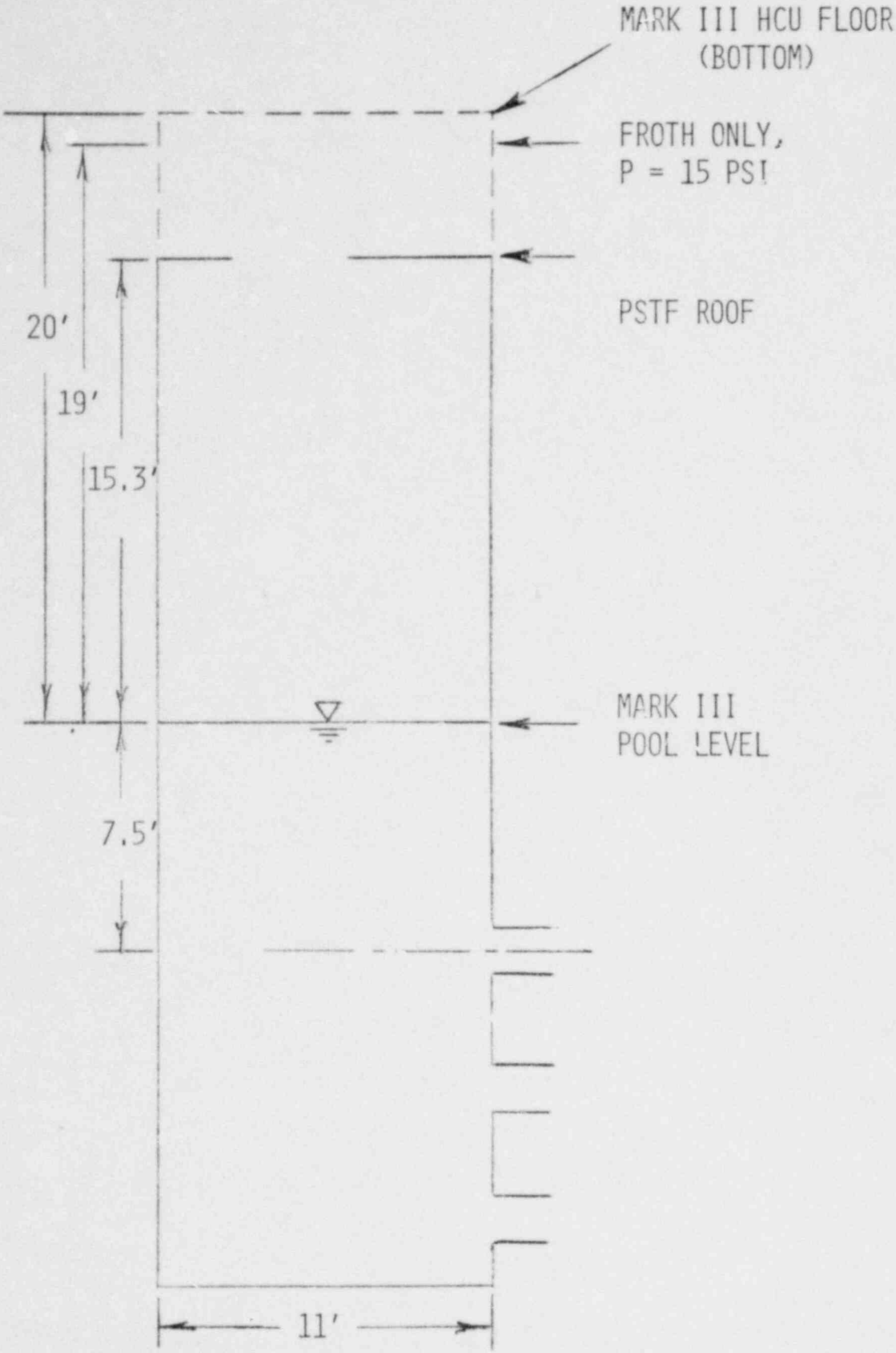
2.0 MSEC FOR CIRCUM.

BASIS FOR GESSAR II FROTH POOL
IMPACT SPECIFICATION OF
15 PSI:

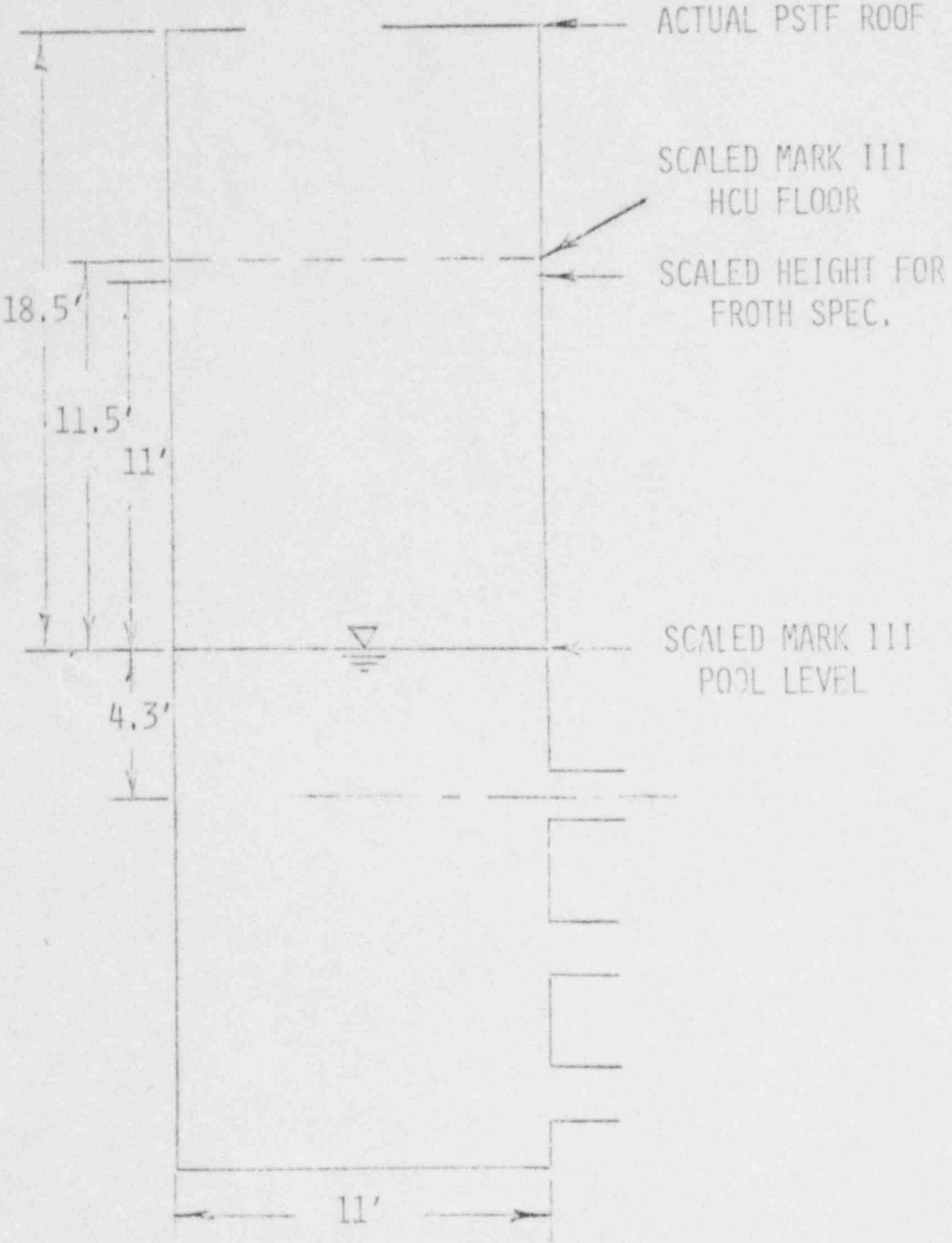
TEST SERIES/RUN	5706/6
TARGET GEOMETRY	20 INCH SQUARE PLATE
VELOCITY AT IMPACT	27 FT/SEC
FROTH TRAVEL PRIOR TO IMPACT	~ 10 FEET
VOID FRACTION (APPROXIMATE)	0.75

MAX. FROTH VELOCITY IN MARK III	50 FT/SEC

ONE-THIRD SCALE PSTF



ONE-THIRD SCALE PSTF AS A GEOMETRICALLY SCALED $1/\sqrt{3}$ FACILITY



MARK III POOL SWELL VELOCITY.

A.C.R.S.
San Fransisco

Ain A. Sonin

SUMMARY OF LOAD, LOAD BASIS AND NRC EVALUATION

G.E.'s DESIGN VALUE (FOR 238 PLANT) : 40 FT/S.

JUSTIFICATION:

I. "FULL SCALE" TEST — 38 FT/S

NRC : simulation poor & nonconservative.

II. DISTORTED-GEOMETRY TESTS

1/9 AREA SCALE
1/3 AREA SCALE } "below 40 FT/s"

NRC : Extrapolation from 1/9 to 1/3 to 1/1 would suggest value > 40 FT/s !

III. "MODIFIED FROUDE SCALED" TESTS.

G.E : "below 42 FT/s".

NRC : "below 47 FT/s ±, with considerable uncertainty".

CONCLUSIONS :

1. ALL AVAILABLE POOL SWELL DATA IS FLAWED IN SOME WAY.

2. MAXIMUM POOL SWELL VELOCITY FOR 238 PLANT MAY WELL EXCEED 40 FT/S.

I. "FULL-SCALE" TEST 5705-4

- full scale poor area
- full scale break area.

- <u>two</u> vents, not three
- half-size drywell
- air blowdown
- post-vent-clearing drywell pressure far below design value.

Measurement: 38 FT/s.

TWO VENTS:

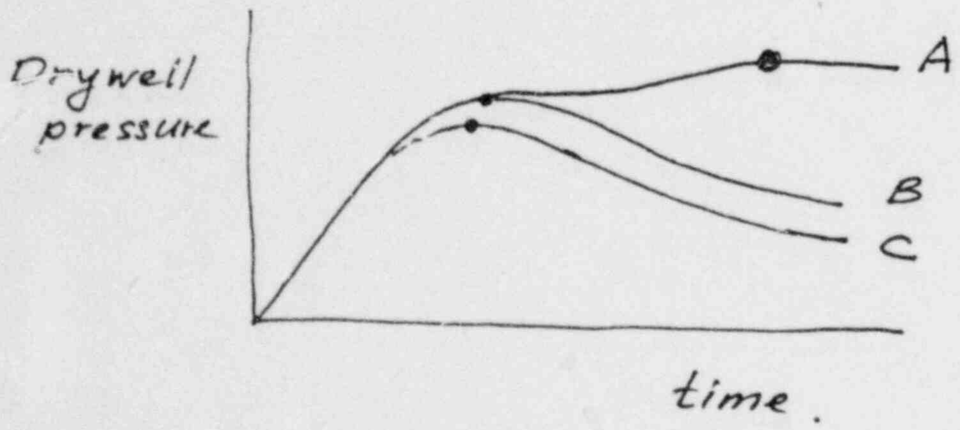
- One vent tests produced half the pool swell velocity of two-vent tests.
- Hence, two-vent tests may well be lower than three-vent tests (i.e. prototype). By how much?

NONCONSERVATIVE DRYWELL PRESSURIZATION

(Next two slides)

PEAK DRYWELL PRESSURE PREDICTIONS FOR 238 PLANT :

A.	GESSAR DESIGN VALUE	23 psig.
B.	GESSAR PRE-BREAKTHROUGH MODEL	20 psig
C.	G.E.'s "BEST ESTIMATE"	16 psig.



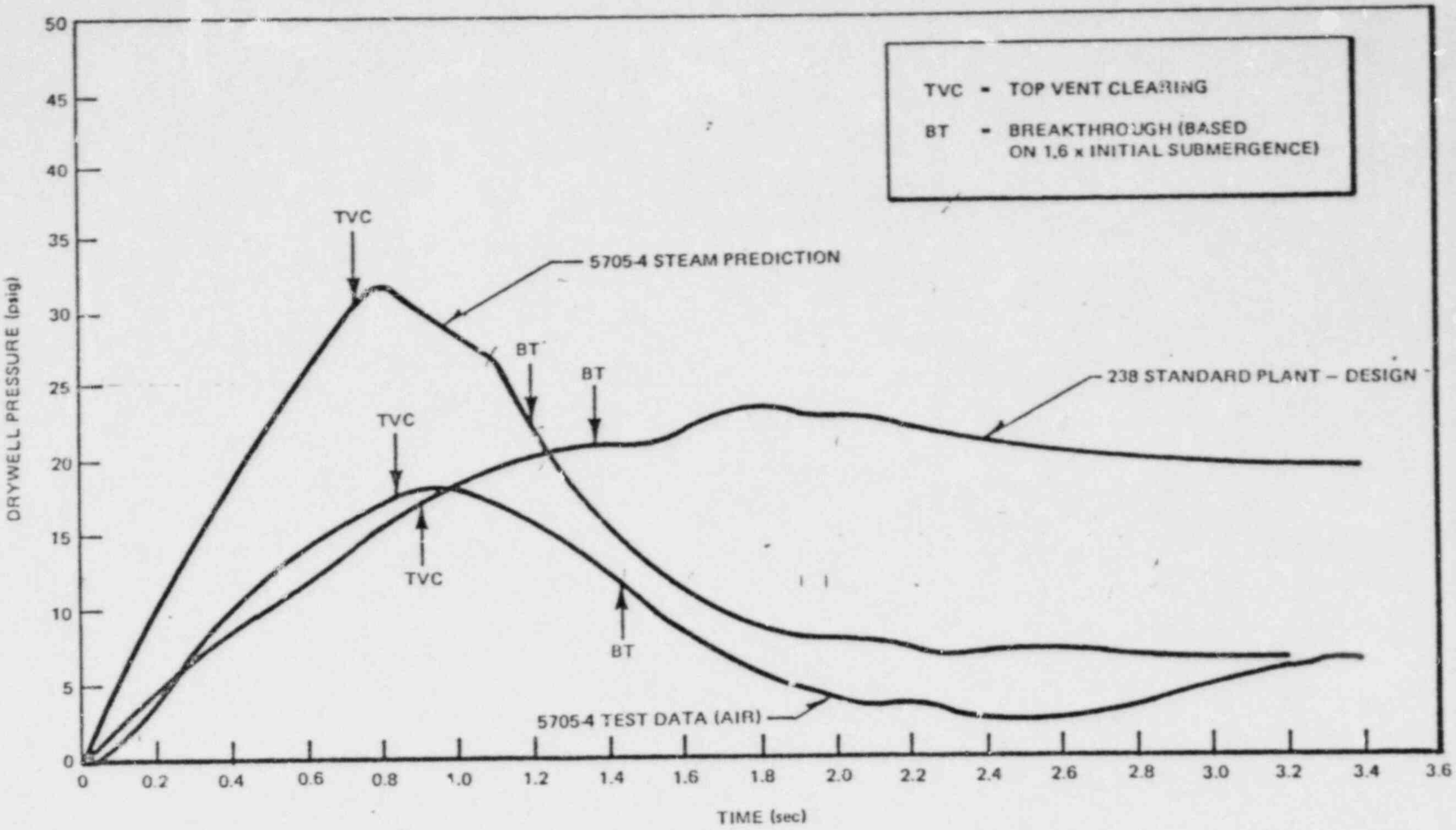
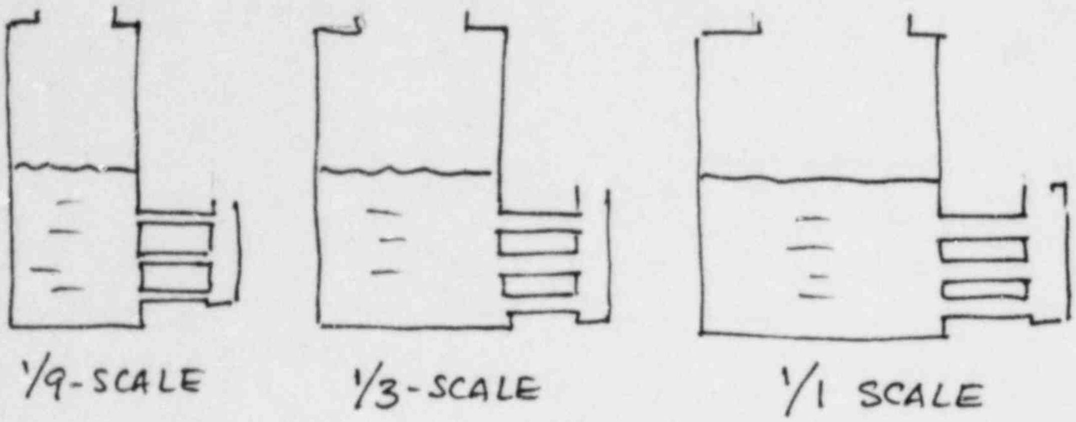


Figure 3B.3-4. Comparison of 238 Standard Plant and Test 5705-4 Drywell Pressure Histories

II. DISTORTED GEOMETRY TESTS.



- Flow areas scaled-down by scale factor
- Flow-wise dimensions full scale

Implicit hypothesis (if results are to be invoked):

Pool swell not significantly affected by scaledown of areas.

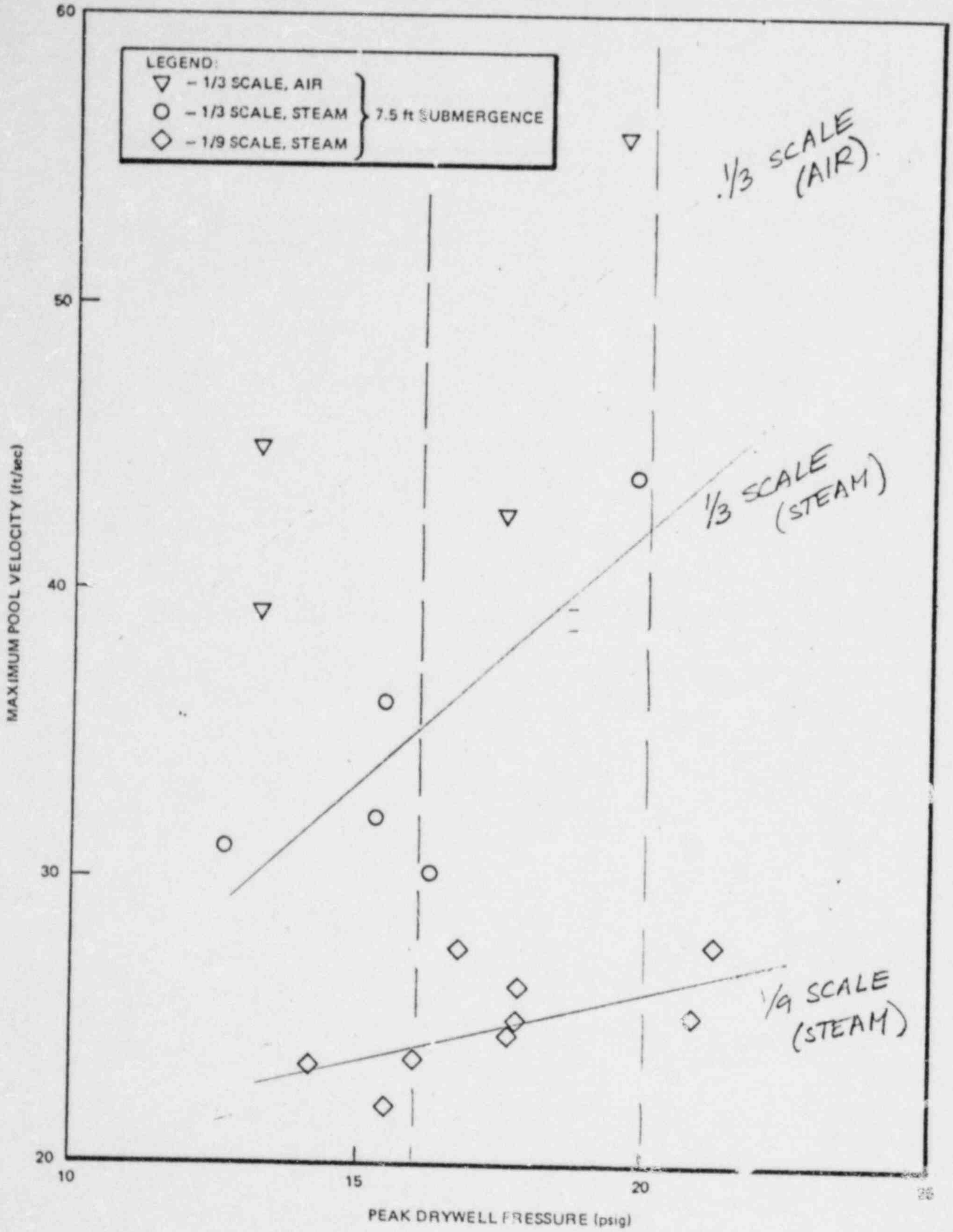

LEGEND:
▽ – 1/3 SCALE, AIR
○ – 1/3 SCALE, STEAM
◇ – 1/9 SCALE, STEAM
7.5 ft SUBMERGENCE
1/3 SCALE (AIR)
1/3 SCALE (STEAM)
1/9 SCALE (STEAM)
MAXIMUM POOL VELOCITY (ft/sec)
60
50
40
30
20
10
15
20
25
PEAK DRYWELL PRESSURE (psig)

Figure 1

MAXIMUM VELOCITIES FROM DISTORTED-GEOMETRY STEAM TESTS. (FT/S).

	@ 16 psig	@ 20 psig.
1/9 SCALE	23 ± 2	26 ± 2
1/3 SCALE	35^{+3}_{-5}	42^{+3}_{-5}
1/1 SCALE	?	?

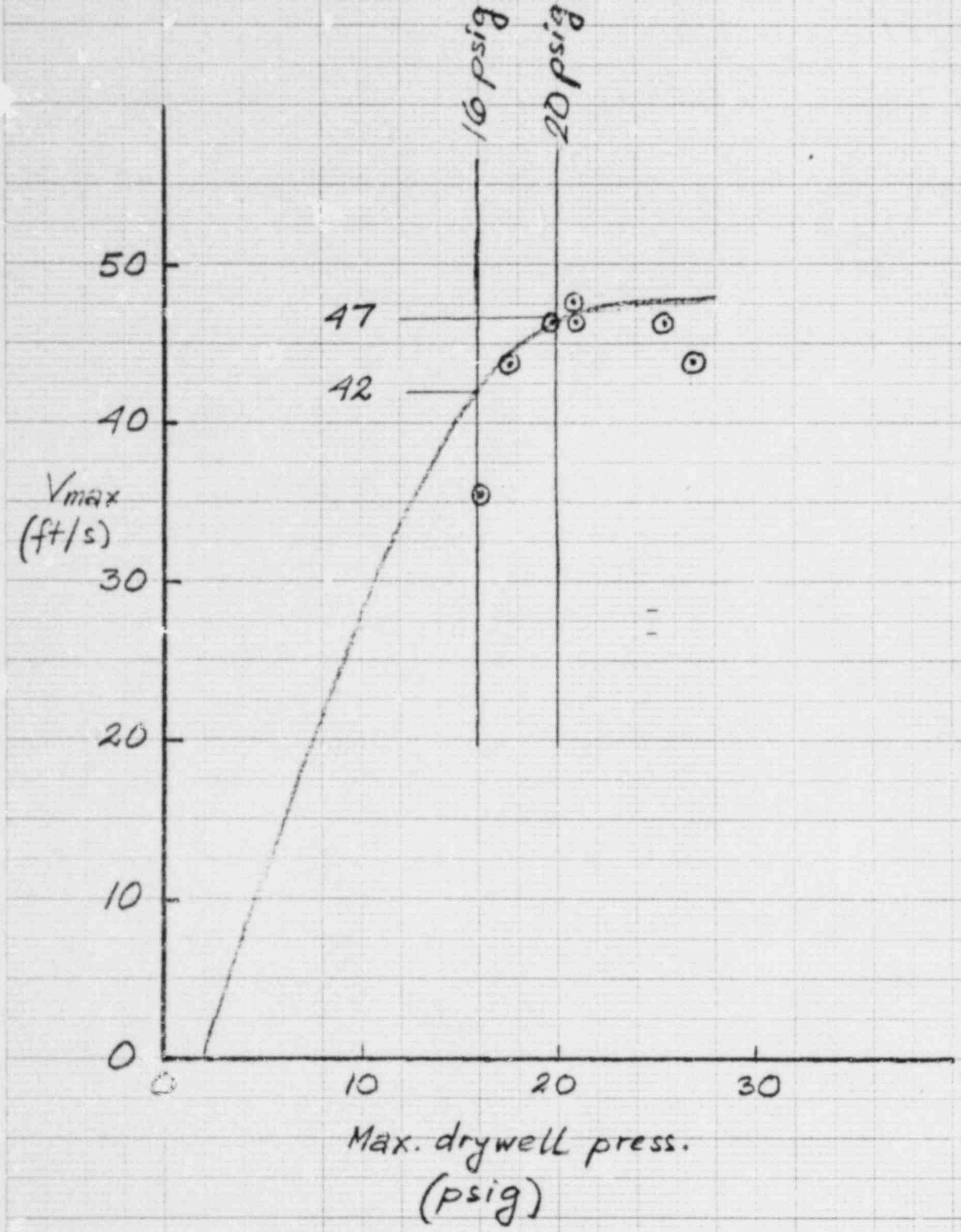
III. MODIFIED FROUDE SCALED (1/3-SCALE) TESTS.

