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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

AUGUST 22, 2001

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE

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WEDNESDAY

AUGUST 22, 2001

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ROCKVILLE, MARYLAND

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The subcommittee net at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Doctor Thomas S. Kress, Acting Chairman, presiding.

PRESENT:

THOMAS S. KRESS, ACTING CHAIRMAN

F. PETER FORD, MEMBER

VIRGIL SCHROCK, CONSULTANT

JOHN D. SIEBER, MEMBER

ACRS STAFF PRESENT:

PAUL A. BOEHNERT

A-G-E-N-D-A

P-R-O-C-E-E-D-I-M-G-S

(8:30 a.m.)

CHAIRMAN KRESS: The meeting will now please come to order. This is a meeting of the ACRS Subcommittee on Thermal-Hydraulic Phenomena. I'm Tom Kress and I'm Acting Chairman of this subcommittee since our regular chairman can't be here.

The purpose of this meeting is 1) to review the GE Nuclear Energy TRACG realistic thermal-hydraulic code version, particularly for its application for evaluation of anticipated operational occurrences and, 2) review the resolution of issues associated with the EPRI Report TR 113594, resolution of generic letter 9606 waterhammer issues.

The subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full committee. Mr. Paul Boehnert is the designated federal official for this meeting.

The rules for participation at today's meeting have been announced as part of the notices of this meeting previously published in *The Federal Register* on July 30 and on August 15, 2001.

Portions of this meeting will be closed to the public to discuss GE Nuclear Energy and EPRI proprietary information. A transcript of the meeting is being kept and will be made available as stated in *The Federal Register* notice.

It is requested that speakers first identify themselves and then speak with sufficient clarity and volume so they can be readily heard, particularly by the transcriber.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

For the benefit of the members who may not have been here during some of our earlier reviews of TRACG, we did have a few problems -- or not problems, maybe issues, questions, related to the treatment of delayed neutrons, the treatment of rental stresses, the treatment of wall shear and heat transfer partitioning from the wall, flow regime transition treatment and interfacial shear and interfacial heat transfer treatment, among others. I think those are just some of the more important ones.

With those comments, I'll ask if our consultant, Virgil Schrock -- I forgot to mention the ACRS members in attendance are Peter Ford, Jack Sieber, and our consultant, Virgil Schrock. If anybody wants to make any comments before we start, Virgil, I'll start out with you.

MEMBER SCHROCK: I'm a little at a loss to know what to say or what depth to pursue the issues, but I found the SER to be a great disappointment. I don't see that it has explained in any way many questions that were discussed at the last meeting of the ACRS on this topic. Some of that may be because some of the things that I thought were important evidently had not been deemed sufficiently important by the full committee to make it on their laundry list of things to have you respond to.

But I understand several of these problems as well as anybody in this room, and I can say to you that you have a superficial treatment of real problems in this SER. If that's what you want, that's what you will have. I think it's a disgrace to the regulatory process. I'll give you as much detail as you'd like to have as we go along, but that's what my reading of it led me to believe.

CHAIRMAN KRESS: Okay. With that pleasant note, I'll go around this way. Do you wish to add to that?

MEMBER SIEBER: I don't think so.

CHAIRMAN KRESS: Peter, I think you wanted to make some sort of statement.

MEMBER FORD: Yes. I'm a retired General Electric employee. Although I had nothing at all to do with the TRACG code, I do have to declare a conflict of interest.

CHAIRMAN KRESS: Okay. With that then, I don't have any additional statements, so we'll proceed with the meeting, and I guess I'll call on Ralph Landry to begin the inquisition. Did we give you a laundry list of comments and issues? Since I wasn't chairing this subcommittee at the time, I don't know whether we did or not.

DOCTOR LANDRY: Okay. For the record, I'm Ralph Landry from the NRR staff.

No, Doctor Kress, we did not receive a laundry list.

CHAIRMAN KRESS: Did we pass Virgil's written thing on to you?

DOCTOR LANDRY: No, I never received a copy of a report from Virgil.

CHAIRMAN KRESS: That might explain, Virgil, why the--

DOCTOR LANDRY: We were surprised when we saw some of these items.

MEMBER SCHROCK: Let me just interject that whether you had it in writing or not, you sat in this room and heard the arguments. We spent a lot of time.

DOCTOR LANDRY: Well, somewhere between all of the discussion and getting the agenda for this meeting, we had missed a number of these points and did not have them down. So this time we didn't have copies of the reports from the consultants, so we missed the specific points. But yes, Virgil, if you do have specifics in addition to what's on the list with the agenda, we'd definitely like to hear your views and specific things that you think should be brought out.

What we're going to talk about this morning is give a real brief review of how we got to the SER. The approach that the staff took in the review of the documentation on TRACG, the applicability intended for the code, what transients and where the code is going to be applied. Talk briefly about the assessment of TRACG. We'll talk about the staff evaluation and briefly about the thermal-hydraulics. We'll go into a great deal more depth on the neutron kinetics. Tony Ulses will present his review of the neutron kinetics aspects of the code. Yuri Orechwa will talk quite a bit about the statistical methodology review which he performed, the uncertainty analysis. We'll talk a little bit about the code user experience. We have been running the code. We've run some cases with the code and tried to look at a few things, so we'll talk about some of our experience in running TRACG. And then review the conditions and limitations that we're suggesting for the code and the conclusions of the staff.

Okay. How did we get to this point? In the spring of 1999 and the summer of 1999, TRACG was presented to us in a preliminary fashion by General Electric and General Nuclear Fuels, GNF. Sometimes we use the two interchangeably, GE and GNF. So if we swap back and forth, we mean the same company.

The preliminary information was to come in and show us how GE would propose to submit the code for review for AOO analyses, what material they would suggest that we review and how they would like to proceed with a review of the code for operational transients.

In January of 2000, we began to receive the materials on the code. That submittal was finally complete in February of 2000. We received manuals and then we received the electronic version of the manuals and finally we received the code itself. General

Electric did submit to us both the source code and an executable version of the code. We installed the code on an alpha machine, a VMS machine which we purchased, so that we could run the code in the same native mode that the applicant ran the code for their own work.

We met with the ACRS Thermal-Hydraulics Subcommittee in middle of November of 2000. We've been issuing RAIs informally as we've been performing this review and the applicant has been looking at the RAIs and responding to those RAIs informally throughout the review.

In July we finally issued the formal RAIs, those that have gone through our full review by management and have been issued formally to the applicant, and we have received now the formal response from the applicant which is really the same responses which we had in draft but this now puts the response officially on the record.

We prepared the draft SER on TRACG in July and we have discussed that draft SER with the applicant. We have provided it to them for review for proprietary content, and I would point out to the committee at this point that the draft SER which you have received from the staff does contain proprietary information. The applicant has determined that there is proprietary information in there, so we are going to withhold this draft version of the SER from the public. We are going to work on the SER and try to take the draft material which is proprietary out of the SER so that we can publish a non-proprietary version of the SER. So at this point, the SER draft which you have received must be treated as proprietary.

CHAIRMAN KRESS: What are the plans for going final with that? What is your time line? Do you have one?

DOCTOR LANDRY: We would like to have the final SER ready in September. Assuming that the Thermal-Hydraulic Subcommittee can report back to the full committee at its September meeting, we would then issue the final version of the SER in September.

MEMBER SCHROCK: Is there an identification of the version of the code that you've reviewed?

DOCTOR LANDRY: It's right at the beginning of the SER. It's TRACG 02A.

MEMBER SCHROCK: What does TRACG 02A mean precisely?

DOCTOR LANDRY: That's the specific version which was submitted to us for a review. We realize that the applicant is working on future versions of the code. They have talked with us about submitting a version of the code for realistic LOCA analysis. So we're being very specific that the version we review has been designated as TRACG 02A.

CHAIRMAN KRESS: Does the A stand for anticipated?

DOCTOR LANDRY: I'd like to ask Jens Andersen from General Electric to answer that one.

DOCTOR ANDERSEN: This is Jens Andersen from GNS. The A simply just designates the computer hardware that it's executed on.

MEMBER SCHROCK: Well, I had raised that question in the previous meeting, but it seemed to be now several different versions of TRAC as opposed to a version which was reviewed comprehensively in the past maybe, maybe not comprehensively but reviewed in some depth and asked and specifically the fact that the decay power was discussed in terms of the May-Witt estimate which goes back to the 1960s whereas the version of TRACBD1 which was developed by INEEL with cooperation from GE had the 1979 decay standard in it. A world of difference between the two in the sense of the technical approach. One recognizes that the decay power is not the same for different fissile muclides.

The other does not.

In any case, that led me to ask the question in that previous meeting. Has the ANS standard been removed from TRAC and Jens Andersen was unable to answer the question, as I remember, at that time. But I presumed that somebody would look and see what is the status. Now what you have in your SER, in one paragraph you kiss off both that issue and the issue of what procedure is employed to weight delayed neutron fractions according to contributions from different fissile species. Both of those are superficially essentially treated as non-issues, non-questions. So if you don't understand what I'm saying to you, Ralph, I'll try to explain it in greater detail. Is that the problem? You don't understand the issue that I'm addressing?

DOCTOR LANDRY: No. I think when we get into the discussion of the neutron kinetics, we'll address that a little bit more.

MR. ULSES: We will now.

DOCTOR LANDRY: Tony Ulses will address that further when we get into the discussion of the neutron kinetics because he has already looked at that. Yes.

MEMBER SCHROCK: Okay. Well, several

related questions are, two technical issues I just mentioned plus the question of what is the code version? How is it defined? How are we understand what the code version is? If it does not have the ANS decayed heat standard in it any longer, then it's not the same code that was reviewed for SBWR. Do you know the answer to that?

DOCTOR LANDRY: Let me ask Jens Andersen if he can respond to that.

DOCTOR ANDERSEN: Yes, I can comment on that. Most of the models in the codes are the same as what was reviewed for the SBWR and if you compare the model description TRACG 2A -- revision one to the model description, which was what was submitted during the SBWR review, and then revision two, which is what we have submitted for this review, there are minor model differences but the majority of the code is the same. The decayed heat model that is being used for the application to transient is based on a simulation of decayed heat cooks and we can get into that later on.

What we have done is, realizing that there were minor differences in the code, is that we submitted a complete qualification of the code as submitted. The material that's documented in the qualification report is all one with the code as submitted to the NRC.

MEMBER SCHROCK: Well, it seems to me that there are guidelines that you have issued for code reviews that are not met by this submittal. Is that incorrect? You needed a starting point, but you had a clearly defined code that you had complete documentation for that clearly defined code. It doesn't appear that you have that.

DOCTOR ANDERSEN: Can I make a comment again? This is Jens Andersen. The documentation that has been submitted for this review, model description, qualification, the user's manual, is all specific to the code version TRAC. It's a two way that has been used and that was made available to NRC for installation on their computers. So it's totally consistent.

MEMBER SCHROCK: But not the same code that was reviewed for SBWR?

DOCTOR ANDERSEN: That's correct.

DOCTOR LANDRY: That's correct. It's been built on the version that was reviewed for SBWR.

MEMBER SCHROCK: Of course it's been built on it, but unless you define changes and explain what the changes are, how can you expect a technical body reviewing it to tell you what yes, what you're saying is fine when you haven't even defined what the product is that you're reviewing?

DOCTOR LANDRY: But they have defined the product and that is the TRACG O2A version of the code and the documentation which they submitted on this version of the code, the staff believes defines the code.

When we did the review of this code, we did build on the work that was done in the review of SBWR version of TRACG. At that time, the contractor which the staff was using, Brooke Haven National Laboratory, did an extensive review of the thermal-hydraulics of the code and a review of the kinetics and other parts of the code.

We looked at the review that was performed, compared that with what was being submitted for the review of the TRACG O2A code for AOO transients, and we felt that the thermal-hydraulic questions and concerns that had been raised during the SBWR review had been addressed in the material submitted for the TRACG O2A submittal.

Because of that review and the depth that that review was taking, the staff made the decision that we would review the material and we only asked a few requests for additional information on thermal-hydraulic aspects of the code and then concentrated heavily on the kinetic aspects of the code and on the uncertainty analysis, the statistical methodology. We felt that that would be a more productive use of the resources which we had available to us in performing the review.

You have to keep in mind what the code is being applied to. The application of TRACG 02A for AOOs is very limited in scope. The code is being applied to only transients in chapter 15. It is not being applied to Atlas, it is not being applaud stability analysis, it is not being applied to loss of coolant accidents. It's being applied only to increase and decrease in heat removal by the secondary system, a few transients in those classifications, a decrease in the reactor coolant flow rate. It's being applied to reactivity and power distribution anomalies, increase and decrease in reactor coolant inventory. Those increases and decreases that are short of a loss of coolant accident.

When we looked at the assessment that was performed for the code, the first thing we did was step back and look at assessment in the way we always do. How has the assessment been performed? Have they looked at the phenomenological tests, separate effects test, integral test, plant system information when available, so that they can assess from the level of correlations to the level of models to the level of the entire code.

Of course, when you look at plant operational data, because of the way the data are taken, they're not experimental, empirical data, so the data set is much more limited. But the assessment that is performed is a global assessment of the code. Does the code adequately represent the global events occurring in a transient when those transients have been run in a plan?

CHAIRMAN KRESS: How do you know when you have enough assessment? I know I've asked this before.

DOCTOR LANDRY: The big question for years has been how good is good enough.

CHAIRMAN KRESS: Yes.

DOCTOR LANDRY: In the case of the code as it has been submitted, since it is doing a statistical uncertainty analysis, has enough assessment been performed is determined by has a phenomena identification ranking table been prepared, a thorough PIRT, that can be reviewed and is thorough, captures all the phenomena. Do we agree that the PIRT captures all the high and medium importance phenomena? And then have those phenomena been properly assessed against data? Have enough assessments been performed that an uncertainty analysis can be performed and uncertainty be placed on the important phenomena?

When we look at codes, as we have in the past, that did not do uncertainty analysis, codes such as LOCA codes meeting Appendix K, we did not put a handle on uncertainty. We simply said does the code meet these set prescriptive requirements and how good is good enough became a much more difficult question to answer because we did not have a definition of statistically what is enough assessment to perform and we would have to look at the assessment and say does it cover an adequate set of the data available. Are there data available from the other aspect to perform an assessment?

And we always run into the problem when we get into those assessments that there are events that can occur, there are phenomena that can occur, for which there are no data and for which you can not properly assess. There are a number of aspects in turbulent flow where it's three-dimensional flow effects where you don't have data and you can't really assess the capability of the code in some of those areas. So I hope this is answering your question.

CHAIRMAN KRESS: Yes. I think that was a good answer.

DOCTOR LANDRY: When a code is submitted with an uncertainty analysis under a statistical or what we sometimes call best estimate or realistic application, we have a better way of saying how much assessment is enough because now we're zeroing in on the phenomena that are important. We're saying are those phenomena assessed properly so that a statistical basis for the uncertainty can be assigned?

This morning later on Yuri is going to go through an explanation of his review of the statistical methodology and he'll give some of his views of what has been performed and has a proper assessment been performed.

MEMBER SCHROCK: You have made the point in the SER that the code and its application meets the guidelines of the CSAU methodology. Do you want to comment on how the uncertainty and decay power evaluated -- assessed. -- provided assessment of the uncertainty. Uncertainty indeed is dependent upon the details of the reactor problem that you're addressing. It's impossible to assess such an uncertainty.

The problem may be that a good case can be made that decay power is pretty much a second order phenomenon in AAOs. That case is not made here. It's nowhere to be found in your SER that I can see. But even so --

DOCTOR LANDRY: Well, we'll take that into consideration.

MEMBER SCHROCK: My recollection, as I said in the previous meeting, of what GE did in using the ANS standard first was to run a lot of Monte Carlo calculations to find a sort of generic decay power curve which they could put some sort of balance on, and I think they take a penalty rather than including that in the assessment. The details are a little bit fuzzy in my mind, but I clearly remember that was the general pattern of what was done. It was not a straightforward assessment of the uncertainty using the uncertainties that are published in the ANS standard for decay power. That would be one way of approaching it. It's not what they did. What they did was found acceptable at the time. I thought it was quite good.

My problem with this is that what I see is superficial discussion of real life problems in an SER. This is the government's evaluation of the safety of that system done in a very superficial way. That frightens the hell out of me.

DOCTOR LANDRY: Tony.

MR. ULSES: I suppose nobody -- to talk about decay heat. Let's do it rather than wait? The issue of decay heat and --

CHAIRMAN KRESS: Go ahead. We'll talk about it now.

MR. ULSES: I would say I would certainly agree with you, Doctor Schrock. It was given a cursory discussion in the SER because I believe it has a cursory effect on the problem, and that's my fault. I should have discussed it in more detail and that's a valid criticism and I will definitely change the SER to expand upon that point. I definitely think you are right, and that's an oversight on my part and that is something that will be fixed.

MEMBER SCHROCK: More than that, you're reviewing a code which is said to have been adequately reviewed for loss of coolant accidents and other purposes in the context of the SBWR review and now you've not called out in any sense here that what you're going to do is substitute for one particular aspect of the whole calculation, a more simplistic approach because it's more computationally efficient.

That is to invoke the Mae Witt implication for decay heat evaluation.

MR. ULSES: Well, again, we were looking at the version of the code that we were given and that's a beyond scope issue. I mean this is not a LOCA code.

MEMBER SCHROCK: Do you review something with blinders on or do you review it with an intelligent assessment of how it fits into the whole picture of your dealing with this code?

MR. ULSES: Well, I reviewed it with the scope of the application in mind.

CHAIRMAN KRESS: If they come back later and want to use this for best estimate LOCA, then you would face up to that problem.

MR. ULSES: Yes, sir. We will deal with it in excruciating detail because it is very important for LOCA applications. However, for AOOs, it is not a significant contributor.

CHAIRMAN KRESS: You're pretty much constrained to have to review the application as it's presented to you.

MR. ULSES: Yes, sir. We're not really allowed to go beyond the scope of the review, and that would have been beyond scope if we would have gotten into the questions about specific details of the decay heat model because it's not a significant contributor to the answer. But your criticism is certainly valid. On what's written in the SER, it is not clearly spelled out and that will definitely be corrected and for that I apologize. The actual discussion of why it was not reviewed in detail is not there and I will definitely correct that.

DOCTOR LANDRY: Let me make one other correction.

MEMBER SCHROCK: The description of the code doesn't say we have different options for decay heat evaluation. Those options are used in this way for evaluation of AOOs. We invoke this simpler thing. That's not in the GE documentation. It's not in your interpretation of the GE documentation. But you're telling us now, after all, that is your interpretation, that's your understanding of it. This is the limit of its utilization in TRACG. Is that right?

MR. ULSES: Yes, sir. That's all that GE will be able to actually use the code for because the SER will be written not to allow them to use it for any other applications. I believe we have an additional comment.

MR. HECK: This is Charlie Heck from Global Nuclear Fuel. In the documentation that was submitted with the application in Section 9.3 of the model description, it clearly describes what is the model we're using for decay heat and it also provides a comparison of the Mae Witt curves with the ANS standard 5.1 and it describes the model that's being used. That was part of the submittal.

MEMBER SCHROCK: In order to make such a comparison, you have to say what the particular reactor state is at the point of this evaluation by the ANS standard. There's not just a single comparison of Mae Witt. Mae Witt is a single entity. That's right. It just relates it to the operating power. But the decay heat standard gives you an evaluation which depends upon the operating history of the reactor and the composition of the fuel. So, Charlie, you can't argue that that was an adequate description. It was a comparison but with an undefined set of circumstances for what the ANS standard part of that comparison was calculated for.

MR. HECK: Doctor Schrock, the documentation that was provided indicates that the comparison was made at end of cycle conditions, exposures and radiation time, and enrichment values that are typical of the application for AOOs, and it was done at that point because that's where the most limiting conditions for AOO occur. So a comparison that we did do -- and I acknowledge your point that it's very specific to what has been the operating history, what was the initial load, what are the fissionable materials. We did provide the comparison at a representative condition for the intended application. But it is a single point evaluation.

MEMBER SCHROCK: Well, I think the point that I'm making is that the documentation of these issues is something that needs to be of concern to the NRC. It's treated in the SER as though the problem would never arise. That's what I have great difficulty with.

DOCTOR LANDRY: Well, this is a draft SER and we'll take your comments back and address them.

In looking at the assessment that has been performed through the uncertainty analysis, we did find that all the medium and high ranked phenomena have been taken into account in the uncertainty analysis and, on that basis, we feel that the proper assessment has been performed that does show the capability of the code to represent the experimental and operational data as necessary for the application to AOO transients.

CHAIRMAN KRESS: Did decay heat show up as important in that PIRT?

DOCTOR LANDRY: No.

