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UNITED STATES
NUCLEAR REGULATORY COMMISSION

In the matter of:

BRIEFING BY R & D ASSOCIATION
ON CONTAINMENT CONCEPT TO
WITHSTAND A CORE MELT

EXEMPT SESSION

Place: Bethesda, Maryland

Date: April 25, 1980 **Pages:** 1 - 79

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Room 550
East-West Towers
4350 East-West Highway
Bethesda, Md.

Friday, April 25, 1980

The Commission met pursuant to notice, for presentation of the above-entitled matter at 1:00 p.m., John F. Ahearne, Chairman of the Commission presiding.

BEFORE:

VICTOR GILINSKY, Commissioner

PRESENT:

DR. A. LATTER
MR. P. HAMMOND
MR. S. ZIVIE

PROCEEDINGS

DR. LATTER: I'll tell you right off that I am getting expectations more or less of misfortunes of what one might -- what we think might arise and hopefully -- We hope (continued on page 2...)

That people don't have the feeling that we have engineering drawings of changes that can be made in reactors; and somehow, all the problems would go away.

Probably helpful if I explain, just take a minute, to explain how an organization like RDA that hasn't traditionally been involved in the reactor technology business at all finds itself here under these circumstances and pretending to say something to a bunch of people who know a heck of a lot more about the subject than I think we do.

The, just, we've got a bunch of nuclear physicists there. Most of them, you may know, or many of them, who haven't emigrated from the nuclear weapons laboratory --

SPEAKER: That's not all bad.

(Laughter.)

DR. LATTER: We have an ex-associate director for the design of nuclear weapons from Livermore -- you probably know most of these people -- and an ex-associate director for the weaponization; so we're, we're good on exp sions. We hope that has very little to do with the prob ems we're going to be discussing today.

But we found ourselves after that, that, that unfortunate reactor incident discussing the point that, while on the one hand we were going home in the evenings and assuring all our nontechnical acquaintances that nuclear reactors are absolutely safe, but when we get together at lunchtime all those ex-nuclear types were arguing amongst themselves as to whether they really believed that.

And we thought as a matter of good conscience it might be worth spending some time in trying to get at least enough enlightenment so that we could speak intelligently to each other, if not to other people, the result of which was a letter which I sent to the Chairman.

And I thought the way we might proceed in this meeting, unless you'd like to deflect this into another channel is that I'd like to remind people who probably haven't seen this letter of the main points contained therein. And to some degree our thoughts have sharpened up a little since that time.

And then if there aren't, if there isn't a major reaction to the conclusions that are drawn there, proceed to the what I hope will be the heart of a, the meeting; namely, the technical reasons why we think a design philosophy of a sort we've advocated here and which I'm sure other people have advocated also -- might be implemented.

CHAIRMAN AHEARNE: Sounds fine.

DR. LATTER: Does that seem like a reasonable way of proceeding?

Well, I just -- we collected our thoughts. And I'll just try to put them in a few words. When we finally got straight on, on, on facts about the industry and policy with, regarding safety, I think what we learned -- a [illegible] se correct me if we have a misunderstanding as of the policy -- well, I'm sure there's a tacit policy, is of course, make accidents of any kind as unlikely as possible.

And that more or less goes without saying.

But that for certain kinds of accidents, I guess if I've got the jargon straight, so-called design-basis accidents have a second line of defense.

If for some reason those accidents occur in spite of the low probability, be prepared to contain them.

Then my understanding is that for more severe accidents, if I've got again the right terminology, so-called class 9 or core-melt accidents, Jane Fonda-type -- those accidents, there is no policy of containment, no requirement. And the justification for that policy seems to be reasonably well founded; namely, that the likelihood of such an accident is estimated to be exceedingly small and, for all practical purposes, negligible, as I understand it.

Now, we asked ourselves whether this, a policy of this nature, could be, could be criticized on technical grounds. One possibility is that the, that this large anti-nuclear sentiment in the country is just based on utterly irrational behavior. It wouldn't be the only segment of our society in which we see evidences of irrationality. That could be the answer.

The other possibility is that there might, looking at it in a purely technical point of view as objectively as possible, could be that technical people might be able to, to level valid criticisms against a policy of this nature.

And we found ourselves really making two criticisms that various people believing them with more or less conviction. But at least two that we got out in the open that we believe have to be faced.

One is that this curious fact that what might seem to be a very low probability, viewed from a point of view of an accident occurring at a specific reactor site. And we had in mind a number that Rasmussen provided in the WASH-1400 report; namely, if I remember correctly, 5 times 10^{-5} for one of these very serious accidents per reactor year.

And then we observe that, without saying that the number is either right or wrong, if one accepts that, it has the curious consequence that if you consider all the reactors that are expected to be in operation over let's say the next period of, that's still within our purview -- I don't want to go out into the indefinite future -- but, say, the next 15 years, we estimated that within the Free World, not to count other parts, but there would be a total of something like 4,500 reactor years' experience in that time frame.

And now I guess it's a simple arithmetic after that.

You've got, you subtract -- there's a small probability that 5 times 10^{-5} from 1, you raise the whole thing to the 4,500 power and you subtract all of that from 1; and that tells you the probability that at least one of these reactors is, might undergo a major core melt.

And the answer to that, however low the 5 times 10^{-5} may seem, the answer to this other number, which is probably more nearly the question that society would ask -- but I'm not sure of that, but --

CHAIRMAN AHEARNE: Some oscillating --

DR. LATTER: Right.

CHAIRMAN AHEARNE: Some distraction in society.

DR. LATTER: Some part. Right.

The question that could be asked, in any event.

And the answer to that was let's, a much more disturbing one is 20 percent.

Now, that isn't; but then one gets to the real point. I don't take that point so seriously. The real point is that nuclear reactor technology is relatively new. And there isn't a heck of a lot of experience. And when one tries to make estimates of probability under circumstances of that sort, we all know that, that, by the time you multiply a whole bunch of numbers less than 1 together, you have something which, in which you can't have a heck of a lot of confidence, because many of those probabilities have got to be judgmental.

SPEAKER: Yes.

DR. LATTER: Until you've accumulated some years of experience, this is true not just of this business. I would say it's true of any complex engineering field. And it's not because it's nuclear; I mean, it's, it, it's, I'm sure it would be started out building DC-10's instead of the way the Wright Brothers did it. We could have asked all the same questions.

Now, so the probability that we're concerned with here is the, is something which is in part visceral.

Now, I might say this is no different from what other parts of the government are forced to do. You go to the CIA, and you ask them what the Russians are up to; they always give you an answer.

But if you have any experience with those kinds of people, you, you just discount it by some large factor.

(Laughter.)

And, and, and that doesn't mean to say that there aren't a lot of things that they do do well. I mean --

CHAIRMAN AHEARNE: It depends though on which type of question you ask them.

DR. LATTER: Yes. Very, very much so.

They do exceedingly well, right. And some other --

(Laughter.)

But anyway.

So, in any event, that's a worrisome thing. Then in addition, quite apart from the probabilities, they think that the, that, that, that a, that the machinery is so complex and the sequence of events that could lead to one of these very serious accidents, so involved and so multifarious in nature, you begin to worry even when you're all done, and you look at the 5 times 10^{-5}, you have to wonder whether there was some sequence of events that you may have overlooked entirely.

Now, you can probably persuade yourself that, well, you don't think so; in fact, people tend to feel that when they've thought about a matter long enough that, well, they probably got it straight now. But disappointments of that kind are, abound in history.

And so it's worrisome that something may have been overlooked. But most importantly, it seems to me what's worrisome is you can't have great confidence in the probability. And I think that, in spite of the fact that that's true, even though I suspect since I know some of the people who work in this industry, and I think very highly of them, probably the best possible job that the country could possibly do that's been done. And that's my guess, in estimating those numbers.

There are a lot of very smart guys doing it.

I, you, you may know better than that. I, I, I won't, because I'm not that familiar with --

MR. BUDNITZ: They did a real good job, and there are major uncertainties.

DR. LATTER: Yes. Well, okay. That's what I like about it.

(Laughter.)

So when we ask ourselves, well --

MR. BUDNITZ: Ten, ten words only.

DR. LATTER: I think that's just fine.

Well, then we, then we say, "Okay, fine. Is there any constructive action in something that one could do to improve this situation?"

And I'm sure we've, we've came to thoughts you've all had thousands of times. And I guess all I can do is bring our emphasis to it for whatever that is, because we're not, we're not going to tell you anything you haven't thought about before, probably again and again.

But it seemed to us rather obvious that there were three kinds of action, actions that, that might be helpful. One is just remote siting. You know, get the thing to land.

I guess a variant of that, since I don't think it solves any real problem -- and you, you know I've always been very close to Edward Teller. And for as long as I can remember, he's always --

CHAIRMAN AHEARNE: Not necessarily always agreeing with him, certainly.

(Laughter.)

DR. LATTER: Well, not always.

But he, he's always said only the, even when I knew him, and I guess when he was still the chairman of the reactor safety committee. And he would always say, "These things are absolutely safe." And then he'd just add, "But we ought to stick 'em under ground."

(Laughter.)

And, well, I think that's more -- I, I don't know. Maybe it has some merit. But technically, I'm not sure about that point. It does solve the, it does deal with the out-of-sight/out-of-mind principle and may have some value in that respect, I don't know.

In any event, remote siting was one possibility.

Second one is, start all over and build reactors that don't have such a huge inventory of radioactive materials stored up.

The third possibility seemed to us to be much more practical and much more, well, much less futuristic and much more interesting for that reason -- and that is, consider the possibility of changing the containment policy, so that you say not only for classes 1 through 8 do we contain in the event that the accident does occur, as unlikely as it may be;

but for class 9, as well, we're going to put a shield around the reactor, between the reactor and the public, and they go to sleep at night. And while we will assure them that class 9 can't occur, if it does by some, some remote chance like they say in the POD, "we're deterring war; but if by some remote chance it should occur, then we'll --" and then, unfortunately, in the DoD they don't have a very good way of ending a sentence.

