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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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SUBCOMMITTEE ON MATERIALS, METALLURGY AND REACTOR FUELS

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TUESDAY,

JULY 7, 2009

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ROCKVILLE, MD

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The Subcommittee convened in Room T2B3 in the Headquarters of the Nuclear Regulatory Commission, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 1:30 p.m., J. Sam Armijo, Chair, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

J. SAM ARMIJO, Chair

JOHN D. SIEBER

DANA A. POWERS

WILLIAM J. SHACK

NRC STAFF PRESENT:

CHRISTOPHER BROWN, Designated Federal Official

STU RICHARDS

ALADAR CSONTOS

TIMOTHY LUPOLD

ERIC FOCHT

WALLACE NORRIS

JAY COLLINS

CAROL MOYER

CHARLES HARRIS

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

(1:29 p.m.)

CHAIR ARMIJO: Okay, the meeting will now come to order. This is a meeting of the Materials Metallurgy and Reactor Fuels Subcommittee. I'm Sam Armijo, Chairman of the subcommittee. ACR members in attendance are William Shack, Dana Powers, Said -- well, Said didn't make it, and Jack Sieber.

MEMBER SIEBER: Sieber.

CHAIR ARMIJO: Sieber.

Okay, Christopher Brown of the ACRS staff is the designated federal official for this meeting. The purpose of the meeting is to review the staff's research activities relate to materials and metallurgy. We will hear presentations from representatives of the Nuclear Regulatory Research Organization.

The subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full committee.

The rules for participation in today's meeting: we're announced as part of the notice of this meeting, previously published in the Federal Register on June 16th, 2009. We have not received any requests for members of the public wishing to make oral statements.

The transcript of this meeting is being kept, and well be made available as stated in the Federal Register Notice. Therefore, we request that participants in the meeting use the microphones located throughout the meeting room when addressing the subcommittee. Participants should first identify themselves and speak with sufficient clarity and volume so that they an be readily heard.

Dr. Shack has an organizational conflict of interest in ANL. ANL under contract with the Nuclear Regulatory Commission has performed work on projects selected for review by the subcommittee. Since Dr. Shack was directly involved in some of this work, he has a conflict of interest in this matter. Of course, he will have no conflict of interest in work performed by other organizations.

We will now proceed with the meeting. I will now call on Michael Case or Stu Richards of RES to introduce the presenters.

MR. RICHARDS: Thank you. I'm Stu Richards. I'm the Deputy Division Director for the

Division of Engineering and Research, and I'd like to thank you for the opportunity to be here today, and tell you a little bit about what we're doing in the materials area.

We have a very strong staff in this area. Tim Lupold and Al Csontos are the two branch chiefs, and they've brought a number of their staff with them today. So, I think we'll be able to answer hopefully a lot of your questions. And without further ado, I'd like to turn if over to Al and Tim.

CHAIR ARMIJO: Well, I just would like to add one thing. This is such a large and complex series of projects in materials and metallurgy, and we are performing our biannual research report for the Commission. So, it's really helpful to us to really understand what you're doing and where you're headed, and why you're doing what you're doing.

MR. CSONTOS: And if you don't see anything here, we can always augment it later.

CHAIR ARMIJO: And we, deliberately in order to make this doable, we selected certain topics. And if there's things that have been left out, well, we'll get written information so that we have a complete report.

MR. CSONTOS: We have plenty other

presentations.

MR. RICHARDS: One thing I'd like to add, just to follow up on your comments: I think that the two branches in research in particular are very well connected with their peers in NRR and NRO. There's a lot of communication. There's frequent meetings. And as a consequence, I think the work we have going on in research is supporting what the program offices need, and there are goals in mind, and I think they an explain that.

CHAIR ARMIJO: Appreciate that.

MR. RICHARDS: So, hopefully we can answer that question for you.

MEMBER POWERS: I will be interested in what you do structurally. Can you get the line organizations involved in your research programs?

MR. RICHARDS: By line, do you mean NRR and NRO?

MEMBER POWERS: Exactly, or NMSS if there are -- if it's pertinent to their needs.

MR. RICHARDS: Well, by and large the work that we do is work that is asked to be performed by either NRR or NRO. We have -- a lot of work is defined under user needs. We have routine meetings. I guess how often do we meet, quarterly, or semiannually to talk about user needs and to cover where the research work is and where it's moving forward to? Changes that need to be made.

And then, we've had a number of meetings where the program offices in the staff and research have gotten together to talk about specific progress in given areas. Just recently, I guess we had a group meeting on xLPR, where we had the different offices come together and talk about what needs to be done, and what the goal is, and how to get there.

MEMBER POWERS: One of the challenges that I think we face in this user needs structure is the user need gets sent over. It gets interpreted. It gets executed, and a product is returned. That's kind of fait accompli at that point. It may or may not exactly fit what the -- what the organization thought they wanted.

If they're caught in a bind of -- you know, they're busy doing their line organization thing, they're not experts. So, they don't always formulate the question exactly along lines that are compatible with the material scientists' thinking, and things like that. And the product they get is not always aligned perfectly with what the line organization thinking is.

And I mean what I'm asking is why do we try to do structurally to try to bridge those differences in both culture and language that exist between research and line organization?

MR. RICHARDS: Well, again, I don't think that fits our business model. They don't send over a user need, and then two or three years later we send them a product, and there's no communication in between.

I think there's a lot of communication. Typically, NRR or NRO, NMSS, they have a project manager for that work, who is in close discussion with the project manager on our side. We do have these routine meetings at the division director level that includes a staff, where there's joint presentations on the progress made, how it's going.

I have to say under Brian Sheron as the office director, him having come from NRR, he's very focused on the research staff, making sure that the work we're doing is supporting the program offices, and we're not doing work that -- we're off doing something on our own.

So, we're constantly being reminded that our job is to work for the program offices, and that comes from Brian Sheron.

MR. CSONTOS: The -- I guess from our perspective, there is a user need, but we hold -- we're lucky in the sense that over at NRR and NRO, they have materials folks who are just as knowledgeable as we are, and they tell us what they need, and we have a real good connection and collaboration.

A lot of our folks intertwine in the same areas. Don Naujock and Wally Norris are very close with Ted Sullivan and myself, Dave Rudland, Ted. I mean we're -- we hold meetings quarterly at a minimum. Many times, it's almost weekly conversations back and forth to get that to what it is.

The user need is a large type of structural format, but it's really to the communication that we have between these staff, as well as the SL's between the two branches, and the groups that we get this communication --

MEMBER POWERS: You're reacting a little too defensively to my question. Historically, materials and metallurgy has been the very best at having a good communication line with the NRR organization, better than any other of the research organizations.

And so, what I'm really trying to find out is what is it that you guys do that we can communicate to the other parts of research to solve the problem that you guys have already solved? Historically, you've never had a problem. And a large part of it, I think, is what Al said, is that over at NRO and NRR, they have guys that speak metallurgy as a first language, and consequently, there is good communication in contract to, say, PRA, where people don't always speak PRA as a first language, and maybe there's not such good communication.

That's probably not the most egregious area, whether it's a miscommunication between research and the line organizations. What I'm really interested in is understanding what you've done, and I agree with you --

CHAIR ARMIJO: I've heard you have structurally scheduled quarterlies. In addition, you have unstructured routine easy communication between the user and -- and the researcher, and that's really very valuable. That is the kind of stuff that keeps everybody in tact.

MEMBER POWERS: I think this is something that deserves a paragraph, and the research report is commenting on what's done here. Because this is -- I mean historically, Metals and Metallurgy has done their job at this better than any other research program. Just I mean not -- and there isn't even a close second as far as being able to do that.

MR. LUPOLD: One of the things I think really helps out in that area is that we have our monthly status calls with the contractors that carry out the research for us, and we encourage the users, the end users for NRR, mainly NRR. We haven't had a lot of interaction with NRO to day, but it's starting to come around.

We encourage them to come to those meetings on a monthly basis, and they help us out with redirections of research if we don't get the findings we thought we were going to get, or we get results that we didn't think we were going to get.

A good example of that actually is that of NMSS with FSS -- FSFT, where we were -- and I'll talk about it a little bit later, but we got some results that didn't really give them what they wanted. So, we had discussions with them and redirected the research plan, and took it down a little bit different path. But yes, communications, the frequency of them, you can't underestimate that. It's very important.

CHAIR ARMIJO: I agree with that. Well, with that, let's just get started. I guess I forgot to mention Argonne National Laboratory is on the phone, either backing up staff or on their own. All right, Al.

MR. CSONTOS: Well, I guess we already approached that there are two branches that we're talking about today that we're talking about today. There's my branch, the Component Integrity Branch. We deal with fracture mechanics, NDE, safety assessments. And your branch, Tim's branch, which is the Corrosion and Metallurgy Branch, and they deal with corrosion, metallurgy and advanced reactors.

MR. LUPOLD: We aren't going to talk about advanced reactors today.

MR. CSONTOS: And so, my staff, it's actually interesting. When you talk about between NRR, NRO and us, and research, but it's also within our own branches; I have staff working with -- with Tim's group on advanced reactors, and we have several -- yes, so there's staff on PWSCC that work with us, and we both intertwine, and that's why it's really -- there's a demarcation here, but it's really not that strong of a demarcation when it comes down to actual work product.

MR. LUPOLD: Pretty blurry.

MR. CSONTOS: Yes.

CHAIR ARMIJO: Just order of magnitude. What's the size of your branches?

MR. CSONTOS: I have about -- right now, I have nine staff members. We're going up to 11, I believe. What was it?

MR. LUPOLD: Something like that.

MR. CSONTOS: I can get you those numbers. I had the numbers in there, but I took them out.

CHAIR ARMIJO: Ten is a good number to me.

MR. LUPOLD: And I've got about seven, and I just brought in one additional co-op this summer.

MR. CSONTOS: And we actually are growing. We have opportunities for young staff, if you know of any. So, the work that we do --

MR. LUPOLD: From good universities, too.

MR. CSONTOS: Yes, from good universities. The research that we do really has to be tied to something, and to our clients. And our clients usually do this through a User Need Request. We have many user need requests from NRR. There are these ACRS letters that you supported back at the end of 2007 after the Wolf Creek AFEA effort that you supported the research that we did on residual stress.

I can talk about that later. That helped support us to -- to continue our work in that area, even though it was tied to the NRR user needs.

There's also the staff requirements memorandum from the Commission. But then there's also a third one, which is a phone call for some of the small stuff. I'm not going to talk about it here, but there is a phone call that we got from NMSS about some failures for storage of -- of sources out there for medical devices.

We did a quick two-week thing to help them out on that, but that didn't require a huge level of effort, and we really would expect user need and such -- such that.

MEMBER POWERS: How do we have a research program in the areas of corrosion and NDE and even fracture mechanics when the industry claims, and I have no reason to doubt them, that they spend enormous amounts of money on corrosion, NDE and certainly do a lot of work in fracture mechanics? I mean why doesn't NRC say, "Okay, we've got a question about corrosion. Industry, go off and solve that for us." Why -- why do we do that?

MR. RICHARDS: I think I can at least start that off. The staff needs to be cognizant enough in these areas so that we can provide that judgement on whether the industry is doing the right research on their own, or whether they're coming to reasonable conclusions.

If we're not knowledgeable to the -- well, close to the degree that they are, we're just not going to have the capability to provide that independent judgment that we're called on to do. So, I think --

MEMBER POWERS: And corrasion, I think -- I mean if the thing breaks, the industry is the one that suffers the penalties.

MR. RICHARDS: Well, you know there have been instances where the industry has put forth certain arguments, and the staff has disagreed. Then over time it's played out that it is a problem, and the staff has turned out right. So, in our -- if you step back from just metallurgy as an agency, our job is to provide that independent oversight of -- of work and operation of the plants that the industry is performing.

They are intelligent people, but they're under a different set of pressures than we are, and our ability to bring value to the table is to have that independent oversight that doesn't share the same pressures as industry.

I think it's important that we participate maybe not taking the lead on some of this, but certainly being prepared to be knowledgeable enough to ask the right questions, to do some independent research so that we can either disagree or agree. Thanks.

MR. CSONTOS: For example, there's a lot of efforts right now that the industry is putting forth a large amount of funding on mitigations for PWSCC. They're spending a lot of money on just PWSCC research in the corrosion areas. We've spent -- I don't believe we've spent as much as they did.

In fact, when I look at some of the mitigation research, we don't get -- we don't spend anywhere close to what they do, but the issue there is really that we need to -- of we're going to be providing the -- the response back to our clients with significant technical basis, we need to be there, and we need to be seen -- we need to see what it is they are proposing, and be there at the regulatory meetings, as well as doing our own independent confirmatory research.

In fact, I'll get into it later, but some of that residual stress work that we're doing is really tied to NRR response to a short term regulatory need on a research project where the industry wants to put an optimized weld overlay in two plants, and we have nothing to support or deny those claims.

And so, NRR came to us and said, "We need you to do the measurements because we're going to ask you for these measurement results." And so, that's where some of the research that they're spending much more higher -- much more expensive than we are, but yet we'll be getting out that information that will be important in the regulatory arena.

So, it's -- it's sort of we're just confirming or denying what they are proposing in a lot of this research, these research areas.

CHAIR ARMIJO: Well, I hear it. You can't believe everything you're told. You got to have some independent basis for either accepting or rejecting what people bring to you, and you -- and you certainly can't match what industry can spend, and you don't have to. You should be selective enough to --

MR. CSONTOS: Water chemistry is another area where they're spending -- industry is spending a lot of money in mitigation for using zinc and hydrogen additions, while we're spending really at a minimum right now just to check what they're doing. But our staff is involved in those reviews, and looking at the data that the industry is providing us because they're hoping to fuse this.

We just don't right now agree with them on several of the -- the contentions or the data that they are trying to present to us.

CHAIR ARMIJO: Yes. As we go through it, some of those things that come up where there are some issues, if you just mention them as you go through them.

MR. CSONTOS: Does that answer your question?

MEMBER POWERS: What I'm actually looking for: the way I can take the requirement that the agency has set up in its plan that it's going to have a good solid technical foundation for its regulatory processes, and come down and say, "Yes, we should research these areas."

And when you say, "Well, we need to do an independent research program so we can understand what the industry is telling us, yes, I say, "Well, that's probably true. Why in this area, and not in this other area?" I'm sure with a little effort I can find something where all you do is read what the industry tells you, and say, "Well, you know, I didn't violate my intuition in this area," and you don't have an independent research program, and some areas you do.

I'm not seeing a roadmap that allows me to come up and say, "Yes, these six areas that you laid down here in your chart for your two organizations randomly are the ones that should be there." That's -- that's my challenge right now is -- I mean I don't know that -- I mean nobody alerted you to come in and be prepared to discuss that, but that's the issue that I'm trying to understand is why these, and not others?

MR. RICHARDS: Well, just philosophically, I think the agency should be putting the resources in those areas that have the greatest -- the risk. And when you come right down to it, for a lot of what their branches are doing, they're dealing with primary system pressure boundary material that is not obviously. You can't turn the vessel on and see if it runs.

I mean you can do that with pumps, and you can cycle valves, and a lot of equipment is operating, but we're looking at passive components that get ISI occasionally, but you're trying to anticipate whether these components are going to be able to maintain their integrity without failing. And if they fail, the consequences can be significant.

MR. CSONTOS: I think that's exactly it. I think NRR has to come up with operability decisions based on a lot of the cracking and degradation issues. And so, they came to us for a technical basis to support or deny those relief requests or whatever. And so, that's where there's a direct link between our groups to NRR for their operability of determinations, and whether they're going to accept and deny -- or deny relief requests.

So, there's a -- I think it's that importance and the -- the safety significance of the work we're doing, but it's also just how we are tied in with NRR on the --

CHAIR ARMIJO: Yes. You've got to make decisions, and you've got to be there to help them.

MR. CSONTOS: Right. I could help. I understand -- but I understand what you're saying about the --

MEMBER POWERS: I mean it's no secret that there is a body of decision making people in this country that thing NRC should not be doing research; that all you guys have to do is read what the licensee is submitting, and if it's not enough, ask them for more, and if it is enough, stamp it, initial it, and move on.

MR. RICHARDS: What basis would we have to know if it's accurate, if it's adequate?

MR. LUPOLD: Right. It's very important to know how some of the material properties change, and what the sensitivity is to certain things, and what the analyses that are done; what the sensitivity is based on the assumptions. Because every analysis that's done has assumptions that go into it, and you need to know if those assumptions change a little bit, what does it do to the results? I mean you guys have done that significantly with some of the finite element analyses and found that some small variables can change the outcome considerably.

CHAIR ARMIJO: I think we better move on. Let's get on with this.

MR. CSONTOS: Well, I'll be talking about our branch's research programs. I wanted to -- I didn't want to just go through a litany of all the -- the individual projects and just give you what the individual projects were because when you look at it, there's a short term -- long-term regulatory means what we in CIB do, and we research. But there's also a context to all the different programs, because they all fit together into a puzzle, into a coherent program.

And so, I want to go in, and I'll discuss some of them in a little bit more detail and show how we drill down, and how it gets to the actual programs themselves. And so, I'm going to go with the next six or seven slides and go over some graph to show you what it is that we're doing, and then we'll try to fill in where those different projects lie. Okay?

So, the topic areas that -- well, first of all, we are evaluating the long-term and short-term of the user needs, and expediting needs. That was Wolf Creek. It was an expedited need.

The ready-to-serve, I know Sam, you had brought up -- I think Chris, you had mentioned that you didn't want to hear about ready-to-serve.

CHAIR ARMIJO: Well, I -- readiness to serve, as I understand it, I don't see it as research.

MR. CSONTOS: Right.

CHAIR ARMIJO: I think you have to have the people with a knowledge and a background to answer those kinds of questions when they come up.

MR. CSONTOS: Right.

CHAIR ARMIJO: I wouldn't put that as part of your research program. It's just a bias.

MR. CSONTOS: And -- well, no. I mean when you look at some of the work we do for NRR, we've been doing it for probably 15 or more years, flaw evaluation and whatnot. But there are some things that I would classify as ready-to-serve, but we still do need research on them, especially when we're starting to reduce conservatisms to understand what role certain factors play, parameters play.

But there's also issues like, for example, let's say an overlay on -- on pipes that we initially said that we would have enough time to determine there would be leakage from them to -- to shut the plant down before we can repair that location.

Well, with an overlay, you do -- you're changing it in such a way where you may not get as much leakage as you initially thought without the overlay when a pipe did have a crack through-wall. So, there's research that needs to be added to what I would call a -- would've called a ready-to-serve type of program in the past with -- with our work with NRR.

So, there are some areas where we do have to have some research tied to a ready-to-serve type of program, like flaw evaluation for example.

CHAIR ARMIJO: Well, I would see those in kind of of like small, short-term, smaller projects.

MR. CSONTOS: Right.

CHAIR ARMIJO: Just terminology.

MR. CSONTOS: Yes. And I just wanted to bring that up. That's all.

CHAIR ARMIJO: Okay.

MR. CSONTOS: So, I'll be talking about two major areas. One is component integrity assessments, and we're going to be breaking that down into the piping, CRDM and RPV areas. We have programs in those three major areas. We have some other smaller ones, but those are three major ones.

We're looking at probabilistic and deterministic fracture mechanics. We're doing both at this time, both for piping and for the RPV. You talked about Mark, Mark is doing it for the PTS rule on the RPV, and we're doing xLPR for the piping side, and that's where we'll go into that in a little bit of detail as well.

Mitigations and residual stress validation for the -- for as long as I've known us here in NRC, we've always -- we've done some validation on some mitigation. Bill, I know you had done some for us on the BWR side during IGSEC days. We, to my knowledge, don't have a validation of residual stresses still to this day on a lot of things that we've done for flaw evaluation.

So, that was a critical part, and that's where ACRS helped us out by -- by putting in for the letter when you approve the -- or reviewed our work on the Wolf Creek effort.

We also have high density polyethylene piping research. That's fairly new in the last maybe two years. We've had that where a couple of plants, Duke Energy plants, have come in with relief requests to replace some of their safety systems with plastic piping. And so, that's interesting work, and we have a couple staff members looking at NDE on that, as well as the fracture or the failure of mechanisms related to it.

That's where -- the other major area that we'll be looking at is the non-destructive evaluation, NDE area. We have that for both RPV's, piping, and for high density polyethylene piping as well.

So, this is the next slide. I broke this down. You had asked me for all these -- these different project numbers. These two over here, this one right here, is -- was not included. This is the xLPR one, 6829. I didn't want to tie that in, other than just to show you that these two -- this program in particular is a lot of xLPR. This one over here has some of it as xLPR. But I just wanted to add that in there.

These revolve around all the dissimilar metal weld issues that we're having, the PWSCC issues.

That is something that is high on the NRR's radar screen. So, we have a lot of programs in that area at this time. So much so, that a few of them are actually closing down: 6433 and 6360 are up to their three-year level. And so, we're shutting those down and building new ones up.

So, for 6433, we have 6687 replacing it. For 6360, we have 6637 replacing it. So, we also have high density polyethylene. We have a couple programs there. What you'll see here is that some of the same numbers are showing up for the -- for different topics, or different technical areas.

That is because why you see the same title, or very similar titles, component integrity project, or reactive coolant pressure boundary project. These are things because there are a lot of different technical areas, but they all rely upon this -- we would like to keep a more over-arching kind of a scope so that we have a little bit more flexibility to tackle the problems NRR finds.

The last one is the RPV, and we're looking at some fracture mechanics there. Those are two programs that you brought up that you wanted to talk about, and I put those. Those are there.

CHAIR ARMIJO: The reason I raised that

one in particular is because I saw PTS and the rule-making on PTS kind of the end of the line for reactor pressure vessel fracture. And maybe I'm wrong. So, I was wondering what -- what newer problem --

MR. CSONTOS: I'll show you in about -- I think the next slide.

CHAIR ARMIJO: Okay.

MR. CSONTOS: And in NDE, we have three programs there, and that's for both RPV, piping and for the -- well, both the metallic piping, dissimilar welds, and the high density polyethylene piping.

So, this is what you were talking about. What I've broken down here is for component integrity assessments in our branch. We have short-term regulatory needs that NRR has asked for. Those are PWSCC mitigations, looking at the -- the -- the -- basically the credit. What credit can we give to the licensees for what different types of mitigations they have proposing on the different dissimilar welds, plus the CRDM as well.

