ORIGINAL

wolf/sh

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON REACTOR OPERATIONS

Room 1046
1717 H Street, N.W.
Washington, D.C.

Tuesday, May 20, 1980

The Subcommittee meeting was convened, pursuant to notice, at 8:45 a.m.

Present:

DR. WILLIAM M. MATHIS, Chairman
DR. D. W. MOELLER, Member
JEREMIAH J. RAY, Member
J. C. EBERSOLE, Member
RICHARD MAJOR, Designated Federal Employee

P R O C E E D I N G S 8:45 a.m.

DR. MATHIS: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Reactor Operations.

I'm Bill Mathis, Subcommittee Chairman. The other ACRS members present today are Dr. Moeller, Jerry Ray, and we expect Mr. Ebersole here a little later on.

The purpose of this meeting is to review NRC research programs in the area of operational safety, including fire protection, noise diagnostics, and man-machine interfaces for the ACRS annual reports to the NRC and Congress.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act.

Towards the end of today's meeting the Subcommittee will hold a closed session for the purpose of reviewing budgetary information. It may also be necessary for the Subcommittee to hold one or more closed sessions for the purpose of exploring matters involving proprietary information.

Mr. Richard Major is the Designated Federal Employee for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on May 5, 1980.

A transcript of the meeting is being kept, and it is being requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she can be heard readily.

We have received no written statements or requests for time to make oral statements from any members of the public.

Do any other members of the Subcommittee have any comments?

Jerry?

MR. RAY: No.

DR. MATHIS: Dave?

DR. MOELLER: No.

DR. MATHIS: We will now proceed with the meeting. I'll now call on Mr.Bill Farmer, the Research Support Branch, to start the presentation. Bill?

MR. FARMER: Dr. Mathis and members of the Operations Subcommittee, I'm going to lead off today, and I'm William Farmer, Branch Chief of the Research Support Branch, and I have a few introductions I'd like to make at the beginning here, and then I propose having the topics that you've asked me to discuss handled by the individual members of the Branch.

The agenda we would propose following is in line with that that you presented in your written announcement of the meeting. We're going to start with evaluation of the qual testing, then proceed to the fire protection, then go on with the noise diagnostics, and at the request of the Committee we've added a short discussion of the safety valve research program, which the branch in conjunction with, I should add, the Mechanical Branch, is monitoring. That is to be conducted by EPRI.

And finally, we will deal with the man-machine interface, and I will cover that initially in terms of the broad aspects of the research program being conducted within the agency on a general basis, and then we'll deal with the specifics of those programs the Research Support Branch is directly in charge of.

Finally, we'd like to take about five minutes and discuss the technical support programs. This branch has the responsibility for the Nuclear Safety Information Center and the Argonne Code Center. These two activities, which are not direct programmatic research activities, do contribute to the agency's work in a very significant fashion, and tend to get overlooked in the budgetary process. Therefore, we'd like to just reiterate some of the work of that particular activity.

Finally, we'll go over the branch plans and budgets at the very end, and during the discussion we will discuss the program plans but will not actually go in and discuss the specifics of the amount of money that we have requested for each program.

Just as a way of introduction, these are the three areas that the Research Support Branch participates in managing within the Reactor Safety Research Division: operational safety research programs that we'll discuss today, the 3D international flow distributional program, which is a program on Loca ECCS refill reflood research, in which the NRC and the Japanese and German research facilities are cooperating, and finally the technical support programs, which again are the Nuclear Safety Information Center and the work of the Argonne Code Center distributing codes.

This details in a little greater detail the operational safety research program. The fire protection program, which has been ongoing for several years now, has as its goal the development of fire protection methodology and the confirmation of various criteria and data that are used in the regulatory guides and standards that the agency uses to judge the adequacy of fire installation facilities at operating nuclear plants.

The qual testing is a similar program in which we do qualification testing under Loca conditions to evaluate the adequacy of the codes and standards that again the regulatory agency uses to judge the applicant's submission for a license.

Finally, the human factors cover a number of programs. We have been participating in assiting both standards and licensing in looking at simulators. We also have a program on safety related operator action, in which we're actually starting work with operating crews on a simulator. We have some additional work looking at human factors in the use of alarms and annunciators.

The noise diagnostics is a program which covers both assistance to the regulatory people in terms of guides and standards, and also performs a great deal of field work in support of NRR in performing measurements on site when some sort of problem or difficulty has arisen and the agency feels the need for an independent appraisal or investigation of that problem.

Finally, the safety valve research program, which I mentioned earlier, which initially will be a program of monitoring the work being done by the industry through EPRI, which is just now about to start.

With that, unless there are any questions -- yes?

MR. RAY: Could you tell me what the size of the Research Support Branch is? How many people are in it?

MR. FARMER: THere are actually four people involved in the operational safety part of the program -- well, it's really three and a fraction and then there's two and a fraction involved in the 3D program. So all told, there are seven members of the branch.

MR. RAY: Has this been expanded recently or has it been this size?

MR. FARMER: The group initially was approximately four people, and the expansion has been in terms of the 3D program. We've added two people in the past two years. One, most recently, Dr. Hahn who's sitting here in the audience, joined us just this past week, and a year ago Dr. Reed joined the program. Both those are working directly with the 3D program.

MR. RAY: So those seven people, in a sense, in a strict sense, monitor this program that you have on the slide now, nationally and within NRC?

MR. FARMER: The program, as outlined on the previous slide, we have roughly three plus people here and two plus people here. It's six people, I take it back, not seven. And the three plus monitor this and this program, and the two plus monitor this program.

Now the dollar values are relative to the people, I might add. Now there's a level of the program that is in accordance with the people.

MR. RAY: Do you have an expansion permission now?

MR. FARMER: WE currently, with the addition of Dr. Hahn, have all the people that we're currently authorized for.

Dr. Tong?

DR. TONG: Yes, there's one slot for branch chief.

MR. FARMER: Yes, I'm in an acting capacity since Dr. Bennett left in January.

MR. RAY: Well, the personnel assignments may be in proportion to the dollars, but from the viewr 'nt of adequate monitoring, the tremendous detail involved in a comprehensive program like this, it seems to me you're undermanned.

MR. FARMER: Well, we would tend to agree that we could use more help. And we certainly agree with the conclusion that additional manpower would be beneficial to expediting and making the program grow.

MR. RAY: In general is this true of the research support activities of the whole division of the NRC staff?

MR. FARMER: Well, maybe Dr. Tong would like to speak to that one.

DR. TONG: What's the question?

MR. RAY: I was just wondering how adequately manned the total research staff of the NRC is.

DR. TONG: In total number? Offhand I cannot give the exact number. Not let me tell you about on water reactors, there are 30 professionals in water reactor safety. Besides that, we have advanced reactor research, and again safety research. So total number I have to check out.

MR. RAY: But in that 30 that you mentioned, does it include the seven?

DR. TONG: Including the seven.

DR. MOELLER: To follow up one other step on that, do these seven people here not only monitor the research but do they have to develop the concepts of the program and where you're headed? Do they do the planning as well as the monitoring?

DR. TONG: Correct.

DR. MOELLER: Everything.

MR. FARMER: There are research review groups that assist, and of course a great deal of our work in the reactor operational area in particular is based on user needs identified by the Office of Standards or by the Nuclear Regulatory Licensing.

DR. TONG: It would be safe to say that the research staff is shorthanded for all the branches. That's true.

DR. MATHIS: One other questions, Bill. You mentioned seven people, and this is basically all of your operational safety research activity, and there is some other interwoven, but what percentage does this amount to? And I think this gets to what Ray was talking about. What percentage of the total research program are we devoting to operational research? It must be very small.

MR. FARMER: Prior to the improved -- initiation of the improved safety research program, this was probably, I would say, of that research, operational represents probably well over half. With the initiation of the improved safety research program, which is under the guidance of the Probablistics Analysis Branch, of course they are spending more money, significantly more than we are. So now we're probably on the order of 30 percent of the operational research.

DR. MATHIS: Well, I'm sure we'll probably get into more of this as we get into the detail.

MR. RAY: Mr. Farmer, one last point. The seven personnel are all professionals?

MR. FARMER: Actually I miscounted. There are really six professionals and there is a secretary. There are seven in the branch.

DR. MATHIS: Anything further?

MR. RAY: Just a little clarification for me, recognizing my lack of background. What is meant by technical support programs?

MR. FARMER: Those are the programs that I mentioned earlier, the Nuclear Safety Information Center at Oak Ridge and the Argonne Code Center, which is really a code distribution center.

MR. RAY: Information gathering and analysis.

MR. FARMER: ANd it includes some other functions. This branch has traditionally sort of been the focal point for -- has been assigned that particular area to manage.

DR. MOELLER: How will Carl Michaelson factor into this with his data analysis and evaluation group?

MR. FARMER: Well, the Nuclear Safety Information Center of course is collecting LER's and other data on nuclear instances and doing a great deal of analysis of cataloguing. And Michaelson does expect, as we understand it, to make extensive use of the Nuclear Safety Information Center.

We also keep his group involved in the output or results of all of our research, the list right here. His group is so new that I couldn't really tell you what the interactions with our other programs will be at the moment.

Okay, Ron Feit will address the fire protection and qualification testing.

(Pause.)

MR. FEIT: Dr. Mathis, committee members, it's a pleasure to be here this morning. I will talk about the qualification testing evaluation program and the fire protection research program. These programs form the basis of what we labeled operational safety research a few years ago.

The qualification testing evaluation program consists of three parts, as reflected by the three objectives. The first portion is aimed at evaluating the testing methodology. Primarily now we're associated with the loca testing and main steamline break. The decision was made for seismic testing to leave that to another branch in the research organization.

The second portion of our program is concerned with evaluation of the radiation simulators that we use for our loca testing. And I'll discuss that in a little more detail later.

And the third portion is what we call our aging study. It's a materials aging program. What we're looking for here are the weaknesses that you would get from natural aging -- radiation, thermal, perhaps pressure stress environments and so on -- that would cause a weakness and could result in a common mode failure if you had a loss coolant accident or a main steamline break.

The organization that's conducting this work for us now exclusively is Sandia Laboratories. However, they do sub-contract, and other subcontractors have been called into the program, such as Franklin Institute.

DR. MOELLER: Excuse me. On item 2, when you say the adequacy of radiation simulators, you're exposing equipment to fields of gamma rays to see how it performs? It that what you mean?

MR. FEIT: I'll pick it up a little later in the program, but just briefly now what we're trying to do is to define in terms of the magnitude in the spectra in the particle type what would be a reasonable radiation source --

DR. MOELLER: To simulate an accident, let's say?

MR. FEIT: Right, to simulate the loss of coolant --

DR. MOELLER: Okay.

DR. MATHIS: One further question there. Are you looking at just a loca in this case? What about aging due to gamma radiation on cable insulation?

MR. FEIT: THe current local philosophy, as adopted by NRC today, includes aging. In other words, the component that is qualified should have gone through an equivalent aging cycle before the loca appeared, the thought being that if you have a loss of coolant accident on the 40th year of the plant, the equipment would be in a degraded condition because of the natural aging and would presumably be more affected by a loss of coolant accident.

So the answer to your question is yes. We are assuming and taking into account the fact that the component should have been aged prior to the loss of coolant accident or the main steamline break accident. That's correct.

This was not always the case with the NRC guidelines. As you probably are aware, in 1974 the IEEE standard adopted or endorsed or made more clear the requirement that aging is necessary, and we have focussed on that program in more detail.

DR. MATHIS: So you feel that those standards then are adequate?

MR. FEIT: I think they're adequate. The problem is in determining just what is an effective accelerated aging program.

MR. RAY: Could I come back to that for a moment? The aging of insultation of conductors, have any samples been taken out of operating plants and submitted to you to determine what has happened to the insultation as a result of the operational exposures that the samples have been through?

MR. FEIT: Yes, we have done some of that. As you can imagine, it's not an easy thing to do. It's difficult. For one thing, the utilities don't like you to come in and rip out cables, and when you can do that, usually the history of what the cable saw, the cable environment, the temperature swing, even things like the original purchase specifications, it's foggy.

So we do have some, and I will mention that briefly.

MR. RAY: Do your testing and research plans include such procedures on samples that presumably will be removed from TMI some day?

MR. FEIT: Yes, it does.

MR. RAY: How about the electrical components themselves, other than the insulation?

MR. FEIT: Yes.

MR. RAY: Coils and so on.

MR. FEIT: I have a viewgraph on that later in the presentation.

I just want to hit briefly, this is the work that has been reported in the past. It's work that we've essentially completed and it was reported in prior years.

The synergistic effects program, this was the radiation and thermal, sequential versus simultaneous, on some components -- cable, connectors, paint samples. We do intend to extend that. We have upgraded our facility. The original synergistic effects work was done at a very small and we felt inadequate facility. We have upgraded that facility and we'll discuss that a little later briefly.

We have identified just what safety related equipment would be and categorized this equipment for future testing. It's amazing when you look at a plant and all the equipment there just what is safety related and what is not and how it all breaks down. And in order to get a handle on these programs, one cannot go through the plant and indiscriminately test 1,000, 2,000 different sensors, unless you logically group these things and pick and choose, and that's what we did. We used the Seabrook plant as an example and we intend to upgrade this list with BWR's and other plant information as it becomes available.

Another item that we completed and I will talk about briefly -- I don't think it was reported last year -- was the Commission-requested connector test, and this resulted from the Union of Concerned Scientists petition to shut down our reactors based upon connector failures that we noticed in some of the research work. That test is completed.

Another piece of work that I'll just briefly mention because it wasn't mentioned the last time we were here was some leakage experiments that we r·n. We were looking for a leakage path between the conductor and the insultation material of a cable that could breach the integrity of a seal in a motor or some instrumentation that was supposedly sealed. And as a result of that work, there have been a number of changes that have been made at the plants to block that leakage path.

So we feel we have a very versatile program. We have the facilities and the people and we try to respond to the licensing staff on a quick turnaround basis to do these types of research that we feel are related to operational safety.

I mentioned the Browns Ferry connector test. The Commission wanted us to verify a small number of qualification tests that were run by industry. There was some question during this review as to the validity of the industry tests. The Commission was I think rightly concerned, and they asked us to conduct an independent verification of these tests. We chose the Browns Ferry plant. THey seem to get their share of attention. And we tested six connectors. These were Bendix connectors, DC and AC connectors. They were purchased and tested in accordance with the specifications laid down by TVA. And to the best of our ability and to the best of the records that were available, we did duplicate those tests.

This shows some of the test categories concerned with qualification tests. It's fairly typical. Resistance measurements are made. We did some additional work. We radiographed the connector assemblies. This is not usually done. We made durometer measurements to look for the hardness changes on the cable. This is something that's not usually done. Dimensional checks and so on.

We also conducted the test and conducted all the functional tests that were required for the qualification program and in addition to that, the connectors were in an active circuit during the application of the radiation and the loca and the thermal agent. So it was an active test in that sense.

This gives you an idea of some of the environments that we exposed the connectors to. It broke down into three categories: nuclear radiation, temperature and aging and the steam. The radiation was about 7 megarads and dose rate was about three-quarters of a megarad per hour. And that lasted for about 90 hours.

Of course, as with most of these qualification tests, we used cobalt 60 as the radiation source, which is what was used by TVA in their original qualification.

This particular connector was aged. Although at the time the connector was put in service or at the time the plant was licensed, aging was not a requirement, the utility did choose to subject the connector to a partial aging cycle and we did duplicate that. The cycle was a combination of air and nitrogen, and I'm not really sure why but that's what they chose and we duplicated it.

The steam profile was scheduled to last for 24 hours with a peak steam temperature of 157 degrees Centigrade and a peak pressure of about 60 psig.

So we duplicated these conditions as accurately as we could and performed the test.

DR. MOELLER: And where was this done?

MR. FEIT: The test was done at Sandia Laboratories.

DR. MOELLER: So you're mainly duplicating what TVA did to see if you can confirm their observations?

MR. FEIT: That's right. The original TVA test was conducted at Wylie Laboratories. We used a different facility, obviously. We didn't go back to Wylie. But we tried to duplicate the conditions to the extent we could. This was in our upgraded facility at Sandia.

This is a schematic of the facility. We have a boiler. It happens to be a six horsepower boiler. We have a cumulator. We use two of them. They were about 25 cubic feet each. There's a series of regulator valves, in-line superheater, another regulator valve, the test chamber. Connectors were generally in this area. We have emergent heaters inside the chamber to add additional superheat, and you usually have a steam trap and another regulating valve on the output.

This is a typical schematic for this type of a loca test.

I might add that although that type of a test looks straightforward, it's not all that simple to maintain these profiles exactly, and what you find, as we did when you go through the industry records, that the profiles, the actual profiles and the requested or the records profiles, are usually quite different. And the reason that that occurs, it takes a certain amount of practice to hit a certain profile, and the industry contracts for the test and they pay about $30,000 for tests. THat doesn't leave any room for practice.

So the testing laboratory does the best they can and they submit the results that way. So you find that what the component actually did see is quite different in many cases from what they thought it should see by analysis of the loca conditions in the containment.

DR. MOELLER: Excuse me. This covers temperature and steam. Where do you put the radiation?

MR. FEIT: If you could hold that question just a moment, I'll show you a schematic of our facility. This is just the test chamber, just to giveyou an idea of how the connectors were located. The connectors are installed in a box. There were three connectors in each one of the two boxes. It's a steel box. It happens to be the configuration that's used in the plant and of course was used in the qualification test by Wylie Labs.

The steam inlet is in this region and there's a baffle, so you do not get direct impingement of the steam on the cover over the connectors. The connector leads are brought out through the bottom and out the side, along with the thermocouple measurements that you make to control the profile.

Just a point, to indicate the point I made before, the industry tests would typically use one thermocouple located perhaps in this region, as an indication of the entire or uniform temperature in the chamber, and of course that's not true. Certainly when you have changing conditions the temperatures in the chamber vary all over the place.

So just simple questions like where was the temperature measured and what did the connectors actually see during the test is not answered by some of the data that we're getting. And of course the emergent heaters down below.

DR. MATHIS: Now the results of these tests, do they verify the previous tests or have you found some differences that are significant?

MR. FEIT: I'm coming to that right now.

So we conducted the test and we found that all aspects of the utility test program was verified. That was the aging, the radiation, and the steam exposure. We had no degradation of the connectors in terms of any of the baseline tests that were considered important to the operation. We did see some changes, discolorations and some changes in the hardness of the cable and so on, but the cables performed adequately and were able to carry the current throughout the entire test.

So in accordance with the acceptance criteria that the utility laid down and our best judgment a reasonable set of acceptance criteria, we judged the connectors passed.

MR. RAY: Did you submit the insulation of the cables to any hypertentil tests after the exposure?

MR. FEIT: Yes. I failed to mention that. We did mega the connectors throughout.

MR. RAY: And they didn't break down?

MR. FEIT: They did not break down.

end 1

This is a schematic of our new facility, and the hole in the center is where the test chamber would be. That's where

t 2

we would put our materials or components. Outside in the periphery would be cobalt pencils. We call this a high intensity adjustable cobalt array or HACA, to justify its cost.

What we can do here, we can change the dose rate in uniforma steps by adjusting the position of the pencils closer or further away from the test chamber, and by spacing them equally around the periphery. We can do this remotely by a hydraulic drive system that forces the pencils up and down these cobalt positioning tubes.

So we have a very flexible and very accurate test facility.

DR. MOELLER: But this is separate from the steam and temperature, so you don't simulate a real accident.

MR. FEIT: Well, the chamber that I showed before --

DR. MOELLER: Or will this fit in it?

MR. FEIT: The chamber fits down inside the hole between the cobalt pencils.

DR. MOELLER: Okay.

MR. FEIT: And we send steam down into the chamber and then out and exhaust it. So we can do simultaneous testing.

DR. MOELLER: You do. Okay, thank you.

Have you done any work to show that there are synergistic effects? I know you've mentioned that, but have you radiated and then steamed and high temperatured it versus doing it all together? What are the differences?

