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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

504th MEETING

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FRIDAY, JULY 11, 2003

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ROCKVILLE, MARYLAND

The Advisory Committee on Reactor Safeguards met at the Nuclear Regulatory Commission, Two White Flint North, Room T-2B3, 11545 Rockville Pike, at 8:30 a.m., Mario V. Bonaca, Chairman, presiding.

COMMITTEE MEMBERS:

MARIO V. BONACA, Chairman

GEORGE APOSTALAKIS, Member

F. PETER FORD, Member

THOMAS S. KRESS, Member

GRAHAM M. LEITCH, Member

DANA A. POWERS, Member

VICTOR H. RANSOM, Member

STEPHEN L. ROSEN, Member-at-Large

WILLIAM J. SHACK, Member

JOHN D. SIEBER, Member

GRAHAM B. WALLIS, Vice Chairman

ACRS STAFF PRESENT:

SHER BAHADUR, Associate Director

SAM DURAISWAMY, Technical Assistant

HOWARD J. LARSON, Special Assistant

MAGGALEAN W. WESTON, Staff Engineer

OFFICE OF NUCLEAR REACTOR REGULATION STAFF PRESENT:

BILL BATEMAN

STEPHANIE COFFIN

ALLEN HISER

MARK MCBURNETT

MATTHEW MITCHELL

STEVE THOMAS

C-O-N-T-E-N-T-S

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

8:29 a.m.

CHAIRMAN BONACA: Good morning. The meeting will now come to order.

This is the third day of the 504th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will consider the following: Recent operating events, future ACRS activities, Report of the Planning and Procedure Committee, the consideration of ACRS comments and recommendations, and ACRS reports.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Sam Duraiswamy is the Designated Federal Official for the initial portion of the meeting.

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

A transcript of portions of the meeting is being kept, and it is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so that they can be readily heard.

For the first portion of the meeting,

recent operating events and actual representation of the South Texas Project, Unit One, Mr. Sieber will lead us through the presentation.

Before we do that, however, I would like to allow one of the members to recuse himself.

MEMBER ROSEN: Yes, thank you, Mr. Chairman. I have a conflict of interest and will recuse myself from the South Texas Project discussions.

MEMBER SIEBER: You have basically three documents in front of you, one of which is a drawing of a bottom penetration and a set of slides for the South Texas Project, Unit One, bottom-mounted instrumentation nozzle leakage issue.

You also have a document prepared by Graham Leitch on recent operating events, April through June. We are going to cover that material on operating events, but very briefly after the session on South Texas. I believe that our awareness of what's going in plants under the NRC jurisdiction and otherwise is an important aspect of our job. So I really didn't want to leave that out.

So, with that, we will start with the South Texas presentation. The South Texas people are here. On the other hand, they have not planned to make a formal presentation, and the presentation will be from NRR. I would like to introduce Mr. Bill Bateman.

Good morning, Bill.

MR. BATEMAN: Good morning.

Well, it's a pleasure to be here this morning. We basically requested the opportunity to come give you folks a briefing on the South Texas bottom-mounted instrumentation leakage.

By the way, I'm Bill Bateman, Chief for Materials and Chemical Engineering Branch, and to my left is Matthew Mitchell. He's a Senior Materials Engineer, who will lead us through most of the briefing.

There's just a couple of things I would like to say, just to set the stage here. There are similarities and differences between these penetrations and the ones that you're very familiar with, those at the top of the reactor vessel. The differences, obviously, are these are at the bottom of the vessel and gravity is working in favor of any leakage dripping out. Also, there is a design clearance between the hole in the bottom of the vessel head and the penetration that goes through it, as opposed to the ones on the upper vessel wherein there is a shrink-fit.

The other key difference is, of course, the diameter. These are a much small diameter. They are about one inch, and the upper-head penetrations for the most part are about four inches.

Similarities: The materials are the same. We have Alloy 600 penetrations in both the top and the bottom, and we have J-groove welds that used Alloy 82 or 182 filler metal. So those are kind of the key similarities and differences.

I would like Matthew to go through the slide package which you folks have in front of you.

MR. MITCHELL: Thank you, Bill. Once again, it's a pleasure to be here today with you all to give you a little more background information on this particular operating event.

As was alluded to in some of the opening comments, we are fortunate today to have members of the South Texas staff who have come up for this meeting: Mr. Steve Thomas and Mr. Mark McBurnett, who are sitting at the back table and will certainly be available to help me answer any of your questions.

Just very briefly, regarding the background information, on April 12th of this year, the licensee was performing a typical boric acid corrosion control program walkdown, which they have implemented as part of their Generic Letter 8805 program.

Their walkdowns include what the staff would consider a bare metal visual examination of the region of the bottom head. They are able to perform this inspection because they have unusually good access to that area of the vessel. They have standoff insulation which essentially boxes in the bottom head. They can remove panels and get a clear view of each of the penetrations that permeates the bottom head.

This similar inspection had been completed both on Unit One and Unit Two, with the most recent one on Unit One having been done previously in November of 2002, with no evidence of any deposits noted at that time.

I will refer, just to orient ourselves, I will refer to the first viewgraph now in the separate package of slides, pictures slides, that you were provided with. This is a drawing provided by the licensee, and I think you will find it, if you go to our website, in some of the information they discussed at their May presentation on the topic.

It's a typical representation of what a bottom-mounted instrumentation penetration looks like, very typical, in particular, of penetration 46 at South Texas, one of the ones that did show signs of leakage, because of the sort of the hillside slope to the vessel that's depicted here.

As Bill noted, the materials are typical of what had also been used in the upper head penetrations, an Alloy 600 tube and INCONEL weld of 82/182-type filler metal, carbon steel vessel, the difference, again, being that there's --

MEMBER SHACK: Carbon steel?

MR. MITCHELL: I'm sorry? Low-alloy steel. Thank you, Bill. I was going by the picture instead of what I knew to be a better statement.

Then there is a 1-to-4-mil gap around the tube, so it is not, indeed, shrunk-fit to the vessel.

MEMBER FORD: Matthew, the diagram is obviously a schematic diagram. It does show the top of the weld flat with the tube. Is, in fact, that weld ground after completion --

MR. MITCHELL: Yes, yes.

MEMBER FORD: It is ground?

MR. MITCHELL: They are ground. As part of the fabrication process, they were finished.

MEMBER FORD: Are there any specifications on the type of grinding, what we used to call "abusive grinding" as opposed to light grinding?

MR. MITCHELL: There were -- we have gotten some of the procurement records that were used when the vessel was fabricated. We also have evidence, based upon the visual examinations which were performed as part of the licensee's NDE process.

Evidence of grinding was noted as part of the visual inspection. So it would be fair to say that there was a fair bit of grinding done on the surfaces of these welds as they were finished as part of the fabrication process.

MEMBER FORD: Is this uniform throughout the bottom head?

MR. MITCHELL: Do you mean on --

MEMBER FORD: Was this evidence of grinding, which we will assume is a grinding, seen on all bottom head penetration?

MR. MITCHELL: I think it would be fair to say, and I will defer also to Steve Thomas on this, that there was grinding evident on most or all of the penetrations. There may have been more or less evidence on various penetrations, but I think some grinding marks were probably noted on almost all the penetrations.

Steve, is that a fair statement?

MR. THOMAS: That's more or less true, yes.

MEMBER SHACK: The fabrication procedure is you put the INCONEL butter on, then you heat-treat the vessel and the butter weld, and then you make subsequent final weld?

MR. MITCHELL: Yes, after the buttering process, there was a stress relief at that point. But post the actual J-groove weld, no stress relief.

MEMBER SHACK: Now is that typical practice for all the plants?

MR. MITCHELL: It's our understanding that that is typical of U.S. PWRs. There may be a small minority of plants for which there was a stress relief of the bottom-mounted instrumentation nozzles after the J-groove weld, but that would be very much in the minority.

MEMBER SHACK: Now do we do that because of our NRC Reg. Guides that tell us not to heat-treat stainless steel welds after --

MR. MITCHELL: Our impression is that the principal concern would have been for distortion, which could have been induced by heat-treating these after they were installed; that you could have gotten misalignment and they would have to have gone back and mechanically straightened the penetrations after the fact.

MEMBER WALLS: You asked about buttering. I don't know what "buttering" is, but, presumably, it's a weld and actually sticks to all three levels --

MR. MITCHELL: It's a weld layer that's laid down in preparation for doing the final weld.

MEMBER WALLS: It's actually welded to the stainless steel and the vessel and the penetration, the butter?

MR. MITCHELL: Yes, it's laid down on the ferritic metal to prepare it for the final weld between the tube and --

MEMBER WALLS: So it's sort of a piece of weld really, isn't it?

MR. MITCHELL: Effectively, yes.

MEMBER FORD: And was there any record in the fabrication records of a weld repair being done to this particular penetration during manufacture?

MR. MITCHELL: No, not on either one and forty-six, and I don't believe we actually had any evidence of weld repairs noted on any of the penetration --

MR. THOMAS: I'm not aware of any, Matt.

MR. MITCHELL: Yes.

MR. BATEMAN: Was your answer, no, there were no repairs or there was no records of any repairs?

MR. MITCHELL: There was no records of any repairs done.

MR. BATEMAN: Okay, no records, Dr. Ford. We don't know that that means there were no repairs done or not.

MR. MITCHELL: So in April of 2003, the licensee performed their bare metal visual examination and noted deposits around penetrations one and forty-six totaling about the size of one-half of an aspirin tablet. Subsequent chemical analysis showed evidence of both boron and lithium, lithium being particularly interesting and giving evidence that the source of the deposits was reactor coolant system leakage, or the most likely source. Subsequent radiochemical isotope dating indicated that the deposits, or the water that led to the deposits, had been out of the reactor for approximately four years.