So, what -- what is it that -- what can we as the NRC say what kind of credit you get for that?

CHAIR ARMIJO: Now, I've heard they're doing something with chemistry, zinc.

MR. CSONTOS: Yes.

CHAIR ARMIJO: Some claim that may be of any value. Is your research program addressing that?

MR. CSONTOS: We are -- in my branch -- I'm not the chemistry man.

MR. LUPOLD: That would fall under mine.

CHAIR ARMIJO: Okay.

MR. LUPOLD: To answer your specific question, as of right now it's no. We're not looking at zinc. We've looked at hydrogen and other chemistries, but zinc is down the line.

CHAIR ARMIJO: Okay, okay.

MR. CSONTOS: There are many different mitigations, and I'll show a slide as well in a little bit that will show where that all breaks down as well. But that's the short-term. And then some flaw evaluations: every spring and fall we seem to get some indications, and NRR asks us for our short-term, rather than our long-term. That's right. That's right.

And this high-density polyethylene, that's becoming more and more of an important topic for NRR in terms of NDE, and for failure mechanisms. We have a lot of work in the code cases for code cases in this area. So, this is tied -- a lot of this is tied to current activities that they need right now, that they need some of our technical assistance at this point.

So, it's really what I would call short-term regulatory evaluations, or technical assistance to NRR.

CHAIR ARMIJO: Now, just briefly, what kind of systems or piping systems are people going to use this high-density polyethylene? Is it service water? Is it --

MR. LUPOLD: They are generally talking about their class three systems of service, water systems. Right now, it's being used on the underground systems for service water. A lot of utilities used it in non-safety related applications already, and some of their --

CHAIR ARMIJO: How big is this stuff?

MR. LUPOLD: Oh, some of the applications I've seen out there right now has been like six-eight inches. But they're talking actually using it 30-40 inch diameters for some of these service water supply lines.

MR. CSONTOS: Eric Focht is our resident expert on the plastic piping. Is that --

MR. FOCHT: At Callaway, they're --

CHAIR ARMIJO: You need a microphone.

MR. FOCHT: For Catawba, they approved it for 12 inches, and for Callaway, I believe it's for two distinct thicknesses -- diameters. Sorry, not thicknesses. Four-inch and 36-inch.

CHAIR ARMIJO: These are like your sprinkler system, or something very --

MR. CSONTOS: Well, that's where we're having the issues is that the joining issues -- there are a lot of issues with joining and NDE. And NDE's licensees industry actually told us that they're -- you want to talk about it, Wally, a little bit? Wally is our NDE expert in the high-density polyethylene. This goes to the -- to Dr. Powers question about why we need this kind of research.

MR. BROWN: Can you give your full name for the record?

MR. NORRIS: Yes, Wallace Norris. I think this goes to the question that you asked in that when the -- Duke first contacted us about this, their technical basis indicated that there was no known NDE method to examine this.

And so, they strictly wanted to have us approve the relief based on a visual examination program, and pressure testing. And so, that's one of the things that was built into the user need is to look to other industries to see what they were doing.

And so, we quickly found just through literature searches that the mining and gas industries have been, in smaller diameter piping of course, but they have been working on this NDE problem for years.

CHAIR ARMIJO: There are -- there are methods of --

MEMBER POWERS: So, your function is being a research librarian?

MR. CSONTOS: No. We have programs at PNNL, which have supported through actual work, but as part of it it was to look at various techniques that are out there that other industries used.

So, the project was find what others are using, see if it's applicable to our case, and our case was then we have our -- our -- our -- Wally is our program manager in this area for PNNL. PNNL is our contractor in this area for NDE. And so, they're the ones out there now looking into whether these techniques are a viable piece to our inspection toolbox.

MEMBER POWERS: Okay. I understand.

MR. RICHARDS: The other thing I just might want to add is you mentioned it's like the pipe you use in your garden for your sprinkler.

CHAIR ARMIJO: I was being felicitous.

MR. RICHARDS: Okay. Because Eric Focht gave a presentation for our division on this, and it is -- it is heavy-walled material.

MR. FOCHT: Right.

MR. RICHARDS: It is very -- you know, at least from the pictures, it looks like it's very robust.

CHAIR ARMIJO: Well, the other thing is aging effects. The program would address things like that.

MEMBER POWERS: It's one that -- I mean it's a perfect example that someone might use when I was talking about the NRC research program. Well, they said, "Well, why are we doing that?" Duke Energy proposed this. Why didn't you say Duke? We're not going to approve a visual inspection on a leak test. We need an NDE method. Go get an NDE method.

CHAIR ARMIJO: And we need aging data.

MEMBER POWERS: And we need aging data, etcetera, etcetera.

CHAIR ARMIJO: Yes.

MEMBER POWERS: I mean it's almost a perfect example, because it's not generic. It's a licensee coming in with a novel proposal. If he wants to do something different, then the onus lies on him.

CHAIR ARMIJO: You could argue that, but you know, if they're solving an existing problem that is really a mess, you know, corroded cast iron pipe, or plugged up cast iron pipe, there's a benefit in them using a better material.

MR. CSONTOS: I don't disagree with Dr. Powers. I mean this is something where we have to take a look at what they're claiming to see if what they're claiming, and what they're claiming was there was no liable NDE technique out there.

MEMBER POWERS: And you feed that with research or something like that.

MR. CSONTOS: Right. Well, I think it was in journal searching, but yes. It was something similar. But then of course we've had our folks look into it to see whether or not it could work in our type of thick walled or whatnot. But these are the types of things that, yes, once we do this, then it -- I tend to agree that the onus is on the industry. They're the ones having --

CHAIR ARMIJO: You don't have to develop the technique.

MR. CSONTOS: We will not be -- we shouldn't be doing industry's work for them. That's the bottom line.

MR. RICHARDS: But on the other hand, I think this is a good example where if you don't have people on staff who have knowledge, then you're not in a good position to ask those kinds of questions. I mean if you -- let's just assume you eliminate the people in research that were involved in this. That license amendment request would come into NR. It would go to a project manager. They would send it to a technical branch, who may not have any knowledge at all in this particular area, and what basis would they have to ask those questions?

You could say, "Well, it's just an engineering ought to be able to think of that." But what basis do they have to say yes or no on whatever comes back? The industry would probably come back and say, "We looked around, and there is no reasonable NEE." I mean you can't -- you have to put some kind of caveat on there, but it's not reasonable, and it's got a long history.

We hear these arguments, for instance, at INC, and we're having a lot of discussions about failure rates, and a lot of different issues. You have to have some knowledge in order to have that discussion.

MR. CSONTOS: We don't have any people who worked with plastic piping. I got to be honest with you. That's something fairly new to us.

Well, let me go on and talk about the long-term programs that we have. We have programs in the RPB, the piping and CRDM. Dr. Armijo, you just mentioned what it is that you saw the PTS as winding down. There are a couple other issues, and this is where NRR has asked us for our support, which is of course the PTS rule, and that's 10 CFR 50.61(a). But we also have these two others, the Reg Guide 1.99 revision, as well as 10 CFR appendix GNH.

The staff here, we're actually working with Oak Ridge National aps on N6438 on that program where they are redoing some of our coding. The code that we use for PTS, and the code that we're using has to be updated to handle the -- the -- the startup and shutdown, cool down, heat up effects, and that is, I believe, in appendix G, and H as a surveillance program.

So, these are the types of things that we are doing in this -- in that one program on the RPB side that we're hopefully going to get out in the next -- within the next year or two.

MEMBER SHACK: Does this provide a probabilistic basis for startup/shutdown curves, rather than the current deterministic one?

MR. CSONTOS: Eric Focht is again our expert in that area. I'll let you --

MR. FOCHT: That's correct.

MR. CSONTOS: And so, we actually have the favor code here at -- in Church Street, and we have a little workstation. We call it research computer --

MEMBER POWERS: How can you resist? You'd call it PARTY FAVOR.

MR. CSONTOS: We're trying to do a lot of things in-house now, and that's -- and so, we have this little computer station set up where we can do a lot of our finite element work. FAVOR now can run on that -- those workstations. And so, that's -- we're hopefully doing this in-house with the next GLOBAL ENTRY revision.

The piping work, long-term research uses xLPR. The xLPR stands for extremely low probability of rupture. The reason I have parenthesis and "LBB," there is that it's really replacing -- that work is hopefully giving a probabilistic assessment took. That's what xLPR is is to assess LBB with cracks, or cracking or other degradation mechanisms, or mitigations as well, to come up with what we're trying to determine: if there is an extremely low probability of rupture with existing plants for existing pipes that have already been approved for LBB - all right, they're already approved - that we can still meet the GDC 4 requirement of extremely low probability of rupture for these LBB approved lines.

CHAIR ARMIJO: And that requirement numerically, what are we talking about?

MR. CSONTOS: Ten to the minus six annual occurrence of -- annual probability of occurrence is roughly what we -- what we have found in the statements of consideration for GDC 4.

Okay, and the long-term program, PWSCC and dissimilar metal welds: we have a lot of areas where we're working corrosion. Our side is doing more flaw evaluation work, and that really is tied to xLPR development. And so, that's why they're hand in hand. Then, of course the HDPE support: it'll be there I imagine for quite a while.

MEMBER POWERS: I'm wrestling a little bit here with what I would call cognitive dissonance. Okay? Because this particular slide, I just loved it because it said, "Okay, here's the name and the general organization," and he has a long-term research program, and a short-term research program, and under short-term, I see a lot of specific activities.

I mean I get the impression: high-density polyethylene piping is a new wild idea that somebody submitted. NRR asked you to take care of it, and you guys did some stuff, and sent them away to deal with the licensee.

Lots of little things in there. Then, I come to the next line under, "Long-term research," and that's there my cognitive dissonance comes out because I see a lot of specific activities, some of which are, I presume -- I don't know whether the PTS will ever come to an end, but I presume that it will one of these days.

By the way, I do consider PTS to be an outstanding example of what NRC research can do, and have said that many times to the Commission. So, don't let me denigrate it.

What I'm missing here is what is your organization trying to do? If I go one slide further forward in your presentation, I actually find the answer. You want the -- your long-term research program is to have an expertise and probabilistic fracture mechanics. That's what you really want.

MR. CSONTOS: That's right.

MEMBER POWERS: And to establish that expertise, you have to carry out activities that pay the bills, but that's what you really want. It's a box that's missing there. Is there anything else in that box besides probabilistic fracture?

MR. CSONTOS: It's really -- we're trying to develop that on the problems of fracture mechanics, but we're also trying to get to some of the fracture issues that were -- we haven't really dealt with, and that is the mitigations. So, we're trying to develop a probabilistic mechanic's tool --

MEMBER POWERS: It seem to be mitigation is where you really run afoul in doing the -- you have the potential of running afoul in doing the industry's work for it.

MR. CSONTOS: And that's why industry is working with us on xLPR. I mean we're trying to create a memorandum of understanding between us and EPRI to help bring this program together. It's a -- what we're trying to do ultimately, and there is a box missing here, and that is we're trying to create in the long, long term -- maybe I should even have a third box here, a long, long-term research program, to look at creating a modular code, probabilistic fracture mechanics code, that can deal with different components.

Focusing right now, we have PTS for RPB's.

For piping, we're looking at xLPR. Maybe at steam generators one day, we can work on steam generator as a component as well. But in the long, long-term, and I'm talking maybe when I retire from here, we'll have something like that. But in the interim, we're trying to develop these individual component-specific modules for probabilistic fracture mechanics evaluation.

The mitigation aspect of it that we haven't taken a good count is there are a lot of aspects, like for example like I said before, inlays, onlays, overlays, MSIP, the different mitigations that are out there. They change the -- the residual stresses. They change the crack growth -- just the way the cracks grow. The cracks grow from two different materials. It goes from Alloy 82 182 to an Alloy 690 material.

These are things that we haven't evaluated deterministically, let along probabilistically. And so, that's where we have some independent long-term work to do, and then in the long-term, pull them into the probabilistic arena.

So, yes, I guess you could say the long-term program is probabilistic fracture mechanics. The short-term would be --

MEMBER POWERS: I think I like your idea

better that your long-term goal is to create a pool so that people in the line organizations can evaluate the fracture probabilities of any of the major components in the primary cooling system.

MR. CSONTOS: Right.

MEMBER POWERS: That's the long-term goal. To carry that out, you have to have an expertise in probabilistic fracture mechanics. There may be a couple of other things, but that's the main one. And then to develop that expertise, then you carry out these -- these various activities.

MR. CSONTOS: Right.

MEMBER POWERS: I like that as a structure much better than what I had in mind, and that sound to me like -- I mean that sounds lovely to me as a -- I mean it's consistent with which we wrote in the last research report that the line organization should be able to call up a routine device that would allow them as a non-expert to do a fracture mechanics analysis on any component of the reactor coolant system, or any of the major components of the --

MR. CSONTOS: And that's exactly it. We came up with that at Wolf Creek. We came up with that every spring and fall. We -- we hear about these cracks, and it takes us about three weeks to really develop the model.

Well, it's already out there. There are tools out there for aerospace --

MEMBER POWERS: Let me ask you this question. And Stu, I may be asking you this. We have in the past had people that very much wanted to see each research activity tied closely back to a regulatory need, a one-to-one correspondence.

But Al has just articulated a long-term version that I labeled lovely, and he may or may not be able to attach the things he needs to do to a specific research activity. He may not be clever enough to siphon off a little of the money from one of these user needs to advance the science he needs to do, and I'm thinking for instance the science he needs to do to take into account that cracks really don't have ellipsoidal shapes, as an off the cuff example.

And what do you think about this? I mean should we try to convince those that make decisions to buy into Al's vision for his long-term research program, or should we limp along?

MR. RICHARDS: Well, I think there's a middle ground there to be sought. I think the Office of Research wants to ensure that we don't go off on work that isn't going to be of some use or some value down the road to the user offices.

A couple of times I think they mentioned that we work for customers. So, we need to be focused on providing products that user offices can put to use, and they've asked us for. On the other hand, I think that NRR and NRO, as they get more engaged with us, they have in some cases and will continue to recognize that in order for us to provide them that service, we need to develop certain capabilities.

We need to have people that have knowledge in these areas, and they need to have the tools to be able to produce those parts.

MEMBER POWERS: There is nothing we need to do here that will solve itself.

CHAIR ARMIJO: Well, we can endorse that kind of a -- I see it's going to happen anyway. Otherwise, you'd wind up with a whole series of ad hoc solutions to short-term problems with nothing at the end. You'll never get out of that mode of quick responses.

MR. RICHARDS: Well, what Al was describing here again is something that has been discussed in detail with NRR. Correct me if I'm wrong, Al, but it's not like we're off doing something without the program offices knowing about it.

This has been discussed at length, and they are on board and support it. I mean if they weren't supporting, then we should know that because it's a collaborative effort. If NRR came back and said, "Gee, I don't think you ought to be spending your time there," we'd stand up and say, "Yes, well, we need to get together and talk about that."

If we're not doing something of value for you, maybe we need to redirect some of our resources.

MEMBER POWERS: The problem is that I don't see in any of the sub-boxes the kinds of things that I would think would be there if my objective is as you've outlined. I can't imagine that everything you need to do to get to this -- this expertise that you need to have in this super system can be tied exactly to a current need, and yet every one of your boxes seems to be tied to a current need.

MR. CSONTOS: That's -- that's purposeful here, I think the long-term, the long, long-term program. We are trying to develop for xLPR a modular -- that modular code that I was talking about, a long-term research plan, and that's where it may take another few more months to develop a draft of it, but I have one of my staff actually doing that right now. That's another mechanism for us is to create what we call a long-term research plan, or just a research plan where we outline exactly where we are hoping to be in five years out.

Maybe that's beyond the -- the user need time horizon because user need time horizons I would say are at most three to five years, and we're looking at maybe ten to 15 years out for something that is modular that handles all the different major components. All right?

MEMBER SHACK: Just a quick question. Where does the embrittlement stuff come now? Is that under your branch, or under Tim's branch?

MR. LUPOLD: Under my branch.

MEMBER SHACK: At least as far as material properties and changes in embrittlement --

MR. LUPOLD: I think it's Reg Guide 1.99. Yes.

MR. CSONTOS: Because we -- yes.

MEMBER SHACK: That seems strange, but okay. Just on this question of independence, too, I mean is FAVOR going to become the fracture code for vessels? Is that what industry is going to come in to convince you guys you can do a deterministic startup curve, and then you're going to confirm it?

MR. CSONTOS: Good question. I'm not so

certain about that. It's something that we're developing ourselves, but there's still -- it has to be -- yes, there has to be some sort of independence there, and I'm not sure. Do you have any ideas on that, Eric?

MR. FOCHT: Specifically for appendix G issues, the industry used FAVOR to develop their risk informed curves, and we're also doing -- obviously we're using FAVOR to develop our technical basis as well.

MR. CSONTOS: I'll get back to you on that one. Any other questions?

CHAIR ARMIJO: In this list, your chart, you don't mention, let's say, AISCC and IGSCC and DWR 6. Is that your view that those problems are gone? Not necessarily gone away, but really sunk to a lower priority than PWSCC?

MR. CSONTOS: At this point, NRR -- I mean you all --

MR. LUPOLD: See, he's talking about his branch.

MR. CSONTOS: Right.

MR. LUPOLD: When you talk about my branch, my branch takes care of research in the areas of IGSCC, PWSCC, the mechanisms themselves.

CHAIR ARMIJO: Okay.

MR. CSONTOS: I just handle the safety issues related to it.

CHAIR ARMIJO: All right.

MR. LUPOLD: We break things, and he analyzes things.

MEMBER SHACK: You crack them, and he wonders if they're going to break.

MR. LUPOLD: That's true.

MR. CSONTOS: So, what I was doing here is you saw that larger slide from the -- the graph, and I want to drill down a little bit into one of them to show you kind of how we do things in -- in research in our branch. This is one of them, and this is a high-priority program for us. It's a PWSCC piping research.

This is the type of program where these slides -- this exact slide here has probably been vetted with NRR management staff at least half a dozen times over the past year to get buy in. And so, this is the kind of communication that we have.

What we're trying to do here is we're looking and trying to access -- currently, the regulations state that you're not allowed to classify something or approve something as LBB approved piping if it has an active degradation mechanism. PWSCC is an active degradation mechanism, and we're trying to assess it now to see if there needs to be any appropriate -- what is the appropriate regulatory requirements or actions needed to be taken?

Industry has taken the lead on this in this area by doing a lot of mitigations on all the different piping. They come in with a lot of efforts, a lot of proposals, and some of them have been resurrected from the IGSCC days, like the MSIP and whole full structure weld overlays.

That is some of the objectives that we have. All short-term objectives that we have are to evaluate these industry mitigation activities to assess what kind of credit we can -- what -- we can say what kind of credit it provides.

Now, on the other hand, 20 years plus of IGSCC, we haven't seen from what -- what I've been told is that we haven't seen locations where there has been an MSIP applied, a Mechanical Stress Improvement, which is basically just squeezing the pipe, and the structural weld overlays. We haven't seen cracks grow in any of those lines.

And so, that's 20 years of operational data. We're looking at several new techniques to optimize weld overlays: water chemistry changes, inlays, onlays. And we have --

MEMBER SHACK: It's harder to squeeze your pipes, too.

MR. CSONTOS: Yes, it's very different. Yes. And so --

MEMBER SHACK: These are big mothers.

MR. CSONTOS: Well, that's probably because Mike Mayfield came up to me one day in the garage, and said, "Why are you guys doing this?" We had done this back in `85, in `86, and that's a different -- different line, different ROT rations, different -- you know, it's just different. So, we needed to do this.

MEMBER POWERS: You should've told him, "Mike, if you'd done it right the first time, we wouldn't need" -- yes, you cut Mayfield a break.

MR. CSONTOS: So, we have a lot of efforts in that area. And some of these, like for example the optimized weld overlay, NRR needs some answers fairly quickly. And so, I'll go into that a little bit.

This is just for the short-term: in the next year, probably within the next year, we need to get a lot of these things done. We also have what we call an initial probabilistic fracture mechanics pilot study.

This goes into xLPR. This is the pilot study to xLPR. We are trying to use some of the knowledge that we used out of the Wolf Creek advanced finite element analysis work that we did back in `07, and pull that into more of a probabilistic framework. Instead of doing hundreds of cases deterministically by changing various parameters, we're trying to create the probabilistic framework to assess cracks and letting them grow to whatever shape they want, rather than just keeping them elliptical, semi-elliptical.

Long-term, that pilot study will help us determine the feasibility of creating this probabilistic fracture mechanics tool xLPR for the piping systems that are out there. There's a fairly large difference between PTS and the xLPR and the -- in the eyes that there's many different piping systems. Many are fabrication processes that were done for the piping systems as a primary loop.

And so, they change the probabilities or rupture quite differently between plant to plant, or even fabricated or fabricator. So, CE versus Westinghouse, and things along those lines.

Those are the types at issue, plus the mitigation. There are determinants to fracture mechanics, models that we -- K factors or K solutions that we just really, really right now do not have a good handle on because of the different mitigations, for an inlay, for example, getting a crack to go through 690 for three layers, and then going into 82. How do -- how do we handle that? How do we do that calculation?

So, that's the short-term or the long-term for this piping research, and in -- in this collaboration that we're doing, this is a safety assessment. We're trying to create a tool that says, "Well, maybe we need to dial down or dial up the ISI's."

We have the NDE. We're trying to create probability detection curves as well for different mitigations. So, if you put an overlay on, what's that probability detection of a crack with an overlay? Without an overlay? You squeeze it.

We have a report that PNNL did for some work that they did in Ignalina. I think it's the -- was it Ukraine? Is that Ukraine? I believe.

MR. LUPOLD: Lithuania.

MR. CSONTOS: Lithuania. And they squeezed a crack that was 70 percent through-wall. And in the US, you're not allowed to do that. You have to repair that location, but over there, they squeeze this pipe that has a 70 percent through-wall crack. After they did the MSIP, it was undetectable.

And so, that's the kinds of issues that we're dealing with here. How do we -- you know. So, that's the kind of thing that we're trying to -- to assess here. What is the proper detection for cracks? Then how do we import them into this probabilistic fracture mechanics tool that really is a probabilistic fracture mechanics safety evaluation? And NDE is part of that.

So, it may behoove us to have a separate discussion at some other point, a presentation on xLPR to show that framework that you were talking about earlier, Bill, that showed all the different ins and outs in the -- so, any way, this is a graph that I just want to show up here to show this -- this -- I guess you could say we just have -- we have to integrate between three major groups.