"MFS" ≡ imperfect Moody scaling

$$\left.\begin{array}{l}\Delta p \propto L \\ V \propto \sqrt{L}\end{array}\right\} \text{retained}$$

$$\left.\begin{array}{l}h_0 \dot{m} \propto L^{7/2} \\ p \propto L \\ \text{geometric similarity}\end{array}\right\} \text{relaxed}$$

• ABSOLUTE PRESSURE TOO HIGH (BY 1.5) • NO ORIFICES IN VENTS	0-10% CONS.
• VENTS TOO LONG (BY 1.5)	?
• VENT SEPARATIONS TOO LARGE (BY 1.5).	NONCONSERVATIVE, POSSIBLY SIGNIFICANTLY
• STEAM	—



Mk III pool swell velocity predicted from
1/3-scale tests based on "Modified Froude scaling"

SUMMARY

SOURCE	V_{max} (FT/S)		COMMENTS
"FULL-SCALE" TEST	38		DRYWELL PRESS. TOO LOW; 2 VENTS ONLY.
	BASED ON 16 psig MAX. DRYWELL	BASED ON 20 psig MAX. DRYWELL	
DISTORTED-GEOM. TESTS:			
1/9-SCALE	23 ± 2	26 ± 2	EXTRAPOLATION TO 1/1 SCALE?
1/3-SCALE	35 ±	42 ±	
"MODIFIED FROUDE SCALED" FROM 1/3-SCALE	42	47	UNCERTAINTIES IN "SCALING"

CURRENT STATUS

OF

MARK III POOL DYNAMIC LOADS

MEL B. FIELDS
CONTAINMENT SYSTEMS BRANCH
NUCLEAR REGULATORY COMMISSION

MARK III OL REVIEW
MILESTONES

- o 5/80 - NRC QUESTIONS ON SRV MONTE CARLO APPROACH TO PHASING SENT TO GE
- o 11/80 - NRC QUESTIONS ON LOCA-RELATED POOL DYNAMIC LOADS SENT TO GE
- o 11/80 - AMENDMENT 1 TO GESSAR-II CONTAINING RESPONSES TO NRC QUESTIONS ON SRV PHASING
- o 5/81 - NRC QUESTIONS ON SRV LOAD REDUCTION FACTOR SENT TO GE
- o 6/81 - AMENDMENT 2 TO GESSAR-II CONTAINING RESPONSES TO NRC QUESTIONS ON LOCA-RELATED POOL DYNAMIC LOADS
- o 9/81 - NRC POSITIONS ON LOCA-RELATED POOL DYNAMIC LOADS SENT TO GE
- o 11/81 - ISSUE NUREG ON SRV POOL DYNAMIC LOADS
- o 12/81 - ISSUE DRAFT SER ON LOCA-RELATED POOL DYNAMIC LOADS
- o 2/82 - ISSUE NUREG ON LOCA-RELATED POOL DYNAMIC LOADS

NUREG ON MARK III LOCA-RELATED
POOL DYNAMIC LOAD CRITERIA

WILL INCLUDE:

- o DESCRIPTION OF THE MARK III LOCA-RELATED HYDRODYNAMIC PHENOMENA
- o DESIGN LOAD SPECIFICATION FOR EACH PHENOMENA
- o EVALUATION OF EACH DESIGN LOAD SPECIFICATION
- o ALTERNATIVE DESIGN LOAD SPECIFICATIONS (IF NECESSARY)

REVIEW APPROACH

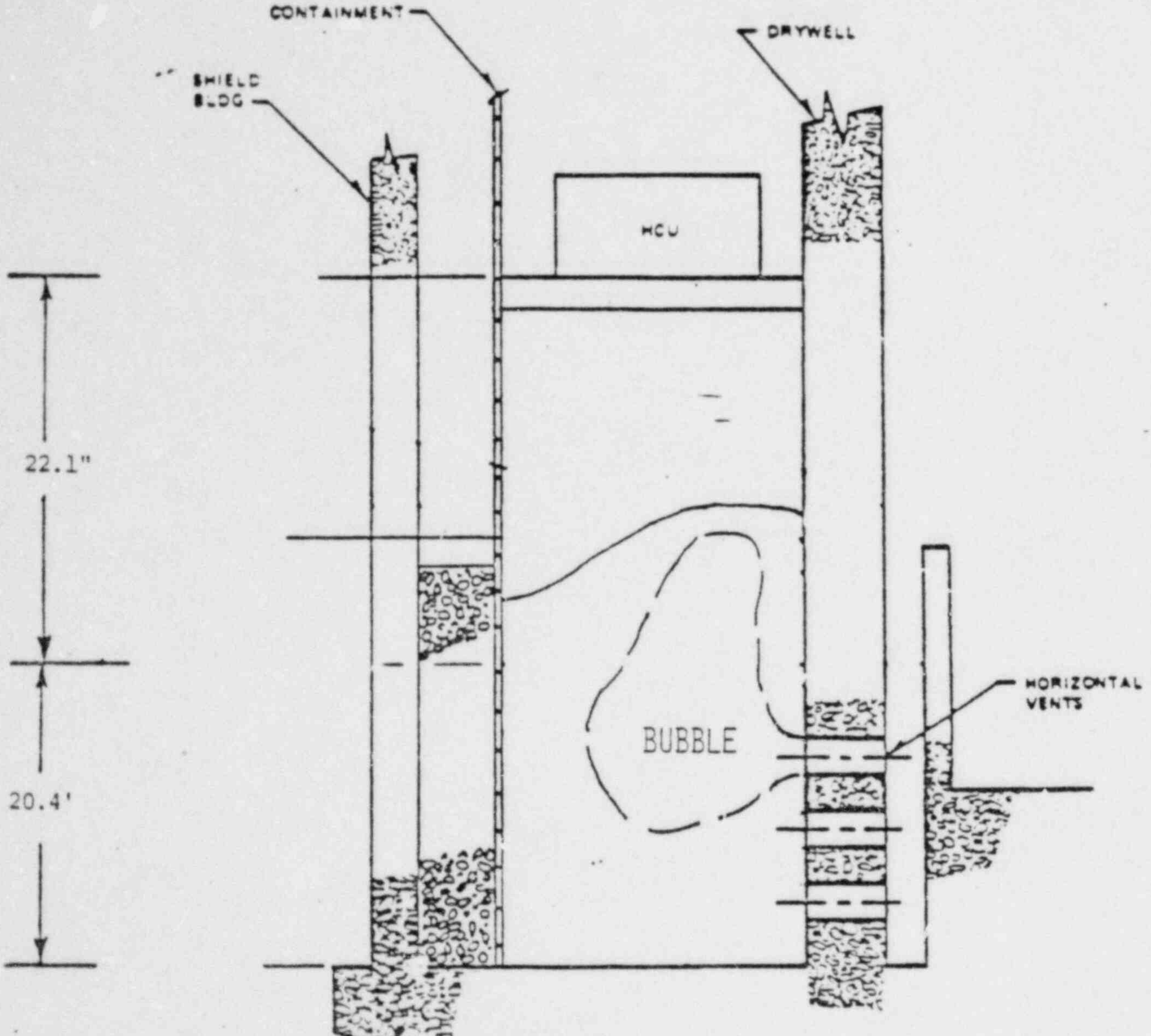
- USE GESSAR-II STANDARD 238 NUCLEAR ISLAND AS MODEL
- POOL DYNAMIC DESIGN LOAD DEFINITIONS ARE CONTAINED IN APPENDIX 3B OF GESSAR-II
- THESE LOAD DEFINITIONS ARE APPLICABLE TO ALL MARK III PLANTS

MARK III

POOL SWELL LOADS

MARK III

POOL SWELL LOADS



MARK III

POOL SWELL LOADS

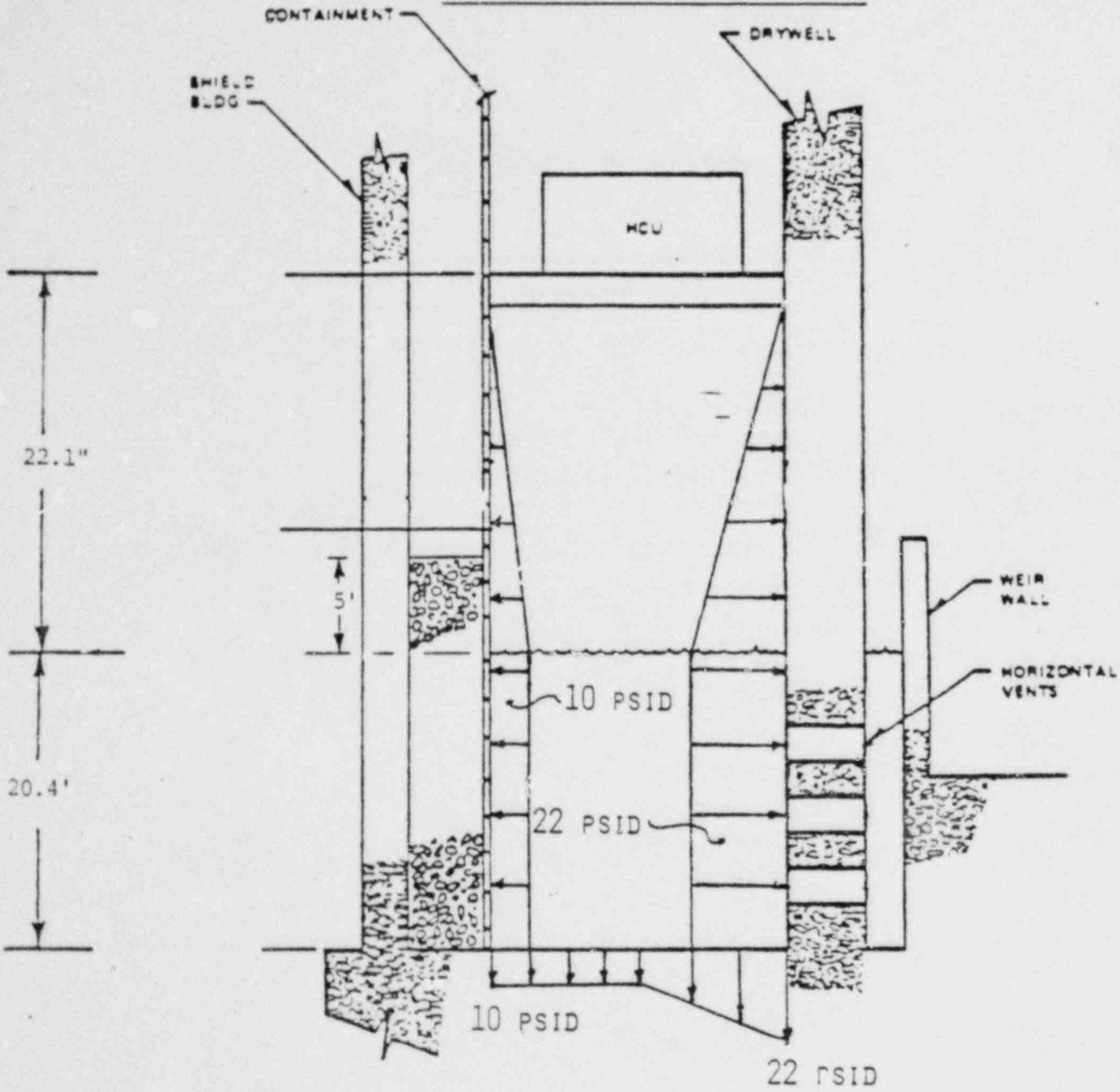
LOAD DEFINITION

	LOAD	VALUE
o	POOL BOUNDARY	DRYWELL 21.8 PSID CONTAINMENT = 10 PSID
o	WATER VELOCITY, - TYPICAL DRAG LOAD	40 FPS (CONSTANT) ~ 20 PSI
o	BREAKTHROUGH HEIGHT	18 FT
o	FROTH VELOCITY - TYPICAL DRAG LOAD	50 FPS ~ 10 PSI

MARK III

POOL SWELL LOADS

BUBBLE PRESSURE ON BOUNDARY



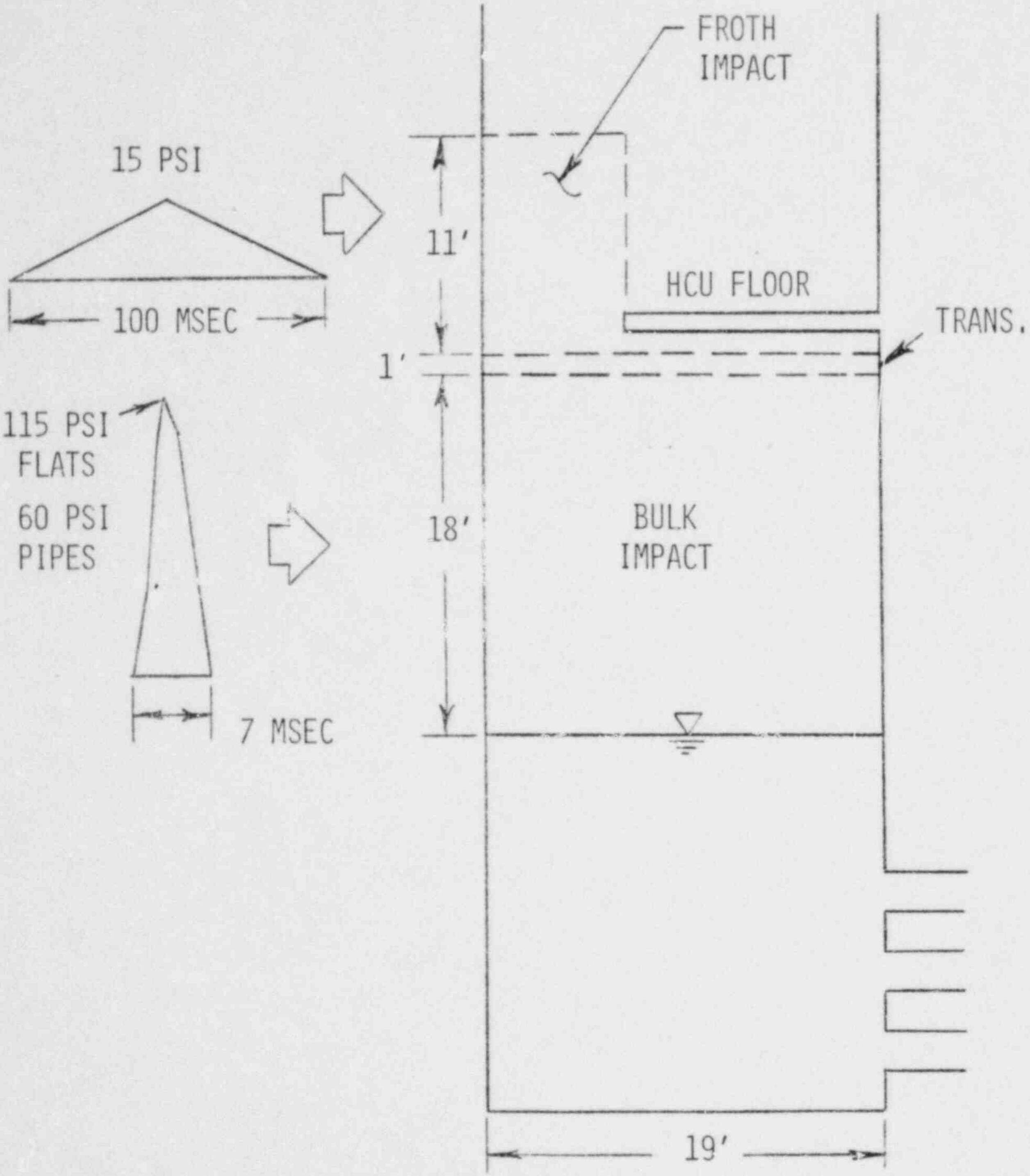
LICENSING ISSUES

POOL SWELL VELOCITY

- o CURRENT GE SPECIFICATION IS 40 FT/SEC
- o STAFF'S JUDGEMENT IS THAT 60 FT/SEC IS A CONSERVATIVE VALUE
- o SCALING RELATIONS ARE BEING PURSUED BY GE AND THE STAFF TO RESOLVE DIFFERENCES

"CONTAINS GENERAL ELECTRIC COMPANY PROPRIETARY INFORMATION"

GESSAR II IMPACT SPECIFICATIONS



LICENSING ISSUES

FROTH DRAG ON GRATINGS AT THE HCU FLOOR

- GE SPECIFICATIONS IS 11 PSID
- LOAD TO BE APPLIED TO TOTAL AREA OF GRATING
- GRAND GULF APPLIED LOAD TO SOLID AREA OF GRATING
- WITHOUT MODIFICATIONS, HCU FLOOR GRATINGS AT GRAND GULF CAN WITHSTAND 3.5 PSID WHEN LOAD IS APPLIED TO TOTAL AREA
- STAFF AND GRAND GULF APPLICANT CURRENTLY PURSUING METHODS OF RESOLVING THIS PROBLEM

MARK III

POOL SWELL IMPACT LOADS

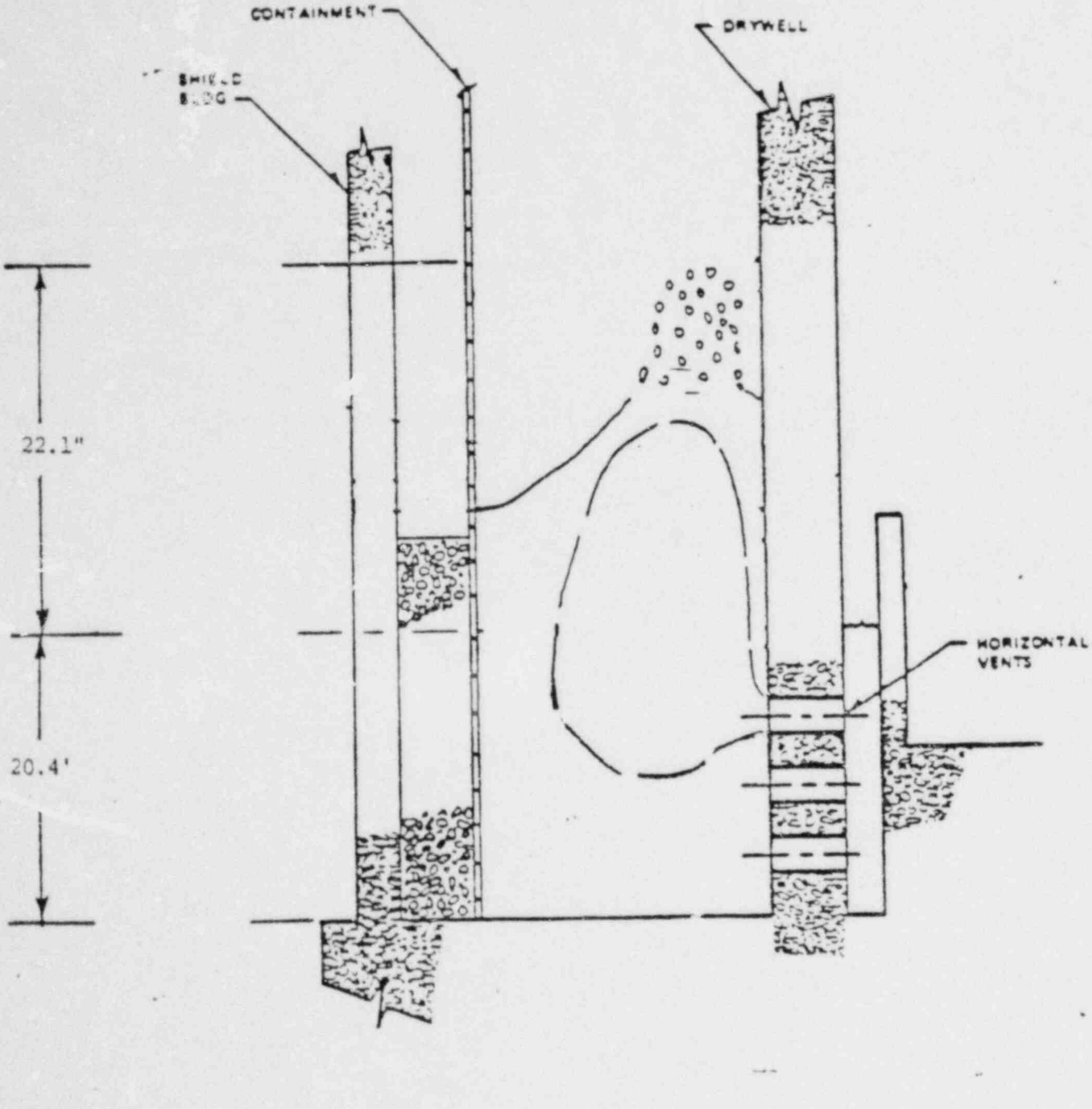
LOAD DESCRIPTION

- SEQUENCE OF EVENTS
  - WATER LIGAMENT IMPACTS COMPONENTS
  - THEN WATER DRAG OCCURS
  - FROTH IS FORMED AND IMPACTS COMPONENTS
  - THEN FROTH DRAG OCCURS
- WATER IMPACT AND DRAG OCCURS FOR STRUCTURES ≤18 FT ABOVE THE INITIAL POOL SURFACE
- FROTH IMPACT AND DRAG OCCURS FOR STRUCTURES ≥19 FT ABOVE THE INITIAL POOL SURFACE
- FOR STRUCTURES BETWEEN 18 AND 19 FEET TRANSITION IMPACT LOAD CRITERIA ARE APPLIED

MARK III

POOL SWELL IMPACT LOADS

POOL SWELL IMPACT AND DRAG



MARK III

LOAD DEFINITION

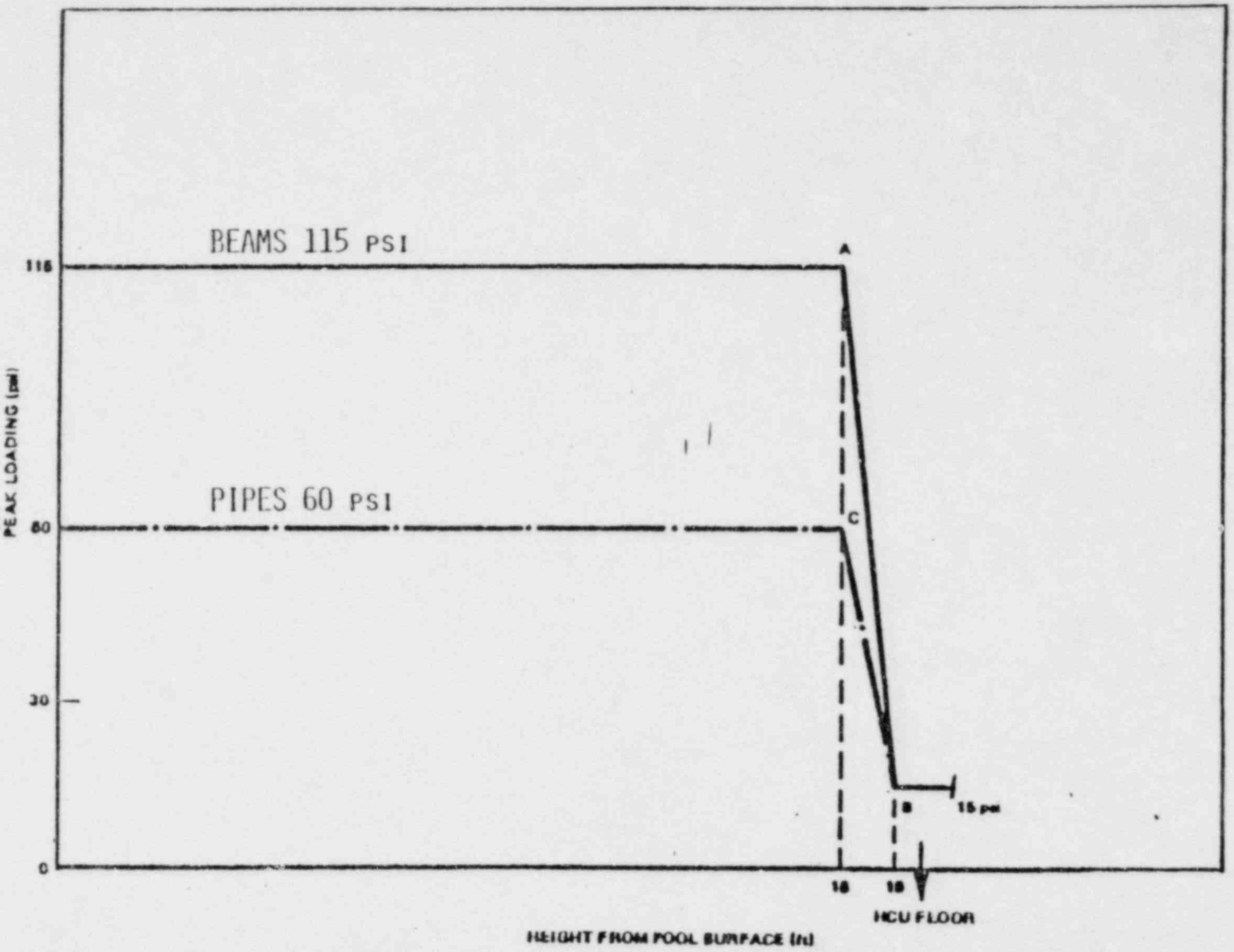
POOL SWELL IMPACT LOADS

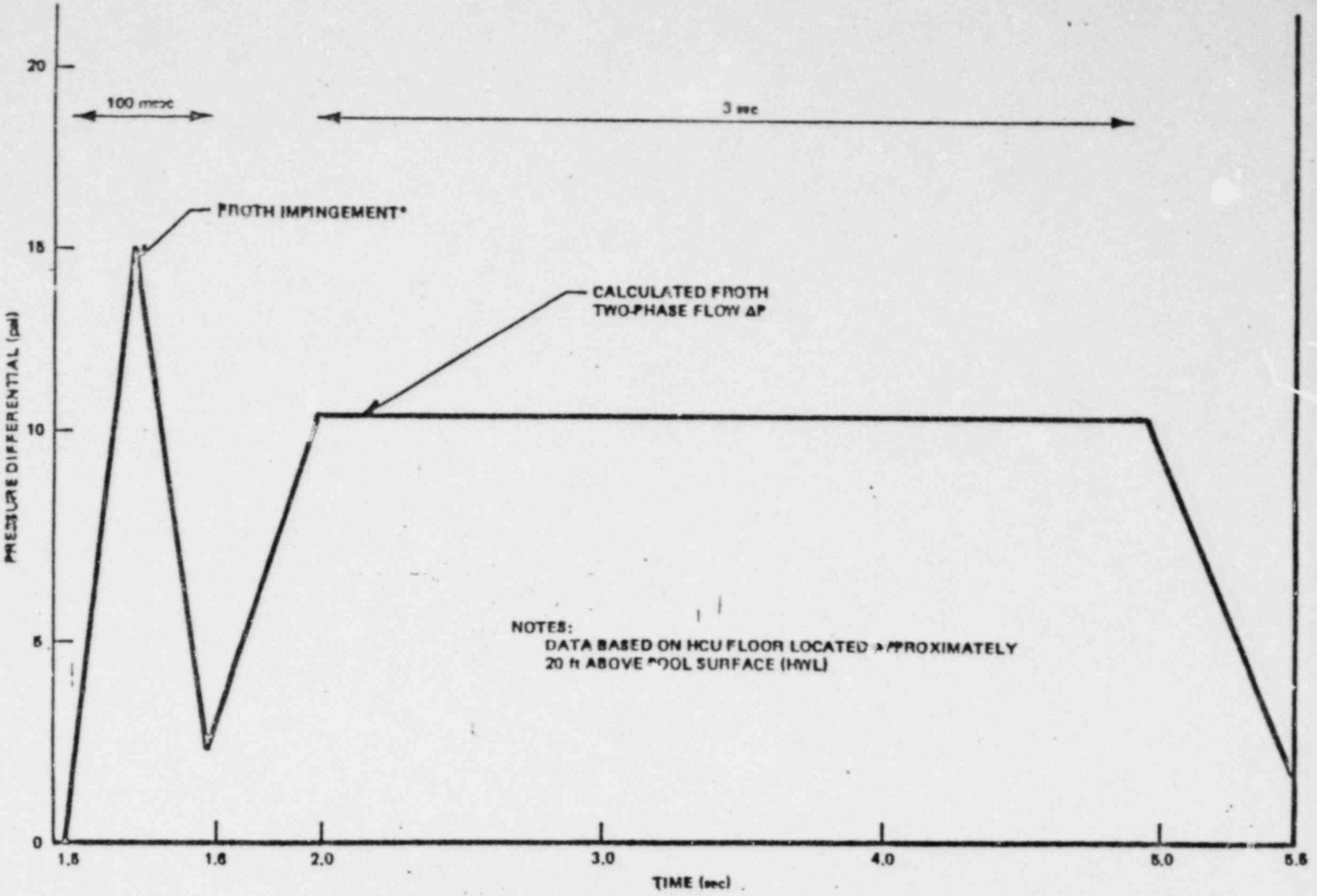
LOADS	VALUE
o WATER IMPACT ON BEAMS	115 PSI
o WATER IMPACT ON PIPES	60 PSI
o WATER DRAG (BEAM)	22 PSI
o FROTH IMPACT	15 PSI
o FROTH DRAG (BEAM)	10 PSI

MARK III

POOL SWELL IMPACT LOADS

IMPACT LOADS ON PIPES AND BEAMS





Loads at HCU Floor Elevation Due to Pool-Swell
Froth Impact and Two-Phase Flow

LICENSING ISSUES

POOL SWELL IMPACT LOADS

- IMPACT LOADS ARE UNDER INVESTIGIATION BECAUSE:
    1) POOL VELOCITY OF 40 FT/SEC MAY NOT BE BOUNDING
    2) IMPACT DURATION MAY BE NONCONSERVATIVE

