BEFORE THE

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON SAFETY PHILOSOPHY

TECHNOLOGY AND CRITERIA

- - -

Room 1046

1717 H Street, N.W.,

Washington, D.C.

Wednsday, February 4, 1981

T! e Subcommittee met, pursuant to notice, at 3:00 p.m., where were present:

For the Subcommittee:

DAVID OKRENT, Subcommittee Chairman
DAVID A. WARD
JEREMIAH J. RAY
PAUL G. SHEWMON
C. P. SIESS

Designated Federal Emp`oyee:

RICHARD SAVIO

8102060296

P R O C E E D I N G S

(3:00 a.m.)

MR. OKRENT: The Committee will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, the Subcommittee on the Safety Philosophy Technology and Criteria.

My name is David Okrent. The other ACRS members present today are Mr. Ward, Mr. Ray, and Mr. Shewmon.

The purpose of this meeting is to discuss requirements for near-term construction permit plants. This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act, the Government in the Sunshine Act. Dr. Richard Savio is the Designated Federal Employee for the meeting.

The rules for participation in today's meeting have been announced as part of the notice for this meeting previously published in the Federal Register on January 19th, 1981. A transcript of the meeting is being kept and will be made available as stated on February 6th, 1981. It is requested that each speaker first identify him or herself and speak with sufficient clarity and volume so that he can be readily heard. We have received no written statements from members of the public.

Before I say what I think the agenda is, I better find out from the staff what they think it should be with regard to timing.

MR. PURPLE: Mr. Denton is tied up in another meeting. He wants to attend this and does want to speak to the Subcommittee. But he is unlikely to be able to get here before 4:00 o'clock.

My name is Bob Purple from the staff.

Therefore, I would like to suggest that the staff portion of the agenda, which seems to come first, be deferred. One possibility is to reverse items two and three.

MR. OKRENT: When Mr. Denton comes, will he have a time limit on when he has to leave?

MR. PURPLE: I don't know the answer to that. I am not aware of any time limit.

MR. OKRENT: All right. I am going to propose we try the following agenda, subject to possible revision. We will begin with a presentation by Offshore Power Systems, and we tentatively allotted 45 minutes for presentation and discussion. By then, the staff representative should be here and they would then give us their current position with regard to requirements for NTCP plants.

Following that, there would be a presentation by Houston Lighting and Power. And after that we would hear from the General Electric Company and from Boston Edison.

I will not try to predict exactly where we are on the clock at that time, since we will just feel our way through the afternoon.

Does the Subcommittee want to make any comments beofre we begin?

(No response.)

MR. OKRENT: All right. So Offshore Power is up.

MR. HAGA: My name is Blair Haga. I am director of power systems technology at Offshore Power Systems.

We are very happy to be here today. As you know, our application is now about eight years old. We would like to make a little progress and we hope we can do so. I sincerely hope that the Subcommittee and the full Committee, as a result of this week's meeting, will see fit to take a positive position on moving forward with our application. We of course believe it is long past due.

We have presentations today in an area that has been most difficult, the degraded core and specifically how to cope with hydrogen resulting from zirconium-water reactions. We have two presentations following my remarks. And then I will summarize for a suggested position on this subject.

The first presentation following me will cover the functional capability of the containment structure and the potential for increasing that capability. The second presentation will cover analytical results of hydrogen combustion within the floating nuclear plant containment.

Before proceeding with these two main presentations, I would like to discuss with you the proposed NRC requirement for a flanged containment penetration for potential future installation of a filtered venting system. As we will show in our later presentation, we really see no significant gain in coping with hydrogen-burning transients by employing such a vent. However, if it becomes a requirement to do so, we can provide such a penetration or penetrations.

MR. OKRENT: Excuse me. Was it your understanding that the only reason the staff was interested in such a penetration was in regard to hydrogen burning?

MR. HAGA: No, it was not. I just wanted to make that point.

This slide --

(Slide.)

-- shows a section through the floating nuclear plant. Can you see that with the lights on?

And I want to show you just how we would employ these penetrations. They would be placed in the upper dome of the containment. I think it is very important to understand how we would propose to use these in the future if that becomes a requirement.

Attached to these penetrations -- and I will come back to this in just a moment -- would be piping that proceeds directly down between the containment and the shield building and straight out the bottom of the platform into the basin water. There would be four of these 18-inch pipes, which are equivalent in diameter to the suggested 36-inch diameter penetration.

We would seal those with a rupture disc, probably here (Indicating), although it could be placed down here (Indicating) if that proved more advantageous for in-service checking and so on. A rupture disc can be permanently sealed. It becomes part of the containment barrier itself.

MR. RAY: Mr. Hagar, I have a little trouble with the concept of a permanently sealed rupture disc.

MR. HAGA: Yes?

MR. RAY: If it can be ruptured, it is not permanently sealed. Would you explain that to me?

MR. HAGA: I mean by that it is not a valve or a gasketed closure. It is permanently welded and is a physical barrier.

MR. RAY: But within that seal there is this disc which can be ruptured by pressure or manipulation or some penetration?

MR. HAGA: By pressure.

MR. RAY: By pressure.

MR. HAGA: This (Indicating) is the disc here.

Now, another feature of this configuration is any pressure leak that occurs through this vent system is then automatically sealed by a water seal equivalent to 15 pounds per square inch gauge. If the disc ruptures and pressure is relieved, when everything settles down again there is still a back pressure on the containment of 15 pounds per square inch. It is sealed by a water seal.

We think it is important to use something equivalent to a rupture disc or a rupture disc, because we believe it is highly desirable not to involve the operator in a decision to open up a vent in the containment.

MR. WARD: Could I ask, Blair, with a backup pressure of 15 pounds, are the four 18-inch lines equivalent to the requirement of a 36-inch line?

MR. HAGA: Dr. Walker will present some analytical results of this later. So you will see what the influence is of that back pressure.

As we envision this system, then, it really is a safety valve on an ASME code vessel. It is used when something has gone wrong and the pressure is exceeding design pressure. It acts to relieve that pressure and protect the vessel.

This configuration would not require the operator to make a decision that something is wrong, I must open up the containment. It can be set. The disc can be set at a pressure somewhere between design pressure and functional capability of the containment.

For examplel if the containment capability is 60 pounds per square inch, it is designed for 20 pounds per square inch, it could be designed for 40 pounds per square inch. You would know something was clearly wrong and pressure was rising.

MR. OKRENT: And you wouldn't be worried about losing the pool of water?

MR. HAGA: That's right, in this case.

I have one more slide for now, which is just a plan view of what you are looking at. You can see the four 18-inch pipes with rupture discs. It enters the annulus, proceeds around to a convenient location, and goes directly out through the bottom of the platform.

There are shielding requirements that go with the system. By placing the pipes inside the shield building, we have no additional requirements above the main deck of the platform. However, beneath the deck we would have to add some shielding, and also on the control room and the relocation area just below the control room.

Looking back at the previous side, you can see that. We would have to add a foot and six inches of concrete extra here on the control building and shielding here (Indicating). And each pipe would have to be shielded beneath the platform.

There are two reasons for the shielding. One is the continued presence of gases in here subsequent to the release. The other is the bubble of radioactivity that would be released beneath the platform and would proceed upwards through the water into the atmosphere. But this amount of extra shielding would limit doses to the current criteria we are using.

I would like to mention one more thing. The added weight to the plant is about 3600 tons for this system. That increases the draft by a little less than one foot. The draft is about 33 feet. So you are looking at maybe almost 34 feet for the system.

MR. SIESS: I missed what that structure on the right has to do with the gas bubble.

MR. HAGA: Well, the pressure relief would occur here, come down and out the bottom of the platform. Particulates and solubles would be picked up in the water. The krypton would proceed along the bottom of the platform and bubble up through the water and provide a source for radiation in the control room and the relocation area.

MR. SIESS: I see. That is the control room on the top. So you are putting shielding around it.

MR. HAGA: It already has existing shielding. But this side is not shielded in the existing design. And now we have shielded it and we have added shielding here

(Indicating).

Yes?

MR. RAY: I presume there will be occasions when there will be personnel on the platform outside the control room?

MR HAGA: Yes.

MR. RAY: Will there be any alarm or alert system to use with this, the operation of the rupture disc, that would warn them that such releases may take place, so that they could seek shelter or close themselves in?

MR. HAGA: The floating plant design includes an emergency relocation area which is in the same building, and these two locations here, they are shielded already. And in the event of a loss of coolant accident, the personnel would proceed to these areas until told to leave.

MR. RAY: So your point is that they should be in those areas before the disc ruptures, is that right?

MR. HAGA: Yes. They should already be there if there is an accident occurring, and they should not leave there until instructed to do so, for whatever purpose.

MR. RAY: Thank you.

MR. SHEWMON: Is it obvious why, if you have your people all on that side, you don't vent it out the other side?

MR. HAGA: No, it is not. But also, there is an adjacent plant to worry about. So it is necessary to protect all sides of this control room.

MR. SHEWMON: All right.

MR. HAGA: And the relocation area also.

All right, that completes my remarks for right now. Mr. Orr will give the next presentation, which will concern the structural capability of the containment.

MR. ORR: My name is Richard Orr. I am chief structural engineer with Offshore Power Systems.

The purpose of my presentation today is to discuss the functional capability of the containment as currently designed, and also to describe some slight modifications that could be made to increase the capability.

I would like to start by showing you a viewgraph we presented to ACRS back in, I believe, the end of 1979. It was submitted as a response to some of the questions on TMI. At that time we calculated the capability of the containment. And let me just quote some of the typical numbers, and I will on the next viewgraph go over some of the methods.

What we were showing was that the lowest capability was at the top course of the shell, a pressure of 49 psig at a location where the plate thickness is five-eighths of an inch, and there are also ring stiffeners and longitudinal stiffeners.

MR. SIESS: Sequoyah was how thick at that level?

MR. ORR: Sequoyah at that level is one-half inch.

All of the other locations have greater capability. The nearest was the equipment hatch at 55 psi.

Since that time, in response to the recent questions, we have had another look at these analyses and have updated some of the numbers. Back in 1979, the viewgraph you just saw, limiting capability, 49 psig, that was calculated assuming actual material properties. And clearly, as we haven't built the vessel we had to make some assumptions there. And we assumed we would achieve actual properties of at least 120 percent of yield.

Since that time we have looked at some numbers on Sequoyah and Maguire, and in both cases their actual yield values are greater than this percentage above minimum yields. We looked at the capabilities of a number of sections above the platform, and at the time we conservatively estimated a capability using elastic analysis. All we were trying to demonstrate was there were no locations in the platform weaker than the top course of the shell.

In going back recently to look at the capability, we have changed the numbers a little bit. The limiting location of shell, the five-eighths plate, we have now recalculated using a Von Mises yield criteria instead of the Truscan yield criteria.

I made a presentation in September on the Sequoyah containment analyses in which we demonstrated by a finite elements elasto-plastic calculations that, firstly, the hand calculations and smearing out of the hoop stiffeners was a valid approach; and secondly, the effect of using Von Mises instead of Trusca was an increase of about 15 percent.

We have also gone back and reviewed each of the locations in the platform. Typically, the platform consists of a plate that spans between stiffeners. The stiffeners in turn span between girders. And the girders span between bulkheads.

So most of these elements behave as fixed beams. We have gone back and calculated the capability using plastic analysis, assuming a three-hinge collapse mechanism. d typically, the capabilities have doubled above the elastic analysis capability we showed in the previous estimate.

The results of these analyses are now shown on this updated viewgraph.

(Slide.)

Looking at the shell, first of all, the limiting location was 49 psi. It is now 55. The other thickness plates have gone up proportionately. Our limiting locations now is above the five-eighths inch shell at 55 psi and the head on the equipment access hatch, and the vessel internal pressure, which is an external pressure on the head, also of 55 psi.

Some of the capabilities in the platform: the lowest one is 138 psi; and at another location, 157, 168, 215. All of the plating, stiffeners and girders are substantially greater capacity than the shell.

The one location I have not addressed is the connection between the shell and the platform. On the previous slide it was 71 psi. This slide shows 80. And I would like to show you a little bit of the background for that calculation.

This viewgraph shows a plan view of the containment where it lands on the platform. The containment shell is 120 feet in diameter and the platform construction, it is a web frame construction with full deck bulkheads. The main platform bulkheads, bulkhead 3 and bulkhead 4, in one direction; and locally in the containment area we have additional bulkheads, bulkhead frame 2C, bulkhead frame 4B.

In the longitudinal direction, we have bulkhead F, bulkhead G, bulkhead H, bulkhead I. These are 37 foot 9 centers. Because the bulkheads are full depth, they are considerably stiffer than the other deck framing. And typically the shell -- uplift on the shell is resisted at the hard spots represented by the intersection of the shell with the bulkhead. We have designated them around the periphery A through N, and we will be seeing on a later table the capabilities.

I would like to show a slightly expanded detail of one quandrant of the platform interface. This is just an expanded view of the previous one, with the addition of some of the web frames. Again, we have bulkhead 4, bulkhead 4B, bulkhead H and bulkhead I.

The other lines that are shown, firstly, inside the shell there is the location of a pressure bulkhead, which is the portion around the reactor cavity and the incore instrumentation. These other lines represent web girders on the main deck. Typically they are between 54 inches and about 10 feet deep, and they are at centers of about 5 to 6 feet apart.

The next view is immediately above the main deck and shows the structure on the containment shell. Where the shell crosses either the bulkheads or the web girders, there are chocks stiffeners welded to the shell that line up with the structure underneath. And putting the two together -- if we are lucky, the viewgraph lines up as well as the structure will. And one can see that the chocks are lining up with both the bulkheads and the girders.

In some locations, we consider the hard spot locations, we are considering that the shell is tied down and hence where the shell and the chocks line up with either the bulkheads or some local structure attached to the bulkheads, we have what we call backup structure.

And it is difficult to see on this view just what overlaps. The next slide picks out only that overlapping portion, which is considered as backup structure. There is a portion here where the shell is crossing a bulkhead, where there are additional members welded to the bulkhead to line up with the shell. And there are also flanges that line up with the chocks on the shell.

The same at this bulkhead, the same at a bulkhead here. And once we get on this portion, the shell is very close to the location of the bulkhead. They are a few feet apart. And so a whole series of chocks are added to both the bulkhead and the shell, lining up.

The next view will be a developed view which shows this quadrant (Indicating) and its backup structure. This is the same quadrant we were looking at.

This is the center line in the after end of the containment. This is bulkhead H, which is one of the longitudinal bulkheads. This is bulkhead frame 48, which is one of the transverse bulkheads; bulkhead 4, which is a transverse bulkhead; bulkhead I, which is a longitudinal bulkhead.

And because of the longitudinal bulkhead, one switches from the longitudinal into transverse. As you can see, where the shell crosses a bulkhead we have substantial bulkhead structure added to the bulkhead, which carries the loads all of the way down until it tapers down at the bottom shell of the platform, 40 feet deep.

Detail AA is shown in the next viewgraph. Here we have bulkhead H, the portion of the containment shell above the main deck, and the shell lines up with these plates at each side of the bulkhead, and a flange. View BB shows these flanges tapering off to the bottom section.

And also, above the main deck there are these chocks on the shell, going up a height of 8 feet to the first hoop stiffener.

In estimating the capability of the backup structure, each of them is a little different. It is a series of hard spots.

What we have done is identified the area of backup structure, which is that area of material common to both the shell and the platform, and on the next table I will be showing the area is identified in each of these hard spots.

Then to calculate the capability and see how it varies around the circumference, we have just arbitrarily assumed spreading the backup structure -- have the backup structure at, say, this location to this arc link, after this arc link, and the same up here; the arc backup structure E over this arc link after this one.

So for each arc link we have smeared out half of the backup structure at each arc end. So the support locations A through N, as on the previous chart, the support area is the common area between the shell and the platform, and varies from 126 square inches up to 276 square inches.

We have calculated the equivalent shell thickness between, for example, E and F. We have taken half of 126 square inches, half of 256 square inches, divided it by the arc link between E and F, and come up with an equivalent thickness of .79 inches.

We have done that at each location to get an ide of the pressure capability. We have taken this thickness and assumed that it is a spool periphery and calculated the pressure in the shell that would produce, yield stress in the shell.

Now, this yield stress is assumed actual yield stress equal to 120 percent of guaranteed minimum, so these numbers represent an estimate of the yield capability at each of the hard spouts.

They vary between 61.86 psi and 137, so one can see that there is quite a lot of non-uniformity around the circumference. The 61.8 at the four location, 61, 61, 63 and 63 -- they occur in the four quadrants, and we will look at between B and C.

MR. BENDER: Richard, when you say that is the equivalent pressure capability, what are you saying? That there is some limiting strain that is acceptable?

MR. ORR: This number corresponds to yield stress only, and this is the basis for our calculation. We think we have margin, because probably rupture doesn't occur until you get to tension capability.

MR. BENDER: But when you say yield stress in this case, you have taken the stiff intersection, whatever it is, and distributed it across the membrane in some way.

MR. ORR: Well, effectively what this gives you is the load capability of each of these hard spots, and if you add up all of the load capabilities and compare that against the upward pressure on the dome, that gives us the pressure capability for the backup structure.

MR. BENDER: All right. Go ahead.

MR. SIESS: Dick, this is for the equivalent vertical stress, right?

MR. ORR: Yes, because this is the backup structure immediately below the main deck. Vertical stress is not seeing any gravity.

MR. SIESS: This is what it takes to hold it down.

MR. ORR: Correct.

MR. SIESS: But how good is that smearing technique?

MR. ORR: Let me try and address it. I am about to come to it.

MR. SIESS: Fine.

MR. ORR: That is one reason I am quoting the yield magnitude, not the ultimate magnitude. The locations that are lowest here are between B and C, between B and C, between D and E, between H and I, between K and L.

It also so happens that the areas that have the greatest capability are immediately adjacent. They are these locations (indicating) and I don't see that there is any problem with some of the load redistributing from here (indicating) to here (indicating).

So what we then did is to say, all right, assume the load redistributes. Let's look at the two halves. And we said, let's take all A to F on one-half and the G to M on the other half.

The reason we did this is it is a little asymmetric this way and the other way it is symmetric. So at the bottom we have smeared out the right-hand side and the left side, and here the equivalent pressure to reduce yield is 89 on one side; 81 on the other side.

Clearly it does not help to have one side holding if the other side has already given way, so we take the lower one and say we can consider the pressure capability is 80 psig.

Coming to the questions raised of, well, can one really smear this, are they hard spots that cannot redistribute, we think there is conservatism in our analysis.

Two areas are definitely conservative. One is we are using yield stress of, in this case, 45.6 KSI, where at these locations the deformations associated with large strain would not create problems because they are very local.

In reality rupture should not occur until we get up to the tension capability. This is 516, grade 70 materials, so probably ultimate capability is going to be 75 to 80 KSI in the material.

MR. SIESS: Are you welds as ductile as the base material?

MR. ORR: The welds are stronger than the strength of the base material. The weld qualification requires that the weld, the test of the weld and the weld qualification procedure must show at least the minimum strength of the base metal.

So the weld can develop the yield capability definitely. It is questionable once you get to the full tensile capability whether it is the weld, the heat effect or the base metal that is going to fail first.

MR. SIESS: How ductile are the welds?

MR. ORR: They are fairly ductile.

MR. SIESS: Because you can simply compute how much conditional strain you would have to get in those low stress areas to get the whole thing up to your average, can you not?

MR. ORR: Typically the welds have greater suction properties than the base material itself. This is a T joint. It is a full penetration weld with a fillet, in addition, so that the minimum section is going to be just probably adjacent to the weld.

MR. SIESS: If you just subjected this to uniform strength, you just pulled it up, when you got up to the maximum strain you could put on it would be the yield strain for the strongest part of it. The others would all be at yield, and then that would yield.

MR. ORR: I think the main question is how much flexibility there is in the platform. You are going to be able to redistribute the load from the slightly softer hard spots to the stronger hard spots.

MR. SIESS: Flexibility helps.

MR. ORR: Flexibility helps, yes.

MR. SIESS: The worst case you could have would be uniform strain in the early yield areas. It would go plastic. It is just a question of how much strain they could take to redistribute to the others.

Now, if it is more flexible, it doesn't take that much, right?

MR. ORR: Right.

MR. SIESS: And maximum strength you can get is that 137 psi elastic strain, and then you have got the whole thing if it is rigid. Isn't that right?

MR. ORR: Right.

MR. SIESS: So that's not very much strain. That is twice the yield strain.

MR. ORR: We feel comfortable one can indeed develop the total yield capability because of the ductility of the weld and the ductility of the local regions.

The other area of conservatism is we have assumed all of the uplift on the shell is taken out at these hard spot locations. In practice there are locations on the main deck where the pressure load acts on the web frames on the girders, and the girders in turn carry the load back to the shell.

So there is both a reduction in load that has to be carried by the hard spots, and in addition, there is the material in thewebbed girders themselves which are capable of resisting some of the uplift.

We have not taken credit for it because it is difficult to quantify the relative stiffnesses and how much load goes into the web frames and how much goes into the bulkheads.

MR. SIESS: What about the stress in your shell just above those checks? The stress in the shell won't be uniformly distributed.

MR. ORR: It will be highly non-uniform, but it will still be elastic in that portion of the cell.

MR. SIESS: So that is a thick shell?

MR. ORR: It is at least an inch and three-eighths. We think we may have to go to an inch and a half because at that level of stress is the top-up portion of the shell; five-eighths inch plate will clearly be inelastic.

MR. BENDER: If you could put that figure 20 on for just a minute, it must have been the fourth slide -- yes, it was that one.

MR. ORR: This was the capability as we presented it back in 1979.

MR. BENDER: Can you point out on that thing where it is you are computing the stresses a little better?

MR. ORR: Yes, we are computing the stresses corresponding to the connection of the shell to the main deck. The shell is one and three-eighths inch. The main deck is one and one-half inches.

Some of the backup structure immediately below the shell, because it is only taking the longitudinal component of the load and does not have to take the hoop component -- the shell does. The backup structure is actually thinner than this material.

MR. BENDER: You are computing a stress right at that corner. Is that correct?

MR. ORR: It is immediately below the main deck.

MR. SIESS: To tie down the whole structure holding it.

MR. BENDER: Thank you. I was just trying to understand it better.

MR. ORR: Okay. We have reviewed the backup structure. We have already got in in this location in the platform, and we think we are fairly close to the maximum we can get in.

There is a lot of piping, systems and mechanical components in the area. It is difficult to put an additional structure up. So we feel the 80 psi number is about the limit of the current design.

We have looked at what is involved in increasing the other locations to the same 80 psi capability, changes we have to make. We have to increase the thickness of the top course. It is elevation 189. This should read elevation 224, and we increase it from five-eighths to one-inch plate.

We increase the shell courses that are currently seven-eighths to one-inch plate between elevations 162 and 199. Then we have various options on how to increase the capability of the equipment patch.

The brute force is just to increase plate thickness from one inch and three-eighths to one inch and three-quarters. There are alternatives. We can add stiffeners because the limiting conditioners is a buckling condition, so we can add stiffeners to prevent buckling, or we can reverse the orientation at the head so the pressure it seizes on the inside radius instead of the outside radius.

So any one of these options can be used.

Just in summary, we feel the existing shell is capable of withstanding a pressure of 55 psig. The capability of the shell-platform interface, 80 psig, and it would be possible to increase the capability to modify the shell courses and equipment patch to obtain that 80 psig at all locations.

Thank you.

MR. SIESS: What is your design pressure.?

MR. ORR: The design pressure is 15 psig.

MR. HAGAN: Dr. Walker will present the analytical material on hydrogen combustion.

MR. WALKER: The purpose of my presentation is to discuss with you the results of our containment pressure calculations for hydrogen burns in the ice container containment.

As you show, Offshore Power Systems is the developer of the classics code, and this code was used to calculate pressure transients resulting from hydrogen burns from holding compartment containments like ice condensers for degraded core condition.

The code was used extensively for the Sequoia hydrogen burn transient calculations and was discussed with ACRS during review of that calculation. The calculations which I shall report to you today were performed with this classics code.

The first viewgraph presents results of bounding calculations. This is for an adiabatic burn of hydrogen, and the pressure is plotted as a function of the pounds of hydrogen burn. The calculations, first of all, assume uniform mixing of the generated hydrogen prior to the burn.

MR. SHEWMON: Sir, down there it says "Mass of hydrogen in containment." That is not right. It was actually what was burned, is that right?

MR. WALKER: What we are assuming is complete burn once it ignites. So it is the mass of hydrogen in containment where these adiabatic calculations, it is assumed that all of that hydrogen burns.

MR. SHEWMON: Whereas, that is really physically impossible?

MR. WALKER: Yes. These are adiabatic.

Just for a benchmark, the 2200-pound number at the end of the bottom axis is indicative of all of the core zirc water. In these calculations, individual burns were assumed in each of the compartments, and the highest pressures were generated in the upper compartment where the burn lasted the longest.

The calculation showed, with the conservative adiabatic assumptions, very high pressures would be generated for hydrogen in excess of about 1000 pounds. They would exceed our containment capability that Mr. Orr just discussed. Also, on these calculations, a six-foot-per-second flame speed was assumed.

On this next viewgraph are numbers generated for adiabatic burn calculations. The purpose of the calculations was to assess the reduction in pressure that might be realized with the vent pipe concept that Mr. Haga showed you at the beginning of our presentations.

In this set of calculations in the middle, we assumed there were 30 feet of water in the vent pipe. Calculations were performed for a 10-square-foot vent area, which is a little more than represented by the four 18-inch pipes, for a five-square-foot area, which is a little less, and, of course, for no vent, for comparative purposes. And for various fractions of zirc water reaction, hydrogen released, 25, 50, 75, and 100.

In addition, we assumed ruptured disks set pressures of two values: 45 psig, and 22 psig ruptures. The 22 rupture pressure represents an increment above current containment design. And the 45, an increment below what we have calculated to be current containment capability. You will remember that number was about 55 which would be contained as currently designed.

As you note, when you get to large fractions of zirc water reaction, there is some reduction in peak containment pressure attributable to the use of the vent pipe here from 114 to 90, for the high-rupture pressure again from 114 to about 90. And these rapid pressurized transients, the rupture disk pressure setting doesn't make a lot of difference to the peak pressure region.

But you will note for zirc water fractions, like 75 or 100 psi even with the vent system present, the ultimate pressures in these bounding calculations exceed containment capacities. The vent system is simply not effective in preventing containment overpressure.

We also did a calculation assuming that we would clear some of the water from the pipe in some manner to determine whether or not the fluid column in the vent pipe had any effect on the pressure response. You can see it has very little effect when you compare two values with a 30-foot and 3-foot water head.

MR. BENDER: If I understand the zirc water percents properly is it all the zirconium, or are we talking about just the cladding? When you say 75 percent zirc water reaction, is that 75 percent of the cladding or 75 percent of the cladding plus structure?

MR. WALKER: I think we have assumed all of the zirconium in the core.

Am I right? Let me ask Mr. Perry back there.

MR. HAGA: That includes all of the zirc alloy. The tube as well as the plugs at the end. That is in the core.

MR. SHEWMON: Let me confuse the question further. I think where this has come up is in BWRs where their channel block is that and maybe stuffed top and bottom. Now, in your case, you don't have any of the channel boxes, the plug is still just part of the fuel element. Is there a structure up above for pickup and flow deflection and other things?

MR. WALKER: I am not completely up to date. But to my knowledge, there isn't any other zirconium. The rest of the structure is stainless, and the grid structure is not zirconium. But I could be out of date with the latest.

MR. BENDER: I was just trying to make sure we understood.

MR. SHEWMON: Okay.

MR. WALKER: Just in summary, from this viewgraph we conclude that a vent system of reasonable size is not effective in preventing excessive hydrogen pressures for a hydrogen burn transient. Similar conclusions have been reached in the industry and by NRC staff, as reported to you by Mr. Ross at the January full committee meeting.

Just in response to an earlier question by Mr. Ward, just so you are clear, before 18-inch pipes represent a vent area equivalent to a single three-foot diameter pipe.

MR. WARD: Well, the flow resistance of the path depends upon the length of the pipe and the back pressures at the submergence here is significant, I presume.

MR. WALKER: Yes. That was included in the calculation.

MR. WARD: Yes, I can see where these calculation results include that. But if the requirement is a 36-inch hole, the four 18-inch pipes will not be quite the equivalent of that, I should not think.

MR. WALKER: Right.

MR. HAGA: Let me make a comment. Regardless of what kind of system you place downstream of that hole, there will be resistance and it will be comparable to resistance experienced in this system. Any filtering medium or any pipes that connect to that penetration will also have pressure drop and resistance. It will end up to be comparable.

MR. WARD: Well, I guess it may or may not. Who knows.

MR. OKRENT: I guess your result for the modest effect of a 3-foot diameter vent on hydrogen burn is, as you say, what one had before and does not come as a surprise. And I am sort of curious why you show it this way, since I have not assumed this is what the staff had in mind when they said that such a provision be included.

Was it your impression that they had in mind it would be useful for hydrogen burning under the circumstances you postulate then?

MR. WALKER: Not recently, no. In earlier times I think there was some question in that regard.

Okay, the results of additional hydrogen calculations. Passive heat sinks have been incorporated in the clasix code, into our clasix code. But not yet radiation heat transfer.

I would like to show you now the effect of the passive heat sinks and the containment safeguards which include sprays and coolers and then ice. These will be in a series of viewgraphs.

MR. SHEWMON: If a passive heat sink does not allow for radiation, what does it allow for?

MR. WALKER: Marty, would you like to explain how that is modeled? I will let the modeler explain that to you.

MR. FULS: Martin Fuls, Offshore Power Systems.

All this has is various correlations for the heat transfer using Tagami,Uchida. This one was using the Tagami.

MR. SHEWMON: I am a simple country boy. Come on.

MR. FULS: Convected heat transfer.

MR. SHEWMON: Thank you.

MR. WALKER: Passive heat sinks are in the first, and you can see there is some reduction in containment pressure when these effects are accounted for.

The second viewgraph adds the effect of the containment, full containment safeguards, which include sprays and fan coolers.

MR. HAGA: Excuse me. There aren't any coolers, just recirculation fans.

MR. WALKER: Excuse me. Just recirculation fans. Okay. You will see that on this. This line is extended. The 80-pound pressure capability is reached at around 2000 pounds of hydrogen burn.

MR. SHEWMON: The cooling then doesn't blow anything more past the ice or the fans; it does increase the amount of convective heat transfer? Is that what we are seeing here, or is there another sink?

MR. WALKER: Mr. Perry will address that question.

MR. HAGA: The primary effect is the spray system.

MR. SHEWMON: I misunderstood an earlier comment then.

MR. HAGA: There is some effect from the recirculation from the fans which flows through the ice.

MR. SIESS: But there are no fan coolers?

MR. HAGA: There are no fan coolers.

MR. BENDER: How fast is this happening when we are talking about picking up the heat with sprays?

MR. HAGA: This is a 20-second burn time.

MR. BENDER: And the sprays act fast enough to do that? Fine.

MR. SHEWMON: It is assumed the sprays were in operation, so there is a burden of moisture around, particulate, I assume, that is evaporated by the front or something.

MR. OKRENT: Instead of singing in the rain, you are burning in the rain.

(Laughter.)

MR. WARD: Could you sketch in there the point where the line for the vented containment would be?

MR. WALKER: The line for the vented containment?

MR. WARD: Yes. I mean if you had these four 18-inch lines.

MR. WALKER: Let's go back and look.

MR. WARD: Well, I guess the 100-percent mark.

MR. WALKER: You would have to go to the 100-percent burn situation and you can see what the pressure reduction is. It is a magnitude of about 35 pounds for that sort of burn.

MR. WARD: Okay. So the vented containment line would be to the right of all of those; is that it?

MR. WALKER: I guess the way I would do that would be look on the viewgraph you are looking at to see with full safeguards pressure calculated for full hydrogen burn is of the magnitude of 80 psi And if you look on the viewgraph for a transient that produces an 80 psi peak pressure, that is about equivalent to 50 percent zirc water reaction, the corresponding pressure reduction is a magnitude of about 15 pounds. So that might give you an additional 15 pounds of pressure reduction.

The last case we did calculations for included the effect of ice. In this calculation we assumed there was still ice in the ice condensor, and the additional pressure reduction which might be accomplished by the ice is indicated on the viewgraph. And if this curve is extended, there is some additional pressure reduction. And if it goes beyond 2000 pounds, the pressure is of the magnitude of 80 psi the containment capability.

I recognize as of the -- the radiant heat transfer has not been included in these, and there might be some additional heat conduction attributable to radiant transfer.

MR. OKRENT: Suppose you have the fan, the ice, but not the spray. Have you done that?

MR. WALKER: Say it again?

MR. OKRENT: You have the circulation, you have the ice, but not the spray, the containment spray.

MR. WALKER: Are you asking what the pressure curve would look like?

MR. OKRENT: Yes.

MR. WALKER: We have not done that calculation, but I think it is apparent from the way these curves have been stepped that the primary pressure reduction effect is a result of the operation of the safeguards systems, the sprays and the fan. And the bulk of that effect, as we mentioned earlier, is due to the sprays.

MR. HAGA: We can give a rough judgment that it would be a little to the right of the passive heat sinks line.

MR. WALKER: A line in here about like this (indicating).

MR. HAGA: Yes.

MR. OKRENT: Another question: Suppose you have the spray but not the fan?

MR. SIESS: Then it would be a little bit to the left.

MR. WALKER: There is just a small reduction from the fans. So perhaps on most -- on top of the existing lines for safeguards.

MR. OKRENT: Now, is the spray in both

compartments?

MR. WALKER: No; it is just in the upper compartments.

MR. OKRENT: And you don't need the spray in the lower one to keep the pressure down?

MR. WALKER: Do you want to address that specifically? There are no sprays there, and the pressures are not excessive.

MR. OKRENT: So you are expanding it to something.

MR. HAGA: These calculations are based upon the system as it exists, the compartment doors and the spray system, so you get this kind of behavior with a spray only in the upper compartment. As you know, the Donald Cooke plant has sprays upper and lower, and it will work either way.

But these are the results with the spray only in the upper compartment.

MR. SIESS: And even so, the fans don't make all that much difference, although they circulate air from the upper to the lower?

MR. HAGA: That's correct.

MR. OKRENT: So it must be the six-foot-per-second flame speed that is critical. I mean if it were a million feet for a second --

MR. HAGA: That would be a problem.

MR. OKRENT: -- it would be a different situation. Yes.

MR. WALKER: All right, the next set of viewgraphs show the result of calculations performed assuming distributed ignition source available in the containment such that combustion will occur in each compartment when hydrogen concentration exceeds 10 percent.