We have to integrate first of all with CMB branch, with all the crack growth folks, and that's what this is here. They give the crack growth rates, and that's where ANL helps us out doing some of that work. PNNL helps us out on that effort.

Looking at dependencies, looking at water chemistry as hydrogen content, different issues there, different types of changes in the materials themselves, the welds themselves, and then looking at mitigations.

So, there's some work that's being done now in Alloy 690. That gets fed into the safety assessment. The probabilistic fracture mechanic and the leak rate models, that's where my group spends a lot of its time. We do a lot of work on loading conditions, susceptible locations, residual stress models, materials, mechanical properties, and also these mitigations in doing deterministic assessments on the mitigations.

Then, we also have in my group the inspection folks, the NDE folks, and that's the third leg of this effort. And so, all these efforts, as you can see here that's where I put all the different programs underneath there to show you where, and you'll see multiple ones being hit on different areas because we don't ask Battelle or our other contractor, Engineering Mechanic Corporation of Columbus, to just do one aspect of it. They really handle a large aspect of -- number of these technical areas.

And so, that all gets fed together to create the safety assessments. Now, this evaluation, or if you want to call it our safety assessment, is what's going to be feeding into xLPR, and that's where I put those two job codes underneath there. Those are the two job codes that xLPR and that were -- at this point, we're probably going to augment that in probably 2010, 2011, with additional programs. But that's where we're heading.

Okay, and now I'm drilling down even further. This is the next slide. So, this is drilling down this block right here, okay? This is the mitigation effects. So, I'm drilling down even further into now specific research programs, and how they feed into xLPR.

This is our mitigation program. We have this broken down into code support, and that's direct tied. We work with NRR on reviewing code cases that the industry or the ASME is provided. Right now, we're talking about conditioning code -- we're talking about whether we should approve it, and we have some -- some discussions with NRR. They're the leads on that area.

We then have the stress analysis and validation portion of it here, and I really can't tell. This is red and this is purple, but then we have the NDE side over here. So, for the mitigations, you can see that we have a lot of issues here that revolved around stresses, and how the stresses get reversed.

And so, this is why we have this residual stress validation program down here because really we haven't had a chance yet to see whether or not our models are validating. We've had a lot of models that we test to known residual stress measurements, but not blindly, and that's where the letter that you sent to support, our work, this is where it's going towards. And I'll go into drilling into this one next. Okay?

So, we have the different techniques, and we're creating reports for those different techniques. So, for a mechanical stress improvement, that report now is with NRR. A full structure weld overlay, that report is done. We're waiting on an optimized weld overlay design from the industry.

The industry comes forward, and they provide us the design that they are planning to use. One of the programs, a phase IV program for this international residual stress validation program is an optimized weld overlay that AREVA is making, and we are doing the measurements, and we're validating our weld residual stress modelers work to those measurements.

Then, we'll let the modelers tweak it afterwards. Initially, I want to see what that variability is before they get the results.

Then of course we have the corollary, which is the NDE side of this. What is the change and probably detection for a crack, or for an indication, or whatever you want to call it, a flaw, before and after the different mitigations that are out there?

And so, that's why we have -- we have some corollaries that are joint. The pink program, or the pink tube program, I know you had asked -- Chris, you had asked me to provide that. That's part of this NDE portion looking into not just mitigation, but also just PWSCC issues with mock-ups.

Now, here is where -- this is basically my branch. There is some support coming from Tim's branch in this area. This is where Tim's group does all this work right here in the green or the yellow. So, you should probably see it.

So, we're tracking the products. We're not actually doing the research other than hydrogen. We're not doing the zinc work. But the -- the user need that came over from NRR said, "Track and evaluate." Not to do the research, but just track and evaluate, and that's what we're doing right now.

MR. LUPOLD: Right.

MR. CSONTOS: We have an annual responsibility to provide result -- provide results and some of our evaluations to NRR, and we're having that as a public meeting August 4th and 5th, I believe. It'll probably be over here at the Legacy Hotel. It's a mitigation meeting with the industry where they have an opportunity to review -- have a chance to look over what we have done.

So, our results from these programs will be provided in a presentation. Industry can respond back. We can take those comments and see whether or not they're worthwhile to address or not before we write the full report.

Okay, so now I'm drilling down into the weld residual stress program. So, what I've been trying to do here is just trying to show you how we get into the nitty gritty of individual programs, and here what we're doing here -- I think you say -- Sam -- I think I heard Chris and Sam when you came to talk about all the different programs, one of the times when Chris said, "We have so many similar sounding names for the programs." And -- and why is that?

And so, what I wanted to do was show you that we have programs that have titles that are --

like for 6547, it's residual stress validation. We have programs with Battelle and the EMC^2 on component integrity, and they're very similar. 6433 is ending; 6637 is starting; 6360 is ending. In fact, they're ending in the next probably month. Then 6687 is taking over for them.

Titles are very similar. I believe one is pressure boundary -- "Primary coolant pressure boundary assessment," or something, and the next one is "Reactor coolant pressure boundary assessment." Okay, it's very similar.

CHAIR ARMIJO: Didn't I buy that before?

MR. CSONTOS: So, what it is is it creates a kind of a over-arching title and scope that allows us to handle all the different issues related to the pressure boundary issues that we deal with. Rather than being specific to, let's say, dissimilar welds, then we would have to create a new program to work on piping, plastic piping for example. Okay?

We don't want to do that because it takes us a long time to get programs started because of the procurement laws and rules. And so, because of that, we want to be able to have a little bit more flexibility in where we can pass people for the emergent issues that we deal with.

So, we have more over-arching kinds of titles that way, but in -- let's say for example there's residual stress programs. We have programs. We have three programs: 6547, 6774 and 6864 that have I would say fairly similar titles, okay?

The difference is that they are all specific to different tasks. For example, 6547 is in charge of making two mock-ups for us. They pressurizer surge coming right over Wolf Creek type of analysis. We were able to procure two ferritic ends from a cancelled CE plant. We welded them up, and created mock-ups out of them to do our residual stress testing and maybe in the future some NDE testing.

That then is for this program, okay? Even though that title is similar. Over here, the title is similar, and it's measurements. We're going to get measurements done from Oak Ridge National Labs because they're experts at neutron defraction measurements, and we have other techniques. They do X-ray defraction and incremental hole drilling that's ferritic as well, and they're experts in that area.

The vector folks, so we have another one, 6864 that wasn't on your list because it's fairly new, but that's for deep-hold drilling. It's a proprietary technique. There's a measurement technique that is really needed, and that's the one that is a through-wall residual stress measurement that just is basically a hole, a small little hole about three millimeters in diameter.

You can get the entire through thickness residual stresses for a weld.

CHAIR ARMIJO: Did you mention what kind of changes --

MR. CSONTOS: You can get all three components: axial, hoop and radial stresses from that, the residual stress. And then it seems to work and there's a lot of folks out there who have used it. The Japanese have used it in their nuclear industry. The Brits have used it a lot. In fact the French, they're doing basically a similar thing that we did with Wolf Creek, and the regulator has stipulated they need to use this deep hole drilling technique to validate that their overlays are going to provide a compressor residual stress for these dissimilar weld joints.

And over there, it's a little more serious because they don't have what we'd call a safe weld, a stainless steel safe end weld, whereas in Wolf Creek we got a lot of credit for that because that really did a good job in reducing residual stressors on a dissimilar weld.

So, they're a little worried about this. So, that's why we have -- and so, this is one of the reason why I think one of the questions was, "Why do we have so many similar sounding names for programs?" I think that -- I hope that answers it. Okay?

MEMBER SHACK: But just on this -- this vector thing. Is this one of these things where I make one measurement, and then I go off and I do a finite element analysis that actually tells me the answer?

MR. CSONTOS: No. That's the one that I was worried about. I knew that one -- in fact, that's a guy in -- Mike Prime from Los Alamos, I believe, has created another technique, and it does that where you slice, and then you do a measurement, and then you recombine it, or combine it up in the FEA analysis, and then come back a residual stress state.

I basically told him that I can't really validate FEA to something that is an FEA. So, I'm just a little nervous about doing that. So, this is --

MEMBER SHACK: One is elastic plastic, the other is just elastic.

MR. CSONTOS: That's true. And so, that's actually one of the problems that we have. That was -- for a long time, we were really not certain if wanted to go to vector for this because of their plasticity issues, and they fixed that through what we call an incremental deep-hold drilling process.

And we have gotten some results back from that, and the difference between the incremental and regular deep-hole drilling is not that much different, but it is only in locations where we anticipate having high residual stresses, ID repair locations, certain ID locations where you have a back chip repair, for example. Westinghouse typically do.

Those locations will be high yield stressors even at the point of yielding basically, and so we have to be very careful there with these types of techniques that we make it plasticity and that it could screw our results up pretty badly.

So, then -- so anyway, I hope that helps out with understanding why there's the similar sounding names.

MEMBER SHACK: So -- and since these guys are going to get to do blind comparisons to the measurements, too, right?

MR. CSONTOS: Oh, yes. Yes, yes. We -- this is -- let me talk about it here. This is where I wanted to drill a little bit more in to show you exactly what we're doing. That was an overview of the different programs. This is exactly what we're doing. That's the letter that you helped to support. That was the date of that letter, supported our research.

The purpose was from the FEA days we found that was the critical parameter for whether or not we had rupture or leakage, sufficient leakage. And so, what we did is we created a program. Right now it's what we call Phase I through IV. We are developing an MOU with EPRI to support this work.

In fact one of my -- one of my staff is not here right now because he's out there at EPRI Palo Alto working on finalizing that MOU. What it is is that we are developing a sequential program that goes into just really simple fabricated geometry to then actual components. And we just had a presentation, a webinar, with international folks on this.

They're very impressed with how we are now taking this and going from beginning to end with this program. They're only going to be available to take into a part with one of the parts, Phase II of this program, because the rest of it is EPRI, and -- and a lot of it is proprietary. So, we have to be careful with that.

But the whole point is, the purpose of this work, is the second bullet. We just want to get reasonable assurance that our FEA models are defensible. That's really what we're getting to.

It's one of those things where I've been noticing that some of the work that we did for CRDMs -- the residual stresses didn't seem to -- from what I read and what I saw, didn't seem -- the models were accurately predicting what I thought we saw from North Anna, and some of the other locations.

Bill Cullen, when he was here, we used to have good discussions about FEA modeling. And so, that's really what this is all about because we're basing a lot of our flaw evaluation work on this residual stress.

Again, it's just blind validation. Oh, and this program and these outcomes down here, after all this is done, we are developing a sequential format to asking the international body, the round robin participants, to provide us the results back in a blind way so that we can get an understanding of what the uncertainty is in 20 different residual stress models that are out there.

And that goes into xLPR to understand what the variability is of that -- of that critical parameter. And so, that's why this program is really Phase II. We have about 15 to 20 international participants who have greed to, as soon as we provide them the data, they'll provide us their results within three months. And so, that's a -- it's a useful tool, and we get a lot of effort out of that.

This is the program: Phase I through IV. And so, we've now drilled down from long-term research programs into now looking into these -- all these residual stress programs that then feed into the flaw evaluation work.

This is a sequential form here where we go from Phase I, which are simple cylinders, and EPRI is the lead. They created these plates and simple cylinders. Some of them have dissimilar metal welds. Some of them are just similar metal welds. Get an understanding of how we're doing our modeling; if we're getting something reasonable or not; what are the little different parameters that we need to change?

Then we go into Phase II, which is our NRC pressurizer mock-up. That has two mock-ups in it. That's the mock-ups that PNNL were making. It's called the international weld residual stress round robin mock-up, and a full structure weld overlay mock-up.

Those are pressurizer sized. They are Westinghouse type fabricated geometry. We have all the different techniques. So, we're not only validating the models to measurements, but we're also validating measurement techniques to measurement techniques.

And in that vain, when we work with the experts outside of the US, one of the comments they said is, "Do you want a neutron defraction?" -- or, "Do you want it defraction based, and do you want it stress relief based?" And we have two of each.

And so, that's where we are, and we're going to have some of that data done by April of next year. We'll hopefully have something in a written form or a report form sometime in May-June. So, maybe about a year from now, we'll be able to present that work.

Phase III is a safety and relief nozzle that EPRI has procured from WNP III. There are four nozzles. I think two safety, one spray, and one relief. They don't have a surge.

From that, we're going to do a simple cylinder. Then we have a fabricated component where we know the fabrication very well, and we can validate two known fabrication steps to then a completely unknown, something from a plant. And then this final fourth phase is also something that came right out of a plant.

I don't have the figure here, but Phase IV is what NRR has the highest priority for us on, and that is the optimized weld overlay mock-up. It's a cold leg that came out of WNP III that EPRI procured, and it was going to cost of probably $500,000 to $1 million to make that mock-up if we had to do it from scratch.

And so, what we did is we're -- they have it. They're doing all the welding. They're doing all the overlay welding. They're doing a lot of the metallography, all the measuring, strain gauging, all that type of work. And actually what Jay over there at NRR asked us to do was to do the measurements because they just wanted us to do it as a -- and EPRI will do some measurements, but we just want to do it to make sure that we are -- that the measurements were done in a -- in a systematic and controlled way, and that we have the measurements; we're not relying upon the industry measurements.

CHAIR ARMIJO: You're going to do both the -- this deep-hold drill --

MR. CSONTOS: We're doing all four. We're doing X-ray defraction, incremental hole-drilling, and deep-hole drilling. Oh, and we're not going neutron. IT's too thick for neutron.

CHAIR ARMIJO: Right.

MR. CSONTOS: It's too thick for neutrons. And I can go through the reasons why X-ray just surfaced.

MEMBER SHACK: Too big for neutrons, but you're going to do X-rays.

MR. CSONTOS: That's right. So, it just surfaced. Incremental hole gives us two millimeters. Deep-hold drilling gets up between the two millimeters on each side.

CHAIR ARMIJO: Yes.

MR. CSONTOS: And so, that's the whole purpose of it. So, that is -- that's where I just kind of wanted to show you how we drill down into -- from large programs into small programs. This is where I just want to say if you had any questions specifically about a program, I can go into it, but something that -- I just wanted to leave it up to you.

MEMBER SHACK: What's the neutron source? SNS or?

MR. CSONTOS: At -- at Oak Ridge, yes.

It's the older source.

MEMBER SHACK: It's the older source?

MR. CSONTOS: Yes, not the spallation source.

MEMBER SHACK: Okay.

MR. CSONTOS: Right. The Vulcan is a new one, and a two year wait in line for that one. So, if we can --

MEMBER SHACK: Enough neutrons out of the other one to get --

MR. CSONTOS: That's true. Well, they have the new Vulcan spallation source. That's -- that's just incredible. It's -- they're trying to do some --

MEMBER SHACK: But which one are you going to get to use?

MR. CSONTOS: Not the new one. We're going to get to use the old one. It's still the highest flux in the US, so that's -- that's --

MEMBER SHACK: Yes, but that's not important.

MR. CSONTOS: I know. I know.

MEMBER POWERS: What type of -- was neutron imaging tanks --

MR. CSONTOS: Well, we had some work at --

one of the things we came across is we also have a -- I haven't talked about it here, but there may be a Phase IV in that program, a Phase V, which is we have some Saint Lucie nozzle material that we had from last year, and that may be something to see cancel components to actual retired components. What's the difference in the residual stresses?

We're getting those cleaned up right now. They're in decon, and the -- one of the things that --

MEMBER SHACK: Those are the famous PANIC components.

MR. CSONTOS: That's right, the PANIC mock. That's all right, the PANIC surge nozzle and cylinders. But the -- the big thing is that one of the guys from Los Alamos is interested in doing proton radiography to see if they can do it, and they'll do it for us for free, plus they'll give us the neutron work for free. So, we're trying to see --

MEMBER SHACK: If the source ever works.

MR. CSONTOS: Yes, that's right. And so, that's one of the things I've asked one of my staff to look into because I don't want to give them just -- I don't want to give them something that's very valuable to us just to test with. I want to get a good plan together. And so, kind of something like this where we have a specific plan of how they're going to attack that mock-up to see -- or that actual component to see what the residual stresses are, and give us time lines, things like that. Just for free doesn't really matter to me. I really want to get something out of it.

Any questions on specific programs? I can answer them now. I was going to go -- I wasn't going to go through them individually unless you wanted me to.

CHAIR ARMIJO: I'm not sure. I'm not sure. I -- we understand your approach.

MR. CSONTOS: Yes.

CHAIR ARMIJO: And -- and --

MR. CSONTOS: I think that was more -- I just wanted to do that because I can go into the individual programs, but really until you get an understanding of how the individual programs fit into a puzzle, that's how we -- how we -- you know, as a final goal, and really the method that we use is these contracts. And the contracts, from our point of view, as long as we meet our budgetary milestones, as long as we get the job done, that's what's important.

CHAIR ARMIJO: We just have some of these --

MR. CSONTOS: Sure.

CHAIR ARMIJO: In the NDE, now, you're -- industry is trying the conventional NDE techniques, using them, and they're also exploring more advanced techniques and --

MR. CSONTOS: Phased array.

CHAIR ARMIJO: -- phased array. You -- you guys have been doing some of that.

MR. CSONTOS: Oh, yes. We have a lot of efforts.

CHAIR ARMIJO: Yes.

MR. CSONTOS: Wally Norris is the PM who has a lot of work at PNNL. We have a very large program over there right now, and in fact, that's on -- what's one of the last slides in my package. I think it's 6398. Is that right?

CHAIR ARMIJO: Yes, that's what I'm looking at. There's also 6593, "Emerging into E for" --

MR. CSONTOS: That's right. That's pink two. There's pink one and pink two. The pink programs are international programs where we have international round robins of mock-ups. Some are dissimilar weld metal mock-ups. Some other types of Alloy 600 mock-ups. They get sent around the world, and some of the locations I -- I think Korea and Japan have some universities. I think Tokyo University is a part of that. Is that correct? I think -- right. And they've used some very interesting techniques that I don't think we ever even -- well, we wouldn't use right now.

MEMBER POWERS: I mean, you bring up one of the issues that I've never really quite understood. I guess there are two things I don't understand. I don't understand -- only two, Bill. Just two in the entire world. I only have two things that I don't understand. One is the relationship between your program and, say, the western European country programs and the Japanese programs. I assume they're confronting. I mean certainly CRDM has to have some trans-national character to it.

I don't understand the relationship between your program and the industry programs, which to me are -- are completely opaque. I mean they claim -- they swear and be damned to me that they're spending huge amounts of money, and I never see it. So --

MR. CSONTOS: They are spending quite a bit of money on it. That's the reason why I went to PNNL for our mock-ups was because they make mock-ups, and the know the people who make mock-ups for the industry for their PDI qualification.

We have, and Wally, you can talk to us if you want, we -- we're actually developing MOU with the french, right? IR Sound?

MR. NORRIS: Have.

MR. CSONTOS: Have, okay. You want to talk about that a little bit, how we interface with the western Europeans in the NDE arena, and also the Japanese? But we just had a kick-off meeting, and we had this tag meeting. That was in Seattle, right? It was a little -- there was a group of -- why don't you go ahead and just -- I've done the job for about a month-and-a-half, I think. So, this is an area that I need to get a little bit more schooled in.

MEMBER POWERS: You don't understand it either, huh?

MR. NORRIS: Well, I think that two different sorts of issues, and one of the things we've learned now in interfacing a little better with EPRI is that many times they are reluctant to investigate state of the art, say, in phased array, because they don't want to get ahead of their vendors, and the vendors are, while they're using phased array, they're still in some areas stuck in conventional because it meets the regulatory requirements.

It generally works, and it would cost them a good deal of money to get into the better techniques. But by not getting into the better techniques, they're having problems in, like, dissimilar metal welds.

The cast austenitic stainless steel issue is what Al was referring to. There was just an industry workshop in Seattle a few weeks ago, and the -- I mean this is one area, I think, where the Europeans are ahead of us. But when you talk about something like CRDMs, we, in the game, got into replacing heads.

The French, rather than getting into repairs and trying to get into the NDE just started replacing their heads as soon as they found the cracking.

So, I think relative to exchange of NDE, there's not as much of some of the research areas, like we -- the MOU with the French, and looking into cast. They very much want to get into state of the art phased array. So, I think in that regard, they're ahead of EPRI on that issue.

MR. CSONTOS: Did that answer your question?

MEMBER POWERS: Well, maybe. It sounds as though you observed thinker, and you go off and do your own thing.

MR. NORRIS: I think it goes back somewhat to the issue that you raised in that the industry sometimes, I think, lets the ball drop on some of these issues; that they'll claim that they can do certain things, but when we push to try and get them to either provide that data, or when it seems like it's an issue that they should be taking a lead on, there are certain times they do not.

MR. CSONTOS: And -- and in the industry's defense, they have a small, small group that EPRI, for example, has a few folks who are just inundated with requests after requests. It just would be nice -- for myself here, I would like to get another NDE expert as well in -- in our branch.

Wally is overworked at times as well because he's our resident expert in this area. It's just hard to get the good NDE folks. And I think that one of the areas that we've been having issues with in the NDE side is that we've been asking for, gosh, six years now for information on probability detection, trying to collect some data from the PDI database, and to see what it is that -- what is the probability of detection.

We're slowly getting this. We have some of our staff right now, through PNNL, down at EPRI Charlotte to try to pull some of that data and create some of the probability detection curves that, for example, French -- when we met with the French, he said that he's had it for years, and their regulator side has asked and demanded it from their -- from their folks.

And so, from our point of view, we're getting that now. So, it's -- it just is somewhat slow in coming. And -- and really the worry there from the industry side is Saint Lucie. You have us act before we really had a chance to see whether or not that indication was really there or not, or was it a 90 percent through-wall indication?

So, they're worried about that, and that's reasonable, I think, to be worried about that, and how we would take that result. But on the other hand, this is something that is really important to us in a probabilistic safety assessment or fracture mechanics space because the probability of detection is really critical to really understanding what it is, and if that flaw is there or not there, and whether or not that probability detection as it gets larger, and the probability detection usually goes up, will we be able to catch a crack in ISI space between the different ISIs?

And so, that's why it's fairly important for us, and they saw that as we spoke with them about the xLPR program, and that's where they're starting to release some of that data. Like I said, we have some -- Pat Hessler from PNNL heading down there to collect some of this data for us, for use in xLPR.

