WESTINGHOUSE CLASS 3

ENCLOSURE 4

STEAM GENERATOR SLEEVING REVIEW BOARD MEETING

SAN ONOFRE UNIT 1

STEAM GENERATOR SLEEVE REPAIR FOR SOUTHERN CALIFORNIA EDISON

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WESTINGHOUSE ELECTRIC CORPORATION
FOREST HILLS DIVISION
PITTSBURGH, PA 15221

Thursday, October 23, 1980
Friday, October 24, 1980

WESTINGHOUSE CLASS 3

STEAM GENERATOR SLEEVING REVIEW BOARD MEETING

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PITTSBURGH, PENNSYLVANIA, 15221

THURSDAY, OCTOBER 23, 1980 - 8:15 A. M.
FRIDAY, OCTOBER 24, 1980 - 8:05 A. M.

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SAN ONOFRE UNIT 1 STEAM GENERATOR SLEEVING
REVIEW BOARD

MR. WESLEY C. MOODY, CHAIRMAN, Manager, Nuclear Licensing Southern California Edison Company.

MR. WARREN E. BERRY, Manager, Corrosion Section, Battelle Columbus Laboratories (CORROSION).

DR. GEOFFREY R. EGAN, President, APTEC Engineering Services, Inc. (WELDING).

DR. STANLEY J. GREEN, Director, Steam Generator Project Office, Electric Power Research Institute (WELDING).

MR. PAUL J. HERBERT, Manager of Quality Control and Nondestructive Examination Services Group Bechtel Power Corporation (METALLURGY, NONDESTRUCTIVE EXAMINATION).

MR. DANIEL M. NOBLE, Director of Operatoring Services Consumers Power Company (STEAM GENERATOR INSPECTION REPAIR AND OPERATION).

DR. WALTER F. WEGST, Director, Research and Occupational Safety, UCLA (HEALTH PHYSICS).

MR. D. H. RAWLINS, Moderator, Westinghouse Electric Corporation.

MR. B. L. CURTIS, Moderator, Southern

REVIEW BOARD (continued)

California Edison.

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Any other questions?

MR. RAWLINS: We will now go into the design verification analysis which will be presented by Al Klein, who is a fellow engineer in our materials and technology group.

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October 23, 1980

8:15 a.m.

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MR. MOODY: My name is Wesley Moody. For those of you who don't know me, I am the manager for nuclear licensing for Southern California Edison Company.

This is a meeting of the San Onofre Unit 1 Steam Generator Sleeving Review Board. SCE has assembled this Review Board to provide an independent review of the steam generator sleeving modifications which are being performed at Southern California Edison's San Onofre Nuclear Generating Station, Unit 1.

I will serve as chairman of this Review Board and we will introduce the other members of the Review Board and ask for the introduction of other members present here today in a few minutes.

First, I want to make a few remarks about the Review Board collectively. The Review Board which we have assembled here today is comprised of distinguished members from various segments of our industry and individually they have expertise in engineering and other technical disciplines which have a bearing on the steam generator sleeving modifications which are being performed at San Onofre. Collectively the Board brings here today extensive experience in steam generator inspection, repair, operation and chemistry as well as in corrosion, metallurgy, welding and health physics.

The purpose of today's meeting is to provide an independent review of the San Onofre Unit 1 steam generator sleeving modifications. I refer to this review as independent because it is, in fact, independent of and in addition to two reviews, one performed by Westinghouse internally and one performed by Southern California Edison internally.

Westinghouse has completed an internal design review of the sleeving modifications which have been undertaken by Westinghouse at San Onofre. This has been done in accordance with Westinghouse quality assurance program and procedures pursuant to 10CFR50 Apprendix B. Southern California Edison has undertaken review of the steam generator sleeving modifications including safety analyses associated

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with those modifications by the company's on-site review committee and nuclear audit and review committee pursuant to 10CFR50.59 and the provisions of our operating license.

The review that is represented by today's and tomorrow's meeting is independent of and in addition to both those reviews.

Let me now introduce the other members of the Review Board. On my immediate right is Mr. Warren Berry. Mr. Berry is manager, corrosion section, for Battelle Columbus Laboratories. He has a Bachelor of Science in chemistry from Ohio University and has been engaged in corrosion research at Battelle Columbus for the past 33 years. Mr. Berry is an active member of the National Association of Corrosion Engineers. Currently he is chairman of the NACE Research Committee. He is past chairman of NACE Group Committee T-7, which is corrosion by water, Unit Committee T-7D, corrosion in high purity and power plant waters, and Unit Committee T-3E, stress corrosion cracking. He is the author of some

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40 AEC project reports in corrosion as well as many distinguished publications in the field of corrosion and, in particular, corrosion as it relates to the nuclear technology.

To Mr. Berry's right is Dr. Geoffrey Egan. Dr. Egan is president of APTEC Engineering Services. Dr. Egan has his Ph.D. from London University in applied mechanics and he has specialized expertise in fatigue fracture and stress analysis of welded structures including pressure vessels, stress analysis and nondestructive inspection for fracture safe design, materials selection procedures, welding methods and procedures and properties of welded joints. Dr. Egan is a member of the American Society of Mechanical Engineers, American Welding Society, the Welding Institute, and a chartered engineer of the Institute of Mechanical Engineers.

Dr. Egan is on the EPRI Corrosion Advisory Committee and EPRI Pressure Vessel Study Group. Dr. Egan has numerous publications in his field of expertise.

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To Dr. Egan's right is Dr. Stanley Green. Dr. Green is director, steam generator project office for EPRI. Dr. Green has a Bachelors, Masters and Ph.D. in chemical engineering and has on the order of 38 years of experience in chemical, thermal, and hydraulic engineering.

Dr. Green was associated with the Bettis Atomic Power Laboratory for some 23 years prior to his present association with EPRI. At Bettis Dr. Green held the positions of supervisor and later manager of thermal and hydraulic engineering, manager of the reactor engineering laboratories and manager of reactor development and analysis activity.

Dr. Green is a Fellow of the American Society of Mechanical Engineers and a member of the American Institute of Chemical Engineering. He is a Registered Professional Engineer in chemical engineering in the Commonwealth of Pennsylvania and has numerous publications in his field of expertise.

To Dr. Green's right is Mr. Paul Herbert.

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Mr. Herbert is manager, nondestructive examination services group for Bechtel National, Inc. Mr. Herbert graduated from the Colorado School of Mines with a Bachelor degree in metallurgical engineering. Mr. Herbert has 21 years of experience in materials engineering, quality assurance and control and nondestructive examination.

In his present capacity with Bechtel, Mr. Herbert is responsible for the Bechtel corporate nondestructive examination program, procedures, education, training, and qualifications.

Mr. Herbert is a member of the American Society of Mechanical Engineers, American Welding Society and American Society of Nondestructive Testing. Mr. Herbert is chairman of the ASME Section V Ultrasonic Testing Subgroup, a member of ASME Section XI Main Committee, Section XI Nondestructive Examination Work Group and Section V Main Committee.

Mr. Herbert is a Registered Professional Engineer in the State of California.

On Mr. Herbert's right is Mr. Daniel Noble

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Mr. Noble is director of operating services for Consumers Power Group. Mr. Noble has earned a Bachelors and Masters degree from Michigan State University in metallurgical engineering.

Mr. Noble has been associated with Palisades Plant steam generator programs since 1973. He has had technical responsibility for Consumers for programs to limit steam generator corrosion and assure pressure boundary integrity since 1974. Mr. Noble has been involved to formulate or review efforts associated with nondestructive inspection and repairs, control of secondary side chemistry, chemical cleaning, water flushing, tube sleeving, tube pressure boundary studies and design features for use in future steam generator designs.

In his present capacity Mr. Noble is responsible for managing a department of engineers and technical personnel providing engineering and technical services to operational nuclear and fossil plants for Consumers Power Company.

Mr. Noble is a member of the American

Society for Metals, the EPRI Nuclear Division Systems and Materials Task Force and is currently chairman of the EPRI Steam Generator Owners Group Technical Advisory Committee.

Finally, on Mr. Noble's right is Dr. Walter Wegst. Dr. Wegst is director, research and occupational safety at the University of California, Los Angeles.

Dr. Wegst has a Bachelors degree in electrical engineering, Masters degree in nuclear engineering and Ph.D. in environmental health.

Dr. Wegst has 23 years of experience in health physics and environmental health and safety at the University of Michigan, California Institute of Technology and at UCLA. He is certified by the American Board of Health Physics and the Board of Safety Professionals. He is a Registered Professional Engineer in the State of California.

Dr. Wegst is past president of the Southern California Chapter of the Health Physics Society. He is a member of several committees of the

National Health Physics Society and for five years served on the panel of examiners of the American Board of Health Physics. Dr. Wegst has numerous publications in his field.

I have had circulated to those present here a roster of the Review Board where I have parenthetically indicated an area of expertise, which is a very shortened notation for the experience that's brought to the Board by the individual Board members.

I also want to introduce Mr. Ken Baskin in the audience, who is the manager of nuclear engineering licensing and safety and he is the Edison management representative at this meeting.

At this time I would like to introduce Blaine Curtis, who is Edison's plant engineer at San Onofre generating station and for the purposes of steam generator sleeving modifications, Blaine has been designated as program manager for all Edison activities and interfaced with Westinghouse.

Blaine Curtis and Dave Rawlins, who is

the manager of licensing and safety evaluation for Westinghouse, will be directing the Edison and Westinghouse presentations to the Board today.

Blaine, could you and Dave take a minute and just introduce the Westinghouse and Edison people that will be making presentations here today. We will not endeavor to introduce everybody in the room from Westinghouse and Edison.

MR. RAWLINS: Some of them may not be present but we can introduce them as their presentations come up.

We have Mr. Malinowski, who is manager of the steam generator data and analysis group. We have Mr. Don Meoli. Don is not here. We will introduce him when his presentation comes up. Mr. Pete DeRose is from our advanced equipment engineering group. Mr. Al Klein and Mr. Vaia from the materials technology group. We have Dr. Wootten, manager, chemical operations and field development. We also have Mr. Warren Junker from our research and development laboratories. In addition, we have

Dr. Dick Begley, Doug Fletcher in the audience and Tom Timmons from our nuclear safety department.

MR. CURTIS: Edison presenters today will be Mr. Bill Allen who is running the ALARA activities for Southern California Edison.

MR. MOODY: We also have present today within the audience Edison-Westinghouse employees and representatives of the NRC regulatory staff and their consultants and I am going to ask Stan Nowicki, who is the NRC project manager for San Onofre, to introduce the NRC observers present here today, NRC regulatory staff members and consultants that are here.

MR. NOWICKI: I am Stan Nowicki. This young man is Emmett Murphy from the materials engineering branch. He is our man working in structural. Right behind him is Mr. Dave Smith, also from the materials engineering branch, our welding and brazing expert. Mr. Herman LaGow is not on the NRC but he is a consultant expert on panels. Dennis Crutchfield, chief for the operating reactors. Next to him is Rich Emch, who is from the operating reactors assessment branch. He is our ALARA man. Next to him is Herb Conrad. He is our chemical engineering corrosion expert. Next to him is Mr. Vince Noonan, assistant director of materials and qualifications engineering. He will be our spokesman at the meeting today.

MR. MOODY: The information to be presented and discussed here today is proprietary and confidential and, therefore, its confidentiality has been protected by the execution of nondisclosure agreements by each of the Review Board members or by their employers on behalf of the Review Board members.

With respect to the NRC staff and their consultants who are attending this Review Board meeting as observers, all rules, regulations and statutes which provide for the protection of any proprietary information applies here. We have endeavored to mark not only within the document which is provided to the Review Board members and to

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the regulatory staff into copies last night of the document entitled Westinghouse Proprietary Class 2, Independent Third Party Review Report, San Onofre Unit 1, Steam Generator Sleeve Repair for Southern California Edison, dated October, 1980, we have endeavored to mark in that document and other documents that will be used today, mark them as to their proprietary nature.

We, except for this announcement, don't plan to at each presentation reannounce the fact that information to be presented by Edison-Westinghouse personnel is proprietary and confidential.

There is a reporter present today to prepare a transcript of today's meeting. However, statements are not being made under oath nor will any testimony be taken.

An agenda has been distributed, which reflects some minor changes from the agenda which was previously provided to the Review Board members and NRC regulatory staff by me. The total presentation time has been reestimated to take on the

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order of eight hours but we will have to see how the presentations bear out those estimates.

At this time I have no intention to either require that the presentations consume the estimated time nor require that the presentations be limited to the times estimated on the agenda. I will, however, monitor the progress of today's and tomorrow's meeting such that the presentations and pertinent discussions can be completed in the two days which we have scheduled for the purpose of this review.

Toward that end I will ask the Board members to limit their questioning during individual presentations to questions of clarification and we will have a suitable question and answer period at the end of each major agenda item to ask technical questions that go well beyond clarification.

I will also ask that the NRC and the NRC consultants who are here today as observers, to identify any questions they may wish to be asked to Mr. Vincent Noonan of the regulatory staff, who

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should direct any such questions to me and I will direct those questions to the appropriate Westinghouse or Edison individual or in the case of Board members, directed to the Board members. The same conditions with respect to limiting questions to clarification during presentations I would ask Mr. Noonan to observe as well.

As chairman I intend to consider the pertinence of all questions asked and I will ask for explanation of such pertinence where that appears to be warranted.

r2 Along those lines, we do not plan to discuss in detail here today several topics which include, one, accident analyses or revisions to existing new accident analyses or revisions to existing accident analyses which are required by the sleeving modifications, as those analyses will be presented to and reviewed by the Nuclear Regulatory Commission in a conventional manner outside of this Review Board meeting. We have not endeavored to bring to the membership of this Review Board particular

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expertise in this area.

A second example is generic questions such as the suitability of eddy current testing as a means to determine steam generator tube integrity, the pros and cons of volatile versus phosphate chemistry control which are beyond the scope of today's discussions.

The third example is steam generator plugging limits which have been established and approved by the NRC and then the fourth example of items which we do not intend to discuss here today are the design details of the tooling used by Westinghouse to accomplish the sleeving modifications except insofar as the design details of that tooling may affect the quality of the final product.

Much of the information presented today, particularly under agenda items 2, 3, and 4, are historical. Much of that information is historical in nature, that is, the work is accomplished and is being presented today primarily as background information upon which the review of sleeving and inspection of steam generator tubes yet to be performed and subsequent operation and testing can be evaluated.

I should note that the Review Board members, and I mentioned very briefly, the regulatory staff has been provided in advance of today's meeting a copy of the volume that I described earlier. They were provided that in order to facilitate their review of the sleeving modifications and to improve the quality of today's meeting.

I also want to note that I will ask Mr. Krieger of my staff and Mr. Rawlins of Westinghouse to keep track of any items which I designate as open items based on an inability to address any particular question immediately in today's proceedings.

I guess in the way of logistics, we have lunch planned at one o'clock in this building, in the cafeteria, and I will evaluate later this morning when it would be appropriate to take a break in the morning.

One other note for those of you that may be interested. In case there are messages or people that need to get in touch with you, there is a number where messages can be left for Board members and others present. It is area code 412-273-3261.

One other procedural note. I would ask those members of the Board and Mr. Noonan to identify yourselves to the reporter at the outset of asking a question until she recognizes who all of us are.

Unless there are questions of a procedural nature, I guess I would like to go on.

MR. NOONAN: I would like to make an opening statement if I could on this thing. As you know, the NRC is more and more involved in panel types of meetings. We have been doing this but this is the first time we have done it with the actual operating reactor. Mr. Denton has hired a consultant, Mr. LaGow, to monitor the progress of all these meetings, as we anticipate that this is going to be done more and more often as operating problems exist. There is a meeting between the utility, its consultants and its vendor or customer, however you phrase it, Westinghouse, we would expect from our standpoint to play a very minor role in that meeting and the major thing we are looking for is the overall safety of the steam generator and its operation. The only time we will really get involved is at the end of the panel questions, if there are certain things we need to be brought out from the standpoint of the regulatory processes we need to have answered, we will identify those items or ask those questions ourselves. Other than that, we will sit here and be strictly observers.

MR. MOODY: Unless there are any other procedural matters, why don't we get on with the meat of the meeting.

Dave, do you want to introduce the first Westinghouse speaker.

MR. RAWLINS: Yes.

As you look at the agenda, we have primarily concentrated on the aspects of this which are unique to the operation of San Onofre and that's

Pages 23 thru 102

PROP INFormation
Intentionally omitted

Don
~~Allen~~ Meoli

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It's installed in the generator and then the mixing is done here, right in the near vicinity of the surface that you are going to decontaminate. By changing the nozzle positions, this is a XYZ arm, and by changing the arm position and by changing the nozzle position you can effectively cover 100 percent of the surface. It takes this position plus there is one cleanup position where it's put on the opposite side to go back and clean the area where the arm was initially.

there is A temporary plug put in the reactor coolant loop pipe and a window or flange at the opening of the generator to isolate the area. The experience prior to the San Onofre or the SCE activity was we in July ~~had been~~ at Takahama in Japan and used a similar process. Instead of using magnetite in Japan, we used a boric acid crystal. Again, ~~it's naturally~~ in the reactor coolant system. The magnetite is much more abrasive and that's why we chose it in this case over the boric acid.

We achieved ~~growth~~ decontamination of the

Don
Allan Meoli

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generator general area fields inside of about two and a half. The generator fields were similar to that at SCE, about ten at the channel head and reduced that down to about three.

We have done extensive testing with this process ~~both from a sampling basis~~ with hot samples that had been put into a generator for some period of time ~~and~~ to measure~~d~~ the effectiveness of the process ~~of both from developing this specific technique to applying that grit spray~~ and to look at the effects ~~of~~ on the surfaces, et cetera.

These are the fundamental technical issues that have been reviewed as related to the reactor coolant system. They really don't relate to the sleeving program. Each one of them has been reviewed and addressed, the cladding, for instance, after the decon process, there is about a half a mill of surface that's removed. The process has been, more or less, fine tuned by changing the characteristics of the grit material and the pressure and angle, et cetera, of the spray nozzles to control that amount

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Don
~~Allen~~ Meoli

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of corrosion. A half a mill is very insignificant. We are looking at a quarter of an inch of cladding or thereabouts on the surface. The residual amount of grit that will be left in after the process is ~~completed~~, because it is magnetite, the amount that we are adding to the system is extremely small.

We have two basic methods of cleaning up. One is a washdown of the channel head after we are completed with the process, and the other is there is a special cleanup cycle of the CVCS system using very small micron filters.

The two major components of concern are the reactor coolant pump seals and the CRDM's. Both ~~of these have~~ processes to be used to clean up before operation.

DNA

~~Dilution, as~~ As I said a minute ago, the process is a closed loop system. ~~There is~~ approximately 200 gallons of water. If all of that water would be dumped into the reactor coolant system, it would be equivalent to ~~about~~ a change in dilution of about 50 ppm. The shutdown requirements of SCE is 2,200 ppm boron concentration.

Don ~~Allen~~ Meoli

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We are presently at about 3,500 ppm plus as I recall, ~~so~~ there is ample shutdown margin ~~there for any activity~~.

And, There is a controlled process of addition of water to the systems. It's part of the field procedure and has worked effectively in identifying when we had a leak, or when we had a failure in the system seal.

Waste handling, there are two media that's being generated as waste. One is the heavy particles, ~~the~~ of magnetite, ~~itself is not~~ reduced. It's taken out by a cyclone separater system inside the containment. It's then cycled to a storage tank. Again, it's inside the containment and will be dealt with ultimately by a subcontractor later. The very small particles are taken out by a dry filter system of about two to three micron size and ~~that~~ is being packaged and baled and held for storage ~~in~~ for transportation ~~for~~ later by the utility.

We are approximately done with half of the deconning activity. I would like to describe to you the results to date. Let's just focus in on this

Don ~~Allan~~ Meoli

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upper curve.

This is the dose rates that you are seeing inside the channel head. This is at about one foot below the divider plate and then these are, further field reduction as we go through various stages of the decon activity. ~~we are plotting~~ it.

The solid curve is the projected reductions for each one of the steps in the processes ~~as it was being described~~. The ones with the little balloons are measured conditions as we are now completing them.

r7 There are four elements. The hot leg decon, an~~d you can see that is~~ where the sleeving activity is taking place, and you can see that is the largest or the most significant reduction. The cold leg, there is a certain amount of shine that comes through the divider plate from the second side. That has an effect of about 1 R. The honing operation, which really is a tube cleaning operation prior to installing the tube or the sleeved area, it's also an abrasive process that ~~also~~ takes the ~~this~~ magnetite film or scale from the tube ~~and~~ It obviously has an effect

Dan
~~Allan~~ Meoli

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on the field as well. It's going on right now and it's a little early to project what ~~that is~~. And, there is a nozzle seal that we will install. ~~that is a~~ lead blanket ~~basically~~ of about two inches ~~of lead~~.

We are approximately on the profile of what we expected. It ~~may~~ appears that there is more activity coming from the tubes than we had anticipated but that's yet to be determined. We are about, ~~I think, about~~ 10 to 15 percent finished with the one side of the generator honing operations. It's a little early yet for us to project. You can see, if you convert that into DF factors, ~~you can see where we are~~. We are about at two and a half.

These are the early projections. ~~and~~ I want to show you some current ~~projections~~ values of the amount of man-rem that is being expended and ~~will be~~, there were some assumptions that were made when we did this. One was it was a very idealized assumption ~~because~~ most of the hardware had not been designed at this point. What we did was ~~we~~ set ourselves a design goal of

~~Allen~~ Don Meoli

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not being more than 10 minutes per sleeve ~~at~~ of actual process time. The other assumption was that we would be working in a very low field in the area of the steam generator platforms, and the other major assumption was the equipment would work almost ideally. Well, in all three cases that's not happening.

Then, the last slide is a current projection of what we see as the total expenditure. ~~So we~~ We have moved our projection from about 1,000 to about 1,300. Let's look at some of the reasons why.

As of the first of the month we were projecting about 260 for the decon process. Earlier we were projecting this to be 40 based on the experience we had at Takahama, we used only 24 man-rem to do three similar steam generators. The process is a little different in that we are using an in-containment recycle system and we have had a series of failures of some of the hardware. The magnetite grit is a very abrasive process and it does tend to cause some failures with the decon arm itself that we had not seen earlier. ~~and~~ We have seen a real degradation in the

Don
~~Allen~~ Meoli

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inflatable balloon ~~which we~~ And have had to totally redesigned, and now think we have under control.

We have consumed to date 120 ~~R~~. If I straight-line ~~that~~ project, I get 260. If I use some engineering judgment that says I have done some things to the process that should not be at ~~that~~ the same failure rate, we are looking at 213. We are at about 8 percent completion of the honing operation of the tubes. The initial projection was around 100. We have used 18. We are beginning to see some of the same failures typical, I think, of a process that's only been designed for three months. If we straight-line the project ~~that~~ then we are at 230 and we have not ~~changed~~ started the sleeving operation. Since we have a little more time to work on the sleeving tools, we are getting closer and closer to having semi-tools available to us. ~~So~~ Our current projection, ~~then,~~ today is 1,330 as compared to about 1,000 about four months ago.

Do you have any questions?

DR. GREEN: A question about the

decontamination process. Is that using this magnetite at 3 to 5 percent by weight in a nozzle is impinging the material with three feet per minute? Is that the process?

MR. MEOLI: Yes, it is.

DR. GREEN: Do you just impinge it on the inner surface? You don't try to decontaminate the ID of the tube?

MR. MEOLI: There is some effect but because of the honing process, we have not tried to optimize.

DR. GREEN: You inject it on the whole surface, that's included on the ligaments as well?

MR. MEOLI: Yes. We have sampled some of that. We have ~~used it~~ looked at the ligaments and there is no degradation.

DR. GREEN: Cleaning the face of the tubesheet as well as the --

MR. MEOLI: Cleaning all three major surfaces; tubesheet, the bowl and the divider plate.

~~Allen~~ Don Meoli

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DR. GREEN: This is essentially room temperature?

MR. MEOLI: Yes. It gets up to about 120 degrees because of the pump ~~ing~~ heat input but it's in that order.

DR. WEGST: You are apparently measuring your decon factor by simply measuring your gross radiation fields in the channel head?

MR. MEOLI: We are doing it by two methods. What I showed you was the gross radiation ~~heads.~~ fields. The same as a worker would see.

DR. WEGST: In this, in the writeup that we got, you indicate that the abrasive process ends up with nice, bright, shiny metal.

MR. MEOLI: That's correct.

DR. WEGST: Is the metal still contaminated even though it looks shiny or is the radiation coming from someplace else besides what you have "deconned"?

MR. MEOLI: I don't think we are that smart, frankly. We believe that most of the activity is

Don ~~Allen~~ Meoli

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coming from the surface; so if we abrade that surface, then, the basic field will go away. It's too early in the process yet because we have not completed the tubes to understand what the total contribution from the tubes ~~are~~; ~~but~~ One of the phenomena is that you have to be extremely effective in getting 100 percent of the surface clean. It's remarkable, if you leave three or four percent, it tends -- the decontamination factor tends to ~~flatten~~ change ~~out~~ very ~~low~~ slowly. Until you become extremely effective in cleaning, ~~that~~ the DF factor will not go up ~~much~~ markedly.

On bench samples, ~~when we have~~ some one foot by one foot cladded plates that we put in an open plant and left for a year, ~~taken out and deconned~~, the surface decontamination effect is anywhere from 100 to 1,000; so that we know ~~we~~ we ~~are~~ can be very effective ~~in that area, we know that most of it is there~~.

The problem is is this is ~~all~~ mostly a very roughe~~ned~~ cladded surface and it's very hard to get the right geometry, the spray angles, to get all the cracks and crevices; so there is a threshold we are going to get to and we are not going to get any clearer than that.

DR. WEGST: It's my understanding that you are going to sleeve just the hot side.

MR. MEOLI: That's correct.

DR. WEGST: But there is some contribution of radiation from the cold leg side?

MR. MEOLI: That's correct.

DR. WEGST: Is there any possibility of filling the cold leg side with water when you do the sleeving to get some more shielding on that side?

MR. MEOLI: I think there is a possibility. We haven't looked at it. The biggest problem will be to dam the reactor coolant ~~side~~ pipe ~~to take that lead, the pipe itself in a reliable way.~~

Right now ~~we have in the divider plate,~~ ~~for instance, we have~~ on the cold side, we have draped a leaded blanket to help aid that process. It probably is as effective to do it that way as it is

Dow
~~Allen~~ Meoli

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to put ~~in~~ in the water. We can put a couple more layers of lead blanket on if we need to ~~in that s~~ide. As a matter of fact, I think Bill had planned on doing that.

We are learning as we go along, ~~in this process and~~ there is a dedicated ALARA team that continually looks at things like that, alternatives.

What is the effect, what can we do, what are the fields, where can we make modifications in the process, and we are learning as we go, ~~along.~~

Thank you.

MR. NOONAN: With your permission, I would like to sort of expand the discussion at this point mainly for the benefit of the panel. I want to get into some of the things that have happened during the decon. In particular, I would like Westinghouse to tell the panel of the problems they have had in the decon process, what has actually gotten into the primary system, as to magnetite grit or other debris that has been identified in that system, I would like for our record to show what we know now is in the system.

~~Allen~~ Don Meoli

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I would also like to talk about the actions that are going to be taken to remove some of this stuff and what the effect is going to be on the overall exposure to people trying to get some of this debris out of the system.

I would like a discussion a little bit here as to the effects of the -- this might be the wrong place for this particular item, but the grit that remains in the system, what effect is that going to have on the reactor coolant pump seals and also the rod drive mechanisms, control rod drive mechanisms and, finally, the summary that you had up here showed a 1,330 man-rem exposure but it did not include exposure prior to decon. I would like to talk about the total expended prior to decon, in other words, back in April. That was the exposure rate that you got back going back to the very beginning.

MR. MOODY: Do you have more?

MR. NOONAN: That's all I have for that.

MR. MOODY: As the agenda reflects, I guess Mr. Meoli's presentation is only part of what we plan to say about ALARA activities. I guess what I would like to do is hold that as an open item at this point in time, let us proceed with Bill Allen's portion of the agenda, item four, and we will return to that as an open item.

MR. NOONAN: Will you return at that time for the panel to hear the discussion, not present it later?

MR. MOODY: We will return to that item as a point of discussion. I don't know if we will be able to answer all those questions in the presence of the panel, but we will return to that item while they are still convened.

MR. CURTIS: Bill Allen is a certified health physicist and certified power reactor health physicist and Edison has obtained his services for the purposes of developing and implementing a health physics program which satisfies the operational ALARA guidelines insofar as the sleeving program is concerned.

He is going to discuss this morning some

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~~Allen~~ Meoli

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of the ingredients of that program which are intended to manage the man-rem exposure that we expect to reach at the site, to values which are as low as reasonably conceivable.

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MR. ALLEN: As Wes indicated earlier, the scope of my presentation is more of a background supportive informational approach. I would like to discuss the health physics program in place at San Onofre and be as specific to the sleeving project as we see it today as possible.

To meet that end, the first identified need was to define an organization that is, if you will, dedicated to this project. We felt we had three major areas that needed to be addressed. We had to provide shift coverage all in the identified functional areas and then implement an adequate staff to support activities in three steam generators constantly. In addition, we had to assure that contamination control was exercised and provide rad waste handling in support of the decon and sleeving projects.

To do that, I have a staffing supplement summary here. It is as we exist today. We have currently approximately 64 health physics technicians

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contracted to supplement the station staff, of which approximately twelve are dedicated to steam generator repair. In addition, we have contracted 16 technicians that whose primary function is decontamination, to manage the contamination problems, and we provide shift coverage.

To give you an idea of our concept with respect to how we would implement this program, we identified seven major functional areas, some of which overlap into plant, normal plant operations such as dosimetry as well as rad waste. We identified training as an obvious need and ongoing basis, dosimetry procedure writing information necessary to support the specific activities of the sleeving project; rad waste organization to manage the activities and end products of the decon process, and the sleeving process.

