ORGINAL ackst-1448

UNITED STATES OF AMERICA NUCLEAR REGULATORY COMMISSION

In the matter of:

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Combined Meeting of Subcommittees on Structural Engineering, Seismic Design of Piping, and Metal Components

Docket No.



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1	UNITED STATES OF AMERICA
2	NUCLEAR REGULATORY COMMISSION
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4	ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
5	COMBINED MEETING OF SUBCOMMITTEES ON STRUCTURAL ENGINEERING,
6	SEISMIC DESIGN OF PIPING, AND METAL COMPONENTS
7	
8	PUBLIC MEETING
9	Room 1046
10	1717 H Street, N.W.
11	Washington, D.C.
12	
13	Tuesday, September 24, 1985
14	The Subcommittees met, pursuant to notice, at
15	8:30 a.m.
16	ACRS MEMBERS PRESENT
17	C. Siess, Chairman
18	P. Shewmon, Chairman
19	J. Ebersole, Member
20	J.C. Mark, Member
21	E. Rodabaugh, Consultant
22	M. Bender, Consultant
23	FEDERAL DESIGNATED EMPLOYEE
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1 SPEAKERS:

2	J.	Richardson	
3	J .	Costello	
4	Н.	Ashar	
5	J .	Burns	
6	R.	Cloud	
7	G.	Kurtz	
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PROCEEDINGS

2 MR. SIESS: This is the second day of the Combined 3 Meeting of the ACRS Subcommittees on Structural Engineering, 4 Seismic Design of Piping and Metal Components.

The two major items on the agenda for today, one is 5 6 the containment integrity program, and the other is really not a research area, is it, Paul? It is an application of the 7 results of research on a leak before break situation. That 8 portion of the meeting may start before noon, and we can do 9 that with the people here because it is a continuing meeting, 10 and that will be chaired by Paul Shewmon as Chairman of the 11 12 Metal Components Subcommittee.

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Who is going to start?

MR. RICHARDSON. I am just going to say a few words, Chet. I would like to have you refer back to the front of the package that we handed out yesterday, and this morning we are going to talk about our Containment Integrity Research Program.

19 The third sheet in is the budget sheet for this 20 program, and if you will notice, in 1985 our budget, including 21 containment buckling, which is not a real integral part of 22 this program but it is in the containment area, is about \$3.9 23 million. In 1986 we are going to \$3.7 million and staying 24 level in 1987 for \$3.7 million.

The program has three major elements: experiments on

1 containment models, containment integrity, which is really the analytical portion of the program, and the third element is 2 integrity of containment penetrations. 3 MR. SIESS: As I said, I don't want to get too 4 involved in budget figures, but how firm is your 1986? 5 MR. RICHARDSON: I have no idea. The budget is as 6 firm as Congress will make it firm. 7 8 MR. SIESS: Let's see. 1986 is at what stage in 9 Congress. Have you got an appropriation? MR. RICHARDSON: No. We have a Senate mark and a 10 House mark, and they are vastly different. 11 MR. SIESS: Okay. The House mark was a whopping 12 13 cut. MR. RICHARDSON: A big cut. And the Senate version 14 was the OMB mark plus \$8 million to cover the demanded salary 15 cut that never came about. 16 MR. SIESS: Okay. 17 MR. RICHARDSON: So the Senate is full budget and 18 the high version is --19 MR. SIESS: Well, where do you stand internally? 20 MR. RICHARDSON: Internally, with the House budget, 21 if the House budget were to prevail, the contingency plans, 22 then, would be to substantially cut severe accident research. 23 That would be one of the plan areas for cut. If that were to 24 come about, then, our Containment Research Program would be 25

also severely cut, probably at least in half.

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2 MR. SIESS: All right. Now, if this is cut in half, 3 what are you going to do, just postpone that concrete 4 containment?

MR. RICHARDSON: We will probably postpone the 5 concrete containment. It will probably bring it to a halt. 6 We put a hiatus on it this summer when we heard the House 7 budget number. We put a hiatus on the construction. However, 8 about the 1st of August we released that and allowed the 9 10 contractor to proceed because it was becoming -- we were at a cost impact point, whereas if we did not proceed, it would 11 start costing us a great deal of money. 12

13 The judgment of Bob Minogue and others was that the 14 program would probably survive. It was not a made gamble to go 15 ahead.

MR. SIESS: Personally, I would agree with that priority in terms of the research needs, not in terms of the dollars because I can understand that it may cost you more to defer something than it does to do it. But of all the things we have heard about, I think that one is least likely to affect regulation in the forseeable future.

22 That is just a personal opinion, for what it's 23 worth

24 MR. MARK: What does this mean? We -- the
 25 committee, that is, have been making noises for a little while

about the need of a containment performance term in the safety 1 goals. Is that directly connected with what we are just 2 talking of here? 3 MR. SIESS: Can I put an intermediate question 4 in? Do you know what we mean by --5 6 MR. MARK: You can rephrase my question, if you want? 7 MR. SIESS: No, I just want to ask them if they know 8 9 what we mean by containment performance criteria. MR. RICHARDSON: No. 10 MR. BENDER: Is a consultant allowed to express an 11 12 opinion? MR. SIESS: Well, I don't know what we mean by it 13 either, and I'm hoping somebody can explain it to me. 14 MR. RICHARDSON: I turn to my colleagues if they 15 have any --16 MR. COSTELLO: Jim Costello from the NRC 17 Staff. Since I have been just made a member of a task force to 18 come up with a plan for possibly implementing or examining the 19 options for implementing a containment performance part in the 20 safety goal, the best I could offer is the guidance that we 21 have in the internal staff exercise, which is to examine 22 options which would add or permit the addition of some 23 implementable requirement to the safety goal prescription 24 which would reflect a defense in depth concept. 25

MR. SIESS: Okay. Well, there have been figures in one of our letters that said -- maybe it's a letter that never got sent out, I'm not sure -- that there should be at least a one in ten probability that the containment will function as assumed, on top of the 10 to the minus 5 core melt probability, you see.

Now, that I understand, but the function of the 7 containment varies tremendously, depending on what containment A you are talking about and what accident sequence you are 9 talking about. It might be a basemat melt-through, it might 10 be a steam explosion, and now we are still talking about a 11 12 conditional probability of one in ten on the containment performance, which is quite a different thing. If you are 13 talking about a steam explosion, then you are talking about 14 flow overpressure; right? 15

16 MR. RICHARDSON: Oh, yeah.

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MR. SIESS: Now, I think we know that if you have 17 flow overpressure from basemat melt-through or sitting there 18 and boiling off water, the containment will fail unless it 19 leaks enough or you open a hole in it. Okay? If you are 20 going to open a hole, deliberately vent, there is some 21 advantage in knowing at what point it would fail, although how 22 precisely you need to know that, I don't have the slightest 23 24 idea.

You know, when are you going to vent? You don't

want to vent too early because everybody is going to be 1 uncomfortable. This is, presumably, one reason we are doing 2 ultimate load capacity tests on containments. Now, you look 3 at the steel containment and what do you say you learn? You 4 want a fairly good, sure point that it won't burst before you 5 start venting. I think we know how to do it for steel ones. 6 Yield. General yield, if you want. First yield isn't 7 positive, but if it is going to leak, none of this has any 8 application. 9

So even if I look at that, I would put this as a bottom priority because -- you have heard me say it -- that test is going to ask questions, not answer them, and I think we have got enough questions now that we don't need to spend \$2 million to ask more if we haven't got the \$2 million. That's why I just said I would agree with your priorities.

MR. BENDER: Well, I think you said most of it, but 17 it seems to me that for the existing containments, which is 18 really the severe accident policy that you are talking about 19 here, a few kinds of containments that are more vulnerable 20 than others, and I think Chet made the point properly that it 21 is largely the steel containments that are the issues in the 22 safety goal policy if you are going to implement it. And 23 knowing the modes of failure concerning those, the ones that 24 have most influence on what the overall consequences might be 25

Everything I have seen shows that the concrete containments, reinforced or prestressed either one, have so much extra reserve strength in them that you don't have to worry about them getting up too high.

4 MR. EBERSOLE: May I ask a question? I see a piece of money in here for buckling, which recalls an old issue of 6 about 19 years ago. We found that in steel containments, 7 fairly thin, that buckling, it's autocatalytic, it's 8 unstable. You know, if it buckles, it bursts real quick. The 9 issue came up, should you test the hypothetical buckling 10 11 pressure with some margin over that since structural catastrophe would result if you really buckle? 12

We had cold water we were spraying containments with, and you really cooled it down. As a matter of fact, some of our plants had to have the water warmed to keep the containment from buckling. So the question I would ask you here 19 years later is do you think you should require a proof test of buckling strength?

We did it much against the objection of the
hieararchy.
MR. SIESS: You can't do it on the containment,

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 Jesse.

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 MR. EBERSOLE: Yes, we did. We pulled a vacuum on

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 it.

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MR. SIESS: You mean build one and test it --

MR. EBERSOLE: No, no, no. I'm talking about in 1 situ. 2 MR. SIESS: Well, you can test a containment up to 3 115 percent of LOCA load, but there is no way of testing a 4 containment up to severe accident load. 5 MR. EBERSOLE: I'm talking about negative pressure. 6 MR. SIESS: Oh, negative pressure. Oh. 7 8 MR. EBERSOLE: Buckling. You see, that thin ice condenser containment is like a paper bag. 9 MR. SIESS: Oh, yeah. No, they are not looking at 10 negative pressure at all. 11 MR. KICHARDSON: Buckling is from overpressure in 12 13 the knuckle region. MR. EBERSOLE: Well, what about the negative 14 pressure aspect? You can certainly wreck a plant if you spray 15 too cold water in it. 16 MR. SIESS: I assume somebody is looking at it 17 because in the severe accident, if your sprays come on at the 18 wrong time, you could develop a negative pressure. 19 MR. RICHARDSON: Yes. We are not working at it, but 20 Jack, why don't you --21 MR. BURNS: Jack Burns from the Staff. I think you 22 might say about the only area we are looking at the negative 23 pressure in steel containments was the reinforcements around 24 the cutouts to see what kind of knockdown factors and so on 25

1 - would be required to at least bring the cutouts up to the normal pressure strength of the cylinder itself. 2 MR. SIESS: But it seems to me I have heard recently 3 in the severe accident the same kind of thing you got in the 4 BWR. When you turn the sprays on, you can condense a lot of 5 steam in there and pull a negative pressure. And I thought I 5 heard some talk about vacuum breaker valves or something. 7 MR. EBERSOLE: That includes whether they perform or 8 not. Sure. 9 MR. BURNS: No, we had not looked at that in our 10 program. We had nothing giving that literally as a need from 11 12 our user office. 13 MR. SIESS: Well, can you follow that up and see if the Containment Performance Working Group -- who was on that? 14 You, Jim? 15 MR. COSTELLO: I am not really on the working group, 16 but I was on one of the advisory committees. 17 MR. SIESS: Well, what they are looking here is with 18 19 the nonhemispherical heads. MR. EBERSOLE: I understand that. I just jumped to 20 that. 21 MR. SIESS: Remember we went through it on GESSAR. 22 23 MR. EBERSOLE: Yes, I understand, but this other thing has -- you know, if you get a sticky vacuum release, it 24 25 can get messy.

MR. SIESS: Well, somewhere you have looked to 1 buckling due to earthquake loads, haven't you? 2 MR. BURNS: Yes, that is part of the program now. 3 At the moment, or coming on the heading buckling problem, that 4 was not an underpressure. That was really an overpressure 5 condition we were looking at for the shallow heads. If you 6 pressurize, you can develop a shear knuckle buckling. 7 MR. SIESS: Yes, that was a toroidal. 8 MR. EBERSOLE: Of course, this was the first time we 9 ever saw a vessel that had substantial catastrophic potential 10 if it buckled in the inward direction and busted the pipes and 11 12 things. MR. SIESS: Well, previously the only --13 containments have been looked at for something like 2 or 3 psi 14 negative. From what -- I can't remember. What is the source 15 of that? 16 MR. BURNS: Spring of cold water. Probably a spray 17 condition. 18 MR. SIESS: In the LOCA condition? 19 MR. EBERSOLE: Anything that steams it up, and 20 21 especially the --MR. SIESS: I'm talking about what they have done in 22 the design, not what we are looking at now for severe 23 accident. 24 MR RICHARDSON Are there any steel containments 25

that maintain a subatmospheric --

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MR. SIESS: No, no. No, that's all the concrete. 2 3 MR. EBERSOLE: There is another thing. If you have lost the component atmosphere which is in there and you have, 4 say, 100 percent steam --5 MR. SIESS: Oh, yes, I know the circumstances. I'm 6 trying to talk about what has been the design basis because I 7 have been -- Hans, what is the design basis now for 8 containment for negative pressure? 9 MR. ASHAR: Generally for the vacuum due to the 10 11 tornado loading, some steel containment had been designed for 3 psi or so. 12 13 MR. SIESS: Tornado loading produces a negative pressure outside. 14 MR. ASHAR: Outside, yes, correct. Tornado pressure 15 outside of 3 or 4 psi and then there are vacuum breakers. 16 17 MR. SIESS: But what would -- something that will 18 produce an external pressure. MR. ASHAR: But they are only in the range of 3 psi 19 or 4 psi, not more than that. 20 MR. SIESS: If a containment is designed for 50 or 21 60 psi gauge inside, you mean they have just added 2 or 3 psi 22 23 to that from the vacuum? MR. ASHAR: Oh, no. I'm talking about negative 24 25 pressure.

1 MR. SIESS: How do you get a negative pressure inside from a tornado? A tornado produces a pressure drop 2 outside, and if you are atmospheric inside, that is a positive 3 pressure inside gauge. 4 MR ASHAR: Chet, there is the pressure from outside 5 and the pressure from inside. On the other side there is --6 MR. SIESS: I still don't understand. 7 MR. EBERSOLE: I don't understand how you can get a 8 positive pressure from a tornado unless you vent it. 9 MR. BENDER: You can get some negative pressure on 10 the downstream side of the wind. 11 MR. BURNS: That is just an unbalanced pressure 12 around the cylinder. 13 MR. SIESS: But there is a design basis. I know it 14 becauase I have seen it in FSARs for 2 or 3 psi negative, but 15 16 that's rot --MR. EBERSOLE: Let me set the stage for the real 17 hairy thing. You have depressurization from someplace. You 18 have the purge valves open. You blow out a substantial 19 fraction of the atmosphere. I am making it bad. Then they 20 succeed in closing, and then you hit it with real cold water, 21 and then, if you want to compound it, the vacuum breakers 22 don't all work. 23 You have available 15 psi. Hot containment. How 24 much will you get and when will you collapse, and what is the

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margin?

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2 MR. SIESS: This has to be looked at in the severe 3 accident thing.

4 MR. BURNS: Keep in mind, though, that a buckle 5 itself may not be a failure of the containment. It has to be 6 large enough to impact on something inside or to crack the 7 containment in one form or another through a buckle or through 8 distortions of the penetrations.

MR. EBERSOLE: Right, but if it starts to buckle, as
I understand it, it's unstable and it will rapidly get worse.
MR. SIESS: It depends on whether the load is -MR. EBERSOLE: Yes. It may just implode.
MR. MARK: Chet, when we were at Sandia, they were
doing some very small-scale looks at buckling features of this
dome.

MR. SIESS: They were looking at two things. One is 16 17 they were looking at the code reinforcement formulas to see if 18 that adequately took care of buckling due to overturning 19 vertical compressions in the shell due to seismic loads 20 overturning, and then they were looking at buckling in the 21 knuckle region of those torispherical heads. I believe with the hemispherical heads, you don't run into the problem. 22 23 MR. BURNS: That was our conclusion from the test,

MR. SIESS: Those were the two things they were

looking at, and one was due to overturning from 1 earthquake-type loadings, and the other was due to internal 2 3 pressure. If you remember, GESSAR went through this 4 complicated analysis because they have got the torispherical head and -- but the internal vacuum pressure -- I think we 5 6 ought to have Al look at it with the NRR people and try to find out what the situation is, and you can follow it up and 7 8 see if there is a problem there and whether somebody is 9 thinking about it.

10 MR. EBERSOLE: Chet, I want to ask you this. I 11 never have personally been able to rationalize where there 12 isn't a very conservative relief value on containments.

13 MR. SIESS: Well, there are a number of us looking 14 at -- we see figures now saying that if you have a 10 square 15 inch opening, you can never overpressure the containment 16 unless you have something like a steam spike.

MR. EBERSOLE: You can back it up with a valve that
 closes by motor.

MR. SIESS: The question of deliberately venting, which the BWRs are proposing, hasn't been seriously considered -- well, it has for the PWRs. I know EPRI looked at it in their studies. But what people have come up with is that the slow overpressure that you could relieve with a modestly small valve takes a week to burst the containment, and by then the fission products are bound to a low level. You could have

evacuated people. And the consequences become negligible. 1 MR. RICHARDSON: Unless you get a catastrophic 2 failure of containment where you might reintroduce aerosols 3 that have plated out. 4 MR. SIESS: The first thing, it isn't a nice idea, 5 let's face it, but neither is a deliberate release. 6 Now, the near-term operating license requirement is 7 that they provide an opening in the containment, equivalent 8 3-foot diameter hole for possible vented filtered 9 containment. Three foot diameter. 10 MR. EBERSOLE: With no intention of really using the 11 hole. 12 MR. SIESS: Well, the idea someday that they might 13 run a pipe through there to 20,000 tons of gravel; not to a 14 lake, to gravel and all of this stuff. The vented filtered 15 containment has been looked at. Even what they call a simple 16 cheap filter. But now the boilers are proposing to vent into 17 cooler water and take a terrific benefit from scrubbing, and 18 if you don't want to overpressure this thing, it looks now 19 from the scenarios that have developed that a 3 or 4-inch hole 20 will take it out. 21 Now, somebody has looked at this for me and said 22 that some of the containments with the double containment in 23 the annulus and a filter system on the annulus can take a fair 24

discharge right there. If you could discharge it under water

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1 into your cooling tower basin, in your ultimate heat sink
2 and take some credit for scrubbing --

3 MR. EBERSOLE: You can scrub the annulus if you want 4 to.

5 MR. SIESS: What about the spent fuel pool? 6 MR. EBERSOLE: There are all sorts of ways of doing 7 this.

8 MR. SIESS: But on Indian Point -- and I talked to 9 Herschel about it -- they say, you know, that is so far down 10 the line you are preventing something where the consequences 11 are negligible, and if you have had the core melt, you have 12 already done the public relations damage. You haven't hurt 13 anybody yet, you know.

MR. BENDER: Well, just so it doesn't get too distorted, a lot depends on when the venting occurs. The Indian Point concept is based on the integrity of the containment being fully assured up to some pressure point, but it doesn't allow for the potential of a leak early in the event.

MR. SIESS: Oh. yes. They have made analyses. Studies have been made as to what the doses are if you have a leak early. Specter sent me a copy of a paper --I don't know whether anybody else has gotten it. Los Alamos, I think, made a parametric study of early leakage and mentioned the Containment Performance Group.

1 It's not simple, obviously, but if you do have the 2 leakage early, you won't overpressure but you will release 3 early, and now you have got the trade-offs. If the late 4 release due to rupture of the containment doesn't hurt anybody 5 because everything is settled out and it doesn't resuspend, 6 then early venting or early inadvertent venting or leakage may 7 not be good.

8 MR. BENDER: They may have been able to make that 9 case. The analysis may be correct, but they had a very 10 prescriptive way of defining the accident. You have to accept 11 their prescription.

MR. SIESS: You are talking about Indian Point?
 MR. BENDER: Yes, I'm talking about Indian Point.
 The other areas that have to be thought about, this
 big, 3-foot diameter opening that was put in way back when, I
 think there is no defensible filter system that goes with that
 particular scheme.

MR. SIESS: Well, somebody had one in mind.
 MR. BENDER: They just don't have enough information
 about it. But the smaller systems where you vent with a
 10-inch pipe or thereabouts, they can be bubbled through water
 or anything and they will do most of the decontamination that
 is needed.

24 MR. SIESS: Yes, but the BWRs just haven't looked at 25 that seriously. As I said, EPRI looked at it and their

cost-effectiveness is poor. Because the dose reduction was 1 negligible, there wasn't any dose there to speak of, so they 2 couldn't afford to spend more than \$50,000 to prevent rupture 3 of the containment seven days down the line. That was the 4 kind of calculation that was -- I said EPRI. IDCOR. Excuse 5 6 me. And if you have an early steam spike or a hydrogen 7 8 detonation, that is not going to help you anyway. Jim? 9 MR. COSTELLO: As far as I know in the matter of 10 practice overseas, the Swedes are, I am virtually certain, 11 going to do something with a PWR that is similar to their BWR 12 venting scheme. I don't know what that is yet. 13 MR. SIESS: Oh, but it involves a huge gravel 14 15 filter. MR. COSTELLO: That is the BWR. Are they going to 16 use the same system on the PWR? 17 18 MR. SIESS: Yes. But the Swedes came to that solution before they had the benefit of the severe accident 19 sequence analyses. You know, I think their decision to go to 20 vented filters was almost a political one without the 21 engineering basis that we might now have for it, but the RDA 22 studies on vented filters, you have seen those, and they come 23 up with one that is fairly cheap looking. It's a separate 24 building sitting over here that is hardly passive. It has got 25

fans. One of them even uses ice condensers. They just go on 1 2 condenser steam. I thought that was interesting. But I just can't see why the PWR doesn't fall 3 somewhere in the same ballpark as the BWR. The BWR is not 4 5 going to vent through a 3-foot hole. Now, the other point, though, is, whether or not you 6 deliberately vent, there may be enough leakage; but again, so 7 8 far, looking at what we have looked at, you are not going to get an awful lot of leakage until you get up fairly high in 9 pressure compared to the design pressure; right? That's what 10 everything seems to be telling us so far. 11 And if it takes three days to get up to where you 12 have significant leakage and you start looking at dose 13 calculations, you don't see too much benefit. If you look at 14 defense in depth, you see something else, I think. 15 MR. COSTELLO: I could also offer from my 16 understanding of what I have heard about the French thinking. 17 For one thing, they feel -- double containment is unlined, so 18 19 they feel they can handle leakage through the inner containment into the anular region and clean it up. Or so 20 21 they say. 22 MR. SIESS: Well, how much can they handle? MR. COSTELLO: I have never seen a clear number on 23 that, but they say enough. 24 As far as the PWR, their 900 megawatt PWR with the 25

similar containment and the liner, I have heard talk over
 there about venting schemes, gravel pit, that kind of stuff,
 although I have never seen any indications they are
 implementing that.

5 MR. SHEWMON: The last time the group was over here 6 a year or two ago, they said they had decided to go to a 7 vented, filtered containment. That was a decision. The 8 building people didn't like it.

0 MR. SIESS: One problem I have is I can't tie numbers together. Some people are talking about leakage and 10 the terms we use for leak testing, percent of the volume per 11 12 day. Then I see filtered systems described as so many cubic feet per minute capacity, and then somebody else tells me from 13 the severe accident study that a whole 10 square inches -- and 14 I can't relate 10 square inches to cubic feet per minute to 15 16 percent per day and get any feeling as to whether what goes out of a hole 10 square inches can be handled by the annulus 17 18 filter system or not. You see?

19 Hans, did you do some looking up on this for me?
20 Was it you?

21 MR. ASHAR: This is Hans Ashar, NRC Staff. Some 22 work has been done, and the way we are going, for testing 23 purposes, is by cubic centimeter or centimeter or length, 24 parameter of penetration, four second, that kind of a 25 parameter, because we are going to integrate a lot of leakages

1 from a lot of penetrations, but as far as the 10-inch diameter 2 or 6-inch diameter, in my own opinion I think it all depends 3 upon the flow rate between the outside and the inside, and 4 depending upon what kind of flow you assume.

5 That's the reason it's not very definite that this 6 diameter hole is going to depressurize containment to the 7 extent that it won't pressurize and rupture the 8 containment. This is an uncertainty that is always there.

MR. SIESS: Yes, but then the containment 0 performance working group has got curves in their report 10 11 showing various size openings, and it depends on a number of 12 things, I will admit; but the simple question -- take a specific plant with an annulus, a 6-foot annulus with a filter 13 system in it, and tell me -- take the filter capacity and feed 14 it back into one of the accident sequences and tell me what it 15 does. 16

This is a filtered vented release through an 17 existing sytem, which I think is Category I if necessary. 18 MR. EBERSOLE: Chet, may I ask a question? 19 MR SIESS: And you can't get the answers to that. 20 MR. EBERSOLE: I would like to know, and I think 21 some pressure should be put on the industry to determine what 22 23 the real leakage rate is under design conditions. My impression is the leakage tests are done like the old 24 general's visit to the Army post. You knew he was coming ten 25

1 days in advance and you fixed it.

MR. RICHARDSON: Well, with the modification that we 2 are in the process of rulemaking right now to modify Appendix 3 J, the integrated leak rate test procedure, and in fact, we 4 are trying to plug that loophole. The Staff has never 5 considered that the applicant had or the utility had the 6 privilege of fixing up before the test. However, some 7 utilities disagree with us. We are going to make that very 8 clear in the revision to Appendix J, that they can't do that. 9 MR. SIESS: But you have been getting some reaction 10 11 from CRGR on that. 12 MR. RICHARDSON: Oh, yes. MR. SIESS: This is under review. 13 MR. RICHARDSON: I might say the CRGR is now -- we 14 have now gotten resolution of CRGR and it is ready to go now. 15 MR. EBERSOLE: Great. What does this mean, that 16 there will be a SWAT team show up at your front door some day 17 and it won't impact on their running condition? 18 MR. RICHARDSON: No. It just says that any time you 19 make repairs to values, you have to count that in the tally of 20 21 leak rates. MR. EBERSOLE: Oh, well that's not what I mean. I'm 22 talking about a black hat team shows up at 2 a.m. in the 23 morning and says: We are going to do a leak test. 24 MR. SIESS: You can't do it, Jesse. 25

MR. RICHARDSON: No, because that involves shutdown. 1 MR EBERSOLE: No, I am talking about a careful 2 program that would not impact on generation. 3 MR. BENDER: What do you want to know, whether it 4 leaks at .1 percent --5 6 MR. EBERSOLE: I want to know whether it leaks 7 before they fix it. I just want to find out what it leaks, Mike. 8 9 MR. SIESS: Well, their procedure would not tell you at any point in time what the leak was because a valve could 10 be open for 12 hours before somebody --11 MR. EBERSOLE: Well, I'm talking about the automatic 12 closure of the system by punching a button. That's the way it 13 14 works. 15 MR. SIESS: I don't know if it can be done the way you say without --16 MR. EBERSOLE: Well, how does it work at all? 17 MR. SIESS: Well, give me a couple hours sometime or 18 the next time we look at Appendix J. But there are other ways 19 the Staff is looking at it. You are going to hear a lot from 20 21 Jim Costello about what they are doing on seals and penetrations and so forth, but what they are not doing in the 22 23 research program is looking at what they refer to as pre-existing leakage. They have said that can be handled 24 administratively. Well, obviously you can't do anything in 25

terms of research on it, and there are a couple of
approaches. One of them, Conn Yankee, for example, operates,
or at least one of the plants operates under 2 or 3 psi.

4 Now, with their recording that they have, it takes 5 them about a week to detect one-tenth of one percent leakage 6 and two-tenths of one percent leakage, whatever their tech 7 spec leakage is. But we are not worried about one or 8 two-tenths percent a day leakage. When you get up to one 9 percent a day or something like that, I'm sure they could 10 detect it a lot earlier.

The subatmospheric plants, which have to pull about 11 6 psi vacuum -- that's about what it is -- they operate at 9 12 or 10, don't they? Well, somewhere in that range. They pull 13 a few psi vacuum. Now, that is leakage in the other 14 direction, but it would catch the open value. There they are 15 giving them oredit for pretty good control because the leakage 16 can't be greater than the capacity of their pumps that are 17 keeping the air pressure down. So there are ways of looking 18 19 at that.

There is another approach, called a blunder test, which is every time you have had an outage and you close things back up, you run a test to be sure that somebody didn't leave something open. But that is the pre-existing leakage, and you won't hear anything from Research on that because it's not a physical research-type problem, and I believe that

administrative controls are being handled in NRR somewhere. 1 Don't you have Pacific Northwest or somebody looking 2 at --3 MR. COSTELLO: No, that's an NRR program. 4 MR. SIESS: Oh, they've got a technical assistance 5 program. 6 MR. COSTELLO: But I guess I could say also on the 7 question of the inerted BWRs, there is also a monitoring 8 there, because nitrogen costs money, and the utilities find 9 10 leakage. MR. SIESS: And inerted BWRs have also got a 11 control, but you are going to hear from Jim about leakage 12 studies, and there are two aspects about leakage. 13 One is, if it leaks enough, it won't overpressure, 14 which is good if you don't want the containment to fail. And 15 what it does to doses is something else, and if it leaks 16 17 early, you get doses. Now our whole thinking about leakage has been LOCA, 18 and we don't want leakage more than 1/10th of 1 percent, 19 because combining that with the source term and the 20 meteorology exceeds 25 rem. You know, that rigamarole we have 21 gone through. 22 So the research is trying to get some numbers, but 23 the thinking about what to do about it is supposed to be 24 coming out of the severe accident program. And I haven't seen 25

that much thought being given to it, frankly.

1

2 MR. FICHARDSON: I have just a couple of words for 3 those that may not be intimately familiar with our containment 4 integrity program.

5 The overall objective, of course, is to study, 6 evaluate and assess the structural and leak behavior of 7 containments up to and including severe accidents, and we are 8 doing this experimentally to validate, improve analytical 9 models and predictions, so that we can then take this 10 methodology into all the various containments that exist.

11 The program consists of three basic elements. That 12 is, the large model testing of steel and concrete 13 containments, and the only concrete that we are testing is a 14 reinforced concrete. We have made a conscious decision not to 15 test prestressed concrete.

MR. SIESS: On the basis that it no longer exists?
The British are going to test one.

18 MR. RICHARDSON: And it still looks like the British 19 are going to test one. That's the word we are getting from 20 NII.

The CEBG doesn't want to do it, but it looks like NII is going to force them to do it. And, of course, our penetrations program, which is a separate effects program, looking at the seal and gasket materials and testing a few penetrations by themselves, using the data from the large

model tests as boundary conditions, and then an analytical 1 effort that puts it all together and develops an analytical 2 process that can be used to assess containments. 3 That, coupled with some supporting programs in the 4 research areas that are feeding into this program, such as the 5 electrical penetrations, are being evaluated under the 6 electrical equipment qualification program and the containment 7 isolation values being evaluated in the mechanical equipment 8 qualification program. 9 MR. EBERSOLE: How come these programs are mixed up 10 like this? How come the programs are mixed up like this? Who 11 really runs the show? We do. 12 Well, let me call out then, as late as on GESSAR II, 13 I saw a line that says electrical penetrations not carrying 1E 14 loads won't need 1E overcurrent protection. That's a flat 15 wrong statement, because these penetrations carry fault loads 16 under accident conditions. If you don't clear them, more 17 often than not, they are the fuses in the circuit and they'll 18 19 blow up.

20 MR. RICHARDSON: Well, maybe I answered too quickly 21 who has control. The control of the research program of 22 containment integrity rests with this branch, and we guide the 23 research in the electrical penetrations area, in that we 24 specify what we want.

25

MR. SIESS. But does the research on electrical

penetrations look at electrical overloads as a way of 1 disintegrating --2 MR. RICHARDSON: No. It is looking at pressure, 3 pressure, temperature, radiation. 4 MR. EBERSOLE: Well, you know the conductors that go 5 through those, that's the pinch point. 6 MR. COSTELLO: They are measuring fault currents and 7 things like that in these. 8 MR. EBERSOLE: And what clears them? 9 MR. COSTELLO: That I couldn't tell you. 10 11 MR. EBERSOLE: That's what keeps them from being 12 sustained and melting. MR. RICHARDSON: Perhaps Hans can --13 MR. ASHAR: The last electrical penetration they 14 tested, what they saw was under pressure and temperature, 15 after aging for so many days -- I don't remember how many days 16 -- the radiation and temperature, they subjected to 17 temperature and pressure, simulating an accident, and what 18 they observed was there was no leakage from inboard or from 19 20 outboard. MR. EBERSOLE: That's not the point. 21 22 MR. ASHAR: But let me say -- go further. But there was a -- to the conductors, and the conclusion -- not 23 conclusion, some kind of a decision was that some of the 24 instrumentation depending upon penetration would not be 25

functioning, because of the heavy damage to the insulation. 1 But --2 MR. SIESS: I'm sorry, but the point Jesse is making 3 is that electrical overload could damage that penetration and 4 reduce its ability to resist pressure or temperature in the 5 subsequent stages of the accident. 6 MR. EBERSOLE: No. It could just fully blow it out. 7 MR. SIESS: Well, I don't think that's a part of the 8 research program. I think it should be looked at. 9 MR. COSTELLO: Okay. 10 MR. RICHARDSON: You have a good point. 11 MR. EBERSOLE: Well, it's an old, old issue, you 12 know. For instance, the main coolant pumps, they have been 13 typically protected by a single circuit breaker out in the 14 15 yard and on seismic iE or whatever, with a battery that has no pedigree, and so when you have a LOCA, these big pumps go to 16 fault current conditions, and the circuit design almost always 17 causes the penetration to be the pinch point of 18 current-carrying ability, so it will simply blow like a big 19 fuse. Physically. I am talking about explosive. Unless you 20 clear it in micro-milliseconds. That has to be done by a big 21 breaker. 22 MR. SIESS: There are some penetrations that may not 23 24 be protected from overload because the circuits are not needed, but if the penetration fails --25

1 MR. RICHARDSON: Yes, you may develop a leak. 2 MR. SIESS: Let me supplement what you said. Two 3 things, Jim:

4 One thing that's very important to these large 5 containment tests, the one that they have tested and the one 6 chat they propose to test, we all realize that there are 7 probably 50 or 60 different containment designs out there, if 8 not 90 or 120, when you really get to looking at them, and 9 there is no hope of ever testing all of them, or even testing 10 parts of all of them.

11 So the whole process here is we think we can analyze 12 containments for their ultimate pressure-carrying capacity, 13 and we are going to test a couple and test out our analysis, 14 and then try to set limits on the analysis, that we can use 15 analysis to handle all these different varieties.

16 Now that is an extremely important assumption, and 17 the results are still going to have "uncertainties."

18 The other point I want to make is that even those 19 tests, failure of a containment is defined now not as 20 structural failure, but as leakage beyond some appropriate 21 limit. The function of a containment is to contain, and when 22 it no longer contains, it has failed.

23 So the emphasis is not on structural failure, but 24 they are integral tests, they are separate effect tests, and 25 they are analyses of the integral tests intended to verify or

validate the analyses and the separate effects tests are 1 intended to provide input, too. 2 I think this is very important, because there's a 3 very basic philosophy behind this, and it's not one that 4 guarantees an answer, by any means. 5 MR. EBERSOLE: Chet, I want to make one comment. 6 You are sort of the chairman of the containment integrity 7 program -- this is an old issue that goes way back again, at 8 least 15 years, and a lot of patch work and compromises have 9 been done on it, but I for one don't know how it was really 10 wrapped up, especially with regard to old plants, because all 11 of them were found to be deficient in this matter of trip 12 integrity. And so it might be worth an overview. 13 MR. RICHARDSON: We will certainly look into it. 14 Well, that's all I have, and I am going to turn it 15 over to our two project managers, Hans Ashar and Jim Costello, 16 who will describe the program. 17 [Slide.] 18 MR. COSTELLO: I am James Costello from the NRC 19 Staff. 20 To get you to the right page in the handout, I have 21 22 put up here the cover page. As has been discussed previously, we have a large 23 effort concentrated on three areas. As Prof. Siess pointed 24 out, the underlying hypothesis behind these efforts is that 25

the state-of-the-art analytical methods, intelligently applied, will give answers that are good enough to make inferences about containment leakage and behaviour near failure.

5 Of course, the question of how good the analyses 6 really turn out to be has to be checked experimentally and, 7 indeed, we will find out, as we get into the history of the 8 steel model test, the iterative process of pre-test 9 prediction, post-test analyses and an assessment of how good 10 the state of the art is.

11 The three activities listed up there are followed 12 by, in your package, a bunch of format pre-'85 activity, '85 13 activity, '86 and '87 activity.

MR. SIESS: This is all Sandia, right?
 MR. COSTELLO: All three of these activities are
 being performed at Sandia Laboratories.

We have in '85 sliced things up into three FINs, mainly for programmatic and management reasons. We have found in the past that leaving the analysis efforts in the same FIN with the model construction led to insufficient attention being devoted to the analytical methods.

I mean it is a simple fact of life, that getting a large experiment designed is a very ticklish undertaking, and attention gets devoted to the most difficult task.

25

So we have attempted to break things out this way.