MR. NORRIS: I think you brought up an interesting point about PDI and POD. It seems to have very much in the past few years that EPRI gets funding only to do certain tasks, and they're some of these areas where they have no budget to look into. And so, we don't get that information. They don't have it, and they have a limited staff to -- to work on some of these questions.

MR. CSONTOS: And that's why we're trying to interface with EPRI. I remember for the last few years, we've been going to Palo Alto in the September-October time frame to see about their what they call IMT's. What does it stand for? Matrix -- Industry Management Table -- Issue Management Table, that's right.

It's where their issues are prioritized to safety significance, and then what research is going towards them. And we're trying to inform them about where some of our concerns are, where our drivers are going. They provide their risk side of the house, and we come to some sort of evaluation at that point.

It's a public meeting, and -- and we sit there and we talk about what it is in research space that is critical to both our sides. Is it industry sides, and our sides? PWSCC stuff was top of the list for -- eight of the top ten, or seven of the top ten at the time. So, that's why you see a lot of our programs the same thing.

Again, those are starting to -- like you said, PTS is declining, and well, PWSCC is trying with the mitigations. It's apexed, and it's starting to come down as well, so.

CHAIR ARMIJO: Okay, any other questions? We're right at 3:00. I think we're on schedule. I think we can take a break.

MEMBER SHACK: Thanks, Sam.

CHAIR ARMIJO: I think we should take a break, and reconvene, let's say, 3:15. Well, maybe 3:20, five minutes later.

(Whereupon, the above-entitled matter went off the record at 3:02 p.m., and resumed at 3:19 p.m.)

CHAIR ARMIJO: Okay, Tim.

MR. LUPOLD: Okay, thank you very much. I'm Tim Lupold, and I'm the -- I have the Corrosion Metallurgy Branch. Okay, I have a few things in here. Some of the things we do: we respond basically to User Need Requests. We don't have near as much ready-to-serve efforts such as Al does.

I mean we get requests in that they need this information, and it takes a while to generate that information. So, it's hard to classify it as ready-to-serve. They all ask us --

MEMBER POWERS: So, you're saying you are slow is what you're saying?

MR. LUPOLD: You could say that, yes. Matter of that, there are some changes in -- all right. But really, in my branch, there's like three -- three particular areas I'm going to go into. I'm going to talk about proactive management and material degradation. And I'm going to talk about the corrosion metallurgy related specific items, which encompass environmentally assisted corrosion, primary water stress corrosion cracking, which is technically an environmentally assisted corrosion.

I'll also talk a little bit, if you want to hear about it, about some of the research we're doing on some spent fuel canisters, the stainless steel cracking that are in marine environments. Okay, and also, another program --

MEMBER SHACK: What's that connected with?

MR. LUPOLD: That was a request from SFST, and some research that was done in Japan where they dripped chloride solution on stainless steel to see if it would crack. Japan has sea water everywhere, all around them, so they were concerned about the cracking in a marine environment.

MEMBER SIEBER: They did, right?

MR. LUPOLD: Definitely they got it to crack, absolutely. I mean it's pretty well known that chlorides and stainless steel are going to cause -- and elevated temperatures are going to cause stress corrosion cracking.

So, SFST personnel questioned it, and said, "Well, we think your tests flawed because you are actually dripping liquid chloride solution on the stainless steel." But then they got to thinking, and said, "You know, we could have salt played out in these things, humidity changes. There could be a potential for corrosion there." So, they asked us to investigate this issue.

MEMBER POWERS: Okay. Ask anybody that

lived next to the ocean what happened to their stainless steel flatware.

MR. LUPOLD: All right, I'm going to talk a little bit about proactive management and material degradation. Project manager on that right now in Gene Carpenter. It used to be Dr. Amy Hall that -- Dr. Hall has been requested to work on some other things, like the generic aging lessons learned update. So, we kind of shifted resources around, and Gene is taking over this project.

It's a really good fit with the other work that Gene had on his plate. Gene had been working with Life Beyond 60, light water reactor sustainability, and really those two programs fit very well together.

All right, I've set these slides up such that there's -- for -- we have a contract out for research. The first slide is going to tell you what the scope of that is, and then the next slide will tell you about the basis. Why are we doing this type thing? And then the third slide will be the approach, all right?

I don't intend to go through and read this. If you want to take a look at it on your own, you can read it and get the detailed information. But

I'll just talk a little bit about the program, and how I perceive the program.

The PMMD program I really see as an over-arching program. It's really looking at what are the material degradation problems that you could run into out on these plants. And we're trying to find what the material behaviors are, and what some of the repair strategies would be on these -- on these materials.

MEMBER SHACK: Is this a user request, or is this an SRM that drives this work?

MR. LUPOLD: This was -- this started out as a user request, but we think we've accomplished a lot of the needs from the user request. What's really driving right now is an SRM in that the Commission likes the fact that we're doing proactive management or materials degradation work. They really --

MEMBER SHACK: Because this is the real opposite of ready-to-serve.

CHAIR ARMIJO: Yes.

MR. LUPOLD: Yes.

MEMBER SHACK: It hasn't happened yet.

MEMBER POWERS: The problem I have is that this program has started what, five years ago or something like that? It was going to be the answer to a maiden's prayer. It was going to charge out, and it has seceded in disappearing below my radar or horizon.

I've never seen anything come out about it. How many viewgraphs have I see that says, "Develop a plan for this program?" I bet I've seen 20 of them that said, "Develop a plan." And I never see the plan. Maybe because I don't look, but I've never seen the plan.

MR. LUPOLD: The plan isn't fully completed right now. I'll tell you that right up front. But obviously I flipped to this next page here, the basis. This is why we're -- the Commission and everyone in the NRC don't want to see another example such as Davis Besse. We also don't want to see another situation such as V.C. Summer, all right, in which you actually had degradation through the primary pressure boundary. And how did we identify those things?

MEMBER POWERS: I want peace and tranquility throughout the world, too. They're going to have another Davis Besse. They're going to have another V.C. Summer. So, the fact that I don't want to is a pipe dream.

MR. LUPOLD: That's true, but we can reduce the probability of having such an event like that if we do the right research, and we specify the right inspections.

MEMBER POWERS: Right.

MR. LUPOLD: Okay, all right. This is -- yes, this system doesn't have all the things I wanted to talk about. The real objective as to what we're trying to do here is to identify degradation mechanisms before they find us, all right?

We want to be able to look and determine ways of detecting degradation, and then take mitigating actions for it, and before it becomes a real problem. Ultimately what this will do is extend the life of some of the programs.

Yes, you do have the slide that shows the pictorial of this. It starts out and says, "The solution of proactive management materials degradation," PMMD.

CHAIR ARMIJO: Which number?

MR. LUPOLD: Yes, my sent doesn't have it.

CHAIR ARMIJO: We don't have any graph or any --

MR. LUPOLD: I added these things in here, just these talking points, and some of my notes. So, I guess you don't have this.

CHAIR ARMIJO: We don't have this.

MR. LUPOLD: Sorry about that. But the whole idea is to look at the degradation, to try and detect the degradation mechanism before it becomes catastrophic, all right? And then you can develop mitigation techniques so it extends the life of your components.

Ultimately, what you want to do is extend it out so that you'll end and retire your plant before you have failures of the components, or you'll come up with another alternative such as replacing the component before it fails.

CHAIR ARMIJO: Now, a year or so ago -- well, about two years ago, you issued a report, a big report, a matrix of where you thought there might be problems and what systems, and the importance of those systems. And what I'm looking for is from that report, did it trigger anything? Either like an augmented inspection, or a special inspection to look for evidence that in fact these predictions meant anything.

MR. LUPOLD: Well, that report you're referring to was New Reg 6923.

CHAIR ARMIJO: Yes.

MR. LUPOLD: All right, and it identified a lot of areas that had degradation mechanisms, and it rated whether it was highly susceptible, low susceptibility, and intermediate susceptibility, and how much we knew about the phenomenon.

CHAIR ARMIJO: Exactly.

MR. LUPOLD: Okay.

CHAIR ARMIJO: That's what I remember.

MR. LUPOLD: Currently, what is happening right now in the license renewal area is we're looking at that report, and we're updating GALL, and we're using that report as a basis to update the GALL report.

So, if they're -- the hope is that the people are doing that. Well, if there's degradation mechanisms in there, in New Reg 6923, that don't exist in GALL, they'll put them in GALL against those components, and then they'll evaluate whether or not the aging management programs adequately address those new degradation mechanisms.

CHAIR ARMIJO: So, it's got to go through the GALL update, and through the --

MR. LUPOLD: Yes.

CHAIR ARMIJO: -- license renewal. But what about plants that aren't going to be license renewal? They still have materials degradation going on.

MR. LUPOLD: They do. Now, what we're going to use the New Reg for there is those -- those components that have a high susceptibility and we have very knowledge of the program, that's the area where we're going to target some additional research in so we can understand the degradation mechanism more, and see if it is really legitimate, and see if we have concerns in these areas.

This program -- you heard me call the PMMD more as an over-arching program. This program is providing input into where we're going to do research in PWSCC, where we're going to do research in ISCC, and those areas.

CHAIR ARMIJO: EPRI had something similar, but maybe it's a different kind of issue.

MR. LUPOLD: Issue management.

CHAIR ARMIJO: Yes, right.

MR. CSONTOS: And that's where we've been having discussions. I think the last one we had was October of last year, where we meet with them, go over some of the PMMD results, go over the IMT's. Then that all helps us with some of the direction for the research program.

CHAIR ARMIJO: Yes, well, I didn't fully understand the EPRI program, nor the NRC program.

But, I would -- the way I interpreted it was based on that expert knowledge and assessments that somewhere out of this, between EPRI and NRC, there would be something that said, "Okay, if there is one problem that's likely to hit us that hasn't hit us yet, it's this, and we'll go inspect a plant, or confirm it in some sort of an accelerated laboratory test." But nothing is happening.

I was just waiting for the other shoe to fall. What are we going to look at first to show that we can use -- we don't have to be caught flat-footed.

MR. LUPOLD: Right. We have not concentrated in that area yet, but we will be turning our attention to that, to identify those areas where additional research is needed, and so we can identify those areas.

What we've been trying to do right now is establish collaborative relationships with international partners who are actually dedicating a lot more money into this program than what we are right now.

We're trying to leverage our working relationship with them to be able to get as much information as possible, and that is being done with the Koreans. That's being done with the Japanese right now. So, we're working with them to leverage our research dollars, and to be able to find out what they have learned in these research areas.

MEMBER SHACK: Well, I like using this thing to inform GALL. I mean that seems to me an effective and efficient use of resources. You take a look at this; you see what the aging management programs that you have in place are going to do, and that would help you focus on where you're going to need the additional research. So, that really strikes me --

CHAIR ARMIJO: I don't have an objection with doing that with GALL. I'm just saying there's -- some plants may never go for that life extension. They're going to need --

MEMBER SHACK: There's not going to be many of those.

CHAIR ARMIJO: I would hope not.

MEMBER SHACK: There will be some.

MR. LUPOLD: All right. And I agree. I mean that is on our scope. That is on our plate as an activity we'll need to do under this program. We recognize that.

One of the things we're doing right now is creating an information tool, and concentrating right now on an electronic search capability of this New Reg 6923. It's 4,000 pages long; so it's very difficult to be able to go through and flip through, and find information in it.

So, right now, one of the biggest activities I can point to under this task is PNNL to develop that information tool to be able to search this. In addition to the -- in addition to just the search capabilities, this information tool draws in experience from many other databases.

So, this can be used for -- to identify what the degradation mechanisms are, what the failures that have occurred in industry, and how we can learn from that and apply it to the reactors. Okay?

There's a lot more work to do in this area, and I admit -- I mean we have not made a real good start from the gate on this one. There is more work to do.

Okay, I'm going to go into the environmentally assisted cracking. Right now, we have a couple programs, and I call them programs; they're really projects. We have our project N6782. This is the project that we have in place with PNNL to conduct cracking -- crack growth rate testing of our Alloy 600 and 690 materials.

Right now, our attention is turning now to the Alloy 690 materials, and their weld filler materials, such as Alloy 52 and 152, 52M. Fifty-two M is one of the most common ones that is used in the industry right now.

This task, this project, took on extended arm from a previous project we had with PNNL, and 6007 was the previous project. We're just continuing on now with more testing, more materials.

One thing I will say here in this project is that we're working with industry and actually collaborating with industry in order to identify those areas where we don't know a lot right now, whether there's information gaps in some of these materials that are being used by industry in the mitigation efforts.

Some of the things we question: what happens in the dilution area of a weld? All right, when you are welding these alloys to low alloy steel, and you really dilute the chromium content, what's the crack growth rate going to do when it -- when it reaches those zones? How big are those zones? Are they significant?

So, we were doing some research to determine what the chromium content was in those dilution zones, and we're trying to measure crack growth rates in those zones, and into the new materials.

CHAIR ARMIJO: Now, these experimental facilities look exactly like the Argonne the way they're described, the Argonne facilities.

MR. LUPOLD: Yes, they are.

CHAIR ARMIJO: Is there a particular reason why PNNL and Argonne are set up to do the same thing? Or, that they're not? I expect they're not doing the same thing, but they're set up.

MR. LUPOLD: Well, they're not doing the exact same thing. They have the same test equipment, and we're doing the same type of tests. Argonne will do certain materials. PNNL will do certain materials.

We're finding out, especially now that we're getting into the 690 with the crack -- how long it takes to do crack growth rate tests. That the more -- the more testing cells we have, the better. And we're actually trying to increase the number of test cells.

CHAIR ARMIJO: This is the production rate, then?

MR. LUPOLD: Yes, right, right.

CHAIR ARMIJO: The production.

MR. LUPOLD: Our customers have told us on several occasions that we need more data, "We need more data." And we're trying to fill that void by generating data as quickly as we can, pertinent data.

MR. CSONTOS: And the two experts, too. We have two experts; one is at PNNL, and one is at ANL. And so, both of them are excellent members. So, that's why we also split it up because we have two folks who can be supported in this.

MR. LUPOLD: Yes. And the basis is -- is the cracking that we've had in the industry. We've seen it internationally. We've seen it here in the United States. We know that the PWSCC will crack. The approach goes through how we actually fabricate the test specimens and put them in the cells, and what the environments are that we subject them to, etcetera.

As we pointed out earlier today, we've looked at different hydrogen concentrations, all right? But we haven't gotten in any zinc research yet. We're monitoring what industry is doing on that, and eventually I believe we'll probably get into some testing with zinc.

Now, I'm not sure what benefit that's going to be. A lot of the research that's been done recently that I'm aware of says that zinc will aid you in delaying initiation, but once initiation has occurred, it really doesn't affect the growth rate at the cracked tip. So, really, the cracked growth rates go --

CHAIR ARMIJO: As opposed to hydrogen in BWR water?

MR. LUPOLD: Right.

MR. CSONTOS: Hydrogen and notable metal chemistry and BWR has a very good technical basis.

CHAIR ARMIJO: Right.

MR. CSONTOS: Hydrogen in the PWS has a good technical basis. The zinc has a questionable technical basis because for initiation it looks okay, but when you -- you cannot prove, I think, that you'll get the zinc to the crack tip because the zinc has to migrate, and it's great; it gets into the oxide film very nice, but the problem is that you just don't know if you have a crack, already existing crack, in a location. I mean heck, which plant had the online zinc, and had --

MR. LUPOLD: Farley.

MR. CSONTOS: Farley had the downline zinc, and they had a crack.

MR. LUPOLD: In their pressurizer surge

nozzle.

MR. CSONTOS: So, it's one of those things where it's questionable. We're going to be waiting. I think -- I used to work in this area a lot when I was a PM, and this area, we're waiting on industry to provide the EPRI guidelines, water chemistry guidelines.

There's an update that was supposed to come out, and it was supposed to come out this March, but there were a lot of I guess questions from the industry side, and Dominion Engineering is the one who is in charge of it, Chuck Marx at Dominion Engineering.

That was supposed to come out in March as a draft, and we were supposed to look at it and take a gander through it to see how it might affect our research, or Tim's group's research. Has not come out yet. So, we're waiting on this still. We'll get an update on that in maybe the August meeting, and that may impact our research.

MR. LUPOLD: Okay, another project that we have -- I've kind of organized these things to talk about primary water stress corrosion cracking first, and then I'll get into some of the IGSEC, and move into other programs after that.

The properties of CRDM welds in 6783: this is a project where we want to take nozzles that come out of plants. We have North Anna nozzle we would like to test, and so we've just gotten to the point where we're initiating this contract. This contract right now has been delivered to Argonne National Lab, and we're in the process of negotiating scope and schedule on this project. That is all the further it has gotten to date.

The nozzles are actually out at PNNL in a box, and our vision is that we'll be shipping them to Argonne National Lab so that they can -- so NDE can be run on them. This nozzle 63 that was taken from North Anna actually had in indication of a leap path on it when it was tested in the field, and we would like to do leak path or NDE to verify that currently before we dissect it, and then we would like to compare the results of that NDE to the actual condition once we remove the nozzle from the low allow steel to see if there really was a leak path there, and to see how significant it is.

Kind of get a benchmark on how good our NDE really is for doing leak path. And then we want to see --

MEMBER SHACK: Is this one of these things where you'd invite teams in to look at it, and you'd get -- you'd have hopefully a collection of results?

MR. LUPOLD: I don't know if we're going to do a round robin on it or not. That's some of the things we're talking about, but I have talked with Argonne about this, about the possibility of bringing EPRI in, possibly bringing Areva in in order to do the examination on the nozzle.

CHAIR ARMIJO: But there's no doubt that there is a significant defect or crack?

MR. LUPOLD: We believe there was a crack on this one because it was overlaid. It was overlaid with 52 materials. This is one of the few samples that we have of Alloy 52, which is applied to a nozzle, and has been in service. So, we think there's some insignificant information that we can extract from this particular nozzle. And we think that --

MEMBER SHACK: Do you think that the 52 is on there for cause, rather than --

MR. LUPOLD: Yes. We think there is an indication. The utility -- my understanding, and what I've been told is that this nozzle had an indication on it in the 82 weld, and it was overlaid because of that. Jay, you might know some additional information on this weld.

MR. COLLINS: Jay Collins, NRR, DCI Divisional Component Integrity. The first inspection was a visual inspection and identified this as a leaking nozzle, and this was what North Anna had. This was back in 2001 when they were just developing the NDE techniques. So, they went in and they looked at this nozzle, and they couldn't identify exactly where the problem was that was causing the through-wall leak.

So, they assumed in the welds, so they did the weld overlay on the -- on the wetted surface of the weld, and then down part of the nozzle.

What they found at the next outage is a possible indication of leakage from this weld, and a definite indication of leakage from another weld, which they had overlaid previously. And what this was was they had not performed the 52 overlay far enough along on the J-groove weld to include the butter.

So, they identified that as a problem. And this weld we have the ability to identify those two things, plus the leak path was identified through NDE only, but identified by NDE and clearly drawn on the NDE specs, which we still have access to. So, we think this is a very good item to go through that.

CHAIR ARMIJO: Forensic science.

MR. LUPOLD: This is also a nozzle. Since it is 52 material, we can look at the 52 material to see what kind of flaws occur in these welds when they're made. There's been a lot of talk about ductility dip cracking, and other cracking in the welding processes. We'll get an opportunity to examine this material for such defects.

Okay, all right. Talked a lot about that. I'm going to the project on environmentally assisted cracking, and 6519. This particular contract covers both ISEC and PWSCC. Okay, the PWSCC work is very, very similar to the contract that we have with PNNL. We did find the opportunity, though, this year, to start to buy some additional materials so that we can build two additional test cells for the research that we have in this area.

And as I think I mentioned, 690 material and its related weld materials, 52 and 152, they do appear to have a slower crack growth rate than what 682 and 182 have. And conversely, when you have a slower crack growth rate, that means your tests take longer.

So, the more test cells we can put into operation, the faster our customer will get the information.

CHAIR ARMIJO: Can you accelerate that by just stressing it more? Or, is that kind of as high as -- without plastic --

MR. LUPOLD: Well, there's a -- we actually don't want to stress it too much because then we're going to get criticized for subjecting these components to stresses that are completely impossible to be seen in service. All right, so we want to make sure that we're somewhat consistent in a range we think could occur in industry, and then get what -- get that particular crack growth rate from that.

MR. CSONTOS: There is an issue here with testing period, accelerated testing. When you do accelerated testing of these high chromium nickle alloys, it's -- it's these issues, and I had this at Yucca Mountain when I was there, and I have it here when I work on the reactor side. To initiate, there's a technique to fatigue pre-crack it, and then that provides I guess enough deformation and plasticity to then generate the crack, initiate a PWSCC crack, and then grow it.

What happens is that it tends to stop, and you have to fatigue it again just to kick it to start it. And then, it'll die off again. So, one of these tests, one CT specimen -- well, actually, there's multiple CT -- there's now two to three CT specimens in each test rig, and it could take six months just to get data from those three.

That's the kind of difficulty we have in terms of we're already accelerating it, and we're at the point already of saying, "Well, is this really realistic to a plant environment where we have to pre-fatigue this thing to a point where we can generate the crack." Is that real?

And so, there's an issue there as well with accelerated testing, in addition to just stressing it more, or whatnot. But, this technique just to start a crack is --

MEMBER SHACK: But of course, I mean that -- the first one is fair because you're trying to go trans-granular and inter-granular.

MR. CSONTOS: Yes.

MEMBER SHACK: And until you get it inter-granular, you're not measuring anything. Now, when you're inter-granular crack stops, whether you should then kick it I think is a -- is another question with the --

MR. CSONTOS: Right.

MEMBER SHACK: You've got to get the sucker inter-granular first --

MR. CSONTOS: Before you can -- right, right. I agree.

MEMBER SHACK: But are you going to do temperature acceleration?

MR. LUPOLD: We have not been doing temperature acceleration. We have been doing temperatures at the environments that they would see in field application. We don't have any current plans to change that right now.

CHAIR ARMIJO: How about any kind of chemical acceleration? Let's say, much lower hydrogen than you normally would expect? You know, in the BWR's you could crank up the oxygen a little bit, and that would nucleate beautifully.

MR. LUPOLD: We have used sulfate in some areas in order to initiate the cracks and get them started, and get them growing, and accelerate them that way. We have not used hydrogen -- we have looked at different hydrogen concentration levels to see what the effect is on crack growth rates. We've run them down low around -- well, some was zero cc's per kg. Others were around 20, and then up around 29. I think some of them have run up as far as 50 cc's per kg on hydrogen. So, we can see what the effects are on that, and see how it changes the crack growth rate.