MR. BOLGER: This is Fran Bolger from GE. We did identify it as a high phenomena for the loss of heat water transient.

CHAIRMAN KRESS: For what are the AOOs only.

DOCTOR LANDRY: Okay. Just to briefly recap some of the thermal-hydraulic aspects of the code because this was, as I said, more of a review of what was done during the review of the SBWR application of a version of TRACG. This was an extensive review. As I said, it wasn't performed to be a complete review because the code was withdrawn. The whole submittal was withdrawn before the review could have been completed. So it was not a complete acceptance review of the code. But it was an extensive review for thermal-hydraulic aspects.

TRACG is just basically like the TRAC code. It's a two fluid, six conservation equation code. Has boron transport, non-condensible mass equation in it. It's a two regime unified flow map instead of some of the other codes that we see typically for PWRs that will have multiple regimes. The regimes that are in the code are adequate to cover the normal operating and anticipated regimes that occur in a BWR. We're saying for AOOs the four regimes that are covered are adequate.

There's a two phase level tracking model which was criticized during the SBWR review because it uses approximations for void fraction above and below a mixture level and uses a cut point for level detection. We feel that because there is not a high degree of mixture tracking going on in AOOs that the shortcomings of this model are acceptable for AOOs. However, to go beyond AOOs, we are going to look at it extensively.

When the application comes back for the LOCA, we will look at this model again.

CHAIRMAN KRESS: Could you refresh my memory on bullet one about the boron transport equation. Is that a K epsilon turbulent transport model or was that empirically based on the tests that were done with salt and thermal?

DOCTOR ANDERSEN: This is Jens Andersen again. We have a boron transport model in the code but let me first clarify one thing is that this particular submittal is for AOO transients, and it does not include Atlas. It does not involve the boron transport model. The model does assume that the boron is transported with a fluid model. Fluid velocity. So it's a relatively simple model. If we make a submittal of TRAC for Atlas, that's one issue that we would have to address in more detail.

CHAIRMAN KRESS: Thank you very much.

DOCTOR LANDRY: In the TRACG code, the kinetic energy term has been put back into the energy equations. The kinetic energy term was removed in the TRACB version of the code that the NRC had supported, and that introduces energy balance errors. By putting the kinetic energy back in, there's better conservation of energy with this version of the code.

CHAIRMAN KRESS: That's merely to keep people from asking questions about why the energy didn't balance because it was a small discrepancy.

DOCTOR LANDRY: -- will have it back in and get rid of those problems. Reduce errors wherever possible.

MEMBER SCHROCK: When was it removed?

DOCTOR LANDRY: That was in the early stages of the TRACB development at INEEL.

MEMBER SCHROCK: It was not in BD1, didn't include kinetic energy?

DOCTOR LANDRY: No. An issue that did come up during this review that is not a TRACG specific issue but came up during the power up rate review is an issue concerning the GEXL heat transfer correlation. The NRC staff review and the power up rate found that data were generated using COBRAG for assessment of the GEXL 14 correlation rather than using up skew, down skew experimental data.

We raised a number of questions on the use of artificial data instead of empirical data for doing a statistical analysis on the MCPR safety limit. The staff is involved with the applicant in resolution of that issue on the power up rate concerns at this point.

CHAIRMAN KRESS: Wouldn't your perception of that depend on how well you thought the other code had been validated?

DOCTOR LANDRY: If the other code was truly independent and was properly validated. Yes. The staff view is we don't like using one code to validate another code rather than data. If the other code has not been validated against data, then --

CHAIRMAN KRESS: You would always prefer data.

DOCTOR LANDRY: We always prefer data.

CHAIRMAN KRESS: But if you have places where you don't have data, it seems like --

DOCTOR LANDRY: But if there are data but they're owned by another entity, then --

CHAIRMAN KRESS: Oh, that's a problem.

DOCTOR LANDRY: This is a very involved question.

CHAIRMAN KRESS: Yes, I can see that.

DOCTOR LANDRY: This is a question that has come up through the power up rate reviews, but we're only pointing out in the TRACG review that yes, if the GEXL 14 correlation is applied in this code for a transient, this issue must be addressed and that whatever the resolution of the GEXL 14 issue is, we expect that to be applied in the TRACG application also.

CHAIRMAN KRESS: I don't know if we have a statistician here or not but it seems to me like if you have a measure of the uncertainty for the base code and you can use that along with comparison with calculation of the TRACC, TRACG, then you can actually develop the uncertainty in the TRACG based on the uncertainty in the other code.

DOCTOR LANDRY: If you have a thorough uncertainty analysis of the other code.

CHAIRMAN KRESS: Yes. What I'm saying, it seems like philosophically it's a reasonable thing to do is to use another code if you know enough about that code and uncertainty is known about it to develop the uncertainty in another code if they are independent, just as a philosophical statement. Seems like an approach that's probably reasonable, especially in places where you can't get access to real data or real experiments.

DOCTOR LANDRY: We did not want to get into that issue--

CHAIRMAN KRESS: I understand.

DOCTOR LANDRY: -- other than to point out that there is an issue which is being dealt with independently of this review but will impact the application of this code when it is finally resolved. I call that out in the SER for that purpose to ensure that the resolution of the GEXL 14 issue is properly addressed in the application of TRACG.

CHAIRMAN KRESS: Yes. I just wanted to give you a hint as to how the ACRS might feel about that issue. I can't speak for the ACRS. Some of the ACRS members --

DOCTOR LANDRY: One of the ACRS members.

CHAIRMAN KRESS: At least one of them.

DOCTOR LANDRY: In looking at the TRACG code, the basic component models are very much the same as in the TRACB version of the code. Models are used as building blocks to construct physical input models for a plant. We did note that the applicability to isolation condensers needs to be demonstrated should the code be applied to transients for which the isolation condenser is important.

We feel that the steam separator model that is in the code has been validated very well against full scale performance data. This issue of steam separator/steam dryer keeps coming up whether we're talking about PWRs or BWRs because there's so much lack of data. But here the applicant has a great deal of full scale data.

CHAIRMAN KRESS: You'd think GE would know more about steam separators and dryers than anybody.

DOCTOR LANDRY: Right, and they have a great deal of full scale performance data which they have used to validate their separator model. We just wanted to call out that yes, they've done a very good job and we feel that the model is very well-documented.

CHAIRMAN KRESS: Where does it show up in PWRs?

DOCTOR LANDRY: We're talking about steam generator performance.

CHAIRMAN KRESS: In generator problems. Okay.

DOCTOR LANDRY: It has default, fully implicit integration for hydraulic equations and heat conduction equation is used. Predictor -- technique is used. There's implicit coupling between the heat conduction and coolant hydraulics and this code is less prone to error on phase shift in thermally induced oscillation. So we feel that the numerics have been improved in going from the TRACB to the TRACG version of the code.

MEMBER FORD: Can I ask a question? I'm trying to come as quickly as possible onto the issues on this particular subject. As I understand it, there's a whole lot of questions about the specifics of the modeling Virgil has brought up. And also there could be presumably some questions about how good the model is to predict the observations. Are we going to see any data at all today on resolving some of these modeling questions and are we going to see any data against which the model is calibrated?

DOCTOR LANDRY: There will be some material presented by Tony. Tony will be coming up next to talk about the kinetics modeling which he has examined.

MEMBER FORD: We'll see some data points.

DOCTOR LANDRY: We'll see some data comparisons which Tony has prepared.

MR. ULSES: Ralph, I want to interject. We actually aren't going to discuss the data because the data is proprietary to GNF. We obviously can't get into it in open session this morning.

MEMBER FORD: I have a fundamental problem then. Again, I'm learning about this whole process.

CHAIRMAN KRESS: You come into this issue a little late, but there is a validation part of the submittal that includes the data they have and their comparisons with the code. We may not have gotten you all that information yet. But it is part of the submittal.

DOCTOR LANDRY: Tony is going to talk about some comparisons with the code which he has performed and the neutronics. Yuri is going to talk about the statistical methodology that's been set up.

CHAIRMAN KRESS: That's largely based on data.

DOCTOR LANDRY: We're trying not to utilize proprietary information in our presentations, so we're trying to stay away from the actual data but by showing some analyses which we have performed how we feel the code is performing.

MR. ULSES: And there also is an extensive assessment manual which was given to the staff and I believe the ACRS as well by GNF and that has a great deal of data in it. It's like an inch and a half thick if I recall. It's an extensive manual. Unfortunately, I don't have it here.

MEMBER FORD: I can see some of the problems. I personally would not like to see some of that data.

DOCTOR LANDRY: We'll try not to show it to you then.

DOCTOR LANDRY: The next person to talk is going to be Tony Ulses. Tony will talk about the neutron kinetics analysis which he has performed, and then Yuri Orechwa will follow Tony and talk about the statistical methodology, and then I'll come back up and talk a little bit about some of the user experience with the code and the conditions and limitations on the code and our conclusions. I would ask during the next two presentations if GE sees stuff coming up that they think is proprietary to alert us so that we can take appropriate action.

MR. BOEHNERT: Yes. We can close the meeting if we need to.

DOCTOR LANDRY: We don't think that what we're going to say is proprietary, but if it looks like we're getting in a proprietary area, let us know.

MR. ULSES: As Ralph said, I'm Tony Ulses of the staff. What I'd like to do is I'd like to try and address your concerns, Doctor Schrock, before I get into the actual details of my presentation because I don't have any specific discussions in there about your questions. But I'd like to make sure that I address them. There's one question you had about beta that I know we haven't discussed. We can talk about decay heat more if you'd like and if there's anything else you'd like to discuss, I'd like to do that now just to make sure I address your questions before I get into the presentation, just to make sure they don't get lost.

MEMBER SCHROCK: You can explain that now or you can explain it wherever you plan to if you did plan to. But I would like to hear it.

MR. ULSES: It's not in the presentation. That's why I'd like to discuss it now.

MEMBER SCHROCK: How you deal with the calculation of beta for -- fissile fuel.

MR. ULSES: This actually goes back to the discussion we had in the past in the RETRAN review. The question of beta within the scope of this review is that it's viewed as input value into TRACG. It's calculated by the upstream codes and it's going to be fuel type specific.

MEMBER SCHROCK: You haven't read my December report and, therefore, you couldn't have responded to that but in that report I said, and I believe this to be absolutely essential in what you do in the regulation, that you have to know what the source of information is for inputs. You can't extract a physical problem from a computer code and say, now, this code doesn't deal with that issue any more because it's input. The fact is it has to be evaluated in order to get a completed calculation using this code and, in fact, the input or whatever is preparing the input has to be based upon the conditions that you're doing the calculation--

MR. ULSES: You're certainly correct, Doctor Schrock, and the reason why it's not reviewed in these contexts is that GE has and uses a licensed code which has been reviewed and approved by the staff for doing lattice physics type calculations and also core analyses.

MEMBER SCHROCK: What I heard is an oblique way of telling me it's not my business to know this. What I'm saying to you is that you, the NRR, has gone on record as saying you have conditions for review of computer codes and those conditions we've reviewed. A lot of time has been spent on that. You're not following the advice that you prepared for industry.

MR. ULSES: I'm not particularly sure I know what advice we're not following.

MEMBER SCHROCK: This is a part of the calculation. I raised the issue because I read things in some other documents, as I explained previously, that planted the seed of the possibility that maybe this distinction is ignored in such calculations which seems incredible.

MR. ULSES: Well, I can assure you that it is not ignored in the GE analysis. We do specific fuel type analysis based on exposure.

MEMBER SCHROCK: I don't think it is either, and Fran Bolger and Charles Heck gave a lot of assurance last time that it is done and it's done well. I'm not challenging that. What I'm saying is that if you're going to review the code, if you're going to ask us to review the code, if you're going to ask me to review the code, don't tell me it's none of my business how this gets calculated.

MR. ULSES: If that's the impression I left with you, I apologize. That was not my point. The issue is is that we have a scope of review which has been defined for us and it's very difficult for us to go beyond that scope and if you look at the application that we were reviewing, it was for one code -- in this case, the TRACG code, which uses beta as an input value. We know because we have access to all the previous reviews that the staff has done that there is an approved code that GE uses for doing those types of calculations and that they do treat all the relevant physics, all the relevant parameters. Unfortunately, that information was not made available to you and actually, I don't know if we could have made it available to you or not. I really don't know actually in this context because again, it really is beyond the scope of the question we were asked to answer. Other than to assure you that it is dealt with and it is dealt with through all the relevant parameters.

CHAIRMAN KRESS: How do you determine what's in scope because it seems to me like the determination of any input value in the code could reasonably be said to be in scope. I don't know how you determine what's in scope.

MR. ULSES: In this case, it's determined because we know that GE has an approved method which the staff has already reviewed and approved. There's an SER written on it that says it's acceptable for doing those types of calculations.

CHAIRMAN KRESS: Okay.

MR. ULSES: That's the finding the staff has made.

MR. CARUSO: Doctor Kress, this is Ralph Caruso from Reactor Systems Branch. I think there may be a little bit of concern here that in the regulatory context there's no opportunity for the staff to review these inputs that are generated for these codes. Realize that reviewing the code itself is just one part of the regulatory fabric. We do, as we've been doing for the power upright reviews, we've been doing a number of audits of the actual calculations where we send people like Tony out to GE to look at the actual design record files to look at the actual input values that are put into these codes and that is the context in which we would verify that they were using the appropriate value of beta, if they were calculating it appropriately with the lattice physics code and then appropriately inputting it into TRACG.

The code review itself does not necessarily include a review of all of the steps of the surrounding methodology because we just don't have the resources to completely review a methodology every time we do a review of a particular part of it. We understand that the other parts are there and we take them into consideration as we do the review, but we don't necessarily review them entirely. We have other regulatory means to verify that they will be done properly.

CHAIRMAN KRESS: You can review it at the time of an application.

MR. CARUSO: We can review it when an individual licensee applies for permission to use this code for their plant. We can review it when we --

CHAIRMAN KRESS: Will part of the limitations on the use of this code for this particular aspect specify that the -- I guess it's the ODYN code must be used to determine this beta.

MR. ULSES: No. Actually, the lattice code G uses is called TGBOA. I don't know where that came from, but that's what they call it.

CHAIRMAN KRESS: But will you specify in your limitations that to determine this input you will have to use that code or if somebody uses a different code to determine that input, you'll have to review that one at the time of the application. Is that the approach?

MR. ULSES: Well, at the time of the application, what'll happen is the applicant in this case -- it would actually be the utility coming in for the proposed application -- they would have to identify what methods that they used.

MR. ULSES: And if they had a method that was not reviewed and approved, we would have to make the choice of whether we're going to review it or whether we're going to say we don't have the resources to review it because it would require an additional code review.

CHAIRMAN KRESS: Does the code have a default value for this particular input?

MR. CARUSO: Does TRACG have a default value? Is that what you're asking?

CHAIRMAN KRESS: Yes, because I understand part of the problem is you have to -- the input value depends on the power history and the loading of the code and so forth, so you can't just have one input value. You have to know what the particular state of the core in order to get it.

MR. ULSES: Sure. Well, there certainly will be default values in the code. However if you look at the application of this particular code -- in this case, TRACG -- it's not really designed to be used outside of the automation mechanism that they use at GNF which basically would require that you have input files which are calculated to the appropriate exposure points for the appropriate reactor being analyzed and, therefore, that's going to be imposed by their QA program which is going to require them to do the analysis with the correct input.

MR. CARUSO: And this actually applies to, I would think, any calculation that is done. The QA procedures Appendix B requires there to be a documented description for every input value that goes into the code and the way we regulate that is we do inspections, we do audits to verify that they have chosen the appropriate value and that they have a basis for it. So even though there may be a default value in the code, if they use that default value without a basis, then they subject themselves to the possibility of this being discovered during an audit or an inspection and appropriate regulatory action can be taken for noncompliance with Appendix B.

MR. ULSES: As an example, what I would

expect is--

CHAIRMAN KRESS: Aren't things like that flagged in the SERs and when you get around to --

MR. CARUSO: Because of the large number of input values, we don't flag in the SER every individual input. That's a requirement of Appendix B is that every value that's used in a calculation should have a basis for it.

CHAIRMAN KRESS: Okay.

MR. ULSES: Just as an example, I would expect when I would go down to, say, the GNA offices in Wilmington and I would audit a design record file, I would expect to see a discussion in there if the analyst, say, made the choice to use the default values and they would say why they did it, why it has no impact, and then the reviewer of that design record file would have to either say I agree with this, I challenge you on this, and this is why I think this is right or wrong. That entire deliberation ought to be documented in the records that are kept on the analysis. That's the QA trail for those types of questions, and those are things that we will audit when we go down to the site.

MEMBER SCHROCK: What is the required detail of the input data?

MR. ULSES: I don't think I understand the question.

MEMBER SCHROCK: Does the input provide spatial distribution of beta?

MR. ULSES: It's handled on a fuel type. Yes, it does. Let me just say yes to that question. I can go into more detail if you want as to how it actually works. Hopefully, I won't tread on any proprietary information here. But it certainly does. You have the information on a node-wise basis which basically means it's a six inch by six inch by six inch square portion of the reactor. Each one of those nodes will have individual values of beta which are appropriate for the exposure points that are being analyzed. That's correct. Yes.

Do you have another question, Doctor Schrock, or shall I go ahead and proceed here? Okay. Let's see. I think I'll skip my name because I think we all know who I am now.

What I'd like to do in this discussion is I'd like to focus really and discuss basically the conclusions of the review and then I'd like to go through what I call sort of a lessons learned on this particular review because this review was very challenging. There were some areas where I ran into some difficulties, and I'd like to discuss those and I'd like to go through some areas where I think I can do a better job the next time and areas where we can improve upon what we've done. That's essentially what I'd like to try and do today.

These are the areas where the review was focused. We obviously reviewed the documentation which was given to us by GE.

CHAIRMAN KRESS: Did you find the documentation sufficiently good and detailed for you to make your reviews?

MR. ULSES: Well, the documentation is acceptable for use internally by GNF. It's not information that I would consider to be acceptable for public dissemination because it's not a discussion from the cradle to the grave on how this code works. But if you use it in the context of the organization that's actually using it, I feel the documentation is acceptable. There actually are some areas where it was kind of disjointed and actually, I plan on discussing those a little later. There were some models that were described in one document whereas I think they should have been in another one, etcetera, etcetera. There were some areas where there were some difficulties, but I think if you put it in the context of the application and who's going to be using this code, I feel that it's acceptable for internal use by the applicant.

As part of the documentation review, we went through a discussion of the actual model development itself, the theoretical development. What I refer to as an auxiliary model is, say for example, like moderator heating effects, heating of structure, that those are discussed in the documentation and, of course, we also reviewed the validation that was presented and we also went through a sample problem which was derived -- this is very similar to what we did in the RETRAN review.

Basically we derived a problem on which we ran the TRACG code. This is actually the staff ran the code and we also ran our own methods and then we tried to do a comparison. Essentially, what we're trying to do there us we're trying to sort of bridge the gap between the data that we have available which is very old data. It's on reactor designs and fuel designs that aren't really in use any more. I wanted to sort of bridge the gap there and try and get an understanding of how the code will perform if we use a more modern fuel design. That's effectively the point of the data analysis.

MEMBER FORD: Just for clarification, your use of the word validation is not validation of a code to make sure that operator A gets the same results as operator B on the code. It's on how well the code predicts experimental observations.

MR. ULSES: Yes, sir. Right. This is a mixture of experimental data and there's also some plant transient data as well which has been validated against it. Again, it's all in that report which I understand you haven't seen so it's very difficult to get into and it's certainly proprietary so I can't get into the details of the actual results. I don't know if we want to maybe do it this afternoon. I don't know if that's possible and if it would be interesting to anybody, we could put some cards up this afternoon in closed session just to show you some of the information. That's something you can think about.

CHAIRMAN KRESS: I think for Peter's benefit and even Jack, he hasn't seen that either, it might be worthwhile to do some of that. I don't know how much time we've got.

MR. ULSES: Perhaps we can think about it and if we have enough time, we can maybe do it this afternoon. That would obviously be up to GNF if they want to do that because it's their data.

MEMBER SCHROCK: Also, I had understood that you had difficulty matching GE calculations in some instances.

MR. ULSES: And that's something I want to discuss. Yes, that's exactly one of the things I wanted to discuss which is why I constructed the presentation as I have. I want to get to the bottom line, and then I want to discuss the problems that I had which basically have been resolved. There were some issues where basically I made a mistake is what happened, and that's why there were differences. I'll say my mea culpa right now. That's what I want to get into, and I want to discuss how that happened, and I want to discuss some areas where we can improve in the future.

So let me move on here. I think I've already discussed most of this. Basically, what we're doing now in these days when we're actually reviewing the code by having the code and executing the code is we're focusing more on the performance of the code rather than just looking at the presented written material. This is a model that we found has worked well for us in the past, and I think it actually worked well in this case, I'd say even when one considers the difficulties that we had along the way.