The meat of our activity obviously is providing an operational health physics program to provide ongoing coverage on a shift basis within the containment sphere. We provide lead individuals who are responsible in the containment, appropriate technicians and relief technicians for work on the platforms on and around the generators.

Decontamination, as I said before, as far as force and equipment, is provided on an around-the-clock basis with appropriate supervision. There are surveys accounting for supportive activities, instrumentation and other identified subareas.

We had to provide around-the-clock checking at the control points and access areas to support massive influx of individuals. We also had to supplement and provide respiratory protection. Body counting, we have contracted a whole body counter to support the personnel; and lastly, we identified an area and provided individuals on an around-the-clock basis to look at our activities and assess them with respect to ALARA.

DR. WEGST: Are these people who audit what's going on?

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MR. ALLEN: They audit activities, procedures, equipment. I will get into that, Dr. Wegst.

Of prime concern was the ability to provide the best available training for the individuals dedicated to the sleeving project. Obviously the plant has an existing station radiation protection training program that is, has been and is currently being utilized to qualify specific individuals for unescorted access. At the time it is SCE support engineering staff, Westinghouse engineers, technicians, subcontractors and their supervisors who are providing escorts within the station. Contracted health physics personnel receive the same kind of unescorted access training and, in addition, we provide approximately three to five days of specific procedure training with respect to how we do business in San Onofre.

Of prime interest are the individuals involved working in and around steam generators. I have just depicted here a sequence of training for

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your information. The first day consists of four plus hours of classroom instruction that is directly related to 10CFR19-12, risk of radiation exposure, biological effects, methods to reduce exposure, et cetera. We do give an examination to these individuals, not only documents the implementation of the program, but justifies understanding of the fundamental concepts of training.

At the end of that day, we provide an initial whole body count. This is done at a remote location near San Onofre where the mockup or steam generator mockup is located.

The second day, a full physical exam with specific attention to ability to wear respiratory protective equipment as well as the ability to perform physical exertive labor. We initially start on this day to familiarize individuals with protective clothing, including practicing dressing and undressing with assistance from a qualified health physics personnel. Also, we give a respiratory protection class with respect to the types of equipment that they are going to see and an examination. Again, to document understanding of the limitations of the equipment and emergency procedures that might be necessary.

On the third day the meat of the training program begins with mockup training, first of all, in civilian clothes to become familiar with the tooling requirements as well as entrance and exit procedures, so they are not encumbered with protective clothing. After that is accomplished, we do a full dress on a simulated platform environment to include step off pads, ropes, signs, barriers and health physics coverage. This particular activity is done in concert with Westinghouse's training activities with respect to tooling qualifications.

Each sequence that an individual becomes qualified for is repeated at least once, usually twice or more, and timing on all of these practice activities is maintained and recorded so that the best and most efficient personnel for a certain task can be selected.

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In addition to this, we obviously hold refresher classes as tooling changes occur or procedural requirements change. I believe currently there are approximately 15 specific separate qualifications that are recorded with respect to the tooling installation, movement and removal. Other training activities related to the sleeving project again includes system reviews and walkdowns by engineers, shift coordinators, support personnel. Health physics personnel on the major activities of decon, honing and sleeving receive about four hours of instruction on the equipment that they are going to see in the containment, how it's going to be installed, removed, as well as watching the channel head worker and what his activities will be on the platform and in the channel head, so they are totally familiar with the activity to be performed.

In the early days of the project we identified a need for some specific features, and I will just run through them very quickly for you.

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These are where we are today that are specific to the decontamination of the sleeving activities, what we felt we needed, a procedure to define how we are going to handle material primarily.

You can see a lot of these relate to waste products that are generated in the various processes. We defined a narrow scope protection program, how we are going to implement that.

The ALARA program procedure requires activities such as equipment reviews that are documented and recommendations for changes, procedural reviews, reviews of installed equipment, as well as training or briefings of personnel who are involved with the project on the contents of the program and the activities therein.

Because of the diverse nature of this entire sequence and multitude of procedures that are in place at the plant as well as these additional, we feel the necessity to implement a miniature health physics program that defines our approach and addresses

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anything unique or somewhat different than plant activity, areas such as dosimetry and access and egress and requirements therein, types of training programs that we are applying, respiratory protection for the project and various exposure limits. That document is currently ready for final approval.

A major concern of the project of this magnitude obviously is access control, control of personnel. We reactivated an existing separate entrance for the majority of the workers, Westinghouse and support, and that is currently manned on an around-the-clock basis to match the work schedule.

In addition, we modified the entrance and exit procedure at the main access to the sphere. I will just run through how we approach handling the influx and egress of personnel.

As I said, there is a separate entrance approximately over here, individual accesses, comes up stairs to the turbine deck. When he arrives here, he is dressed in two layers of protective clothing, head cover, cotton gloves. In this area plastic booties are applied, pair of rubber gloves are secured. The individual progresses down the entrance path in here, dons a pair of rubber shoe covers. Main access to the sphere is through the large equipment hatch.

We have marked ingress and exit routes so that traffic flow patterns within the sphere, problems associated with that will be minimized.

Upon leaving the containment building, at the first step off pad the rubber shoe covers are removed, the most highly potential source of contamination. On this area of the personnel hatch the outer layer of protective clothing, rubber gloves, coveralls, head covers. The individual egresses here, removes the inner layer of booties, does a shoe frisk. At this point the individual is, in essence, in street clothing, exits and does a final frisk in view of the health physics aid of the whole body prior to exiting this sphere.

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In addition to that protective clothing sequence I have just described, obviously we have steam generator platform workers and channel head workers who would don an additional layer of protective clothing, including a bubble hood. That particular layer is removed at the platform upon completion of work.

I would like to run through the various activities that have been performed that are directly or indirectly related to the reduction of personnel exposure. On the front end of the project, the first need that was identified was an extensive survey of containment and extensive posting program to identify as many hot spots as possible and identify those areas and identify the cool areas.

We applied temporary shielding wherever practical. I gave you an idea, this is one of my ALARA technicians who is not a very good artist but this represents the B steam generator, believe it or not. It's hard to see in the viewgraph. This is the shield wall, hot leg of the generator, catwalk above the platform. This particular area are the grit pots that feed the decontaminant for this generator as well as the C generator.

High occupancy area, we did an extensive lead curtain in this entire area to shield, particularly from the pressurizer that sits over here. Spray line from the pressurizer runs here and we leaded this, we leaded here because of equipment pumps, pressure gates that require periodic access.

In addition, the platform itself is difficult to see, has a hand railing around it. Lead was erected up to the hand railing to try to reduce shine from the bottom of the pressurizer for personnel who require access to the steam generator platform.

Back to this slide, another area that we implemented in concert with the access control, wherever practicable, we are doing the entire suitup for steam generator entry or platform work out on the turbine deck at the entrance of the facility other than the bubble hood, obviously, to reduce personnel stay time in relatively higher radiation areas.

We did some extensive modifications with respect to dose assessment. We established several blanket radiation exposure permits and utilizing a coding system we are able to relate them to work function as well as steam generator; so we can evaluate not only the exposure by generator, but by work activity.

Here is a typical example here of a computer printout of our REP's that exist. Here to here we are related to decontamination activities.

Decon system, you can see the entire sequence is trying to fall in line with the areas of activity. In front of each of these numbers we code a radiation exposure permit with six, seven, eight, representing steam generators A, B, C, or we can search on a particular work function, such as automatic decon, by searching REP71034, the steam generator, B steam generator. The other remaining activities are somewhat associated with honing that we expect, honing and sleeving that we anticipate, and this is currently being expanded to match plans for methods of approach.

This is a computer printout of an example of what would appear on a CRT at access control points where I'd walk up to ask access to work on steam generator B and I want to go in and work on the automatic decon activity. However, my particular film badge is coded such if I'm not one of these people, I will not be allowed to access on that particular radiation exposure permit, so the individuals involved with decon activity would be coded with respect to decon activity. Each one is controlled at the outer control point. We are in the process of moving that control to the turbine deck.

Another area of good ALARA program is management attention obviously as well as providing qualified individuals to provide coverage, to look for improvements, record discrepancies and bring those discrepancies to the attention of personnel who can resolve them.

In addition, we provide daily exposure update.

This form is currently being modified and probably has been since I left the station, so we will just talk concept. This one here represents where we are, where we were with respect to honing on October 18, B generator. You can see we tried to reflect where we are with respect to Westinghouse and SCE exposures as opposed to what we projected, total with respect to percent completion. This is distributed to plant management, Westinghouse personnel.

Training. I have already touched on this area. We do perform ALARA briefings that define the program, radiation permit process, methods we are utilizing to try to reduce exposures and inform personnel of their responsibility to do that.

In addition, the training that I described on the mockup is extensive and, again, timing is used and records are maintained so we may select the best manpower for a specific task.

Of major concern in any project of this size is controlling contamination, obviously. These are four areas that we are implementing and are very successful in maintaining to date contamination levels within the sphere. We have applied a filter exhaust blower on opposite manways to try to control airborne concentration. That seems to be very effective. The use of step off pads in the sequence I have described before, with the additional step off pad near the platform to confine the highest possible source to the smallest possible area. Again, we have established a step off pad to control the next most serious potential source within the sphere of where we can decontaminate and control the spread of decontamination. Prior to work activities, we are covering the grating on the platforms, work platforms with multiple layers of throwaway plastic. It allows us to do two things. It allows us an option on the decontamination program and protects the grating at lower elevations. Where levels become too high or physically dirty, the upper layer may be removed to reduce decontamination time in a high radiation area.

We have described before we are performing routine decontamination as a matter of shift coverage around the clock on walkways, specifically exit areas from platforms, wiping them down, mopping them down on a shift basis. Step off pads are routinely changed and we provide three shift coverage to show positive control of contamination spread.

I would like as a summary to run through major areas within 10CFR20 with health physics. I will not touch all but try to relate them to regulatory requirements.

Obviously, 10CFR20.101 concerns itself with exposure in restricted areas. Certain limits of exposure have been applied to implement this. We are applying head and chest film and tld ratings for all platform workers and steam generator workers. We also utilize a multitude of self-readers, including a bubble head for channel head workers, most restrictive self-utilized by the computer to update on each exit from the sphere. So we have a lifetime indication at least where we are with respect to exposure limits.

10CFR20.102, determination of accumulated dose and establish appropriate limits. That is accomplished on the front end prior to any film issuance. Any missing documentation would require a limit lower than one and a quarter rem. We are applying that administratively through the use of the computer.

10CFR20.103 concerns itself with airborne radioactive material, exposure of individuals to concentrations of radioactive material in restricted areas, even though airborne concentrations seen to date are extremely low. Those are the processes we are involved with right now. As I mentioned before, we are exhausting and filtering the opposite leg of the generators to insure positive airflow away from workers and occupied areas prior to (inaudible.) We are utilizing protective clothing and equipment obviously to prevent inadvertent intake of radioactive material that might otherwise be inferred to be exposure to an airborne concentration. We are performing continuous air sampling in areas of concern as well as grab samples so we get a quick indication.

10CFR20.105, we have to address because of a significant amount of waste and materials that are moving, permissible levels of radiation in unrestricted areas. We have identified control storage locations for radioactive material and providing routine surveys to implement the requirements of 10CFR20.105.

10CFR20.201, the heart of any health physics program is the collection of information for surveys. To run through the bases of what we are doing, we are performing contamination surveys within the sphere on a shift basis so that our decontamination people have some ideas as to what to work with, radiation levels on the same frequency, the implementation as related to requirements of 20.101 as well as the posting requirements. We are doing site perimeter surveys on a daily basis, surveys as required at 20.105.

Air sampling, as I said before, we are continuous on platforms and near the decon process equipment, performing grab samples during channel head work on the catwalks, in the channel head and on the platform. We are establishing plans for 20.103.

10CFR20.202, personnel monitoring, requires that appropriate dosimetry be issued to all personnel accessing restricted areas. Minimum requirements to access the sphere and, in fact, before the sphere, is a chest badge, official station record, and two self-reading dosimeters. In addition, we are applying head and extremities monitoring for all platform and channel head workers.

10CFR20.203, posting and labeling is of prime concern. It is fairly easy to establish compliance with it with our approach, which was to overdo it to assure that the worker has at all times within eyesight of where he is with respect to a radiation area within the contained sphere and what he is doing, access and egress.

That summarizes as best that I can the health physics program specifically applied to try and assist in the decontamination and sleeving projects.

I would be glad to answer any questions if you have any.

DR. WEGST: How do you read out film and tld ratings?

MR. ALLEN: We are currently pulling all channel head workers and steam generator entrants at the end of each shift, updating the exposure based on the self-readers.

DR. WEGST: On self-readers but the film --

MR. ALLEN: The process is at the end of the shift.

DR. WEGST: Every shift?

MR. ALLEN: Every shift. It's a lot of work. However, with the overresponsive film, it was of prime concern we have an accurate number to work from and we, so far, have been able to turn around the data with the film supplier in a relatively short period of time.

DR. WEGST: How does the film record compare with the self-readers?

MR. ALLEN: Usually a little bit higher, 10 to 20 percent, because of the E bar and the film would overrespond.

MR. NOONAN: I think we have a number of questions that Mr. Nowicki would like to ask. However, I have one question.

On one of your earlier slides you had a computer printout of various activities that are done in your health physics program.

MR. ALLEN: Yes.

MR. NOONAN: One of those items on there listed housekeeping.

MR. ALLEN: Yes.

MR. NOONAN: I am sitting here with the report in front of me that says we have tool parts, hose clamps, plastic sheets that have gotten into the primary system. I don't understand how we can get that kind of stuff in the primary system if we have as good a program as you say we do.

MR. ALLEN: This housekeeping REP, first of all, was designated to perform routine cleanup activities other than floor decontamination within the sphere. It is not related to any channel head work entry or recovery from problems within the channel head. It wouldn't be utilized for that.

MR. NOONAN: Is there any process to check people that go in and out to see that they bring out what they have taken in?

MR. MOODY: We are going to return to that as part of the open item created as a result of your question following the last presentation, namely, your question concerning what has gotten into the direct coolant system.

MR. NOONAN: I am concerned about the latter consideration because we have gone through the big program to offer views on the man-rem exposure. We now have got to go back in and recover stuff.

MR. MOODY: I understand that to be one of your questions last time around as part of the open item, namely, what is the ALARA consideration for the people that may be required to rectify any situation where something has gotten into the system.

MR. NOONAN: The overall program that you have --

MR. ALLEN: A, being activities such as working the channel head to recover something that has been lost, would not be covered under the blanket. Specific radiation for that particular item would be designated. That answers your question. These are designed for routine required activities as applied to decontamination and any activity such as that would be done on a specific REP.

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MR. NOONAN: Maybe you can identify what do you plan on your schedule to cover that?

MR. MOODY: I have kept that as an open item. I want to discuss that with Edison and Westinghouse personnel at a break. When I return, I will discuss that, what our intention is.

MR. NOONAN: I think Rich Emch would like to talk.

MR. EMCH: We held questions through Mr. Meoli. Is it possible to have sort of a joint thing here with Meoli? Is he still available.

MR. ALLEN: Yes.

MR. EMCH: In looking at the report that came out before this meeting, this green volume, it looks like there is only a total of maybe 15 curries of activities that's being removed from the steam generator and that's both in the magnetite and the water and only two curries of it in magnetite. I guess I don't quite understand, you know, where is the rest of it going or is that all that's being removed; and if that's all that is being removed, it's hard for me to see how the dose rating can go down at all? I would expect the amount of activity inside the channel head would be an awful lot more than 15 curries.

MR. MEOLI: I didn't generate those numbers but I have got a report in back of the room that maybe we can go back and dig through those numbers. To the best of my knowledge, and these are assumptions because we have nothing other than the one experience we had at Takahama and the lab data that we have generated, There is really not any good industry ~~recorded~~ records of where the activity is and how substantial the activity is, ~~and~~ those are really based on some very sketchy set of information, ~~and the~~ projections on our part.

MR. EMCH: Do you think you have taken more than 15 curries out of that steam generator?

MR. MEOLI: No.

MR. EMCH: But yet you are only taking 15 curries out and yet you are reducing the dose rate

10R to 5R per hour or something like that?

MR. MEOLI: Those are actual measurements.

MR. EMCH: I guess all I am saying is if 15 curries only (inaudible) cobalt 60 doesn't correspond to a drop in dose rate.

MR. MEOLI: If it's spread over a thin film and large surface areas in a general field, it is. ~~You know, you see that every day.~~ Film is really not very thick, 2 to 4 mills, but we know that we are getting fields in other generators as high as 35 or 40 but yet any point of activity that you take out is fairly low. That's why ~~when~~ I talked about a cleaning efficiency, it's spread over this very thin film, over a large surface area. It's not ~~intended to act as~~ a point source, ~~this large field~~, and you have to be very effective ~~to get~~ it. I don't have any good evidence one way or the other. After this project we hope to have a lot more evidence.

MR. MOODY: Dr. Wegst, I wonder if you could express if you have an opinion with respect to this?

DR. WEGST: Yes. It seems reasonable to me, you are talking about having a sort of the reverse of a normal exposure situation, instead of having the point source with the receptor outside the point source, you have got a volume or surface course 360 with receptor inside the 360 degree sphere and so it wouldn't take very much activity spread over that sphere and produce a pretty good high dose rate in the center, and removing relatively small amounts of activity would make significant dose rate changes. That makes sense to me.

MR. EMCH: How much would this middle plate hold and how thick is it?

MR. MEOLI: Inconel or carbon steel about one inch, one and a quarter solid.

MR. EMCH: (Inaudible) inch thick metal plate yet it seemed to be getting distribution from the cold side to the hot side.

MR. MEOLI: Absolutely.

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DR. WEGST: You are looking at what, 88kV, 1 MeV (inaudible)?

MR. MEOLI: ~~8keV, somewhere in that area.~~ Because ~~of~~ the fields aren't high compared to other generators, I ~~see~~ have seen some generators maybe 30 or 40 R, you ~~are not seeing -- you are seeing~~ can see a factor of 2 ~~an order of magnitude~~ change from the second side, there ~~but~~ it's not as dramatic because you didn't start it at the same elevated level. You started at 8 and reduced down to 5 maybe, by totally cleaning the other ~~second~~ side. If I look at another generator and I was looking at a field that ~~we~~ started out at 35 or 40, the effect of that second side would be very dramatic, same order of magnitude, but it's much more apparent.

MR. EMCH: I guess the thoughts I have is that the cold side is usually less contaminated than the hot side. I don't have any real number to back that up.

MR. MEOLI: There is ~~only in measurements gross fielding~~, only about 1R difference between the

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hot and cold, maybe 2R. It's 10 compared to 8 or 8 compared to 6, something like that. There is usually less activity on the cold side but probably because of the tubes. There is more material concentrated on the tube ends on the hot side than on the cold side but that's usually about all.

MR. EMCH: Did you find the cold side as contaminated as the hot side?

MR. MEOLI: Yes.

DR. WEGST: Let's go back to an opinion I had earlier. You indicated you have got some lead blankets draped across the divider plate on the cold side. Do you have any numbers as to what effect that had, what reduction that had on the dose rate on the hot leg side?

Mr. Allen
~~MR. MEOLI~~: I believe it was on the order of center bowl reading 250 (inaudible) with two layers of, I believe, a fifth of an inch.

DR. WEGST: How much lead?

Mr. Allen
~~MR. MEOLI~~: Two layers of, I believe they

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are a fifth of an inch apiece, lead wall blankets, less than a half an inch total. We designed a blanket to hang on the environmental ledge with prongs long enough to support an additional two layers. Reduction was there, questionable with respect to instrumentation as far as the center. We are talking about 3R per hour and between two surveys you see (inaudible) 200 mill rem per hour, you are almost within human error.

DR. WEGST: You are talking about adding 400 mills of lead to already something that's an inch and a half or so of steel?

~~MR. MEOLI~~ MR. Allen: Right.

DR. WEGST: It sounds like it might be worth adding some more lead.

MR. MEOLI: Yes. We designed it into it ~~so~~ we can hang four layers. This was after decontamination of the majority of the cold leg side of the divider plate to eliminate that source of direct involvement in the hot leg.

One of the things ~~you~~ do, ~~we are~~ playi~~ng~~

off how much exposure we are getting pulling the lead off what we think the reduction on the side is going to be reverses how much activity is going to be there to put up that lead blanket. I think we used about 500, half a man-rem. To put another layer on that would use about that much again, but I think that's very effective and that's a decision process we are going through as we go down that path.

MR. ALLEN: What we plan to do is we are still in the situation in the hot leg where we are only partially complete with honing and we still have to apply the nozzle shielding and I think once those two activities are complete, some realistic measurements would be more meaningful as we lower down in the dose rate areas so we can see a reduction of 200 mill rem or 300 at that point would be decision-making time.

MR. NOWICKI: I am confused by your comparison earlier of boric acid and magnetite. Apparently, to me, it seems like we are comparing

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oranges and apples or something.

MR. MEOLI: From what standpoint?

MR. NOWICKI: I thought originally the projection you were going to get a decontamination factor from magnetite of ten and from boric acid crystals you were going to get a decon of two or that you have seen a decon factor of two. I understand after you completed the hot leg you found the decon factor of about two with magnetite. Now you are taking credit for the honing. You did hone in Japan?

MR. MEOLI: No, I didn't.

MR. NOWICKI: So the two, factor of two in Japan was strictly from the boric acid?

MR. MEOLI: Abrasive process.

MR. NOWICKI: That's all you got from the magnetite?

MR. MEOLI: Appears that's all we have gotten at this point.

MR. NOWICKI: There wasn't any advantage to the magnetite?

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MR. MEOLI: There may not have been. Certainly in the laboratory there was at least a tenfold order of difference in the effectiveness of cleaning the surface, boric acid grit vs magnetite grit

MR. NOWICKI: In this case you are finding you are getting the same results as if you had used boric acid crystals?

MR. MEOLI: It's a little higher, maybe it's 50 percent higher with magnetite at this point.

MR. NOWICKI: Since you were projecting a much higher decon with magnetite, you are still saying you expect to get a factor of ten. How are you going to get that because you were planning to hone in the first place?

MR. MEOLI: Let me go back and get my graphs. I initially did not take that much credit for what we were going to get from magnetite. I wasn't as optimistic.

DR. WEGST: Didn't your factor of ten include the honing which you haven't done yet?

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MR. MEOLI: Yes.

MR. ALLEN: I can give you a feel for that, Stan. Two or three days ago we had a honed region completed in the tubesheet and with a portable long reach survey instrument we took a reading and also got one in the unhoned region. We do see a 1R per hour difference in that.

MR. NOWICKI: If you expect to get ten that you originally had hoped for, is the honing going to give you that much more?

MR. MEOLI: What you do is look at the increment here. There's about 3 1/2 to 4R for the ~~process of~~ the magnetite process. There is about 1R for the second side. There's about another R for the honing operation.

MR. NOWICKI: Are you going to do the second side in all steam generators?

MR. MEOLI: If it turns out to be effective, yes.

MR. NOWICKI: When you finished with one

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steam generator --

MR. MEOLI: And we did the second side.

MR. NOWICKI: Did you find out if it's effective?

MR. MEOLI: We can't tell until we finish this process. It's too masked by what's going on. The plan was to do the first generator totally and as we made measurements through the process, we would use that to guide us in whether or not we put in shielding in lieu of doing the second side.

MR. NOWICKI: Did you not do the second side?

MR. MEOLI: Yes. In the B generator we did about 70 percent of it.

MR. ALLEN: We did the majority of the divider plate and 70 percent of the tubesheet on the cold leg side.

MR. NOWICKI: Do you plan to complete it?

MR. MEOLI: Yes. I didn't take credit for thinking that we were going to get a very high DF because of the magnetite. I refused to take credit. I had quite a discussion with my own people, and I have yet to weed out why there does not seem to be a dramatic difference between using magnetite and boric acid crystals, but that's very apparent, that's right. It's better but it's not as significant as we first might have expected.

By inspection, the inside of the generator is getting to bright metal. By inspection there is a visible difference between the way this generator looks inside and the one in Takahama.

DR. EGAN: They are both cladded surfaces, same form of cladding?

MR. MEOLI: Same form.

DR. EGAN: Machined cladding?

MR. MEOLI: Yes.

FROM THE FLOOR: Not machined.

MR. MEOLI: The bowl isn't machined. The bowl is ~~very~~ most difficult to clean.

DR. WEGST: When you got down to the

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point where you have got all of your steps in, I take it it might be worth trying to make some measurements throughout that volume to determine as much as possible where the remaining radiation field is coming from?

MR. MEOLI: One of the things we are doing, for instance, ~~we are~~ using surface shielded detectors to take some local measurements before and after.

DR. WEGST: All right.

MR. MEOLI: For instance, the before and after ~~gross rating~~ ~~is taken~~ by ~~a series of film badges. We put~~ an array of film badges in the ~~metal~~ of the tubesheet that -- I think there is four or six of them as I recall, one right next to the tubesheet, one a foot down, one two feet, one near the bottom, and we average those numbers before and ~~after~~ the decon to see really what this DF factor ~~was~~ ~~and~~ we are using film badges as the basis because that's what we are using. That's really the method the people are using, plus we are doing some of this other work to

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look at what the surface effects are.

MR. MOODY: Are there other questions?

MR. EMCH: I guess to go on that particular subject even further, there are some people who might wonder if boric acid is as effective in this type situation, which I am not ready to judge that myself (inaudible) we could avoid some of the hassles that we have with the sealer.

MR. MEOLI: Certainly that's ~~another~~ obvious conclusion. It's too early to make those judgments.

MR. EMCH: I was thinking of that question not so much for your job but as for the next time, particular point or whatever. There are several options here and I know some of them are remote, semi-remote manual. Could we quickly -- I know the decon itself with this head that sweeps around is a remote situation, the honing is a remote situation as best I understand. There is some question as to whether sleeve insertion is a remote, semi-remote or manual process.

MR. RAWLINS: Mr. DeRosa, when he comes up, will discuss those aspects.

MR. MOODY: That is something that will be covered as part of the sleeving. If you want to return to ALARA considerations as a result of what you have learned about it, its remoteness or lack thereof, we can return to ALARA considerations, but let's get that on the record first.

MR. EMCH: Decon and honing.

MR. MEOLI: As a general rule all of the processes are aimed toward a remote, semi-remote process; but depending on where we are in time, ~~what~~ we ~~find during~~ and the conditions ~~that were~~ at the time there, you may use a hand-on tool, may use a semi-remote or totally remote tool.

MR. EMCH: You mentioned you have run into several, I guess, problems in going through this. Could you expand for us just a moment. One problem I heard was magnetite seemed to cause problems with equipment.

MR. MEOLI: I would like to defer those kinds of questions. I think we are getting off of the basis of the review, which was sleeving. I'd be happy to have those kinds of questions a little bit later.

MR. MOODY: Dick, isn't that part of Vince's question, which I have agreed is an open item and I will address right after our break, how we are going to handle that, namely what the effect of magnetite or anything else introduced into it has on the plant?

MR. EMCH: Could you give me a little information on how it affects the overall sleeving; that is, we have already talked about the fact that the dosage estimate for sleeving process does not include what might be referred to as contingencies or equipment not operating the way we expected it to be. You have already experienced that problem with the decon where you originally said 30 or 40 and now it's going to be 200. Just looking at that and knowing a lot of the machinery is similar or at least I think it is to what you are going to be using for sleeving, the arms, the movement, the manipulator and things like that, in my own mind I think that maybe there is a pretty significant dose possible from those same contingencies throughout the project. That's what I am driving at.

MR. MOODY: We will be describing the process itself of the sleeving and after we have described that and got that on the record, if you would like to return to the ALARA considerations as a result of any hypothesized failure in the equipment, we can do that.

Why don't we take a 15 minutes break by that clock, which would bring us back at 11:45.

(Short recess taken.)

MR. MOODY: I would like to address for a moment the second open item which was created this morning as a result of a question or a series of questions, I should say, which Vince Noonan stated concerning problems that we have had in the decontamination process and problems with the seal, in particular, what's got into the reactor coolant system, what effect does that have on the operation, what effect does the magnetite have on reactor coolant pump seals, what is the ALARA considerations associated with correcting that, that is to say, having people remove whatever is in the reactor coolant system. Another element was total doses prevented did not include doses obtained during what we called the diagnostics, information that was presented by Dan Malinowski earlier, and then Vince also questioned if and when we were going to present information concerning what would be done in the way of cleanup prior to operation.

I would like to group those into four categories and I will endeavor to get from Vince the whole list to make sure that we have adequately covered all the items in the four categories; but the categories as I see them are what's been introduced into the reactor coolant system and what effect does that have; second category is what are we doing to mitigate or eliminate any potential adverse effects of that being introduced; third is, I guess, is what effect on dose estimates would actions that we have to take to remove that have; fourth is how are the total dose estimates changed by inclusion of the diagnostics; and then fifth, what measures are we taking now to clean up the reactor coolant system, magnetite or any other debris prior to startup; and all but the last one I mentioned, the first four, that is to say, we will treat as a question on the presentations today and endeavor to put an answer to those before the close of the Board meeting tomorrow and right now we are intending to do that first thing in the morning tomorrow.

The fifth item, namely what are we doing in the way of cleanup to remove the magnetite, chemistry control, that sort of thing will be made part of agenda item eight, summary of systems chemistry operations, specifically chemistry during startup, chemistry during operation. So, we will retain this as an open item at least until tomorrow morning.

Now, there is one other thing I want to say about this. Much of this information has been presented and discussed with the staff, not only NRR but Region 5 and some of this is already resolved to the staff's satisfaction, but for the same reason that we presented information earlier today, which has been presented and resolved, because of its historical significance and because we want to provide a good background to the Board members, we will endeavor to present this information tomorrow morning before we start or as we start.

We have created earlier another open item, a question that Vince Noonan asked of Dan Malinowski, I guess, and we are prepared to address that open item right now before we resume the agenda.

MR. RAWLINS: This was the question on the values given where the sludge restricted (inaudible) and there was a question on what would the leak rate have been had the sludge not been there; and I will ask Carl Hirst from our nuclear safety department to address that.