MR. FEIT: Well first, the results that we talked about last year have been published. On a limited number of components we did not see any significant synergistic effects.

We saw differences, discolorations and minor changes, but nothing that we could say would result in a funcational difference. We're encouraged in that sense because most people cannot do the kind of testing we're talking about here. It's expensive. They'd rather radiate and then expose to the steam.

But we feel the question is not answered. We must go through and do this for other generic pieces of equipment. Now we are planning to do that for pressure transmitters, as a matter of fact, within the next two months.

Just in closing on this HIACA, we can get up to about megarads per hour with a smaller test chamber by moving the pencils closer in, or in this configuration with the largest chamber, we can get about two megarads per hour, which is pretty close to what the industry dose rate is, although I might add something lower than what you would get from the Reg. Guide 1.89. I'll come to that a little later.

DR. MOELLER: How many curies are you dealing with?

MR. FEIT: I think that the purchased cobalt for this facility was something like 200,000 curies, if I remember correctly. Of course that's deteriorated a little bit. We made that purchase a few years ago. Of course we can upgrade that with new pencils at any time. It's flexible in that regard.

DR. MOELLER: Well, for something like this, what is your dosemetry, or is this dose a theoretical dose?

MR. FEIT: No, we measured the dose. As a matter of fact we went through a very elaborate mapping procedure.

DR. MOELLER: For the distribution?

MR. FEIT: Yes. Sandia Laboratories is very experienced in test reactors. They have more talent than we need in that regard. They try to overdo that portion of it, as a matter of fact. This just gives you an idea of the chamber that we have now. We built one chamber. We can construct other chambers. They're a few thousand dollars a piece. This is the one we're working with now and this will give us a dose rate of about 2 megarads per hour. It's about 90 inches high and the inside diameter is about 21 inches.

So we can put components in that chamber fairly substantial, even small motors or valve actuators and so on.

DR. MOELLER: What is the safety factor? Does that apply to the pressure?

MR. FEIT: That's a question of how much overpressure --

DR. MOELLER: Okay.

MR. FEIT: That doesn't have any bearing on qualification. It was on the viewgraph and there was no way to take it off.

This summarizes the first portion of the program, methodology assessment portion, the loca and main steamline break testing portion, with regard to what we're doing now and in the next year and what we plan to do after 1982.

I mentioned the connector test. We had one series. That was the Bendix connectors associated with the Browns Ferry unit. We're going to run one more set of connector tests, and that will probably be McGuire reactor.

We will start to do some of our methodology testing. We'll do some more synergistic effects testing. We'll do some superheat testing, superheat versus saturated conditions. Thermal shock testing. We want to look at the oxygen depletion problem. That's an interesting effect. When you think about a loss of coolant accident in a typical containment, there will be oxygen present. If you look at the way qualification tests are conducted in the laboratory, there's usually a flooding condition and the depletion of oxygen. There is a strong indication that those are not conservative tests because much of the degradation is a function of the oxidation. So we want to look at that problem.

Another issue we want to examine is the flow effects. Every facility around the country has different flow capabilities. We're not sure how important this is. Certainly it changes the heat transfer to the component, and when one considers the actual thermal shock on the component, it will be different. So we want to try to get a quantitative handle on that that we can use for regulatory guidance.

ANd the other item that we're carrying along, the confirmatory testing, we feel that there will be questions that will be asked by the licensing people on field equipment, and we will have to do confirmatory testing. And right now we're getting ready to test some terminal blocks that we were requested to look at by the Inspection and Enforcement people.

So we feel that mode of operation, although it's not methodology and it's not research, we feel it's important to the overall NRC mission. So we do leave an open window and drop other things and pick that up when necessary.

Now the long term program, which essentially is 1982 and later, although there is a certain amount of overlap, we want to get into the question of requalification. We feel there are many issues that will come up in the licensing arena where a piece of equipment will be in the field for five or ten years, something will be found out or some new question will be asked, and one has to concern themselves with is that piece of equipment still reliable. Could it still live through a loss of coolant or main steamline break accident?

We'd like to develop procedures for requalifying equipment rather than say categorically take the equipment out and put new equipment in. There should be some middle ground. We want to work in that area.

We want to look at the statistical question for qualification. Right now when a utility is qualifying a piece of equipment they run a single test. These tests are expensive. You can't run more than one test. There ought to be a tie-in between our quality assurance program and our qualifications program. We ought to understand what requirements to place, from a quality assurance point of view, on our qualification tests so we have a statistical basis for saying the equipment will survive.

Then we want to go through that generic list of equipment I talked about; we've identified about 20 categories, things like transmitters, limit switches, cabling connectors and so on; and just conduct additional tests on other pieces of equipment that we haven't looked at yet.

And the last item is a cooperative program with the French. They have some very unique facilities and we are trying to cooperate with them. And probably it will be in the area of the oxygen depletion effects program that I had mentioned briefly before.

So that summarizes the methodology, loca methodology program. If there are any questions on that? If not, I'll go on to the next item.

DR. MOELLER: Well, on the oxygen depletion, what do you expect there?

MR. FEIT: Well, what we're concerned about is that if you run a test in a small closed chamber where you're continually flowing steam, you have a situation of depleted oxygen. If you compare that to the situation of a loss of coolant accident in containment or something like Three Mile Island, we know that there was oxygen available at the surface of the component. And we have indications that a lot of the degradation is due to oxidation. So that the qualification test in the chamber might not be conservative. I can say it certainly isn't conservative. The degree, we don't know. That's something we want to look at.

Now the French have a facility where they can continually introduce air into their facility. It's driven by a very large boiler. It's a very large system. That's an ideal facility for making this type of comparison.

DR. MOELLER: Well, do you incur in your program the effects of hydrogen, hydrogen at TMI and the burning of hydrogen?

MR. FEIT: No, that is not in our program. We probably will use a facility for that, though, as a matter of fact. There's another branch in the research program. Perhaps Dr. Tong will talk about that. But they are considering the hydrogen release from different materials and the effect on components of course and the issue of how much hydrogen will accumulate in the containment. Probably we'd use that facility. It can be modified for that. But it would be our program.

DR. MATHIS: One more question. There's another very simple kind of problem that seems to show up in LER's, and that is just the simple corrosion aspects of failure of connectors, particularly in instrument circuits.

Are you doing anything about coatings or anything of that nature that might simplify and eliminate if you will that kind of problem? Because if you look at the LER's, there's an abundance that's just attributable to corrosion, and I assume it's probably just a wet atmosphere, but this puts a lot of instrumentation out of service. And here, to me, from the standpoint of safety, is an area that really needs some looking at.

MR. FEIT: We have a full category of research we call design adequacy studies, and I have a viewgraph at the end. It's something that we want -- actually we've been trying to get into that for a few years. It's not anything new. We proposed it two years ago. And I think now, after Three Mile Island, the kinds of comments that you're making are beginning to sink home to all of us. I think there's unanimous opinion in NRC that this kind of thing is important.

And we will be looking at just these kinds of design deficiencies, operational problems and so on, with the end goal in mind of either improving the instrumentation ourselves, NRC, if that's our goal, or at least suggesting to industry where the shortcomings are, the areas of vulnerability, so they can upgrade them, or to our licensing people so they can say you will upgrade these areas. I'll talk a little more about that when I get to it.

The next item in the qualification testing programs are accelerated aging study. This just summarizes some of the work that's been reported here before. We've built some facilities to conduct these aging studies, both radiation and thermal. We can do aging thermally and radiation together or separately.

These experiments are long-term. You cannot verify

40-year aging by doing 40-day tests. Some in the industry tried as an expedient, but from the research point of view you can't verify that.

So this is a long-term program. It's ongoing. We have samples that are in our test chambers now for three years.

We obviously have not worked on very material. We tried to work on those that we do find. Right now our work is limited to cable insulations. We will get into other materials later on. And we have tried to get a comparison with cable that has been naturally aged. I think the question was asked before, have we done that. This work we've done on the polyethylene cable is an example of that category of work.

We were lucky enough to obtain some samples from the Savannah River reactor, and they did keep excellent records. That was a very good piece of data for us. We used the method that we're working on for accelerated aging and then compared that to the naturally aged sample and found excellent correlation.

The reason that we got into the problem, the Savannah River reactor people noticed severe degradation in the polyethylene cable that did not or would not be predicted using the renius methods that they had used when they bought the cable. They went back and rechecked their calculations and the damage that they had seen in the cable was significantly different from what they would expect. It's not a mistake. It's just that the method didn't apply.

They knew we were working in this area so they came to us and collectively we worked on this problem.

Now using the methodology that we have developed in our program, we were able to block out almost the exact damage that we saw on the Savannah River cable. So in answer to your question, yes, we do wherever we can, but it's very difficult to get these kinds of naturally aged samples.

Another item that we had worked on is the aging of fire retardant cable. The fire retardant is added to the cable during the process. It's not a chemical bond usually. It's in a mixture state and the fire retardant material is quite volatile. That's in a sense how it works. When the cable heats up, the fire retardant boils off and prevents the oxygen from getting to the fire and also reacts chemically in the flame to inhibit the fire.

The drawback to this type of retardant, or at least the theoretical possibility is that the fire retardant would age, so to speak, and diffuse naturally, so if you had a fire after 40 years you might find that there's no fire retardant left.

The other problem we were concerned about, if you had a smoldering fire that lasted for a long time when the cables got hot, and they might be in that condition for a year, by the time they finally burst into flame there wouldn't be any fire retardant left.

So, that was the concern, so we decided to look at that aging aspect of the cables, and that work is almost completed and we're very happy to report that it's not a problem. There is one problem that we thought we were uncovering and it turned out not to be a problem.

We're also doing some modeling work with this type of material, cable material, trying to understand the aging mechanisms a little better so that we can predict beforehand, when we look at a cable, essentially how it would age.

There are two basic methods that govern cable aging. One is oxidation sission, which is a destruction of the boundary between the molecules. And the other is the cross-linking, which is the radiation effect. And of course these two interplay as you change the radiation levels and the temperature levels, and we were hoping to come up with a statistical model that would at least point us in the right direction when we make a choice of cable or a choice of test. And it's very preliminary but it does look promising.

This is just some typical data that we get out of the program. I obviously can't show it all. There are books of it. But just to give you an idea, this is the tensile strength versus the total dose of material for different dose rates, and also showing the effects of water, air and nitrogen. And you can see by looking at the -- this is for the same material, by the way. It's a cross-linked polyolefin. And you can see by looking at the same material radiated at different dose rates that you get different effects. And they're quite significant. And a matter of fact, you even note that for something like cross-linked polyolefin radiated in nitrogen, which is this curve, that you actually get an increase in tensile strength with radiation. Of course this is the cross-linking process.

Now as you get down to lower dose rates that take a longer period of time, then the oxygen issue comes into effect and you don't have a depletion of oxygen and you get the degradation.

Now this is important to us because many of the qualification programs that we see are quick, get-in, get-out, and they radiated very high dose rates. And we used to think, or I certainly did when I came into the program, that this was a worse condition for the material. You get the surface heating and damage and so on. Studies we've done on surface heating show it's usually negligible and that effects like this usually are predominant.

MR. RAY: Do you have any tests similarly that relate foliage breakdown in the insulation level with the dosage?

MR. FEIT: That's a good question. We've toyed with the idea of working in that area a number of times and we've always come back to the same answer, that it's not as important as what we're doing here. But we do want to get into that area.

MR. RAY: Well, in the last analysis that determines whether or not the cable's going to fall and you lose your systems.

MR. FEIT: We have stayed away from the electrical problems but it's not our of our minds. We're just prioritizing the work and we did the thermal and the radiation first and we backed away from the electrical. One reason we did is the electrical cable manufacturers concentrate on the electrical properties but they do nothing in this area of thermal and radiation, certainly not radiation.

MR. RAY: They may concentrate on the electrical properties but they have commercial advantages that influence their judgments and their procedures and everything else and it would seem to me that you people should get into that. In the last analysis that's the bottom line.

MR. FEIT: Yes, we've talked about it and as I say, it's not out of our mind. Your point is well taken. Perhaps we should speed that up.

Some of the other results that I don't have a viewgraph for, unfortunately, some of the other results show a strong synergistic effect with the materials that we're using, and by that I mean if you radiate separately and you apply temperature separately, you get different effects than if you apply the radiation and temperature together.

Furthermore, if you do sequential testing, the order of the testing becomes significant. If you radiate first it's generally a worse condition than if you apply the temperature first.

So it's not a simple answer and we hope to do two things. We hope to come up with a methodology that we can present in a cookbook fashion, if you will, so that it can be used by experimenters and by NRC reviewers. And also, we hope to come up with a collection of data, ours and others that we scrutinize, that can be used in this review process.

This summarizes the near-term and long-term objectives for the aging program. We want to continue the aging experiments and the model verification as I said. This is an on-going program. We hope to finish the fire retardant aging work. We're doing some long-term studies and we should wrap that up within the next six months.

We want to extend the program to alternate damage indicators. What we're using now is elongation. It's a generally accepted method for looking for cable degradation. There are other methods, some new equipment that's been put on the market recently, and we want to look at some of these other methods.

We want to extend the program to seals and gaskets. Right now we're just working with temperature and radiation. We want to introduce a new variable, the stress on an O-ring or a gasket, in addition to the radiation and the thermal.

MR. EBERSOLE: May I ask a question in that connection? When you look at the fire retardant aging on cabling, and you're going to extend the methodology to seals and gaskets, well, one can cope with the fire susceptible problem with a prudent design by simply separating these cables into different regional zones, preferable separated by concrete. But when you get into something like a containment you have the common modus alter of moiture and high temperature and so forth and it's pretty difficult to isolate yourself from that common thread.

MR. FEIT: That's right.

MR. EBERSOLE: What are you doing regarding the moisture and penetration susceptibility of cabling in the aged condition for use inside containment?

MR. FEIT: You mean insofar as it would be vulnerable to a loss of coolant accident?

MR. EBERSOLE: Yes.

MR. FEIT: Or to a fire?

MR. EBERSOLE: Or to any accident that makes the containment a hostile place for cabling.

MR. FEIT: Well, I guess the one saving grace in all this is in the containment you don't have as large a collection of cable, so the fire problem is something reduce, but I don't think it's eliminated.

MR. EBERSOLE: But you have the temperature and the moisture --

MR. FEIT: The moisture and the radiation. And of course that's the area that we're working primarily with.

MR. EBERSOLE: You're looking at the moisture penetration characteristics of cable after aging?

MR. FEIT: Yes. As a matter of fact, the cable leak, moisture leak program that I talked out is concerned with the moisture leaking between the copper conductor and the insulator and getting into the penetration or into the junction box down into a motor or an instrument.

MR. EBERSOLE: Well, you're talking past the strands, down the strands?

MR. FEIT: I'm not familiar with that trade name.

MR. EBERSOLE: I'm talking about the strands, the copper stranding.

MR. FEIT: Oh yes, that's right. Between the strands of copper and the insulating material.

MR. EBERSOLE: Well, that's long been a pipeline for water.

MR. FEIT: Yes, we found some.

So that's the area we're working in. The vulnerability of this cable is primarily in the containment, yes, because outside the containment you don't see the radiation. You see some moisture perhaps but not the steam. That's the area that most of the program is aimed at.

Well, let me go on. The long-term program is to continue this aging work. We hope to get more naturally aged samples. When we started this program we asked a number of people to start putting away samples in their plant, and we have some promised samples that should come up in the next few years. We also expect to get some from Three Mile Island that we feel is going to be reasonably well defined.

MR. EBERSOLE: Along this line, there's a few designs that incorporate cabling which is supposed to be submerged after an interval of 40 odd years and maintain its functionability, even though it had been submerged for the first time in 40 years. These are the maximum possible flood designs that theorize the use of certain electrical functions which have been innundated in the cabling area.

Do you have any of your tests oriented toward showing that that's a practical approach to that problem, without --

MR. FEIT: We haven't run any flooding tests yet. It's something we want to do.

MR. EBERSOLE: In the meantime, one of the practical solutions has been to flood these things out deliberately at periodic intervals just to see that the aging process hasn't destroyed the waterproof characteristics. I presume that's still the only practical solution.

MR. FEIT: We'll be looking at the Three Mile Island cable and see what the emergence did to that cable.

This is the last portion of the program, the radiation source term program. The work that we've done so far, we've completed an evaluation of the Reg. Guide 1.89 insofar as extrapolating the source term assumptions to what the magnitude spectrum particle type would be if one had to radiate the equipment in a simulated environment.

We have then of course shown that there were difference. The type of radiation that's used in simulating the accident is not identical to the radiation that one calculates based upon the Reg. Guide assumptions. The question comes up, what's the significance of that? Is that a significane thing? And we've evaluated these differences and we're just coming out with a research information letter, which, just to summarize, says that although there are differences, they're in a conservative direction or conservative enough that we don't have to make any major changes right now.

So in summary, I guess, the simulators we feel are adequate.

We've started what we call best estimate calculations. This is to -- the Reg. Guide assumptions are based upon the old TID source term, and there really is no direct tie-in to what you would see in the containment. There are arbitrary assumptions to start with.

We've done some calculations based upon the WASH 1400 accident and more realistic fission product release assumptions to try to find out what the dose rate really would be in containment if you had an accident. So that's the third area we're working in.

The results of the calculations that we've done so far, we found that the total dose, if one calculates out of Reg. Guide 1.89, is approximately equal to the core melt release, which shows that it's extremely conservative. The dose rate that you would get in running through the 1.89 assumptions is much higher than what you would get if you actually had the accident.

And we looked at the damage that you would get, difference in damage you would get between the calculated source term and the simulated source term and we found that the damage is pretty much the same. That was the basis of our determining that the simulators that are used now are adeuate.

This just gives you an idea of where we're at. The Reg. Guide -- this is a plot of course of -- this is the gamma versus time and this is the total dose that you would get, the dotted line, from the Reg. Guide 1.89 and also shown are what you would get from the different portions of the core melt accident.

As you can see, the Reg. Guide 1.89 source term is almost equal to the total core melt release, which makes it an extremely conservative test.

And the other thing you see of course is that the actual core melt, you don't get any release initially in the first ten seconds, but the Reg. Guide 1.89 assumptions, of course you get a release instantaneously because the Reg. Guide assumes instantaneously release. And that's the basis of the very high dose rates that you get, calculate out the Reg. Guide assumptions.

MR. EBERSOLE: This is inside the containment, I assume?

MR. FEIT: This is inside the containment, that's correct.

MR. EBERSOLE: In a sense, this is the only place that cabling would be expected to get any significant dose and it would be unnecessarily expensive to put one E cable in that context outside the containment. I don't know whether there's just a general thrust to make all of it resistant to radiation or just that in the containment, and one defines a parting line or not. But it's --

MR. FEIT: I don't think that the cable manufacturers are designing cable specifically for radiation --

MR. EBERSOLE: Or in containment, right. It's just a shotgun approach.

MR. FEIT: That's right.

MR. EBERSOLE: That means probably 3 percent of the cable will see a radiation dose.

MR. FEIT: That's right.

MR. EBERSOLE: Although there may be a great deal of expense in making it radiation-resistant.

MR. FEIT: Yes. Most manufacturers that I know use the same cable. The only thing they do change is they add the fire retardant.

MR. EBERSOLE: I wonder if that represents a misuse of resources, really, to make radiation-resistant cable and use it in places where there is no radiation.

MR. FEIT: That's a good point. I haven't thought about that.

MR. EBERSOLE: If it's a costly process it would be worth looking at.

MR. FEIT: Good point.

This summarizes the work we're doing now in the source term evaluation effort and the longer term work. One of the things I hadn't mentioned that I will touch on, if you calculate out the source term from the 1.89 assumption, of course you get a very large beta contribution, which you don't get with the cobalt 60, since the beta's all trapped in the cobalt and the container around it.

The question is, how significant is this beta? We looked at this and we did some analytical studies and we came to the conclusion that it's probably all right, but we want to do some scoping tests with beta to see what kind of damage we're getting.

So the position that we're taking now is we feel it's an adequate representation but we want to prove that with some small amount of experimental work, and we will be conducting that within the next six months, this work here.