The policy is always stated in terms of we're primarily interested in deterrents, but they -- presumably, there is something we do if deterrence fails.

So the second line of defense, containment, seemed like just the right answer.

Now, then we ask ourselves, "Well, you know, as simple-minded and as obvious as that conclusion seems to be, this experience that most of us have had with people make it pretty sure that some bright guy's going to find some objection to the argument anyway.

So we asked ourselves, "Well, what's the objection that's going to made to this argument?"

And just on philosophic ground, quite apart from the technical or economic feasibility -- and an objection, we assume, would go something like this:

"Well, the first place, the 20-percent figure -- in other words, that the probabilities that we, tha' have been bequeathed to us, low as they seem at first, on second thought appear to be higher -- someone's going to say, 'Oh, yes, but without going to a new, new policy involving containment, just with the current policy, if we keep working away at this, we can get that 20 percent down to any number like. In fact, in this game, I mean I'll undertake to get it zero in any, you know, a reasonable amount of time. It'll take a little effort, but I'm sure we could do that.'"

But under the current policy, we can reasonably count on the 20 percent gradually decreasing to a point where it may seem acceptable in, in, in quantitative terms, to the extent that the people who have to understand this number have any apprehension of these kinds of numbers anyway.

It's hard to explain to the public that there's only a 10-to-the-minus-something probability and have that have any great impact on it.

Somebody usually has to interpret it. But in any event, I'm sure the 20 percent figure can be lower.

And so the next argument would be: and now we've got the probability so low that if you put in containment, what will you have accomplished?

Practically nothing. You will have made a zero probability just more zero. So this is ourselves trying to find out what's wrong with what we're saying.

And then finally, on the other side, that's on the, on the benefits side; there's no benefit, in other words -- there's bound to be some cost. We're not going to completely contain class 9 accidents without spending some money.

So there's a cost and little or no benefit.

So that, that, that's kind of a -- that's the objection.

And then we said, "Now, what's our answer to that objection?" I mean, it, it wouldn't be appropriate for us to come and bother busy people unless we had some answer to that.

And I think there's a very important fundamental answer. I, I continue to beg the question of technical feasibility, but I want to come back to all that.

The fundamental answer is that it's not replacing one zero probability with another zero probability. When you tell someone that the probability of a dreadful accident occurring in a nuclear reactor is, can be made virtually zero, it has this defect that it's not what, what a scientist means by a probability; he means relative frequency. And relative frequency has always got to be related finally to experience. There has to be a lot of experience.

We believe that a die gives a phase 1 with a probability of a 6 because we've thrown the darn thing so many times. And now, if you go to containment however, then the interesting thing if you do it right, it's done right, the containment can be based on engineering.

CHAIRMAN AHEARNE: Sure. It's a different technology.

DR. LATTER: It's a, it's a, it's a technology which everybody suddenly has a lot of experience, that he can, that he can relate to.

And so while it's true, it's just another probability. And someone might say, "What's the probability that your containment may fail?" And it will never be utterly nonzero. At least if he's convinced that it's a very low probability and it's a container, he can have a different kind of confidence.

What's more, I believe there's an even more, a far more important point. If it's containment -- in other words, if you say, "Suppose the core melts," and you start with it, you can actually -- I mean that can not only, I mean you can not only calculate pretty well or do engineering analysis, but you could have stimulation of that kind of thing. You could do a lot of things --

CHAIRMAN AHEARNE: It's called --

DR. LATTER: Pardon?

SPEAKER: Originally called --

(Brief discussion.)

Incidentally, you'll soon find I don't know much at all about reactors. I can design a nuclear weapon, but I don't --

CHAIRMAN AHEARNE: No, no. No. No. No, no. No, no. I found out a long time ago that there was the idea that we're, we're going to contain the containment. And they started with an experiment.

DR. LATTER: Right.

CHAIRMAN AHEARNE: And it, along the way it increased in cost by factors of 10. It got changed completely, so they never did it.

MR. HAMMOND: It's an important fact that they, that once the containment is called upon to do its job, then all the uncertainties have vanished. You know exactly what's there. You know what properties it has, and you know the physical laws that are going to control it.

So it comes from a, uncertain as to how the thing happened to a very, very bounded problem at that point.

All right. Now, of course, the, the obvious question even if you go along with all this, is "Well, that sounds great; but is it really technically economically feasible to do this kind of thing? And most especially since we left it there. Most of the reactors that we know about at any rate exist. It would be nice if they were retrofittable actions that you could take. That would be great.

So those are the good things. I --

Well, that's the question. And I think, John, you were kind enough in conversation we had on the telephone to tell me that it was your understanding -- and since then, we, I, I, I, we found that to be the case -- that in fact, the philosophy I just enunciated is the way it all began. I mean, that is the way people thought about it. And I expect whenever the decision, we got to the crossroads -- and I think that John pointed out, that probably happened somewhere around 65 megawatts or whatever -- at probably no precise moment in history, but somewhere about that time the power levels began to --

MR. BUDNITZ: It was a precise moment in history.

(Laughter.)

DR. LATTER: Oh, really? All right.

I'm sure as the power levels started to increase, the natural tendency -- and if I were a utility, that's how I'd feel. I'd say, "Oh, my gosh; this is going to cost me more money. And, and, and I, I would, you know, since I'm sure the people who build these things have great confidence that that they're safe and all."

If I had the other responsibility, I'd try to discourage this view.

CHAIRMAN AHEARNE: Yes. Now, these guys may know a lot more about it than I do. I would guess that at some stage also there are utility people saying, "Well, if I got x dollars to spend, and on one side I can spend it so that when my reactor gets completely destroyed, nothing gets out;

on the other side I can spend it so the reactor doesn't get destroyed."

CHAIRMAN AHEARNE: Right.

DR. LATTER: It's a simple choice between those dollars.

CHAIRMAN AHEARNE: Right.

MR. BUDNITZ: I wasn't involved in that history. Some, some people in the room might have been. But I don't think that that was the way it was framed.

They came to a stage where they realized that they couldn't contain it. And so the concept of perfect containment was abandoned.

CHAIRMAN AHEARNE: Yes.

MR. BUDNITZ: And this happened about 1965 or '6. Is that accurate?

MR. FRALEY: It was around that time, yes.

DR. LATTER: That, that, that is the action and objectively concluded that it was indeed valid.

Actually, Ergin's report said that, that the way to go is to prevent the core melt, but, but we should have a little bit of research on containing the molten core and tube.

(Laughter.)

Unfortunately, that was never implemented, you know, in a, in a, in a serious way. In connection with fast reactors, if you did a little work on it.

CHAIRMAN AHEARNE: Yes, right.

DR. LATTER: But not, they're not really water reactors.

But Mr. Shaw used to say, "We're doing all that fast reactor work is going to be applicable to water reactors."

MR. BUDNITZ: Until it turned out to be true.

(Laughter.)

MR. KELBER: The primary, as I recall --

CHAIRMAN AHEARNE: Mr. Charlie Kelber.

MR. KELBER: The primary impetus was from the need felt by the joint committee to prepare a finding of commercial value. And that was a fairly long struggle, as I recall, about a year to a year and a half before they made the findings.

But to make a finding of commercial value, they could not have a significant unresolved safety issues staring them in the face. And so it was decided that this was not a significant unresolved safety issue.

(Laughter.)

MR. FRALEY: Well, I -- the members of our task force were, were heavily from industry; and I think there was a lot of thinking that you mentioned, that if I got two ways to go, the way to save my reactor -- and I, I think there was a --

DR. LATTER: Now, now, now of course, an interesting point is that the -- I think back until the mid-60's, what I think you were saying -- that was a rather different world that we lived in. I think our thoughts about energy and availability were quite different then from what they are now, and frankly I just came from a couple of days of meeting on the subject of Afghanistan and Iran and military actions and all of it.

The problem of living in the world possibly cut off from our oil supply and all that is pretty, pretty frightening. And I think the general attitude of the public, perhaps of industry, might be a little bit different. I suspect in mid-'65 a mil per kilowatt-hour this, this way or that, was a big thing.

I wouldn't be surprised if the industry thinks in terms of larger units now, because I -- well, I don't know. I guess in summary I'm saying it's a very different world; and perhaps what was a wise decision in those days might not be all that applicable to the present time.

So in any event, at, at this stage we found ourselves saying, "Well, all of this is, you know, good philosophy. But is it, is it really sensible to talk about containment of extreme accidents of this nature?" I mean, is, is that something that is doable?

Now, there we had the advantage over other people with the exception of the two people here who have had some experience in this field. Most of us, we're just nuclear physicists; and we were free to think about anything. And we just decided we'd sit down and ask ourselves whether it violated physical principles or something like that.

Since then, we've, I should explain there's been a short-term effort, intermittent use of time of four or five people. So I hope you all understand that we're not prepared to do anything in depth. But --

CHAIRMAN AHEARNE: I think they understand.

DR. LATTER: But what we did do --

CHAIRMAN AHEARNE: Certainly you made that clear when I talked to you on the phone.

DR. LATTER: Right.

What we did do was ask ourselves whether there were any, whether it was plausible that, whether you find plausible arguments for believing that this is an exceedingly difficult problem, either technically or economically, or whether it appeared to be the other way around, that it looked as though it was something that might be rather tractable.

And just to state the conclusion, that's kind of where we came out. Now we may -- we had hoped we could just pick up a, a report from one of the national laboratories or some expert in the DOE or whoever, and that we could just find means described that would satisfy all of the conditions we thought ought to be imposed in trying to maintain control of this, of, of a fission products when, it's, if there were an accident.