MEMBER APOSTOLAKIS: How often are these inspections performed?

MR. MITCHELL: The licensee performs these inspections at a minimum every refueling outage. They also have independent criteria which, if they had been operating for a specified period of time and have an outage of a certain length -- I believe it had been operating for three months and then an outage of 72 hours?

MR. THOMAS: That's correct.

MR. MITCHELL: Yes. Then they also go in and perform an inspection at that opportunity as well.

MR. BATEMAN: I just want to make it clear that is not typical. That information that Matt just gave you is for South Texas. That's not typical of other plants in the fleet.

MR. MITCHELL: South Texas' program appears to be particularly robust in this regard.

MEMBER APOSTOLAKIS: So if they were four-years-old, they didn't see them in what, two inspections, three inspections?

MR. MITCHELL: That is an interesting point. One hypothesis would be that, given the very small amounts of leakage that you would be talking about in this case, it may have taken quite a long time for the material to be deposited and then eventually extruded from the bottom of the annular region.

So it would be possible that the evidence, the deposits, was not there at the last inspection opportunity and then only became evident for the April inspection. At least that would be the working hypothesis at this point in time.

So, based upon having the information that was available, the licensee determined that it would be appropriate to undertake a rather extensive, non-destructive examination of the bottom head penetrations at Unit One. They contracted with Framatone Technology to perform NDE inspections using tooling very similar or identical to that which has been used for the inspection of bottom-mounted instrumentation nozzles in France.

This included ultrasonic testing using axial, circumferential, and zero-degree probes from the inside diameter of all the nozzles, enhanced VT-1 examinations of the J-groove weld surfaces, inside diameter eddy current, which was used to confirm the UT data, and also a new application of eddy current which had not been tried before, which was to perform what we call "eddy current on a stick" off of the refueling branch through approximately 80 feet of water to examine the J-groove weld surfaces on eight of the penetrations, including one and forty-six.

This was used to double-check, if you will, or to further check for evidence of cracking that would break the surface of the J-groove weld.

MEMBER SHACK: Now the UT is done from inside the tube? You're not shooting through the weld, are you?

MR. MITCHELL: No, but it's done from the ID of the tube, based upon using tooling coming from the refueling bridge down through the vessel. It is not qualified for examining or interrogating the weld volume. It has not been demonstrated to be reliable.

MEMBER SHACK: That's why all these graphs sort of stop at the --

MR. MITCHELL: Yes, and, well, I'll get to those graphs after one more viewgraph.

MR. BATEMAN: That's also similar to the upper head, where we don't have any qualification much beyond the OD in the housing.

MR. MITCHELL: Actually, let me just move to another picture which has been provided by the licensee regarding penetration one, and I'll just talk from the accompanying text slide about the non-destructive evaluation results.

The picture you have in front or that I have up on the slide projector now shows a depiction of the indications which were characterized in penetration one, which is the one which showed evidence of leakage. It is near the dead-bottom center of the South Texas One head.

What this shows is one large flaw of about a length of 1.38 inches which extends from above to below the J-groove weld. So it connects with the reactor coolant at this point and with the annular region around the penetration at this point, and it also perforates the ID surface of the tube wall.

Two smaller penetrations were also noted down in this region near where the root of the weld would be.

MEMBER SHACK: Is that a goodly azimuthal distance away from this other crack?

MR. MITCHELL: There was angular or azimuthal separation between them. Steve, would you have a recollection

MR. THOMAS: It was approximately 60 degrees between the three indications on penetration No. 1.

MEMBER SHACK: So they are a good piece apart.

MR. MITCHELL: There was some slight helical nature also to the main crack. It was not completely axial. There was maybe like with a 30-degree twist. Is that approximately right?

MR. THOMAS: I don't think it was quite that much on penetration one, but something on that order of magnitude.

MEMBER SHACK: Now does the enhanced VT or the eddy current on a stick see anything coming through that weld?

MR. MITCHELL: There was no indication of any cracking in the surfaces of the J-groove welds, either by visual or by eddy current exam, for any of the penetrations.

MEMBER SHACK: So we have got this little, itty-bitty flaw sitting out there all by itself?

MR. MITCHELL: Yes.

MEMBER FORD: Just to make sure that I'm right, on the righthand side of that diagram, the liquid is at the top part of the --

MR. MITCHELL: Yes.

MEMBER FORD: Where's the liquid?

MR. MITCHELL: The reactor coolant --

MEMBER FORD: Yes.

MR. MITCHELL: -- would be right here, and, also, it comes down and is on the inside of the penetration. So you have coolant in here and out here.

The penetration is open-ended at the top.

MEMBER FORD: So how did that crack on the righthand side arrive, because that's not in contact liquid, is it?

MR. MITCHELL: That's a good question.

MEMBER WALLS: Well, if would be if there was a leak from the other crack that filled the -- there might be; it might have come up from the bottom. It's awfully close to the bottom annular space there, isn't it?

MR. MITCHELL: There are a number of hypotheses that I will flag as we get further into the presentation. There may be issues related to initial fabrication defects. There may be some connectivity within the wall between the leakage path and the main crack and the more minor indications, but at this point I would say it is fair to say we don't exactly know where these particular indications came from.

Given their location, however, it would not be unusual to have a welding fabrication defect in that region, which could lead to a small flaw of that nature. Whether that's the same mechanism which would have led to the larger crack would remain a topic of discussion.

MEMBER FORD: This particular tube did not have or did it have excessive pit-up stresses, a sledgehammer?

(Laughter.)

MR. MITCHELL: The records that we have available don't go into that detail to let us know whether there was extensive mechanical straightening on any of these particular tubes.

MEMBER FORD: Okay.

MR. MITCHELL: It is possible that that was applied to this penetration, but it's not able to be discerned as to whether this particular penetration or penetration forty-six was extensively mechanically straightened.

MEMBER FORD: But if it was, that is where you would expect it to be attracted, would it not be, in that position there?

MR. MITCHELL: I might expect it to be closer to the top of the weld, given that it's done after the welding process, and if you're straightening it from the inside, I mean if you're straightening on the top, you might get more bending load near the top end of the weld. If you're straightening the bottom --

MEMBER FORD: But you don't have much room to --

MR. MITCHELL: You don't have a whole lot of room in there.

MR. BATEMAN: Matthew, did South Texas do some testing wherein they weld-tracked, tried to simulate the welding process to see how much annular deflection they would have gotten through the welding process?

MR. MITCHELL: As part of their repair and NDE effort, South Texas fabricated mockups of these penetrations, and, in particular, penetration forty-six. Their experience with performing this same type of installation procedure on the mockup indicated that one could control the angular distortion quite well as you're welding this into the head. You could keep the deflections down to, Steve, approximately one degree, was that right?

MR. THOMAS: Yes. I would point out, though, that there are opportunities for straightening these nozzles after any of the number of passes it takes to build up the J-groove weld. So it is possible that there could have been straightening done after the first or second pass that could have resulted in some deformation at that location shown in the drawing.

MR. MITCHELL: That's true. Thank you, Steve.

MR. BATEMAN: But there was PT testing done after that process.

MR. THOMAS: We passed 50 percent in the final pass with the penetrant examinations.

MEMBER WALLS: This thing that says "weld" here, that covers butter and weld, does it? Or where's the butter --

MR. MITCHELL: Yes, that would be the entire butter and weld.

MEMBER WALLS: Where was the weld butter, then?

MR. MITCHELL: It would be approximately running along the line --

MEMBER WALLS: So it would come down to about where the flaws two and three are?

MR. MITCHELL: Roughly.

Penetration forty-six then showed two indications, one very similar to the penetration or to the flaw in penetration No. 1, with the exception of the fact that it did not appear to perforate the inside diameter of the tube wall.

A second penetration, which did not show connectivity to the ID surface of the tube or the annular region ID or the OD surface of the tube or the ID of the vessel or the annular region. So it's what you would characterize as an embedded flaw, but a rather large embedded flaw.

MEMBER RANSOM: What are the accuracies of the finding, the boundaries of these areas?

MR. MITCHELL: Do you mean in terms of the NDE uncertainty?

MEMBER RANSOM: Right.

MR. MITCHELL: I'm going to defer Steve, if he's got some detailed information about --

MR. THOMAS: I don't have the specific parameters, but it's sufficiently accurate, I think well within, to explain anything that we've seen here, would not be within the error band. I mean I think this is an accurate depiction, considering the errors associated with the process.

MR. MITCHELL: We have received the final NDE report from South Texas. We have folks who are now looking at that, and if they have any questions about such topics, they will be getting back to South Texas regarding those aspects.

It is our understanding, though, that as Steve pointed out, it is a rather accurate technique for determining the boundaries and borders for these flaws.

MEMBER RANSOM: Does that mean like within a sixteenth of an inch or a quarter of an inch?

MR. MITCHELL: We'll have to get back to you on that, on these specific numbers.

So, based upon those results from the ultrasonic eddy current and visual exam, the licensee then proceeded to pursue some other non-destructive evaluation techniques. One was to perform eddy current profilometry on nozzles one and forty-six to compare the distortions in the tube wall that were produced by the weld residual stresses compared to some predictions they had made based on finite element modeling. The preliminary results were that the profilometry measurements were consistent with their welding models from the finite element runs.

They did helium pressurization tests on nozzles one and forty-six. Essentially, they put a box around the OD portion of the nozzle that extends below the vessel, pressurized it, and looked for signs of helium bubbles coming up through the coolant on the inside.