MR. HIRST: When the tubes are pressurized, there is a mandrel used and at the end of the mandrel an eight inch diameter orifice and with the pressure that we are using, 5,000, 6,000 psi, we have estimated that would take 18 to 25 gpm, which is free flow, through the orifice.

Now, looking at the pumping system that was used for pressurization pump capacity and line losses, the capacity on that we have estimated at 12 to 15 gpm; so those are way in excess of what was observed during the test.

Another piece of evidence is we have had some tubes that when tested in the lab, 210 to 220 degree circumferential crack around the tight fatigue crack, that was pressurized to 2,500 psi and had 10 gpm leak. When the tube was removed, the test crack was still tight and could not see through it.

Now, fiberoptics, in the generator itself, you could visually see through the crack in the tube but were not able to quantify the size of the opening, so really can't estimate what you would have gotten if there was no sludge, but that gives you a feel if the sludge was not impeding the substance.

MR. MOODY: Can we proceed on with the agenda item five.

MR. RAWLINS: We now start into the portion of the presentation that deals specifically with the sleeve, its design, application of the sleeve into the steam generator.

The design criteria, the process description will be given by Mr. Pete DeRosa, who is manager of our advanced engineering applications group.

MR. DE ROSA: What I would like to do is give you a description of the sleeving design, discussion of the criteria that was established for that design, a brief background of where Westinghouse

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has been prior to initiating this design in the area of sleeving, and also a discussion of stress analysis that was performed to the ASME Code 3 on the design of the sleeve as well as some special considerations that were provided in the design.

Westinghouse has had some experience in the past with regard to sleeving repair. These are just some of them. There has been experience in the form of tube implants where pieces of tubing were removed from a cold plant, replaced with a new tubing material and welded into place. It is a viable method in a cold plant. It is not a viable method in terms of time and exposure in a hot plant.

Also, there has been a development program in the past to develop a sleeving process where the method of attaching the sleeve to the tube was a [ ]c,e boundary. The process is viable for a very small number of tubes; and in the laboratory, it takes approximately four hours to perform the sleeving [ ]c,e but in reality, in the field, it would probably take more than that, in the order of, say, 12 hours or more, and it is not deemed a viable approach for sleeving 2,500 tubes per steam generator.

Also, hydraulic expansion, though it has not been used within Westinghouse for sleeving, it has been used by others. Westinghouse has a considerable amount of experience with hydraulic expansion [hydraulic expansion is a part of the Westinghouse] a,c,e

[ ] a,c,e

design criteria, in assessing the problem, we decided there was more than just picking out the requirements of the equipment specification and replacing the structural integrity and pressure containing capacity of the tube. Recognizing that the ASME provided guidelines in terms of material selection in Section II, material selection, in Section III, design and analysis, [ ]a,c,e,f and Section XI, in terms of inservice testing requirements and inspection, we also felt that we had to accommodate the conditions of the unit as they are in the field today. Those conditions include tubes that have an oxidized layer on the ID. As you heard earlier, that is [ ]a,c,e Obviously the area is radioactive in nature. There is denting within the tubes at the tube support plates and at the tubesheet. There may be nonstraight or nonparallelism of the tubes. We have attempted to accommodate that into the design, so it's very difficult to provide a magnitude for that; and there is also the possibility of distorted tube ends. By that, I mean tube ends that may have been repaired as part of the manufacturing process of the unit when the tube to tubesheet welds were repaired, any potential slight variation as a result of the tube to tubesheet welds or whatever else might have happened to the unit in service.

In addition, we want the ~~tube~~ sleeve to minimize the effect on primary flow resistance and also wanted to span the effected region of the tube obviously.

Translating some of the more formalized requirements in the design, I just simply refer you to this table where the specific sections of the ASME Code and Code cases are called out in terms of criteria for the design.

The reference sleeve design looks like this. The sleeve is made of [ ] a,c,e

a,c,e,f

[ ]

Just referring to the photograph that is in the report, you see a likeness of the sleeve joint.

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It doesn't look much different than the artist's conception that I had.

In the unit the sleeve looks like this. a,c,e,f

It goes from the

the tube open end, up its respective length to the area where it's brazed. You see a slight region of expansion in the brazed area and at the primary phase

The sleeving process, in as few words as possible, is this. After the channel head is

a,c,e,f

:d

Getting into a bit more detail on each of those processes, concentrate here on the

a,c,e

Just to give you a bit of a feel for what that particular apparatus looks like, I have a

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viewgraph that may not be clear but if you consider a,c,e

required condition, the unit is ready to receive the sleeves.

The sleeves are brought down to the

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channel head area with [ ]a,c,e

T11 A significant number of samples were run in terms of controlling [ ]a,c,e This represents one set of data that was accumulated in establishing the [ ]a,c,e that was needed to maintain the parameters within the design objectives. In this case, 66 tubes had sleeves inserted into them and they were [ ]a,c,e with the reference process. The tubes came from heats of materials that had yield strengths that represented the range of yield strengths on the actual tubes within the SCE steam generator.

We went back into the records of the actual steam generators, retrieved the material data on the heats of tubing that were in those steam generators and made sure the heats of tubings we were testing for included yield strengths in that range. [ ]a,c,e,f As an added control in the application

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in the field, after every [ ]a,c,e sleeves, the production piece of [ ]a,c,e equipment will be used to [ ]a,c,e a bench specimen and that configuration confirmed to still meet the design parameters.

MR. NOBLE: Question. How much [ ]a,c,e do you need for the tolerable stackups you think you are dealing with to get [ ]a,c,e with the parent tube?

MR. DE ROSA: With none of the materials that we tested in terms of the range of yield strengths that we had in the tubes and range of yield strengths that we have, that we know we have in the heats of sleeving material do you wind up with a condition

[ ]a,c,e

DR. GREEN: I was going to ask the same question. Did you run a [ ]a,c,e test on tubes that bracket the tolerance? Do you make all the tests on one tube?

MR. DE ROSA: No.

DR. GREEN: Did you try it with -- match the tolerance areas?

MR. DE ROSA: I am talking about the diameters.

MR. GREEN: Yes.

MR. DE ROSA: These samples which I reported here is simply the yield strength. That does

DR. EGAN: The question is how many production runs of tubing did you those sleeves into? The concern is if you are looking at so many thousand tubes you are going to put sleeves in, they will all have an initial difference in diameter, in

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thickness. Some may have been off but within the permitted supply tolerances by the steel maker. How many different runs of tube did you [ ] gage those sleeves into?

MR. DE ROSA: One run and about seven different heats. When you look at the manufacturer's ability to maintain wall thickness and diameter, you see that there's a very peak distribution in terms of wall thicknesses maintained in straight section of tube within a mill or two; and if you look at the diameter that's also maintained very close tolerance, so I think we are talking about a very small effect in terms of going from one draw of the material to another; but all of our testing was associated with a single run of tubing simply because that is an odd size tube, three-quarter inch on .55 wall and we had our tubing manufacturer manufacture tubes for us from those dimensions.

DR. GREEN: Couldn't there be any wastage of the original tubing in the area where you are going to do the [ ]a,c,e that would change the response?

MR. DE ROSA: I'd answer that question and hope it would be confirmed later. The data that we have in the region that we are going to be performing this [

]a,c,e

DR. GREEN: No denting either?

MR. DE ROSA: No.

DR. WEGST: You won't always be above the sludge pile, will you?

MR. DE ROSA: [

]a,c,e

MR. MOODY: Are we getting into questions that ought to be in the question and answer period at the end as opposed to clarification? It seems like we are to me.

MR. DE ROSA: Once the tubes are [ ]a,c,e in a single steam generator, you then go in and [ ]a,c,e,f them

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all. We are going to perform the operation in regions of the tubesheet at approximately [ ]a,c,e tubes, go through the entire sequence on them.

The next operation is the insertion of a,c,e,f

[ ]

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supply and designed it separate from the other components so it can be kept outside the containment building.

a,c,e,f

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a,c,e,f

process. We are in the process of qualifying per Code requirements temperatures slightly below that and slightly above that.

I apologize for some spelling errors on this viewgraph. Let me go through it.

In establishing the [ ]a,c,e,f process, these are some of the things that we went through. First of all, there was an extensive literature search in terms of establishing what is the best [a,c,e,f

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a,c,e,f

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[ ] a,c,e,f and what that would have as an impact on the sleeve and the tube.

I would like to tell you a little bit about how we established the design for the lower end of the sleeve, which is a [ ] a,c,e In performing some initial qualification tests -- I use initial qualification tests on the joint, we established an acceptance criteria. It, first of all, said the joint must maintain structural integrity of the component, must be able to take the cyclic loading of the heat up-cool down that reflect themselves in terms of push-pulls on the joint and must also be able to maintain leak tightness.

In the laboratory what we decided to use for leak tightness was a leak rate that is [ ] a,c,e All the testing that I am going to describe to you, [ ] a,b,c,e

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were to leak but, again, I emphasize the testing to date, and you will see how extensive it was, [ ]a,b,c,e

The type of testing that was done initially on the joints that we have looked at were [ ]a,b,c,e

The configuration of the joint looks as you would imagine. We see the several [ ]a,c,e made when the unit was fabricated and just below that but not interfering with that you see the [ ]a,c,e,f

In establishing the loading, if you are following on the handouts, I am going to skip a few there for a moment, in establishing the loading that we wanted to test the [ ]a,c,e at, we took the loads out of the equipment specification. The equipment specification has a postulated number of heat up-cool downs, loading, unloadings, upset conditions and what have you and traditionally they reflect more than what actual experience the plant has seen. Nevertheless, in addressing these loads, this is what we did. You will see what is reflecting a single year's estimated E-spec operation. There are

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five heat up-cool downs to a hot standby condition. Consistent with each one at the standby temperature

[ ] b a,c,e

as a conservative estimate taking into account the loading that's occurring inside the unit as a reasonable load to conservatively estimate what the joint is seeing. Those loads, the number .55 cycles wound up this way.

There are 250 loadings and unloadings per year estimated in the E spec, so that's 50 on top of each heat up cycle; and then when you look at all the other transients that have a lesser significance in terms of normal operating loads on that joint, there are approximately 25 others that we lumped into that cyclic load. So we [

] b a,c,e

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The test apparatus looks like this. The sleeve, the tube is rolled into a collar and it's rolled to the same torque, the same parameters that the original tubes were rolled into the original steam generators. We retrieved the original rolling spec, same type rollers, rolled those tubes to that same torque prescribed in that process specification.

Sleeve a,b,c,e

I think I am going to again skip a viewgraph. I apologize for that. First, this is a description of tests that we are currently doing; and after discussing these, I would like to show you some test data that was performed prior to doing these tests, but these are tests that are relevant to the test configuration that I was just describing.

We created 22 specimens with the reference a,b,c,e

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Preliminary data that was established with regard to this had various loading cycles on approximately 28 different [ ]a,c,e and what we are attempting to do here was establish a [ ]b,a,c,e our testing to since then. In addition, we took [ ]a,b,c,e

I would like to discuss the analysis that's been performed on the sleeve configuration. I would like to discuss the criteria as far as the Code is concerned that was used, how it was applied to the sleeving design and discuss the loading conditions that were elevated, methods of analysis used, what were the results and some discussions of special considerations that you don't find in the ASME Code.

Very simply, the sleeve structural integrity was evaluated in Section III, evaluated by both analysis and testing. The [ ]a,c,e,f structural integrity is elevated to Section III of the Code. A plugging criteria was calculated in terms of allowable or in terms of necessary wall remaining to carry the load associated with the various conditions consistent with criteria established in reg guide

T12 1.121; and as far as the design life, when you choose the E spec 4 criteria as a design document, what you are doing is setting as your design objective the remaining life of the plant.

The artist's conception of the sleeve as it appears inside the tube, see the tube [ ]a,c,e,f joints. You see an actual and a typical, that is a result of the fact that as we were performing the analysis, the [ ]a,c,e,f process was still being tweaked and the analysis has been compared to the ~~vinyl~~ final process and found to be more than adequate. In performing a Section III analysis you simply go through what are kind of standard design, faulted tests, normal and upset evaluations and also some special infield considerations associated with flow slot hourglassing, which is a definite support plate result of denting and also some special considerations in terms of flow velocity erosion and what have you.

Very specifically these are the pressure loadings that we used for the design, faulted and test conditions, came out of the equipment specification for the original component. We have modified them somewhat in the test areas because the testing that's being done in this component now is being done according to Section XI of the ASME Code since it's an operating unit. I wouldn't expect that unit to be required to see a full primary side hydro test, for instance. You can see a primary side leak test.

In evaluating the designs, several configurations had to be considered. For instance, one consideration is you will be sleeving a tube that is not leaking and you will be sleeving a tube which is leaking, so the analysis was done to incorporate both those extremes. Here you see a representation of first the primary pressure, how it would be applied to the sleeve in the analysis or the tube, were the tube not penetrated. If you refer to documentation in the report, you will see several other configurations and how the loads were applied relative to the tube and the sleeve, whether or not there is a penetration in the tube. The pressure loadings were evaluated, unit load cases 1,000 psi and we superimposed various combinations with a multiplying factor in order to minimize the amount of analysis that had to be run. The detailed view of the fundamental analysis used lower and simply sees the modeling of the [ ]a,c,e and like to make note that the nodes that you see between the tube and this tubesheet and the tube and the sleeve are coupled and that the tube node and sleeve node at the interface are the same node and the tube node and the tubesheet node at the interface node are the same node. This is simply an expanded view of that.

The upper joint is a bit more complex because it does have an [ ]a,c,e that on sleeve and tube where nodes are coupled; and what you see here simply is just an expanded version of the final element that was used in it. [illegible]

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In terms of where did we focus our attention on that analysis, these are the cross sections of the tube and sleeve interface where we tabulated our loads after looking at the data and after using some judgment in saying where is there likely to be the most activity from a stress point of view. We looked at cross sections in both the

[ ] a,c,e,f

to Code allowables. Results of that analysis, very briefly, indicate that, for instance, from the design, for the design conditions, and again there were two conditions evaluated for design, perforated and unperforated tube, the maximum strength was approximately [ ] a,c,e The minimum required wall thickness for membrane calculations per Code is [ ] a,c,e mills and the minimum collapse pressure calculated per Code with collapsed pressure curves is [ ]a,b,c,e Sleeve configuration meets primary stress considerations for the ASME Code.

Very similarly for test conditions, these are the test conditions that were evaluated. Primary tests, 1.1 times the operating pressure or 2,295 psi 0; primary test, approximately the operating pressure, 0; secondary test, which is one and a quarter times the design pressure, secondary being assumed as a Class II vessel and requiring a full hydro test should there be a repair made on the secondary, 0; secondary leak, 695 operating pressure.

I think you can see by looking at the allowable ratio of the maximum stress verses the allowable of [ ]a,b,c,e at the section of the sleeve you see there is ample margin for Section III criteria for the test conditions, though, postulated. Minimum collapse pressure [ ]a,b,c,e psi again calculated with collapse pressure curves from Section III and you can see [ ]a,b,c,e psi compared to [ ]a,b,c,e psi is margin with regard to collapse and understanding the Section III curves, there is margin within the curves as well.

For the faulted conditions, and these are the conditions of steam line break, feed line break, loads associated with each of those are tabulated here, the maximum stress versus allowable ratio of [ ]a,b,c,e the section of the sleeve that is rather to itself. When you evaluate primary stresses for faulted conditions, it's really membrane and primary bending and, again, you see there is a significant margin in the configuration. Maximum collapse pressure per Code [ ]a,b,c,e psig compared to a maximum it should see at 710. We also calculated minimum wall required to meet one. Again, this is membrane considerations since we are talking about a straight section of tube, you get [ ]a,b,c,e is what's required or [ ]a,b,c,e percent of wall to meet that requirement.

Normal and upset conditions is a little bit more substantial since you are evaluating the primary and secondary stress range as well as tabulating a user factor considering peak stresses.

The methods of analysis that were used were the final element model. In addition, we incorporated stress resulting from some defamation that's occurring at the top support plate and having that defamation continue after the sleeve was installed flow slot hourglassing. Results are there is ample margin from the primary to secondary stress range point of view [ ]b,c,e Fatigue usage factor is [ ]a,b,c,e at Section WW. That's the lower [ ]a,b,c,e,f of the sleeve; and for normal and upset conditions the minimum required wall to meet reg guide 1.121 is approximately [ ]a,b,c,e of the wall.

There were and still are several other considerations that are made. One, for instance, is the flow slot hourglassing. The effect of the flow slots within the steam generator closing as a result of the denting phenomena progressing and if you will

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recall earlier steam generator B has no denting, steam generators A and C do have denting, this evaluation, considered after the sleeves were installed, should steam generator B, for whatever reason, begin to dent and flow slot close, what's the effect of that closing on the stress level in the sleeve? That evaluation was performed assuming the flow slot closed entirely after the sleeve was installed and the axial bending stress component was approximately [ ]a,b,c,e and that was incorporated into the fatigue analysis that was performed for Section III.

Also, when the effect of that level of bending stress on the sleeve and the tube with regard to its effect on burst pressure and stress corrosion cracking susceptibility was investigated on sleeves of a slightly different size but the same geometric consideration, same area of fatigue and those effects were seen to be rather minimal if at all existent.

The second consideration was the effect of the sleeve on tube-sleeve vibration. The first

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thing, a modal analyses were performed with the sleeve installed in the tube. The natural frequency of that system went up by approximately [ ]a,b,c,e and is in a range that is still not an issue in the design of the unit. That cyclic load stress was calculated for that cyclic load and it was less than [ ]a,b,c,e

Flow velocity through the sleeve, there was question raised amongst ourselves as to what is the effect of the velocity fluid in the sleeve since that sleeve is a smaller diameter than the tube, flow through that sleeve being a higher velocity, what is the effect from an erosion point of view of the velocity within that sleeve. That was evaluated. The flow velocity in the sleeve was calculated to be [ ]a,b,c,e feet per second and the calculation assumed that [

]a,b,c,e and in concluding that there is not an erosion issue with the design, we considered the fact that it takes [ ]a,c,e feet per second with direct impingement to have erosion as an issue in that design.

The final event that we are looking at is the effect of tube support plate bending, and that is what is the effect of the tube support plate having already dented a tube, holding that tube in space at some unknown degree of fixity, what is the effect on the braze and what's the effect on resultant loads in the tube as a result of the [ ]a,b,c,e,f

We have run several tests to indicate that the [ ]a,b,c,e,f is not affected as a result of that condition and we are continuing to run tests to determine if there are other issues associated with [ ]a,b,c,e,f

That concludes my presentation. If there are any questions, I will try to answer them.

DR. EGAN: Do you have a strategy for [ ]a,b,c,e,f inspection? Is the system set up so you can [ ] that and do it again or just plug that tube?

MR. DE ROSA: If the [ ]

DR. EGAN: And in your experiences if you don't get it the first time, you don't get it. I just wondered what your strategy was if you ended up

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in that position.

MR. DE ROSA: If you don't get it the first time --

DR. EGAN: You plug it?

MR. DE ROSA: -- [ ] a,c,e

DR. GREEN: I have a number of questions. Let me ask one at a time.

I am still concerned about the wastage because there is evidence that wastage occurs about one or two inches below the top of the sludge. There's been some experience with phosphate chemistry. Are you saying again you haven't detected any wastage about where you are going to [ ] a,c,e,f

MR. DE ROSA: Let me say I am not armed with the facts to properly answer that question.

DR. GREEN: There have been reports by Westinghouse that generally the wastage occurs about one or two inches below the top of the sludge.

MR. DE ROSA: Again, let me defer that question until I can get the proper facts.

MR. MOODY: Let's carry that as an open item.

DR. GREEN: The loading, you got the loading -- I am questioning the nature of the support. Are you supporting right at the [ ]a,c,e,f it and then you can have it locked into the denting? Have you considered all those types of loading?

MR. DE ROSA: Yes.

DR. GREEN: The fact it could be rigidly supported at these several axial locations?

MR. DE ROSA: We have tests under way and partially completed where we have taken the tube, [ ]a,b,c,e

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a,b,c,e,f

[ ]

DR. GREEN: One more, another loading problem, is that the tubesheet can bow under pressure and there could be some misalignment, so that creates some additional bending forces.

MR. DE ROSA: When the push-pull loads were calculated, that we are exercising on the joint and, for instance, on the [ ]a,c,e joint, that load was considered as part of the load on the push-pull.

DR. GREEN: When you add -- you also added the load into the hourglassing. My concern, do you do them all at once and consider all of them? You have the hourglassing creates some extra bending loads and distortion of the tubesheet plus the out of misalignment tolerance, do you put them altogether in calculating the load?

MR. DE ROSA: Can you clarify what you mean by the misalignment tolerance?

DR. GREEN: When you drill the hole, the hole through the tubesheet may not be perfectly normal to the face of the tubesheet. It could be slightly out of line.

MR. DE ROSA: With regard to that particular tube, there is not much load there because you have very little accessibility in the tubing operation to get that load.

DR. GREEN: Here is another wild one. In the fuel element, they consider waterlogging, that is, you can conceivably put water into the annulus between the tube and the sleeve and then it can get plugged up before you go to pressure, then you can really get a large pressure in the annulus.

MR. DE ROSA: We looked at that. If the gap is -- if there is no water in the gap and it's arid, at 100 percent humidity pressure goes about to 35 psi.

DR. GREEN: If there is water and filled up at room temperature and you start to get primary temperature in there, you can really --

MR. DE ROSA: It could go to around

[ ] a,b,c,e

DR. GREEN: No. I am saying if it plugs afterwards, then it's really got a volume of water in there that could -- and you just get the large pressure just because of the temperature expansion, it's a fixed volume. You understand?

MR. DE ROSA: I understand what you are saying. I am having a hard time understanding how it goes above T sat.

DR. GREEN: Because it's a fixed volume in there and you are expanding it and there is no vapor space. It's a pressure produced by expansion of the compression of a liquid.

MR. DE ROSA: I will confirm my numbers

with you but numbers we have calculated for that condition indicate [ ]a,b,c,e psi was the pressure built up in that gap.

DR. GREEN: I am not talking about where it's closed. Then it gets -- for some reason it gets plugged, waterlogging.

MR. DE ROSA: Are you talking about water trapped between the sleeve?

DR. GREEN: It's trapped in the annulus.

MR. DE ROSA: Between what?

DR. GREEN: Between the sleeve and the tube. Then, somehow, it gets plugged, so the water that was in there at room temperature stays there. It's a fixed mass of water, then you start heating everything up and you have a volume of water in there, of weight that's fixed and you get very large -- it is essentially a solid. It goes solid.

MR. DE ROSA: Let me review the numbers. My recollection is that that pressure was calculated to be less than [ ]a,b,c,e psi.

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DR. GREEN: Because that could then create a very large external pressure.

MR. MOODY: Let's carry that.

DR. GREEN: Underbalanced by the primary operating pressure within the sleeve itself.

MR. MOODY: Let's carry that as an open item.

DR. GREEN: I would be concerned about the possibility of erosion, corrosion downstream of the sleeve. You have an [ ]a,c,e in there and you can possibly get some water seas because of the change in the flow area. I wonder if you have run any visual tests to see whether there is any water seas or any flow separation could occur downstream of the sleeve.

MR. DE ROSA: I haven't run any visual tests.

DR. GREEN: Particularly if you have some magnetite present, you can get some. There's been some evidence of erosion corrosion downstream of

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the flow disturbance, not right at but going through an orifice, there's been a number of studies particularly, I think, people have found problems with erosion and corrosion downstream of the flow expansion. I would be concerned about that. MR. P. DeRosa: We have not done tests to evaluate that condition but we have analytically evaluated that consideration.

DR. GREEN: I am suggesting you might run a visual test with some fine particles just to see what happens.

MR. BERRY: That bottom [ ]a,c,e seems fairly critical. When you [ ]a,c,e

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MR. DE ROSA: Yes, to answer your question directly, we have cyclic -- we have tests planned that incorporate both the [ ]a,c,e,f in a model boiler configuration that

I think Mr. Klein will give you a better description of. That [ ]a,c,e,f and the loads associated with that, with the strain that you may see as a result of [ ]a,c,e,f are not as large as the loads that we are cycling the joint.

DR. EGAN: Most of the tube damage seems to be focused at just the tubesheet. Do you believe that focus is provided by the geometry or by the fact that's where the sludge pile starts?

MR. DE ROSA: I have no idea.

DR. EGAN: I ask the question because I did notice that you are intending to put in some sleeves which will currently end [ ]a,c,e Do you expect the sludge pile to grow?

MR. DE ROSA: I am not qualified to answer that question. I have no idea in terms of what is happening to the sludge pile.

MR. MALINOWSKI: It's likely that you can refill the sludge pile to the amount you were able to remove the last time. It is not likely it would go on indefinitely.

DR. EGAN: What proportion of the sleeves will be [ ]a,c,e

MR. DE ROSA: I will have to get that answer for you.

DR. EGAN: It may not be an important question if the focus is focused on the geometry. I wondered if you looked at different fixity conditions when you did your analysis between the hard roll coming up the crevice to the top of it. I happen to believe the geometry that focuses on it but I may be wrong.

MR. DE ROSA: Let me understand your question. Could you rephrase the question and I will try to answer it later.

DR. EGAN: Is the focus of the damage provided by the geometry and the fact that the crevice between the original tube and the tubesheet may be filled so you have a fixed in condition at the inside surface of the tubesheet?

MR. DE ROSA: That's the question I said I don't know the answer to. I really don't know and someone else perhaps in this room can answer that. I can't.

DR. EGAN: When you did your stress analysis, you did look at different fixed conditions between the hard roll?

MR. DE ROSA: When we did the stress analysis, we did not assume that the tube was fixed at the secondary side of the tubesheet. We assumed that it was only fixed at the [

] a,b,c,e,f

MR. MOODY: I want to carry Dr. Egan's last question, next to the last question as an open item.

MR. RAWLINS: The one on the percentage of tubes versus --

MR. MOODY: The question as to whether

or not its function in geometry or sludge pile.

MR. DE ROSA: What was the last question? The function you want to know is if --

DR. EGAN: The focus of the degradation is at the tubesheet because of the geometry and stresses or is that because where the sludge starts to build up first.

MR. MOODY: Even though we may not have an answer to that, even tomorrow or the next day or a year from now, I want to address that as an open item.

MR. NOBLE: If somehow the [ ][a,c,e,f] is defective or something, there is a leak path, you know, the leakage rate through the [ ][a,c,e] would be if you didn't take any credit for the [ ][a,c,e,f]

MR. DE ROSA: Just a second. I have it written down here. [ ][a,b,c,e,f]

MR. NOBLE: I guess I don't understand.

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MR. DE ROSA: That's assuming that the tube is not the restricting factor, that the tube is opened and it's not the restricting factor in the flow.

MR. NOBLE: Don't you have some

MR. DE ROSA: You do but looking at the

MR. NOBLE: So conceivably with the stackup of tolerances, you could have that kind of a gap. Are you prepared to deal with it?

MR. DE ROSA: It will be

what's the leak rate through the configuration.

MR. NOBLE: I guess it's realistic to

expect that large a gap or you don't expect it?

MR. DE ROSA: You may have an [ ]a,c,e,f but that's not going to stop you from getting a successful [ ]a,c,e,f

MR. NOBLE: In the [ ]a,c,e process, in the qualification of that effort, how many tubes were [ ]a,c,e and that kind of qualify that process?

MR. DE ROSA: There were, from the cleaning point of view in terms of cleaning the tubes, [ ]a,c,e

MR. MOODY: Isn't that going to be discussed on the next item?

MR. DE ROSA: That particular item, I

don't think so. There were several -- after every [ ] a,c,e

MR. NOBLE: Turning to the [ ] rolling in [ ] a,c,e did you encounter any -- if you did the process development repetitively, did you encounter any [ ] a,c,e

MR. DE ROSA: They are [ ] a,b,c,e

MR. NOBLE: Do you have any limitation,

then, on the number of tubes that are [ ]a,c,e

MR. DE ROSA: Yes. In the [ ]a,c,e

MR. NOBLE: In the [ ]a,c,e,f process you mentioned that is controlled by a [ ]a,c,e Can you elaborate, though, a bit? Can you talk about the process qualification and number of [ ]a,c,e,f being made and examined?

MR. DE ROSA: Well, as far as process qualification is concerned, the Code requires [ ]a,c,e,f joints to be done in succession and for those joints to be examined in several different ways. If each of those [ ]a,c,e meet the criteria of the Code, you have a qualified process as long as you have maintained control over what the Code calls the

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essential variables. So to qualify a joint per Code, you need [ ]a,c,e samples.

Now, we have [ ]a,c,e,f in the process development. The way to go into more detail is on the [ ]a,c,e

In the early portion of the program we were [ ]a,c,e

Originally we had decided we were going to see if we could develop the process and maintain process control as the method of assuring proper [ ]a,c,e,f

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a,c,e,f

[ ]

... ... heated.

DR. WEGST: Have you done any [ ] a,c,e,f tests with [ ] a,c,e outside the tube?

MR. DE ROSA: Yes, we have. We have [ ] a,b,c,e

[ ]a,b,c,e

MR. HERBERT: Were those samples evaluated for any effect of the [ ]a,c,e of the material at that [ ]a,c,e

MR. DE ROSA: Yes, they were, and I believe you will get a description of that from Mr. Klein and Mr. Vaia as part of the testing program.

MR. HERBERT: One question further. In your qualification of your [ ]a,c,e,f procedure have you taken into consideration the difference in time span that you will be experiencing from the [ ]a,c,e,f until the time of the [ ]a,c,e,f operation in laboratory versus the installation? I think you said [ ]a,c,e

MR. DE ROSA: Yes. What we have done is we have [ ]a,c,e,f

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[ ] a,c,e,f

DR. GREEN: Can you plug the tubes if the [ ] a,c,e,f fails?

MR. DE ROSA: Yes.

DR. GREEN: What was the extent of the flow decrease due to the insertion of the reactor flow decrease?

MR. MOODY: As a result of plugging?