This just summarizes some of the work that we've done since Three Mile Island. I think I've touched on the reasons before and Dr. Mathis expressed his concern as to getting at the real operational problems associated with this instrumentation.

These specific work items represent the steps that we feel we have to take before we actually get to an analysis of the equipment. We had to first determine what the exposure environment would be. There's no point pulling equipment out if you don't know what it saw. If you don't know how it performed during the accident, there's no point in looking at it.

So we had to go back, and we're doing this right now, trying to reestablish what went on at Three Mile Island in terms of the environment and the performance of the equipment is concerned.

And then of course you have to be intelligent about what you decide to pull out. There are literally thousands of pieces of equipment one could do work on. So we've narrowed this down to a list we think is reasonable. It's well under 100. I'm sure we'll narrow it down even further. And as soon as we can we will pull this equipment out and we will do a post-mortem on it and see what we can learn.

end 2

NRC 5/20
Wolf
Tomalonis
Tape 3

(slide)

MR. FEIT: Another item that we did since Three Mile Island, we wanted to review the Three Mile Island terminal blocks to determine if their replacement before the accident actually improved the reactor's safety. The terminal blocks at Three Mile Island were replaced as a result of some earlier work we did showing the shortcomings of the qualifications of a lot of this equipment.

It turned out that the terminal blocks were not qualified so they were pulled out and replaced with splices. So the question was asked, did that improve the safety reactor? Could the sitaution been worse had they not been changed?

We felt that as long as we were going to do that kind of a study, we ought to get some mileage out of it rather than just the self-serving exercise that that appeared to be, so we started to look for generic design deficiencies in the terminal blocks to see if there were shortcomings in the way these things were designed and installed and used, and we have completed a preliminary study and we have identified what we think is a failure mode that must be considered.

It turns out that with the terminal block that was used in Three Mile Island and, I might add, still is used in nonsafety related circuits, it is prone to a low voltage breakdown which is made worse by effects of humidity and contamination.

So we have gone that far. What we hope to do is get a statistical determination on this type of a failure so that we can factor this back into our probablistic report to see just how vulnerable we would be with a loss or cooler accident where these types of terminal blocks are still being used.

Yes?

MR. EBERSOLE: May I ask a question in this connection, there is two kinds of cabling you can go into containment. There is the 1E kind that is supposed to do something in there. There is a non-1E which is probably going to fail.

The current practice is not to attempt to disable or to de-energize the non-1E circuits, which leads to the thesis, which is probably right, that you are going to get a lot of malfunctions and faults as these systems fail, which will challenge the reliability of the interfacing circuits, which are frequently 1E.

It may be prudent to cut all these off deliberately, the ones which you don't need anyway, to avoid the unexpected upsets later on. Now, that's not done now, but in looking at the ones which do have to work, the 1E circuits inside, as a part of your investigation, do you ask yourself as you look at it, why is this circuit here in the first place and could it be done better by a mechanical impulse tube or by bringing the circuits in by piping?

Why I am I having to deal with htis problem in the first place, with this terminal block in a place where it shouldn't be, after all, which should be outside and I could have gotten in here by some other means, mostly the way GE does it.

MR. FEIT: We have not gone that far in our program.

MR. EBERSOLE: Does the staff do that? Do they examine why these circuits are in there and what might have been a better way to get the service out?

There's a case in point. Most of the GE systems use impulse lines and therefore it is not necessary to carry electrical apparatus into the container where you use mechanical impulse lines. On the other hand, the PWRs use a host of electrical systems. They even put the terminal blocks and the transducers inside the containment and create a maintenance problem which necessitates frequent entry into the containment under operation.

Who is it in the NRC who examines the relative merits of doing it either one way or the other?

MR. SILVER: We have an electrical branch that does that, but we're going to have to go back and ask that question.

MR. EBERSOLE: I think it's important to say why am I doing what I'm doing here, why am I having to solve a difficult problem when I could have averted it in the first place, and it might be a lot simpler and cheaper answer not to have to fight it.

Thank you.

MR. FEIT: I think the area of interaction between circuits, and certainly the nonsafety related and safety related circuits is important because our safety systems are not totally isolated, we know that. There are many points of commonality.

(slide)

MR. FEIT: The last item I wanted to mention, which is not currently planned until 1982, is the question that you raised, Dr. Mathis, and we call that the area of design advocacy. And especially what we want to do is categorize the instrumentation and electrical equipment to a reasonable group, let's say connectors. We want to find out what generic types of connectors are around.

It turns out there aren't that many different. There may be different manufacturers, but generic designs, there are two, possibly three.

You can do that for most pieces of equipment and you find that you certainly have generic categories that are, say, under 100 for a flange. You might have, say, 20 or 30 generic pieces of equipment like connectors, limit switches and so on, and maybe two or three different generic designs for each, so when you are all finished, you end up with generic categories of equipment that are under 100. It is in the realm of manageability.

And for these pieces of equipment, you want to go back and look at these various items that we have here. You want to look for materials compatibility problems, problems that might arise in fabrication. You want to look at how vulnerable these items would be in accident conditions, so just normal ambient wear and aging. What problems you can get into at installation, for example, that terminal block I talked about.

There is a very serious installation and maintenance problem with these in that the very active assembly in these connectors exposes a ground lug to shorting, and these kinds of problems.

We hope the end result of this kind of a study will be concrete suggestions of how to improve the safety-related equipment and I hope to get started in this work in 1982.

That concludes what I have to say on the Qualifications and Testing Program. If there are any questions -- if not, I will go on to the next part.

MR. MATHIS: Are there any questions?

(No response)

MR. MATHIS: Let's go on, then.

MR. FEIT: Okay.

(slide)

MR. FEIT: The overall objective of the program is to provide better data upon which we can judge the adequacy of the fire protection measures that are currently used in licensing. The organizations that have been involved in helping us are Sandia Laboratories, Underwriters Laboratories and the Applied Physics Laboratories.

(slide)

MR. FEIT: This summarizes the work that we've done to date. Most of this has been discussed in previous years. I'll just quickly go through it.

We started off with the evaluation of the Reg. Guide 1.75, and we found that the Reg. Guide was adequate for electrically initiated fires, but was not adequate for a exposure fire.

This position endorsed the regulatory posture of requiring additional protective measures. We then went on and looked at these additional protective means: fire retardant coatings, shields, barriers of various types, and we published that work and found that some of the measures worked better than others, but in all cases, they seemed to be effective against preventing the spread of fire through a series of cable trays.

We also have done some work with sprinkler systems.

MR. EBERSOLE: Before you go further, when you say, preventing the spread of fire along the cable trays, do you say that in the context that the cable is under high voltage and under operational conditions and is being measured and is electrically functional as well as not burning?

MR. FEIT: We have conducted test with cable tray rays in horizontal, mostly and some limited work with verticl trays, but mostly in horizontal with the cable under operating voltage and current.

MR. EBERSOLE: And the test includes whether or not it remains functional?

MR. FEIT: Yes.

MR. EBERSOLE: Does that include tests after you have sprinklered it, after you have applied fire extinguishing agents to it and therefore introduced the possibility of short circuiting?

MR. FEIT: Yes. There is a limited amount of data on that.

We've run two tests with sprinklers. In both cases the circuits were monitored. In one case, there was a failure in that the redundant cable burned, and that was the test that we felt we had proved that the Reg. Guide 1.75 was not adequate for guaranteeing -- for exposure fires, for isolation and exposure fires.

Then we ran another test at Underwriters Laboratory where we used sprinklers on vertical trays and we were monitoring the continuity of the redundant divisions and, as a matter of fact, we did see some failures, but it was not due to the sprinklers, it was due to the fire.

MR. EBERSOLE: When you say continuity, do you mean at high voltage?

MR. FEIT: At operating voltage.

MR. EBERSOLE: So it maintains its insulation to ground?

MR. FEIT: Yes.

MR. EBERSOLE: Except for the failures. Thank you.

MR. FEIT: But I must add that the trays were not submerged.

MR. EBERSOLE: They were just being sprayed?

MR. FEIT: They were just being sprayed.

And some of the otehr work that we have done is the evaluation of the IEEE383 flame test. I'll talk about that today because it wasn't reported last time. Corner effects work, looking at the differences in cable trays, whether an open room or close into a wall or ceiling, and that was reported last time.

We are starting to do some work with penetration fire stops and I'll talk about that and some fire suppressers.

(slide)

MR. FEIT: We modified one of our facilities so we can examine the effectiveness of various fire suppressant agents. What we plan to look at is the halon 1301, water and CO_2. Right now, we just started work with the halon.

(slide)

MR. FEIT: This just gives some of the reasons that we got into this work. We noticed that some of the early work we did at Sandia, that the cable tray fires ended up being what we called deep-seated fires. When you get a material like cable, porous material, burns, you get burning from within and the fire can become deeply imbedded in a cable bundle and can continue to glow and it's very difficult, or one might think it's difficult, to suppress the fire with some type of a gas that just predominantly works on the surface.

So we were concerned that the plants that were using halon and CO_2, supposedly to put out a deep-seated cable fire, would not be adequate.

Also, the NFPA guidelines require, although they don't say how, they do require that the suppressant be tested with deep-seated fire. But no standard is given to how to perform these tests.

So we decided to try it.

(Slide)

MR. FEIT: This just shows some of the work that we had to go through. We had to construct the test bed. We first had to look at the question of what is a deep-seated fire. That sounds easy, but it's not clear and obvious when you try to define it in a mathematical way, or hope to be able to reproduce it experimentally.

So we looked at that, and we're s+ill looking at that, as a matter of fact.

And in the long term, item number D, we hope that we can relate the information that we get from this test facility to the fire hazards analysis that is required of the licensees and try to provide enough information so that you can get a qualitative handle on how effective the suppressant would be on various design basis fires.

MR. EBERSOLE: To establish a base for this, I would like to ask the staff a question. While all this work is going on, is it still the position that single cable spreading rooms under the main control boards are tolerable types of designs, with all of the safety investment in that single cable spreading room?

Do you follow me?

I'm saying that some of the old designs have all of the safety investment in single cable spreading rooms, which is literally a warehouse full of cables under the control room. Some of the newer designs strive, for instance, to split the spreading room into two parts so that you could hypothetically lose one spreading room and run on the other.

That still leaves the question of whether you can have a massive fire in there and whether you can regard cabling as a fire source which would structurally damage the building, and I guess that's a question I'd like to ask you.

MR. FEIT: Well, the requirement for the new plants are separate spreading rooms. That's true.

MR. EBERSOLE: Well, then, the direction of this program, then, is to look at a single cable spreading room and to look at the fire potential within it, not in the safety context of preserving function, but just to keep the fire from being a disastrous fire in the chemical damage sense?

MR. FEIT: You have to understand that we don't have any new plants.

MR. EBERSOLE: You're dealing with old plants and the wire's already pulled in.

MR. FEIT: There will be 100 of the variety that we're talking about now.

And the other aspect was, you can say a cable room is separated, but at some place you have to come together at the control room, or you end up with separate control room and separate control rooms and separate crews.

There are always areas of vulnerability. But primarily you're right. The work that we're doing now is focused towards the 70 now and projected 100 plants where there is potential vulnerability.

MR. EBERSOLE: Would you consider a cable spreading room at this time to be a combustible source which would threaten the structural integrity of the building above it?

MR. FEIT: Well, not the structural integrity, no.

MR. EBERSOLE: You don't consider that to be necesary -- for instance, is it not necessary to protect structural steel in our spreading rooms?

MR. FEIT: Well, I think the spreading rooms I've seen -- maybe the staff can help me -- but the ones I've seen have been concrete. The thing that I'm worried about, though, is the concentrations through the spreading room and long before you'd destroy the building --

MR. EBERSOLE: You'd lose functions, sure.

MR. FEIT: You'd lose functions and you'd get to a point where you couldn't inhabit the rooms around the spreading room.

MR. EBERSOLE: Well, you're really looking at diminishing the fire potential of cable in the future context of having separate spreading rooms, or something like that, right?

MR. FEIT: Yes.

MR. EBERSOLE: Thank you.

(slide)

MR. FEIT: This just shows some of the testing that we had to go through, just as a matter of interest, to get a facility ready like this. You have to worry about all your instrumentation. We had to discharge the halon cold to establish that the halon system worked properly. We had to go through a series of burns with the propane burners to establish the air flow patterns in the rooms. Essentially you have to calibrate a new fire room. It's not a simple matter of just putting the building together and lighting a fire off. A lot of work goes into this.

And then, of course, we had to actually conduct a fire test to establish a base that we could compare to the previous work we've done. We are working with experimental cable trays and experimental fires and unless we can tie this back to previous work that we've done, there's no hope of ever extrapolating from the simple cable tray all the way up to a large system.

So this is an elaborate procedure we had to go through to get this facility ready and one wants to run these tests -- I know the licensing people wanted this day a year ago -- but we have to force ourselves to do it in a rigorous way.

(slide)

MR. FEIT: Perhaps I'll show this one first. It's out of sequence from your hand-outs. But this is the overall building. It's an old quontset hut about 19 feet high and 25 feet across the bottom and we've taken about 25 feet of that, so it's about 25 feet square with a rounded dome.

It's totally enclosed in that we can control all the air. There's a pipe that goes around the floor about two or three feet from the floor level with openings and the air is forced in from outside through ducts in that pipe and the exit from the air is at the top and we can control the air leaving the test facility.

So we have total control over the air in and the air out of this facility and we feel we can not only control, but map, the plume of the fire as the fire develops and watch the performance of the halon.

(slide)

MR. FEIT: The cable trays sit on an assembly and are held to the frame by load cells, so we can actually monitor the loss of weight due to the burning. We have instrumentation that comes down into each cable tray so we can sample the gas, we know what's coming off at any time, and of course, we have calorimeters and thermocouplers and so on.

All of this information comes out of the building into an instrumentation room where we can analyze and report the data.

MR. MOELLER: Are there toxic substances airborne from the burns?

MR. FEIT: Yes.

MR. MOELLER: What are they, I guess I should say.

MR. FEIT: Well, you get some carbon monoxide and it's an interesting point, but we've always felt that the PGC,

15

you know, with the chloride and so on ---but probably the worst thing, from a toxicity point of view, is the carbon monoxide.

I see Lauren Hunter from APL. He'll talk to us briefly. APL did some work on toxicity and they went around and actually found out what people were dying from in fires -- they followed firemen around -- and they found that carbon monoxide was actually the bad actor, even with PGC fires. So that's the worst and then, of course, some of the reactions and other things you have in there, you have other metals and so on.

We do, by the way, have tabs of metal around all our fire tests and we periodically take scrape samples to analyze what these products of combustion are. We have reported that from time to time.

(slide)

MR. FEIT: Here's the sequence of testing we decided to go through. What we're trying to do is establish what the minimum soak and concentration levels would be for Halon 1301 to put out a deep-seated fire. It's not clear -- or it is certainly has never been substantiated -- as to what concentration you require in a given room and how long you must keep the room buttoned up to guarantee that the fire will go out.

So we have this sequence of tests, and we decided we

16

would start off with a 6 percent concentration of halon and we'd keep it buttoned up for 45 minutes and if we failed, we would go down to this part of the tree; if we passed, we would go down this part of the tree.

We just did conduct this test on Friday and it turned out we did get a pass on it, which is very encouraging.

So this part of the tree is out, so we'll be going down this part.

MR. EBERSOLE: What's the breathing concentration you can tolerate with halon?

MR. FEIT: I think it's -- under 7 percent, you're certainly supposed to be all right.

MR. EBERSOLE: Under 7 percent.

MR. FEIT: I would suspect it's somewhere between 7 and 10.

MR. EBERSOLE: So we conducted the tests Friday and, as I say, it was a 6 percent concentration, 45 minutes, two cable trays. We had a set of burners under the first cable tray, a barrier between the first cable tray and the second cable tray.

We got a fully developed fire. We shut the burners off, we removed the barrier and we buttoned up the facility in that we stopped all air coming in and we closed the exhaust.

Now, that's the mode of operations that I think all Halon applications conform to. You shut down all of your

17

dampers and you button up the room.

Now, of course, one of the control tests that you have to run is to do the same thing without halon. We haven't done that, to see whether just the lack of oxygen would put the fire out.

MR. EBERSOLE: Does this suggest that you could take an old spreading room, like Indian Point or one of the old-stye jobs which is a hazard and deliberately put, say, 6 to 7 or 8 percent of halon in it and put some room coolers in it and simply let it sit there like that and it wouldn't burn?

MR. FEIT: Well, that's what we're trying to find out.

MR. EBERSOLE: I mean, leave it saturated?

MR. FEIT: One interesting thing about halon, which I guess people in manufacturing knew, but I didn't, is that it is such a heavy gas that you really don't get much leakage and we didn't take any great pains at constructing this room. I mean, we don't have gas concealers in the doors, and things like that, but at the end of 45 minutes the concentration of halon was still pretty close.

MR. EERSOLE: You could walk in and do minor service, and so forth, and it would be all right?

MR. FEIT: We did not, but supposedly you can.

MR. RAY: What determines the 6 percent? Is that the standard application concentration?

MR. FEIT: I'm not sure, and I really shouldn't speak for the halon manufacturers, but I think they recommended the 6 percent because that is a safe concentration, number one, and I think their tests have shown that it would put out a fire.

You have to understand why halon is used normally. It's used with a very fast-acting detector and chemically, the way the halon works, it works on the flame. It does very little to remove the heat.

So the idea in the halon application is to catch the fire at an early stage of development and you suppress the flame and they found by experience that this is effective. The problem was there is no data on deep-seated fires. They thought it probably would be, but no one really knew.

MR. EBERSOLE: There is a strong suggestion here that what you want to do is pre-inert the whole complex with 6 percent.

MR. FEIT: It certainly would help. It's expensive, though.

MR. EBERSOLE: Well, it's not going to leak away.

MR. FEIT: It will leak away over a period of time.

MR. EBERSOLE: If it's well-sealed, it won't leak.

MR. FEIT: I think that would.

MR. EBERSOLE: You mean it's difficult to hold in ordinary sealing?

19

MR. FEIT: Well, if you inerted the entire room and never went in there, I think you probably could.

MR. EBERSOLE: Yes, that's what I mean, except going through locked doors or whatever.

MR. RAY: How is that applied? Are injection jets placed over the cables, similar to sprinklers and water systems?

MR. FEIT: Yes.

MR. RAY: So it's concentrated, then, in the area where you'd expect to have a fire?

MR. FEIT: Yes.

MR. EBERSOLE: Then the concept of having a pre-inert in an otherwise hazardous environment is perhaps practical.

MR. FEIT: It is pracical but very expensive, I believe. I don't know how often you would have to reinject the halon.

For example, in the spreading room, people do go in there.

MR. EBERSOLE: Well, yes, one has to do a leakage study, right. But if you have good seals, I presume it stays in. It's not like helium.

MR. FEIT: No, it's not like helium.

We got very good dispersion. That's one of the things we checked in our coal discharge test. We had

20

uniforming of halon throughout the building.

MR. MUELLER: I didn't understand the point of having the room and shutting off the air coming in and the air going out. What was it? Because that doesn't simulate a fire. That's not the conditions of the fire, necessarily.

MR. FEIT: Well, the conditions in the plant, if the fire is detected and halon is to be used, the dampers would be closed.

MR. MUELLER: Oh, okay.

MR. FEIT: We also would run tests at the end, particularly now that we are going down the tree that requires less testing and we'll have some money left over, we will run tests where we'll leave the top open.

But the feeling of our people in Sandia -- and I haven't seen the results yet, so I can't substantiate it, but their feeling is that the results would have been identical had the vent been left open.

MR. MUELLER: The effluent.

MR. FEIT: The effluent.

MR. MUELLER: Right, sure.

MR. FEIT: That's their feeling.

MR. MUELLER: Well, what if you turned off the effluent and didn't turn off the inlet? What would happen?

MR. FEEIT: Well, if you'd leave the effluent open, what would happen --

MR. MUELLER: No, close the effluent and leave the inlet open.