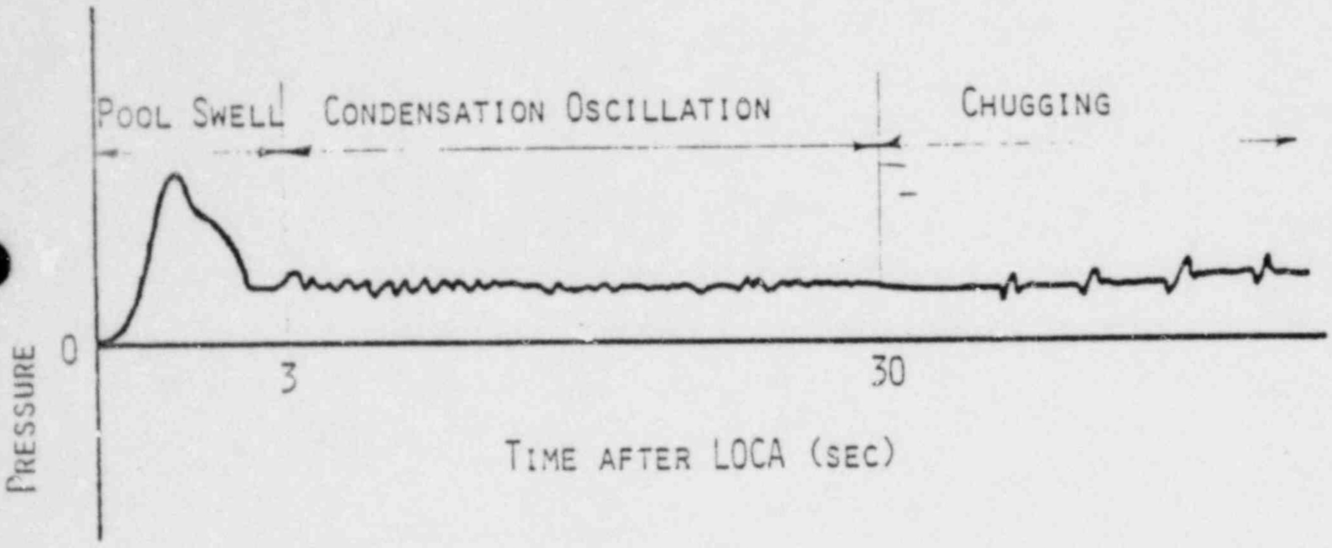
MARK III

CONDENSATION OSCILLATIONS

PHENOMENA DESCRIPTION

- OSCILLATING PRESSURE ON SUPPRESSION POOL WETTED BOUNDARIES
- CAUSED BY MOVEMENT OF CONDENSATION INTERFACE AT THE VENT EXIT
- INTERFACE MOVEMENTS CAUSE POOL MOVEMENTS
- LOAD DEFINITION GENERATED FROM THE 1/3 SCALE DATA

CONDENSATION OSCILLATION



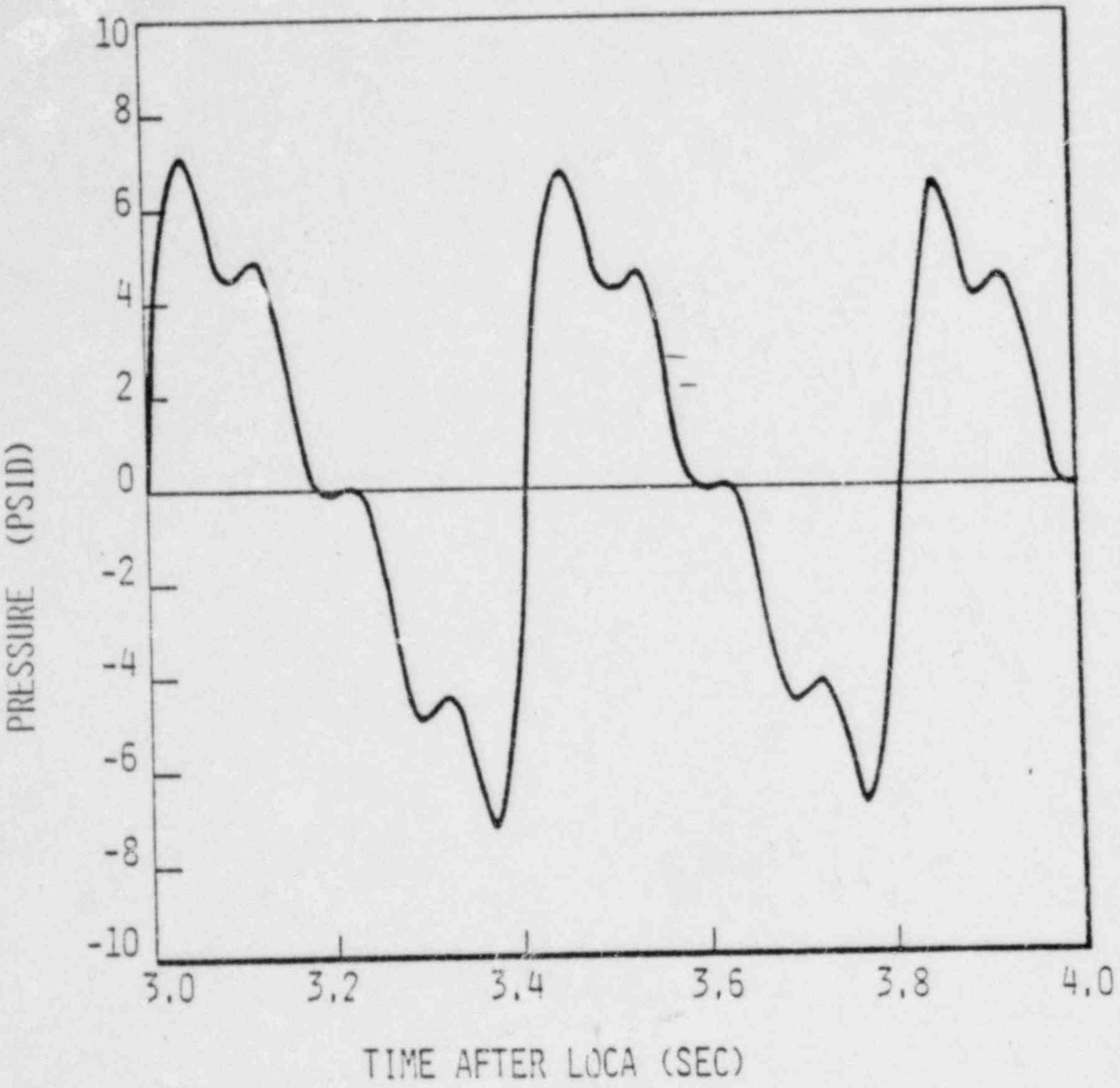
Typical Containment Wall

Pressure Time History

LOAD DEFINITION

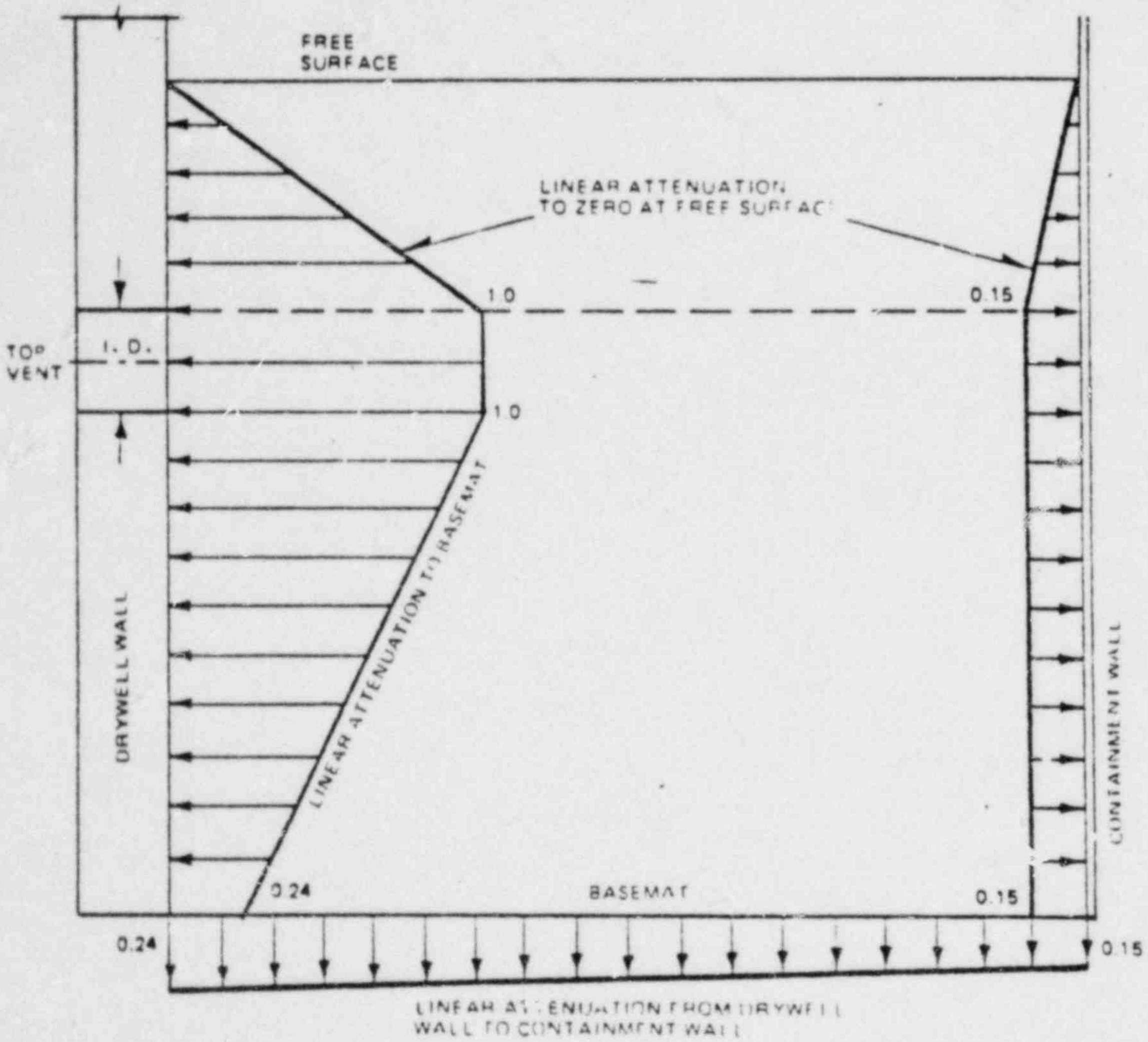
CO FORCING FUNCTION WAVE FORM

DRYWELL WALL



LOAD DEFINITION

CO PRESSURE DISTRIBUTION



CONDENSATION OSCILLATION

LICENSING ISSUES

- FREQUENCY SCALING ($F \propto 1/D_{VENT}$)
- EFFECT OF VARYING INITIAL PLANT PARAMETERS
- HIGH FREQUENCY DATA NOT BOUNDED BY CO LOAD SPECIFICATION

MARK III

CHUGGING LOADS

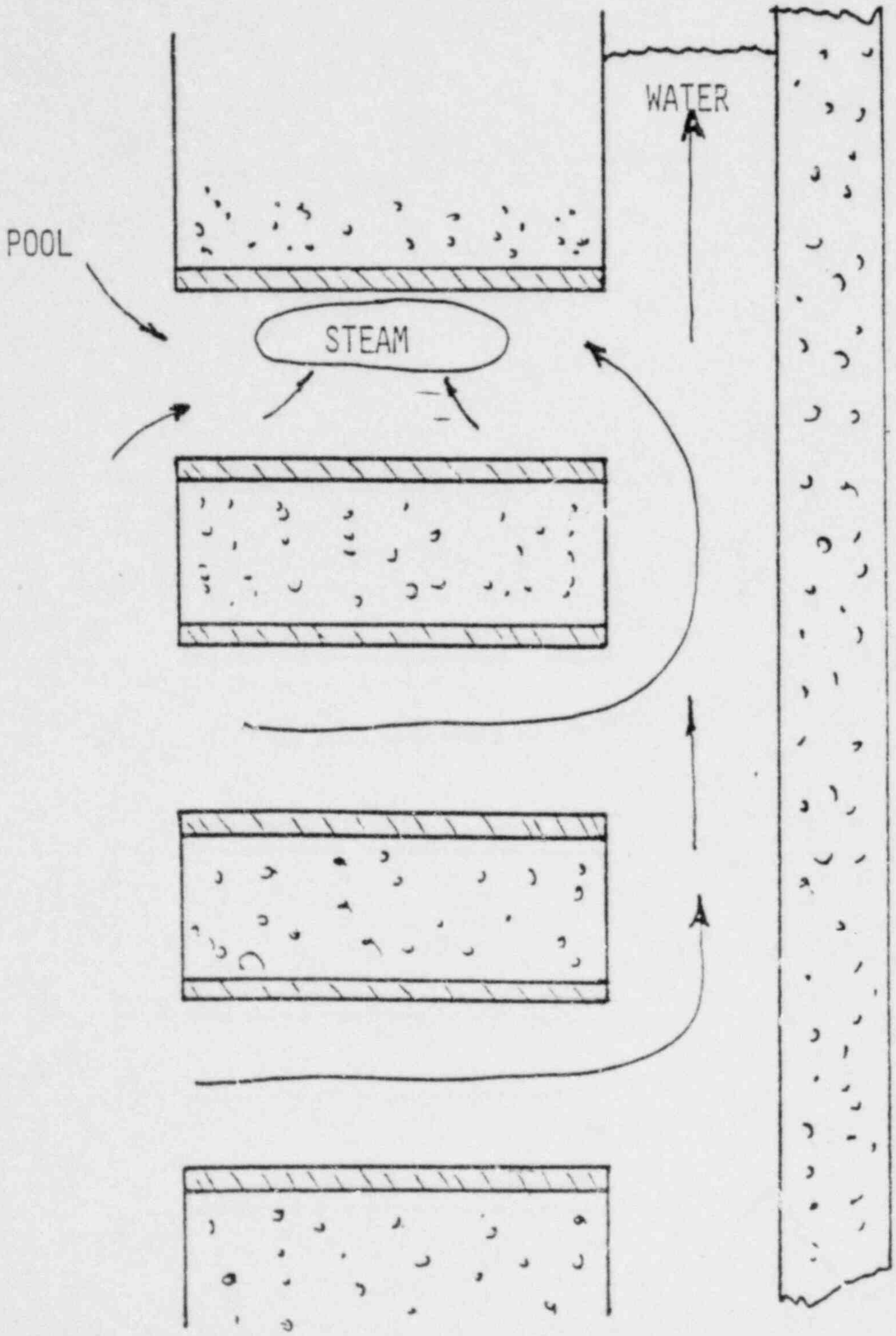
DESCRIPTION

- LOCA PHENOMENA
  - STEAM CONDENSATION
  - LOW MASS FLUX
- INTERMITTANT CLEARING OF TOP VENT
- PRODUCES DYNAMIC LOADS
  - TOP VENT
  - WEIR ANNULUS
  - POOL BOUNDARY

MARK III

CHUGGING LOADS

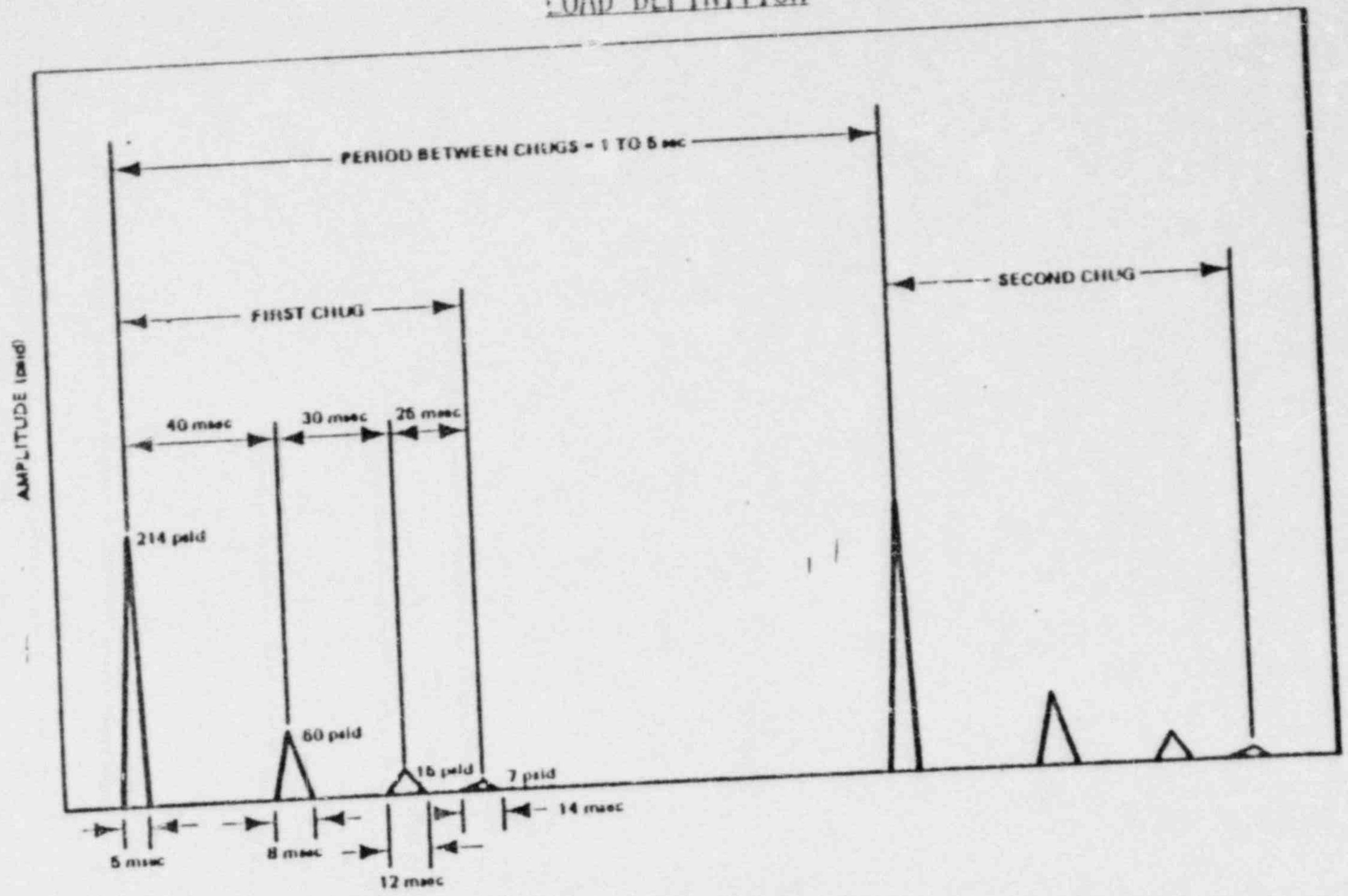
DESCRIPTION



MARK III

CHUGGING LOADS

LOAD DEFINITION

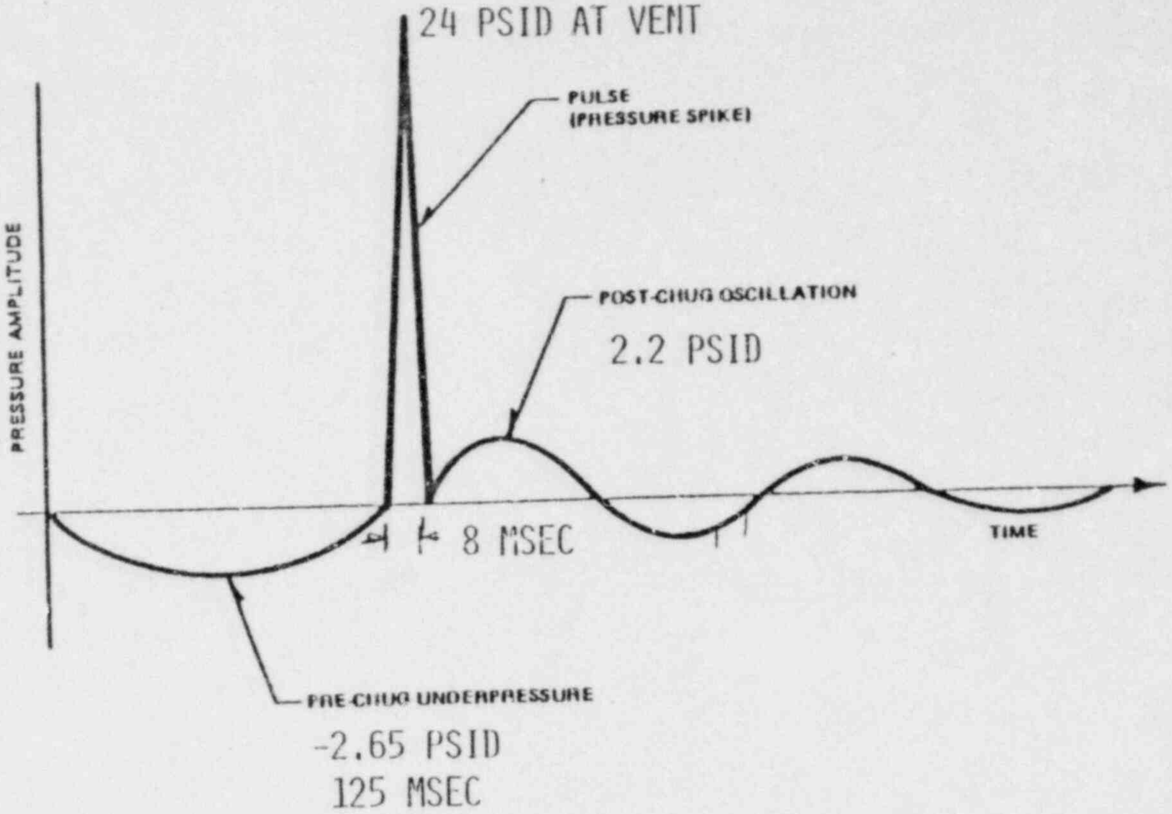


TOP VENT CHUGGING LOAD

MARK III

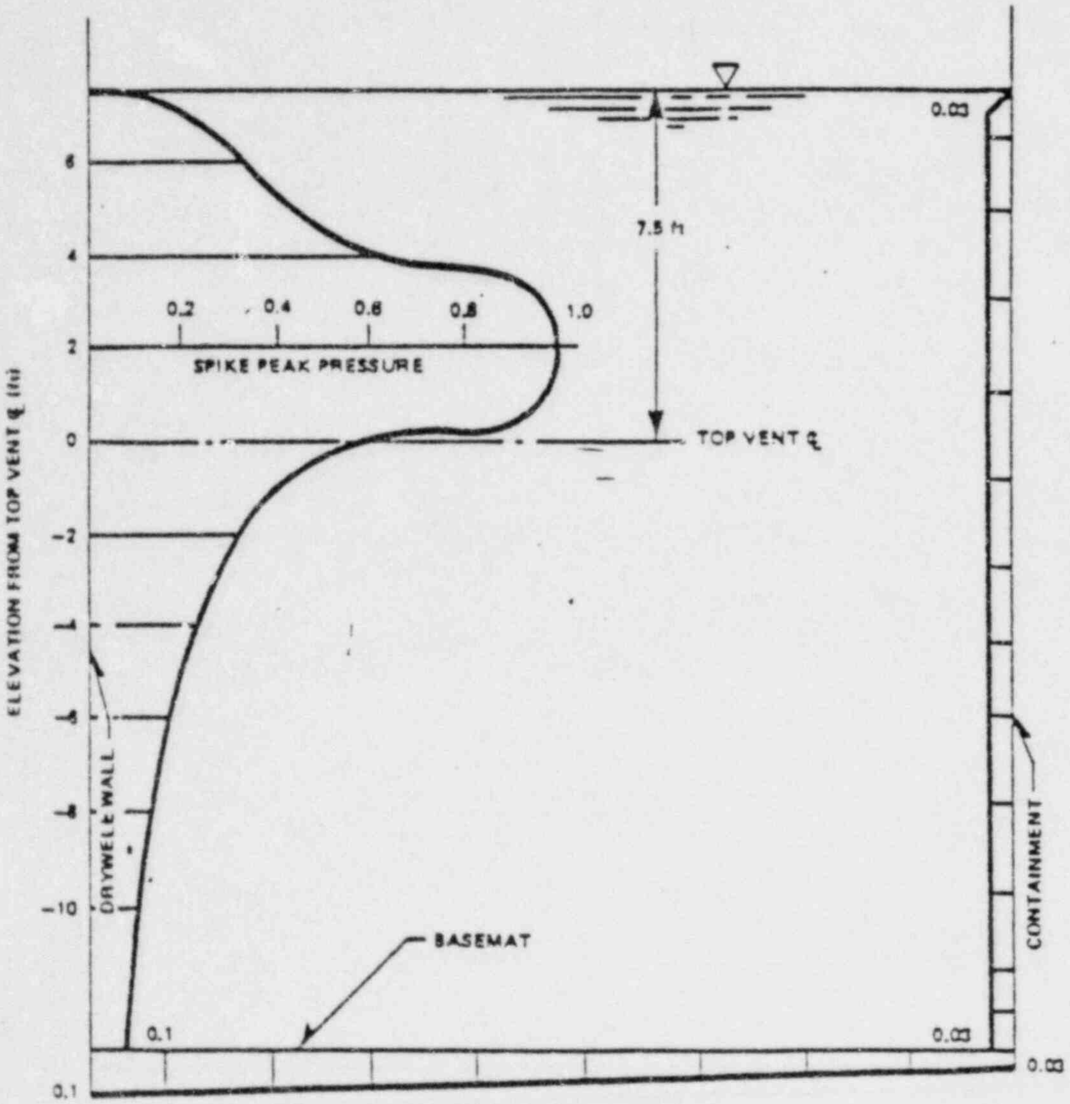
CHUGGING LOADS

LOAD DEFINITION



POOL BOUNDARY CHUGGING LOAD

MARK III
CHUGGING LOADS
LOAD DEFINITION



SUPPRESSION POOL CHUGGING SPIKE ATTENUATION

CHUGGING LOADS

LICENSING ISSUES

- EXPERIMENTAL WEIR WALL CHUG EXCEEDS DESIGN VALUE IN 30-40 Hz FREQUENCY RANGE
- SPACIAL DISTRIBUTION ON WETTED BOUNDARIES DURING THE CHUGGING PHASE NEEDS FURTHER JUSTIFICATION
- ASYMMETRIC CHUGGING LOAD NOT DEFINED
- CHUG SOURCE STRENGTH SELECTED NEEDS FURTHER JUSTIFICATION