They were able to observe bubbles on nozzle one but not on nozzle forty-six. This was important also in the fact that it provided them with a benchmark location for their future boat samples that they would be taking to try to sample the flaws in these penetrations.

MEMBER SHACK: Matt, on those residual stress measurements, was there anything unusual? Were they high or low compared to CRDM heads?

MR. MITCHELL: I have not looked at the CRDM results. So perhaps I ought to pull back and not speak too strongly to that.

To my knowledge, there was nothing atypical about them in terms of -- I mean it would be what you would have expected from a nozzle consistent with this geometry. They essentially modeled typical welding practices that would have been employed for this type of penetration.

MEMBER SHACK: But we didn't see particularly high stresses, though, that would explain the low-temperature cracking that we are seeing?

MR. MITCHELL: Nothing out of the ordinary. But that doesn't --

CHAIRMAN BONACA: I have just a question -- I'm sorry.

MR. MITCHELL: I was just going to say, that doesn't preclude the fact, however, that if there were repair welds made which would make these particular penetrations vary from typical, if there was extensive grinding or grinding marks on the surface that would make them particularly sensitive --

MEMBER SHACK: But you don't see any particularly on the surface here. I mean that's sort of the surprising thing.

MR. MITCHELL: Well, again, there were indications of grinding. Were these two penetrations particularly unique in that regard? Not necessarily --

MEMBER SHACK: But I mean grinding stresses certainly wouldn't seem to explain the cracking which we're seeing here. You know, you don't see anything, no cracking in the welds.

MR. MITCHELL: Right. It does provide a bit of an unusual story in that regard.

CHAIRMAN BONACA: The question I had was that, looking at the figure on penetration one, that shows significant opening through the wall. I'm surprised that the leakage was so minor if I look at flaw No. 1.

MR. MITCHELL: Yes, it is a very tight flaw, apparently.

CHAIRMAN BONACA: Okay.

MR. MITCHELL: Also, if this flaw is growing with time, the leakage path would not have always been as shown here. It would have sort of grown into this type of a connection.

So it may very well have been that the potential for leakage and the leakage rate was accelerating with time. So you sort of have to do a time intregal over the entire course of the leakage period.

CHAIRMAN BONACA: Yes.

MEMBER SHACK: When you've got the weld, the whole tube constrained by the weld, you just can't expand and open that very much.

MEMBER KRESS: Does that explain to some extent why the boric acid appeared to be four years old? It's because it may have stayed in that crack a long time before it ever got out to the end?

MR. MITCHELL: Either in the crack or in the annular region, once it got to the outside.

MEMBER KRESS: So it wasn't out there on the surface all those four years? It was just on its way there?

MR. MITCHELL: It did not appear to be so. I think that would be a fair -- I mean it certainly was not there for four years.

MEMBER WALLS: How about the volume of the -- the volume of the annulus is pretty small, isn't it?

MR. MITCHELL: Yes.

MEMBER WALLS: How does that compare with half an aspirin?

MR. MITCHELL: I believe the licensee has performed a calculation regarding how much leakage it would have taken to fill the annulus and to provide that amount of extruded material. The number I recollect -- and Steve will correct me if I'm wrong -- is about 400 liters, isn't that --

MEMBER WALLS: Liters?

MR. MITCHELL: Liters. Is that --

MR. THOMAS: Let me revise that, Matt. That was really based on a number of absolute worst-case assumptions. Since they are old, we revised that calculation to not use the highest lithium concentrations but an average lithium concentration over several cycles. I think the number is about a factor of ten lower than what you've quoted now. So we are talking maybe 30-40 liters over a period of --

MEMBER WALLS: Is the total amount of leakage?

MR. THOMAS: Yes, in liters, the total amount of liquid leakage.

MEMBER WALLS: If it's four-years-old, presumably, there's some one-year-old stuff in the annulus. So I was trying to figure out how much stuff could be in the annulus if we're extruding it -- presumably, the leakage, you would expect an increase with time. So you would expect to find the volume of the annulus bigger than the half an aspirin.

MR. THOMAS: Well, you're correct. Obviously, there is more volume in there. When we --

MEMBER WALLS: There's more than half an aspirin in the annulus?

MR. THOMAS: I think that's a fair conclusion, yes.

MEMBER SHACK: Did you try to sample anything out of the annulus?

MR. THOMAS: No, we didn't. The repair technique offered us a slight opportunity to remove the lower portion of the nozzle during the repair, but there was no unusual amount of deposited material recovered during the repair activities.

MR. MITCHELL: I should make one more point from this slide: that given our recent interest certainly in the potential for boric acid corrosion of low-alloy steel base material, that the licensee also performed a phased-array examination from the OD of the vessel head to see if there was any evidence of wastage in the annular region before going in and performing the repair, and there was no evidence of substantial corrosion in that area.

MEMBER WALLS: So this aspirin didn't have any of ferrite material in it?

MR. MITCHELL: No, sir.

MEMBER KRESS: Remind me, what's the temperature down there on that bottom head?

MR. MITCHELL: The temperature of the coolant in the bottom head at South Texas is approximately 560 degrees. It would be, I think, fair to say it's one of the warmer bottom heads of plants in the industry.

MEMBER WALLS: Did you say anything about this helium pressurization on slide six?

MR. MITCHELL: Other than the fact that, just going through what was on the slide, that they did see evidence of leak, of bubbles from penetration one and not from penetration forty-six.

They performed the tests to the best of their ability.

MEMBER WALLS: At 150 psi?

MR. MITCHELL: Yes.

MEMBER WALLS: You actually see bubbles coming out? It sounds like a fairly substantial leak.

MR. MITCHELL: You're talking about a

very, very small molecule atom going through that gap, but you're using a helium pressurization, and that's particularly the reason why it is used, obviously. So it is very possible that they could get it at 150 psi.

MR. THOMAS: We did not see anything at 100 psi with helium, and we did not see any bubbles coming through the ID of the tube. It was approximately one bubble every second or two at the surface of the tube weld interface on the outside of the tube.

MR. MITCHELL: And I think another one of the principal reasons for performing that test was to see if they could substantiate any leak paths through the weld as well, which would be going through the weld volume and being evident on the weld surface. That was not substantiated.

MEMBER WALLS: Just if you can see bubbles at that rate, it seems to me that if you translated that into a flow rate of liquid going the other way, it would be substantial. I mean it would be enough to create deposits. I haven't done the calculation. I just did some analysis --

MR. THOMAS: It has just been our experience that you probably would not be able to push any air through at that pressure, and I am just not sure that you can correlate what you might see with borated water with deposits in the defect with the helium leaking. I would expect that you might not see anything at all.

We have had some experience with canopy seal weld leakage on the upper head, and you'll see a small deposit below in there and no leakage at all with, you know, a full-reactor coolant system pressure.

MEMBER WALLS: You're thinking that's because the crack is so small that it's no longer a continuum that's going through there? It's some sort of -- down to the mean-free path of the helium or something?

MEMBER SHACK: We run tests on steam generator tubes so we can see air bubbles at 40 psi, and we don't get water leakage until 2,000 psi.

MEMBER WALLS: It sounds very strange.

MEMBER SIEBER: And helium --

MEMBER SHACK: And helium is going to be --

MEMBER SIEBER: Yes, it leaks like crazy.

MEMBER WALLS: It seems to defy the normal ideas of flow-through for speed.

MEMBER SHACK: It's a pretty small

molecule.

MEMBER WALLS: Yes, okay.

MEMBER POWERS: You don't really think that you have molecular sieving here? I mean you're not pushing this stuff through molecule by --

MEMBER WALLS: I think it's a continuum, isn't it? It's not three molecules --

MEMBER SHACK: Right. To get a bubble, you would have even a hard time with a single molecule.

MEMBER POWERS: I find this small molecule business to be perplexing.

MEMBER SHACK: We do see that all the time, and, you know, we run dozens of steam generator tube tests where you get leakage with air at very low pressures and you don't see water leakage until thousands of psi.

MEMBER WALLS: So you must be down to very tiny dimensions where the molecular forces matter.

MR. MITCHELL: I'll move on to slide seven now, regarding the preliminary root-cause analyses that the licensee is pursuing. They generally boil down into one of two descriptions.

Obviously, primary water stress corrosion cracking is a possibility in these materials, but we have extensive experience with that at this point. The one outstanding quandary for that particular description is the fact that we have seen in the South Texas case only cracking of two out of the fifty-eight penetrations, and that cracking was rather extensive, obviously, leading to through-wall leakage, without any evidence of cracking in any of the other penetrations.

That's atypical for what you would have expected from a primary water stress corrosion cracking mechanism. You would have expected to have seen at least smaller cracks having initiated in the other tubes, if, indeed, all the tubes were effectively equivalent.

MEMBER WALLS: You've got cracks which are not wet, haven't you, here?

MR. MITCHELL: I'm sorry?

MEMBER WALLS: You have cracks which are not wet? It also looks as if even the ones that got wet probably started out not wet.

MR. MITCHELL: That may very well be.

MEMBER WALLS: So how could this be an initiating mechanism if it has dry cracks?

MR. MITCHELL: Again, there may be connectivity within the wall which could have allowed reactor coolant to reach some of these other locations. That's yet to be substantiated. It may be that we're looking at more than one mechanism. Some of the smaller flaws may be a result of fabrication defects, while the larger flaws may be the result of primary water stress corrosion cracking.

MEMBER SHACK: Your big crack on forty-six is the hard one to explain. I mean, the little ones, you can do that with --

MR. MITCHELL: Correct.