And, and we, we didn't -- perhaps because we didn't have access to all the information -- there may be perfectly good solutions that other people have found, but we at least tried to invent one for ourselves that seemed plausible enough so that we're, we're willing to come here and at least urge that serious consideration be given to this point of view.

And perhaps that's what we could turn to now.

CHAIRMAN AHEARNE: Fine.

DR. LATTER: Kind of a technical detail.

CHAIRMAN AHEARNE: Good. Good.

DR. LATTER: I'll just make a comment. When I was much younger, I, I was asked to give a briefing. It was the only time I ever gave a briefing in the State Department. And it was the time that Christian Herter was the Secretary of State. And he said to me:

"Okay. Your turn. Get up and speak."

And my answer was: "Well, what in the world can I say? I don't see a blackboard."

(Laughter.)

"Blackboard?" He almost didn't know what it was. And so while they sent out and looked for one, which they finally found, not in the State Department, but in the Treasury Building, I gave a lecture on how impossible it is to do anything useful without one. And maybe that's why we're in trouble in the State Department.

(Laughter.)

So I really don't need one.

(Laughter.)

CHAIRMAN AHEARNE: John, that's a little bit like --

MR. HOYLE: Let me run over to Treasury.

(Laughter.)

DR. LATTER: They may have that old board there.

(Laughter.)

But anyway, it's a little bit hard to proceed. We, we have some -- I think we have some --

SPEAKER: We have some vuegraphs.

DR. LATTER: -- vuegraphs or -- oh, that's plenty. Thank you. It'd be helpful to have a picture of a, at least a schematic picture of a reactor on the --

(Laughter.)

MR. HAMMOND: All you'll see is schematic. Don't look at, don't look at the mess.

(Brief discussion.)

MR. FRALEY: Will a grease pencil help?

DR. LATTER: While he -- probably has that.

(Pause.)

Okay. Well, we said -- that's a -- what? Megawatt electric or -- I mean a gigowatt electric and, and that speckled stuff is concrete, I guess. And that's a, I think it's somewhat surrealistic, but maybe not too bad.

Well, we, we said, "Okay. For the radioactivity to cause the problem, some energy's got to get out of control." That'd be an energy problem. "And well, we could, you could get some kind of a critical, a little nuclear excursion." And we'll say a word about that. We understand that there are steam explosions, and maybe because of the zirconium that you might get some hydrogen, which later could combine with oxygen and you get an explosion that way.

But in any event, whether there are some explosions or not, if, if that, if we have by definition core melt, the water, loss of coolant, or whatever, that object in the middle is going to start melting. And under the most benign circumstances, let's say even without explosions, and then I'll come back and address the explosions, which seem like a very complication to us, the best you could hope for would be that that, that that reactor after some period like a half an hour or an hour would begin to be melting and slumped on the, on the floor there of that containment facility.

Now you could sort of have, I guess you can think about it in two ways. One is, "Well, let's try to keep it in the building and somehow cool that,"that, that object as nearly as I can tell -- and these engineers put it in terms of it's got to, it will eventually release an amount of energy in fission, fission product decay, which is equivalent to 40 hours at full power of the reactor; that is, the 3,000 megawatt. My way of saying that is, since I'm used to explosions, is that's roughly a hundred and some kilotons.

And if you got a hundred kilotons of energy that eventually will be released by those fission products, and unless there is some means of getting that energy out of there, well, you certainly rupture the containment building, if that's where it were being released.

And I guess I understand why people who thought about this in the early days, I understand, preferred just to let it melt through and get out of there and let it be somebody else's problem. And that's not, that doesn't seem like such a dumb idea, actually -- just to let it get into the ground.

I suppose a problem with that is that then you get all kinds of reaction without, well, what if there are aquifers? And you've lost control, in other words.

And since it is a lot of radioactivity, I suppose it would, I believe it's a lot better, safer, to maintain control of it.

So we decided the way to maintain control of it is not to keep it in that building, let it get out, but then let's maintain control anyway. And I wanted to -- there's a picture of sort of, well, we, this, this is all, we're, we're not advocating the system. Let me just say that. This was an attempt to find a means where at least we couldn't criticize ourselves and say, "Hey, this is obviously dumb; and we ought to throw it out."

So we're just trying to convince ourselves that there's a way in which you do it. And I'm willing to believe that there are a hundred ways that are better, because we didn't spend a lot of time on it.

MR. DENTON: At, a year ago one of our esteemed was that we could have a mile-deep hole --

DR. LATTER: Is that right --

MR. DENTON: -- underneath each reactor --

DR. LATTER: Well, we thought about 60 feet might be all right.

(Laughter.)

We, we did have in mind, we would like to be able to retrofit it, whether -- that, that's a pretty ambitious notion, but might as well be ambitious --

MR. HAMMOND: The bottom of that hole is called Peking, junior.

(Laughter.)

DR. LATTER: Well, okay, so the idea was that we'll, we'll, we'll suppose that this thing melts and starts on its way to China or wherever it's supposed to go

MR. ZIVIE: Australia?

DR. LATTER: Australia -- I'm never sure.

And it has -- and let's say it has some kind of a flow material here, for the moment it could be dirt or sand. One might want to control that. But -- and it starts melting down. And this dimension, I am told, is a little bit large for our purposes. It's something like 6 meters or so. And we prefer it for heat transfer reasons to have dimensions more like a couple of meters, by which I mean you want, if you're going to transfer, take heat out, the first thing a heat-transfer guy likes is area, or whatever form he's going to take it out in.

And so we said, "Well, maybe we dare to taper this rather gradually. We don't want the shucks getting into the wall and getting away from us."

We decided that a good thing to do would be to use refractory materials. This -- the refractory materials, if you lie them down, they're right here but they actually go on down in the water-coolant region.

And then in the event that solid hunk of matter, say solid UO_2 or whatever were to hang up there for a while, we don't want it melting its way out this way. And so we'll put some material here that melts at a higher temperature than the UO_2. And that way, we're always sure that the UO_2 will then, before it can get out, will then ooze its way on down. So it's always going down.

In the picture we have of it, that finally -- I, I don't know how long this takes; I would guess a good fraction of the day or more, before it would go down some 10 feet, 60 feet. And I'll explain why we wanted it to go to 60 feet in a moment, and not just do this much closer to the reactor.

But they, in the idealized picture now, this stuff would melt, melt its way through the floor onto the filter and get down here and occupy a region about two meters in diameter and my recollection is about 10 meters or so in this dimension.

If you have that much area, then we believe that with -- certainly with experimental truth of this, in physical intuition that it'll work anyway -- that you can take the, when this goes off, by the way, my recollection is that you go from 3,000 megawatts almost instantaneously to something like 200 megawatts, 220 something; and by the time it gets down here, it probably would be of the order of 40 megawatts: 40, 50, 30 -- I just don't remember.

So you got to take out that amount of heat. Now, you have a -- well, you see, there's going to be water coming in here and water going out. And here's a little better picture of what seems likely to happen, almost certain to happen if you have a frozen, if you have UO_2 and most of it's going to be molten for a long time, but it's bound, it's got to convect.

As a matter of fact, if it didn't convect, you suppress the motion of this meeting, you'd soon vaporize material in here; and that would produce bubbles which would force it to convect in any event.

So this is a big convecting region. And around that convecting region you have water, you have water, a water cool jacket. I think I pointed to the right region. Is that right? The water cool jacket right there.

And therefore, what you expect to happen, since there's bound to be some kind of a boundary layer form -- here -- you expect a, that there'll be a little bit of material that will freeze between the cold collector and the, and the molten material -- you will, there will have to be a frozen region. And we've estimated, as best we can, with the kind of heat conjunctivities as we know them -- you've probably done much better numbers. But that this would, after a very short time, become -- it's not a big process, but some good fraction of obsenity (phonetic spelling) -- that's the kind of thing that we think will happen: have a fraction of a centimeter there.

And then this thing is boiling around, doing its thing. And I suspect in here are calculatedly saying, "We have better numbers."

Okay. So now, now -- and then, and then, of course, at other levels they anticipate that lighter materials will be falling through similar kinds of motions, because there isn't just UO_2 in here. Steel and heaven knows what else.

And so this is a picture, this is an idealized picture now; and I'll come back to some of the things that would worry us about it -- in which, down here, through pipe, through a pipe that comes from someplace well removed from this containment building -- we don't want to take any chances on this wire -- there are no pumps here. This is just a big water cooler, as you'll --

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CHAIRMAN AHEARNE: Could you just go back and repeat all that --

(Laughter.)

Back up one slide.

DR. LATTER: Okay.

COMMISSIONER GILINSKY: I apologize. I had to deal with another container problem.

CHAIRMAN AHEARNE: I see.

COMMISSIONER GILINSKY: You don't know of any krypton, do you?

(Laughter.)

(Brief discussion and laughter.)

DR. LATTER: Okay. We're, we're describing not the way to do something, but a means of containing a molten core which allowed us to think it was plausible to suggest that this, the containment for class 9 accidents, molten-core accidents in particular, ought to be taken seriously.

And this is an attempt not at finding the way, but some way that seemed plausible to us that had a good chance of working with it. And there may be better ways that experts in the room here are, already know about; and it sort of works like this:

We said, "Well, I'll come to explosions later. But for a moment, suppose it's core melts." It starts down and it's doing its China --

And then it runs into a region with some kind of filler material. We can talk about what that might be, but for the present let's say it's just some sand and/or dirt. And refractory material is placed along here. They simply extend that down farther, mainly for the purpose of making sure that as we narrow this thing down -- it's rather difficult to explain why we do that at the moment -- as we narrow down this region, we don't have pieces of this material trained to work their way out of this, out of our container.