I'd say this was an effective review model. I don't know if GNF would agree with that, but I think it was an effective review model from the staff's perspective.

CHAIRMAN KRESS: That's interesting to know because ACRS has pretty much been advocating that approach for a long time.

MR. ULSES: One thing that was certainly useful with the way we did it this time is it actually led us into reviewing some models that we probably wouldn't have reviewed which actually were more important than I originally suspected. So I guess in a sense that was certainly an effective outcome of this review process and again, I'll discuss that in more detail after we get to the SER conclusions.

Basically, all the information at the beginning of the presentation is all contained in the SER. It's just sort of ground out of there.

These are the validation studies that are in the assessment manual. These are the areas where they have data. Obviously, the Peach Bottom turbine trip tests which are validated against. And the rest of this information is -- there's start-up testing in there and there's also some data from planned events which has been assessed and it is in the manual. I just wanted to put this up here to show you that they do have actual data that they compare their code to.

CHAIRMAN KRESS: Is this the proprietary data?

MR. ULSES: Yes. If we actually wanted to show the actual results, that would be proprietary.

These are effectively the conclusions that are in the SER. We felt that the theoretical development captured the relevant physics necessary to predict an AOO type transient.

CHAIRMAN KRESS: It captures them to sufficient degree?

MR. ULSES: They provided reasonable assurance that the code will accurately predict these answers for application to licensing.

And again, what I refer to as auxiliary models which are basically gama heating of the liquid in the structure. I felt them to be very well developed, and that they would be effective in the proposed application. And again, the decay heat modeling. I felt it was adequate for the proposed purpose and, again, Doctor Schrock, I definitely think your criticism is valid, and I will definitely change what's written in the SER to describe the constraints on the review.

MEMBER SCHROCK: I don't know what you mean by you feel it's adequate. I mean you need some quantitative --

MR. ULSES: Well, let me say that it is adequate for the proposed application because decay heat is at best a second order effect, perhaps even a third order effect, for the application that's been proposed.

MEMBER SCHROCK: Well, I don't know that it's a third order effect but --

MR. ULSES: It's definitely a second order effect, at best.

MEMBER SCHROCK: Yes. What I'm saying is that we haven't heard evidence of such conclusions, and I think we should.

MR. ULSES: Interesting.

CHAIRMAN KRESS: What do you do about loss of feed water with respect to that?

MR. ULSES: Well, it's A) not a limiting transient. It's one that's analyzed because it's required by Chapter 15.

CHAIRMAN KRESS: It's a low frequency.

MR. ULSES: It's usually a low effect transient. Correct me if I'm wrong here. I think it's usually not one that sets any limits on the plant and, therefore, the decay heat, if it's high for that particular scenario, the uncertainty in the model would not have a significant effect on plant operations. Again, correct me if I'm wrong but I believe that's correct. And that again would be why that was dispositioned as it was.

Again, this goes back to a discussion of documentation we had earlier, Doctor Kress. It's acceptable for use by the applicant, and that's obviously the intended audience of the documentation. It certainly isn't documentation that I would expect somebody who didn't have a great deal of knowledge of the methodology to pick up and be able to fully understand it. But again, that's not the intended audience of the documentation.

This goes on to our test problem that we derived. Essentially, like I said, what we were trying to do here is we were trying to bridge our understanding of the code's ability to handle the reactors that are being run and used right now in this day and age. The core is based on an ABWR reactor. It was designed to be as easy a model as we could. A zero exposure so we didn't have exposure effects.

MEMBER SCHROCK: That may be because in the SER you do not include ABWR as the reactor types to which the code may be applied.

MR. ULSES: Well, the issue though is that that was a model that GNF already had available and it was based on modern GE fuel. That was the reason that was chosen. And all we modeled there was the reactor core itself. We did not model the rest of the steam supply system at all.

MEMBER SCHROCK: Well, I asked myself the question in the opposite sense as I read that. Why is ABRW excluded from what the code is approved to do?

MR. ULSES: Well, I'd say right now off the top of my head we're not running any ABWRs in the United States and plus that's a good question. I think that's something that we were asked to review and approve more than likely.

MEMBER SCHROCK: Is it necessary to call it out?

MR. ULSES: Well, it's going to be trying to identify the source.

MEMBER SCHROCK: Or exclude it from the list of those for which it could be applied.

DOCTOR ANDERSEN: Jens Andersen from GNF. When we made the submittal to the NRC, we made the submittal to be valid for operating BWRs in the United States. There are no ABWRs in the United States.

Clearly, the difference --

MEMBER SCHROCK: So it's GE's choice, not NRC's choice.

DOCTOR ANDERSEN: It is our choice. The difference in the ABWR design and the conventional BWR design is mostly in the recirculation system. There's clearly no relevant significant differences in the core design. We chose NABWR core design because it would simplify the process of generating the nuclear input that would allow us to do the comparisons between the NRC codes and the GE codes because it was an initial core at zero exposure. It greatly simplifies the process.

MR. ULSES: And it's just discussed in the SER because we were trying to identify it.

MEMBER SCHROCK: You could manage to have the approval cover the SBWR, but that's your business, not ours.

MR. ULSES: I was just simply trying to identify the source of the model. That was the reason it was discussed in there. And again, obviously we looked at the steady state results to make sure that we didn't have any gross discrepancies between the application in TRACG and the application with our methods, and we didn't see any differences. Well, we didn't see any large differences. The codes compared well. And we also ran some small perturbation transients to look and make sure that we didn't see any gross discrepancies in the way the model would respond to, say, a small perturbation in pressure, a small perturbation in flow.

I just want to briefly put up again. This is all in the SER. This is the initial steady state power distribution out of the two models, the two codes, and they compare very well. There are some discrepancies on the periphery due to the handling of the modeling of the reflector. However, for this case, we feel that this is a pretty good comparison and that the model is working very well in both cases.

MEMBER FORD: You said the model was working well. What is your definition of working well?

MR. ULSES: Well, in this case, since we're trying to compare one code to the other, if we get good comparison, we feel that both codes are modeling the problem in the same way and giving the same answers. That was a figure of merit.

MEMBER FORD: Validation of those models is based presumably on data from off-shore reactors?

MR. ULSES: Actually, the data for TRACG

is based on all data, I believe -- actually, there's a couple of data stats from overseas reactors but, for the most part, it's based on U.S. data.

MEMBER FORD: That's not ABWR.

MR. ULSES: Right. Again, it was just intended to make everyone's life easy. That's the reason why that reactor was chosen, because it was available, there was zero exposure, and all we're trying to do here is examine the response of the code to a perturbation, not necessarily the ability to actually model the steady state characteristics of the reactor which would be burn-up, for example. That's basically a steady state response, and that's not really modeled in TRACG. I mean it's handled as an input parameter to the code. So what we're trying to do is we're trying to examine the code's ability to model the effect of a pressure perturbation.

MEMBER FORD: The number of ABWRs against which this prediction would be compared were not large.

MR. ULSES: But this reactor will never exist. This is a hypothetical reactor that we made up. This is a sample problem. This reactor will never exist.

MR. HECK: Excuse me. This is Charlie

Heck from Global Nuclear Fuel. The loading, the core specification bundle designs here, one of the constraints was that it be an initial core so that there would be no issues regarding how exposure differences possibly in lattice physics. And that was Tony's specification. He said initial core as realistic as possible, so we chose a real design which was an ABWR core.

The only initial core we have these days. And we took it and we trimmed it so it's really not ABWR core per say. This is actually a 560 bundle core. ABWR is much larger than that. Eight hundred and twenty, I think. We trimmed it to the right size maintaining the same proportions and the calculation that's being done here is just for the core model hydraulics. The vessel boundary conditions above and below the core are specified. So this is a problem designed specifically to focus on the neutron kinetics and coupling of that with the hydraulic models.

CHAIRMAN KRESS: Tell me what I'm looking at. This is one quarter of the core.

MR. ULSES: It's one quarter steady state power distribution.

CHAIRMAN KRESS: Steady state full power distribution and if I were to ask how to compare the two code calculations in terms of some figure of merit, would I be asking what the differences were in terms of some root mean square area or would I be asking how the differences affect peak clad temperature of the hot model? How do you compare two curves like this and ask yourself whether they're the same or close enough? I see very little difference. I can see the parts around the periphery where you say there's some difference but it's a little hard for me to figure out how good the comparison actually is. It looks almost identical.

MR. ULSES: Well, the real figure of merit for this study was the energy deposition which is calculated by this code following a simulated pressurization transient.

CHAIRMAN KRESS: You started at steady state and then you ran through --

MR. ULSES: What effect are any discrepancies you see here going to have on the effect of the analysis with these two codes on the energy deposition following a pressurization transient.

CHAIRMAN KRESS: It's a total energy deposition.

MR. ULSES: Right. That's what's going to lead to changes in MCPR. That's going to lead to changes in the calculated changes in critical power ratio which are clearly the figure of merit for an AAO analysis. So that's basically the bottom line. What we're trying to do here is make sure that the models had no gross discrepancies at the steady state point. That was the only point of doing this particular figure.

MEMBER SCHROCK: TRAC/Nestle has been used previously for AOOs.

MR. ULSES: No. It was used -- the staff code that we used for these types of simulations, we used it in the RETRAN work where we worked on RETRAN 3D. And it's a code that's used by the staff for these types of audit type of calculations. It's not a licensing code. It's not an industry code.

MEMBER FORD: I shouldn't be reading anything more into that draft than to say that there's little difference. Whatever the difference between those two models are if it's an input -- it has no impact at all on the resultant prediction.

MR. ULSES: I wouldn't say no impact but there's a small impact on the final bottom line. That's the only point of this curve is to make sure that there are no gross discrepancies in the initial conditions.

MEMBER FORD: I may be a devil's advocate here but the model could be completely wrong because I don't see any data, observed data.

MR. ULSES: Right. Both codes have the potential to be completely wrong. You're correct. And that's why you need to fold in the existence of experimental data into these types of studies.

MEMBER FORD: For ABWRs, whatever the fuel configuration is, there's very little data existing.

MR. ULSES: Well, I can ese it was a mistake to put ABWR on here. The only point of this study, this reactor, like I said, is hypothetical. It will never exist. It will never run. It's just on paper.

MEMBER FORD: I'm trying to understand what may take away from that

MR. ULSES: What we're trying to do is we're trying to design a sample problem which would be easy for both organizations to set up and what we want to do is we want to isolate the kinetics modeling from the reactor system modeling as much as we can. Obviously we can't do it entirely. So we stripped out all the rest of the vessel model. There's no separators. There's no recirc flow. There's nothing. All it is is the reactor model and it's got a velocity boundary condition at the lower tieplate and the pressure condition in the upper plenum.

So that's the point in this. The existence of this model was used because it already existed and they were able to take it, they were able to scale it down and make a smaller core out of it without doing a great deal of work. That was the only point of using this model. It's not intended to validate against the ABWR at all. It was used because we were able to isolate the kinetics modeling from the rest of the reactor system. That's the point of this study.

MR. BOLGER: This is Fran Bolger from GE. I just wanted to point out that the model that you see under the TRACG is based on the GE steady state simulator. Now that steady state simulator is the same simulator that is run at the plants and those simulators are compared to LPRM and trip data regularly. So that's the same model that's validated on a day to day basis in the fleet.

MR. ULSES: Let me move on here.

MEMBER SCHROCK: Let me make one last point. The TRAC/Nestle is what version of TRAC?

MR. ULSES: It's using the NRC version of TRACB which we all know and hopefully love or don't love. It's the version that came out of INEEL.

MEMBER SCHROCK: But you have other experience to tell you how good or not good that should be expected to do on a typical problem like this.

MR. ULSES: That's correct. TRACB itself has validation. It's not an unvalidated model. Obviously it's not validated against the same data that they validated TRACG against obviously because most of the data they use is going to be GE proprietary information. But it is a validated method for things like, say, void fraction predictions, density predictions, fuel temperature predictions, things that are going to be relevant for this particular study.

MEMBER SCHROCK: But you don't use its kinetics model.

MR. ULSES: No, not using its kinetics model.

MEMBER SCHROCK: Because it's not multi-dimensional.

MR. ULSES: It has a one-dimensional model, but it's not being used. All it's doing is it's giving Nestle density fuel temperatures. That's it's only function for this study.

I just wanted to put up again the axial void fraction profile radially collapsed, one-dimensional. The only difference is this little change here and that comes in because of the existence of the part length rods and that's the TRACB modeling. There's a difference. You could go into the part length rod and region. But again, as you'll see, it does not have an effect on the overall bottom line answer.

CHAIRMAN KRESS: Is this integrated radially across the core?

MR. ULSES: Yes. This is radially collapsed, one-dimensional average axial power distribution. I'm sorry. Average in channel void fraction. Okay.

This is just a brief description of how we set the problem up. What I did was I ran an input deck that had the entire reactor system model to get the boundary conditions which were then imposed on our simpler model and that enabled us to do the transient modeling. And then we modeled the case in TRACG using multiple options available in the code. We turned switches on and off to see if they had effects on the results.

MEMBER FORD: Again, I keep coming back to this and you gave the key answer. This tells me nothing at all how good the model is.

MR. ULSES: Right. All this is telling us is -- well, it's telling us that we're able to bridge the gap and that we have an understanding that we have multiple codes which can model a reactor using modern GE fuel. It's telling us an area where we do not have any data because there is no data that exists.

MEMBER FORD: But the critical question is any of these codes, they all seem to give the same results. Are there operational data against which you can have a one to one comparison between the prediction and the observation? What you've told me is there is.

MR. ULSES: For pressurization transients with modern fuel, it's my understanding that there is no data available. We have data from the '70s using fuel that's no longer run in reactors which allows us to do validation against or verification if you want to look at it. The only point of this particular study was to attempt to understand the ability of TRACG when compared to another method, whether there's anything unique about modern fuel designs which will lead the staff to believe that the code is not capable of modeling a modern reactor. That's the only point of this study because there is no data with modern fuel, as I understand it, for pressurization transients. Correct me if I'm wrong here.

DOCTOR ANDERSEN: This is Jens Andersen from GNF. I understand that you're a little at a disadvantage but if you remember from Ralph Landry's presentation, we have one of the reports that was submitted to the NRC and also to the ACRS was the TRAC qualification report which is about an inch and a half thick and it has an extensive qualification consisting of basically four sets of qualifications.

One was a set of separate effects test where we had isolated individual phenomena and tried to qualify those phenomena like could we predict a given heat transfer core regime? Could we predict a void fraction in the fuel bundle? Then it has more a complicated section on component performance like how well do we predict a steam separator performance? How well do we predict a jet pump performance? This is all based on data and full scale data wherever full scale data was available.

Then we have a section in the report which is what we call integral system effects test which is basically scale simulation of an entire BWR typically scaled down to a few bundles that are simulated through electrical heating. That gives us a qualification of how well the code predicts system interactions between various components in the systems. And then we have the final section is a section of comparison against plant data where we have full scale plant data, typically data taken during plant start-up tests.

That includes data like the Peach Bottom turbine trip test. Those are, as Tony Ulses mentioned, all the data based on 7 X 7 and 8 X 8 fuel. We have later data with more modern fuel types like the Nine Mile Point pump up-shift test which contains predominantly GE11 fuel which is typical of the modern fuel with a large central water rods and the part length rods. So we do have qualifications for modern fuel types, and it shows how the kinetic reacts to changes in the hydraulic conditions in the core.

So all of that is in the qualification report and it's based on comparison to actual plant data. Now, we have taken that a step further in the application methodology report, and that's where we apply the statistical methodology is that we have gone in and done a statistical analysis of all the qualification data and quantified what are the uncertainties in predictions of the individual data so that we can properly account for this uncertainty in the application methodology.

So all of that is in the report and, unfortunately, I understand you haven't seen these reports, and we'll be happy to show one of the reports. We can do it during the break.

MEMBER FORD: I'll look at it like this. (Indicating blindness with his hands.)

MR. ULSES: Well, anyhow, I'd like to move on to the next slide. Basically the next slide is the results of the sample problem. Again, the ABWR problem which is not a real reactor which is intended just to allow us to bridge the gap between the areas where we have data for the pressurization transients which are typically limiting AOOs and BWRs to the reactors that are operated in the year 2001. That's the only point of this problem, again.

Actually, what I'm going to do is put up another slide that's not in your handout. I apologize for this. I'll get to this to you, Paul. This is a slide that actually is in the SER. Essentially, these are the results. These are the relevant results. What you see here is the power on the top one, the total power from the reactor. Obviously, there are some discrepancies there between the codes. We have a couple of hundred megawatt difference in the peak power between the TRACB calculations and the TRACG calculations. But if you look at the effect --

CHAIRMAN KRESS: Under a pressurization transient without scram, you're basically checking the void coefficient effect and the temperature coefficient effect.

MR. ULSES: That's correct. That's what we're doing. What we're doing is looking at the balance of the reactivity from the void effect and the fuel temperature effect.

CHAIRMAN KRESS: The voids get collapse and that adds power and the temperature goes up because of the increased power and it turns it around.

MR. ULSES: That's exactly what happens and you also have a trip of the recirculation pumps as well.

CHAIRMAN KRESS: Okay.

MR. ULSES: Which will also significantly drop the power. That's what's going to happen. But if you look at the bottom curve, which is just simply the interval of the top of the curve, what you're going to see is that the effect on the energy, which is really the figure of merit for an AOO transient, is effectively -- well, it's not nil. It's obviously very difficult to see on this scale. But it's very small which would mean that the actual calculated change in the critical power ratio from these multiple simulations would be very small which tells us that these two codes obviously are able to predict that this model is the same, if you will, in effect. Obviously, there are some differences.

CHAIRMAN KRESS: What are the differences between the blue and the red?

MR. ULSES: That's using a different model in the TRACG code which I'd like to discuss next actually. That's one of the things that I discovered going through this review which was very intriguing.

CHAIRMAN KRESS: What's the cause of that little plateau on the right?

MR. ULSES: Right here?

CHAIRMAN KRESS: Yes.

MR. ULSES: This is, in effect, the competition of the void reactivity and the fuel temperature reactivity and how it's affecting the power. That's what's causing that.

I'd like to just move on to the review conclusions which again are in the SER. Effectively, what we concluded is that we have reasonable assurance that TRACG can model AOO transients. This is based on obviously evaluation of the GNF validation, benchmarking, if you will, comparison to actual plant data and also based on the sample problem which we derived. And again, this is just simply stating what we've already stated, that the code that's being applied to Chapter 15 transients and that is the scope of the SER.

MEMBER SCHROCK: In the SER you address difficulties that you had in predicting results from the SPERT 3 tests. You've not commented on that. Is that because you're excluding RIAs?

MR. ULSES: That's basically the bottom line. RIA is not included in the scope of review, but actually I do plan on discussing --

MEMBER SCHROCK: Why is it in the SER?

MR. ULSES: Well, because it was in the validation documentation which was given to us by GNF and, therefore, I wanted to discuss it. And that's one of the things I plan on discussing in the discussion of review challenges which is what I'd like to go to next.

CHAIRMAN KRESS: I was wondering. We need to take a break some time right about now. Would this be a good time?

MR. ULSES: This would be a great time.

This is sort of a change in the focus, but I do plan on discussing really the why. I didn't discuss the SPERT test and the SER because it really is not relevant for the proposed application. You are correct.

MEMBER SCHROCK: Well, if I read your SER conclusions correctly, you have a very different view of that than I have. It seems to me that SPERT 3's very small core has essentially nil spatial difficulties.

MR. ULSES: Very little, if any.

MEMBER SCHROCK: It's practically a point reactor calculation and for what reason, I can't imagine that a more sophisticated code shouldn't be expected to give good results on that.

MR. ULSES: And that's a very good question and that's the question that I had in my mind and that's one of the reasons why I decided to discuss it, and I do plan on talking about that in this presentation a little bit later.

CHAIRMAN KRESS: In that case, I'm going to declare a recess for 15 minutes. So be back 20 minutes after 10.

(Off the record for a 15 minute recess at 10:07 a.m.)

CHAIRMAN KRESS: I think we can go back in session now. Talk about challenges. Is that what you were going to do?

MR. ULSES: Right. This is basically the mea culpa I referred to earlier in the presentation. Effectively, the differences that you were talking about, Doctor Schrock, in that one draft RIA that I prepared which showed those major discrepancies in the code results. Basically, the bottom line of why that was there is I made a mistake in the input stream of my analysis. It was discovered, and the differences went away. The mea culpa is that I made the wrong conclusion based on what I saw and that's what led to that draft RIA which hasn't made it into the final RIAs, by the way, because it was not pertinent because it was incorrect. But that's basically the issue. If you want, I can go into more detail as to why the differences were there or we can leave it at that. I will pose that as a question.