MR. CSONTOS: We run into problems with the industry reps and experts saying, "Is this representative?" And so, for us, we've tried to multiply the number of CT specimens from one to three per chamber, and now we're looking at multiplying the number of chambers, and that's where Tim has bought a couple more chambers.

And so, that's the way we're trying to get to this, and it's -- it's a slow, tedious process, and we really need to note some of the properties, 692 properties, 52 properties, fairly soon because we have a lot of flaw evaluation to work that I'm doing in my branch for NRR: overlays, inlays, all these things.

In fact, inlays is a real big one for us. We're looking at three layers of 690 to prevent cracking in these joints. And so, we have an inlay analysis that we presented at the ASME code, and we used three different crack growth rates. Because what Tim's group has provided us is basically three lays -- three steps of crack growth rates, and then we have to evaluate it to those three, and come up with a --

MR. LUPOLD: Any time you generate crack growth rates, you're going to get a curve, a distribution of crack growth rates. And what Al is talking about is when you take a 75^{th} percentile through that data, or you take a 90th percentile, or you take a 50th percentile, and then he evaluates them and this is -- this is kind of like the sensitivity analysis that's done.

How much does that crack growth rate really affect the final results? And in some cases, very much so. In other cases in certain designs, the crack growth rate may not affect it a great deal because the stresses are at certain levels that no matter -- they're just not going to grow.

MR. CSONTOS: And so from our -- bottom line for us was you put an ID repair basically is what it is. You put high tensile stresses on the ID. You're saying that your crack growth is very low, okay? Well, does that -- how does the ISI, current ISI schedule, okay? How does that fit into this type of inlay interval? How does that inlay change and effect that ISI interval? And that's where Argonne has gone in and used what Tim has developed. And that's why I'm saying we worked really well together, and then we provide it over to Jay, and Jay may have some questions about how well we worked together, but -- but I think we work well together.

MEMBER SHACK: You're right. I mean I keep thinking that it's never going to grow through a whole 690 weld, but if you're talking about three layers, boy, that's not a whole lot of material.

MR. CSONTOS: And then you put a high, high tensile stress in there, and I just don't know what -- that's where that -- you have the one layer, and then you have two layers. That's where we have problems right now with our fracture mechanics is that we really haven't done that yet. This is the first time we've done it, and we've spent probably the last six months trying to develop the technique first of all, and then give the analysis.

MR. LUPOLD: And then you throw in the potential cracks that you can have in your as-welded condition.

MR. CSONTOS: We have this issue now.

MR. LUPOLD: And hot cracking.

MR. CSONTOS: We have --

MR. LUPOLD: You're already starting with some flaws that could potentially nucleate in that place.

MR. CSONTOS: There are some issues with these 690 or 52 welding, and there are some hot cracking issues. We had several overlays had to be ground down or stopped because of it, because we've had a lot of these cracking issues related to it.

Some people -- in fact, we had one that recently was done for -- I can't remember what plant it was. It was a Duke Energy plant, I believe. It was on a cold or hot leg, and they stopped mid overlay. Luckily, it didn't go over the end weld, so they just stopped it. They didn't grind it off. They just left it there. And we're trying to figure out what's going on.

So, we're looking into a new program this coming fiscal year to look at some of those issues, and seeing whether or not we need to really worry about this. And this is where it's more of an issue for inlays because do you really get three layers? How big are these cracks? What's the distribution?

We did a cursory examination with some overlay materials through PNNL. So, one of your contractors, Steve Bremer, Dr. Steve Bremer up there, and he's looked at some densities of hot cracks from overlaid materials, and some of the crack growth testing material that he had.

He did a corollary study for us to look at how many hot cracks there were, and what the size of distribution was. So, that fed into some of the ideas for our initial crack sizes for the inlay work.

CHAIR ARMIJO: Doesn't sound very

encouraging. You don't need another problem with hot cracks.

MR. LUPOLD: Okay, I'll talk a little bit more about some of the ISEC right now. There have been several new regs issues in the previous programs that we've run for ISEC. These other programs were Y6388. This program right now, 6519, is really a carry on from some of that preliminary work, which was done on those -- on those previous programs.

What we're really doing right now is wrapping up the work on the BWR environment, and the materials for the BWR internals. And we'll be issuing the new reg summarizing that work under this project 6519.

Soon, hopefully we'll have a draft by the end of this year on that. And now, we're turning our attention on the environmentally -- on the ISEC to PWR materials and environments. Materials are pretty much the same, stainless steel materials.

CHAIR ARMIJO: Does that mean your concern about ISEC and BWR is with modern water chemistry and whatever materials are there, that you -- it's reached some sort of a low level of concern?

MR. LUPOLD: I think that we could say that it has reached a low level of concern because we've done the research on it. We know what the fluence levels are in the BWRs, and we feel that we've conducted enough tests to statically characterize those materials and those environments, and don't have major concerns in those areas.

All right, now, PWR's, pressurized water reactors, have higher fluences. So, we're concerned with the internals there. Because not only do you have ISEC, you can avoid swelling and embrittlement of materials, and we need to -- we need to look at that and some of the synergistic effects that occur, and evaluate whether that's a concern or not.

Okay, and the approach is really we general the fracture toughness, J-R curves and measure crack growth rates on the materials that we have. We've set a number of materials out and had them irradiated. We've used the Halden reactor to irradiate some of the materials. We've used the BOR-60 reactor in order to irradiate some of the materials, and then we get these materials back, and then we subject to these tests.

Okay, I'll talk about N6818. This program is, again, in its infancy. We've initiated the contract with Argonne National Lab on this. It's set up really to look at all the research that we've done in the past, look at what the industry research has, and identify where there are gaps in that information, and where it would be important for us to do some type of research or confirmatory research in those areas, all right?

Omesh is the expert in the area, and we're looking to get him to help us review the data and help us generate our research plan going forward, okay?

We also set this contract up so that we could use Argonne National Labs if we need additional resources to help review some of the aging management programs that the existing licensees are proposing for --

MEMBER SHACK: Now, does 227 have a lot of technical content, or that's really more a programmatic thing?

MR. LUPOLD: 227 is the inspection and evaluation guidelines for the internals. It doesn't have a lot of technical content in it because it refers to other documents, which contain that technical information, and they draw from that in order to make conclusions that these are the inspections that should be done, etcetera.

There's a lot of technical basis. Not in 2007; they're in the other documents. Okay? That was one of the problems that we had right now with reviewing 227. Our first go-round of RAI's on that was, "Can you give us all these other documents that you refer to in this so that we can really do a proper evaluation?"

Okay, let me talk about 6270. This is our Halden environmentally assisted cracking program. Now, we set these thing up. Y6279, what this really is is a line item in our budget that we use in order to fund the ongoing Halden reactor project, which has been going on for many, many years, all right?

We participate along with many other countries. The NRC is actually an original member in this research program. We pay X dollars a year in order to maintain membership with the reactor project. The whole does much more than just materials, but the area I'm interested in are the materials.

CHAIR ARMIJO: You provide part of the funding, and then, let's say, fuels provides -- fuels research provides part of the funding. Then there's this man materials interface.

MR. LUPOLD: Digital, our INC groups. There's pre-funding for that.

CHAIR ARMIJO: Pots of money go into the --

MR. LUPOLD: Right. So, in effect we basically pay about $1.3-1.4 million a year in order to participate in all these different programs from the Halden Research Project. We've gotten materials from them to evaluate, and we've gotten information from their programs, and we use that in our reports and our evaluations.

MEMBER SHACK: Have you looked at ATR these days? I've been told it's a much more reasonable effort to deal with them now.

MR. LUPOLD: We've actually been talking with them about the potential for irradiating some of the materials. Matter of fact, the last batch of materials that we sent over to Halden we considered sending out to ATR for radiation. The problem was there was a backlog with the ATR. They've got a lot of people in line for radiations. So, the earliest we would've been able to get the samples in there would've been about 2010.

Okay, now, the ATR, the advantage with them is they had such a high flux. They irradiate materials much quicker than Halden. But if I can't get in line to get them irradiated for a year-and-a-half to two years, it kind of defeats the purpose.

Okay, now, the Zorita Internals Research

Project. If you look on your spreadsheets, this number K6202 will probably say something like CIR2 extension. Again, CIR2 extension was a line item in the budget, which we allocated money to. But what we're spending it on is -- that's for Zorita.

All right, now Zorita is the name of a reactor in Spain. It's the region in Spain, actually. The actual reactor is the Jose Cabrera Nuclear Power Plant. It shut down in 2006. They offered the materials to CSNI, and there was an initiative started through the -- was it the IEC? International ISEC Cooperative Program. I can't remember what the actually initials stand for off the top of my head.

The plan originally was that there would be an industry group, and there would be a regulatory group under this project. Each would pay half the costs, and they would get materials that they could test.

We tried to work with Spain. Spain and us, we are the ones that are interested from the regulatory side, and we're the only ones in the world from the regulatory side that were willing to actually put forth money on this effort in order to obtain materials from Zorita.

Now, the industry is banking most of this now. They have to to carry it through. They'll have to pay a majority of the costs. We approached the IEC recently, and proposed Spain and ourselves joining in with the industry members, and becoming a member ourselves.

We were willing to pay maybe 1.5 times what every other member was. And so, it was both Spain and ourselves. And they basically agreed to that to allow us to join this program as basically a partner with industry, and industry consists of Westinghouse, EPRI, Mitsubishi Heavy Industries, and there may be a few other ones there, but those three are the real heavy hitters in the program.

And what we want to do is get materials. The reason these materials are so much of interred to us is they have a very, very high dose rate on them, some of them, up to about 55 and 58 dpa on the baffle wall.

So, we think that this information could be very valuable in evaluation plants not only for their current licensing, but in their extended license, and possible even in the 60 to 80 year license extensions also.

CHAIR ARMIJO: What kind of tests are going to be performed on these things? Stress corrosion tests, or what?

MR. LUPOLD: Well, there's a lot of -- most of them -- see, this is -- this is an interesting area. This is another reason why we think we have to be involved in this. Most of the tests that were proposed by the industry were material property changes. They were going to look for material property changes and see how they changed; see how the fracture toughness changed, things like that.

In the industry matrix, there was absolutely no crack growth rate testing of any of these materials, and we thought that was important that you had that information such that if you ever do develop a crack, then you can evaluate what the effects of that crack are on some of these components.

All right, so we included that into our matrix, and it was our intent to do that type testing. And the industry said -- that was one of the I guess conditions that industry placed on us to join this that you can join in and become a member, but we want you to pay for the crack growth rate testing since you're the ones that want it.

So, again, this is -- this is an area where I think it's important that we do research like this because the industry really did not want to do the crack growth rate tests which we really thought were important.

MR. CSONTOS: And for my group, we're looking at the reactor vessel deterrent to see about late-blooming phase that may have irradiated more afterward, and then do some more metallography and fracture and mechanical property testing. And that's something that -- we're working that new.

MR. LUPOLD: It's kind of like a side thing with this project. We want to be able to get a full thickness part of the vessel, see if we can do it. I don't know if we're going to be able to do it, but we keep planting that seed in the members' ears that we want to do this.

MR. CSONTOS: There's I guess a larger issue here, and that is it would be nice to start to look at I think more -- you know, like the Saint Lucie nozzles, and getting some more -- maybe with these retired components, the components or even plants, as to try to capture some more of these materials before they get thrown away or disposed of in some way, and do some more testing on them to fill in more data for aging issues.

So, that's something that we're really -- other than the Saint Lucie and this project -- I'm not really too familiar with -- and North Anna. I guess North Anna was one of them. But again, for the domestic stuff, we had a real issue with North Anna because we really can't take ownership of it. And so, there's still issues with that.

But anyway, the bottom line is I think these are some of the areas that we'd probably like to get a little bit more effort in to start capturing some of these retired components, doing more testing in it. I think you're starting to see a little bit of that Zorita with the Saint Lucie/North Anna, and I think that's something useful that you may want to --

CHAIR ARMIJO: That's a trend, do you think?

MR. CSONTOS: I hope. I hope. I don't know.

CHAIR ARMIJO: But you want it to?

MR. CSONTOS: That's what we're hoping, yes.

MR. LUPOLD: Yes.

MR. CSONTOS: And that may be helpful if the report --

CHAIR ARMIJO: Mentions that?

MR. LUPOLD: Again, when we send materials out and we have them irradiated, some of the questions that come up are, "Well, what is the spectrum of the flux that was used to irradiate these things? And is this representative of the spectrums that you're going to see in an actual core?" And some of the test reactors are much higher, higher energy neutrons, than what you are going to see in the core, and I don't think we can defensibly say --

MEMBER SHACK: I mean it would be nice if in Zorita you could get low-fluence specimens of the same materials that you could then take to a test reactor because you're never going to get enough of these retired -- I mean getting these materials and making specimens out of them is a budget buster.

MR. CSONTOS: And that's what, actually for my budget for this year, I think it's -- no, no, for next year I got an extra $1 million for the Saint Lucie work, and that was -- I think that was above us somehow provided that because of the Saint Lucie work and seeing what effect that had for that quick, short-term issue that we had, that someone saw that it was a big deal.

So, that's the kind of funding that hopefully we can take and use to get more materials and do some of these testings. Anyway, like you said, comparing real materials to --

MEMBER SHACK: We'd really like to be able to know just how much you can rely on test reactor radiations.

MR. CSONTOS: Exactly.

MEMBER SHACK: Because there sure are a whole lot more --

MR. CSONTOS: Correlation work, right.

MEMBER SHACK: -- convenient.

MR. LUPOLD: They're easier to control. You can irradiate your specimens to set levels, and have much more knowledge.

MEMBER SHACK: You just have to be able to believe the results. You need to know if they're applicable to the actual power plants.

CHAIR ARMIJO: Speaking of test reactor, if you go to back to the Halden thing.

MR. LUPOLD: Yes.

CHAIR ARMIJO: From the materials for EAC work, what do you expect to be able to get out of the Halden program that you aren't getting from Argonne, or PNNL, or elsewhere? Is there some unique experiment going on?

MR. LUPOLD: Well, I wrote some notes down here. I'm not overly familiar with this program. I'm not the expert in it. But let's see now. We have some --

MR. CSONTOS: Carol could probably answer some of that.

MR. LUPOLD: Yes.

CHAIR ARMIJO: They gave a presentation at the RIC conference this year, and I sat in on it. I was pretty impressed at the time, but I've since forgotten.

MS. MOYER: I'm Carol Moyer, also in the Corrosion Metallurgy Branch. I had some involvement in this program a couple of years ago, and I do know that Halden did some tests on material that was from a BOR-60 reactor, and they did some work on other remove from service materials.

MEMBER SHACK: French reactors, yes.

MS. MOYER: They did look at baffle bolts and some pre-irradiated specimens, and then they --

CHAIR ARMIJO: But do they have the capability to do in-reactor stress corrosion cracking.

MS. MOYER: They do. That's what's neat about them is they have the ability to load specimens. They have tiny little compact tension specimens that are placed under load, and in environment, and under a radiation all at the same time, which is something that we cannot do at Argonne, and in PNNL facilities.

CHAIR ARMIJO: Well, they could do crack growth or crack nucleation work, stuff like that.

MS. MOYER: Nucleation, yes. Crack growth rate: the specimens are small and the monitoring of them is not as continuous as we get in the Argonne lab.

MR. CSONTOS: Also, I don't think the constraint is there as well.

CHAIR ARMIJO: Yes, yes.

MR. CSONTOS: So, it wouldn't be applicable.

CHAIR ARMIJO: It's like a fracture mechanic.

MR. LUPOLD: One of the big areas I think we can get out of there I think is relaxation. That's one of the areas we expect to get some information is on the relaxation, like bolt relaxation. How much relaxation do you get from different dose levels on the materials?

CHAIR ARMIJO: So, if you were interested let's say in the water from the water chemistry, zinc effects on nucleation, you might do some tests at Halden in reactor.

MR. LUPOLD: I don't know if we could actually have zinc in the chemistry in the sample. We might be able to irradiate it and then subject it to tasks with the zinc chemistry.

CHAIR ARMIJO: They have these loops for --

MR. LUPOLD: You might not want to crap up their loops. I'm not sure if they would let us do that or not.

MR. CSONTOS: The reason -- the reason why we don't do it right now in our autoclaves is because the zinc will crap up the autoclave. I hate to use that word, but it really will mess it up, yes. It will -- it will play out into the autoclave material, and cause some real problems in the future with water chemistry control. So, if we have --

MEMBER SHACK: You'll forever have to live with it.

MR. CSONTOS: Exactly. You'll forever have to live with it. That's exactly it. And so, for our guys, what they're saying is, "Well, if we're going to do it, we're going to do it at the end of our test matrix because we don't want to have our autoclaves screwed up for the rest of eternity for the rest of testing." Because autoclaves are expensive.

MR. LUPOLD: Or we will just designate one autoclave, and then do all the testing on that one autoclave.

MR. CSONTOS: Right, right.

CHAIR ARMIJO: Okay, do you have a write up of the scope of the Halden experimental program for materials?

MR. LUPOLD: I can get you one.

CHAIR ARMIJO: Yes, if you'd get me one.

MR. BROWN: You can send it to me.

MR. LUPOLD: Yes. And now I'll talk a little about steam generator program. This again is a long-term program. It's a five-year program. Charlie Harris is the project manager on this particular project.

This is a project conducted at Argonne National Lab, and this is in response to User Need Requests that we've received from our customers, and it involves various things like wrapping up of some of the severe accident work that has been done concerning what happens to cracks in tube sheet region under severe accident conditions.

We've seen some interesting facts from severe accidents on that, how leak rates through the tubes can change on that due to creep of some of these tubes. We're looking at a number of things. We're assessing the inspection techniques and reliability of those techniques, the eddy current exams that were done.

We're looking at the tube integrity, and the predictions. Models have been developed in the past for the Alloy 600 tubes, and it's our intent under this project to update those to the new materials that are being used for tubes in replacement steam generators. We're also looking at the different degradation modes in these.

Some of the things we're looking at here are what kind of defects are actually occurring in the tubes. A lot of the problems that you have with new steam generators are associated with wear from foreign materials. And some of the questions you have are, "What happens if you have wear, and you have actually a crack that occurs in that area?"

First off, you're going to ask yourself, "Well, can I even see it if it occurs?" All right? Because typically licensees will use bobbin probes. They'll identify that they have a wear there, or some indication there, and then they'll characterize it greater with a rotating coil.

If they have a flat spot, are they going to miss a potential flaw that might be created there between when you first identified the wear spot in future exams? You don't want a flaw to start to develop, and then miss it every time you examine tube from there on out.

We're also looking at some of the U-bends now; our capabilities for finding flaws in those U-bend areas, basically looking in different regions. Ultimately, we're also going to start -- well, one of the big -- one of the big activities I really need to mention is our structural evaluations that we're currently doing through steam generators.

There is a concern that if you have circumferential flaws in the ones through steam generators, and then you have an event that effectively cools down the steam generator, these flaws could potentially cause the tube to rupture. That's the big area where we're doing research on right now, concentrating our efforts.

Charlie, anything you want to say on the scope? Any additional research that we're working on? I guess one thing it is worthwhile saying is that these data systems that the vendors use for any current testing are changing. There's constantly new versions coming out, and utilities are using -- licensees are using these automatic -- automated evaluations systems more and more because it becomes -

- they're trying to cut down on the time it takes in order to do these examinations.

And so, a lot of our effort goes into that and into evaluating these new systems that come out.

MR. HARRIS: Charles Harris in the Corrosion and Metallurgy Branch. As Tim was just saying, the -- the NDE side in combination with some of the defect areas he mentioned. The program is looking at, for instance, any current signals in combination at the tube sheet, and then maybe with a foreign object present, what kind of signals can you get there?

The automated systems currently in use, NRC, we don't have a lot of information on how they work. Computerized data screening has been in use for a while, and now there's a new generation being introduced, for example, by Z-tech. They have a new product they all a RevoSPECT, which is an acronym for revolutionary, I believe. Revolutionary Specialized Eddy Current Testing.

This steam generator project, we've chosen that as one of the automated analysis screening systems that we want to evaluate independently of the industry. And actually, we've recently seen some questionable conflicting results from what industry has told us.

CHAIR ARMIJO: These are in independent tests that you've performed?

MR. HARRIS: At Argonne, yes.

MR. LUPOLD: Independent evaluations of the software systems.

CHAIR ARMIJO: Using your own standards, or defected tubes, or?

MR. HARRIS: We have samples, and we've also obtained eddy current data from EPRI. So, we can run all the -- for example, from -- EPRI will give us complete set of eddy current data from a tube that has come from a plant, and Argonne can screen that data looking for indications automatically with the new software.

CHAIR ARMIJO: So, it's software?

MR. LUPOLD: So, some of it -- some of it is just an independent evaluation of the software, the results that you get from the NDE. But there are other instances where they will -- we'll take the probes and collect the data from tubes with known flaws in it, and run it through the software, and then evaluate it versus the reality that we know in that tube.

CHAIR ARMIJO: This software turns an eddy current electrical signal into a defect size, shape, or something like that?

MR. LUPOLD: Right, right. And like I said, Charlie mentioned to me just the other day that they were starting to find some problems where some of the software may actually miss some defects somewhere. Or, not evaluate them properly.

MR. HARRIS: We could say it's revolutionary in the sense that this new software screens through all the eddy current signals in the whole entire length of the tube, eliminating the need for an operator to screen through, supposedly to alleviate fatigue. You're looking at signal for hours on end.

MR. LUPOLD: Tedious tasks trying to automate it.

MR. HARRIS: The question is --

CHAIR ARMIJO: Does it do it right?

MR. HARRIS: -- are you doing it right. Exactly. Are you doing it right? Are you setting your thresholds properly?

CHAIR ARMIJO: I imagine all of this is very dependent on the quality of your -- your standards, various defects for wear standards and cracking standards?

MR. LUPOLD: Absolutely. Eddy current is extremely dependent on having good standards in order to calibrate your equipment with.

CHAIR ARMIJO: Yes.

MR. LUPOLD: If you don't have that, you can do an eddy current examination, and you have no idea exactly what conditions you have. I learned that painfully one time. We were trying to examine a component pulling heat exchanger tubes.