We don't want them, we don't this stuff to get away from us. And so we choose a material here that melts at a higher temperature than the temperature at which UO_2 melts. And therefore, we're reasonably assured that before this loses all of its strength, and even with this gradual tapering, that we are sure that none of this will get away, because this is going to melt before that melts and therefore drip on down any level, but finally getting somewhere near the bottom, at which time we're going to cool it.

The reason for tapering it is that we're interested in retrofit. It's a little blissful, but I mean we might as well try it, or we're in trouble. And this thing is about 6 meters, and we find that for heat transfer reasons with a lot of area you'd rather squeeze it down to a couple of meters or so, which gives you more area in which to extract heat. And so that's the reason for this, is to take us too literally. We were thinking of dimensions like 20 meters here, so -- down at the bottom -- and tapering it this way to get the maximum amount of heat transfer area.

Now, the next picture kind of shows what we think we're looking --

MR. DENTON: What does that have to do with retrofitting?

DR. LATTER: Well, as this -- one thing you could do is make this a mile long, in which case some of the problems would be simpler but less credible that you'd really ever be able to do it.

MR. DENTON: Yes.

DR. LATTER: With 60 feet, or some such number, we felt we were still talking about, we were still in the realm of practicality, as far as back tape is concerned.

MR. FRALEY: Did, did you do any kind of a cost estimate at all?

DR. LATTER: Well, yes, we haven't come to that. Not a good one. Well, this, this is -- as a picture, probably everybody knows, it probably visualizes it. This is a bunch of physicists and a few engineers standing at a blackboard mostly and arguing with each other.

So, we, we -- again, it's not an in-depth engineering analysis.

Now, what we imagine would happen after whatever it is, a day or however long it takes for it to get through here -- and that depends to some extent on our decision as to what to put in there, what sort of material.

You finally get down to something that -- this, this is a dimension of like 10 meters; and this might be a couple of meters, and the physical picture is believed to be something like this. We have liquid UO_2 convecting here, and a water-cooled jacket around, which keeps this surface at a low temperature and just to stay in the gradient between the temperature of the local material, which I understand to be something like, what, 2,700 Fahrenheit degrees?

MR. HAMMOND: Between 2,000 and 3,000 somewhere.

DR. LATTER: Somewhere between two and three thousand degrees Centigrade.

You would therefore have a little frozen crest of UO_2. We estimate that as the fraction of a centimeter. And so here this starts percolating around like so, convecting, a little solid layer there, and water that keeps it cool. At the time of interest, 40 megawatts or thereabouts being generated; and you have to kick all that heat out.

CHAIRMAN AHEARNE: What, are you taking the container out of there?

DR. LATTER: Pardon me.

The container is, it probably would just be -- well, I, I don't know. That's an intangible question, but we were thinking --

MR. FRALEY: What kind of coolant flow velocities are we talking about?

DR. LATTER: All right, we'll give you all those numbers and --

MR. BUDNITZ: But you did say that this is natural unforced --

DR. LATTER: Right. It is. And in --

MR. BUDNITZ: Normal cycle. No pumping.

DR. LATTER: No pumping.

If you'll do the analysis, which is an easy one to show that that is --

MR. BUDNITZ: Yes. Right.

DR. LATTER: And hopefully did it right. I didn't do that.

(Laughter.)

MR. BUDNITZ: That's easy to believe. It's harder, it, it's, it's many harder to show that you really can maintain that with the reliability.

DR. LATTER: That's right; that -- these, of course -- we've set the goal of only trying to make it plausible enough, so that you might then want to, to consider the possibility of getting some really good work done on it. I mean, detailed engineering analysis.

CHAIRMAN AHEARNE: Sure. Sure. You made that clear on it.

DR. LATTER: Yes, that's pretty clear to me, even though it's dark. The picture looks quizzical, so I'm --

Well, okay. So this is what we think of it. It looked like your other materials in there, and it would probably keep floating on it.

And now, now I talk about what started it with, now that you say, "Oh, but we've invented this great thing. Look how easy it is. Now I want to start talking about the things that seem worse to us. I mean, because I think there are a -- there's a lot to be worried about here. You want to --

And, well, no, no, no. Let's go back to the, to the first vuegraph, because I haven't really said anything about explosion. And I think it's a lot easier to take care of this China syndrome if, if you don't have explosions.

For instance, if you had an explosion, let's say a, a nuclear -- you can't much nuclear energy out of there. It's pretty unenriched. But you sure as heck can some, and if you toller all those rods, some excess reactivity in that thing can go prompt critical. I don't know just how much energy it can release, but some of our guys were guessing it might be 20 tons. And that's not enough to melt -- it's probably, it may be on the high side. I don't, I, I don't know. That was the worst case that we could dream up, and it's probably much too bad.

But in any event, most of that doesn't go into a form that produces pressure anyway. That, that isn't enough to --

MR. DENTON: Calibrate me in terms of megawatt-seconds. Is that --

(Laughter.)

DR. LATTER: A megawatt is 10 to the -- a megawatt-second is 10^{13} ergs. Okay? Megawatt: 10^{13} ergs.

And a ton, 18, in ergs is 4 times 10^{16} ergs. So it's 1/4,000 of a ton.

MR. HAMMOND: It's something like 40 seconds full power --

DR. LATTER: I guess a megawatt-hour -- and there is a good way to remember it -- a megawatt-hour --

MR. BUDNITZ: Wait a minute. Wait a minute. None of us, none of us dispute here that issue. And that is, we don't generally think that getting that sort of release is one that we deal with as a vital safety issue.

DR. LATTER: Sure. All I, I --

MR. BUDNITZ: So we don't have to worry about the numbers too much.

DR. LATTER: No. The reason, the reason I worry about it is that I don't have your responsibility now. And I, I, I got to convince myself that there isn't some kind of nuclear aberration that could on. And we, we couldn't --

MR. BUDNITZ: Megawatt-seconds here.

DR. LATTER: Pardon?

MR. BUDNITZ: Charlie Gilbert says a hundred megawatt-seconds.

DR. LATTER: Okay. Well, the --

Well, the --

(Brief discussion.)

I said that it was imaginative. You can't get much of this, but it was imaginable to some of us that in a worst possible case, if you created all the excess reactivity that you could possibly find around here, that you might get some tons of energy released.

And while that wouldn't be enough to produce any pressure or do anything harmful, it just heats up the UO_2. I suppose there's always a worry of differential heating and some object being impelled and some -- you get some kind of a flying object, get some of the UO_2 moving around. So one, since we propose to come in right here, which is 6 meters, as opposed to this dimension, which I understand to be closer to 60 meters, we don't want to lose control of this stuff, even in the containment program.

So we want to take advantage of the fact that there's a huge shield that's built around most of these things anyway, and we want to beef up that shield if it isn't already good enough. And I just don't know the answer, so that we can say with confidence that even if there is a small amount of nuclear energy released or, in case this things falls and there's some water in the bottom and we get a steam explosion of some kind, no matter what happens in there, that all that radioactivity will remain confined to this region, because if it ever --

SPEAKER: All the UO_2.

DR. LATTER: All the UO_2. The radioactivity, some of it will --

Oh, I'm sorry: not the volatile stuff. Yes, the molten stuff. Right.

Because if it ever gets out here, then we've got an additional problem on our hands of how you collect that; and I want to keep it as much under control as possible. And I'd like to start, confine it within the, within a volume, within this volume. And then if it starts to, when it starts melting, it will melt down here, rather than all over the place, because -- I'm not saying that principle there's any difference, but my guess is that the cost of retrofitting it, you'd have to start fooling around with this 60 meters instead of the 6 meters.

It'd be highly different. But that, that was the reason for wanting to be able to say that even in the presence of explosions that we would have, we would hope that all this material would find its way straight down.

Now comes a fundamental difficulty in that this is now in the phase of self-criticism. Say, well, all of that is great; and it sounds so good. And you have a nifty way of extracting the 40 megawatts. And down at the bottom there.

And then you say, "But what if nature is unkind? What if core catchers are a lot easier than we think they are? And, as a matter of fact, what if this thing starts down here, gets part way, and all the steam that's going to be in this building begins to circulate around this object, and we were able to extract enough heat from it, whatever it is -- it's 40 megawatts -- so the thing doesn't go to China?"

Then it will stay in the building. And if it stays in that building, then the 40 megawatts is built into this building, rather than down -- we've got a great collector sitting down there at 60 feet waiting for the 40 megawatts, and it never gets there.

So you say, "Wait a minute. We'd better be prepared for those possibilities."

And so we find ourselves putting a requirement on this core catcher, that even if it stays here, then we've got to be able to take the heat out.

And that -- so whether it chooses to stay here or whether it goes to the bottom, and I don't think it can do any, it's got to do one or the other -- we'll take the heat out. And I'll explain how we do it, if it stays here.

Well, essentially, you'd come in with the side of the containment building; and for instance, you cool it -- I mean this is just straightforward in a sense -- you cool it at, I don't know, Fahrenheit, I guess. I just don't know what to do about --

(Laughter.)

Well, anyway, since it's colder here, then the gases are going to flow this way. That'll be a pressure gradient. And, and then you just circulate this stuff. In a closed system, as I, as I see it; I, I'll just put it in my terms: You put a pipe here and a pipe, you run a proposed pipe around. And you cool the lower pipe, and it will just circulate. And then the rest of it is heat transfer and calculating, making sure you have enough surface area.

And now there's one thing that worries me about this; and I'd like to say what it is: Since this part is not in, in this part now is not in the, is in the containment building, we've got to worry about something about explosions, and I guess I should go back now and, and clarify something I left rather confused, as to why we went down 60 feet and didn't do, try to do the cooling closer to the containment.

And we want to show the second slide.

And then I'll also answer the question of what worries us about, well, I -- here is the whole thing, then.

Next slide. Next slide.

Here is the picture of what I showed before with water coming in here to cool the, this region, coming out here, some kind of a -- this is not meant to be right next to the building that may be removed quite a ways.