MARK III

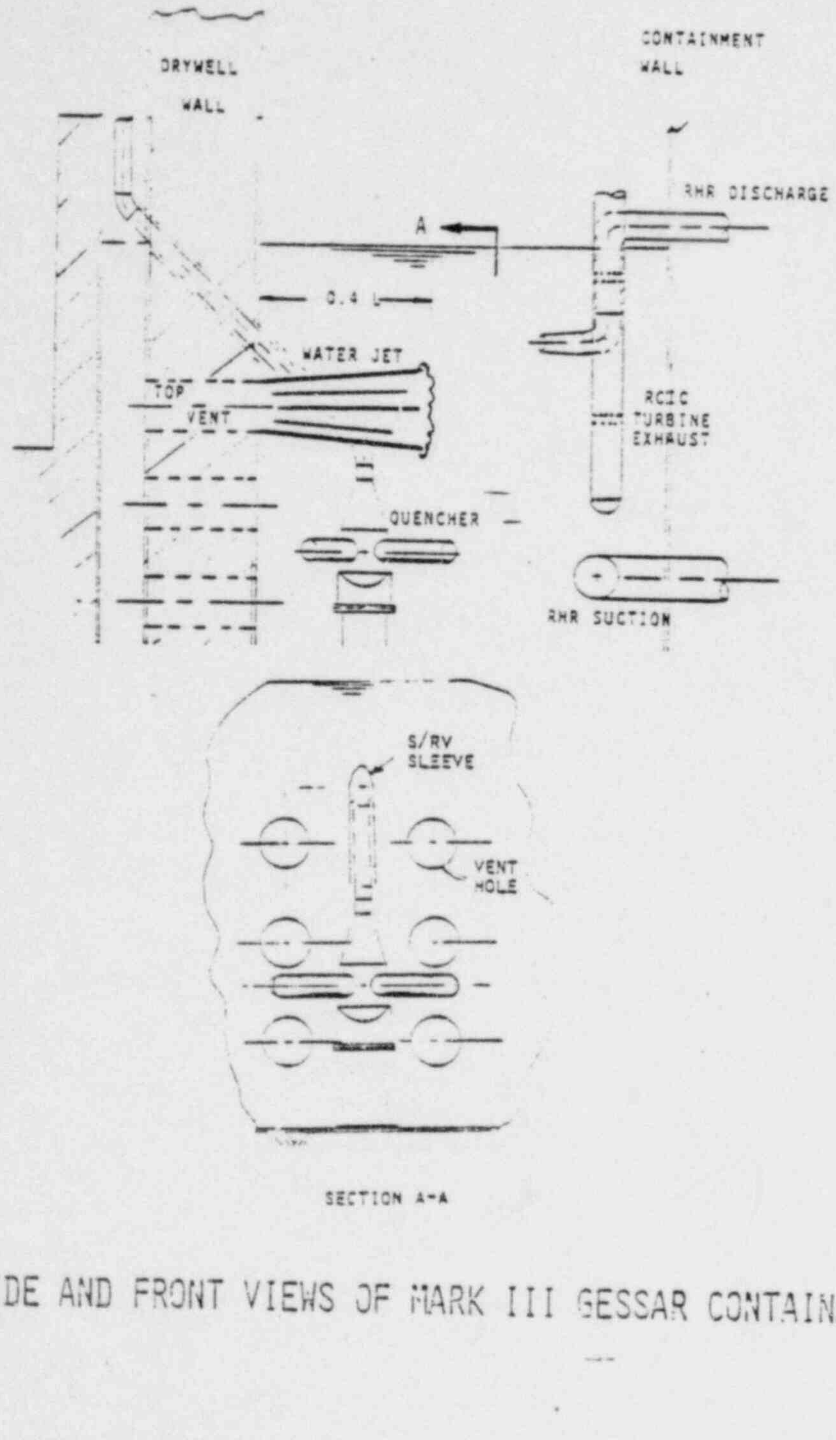
SUBMERGED STRUCTURE LOADS

- LOCA WATER JET
- LOCA AIR BUBBLE LOAD
- CONDENSATION OSCILLATION LOADS
- CHUGGING LOADS

MARK III

SUBMERGED STRUCTURE LOADS

LOCA WATER JET



SECTION A-A

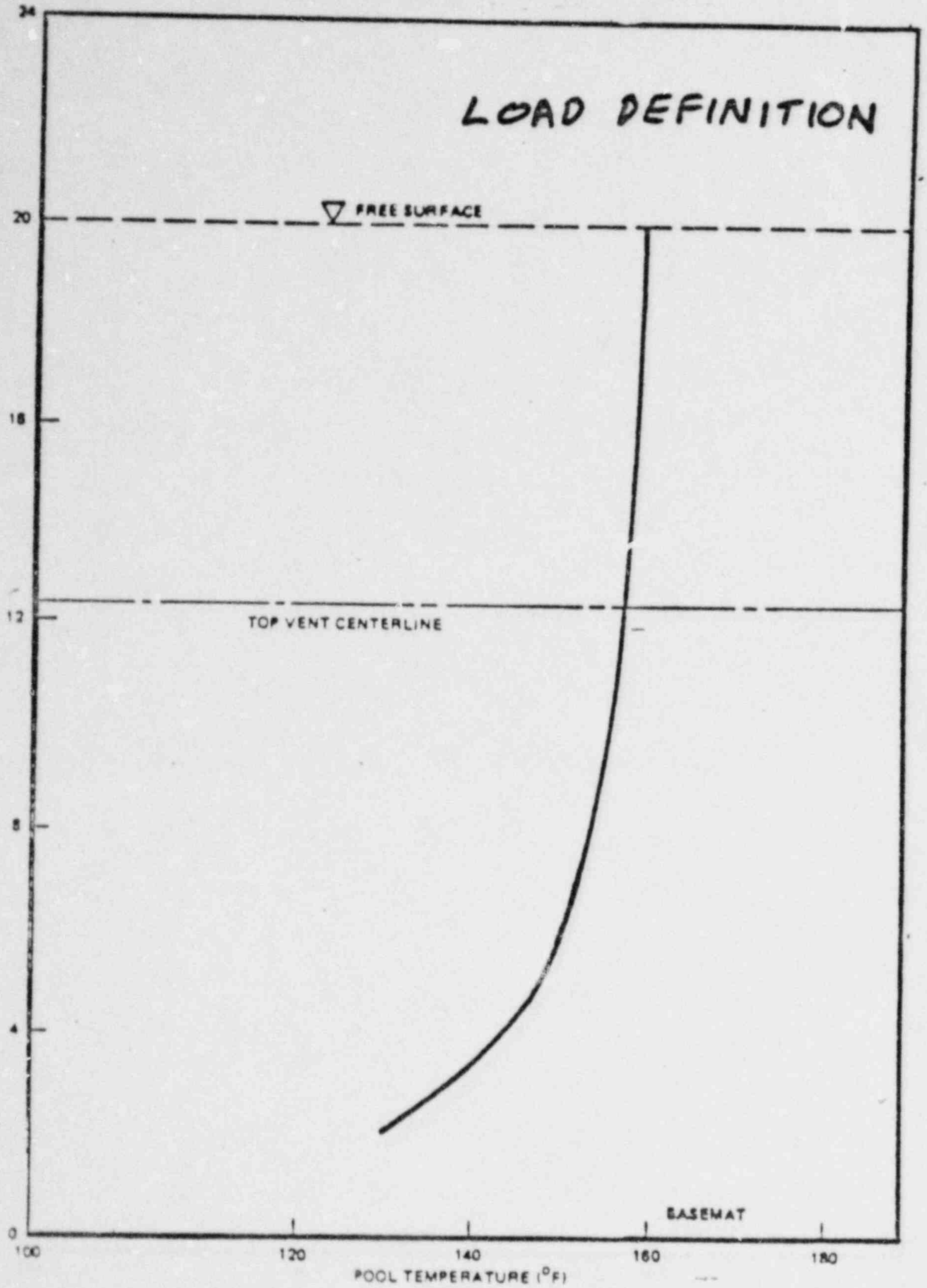
SIDE AND FRONT VIEWS OF MARK III GESSAR CONTAINMENT

POOL TEMPERATURE

LOAD DESCRIPTION

- NON-UNIFORM TEMPERATURE
  - IN SUPPRESSION POOL
  - DURING A LOCA
  - DUE TO UNEVEN HEATING
  - DUE TO BUOYANCY

LOAD DEFINITION



FLUID-STRUCTURE INTERACTION

DESCRIPTION

- ADDITIONAL PRESSURE COMPONENT IN A FLUID CONFINED IN AN ELASTIC CONTAINER, DUE TO MOTION OF THE CONTAINER

FLUID-STRUCTURE INTERACTION

LOAD DEFINITION

- GESSAR RIGID WALL LOADS ARE APPLIED TO MARK III CONTAINMENT
- A/E'S ACCOUNT FOR FLUID IN STRUCTURAL ANALYSIS

FLUID-STRUCTURE INTERACTION

LOAD BASIS

PSTF DATA BASE FROM THREE SCALED TESTS

- o FULL SCALE - CHUGGING LOADS
- o 1/3 AREA SCALE - CONDENSATION OSCILLATION LOADS
- o 1/9 AREA SCALE - MULTIVENT EFFECTS

THREE SCALED TESTS SEPARATELY ANALYZED FOR FSI (ALL SCALES USED SAME PSTF)

- o CONCLUSION FROM ANALYSES
  FSI WAS SHOWN TO BE A SMALL EFFECT ON MEASURED WALL LOADS

ACRS FLUID
DYNAMICS SUBCOMMITTEE
MEETING

MARK III
CONTAINMENT POOL
DYNAMIC LOADS

Kodank

MEETING OBJECTIVE

- DISCUSS RESOLUTION OF ISSUES FOR GENERIC MARK III POOL DYNAMIC LOADS.
- APPLICATION OF THESE ISSUES TO THE GRAND GULF NUCLEAR PLANT.

AGENDA

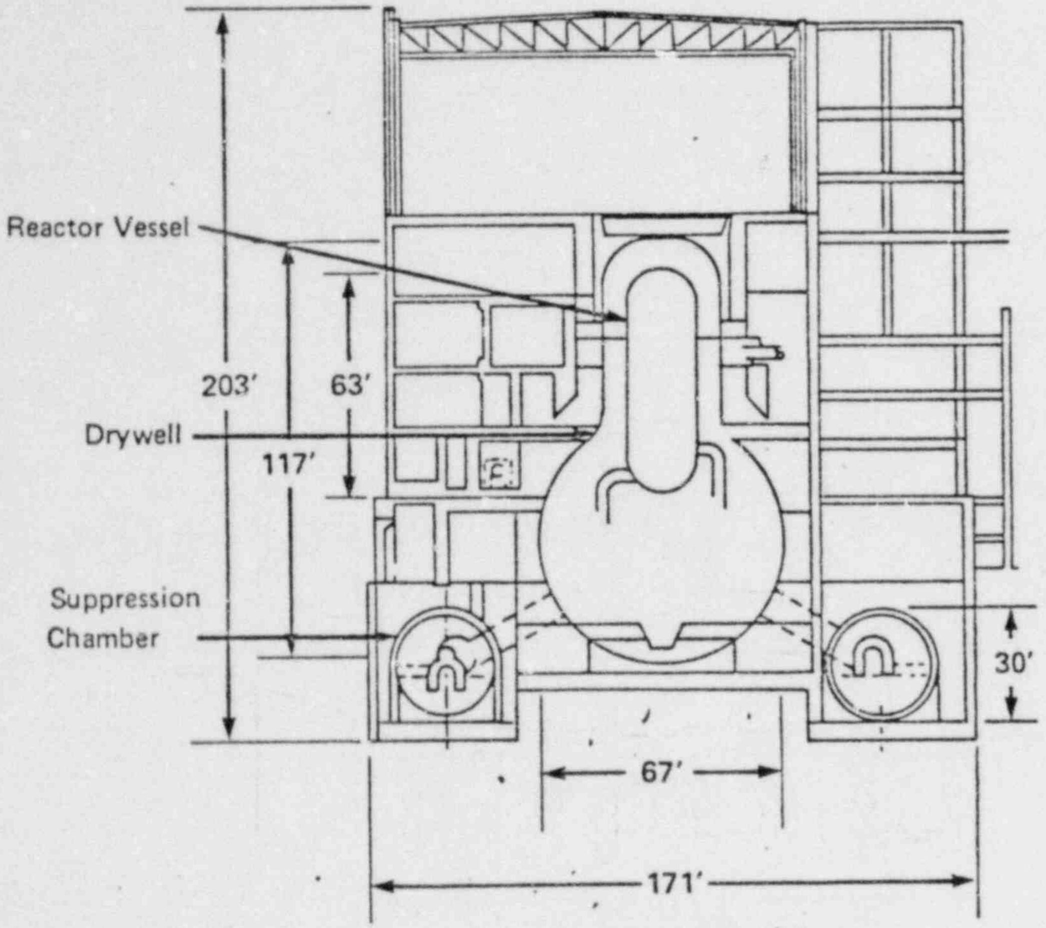
SEPTEMBER 24, 1981	TIME
I. INTRODUCTION - M. PLESSET, CHAIRMAN	8:30 A.M.
II. NRC INTRODUCTION	
A. BACKGROUND OF MARK III PROGRAM J. KUDRICK (NRC)	8:45 A.M.
B. CURRENT STATUS - M. FIELDS	9:45 A.M.
- BREAK -	
III. GENERAL ELECTRIC MARK III TEST FACILITY GE (PERSONNEL)	10:25 A.M.
A. OVERVIEW	
B. FULL SCALE TESTS	
C. 1/3 SCALE TESTS	
D. 1/9 SCALE TESTS	
E. DATA INTERPRETATION	
F. SUMMARY	
- LUNCH -	1:00-2:00 P.M.
IV. LOCA LOADS (BNL)	2:00 P.M.
A. POOL SWELL VELOCITY - A. SONIN	
B. IMPACT LOADS - G. MAISE	
C. CONDENSATION OSCILLATION (CO) LOADS - C. ECONOMOS	
D. CHUGGING LOADS - C. ECONOMOS	
V. RECESS	5:30 P.M.

SEPTEMBER 25, 1981	TIME
VI. RECONVENE - M. PLESSET, CHAIRMAN	8:30 A.M.
VII. SUBMERGED STRUCTURE LOADS (BNL - G. BIENKOWSKI	8:40 A.M.
A. JET LOADS	
B. AIR BUBBLE DRAG LOADS	
VIII. POOL THERMAL STRATIFICATION (BNL) - C. ECONOMUS	
IX. FLUID STRUCTURE INTERACTION EFFECTS (BNL) - C. ECONOMUS	
- BREAK -	10:30 A.M.
X. SAFETY RELIEF VALVE (SRV) LOADS	10:40 A.M.
A. OVERVIEW - T. SU (NRC)	
B. TRIPOWER MARK III INPLANT TESTS - T. SU	
C. MULTIPLE VALVE BUBBLE PHASING (BNL) - C. ECONOMUS	
- LUNCH -	12:30-1:30 P.M.
XI. MARK III CONTAINMENT MODIFICATIONS	1:30 P.M.
A. GENERAL PLANT DESIGN - M. FIELDS	
B. GRAND GULF DESIGN (MP&L)	
XII. GRAND GULF IN-PLANT SRV TEST PROGRAM (MP&L)	2:30 P.M.
XIII. SUMMARY OF MARK III PROGRAM (NRC)	3:00 P.M.
XIV. SUBCOMMITTEE DISCUSSION	3:30 P.M.
XV. ADJOURN	4:00 P.M.

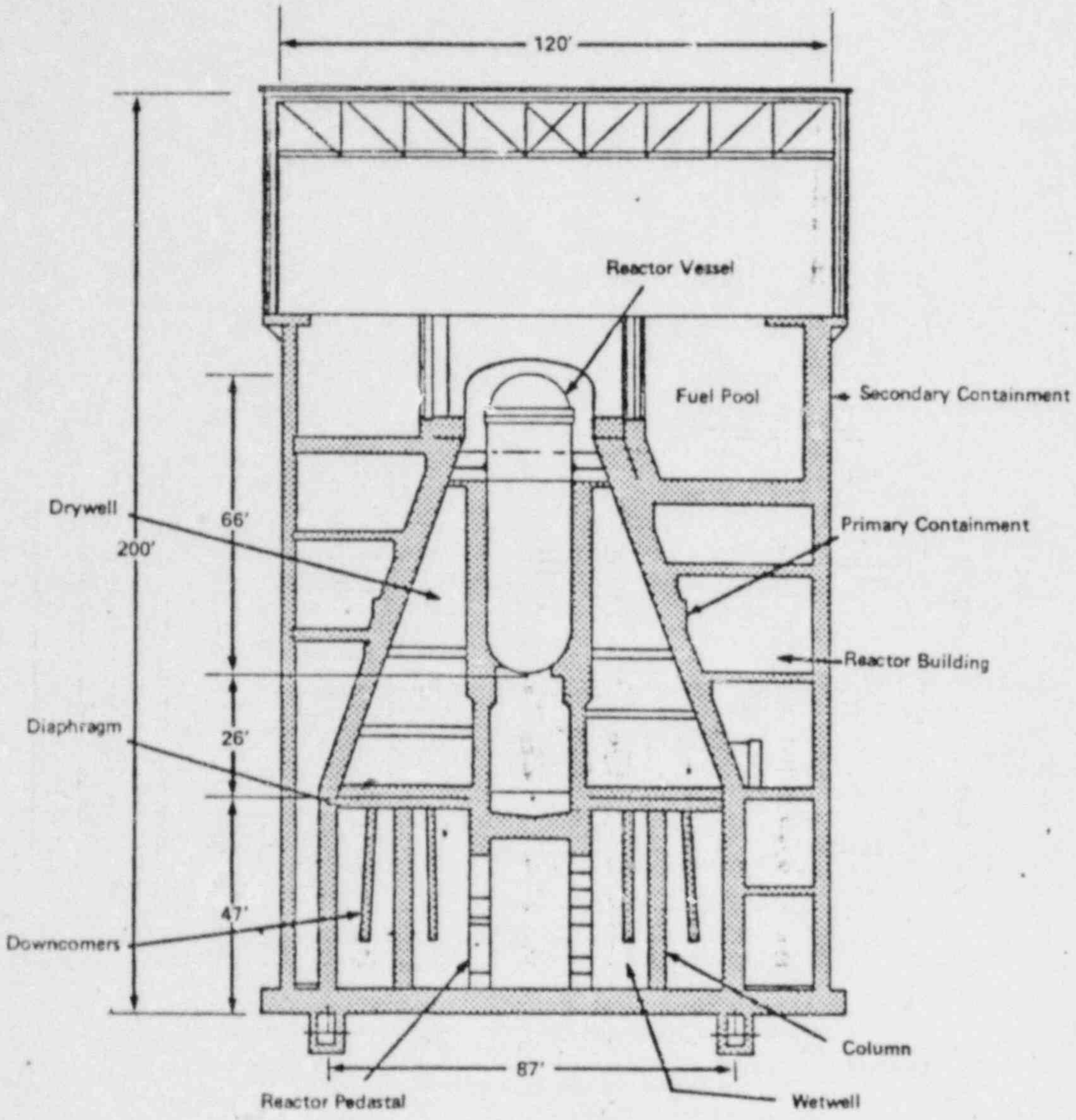
ACRS MEETING SUMMARY

DATE	DESCRIPTION
MAY 9, 1974	GRAND GULF FULL COMMITTEE
DECEMBER 29-30, 1975	MARK I, II, III POOL DYNAMIC LOADS
JANUARY 31, 1978	MARK III TEST PROGRAM
MAY 23, 1978	MARK II POOL DYNAMIC LOADS
NOVEMBER 29-30, 1978	MARK II POOL DYNAMIC LOADS
SEPTEMBER 13-14, 1979	MARK II POOL DYNAMIC LOADS
APRIL 29, 1981	MARK II POOL DYNAMIC LOADS
JULY 1981	MARK II POOL DYNAMIC LOADS

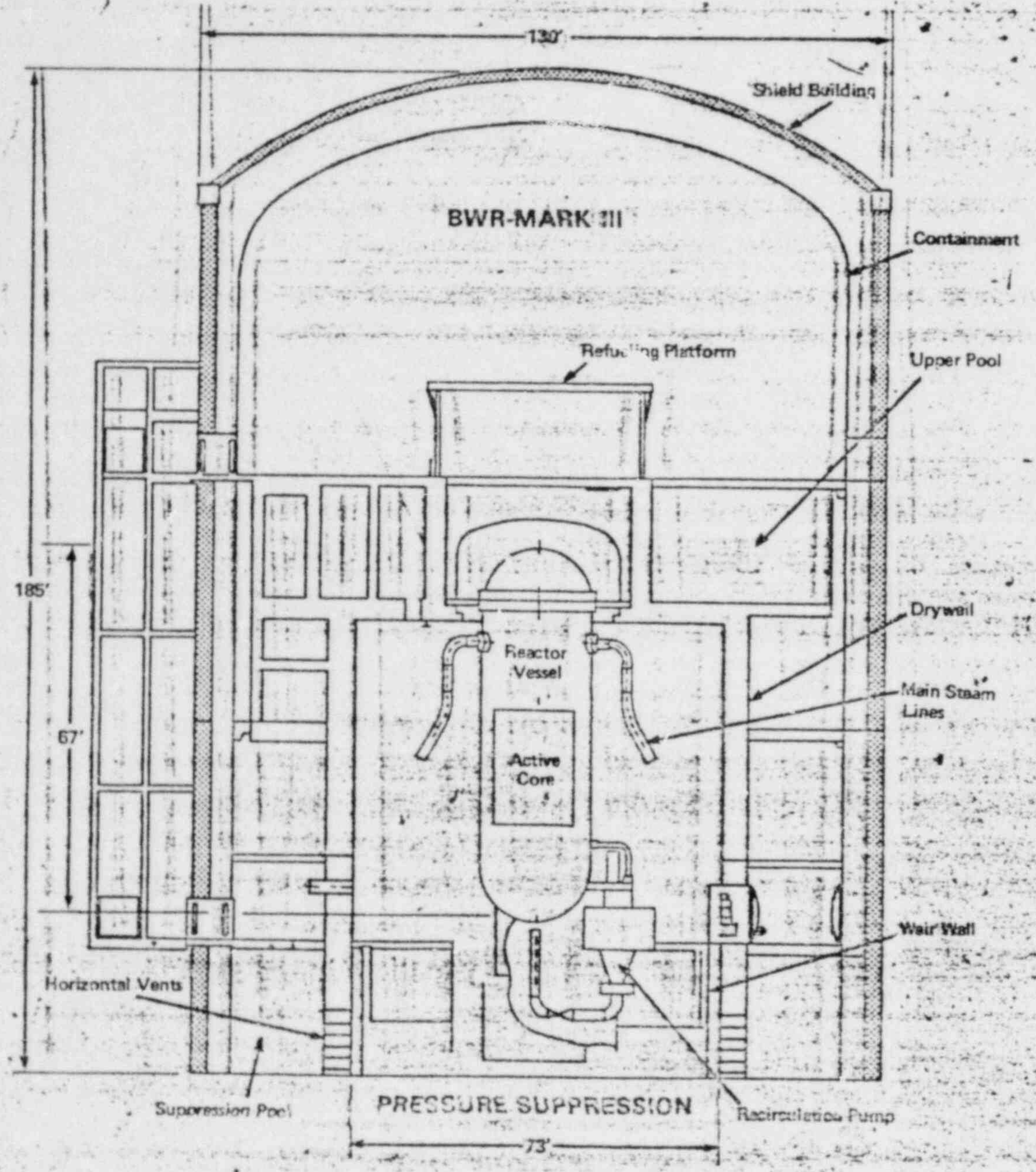
INVERTED LIGHT-BULB AND TORUS



BWR-MARK I
PRESSURE SUPPRESSION



BWR-MARK II
PRESSURE SUPPRESSION


130'
Shield Building
BWR-MARK III
Containment
Refueling Platform
Upper Pool
185'
Drywell
Reactor Vessel
Main Steam Lines
67'
Active Core
Weir Wall
Horizontal Vents
Suppression Pool
PRESSURE SUPPRESSION
Recirculation Pump
73'

COMPARISON OF BWR CONTAINMENT DESIGNS

DRYWELL	MARK I (BROWN'S FERRY)	MARK II (ZIMMER)	MARK III (GRAND GULF)
TYPE OF CONSTRUCTION	STEEL SHELL	STELL-LINED REINFORCED CONCRETE	REINFORCED CONCRETE
AIR VOLUME (FT^3)	159,000	184,000	280,000
DESIGN PRESSURE (PSI)	56	45	30

WETWELL	MARK I	MARK II	MARK III
TYPE OF CONSTRUCTION	STEEL SHELL	STEEL-LINED REINFORCED CONCRETE	STEEL-LINED REINFORCED CONCRETE
AIR VOLUME (FT^3)	119,000	103,000	1.4 X 10
POOL VOLUME (WATER)(FT^7)	85,000	100,000	157,000
DESIGN PRESSURE (PSI)	56	45	15
THERMAL POWER (MWT)	3,293	2430	025

DOMESTIC MARK III
PRESSURE SUPPRESSION PLANTS

PLANT NAME	LICENSING STATUS
GRAND GULF	OL SER 9/81
CLINTON 1, 2	OL SER 1/82
PERRY 1, 2	OL SER 5/82
RIVER BEND	OL SER 10/82
ALLENS CREEK	CP HEARING
BLACK FOX 1, 2	CP HEARING
SKAGIT 1, 2	POST CP
HARTSVILLE 1, 2, 3, 4	POST CP
PHIPPS BEND 1, 2	POST CP

NRC ORGANIZATIONAL APPROACH

POOL DYNAMIC LOADS

LOCA LOADS

MARK I - TAP A-7

MARK II - TAP A-8

MARK III - TAP B-10

SRV LOADS

MARK I

MARK II — TAP A-39

MARK III

NRC
ORGANIZATION

TAP B-10

TASK MANAGER - M. FIELDS

NRR BRANCHES INVOLVED

- CONTAINMENT SYSTEMS BRANCH
- STRUCTURAL ENGINEERING BRANCH
- MECHANICAL ENGINEERING BRANCH

CONSULTANTS INVOLVED

- BROOKHAVEN NATIONAL LABS.