Before I show you that, let me show you the assumptions utilized in these calculations. We did the calculations over a range of hydrogen release reates to the containment. The range was from one-half to five pounds per second. We assumed 100 percent zirc water reaction equivalent.

We assumed we had full functioning containment safeguards. We utilized the effect of passive heat sinks and no radiant heat transfer, of course, since we don't have that incorporated in our code. We assumed distributed ignition source and 100 percent burnout at 10 volume percent in any compartment.

We assumed that when the hydrogen concentration in that compartment reached 10 volume percent, there would be ignition and burnout of the hydrogen in that compartment.

These are the calculation results. The time column is simply the result of taking the burn rate and assuming that burn rate -- I am sorry -- taking the generation rate and assuming that generation rate is in effect until the 2200 pounds of hydrogen are produced.

Calculated then are the peak pressures which occur for each of these hydrogen generation rates.

Of significance, of course, is at the low generation rate. There were no burns at the upper compartment. For all of the subsequent release rates, the maximum pressure occurred in the upper compartment.

From the standpoint of calibration, generation rates calculated for the TMI event are in the range between one-half pound and one pound per second. And the March calculations for the small-break loss-of-injection-capability transient indicated a maximum generation rate of about one pound per second.

For this set of calculations, which we consider much more realistic than the previous ones presented, you will note peak pressure is up to about three pounds per second, or about 25 pounds or below. And for four and five, in the range of 30 to 35 pounds.

MR. SHEWMON: If I can come back, the total time here is the time then to burn the hydrogen produced by all of the zirconium. Isn't that the time to the first burn?

MR. WALKER: No. The time listing is the time required to generate all the hydrogen

MR. SHEWMON: Yes, but what is the time to the first burn?

MR. WALKER: That is variable. There are multiple burns.

MR. SHEWMON: Give me one of them.

MR. WALKER: I would have to go back to the guys with the detailed plans at the back of the room.

MR. HAGA: Let us take a look at some printouts here and we can tell you that in a minute.

MR. SHEWMON: Okay.

MR. WALKER: While he is looking, let me mention to you there are multiple burns that occur as a result of these transients, and the maximum pressure may occur in the first, second, third, fourth, or fifth burns.

(Pause.)

MR. SHEWMON: The temperature of the structure goes up each time, so you are likely to get a higher pressure but you have less oxygen, so it may not burn as well.

MR. WALKER: Remember, these are transients calculated with the spray system operating, so the temprature comes back down again when the burns are being separated by time.

MR. OKRENT: I think we are going to have to move along on this topic. We have three or four more.

MR. WALKER: Do you want to wait for that?

MR. SHEWMON: (Nodding affirmatively.)

MR. WALKER: Let me present my conclusion. We have two basic conclusions as a result of these calculations.

First of all is the one Dr. Okrent mentioned, which has been obvious to all of us for quite a while. And the second is the peak pressures are well within the containment functional capability with safeguards operational and this distributed ignition sources.

MR. BENDER: One quick point while Blair is going up. This is based upon some prescribed spray system. Is it the largest spray system you can conceive, the one in there, or what?

MR. WALKER: The one in our plant right now.

MR. BENDER: Would there be an impact of having more capacity in the spray system?

MR. WALKER: Not much. We don't think there would be much impact of even operating two or three of the four available trains. It seems the pressure would be about the same.

MR. OKRENT: You would need a better raincoat, though.

(Laughter.)

MR. HAGA: This slide summarizes what we believe would be appropriate requirements in manufacturing license and consideration of a degraded core accident.

First of all, it is an accident similar to the TMI accident with zirconium water reactions up to 50 percent of the total in the core.

Second requirement would be hydrogen release rates up to a maximum uniform rate of one pound per second. You have just heard from Dr. Walker that that is the maximum rate calculated by the March code for SD2 type accidents.

We believe the containment pressure calculation resulting from hydrogen combustion, if any occurs, should be based upon realistic methods of analysis, realistic heat losses to sinks, realistic assumptions for operation of safeguards and mitigation features. And C here really leads to D and E. That means that the burns initiated by distributed ignition sources, again, if provided, and if there is one single active failure of containment safeguards -- in other words, if you have four spray pumps and four fans involved, either one fan or one pump would be assumed to fail.

And the final assumption is that electric power is available either on or off site. And finally, the calculated containment pressures shall be less than the functional capability of the containment defined by plastic analysis methods including consideration of the effects of deformations and actual material properties.

This last slide summarizes our understanding of the status of the manufacturing license application with respect to NRC requirements. We believe everything else has been taken care of except what is shown on this viewgraph. The first requirement are those requirements in NUREG-0718. We have submitted responses in April of '80. The latest revision of 0718 would require minor revisions to that submittal.

The second requirement is reliability evaluation. We have already committed in that response of July '80 to do that evaluation. And we will factor that evaluation in the design as it progresses. As a matter of fact, we have already done some of this kind of work on several of the systems in the plant. We did that, I suppose, two years ago.

Another requirement is a provision for a flanged penetration in the containment. We will do that if it is required. And containment pressure capability, currently we have a 15-pound-per-square-inch design pressure with a 55-pound gauge functional capability. We could have required increased loads to 25 pounds gauge design and 80 pounds gauge functional capability.

Two other requirements for near-term construction permits and manufacturing license relate to siting and evacuation. And we understand they are not applicable to our application.

As I indicated in my introductory remarks, we really believe it is time to move on. And I hope the committee will see fit to recommend to the Commission that a rule be promulgated and we get on with the manufacturing license.

That completes our presentations.

MR. BENDER: Two points. First, the 50-percent burn is associated with what pressure containment?

MR. WALKER: Well, you remember the charts you were just looking at?

MR. BENDER: Yes.

MR. WALKER: They went 25, 50, 75, and 100. So if we could get one of those back --

MR. SIESS: That wasn't the one-pound rate, though.

MR. HAGA: The one-pound-per-second was for 100-percent zirconium water reaction.

MR. SIESS: And in one pound per second you only got 25 psi.

Mr. HAGA: That's right. I don't remember, but I will take your word for it. I don't remember the exact number, but it is not a high pressure.

MR. SIESS: If the staff accepted your recommendations for this requirement, you wouldn't even need to modify your containment, would you?

MR. HAGA: That is correct. We believe these are a reasonable set of requirements for the near-term applications. If you recall, I mentioned it is an accident similar to TMI with up to 50 percent zirconium water reaction.

MR. BENDER: I realize that is your recommendation. I was trying to see what you could really do. And I probably could have gone through this exercise with you, but 80 pounds is somewhere close to what, between 50 and 75?

MR. HAGA: Well, if you take zero vent area, for example, 50-percent zirc water, the peak pressure is around -- it is slightly over 80 here. Remember, these are adiabatic numbers we are looking at here.

MR. SIESS: That is one burn, isn't it?

MR. OKRENT: If it is adiabatic, it doesn't matter how many burns.

MR. HAGA: The energy is just put in the containment.

MR. BENDER: If I take it out with the sprays, that helps to some degree?

MR. HAGA: Yes. And then you move to this chart. This is 100-percent zirconium water reac'ion and it has safeguards operating. You get results of one pound per second for 100 percent; you get a result like 25 pounds gauge. So you would get something less than that, there, only 50 percent.

MR. BENDER: It sounds to me like with the right combination, the number could be higher than 50 percent.

MR. HAGA: Oh, yes, it can be.

MR. BENDER: So when I read these recommendations, I read them as 50 pounds based upon some adiabatic burning with some current pressure limit on containment. If I want to take the other combinations, I think it would be more enlightening to see what it might turn out to be.

MR. HAGA: We are saying we believe this is an appropriate set of assumptions, and we believe this is a reasonable assumption. You can go 75 percent or 100 percent, but we think these are a reasonable set of assumptions is what I am saying.

MR. SIESS: But not conservative, necessarily.

MR. HAGA: Not unconservative, either.

MR. SIESS: There is no conservatism in three. Everything is a realistic analysis.

MR. HAGA: But there is conservatism here (indicating). TMI is something between one-half and one pound per second, as I heard a moment ago. So there is some perhaps conservatism here. This is a uniform rate over the time span to consume the hydrogen associated with a

50-percent zirc water reaction.

MR. BENDER: If I assumed the existence of the sprays as a heat sink, I could burn all of the hydrogen; it is just a matter of how fast I could burn it.

MR. HAGA: That's right.

MR. BENDER: I think that point should not be ignored.

MR. HAGA: I do not want to obscure it at all. We present these simply as what we believe are a reasonable set of assumptions.

MR. OKRENT: Could someone remind me, is there a turbine missile question open on the FNP, or is that resolved?

MR. HAGA: Since you asked me, I think it is resolved, since the regulatory guide permits either orientation of the turbine or analytical results on probability. And we chose the latter, and I think it is all settled.

MR. OKRENT: I didn't know whether, if you were relying on probability, for example, any of our recent experience with turbine cracking would have to be factored into it or not.

MR. HAGA: It would have to be considered. But correct me if I am wrong, it would not change the results.

MR. OKRENT: I don't want to get into it today, but someone might think of it, on the staff. It is so long ago, as you pointed out, I couldn't remember quite what the basis was.

MR. WALKER: As far as I know, the only thing we didn't settle with the committee outside of post-TMI items is the question of how you handle accident probabilities for things like ship collisions. We had a discussion but never got a letter on that point.

MR. HAGA: Remember, you asked about the green ships and the purple ships?

MR. OKRENT: Yes, I know. We had better move along. Is the staff ready for their presentation?

MR. PURPLE: Yes, we are. First I will explain we haven't found Mr. Denton yet, but I will proceed in his stead.

Since our last ACRS presentation and, shortly thereafter, the Commission presentation, the staff has been continuing to work on trying to develop these requirements. As you may recall where we stood as of the last time we spoke to the full committee at least and to the Comission for the special measures for these pending CPs, we had several areas we identified.

One was to require a full plant site probabilistic risk assessment to be performed. The other was the three-foot or equivalent hole or holes in containment. And the third was a specification of a strengthened containment, and we attempted to specify a number for that.

As of today we are still carrying the probabilistic risk assessment and the three-foot hole or its equivalent in more than one hole.

We are still hoping to achieve suitably strengthened containment in all of the pending CP's, and we think we are being close to being able to define that in a more meaningful way and a way that had more of basis than we were able to articulate a month ago.

Since the last meeting we have had -- well, as a matter of fact, just yesterday we had the benefit of hearing the presentation you are hearing today from -- well, we didn't hear OPS yesterday. We heard them on the 23rd of January.

Yesterday we had three sessions, one with General Electric on their Mark III's in general; another presentation from Boston Edison for Pilgrim-2, and finally the longer presentation from Houston Lighting and Power on the work they had commissioned last fall.

We have not had a lot of time to think about what we heard, but we do have a draft position that I would be happy to hand out to the subcommittee for your review between now and the committee meeting.

Then I will try to describe where we are coming from on that.

One of the things we want to make sure we stay away from and we want to specify that like we want to stay away by a factor of two from any detonation condition in any of these containments on hydrogen. For that we had a stated requirement.

Al, you can pass those out now, and I will come back to these if you want to get into the worded language in more detail.

So we do have a requirement that these applicants demonstrate that they can stay well away from any condition that would lead to detonation. This implies in our judgment that they will all either have to put in distributed ignition systems or some form of post-accident inerting.

MR. OKRENT: This is local detonation or --

MR. PURPLE: Widespread uniformly mixed detonation, not local, given that it appears that these applicants will be required to have either distributed ignition or post-accident inerting.

We are not prepared to proscribe which is the best today. I don't think we know enough about it. Certainly post-accident inerting is a new idea without a lot of study yet, but each of those hydrogen control measures results in certain increased pressure in the containment if they are ever used, one, from the multiple burning in one case, or in the other case, simply by adding more atmospheres of gas into the containment.

So we want to be sure the containments will be able to withstand these added pressures, so we have written a requirement to preserve the containment when these systems are in use, and our criteria in this case will be to ask that they demonstrate that they do not go beyond yield in the containments when the systems are actually called into use.

I think the proper expression is the ASME service level C criteria.

Given that we don't know which of the two options either an applicant would choose or that we may ultimately settle on as being the required one for the degraded core rulemaking, for example, we worded this requirement such that the applicant must determine which is the more severe in terms of the pressure. -- That would be item three in the handout I gave you -- the more severe in terms of pressure transient, if you will, of either burning hydrogen or post-accident inerting CO-2.

We specify CO-2 in the wording of this requirement not because we have settled on this CO-2, but because of the two viable options we have discussed between CO-2 and halon. CO-2 has a higher pressure, so we are not choosing CO-2, but by specifying it for this requirement of pressure containment, we are sure we are on the upper bound, depending on what people may choose or what may be required in the future.

The main idea -- and I want to repeat, we are still focusing on what we want to accomplish by all of this right now -- is not to foreclose options as the rulemaking proceeds, so we are concentrating on the containment structure it.

We are not concentrating on the various subsystems that may go in. We are not trying to specify what a post-accident inerting system might look like. That is a system which could be installed later on, in our view, and by letting the CP's proceed with the construction of the basic containment, you have not foreclosed those kinds of options.

So our main focus has been and is today on making sure that the containment itself gets filled in the manner that doesn't foreclose various options.

Now, given that it is possible that there may be a post-accident inerting system installed, I believe it is prudent to believe that sometime during the life of the plant that post-accident inerting system may go off when it is not wanted to go off, and inject an overpressure into the containment.

We would not want to be in a condition of yield stresses at that point, so the requirement, which is number four in the document I handed out, is aimed at making sure that the design basis stresses and pressure and capability of the containment is such that it is not exceeded when there is an inadvertent introduction of carbon dioxide.

Again, we specified it be carbon dioxide so we are reasonably sure we have upward bounded it.

Item number five on page two, the first set of items, one through five, apply to all three types of reactors under consideration. Item number five is simply a restatement of a three-foot diameter opening or its equivalent.

We believe from what we have heard from the presentations yesterday and earlier from OPS and again today, that these requirements as stated will result in the necessity for some strengthening of the containments as presently designed on the one hand, and on the other hand that they can be reasonably achieved without major redesign effort.

We have had some discussions about major redesignings and when we say major redesign, we are speaking of a design change possibility that might invalidate the basic containment concept, recognizing they may have to go back and do a full redesign of the containment.

When we say major redesign, without a major redesign we mean without invalidating the basis containment concept which has been posed.

Now, in the presentation you will hear in more detail in a few minutes from Houston Lighting and Power, we have reflected it in this paper. They went beyond looking at simply mitigative features. They looked at a spectrum of mitigative, as well as preventive features, and rated these in terms of the potential risk reduction and rated them in terms of impact on the plant schedules and cost.

They ended up identifying one possible preventive measure that was, as I recall, either small or medium impact on the plant, which they believe would provide a factor of five risk reduction on the preventive side, and that is the item identified on page two, where it says for BWR's to add an in-containment isolation condenser.

You will hear much more about that in the ensuing presentation. We have looked at that enough in the short hour since we have heard of it to believe that was a good idea. It sounds like a large return, so we are proposing to add that into the regulation.

In dealing with the pressurized water reactors, it is not clear there could not be a similar type feature which would be as worthwhile, so we have added as a final item on page two that as part of the probabilistic risk assessment performed, that the BWR's with ice condensers and large dry containments specifically look at the feasibility and returns of putting in a thing that is functionally similar to what we are requiring on the BWR's.

So in effect we are deferring for now, since we don't have enough information, nor has it been looked at enough to be able to say that ought to be done. We are deferring a decision on that particular item until we see the risk assessment.

Now, that is a very brief overview of what this statement of requirements are. It is in draft form right now. I don't anticipate between now and Friday afternoon major changes, more wordsmithing changes and trying to make sure we have covered and made clear what we mean by the language.

We are scheduled for a presentation to the Commission on the 12th of February, at which we will have finalized this position, so we are clearly seeking advice from the ACRS as to their views on this proposals, and for what they have heard and will hear from the various studies done by the applicants.

Some specifically noted it would be very useful if there is a possibility of a letter from the ACRS to be forthcoming on this issue so we could take it with us, consider it and speak to it at the February 12th meeting.

Those are all of the p.epared remarks I have.

MR. OKRENT: Mr. Shewmon?

MR. SHEWMON: This in-containment isolation condenser has roughly what capacity? Enough to take all decayed heat in the absence of any other sink, or what vaguely are you sizing it as?

MR. PURPLE: We haven't specified a size, and if I might defer until you hear that specifically, there is a specific presentation on that item itself. It should be sufficient to remove the decayed heat that would result if you lost either the RCIC or the HPCS, because that is what it is a backup for, to take care of the loss of those two items.

MR. SHEWMON: I don't know what those are in PWR. That was a part of my question, but go ahead.

MR. OKRENT: Let's see. You say there are no other prepared remarks you have from this staff?

MR. PURPLE: That is correct.

MR. OKRENT: Let's see if I can understand what this proposal seems to be. Part of the proposal that you forwarded to the Commission in writing, I don't know what the oral remarks were that accompanied it -- were to the effect that with regard to containment strengthening, they should all be designed for 60 psi, if I remember correctly.

In the oral discussion with the full committee, Mr. Denton indicated that should be some kind of a sliding scale. What I am looking at here, if I interpret it correctly, seems to now have an approach which leads to bases which result from whatever measures one takes with regard to hydrogen control.

MR. PURPLE: Yes.

MR. OKRENT: Now, I have recently had the privilege of seeing some staff memoranda, one coming from Mr. Ernst, and one from Mr. Bernero or someone working with Mr. Banera, both of them concluding that if you have serious accidents which go into the degraded core or core melt situation, the public risk rises from the accidents that get to the core melt, whether or not the degraded core is less probable or more probable than core melt.

They are not necessarily in agreement on which of these were more probable, but they both felt the risk would arise from the situation - the greater risk would arise from situations which got all of the way to core melt.

Let me assume that that is at least a possible way of thinking, and since those are the only two staff memoranda I have seen on this subject, I will assume it is a part of the staff's thinking.

Why is that thinking not factored in some way into what you have in mind with regard to containment strengthening? Why is it all focused on the hydrogen control question?

MR. ROSS: There is not an altogether satisfactory answer. It is true. Mr. Bernero and I both have been working on the degraded cooling steering group now for about four months. There has been a lot of discussions on the fact that what I would call the arrested degraded core or the terminated degraded core are degraded core somehow brought back to coolability.

There seems to be general agreement that if you cope with a degraded core and arrest the degradation and return it to a cooled state, given that you have perfect systems that do that, but you have not altered the basic core melt sequence, public risk has not been diminished very much.

The complete core melt completely still dominates public risk. There are not that many sequences identified that produce degraded cores that produce hydrogen like we are talking about, and then you turn around and you cool them.

So if the net result of all of what we are talking about is to reduce public risk, we might not have done that much. Everything we are talking about today in this whole effort might produce marked differences in Wash-1400 time studies in terms of offsite consequences.

One of the viewpoints was on these arrestable core sequences, you would have to have a very high likelihood of arresting it before you begin to make an effect. The rationale for hydrogen, I think, is more pragmatic. It happened there was an event, and it is difficult to say it is impossible given data not two years ago.

I think the reason we are focusing on hydrogen is primarily that if you took a backward look and said, this reactor facility has 50 or 75 percent metal water reaction and hydrogen production, what is the likelihood that this hypothetical facility also has a core melt?

I am sure many times out of a hundred you would say, yes, it is a core melt sequence. The likelihood of getting that far and stopping is not all that high, so this is what I am saying. It is intellectually not a very pleasing situation because the rationale that gets us there is not very precise.

I think if you have read the Nuclear Safety Oversight Commission's thinking, that may be somewhat the policy. It happened; therefore, it may happen again. therefore, we must protect against it.

MR. OKRENT: Well, I myself am not prepared to adopt that as the basis for my judgment. I will just put it that way.

We were supposed to get some other information from the staff, like what are the disadvantages or advantages of requiring a dedicated space for the addition, the possible addition of some future facility for filtered venting situations?

That was one of the things on your long list from a month or two ago, whenever we met.

MR. ROSS: It may be that Jim Meyer can elaborate. When were discussing Item 5, page 2, which I call the manhole cover, we did discuss putting that in to provide for the future capability of a filtered vent, should the need for one emerge from a longer term hearing, and Jim reminded me that is one feature that would be potentially useful for the full core melt sequence.

Beyond this penetration, we thought that was all that needed to be done at this time. If five years from now it is decided to put in a full filtered vent containment, at least you have the access hatch.

MR. OKRENT: Again, thinking back to the subcommittee meeting we had, I guess it was last month --

MR. SAVIO: January the sixth, yes.

MR. OKRENT: All right. I am told it was January 6. One of the possible items on the list at that time was that you not only have a manhole cover, as you call it, but you lay out the plant so that if you want to use that manhole cover to connect it to something, you have not put the restaurants or men's rooms or whatever it is in all of the places where you could possibly connect.

MR. ROSS: I was inquiring from Jim about should one be needed, about how much space might it be. The direct answer is we are not prepared to discuss it much except the speculation I got from Jim -- and perhaps he should speak for himself -- is the space would be anywhere from a football field on down, depending on the concept.

MR. OKRENT: You did get our list of questions, didn't you, where we thought we would like to have some information?

MR. PURPLE: I don't recall a list of questions.

MR. SAVIO: I think Allen discussed them over the phone.

MR. ROSS: Let me make this offer. It is not very helpful for today, but if you have a list and you would like us to regroup and address the list for the Friday meeting, I will make that offer, but we don't have any preparation on any list of questions.

MR. OKRENT: Let's see. They were transmitted by phone.

MR. SCHWENCER: I am sorry. I didn't transmit those to the staff. I will have to make the same statement Denny did. We will have to relook at that list and have the staff be prepared to discuss it on Friday.

MR. OKRENT: I guess if in the future we have to make sure to send things in writing that we send by phone. There was also a request, the staff-provided estimate of the capability of increasing containment design pressures of the various containment types, since you were recommending 60 psi for all containment types.

Is there a presentation you have available in that area?

MR. ROSS: I am not prepared on that.

MR. VOLLMER: Dick Vollmer of the staff. No, we have not made a containment-by-containment concept estimate of that beyond what we talked about at the last committee meeting.

MR. OKRENT: Gee, I am curious. You sent something in writing up to the Commission, as well as to the committee, which showed a 60 psi recommendation. When you met with the full committee, the information was a little thin, but I had assumed by now there would be more information that you had along this line.

MR. VOLLMER: The work is in progress, but we really haven't gotten any results. We have some of our structural containments, making estimates of the capability of the various containments.

We also have some results that were done on the ice condenser type containments in terms of capability and those were passed along at the last meeting, but I would suggest that the information that Offshore Power Systems presented here today and that which Houston Lighting and Power will indicate is quite a bit further than the staff has gotten at this time.

We were basing the judgments made at the last committee meeting on a couple of items. One of these is there are free-standing metal shell containments, code vessels which have been built in the field of the pressure capabilities we are talking about.

We also had some estimates, preliminary estimates from the staff, that an addition of plate-thickness stiffeners and other modifications, such as head design, would bring the capability of the containments up to the order of 30 pounds and more extreme design measures such as what we have seen in the design of 60 pound containments could bring them up to that and might include such things as field weld heat treating.

We were not able at that time to really determine in any way whether or not such changes would be of a magnitude to really effect the fundamental concept of the containment, either through requiring a different plant layout or just by the sheer magnitude, require that one look at a different type of containment because of the costs and things of that nature, scheduling costs.

So all I can say is I think based upon where the staff is right now, the information provided by Offshore on the ice condensers and by the people from Allen's Creek would give a better indication of capabilities of containments without affecting concept.

MR. OKRENT: What would you have done if the committee had said, "Gee, we agree with the staff," and had gone up to the Commission, and they approved it last month, and said 60 psi for all of these?

Where would you be now?

MR. VOLLMER: I think at this time we indicated to the Committee and the Commission it was our view that 60 psi was a rather thin basis, and I think we characterize it as such.

I think also, in fairness to your other question on whether or not hydrogen is a driving ingredient on this, I think Mr. Denton in his presentation felt other comfort from stronger containments could be obtained beyond just the hydrogen scenarios.

These were not expanded on at that time, and I think the general feeling he tried to project at that time was one of strengthening of containments would be able to, say, accommodate many of the uncertainties, in particular, of course, with the hydrogen, but many of the uncertainties we felt might exist at that time.

We have learned a fair amount perhaps in the past month on some of the calculations that have been done by industry and us in terms of ways or proposals and calculations, ways to mitigate the consequences of hydrogen and keep pressures there from within a range for both ice condensers and Mark III type containments.

It looks like the proposals we have come up with here would be viable ways of accommodating the worst possible hydrogen scenarios, and would give us some containment strengthening, but more importantly perhaps would not impinge on any of these concepts, because the concepts themselves do have features which are risk reduce--

MR. OKRENT: Has Mr. Denton changed his position then from what he expressed to the committee last month? He is not here to tell us.

MR. VOLLMER: In what specifics I will try to respond. On the 60 pounds, yes.

MR. OKRENT: But he was not himself urging the 60 pounds when he was meeting with the full committee. That was in the document you transmitted to the Commission, which we have had before us. He himself was not doing that.

On the other hand, he was not relating it strictly to hydrogen control and now I am trying to understand whether he has modified his position to say what we need to do is focus on hydrogen control.

MR. VOLLMER: I can't answer specifically. I would say it is my opinion that he is in fundamental agreement with the way we have -- with what we have laid out here as a viable position for near-term CP's that will address as best we can the concerns prior to the degraded core rulemaking.

To the best I know, the answer is yes to your question.

MR. OKRENT: Has the staff does its own assessments of the capability of ice condenser or large dry containments or Mark III containments to be increased in design pressure, and what the costs thereof are, and what the practicality is, and so forth on one or any or all three of these containers?

MR. VOLLMER: As I indicated, we looked at the capability of the containments as designed and had done not what I would have called an analysis, but had done a judgmental review of how we felt the steel containments could be upgraded.

We have not done it for the reinforced concrete, and the results of those, as I indicated, were changing a head design, adding stiffeners and plate design. We felt these containment concepts could get up in the 25 to 30-pound range without extensive changes to the containment.

MR. OKRENT: Are you talking about the ice condenser basically?

MR. VOLLMER: Or the Mark III of the steel shell variety, yes. These were judgments. We have not done any detailed analyses. We have some consultants working on that to try to provide independent verification of some of the things we have heard from Offshore Power and Allen's Creek.

MR. OKRENT: Are there any reports or draft reports or memoranda either from one member of the staff to another member of the staff, or from contractors to the staff that deal with the pros and cons and practicalities of containment modification for a Mark III?

MR. VOLLMER: Not that I am aware of. Some of it is in process, but I know of no memoranda to that effect.

MR. OKRENT: Has the staff done any of its own hydrogen control studies for the Mark III?

MR. ROSS: No. The work we have done so far has been limited to Sequoia and MacGuire. We are scheduling -- we have scheduled our first technical meeting with a Mark III owner Friday on Grand Gulf where we understand there will be some proposals by them to put in a distributed ignition system.

But heretofore, we have spent a lot of time and money, both us and our contractors on hydrogen control, but it has been almost totally for the ice condenser.

MR. OKRENT: I suppose you don't have the benefit then of any studies by your contractors on changes in Mark III containment and their pros and cons for dealing with accidents that go to a melted core, if you don't have one for hydrogen?

MR. ROSS: No. Considering the acute licensing difficulty Grand Gulf is in, I expect this to be a very rapidly developing field, both on our side and the utility's side, so two months from now I expect us to be in a lot better shape on this subject than we are now, just because we have to move fast.

MR. OKRENT: All right. You don't suppose Mr. Denton is going to get here late, do you?

MR. PURPLE: I just have no idea. We have lost contact with him.

MR. OKRENT: Well, I am going to suggest that since we have been going for about two hours, we take a short break.

MR. ROSS: Dr. Okrent, let me renew my offer. If we could get the questions, we will do what we can to get some written response by tomorrow night so you can deliver on it before the full committee meeting.

MR. OKRENT: Fine. Mr. Savio will get you what he gave orally some weeks ago. He will get it to you within the next two minutes and we will reconvene in 10 minutes, and Houston Power and Light will be up.

(A brief recess was taken.)

MR. OKRENT: You have in this draft some suggested specific heat removement capabilities as a possible -- I think before wanting to offer an opinion on these, the committee would like to understand better why these -- if you are going to single out specific improvements as either required to be included or to be specifically noted for study, for example, why not the kinds of improvements in heat removal capability that this Sandia group has identified in their studies on BWRs and PWRs as representing possible avenues for improving the capability of a plant to not get into a serious accident. Okay?

MR. PURPLE: Understood, but let me make sure that I do. The main focus -- we are not selecting any systems other than those we believe would determine the necessary strength of the containment.

MR. OKRENT: No. Number two for BWR's, number three for ice condenser.

MR. PURPLE: Those last two items, okay.

MR. OKRENT: Is it clear, or should I restate it?

MR. PURPLE: No, no, I understand.

MR. OKRENT: All right. If you understand, I assume we will get an answer. Do we have to send it in writing?

MR. PURPLE: You don't even have to send that one in writing.

MR. OKRENT: All right. Houston Power and Light.

MR. OPREA: I am Executive Vice President for Houston Light and Power Company. We appreciate the opportunity to meet with you today and be on your busy agenda.

The express purpose of our being here is to inform you of the studies we have undertaken relative to degraded cores and of course give you our views on a proposed rule the staff has been attempting to announce and enunciate for the last several months.

We have a two-part presentation. I have some opening comments. I will summarize a prepared text that will be given to the recorder, to be followed by a technical presentation led by our Vice President, Jerry Goldberg, who is in charge of our nuclear engineering construction activities.

At the conclusion of the discussion he will lead, he will give you our feeling of what should be done with respect to BWR, particularly the Allen's Creek project, and also give you an insight into what we think the proposed rule ought to be, again pertaining to the policy pertaining to near term construction permits.

1980 was not a very encouraging year for our company and other companies that were involved in pursuing the licensing of BWR's. This is our third successive year of delay on that project, amounting to several hundred millions of dollars.

We have in addition to the delay a loss of project schedule and loss. We have been concerned about what appears to be lack of fiber pertaining to a licensing basis. We are still concerned.

When the October policy, interim policy statement came out pertaining to what needs to be done for near-term construction permits, we were concerned with that position and the various positions that have up to this day been brought to this forum.

We are still concerned. We are now at what we think are the crossroads with regard to whether or not nuclear is a viable option. We need to have a construction permit for our project, which is Allen's Creek, by March of 1982, and our future and the success of pursuing this project hinges very strongly on those things that result from this forum, as well as ensuing NRC action to what does ensue.

We feel if we are to proceed we must have a definite approach with regard to resolving the degraded core position pertaining to near-term construction permits, and we feel it can happen if regulatory action includes four items.

First there is a clear-cut understandable criteria for meeting degraded cores.

Second, there is a sound licensing basis in support of that criteria that does result in the issuance of construction permits.

Third, there is a design stability during the construction period that will result in sufficiency for operating licensing purposes; and lastly, that there is a dedication on the part of NRC in regard to providing sufficient resources to pursue the licensing process.

Now, as a result of the concerns we had with regard to what was not happening in 1980 and particular to the licensing process and that which included degraded cores, we embarked upon developing a straightforward basis for licensing the Allen's Creek project, which would account for degraded core concerns.

Consequently we pursued a guiding safety philosphy based on risk reduction, and you heard Mr. Purple identify that as one of the categories we pursued with vigor in our studies.

When I refer to risk reductions, I don't want anyone to get the understanding that Allen's Creek is not as it is presently designed, in an adequate state of license ability. In other words, it is a very good safe project.

We feel risk reduction can be discussed technically, and we hope everyone agrees that reducing risk is definitely a desirable role and one we want to pursue.

When I talk about risk reduction, I mean relative risk reduction. We believe our presentation today will earmark to you that Allen's Creek is already designed at a lower risk level than that BWR represented in Wash-1400.

Nevertheless, we set out in our studies to determine whether risks associated with degraded core concerns should be reduced further.

We also have an understanding after taking the risk studies that there are three levels of regulatory activity underway concerning degraded cores. First is a long-term degraded core ruling which, as we all know, will involve massive time and effort and dollars on both industry and the NRC staff.

The second level is that relative to the proposed interim rule on hydrogen control, and we anticipate these studies in addition will require formation of industry groups in close working with NRC.

The third level at which we are concerned about in this forum today and to which we address ourselves concerns the degraded core considerations for the pending construction permits.

Our studies seek to provide the engineering information essential to formulate a risk reduction strategy which could form the basis of a rational licensing plan for Allen's Creek and at the same time, anticipate reasonable actions which could accommodate the outcome of the long-term degraded core rulemaking and also the hydrogen studies.

Relative risk reduction seems to us to be a reasonable way to proceed until a quantitative safety goal is available, and I believe the story you will hear from us today relative to our study represents that position.

I would like to now call on Mr. Goldberg to present our technical position, and also a discussion on a study which we have underway.

Jerry?

MR. GOLDBERG: Good afternoon. Carrying a little further the remarks of George Oprea, we are somewhat pragmatic in our approach to this particular issue. Our plant is approximately 80 percent designed. We feel that it would perhaps be even more realistic to treat us as an operating plant rather than a new construction permit applicant.

We have been working on this unit for about six years. Anything we do to address this issue, in our view, should be done in recognition of trying to get a plant on the line before the end of the eighties.

To do that we have to get started with construction, in effect, next spring. If we do not it is apparent to us that Allen's Creek will not solve the needs of our company as far as source of increased capacity.

We determined at the outset that one of the issues that would clearly have to be articulated is what can we do to increase the strength of our containment? When we commissioned a study which was spearheaded by Sol Levy, Incorporated with assistance from Ebasco, our architect engineer for General Electric, one of the clear objectives was to establish what margins we might have in containment strength; what additional things we might be able to do to that design without in effect destroying the vast amount of work that had been done to date to enhance its pressure containment capability, and further, to examine various features, both of the preventive as well as the mitigative variety, to provide a meaningful measure of the ability to cope with a degraded core type accident.

To that end, we did in fact embark upon this study. Today, Mr. Levy will present the meat of that study. He will defer from making any recommendations and following any questions from the Committee, then we will identify those recommendations based upon the results of that study.

At this point I would like to ask Mr. Levy to carry on with the program.

MR. LEVY: If I can just take a little time, I will call on Chuck Johnson to put on the charts because we may have to call on some backup charts to answer questions. I think you have pretty well heard what the objectives of this study were to be, and I will flip that chart and for the interest of time, not take too much time on it.