And then the heat pipe here with, okay, some kind of heat exchange.

Now, the reason we went down as far as did was that we said, "Where is the worst explosion that is, credible?"

And the answer to me -- I, I don't know if it would have to be done with crater assignment -- but maybe it's 10 times, maybe it's 20, I doubt it; but whether it's 10 or 20 doesn't matter. What you have to make sure of is that you're not going to wreck these pipes if that explosion occurs, and particularly as I understand that some of these things are sited at hard rock, if you have an explosion over hard rock, a terrible thing can happen to you.

It -- well, the shock'll go down, but, but this awful thing happens in rock. There are faults in it, and you can get block motions in it. Just what you're saying, that's exactly right. And so you've got to worry about that.

And so we said, "That's the kind of thing we do know something about, even if we don't know anything about reactors. And so we asked some of our guys, and we have the experimental data taken from a lot of explosions in Nevada, some of them nuclear, but many of them nonnuclear."

And we try to go down far enough -- and whether we've got the right, exactly the right depth or not -- so that this environment will be sufficiently benign and you won't have to worry about the engineers.

Yes?

MR. BUDNITZ: If it wasn't true hard rock, you'd have to work out some way to insulate those pipes from that hard rock environment --

MR. HAMMOND: They're in a big tunnel.

MR. BUDNITZ: Yes, yes, but --

DR. LATTER: That's exactly right.

MR. BUDNITZ: That's knowing how to do it.

DR. LATTER: Yes. Right. Sure.

MR. BUDNITZ: Otherwise, that distance doesn't allow you very much.

DR. LATTER: No, because it doesn't fall off very fast. Right.

What, what buys you the most -- now, this goes to a very important point. The thing that buys you the most is the free surface.

If energy -- you see, the way I described up till now, I said we're going to continue on these -- well, uranium oxide materials inside of this sheath, which exists and could be modified and improved.

But if I did that at the expense of containing all the pressure there as well, and if, if I don't have pressure equilibrium between here and the rest of this containment building, there'll be an enormous pressure build-up here, and we won't have these things probably to worry about; this part, in my opinion will take off and go right through the ceiling.

So you have to have, you have to have a means of letting gas -- I'm sure you do. I mean, I'm sure it exists in the reactor, even though I've never seen one, there must be big enough vents that allow any gas pressure build-up here to equilibrate rather rapidly with the surroundings.

But that requirement has to be matched to the requirement or mated to the requirement that we don't want UO_2 fragments, we don't want UO_2 fragments getting out through those vented regions.

Well, you can invent an answer to that in your own mind. You have a labyrinthine package laid here, then the gas can get out. But any particle which -- or macroparticle that's on a straightline trajectory can be stopped, because it can't turn a corner.

So, so just to make that clear, we have to assume here if you get into all kinds of trouble, that, that the pressure that develops in here relieves rather quickly coming into equilibrium with this entire, with that entire volume.

And at the same time you don't want any UO_2 being ejected into the rest of the container.

So those, those are the requirements.

And putting in the pressure, when you have an explosion on a surface now, determining what can happen down here, it's not like having it fully buried in the ground. It, it now has a free surface; and the energy preferentially wants to go out in the easy direction, which is into the atmosphere.

Nevertheless, we know from cratering experience that energy will go down. And therefore, this must be far enough down and lined appropriately as was mentioned before, so that these, these pipes can't be shared. That's an extremely important point, but there's a lot of experience and I believe that that's all doable.

Now finally, because of these pipes, which again you're going to be utterly dependent on, we'd rather not have explosions out here. Now we've asked ourselves how you can get explosions out there anyway. But if you really confine the molten material to this region, then the explosions have got to occur in here, while any criticality energy, if you believe in that stuff, will take place in here.

And the only one that's worrisome is this crazy hydrogen stuff which, since you've got zirconium in there, but that looks like a trivial matter. It must be possible to make one of these poly things recombine us.

And for that matter, you can just have an inert atmosphere and, and no way to make hydrogen explode if I don't have oxygen or I don't put fluorine in there. I mean if you do it sensibly, that should be a really trivial matter to keep the hydrogen from exploding, in which case the only, the only things that can hurt these pipes, then, would be objects that are identifiable beforehand.

You can go in the reactor and you can say, "Oh, look, there's a thing that looks like a gun pointing right at it."

Well, fine. You can put a shield on that. I mean, we can go in there and methodically make sure that there's nothing that's in that reactor that could hurt these pipes, except for the case in which the explosion occurs everywhere.

And so I'd say, "Let's suppress that." And I believe the only case of, that could be of that nature is hydrogen; and I believe that must be thoroughly manageable if you want to manage it.

So this kind of -- you know, it's an arm-waving exercise. But we had some pretty good critical guys stand there with us, and I mean to get some more in eventually. I'll drag in Hal Lewis and, you know, all his critics, and --

But we've had some good scientists; and we've said, "Okay, find some reason why it's, it can't work."

And so far we've passed that test. I don't mean that that's a subject to go deep into here and now. But that's kind of where we are at the moment, and we felt -- well, as I explained, all of us have been in the position of seeming an ardent proponent of this industry, and I, and I must admit I, when people say, "How do you know it's safe?"

But my friends tell me it's safe, and I --

(Laughter.)

Well, in any event, I in fact think there are some valid concerns, just to summarize, that can be made of the present policy. How cogent they are with respect to the public conceptions issue, I don't know. But those concerns can be overcome, I believe, by a policy of complete containment.

And whether that's portable or not -- and the way we estimated costs, by the way, I didn't say that, but at least in my world; it isn't the very best way of doing it; but since costing comes up again and again, whether you're talking about a new carrier or a missile or whatever, about the way to do it is to just take away the whole thing that you're going to --

And then start quibbling about how many dollars per pound. I mean, you know it for how many, for excavation you know that the AEC or now called the DOE pays for tunneling in Nevada. Okay. And then you can take that number, and you can -- you know what it costs for iron or steel, at some many dollars a pound. But you're going to have to put it in place, and you can fiddle with it. And let me say: it's very hard to make this add to much money.

It may add up to a lot of ingenuity. I don't want to say anything, but it's hard to make a facility of this kind add up to much money.

CHAIRMAN AHEARNE: Even on a retrofit?

DR. LATTER: If it's retrofitable. I, I, I want to qualify it. If there isn't some important engineering consideration that, that we aren't familiar with, and there could well be -- that would make it literally impossible to retrofit without extraordinary measures.

But if it, if that isn't the case and it looked as though there was some hope that it might not be a problem, then I would assume that the cost would come out not -- well, it'd be very, very reasonable, meaning -- well, I'll say what I mean by "reasonable" -- considerably less than 10 percent of what you paid for it on this containment stuff --

(Brief discussion.)

DR. LATTER: That may be optimistic, I don't know. Pardon?

MR. FRALEY: How long would it take?

SPEAKER: No, we haven't done that, Ray. That, that -- we're, we're just, you know, we are really seeing the whole --

MR. FRALEY: The cost of that might not be much compared to --

CHAIRMAN AHEARNE: As Al made clear --

DR. LATTER: Yes, I thought it would be helpful just as a provocative --

Sure. Sure.

(Pause.)

MR. STELLO: When you think this through, are you thinking it through with the assumption that the container is not violated, does not leak excessively, and its integrity is intact?

DR. LATTER: That's what, yes, that's what we're assuming.

I mean, well -- we, now, we made some assumptions that the building has indeed been designed to withstand the sudden flashing in a pressurized water reactor.

MR. HAMMOND: What about the four bars?

DR. LATTER: If you're fooling around in licensing reactors that don't have that inch of steel or whatever around there, I don't know. We were looking at what we --

MR. STELLO: Considerably more than the four bars forward pressure --

DR. LATTER: Well, we hope not. Why, why, why is that?

MR. HAMMOND: It will be four bars when the primary system is released, but then when you release and react all the materials, the older pressure of all of the gases and the increased energy in the containment and --

DR. LATTER: Well, but we're planning to remove energy continuously -- to me. So that the four bars will probably start down before it starts up.

In other words, we, we had, we were going to remov the 40 megawatts from the top containment building, as well as from here. It, it, that starts at once. And, and maybe that this stuff will never even get down there. If we're going to be prepared to live with the, this material in the containment building.

MR. STELLO: I don't remember whether the liquid pressure of the gases themselves that gets in there --

MR. HAMMOND: If it's heating concrete and adding CO_2, that would add to the pressure. The steam pressure is normally 60 percent of the total in a PWR.

For example, the amount of hydrogen you're going to have in the reactor, planning that, that was small. When you start reacting with metal -- excuse me. Reaction rates are steeling phenomenally, the amount of hydrogen evolves the triggering level. So the reaction -- I can't remember whether or not an overpressure by itself is a melt-down -- I don't think that does it by itself.

SPEAKER: No, not the gas pressure --

MR. STELLO: When you add all of the reactions and then any final slump in the water, I think that the pressure would be a very large impact.

DR. LATTER: Numbers we have, the molten material would be falling into the water? Numbers like some number of tons.

And we understand that this thing is felt to withstand a --

MR. DENTON: Tons of energy?

DR. LATTER: Tons of energy -- and that we, we understand that when there's something like 60, it I remember correctly; you correct me if I'm wrong -- something like 60 tons of water in this -- well, it's maybe 10 tons that are in the reactor vessel themselves and another 50 tons in the primary water line. I'm not talking -- some 25 percent of all of that will flash over into steam. Is that --

MR. DENTON: That's about right.

DR. LATTER: I think that's right.

SPEAKER: I have a, a paragraph here.

DR. LATTER: Yes, we did deal with your question to some extent. This, I think this comes out of the Sandia --

SPEAKER: That's right.

DR. LATTER: -- report on it.