BNL ORGANIZATION

LOCA-RELATED POOL DYNAMIC LOADS

C. ECONOMOS (BNL) - COORDINATOR

G. MAISE (BNL)

J. RANLET (BNL)

R. KAMM (MIT)

A. SONIN (MIT)

G. BIENKOWSKI (PRINCETON)

SRV RELATED POOL DYNAMIC LOADS

C. ECONOMOS (BNL) - COORDINATOR

J. RANLET (BNL)

C. C. LYN (BNL)

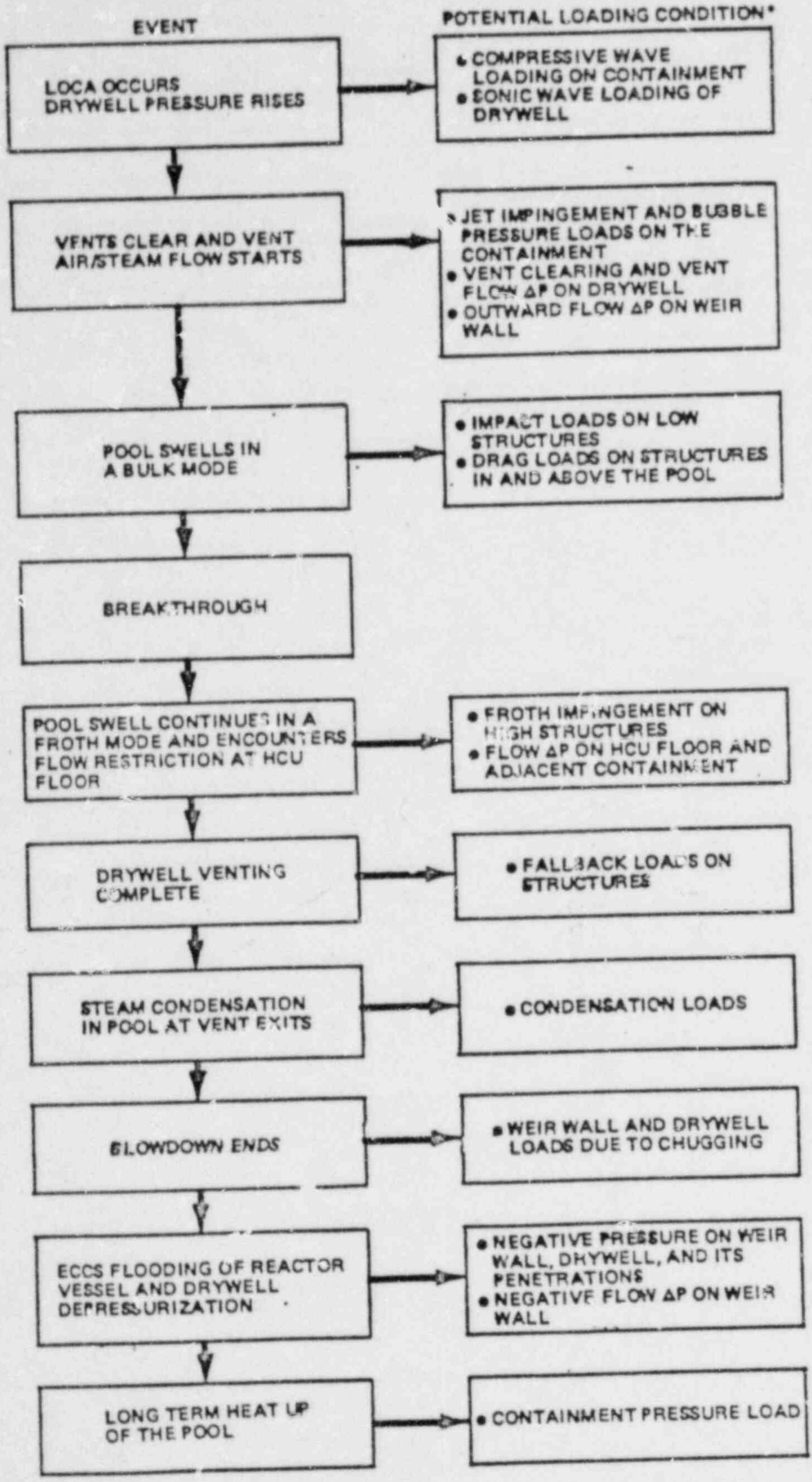
P. HUBER (MIT)

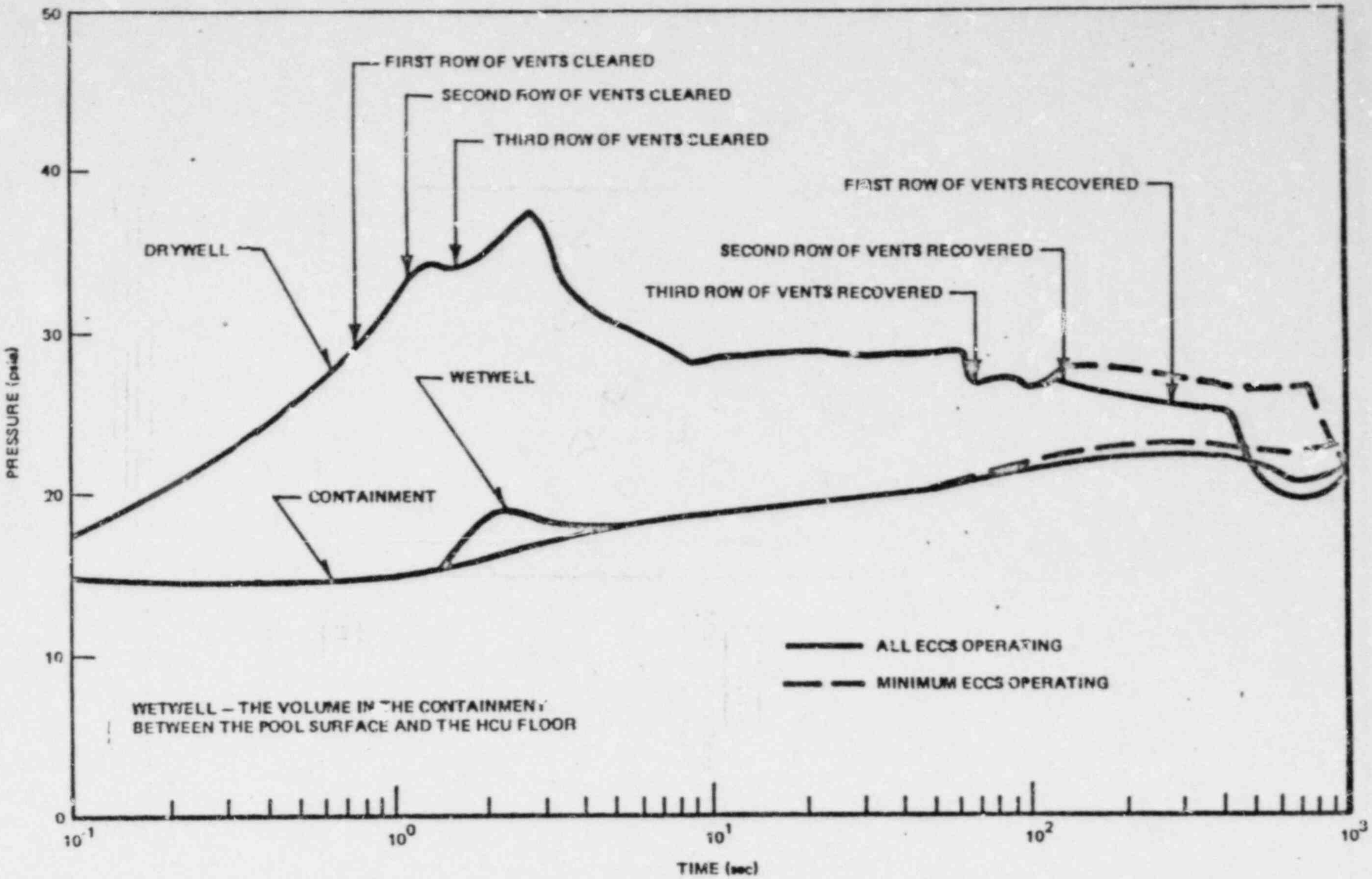
A. SONIN (MIT)

PROGRAM APPROACH

- GENERIC WHERE POSSIBLE
- DOCUMENTATION WITHIN GESSAR II
- GENERAL ELECTRIC THE FOCAL POINT RATHER THAN AN OWNERS GROUP
- LIMITED PLANT SPECIFIC AREAS

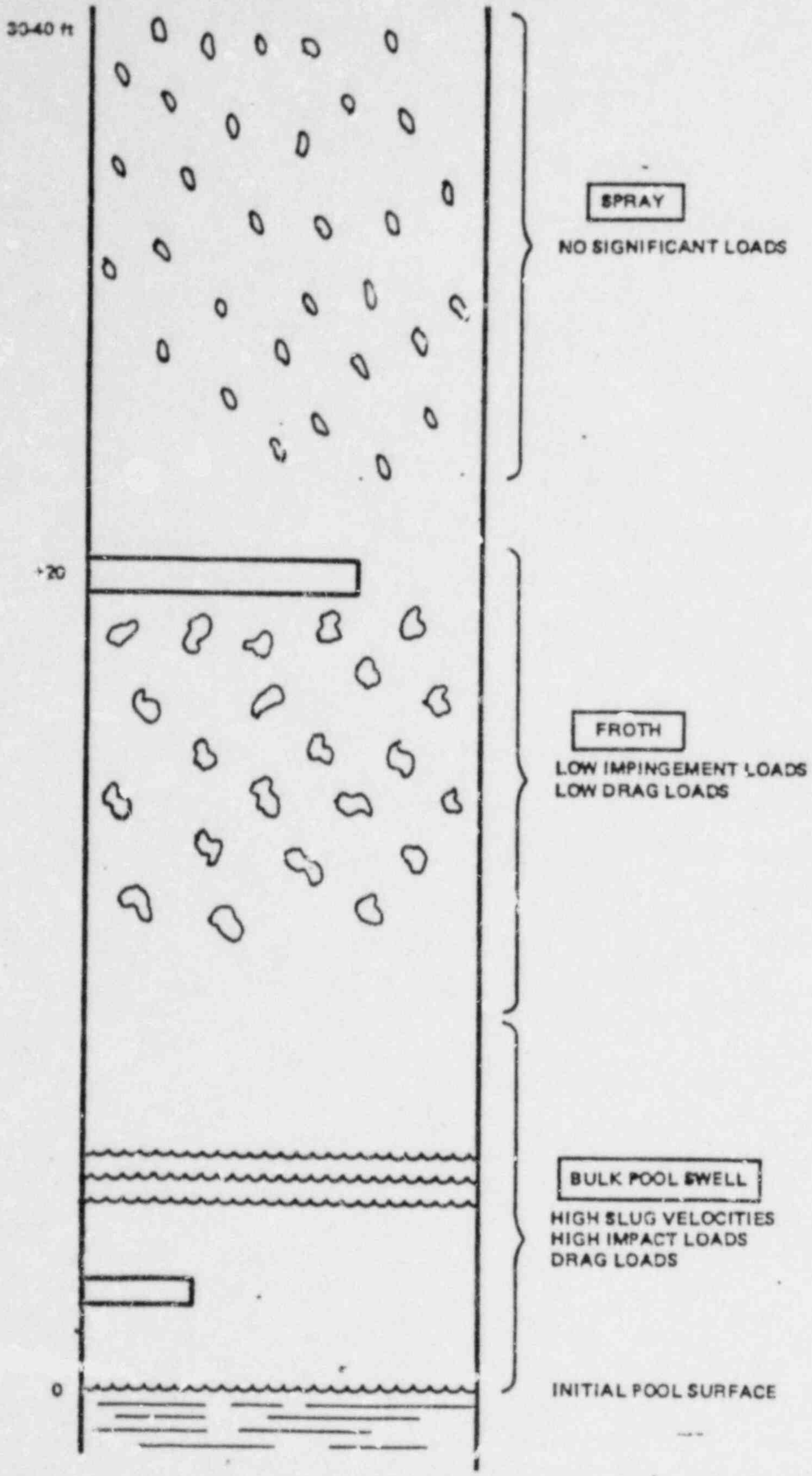
LOSS OF COOLANT ACCIDENT CHRONOLOGY



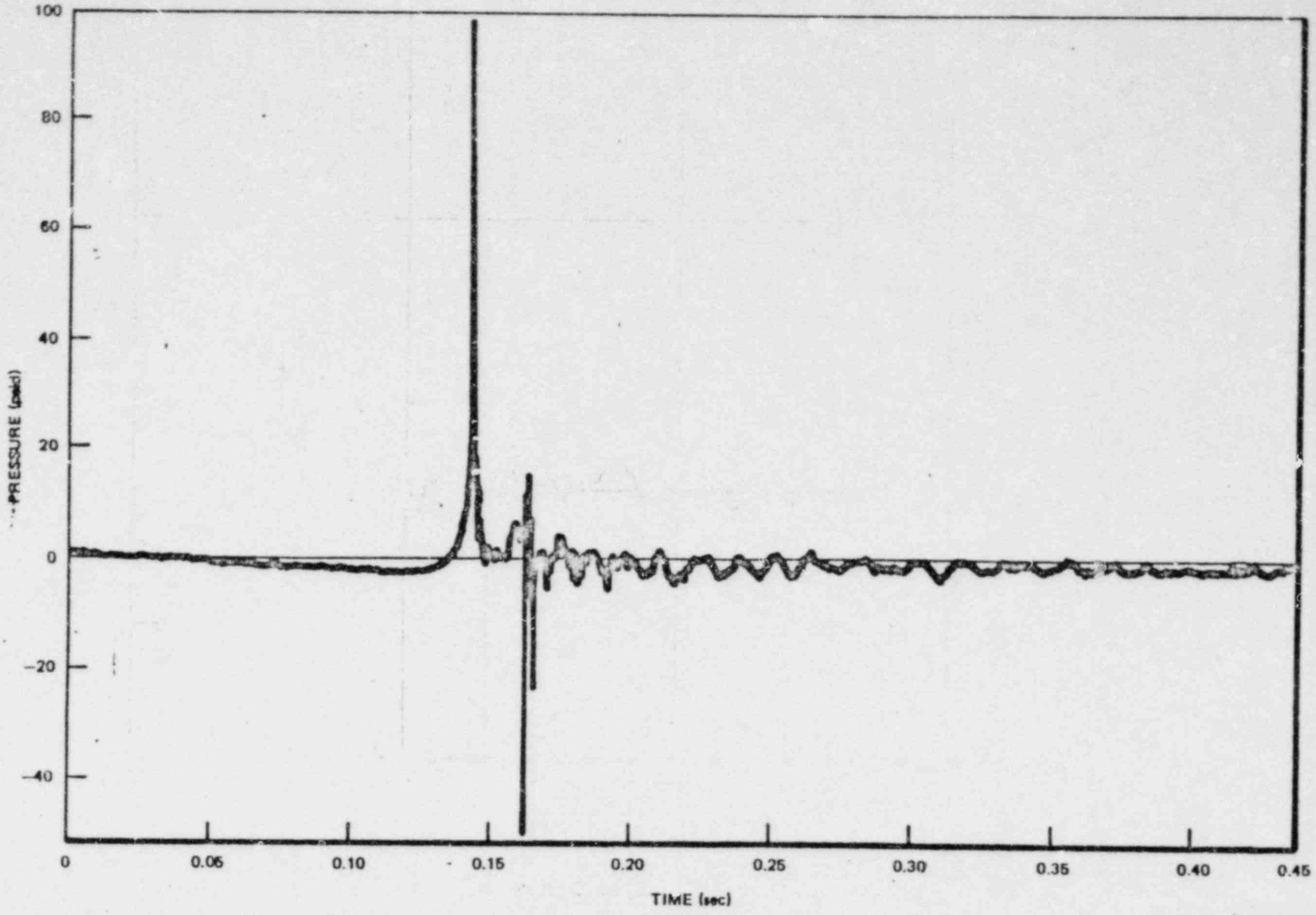


WETWELL – THE VOLUME IN THE CONTAINMENT BETWEEN THE POOL SURFACE AND THE HCU FLOOR

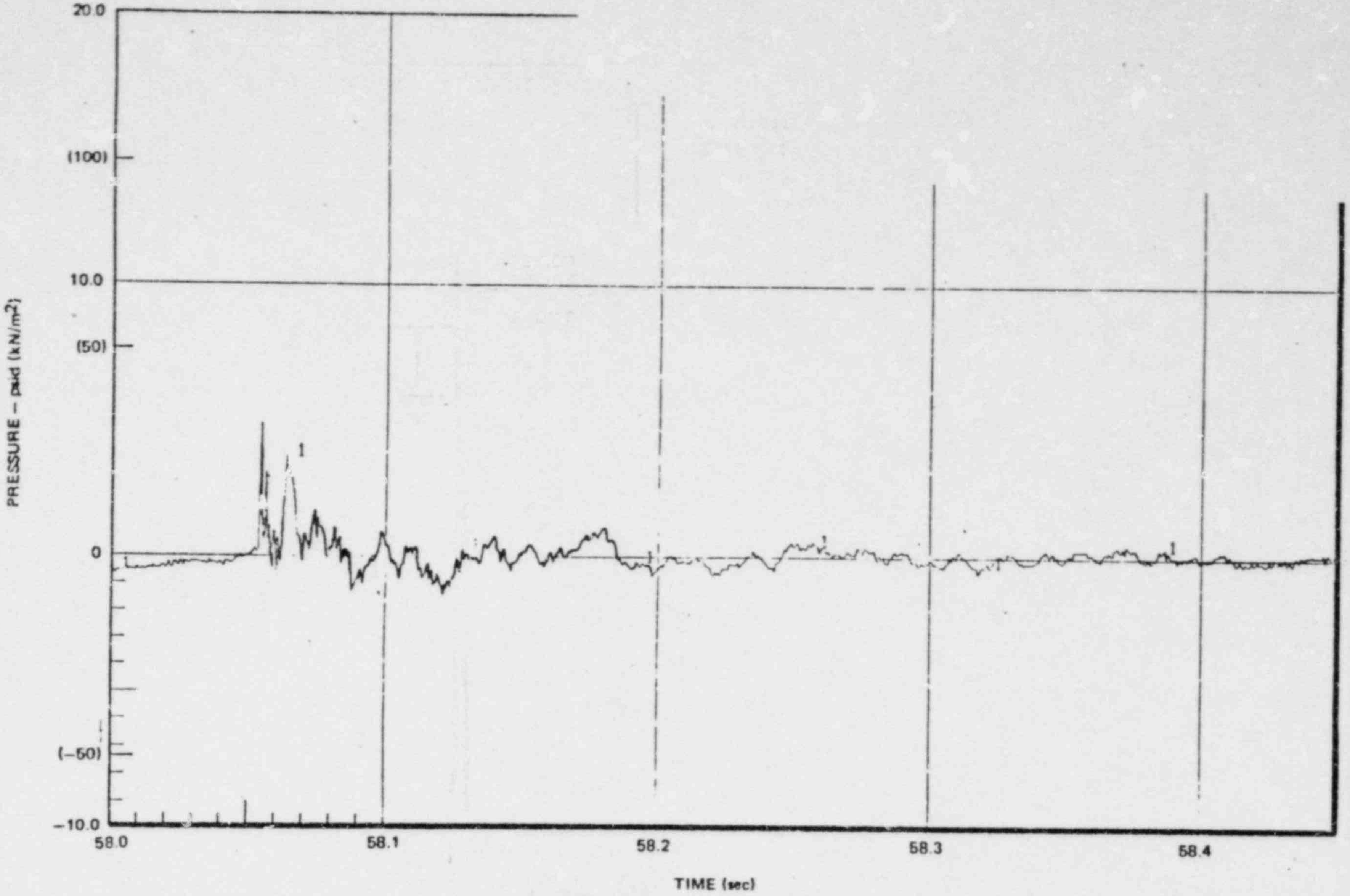
Short Term Drywell and Containment Pressure Response to a Large Steamline Break (DBA)



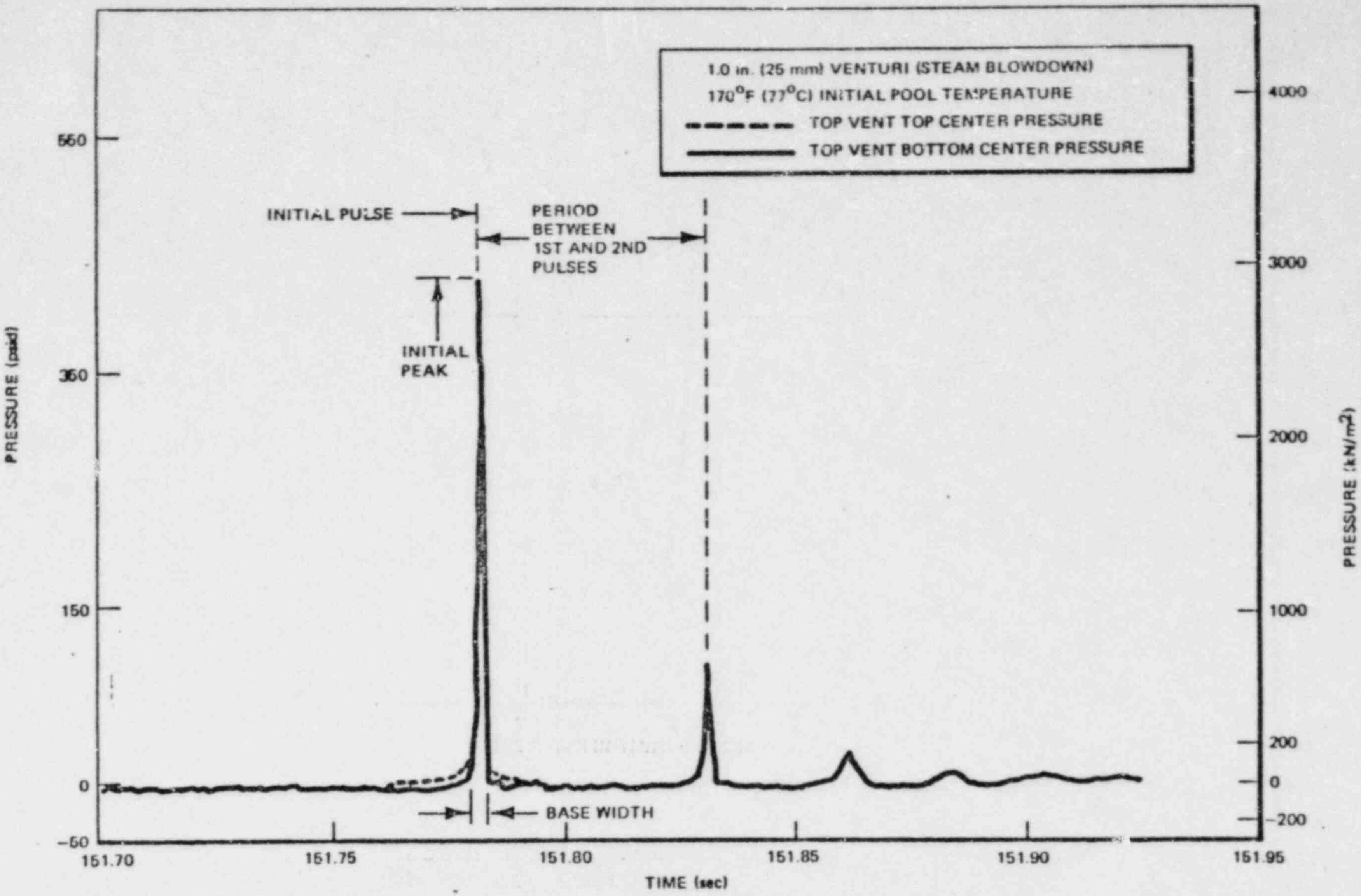
Schematic of the Mark III Pool Swell Phenomenon



DRYWELL WALL MAXIMUM PRESSURE TRACE



Basemat Chugging Pressure Time History



Typical Top Vent Pressure Trace During Chugging]

STATUS OF MARK III
GENERIC LICENSING POOL
DYNAMIC PROBLEMS
AT CP STAGE

- FULL SCALE TESTS (PSTF) OF A SINGLE ROW OF THREE VENTS SIMULATING THE WET AND DRYWELL VOLUMES TO STUDY VENT CLEARING, CONDENSATION AND SEQUENTIAL VENT CLEARING (TESTS INDICATED UNEXPECTED AND SIGNIFICANT POOL RISE).

- FULL SCALE TESTS (PSTF) AS IN ABOVE TO MEASURE IMPACT FORCES.

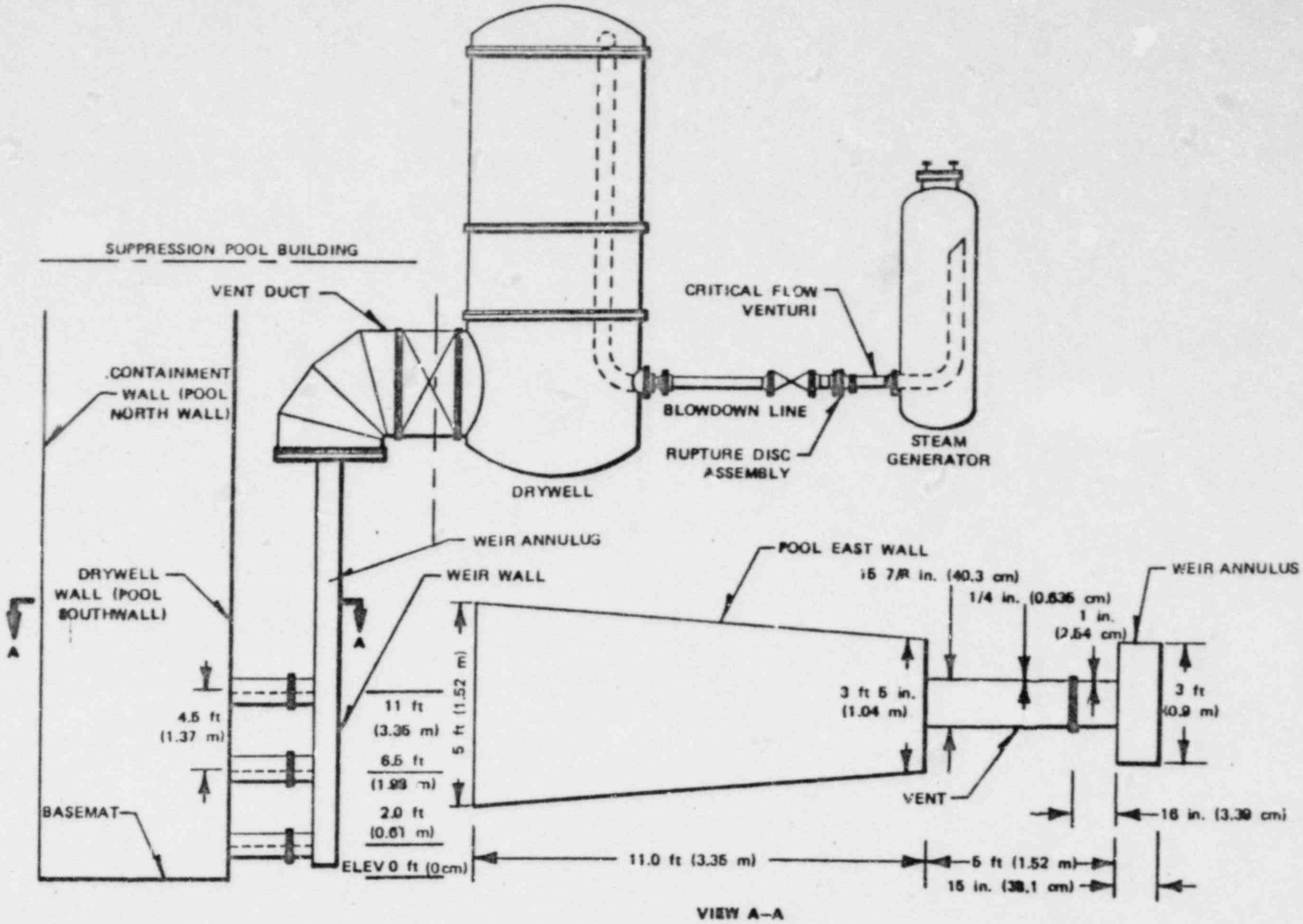
- 1/3 SCALE TESTS (PSTF) PERFORMED TO PROVIDE LICENSING DATA BASE ON POOL MOTION, VELOCITY, AND IMPACT LOADS FOR EQUIPMENT; E.G., GRATINGS.

- 1/3 SCALE TESTS (PSTF) PERFORMED TO INVESTIGATE CONDENSATION AND STEAM CHUGGING.

MK III OVERVIEW

- BWR6/MK III CONCEPT TAKEN TO ACRS 1972
- MK III TEST PROGRAM 1973-1975
  - 11/73 MODEL CONFIRMATION
    #5701-5703
  - 2/74 POOL SWELL (AIR)
    #5705-5706
  - 3/74 CONVERT TO 1/3 AREA SCALE VENT SYSTEM
  - 6/74 POOL SWELL (STEAM & LIQUID)
    #5801-5804
  - 1/75 POOL SWELL (SATURATED STEAM)
    #5805
  - 6/75 POOL SWELL (AIR)
    #5806
- NEDO 11314-08 SUBMITTED (LOAD DEFINITION REPORT) 7/75
- GESSAR - PDA NO 1 GRANTED 12/75
- GESSAR - PDA NO 1 CONDITIONS REMOVED 7/76-6/77

PSTF TEST FACILITY



TESTING SINCE
CP STAGE

- FULL SCALE TESTS (PSTF) TO INVESTIGATE CHUGGING.

- 1/3 SCALE TESTS (PSTF) TO INVESTIGATE STEAM CONDENSATION.

- 1/9 SCALE TESTS (PSTF) TO INVESTIGATE MULTI-VENT EFFECTS.