MR. DE ROSA: As a result of sleeving?

DR. GREEN: As a result of sleeving.

MR. MOODY: That's really not germane to this discussion but if you want --

MR. RAWLINS: [ ] a,c,e

DR. GREEN: You obviously have got a crevice, new crevice and you shut down whatever is remaining in the reactor?

MR. DE ROSA: The questions you are asking will be definitely covered later.

MR. NOBLE: Question about the sleeving sequence. Is the

MR. DE ROSA: Yes, it is.

MR. NOBLE: When you made that did you encounter any of the sleeve itself inside the tube?

MR. DE ROSA: No. Actually the

MR. NOBLE: One final question. In the mechanical testing that you did to simulate the loads on the tubes, you had push-pull tests. Did the loads imposed during those push-pull tests incorporate the thermocycling loads because you actually did a very small number of thermocycle tests?

MR. DE ROSA: Well, what the loads

represented were, first of all, cycling a load that was consistent with the condition that would exist at 100 percent load. I forget now whether it's 100 percent hot or hot standby, the condition that existed, and loads were cycled with consistent, what we felt, configurations and constraints within that geometry were as a result of going from zero load to 100 percent load, zero load to 100 percent load, about that mean.

MR. NOBLE: That was like hot standby to 100 percent?

MR. DE ROSA: Yes.

MR. NOBLE: What in your mechanical testing, how did you account for cold condition to the hot condition? How was that accounted for?

MR. DE ROSA: We just evaluated the hot condition, hot leg side. That's the only site we are putting the sleeves in and what's happening around the U-bend to the cold leg side is of a negligible condition.

MR. NOBLE: From the ambient condition, cold shutdown condition.

DR. EGAN: Didn't your test load result in stresses that would be a result of the combined mechanical load and thermoload cycle?

MR. DE ROSA: Yes. The reason we were cycling about [ ] is after you load to the hot standby condition, you have a state of stress in the configuration. The ambient condition is represented by the strating point that the -- at the start of the heatup cycle. I don't know if I am answering your question.

DR. EGAN: Test loads are supposed to simulate the both mechanical and thermoloadings.

MR. NOBLE: That's really my question.

DR. GREEN: I was trying to make sure you put all of them together so you really mocked up the extreme conditions.

MR. DE ROSA: We generated a matrix, we believe, that reflects the significant contributors to that load.

MR. MOODY: Recognizing there may be some questions from the staff, are there other questions from the Board?

DR. GREEN: You don't inspect after that first [ ] a,c,e You don't do any inspection to see if that was done properly?

MR. DE ROSA: [ ] a,c,e

DR. GREEN: Before you do the [ ] a,c,e,f according to your sequence you don't have any inspection?

MR. DE ROSA: No, except at the end but before we do the [ ] a,c,e,f

MR. NOBLE: Do you have some control on the [ ] a,c,e

MR. DE ROSA: There is a [ ] a,c,e

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a,c,e

DR. GREEN: Does that produce any excessive residual stress? That's something you are really testing in the chemistry area?

MR. DE ROSA: Yes. I think that can be addressed, Wes, by Mr. Klein or Mr. Vaia: but, yes, it is, when you put a

a,c,e

you did create a situation that's different from the parent metal and that is part of the evaluation.

MR. MOODY: Vince, do you have any questions of the staff and can you give me some estimate of perhaps how many or how many minutes might be consumed in just asking the questions?

MR. NOONAN: I think the Board did an excellent job of addressing most of the questions I know about right now. There might be one or two items. I think I would prefer to wait until after lunch.

One point of clarification. When you talk about your loading conditions, I would like to talk in terms of the accident conditions. You did include the accident conditions (inaudible) when you said loading conditions.

MR. DE ROSA: Performed an evaluation of the sleeve associated with the pressure differentials resulting from steam line, feed line break and local.

MR. MOODY: Why don't we reconvene at two o'clock, which will give us 45 minutes.

(At 1:15 p.m. the meeting was recessed until 2:00 p.m.)

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Afternoon Session
2:10 p.m.

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MR. MOODY: On the record.

Are there any other questions that the Board has of this last presentation, recognizing that the next item on the agenda is going to talk about verification analysis and testing and there may be some questions in the sleeving process itself which will be answered by some combination of the two different Westinghouse presenters. Are there any other Board questions at this point in time?

MR. BERRY: This literature survey you did with (inaudible) the metal reactor had used the [ ]a,c,e,f was that in a liquid steam generator, liquid phase or steam phase of the generator?

MR. DE ROSA: I can't answer. I recall the paper but I cannot answer.

MR. BERRY: Sometimes metal performs much better in steam than it does in water, if you are

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leaching one phase of it out of it. I am concerned about the --

MR. DE ROSA: Corrosion resistance in the [ ]a,c,e,f

MR. BERRY: Yes.

MR. DE ROSA: I can respond somewhat to that.

MR. BERRY: Later on you will do that.

MR. MOODY: Other Board questions?

Vince, does the staff have any questions they wish to ask at this point in time?

MR. MURPHY: I would like to have some clarification of the displacement boundary conditions employed in the various structural analyses. Did I understand you to say that you looked -- you covered each of two cases, one where you did not, I assume, displacement supported due to denting and the other where you did? In all the cases you evaluated denting, flow slot hourglassing, vibration and what have you --

MR. DE ROSA: In the fatigue analysis

we superimposed the cyclic stresses as a result of flow induced vibration and we also superimposed a bending stress associated with a total closure of the flow slot that would occur after the sleeve was installed.

For instance, in steam generator B where there is no flow, flow slot were to occur, the bending stresses associated with that flow slot closure.

MR. MURPHY: I understand. Bending stresses, for example, acting on the [ ]a,c,e,f would depend upon what sort of support you have on the sleeve at the top of the tubesheet as a result of denting and could provide either (inaudible) fixed, perhaps fixed support of the slot. It would affect (inaudible) would be transmitted across the [ ]a,c,e,f joints which you have for the case, flow slot hour-glassing. There might be two cases would be elevated there. That is one case you would not consider denting to be present?

MR. DE ROSA: Two boundary conditions

would be fixed or simply supported.

MR. MURPHY: Or free, maybe free is to be considered.

MR. DE ROSA: I don't see free. Free, if you displaced the whole, free is the same as simply supported because you are allowing it to rotate up to a certain point. I will have to take a look at the document to remind myself whether both conditions of the fixity were considered or whether one condition was considered because the other was thrown out.

MR. MOODY: Let's carry that as an open item, then.

MR. MURPHY: Vibration analysis, did you consider the case where the tube was defective all the was around, 360 degrees, or the vibration analysis, making no assumption regarding a defect?

MR. DE ROSA: I believe the vibration analysis did not take into account when the tube was totally separated at the bottom joint, at the area of IGA. I think it kept that tube intact and is

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considered essentially a double tube up to the [ ] a,c,e,f joint and a single tube above it.

MR. MURPHY: Is that assumption that was made in some of your other structural analysis?

MR. DE ROSA: Yes, it was.

MR. MURPHY: Finally, a final simple question, in conditions of SSE or ~~below~~ blow down (inaudible) the writeup has little to say about lateral loadings, induced bending movements in the tube as a result of, say, lateral shaking of the tubesheet or the whole structure. It said that the discussion, one or two sentences simply say the bending movements at [ ] a,c,e,f joints are very small and, therefore, negligible.

I would think -- I read into that statement the idea that you must assume that the lower support of the tube, that is only at the [ ] a,c,e the next support is the support plate up above, there is nothing in between in the way of support. Is that true or false?

MR. DE ROSA: Well, that statement was

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upon the repair program effort. The areas that we want to talk about are, A, what is listed as hydrostatic testing prime in-service inspection program that we intend to propose, for continued operation, your initial operating period that we would intend to run prior to the first in-service inspection, and some information relative to revised primary to secondary side leakage limits.

As we all know from previous discussions, the peripheral tubes, although they have been subject to individual pressure tests and have been examined by rotating pancake coils as well as the bobbin coil, we have not been able to, because of the geometry of the primary side channel head, to remove any of those tubes to get any positive confirmation of what we believe to be the level of degradation in that region. So what we are proposing to do is during the process of startup, is to undergo a primary to secondary side hydrostatic pressure test, probably more accurately characterized as a leak test, and this would be done after the sleeving repair had been implemented and after an initial secondary side_hydro had been accomplished to discern whether or not there are any leaking tubes, tubes that require plugging and so forth; and, of course, after the soaking operations and as a part of, in fact, the hot soaking operations that Dr. Wootten discussed and the motivation or the criteria for this test or the objective, I should say, is to provide a whole bundle integrity test.

We would be, in fact, testing not only the peripheral tubes, but we would also be testing the sleeve tubes and, in particular, we would be testing and challenging the integrity of the brazed joint and the rolled joint for those tubes which are in the leader-follower program, those that have been deliberately defective.

The process is simply to run the unit up with reactive kilohm temperature of approximately 400 degrees and then exercise the pressurizer heaters to drive the primary side pressure up to approximately operating values of about 2,100 pounds absolute. That would yield a secondary side pressure on the order of

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250 pounds and thereby achieve a primary to secondary side differential pressure of 1,900 pounds as compared to the normal operating differential of 1,300 pounds; and using this as a basis to provide, to demonstrate bundle integrity and margin to normal operating conditions and to at least get close to the differential pressures that you might expect to see in the event of a mainstream line break or a feed water line break.

As is indicated on the slide, we would then follow this primary side pressure test with an additional secondary side test and these tests are accomplished by filling the secondary side of the steam generators, pressurizing, using the auxiliary feed water system to a level of approximately 800 pounds while the primary side is depressurized and then pulling the manways open and checking for any leakage at the bottom of the tubesheet; and both of those operations would, in effect, accomplish two objections.

They would determine whether or not there were any leakers, primary to secondary leakage, secondary to primary leakage and would, in effect, provide some

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assurance under accident conditions, representative accident conditions in loss of steamline break and feed line break, there is adequate protection, integrity in the bundle. That would be performed during the startup operation.

In the next slide in your handout it simply indicates the flow diagram indicating the test logic.

As part of the overall package, if you will, to provide assurance that the sleeving repair effort does restore the units to their full integrity, provides adequate margin against all of the design bases conditions, we are including as an element of that program the in-service inspection program. This is intended to address both the sleeved and nonsleeved tubes in the generators.

The fundamental criterion is that in-service inspection utilizing eddy current techniques, that indications in excess of 50 percent on both the sleeved tubes and the nonsleeved tubes would be plugged.

T-30 The first component of the in-service

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inspection program is the eddy current testing and, as Dr. Junker indicated yesterday, we plan to do a complete 100 percent baseline eddy current testing using the magnetically biased bobbin coil on the sleeve tubes prior to return to power.

We will take credit for the already existing eddy current data that we have on the bundle and we both in the periphery and in the other regions of the U-bends for those tubes that are sleeved.

At the first shutdown, that is to say, the first in-service inspection, we would plan to conduct an eddy current program again using the magnetically biased bobbin coil for the sleeved region and also we would use a push-pull hopefully pancake type coil for the peripheral tubes and we would inspect at a minimum three percent of the tubes in each of generators A, B, and C. The inspection criteria would conform to or be consistent with the guidelines of NRC Regulatory Guide 1.83. Dependent upon the results of those inspections, we would perform subsequent inspections consistent with the requirements of the Regulatory Guide 1.83 and our own technical specifications and we would expect, given successful results on this first interval, those would be conducted on normal refueling outages.

In addition to these eddy current testing, using -- and I would say these point out that these tests utilize essentially off-the-shelf technology, and keeping in mind that there is a developmental work underway at Westinghouse with respect to developing improved eddy current techniques for examination of the brazed region, in particular, and possibly ultrasonic techniques for that region, as a compensatory measure for the absence of those improved techniques, we would propose what we call a leader-follower program in which we would in each steam generator select four tubes that would be deliberately perforated at the tube sheet area to permit the ingress of aggressive contaminants. These are sleeved tubes and these would be earmarked for eventual removal in successive outages for in-service inspection.

As was previously indicated, a program would be established for metallurgical examination of tubes, eddy current testing of tubes, ultrasonic examination of tubes. The leader-follower concept would be that, as an example, on the first operating interval of these four tubes in each generator, we would select one tube from each of these four, no greater than four in each generator for initial examination at that time in simulation. We would pull those sleeves out of the generator and send them back to the Westinghouse laboratories for further nondestructive and destructive examination.

MR. NOBLE: Point of clarification here. How many of these leaders are you going to pull from the generators?

MR. CURTIS: We pull one at a time.

MR. NOBLE: Is it one per generator?

MR. CURTIS: One per generator.

MR. NOBLE: At the first outage?

MR. CURTIS: At the first.

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DR. WEGST: How many, how long? First outage you pull one, then what is your schedule for the next one?

MR. CURTIS: I would say that would be somewhat contingent upon the results of that first pull; but giving if things were going well, we would just plan to pull those successfully in each subsequent outage, one at a time.

The location, the selection of these leader tubes would be in the region most susceptible to IGA as has been identified in the diagnostic program.

In view of the sleeving program, the analytical work, the design work, test work that's been done, in view of the eddy current program, pressure testing program, tube removal efforts that led us to our conclusions relative to the condition of the peripheral tubes, we believe that there is sufficient technical basis to return the San Onofre unit 1 to full power operation at the conclusion of the sleeving program.

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We would propose that an operating period be established, an initial operation period be established of six months of effective full power operation, at the conclusion of which we would perform the in-service inspection which, I believe, has been previously described.

Some of the factors that bear on this operating interval are the corrosion rates that Mr. Malinowski has discussed; and if you applied the worst case of corrosion rate of the interior of the bundle at 15 percent per year, we can see for tubes on the periphery, assuming those are in the 40, 45 percent range, we would experience degradation which world not take them in excess of the established plugging limits within that six month operating interval. And similarly, for the sleeved tubes, if you apply the similar corrosion rate to the thermally treated Inconel sleeves, the 4 mills of penetration would correspond to roughly nine or ten percent through-wall penetration during that initial operating interval.

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So from the standpoint of tube degradation under projected worse case corrosion rates, there would be no infringement upon the plant safety margins for any of the tubes sleeved or unsleeved during that operating interval.

This approach is further justified, we believe, based upon the residual accident properties of the tubes as discussed earlier this morning and in yesterday's presentations. We have found in our first laboratory burst tests of tubes removed from San Onofre, that tubes which have experienced degradation at the top of the tubesheet in excess of 50 percent have, in fact, been able to withstand burst pressures on the order of, for the virgin material, 15,000 pounds, number one.

Number two, the failure mode is ductile failure as evidenced not only by the burst test, but by the specimens that were removed which were not subjected to the burst test but which were fractured on removal. I will refer you back to the slides that

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were presented yesterday for that.

Following the initial operating period of six months and the initial in-service inspection at that time, and, again, dependent upon the results of that inspection, we would propose to resume in-service inspections and operations at a normal refueling interval basis.

MR. NOBLE: What is normally the time between refuelings?

MR. CURTIS: Normally about 15 months.

For the benefit of the Board, I would like to point out that from the standpoint of the sleeving program and the steam generator problems that we are experiencing, we feel, we are confident that we can justify from the technical basis this type of an operating interval; but I would like to point out that there are external factors unrelated to the steam generator repair effort that may preclude us operating for that extent.

The obvious example would be the

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industry is faced with a requirement to implement Three Mile Island type modifications; and dependent upon the schedule for that implementation, then the requirements for a shutdown, this operating interval of six months could be something on the order of 30, 60, 90 days as opposed to the six months.

Given that thatnlesser operating interval occurs, I think the posture Edison would take would be to work with the staff, not only the NRC staff on the length of that interval obviously, but on the details of the inspection programs that would be conducted.

For example, it may not be based upon a 60 day operating interval prudent to remove all of the first group of leader tubes simply because they haven't been challenged in that environment for a sufficient time. So that what we are saying is that this would be reference program, the six months' operating interval.

Some leader program that's governed by

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external factors may require some modification or provocation of these principles.

As a final layer of conservatism, we propose to modify our primary to secondary leakage limits as presently established in the plant technical specifications as follows. Incidentally, those limits are right now .3 gpm in any one steam generator.

What we would do in the case of a sudden primary to secondary leak, we would apply a factor of three to those leakage rates and promptly bring the unit down for diagnosis and plug the effected tubes. Any primary to secondary leakage in excess of basically zero, if you were ramping up in our leak rate where we finally reach a 250 gallons a day threshold, we would require a shutdown. That would be a factor of two over the existing requirements of the plant technical specifications.

Finally, if we are at a level of 140 gpd and we get an excess of 15 gpd, upward trend in leak rate, we would again bring the unit down promptly for

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investigation and plug the effected tubes. Fifteen is a target value and it's basically that value we can measure with some confidence without any large statistical variation.

Second phase of the tightening up of the primary to secondary leakage limit would be that in the event that we did, of course, achieve our 430 gallons a day current expected limit, we would not only shut down for plugging, but would apply a comprehensive eddy current inspection program to the steam generators.

We feel that these operating measures provide added conservatism and provide, in addition to the other measures we are taking, would provide the necessary confidence and technical bases for being able to resume full operation at the unit for the intervals that I have stated.

MR. NOONAN: Let's have a point of clarification on that last slide. You talk about the 15 gpd per day.

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MR. CURTIS: Right.

MR. NOONAN: Can you clarify that? Is that based on one day's sample or how many days would you base that sample on in order to establish that rate?

MR. CURTIS: When we have detectable steam generator leakage, we are essentially monitoring leakage rates twice a shift is really what it boils down to. We get samples every four hours. That's a turnaround time. What that would mean on a gpd basic, there would be a sufficient data base in any given day to establish that, in fact, you had a trend in that day; but whatever the sampling period was, the data points to that, of course. If it were around .15 gpm based on the first sample, you'd want to take a second sample to confirm that; and if you did this, you'd go into this mode.

What I am trying to say is because you have already established that you have primary to secondary leakage, we are going to be on an

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accelerated program of sampling; and, therefore, with any one day interval, this trend would be manifested.

MR. NOONAN: It appears to be a very tight leakage rate increase and what I am wondering about, the accuracy of that rate based on a one day sample compared to two or three days' sample.

MR. CURTIS: Well, as I said, the 15 gpd is about the value that you can measure with some degree of certainty; and I think there is a matter of judgment applied to this, depending upon the data, the statistics involved, to determine what constitutes a measured increase or trend in primary to secondary leakage.

I would propose to refine the procedures for effecting that type of a criteria.

DR. EGAN: Do you have a plan for the distribution of your inspection at the first inspection period? Are you going to inspect three percent? Do you have a plan to focus in the worst region, peripheral?

MR. CURTIS: The way I do Rule 1.83 and it, in fact, causes you to address those areas of known worse degradation and we would develop a sample which focuses on the area of greatest attack.

For example, in the periphery we would probably remove the pancake coil towards the peripheral boundary and then in the interior we would inspect the protractor region.

MR. NOBLE: Would you inspect up to the first support plate?

MR. CURTIS: Up to the first support plate.

MR. NOBLE: Point of clarification. I thought I heard you say something you are going to use the standard bobbin type coil in the areas that are sleeved but a different coil in the peripheral areas. I didn't quite catch that.

MR. CURTIS: The intent is to use in the periphery, to monitor the progression of the IGA attack for the unsl eaved tubes in the way

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we have done that through the surface.

MR. NOBLE: Rotating pancake?

MR. CURTIS: We would hope to have at that time a push-pull pancake multiple coil mounted on a single unit so you can speed up the process.

MR. NOBLE: Would your inspection plan include any sampling on the cold leg side?

MR. CURTIS: No. We did a rather extensive cold leg inspection and I didn't get a chance to look at the table but in excess of a thousand tubes, I think, on steam generator A and several hundred in B and C on the cold leg and we have found the thinning indications which were identified actually eight years or so ago have not substantially progressed.

We did a rotating pancake coil inspection of three percent of the tubes on A cold leg, I believe, this outage, and Mr. Malinowski presented those results.

We pulled one of those tubes and found no evidence whatsoever of IGA attack. We don't

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believe there's any basis for expending resources for a cold leg examination plus all of the evidence indicates that the phenomena is temperature sensitive and the threshold temperature is somewhat in excess of 575 degrees, so right now we don't have any reason to believe through other operating experience, our own experience in this diagnostic outage, that we have any cause for concern on the cold line.

MR. MOODY: Blaine, the table you are referring to was appended to Dan Malinowski's presentation earlier this morning.

MR. CURTIS: All right. 1,400, 366 and 279, that's quite a healthy sample on the cold leg.

MR NOBLE: With the stated knowledge regarding this corrosion, the IGA, I personally don't know enough to say that it wouldn't occur sometime in the future on the cold leg and there is, indeed, a temperature threshold effect that would indicate that it's going to be limited.

A. W. Klein

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MR. KLEIN: Good afternoon, gentlemen.

I represent the materials technology section of the Strategic Operations Division, and this organization was given the responsibility at the onset of the sleeving development program to provide an independent technological overview of the whole sleeving process; and, further, by appropriate testing to verify the adequate mechanical integrity, corrosion resistance and inspectability of the sleeve, both the tube and the brazed sleeve.

My primary objective was to assure as best we could that there would not be any unanticipated effects due to the sleeving procedure that would provide a premature degradation of either the original tube or the sleeve. In other words, in correcting a problem, we did not want to create a new one.

The test program that we identified really composed of four parts. First, we wanted to characterize the microstructural and mechanical properties in both the original tube and the sleeve.

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As a result of the brazing cycle the temperature to which the components are exposed during the brazing, of course, is significantly higher than the normal fabrication temperatures and certainly higher than operating temperatures, so one would expect some changes in the structure and related changes in properties.

The purpose of this phase was to characterize what the effect was on these properties and material.

Secondly, we were concerned with the corrosion and the corrosion, stress corrosion resistance of the components as a result of the brazing cycle, the effect of temperature and the effect of the flux which was an inherent and necessary part of the brazing cycle.

Third, we wanted to consider the effect of the entire assembly when exposed to simulated operating conditions as best we could simulate in a model boiler test where the brazed assemblies in entirety would be subjected to the primary water temperature and stress and the secondary side environment

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in this case, though, with deliberate contaminants.

Finally, the fourth phase was to assure the mechanical integrity of the joints, that is, to expose them to the most severe mechanical and thermal loads that they would possibly see in service and satisfy that they could withstand those loads and remain leak tight.

In each of these four areas we attempted to define what the potential issues were, what were the considerations, what were the concerns and to identify the specific tests that would address each of those concerns.

For example, in the case of what is the effect of the high temperatures on these various properties, we identified what we believed to be the appropriate tests to address each of those issues and these are all described in detail in your report. I am merely presenting a brief summary and highlight of the issues at this time.

This page had all of the corrosion tests

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and other series of tests, of course, were addressed to the mechanical properties.

Now, for each of the tests, prior to testing, we identified what the acceptance criterion would be; and in the case of the mechanical tests, they are relatively straightforward. We have to satisfy Code requirements. We have to satisfy the functional requirements that were established in the equipment specification to which the steam generators were originally built.

So, for example, to assure that we have protection against rupture, internal pressurization, we pressurized a number of tubes at three times the maximum operating felt to be present and leak tested them to assure no degradation; and with each of the remaining issues of mechanical properties, we were able to readily identify the criterion and the testing relatively straightforward.

I think the corrosion testing differed in that there are no specific Code requirements that

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one could address. We are directed by, I guess, two thoughts. One, the Westinghouse design philosophy which states that in verifying a component or a procedure by testing, one should test at the most severe conditions that could be postulated, and we have done that.

As far as the acceptance criterion, we were led to test in every instance material which was unaffected by the brazing cycle, that is, compare the effect of the braze and the brazing temperature and so on with, in the same head to head test, with material that had not been exposed to the braze, to the minimal tubing, for example, that would be above or below the braze locations. So that we could say at the conclusion of every test whether or not there was any degradation of the parent material due to the brazing procedure.

A constraint which we had in this entire test series, of course, was that of time. We had to complete the test program within very roughly a

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three-month period and this necessitated, then, the selection of accelerated tests in order to condense the time to within that frame. So that normally the tests which might be inspected to run for months or years were condensed into days or weeks; and when this, by increasing the temperature very significantly, the operating temperature very roughly 600° F. Many of our tests were performed at 650 and 680° F, which provides, in some cases several orders of magnitude, increase in the intensity of the test.

We also increased the stress levels and in some cases applied an electro-potential which is designed to drive the material into the region where cracking would occur if the material were susceptible to those cracking.

I want to briefly present the conclusions of our test program, much of which has been completed, some still confirmatory testing remains to be done. With regard to the effect of the high temperature cycle on the equal properties of the tube and the sleeve, we

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found in the area of the peak temperature, that is, in the center of the brazed joint there was, in fact, a reduction in the yield and ultimate strength of both materials, the tube and the sleeve; but as one progresses from the center of the braze to the end of the brazed joint, we find that both the hardness and grain size revert to that of -- essentially revert to that of the unaffected material, so that the actual effect on the joint is negligible.

We have pulled a number of samples both at room temperature and 600° F and the failures are invariably at the outside of the braze joints and heat affected zone or two or three inches below the braze zone at strength levels in excess of the minimum requirements.

Similarly we found the microstructure would be affected to a degree within the high temperatured zone but as one looks at the extremes of the brazed joint, we find we revert to essentially the properties of the unaffected material. The corrosion resistance of the tube and the sleeve due to the high temperature cycle we found to have no adverse effect.

A concern perhaps which I shared more than others was what is the effect of deposits, contaminants which one would expect to have on the secondary side of the tube? We know it's in the sludge pile in many cases. We have analyzed the deposits. We know that there are a variety of elements that are present, sodium, potassium, calcium, magnesium, silica, iron, et cetera, and the concern was we now expose that material to a 1,950 degree cycle, would those contaminants enter the (inaudible) inside the tube and cause embrittlement and impair corrosion resistance. We found that that was not the case either in tubes that we brazed in simulated sludge or in a tube which we brazed in the actual steam generator, removed and examined back here at the laboratory.

A lesser concern is one of sensitization, that is, as a result of the heating and cooling cycle,

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did we affect the microstructure to the extent that there would be carbide precipitation at the boundaries, with an accident, so-called sensitized structure.

It's really a low level of concern because the work we have done in the past has shown in the environments of concern here, on the primary side, primary water, secondary side, probably caustic, that sensitization is, indeed, not a problem but, in fact, that is beneficial but, nevertheless, the low level concern, that we would prefer to avoid sensitization in the event of some other abnormal chemistry. We found very low and acceptable levels of sensitization.

An issue, the effect of residual braze flux, we selected a flux which is perhaps more benign than many, no halogens but it does break down and dissolve in high temperature water to boric acid and sodium hydroxide and the issue here or the concern here was residual flux remaining in the bottom, the primary and the secondary side crevices. Would there

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be sufficient flux which would dissolve in solution and cause a stress corrosion environment in or near the brazed joint; and we were able to show that that was not the case with the reference flux application, and we have also showed in flowing tests that at low temperatures, that is prior to the operational temperature, on the primary side, the crevices exposed to the primary water, the residual flux will go in solution and be readily removed at temperatures well below the operating temperature; and we intend to include as part of the pre-operational testing a flowing period where we expect on the primary side crevice most of the residual flux to be dissolved and removed by the purification system prior to operation.

Compatability of the gold-nickel braze alloy, did not anticipate a problem here. There was some study some years ago that showed coupling Inconel with gold was apparently beneficial, at least in stress corrosion cracking in the primary side, so there was no large concern here but there was no test data.

We did test and we found that there is no effect of the gold-nickel braze, galvanic effect or any other effect on the tubing in either primary water or caustic tests.

A concern and issue we addressed is what would happen if we had a penetration of the original tube, that is, if the attack would continue from the secondary side, would penetrate the tube and then expose the annulus between the tube and the sleeve with that contaminant. The first line of defense here is we selected the sleeve material to be thermally treated. This is a special heat treatment that produces a microstructure that enhances the resistance of the material to both primary water attack on one side and caustic attack on the other side.

However, we have found that adjacent to the braze there is a small zone where the temperature was heated sufficiently high that we get some inconsistent results. We found there that we have

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lost some of the benefit of the thermal treatment. It is still better than the mill annealed material but it is not as good as the thermally treated material at all other sections, perhaps a half-inch or so beyond the braze joint. We will report in some detail subsequently those findings.

With regard to the structural integrity, these are the mechanical tests, pressure tests and so on, we found absolutely no effect, we have been able to meet the design criteria readily in all the tests that have been performed to date. These are external pressurization, internal pressurization, axial fatigue and we are presently concluding that test series with a comprehensive test at a temperature that combines axial fatigue and internal cyclic pressurization, pressurizes between the annulus and the tube and the sleeve. This is a test that simulates mechanically and pneumatically the various loads that are applied to the sleeve under transient conditions.

We have completed two tests at room temperature through the equivalent of three years of

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operation with absolutely no effect. We are now testing at the elevated temperature, at operating temperature, and we have concluded again the equivalent of three years of operating time with no effect.

We are quite confident that while we are going to continue that test to the 30 year design life objective, we are quite confident that we would not see any problem there.

I will summarize by saying that in all of the tests which we have performed, corrosion tests, mechanical property tests, we have not identified any area that we would be concerned that would result in a reduction in the inherent corrosion resistance of the mill annealed material.

I am going to ask my colleague, Mr. Vaia, to present the details of these tests which are in support of the conclusions which I have drawn.

Are there any questions? Perhaps I can hold off until the completion of Mr. Vaia's presentation.

MR. NOONAN: Just one point of clarificatio if I could.

On your slide when you talk about the flux, initial flux where you are talking about that side exposed to the primary, not in the end --

MR. KLEIN: That's right. What we have shown in the testing, that even if it were not, if it were still present as brazed, we have no problem, even if the secondary side were to be filled with water, but the fact is on the primary side we will resolve it.

MR. VAIA: My name is Albert Vaia and I am a senior engineer with the strategic operations division.

As Mr. Klein mentioned, I would like to present the tested data in support of the conclusions that Mr. Klein presented. The program which we undertook, I would like to present the information with respect to two factors.