I want to reiterate, we had to find a way to evaluate these options to develop what we think made sense in terms of a safety philosophy to approach degraded cores. I think I will hit that very hard because I think the recommendations that will be made by Mr. Goldberg at the end of the meeting will reflect that philosophy.

We decided to look at risks, and I think the next chart shows what the major risks are in a boiling water reactor and what we have plotted here is the probability of core damage or containment figure for a year.

The solid bars are the Wash-1400 values. The dashed bars are estimates for Allen's Creek. The boiling water reactor risks, more than 90 percent of those risks are actually controlled by three types of failures.

The first one deals with a failure to remove the decayed heat. What we are talking about there is that the core is covered with water. We are moving the energy to the containment suppression pool, but we cannot remove that energy from the suppression pool and the containment pressure increases until the containment fails from overpressure.

It is important to recognize that for this type of failure, the containment failure precedes the formation of a degraded core. Since I have assumed the core is covered with water all during this time, the reason I am stressing this point is to reduce the risk in this area, for example, a hydrogen control system or filter vent system would not be useful since we would have failed the containment long before we have to deal with the formation of any hydrogen or having to filter inefficient product produced from degraded core.

The second failure is failure to shut down the reactor, sometimes referred to as ATWS. This type of failure again is characterized by the fact that we have not been able to either scram the reactor or to have an effective injection of the standby liquid control poison system.

In this particular case again, the reactor settles out at the reduced power level. It pushes the heat it generates out to the suppression pool. Again, the suppression pool temperature increases; the containment pressure increases faster than the shutdown system capability can provide for, and again in this particular case, the mechanism is one where containment fails prior to a degraded core formation.

The third major failure possibility for a boiling water reactor is failure to provide water makeup to the reactor. What we are talking about here is a failure case where we cannot keep the core covered.

We have incorporated in this bar chart both cases in which we have a break or a LOCA, a small break or a large break, or wherever we actually do not have any break at all. Actually, what happens is the primary system is solid, but we cannot get enough water to the core to actually keep it covered. In that case we will have really core damage or degraded core formation, and that degraded core formation will in turn lead to containment failure.

It is in this particular area that hydrogen control systems and other things dealt with in some of these recommendations come into play. Let me make a few comments about these bar charts.

First, I think with respect to the Allen's Creek estimates, those estimates are preliminary, but we think they are representative of what will happen in this type of plant. They first show the risks associated with this design are lower than those prescribed in WASH-1400.

The second thing I would like to say is in a particular case of ATWS we arbitrarily drew those risks on the basis that saomething would be done in the area of ATWS to satisfy the new requirements of ATWS, and we put that level at one times 10^{-6}, because that is the level specified in the ATWS NUREG document for this type of vintage plant.

We did not deal with this area on the premise that the Applicant, General Electric, the staff and ACRS will reach agreement that the provisions that will be made in this area will be capable to meet that level. It is General Electric's contention that what they will propose will actually give an ATWS risk level lower than what is shown on this chart.

A second comment I would like to make, because what we are going to deal with is relative risks, what we have done is to not necessarily enter the argument whether the absolute values of these bar charts are valid. If you notice, if you do not believe where those bar charts are, still in proportion to the WASH-1400 bar charts they remain relatively at about the same level once we leave out the ATWS area.

So I think I would like to state that when we look at this, what we will be talking about is what can we do in terms of design options that will help reduce the risks associated with these three bars. And I will employ the Allen's Creek number and I will do all of my numbers in terms of reducing the relative risk of the probability of having a core damage or containment failure.

MR. OKRENT: Can I ask, just for a point of information, if you are on a scenario of the type corresponding to failure to remove the decay heat, the one on the left, if you have some kind of a pressure relief mechanism on the containment set at some value between design pressure and containment failure, how much time would it buy you, if any, to get the system to cool and working again?

MR. LEVY: We will design that option. It is one of the design features we studied as a way to resolve that.

MR. OKRENT: I will wait, fine.

MR. LEVY: Let me make clear that there are some major advantages that this particular plan offers over and above the WASH-1400. And I will come back to that point at the end of the presentation.

On the WASH-1400, any time containment failure took place core damage followed, because the ECCS pump would not have enough NPSH. This plant is designed with a low NPSH pump and containment failure does not mean we are stopping water pumping into the core and removing heat from the suppression pool.

Let me make a second point. This containment has a lower wet well pressure than the dry well, considerably lower. And if you are actually approaching a containment figure marked by overpressure, the place you will see the pressure will be in the wet well. We will come back and discuss that.

This means any fission products you want to put through that vent that was just created due to overpressure will actually fall through the pool in this particular design. And therefore, the point I want to stress is that the Mark III design has in it built what I would call a water filter followed by vent, because the vent will occur on the wet well side.

I am saying, even if we let the overpressure occur -- and we can come back and discuss that point more. The reason I am stressing it here is because you can see that this feature will lead to considerably less consequences than WASH-1400, in which overpressure was actually assumed to occur in the dry well, and one could not scrub for the suppression.

In this case the failure will occur in the wet well rather than the dry well, from overpressure considerations.

Let's go to the next chart.

(Slide.)

This summarizes what I've just said. We think the risk probabilities and the consequences are quite a bit low WASH-1400. I want to caution that because, having said that -- and I think, as Mr. Okrent has made clear, we are not saying that you should have to take action in this plan. We believe riskwise it is at a certain level and a very satisfactory level.

I think, on the other hand, our study was commissioned with the idea: What feature could you put in, what relative risk reduction can you get? And this is what I am going to do at this point.

Now, to orient you, we evaluated what kind of risk probability reduction factor you could get. First, let's say if you eliminated all of the failures that provide water makeup to the reactor, that says you hav- 100 percent assurance the core is always covered. You will get a risk probability reduction factor of 1.3.

If we eliminated all the failures to remove decay heat, we will get a risk probability reduction factor of 2.8. If we eliminate all failures to provide water makeup to the reactor and all failures to remove decay heat, we will get a risk probability reduction factor of 8.5, controlled by what is left in ATWS.

Finally, the last point I want to make is if we could be smart enough to devise a mitigation system that could handle all the things coming out of a degraded core, if we went mitigation all the way and said we were going to mitigate the degraded core and were smart enough t[illegible] t, all we would do -- we deal with the last bar chart, and the only risk reduction probability factor we would get is 1.3.

I think with this in mind I am going to tell you which features we studied, why we picked them, and what results we got for them. This chart shows a list of features we looked at.

I would like to say as an introductory comment that we did not start with just this list. We spent several days, several meetings, creating a much broader list, and then narrowing the list to some of these features that made sense to us from a judgment viewpoint, from a risk reduction viewpoint.

So we came down to this list as a basis from which we should carry studies on.

MR. BENDER: Mr. Levy, just to be sure we understand what you are saying, if you provide water makeup to the reactor, I guess some people would argue that is equivalent to maintaining the boiling system and it ought to provide decay heat removal. Why is it it does not?

MR. LEVY: The way the reactor works in these events is you provide water to the reactor and keep the core covered. That energy in the water in this machine tends to find itself back in the suppression pool. What happens is you are depositing energy in that water you provided. Most of the time in these systems you would have relief valves to take the heat from the water and put it back in the suppression pool.

That is the mode of operation you get into. Do you follow me? We have water in the core. It takes the water and the fuel, makes steam. That steam gets carried out to the suppression pool, where it is condensed. And the suppression pool becomes your big storage of energy to finally remove decay heat.

MR. BENDER: I haven't followed your logic all of the way, I think. I can see failing the containment by this mode, eventually. But at the same time, I cannot see that it necessarily says that there will be fuel damage.

MR. LEVY: I did not say that there was fuel damage in that particular damage. I said I will look at the risk of probability of having containment failures or having core damage. The reason I look at containment failure is once a containment failure occurs you have to transform that to what does it mean to the core.

MR. BENDER: That is what I was trying to get at.

MR. LEVY: Those things become more difficult to get into. And rather than to deal with the consequences, how much damage we did, we remained at the level of containment failure or really core damage.

MR. BENDER: Let me repeat what I said. I think you could have containment failure and still not have core damage, and that would have important public safety values.

MR. LEVY: Yes.

MR. BENDER: And you may be hiding that in the kind of discussion you are making.

MR. LEVY: Let me answer that by saying, we run the calculations all four ways. The numbers I'm showing you would get better if you went all of the way, because, as you indicated, many containment failures do not necessarily lead to a large amount of fission release.

MR. BENDER: All right, go ahead. Fine.

MR. OKRENT: I am still trying to understand something, though. If I have a system that could provide water to the core endlessly from the ocean or whatever -- not the ocean, since it is salty, but the equivalent, you know -- then the pumps will function whether the containment has failed or not, if I understand correctly. And so why wouldn't that system not only handle those accidents in your bar chart that arise from failure to provide water makeup to the reactor, but if it will function when the containment fails it will also have removed any problem from those where the containment fails?

MR. LEVY: Yes. There are, as you know, decay heat removal systems that, if this plant is depressurized, it can bring water in and take it out, take it through the heat exchanger, and not have to use the pool. As you point out, I think those events will turn out to have really no impact per se in terms of creating a degraded core.

The cases we end up being concerned with are those that do not have that system, do you follow me, and really deposit the energy in the pool, and therefore lead to containment failure, or those that do not give enough water to the core and therefore creates a degraded core.

The path you described is a success path and therefore would not appear anyplace on this chart, in the sense that if they are events they would not produce a problem.

MR. OKRENT: Maybe after we hear your presentation we can come back to this observation on risk, because I have that question and a different one as well. But let's see how it goes.

MR. LEVY: The features we looked at, we divided them into both preventive and mitigation type features. We did not just try to look at one type or the other. And a range on this chart, for your benefit, addressing these major failure categories:

First, the failure to remove decay heat. We looked at improving onsite power source. One of the possibilities that we cannot get the heat out of the suppression pool is where we do not have power of any kind to run those pumps tha' take water from the pool and take it to the heat exchangers.

A second feature we looked at is one you mentioned, the possibility that as the pressure in the containment goes up we could employ containment pressure relief and in so doing avoid containment overpressure failure from that mode. And I will come and describe that one in more detail.

A third feature was to provide another independent system from the suppression pool to remove decay heat. We looked at two such systems, an internal system -- by "internal" I mean a system internal to the containment -- and an external system where we actually get all the way outside of the containment.

Both of these systems take the steam generated from the reactor from the condenser, condense it, and take it back to the core. So it is another means of decay heat removal. Just like you were saying, you were looking for another success path, we are creating another success path where we could remove decay heat by this technique, now using the suppression pool as our reservoir of energy.

In the area of failure to provide water makeup to the reactor, we again looked at improved onsite power, because that applies to both cases. In this particular case, we looked at what we could do to improve the emergency core cooling system network.

What was done in this particular case was to recognize that the low pressure system in a boiling water reactor is stronger in terms of capability and reliability. So what we set out to do was to improve the depressurization we presently had, which was the automatic depressurization system, to go into a depressurization mode and some other circumstances. And I will describe that in more detail.

Finally, we looked at a combination of a couple of features in which we employed containment pressure relief and reactor depressurization augmentation in the area of mitigation. We arranged our features by the way we would face the problems.

We believe that the problems that would occur if you have a degraded core is, first you would have to solve the hydrogen problem. If you have not solved the hydrogen problem, your overpressure control situation gets solved by itself. In a sense, you don't have to worry about it.

So we arranged them, we said, hey, if we have to work on anything in mitigation, let's work on hydrogen control first. In this particular case we looked at four types of things: containment pre-inerting, containment post-inerting, controlled hydrogen burning, and increased containment pressure capability.

Once the hydrogen control situation is brought under control, then one has to deal with overpressure inside the containment, and this overpressure comes about from really noncondensibles being formed, therefore raising the pressure in this containment. In this particular case, we looked at two features: venting or venting filter of the containment; low-carbon concrete, because that would reduce the amount of noncondensibles formed; and the third and final mode in which this containment can fail is basemat penetration. In this case we looked at flooding of the containment and molten core catchers and ladle.

Because I think of the urgency of time, I would like to use this chart to give a quick summary of some features and not spend more time on it. If at the end you want to come back to some of these features, we would be glad to come back and answer questions and present more details.

MR. OKRENT: Could you give me one or two scenarios that you have in mind whereby you get to significant fission product release arising from a loss of ability to remove decay heat, what you call containment failure?

MR. LEVY: We believe containment failure per se now has to be pursued, where is the containment failure, what its impact is on those systems that provide water to the core. Were those systems impacted? Were they impacted enough to now lead to a degraded core?

So you have to follow that chain to finally generate a degraded core under that set of circumstances.

MR. OKRENT: Is it the mechanical failure of the containment that leads to damage of these systems in this scenario, or is it something else?

MR. LEVY: We believe a mechanical failure could do that. We will discuss that again. Many of the scenarios we look at in this design, in contrast to the WASH-1400, do not lead to the degraded core situation that occurred in WASH-1400.

MR. OKRENT: It is still the highest, albeit the lower, the highest grade column on your bar chart.

MR. LEVY: It is the highest because I defined it in terms of risk, probability of containment failure. And I'll stop at that point. I didn't translate it back to full core damage. Do you follow me?

The reason I didn't want to enter that area is because that area becomes a little bit more controversial in terms of how we did it, how good it is, how good the numbers are.

So I think to do these studies, we just confined our attention to that level, rather than to enter the others. I think General Electric has performed these studies with the others, and I think we have carried on such studies.

You understand that in WASH-1400, containme failure was synonymous with degraded core. There was one probability. If you had containment failure, you had probability one of having core melt. So I tried to remain at the WASH-1400 level without penetrating some new consequence model. And I hope General Electric later on today will have the opportunity to describe some of their work in this area, because I think it points to some major gains in this particular design.

Let me say with respect to improved onsite power, we felt the most meaningful thing we could do would be provide diversity. The main thing that really is in the way of power is this common mode type of failure. So the thing we went to was to look at diversity.

We went to gas turbines. We evaluated the risk reduction factor associated with this. We got a risk reduction factor of 14.12. We felt again the medium of this particular feature was large.

I think what you will hear finally and what Mr. Goldberg will recommend, you will understand why we picked certain features or not. We looked at risk reduction. I would like to put in, what do we get with them in a risk reduc'ion factor. I will describe them and you will get a good feel for what it means in terms of impact. And you will see in the chart, in terms of small medians and large impacts.

But I would like to defer discussion of how we weighted those back to Mr. Goldberg, because I believe Houston should tell you, really, what they viewed as acceptable or not acceptable in terms of impact on the project.

MR. BENDER: When are the gas turbines applied?

MR. LEVY: They are applied any time you have a loss of AC power.

MR. BENDER: They feed in where a diesel generator would feed in as an alternative?

MR. LEVY: Yes. The preliminary design is where you have a diesel you have a gas turbine capability. That is the design we laid out.

MR. OKRENT: And by "impact" do you mean impact on the plant, either schedulewise or costwise?

MR. LEVY: Schedulewise, costwise, and you know, there are a lot of things that go into this impact. I would like to defer back to Mr. Goldberg in his conclusion to comment on that area.

MR. BENDER: But they presume the integrity of the internal distribution system.

MR. LEVY: That is correct, yes. I think that is correct. That was evaluated in terms of what kind of availability we get out of it, what kind of reduction we get out of it. The evaluation was made of the gains, how much did we improve the power source availability. Then we went back to the risks and evaluated what it meant to the risks.

The second area I world like to talk to is the external isolation condenser. It accomplishes the same risk objective as the internal. It had a much greater impact on the project, and therefore I will say we don't need to spend time on it. I will spend time on the internal isolation condenser as an alternative.

I would like to say the same thing with containment pre-inerting. It was looked at. It would involve substantial movement of equipment, some great difficulties in terms of operation. And again, as a feature I would like to discard it at this point and narrow my list again. If there are questions at this point, we can come back and discuss them.

I would like to deal the same way with low-carbon concrete. We felt that the low-carbon concrete actually didn't give us very much. It is a small reduction of noncondensibles. It is not a solution to the noncondensible problem. We are also not so convinced it actually helps the risk, first, that comes in the overpressure control area.

The thing that a little bit bothered us -- and I am here expressing a personal opinion -- that the generation of a small amount of gas will force more heat from the molten core upwards and downward. What actually encourages the movement downward is that the gas generated helps mix the molten mass and allows you to penetrate downward.

And this says one could formulate a model in which as you cut that gas formation you are actually pushing more and more heat upward through this molten mass. And we think pushing more and more heat upward might increase your risks.

I will not say we made a risk assessment. Let me make it clear, in the mitigation area we did not generate risk reduction factors, because they involve certain phenomena we believe are not as well understood.

We tried to put some judgment of what we felt would contribute to risk reduction in that area, and we felt that low-carbon concrete would have a small justification for being looked at. And it is a change to the project in many waysl

With regard to the basemat penetration, our position was that flooding of the containment and a molten core catcher come right at the end of these events, that their contribution at that point in terms of really risk reduction is quite minimal, because you would have gotten already the contribution of hydrogen control, you would have gotten the contribution of overpressure control. We therefore view them, in term of risk reduction, as not providing a meaningful risk reduction.

I would also like to say the reason we did not feel we should look at them in more detail was because the state of the art on what to do with these things and what to assess, what impact they would have, is quite difficult. So we feel from a state of the art technology we were not in a position to evaluate these in any meaningful way in terms of impact, for example.

Having said this, I would now like to go to the next chart and show you the first screening of the features, the ones I'm going to talk about.

MR. OKRENT: On the low-carbon concrete, if it were there it would reduce the amount of noncondensibles?

MR. LEVY: It would reduce the noncondensibles.

MR. OKRENT: And if I recall correctly, you said having less gas going upward through this material would lead to something. Would you tell me what you thought that something might be?

MR. LEVY: Well, here's this molten mass which I don't like to think about. But anyway, it's a molten mass sitting on the concrete, eating through the concrete. And it has a choice of pushing the heat downward or upward. It can push it upward for alleviation means. It can push it downward by reacting with the concrete.

Now, when you generate gas that gas formation helps the heat transfer downward. As you cut that gas, I think that molten mass, which is generating a certain amount of heat, if you cut the penetration downward, the amount of heat generated, more of it would flow downward than upward, if you follow me.

The upward flow can cause some problems. If you just look at the amount of generation you have, from a small heat transfer area you could have some pretty high radiation fluxes, and you might get into some other types of failures, if you follow what I am driving at, from that very high flux upward.

MR. OKRENT: Again, you think, then, with the generation of more gas there might be a higher rate of heat flowing downward?

MR. LEVY: I feel if you're going to fail this containment you might as well flow downward to the basemat. That takes a long time. The risks are small. Go on and impede that path.

MR. OKRENT: A question I was going to ask, and this is as good a time as any: Since we have a finite amount of time here today, it would be of interest to know if there are reports that you have prepared which Houston Power & Light can make available some time in the future or not? I don't know.

MR. LEVY: Why don't I leave it to Mr. Goldberg to comment on that.

MR. OKRENT: I'm sure we would appreciate having the benefit of these if they can be made available.

MR. GOLDBERG: We do have some copies of a draft report that represents the work done to date, and we would be glad to leave some with you tonight.

MR. OKRENT: Thank you.

MR. LEVY: I would like to say, though, the work is preliminary in many places, as I am sure you understand.

The first screening of the features, we come down to the features shown on this chart: containment pressure relief. We assess that containment pressure relief will have a pretty good risk reduction factor. That is what the numbers are in parenthesis. We assessed it at 2. It probably will do better than 2. We went out of our way to make sure we didn't make it as large as it might be.

Internal isolation condenser gave us a risk reduction of five.

The reactor vessel depressurization augmentation gave us only a risk reduction factor of 1.1. The reason is because the ECCS system is already pretty effective, and making it a little more doesn't get that far down the line.

I think we looked at a combination of 1 and 3 and got a total risk reduction factor of 3.

In the mitigation area, I will talk about containment post-inerting. If you notice, the way I would define my risk reduction factor, it cannot be above 1.3. It has to be less than 1.3. If it did it all, that's all we would give it.

MR. OKRENT: I would like to talk about that a minute here, because that is somewhat a result of the way you did the calculation. Your definition of risk is a different one, let's say, than we usually use, about release of radioactive materials.

MR. LEVY: Yes. They have been usually done in terms of total consequence. As I said, those numbers were usually carried out -- except in the mitigation area, they were not carried out all the way to consequences. In preventive, they were carried out all the way to consequences.

I think one could carry mitigation to the total consequences, but we didn't get the opportunity to do it.

MR. OKRENT: In what we are going to hear later from General Electric, are we going to somehow get a tie-in which gives us their opinion on when containment failure does or does not probably lead to more trouble?

MR. LEVY: Yes. I am just going to make a reference to it, that will be my last chart.

MR. OKRENT: I don't want to use up their time.

MR. BENDER: Just to be sure I understand this internal isolation condenser, that is something that parallels a suppression pool?

MR. LEVY: I will show a picture of it in just a minute.

MR. BENDER: I will wait, then.

MR. LEVY: Controlled hydrogen burning with present containment spray is another feature; increased containment pressure capability and venting of containment.

Let's go now to containment pressure relief. What this consists of is providing a way to relieve this containment when it reaches a certain pressure, so we can avoid the overpressure failure. And what will happen is we will start to boil that pool. We will push air first from the containment, and eventually we will push steam through this relief. And this can go on for a substantial amount of time, many, many hours.

We also looked in this at a slightly additional feature: Could we even add some water to the pool's makeup? And we studied the possibility of doing it with a fire diesel system which is available, and we could even bring some cold water up to make up for water we lost or to keep the pool cooler. And in so doing we could delay when the venting will occur and we will buy extra time.

I think the advantage of this approach is very clear. It is a simple fix within current practice. I think it discusses cost and impact. It will provide a substantial risk probability reduction of 2.

The disadvantages, as we looked at them, were that we could not pin down the suppression pool loads. If the pool reaches saturation temperature, we did not get a chance to see what the loads would be. Could them come back to hurt the design of this containment in terms of dynamic load capability? And finally, there is the danger that if we provide the way to add water we made add too much water and eventually it would spill into the dry well and we would start to flood the dry well with water. And that is clearly a disadvantage and a concern, as we look at it.

The internal isolation condenser is really a backup. It serves several things. It is a backup for the two systems that could be used to keep this plant at full pressure and operating, removing decay heat. One is the so-called reactor core isolation cooling system, and the other is the high pressure core spray system.

The reactor core isolation cooling system takes steam from the reactor, takes it to a steam-driven pump, and pumps water from the containment back into the core. In so doing, it therefore keeps the core covered while the plant is at full pressure.

The high-pressure core spray is driven by a diesel in this particular design. It can provide water to the core. Any time the water level gets low, it goes and takes water from the condensate storage tank or the suppression pool and adds it to the core, keeping the core covered.

We have provided here for another way to handle this decay heat, and I will describe what it is in a few seconds. This I think is shown on the next chart. They are a fusion of what the system was yesterday, and I felt it would be worthwhile to make sure people understand what we are talking about.

What we are talking of doing is taking steam from the reactor by natural circulation, taking it up to a condensing pool. We located this condensing pool in the upper containment pool. And then as the water is condensed it is returned back to the reactor. It is very similar to the old isolation condensers that were provided in the early General Electric plants.

This system does not need any power. Natural circulation is on the primary side. There is natural circulation around the coil on the secondary side. So it has an important advantage that it can operate without AC power.

I think the question was asked, what was it sized for. It was sized for two percent decay heat. So it does not handle the first thing that occurs, but it is sized enough to make sure enough water remained in the reactor vessel, and at that level it's capability of operation was about 24 hours. It can operate 24 hours.

What finally limits it is you may need to make up water, because the primary system has leaks to it.

Now, this system really keeps the primary system fully enclosed. As we keep dumping more and more power to the upper containment pool, we will again heat up that pool. We could eventually even steam that pool.

We think that since we have the primary system completely isolated, we should be able to purge that containment under those conditions. There are no fission products, really, except maybe the first opening of the relief valve in that containment. So we think that system can continue to operate, and if we continue to dump more and more heat into this upper containment pool we could eventually just purge the containment, if you want to look at it that way, or relieve the containment.

It's advantages are its independence from the present system and its independence from the suppresion pool, it is effective for total loss of AC power, it provides a barrier between the reactor and the containment, and it provides a substantial risk reduction factor of 5.

Now, why does it provide 5? First, it solves the problem of long-term decay heat removal. But it also goes out and catches those events in which we did not have a break, where we do not have power to keep bringing water to the core. This system will employ natural circulation to accomplish the mission.

Do we have any question on this system, how it works and what it does?

MR. BENDER: If you put this in with the suppression system, will normal conditions still exist? You would have both systems, either one of which could do the job.

MR. LEVY: Yes. This is an additional system, as we look at it, to provide what we spotted as that bar chart. As I say, the disadvantages -- I think, as you realize, that is a substantial system. I don't think I have to say so. The picture points it out.

We feel we would like to take some additional studies of it to make sure we don't have any surprises. We probably will have some interference with refueling and upper pool usage. We have made some preliminary evaluations of that.

MR. OKRENT: One or two questions: Was there something like this in the early BWR designs?

MR. LEVY: Yes.

MR. OKRENT: Does it function well?

MR. LEVY: Yes. It's used at Jersey 2, Jersey Central, Nine Mile Point. It is really the system used for isolation.

MR. OKRENT: There are no water hammer problems or anything like that?

MR. LEVY: Well, you know, function well. Let's be careful. There have been a few water hammer problems, a few leaks. But it has operated effectively as a safety system. That is my definition of it.

I mean, I am not going to say it runs with no problems whatsoever. I think we all know the list.

MR. OKRENT: But you think it can be engineered to be quite reliable?

MR. LEVY: We hope to engineer it to benefit from the experience of some of those other things.

Reactor vessel depressurization augmentation. What we are talking here is to make some electronic changes and to provide another energy source to allow depressurization of a plant. What we are thinking of is providing an air supply that could be operated manually and that would allow someone to actuate relief valves not involved in the ADS system. This is another way to depressurize the plant manually if you need it, and it employs an air supply.

The other thing that has been suggested for this system by General Electric is that we should maybe automate the depressurization system on low level rather than low level and high containment pressure, which is what it takes right now for EDS. What this will do is cover some situations in which the break actually takes place outside the containment, if you want to look at it this way, so we will move depressurization to catch some other events that maybe were not caught on the present scheme.

MR. OKRENT: Maybe this the point at which to ask why on your list you did not, as I recall, show another high pressure system. You indicated a low pressure system is more reliable, so the thing to do is to move toward making your depressurization still more reliable.

MR. LEVY: You have got to understand, on this ECCS side that bar chart is already small. Do you follow me? Those ECCS networks are very good. The BWR does not have a LOCA. The risks are not associated with LOCA. I wish people would realize that when they want to impose additional hydrogen conditions, because the TMI problem, that is not an apparent problem to the BWR.

MR. OKRENT: It has sometimes been suggested maybe giving more reliability in the ATWS.

MR. LEVY: Our bar chart shows that. I don't think there's been any problem in that area. This is a simple fix. It is easy to provide. It has a small impact on the project. The risk probability is rather a minimal one, .1, because already the network is pretty good.

We like to look at inadvertent operation. It was not fully assessed, and we want to make sure it does not degrade the automatic depressurization system reliability.

I am now going to switch to the mitigation features. Containment post-inerting; two systems we studied, one to add halon and the other to add CO-2. The basic idea here is you would have your halon and CO-2 in enough quantities so that the hydrogen could not burn. So you actually inert the containment, but you do it after you have detected some signal that says, this is the time to go in and inert this containment.

The advantage is: it solves the hydrogen problem, if actuated properly. The disadvantage, which I think has been discussed already, is it increases the containment pressure. If we use halon for the suppression, it will add about 6-1/2 psi. If we use Co-2, it will add about 22 psi.

I think it is an active system and assurance of actuation is a disadvantage. There are some potential material corrosion problems for halon if it decomposes. There is a concern with inadvertent actuation with people inside the wet well.

And it is a system, I think as you will hear later, that might have made the final cut.

Controlled hydrogen burning. This is a comparative system to control hydrogen. It employs igniters to burn the hydrogen before it reaches excessive concentrations. It has a major advantage in that it has a minimum impact for inadvertent actuation.

It has some disadvantages. If we don't ignite it at the right hydrogen, we might have some pressures high enough to give us a problem. We are concerned about the impact of the burning flame on the equipment. We feel we do not have all of the answers, although some other people working on it may have them, with regard to what should we do with the containment spray. If there is some need to mix this thing to ensure hydrogen concentration to ensure good ignition.

I think, as I put down there, if there are some major changes involved in either containment spray or mixing, it has a very different perspective about whether it is a system that makes sense or not.

MR. OKRENT: Do you mean if it requires the containment spray it makes less sense?

MR. LEVY: There is a containment spray in this plant in the wet well. But we are saying, if it goes on and requires a completely modified containment spray, bigger, bigger-sized drops, et cetera, and it requires some mix of all of this, I think it would be a different animal.

In fact, we did not have enough information to decide what to do in those areas. I think clearly we want to follow the work going on. There are other people following this idea. But I wanted to make sure you understood we did not have enough to judge the system.

Increased containment pressure capability. We looked at what could be done to raise the containment pressure capability. What we primarily looked at was raising the pressure capability as it is above defined in the NRC proposal. What we looked at was what can we do to raise the static capability of this containment, based upon an accident condition.

So are we talking of using, for example, yield stress for the metallic portions, or are we talking of using factored conditions for those involving concrete?

Now, the advantage of this is pretty clear: increased overpressure for hydrogen control and subsequent events. We found that there was a way to raise the containment pressure capability, as I have just defined it, from 38 to 45 psi gauge.

If I could show you the next picture, the study showed that the place we were being limited was actually the place where we were actually anchoring the steel containment to the basemat. And the concern really is where you made this connection over here (Indicating).

We found we could add some additional anchorage and raise this capability from 38 to 45 psi gauge. We wanted to make sure that as we raised this capability it was very clearly understood, if we go back to the other chart, that we were not talking about any kind of increase in dynamic loads.

We are saying this is an end of spectrum, and we don't want to look at the usual combinations we have been faced with, because this is pretty tight in its dynamic load capability with all of these loads of chugging and relief valves, et cetera.

Venting or venting filter containment. I am coming to the last chart.

MR. OKRENT: So where you say "disadvantages," you mean you would need assurance that there was not?

MR. LEVY: I would want to make sure the capability we have committed is very clearly understood and that capability does not grow on us and we are not committing things we don't have.

I think Mr. Goldberg will stress that point clearly in his recommendation, and I will defer to him.

MR. OKRENT: Did you look at any other measures in the area of increased containment pressure capability? When you make a change there -- well, maybe I am incorrect in that.

MR. LEVY: That still remains the weak point. To answer your question, that still remains the weak point.

MR. OKRENT: I assume therefore it's not easy to go to the next step.

MR. LEVY: And that's it. I think we went as far as we felt we could do, I think, and we can discuss that. We have people from Ebasco, if you are interested in that. But that is about the way we did it. That was the weak point. We took it about as far as we could and that was about it. If we had any more, to my understanding there wouldn't be room for a rebar.

But I will pass up on that point. I am not an expert in that area.

Venting or venting filter of containment. We think that venting or venting filter of the containment could be used to avoid overpressure failure. It only provides risk reduction after we've brought the hydrogen under control. We also see that the vent alone provides the dominant portion of the risk reduction, due to the presence of a suppression pool.

Based on that, we also concluded that a vent filter did not make sense because, as I have said already, we have a pool filter already in place. And to go out and add another vent, another filter, would have a very large impact on the project. We are concerned about uncertainty in the technology of how to design these, and these gases we have with hydrogen in them and how to really maintain them, and things of this type.

So we didn't see that the benefit was large. We felt that when we were considering the idea of a vented filter, the benefits were small, we were probably entering into uncertainty in technology. And a final disadvantage we show there is obtaining public acceptance.

I want to show one more chart to explain why a vented filter didn't pay so well. This is a very simplified picture of a Mark III containment. I think it shows the dry well. And I think, as Steve points out, the dry well design is a very strong dry well, for other reasons.

So what happens is, when you go to an overpressure control load, you actually create the same pressure on the dry well and wet well sides, because it can communicate through both vacuum breaker and through the pool. And really, the wet well is designed for a lower pressure. That is where the potential failure mode would occur.

Well, from many of the scenarios one would look at, you would still have the suppression pool as a filter to work for you.

I think that is about all I wanted to say. That's my coverage. I think I have given you quickly the results of the study, and I will turn it back to Mr. Goldberg for additional comments.

MR. GOLDBERG: Now we get to our conclusions and our recommendations for what we ought to be doing for Allens Creek. Again, I would only like to repeat that our criteria perhaps is different than other plants. We need to add generating capacity to our system before the end of this decade. We are counting on Allens Creek.

However, if what we have to do to Allens Creek makes that an impossibility, then there won't be an Allens Creek. We will have to take that money and put it into some other source of added capacity.

So with that kind of a constraint, and in light of the early results we have this far, if we were writing the rule for Allens Creek we think it would sound as follows: We would equip our containment with a post-accident inerting system to preclude detonation of hydrogen resulting from a 100 percent fuel-clad metal-water reaction.

We would further enhance containment pressure integrity such that it could accommodate the following: anticipated peak containment pressure resulting from a postulated 100 percent fuel-clad metal-water reaction, without loss of functional integrity.

Further, that the anticipated peak containment pressure resulting from the accidental initiation of the post-acting inerting system with the reactor at power would not result in containment stresses exceeding code allowables for normal operation.

And in order to get away from this uncertainty of a process vent, which the staff characterizes might be as big as a football field -- and of course, the Houston Astrodome is a football field -- we would provide for this internal isolation condenser. We feel that the scenario of a total station blackout represents one of the serious contributing scenarios to degraded core.

And we'd be willing to provide that, but we would hope that it would buy us some exchange for the millenium of possible mitigative features that the staff is considering. That would represent our conclusions, based on our work to date, on what we would do for Allens Creek.

That completes our presentation. We do have copies of our suggestions pertaining to the rule, which have just been handed to the Committee. I guess at this time we are open for any further questions.

MR. BENDER: You said you would provide inerting and you would provide the internal condenser. Is that the sum of what I heard?

MR. GOLDBERG: And a strengthened container.

MR. BENDER: Up to 45 psig, or is that number still open?

MR. GOLDBERG: That number is still open. But what we are saying is, we have a considerable margin on the steel side. But what is limiting is our mat. We think it is somewhere around 45. That is the pressure we believe we can sustain without loss of functional integrity.

MR. BENDER: You consider that preferable to the external fire water pump, because you cannot assure the fire water pump will do the job?