CHAIRMAN KRESS: Are you asking Virgil or me?

MR. ULSES: I'm asking any of the members and consultants if they have any interest in going into more detail as to why there was a large discrepancy in the initial analysis.

CHAIRMAN KRESS: You know, I think in the interest of clarity, I would like to hear a little more. Yes.

MR. ULSES: Well, basically what it really boils down to is the way the moderator density is handled in the TRACG code versus in the methods that I used traditionally. I think I'm probably going to tread on proprietary ground here.

CHAIRMAN KRESS: Yes, be careful.

MR. ULSES: With the modeling, you will halt me. Okay. Basically, the way GE handles the modeling of moderator density is they use a weighted average of the in-channel density. In other words, the water that's inside the box with the water that's in the bypass region where the control blades run. That's an average parameter which is passed between the kinetics and the thermal-hydraulic solver. Hopefully, that wasn't proprietary. That's not the way I traditionally model that in the methods that I use. I usually base it on the in-channel density alone which for AOO analysis is perfectly adequate because you don't expect to see any changes in the bypass. It's going to start off as water and it's going to stay solid water throughout the transient.

What I had to do was go into the codes

that I had and modify the algorithm to handle that and I made a mistake in the way that was done and that was discovered and the error went away. That was the bottom line.

CHAIRMAN KRESS: So the difference was in the void coefficient effect --

MR. ULSES: Right. And that's what was leading to that huge discrepancy which one would expect because obviously this transient is definitely void dominated.

CHAIRMAN KRESS: Okay.

MEMBER SCHROCK: So that part of the SER will be corrected.

MR. ULSES: I don't think it's in the SER.

CHAIRMAN KRESS: It was an RAI.

MR. ULSES: It was an RAI. It was a draft RAI which is not going to be in the final RAIs because it was incorrect. That's basically the bottom line. Anyhow, one thing that I think was good out of all this is that it did lead me down a path that I wouldn't have gone into originally which leads me to the next slide which discusses how GE and I would say probably every other organization in the United States uses the MCMP code for validation and verification of lattice physics methodologies. It's widely used, widely accepted in most organizations that I'm familiar with and probably the ones that I'm not familiar with. It's used to check the results from lattice physics calculations in the absence of data if the MCMP is accepted as a very accurate methodology and it's used for that purpose.

CHAIRMAN KRESS: That's a Monte Carlo.

MR. ULSES: Right. It's a Monte Carlo solver which was written by Los Alamos and has been extensively used for these types of applications over the years.

This leads mein to a discussion of what --

MEMBER SCHROCK: I ask you to look at page eight of your SER.

MR. ULSES: I'm going to have to ask you for a copy of it. I don't have one in front of me here. Okay.

MEMBER SCHROCK: I mean you don't need to review it now but I mean --

MR. ULSES: If there's something in there that I have an error in, I'd like to see it.

MEMBER SCHROCK: The paragraph that addresses the SPERT 3 report.

MR. ULSES: And that I'm going to discuss more in the end of this presentation, Doctor Schrock.

I have a slide on it. I'd like to discuss that. Certainly you are right. I agree with you that I would expect a more modern accurate method to be able to handle the E-core experiment because if you look at the documentation that was written up on that experiment back in the '60s, they were using point kinetics models and they were very sufficient to model that reactor. But I'd like to defer that until a couple of slides from now if that's possible because I certainly think that needs to be discussed.

Basically what this led me to was the discovery of a model that I've dubbed the PIRT 18 model for lack of a better word. I don't think that's what GE calls it, but I sort of made that up because I needed a word to write in the SER. And what that basically does is using MCMP and then based on MCMP results they have a model in TRACG which effectively modifies the void reactivity which they would have calculated out of their licensing basis tool to better compare to the MCMP results. That's effectively how the model works in a nut shell. I hope that's a correct characterization of the model.

DOCTOR ANDERSEN: This is Jens Andersen. If I can just make one comment. You are right in this characterization. This particular model is described in the application methodology report and the reason it's described there is that this was part of the effort that we undertook to quantify the accuracy of the various models in TRAC to determine what is the bias and what is the uncertainty of all the models in TRAC in order to know what these uncertainties are in order to apply these uncertainties in the application methodology.

We have quantified all the model uncertainties for the models that we thought were either of high or medium importance based on our tables. The void coefficient is one of these models and the benchmarking against the MCMP calculations were how we quantified the uncertainty in the void coefficient. So this is part of the process of quantifying what bias and uncertainty of the models are so we could account for it in the application methodology.

We can go into details on that particular model, but we probably would want to do that as part of the proprietary session in the afternoon.

MR. ULSES: Sure. Well, one thing I definitely want to point out though is I just want to point out the area where the staff had difficulty with the model, as we understand it.

DOCTOR ANDERSEN: Yes.

MR. ULSES: And the issue basically boils down to the fact that when you run a Monte Carlo code, as I'm sure you're all well aware, you don't get a point answer out of that code. You don't get an answer. You get a range of answers. And the way GE has applied the MCMP results within this uncertainty methodology, they're using the mean value of the predicted eigen value without consideration of the error or of the uncertainty in the analysis.

The issue that I had with that, I mean let's go to a couple of plots here. I don't think any of this is going to be bad. This is basically -- these are the comparisons of the lattice physics results of the code that I used compared to the one that GE used for the sample problem. In other words, the ABWR test reactor that's fictional that's never going to be run.

And then these are some calculations that I did with MCMP myself here at NRC looking at the lattices that were used in that problem with the uncertainty bounds. These are the 95 percentile confidence intervals which are plotted here as error bars. And again, that has it on there. The issue that I really had with this model is that let's say we choose a mean value to do our comparisons with the TGBLA results and we say that there's a difference between the results and let's say we're going to believe the MCMP results and what we're going to do is we're going to change the TGBLA results to match the MCMP results.

But if you look at this plot, it would be equally valid to take the prediction down here versus the prediction up here because again, this is a value which is not a point value. All these values here have been deemed to be effectively the same number within the way that MCMP is usually applied. And if you take this difference and you span this across this curve, it will have an effect on the predicted power response.

It's not going to be significant, but there'll be an effect, and that's not accounted for in this model and that's basically the problem that I had with it, and that's why the SER is written as it is on this particular model. It doesn't have a significant effect on the bottom line answer, which is energy deposition, but I don't believe that it's well enough quantified in this context simply because of the lack of the consideration of this uncertainty band.

MEMBER SCHROCK: Isn't there a probable

value in some distribution?

MR. ULSES: That's basically what this is but the way these codes are usually applied is that you don't simply take the most probable value. Let's say I was going to use this and I was going to do like a criticality safety analysis, for example, which obviously is not really applicable here but that's just an example. What I would do is I wouldn't take this as the answer. I would usually take the upper bound because what MCMP is telling me is that it can't give me an answer with any better accuracy than with what's within this error bar. That's what I'm getting out of MCMP. And the point, that's just simply a mean value, but the code is really telling me that I can't give you an answer with any more accuracy than what's within the error bound and, therefore, I question why the mean value was chosen as opposed to the upper bound versus the lower bound.

CHAIRMAN KRESS: Those error bands, are those one sigma, two sigma?

MR. ULSES: I actually don't recall when I plotted here. I apologize for that. I should have had that in front of me.

CHAIRMAN KRESS: It's probably one sigma.

MR. ULSES: It probably is, I think. Yes.

CHAIRMAN KRESS: Standard.

MR. ULSES: That's what usually is plotted.

MR. HECK: Excuse me, Tony. This is Charlie Heck, Global Nuclear Fuel. I think you said those are 95 percent confidence bands. Those would be equivalent to two sigma.

MR. ULSES: That's right. This is the confidence interval. You're right, Charlie. Thank you for correcting me.

MEMBER SCHROCK: So they're not bounds at all.

MR. ULSES: This is the confidence interval which is what's applied or which is what's usually used as the output for Monte Carlo codes.

MEMBER SCHROCK: You're calling it bounds and they're not bounds.

MR. ULSES: Well, that's probably the wrong choice of terminology. You're correct. But this is a confidence interval which is what the code is telling us. This is the highest level of confidence that the user should put obviously on any number that's in that range. And the way these methods are usually applied is they're not used to derive a point value. If I was simply going to run my lattice code and I wanted to compare it to MCMP, then I would say if I had an answer which landed anywhere within this error bound, I'd say I'm happy with that. But I wouldn't go in and modify the results of my lattice code based on that comparison. That's the area where the staff is a little uncomfortable here. Everybody goes out and they modify and they actually validate their code against this number with the error bars on it and if they say that the answer landed in the error bars, I'm satisfied with that. But this is the first application that the staff has come across where they actually use this result to go in and modify the results of the licensing tool within the framework of a code application. And that's the area where we had some questions. And this was the fist what I would call challenge of this review.

CHAIRMAN KRESS: So what was the final resolution of this challenge?

MR. ULSES: Well, the final resolution is that it does not significantly effect the energy deposition. However, I do not feel that the model has been adequately justified and I wanted to make sure it was pointed out in the SER as such in case it's ever reviewed again. If in the context of that review it's determined that the model would have a significant impact on the result, then a future reviewer would know to look at it. That's the reason why it's documented in the SER, for future reference.

CHAIRMAN KRESS: I was trying to figure out how I would use that distribution and convert it into an uncertainty on the other calculation. I'm not sure how I would do that. But that's what you said you did. You used this distribution to determine the uncertainty in the other calculation.

MR. HECK: This is Charlie Heck, Global Nuclear Fuel. We did use the mean value from MCMP. Those do not get used directly. It's rather the slope of the value versus a void fraction which is what defines void coefficient and we use that to quantify the bias in the void coefficient and the uncertainty in the void coefficient as a function of two parameters that are proprietary in nature that we'll discuss this afternoon.

CHAIRMAN KRESS: But basically you're saying the MCMP is truth and you use that to look at a bias in the thing you got then.

MR. HECK: I acknowledge the point that we are using the mean value from MCMP as the basis for quantifying the void coefficient that MCMP would get for purposes of comparing it to the void coefficient that our TGBLA lattice physics method would predict for the same conditions.

CHAIRMAN KRESS: Okay. I'm not sure I have a problem with that. I'll have to think about it a while.

MR. ULSES: I don't think I have a problem with using it to validate. The issue I had a problem with is using it to modify the output of the licensing basis tool. That's the area of contention. I have no problem actually using MCMP as a validation tool because I believe it's a very accurate code. The issue the staff had was that those results are used then to actually modify the output of the TGBLA results for application in TRACG. That's the area where we had contention. It's not the application of the code as a validation tool. I think that's very acceptable.

MR. HECK: This is Charlie Heck again. I'd just like to put this a little bit in perspective. What we're talking about here is about a three percent bias in void coefficient and about a five percent standard deviation in void coefficient and the results of that on the impact for calculating CPR. So I think we need to consider it within that framework. We're looking at basically the bias and the uncertainty associated with these inputs. In this case, the lattice physics captures these inputs and it propagates from upstream so it's really looking at the variability and the inputs.

I want to emphasize that the variation lattice to lattice across the fleet and the different kinds of lattice configurations. This is just one of hundreds of thousands that that variation that's accounted for on an exposure point by point for each specific core condition is much greater than any sort of bias that we're seeing here on a particular lattice by lattice. It's much, much larger.

And so I would contend that consideration of the fact that the Monte Carlo variation is uncertain within this band is more than washed out by much larger and more important variations associated with modeling the specific problem.

MR. ULSES: What I'd like to do is move on if there's no other questions, comments.

MEMBER SCHROCK: Have I got the right interpretation of the Monte Carlo code? It's a transport theory level code?

MR. ULSES: Yes. You could characterize it as such. Yes. Without going into painstaking details, yes.

That's a good lead-in to the next discussion of the validation which is where I'd like to discuss the SPERT question that you raised, Doctor Schrock. The emphasis in the review was on the validation which was presented against the pressurization transients because those are what are typically limiting. We certainly considered all the validation, but if you look at the SER you're going to find a discussion only on the pressurization transients mainly because that's where the emphasis was placed in the review.

And we discussed the SPERT results in the SER and obviously those are like an RIA type of experiment. They're not really applicable to AOO. They're really beyond scope. But the point of discussing them in the SER was to ensure that if TRACG is ever applied to a situation where they would be significant, that they're reviewed in detail because I agree with you, Doctor Schrock, I believe that with a code like TRACG you should be able to accurately model the SPERT tests, and that's the reason why it's in there. To make sure that in the future if this code is ever reviewed for an RIA type application that it is reviewed and also point out that the staff right now would not be satisfied with those results in that application.

As an example, we've demonstrated that you can model. Let me just put a slide up here. This is from our RETRAN work where we modeled SPERT. You can model the SPERT reactor experiment. This is what I was showing you before. This is what the Nestle code comparing to a SPERT test. It's possible to model that test very accurately with these types of codes. These are the kinds of results that I would have expected to see and that's again why it was pointed out in the SER. Simply to ensure that if it's ever reviewed in the future that it's looked at in greater detail than what it was looked at in this case because it was considered beyond the scope.

CHAIRMAN KRESS: The SPERT just pulls out a control rod and--

MR. ULSES: Right. Yes. It was a rod ejection type experiment. It was a very small reactor. There were no spatial effects. Basically what you're modeling is the ability to balance the reactivity of the system. That's really all you're after here. Which is why point kinetics models do very well on SPERT because the reactor is very small. But the point here is simply that these types of modern, multi-dimensional methods can and ought to be able to model this reactor. That's the point. And to make sure that in the future it is reviewed.

CHAIRMAN KRESS: What did the results look like with the GE code?

MR. ULSES: Well, they're proprietary obviously, but they did okay on the energy.

CHAIRMAN KRESS: The bottom line.

MR. ULSES: Right. Did okay but the power curve was off.

CHAIRMAN KRESS: Shifted?

MR. ULSES: I think it had the peak, if I recall, in the right point but they missed the magnitude by a pretty large percent and then they undershot the tail which is why the energy came out okay in the long run. And again, I can't put the curve up here because I'm sure it's proprietary. But that's the recollection that I have in generalities.

MEMBER SCHROCK: I'm afraid I still have to contend that this paragraph on page eight in the SER--

MR. ULSES: Let me look at this. I apologize. I haven't actually looked at it yet.

MEMBER SCHROCK: It's a totally different picture than you've just described. It's attributing difficulties that you were unable to resolve to the challenging nature. I mean SPERT 3 E-core is a challenging experiment to model. That's what you just said.

MR. ULSES: And the reason why I put that in there is because it is a challenging experiment to model. There was a great deal of effort that went into the results I'm showing you right here. It's not something that you can sit down and model just right off the bat. You're going to have to do code changes in order to do it. It's not going to be something that you're going to be able to handle very easily. It's a very challenging model. It's very challenging to set the input up generating cross-sections. They're very challenging. This thing used control rods.

MEMBER SCHROCK: You could say that of any calculation. I mean if you don't have the proper inputs to match the experiment, you're not going to get --

MR. ULSES: Right, but if you try to apply say like a licensing basis lattice physics tool which you use to model a standard in a light water power reactor, it's going to have a very hard time trying to model this reactor because it used control rods that are the flux trap style. Very difficult to model.

And that's going to be a very large challenge for code model. It's not very easy to do.

MEMBER SCHROCK: I don't find any relevance of that to your purpose in review.

MR. ULSES: Well, the intent of the sentence was to concede the fact that it is a very difficult and challenging experiment to model. However, the point that I'm trying to make here and I believe I make in the end here is that we expect that they should have been able to do a better job and that we would expect to see a better job if we ever had to do a review where we had the results of the discrepancies between TRACG and SPERT which in this case we felt we did not because of the scope of the application.

MEMBER SCHROCK: I read this paragraph and I came away with the interpretation that you're saying that you got poor results and you're not sure why you got poor results but there may be something here for investigation.

MR. ULSES: Right. That's basically the point of this paragraph. To make sure that in the future if the scope of review or whatever include these types of simulations, that the staff would give it the level of review necessary and would then have to resolve the question of why TRACG predicted one thing and the experiment was something else. There are literally a whole host of possible explanations which we didn't delve into in this review because we didn't need to because this was beyond the scope. But I wanted to make sure we reenforced it because it was in the documentation which we reviewed. I wanted to make sure that it had the proper emphasis.

MR. HECK: This is Charlie Heck, Global Nuclear Fuel. I'd just like to comment a little bit more on what you're saying, Tony, about the difficulties in modeling this SPERT core. I'll first of all make the point that it's a code core, so any comparison relative to AOO applications would be questionable at best.

Secondly, it has a much different rod configuration than anything in light water reactors so that again introduces variability. Also, I'd make the point that modeling it in point kinetics where many of the things are of unknown nature and are collapsed down to a single point is perhaps easier than trying to actually model the lattice physics, especially, as you pointed out, Tony, the lattice physics codes themselves have to be modified to handle this particular geometry. In which case you'd have to question whether or not -- well, certainly they're not the same code that's being used to model the AOO events.

Thirdly, I think you make the point right up there on your very slide where you indicate the control rod worth for this particular experiment plus or minus five percent. That's probably very optimistic when you take a look at the data and not even knowing how quickly the rod was ejected and some variations on the speed.

I make the point that the experimental description itself is not of a fidelity that allows it to be terribly useful. Plus or minus five percent is probably a pretty low number. One of the reasons we over-predict the peak in TRAC is because our control rod worth is $1.23 instead of $1.16 or .17 as you show there. We get a higher peak and a narrower pulse. And that thing depends on a lot of conditions all specific to the lattice physics, all of which have been modified in order to accommodate this particular problem. I question its validity for application to AOO events and, in fact, I question its validity for purpose of quantifying rod drop backs events, but it's all we have.

MR. ULSES: Well, I don't think I question the validity for RIAs myself personally but I don't really want to get into that discussion right now. This experimental uncertainty is out of the documentation from the experimenters. I'm not in a position to question that, whether or not it's accurate or not at this point. As for control rod speeds, when I took a look at the documentation, I was able to derive a number that I used for this particular case. This was not an easy experiment to model. This represents a couple of months worth of work.

CHAIRMAN KRESS: The actual rod worth doesn't depend on speed, does it?

MR. ULSES: No. The actual instantaneous value will but the actual final value will not. It's a static analysis.

The point I wanted to make here is that I believe that this particular reactor can be successfully modeled with these methods and at this point, if I was reviewing TRACG for RIA calculations, I would not have been satisfied with those results. But in the context of an AOO review, I believe that it's not applicable for this particular point but I wanted to be sure and emphasize the fact that it would need to be looked at in further detail if the application for RIAs was ever proposed. That's the bottom line. That's the bottom line conclusion and that's the point of having it in the SER because it was in the documentation that was given to us by GNF.

CHAIRMAN KRESS: Does this put into question stability analysis at all?

MR. ULSES: No, I don't think. I think what you're seeing here is I think you're seeing an issue of the rod speed that was used in the analysis myself personally. That's the place that I would look first if I was --

CHAIRMAN KRESS: It would affect the whole--

MR. ULSES: If I was GNF trying to evaluate this, I would look at the assumed rod speed myself.

MEMBER SCHROCK: Because you haven't show us how different your result was from the experiment.

MR. ULSES: Well, these are my results here. This is experimental data. The Xs are experimental data and the red is the Nestle prediction for this particular experiment. What I haven't shown you are the GNF results which are proprietary and I can't put up here right now.

CHAIRMAN KRESS: But you know the peak is higher and the tail is lower.

MR. ULSES: Tail is lower so the energy is in reasonable agreement with the experiment. The only point of putting this particular curve up here is to emphasize the point that the staff believes that it is possible to model this reactor. That's the only point of putting this up here.

CHAIRMAN KRESS: With the same kind of neutronics actually that's's in the GNF code.

MR. ULSES: Well, I'd say generally speaking that's true. This method here is a little newer than the GNF methodology but generally speaking, they're similar.

CHAIRMAN KRESS: Yes, but my conclusion may be different than everybody's. I'm looking at Nestle and I'm saying this has got basically the same kind of neutronics as GNF. Therefore, GNF ought to be usable for these kind of transients. There's just something wrong with the way they model it.

MR. ULSES: Exactly. That's basically my conclusion. That's what I would have concluded had I had the need to get into it in further detail. That's the only point of putting this curve up here is just simply to emphasize that point.

MEMBER SCHROCK: You talked about the

uncertainty in the rod worth. HaVe you done the calculation for the limits on how much effect would Nestle tell you it has?

MR. ULSES: No, I have not but it would be very large. This reactor is very small and very sensitive to rod worth. Extremely sensitive to rod worth.

CHAIRMAN KRESS: Well, your Nestle predicted $1.16 rod worth.