It somehow makes it difficult when we come for a presentation, 1 when we compartmentalize things this way, but we will do our 2 best to give you presentations on the highlights. And since 3 4 we are doing it all in the same morning, I trust you can see 5 how they hang together. MR. EBERSOLE: May I ask a question in sort of an 6 7 overview? I would have thought this test would include severe accident potential capability of the containment, which goes 8 whole-hog down the road. 9 10 MR. COSTELLO: It does, yes, sir. MR. EBERSOLE: Well, then, for instance --11 MR. SIESS: Except temperature. 12 13 MR. EBERSOLE: Well, there I go. MR. SIESS: I know. Temperature doesn't have any 14 effect on the steel itself. It's mainly on the penetration. 15 MR. EBERSOLE: Well, let's say the hypothesis is we 16 melt the core and the vessel fails and it falls down into 17 something, and I think the rationale has to be it is 18 concluding now whatever the heck we're going to do under those 19 circumstances, we will never fail to try to drive water to the 20 21 core, we'll do it anyway. We don't know what else to do. 22 So this says if I can't drive water, I'll surely be 23 in trouble. If I can, I might be. And this automatically 24 leads to the thesis that a containment might be optimized by having a pre-existing pool of water into which the residual of 25
the vessel and fuel would progressively descend. 1 I'm talking about a hypothetical model, not -- we've 2 got, as Chet says, maybe a hundred models, but I'm talking 3 about one that you hope would work. 4 What is being done about any sort of thing like 5 this? 6 MR. COSTELLO: This program? Literally nothing. 7 The focus of this program is developing reliable predictions 8 of the pressure and temperature conditions. 9 MR. EBERSOLE: In the field of containments we have? 10 MR. COSTELLO: Yes. Under which leakage or 11 significant leakage will begin. 12 MR. EBERSOLE: There's no attempt then to really 13 14 devolve a containment --MR. COSTELLO: No, sir, this is just establishing 15 facts. 16 MR. BENDER: It just seems to me that based on the 17 discretion here, that you would be way ahead if you just wrote 18 down a few scenarios and related the experiment to the few 19 scenarios that you are using. They exist somewhere, and it 20 seems to me that if they were just tied together a little bit 21 22 MR. SIESS: Mike, what do you mean? 23 MR. BENDER: For the purpose of showing what these 24 containment tests tell you. You have to have some reference 25

1 accident condition that you are relating to, and I think it is 2 still quite abstract.

3 MR. SIESS: You mean the rate of pressure increase? 4 MR. BENDER: No, I am talking about the conditions 5 including rate of pressure increase that have to be 6 considered.

7 MR. SIESS: In the penetration studies, as you will 8 hear, the pressure temperature from accident scenarios is 9 being involved, or being considered. In the model containment 10 test, there is no way they could get the temperatures on 11 there, and they would have no effect on the basis shell. That 12 couldn't be predicted. And the idea is to verify or validate 13 analysis, so they are simply applying a pressure.

14 Now the time rate would be the only variable there, 15 and they can't really do anything about it, because they have 16 got to stop and take readings and so forth.

17MR. BENDER:I am not trying to argue that the18experiment should simulate the event.I am trying to get --19MR. RICHARDSON:What is it going to address?20MR. BENDER:Yes, what event?Not what event, but21what events?22MR. SIESS:Well, that's covered.Containment loads

23 working group has come up with scenarios and they are
24 summarized in 956, or whatever it is, in the appendix, and
25 they are all in their report, and they have taken various

scenarios, Mike, at various leak rates and various kinds of 1 2 containments. MR. BENDER: I don't disagree with the point you're 3 making, Chet. All I'm saying is that if it is put into 4 context, it will make it a lot easier to understand why the 5 experiments have meaning. 6 MR. SIESS: Well, the thing is, it's going to be 7 hard for them to put it into context here when we have spent 8 several days in meetings on the Class 9 accidents, looking at 9 the scenarios. 10 I think there is a problem here for the consultants 11 who haven't been sitting in those meetings. 12 MR. RICHARDSON: It probably would have improved the 13 presentation if we would have shown some bounding curves, 14 showing the range of accidents that are being considered and 15 how this fits into what we are addressing. 16 MR. SIESS: Yes. Well, Mike and Rodabaugh are at a 17 disadvantage there. I have seen them, I think Carlton has 18 seen them from Class 9 meetings, and Jesse, and this is not 19 being done in a vacuum, I can assure you. 20 MR. RICHARDSON: We confess that we were probably 21 under -- having worked with Chet pretty closely at this, we 22 made the assumption that we weren't going to give much 23 background. But your point is well taken. 24 MR. BENDER: I'm not all that uncomfortable with 25

1 that myself.

2	MR. SIESS: Mike, what we should get to you is that
3	discussion I forget what chapter it is of 9.56 that came
4	out of the containment loads working group, where they take
5	the five or six plants and take the various scenarios and take
6	the various containment failure possibilities, and they build
7	up the scenarios very well in that. It is very well written.
8	And it will give you exactly the picture you want. And what
9	is in 9.56 is the executive summary I think from that report,
10	and it is very good and we'll get a copy of that for you
11	because I think it will help you a lot.
12	MR. COSTELLO: But your point is well taken, and it
13	might not hurt for us to start off the first 10 minutes with a
14	perspective of that type. We will make note of that. Thank
15	you.
16	But as has been pointed out, in the large model
17	tests we are proceeding oh, and by the way, I suppose the
18	order in which the FIN activities are listed here are in
19	increasing order of expenditure. The analytical efforts are
20	relatively modest; the penetration experiments which are done
21	in separate effects are more costly, and the construction of
22	large models is most costly.
23	Going from the bottom up, the large model tests, it
24	became apparent that (1) pressure effects are the predominant
25	factor leading to leakage with temperature effects being

clearly secondary as the conventional wisdom has it for steel 1 containment and likely to be more important than steel but not 2 3 likely to be dominant in concrete containments. So we have focused the large model tests on behavior 4 under increasing pressure up to total failure, and it attempts 5 to correlate how well state of the art predictive methods 6 7 could predict what is going to happen. The penetration tests are focused on possibilities 8 for generating local leakage, and here temperature, time of 9 10 temperature are likely to be very important. And consequently, accident scenario temperature and pressure 11 12 histories are used in the penetration experiments. MR. EBERSOLE: Let me ask you about the penetration 13 experience and then the findings that you might make. You 14 come to a conclusion pretty quick that the penetration ought 15 16 to have a very robust margin in current-carrying capacity relative to the conductors that enter it and leave it. That 17 when you started out, you should have designed it as not the 18 weak point but the strong point in the circuit. 19 But you're going to find real quickly -- this is 20 just a random combination of this, but to go back to what it 21 ought to be might be worth considering, which says 22 electrically speaking, from the time/temperature standpoint 23

24 carrying overloads and current, the penetration ought to be 25 the best thing in the whole circuit.

MR. COSTELLO: That's something we will convey to 1 the electrical engineering research people when we talk to 2 them. But we are also focusing on the mechanical penetrations 3 which have great potential for leakage -- the larger diameter 4 ones being the most likely. 5 MR. SIESS: Jim, you didn't mention that the large 6 containment tests emphasized deformation measurements that 7 would be input to the penetration tests. 8 MR. COSTELLO: That's correct. 9 MR. SIESS: Not just the failure. 10 MR. EBERSOLE: In that latter thing, mechanical 11 penetrations, I hear that flued fittings are getting out of 12 style now because you can't look at them. You know, the 13 double-walled flued fittings that fire the broken pipe 14 contents back into the containment? Is that true, that we 15 won't be using anymore flued fittings? 16 MR. COSTELLO: I can't speak to that. 17 MR. SIESS: Jesse, this whole thing is directed at 18 19 existing plants. MR EBERSOLE: Oh, they have flued fittings. 20 21 MR. BENDER: I just want to get a point clear in my The tests that you're doing are directed not to the 22 mind. organic materials that provide the sealing devices for the 23 electrical fittings, are they? They are directed to the 24 structural -- to the main structure? 25

MR. COSTELLO: No. The effort on electrical 1 penetrations actually are full-sized tests. We're not talking 2 about these here today, but the electrical penetration tests 3 are actual full-sized electrical penetrations subjected to 4 these constructed severe accidents -- the histories. 5 MR. BENDER: Well, that's all right but I guess I am 6 7 pre-supposing something that may not be correct. But the verification that the seals themselves have the capability to 8 withstand the structural loadings is done in some other way, 9 then, in these tests. That would be just incidental if they 10 failed here due to something, I would guess. 11 MR. COSTELLO: In the separate effects tests? No, 12 the pressure and temperature histories. 13 MR. BENDER: No, the organic materials that are used 14 to make sure that --15 MR. SIESS: Are aged and subject to pressure and 16 17 temperature. MR. BENDER: Are they pre-conditioned to establish 18 their historical --19 MR. COSTELLO: Yes, sir. Temperature and radiation 20 aging, yes. And also, in some of the separate seal and gasket 21 materials tests that are being performed in this program, my 22 colleague, Hans Ashar will talk about it later on the agenda 23 but we will give you a little rundown on what's done. 24 MR. SIESS: We're not going to cover the electrical 25

1 penetrations? MR. COSTELLO: No, sir, not today. 2 MR. SHEWMON: Well, the penetrations tests then 3 consisted of heating it up, putting pressure on it and seeing 4 if it will move; is that it? 5 MR. COSTELLO: The electrical penetrations test, 6 7 yes. MR. SHEWMON: Is that what penetration means here? 8 MR. COSTELLO: No. Here we will be talking about 9 the efforts looking at the mechanical penetrations and 10 potential leakage. 11 MR. SIESS: These guys are not doing the electrical 12 13 penetration tests. MR. SHEWMON: Well, they are doing structural 14 integrity of the containment and I'm trying to find out what 15 structures they're talking about. So there's a lot of 16 penetrations, and you're talking about doors and hatches more? 17 MR. SIESS: I think it might help if we would let 18

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19 them tell us.

20 MR. SHEWMON: Well, we won't find it on what was 21 given out as a handout, so maybe he has a separate slide. 22 MR. SIESS: Well, he will explain it. 23 MR. COSTELLO: Again, corresponding to the agenda, 24 we will run through the activities which are currently going 25 on and will be going on in 1987, and give some historical 1 background on what went on in the past to try and put a 2 picture together.

MR. RICHARDSON: Can I interrupt because I think it 3 is such a simple thing. The containment, of course, is made 4 up of the shell and many types of penetrations. We have the 5 large mechanical penetrations such as airlocks and equipment 6 hatches and large pipe penetrations with bellows. There are 7 valves on those pipes that represent penetrations and 8 electrical penetrations. Those are the four classes of 9 10 penetrations of the containment.

11 Within this program, we are evaluating the large 12 equipment hatches, airlocks and pipe bellows. In two other 13 programs, in the equipment qualification area we are looking 14 at the electrical penetration and the values. So what you 15 will not hear today is the leak integrity investigation of 16 electrical penetrations and values. What you will hear today 17 are hatches and pipe penetrations.

18 MR. SHEWMON: Thank you.

MR. COSTELLO: And in the order of the presentations that we have today we will first talk about the planned concrete model tests that my colleague, Hans Ashar, will now speak to. And then I will be back to talk to you a bit about what went on in the large steel model series, and summarize that and what we learned in the way of pre-test analysis, post-test evaluation.

Then I guess -- and the problem of making models. 1 And Bob Kassawara is not here and I would leave it up to you, 2 Mr. Siess, to decide how would you best like us to speak to, 3 or when you would like us to speak to EPRI's undertakings. 4 MR. SIESS: I think, Jim, about all we can do there 5 is to have -- is for you to assume that I know what they are 6 doing and not take the time to try to explain to everybody 7 else because I think that's too much of a burden to put on 8 you. And to take a few minutes to tell me what you think it 9 will help you do. Okay? 10 MR. COSTELLO: And I will speak to that when I come 11 back to talk to you again about pre- and post-test analyses, 12 in the next go-around. 13 Then we will pass over the EPRI part of the agenda, 14 15 and then my colleague, Hans Ashar, will be back to talk to you about what is ongoing and planned in the efforts on 16 penetration experiments, and then I will finish up by talking 17 about what we sense as the likely scope of the effort on the 13 seismic question and ask for your advice on how -- any input 19 you may to help in proceeding in 1987 and beyond on the 20 21 seismic guestion. 22 MR. SIESS: Jim, this is an area where I am particularly unhappy that EPRI is not here because one thing 23 that concerns me is where their containment program, which is 24

25 all concrete containments, fits in, in the event that your

model test has to be deferred because of budgetary reasons.
 Because that then becomes the only work on concrete
 containments.

MR. COSTELLO: Well, if I can defer it I will speak 4 to that when we get into the pre and post-tests. Okay. 5 MR. SIESS: Well, I think that was particularly 6 important because that may be all that gets done on concrete 7 containments for a couple of years if the budget gets whacked. 8 MR. COSTELLO: Thank you. I guess with that in 9 10 mind, then, I guess I will have Hans Ashar come and talk about the concrete model experiments for which the initial 11 construction has begun on the model right now. 12 MR. ASHAR: The first part of this presentation will 13

be just a boilerplate format in which I will talk about the
overview and budget requirements in a very generic way; what
is the issue, objective and integration, et cetera.

17 In the second part I will show you some of the 18 slides on what is going on in the reinforced concrete model 19 testing.

20 [Slide.]

The contract is with Sandia National Lab and the budget requirement in 1985 going on, there was \$2,060,000. For FY86 we have earmarked about \$2 million. For 1987 we are estimating about \$2,400,000, and in that one there will be completion of reinforced concrete model as well as some of the

needed separate effects test, such as we are thinking it all depends on how the evaluation by Sandia turns out as to the temperature effect on concrete containment. If needed, we might perform some separate effects tests for temperature on liner-concrete interaction.

6 And another thing that is an issue is: is there a 7 different behavior of pre-stressed versus the reinforced. 8 This is the one which we'll be talking of in the near future 9 and work out if we need any separate effects to get the idea 10 about the behavior of pre-stressed, if it is different from 11 the reinforced concrete containment for overall pressure 12 capacity.

13 [Slide.]

pressure?

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14 MR. RODABAUGH: Are you going to be using air as the 15 test pressure medium? Are you going to be using for test

17 MR. ASHAR: For test pressure?

18 MR. COSTELLO: No. Nitrogen.

19 MR. ASHAR: Nitrogen will be the medium.

20 MR. SIESS: Why nitrogen instead of air?

21 MR. COSTELLO: The principal reason is it turns out 22 to be cheaper. Considerable effort was done in scoping it out 23 back when the initial steel model tests were done. The 24 question of the size of pump you needed and the power 25 requirements when compared against the easy availability of

nitrogen with oil field trucks and the like pointed to
 nitrogen.

3 MR. SIESS: And the leakage through a crack would be 4 or would cost you about the same?

5 MR. COSTELLO: There was an old scoping calculation 6 and it was felt that with the level of accuracy we're going to 7 get, that would not be a problem.

MR. ASHAR: Okay. The issue is well known to you. 8 You have discussed it here for about 45 minutes, which is to 9 have some kind of idea as to the analytical prediction of 10 11 containment failure modes by experimental means. We can find out as to what would be the failure capacities of various 12 types of containments. That is the aim. For steel 13 containment we know we learned a lot, and it will be 14 15 transferred.

The objective -- perform experiments on containment models that will produce failure data under extreme loading conditions and permit an evaluation of the capability of state-of-the-art calculational methods.

As it was discussed, the pressure that we are putting in is a steady pressure at a particular rate of pressurization. It may not completely simulate pressure during the severe accident, but analyses and evaluations as to the effect on the containment itself show that it won't make any difference at what rate we pressurize the containment.

1 The temperature effect will be separately evaluated for steel 2 as well as concrete containment, if there is any temperature 3 effect.

4 MR. RODABAUGH: Do you anticipate building the 5 pressure up and then dropping it to make inspections?

6 MR. ASHAR: For reinforced concrete containment the 7 way the pressurization will be done is first it will be done 8 at peak calculated pressure. That means, containment design 9 pressure. It will be stopped and the readings will be taken 10 for the deformations, et cetera. Then it will be stopped 11 again at structural integrated test pressure, which is about 12 1.15 the design pressure.

MR. RODABAUGH: My question was are you ever going
to drop the pressure before you get to your final pressure
stage?

MR. COSTELLO: Not intentionally.
 MR. SIESS: Hans, what did you say about
 temperature?

19 MR. ASHAR: For reinforced concrete containments? 20 What I said was you might be aware of the discussion on 21 including the temperature into the model, but what has 22 happened is that there are more problems with including 23 temperature than deriving any benefit we can get out of it. 24 So we have decided is that Sandia is going to make 25 an evaluation based on the expert advice on temperature

effects on concrete containment. They are going to come out 1 with a recommendation as to do we need any separate effects 2 test to see that we can superimpose some of the effects in the 3 discontinuity areas. 4 MR. SIESS: The effect you're considering is that 5 the increased temperature puts the liner in compression. 6 MR. ASHAR: That's correct. But in the 7 discontinuity area that effect might be a little different 8 than in some areas. This is what Sandia is evaluating, and 9 they have a letter report to us --10 MR. SIESS: I don't care what they come up with; 11 you're going to need separate effects test, I think. 12 MR. ASHAR: Probably you are right. 13 MR. SIESS: It will depend somewhat on how it fails, 14 15 you know. MR. RODABAUGH: When I run tests with nitrogen 16 coming out of compressed nitrogen bottles I ended up with 17 quite a cooling effect. Have you worried any about -- that 18 you may be running your tests at lower temperature than you 19 20 want to? MR. COSTELLO: Well, on the steel tests that was 21 compensated for to some extent by the fact that we actually 22 had heaters in the containment, primarily to try and keep 23 constant temperature during the diurnal cycle. And that had 24 the effect also of --25

MR. RODABAUGH: Okay, very good.

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MR. ASHAR: The integration. As pointed out by Jim, 2 this project has been integrated together with the containment 3 penetration as well as the analytical pretest analysis and 4 post-stress analysis, as well as with the wall testing program 5 and the electrical penetration program. 6 In 1985 what we have done is the facility, as you 7 all might have seen, the facility at Sandia National Lab, 8 probably, tests the failure of three small steam models, and 9 in '85 the large steel model also was tested, as you must be 10

11 aware. Prior to 1985 was the site selection and three small 12 steel model testing, and in '85 we completed the large steel 13 model, one-eighth scale steel model testing, and completed 14 design and started construction of the concrete model.

15 In '86 what we have planned is the complete construction and instrumentation of the concrete model and 16 initiating testing. In 1987, complete testing to failure of 17 concrete model, performing necessary supplementary tasks, what 18 I was talking about today, the separate effects test; initiate 19 20 experiments in seismic performance, that is, eiter the planning stages are over in that area. That is what Jim will 21 talk about a little more later. 22

Regulatory use. Confirmatory assessment of severe
accident policy statement that the containments are safe,
probably, and the basis for possible addition of containment

performance requirements for safety goal implementation.

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Now, the practical usage has been made in quite a number of areas, like in preparing NUREG-1037 for containment performance working group. They have taken the analyses done by Argonne National Lab on penetration, and they are finding out if their penetrations are the weak points at Sequoyah or at Brown's Ferry or at Peach Bottom, whichever containments they were looking into.

So they made extensive use of the survey and of the 9 analyses of Argonne and Sandia National Lab. Also in the 10 regulatory use, in addition to this very generic regulatory 11 use, there will be code development as part of the computer 12 13 code developments. These will be useful to a lot of people in conforming their nonlinear codes or to make sure that they 14 modify their codes to suit certain data being available in 15 16 this particular test.

MR. SIESS: Hans, are the analyses, the pretest
analyses, far enough along on this to give you a prediction of
what will happen?

MR. COSTELLO: I guess I could speak to that. There has been a modest effort at Sandia to do at least an axisymmetric modeling of the specimen to help in deciding where to put instrumentation, and the axisymmetric modeling again points to the basemat-wall intersection as an area of exceptional interest.

1 MR. SIESS: All right. That's where the concrete 2 will be most highly stressed. Is it predicted that the liner 3 will fail at that location?

MR. COSTELLO: What happens in this axisymmetric 4 modeling at the level of detail that's done is the same that 5 has happened in other models of the same ilk, which is that 6 the local loss of stiffness leads to numerical instability in 7 the calculation, and the argument is whether that is a 8 numerical concrete modeling problem or it actually is 9 reflective of a large deformation in concrete liners. 10 11 The answer is the level of analysis done so far is 12 indeterminant on that point. MR. SIESS: Has anybody ever considered getting away 13 from a finite element analysis and trying to make some 14 calculations using statics? 15 MR. COSTELLO: Hand calculations? I believe we may 16 17 have actually --MR. SIESS: Nobody knows how anymore. 18 MR. COSTELLO: We may have actually come to that. 19 20 MR. SIESS: Well, once I get to a certain point, I could model this as a little angle here and then I am pushing 21 it apart. 22 23 MR. RICHARDSON: Do they teach those simple 24 techniques in college anymore? MR. SIESS: I don't know whether they teach anybody 25

any more. We do because we don't use computers that much. We
 think people ought to know how to do things that computers are
 doing.

MR. ASHAR: Now I will concentrate on some of the details of the reinforced concrete model testing. First, let me give you the status of where we are in this particular area. As Jim Richardson pointed out before, we have stopped the work in between and restarted again after Mr. Minogue gave us the go-ahead. So there was a slight delay, but it appears that there won't be a schedule delay because of that.

Now, at this time they have already broken the ground. They are all ready to put the mud mat for the basemat and are ready to make the fabrication for reinforcing for the mat. That's where they are. They expect to start putting the reinforcing for the mat sometime in October. That's what I heard last from Sandia. So that's where we are.

17 But the one-sixth scale reinforced concrete 18 containment, the contract was given to United Engineers in 19 design and construction of the model. United will work with 20 two subcontractors, Chicago Bridge and Iron for the liner 21 fabrication and supplying the penetrations, and Wiss, Janney & 22 Elstner will be doing some modeling and testing of the 23 materials.

24 MR. RICHARDSON: Is there any problem with pouring 25 concrete in the winter out in that desert?

MR. SIESS: None that they couldn't overcome. They
 could keep it heated.

3 MR. ASHAR: Well, there might be some, but I think 4 there are enough precautions taken by Wiss, Janney in that 5 area to make cold weather concreting a possibility. I don't 6 think there should be a problem. Maybe they may have to delay 7 some work once in a week or something like that, but there 8 won't be a break, as far as I understand it.

9 MR. SHEWMON: A different question. I am confused, 10 maybe, by the use of your word "model." Now, do you recall --11 I take it you use the word "model" to describe the one-sixth 12 scale reinforced concrete containment. The word "modeling" is 13 often used to try to write a computer program or do 14 something. So what this Janney & Elstner did was to design 15 the one-sixth scale structure; is that right?

16 MR. ASHAR: Yes. Modeling includes guite a number of 17 things, like making an assessment as to the size of the liner. MR. SIESS: Excuse me. I think scaling would be a 18 better word. And this was designed as a small containment. It 19 was not scaled down from a full-scale design. They were told 20 to design a containment of this size using the code. They 21 didn't try to design something with No. 18 bars and scale 22 23 everything down, but to keep things about right, and they used 24 Wiss, Janney for scaling questions.

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ME. BURNS: In particular, it does not represent any

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single containment in existence.

MR. ASHAR: But it is a containment as such. 2 MR. SIESS: It is typical and will be analyzed. 3 MR. COSTELLO: I can't let the question about the 4 weather in the winter go. The answer is fundamentally it 5 depends an awful lot on the winter as to how much time might 6 be lost. 7 MR. ASHAR: The model is designed to the Code, 8 Section III, Division 1 and 2, and there won't be a 9 requirement for an N-Stamp on this one. 10 MR. MARK: How many pounds extra would you expect if 11 you did have an N-Stamp? 12 MR. ASHAR: Well, as a matter of fact, at this time 13 NRC does not require an N-Stamp on regular containments even. 14 MR. SIESS: No, this thing would not be N-stamped. 15 [Slide.] 16 MR. ASHAR: The work with United Engineers has been 17 divided into two phases. The first phase includes development 18 of quailty assurance program, plans for support tests for 19 concrete using reinforced steel and splices, et cetera, 20 conduct the support tests, design the model, prepare 21 fabrication drawings, report the results of the prefabrication 22 test, and summarize the design work to Sandia in design review 23 meetings. 24 The first one is completed and all the drawings are

available now. We are in Phase II right now, revise the
design drawings and supporting specifications. I understand
that has been done. Sandia has reviewed the comments. Site
preparation has been done. Fabricate the model -- that will be
done. Perform the post-fabrication support tests -- that will
be done in fiscal year 1986.

[Slide.]

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8 These are some of the features of the model 9 testing. Its design accident pressure will be 46 psig. There 10 will be two equipment hatches with three doors -- I think I 11 have a slide to explain the three doors -- two personnel 12 airlock representations, and two constrained penetrations. I 13 will be explaining that to you later.

1/16th inch and 1/12th inch steel liner with 14 15 studs. The 1/16th is for the cylinder part of the containment model, and the 1/12th inch will be for the dome area. That is 16 why there are two sizes of steel liner. Piping penetrations 17 will be there, simulated piping penetrations, and layers of 18 major reinforcing just to simulate what would happen to 19 various layers in the cracking because of the layering. 20 MR. RODABAUGH: What kind of material will that 21 1/16th inch steel lining be? 22 MR. ASHAR: I think I have something on it later 23 24 that I will come to.

MR. RODABAUGH: Thank you

[Slide.]

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2	MR. ASHAR: The equipment hatches are two 40-inch
3	diameter hatches. One is centered in the cylinder wall. It
4	has two hatch covers. One is inside and one is outside. In
5	the initial testing, up to a certain level, line 1.15, the
6	design pressure, it will be used the inside cover will not
7	be in. The outside will be in. So that we can know that
8	unseating of the hatch cover, what will be done, will it leak,
9	will anything happen to the seals and gaskets and that kind of
10	thing.
11	MR. SIESS: The outside door will open out?
12	MR. ASHAR: We will try to open it. Whether it will
13	open or not, we don't know. It is a pressure unseating.
14	MR. SIESS: Which is not the way we designed them.
15	MR. ASHAR: That's correct, yes. This is just to
16	understand the behavior.
17	MR. SIESS: You are looking at seals, though,
18	drywell seals, to see if drywell seals do open up. Drywell
19	hatches, if I'm not mistaken, do open up
20	MR. ASHAR: Unseating hatches uses a double-tongue
21	and groove seal geometry. Pressure seating hatch uses a
22	double gumdrop seal geometry. These are used in regular
23	nuclear power plants. The other hatch projects out from the
24	containment has one pressure seating cover and uses double
25	gumdrop seal geometry.

MR. SIESS: These are not intended to be typical 1 equipment hatches; they are intended to test doors. 2 MR. ASHAR: They test doors. Airlocks, all 3 equipment hatches are not typical, but the equipment hatch is 4 5 more or less simulated. [Slide.] 6 The steel liner. It will be A414 grade D that will 7 be used. Generally what is being used on concrete 8 containments is A516 steel, but A516 cannot be available in 9 these sizes, so they had to make some tests on the A414 grade, 10 and they did testing to see if the properties of A516 and A414 11 are approximately the same as far as the use strength and 12 ultimate strength. They have been reviewed by the expert 13 committees, and it looks to be a promising one. It almost 14 simulates the steel liner --15 MR. SIESS: Does it have a flat yield? 16 MR. ASHAR: No, it is quite a curving yield. It 17 isn't flat. 18 MR. SIESS: What is the ultimate strength? 19 MR. ASHAR: The ultimate strength is in the area --20 guaranteed ultimate strength is about 60 ksi. 21 MR. SIESS: No, strain. 22 MR. ASHAR: Oh, strain? Twenty percent. 23 MR. SIESS: So that compares pretty well with the 24 25 liners --

1	MR. ASHAR:	Yes, that's correct
2	MR. SIESS:	And the typical liners don't have a flat
3 yield eit	her?	
4	MR. ASHAR:	No.
5	MR. SHEWMON	: A curvy yield means there is a yield
6 drop?		
7	MR. ASHAR:	It is a variation. It is some kind of
8 variable	plateau, and	you weigh the yield strength at that .1
9 percent o	r .05 percen	it, what ever is defined as the yield

10 point. 1/16th inch thick in the cylinder region, 1/12th inch 11 thick in the hemispherical dome, thickened in discontinuity 12 regions as required, and 3/4 inch and 1/2 inch long studs will 13 be attached to the liner as designed in free field, one to one 14 replacement near the penetrations.

Now, on start, I think there is a linear deviation from the scaling. In the general shell area, the spacing of the studs, attachment into the concrete liner, attachment to the concrete, is more spaced than what would be in the typical containment, but in the area of discontinuity like hatches and piping, it has been one to one scaling ratio.

There has been quite a long discussion on this as to whether we should spend money on buying hundreds of studs. It was decided by the peer review committee and all the other experts involved that it is not necessary to have one to one stud pacing for model testing, because we are doing it for

1 pressure and not for seismic or anything. MR. SIESS: And you don't have a temperature? 2 MR. ASHAR: We don't have temperature in this. 3 MR. SIESS: The original stud spacing was based on 4 buckling between studs? 5 MR. ASHAR: Between the studs, and under pressure 6 only, there is no question of buckling as such, but in the 7 area of penetrations there is some need for it, so you have A 9 the one to one ratio in that area. MR. SIESS: And the one to one has nothing to do 10 with the studs? 11 12 MR. ASHAR: No. 13 MR. SIESS: It's just confusing there. MR. ASHAR: Yes. It means that it is simulated 14 15 correctly in that area. 16 [Slide.] Reinforcing steel. ASTM, A615, Grade 60. That is 17 typically used in concrete containments. No. 4's are the 18 major reinforcing which are available. Four layers of hoop 19 20 steel, two layers of meridonial steel, two layers of diagonal 21 steel. Diagonal steel will be for the shear reinforcing. 22 Simulator seismic reinforcing, really. Nothing more than that. MR. RODABAUGH: What kind of a space do you have 23 between the liner and the concrete? 24 MR SIESS: None. 25

1 MR. RODABAUGH: None at all. MR. ASHAR: They are attached to each other by 2 studs. Studs are connected to the liner. 3 4 MR. SIESS: There might be a space, but it isn't 5 deliberate. MR. RODABAUGH: Okay, thank you. 6 MR. SIESS It is uniform. 7 MR. ASHAR: Additional layers of discontinuity 8 regions, 6 millimeter, No. 3, No. 5 and No. 6 bars will be 9 10 used, reinforcing bar splices, 4500 cold swaged bar splices, and 50 modified cadwelds. Now, there are some problems 11 because what was happening was, generally in the typical 12 13 containment, the cadwelds are No. 18 bars. No. 18 bar cadwelds slipped about yield strength or something, and No. 4 14 bar cadwelds don't slip. This was being discussed at length 15 16 in our peer review meeting, and they have tried to define a 17 cadweld that would slip for No. 4 bars. That is another way of getting around it. 18 MR. SIESS: Lots of luck. I have tried it with 19 bigger ones. 20 MR. ASHAR: And the last I heard on this one was 21 22 that they could slip it but then the ultimate capacity was reduced, and that we cannot tolerate. So probably we might 23 use a few cadwelds for No. 4 bars, but without simulating the 24 25 slip for the No. 18 bars.

1 MR. SIESS: I think you could do that with separate effects tests if you had to. 2 MR. ASHAR: That has been done. That has been done. 3 MR. SIESS: Are the small bars likely to end up a 4 little stronger than the No. 8, and that you could take care 5 of in your analysis? 6 MR. ASHAR: Yes, that is the intent, correct. 7 8 [Slide.] Now, personnel airlocks. There are two of them. 9 Both have a 1 foot, 8 inch diameter. One is used as an escape 10 lock, which is not representative of an actual airlock because 11 of the bulkhead door openings and the seals and everything. It 12 is not simulating the actual airlock. The other has two 13 bulkheads with a typical stiffener pattern. 14 As far as the shell penetration interaction, it 15 simulates very well with the actual airlocks, but as far as 16 the detail of the envelope itself, of the airlock itself, it 17 still is not the right one because of the diameter. 18 MR. SIESS: As far as the structure is concerned, it 19 is seeing a typical airlock, but as far as the doors are 20 concerned, you are testing doors. 21 MR. ASHAR: That's correct. 22 23 Now, there are no operable airlock doors on that one, so we are going to have a separate test on airlocks, 24 which I will talk about in the penetration presentation. 25

[Slide.]

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Constrained penetrations. In our testing of the 2 steel containment, the one-inch steel containment model, we 3 also had one constrained penetration, and the results of that 4 particular testing were quite interesting. We are going to do 5 the same kind of testing, a little different than what we had 6 in the steel containment, but the purpose of this one was to 7 represent the constraint placed on the containment by major 8 piping penetrations. 9 Basically, the supports for the main steamline and 10 feedwater lines, et cetera are sometimes very near to the 11 containment face, and in order to simulate how much restraint 12 will be given by them -- this is only one of the parameters. 13 There might be much more. But this is to simulate that kind 14 of a constraint to the piping penetration as to will it yield 15 faster, will it punch through. This is the thing we are 16 trying to figure out. 17

18 MR. SIESS: Now, in the steel test, that didn't have 19 any effect, did it?

20 MR. ASHAR: As far as we know, there was no effect 21 because of the constraint placed, but the results around that 22 penetration are very interesting. That is why the strained 23 configuration.

24 MR. SIESS: Did the tie yield?

MR. ASHAR: No. It was not supposed to yield and it

1 didn't yield. MR. SIESS: It wasn't a weak spot in the 2 containment. 3 [Slide.] 4 MR. ASHAR: The final drawing shows you how the 5 model looks. The concrete model will have --6 MR. SIESS: Where is the ground surface? 7 MR. ASHAR: The ground surface is here [indicating]. 8 MR. SIESS: I just wondered if you had any seismic 0 instrumentation on this in case they had an earthquake. 10 [Laughter.] 11 MR. ASHAR: No, there is no provision for that, but 12 one foot diameter is not correct now because after the 13 preliminary analysis that was done between the wall and the 14 mat, there was absolutely no convergence of the finite element 15 analyses they are performing. 16 MR. SIESS: And you have got an interior concrete on 17 18 top of the base? MR. ASHAR: Yes. There is going to be fill concrete 19 on top of the base, so this dimension is going to be 40 inches 20 now, 3 feet 4 inches, am I correct, Jim? 21 MR. COSTELLO: Yes 22 MR. SIESS: Does that line knuckle the same all the 23 way around? 24 MR. ASHAR. You mean this one here? Yes. 25

MR. SIESS: Is any thought given to changing that 1 around the periphery? They are different details if I'm not 2 mistaken. Am I right? 3 MR. ASHAR: Well, there has been a code detail used 4 on the sloping bottom part, but that is not dissimilar. All 5 the recent reinforced concrete containments have a straight 6 7 face, so --MR. SIESS: I'm talking about the details of the 8 steel liner. If that is the weak spot in the concrete and the 9 liner sees large deformation, that might be where the liner 10 ruptures if it does. And if it is, it is going to be a 11 function of a detail, I would think. 12 MR. RODABAUGH: I would think so, too, and I wonder 13 if there is a weld there. 14 MR. SIESS: There is a weld there, but that could be 15 had by separate effects test. But I was thinking would it have 16 been possible to take three arcs around and put a different 17 detail in each one. 18 MR. COSTELLO: Frankly, we haven't thought of that. 19 MR. SIESS: At this stage I'm not about to suggest 20 it. 21 MR. COSTELLO: We hadn't thought about that. 22 MR. ASHAR: What happened was this detail was a very 23 typical one being used for the recent reinforced concrete 24

containment, like Seabrook has the same detail.

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MR. SIESS: After what happened to the steel one, I 1 wouldn't use the word "typical" on anything. 2 MR. ASHAR: That is true. 3 MR. RODABAUGH: This is 1/16th inch steel liner, a 4 16th-inch thick? 5 MR. ASHAR: Yes. 1/16th inch. 6 MR. RODABAUGH: You are going to have the problem of 7 welding 1/16th inch steel in a corner weld? Is that just a 8 corner weld at that critical point here? 9 MR. ASHAR: Yes. 10 MR. SIESS: Is it just this? 11 MR. ASHAR: The way we are planning it is that up to 12 some point here, this part will be welded outside -- on the 13 fill, and then it will be placed on the site. This part will 14 15 also be done in the same way, so that there is no grouting. It will be --16 MR. SHEWMON: But the guestion is you have to match 17 this up and it is very easy to burn through. 18 19 MR. ASHAR: That's correct, and CBI has developed a special procedure for the T liner welding. We hope it does 20 21 simulate the way it should be done. MR. SIESS: Those steel models, how thick were the 22 small-scale steel models? 23 24 MR. COSTELLO: The small-scale steels were .056. MR. SIESS: And they welded those. 25

MR. RICHARDSON: Is this just a fillet weld in the 1 corner? 2 MR. ASHAR: No, it will be a groove weld. 3 MR. SIESS: This may be better than the typical ones 4 by the time they get through. 5 MR. ASHAR: This is a diameter of 32 feet and a 6 height up to the spring line of 32 feet, 3 inches, and it is a 7 hemispherical dome. 8 MR. SIESS: Can I ask you a question about material 9 properties? Do you know the NDT of the liner material? Is 10 that a test that will be made? 11 MR. ASHAR: Yes. The test was going to be conducted 12 on it to make sure that it is as per the ASME Code. 13 MR. SIESS: Do you know the NDT of the rebar? 14 MR. ASHAR: No, we don't know the NDT of the rebar, 15 either in this model or in actual prototype containment. 16 MR. SIESS: I know what it is in ordinary rebar. 17 It's about the temperature in here. 18 19 MR. ASHAR: Right. MR. SHEWMON: You don't do a Sharpy bar on 1/16th 20 21 inch steel. MR. ASHAR. They are going to do some energy tests. 22 Whether it's Sharpy or drop rate or what, I have no idea at 23 this time, but I will let you know if you are interested. 24 MR. SIESS: I would save some rebar just in case you 25

wanted to know what the NDT is later.

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MR. SHEWMON: I rebar you could do it, but none of 2 those tests are done on 16th-inch sheet. They are all thick 3 plate. 4 MR. ASHAR: That's right. They are at least 5 half-inch specimens, yes. They plan to do -- I have not heard 6 about the results and how they have done it, but I will find 7 8 out for you. MR. SHEWMON: Chet, the other thing is there is no 9 Sharpy test on stuff thinner than half-inch or something 10 because you can't get the thickness to make it relevant. It 11 is all shear lift. 12 MR. ASHAR: Well, this is about the end of my 13 presentation. If you have any question on details, maybe I 14 have some slides I can show you. 15 MR. SIESS: And right now they have poured the mud 16 17 mat. MR. ASHAR: Yes, they are ready to pour the mud mat. 18 MR. RICHARDSON: How many channels of 19 20 instrumentation do you anticipate? MR. ASHAR: About 1500. There are more than in the 21 steel model. The steel model had about 1100 or so. 22 MR. COSTELLO: About 7. We do have a graph where we 23 have some of the --24 MR. RICHARDSON: I was just after a rough order of 25

magnitude.