MR. FEIT: That would overpressure the building.

MR. MUELLER: Is it that -- well, I guess it is tied enough to that.

MR. FEIT: You see, one of the things that happens if you leave the effluent open is the combustion products will leak. Of course, you might carry some halon with it, and that's a question of how much -- but it also carries some heat with it.

One of the effective ways of controlling fire post flashover is to get the heat away, ventilate the fire. This is something, you know, that I didn't realize until I got into this business, but I think the most effective way to keep the fire from spreading is to cool it, by ventilating it.

MR. MOELLER: Sure. Well, that was the Brown's Ferry problem, was carrying the heat away, wasn't it?

MR. EBERSOLE: For that reason, everybody said -- well, most people say water is the only solution because it cools.

MR. FEIT: Well, quite frankly, I was in that group, but the results of this one particular test -- and as I say, it's very preliminary -- was the fire was put out and the temperature in the center of the cable tray dropped from 660 degrees Centigrade at the start of the test -- that was the center bundle temperature -- to 30 degrees Centigrade at the end of the test.

That is very preliminary. I haven't seen the data, and the report is not out yet.

MR. EBERSOLE: Did you say halon is heavy gas? Does it stratify to the bottom?

MR. FEIT: It's very heavy, yes.

MR. EBERSOLE: That then forces the atmosphere and the combustant mixture to the top, I take it?

MR. FEIT: Yes.

MR. EBERSOLE: Unfortunately most cable trays, for some reason, are put at the top, not the bottom.

MR. FEIT: Yes, that's a very good point. As a matter of fact, we want to conduct the same test and one of the variations we want to run on this test is with the cable trays higher in the room. Exactly. Very good.

MR. MOELLER: Well, then again, when you say a 6 percent concentration, unless you keep the air moving around this doesn't disperse, or dilute uniformly. Is that what your point is?

MR. FEIT: Well, the coal discharge test that we ran without a fire, it did. Now, what I don't know, I don't have the data on the distribution of the halon with the fire. I don't have that data.

But we will know how well the halon was distributed with the fire. I will have the data when the report comes out.

MR. EBERSOLE: Well, in CO_2 systems you have to program the discharge so that you scavenge all the air out and fill the rooms up with CO_2 up to the ceiling and then turn it off to keep from drowning people above that point.

Do you have to do that with halon?

MR. FEIT: No.

MR. EBERSOLE: But you do have to fill the room and displace the atmosphere in it, do you not?

MR. FEIT: It moves the atmosphere. It doesn't displace it.

MR. EBERSOLE: Does it diffuse into the atmosphere?

MR. FEIT: Yes.

MR. MATHIS: There is a gentleman back here that wishes to make a comment.

MR. NOTLEY: Yeah, Ron and Mr. Ebersole, the --

MR. MATHIS: Identify yourself, please?

MR. NOTLEY: Excuse me. I'm Dave Notley. I'm Fire Protection Engineer with Standards.

I believe when the tests are run and the 6 percent concentration, you should be getting essentually 6 percent concentration uniformly throughout the room and there should be little stratification afterwards. Any of the dynamics of the fire should keep it pretty well mixed up, too.

MR. EBERSOLE: You don't have to mix it mechanically with fans?

MR. NOTLEY: No. The nozzles are such that you get very good distribution. The 1301 vaporizes almost immediately as it exits the nozzles.

MR. EBERSOLE: But don't you discharge a certain amount and then turn the nozzles off and then doesn't it stratify after that and it would present a personal hazard to people who went in there because it's stratified on the bottom?

MR. NOTLEY: It should not.

MR. EBERSOLE: It will remain diffused?

MR. NOTLEY: Pretty well.

MR. EBERSOLE: Thank you.

MR. RAY: Ron, I think I missed the point. This test you were talking about where the temperature drops erratically, was that a ventilated test?

MR. FEIT: No.

MR. EBERSOLE: What took the heat away? That was my question.

MR. FEIT: That's what I was wondering. That's what we're going to look at.

MR. RAY: Oh, I see. But it definitely was not scheduled to be a ventilated test?

MR. FEIT: No, it wasn't that. We closed the

25

facility because we wanted to duplicate the conditions that we'd see most likely in a plant and we were very pleasantly surprised that the fire was put out and in 45 minutes we did cool down to almost ambient conditions.

(slide)

MR. FEIT: I'm running a little bit behind schedule here. Let me see if I can't catch up a little bit.

We did some work on evaluation of the flame test for the 383. We got into this because we looked at the different flame test results from different manufacturers on the same cable and we found significant differences which led us to believe that the results were facility dependent. There were some facility anomalies, or test anomalies, giving us different results.

The other problem that we're concerned with is that the cable that would pass the 383 test would not necessarily guarantee that you wouldn't get flame propogation in a large cable system.

So we started the program and the objectives were to critically evaluate the 383 flame test. We're looking for repeatability and parameter sensitivity. We're looking for a comparison to full-scale results and, where necessary, we would develop an improved test procedure.

Now, with regard to the problem of developing a test that we can extrapolate from the small scale to the large scale, we have not been successful in that regard. We had a limited amount of money in the program and we decided to focus our attention to cleaning up or tightening the 383 test as it was in the standard.

So emphasizing that portion of the program, we looked at these types of parameters for sensitivity to results. In other words, we wanted to see whether changes in these parameters would significantly affect results.

For example, all facilities have different test cell sizes and there's no requirement in the standard. There's also no requirement in the standard on airflow, and so on.

The standard is loose. It just does not tie these things down.

MR. EBERSOLE: Before you leave that, please, isn't item 4 really the most controversial?

I heard you say awhile ago that IEEE279 has been considered to be adequate from an electrical standpoint of fire -- and I presume that means just with instrumentation currents and energy levels, not with fire cables -- so IEEE279 failed --

MR. FEIT: 383.

MR. EBERSOLE: Sorry. IEEE383 and Reg. Guide 1.75 failed where you are dealing with item 4 when you have an exposure fire, and isn't the real controversy what is the nature of the exposure fire that you must bring into the picture?

MR. FEIT: Yes.

MR. EBERSOLE: Does the staff agree that 383 is what they call a flame source energy rate, is that a practical identification of the exposure fire source term, so to speak?

Is this the fire that you will learn to bring into the spreading room from nonelectrical sources and expose the cable groupings to?

MR. FEIT: Perhaps I could answer that.

MR. EBERSOLE: Okay.

MR. FEIT: The design basis fire that's used from the licensing point of view comes out of the fire hazards analysis and that's based upon an estimate of the combustibles and the potential ignition sources in that particular room --

MR. EBERSOLE: The latter one is the one I'm particularly interested in.

MR. FEIT: -- and that bears -- it does not necessarily resemble this flame source. This was an arbitrary flame source that was established by the IEEE without any regard to nuclear power.

MR. EBERSOLE: Is there any relationship between this flame source and the arbitrary exposure fire?

MR. FEIT: The other aspect of the program, trying to relate the 383 test to how the cable would perform in large cable systems was one we felt, as you do, to be extremely important, and we tried to address that and we spent some money and did some testing and we felt -- and this was all of NRC, not just research -- and we felt that we had a hand in that because it didn't seem like we were making any headway and it just seemed like a big money sink.

So we decided to concentrate what resources we had on making the 383 test an effective screen, without --

MR. EBERSOLE: I see. However arbitrary item 4 might be?

MR. FEIT: However arbitrary item 4 might be, that is correct.

MR. EBERSOLE: I see.

MR. FEIT: So now, with the improved test that we have, we feel that we can at least break cable relatively.

MR. EBERSOLE: Yes, all right.

MR. FEIT: Although it may bear no resemblance to absolute performance in the plant.

MR. EBERSOLE: All right.

MR. FEIT: That still remains to be done, but we felt that with the money we had for this program, we couldn't accomplish that.

MR. EBERSOLE: Okay, thanks.

We got relative results, then?

MR. FEIT: Yes.

Tape 4
NRC 5/20/80
ACRS
Oatfield

MR. FEIT: And we went through all these sensitivity tests and so on, and the bottom line of all this is, we decided that how we'd better test, we'd ought to standardize the following items. We ought to come up with a standard enclosure -- and I'll show you a schematic of what that looks like. We ought to standardize on the cable trays and, of all things, cable ties, that turned out to be important. One of the things that happens in these tests, if the cable tie moves fast and the cable moves during the test, that significantly affects the performance of the cable. So one must lock the cables in securely to get a good, repeatable test. Fuel and air flow rates --

DR. MOELLER: Excuse me. That gives you a good, repeatable test, but does it simulate true conditions?

MR. FEIT: No.

DR. MOELLER: Oh. Okay.

MR. FEIT: This test is only a screen right now. But we feel we have improved the screen.

But, I might add, it turns out, for whatever reason, maybe it was just luck, but it turns out to be a reasonable -- a reasonable test, because there is a very distinct difference in the performance of 383 cable versus non-383 cable; we've seen this throughout our testing. The 383 cable performs much better in all of our coating and barrier testing. There's a very distinct difference. And I think the simple reason is, the 383 cable has fire retardant; the non-383 cable the manufacturers sell without fire-retardant.

MR. EBERSOLE: So, really, there's another item up here which is a standard cable -- right? I don't see standard cable.

MR. FEIT: Well, what we mean by standard cable -- you, you're referring to the other Vu-graph -- meant that --

MR. EBERSOLE: Well, you are standardizing your test up there: you're using now standard cable.

MR. FEIT: Well, what we're saying about the cable, if a manufacturer or a utility wants to use varying size cables in his plant, they should do a test for each size cable.

MR. EBERSOLE: But what about the materials?

MR. FEIT: They would have to do a different test if it's a different cable. Otherwise you cannot extrapolate.

MR. EBERSOLE: Have the old steel tape cables been ruled out, that used to be thought fire-resistant?

MR. FEIT: No, we haven't -- we haven't ruled any cable in NRC, except cable that cannot pass the 383 test.

MR. EBERSOLE: It turned out, in the Peach Bottom incident, that those turned out to be boilers which contained vaporizable materials and exploded, I believe.

MR. FEIT: Yes. I know.

MR. EBERSOLE: Right.

MR. FEIT: Yeah, we've noticed that, too. When you heat this cable in a fire, you -- even though the jacket remains intact, the vapors can come out a hundred feet away.

MR. EBERSOLE: Yes.

MR. FEIT: And this concerns us, because you could get these vapors coming out through a penetration.

MR. EBERSOLE: Yeah.

MR. FEIT: That was an important one, getting back to the standard fuel-and-air ratio; that has to be specified correctly. The burner location is one that had to be tied down. Ambient temperature was important. We found significant difference in testing in the winter and the summer, for example. And the standard ventilation rate, that's one that we're still working on.

(Pause)

This is a standard enclosure that we came up with, and this has been proposed in the reg' guide and it will go out for comment shortly. The original proposal was to leave the top open, the air comes in from underneath, the enclosure is on concrete blocks, so you have air put in the bottom, flows past the cable, on the vertical cable tray and out the top.

We found -- and also from some industry data when they looked at this proposed test -- that they were getting some variations that they felt, as we did, were because of the changes in ventilation if this is put in different sized rooms. So the latest version of the tests that we're running right now is the same configuration with a closed top where we can control the exhaust, pretty much the way we did in the halon test. And we have run some preliminary tests and that looks very encouraging. So we probably will recommend this enclosure with a hood on the top and that will be the final 383 test.

That will go into a reg' guide which will go out for comment probably in the next few months.

One other program that we're working on now is penetration fire stops. There's an IEEE standard -- 634, I believe -- which is based on ASTM 119, design basis fire. This is a standard that's out for industry comment now. NRC has endorsed it tentatively. And we're doing research to try to determine whether the methodology is effective.

The two main issues that we're concerned with here are the differential pressure and the excess fuel that we feel must be on the hot side. Right now the test is conducted with propane burners but very little fuel. The propane burners, of course, burn almost completely; we don't have any hot gases in the chamber. The failure mode on the penetration is the hot, combustible gas which leaks through the cracks and carries the fire to the cold side. So we want to look at those two aspects, to ensure ourselves that the test is adequate.

One other item that we are getting into is what we call replication testing. We've been asked by the licensing people to conduct full-scale tests on portions of plants that have been designed from a fire-protection point of view using NRC guidelines, inspected by NRC inspectors, reviewed by NRC

JO-5

reviewers; and they want us to run a test on these configurations to see whether the protective measures are adequate. So, in a sense, this is a proof test, a full-scale proof test.

Some of the possible candidates that have been identified by our licensing staff: the Rancho Seco, Arkansas One, so on. We were about to make provisions to run the Rancho Seco test, but when we looked at it in more detail we found they had made some modifications which made the test unnecessary. So right now we are focusing on Arkansas One, and as soon as we determine that there are functional redundancies in the area that we want to test, we will mock up that configuration and test it.

Now, the kind of testing we want to conduct is a full-scale test with a suppression system. And we want to repeat the test, assuming the suppression system doesn't work, with a mocked up fire brigade, to see if the fire brigade would put out the fire.

So, for each configuration we choose, we'll have two separate tests. One will be a test with the suppression system with a pre-determined release time on the detectors, and that will be based upon some separate effects testing; and then we'll repeat the test with a -- with the fire suppression simulated to be in the disabled mode with a fire brigade.

In summary, then, some of the near-term work, we want to complete the suppression work, we want to complete the penetration work, the replication tests, and we want to do some modeling work to see if we can't come up with some mathematical models for these protective measures we're working on. The long-term program: we want to get into carbon dioxide and water; I'm sure we'll be doing some more of the full-scale replication tests; we want to try to develop an in-place detector test -- this is a fire and smoke detector, and what we're thinking about there would be to, after we've done a survey of smoke detectors, which is pretty well, pretty much done by work the standards people did, standards development, we want to review the sensitivity, the detector sensitivity, tests that are around now that you can use in-place, we want to look at some of the tracer gases, like the SF-6, the sulfer-hexachloride, and see if we can't correlate that tracer gas to typical design-basis fires and what their smoke would be; and if we're successful in doing those two things, namely, developing a good correlation on the sensitivity tests with a detector, comparing that to the DBF, and -- and also the -- characterizing the tracer gas, if we do those two pieces, we feel we can accomplish number four, come up with an in-place test for detectors.

That concludes the portion of the program that I had. If we have five minutes, I would like to ask Dr. Hunter to just summarize briefly some of the mathematical modeling work that he performs for us in support of the experimental programs that we have at UL and Sandia. Those programs are primarily experimental and Dr. Hunter provides the mathematical support for these two

JO-7

programs.

So if I had five more minutes I would appreciate it.

DR. MATHIS: We'll give you five minutes.

MR. FEIT: Unless there are any questions. I'm sorry, I didn't mean to cut you off.

DR. MATHIS: Are there any other questions for Ron before we release him?

I guess not.

DR. HUNTER: Good morning. My name is Lawrence Hunter, from Applied Physics Laboratory at Johns Hopkins University. And Ron has asked me to comment very briefly on some of the modeling aspect of our -- the cable penetration modeling aspect of our program.

We are in the course of developing mathematical models of -- of the fire resistance of walls, specifically, walls which are penetrated by cables, indicated roughly here, but also walls which simply have a small hole in them. Now, a hole can either -- it can arise if someone were to pull a cable out of the wall and not replace it, or it can arise when cables warp and expand differentially when heated and a crack opens up, or reasons of this nature.

A wall can fail, we say, when its back face temperature is too, becomes too hot. If it's too hot, for example, this insulation might ignite, or you might get structural degradation of the back face of the wall. That's if there's cables in the wall. If there's a hole, we have another mechanism of failure in addition to the excess back face temperature. As Ron pointed out, you can have unburnt flammable gas from this side going through, contacting oxygen out here, and if it's hot enough it will then ignite. The most likely fire in the interior of a building is an oxygen-starved one. And so you might have unburnt flammable gases coming through.

The models, then, are directed toward calculating the back face temperature and the temperature of any gas that comes through. If the back face temperature is too hot, there's a failure; gas temperature too hot, there's a failure. This -- these quantities are calculated in terms of a large list of experimental parameters that are -- that are available.

The thickness of the wall, obviously, has an effect. Diameter of the cable, spacing of the cable, the intensity of heating are some of the other parameters. Another one is the pressure difference across the wall: you can get a pressure difference due to ventilation in the building; upwards of, say, half an inch of water is a possibility, even one inch of water; you can get a very large pressure rise due to the heat release if the room is sealed, large enough to break windows; but if there are any leaks, that kind of a pressure rise can be, people have guessed at about a tenth of an inch of water, but whatever the pressure rise, we are assuming that it's forcing the gas through.

These are the -- this is the goal of the model, then, to calculate this fire resistance. This is one-third, really, of a collaborative effort which is coordinated by NRC that involves experiments at Sandia -- at Underwriters Laboratories and the University of California at Berkeley. And we are pooling our resources to attempt to understand the fire resistance of these walls -- of walls penetrated by cables and air channels.

Sir?

MR. EBERSOLE: Concerning your observation about most of the fires tend to be oxygen-starved fires, when you do get window breakage and openings of apertures as the fire progresses, isn't it true that one of the major pressure problems is that when that happens you get a sudden influx of oxygen which now mixes with the combustible gases and you have a soft puff explosion which really may be the major mechanical load you'll see?

DR. HUNTER: That could be. I haven't investigated that question.

MR. EBERSOLE: You know, these are the explosions that you see typically in large fires, the warehouse fires and whatever.

DR. HUNTER: Yeah.

MR. EBERSOLE: It's initial --

DR. HUNTER: You have a sudden ignition -- yeah -- a sudden ignition of all that flammable gas.

MR. EBERSOLE: It's a secondary explosion, following the generation of combustible gases in oxygen-starved atmospheres --

DR. HUNTER: Yes.

MR. EBERSOLE: -- which then suddenly ignites and produces wall pressures --

DR. HUNTER: Yes.

MR. EBERSOLE: -- that knock it down.

DR. HUNTER: Yes. If you have a sealed room, a completely sealed room, this is an imaginary situation --

MR. EBERSOLE: Yeah.

DR. HUNTER: -- then, in ten seconds or so, a small fire, say, 100 kilowatts, can produce 30 inches of water pressure.

MR. EBERSOLE: Yes.

DR. HUNTER: That itself is enough to break down barriers.

MR. EBERSOLE: Yeah.

DR. HUNTER: But your point is certainly well taken.

MR. EBERSOLE: Thank you.

DR. MATHIS: Okay, thank you, Mr. Hunter. We'll take about a ten-minute break now.

(A brief recess was taken.)

Tape 5
NRC 5/20/80
AC
Wolf/
Oatfield

DR. MATHIS: Let's reconvene. I think the next item on the agenda is the noise diagnostics.

(Pause)

MR. FARMER: The noise diagnostics, as the term implies, is the application of various noise techniques to the understanding of, analysis of the behavior of various systems. This work has been ongoing for several years. And just to give you an idea of where it fits into the picture, the work on noise diagnostics, one, it supports NRR's independent assessment of reactor operational problems, it's played a role in the past in the Palisades and the Calvert Cliffs core barrel vibration problem, it played a part in the General Electric BW4 instrument tube vibration problem, and it's been used on other instances where, like Fort St. Vrain, where there was a graphite tilt associated with some temperature changes. And it's a powerful tool for looking at things that happen out in the field of operating reactors and trying to relate the abnormal occurrence to some identifiable cause.

The work that we do is largely in support of NRR, by having the contractor whom we -- namely Oak Ridge National Lab -- whom we support regularly perform these services, both on an on-call basis -- some of the funding for this type of work will come from NRR, other times research will provide it. So we generally act sort of as a joint pool of funds for such industry-independent assessment.

In order to provide the capability to do this thing effectively, to, that is, conduct the field measurements, we support a fair amount of work at Oak Ridge to expand and develop techniques that will facilitate this analysis. We also perform work at Oak Ridge where we're assessing various monitoring and surveillance systems to try and evaluate their effectiveness and what their utility would be in operating plants. And, in addition, we are looking at new applications or uses of noise diagnostics, to see what greater information we can obtain that will further reduce the risk assessment.