MR. GOLDBERG: I guess what I would say is, assuming we postulate we have a hydrogen condition, and further assuming we would not be able to sustain a pressure buildup resulting from detonation, our feeling is we ought to provide for a post-accident inerting system. If we provide that system and we take its pressure contribution in consequence with other sources, we believe we can get pressures in the range of 45 psig.

MR. BENDER: I haven't been able to go through Levy's scenario completely. But if the postulate is the existence of hydrogen, which we haven't logically established, I would have to say that the existence of hydrogen in containments says the containment is open. And I have to ask myself, well, how does that relate to this closed condensing loop that you are proposing as a fix? Are those things mutually compatible?

MR. GOLDBERG: No. I think it is fair to suggest this, that if one were to take as a scenario a total station blackout and therefore all of the current existing emergency core cooling provisions are not functional, this system is basically a passive system and it would function, and it would buy us a considerable amount of time to get these other features back in service. And in effect, it would represent a preventive device for that scenario, to preclude getting into a condition of degraded core.

MR. BENDER: But it is instead of creating hydrogen?

MR. GOLDBERG: Yes.

MR. LEVY: It avoids the occurrence of a degraded core from either that event, or it avoids the occurrence of a degraded core from the case in which so much decay heat is deposited in the pool that the containment fails and the containment failure leads to a degraded core. So what that feature does is reduce the probability of occurrence of a degraded core, if you follow me, in contrast to the post-inerting system which deals with the fact that you have hydrogen.

MR. BENDER: Thank you.

MR. OKRENT: Have you concluded that the ignition or ignition with spray was less effective or was not effective or was more costly or something, compared to post-inerting?

MR. GOLDBERG: To be honest, we haven't carried that degree of work to that conclusion. Our initial feelings about ignition were that we would have a considerable amount of areas we would have to examine that that would be an acceptable option. At this point in time I think it would be fair to characterize it that post-inerting looked to us to represent a lesser challenge to the design of this particular plant.

Now further work may cause us to change that feeling. But that is where we are today. I could not say conclusively, but maybe further work would disclose that the ignition and burning might prove to be a lesser situation than we first imagined.

MR. OKRENT: Are the general performance requirements of this post-inerting system written down in Mr. Levy's report, in other words, that it is going to get a certain amount of CO-2 in in a certain time, or however it is specified?

MR. GOLDBERG: No, the system has not been fully designed. E[illegible]n the criteria for the system has not been establishe[illegible]

MR. [illegible]Y: There is a conceptual description of the system in the report in terms of the amounts of gas you need, et cetera, to accomplish the mission, the time, et cetera. But I think, to answer your question, there is not a complete set of criteria. It is not a detailed design.

MR. OKRENT: No, I assume not detailed. But at the moment, I have heard a lot of discussion in the last few months on ignition systems, as you may understand. I haven't heard that much on post-inerting systems, and I wasn't quite sure what requirements they were envisaged to meet and so forth.

MR. LEVY: We can have Chuck Johnson show you what it looks like, a sketch.

MR. OKRENT: If we could see a quick sketch, I would appreciate it. And then if Ebasco could give us a couple of minutes on containment, where the next weak point is, et cetera, I think it would be helpful.

MR. JOHNSON: My name is Chuck Johnson. I worked with Dr. Levy on this project for Houston Light and Power. If you give me a moment I will find a sketch.

Here is the sketch of a physical system as roughed out by Ebasco. It consists of refrigerated tanks of liquid carbon dioxide which would be energized on demand to drive the carbon dioxide through a line into the containment at a point about 20 feet above the suppression pool in the wet wool and then sparged around to lay down a blanket of CO_2 in that area. The amount of CO_2 is taken from experimental data that says you need about 165 percent in air; in other words, you have to put about 165 percent, mole percent, into 100 percent of air so that you can make sure the hydrogen and oxygen in the air can't burn.

So we prohibit the possibility of hydrogen burning, any amounts of hydrogen, by simply diluting the oxygen to the point that it can't burn.

MR. OKRENT: And you would envisage this needed amount of CO_2 would enter in what period of time approximately?

MR. JOHNSON: We are planning on a 15-minute insertion period. There would be a demand signal which has not been defined yet, how we generate the demand signal. There would then be a five-minute delay for evacuation of personnel from the containment, then a 15-minute insertion period.

MR. OKRENT: What would be the approximate cost of the CO_2 involved in that?

MR. JOHNSON: I would have to defer to people at Ebasco, how much would that be. I never saw any CO_2 numbers.

Do you mean the actual CO_2 itself?

MR. OKRENT: Yes. Not the system.

MR. JOHNSON: I don't know. I didn't see any numbers on the study.

MR. OKRENT: Is it a trivial amount of money?

MR. JOHNSON: It is quite a bit less than Halon.

VOICE: Half a million feet of CO_2, is that what you said?

MR. JOHNSON: Did I miss the point? Did you say dollars or quantity?

MR. LEVY: How many dollars are tied into the CO_2 itself, not the tanks, not the system.

MR. JOHNSON: No. I don't have that number.

MR. OKRENT: Okay.

MR. JOHNSON: That is not the criteria for the CO_2, the cost of the gas.

MR. OKRENT: Let's see. You would have the capacity to achieve this concentration throughout the wet well or whatever it is called?

MR. JOHNSON: Yes. There is sufficient gas in the system tc completely dilute all of the gas in the dry well and wet well. We have got to do some more work on whether that sparging system will actually do the mixing required and get a uniformity of concentration that we need.

MR. OKRENT: Are there any questions on this at the moment?

(No response.)

MR. BENDER: There is one, Dave, I want to ask. When you put the CO_2 in what is its pressure contribution?

MR. JOHNSON: A simple way of thinking about it is if you say it takes 165 percent, mole percent to dilute, then that is 1.63 atmospheres. So you can take 1.63 times 14.7 psi and you get 22 psi. Now, that is not exactly what happens, of course, because the temperature is higher and there is hydrogen in the air; so if you calculate what happens in an accident, it will be greater than 22 psi.

MR. BENDER: But it is of that order.

MR. JOHNSON: That is right.

MR. OKRENT: Could we hear a little bit on the containment?

MR. SULLIVAN: Yes, sir. My name is Ray Sullivan from Ebasco Services, Supervising Civil Engineers.

MR. OKRENT: I thought maybe you could just lead us through what --

MR. SULLIVAN: I thought you had a specific question.

MR. OKRENT: What we heard was the weak point was what you would call a hinge or a joint, and that also after you strengthened it, it still remained a weak point. Could you tell us a little bit more about why you ran into a roadblock there in strengthening it further and so forth?

MR. SULLIVAN: Okay. The containment shell itself had a capability of higher than 45 pounds.

MR. OKRENT: How much?

MR. SULLIVAN: Upwards, around 60 to 65 pounds. We are talking yield stress limit. In the concrete foundation we are talking the Division 2 code for concrete containments, stress limits for the factored accident conditions.

We found that the anchorage capability due to anchorage depth and the thickness of our mat, to go beyond 45 would require possibly thickening the mat and otherwise reconceiving the anchorage detail. We have an embedded skirt. We added additional shear reinforcing to the mat to go from that 38 to the 45, and the reinforcing becomes quite crowded, in our judgment. We stopped at that point because we thought that is the point we would get into what we would call a major modification of that area.

MR. OKRENT: Just so I understand it a little better -- designing concrete structures is not my business -- in fact, if you were to try to make that joint equivalent in its capability, whatever that means, to the shell, what would be the avenue you would follow?

MR. SULLIVAN: We would investigate making a deeper embedment, possibly thickening the mat.

MR. OKRENT: Are you talking about one foot thicker out of 12 feet or 20 feet added to two feet, or what is it that you mean when you talk about thickening the mat?

MR. SULLIVAN: I would have to guess, because I want to emphasize our study stopped there, that particular study. If I were to make an estimate, you would probably be talking of a minimum of four feet.

MR. OKRENT: Adding four feet?

MR. SULLIVAN: That's correct.

MR. OKRENT: To how many?

MR. SULLIVAN: Presently it is 12. The embedment is six feet into the 12.

MR. BENDER: And that is to get the pressure from what to what, 45 psig to where?

MR. SULLIVAN: Up to the range where you had the capability already on the upper shell, which would be in the area of 60 to 65 pounds.

MR. OKRENT: Do you have any other questions in this area now?

MR. SULLIVAN: Maybe I could clarify why that became our stopping point. If we make such a modification to the foundation mat, it puts us back into remodeling from a soil structure analysis, remodeling the reactor building for the pool dynamics analysis, and a very substantial reanalysis because of making that kind of a basic change.

MR. OKRENT: If I understand correctly what you are telling me, as far as you can see, this is the avenue you would need to follow if you were going to try to increase the capacity at that region of the containment. You don't have an alternative that does not get you into this major redesign, reanalysis.

MR. SULLIVAN: At this time I do not, sir, no.

MR. OKRENT: Okay. Are there other questions that the subcommittee members may have with regard to any of the speakers from Allen's Creek?

MR. BENDER: Dave, I would like to ask one further question about the isolation condenser.

MR. OKRENT: Go ahead.

MR. BENDER: This gives you a closed loop. It still leaves the suppression pool, as I understand it, as heat. Have you given any thought to ways of taking heat out of the heat sink?

MR. LEVY: Let me make sure I first understand your question. If you use the isolation condenser, we don't use the suppression pool. We use another pool which is an upper pool. It's another pool, a fuel storage pool.

Some of the early alternatives we looked at, in some of the early studies we did we looked at ways to maybe add systems to improve the heat removal capability from the suppression pool. We actually looked at the idea of adding another system. It did not make the first cut because we were concerned about common mode failure. They look so much like the ones we have that we felt we were not biting, so maybe it was just a matter of judgment, but we decided to go for something different that utilized another place to store energy.

MR. BENDER: The fuel storage pool, I think -- I may be wrong -- is relatively small, I think, compared to the suppression pool in terms of volume of water.

MR. LEVY: It turns out to be a pretty good-sized pool.

MR. BENDER: Is it about the same size?

MR. JOHNSON: No. It is about 4 1/2 million versus 8 million for the suppression pool. It's about half the size.

MR. BENDER: That is a pretty good size, I agree with you, but it has a cooling system associated with it already.

MR. LEVY: And it has a cooling system associated with just removal of whatever elements are in there.

MR. BENDER: I don't know how capable that heat removal system is, but I can envision that it might be fairly small at the moment.

MR. LEVY: That is correct.

MR. BENDER: And if I wanted to reinforce it, I might still think about whether that is the place to tie the firewater system in or some such thing as that, so that it would be, therefore, a long time. It might be operated with a gasoline pump or some such thing as that.

Are those kinds of things out of the realm of --

MR. LEVY: We went with the idea that we could use that pool and eventually even turn it to steam. Our basic approach was to think of something that doesn't use any power, but I am not saying the options you describe --

MR. BENDER: If you could use steam, that would be great. I hadn't thought of that. You understand my thrust.

MR. LEVY: Yes. I must say we have not looked at that. You have to understand what we are saying. We are saying we've got to make a provision for this, and I think there is nothing that says one could not look at some other refinement; but for the time we had we tried to work this in in what made sense, so it's a combination.

MR. BENDER: I am just looking at things isolated from the accident and are not vulnerable to accident conditions that I can get to in a hurry. I think the idea of having alternative heat sinks like that are very attractive; but I would like to see that it has longterm continuity.

MR. LEVY: It has a fair amount of capability, as you can sense already.

MR. BENDER: All right. I have asked all of the questions I want to ask.

MR. OKRENT: All right. Well, why don't we go on to the next part of the agenda. We may think of some more things either tonight or by Friday. I believe General Electric is up next.

MR. BUCHHOLZ: My name is Robert Buccholz, and we are here today, General Electric is, to provide you information regarding the containment capability of the BWR-6 Mark III standard plant under postulated degraded core conditions.

We recognize you are in the process of deliberation regarding the need for additional requirements for hydrogen control for the near-term construction permit plants, NTCP plants as they call it; and we want to bring to your attention some generic information just as we did yesterday with the staff, some generic information about the features of the BWR which both reduce the potential for degraded core conditions and mitigate the consequences should they occur.

We will present the information in three principal parts and areas. Following my introduction, Steve Stark will talk about these and summarize briefly the results in these three areas: first of all, the results of a risk assessment we did or the BWR-6 Mark III; then talk about the results of a structural evaluation of the containment we did where we were trying to get at the actual capability of the containment versus simply identifying the design requirements and design pressures; and third, talk about some work we have done in terms of hydrogen control options.

Now, since time is short and the day is coming to a close, what I would like to do is put on a summary chart that will help focus our thoughts for the discussion. As I said, we have performed a risk assessment for the Mark III design which accounts for several things, namely the first two bullets here.

As a result of the BWR design and its evolution, there have been incorporated in that design several features which mitigate the consequences as well as avoid in total the degraded core condition. These features start with such things as -- such basics really as our natural circulation capability and having a single pressure vessel with boiling going on already. They go on to the ability to keep the core covered both at high and low pressure, and for us to depressurize.

Now, there were several things that came up as a result of this study that we particularly want to point out, and Steve will do that shortly. The two areas really are the fact that the suppression pool allows us to scrub the water and scrub the fission products should they come about, and the fact that the dry well will also remain intact. I think Dr. Levy touched on the importance of that in his presentation already.

We have also incorporated in this risk assessment the results of the efforts since TMI, and we will show a chart, Steve will show a chart as to what the improvements for each of these steps are relative to WASH-1400.

The bottom line is that in terms of core damage we consider that there has been a factor of 20 reduction in core melt probability relative to the WASH-1400 BWR. Carrying that through to risk, that probability, that ratio would be a factor of about 200. We could provide more details when Stark gets up to chat.

Our conclusion, though, is that we would not expect it to be necessary to make any significant design changes to the Mark III design in order to meet a safety goal.

Now, I think I am forced to comment at this point on the staff's requirement for addition of an isolation condenser in the BWR design. We see no basis for that requirement as a result of the work we have done to date, and it is certainly not associated with a rule on hydrogen control; so that we do not endorse at this point in time or find it necessary to require an addition of an isolation condenser to the BWR design.

Notwithstanding the results of our risk assessment, we did look at hydrogen control, and the next chart summarizes the results that Stark will provide you the basis for shortly.

First of all, we found mitigation already exists in the BWR for hydrogen control, when you take the pool, the dry well, and the containment together as a triad. The containment function is likely to be maintained in our most probable accident scenarios, and having contained that containment function -- that is, having maintained the suppression pool water intact -- we have the suppression pool to act as a filter vent, if you will.

I have identified on the chart the actual static capability of, in the first two bullets, the 22 and 41, of the containment, the wet well containment.

The third number, the 70 psi, is equivalent to the service level, our estimate of service level C, working backwards trying to calculate what the service level C pressure would be for the dry well.

We have looked at containment strengthening and even in the standard plant design where we have done considerable work already, we don't consider it practical nor, as Stark will show, is there any significant change in the risk, any significant reduction in the risk due to the strengthening of the containment above these levels.

If it is judged ultimately that additional hydrogen control requirements are to be imposed, then we have identified that we consider there are two options available: the post-event inerting we will discuss in detail, and the igniters. We frankly focused our efforts on post-event inerting because it seems like the rest of the world is working on igniters, and insofar as just using our manpower, we think it is most effective for us to look at post-event inerting, and that is why we are concentrating on that area. And in particular, our discussion today will focus more on that than anything else.

This chart summarizes the points that Stark will make now, and we will come back to the chart at the end of the presentation to focus and make sure that we have clarified our basis for that.

MR. BENDER: Before you leave, let me find out first whether there is going to be any further discussion of the filtering capability of the suppression pool. Will there be more?

MR. BUCCHOLZ: Yes. He has a chart. I don't think we eliminated it in shortening the presentation.

MR. STARK: That is correct.

MR. RAY: Just for clarification I would like to make sure I understood. Your lack of endorsement of the isolation condenser is based upon the unnecessary nature of it, not its effectiveness as a means of cooling, its feasibility. It is not that you feel it is not feasible.

MR. BUCCHOLZ: No, certainly not. It is just our judgment of where the safety ball is likely to end up tells us that this design already meets that. Therefore, there is no established need for it. Would be that things could be taken out of the plants as easily as they are put into the plant, right?

MR. RAY: Another question, it passed pretty fast, and I did not grasp it. Why do you say the dry well plus pool plus containment mitigates or effectively provides hydrogen control?

MR. BUCCHOLZ: Steve will take you through that. He was pointing to himself there to answer the question. Why don't we let him take you through? I think it is his first chart.

MR. OKRENT: Go ahead.

MR. STARK: My name is Steve Stark. I am manager of BWR evaluation programs at General Electric.

During the last several months as we have been preparing the risk assessment for the BWR-6 Mark III, we have of course reviewed the plant design in order to identify and develop the items needed for the risk assessment.

This has led us through the process, of course, of identifying those features in the plant that have significant influence on the plant risk for degraded conditions.

The configuration of the Mark III containment, which of course includes a dry well, a suppression pool with one million gallons of water, 10 million pounds, and a wet well, and a steel containment surrounding that.

My remarks will be addressed to our standard plant design. Of course, a plant containment configuration varies from one plant to another, but we have information specifically for the standard plant which I think would be very helpful.

In our standard plant we have in its design a freestanding steel sheel, and then surrounding that we have a concrete shield. What these three features of the Mark III containment provide is both a hydrogen control and fission product control.

What I mean by hydrogen control is if there were to be hydrogen detonation within the wet well, we would still expect to have maintained in the containment the dry well and the suppression pool. Those we expect for most accident sequences to remain intact and provide water filtering for any possible releases of fission products.

So let's look at what might happen if hydrogen were to be generated in the reactor core. We would not expect combustion to occur in the dry well. The reason for this is that the hydrogen is piped out to the wet well. For cases of transients, which would probably be the most likely cause of degraded conditions, the hydrogen is piped to the suppression pool directly through the safety relief valves.

For the case of a LOCA, the hydrogen would escape along with the saturated water and steam from the reactor vessel directly into the dry well; but by that time the dry well would be purged of its initial atmosphere, and the hydrogen would be entering a steam atmosphere. So because of that the hydrogen will eventually end up over in the containment, and it is most likely if there were to be detonation, the detonation or combustion would occur there. That is where the majority of the electrical equipment is that could lead to a spark to give some combustion.

As to fission product control, with the dry well intact and the possibility of release of fission products from the core, the majority of them would end up in a suppression pool, especially the iodine and the particulates for a risk assessment.

We have performed the consequence calculations assuming the noble gases escape into the environs. If the break is a transient that caused the degraded conditions, then the fission products will end up in the suppression pool via the safety relief valve. If it is a LOCA that caused the degraded condition, then the fission products will eventually end up in the suppression pool after they pass through the dry well.

Now I would like to move on and provide some information on what type of effectiveness we expect in retaining fission products in the suppression pool.

Like I said, we have a rather large suppression pool, a million gallons, and it is not only a source for our pressure suppression system, but we expect in case of degraded conditions it would give significant scrubbing of the fission products.

Now, there has been a lot of attention in this area, and most of the literature is supporting decontamination factors for cesium iodide and particulates, for example, of 1,000 to 100,000, if the fission products are to be directed a large body of water like the suppression pool.

We have gone ahead and performed our risk assessment using the lower end of this range of possible decontamination factors. We have used a DF factor of 1,000 for the cesium iodide, and for the particulates for the noble gases we have assumed that they pass right through the suppression pool.

MR. WARD: Excuse me, Steve.

MR. STARK: Yes.

MR. WARD: For the iodine you have assumed there is no elemental iodine released, is that it? You have taken 1,000 for --

MR. STARK: I think maybe Roger McCandless can best answer that question.

MR. MC CANDLESS: Yes. My name is Roger McCandless from General Electric.

The modeling assumed that only one-tenth of one percent of all the iodine was released, none of it in the diatomic form.

MR. BENDER: What does that mean, that most of the iodine is still in the fuel?

MR. MC CANDLESS: It means that most of the iodine is left in the pool.

MR. BENDER: As elemental iodine or as cesium iodide?

MR. MC CANDLESS: Cesium iodide.

MR. BENDER: I think the question is what is the basis for assuming it exists as a cesium iodide?

MR. MC CANDLESS: I don't have the specific literature here to cite.

MR. WARD: Well, isn't that a little optimistic in the present state? I know this is an evolving issue and there are certainly some strong indications that you may be able to make this sort of optimistic assumption; but okay, all of the rest of your numbers are based on this, though.

MR. STARK: That is correct. We do plan soon, this month to have an interchange with the staff to provide the bases for the decontamination factor calculations we have performed and the consequence analyses.

MR. BENDER: Let me try one more question in the same area as long as we have started. The decontamination fact[illegible] going to be a function of when the iodine comes thr[illegible]n the system and whether it is carried through with the hydrogen as opposed to coming out by itself. And I don't have any opinion about it, but it seems to me, for example, that if there were a bubble of hydrogen coming out and it was carrying the cesium iodide with it, you might not be able to make the case for the intimate contact with water needed to get the decontamination capability.

Has all of that been sorted out in this review?

MR. BUCCHOLZ: Let me try to answer that. First of all, it was our intent in establishing the decontamination factor of 1,000 to be on the non-optimistic side of realism. We based the 1,000 on a lot of contact with the people at EPRI and the people who are involved in trying to establish realistic bounds for these parameters.

In particular to your question, though, I guess for the scenarios most probable, that is, the transient scenarios, you will get the discharge into the suppression pool through the safety relief valves, and there will be intimate contact through the quenchers.

This has a design for those quenchers on the end of the safety relief valve discharge lines, and that contact there is very intimate.

MR. BENDER: It depends upon what's coming out and when. The quenchers are put in there to take care of a circumstance where you are blowing down steam. This is not by comparison a large volume of gas, but it is an inert gas. And I guess I am not really sure that I know what it is carrying through.

Don't misunderstand me. I am not trying to tear apart your basis, but I think you have to look at the physical phenomena well enough to be sure that when the iodine comes through, it is not prevented from contacting the water by the fact that there are inert gases there.

Now, that is the end of my dissertation.

MR. BUCCHOLZ: We will be better prepared the next time we chat to discuss it.

MR. STARK: This is probably a good time to highlight that of course this is a preliminary assessment, and there is quite a bit of work that we see for ourselves to do. And I am sure addressing the questions you raised will be a part of that work before this is a final risk assessment.

We have carried through these assumptions into our consequence calculations, and we have one example result here that is rather illustrative. If we go ahead and assume there is a hydrogen detonation in the containment and that the containment is ruptured but the dry well and pool remain intact, and we take credit for a decontamination factor of 1,000, in that particular situation consequence evaluation shows that there would be no early fatalities, the reason for that being that the release of fission products to the environs and the doses to the population would be below a threshold dose.

MR. OKRENT: Can I ask some questions there?

MR. STARK: Yes.

MR. OKRENT: First, I guess it is not completely clear to me, but if you had a detonation, it would be logical to assume that the pool stays there and the water stays in the pool, at least for a longer period of time if not for a shorter period of time.

Should that be obvious to me?

MR. STARK: Let me give some supportive reasoning for why we believe the dry well and pool should remain intact. There are about three contributing factors to that relief.

MR. OKRENT: Where is ground level on this picture, by the way, usually?

MR. STARK: I can only show approximately about right here, I would say (indicating).

Joe, is that correct? Yes, there are about three contributing factors for why it is most likely that the dry well and pool would remain intact. Of course, we have accounted for in our risk analysis other containment failure paths that lead to the failure of the dry well and releases that would not be filtered through the pool or minimum filtering through the pool. But the greatest number or the highest probability of failure paths leave the dry well and the suppression pool intact.

First of all, I have already indicated that most of the hydrogen is going to finally be ending up in the containment. If it enters the dry well, it will be entering a dry well filled with steam. As it passes up out of the suppression pool, it will pass areas like the hydraulic control units for the control rod drive system that have a lot of electrical equipment attached to it. And if there is going to be an ignition, that is where it would probably occur.

Finally, we should look at what the relative structural characteristics are of the dry well and of the steel shell. I will get into this in detail in just a little bit, but let me just summarize to say if there were to be a hydrogen combustion inside the dry well, the yield strength of the dry well for detonation pressures is on the order of 200 psig. If the hydrogen combustion were to be in the containment, the yield strength of the dry well for external loading on the concrete is 200 psig and 70 psig for the dry well pit, which is steel.

The yield strength is much lower for the containment. It is approximately 41 psig. So if a pressure pulse is going to occur like fast-burning to last several seconds in the containment, that would give -- and something were to give, we would expect the containment to give first and then relieve the pressure by that route, leaving the dry well and pool intact.

MR. OKRENT: In the first place, I can't tell whether you would fail structurally at a point you could lose water, and another thing is I don't know whether you will fail equipment you will need to keep the pool cool.

Maybe there are other things. In other words, you have made an assumption which in fact you may have good reason to make, but at the moment I have to remain skeptical, let me put it that way.

MR. STARK: I am sure this, as well as decontamination factors; will take time.

MR. OKRENT: The trouble is if you lose the water, if you lose it half a day later, your cesium presumably and other things will move. Some of your iodine may have decayed.

MR. STARK: You did raise a couple of good questions, though, and let me at least give them a very brief response.

If we were to have a failure of the containment, where would it most likely fail? That's a real good question. Would it fail low down so that it might endanger the integrity of the pool, or would it be higher up?

Our calculations show that the weakest point in standard plant design is up toward the dome. We would expect for a gross pressure pulse from combustion in the containment, the rupture would occur high up rather than low down.

MR. OKRENT: A moment ago we heard of a design that seemed to have a different point. Anyway, I have to assume if you have detonation, you may not know quite where the loads are the most severe; so maybe it is a random thing at the moment.

MR. STARK: Let me finish up on the scrubbing. We have talked about early fatalities. For latent effects, looking over a 30-year period, we would see latent fatalities of less than one percent of that expected due to natural background radiation.

MR. BUCCHOLZ: Steve, while you are putting up that chart let me just clarify to Dr. Okrent that what you have seen is a difference in design, not an inconsistency. The two designs are different in that respect you noted regarding --

MR. OKRENT: I understand it's a difference in design, but I don't think that is sufficient to conclude that you know that given hydrogen detonation, where it would fail, for a variety of reasons.

MR. BUCCHOLZ: I understand your point. I just wanted to make sure. Okay.

MR. STARK: Let's look at an example from the results of the preliminary risk assessment, a more global view of what the results are. We looked, of course, at the probability of core damage, and we see an evolutionary improvement in the BWR design so that in moving from the WASH-1400 BWR-4 reference plant to the BWR-6 with the post-TMI improvements that have beer made to the standard plant both in response to items like Lessons Learned and also items we have identified ourselves within General Electric, we see a reduction in probability of core damage of a factor of 20.

Maybe I had better explain here what my format of presentation is here. I call base case A the WASH-1400 reference plan, and then I show the probabilities of core damage and the total risks on the lefthand side. And then just to make our mathematics a little easier, I have shown the reduction in probability or in risk as relative to case A.

So we see a reduction of a factor of 20 with a BWR-6 standard plant with the improvements we plan to make for the standard plant.

Now, that reduction in probability of core damage has, of course, carried on over into the risk picture as well, so we see a reduction in risk, but we see the reduction in risk of greater than a factor of 20, and the reason for this is because of the additional mitigative effects that you get of the Mark III design relative to the Mark I design, the greater probability of retaining a dry well and a suppression pool intact in case of these events.

Also, in the improvements we have made or plan to make for our BWR-6, we have included venting as a backup for loss of decay heat removal, as a loss of total RHR decay heat removal. And this knocks out one of the contributing sequences that was identified in WASH-1400. So that is also a reason for reduction in the total risk picture. So we see a reduction of a factor of 200 for the BWR-6, and then we have also done some examination of what possible additional reductions in risk we could get by introducing additional mitigative features.

We look, one, at putting in a stronger containment, making modifications there. What we looked at specifically was increasing the pressure by approximately a factor of two. We show here in rounded off numbers no improvement. Actually, if we carry out a few significant figures here, we get approximately a ten percent reduction in risk for doubling the containment strength.

We have looked also at post-event inerting and hydrogen igniters here. We see a more measurable relative improvement relative to case C and approximately equal improvements for the introduction of either post-event inerting or the hydrogen igniters.

In bringing our preliminary risk assessment to this point, we have come to several conclusions. One is that the Mark III containment configuration yields substantial capability relative to both protecting against core damage and also mitigating the effects of possible hydrogen generation.

But just if we go ahead and assume that hydrogen generation does occur and we have combustion, we do not expect that the combustion would fail the dry well. If combustion did occur in the containment, we would most likely expect the failure to occur at the dome level.

We would expect not only the dry well to remain intact but also the suppression pool, and thus we would expect a significant scrubbing result.

And finally, in responding to another one of your questions, Dr. Okrent, we believe because of the location of the ECCS equipment and the section locations, etcetera, the ECCS function would be retained with decay heat removal. So our overall conclusion is with these features maintained and having a dry well and suppression pool, and in essence containment function would be retained, so would still have, although some fission products would be released, there would be a significant reduction or limit to the release of those fission products, even for a degraded case.

So with that significant reduction in risk for the BWR-6 below WASH-1400 -- I must again indicate this is a preliminary risk assessment. We expect to carry on additional work here so we can confirm the conclusions, and I am sure we will have continued discussions as well.

But right now if we look at the work we have and assume it can be justified by additional work, we see that we cannot identify any basis for justifying further design changes to further reduce risks. We think we have already accomplished quite a bit of risk reduction in the BWR-6 Mark

III design.

Now I would like to move from the risk assessment area to the containment structural area and provide some information on the structural capabilities for the Mark III standard plant.

MR. BENDER: Before you go --

MR. STARK: Yes.

MR. BENDER: Having listened to the Houston Power and Light discussion a little while ago, I find your presentation essentially devoid of a number of the things that were suggested. And one of the things that occurs to me is to ask having seen the Browns Ferry fire and recalling that one of the contingencies that had to be dealt with there was the need to open the ADS system by some kind of special operator action that involved smarter operators than some I know about, I have to ask myself well, what thoughts have been given to assuring the ability to depressurize the reactor system beyond what now exists?

MR. STARK: Well, one improvement that has been made to the BWR-6 design has been a response both to the Lessons Learned and to a need identified by ourselves; and that is to automate the ADS system for some events where currently we would assume the operator actually ADS.

Those particular cases are for a stuck open relief valve where your high pressure systems are assumed not to come on, or for a loss of feedwater where the high pressure systems are assumed not to come on, but specifically those events not generating high, dry well pressure.

MR. BENDER: And they all rely on the same electrical circuitry to get the valves open.

MR. DUNCAN: Jack Duncan, General Electric.

Steve's second indication that says "with improvements" include a number of improvements, both the one he mentioned about the automatic depressurization system logic change, and the same system Dr. Levy talked about in which the non-ADS, the SRVs, which are not dedicated to the ADS function, have another way of opening them which is manual. The operator opens a valve and bleeds air to those valves to open for just the reason you mentioned, and there are others included in that.

MR. BENDER: Okay. Thank you.

MR. STARK: I will move along to the results of our structural evaluation. The nominal design pressure for the Mark III standard plant, based on ASME Code Section 3, subsection NE, is 15 psig. If we do an evaluation of what its capability would be using the same code for service level A, where we use the actual thicknesses of steel in the containment and don't include an additional load combination, other loads like seismic, then we see a capability for service level A, a 22 psig for pressurization.

If we go beyond the Code and look at expected capabilities, the next step would be to start to look at the yield strength, using a yield criteria based upon ASME service level C. Then we find a capability of approximately 41 psig for pressurization.

So we can see the realistic expected capability of the containment is well above the 15 psig. Still, we are just at yield. If we take it a step further and look at what we could ultimately expect based upon ultimate strengths of the materials for static loading conditions, then we have 60 psig. Of course, as we get to higher and higher pressures, the dynamic loading function becomes more important, especially for pressure pulses as a result of detonation.

As we get to detonation, the period of the loading gets very short, in the duration of approximately 5 milliseconds. For a triangular pulse wave of 5 milliseconds maximum duration, we see a capability for the Mark III containment of approximately 150 psig. So there is a very significant capability existing in the standard plant design of the Mark III.

Now, the numbers for other plants with Mark III containments will vary because of the specifics of the detailed design of the containment.

MR. WARD: Are the differences here with the numbers that were quoted a little earlier for Allens Creek reconcilable readily?

MR. STARK: Joe Love?

MR. LOVE: I am Joe Love of General Electric Company. I am responsible for structural design in our engineering group.

Those differences can be rationalized. We have not done so because we have not had access to the details of the Allens Creek design. But in talking to the Ebasco engineer in the last couple of days, he and I would agree we could find our way to a common ground and could say, this is why these plants differ one from another.

MR. WARD: Thank you.

MR. STARK: Let's move, then, from the free-standing steel containment into the dry well. I have said that for hydrogen combustion we expect the dry well to remain intact. I think I need to provide you with a basis for why we believe that.

First of all, the nominal design pressures for internal pressure, the design is 30 psi actually differential, not gauge but differential pressures; for the external loading, 21 psi differential. That is what the design values are. This is the design basis.

The actual capability based upon yield strengths of the materials are, for internal pressures they show a rather stout dry well, 200 psig for the dry well head and approximately 190 psig for the concrete wall; for external pressures, again a rather high capability, 70 psig for the dry well, for the concrete greater than 2C0 psig. And these are for static loadings.

If you were to apply dynamic loadings for a short duration of the pressure response, then these capabilities would be even higher.

Now, the staff has been considering, or was considering, a requirement to increase the design pressure of the containment. And in response to their questions, we have looked at this some and this is what we see would have to be done to the standard plant in order to increase its structural capability.

Now, these are changes which, on a practical basis, could only be really achieved at the design initiation of a new plant. I think that all three NTCP's or BWR's have already purchased a lot of equipment for their structural containment, and that is a significant consideration on a financ al basis.

But moving along to what we would have to do, we would have to change the head design from elliptical to hemispherical. Currently the standard plant has an elliptical head. These of course, once again, are items which change from plant to plant.

And cylindrical wall thickness; we could get some improvement by increasing the wall thickness up to one and three-quarter inches. That is as thick as you could get on a practical basis, because going to thicknesses greater than that would require post-weld heat treatment. Right now there are some elements in the standard plan that have a wall thickness of one and one-quarter inches. So the greatest increase would be half an inch.

The results of these two major changes, as well as detailed modifications that would have to be made, where appropriate, would be to give a service level A capability of 45 psig and service level C capability of 79 psig. It was these values we used to plug into our risk assessment to see how sensitive the risk would be to making such changes. And we saw approximately a ten percent reduction in risk, rather minimal compared to the other hydrogen control options we looked at. Still, even those were not really greatly significant.