MEMBER SHACK: -- but that big one on forty-six is --

MR. MITCHELL: The large embedded, what appears to be an embedded flaw in forty-six at this point defies a good rationalization. The licensee certainly is looking at option two on this particular viewgraph regarding cracking which may have been initiated at discontinuities within the weld, welding fabrication defects, lack of fusion, which were evident in penetrations one and forty-six. The zero-degree UT probe, in particular, showed evidence of these spots within the weld which are believed to be a welding defect, which may have served as an initiation location for cracking.

MEMBER SHACK: Did somebody try to do a

thermal fatigue analysis, you know, how big an initiating crack would you need to grow the sucker by fatigue, something like this size?

MR. MITCHELL: You've hit on the question I keep asking. I'll defer to Steve on this, if you would like to follow up on that --

MR. THOMAS: We're doing some preliminary studies along those lines to try to reproduce these sorts of defects in similar materials and configurations. That work has not been completed yet.

I would just say, though, that it was successful at generating cracks under these circumstances, but how that is going to relate to our as-built condition or to this particular condition is yet to be determined. But it is certainly at least theoretically possible, and under the conditions that we have created, possible to reproduce cracks under these types of conditions without contacting primary water.

MEMBER FORD: Matt, could you just go back to the third sub-bullet in No. 1 there? You say, "Observed other penetrations." You mentioned earlier on that the French have done an extensive amount of bottom head penetration inspections. Did they share with you their observations?

MR. MITCHELL: We have had frequent interactions with our French colleagues. It is our understanding that their inspections have shown no evidence of degradation in bottom-mounted instrumentation tubes at any of the French facilities.

MEMBER FORD: And that was an extensive number of examinations?

MR. MITCHELL: My understanding is, I believe they singled out approximately 12 of their facilities for inspection. They have done on the order of 15 to 20 inspections of those, those 12 facilities.

Dr. Allen Hiser is also with us in the back of the room. He and Stephanie Coffin just got back from a bilateral meeting with our colleagues over there. I'm not sure if Allen would have anything he would like to add regarding that experience.

MR. HISER: I would be happy to afterwards.

MR. MITCHELL: Okay.

MEMBER WALLS: Now when a guy welds this thing, he strikes an arc, does he, when he stops welding? Does he strike an arc to the tube or to the stainless steel or the buttering, or what?

MR. MITCHELL: Well, the arc strike would have to be in the, obviously, within the weld volume or where the welding was going to be performed.

MEMBER WALLS: Well, he's got to be -- he has electrodes and things, and he strikes an arc. Does the arc get struck first to the tube or to where?

MR. MITCHELL: My experience, my limited experience, with actually doing welding is the arc often goes where it wants to go.

MEMBER WALLS: Well, that's right. Is there any control over how he starts heating this thing?

MR. MITCHELL: I don't believe it's controlled to that level. Steve?

MEMBER WALLS: I don't know if it makes any difference, but I think conceivably --

MR. THOMAS: No, I don't think I can help you here. But I kind of tend to agree with Matt; I would say that it could be either one.

I know that we have seen on the surfaces of the tubes a lot of the grinding marks that we have been referring to. We also see grinding marks in the tubes, which is somewhat of a surprise to us initially. But I think it's fair to say that you could probably have arc strikes or perhaps excessive heat at either location.

MEMBER WALLS: Yes, but the grinding is after the whole weld is complete. It's not inside, is it?

MR. THOMAS: No, I think you would find grinding at several stages. The procedures specifically require grinding at each stage prior to penetration testing. So I would think there would be multiple opportunities for grinding as this is weld. It's also done with a small process, shielded-metal arc process. So I would think from time to time we would want to clean up that weld if there is a slag inclusion or some residual --

MEMBER WALLS: Would the grinding leave pieces of grind stone stuck in the metal? Do they always come out?

MR. THOMAS: I really don't know. I would presume there would be some residual material there. There are certainly residual markings there.

MR. MITCHELL: So I think it would be fair to say that one would anticipate that grinding was done probably a minimum of three times.

MR. THOMAS: At least.

MR. MITCHELL: The root pass, the 50 percent level, and after the surface, if the welder noted that there was a reason to grind another pass or at a different time, based upon what he saw was the condition of the weld, he would also have been provided the opportunity to do that by the welding procedure.

MR. BATEMAN: But, again, after that process, there's a liquid-penetrant inspection to look for flaws. So if there were any flaws that remained behind, they would be identified and then ground out and repaired and reinspected.

MEMBER SIEBER: But that's done throughout the process of building up the weld?

MR. MITCHELL: Yes.

MR. THOMAS: But not at each pass.

MR. BATEMAN: I think three times on the way out.

MR. THOMAS: Three times on the way out. The root, 50 percent, and the final pass, but not at each pass.

MEMBER FORD: But, again coming back to this question observed at other penetrations, I remember at one of the Subcommittee meetings we had just two months ago, I think it was, when this issue first came up, we raised the hypothesis that maybe another prediction curve, temperature or Arrhenius type of prediction curve which we currently use for vessel head penetrations, there's a different one which is offset because of stress for the bottom head penetrations.

Your observation of the higher bottom head temperatures would indicate that maybe this was just the beginning of the lead of our fleet of observations. Is that a reasonable statement, that we are now starting to go up a prediction curve which is offset from the vessel head penetration curve?

MR. MITCHELL: I wouldn't be prepared to draw that conclusion as of yet, no. For one reason, we have not yet substantiated that this is, in fact, primary water stress corrosion cracking

MR. BATEMAN: Correct.

MR. MITCHELL: I believe that we're still looking for confirmation of that or contradiction to that from the material samples that South Texas will be removing and testing.

And even if it is determined that primary water stress corrosion cracking is a significant contributor to initiation or propagation of these flaws, you are left with the quandary of, why is it only two out of the fifty-eight penetrations at South Texas? Ostensibly, each of those penetrations has been in the same environment, particularly if we are talking about a time-at-temperature, Arrhenius-type model.

So there must be some --

MEMBER SHACK: But this is a multiple-arrival process with a high B.

MEMBER FORD: Yes, but you could also say that this is one where you had excessive grinding or sub-stresses. You're right.

MEMBER SHACK: You know, these statistics of initiation, you're not terribly surprised that there is a considerable scatter.

MR. MITCHELL: That's true. I guess my gut instinct was still, though, that the tube --

MEMBER SHACK: You're a mechanics guy. That's why you --

(Laughter.)

MR. MITCHELL: To see two flaws or to see flaws this large with evidence of nothing else kind of unsettles me just a bit.

MR. THOMAS: I feel compelled to comment at this juncture. Of course, these questions are very similar to the questions that we were certainly asking when we were at the beginning of this process. I think at our first public meeting here I said that the ID-initiated primary water stress corrosion cracking was our favorite theory.

I think we have seen compelling evidence to cause us to question that theory. First of all, we don't see that these cracks do not appear to be ID-initiated. We only had one of the five cracks that actually penetrated the ID of the tube. We see three of the five defects apparently not in contact with any wetted surface or in contact with primary water.

We see that the cracks are relatively old, and yet we do not see any raddling/cracking in any of the other tubes, and you would just suspect that, if it was a random time-progressive type of process, such as primary water stress corrosion cracking or general fatigue, that you would see some less material cracks in other tubes, and we saw absolutely nothing like that. We were certainly expecting to see something, but we didn't.

So I think that there is, in my mind at least, and most of the folks that we are working with, compelling evidence that suggests that the second cause that's shown on this slide is the prevailing theory at this point in time. We do need to do some other work to attempt to confirm this, and we have that planned.

MR. MITCHELL: Okay, I think I may have

already spoken about all the bullets on this slide in one way or another, just to get here.

The licensee is taking material samples from nozzles one and forty-six to try to investigate the degradation mechanisms at play here. It may substantiate one or the other mechanism. It may substantiate some combination of the two mechanisms. It may be something as yet unrecognized or unacknowledged at this point. But that it is not one of the two leading mechanisms may also become evident.

We expect to have the licensee's evaluation and final root-cause report in the September or early October timeframe of this year, which will include the information from the boat sample analysis.

Very briefly, the licensee has repaired the two nozzles on Unit One. They have employed what I think the Committee is familiar with: half-nozzle repair techniques where they have sectioned the nozzle, removed the outer part of the old nozzle, installed a new Alloy 690 tube, and welded it in this case to the outside surface of the reactor vessel head using a tempered pad also as part of the fabrication process.

MEMBER FORD: So if I remember this one

right, you leave the cracked component in the vessel, but it's not load-bearing? It's not --

MR. MITCHELL: The cracks which were observed continue to be within the vessel. They are no longer, however, at that point part of the reactor coolant pressure boundary. The pressure boundary has been moved to the outside of the vessel with a new weld.

MEMBER FORD: And a boat sample will be taken from the cracked region?

MR. MITCHELL: They will remove part of the observed flaws, not the entire defects, not the entire indications which were seen.

MEMBER SHACK: And that leaves an internal crevice, right, where you put the half-tube in and there's no weld joining to the old tube? You just sort of stick it in there?

MR. MITCHELL: That's correct. There is a small gap between the old tube and the new tube, which then allows a coolant environment to exist between the tube and the low-alloy steel base metal.

MEMBER SIEBER: But no mechanism for concentration?

MR. MITCHELL: No, apparently not. We have had experience with half-nozzle repairs at another part of the reactor coolant system. To date, we have no experience which suggests that this leads to an environment which is an aggressive corrosive environment with respect to the low-alloy steel.

MEMBER POWERS: I'm wondering why not.

MEMBER FORD: Well, I think the reason there is that there's no concentrated mechanism; there's no oxygen there to give a corrosion potential-driven oxidizing potential and there's no heat transfer to give you a concentration that could survive that means. I think that's the outcome.