The current programs, that is, those have been conducted this fiscal year, are as follows. We -- and I'll go through in the subsequent Vu-graphs, each with details of each of these program areas -- but we're doing work on stochastic modeling, doing work on finishing up the loose parts monitoring system assessment. We have an active program of accumulating base line signatures. We've been looking strongly at BWR stability measurements, that's how one makes field measurements to determine BWR stability. We are looking at other methods development, as I mentioned earlier, in support of the capability that Oak Ridge has. And a recent endeavor that is partially started is the use of the Californium 252 technique along with noise diagnostics, in order to measure subcriticality.

DR. MOELLER: Excuse me. Will you be elaborating on that last item?

JO-3

MR. FARMER: Yes. I will.

DR. MOELLER: Okay.

MR. FARMER: The subsequent slides will go through with each of these particular program sub-items.

The stochastic modeling, what stochastic modeling amounts to is, we take a time-dependent code, neutron code, and derive the power-spectral density that one would expect at a detector location for various changes in the physical geometry within the reactor system. The -- basically, what it -- the objective of stochastic modeling is to determine the degree of detectability and sensitivity that one can achieve using noise diagnostics.

For example, they did a one-dimensional stochastic model for a BWR, in which they varied the voids in a one-dimensional fashion within the core and then computed the power-spectral density at the adjacent local in-core detector; and one was able to show the frequency -- the gain at the appropriate frequency that was indicative of the presence of a higher than normal void structure.

The application of this to a two-dimensional problem is, of course, the area of principal concern, because most of our problems will be very local. And that is where we're focusing currently, the modeling work on the two-dimensional kinetics. We have identified a code and have it operational, so that we think that we now have a powerful tool to actually run off these problems on a computer. And we want to apply these to looking at the BWR and PWR local neutron noise. And eventually we want to show that our modeling does, indeed, accurately predict what goes on in the reactor.

This is just a plot of the work on the BWR noise. Here's your normal power-spectral density versus frequency plot. This is the type of signal that you'll get when you measure in the actual BWR -- this is the range of variation that the signals fall in. And using analytical techniques, they were able to derive a power-spectral density plot like this.

Now, this, again, is a one-dimensional derivation. But it's -- it shows the progress we're making towards being able to accurately model and calculate things that will go on in a reactor and relate them to measurements that we could make in the field to determine if these phenomena or occurrences are actually occurring in a power plant.

And here is sort of a partial scenario of the type of applications that we think the stochastic modeling will fulfill. For example, in the PWR using the neutron noise, the power-spectral density plot, we think that we can identify in-core vibrations if they're large enough. We think that it'll be capable of identifying some degree of flow blockage, the presence of coolant boiling, or even core coolant level or core barrel vibration -- the latter, of course, we've already done in our previous site investigations.

But this is, the modeling is, so to speak, the analytical confirmation that the field measurements can be directly related to these types of abnormal occurrences in the reactor core.

In the case of a BWR we have the same situation. We can get -- feel we can identify greater than normal voids or the presence of in-core vibrations of one kind or another.

MR. EBERSOLE: Excuse me a minute. All of these things are in the context that you are looking at a working core --

MR. FARMER: That's right.

MR. EBERSOLE: -- that is not shut down?

MR. FARMER: That is correct.

MR. EBERSOLE: All right. I'll make an observation that about 95 percent of our problems occur after the reactor is shut down. And to this extent, noise studies on this kind -- that is, neutron noise studies don't address that 95 percent of our safety problems; however, they do address the 5 percent.

MR. FARMER: Well, of course, the core barrel problem and the --

MR. EBERSOLE: It's a running problem.

MR. FARMER: -- core vibration tube were --

MR. EBERSOLE: It leads to problems.

MR. FARMER: -- identified at power. And --

MR. EBERSOLE: Yes. All right. Thank you.

0-6

MR. FARMER: Now, in the loose parts monitoring area, what we have been doing is using the old EGCR gas-cooled graphite vessel and have mounted a series a sensors, sonic detectors, at various locations on that vessel and have been conducting -- the latest series of studies this year, which is now just about done, was to look at what's the capability of a loose parts system for locating the actual impact, where the loose part is hitting some portion of the reactor system, and trying to characterize the loose parts that one can expect.

The -- this work focused on these particular problems in the recent months. One they did, they looked at -- with a series of detectors spatially distributed on a vessel -- at how one can identify where an actual impact is occurring. They looked at two methods for doing this. One was the arrival time difference method, which is purely a matter of calculating the wave propagation in the steel structure, based on the time elapsed between the impact and the detection. They also looked at an amplitude-based location method, where they were RMS-averaging the amplitude segment. This method has serious short-comings, because it requires a continuous, uninterrupted path, and, as you know, this is practically nonexistent, the vessels have nozzles and other structures which perturb and divert the -- lead to a error in this signal which may be of the order of a foot or two in distance between the actual location of the impact and that which the time difference method would predict.

The amplitude-based method was far more successful and appears to be able to locate the impact within about one foot.

We also looked at hitting the outside and the inside of the vessel to see what sort of calibration error is associated with this type of method of calibrating the sensors. In an actual field installation, the sensors are usually calibrated by somebody taking a impactor and impacting the external part of the vessel and recording the signal on the sensors --

MR. EBERSOLE: Do you mean like a hammer?

MR. FARMER: Yes. And, of course, the question is, the real loose parts is inside the vessel, so how accurate is your calibration? Well, we found that it -- this test showed that it was relatively good, that the external impact calibration was within 10 percent of the impact calibration as a signal amplitude that one got with an internal impacter, if one could go inside the vessel and hit the inside surface at a precise, known location.

In line with this locating things, we found, as mentioned earlier, that vessel penetrations have a deleterious effect on trying to predict where the impacts are. And they used the type of scheme known as the Rosenbrock hill climb method, which is really the system that was developed for locating submarines ultrasonically. With a series of sonic detectors one can, by determining the gradient and following the gradient can, converge, it's a convergence scheme, map that convergence scheme and it enables one to converge on a precise location.

This work will be complete within a month or so. And the plans are to wrap up the work and report it between now and fall. As far as I know, there'll be no further experimental work conducted on those parts, unless NRR or standards identifies some specific additional need.

The base line signature measurements started back in fiscal '79. These are initially what we've been accumulating to date, are neutron signal measurements. And this is, basically, taping or putting in some storage means, either by tape or on cards or otherwise, a collection of the output from neutron chambers for specified operating conditions, in terms of power-spectral density as a function of frequency. There's a characteristic signal associated with almost all operating reactors, and having that characteristic signal on file has proven to be very important. The last item here says, "Why is baseline data needed?" And let me just give you some of the areas where we have been handicapped by the lack of this characteristic basic signal which exists for all reactors.

There was no such signal on Palisades. It took some time to determine what was abnormal in the frequency spectrum. As you know, the frequency spectrum has a lot of dips and bumps in it, anyway. And it's trying to pick out that part of that abnormality which is that particular gain which occurs at some specific frequency that's not normally present. And that seriously handicapped the analysis at Palisades of the core barrel. It was a problem when we got to the BWRs, on the vibrating instrument tube. And it was a serious limitation in terms of assisting in the post-accident evaluation of TMI. There we had no signals for base line measurements, so it became a scramble to try and tell what was abnormal and what was normal under the type of circumstances that existed following an accident.

For that reason, we have been having Oak Ridge, through the cooperation of the different utilities, try to collect enough base line so that in event of future problems we would have a library, let us say, of characteristic signatures of the principal vendors' plants. And the ones that we've accumulated to date, we've made measurements of the neutron ex-core channel detector power-spectral density versus frequency at full power for the Calvert Cliffs 1 and 2, we've gotten data on loan to H. B. Robinson 2, data was made available through the Carolina Power Company, we have just completed measurements this year out at ANO 1 and 2 on a BWR and a CE plant.

DR. MOELLER: Excuse me. On the previous slide, where you cited post-accident conditions at TMI-2, you meant during the course of the accident?

MR. FARMER: Within that period of --

DR. MOELLER: The hours.

JO-10

MR. FARMER: -- the days -- well, actually the --

DR. MOELLER: Days.

MR. FARMER: -- days following the accident.

DR. MOELLER: Okay.

MR. FARMER: For example, they tried to derive what was going on, from various detectors, as to the extent of voiding in the core. There's inadequate data base to be able to tell for sure in many instances what one would normally have seen in a normal shutdown versus what one would see under conditions of an accident where the coolant, primary coolant, was lost.

DR. MOELLER: And in all of the discussion you've been covering, say, in the last few minutes, you're talking primarily about looking at neutron noise in order to detect all of these other conditions, such as a loose core barrel --

MR. FARMER: Yes. That --

DR. MOELLER: -- and so forth?

MR. FARMER: These are primarily in-core phenomena.

DR. MOELLER: Now, are you also looking at regular noise, meaning audio?

MR. FARMER: This is one of the areas -- we want to look at other signals.

DR. MOELLER: At other signals.

MR. FARMER: Such as the temperature and pressure.

DR. MOELLER: Well, what about for, you know, for a while on loose parts monitoring they were looking at regular --

MR. FARMER: We want to get the basic signatures for a loose parts monitoring system as well. That is --

DR. MOELLER: But that's not neutron noise, though.

MR. FARMER: No.

DR. MOELLER: There you are talking about regular noise that's in there.

MR. FARMER: Well, just the accelerometers, the --

DR. MOELLER: Yes.

MR. FARMER: -- signals off of the accelerometers.

MR. EBERSOLE: Isn't it true that in your topic list here, which is seven, loose parts monitoring is really the only one that pertains to mechanical knowledge?

MR. FARMER: That's correct.

MR. EBERSOLE: And yet isn't there a very large field of need for occasional knowledge of mechanical noise -- I'll take a case in point: we don't know how a valve works, because it's a complex function. And we try to do it with limit switches and a variety of things, and we can never quite agree that we know when a valve has, in fact, functioned and whether or not it functioned with some margin. What is suggested is that a valve generates an audio signature when it's doing the right thing and it's reproducible and when it doesn't do the right thing it's a different signature. Are you doing any work like that?

MR. FARMER: That is one of the areas that when we come to it I'll point out we are looking at for future planning.

MR. EBERSOLE: Yeah. I have a disturbed feeling that we're hung up on neutron noise, and what bothers me there is, neutron noise reflects a desire to know things when the reactor is running; by and large if the reactor doesn't run right we are going to trip it, for some gross effect which we will measure somewhere, and then our problems really begin in monitoring the function of the post-trip condition. And we can use some noise research in that area -- and we haven't got it.

MR. FARMER: No, this is true. This is the focus we want to add to the program, is a look at these various other signatures that are indicative of systems and component behavior.

MR. EBERSOLE: Yeah, right.

MR. FARMER: Yeah.

MR. EBERSOLE: That's really what I'm after.

MR. FARMER: I think the -- of course, the -- I think it's like the whole research endeavor in general. The focus has always been on the core, because that's where all the fission products are.

MR. EBERSOLE: And it's been on the running reactor, too.

MR. FARMER: Yeah.

DR. MOELLER: Help me with an understanding back on your comment on TMI-2. The reactor, now, was immediately, or within, you know, ten, eight or twelve seconds it was, scrammed.

0-13

MR. FARMER: Yes.

DR. MOELLER: Now, are there enough neutrons, then, to -- if we had had a neutron noise measuring system, to have learned things in the post-accident sequence?

MR. FARMER: The self-powered generators would still generate a power-spectral density on your start-up channels, yes, at low power.

DR. MOELLER: Okay.

MR. FARMER: You'd be able to see things like voids and phenomena --

MR. EBERSOLE: Could you see level?

MR. FARMER: It would have been indicative of presence or absence of core coolant, yes.

DR. MOELLER: So, in a sense, the committee, for example, in the post-TMI-2 review, discussed many times a positive method of determining the level that -- the level of water above the core.

MR. FARMER: Yes.

DR. MOELLER: Now, you're telling us, then, that neutron noise could be one possible way to do it?

MR. FARMER: Yes. And this is one way, although it is not, of course, as precise as an instrument would be. It -- you're looking at the signal coming from a fairly large section of the reactor, so you can tell in general, you can't get the precise measurement that you would from a level detector. So we wouldn't propose this as a mechanism of replacing an instrument. It's a means of acquiring information under situations where the instruments may not be available.

DR. MOELLER: Well, now, back on Mr. Ebersole's question about the fact that this applies primarily while the reactor is running, you're telling me that you can follow down to what, 1 percent of power, or what range are we talking about, in terms of following, say, decayed heat after you've shut the reactor down?

MR. FARMER: Well, as far as the -- you know, as far -- we can take a signature at essentially any power level, although --

DR. MOELLER: But I mean if it's shut down and it's only decay heat, what -- how sensitive are you there? You're -- you've given me the impression you can follow down quite low.

MR. FARMER: Yeah. Most of your signals are generated by flow phenomena. So it's a function of, in the case of flow, how much there is. In the case of a BWR, of course, at low power you don't have the steam formation or the voids or velocities. In the case of a PWR, if the pump's on, you would probably see the same flow phenomena at low power as you see at high power.

MR. EBERSOLE: Yeah. But your signal source is neutrons.

MR. FARMER: Yes.

MR. EBERSOLE: And when you're shut down you don't have them.

MR. FARMER: You just have a low level. It's a more difficult signal to work with.

MR. EBERSOLE: Yeah, but the few that you have are really not enough to be within your scope, correct?

MR. FARMER: You're more subject to noise and to background problems.

MR. EBERSOLE: So, in essence, it's still fair to say that neutron noise measurements are functionally useful when the reactor is running and only when it's running?

MR. FARMER: Yes. I would say generally that is correct.

MR. EBERSOLE: So when it's shut down, which is where trouble begins, neutron noise techniques really go out the window?

MR. FARMER: Well, I --

DR. MOELLER: All right, well, then, Jesse, though, see, if that is correct, then what -- see, my question was what could we have learned post-TMI-2.

MR. EBERSOLE: He said there was a borderline condition where you might have detected some noise due to such residual neutrons as might be present. Right?

MR. FARMER: Yes. And their attenuation based on the amount of water or steam that was present.

MR. EBERSOLE: But the background noise would be so great.

MR. FARMER: But generally neutron noise has been a very powerful and effective way of looking at in-core problems and --

MR. EBERSOLE: The running reactor.

MR. FARMER: This is true: it's the running reactor, although that seems to be where to date we have -- the problems get accentuated, because, as I said before, the flow is the amplifier.

MR. EBERSOLE: Yeah. Well, you appreciate that our problems begin after scrams.

MR. FARMER: Yes. There are other problems, I know, that come into play.

This is -- I seem to be having a hard time getting it right side up here -- this is just a plot of the data, some of the data, that I referred to a moment ago that we've gotten on power-spectral density variation versus frequency for Calvert Cliffs 1 and 2 and ANO 1. And you can see the characteristic plots. What we are trying to do is -- is restrict our data taking to a few select plants of each generic category, because, obviously, it becomes a very formidable problem to go out and measure the characteristics of a hundred plants. So we're trying to get a characteristic signal for a Calvert, for a Combustion Engineering plant, a B&W plant, and a GE plant. And they show some generally consistent trends. I haven't the plot here, but we've shown you in the past that in the case of a core barrel problem or the G vibration problem you always see the signal, it shows enough gain to extend the signal above the range at which the measurements are made, so that even though these measurements are made on one reactor and being applied generically to a class, that we can still see the type of abnormality.

DR. MOELLER: Excuse me. Why does the title say "3-8 HZ" in the abscissa when it's to 25?

MR. FARMER: Three to eight is where most of your signals of importance occur.

DR. MOELLER: The important. The important ones. Okay. Thank you.

MR. FARMER: Yes. They're down in this range.

DR. MOELLER: Okay.

MR. FARMER: The ones that are indicative of failure of system.

Well, this is our base line signature measurement plan for fiscal '81. We're going to get signals off the Sequoyah 1, which I'll discuss when I come, later on, to the discussion of the continuous on-line monitoring effort. And as we mentioned a moment ago, we want to extend the measurement to include thermocouples, process signals, and other indicators which would be significant in analyzing the behavior of components and of systems, where many of your failures tend to occur.

This just further amplifies our intended program in the signature area. As I mentioned, we'll take this signal, the component signal, process signal data and get at system behavior and component behavior as well as the current neutron noise data. And this, of course, is off into fiscal '82; within the funding limitations and scope of this program, which are relatively small, we just can't do things much quicker than that.

On the BWR stability monitoring, the question we asked ourselves some time ago is, can neutron noise be used to monitor BWR stability? And this arose out of some of NRR's concerns about the decrease in stability in a BWR as fuel burn-up occurs. The coefficients tend to change; and as a result, the stability ratios start approaching .9 or .8 -- there's been some conjecture as to where they are -- they aren't unstable but they have been decreasing with fuel burn-up. And so one of the questions that we were trying to pursue was is there a way of actually making an intermittent or continuous field measurement that would quickly identify how stable the reactor was.

The current techniques perturb the plant. For example, General Electric on Peach Bottom went in and measured the stability, but they did it by tripping the turbine and introducing a dynamic situation and then analyzing the data through conventional dynamic calculations. We feel that, based on work that has been done in Japan that we looked at, that around the

O-19

half-Hertz frequency range in that power-spectral density plot, you will see a signal which is characteristic of the global behavior of the reactor. And if we can measure the global behavior and the change in that, we can measure the stability.

What we've done to date this year is, we got hold of the Peach Bottom data which the General Electric Company made and EPRI made available to us from the cycle 3, which was again neutron noise data, taken on the -- some of the APRMs, the in-core channel, and compared that to calculations that we made using the Lapur code, which is a time dependent kinetics code which also calculates the gain in -- as a function of frequency; and the results of these calculations, which are shown here, indicate -- gave us a lot of encouragement -- they seem to indicate that the noise analytical technique is leading to decay ratios and resonance frequencies that are in relatively good agreement, which encourage us to believe that measuring reactor stability, for boiling water reactors, using neutron noise is a very promising way to obtain this information.

This is just another plot of the data. It just shows the -- as I mentioned, the frequency. The global noise generally is in this range around the half Hertz, as you can see; both by calculation and by field measurement we see the high gain in the power-spectral density plot at about the same frequency.

Well, this is just our future planning in this area. We want to complete the look at the General Electric data, that there is some additional data that will be made available to us this fall, we want to look at that, and then we'd like to go out and set up a field measurement at one of the existing BWR sites in fiscal '82 and actually collect some measured power-spectral density data and see if we can actually show that it's possible to follow the stability of the plant through the entire fuel cycle.

I won't --

DR. MOELLER: Now, you say through the entire fuel cycle?

MR. FARMER: Yes. Generally, as the reactor goes through the fuel cycle the fuel burns up and the coefficients change and, as a result, the reactor gets less stable.

DR. MOELLER: And how frequently might you take a profile?

MR. FARMER: Probably every three to four months, something of this sort.

MR. EBERSOLE: I'm having a little difficulty identifying this kind of work with what I would really call reactor safety rather than commercial utilization of reactors --

MR. FARMER: Yeah.

MR. EBERSOLE: -- to optimize the core performance.

MR. FARMER: Well --

MR. EBERSOLE: My problem is seeing a strong safety implication here in doing this detail work on power distribution of running reactors.

MR. FARMER: The concern, as I say, stemmed from NRR's deep concern over the stability ratios approaching one, or being down around .9, at the end of a fuel cycle.

MR. EBERSOLE: Well, that must express, then, a concern over inability to identify parameters with which to trip the reactor if it gets in trouble. Is that right?

MR. FARMER: It's a concern over licensing. The plant would trip -- it would be tripped on a flux trip if it got unstable, obviously.

MR. EBERSOLE: But is the object to push closer and closer?

MR. FARMER: No. We're not supporting pushing closer and closer. I think the object is to verify that -- one is, they've never been quite sure what the stability ratio is, so one of the objectives is what -- can one get at what the true stability ratio is. Second is to see if we have available a means of confirming that what the vendor tells us is the stability ratio is, indeed, the actual ratio to be observed.