MK III OVERVIEW

- ADDITIONAL MK III CONFIRMATORY TESTS
  - 12/76 1/3 SCALE PSTF
    # 5807
  - 2/78 FULL SCALE
    #5707
  - 4/78 ICLR REV 1 (1/3 SCALE)
  - 10/78 ICLR REV 2 (FULL SCALE)
  - 5/79 MULTIVENT
    #6002-6003
  - 11/79 ICLR REV 3 (MULTIVENT #6002)
- ADDITIONAL SRV X-QUENCHER TESTS
  - 5/79 CAORSO PHASE I TEST REPORT
  - 5/80 CAORSO PHASE II TEST REPORT

SEPTEMBER 25, 1981	TIME
VI. RECONVENE - M. PLESSET, CHAIRMAN	8:30 A.M.
VII. SUBMERGED STRUCTURE LOADS (BNL - G. BIENKOWSKI	8:40 A.M.
A. JET LOADS	
B. AIR BUBBLE DRAG LOADS	
VIII. POOL THERMAL STRATIFICATION (BNL) - C. ECONOMUS	
IX. FLUID STRUCTURE INTERACTION EFFECTS (BNL) - C. ECONOMUS	
- BREAK -	10:30 A.M.
X. SAFETY RELIEF VALVE (SRV) LOADS	10:40 A.M.
A. OVERVIEW - T. SU (NRC)	
B. TRIPOWER MARK III INPLANT TESTS - T. SU	
C. MULTIPLE VALVE BUBBLE PHASING (BNL) - C. ECONOMUS	
- LUNCH -	12:30-1:30 P.M.
XI. MARK III CONTAINMENT MODIFICATIONS	1:30 P.M.
A. GENERAL PLANT DESIGN - M. FIELDS	
B. GRAND GULF DESIGN (MP&L)	
XII. GRAND GULF IN-PLANT SRV TEST PROGRAM (MP&L)	2:30 P.M.
XIII. SUMMARY OF MARK III PROGRAM (NRC)	3:00 P.M.
XIV. SUBCOMMITTEE DISCUSSION	3:30 P.M.
XV. ADJOURN	4:00 P.M.

GRAND GULF NUCLEAR STATION

IN PLANT TESTING

- BACKGROUND
- TEST DESCRIPTIONS
- PRESSURE MEASUREMENTS
- ACCELEROMETER MEASUREMENTS
- SCHEDULE
- CONCLUSIONS

Johnson

BACKGROUND

- NRC INDICATED IN REVIEW OF GESSAR-238 NUCLEAR ISLAND APPLICATION THAT VERIFICATION OF QUENCHER LOADS WOULD BE REQUIRED BY THE FIRST PLANT REFERENCING THE GESSAR NUCLEAR ISLAND DESIGN.

- NRC INDICATED THAT A PROTOTYPICAL TEST WOULD BE REQUIRED FOR EACH TYPE OF CONTAINMENT STRUCTURE (I.E. CONCRETE AND STEEL).

- KUOSHENG PLANT RECENTLY COMPLETED IN PLANT TEST WITH OBJECTIVE OF DEMONSTRATING SIGNIFICANT REDUCTIONS IN STRUCTURAL RESPONSE AND THEREFORE REDUCED LOADS TO PIPING AND EQUIPMENT.

- KUOSHENG AND GRAND GULF ARE REINFORCED CONCRETE CONTAINMENTS.

- MP&L PRESENTLY HAS PLANS FOR IN PLANT TESTING. IN ADDITION, MP&L IS REVIEWING KUOSHENG DATA AND ITS APPLICABILITY TO GRAND GULF TO DETERMINE IF ADDITIONAL TESTING IS NECESSARY.

TEST DESCRIPTION

- 6 SINGLE VALVE ACTUATIONS (SVA)

- 6 CONSECUTIVE VALVE ACTUATIONS (CVA)

- 7 MULTIVALVE ACTUATIONS (MVA)

- 1 EXTENDED VALVE ACTUATIONS (ESVA)

- 27 PRESSURE SENSORS
  34 STRAIN GAUGES
  16 TEMPERATURE SENSORS
  41 ACCELEROMETER CHANNELS IN 17 LOCATIONS

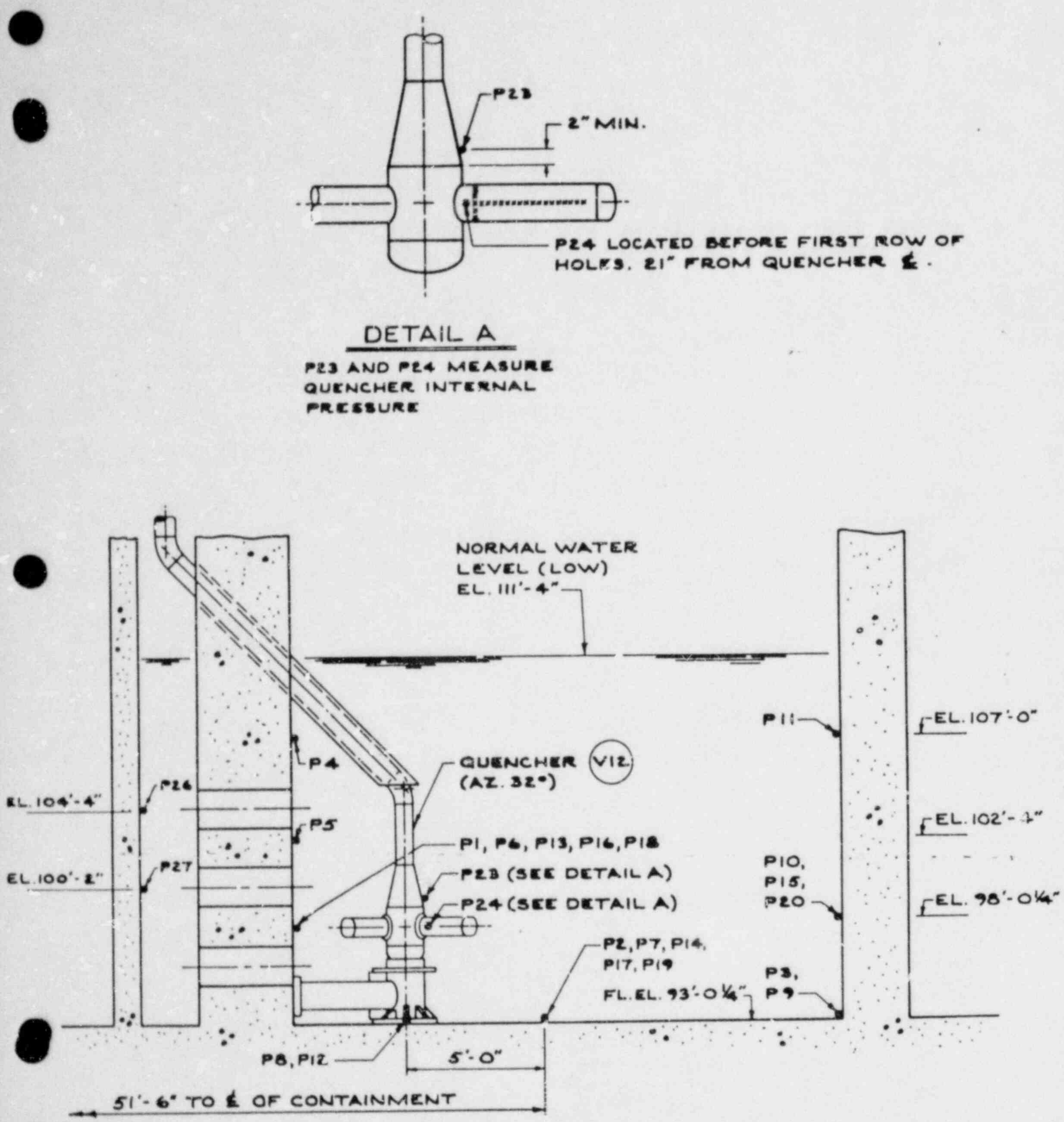


Figure 4-2. SUPPRESSION POOL PRESSURE SENSORS - ELEVATION VIEW

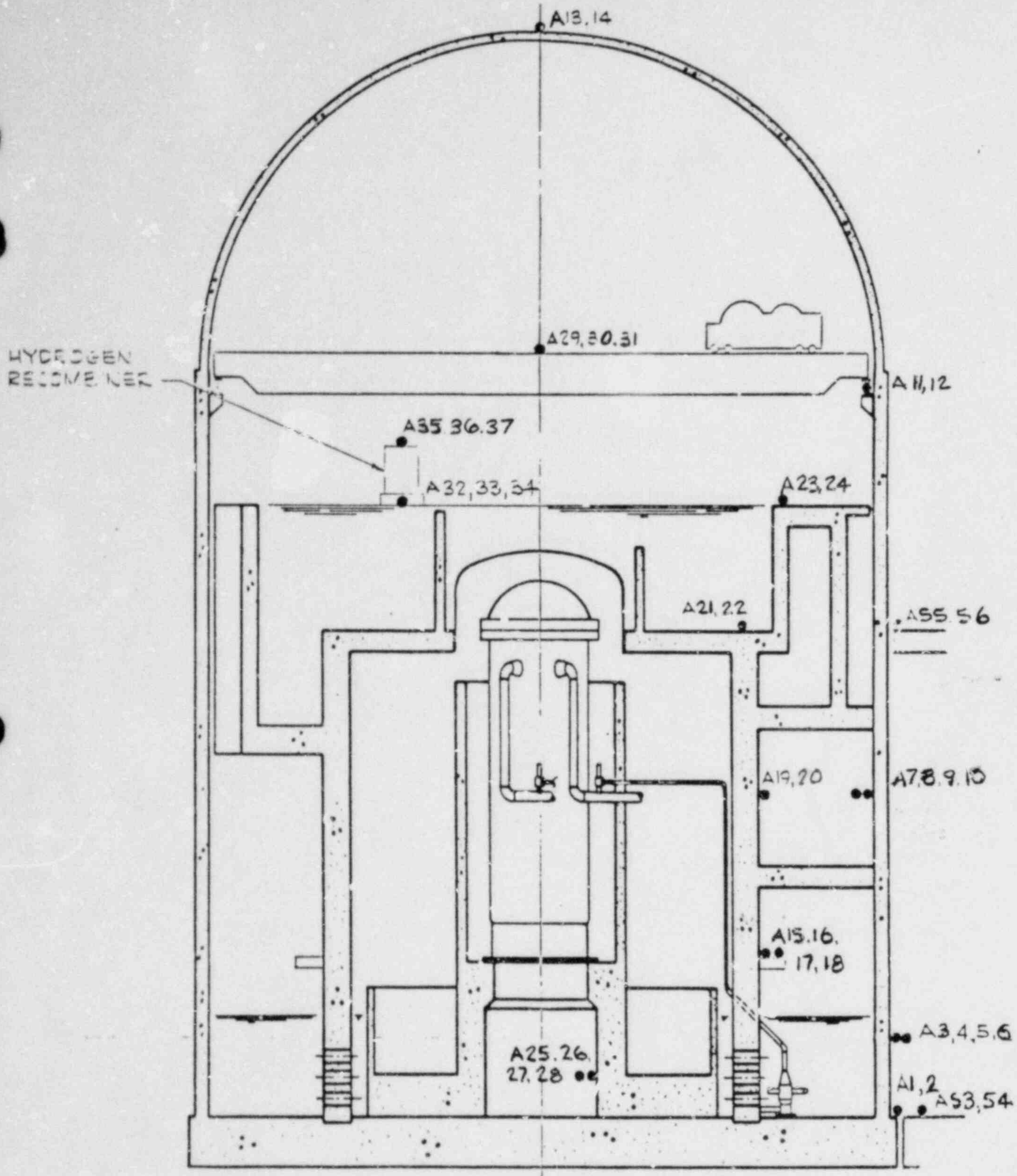


Figure 3.1

GRAND GULF ACCELEROMETER LOCATIONS
(Elevation View - Accelerometers Rotated into View)

EVALUATIONS

DEC. 31	FUEL LOAD
APRIL 10	TEST AT 50% POWER
JUNE 15	QUICK LOOK REPORT
SEPT. 1	FINAL REPORT

CONCLUSIONS

- TEST PROGRAM, AS DEFINED IS CONSIDERED SUFFICIENT TO PROVIDE A DATA BASE FOR EVALUATION OF LOAD DEFINITIONS.

- SIGNIFICANT CONSERVATISMS THOUGHT TO EXIST IN THE STRUCTURAL MODEL RESULTING IN ADDITIONAL SAFETY MARGINS.

- MP&L WILL COMPLETE EVALUATIONS OF KUOSHENG DATA IN EARLY OCTOBER AND, IF APPROPRIATE, MEET WITH NRC STAFF AT THAT TIME WITH THE OBJECTIVE OF DELETING FURTHER TEST PLANS.

SIMILARITY BETWEEN GRAND GULF AND KUOSHENG

WITH REGARD TO IN PLANT TESTING

REF. NUREG 0763

TMJ 9/17/81

- QUENCHER DEVICE GEOMETRY:

  BOTH X-QUENCHERS
  IDENTICAL ARMS AND HOLE PATTERN

- BUBBLE PRESSURE PARAMETERS:

  18.2 PSI CVA DESIGN VALUE FOR GRAND GULF
  16.6 PSI CVA DESIGN VALUE FOR KUOSHENG

- STEAM FLOW PER LINE AREA

  FLOW RATES IDENTICAL WITH NO IMPACT ON PREDICTED PRESSURES.
  LINE DIAMETER SIZE IDENTICAL.

- QUENCHER/POOL GEOMETRY

5'-0"	DRY WELL TO QUENCHER ℄	BOTH UNITS
5'-0"	ARM ℄ TO FLOOR GGNS	~~BOTH UNIT~~S KUOSHENG
18'-10"	POOL DEPTH @ NWL	GGNS
19'-2"	POOL DEPTH @ NWL	KUOSHENG

- CONTAINMENT CHARACTERISTICS

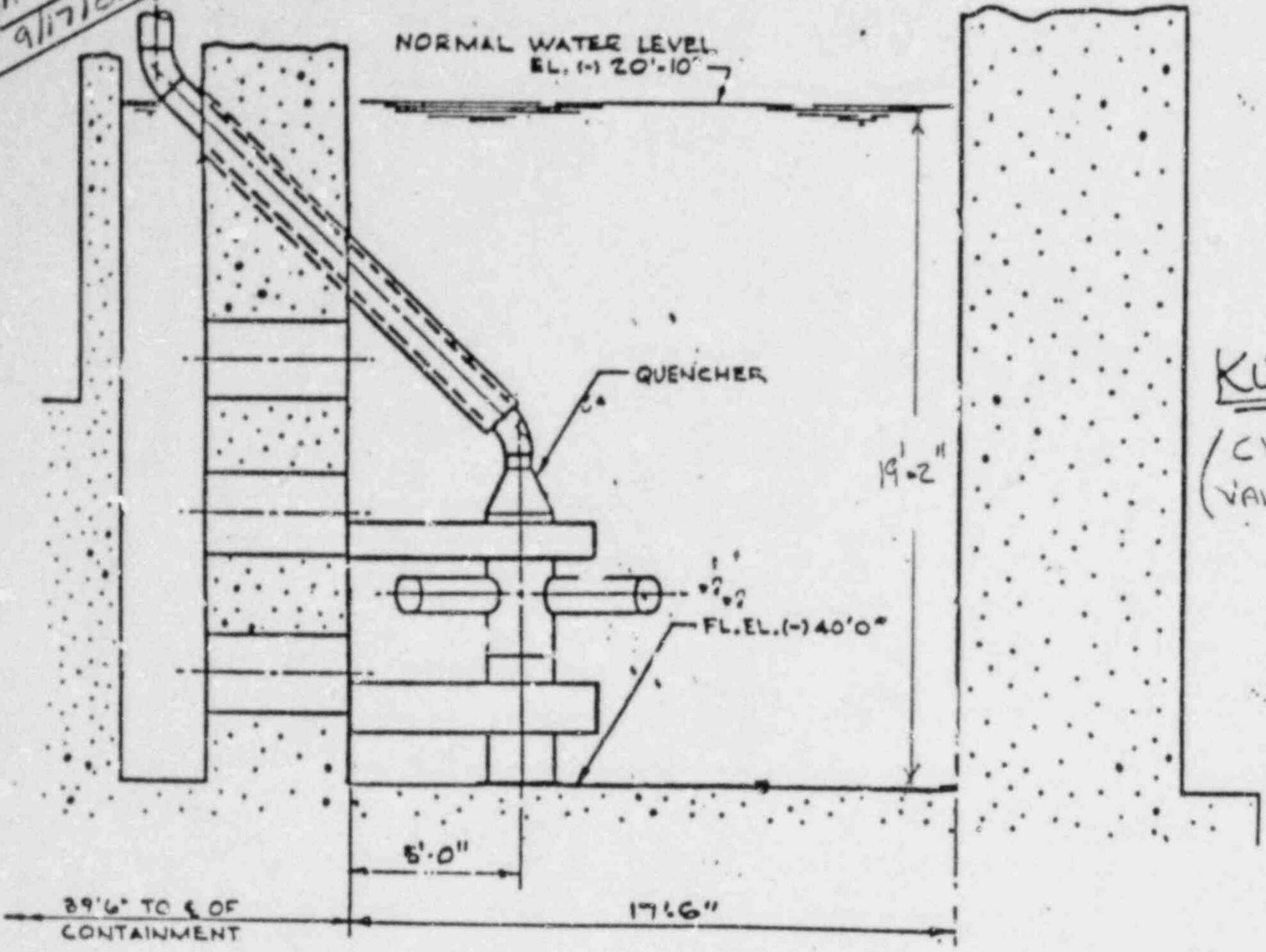
  REINFORCED CONCRETE CONTAINMENT BOTH UNITS DRYWELL AND PEDESTAL OF SIMILAR CONSTRUCTION PLATFORMS AND FLOORS SIMILARLY LOCATED.

- THIS DATA IS PRELIMINARY AND IN SUMMARY FORM. DETAILS TO BE DEVELOPED AND DISCUSSED WITH NRC STAFF IN NEAR FUTURE.

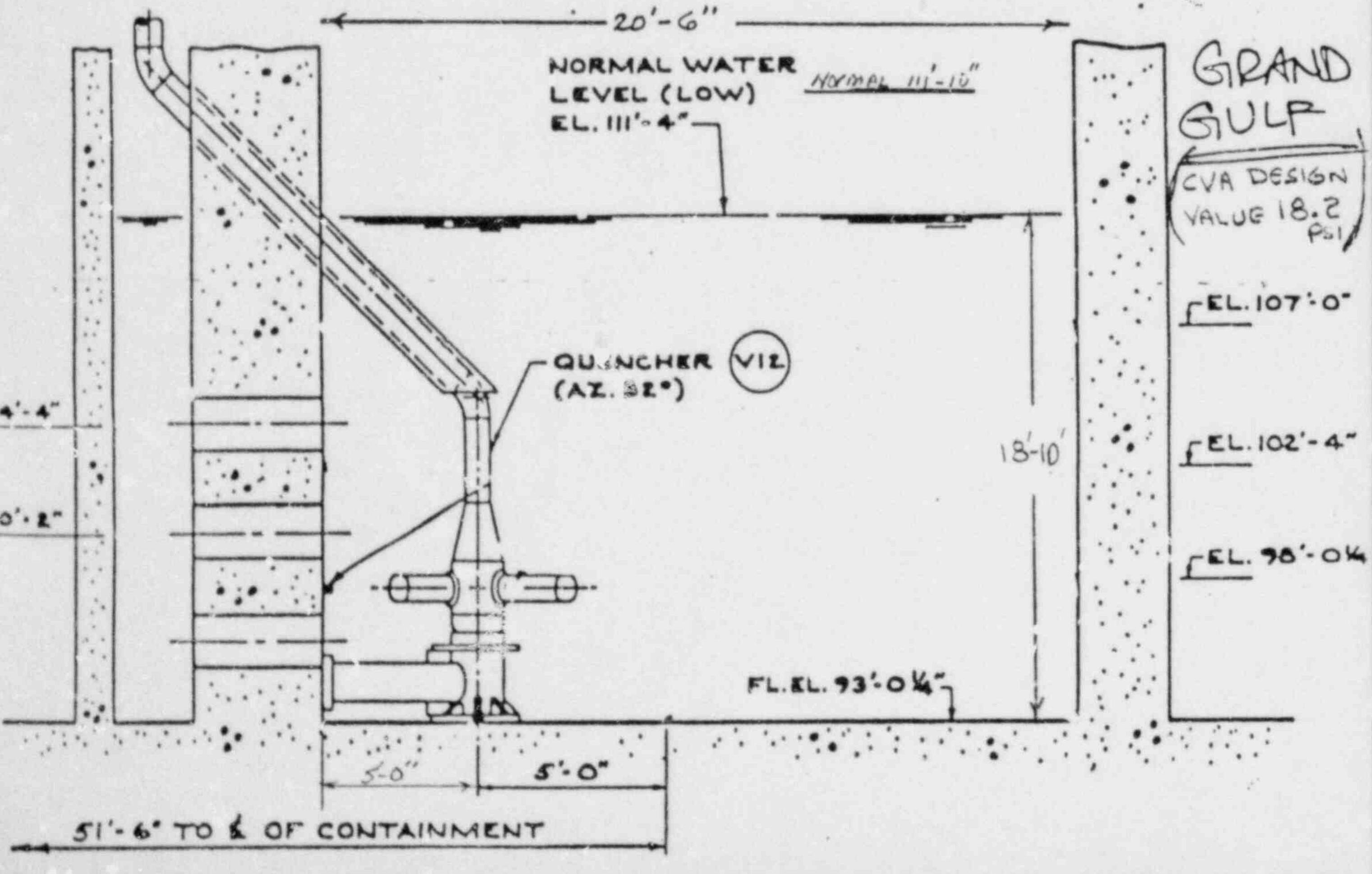
PRELIMINARY
JT 9/17/81

FIGURE 2. QUENCHER ARRANGEMENTS

MPL-01-104
8/11/81



KUOSHENG
(CVA DESIGN VALUE 16.6 psi)



GRAND GULF
(CVA DESIGN VALUE 18.2 psi)

MARK III MODIFICATIONS

MEL B. FIELDS
CONTAINMENT SYSTEMS BRANCH
NUCLEAR REGULATORY COMMISSION

Fields

MARK III MODIFICATIONS

OBJECTIVE - DETERMINE EXTENT OF PLANT MODIFICATIONS MADE DUE TO CHANGES IN GENERIC MARK III POOL DYNAMIC LOAD CRITERIA

METHOD - SELECTED 4 PLANTS FOR EXAMINATION:
CLINTON 1&2 - OL STAGE UNIT 1 80% COMPLETE
RIVER BEND - OL STAGE -35% COMPLETE
BLACK FOX - CP STAGE
ALLENS CREEK - CP STAGE

MARK III MODIFICATIONS

CLINTON 1&2

- SUPPRESSION POOL LINER STRENGTHEN
- GENERAL MODIFICATION OF HCU FLOOR, EQUIPMENT MOVED FROM GRATING ONTO CONCRETE, PIPING RAISED
- SRV PIPING AND SUPPORTS MODIFIED, ECCS SUCTION STRAINERS AND SUPPORTS REDESIGNED
- POLAR CRANE GIRDERS AND BRAKETS REDESIGNED
- GENERAL UPGRADING OF PIPING, PIPE SUPPORTS

MARK III MODIFICATIONS

RIVER BEND

- STEEL HOOPS AND STIFFENERS ADDED TO OUTSIDE OF FREE-STANDING STEEL CONTAINMENT, UP TO THE ELEVATION OF THE SUPPRESSION-POOL SURFACE
- WILL FILL THE ANNULUS BETWEEN THE CONCRETE SHIELD BUILDING AND STEEL CONTAINMENT WITH CONCRETE TO A LEVEL 5 FEET ABOVE SUPPRESSION POOL SURFACE

MARK III MODIFICATIONS

BLACK FOX 1&2

- MODIFIED STUD PATTERNS ON WEIR WALL
- MAY ADD STIFFENERS TO FREE-STANDING STEEL CONTAINMENT
- WILL FILL THE ANNULUS BETWEEN THE CONCRETE SHIELD BUILDING AND STEEL CONTAINMENT UP TO A LEVEL OF 25 FEET ABOVE SUPPRESSION POOL BOTTOM

MARK III MODIFICATIONS

ALLENS CREEK

- ADDED VERTICAL STIFFENERS TO OUTSIDE OF FREE-STANDING STEEL CONTAINMENT IN THE SUPPRESSION POOL REGION
- MODIFIED DOME DESIGN FROM ELLIPSODIAL TO HEMISPHERICAL
- RELOCATED ALL PIPING OUT OF SOLID IMPACT AREA

GE CROSS QUENCHER SRV LOAD METHODOLOGY - DESCRIPTION

APPLICATION - STRUCTURAL DESIGN.

DYNAMIC PRESSURE LOADING APPLIED DIRECTLY TO WETTED BOUNDARIES.

IDEALIZED PRESSURE SIGNATURES - DAMPED RAYLEIGH BUBBLE.

FREQUENCY CONTENT - DOMINANT BUBBLE FREQUENCY (DBF) ARBITRARILY RANGED FROM 5 TO 12 HZ.

PEAK PRESSURE AMPLITUDE (PPA) - FUNCTION OF PLANT PARAMETERS AND OPERATING CONDITIONS - STATISTICAL MODEL OF SMALL (0.1), LARGE (0.5) AND IN-PLANT (1.0) TEST DATA - (95-95) CONFIDENCE LEVEL.

SPATIAL DISTRIBUTION

$2r_0$ PLATEAU

$1/r$ ATTENUATION

"LINE OF SIGHT" CUTOFF

ABOVE 3/4 POOL LINEAR DECAY TO ZERO AT POOL SURFACE

MULTIPLE VALVE EFFECTS

SYNCHRONOUS BUBBLE OSCILLATIONS

SRSS INDIVIDUAL CONTRIBUTIONS

"CUTOFF" AT PPA

GE CROSS QUENCHER SRV LOAD METHODOLOGY - DESCRIPTION

(CONTINUED)

LOAD CASES

SVA AT LOW POOL TEMPERATURE.

CVA AT ELEVATED POOL TEMPERATURE.

TWO ADJACENT (FIRST) AT LOW POOL TEMPERATURE.

TEN VALVES (ONE LOW - NINE NEXT LOW-FIRST) AT LOW POOL TEMPERATURE.

ADS (FIRST) AT ELEVATED POOL TEMPERATURE.

ALL VALVES (FIRST) AT LOW POOL TEMPERATURE.