Number one, was to evaluate the effect of the high temperature braze cycle on both the mill annealed tube and the thermally treated tube; and the areas that we investigated were mechanical propertie

A. R. Vaia

a,c,f

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A. R. Vaia

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a,c,f

For example, in environment we looked at caustic environment, pure water, primary water and also an environment of a secondary contamination type environment. The test techiques we utilized were conventional stress corrosion cracking type test techniques where you utilize C-rings, U-bends, pressurized capsules. In each of these areas we utilized accelerated parameters.

Mainly from a view of C-ring tests in caustic, we increased the temperature from approximately 600 up to 650 degrees, which gives you a rapid acceleration of the stress corrosion cracking phenomena. We also increased the stress level on these C-rings from a point of view that the tests were conducted with C-ring stress to 50 to 60 KSI, whereas, normal operating stresses, you are in the neighborhood of 15 to 20 KSI in a plant.

The concentration of caustic that we selected was the concentration that gave us the most susceptible cracking or the caustic level that gave you the most cracking with respect to Inconel 600, and that concentration level was 10 percent.

Another test technique used for evaluating the caustic corrosion performance of Inconel 600 was what we refer to as the control potential test. This in itself is an accelerating test. The reason that it is an accelerating test is the fact you apply a fixed potential to the C-ring. In this case, for Inconel 600, we maintained a potential within the active-passive transition, which is the potential which gives you the maximum cracking of Inconel 600. Once again, we utilized high stress and also the 10 percent caustic environment.

A. R. Vaia

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In pure water two factors we utilized to accelerate the test, number one, we went to higher temperature once again, 680° F as compared to normal operating conditions, which are between 550 and 600. Once again, increase in stress.

We used reverse U-bends where the -- and also conventional U-bends where the material is, you know, heavy under a straining condition. In primary water type of environment we use the pressurized capsule test technique. Once again, in order to accelerate whatever phenomena would occur, we utilized a higher temperature, 650° F. In the module boilers where we looked at a dilute secondary side contamination, with respect to OH plus chlorides and also a second model boiler test where we utlized a sodium phosphate environment plus chlorides. In this test approach we used no accelerating features other than the fact that we did have bulk water impurities in the system.

Now, going into a little detail with respect to each of these areas, as I mentioned earlier,

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the initial work that we performed was to evaluate the effect of the [ ] a,c

The way we approached this mainly from the mechanical property point of view, we took single lengths of tubes, Inconel 600 tubing. [ ] a,c,f

This viewgraph presents the ultimate strength and tensile strength for that regenerated

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a,c,f

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We were able to separate the rings. We were able to separate the sleeve from the outer tube, then we ran two types of sensitization tests to this type of configuration.

We utilized the 25 percent nitric acid test, which is a widely used test for determining sensitization of Inconel 600.

As you can see with respect to the sleeve and the tube, the numbers listed here are percent weight loss. In order to observe or to have a large amount of sensitization the necessary numbers would be 10 percent, 15 percent. 100 percent would be severe sensitization.

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As you can see, all the numbers are below one except at this one location, all the other numbers are .6, .7. So, this indicates that during [a,c,e], you observe a very small amount of sensitization; and we believe that you know these types of numbers are within the acceptable limits for Inconel 600.

We did this on two sets of tubes. Once again, the second set of tubes indicated [a,c,e], we also verified the initial sets of information where we saw a very little amount of sensitization.

We also utilized a second method of determining sensitization, and that is referred to as a reactivation polarization test for sensitization. In this test technique you take a metallographic cross [a,c] that test technique, in simple terms, you attempt to passivate the surface. If you have any chrome depeletion, you then tend to attack these areas. So if you look at the sample after the test, if you have any degree of sensitization along the grain boundaries, the grain boundaries will tend to be grooved.

So based on this test, [ ]a,c definitely within the accepted limits for Inconel 600.

As Mr. Klein mentioned before, with respect to caustic environment and high temperature water environment sensitization itself is not detrimental.

[ ]a,c,e. As I mentioned before, it's an

accelerated test, within 60 days you can realize cracked depths that would take six months to a year to observe without the application of the controlled potential.

The parameters we utilized were 600 degrees if we did not accelerate the test with respect to temperature. Ten percent caustic six days, it was 140 millivolts applied potential, which is the potential at the active-passive transition; and we used C-rings which were stressed to above yield, in excess of 50 KSI.

In this column I have presented reference type information. Mill annealed material, C-rings in this type of environment, there is a large amount of information available both in the literature and within Westinghouse that indicates that mill annealed material, you will get extensive cracking in this time frame, anywhere from 20 to 40 mills, depending on the specific test; whereas, thermally treated material will show no cracks in this same type of test for the same period of time; so with this

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background information, we then selected C-rings [ ] a,c

For example, we took C-rings from area one, [ ] a,c We ran two series of tests.

The first series, areas one and two, exhibited cracking susceptibilities to mill annealed material, which is what we would expect within this region. [ ] a,c

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a,c,e

[ ] We then took a second series of samples, once again taking a C-ring from the outer tube at area one and an inner C-ring from the inner sleeve, area three, and also then took a C-ring from area four.

This C-ring is a double wall C-ring where you have the outer tube, [ ] and the inner sleeve, and we have exposed these three C-rings under the same test parameters. a,c,e

Area one, once again, we saw cracking similar to what you expect with the mill annealed material. This time, area three gave us cracking susceptibilities similar to mill annealed material. Area four showed with respect to the outer tube, we showed somewhat of an improvement with respect to the stress corrosion cracking susceptibility.

In the sleeve area this C-ring was taken

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[ ] a,c,e we did a similar analysis except we did not run the bend test. We used a microanalytical approach and, again, with the microprobe analysis, we showed that we had iron, phosphorous, silicon, copper, calcium and sodium on that OD surface due to the sludge or just due to the in-service operation; but once again, based on microprobe, we saw no diffusion of these OD contaminants into the surface of the outer tube.

Just reiterating the conclusions that Mr. Klein presented with respect to the OD contaminants,

T-16 The conclusions from the point of view of the review of the literature that was generated with respect to welding of archives tubes, we observed no appreciable diffusion of these OD contaminants; and also the work that's -- [ ] a,c,e we have found no evidence of embrittlement or diffusion of these OD species into that outer surface of the existing tube.

I would like to move on to the second area

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of the investigation, and that was to evaluate the corrosion and stress corrosion cracking of the [ ] a,c,f joints themselves. The approach that we utilized, once again keeping in mind that most of these tests are accelerated tests, we utilized U-bend exposures where we took sections through actual [ ] a,c joints, bent them into U-bends and then exposed them to environments.

We also did some additional C-ring tests in caustic. We also took actual [ ] a,c joints, fabricated the assembly into a pressurized capsule and exposed this assembly to primary water at 650° F. We did this both under static conditions and also under a condition where we had flowing high purity water.

DR. EGAN: Are any of these tests carried on a material [ ] a,c,e a sludge present?

MR. VAIA: No.

DR. EGAN: Have you done any such tests?

MR. VAIA: We have done no corrosion tests of samples [ ] a,c,f in sludge. The only work we

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have done is the OD contaminant work.

Breaking it down into specific tests, this viewgraph presents the results from an eight-week exposure to high temperature water. This is a 680° F test in high purity water where we looked at samples which [ ]a,c,f [.]a,c,f We elevated both the ID sleeve. We made U-bends with the ID sleeve in tension, so really it's a reverse U-bend, where the inner sleeve is now the outer surface of the U-bend. We also took U-bends where the outer tube was the tension surface.

We exposed these samples along with reference samples. The reference samples we are thermally treating Inconel 600 reverse U-bends loaded to the same level of stress and also mill annealed Inconel 600. After eight weeks of exposure, we saw no cracking of specimens where the sleeve was in tension or we saw no cracking with the other tube that was in tension.

In this same time frame we saw no

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cracking with respect to U-bends made from thermally treated material. In the same time frame we did see cracking of mill annealed material within the eight-week exposure to the high temperature water.

DR. GREEN: Point of information. Did you have the mill annealed in contact with the thermally treated tubing during these tests?

MR. VAIA: No. These are single U-bends.

DR. GREEN: Or no magnetite was present?

MR. VAIA: No, no magnetite was present.

So the conclusion from this series of tests would be that, you know, [ ]a,c,f has not, you know, affected -- in real terms, it has improved the stress corrosion cracking performance of the Inconel 600. We see no degradation of the thermally treated material but we do see some reduced susceptibility to cracking as a result of the [ ]a,c,e with mill annealed material.

We further investigated the caustic stress corrosion performance of, you know, [ ]a,c,f joints. In this test we utilized the effective

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temperature in order to accelerate the aggressiveness of the environment. We, once again, maintained the 10 percent caustic, which is the most aggressive caustic concentration from a stress corrosion cracking point of view. Once again, we took C-ring specimens from locations within the [ ]a,c,f joint at location four, which is the location of [.]a,c,f We also took samples away from the [ ]a,c,f joint within the thermally treated sleeve, which would be location two -- location five was conventional mill annealed material, which was not affected by the [ ]a,c,f [.]a,c,f

We ran the tests for 24 days and we looked at specimens after every six days of exposure. As you can see, as the time increased with respect to environment, we also observed more cracking with respect to -- with respect to five, which is mill annealed tubing, we saw extensive cracking within 24 days.

Area two, which is the conventional thermally treated material, we saw no cracking, which is what we'd expect for thermally treated material, which is not affected by the [ ]a,c,f

Area four, which is an area that has seen the [ ]a,c,f where this has been the area where you have the [ ]a,c,f it's also an area -- this sample, once again, was taken [ ]a,c,f so this sample had both the outer tube exposed to the enviornment, also the tension side of the inner sleeve was exposed to the environment; and, as you can see, up to 24 days the outer sleeve or the outer tube showed approximately 20 mills of cracking, which is virtually the same, if anything, a little bit more resistant to stress corrosion cracking than the conventional mill annealed material which, for example, area five, the inner sleeve at area four shows a cracking susceptibility somewhere between mill annealed material and thermally treated material. So, it indicates in that area you have lost some of the benefit of the thermal treatment but you still have a structure that is more resistant than the mill annealed material away from an area which

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has been affected [ ]a,c,f

The other point I'd like to make on this before I move on is that we also evaluated the corrosion resistance [ ]a,c,f in this environment, keeping in mind, this is a very aggressive environment both from a corrosion point of view, from the fact that it's 10 percent caustic and also the effect of temperature on the corrosion, stress corrosion cracking phenomena.

Within 24 days we saw no appreciable corrosion of the [ ]a,c,f These numbers are weight losses or weight before the test, weight after the test, and these are an average or the minimum to maximum for four samples at each of these time intervals and these are milligrams. We are talking about anywhere -- in one sample it indicates .8 milligrams of weight loss, another sample 2 milligrams of weight gain. So, there is no appreciable corrosion observed with respect to the [ ]a,c,f in 10 percent caustic even at 650.

MR. BERRY: Point of clarification. Were

they bright and shiny?

MR. VAIA: No. They had a slightly colored dull appearance. They were not -- they had a very thin oxide deposit on them. They were not clear and shiny.

As I mentioned earlier, we also utilized the pressurized capsule tests techniques for evaluating the effect of the [ ]a,c,f on the inherent corrosion resistance of the Inconel 600.

This test technique involves taking a [ ]a,c,f joint, which includes both the inner sleeve and the outer tube, welding end plugs to the top, to the bottom, and to the top, at the top there is a filler tube which is utilized to evacuate the capsule and then backfill the capsule with the environment that you want to test. You then seal off the capsule and [ ]a,c,f the entire capsule in a furnace, raise the temperature to whatever you want to test at.

In this case we filled the capsule with primary water, exposed the capsule at 650° F, so that's the test parameters we used for the static

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pressurized test techniques which was primary water at 650° F.

We ran three series of tests. The first series, the [ ]a,c was carried out

[ ]a,c

We attempted to analyze. It was very difficult. Once these capsules leak, they tend to boil dry and you have no solution available to analyze after the test; but we were only able to obtain solution from one capsule, 1 milliliter of solution.

We analyzed the solution and found, you know, sodium and OH in the solution.

We also did some microanalytical work with respect to characterizing the cracks in this area, and the cracks were intergranular. They had a chrome-nickel, chrome oxide within the grain boundaries. We were unable to determine any sodium or any OH within the crack front.

DR. EGAN: Would you mark on there where the cracks occurred.

MR. VAIA: This is a weld (indicating), at both ends. We observed cracks adjacent to the weld and also in the weld metal itself and we had through-wall cracks. Other locations, we had cracks that were 70 percent through wall. The cracks were definitely isolated within the heat affective zone and the weld metal as a result of the fabrication.

DR. EGAN: Where was the IGA attack that you said?

MR. VAIA: We saw in these crevices, we saw 1 mill or 1 grain boundary of attack.

A. R. Vaia

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DR. EGAN: It was in the thermally treated sleeve?

MR. VAIA: We saw more on the outer tube and a slightly less amount on the inner sleeve.

DR. EGAN: Thank you.

MR. VAIA: We then repeated the tests with what we are referring to as the second series of pressurized capsule tests. [

a,c,f

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A. R. Vaia

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We took those samples and also exposed them to the primary water, with the similar type of testing configuration, where both crevices, both the top crevice and the bottom crevice is exposed to the solution.

The results, after six days of testing, a,c

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a,c,f

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to evaluate all the corrosion and stress corrosion cracking of [ ]a,c,e is the model boiler test technique.

These tests were run with the single tube model boiler configuration. The objectives were threefold.

Number one, further determine if there is any stress corrosion cracking, corrosion phenomena occurring associated with the [ ]a,c,e and also to evaluate these effects under heat transfer conditions. All the other tests were performed under isothermal conditions with a concentrated environment. In this case we utilized a test configuration where we had dilute bulk solution, dilute concentration in a bulk solution and we used super heat within crevices to obtain a local concentrated environment. We also wanted to evaluate the effect of leakage through the outer tube. If you develop a leak through the outer tube, there will be a concentration within that secondary side crevice which exists between the sleeve and the outer tube.

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I have a schematic of the test configuration. I think at this point it will become obvious from looking at the schematic, we also wanted to further determine what effect the [ ]a,c,f had on the corrosion and stress corrosion cracking performance of both the outer tube and the sleeve.

As I said, I have a schematic to explain the test setup.

The environments we utilized a 5 PPM OH environment plus 0.1 PPM chloride. This is the concentration of species in the bulk water.

We also utilized a sodium phosphate type environment with, once again, the .1 PPM chloride.

The caustic test ran for 20 days, which the test was then terminated for destructive examination.

The second test ran, for the second test which was a phosphate test, ran for 30 days before it was terminated for destructive examination.

Both the sodium phosphate test and the

sodium hydroxide tested this type of test configuration. We incorporated [ ]a,c,f in these tests. The solid inner tube represents the inner sleeve. The outer tube is the mill annealed Inconel 600. In order to maximize the amount of information that we can generate for two tests is the reason we went with [ ]a,c,f joints.

What we wanted to do within the one test was to evaluate the corrosion of the outer tube represented, say, within a sludge pile. So, this lower [ ]a,c,f joint we incorporated a sludge collar where we packed simulated SCE sludge in this outer sludge collar so this area would be representative of a [ ]a,c,f joint within a sludge pile. This area represents a [ ]a,c,f joint which would be operating in bulk water in a clean bulk, away from the sludge, where you have no concentrating mechanisms associated with the sludge pile. The upper area we wanted to utilize as the reference information. This is mill annealed tubing unaffected by the [ ]a,c,f and we wanted to evaluate its performance under sludge pile;

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therefore, we can compare this, what we observed in this area with what we observed in this area in order to determine if there is any detrimental effect of the [ ]a,c,f on the performance.

We also had EDM slots which are electron discharge machining grooves. We machined them in the outer tube, both between the two [ ]a,c,f joints. What we wanted to evaluate at this area is, as I mentioned before, the effect of bulk water impurities that might concentrate within this crevice, which exists between the outer tube and the sleeve.

We also had another area where we had EDM slots and this area, this simulated a through-wall leak which might occur under the sludge pile, so we had a simulated sludge crevice, sludge cup and we had EDM slots machined in the outer tube.

As I mentioned before, we kind of had three objectives with these model boiler tests, and this is the test configuration we utilized in order to address those three objectives.

did we or didn't we

This is just a viewgraph of the test

setup where you have the upper sludge collar, which is located at an area above the [ ] a,c,e joint. This area in here is, more or less, the second [ ] a,c,e joint. This lower area is now the area that was the lower [ ] a,c,e joint where we now have a sludge cup to simulate operation within the sludge, and this lower portion is the lower crevice sludge cup where we wanted to simulate concentration.

DR. GREEN: Question. Was there a reentry tube to get flow of primary water?

MR. VAIA: Yes.

DR. GREEN: Inner tube?

MR. VAIA: Inner tube, yes.

The results from the two model boiler tests, from a point of view of nondestructive examination, there was no corrosion per radiography for either the caustic test of the phosphate test.

The samples or the two model boilers were then destructively examined. We took metallographic sections, through all the areas of concern, both in the mill annealed tubing, where we had the sludge cup

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through the [ ]a,c,f both in an area which had no concentration and also through the area where we had the sludge collars. We saw no corrosion either of the mill annealed material, thermally treated material or the [ ]a,c,f joint itself showed no corrosion. There was no -- in simple terms, there was no corrosion anywhere on either sample. The conclusion is that, you know, there was no corrosion with respect to these two tests.

Now, we believe that the reason why we did not observe corrosion even in the mill annealed tubing is the fact that we terminated the test too early. From my operating experience with single tube model boilers, if you have model boilers where you have low stress level, we did not attempt to increase the stress in any location on this tube, so this was a low stress condition where it was exposed to bulk water impurities and what we feel now is that we terminated the test too early. We were unable to, within the time frame of the test, generate an aggressive enough environment to distinguish any

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variation in performance relative to the mill annealed tubing or the sleeve.

What we are doing now, we are running longer term model boiler tests with simulated -- what we are attempting to do now is simulate [a,c,e] that is going to be used at SCE; that is, we will have a lower collar which is [a,c,e] We will have the [a,c,e] joint with the [reference applied flux,] a,c,e so the further model boiler test will be [reference brazed and also reference mechanically rolled test samples.] a,c,e

That about concludes the corrosion material or material corrosion program information and I am sure we would be happy to address any questions at this time.

DR. GREEN: One of your tables 6.1.8, page 6.25, you talk about these inconsistent results in the thermal sleeve. You have some corrosion in region four. How do you know that, when you extrapolate this to the real 30 year lifetime, that it won't really corrode?

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MR. VAIA: Well, the inconsistencies we are referring to is the inconsistencies observed in area three where you have --

DR. GREEN: Yes.

MR. VAIA: Where you have the thermally treated sleeve.

DR. GREEN: You still have got some cracked depth there of 15 to 36 mills.

MR. VAIA: Correct. What we are saying is that depending on the time temperature that you have at that location, it will vary from one sample to another sample because it's almost impossible to guarantee where that [ ]a,c,e is going to stop [ ]a,c,f That will vary from one sample to another.

DR. GREEN: In light of those results, how can you assure satisfactory operation over 30 years?

MR. VAIA: What we are saying is that in this accelerated environment the performance in that region is the same as you would realize for mill annealed material. Also keeping in mind, that

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that is an accelerated test from a concentration point of view, temperature and stress. In a real world you are going to be running at 600° F, stress levels presumably substantially lower than what we ran these tests at, so both of these parameters would indicate that in a real world you will not realize as much cracking as we observed in these tests.

DR. EGAN: Question. Do you or do you not have a predicted methodology to assure your 30 year life? I can answer that question myself. The answer is no.

DR. GREEN: You can say it's better but you don't know if it's good enough.

MR. VAIA: There was no way from accelerated cross tests you can predict life in a plant, correct.

DR. EGAN: All the tests you have done one 360, 30 days compared with 30 years.

MR. VAIA: The whole program was a relative material comparison program. It wasn't attempted to predict life.

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DR. GREEN: Another one, 6.28, you had the same problem. You have had some attack of the sleeving material.

MR. VAIA: Correct.

DR. GREEN: Now, it seemed to me in the primary water tests, some of the tests perhaps should be where you have the thermally treated material, mill annealed material and some magnetite all in contact because you could conceivably have the open crevice on the primary side, some accumulation after a while of magnetite.

MR. VAIA: Correct.

DR. GREEN: And three materials perhaps should be in contact together because if there is an adverse galvanic effects, it might make things worse. So my suggestion is perhaps some tests should have the three materials together including magnetite. I think after a while it will shut down, some of the magnetite will become present in the primary, would settle in that crevice and then it would be stagnant and couldn't get out.

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MR. VAIA: That definitely might occur. We have not addressed that with the magnetite.

MR. MOODY: Let's carry that as an open item to evaluate.

MR. VAIA: There may be information that might answer that question from a point of view there may be tests already in the literature which indicate there is no galvanic effect with magnetite, so we can check that.

DR. GREEN: You mentioned [ ] a,c,f attacked the weld. Is it possible that same [ ] a,c,f can attack the original tube to tubesheet weld? You have a weld there. It's a different condition. Would that be bad if that original weld was attacked?

MR. VAIA: I think the results indicate that if the [ ] a,c,f if care is taken in the application of the [ ] a,c,f even if you do have a weld there, you do not have enough [ ] a,c,f problems, even in the area where you are going to be

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susceptible.

DR. GREEN: Even when you are sliding it in, you might get some ruboff and perhaps, you get a deep crevice --

MR. VAIA: There is a [ ]a,c,e

[a,c,e], which it's a hard -- Pete may be able to address that.

MR. DE ROSA: [ ]a,c,e

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DR. GREEN: I guess it's pretty clear any testing, you test the secondary coolant is not successful if in the process you haven't caused an attack to the mill annealed material because you know that there is environment in there that does attack mill annealed material.

MR. VAIA: Correct.

DR. GREEN: That's really almost a qualification for the validity of the test, you have to get an attack.

MR. VAIA: Right, because it's a relative. We wanted to compare [ ]a,c,e

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with as received material.

DR. EGAN: I have a few comments related to the significance of your test data and I shutter to recommend any more tests but looking at table 6.1.8 where you do indicate for location three. There is an anomaly. Essentially what your data is for section three, you have a 50 percent chance of getting cracks. You might as well toss a coin. I think your data statistically insignificant and you have to look at more tests in that area.

MR. VAIA: Correct. And we are looking.

DR. EGAN: Another point is if you look at the data table 6.1-16, modified Huey test, I am not sure what the answer to this is. I am going to ask it anyway. If I had done the modified Huey test on the original steam generator material, I would have got the same results?

MR. VAIA: Correct.

DR. EGAN: In other words, the test would not have told me that I was going to get what we have got today?

'A response required.

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MR. VAIA: Right. You mean relative to the IGA attack?

DR. EGAN: Right.

MR. VAIA: Yes.

DR. EGAN: It doesn't have much to do with what we are trying to look for?

MR. VAIA: Correct.

DR. EGAN: I think I asked you a question during your presentation that it would be, in my opinion, useful to look at corrosion tests on the OD contaminants using the same parameters you used for these other screening tests. I know you are doing it in your model boiler but it may be some time before you learn anything from there.

MR. VAIA: Correct.

DR. EGAN: I think your model boiler tests are going to be the important thing because they will tell you how long it takes you to get your service value. In the model boiler tests you don't have anything to key these other things on. What do the six days mean or 20 days?

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MR. VAIA: They are all accelerated from some factor, whether temperature or controlled potential or stress level crack.

MR. NOBLE: Did you look at the effect of the [ ]a,c,f

[ ]a,c,f

MR. VAIA: No, other than the fact at that lower joint we have thermally treated material which is unaffected by any temperature and we have a large data base that indicates in primary water that -- or pure water thermally treated material is of benefit, less susceptible of cracking and also has a higher threshold for cracking in an aggressive environment.

MR. NOBLE: That might be something else to consider in those screening tests.

The sludge you packed things with here, do you have an analysis of that?

MR. VAIA: I don't have it with me. We have it. It's magnetite, copper, copper oxide, zinc oxide. I can get you the exact composition.

MR. HERBERT: Was there any attempt made

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in your setup of that simulated sludge to take scrapings or any other samples from the crevices that existed when you pulled these tubes?

MR. VAIA: The chemistry or magic mixture was the result of sludge samples taken from the unit, but we did not take any of that sludge and incorporate that into this test.

MR. HERBERT: I recognize that but when you were taking these sludge samples, you were not taking any samples in this crevice that existed by your tubes or did you?

MR. VAIA: I can't answer that.

MR. HERBERT: That would have been a collection location for much in that secondary side. That's why I asked did you consider taking any samples in the areas where you have pulled tubes, either samples from the tube surfaces themselves or scrapings in the exposed cylinder of that sludge.

MR. VAIA: I believe we have.

MR. KLEIN: Let me address that. We have analyzed the deposits on the surface of the tubes. We don't find anything unique or different there than we see in most other tubes we removed from operating plants. We attempted to remove samples of the actual sludge above the surface of the tubesheet, and I think we were generally unsuccessful in our first attempt to do so.

MR. HERBERT: You found no sulfur ions in those areas?

MR. VAIA: No.

DR. GREEN: Did you get any liquid sample when you pulled the tube out, had a bucket under it?

FROM THE FLOOR: I will be addressing some of these questions in my presentation. Hold them up until then. We have liquid. The analysis of the tube deposits are very similar to the analysis of samples in that.

DR. GREEN: The point is, the tests, when you are testing corrosive environment like the secondary side should include some of those components rather than caustics and chloride.

MR. VAIA: Simulated sludge was -- the

sludge had a composition that everything we analyzed greater than 1 percent in the sludge removed from SCE was incorporated in the sludge that we utilized for the model boiler test.

MR. NOBLE: Was there any sulfur species in that sludge or in the simulated sludge?

MR. BERRY: You said in your report there was sulfur. In the report there is mention of sulfur.

MR. VAIA: We analyzed on the OD surface but there was not, there is no sulfur in the simulated sludge that I am aware of. We can check that.

FROM THE FLOOR: Occasional sulfur was made, sulfur or sulfate.

MR. VAIA: Just the elemental sulfur.

FROM THE FLOOR: Sulfur was identified.

MR. BERRY: You are saying you don't know the prevalent state of it?

FROM THE FLOOR: That's right.

MR. NOBLE: I think you made a statement that you plan to have ongoing single tube model boiler tests. Is that in a sense you are going to run the tests in these environments you told us about for a longer time period or is it something different?

MR. VAIA: It's similar environments for longer time frames with tubes, [ ]

MR. HERBERT: You made a statement -- I'm not sure I heard it correctly -- that your simulated sludge had a -- then you quoted a percentage of whatever trace elements were found in the San Onofre sludge. Is that 1 percent?

MR. VAIA: I believe anything greater than 1 percent was also included when we mixed together our magic simulated sludge, includes everything that was analyzed to be greater than 1 percent.

MR. HERBERT: Anything less than that, is that tabulated?

MR. VAIA: We have all that tabulated. We have all that tabulated but I am not the person to ask about that.

MR. KLEIN: Can you discuss that, John,

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composition of the sludge removed?

FROM THE FLOOR: I was not prepared to discuss it.

MR. MOODY: Why don't we carry that as an open item to discuss, sludge content.

MR. BERRY: That's one of the items I was considering and that is, that a lot of times sludge has an appreciable quantity of lead in it and lead has been found to be harmful in laboratory studies; but despite that fact, we find a lot of lead accrued in an operating plant and it hasn't cracked Inconel. I have a number of other questions.

Did I understand you to say that you have [ ]a,c,f

MR. KLEIN: Yes. [ ]a,c,f

[.]a,c,f

MR. BERRY: No wonder you have got carburization.

MR. KLEIN: [ ]a,c,f

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MR. BERRY: Then while we are on the same subject, you said that there was stress corrosion cracking in the heat affected zone in that particular test. Do you think that is because it was sensitized or because that was a high residual stress area?

MR. VAIA: I don't believe because it was sensitized. It is just a combination of factors that, for example, this pressurized capsule, let's say we are utilizing 10 percent caustic as the environment. We observed a large amount of times you get failures in either the weld or that heat affected zone. I don't believe it's a result of

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sensitization. I believe it is a result of stresses and just a temperature that you were at there during the welding cycle and not related to sensitization.

MR. BERRY: Following up Stan's question, when you do the sleeving operation, you are going to come down to bare metal and then you are going to put a sleeve in and then just beyond that, you are going to have an oxide coated tube; and this is a little different than what Stan mentioned because you now have good galvanic contact between the barrier and the area that's to be tubed. Some experiments have been conducted in the past when you run loop tests and halfway through the test you take half the specimens out and put new specimens in, they corroded at a much higher rate than those that have just been taken out. Were those started originally and there's been some suspicion that it may be a galvanic effect. That doesn't bother you too much if your corrosion rate increases slightly in the sleeve but what would bother me is if during the time that less protective oxide film was forming you were setting up conditions to

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cause stress corrosion cracking because of the active-passive condition that you might have in that area.

MR. VAIA: On the primary side?

MR. BERRY: Yes. I am wondering in your model boiler test have you considered prefilming removing the film and sleeving just the way you are going to do it because the one test I seen so far --

a,c,f

MR. VAIA: [ ]

MR. BERRY: [ ]a,c,f I'm sorry, whatever the operation is.

Then, there's another point. Have you really found out how much corrosion is taking place on the [ ]a,c,e In other words, do you know what is lost to the stream, the flowing stream with the [ ]a,c,e

MR. KLEIN: Let me address that. We have data generated here in the early 1970's in flowing primary water, this particular [ ]a,c,f joint on stainless steel and at the end of some 5,000 or 6,000

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MR. NOBLE: Do you have any question?

MR. BERRY: I think that's all I have for the moment.

MR. NOBLE: The levels of hydroxide and chloride in your test that you have, do those bracket

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the level the fault chemistries that you really can expect in the operating generators?

MR. VAIA: I believe they do. They represent environments that have been utilized before for single tube model boilers for material tests.