All right, well, the last thing I mention there is other things we're doing in the U-bend region is we're looking at leak rate and burst pressure modeling of flaws in a U-bend area. That's a section of the tube that we haven't looked at that in the past. So, new areas.

All right, do you want to continue on? The last one I have is really on the spent fuel storage casks. We talked about that --

CHAIR ARMIJO: Might as well. You put it together.

MR. LUPOLD: Okay. This is our project, N6195. This is a project with Southwest Research Institute, and again, it was initiated because of some testing that the Japanese did, and we questioned whether their testing approach was too harsh; whether it caused what some people call a false positive test here.

So, we initiate -- initially made some samples, some U-bend samples, from a couple of different types of stainless steel. We use 304, 304L, 316L, and we put them in a test chamber. The specimens were heated, and we used the spray on these. They get sprayed for a short period of time. Then they would just heat back up.

The heaters were always on, maintaining them at set temperatures. The temperatures we used on these things were like 77 degrees Centigrade. We had higher ones up to 200. Well, 77 degrees Fahrenheit, I'm sorry. Two hundred degrees Fahrenheit, and 350 degrees Fahrenheit. Because some of these chambers are canisters. They're designed to maintain skin temperatures below 400 degrees.

MR. CSONTOS: With the aging of the fuel, you don't know which -- each one could be different temperatures.

CHAIR ARMIJO: Do you know if these casks can get up to -- the cladding is limited to 400 Centigrade.

MR. CSONTOS: Right.

MR. LUPOLD: Centigrade, Centigrade.

CHAIR ARMIJO: But on the surface of these casks, you --

MR. LUPOLD: They could get -- they could get as high as 400 degrees under designed conditions, okay? That's why we selected a value close to that.

MR. CSONTOS: When I was in NMSS, you can look at the surface of some of these, and the wells on the top were -- you can see some distortion because of that. I don't think they were heat treated afterwards. I'm pretty sure they weren't heat treated afterward.

All the design basis evaluations that NRC did weren't around corrosion or cracking. It was all based on drop tests, mechanical tests. I was at Sandia watching drop tests for these types of canisters to see if they could withstand the 30 feet drop, and all these different drop tests. But in terms of corrosion, this is where this is coming in is now that we may be out there for a longer period of time, aging these -- these cask storage units out there aging the fuel and the waste, how long can we -- stainless steel corrosion or chlorides, stainless steel, everybody -- we all knew -- when we first started this program we went, "Okay."

We're going to tell you right now it's

most likely going to crack, but the issue there was, "Okay, if we have salt forming on the surface; if we have deliquescent brines form because that's where -- that's kind of the mechanism that we see. Not this dripping of the -- of the salt solution. But if you have a deliquescent brine from the surface, what level of deliquescent brine?

What kind of combinations of brine? Is it just potassium chloride? Is it sodium chloride? What kind of brines could form there, and what would happen? And so there's a whole aspect --

CHAIR ARMIJO: I wish Dana was here because I would say that's a responsibility of the cask manufacturer to qualify the component for salt water or coastal --

MR. CSONTOS: If it's not part of Part 72 or 3. I can't remember which one it is, but that's not part of the design requirements NRC has developed yet.

MR. LUPOLD: See, this may lead into -- into future discussions with the industry when we present our research results, and say, "Hey, we subjected them to this. We've got cracking. We changed the model, and we subjected them to this, and we got cracking." Then we start to say, "We think we have an issue here, and we think you need to do some additional work here to prove why there is not a problem."

CHAIR ARMIJO: I think you're doing a good thing, but I would -- I'm surprised at the utilities that are buying these things from some cask manufacturer. Simply say, "Guys, qualify it."

MR. CSONTOS: Remember originally they weren't going to be at the site for decades.

MR. LUPOLD: Right.

MR. CSONTOS: They were only going to be onsite until Yucca Mountain could take them.

MR. LUPOLD: Exactly. And now, these things are starting to get license extensions on them. Originally, they were only licensed for 20 years. Then they were getting 40-year license extensions, and now people are talking about some of these canisters being onsite for 100 years or something like that. That's why we really need to look into this.

Now, one of the key arguments that the licensees are going to say is that we have our casks in -- called a mausoleum. Now, they're encased in a concrete cover. We don't get direct chloride on top of these, all right, and things like that.

So, that's probably our next evolution on this is to try and see what the effect of having a sheltered canister is versus a non-sheltered cannister, and how much more does salt develop played out on the surfaces for a sheltered canister, versus one that's not sheltered.

CHAIR ARMIJO: It depends on the kind of the shelter.

MR. LUPOLD: Right. And that may make a huge amount of difference. Now, obviously all these -- all these bunkers that they're installed in, there's no direct line of site from the vents down to see these canisters, and that's there because of a radiation shielding hazard. All right, so the question is really do you get a lot of salt buildup on some of these canisters?

We know that we have salt buildup, and then we have certain extremely high levels of humidity in the air, absolute humidity, that it can lead to some cracking. The latest results were you had to have like 60 grams per cubic meter of humidity of absolute humidity, moisture in the air.

If you look at the environmental data for all the sites in the marine environments, they're not going to get 60 grams per cubic meter. They're probably going to be more in the area of 30 grams per meter.

So, the question is in our -- in the testing we just did, did we still make the conditions in our attempt to accelerate it too hazardous or too conservative, and made it unrealistic for the conditions.

MR. CSONTOS: We were looking at types of salt that could form early on. What's the relative humidity that they would start to deliquesce at? And then look at what the consequence would be. We came out at the consequence was, well, they crack. But then, they looked at it and said, "Let's see what the realistic conditions would be at these locations." And we think we may have been a little too conservative.

This is where dropping water, salt water, on stainless steel, chloride water, you're going to get cracking. It's -- so we're going -- we're trying to reduce that conservatism to somebody more realistic, and that's what I think you're talking about you're moving towards.

MR. LUPOLD: Right, exactly. So, really, our next approach is, yes, we're just trying to become -- we want to get a realistic test. We want it to be accelerated tests. We're struggling with how do you make it accelerated --

CHAIR ARMIJO: You don't want a 100 year test.

MR. LUPOLD: -- without -- exactly. We don't want a 100-year test. We want to accelerate it, but we don't want to create the conditions such that it's not realistic than in the environment --

CHAIR ARMIJO: Did any of these guys do any of the techniques that were developed long ago? Shot peening with compressive stresses on it so it doesn't crack or anything like that?

MR. CSONTOS: This is something -- this is something that we dealt with in Yucca Mountain quite a bit. Deliquescing brines for localized corrosion, and also the initiation of stress corrosion and cracks. Okay, so you had pitting localized corrosion and stress corrosion cracks. That's where the SFST guys and the Yucca Mountain folks were closely related at some points.

And so, we were talking about this, and one of the things that I brought up was that there were a lot of techniques that were identified during the Yucca Mountain days to try to get away from this one location where you could not relieve some of the stresses globally was that end-cap weld. And this is where the end-cap weld, for some of these canisters, like I said, they're highly distorted.

So, there's all sorts of induction, shot-peening, laser-peening that were identified as potential techniques to try to relieve those -- those tensile stresses on the OD of -- of the canister. To my knowledge, we haven't heard anything yet from the SFST guys because really, it's because the design review never had corrosion at all. It was -- corrosion was never part of it. And so, now we're looking at it.

MR. LUPOLD: So, that was the last real major program that I had in my area. So, really, I turn it back over to you for additional questions and comments.

CHAIR ARMIJO: Bill, Jack, comments, questions? I just had one question that's always bothered me. In coming from the BWR side, because I think the IGSCC problems clearly is the beginning of all these things, then IASCC and all of that. And the solution seemed to have been developed with better materials when you're replacing with 316 nuclear grade, and the water chemistry, which really I think is -- takes a heart out of the IASCC problem. But do we know that this problem is solved? And is -- the

NRC's positions says, "Well, it's solved well enough for now." And how would you -- could you do anymore to say, "Hey, we really did solve this problem, and we don't want anybody to run a BWR without hydrogen water chemistry? We sure don't want anybody building a BWR with 304 stainless steel."

As far as the NRC's concern is is the IGSCC and IASCC and BWR's pretty much put to bed? I'm a research guy. So, I'm not much of a regulator because they probably won't --

MR. LUPOLD: I don't think it's completely put to bed. It's something we're going to have to look at under the PMMD program, and determine if there's anything that needs to be done, particularly when you start licensing these plants from 60 to 80 years. There could be some things that -- the thing I run into that we have absolutely no idea on right at this moment.

CHAIR ARMIJO: The reason I asked this is a couple of years ago I wrote up something on the research program, and in doing that, I came across a couple of references of cracking of shrouds in Japan. 316 nuclear grade. I don't think they used hydrogen water chemistry, but 316 nuclear grade was not supposed to --

MR. CSONTOS: That is an issue, and EPRI is looking into the core shroud issue quite heavily. To my knowledge, we haven't really been approached by NRR to look at this issue. That issue is such a big deal in Japan that the deep-hole drilling technique for residual stresses that Mitsubishi built an entire core shroud from scratch to look at the welds, and to see what the -- it's really the H5, and I think it's the H4 welds on the core shroud. Those are cracking quite a bit, and they're a little concerned -- they're really concerned about it.

And so, we haven't really seen that from NRR's side. I mean to my group. I've been seeing it during -- when I go to conferences, and I see about it and I talk to various regulators internationally, and the core shroud issue is a big deal, especially in Japan and in Korea. Mostly Japan.

But it is an issue, and I think they're looking at different types of -- EPRI is looking at this as well. That's why I put a little caveat on my presentation about mitigation. I had surface treatments. One of the things that they're talking about are doing surface treatments on some of those welds to reduce the cracking.

CHAIR ARMIJO: I think they did a bad

surface treatment. They ground the hell out of them, and created nucleation sites. I mean the other problem I saw was a 316. I think it was a piping in Sweden. It was restrain weld or something that failed, and maybe it was -- you know, but it was in the piping system. It wasn't in the core. The shroud was in the core, and it cracked, and maybe bad fabrication, but I was surprised about the piping weld in the Swedish reactor.

And so, I'm just saying is 316 nuclear grade really all that we hoped it would be? Or, is it just going to take a little bit longer?

MR. CSONTOS: It could just be that. We just -- right now, it's not that we're -- in terms of research, we haven't closed it off, but we also haven't been asked to really -- it hasn't been a regulatory issue that has come up yet for that to the point where we are that engaged to spend dollars --

MEMBER SHACK: What is in the proactive thing is the principal degradation.

MR. CSONTOS: Yes.

CHAIR ARMIJO: Through that, if in fact it's actually happening, maybe not in US plants, maybe not fabricated or operated the way we do, but it's out there, and should be kind of do something to make sure that we aren't going to be susceptible? I don't know.

MR. LUPOLD: We'll definitely need to consider it.

CHAIR ARMIJO: Okay, we're wrapping up. Dr. Powers came back. Do you have any comments? Do you? Comments questions?

MEMBER POWERS: Well, I had started a draft set of conclusion, and I have to admit I've only gotten the first -- I've gotten more than two programs here digested. And so, I will -- maybe I should work further on this. Again, to my mind, the materials metallurgy kind of research program is central to the agency's mission in the coming years because it seems like everything is cracking, corroding and degrading in these plants as they get older.

I have always thought that the Materials and Metallurgy Research Program had the best coordination with the User Needs, and I've used it as an example. I worry that you resting too much on your laurels there, and encourage you to maintain that leadership in that area with diligence.

I have just met with the research director, and he assures me on no uncertain terms that he's going to insist that you maintain your diligence in that area. But I think you guys are in very good shape on that.

If I were to point to a weakness in the grand scheme of things, I think I would point in two directions. One is it's not clear to me that you are aggressively pursuing the opportunities to leverage your programs by collaborations internationally. I know that you certainly participated in international meetings, and I know that in your programs you have data exchanges and things.

I think that you can do more in leveraging limited resources in those areas, and so it's worth looking at because I think everybody is facing the same problems you are. They may be lagging behind by five years, but it's not ten they're lagging behind.

I think I do continue to worry that the Proactive Materials Degradation Program has dropped below my horizon, and I don't think it's living up to its advertising in the past. And so, I worry a little bit about that in the grand strategies of things.

Tim, I apologize that I didn't get to understand your grand strategies of things. Al, I saw more in yours, and I like your objective. I think it's unfortunate that it's hidden; that I had to draw it out of you to find out where it's going. I don't know why that is, but I think you got the right grand strategy.

It is -- it aligns with my word view, an I am only one member of the ACRS. My world view and $2.50 will get you a cup of coffee at a cheap diner now days, but I think yes, you want to be able to establish an expertise in fracture mechanics in that you can produce this tool that can routinely be used by a non-specialist who evaluates systems for which he's responsible.

I mean it just seems beautiful to me, and what you have to do then I -- I think you need a structure to make sure you're driving to that end some metrics to see that you're driving that. Again, Tim, I apologize I didn't get to go through yours, but it may be that similarly when I go through the viewgraphs I can understand better what's going on there.

But those are the things that have come to my mind in listening to what is a crucial research program for the NRC. I think it's natural for a research programs review, but for your own benefit you need to be a lot more capable of saying why we do research in these areas, and why we cannot let the -- just wait for the industry to deliver things.

Yes, I would work on that language because that question is being asked of me whenever I talk to the Commissioners about research in general. That question, if it's not explicitly asked, is implicitly asked. Now, some of those people who are the most aggressive in asking that question are no longer a part of the Commission, but you don't know what's going to come to the Commission in five years from now, and unfortunately your research program is such that it's -- it is measures in decade scales and not particular Commission scales.

At any rate, I toss those things out. As far as the specific programs, I think we understand what each one is trying to do. I don't think I need to make specific comments on them.

CHAIR ARMIJO: One more time: Jack, you're okay?

MEMBER SIEBER: Yes. It would've helped me if I would've had an overall discussion of the direction of things. "Here through the objectives that we're trying to achieve, these are the groups or programs that will get us there." That would've helped me deal with the details. You know, the hundreds of projects.

MEMBER POWERS: I think our research --

CHAIR ARMIJO: That's been the problem in reviewing the materials because there's so many things and so many fingers --

MEMBER POWERS: Little pieces.

CHAIR ARMIJO: -- all inter-woven.

MEMBER POWERS: Right.

CHAIR ARMIJO: Read one task, and then it starts sounding much like another task that you just read. And I understand why it's gotten that, but you may --

MEMBER SIEBER: That's the way you organize and assign the work, but it doesn't help the --

CHAIR ARMIJO: Presentation understanding?

MEMBER SIEBER: -- casual reader understand the overall direction of the various phases of the program. If somebody can do that --

CHAIR ARMIJO: Well, we in fact -- Hossein has made a first cut. Not just for materials, but for all of the programs to try and put in an overall structure. When it looks like we've got something, we'll be bouncing that off of you guys to be sure it's --

MEMBER SIEBER: The structure should belong to them.

CHAIR ARMIJO: Well, maybe we would prefer that you put it together.

MEMBER POWERS: I think it's also fair to say that we're preparing this biennial report to the Commission, but I mean what we want to do is communicate accurately to the Commission about the research program. And so, we're going to ask that you help us in producing this thing.

MR. CSONTOS: Certainly.

MEMBER POWERS: And this is -- this is not a grading exercise. This is a communication exercise, and you will notice that on the web when that research program -- when that research report comes out. And so, you want to help us put the best foot forward --

MR. CSONTOS: Sure.

MEMBER POWERS: -- that we can on that.

CHAIR ARMIJO: Okay, Bill?

MEMBER SHACK: It's all music to my ears. I like this stuff.

CHAIR ARMIJO: Okay, well, with that, I want to thank everyone for this afternoon. It's been very informative. A lot of material. Appreciate it. And we will adjourn ten minutes ahead of schedule.

(Whereupon, the above-entitled matter went off the record at 4:47 p.m.)

Materials Research Projects Presentation to the Advisory Committee on Reactor Safeguards

Aladar Csontos
Timothy Lupold

July 7, 2009

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overview

- Materials research conducted by two branches:
  - RES/DE/CIB: Component Integrity Branch
    - Fracture Mechanics, NDE, and Safety Assessments
  - RES/DE/CMB: Corrosion & Metallurgy Branch
    - Corrosion, Metallurgy, and Advanced Reactors
- Research related to needs of other NRC offices
  - Generally, through a User Need Request (UNR)
  - ACRS letter for residual stress research program
  - Staff Requirements Memorandum from Commission

RES/DE/CIB Research Programs

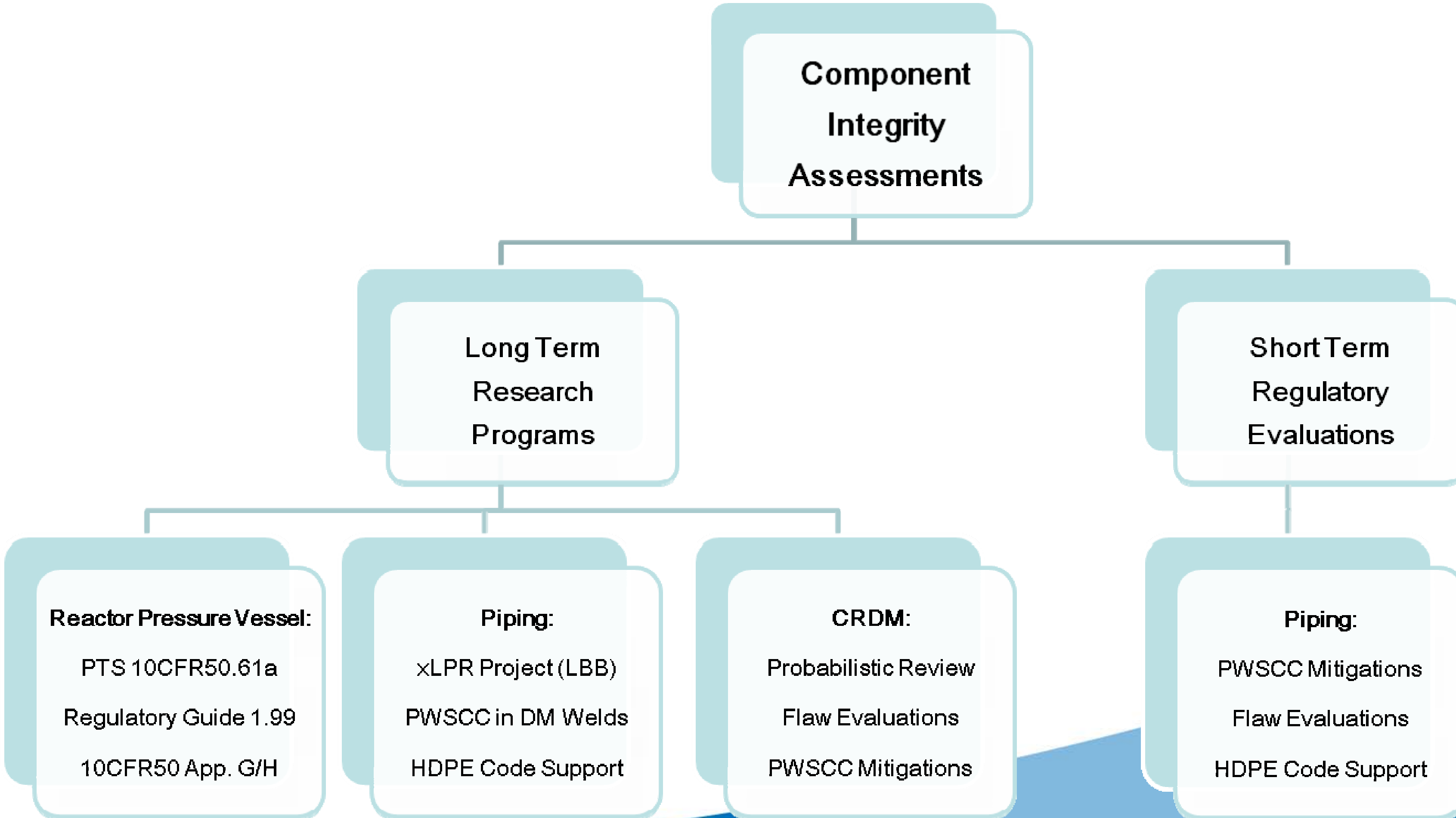
RES/DE/CIB: Overview

- Materials research supporting NRR:
  - Evaluating short/long term regulatory issues:
    - UNRs and expedited needs
    - ‘Ready to serve’ efforts include research
- Topical areas:
  - Component integrity assessments:
    - Piping/CRDM/Reactor pressure vessel
    - Probabilistic/deterministic fracture mechanics
    - PWSCC mitigation and residual stress validation
    - High Density Polyethylene (HDPE) piping research
  - Non-Destructive Evaluation (NDE):
    - Dissimilar metal welds and advanced techniques
    - HDPE piping

Topical Areas: Projects

- Component integrity assessments:
  - Dissimilar metal welds (piping and CRDM)
    - PWSCC mitigations, residual stresses, & xLPR
    - N6319/6433/6637/6547/6774/6360/6687/6829/6438
  - HDPE piping: failure mechanisms
    - N6637/6433
  - Reactor pressure vessel: fracture mechanics
    - N6578/6438
- NDE: Metallic and HDPE piping
  - N6398/6319/6593