MR. ZIVIE: This was taken from a Sandia study of advance containment, in which they calculated the constituents of the atmosphere at, at incipient failure of the containment. And we see that, we see how much steam it represents there, which gives us encouragement that if we can condense the steam as well as keep the other gases cool that we won't over-pressurize --

DR. LATTER: Now, your point's well taken. We, we did not do this calculation carefully ourselves; this is a Sandia calculation that is an objective, that in fact what we're doing might not have too much of a --

MR. BUDNITZ: Charlie wanted to say something, but I can add first:

That particular accident did not necessarily --

DR. LATTER: Yes, a good point.

MR. BUDNITZ: Charlie Kelber is going to say something about that.

MR. KELBER: Actually, I think Patrick's in control. I think Vic is absolutely correct. Nitrogen control is a vital issue. You yourself have --

DR. LATTER: Yes, indeed.

MR. KELBER: -- alluded to this. That's to be worked out.

Yes. But we did find in our most recent study is that we predict a steam spike, a very rapid rise in steam pressure which then rapidly falls off when the core is dropped into the water. Or when accumulators come on. It doesn't matter which way. You just have to get the accumulators' water to dump on the, on the dry molten core. And you've evaporated all the steam in a real hurry, less than a minute, according to the Code, which is very conservative.

Now, if that pike is correct, then even though that steam does start to condense, it takes quite a long while for it to do so, several minutes. And during that time you're in the region where they expect the containment to fail. You have roughly twice the static design.

DR. LATTER: Okay.

MR. KELBER: So that's, that's the problem that's, that we face, and that, that, we find, governs whatever mechanism you use to reduce the steam pressure, whether you want to spray it out, condense it out on a cold surface or ventilator.

MR. BUDNITZ: But, but there's a problem. You know, I'm not, I, I, I'm not an expert the way Charlie is. But my understanding of the problem is that to try to do that calculation more accurately than factors of -- really gets into details that are hard to do.

DR. LATTER: Yes, that's probably true. And you may, you may want to do some experimental work --

MR. HAMMOND: I imagine in the course of some of the normal accidents there have been a certain amount of your standard containment cooling, has gone into operation and is then somehow failed or didn't go into operation.

MR. BUDNITZ: You assume that.

DR. LATTER: What we're talking about is something in addition to that.

MR. KELBER: The postulated system, the postulated case here is the sequence in which there's been a station blackout and a loss, therefore, of normal containment cooling systems.

Yes, if you have the sprays on, for example, which is -- and that would be possible to design a spray system that might help, you can ameliorate that spike for a while.

SPEAKER: In fact, by putting a tank on the roof, you could almost have one that didn't require pumps --

MR. KELBER: Well, we've talked about this, it was speculated, some speculation about it. I think about this in another connection with this, using water as a hydrogen control. But I guess the point that we have to make is that we get involved -- once you postulate the failure for any engineer safety feature -- and that's what gets you into this accident. You then get involved in the science of how to manage the accident and control the damage.

So what we find is that system interactions tend to be very complex. And it isn't an easy or obvious choice that one strategy is superior to another one, because you have to look at them, the question of what is the effect of failure on your system and are inadvertent to operation under circumstances where you don't want to, could make a small accident into a big one, for example.

And I think that's as obvious to you as it is to us.

DR. LATTER: Sure. Sure.

MR. KELBER: So -- but I must say that I'm glad I came this afternoon, because I think that the thought of putting a natural convection coolant on this, on the containment is a valuable idea. The question I would have is, I am not sure what the square foot of the wall surface is in the containment.

DR. LATTER: There's plenty of wall surface, but we really don't intend to use the wall surface. We would, we would design a standard heat transfer bundle and then protect it from the --

DR. LATTER: At least that's one way of doing it.

MR. HAMMOND: The wall surface would do it, but some, some of them don't have a free wall.

DR. LATTER: Apparently, in some of the reactors there's a space between the -- and you really could go and do it easily.

MR. KELBER: Well, if the pressure builds up, that's, it'll --

(Laughter.)

(Briefdiscussion and laughter.)

Well, we found there might be an engineering consideration.

(Laughter.)

MR. STELLO: I think there are certain containments for which the gases have evolved by themselves, get you in an overpressure condition, so you might have them.

Or certain of these containment concepts -- if the carbon dioxide is there, you're certainly right: that, that is the final straw. And I think we have to assume that the attack of concrete is limited, and we may want to line that --

SPEAKER: Try to minimize the --

MR. STELLO: -- with something that will not generate CO_2.

For new plants I think there's an awful lot you can do to minimize --

DR. LATTER: We'd like to stick to the retrofit if we can, as long as --

MR. STELLO: Until we really die.

SPEAKER: There might be one other dimension to the problem that needs to be looked at in terms of feasibility. And that's a way which is accommodated, you know, assuming that you don't have that hydrogen explosion to deal with, just accommodating the extra, the mass of gas that you --

I think you also need to look very carefully at the --

There's a fantastic amount of energy in the primary system.

All right, that's a single -- dealing with that particular --

Primary and secondary, you're talking on the order of what?

(Brief discussion.)

MR. HAMMOND: The stored, the stored water amounts to a hundred full-power seconds.

MR. BUDNITZ: That's about right. That's got to be about right.

MR. FRALEY: Well, once that, the, your 40 megawatts of decay heat, when you look in your crucible, the time that's about half a million BTU per hour. And you think you can remove that by natural circulation?

DR. LATTER: Well, that's what we intend to do, try to do, I mean -- all wishful, but I mean yes.

MR. HAMMOND: You haven't got the water -- this natural -- actually generates 5,000 gallons per minute flow very easily. It's a big enough pipe so this friction is --

DR. LATTER: And that takes -- was it 5,000 gallons a minute that we calculated would take away the 40 megawatts. So that's a -- and that's not a -- 5,000 gallons a minute isn't a lot of water.

MR. ZIVIE: And so, Ray, the heat rocks need not be 500,000; depending on the dilution and the geometry, it would be lower than that by a factor of 5 or more --

MR. FRALEY: Do you expect to fill the mouth --

(Brief discussions.)

DR. LATTER: Doesn't your present safety requirement demand that you worry about pressure spikes of that sort?

Oh, you don't have to do that today?

MR. STELLO: Not in a class 9 accident.

CHAIRMAN AHEARNE: Worry about --

(Laughter.)

DR. LATTER: I didn't realize that you didn't have that problem today. Other than that, sort of worry about them.

MR. DENTON: What do you say as to the advantages of this sort of system versus going down to the 10 feet with magnesium oxide to provide a non-melt-through base mat and then taking all the heat out --

DR. LATTER: Well, if you take out the heat, the only worry I had -- that led to this one -- is that we figured -- I think there is a magnesium oxide system that can have that, and it doesn't take out heat. Is that right system to detain the -- okay.

But if you're going to take out the heat, which means you're going to put some kind of pipes or whatever in there, we wanted to get down deep enough so that we felt comfortable that no violence in the building could do damage to that equipment. Otherwise, you'd -- and, and I don't feel right about it till I get to something like 30, 40, or 50 feet.

And, and, and that was the reason for our going on down a ways. That, that was the main point. Now, maybe additional work and you can change your mind and get bolder on that score and dare to come up closer. I, I -- certainly, the amount of work we did, we were constantly saying, "Well, if we'd go this far, we feel all right."

That doesn't mean with a lot of additional tension you wouldn't feel confident in -- that requirement.

MR. HAMMOND: It's partly for the mining problem. You wouldn't want to bore in right under the foundation. You'd want to get down far enough so you could go in, maintain support, and then raise, raise bore to get your central pole.

SPEAKER: That's right.

MR. BUDNITZ: Let me, let me make another observation which -- if you set about to design this today, would leave you awash a little. We don't know well what the partitioning would be in the course of -- you have a little tact core and openly it ends up as a molten something or other.

We don't, we don't really know the partitioning of where all the fission products go. As in the course of this melting and whatever, how much of it is -- what gases and what other things are going to go out and get the water around, go into them? where it's going to go from there, what the, what the partition is.

In fact, at TMI there was what amounted to a surprise to a lot of people that so much of the island, but in the water it's a little of the gas compared to what had been some people's kind of rules of thumb.

And until you knew that, you'd have to worry about how much radioactivity was still left hanging on that containment after the thing went down.

SPEAKER: Well, the point -- one thing --

MR. BUDNITZ: In the water.

Hm?

You're going to contain that melt. What are you leaving behind upstairs in that --

DR. LATTER: Well, that's why I said that --

See, that's why we --

MR. BUDNITZ: The design is the way it is. You're just on the -- but we figured -- well, you guys would know this; but we knew we didn't know it, but now you're telling me even you don't know --

(Laughter.)

MR. BUDNITZ: We don't know how much radioactivity would be left in that containment after that dropped down.

DR. LATTER: That's why we said that we, we're going to take out the 40 megawatts here and here.

MR. BUDNITZ: No, I'm not arguing that there's a lot of heat generation from the radionuclear effect upstairs. But I'm arguing that there's a lot of hazard from some of them.

DR. LATTER: Oh, look. When this time, a year, let's say it's a year later. Let's say we did our job, and we've got it all in there. You just got a mess. You got this -- but at least it's under our control, and nobody can say that if --

MR. STELLO: Do you really care as long as you are sure you have containment integrity?

If you have containment integrity, I don't care whether they're up there, down here, or --

MR. FRALEY: Well, one of the benefits of your design is that you do keep on inside the biological shield.

SPEAKER: That's right. And --

MR. FRALEY: But, but what he's worried about is if something gets those, much of those fission products outside the biological shield, then you got a problem.

DR. LATTER: Oh, sure. And it's going to be a lot of --

(Brief discussion.)

DR. LATTER: Several questions raised by your question.