MR. ULSES: Right.

CHAIRMAN KRESS: So you did calculate it.

MR. ULSES: Well, I calculated the value but I didn't assess what would be the effect if I actually increased it by five percent.

CHAIRMAN KRESS: You didn't do a sensitivity analysis.

MR. ULSES: Right. I didn't do a sensitivity analysis because that was not the point of this study. This was simply to see whether or not the code could model the reactor. Again, this was out of the context of the RETRAN review where they were trying to do RIA analysis. That was the point of that review.

CHAIRMAN KRESS: I would have guessed about a five percent effect on the --

MR. ULSES: I don't know whether it would be linear or not but it would definitely be there. It should be there and it would be fairly significant. Anyhow, I'd like to not dwell on this because this is just simply to emphasize a point.

CHAIRMAN KRESS: But the message I get out of that is that this kind of code can calculate SPERT.

MR. ULSES: And that was the point.

CHAIRMAN KRESS: And the GE code ought to be able to do it, too. They just did something wrong with the analysis somewhere.

MR. ULSES: And again, we're just simply trying to emphasize the point for future if it's ever looked at again.

This is almost some philosophy as much as anything else. Obviously, difficulties in this case led to a success, I would say, in that we actually were able to get into the MCMP modeling which is something that I wouldn't have looked at had I not had these problems. Obviously, this is almost a personal pep talk. Work harder at trying to define a problem where we can eliminate any of these cross-section issues at all. That was not something I was successful at in this case, and that's what led to a lot of these issues. I was trying to find a problem where I can give the applicant cross sections. So that is not a question at all. So all we're doing is looking at the results of the diffusion theory solver with absolutely no effect on the input stream which was an effect here that was very difficult to try and resolve.

And I think it would be very important for the staff when we're trying to review these codes -- like, for example, TRACG -- to have access to the up-stream codes which are used to generate input. That would allow the staff to do further sensitivity studies and to try and answer some of these questions about the input stream as well as it would also help us to eliminate input stream issues which is really the bigger reasons.

And obviously the bottom line conclusion is think before I jump to conclusions and write out these RIAs which end up being incorrect. So that's the bottom line philosophy. And that's really all I had to say today. If there's any other questions, I certainly can entertain them now or we can talk later. But that's the bottom line conclusion of the staff review of TRACG kinetics. And I believe now we're going to hear from Yuri to discuss statistics.

CHAIRMAN KRESS: That ought to be

interesting. Thank you, Tony. Appreciate it.

MR. ULSES: I didn't know your water over or hit my head on your television screen.

DOCTOR LANDRY: Doctor Kress, while Yuri is getting set, I think this has again shown us that this move to insist on the applicant's code being in-house for our own use has been a good move to make.

CHAIRMAN KRESS: Yes, I agree with you.

DOCTOR LANDRY: Much of this would not have occurred had we not had the code and done this experimenting with the code. If we had not done this experimenting with the code, we would not have seen much of this. Whether you go down the right path or the wrong path, you're learning something about the code and the methodology that's being used and we've been gaining experience through this whole process. This has in some ways been a little painful. Tony said mea culpa. But it's been good in that we have learned a great deal in the process. I think that, all things considered, it has enabled us to perform a better review than simply looking at documentation.

CHAIRMAN KRESS: I think that's a good perspective. I'm glad to hear you say that. We'll continue to support that type of review.

Yuri, I don't think we've met you before.

DOCTOR ORECHWA: No. I'm a new kid on the block. My name is Yuri Orechwa. I'm from NRR in the Reactor Systems Branch and the staff.

What I want to review is the uncertainty evaluation that was presented to us for evaluation with TRACG analysis of anticipated operational occurrences. What I'm going to focus on is the methodology. I can't repeat all their calculations. So the question is if they did the arithmetic according to the rules which they presented, then we can judge the results accordingly.

So what we're going to look at, the review topics that were requested, was to look at the model uncertainties and biases. TRACG is a deterministic code. So what we're saying is the models are imperfect. Those imperfections, we need to express them somehow in the results. Once that's established, how do we combine that in order to make statements concerning design limits and operating limits?

Let me give a heuristic overview so that you see where I come from, where I'm going, and some of the notation that I'm using. I have to apologize. I'm of the old school. I still write things down. I have a tough time with the modern software which is so helpful that it takes you an hour to find one symbol that you need.

CHAIRMAN KRESS: To tell you the truth, I prefer this. I'm used to seeing them like that.

DOCTOR ORECHWA: All right. Let me say then what's TRACG in the context of what we're going to do. We can write down in operator notation the neutronics model and the thermal-hydraulic model. Those are coupled through the thermal-hydraulic conditions and the power of that. Both operators are dependent on parameters. Those parameters, like in the neutronic model, the reactivity coefficients of course are important. In the thermal-hydraulic model it would be from correlations and things like that. In my notion, the theta and phi set are the things that are the beginning and are at issue at the starting point.

TRACG is deterministic. You put in your input, you specify theta and phi. You will get a number when you do your computation. If you put the same input, the same phi and the same theta, you're going to get the same number. Whether that number is right or wrong, Tony discussed. We're assuming that that's done. Now the question is what are the theta and phi going to do? We have also initial conditions where there are also some parameters usually and stuff like that.

So at issue is the determination of the distribution of those parameters. In order to do anything statistically, you've got to have sample from somewhere and you have to characterize that sample. To determine the model uncertainties, we need to always estimate some distribution and the parameters for that distribution. That represents then, it summarizes the state of knowledge. And GE has presented in my view, an enormous amount of data from tests, from qualifications and all that.

Now, suppose we get our distribution of those parameters of theta and phi. Then we know that the solution, the TRAC solution -- that is the parameters that are the output of the TRAC -- will be dependent on the theta and phi. Because those come from the distribution, will give us a distribution of TRAC solutions. So in the TRAC solution which I kind of write like a vector. It's not really a vector in the mathematical sense but the set parameters. Each parameter will be distributed. Given that distribution, you can them make some kind of determination of the confidence you can put into a design limit. So that's the issue. How do I get then to the design limit?

MEMBER SCHROCK: Yuri, could I ask, how does the selection of the node size enter into what you're describing, or does it, for a specific --

DOCTOR ORECHWA: Because it was considered, but I don't think it's big. I don't consider it here. It's not a statistical issue.

CHAIRMAN KRESS: It seems like the only way you could incorporate it is to change it and see what effect it has on the distribution you get out.

DOCTOR ORECHWA: That's a question of algorithm. It's not a statistical issue.

DOCTOR ANDERSEN: This is Jens Andersen. We did do a fair amount of nodalization sensitivity studies that are documented in the qualification reports. We did it both for simple tests as well as for full scale plant cases. What we did was that we basically looked at the simpler test to determine what was an adequate nodalization. We then ran a plant case and we did nodalization studies around what was considered an adequate nodalization and we basically quantified how large the sensitivity were on the critical safety parameters, and we were able to show -- and this is actually documented in the qualification report -- that with the nodalization we had chosen, doing further refinement to the nodalization had very little impact on the calculated results.

DOCTOR ORECHWA: Nodalization is a convergence issue. It's not a statistical issue.

MEMBER SCHROCK: Well, I'll have to think about that a little more. I think the distributions are influenced by the nodalization.

DOCTOR ORECHWA: The distribution of the basic parameters has nothing to do. Once you do a solution to the TRAC equation, it will be. Nodalization will enter a bias, you might say, but that should come out given some parameter. If I pick a theta and a phi, then I can compare a TRAC for different nodalizations and see if I'm going to a solution. I converge to this level. Now this level will vary because I choose different parameters for my models. So it's a convergence issue.

CHAIRMAN KRESS: There may be a question about when you use nodalization to determine the input as to whether or not that might affect the distribution.

DOCTOR ORECHWA: I think, at least in my experience, any code that's been nodalized is in a fine mess. Once you get it, somewhere there has to be in the manual documented what the effect of nodalization is. That's a verification and validation issue. The models that enter for the specific versions is a different issue. Just say with respect to thermal-hydraulics.

CHAIRMAN KRESS: So so far you're saying that there are specific inputs to the code that have to have a distribution.

DOCTOR ORECHWA: That's right.

CHAIRMAN KRESS: And that distribution has to be determined.

DOCTOR ORECHWA: That has to be determined.

CHAIRMAN KRESS: And it's generally determined as much as possible by data and GE has a lot of data.

DOCTOR ORECHWA: Right. I will go through each of these points again.

CHAIRMAN KRESS: And the input has to be propagated through the system to get these outcome design limits.

DOCTOR ORECHWA: That's what I want to step through afterwards.

CHAIRMAN KRESS: Okay.

DOCTOR ORECHWA: I was just going to say with regard to nodalization and convergence, one of the millennial problems in mathematics is the uniqueness of the Navier-Stokes equation. So we don't even know if the solution exists.

MEMBER SCHROCK: We don't solve Navier-Stokes equations here so that's not a problem.

CHAIRMAN KRESS: We bypass that.

DOCTOR ORECHWA: We can all run out and solve the how the existence and come home with a quick million dollars. But those are the issues.

Okay. Now, suppose we have the distribution of the TRAC output. Then the third basic figure of merit which is used by GE is based on critical power ratio. And that's defined as the GEXL correlation as a function of what the thermal-hydraulic conditions are that TRACG gives over the power given by TRACG.

Because our TRACG solution has a distribution, the critical power ratio will have a distribution and there again then we can talk about what is the confidence level with which we pick some limit or operating limit?

CHAIRMAN KRESS: Is there a distribution on the GEXL part of that?

DOCTOR ORECHWA: No, because the input -- this is the thing that has a distribution. It has its own uncertainties.

CHAIRMAN KRESS: I know. There are parameters in it.

DOCTOR ORECHWA: Right, but that's a separate issue.

CHAIRMAN KRESS: That's a separate issue.

DOCTOR ORECHWA: I don't want to touch that one. But the point is that we start with parameters in the TRACG. Varying those, we get a distribution of the output, the thermal-hydraulic conditions and the power distribution. Putting that into this correlation, we can get a distribution of the CPR and we can then make statistical statements about it. So that's the basic name of the game.

So the first thing is model uncertainties. That's in my notation theta and beta. GE follows the CSAU methodology for that and begins with what I would call the delphi method. People see what phenomena are important in the TRACG calculation, the relative importance, and identifies those. Those are then the phenomena that are associated with parameters that will have the highest impact on the solution and, therefore, we need to go out and get them.

The next step then is, having identified what phenomenon there are and what parameters are associated with those, you establish the nominal values and uncertainties for these parameters. There is an enormous amount of data that is presented from separate effects test facility data, integral test facility data, components qualifications, BWR plant data, and these are all analyzed and the statistical analysis for each is presented in the report.

For some parameters for which there is no data, code comparisons are made. In particular, for the void coefficient, for example, which Tony discussed, code comparisons need to be made. And also everywhere there always lurks engineering judgment, no matter what you do.

Now, let me just comment with regard to the void coefficient, the analysis there. Overall, the evaluation of the experimental plant, etcetera, data is done by standard techniques. Look at the distribution. You assess whether it's normal. They use a test which I had never heard of before, the Anderson-Darling test, but that's neither here nor there. And goes through, presents the data, shows everything in regular fashion so it can be assessed. And it looks proper.

In the void coefficient analysis, the main variation comes with the variation across assemblies or fuel types, whatever they call it. There is an enormous number of them in the GE stable. There's 11, Charlie, or nine? Eleven. Eleven are chosen as representative of variation. These aren't chosen by random. These are chosen to be representative because there are so many. If you get down to the nitty-gritty, you should have chosen them by random but that would have been an extremely small sample. Probably would have had a big bias. So the natural tendency is we would like to choose something which is representative. I don't have a problem with that, but it is not according to the rules of sampling statistics, and I don't think -- with small samples, you will always have a problem of bias and I think by trying to be representative you're probably moving in the right direction. I just want to comment on that issue. So the spirit is there.

CHAIRMAN KRESS: When an application comes in to use this, the variation in fuel types across the core won't be random.

DOCTOR ORECHWA: There are a lot of different fuel types in the core.

CHAIRMAN KRESS: Yes, but they'll know what they are.

DOCTOR ORECHWA: Oh yes, but you're putting in one number to say the uncertainty is. The uncertainty is not being associated with each lattice, type of lattice. Okay. It's across lattices.

MEMBER FORD: Would you mind going back to your previous slide, please. Maybe I missed the discussion of the very first bullet. Have an impact on what?

CHAIRMAN KRESS: On the important outputs.

DOCTOR ORECHWA: Looking at anticipated operational occurrences, these are measured with what's happening to the power pressure and things like that in a transient. What will affect those the most? You have a huge equation. Some parameters will be more important than others.

MEMBER FORD: So if I was worried about a materials problem -- just for instance -- for instance, what is a fast neutron flux of the core shroud? Outside this --

DOCTOR ORECHWA: No, it's not a transient issue of materials.

MEMBER FORD: I'm still learning here.

DOCTOR ORECHWA: Okay. Then, of course, as I said, for all of these different phenomena that have been rated, the normality of the distribution is assessed, which is nice, and then there's an estimate made.

Do you have a question?

CHAIRMAN KRESS: Yes, on the "evaluate the normality." That's based on the assumption that the distribution will be normal and you'll want to check to see if your assumption is correct.

DOCTOR ORECHWA: Yes, there are statistical tests.

CHAIRMAN KRESS: Yes, I understand the test.

DOCTOR ORECHWA: You look at the data and it gives you a statistic for various --

CHAIRMAN KRESS: And suppose that statistic makes you question your assumption of normality. What do you do then?

DOCTOR ORECHWA: Statistic tells you at what confidence you can say and those chose at the 95 confidence level that it is normal. You never have 100 percent.

CHAIRMAN KRESS: But suppose I only had 70 percent confidence in my normality. What do I do then?

DOCTOR ORECHWA: Okay. You can approach it in different ways with non-parametric statistics and stuff like that. I think this is experimental data and this is traditionally normal because there are so many other small things that come in. I think in what GE has presented invariably it is. In a few cases, it looks kind of ---

CHAIRMAN KRESS: So it's just kind of a hypothetical question.

DOCTOR ORECHWA: Later on it becomes a little bit more of an issue.

Let me just say that although in the report it's almost parenthetic that they do a sensitivity analysis, but I think it's very important in the long run that the sensitivity of CPR in the turbine trip event with respect to each parameter as to what the sensitivity to that is and it's diligently done for each case.

CHAIRMAN KRESS: You'll already have a distribution.

DOCTOR ORECHWA: Yes.

CHAIRMAN KRESS: But you don't know what particularly caused that distribution or what the most important parameters are so you go back and do a sensitivity study to find out which of those parameters had the biggest effects.

DOCTOR ORECHWA: How big the effect is if I vary that one parameter only.

CHAIRMAN KRESS: That one only. It gives

you just additional information.

DOCTOR ORECHWA: It gives you very important information later on, at least the argument that I will make. So that's important.

Design limits. The parameters are combined by random sampling from each of the parameters. Now, GE just does straight random sampling. There are methods where you can kind of tighten up by using choice of sampling.

CHAIRMAN KRESS: Latin Hypercube test.

DOCTOR ORECHWA: Latin Hypercube is the one in KSU and things like that. Let me jump ahead a little bit. I think for this application it's probably okay because things are kind of -- the transients are slow and things like that.

CHAIRMAN KRESS: The only issue that generally comes up with strict random sampling is how many do you need to get the right --

DOCTOR ORECHWA: How many. For small samples, it's an issue because you introduce bias right away in a small sample. So it's just something that needs to be noted but if you have rapidly changing functions as you would have in a severe transient, you might want to pay a little bit more attention as to your sample size and its behavior in that case, I think. But it's something that has no definite yes or no answer again, as usual. So I want to bring that up.

So you sample from these parameters, you stick them in TRAC, you compute values. We get those values and then we do our usual normal theory. Put them in the frequency table and we again check normality. If it's normal, we can then make a statement concerning at 95 percent level various design parameters, temperature, pressure, etcetera, whatever you want to do, and you can set those.

Note greater than or equal to 59. Why is that? As you said, suppose it's not normal. Then what do you do? I still want to talk about setting a limit with this level of confidence. And GE does the usual thing. You look at order statistics. What you do is you sequentially by size put your sample down, 59 out, and then the 95th limit is the 95th one. So if I random sample all those, it comes from the theory that 59 is -- it's not 60, it's 59.

Now note though. This isn't mentioned. You can't get blood out of a turnip. Because when you say you have a normal distribution, that's an enormous amount of information so the non-parametric interval is going to be usually significantly larger and then it might be so large as being not very meaningful at times. So just because you have an interval that's 95, your data may really be somewhere else or something. Just because you're using order statistics, that's fine and you can talk about it but you still have to be careful as to exactly what you're doing underneath that. This is just a comment on that.

CHAIRMAN KRESS: The bottom line is for realistic code applications the rule calls for a 95/95 -- figures of merit?

DOCTOR ORECHWA: Yes, that's what people usually talk. And for that you need 59 samples.

CHAIRMAN KRESS: You need 59 samples and you reached it then.

DOCTOR ORECHWA: Yes. And even for normal that's my experience is it's getting to be. Okay. So using that, you can get your design limits. But what we want in order to assess the transient is what GE does is talks about the operating minimum critical power ratio. It has two components. The safety limit critical power ratio, which is the value of CPR which is less than .1 percent of the rods and the core expected to experience. That's just a definition.

In the transient, delta CPR is the contribution from the transient itself and then the equation says that steady state CPR basically equals -- you have the absolute limit plus the contribution from the transient. So that's the relationship on which we base.

The key element in the computation is the computation of the probability of rod experience in transition or boiling. There are two things that GE focuses on. The two ingredients, I should say, that are in the computation that they use. Experimental data from the Atlas facility which gives you a distribution of experimental CPR. This is defined this way and because it is experimental data, it will give you a distribution.

Now, then you have a computed by TRACG for a specific reactor. Minimum critical power ratio. I have an intellectual disagreement with GE on their computation of the probability. Let me first, because this dates back, I think, 30 years. Let me just point this out. The probability is the integral over a distribution function of CPR. What is done is the computation, if this is your experimental data, this value that they put on to compute the probability, this is determined by TRACG. You're mixing two distributions. The TRACG value is in your limit and you're integrating over an experimental value. So you can do this only if this is true that the two distributions are the same.

Let me give an analogy that's extreme. Let's take the price of bananas, 1.25 per pound or something. I can put it on here and calculate a number, a probability. You say you're crazy, price of bananas has nothing to do with CPR, which is true, and to a more limited extent, the computation of TRACG and the experiment, there is a difference. This is the heart of the matter that we're getting at and you can't just slough over this intellectually.

CHAIRMAN KRESS: Experimentally. Can you extract a CPR out of that?

DOCTOR ORECHWA: Let me go on.

CHAIRMAN KRESS: Okay.

DOCTOR ORECHWA: Fundamentally, this is strictly verboten to mix.

CHAIRMAN KRESS: I can see that.

DOCTOR ORECHWA: You can do it in the context of Bayesian statistics but then you're going to have to find a loss function in order to get your point estimate of the probability. That would be the correct way to go, blah-blah-blah. But you still have to then-- you can mix the distributions and then say I have --

CHAIRMAN KRESS: The problem I have is experiments don't actually measure the critical power ratio. You have to derive it somehow.

DOCTOR ORECHWA: Excuse me.

CHAIRMAN KRESS: I'm trying to figure out how you would overcome your objection.

DOCTOR ORECHWA: Let me go on. I will overcome my objection.

CHAIRMAN KRESS: I'll let you go on.

DOCTOR ORECHWA: Let me say we apply statistics and there are certain assumptions for all these things. We will never meet the assumptions exactly. So you got to have a little bit of judgment. So given that in principle, what we're doing is strictly verboten. GE doesn't do this but let me try to argue the following. This will be my argument and you can give me a grade on it. With classical statistics you come through the back door and you bring engineering judgment.

Point one is if we take the experimental value and we just expand it -- I mean we live by that. Here is all the sensitivity. Now they've computed all the sensitivities. I can use just chain rule and get all the sensitivities through there. The sensitivities are all very, very small if you look at them down the line. The qualification examples that they give and I think what Tony showed, that this is pretty good. So the correction that differentiates these from what we know of the real world and TRACG and all that is probably okay.

My other argument would be we're talking about .1 percent probability and less. So we're way out in the tail end of the distribution. The contribution to the probability of a difference in the CPRs out there will be almost negligible. So either one or both will, I think, support that what they are doing is, I think, within our engineering judgment.

MEMBER SCHROCK: The experimental CPR from Atlas is for one bundle.

DOCTOR ORECHWA: Is it for one? I thought it was for many bundles.

MEMBER SCHROCK: A small number, in any case.