MR. MITCHELL: It's a generally stagnant environment, and there's inherently a low oxygen concentration throughout the RCS.

MEMBER FORD: You are inventing a relatively low-boron activity.

MEMBER SHACK: I mean primary coolant and low-alloy steel will corrode maybe a mil or two a year sort of a rate. I mean it does corrode. It's just that it's a fairly gentle corrosion process.

MR. MITCHELL: Yes.

MEMBER FORD: Especially at those temperatures.

MR. MITCHELL: Yes, and I think it's worth noting that, given the leakage that was observed already and the lack of any corrosion actually in the annular region, gives you some confidence that, even in this case in sort of an open-ended, open-to-the-containment-environment situation, there was little or no corrosion of that particular penetration or these particular --

MEMBER SHACK: Well, as one of our public people has pointed out, we operate reactor vessels with cladding removed from patches of it, exposed to the coolant.

MR. MITCHELL: Correct.

Moving on to the final slide, then, on potential generic implications of what was being observed at South Texas, bullet one is, I think, one of my favorite bullets, and I end up saying this to a lot of people often: that none of the available information suggests that South Texas Unit One is unique with regard to its being susceptible to bottom head penetration cracking.

I think that statement holds whether this turns out to be primary water stress corrosion cracking, fabrication-related issues. We know at this point of no particular reason to single out South Texas Unit One as unique.

MEMBER POWERS: Earlier in your

presentation, you mentioned that South Texas had one of the hotter bottom temperatures.

MR. MITCHELL: That's correct.

MEMBER POWERS: Well, I mean, that strikes me as an important observation.

MR. MITCHELL: That's true. It may be --

MEMBER POWERS: Don't you think your first statement is just a little strong then?

MR. MITCHELL: Well, on a scale of susceptibility, it may be the leader, based upon that fact. If it turns out to be primary water stress corrosion cracking, that would probably only mean that other vessels may take more time.

So, in that sense, I could not dismiss the possibility of a similar mechanism at the other facilities. I could only say it would take longer.

MR. BATEMAN: The interesting thing is -- and, Steve, you might correct me if I'm wrong here -- but I understand the upper head temperature at South Texas is also around 560, but I don't know how long it's been at that level. We don't have any evidence of cracking in your upper head penetrations at this point, as I understand it.

MR. THOMAS: No, that's correct, we do not have any evidence of cracking in the upper head. I think we've operated three cycles since we replaced steam generators in Unit One that essentially take cold temperatures in our upper head with the additional bypass flow.

MR. MITCHELL: Based on the as-found condition, however, of the Unit One bottom head, given the axial orientation of the flaws, the overall risk significance of this observation is deemed to be minimal. This is not an orientation which would particularly lead to the failure of the tubes and the onset of a gross failure or a leakage from the bottom head penetration.

However, going to bullet three, if the mechanism or mechanisms in play have the potential to lead to circumferentially-oriented cracking, one would have to modify the thought about how risk-significant this might be with regard to the rest of the fleet. That will only come with time and more information coming from the analysis of the metallurgical samples that the licensee will be taking, if we can make a determination with that regard.

MEMBER SIEBER: It seems to me you don't have enough information to make a firm determination one way or the other right now.

MR. MITCHELL: I would agree with that

statement.

MEMBER SIEBER: Okay. So when you come to a conclusion, come back and tell us what it is.

MR. MITCHELL: I am sure that in one venue or another we will be back over here discussing a similar topic in the future.

MEMBER SIEBER: All right. Okay.

MR. MITCHELL: And it may be in conjunction with bullet four, which is that, currently, the staff is in the advanced stages of determining and evaluating what path we intend to follow with regard to generic communications with the industry regarding the overall topic of bottom head inspections, the potential for bottom head cracking, issues of that nature.

MEMBER FORD: The third bullet, of course, is the key to this from a safety significance aspect. It seems to me that if the root-cause evaluation cannot rule out primary water stress corrosion cracking as a root cause, it cannot absolutely rule it out, then the sensitivity comes down to, how sure are you that you are not going to have a residual stress cracking which will give rise to a circumferential cracking?

Will that thought process go into your

thinking? Would you go through it through item four?

MR. MITCHELL: I think absolutely so. As we move forward on this topic, the staff is going to have to assess what we know and what we don't know and act accordingly, based upon not only the facts at hand, but the uncertainties associated with those facts. That always plays a role in our thought processes, when we determine what needs to be addressed in a generic sense, based upon one plant-specific observation.

MEMBER SIEBER: Okay, any further questions?

(No response.)

Well, I appreciate the staff for coming in and giving this presentation. I also appreciate the folks from South Texas for coming here. It makes me feel good to know that the licensees are aggressive in doing more than they are required to do to assure the safety of these plants. For that, I'm especially grateful to South Texas.

What I would like to do with the remaining few minutes here is to turn it over to Graham Leitch, and he will discuss some recent operating events. He can give you a handout. We will not go through the details of the handout. It is there for your further individual investigation.

MEMBER POWERS: Well, I hope there's at least one we go into in some detail.

CHAIRMAN BONACA: Well, no, no, no. Well, for this part here, yes.

MEMBER LEITCH: I refer to the document here that we passed out. Rather than going through the whole thing, in the interest of time, I would just like to highlight a couple of points that I felt were interesting in the past three months.

Obviously, one is the South Texas that we just finished talking about. The next one is Quad Cities Two. There were three interesting events, apparently unrelated, at Quad Cities Two: a stuck-open relief valve, you know, a spontaneous opening of a relief valve, and a blowdown situation there.

They have had some fuel-leaking problems, and also there's a recurrence of the dryer cracking issue that occurred last year. This is the same dryer cracked again, basically the same symptoms: moisture carryover into the --

MEMBER SIEBER: But it is just a small crack. You don't have to bend down to walk through it, but what is it, seven feet or something like that?

(Laughter.)

MEMBER LEITCH: Yes, it's a pretty appreciable crack.

MEMBER FORD: When we visited --

MEMBER LEITCH: Also, in addition to a crack, some of the stay braces were broken as well.

So the repairs have been made, and the plant, I believe, is back up to 100 percent at the moment. But we're still somewhat concerned about that issue. General Electric says that it is a harmonic.

Obviously, one of the things that we are concerned about is the relationship of the power uprate to this situation that has occurred since the power uprate, but also this similar situation occurred on -- that is, Quad Cities No. 1 was uprated and has not experienced dryer cracking problems. So it's a bit of a mystery at the moment.

MEMBER ROSEN: Graham, can you say more about the stuck-open relief valve? Did they have to shut down and get it seated and go back up?

MEMBER LEITCH: Yes, yes, they did. It would not reclose. They had to shut down and maintain the valve.

MEMBER ROSEN: Did these blow down into the suppression pool?

MEMBER LEITCH: Into the suppression pool, right.

MEMBER ROSEN: Then was it fully open? Did it go full open?

MEMBER LEITCH: I don't know that. I suspect it was fully open. They are usually either --

MEMBER SIEBER: Yes, once they start --

MEMBER LEITCH: You know, it was not a leak. Let me put it that way. It opened.

MEMBER ROSEN: It opened, and that depressurizes the vessel; the SCRAMs react. Was it an automatic SCRAM or it seemed like it?

MEMBER LEITCH: No, I don't think it was an automatic SCRAM.

MEMBER SIEBER: PWRs are strange that way. They just keep going.

MEMBER ROSEN: You don't think it would have created a low-pressure reactor vessel scenario and --

MEMBER SIEBER: Not one --

MEMBER ROSEN: -- resulted in a SCRAM --

MEMBER LEITCH: I don't think it did, no.

MEMBER ROSEN: No? It just opened full open and the plant goes on merrily? It's a little noisy, exciting.

(Laughter.)

MEMBER SIEBER: It's like another turbine with no generator.

MEMBER LEITCH: It's not entirely unusual in the industry. There was, on the order of 10 to 15 years ago, there was a number of spontaneous openings of Target Rock safety relief valves. This was not a Target Rock valve, though.

MEMBER ROSEN: But this is a big valve. It's a six- or eight-, ten-inch valve, or something like that?

MEMBER LEITCH: At least, yes. I would say it's probably 10-inch, yes. I don't know for sure, but, you know, of that magnitude, yes.

Another thing that I'm hearing from several different sources is I have a little bit of concern about BWR fuel. I hear a lot of BWRs with leaking fuel these days. I've listed a few plants there that have leaking fuel.

It does not seem to be only General Electric fuel. There's Framatome fuel that is also experiencing problems in BWRs.

I think perhaps we should be hearing a presentation on this. You know, it's maybe something that the Committee wants to consider, whether we hear something about the --

MEMBER ROSEN: I think you're right on target. With all of these advanced fuel management schemes that we are hearing about, which are, in fact, the way BWR uprates are being driven, this is interesting and provocative information.

CHAIRMAN BONACA: Although, I mean, the first thing you want to hear is, is it one ping per plant or is it several ones? I mean, the way I understand, it is more like --

MEMBER LEITCH: See, I don't have access to all that information.

MR. CARUSO: I just want to make a comment. I have been talking to some people in the industry, and in preparation for the fuels meeting in late September, we're going to have Ralph Meyer come out and NRR, and we're going to have EPRI come out to talk about their robust fuel program.

In the course of discussion with EPRI, they seemed a bit distraught because the number I heard was one-third of the BWRs right now have leaking fuel. They are distraught because they have this robust fuel program and leakers.

CHAIRMAN BONACA: Along those lines --

MR. CARUSO: So that might be a good opportunity to have the industry come in and talk.