Now I would like to move along --

MR. OKRENT: Excuse me. I would just like to suggest that in future presentations you be, first, very careful that you define the term "risk" as you are using it, because it is not always used the same way. And then, I assume you are using it in terms of a WASH-1400 risk, not the definition Dr. Levy used.

MR. STARK: Let me clarify the definition we are using. We are adding both early fatalities and latent fatalities. The figures I gave were on a per-year basis.

MR. OKRENT: All right. Then let me, using that term or the two categories separated -- I strongly suggest that you do not use these risk reduction factors loosely, that you don't present the information in a way which can be in fact reversed if one looks more deeply into the assumptions or whatever.

What I am urging is that one act, in presenting risk reduction numbers, like his reputation depends upon it. Okay?

MR. STARK: Thank you.

MR. OKRENT: In other words, you should have yourself envisaged what assumptions you are making in whatever it is you are presenting and either put them all out front and say, these may change my numbers, or have satisfied yourself that they won't and say that they won't. But don't leave it for someone else to have to pick it apart, because this is now becoming -- let me say it is a line of argument that is being used. If it is abused too much, it is going to create a lot of problems.

MR. BUCHHOLZ: Dr. Okrent, it certainly wasn't our intent to abuse it.

MR. OKRENT: No, I am not saying that. I am just saying this as a general caution. I said the same thing to the staff. We have had some numbers brought into this room within the last year that you could look at and see didn't make sense. Now, sometimes it's more subtle and they still don't make sense.

And I think it's now time for people to use a lot of caution in displaying risk reduction numbers. And let me leave it that way. And I say to act like your reputation and the reputation of your company and, in a sense, the businss rests on it.

MR. BUCHHOLZ: It certainly would be our intent to act in that manner.

MR. OKRENT: Fine.

MR. STARK: I would like to summarize briefly to provide you the results of our examination of a variety of hydrogen control options.

We started out, you might say, in a brainstorming session, or several of them, trying to put together an extensive list of ideas that could possibly in the future show some promise in providing additional hydrogen control. And once identifying the possible alternatives, we initiated a screening process and tested each one of these alternatives and its feasibility, how much risk reduction it would be expected to yield, what its cost was, et cetera.

Coming out of this process, we concluded that we could identify two options that showed some significant promise for hydrogen control, and those are the igniters and post-event inerting. We have focused our efforts on the post-event inerting because effort is being applied already outside GE quite extensively on the igniter system.

And for the post-event inerting, we have taken it and tried to develop a design basis for it. We have described the concept in some detail, evaluated the design considerations for it, and identified open issues which we want to follow up in the future to assure that we can bring them to a satisfactory resolution.

MR. BENDER: It is understandable that you might not want to dilute your effort by working on something someone else is working on already. But sometimes we have to come to grips with the matter of whether inerting is better than igniters or vice versa.

Is it your plan to address that at some time?

MR. STARK: There are several utilities with BWR's that are looking at the igniter concept and addressing it that way, and we will be following their development and also the work the national labs are doing. We have done some work on distributed ignition systems to identify for the BWR what type of functions would have to be satisfied for such a system.

We would think that the glow plugs would probably be the best ignition source and should be located for the Mark III configuration containment both in the containment and dry well. And they should assure that the hydrogen is ignited at sufficiently low concentrations so that we do not get significant pressure loading from them. They should be actuated both automatically and manually by the operator. When necessary, for the automatic initiation system, we would see it probably being on low water levels in the reactor, probably using level one, which is the same signal used for the low pressure ECCS signal and part of the input signal to call on ADS.

We would probably want to assure that the contents in the containment were well-mixed, so that you would have a uniform mixture and minimal pocketing. We would want to assure there was not such a significant heat generation and buildup in the containment due to this ignition that you could overpressurize the containment by that mode.

And then, finally, you would want to assure that the equipment that is located in the containment would be protected against pressure and temperature conditions.

MR. BENDER: Leave that up for just a moment. There are a few points about it I might as well raise.

One of the things that is not discussed at all in that list up there is where the hydrogen should be burned. I think you suggested something that is maybe right now hard to accept, and that is there will be uniform mixing associated with hydrogen burning. I think most of us are thinking in terms of the hydrogen starting to burn in the place where it comes out, and I might even consider whether it would burn in the dry well, as opposed to burning in the external containment system.

Is any thought being given to where the burning occurs and how it occurs, if you want to use that avenue?

MR. STARK: At the conceptual stage, you mentioned one important factor, and that is it should be burned at the location where it is released. And of course, we see the principal release location as being in the suppression pool. So it would probably make the most sense to at least concentrate some of your igniters above the suppression pool and to have the burning occur there before it escapes any further and while it is concentrated.

Of course, it probably would also -- well, with the remaining glow plugs, you would probably want to distribute them throughout the rest of the dry well.

MR. WARD: If you had a pipe break, it wouldn't necessarily be in the suppression pool, would it?

MR. STARK: It will eventually get to the suppression pool. With a pipe break, of course, not only would you probably be releasing the hydrogen, you would probably be releasing saturated water and steam from the vessel as well. And that would tend to purge any of the initial atmosphere in the dry well over to the containment. So you would be oxygen depleted in the dry well, and it would probably be rather improbable that you would have a combustion in the dry well.

That is why I said eventually it will get over to the suppression pool.

MR. BENDER: You would displace the air right away.

MR. STARK: Yes, very, very rapidly. For a DBA LOCA, it takes approximately one second to purge the air on over.

MR. OKRENT: You don't have a vacuum relief between dry well and wet well in this system?

MR. STARK: There is a vacuum breaker between the containment and the dry well.

MR. OKRENT: There is?

MR. STARK: Yes, yes. So there is a potential flow path back into the dry well from that vacuum breaker. That would conclude -- you would also want to just back yourself up and put them in the dry well, if you were to put them in.

On post-event inerting, as I said, this is where we have put most of our emphasis. We have seen a P&ID for the system. There the liquid CO-2 was stored outside the containment. Following an event where you saw it was appropriate to inject the CO-2, it would be injected, probably over the suppression pool.

Our evaluation of this particular approach would be to initiate the injection, again either by an automatic signal or a manual signal, again probably using low water level. It would be important to include a time delay on the system to ensure that any operations personnel in the containment would have time to evacuate and get out of the containment prior to the injection of CO-2.

And probably it would be appropriate, then, to put a five or ten-minute delay on the injection, in order to ensure that that is accomplished. So we would see the CO-2 being injected -- probably, you would want to design it so it is injected approximately 15 minutes after the initiating signal or the manual activation signal. And then it is taking approximately 15 minutes to reach a 61 percent concentration of CO-2 in the total containment, so as to preclude any combustion.

MR. OKRENT: A problem, of course, is one of your lines there says, "Liquid CO-2 rapidly injected into containment before hydrogen formed and transported into containment."

At TMI the hydrogen had been formed and transported to the containment really before it was recognized that this had occurred. In other words, it is easier to design some of these features for well-defined scenarios than it is for what you didn't think of.

MR. STARK: We would see it also as important to inject it as rapidly as we can. So we would plan on getting it injected within the first 30 minutes. For most of the evaluations we have performed on core heat-up, we believe the most probably sequences would, even under degraded conditions, not give significant hydrogen generation until after 30 or 45 minutes. We believe we would be in a fully inerted condition by that time.

MR. DUNCAN: Steve, let me add something directly addressing Dr. Okrent's point. There the operator didn't realize he was threatening the core. He didn't have an indication his core was uncovered.

In our view, our direct water level indication provides that warning to the operator, and that is the signal we are considering to be the initiator of this.

MR. OKRENT: Would this also put CO-2 into the dry well at the same time, or is it a wet well system?

MR. STARK: As you pointed out, it would naturally enter the dry well through the vacuum breaker.

MR. OKRENT: Well, DDD, I can think of scenarios where it will enter too late if you force me to. So let me just leave it at that. You better think some more.

MR. STARK: As far as pressure response, we would want to make sure that the pressure in the containment that would result from the presence of the CO-2 and possibly the hydrogen would be within the containment capability. If we were to inject the CO-2 to the desired concentration, 61 percent molar concentration, and if the hydrogen were to be generated from 100 percent metal-water reaction of the fuel cladding, then the containment pressure we calculate is approximately 35 psig.

For comparison sake, recall service level C for the standard plan of 45 -- we are below yield condition -- or service level C for the expected pressure.

If the system were actuated, but the CO-2 never evolved because the ECCS system worked as you expected it to, then the containment pressure would be approximately 22 psig or about equivalent to the service level A condition for low combinations.

Then the final point I want to make is, of course it would still be necessary to provide heat removal for the containment. Of course, you would expect in this situation for your RHR system to be available.

So that is the end of my prepared presentation. Do you have any question?

MR. OKRENT: I have a question which I will address to you and to Mr. Levy and Houston Power and also to the staff. It's my understanding that in some of the European countries -- and this may also be true in Japan, but in some of the European countries with new BWR's they have more capability, if you want to define it that way, both for cooling the suppression pool and I think for getting water into the primary system than is available on the standard BWR in the U.S.

This is my impression for I think Switzerland and Germany, for whatever reason, perhaps in Sweden. I don't think any of them happen to be providing it the way Houston Power, for example, has chosen as a possible way of augmenting the current systems.

I am not currently prepared to judge that one of these is better than another. But I do wonder whether General Electric or Houston Power and its consultants or the staff have looked at what is being done in this regard in some of the newer European BWR's, and do they have a basis for judging that -- I suppose GE might say none of these are necessary, but at least for telling me how I could judge what improvement gives you more and why.

MR. LEVY: I will go first. I am familiar with those systems, having had to participate in designing one of them.

MR. OKRENT: Why don't you define the one you're talking about?

MR. LEVY: The one I am talking about -- as you know, these systems are not supposed to be described in considerable detail.

MR. OKRENT: In general.

MR. LEVY: In general, the country I am talking about is another RHR system, which is made completely independent. What it does is take water from a containment pool, takes it out of a heat exchanger. It has another source of water to take the heat from the heat exchanger. It is all bunkered up and set up that way.

I think to my knowledge that plant does not have any additional provision to provide more water to the core. That is, the only feature that is provided is additional containment pooling.

I am also familiar that there are similar systems used in another country, in which actually the ECCS systems are a little different than the boiling water reactors. They may have a little more high pressure coolant injection capability, but a little less low pressure. They don't have as much low pressure as the BWR's we are talking about.

I think, as I say, we looked a little bit at that system in the sense of looking at another RHR train, and considered it with that realization in mind. And it would provide some risk reduction.

I think our concern with it, as I indicated, was one that it has -- it looks in many ways similar to the present RHR's that are provided on these plants. I think the second thing that those systems have in them is considerable power capability. There are a lot of pumps to be turned out in the system I described, for example, in Switzerland.

So we went toward this thing because it had this capability of running with natural circulation on the site. It has the capability without dealing -- it deals with a total blackout. It does many of the same things that can be accomplished with that. It is just a decay heat removal system.

As you probably know, Sandia has carried out extensive studies of that area with different contractors to look at different kinds of systems to be added. I had the opportunity to look at some of the preliminary results from that, and I think you get some benefits out of it. There are some risk reductions.

But the point I want to leave you with is the concept we presented does many of the same things. We feel it has this blackout advantage, which helps you on the other side. And this is a little bit why we tipped toward it. I am not saying you could not devise a system as used in Switzerland, probably with a different power source. You would have to hook it to like a gas turbine to get some diversity. I wouldn't say good engineers could not accomplish the same objective and do it the way they did it.

But I think if the primary purpose of bunkering and so on is it is highly oriented toward another issue, which I think is one of the reasons these systems are made so independent, so bunkered.

Does that answer your question?

MR. OKRENT: Well, it is a beginning. I wouldn't say it gives me a definitive answer.

One of the things I have in mind is, the staff has put before the Subcommittee and plans, if I understand it correctly, on Friday, plans to put before the full Committee a specific proposal which encompasses in fact not only, for example, improving the capability of cooling the containment and of also improving the capability of getting water back to the core, but it says do this.

It may be in fact the right thing or the best thing to do. But at the moment I myself don't have enough knowledge to know that that is the choice. And although I am clearly in favor of trying to augment these plants' ability in this general regard -- well, maybe Mr. Purple wants to add some color.

(Laughter.)

MR. PURPLE: Other than in our handout and in our proposed position, other than the requiring of the in-containment isolation condenser, all the other features of that litany of things are things dealing with the containment structure.

MR. OKRENT: I am addressing that one specific one.

MR. PURPLE: I know. Let me first say our main approach has been only toward containment, not foreclosing the major structural features that would get built when the construction began.

Our general approach has been, at least in the last month, to defer to both the degraded core rulemaking and to things like the dedicated heat removal system, USI, for more of the system kind of changes that might be required. We certainly have made no concerted study of all the various options as you have mentioned and said, this is the option that makes sense.

It was an option described to us as recently as yesterday. It appeared to be reasonable. It appeared to be reasonably achievable and was at least part of a program plan of at least one of the vendors. On that basis we said, well, it is practical, it seems to offer significant improvement. I will avoid the word "risk." Therefore we decided to put it in as a requirement.

We are also depending upon the probabilistic risk assessment, which is item one of the set of requirements for this set of CP's, to perhaps turn up other ideas, and those may end up being requirements that need to be put in further down the line if they showed great gain for small cost. So we haven't foreclosed anything, nor is that one item in there intended to be that's it and that's all you need.

MR. OKRENT: We have one more presentation. I think we should take a break so that we can listen with more vigor to the BWR presentation. So why don't we come back in seven minutes.

(Recess.)

MR. BUTLER: I am Robert Butler of Boston Edison Company, the project engineer for Pilgrim 2. We were asked to come here today through the staff to describe our containment capability and ways of dealing with increased quantities of hydrogen from a degraded core.

Boston Edison asked our containment designer about a year ago to look at those very questions. A study was initiated and completed in May. And I have with me today Ron Jagels of Bechtel, a project engineer for safety systems and licensing, who will give you a summary of the results of that study.

MR. JAGELS: What I would like to share with you today is a summary of the hydrogen analysis conducted for the Pilgrim 2 project, and also give you some preliminary figures on our assessment of the containment pressure capability.

The Pilgrim 2 containment is a prestressed post-tensioned concrete containment. We have a free volume of some 2-1/2 million cubic feet. The containment is designed for a pressure of some 60 pounds gauge, and this is based upon a LOCA calculated pressure of some 54 pounds gauge. Physically, the containment building itself will be pressure tested to some 69 pounds gauge.

In conducting the hydrogen analysis, we first identified the sources of hydrogen inside the containment building, and then calculated the hydrogen concentrations that would result from various percentages of metal-water reaction with the fuel cladding. What we have plotted on this chart along the bottom is a percentage of the metal-water reaction with the fuel cladding from zero to 100 percent reaction.

And plotted here we have the hydrogen concentration in percentage. The lines here (Indicating) represent the initial temperature conditions within the containment. The 120 would correspond to a relatively dry containment atmosphere. The 282 degrees would correspond more to a LOCA-type environment, where you have more steam dilution and hence would realize lower hydrogen concentrations.

The point I want to make with this figure is, with all of the cases we have looked at and assuming we have uniform mixing within the containment building itself, none of the hydrogen concentrations would exceed 18 percent, which would be the detonation point of the hydrogen.

Next we took a look at what the containment peak pressures would be if we made some assumptions on a hydrogen burn. So again, we looked at a range of initial containment conditions, and those pressures are shown here by the bottom dotted line.

Here we have a low temperature, relatively dry containment atmosphere. As we move to the right, we have more and more steam in the containment atmosphere. So here, at the 282 degree range, we would be again close to a LOCA-type environment, the second dashed line. And the difference here would indicate a difference in pressure due to the addition of the hydrogen. We have not yet taken a burn over this point.

We then looked at what would be the pressure increase as a result of the hydrogen burn, again at various metal-water reactions. We have plotted here 40 percent metal-water reaction, 50, 60. I have colored in the interim rule requirements, 80 and 100.

We have made some assumptions in calculating these pressures. First of all, we have taken credit for the limits on hydrogen flammability. For hydrogen concentrations under four percent, we have assumed we would not have a combustion. For hydrogen concentrations in the range of four to eight percent, we have assumed a partial combustion. And for concentrations greater than 80 percent, we have assumed complete combustion.

The other thing we have done here is taken a look at the effect of steam dilution on the flammability of the hydrogen. What you would see here is a wetting down, a reduction of pressure as we come to wetter and wetter containment atmosphere conditions.

Now, these peak pressures correspond to a rapid burn. We are looking at a burn on the order of seconds here, as we plotted peak pressures.

If you were to look at a hydrogen mitigation device, such as an igniter, you would see a reduction in the pressure, because we would be either igniting it at lower concentrations of hydrogen or we would be perhaps extending the duration of the burn, and these would all tend to reduce the pressure.

I would like to overlay on this figure the containment test of pressure, which is some 84 psia or 69 pounds gauge, as I have shown on my first figure. As you can see by this overlay, just with the containment test pressure we will cover a lot of the hydrogen burn in the cases we have studied.

MR. OKRENT: Remind me. That four percent figure is for no combustion independent of the amount of steam?

MR. JAGELS: That is correct.

MR. OKRENT: That is the operating ground rule?

MR. JAGELS: That is correct.

Shown on this figure is a cross-sectional view of the Pilgrim 2 containment vessel. As I mentioned earlier, we have a prestressed, post-tension containment, cylindrical in this portion, with a hemispherical head. The basemat is of conventional reinforced concrete design and is not prestressed.

We have a 143-foot inside diameter, 200 feet overall height, a quarter-inch liner plate on the inside, and several equipment hatches. Shown here we have a large equipment hatch. We have a small equipment double-door hatch here, and also a smaller personnel airlock at a lower elevation.

We have made some preliminary assessment on the containment pressure capability. And to establish a reference point, we looked at two points. One would be the 75 percent metal-water reaction. We have shown the results of that on this figure. The resulting containment pressure would be roughly 80 pounds gauge. And at that point we would be at less than yield on the primary structural elements inside the containment.

If we looked at 100 percent metal-water reaction, with the use of hydrogen igniters, we would feel we would also be able to keep this pressure under 80 pounds gauge, and hence would also be at less than yield.

MR. BENDER: Roughly what is yield? Do you have any idea?

MR. JAGELS: I will be coming to that.

MR. BENDER: All right.

MR. JAGELS: We have also made some very preliminary checks on what we feel the yield point or capability of the containment would be. I would caution that these are very preliminary numbers, and we expect that, with the discontinuities we have in equipment hatches and the joint of the basemat to the vertical wall in the containment, we would find that we would lie somewhere in this range, 105 to 110 psia.

I would also hasten to add that this is based on the ASTM or ASME material properties. You have heard other people mention today that they have looked at the actual material properties and would be able to realize slightly higher values by utilizing the actual material properties. If we went to that length and refined our analysis, I expect you would see some shift upward in this.

MR. BENDER: Where is the design pressure, again?

MR. JAGELS: The design pressure is 60 pounds. So that would put us at about 65 psia, which would fall about here where I have the pointer (Indicating).

MR. BENDER: That chart is psia?

MR. JAGELS: This is psia, that is correct. I am sorry, I have been switching back and forth.

So really, the bottom line in the case of the Pilgrim 2 containment is, with the existing design we feel we have a large capability to withstand the hydrogen burn scenarios we have looked at. And in addition, based upon some preliminary numbers, we feel that with some refinement we could go well towards enveloping a lot of the scenarios.

MR. BUTLER: Just to be sure that is clear, the data on the curves do not reflect the utilization of hydrogen ignition systems. With the hydrogen ignition systems, we expect something less than 80 psig, below the yield, as he showed on a previous slide

MR. BENDER: Does that analysis take into account all of the reinforcement?

MR. JAGELS: All of the reinforcement?

MR. BENDER: Yes.

MR. JAGELS: We looked at the primary reinforcing. If you took a cross-sectional area through the pressure membrane, you would have the liner, the reinforcing bar, and in places the tendons.

MR. BENDER: Are all of those in or just the primary reinforcement?

MR. JAGELS: No, those three were considered in the preliminary numbers.

MR. BENDER: Did you say they were or were not?

MR. JAGELS: Were.

MR. BENDER: There is steel in there for temperature purposes? That wasn't added in, I take it?

MR. JAGELS: Are there any other questions or comments?

(No response.)

MR. JAGELS: If not, that concludes the presentation we had for Pilgrim.

MR. OKRENT: Thank you.

Are there any further comments you would like to make this evening, Mr. Purple?

MR. PURPLE: I don't believe so, thank you.

MR. OKRENT: Well, on Friday I think we have three hours shown on the agenda. I suspect it may be useful to have some kind of report from the Subcommittee meeting, just to indicate to the full Committee what we think they are going to hear or at least as we understand it today, since there may be some changes.

I guess my inclination -- and I am looking to the Subcommittee to see what they think -- would be to allow a reasonable amount of time for the staff to tell us what their position is and why, and that probably should come after the Subcommittee report. And then I would be inclined, I think, to have a perhaps short presentation from Offshore Power, only giving what was new, because I think the Committee has heard from them.

So I think I would suggest, I don't know, five minutes on containment capability and five minutes on venting, or ten minutes divided up in some way. But if I recall correctly, those are the two major new items; am I right?

MR. HAGA: Are you interested in the venting system at all?

MR. OKRENT: Yes. I think the Committee would want to hear that, plus what your latest look at containment capability tells you. But I hope we can keep that not too lengthy.

I would like to give Houston Power, let's say, an hour for a presentation if there were not questions, which there are going to be. So that means I think we must assume an hour and a half of the three hours for that.

The question that comes up is, are there things we would like to have GE present, if so what, and think on that. And can we summarize what we have heard on the large dry containment, which sounds roughly like what I might have anticipated for its capability.

It was interesting to hear that this is what you get, but it sort of falls into the area that one might have anticipated. Maybe there we don't need a presentation unless the utility wants to make a presentation, a summary one.

MR. BUTLER: It is your pleasure.

MR. OKRENT: I see.

MR. WARD: You could summarize that.

MR. OKRENT: I think I could summarize that and we could save some time there.

MR. WARD: What about your ten questions to the staff?

MR. OKRENT: I assume that we are going to get something, perhaps in writing beforehand. And we can then see. We will have it available to the Committee and see if they have any questions for the staff that arise.

By the way, those were prepared when we didn't know quite what we would be having at this meeting. All we had was a recommendation for 60 psi in writing, and it was not clear who we would have in, also. I think the information is still relevant background information. We don't have the kind of time GE used today for a presentation,

MR. WARD: If you give them an hour, you've got about 30 minutes left for GE.

MR. OKRENT: At the most.

Are there major points you feel in what GE presented that you would like to have them present to the Committee?

MR. BENDER: Dave, I think the key points that GE could elaborate on -- I don't know that we accepted them in total, but the decontamination effectiveness of that suppression pool I think is an important consideration, and I think it may be the most important thing that we heard today from GE. The rest of it sounded a lot like Houston Power & Light, with some exceptions to what they were willing to do.

MR. OKRENT: Well, if you get into a discussion on decontamination effectiveness and if you think you have a factor of 1,000 to talk about, that is a big factor. And now you have to start looking at what are the ways in which you bypassed it or you lose the water or so forth. And if we are going to have a presentation, I think we will want a balanced presentation; let me put it that way.

MR. BENDER: My point is to get the issues out where you can see them. I think you are right, we wouldn't want to have it without being able to look at all aspects of the question.

MR. WARD: The assumption of cesium iodide as opposed to elemental iodide makes a big difference in how effective the water pool is going to be, to my knowledge. So if they are going to present that they should have a fairly sophisticated presentation, I think.

MR. OKRENT: I suggest to GE they prepare a ten-minute presentation which will compliment what we think we are going to have heard from Houston Power and not repeat it. For example, if your containment is a little different than the standard one, then you can say that it's different and these are the results, but not go through the details. So you pick out what you think is the most relevant and reasonably plausible, as it were. And we will rely on your judgment.

Assume it may be only ten minutes, because my experience tells me time will be eaten up. And furthermore, it comes, I think, after what is going to be a hard day, because there are going to be some difficult issues early on in the day.

Anyway, we will assume there will be a not too long Subcommittee report. I don't know how long we will meet for the staff. That will depend upon the discussion. But I hope they give us a reasoned position or alternatives, if that's what they are, or whatever. And Houston Power assumes that they have an hour for their presentation if they are not interrupted, and GE assumes it only has ten minutes, which may go, and ten minutes, I think, for Offshore Power, which may go.

I can't anticipate where the Committee is going to want to go. This is just a guess, obviously. I tried to leave a little bit of time for the Committee to move into.

Are there any other comments? If not, I will thank you all. I apologize for running this late in the evening, but I guess it was a little bit unavoidable.

(Whereupon, at 9:10 p.m., the Subcommittee was adjourned.)

* * *

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

____

in the matter of: ACRS/Subcommittee on Safety Philosophy Technology and Criteria

Date of Proceeding: February 4, 1981

Docket Number: ____________________

Place of Proceeding: Washington, D. C.

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

Sharon Filipour

Official Reporter (Typed)

Sharon Filipour

Official Reporter (Signature)

PROPOSED MEETING AGENDA
FOR THE
ACRS SUBCOMMITTEE
SAFETY PHILOSOPHY, TECHNOLOGY, AND CRITERIA
1717 H ST NW, WASH, DC, RM 1046

3:30 PM	1.	EXECUTIVE SESSION	15 MIN
3:45-4:30	2.	STATUS REPORT ON THE NRC DEVELOPMENT OF NTCP REQUIREMENTS - (NRC)	45 MIN
4:30-5:15	3.	PRESENTATION BY OFFSHORE POWER SYSTEMS ON PROPOSED SAFETY IMPROVEMENTS FOR THE FNP	45 MIN
5:15-7:00	4.	PRESENTATION BY HOUSTON LIGHTING & POWER	1 HR 45 MIN
		(A) Introduction-(5 min) (B) Description of HLP Study and Principal Results-(40 min) (C) General Discussion-(45 min)	
7:00-COB	5.	PRESENTATION FROM NTCP APPLICANTS	

OPS PRESENTATION TO

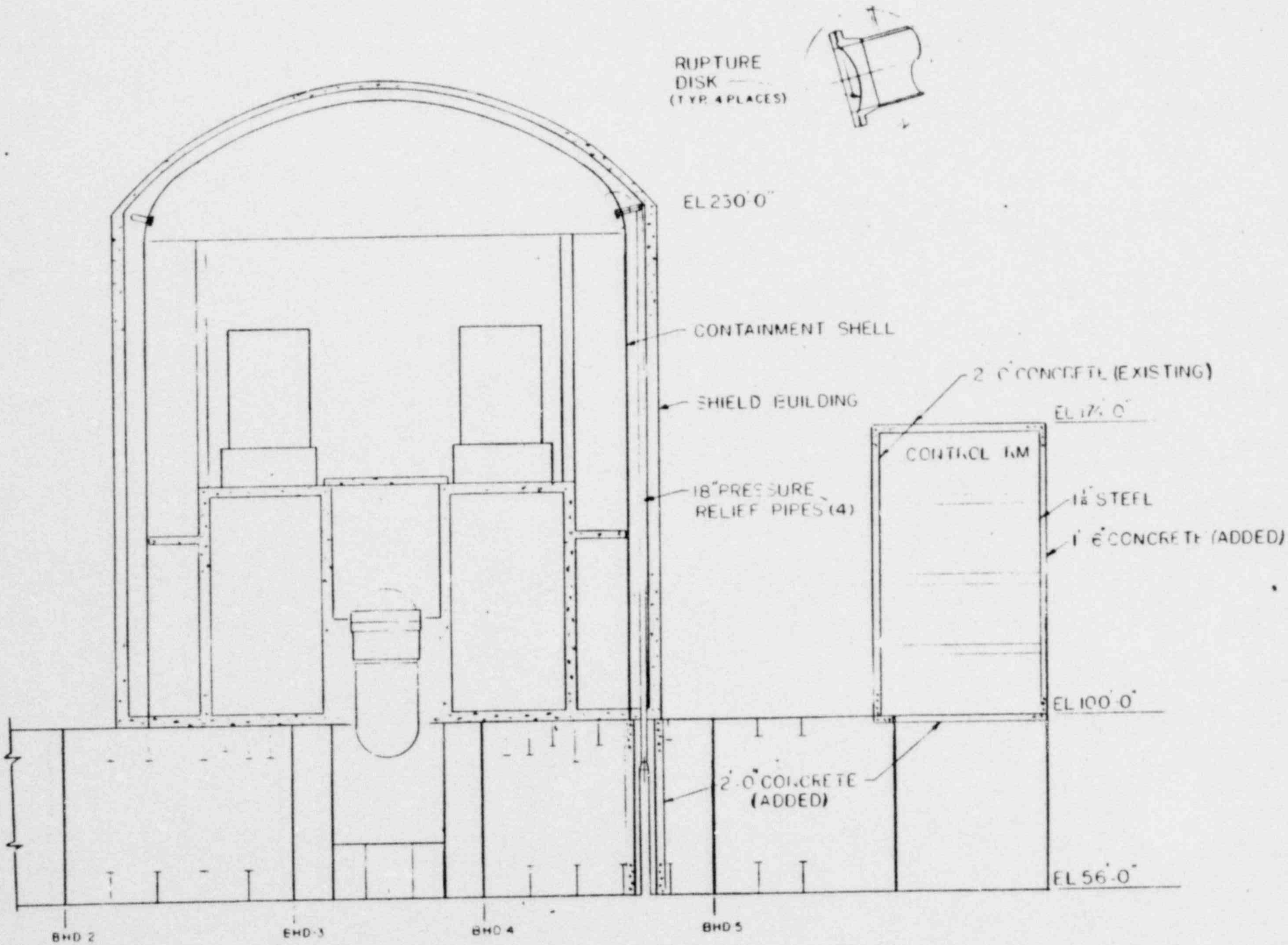
ACRS SUBCOMMITTEE

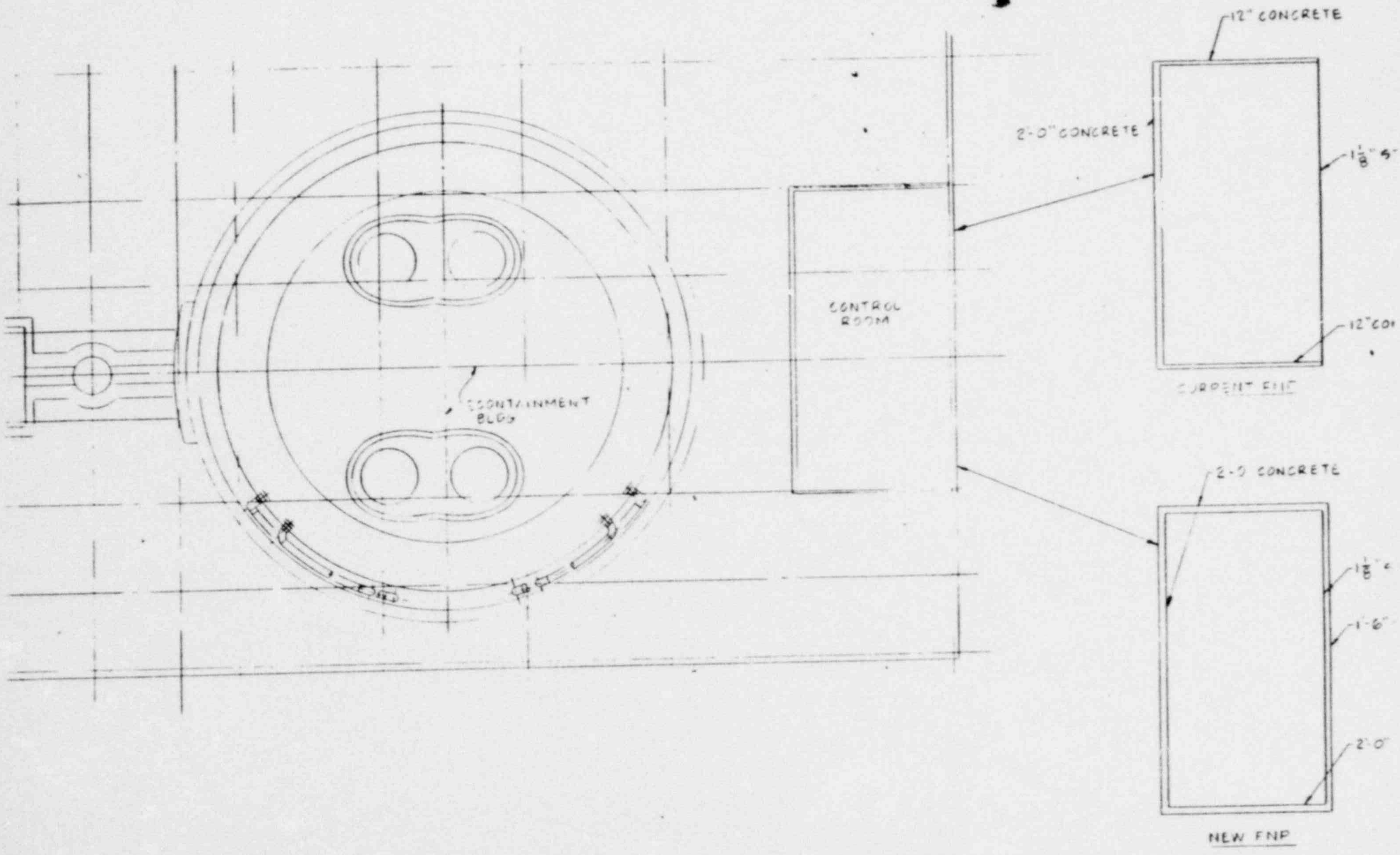
2/4/81

DISCUSSION OF MANUFACTURING LICENSE REQUIREMENTS

RELATED TO

CONTAINMENT CAPABILITIES


RUPTURE
DISK
(TYP. 4 PLACES)
EL 230'0"
CONTAINMENT SHELL
SHIELD BUILDING
18" PRESSURE
RELIEF PIPES (4)
2'0" CONCRETE (EXISTING)
CONTROL RM
1¼" STEEL
1'6" CONCRETE (ADDED)
2'0" CONCRETE
(ADDED)
EL 100'0"
EL 56'0"
BHD 2
BHD 3
BHD 4
BHD 5