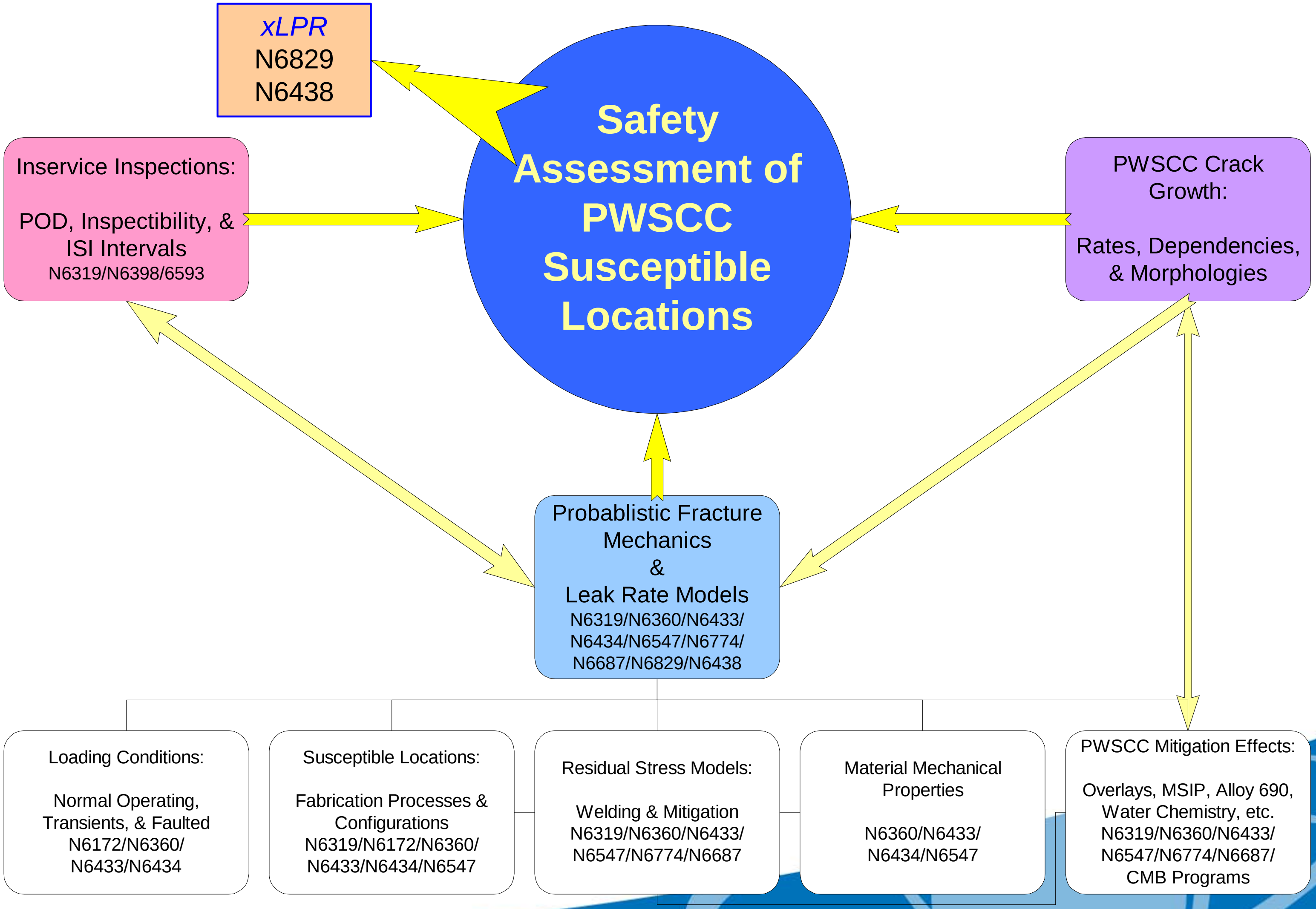
Component Integrity Assessment Programs



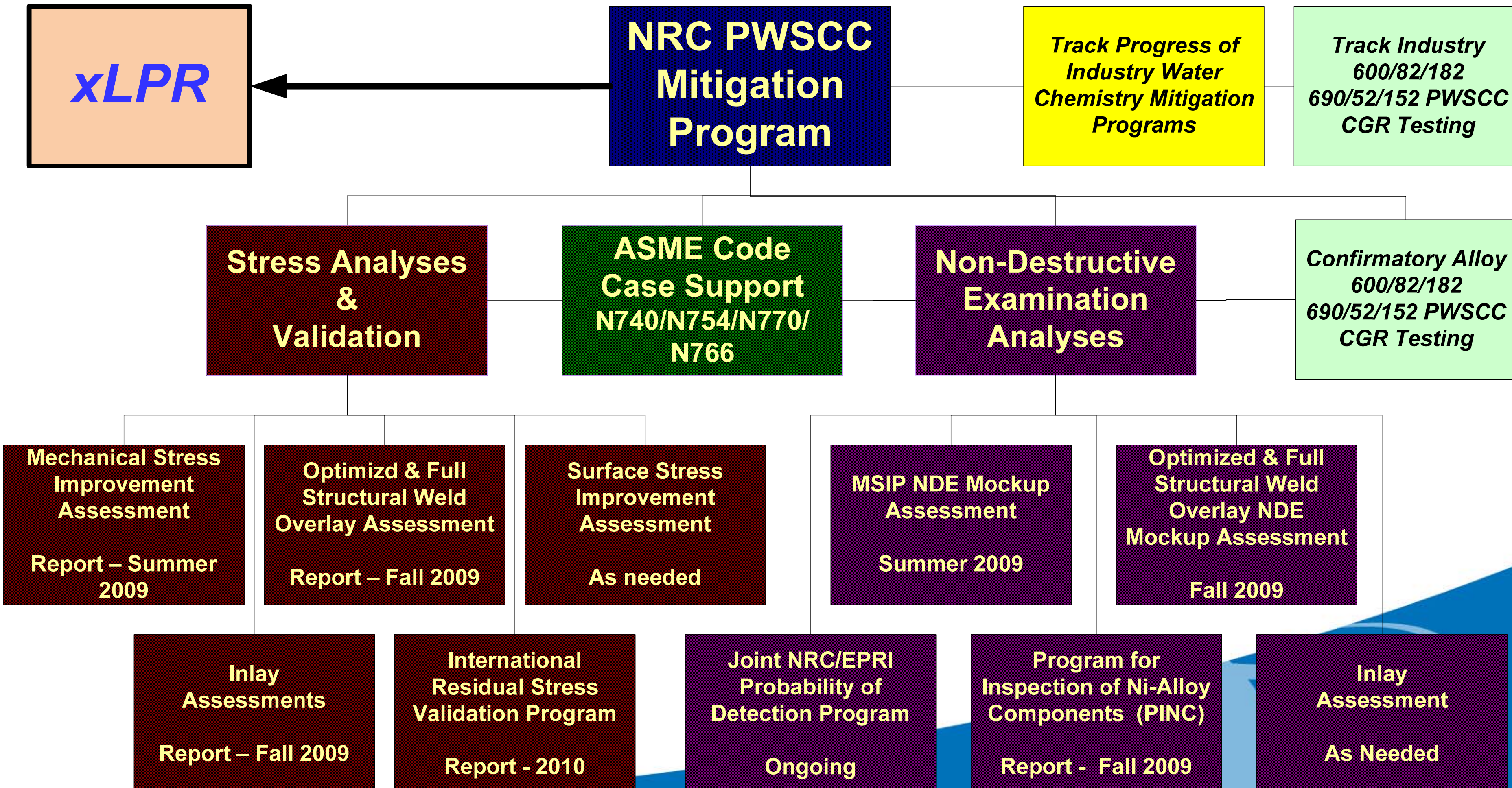
PWSCC Piping Research

- Purpose:
  - Support NRR/NRO in considering appropriate regulatory requirements to address PWSCC in xLPR piping systems.
- Objectives:
  - Short Term (1-2 years):
    - Evaluate the near-term adequacy of industry's mitigation activities
    - Initial probabilistic fracture mechanics (PFM) pilot study
  - Long Term (3-5 years):
    - Complete and validate a regulatory PFM tool to assess xLPR in piping systems susceptible to active degradation mechanisms (PWSCC)
- Collaborations across key technical groups critical to developing the probabilistic xLPR tool
  - NDE, corrosion, fracture mechanics, fluid mechanics, metallurgy

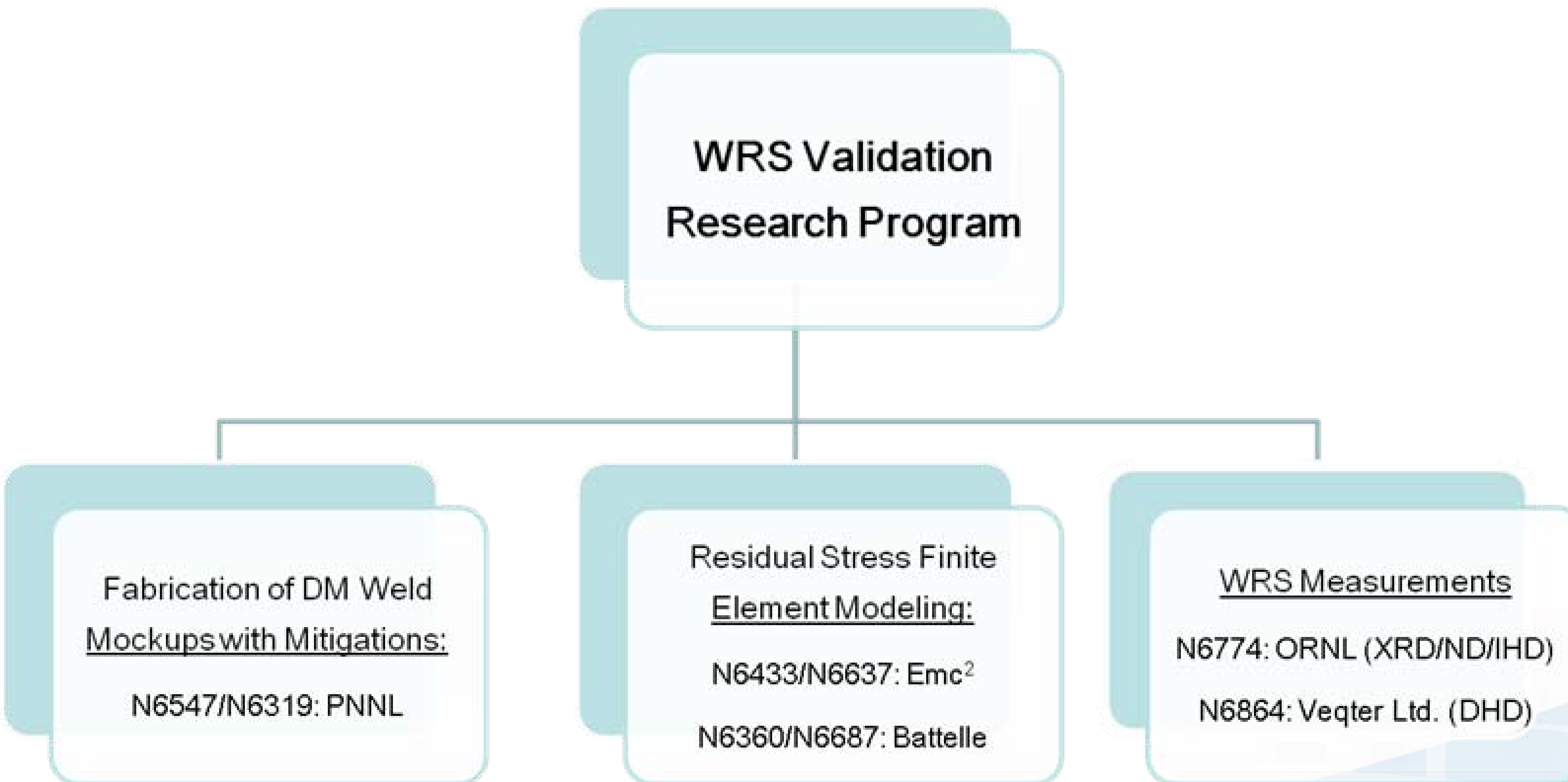
PWSCC Piping Research



PWSCC Piping Research



Piping WRS Validation Research Program



Phase I-IV Piping WRS Validation Research Program

- Background:
  - Component integrity analyses for PWSCC in DM welds showed that the results were highly dependent upon WRS profiles
  - ACRS letter dated 10/19/07 supported further WRS research
- Purpose:
  - Refine WRS FEA model development for 82/182 DM welds through sequential development from Phase I to IV
  - Develop reasonable assurance that WRS FEA models are defensible through a blind validation using well controlled mockups to various WRS measurement testing techniques
- Expected Outcome:
  - Blind validation of WRS FEA models using well controlled mockups focusing on through-wall axial & hoop stresses
  - Develop uncertainty distributions in WRS modeling

Phase I-IV Piping WRS Validation Research Program

- Phase I: EPRI Simple Plates & Cylinders
  - EPRI Lead: Mockup fabrication, WRS measurements, & project aims
  - Purpose: Refine WRS FEA model development by varying welding parameters and validate models to ND and DHD techniques
- Phase II: NRC PZR Mockups (Intn'l. WRS & FSWOL)
  - NRC Lead: Mockup fabrication, WRS measurements, & project aims
  - Purpose: Blind validation of mockups to XRD, ICHD, DHD, and ND
- Phase III: EPRI WNP III Safety & Relief PZR Components
  - EPRI Lead: Mockup fabrication, WRS measurements, & project aims
  - Purpose: Blind validation of real components to XRD, ICHD, and DHD
- Phase IV: EPRI WNP III Cold Leg OWOL Validation
  - EPRI Lead: Mockup/OWOL design and fabrication, WRS measurements, FEA modeling, and project direction and planning
  - Purpose: Blind validation of OWOL process to XRD, ICHD, and DHD

Specific Research Programs

N6360: Evaluation of Leak-Before-Break Criteria

- Vision:
  - Evaluate industry proposed PWSCC mitigation strategies of full structural weld overlay and mechanical stress improvement (MSIP) for current LBB systems to ensure that the probability of fluid system piping rupture remains extremely low
  - Benchmark and validate finite element models of residual stress profiles of representative DM welds with MSIP and weld overlay configurations
  - Quantify the changes in operational risk that PWSCC susceptibility creates for acceptability of LBB criteria as found in Appendix A of GDC-4
- Basis:
  - PWSCC has been determined to be the cause of in-service failures of nickel-based alloy DM welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Supports UNRs NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006
- Execution: Estimated completion - FY2009
- Deliverables:
  - Technical letter reports on the effectiveness of full structural weld overlays and MSIP to mitigate PWSCC growth in DM welds
- Coordination: Battelle Lead with PNNL, Emc^2, EPRI, MRP

N6433: Component Integrity Analytical Support

- Vision:
  - Develop more realistic flaw evaluation tools and fracture mechanics models to assess the risk of failure and leakage caused by PWSCC of nickel-base alloys
  - Conduct initial studies into integrity issues for polyethylene piping materials
- Basis:
  - PWSCC has been determined to be the cause of in-service failures of nickel-based alloy DM welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Supports UNRs NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006
  - Relief requests have been submitted by licensees that proposed the use of polyethylene piping for safety-related applications
  - Supports NRR-2006-007 for polyethylene piping
- Execution: Estimated completion - FY2009
- Deliverables:
  - Improved tools for performing fracture mechanics evaluations of DM welds, assessments of the risk of failure and leakage of DM welds due to PWSCC and preliminary assessments of the integrity of polyethylene piping
- Coordination: Emc^2 Lead with Battelle, PNNL, EPRI, MRP

N6687: Reactor Coolant Pressure Boundary Analyses

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- Vision:
  - Provide flexible technical analyses to NRR to develop and/or confirm the technical bases for future regulatory decisions related to reactor coolant pressure boundary and LBB system integrity with PWSCC mitigation assessments
  - Benchmark and validate finite element models of residual stress profiles of Phases I-IV of the NRC/EPRI WRS research program
- Basis:
  - PWSCC has been determined to be the cause of in-service failures of nickel-based alloy DM welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Supports UNRs NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006
- Execution: Estimated completion - FY2011
- Deliverables:
  - Technical letter reports on the effectiveness of optimized weld overlays and other mitigation methods to mitigate PWSCC growth in DM welds
  - Improved tools for performing fracture mechanics evaluations of DM welds, assessments of the risk of failure and leakage of DM welds due to PWSCC
- Coordination: Battelle Lead with PNNL, Emc^2, EPRI, MRP

N6637: Pressure Boundary Integrity Analyses & Support

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- Vision:
  - Support ASME code case review and confirmation for nickel-base alloy fabrication and inspection, polyethylene piping structural integrity, flaw tolerance, joining and inspection and other ASME Code-related activities determined to be necessary to support NRC regulatory considerations
  - Perform fracture mechanics based flaw tolerance evaluations of RCPB components including nickel base alloy welds and polyethylene piping base materials and joints
  - Confirmation of 50 year service life of high density polyethylene piping material, including fusion joints, considering the effects of flaws on slow crack growth rate at elevated service temperatures

N6637: Pressure Boundary Integrity Analyses & Support

- Basis:
  - Supports UNRs NRR-2002-018, NRR-2005-011, NRR-2006-006
  - New issues arose from prior research to support NRR-2002-018 that were out of scope of the existing contract, hence, N6637 developed
  - Relief requests have been submitted by licensees that proposed the use of polyethylene piping for safety-related applications
  - Supports NRR-2006-007 for polyethylene piping
- Execution:
  - Current research efforts conducted under job code N6637
  - Prior research conducted under job codes N6363 and N6433
- Deliverable:
  - Expedited and ongoing ASME code case reviews
  - Technical letter reports on component integrity analyses and model assessments used to predict the service life of polyethylene piping
- Coordination:
  - Industry/Licensees/EPRI/MRP/ASME

N6547: Weld Residual Stress Validation

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- Vision:
  - Develop reasonable assurance that WRS FEA models are defensible through a blind validation using well controlled mockups to various WRS measurements
- Basis:
  - Component integrity analyses for PWSCC in DMWs showed that the results were highly dependent upon WRS profiles
  - PWSCC has been determined to be the cause of in-service failures of nickel-based alloy DM welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Supports UNRs NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006
- Execution: Estimated completion - FY2009
- Deliverables:
  - Technical letter report on available WRS measurement techniques
  - Design and fabrication of two mockups for international round robin tests
- Coordination: EPRI and over 20 international WRS modeling and measurement groups for international round robin study

N6774: WRS Measurements and Assessments

- Vision:
  - Develop reasonable assurance that WRS FEA models are defensible through a blind validation using well controlled mockups to various WRS measurements
- Basis:
  - Component integrity analyses for PWSCC in DMWs showed that the results were highly dependent upon WRS profiles
  - PWSCC has been determined to be the cause of in-service failures of nickel-based alloy DM welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Supports UNRs NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006
- Execution: Estimated completion - FY2010
- Deliverables:
  - WRS Measurements using the following techniques: X-ray diffraction, neutron diffraction, and incremental hole drilling for Phases II-IV of the WRS program
  - Provide website for international round robin uploads and downloads
  - Technical letter report on results of the international round robin study
- Coordination: EPRI and over 20 international WRS modeling and measurement groups for international round robin study

N6864: Deep Hole Drilling WRS Measurements

- Vision:
  - Develop reasonable assurance that WRS FEA models are defensible through a blind validation using well controlled mockups to various WRS measurements
- Basis:
  - Component integrity analyses for PWSCC in DMWs showed that the results were highly dependent upon WRS profiles
  - PWSCC has been determined to be the cause of in-service failures of nickel-based alloy DM welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Supports UNRs NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006
- Execution: Estimated completion - FY2010
- Deliverables:
  - Through-wall WRS measurements using the proprietary Deep Hole Drilling technique for Phases II-IV of the NRC WRS program
  - Technical letter report on results of the measurements
- Coordination: EPRI and over 20 international WRS modeling and measurement groups for international round robin study

N6438: Probabilistic Pressure Boundary Safety Assessment

- Vision:
  - Develop more realistic flaw evaluation tools and fracture mechanics models to assess the risk of failure for reactor pressure vessels through validating and benchmarking physically-based material models and generic analysis methodologies to provide more robust prediction and assessment tools than current-day design-specific empirical and experimental approaches
- Basis:
  - Develop the technical bases for currently-identified RPV integrity needs:
    - Plant-specific PTS analysis guidance (Regulatory Guide 1.154)
    - Heat up and cool down limits (10CFR50 Appendix G)
    - Surveillance requirements (10CFR50 Appendix H)
    - Embrittlement trend prediction (Regulatory Guide 1.99)
    - MODULAR probabilistic code for structural integrity assessments
  - Supports UNR NRR-2007-001
- Execution: Estimated completion - FY2013

N6438: Probabilistic Pressure Boundary Safety Assessment

- Deliverables: Data, analyses, and reports for
  - Regulatory Guide 1.154 & 1.99
  - 10CFR50 Appendix G & H
  - Current embrittlement trends for 40+ & 60+ years
  - Modular code for component integrity assessment of structures
- Coordination:
  - EC Projects
    - PERFORM-60: Computational platform to project embrittlement & assess structural integrity to 60 years
    - STYLE: Assessment protocols for non-RPV components (e.g., piping)
    - PC-1: High fluence and flux effects on embrittlement
  - IAEA Projects
    - CRP-8: Master curve
    - CRP-9: PTS

N6578: Pressure Boundary Materials

- Vision:
  - Develop and validate predictive material property models aimed at the continued development, refinement, and generalization of structural integrity assessments
  - These models aim to ensure that NRC staff have tools to independently assess licensee submittals and to maintain the safety of the operating fleet by ensuring that all active embrittlement mechanisms and potential failure modes are appropriately accounted for
- Basis:
  - Accurate prediction of RPV structural integrity relies on data and models that describe the mechanical behavior of RPV materials across a spectrum of loading rate and temperature conditions, and how this behavior is influenced by the effects of neutron irradiation.
  - In recent years, trends across a wide variety of ferritic steels are now sufficiently well accepted that they are used in the probabilistic fracture mechanics computer codes as part of its risk-informed development of regulatory products. Nevertheless, certain datasets need to be developed to confirm the predictions made and the models that have been developed based on amalgam of smaller datasets, and to quantify and refine the scatter/uncertainty characterization adopted by current models. Because failure is usually predicted by probabilistic fracture mechanics models in the tails of toughness distributions, these models aid in reducing the uncertainty in failure predictions made by PFM computer codes
  - Supports UNR NRR-2007-001

N6578: Pressure Boundary Materials

- Execution: Estimated completion - FY2014
- Deliverable: Technical letter reports detailing the following items:
  - Heat treatment, metallurgical conditions, cleavage crack initiation and arrest toughness, ductile fracture toughness, and Charpy V-notch energy characterization of low and high transition temperature material
  - Design, analysis, and test results from an improved crack arrest specimen
  - Effect of prior hardening on the plastic flow and T_o properties of ferritic material
  - Cleavage crack initiation (K_{Jc}) characterization of the low and high transition temperature material using shallow crack specimens
  - Effect of elevated loading rate on fracture toughness characterization of the low and high transition temperature material
- Coordination: Carderock is the Lead with ORNL, Naval Air Systems Command, and various university and research organizations involved in fracture mechanics