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MR. COSTELLO: Around 1100, I think. 2 MR. SIESS: Let me ask a question. The reason for 3 using a gas to test this -- of course, there are two reasons. 4 One is you are interested in leakage and it is leakage of a 5 gas, and the other is that the mode of ultimate rupture will 6 be, presumably, different with a gas than with a liquid. But 7 is it conceivable that you could get far enough in a gas test 8 that the thing -- if it leaked, you would have called it a 9 leakage failure and you could back off and make a final test 10 with a liquid where you could observe things more easily. 11 MR. COSTELLO: I think that's possible if that is 12 13 the outcome. If we do get a small stabilized tear in the liner which leads to depressurization and inability to add the 14 pressure in the gas, then we are in mode 2 of what to do 15 next. 16 MR. SIESS: Would it be possible? I mean are your 17 gauges protected inside well enough that you could fill it 18 19 with water? MR. COSTELLO: I think with a bladder. 20 MR. SIESS: That would be pretty expensive. You 21 know, a Canadian test was made with water and a bladder, and 22 they learned quite a bit from that, but I'm not sure they 23 couldn't have learned it with air, but they couldn't have used 24 air at their site. You know, the pieces would be a lot easier 25

1 to find.

2	MR. COSTELLO: But I think, you know, we haven't
3	gotten down to Phase II yet, but our thought in the steel
4	model was to bring it up to pressure failure and then see
5	where we were about the possibility of maybe finding the next
6	failure mode up by repairing and raising pressure again One
7	of the thoughts there was you know, what you might find out
8	depends an awful lot on how far you are out in strain.
9	MR. SIESS: Well, it is just a thought.
10	MR. EBERSOLE: May I ask a question? Chet, you said
11	the Canadians did this with a bladder?
12	MR. SIESS: They build a model of prestressed
13	concrete, a can-do type containment. They don't line their
14	containments with steel. They had a rubber liner in it.
15	MR. EBERSOLE: Well, can't you do a test like this
16	with a mixed environment inside which is mostly filled with
17	water or with x percent in a pneumatic ball and diminish the
18	terrible consequences but still get
19	MR. SIESS: The tests have to be with gas because
20	they are interested in leakage. It's a gas that is leaking.
21	I was just trying to find some way to avoid the explosive type
22	where you can't see what happens and you just hope your
23	cameras and your strain gauges catch enough information.
24	This tends to be a one-shot test. You spend a lot
25	of money on it and you would like to milk it for all it's
worth

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MR. EBERSOLE: Well, for a strength test, you could 2 fill it 99 percent water and have the rest pneumatic. 3 MR. RODABAUGH: The problem with water, of course, 4 is any inside instrumentation like strain gauges --5 MR. SIESS: Yes, if they are not waterproofed, and 6 that is quite a job. At that stage you may not be interested 7 8 in strains anymore. MR. RODABAUGH: It's very possible, but it might be 9 worth keeping in mind. 10 MR. SIESS: I mean you expect it to do more with the 11 12 steel. MR. COSTELLO: Another possible desirable use for 13 this model is we do get a localized tear in the liner and a 14 leakage through the concrete would be the same as you might 15 have used for the steel model as a vehicle for some nice 16 thermalhydraulics test in a large volume. 17 MR. BURNS: Actually, I would hope this would not be 18 a catastrophic failure but that we could use it for a test 19 vehicle for testing other things, like other forms of 20 21 penetration and such. MR. EBERSOLE: What is the time interval for a 22 catastrophic failure? How many milliseconds are we talking 23 24 about? MR. COSTELLO: Very few. I have a little something 25

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to show you here later.

MR. EBERSOLE: Not time enough to detonate a member, 2 though, or anything like that. 3 MR. SIESS: I don't think this one can go the same 4 way, but then --5 MR. RODABAUGH: Chet, for my information, what 6 happened to the steel model? 7 MR. SIESS: They are going to show you. I think that 8 is waht we have here up on the film. 9 MR. COSTELLO: We have a little summary --10 MR. SIESS: Is that the failure test? 11 12 MR. COSTELLO: Yes, sir. MR. SIESS: Okay. We will wait. They couldn't get 13 all the pieces in one photograph, I will tell you that. 14 MR. RODABAUGH: It failed under gas pressure. How 15 big was it? About the same size as the concrete one? 16 MR. COSTELLO: Just a little bit smaller, about a 17 18 one-eighth size. MR. RODABAUGH: I would guess you have got pieces 19 around a radius of a mile, more or less. 20 MR. SIESS: No, not quite. 21 22 MR. COSTELLO: No, thank God. MR. SIESS: No, they weren't that far away from it. 23 A mile away would have put them over in the -- what is that 24 25 mountain?

MR. RODABAUGH: There is a fair number of industrial 1 accidents where a tank had a gas pressure break off and could 2 3 go a mile. MR. BURNS: If the pieces went a mile, I doubt if 4 Sandia would allow us to test this particular model at this 5 site. 6 7 MR. SIESS: This was at an isolated site, but not that isolated. 8 MR. RODABAUGH: Battelle had a site they thought was 9 isolated. They broke windows within three miles. 10 MR. SIESS: Gentlemen, this is the time for a break, 11 12 and then what are we going to hear, the steel one? MR. COSTELLO: After the break, I will talk about 13 pretest and post-test analyses, primarily with emphasis on the 14 steel model series, and then some lead-in into the concrete. 15 [Recess.] 16 17 MR. SIESS: All right. MR. COSTELLO: James Costello from NRC Staff again. 18 I would like to start talking about the pretest 19 predictions and post-test analyses and attempts to make sense 20 of it all, which activity we have more or less concentrated 21 into a single FIN, and having the other two FINs that Hans 22 Ashar was talking about concentrating on trying to get the 23 experiments built and done, which is the major undertaking 24 that we have. 25

I would like to give some indication about some of the cooperating organizations involved in pre and post-test analyses. We have had with KFK in Germany some collaboration on the steel model. We had somewhat hoped that they might be inclined to try to predict the large steel model tests bearing in mind that the containments that they have been looking at in their research program are spherical.

8 However, they thought about it and decided that they 9 are better off putting their analytical money into spherical 10 models. However, they are cooperating with us to the extent 11 of testing, doing biaxial testing in a machine that they have 12 of some of the materials that we had in the steel models.

We also expect that we may well have cooperation down the road in the seismic question in Germany. That is, we have not yet gotten to that, and I will talk some more about the seismic question later.

As far as the concrete experiment, we do have 17 agreements with EPRI to provide pretest predictions for the 18 model. We also have agreements with the Commisariat A 19 L'Energie Atomique, CA, Ensacle and Fontaneeurs to perform 20 pretest predictions. They now have copies of the drawings and 21 are at work. The same with the Nuclear Installations 22 Inspector in the United Kingdom. They are having a contractor 23 doing a pretest prediction. I will talk a little more of that 24 later. 25

MR. SIESS: What are they predicting, leakage or failure?

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MR. COSTELLO: Deformation. 3 MR. RICHARDSON: I think there is an interesting 4 contrast between these two organizations. CEA is going to do 4 a very complex, three-dimensional, sophisticated analysis, 6 kind of representing the people that are enamored with 7 computers and 3D finite element approaches, where NII is going 8 to take a very simple approach, not quite back of the 9 envelope, but a very simple approach, and I think it will give 10 us a chance to see the sensitivity of complex versus simple 11 methods and models. 12 MR. COSTELLO: Yes. The whole idea here is to try 13 to get some handle on how well state of the art techniques can 14 work and what do you have to model and how well to get 15 predictions that are viable. 16 17 [Slide.] I think at this time I would like to give a quick 18 summary of where we were. In fact, in talking about the 19

pretest predictions on the steel model series, I have to say that is one place where I bet on the wrong horse. I had the mistaken belief that self-interest, enlightened self-interest would have A&Es and/or computational mechanics firms want to show off how well their calculational techniques could predict the outcome of these experiments.

It all went along fairly well. We did invest some 1 money in mailings and winnowing lists, asking people would 2 they be interested. The answers of a great number were yes, 3 and apparently when it required only a 20 cent stamp, they are 4 willing to say yes. We sent out some drawings and responses 5 began to flag, and in fact, no A&E firm or computational 6 mechanics outfit actually went through the in-house expense of 7 doing the calculation. Perhaps they just didn't see the 8 market for it in the aftermath, but that is one place where I 9 10 11 MR. SIESS: Are you assuming that they knew how? I mean it's a lot different calculating when something will fail 12 and calculating when something will stand up, which is what 13 14 design is. MR. COSTELLO: I believe that all these firms had 15 the same tools that were available to the people who did the 16 17 calculations at Sandia. 18 MR. SIESS: Inelastic? 19 MR. COSTELLO: Yes, sir. 20 MR. SIESS: Yes, but how much experience did they 21 have using them? 22 MR. COSTELLO: More, I think, than some of the people at Sandia who actually did the calculation in some 23 24 firms 25 MR. SIESS: You mean the AEs had made inelastic

calculations of containment behavior?

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MR. COSTELLO: These have not, to my knowledge, made 2 much more than the capability prediction kind of calculation. 3 MR. SIESS: Some of those just say calculate the 4 yield strength and that's it. That's not really inelastic. 5 MR. COSTELLO: Or one percent --6 MR. SIESS: That's still elastic. 7 MR. COSTELLO: But I think the people are there. 8 Certainly the A&E firms have garnered a large number of the 0 graduates of major universities over the last 10 to 15 years, 10 11 and all of these fellows, many of them have been engaged in those kinds of calculations. Certainly the computational 12 mechanics firms have that as their stock in trade, but I guess 13 14 they simply didn't see the market and didn't want to make the in-house investment. 15 The activities currently going on I will talk about 16 on pretest predictions of the model tests at the end. 17 I would like to go down to 1986 and 1987 a bit with 18 19 you and then go back. As Jim mentioned before, we made a conscious 20 decision some years ago after discussions with our peer review 21 panel and other members of the NRC Staff that a single model 22 test of a reinforced concrete model, given that it was about 23 all we could afford, was also the most likely vehicle to give 24 us enough understanding to try and predict prestress behavior. 25

We had as background the fact that there had been the Canadian model test, albeit on line, at 1/14th size of a prestressed containment. There had been in the past, albeit tit at much greater wall thicknesses, PCRV test to failure, and the prospect that there might be a prestressed model test of something representing the SNFPS type containment undertaken in the U.K.

That's an off and on -- as Jim reports from last 8 August, it looks more on than off, but things might change by 9 10 October. Nonetheless, we had that for background, and we also had the belief that, given that the cracking phenomena are the 11 12 hardest to model and the effects of the cracking phenomena on the liner are the hardest to model, the reinforced concrete 13 model would be a harder test of the ability to model behavior 14 near failure. 15

Further, or taking the belief that you could reliably predict failure in a reinforced concrete model, extensions to prestressed where you have much less cracking along the path would be easier done. We still believe that. We now have to prove it. We will begin that in '86.

We also have to look seriously at the question of what do we need to do, if anything, to look at the question of degradation of containment capability under large seismic loading. Is it possible that you might lose containment capacity in a containment in an accident to follow?

MR. EBERSOLE: When you do this, are you
 hypothesizing that a coincident loss of coolant accident or a
 secondary failure will occur?

4 MR. COSTELLO: No, sir. I will get to that later, 5 at the end. At the end I have to say a few words about where 6 we are gonig to go there.

7 We will then in 1987 be going back to try and figure 8 out what happened in the concrete model test, and I, frankly, 9 am not as optimistic about that as I was about the outcome in 10 the steel experiments. In the steel experiments, I stood here 11 cheerfully four years ago and said it will all come out, not 12 to worry, we will figure out rather easily what happened. I 13 think we did and I will talk about that a little later.

In the concrete model, the state of the art of large deformation modeling is not anywhere near as vast and tried and true as in other applications in steel, and I expect we will have, in Professor Siess' phrase, a good deal more questions after the experiment than we had in the steel.

19 With that, I would like to spend about 10 minutes or 20 so on the videotape machine giving you a little precis of what 21 went on in the steel experiments. Now, this is not a very 22 elaborate production. It is not, shall we say, of the caliber 23 of those produced by KFK on the HTR experiments. It is simply 24 a splicing together of pictures, graphs and the like collected 25 over time in the series of steel model experiments, with

1 admittedly a little bit of music and some file footage taken in, but I think it does rather neatly summarize what went on 2 in the steel experiments area. 3 [A videotape was shown.] 4 MR. SIESS: Jim, have you got an explanation for why 5 those cracks did not run in the first two steel models? 6 MR. COSTELLO: We have a pretty strong hypothesis 7 which is being checked now in the closeout. The answer is 8 most likely extreme thinning, and we have measurements on that 9 done by the grinding wheel at --10 MR. SIESS: Yes, but why didn't it run? 11 MR. COSTELLO: The primary suspicion is that the 12 13 material was so thin that even --MR. SIESS: The stresses outside of --14 15 MR. COSTELLO: Yes, it was confined by the material. MR. SIESS: In both cases? 16 MR. COSTELLO: In both cases. And that is one of 17 the things that we are going to check out. The fundamental 18 thing, in the words of Dr. Von Reisman, his observation was 19 20 that grinding wheels don't scale very well. 21 MR. SIESS: You know, I'm going to make a semi-facetious comment that maybe that is the way we ought to 22 23 build them. You know, just put a thin spot in there so that when they do fail, it will just be a nice, good-sized leak and 24 they won't end up in pieces around the countryside. 25

MR. EBERSOLE: That notion of programmed failure, 1 Chet, that's what you are talking about, isn't it, programmed 2 failure? 3 MR. SIESS: This is leak before break. 4 MR. EBERSOLE: Yes. I never really had heard that 5 treated as a design thesis. I don't know why. 6 MR. SIESS: I mean it's just like a rupture disk. 7 MR. RICHARDSON: What would be the difference 8 between that and a relief value? 9 10 MR. SIESS: Well, somebody has got to decide to open 11 that relief value. MR. RICHARDSON: Well, it could be set at some 12 13 pressure. MR. SIESS: Well, they will debate that for five 14 15 years. MR. SHEWMON: I was going to ask the question a 16 different way, and that is, how do you think the NRC is going 17 18 to approach what they will have for the limit on this. There is a decision of, okay, when do you recommend opening it so it 19 doesn't blow? 20 21 MR. EBERSOLE: Well, it certainly doesn't seem rational to build it like the wonderful one-horse shay. 22 MR. SIESS: Paul, your question is great because, if 23 24 that question could be answered now, we would probably end up saying that we want to be sure that it doesn't rupture, and we 25

want to open a value or have a rupture disk or something in 1 it. We would probably choose a pressure that could be 2 predicted with a great deal of confidence, and we wouldn't 3 4 need these kind of tests. But nobody has answered that 5 question. In fact, they haven't even asked it properly. So we go ahead and try to get all the answers. You know, whatever 6 anybody decides to do, we will be able to tell them how this 7 thing will behave. 8

MR. COSTELLO: I think that, you know, an outcome of 9 10 a series of steel experiments was to pretty strongly reinforce the suggestion that if you picked -- and some other 11 12 penetration experiments that Hans is going to talk about next -- is to suggest that if you picked something like general 13 membrane yielding, you would be quite sure that you were well 14 15 below onset leakage from penetrations and that you are well 16 below likely gross failure.

MR. SHEWMON: What was the pressure for general
 membrane strain on this one?

MR. COSTELLO: I don't have the Vu-graph -- well, it 20 was around 160.

21 MR. SIESS: Your post-test analysis, you can 22 probably explain why that thing failed, the big one that 23 failed when it did.

24 MR. COSTELLO: Yes, sir.

25 MR. RICHARDSON But that doesn't mean you could

predict it because it was sort of a localized effect of the 1 people going back looking at had they accounted for the 2 eccentricity Sure. And they debated it at the time when they 3 made their pretest predictions. They debated whether they 4 should model that eccentricity or not. They erroneously 5 concluded that it was a never-mind. 6 MR. SIESS: But how many places would they be in a 7 typical containment where somebody would have to make that 8 decision, you see. 9 10 MR. RICHARDSON: Probably a lot. MR. SIESS: And yet, to make a decision to take a 11 general membrane yielding or smeared -- you know, you have 12 established you can smear the stiffness. 13 MR. SHEWMON: That is four times design. You know, 14 one shouldn't be greedy. 15 MR. SIESS: Yes, but it's four times LOCA design, 16 but it's not four times what the severe accident predicts at 17 certain stages, and you get peaks at early stages. In some 18 containments those peaks are within the uncertainty range on 19 the ultimate capacity. 20 MR. COSTELLO: Yes. TMLB sequences and things like 21 22 that. MR. BENDER: In these tests that you have run, 23 somehow or other they have to be put in relation to the 24 25 leakage characteristics of the closures that some people are

1 arguing will occur before the failure of the vessel itself happens. Do we have any feeling yet for what the relative 2 capability of the sealed closures is? 3

MR. COSTELLO: Hans is going to talk to that in his 4 summary of the penetration work, but it simply comes down on 5 6 the steel model test to this. The ovalization of the equipment hatch, which was suspected to be the most likely 7 8 failure mode of leakage through that equipment hatch, was predicted very accurately. 9

10 MR. BENDER: That is not quite what I'm asking, but it may be around it. If the burst pressure of this vessel is 11 four times the design pressure or whatever it is, and the 12 13 leakage capability of the gaskets is 2.5 times the pressure --I don't know really what it is. I'm just picking a couple of 14 15 numbers.

16 MR. COSTELLO: It was substantiall more than 4.5 because the leakage did not occur. 17

18

MR. SIESS: This one did not leak. 19 MR. BENDER: Well, this one did not leak, but I don't know whether this is representative of the gaskets --20 21 MR. COSTELLO: Let me speak to that question. One of the exercises we went through in the post-test analysis, 22 23 which I have not reported here, is to ask the "What 24 if?" question, to say, what if, instead of this equipment 25 hatch reinforcement configuration, another one or two which

are typical of the population were put in?

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It was easy to examine that question because one had 2 great confidence about the finite element model's ability to 3 predict the ovalization having been benchmarked against the 4 test data. I think five were examined that spanned the 5 population. The outcome was that two of them would surely not 6 have leaked in this experiment. The one that was in there 7 didn't, and two others would almost surely have leaked 8 9 earlier.

MR. BENDER: Well, there are a couple of ways to deal with Paul's point. One obviously is to put in a rupture disk. Really. Another is to have some weakened structural capability, and the third is to select the kind of sealing for the closure that would assure that leakage does occur in sufficient quantities so that the bursting never occurs.

Now, all those remedies are out there and they are all within the limits of the present regulatory system. The only one that is not in there, maybe, is that nobody wants to be in the position of saying, well, I'm going to be the guy that is going to press the button. That's not exactly rational, but that is the way it is.

22 MR. COSTELLO: Again, as Professor Siess pointed 23 out, there is that question of how much more is really there 24 that might be of benefit to you. If, indeed, you believed 25 that the pressure in an accident was going to peak at 165 or

170, you would not have wanted to push the button at 160 given
2 that this thing was going to ride out until nearly 200.

MR. BENDER: Well, if that is the game you want to play. But if you really would prefer to be in the position of saying I want to have an assured capability up to some level, and when that level occurs, I want to direct whatever comes out in a certain way, you would be far better off to select some mechanism and say, I'm going to work on the reliability of that failure mechanism happening.

MR. SIESS: Mike, what you are bringing up, it would be very nice to know at this point just how somebody is going to use these results, and that is what I was stressing. In contrast to some of the stuff we heard yesterday, the severe accident business has not been carried far enough yet that anybody knows how they are going to use it.

16 Now, we have had that trouble with the whole severe 17 accident program, that people could not tell us what they were 18 going to do with it when they got through; they were just 19 going to learn everything about everything. The severe 20 accident program hasn't really addressed the possible uses of 21 this. Until some of this work was brought in, the people that 22 were calculating containment loads, containment pressures were assuming it wasn't going to leak at all. They were drawing 23 24 curves that just went on up. You know, the idea of 25 containment leak never entered their minds.

And then their attention was gotten and they started 1 calculating containment loading as if it might leak, and they 2 are just beginning to think about these things. 3 4 MR. EBERSOLE: Well, Chet, it must surely be true 5 that nobody contemplates that we will ever allow a containment to approach a burst pressure. 6 7 MR. SIESS: They haven't even thought about it yet, 8 Jesse. 9 MR. EBERSOLE: Well, it has been around for 20 or 30 10 years. MR. SIESS: I know, but in addressing a policy on 11 12 severe accidents, this has not been addressed except to talk 13 about vented filtered containment. MR. EBERSOLE: I would rather have a big cannon out 14 there on the site to open it up if I had to. 15 16 MR. SHEWMON: Well, that is part of why you are here, you know. 17 18 MR. SIESS: We are not so sure that the burst of 19 this thing seven days down the line makes that much 20 difference. MR. EBERSOLE: Well, if it bursts violently and 21 22 re-entrainment occurs, that is something else. 23 MR. SIESS: That is something they are just beginning to think about. As far as I can see --24 25 MR. EBERSOLE: I can't see by any stretch of the

imagination that we would ever approach a burst pressure; that 1 we would take violent means to preclude that. 2 3 MR. MARK: Well, this is at leat telling you that 4 you have a good chance to know where that burst pressure is. MR. EBERSOLE: Right. That is all I see here, is 5 that you are finding the margin at which point you would 6 7 deliberately open it. MR. SIESS: Well, if somebody would say that they 8 9 wanted a highly reliable, conservatively-established burst 10 pressure below which they could vent, I don't think we would need that test. 11 12 MR. EBERSOLE: That is the point. 13 MR. RICHARDSON: Except you may need it to establish the validity of your models that predict that burst pressure. 14 15 MR. EBERSOLE: But you could put margins in the 16 strength. 17 MR. SIESS: But I think on the steel ones -- maybe 18 it took the big one. I'm not sure. I said to predict a 19 highly reliable lower bound, and if somebody says, okay, we 20 will accept yield as that, we don't really need a lot of model 21 tests. 22 MR. RICHARDSON: But that may be so low that it 23 would --24 MR. SIESS. It may be too low, but you see, you have 25 got to think about it.

MR. SHEWMON: We are talking about concrete now. 1 MR. SIESS: I'm talking about either one. 2 MR. SHEWMON: Well, but the steel, if that was four 3 times the design pressure --4 5 MR. SIESS: I know, but it's not four times the accident pressure. Design pressure doesn't mean anything when 6 you are talking severe accident. 7 MR. BENDER: It only sets an upper bound on what the 8 pressure is --9 10 MR. SHEWMON: When you say a highly conservative lower bound, the design pressure is that, and that is much too 11 12 low. MR. SIESS: Well, no, 115 percent of design pressure 13 14 is a highly conservative lower bound, but the higher you go, 15 the greater the uncertainty is, obviously. MR. EBERSOLE: Chet, let me ask you. With the 16 concrete vessel, I understand that at least for the primary 17 concrete vessels for gas, they have an intrinsic phenomenon 18 that the reinforcement will stretch, the concrete will crack, 19 and it will become its own permeable relief system. 20 Will that apply to this containment? 21 22 MR. SIESS: The liner has to fail. The concrete is not leak-resistant material. The liner is. 23 MR. SHEWMON: But the concrete limits the strain on 24 the liner so that you may well have -- well, you certainly 25

1 will have a limited rupture.

2	MR. SIESS: Yes, that's right, but the cracks in the
3	concrete can get pretty large before the liner fails. We
4	don't know. The reason for testing the concrete containment,
5	in my mind, is to see if there are some questions we haven't
6	thought about.
7	MR. EBERSOLE: If the liner failed and it
8	pressurizes the concrete inner surface, then the concrete is
9	pressurized, and will it not then act as its own relievable
10	structural
11	MR. SIESS: Oh, yes. Unlined concrete, you can
12	probably get enough cracks so if the stuff would leak out, it
13	would go out through cracks, and then you have the question of
14	how much deposition there is and aerosols in the cracks. You
15	know, the devious path and so forth. But again, the unlined
16	concrete one would not work for a LOCA, which has always
17	governed our design
18	Now, in a prestressed concrete containment, they are
19	designed not to crack under LOCA load, and the Canadian
20	prestressed containments, the French prestressed containments
21	no, the French have liners, I believe, although they have
22	looked well, anyway, the Canadian one, I know, is not
23	lined. It has an epoxy paint that will take care of
24	MR. EBERSOLE: It will stretch.
25	MR. SIESS: But it is prestressed, so at LOCA loads

it is not cracked, and nobody has looked beyond LOCA loads because that is what they were designed for. But a reinforced concrete one would not stand the LOCA. You could not get one-tenth percent leakage at LOCA loads on a reinforced one because you would have enough stress to get some cracks and you would get some leakage. I don't know whether anybody has even tried to calculate it.

But now we are talking about accident loads. At 8 Indian Point, for example, TMLB' gets you up within a few psi 9 of the predicted yield capacity, I think, in a coupe of hours, 10 if I am not mistaken, and then it drops off a little bit and 11 then a slow overpressurization comes and it keeps on going. 12 But at that first stage where there is a lot of fission 13 14 products in containment, it is within a range where you might like to know it better. In some others, you would be a mile 15 off. 16

You see, you remember the trouble we went to on 17 Sequoyah trying to get the capacity -- you know, we had four 18 19 different answers and we sat around a table one day. You take the same design, essentially, for McGuire, where they didn't 20 21 reduce the thickness of the liner as they went up. Remember, Seguoyah had the liner getting thinner and thinner as it went 22 23 up; McGuire didn't. So McGuire had something like, what, 50 24 or 60 percent more capacity. And this was just the designer's 25 choice of trying to save steel as he went up on this thing

because of vertical load. Remember that? So you have to look 1 at those things. It makes a difference. 2 3 But if somebody would tell us what they wanted --4 they were really going to vent these things and they wanted, you know, a 99 percent probability that they would vent below 5 6 MR. EBERSOLE: Well, who is that somebody and why 7 don't we find him? 8 9 MR. BENDER: It seems to me if we were doing it in a rational way, you would lay out all the strategies, and if you 10 had a good probabilistic risk analyst, he would make the 11 12 arguments for the various data --13 MR. SHEWMON: We would submerge him in severe accident codes and he would never be seen again. 14 15 MR. BENDER: Well, that's probably right. MR. SIESS: Well, if you believe the severe accident 16 17 codes, which, you know, takes a certain amount of faith, you could be at that point right now. But as I pointed out, IDCOR 18 19 looked at this venting thing; but on a cost-benefit type 20 thing, venting to prevent rupture of the containment seven days down the line isn't worth anything in terms of dose 21 22 release. 23 Now, they didn't talk about the resuspension. MR. RICHARDSON: Yes, with catastrophic failure. 24 25 MR. EBERSOLE: That is what would be a key effect.

 MR. BENDER: You won't have it if you will accept

 2 the argument of gasket leak -

MR. SIESS: But Jesse, the severe accident research has placed -- I am prejudiced -- has placed 99 percent of its emphasis on source term, and what is in the containment, all the scenarios and how it gets there and so forth, and on containment loading phenomena, and have not really been thinking about the things the are asking questions about. I have tried to get their attention on it.

MR. EBERSOLE: The cart is always before the horse,
 then.

MR. BENDER: No, that's not quite right. MR. SIESS: The people that were doing the work got absolutely fascinated with this suite of codes, and they are going to get answers to what people thought were unanswerable questions, and now we are doing it, you know, and we are doing research on core-concrete interaction.

MR. EBERSOLE: The war is being won by the patrols.
MR. SIESS: Yes, it's the old question, Jesse. The
ACRS has been asking it ever since they started. What are you
going to do with this? What are you going to use it for?
MR. EEERSOLE: Yes. If you had already done it,
what would it be worth?

24 MR. SIESS: If I told you this, what would you do 25 with it?

MR. EBERSOLE: Yes. Well, I think every research program has all this. Suppose you are already done? What have you got?

MR. SIESS: Yes. What they did on severe accident 4 -- I said it and I will say it again. Their approach was we 5 are going to learn everything about everything, and when we 6 get through, we will know what to do about it. And they are 7 still trying to learn everything about everything. And here 8 we tried to learn everything about everything because nobody 9 has told us what they might do about it. And you can't ask 10 the structural engineers what to do about it. 11

12 MR. COSTELLO: Well, I can't say that we are so 13 immodest as to try to learn everything about everything.

14 MR. SIESS: No, I didn't say you are doing that, but 15 again, you may be learning more than you have any use for if 16 somebody could tell you what they wanted to do with it.

MR. COSTELLO: Yes, but one has to look at the prospect that a high degree of confidence of when and where if it's going to fail is something in the end game that will be important.

21 MR. SIESS: You heard me state one of my famous 22 generalities that one of my old professors taught me, and it 23 has been borne out by my own experience. It says tests on 24 full-sized structures never answer questions, they only ask 25 guestions. And this is about as close to a full-sized

structure as you are going to get.

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Take the steel one. Did it ask any questions? 2 MR. COSTELLO: I would say it asked three questions, 3 two of which were easy to answer, one of which was a little 4 harder, and I think we have got the answers to them. And the 5 net outcome I say is this: that the capability exists within 6 the A&E firms and/or some of their consultants on behalf of 7 utilities to go back and look at the steel containments they 8 9 designed and built, use available technology and come up with very good estimates of when and where the containment is going 10 to fail if they choose or the utility chooses to put the 11 12 money into it. MR. BENDER: I wonder if I could make a point that 13 develops something Dr. Siess said a moment ago. When the 14

15 Sequoyah vessel was looked at, there were four methods of 16 analyzing them and they gave four different pressures.

MR. COSTELLO: I think it was closer to ten. MR. BENDER: Well, I'm not sure how many there are, but four is enough for my argument. I am not clear right now which of the four was near to the right answer based on the experimental program that you did here, but it might be useful to be able -- to make that comparison just for the purpose of showing --

24 MR. SIESS: Well, one thing they established clearly 25 in the small scale was that smearing works. You can smear the

stiffness, and that was an issue in the Sequoyah thing.
 Somebody assumed it, What's-His-Name with Westinghouse, with
 Ops, made the finite element type thing and supported it, and
 that came out very clear.

5 MR. BENDER: But I guess the point I am really 6 trying to make is that, yes, all the architect engineers can 7 predict these capabilities. The question is which of the 8 several methods that is out there is the one that you want to 9 give preference to for this purpose. That's the most useful 10 part of this program.

MR. COSTELLO: I will give two answers to the 11 12 question. The answer to Problem 1 is, as I tended to call it over the years, that is a not unreasonable lower bound 13 14 estimate. I believe there is sufficient evidence for steel containments that membrane yield guite suffices, and the 15 outcome of the attempts to get leakage around these 16 17 penetrations and some of the other experiments that Hans will talk about, if I ever give him a chance, at temperature will 18 19 support that hypothesis.

The second one is Problem 2. Do you really have to know when and where it is going to fail? I say that the outcome of these experiments has been reasonably conclusive that the state of the art will do it if someone wants to model it in the kind of detail that's required.

25

MR. SIESS: I think Mike may not be aware of how

that steel containment failed and why. 1 [Slide.] 2 MR. COSTELLO: Oh, yes. May I wrap up? 3 Here we go with the picture. Up here you have a 4 formed stiffener, a formed horizontal. There are eight such 5 details like this. 6 [Slide.] 7 The design had what amounted to a half-inch of 8 eccentricity. That is in the lower picture. Why? In order 9 to make the weld, I guess. The belief by the fabricator was 10 that that is the common thing to do. The judgment was 11 made, after some agonizing early on in the pretest prediction, 12 to model it as if there was no eccentricity. 13 MR. SIESS: Now, here you mean mathematical model 14 and analyze that? 15 MR. COSTELLO: Yes. The analyzing pretest 16 analysis. Let's not try and bring in a little bit of bending 17 in here because tradition says that's not really 18 important. Again, in yielding, things will -- et cetera. So 19 they went with this model [indicating]. 20 The outcome of the experiment was that at around 165 21 psi, a crack was noticed in the formed stiffener. The crack 22 was spotted by an operator. One continued to raise the 23 pressure in the programmed fashion. On the way from 192.5 to 24 25 195, there was the outcome.

This, as I say, was the third question, the hard 1 question that was harder to explain, but it turned out to be 2 not that hard. They went back -- you know, no curve fitting, 3 no derivation of constants. Just went back in and did a 4 finite element model, which included that eccentricity. 5 [Slide.] 6 MR. SIESS: Would the model predict the crack 7 running? 8 9 MR. COSTELLO: Yes. MR. SHEWMON: No, you don't really get into fracture 10 mechanics in your model, do you? 11 MR. SIESS: No, but you get into propagation. Was 12 the crack a brittle crack? 13 MR. COSTELLO: Oh, no. It's ductile. 14 What happened at predicted strain in the cylinder 15 right next to that juncture in the pretest analysis, the 16 membrane yielding roughly at 160, things beginning to happen, 17 but nothing that would lead you to believe that you would have 18 a catastrophic failure. And the predictions went out 19 20 somewhere up here, around 220. The other predictions for deformations around the 21 hatch in ovalization suggested that you really would have lost 22 metal-to-metal contact around 210. You would expect leakage, 23 but it never got there. 24 MR. SIESS: Jim, the knee in the curve at 165 could 25

be predicted without a finite element analysis? 1 MR. COSTELLO: Yes. 2 MR. SIESS: That could be just membrane-type. 3 MR. BENDER: Well, the point that I was trying to 4 make, and I will try to make it again, is if I can establish 5 that 165 psi, or 160, whatever it is, is predictable by the 6 methods of analysis that are available to me right now, and I 7 don't have to worry about the sophisticated details that come 8 with having to predict the rest of the behavioral pattern, I 9 probably know enough to say if I can make the case for that 10 160 pounds being an acceptable upper limit and I can design 11 12 the vessel so it relieves before that point, I have got a better case for accident control than I had with any of these 13 things based on ultimate failure. 14 MR. SIESS: Right. 15 MR. COSTELLO: That is certainly a more robust 16 argument if that is the one you want to make. 17 MR. BENDER: That's the one I ought to be trying to 18 make, and that's the one you ought to be trying to make. 19 MR. SIESS: I think that's the one they are about 20 ready to make on the steel containment. I think they are 21 satisfied now that if somebody will look at the details, which 22 conceivably could affect you even lower, but if they would 23 24 look at the details, that you could predict that level with a 25 high degree of reliability and you could probably predict some

other level with somewhat less reliability because there is 1 always the guestion of completeness; right? And they don't 2 propose to do any more tests on steel containment. 3 MR. COSTELLO: No. As far as we are concerned, the 4 ballgame is over from a research point of view. 5 MR. SIESS: Now for concrete containments, what you 6 would hope to get out of the test is some similar surprises or 7 details or -- I hate to use the word "outliers" or something 8 of that sort. But that can be overcome by a suitable analysis 9 and end up on the same state with the concrete containment. 10 MR. BENDER: Let me go back to the other point that 11 I was trying to make. Sequoyah had an analysis. If I were to 12 take one of these analytical methods and relate it to 13 Sequoyah, what answer would I get? 14 15 MR. SIESS: Oh, you could predict 165 --MR. BENDER: For that particular vessel, in 16 comparison to what they did get. Do you understand what I'm 17 trying to say? 18 19 MR. COSTELLO: Sure. MR. BENDER: Let's get a real case and compare it 20 with a model so we have something that exists, that we can 21 make a case with. 22 MR. COSTELLO: Well, let me tell you how we are 23 going to close this thing out. We are going to have -- it is 24 part of this question. We are going to examine the question 25

of how different details in the population might lead you to something like this. Just as we examined previously how different penetration designs -- as part of doing that examination, we are going to be looking at what kinds of modeling would have to be done for real penetration, and real details in reinforcement. And those kinds of calculations will be done on a sampling basis.

8 The real answer is, to my thinking, that the persons 9 most capable of giving a good analysis of the containment are 10 the people who designed them.

MR. SIESS: But, Jim, you take the Sequoyah analysis and use the smeared stiffeners, ignored the penetrations, except for looking at the capacity for buckling and so forth. The prediction that that analysis made of the general yield -if you tested the model of Sequoyah, if you tested Sequoyah, don't you think there's a very high probability that it would reach that pressure --

MR. COSTELLO: I would say virtually certain, yes, 18 19 sir. And in fact Gryman has done that calculation already. 20 MR. RICHARDSON: It seems to me Mike is asking, look, a few years ago in an atmosphere of a lot of ignorance, 21 22 they made some predictions. Doesn't it make sense now to go back and revisit how well they did, using today's technology? 23 24 MR. SIESS: I don't think you have to go back, 25 because all they did was look at free field, smeared the

stiffeners and --

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MR. RICHARDSON: It seems to me, though, it may not 2 be a big deal to do, but an interesting --3 MR. BENDER: My reason for wanting to do is 4 pragmatic. It says, look, here is a case we had out here, 5 here is how the research would have influenced that action. 6 If you did what Jim did later and looked at all the variations 7 that have to be thought about, I think that is a constructive 8 thing to do. 9 10 MR. SIESS: But, Mike, I think it has already been done. 11 MR. BENDER: I know, but they haven't put it out 12 there where people can see it. 13 MR. RICHARDSON: But it would lend credibility to 14 15 what we have done. 16 MR. SIESS: This shall reach general yielding, which is all the Sequoyah analysis was. 17 MR. BENDER: I think it would show that one of those 18 methods was the right one to use. 19 MR. SIESS: To predict general yielding. That it 20 21 wouldn't fail --MR. BENDER: That was enough for them at the time. 22 MR. SHEWMON: Mr. Chairman, are we at 9:30 or 10:30? 23 MR. SIESS: Well, we are closer than you think. 24 I have suggested to Jim Richardson that we will skip 25

seismic performance of containments, which is clearly in the future, and pick it up at some other time. But I think we should have you -- can we go on now to penetrations, and then we will take a few minutes and see what time it is and talk a little bit about the EPRI stuff.