MEMBER LEITCH: Yes.

MEMBER FORD: That presentation should cover also, Graham, the correlation, if any, between those plants with these fuel failures and application of a metal-chemical addition.

MEMBER LEITCH: A what?

MEMBER FORD: A metal-chemical addition.

MEMBER ROSEN: And correlation with those on power uprate.

MEMBER LEITCH: Yes, most of these plants have, I think -- well, I shouldn't say that. I think most of these have had power uprates.

MEMBER ROSEN: But not EPUs, not these 20 percent or 15 percent.

CHAIRMAN BONACA: Well, anyway, we'll have to see. I mean, if it is one-third, that is certainly a major concern that we have to look at.

MEMBER LEITCH: Yes.

CHAIRMAN BONACA: It is a big change that we see in the industry.

Now they have made an effort to maintain kilowatt-per-foot load, but --

MEMBER LEITCH: So it sounds like in September we will hear some more about that topic.

CHAIRMAN BONACA: Okay.

MR. CARUSO: I will ask all the participants to talk about that.

MEMBER LEITCH: Yes, good. Thanks, Ralph.

The other thing I thought that was interesting, looking through this data, and I've mentioned this before -- you know, I'm somewhat concerned about this issue -- is in the last three months eight of the thirteen automatic full-power SCRAMs that occurred, or almost full-power SCRAMs, were as a result of loss of electrical load, either electric generator exciter or transformer substation. But the main generator breakers opened.

I think it indicates perhaps that we are not focusing enough attention on the electrical side of the house. You know, there are different maintenance practices there, and a lot of times the maintenance practices out in the substation are actually run by somebody else other than the nuclear plant.

I think it might be interesting to hear some more about this because I think it is particular disturbing to open the generator, you know, walk up to a unit that is running at 100 percent, and to trip the generator breaker is not a good thing to do, because I'm always concerned about turbine runaways.

You know, not only the main turbine stops, but most of these plants have enough stored energy in the feedwater heaters, or at least the high-pressure, couple of high-pressure feedwater heaters, that if the extraction checks don't check, it could overspeed the turbine from the stored energy in the feedwater heaters.

So there's. you know, maybe a dozen or fifteen valves that have to operate properly to prevent the turbine from overspeeding in these situations. But if the main stops and the --

MEMBER ROSEN: We didn't run the tests on the full-scale, a full turbine, but we did it on a feed-pump turbine in South Texas, where the extraction stops didn't work, and we ran that feed-pump turbine up to 13,000 RPMs before it went off, before it disassembled.

MEMBER LEITCH: Before it disassembled? It stopped by itself.

MEMBER ROSEN: Right.

(Laughter.)

MEMBER LEITCH: Yes.

MEMBER ROSEN: In a most spectacular fashion.

MEMBER LEITCH: Yes, yes. It doesn't take much energy to overspeed a bunch and lose the electrical load.

MEMBER POWERS: There's these little tubes at the bottom and --

CHAIRMAN BONACA: Is it a way to disassemble it?

MEMBER ROSEN: Very suddenly, yes.

MEMBER LEITCH: Very suddenly.

(Laughter.)

MEMBER SIEBER: No warning and with great suddenness.

MEMBER LEITCH: The other thing that's a little pet peeve of mine, too, is, of the remaining five automatic SCRAMs, three -- and I would discount the fourth one, now that I've done a little more research, but three of those five appear to have been electronic component failures. I guess I continue to be concerned about little components in electronic systems which, in and of themselves, can cause a SCRAM.

I think maybe that's another issue that we need to focus on: What are we doing? Are we just leaving it up to the licensees? I think most licensees have programs that identify electrical components, which, if they fail, can all by themselves cause a SCRAM.

We are experiencing a number of these SCRAMs. So when you take a look at it, about the only ones that we haven't really discussed -- I recall at Peach Bottom there was an instrument, a pneumatic line failed that caused an MSIV to go closed, and that was one of the other SCRAMs.

One of the other ones was at Calvert Cliffs, which was a troubleshooting screwup, basically, and they grounded a jack.

If we put those two aside, the SCRAMs are basically occurring because of electrical problems, causing the main generator breaker to open, or because of failures of power supplies, capacitors, little goodies deep in the electronic system, particularly the EHC system. I mean there's only one EHC system. If failure occurs there, why, it can all by itself cause a SCRAM.

MEMBER KRESS: You expect variations in transient events if they're randomly-caused. This may just be a blip in the randomness.

MEMBER LEITCH: Sure.

MEMBER KRESS: But the question I would have is, we input transient initiating events into PRAs and come out with a contribution to the risk.

But at some point that initiating event would get high enough for me to be of concern, to worry about it.

I don't know where that is. Is it two or three, maybe thirteen, SCRAMs? Is that just random events? Or do we have to worry about it when it gets up to -- what was the reactor oversight process, 25 SCRAMs in one plant?

MEMBER LEITCH: That's per unit. This is in the whole fleet I'm talking about now.

MEMBER KRESS: Yes. So I'm not sure I worry about this as some performance decrease or not. It just may be random variations.

MEMBER LEITCH: It could be.

MEMBER KRESS: But I think it's a thing to think about before we start worrying too much about it.

MEMBER LEITCH: Yes, I mean, that's one of the reasons we're -- you know, we can't, just reinforcing what you said, Tom, we can't jump to a lot of conclusions on the basis of three months' data. But what I'm saying is we've got to continue to look at this and see where we're going.

MEMBER WALLS: It's not the SCRAMs so much as the reliability of these electronic components that is of concern, because they do other things than just

SCRAMs.

MEMBER KRESS: What I would be interested in is -- I don't know if this is tracked on the trending programs or not. Is this an aberration in the trend or is it just part of, say, a trend that has been going on for years?

MEMBER LEITCH: Yes, well, see, there may be -- you know, I just wonder if there's folks on the NRC staff that have more information about this than we do, like if there's somebody out there that's worrying about this, too. If there is such a person, maybe we should have them come in and talk to us a little bit about what they are doing.

CHAIRMAN BONACA: Yes, one possibility is also the fact that on the primary side, I mean there has been such an improvement from procedures, and so on, the support. There used to be a lot of SCRAMs that were caused by testing, doing things, and now the plant seems to be much more capable. So that could be a possibility, that then you have --

MEMBER LEITCH: So you get a higher percentage of these other things, yes.

CHAIRMAN BONACA: That's right.

MEMBER LEITCH: Yes.

CHAIRMAN BONACA: But, still, I think it

is a very good insight and I think we ought to do it.

MEMBER ROSEN: Something's always a leading problem.

MEMBER LEITCH: Yes, as you drain the swamp, you see more rocks.

Okay, well, I think one other note that I put there that I thought was just interesting to me, as I looked at the plants on a daily basis, on July 7th, Monday of this week, all the units in the country, with the exception of Davis-Besse, and we all know what the issue is there, and South Texas One -- we know what the issue is there -- all the other plants were nominally at 100 percent power, some at 98, 96.

MEMBER ROSEN: Those two plants were out for opposite reasons, the two plants that he just mentioned: one because they let the vessel go and the other one because they wouldn't.

(Laughter.)

MEMBER LEITCH: It's unusual to see them all humming along. Of course, they all try for that in July.

MEMBER APOSTOLAKIS: Unit One South, that's just to be lumped together with Davis-Besse.

(Laughter.)

MEMBER ROSEN: Well, they're in the same category, but they both shut down on July 7th, but for the opposite reason.

MEMBER LEITCH: Let me just quickly highlight a couple of other things here, and I will only take another minute here.

There's a lot of siren malfunctions, most of it weather-related, traffic accidents. I mean you can see where the storms are when you look, and there's a lot of siren problems.

There's a couple of interesting fires. Two were interesting, one at Seabrook and one at TMI No. 2. They're both in unused, if you will, containments.

The other thing I think might be interesting is DC Cook. Both units had a plugging of the cooling water intake caused by fish.

North Anna, the old reactor head, on its way to Utah, was involved in a traffic accident in Kansas.

(Laughter.)

CHAIRMAN BONACA: They had a rollover, I believe.

MEMBER LEITCH: A drunk driver hit it. No damage to the reactor head.

(Laughter.)

I'm not sure how the drunk driver made out, but some of the covering was nicked.

MEMBER SIEBER: Yes, it ripped the tarp on it.

MEMBER LEITCH: There was a fairly significant operating event at River Bend, an operating error where the operator removed the wrong circuit breaker. Fortunately, it was recognized and there were no personnel injuries. They recognized the ensuing situation in time.

A couple of interesting labor relations security issues: Oyster Creek, there was a work stoppage, and management was manning the workstations. I think that is still the case. I'm not positive of what the current situation is there, but I think there's an ongoing strike at Oyster Creek.

The potential strike at Hatch was averted, and there are some other interesting things that continue to happen in security: an unaccounted-for security weapon, an inadvertent discharge. A security officer discovered --

MEMBER KRESS: Was it Bernie Cly?

MEMBER LEITCH: -- to have committed a --

MEMBER KRESS: Was it Bernie Cly?

MEMBER SIEBER: No, this was not --

MEMBER LEITCH: I'm sorry, I didn't understand the question, Tom.

MEMBER KRESS: Okay, well, it's not worth repeating.

(Laughter.)

MEMBER LEITCH: But the real interesting thing --

MEMBER ROSEN: Do you want to tell us any more about the MIT operation?

MEMBER LEITCH: Well, that's the real interesting thing. I thought I might not normally have included that on the list, but considering where it occurred, one of our colleagues may want to explain that.