DOCTOR ORECHWA: There are thousands, I thought.

DOCTOR ANDERSEN: This is Jens Andersen from GNF. We have measured the critical power for each single fuel design that we have developed in the Atlas test facility, 7 X 7, 8 X 8, 9 X 9, 10 X 10 fuel. For each fuel design, we run a large number of tests, typically anywhere from 500 to 1,000 tests in order to characterize the critical power as it depends -- pressure inlets, up-cooling. So we have typically a database of 500 to 1,000 data points in order to determine the experimental uncertainty or the uncertainty in the jet fuel correlation in predicting the critical power. That's an ECPR distribution.

MEMBER SCHROCK: So you've put together many tests to build up a core characterization of CPR. Is that the picture?

DOCTOR ORECHWA: Yes. Right.

MEMBER SCHROCK: The reason I ask the question is that you're defining minimum critical power in terms of one-tenth of one percent of rods in core. I didn't think that you had that kind of capability in the experimental determination, but I see that you do.

DOCTOR ORECHWA: There's a tree you're barking up on that I'd like to address that should really be looked at. And I think it's mentioned in CSAU methodology, which is when you have a lot of parameters, which you do in this case, in order to really represent the response surface for that, you quickly need a lot of data because it goes by the number of values on each axis to the power of the dimension that you run out of data very quickly in order to give a characterization and, here again, I think what saves this case, at least my view of looking at the data, is the transients are mild, response is smooth.

Once you get into something else where you may be getting into instabilities or something like that, you're not going to have smooth functions, and I think there you're going to have to very carefully look at that issue. So this case, yes. Another case, it's not going to be so smooth.

Any other questions? What grade do I get?

CHAIRMAN KRESS: On your proposed fixed, you get an A.

DOCTOR ORECHWA: Thank you.

CHAIRMAN KRESS: That's a good fix. Expect I really don't think you need a fix.

DOCTOR ORECHWA: All right. Since I got an A, we can now determine the operating limit critical power ratio. Let me just make a comment here, one comment concerning the submittal. This is probably one of the most critical parts and it gets one page in the write-up and it's pretty undecipherable. Things should be written up a little bit better, I think, for us even to review. So I made my best stab at it.

I think the spirit of the thing is that we can't track any of these large codes which take a half a year to set up. You're not going to run random sampling on them. It will take an enormous amount of runs. You'll be there forever. So how do you divide and conquer? How do you compartmentalize some of the calculations to maximize your information so you can make a statement with a little bit less effort by emphasizing certain things?

GE's approach, the way I read it, is that you first look at the generic behavior of transients for classes. You have a transient class, you have this type of BWR, you have this type of fuel, etcetera, and you can develop a distribution of the CPR for that. So the ingredients are first by class a distribution. The other one then is for a specific case you run a specific transient all the way through. Then you can also for the specific case just in steady state, your initial condition because it's not a transient, it's an easier calculation, you can do sampling on that and run them through.

You can then combine them via this equation by sampling the two distributions that you have and you get a distribution of MCPRs for which you can then compute the value which is the criteria for setting your operating limit minimum critical power ratio. To my mind, that looks legitimate. I think it accomplishes the purpose. You do capture the uncertainties present both in transient, both in the initial state and you kind of bridge them with a calculation which is specific to the case under consideration. I don't think that that's an unreasonable approach.

Now, I think now having gone through the methodology and it looks okay, GE does present a lot of qualifying data where they look at actual transients, the uncertainty band which is generated using this methodology and I believe that there is sufficient agreement to be able to use it for analysis of AAOs given the background of all the back when we started with the uncertainties that today we associate with the input parameters to the TRAC calculation.

CHAIRMAN KRESS: So your bottom line is that uncertainty methodology is pretty good with the possible exception of the philosophical difference which probably doesn't make much difference.

DOCTOR ORECHWA: Yes. I wanted to bring that up because it can make a difference in some situations.

CHAIRMAN KRESS: Could later.

DOCTOR ORECHWA: I think in that case it has to be -- because for 30 years that calculation has been done as if those two distributions are identical. And I just want to put a flag out there not in principle because if they're not in principle, then you have to make an argument for why you think you can get away with it and I passed the argument by you guys why I think they can get away with it.

CHAIRMAN KRESS: Are there any other questions? You're getting hungry? Well, thank you very much for a tutorial on how to do uncertainties, Staff us not through yet.

MR. BOEHNERT: It should be short.

CHAIRMAN KRESS: Why don't we go ahead and hear it then and that won't give such a gap in between. Sorry, I thought that was it.

DOCTOR LANDRY: I'd like to cover just a couple more items before we break and go on after lunch to the applicant's presentation. You've heard a great deal of the experience that Tony has had running the code and some of the work that he has done. We've also been running the code on plant decks and to look at the overall experience of a user in applying the code to an analysis of an AOO transient.

That experience has shown us that TRACG uses input decks that are very closely related to the decks that are from the original TRACB code which really means that if you have a knowledgeable TRAC user, that person can come in and pick up work with TRACG with a minimal level of additional education or retraining.

Major changes from TRACB to TRACG are well-described in the model description report appendix. We're pleased with that. We did note that the execution structure of control blocks though has been retained from the TRACB. In other words, the control box must be executed in numerical order and if you want to go back and use the same control block, you have to put it in again. There's no ability to select control blocks according to the use within the input stream. You have to continue in a numerical sequence.

We did feel that additional guidance could be provided to the user on time step size. The time step size selection. But on the other side of that issue, the applicant has developed a set of standard input decks for all of their plants which takes the user effect out very much, that the user doesn't have too much option and doesn't have too much effect on the calculation with TRACG.

We also noticed that TRACG determines the correct flow regimes during the steady state initializations, unlike some other codes where the user can select flow regimes randomly or for different stages, different components. The user doesn't have that option with TRACG so we're pleased that this removes the user effect from the code.

CHAIRMAN KRESS: Is the time step checked internally in the code to see that it meets stability criteria?

DOCTOR LANDRY: There are time step checks but we thought that in looking at the material it would be useful if the user had a better definition of proper selection of time step.

CHAIRMAN KRESS: I was trying to figure out what you thought was needed as additional guidance there.

DOCTOR LANDRY: There are checks and balances there but we thought that the user would benefit by having it better defined. But then again, as has been said a couple of times already, the code is used internally within the General Electric corporation where they have the ability to educate the user beyond what the documentation would say. They have an ability that if the documentation is not adequate for the general public, they can cover for that by making it part of their training program.

MEMBER SIEBER: Is that institutionalized?

DOCTOR LANDRY: Yes. They have a training program within the corporation.

MEMBER SIEBER: It has a QA program attached to that so that you can carry on?

DOCTOR LANDRY: Right. That all comes under the QA program also. The use of the code, the ability of the user, all gets checked and balanced through the QA program.

MEMBER SCHROCK: Does this imply the utility user is less skillful?

DOCTOR LANDRY: Well, the utility doesn't use the code.

MEMBER SCHROCK: Not at all?

DOCTOR LANDRY: Unless General Electric is licensing the code to their utilities, all the calculations are done by General Electric.

MEMBER SCHROCK: Okay. I didn't understand that.

DOCTOR LANDRY: Some of the conditions and limitations that we identified in the SER. We have already discussed the GEXL 14 correlation and the issues surrounding GEXL 14. Again, to emphasize that once resolution of those issues is arrived at, that we expect that to be applied within the use of TRACG.

We've also pointed out in the presentations already this morning and in the SER that TRACG, if it is to be applied to stability analysis, will have to be submitted for staff review for that application. We are not approving the code for a stability analysis. They haven't asked for that either. It has not been reviewed for Atlas. They have not asked for that, but we want to call out. Since Atlas is considered a transient, we want to identify that if it is applied to Atlas, we want to re-review it.

The discussion that Tony presented, the PIRT 18 model needs further justification before application to reactivity insertion or control rod ejection accidents. Tony raised that question. How can Monte Carlo model reliably predict point kinetic answers? Of course, the code is not being applied for that at this point anyway, but if it should be, these are issues that are going to have to be addressed.

We also identified in the review that for isolation condensers further justification or review may be necessary.

MR. BOEHNERT: What's the deal there, Ralph? What's the problem?

DOCTOR LANDRY: This was identified back when the in-depth thermal-hydraulic review was performed. There was a feeling that the modeling of isolation condensers was not adequate and needed further review. So again, we did not see where that had changed and we felt that we needed to point out to future reviewers, as has been said a couple of times this morning, this is a flag to reviewers of applications of the code that if it is applied to a plant with an isolation condenser, they need to look carefully at this condenser to see if it is critical to the transient progression. Then they need to look at it more carefully. If it's irrelevant or low meaning for the transient, we're not so concerned.

MEMBER SCHROCK: You had another proviso in the SER which says that if the level tracking model is invoked where there is significant void, it will have to be re-evaluated.

DOCTOR LANDRY: Right. That's an identification to the staff also when this code is submitted for LOCA, which we anticipate in the not too distant future, that we want to look at that level tracking model. There is not significant voiding for the transients for which it is being applied, but when they get into LOCA space, then we want to look carefully and we want the staff involved to look carefully at the level tracking model.

MEMBER FORD: On the staff evaluation and conditions limitations, there's a whole series of questions arising out of the earlier subcommittee meeting here. Are these conditions/limitations you have there, would they be changed if you took into account these questions?

DOCTOR LANDRY: We could put in more but we have looked at and discussed with the applicant those concerns that were brought out and identified on the agenda and this afternoon General Electric is going to present information dealing with those specifically. We have been discussing with General Electric what they're going to present and we do not have problems. We are not in conflict with them at this point.

MEMBER FORD: So these are merely points of detail which get washed out.

DOCTOR LANDRY: Well, they're points of detail that may not affect the application to AOO transients, but they are some points which we will be looking at carefully when we see the code for LOCA analysis. Some of those are not important for AOOs and will be important for LOCA.

MEMBER FORD: But that will be discussed this afternoon.

DOCTOR LANDRY: Yes.

MEMBER FORD: The justification for that statement will be discussed this afternoon.

DOCTOR LANDRY: General Electric is going to present information on those this afternoon.

Staff conclusions. Again, GEXL 14 will be acceptable when it is handled in accordance with agreement with the staff. The kinetic solver is adequate to support the conclusion that the models are correctly derived and account for phenomena involved in AOO transients. Kinetic solver benchmarking demonstrates that TRACG adequately predicts results for AOO transients. Staff analyses provide confidence that TRACG is acceptable for AOO transients.

Uncertainty analysis follows accepted CSAU analysis methodology. Uncertainties and biases have been identified and all highly ranked phenomena based on experimental data have been validated. The process is acceptable and the quantities are reasonable.

MEMBER FORD: I guess my frustration with all these conclusions. If you are reading those conclusions from a paper, certainly there's been no support from any of those conclusions given today.

DOCTOR LANDRY: No support?

MEMBER FORD: Well, the last one, the process is acceptable and the quantities are reasonable. We haven't seen any detailed documentation to support those conclusions. I'm assuming that the back-up for those conclusions are given in other documents.

DOCTOR LANDRY: In the documentation on the code, but that's what Yuri was going through, that yes, the process that they went through in their analysis, he had some philosophical differences, but for the application the conclusion was it's acceptable.

MEMBER FORD: I guess I'm learning about this process as to what we're signing up to approve. That's where I'm -- if I was a reviewer of a paper or of a report, I wouldn't sign off on it based on what has been presented today.

CHAIRMAN KRESS: No, you have to do it in connection with all of the documentation we've been supplied which is a lot of stuff to go through.

DOCTOR LANDRY: We don't reiterate all of the submittal. What we're doing is saying what our findings are based on a review of the submittal without going through a reiteration of everything that was submitted to us.

We also have concluded that the standard input has been developed for the classes of BWR systems for which TRACG is to be applied, BWRs 2 through 6, and that the staff finds TRACG 02A code -- again, that's designation of which version this is -- is acceptable for application to the AOO transients presented in the submittal that's dated in January of 2000.

So those are the conclusions that the staff has arrived at. Based on our review, we feel that the code is acceptable for application to the AOO transients. We've identified areas of concern and we've identified items that we would call out as flags for future applications, that if it goes outside the scope of AOO transients, other things need to be looked at.

CHAIRMAN KRESS: Thank you. Are there any other additional comments from either members or from GE before we break for lunch? I propose we come back at 1:00 and hear the rest of the story. Recess.

(Whereupon, off the record at 11:55 a.m. to reconvene at 1:00 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:00 p.m.)

CHAIRMAN KRESS: Okay. We are now back in session again and you guys may proceed. Here's the part where you're going to answer all of our previous questions. Right?

DOCTOR ANDERSEN: My name is Jens Andersen and I'm going to give a brief presentation on the TRAC application for anticipated operational occurrences for transient analysis. If you'll go to the second slide, Charlie.

Let me just introduce the people that are here for General Electric. Over there we have Jim Kapproth who is the manage of engineering and technology. This is myself. We have Fran Bolger who's sitting here who's team leader for the transient analysis. Charlie Heck is helping me who's the responsible engineer for TRAC. Brian Moore who's team leader for technology and development who is our nuclear expert and we have Antonio Possolo from corporate research and development who is a statistician that has helped us out. And then finally we have Bharat SHiralkar who is the project manager for the application of TRAC to LOCA which is the submittal that we are planning.

What I'm going to talk about is the submittal of TRAC. We submitted fairly extensive documentation of TRAC to the NRC. We have had a long review of TRAC. We have had numerous meetings and communications with the NRC, phone conversations, emails, meetings. There were a number of requests for additional information, and GE Has provided responses to these questions and I'll get into details on that.

We've also had review with the ACRS Thermal-Hydraulic Subcommittee. We had a meeting on November 13 last year. I'm going to address some of the comments that we have received from the ACRS and I'm also going to comment on some of the issues that came up at the end of the SBW review. And finally, I'm going to go into some concluding remarks.

Just to reiterate. The scope of the application was to apply to operating boiling water reactor in United States and that would be BWR 2 to BWR 6. The events that we applied for are the anticipated operational occurrences, also called transients, which are basically operational events that deals with either increase or decrease in reactor pressure, increase or decrease in core flow, increase or decrease in reactor coolant inventory and decrease in core coolant temperature. These are the so-called

Chapter 15 events.

The documentation that has been submitted for TRAC is that we first had a document that was called the TRAC licensing application framework for AOO transient analysis. That was actually submitted to the NRC in 1999 and that was basically a document that laid out the entire plan for how we would apply TRAC to transient events. And then later towards the end of 1999, we submitted the model description. In early 2000 in January, we submitted the qualification document and the application methodology.

In addition, we submitted the TRAC user's manual and we made the TRACG 02A source code available to NRC and, together with the source code, we made a number of sample problems and test cases available.

The scope of the review has been to review the application of TRAC to transient and the objective was to get a safety evaluation report for the application and evaluation of the TRAC's capability for AOO transients and evaluation of the qualification we have supplied to support that application and finally, an evaluation of the application methodologies which is how we apply TRAC for transient events.

The time line. As I said, we submitted

the road map, the plan for the whole process in May of 1999. All the LTRs were submitted to the NRC by February of 2000 and we had a kick-off meeting that involved a meeting both with the NRC and the ACRS Thermal-Hydraulic Subcommittee on March 16 of the year 2000. In April of 2000 the NRC issued the acceptance review which is basically that the documentation that was provided was sufficient to allow the review to go on.

We had first a major meeting with NRC on NRC review concerns in September of the year 2000. The ACRS Thermal-Hydraulic Subcommittee was in November of 2000. And then we had numerous other communications. During this period, we have received 23 requests for additional information and we have provided responses to all these requests and all issues have been resolved. The draft safety evaluation report, we received that in July 2001 and we're having this meeting today on August 27, 2001 and, of course, what we are hoping to get out of it is closure by September and get the safety evaluation report by September.

As I said, we had submitted extensive documentation on TRAC and the previous slide listed the number of documents we have submitted. We have relied on prior NRC reviews and acceptance of TRACG application. There has been numerous application of TRAC where it has been applied for LOCA, transient, ATWS and stability applications that have been accepted by the NRC and the thermal-hydraulic model of TRAC was substantially reviewed during the SBWR project. That project was canceled in 1996 and that review was then subsequently stopped. However, NRC issued a letter documenting the status of the review when the SBWR program was stopped.

Anyway, we have had numerous interactions with the NRC. We have supported the TRAC installations of the NRC computers and the benchmarking against the NRC codes. We've had the review with the ACRS Thermal-Hydraulics Subcommittee in November. We received a total of 23 requests for additional information including an RIA that was generated from ACRS comments. Most of these RIAs dealt with providing additional information and clarification of issues and we have provided all of these responses and I would like to make the comment that I feel that we have had a very good interaction with the NRC reviewers. We have had a very professional and open candid communication with the NRC and I personally have been very pleased with how this review has progressed.

Now is probably the time where we are getting into some of the proprietary material.

MR. BOEHNERT: So we close the meeting. We'll go to a closed meeting transcript.

(Whereupon, at 1:10 p.m., the proceedings went into Closed Session.)

CHAIRMAN KRESS: Does the staff wish to make any additional comments at this time? I'll tell you what. Let me go around the table here and see if we have comments from the consultants or the members, and then you might want to respond to some of those. I guess I'll start with you, Virgil. You have any comments in the way of wrap-up comments you'd like to make now or would you prefer to wait until you digest it?

MEMBER SCHROCK: I think I'm going to have to write the comments. I just don't see any way I can summarize them all now. In some respects, the report that I submitted in November has been addressed. In some respects, it's not.

CHAIRMAN KRESS: Yes. I think that was what I was looking for.

MEMBER SCHROCK: I could try to sort those out for you.

CHAIRMAN KRESS: I think it's a little premature. Why don't you think about it and do it in your second report. There's no use doing it now.

MEMBER SCHROCK: My comments on the SER at the beginning of this meeting may have been more severe than they should have been, but I do think the SER should be written in clearer language than it is.

I think it needs to be more technically correct than it is. I think there are still some problems that I'm going to comment on in my final report.

CHAIRMAN KRESS: That would be helpful.

I guess you're not allowed to comment at this stage. Do you wish to make any more comments?

MEMBER SIEBER: No, I don't think so.

CHAIRMAN KRESS: I don't have any additional ones, so I think I'll see if the staff has any additional comments they want to make before we decide what to do for the full meeting.

DOCTOR LANDRY: I think we've tried to make it clear that this is a draft SER. There are areas in which we intend to make some revisions. We had intended some revisions coming in. There are areas that we felt could be bolstered and we'll, of course, take into consideration the comments and views of the subcommittee in making those revisions to the draft SER so that our goal is to have a complete product.

CHAIRMAN KRESS: Okay.

DOCTOR LANDRY: We would appreciate getting a copy of Professor Schrock's comments.

CHAIRMAN KRESS: We will. That was an omission and that shouldn't have happened. We'll be sure you get the next one.

How much time do we have on the agenda?

MR. BOEHNERT: We have an hour and 40 minutes.

CHAIRMAN KRESS: On the full committee. An hour. Almost two hours. Right?

MR. BOEHNERT: 10:20 to 12:00 noon on the 6th of September.

CHAIRMAN KRESS: Okay. My suggestion would be, #1, that this GE presentation we just heard, answering the previous questions I think would be valuable for the whole committee to hear. So I would want to see that from GE. From the staff, I think the committee is pretty familiar with the way the uncertainty analysis was done so we don't really need much on that. But I would like to see sort of a shortened overview of the SER because we really have to have that. Not necessarily the full thing but at least talk about the limitations and the code assessment part. Something like slide seven on or something in Ralph Landry's.

I think we would want to hear a little bit, an abbreviated version of the kinetics part. I'd like particularly to have a little bit of that where you talked about your experience with the use of the code itself. I think that was helpful. And maybe some abbreviated discussion of the use of MCNP and, of course, your final wrap-up slide of your findings. I think that would be my impression. Do any other committee members want to comment?

MEMBER SIEBER: I'd start with slide five rather than seven so that people understand what the scope really is. Slide five actually states that.

CHAIRMAN KRESS: Let's see. Maybe the staff would have about 45 minutes and GE 35. Do you think you can fit it into that kind of time frame?

MR. BOEHNERT: That's total time so allow some time for questioning.

CHAIRMAN KRESS: Yes, that's total time. Normally we say presentation time is 50 percent of total time. So if there are no more comments or questions, I'd like to thank everyone. GE, thank you, and thanks to staff, particularly those from Frank Rosenfeld for coming back and helping us out. Hope you can make it to the September meeting, too.

MR. ULSES: Absolutely no problem. It's always a pleasure.

CHAIRMAN KRESS: Okay. Thank you very much. With that, I guess this is a recess because tomorrow is a continuation of the same subcommittee.

MR. BOEHNERT: That's right.