12" CONCRETE
2'-0" CONCRETE
CONTROL ROOM
CONTAINMENT BLDG
CURRENT FNP
2'-0 CONCRETE
1'-6"
2'-0"
NEW FNP

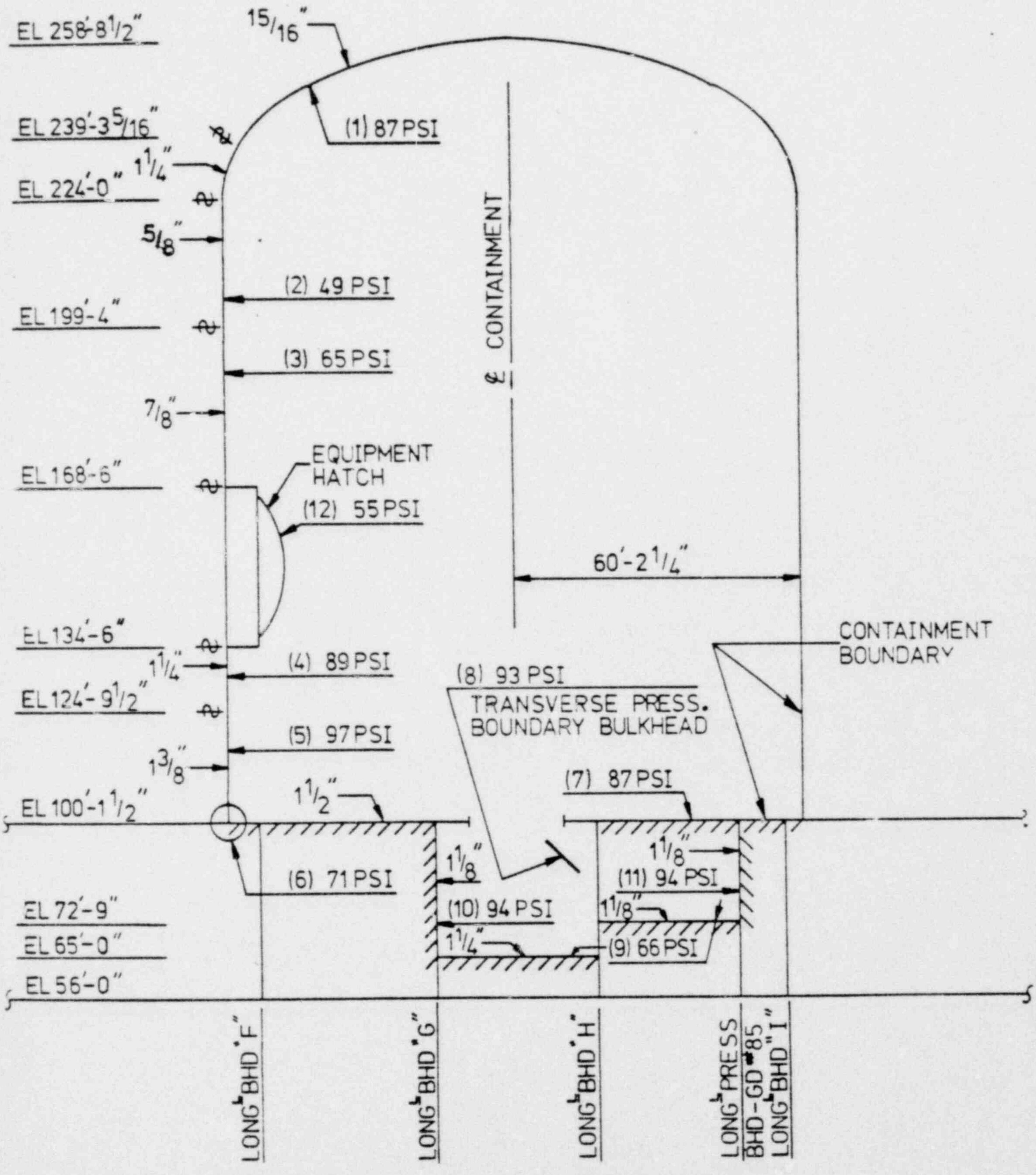


FIGURE #20

TRANSVERSE SECTION FRAME "3(b)"

ESTIMATED CONTAINMENT BOUNDARY FAILURE PRESSURES-(PSI)

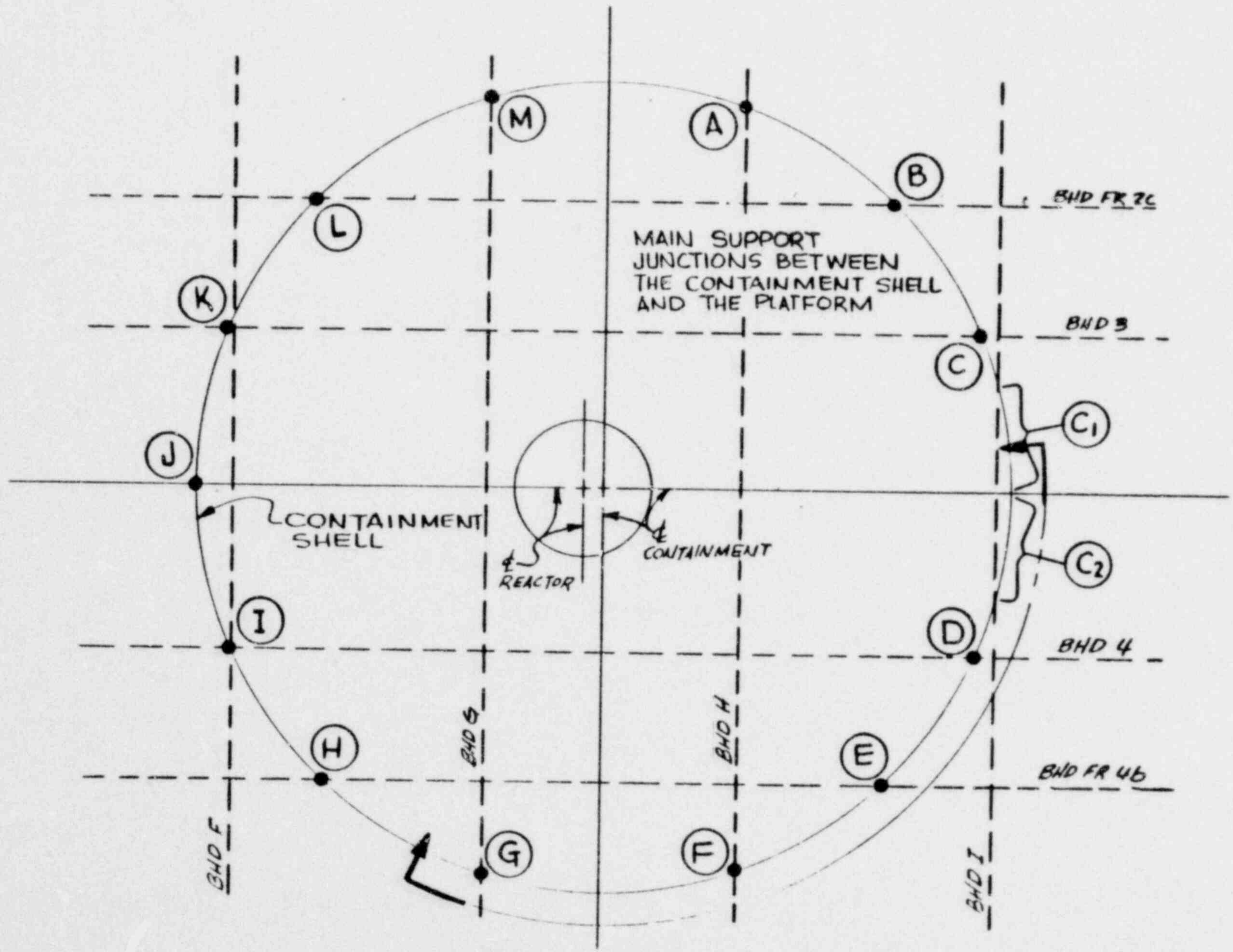
ESTIMATED CONTAINMENT BOUNDARY FAILURE PRESSURES

ESTIMATE SEPT 1979

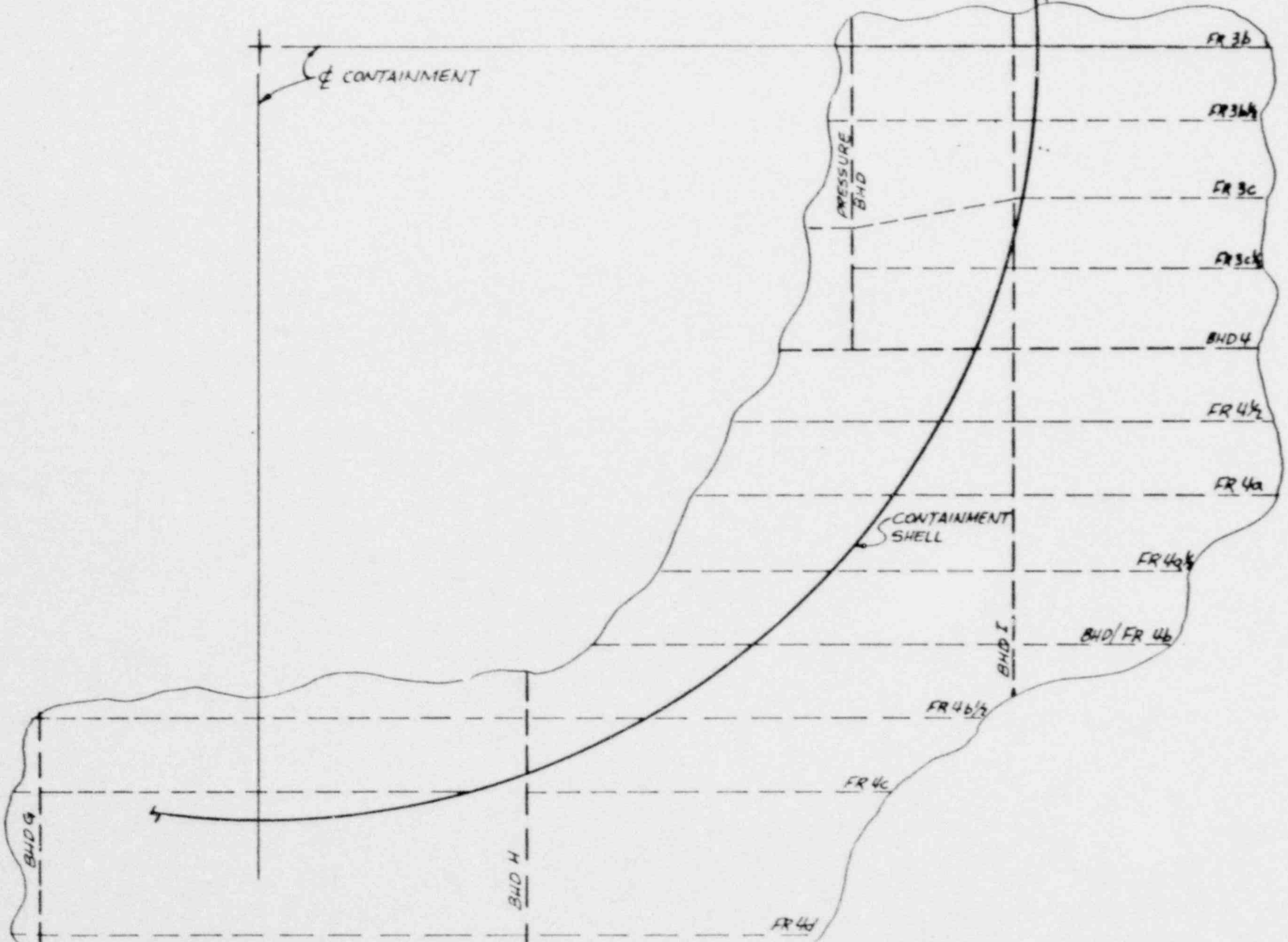
- SUBMITTED IN RESPONSE TO ACRS QUESTIONS ON 9-14-79
- LIMITING CAPABILITY IN TOP SHELL COURSE OF 49 PSIG
- CALCULATIONS USED ACTUAL YIELD = 120% OF MINIMUM YIELD
- PLATFORM CAPABILITIES CONSERVATIVELY ESTIMATED BY ELASTIC ANALYSIS

ESTIMATE FEB 1981

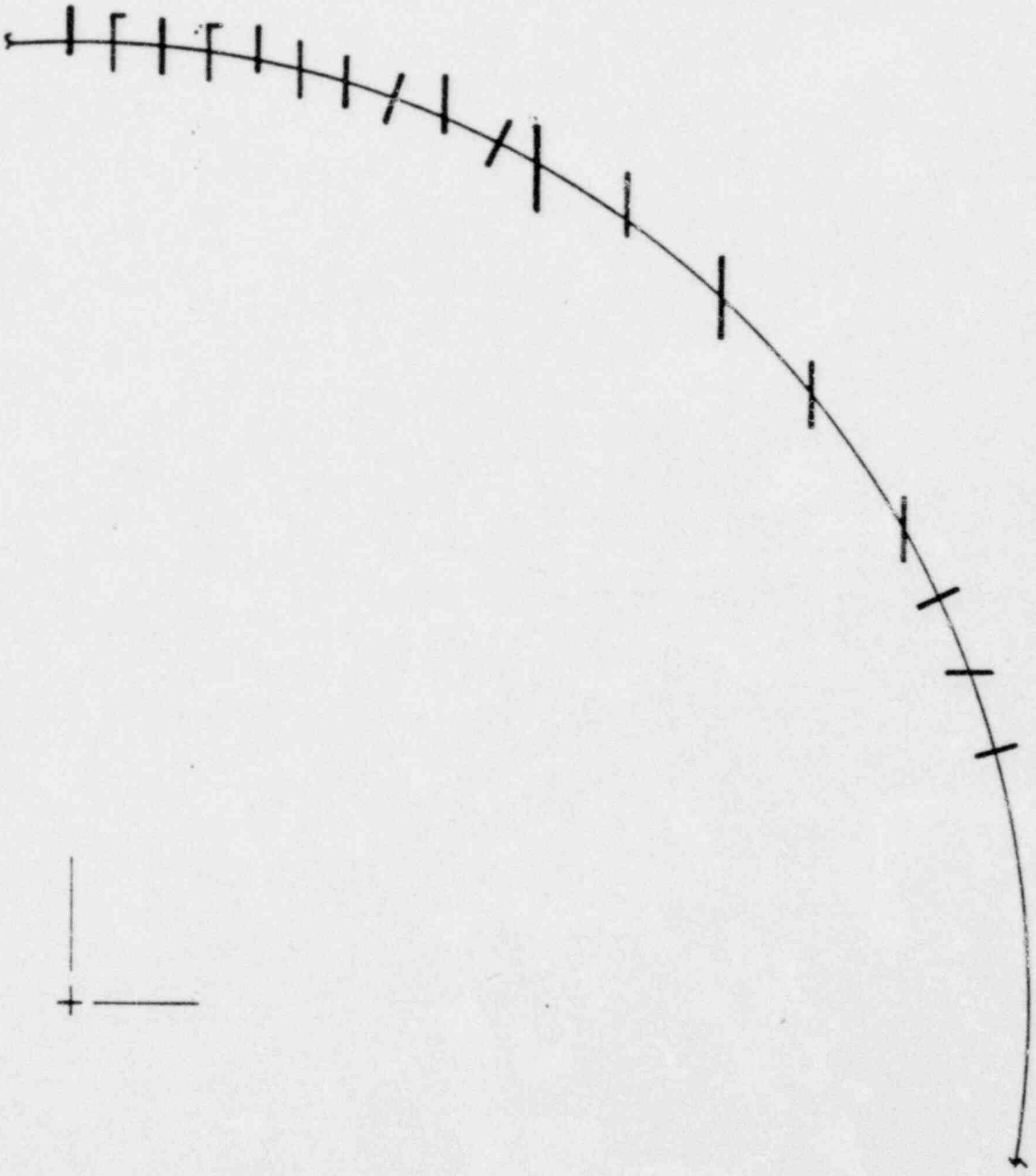
- SHELL CAPABILITY BASED ON VON MISES YIELD CRITERION INSTEAD OF TRESCA
- HAND CALCULATIONS ON SHELL, SMEARING OUT HOOP STIFFENERS, VERIFIED BY FINITE ELEMENT ELASTO-PLASTIC ANALYSES OF PANELS ON SEQUOYAH AND MCGUIRE
- PLATFORM CAPABILITY RECALCULATED USING PLASTIC ANALYSIS METHODS
- DETAILED REVIEW OF SHELL/PLATFORM INTERFACE
- LIMITING CAPABILITY IN TOP SHELL COURSE AND EQUIPMENT ACCESS HATCH = 55 PSIG

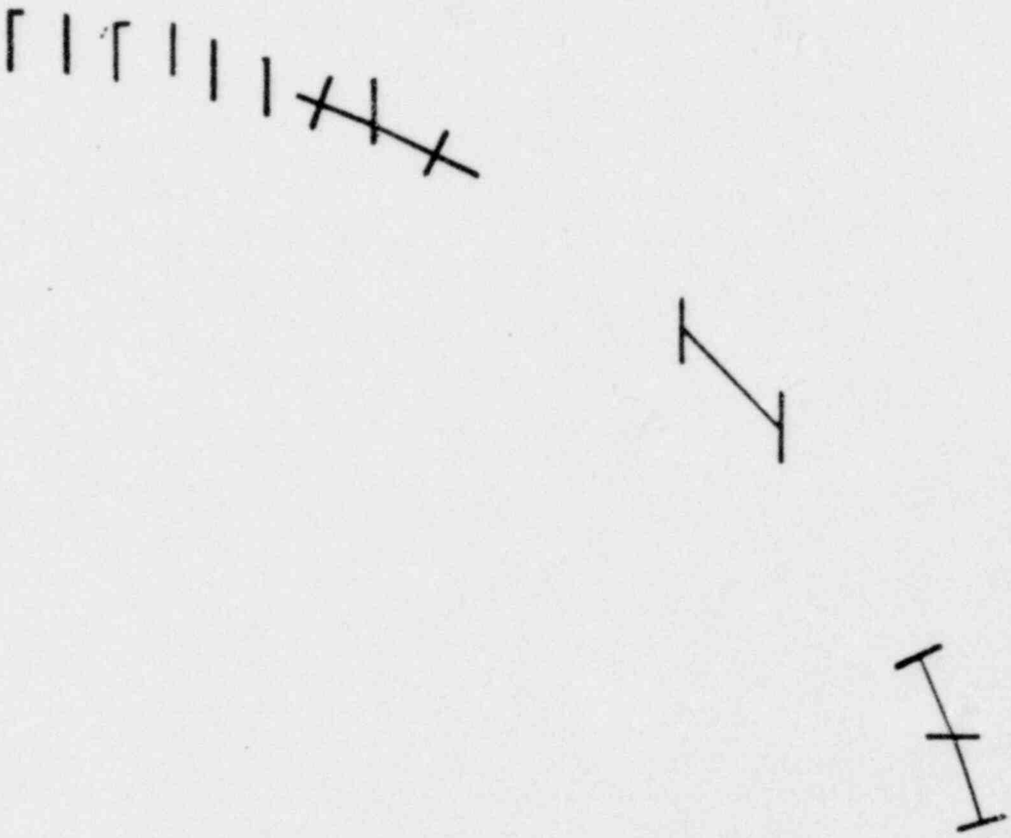


MAIN SUPPORT JUNCTIONS BETWEEN THE CONTAINMENT SHELL AND THE PLATFORM
A
B
C
C_1
C_2
D
E
F
G
H
I
J
K
L
M
BHD FR 2C
BHD 3
BHD 4
BHD FR 4b
BHD F
BHD G
BHD H
BHD I
CONTAINMENT SHELL
℄ REACTOR
℄ CONTAINMENT



℄ CONTAINMENT
PRESSURE BHD
CONTAINMENT SHELL
FR 3b
FR 3b½
FR 3c
FR 3c½
BHD 4
FR 4½
FR 4a
FR 4a½
BHD/FR 4b
BHD I
FR 4b½
FR 4c
FR 4d
BHD H
BHD G





EXISTING BACK UP STRUCTURE FOR CONTAINMENT SHELL

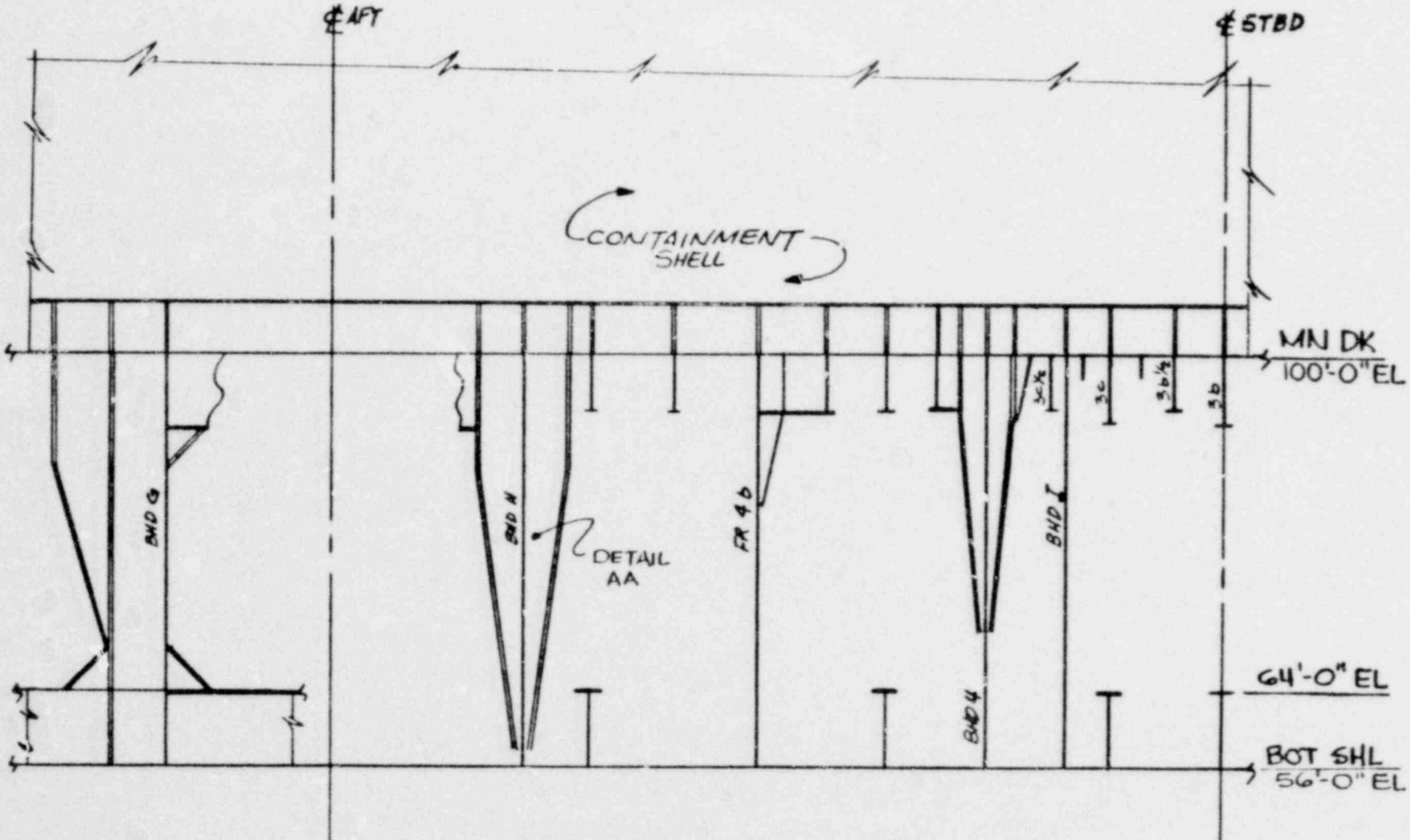


IMAGE EVALUATION
TEST TARGET (MT-3)

6″

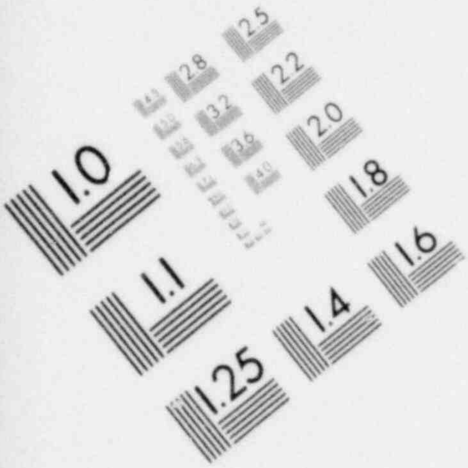
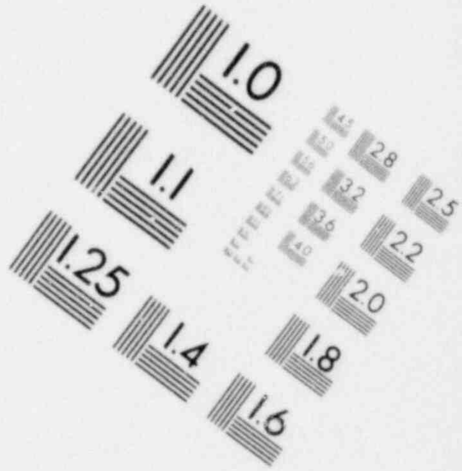
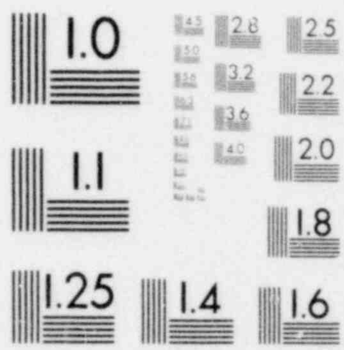
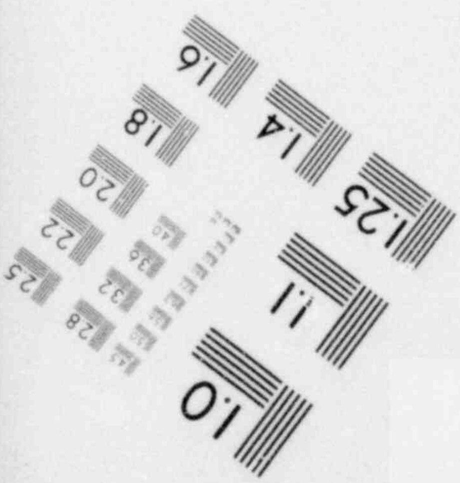
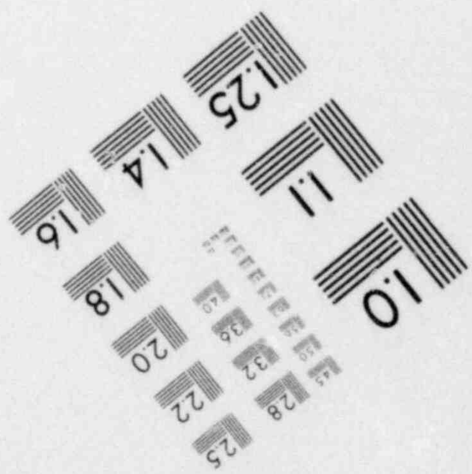
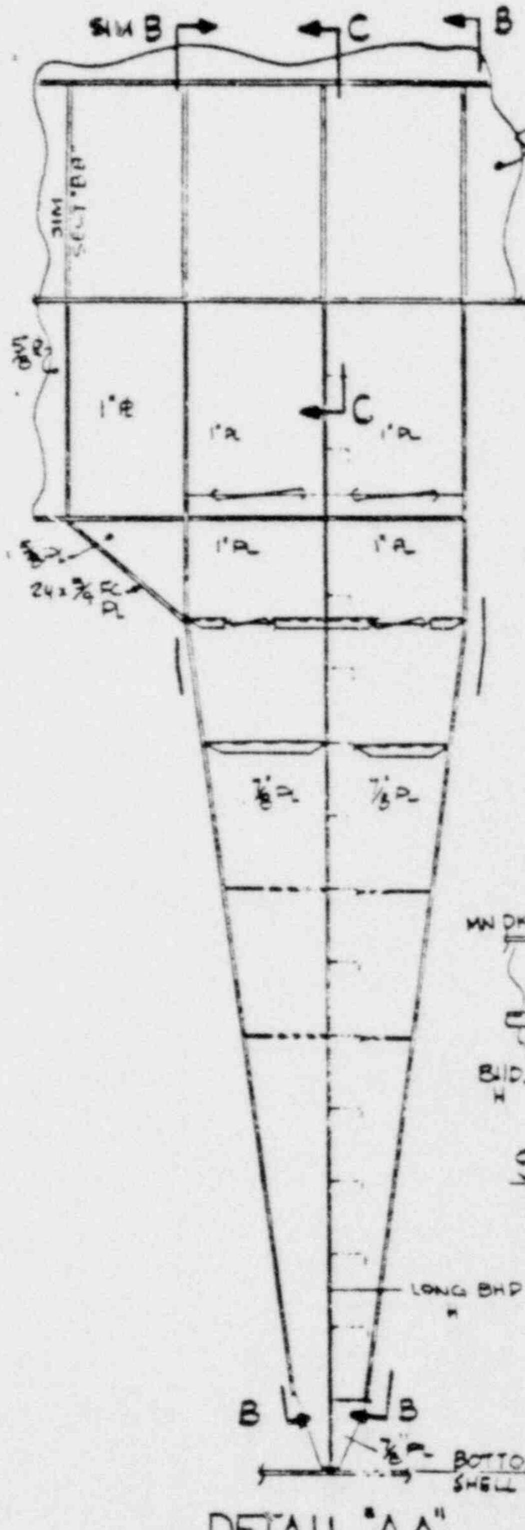



IMAGE EVALUATION
TEST TARGET (MT-3)

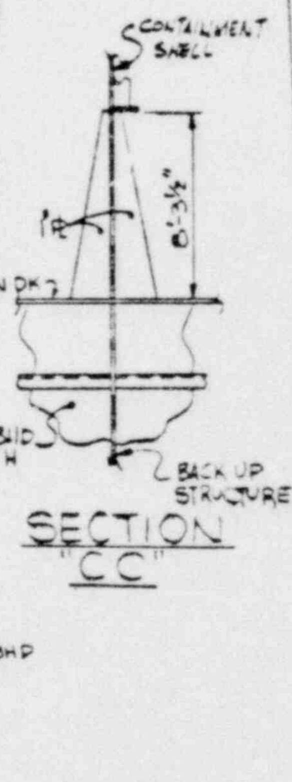


6″

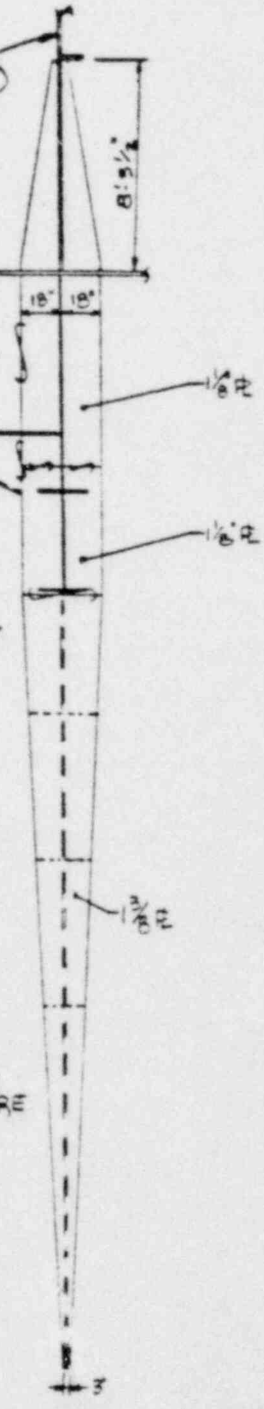





DETAIL "AA"



SECTION "CC"



SECTION "BB"

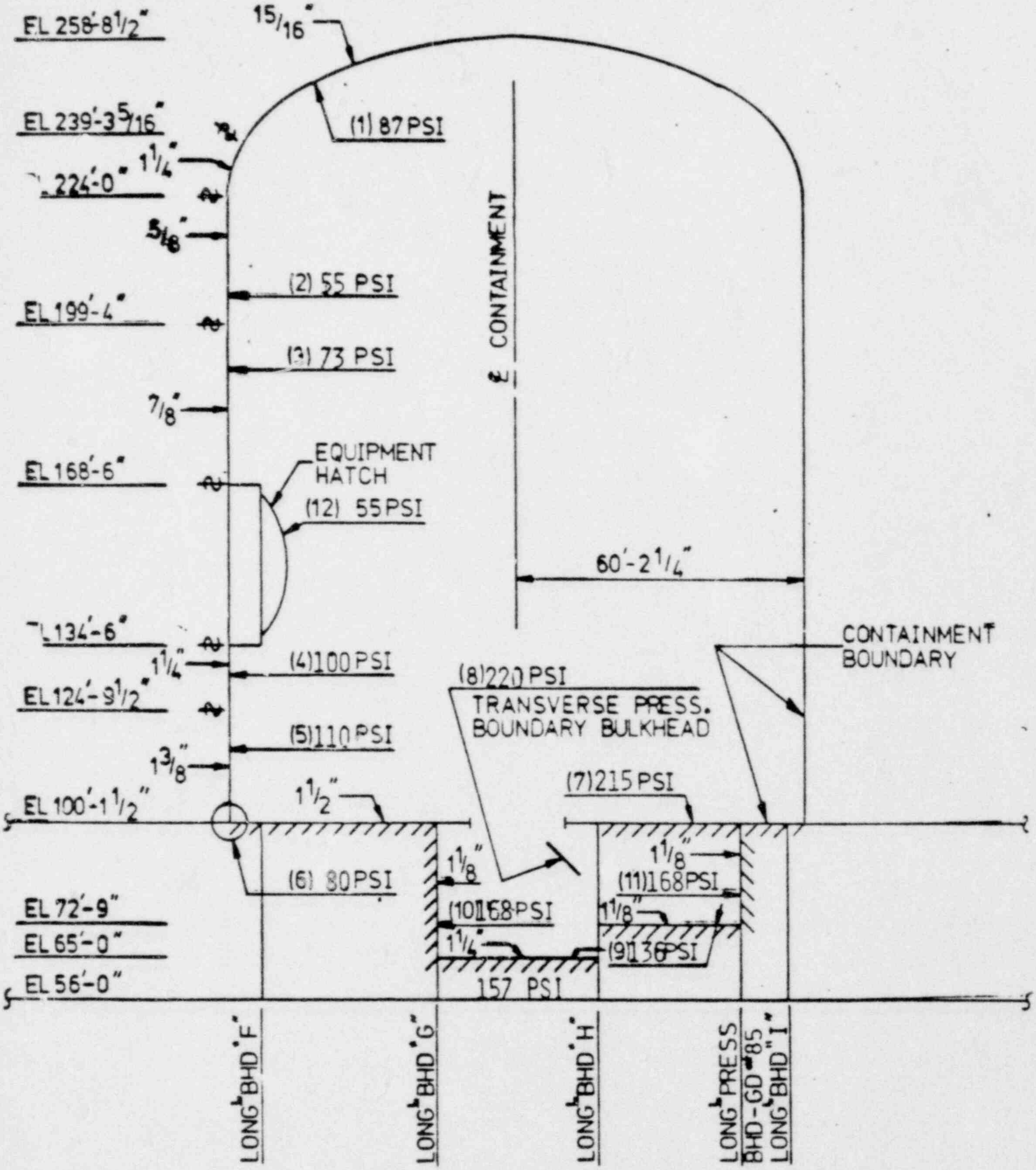
PRESSURE CAPABILITY OF CONTAINMENT SHELL-PLATFORM JUNCTION

SUPPORT LOCATION	SUPPORT AREA FROM DWGS. (IN²)	BETWEEN SUPPORT LOCATIONS	
		EQUIV. SHELL THICKNESS (IN)	EQUIV. PRESSURE TO PRODUCE YIELD IN THE SHELL (PSI)
A	256		
		.79	99.44
B	126		
		.49	61.86
C	215		
C1	207	1.09 (C1–C2)	137.09
C2	207		
D	215		
		.49	61.86
E	126		
		.79	99.44
F	256		
		.58	72.85
G	276		
		.69	87.39
H	126		
		.50	63.24
I	222		
		.76	95.90
J	218		
		.76	95.90
K	222		
		.50	63.24
L	126		
		.69	87.39
M	276		
		.58	72.85
A	–		

A thru F	1608.	.71	89.49
G thru M	1466.	.65	81.58

ESTIMATED PRESSURE CAPABILITY = 80 psig

FEB 1981



TRANSVERSE SECTION FRAME "3(b)"

ESTIMATED CONTAINMENT BOUNDARY FAILURE PRESSURES-(PSI)

CONTAINMENT MODIFICATIONS REQUIRED FOR 80 PSIG CAPABILITY

1. INCREASE THICKNESS OF SHELL (ELEVATION 199'4" TO 244'0") FROM 5/8" TO 1".

2. INCREASE THICKNESS OF SHELL (ELEVATION 162'2" TO 199'4") FROM 7/8" TO 1".

3. INCREASE CAPABILITY OF EQUIPMENT HATCH COVER BY ONE OF THE FOLLOWING:

   A) INCREASE THICKNESS FROM 1-3/8" TO 1-3/4".