N6319: PWSCC in Leak-Before-Break (LBB) Systems

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- Vision:
  - Develop strategies for managing PWSCC in LBB systems to ensure that the probability of fluid system piping rupture remains extremely low (GDC-4)
  - Assess POD in DM welds through collaboration with EPRI PDI
  - Determine ability to detect existing cracks in post-MSIP and overlaid welds
- Basis:
  - PWSCC has been determined to be the cause of in-service failures of nickel-based alloy dissimilar metal (DM) welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Supports UNRs NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006
- Execution: Estimated completion - FY2010
- Deliverables: Technical letter reports:
  - Overall PWSCC management strategy
  - NDE effectiveness of PWSCC mitigations
  - Reliability of NDE to detect PWSCC flaws in DM welds (POD curves)
  - Fabrication of Overlay and MSIP Mitigation NDE/WRS mockups
- Coordination: PNNL Lead with EPRI, MRP, Battelle, Emc^2

N6593: Assess Emerging NDE For DM Welds

- Vision:
  - Provide data and correlations necessary for NRC staff to independently evaluate licensee ISI programs for assessing integrity of DM welds
  - Evaluate current and emerging NDE techniques that licensees may be planning to apply for ISI of passive components.
  - Review and analyze results from the initial international Program for Inspection of Nickel Alloy Components (PINC) Round Robin Testing
  - Establish extended international collaborative partnerships (PINC II)
  - Expand upon the “Atlas” information tool from PINC
  - Use Results to Assess Current ISI Inspection and Acceptance Criteria Specified in ASME BPV Code Section XI
- Basis:
  - International PINC program with 7 participants was successful in addressing the effectiveness of some NDE techniques at finding PWSCC cracks in Alloy 600 and 82/182 components, i.e. particularly bottom mounted instrumentation penetration tubes and DM welds
  - PINC ended in FY09 with some issues unresolved
  - Supports UNR NRR-2006-006

N6593: Assess Emerging NDE For DM Welds

- Basis (continued):
  - PINC II or **P**rogram to **A**ssess **R**eliability of **E**merging **N**ondestructive **T**echniques for DM welds (PARENT) will focus on tight cracks, including PWSCC and hot cracks in welds in piping and in other components
  - PINC II or PARENT program (~10 participants) is designed to address some of the issues remaining from PINC and to look forward to new challenges for emerging NDE technologies
  - Supports UNR NRR-2006-006
- Execution: Estimated completion - FY2013
- Deliverables: Technical letter reports on the following:
  - Large-diameter inside-surface DM NDE techniques
  - Evaluate new techniques for rapid-growth degradation mechanisms
  - Atlas database tool with PWSCC crack morphology and corresponding NDE results, developed under the PINC program, will be reviewed, applied and extended to support NRC inspectors for ISI
  - NDE test results from mockups containing representative simulated and fabrication flaws
- Coordination: PNNL Lead with ~10 international participants

N6398: Reliability of NDE for NPP Inservice Inspection

- Vision:
  - Evaluate accuracy and reliability of NDE methods used for ISI
  - Provide info to assess adequacy of proposed industry changes to ISI programs
  - Evaluate effectiveness of ISI techniques for detecting service degradation, e.g.:
    - PWSCC in Alloy 600, 82, 182 DM welds and J-groove penetrations
    - IGSCC in austenitic welds
    - Potential degradation in cast stainless steel and weldments
    - High density polyethylene piping (HDPE)
    - Weld overlays/cladding/in-lays
    - Reactor internal examinations
    - Vessel Penetrations (CRDM and BMI nozzles)
  - Provide technical assistance to NRC program offices on as-needed basis
- Basis:
  - PWSCC has been determined to be the cause of in-service failures of nickel alloy DM welds and the source of limiting indications found in reactor coolant pressure boundary components
  - Relief requests submitted by licensees for use of HDPE piping for safety-related applications

N6398: Reliability of NDE for NPP Inservice Inspection

- Basis (continued):
  - Supports NRR UNRs:
    - Metallic Piping: NRR-2002-018, NRR-2002-020, NRR-2005-011, NRR-2006-006, NRR-2006-012
    - Polyethylene Piping: NRR-2006-007
    - Vessels: NRR-2006-012
- Execution: Estimated completion - FY2012
- Deliverables: NUREG/CRs and technical letter reports on the effectiveness of ISI techniques for detecting service degradation, e.g.:
    - PWSCC in Alloy 600, 82, 182 DM welds and J-groove penetrations
    - IGSCC in austenitic welds
    - Potential degradation in cast stainless steel and weldments
    - HDPE piping
    - Weld overlays/cladding/in-lays
    - Reactor internal examinations
    - Vessel Penetrations (CRDM and BMI nozzles)
- Coordination: PNNL Lead with EPRI, MRP, IRSN through MOU

RES/DE/CMB Research Programs

RES/DE/CMB: Overview

- Materials research supporting NRR:
  - Evaluating short/long term regulatory issues:
    - UNRs and expedited needs
    - ‘Ready to serve’ efforts include research
- Topical areas:
  - Pro-active Management of Materials Degradation
  - Corrosion/Metallurgy:
    - Environmentally Assisted Corrosion
    - Primary Water Stress Corrosion Cracking
    - Stress Corrosion Cracking of Stainless Steel in Marine Environments
  - Steam Generator Tube Integrity

Proactive Management of Materials Degradation

Pro-active Management of Material Degradation (PMMD) – N6029

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- The objective of this program is to provide technical support to NRC staff in developing information regarding materials degradation mechanisms, inspection or monitoring, and behavior of materials. The goal is to proactively address potential future degradation in operating plants to avoid failures and to maintain integrity and safety. This work will become part of the activities of an international cooperative research group whose function will be to conduct research that is needed and share the results for implementation of programs to proactively manage materials degradation. The information developed will provide NRC a foundation to implement appropriate regulatory actions to keep materials degradation from adversely impacting safety and to evaluate licensee's programs for the proactive management of materials degradation.
- The research is to:
  - Develop a master program for the proactive management of materials degradation
  - Establish international collaborative partnerships
  - Expand upon the information tool that started under JCN N6019
  - Identify research needed to address/establish a level of understanding of the degradation processes to ensure the ability to proactively manage degradation

Pro-active Management of Material Degradation (PMMD) - Basis

- Degradation of materials in certain nuclear reactor components progressed to the point where the reactor pressure boundary and defense-in-depth features were compromised.
- Many plants are also applying for increases in power rating.
  - could increase the likelihood of materials degradation and underline the interest in proactive management.
- The majority of the U.S. reactor fleet is applying for license renewal to extend the operating life from the current 40 years to 60 years, and there is now active interest in extending the operating life to beyond 60 years.
- Material degradation processes from known and emerging mechanisms and those previously experienced probably will continue to affect susceptible plant components and may increase in occurrence as the operating fleet of reactors continues to age.
  - With aging nuclear power plants, degradation that was not an issue during the initial years of operation may become an important process during later operation.

Pro-active Management of Material Degradation (PMMD) - Approach

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- Establish a refined plan
- Establish international collaboration
- Target items of low knowledge and high/medium susceptibility to degradation
- Create an information tool

Environmentally Assisted Cracking

SCC of Alloys 690/52/152 N6782

- The objective of this program is to obtain crack growth rate data for Ni-base alloys, with emphasis on those with higher Cr content, specifically Alloy 690 and its matching weld fillers Alloy 152, Alloy 52, and Alloy EN 52H. These alloys are likely replacements for Alloys 600/82 /182. Alloy 690 and its weld metals have been reported by industry to be resistant to SCC.
- In order to accomplish this objective, autoclave systems in suitable load frames and the associated water supply, conditioning and pressurization subsystems will be operated reliably.
  - These autoclave systems will allow testing under simulated and/or accelerated (e.g., increased temperature, more aggressive environments, increased load range or load interaction effects) PWR and BWR conditions.
  - Direct current electric potential drop (dcpd) methods will be used to acquire crack extension data, and effective reference electrodes will be used to acquire corrosion potential data.
  - The systems will be capable of both dynamic and static loading with load control to better than 1%.

SCC of Alloys 690/52/152 Basis

- Primary water stress corrosion cracking (PWSCC) in nickel-base alloy primary pressure boundary components is a significant safety concern due to the potential for reactor pressure boundary leaks and the associated potential of boric acid corrosion of low alloy steels and the development of flaws in piping or welds. Either condition, depending on the size and location of the flaws, could result in a significant loss of coolant accident. The use of Alloy 690 and associated weld metals, Alloy 52 and 152 have been reported by industry to be resistant to PWSCC. Although the issue of PWSCC susceptibility is being addressed by industry, user need request NRR-2006-006 specifically identifies the need to obtain PWSCC growth rates of these resistant alloys to determine the validity and acceptability of licensee flaw analyses, and to support regulatory inspection requirements.

SCC of Alloys 690/52/152 - Approach

- Stress-corrosion, CGR systems designed specifically for testing in high-temperature, simulated LWR coolant will be used.
- SCC behavior of Ni base alloys in PWR primary water will be evaluated.
- Each CGR test system will be able to test two samples (0.5T to 1T compact tension) simultaneously at temperatures up to 360° C.
- The autoclaves and the water make-up system will effectively simulate high-purity BWR and PWR water as well as control levels of oxygen, hydrogen and selected impurities.
- The systems will have active dcpd for crack-length measurement and load/K-control plus in-situ measurement capability for temperature and electrochemical potential (ECP).
- The hydrogen over pressure will be varied to evaluate the effect of ECP on crack growth rates.
- At least one CGR system will be capable of testing metallic alloys with low activity levels.

Properties of CRDM Welds – N6783

- The objective of this program is to conduct nondestructive testing, metallurgical evaluations, leak path assessment, mechanical tests, and crack growth rate tests on CRDM nozzles and nozzle welds using material that has been in service.
- Materials examined will include Nozzle 63 from North Anna Unit-2. Material from Davis Besse Nozzle 1 may also be examined.
  - Test specimens will be obtained with orientations and geometries that allow the characterization of the Alloy 600 CRDM nozzle materials and the Alloy 82/182 J-groove weld and butter.
  - Information from mechanical tests will be used to obtain yield and tensile strengths necessary to establish conditions for crack growth rate tests.
  - The results for the crack growth rate measurements will be compared to data for Alloys 600 and Alloys 82/182 obtained from a variety of specimens including the previously tested material from Davis-Besse and V.C. Summer.

Properties of CRDM Welds – Basis

- More than 30 head replacements have occurred at operating PWRs, however, only a limited number of materials that have actually been in service are available for characterization and testing. In the 2001 refueling outage, some of the North Anna Unit-2 nozzles were repaired using Alloy 52/152 including nozzles 63 and 51. In the 2002 refueling outage, 63 of 65 J-groove welds had indications and 42 of these welds would require repair. At that time, the utility decided to replace the reactor head. Previously, EPRI sponsored the removal and analysis of several nozzles. Nozzle 63 is available to the NRC to conduct independent tests. Some prior characterization of Nozzle 63 has been performed including visual examinations, a volumetric leak path assessment and surface examination of the J-groove welds that identified axial indications.

Properties of CRDM Welds – Approach

- Non destructive examination of the nozzles will be conducted to the requirements of 10 CFR 50.55a(g)(6)(ii)(D) to determine the as-left condition of the nozzle and welds to position and size indications, as well as perform a volumetric leak path assessment.
- The results of the non destructive evaluation should be compared to the previous examination results as well as identify regions where specimens will be extracted for additional analyses.
- After the nozzle has been removed from the low alloy steel head material, a visual inspection should be conducted of the low alloy steel head surface in the leak path area defined by information obtained from the current and previous volumetric leak path assessments.
- Remaining material will be used to obtain samples for metallurgical analyses, mechanical test specimens and crack growth rate specimens using specimens machined from the Alloy 600 CRDM nozzle material, and the Alloy 82/182 J-groove weld and butter.
- Crack growth rates will be compared to published data for previous laboratory tests as well as data obtained from the testing of the Davis-Besse and V.C. Summer materials.

Environmentally Assisted Cracking (EAC) – N6519

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- The objective of this project are to:
  - evaluate the susceptibility of austenitic SS to irradiation-assisted stress-corrosion cracking (IASCC) in BWRs as a function of the fluence level, material chemistry, welding process, fabrication history, and water chemistry.
  - evaluate the susceptibility of austenitic SS core internals to IASCC in pressurized water reactors (PWRs) as a function of the fluence, water chemistry, material chemistry, and cold-work. At this time, the database and mechanistic understanding of IASCC under the PWR conditions of higher temperature and higher fluence are very limited.
  - provide the NRC with technical data and analytical methods on the cracking of nickel-alloy components and welds necessary to independently estimate CGRs in reactor components for regulatory determinations of residual life, inspection intervals, repair criteria, and effective countermeasures for reactor internal components.

Environmentally Assisted Cracking (EAC) – Basis

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- Neutron radiation embrittlement of reactor core internal components constructed of cast SSs is considered significant if the neutron fluence is greater than 1×10^{17} n/cm2 (E >1 MeV). This conservative value for the threshold fluence has been proposed for cast SS internals because the possible synergistic effects of neutron radiation and thermal embrittlement are not known.
- For cast SSs with duplex austenite/ferrite structure, a loss of fracture toughness can occur due to three processes: (a) thermal embrittlement of ferrite, (b) radiation embrittlement of ferrite, and (c) radiation embrittlement of austenite.
- The kinetics of thermal embrittlement is well known and the kinetics of radiation embrittlement may be estimated based on vessel embrittlement data. However, concurrent exposure to high temperature and neutron fluence could result in a synergistic effect that leads to more rapid embrittlement than would be expected for either of the two processes individually.
- Nickel alloys, including Alloy 600, Alloy 690, and Alloy X-750 and welds using other nickel-base alloys (weld metals 82/182 and 52/152) appear to be susceptible to primary water stress-corrosion cracking (PWSCC) to varying degrees. Evaluations are needed of the time to form axial and circumferential cracks and the CGRs in such components and their welds under applicable service conditions.

Environmentally Assisted Cracking (EAC) – Approach

- Crack growth and fracture toughness J-R curve tests will be performed on SS base metal and weld heat affected zone (HAZ) material to further establish the effects of fluence level, material chemistry, thermal treatment, and welding process on IASCC.
- Models and codes developed under CIR-II and from industry sources will be benchmarked and used in conjunction with this work.
- Slow-strain-rate-tensile, CGR, and fracture toughness J-R curve tests will be conducted on austenitic SSs that have accumulated fluences typical of PWR components.
- CGR tests will be performed on a few compositions of thermally treated Alloy 690 and Alloy 152 weld, including the Alloy 690 HAZ material from Alloy 690/152 weld.
- Also, tensile property data will be obtained on thermally treated Alloy 690 and Alloy 152 weld metal at temperatures from room temperature up to 870° C.
- Furthermore, the possible deterioration of mechanical properties of low-alloy steel HAZ region will also be investigated.

Environmentally Assisted Cracking – Reactor Internals – N6818

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- While the objective of the Environmentally Assisted Cracking (EAC) program at a global level is to address the regulatory concerns arising from irradiation induced materials issues and assure structural and functional integrity of reactor core internals, the objective of this supporting project is:
  - to assist in development of a research plan following a thorough review of the available literature based on the research performed by the NRC and the industry, and
  - to review the MRP 227/175 and the PWR Internals AMP and provide a detailed analysis projecting the gaps that must be addressed in both the MRP and AMP documents prepared by the Industry.

Environmentally Assisted Cracking – Reactor Internals – Basis

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- Austenitic stainless steels (SSs) are used extensively as structural members in the internal components of light water reactor (LWR) pressure vessels because of their relatively high strength, ductility, and fracture toughness. However, exposure to neutron irradiation for extended periods changes the microstructure (radiation hardening) and microchemistry (radiation-induced segregation or RIS) of these. Irradiation leads to significant increase in yield strength and loss of ductility, degradation of fracture toughness, radiation embrittlement, susceptibility to irradiation assisted stress corrosion cracking (IASCC), void swelling, and radiation creep relaxation.
- The major concern regarding the structural and functional integrity of core internal components is IASCC of austenitic SSs. In addition, although radiation embrittlement has not been considered in the design of LWR core internal components constructed of austenitic SSs, it has become an important consideration in ensuring that adequate structural integrity exists over the license renewal period. Another issue related to high neutron exposures that are relevant for PWRs is void swelling, and its effect on fracture toughness.

Environmentally Assisted Cracking – Reactor Internals – Approach

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- Document the important conclusions from earlier studies that identify (i) the materials and environmental conditions that lead to significant effect of neutron irradiation, (ii) establishment of the crack growth rates (CGR) for core internal materials (iii) the potential of radiation embrittlement under BWR and PWR operating condition including the synergetic effects of thermal and neutron embrittlement of cast SS, (iv) the effects of void swelling including its effect on fracture toughness and (v) the effectiveness of the methods proposed by industry to mitigate radiation effects and the deficiencies/ the knowledge gaps in the existing research.
- Propose research plans that addresses the issues found as research program gaps.
- Propose additional test plans that will aid in fulfilling the NRC objective to develop regulations for the license renewal for life beyond 60 years.
- Review and assess the industry's reactor internal aging management program.

Halden: Environmentally Assisted Cracking – Y6270

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- The Halden Reactor Project has been in operation for 50 years and is the largest NEA joint project. It brings together an important international technical network in the areas of nuclear fuel reliability, integrity of reactor internals, plant control/monitoring and human factors. The program is primarily based on experiments, product developments and analyses carried out at the Halden establishment in Norway, and is supported by 130 organizations in 17 countries.
- The material work encompasses the embrittlement and cracking Behavior of internal reactor materials.
- Key program areas are:
  - plant lifetime assessments (reliability of internals).

Zorita Internals Research Project-K6202

- *OECD Nuclear Energy Agency*
  - Committee on the Safety of the Nuclear Installations (CSNI)
- Cooperative research project on ex plant materials from José Cabrera NPP (Zorita NPP)
- José Cabrera NPP (Zorita NPP) was shutdown on April 2006, and the owner of Zorita NPP, has offered materials of potential interest in R&D
- The research could be focused on properties of long time operating and in-plant irradiated materials
- The current proposal of this cooperative research project is limited to Core Internals
- Some important features of these internals are: 26,5 EFPY, high fluence and thick sections The Deliverables will be the results of the tests performed
- Potential applications are up to each participant, some potential applications: Licensing purposes, Inspection programs, Lifetime management and Lifetime extension

Steam Generator – Tube Integrity Program

Steam Generator Tube Integrity Project - N6582

- The overall objective of this program is to provide the experimental data and correlations to permit the NRC staff to independently assess licensees’ programs for evaluating the integrity of steam generator (SG) tubes as plants age. The research program results will also support the office of Nuclear Reactor Regulation (NRR) in a variety of regulatory decisions and licensing actions. Currently, the program objectives of NRR envelop the needs of the Office of New Reactors.

Steam Generator Tube Integrity Project - Basis

- Steam generator tubes provide an integral part of the reactor coolant pressure boundary. They serve as a barrier to isolate the radiological fission products in the primary coolant from the secondary coolant and environment. Knowledge of SG degradation phenomena has evolved along with SG designs and the various SG chemistries. Degradation of SG tubes has resulted from corrosion and wastage, pitting, denting, stress-corrosion cracking, and intergranular attack. Both the primary and secondary sides of the SG tubes have experienced cracking. Axial cracks, as well as circumferential cracks, have occurred. Tubes with cracks, if not detected and either removed from service or repaired, may rupture and possibly release radiological products.
- Degradation of SG tubes is an issue that continues to pose a potential safety risk to the public. This degradation has occurred as (a) intergranular stress-corrosion cracking (IGSCC) in the free span of tubes, (b) intergranular attack and IGSCC (IGA/IGSCC) at the tube support plate and egg-crate location and in regions of sludge accumulation, and (c) axial and circumferential cracking at the top of the tubesheet.

Steam Generator Tube Integrity Project - Approach

- This program builds upon the findings and conclusions of previous research programs as well as recent licensee operating experiences. At the beginning of the program, the work will focus on developing plans of action to address issues that were identified during the previous SG tube integrity program. Then, the research will incorporate additional topics which are important to evaluating SG tube integrity. These new topics arose largely from licensee operating experience.
- Research tasks under this program include:
  - Assessment of inspection techniques and reliability
  - Tube integrity and predictions
  - Degradation modes

Spent Fuel Storage Casks

Spent Fuel Cask Corrosion in a Marine Environment – N6195

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- The purpose of this experimental work is to investigate the susceptibility of austenitic stainless steels to chloride induced SCC in a representative atmospheric marine environment. The experiment is being conducted with representative materials and marine atmospheric conditions specific to the austenitic stainless steel surface (including weldments) on spent fuel storage casks. The experimental objective will be obtained through an accelerated testing method, in order to obtain results in the specified time of this contract.
- The research is to:
  - Investigate the susceptibility of various grades of austenitic stainless steels to chloride-induced SCC
  - Establish the effect of temperature on the susceptibility of austenitic stainless steels to chloride-induced SCC
  - Establish the relative susceptibility of austenitic stainless steels base metal, heat affected zone, and weld metal to chloride-induced SCC

Spent Fuel Cask Corrosion in a Marine Environment – Basis

- Some domestic spent fuel storage casks are to be located in areas where salt-laden air can come into contact with the surface of austenitic stainless steel spent fuel casks due to the proximity of the casks to either brackish water or sea water. The staff of the Spent Fuel Project Office (SFPO) has requested that the Office of Nuclear Regulatory Research (RES) assist in determining the susceptibility of austenitic stainless steel to chloride-induced stress corrosion cracking (SCC) when exposed to an atmospheric marine environment. The SFPO needs to know if a spent fuel storage cask would be susceptible to SCC when the cask is located at a coastal facility for 20 years or more. A foreign study has shown that austenitic stainless steels commonly used to construct spent fuel storage casks do fail by chloride induced SCC when synthetic sea water is applied by dripping on a heated U-Bend specimen.

Spent Fuel Cask Corrosion in a Marine Environment - Approach

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- The test shall expose the test specimens to a representative atmospheric marine environment.
- use environments that best represent the environmental conditions contacting spent fuel storage casks located at domestic independent spent fuel storage installations in proximity to sea water.
- The specimens shall be continuously heated and continuously monitored with thermocouples (constant temperature) throughout the testing.
- specimen shall be photographed, and samples taken of any salt films present.
  - The salt films shall be chemically analyzed qualitatively and quantitatively.
- The specimens shall then be cleaned and the surface examined using a low powered microscope.
  - Any evidence of pitting or stress corrosion cracking shall be verified metallographically.