MR. COSTELLO: I guess if I could say I'd like to 6 7 get the last word in on the steel models. Basically we are not prepared to declare total victory yet, but we are having 8 this one set of closeout calculations in which someone else 9 will try different but equivalent code to see if they 10 11 reproduce those effects, and also look at the question of, if 12 you look at something like Sequoyah -- which in fact this person has looked at before, and look at some of the details, 13 would you come to the conclusion that you would get the 14 15 membrane yielding, or is it something you would have to model? And I think at the end of that we can claim that the 16 game will be over and the good guys have won. 17

18 MR. SIESS: But in the meantime, would you try to 19 convince some of these people that they ought to decide what 20 they are going to do with this?

Okay, let's go on to Hans, and he will describe what Sandia is doing on large hatches, small hatches, and pipe penetrations.

24 MR. EBERSOLE: Chet, while he is getting ready, it 25 always bothers me that if a failure occurs prior to core

1 damage, which can be a sequence of events, if the failure occurs in the regressive context, that it blows into the aux 2 buildings of that region where the penetrations generally are, 3 4 that will virtually guarantee core failure and disaster. 5 If it can be made to fail some place into open atmosphere, you have still got a chance. 6 MR. SIESS: Well, we could probably arrange that. 7 8 MR. ASHAR: Before I start on penetrations, let me make a little remark on Sequoyah. 9 Sequoyah has been looked at guite closely in NUREG 10 11 1037 on leak rate estimates in which, as far as I remember, at a peak pressure or peak acceleration pressure for the worst 12 case scenario, they are predicting the pressures which does 13 14 not prove the leak-before-break hypothesis. 15 The leakage is so small for penetrations in all the other areas that they have examined, they figured that if the 16 pressure was any higher than what they had predicted, it would 17 rupture the containment rather than leakage. 18 MR. RICHARDSON: Hans will discuss this later. But 19 20 Mike's point is, it is in essence a PR -- an excellent one. MR. SIESS: NUREG 1037 chose Sequoyah, and you would 21 have gotten a different answer if you had chose McGuire, which 22 23 is the same design of plant but a different design of 24 containment. 25 [Slide.]

MR. ASHAR: I am going to show first the boiler 1 plate slides on the project, and then I will show you some of 2 the work that has been done in the past, and what will be done 3 in the future, and then some of the sketches of the pressure 4 chambers. 5 6 This is with Sandia National Lab, and the budget for '85 was 900K. For '86, it has been earmarked for 900K. For 7 '87, it has been marked down to 600K. 8 9 We wish to complete most of the seal and gasket testing and probably most of the needed tests for the bellows 10 for the fixed penetrations. 11 12 [Slide.] The issue, I think it has been pointed out quite a 13 14 number of times by the ACRS members, that leak-before-break is 15 the one that we should examine more closely than anything else, and this is the attempt to do that. As to whether the 16 17 containment will rupture first, or there will be leakage enough through the various penetrations in the containment 18 that that will start depressurizing the containment. 19 20 So the issue is basically the analytical prediction 21 of the containment failure modes -- that is what will be the failure mode, will there be leak-before-break or break of the 22 23 containment. 24 The objective is to determine the major characteristics of operable and fixed containment penetrations 25

that could contribute to leakage during severe accidents. 1 The effect of pressure, temperature and deformation 2 must be studied. 3 Now let me define for you, if there are some who are 4 not aware of it, what our operable and fixed penetrations 5 are. There are obvious terms, but still operable penetrations 6 7 which are likely to be opened and closed during the operating 8 years. MR. SIESS: Other than values? 9 MR. ASHAR: Other than values. Values are operable, 10 11 but they are not included in this project. What comes out are equipment hatches, air locks, 12 escape hatches, drywell of the BWR head, and maybe in some 13 cases fuel transfer tubes which are blind flanged, but they 14 15 are operable, they can be opened and closed. So these are the operable penetrations. The others 16 17 are piping penetrations which are considered fixed 18 penetrations. MR. RODABAUGH: When you use the term 19 leak-before-break, are you thinking of gasket leakage or 20 21 mechanical? 22 MR. ASHAR: We are thinking of gasket and seal 23 leakage. 24 Integration. It has been pointed out before that 25 the three projects are closely integrated. In addition, the
valve leakage program, as well as the electrical penetration 1 and assembly program, they are all integrated to assess the 2 containment capacity. 3 MR. SIESS: The term leak-before-break here is 4 different. It means anything that happens before the 5 containment ruptures. 6 MR. BENDER: Yes, it is a different kind of leakage. 7 MR. SIESS: Yes. But they just adopted the term 8 here. 9 MR. BENDER: They ought to fight not to use it, 10 because it confuses people. 11 [Slide.] 12 MR. ASHAR: This project was initiated in 1984. The 13 first thing that has been done was to survey penetrations. We 14 really didn't know what type of penetrations exist, what type 15 of seals and gaskets are used in penetrations, what are their 16 configurations and sizes, their types, and the materials, et 17 cetera. 18 So the first thing that was done was a survey of the 19 existing operating plants to see as to what are the parameters 20 that we ought to look into as far as testing was concerned. 21 I will go more into detail along with the survey 22 results. 23 24 That was done prior to FY '85. In '85, basically what has been done is testing of 25

seals and gaskets. Seal and gasket tests have been done.
 Some of them have been done at Sandia National Lab in the
 pressure chamber. Some of the tests have been done at Argonne
 National Lab, and by a subcontractor.

5 In '86, we plan to complete the seal and gasket 6 tests and complete the air lock tests.

7 I pointed out during the presentation of containment 8 model tests that air lock in the model does not represent the 9 real air lock. It doesn't have an opening in the bulkheads 10 required, et cetera. That's why we are going to test one air 11 lock which we have procured at a bargain price. I will show 12 you the schedule later.

13 Procurement of bellows and development of test
14 plans. This will be done in 1986 so we can test the bellows
15 in 1987.

[Slide.]

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In '87, the evaluation of the air lock test and performance of bellows test. The regulatory use in a generic way, it is the same as before. Confirmatory assessment of severe accident policy statement, and the basis for possible addition of containment performance requirement for safety goal implementation.

But in detail, there are quite a number of uses.
The first thing, it has been used in preparing NUREG 1037,
which is going to be a part of the severe accident reporting.

Also, we are making a move to have some of the 1 results used for the standards committees, such as the 2 replacement of gaskets and seals. Right now there are no set 3 requirements that people have to replace certain gaskets. 4 We will try to push that kind of idea into the ASME 5 Section 11 committees, and there are a lot of details which 6 have been learned from this testing which we will be 7 transferring to the code committees which would be of use for 8 9 modifying the codes and standards. MR. SIESS: Hans, who has the job of looking at 10 pre-existing leakage? NRR? 11 12 MR. ASHAR: That particular project is under John Wang in Containment Systems, NRR. BNL has looked at it. And 13 he has some of the results. 14 15 MR. SIESS: And they don't call that research? MR. ASHAR: They call it technical assistance, 16 because it helps them in assessing as to what is available. 17 [Slide.] 18 Now I am going to give some details of what has been 19 done. A survey of mechanical penetrations. The survey was 20 conducted by Argonne National Lab under subcontract from 21 Sandia National Lab. 22 A preliminary analysis of some of the structural 23 analyses was done by Argonne and later on by Sandia National 24 25 Lab.

1 Tests on penetrations are being performed by Sandia, and Idaho National Lab. 2 An investigation of electrical penetration 3 assemblies is being conducted in another program, which I 4 pointed out before. 5 [Slide.] 6 MR. SIESS: That is in another program because it 7 8 started out under qualifications. MR. ASHAR: That is correct. 9 [Slide.] 10 Program steps are: survey of penetration types and 11 designs performed by ANL on 48 U.S. plants. 48 plants, I 12 13 think, is a good sample. It's about half the available sampling, and attempts were made to make sure that there is 14 enough PWRs, enough BWRs, enough steel in the prestress and 15 reinforced concrete containment, because the inside is 16 17 different in each of those cases. MR. SIESS: There is a report out on that. 18 19 MR. ASHAR: There is a report out on it, and it is available, yes. If anybody is interested, I can send it to 20 21 them. Qualitative figures of merit developed. Figures of 22 23 merit is a matter of finding out which are the parameters in the operable penetration assembly. As to how the sleeve 24 length, how the diameter, how the thickness of the collar or 25

thickness of the reinforcing plate around the sleeve would
 affect the potential performance.

These are figures of merit according to what is considered as more important than the other. So that we can figure out what we should do and what we should keep in our minds. And that also is in that particular report. If any of you are interested, I can send these reports. MR. SIESS: I think what you omitted was those 48 plants yielded about several hundred different types of

MR. ASHAR: Oh, absolutely, yes, they did. 11 Preliminary analyses were conducted based on the 12 13 survey. They came out with some typical design for analysis 14 purposes as to what a typical -- really, it's not typical, but just for the purpose of analyses, to get an idea about what is 15 predominating. The preliminary analysis -- there is a report 16 17 on those analyses, too. So if anybody is interested, I will 18 be able to transmit the reports to them.

Program plan developed and conduct the program. I
 will be getting more details on those.

21 [Slide.]

penetrations.

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Experiments and analyses of penetrations. The shell structure interaction, equipment hatch and personnel air lock. They were all tested on a 1/32nd scale, 1/8th scale steel model, as well as they will be presented in a 1/6th

1 scale concrete model.

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2	The equipment hatch with seal, 1-to-8 scale steel
3	model, had one type of seal there. The equipment hatches, two
4	pressure seating and one unseating in 1/6th scale reinforced
5	concrete model, I showed you before in the concrete model.
6	[Slide.]
7	MR. SIESS: Excuse me. Is it clear to everybody
8	that what we are looking for there is deformation, such that
9	the two metal surfaces separate far enough that the
10	elastomeric seals are no longer sealing?
11	MR. RODABAUGH: I was about to ask a question on
12	thøt.
13	MR. SIESS: There are two issues. One is the
14	deformation that occurs, and the other is the elasticity of
15	the integrity of the seal material which might degrade with
16	temperature.
17	MR. RODABAUGH: Car Wet scale I was wondering
18	about that 1/8th and even smaller scales. Assuming the
19	elastomer seals.
20	MR. SIESS: Those were the tests you just saw. And
21	all they used those for were to get the effect of the shell
22	behavior in the deformations. The other tests are not being
23	scaled.
24	MR. RODABAUGH: Okay. The ones that I was just
25	looking at are not

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MR. ASHAR: They were performed separately, and will 1 be integrated together when the final reports come out. So as 2 Dr. Siess pointed out, the deformation is how the structure in 3 general will affect the deformation on the sleeves, on the 4 penetration. 5 MR. SIESS: They have seals in there, but they don't 6 7 expect to get definitive answers with those particular seals. It's just illustrative. 8 9 MR. ASHAR: A full sized personnel air lock will be tested in '86. 10 Expansion of bellows in '86, '87, and drywell head 11 12 for BWR Mark I and Mark II analyis did not indicate a need for experiment. 13 I will have a little bit on the drywell head later. 14 MR. SIESS: That was interesting. It started out 15 16 being pretty bad. MR. ASHAR: Yes, it did. 17 [Slide.] 18 19 MR. SIESS: Can you get to pressure without the temperature? 20 MR. ASHAR: Well, in the Limerick study done on 21 NUREG 1037, they predict leakage at very low pressure, around 22 86 psig or something for Mark II containment, only considering 23 the pressure, and if the temperature is included, then it just 24 so happens that it sinks back, and there is no leakage until 25

up to 130 psi. I will be elaborating on that a little later. 1 Pressure seating equipment hatches. Models for 2 predicting the deformation and leakage for pressure seating 3 hatches in the steel containment were verified by the 1/8th 4 scale steel model test. Jim showed some of the slides and 5 they have been discussed before. 6 7 Significant interaction between the cylinder and the penetration sleeve occurs. That is quite a legitimate 8 9 concern. Average membrane strength from 2.3 percent up to 5 10 percent must arrive before the sleeve deformation is 11 sufficient to cause a mismatch that results in leakage. We 12 13 are up to 2.3 to 5 percent, and they do occur in the 14 discontinuity areas in some places. 15 MR. BENDER: When you talk about membrane strains in 16 this case, what are you talking about? What part of the 17 membrane? MR. COSTELLO: Free field. That's one of the back 18 calculations I referred to. The range was a factor of two, 19 20 looking at existing typical penetration geometries, and in 21 that experiment, some of the low end would surely have leaked 22 before we had the rupture, and some of the high end surely would not have. 23 24 MR. BENDER: Can you generalize, tell me that is 25 typical of all shells?

MR. COSTELLO: Of steel models, it certainly -- you 1 can generalize that one of the population would leak before 2 they break, and some would break before they leak. 3 MR. BENDER: Until I get the 2.3 percent strain, 4 none of them would leak? 5 MR. COSTELLO: I would be hesitant to do that 6 7 without looking at the penetration design itself. But of the population they found, the one that had the thinnest or 8 skimplest reinforcing still took that kind of free field 9 10 strain before --MR. SIESS: Jim, you had a couple of small scale 11 12 models that ballooned. What kind of strains did they reach? 13 MR. COSTELLO: I believe it was around 15 or 16 14 percent. 15 MR. SIESS: Now you could generalize, I think -- or could you generalize and say that a real containment with 16 hatches in it could not reach 15 percent without leaking? 17 MR. COSTELLO: Absolutely. That one I will go for. 18 19 MR. SIESS: Okay. Every little bit helps. MR. BENDER: I've got even more of an axe to grind. 20 21 I would like to be selective in the seals that I want to leak, 22 and if I am selective, I can make the leak go where I want it 23 to go, and when you're doing something like this, that's part of what you want to be able to display. 24 MR. COSTELLO: I think it is fair to generalize that 25

1 if your choice is the large diameter equipment hatch and you are willing to take the leakage there, then that should be 2 rather easy to arrange. 3 MR. BENDER: But that's not where I want it. 4 That thing is too big, and I can't --5 MR. SIESS: Suppose you used a metal O ring on the 6 equipment hatch. Would it keep the local leakage down if you 7 still have regulations on that? And about what membrane 8 strain would that start to leak? 9 MR. COSTELLO: I'm afraid that's too complex a 10 question for me to try and wing off the top of my head. 11 12 MR. ASHAR: Let me address that question. If PWR conditions, as I will show you later on, probably you would 13 not need to go that far to use the metal rings --14 15 MR. SIESS: I'm talking about an equipment hatch. MR. ASHAR: Even for an equipment hatch in a PWR, it 16 17 won't be necessary. I will show you by the seal and gasket test we have performed. For a PWR, that is one of the 18 19 possibilities that we should look into. 20 MR. SIESS: You said the BWR drywel head wouldn't? MR. ASHAR: Oh, yes, BWR is a different thing we 21 should think about, I'm saying. 22 23 MR. SIESS: All right. Now I was talking about the equipment hatch for duy containment. 14 to 20 foot hatch. 24 MR. ASHAR: Yes, okay. For that, I don't think it 25

will be necessary to go to that type of failure break. It is 1 an elaborate system, but I'll show you that it is not of 2 3 concern. [Slide.] 4 Now back to the drywell head analyses. The CPWG, 5 which is essentially NUREG 1037, shows that there will be 6 unseating of drywell head due to internal pressurization at, 7 as I pointed out, approximate 86 psig or something. And then 8 substantial amount of leakage in the Mark I and Mark II 9 10 containments. 11 However, the conclusion is based on analysis that did not take into account the effect of elevated temperatures 12 which are also present in the accident. 13 14 Argonne National Lab and Sandia have conducted independent analyses to show that these elevated temperatures 15 inside the containment are considered in the analysis. 16 Metal-to-metal contact will be maintained between the sealing 17 18 surfaces, thereby precluding leakage. 19 Differential thermal expansion between the drywell head flanges, which house the seal, and the bolts which attach 20 the drywell head to the lower part of the containment, have 21 the effect of additional preload on the bolts, thereby 22 substantially increasing the pressure needed to unseat drywell 23 24 heads. I will show you some of the sketches on this --25

1 MR. SIESS: I don't think you need to go into that. MR. EBERSOLE: Is this due to the thermal gradient 2 across the metal? 3 4 MR. ASHAR: Yes. Basically this is due to the difference between the flange of the drywell and the bolt 5 outside. 6 MR. EBERSOLE: It's like a fin? 7 8 MR. ASHAR: Yes. There is a fin going out there, and then there is a bolting on top of it. The bolt tension 9 keeps it compressed because comparatively it is in 10 11 compression. 12 MR. SIESS: Are there any scenarios which would give 13 you the pressure without the temperature? 14 MR. ASHAR: That also I will look into. MR. EBERSOLE: Well, surely ATWS does. 15 MR. SIESS: No, you've got to have a coremelt to get 16 anything in there. 17 MR. ASHAR: There is one scenario in a BWR that I 18 recall. 19 20 MR. SIESS: Inside the vessel, the drywell head, not the vessel head. 21 MR. EBERSOLE: I'm offbase, yeah. 22 23 MR. SIESS: This drywell head. [Slide.] 24 25 MR. SIESS. The drywell equipment hatch is pressure

1 unseating?

2	MR. ASHAR: You mean the BWR equipment hatch? No,
3	they are pressure seating, most of them.
4	MR. SIESS: On the inside?
5	MR. ASHAR: From the inside. Now a little more in
6	drywell head analyses. Argonne National Lab used a
7	sophisticated finite element approach, whereas Sandia derived
8	closed form solutions based on the strength of materials
9	approach.
10	Sandia analyzed the response of drywell heads in
11	eight containments. There were significant differences in the
12	drywell head diameter, flange thickness, number of bolts, bolt
13	diameter and bolt preload, which is quite important, within
14	this group.
15	Only one of the eight unseated at the maximum
16	accident pressure of 120 psig, and the gap was less than 2
17	mils, which would most likely be closed by the seal material.
18	There are significant conservatisms in Sandia's
19	analysis, and the actual separation pressure is probably
20	higher.
21	Based on the analysis, the test of the drywell head
22	was not felt to be necessary, so we have been able to
23	eliminate that elaborate test.
24	[Slide.]
25	Pressure unseating equipment hatches. A pressure

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unseating equipment hatch will be tested in the 1-to-6 scale 1 reinforced concrete model. I have shown you there will be one 2 equipment hatch model in the reinforced concrete model which 3 will have two, an inner cover and an outer cover. 4 The outer cover will be tested first as a pressure 5 unseating type of cover. The same methodology used to analyze 6 drywell heads will be used to analyze the pressure unseating 7 hatch. 8 Data from the test, gap measurements, compression in 9 the flanges, will be used to assess the method. 10 [Slide.] 11 Personnel air locks. Tests will be conducted in FY 12 '86. The air lock has been procured. The RFQ will be going 13 out to the public somewhere next month or the month after, as 14 I understand, for test facility, where the testing will be 15 conducted. 16 17 The preliminary analyses suggest that no significant interaction occurs between the shell and sleeve, and the door 18 and bulkhead will undergo locked deformations associated with 19 20 bending. That is the basic reason for conducting a separate 21 22 test for the air locks. 23 The first thing, there is no significant interaction between the shell and the sleeve of the air lock, because the 24 25 air lock sleeve is quite a bit protruding out of the shell

liner or in the steel containment and steel face. 1 MR. SIESS: It seems to me there has to be an 2 interaction between the shell and the sleeve, but the effect 3 on the sleeve doesn't carry out to where the doors are. 4 MR. ASHAR: That is what it is, yes. 5 Finite element analyses will be performed with the 6 actual material properties and a leakage criterion will be 7 proposed prior to the test. 8 MR. SIESS: So it is just the bending of the door. 9 MR. ASHAR: And the bulkheads, yes. 10 11 [Slide.] MR. SIESS: What about the doors that have -- I 12 don't know what you call it, a mechanical lock where it 13 actually rotates and slides in and locks it tight? Are those 14 15 considered? MR. ASHAR: In the personnel air lock? 16 MR. SIESS: Yes, in the personnel locks. 17 MR. ASHAR: All these personnel locks have a hinge 18 on one side and they have been bolted on the other side by 19 20 bolts. 21 MR. SIESS: Yes, and what holds them shut? What squeezes that seal? 22 MR. ASHAR: I will show you the sketch of the air 23 24 lock later. 25 MR. SIESS: Okay.

MR. ASHAR: Test on seals' materials. As a result 1 of the survey that was done on the 48 containments, these are 2 the four materials of importance, but the most used materials 3 are the silicon rubber and the EFI/EPDM material, which is --4 I don't remember the whole name. It's a polymer, some kind of 5 a polymer material, with specific material properties on it. 6 Viton has been used on a few plants in some of the 7 penetrations, and unspecified rubber or neoprene has been used 8 on some of the older plants. 9 We will be doing some tests, trying to get samples 10 from those plants. 11 MR. SIESS: These are for both kinds of locks? 12 All types of operable penetrations. 13 MR. ASHAR I thought some had inflatable seals. 14 MR. SIESS: MR. ASHAR: Yes, that I have not shown, but that is 15 a different configuration. But the material will still be in 16 17 the same range. Cross section geometry. There are O rings, dog ears 18 19 and gumdrop and tongue-in-groove type. 20 I might show some of them. I might have some slides 21 to show them. MR. BENDER: Some of these seal materials are more 22 temperature-sensitive than others? 23 24 MR. ASHAR: That is correct. I will show you some slides on how bad they are. 25

[Slide.]

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2 Tests on seals. Environment. The seals will be 3 aged and unaged. Both will be tested. Aging will be thermal 4 and radiation exposure before test.

5 Now on the tests that have been performed at Sandia, 6 they will undergo both types of aging, radiation and thermal, 7 but the tests which are being performed at Argonne National 8 Lab will only undergo thermal aging, because they don't have 9 the facility to do the radiation. But we will be able to get 10 a simulated comparison as to what the effect of various aging 11 is.

12 Pressures will be up to 160 psia. I will be showing 13 you the sketches on the pressure and temperature later on.

14 [Slide.]

15 The test set-up pressure chamber. I will be showing
16 you the pressure chamber.

Saturated or superheated steam, heated air or
 nitrogen.

Sandia in all cases will be superheated steam.
Sometimes they might use saturated steam just to get the
comparison as how it will influence the material properties.
At Argonne National Lab, they are only using
nitrogen, heated nitrogen.

The mating surfaces, metal-to-metal contact,
 prescribed gap, rotational surface, machine-inclined.

Metal-to-metal contact, there will be another prescribed gap, 1 but the gap will depend upon 48 mil or 10 mil, and the 2 rotational one-surface. 3 This is to simulate the potential rotation that that 4 particular mating surface would undergo because of the shell 5 6 deformation. There will be three rotations that we will be 7 8 examining. 9 MR. SIESS: On the door deformation? Not just the shell? On equipment hatches it is door deformation, isn't it? 10 MR. ASHAR: Yes. Yes, that is correct. 11 [Slide.] 12 Future work. Complete tests on seals, investigate 13 effect of aerosols on leakage, test personnel air lock, 14 15 equipment hatch, test reinforced concrete model. These are the things I already mentioned. 16 17 [Slide.] Let me show you some of the sketches which might be 18 19 of interest to you. This is the test chamber at Sandia National Lab. 20 This is the whole chamber, and these are the three lengths of 21 22 fixtures in the seal stage. I will show you a separate sketch of this particular assembly, but this will be exposed to the 23 severe accident pressures and temperatures inside, like a 24 pressure seating kind of condition. 25

MR. SIESS: And leakage will be measured? MR. ASHAR: The leakages will be measured. [Slide.]

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Let me show you the profiles under which the seal tests are conducted. This is a PWR accident scenario. The pressures will be going from here to here (indicating) at 155 psia, will be PWR conditions, temperature will start from 293 or something and 361 degrees will be the highes: temperature maintained for FWR conditions. And these are enveloped --

10 MR. BENDER: With regard to the air locks, somebody 11 pointed out once that the way these air locks are designed, 12 the outer air lock -- there is a chamber between the inner air 13 lock and the outer air lock which reaches a temperature 14 barrier. Does that influence what is up there?

MR. ASHAR: These temperature-pressure profiles are 15 containment air profiles. They are not even at the site of 16 the containment, which is lower than what they are shown here. 17 MR. SIESS: That's what the inside door will see, 18 and what the outside door will see if the inside door failed. 19 20 MR. BENDER: Well, if it failed -- even if you get a leak there, if it's stagnant, they'll have a big insulator 21 there. I am just asking because it may have an influence --22 23 MR. SIESS: You could get the pressure on the outside door, but you are not likely to get temperature. 24 MR. EBERSOLE: I would like to raise a question 25

about these air locks, including both the equipment as well as
 personnel. I think they are an anachronism.

3 MR. SIESS: They are there, Jesse.

MR. EBERSOLE: I know, but they look like submarine 4 air locks, and we have long since departed from the thesis 5 6 that we don't have a moment in time to exposure ourselves to an open containment. As a matter of fact, containments for 7 years ran with open purge valves that you couldn't even shut. 8 32 inch butterflies. They couldn't even shut them against an 9 inflow from a LOCA. There had to be revolution that had to be 10 imposed on NRC to get those things fixed. 11

12 So we have run, therefore, in the presence of wide 13 open containments blowing air through them that didn't have a 14 ghost of a chance of shutting up for a LOCA. In the meantime, 15 we go to the ridiculous opposite extreme of having to double 16 ourselves through this lock, thus saying I can't expose myself 17 to an open containment for five minutes while I go through.

18 MR. SHEWMON: When the Westinghouse advanced reactor 19 subcommittee chairman gets through with that, I hope they have 20 something in it about better containments that don't have 21 these problems.

22 MR. EBERSOLE: Well, I just want to recognize the 23 curious contradictions in our logic.

24 MR. SIESS: Well, there's a proposal from RDA for an 25 unpressurized containment. It just vents out through a

system. You would like that one. 1 2 [Slide.] MR. ASHAR: This is a BWR profile for pressure, 3 4 which the maximum is 135 degrees. [Slide.] 5 This is a BWR profile for temperature, which some 6 people say is not conservative enough. Some of the studies 7 have shown the temperatures as high as 1000 degrees, but the 8 consensus showed that. 9 10 MR. BENDER: Did you say that's not conservative 11 enough? 12 MR. ASHAR: Yes. We heard from the IDCOR study using some code, I don't remember, and Oak Ridge did some 13 14 studies which showed that the temperatures could be much 15 higher in certain severe accident sequences than 700 degrees. 16 MR. SIESS: Is this hydrogen burning? MR. ASHAR: No, there's no hydrogen burning; just 17 core-concrete interaction giving very high amount of energies 18 19 and temperatures. MR. SIESS: Because there is an issue, isn't there, 20 about hydrogen coming out of the wetwell and burning as it 21 escapes, in the MARK III? 22 MR. ASHAR: Yes. I don't know the exact reasons, 23 but some people do think the temperatures will be higher in 24 certain BWR severe accident scenarios. 25

1 But we had modified this particular chamber from 500 degrees to 700, and we are not ready to do 700 to 1200 degrees 2 because it is guite a job to change the chamber from one to 3 another. And everyone said that this would give us enough 4 idea about the material properties. And we will see from the 5 results that it does. 6 7 [Slide.] MR. RICHARDSON: But Hans, how will you eventually 8 answer the question of these people that are claiming 1000 9 10 degrees? That would not be an acceptable answer, that our test fixture wasn't high enough to get it. 11 12 MR. SIESS: Have to look at the probabilities, Jim. 13 MR. ASHAR: You will see in some of the results on seals and gasket that by 700 degrees, those things deteriorate 14 to such an extent, it doesn't matter 800 degrees or 1000 15 16 degrees. 17 MR. SIESS: Yes, but at 1000 degrees I'd start worrying about the steel. 18 19 MR. ASHAR: That's correct. Yes. 20 [Slide.] These are the assemblies for the three parameters. 21 We wanted to see the scale effect as to the parameter is 22 larger, is the leak rate larger. That's why we've got three 23 separate diameters here. And these are the channels through 24 25 which the leakage will be monitored. It gets into one

1 particular place and --

MR. SIESS: Where is the test specimen? Where are 2 the seals you're testing. 3 MR. ASHAR: The seals are here in the top set. 4 5 MR. RODABAUGH: How long are you going to run these tests? How many hours? The length of time? 6 MR. SIESS: You saw the curves. 7 MR. RODABAUGH: But I didn't make a note of it. 8 Twelve hours or something like that? 9 10 MR. ASHAR: They will be going for around 12 hours or so at the highest temperature. First, at the PWR pressure 11 and temperature, they will be maintained at 12 hours, and then 12 it will be raised to BWR temperatures. 13 14 MR. RODABAUGH: Okay. So at 700F in 12 hours you wouldn't expect, for example, neoprene to be anything but a 15 piece of liquid. 16 17 MR. ASHAR: That's correct. 18 MR. SIESS: Incidentally, there arer test data available on seal materials, independent of these tests that 19 they're using I think to decide on those lengths. Am I 20 right? I remember seeing great big sets of curves on seal 21 materials. 22 MR. COSTELLO: Oh, yes. They are basic supplier 23 24 material tests. 25 MR. SIESS: So you know this is long enough.

Mr. Rodabaugh says it's probably much longer than it needs to 1 be. 2 MR. RODABAUGH: Yes. I was just wondering what you 3 are going to get. I was trying to imagine. If you've got 4 something like neoprene in there at 700F for 12 hours, that 5 would be a liquid. 6 7 MR. COSTELLO: The real question here is, are there, in the whole panoply of geometries and material combinations, 8 9 the first question is are there any surprises about the seal behavior beyond handbook kind of stuff. 10 The second question is, can you account for size 11 12 effect in the different diameters and different perimeters. That's the second question. 13 MR. RODABAUGH: Okay. In that test setup, were you 14 able to measure leakage in between -- it looked like you had 15 four rights on that top set. 16 17 [Slide.] MR. ASHAR: There are two rings in each of the 18 19 sections. MR. RODABAUGH: Okay. And on what pair -- are you 20 going to measure leakage across pair rings? 21 22 MR. ASHAR: They will represent something like a 23 double dog ear, or --24 MR. SIESS: Where are you going to measure leakage? You've got two rings. Are you going to measure both --25

MR. ASHAR: In between channels; aite: the first 1 seal, there is a channel. After the second seal there is 2 another channel, so both will be measured to see what goes 3 from first to second, and then how it transpires. 4 MR. RODABAUGH: What I'm thinking is some of those 5 materials at 700F the gas will be pushing through this liquid 6 7 gasket --MR. ASHAR: I'll be telling you some of the 8 results. I don't have the slide for some of the results we 9 have seen so far. 10 MR. EBERSOLE: May I ask, can the outboard door be 11 justified on the basis it will be out in a cooler 12 environment? That's the only reason I could justify it. 13 MR. ASHAR: For BWR you are thinking about? 14 15 MR. EBERSOLE: Well, any containment. MR. SIESS: Two-door personnel hatch. 16 MR ASHAR: Yes, okay. 17 MR. SIESS: The outside door will not see the same 18 temperature. It's the same problem you went through with the 19 electrical penetrations. 20 MR. ASHAR: Absolutely, that's correct. 21 MR. EBERSOLE: Well, in that case it is useful. 22 Otherwise, it isn't. 23 MR. SIESS: It just may turn out to be. 24 MR. BENDER: It's a way of getting some use out of 25

1 it. MR. ASHAR: Now let me give you some of the results 2 just from what I remember. For silicone rubber material --3 MR. SIESS: Let's don't get into results. The main 4 purpose here is to talk about what you're doing and why. 5 6 We'll explore the results at another meeting. 7 MR. ASHAR: Okay, very good. MR. SIESS: What about the bellows, the pipe 8 9 penetrations? 10 MR. ASHAR: They are being studied at this time. 11 MR. SIESS: And the mode of failure that you're 12 looking for? MR. ASHAR: In the bellows? Is the excessive 13 14 compression or twisting. 15 MR. EBERSOLE: What about the big purge valves? Those are big things. 16 17 MR. SIESS: That's another program. 18 MR. ASHAR: There's another program where purge 19 valves are being tested. 20 MR. SIESS: And we ought to look at that sometime 21 but that's not in Research and it's under the cognizance of, I 22 guess, the Containment Performance Working Group, isn't it? 23 MR. ASHAR: Purge valves are under the research. MR. RICHARDSON: That is under our Equipment 24 Qualification program. They are being tested at --25

MR. SIESS: I'm talking about the whole problem of 1 pre-existing leakage. Are the big values a part of that? If 2 they open, they open. 3 MR. RICHARDSON: Yes, right. 4 MR. SIESS: And how much they leak under pressure is 5 something else. But purge valves are the prime suspect 6 7 because they open at both ends, don't they? Containment atmosphere at one end and --8 9 MR. RICHARDSON: You mean normally open? 10 MR. SIESS: No. The other so-called isolation valves that don't open at containment and don't open into the 11 12 atsmophere. Those values open at containment atmosphere at one end and the aux building at the other --13 MR. EBERSOLE: I hope it isn't the aux building. 14 MR. SHEWMON: Who is responsible for that program? 15 MR. RICHARDSON: For the valve penetration? That is 16 under our branch and it is in our Equipment Qualification 17 18 Program. But we're also going up to severe accident conditions. 19 MR. EBERSOLE: By the way, what Chet said is 20 certainly not true, is it? Those purge valves don't ever open 21 22 into the aux building, do they? 23 MR. SIESS: I don't know where they open to. MR. RICHARDSON: I don't know. 24 MR EBERSOLE: If they do, that ought to be hammered 25

out right now and fixed. I hope they open into the annulus or
 the outdoors or something. If they open into the aux building
 --

MR. SIESS: Don't they open into some filtered area,
 or do they purge directly --

6 MR. EBERSOLE: I think they open into the filtered 7 -- the secondary system. Secondary filtrated, you know, 8 secondary containment. But if they open into the aux 9 building, Chet, we have got a regressive consequence 10 instantly.

11 MR. SIESS: Jim, could we talk about the EPRI work 12 in a very short length of time? Let me introduce it and tell 13 the other people what I think they ought to know about it. 14 And correct me if I leave something out.

EPRI is having some tests made at the Construction Technology Laboratory, the Portland Cement Association. They built a testing rig that can suggest or subject a slab of concrete of full containment thickness to biaxial in-plane tensions like it would see under pressure, and to a transverse load that it could see on a penetration, and can measure leakage.

In other words, it can stretch it in two directions with reinforcement in it with a liner on it, and it could be full scale. So they are going to be making tests on sections of a containment wall to look at what might happen through the

1 wall or through the penetration; they can imbed penetrations. Now, is that reasonably correct? 2 MR. COSTELLO: I think that's a fair estimate, yes. 3 MR. SIESS: And there's no modeling. They have done 4 some work on smaller-scale models in another area and some in 5 this area, but this is their potential. 6 7 Now, are you involved? You are following this, I'm 8 sure. MR. COSTELLO: Yes, we follow it. We are also 9 involved to the extent that usually, Dr. Tang from EPRI or 10 11 Dr. Wahl from EPRI does appear at our meetings of our peer 12 review panel. MR. EBERSOLE: Is this the Dr. Tang that used to be 13 14 up here? MR. COSTELLO: No, it's H.T. Tang, used to be G.E., 15 I believe. But EPRI does come and chat with our peer review 16 panel and lets them know of progress and that way, fill in 17 ourselves and the Sandia staff. 18 19 We have a rough idea of their test plan and in the last iteration they have been taking the benefit of 20 comment from our peer review panels to help them think about 21 what they're going to do in the outyear. 22 But their basic approach is to focus on the 23 24 possibility of premature liner failure, the so-called, as I call it, the Rashid hypothesis. 25

MR. SIESS: Okay. That's really what they're 1 looking at; to see when the liner will fail in relation to the 2 concrete behavior. 3 MR. COSTELLO: Yes. With the suspicion that --4 MR. SIESS: So that if you developed a premature 5 liner failure in your concrete model, that work could be used 6 to expand it into looking at how the anchors might have 7 affected it and so forth. 8 MR. COSTELLO: Yes, sir. 0 MR. SIESS: If you don't develop anything in your 10 concrete model and they do in their full scale model --11 MR. COSTELLO: It should be interesting, yes. 12 MR. SIESS: Okay. And if neither one of you 13 develops it, we quit. 14 15 MR. COSTELLO: Maybe. Now the other thing that they are attempting to do 16 and it's rather difficult and it's not clear yet that they 17 18 will pull it off, is to do a modeling of the basemat-wall intersection that we talked about as being so interesting 19 20 before. MR. SIESS: And the same kind of answers go. 21 MR. COSTELLO: With something less than a complete 22 wall with a segment. They have had difficulty -- and with 23 loading by a bladder. They have had difficulty in getting the 24 loading on in a couple of tries, but that should give us some 25

insight --

1 MR. SIESS: [Inaudible.] 2 MR. COSTELLO: That's something I haven't explored 3 with them. 4 5 MR. SIESS: There was something said about possibly testing a 360 degree ring of something. What's that supposed 6 7 to show? 8 MR. COSTELLO: I am not sure that that's an EPRI proposal or a PCA proposal. 9 MR. SIESS. I saw it in a report that EPRI 10 distributed. 11 MR. COSTELLO: We have certain difficulty in getting 12 EPRI plans in the same frame as we are. You see, we're 13 talking about the 1987 budget. As of now, EPRI is just 14 15 firming up their 1986 budget, so we have a timescale 16 difference. But we hope that they are able to bring off this basemat wall test and get something out of there that will be 17 beneficial to us in the model. 18 19 MR. SIESS: You had questions about scaling of your shear connectors, and that is not unrelated, I guess, to 20 Rashid's problem and what they are looking at there. Will 21 22 they do anything, varying the shear connector spacing? 23 MR. COSTELLO: I believe the series of tests they have do have different shear connector spacings and different 24

imbedments, both studs and channels. 25

MR. SIESS: Okay.