   B) ADD STIFFENERS TO PREVENT BUCKLING.

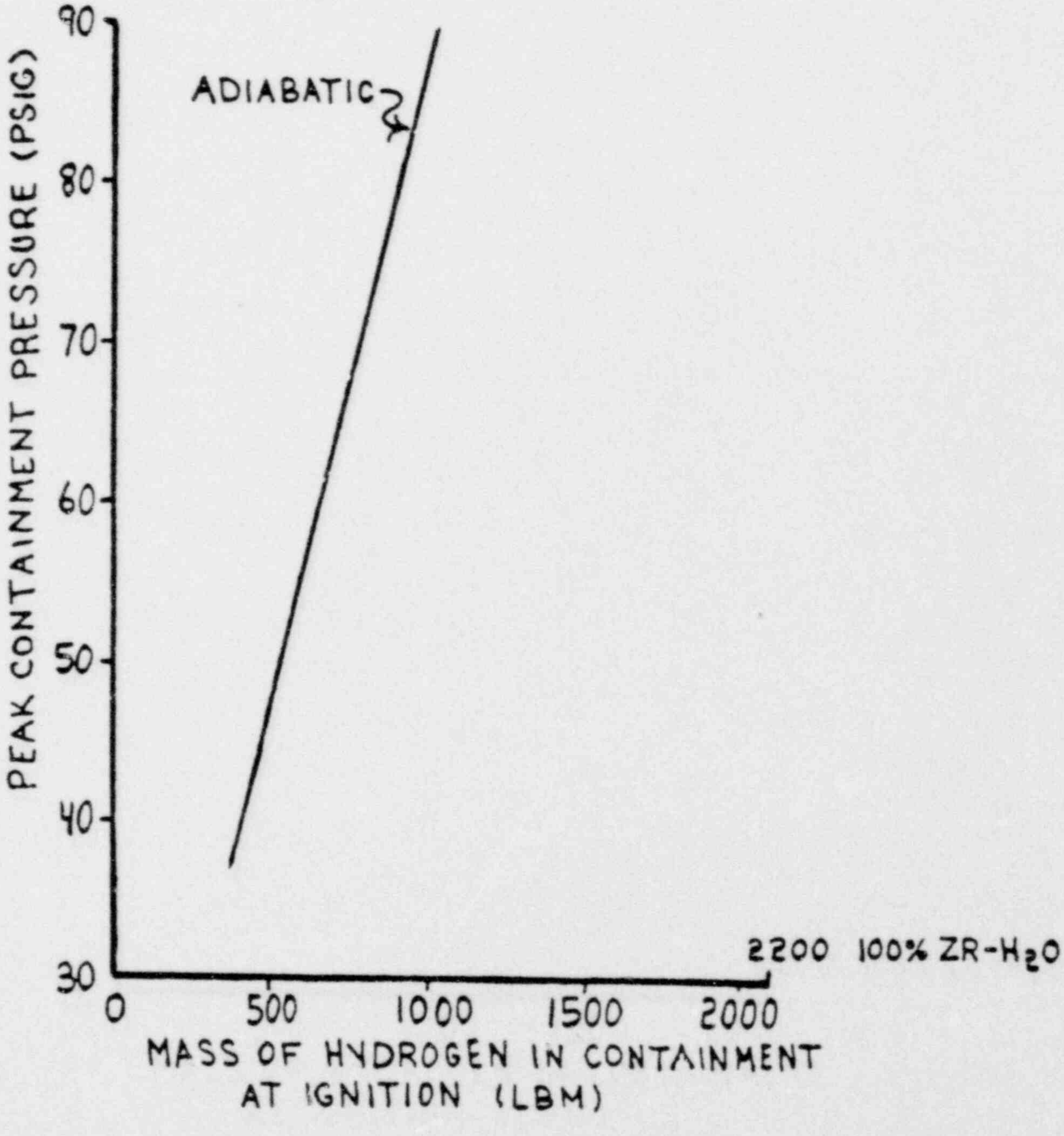
   C) REVERSE ORIENTATION SO THAT PRESSURE ON COVER IS INTERNAL PRESSURE.

CONTAINMENT BOUNDARY CAPABILITY

SUMMARY

1. CAPABILITY OF EXISTING CONTAINMENT = 55 PSIG.
2. CAPABILITY OF SHELL/PLATFORM INTERFACE = 80 PSIG.
3. CONTAINMENT CAN BE MODIFIED TO INCREASE CAPABILITY TO 80 PSIG.

CLASIX ANALYSIS OF A UNIFORMLY MIXED H_2 BURN



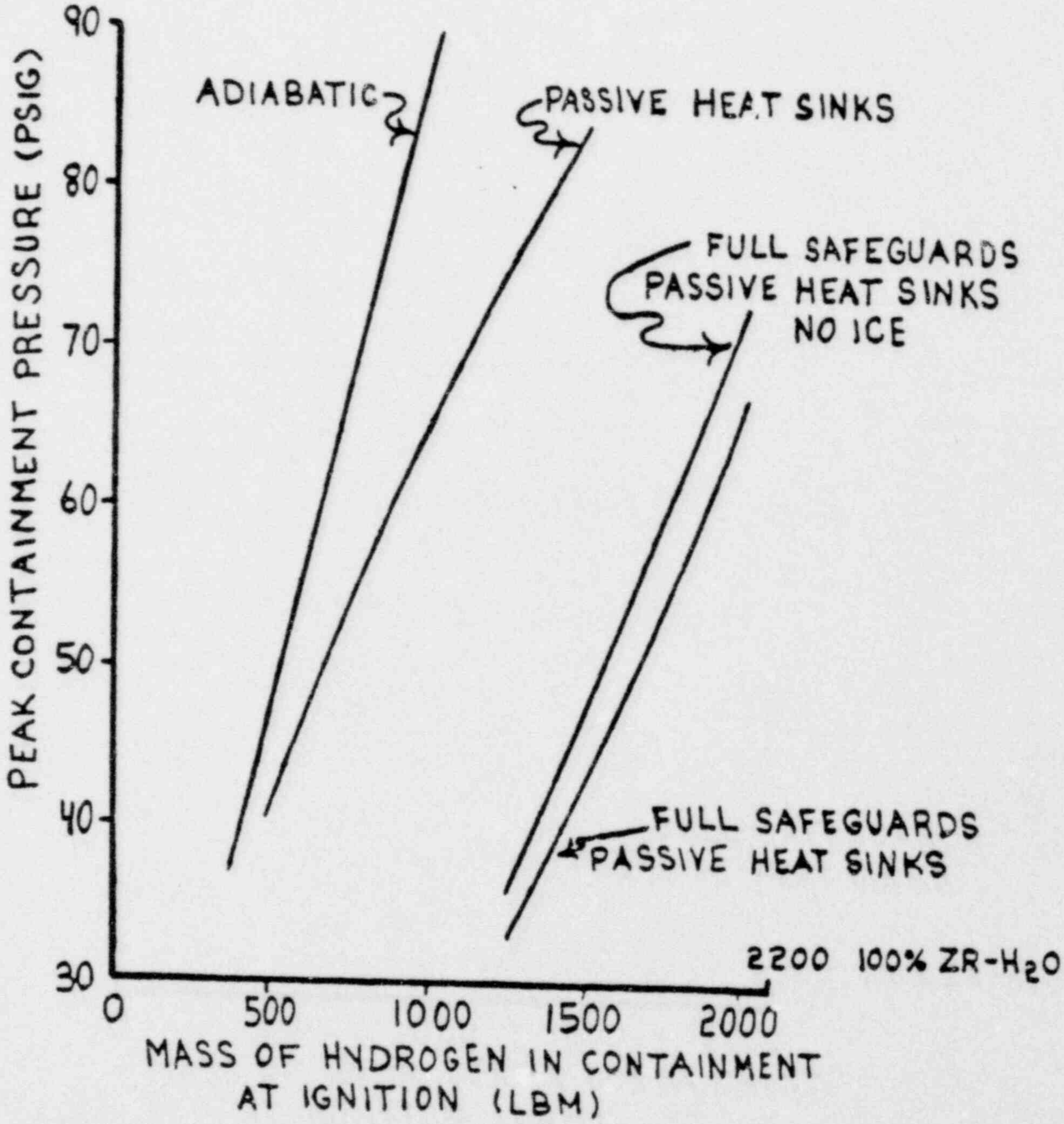
FNP H_2 VENT RESULTS

UNIFORMLY MIXED, 6 FPS FLAME SPEED

30 FT SUBMERGENCE

	VENT	PEAK PRESSURE		
	AREA	30 FT H_2O IN PIPE		3 FT H_2O IN PIPE
%Zr-H_2O	(FT^2)	45 PSIG RUPTURE	22 PSIG RUPTURE	22 PSIG RUPTURE
25	0	45.7	45.7	45.7
	5	45.5	42.9	42.8
	10	45.5	40.4	40.1
50	0	83.1	83.1	83.1
	5	76.2	74.9	74.9
	10	70.0	67.9	67.9
75	0	114.9	114.9	114.9
	5	101.5	100.8	100.6
	10	90.4	89.3	89.2
100	0	142.6	142.6	142.6
	5	122.6	122.3	122.1
	10	107.0	105.1	104.7

CLASIX ANALYSIS OF A UNIFORMLY MIXED H_2 BURN



CLASIX ANALYSIS ASSUMPTIONS

1. UNIFORM H_2 RELEASE RATES, 0.5 TO 5 LBM/SEC
2. 2200 # OR 100% Zr-H_2O EQUIVALENT
3. FULL CONTAINMENT SAFEGUARDS
4. PASSIVE HEAT SINKS – NO RADIANT HEAT TRANSFER
5. DISTRIBUTED IGNITION SOURCES
6. 100% BURN OUT WITH IGNITION AT 10 $V/_O$

CLASIX COMPARTMENTED ANALYSIS

PEAK CONTAINMENT PRESSURE AS A FUNCTION OF H_2 RELEASE RATE

RATE (#/SEC)	TIME (SEC)	PEAK PRESSURE (PSIG)	COMMENTS
0.5	4400	12	NO BURNS IN UPPER COMPARTMENT
1.0	2200	25	MARCH S_2D MAXIMUM
2.0	1100	24	
3.0	767	25	
4.0	550	34	
5.0	440	30	

CONCLUSIONS

- VENTS INEFFECTIVE FOR CONTROLLING H_2 BURN TRANSIENTS

- PEAK PRESSURES WELL WITHIN CONTAINMENT FUNCTIONAL CAPABILITY WITH SAFEGUARDS AND DISTRIBUTED IGNITION SOURCES

PROPOSED DEGRADED CORE HYDROGEN REQUIREMENTS – MANUFACTURING LICENSE

1. DEGRADED CORE ACCIDENT SIMILAR TO TMI UP TO 50% ZR-H_2O REACTION

2. HYDROGEN RELEASE RATES UP TO MAXIMUM UNIFORM RATE OF 1.0 LBS./SEC.

3. CONTAINMENT PRESSURE CALCULATIONS RESULTING FROM HYDROGEN COMBUSTION (IF ANY)

   A. REALISTIC METHODS OF ANALYSIS

   B. REALISTIC HEAT LOSSES TO HEAT SINKS

   C. REALISTIC ASSUMPTIONS FOR OPERATION OF SAFEGUARDS AND MITIGATION FEATURES

   D. BURN INITIATED BY DISTRIBUTED IGNITION SOURCES, IF PROVIDED

   E. ONE SINGLE ACTIVE FAILURE OF CONTAINMENT SAFEGUARDS

   F. ELECTRIC POWER IS AVAILABLE

4. CALCULATED CONTAINMENT PRESSURE SHALL BE LESS THAN FUNCTIONAL CAPABILITY DEFINED BY:

   A. PLASTIC ANALYSIS METHODS INCLUDING CONSIDERATION OF EFFECTS OF DEFORMATIONS

   B. ACTUAL MATERIAL PROPERTIES

STATUS OF MANUFACTURING LICENSING APPLICATION WITH RESPECT TO NRC REQUIREMENTS

REQUIREMENT	STATUS	
NUREG-0718	RESPONSES SUBMITTED 7/80. MINOR UPDATE REVISION REQUIRED.	
RELIABILITY EVALUATION	COMMITTED TO PERFORM RELIABILITY ASSESSMENT 7/80. RELIABILITY EVALUATION WILL BE FACTORED INTO FINAL DESIGN PROCESS.	
PROVISION FOR FLANGED CONNECTION IN DESIGN	WILL BE PROVIDED, IF REQUIRED.	
CONTAINMENT PRESSURE CAPABILITY	CURRENT	15 PSIG DESIGN 55 PSIG FUNCTIONAL CAPABILITY
	POTENTIAL	25 PSIG DESIGN 80 PSIG FUNCTIONAL CAPABILITY
SITING, EVACUATION	NOT APPLICABLE FOR FNP APPLICATION.	

STAFF POSITION RE. CP REQUIREMENT WITH RESPECT TO DEGRADED CORE RULEMAKING

1. For All Pending CP's

1. Commit to performing a site/plant probabilistic risk assessment and incorporating the results of the assessment into the design of the facility. The commitment must include a program plan, acceptable to the staff, that demonstrates how the risk assessment program will be scheduled so as to influence system designs as they are being developed.

2. Demonstrate by analysis, that the containment and associated systems will provide reasonable assurance that uniformly - distributed hydrogen concentrations do not exceed 10% following an accident that releases hydrogen generated from 100% fuel clad metal-water reaction, or demonstrate that the post-accident atmosphere will not support hydrogen combustion.

3. Demonstrate, by analysis, that containment integrity (based on ASME Code yield criteria and on ASME Service Level C assuming a single load condition) will be maintained following an accident that releases hydrogen generated from a 100% fuel clad metal-water reaction accompanied by the more severe condition of either hydrogen burning or the added pressure from post-accident inerting assuming carbon-dioxide is the inerting agent. Systems necessary to ensure containment integrity shall also be demonstrated to perform their function under these conditions.

4. Demonstrate, by analysis and test, that containment structure loadings produced by an inadvertent full inerting (assuming carbon dioxide), plus mechanical and other stress-producing loadings, (but not including seismic

or design basis accident loadings) do not produce stresses in excess of the acceptable maximum specified in ASME Code Section III, Subsection NE. Also demonstrate, by analysis and test, that the inadvertent full inerting while at operation can be safely accommodated. The containment shall be pressure-tested at 1.15 times the pressure calculated to result from inadvertent full inerting (assuming carbon dioxide).

5. Containment design shall include provisions for one or more dedicated penetrations, equivalent in size to a single 3-foot diameter opening, to accommodate a future possible requirement to vent the containment.

2. <u>For BWR's</u>

Incorporate a ~~an additional~~ capability for natural convection decay heat removal ~~preventing core damage from small-break loss-of-coolant accidents~~ by including an in-containment isolation condenser as a backup to the RCIC and HPCS, capable of operating with loss of AC power.

3. <u>For Ice Condenser and Large Dry Containments</u>

As part of the required probabilistic risk assessment, evaluate the feasibility of incorporating a ~~an additional~~ capability, functionally similar to the in-containment isolation condenser being provided in BWR's for ~~preventing core damage from small-break loss-of-coolant accidents.~~ natural convection decay heat removal, capable of operating with loss of AC power.

Presentation
by
Houston Lighting and Power
Before the
ACRS Subcommittee on
Safety, Philosophy, Technology and Criteria
February 4, 1981

Introduction

We appreciate the opportunity to appear before the subcommittee and give our views on the proposed rule by the NRC Staff for pending construction permit applications and to inform you of the studies we have underway as a result of the proposal.

We have been concerned for sometime by the delays which the Allens Creek Nuclear Generating Station has experienced in attempting to receive a construction permit. The delays are now threatening the ability of my company to support our future loads while at the same time adding hundreds of millions of dollars of unwarranted costs to the project.

The Fuel Use Act of 1978 */ prohibits HL&P from constructing new power plants that use either petroleum or natural gas, and prohibits natural gas from being used as a primary energy source in any existing power plant after January 1, 1990. As a result, nuclear power does represent a viable alternate to our generation capacity requirements for the future.

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*/ 42 U.S.C. §§ 8301 et seq.

The ability to use the nuclear option -- in our case -- is highly dependent on the timeliness of getting on with the construction of our Allens Creek project and its ultimate operation. Allens Creek is presently three years behind the beginning of construction, and is presently scheduled for operation by mid-year 1989. If Allens Creek is to be part of my company's future we must have a construction permit by March 1982. The next few months are critical decision making months. Depending on the outcome of NRC's position on near-term construction permits and the commitment to supportive resources, we will decide whether to proceed with the project or terminate it. If we are to proceed with Allens Creek the approach for resolving the degraded core issue for pending construction permits must be concluded without further delay.

We feel this can happen, if NRC regulatory actions contain the following:

1. Clear criteria for meeting degraded core concerns;
2. A licensing basis which assures that meeting the criteria will result in issuance of a construction permit;
3. Design stability during the period of construction and some assurance that the design will be sufficient for issuance of an operating license; and
4. Sufficient NRC staff for reviewing TMI-related submittals without delay.

To achieve regulatory actions which contain these elements, it seems to us that one must proceed on the basis of a sound safety philosophy rather than by trying now to predict the outcome of rulemaking proceedings and other regulatory actions which are likely to take years to complete.

I cannot predict the outcome of the degraded core rulemaking proceeding, and I do not know anyone who can. Neither can I forecast now what safety goal may be established at some time in the future. I do know, however, that these are highly controversial areas and that these pending applications will never result in the issuance of construction permits if we are forced to try to resolve those matters in licensing hearings.

As 1980 progressed, HL&P became increasingly concerned with the delay of Allens Creek and the lack of a licensing basis from the NRC including degraded cores. Publication of the proposed NTCP rule in October only heightened our concern. We saw no underlying safety philosophy in the proposal and the elements which we consider essential for licensing were missing. The different versions of the NTCP rule which we have seen since October do not resolve our concerns.

Consequently, we decided to try to formulate a clear, straightforward basis for licensing Allens Creek which would account for the degraded core concern but also avoid attempting to resolve now those matters which are clearly the subjects of future rulemaking activities.

We believe that the guiding safety philosophy should be risk reduction. We asked whether it is possible to develop a balanced approach to the reduction of the risk of a degraded core by reducing the probability of transients leading to a degraded core and by mitigating the consequences of a degraded core. We thought that if this could be accomplished it would be far more meaningful than trying to predict what might happen in future proceedings.

When I refer to risk reduction, I want it to be clear that I believe the Allens Creek plant as currently designed is fully adequate for licensing. I think that the constant addition of new design features and additional minute regulatory requirements may be more of a deterrent to safety than an improvement to safety. But in the real world of licensing nuclear plants today the technical merits too often get lost in other consideration.

But risk reduction can be discussed technically, and I hope that at least we can get everyone to agree that reducing risks is a desirable goal. The risk reduction I am referring to is relative risk reduction. It is not appropriate to ask the question "How safe is safe enough?", for that will be resolved in setting the safety goal, and not on the Allens Creek docket.

Allens Creek is already designed to reduce risks orders of magnitude below those of the BWR studied in WASH-1400, as will be shown later in our presentation. Nevertheless, we set out in our studies to determine whether risks associated with the degraded core concern could be reduced even further.

Relationship of the Study to Other Regulatory Activities

In undertaking these studies, we recognized that there are three levels of regulatory activity underway concerning degraded cores. The first is the long-term degraded core rulemaking. As we understand it now, this proceeding will explore the basic phenomena associated with degraded cores and seek to determine whether additional regulatory action is required regarding the fundamental design of nuclear plants. This proceeding is expected to last several years, require a massive effort by both NRC and the industry, and cost many millions of dollars.

The second level of regulatory activity is the proposed interim rule on hydrogen control and degraded core considerations. The proposed rule, if adopted in substantially the form as proposed, would require extensive studies on hydrogen which, in the case of Allens Creek, would not be required until docketing of the operating license -- an event which will not take place for several years. The NRC also anticipates that these studies will require formation of industry groups and an extensive effort to complete.

The third level of activity concerns the degraded core considerations for pending construction permits. In undertaking our studies, we considered that we could not reasonably resolve in a matter of weeks the questions involved in the first two levels of regulatory activity -- questions which NRC contemplates will take years to answer.

Our studies seek instead to provide the engineering information essential to formulate a risk reduction strategy which would form the basis of a rational licensing plan for Allens Creek and at the same time anticipate reasonable actions which could accommodate the outcome of the long-term degraded core rulemaking and the hydrogen studies.

We have also avoided getting into the safety goal area when considering risk reduction. Relative risk reduction seems to us to be a reasonable way to proceed until a quantitative safety goal is available.

Conclusion

I believe that we have been diligent in moving forward to assist in establishing a sound licensing basis for the Allens Creek plant.

Mr. Goldberg, our Vice President, Nuclear Engineering/Construction will lead the discussion on the degraded core studies which we have underway.

DRAFT
2/4/81

HOUSTON LIGHTING & POWER COMPANY'S PROPOSED RULE CONSIDERATIONS

1. The containment shall be equipped with a post accident inerting system to preclude detonation of hydrogen resulting from a 100% fuel clad metal water reaction.

2. The containment pressure integrity should be such that it can accommodate:

   a. The anticipated peak containment pressure resulting from a postulated 100% fuel clad metal water reaction without loss of functional integrity.

   b. The anticipated peak containment pressure resulting from the accidental initiation of the post accident inerting system with the reactor at power without resulting in the containment stresses exceeding code allowables for normal operation.

3. A provision for a preventive feature should be allowed in place of additional mitigative features. For example, a provision for an isolation condenser for decay heat removal should be accepted in place of a three foot diameter dedicated penetration for a processed vent and other potential mitigative features.

GENERAL ELECTRIC BWR 6/MARK III STANDARD PLANT

REVIEW OF CONTAINMENT CAPABILITY

FEBRUARY 4, 1981
WASHINGTON, D.C.

AGENDA

- o INTRODUCTION
- o BWR/6 MARK III PRELIMINARY RISK ASSESSMENT
- o CONTAINMENT STRUCTURAL EVALUATION
- o HYDROGEN CONTROL OPTIONS
- o SUMMARY

SUMMARY

- SUBSTANTIAL IMPROVEMENTS ALREADY INCORPORATED IN BWR/6 MARK III

- ADDITIONAL POST TMI IMPROVEMENTS INCORPORATED IN STANDARD PLANT

- SIGNIFICANT REDUCTION IN PROBABILITY OF CORE DAMAGE AND RISK RELATIVE TO WASH 1400

SUMMARY (CONT'D)

- MITIGATION EXISTS FOR HYDROGEN CONTROL
  - DRYWELL + POOL + CONTAINMENT
  - CONTAINMENT FUNCTION MAINTAINED

- CONTAINMENT HAS SUBSTANTIAL STATIC AND DYNAMIC CAPABILITY
  - 22 PSIG (NOT 15) FOR ASME SERVICE LEVEL A
  - 41 PSIG FOR ASME SERVICE LEVEL C
  - 70 PSIG FOR DRYWELL

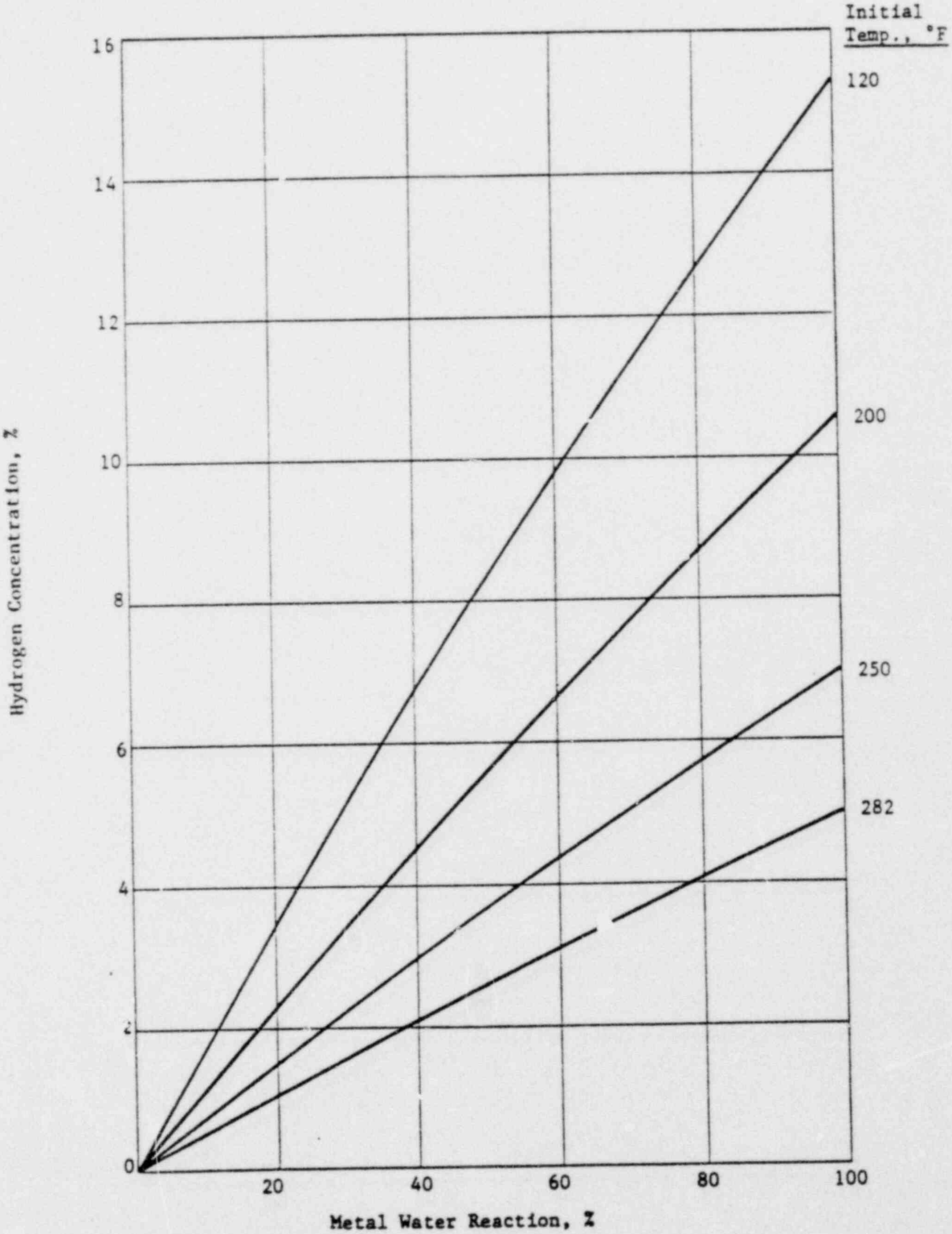
- SIGNIFICANT CONTAINMENT STRENGTHENING ONLY PRACTICAL AT NEW PLANT DESIGN INITIATION

- IF ADDITIONAL HYDROGEN CONTROL REQUIRED ... TWO OPTIONS IDENTIFIED
  - POST EVENT INERTING
  - IGNITORS

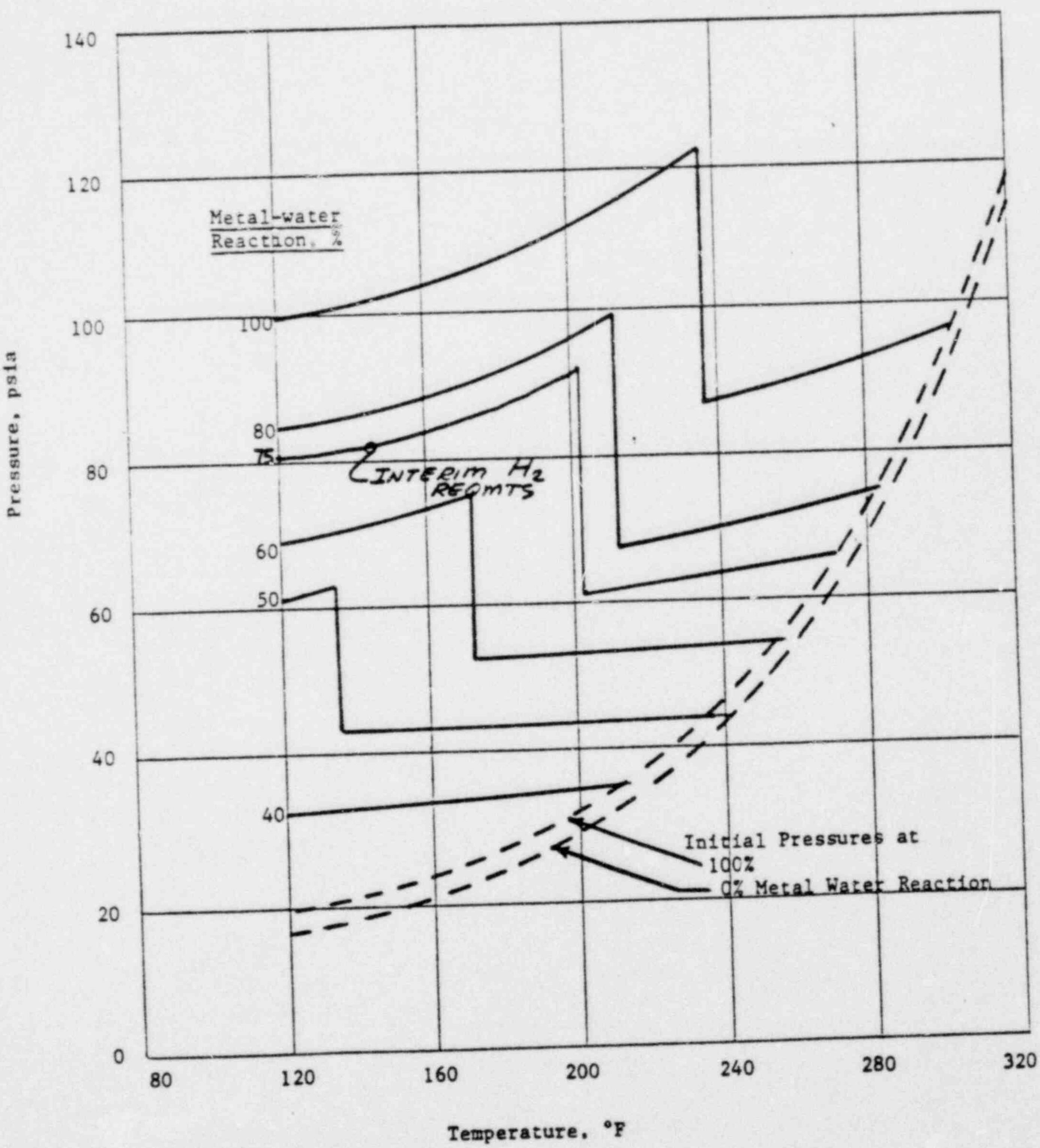
PILGRIM 2 CONTAINMENT
(1200 MWe PWR)