MR. EBERSOLE: Well, the ultimate penalty, isn't it -- oh, excuse me.

MR. WHITE: Excuse me, may I make a comment? My name is Bob White; I'm here from EPRI, and I'm the manager of EPRI's BWR stability project. And what he is getting at here is it a worthwhile objective. And your point, sir, is correct, that there is not a safety implication involved here. The calculations with the code which GE has available show that as you get through a particular operating cycle the decay ratio declines from the .5 measurements we made at Peach Bottom. The calculations tend to very much overpredict instability; I would say that they show numbers like .9 or .95. In the cycle 3 work at Peach Bottom we never observed anything above .5.

EPRI's goal in all this is reactor operations: running the reactor at much higher power with low flow to achieve operating flexibility. But I think we have calculated ourselves some safety problem which is, in fact, not real, and that's part of the --

DR. EBERSOLE: I see. Thank you.

MR. FARMER: On the methods development, I won't dwell on this part, but basically, all of Oak Ridge's work in recent years has been using data that has been analyzed by making a Fourier transfer and then dealing with the frequency spectrum. The early work in noise analysis was initiated using the time domain but was -- that work largely fell off and people went to the Fourier method in frequency spectrum analysis to -- because of the extensive computing time required to deal with the time domain. With the advance that we now have in micro-processors and computers, we're -- the limitations that existed in the use of the time domain are not present today. So one of the things that we have wanted to do is go back and look at this alternative signal analysis technique using the time, because it seems to offer some benefits in terms of use in, let us say, developing signature -- developing pattern recognition or automating the treatment of the data in terms of monitoring systems; and for that reason we -- among the programs that we have Oak Ridge looking at is the reassessment of the time domain analysis technique.

MR. FARMER: This is sort of again just basic background development. It's not directly related in terms of solving a particular safety problem. So I'll pass over these viewgraphs and say this is just part of our improving the capabilities of our contractor to be able to deal with future problems that are likely to arise.

The last item is the work on the use of the Californium 252 in conjunction with noise analysis to try to determine reactor subcriticality. As you know, the general technique for measuring whether the reactor, the subcriticality, is by bringing it to criticality and using various calibrations, raw drops or other known statistical counting on the counters, to arrive at calibrations and then when one goes subcritical, they by comparison determine the extent to which the reactivity has fallen to some specific value.

All of these current methods have one problem and that is that they don't give you a means of knowing, without moving the rods, where your true subcriticality is. And one of the concerns that NRR has expressed is that there's no independent way of monitoring for for example BWR fuel loads, monitoring in the case of the maintenance where one wants to withdraw a particular fuel element or control rod and other instances where one would like to know the subcriticality without actually taking the reactor critical.

This particular method was developed out at Oak

Ridge. Actually it was one of the swimming pool reactors. It involves the use of three fission chambers, one of which will contain Californium 252 as a source, and by cross-correlating the signals, it's possible to derive directly the subcriticality measurement for the reactor core.

This technique, though, has never been applied to a large LWR core where one can have in effect multiple cores and hence there are a lot of questions as to whether we would run into various problems.

DR. MOELLER: Excuse me. When you say using Californium 252 as a source, you mean as a neutron source?

MR. FARMER: Yes. It's in effect introducing a known noise signal, so to speak, which can then be cross-correlated.

MR. EBERSOLE: Well, if I recall correctly, the old gas reactor at Oak Ridge had an artificial source in it which ran for some months while AEC was figuring out whether to start it or not. Is there anything particularly different about using Californium as a source than any other kind of source?

MR. FARMER: Well, you're thinking of things like the old barrilium where you have to have -- you have to be able to have a detectable signal on your chambers before you had a rod withdrawn.

Actually here we're not using anything that strong.

sh 3

What we're using here is -- well, the experiments for example that have been run this year were 5 grams fission counter, with Californium introduced into the fission counter in capsule form. So it's a very small source.

One of the questions that arises in applying this, how long does it take to get an answer before one -- as to what the shutdown margin strictly is, and using this 5 gram fission counter it kind of took a few hours. And they studied as far as determining what the lithium inhalation detector, they can reduce the measurement time to under one hour.

This work has sort of ground to a halt because of the rather limited funding that's available, and what we're hoping to do in fiscal '81 is go on and determine whether the spacial harmonics are a problem. As I say, you have in a large LWR multiple cores so that you can't determine the spacial harmonics from the harmonics that you're trying to measure relative to the source and the two chambers.

Other work that was performed, and this was largely done under DOR funding, although as I mentioned earlier we sort of comingled the funds to support the on-call technical assistance because this takes precedence generally over any other part of the program. One was Oak Ridge assisted DOR in their review of the hot lake coolant temperature problem with ANO 2 where the RTD in one loop was reading two degrees above the RTD in the other loop.

They also helped when North Anna 1 experienced a signal on their LPN system indicative of the presence of a loose part. They provided some technical support in evaluating that problem.

DR. MOELLER: What was the final resolution on that, because I read the LER and all I got out of that, this North Anna situation, was th y detected noise on the loose parts monitor, they thought something was moving around. They couldn't decide what it was so they sort of forgot about it and operated.

MR. FARMER: Actually, the noise is only heard when the system is in a changing dynamic mode. That is where you're bringing the pumps up or down you'll get the noise. They concluded that the system, that if this was indicative of a loose part, that it was not floating, that it was lodged and concluded that it was lodged in a location that would not pose a safety problem.

So my last understanding was that they had asked VEPCO to continue to monitor the system, but they were not requiring them to shut down or undertake large scale actions to look for the part.

This is our fiscal '81 plans. We want to complete, as we mentioned, the two-dimensional stochastic models. We want to go on and look at the various applications to vibration and flow blockage within the core. We'll be going on with the sequoyah measurements. We want to complete the BWR stability calculations. We want to complete our evaluation of the time series methods and we want to finish up the calculations on the Californium 252 spacial harmonics question.

In fiscal '82, our program plans include trying to go into the field and confirm some of our stochastic model observations. We want to get -- Stan mentioned earlier the baseline measurements to process and component signals so that we can look more at system operational behavior. We want to see if we can demonstrate the BWR stability through noise analysis by further field measurements.

We're going to look at this time series method in terms of introducing artificial intelligence in some of the plant monitoring and surveillance schemes that we're looking at currently. We will if necessary, that is if it appears to be warranted we'll go on and do a few laboratory tests of the Californium technique to just confirm the analytical results.

And we wanted to get into a couple of new areas. One was looking at leak detection in terms of studying how one can get a better means of actually locating and quantifying the leakage from primary systems. Another is functional redundancy, which is trying to tell when you have an instrument that has failed or is giving you an erroneous signal.

That pretty much is the extent of the program as currently proposed and including the budget. We'll come back to the funding of course later on in the discussion.

Were there any other questions?

(No response.)

MR.FARMER: All right. The next speaker is going to be Milt Stolzenberg, who has been following the EPRI program from the point of view of dealing with NRR to try to provide a system support contractor to monitor that program.

MR. STOLZENBERG: This is an outline of what I intend to cover for you this morning. I'll first try to cover the requirements which have generated this safety and relief valve program. There are two basic requirements. One is a result of the TMI-2 lessons learned recommendations and the other is a result of -- or are still being generated under ATWS. Where the Research Support Branch comes in. I'll give you a brief description of the EPRI program. By the way, the EPRI program will be discussed in greater detail. EPRI or the PWR owners group has been invited to give a presentation by the Subcommittee on Metal Components on the 18th. They were invited for the main committee meeting but they were pushed back because the main committee apparently didn't have enough time.

Now the EPRI program, I should say at the beginning, is only for PWR's. There is a separate program for BWR's, of which I can't give you much because they have never presented their program to us. I can give you this much, that the BWR owners group, in conjunction with General Electric, have gone to Wylie Labs in Huntsville, Alabama and they have a test program under way. We've been trying to get a meeting with them but for a number of reasons that meeting has never come about. As of this morning the BWR owners group Task Force on Testing is meeting in Florida some place and my understanding is that a meeting will be set up, at least will be discussed and set up later this week.

Then I'll give you the status of the EPRI program as of last week, anyway.

This is the extract from letters to all licensees and applicants. This includes the BWR's. They had the same instructions. The essential part of this is that they were all requested to qualify their relief and safety valves under expected operating conditions for design basis transients and accidents.

To go a little further, the significance of that is as a result of TMI that these valves which were all designed for steam operation are now expected to see two-phase slow, slug flow, as well as solid water discharges.

These are some of the clarifications that were generated as a result of the discussions when this was implemented, the accident's valve operability. Now I want to make it clear, because it's been confused with reliability. This is an operability demonstration only, to see that these valves and piping systems will function under conditions they were not originally designed for. And of course they don't expect all the valves to be tested. This is EPRI's problem, to determine the prototypical valves as well as prototypical piping configurations. They do want the piping to show that the effect of flow on piping does not affect the valve operability.

This is some further clarification that was provided and the big date here is July 1, '81, which they're pushing to complete testing and have these valves and systems qualified. This is all BWR and PWR.

Now the ATWS situation is a little bit vague. NRR did request the licensees and applicants to include in this test program testing with ATWS. They did provide these conditions as a result of NUREG 0460 volume 3. Volume 4 may change them a little bit.

But EPRI's position was that ATWS conditions are not firm, and they're right, that the ATWS situation is not firm and besides, they couldn't possibly include that 4,000 pound requirement within their date.

So as of now, they do not plan to test under ATWS conditions, but they have indicated that as soon as their test program is under way, they will start considering what will be required and how long it would take to do ATWS. But ATWS at the moment is not a requirement. It's desirable but it's not been stated as a requirement.

MR. EBERSOLE: I'd like tc ask you a question about the reality or lack of reality about valve performance under these conditions. What you must mean in the context of testing is reclosing of the valve. I feel fairly certain at 4,000 pounds it will have been opened. Therefore, the test objective must be to show that it will reclose, and I think that's a very dismal prospect. It even suggests that you're wasting your time not to realize it. And you need to go to different valves or different valve concepts like ball or plug valves, which are pilot-operated or self energized, which do have a hope of closing.

Could you comment on that?

MR. STOLZENBERG: I'm not sure why you're so sure the valve would not close at 4,000 pounds if the valve itself will survive the 4,000 pounds.

MR. EBERSOLE: The internal structure of the valve is certainly not designed for that function, to handle two-phase forward 4,000 pounds.

MR. STOLZENBERG: Well, at 4,000 pounds under ATWS it won't be two-phase. It'll be solid water, I believe. Subcooled water.

MR. EBERSOLE: It'll go through two-phase later.

MR. STOLZENBERG: It may go to two-phase later, but --

MR. EBERSOLE: So it's such a terrible imposition on a valve not designed for that function that it's a little bit like asking a horse to run 1,000 miles an hour.

MR. STOLZENBERG: It may be. Well, the first thing about the 4,000 pounds is that in my mind there's confusion. The ATWS requirement originally was 3200 pounds or limit the pressure to level C stress conditions. This 4,000 pounds came later. I think NUREG 0460 implies 3200. I don't know where it's going to wind up. At 3200 it's a different story.

So we haven't -- nobody's forced this on them. They were asked to do it, they've said no, that's the way it stands.

No I agree with you if the valve will not even survive the 4,000 pounds itself, then there's no question, but there is indication that the valves could survive and their interest here is would the valve and the piping system allow the valve to close again?

This is Frank Cherney of the Mechanical Engineering Branch. He wants to help me, I hope.

MR. CHERNEY: I'm from NRR, from the Mechanical Engineering Branch. I have been involved in the latest requirements that were in Volume 4 for ATWS and I think both the staff in that document and also I believe the ACRS recently recommended that indeed we do hold PWR pressures to such a level that stresses in the vessel and the other components would not exceed service limit C. So I don't think, assuming that those recommendations hold down the line, I don't think we're going to be allowing pressures quite as high as 4,000. I would assume they would be, just to pick a number, more like 3500 maximum, somewhere in there. But as he says, it's not absolutely certain today how it will come out but I think 4,000 is probably a little high.

MR. EBERSOLE: Well, even at that pressure, isn't two-phase flow a terrible imposition to put on the valve of the typical design of a PRV?

MR. CHERNEY: Yes.

MR. EBERSOLE: And doesn't it suggest that you should go to a valve which is really designed to handle that fluid?

MR. CHERNEY: It may. I would hesitate to speculate without running the test, myself.

MR. STOLZENBERG: Let me inject here in what you're saying, it may do that but what we're doing, and what I'll get onto later, is we're following the industry program. The industry was told to qualify these. Whether or not these valves that are already in service will meet the requirements that are being put on them now is anybody's guess.

MR. EBERSOLE: Was industry offered the recourse of adopting a different design approach and not using valves of this sort?

MR. STOLZENBERG: The only thing they were asked by that first slide, was you've got to qualify the system, whatever the system is. They've got to show that those systems are qualified. That's what NRR has asked them.

MR. EBERSOLE: They weren't then precluded from looking at other valves?

MR. STOLZENBERG: If they redesign the system, the requirement would still apply. Now agreed, it might have been better to redesign the system than to qualify the new one. That's a possibility. At the moment, they've chosen to test, to try to qualify what exists, and their final test agenda has not been issued yet.

MR. FARMER: I think, in answer to Dr. Ebersole's question about the rotating plug valves and some of the others that don't suffer from the forces, well you have to deal with code-acceptable valves in the system, and this is why we're focussed on the type of valves we are.

MR. EBERSOLE: But in view of the adoption of code acceptance of pilot-operated valves anyway, I wouldn't find that very much of a stricture of the imagination to self-energize some of those plug and ball valves.

MR. CHERNEY: That's a very interesting point. I myself have talked to some of the valve manufacturers about some of their code valves and as far as how they'll handle these subcooled liquid conditions and so forth, and verbally speaking at least -- no one's given me anything in writing -- but verbally speaking I find the pilot valve manufacturers have more confidence before any of these tests are run. It's an interesting point.

MR. STOLZENBERG: The difficulty may be in the self-energized safety valve, not the pilot.

MR. EBERSOLE: The merits of self-energization are somewhat lost here in the terminal function.

MR. STOLZENBERG: They may be but that's still the code we have to live with.

Now RES got involved as a result of a research request, and we have contracted with INEL to act as what we call a system integrator. Here's a broad outline of their functions, so that we have a contractor to coordinate all of our efforts and to oversee what INEL as well as what the BWR owners group will do as soon as we find out.

Now the next groupof slides are extracted from an EPRI presentation. These are EPRI slides and this is a broad view of their program. This is what they're trying to do, and again this is only PWR's. This is the pressurizer relief and safety valves. These are their general objectives of their program.

Now, when we talk about operability, they have tried to define it a little better here. Operability or what constitutes a satisfactory test as far as we're concerned and them, still requires further definition. Again, these are rather broad, open and closed how. We are really dealing with a valve now that's operating on the conditions it wasn't designed for, so to pin that down as to what constitutes a satisfactory test is still to be done.

MR. EBERSOLE: Before you leave that subject, I'd like to relate that to the current flap on the feed and bleed program. The requirement of the current feed and bleed design -- some of them are, at least -- is that you can actually operate the power-operated relief valves to open and close to get feed and bleed, although those valves are currently not safety grade.

Is it intended in the work you're doing that these be elevated to so-called safety grade status to guarantee an opening of the primary circuit when you need to open it, at less than safety valve set pressures?

MR. STOLZENBERG: Well, the relief valves do have two actual set pressures. One is a low pressure set pressure for when pressurizing during start-up, and they will be tested at both pressures. But I'm not sure what the feed and bleed requirement is and how that would apply here.

MR. EBERSOLE: Well, the last ditch mode of cooling is to put water or a two-phase flow through the core with make-up from the high pressure injection systems, and this requires in some designs, since you can't raise safety valve set pressure, that you open these valves to get some water in at the reduced pressure, for which the pumps are qualified. But these valves are not safety qualified and you can't really assure yourself you can get them open and handle that two-phase flow and reclose.

MR. STOLZENBERG: Frank may have an answer.

MR. CHERNEY: I'd like to comment on that a little bit. I think what you're talking about is such things as whether the valve has been qualified environmentally and whether it's a size that's been qualified, for example, and all those other good things that most of the reactor coolant component systems --

MR. EBERSOLE: Can it handle two-phase --

MR. CHERNEY: This program here I don't think was really geared toward that sort of a decision. It's a basic operability type program. Now it may be true that in this program we'll cover sufficient pressure ranges for what you're talking about, but I think a decision on whether or not those valves should be upgraded to safety grade is a little bit different consideration.

MR. EBERSOLE: In that context I'd like to mention I heard through the back door not long ago that Arkansas Nuclear 1, Unit 2, because of presumed deficiencies in these valves, has in fact installed I think they're three-inch plug or ball valves, to deliberately open the primary circuit in case this system doesn't work.

Now that came as a surprise to me. So I'm just passing in on to you secondhand, that somebody's taken the bull by the horns and fixed that. It came as a surprise to me because I think there's some element of hazard in it as well as alot of merit.

DR. MATHIS: Milt, where's this test work to be done? Is this Wylie Labs, too?

MR. STOLZENBERG: I've got that later but quickly they have three facilities in mind. One is Combustion Engineering Windsor; one is Wylie Labs Norco and the other one is a fossil-fired station in North Carolina, part of Duke Power, they're going to use for steam testing.

This is a quick summary of the types of valves that are in service and size range and flow capacities.

Here's a breakdown by types of valves and where they're used and the number of plants, units using them and the number of valves per plant and their percentage to the total. That's for relief valves. This is the same breakdown for safety valves, dispersion.

This is an early summary of the valves they consider prototypical, EPRI, of which valves they would be trying to test. Now the testing of which valves is, besides selection as prototypicality, is also a function of what valves they can get. These valves will be from the utilities as to where they have extra valves as replacement valves, so we do not have -- we expect a final test matrix some time in early part of June. They expect to go over with us exactly which valves to be tested, when and how.

MR. EBERSOLE: Is all this work pitched solely at pressurized water reactor?

MR. STOLZENBERG: EPRI is. EPRI is only pressurized water. The BWR's is going a separate route, yes, sir.

These are the considerations for the upstream and downstream piping and how it will affect the valves. This is significant in that they will not be doing full prototypical downstream piping. The downstream piping from the valve to the dumptank can be rather complex, and there I have a drawing of what these look like. Their expectation is to get a simplified system which they can get enough data to allow them to analyze any type of system.

Here is -- this is the early version of what their test set-up would look like. THis is for safety valve, safety valve located here. The accumulator with steam and/or water for discharging through the valve, downstream piping. They expect to instrument this so that they can take the phenomonen drawn on here and try to extrapolate it to a rather complex system.

There's a question here as to how well this can be done. We've questioned it of them. They feel they have to take a simplified system; otherwise they'd wind up having to mock up each and every type configuration if they can't develope a method to extract.

MR. EBERSOLE: How big is the accumulator?

MR. STOLZENBERG: I don't know offhand. I've forgotten.

MR. EBERSOLE: I ask the question because it's my understanding if the accumulator is too small when you strike the set point, the valve will open and the pressure will virtually instantaneously be lost and the valve would crash down on its seat and destroy itself.

MR. STOLZENBERG: They have a number that -- this is the CE facility -- that is expected to give them ten seconds of full flow.

MR. EBERSOLE: Ten seconds?

MR. STOLZENBERG: Yes, without this --

MR. EBERSOLE: So it'll cushion the reseat, then.

MR. STOLZENBERG: Yes, it will provide a reasonable one, a reasonable time to let the valve function as required.

Here is the -- these are the three facilities and some general specifications for it. The prime contractor is Combustion Engineering and they can get ten seconds on a 4.4 square inch orifice valve.

This has potential. At the time this came out they were not sure. They still don't have everybody under contract but they've got working agreements with Duke Power and Wyle Lab. Duke Power will run the relief valves on steam only and Wylie Lab will run those relief valves on steam and water.

These are some of the analytical considerations which Wyle is going through. Their main objective is to verify the transients. They need a contingency plan when the valves or piping configurations don't work and they want to establish test data so that they can verify the plant-specific designs as well as future designs. They will call upon the nuclear steam system vendors to verify the transient effects and to compare their analysis.