MEMBER POWERS: You know, when we had this incident at Limerick, I think it was, what, 20 years ago?

MEMBER LEITCH: No, no, no, not Limerick.

(Laughter.)

Just because I'm taking a shot doesn't mean --

(Laughter.)

MEMBER POWERS: At Peach Bottom there was a major uproar and what-not.

MEMBER LEITCH: Yes.

MEMBER POWERS: This Committee has oversight on research reactors, right? We have an interest in safety culture. The safety culture is basically pretty good. It looks like it's falling down pretty bad here. I think maybe we ought to have some explanations on this by the licensee and appropriate staff.

CHAIRMAN BONACA: All right.

MEMBER LEITCH: So that concludes my presentation.

MEMBER FORD: I have an addition because Tom asked a question about operating experience. Seventeen of the 18 TECCO PWRs are out right now, primarily because of -- it is in the trip report that you all have.

No, but the main technical reason why they're out is cracking of core in tunnels. The surprising thing is it's mostly 316L, which is not supposed to crack, but which it does if they had done to it what they did to it.

MEMBER ROSEN: Did you say that? "If they had done to it"?

MEMBER FORD: Done what they did to it. In other words, mostly cold work suffices --

MEMBER SIEBER: Okay, I think that that covers it. Thanks very much, Graham.

MEMBER LEITCH: Thank you.

MEMBER SIEBER: Mr. Chairman, I'll turn it over to you.

CHAIRMAN BONACA: All right, we will go now off the record, so we don't need a transcriber anymore.

(Whereupon, the foregoing matter went off the record at 9:47 a.m.)

SOUTH TEXAS PROJECT UNIT 1
BOTTOM MOUNTED INSTRUMENTATION NOZZLE
LEAKAGE ISSUE

Matthew A. Mitchell, Senior Materials Engineer
Materials and Chemical Engineering Branch
Office of Nuclear Reactor Regulation

Advisory Committee on Reactor Safeguards Full Committee Meeting
July 11, 2003

BACKGROUND

- April 12, 2003 - Licensee performed boric acid corrosion control (BACC) walkdowns as part of GL 88-05 program. Inspections included a bare metal visual examination of the reactor pressure vessel (RPV) bottom head.

- The licensee's access to the South Texas Project Unit 1 (STP Unit 1) RPV lower head is very conducive to these inspections. Plant design includes an insulating "box" around the lower head with panels that can be opened to permit direct viewing of the bare metal.

- Licensee had performed similar inspections of the lower heads of both STP Unit 1 and Unit 2 previously. The most recent inspection of Unit 1 had been conducted in November 2002 with no evidence of deposits noted.

BACKGROUND

- In April 2003, the licensee discovered deposits characterized as, in total, “about the size of one half of an aspirin tablet” around bottom mounted instrumentation (BMI) penetrations #1 and #46.

- Chemical analysis showed evidence of boron and lithium, indicating the reactor coolant system (RCS) to be the most likely source of the deposits.

- Radiochemical analysis based on cesium isotope dating indicated that the deposits were approximately four years old.

NONDESTRUCTIVE EXAMINATION - SCOPE

- The licensee has conducted extensive nondestructive examination (NDE) on all 58 STP Unit 1 BMI nozzles. Framatome Technologies was chosen as the vendor for the inspections, using a tooling system which had been used previously for BMI inspections in France.

- Performed ultrasonic testing (UT) using axial, circumferential, and zero degree probes from the tube inside diameter (ID) on all nozzles.

- Performed enhanced visual testing (EVT-1) examinations of the J-groove weld surfaces of all nozzles.

- Performed ID eddy current testing (ECT) on some nozzles to confirm UT data.

- Performed “ECT-on-a-stick” examination of the J-groove weld surface of eight penetrations, including #1 and #46.

NONDESTRUCTIVE EVALUATION - RESULTS

- The licensee's NDE results showed:

  - Three axially-oriented indications in nozzle #1. One indication characterized as having a length of ~1.38 inches, extending from above to below the J-groove weld and penetrating the ID of the tube. The other two indications were much smaller and near the root of the weld.

  - Two axially-oriented indications in nozzle #46. One indication characterized as having a length of ~0.98 inches and extending from above to below the J-groove weld. The other indication characterized as having a length of ~0.95 inches and not surface connected.

  - EVT-1 examinations showed signs of extensive grinding on the nozzle and J-groove weld surfaces of many penetrations.

NONDESTRUCTIVE EVALUATION - ADDITIONAL

- The licensee performed additional NDE tests on penetrations #1 and #46, including:

  (1) ECT profilometry on nozzles #1 and #46 to compare as-found nozzle distortions with that predicted from weld finite element modeling to validate predicted weld residual stresses. Preliminary results suggest that the profilometry measurements were consistent with finite element modeling predications.

  (2) Helium pressurization tests on nozzles #1 and #46 to further investigate potential leakage paths in these penetrations. At 150 psi, bubbles were observed on nozzle #1, but not on nozzle #46.

  (3) Phased-array UT from the RPV head outside surface to look for evidence of wastage of the ferritic base material of the head. No evidence of wastage was found.

PRELIMINARY ROOT CAUSE ANALYSIS

- Based on the information currently available, two principal root cause theories are under consideration by the licensee.

(1) The cracking was caused by primary water stress corrosion cracking (PWSCC) which initiated in the nozzle at the toe of the J-groove weld.

- PWSCC of Inconel 82/182/600 observed in other applications
- Consistent with expectations in 1991 Westinghouse report for Sequoyah which assessed potential for BMI cracking
- Inconsistent with the fact that no cracking was observed in other penetrations

(2) The cracking initiated at "discontinuities" (weld lack of fusion, etc.) at the tube/weld interface and propagated to the tube surface.

- Consistent with observed discontinuities in #1 and #46
- Consistent with understanding of general fabrication practices/issues
- Inconsistent with the fact that discontinuities were evident in other penetrations
- No specific mechanism to explain subcritical crack growth

PRELIMINARY ROOT CAUSE ANALYSIS

- The licensee is taking material samples from nozzles #1 and #46 for evaluation. Information from these samples is expected to confirm the degradation mechanism(s) and, potentially, the initiation sites for the observed indications.

- Information from these material samples is expected to clarify whether either of the two principle preliminary root causes is substantiated. Some combination of mechanisms may also be indicated by the information from the material samples.

- Information from the licensee's evaluation of the materials samples will be included in the final root cause report which is currently projected to be completed in late September/early October, 2003.

STP UNIT 1 BMI NOZZLE REPAIRS

- The licensee has repaired STP Unit 1 nozzles #1 and #46 using a "half nozzle repair" similar in design to those used to repair other Alloy 600 penetrations.

- The repair was made using Alloy 690 nozzle material and Alloy 52/152 weld material, including the installation of a temper bead weld pad on the outside of the RPV lower head. The RCS pressure boundary weld was moved to the outside surface of the RPV.

- Questions regarding future inspections of the repair, along with inspections of the ferritic base material which will be left exposed to the reactor coolant, are being addressed by the licensee in support of NRC staff review and approval of the repair.

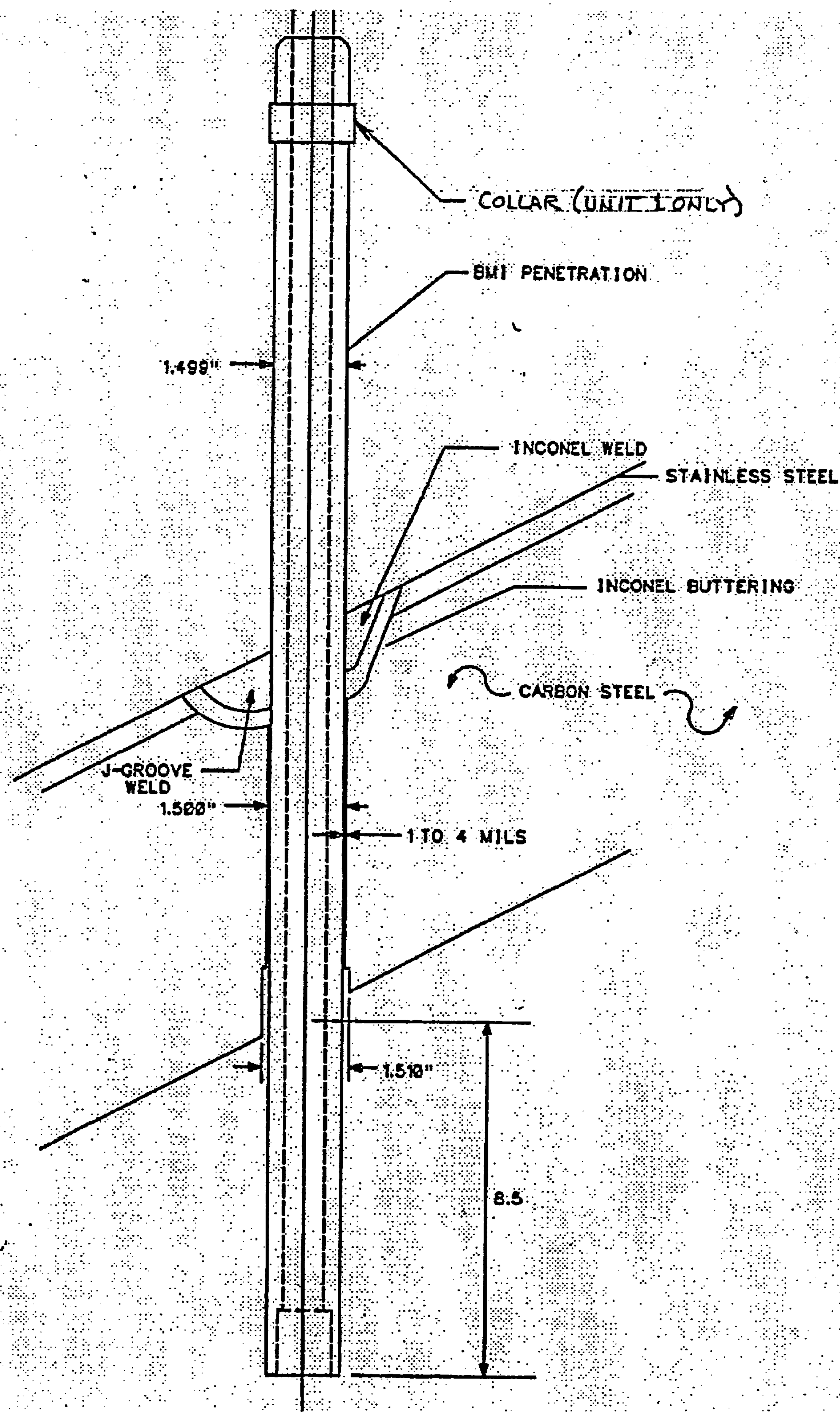
POTENTIAL GENERIC IMPLICATIONS

- None of the available information suggests that STP Unit 1 is unique with regard to being susceptible to lower head penetration cracking.