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MR. BENDER: Jim, there is another variable of this 2 thing that probably they should look at if they haven't. And 3 that is that the conformance of that shell basemat connection 4 to the concrete backup or whatever it is they've got there 5 varies all over the map, depending upon who has designed and 6 who built it and when it was built. 7 And I wonder if just one model without some 8 9 understanding of what the performance is going to be of the steel shell and the concrete will wind up being all that 10 11 meaningful. MR. COSTELLO: I think in many cases, the liner was 12 used as one of the forms, right? 13 MR. BENDER: In some cases. But even when it was 14 I think you will find that there is some uncertainty about 15 whether the concrete really was up against the steel liner. 16 MR. COSTELLO: That's one of the things we're going 17 to be looking at in our tests. 18 MR. BENDER: They may have a very good setup for 19 their tests but the real skills may be a lot different. 20 MR. EBERSOLE: I thought that had to have about an 21 inch or so of some sort of flexible membrane because of the 22 differential expansion suddenly occurring, the 23 suddenly-occurring thermal profile when you swell up the liner 24 against the concrete, and you had to leave room for it or 25

otherwise it will surely buckle before the concrete heats up. 1 2 MR. SIESS: No, the stud spacing is based on buckling. 3 MR. EBERSOLE: Isn't there an insulation pack in 4 there, though? 5 6 ME. BENDER: There are all sorts of variations in 7 that connection. MR. SIESS: Has anybody looked at, you know -- has 8 anybody looked at the variation of details in those corners? 9 MR. COSTELLO: I don't know for sure. I do know 10 that the design was chosen based on being representative, but 11 I think we would be well advised to go back and look. 12 MR. SIESS: Yes, I think somebody cught to look. 13 MR. EBERSOLE: I know one containment has insulation 14 15 and I'm not so sure that it isn't Sequoyah. MR. SIESS: That is a steel shell. 16 MR. EBERSOLE: Well, it's not that then. But I 17 remember one, they had trouble with it, Chet, this insulation. 18 MR. SIESS: That's another problem, you see. We 19 tested a steel shell with a steel bottom to it and the steel 20 shell sitting out there anchored down to a concrete base and 21 that's quite a different story. 22 MR. EBERSOLE: Well, there's some containment that 23 has this flexible, thick liner. 24 MR. SIESS: Well, some of the steel ones do because 25

1 they had to allow --

2	MR. EBERSOLE: There was a lot of trouble about it
3	not always being, you know, fully cleared of concrete, too.
4	MR. SIESS: Well, steel shells have got some
5	flexibility, they will come away from the concrete but that's
6	not the concrete liner; that is the steel shell. And that
7	concerned me because I thought the steel one was going to fail
8	at the base.
9	Your steel one didn't have a bottom head, it had a
10	flat bottom, didn't it?
11	MR. COSTELLO: No, it had an elliptical head.
12	MR. SIESS: The steel ones vary quite a bit in that
13	detail where the steel and the concrete connect. There's a
14	concrete floor in there and ? figured that was going to be the
15	weak spot and then we were going to have another problem.
16	But you know, I don't see why, in the reinforced
17	concrete containment, the phenomenon is a local bending in
18	that joint. I don't think it is three-dimensional even. And
19	if you are going to explore it, I don't know why they just
20	can't do that they can't look for leakage but they could
21	look for the mechanics of how the thing fails. At some point,
22	you've got to quit worrying about leakage and just look for
23	cracks in the steel and assume if it cracks it's going to leak
24	through it.
25	MR. EBERSOLE: I recall a detail, Chet, where at one

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point the steel actually was poured against the concrete but 1 as it turned vertical is where the insulation tore. So there 2 was a joint where a transition took place. 3 MR. SIESS: I think you're thinking about what some 4 people call the hybrids; the steel containment on a concrete 5 base. It's got a steel bottom to it and that is for 6 leaktightness, and it is not a code vessel. And those are the 7 8 ones that have a problem. Gentlemen, I think it is time for lunch. I will let 9 the Chairman after lunch tell you what time to be back. 10 11 MR. SHEWMON: How about 50 minutes. 1:30. [Whereupon, at 12:43 p.m. a lunch recess was taken, 12 the meeting to resume at 1:30 p.m. the same day.] 13 AFTERNOON SESSION 14 MR. SHEWMON: This afternoon we will hear about 15 containments of concrete, steel and piping. As I understand 16 it, gentlemen, this will deal with the extension of the leak 17 before break ideas into other parts of the primary system. 18 Without any other introduction I will turn it over to Gene 19 20 Kurtz to talk to us. MR. KURTZ: Thank you. I would like to thank the 21 subcommittee for giving us this opportunity to speak this 22 afternoon. We would like to keep the subcommittee abreast of 23 an effort that we have ongoing right now with NRR staff, which 24 has currently been received quite well by the staff and 25

management of NRR. I am referring to the Whipjet program 1 which we are pursuing which we believe will improve plant 2 safety while reducing plant costs not only during the 3 construction phase but also continue to reduce costs 4 throughout the plant life. And to explain the technical 5 aspects of it, I'd like to let Bob Cloud discuss the issues. 6 MR. SHEWMON: What is the name of the program? 7 MR. KURTZ: Whipjet is the name of the program that 8 Bob Cloud has blessed the endeavor with. 9

10 MR. CLOUD: Thanks, Gene. I was doing some work at 11 the Beaver Valley Power Plant last winter in a review mode 12 looking at the methods and the approaches being taken by Stone 13 & Webster in the conduct of the engineering qualification of 14 the piping systems.

As part of that, I realized following the trends that were going on in the industry, I realized that Beaver Valley would be in the situation in a year or 18 months where they would be installing their whip restraints just about the time that the industry decided that they weren't necessary at all, which struck me as an unhealthy situation.

MR. MARK: Are you implying that Beaver Valley has
never had them?
MR. CLOUD: No, they have always had them, but they
are building them, they are welding them in.

25 MR. SIESS: Is this Beaver Valley 2?
MR. CLOUD: Two, I'm sorry. I should have said 1 Beaver Valley 2. It's a plant under construction. 2 MR. MARK: Oh, I was just wandering in my mind. 3 MR. CLOUD: Well, that's guite all right. 4 So to that end, we thought that it should be 5 possible to put together an engineering approach to the 6 7 problem of pipe break protection that would hopefully be an improvement on the way it was planned to be done. And that's 8 what we have done and that's what I would like to explain to 9 you today. 10 11 [Slide.] 12 Our program -- this is a contraction of the terms whip restraints and jet shields. And we have labled it that 13 14 to give us a reference point. 15 Fundamentally, what we are proposing, we are proposing an alternative approach to the engineering for the 15 pipe break protection. And very specifically, we wanted to do 17 two things. The first is -- in the first place, I should 18 mention that the leak before break -- the fracture mechanics 19 technology -- has advanced in the last ten years from the 20 elastic fracture mechanics or the so-called linear elastic 21 fracture mechanics to the point where now it works very well, 22 quite adequately in the elastic plastic regime. And I think 23 it is non-controversial to say that that is accepted on a 24 technical basis, that the method works when it's applied in 25

1 applicable situations.

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2	Our approach is to through an engineering program, a
3	program of analysis and testing, to determine those places
4	where the leak before break approach is appropriate for the
5	balance of plant systems. When I say balance of plant, I am
6	talking about those systems other than the primary system.
7	Now also I should mention that Beaver Valley 2 has
8	requested, as have many others, relief from the so-called
9	arbitrary intermediate breaks, and I believe that this is in
10	the works and we'll talk about those some more in just a
11	moment.
12	In those places where the leak before break approach
13	can be shown to be appropriate, then we will implement it.
14	That is to say we will perform those analyses and that testing
15	that's required to prove that the pipes will leak before they
16	will break and that they will leak in a detectable manner, and
17	then we will review the leak detection capabilities as well.
18	An extremely important aspect of our program and our
19	approach is that in those areas where the leak before break
20	doesn't work or for some reason it's inapplicable or
21	inappropriate, we'll do the work in the conventional way. In
22	those cases where let's see, I guess I should mention that
23	most of those areas would be related to reasons that are
24	delineated in the recent Reg Guide 1061; they are laid out in
25	Volume 3

Further, in the second --

1 MR. SHEWMON: Is that a NUREG or a Reg Guide? MR. CLOUD: I'm sorry, NUREG. My mistake. 3 Another very important aspect of our work is that we 4 are attacking the issue of the dynamic effects on the pipes 5 and protecting the plant from that phenomenon alone, and all 6 those other aspects of the plant design that are related to or 7 based upon the assumptions of the double-ended break we are 8 leaving unaltered. In no way, for example, are we 9 re-examining any of the equipment qualification, nor 10 compartment pressures, nor containment pressure, nor ECCS 11 12 assumptions, nor any of those other aspects of plant design related to or based upon the assumptions of the double-ended 13 14 breaks. I wanted to go over this very slowly and very 15 carefully because we talked with the staff about this two 16 weeks ago and we got a lot of questions that suggested to us 17 that we went over this slide perhaps a little too fast. 18 MR. EBENSOLE: Is this to say that the only thing 19 you intend to do physically then is to take off some pipe whip 20 21 restraints? 22 MR. CLOUD: I'm sorry? MR. EBERSOLE. Take off some pipe whip restraints, 23 24 is that the objective?

MR. CLOUD: Our objective is to show that the leak

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before break analysis will work in the balance of plant. 1 Assume pipe breaks, then apply that approach and do not 2 install whip restraints wherever the leak before break 3 4 approach works. Yes. MR. EBERSOLE: But is it just in the context of 5 removing the pipe restraints? 6 MR. CLOUD: That's exactly correct. 7 MR. EBERSOLE: If you squirt water across 15 feet 8 and hit an electrical box you will retain that thesis? Is 9 10 that a leak? MR. CLOUD: We have two kinds of break protection 11 that we are addressing here. The whip restraints which are 12 supposed to physically restrain the pipe, and the second means 13 of protection are the so-called jet shields which are 14 protective covers placed over presumably vulnerable 15 equipment. Those two features are being addressed in our 16 17 program.

MR. EBERSOLE: And is this for just primary piping?
MR. CLOUD: No; for everything except primary
piping. Primary piping is already being addressed -MR. EBERSOLE: Oh, this is for everything except
primary?

23 MR. CLOUD: That's exactly correct; for the balance 24 of plant systems. Everywhere else in the plant where we have 25 high energy lines and whip restraints related to them.

1 MR. BENDER: Bob, I think you ought to reiterate 2 again that it's where you can show that this concept is 3 justifiable that you are arguing for the elimination. Not 4 proposing universal elimination at this stage.

MR. CLOUD: Yes, exactly. I want to emphasize 5 that. I want to reiterate it. I want it absolutely clear 6 that we are not asking for any favors, we're not asking for 7 any relief, we are not asking for any exemptions. But instead 8 what we are proposing to do is to do a serious job of looking 9 at the engineering involved in the postulated breaks, and when 10 it's possible, to apply the leak before break which we think 11 is a technologically improved means. Then we want to change 12 away from the old-fashioned, well, blindly installing whip 13 restraints in the hopes that it will do something. 14

MR. RODABAUGH: Bob, I would like to follow up on Jesse's question. I think it's a key point here. Your analysis will say that it's going to leak before it breaks. It could be a very big leak. Now you don't have the shields anymore. Just how big a leak is a leak?

MR. CLOUD: Yes, I understand that. Please know that we have not completed our program; we are just talking about doing it. We are here talking with you today, and we are not proposing to develop a situation that will expose sensitive equipment and then increase the risk of hazard. So if we have that situation, then that would

1 definitely fall in the category of a jet shield that we know
2 does some good, in which case we would leave it.

MR. RODABAUGH: Well, let me phrase it in terms of a regulatory guide or SRP's. Right now, you have in a sense postulated that you are going to get a split everywhere, for the purpose of equipment qualification, spraying on cabinets and so forth. Is your program -- or do you anticipate that you will change that part of it?

9 MR. CLOUD: I tried to say it before and I'm glad 10 you asked the question because I want it to be crystal clear. 11 Any equipment qualification that is required to be done before 12 our program will be done after our program. Our program in no 13 way, manner, shape or form affects the qualification of 14 equipment, whether it does or not.

MR. RODABAUGH: So you would assume in the case of Jesse's question that yes, you will have a leak, that it will spray on an electrical cabinet nearby.

MR. CLOUD: If that cabinet is presumed to be
 sprayed on today, or before our program, it will be presumed
 to be sprayed on after our program, whether it will be or not.
 MR. RODABAUGH: Okay, thank you.
 MR. EBERSOLE: That's whether it's got a shield or

23 not.

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24 MR. CLOUD: Yes.

MR. SHEWMON: Why don't we assume you have covered

that slide, and we may return to it but let's go on. Maybe
 you can show us what you're doing.

3 MR. CLOUD: Okay, splended.

The other thing is this. I want everybody to be 4 aware of a problem that we have and we are talking with the 5 NRR about it, and Mr. Bosnak is here and he can elaborate on 6 7 it. But we do have a bit of a licensing issue in the sense that Beaver Valley 2 will come up for their license at what, 8 early 1987, and in order for us to do this program -- we can 9 do it, we can begin now, we can do it in the next 18 months or 10 16 months, 14 months, whatever. But then we will come into a 11 situation where it will be time for Beaver Valley to have 12 13 their license awarded and they will be -- there will be some whip restraints that may not be installed because we are not 14 going to know which ones need to be installed until our 15 program is done. 16

We think, as a matter of actual fact, that there will be very, very few that will be required. But still and all, the situation will be that there will be time to load fuel and operate the plant and there will be some whip restraints not installed, and it will be necessary for the power company to get some assurance that it will be okay to install those in the refueling outages that follow.

24 We feel that that is a perfectly justified -- the 25 position to be in. In fact, we think it is a preferable

position to be in than the alternative. The alternative being 1 to close our eyes and blindly install the whip restraints. We 2 feel that there will be very few whip restraints required. 3 In the second place, we feel that there will be very 4 5 low risk of operating in the first cycle or two or three early in life with whip restraints absent because the initiation and 6 growth of cracks does, in fact, require time. 7 Secondly, any construction errors we think will have 8 been uncovered during the shakeout; that is to say, in the 9 testing before the plant goes online. And in the third place, 10 I think events have shown pretty well that in general, whip 11 restraints don't work anyway. 12 13 And so that's basically where we stand. Excuse my bluntness on this point. 14 [Slide.] 15 MR. MARK: You said whip restraints don't work. Is 16 that what you really mean, or is that you mean they are not 17 necessary or they have nothing to do? 18 MR. CLOUD: Well, I meant what I said but I think 19 20 what you said is also true. MR. MARK: What? We have been putting these in and 21 they just don't hang onto a pipe, or what? 22 23 MR. CLOUD: Well, I'm thinking, for example, specifically, we had an instance in a fossile plant of a major 24 pipe rupture which, by the way, we wouldn't have had in a 25

nuclear plant, at the Mojave Station out in California three
 or four months ago. A number of us went down and looked at
 that. Mr. Bedoin from my group went down to see it and
 Mr. Bosnak went down to see it.

5 And if that line had had whip restraints on it at 6 both ends, it wouldn't have helped any. All those people that 7 were injured would have been injured. The line would have 8 broken and everything would have been the same as in fact 9 actually happened. Whip restraints wouldn't have done 10 anything for us.

And I think in general what happens is if we are going to get a crack, if we're going to get a leak, it's going to happen in some way that we didn't think of anyway, in some location that we didn't think of, for reasons that we didn't think of.

16 MR. BENDER: Bob, in that instance it was not a 17 double-ended guillotine break?

18 MR. CLOUD: That one was a split.

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MR. BENDER: It was a split, and so it didn't follow the same mechanism that pipe whip restraints would be expected to resist.

22 MR. CLOUD: That's right. That's exactly right 23 because the pipe didn't break the way it was supposed to. 24 That's right.

What I'll be talking about today is this is the work

1 that we're going to be doing, and first I'll begin with the 2 scope of the problem.

3 [Slide.]

4 At Beaver Valley 2 --

5 MR. EBERSOLE: I can't remember, what is Beaver 6 Valley? Is it a PWR?

7 MR. CLOUD: Beaver Valley 2 is a pressurized water 8 reactor, Westinghouse primary system, three-loop plant, and 9 there are two units. One of them is now operating and one is 10 presumed or hopefully will start in a couple of years.

On the whip restraints and jet shields, where the 11 12 NRC has said that they are not needed on the primary system, we have about nine. We have also said that we need no longer 13 14 consider the arbitrary intermediate breaks; there's about 15 127. In the balance of plant, those which we are talking about today, there's about 136, and it is a sheer coincidence 16 that these turn out to be exactly half. So these are the ones 17 18 we're talking about [indicating].

19MR. RODABAUGH: Bob, by primary system, does that20include the surge line to the pressurizer?21MR. CLOUD: No. The main coolant system --

23 MR. CLOUD: Yes. The main coolant loop, right.

24 [Slide.]

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Our first jobs are to demonstrate the applicability

MR. RODABAUGH: Not the whole primary system.

of the technical approach, and there are four major tasks involved in doing that. We will talk about each of them in detail.

Secondly, after it is shown that it is applicable, 4 then the performance of the work itself to show that it works. 5 MR. EBERSOLE: In respect to the size range of 6 pipes, do you go clear down right on to the instrument lines? 7 MR. CLOUD: That's a very good question. At the 8 9 moment, and a priori, we are making no distinction as to size. We know that there has been some discussion in learned 10 circles that perhaps bigger pipes -- that the approach works 11 better, and it doesn't work so well on small pipes. And we 12 understand that, and we take that as a caveat. 13

We feel that it's wrong for us to tie our hands 14 15 before our back before we ever get started with the program. We noticed that a high energy line -- there has been an 16 instance very recently of a high energy line rupture in a 17 nuclear plant of a one-inch line at Rancho Seco, which is 18 well known to you people, I'm sure. That was a one-inch line 19 and I think it was detected very, very early and very easily 20 and very readily. 21

MR. EBERSOLE: Well, there have been others. They blow out at the welder let. I've heard of others where they blow out at the welder let. You know, where they weld it in. MR. CLOUD: Well, you're ahead of me on that one. I

don't know which one you are referring to.

2 MR. EBERSOLE: There was one on a turbine, I think 3 at Sequoyah. I'm not sure. It came out where it was attached 4 to the primary pipes.

5 MR. CLOUD: But specifically to answer your 6 question, we propose to study the entire range of sizes 7 involved, and if we find that we can't show that a detectable 8 leak will occur in the smaller lines, then we will continue in 9 the old-fashioned way.

10 [Slide.]

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11 Our first task is the stress corrosion review. Of 12 course, it's a major problem in some plants, the business of 13 the stress corrosion cracking, and it is much less of a problem in the pressurized water plants, although we feel that 14 15 in some instances it could be a problem. And our task 16 involves a specific review on a system-by-system basis where 17 we are assessing the causative factors for stress corrosion 18 cracking including stress levels, material, the environment, 19 and putting the whole picture together.

If we see either from the point of view of history or for other reasons, we think that we have a place where we can have stress corrosion cracking in a higher energy line, then that would be a cause for us perhaps to have second thoughts about taking the new approach.

MR. BENDER: Bob, I guess just speaking personally,

I don't know that much about the materials that are involved 1 in the balance of plant to know whether stress corrosion 2 cracking is a big problem or a little problem or one that 3 hasn't been thought about much. Is there some set of 4 materials or references that are around that you are using as 5 the basis for judgment, or are you going to create these? 6 MR. CLOUD: Fundamentally, Mike, we have three --7 8 MR. BENDER: If I'm getting ahead of you I'll wait. 9 MR. CLOUD: No, it's quite all right, we can discuss it. Basically, we're talking about three materials. We are 10 talking about carbon steel, A106, Grade B, and perhaps there 11 12 may be some Grade C. The carbon steels, as you know, are essentially immune to stress corrosion cracking except in 13 14 severe caustic environments. So we will look for that. The second class of materials is the austenitic 15

16 stainless 304 and the stabilized grade, 316. Those materials, 17 as is well known, in the right circumstances are liable to 18 stress corrosion cracking. The water has to be hot, there has 19 to be a chloride or other causative agent and there has to be 20 enough temperature and there has to be some stress. So we are 21 going to watch for those situations.

And further, we will review the history of stress corrosion cracking in plants of this nature. We think that -in fact, if my memory is correct, there have been instances of stress corrosion cracking in pressurized water plants. If my

1 memory is correct, they were not in high energy systems; they were, in fact, in stagnant, low energy systems. 2 But as best ! can, that is the stress corrosion 3 picture. 4 MR. BENDER: What is the third material? 5 MR. CLOUD: 304, 316 and 106. 6 7 MR. BENDER: The high pressure steam lines are what? MR. CLOUD: They are 106 carbon steel. 8 MR. SHEWMON: Bob, there has been work on stress 9 corrosion cracking of ferritic steels in BWR environments, and 10 there was a paper given at a conference in Monterey a week or 11 two ago by a man whose name I'll think of in a minute who used 12 13 to work for a Swiss turbine manufacturer, Brown-Bravera, and he started off talking about what happens in rotor steels but 14 then had also done work in waters for other carbon steels and 15 16 found that indeed, he could get stress corrosion cracking above the threshold in water, again with about the same 17 kinetics as the other, as the turbine steel. 18 19 So I agree with you, it's not normally looked upon as a problem but there are well-documented cases of it showing 20 21 up. 22 MR. CLOUD: Yes. Now, I want to be clear on what you said. Did you say boiling water reactors or pressurized 23 24 water reactors? 25 MR. SHEWMON: I said boiling water reactors because

they have a higher oxygen content and that's what it got blamed on. But he, I don't think, found that it varied much or at all with the variation of water composition, but he had not gone to extremely low oxygen, as I recall. It was not a highly caustic solution, which is what you mentioned earlier as a well-documented example.

7 MR. CLOUD: Right. Ey the way, I should mention 8 that I have Bob Romer from Stone & Webster here tod_y, as well 9 as Ron Bedoin from my group, and hopefully they are taking 10 notes on these questions.

MR. SHEWMON. Marcus Fidel was the author. He used to be in charge of materials for Brown-Bravera in the research area and is now a professor in a university in Switzerland.

MR. CLOUD: I think one of our people was at the
 conference, so hopefully we will have that information.

[Slide.]

16

Our second task, from a technical viewpoint, is the assessment of water hammer analyses. What we are doing here basically is following the guidance in NUREG-1061, which lists the series of caveats that the writers of those reports were concerned about from the point of view of applying leak before break. And water hammer or lines that are susceptible to water hammer was one of them.

24 So what we will be doing is making a specific review 25 of the transients, also the history of water hammer and assess

its potential for water hammer on a system by system basis,
and we will provide the technical justification to show that
we don't have a water hammer problem in the high energy lines
that we are addressing ourselves to.

5 If we can't show that, then we will, as I said,
6 follow the old-fashioned way.

[Slide.]

7

8 MR. SHEWMON: Let me go back to stress corrosion 9 cracking again. There has been this work of finding of cracks 10 in the joints in steam generators. Indian Point and, I guess, 11 Surry was the other, some Vepco plant. These may well have 12 had cracks in them, but that is the secondary side. Are you 13 talking primarily in the steam lines or water lines?

MR. CLOUD: We're talking about -- first I would say 14 this. Your concern about the stress corrosion cracking in the 15 steam generator is a legitimate concern, it's one of our 16 17 concerns. We're talking about the high energy lines in the balance of plant. This does include the main steam lines and 18 19 it does include a number of other lines pressurized with high 20 pressure water. And certainly, the steam generator experience 21 is applicable experience that I feel we will have to address 22 head on.

[Slide]

23

24 Another concern that the framers of the NUREG had 25 was the concern about lines which might have an overly high

fatigue usage. It's an important question for the lines that
 we are working with because normally, these high energy lines
 do not have -- except the Class 1 lines -- do not receive a
 full-fledged fatigue analysis.

5 So what we will have the job of doing is to 6 characterize the fatigue loading and the fatigue resistance 7 and the fatigue capability of our lines, which we will do when 8 we work out an approach to do that. And we will do 9 straightforward ASME fatigue analysis on a certain 10 representative number of them.

MR. SHEWMON: Does the fatigue come only from power
 cycles, or do some of these lines attach to pumps?

MR. CLOUD: Undoubtedly, there will be lines
attached to pumps, and undoubtedly we will have to consider
that form of loading.

MR. SHEWMON: I remember some outfit, it wasn't Beaver Valley, that the LER or whatever it was said this is the third time in a year that that line off a pump had broken. One wonders what kind of a clown was applying what kind of codes to keep doing the damn thing back again -- but that's enough. Go ahead.

22 MR. BENDER: It's the feedwater lines primarily 23 that you're going to be looking at, I guess.

24 MR. CLOUD: Right.

25

MR. MARK: You have spoken of high energy lines;

those are the only lines I suppose which have whip restraints. 1 MR. CLOUD: That's right. That's what we're talking 2 about. 3 MR. MARK: And there are lines in pipes which are 4 not high energy lines. 5 6 MR. CLOUD: That's correct. 7 MR. MARK: And what is the rate point between the two? 8 MR. CLOUD: 200 degrees F and 270 pounds per square 9 inch, either/or. 10 [Slide.] 11 12 MR. CLOUD: Another concern that has been raised -and this is mainly much more of a concern in the primary 13 system than in the balance of plant, but nevertheless we are 14 going to consider it -- is the potential for the failure of a 15 high energy line as the secondary or as an ancillary event to 16 the failure of the supports for major equipment. 17 18 I think the original concern grew out of the potential or the concern that the steam generator supports in 19 some plants might be vulnerable to a brittle failure, and 20 might precipitate the failure of the primary coolant system, 21 22 and so this is sort of a carryover concern, if you will, into 23 the balance of plant. Nevertheless, we will make a systematic adjustment 24 of the potential for this problem to occur. 25

[Slide.]

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What I have just described to you is the work that 2 will be performed to show that the fracture mechanics analysis 3 and the leak-before-break methods will be applicable to the 4 lines in guestion. 5 If any of the systems that we are talking about or 6 any of the postulated breaks fail the test that they will be 7 subjected to as a result of this work then, as I mentioned, 8 the whip restraints will be installed or at least earmarked 9 10 for installation. MR. MARK: You have had it on the slide, but you 11 didn't say much about it. It is necessary if it leaks before 12 13 break that you are in a position to detect the leak. There must be situations when there's a little difficult to assure 14 15 yourself. MR. CLOUD: That's correct. Yes, indeed, that is 16 exactly correct. And, in fact, that is the part that comes 17 into when we implement the program itself. We start assessing 18 detection capability so we will be talking about that. 19 MR. SHEWMON: That is one reason why small lines get 20 harder to be detected, too. 21 MR. CLOUD: That is exactly right. 22 [Slide.] 23 I will go fairly quickly through the specific 24 25 technical analyses that are earmarked for the

1 leak-before-break analyses.

2	Basically we have three components. First, some of
3	these materials, we have to be sure of their properties, so we
4	are going to get left-over pieces of pipe from the plant and
5	do the materials testing of the actual materials of the plant.
6	And the second are the two kinds of analyses that
7	are very well and exhaustively described in the NUREG, the
8	stability analysis for a throughwall crack and the crack
9	growth rate analysis of a postulated flaw consistent with the
10	tenets of Section 11.
11	MR. RODABAUGH: Before you leave the materials
12	testing, how about all these hundreds and hundreds of welds,
13	and what are you going to do about
14	MR. CLOUD: We are going to do some testing. In
15	fact, I am going to talk about that right now. Why don't I
16	just
17	[Slide.]
18	We hope it's a good question. We hope to, as I
19	mentioned, get actual material and we anticipate the need to
20	actually construct some welds, using the weld procedures that
21	are in force at the plant and the weld materials, the welding
22	rods in place at the plant, and characterize the properties of
23	those welds.
24	MR BENDER: Bob, every now and then you hear people
25	with stories about whether the right materials are installed

1 in the right lines, and while A106 pipe is very good material 2 and it is highly ductile and probably the right stuff to make 3 this argument for, how are you going to make an argument for 4 being sure that the right material is there?

MR. CLOUD: Well, I might ask for some help in 5 answering that question, but I think what we would do -- and 6 certainly my right-out-of-the-barrel answer would be that we 7 8 do feel that -- and I'm sure that Stone & Webster feels very 9 strongly about their quality assurance and their quality control programs, but we believe, and particularly for the 10 high energy lines in safety-related systems, that those 11 programs are adequate to ensure that we have the right 12 material in the right place. 13

MR. BENDER: Well, the points that need to be 14 considered, I think, are first of all that you are dealing 15 with a chemistry range that you have to worry about, and that 16 you have got a legitimate sample of the materials, of the 17 18 various types that are used in the plant, and I don't know who is going to vouch for that, but that is often difficult. 19 MR. CLOUD: Yes. 20 Bob, do you want to add anything to what I said? 21 MR. ROMER: Robert Romer, Stone & Webster. 22 What we had talked about doing -- and we are 23 interested in exactly the same concern -- was doing a detailed 24

25 review of the CMTRs, material characteristics that came in for

those three materials and determine that we do have a 1 representative sample, and work back to particular material 2 samples that will undergo the fracture mechanics test. 3 MR. BENDER: Well, that helps some. Do you have any 4 residual pieces off the pipe that's actually in there? 5 MR. ROMER: Yes, and that was the intent, to take 6 actual residual marked pieces of piping from the plant and use 7 8 them in the actual testing program. 9 MR. BENDER: Thank you. MR. EBERSOLE: May I ask a question about this pipe? 10 Is there such a phenomenon as tight cracks or cracks 11 12 that have been filled by corrosion products or crud? You know, that conceal the fact that you have lost structural 13 strength until you lose too much of it? 14 MR. CLOUD: Excuse me, I'm not sure I heard you 15 right. I tried to understand you, but I'm not sure I heard 16 17 you. MR. EBERSOLE: All right. I'll give you what I gave 18 them yesterday, the old corn meal treatment to the Model T. I 19 can fill up cracks with crud so you never know they are 20 21 there. I don't know whether such materials are generated in these loops you are talking about or not, to fill up a crack 22 and obscure the fact that you have lost structural strength, 23 but it is not leaking. 24 MR. CLOUD: We used to do it with oatmeal, as I 25

recall.

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MR. EBERSOLE: Well, call it oatmeal. 2 MR. CLOUD: In the transmissions, yes. 3 Well, our program does not depend upon a pipe crack 4 inspection. Our work is based upon the presumption that there 5 will be a priori the largest crack that would be acceptable 6 under the ASME Section 11, on the one hand; and on the other 7 hand, the analysis that we are talking about requires the 8 postulation of a throughwall crack in the pipe to prove that 9 the pipe will remain stable in the presence of that crack. 10 So whereas it is conceivable that we might have 11 cracks in the piping that would be concealed by the presence 12 13 of the corn meal, that would in no way either affect our conclusions or our program. 14 MR. EBERSOLE: Plain old rust makes a pretty good 15 16 crack filler. MR. CLOUD: That is correct. 17 MR. EBERSOLE: It swells up. So how do I know you 18 haven't got a cracked pipe that is waiting for that next 19 impulse to break it? 20 MR. CLOUD: You don't, but -- you do not know. 21 However, what we will prove to you, if we continue with our 22 program, we will prove that the result that concealed crack 23 which just is getting ripe and springs open will produce a 24 leak that will be detected, rather than a catastrophic break. 25

MR. EBERSOLE: You mean if I hit it with a hammer or 1 a jolt or water hammer or whatever, it will then spring into a 2 leak rather than a break? 3 MR. CLOUD: That is correct. 4 MR. RODABAUGH: Supposing you have a crack in a --5 well, let's take a steam pipe 24 inches diameter by 1 inch 6 thick, and following up Jesse's point, there happens to be a 7 longitudinal seam in this pipe, and that is the point where 8 the crack is developing. 9 It now, under Jesse's postulant, might grow to be 10 seven feet long. Now when that pops through, that is an 11 unstable crack. You are not going to show by fracture 12 mechanics, unless we are talking of a different definition of 13 break. To me, that would break. It will be an unstable 14 15 failure. MR. CLOUD: I think what you are saying is that you 16 are visualizing that there will be some circumstances where it 17 will not be possible to show that there will be a leak before 18 break; is that what you are telling me? 19 MR. RODABAUGH: Depending a bit on just what you 20 mean by a break. Circumferential breaks are one thing I 21 think you could almost rule out, and longitudinal braks are 22 something else. 23 Yes, there may be longitudinal breaks where you are 24 going to have a hard time showing that it can occur. 25

MR. CLOUD: That's right. And we said we 1 anticipated that circumstance, and we have said at the very 2 outset -- and I am glad, in fact, that you brought it up, 3 4 because I don't want to lose the opportunity to become repetitive on this point. 5 [Slide.] 6 But I want to bring back my first slide again, to 7 say that we are going to retain the rupture restraint in the 8 areas where the leak-before-break is not applicable. 9 10 So I am going to keep this one handy, and I want to say that we definitely have what we hope -- we hope that we 11 12 have got -- for lack of a better term, I will say a more 13 intelligent approach to the pipe break protection by using --14 by making use of the program that we have, which envisions several different ways. 15 16 MR. RODABAUGH: Is it not true that a longitudinal 17 split requires much less in the way of pipe whip restraints? 18 MR. CLOUD: As far as I am concerned, a longitudinal 19 split -- a pipe whip restraint doesn't do any good on the 20 longitudinal split, anyway. And so probably they wouldn't be 21 there. But it might be that there would be some jet shields nearby because of that. 22 23 MR. RODABAUGH: Yes. 24 MR. BENDER: Bob, you stated that you are going to 25 make your argument around the Section 11 inspection limit, and

I guess I am not all that comfortable with the assurance we 1 have that inspection process under Section 11 for this raft of 2 piping we have got out there necessarily will give you the 3 confidence that you have exposed all the cracks that are 4 within the limits. 5 I think in a statistical sense they find most of 6 them, but how much does the argument hinge on Section 11 7 inspections? 8 9 MR. CLOUD: Well, not really at all. It really doesn't hinge on the Section 11 inspections at all, because 10 part of our methodology is to assume that --11 12 [Slide.] -- this is the testing, this is the crack stability 13 14 analysis, and this is the crack growth rate analysis. This is an entire class of analyses which is based on beginning with 15 the assumption that you have a throughwall grack, a complete 16 throughwall crack of a certain size that of and by itself 17 18 would be significantly larger than Section 11 would ever permit. 19 And then we need to prove that pipe will remain 20 stable in the presence of that crack. 21 22 The Section 11 comes in where we are basically following the methodology or, I guess, the practice, really, 23 that has been formulated by NRR and others who have gone 24 25 before me in saying okay, well, what kinds of crack growth

rates am I to anticipate in this circumstance, and to assume 1 that we will have the largest crack that will pass through 2 3 Section 11, and see how fast they would grow. But we still need to show that a very large crack, 4 much larger than Section 11 cracks, would remain stable and 5 with detectable leaks. 6 7 MR. EBERSOLE: If I can take as an example the main steam lines from the steam generators to wherever, you know, 8 the turbine, would you allow these to lay on top of the 9 control room roof if it was say a four inch concrete slab? 10 11 MR. CLOUD: I don't know. I think -- I intended to say of course not. 12 MR. SHEWMON: What is your point, Jesse? 13 MR. EBERSOLE: The point is if he says it is not 14 going to break before it leaks, that would be perfectly all 15 right. 16 MR. CLOUD: Yes. If the leakage is acceptable in 17 18 that location --MR. EBERSOLE: Yes, but a big split would not. 19 MR. CLOUD: And then we get into the situation that 20 would in fact we be vulnerable to a big split or not. And the 21 important thing, I think, today is that we are in a position 22 with the improvements in our knowledge, the analysis 23 24 procedures, we are in a position to say whether or not we are vulnerable or we are not vulnerable. 25

[Slide.]

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Just to briefly wrap it up, these are the -- filling 2 in the blanks on the types and kinds of analyses. Once this 3 4 is done --MR. MARK: Excuse me. Are materials testing -- you 5 have mentioned several kinds of material, like 106, whatever 6 it is, steel. You only have to test a sample of that from one 7 of these residual pipe ends. You don't have to go around and 8 9 sample the metal at which whip restraint location, do you? MR. CLOUD: No, sir, I don't believe we do. I 10 believe that if we could characterize -- one of the things we 11 12 have to do is see how many heats of this material we are dealing with. 13 MR. MARK: So you might go with taking a sample of 14 15 each heat? MR. CLOUD: That's the kind of thing that we are 16 presently engaging in. 17 18 MR. MARK: Or each weld type, perhaps? MR. CLOUD: Yes. And there are certain numbers of 19 20 types of welds that would be permitted, and weld materials that would be permitted, and procedures that would be 21 permitted. So we would sort through all of that to make sure 22 23 that we have characterized the welding adequately, and similarly with the materials themselves. 24 25 [Slide.]

1 Now we have got a situation where we have come this 2 far, we have gotten our postulated breaks, and we have seen 3 that at these break locations we can be sure that we will get 4 a significant leak prior to the catastrophic failure.

5 So now we have to go through an assessment of our 6 leak detection capability to ensure that we have the -- that 7 we have the ability to detect the leakage, and the most 8 important thing is that we believe that there are several 9 different ways to detect leakage, and we feel that a good and 10 a sound leak detection program will incorporate several 11 techniques.

12 In particular, it will have the instruments that are 13 presently available. We will do a good study, a thorough 14 study of the plant instrumentation in the sense that we 15 believe that there is a tremendous amount of leakage that 16 could be detected by a study of the pressure drops and liquid 17 levels and other instrumentation that we have in place at the 18 moment.

And the outcome of this study would result in
instructions to the plant operators and alarms and things of
that nature.