MR. NOBLE: With respect to the actual operating experience and given, I think, maybe a stackup of worse case events --

MR. VAIA: I cannot address that.

DR. GREEN: The test is only successful if the volume is aggressive enough to cause intergranular attack on mill annealed tubing, that's the proof of it. It could be a lot higher than that. The fact it didn't corrode indicated it wasn't high enough.

MR. NOBLE: We have assembled many of the effects on materials of treatment.

DR. GREEN: At minimum, it has to attack the mill annealed. Hopefully in thermally treating, discriminating, it won't be attacked.

MR. VAIA: We believe it's a function of time and also the aggressiveness of the environment from

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what we start on the bulk environment, you know, based on other tests that should have been aggressive enough to cause problems, to cause attack of the mill annealed material, but I think we didn't run the test long enough because we were at a low stress level. We didn't have any highly stressed components within the model boiler test.

MR. BERRY: Did I read someplace in the report that [ ]a,c,f does not increase the boiling point of the solution or was that stated? Were you just thinking of components that were in the secondary side of the system when you said that only [ ]a,c,f caused the boiling point evaluation, therefore, would cause a concentration effect because of the 80 degree super heat?

MR. VAIA: That's addressing the secondary side crevice.

MR. BERRY: But the secondary side crevice also had [ ]a,c,f if you have a leak in the external tubing.

MR. KLEIN: Yes.

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MR. BERRY: Ergo, you can get conceivably a high concentration of [ ] a,c,f relatively speaking, in that annulus.

MR. KLEIN: I guess the way we addressed that, Warren, we concluded that if there were a leak in the tube, such as to have penetration, that was caused by this very aggressive environment on the secondary side that caused the attack of the tube in the first place; and that that, whatever, presumably high concentration caustic would really be more severe than any small amount of residual that would be remaining in that.

DR. GREEN: Did you address the possibility of the secondary side environment getting into the crevice and attacking the [ ] a,c,e

MR. KLEIN: Yes. We did test the [ ] a,c,f in 650° F 10 percent caustic and found this very slight or insignificant attack, admittedly a short time period, but --

MR. HERBERT: Was that a general attack or --

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MR. VAIA: Well, there was no metallographic examination of the sample afterwards, couldn't see any evidence of attack. The numbers I presented were just weight loss or dealt with weight loss, gain. There was no obvious attack of the [ ] a,c,e [ ] a,c,e as a result of metallographic examination, based on metallographic examination.

MR. BERRY: As a point of just a question, have you measured the potential of the [ ] a,c,e Does it, in fact, raise the potential of the Inconel 100 millivolts more positive than the free potential in much the same manner as your tests were conducted?

MR. KLEIN: No attempt was made to measure.

MR. BERRY: You would expect it to raise it somewhat. I thought maybe you may have measured it in the caustic.

MR. KLEIN: No.

MR. MOODY: Any other questions from the Board?

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MR. NOONAN: I have one question to ask on the [ ]a,c,e Given the Three Mile Island accident, we have high radioactive coolant, can you tell me what happens to the [ ]a,c,f under this environment, say, for a period of maybe operating Three Mile Island for 18 months, flowing high radioactive coolant through those steam generators, can you tell me what happens to the [ ]a,c,f in that condition?

MR. KLEIN: Yes. The [ ]a,c,f transmutes [ ]a,c,f so this was initially to be addressed. We conservatively conclude that we will not corrode more than half a gram per year of [ ]a,c,f some fraction of that. We asked our fuel division to examine this and in their judgment it's inconsequential and insignificant with regard to the amount.

MR. NOONAN: (Inaudible.)

MR. VAIA: Well, we are assuming a half a gram of [ ]a,c,f

DR. WEGST: I think there is confusion there if I understood your question. If there is some

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corrosion of the [ ]^{a,c,f} into the coolant water, while the reactor is operating, that [ ]^{a,c,f} will get circulated through the reactor and (inaudible) neutrons and transmitted to (inaudible). Three Mile Island, the radioactivity has no neutrons in it and it isn't going to affect the [ ]^{a,c,f} or anything else. It's circulating back at G efficiency in depth and that there won't be physical damage to the [ ]^{a,c,e} or the [ ]^{a,c,e} and I think there's two different questions there.

MR. KLEIN: Yes.

MR. VAIA: Are you answering his question?

MR. MOODY: Dr. Wegst has answered his question.

MR. NOONAN: You answered it.

DR. WEGST: From the physics of the interaction, the radiation in the circulating water at Three Mile Island would have no effect on [ ]^{a,c,e}

FROM THE FLOOR: There is a [ ]^{a,c,e} effect on nickel, which obviously you need much more than you would possibly transmit.

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DR. WEGST: Yes.

MR. MOODY: Other questions?

MR. CONRAD: I have a comment. I think Dr. Green's point that qualification of the boiler running longer is really necessary and the question is, how much longer should it be run?

Commitment here

MR. KLEIN: We propose a continuing test to the extent of the year perhaps.

MR. CONRAD: But you will be going back to service before that?

MR. VAIA: Oh, yes.

FROM THE FLOOR: Let me comment on that. I heard the whole essence of these tests were to demonstrate and compare to the existing material. There was no degradation involved and I think that's been adequately demonstrated by the acceleration of both temperature and stress; and in conclusion, from our internal review is that what we are putting in the way of sleeve material, both the [ ]a,c,e [ ]a,c,e does not degrade it in any way. Now, the question is will it last for

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40 years, and that is difficult to answer. However, we do have the data base that says this process has been proceeding for some time. You saw in Dan Malinowski's data it estimated conservatively about 13 percent a year. Since we have improved in most areas the corrosion resistance of the material, we could expect a reasonably long service and that really, I would think, qualifies the sleeving process as far as installation.

We would, of course, like to get more information from the actual stress temperatures and that's what we perceive showing, a lead experiment, if you will.

MR. BERRY: That brings up a further question I had, and on your table 6.1.7, on page 6.24 in your text, you didn't get any cracking of your mill annealed as received tubing in your special tests that's suppose to produce cracking. Isn't it that consistent a test?

MR. VAIA: That was a four day test where we attempted to accelerate it further, that we

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loooked at it four days instead of six days, which is not -- it's not what we consider to be our reference control potential test. We wanted to accelerate a little faster or look at the results obtained in an attempt to examine specimens after four days.

There was also some problems with the application of the potential in that test, so that's included in there because that's the test information we had before we ran additional tests. So, I do not believe that information, that controlled potential results there are really meaningful.

MR. BERRY: It is better leaving them out?

MR. VAIA: Right.

MR. MOODY: Are there additional questions?

Why don't we take a ten-minute break.

(Short recess taken.)

MR. MOODY: On the record.

Let me state my intentions for the balance of the day. We are now at agenda item six,

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which we have previously estimated would take about 40 minutes. What I would like to do is get through that presentation and the question and answer period associated with that tonight and that would leave for tomorrow open items and the balance of the agenda.

The reporter, for good reason, I think, has had difficulty in these last couple of hours with identifying people, particularly those in the audience. So, I would remind people to please identify yourselves prior to speaking, particularly those in the audience that haven't been identified except for early this morning.

One other procedural matter I want to mention and that is, that I was hopeful we would this afternoon be able to rearticulate the open items that we have from today; but I would like to do that first thing in the morning, so now the first thing we will do in the morning tomorrow will be to articulate what we believe to be the open items and by then, we will be in some position to assess whether or not the open items will be addressed in the course of subsequent

~~Dr. Warren Junker~~

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presentations or at that point in time or hopefully not some other alternative.

With that, why don't we get on with agenda item six.

MR. RAWLINS: Nondestructive examination of the sleeve will be presented by Warren Junker, who is with our nondestructive test development group at the research and development center of Westinghouse.

DR. JUNKER: What I am going to talk about this afternoon is the nondestructive evaluation of the sleeved tube assembly. In particular, what we are interested in are two aspects. One is a process control inspection for the braze under

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The techniques that we have addressed to answer these questions are primarily ones that are well known to all of us. They are eddy current for the in-service of the assembly and as a technique for assessing

Under eddy current, just to refresh your memory, there are various types of eddy current inspection and Dan Malinowski mentioned this morning, up until recently the primary inspection mode has been single frequency eddy current inspection. What we have gone over to very recently is the multi-frequency inspection where we can acquire data at several frequencies simultaneously.

The types of eddy current probes which we will be involved with, as Dan Malinowski mentioned, the workhorse of inspection of steam generators has been the bobbin type eddy current probe, differential structure where we have two coils mounted on a single body and where we are comparing the difference in the properties of the materials surrounding the various

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coils.

Another type of coil we have investigated for this program is the [ ]a,c,e eddy current probe. The probe offers some advantages in improving inspectability of various regions within the steam generator.

We have a rotating pancake probe that was discussed this morning; and as a variant on that, we have a [ ]a,c,e

The first thing that we investigated was the applicability of the conventional bobbin probe in inspecting the tube and sleeve. We went about and confirmed that for the tube on the outside of the sleeve, that the conventional phase versus percent of wall lost, curves are applicable.

The other thing we found out and made a measurement, of WAS the [ ]a,c,e kilohertz response of the tube. On inserting the sleeve inside the tube, we found that there was a loss of between [ ]a,c,e percent of the original amplitude of the signals. So by inserting the sleeve inside the tube, we have reduced

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the sensitivity of our measurement capabilities for the tube.

With the present inspection frequency at San Onofre at [ ]a,c,e kilohertz, we see on the outside we have a similar phase versus wall loss and now at the higher frequency, as one might expect, the loss in sensitivity is somewhat higher. Similarly for the sleeve, at [ ]a,c,e kilohertz, again, for the set wall loss versus phase measurements, the curves ~~curbs~~ are as one might expect. However, we found something fairly

[ ]b,c,e

The frequency we would recommend for inspecting the sleeve is approximately [ ]a,c,e kilohertz. At this frequency we have in the sleeve a wall loss versus phase curve showing here between a through wall and [ ]a,c,e percent wall loss, we have about [ ]a,c,e degrees, which is consistent with the [ ]a,c,e kilohertz inspection that's presently being performed at San Onofre. Again, there is some loss in sensitivity due to inserting the sleeve inside the tube; however, for the deepest penetrations, it's not very significant.

Now, if we look at the response of the [ ]a,c,e

One thing we did find out is that as [ ]a,c,e

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to inspection.

If we compare the two sets of graphs, you can see that the waveforms in this region have been reduced fairly significantly by applying a very [ ]a,c,e

Now, as an alternate means to further improve inspectability in the region of the [

]a,c,e

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significantly improved the inspectability and the origin of this stems from the fact that the [ ] acef

Now, to help understand the response in the eddy currents in the region of the [ ] acef and in order to determine whether or not the eddy current techniques are a means of assessing the [ ] acef we did a further number [ ] acef

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we began to realize that if we concentrate our attention on this structure here in the [ ]ace kilohertz, that relates to the [ ]acef

The first thing we did is a simulation. The first thing we did, a fairly simple simulation, one [ ]ab,ce

The two responses look somewhat similar [ ]acef

Now, to further get a feel for how [ ]acef

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information as to slow gross degradation of the [ ]^{a,c,e,f}

itself.

Moving on to the [

]^{a,c}

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acef

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when

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acef

indeed, a characteristic pattern very similar to what's shown in the ultrasonic examination. Indeed, there was a leak path here.

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a,c,e,f

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acef

[ ]

result, we plan to use this technique as part of our process control plan. In order to implement it, we have developed a process sampling plan. This plan has three major objectives. First, that the [braze] acef will not yield to a primary to secondary within a year.

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Second, that when we begin the [ ] a,c,e,f process, that we are, indeed, in control of our process; and third, that as we go along in the process, that the parameters are being maintained.

In order to come up with a sample size for this, we consider three separate events. One is that the wall, that the outside tube will be penetrated within one year. The second event would be that there is an unacceptable [ ] a,c,e,f and the third is that the [ ] a,c,e would leak within one year.

On the basis of assuming a [ ] percent failure rate for the rolled joint within one year and a projected corrosion rate for failure of the outside tube, we arrived at what we would anticipate. In order to have a [ ] a,c,e percent condition, we will not have a tube leak within one year, our probability of having a bad [ ] a,c,e,f must be less than [ ] a,c,e percent.

Since, in order to implement this, we developed a process inspection plan. Now, as Pete mentioned, we plan to insert sleeves in [illegible] lots of [ ] a,c,e This lends itself to a progressive sampling

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plan. Out of our first lot we anticipate inspecting

ace

Now, the acceptance criteria that we are working to comes from the Code. Just to remind

acef

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[ ] acef

Analysis is continuing. Indeed, we may not even need that much of an area and, again, that area should have less than [ ] acef

So, at this point we anticipate inspecting via this inspection plan and at the [ ] ace

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eliminate the effects of the oxide.

We are also recommending that a leader group of sleeved leakers be considered, and this would help supplement our understanding of the potential degradation mechanisms in the [ ]acef itself and point the way to improved inspection in the [ ]acef should degradation take place in the future.

This concludes what I have to say at this point about the inspection and the activities for [ ]acef. Do you have any questions?

MR. NOBLE: Yes, I have a couple. I think I need to understand a little bit more about the eddy current inspection of the [ ]acef. You are going to use a multiple frequency exam technique. Are you going to get a frequency mix to mix out the effects of the diameter changes there?

DR. JUNKER: That can be done, yes.

MR. NOBLE: Is that what you are planning to do?

DR. JUNKER: That is one of the things that we considered, yes.

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MR. NOBLE: You mentioned this

Are you planning on using that?

DR. JUNKER: In the future if it becomes necessary, we would anticipate using that type of a probe, yes.

MR. NOBLE: Because you mentioned that it was insensitive to or it had the advantage of eliminating signal input from symmetrical features but it also has the disadvantage of showing symmetrical defects.

DR. JUNKER: That's correct.

MR. NOBLE: Did you do any development work on this area near that transition and crevice area? Did you put any defect and see if you can --

DR. JUNKER: You mean using eddy current techniques?

MR. NOBLE: Using eddy current techniques.

DR. JUNKER: In the past we have done studies of that type and it is possible to pick up indications in that vicinity. The biggest problem is that you are very close to the end of the tube.

MR. NOBLE: Do you have something on your gear that positions the [ ]a,c,e

DR. JUNKER: The tool that we have right now is basically fixed to [ ]a,c,e region.

MR. NOBLE: It is fixed on the axial length?

DR. JUNKER: Right.

MR. NOBLE: What do you have to [ ]a,c,e that?

DR. JUNKER: Exactly what you are seeing there in that one [ ]a,c,e

MR. NOBLE: Is it hand maneuvered or machine maneuvered?

DR. JUNKER: That's all automatically displayed.

MR. NOBLE: The [ ]a,c,e

DR. JUNKER: Yes.

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MR. NOBLE: And you were talking about some flat bottom holes that you had drilled. The smallest one was what?

DR. JUNKER:

MR. NOBLE: Were these data taken in the vertical position using your kind of simulation or were they taken in the horizontal?

DR. JUNKER: They were vertical. We have always been working in vertical position.

MR. NOBLE: Were they taken at the similar height to what you had been working at?

DR. JUNKER: This specific data was not but we have. We have a tool and we have tested it in mockup successfully. In fact, the tool's been running close to three weeks in the laboratory, maybe close to a month.

MR. NOBLE: I am still not clear about your eddy current techniques that you are going to use on that

Can you describe that a little bit more for me?

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DR. JUNKER: Basically we are going to get a signature from the region and monitor how that signature changes with time. If there is any significant change, other measures will have to be employed at that point. That's why we want to use the probe.

MR. HERBERT: Your acceptance, final acceptance, then, is on the basis of eddy current tests or

DR. JUNKER: You mean for the

MR. HERBERT: For the

DR. JUNKER: On the basis of the

MR. HERBERT: You have done a comparison between the Have you confirmed this by any sectioning, metallographic evaluation?

DR. JUNKER: Yes.

MR. HERBERT: What is the correlation there?

DR. JUNKER: Quite good, we tend to

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DR. GREEN: You say you are going to do acceptance criteria with the [ ] and in-service with the eddy current. You are not going to do any in-service inspection with the [ ]

DR. JUNKER: At this point we are not anticipating any.

DR. GREEN: Do you have any correlation between the [ ] and eddy current means?

DR. JUNKER: We have done that type of correlation. Basically what the eddy current shows us is rather gross degradation of the [ ]. In other words, we get a base-line signature from which we can compare and look for changes in that [ ]

DR. GREEN: What will the purpose of the in-service inspection be, then, with the eddy current? What are you looking for there?

DR. JUNKER: Well, generally why one does an inspection.

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DR. GREEN: Standard information?

DR. JUNKER: Right.

DR. WEGST: As I understand it, you are going to use an eddy current inspection on every single one of the [ ]a,c,e to assure that you haven't missed a tube and then go back and do your screening with the [ ]a,c,e

DR. JUNKER: Actually it will be the other way around. We will, as the process goes along, we will sample a number of tubes using the [ ]a,c,e and when the whole process is done, we will do a 100 percent inspection with the eddy current.

MR. NOBLE: Do you plan on collecting eddy current data on three frequencies on the entire length of the sleeve?

DR. JUNKER: Yes.

DR. GREEN: What happens if you flunk the acceptance criteria and plug the tube?

DR. JUNKER: The first step in this is our acceptance criteria from a nondestructive point of view. It's been turned over to engineering for disposition as to whether or not it will meet the functional requirements according to the Code; and if it then fails that, on the basis --

DR. WEGST: What happens if it fails?

DR. JUNKER: It is plugged.

DR. GREEN: How long does it take to

[ ]a,c,e,f

DR. JUNKER: Right now about [

]a,c,e

MR. BERRY: Are you recommending some leakers be sleeved and then you follow the progress of the attack of the [ ]a,c,e

DR. JUNKER: Yes.

MR. NOBLE: In those leakers have you evaluated the consequences of doing this as, you know, if the leaker tube should continue to degrade on the outside -- in other words, what is the safety analysis?

DR. JUNKER: We are assuming our sleeve is the primary-secondary boundary anyway. Basically we don't need the tube.

made because of many other analyses that were performed on steam generators in the seismic or lateral shaking distribution to stress. Region two bundle has always been minimal.

MR. MURPHY: My thought is if you were to assume that the tubes were supported all the way up the tubesheet, that the bending movement under those circumstances might not so be negligible?

MR. DE ROSA: I'd have to take a look at the boundary conditions that are used in the standard analysis and I don't know if I could agree with your conclusion but I believe they would still be minimal.

MR. MURPHY: I guess those are all the questions I had with it.

MR. NOONAN: You are going to take it the next time (inaudible)?

MR. DE ROSA: At the support plate and tubesheet.

MR. MOODY: Open item.

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MR. NOBLE: If you have a complete failure around there, you still feel --

DR. JUNKER: We have -- the whole idea of the sleeve is it will sustain normal load.

DR. EGAN: There is a sampling plan for assuring a

DR. JUNKER: Basically that work is continuing. Up to this point, Pete addressed that this morning --

MR. DE ROSA: That work is continuing. What I mentioned earlier is that we have established first two samples to determine what margin we have. After the significant pressure testing, because pressure that it creates first leak and pressure (inaudible). We have approximately another [ ] b,a,c,e samples we are going to put through the same testing to establish the life cycle of those [ ] b,a,c,e samples with testing I described at a pressure consistent with (inaudible) should they meet the criteria.

DR. EGAN: Either from those data you have to derive probability of failure to go into this equation, so you can assure yourself your sampling frequency is sufficient. If you get no failures, and I suspect that's what will happen, you have to get a probability of failure having a data base in it that has no failures. I wondered if you considered that.

MR. DE ROSA: We haven't considered the number of samples we would need in order to establish

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[ ]a,c,e percent.

DR. EGAN: [ ]a,c,e percent I think it was.

MR. NOBLE: In your eddy current work data currently have you taken that sleeve area there and mocked up different types of defects in terms of size and volumes and attempted to try to do some development work on different mixes and frequencies?

DR. JUNKER: No, we haven't. We have done some but not an extensive amount. We have been concentrating on the [ ]a,c,e A lot of that work has been done and exists already.

MR. NOBLE: But not necessarily for this place?

DR. JUNKER: Transition regions exist already in other areas.

DR. GREEN: Are you planning any base-line profilometry reading to characterize the ID ~~area~~ of the sleeve so you know where you are in case any future problems develop?

DR. JUNKER: No.

MR. NOONAN: I think I am going to have a

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few questions on this one. This is on the eddy current testing, nondestructive, I should say.

First of all, has there been any calibration standard for production established?

DR. JUNKER: Yes.

MR. NOONAN: It has been done?

DR. JUNKER: What we are using is a series of what one calls workmanship samples.

MR. NOONAN: In answer to Dr. Green's question in the negative, can you explain why?

DR. JUNKER: I don't remember what his question was.

DR. GREEN: Which one? Last one? The question about why not use profilometry for some selected tubes to characterize the ID so you monitor any possible future degradation? Absent future tubesheet denting, perhaps some buildup of fluid in the annulus causing some collapse in tubes.

DR. JUNKER: The collapse of the tube would be apparent in the conventional eddy current inspection.

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DR. EGAN: They are going to use the same criteria they used before. If you can't get the damn probe up, it's dented. Isn't that the industry standard?

MR. NOBLE: It doesn't take a very large diameter to show the eddy current.

DR. JUNKER: That's right, particularly since we plan to use [ ]a,c,e kilohertz.

DR. GREEN: That kind of measures an average change.

MR. NOONAN: Couple other questions. On the [ ]a,c,e that you were doing on the [ ]a,c,e that was done manually?

DR. JUNKER: First ones were. These weren't.

MR. NOONAN: Those are done --

DR. JUNKER: Those are automatic.

MR. NOONAN: Automatic?

DR. JUNKER: On the basis of that [ ]a,c,e system that I described.

MR. NOONAN: What is the length of time

it takes to run one of those, obtain a [ ]a,c,e

DR. JUNKER: About [ ]a,c,e

MR. NOONAN: [ ]a,c,e

DR. JUNKER: We are hoping to cut that down even further.

MR. NOONAN: All right. The reason I asked that question is because (inaudible) the staff agreed with your sampling. I was wondering how long it would take to run those types of maps, say, for a larger sample. You say about [ ]a,c,e

DR. JUNKER: [ ]a,c,e

MR. NOONAN: And one other question I have. Maybe I didn't hear this but did you address the inspection of the rest of the tube now with the sleeve in there?

DR. JUNKER: I didn't mention it here. If we use a conventional bobbin probe, which will fit through the sleeve, say, in other words, for the inspection of the hot leg, we will lose some available signal to reduced fill factor. At this point we don't consider that significant.

MR. NOONAN: I guess what concerns me is the fact that going through the U-bend, we always have problems looking at eddy current testing in that area and trying to decipher just what we have. With the sleeve now, instead of bobbin, it seems to me it's going to make that bobbin much more worse.

DR. JUNKER: Not really. Generally what we do to get through the U-bends anyway is to use a smaller diameter probe.

MR. NOONAN: Small radius?

DR. JUNKER: For the small radius tubes.

MR. CURTIS: You still have the option of going through the cold leg.

MR. MURPHY: Is there any reason why in this [ ]a,c,e inspection you don't intend to use it in-service if it only takes [ ]a,c,e a tube?

DR. JUNKER: It's a rather cumbersome inspection if we can get basically the same information another way.

MR. MURPHY: Can you get the same

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information from the eddy current inspection? I understand you are looking for gross changes from your base-line inspection. It would not tell you, for example, if you haven't established early on the true condition of the [ ]a,c,e,f if it wasn't one of the lucky tubes picked out, you wouldn't know the basis of the eddy current information alone, whether you satisfied the criteria you set out for yourself? All you can tell is the gross fashion, not what you may have degraded relative to previous inspections; is that correct?

DR. JUNKER: That is true.

MR. MURPHY: Your stated projection sleeves are intended to last the [.]a,c,e The extent of possible processing inspection is based upon assuming that you won't get a leak within one year. It's based upon the likelihood only a small number of tubes will have through-wall penetration through that year; but, of course, beyond the first year's degradation the other tubes will continue. We have already established [.]a,c,e percent probability of a bad [ ] a,c,e percent. Don't you feel it's questionable whether you can establish an adequate base line ~~for~~ from which you can more properly evaluate the correctness of the eddy current data? In other words, the only reliable base-line technique that's going to establish early on the true condition of the [ ] a,c,e examination?

DR. JUNKER: I think the assumption is that the process will guarantee us even though we are only sampling for [ ] a,c,e percent, I think we will probably be somewhat better than that, much better than that; and all we really need is that eddy current base line.

MR. MOODY: Do you have an opinion on that, Mr. Herbert?

MR. HERBERT: I am sitting here listening to sampling plans and I have got a question in my own mind, does that really meet the intent of Section XI for a replacement seal. Going through a few figures, it's rather significantly time saving but I am wondering

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I have a question really in that I think I do agree with the statement I heard from the staff here that I'd like to think a little bit about this sampling plan before making comment on it.

MR. NOONAN: May I make a suggestion on this particular item. I know I would like to talk with the staff on it, what we heard here today regarding the NDE. Maybe we can start that first thing in the morning.

MR. MOODY: All right. We have a couple of first things in the morning but we can certainly do that in the morning. I don't know if it need be the first.

MR. NOONAN: I would like to talk to some of the staff tonight and get back to it tomorrow with any concerns I have.

MR. MOODY: I don't intend to preclude questions on today's material tomorrow, so we won't keep that as an open item now but you are free to bring that up tomorrow and we will endeavor to respond to it then.

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Other questions from the Board or comments?

Why don't we reconvene tomorrow morning at 7:45 again and at that time we will rearticulate the open items and address as many of the open items as possible. Following that, we will proceed with agenda item seven.

(At 5:05 p.m. the hearing was adjourned until Friday, October 24, 1980, beginning at 7:45 a.m.)

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MORNING SESSION

October 24, 1980

8:05 a.m.

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MR. MOODY: The last thing we heard yesterday was agenda item six and Pete DeRosa from Westinghouse is going to provide some additional information on that same agenda item the first thing this morning. From there, I want to proceed to identify and address the open items from yesterday's session, and we have a list of eight open items which is being typed and will be distributed, which is a summary characterization of the eight open items left from yesterday. Then, following the eight open items from yesterday, we will proceed with agenda item seven.

MR. RAWLINS: Let me just introduce Pete DeRosa, then, who will continue some of the discussion we had on in-service inspection and nondestructive examination.

MR. DE ROSA: What I wanted to do before we entered into what appeared to be some discussion on the [illegible] sampling program, the consequences of

Pete DeRosa

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understanding it, I think, are of first importance.

In performing the [ ]a,c,e inspection of the [ ]a,c,e certain things that were not really brought out yesterday should be brought out. First thing is that in each steam generator, the first ten tubes that get [ ]a,c,e,f will be 100 percent [ ]a,c,e inspected at the [ ]a,c,e,f If those ten that are [ ]a,c,e inspected are successful and [ ]a,c,e,f are acceptable, then we will go into the sampling plan on the [ ]a,c,e If those ten are not 100 percent acceptable in a [ ]a,c,e,f point of view, another ten will be made and those ten will be looked at 100 percent and we will go that way until we get a series of ten [ ]a,c,e,f consecutively made that are acceptable and demonstrating the process is performing as intended.

Another thing that we neglected to tell you yesterday is that this week, this week we are commencing life cycle tests of the [ ]a,c,e,f Upon completion of those life cycle tests, we will know how often that [ ]a,c,e We will also know what the life

Pete DeRosa

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cycle of the [ ] itself is and what the necessary change out time for that [ ] is.

Yesterday when we discussed the sampling plan itself, we didn't emphasize that what I think is a reasonably conservative sampling plan. We put a viewgraph up on the board that was up there yesterday. First thing this is telling us is that once we have established that we got the process performing as intended with the ten conservative

a,c,e

a,c,e

a,c,e,f

[ ]

Pete DeRosa

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When you compare that sampling plan to standard sampling plans such as a mill standard 105, you can find that it is more restrictive in terms of the number of defective you must find before you have to reject the lot and proceed back to a more severe inspection.

I don't think it was brought up yesterday in enough detail to explain the fact that it is a very conservative sampling plan and, quite honestly, it's motivated by many things, one of which

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is the fact that it does provide a level of confidence that is perhaps just as conservative as Section XI may be providing when it says perform a visual inspection on the tube to tubesheet repair weld, because a visual inspection doesn't necessarily tell you the load carrying capability of a tube to tubesheet weld. It just tells you that on the surface you don't have any porosity or visible defects. This is giving you a value of the load carrying capability of the joint.

MR. BERRY: Point of clarification. You are talking about the [ ] a,c,e,f here now?

MR. DE ROSA: I am talking about the [ ] a,c,e,f versus the acceptance criteria.

MR. BERRY: In other words, this applies to both the [ ] a,c,e,f

MR. DE ROSA: Yes. The [ ] a,c,e,f

So, I did want to make that one point, that it is a conservative sampling plan and in some

Pete DeRosa

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cases, though, you may not be looking at 100 percent of the [ ]a,c,e You may, in fact, be getting a better confidence level than a visual inspection of a repair weld or you may, in fact, be getting a better confidence level than a repair weld that is not accessible for inspection because, I believe, Section XI does provide a confidence when it says you make a repair weld, it must be examined if it's in an accessible position.

To go a little further now in terms of the inspection of the [ ]a,c,e several other things are being done along the line of NSS.

After all the sleeves are installed, the tube and the tube with the sleeve in it and the region of the tube will be 100 percent base-line inspected in multi frequency eddy current coil the entire length of the sleeve. As we found out yesterday, that any gross anomaly in the [ ]a,c,e will provide a signal with eddy current that can determine that there is something grossly wrong with that joint. When that occurs, that joint should and

Pete DeRosa

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will be { } [a,c,e] examined if there is something very grossly wrong with it. That base line on 100 percent on the sleeve, with that { } [a,c,e] multi frequency eddy current coil it will give us the signal for the tube behind the sleeve, for the sleeve and for the { } [a,c,e,f] Those signals can then be compared with signals that are done during a routine 3 percent eddy current inspection.