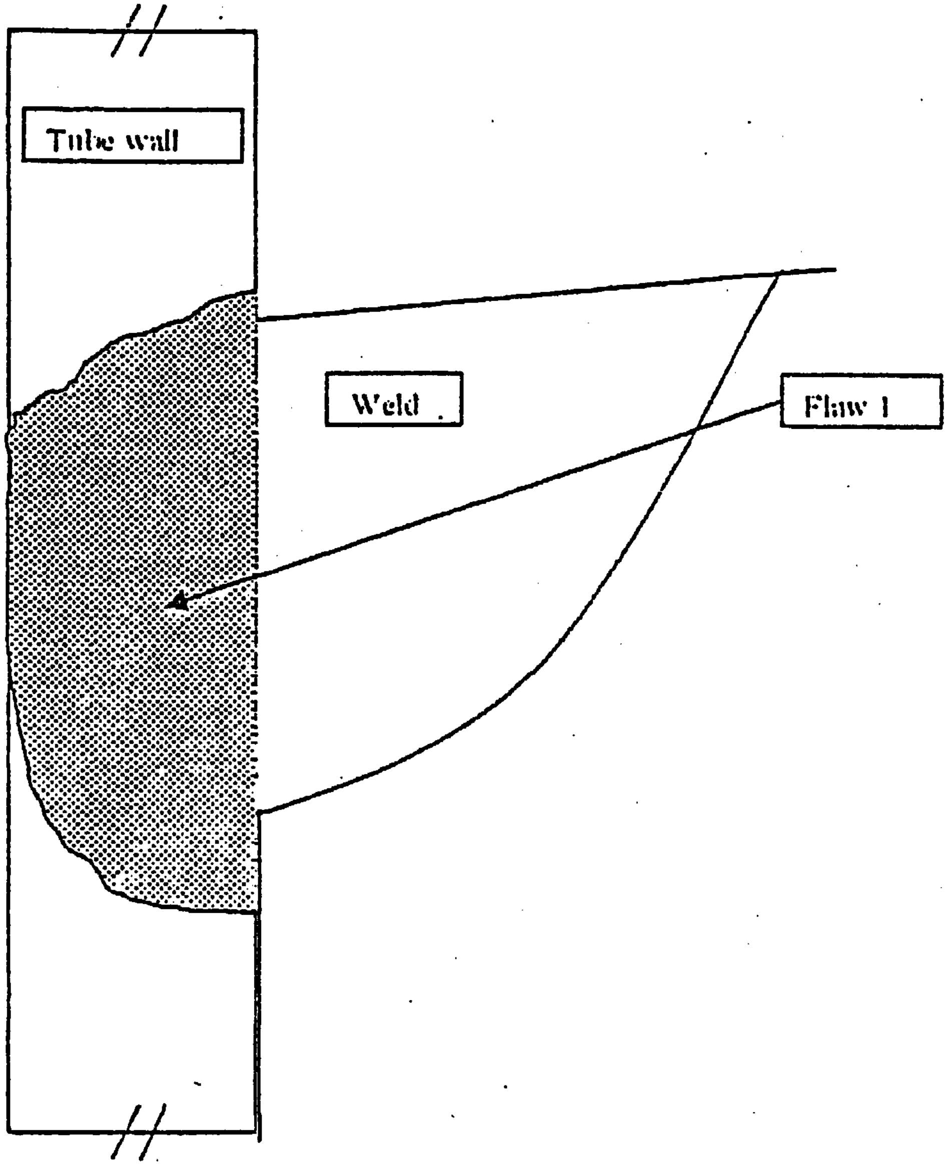
- Based on the “as found” condition of the STP Unit 1 BMI penetration nozzles, the NRC staff has concluded that the risk significance of the situation at STP Unit 1 was minimal.

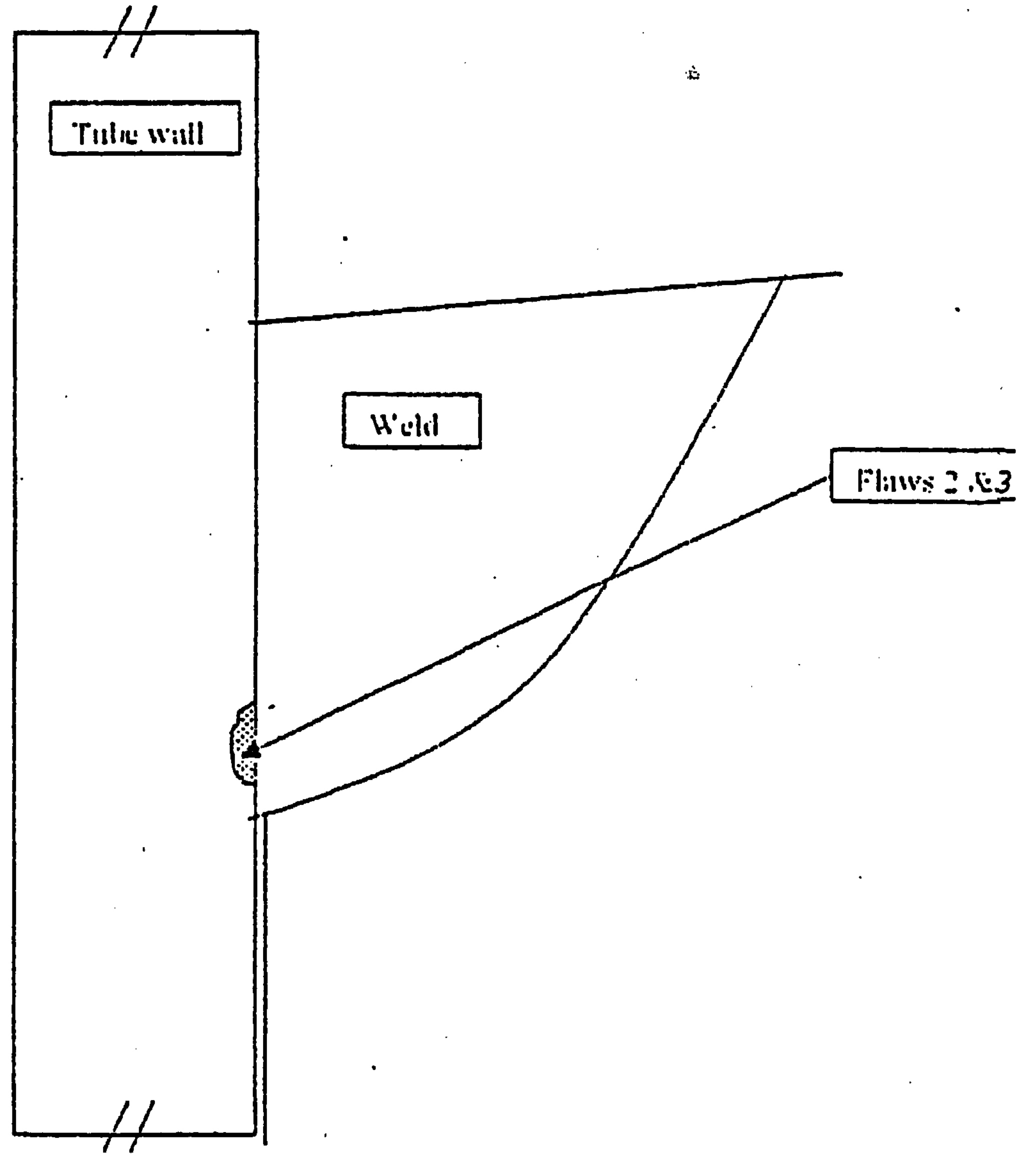
- However, should the operative degradation mechanism(s) at STP Unit 1 be directly or indirectly capable of inducing large, circumferentially-oriented flaws in RPV lower head penetrations, the risk implications for the U.S. PWR fleet could be significant.

- The NRC staff is in the advanced stages of determining what path we intend to follow with regard to developing generic communication(s) concerning PWR RPV lower head inspections given the information coming out of the STP Unit 1 event.


COLLAR (UNIT 1 ONLY)
BMI PENETRATION
1.498"
INCONEL WELD
STAINLESS STEEL
INCONEL BUTTERING
CARBON STEEL
J-GROOVE WELD
1.500"
1 TO 4 MILS
1.510"
8.5

Penetration #1





Penetration #46