In addition, we have physical inspections that we could impose upon the plant operators and we believe that there are various other features. So we visualize a comprehensive leak detection program specifically for each of

the -- and we will show the path for leak detection for each 1 of the postulated breaks that has the whip restraint 2 eliminated. 3 [Slide.] 4 MR. BENDER: This leak detection concept is a 5 two-edged sword. I think you might be able to make the case. 6 The constraints put on the operation may have to be kept in 7 8 mind, just as has been the case in the primary system. If you specify leaks requiring action that are too small, you may 9 find the plant being shut down more than you would like, 10 11 because you can't be sure you know where the leak is coming 12 from. It seems to me that side of it must be included when 13 you make your major case. 14 MR. CLOUD: Yes, I guess I couldn't agree with you 15 more, Mike. We definitely don't want to get into a situation 16 where we are shutting the plant down for every valve leak. 17 That's exactly right. 18 MR. SHEWMON: The current tech specs talk in terms 19 20 of five gallons a minute for Beaver Valley 1? MR. KURTZ: I believe it's one gallon per minute and 21 10 gallons per minute; one being unidentified and 10 being 22 23 identified. 24 MR. RODABAUGH: To get back to Jesse's example, which I think is a good one since we're talking about balance 25

of plant, is the steam line. You have a fairly healthy steam 1 leakage from the value stems. What leakage method, other than 2 3 going outside of the containment -- you could go look at the steam line. But inside the containment, would you depend then 4 on your existing in-containment leakage system? 5 6 MR. CLOUD: Well, you're asking me questions that 7 I'll be better able to answer when I'm done with the work. I believe that there are humidity indicators inside containment. 8 9 MR. RODABAUGH: Well, I was thinking of the valve house in the steam line in particular, which is moist, it's 10 got steam. 11 MR. CLOUD: Yes. 12 MR. SHEWMON: How much lower than this one gallon a 13 minute do you think you'll have to get, or are you aiming 14 15 for? Are you talking about factors of 10 percent or 2 or an order of magnitude, or do you know at this point? 16 MR. CLOUD: No, sir, I don't know at this point. 17 18 I will point out to you, though, that the Rancho Seco line was a one-inch line, it was a very small line, and 19 it developed a crack. Behaved, by the way, as we anticipated 20 it would have behaved even though it was improperly 21 supported. And I believe that that crack produced a leak of 22 some 30 gallons a minute. So that the high energy lines leak 23 a lot. Once they start leaking, well, it comes pretty good. 24 25 [Slide.]

I'd like to talk briefly about what we visualize
 some of the benefits. I'm going to talk about the benefits
 from a technical point of view, and the benefits from a cost
 point of view.

5 We think that just getting rid of the whip 6 restraints, of and by itself, will be of benefit to the plant 7 by improving the accessibility, minimizing restrictions on the 8 inservice inspection, and we feel that there is additional 9 radiation exposure that is incurred as a result of having a 10 congested plant.

By focusing the plant operation on the detection of leakage, we feel that we are running the plant in a more intelligent way. It is known that it is possible to get binding with the whip restraints whenever there's a problem, so we visualize that there are unanticipated events that will be eliminated.

17 We are clearly, clearly, clearly going to have a much better understanding of the behavior of our high energy 18 piping than we do using the current technology. The current 19 20 technology doesn't do anything; very little engineering on the high energy piping. So we're talking about very serious study 21 of exactly how that piping behaves, and we feel that that, of 22 and by itself, will be a major contributor to improved safety 23 24 of the plant.

25

MR. EBERSOLE: How does this interface with the

other hoped-for advantage in getting rid of most of the 1 2 snubbers? MR. CLOUD: I'm sorry? 3 MR. EBERSOLE: How do you interface this effort for 4 getting rid of the pipe restraints with the other ongoing 5 effort to get rid of the snubbers? 6 MR. CLOUD: Well, getting rid of the snubbers is --7 those are essentially independent efforts. We have no 8 snubbers, for example, that serve as whip restraints. And the 9 10 snubbers are a part of the pipe support system, whereas the whip restraints --11 MR. EBERSOLE: They are? I didn't understand that. 12 13 I thought pipe supports were independent from snubbers. MR. CLOUD: Well, yes and no. It depends on what 14 you consider to be independent. But the snubbers --15 16 MR. SIESS: They are unbroken pipe supports as 17 opposed to broken pipe restraints. MR. CLOUD: In any event, we believe that by 18 19 addressing ourselves and doing the engineering work on the 20 high energy lines, that we have got to end up with a better 21 plant. MR. RODABAUGH: Bob, before you leave that slide, I 22 think Jesse and I keep running into the same confusion with 23 yesterday's program. An improved understanding of piping 24 failure modes. Yesterday, we were discussing the difference 25

between collapsed failure mode and fatigue failure mode. 1 2 Now ordinarily, a pipe whip restraint, if properly designed, never touches the pipe. 3 MR. CLOUD: That's right. 4 MR. RODABAUGH: So in your program, how are you 5 6 improving the understanding of piping failure modes? MR. CLOUD: Okay. We are improving the 7 understanding of the high energy piping failure modes because 8 9 of the fact that we will know, for example, about the susceptibility of our high energy lines to stress corrosion 10 11 cracking. 12 MR. RODABAUGH: Okay. You're using the words "failure mode" in a different term than it was being used 13 yesterday. 14 MR. CLOUD: I'm using it in the general sense. 15 MR. RODABAUGH: All right, fine. 16 17 [Slide.] MR. CLOUD: We're talking about significant amounts 18 of cost, too, which is what got me starte. thinking about it 19 in the first place. I want to talk about two kinds of costs. 20 What we are going to call the quantitative costs. 21 Quantitative costs are costs that we can estimate reasonably 22 well, and we have two kinds of costs that we are going to be 23 talking about today. 24 The first are these quantitative costs that we can 25

estimate reasonably well, and the second is a whole lot of 1 other costs that we know about, we know we are going to incur. 2 but we cannot estimate them nearly so well as these 3 quantitative costs. In the quantitative costs we have the 4 analysis, design, fabrication, installation and the indirect 5 6 costs of designing and installing the whip restraints. We're 7 looking at about \$8 million for Beaver Valley, considering the work that has already been done. 8

9

[Slide.]

10 The more difficult to estimate costs are the 11 construction sequence frequently gets seriously screwed up 12 because of the presence of congestion. We have a major gap 13 adjustment verification program that must be conducted just 14 before -- after all the whip restraints are in and just before 15 the plant goes into operation. And this is a big program and 16 it varies a lot.

17 Structural changes that we know will be required 18 which will be due to the rupture restraint loads, -- big loads 19 get calculated out of these whip restraints.

20 Another congestion cost [indicating].

And subsequently, in our outages we feel that we are going to save, or make major savings, once again due to congestion. And then there is the heat loss. The fact that we have the insulation off of the pipe at the rupture restraints; we will be able to insulate the whole pipe. So we

1	lose a lot of heat in the operation of the plant.
2	[Slide.]
3	Taken all together for this particular plant, we
4	have costs that will save somewhere in the range of \$12 to \$16
5	million.
6	[Slide.]
7	And we felt that those are savings that are very
8	definitely worth going after, particularly in the present
9	situation where we have the leak before break technology that
10	we have developed over the years.
11	Secondly, from the questionable validity or the
12	questionable practicability of the rupture restraints anyway.
13	Thirdly, we feel that by doing this additional
14	engineering work that we de facto, on the face of it, will end
15	up with a safer, better plant.
16	[Slide.]
17	So taken all together, what we are doing is we are
18	proposing to provide for the pipe break protection using the
19	state-of-the-art today. We are not asking for any exemptions,
20	we are proposing to provide for the protection in a different
21	way. We want to use the ability to successfully detect pipe
22	leaks. We believe, as I mentioned, that this will be a major
23	improvement in plant safety and design, both during operation
24	and during the outages.
25	Second, it's a strong industry initiative. We are
here offering, I think, to do more than -- we are giving for
 what we get on this one.

That is the conclusion of my presentation. Thank you very much for taking the time to hear it through. And understand the complexities of the licensing process which will require some assurance be given Duquesne Light that if this approach is followed, that there won't be a glitch at the licensing -- at the time for licensing, and that the license of the plant will not be jeopardized.

10 Thanks again, and I'll be glad to answer any further 11 questions if there are any.

MR. RODABAUGH: A couple of details on what you, at this stage, think you may be addressing. There is a flange joint, several flange joints, for example, off the safety relief value. Are you going to address in any way flange joints?

MR. CLOUD: We have to consider the geometry of the
pipe as it is, so definitely we will consider the flange
joints.

20 MR. RODABAUGH: Well, I asked the question because 21 nobody that I'm aware of has done any leak before break on 22 flange joints -- analysis and tests.

I guess my second curiosity is the leak before break technology is fairly well advanced for straight pipe and welds in straight pipe, but I've seen essentially nothing on

application of the leak before break technology to elbows, 1 reducers, branch connections, which you run into a lot of. 2 MR. CLOUD: You're talking about -- when you say --3 in the question you're asking, are you referring to the 4 calculation of the growth of cracks and the stability of 5 6 cracks? 7 MR. RODABAUGH: The stability, primarily. What is the stable crack size, an approximation? 8 MR. CLOUD: Oh, yes. Well, we feel that whereas in 9 the case of straight pipes, for example, where we might have 10 very exact solutions for the various different kinds of 11 cracks, nevertheless, in the fundamental mechanics of the 12 behavior of a crack it's the same regardless of anything 13 else. It is only complicated by the geometry of the material 14 and the geometry of the crack. 15 16 And we believe that, like any other analysis problem, we are entirely confident that it will be possible 17 for those cases where we do not have exact solutions to have 18 approximate conservative solutions like we do in so many other 19 analysis areas. 20 MR. RODABAUGH: Well, I certainly want to encourage 21 22 work along these lines. 23 MR. CLOUD: You are in a position to do so, I might 24 point out. MR. RODABAUGH: Well, I'm not sure if I am or not, 25

1 but I think it's a very worthwhile thing to attempt to do. MR. CLOUD: I couldn't agree with you more. 2 MR. SHEWMON: Let me ask a simple question. A 3 branch is a T-joint of dissimilar diameter points? 4 MR. RODABAUGH: Yes. 5 MR. BENDER: Like Ev, I am a supporter of this 6 idea. I think it is constructive for a number of reasons, not 7 the least of which is that you get rid of pipe whip 8 restraints. 9 But there are some things that I think ought to be 10 done as a preliminary, and that the regulatory staff will have 11 to do in order to give you any assurance that what you are 12 13 proposing will be acceptable after you do all the work. I think really you have to be somewhat more quantitative than 14 you have been about the size breaks, or size of crack that 15 you are going to have as the initiator, from which you are 16 going to extrapolate growth rates. And I'm not at all sure 17 18 that I want to accept the Section 11 limits as being the 19 starting point. But you probably don't have to start that small. I 20 think you probably could start with something somewhat bigger 21 because the A106 pipe in particular has good fracture 22 properties, and you probably have a long way to go. 23 The second thing I want to say again, I think you 24 may be letting yourselves in for more than you know when you 25

commit yourself to do something if you have a leak of a
 certain size, recognizing the fact that finding out where the
 leak is is sometimes a difficult job in a primary steam
 system. And that that may influence, to some degree, what
 parts of the system you want to defend.

6 The third point is the one which Ev has I think 7 articulated well enough, and that is that the fittings are a 8 separate case.

9 Now, the regulatory staff had difficulty dealing 10 with the fitting question for the primary system, as you know, 11 and stayed with the straight pipe. Whether they will get the 12 fittings in the picture or not later, I don't know but I think 13 that in view of that precedent, you ought to think about what 14 your case for fittings is going to be, and whether it fits 15 with the other arguments.

16 That's all I have.

MR. CLOUD: I would like to reply to those points becasue they are all three important ones. The first thing, the most obvious and most important aspect of the reply is that everything you say in every aspect of your remarks is in fact true. Everything that you pointed out in every aspect of the things in our program that you discussed are things that are completely ignored with the conventional approach.

24 So that just by virtue of the fact that we are in 25 and poking around trying to understand how the systems behave

to protect against the potential breaks in an intelligent 1 way is almost, de facto, of and by itself, I think an advance. 2 3 And I agree, we certainly don't know all of our answers in advance, but we believe that we can develop them as 4 we go along, and we believe that the state-of-the-art is 5 advanced to the point where we can develop workable, 6 7 satisfactorily conservative answers as we go through. 8 Another thing I'd like to point out with respect to the discussion related to the primary system is that the 9 10 primary system piping in the pressurized water plants, that is all cast material. That is the least tough material in the 11 plant, and that's the part that we've accepted the leak before 12 13 break on. We have all the rod material in the balance of plant 14 is much tougher, much more fracture resistant. Mr. Mark? 15 MR. MARK: I am certainly favorably impressed with 16 the direction of things here. You have mentioned that the 17 state-of-the-art is advanced, and that was particularly with 18 respect to fracture mechanics and crack growth calculations. 19 How is it with respect to leak calculations? 20 MR. CLOUD: That is not my field and I'm not sure. 21 [Laughter.] 22 I'm not in the fluid mechanics business, but I 23 believe we can calculate the amount of leak once we have a 24 25 given --

MR. MARK: Well, once you have a through-wall crack 1 and it's big enough that the pressure will probably pry things 2 apart slightly, then I could understand some leaking must go 3 on but I'm not sure that that's the way things always happen. 4 Nor am I sure that you are necessarily so good at calculating 5 6 the opening of the crack as you may be at the progress of the 7 crack. MR. SHEWMON: The opening should be elastic, and if 8 you assume it's elastic then it gets down to a question of, 9

10 you know, how rough it is. And they can calculate smooth 11 cracks -- smooth-walled cracks, I understand it, or you can do 12 tests on that. And they can talk about, with a given 13 pressure, given two surfaces, if we now make a cut through 14 here, how much will it open up.

My impression is it gets worse as you start talking
 about how much --

17 MR. MARK: Zig-zag, yes.

MR. RODABAUGH: There is a good deal of test data,
 Carson, on leak rates and small cracks.

20 MR. MARK: It was a question; it was not an 21 assertion of doubt.

MR. RODABAUGH: Well, your doubt is well taken, and I think Jesse's point enters here, too. Crud stoppage of cracks. But the research work is mostly on a piece of straight pipe. I know of very little on leakage rates in a

1 crack in branch connections, for example. So your question is 2 a good one.

MR. EBERSOLE: Paul, I was just going to renew that 3 question I discussed with you about the wide range of material 4 properties you can get within the context of A106, B. Are you 5 going to sharpen that up? I recall having --6 7 MR. SHEWMON: He said that they knew what heats were in the plant and thought they could get samples from that. 8 9 MR. EBERSOLE: Right. I'd like to know what that range of property is which is under the cover of A:06-B. I've 10 heard stories ranging from almost brittle at 40 degrees to 11 stuff that you could forage around and bend into duplex bends. 12 MR. LOUD: Well I'll tell you what. Give us the 13 14 go-ahead on this program and we will tell you what the range 15 is. MR. EBERSOLE: 106B, I think that's something that 16 17 needs --MR. SHEWMON: And also hot pipes at 200 or 270. 18 MR. EBERSOLE: Well, I'm interested in the cold 19 pipes, too, that service water. 20 21 MR. CLOUD: That's an excellent question, Mr. Ebersole, and I'd like to reply in the same way I did to 22 23 Mike and that is that the questions you are asking you will 24 get the answer to if we could go ahead with the program. But you're not going to know nothing if you don't, if we don't. 25

MR. SHEWMON: Let me ask one more simpleminded 1 question. Would you list the systems that you will be looking 2 at -- steam systems, certainly. Feedwater. 3 MR. CLOUD: Those systms are listed and well 4 defined, and they are the so-called high energy line systems. 5 I don't have it right now, but it's the main steam lines, the 6 feedwater lines, and all the other lines that are higher than 7 275 8 MR. EBERSOLE: Service water is about maybe 200 or 9 300 pounds at 40 degrees. 10 MR. SHEWMON: I see a violent shaking of the head 11 12 back there. MR. CLOUD: Bob, can you help me out informally with 13 anymore of the lines, anymore of the hydrogen systems? 14 MR. ROMER: Steam generator blowdown lines, low 15 pressure injection, other injection lines. Of course, we 16 17 mentioned feedwater, main steam, aux steam, charging. It 18 definitely doesn't cover service water. 19 MR. EBERSOLE: Component cooling? It doesn't cover 20 that? MR. ROMER: I don't believe so. In some cases we 21 22 have postulated breaks in lines and the effects are virtually 23 non-existent. MR. EBERSOLE: So really you're looking at just the 24 25 elimination of pipe whip.

MR. CLOUD: In general, that's correct. 1 MR. EBERSOLE: You're not looking at the loss of 2 service function due to breaks. 3 MR. CLOUD: That's exactly right. 4 MR. SHEWMON: So these are steam lines and feed 5 lines. Okay. 6 Any other questions for Bob before we go on to the 7 other Bob? 8 0 [No response.] 10 MR. SHEWMON: Okay. Thank you very much. MR. BOSNAK: The staff has had several informal 11 meetings with the people from Beaver Valley, Duquesne Light, 12 13 and I would characterize the staff right now as being sympathetic particularly to the removal of these items of 14 hardware that are in there to protect against postulated pipe 15 breaks. And we are also sympathetic to the approach that is 16 being proposed. 17 We are also I think -- in preface, we are pleased 18 19 that Duquesne has chosen to do these kinds of analyses and testing. I want to stress that testing is an important part 20 of this thing because we believe that the broad scope rule 21 change which is in preparation now through GDC-4, I think will 22 be aided. It has to be helped by this program. 23 Now, what are some of the problems that we see? We 24 expect that within a couple of weeks we will get a formal 25

transmission with all of the meat on the skeleton that Duquesne is able to come up with at the present time. But certainly, identification of systems to which fracture mechanics techniques may not apply -- that is going to be quite important.

I think Bob said that the method works when applied б in appliable situations, and we quite agree. So we don't want 7 to be down at the last minute arguing about whether or not 8 this system is subject to stress corrosion cracking, or this 9 one has large dynamic loads which we don't know how to 10 analyze. So we want to be sure that they go through, at least 11 now, a preliminary screening and eliminate or kick out the 12 systems which we will be arguing about. So in particular, Bob 13 did mention the large dynamic loads, stress corrosion cracking 14 15 and the fatigue situations.

From a legal and administrative point of view, we have talked several times with the staff counsel, and I think originally they felt that the broad scope rule had to be in place before they were able to go ahead with this. That has changed now.

I think the caveats that they have are that the broad scope rule is proceeding on track. In other words, there have been no hangups identified. And of course, we and they would be hopeful that there wouldn't be too many systems for which these analyses and testing techniques cannot be

1 applied.

2	Now what they see happening and what we would see
з	happening is that there may be one or two systems at the end
4	and this is at the point at which the license has to be
5	issued, and I guess we're talking about the end of 1986 or
6	early 87 if that is the case, then we would handle that
7	and this is what's being proposed now by a schedular
8	exemption that would be similar to what we are doing with the
9	narrow scope rule for the main loop.
10	By that I mean that they have gotten to the point
11	now where they are ready for the license and there is this one
12	system which we believe we need to install the hardware that
13	we have been used to. And if that is the case, an exemption
14	schedule or an exemption, if you will, will be granted for
15	perhaps one or two refueling outages, and after that period
16	the hardware would have to be installed.
17	So that's the way we look at it. Obviously, if
18	there are many, many such systems when we get down to the end,
19	that will be bad news, and it would have to delay the
20	licensing. We hope that there won't be such a situation. And
21	that is why right now we believe that preliminary work, going
22	through and screening the number of systems, is very, very
23	important.
24	MR. SIESS: Bob, if Beaver Valley 2 were allowed to
25	second without all three size whis sectorists is sizes would

they be the only plant operating without pipe whip restraints? 1 MR. BOSNAK: Other than the primary loop which we 2 have been talking about, they would be the only plant recently 3 licensed --4 MR. SIESS: That wasn't my question. Could you say 5 yes or no and then elaborate? 6 MR. BOSNAK: If you go back to the very old plants 7 -- and there are those plants that were never designed for 8 these kinds of situations. 9 MR. SIESS: There are plants -- what do you call 10 11 very old? Dresden? MR. BOSNAK: I'm not sure whether Dresden --. Maine 12 Yankee -- well Connecticut Yankee perhaps. Maine Yankee may 13 14 have --MR. SIESS: SEP plants? 15 MR. BOSNAK: Essentially, the SEP plants, but again, 16 those have been looked at from a consequence point of view and 17 during the recent SEP exercises. So even though they may not 18 have the hardware in there, they have been reviewed from a 19 systems and consequence point of view. 20 MR. SIESS: Okay. I was just trying to get some 21 perspective in terms of risk, of this plant operating, say, 22 for two years without these restraints versus the sum total of 23 risk. You know. Not a regulatory approach; strictly a safety 24 25 view of it, without consulting a lawyer.

1 MR. BOSNAK: Staff, at least in the Division of Engineering, feels that these, particularly the pipe whip 2 restraints, really don't contribute to safety and may actually 3 detract from safety because you can have an interaction 4 5 between a whip restraint and a system in normal operation, and over the years these things can settle and change position. 6 And that may, in fact, under certain situations, lead to a bad 7 8 situation. 9 MR. SIESS: So your problem was simply a legal one of some way to defer this until the whole issue is settled by 10 11 the rulemaking. MR. BOSNAK: Well, even if --12 MR. SIESS: You don't have a real safety concern. 13 MR. BOSNAK: That's right, because we are not 14 changing -- I think what Bob pointed out, even though some of 15 the letters that have come in on the narrow scope rule have 16 17 indicated we should go further, we are not making any changes with respect to equipment qualification 18 19 When you are talking about balance of plant, that is the important thing. That is not being changed. 20 21 MR. MARK: On one of the slides we saw there were 136 pipe whip restraints in the balance of plant. 22 23 MR. BOSNAK: Items of hardware. Perhaps pipe whip 24 restraints, jet shields. 25 MR. MARK: Yes. Is that the total number that are

out there, some of which might later be decided were not --. 1 MR. BOSNAK: I think that comes from about 400 or so 2 breaks and those are the only things for which they have 3 necessity to have this kind of break protection. In other 4 words, for the other breaks they expect that they don't need 5 these kinds of hardware. 6 7 MR. CLOUD: It is the total number. The numbers I presented on the pie chart were the total numbers. 8 MR. MARK: So some of those probably won't be 9 10 relieved in this way, since you will find that they are subject to corrosion or fatigue or something. 11 MR. CLOUD: That's exactly correct. 12 13 MR. RODAEAUGH: Bob, in terms of your MEB 36.2, right now you have this requirement for longitudinal pipe 14 breaks which are more of a vigorous crack. What are your 15 plans regarding that part? Is that involved at all here? 16 17 MR. BOSNAK: Well, if you go into the fracture mechanics approach, both the longitudinal and circumferential 18 breaks go away. 19 MR. RODABAUGH: I guess 36.2 requires the 20 longitudinal breaks even in a moderate energy piping. 21 MR. BOSNAK Well, certain locations might have 22 longitudinal. It depends on the stress ratio. 23 MR. RODABAUGH: Maybe I'm confusing this with 24 through wall leakage cracks. 25

1 MR. BOSNAK: Through wall leakage cracks are there in moderate energy situations, and you know if you don't have 2 a postulated pipe break in those areas, then you go into the 3 through wall leakage crack which --4 MR RODABAUGH: I am trying to explore this 5 equipment qualification bit -- maybe it wouldn't make any 6 7 difference. MR. BOSNAK: Right now from what the equipment 8 people tell me, the difficult area is not the large break; 9 10 it's the smaller break in which they can get some superheated 11 steam. 12 MR. RODABAUGH: That's exactly the point I'm trying 13 to follow. Would this impact how you evaluate --MR. BOSNAK: It wouldn't impact that at all. Not at 14 the present time at least. But we do have all of these 15 16 suggestions that say we should go further but we are not 17 intending to do that now. MR. SHEWMON: Any other questions? I think the 18 19 sense of the consultants and the members here is positive and 20 encouraging. Now, do you want anything other than warm 21 feelings out of us at this time? 22 MR. BOSNAK: I think that's what we were looking for. That you don't see reasons that this program should not 23 24 proceed. That's what we wanted to know; if you had any doubts at all. But if you have warm feelings --25

MR. SHEWMON: I have a note from Jesse. He says, "Sounds like a really worthwhile program," and I think that tends to be the sense of the meeting. So I think on that, unless I am misquoting anybody, -- any other questions or discussion? If not, the meeting is adjourned. [Whereupon, at 3:03 p.m., the subcommittee meeting was adjourned.]

1	CERTIFICATE OF OFFICIAL REPORTER
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4	
5	This is to certify that the attached proceedings
5	before the United States Nuclear Regulatory Commission in the
7	matter of ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
9	
9	Name of Proceeding: Combined Meeting of Subcommittees on Structural Engineering, Seismic Design
10	of Piping, and Metal Components
11	Docket No.:
12	Place: Washington, D. C.
13	Date: Tuesday, September 24, 1985
14	
15	were held as herein appears and that this is the original
16	transcript thereof for the file of the United States Nuclear
17	Regulatory Commission.
13	0 01
19	(Signature) Sugar Dy Gome
	(Typed Name of Reporter) /Suzanne B. Foung
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MECHANICAL-STRUCTURAL ENGINEERING BRANCH PRESENTATION TO ACRS SUBCOMMITTEE ON STRUCTURAL ENGINEERING SEISMIC DESIGN OF PIPING METAL COMPONENTS SEISMIC, STRUCTURES, AND CONTAINMENT INTEGRITY RESEARCH PROGRAM

SEPTEMBER 23 AND 24, 1985

72 1-10

MSEB BUDGET FOR STRUCTURES AND SEISMIC RESEARCH

.

		BUDGET	
TITLE	<u>FY 1985</u>	FY 1986	FY 1987
SEISMIC MARGINS STUDIES	\$650K	\$600K	\$900K
VALIDATION OF SEISMIC RESPONSE PREDICTIONS	1100	1750	1900
COMPONENT FRAGILITY DATA ACQUISITION AND EVALUATION	240	1100	1000
SEISMIC CATEGORY I STRUCTURES	820	1200	1500
BEHAVIOR OF CONCRETE STRUCTURES (BNL)	0	200 -	400 -
STRUCTURAL DEGRADATION	0	0	300
STRUCTURAL COMPUTER CODE BENCHMARKS	300	200	200
NRC/EPRI PROGRAMS ON PIPING DYNAMIC LOAD CAPACITY	200	700	900
OTHER NRC PIPING RESEARCH	333	375	600
PARAMETERS INFLUENCING DAMPING IN PIPING SYSTEMS	230	200	0
	\$3873K	\$6325K	\$7700K
PROGRAMS THAT TERMINATE IN FY 1985	<u>1,418</u> \$5291K		
			1 4

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MSEB BUDGET FOR CONTAINMENT INTEGRITY RESEARCH

		BUDGET	
TITLE	FY 1985	FY 1986	FY 1987
EXPERIMENTS ON CONTAINMENT MODELS UNDER EXTREME LOADING CONDITIONS	\$2,060K	\$2,000K	\$2,400K
CONTAINMENT INTEGRITY UNDER EXTREME LOADS	740	600	700
INTEGRITY OF CONTAINMENT PENETRATION UNDER SEVERE ACCIDENT CONDITIONS	900	900	600
CONTAINMENT BUCKLING	250 \$3950K	200 \$3700K	0 \$3700K

EFFECTS OF EARTHQUAKES OMOPERATING PLANTS



SOME OPERATING PLANTS MAY BE REQUIRED TO WITHSTAND EARTHQUAKES LARGER THAN THEIR ORIGINAL DESIGN BASIS BECAUSE OF NEW SEISMOLOGICAL INFORMATION. IT IS IMPORTANT TO ESTIMATE AVAILABLE DESIGN MARGINS OF PLANTS TO WITHSTAND THESE LARGER EARTHQUAKES TO PROVIDE THE BASIS FOR REGULATORY DECISIONS AND AVOID UNNECESSARY SHUTDOWNS. DBJECTIVE TO EXPERIMENTALLY VALIDATE COMPLEX METHODS USED TO PREDICT SEISMIC BEHAVIOR OF THE PLANT; IMPROVE

AND REDUCE UNCERTAINTIES IN COMPONENT FRAGILITY DATA BASE USED TO ESTIMATE MARGINS; DEVELOP PROCEDURES FOR ESTIMATING SEISMIC DESIGN MARGINS; AND ELIMINATE EXCESSIVE USE OF SNUBBERS TO PROVIDE BETTER BALANCE OF SAFETY.

ELEMENTS

CONDUCT EXPERIMENTS USING LARGE SCALE INTEGRATED FACILITIES TO VALIDATE COMPLEX PREDICTIVE
 METHODS. __ HDR (FRG.) with w/eccentric shaker whole Bidgs (opera. reed. wyt doce)
 METHODS. __ dap. shaker ... negotiation on-going : PWR loop 1/3 - 1/2 scale & contain. sti
 ASSEMBLE EXISTING COMPONENT FRAGILITY DATA AND CONDUCT FRAGILITY TESTS TO IMPROVE THE DATA
 BASE.

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O DEVELOP AND DEMONSTRATE PROCEDURES FOR ESTIMATING SEISMIC DESIGN MARGINS AND PROVIDE BASIS FOR REDUCING THE NUMBER OF SNUBBERS USED IN SEISMIC DESIGN.

INTEGRATION

pipe supports

PROGRAM INVOLVES COOPERATION AND COORDINATION WITH EPRI, INDUSTRY, GERMANY AND JAPAN.

FEGULATORY USE

METHODS, DATA BASE AND REVIEW PROCEDURES WILL BE USED BY THE REGULATORY STAFF TO EVALUATE LICENSEE SUBMITTALS, PROBABILISTIC RISK ANALYSES, AND ESTIMATE SEISMIC MARGINS.



ISSUE:

MODIFICATIONS OR SHUTDOWNS. EXCESSIVE USE OF SNUBBERS HAVE LED TO OVERLY STIFF PIPING SYSTEMS WHICH THAN WHAT THEY WERE ORIGINALLY DESIGNED FOR (E.G., THE USGS HAS STATED THAT AN EARTHQUAKE SIMILAF TO NEW SEISMOLOGICAL INFORMATION INDICATES THAT SOME OPERATING PLANTS MAY EXPERIENCE EARTHQUAKES LAFGER THE 1886 CHARLESTON, S.C., EARTHQUAKE MAY OCCUR OVER A WIDER AREA THAN ORIGINALLY THOUGHT). IT IS IMPORTANT TO UNDERSTAND THE BEHAVIOR AND CAPACITY OF NUCLEAR POWER PLANTS TO WITHSTAND EARTHQUAKES LARGER THAN THEIR ORIGINAL DESIGN BASIS TO MAKE REGULATORY DECISIONS AND NOT IMPOSE UNNECESSARY MAY DIMINISH OVERALL SAFETY.

OBJECTIVE:

- TO EXPERIMENTALLY VALIDATE COMPLEX METHODS USED TO PREDICT THE BEHAVIOR OF STRUCTURES, SYSTEMS AND COMPONENTS UNDER VERY LARGE EARTHQUAKE LOADS THAT WOULD CAUSE RESPONSES INTO THE NON-LINEAR RANGE. THESE COMPLEX METHODS WILL THEN BE USED TO BENCHMARK SIMPLIFIED APPROACHES TO BE USED TO MAKE REGULATORY DECISIONS FOR INDIVIDUAL PLANTS WHOSE DESIGN EARTHQUAKE HAS BEEN INCREASED. ..
 - (FUNCTIONAL CAPACITY) OF CRITICAL COMPONENTS TO BE USED TO QUANTIFY THE SEISMIC MARGIN OF A TO IMPROVE AND REDUCE THE LARGE UNCERTAINTIES IN THE DATA BASE THAT DESCRIBES THE FRAGILITY NUCLEAR PLANT AND PERFORM PROBABILISTIC RISK ANALYSES. 5.
- TO DEVELOP AND DEMONSTRATE PROCEDURES TO ESTIMATE THE SEISMIC DESIGN MARGINS OF NUCLEAR POWER PLANTS. 3.
 - TO DEVELOP CRITERIA FOR REDUCING THE NUMBER OF PIPING AND COMPONENT SNUBBERS USED WHICH WILL PROVIDE BETTER BALANCE IN SAFETY BETWEEN NORMAL OPERATING AND ACCIDENT CONDITIONS AND REDUCE RADIATION EXPOSURE TO WORKERS. 4.

EFFECTS OF EARTHQUAKES ON OP TING PLANTS (CONTINUED)



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- 1. VALIDATION OF METHODS IN FY 1986 AND FY 1987, PARTICIPATE IN HIGH LEVEL VIBRATION EXPERIMENTS AT THE HEISSDAMPFREAKTOR (HDR) IN COOPERATION WITH THE FEDERAL REPUBLIC OF GERMANY TO PARTIALLY VALIDATE SEISMIC CODES. ALSO COOPERATE WITH EPRI IN A SOIL-STRUCTURE INTERACTION EXPERIMENT BEING BUILT IN AN ACTIVE EARTHQUAKE REGION IN TAIWAN (FY 1986-1988). PARTICIPATE IN FY 1987 IN VIBRATION EXPERIMENTS IN COOPERATION WITH THE JAPANESE ON LARGE INTEGRATED PIPING SYSTEM AT TADOTSU FACILITY (WORLD'S LARGEST SHAKER TABLE) TO VALIDATE NON-LINEAR PIPING COMPUTER CODES. VALIDATION EFFORT WILL BE COMPLETED IN FY 1987.
- 2. IMPROVED FRAGILITY DATA BASE IN FY 1986, WILL COMPLETE GATHERING OF COMPONENT FRAGILITY (FAILURE) DATA IN COOPERATION WITH EPRI AND INDUSTRY (SEISMIC QUALIFICATION USERS GROUP) AND IDENTIFYING WHAT SPECIFIC FRAGILITY DATA IS NEEDED. IN FY 1987, WILL COMPLETE FRAGILITY TESTING OF SELECTED COMPONENTS. CONTINUE IN FY 1986 AND COMPLETE IN FY 1988, EXPERIMENTS ON SMALL SCALE CONCRETE SHEAR WALL STRUCTURES TO INVESTIGATE THEIR BEHAVIOR UNDER SEISMIC LOADS EXCEEDING THE DESIGN BASIS TO DETERMINE THE MODE AND LEVEL OF FAILURE. THE COMPONENT AND STRUCTURAL FRAGILITY EFFORT WILL BE COMPLETED IN FY 1988.
- 3. SEISMIC DESIGN MARGINS IN FY 1986, COMPLETE DEVELOPMENT OF PROCEDURES AND REVIEW GUIDELINES TO ESTIMATE THE SEISMIC MARGINS FOR PWR PLANTS AND CONDUCT A TRIAL PLANT REVIEW TO DEMONSTRATE AND IMPROVE THE PRO-CEDURES. IN FY 1987, SIMILAR PROCEDURES AND PLANT REVIEW WILL BE COMPLETED FOR A BWR AND WILL COMPLETE THIS EFFORT.

INTEGRATION

- 1. COOPERATING WITH THE FRG AT HDR FACILITY TO VALIDATE SEISMIC METHODS. (FRG-\$10M, NRC-\$500K)
- NEGOTIATING WITH JAPANESE (MITI) TO COOPERATE ON TADOTSU SHAKER TABLE TO VALIDATE NUCLEAR PIPE CODES. (MITI-\$12M, NRC-\$700K)
- 3. COOPERATING WITH EPRI ON SOIL-STRUCTURE INTERACTION EXPERIMENTS IN TAIWAN. (EPRI-\$1M, NRC-\$200K)
- 4. COOPERATING WITH EPRI AND INDUSTRY (SEISMIC QUALIFICATION UTILITY GROUP) TO GATHER FRAGILITY DATA. (INDUSTRY-\$50M, NRC-\$500K)
- 5. COOPERATING WITH EPRI ON SEISMIC DESIGN MARGINS. (EPRI-\$1M, NRC-\$1.2M)

NRC RESEARCH IS FOCUSED ON DEVELOPING THE TECHNICAL BASIS FOR LICENSING DECISIONS AND ESTABLISHING REGULATORY CRITERIA USING RESULTS OF INDUSTRY RESEARCH WHERE POSSIBLE.

REGULATORY USE

- 1. VALIDATED SIMPLIFIED METHODS WILL BE USED TO EVALUATE LICENSEE SUBMITTALS.
- 2. IMPROVED FRAGILITY DATA BASE WILL BE USED TO EVALUATE AVAILABLE SEISMIC MARGINS AND PROVIDE IMPROVED PROBABILISTIC RISK ASSESSMENTS.
- 3. SEISMIC DESIGN MARGIN PROCEDURES WILL BE USED TO ASSESS CAPACITY OF NUCLEAR PLANTS TO WITHSTAND LARGER EARTHQUAKES AND MAKE SOUND REGULATORY DECISIONS WITHOUT UNNECESSARY MODIFICATIONS OR SHUTDOWNS.
- 4. ASME CODE, REC'LATORY GUIDES, AND STANDARD REVIEW PLAN MODIFIED TO PERMIT REMOVAL OF SNUBBERS TO MAKE PIPE SYSTEMS MORE FLEXIBLE AND PROVIDE IMPROVED BALANCE OF OVERALL SAFETY.