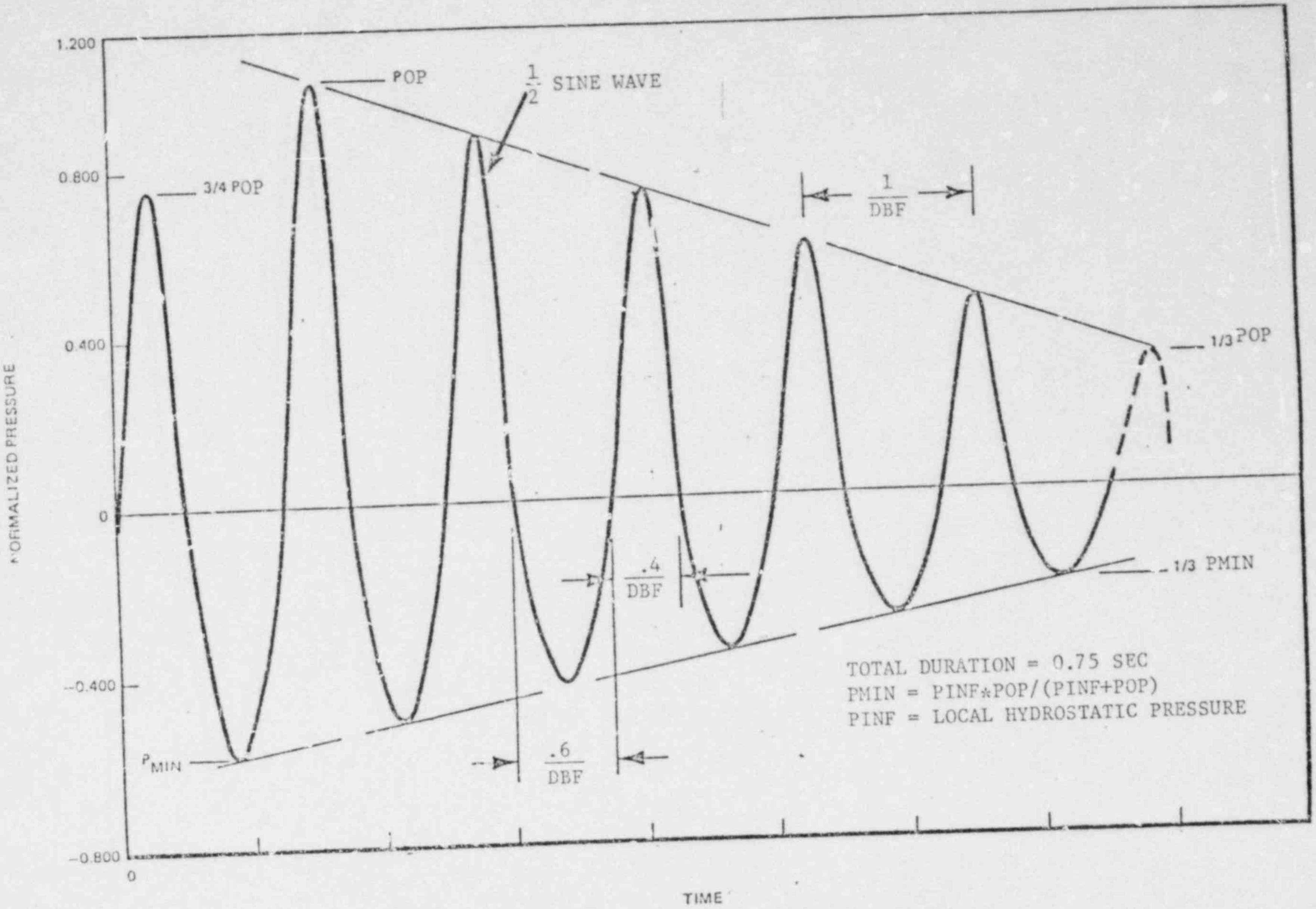


Figure Q1 - Cross Quencher Design Pressure Signature

GE CROSS QUENCHER SRV LOAD METHODOLOGY - REVIEW STATUS

ORIGINAL METHODOLOGY ACCEPTED BY STAFF SEPTEMBER 1976 (NUREG-75/110).

GE PROPOSES MODIFICATION TO METHODOLOGY (1980).

PPA REDUCED BY 20% FOR FIRST ACTUATION.

PPA REDUCED BY 35% FOR SUBSEQUENT ACTUATION.

BASIS - CAORSO (MARK II CONTAINMENT) IN-PLANT TESTS.

STAFF REVIEW IN PROGRESS.

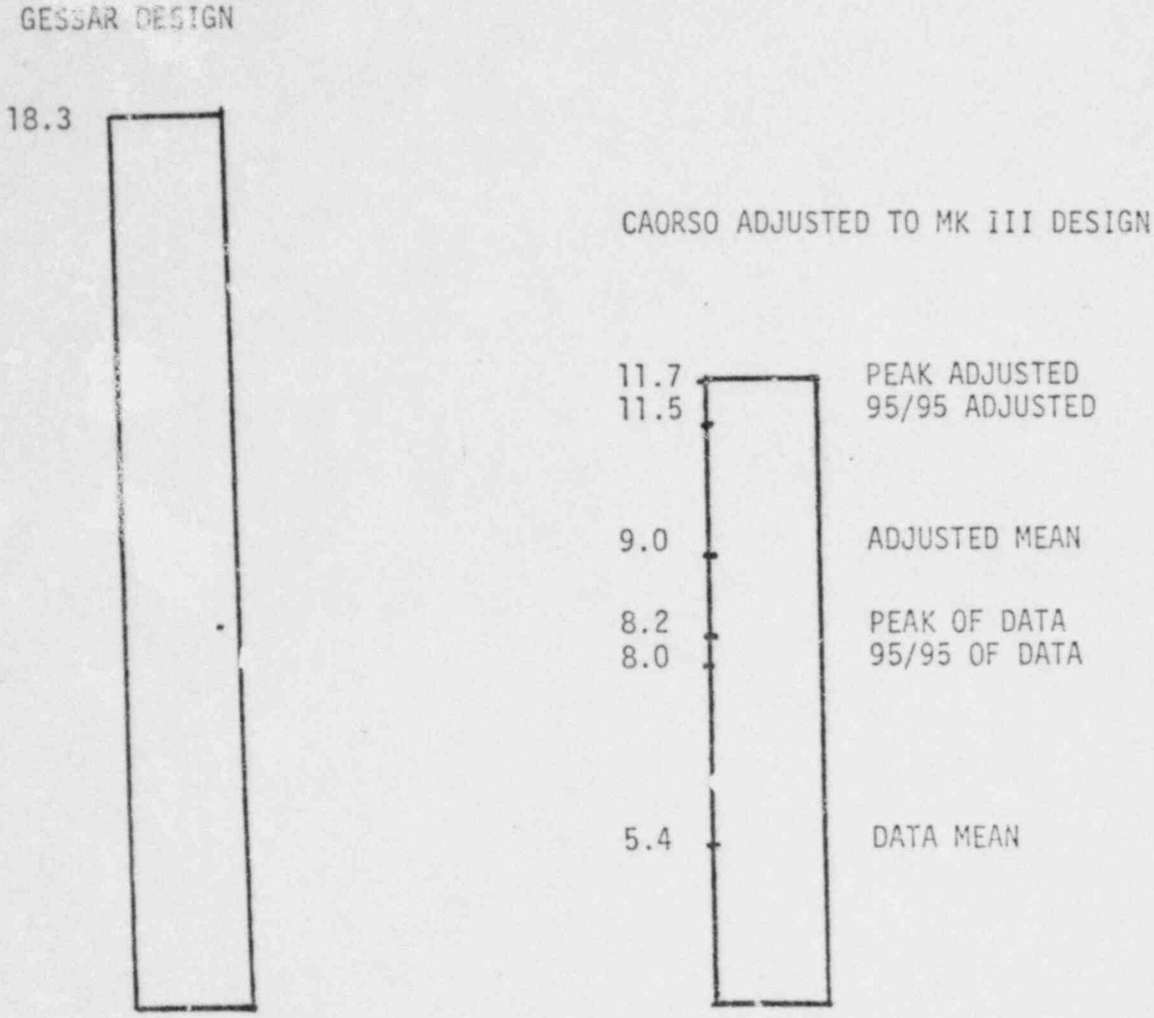
ISSUES - .

NON-CONSERVATIVE APPLICATION OF LOAD TREND WITH LINE VOLUME.

MODIFICATION APPLIED INCORRECTLY FOR MAXIMUM UNDER-PRESSURE.

VACUUM BREAKER EFFECT NOT ACCOUNTED FOR.

AGREEMENT ON ISSUES - RESOLUTION EXPECTED SINCE SUFFICIENT MARGIN EXISTS TO ACCOMMODATE CORRECT INTERPRETATION OF CAORSO DATA BASE.



CONSECUTIVE VALVE ACTUATION COMPARISON

MULTIPLE VALVE BUBBLE PHASING

APPLICATION - PIPING SYSTEM AND EQUIPMENT RESPONSE EVALUATION.

SYNCHRONOUS BUBBLE OSCILLATION OVERLY CONSERVATIVE.

METHODOLOGY EMPLOYS MONTE CARLO SIMULATION TO DEVELOP MORE REALISTIC BUT CONSERVATIVE LOADING.

MULTIPLE VALVE BUBBLE PHASING - PROBABALISTIC FEATURES

CHOICE OF RANDOM VARIABLES

- REACTOR PRESSURE RISE RATE (PRR).
- VALVE SET POINT TOLERANCE (VST).
- VALVE OPENING TIME (VOT).
- DOMINANT BUBBLE FREQUENCY (DBF).

PROBABILITY DENSITY FUNCTIONS

PRR - OPERATING EXPERIENCE AND PLANT TRANSIENTS ANALYSIS.

VST - GAUSSIAN - TESTABILITY FEATURE PRECLUDES DRIFTING OF NOMINAL SETPOINT FOR VALVE GROUPS.

VOT - SHOP TESTS.

DBF - FOREIGN LICENSEE IN-PLANT TEST DATA.

CONFIDENCE LEVEL OF LOAD SPECIFICATION

- 59 MONTE CARLO TRIALS.
- (95-95) CLAIMED.

SELECTION OF DESIGN MONTE CARLO TRIALS

- AS MANY AS 9 USED FOR DESIGN.
- SELECTED TO BOUND SPECTRAL PEAKS IN VERTICAL AND OVERTURNING MOMENTS.

MULTIPLE VALVE BUBBLE PHASING - OTHER FEATURES

DBF PROBABILITY DENSITY FUNCTION SHIFTED DETERMINISTICALLY TO ACCOUNT FOR DISCHARGE LINE VOLUME VARIATION.

ALGEBRAIC SUPERPOSITION OF LOCAL PRESSURE CONTRIBUTION FROM EACH VALVE.

PRESSURE SIGNATURE PPA, SPATIAL DISTRIBUTION, LOAD CASES, AS BEFORE.

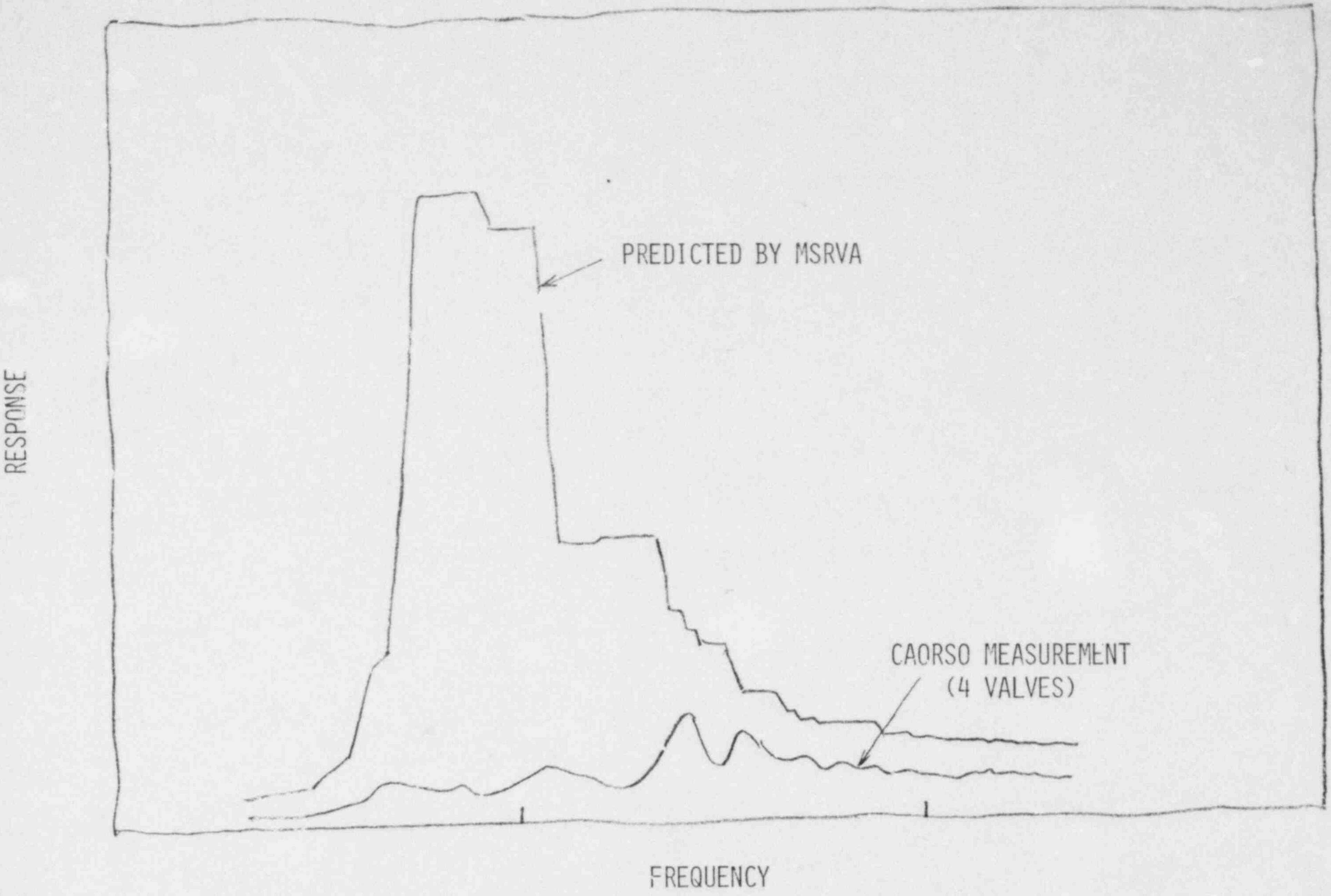
MULTIPLE VALVE BUBBLE PHASING - STAFF EVALUATION

- Individual elements of methodology not completely validated to staff satisfaction.
  - PDF for DBF not prototypical of behaviour exhibited by Caorso tests (μ and σ of former too high).
  - (95-95) confidence level cannot be claimed for final load specification.

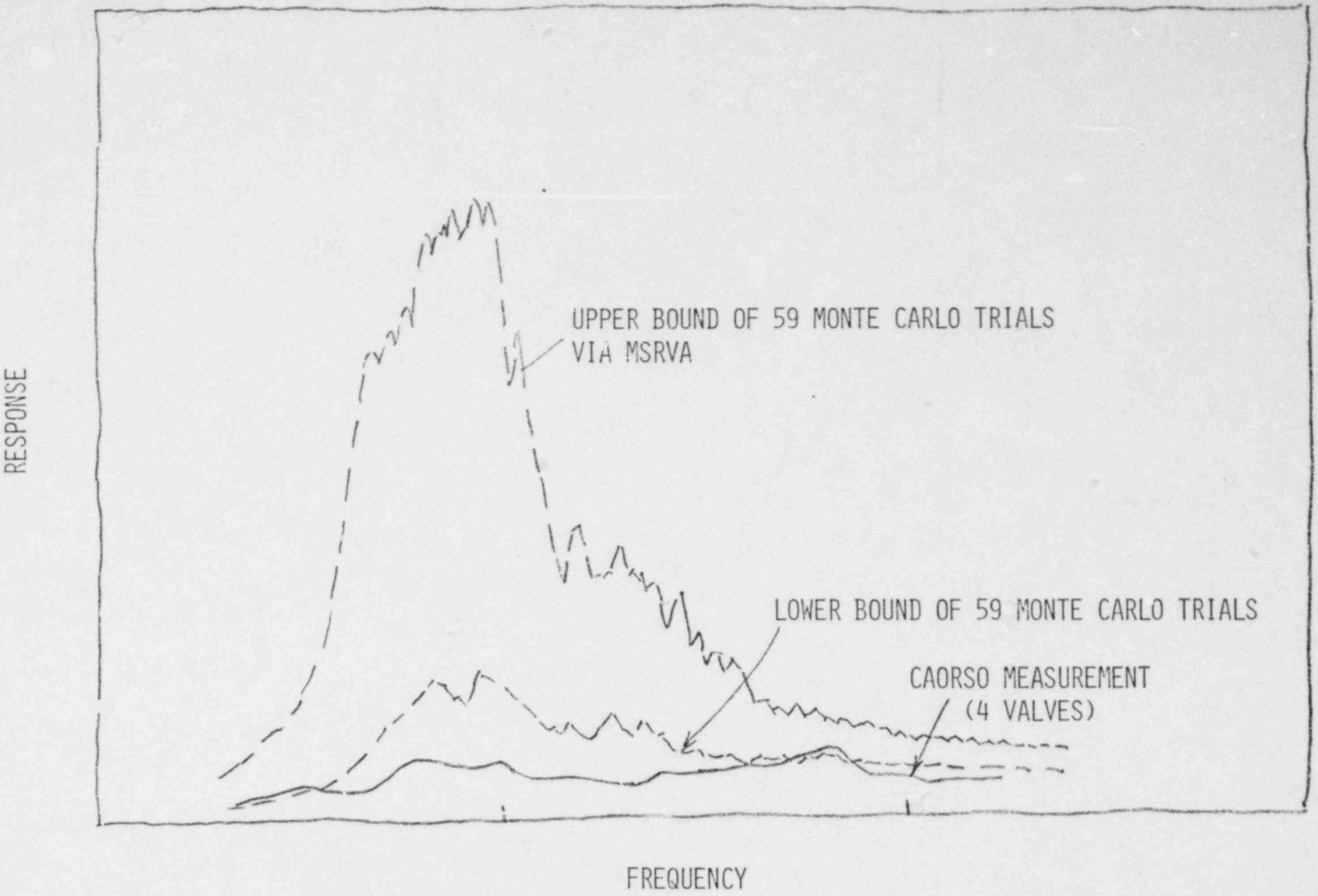
- Methodology Acceptable when Considered in its Entirety
  - Sensitivity studies.
  - Overall conservatism demonstrated by application to Caorso tests.

- In-Plant Tests (Grand Gulf) to Provide Further Confirmation

ARS COMPARISON - SELECTED POINTS ON WETWELL



ARS COMPARISON - SELECTED POINT ON WETWELL



MARK III
SRV RELATED POOL
DYNAMIC LOADS
OVERVIEW

I. Background

II. Areas of Review

III. Status

9/17/81

So

I. BACKGROUND

- METHODOLOGY FOR PREDICTING SRV LOAD
  - USE KWU X-QUENCHER DATA
  - GE X-QUENCHER - MODIFIED VERSION OF KWU X-QUEN
  - STATISTICAL METHOD (1975)
- ACCEPTANCE CRITERIA (1976)
  1. GE PROPOSED LOAD METHODOLOGY, CONSERVATIVE, ACCEPTABLE
  2. ALL BUBBLES OSCILLATING IN-PHASE
  3. LOAD CASES

9/17/81

II. AREAS OF REVIEW

GE PROPOSED MODIFICATIONS TO THE 1975 METHODS:

1. LOW-LOW SET LOGIC
2. 35% LOAD REDUCTION FACTOR
   BASIS: CAORSO INPLANT TEST
3. BUBBLE PHASING –
   MONTE CARLO APPROACH

9/17/81

III. STATUS

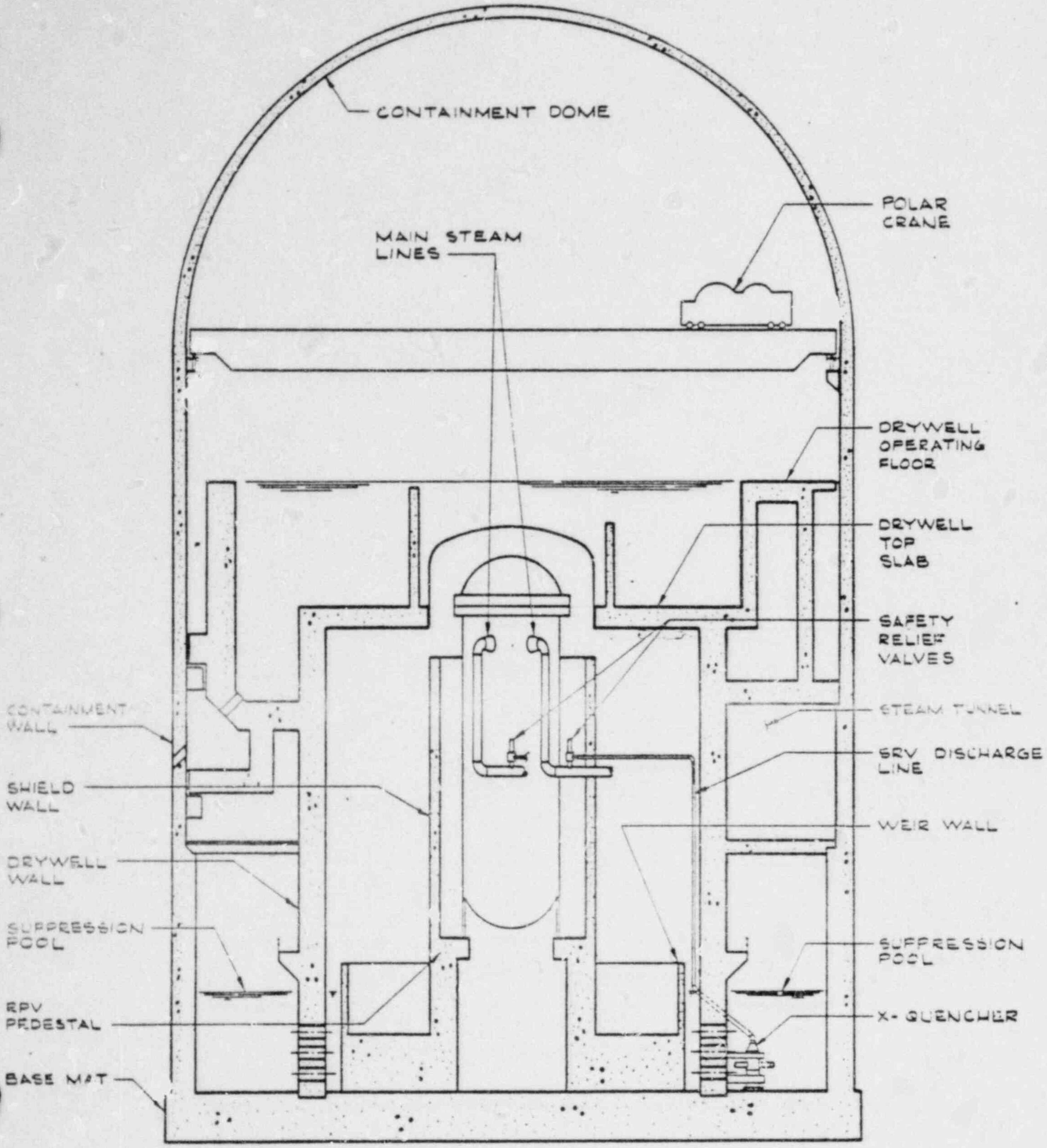
- NO OPEN ITEMS FOR GESSAR DOCKET
- NUREG-0802, "SAFETY/RELIEF VALVES - LOAD EVALUATION REPORT - MARK II AND III CONTAINMENTS," NOVEMBER 1981 (SCHEDULES)
- NUREG-0783, "SUPPRESSION POOL TEMPERATURE LIMITS FOR BWR CONTAINMENTS." DRAFT ISSUED TO ACRS IN JULY 1981. FINAL ISSUANCE: OCTOBER 1981.

KUOSHENG NUCLEAR POWER STATION

BACKGROUND

- LOCATION: NORTHERN TIP OF TAIWAN
- 2 UNITS, 985 MW EACH
- FIRST OPERATING BWR6/MARK III IN THE WORLD
- FIRST UNIT: 60% POWER IN AUGUST 1981
- SECOND UNIT: FUEL LOADING - 2ND QUARTER 1982

9/17/81



KUOSHENG PRESSURE SUPPRESSION CONTAINMENT

KUOSHENG SRV INPLANT TEST

- OBJECTIVES

1. CONFIRM SRV LOADS

    - PIPING, EQUIPMENT AND CONTAINMENT STRUCTURES

2. PROVIDE DATA BASE FOR STRUCTURAL MODEL

3. PROVIDE DATA BASE FOR X-QUENCHER THERMAL PERFORMANCE - POOL MIXING

9/17/81

- GENERAL INFORMATION
  - TESTS STARTED ON AUGUST 22, 1981
  - TESTS COMPLETED ON AUGUST 28, 1981
  - TOTAL NUMBER OF TESTS - 32
  - INSTRUMENTATION
    - 128 ACCELEROMETERS
    - 71 PRESSURE SENSORS
    - 62 STRAIN GAGES
    - 22 THERMOCOUPLES
  - TESTS INCLUDED
    - SINGLE VALVE FIRST ACTUATION
    - SINGLE VALVE CONSECUTIVE ACTUATION
    - TWO ADJACENT VALVE ACTUATION
    - FOUR VALVE ACTUATION
    - EXTENDED BLOWDOWN
      - WITH RHR
      - WITHOUT RHR

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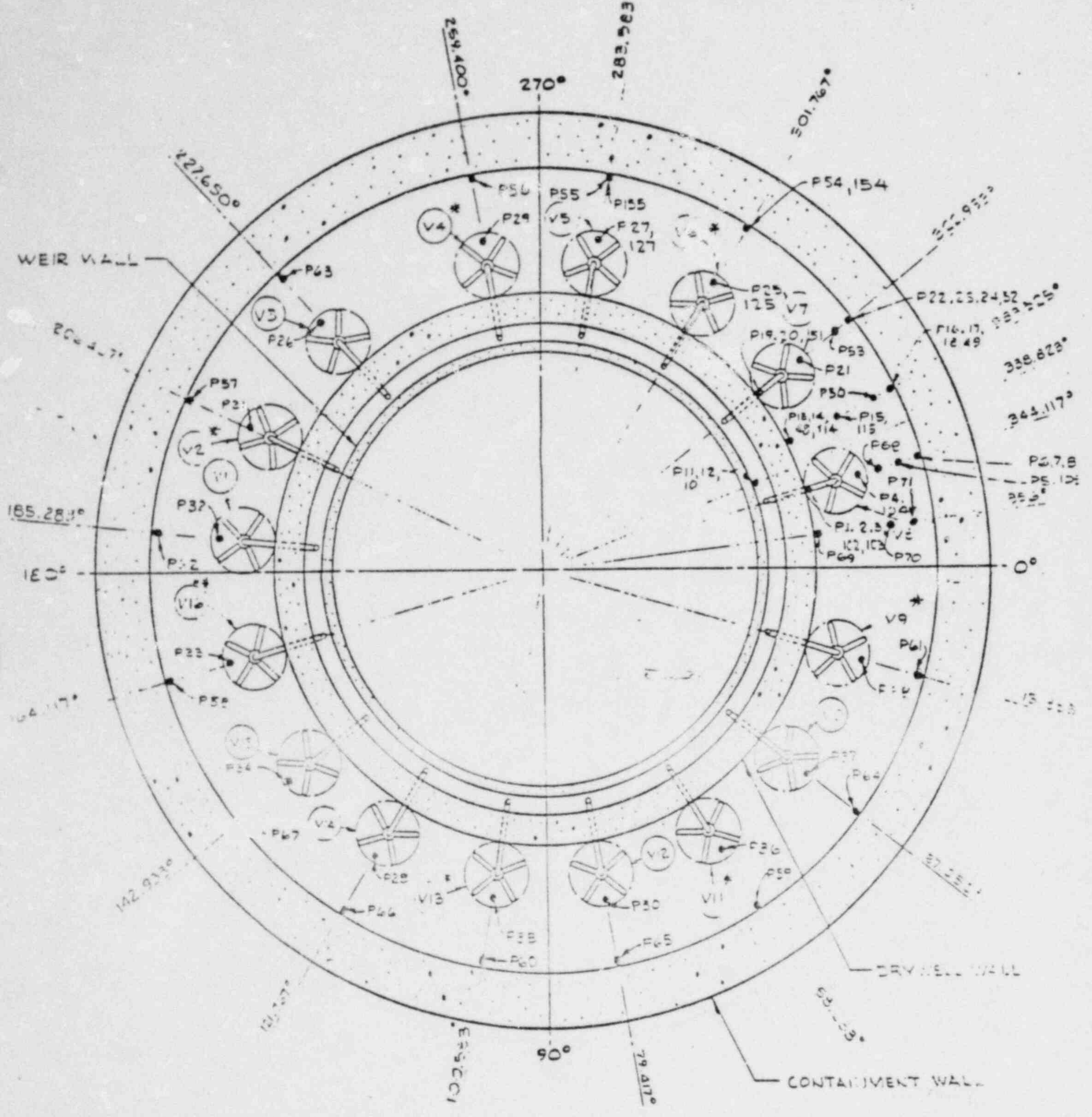
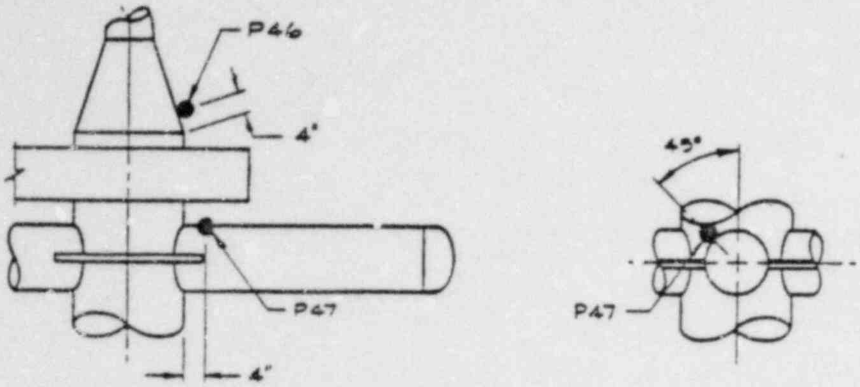