The valve vendors, they've gone to to try to establish which are the prototypical valves, and then they have a code program of which I know little more than this at the moment. And they intend to have some analysis of the valves and the systems.

Now this is rather vague and as of now, that's the way it is. They are working on this but they haven't given us much more. We have a little more detail than I've given you here, since this is basically an outline.

Here is their broad schedule. Duke Power will do some of that steam testing starting next month. Wyle Lab will start in October. Their final test matrix should be available to us the beginning of June and the main facility testing won't start 'til next March, with completion in July of '81.

That about concludes my remarks. Do you have any questions?

(No response.)

DR. MATHIS: Thank you.

We've got one more item on the agenda as far as the presentations are concerned. That's the man-machine interface. Do you have any idea how long you're going to take on that?

MR. FARMER: I would say it would be about 45 minutes, 45 to an hour.

DR. MATHIS: Well, let's go on, then.

END 6

Tape 7
NRC 5/20/80
A[illegible]S
Wolf/
Oatfield

MR. FARMER: As I mentioned earlier, only part of the man-machine interface work is carried on within the research support branch. A very large and significant amount of this work, in terms of dollar value and effort, is conducted within the probabilistic assessment branch, under the improved safety program and in the (WORD UNINTELLIGIBLE) program and within other areas of the PAS organization. And on the subsequent charts, I'll point out where these particular programs fall.

This is a general outline, an effort to try and systematize the approach to human factors. And what we have as the first item or area of focus is monitoring, that is, instrumentation to provide for better information display and greater surveillance of the plant during the course of an accident.

There are two areas in that. One is the development of instrumentation, such as you mentioned earlier, to give you specific output as to the liquid level in the reactor vessel or pressurizer. Another area is a display system to show where the engineering safety features stand in terms of their status.

A second area under this activity is diagnostics, that is, giving the operator the capability to quickly determine what the malfunction or difficulty is and to provide him with the information and tools to respond to unusual occurrences. And that work is going on in terms of the disturbance analysis system, which is a fairly broad effort being conducted within several parts of the NRC organization and for which both EPRI and the Halden (phonetic) program in Norway have extensive parallel efforts.

Then we have the continuous on-line surveillance system which the research support branch is working on, which I'll deal with in a little more depth in a moment.

Down under the man-machine interface, that is, dealing with the problems of the interrelationship of man to his controls and his procedures and guidance, we have some small effort going on procedures, to upgrade and improve on the procedures for dealing with accidents in operations. The control room design work is largely going on within NRR, their existing effort which is being aided by the support effort of the Essex Company, Essex having performed the TMI control room evaluation, assessing the human factors aspects of its design, and currently supporting NRR in looking at designs on a generic basis and developing guidelines and criteria for later implementation in the review of control rooms of plants that are now in operation.

In addition, there is a -- some advanced research going on looking at the use of CRTs and other display devices to enhance operator information display and enhance operations controls over the more conventional systems that are now in existence.

Finally, down here, we have operator behavior. We have a safety related operator action, which again is a research support branch study, which I'll deal with. We have not got under way yet some of the work that we would like to do on performance of the operator under stress. That's a future area of interest. And then there will be some more work on simulator training, which the research support branch has been looking into for the operator licensing branch.

Finally, the last area is the human errors. And this is largely in the probabilistics group, where they are doing data evaluation and risk assessment.

I have expanded on this in the next slides. And along the margin I have shown the particular organization that's responsible for the study. This is the systems effects branch, which is part of Dr. Tong's water reactor safety. PAS is the probabilistic assessment branch, which is in research but is another part of the organization. And although not in this chart, RSP will stand for the research support branch.

In the instrumentation area, the separate effects branch has going on at Oak Ridge several studies. The ones currently under way are looking at heated TCs and ultrasonics as means of providing level indication, to answer some of the questions that arose with respect to the lack of knowledge of the level in the vessel and the level in the pressurizer during the TMI incident. They intend to extend this work in the future to cover some measurements on testing the DP systems that traditionally are used in the PWRs.

JO-4

The -- both the separate effects branch and the probabilistic assessment branch are looking at what sort of instrumentation do you need during an accident, over what ranges should it function, that is, what is the exposure environment of radiation, steam temperature, pressure, what range should it be capable of. This is -- so there's two, two looks being made here. One is at the requirements, and a second at actually plans for testing instrumentation to verify that they work over appropriate range to follow accidents.

The status of engineering safety features is being conducted out at INEL under a PAS program, where they're looking at plant status monitoring. Currently they're doing a requirements assessment as a starting point. They're looking at instrumentation requirements, at what sort of status indicators are desirable, what sort of accident signatures should be available; and ultimately they intend to get into the human factors of plant status.

On diagnostics, the major effort is in the disturbance analysis system, which you'll find is in the Loft program. The Loft program initiated last fall a program of augmented operator capability. They have installed a series of CRTs and are looking at various display forms, such as using process or schematics, displaying information in parameter trend versus time, and displaying the system in terms of status symbols and status information. This program is -- was -- is heavily hardware-oriented;

JO-5

the hardware is in place and a good bit of the research is just now started.

They intend to extend this to develop diagnostic capability using the Loft as a test bed to determine what sort of diagnostic -- event trees and what sort of display information should be available to aid the operator in performing a true assessment of the plant malfunction and the action to be taken.

PAS has ORNL working on disturbance analysis systems in sort of a overview basis. They are gathering information from both the Loft program, from the Halden program that Norway is conducting at a German reactor in conjunction with the Kraftwerk Union company, and at the work that CE is doing for EPRI.

And finally, the -- our branch is carrying on a application of a continuous on-line surveillance system to develop ability to give the plant operator further information on the status of the systems and whether they are performing according to the specifications.

In man-machine interface, PAS has ORNL looking at operational aids for reactor operators. The inspection and enforcement division has just completed a study, which was conducted by Sandia, on the evaluation of accident response procedures for nuclear power plant operations. Primarily, this is to give the I&E inspectors a basis for assessing the procedures that each utility has in place at their site.

Down under the control room design, as I mentioned earlier, there's a human factors evaluation of TMI-2 which the Essex Corporation performed. They are now developing guidelines for the control room review that NRR intends to have be performed over the next year. In addition, there is this work dimension on looking at the types of CRT displays and the best way of displaying information on CRTs, that INEL is doing for PAS.

We had a small effort out at INEL on the alarm annunciator panels, trying to see if there isn't a way to provide the information to the operator for system outages or upsets, with improvements in the mechanisms of displaying the lights and different ways of annunciating the existence of a system that's out of limits.

On the -- so that, that's sort of a roundup of the programs in general that are going on within the agency. In terms of RSB programs now, we have under the operator behavior, the safety related operator action study. We haven't initiated any work as yet on this, but we hope to. And then down under simulator training, we have already performed a study of nuclear power plant simulators and their use in operator training and requal' for the operator licensing branch.

DR. MATHIS: Bill, before you leave, nearly everything we've talked about today has been basically oriented toward equipment and process. There is very little that's oriented toward people as such. Is there any kind of effort going forward to try and set forth criteria that could be used for licensing or even hiring people for potential licensees?

MR. FARMER: Yes, the operator licensing branch has actually been, of course, addressing the licensing requirements and training requirements for operators and have been modifying and upgrading those requirements.

DR. MATHIS: But have they been concentrating more on training -- or pre-screening I guess is what I'm trying to get at? How do you select the kind of guy that's going to react the way you want him to, assuming you've properly trained him? And we've talked about the need for college education, and that certainly isn't a very good criteria.

MR. FARMER: They are looking, in terms of their regulations, at both educational requirements and emotional stability and other things. And, in fact, the direction seems to be in terms of -- out where the utilities are selecting and training their operators -- they generally are now using psychologists to conduct tests for emotional stability, maturity, and try to determine that the operator candidates in the selection process are capable of performing under stress. So they are going through that type of training -- type of testing, in order to select the candidates. And, of course, they also are looking at the educational qualifications. But --

DR. MATHIS: And this will eventually come forth in the way of a recognized standard of some sort?

MR. FARMER: I would expect that this will ultimately end up in changes in the licensing requirements and the guidance that the agency endorses to be used by the utilities in selecting operators.

DR. MATHIS: Thank you.

MR. FARMER: The last of those generalized slides -- and I will -- this is just on human errors, the data evaluation area. Of course, I think PAS has had a human error rate data analysis effort going which has been largely LER-based, using Brookhaven and Iowa State to try to categorize and correlate human errors as they relate to plant operations. The human error handbook, which Alan Swain (?) generated for PAS, has just recently been distributed and is to be used in risk assessments involving the quantification of the contribution of human error to risk in operations. And the human error sensitivity study is a new one that BNL just started.

So this mostly is all related to risk and is work conducted within the probabilistic assessment branch.

Going now to the programs conducted within the research support branch, I'll start off with the first one under the monitoring, which is the continuous on-line reactor surveillance system. And this is being conducted by Oak Ridge in conjunction with the Tennessee Valley Authority Sequoyah-1 plant. But the motivations for looking at this, is to see if one could monitor selected reactor signals for indications of anomalies, see if one can get an early detection of impending component or system failure, and provide a record of plant operational behavior when bounds are exceeded. And these are the general objectives of the particular set of equipment and the program that the agency is sponsoring.

Now, ultimately this would contribute to the man-machine interface, through improved diagnostics and providing an early warning to the operator of an impending system problem.

The system we're employing was initially developed back in 1979, under DOE sponsorship, using the high flux reactor as a test bed. What it amounts to is, it's a computerized system for recording a set of the key process and nuclear instrument channels and for generating power-spectral density information for selected channels out of those, and then by continuously recording these initially, to build up a established pattern and then that pattern is used within the software program to -- as a basic pattern against which periodic samples of the signals are assessed, and when those signals exceed the range of the basic pattern, the system will go into an automatic mode of recording and analyzing the signals and provides alert capability to the operator.

Now, the test at the high flux reactor was, as I say, primarily a demonstration. The principal test, it was performed over four months' period. The equipment was set up in an automatic mode and was used with infrequent attention. One of the concerns was would the -- if one set a bound on the signal that one was monitoring would one get an excessive alarm rate. And they were able to find that they could get a recognizable pattern and detect the signal when an unsafe condition existed and still not get an excessive alarm rate.

The system that we're proposing to take down at Sequoyah is this same system, while -- and it will be set up at the Sequoyah plant to conduct measurements. Let me just describe the system a little bit here.

There are two systems on this sheet. This is the one that was used at the high flux reactor. It's used as a mini, mini computer, and it has the usual set of -- of electronic capability; it goes with field measurement noise diagnostics equipment, namely, the -- it has provisions for signal conditioning, for filtering, and the particular system can generate four power-spectral density plots simultaneously or -- in other words, it's limited to four signals from which one can derive power-spectral densities and six channels of signatures.

This is being loaned to the NRC to use until we can procure a system which will be similar. It has slightly greater capability of storing information than the DOE system.

MR. EBERSOLE: This is nuclear instrumentation, isn't it?

MR. FARMER: It's both. This -- the system has shown here, this is the Hyper (phonetic) system. And what they did on Hyper -- and we'll be doing the same -- is, they had flow signals going to the channels of the computer, they had reactor outlet temperature and inlet temperature, and in addition they had several channels from the different flux. So all of these were fed into the patch panel and then went through processing and into the computer. In addition, you have to have control rod position signals and other signals that enable you to screen out the -- when the system is being perturbed by normal changes that accompany changes in power level or changes in flow.

A system -- this system would be used in simulator mode on the Sequoyah plant. The signals that have been chosen to be introduced into the system consist of six of the Sequoyah excore power range detectors and one excore intermediate range detector. It's true that their -- that the neutron signatures are there. In addition, though, for process information, on the primary and secondary loop four, we have this collection of signals that's shown here. And you can see temperature, pressure, steam flow level. In effect, we think that this pretty well characterizes the status and behavior of that loop.

Well, this system -- where we stand, and this is where we stand, the -- the TVA has agreed to participate with us. They have agreed to provide a space in the computer room for mounting or stationing this package, this portable computer package which is all rack-mounted. They have agreed to run in a patch panel. And, of course, they have to buffer all the tie-ins to their instrumentation system, because of the safety concern of feedback between the two systems.

One of the things we found is that the Sequoyah plant has been so long in building that the computer on it is antique, and we've analyzed some of the signals from the system, because we're picking our systems off on the input to the computer; we find the computer is a tremendous generator of background noise, and we're having to filter out the computer in order to get a recognizable signal from the plant.

We intend to operate this system without continuous monitoring by anybody from ORNL, and we're going to install a data link, so that periodically when desired the data which is being put on the disk can be dumped through the telephone link to the computer back at Oak Ridge for off-line analysis.

Right now the schedule or set-up that we -- to install or move the system to Sequoyah in June. It takes, roughly, about a week to hook up and get the system checked out. And so we hope to be in operation by the end of June at Sequoyah. The main impediment to this is going to be the speed with which we can get TVA to install the filters required to take the computer noise out of the system.

This will be, presumably, at a time in the Sequoyah start-up where they are running at, roughly, 5 percent of power. And we would plan to take signals and observe how the system behaves through the entire start-up phase from 5 percent on up to full power.

The NRC system has been ordered; we expect to receive it December of '80, and then in January we will return the DOE system and install the NRC system at Sequoyah.

The intent is to conduct the demonstration through the end of the first refueling, which is anybody's guess but right now we are saying March of '82, which would be roughly 18 months from this September.

In '82, we plan to complete the data collection. Along with this, one of the things we want to do is, as the system is now set up it is a surveillance system, that is, it takes signals, it records them, it looks at them, compares them, through the computer software, and tells you whether the signal is above or below the bounds of what is considered acceptable or normal operation. The normal operation having been determined by the machine through a short learning period at the beginning of any particular phase of operation.

We feel the utility of this system is -- will contribute the most if it can be used to identify impending accidents or abnormalities that would be of more significance in terms of a major accident. And so what we want to do is, look at signal characteristics -- for example, some of the work we've done to date on thermocouples indicates that by plotting out the power-spectral density of a thermocouple signal versus frequency we can actually determine whether that thermocouple is sitting in a boiling or a liquid coolant environment; and that sort of information would, in conjunction with the surveillance system, enable one to tell, using the core exit thermocouples, whether there was significant boiling going on within the core of a reactor. And so some of our work in '82 is to do the laboratory work to get signal characteristics so that we can interpret the plant process signals in terms of potential abnormal occurrences.

MR. EBERSOLE: Are you speaking in the context of that thermocouple being artificially heated or not heated?

MR. FARMER: No, if you put -- what we have seen to date is, if you put a thermocouple, let us say, downstream of a heater bundle and you had that heater bundle in single phase cooling, you'll get one type of spectrum. You may have the same temperature on that thermocouple under conditions where you're getting some local boiling: you'll get another spectrum. And you may have even bulk boiling and you'll get a third spectrum, all the thermocouple as far as gross measurement is concerned showing the same temperature throughout. But by looking at the power-spectral density we can tell you specifically what the upstream conditions are. This is the type of thing we want to get at in our laboratory study here.

MR. EBERSOLE: Well, it suggests you could almost use it as a level gauge.

MR. FARMER: Yes, it would be an indicator in part, although it's a pretty gross -- you know.

MR. EBERSOLE: But not as good as a heated

JO-15

thermocouple?

MR. FARMER: No, it's -- well, a heated thermocouple, of course, is --

MR. EBERSOLE: Yeah.

MR. FARMER: -- spaced along the whole length, so you get incremental measurements. This is sort of a gross measurement.

We also want to look at extending the computer system to primary coolant inventory surveillance, which is another approach to establishing the safety of the system such as at TMI.

The next program is the safety related operator action study. And that is being conducted by Oak Ridge using the General Physics Corporation and the Memphis State University Center for Nuclear Studies. The General Physics Corporation operates for TVA the simulators at Browns Ferry -- at (WORDS UNINTELLIGIBLE), which duplicate the Browns Ferry and the Sequoyah plants.

MR. EBERSOLE: Before you throw that away, I wonder if you'd show it back. For about the last five years, there's been a great deal of effort put in on safety related operator actions by an AMS group with industry representatives; they've been fighting it for five years, it's a very controversial -- N660, I think, is the standard.

MR. FARMER: Yeah, right.

MR. EBERSOLE: And I wanted to ask you, to what extent

JO-16

is that going to be a base document, if at all, for all this work you're going to do?

MR. FARMER: The N660, the fellow at Oak Ridge who is working on this is a member of the N660, as are the standards office. And we intend to keep the code committee, the standards committee fully versed in what we're doing and involved in the development.

MR. EBERSOLE: Does this mean N660, the work on it is going to be accelerated and it is going to become a base against which all this other work will be fitted?

MR. FARMER: I don't believe N660 at the moment -- I think it's in sort of abeyance. It's kind of on the shelf, and I believe it will remain there until such time as we get enough information out of this program or the standards committee, through some of the other activities, such as the work Westinghouse is doing in support of that, come up with information which would enable them to feel they had a basis of establishing a firm position. I think right now there's just so much conjecture as to how one quantifies operator behavior and the time intervals that are used in N660 are so conjectural that I think it will just stay, so to speak, dormant for a while.

MR. EBERSOLE: Something else will take its place?

MR. FARMER: No, I think -- well, eventually, we would expect that when this information and that of Westinghouse and others is available, that N660 would take on a dynamic role of

JO-17

coming up with a industry recommendation; and hopefully, it'd be one that NRC could possibly support.

MR. EBERSOLE: Thank you.

MR. FARMER: This is the objective of the program. We want to evaluate operator, plant operator, time response to a range of abnormal occurrences. We want to develop a quantitative basis for assigning safety functions for operator action. We want to look at the effects of stress, to the degree it can be done so, on operator action. And last is sort of a research function, namely, a great -- what we're trying to do is get a correlating -- correlation factor that will enable us to relate plant experience data or field behavior to simulator behavior, because the simulator is the ideal tool for conducting research and there are so many questions raised as to the behavior of the operator on a simulator versus his anticipated behavior in a true plant environment, that we would like to get some correlation factors to be able to deal with that question in the future.

The program to date has been under way for a short time, and we have collected and assessed data on operator response to accidents. This was done in conjunction with, working with the N660 group, in part. We have gone through and collected a certain amount of field data. We have looked at how we might program this on the simulator, that selected accidents. And we have considered techniques for trying to correlate the two.

The program was initiated in April of '79, went through a six months' phase where they collected data from five field sites and reviewed the NRC dockets, the site records, and did a critical instant technique to obtain operator surveys of their perceived time response to various operator actions. This has been reported; it was reported last summer. And the work of this effort was diverted for about six months to do some simulator studies, and I'll discuss those a little later on, and then this work was re-initiated this past January.

These are some of the conclusions that came from this initial six months' study. There was -- some of the term was, there wasn't enough field data for an adequate data base, and therefore this supported the conclusion that the only way one could really get a reliable set of answers to this question of operator action was possibly through the simulator and then correlating to field data. They -- these were just some of the observations of the researcher. He found it quite, quite a chore to find records are incomplete and difficult to obtain; if one goes to an operating reactor and goes back in the closet where the records are stored, you find that it's quite a job extracting data in the type of detail required to specify when an operator took a response to a specific signal.

This was just a plot of the data that was then available. From that initial study, they took 42 reported cases of PWR inadvertent safety injection and they correlated the length

JO-19

of time it required for the operator to shut off the system. And these are the sort of variations that were observed that fitted a typical logged normal distribution of times. And as you can see, the fastest operator performed this action -- it was from .2 minutes up to 10 minutes. So it shows you quite a spread in the operator performance.

Wolf
Lupton
5-20
NRC
Tp 8

MR. FARMER: This is the program that we are now -- that we initiated in January. We have broken it into two phases, or two parts. General Physics Corporation is going to run the BWR and PWR simulator experiments at the Soddy Daisy simulator. They are going to use real operator crews that are in training. These people will be down there for normal training, and what will happen is that the events that we select will be introduced in the course of this training, so that we will try to achieve as much normality as possible in operator response.