CHAIRMAN KRESS: So tomorrow we hear about water --

MR. BOEHNERT: That's correct.

CHAIRMAN KRESS: Okay. I'll call this subcommittee meeting recessed until tomorrow.

(Whereupon, the meeting was recessed.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: ACRS Thermal Hydraulic Phenomena Subcommittee

Docket Number: (Not Applicable)

Location: Rockville, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Rebecca Davis

Rebecca Davis
Official Reporter
Neal R. Gross & Co., Inc.

TRACG CODE FOR ANTICIPATED OPERATIONAL OCCURRENCES

DRAFT SAFETY EVALUATION REPORT

ACRS THERMAL/HYDRAULIC SUBCOMMITTEE

RALPH R. LANDRY
REACTOR SYSTEMS BRANCH
AUGUST 22, 2001

TRACG DSER

TOPICS

- REVIEW TIMELINE
- APPROACH TO REVIEW
- CODE APPLICABILITY
- CODE ASSESSMENT
- STAFF EVALUATION
  - THERMAL-HYDRAULICS
  - NEUTRON KINETICS
  - STATISTICAL METHODOLOGY
  - CODE USER EXPERIENCE
- CONDITIONS AND LIMITATIONS
- CONCLUSIONS

TRACG DSER

REVIEW TIMELINE

- MAY 25, 1999 - PRELIMINARY INFO MEETING
- JULY 15, 1999 - PRELIMINARY INFO MEETING
- JANUARY 2000 - TRACG SUBMITTAL
- NOVEMBER 13, 2000 - ACRS T/H SUBCOMMITTEE
- JULY 2001 - FORMAL RAIs ISSUED
- JULY 2001 - DRAFT SER

TRACG DSER

STAFF APPROACH TO REVIEW

- EXTENSIVE T/H REVIEW DURING SBWR REVIEW EFFORT FOR LOCA APPLICATION
- STAFF BUILT ON THAT REVIEW FOR AOO REVIEW
- EMPHASIS ON NEUTRON KINETICS AND STATISTICAL METHODOLOGY

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TRACG AOO APPLICABILITY

- INCREASE IN HEAT REMOVAL BY SECONDARY SYSTEM
  - DECREASE IN FEEDWATER FLOW
  - INCREASE IN FEEDWATER FLOW
  - INCREASE IN STEAM FLOW
  - INADVERTENT OPENING OF SAFETY RELIEF VALVE

- DECREASE IN HEAT REMOVAL BY SECONDARY SYSTEM
  - LOSS OF EXTERNAL LOAD
  - TURBINE TRIP
  - LOSS OF CONDENSER VACUUM
  - CLOSURE OF MAIN STEAM ISOLATION VALVE
  - STEAM PRESSURE REGULATOR FAILURE
  - LOSS OF NON-EMERGENCY AC POWER
  - LOSS OF NORMAL FEEDWATER

- DECREASE IN REACTOR COOLANT FLOW RATE
  - LOSS OF FORCED REACTOR COOLANT FLOW
  - FLOW CONTROLLER MALFUNCTION

- **REACTIVITY AND POWER DISTRIBUTION ANOMALIES**
  - STARTUP OF INACTIVE OR RECIRCULATION LOOP
  - FLOW CONTROLLER MALFUNCTION CAUSING INCREASE IN BWR CORE FLOW RATE
- **INCREASE IN REACTOR COOLANT INVENTORY**
  - INADVERTENT OPERATION OF ECCS
  - CVCS MALFUNCTION
- **DECREASE IN REACTOR COOLANT INVENTORY**
  - INADVERTENT OPENING OF PRESS RELIEF VALVE

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CODE ASSESSMENT

- ASSESSMENT PERFORMED BY COMPARISON WITH DATA FROM:
    - PHENOMENOLOGICAL TESTS
    - SEPARATE EFFECTS TESTS
    - INTEGRAL SYSTEMS TESTS
    - PLANT OPERATIONAL DATA
- PLANT NODALIZATION IS TO BE CONSISTENT WITH ASSESSMENT MODELING
- PIRT PREPARED CORRELATING PHENOMENA WITH TESTS AND QUANTITATIVE ASSESSMENT PERFORMED
- ALL MEDIUM AND HIGH RANKED PHENOMENA ASSESSED
- ASSESSMENT SHOWS CAPABILITY OF CODE TO REPRESENT EXPERIMENTAL AND OPERATING DATA

TRACG DSER

STAFF EVALUATION
THERMAL-HYDRAULICS

- Two-fluid model, six conservation equations, boron transport equation, noncondensible gas mass equation.

- Two-regime unified flow map - covers normal operating and anticipated regimes for BWR.

- Two-phase level tracking model uses approximations for void fraction above and below mixture level with cutpoint, α_{cut}, for level detection. Acceptable for AOO, but will be reevaluated for LOCA application.

- Kinetic energy term retained in energy equations. Avoids energy balance errors due to nonconservation of energy.

- GEXL heat transfer correlation:

    - NRC staff review related to power-uprate found data generated by COBRAG code used for GEXL14 correlation instead of experimental data.

TRACG DSER

STAFF EVALUATION
THERMAL-HYDRAULICS

  - Use of artificial data instead of empirical data called into question validity of statistical results used to establish MCPR Safety Limit.

  - Resolution pending - when NRC staff approves critical boiling length correlation uncertainty, it will be applied in use of TRACG.

- Basic component models are used as building blocks to construct physical models.

- Applicability to isolation condenser needs to be demonstrated should the code be applied to transients for which the condenser is important.

- Steam separator validated against full-scale performance data for two-stage and three-stage steam separators.

- Default - fully implicit integration for hydraulic equations and heat conduction equations by predictor-corrector iterative technique. Implicit coupling between heat conduction and coolant hydraulics. Less prone to error on phase shift in a thermally induced oscillation.

TRACG DSER

STAFF EVALUATION
NEUTRON KINETICS

TONY ULSES

TRACG DSER

STAFF EVALUATION
STATISTICAL METHODOLOGY

YURI ORECHWA

TRACG DSER

STAFF EVALUATION
USER EXPERIENCE

- TRACG uses input deck closely related to input deck specification of original TRAC-B code.
- Knowledgeable TRAC user can readily understand structure and design of TRACG input.
- Major changes from TRAC-B to TRACG well described in Model Description report appendix.
- Execution structure of control blocks retained.
- Additional guidance to the user on time step size would be useful.
- TRACG determines correct flow regimes for components during steady-state initialization.
- Standard input has been developed for classes of BWRs and transients. Reduce user introduced errors in code results.

TRACG DSER

STAFF EVALUATION
CONDITIONS AND LIMITATIONS

- USE OF GEXL14 CORRELATION IS ACCEPTABLE PROVIDED THAT WHEN NRC APPROVES THE CRITICAL BOILING LENGTH CORRELATION UNCERTAINTY IT IS APPLIED IN USE OF TRACG.

- SHOULD TRACG BE APPLIED TO STABILITY ANALYSIS, THE METHODOLOGY IS TO BE SUBMITTED FOR STAFF REVIEW.

- TRACG HAS NOT BEEN REVIEWED FOR ATWS.

- PIRT18 MODEL NEEDS FURTHER JUSTIFICATION BEFORE APPLICATION TO RIA ANALYSES. HOW CAN A MONTE CARLO MODEL RELIABLY PREDICT POINT KINETIC ANSWERS?

- SEPARATE ISOLATION CONDENSER MODEL OR ABILITY TO ADEQUATELY MODEL THE CONDENSER NEEDS TO BE DEMONSTRATED SHOULD APPLICATION BE MADE TO ISOLATION CONDENSER IMPORTANT TRANSIENTS.

TRACG DSER

CONCLUSIONS

- USE OF GEXL14 CORRELATION ACCEPTABLE PROVIDED NRC APPROVED UNCERTAINTY APPLIED.
- KINETICS SOLVER IS ADEQUATE TO SUPPORT CONCLUSION MODELS ARE CORRECTLY DERIVED AND ACCOUNT FOR PHENOMENA INVOLVED IN AOO TRANSIENTS.
- KINETICS SOLVER BENCHMARKING DEMONSTRATE TRACG ADEQUATELY PREDICTS RESULTS FOR AOO TRANSIENTS.
- STAFF ANALYSES PROVIDE CONFIDENCE TRACG ACCEPTABLE FOR AOO ANALYES.
- PIRT18 RESULTS DO NOT SIGNIFICANTLY AFFECT AOO ANALYSES.
- THE UNCERTAINTY ANALYSIS FOLLOWS ACCEPTED CSAU ANALYSIS METHODOLOGY.
- UNCERTAINTIES AND BIASES HAVE BEEN IDENTIFIED AND HIGHLY RANKED PHENOMENA BASED ON EXPERIMENTAL DATA VALIDATED.
- THE PROCESS IS ACCEPTABLE AND THE QUANTITIES ARE REASONABLE.

TRACG DSER

CONCLUSIONS CONT'D

- STANDARD INPUT HAS BEEN DEVELOPED FOR THE CLASSES OF BWR SYSTEMS TO WHICH TRACG IS TO BE APPLIED.

- THE STAFF FINDS THE TRACG02A CODE ACCEPTABLE FOR APPLICATION TO THE AOO TRANSIENTS PRESENTED IN THE SUBMITTAL, NEDE-32906P, "TRACG APPLICATION FOR ANTICIPATED OPERATIONAL OCCURRENCES (AOO) TRANSIENT ANALYSES," DATED JANUARY 2000.

TRACG Kinetics Review

Tony P. Ulses
USNRC
August 22, 2001

Outline

- Topics Covered
- Method of Review
- Review Conclusions
- Lessons Learned / Detailed Description of Specific Review Areas

Areas of Review

- Documentation
- Theoretical Development
- Auxiliary Models
- Validation

Method of Review

- As in the past, performance based
- Documentation and theory were reviewed
- Emphasis on execution of code and comparison to relevant benchmarking
- Executing the code led the staff into review subjects that would have been missed had we not run the code

Review Summary

- Modeling captures relevant physics
- Auxiliary models (i.e. direct moderator heating, structural heating, etc.) well theoretically developed
- Decay heat model adequate for proposed application
- Documentation acceptable for internal GNF use. Some models undocumented or documentation is weak.

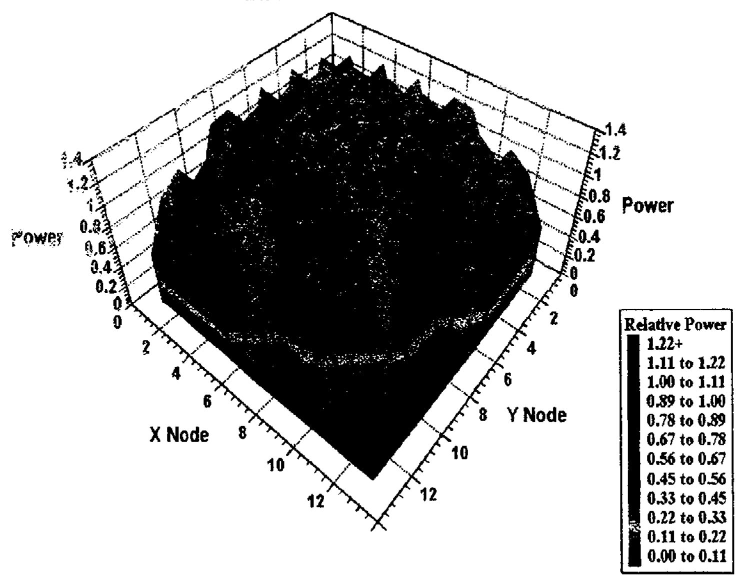
GNF Validation Studies

- Peach Bottom Turbine Trips
- Hatch 2 pump trip and MSIV closure tests
- NMP2 Pump Upshift
- Leibstadt Loss of Feedwater Event
- Numerous stability events

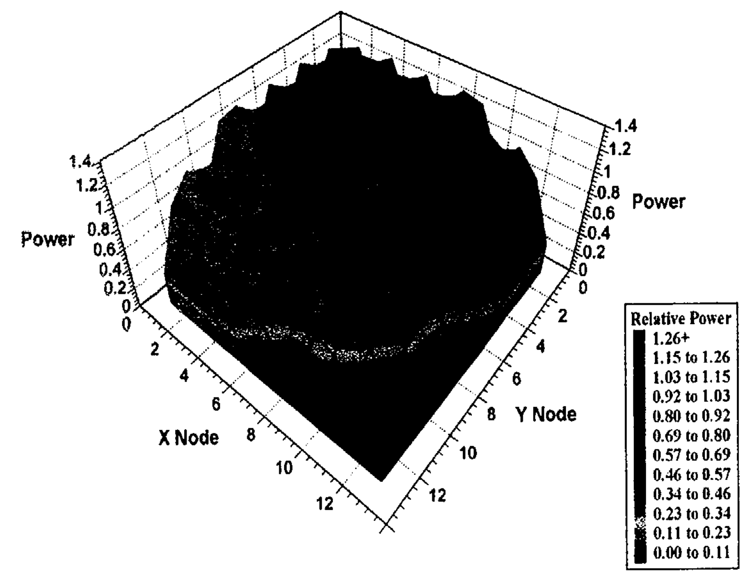
Test Problem

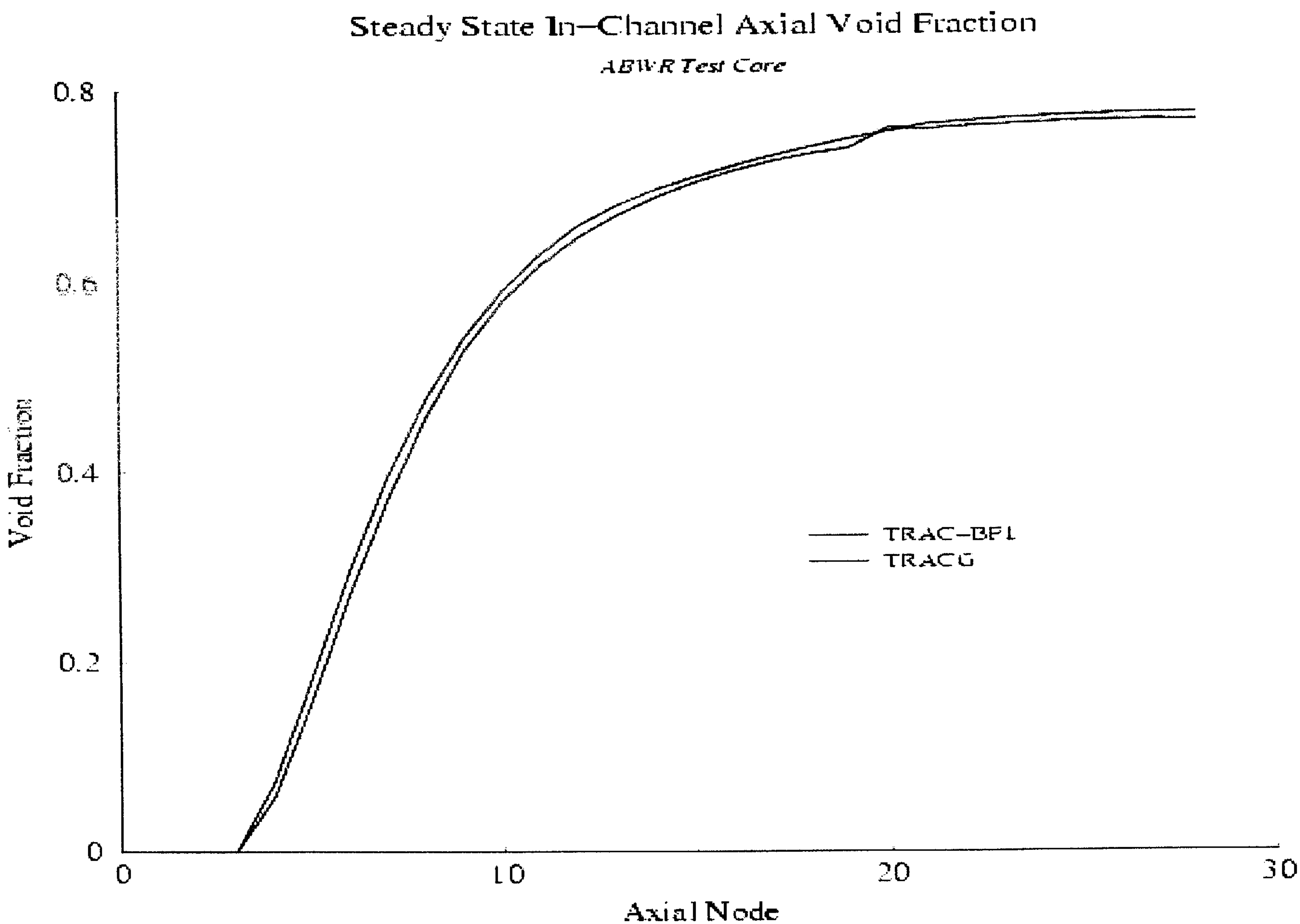
- Intended to improve staff's understanding of TRACGs ability to model a core with modern fuel design
- Based on ABWR core design
- Only models reactor - no balance of plant
- Steady-state results compare well
- Small pertubation transient results compare well

TRAC/NESTLE



TRACG





Steady State In–Channel Axial Void Fraction
ABWR Test Core
0.8
0.6
0.4
0.2
0
Void Fraction
TRAC–BF1
TRACG
0
10
20
30
Axial Node

Simulated Pressurization Transient

- Simulated MSIV closure without SCRAM using complete deck to generate boundary conditions
- Modeled transient with different modeling options

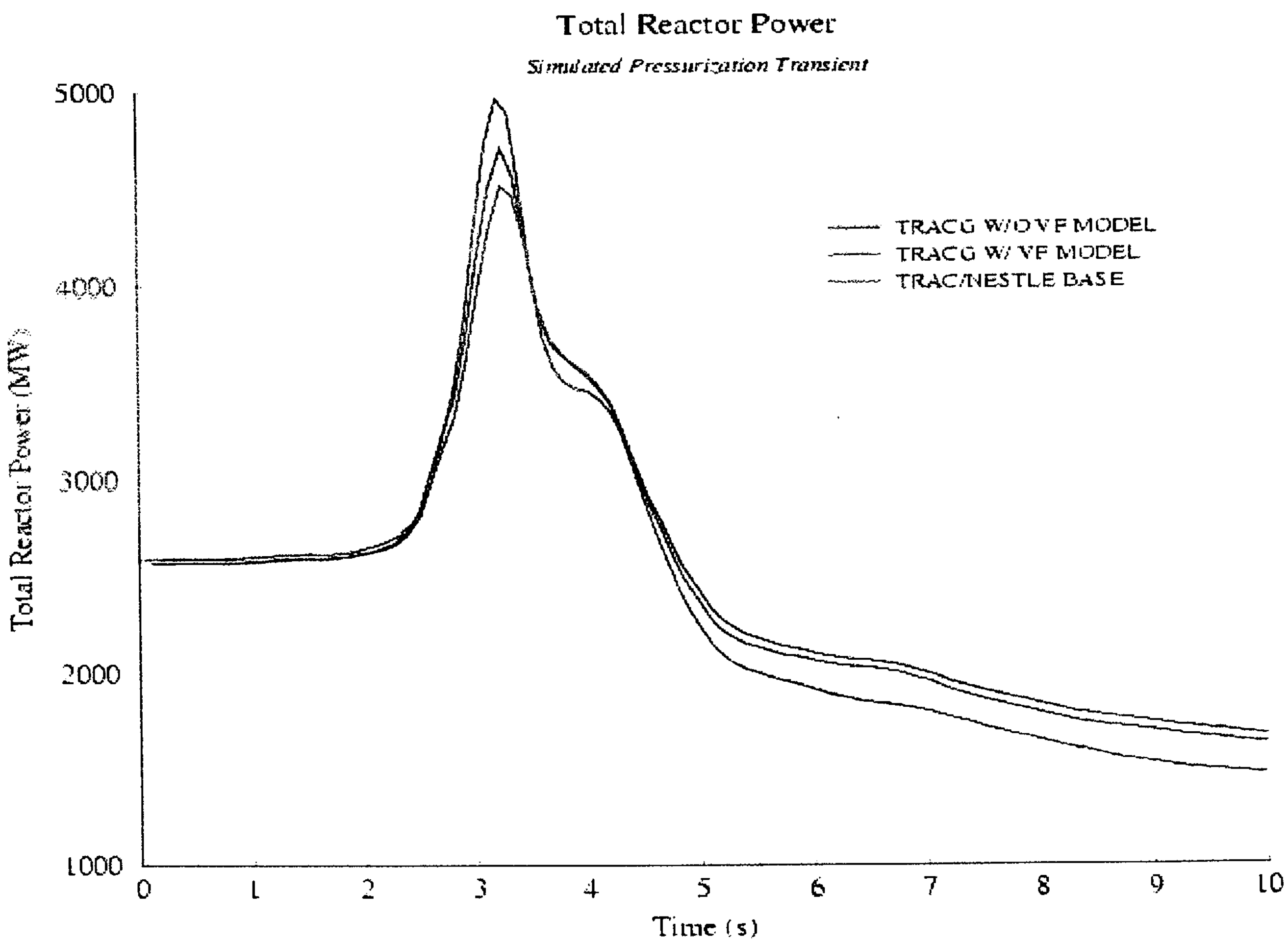


Figure 5 Total Reactor Power for Simulated Pressurization Transient

Review Conclusions

- Reasonable assurance that TRACG can be used as an AOO analysis tool

- Based on staff analyses and evaluation of GNF benchmarking

- Not reviewed for licensing application to any non-AOO transient (i.e. stability, RIA, etc.)