FOREIGN AND DOMESTIC

SEISMIC HAZARD

- o EPRI and Industry Probabilistic Seismic Hazard Program
- o USGS Ground Motion Studies
- B National Earthquake Hazard Reduction Prog. (USGS, NSF, FEMA, NBS)
- a Corps of Engineers Seismic Soils Settlement Program

VALIDATION OF SEISMIC METHODS

- 6 Germany KfK HDR Program
- a EPRI Taiwan SSI Experiments
- o Japan MITI/NUPEC Seismic Experiments

FRAGILITIES AND RESPONSE

- o EPRI Piping Program
- e EPRI Equipment Qualification Program
- o NRC Equipment Qualification Program
- o NRC Aging Program
- o Seismic Qualification Utility Group Data

SEISHIC MARGINS

- o EPRI Seismic Margins Research Program
- o Industry Probabilistic Risk Analyses



NRC SEISMIC SAFETY RESEARCH PROGRAM



Figure 1 Project Interrelationships and Regulatory Applications

which see pays about 25% of Research sudget

SEISM C HAZARD

o New B unswick Earthquake

REGULATORY APPLICATIONS

o Site-specific Spectra

SEISMIC RISK

- o Licensee PRAs
- o Integrated Safety Assessment Program
- o Risk Methodology Integration & Evaluation Program

SEISMIC MARGINS

- o NTOL Seismic Issues
- o Pipe Damping (R.G. 1.61)
- o Floor Spectra (R.G. 1.122
- o ASME Code-Piping & Structures
- o Equipment Qualification
- o Structural Damping (R.G. 1.61)
- o Independent Pipe Support Motion

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SEISMIC P	ARCH INTEGRATION	program = infor	puralular
	DEC CONTRACTOR	OTHER SOURCES	RELATIONSHIP
ELEMENT	KES CONTRACTOR		
BUILDING BEHAVIOR			
SOIL-BUILDING INTERACTION	BNL	EPRI, TAIWAN	JOINT
BUILDING FAILURE	LANL, SNL	JAPAN	COMPLEMENTARY
		TATUAN CDC. JADAN	COMPI FMFNTARY
BUILDING RESPONSE	LANL	INIMAN, FRU, UNIMI	
PIPING BEHAVIOR			
PIPING-BUILDING INTERACTION	LANL	•	
PIPING FAILURE	ETEC, ANCO	EPRI	JOINT
PIPING RESPONSE	HEDL, INEL, BNL	EPRI, JAPAN, FRG	JOINT & COMPLEMENTARY
PIPING CRITERIA CHANGES	INEL, BNL, ORNL, LLNL	ASME, PVRC, EPRI	JUINT
EQUIPMENT BEHAVIOR			
EQUIPMENT-BUILDING INTERACTION	LANL	•	
FOULPMENT FAILURE	LLNL, BNL	EPRI, SQUG	JOINT & COMPLEMENTARY
EQUIPMENT RESPONSE	INEL	FRG	inior
VALIDATION OF SEISMIC CALCULATIONAL METHODS			
SOIL-BUILDING INTERACTION	BNL	EPRI, TAIWAN	JOINT
BUILDING-EQUIPMENT/PIPING INTERACTION	ANL, ANCO, INEL	FRG	JOINT
EQUIPMENT RESPONSE	BNL, INEL	JAPAN	JOINT
SEISMIC DESIGN MARGINS			
DEVELOP REVIEW PROCEDURES FOR ESTIMATING MARGIN	LLNL/EXPERT PANEL	EPRI	JOINT
DEVELOP FRAGILITY DATA BASE	LANL, LLNL, BNL	EPRI, SQUG INDUSTRY EQUIPMEN TEST LABS (I.E.,W	JOINT & COMPLEMENTARY
CONDUCT TRIAL PLAN REVIEWS	TLAL	EPRI	O TNIOL



ADEQUACY OF SAFETY EQUIPMENT UNDER ABMORMAL CONDITIONS CONTAINMENT INTEGRITY

ISSUE

CONTAINMENT BUILDING IS THE FINAL BARRIER TO RELEASE OF RADIOACTIVE MATERIAL TO THE ENVIRONMENT FROM SEVERE ACCIDENT. IT IS IMPORTANT TO UNDERSTAND THE STRUCTURAL INTEGRITY AND LEAK BEHAVIOR OF COM-TAINMENTS UNDER SEVERE ACCIDENT CONDITIONS.

OBJECTIVE

OBJECTIVE IS TO EXPERIMENTALLY VALIDATE METHODS USED TO PREDICT STRUCTURAL AND LEAK BEHAVIOR OF STEEL AND CONCRETE CONTAINMENTS UNDER SEVERE ACCIDENT LOADS THAT ARE BEYOND THE DESIGN BASIS.

ELEMENTS

AS WELL AS SEPARATE EFFECTS EXPERIMENTS ON LARGE CONTAINMENT PENETRATIONS AND SEAL AND GASKET MATERIALS PROGRAM CONSISTS OF SCALE MODEL EXPERIMENTS OF STEEL AND REINFORCED CONCRETE CONTAINMENT BUILDINGS TO VALIDATE STRUCTURAL AND LEAK BEHAVIOR PREDICTIVE METHODS.

INTEGRATION

PROGRAM INVOLVES COOPERATION AND COORDINATION WITH EPRI, ENGLAND, FRANCE, AND GERMANY.

REGULATORY USE

VALIDATED METHODS WILL BE USED BY LICENSING STAFF TO MAKE REGULATORY DECISIONS REGARDING LEAK BEHAVIOR RESULTS OF PROGRAM WILL ALSO SUPPORT COMMISSION OF CONTAINMENTS UNDER SEVERE ACCIDENT CONDITIONS. POLICYMAKING ON SEVERE ACCIDENTS.



ADEQUACY OF SAFETY EQUIPMENT UNDER ABNORMAL CONDITIONS

CONTAINMENT INTEGRITY

I SSUE:

IN ORDER TO EVALUATE THE EFFECTS ON PUBLIC HEALTH AND SAFETY RESULTING FROM POSTULATED SEVERE ACCIDENTS, ACTIVE MATERIAL TO THE ENVIRONMENT MUST BE KNOWN. THERE ARE LARGE UNCERTAINTIES IN PREDICTING THE LEAK THE ABILITY OF THE CONTAINMENT BUILDING TO PROVIDE A LEAK TIGHT BARRIER AGAINST THE RELEASE OF RADIO-AND STRUCTURAL BEHAVIOR OF THE CONTAINMENT SYSTEM UNDER SEVERE ACCIDENT CONDITIONS (PRESSURES AND TEMPERATURES LARGER THAN THE DESIGN BASIS).

OBJECTIVE:

- DEVELOPMENT AND VALIDATION OF METHODS FOR ESTIMATING THE LEAK AND STRUCTURAL BEHAVIOR OF CONTAINMENT 1. DEVELOP AND CARRY OUT EXPERIMENTS ON SCALE MODEL STEEL AND CONCRETE CONTAINMENTS TO SUPPORT BUILDINGS UNDER SEVERE ACCIDENT CONDITIONS THAT EXCEED THEIR DESIGN BASIS.
- DEVELOP RELIABLE METHODS FOR ASSESSING THE INTERACTION BETWEEN CONTAINMENT PENETRATIONS (E.G., HATCHES, AIRLOCKS, VALVES, ELECTRICAL PENETRATIONS) AND CONTAINMENT STRUCTURES TO PREDICT LEAK BEHAVIOR UNDER SEVERE ACCIDENT CONDITIONS THAT EXCEED THE DESIGN BASIS. VALIDATE THE METHODS EXPERIMENTALLY. 2.

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ADEQUACY OF SAFETY EQUIPMENT UNDER ABNORMAL CONDITIONS CONTAINMENT INTEGRITY (CONTINUED)



PROGRAM ELEMENTS:

- COMPLETED IN FY 1985, EXPERIMENTS ON A 1/8 SCALE STEEL CONTAINMENT THAT VERIFIED THE ADEQUACY OF THE //SME BOILER AND PRESSURE VESSEL CODE USED TO DESIGN STEEL CONTAINMENTS. IN FY 1986, THE EXPERIMENTAL RESULTS WILL BE USED TO VALIDATE THE PREDICTIVE METHODS USED TO EVALUATE STEEL CONTAINMENTS. -
- IN FY 1986, A 1/6 SCALE REINFORCED CONCRETE CONTAINMENT BUILDING, INCLUDING SOME PENETRATIONS, WILL BE CON-STRUCTED. IN FY 1987, EXPERIMENTS WILL BE CONDUCTED ON THIS BUILDING TO INVESTIGATE ITS BEHAVIOR UNDER SEVERE ACCIDENT CONDITIONS AND VALIDATE THE PREDICTIVE METHODS. 2
- IN FY 1986, EXPERIMENTS ON VARIOUS PENETRATION SEAL AND GASKET MATERIALS UNDER SEVERE ACCIDENT CONDITIONS WILL BE COMPLETED. IN FY 1986, EXPERIMENTS WILL BE COMPLETED ON ELECTRICAL PENETRATIONS. e.
- IN FY 1987, EXPERIMENTS WILL BE COMPLETED ON LARGE PENETRATIONS (E.G., AIRLOCK, PIPE BELLOWS) TO INVESTIGATE THEIR LEAK BEHAVIOR UNDER SEVERE ACCIDENT CONDITIONS. 4.
- IN FY 1988, THE PROGRAM WILL BE COMPLETED WITH VALIDATION OF ANALYTICAL METHODS USING THE EXPERIMENTAL DATA AND INVESTIGATING THE BEHAVIOR OF CONTAINMENTS UNDER VERY LARGE EARTHQUAKE LOADS. 5

INTEGRATION:

- EPRI IS CONDUCTING SEPARATE INVESTIGATIONS OF CONCRETE WALL ELEMENTS AND WALL-BASEMAT INTERACTIONS THAT WILL PROVIDE INPUT TO THE NRC PROGRAM. (EPRI-\$2M, NRC-0) -
- EPRI WILL PROVIDE PRETEST PREDICTIONS TO EVALUATE METHODS FOR CONCRETE MODEL EXPERIMENTS. (EPRI-\$200K, NRC-0) 2:
- (UK-\$200K, NRC-0) UK-NII WILL PROVIDE PRETEST PREDICTIONS TO EVALUATE METHODS FOR CONCRETE MODEL EXPERIMENTS. 3.
- FRANCE-CEA WILL PROVIDE PRETEST PREDICTIONS TO EVALUATE METHODS FOR CONCRETE MODEL EXPERIMENTS. (CEA-\$200K, NRC-0) 4.
- FRG-KFK IS CONDUCTING EXPERIMENTS ON STEEL VESSEL MATERIAL TO INVESTIGATE BIAXIAL EFFECTS AND WILL ALSO PROVIDE ANALYSIS AND INSIGHTS ON STEEL CONTAINMENT UNDER LARGE EARTHQUAKE LOADS. (KFK-\$500K, NRC-0) 5.

NRC RESEARCH EFFORT IS FOCUSED ON BEHAVIOR AND LEAKAGE OF CONTAINMENT BEYOND THE DESIGN BASIS (SEVERE ACCIDENTS). INDUSTRY EFFORT IS FOCUSED ON BEHAVIOR OF CONTAINMENTS FOR DESIGN BASIS ACCIDENTS.

REGULATORY USE:

ALSO RESULTS FROM THE SCALE MODEL CONTAINMENT AND PENETRATION EXPERIMENTS WILL PROVIDE THE BASIS FOR VALIDATING ANALYTICAL PREDICTIVE METHODS. THESE METHODS WILL BE USED BY THE NRC LICENSING STAFF TO MAKE REGULATORY DECISIONS REGARDING THE THE RESULTS FROM THIS PROGRAM WILL 1 INTEGRITY AND LEAK BEHAVIOR OF CONTAINMENTS UNDER SEVERE ACCIDENT CONDITIONS. SUPPORT THE COMMISSION POLICYMAKING ON SEVERE ACCIDENTS.

CONTAINMENT INTEGRITY RESEARCH PROGRAM

ELEMENT	RES PROGRAM CONTRACTOR/SUB-CONTRACTOR	OTHER SOURCES	RELATIONSHIP
EXPERIMENTAL EVALUATION OF OF CONTAINMENT MODELS UNDER EXTREME LOADING	SNL/UNITED ENGINEERS SNL/CHICAGO BRIDGE & IRON	EPRI, FRG	COMPLEMENTARY
CONTAINMENT INTEGRITY UNDER EXTREME LOADING	SNL	EPRI, FRANCE, UK	JOINT
INTEGRITY OF CONTAINMENT PENETRATIONS UNDER SEVERE ACCIDENT LOADS	SNL/INEL	EPRI	COMPLEMENTARY
CONTAINMENT MARGINS TO FAILURE - CONTAINMENT BUCKLING	LANL	PVRC	COMPLEMENTARY

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TITLE:

SEISMIC MARGINS STUDIES

FIN;

A 0398

CONTRACTOR:

LLNL

EXPERT PANEL: R. BUDNITZ, P. AMICO, A. CORNELL, W. HALL, R. KENNEDY, J. REED, M. SHINOZUKA

BUDGET:

FY 1985	FY 1986	FY 1987
\$650K	\$600K	\$1100K

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NEED TO DETERMINE THE CAPABILITY OF NUCLEAR PLANTS TO WITHSTAND EARTH-QUAKES LARGER THAN THE DESIGN LEVEL.

OBJECTIVE:

DEVELOP THE BASES FOR EVALUATING NUCLEAR PLANT SEISMIC MARGINS.

- 0 ASSESS EXISTING MARGINS INFORMATION (EXPERIENCE DATA, TESTS, PRA'S).
- 0 DEVELOP MARGINS REVIEW PROCEDURES

F.

0 IDENTIFY INFORMATION NEEDS

NURER/CR-4334 An approach to the Quant-pratic J Sermie mergins in Nuclear Prese Plants

lung 85 14

SCOPE/ACCOMPLISHMENTS:

FY 1985

0 NRC SEISMIC DESIGN MARGINS PROGRAM PLAN EXPERIMENTS.

- O EXPERT PANEL REPORT ON "AN APPROACH TO THE QUANTIFICATION OF SEISMIC MARGINS IN NUCLEAR POWER PLANTS" (NUREG/CR-4334).
 - ASSESSMENT OF EXISTING MARGINS INFORMATION
 - DEVELOPMENT OF THE HCLPF CONCEPT AND SCREENING APPROACH
 - OUTLINE OF REVIEW PROCEDURES

Chiempidence low probability failure

O EXPERT PANEL REPORT ON GUIDELINES FOR SEISMIC MARGINS REVIEWS.

0 FY 1986

- SEISMIC MARGINS REVIEW GUIDELINES REVIEWED BY NRC WORKING GROUP AND FINALIZED AS A NUREG.
- TRIAL SEISMIC MARGINS REVIEWS OF A PWR.
- MULTILEVEL EARTHQUAKE "TARGETS". (g levels)
- EXPERT PANEL TO MONITOR TRIAL REVIEWS.



0 FY 1987

 REVIEW GUIDELINES FOR PWRS UPDATED BASED ON REVIEW EXPERIENCE AND NEW RESEARCH.

- BWR REVIEW GUIDELINES DEVELOPED.
- TRIAL SEISMIC MARGINS REVIEW(S) OF A BWR.
- PROCEDURE FOR POST-OBE EVALUATION DEVELOPED.



- O SEISMIC MARGINS REVIEW GUIDELINES WILL PROVIDE AN EFFICIENT AND COST EFFECTIVE WAY TO ADDRESS THE SIGNIFICANCE OF PERCEIVED CHANGES IN SEISMIC HAZARD.
- O SEISMIC MARGINS REVIEW GUIDELINES CAN BE USED TO IDENTIFY PLANT-SPECIFIC "WEAK-LINKS" AND THE NEED TO UPGRADE SEISMIC DESIGN PROCEDURES.

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TITLE:

VALIDATION OF SEISMIC RESPONSE PREDICTIONS (experimental à analytical) pour motion quourd spicina How good the method is ... E Not how to improve A. FIN;

A 2251, B 5702, D 1603

CONTRACTOR:

ARGONNE NATIONAL LABORATORY BROOKHAVEN NATIONAL LABORATORY NATIONAL BUREAU OF STANDARDS

COOPERATING ORGANIZATIONS:

JELECTRIC POWER RESEARCH INSTITUTE KERNFORSCHUNGSZENTRUM KARLSRUHE (FRG) MITI MINISTRY FOR INTERNATIONAL TRADE AND INDUSTRY, (JAPAN)

BUDGET:

Y 1985	FY 1986	FY 1987
\$1100K	\$1750K	\$1900K

ISSUE:

ANALYTICAL METHODS THAT ARE, ESSENTIALLY, LINEAR ARE USED TO PREDICT SEISMIC RESPONSE OF STRUCTURES AND COMPONENTS. THERE IS LITTLE DATA TO INDICATE HOW WELL THESE METHODS CAN BE USED TO PREDICT BEHAVIOR NEAR FAILURE. NOR IS THERE A CLEAR PICTURE OF HOW GOOD PREDICTIONS HAVE TO BE FOR SOUND DECISIONS ABOUT PLANT SAFETY.

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OBJECTIVE:

OBTAIN INFORMATION THAT CAN BE USED TO DEVELOP ACCEPTANCE CRITERIA FOR PREDICTIONS OF THE BEHAVIOR OF NUCLEAR POWER PLANTS SUBJECTED TO LARGE EARTHQUAKES.

INTEGRATION:

- O THE QUESTION OF ADEQUACY OF PREDICTIVE METHODS HAS A STRONG CONNECTION WITH EFFORTS TO DETERMINE SEISMIC SAFETY MARGINS,
- O ONGOING NRC-SPONSORED EXPERIMENTAL PROGRAMS ON CONTAINMENTS AND OTHER CATEGORY I STRUCTURES ARE AN INTEGRAL PART OF THE VALIDATION EFFORT.

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SCOPE/ACCOMPLISHMENTS:

0 FY 1985

- DEFINE SCOPE OF COLLABORATION IN HDR SEISMIC TESTS.
- LOW LEVEL EXCITATION OF EPRI MODEL IN TAIWAN.
- EXPLORATION OF INFORMATION EXCHANGE POSSIBILITIES WITH MITI.
- SCOPING CALCULATIONS FOR EXTENDING JAPANESE TESTS AT TADOTSU FACILITY INTO THE INELASTIC RANGE.
- 0 FY 1986
 - PARTICIPATION IN LARGE SHAKER TESTS AT HDR.
 - PRE-EARTHQUAKE PREDICTIONS OF RESPONSE OF EPRI MODEL. (Taiwaw)
 - IMPLEMENTATION OF INFORMATION EXCHANGE AGREEMENT WITH MITI.

0 FY 1987

- PARTICIPATION IN LOCAL PLASTIFICATION TESTS AT HDR.
- CONTINUATION OF INFORMATION EXCHANGE AGREEMENT WITH MITI.
- ASSESSMENT OF PREDICTIVE MODELS FOR EPRI MODEL RESPONSE. (Taiwan)

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- 2 eq. in Fubushima's plant ... real earthquases, data forthcoming rocking-tression soil struct interaction ... not obtained.

TADOTSU - 20-25,000 Jan cost to operate facility.



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- O ASSESSMENT OF SEISMIC MARGINS AT EXISTING PLANTS.
- 0 JUDGEMENT ON THE RELIABILITY OF PROBABILISTIC RISK ANALYSES FOR EARTHQUAKES.



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TITLE:

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COMPONENT FRAGILITY DATA ACQUISITION AND EVALUATION

FIN:

A 3278

CONTRACTOR:

BROOKHAVEN NATIONAL LABORATORY (BNL) PROJECT MANAGER: C. H. HOFMAYER

BUDGET:

FY 1985	FY 1986	FY 1987
\$240K	\$1100K	\$1000K

ISSUE:

MORE RELIABLE AND REALISTIC COMPONENT FRAGILITY INFORMATION IS NEEDED FOR SEISMIC MARGIN STUDIES AND PROBABILISTIC RISK ASSESSMENTS. IT IS ... all electrical NOW BELIEVED THAT PESSIMISTIC ESTIMATES OF THE SEISMIC THREAT TO NUCLEAR POWER PLANTS HAVE DEVELOPED BECAUSE OF UNDUE CONSERVATISM IN THE INPUT COMPONENT FRAGILITIES.

OBJECTIVES:

FY 1985

- TO INITIATE COOPERATION WITH DOMESTIC AND FOREIGN INSTITUTIONS TO OB-0 TAIN ALREADY EXISTING COMPONENT FRAGILITY DATA.
- TO ASSEMBLE, ANALYZE AND INTERPRET EXISTING COMPONENT FRAGILITY DATA 0 AND COMPARE WITH INFORMATION CURRENTLY BEING USED.
- TO DEVELOP A SCHEME FOR PRIORITIZING AND GROUPING COMPONENTS FOR FRA-GILITY TESTING AND TO DEMONSTRATE A PROCEDURE FOR PERFORMING COMPONENT 0 FRAGILITY TESTS WHICH WILL PROVIDE A BASIS FOR COMPREHENSIVE TESTING IN FUTURE YEARS AND USEFUL FRAGILITY DATA IN FY 1985. (LLNL OBJECTIVE UNDER A DIFFERENT FIN),

remponents

... mechanical is very rugged.

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- run shuke telbly for propility toots
- + bear confirmed walkes to to used PRA analyses.

OBJECTIVES: (CONTINUED)

FY 1986 AND 1987

- O TO REDUCE BY ADDITIONAL DATA ACQUISITION AND SOME LIMITED LABORATORY TESTING THE INADEQUACIES OF THE PRESENT COMPONENT FRAGILITY DATA BASE.
- O TO IMPROVE SEISMIC PRAS AND OBTAIN BETTER ESTIMATES OF SEISMIC MARGINS BY USING MORE REALISTIC TEST BASED COMPONENT FRAGILITIES WHICH CHARACTERIZE ACTUAL FAILURE MODES.

SCOPE:

SCOPE INCLUDES ELECTRICAL AND MECHANICAL COMPONENTS AT NUCLEAR POWER PLANTS WITH EMPHASIS ON ELECTRICAL COMPONENTS SINCE THEY ARE MAJOR RISK CONTRIBU-TORS ACCORDING TO PRESENT VIEWS. (MECHANICAL COMPONENTS ARE INHERENTLY RUGGED SINCE THEY MUST, IN GENERAL, BE DESIGNED FOR TEMPERATURE AND PRES-RUGGED SINCE THEY MUST, IN GENERAL, BE DESIGNED FOR TEMPERATURE AND PRES-SURE LOADS). ONLY ACTIVE MECHANICAL COMPONENTS TREATED, BUT BOTH ACTIVE SURE LOADS). ONLY ACTIVE MECHANICAL COMPONENTS TREATED, BUT BOTH ACTIVE AND PASSIVE ELECTRICAL COMPONENTS ARE CONSIDERED. PIPING IS EXCLUDED FROM THIS PROGRAM.

SCOPE: (CONTINUED)

EMPHASIS IS ON SEISMIC LOADS, BUT CONCURRENT OPERATING LOADS INCLUDED. NO OTHER SEVERE ENVIRONMENTAL OR ACCIDENT LOADS TREATED; ALSO SEVERE ENVIRON-OTHER SEVERE ENVIRONMENTAL OR ACCIDENT LOADS TREATED; ALSO SEVERE ENVIRON-MENTAL EFFECTS EXCLUDED. AGING, SCALING AND ANCHORAGE VARIABILITY MENTAL EFFECTS EXCLUDED. AGING, SCALING AND ANCHORAGE VARIABILITY INCLUDED. NOT NECESSARILY DEVOTED TO OBTAINING FRAGILITY LEVELS; HOWEVER, INCLUDED. NOT NECESSARILY DEVOTED TO OBTAINING FRAGILITY SARE GREATER TESTING OR DATA ACQUISITION MUST DEMONSTRATE THAT FRAGILITIES ARE GREATER THAN PRESENTLY ASSUMED BEFORE BEING DISCONTINUED.

ACCOMPLISHMENTS: (SINCE NOVEMBER 1984)

- O OBTAINED FRAGILITY INFORMATION FROM GE, WPPSS, BROWN-BOVERI, GOULD, SDRC, FARWELL & HENDRICKS, ANCO AND OTHER SOURCES. EVALUATION OF TEST RESULTS UNDERWAY.
- 0 ESTABLISHED COOPERATIVE AGREEMENT FOR INFORMATION EXCHANGE WITH EPRI. TWO-WAY INFORMATION TRANSFER IN PROGRESS.
- O HOSTED THREE DAY WORKSHOP AT BNL WHERE CRITICAL ISSUES WERE DISCUSSED AND TEST RESULTS WERE REVEALED. (SEVENTY-FIVE ATTENDEES AND TWEN-TY-TWO PRESENTATIONS). DURES DOE OUT! Within wat.
- 0 DEVELOPED PRIORITIZATION SCHEME AND IMPORTANCE CLASSIFICATION FOR COM-PONENTS.

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ACCOMLISHMENTS: (CONTINUED)

O DEVELOPED STANDARDIZED COMPONENT FRAGILITY TEST PROCEDURES; EXECUTION OF TEST PROCEDURES BEGINS ON SEPTEMBER 24, 1985, FOR APPROXIMATELY TWO MONTHS USING A THREE BAY MCC LOADED WITH ELECTRICAL COMPONENTS TO BE TESTED FOR BOTH STRUCTURAL AND FUNCTIONAL FRAGILITY.

FUTURE PRODUCTS:

FY 1986

- 0 RECOMMENDED LIST OF COMPONENT FOR TESTING BASED ON PRIORITIZATION AND GROUPING.
- 0 TEST PLANS AND TEST RESULTS FOR FRAGILITY TESTS ON ELECTRICAL COMPO-NENTS MOUNTED IN A THREE BAY MOTOR CONTROL CENTER OF VARYING STRUC-TURAL STIFFNESS AND VARYING ANCHORAGE.
- 0 SUMMARY OF CURRENT UNDERSTANDING OF COMPONENT FRAGILITY IN NUCLEAR POWER PLANTS.

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FUTURE PRODUCTS: (CONTINUED)

FY 1987

0 RECOMMENDATIONS FOR COMPONENT FRAGILITY LEVELS AND MODES OF SELECTED COMPONENTS FOR SEISMIC MARGIN AND PRA STUDIES.

REGULATORY GUIDES OR STANDARD REVIEW PLAN SECTIONS AFFECTED:

NONE; HOWEVER, COULD LEAD TO THE ESTABLISHMENT OF A COMPONENT FRAGILI-TY DATA BANK AT ONE OF THE NATIONAL LABORATORIES.

REGULATORY USE:

RESPONDS TO QUESTIONS RELATING TO EAST COAST SEISMICITY, PARTICULARLY THE CHARLESTON AND NEW BRUNSWICK EARTHQUAKE ISSUES. INTENDED TO PRO-THE CHARLESTON AND NEW BRUNSWICK EARTHQUAKE ISSUES. INTENDED TO PRO-VIDE A RATIONAL BASIS FOR DECISION SHOULD THESE ISSUES IMPOSE NEW LI-CENSING REQUIREMENTS ON EAST COAST OPERATORS.



TITLE:

SEISMIC CATEGORY I STRUCTURES PROGRAM neinforced ent 1 struct. not containment <u>FIN;</u>

A 7221

CONTRACTOR:

LOS ALAMOS NATIONAL LABORATORY

BUDGET:

FY 1985	FY 1986	FY 1987
\$820K	\$1200K	\$1500K



ISSUE:

ABILITY OF CURRENT LIGHT WATER REACTOR PLANTS TO ACCOMODATE LARGER EARTHQUAKES THAN THOSE CONSIDERED IN THEIR INITIAL DESIGN.

OBJECTIVE:

REDUCE UNCERTAINTIES IN METHODS USED TO PREDICT HOW THE INCREASED EARTHQUAKE LOADS ARE TRANSMITTED BY THE PLANT BUILDINGS TO THE SAFETY SYSTEMS AND COMPONENTS NEEDED TO OPERATE AND SHUTDOWN THE PLANT.

- 0 EXPERIMENTAL DATA ON THE SENSITIVITY OF STRUCTURAL BEHAVIOR TO VARIATIONS IN CONFIGURATION AND EARTHQUAKE LOAD.
- O CHANGES IN FLOOR RESPONSE SPECTRA RESULTING FROM INCREASED EARTH-QUAKE LOADS.
- O EXPERIMENTAL DATA TO VALIDATE COMPUTER PROGRAMS USED TO PREDICT STRUCTURAL BEHAVIOR IN THE ELASTIC AND INELASTIC RANGES.



INTEGRATION:

- O STRUCTURAL BEHAVIOR INFORMATION WILL BE PROVIDED TO:
 - VALIDATION OF SEISMIC CALCULATIONAL METHODS PROJECT
 - SEISMIC DESIGN MARGINS PROJECT
- 0 FLOOR RESPONSE SPECTRA INFORMATION WILL BE PROVIDED TO:
 - PIPING RELIABILITY PROJECTS
 - COMPONENT FRAGILITY PROJECT

SCOPE/ACCOMPLISHMENTS:

- 0 PRIOR TO FY 1985
 - STATIC OR SEISMIC TESTING OF 23 DIFFERENT MODELS REPRESENTING TWO TYPES OF STRUCTURES.

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- MODELS BUILT TO TWO DIFFERENT SCALES (ONE INCH AND THREE INCH WALL THICKNESS).
- NUMBER OF FLOORS IN THE MODELS VARIED FROM ONE TO THREE.
- STIFFNESS OF THE MODEL WAS LOWER THAN THE COMPUTER UNCRACKED CROSS-SECTION VALUES BY A FACTOR OF 4.
- SCALEABILITY OF RESULTS ILLUSTRATED IN THE ELASTIC AND INELASTIC RANGE, HOWEVER, ALL MODELS WERE FABRICATED USING MICROCONCRETE.

anti-mass system to get necessary freq.



SCOPE/ACCOMPLISHMENTS (CONTINUED)

0 FY 1985

- WITH THE AID OF THE PROGRAM TECHNICAL REVIEW GROUP A MODEL WAS DESIGNED TO HELP RESOLVE THE STIFFNESS DIFFERENCE ISSUE AND PROVIDE CREDIBILITY FOR SCALE MODEL EXPERIMENTAL DATA.

- TEST TWO 1/4 SCALE MODELS OF THE TRG STRUCTURE. THESE MODELS WERE FABRICATED WITH MICROCONCRETE AND SIMULATED REBAR.
- START FABRICATION OF THE FIRST TRG STRUCTURE. THIS MODEL WILL BE FABRICATED WITH PROTOTYPICAL CONCRETE AND REBAR. 4000 psi

In= 30 hertz seismistalie

SCOPE/ACCOMPLISHMENTS (CONTINUED)

0 FY 1986

- TEST TWO TRG STRUCTURES; THE FIRST ONE WILL BE SUBJECTED TO LOW LEVEL STATIC THAN INCREASED SEISMIC EXCITATION TO FAILURE (NOVEMBER 1985); THE SECOND ONE WILL BE TESTED QUASISTATICALLY TO FAILURE (MARCH 1986).

El Centro Barthquete Input Othrough ghaker prover timed .

- CONTINGENCY PLANS HAVE BEEN DEVELOPED FOR SCENARIOS IDENTIFIED AS LIKELY POSSIBLE OUTCOMES OF THE TRG EXPERIMENT.
- PENDING RESOLUTION OF THE STIFFNESS AND SCALEABILITY ISSUES INITIATE A LIMITED NUMBER OF EXPERIMENTS TO MEET PROGRAM OBJECTIVES AND AID IN BENCHMARKING THE ANALYTICAL MODEL DEVELOPMENT.
- A STATISTICIAN, KNOWLEDGEABLE IN EXPERIMENT DESIGN, WILL BE USED TO INSURE THAT CONTROLLED AND UNCONTROLLED VARIABLES ARE INCORPORATED INTO A COST-EFFECTIVE TEST MATRIX TO MEET PROGRAM OBJECTIVES.

(Test to compare to analysis)

SCOPE/ACCOMPLISHMENTS (CONTINUED)

0 FY 1987

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- ENHANCED ANALYTICAL EFFORT TO REDUCE THE NUMBER OF TESTS AND BENCHMARK ANALYTICAL METHODS.
- SEISMIC TESTS ON 1 FLOOR MODELS WITH 1 INCH THICK WALLS (IF FY 1986 RESULTS ALLOW) TO DETERMINE THE AFFECTS OF WALL ARRANGEMENTS AND EARTHQUAKE INPUT.
- SEISMIC TESTS ON 2 FLOOR MODELS WITH DIFFERENT WALL CONFIGURATIONS ON THE FIRST AND SECOND FLOORS (3 OR 4 INCH WALL THICKNESS). (The wall module many expensive)

REGULATORY USE:

- O PROVIDE EXPERIMENTAL DATA AND ANALYTICAL METHODS TO DETERMINE THE BEHAVIOR OF REINFORCED CONCRETE BUILDINGS SUBJECTED TO EARTHQUAKES LARGER THAN THE DESIGN BASIS.
- 0 RECOMMEND IMPROVEMENTS AND REDUCE UNCERTAINTIES IN REGULATORY GUIDES (E.G., 1.61, 1.122) AND STANDARD REVIEW PLANS (E.G., SECTIONS 3.7, 3.8, 3.9 AND 3.10).
- 0 ESTABLISH NEW REGULATORY CRITERIA CONSIDERING NONLINEAR RESPONSE EFFECTS.
- 0 WHEN COUPLED WITH COMPONENT AND PIPING RESEARCH HELP DETERMINE SEISMIC DESIGN MARGINS IN OPERATING PLANTS.

Strud. Load Continations



TITLE:

RELIABILITY ANALYSIS OF NONLINEAR BEHAVIOR OF CONCRETE STRUCTURES

FIN;

A 3292

CONTRACTOR:



BROOKHAVEN NATIONAL LABORATORY

OBJECTIVES:

- O DEVELOP STOCHASTIC, PROBABILISTIC, NONLINEAR ANALYSIS METHOD FOR MORE RIGOROUS STRUCTURAL CAPACITY ESTIMATES FOR USE IN PROBABILISTIC RE-LIABILITY ANALYSES AND STRUCTURAL SEISMIC MARGIN STUDIES.
- O DEFINE WHEN APPROPRIATE TO USE THIS NONLINEAR METHOD OR SIMPLIFIED METHOD BY SAMPLE PROBLEM COMPARISONS.
- 0 VERIFY THE APPROXIMATE NONLINEAR LIMIT STATES DEVELOPED FOR CONCRETE STRUCTURES UNDER FIN A3802, "FRAGILITIES OF CONCRETE STRUCTURES".
- SCOPE: FY 86
- TASK 1. DEVELOP STOCHASTIC, PROBABILISTIC, NONLINEAR STRUCTURAL ANALYSIS METHODS FOR CATEGORY I STRUCTURES. DEVELOP A STOCHASTIC EQUIVALENT LINEARIZATION METHOD IDEALIZED IN TERMS OF STICK MODELS. COMPARE RESULTS OBTAINED WITH RE-SULTS FROM MONTE-CARLO SIMULATION TECHNIQUES.
- TASK 2. VERIFY ANALYTICAL RESULTS BY INITIATING PSEUDODYNAMIC TESTS ON STICK MODELS OF IDEALIZED STRUCTURES. REPRODUCE NONLINEAR DYNAMIC BEHAVIOR UNDER SEISMIC LOADING ON A DECELERATED TIME SCALE, AND ESTABLISH A RELATIONSHIP BETWEEN THE MAXIMUM NONLINEAR RESPONSE AND PEAK GROUND ACCELERATION.



TASK 3. INITIATE EXTENSION OF THE RELIABILITY ANALYSIS METHOD TO INCLUDE NONLINEAR STRUCTURAL RESPONSE.

verying random

COMPLETE REPORT ON STOCHASTIC EQUIVALENT LINEARIZATION TASK 4. TECHNIQUE FOR CATEGORY I STRUCTURES.

nonlinear li havine into a more mana pable technique an approx.

87 about some as 86 except compte grogram.

--- containment performance cilleria (in aces pattie) us wants (WBNL) to review program with us. ... is essingwood still involved ? don't know !

38



O DEVELOP MORE RIGOROUS STRUCTURAL FRAGILITY ESTIMATES FOR USE IN PRAS AND SEISMIC MARGIN STUDIES.

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- 0 EVALUATION OF EXISTING STRUCTURAL CAPACITIES AND PRAS FOR OPERATING REACTORS.
- 0 EXTEND BNL-DEVELOPED PROBABILITY-BASED LOAD COMBINATION METHODOLOGY TO INCLUDE NONLINEAR BEHAVIOR.



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TITLE:

STRUCTURAL DEGRADATION

FIN;

TO BE ASSIGNED

CONTRACTOR:

TO BE SELECTED

BUDGET:

4

FY 1985 FY 1986 FY 1987 \$0 K \$0 K \$300K proposal for 1987 hot hi privieity iten yet!

40



OBJECTIVE:

PREPARE NRC STAFF TO BE ABLE TO IDENTIFY:

- O STRUCTURAL ADEQUACY UNDER EXTENSIONS OF PLANT DESIGN LIFE.
- 0 POST-LOCA ENVIRONMENTAL EFFECTS ON STRUCTURAL RELIABILITY.
- 0 HOW TO ADJUST STRUCTURAL CAPACITIES AFFECTED BY DEGRADATION WHEN PER-FORMING SEVERE ACCIDENT ANALYSES.
- 0 WHAT SECONDARY EFFECTS RESULT FROM DETERIORATION OF MATERIALS UNDER OPERATING OR POST-LOCA CONDITIONS.

SCOPE:

- O BEGIN INVESTIGATIONS INTO LONG-TERM CHEMICAL REACTIVITY BETWEEN SPE-CIFIC TYPES OF CONCRETE AGGREGATES, ADDITIVES (SUCH AS FLYASH), AND CEMENTS OF DIFFERENT ALKALINITIES.
- 0 MORE ADVANCED UNDERSTANDING OF HOW DIFFERENT CONCRETES BEHAVE UNDER LONG-TERM CONDITIONS OF LOCALLY HOT (150^OF - 300^OF) TEMPERATURES SUCH AS THOSE AT PENETRATIONS.