In addition, we are putting in place a leader group philosophy on each of the three steam generators. We are going to penetrate the pressure boundary of a sample number of tubes and create leakers. We are going to install the sleeves into those tubes and monitor those tubes as with life during the performance of the unit.

We have another group that is a control group with that leader philosophy that is not being penetrated but is being sleeved.

At periodic outages, first outage to be determined -- I guess Blaine will give us a little bit more of a discussion on the leader group and

Pete DeRosa

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he will discuss the outage plans -- we intend to first perform NDE on that [ ]a,c,e,f and on that sleeve prior to pulling it out. Pull out at least one leaker tube that has been sleeved per outage. We will perform a [ ]a,c,e on that tube and perform a multi frequency eddy current inspection with [ ]a,c,e and compare those signals to what we had originally on those tubes. We will then pressure test that tube with a mandrel, extract that tube and destructively examine that tube. At that point we will have an understanding, if there is any degradation in that joint, of what it is that must be looked for from the point of view of in-service inspection of that [ ]a,c,e,f

Our laboratory data suggests that the [ ]a,c,e,f itself is not to be considered the weak link in that joint; but just knowing Murphy's law, we intend to discover what it is we have to look for before we go in and try to look for it and that's the reasoning behind the leader group philosophy plus, quite honestly, it's the best thing you can do to

Pete DeRosa

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determine how those joints are actually behaving in service.

One other point that must be made clear is what is the consequence of that joint being unacceptable or becoming unacceptable during the service life. Yesterday we had a viewgraph like this up on the board which showed you that the [

] a,c,e I didn't emphasize it at that time. Now I think it deserves its time.

What that does, that was put there intentionally and the reason it was put there was to ~~insure~~ provide as best as we can in the design a leak before break situation should the [ ] a,c,e material become degraded as a result of service life. That distance is well over one diameter of the tube and it is a distance that we feel should that tube, even if that tube should break and the sleeve be intact, that sleeve would hold the tube in a position from going far enough up to separate the tube from the sleeve.

Pete DeRosa

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This morning before I came here I went to my office and very quickly picked up an [ ]a,c,e and, I am not going to try to explain what these three samples indicate. I just want to make my point. I don't know if it can be seen clearly enough. Here is the [ ]a,c,e

degrade 360 degrees. Just my engineering judgment says it won't do that. The first thing it will do, if anything, is it will develop a leak pattern; and you will notice that leak pattern just like you would any other leak that develops in the tube and you will be able to deal with it in a prescribed manner for dealing with leaks in an operating plant.

The other thing is should that tube for

Pete DeRosa

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one reason or another in this [ ] a,c,e,f sever itself, I can't imagine a situation where that would happen here, but if it did, it still would create a situation that was a leak and not a double ended rupture because the tube is captured in the sleeve. It's captured in a portion of the sleeve that has not seen heat, has not seen [ ] a,c,e and is literally just capturing that tube. I don't think that point was brought out yesterday in sufficient detail.

Those are really the points I wanted to bring up. I don't think they were brought up yesterday and I don't know if it has answered some of your questions before they were asked, but now I feel a little bit more comfortable with the information you have been provided.

DR. WEGST: I had a question. Your sampling procedure assumes that all of the sleeves or each lot of [ ] a,c,e sleeves is random and is similar to each previous lot of [ ] a,c,e sleeves. As I understood it, in some of the material that was handed out, you

Pete DeRosa

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plan to prepare the sleeves in lots of [ ]a,c,e before they are installed. What kind of quality assurance program do you have to inspect the sleeves before they are put in to assure that, in fact, each lot of [ ]a,c,e is similar to the previous lot of [ ]a,c,e otherwise, your [ ]a,c,e inspection plan doesn't make sense.

MR. DE ROSA: The lots are really not being -- the sleeves are not really being prepared in lots of [ ]a,c,e They are being packed in lots of [ ]a,c,e They are being manufactured in lots of many more than that, approximately, let's say, the capability to produce [ ]a,c,e a day.

The sleeves themselves undergo quality assurance and quality control check system with any others in the Section III pressure boundary. The sleeves themselves are [ ]a,c,e prior to being accepted. Dimensionally sleeves are verified, the

[ ]a,c,e

Pete DeRosa

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DR. WEGST: This is the [ ]a,c,e

MR. DE ROSA: Yes. There's a rigorous quality control program associated with the manufacture of this sleeve. Once the sleeve is manufactured, it's placed into a sealed container packed in boxes of approximately, I don't know, I think maybe in boxes of [ ]a,c,e brought to the site and placed in a control storage.

The groups of [ ]a,c,e that you are referring to are groups of [ ]a,c,e that are going to be released from storage to a quality control person who will then ~~insure~~ determine that only the proper sized sleeves get to the steam generator because those are the size sleeves they are operating on at that particular point in time.

So that the lot of [ ]a,c,e was more based upon a sample size, a lot size that provided us with the level of inspection we thought was reasonable and also it seemed to be consistent with what we felt would be done per shift; and the shift change became a good opportunity to bring the [ ]a,c,e equipment in to perform the { ace } examination.

Blaine asked me to make point of fact that the { } ace

MR. NOBLE: Question of clarification. When you are talking about this leader group, I think you were mentioning you were going to destructively examine something. I didn't catch what it was.

MR. DE ROSA: Once we pull these sleeves out, we are going to do everything we can to them both in terms of sectioning, in terms of

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pressure testing.

For instance, we may take a tube that has shown some -- we will take a leader tube out that has experienced secondary slide pressure on the sleeve, that has a hole placed in the tube. One thing we will do is we will take that tube and exercise it to a pressure we know it hasn't seen during operation but we know the load of pressure we would like it to see in order to establish a fact that we still have an acceptable margin in the joint.

Another thing we may do, and quite honestly, I don't think it's been laid out in a sequence of steps of how to make the most usefulness out of a single pulled tube, absolute, one from each steam generator or whatever, but the sequence of events may be we will take that tube and pressurize it to burst if it shows from the NDE that there may be a margin question. If it shows there is not a margin question, then I think we take that leader tube and rather than pressurize it to burst, because we

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can NDE, it has its integrity, pressurize it to a certain margin, be sure it can hold that margin and then section it and try to determine metallographically what is happening in the joint, if anything.

It's really an intent to say we will get as much information as is physically possible on the sleeve joint.

MR. NOBLE: With respect to the eddy current testing of the sleeve area itself, you are going to do some eddy current testing on the leader tube that you remove?

MR. DE ROSA: Yes. Well, the leader tube will be one of the tubes that gets eddy current inspected in the [ ] percent base line. Also make sure that it is one of the tubes that we [ ]a,c,e We will [ ]a,c,e that in addition to our sample.

MR. NOBLE: Is there a plan to further develop the eddy current examination of that area by putting in some defects of the type you might expect to calibrate your eddy current examination method of the sleeve area?

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MR. DE ROSA: Putting in some defects I might expect in the [ ]a,c,e

MR. NOBLE: [ ]a,c,e some different areas you might expect problems from the standpoint of corrosion, residual stress, geometrical discontinuity?

MR. DE ROSA: No. There are no plans to put any defects in the leader group. The thing we are trying to establish in the leader group, quite honestly, is what, if any, is the form of breakdown of the [ ]a,c,e

MR. NOBLE: I really wasn't speaking with reference to the leader group. I was talking more about a sample --

MR. DE ROSA: There certainly is going to be a continuing program with regard to the nondestructive examination of the tubes with eddy current. That's not going to stop. When we put the sleeves in -- I think Warren had got some very promising data with respect to equipment to detect what is happening in that sleeve tube and at those transitions and that will continue.

MR. NOBLE: All right.

MR. CURTIS: Can I make a further comment. When we talked about the lots of [ ]a,c,e and a successively diminishing sample size depending upon the success rate of the [ ]a,c,e in those lots of [ ]a,c,e I think one of the perceptions was that there is an inconsistency there because the process itself may be deteriorating over a time and as your sample sizes are deteriorating, therefore, you are not really accounting for that deterioration. I simply want to make the point or reemphasize the point that the [

]a,c,e

program. So that the process itself is being continually maintained at a level that meets or exceeds the acceptance criteria for the process. So that we are not in a mode where the process is being allowed to degrade or deteriorate while a sample

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size is also being allowed to degrade or deteriorate. We are continually calibrating and maintaining the calibration of the process at a rate which far exceeds the [ ]a,c,e lot in-service rate.

DR. EGAN: I think there is a major inconsistency between your statements on what you are going to do with the statistics and your sampling plan and I will try and explain the reason for my comment.

First of all, in the writeup your sampling plan does not end up with an estimate of the [ ]a,c,e,f that is going to be defective and that's the whole purpose of your sampling plan. You have written down equipment that says this is what we expect the probability of the failure of a tube to be in one year; and from that, with some assumptions, we can, therefore, estimate the quality that we need to have in the [ ]a,c,e,f to get a certain property of failure of the [ ]a,c,e,f The net result of your sampling scheme has to be some estimate of the probability of failure of

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the [ ]a,c,e after a period of one year, and I don't think that's what your sampling scheme does. I think you need to readdress that. I think also that having used the statistics, certainly the equation that describes the property of failure as a tube leak at the end of one year, you have to be very careful about the assumptions you put into that equation.

Specifically, you have two other parameters you are dealing with. One is the [ ]a,c,e integrity and the other is the [ ]a,c,e integrity, and you have only addressed the [ ]a,c,e integrity. It does have the impact on the probability of a tube leak. At the end of a period of one year you also make the assumption in here that the probability of the [ ]a,c,e leaking is independent of time. I think that's correct. A further point is that when you go to your lead the fleet exercise where you are going to penetrate the outer tube, I think it's a good idea but I think having used statistics in an equation to describe the failure, you have to go

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back and address the impact of what you are doing with a lead the fleet ones and if you do that, you find out, in fact, that now the probability that the tube is penetrated by crack within one year is one. You drilled a hole in it and if you put that into the equipment to prevent leaks in a year with the confidence level that you have acquired in the writeup, you have the probability of failure of the [ ]a,c,e four orders of magnitude lower than you are actually aiming for. So, I think you have to take a good hard look at your statistics and analyze the impact when you do the lead to fleet stuff.

MR. DE ROSA: I think, though, when you provide the leader, I think you can divorce that from the probability of -- from the sampling plan provided you are certain that you do and you do [ ]a,c,e to an acceptable level if that leader tube -- the leader philosophy is really an attempt to get a meaningful answer to the question "will a good [ ]a,c,e degrade as a result of the service conditions."?

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The sampling plan is an attempt to provide a level of condition in the proper control of the process and it's not really attempting to answer the question how long will it take a [ ]a,c,e,f to degrade.

DR. EGAN: I disagree with that. I think the whole purpose of your sampling plan is to estimate the probability of [ ]a,c,e,f That's the whole purpose of it. You are disputing in a sampling plan to assure yourself that the probability of [ ]a,c,e,f is sufficiently low that the calculation for the probability of tube leaks at the end of one year is the number that you are aiming for.

Incidentally, I think you have backed yourself into the corner with these statistics. You ought to take another look at those and figure out what you are doing if you look at the statistics. I think it's a lot easier to treat the problem another way than what you are doing here. I think your sampling plan is focused directly on estimating the probability of [ ]a,c,e,f That's what's for and you actually have two systems. You have the lead to

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fleet one and the others and the requirements for the lead to fleet ones is much too high by simple arithmetics. You need to readdress that.

MR. NOBLE: I wanted to make one comment with respect to the statement that was made. We were talking about the time that would be required to [ ] a,c,e examine one of these [ ] a,c,e I don't recall, something like [ ] a,c,e Practically speaking, I think the time is going to be longer than that by some significant amount because you have got to move from tube to tube. You have got other setup times and checkpoints to make. So, I guess I don't really think that [ ] a,c,e is going to be a realistic time to examine all these [ ] a,c,e I think it's going to be something longer than that, maybe by a factor of three or maybe even ten in some cases where there is equipment problems.

MR. DE-ROSA: That was, I think, what Warren was referring to, idealistically what it's taking him to [ ] a,c,e

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[ ]acef

A question was raised that [

]ace is kind of idealistic in terms of ignoring the fact that there is, first of all, an interpretation to be made. There is changing of a tool from one position to another. There is also the fact that there may be problems in the tool itself, and a realistic time is probably maybe two to three more times that.

MR. NOONAN: As a matter of procedure, I wonder if we can make the responses of Dr. Egan an open item.

MR. MOODY: I was going to ask Westinghouse as part of this discussion to identify whether or not they believe Dr. Egan's question about relooking at the statistics is something that can be addressed by Westinghouse during the course of the meeting today sometime.

MR. RAWLINS: I would like to caucus on that particular aspect before I give you an answer.

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MR. MOODY: Why don't we keep that as an open item, first open item today.

Are there other questions or comments of the Board?

MR. NOONAN: Just one minute. I think you might have said it yesterday but giving your last postulated condition where you fracture a tube at the braze and you said the tube is basically captured by the inner tube, that leak was developed there, is that any greater than the leak you normally expect in the equipment in the tubesheet?

MR. DE ROSA: Yes, depends on the mechanism of leakage. If I double end rupture in a brazed joint, double end rupture the tube, I don't -- I really can't give you a quantitative answer.

MR. NOONAN: In numbers that Westinghouse presented on other plans where you break the tube down in the tubesheet, the tube is still captured by the tubesheet, can't go very far, you get a leak. I think their numbers are probably very close to the

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same condition you spoke of.

MR. DE ROSA: I'm not familiar with those leak rates in the tubesheet.

MR. RAWLINS: I would ask if Dick or Doug might have that.

MR. MOODY: Dick, could you speak up; and let me remind people to identify themselves as they speak. Mr.

[redacted]

MR. MOODY: Why don't we carry that as an open item.

MR. DE ROSA: Any more questions?

MR. MOODY: Vince, is there anything else from the staff?

MR. NOONAN: I don't think so.

MR. MOODY: Before we leave this, I want to make sure Westinghouse and particuarly you, Pete, have a good understanding of Dr. Egan's question and point.

DR. EGAN: I think I could make some

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recommendations afterwards on how you should address that. If you look at the stream, if you go and inspect every [ ]a,c,e then the probability of [ ]a,c,e is not equal to zero. It's an assumed number defined by the uncertainty in the inspection scheme. You can define that with the sort of numbers with the test analyses that you are doing now. I think there is a way to do it. I think you have written it down probably.

MR. MOODY: Is there any other point of clarification you want to get from Dr. Egan?

MR. DE ROSA: I think I would like to discuss this with some of my colleagues and see how they perceive the problem before I ask for clarification.

MR. MOODY: All right.

MR. CURTIS: I would like to make a follow-up comment to Mr. Noble's statement. In the sampling plan versus the ideal, the 100 percent inspection, we have data on the [

]a,c,e

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to scan a --[

] On that basis, we are able to get about [ ] tubes inspected per shift with a normal bobbin type eddy current push-pull type of coil. You are talking about [ ] tubes per hour. So, there is a rather substantial difference in time.

MR. NOBLE: I expect there would be.

MR. CURTIS: The mechanical breakdown, all the other factors that go from this [ ] approach, even though it's been optimized quite considerably over the last several weeks, but it poses a monumental problem to try to expand the inspection program.

So to respond to your statement, I am simply saying that I would project maybe [to] tubes a shift would be the best you can get out of the [ ] process.

MR. MOODY: Pete, you will be involved in response to some of the eight open items from yesterday. From the point of logistics with Westinghouse,

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would you prefer at this point in time to get together with your colleagues on Dr. Egan's question and defer until later this morning the response to those open items or are you prepared to proceed with the response to the open items now?

MR. DE ROSA: Let's meet first. I prefer to meet first.

MR. MOODY: All right. Thank you.

One thing I want to do is pass out the open items from yesterday, and this is a summary statement of the open items and we will go over the answers to those later today. First, let's proceed with the agenda item seven, sleeving and plugging program.

MR. RAWLINS: This will be given by Dan Malinowski.

Why don't we take a ten minute break.

(Short recess taken.)

MR. MOODY: On the record. We will proceed with agenda item seven. We will endeavor to respond to the eight open items from yesterday's meeting

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that I have passed out now and the two open items already identified this morning a little later on in the presentation. We will proceed with the agenda now.

MR. RAWLINS: I would like to make a comment before Dan starts. One of the open items which was asked by Dr. Egan concerned item four on your listing, what percentage of sleeves will be [ ]a,c,e in sludge versus above the sludge and is the IGA attack at the top of the tubesheet due to geometry or sludge itself. I think Dan will attempt to answer that open item during his presentation here.

[redacted]: The topic again is the boundary of tubes that will be sleeved in the steam generators and the first thing I want to do now is show you the distribution of the RPC indications which were found in the second phase of the eddy current testing during the summer of this year.

You have color photographs in your handout of these and I will be using color photoheads to show these.

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What you basically see here are all the tubes that were tested, for instance. So, this is the actual sampling plan that was used to interrogate the area at the top of the tubesheet using the rotating pancake coil, and the key for these indication colors is given on top for steam generator A. The red indications are tubes that were tested and showed no evidence of any eddy current indication. Those indicated in yellow showed an indication but it was less than 50 percent, and those indicated in black are the tubes that had indications greater than 50 percent.

You will recall the pattern of tubes we showed yesterday for steam generator A, basically you have made this arc a little more continuous and thick and sealed in additional tubes along the base of the protractor shape that I described yesterday.

Note, there are some tubes in the center of the bundle but still the proportion of tubes found in here is lower than has been found in

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the region where the most intense population of tubes has been found.

In Steam generator B, you will recall there were only 60 tubes with indications. All of those were plugged before this testing was conducted. So on close inspection of these graphs you will see that there are, I guess, blue indications or at least another color, perhaps green -- you can't tell from this, the light is dim, I think it's green -- indicating where the original indications were and now the additional 176 that were found to be greater than 50 percent are indicated in black and they basically seen in the same sort of pattern that was found in steam generator A, and the testing across the center of B again shows a relatively low intensity in the center of the bundle; and note, none of the tubes on the outer perimeter show any indications.

The test program was developed originally as described from a variation in 100 kilohertz signals utilizing the bobbin probe where we just looked for

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something other than the normal signal expected when you saw the tubesheet at 100 kilohertz; and then, anytime an indication was found, there was an expansion of the program done. So, we bounded the area to reach the good tube on the other side of the last indication.

MR. NOBLE: What is TTS?

MR. MALINOWSKI: Top of tubesheet. Now, the category of plugging that's indicated here are the ones at the top of the tubesheet on the top and a few indicated by square colored marks which are additional tubes which are plugged for indications at the antivibration bar are above the tubesheet on the cold leg for, I guess, a total of four, I believe -- no, a total of six.

In 60 tubes [redacted] were plugged, were removed from service before this test was done --

MR. BERRY: Black squares?

MR. MALINOWSKI: Black squares. As noted in the early, first presentation, black squares are tubes that had been plugged in earlier inspections.

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Steam generator C, where the largest program of tubes to be tested was conducted, and the largest number of indications were found. That's due largely to the intensity of tubes found with indications right about here. The difference between this and A steam generator is largely that this population in here is much more dense in C steam generator than A steam generator. Remember, this is where the leaks occurred, row 11 and 12, right in here.

So, you can see all the tubes immediately around the area of the leakers had, in fact, been degraded substantially; but, again, the overall pattern indicates this protractor shape, perhaps not quite as extensive in the right-hand arc of the protractor but certainly very similar to A steam generator over here and here.

So that brings us to a point where we are now, having this data, we try to decide how to correlate this with the pattern for corrective action. The first thing we did was to note and, as we mentioned earlier, that the sludge pattern appeared

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to correlate fairly strongly with the distribution, at least in terms of its outline.

The topographic map here begins with one inch deep sludge on the outermost profile and as you move inward you are going to higher and higher values. What is pointed out here, because it's hard to read this kind of map, that there is a 20 inch area right around here and in the center of the bundle and then there are 15 inch areas right about there and about there and largely it descends pretty uniformly from those --

DR. GREEN: How is this determined?

MR. MALINOWSKI: Basically what we have done is take a pattern of tubes across the entire bundle and determine the sludge there from the eddy current measurements and then drew profiles connecting points of equal height.

These have been done both individually, so we can see which tubes have one inch sludge, which two, three, et cetera, until you reached the topmost depth and then if you superimpose all those,

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that's what you get. This shows the entire sludge pile, gives you some perspective as to how it varies.

DR. EGAN: Could you clarify for me, please, the statement where you said they seemed to correlate with the damage. It looks like the deep sludge is in the center.

MR. MALINOWSKI: I didn't say the height. I said the pattern correlated.

DR. EGAN: That is all I wanted.

MR. MALINOWSKI: Basically, remember, there were no indications found out here and there is no sludge out here, outer perimeter. We tested tubes outside the general protractor shape for indications and there were no indications out beyond this point; and when you look at the sludge data, you find the values for the sludge are zero out there.

DR. WEGST: On the other hand, you have a pile that's 20 inches deep right in the middle; whereas, in all three generators you have also no indications.

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MR. MALINOWSKI: There are varying intensities of indications but it's generally quite low for the center of the bundle.

The fact that you have some indications in here -- and remember, that the tube with the indication below the top of the tubesheet was right about in here, 1752, which says rather than pick out tubes to sleeve, individual tubes to sleeve, maybe you ought to sleeve the entire region within this area if it has detectable sludge. I'm sorry, not detectable sludge, whether or not it has an indication, as long as it's within the broad boundary of that, of the lines that would be described by connecting all the tubes that have indications.

Now, that brings us to the question about what's causing it, I guess, or does it relate to the top of the sheet geometrically as it related to the sludge location. Well, the fact is that all the indications that we have observed are under some depth of sludge, ~~whether it's~~ -- generally it's about four inches or better, that correlate with the

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actual finding of the indications.

If you are trying to superimpose those maps, they are not to the same scale, so it will be difficult to do it; but take some tubes and just look for the corresponding location on the topographical profiles, you will find after you get below about four inches of sludge, you don't find any more indications. I am not sure that -- I believe that that will be an absolute correlation in terms of a necessary depth, but it certainly is striking in terms of that's about where the indications that are detectable disappear or we stop finding them. The fact that there is sludge above the indications suggest that we need an amount of solid material on top of the tubesheet to form the locus where we can get the concentration of chemicals which produce the attack, in that quarter-inch band at the top of the tubesheet.

The kind of attack that we have seen, this intergranular corrosion appears to be, at best, very weakly, dependent upon the stress level of the

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tubing. So, it's not likely that we could associate some kind of mechanical disturbance at the top of the tubesheet with the existence of the attack; so without a very strong conviction as to what height it takes or whether or not there is an influence as you get to some magic height where it will stop being an influence to try to explain what happens in the center of the bundle, it appears that you do need something on top of the tubesheet, like the sludge, in order to give you the ability to dry out that region and accumulate the high concentration of chemicals which will be necessary to cause the attack on the Inconel.

The data that laboratory tests have generally developed, that anything that is very weak, and caustic is generally not effective in causing cracking of Inconel, has to be of substantial concentration, in the order of percent, before you get to get an attack of the tubing.

So I think I answered half, that optimistically our opinion is we need the sludge and

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we don't believe it's the -- a mechanical effect associated with the tubing at the top of the tubesheet because of the lack of dependence of stress for the intergranular corrosion.

That brings us to what the actual pattern should be for the sleeving, and basically I think I have already implied most of these. Any tube that has an indication of detectable degradation by the rotating pancake coil should either be sleeved or plugged. Any tube immediately adjacent to a tube which has a greater than 50 percent indication, whether or not it has an indication itself also should be repaired, sleeved? and then because it isn't clear exactly how much sludge you need and the fact that there is a lower density of tubes with indications in the center, it's not zero, we don't know exactly that these tubes will be indefinitely free from the attack if we can't change the entire situation with respect to the sludge accumulation and potential for concentration at the top of the tubesheet, then any tubes within the broad boundary you

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would form by connecting the tubes that have indications ought to be sleeved in the center of the bundle.

So what we wind up with, then, is a pattern which you saw a little bit of yesterday when we described the pressure testing, which shows this solid line which steps along the boundary. These are the tubes which would be -- this is the line which would encompass the tubes that ought to be repaired by the criteria I just stated.

Sleeved or plugged.

It does not incorporate row one. There ought to be a line across here. Where there are indications in row one, those tubes will be plugged if they can't get a sleeve into them. It's very difficult to get a sleeve in at that point but there are also very few indications in row one and there are none in the greater than 50 percent category.

The pattern shown here is shown also within the reach of the sleeving equipment, and you note that some of the tubes lie beyond the reach of the shortest sleeves in those corners and then you

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see the reach of the sleeves themselves in terms of their length; of the outermost boundary you can get only [ ]a,c,e sleeves into it.

This pattern of tubes represents the boundary for getting in [ ]a,c,e, and this boundary here for the [ ]a,c,e

Where a tube falls outside of the reach of the sleeving equipment but inside the boundary of the sleeving recommendation, those tubes would be plugged.

To give you an idea what effect this has on the bundle, the tubes that are within the boundary count, then you add them all together, to about 7,200 tubes, remembering that there have been tubes plugged in the center of the bundle for various reasons, including antivibration bar wear and some indications at the top of the tubesheet. Some of them are not available for sleeving. ~~so~~ There are 54 in A, 8 in B, and 17 in C. Tubes that have already been plugged as a result of the earlier operations during this outage include the 60 tubes in steam

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generator B; the initial phase of plugging that was done in steam generator A concentrated mostly on the cold leg but it effectively removes these tubes from availability for sleeving. These are the four tubes that were pulled in steam generator C.

Tubes that are in the pattern that should not be sleeved include tubes that were leakers, tubes that were removed, damaged in any way during the mechanical operations that were done to sample the tube bundle.

That leaves us the final bottom line with about 2,300 tubes for each steam generator. So we are talking about sleeving approximately 6,930 tubes by this count.

MR. HERBERT: May I ask a question at this point. In the presentation yesterday, I would like to go back to the four tubes on C that were pulled.

MR. MALINOWSKI: Yes.

MR. HERBERT: And tube number four in the presentation yesterday, R14C70 was selected because

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it had no RPC indication.

MR. MALINOWSKI: That's right.

MR. HERBERT: Yet in your report when you visually examined it after pulling, your report has indications of 40 to 50 percent.

MR. MALINOWSKI: That's right.

MR. HERBERT: In that.

MR. MALINOWSKI: That's right. There was a visible crack on that tube when it was removed from the steam generator.

MR. HERBERT: I am having difficulty with the premise that you are using the RPC as a criteria for selecting tubes for plugging, since here we have a situation where you have the same type of indications in the absence of these things.

MR. MALINOWSKI: That's why the general area in the center of the area is being plugged.

MR. HERBERT: You are going to plug as many as you can?

MR. MALINOWSKI: Sleeve as many as we can, all that we can in the center of the bundle whether

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or not they meet the criteria of the RPC indication or not; and we ~~take~~ took tubes farther toward the periphery in A steam generator, 2284 or 2283 where we showed the degradation on tubes which did not have RPC indications, ~~there were~~ WAS less than 50 percent at the very boundary of the pattern. So the idea is that, okay, we have ~~RPC indications~~, no RPC indication on tubes in the active zone but, in fact, it is corroded, corroded to 50 percent. We go to the boundary, again we have no RPC indication on the tubes that were pulled but at the boundary it's considerably less than 50 percent. The trend indicated, we can't pull tubes from further out, is that -- let me get the other graph up. That as you move away from the active zone, which is largely here, we were talking about tubes out here, there's a discernible decrease in the amount of degradation on tubes that were in here as compared to there and there is nothing found (no RPC indications) in any tubes out here which says that there is a trend toward improving integrity of the tubes as you head toward the periphery

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of the bundle.

Now, before we leave the questions of the tubes that are to be sleeved, the other half of that open item had to do with those that are in the sludge and not in the sludge; and it appears that we have about an equal distribution. About half the brazes are likely to be made above the sludge and the other half below the top of the sludge. All the tubes that are to be sleeved are within the sludge pile. Does that satisfy your question? You wanted to know how many were in and how many were out, I think. Half will be brazed above the sludge and half below it but all of them are within the sludge pile.

DR. EGAN: I don't know whether I understand actually what's going on. You have got a general correlation that says you have to have sludge to get the damage?

MR. MALINOWSKI: Yes.

DR. EGAN: We also have some uncertainty in what we are doing because we pull a tube with no

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indication on it and it has cracking. How many others at the extremity of the bundle, which are not under sludge, have you pulled that have no indication?

MR. MALINOWSKI: We have not pulled any of those out of there. Those are out of reach from the equipment to sample.

DR. EGAN: All right.

MR. MALINOWSKI: If you take the tubes that are on the perimeter and count them all up, you will get about 300 or 400 tubes all together beyond the boundary and you will find, at most, you will find one indication out of the three steam generators that might fit the peripheral zone definition; but what you find is that the probability of finding any indication is so different there from any region you might pick in the inside of that protractor shape that it's a fair assumption to make you don't have degradation that's beyond 50 percent, not that there is zero degradation. That's really the subject of the next slide.

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In The peripheral zone itself, testing was performed at least one tube beyond the last indication found in the pattern and the peripheral region was sampled on a four by four basis. Now, I ought to qualify that.

If the last indication was less than 20 percent, there is a chance it may not have been bounded but it appears there is only one case where that may have happened and that's in C steam generator. The results in the peripheral region, that is the region beyond the sleeving boundary, as I just indicated, are free from indications, certainly free from any ~~serious~~ large indications; and with the exception of one tube, totally free. This region corresponds, first, to a zone of much higher cooling fluid velocity across the top of the tubesheet. This is where the flow is coming from, it comes down, comes under the annulus and should have the most rapid velocity as it enters the bundle. So it would not be surprising that there would be no sludge there; and that is, in fact,

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what we find.