* INDICATES ADS SAFETY RELIEF VALVES

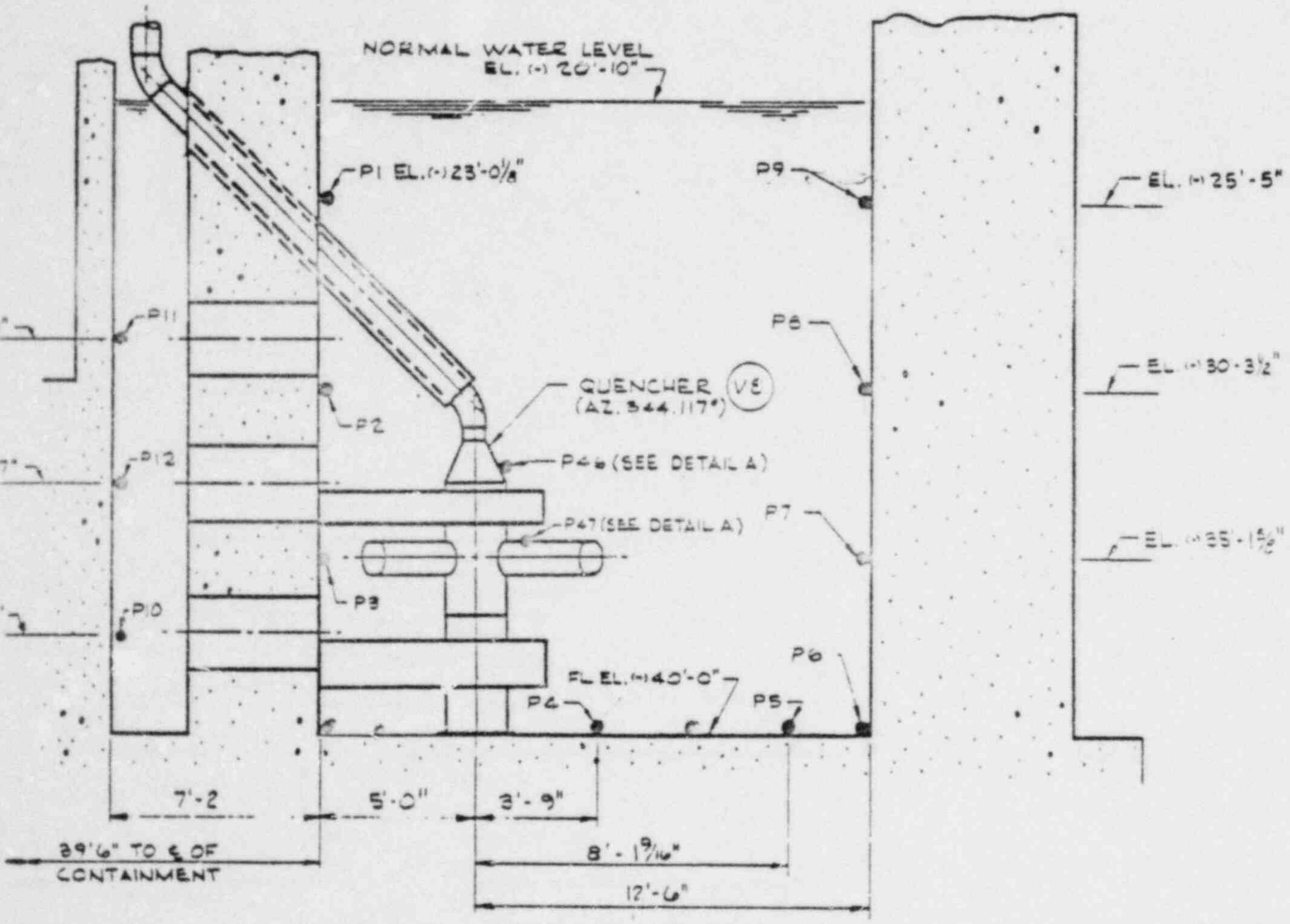
SUPPRESSION POOL PRESSURE SENSOR LOCATIONS

(PLAN VIEW)



DETAIL 'A'

QUENCHER ARMS ROTATED INTO VIEW
(P46, P47 MEASURE INTERNAL PRESSURE)



PRESSURE SENSOR LOCATIONS - QUENCHER V-8

(Elevation View)

NRC PARTICIPATION

IN THE

KUOSHENG SRV INPLANT TEST

- REVIEW AND COMMENT ON TEST PLAN (JULY 1980)

- NRC TEAM DURING THE TEST INCLUDED:

T. M. SU	NRR/NRC
P. HUBER	MIT/RES/NRC
E. MCCAULEY	LLL/RES/NRC
C. MOORE	EG&E/RES/NRC

- PARTICIPATE IN REVIEW OF TEST RESULTS TO DETERMINE WHETHER THE SUBSEQUENT TEST CAN PROCEED

- PROVIDE TECHNICAL GUIDANCE FOR THE TEST PROGRAM

9/23/81

SUMMARY OF THE TEST RESULTS

1. SRV LOADS

- STRAIN GAGE MEASUREMENT
  - VERY SMALL IN COMPARISON WITH EXPECTED VALUES
- ACCELERATION
  - WITHIN EXPECTED VALUES
  - SIGNIFICANT ACCELERATION IN POOL REGION ONLY (REQUIRES FURTHER INVESTIGATION)
  - FOUR VALVE TEST SHOWS SIGNIFICANT ACCELERATION ON CRANE GIRDER
- PRESSURE MEASUREMENT
  - WITHIN EXPECTED VALUES
  - SOME EXCEEDANCES (LOCALIZED LOADS)
  - NO SIGNIFICANT PRESSURE INCREASE FROM CONSECUTIVE ACTUATIONS

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II. POOL MIXING

- TOTAL DISCHARGE TIME - 9 MINUTES
- BULK-TO-LOCAL TEMPERATURE DIFFERENCE
  - 19°F WITHOUT RHR
  - 9°F WITH RHR OPERATING ONE HOUR BEFORE SRV WAS ACTUATED

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CONCLUSION

- FULFILL THE OBJECTIVES OF THE TEST
- STRUCTURAL MODEL OVERPREDICTED PIPING, EQUIPMENT AND BUILDING RESPONSE
- FORCING FUNCTION PREDICTION
  - FIRST ACTUATION MARGINALLY PREDICTED MAXIMUM PRESSURE FOR FIRST ACTUATION (REQUIRES FURTHER INVESTIGATION ON GLOBAL PRESSURE)
  - CONSECUTIVE ACTUATION OVERPREDICTED IN MOST OF THE CASES
- APPLICABILITY OF THE TEST RESULTS
  - SRV FORCING FUNCTION REQUIRES DETAILED INVESTIGATION BEFORE ANY CONCLUSIONS CAN BE MADE
  - THERMAL MIXING DATA WILL BE APPLICABLE FOR ALL MARK III PLANTS

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MARK III LOCA LOADS
FLUID-STRUCTURE INTERACTIONS

Are PSTF pressure measurements influenced by FSI?

GE approach: (1) Numerical models used to predict FSI effects.

(2) Predictions compared to 1/9 - 1/3 - and full-scale PSTF measurements.

Conclusion: FSI has little effect.

When FSI *is* significant, it leads to conservative load estimates.

Economos

FSI IN 1/9 - AND 1/3 - AREA SCALE TESTS

(ONLY CO CONSIDERED)

NUMERICAL ANALYSIS:

- FSI EFFECTS SIMULATED USING NASTRAN CODE.
- NO SIGNIFICANT EFFECTS FOUND IN EITHER TEST FACILITY IN THE RANGE OF CO FREQUENCIES ($\lesssim$20 Hz).

EXPERIMENTAL VERIFICATION:

- PSTF PRESSURE DISTRIBUTIONS COMPARED TO RIGID-WALL, POTENTIAL FLOW PREDICTIONS.
- RIGID-WALL ANALYSIS GENERALLY OVERESTIMATES PRESSURES AT ALL LOCATIONS.

NRC ASSESSMENT:

- AGREEMENT BETWEEN EXPERIMENTS AND ANALYTICAL PREDICTIONS IS POOR.
- ERRORS TEND TO MAKE LOAD DEFINITION MORE CONSERVATIVE.

FSI IN FULL-SCALE PSTF

(CHUGGING ONLY)

NUMERICAL ANALYSES:

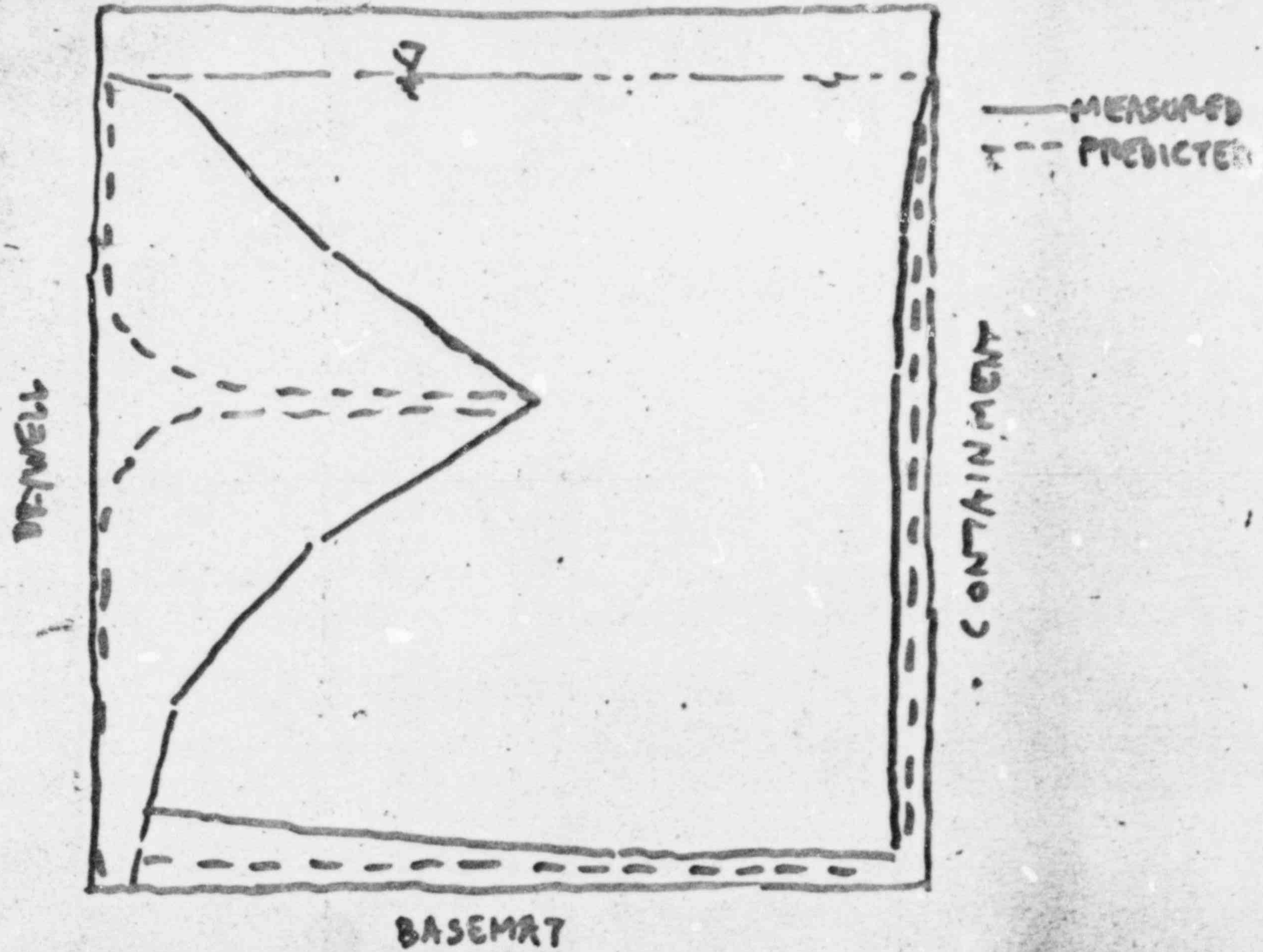
- TWO DOF MODEL WITH CHUGGING FORCING FUNCTION
- FINITE ELEMENT MODEL INCLUDING THE EFFECTS OF FLUID COMPRESSIBILITY

EXPERIMENTAL VERIFICATION:

- PREDICTED TRANSFER FUNCTIONS ($P_{TOP\ VENT}/P_{CONT.}$) COMPARED TO PSTF RESULTS
- AVERAGE OF SEVERAL CHUGS EXHIBITS ALMOST NO FREQUENCY DEPENDENCE

NRC ASSESSMENT:

- ANALYSIS APPEARS TO OVERESTIMATE FSI EFFECTS
- TRANSFER FUNCTION SHOWS ALMOST NO DEPENDENCE ON FREQUENCY
- FSI NOT IMPORTANT IN FULL-SCALE PSTF



COMPARISON OF MEASURED PRESSURE
WITH PREDICTION OF ACOUSTIC ANALYSIS
(FULL SCALE PSTP)

POOL THERMAL STRATIFICATION

- VERTICAL TEMPERATURE GRADIENT NEEDED FOR DESIGN (THERMAL STRESSES ON CONTAINMENT)
- DESIGN GRADIENT DEVELOPED FROM $\frac{1}{5}$ AREA SCALE PSTF TESTS
  - MONOTONICALLY INCREASING UPWARD
  - OVERALL ΔT MAX = 60°F
  - BASED ON FINITE CELL ENERGY DEPOSITION
  - TIMEWISE VARIATION OF GLOBAL (BULK) TEMPERATURE ACCOUNTED FOR

Economus

POOL THERMAL STRATIFICATION

- CONCERN:
  - ·· APPLICABILITY OF $\frac{1}{3}$ SCALE AREA DATA FOR PROTOTYPE (DISTORTED GEOMETRY)
  - ·· BREAK SIZE EFFECT (SBA, IBA, DBA)

- RESOLUTION
  - ·· NUMERICAL MODELING VIA RELAP COMPUTER CODE
  - ·· SHOWS SCALE EFFECT NEGLIGIBLE
  - ·· SHOWS IBA WORST CASE
  - ·· RELAP PREDICTION FOR STANDARD PLANT SHOWS ΔTMAX USED FOR DESIGN IS CONSERVATIVE (RELAP PREDICTS ΔTMAX = 56°F)

MARK III - SUBMERGED STRUCTURE LOADS

OVERVIEW

- PHENOMENA WELL UNDERSTOOD-METHODOLOGY PRACTICAL AND CONSERVATIVE
- RELATIVELY UNCLUTTERED POOL
- HERITAGE FROM MARK I AND MARK II CONCERNS
- SOME EXPERIMENTAL INFORMATION

Bienkowski

MARK III - SUBMERGED STRUCTURE LOADS

- LOCA
  - WATER JET LOADS (TO VENT CLEARING)
  - AIR BUBBLE LOADS
  - FALLBACK LOADS
  - CONDENSATION OSCILLATION LOADS
  - CHUGGING LOADS
- S/RV ACTUATION
  - QUENCHER WATER JET LOADS
  - QUENCHER BUBBLE LOADS

MARK III - SUBMERGED STRUCTURE LOADS

- LOCA WATER JET

APPROACH - REGION OF INFLUENCE

BASIS - EXPERIMENT AND CONSERVATIVE BOUNDS

CONCLUSIONS - NO STRUCTURES IN MARK III FOR WHICH JET LOAD IS NOT BOUNDED BY BUBBLE LOAD

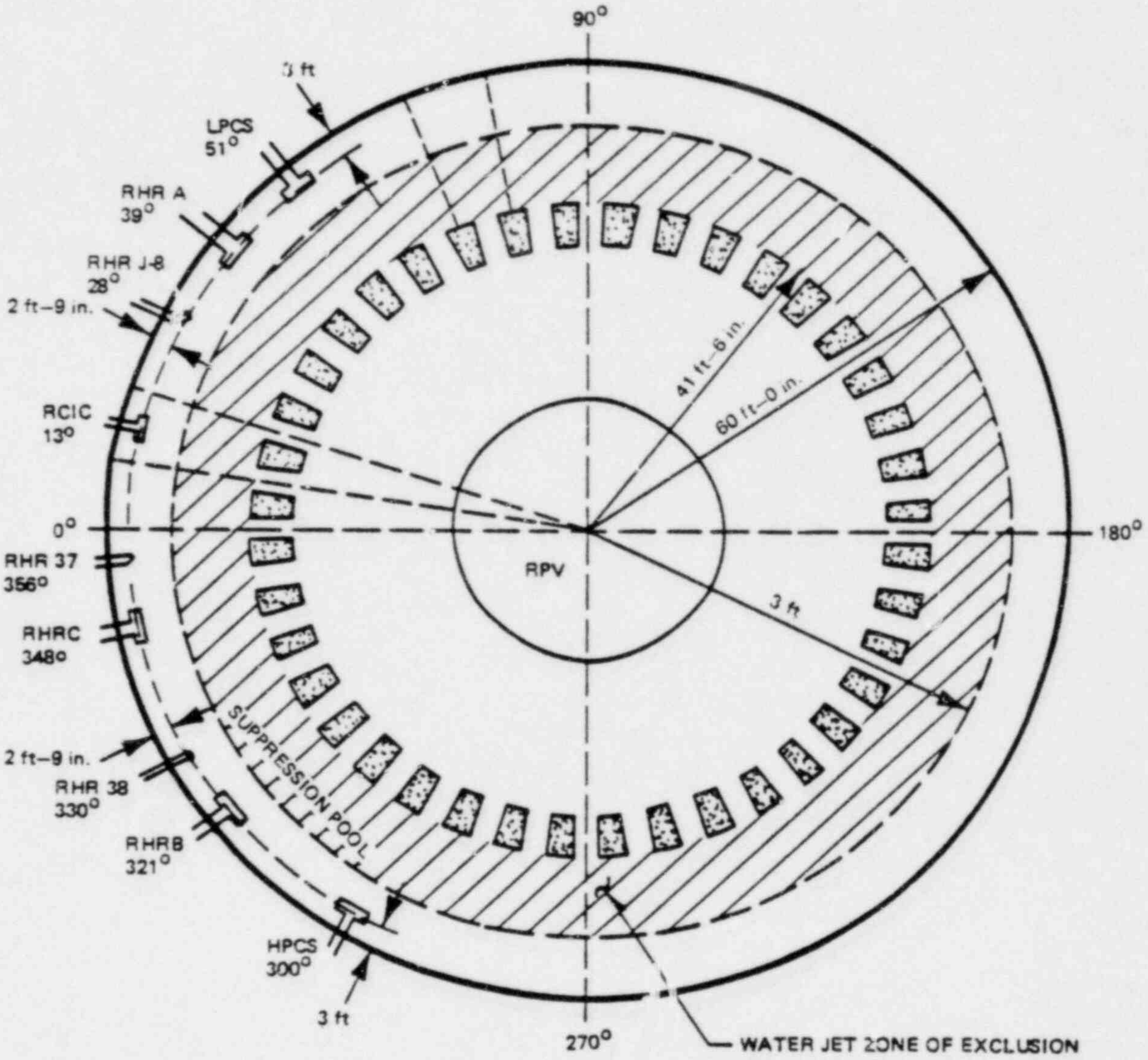


Figure 3B.31(a)-1. LOCA Water Jet Zone of Exclusion

GKB 9/25/81-4

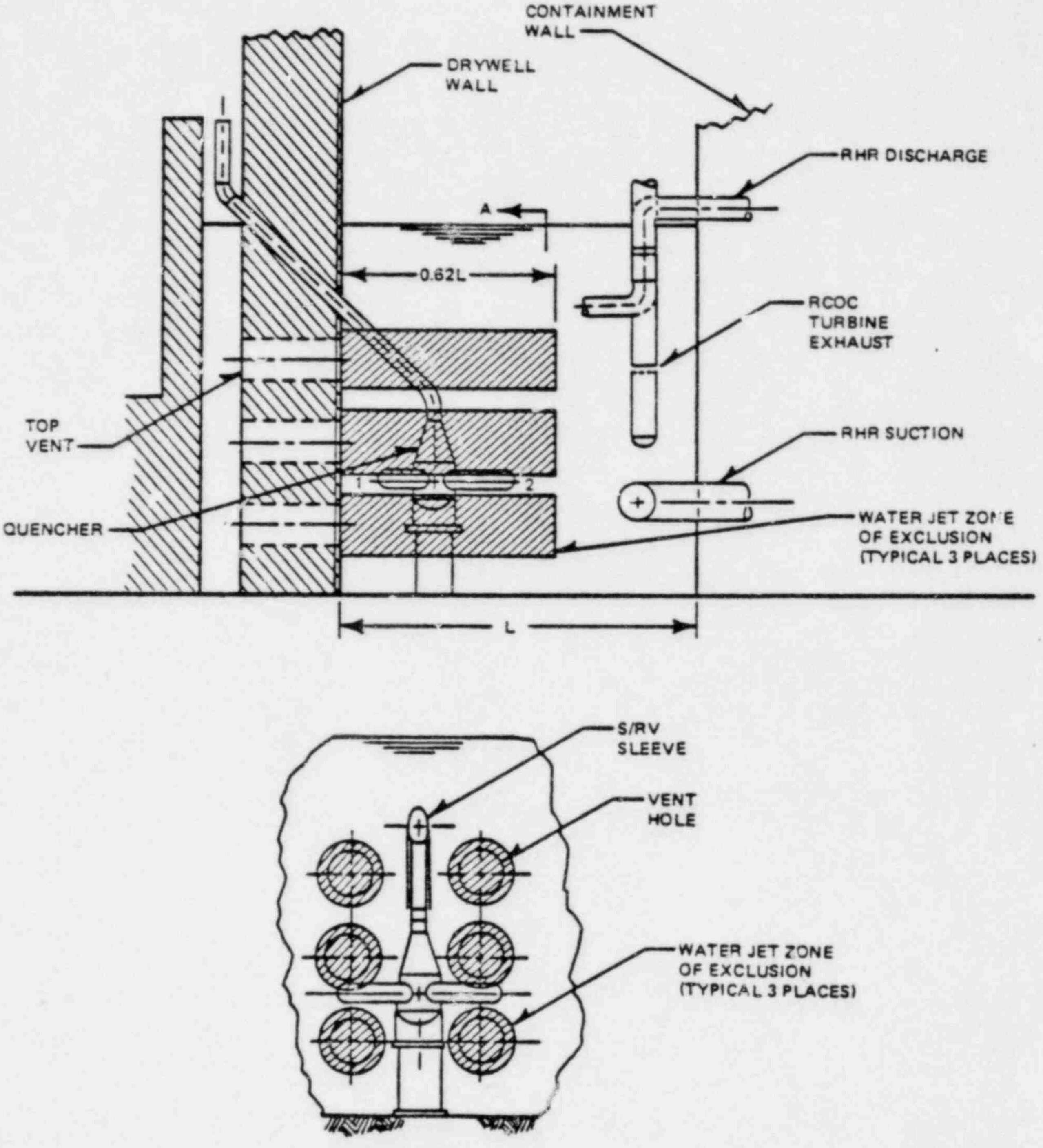


Figure 3B.31(a)-2. LOCA Water Jet Zone of Exclusion

GKB 9/25/81-5

MARK III - SUBMERGED STRUCTURE LOADS

- LOCA AIR BUBBLE

APPROACH - SPHERICAL BUBBLE GROWTH
METHOD OF IMAGES
MULTIPLIER OF TWO FOR BUBBLE MOTION
EQUIVALENT UNIFORM FLOWFIELD
LOCAL ACCELERATION AND STANDARD
DRAG ON EACH SEGMENT

BASIS - THEORETICAL/SOME EXPERIMENTAL CONFIRMATION

CONCLUSIONS - APPROACH ESSENTIALLY SIMILAR TO MARK I AND MARK II

MULTIPLIER FOR BUBBLE MOTION GIVES CONSERVATIVE BOUND ALTHOUGH DIFFERENT TIME HISTORY. O.K. BECAUSE $W_N T_b >> 1$

MARK III - SUBMERGED STRUCTURE LOADS

- FALLBACK LOAD

APPROACH - FREEFALL FROM S = 20 ft.
STANDARD DRAG ALONE AT U = 35 ft/sec

BASIS - THEORETICAL BOUND

CONCLUSIONS - CONSERVATIVE
- ACCELERATION FORCE NEGLIGIBLE

$$\frac{F_A}{F_D} \sim \frac{gD}{U^2} \sim \frac{D}{2s} \ll 1$$

MARK III - SUBMERGED STRUCTURE LOADS

- CONDENSATION OSCILLATIONS

APPROACH - SOURCE STRENGTH BOUNDS DATA
METHOD OF IMAGES
EQUIVALENT UNIFORM FLOWFIELD
ACCELERATION DRAG
STANDARD DRAG (ONLY WHEN SIGNIFICANT)

BASIS - THEORY + EMPIRICAL SOURCE STRENGTH
+ DRAG COEFFICIENT BASED ON OSCILLATING
FLOW DATA

CONCLUSIONS - CONSERVATIVE SOURCE EVALUATION
- STANDARD DRAG NEGLIGIBLE EXCEPT FOR RHR
TEST LINES ($D \approx 1.5''$)

MARK III - SUBMERGED STRUCTURE LOADS

- CHUGGING LOADS

APPROACH - EMPIRICAL SOURCE STRENGTH
- APPROXIMATE ACOUSTIC MODEL
- FORCE $\propto$ PRESSURE DIFFERENCE
- USE FULL PRESSURE DIFFERENCE IN CHUG PULSE

BASIS - THEORY
- EMPIRICAL CHUG SOURCE (FULL SCALE TESTS)

CONCLUSIONS - HYDRODYNAMIC MASS EFFECT BOUNDED BY CONSERVATIVE REPRESENTATION OF PRESSURE GRADIENT MINIMUM CONSERVATISM $\left({}^{2.54}/_{2.00}\right)$
- PHASING AND GEOMETRIC CONSERVATISMS DIFFICULT TO QUANTIFY
- SOURCE STRENGTH??

MARK III - SUBMERGED STRUCTURE LOADS

- S/RV LOADS

APPROACH - WATER JET - SPHERE OF INFLUENCE
- QUENCHER BUBBLE - SIMILAR TO LOCA BUBBLE AND CO METHODOLOGY
- USE FOUR BUBBLES AND INCLUDE BUBBLE TRAJECTORY CALCULATIONS
- ACCELERATION AND STANDARD DRAG

BASIS - THEORY WITH CONSERVATIVE INITIAL BUBBLE CONDITIONS
- EXPERIMENTAL VERIFICATION (CAORSO)

CONCLUSIONS - CONSERVATIVE LOAD EVALUATION FOR IN-PHASE BUBBLES
- NEGLIGIBLE PHASE DIFFERENCES ESTABLISHED BY TESTS