- PRESTRESSED CONCRETE
- FREE VOLUME: 2.5×10^6 CU. FT.
- DESIGN PRESSURE: 60 PSIG
- TEST PRESSURE: 69 PSIG

Hydrogen Concentration Vs. Metal Water Reaction at Various Initial Temperatures

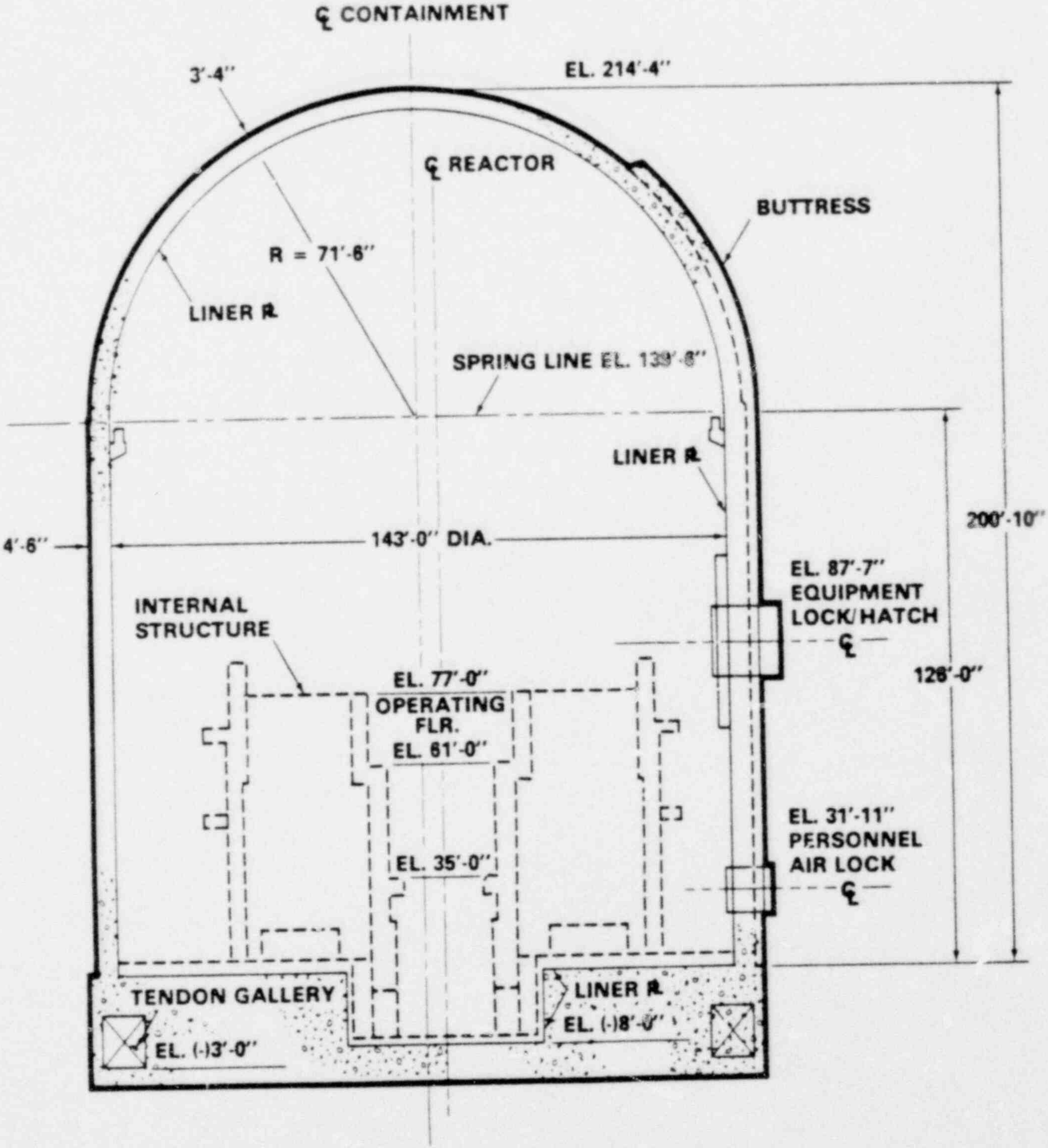


Equilibrium Pressure Vs. Initial Temperature at Various Metal Water Reactions - Adiabatic Partial Combustion Above NRC Flammability Limit



Pilgrim Station — Unit 2 Job 8791

CONTAINMENT GENERAL ARRANGEMENT



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CONTAINMENT DESCRIPTION

- PRESTRESSED, POST-TENSIONED CYLINDER AND HEMISPHERICAL DOME
- NON-PRESTRESSED BASEMAT
- 143' INS. DIAMETER X 200'-10" OVERALL HEIGHT
- CYLINDER WALL — 4'-6" THICK
  DOME — 3'-4" THICK
  BASEMAT — 28' THICK (NOM.)
- LOCKS AND HATCH —
  19' DIAMETER BOLTED HATCH
  2 DOUBLE DOOR LOCKS
    1 — 16' DIAMETER IN HATCH COVER
    1 — 10' DIAMETER THROUGH CONCRETE
- LINER — 1/4" THICK

G100329 1 04

CONTAINMENT CAPABILITY

CONDITION	CONTAINMENT PRESSURE	CONTAINMENT STRESS LEVEL
75% METAL WATER REACTION	$\sim$80 PSIG	$<$YIELD
100% METAL WATER REACTION WITH H_2 IGNITORS	$<$80 PSIG	$<$YIELD

PRESENTATION

ALLENS CREEK

TECHNICAL STUDIES

ON DEGRADED CORES

FOR

HOUSTON LIGHTING AND POWER COMPANY

BY

S. LEVY

FEBRUARY 1981

OBJECTIVES OF STUDIES

- RESPOND TO NRC REQUIREMENTS FOR DEGRADED CORES FOR NTCP APPLICANTS

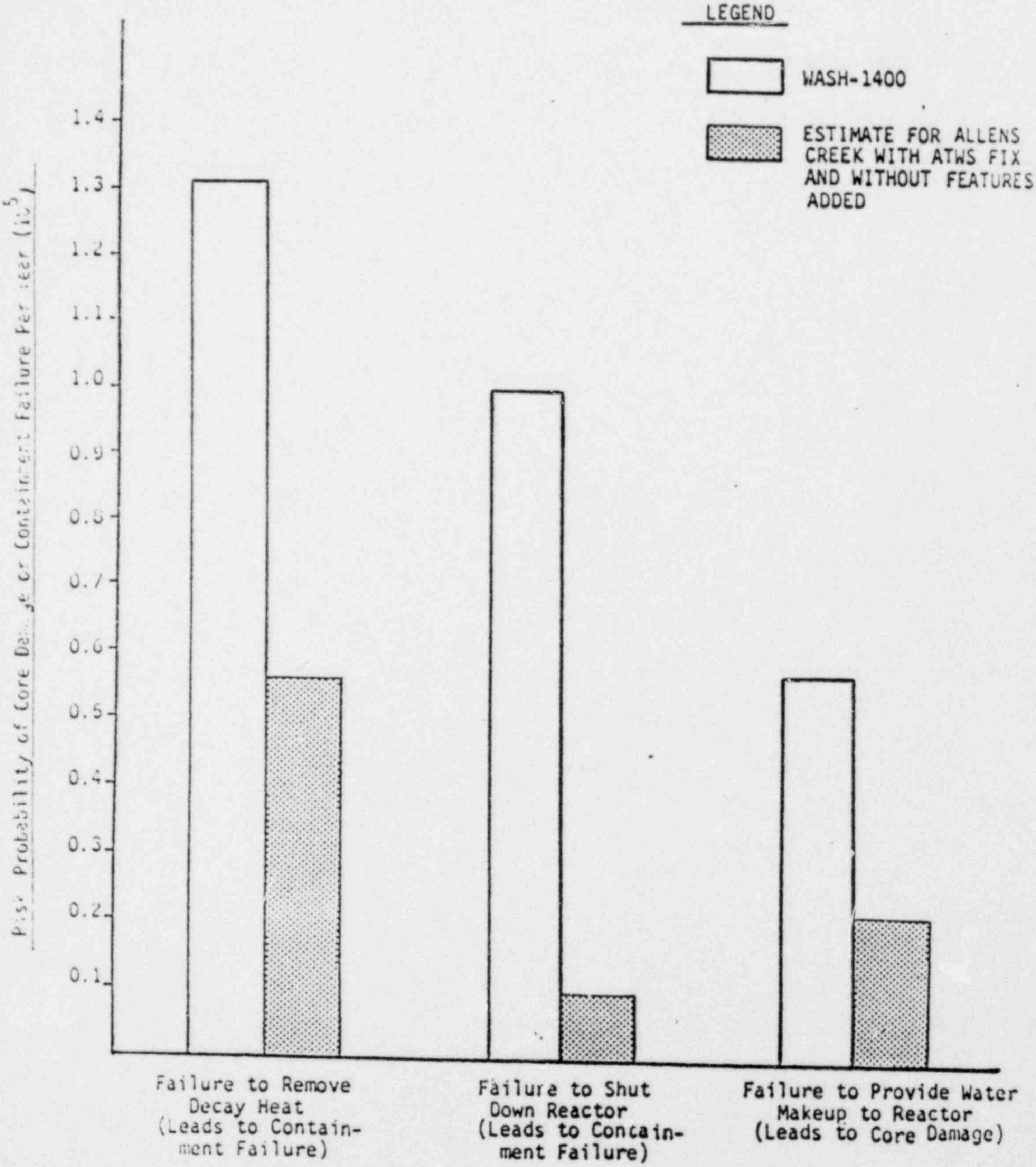
- MINIMIZE IMPACT OF FUTURE RULE MAKING ON DEGRADED CORES AND HYDROGEN CONTROL

- MINIMIZE IMPACT ON PROJECT

- EVALUATE FEASIBILITY, EFFECTIVENESS, AND RELATIVE RISK REDUCTIONS OF PROSPECTIVE ADDITIONAL PLANT FEATURES

DIFFICULT SET OF OBJECTIVES

PROBABILITY OF CORE DAMAGE OR CONTAINMENT FAILURE



OBSERVATIONS ON RISKS

- RISK PROBABILITIES AND CONSEQUENCES BELOW WASH-1400

- RISK PROBABILITY REDUCTION FACTORS ARE LIMITED
  - ELIMINATE ALL FAILURES TO PROVIDE WATER MAKEUP TO REACTOR = 1.3 RPRF
  - ELIMINATE ALL FAILURES TO REMOVE DECAY HEAT = 2.8 RPRF
  - ELIMINATE ALL FAILURES TO PROVIDE WATER MAKEUP TO REACTOR AND ALL FAILURES TO REMOVE DECAY HEAT = 8.5 RPRF

- COMPLETE MITIGATION OF ALL FAILURES TO PROVIDE WATER MAKEUP TO REACTOR = 1.3 RPRF

RISKS ARE BELOW WASH-1400 DEGRADED CORE CAUSING CONTAINMENT FAILURE NOT DOMINATE RISK

FEATURES STUDIED

PREVENTIVE

- FAILURE TO REMOVE DECAY HEAT
  - IMPROVED ON-SITE POWER SOURCE
  - CONTAINMENT PRESSURE RELIEF
  - INTERNAL ISOLATION CONDENSER
  - EXTERNAL ISOLATION CONDENSER
- FAILURE TO PROVIDE WATER MAKEUP TO THE REACTOR
  - IMPROVED ON-SITE POWER SOURCE
  - REACTOR VESSEL DEPRESSURIZATION AUGMENTATION
  - COMBINED CONTAINMENT PRESSURE RELIEF AND REACTOR DEPRESSURIZATION AUGMENTATION

MITIGATION

- HYDROGEN CONTROL
  - CONTAINMENT PRE-INERTING
  - CONTAINMENT POST-INERTING
  - CONTROLLED HYDROGEN BURNING
  - INCREASED CONTAINMENT PRESSURE CAPABILITY
- OVERPRESSURE CONTROL
  - VENTING OR VENTING/FILTER OF CONTAINMENT
  - LOW CARBON CONCRETE
- BASEMAT PENETRATION
  - FLOODING OF CONTAINMENT AND MOLTEN CORE CATCHER AND LADLES

^ RST SCREENING OF FEATURES

PREVENTION

1. CONTAINMENT PRESSURE RELIEF (2)
2. INTERNAL ISOLATION CONDENSER (5)
3. REACTOR VESSEL DEPRESSURIZATION AUGMENTATION (1.1)
4. COMBINATION OF (1) and (3) ABOVE (3)

MITIGATION

1. CONTAINMENT POST INERTING (< 1.3)
2. CONTROLLED HYDROGEN BURNING WITH PRESENT CONTAINMENT SPRAY (< 1.3)
3. INCREASED CONTAINMENT PRESSURE CAPABILITY (< 1.3)
4. VENTING OF CONTAINMENT (< 1.3)

CONTAINMENT PRESSURE RELIEF

FEATURE

VENTING TO AVOID OVERPRESSURE FAILURE DURING FAILURE TO REMOVE RESIDUAL HEAT

POOL MAKEUP WI[illegible] FIREHOSE DELAYS VENTING AND TIME FOR REACHING PURE STEAM ATMOSPHERE IN CONTAINMENT

ADVANTAGES

SIMPLE FIX WITHIN CURRENT PRACTICE

PROVISION COSTS NEGLIGIBLE

SMALL IMPACT ON PROJECT

SUBSTANTIAL RISK PROBABILITY REDUCTION OF 2

DISADVANTAGES

SUPPRESSION POOL LOADS IF POOL ALLOWED TO REACH SATURATION TEMPERATURE

EXCESSIVE WATER POOL ADDITION

INTERNAL ISOLATION CONDENSER

FEATURE

ISOLATION CONDENSER BACKUP TO RCIC AND HPCS

INTERNAL TYPE (CONDENSING COIL LOCATED IN UPPER CONTAINMENT POOL)

ADVANTAGES

INDEPENDENCE FROM PRESENT SYSTEMS AND SUPPRESSION POOL

EFFECTIVE FOR TOTAL LOSS OF AC POWER

PROVIDES ANOTHER BARRIER BETWEEN REACTOR AND CONTAINMENT

SUBSTANTIAL RISK PROBABILITY REDUCTION FACTOR OF 5

DISADVANTAGES

INTERNAL TYPE HAS MEDIUM IMPACT ON PROJECT

ADDITIONAL STUDIES NECESSARY FOR INTERNAL TYPE TO AVOID SURPRISES

INTERNAL TYPE WILL INTERFERE WITH REFUELING AND UPPER POOL USAGE

REACTOR VESSEL DEPRESSURIZATION AUGMENTATION

FEATURE

ELECTRONIC CHANGES AND ENERGY SOURCE ADDITIONS TO ALLOW DEPRESSURIZATION OF PLANT -- USE OF LOW PRESSURE SYSTEMS FOR NON-LOCA EVENTS

ADVANTAGES

SIMPLE FIX, EASY TO PROVIDE FOR

SMALL IMPACT ON PROJECT

DISADVANTAGES

RISK PROBABILITY REDUCTION FACTOR MINIMAL (ABOUT 1.1)

INADVERTENT OPERATION IMPACT NOT FULLY ASSESSED

COULD DEGRADE AUTOMATIC DEPRESSURIZATION SYSTEM RELIABILITY

CONTAINMENT POST INERTING

FEATURE

ADD GAS (HALON OR CO_2) TO PRECLUDE HYDROGEN BURN

ADVANTAGES

SOLVES HYDROGEN PROBLEM IF ACTUATED PROPERLY

DISADVANTAGES

INCREASES CONTAINMENT PRESSURE (6.5 PSI MIN FOR HALON, 22 PSI MIN FOR CO^2)

ACTIVE SYSTEM AND ASSURANCE OF ACTUATION WHEN NEEDED

POTENTIAL MATERIAL CORROSION PROBLEMS FOR HALON

INADVERTENT ACTUATION

MEDIUM IMPACT ON PROJECT

CONTROLLED HYDROGEN BURNING

FEATURE

INSTALLATION OF IGNITERS IN CONTAINMENT TO BURN HYDROGEN BEFORE IT REACHES EXCESSIVE CONCENTRATION

ADVANTAGES

MINIMAL IMPACT FOR INADVERTENT ACTUATION

DISADVANTAGES

FAILURE TO IGNITE HYDROGEN AT LOW CONCENTRATION COULD LEAD TO CONTAINMENT FAILURE

IMPACT OF BURNING FLAME UPON EQUIPMENT

DEVELOPMENTAL, COULD REQUIRE SPECIAL CONTAINMENT SPRAY WITH

LARGE IMPACT ON PROJECT

INCREASED CONTAINMENT PRESSURE CAPABILITY

FEATURE

RAISE CONTAINMENT PRESSURE CAPABILITY (CAN INCREASE FROM 38 to 45 PSIG STATIC CAPABILITY BASED ON MAT ANCHORAGE ACI CODE 359 - ACCIDENT CONDITION)

ADVANTAGES

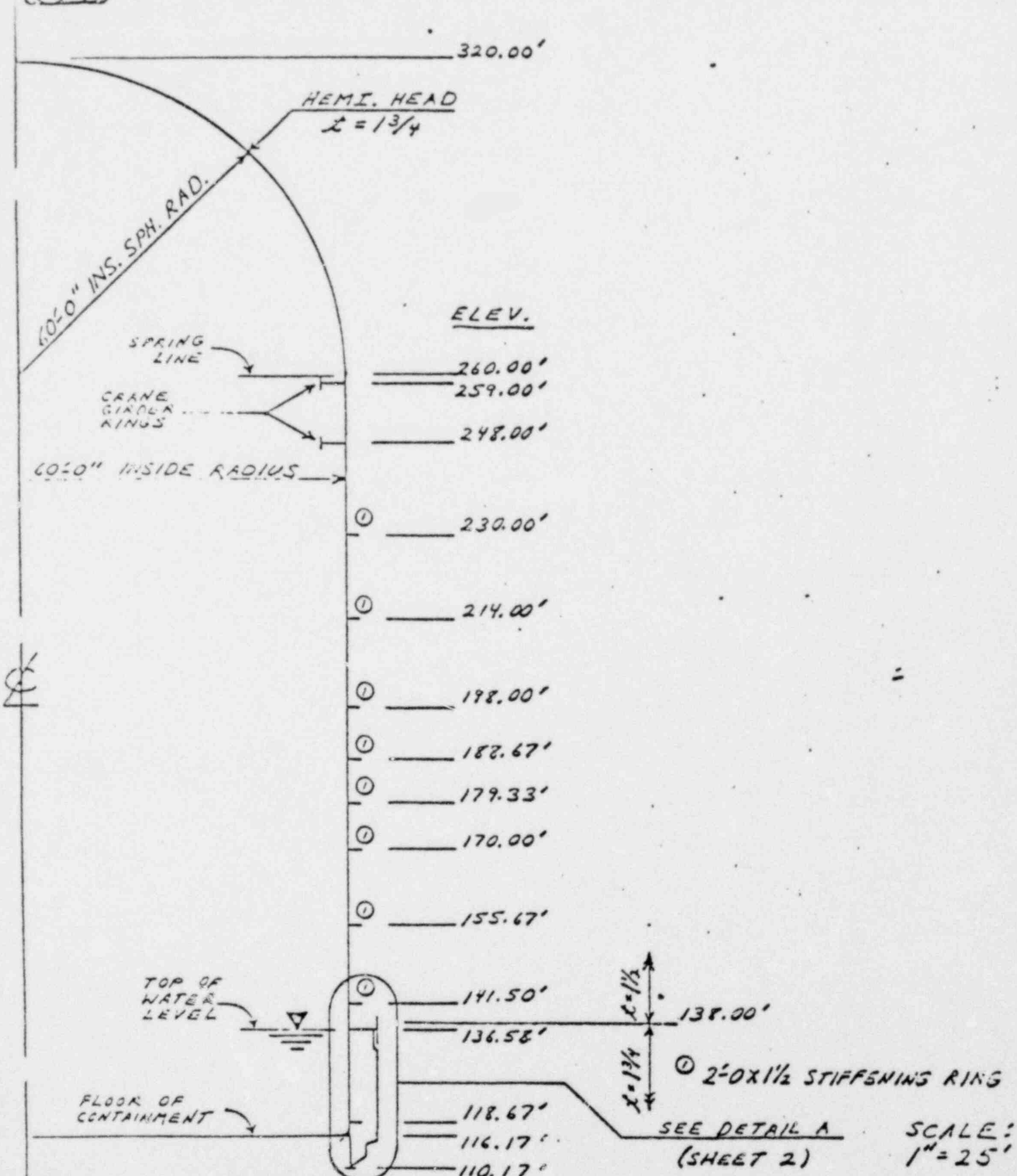
INCREASED OVERPRESSURE FOR HYDROGEN CONTROL AND SUBSEQUENT EVENTS

SMALL IMPACT ON PROJECT

DISADVANTAGES

ASSURANCE THAT THERE WILL NOT BE ANY INCREASE IN DYNAMIC LOADS

Location OSE



SCALE: 1" = 25'

SUBJECT ALLENS CREEK

MODEL 6

MADE BY | CHKD BY | BY | CHARGE NO.

VENTING OR VENTING/FILTER OF CONTAINMENT

FEATURE

VENT OR VENT/FILTER TO AVOID OVERPRESSURE FAILURE

ADVANTAGES

RISK REDUCTION ONLY AFTER HYDROGEN CONTROL ACCOMPLISHED

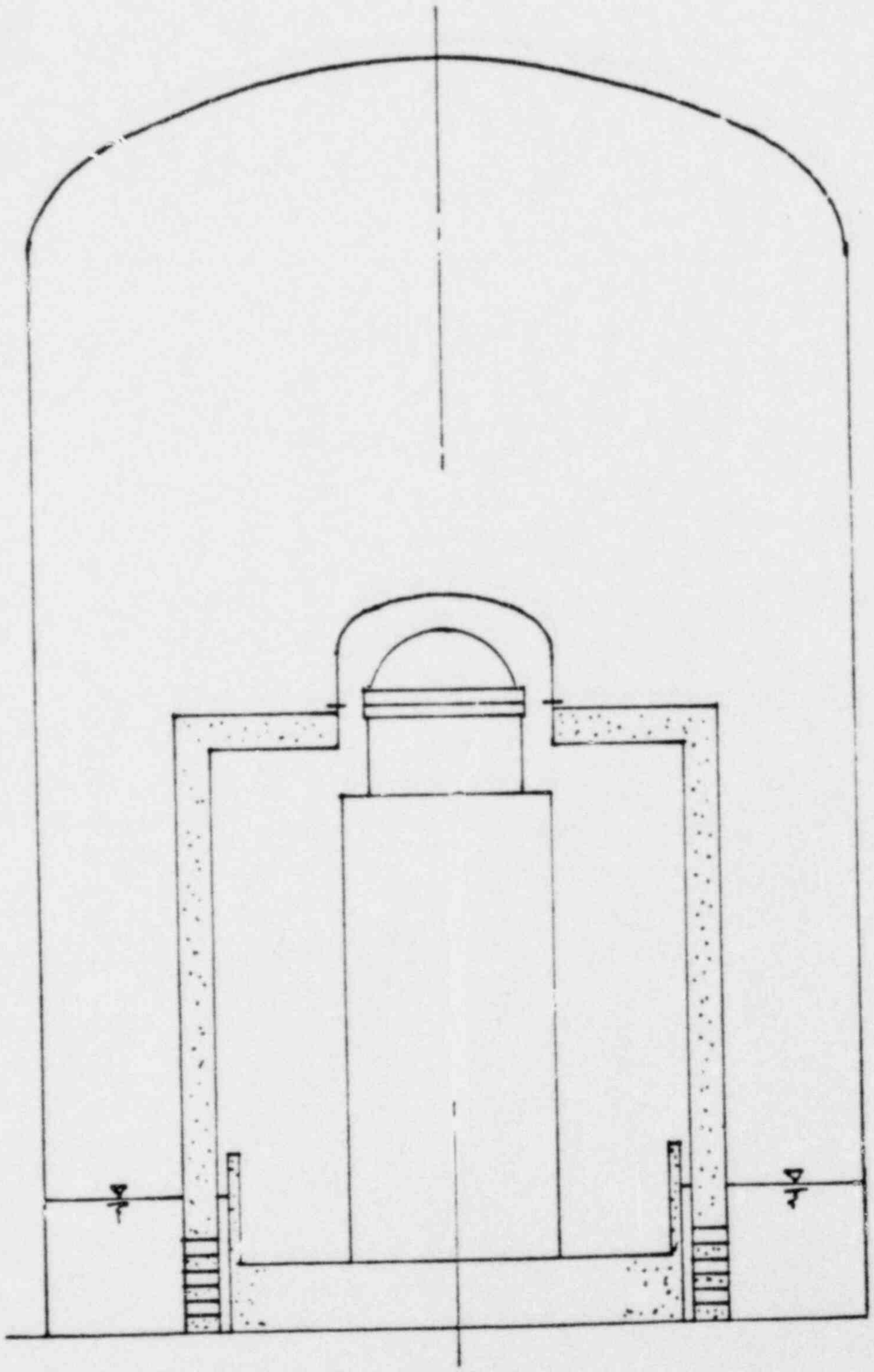
VENT ALONE PROVIDES DOMINANT PORTION OF RISK REDUCTION DUE TO PRESENCE OF SUPPRESSION POOL

DISADVANTAGES

VENT/FILTER-LARGE IMPACT ON PROJECT, UNCERTAINTY IN TECHNOLOGY AND LITTLE ADDED BENEFIT

VENTING-PUBLIC ACCEPTANCE

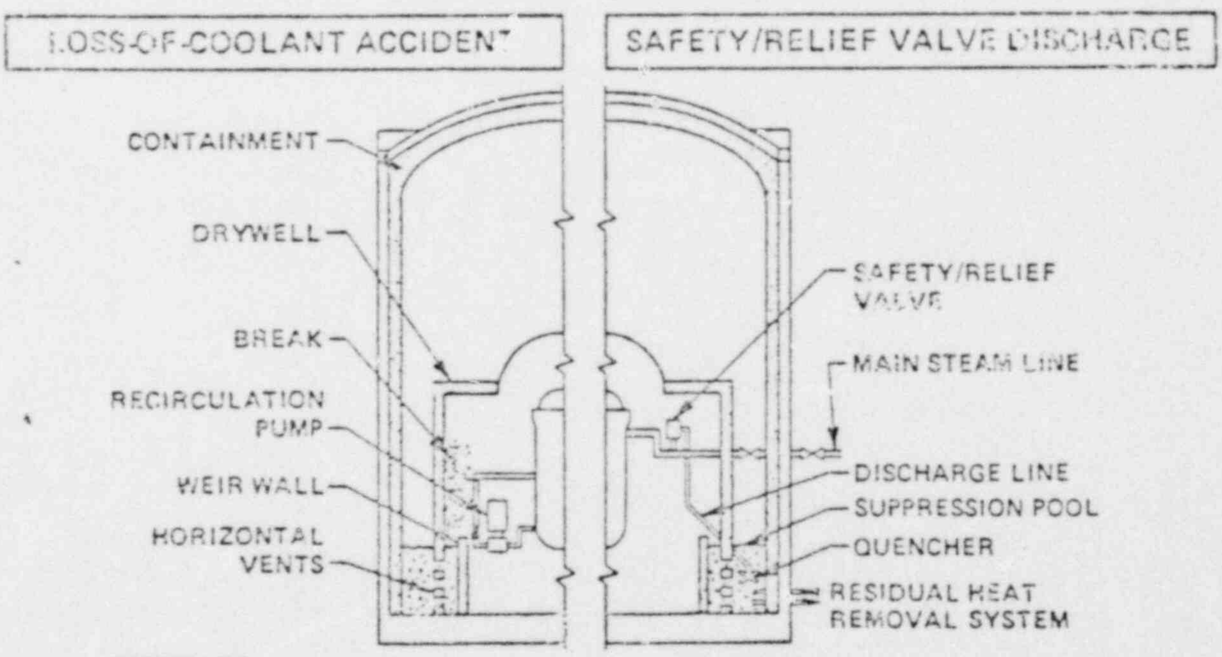
MARK III CONTAINMENT



KEY BWR SAFETY FEATURES

- o HYDROGEN CONTROL
  - COMBUSTION NOT EXPECTED IN DRYWELL
    - HYDROGEN PIPED TO POOL FOR TRANSIENTS
    - HYDROGEN ENTERS PURGED DRYWELL FOR LOCAs
  - FOR BURNING/DETONATION ABOVE POOL, DRYWELL EXPECTED TO REMAIN INTACT

- o FISSION PRODUCT CONTROL
  - WITH DRYWELL INTACT
  - ASSUME CORE DAMAGE RELEASES FISSION PRODUCTS
  - INSIDE VESSEL: DIRECTED TO SUPPRESSION POOL VIA RELIEF VALVES
  - OUTSIDE VESSEL: DIRECTED TO SUPPRESSION POOL VIA DRYWELL, HORIZONTAL VENTS
  - MOST IODINE, PARTICULATES REMAIN IN SUPPRESSION POOL



SUPPRESSION POOL SCRUBBING

- MILLION GALLON PRESSURE SUPPRESSION POOL
- EXPECTED DECONTAMINATION FACTORS (DF) FOR POOL SCRUBBING

SPECIES	DF_{POOL}
CsI	$10^3 - 10^5$
PARTICULATES	$10^3 - 10^5$

- PRESENT PRELIMINARY RISK ASSESSMENT CONSERVATIVELY ASSUMED $DF_{POOL} = 1000$, MINIMUM DF_{POOL} SUPPORTED BY LITERATURE
- RESULT

FOR H_2 DETONATION EVENT (ASSUME IT HAPPENS), AND CREDIT FOR ONLY POOL DF = 1000

- NO EARLY FATALITIES
- LATENT EFFECTS <1% OF EFFECTS FROM NORMAL BACKGROUND RADIATION

BWR/6 MARK III RISK ASSESSMENT

PRELIMINARY RESULTS

DESIGN/CONCEPT	CORE DAMAGE PROBABILITY*	TOTAL RISK**
A) WASH-1400 BWR	3×10^{-5}	2×10^{-3}
B) BWR/6 (AS IS)	9×10^{-6} (A/4)	7×10^{-5} (A/30)
C) BWR/6 (WITH POST TMI IMPROVEMENTS)	2×10^{-6} (A/20)	1×10^{-5} (A/200)
D) BWR/6 (WITH POST TMI IMPROVEMENTS)		
PLUS		
– STRONGER CONTAINMENT	2×10^{-6} (A/20)	1×10^{-5} (A/200)
OR – POST-EVENT INERTING	2×10^{-6} (A/20)	3×10^{-6} (A/300)
OR – H_2 IGNITERS	2×10^{-6} (A/20)	8×10^{-6} (A/300)

* FREQUENCY PER PLANT YEAR

** EXPECTED FATALITIES PER PLANT YEAR

BWR/6 MARK III PRELIMINARY RISK ASSESSMENT

CONCLUSIONS

- o SUBSTANTIAL CAPABILITY IN EXISTING DESIGN - ASSUMING HYDROGEN COMBUSTION
  - CONTAINMENT OVERPRESSURE DOES NOT FAIL DRYWELL
  - CONTAINMENT RUPTURE EXPECTED AT DOME LEVEL
  - SUPPRESSION POOL SCRUBBING RETAINED
  - ECCS FUNCTION RETAINED
- o CONTAINMENT FUNCTION RETAINED
- o BWR/6 RISK BELOW WASH-1400
- o MORE DETAILED WORK EXPECTED TO CONFIRM CONCLUSIONS
- o PRESENT WORK SHOWS NO BASIS FOR JUSTIFYING FURTHER DESIGN CHANGES TO REDUCE RISK

CONTAINMENT STRUCTURAL EVALUATION

GENERAL ELECTRIC STANDARD PLANT

CAPABILITY SUMMARY

- Nominal Design Pressure — 15 psig

- Capability Based on ASME Code
  Service Level A — 22 psig
  No other loads in combination

- Capability Based on Code Yield Criteria — 41 psig
  Based on ASME Service Level C

It is expected that locks, hatches, penetrations and other details are not limiting in any of the pressure statements above.

- Capability Based on Ultimate — ~ 60 psig
  Static Conditions
  Applicable to Fast Hydrogen Burning

- Capability Based on Dynamic Loading — ~ 150 psig
  (5 ms pulse)

Other Mark III Steel Containments will vary from these values.

CONTAINMENT STRUCTURAL EVALUATION

GENERAL ELECTRIC STANDARD PLANT

REFERENCE DESIGN FOR DRYWELL

- NOMINAL DESIGN PRESSURE - INTERNAL 30 PSIG
- NOMINAL DESIGN PRESSURE - EXTERNAL 21 PSIG
- DESIGN BASES - WALL:
  AMERICAN CONCRETE INSTITUTE CODES
  DRYWELL HEAD: ASME CODE
- STRUCTURE: REINFORCED CONCRETE AND
  STEEL FOR DRYWELL HEAD

DRYWELL CAPABILITY

INTERNAL PRESSURE

- YIELD STRESS LIMIT (DRYWELL HEAD) ~ 200 PSIG
- CONCRETE WALL ~ 190 PSIG

EXTERNAL PRESSURE

- YIELD STRESS LIMIT (DRYWELL HEAD) ~ 70 PSIG
- CONCRETE WALL > 200 PSIG

CONTAINMENT STRUCTURAL EVALUATION

DESIGN ADJUSTMENTS TO IMPROVE CAPABILITY OF FUTURE STEEL CONTAINMENT (APPLIES TO GE REFERENCE ONLY - WILL DIFFER FOR EACH PROJECT).

- CHANGE HEAD DESIGN TO HEMISPHERICAL
- INCREASE CYLINDRICAL WALL THICKNESS
- MODIFY DETAILS AS NECESSARY
- RESULTS WILL BE:

ASME CODE SERVICE LEVEL A	45 PSIG
ASME CODE SERVICE LEVEL C	79 PSIG

THESE CHANGES ARE PRACTICAL ONLY AT A NEW PLANT DESIGN INITIATION.

RISK ASSESSMENT SHOWS NO RISK REDUCTION FOR INCREASED CONTAINMENT PRESSURE CAPABILITY.

BWR/6 - MARK III

- HYDROGEN CONTROL OPTIONS -

INTRODUCTION

- BACKGROUND
- INITIAL SCREENING
- CONCEPTS EVALUATED
  - IGNITORS
  - POST EVENT INERTING

DISCUSSION OF CANDIDATE CONCEPTS

- DESIGN BASIS
- CONCEPT DESCRIPTION
- DESIGN CONSIDERATIONS
- OPEN ISSUES

CONTROLLED HYDROGEN COMBUSTION

- DISTRIBUTED IGNITION -
- CONCEPT DESCRIPTION -

- O MULTIPLE DIESEL ENGINE GLOW PLUGS LOCATED THROUGHOUT CONTAINMENT AND DRYWELL IGNITE HYDROGEN AT SUFFICIENTLY LOW CONCENTRATIONS TO PREVENT CONTAINMENT OVERPRESSURE AND FAILURE
- O SYSTEM AUTOMATICALLY INITIATED ON REACTOR LEVEL 1 SIGNAL OR MANUALLY BY OPERATOR
- O MEANS IN CONTAINMENT AND DRYWELL TO ASSURE SUFFICIENTLY UNIFORM MIXING
- O MEANS FOR BOTH LOCAL AND GLOBAL HEAT REMOVAL FROM THE CONTAINMENT ATMOSPHERE
- O VITAL EQUIPMENT IN CONTAINMENT IS PROTECTED/OR WITHSTANDS PRESSURE/TEMPERATURE CONDITIONS

AWAITING RESULTS OF NATIONAL LABS PROGRAM

POST-EVENT INERTING

- CONCEPT DESCRIPTION -

- LIQUID CO_2 IS STORED OUTSIDE CONTAINMENT
- LIQUID CO_2 RAPIDLY INJECTED INTO CONTAINMENT
  - AFTER EVENT SEQUENCE STARTED
  - BEFORE HYDROGEN FORMED & TRANSPORTED TO CONTAINMENT
- CO_2 PREVENTS HYDROGEN COMBUSTION & REDUCES CONTAINMENT FAILURE PROBABILITY
- NORMAL CONTAINMENT HEAT REMOVAL IS NEEDED TO PRECLUDE VENTING