REGULATORY USES:

- 0 IMPROVED PREDICTIONS OF LONG TERM MATERIAL DETERIORATION
- 0 LIMITS ON HOSTILE OPERATING ENVIRONMENTAL EXPOSURES
- 0 REDUCTION OF LICENSING RELIANCE PURELY ON INSPECTION AND SURVEILLANCE
- 0 IMPROVEMENTS IN DAMAGE INSPECTION AND INCORPORATION INTO SRP-REFERENCED NATIONAL DESIGN STANDARDS

WILL ENABLE NRC STAFF TO:

- O BETTER ACCEPT MATERIAL SELECTIONS
- O REQUIRE APPROPRIATE DESIGN PROVISIONS
- O PERMIT CONTINUED OPERATION NEAR, AT, OR BEYOND 40-YR DESIGN LIFE

42



O ASK LICENSEES THE RIGHT QUESTIONS WHEN REVIEWING REQUESTS FOR EX-TENSIONS OF PLANT DESIGN LIFE

EXAMPLES:

- 0 MICRO/SHRINKAGE CRACKING STIFFNESS DEGRADATION IN LANL SHEAR WALL TESTS
- O USE AT SEABROOK OF AGGREGATE SHOWING ALKALI-SILICA REACTION AT PEASE AFB RUNWAY
- O CHEMICAL REACTIVITY IN ONTARIO-HYDRO CONTAINMENT BLDG
- O TENDON FAILURES IN ORNL MODEL PCRV, PERHAPS DUE TO THERMAL DECOMPOSI-TION OF TENDON GREASE
- 0 W. R. GRACE & CO. EVIDENCE THAT HALOGENS, ESP. PVC, DECOMPOSE LINEARLY VS. AT SOME THRESHOLD LEVEL OF ENERGY INPUT

43





- 0 WOLSUNG 1 (KOREA) CONCRETE BASEMAT SWELLING, DUE TO ALKALINE CEMENT REACTION W/VOLCANIC AGGREGATE
- 0 DEGRADATION OF SONGS-1 EQUIPMENT SUPPORTS DUE TO PLANT ENVIRONMENT
- 0 9 MILE PT.-1 REACTOR BLDG WALL CRACK, POSSIBLY DUE TO THERMAL GRADIENT

CPS: not a very finitfie endeavor ... lots of info on concrete degradetion. (our normer the questions) to ark skichendson: Program to develop impostent questions. for heiming, in now to extend plant hiersing.

MB: need a mall list



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TITLE:

STANDARD PROBLEMS FOR STRUCTURAL COMPUTER CODES

FIN;

A 3242

CONTRACTOR:

BROOKHAVEN NATIONAL LABORATORY (BNL)

BUDGET:

FY 1985	FY 1986	FY 1987
\$300K	\$200K	\$200K

45

ISSUE:

VARIOUS ANALYTICAL APPROACHES WITH DIFFERENT DEGREES OF APPROXIMATION HAVE BEEN DEVELOPED AND USED TO DETERMINE STRUCTURAL RESPONSE AND SOIL-STRUCTURE INTERACTION OF NUCLEAR STRUCTURES TO SEISMIC AND DYNAM-IC LOADS. APPROXIMATIONS USED MAY OR MAY NOT REPRESENT THE PHYSICAL BEHAVIOR OF THE STRUCTURE, THUS, THERE IS A NEED TO ESTABLISH BENCHMARKS SOLUTIONS TO DETERMINE THE VALIDITY AND ACCURACY OF ANALYT-ICAL METHODS PRESENTLY USED.

OBJECTIVE:

TO ESTABLISH PROBLEMS WITH EXPERIMENTALLY KNOWN SOLUTIONS (BENCHMARKS) FOR USE BY THE LICENSING STAFF TO VALIDATE MAJOR PARTS OF LICENSEE METHODS USED TO CALCULATE STRUCTURAL RESPONSE AND SSI OF SAFE-TY-RELATED BUILDINGS, SYSTEMS AND COMPONENTS.

46

INTEGRATION:

- O THE FINDINGS OF THIS PROGRAM CAN BE USED IN EFFORTS TO DETERMINE SEIS-MIC SAFETY MARGINS.
- O EXPERIMENTAL RESULTS FROM VARIOUS STUDIES CURRENTLY BEING PERFORMED FOR THE NRC AT SNL (CONTAINMENTS), WCC (E.Q. CHARACTERIZATION) AND LANL CATEGORY I STRUCTURES) WILL COMPLEMENT THIS PROGRAM, ALSO WORK FUNDED BY EPRI (SIMQUAKE) HAS BEEN USED.
- O DATA HAS ALSO BEEN OBTAINED THROUGH COOPERATIVE AGREEMENTS (FUKUSHIMA)

SCOPE/ACCOMPLISHMENTS:

0 FY 1985

- WORK WAS CONCENTRATED IN THE SSI AREA; SPECIFICALLY, WITH DE-TERMINING THE EFFECTS OF FOUNDATION LIFTOFF, HIGH GROUND WATER TABLE, AND SOIL LAYERING ON SSI ANALYTICAL METHODS.

0 FY 1986

48

- COMPLETE FY 85 EFFORTS (WATER TABLE)
- INITIATION OF A STRUCTURAL DATA SURVEY AND EVALUATION OF DATA
- WORKSHOP ON SSI _ L blig response reinforce concrete strud.

0 FY 1987

- DEVELOP SSI BENCHMARK PROBLEMS shear well type struet
- DEVELOP STRUCTURAL (CONCRETE) BENCHMARK PROBLEMS
- EVALUATE AVAILABLE NEW DATA WITH THE AIM OF IMPROVING BENCHMARKS

CPS- was Humboltd by data used ... not enough instrumentation

- to find oil how good your codes are.

REGULATORY USE:

- O PRELIMINARY FINDINGS HAVE BEEN USED BY BNL TO HELP NRR (SGEB) RESOLVE SSI ISSUES ON BYRON, BEAVER VALLEY 2, AND DIABLO CANYON NUCLEAR PLANTS.
- O BENCHMARKS WILL BE USED TO ASSESS THE ACCURACY OF LICENSEE METHODS USED TO PREDICT THE BEHAVIOR OF SAFETY RELATED STRUCTURES UNDER SEIS-MIC LOADS.
- 0 BENCHMARKS AND OTHER DATA DEVELOPED WILL BE USED TO EVALUATE/REVISE AND WHERE NECESSARY ESTABLISH NEW SEISMIC DESIGN CRITERIA (I.E., SRP, REG. GUIDES).]

49

REPORTS:

S. SHARMA, M. REICH, AND TY CHANG, BROOKHAVEN NATIONAL LABORATORY, "REVIEW OF CURRENT ANALYSIS METHODOLOGY FOR REINFORCED CONCRETE STRUCTURAL EVALUATIONS," USNRC REPORT NUREG/CR-3284, APRIL 1983.

C. A. MILLR, C. J. COSTANTINO, A. J. PHILIPPACOPOULOS, AND M. REICH, BROOKHAVEN NATIONAL LABORATORY," VERIFICATION OF SOIL-STRUCTURE INTERACTION METHODS," USNRC REPORT NUREG/CR-4128, MAY 1985.



NUREG - 1061 Based or vol 264 Re reports [12 ticked recent

NRC/EPRI PROGRAMS ON PIPING DYNAMIC LOAD CAPACITY

EPRI/NRC COOPERATIVE PROGRAM "PIPING AND FITTING DYNAMIC RE-0 LIABILITY" (FIN D1157) - main effort. [elbours ; systems.] ETEC DEMONSTRATION SEISMIC FRAGILITY PIPE TEST (FIN B3052)

187 0 INDEPENDENT ASSESSMENT OF PROPOSED ASME PIPING RULE CHANGES ... 28. 9 187 0 INTEGRATION WITH NRC DEGRADED PIPING PROGRAM

PIPING FRAGILITY REDEFINITION FOR PRA USE

CONTRACTOR:

GE (THROUGH EPRI), ETEC, ANCO, OTHERS

MSEB BUDGET:

EV 1005	FW 1000	FV 1007	Oland.
FY 1985	FY 1986	<u>FY 1987</u>	Kennoh
\$200K	\$700K	- \$900K	Busnak
	BOOK - FRIEL	adding 2×10	Janes

Ergent pauel recommendations designé contraction

Lows.





- O PRA PIPING FRAGILITY ESTIMATES NEED VALIDATION.

OBJECTIVES:

- O EXPERIMENTALLY DETERMINE DYNAMIC FAILURE LEVELS AND MECHANISMS (FA-TIGUE/RATCHETTING OR COLLAPSE) FOR PIPING SYSTEMS AND COMPONENTS.
- O DEVELOP NEW DESIGN RULES FOR ASME CLASS 1, 2, AND 3 PIPING.
- 0 ASSESS THE IMPACT OF THESE PROPOSED CHANGES.
- 0 IMPROVE PRA PIPING FRAGILITY ESTIMATES.
- O BENCHMARK NONLINEAR BEHAVIOR IN THE PIPE FAILURE RANGE.

SCOPE/ACCOMPLISHMENTS:

0 FY 1985

- NRC/EPRI COOPERATIVE AGREEMENT ESTABLISHED
- PROGRAM PLANNING COMPLETED
- ANCO COMPONENT TESTS INITIATED (FIRST 12 OF 40 TESTS)
- ETEC DEMONSTRATION TEST INITIATED
- 0 FY 1986
 - COMPONENT TESTING CONTINUES
 - SEISMIC PIPING SYSTEMS TESTS (SEISMIC) ... also water hummer
 - FATIGUE/RATCHETTING SPECIMEN TESTS
- 0 FY 1987
 - COMPONENT TESTS COMPLETED
 - HYDRODYNAMIC LOAD & WATERHAMMER PIPING SYSTEMS TESTS
 - FATIGUE/RATCHETTING TESTS COMPLETED
 - DEVELOPMENT OF PROPOSED CODE CHANGES
 - ASSESSMENT OF THESE CODE CHANGES
 - RESULTS OF TESTS INTEGRATED WITH RESULTS OF THE DEGRADED PIPING PROGRAM
 - PRA FRAGILITY MODELS VALIDATED/IMPROVED



REGULATORY USE:

- O PROVIDES THE BASES TO ENDORSE CHANGES TO ASME CODE RULES (SECTION III, SUBSECTIONS NB/NC/ND 3600).
- O PROVIDE FURTHER JUSTIFICATION FOR SNUBBER MINIMIZATION.
- O ESTABLISH PIPING FAILURE MECHANISMS AND MARGINS.

54






	5-in. System (Fig. 1)	3-in. System (Fig. 2)
End supports only	no supports	no supports
Hydraulic snubber	1	
Mechanical snubber	1	1
Rigid strut	1	2
Combination strut and snubber	1,2	1,2
Strut combination	1,2	



LITL

TITLE:

OTHER NRC PIPING RESEARCH (low property tems except nozile.)

NOZZLE DESIGN GUIDANCE (ORNL FIN B0474)

- COMBINATIONAL PROCEDURES FOR PIPING RESPONSE SPECTRA ANALYSIS (BNL FIN A3287)
- NONLINEAR PIPING RESPONSE PREDICTIONS (HEDL FIN D1611)
- ASSESSMENT AND IMPROVEMENT OF SPECTRUM-BROADENING PROCEDURES (LLNL FIN A0453)
- TIME HISTORY PIPE DAMPING (UNDESIGNATED)
- ADDITIONAL STUDIES OF COMBINED EFFECTS (UNDESIGNATED) ->. pure + independent suppose point. instrim ! loss of concervation.

BUDGET:

FY 1985	FY 1986	FY 1987
\$333K	\$375K	\$600K

59



ISSUES:

- 0 NEED TO IMPROVE PIPING RESPONSE PREDICTION TECHNIQUES, AS ITEMIZED IN NUREG 1061 (PIPING REVIEW COMMITTEE RECOMMENDATIONS)
- 0 NEED TO ADDRESS COMBINED EFFECTS OF PRC RECOMMENDATIONS ON PIPING DE-SIGN
 - ISM METHOD IN COMBINATION WITH PVRC DAMPING
 - RECLASSIFICATION OF SEISMIC STRESSES
 - SUPPORT DESIGN

SCOPE/ACCOMPLISHMENTS:

- 0 FY 1985 AND 1986
- 0 IMPROVE NOZZLE DESIGN GUIDANCE
- O EVALUATE ISM METHOD IN COMBINATION WITH PVRC DAMPING
- 0 IMPROVE MODEL COMBINATION METHODS
 - ISM WITH KNOWN PHASE CORRELATION
 - CLOSELY SPACED MODES
 - HIGH FREQUENCY MODES

60





- O EVALUATION OF APPROPRIATENESS OF R.G. ±1.122 PEAK BROADENING RANGE
- O DEVELOPMENT OF BASES FOR "FLATTENED AND BROADENED" SPECTRA
- O RECOMMENDATIONS FOR DAMPING VALUES TO BE USED IN TIME-HISTORY ANALYSIS

61

- 0 FY 1987
- 0 INVESTIGATION OF COMBINED EFFECTS OF NEW PIPING DESIGN CRITERIA
 - DAMPING
 - NEW ASME DESIGN RULES
 - NEW NOZZLE DESIGN CRITERIA
 - PIPING SUPPORT DESIGN RULES

TITLE:

PARAMETERS INFLUENCING DAMPING IN PIPING SYSTEMS (ment. of 1000 grages) <u>FIN;</u>

A 6316

CONTRACTOR:

INEL

BUDGET:

FY 1985 \$230K <u>FY 1986</u> \$200K \$0 K

62

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TRANSING SALANCED STATES OF A STATES OF A



- O OVERALLY STIFF PIPING DESIGNS HAVE RESULTED FROM USE OF R.G. 1.61 DAMPING VALUES.
- O DATA AND GUIDANCE IS LACKING FOR HIGH FREQUENCY MODAL RESPONSE CAUSED BY NONSEISMIC LOADS.

OBJECTIVES:

- O COMPILE AND EVALUATE EXISTING DAMPING DATA
- O TEST SIMPLE SYSTEMS, VARYING RESPONSE AND DESIGN PARAMETERS
- SCOPE/ACCOMPLISHMENTS:
- 0 FY 1985
- O ESTABLISHED WORLD DATA BASE ON PIPE DAMPING

0 TESTING OF 3-DIMENSIONAL SYSTEM

- LOW STRAIN AMPLITUDES
- DIFFERENT SUPPORT CONFIGURATIONS
- PRESSURIZED AND UNPRESSURIZED
- DIFFERENT FORCING FUNCTIONS
- O REVIEW OF EXISTING HIGH FREQUENCY DAMPING DATA
- 0 FY 1986
- 0 CONTINUED TESTING OF 3-DIMENSIONAL SYSTEM
 - HIGH FREQUENCY LOADS
 - INSULATION
 - HIGH STRAIN SEISMIC LOADS
- 0 TESTING OF 1-DIMENSIONAL SYSTEM AT HIGH FREQUENCY
- 0 FINAL REPORT

64

REGULATORY USE:

PROVIDE BASIS FOR ENDORSING ASME CODE CASE N-411) 0-33 hz nauge

PURC and N-411

- 0
- PROVIDE BASIS FOR REVISING R.G. 1.61 AND SRP 0

CONTAINMENT INTEGRITY PROGRAM ACTIVITIES

FIN A-1401 ANALYSIS AND EVALUATION

- PLANNING OF EXPERIMENTS
- PRETEST PREDICTIONS
- POST TEST EVALUATIONS
- DEVELOPMENT OF PREDICTIVE METHODS
- INTERACTION WITH PEER REVIEW PANEL

FIN A-1375 PENETRATION TESTS

- PROCUREMENT OF SPECIMENS
- DETAILED DESIGN OF TEST FIXTURES AND INSTRUMENTATION
- CONDUCT OF EXPERIMENTS
- COMPILATION OF TEST REPORTS

FIN A-1249 LARGE MODEL TESTS

- DESIGN AND CONSTRUCTION OF MODELS
- INSTALLATION OF INSTRUMENTATION
- EXPERIMENTAL PLAN AND SAFETY ANALYSES
- CONDUCT OF EXPERIMENTS
- COMPILATION OF TEST REPORTS

TITLE:

CONTAINMENT INTEGRITY UNDER EXTREME LOADS

FIN;

A 1401

CONTRACTOR:

SANDIA NATIONAL LABORATORY

COOPERATING ORGANIZATIONS

KERNFORSCHUNGSZENTRUM KARLSRUHE (FRG) ELECTRIC POWER RESEARCH INSTITUTE (EPRI) COMMISARIAT A L'ENERGIE ATOMIQUE (FRANCE) NUCLEAR INSTALLATIONS INSPECTORATE (UK)

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BUDGET:

FY 1985	FY 1986	FY 1987
\$740K	\$600K	\$700K



ISSUE:

THE CONSEQUENCES OF A SEVERE ACCIDENT WOULD BE SIGNIFICANTLY AFFECTED BY THE PERFORMANCE OF THE CONTAINMENT. ANALYTICAL PREDICTIONS OF CONTAINMENT FAILURE MODES REQUIRE EXPERIMENTAL VALIDATION.

OBJECTIVE:

DEVELOP A METHODOLOGY THAT CAN BE USED TO PREDICT THE PERFORMANCE OF CONTAINMENT BUILDINGS DURING SEVERE ACCIDENTS.

68

INTEGRATION:

- 0 LARGE MODEL TESTS PERFORMED UNDER FIN A1249 PROVIDE THE DATA FOR BENCHMARKING ANALYTICAL PREDICTIONS OF STRUCTURAL DEFORMATIONS.
- O PENETRATION TESTS PERFORMED UNDER FIN A1375 PROVIDE DATA FOR ANALYTICAL PREDICTIONS OF LEAKAGE.

SCOPE/ACCOMPLISHMENTS:

- O PRIOR TO FY 1985
 - PRE TEST PREDICTIONS AND POST TEST ANALYSES FOR SMALL STEEL MODEL SERIES.

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- 0 FY 1985
 - POST TEST ANALYSIS OF LARGE STEEL MODEL TEST.
 - PRE TEST PREDICTIONS FOR CONCRETE MODEL TEST.
- 0 FY 1986
 - DEVELOP A BASIS FOR EXTENDING CONCRETE MODEL TEST INSIGHTS TO PRESTRESSED CONTAINMENTS.
 - DETERMINE EXPERIMENTS NECESSARY TO VERIFY PREDICTIONS OF PERFORMANCE UNDER SEISMIC LOADS.
- 0 FY 1987
 - POST TEST ANALYSES FOR CONCRETE MODEL.
 - PRE TEST PREDICTIONS FOR SEISMIC EXPERIMENTS.
 - DEVELOPMENT OF A LEAKAGE METHODOLOGY BASED ON PENETRATION
 - EXPERIMENTS.



REGULATORY USE:

- O CONFIRMATORY ASSESSMENT OF SEVERE ACCIDENT POLICY STATEMENT.
- 0 BASIS FOR POSSIBLE ADDITION OF CONTAINMENT PERFORMANCE REQURIEMENT FOR SAFETY GOAL IMPLEMENTATION.

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71

TITLE:

INTEGRITY OF CONTAINMENT PENETRATIONS UNDER SEVERE ACCIDENT CONDITIONS

FIN;

A 1375

CONTRACTOR:

SANDIA NATIONAL LABORATORY

BUDGET:

FY 1985	FY 1986	FY 1987
\$900K	\$900K	\$600K



THE CONSEQUENCES OF A SEVERE ACCIDENT WOULD BE SIGNIFICANTLY AFFECTED BY THE PERFORMANCE OF THE CONTAINMENT. ANALYTICAL PREDICTIONS OF CONTAINMENT FAILURE MODES REQUIRE EXPERIMENTAL VALIDATION.

OBJECTIVE:

PENETRATIONS THAT COULD CONTRIBUTE TO LEAKAGE DURING SEVERE ACCIDENTS. DETERMINE THE MAJOR CHARACTERISTICS OF OPERABLE AND FIXED CONTAINMENT THE EFFECT OF PRESSURE, TEMPERATURE AND DEFORMATION MUST BE STUDIED.

INTEGRATION:

THE PREDICTIVE METHODS TO BE DEVELOPED UNDER FIN A1401 WILL RELY IN LARGE MEASURE ON THE PENETRATION EXPERIMENTS. 0

INTEGRATED INTO THE LARGE MODEL TESTS PERFORMED UNDER FIN A1249. TESTS OF LARGE DIAMETER PENETRATIONS UNDER PRESSURE LOADING ARE 0

77

SCOPE/ACCOMPLISHMENTS:

- O PRIOR TO FY 1985
 - SURVEY OF PENETRATION TYPES, GEOMETRIES, AND MATERIALS TO IDENTIFY MOST LIKELY CANDIDATES FOR LEAKAGE TESTS.

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- DESIGN OF TEST MATRIX FOR SEAL AND GASKET GEOMETRIES AND MATERIALS.
- 0 FY 1985
 - INITIATION OF SEAL AND GASKET TESTS.
 - PROCUREMENT OF A FULL SCALE AIR LOCK AND SELECTION OF A TEST FACILITY.
 - DESIGN DETAILS COMPLETED FOR AIR LOCK AND EQUIPMENT HATCHES IN CONCRETE MODEL.
- 0 FY 1986
 - COMPLETTION OF SEAL AND GASKET TESTS.
 - COMPLETION OF AIR LOCK TEST.
 - PROCUREMENT OF BELLOWS AND DEVELOPEMENT OF TEST PLAN.



0 FY 1987

- EVALUATION OF AIR LOCK TEST.
- PERFORMANCE OF BELLOWS TEST.

REGULATORY USE:

- O CONFIRMATORY ASSESSMENT OF SEVERE ACCIDENT POLICY STATEMENT.
- 0 BASIS FOR POSSIBLE ADDITION OF CONTAINMENT PERFORMANCE REQURIEMENT FOR SAFETY GOAL IMPLEMENTATION.

79



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75

TITLE:

EXPERIMENTS ON CONTAINMENT MODELS UNDER EXTREME LOADING CONDITIONS

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FIN;

A 1249

CONTRACTOR:

SANDIA NATIONAL LABORATORY

BUDGET:

FY 1985	FY 1986	FY 1987
\$2060	\$2000K	\$2400K





ISSUE:

THE CONSEQUENCES OF A SEVERE ACCIDENT WOULD BE SIGNIFICANTLY AFFECTED BY THE PERFORMANCE OF THE CONTAINMENT. ANALYTICAL PREDICTIONS OF CONTAINMENT FAILURE MODES REQUIRE EXPERIMENTAL VALIDATION.

OBJECTIVE:

PERFORM EXPERIMENTS ON CONTAINMENT MODELS THAT WILL PRODUCE FAILURE DATA UNDER EXTREME LOADING CONDITIONS AND PERMIT AN EVALUATION OF THE CAPABILITY OF STATE-OF-THE-ART CALCULATIONAL METHODS TO PREDICT CONTAINMENT FAILURE UNDER SEVERE ACCIDENT CONDITIONS.

INTEGRATION:

- O THE MODEL EXPERIMENTS ARE COORDINATED WITH THE ANALYTICAL PREDICTION EFFORT PERFORMED UNDER FIN A1401.
- O THE LARGE DIAMETER PENETRATIONS INCLUDED IN THE MODELS PROVIDE DEFORMATION DATA USED IN THE PENETRATION EXPERIMENTS PERFORMED UNDER FIN A1375.

76

SCOPE/ACCOMPLISHMENTS:

- O PRIOR TO FY 1985
 - DEVELOPMENT OF A REMOTE TESTING FACILITY FOR HIGH PRESSURE EXPERIMENTS.
 - TESTS TO FAILURE OF A SERIES OF THREE SMALL STEEL MODELS TO VERIFY THE ABILITY OF LARGE DEFORMATION COMPUTER CODES TO MODEL STIFFENER BEHAVIOR AND BEHAVIOR AT PENETRATION DISCONTIUITIES.
 - DESIGN, CONSTRUCTION, AND INSTRUMENTATION OF A LARGE STEEL MODEL.
- 0 FY 1985
 - COMPLETED TESTING TO FAILURE OF A LARGE STEEL MODEL.
 - COMPLETED DESIGN AND STARTED CONSTRUCTION OF CONCRETE MODEL.
- 0 FY 1986
 - COMPLETE CONSTRUCTION AND INSTRUMENTATION OF CONCRETE MODEL AND INITIATE TESTING.
- 0 FY 1987
 - COMPLETE TESTING TO FAILURE OF CONCRETE MODEL
 - PERFORM ANY NECESSARY SUPPLEMENTARY TESTS
 - INITIATE EXPERIMENTS ON SEISMIC PERFORMANCE





- O CONFIRMATORY ASSESSMENT OF SEVERE ACCIDENT POLICY STATEMENT.
- 0 BASIS FOR POSSIBLE ADDITION OF CONTAINMENT PERFORMANCE REQURIEMENT FOR SAFETY GOAL IMPLEMENTATION.

POST-TEST ANALYSIS OF FAILURE

The failure mechanism and capacity of the model were not predicted correctly. Metallurgical investigations showed that the failure was ductile, and no degradation or defects in the materials or welds were detected.

10.1-10

A crack in the formed stiffener around EH1 was observed during the test (first reported at 165 psig). A post-test analysis was conducted to investigate: (1) what caused the initial crack in the formed stiffener, and (2) how a crack in the stiffener would affect the response of the containment wall.

The model was similar to that used for the pretest analyses, except for an "eccentricity" at the junctures between the formed stiffeners and circumferential stiffeners.

POST-TEST ANALYSIS - RESULTS

At 165 psig, the max. principal strain was 16% at the outer fibers of the formed stiffener where it intersected the circumferential stiffener. This is consistent with the observed crack. With the introduction of the eccentricity, equilibrium at the juncture could not be satisfied with membrane forces only, thereby resulting in bending moments and high shear.

A strain concentration occurred in the cylinder near the stiffener's juncture, with the maximum principal strain (primarily hoop) exceeding 14% at 195 psig. Again, the calculated strain in conjunction with the rupture criterion is consistent with the experiment. This strain concentration is a direct result of the redistribution of load from the stiffener (after it has cracked) into the shell wall.



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PROGRAM ACTIVITIES

SURVEY OF MECHANICAL PENETRATIONS (ARGONNE NATIONAL LABORATORY)

PRELIMINARY ANALYSIS (ANL, SANDIA)

TESTS ON PENETRATIONS (SANDIA)

TESTS ON SEALS (SANDIA, IDAHO NATIONAL ENGINEERING LABORATORY)

DS-11-12

NOTE - INVESTIGATION OF ELECTRICAL PENETRATION ASSEMBLIES IS BEING CONDUCTED IN ANOTHER PROGRAM





PROGRAM STEPS

- SURVEY OF PENETRATION TYPES AND DESIGNS PERFORMED BY ANL ON 48 U.S. PLANTS
- QUALITATIVE FIGURES OF MERIT DEVELOPED
- PRELIMINARY ANALYSES CONDUCTED
- PROGRAM PLAN DEVELOPED
- CONDUCT PROGRAM



PERSONNEL AIR LOCK (FULL SIZE) 1986

EXPANSION BELLOWS

DRYWELL HEAD FOR BWR MK I OR MK II 1986-37

ANALYSES DO NOT INDICATE NEED FOR EXPERIMENT

PRESSURE SEATING EQUIPMENT HATCHES

Models for predicting the deformation and leakage for pressure seating hatches in a steel containment were verified by the 1:8-scale steel model test

Significant interaction between the cylinder (shell) and the penetration sleeve occurs.

Average membrane strains from 2.3% up to 5% must arise before the sleeve deformation is sufficient to cause a mismatch with the cover that results in leakage.

Two additional pressure seating equipment hatches will be tested in the 1:6-scale reinforced concrete model.

DRYWELL HEAD ANALYSES

CPWG cites unseating of drywell head due to internal pressurization as a major contributor to leakage in Mk I and Mk II containments in a severe accident. However, the conclusion is based on analysis that did not take into account the effect of elevated temperatures, which are also present in the accident.

ANL and Sandia have conducted independent analyses that show that if elevated temperatures inside the containment are considered in the analysis, metal to metal contact will be maintained between the sealing surfaces, thereby precluding leakage.

Differential thermal expansion between the drywell head flanges, which house the seal, and the bolts, which attach the drywell head to the lower part of the containment, has the effect of additional preload on the bolts, thereby substantially increasing the pressure needed to unseat the drywell head.

DRYWELL HEAD ANALYSES

ANL used a sophisticated finite element approach, whereas Sandia derived closed form solutions based on a strength of materials approach.

Sandia analyzed the response of drywell heads in eight containments. There were significant differences in the drywell head diameter, flange thickness, number of bolts, bolt diameter, and bolt preload within this group. Only one of the eight unseated at the maximum accident pressure (120 psig), and the gap was less than 2 mils, which would most likely be closed by the seal material. There are significant conservatisms in Sandia's analyses, and the actual separation pressure is probably higher.

Based on the analyses, a test of a drywell head was not felt to be necessary.

PRESSURE UNSEATING EQUIPMENT HATCHES

A pressure unseating equipment hatch will be tested in the 1:6-scale reinforced concrete model

The same methodology used to analyze drywell heads will be used to analyze the pressure unseating hatch.

Data from the test (gap measurements, compression in the flanges) will be used to assess the method.

PERSONNEL AIRLOCKS

Test will be conducted in FY 86

Preliminary analyses suggest that: (1) no significant interaction occurs between the shell and sleeve, and (2) the door and bulkhead will undergo large deformations associated with bending.

Finite element analyses will be performed with the actual material properties, and a leakage criterion will be proposed I or to the test.





TESTS ON SEALS

MATERIALS -

CROSS-SECTION GEOMETRY - SILICONE RUBBER EPM/EPDM VITON (FKM) NEOPRENE

"O" RING DOG EAR GUM DROP TONGUE-AND-GROOVE




TESTS ON SEALS

ENVIRONMENT - SEALS AGED AND UNAGED AGING (THERMAL AND RADIATION EXPOSURE BEFORE TEST)

> PRESSURE - UP TO 160 PSIA (1100 KPA)

TEMPERATURE - UP TO 700° F (370° C)



TEST SET-UP - PRESSURE CHAMBER (SATURATED OR SUPERHEATED STEAM, HEATED AIR, OR NITROGEN)

MATING SURFACES - METAL-TO-METAL CONTACT PRESCRIBED GAP ROTATION OF ONE SURFACE (MACHINED INCLINE)





EXPERIMENTS/ANALYSES OF PENETRATIONS

SHELL-STRUCTURE INTERACTION EQUIPMENT HATCH PERSONNEL AIR LOCK

EQUIPMENT HATCH WITH SEAL

EQUIPMENT HATCHES 2 PRESSURE SEATING 1 PRESSURE UNSEATING TESTS ON 1:32 SCALE STEEL, 1:8 SCALE STEEL, & 1:6 SCALE CONCRETE MODELS

1:8 SCALE STEEL MODEL

1:6 SCALE REINFORCED CONCRETE MODEL, 1987

FUTURE WORK

- COMPLETE TESTS ON SEALS
- INVESTIGATE EFFECT OF AEROSOLS ON LEAKAGE (PLUGGING)
- TEST PERSONNEL AIR LOCK (THERMAL AND STRUCTURAL)
- EQUIPMENT HATCH TEST IN REINFORCED CONCRETE MODEL







WHIPJET PROGRAM

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DUQUESNE LIGHT COMPANY

BEAVER VALLEY POWER STATION - UNIT 2

WHIPJET PROGRAM

AN ALTERNATIVE ENGINEERING METHOD FOR PIPE BREAK PROTECTION

- PERFORM TEST & ANALYSIS TO SHOW LBB APPROACH IS APPROPRIATE FOR B.O.P. SYSTEMS
- IMPLEMENT THE LBB APPROACH
 DEMONSTRATE LEAKS OCCUR FIRST
 DEVELOP LEAK DETECTION PROGRAM

RETAIN RUPTURE RESTRAINTS IN AREAS LBB IS NOT APPLICABLE OR ECONOMICAL

RETAIN DEGB ASSUMPTION FOR ECCS, CONTAINMENT DESIGN, ETC.



PROGRAM

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o SCOPE

O ACTIVITIES

- STRESS CORROSION REVIEW
- WATER HAMMER ANALYSES
- FATIGUE EVALUATION
- EQUIPMENT SUPPORT EVALUATION
- LBB ANALYSES
- LEAK DETECTION PROGRAM
- COST BENEFIT ANALYSIS

SUMMARY AND CONCLUSIONS



THE NUMBERS REFER TO BVPS-2 RESTRAINTS AND JET SHIELDS

SCOPE

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ACTIVITIES

DEMONSTRATE APPLICABILITY OF LBB

- O STRESS CORROSION REVIEW
- O WATER HAMMER ANALYSES
- O FATIGUE EVALUATION
- D EQUIPMENT SUPPORT EVALUATION

IMPLEMENTATION OF LBB PROGRAM

- O LEB ANALYSES
- - O LEAK DETECTION PROGRAM
- O COST BENEFIT ANALYSIS

STRESS CORROSION REVIEW

 CONDUCT A SPECIFIC STRESS
 CORROSION REVIEW ON A SYSTEM-BY-SYSTEM BASIS

ASSESS COMBINATION OF STRESS LEVELS, MATERIAL, AND CORROSIVE FLUID ENVIRONMENT FOR EACH CLASS OF PIPING

ASSESS THE POTENTIAL FOR STRESS
 CORROSION CRACKING AND FORMULATE
 A CONCLUSION FOR B.O.P. SYSTEMS



WATER HAMMER ANALYSES

- REVIEW TRANSIENTS CONSIDERED APPLICABLE TO BVPS-2 WATER HAMMER ANALYSES
- ASSESS THE POTENTIAL FOR HARMFUL WATER HAMMER ON A SYSTEM-BY-SYSTEM BASIS
- PROVIDE TECHNICAL JUSTIFICATION TO SHOW WATER HAMMER IS ADEQUATELY CONTROLLED
- DOCUMENT TREATMENT OF FLOW TRANSIENTS FOUND APPLICABLE TO BVPS-2



FATIGUE EVALUATION

- O THERMAL FATIGUE EFFECTS PREDICTED BY USING:
 - NUMBER OF THERMAL CYCLES
 - ALLOWABLE STRESS LEVELS TO OBTAIN CUMULATIVE USAGE FACTORS (CUF)

PERFORM MORE FATIGUE EVALUATION FOR LINES WITH CUF GREATER THAN 0.1



EQUIPMENT SUPPORT EVALUATION

ESTABLISH CRITERIA TO EXAMINE
 EQUIPMENT SUPPORTS AFFECTING
 B.O.P. PIPING

SUPPORT FAILURE POTENTIAL MUST BE EXAMINED TO ENSURE PLANT SAFETY IS NOT COMPROMISED







- PLANT SPECIFIC









- CONSERVATIVE
- CIRCUMFERENTIAL CRACKS
- CRITICAL CRACK LENGTH
- LEAK RATES



ANALYBEB LBB

PIPE CRACK ANALYSIS

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HURPROACH

LOAD SAFETY Margin 1

STABLE GROWTH I

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LEAK DETECTION

PROVIDE CAPABILITY TO DETERMINE, LOCATE, AND QUANTIFY PIPE CRACK LEAKAGE

OPTIMUM LEAK DETECTION TECHNIQUE IS A COMBINATION OF MORE THAN ONE METHOD

EXAMINE LEAK DETECTION RATES OF EXISTING AND/OR ADDITIONAL INSTRUMENTATION

D ESTABLISH OVERALL LEAK DETECTION STRATEGY



BENEFITS

IMPROVE ACCESSIBILITY TO MINIMIZE
 RESTRICTIONS TO ISI AND REDUCE
 PERSONNEL RADIATION EXPOSURE

O TIMELY AWARENESS OF LEAKAGE

MINIMIZE UNANTICIPATED THERMAL EXPANSION STRESS DUE TO INTERFERENCE

D IMPROVE UNDERSTANDING OF PIPING FAILURE MODES

O REDUCE PLANT COST



HAZARDS ANALYSIS

DESIGN

FABRICATION

INSTALLATION

INDIRECT COSTS

TOTAL QUANTIFIABLE COST SAVINGS (NET)

\$8,020,000

330,000

2,980,000

\$1,420,000

1,890,000

1,400,000

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QUALITATIVE COST SAVINGS

- INCREASED FLEXIBILITY IN THE 0 CONSTRUCTION SEQUENCE
- ELIMINATION OF GAP ADJUSTMENT 0 VERIFICATIONS DURING START-UP AND POWER ASCENSION WALKDOWNS
 - ELIMINATION OF STRUCTURAL CHANGES WHICH ARE DUE TO PIPE RUPTURE RESTRAINT LOADS
- REDUCTION OF ENGINEERING AND 0 CONSTRUCTION COSTS WHICH ARE DUE TO DESIGN AND CONSTRUCTION IN CONGESTED AREAS
- DECREASED OUTAGE COSTS DUE TO 0 ISI DIFFICULTIES AND CONGESTION
- REDUCTION IN HEAT LOSS FROM 0 PIPING TO ADJACENT PIPE RUPTURE RESTRAINTS.



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DIRECT COST SAVINGS IN DESIGN, ANALYSIS, FABRICATION, AND INSTALLATION

INDIRECT COST SAVINGS DUE TO BETTER SCHEDULE AND AN IMPROVED PHYSICAL PLANT 4M TO 8M

TOTAL COST SAVINGS 12M TO 16M

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SUMMARY AND CONCLUSIONS

PROVIDE PIPE BREAK PROTECTION USING STATE-OF-THE-ART ENGINEERING TECHNOLOGY

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USE THE ABILITY TO SUCCESSFULLY DETECT PIPE LEAKS

- D IMPROVE PLANT SAFETY AND DESIGN DURING OPERATIONAL PERIODS AND OUTAGES
- SHOWS REASONABLE, AGGRESSIVE INDUSTRY INITIATIVE TO IMPROVE SAFETY AND LOWER COSTS





SCHEDULE

NRC GRANTS SCHEDULAR EXEMPTION FOR B.O.P. WHIP RESTRAINTS

SEPT. 1985

DLC COMPLETES WHIPJET PROGRAM

DEC. 1986

INSTALL WHIP RESTRAINTS, IF ANY REFUELING ARE REQUIRED OUTAGES