Challenges!

- First time that the staff was unsuccessful defining a problem to eliminate cross section effects
- Difficulties identifying reasons for differences
- Improper conclusion regarding the source of differences
- Problems led staff to review items that would have not been fully reviewed

Use of MCNP

- GNF relies heavily on MCNP
- MCNP used to validate TGBLA code results
- MCNP results used to tune TGBLA results in TRACG
  - PIRT18 model
- Everyone uses MCNP to validate; staff knows of no other organization using MCNP results to modify licensing code predictions

PIRT18 Model

- MCNP, like all Monte Carlo codes, does not provide user with single valued results
- Predicted eigenvalues are statistically derived and have uncertainty
- Uncertainty represented by the 95th percentile confidence interval needs to be accounted for
- Staff predicted uncertainty bands would lead to small differences in TRACG predictions if applied to results
- Effect of model is minimal - not well justified

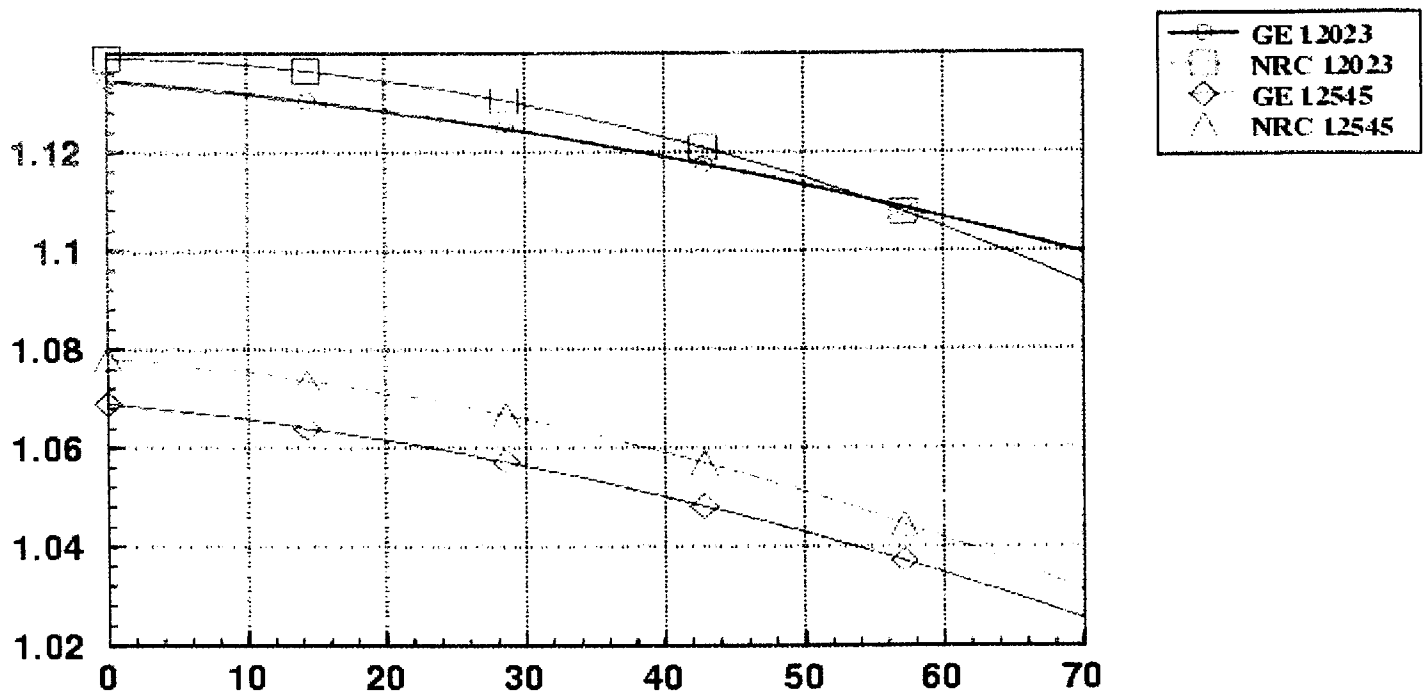


Figure 2 Comparison of Void Reactivity between NRC and GE Methods for Sample Core

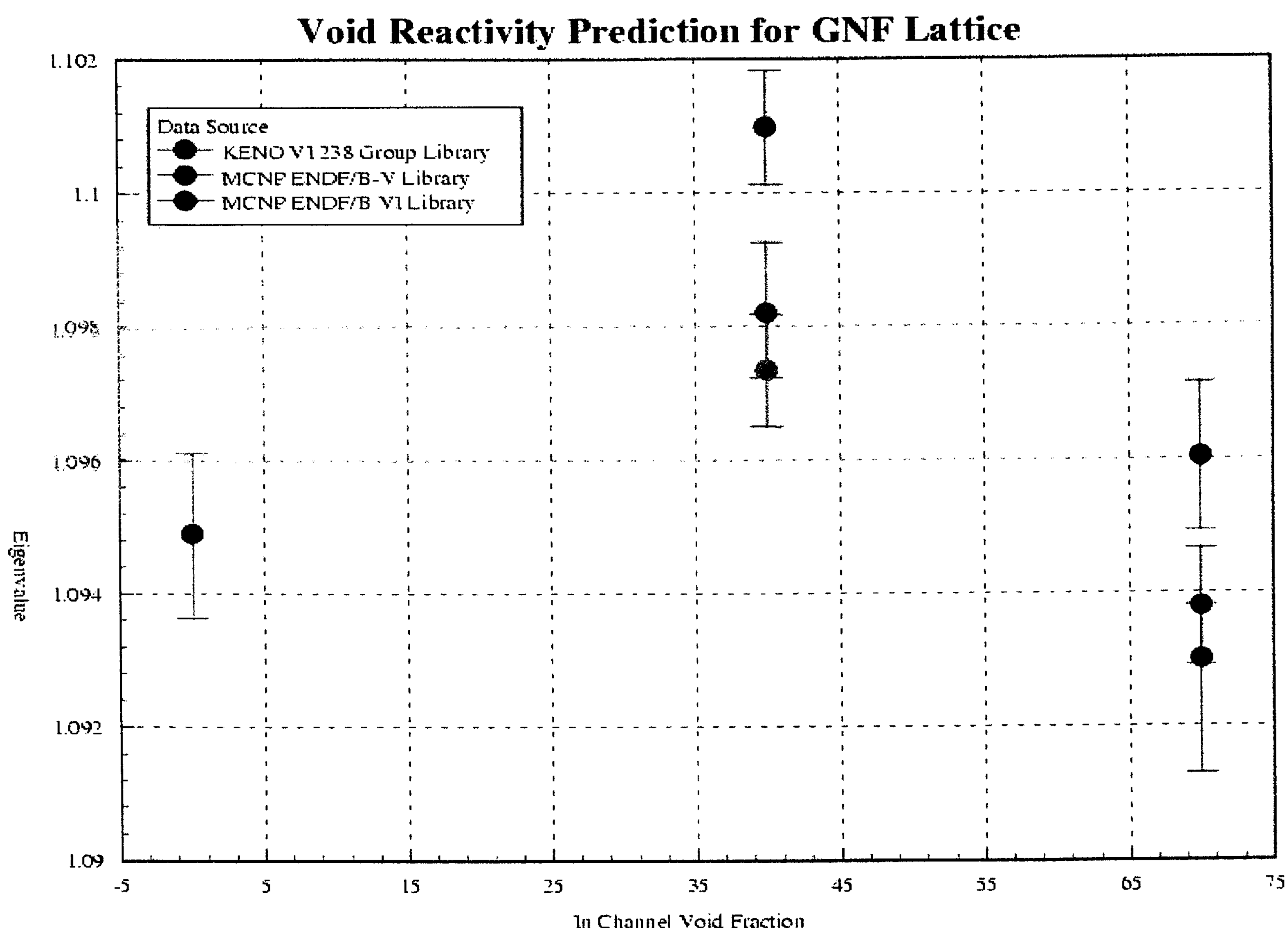


Figure 6 Comparison of Different Monte Carlo Evaluations of the Same GNF Lattice

Validation

- Non-valve closure transients were considered, but did not form a large part of our review conclusion
- Staff conclusions regarding SPERT predictions differ from GNF
- Staff's own methods validate very well against SPERT demonstrating that three-dimensional diffusion theory codes can predict test
- GNF results do not compare well with experiment - not considered in our review because of proposed application

Lessons Learned

- Even difficulties can be successes
- Work harder at defining problems that eliminate cross section effects
- Require that upstream codes needed to properly perturb input stream information be supplied
- Don't jump to conclusions - THINK!

TRACG Analysis of Anticipated Operational Occurrences

Review of Uncertainty Evaluation

Y. Orechwa

NRR/DSSA/SRXB

Review Topics

- Model Uncertainties and Biases
- Combination of Uncertainties to Estimate Design and Operating Limits

TRACG

Neutronic Model:

$$\underline{\underline{A}}(\underset{\sim}{\theta}, \underset{\sim}{\psi})\, \underset{\sim}{P}(\underset{\sim}{r}, t) = \underset{\sim}{S}(\underset{\sim}{r}, t)$$

Thermal-Hydraulic Model:

$$\underline{\underline{B}}(\underset{\sim}{\varphi}, \underset{\sim}{P})\, \underset{\sim}{\psi}(\underset{\sim}{r}, t) = Q(\underset{\sim}{r}, t)$$

Initial and Boundary Conditions

$$\underset{\sim}{\theta} \sim f_N(\mu_\theta, \sigma_\theta^2) \qquad \underset{\sim}{\varphi} \sim f_{TH}(\mu_\varphi, \sigma_\varphi^2)$$

∴ Determination of Model Uncertainties and Biases

$\Rightarrow$ estimate $f(\mu, \sigma^2)$

TRACG Solution:

$$\underset{\sim}{\psi}^{TRACG}(\underset{\sim}{r}, t \mid \underset{\sim}{\theta}, \underset{\sim}{\ell}) \equiv$$ thermal-hydraulic conditions at $(\underset{\sim}{r}, t)$

$$\psi_k^{TRACG} \sim$$ distribution function

$\Longrightarrow$ **Design Limits**

$$CPR = \frac{q_{crit}^{GEXL}(\underset{\sim}{\psi}^{TRACG})}{q^{TRACG}(\underset{\sim}{\psi}^{TRACG})}$$

$\Longrightarrow$ **Operating Limits**

Model Uncertainties and Biases of $\underset{\sim}{\theta}$, $\mathcal{L}$

- Identify Phenomena that have an impact

- Establish nominal values, biases, and uncertainties for the model parameters in TRACG associated with the phenomena identified above.

  - Separate effects test facility data
  - Integral test facility data
  - Component qualification test data
  - BWR plant data
  - Code comparisons
  - Engineering judgement

- **Evaluate normality and estimate distribution parameters for $\underset{\sim}{\theta}$ and $\underset{\sim}{\phi}$.**

- **Sensitivity of** $\Delta CPR / ICPR$ **to variation in each model parameter for a turbine trip without bypass.**

Combination of Uncertainties

A. Estimation of Design Limits

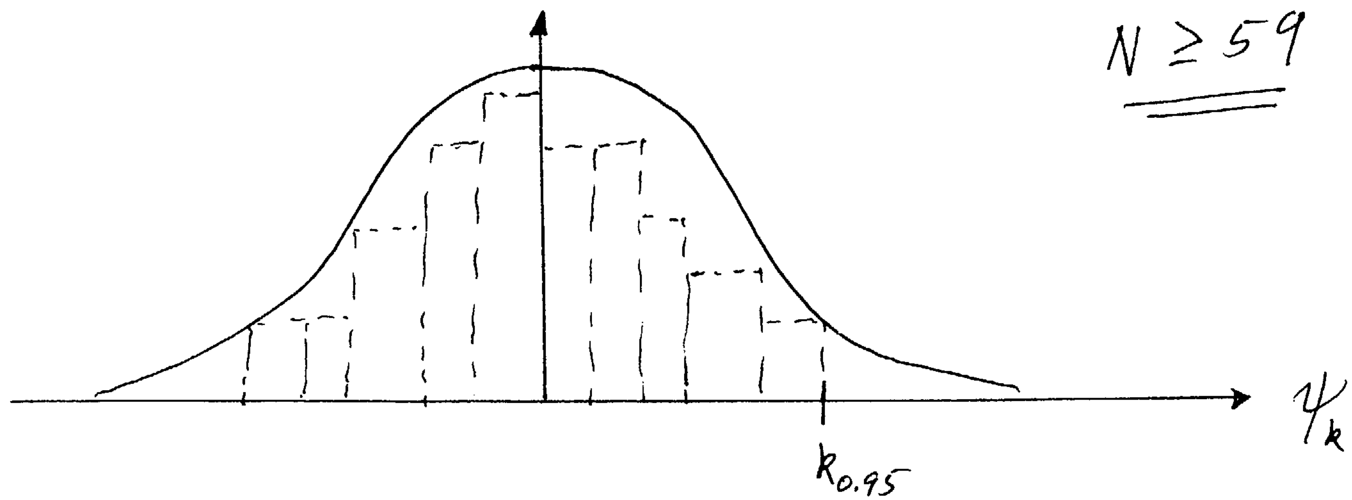
Design Parameters

$$\psi_k = \psi_k(\underline{r}, t \mid \underset{\sim}{\theta}, \underset{\sim}{\varphi})$$

where

$$\underset{\sim}{\theta} \sim f_\theta(\mu_\theta, \sigma_\theta^2) \qquad \underset{\sim}{\varphi} \sim f_\varphi(\mu_\varphi, \sigma_\varphi^2)$$

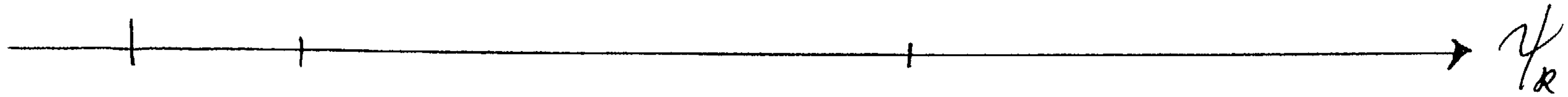
I. Normal Theory



$$\psi_k \leq \bar{\psi}_k + z_{0.95} \times \sigma_\psi$$

II. Order Statistics

$$\psi^{(1)} < \psi^{(2)} < \cdots < \psi^{(59)}$$



$$\psi_R \leq \psi^{(59)} \text{ at } 95\%$$

Note: Normal Theory intervals are likely to be much smaller than the Order Statistic estimates.

B. Determination of Operating Minimum Critical Power Ratio

- **Safety Limit Minimum Critical Power (SLMCPR)**

  "Value of CPR at which less than 0.1 % of the rods in the core are expected to experience boiling transition"

- **ΔCPR**

  "Change in CPR due to transient event"

- **OLMCPR = SLMCPR + ΔCPR**

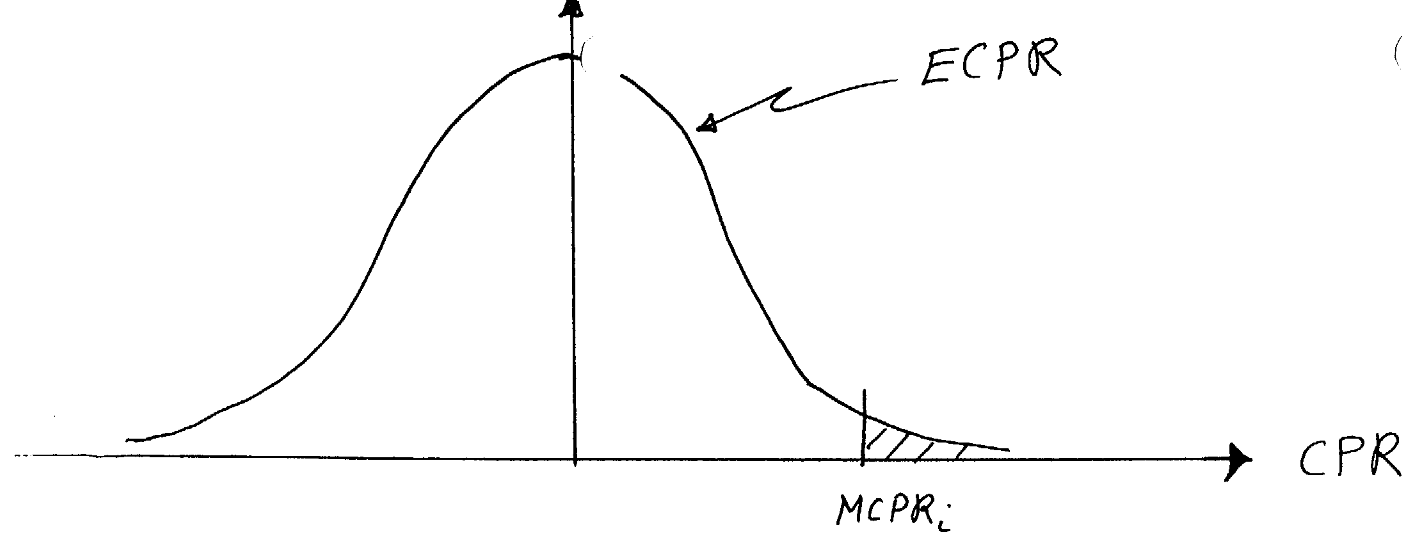
Computation of the Probability of a Rod Experiencing Transition Boiling

- **Experimental Data (Atlas facility):**

$$ECPR \equiv \frac{q^{GEXL}(\underset{\sim}{\psi}^{Exp})}{q^{crit}_{Exp}}$$

- **Computed by TRACG (Reactor):**

$$MCPR \equiv \frac{q^{GEXL}(\underset{\sim}{\psi}^{TRACG})}{q_{TRACG}}$$



$$P_i = \int_{MCPR_i}^{+\infty} f_{ECPR}(CPR \mid \mu, \sigma)\, dCPR$$

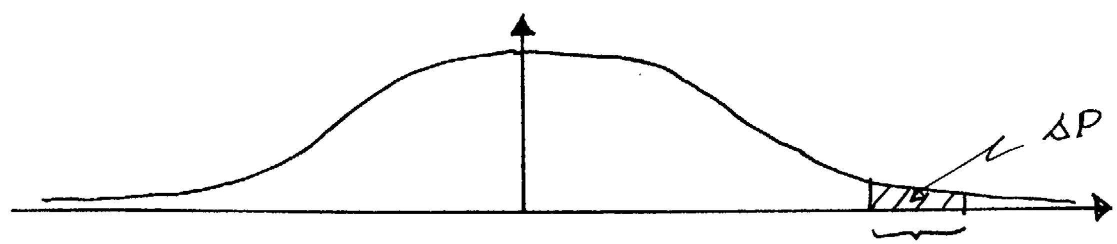
only if $\quad f_{ECPR} = f_{MCPR}$

Engineering Judgement

I.

$$ECPR \cong MCPR + \underbrace{\frac{\partial MCPR}{\partial \underset{\sim}{\psi}^{TRACG}}}_{<<1.0} \underbrace{\left(\underset{\sim}{\psi}^{TRACG} - \underset{\sim}{\psi}^{exp}\right)}_{\lesssim 1.0}$$

II.



$$\Delta P = \int_{\Delta CPR} f_{ECPR}(CPR \mid \mu, \sigma)\, dCPR \approx 0$$

Determination of OLMCPR

- **Generic (by class and type) distribution of ΔCPR/ICPR via TRACG trials**
- **Nominal (reactor specific) TRACG trasient calculation of ΔCPR/ICPR**
- **Random trials of ICPR**

$$MCPR_i = ICPR_i \left[1 - \left(\frac{\Delta CPR}{ICPR} \right)_i \right]$$

Compute the Number of Rods Subject to Boiling Transition (NRSBT)

if $\overline{\text{NRSBT}}$ = 0.1%

Initial minCPR = OLMCPR