Most of the data will be collected on line, that is, the Soddy Daisy installation, through EPRI, developed software and hardware, so that they can actually record and log in the computer the timed response of all the control room operators during their response to a specific set of training exercises, and that data will be recorded on-line and the off-line we will process it and analyze it and try and extract correlations for operator response.

We intend -- or General Physics intends to provide both human factors and psychologists to assist in further extending the types of information we will get, although we have already run afoul in the psychological area of typical problems one encounters in dealing with humans that are concerned about their being monitored.

We wanted to put some stress monitoring devices on the operators to try and give some psychological measurements, and they strenuously objected. So, since this is a semi-voluntary program, that sort of ended any field measurements other than observations.

In parallel with this, we are having Memphis State continue the look at field data, and they are visiting various sites, looking through the logs, trying to identify the most significant operator occurrences and operator responses, and trying to extract times for operator response, and out of this we have tried to pick the candidate events that will be used on the simulator, and for the PWR these are the eight events that we are now using at Brown's Ferry.

We are using the inadvertent safety injection, the flux steel small LOCA, dropped rod, RTD failures, nuclear instrumentation failures, main steamline rupture, and loss of feedwater flow. These are not all, obviously, that one could use, but the intent was not necessarily to get those that would lead to a core meltdown, nor to get those that encompass all of the events that one could potentially test for.

It was to select events covering a spectrum of safety concerns and that we could get a true measure of how an operator responds to the demands from the signals at the control room.

Then, work that we are doing at Soddy Daisy with General Physics involves a cost-sharing with the cooperating utilities. What we will have under our contract is, we will have 12 eight-hour sessions on each of the Sequoia and Brown's Ferry simulators, and these will involve, as we have set it up, approximately six event sequences per session, that is, per eight-hour session. These sequences will be introduced at random, not in accordance -- In other words, the operators are not being told, hey, this is what you are going to be tested on. The operators are going through a normal training program, and then in the midst of their normal training, be it a start-up, shut-down, or change in power, or whatever, they -- one or another of our event sequences are fed into the system, and then we record the operator's response to the particular occurrence that we are testing.

MR. MOELLER: At this point in their training, they will be trying to correct any problems that develop? I mean, they won't say, well, the simulator isn't working right, or --

MR. FARMER: No. They are trained to -- Well, they have to make a decision, a judgment on all signals, whether there has been an instrument failure or a true plant upset, and generally I think the answer is, they treat the signals as being valid signals until they are told otherwise.

MR. MOELLER: How will the experience here compare to that of a real operator on a real plant, meaning an experienced operator on a real plant?

MR. FARMER: The operators, the first crew, which started very recently, is a crew which has been through training and is in their final throes of licensing. They -- and of course -- I guess in answer to your question, the answer is that to the extent that the simulator models the plant, they will experience the same interaction in the man-machine interface that you would observe in the plant.

MR. EBERSOLE: Are you going to have audio recorders in the control room and require the operators to annuniciate their intended actions, and do it in the way critical operations are performed, such as in a commercial airline cockpit?

MR. FARMER: No, we haven't used audible signals, but we do have all of the -- every switch or action is recorded, and there is an observer who records in conjunction with this cycle observations.

MR. EBERSOLE: Do you intend to think about having the operator annunciate his intended action and then go ahead and tape that? That is the way a cockpit works.

MR. FARMER: Yes. We have not used that technique, because primarily it is not used in a reactor power plant.

MR. EBERSOLE: Oh, it is not used in a steam plant, and therefore it hasn't been used in a nuclear plant.

MR. FARMER: Yes. It might be a good suggestion to raise this question, but at the moment the answer is, we are dealing with the way they are trained in the normal plant.

MR. EBERSOLE: Yes, the old style.

MR. FARMER: Right.

DR. MATHIS: Bill, could we move along, and just highlight things here?

MR. FARMER: Yes. Well, this is the current status, and I will push here to get it done.

We started to work with one crew from a utility, and I will leave the utility unnamed, because we ran into problems. April 26th, we completed two site visits at two PWR's. We've got eight more to go, and we've got several more crews to go on this. We are going to use crews at several -- some that are in requal and some that are in initial licensing. We expect to complete the PWR experiments in the fall of 1980, and we will be doing BWR test experiments next spring, and the work will come out as it evolves over the period of the next two years.

MR. MOELLER: So this portion will certainly be real plant experience?

MR. FARMER: The simulator, as near as we can tell, would give you representative data of operator behavior in a real plant. All our understanding is that the operators even exhibit the same stress factors that one observes in a real control room, even to the extent of sweating or perspiring or other manifestations of stress.

So, we think it is valid data.

MR. ABBOTT: Dr.Mathis, could I ask this one quick question?

DR. MATHIS: Yes.

MR. ABBOTT: I was part of this -- Before I came here, EPRI had started this program with General Physics, and I was subject to it for at least two times at the simulator, and the first thing I remember is, one, you had to sign a release saying that your actions could be used in the study, so therefore the program was voluntary. Is that true now?

MR. FARMER: Yes. We have no way of compelling these people to participate except in a --

MR. ABBOTT: So the operator would sign a release saying that his recorded actions on the computer can be used in the study?

MR. FARMER: Yes.

MR. ABBOTT: He can also refuse to do that?

MR. FARMER: So far, the only thing we have had trouble with is that they would not let us put eye motion and stress, heartbeat and this sort of devices on them for psychological measurements.

MR. ABBOTT: The second question is, on the slide for PWR transients, I noticed a small break at the top of the pressurizer wasn't included. There was a small break in the left outline.

MR. FARMER: Yes.

MR. ABBOTT: So you are not looking at the Three Mile Island type accident?

MR. FARMER: Not specifically, no.

MR. ABBOTT: Is there any reason for that?

MR. FARMER: Actually, the events were selected based on a combination of factors, the significance to safety, the degree to which the number of occurrences occurred. The weighting factors came out, in terms of these --

MR. ABBOTT: Of the people that are being -- The operators that are participating in this program, are they experienced, licensed operators, or are they people who are just going through --

MR. FARMER: The crew that is now being tested are people who are going -- who have been through their training and are waiting to start up their plant.

MR. ABBOTT: But they haven't operated a nuclear power plant?

MR. FARMER: Well, the crew is composed of a cross-section. Several Navy people, for example, are represented. And so there is -- within that six people or so, there is represented personnel who have had prior operating experience.

MR. ABBOTT: Prior operating commercial experience?

MR. FARMER: Prior -- for the most part -- Navy experience.

MR. ABBOTT: Thank you.

MR. FARMER: We will be testing crews -- I think the ones coming up in June are coming off of a utility for requal, so we will be testing in the next round people that are concerned with -- who have had -- been out in the plant operating. That is one of the things we are looking forward to seeing, is the parameter of experience, how it affects their behavior.

Well, this was the work that I mentioned that was done last summer and fall in conjunction with the Operator Licensing Branch. As a result of TMI 2, they asked us to make an assessment of the current status of simulator -- simulators and their use in training reactor operators, and to assess them against some of the problems that were identified from TMI. Specifically, one of the areas was assessing the capabilities for training in abnormal emergency events. I will go very quickly, because all there are here are the conclusions. I haven't given the -- Of course, in the reports are tabulations of the plants, their capability, and the range of capability, and although there is some difference, for the most part, the simulators in use are generally comparable.

The more recent -- The ones built more recently have greater capability of running more instances, but for the most part they are similar in behavior.

These are the conclusions of the study. One is that training programs have developed historically without comprehensive study,employing human factors. The simulator usage, they felt, pre-TMI, was limited in the sense that -- to the extent that it was desirable, and in particular, there was little or no use of the simulators for some of the problems enunciated below, for research, for certification, and for a review of abnormal occurrences.

In terms of the TMI-related issues that we asked the contractor to look at, we asked him, one, how well are multiple functions and compounded abnormalities taken care of in the training program given on a simulator. And they found that there was really in this area no basis for a universal selection of the particular malfunctions or compounded abnormalities that were used, that it depended largely on the decision of the individual instructor.

We wanted to know whether saturated conditions were handled in the training and what -- pre-TMI they found that most of them had attempted, had limited success, and because of the lack of models, were not looking at this particular problem.

In terms of feedwater transients, they found that the normal cases that are commonly tested, they didn't find much stress on looking at multiple failures, various feedwater pumps out. They didn't find any particular simulation for saturated conditions.

We also looked at natural circulation, how it was modeled in the simulator training, and found that there was little or no work along this line, although since then most of the simulators have been upgraded to include some testing in natural circulation.

These were other areas: pressurizer level, control interpretation, initial board checks, and plant-specific simulation. As you know, most of the simulators were built for one plant, but there is not a simulator for all plants, and so generally operators are trained on simulators that are typical of the type of generic class of reactor they are going to ultimately operate.

These are the problems that the contractor identified in the training programs. He found that there was no real basis for evaluating the training program in terms of it having evolved from a comprehensive research and analysis and plan. He found that regulatory requirements on the use of simulators had generally been lacking, and that the shortcomings in the lack of requirements and the lack of a consistent plan led to limited use of what was believed to be a powerful tool, and this is his recommendation at the bottom.

In terms of specific problems, one of the problems they particularly highlighted is, there is no consistent basis for the selection of malfunctions. Another was that the adequacy of training for abnormal emergency events is dependent solely on the instructor at the time, and no NRC requirement existed.

They were particularly concerned about the non-site-specific simulator being used for training, and felt that in the case of the hot license, the site-specific simulation is desirable.

They found that of the total two or some years of training that the typical operator goes through, only a small portion has been allocated to simulator training, and the last item was that the simulator fidelity or its -- how well it duplicates plant behavior has never been really subjected to a quality audit of any kind by NRC, and again, in those terms, there are no NRC procedures to verify, to update, to be sure that the simulator truly reflects the referenced plant. There is no assurance of the simulator incorporating operating experience, that is, if the training program is modified periodically to include frequently occurring abnormal events that have occurred out in the field, and that the TMI specifics were, at the time of this survey, not dealt with extensively, that is, the saturated conditions, natural circulation.

The last two --

MR. MOELLER: On the previous slide, under Item 3, what is a hot license?

MR. FARMER: Well, a hot-license is the hands-on training. The cold license is really when you go through the educational training for reactor operations.

Well, these were their recommendations. They just felt that we needed a past analysis and comprehensive study of training goals to give a more goal-oriented objective tc simulator usage. They felt we needed a consistent procedure for determining what malfunctions are used to train the operators with, so that they were trained on the type of malfunctions that had the highest frequency of occurring and the greatest safety significance.

This was their opinion, that they were promoting the use of site-specific, that is, simulators that duplicated the reactor that the operators do ultimately work on, in contrast to the current situation where, due to the lack of simulators, many operators are trained on ones that are typical, but not necessarily duplicative of the controls in an actual plant.

And they felt that there was a need for NRC policy to give minimum qualification for certification of instructors, requirements for verification of fidelity of simulators, requirements for verifying that simulators had been updated, and procedures for ensuring incorporation of actual or feedback of operating experience.

As far as the TMI-2 fix, they felt, and I think this is -- that we needed improved modeling for saturated conditions and natural circulations, and they made a promotional recommendation as far as research is concerned.

Well, this is -- They recommended a mechanism for identifying which malfunctions should be used in the training program, and they went through an exercise using a detailed study of LER's as the basis of identifying the malfunctions that should be employed.

MR. EBERSOLE: In that connection, and going back to your candidates for events, I notice there are eight of those. Every one of them is based on the thesis that the single failure criterion will always work, and the operator can do something, and the parameters will stay within bounds, but the real problems lie when the single failure criterion doesn't work, and the operator experiences, say, loss of all circ water, or, worst of all, DC power failure, or some other such service for which it is theorized there will always be a redundant function to support the operation.

The worst events are when there are no redundant functions to perform the support functions, and the operator has to use his resources to recover the plant from a non-standard condition.

Are you going to put any of those in the programs?

MR. FARMER: Yes. They have plans later on to look at that type of situation as well as looking at pyramiding or cascading types of malfunctions.

MR. EBERSOLE: So this is just part of the program?

MR. FARMER: Yes. That is what is being done initially, and later on they hope to introduce some of the additional exercises.

MR. EBERSOLE: Thank you.

MR. FARMER: I will just conclude with where we stand. This is the survey that we just went over, and which is completed. This is what we are hoping to do in 1981 under this program. In support of the Office of Standards, we are going to help in looking at ANSI 3.5 in terms of verification of simulator updates, selection of accidents, and simulator fidelity.

Finally, in 1982, we would like to go back and re-review the usage of simulators following the various upgrades and changes in NRC requirements to see exactly what has gone on.

This is the last piece of research. It is a very small effort that is going on at INEL. We had them do a human error review study using LER's, and they also included in there a study of compliance reports, in other words, how human errors versus the frequency with which events ended up in the compliance 766 file. They also were trying to correlate human errors to nuclear plant characteristics, both as to size and by particular date, the age of the plant, that is, in terms of how long it has operated and when it was built, and this report we are working on now.

The work next year will be largely on this alarm problem, which I mentioned earlier, and they also want to look some at taking a questionnaire through the maintenance organizations to try and determine the big contributors to human errors in maintenance, instrumentation calibration.

This work would carry over into fiscal 1982.

I am sorry I ran about 15 minutes longer than I intended, but --

DR. MATHIS: That is all right. We are still doing pretty well, Bill.

Any further questions from Bill on this particular subject? Dave?

MR. MOELLER: I just had a comment. In listening to the presentation, I think they are addressing most of these matters, but I wanted to be sure that the research staff in terms of man-machine interactions was familiar with Chapter 6 in the report, NUREG-0642, which was issued by the Advisory Committee in January of 1980, or published then, and it is called, "A Review of NRC Regulatory Processes and Functions."

In Chapter 6, specifically, on Page 6-7, of this report, it contains what I would say or what could be briefly paraphrased as four recommendations or comments on this subject. One, the Committee stated that, "There may be advantages to expanding the automated plant features to reduce the need for operator action during transient operating periods, but how and whether this should be done deserves considerable thought."

We pointed out that the real concern is whether the diagnostic burden on operating personnel is excessive.

Secondly, the Committee stated, "There is need to improve the information displays in control rooms. Specifically, we need to draw operator attention to the crucial instrumentation needed in emergencies. The alarm systems may be excessively confusing, and some information displays could be better located."

The third item, we stated that "Attention will have to be concentrated on integrating information from diverse sensors and combining the information in such a way that the accident systems lead the operators to initiate correct safety control actions. Symptom correlation with instrument signals to direct operator action to the appropriate safety procedures could eliminate much of the concern about man-machine interfacial response. Not enough attention has been addressed to this matter."

Lastly, Item 4, the Committed stated that "Operating personnel must have some emergency instrumentation provisions to maintain cognizance of accidents that do not proceed along anticipated lines. An example is instruments that show whether fuel has failed and what type of failure may have occurred. Without such provisions, the operating personnel are less able to correct unforeseen events that may have been overlooked during accident analysis, even though the corrective action might be easily performed."

I simply wanted to put those in the record. As I say, in listening to you, I think that you are addressing a number of these items, but it might be helpful or useful if you had not done so if you looked at this report. It was not issued as a research review report, and yet indeed it considered these matters.

MR. FARMER: I believe we are addressing most of the issues you mention there, not all of them. The one on automation, the first one you mentioned, actually is one of the areas that we would like to initiate some additional work in fiscal 1982 on. This would be at a time when we felt we had enough information from our simulator experience to be able to determine what -- the operator versus the computer role in optimum safety performance in the control room.

The other studies, I think, between our diagnostics, our display studies, our use of CRT's, our operator aids, the various studies that are being conducted both at INEL, at Oak Ridge, and in the industry, I think, are being addressed fairly extensively.

DR. MATHIS: Any other comment?

(No response.)

DR. MATHIS: Bill, you wanted to take a few minutes on the technical support program?

END TP 8

Tape 9
NRC ACRS
5/__/80
Wolf/
Oatfield

MR. FARMER: We'll try and hold this very short.

MR. SCOTT: Well, we appreciate the chance to mention these technical support programs. The only ones I'll talk about now are the first one, Nuclear Safety Information Center, and the National Energy Software Center, formerly called Argonne Code Center. These other items are not funded every year, though we have funded the (WORD UNINTELLIGIBLE) Institute several times. I believe this was going on in the past, we did one on -- yeah.

Most of you fellows, being on the LER subcommittee, have heard presentations from Cattrell (phonetic) and Joe Buchanan (phonetic) at the NSIC before. The main point I think we want to put about the NSIC is that all this money we're spending on research generates a lot of reports, and some people are aware of it, some people are not, eventually when you get all down to the end you have to synthesize a lot of this information, you gather it together, and you have to present it to a number of people and let it be mulled over by the scientific community; and only if you have an automated way of recalling all this information, abstracting the reports, going back, getting all the various reports, will you be able to really get a good answer that satisfies everybody.

We believe that the Safety Center by collecting and keeping track in an automated data base of reports and that information, will be able to write final synthesized reports in a better manner.

Also notice here we have foreign safety documents. These sort of come in in a haphazard manner and only through the NSIC are we really keeping track of what kind of information we are getting.

Also the Nuclear Safety Journal, I think most of you are familiar with that. It's put out six times a year.

What kind of information is in the Nuclear Safety Information Center data base? This was for 1978. And you'll notice here of interest -- about 25 percent of the items were licensee event reports. The data bank now has close to maybe 150,000 items that have been collected since the early '60s. And they're adding, I believe it's about, 10- or 12,000 items every year.

Now I have one more here there that shows some of the work that the Nuclear Safety Center does for other groups. This was previously some work they did for AMPA, and for (WORD UN-INTELLIGIBLE), analysis. Here's one down here that we really haven't started yet that may be of interest. The Office of International Programs had several boxes of information from accidents and events at foreign reactors, that's never been entered into a data file, so there's no way to go through it until it is and see what results they had.

And the point of this is, unless we have a strong base program that keeps the data base full of information, you can't have people coming in and saying, "Well, gee, give me a spit-out of LERs or tell me all the reports," that you're missing half of them.

Let me just for a minute here, then, talk about the NESC at Argonne, which collects and distributes our computer codes. We're spending quite a bit of money developing loca codes and other codes that calculate response to the fuel and system internal behavior. And what the Code Center does is, it makes available to customers in the United States and, through its arrangements -- I guess it doesn't show in this slide -- with the OECD European data bank to exchange our computer codes. And here's a little example of some of the codes that are there now. This is a containment code. This is a fast reactor code. Here's readout form Mod Six. Fuel codes, back fuel codes. Here's a licensing code. So these are some of the ones that'll be available soon. They either are being produced by the research program or they have come to the Code Center and they're being set up.

And one of the advantages of doing this in this way: it saves people from going to individual contractors and saying, "Well, give me your codes," because by doing it this way it is now put into a standard format, so that supposedly you could go to the Code Center, ask for that code, and you know when you get it on your computer, if you've requested codes from them before, it's in a format which you can run. And a lot of times, the codes, they're pretty much used by the developer and nobody else has used them. And this is one way to get somebody else to use these codes.

Here's the ones that licensing wanted the (WORD UNINTELLIGIBLE) program. Here's a program that's being developed for transients. This is another fast reactor code.

That's all I had to say. If there's any questions?

DR. MATHIS: Any questions?

If not, thank you, Mr. Scott.

MR. SCOTT: Thank you.

DR. MATHIS: Well, I guess we're ready to get into the budgetary numbers, proprietary information. So shall we close the meeting as far as the recorder is concerned and any members of the public.

(Whereupon, at 1:32 p.m., the committee went off the record for an executive session.)

This is to certify that the attached proceedings before the

NUCLEAR REGULATORY COMMISSION

in the matter of: ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE ON REACTOR OPERATIONS

Date of Proceeding: May 20, 1980

Docket Number: ____

Place of Proceeding: Washington, D. C.

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

Shirley Wolf

Official Reporter (Typed)

Shirley Wolf

Official Reporter (Signature)