The first one might be: if you left enough of that behind, whether the, you then have a, you would then have to take a large part of the heat being generated by --

MR. BUDNITZ: No, this is not a question of the heat.

DR. LATTER: Okay, that wasn't the question, but this is a --

SPEAKER: A question of the time?

MR. BUDNITZ: No, his question is: it's got a lot of radioactivity up here now. Most of the items, nearly all the items. TMI didn't have water.

DR. LATTER: Of course, one nice thing about iodine, as I remember, is it's got a half-life of eight days; and we aren't going to go back in here for a long time. So I wouldn't worry about the iodine.

SPEAKER: Well, but there's the 30-year stuff, which is --

DR. LATTER: Well, I understand it. I just --

(Laughter.)

MR. BUDNITZ: Cesium, no.

DR. LATTER: You mean strontium gets in here?

MR. BUDNITZ: Cesium.

DR. LATTER: Cesium. Well, all right.

MR. BUDNITZ: That's the same thingq

DR. LATTER: Is that true: that cesium gets in the water?

MR. BUDNITZ: That's where it is.

MR. STELLO: Beaucoup.

MR. BUDNITZ: And that's 30-year stuff. That's the worst possible stuff.

DR. LATTER: I would say that is part of our problem of what we do with this.

SPEAKER: We're running a big experiment up at Three Mile Island. The cesium.

(Laughter.)

DR. LATTER: Well, tell us about that. What, what happened there?

SPEAKER: There's no problem.

MR. BUDNITZ: You're cleaning it up?

nd T-2

DR. LATTER: You, you're on the --

nd Tape 3:

Oh, sure. We're --

SPEAKER: One inch of steel -- and if that's not enough, well, got to have --

MR. BUDNITZ: I'm still thinking about protection --

DR. LATTER: I think the pressure will drop within days.

MR. BUDNITZ: Depends on what it is. That's CO_2 you're stocking.

MR. STELLO: You're not going to drop the pressure in this system unless you put a system to interrupt the pressure, and that you're going to have a hell of a lot of gas. You're going to be at least of hours, maybe several --

DR. LATTER: Well, let me ask you a question: how bad is it, just so I understand? How bad is heat transfer from CO_2 to, to the cooling system?

MR. STELLO: No problem.

DR. LATTER: So what if there is CO_2 in here? Then you're circulating the thing, and it's been cool CO_2?

(Brief discussion.)

MR. BUDNITZ: But if you're sitting there with several bars of stuff above ground, Vic is saying we have no easy way to release that right now. It's been hard about that.

DR. LATTER: No, all we can talk about doing is cooling it so that it can't rupture -- that's our first goal.

MR. HAMMOND: There's two categories. It's either chemically combinable, or it's inert. If it's nitrogen, you're going to have a hard time.

DR. LATTER: But let's, let's make sure. I, I have never carefully factor these metals, knowing that I appreciate the importance of the problem you're talking about. But the first problem we said is contain the whole thing. And the factor that gets in the CO_2 I don't consider to be a serious problem. I mean I'd rather it didn't..

But as long as we keep cooling the CO_2, then we'll contain everything. And now a problem of eventually getting in there and letting go of all of that is a nightmare, but I mean it's better than having it out in the public.

SPEAKER: But have you looked at the distribution of fission products so you're sure it won't burn through some place because of a hot spot where it collects in a corner, and it doesn't get to your heat pipes?

Have you thought about that?

DR. LATTER: Well, that's why I said I was very anxious to make sure that, except for gases, which don't collect in corners -- I mean like krypton. I don't expect krypton 85 will go and collect in some corner.

I'm pretty --

(Laughter.)

But the UO_2 might do that. And that's why I very carefully wanted to make sure it was confined to a region where it was under our control. And there may be others.

MR. BUDNITZ: Let me just try to --

DR. LATTER: Right.

MR. BUDNITZ: -- clarify the point:

The fact that at Three Mile Island that containment had remained in good shape is not to me a sufficient demonstration that it'll do so for all the accidents we --

We're talking about, we're only talking about containment integrity. And there are some very subtle systems interactions questions that you have to address which haven't been addressed yet before we can assure ourselves on that.

DR. LATTER: Oh, I, I fully agree --

MR. BUDNITZ: And that's, that's almost a, you know, that's a trivial statement to say. But that --

DR. LATTER: It's a terrible thing: I keep wanting to make my apology --

MR. BUDNITZ: You don't have to make --

DR. LATTER: John's tired of --

(Laughter.)

MR. BUDNITZ: That's the job we have to press in detail.

MR. DENTON: From listening to this, it seems to me it would be feasible to design a system like this for a plant that's never been built.

DR. LATTER: Yes, I agree that is --

(Brief discussion.)

No, all I meant was that, all I meant was that I think it's worth exploring retrofit, and I didn't want to abandon it on the grounds that it's obviously a much harder job.

But sure, if you, you don't have to worry about retrofit, there's so many things you do right from the start. And, and of course, that is a large part of the future of this business is to --

MR. BUDNITZ: Would you do anything very differently if you were not thinking about retrofitting?

DR. LATTER: Well, a lot of the uneasiness one might have about the pressure spike or something that you might just say, "Well, okay, we estimated the absolute upper limit is such and such, and you might sort of cope with that."

And it's just a lot more flexibility --

MR. STELLO: What about this below-ground --

DR. LATTER: No, I, I -- that still looks like a sensible thing. But again, that's a -- I feel it needs a lot more careful work --

I want to endorse it, because it seemed like an interesting enough thing for a discussion of this sort to --

And at least I've come away believing that in the real hope that you might be able to say to the public some day, "Well, for all types of accidents -- and we have provided a defense. We don't -- for these accidents are not likely to occur, we do everything in the world to make them almost impossible. But even if one did occur, the consequences to the public are calculated to be virtually nil by -- and now you, you don't have to cope with the community. You can get ordinary engineers, guys who work at, you know, in aerospace industry, can look at it and say, 'Well, that looks pretty good to me.' We won't all be mystified."

MR. STELLO: Now wait a minute. Let me follow this philosophy.

DR. LATTER: Okay.

MR. STELLO: Let's assume we had this --

And all of a sudden we have a set of class index instead of class 10. The definition of a class 10 accident is an accident where you have a melt down, and this is --

What got us into this in the first place is some quantitative an attempt to trying to decide how safe -- or how we are.

SPEAKER: Right.

MR. STELLO: And then we said, "Well, we have 5 times 10^{-5}," and I suspect that now with this new approach we might be talking in 1984, well, what's the probability of the class 10 accident? which means you had, if you did know better, 5 times 10^{-5}. And you put this system in, what really do you get in terms of true, true addition of safety.

Aside from the philosophical question, for the moment. And did I really change it from 5 times 10^{-5} to 5 times 10^{-9}, would I really make it 5 times 10^{-5}, 5 times 10^{-6}.

(Brief discussion.)

What I hope, and whether it's truly achievable I don't know, I hope that by going to containment technology instead of accident technology, which leads me to fault-tree analysis and all that, I hope that I can look and say, "This is an engineering problem. As soon as this core starts to melt, assume x amount of energy is released" -- these are problems that engineers can deal with, not so much on probability terms -- I mean when a guy says a bridge is going to work, we know they sometimes fail, now I don't think he means the probability is .9999; he means it's going to work.

MR. BUDNITZ: No, sir. No, no. He means that the Golden Gate Bridge will survive a certain earthquake that he designed against.

DR. LATTER: Well, okay, if you want to, if you want --

MR. BUDNITZ: No, no. That's what he means, and that's what we mean when we talk about a design basis earthquake. We mean the earthquake that designed against.

DR. LATTER: Yes. Yes.

MR. BUDNITZ: And if one comes along that's bigger, while we assume there are engineering margins and so on, we haven't designed against that; and that's all we --

DR. LATTER: But you're focusing on a point I'd like to disagree with.

MR. HAMMOND: But that's a critical point.

DR. LATTER: But there's a different point. The guy who designs the bridge doesn't believe that there are any factors that may have been overlooked. Where he put in judgmental probabilities and all of that kind of thing --

(Brief discussion.)

MR. BUDNITZ: No, but really, the Bay Bridge is built with a lot of judgment in it. And, and what it has, it has safety margins to account for that, which, which is --

DR. LATTER: Well, fine. Fine.

No, I understand there are certain --

MR. BUDNITZ: Uses the ASME Code and so on, and he chooses his material to make sure the impurities are such and such; and he -- these conservatisms are over and above to provide the safety margin for his ignorance.

DR. LATTER: Sure. But, but he knows where his ignorance lies, and he can do something about it.

The trouble with this thing is it's complicated enough so they can get bright guys in a room, take a reactor and say not what will happen if this pressure vessel fails or whatever. But what do you think the likelihood is that this core could melt?

You could keep a hundred people, no matter how smart they are, in a room arguing with each other for a hundred years on that.

SPEAKER: That's what we did.

(Laughter.)

MR. STELLO: Why don't you just go to Tennell and say, "The new argument in 1984 is with 200 guys in the room" --

COMMISSIONER GILINSKY: Now, wait a minute, Vic. I, I think it is worth saying that the idea used to be that the containment was an independent line at the time.

MR. STELLO: It used to be.

COMMISSIONER GILINSKY: So what Al is talking about is restoring it --

MR. HAMMOND: That's what I'm trying to do is make it independent. And if it's not independent, then we -- it, okay?

COMMISSIONER GILINSKY: But I've let that go somewhere along the way.

MR. STELLO: In 1964.

COMMISSIONER GILINSKY: Fine. Okay. And so it isn't a matter of just saying "yes." You know, going another step; and then somebody will say, "What about that? What if that fails?"

You're really getting back to a concept that was an important part of the --

MR. STELLO: You either decide we're going to talk for the moment philosophy of safety or quantitative systems, which we'll talk about. So if we talk quantitative, we're back to the same identical issue. It just has a few twists --

COMMISSIONER GILINSKY: I don't want to put words in his mouth, but what he's saying is that when you start calculating these numbers you're not really sure you know how to calculate it.

MR. STELLO: When you have this system, you're not going to be certain that--

DR. LATTER: Well, if you are right about that, then I want to be the first to agree. If it turns out that when you go to design the containment system, you find yourself as confronting judgmental issues constantly asking the question, "Will this work?" -- and not being able to say with absolute conviction, as well as just simply by saying, "Well, I'll put in the safety factor" -- okay?

If it turns out you say, "Well, even with that, is it possible that there's some devious physical phenomenology going on and I haven't been aware of it," in short we're back in the same position.

I guess the right way to say this: suppose you tried to make your containment system very sophisticated, you decide, "Well, I'm not going to spend money; I'm going to be very clever. I'll use, I'll use microelectronics or whatever."

Well, pretty soon your safety system would probably be much, much less reliable; and then you prefer to go back to the old way -- is my guess. And I'm asking whether just to understand the philosophy, I'm saying, "Can I make a hole? Can I appeal to some rudimentary nature, natural law that says, 'Well, this way is down; and it can't do anything but go that way. And it's all that simple.'"

I can't do it. You can't engineer that. And it's a failure. But that's the suggestion.

MR. STELLO: Let me tell you the arguments that have occurred to me that come up in that meeting.

DR. LATTER: You're really worried about my --

(Laughter.)

MR. STELLO: If you have a hole in that --

But if we get two valves that somehow didn't close and had to close, all on the very same arguments we have today, because if you did, you don't need a very large failure to contain it. Smaller, I hope. Smaller than the size of the tipe of my finger. They're going to dump those fission products out there like you wouldn't believe.

DR. LATTER: Sure.

MR. STELLO: So you really are dealing with this very complicated issue, even though you have heuristically a philosophy that deals with it.

MR. DENTON: That, that's the argument as you lower lower lake level you see more rocks, but you may have really reduced the probability of failures in that direction. You don't have to go very far before you are predominated by other things.

MR. HAMMOND: You brought up another requirement we didn't mention because we, we know you already deal with; and that's the question of a reliable means of isolation. But if that doesn't operate, you've lost it. And I think in the long run you would have to provide a passive means of isolating it that was independent of the operator's volition. It might be owned and operated by the NRC and not by the operator, in addition to the ones that are there.

MR. STELLO: The reason I bring up the issue is that in order for us to decide we're going to either go down a truly independent philosophical path for which there's no doubt in my mind I'd love to be --

(Laughter.)

But if you are, then I think you have to deal with it as a completely new philosophical path.

We're not, we're really not vulnerable to all these very damn same arguments for which it would have a sensitive a hundred. And the engineers arguing about the number is 200.

DR. LATTER: Sure. You're just right, Vicq And, and that's what we're advocating, folks. That's at least what we'd like to explore, the possibility that you could go down a completely different philosophic path and, with good engineering, actually stand up and say, "My gosh, independently of all these complex problems that we're used to, we've superimposed a containment, but that in principle you can do this, I've made plausible in myself in the following way." Now it isn't just a cartoon, and I don't, I don't mean it seriously.

Suppose you say, "There's a containment building." And you go out somewhere, and I'm about a hundred yards away and I start building a steel wall around this thing. Wherever you say, if you're short of a real estate. And I'll just put, make a wall so thick that no matter what happens in there, that the U_{235} and its 3-percent stuff, all the sides that collect on one end, you know, and those critical -- I'll, I'll claim in principle that I can build an object -- I might not be able to afford it or -- I can build an object where I'll say, "Fine. It won't hurt anybody on the outside."

So that's an illustration of how you can implement philosophy in an impractical manner, but at least clearly illustrates the difference in philosophy. I can go and quite independently of every detail that you're left with, I can go containment system and say, "Don't worry."

MR. STELLO: I, I agree. That's precisely my point. It's truly independent philosophy --

DR. LATTER: Right.

MR. STELLO: -- then that's what matters. But this to me, you've got to recognize where we do come out. And that's, I think we're still stuck without the quantitative --

DR. LATTER: Well, Iwould propose that we systematically go about reducing all those. That's what a program would consist of.

You see, if we had done all the homework, we'd come in and say, "Oh, no." And then we'd give you the reasons why you don't have to worry about that.

But the homework hasn't been done. It takes a lot more talent than this little group of people could put together. But if you do it right, you may come up with a system where you say, "Yes, indeed, this is like the big steel stair around it. It's independent, and we, and if the other thing can fail, then it has no influence on us."

And I believe that's what it's -- if I caught the spirit of your question.

(Pause.)

MR. BUDNITZ: I guess philosophically it's one of the most attractive notions I've heard in a long time, and I have tell you that, although this is very nice, this is not brand new to me. What was brand new to me, what was brand new to me was only just last week Vic steered me to some of the data compiled, which I read and which illuminated for me how those decisions were made in the middle 60's about containment.

MR. HAMMOND: The Dave Okrent report, yes.

MR. BUDNITZ: Yes, okay?

And although I was aware of it, it crystalized for me the process whereby the people making these decisions, the Commission, and so on -- went from a containment that was supposed to contain to one that was not necessarily going to contain. So this discussion has added another dimension.

But the question that has to be faced here and in the industry is, to what extent should a record offense be urged?

And to me there is some limit. I'll tell you what the limit is, in my view:

The record could cost a factor n. I don't know of more than building a new better.

DR. LATTER: Oh, sure.

MR. BUDNITZ: Comprenez?

MR. STELLO: Gees, don't say that; we've done that already.

(Laughter.)

CHAIRMAN AHEARNE: You didn't agree to a --

MR. BUDNITZ: On the other hand, if one ends in a big number, why, that's, you know, very attractive.

And what it really will cost depends on some of these engineering thoughts that you've heard that, really we have, we don't, not even in a position to regard some of the --

DR. LATTER: Well, you know, I ask myself the following questions: I'm getting now, I understand parts of the Washington bureaucracy. Anything that has to do with the Department of Defense, I, I don't have any idea about this bureaucracy, but I'm sure it's --

CHAIRMAN AHEARNE: Any of us --

(Laughter.)

MR. BUDNITZ: Join the club.

(Laughter.)

DR. LATTER: Would it be utterly unreasonable for the NRC to issue some kind of a directive to, to your own agency and DOE or whoever supports what I -- and say that you'd like seriously to consider over some coming period of time, you'd like to consider the possibility of modifying regulations or the safety policy to include containment for class 9.

CHAIRMAN AHEARNE: We, we do that.

DR. LATTER: Oh, okay. I, I didn't know whether --

MR. STELLO: Is it out yet?

CHAIRMAN AHEARNE: No, it, it's not out. They're --

(Brief discussion.)

CHAIRMAN AHEARNE: Yes, we have to consider class 9 accidents. And as far as the regulations on what plants have to be built, well, yes, we issue those.

SPEAKER: Right.

CHAIRMAN AHEARNE: As far as research developed, there's a split between dealing from some of it and --

(Brief discussion.)

(Laughter.)

DR. LATTER: Well, I was thinking you go to your own lab and you tell them you're interested in this, and you, and you will be, you will undergo serious consideration and you'd like information of various types and they start generating, and, and you may set the target --

(Laughter.)

SPEAKER: The key, that's what I call the Form 189.

(Laughter.)

CHAIRMAN AHEARNE: But the, yes, there are, there are mechanisms that -- at least we can, we can have the sense that we are trying to get our act together.

(Laughter.)

MR. KELBER: I'd like to make a comment here.

There, the concept of a completely containment is topologically impossible, because you must have a heat rejection. The heat rejection, although heat rejection is universal -- Sam knows what I'm talking about -- and I guess what I'm getting at is that even conceptually you must allow some way for heat to be transported out of the system, saving on electricity.

MR. HAMMOND: But not radioactivity.

MR. KELBER: I'm not, I'm not arguing with that point. What I'm saying is that the concept of completely containment -- and let's not talk about practicality; let's talk about the impervious steel sphere -- is not tenable, because of this question of transport.

And obviously, in a practical system you have to provide ways for materials to be brought in and out -- and I know of at least incidence; no, two now -- where reactors have operated with, with equipment doors wide open.

So this does happen. And it's nothing that hasn't been taken into account.

And once we've done some thinking about this, for some that many years and lately in a very concentrated way, I think the point that was made by a number of the office directors here and others earlier, is a extremely important one: that they're, as you lower the level of the lake, some of the other rocks come up.

But I think it will be reasonable in talking about retrofitting plants, to aim for at least a factor of 10 in reduction of the relative risk, and possibly as much as a factor of a hundred. And I think that going beyond that is going to be extremely difficult.

DR. LATTER: Yes. I'm not sure it makes sense to retrofit at all. I just said --

MR. KELBER: Well, I think it makes a great deal of sense.

DR. LATTER: Well, I, I, yes, I --

SPEAKER: Well, let me ask you --

(Brief discussion.)

MR. GILBERT: One other technical point on the discussions of core melt. Our postulates now are that -- containments at least, the molten core will solidify relatively early into the sequence; and you then deal in a fashion with a question of a penetration of this copper flag, which may if you have a very thick basement, say, may never get discussed.

That doesn't -- the virtue of the idea is to suggest that if it doesn't, there are other alternatives.

So I think that the latest data do suggest that there, you know, there's a range of alternatives.

(Brief discussion.)

(Laughter.)

CHAIRMAN AHEARNE: I think we're going to have to break.

MR. BUDNITZ: This falls in my corner.

CHAIRMAN AHEARNE: Yes, I want to talk some more about it.

And I want to thank Alex. It was very informative.

(Laughter.)

(Thereupon, at 3:00 p.m., the meeting was adjourned.)

End T-32