The corrosion observations on the peripheral tubes on these and other steam generators generally now, along in the past history, again show that there is a much lower degree or incidence of corrosion on tubes that are outside of the sludge covered zone than on those that are in the sludge covered zone. Given the absence of detectable indications and given that you will assume they are degraded to just under the plugging criteria anyway, 49 percent, and then extend that value over the life of the plant, you have an estimate of corrosion that's approximately four percent per year as compared to a number we calculated from the tubes in the center of the bundle where we are talking about 13 percent. That number ought to be conservative because we don't have any data that says there's any quantifiable corrosion at this stage. If we say they are all 49 percent and then say, all right, I'm going to go back and find if there is any distortions on any of these tubes, look at for the

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zero ~~rate~~ date which is less conservative than assuming that it started from the startup of the plant.

Some of this will be repetitive on that, but basically to put an overall perspective on the sense of operability of the plant, with the sleeving repair, leaving the peripheral tubes unrepaired, the tubes that are not being repaired are generally free from both bobbin probe and RPC probe, eddy current degradation; that is, anything that is quantifiable. Even if those tubes do have degradation as I have just stated, the tests of tubes with the degradation we have seen even to 50 percent on that 14/70 in C steam generator, show that the strength of those tubes is very close to what you'd expect from virgin tubing.

The first test on that tube gave a pressure of around 13,000 psi before burst and it burst axially, not along the crack orientation.

The peripheral zone and the low row area, that's row one, which is excluded from this map -- I'm sorry, from the sleeving repair -- are

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usually low corrosion zones because they generally correlate with better tubesheet velocities and have very little, if any, sludge found when you review the data for sludge distribution.

Again, remember that the sludge distribution does correspond fairly strongly with the location of the tubes that have exhibited detectable corrosion.

Now, in the unlikely event you do get tube leakage on tubes that are close to the boundary, that is, where there still is sludge, you could still on the basis of what we have seen from the testing that was done, pressure tests and examination for actual depth and character of the sludge present through those open holes after the tubes were removed, you could expect some reinforcement that might limit the leakage that might occur on that outer perimeter.

The examination of the tubes show that the damage (CORROSION?) that does occur occurs in an irregular pattern around the circumference of the tube and only

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rarely does it actually encompass 360 degrees. When it does, it still is going unevenly and you would expect you would breach the integrity of the tube at a small point rather than simultaneously sever the entire tube at that location.

Finally, even after all of this is done, a whole bundle hydro will be conducted to demonstrate the tubes, in fact, do have the requisite strength.

DR. WEGST: A couple of questions on that. The third one up from the bottom, I don't understand. I think I am missing something or I thought you said that around the boundary -- well, first you make the assumption or the statement that the sludge distribution correlates strongly with the location of the tube corrosion, then you said in the unlikely event of tube leakage on the boundary where there isn't very much sludge, if there is leakage, the sludge will stop it. I don't understand that.

MR. MALINOWSKI: Not stop it, limit it.

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In any case, we are talking here about less than about five inches of sludge close to the boundary as compared to anywhere from three on up to 23 as you go on in. What I am saying is right on the boundary you have four or five inches of sludge. That's what we have seen. After the boundary there are no more indications, but there could still be, you know, you presuppose you will get a leak on the tube right outside the boundary, there will be some sludge on that tube.

Those are the ones that are most likely to have some degradation as compared to the ones that are on the outermost periphery. That's why it shows that close to the boundary statement here.

Let me go back on the graph and show you what I am talking about. I guess the sludge map will be helpful, too.

Just to get an idea where we are here, this is the boundary that I am talking about, this solid line. Let's take a tube that might be in, say,

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about 85, column 85 and about row 23 area. That would be the boundary to see whether or not the sludge still exists at that point. Coming over here to about 85, you see there is still three or four inches of sludge at that point but we are outside the boundary of the tubes that are being sleeved.

The point there is these are more likely to have degradation on them because of the correlation with the sludge than these out here where there is no detectable sludge.

DR. WEGST: I have another problem. Leaving that one up, right in the center you have 20 inches of sludge.

MR. MALINOWSKI: Right.

DR. WEGST: And yet you look at your distributions, these pictures, and at least on two of them, right where you have got 20 inches of sludge, the testing distribution doesn't look any different than it does around the outside of the pictures where you have no sludge and I don't -- I just can't

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see the rationale for saying you should plug all the tubes in the center of the bundle and none of the tubes around the outside the bundle when you look at these pictures and the tubes in the center and the tubes around the outside look identical in terms of the test results.

MR. MALINOWSKI: The finding of no RPC indication on the tube, we mentioned a little bit earlier 14/70, which perhaps is not representative of that center bundle section, but it certainly ~~is a~~ has no RPC indication, I mean, a tube that has no RPC indication that's within the pattern of tubes to be sleeved and certainly within the actual geometrical distribution of the deep indications did, in fact, have 50 percent penetration when the tube was removed from the bundle. We could see the crack and it was measured by eddy current to be about 40 to 50 percent. We are assuming 50 percent for that purpose. That tube was then pressure tested and gave strength of 13,000 psi but that, by itself, if you were going to leave tubes that were not -- did

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not have any indications in service, you probably would be all right but the idea here is because we don't have the confidence that every one of them will be less than 50 percent, in the absence of a RPC indication, in the area where we have reason to believe that the attack could be occurring, we are going to sleeve all those tubes.

DR. GREEN: To further supplement that, in the center of the bundle we have that 20 inches high probably steam blanketing the temperature in that region in the center. It's very close to the primary temperature. In the outer periphery where there is little sludge, the temperature in the tube is close to the secondary side temperature, so it's a much more hostile environment in the middle even though the damage isn't there. It might be due to the steam (inaudible), so it's a more vulnerable region, middle of the bundle, than the other periphery.

DR. WEGST: Maybe I am nitpicking but you have got one tube that you took out of the center of

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the bundle, one tube out of all three?

MR. MALINOWSKI: A second one, 2060, taken from A.

DR. WEGST: You don't have any tubes from around the periphery because you can't pull those tubes, so you don't know what those look like?

MR. MALINOWSKI: Right.

DR. WEGST: Really the reason you are not sleeving the outer tubes is because you can't sleeve the outer tubes, not because of any of the indications about the sludge pile or the RPC measurements or anything else?

MR. MALINOWSKI: Granted that you can't reach those tubes with the sleeving technique that's available right now, but the question really is, given that, should they be sleeved when you can develop something, or is it safe to leave them out of sleeves? That's the question I am trying to answer, that it's still as safe to leave them unsleeved.

DR. WEGST: You don't know, that's what I am saying.

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MR. MALINOWSKI: Well, I don't know it from a physical examination of a tube, that's right; but if I take the pattern of tubes that is examined even in the center of the bundle, and I think you perhaps didn't state that case quite strongly enough about the distribution, if you isolate on this one, for example, you probably are ignoring findings in the center of the bundles in the others.

Take the three together, you find there is a substantial although lower than the active region, probability you can have some corrosion in that center of the bundle. If you compare that probability from the center of the bundle for all three with what's found in the outer perimeter for all three, you find there is a much lower probability on the outside than there is in the center, even though that's relatively low compared to what we found in the active zone, that, plus the argument from findings from all other cases where there have been sludge related activity in terms of corrosion.

I am talking about thinning above the

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top of the tubesheet at plants like Turkey Point and cracking that's occurred in plants like Robinson and Point Beach where we have actually seen those distributed in the same general region as the thinning and under the sludge pile by a couple of inches in general if it's that deep at that point.

DR. GREEN: There is another potential technique for defining the margin and that is to do thermal and hydraulic calculation with the actual sludge dimensions. Previous calculations I have seen have always been with a clean steam generator. If you actually took the distribution of sludge that existed there and used those dimensions and calculated the local flows and local qualities and then see what the pattern there is and you talked about the higher transverse velocities in the outer region keeps the sludge from forming, you think that affects it?

MR. MALINOWSKI: Those calculations have been done in the past.

DR. GREEN: With the actual sludge

Is This general knowledge

T&H Ds

dimensions?

MR. MALINOWSKI: What we did was measure velocities in an instrumented steam generator to predict and to confirm the productions.

DR. GREEN: I understand that's done with no sludge but here you have got 20 inches of sludge in the middle of the bundle. That would seriously change the geometry of the steam generator since if you did it with the actual dimensions, you could see what the quality is and the velocities are and see if that would influence the damage patterns in the boundary.

MR. MALINOWSKI: I guess I'm not familiar with whether or not there actually have been calculations done with that combination.

DR. GREEN: I would like to see that as some kind of response.

MR. MOODY: All right. Dan, can you restate the item as you believe it.

MR. MALINOWSKI: It appears the question is what is the difference between the flow velocities on the top of the tubesheet calculated with the sludge observed actually in place.

DR. GREEN: The local velocities and the local qualities using the dimensions corresponding to the actual sludge heights.

MR. MALINOWSKI: Yes. You take an actual sludge distribution, impose that on the tubesheet dimensions and then say what will be the velocities you would predict for this.

DR. GREEN: And the qualities.

MR. MALINOWSKI: Velocities and qualities, those are both predicted by the same calculation.

DR. EGAN: What is it that's going on between the sludge and the tubesheet that makes all the action happen there? What is the nature of that process and is there any adherence between the sludge and the tubesheet? What do you find in that region?

confusing

MR. MALINOWSKI: I don't know that we could answer the question. We can answer the question.

see next page.

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I don't know if we can answer it to your satisfaction.

The velocities, of course, at the top of the tubesheet are going to be zero. There is going to be no effective flow across there, so any accumulation of concentration of chemicals which should occur at the heat transfer surface of the tubing, would then have the potential for seeking out, perhaps by gravity, the lowest point of the top of the tubesheet at the bottom of the pile, basically either along the surface of the tube or just by diffusion in the porosities of the sludge matrix itself.

DR. EGAN: I think the reason for my question is I don't see any good reason why it should stop at the surface of the tubesheet. Why doesn't it keep going down the crevice?

MR. MALINOWSKI: Well --

DR. EGAN: Which comes back to my original point is where it's focused at the tubesheet. Why doesn't that, if that's a boiling phenomena, why doesn't that concentration of chemicals go down into the crevice in the tubesheet which, I guess, is

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done in some units?

c24 MR. MALINOWSKI: I would guess because of the fact that the unit is operated with phosphates from startup, we probably have a high probability that those crevices may be largely plugged with chemical deposit of or precipitated chemicals, combinations of ~~erosion~~ corrosion products.

DR. GREEN: But this plant has continued to operate on phosphate and he is saying it's probably baked in there very hard.

DR. EGAN: None of the chemicals get into that crevice.

DR. GREEN: It could be an expansion, an expansion of the tube, in the tubes that provide gap between the sludge and the face of the tubesheet. It's heating and cooling and may not be bonding as well and the crevice has no place to go, but above the tubesheet there is some space in between. So, that's the speculation, there is a crevice between the tube and the sludge above the tubesheet and between the sludge and the tubesheet itself because of the heating

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and cooling prevents it from bonding there, so there could be some gap right at that interface and provide --

DR. EGAN: No gap between the tube and tubesheet. I agree with that speculation.

DR. GREEN: That's a mechanism that explains the facts.

DR. WEGST: Isn't that observable when you pull a tube?

DR. GREEN: There is no intergranular attack in the tube~~,~~ tube ~~[illegible]~~ sheet crevice ~~but are~~ there is in other plants which operated initially on phosphate but switched to ~~a (inaudible)~~ AVT.

DR. WEGST: Isn't it speculation that the crevice is filled with phosphate? Isn't that verifiable by looking at it when you pull a tube? When you pull the tube out, can't you see if there is a deposit in there?

MR. MALINOWSKI: You would go back into the hole and try to remove the deposits.

DR. GREEN: He's not talking about reporting what they found.

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MR. MALINOWSKI: I am. John Wootten is going to be talking about that.

DR. GREEN: My recollection is there is phosphate.

MR. NOBLE: --I have a question. In the examination data that you showed on the B steam generator, there is an indication of some tubes that are listed as being plugged in 1968 due to above tubesheet and antivibration bar indications and those two blue squares are shown on the periphery there; and I guess it's not clear from what you have presented in terms of the inspection that was conducted and it's not clear there may not be others elsewhere in the generator, tubes that weren't completely inspected, so I guess I am wondering what have you done or what will you do to address the potential of other things or antivibration bar problems in steam generators.

MR. MALINOWSKI: Remember, that the eddy current inspection plan originally included a large sampling of tubes for U-bends with all the eddy

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current indications associated with it and antivibration bars were, in fact, found. When we find an indication that's above 50 percent, the program is expanded around that tube to make sure there are not additional ones adjacent to it; and then anything that's actually above 50 percent is plugged.

In addition to that, when all, all the eddy current indications found at the antivibration bars are reviewed to (inaudible) compare their signals with what was found the last time the tubes were inspected and calculate the overall change rate, what we found is that there is no significant change in those indications on an average basis.

Now, remembering that we have an error associated with the eddy current measurement that allows for tubes which were less than 50 percent last year to look like they are greater than 50 percent this year and still not have changed.

MR. NOBLE: Is that the case in these two particular tubes?

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MR. MALINOWSKI: I don't have the numbers in my head. I can check that but there were no antivibration bar indications that were very far beyond 50 percent. I don't know what the actual difference between the two consecutive inspections was.

MR. NOBLE: What percentage of the tubes in the steam generators were inspected?

MR. MALINOWSKI: Well, first of all, it's 100 percent of the hot leg tubes were inspected to the first support plate, then a substantial fraction, which would be in excess of 10 percent, I think, through the antivibration bars and then another fraction which, if they were not already included in the antivibration bars, were inspected to the sixth support plate to fill out this denting evaluation, which basically concentrated on regions around the perimeter like that, where there had been some observations of restrictions of tubing associated with denting.

MR. CURTIS: Let me amplify on that. Since we made the antivibration bar modification in the 1976-1977 outage and since that time we have conducted, I think, about four eddy current programs to address not only antivibration bars but also the denting problem; and whatever we inspect, we are governed by our technical specifications which, in fact, required that, A, we select on the AVB's mounted to their status; B, we select on the denting tubes mounted on their status; and C, in addition to that, we do a reg guide 1.83 type inspection where we look at -- set that population aside and do a 3 percent examination and expand accordingly.

We have done that and we have demonstrated in that process that the AVB degradation is not occurring, it's not continuing. In fact, there haven't been any new tubes added to the population of AVB wear. Some of the individual tubes, I think as Dan mentioned yesterday, have entered a pluggable category, more than likely based upon the statistics of the eddy current examination process as opposed to any real wear. The issue is not one to be concerned about.

MR. MALINOWSKI: These discussions are basically addressing the adequacy of the bobbin probe inspection and is there a connection that you are trying to make with the sleeving process?

MR. NOBLE: No. I guess I am just trying to make sure there isn't some other area of tubing that might potentially leak. It looks to me like there are several areas that were plugged, pluggable on the B steam generator even away from the periphery. There are several other blue squares there. I don't know, I guess I'm not as convinced as you are. I haven't seen all the data that you have but just from what I am seeing here on these color charts, I am not as convinced that there isn't something going on with respect to those antivibration areas.

MR. CURTIS: Those tubes were plugged before we made the AVB modification. They were the result of original AVB design. The tubes were then plugged, the repairs were made, we monitored.

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In fact, we did the first two examinations were 100 percent examinations of every tube that was in contact with the AVB, that's every tube above row 14.

MR. NOBLE: The color code says plus 680.

MR. MALINOWSKI: That's just a limited number of tubes in there. There is one here, here, here, here, here, and here. There are some thinning on the cold leg side of the bundle above the top of the tubesheet. That's what these -- this one, for example, although it could be an antivibration bar -- I'd have to check the actual indication, but those tubes are tubes which are being plugged where they can't be repaired by sleeving. The repair process when you find degradation, whether antivibration on the cold leg, the support plate or from denting, is to plug the tube and do enough inspection to verify you haven't got a systematic problem elsewhere which is going to cause you damage that you could have anticipated, that you could anticipate.

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MR. NOBLE: My concern is the number of these incidences seem high here, perhaps higher than just what would result from going from 48 to 51 percent in terms of eddy current verification.

MR. MALINOWSKI: You think seven tubes is a high frequency, five, six or seven? That's not an unusual finding.

MR. NOBLE: I don't know your population. How large a population of tubes is it you are following in this respect?

MR. MALINOWSKI: In the Hot leg, we tested all of them.

MR. NOBLE: I mean tubes that have --

MR. CURTIS: I think there's been four examinations. The first AVB examination after the repairs, there was a base line done during the outage 1976-1977 of the repair. We did -- we operated for some six or seven vector full power months (inaudible) and did an examination September, 1977, and at that examination again we looked at every tube and contacted (inaudible) AVB. As I say, that's every tube

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above row 14, so there are some 2,500 or so tubes in that population.

We then looked at the statistics, growth rates, compared this September of 1977 against the base line and found no increase in degradation in that population, that's for all three steam generators.

We did another inspection in April of 1978, did the same type of examination, got the same kind of result.

We did another one in October of 1978, October, 1978, refueling outage, same kind of examination, no change in the growth rate.

Each one of these findings, incidentally, was backed up by the ~~results of~~ reports to the Commission.

Then, finally at this outage we did not do every tube (inaudible) through the U-bend above row 14 but every tube that had a AVB indication of any kind.

MR. NOBLE: Do you know what that population is?

MR. MALINOWSKI: If you look in the

presentation from yesterday morning, the one I gave out, there is a number of indications that are greater than 20 percent, are listed for each steam generator at the antivibration bar top of the tubesheet, hot leg and cold leg, in the crevices, tube problem because of prior restrictions, those categories are all given. That will give you an idea of the number of tubes with indications.

There are a greater number of tubes that were inspected. That's at least the number of tubes we are following as to prior degradation. That really was part of the overall background for the discussion; that is, it really wasn't the subject of the decision to sleeve the area at the top of the tubesheet, and we were giving that information just for reference.

MR. CURTIS: It's a point well taken. We would not have embarked on the sleeving program at all. You have to consider the more catastrophic option if there had been any doubt in our minds that the AVB problem had not been arrested, that the denting

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problem had not been arrested and the thinning problem hadn't been arrested.

We have a large data base that tells us that those problems are nonexistent. They are not of concern to us. Hence, we selected to go to the sleeving route. If there had been any doubt, we --

MR. NOBLE: Has there been some detailed examination of the eddy current patterns that try and ascertain in addition just to the statistics, as to whether or not there's been any change in the U patterns from one inspection?

MR. MALINOWSKI: Absolutely. That is exactly what I am talking about when we say we compared the degradation from year to year. This is a copy of the summary of inspection programs that's done for the steam generators. You will note that the total examined and everything that was unplugged, the inspection of these 400 to 600 tubes in each steam generator through the U-bend and then through the top support and in one steam generator there were 380

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tubes done to query the denting process.

This was further extended in C steam generator to the first support plate. Basically all the tubes plus the remainder of them were done through the U-bend but you add them up and you get the same number of tubes that were in the bundle.

The actual inspection versus the planned inspection, it's more extensive. Less extensive to the support plates in B because there was no denting in the support plates.

MR. MOODY: Is that the summary you provided yesterday?

MR. MALINOWSKI: That's the summary of the results yesterday. This is in our summary, of what tubes were inspected.

MR. MOODY: Could you append a copy of that to the slides that were used yesterday by you in open discussion?

MR. MALINOWSKI: Sure, we can.

MR. NOBLE: I guess maybe just to close this out, if we are only talking about seven or ten tubes out of a large population of tubes with degradation that you are following, I wouldn't be concerned because, I agree, that statistics may just bump some of them into the bundleable category.

MR. MALINOWSKI: If you look at the numbers at the top of the tubesheet that are not explainable on the basis of prior reports, you see there is a radically different situation to consider at the top of the tubesheet than anyplace else.

MR. NOBLE: But if the seven or ten tubes are statistically significant to your population, then there is a problem.

MR. MALINOWSKI: Well, first, you have to remember that we pick the tubes that ~~are bad~~ have indications for inspection. We are always biased to look at a higher percentage than it ought to be. Dr. Egan, I would like to come back to the sludge pile. I just realized that in response to Paul Herbert's question, you located a tube on the sludge diagram but the tube was in the C steam generator and the sludge pile is for A.

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MR. MALINOWSKI: Was that right?

DR. EGAN: Do you have the data, do you have the sludge maps for B and C?

MR. MALINOWSKI: We can provide those. They are available.

DR. EGAN: I would like to see those.

MR. MALINOWSKI: Sure.

MR. MOODY: Let's create an open item for that.

MR. HERBERT: Could I ask a question along that line also.

It's very difficult to tell from the sludge map here but do we have any sludge migration into the cold leg side?

MR. MALINOWSKI: Oh, yes. We haven't mapped that as extensively as we have done this. We can confirm that the sludge is there without any question. The actual distribution of it compared to something like this, we have not actually gone through the work of doing that.

MR. HERBERT: In your opinion do we have

a potential future problem profile?

MR. MALINOWSKI: We certainly have a potential for corrosion on the cold leg side of the bundles; and, in fact, we have corrosion in the sludge pile on the cold leg side of the bundle. It is basically the thinning variety as opposed to intergranular attack.

We did take one tube out from the cold leg and the indication found, the result was from thinning rather than intergranular attack.

MR. HERBERT: That will be part of the ongoing program and you will continue looking at that?

MR. MALINOWSKI: Yes. Anytime there is an indication that's greater than 20 percent reportable in an inspection, that, too, has to be reexamined in subsequent inspections; and as you recall, the numbers of tubes reported with indications is rather substantial in terms of several hundred for each steam generator, so they will all be followed.

MR. NOBLE: Will you be doing a RPC exam

on the cold leg side?

MR. MALINOWSKI: There was some done.

MR. NOBLE: In the future I am talking about.

MR. MALINOWSKI: That really is a question for Blaine.

MR. CURTIS: We don't intend to do any pancake probing of the cold leg section.

DR. EGAN: In anticipation of getting the sludge maps, is the extent of the sludge pile about the same in each steam generator?

MR. MALINOWSKI: It is.

DR. EGAN: Which steam generator do you use for shutdown cooling? Do you use one?

MR. CURTIS: All three. We don't isolate them.

Dr. Wegst, are you satisfied with your fundamental question?

MR. WEGST: No, but I will think about it some more.

MR. CURTIS: Let me see if I can restate

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where we are coming from. It's no coincidence that we are not sleeving the periphery and that we can't get sleeves in it. The option that we are faced with was -- there were a couple options we were faced with but the fundamental one was to sleeve those tubes that we could sleeve and plug the remainder. In this case it would represent something in the order of 30 percent plugging, which would, of course, be somewhat damaging in terms of power capabilities of the unit.

Not wanting to elect to be faced with that option, we considered a number of factors. We considered the results of the tube pulling operations, which even for the tubes in the center of the bundle, indicate you have no RPC indication, that you don't have degradation which is in excess of the structural, what I would call the design basis, if you will, of plugging, required plugging of all of the tubes -- in other words, tubes that are experiencing corrosion at the top of the tubesheet being that [illegible] wall degradation in excess

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of 50 percent before they should be taken out of service in consideration of the design basis axial quotings, so we find that any tube that has a (inaudible), that there is evidence by the pancake probe, there is sufficient body of evidence to say that tube is experiencing degradation less than 60 percent and, in fact, we feel on the periphery that evidence supports less than 50 percent, in our gross bundle, if you will, plugging limit for a degradation no matter where, it's location is 50 percent, then plugging limit is applied uniformly throughout the bundle.

In addition to that, as you will see later on, we are taking other steps. We are tightening up on some chemistry controls at the unit. As Dan mentioned, we feel insofar as the periphery is concerned there is the very fact that's a high flow area and we know that the sludge profile tapers off in that region and we also know that the intergranular attack is very much sensitive to temperature, gives us additional confidence that if there

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is attack out there, it's not progressing at a rate as in the interior of the bundle.

Superimpose upon that, there is a service inspection program we talk about later that we will continue to monitor that, the periphery of the bundle as well as the sleeved tubes, and that is -- I will tell you later, we are tightening, we are broadening, an additional margin to our primary to secondary leakage limits.

So I think when we talk about not sleeving the periphery, we don't want to point to any one basis for not sleeving the periphery. We have to look at all of the things we have considered and all of the things we are doing in terms of inspections, operating intervals, leakage limits, r25 et cetera, et cetera, to support that; and then beyond that, we have asked Westinghouse to continue with the development of the sleeving process for the peripheries. We actually expect within six months to a year that technique will be available.

So, as I say, in the event we find that

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the degradation on the periphery is intolerable, we will, in fact, sleeve those tubes as well.

I prefer to look at that picture or prefer you to look at it from a total package, all of the things that we are considering, all we have looked at, all we have been doing in view of what our options are.

Of course, another factor, as mentioned, was the corrosion rates. Even if you applied the most conservative rate of approximately 15 percent per year to the peripheral tubes, I think you will find that we are in a select operating interval that would not place those tubes into a category of exceeding the design basis of plugging those tubes. With all of these things in mind, that we are not intending to sleeve the periphery.

We don't want to leave the impression that we are comfortable or we are happy with what's going on in the periphery, we are just riding along. That's not the case.

MR. MOODY: Any other questions or comments

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from the Board?

DR. EGAN: I probably have to state, since this was related to an open item that I brought up, that I agree, that the facts indicate that the focus of the damage is caused by the sludge pile. However, in response to a comment from Dr. Green that, in fact, the reason why the attack is not progressing down into the tubesheet is that the crevice is filled, that means that your stress analysis model will focus the stresses right at the tubesheet. In fact, your stresses will peak in that area if the mechanism that he is talking about is operative. I think it's mostly the sludge pile. I'm not convinced the sludges are completely eliminated.

MR. MALINOWSKI: How about the magnitude of the stresses? I am not a stress analyst. I can't answer in terms of what they are. The degradation that's occurred appears not to have any strong correlation with the stress. When you get intergranular attack, you are generally talking about a corrosion that's occuring where there is no high stress as opposed

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to one where if there is any stress, you are going to get a crack in the same environment.

MR. MOODY: Dr. Egan, is the question you asked yesterday that we have noted here as open item four, was intended to be addressed now and I believe and perhaps as a result of Dr. Green's postulation, is there another concern that needs to be addressed?

DR. EGAN: I don't think so, no.

MR. NOBLE: There is some kind of an associated question with that. Perhaps it may be addressed in a somewhat later presentation but I would like to know what thought has been given to the potential for the corrosion damage to move up in the sludge pile above the tubesheet.

MR. MALINOWSKI: We thought some about that. One thing is if you do, indeed, assign the degradation to a continuing process over a number of years, it certainly had the opportunity to begin to progress up the bundle and it has not in all the tubes that we have pulled, it is limited to that quarter-inch band right at the top of the tubesheet. That's a total of about 13 or so odd tubes that have been examined in that region. There is no intergranular attack associated with any of the regions beyond that point up the tube.

The indications of thinning that have been indicated on several of those tubes before they were pulled were, indeed, that. They were found to be thinning. Some slight thinning is observed on most of the tubes that ware removed.

If it, indeed, is temperature dependent, the highest temperature is there at the top of the tubesheet or lower within the crevice. It ought to be cooling down as you go further up the tube, gradually, perhaps not any steep fashion, that you would say would satisfy you with a very comfortable feeling that it couldn't happen.

DR. GREEN: I would disagree. The test data indicate that you reach primary temperature one or two inches below the top of the sludge. It was not a gradual decrease in support of what he is saying

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the temperature.

MR. MALINOWSKI: I am talking about going above the top of the tubesheet up.

DR. GREEN: I am saying the same thing, it would stay pretty much the primary temperature up in the crevice, in that region between the tube and sludge presuming there is not much circulation up to about one to two inches below the top of the sludge. That's what the data shows.

MR. MALINOWSKI: As you go further up the tube, it will be gradually cooling down as heat transfer occurs.

DR. GREEN: Above the sludge?

MR. MALINOWSKI: You are saying the sludge is as good an insulator as the tubesheet.

DR. GREEN: One, two inches below the top of the sludge the temperature is close to the primary temperature. It won't be a gradual decrease of temperature. Fifteen inches of sludge up to maybe 13 inches it will be almost the primary temperature.

MR. MALINOWSKI: I guess I can't dispute

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that possibly but I guess the corrosion data itself tends not to correspond with it. It suggests there may be something missing in that analysis that says it's going to stay that hot.

MR. NOBLE: It seems to me in order to substantiate a theory that this is going to occur always predominantly at the top of the tubesheet, you have to have a model of the tubesheet, corrosion or concentrates stress in a particular way?

MR. MALINOWSKI: I don't think you have to concentrate stress, not when the attack you are seeing is apparently only at best weakly related to stress.

MR. NOBLE: I guess the thing bothering me, you haven't really discussed a coherent model for either cause.

DR. WEGST: Yes.

MR. HERBERT: The last statement of this kind of stress, I don't believe that can be made because we are talking about sludge contaminants, which at certain temperatures under certain stress conditions would predominantly attack the grain boundaries, which is what we see here. I am not convinced of the failure model yet myself.

MR. MALINOWSKI: There is no question the failures that occur when you do have stress dependence with caustic, for example, do occur in an intergranular fashion. Given that, you must have a corrosion concentration adequate to attack grain boundaries based on the observations we found here and the fact that the attack is largely generalized as opposed to focused in a crack, does suggest that the stress influence isn't an absolute necessity or at least not a high stress.

When I say weakly dependent, it may be that the stress there is very low and it takes that much anyway to get that attack going, but it's not such that it would get stress corrosion cracking.

DR. GREEN: Is there any connection it can be a galvanic effect between the proximity of the tubesheet and the tube itself, you know, current path is in that local region? Usually when you get some galvanic effect, it's very close to where two materials contact.

MR. MALINOWSKI: I'd have to look for help to answer that question. I don't know of any evidence of that.

MR. RAWLINS: Let me ask Al Klein if he can add anything to that.

MR. KLEIN: The only thing I want to state is that we have reviewed the test data where we exposed mill annealed to 600 to various concentrations of caustic at various stress levels and what we find at 600° F in 50 percent caustic, an intergranular attack whose rate is essentially what we have observed in the field, that is, about 10 or 12 percent true balance in one year.

Unfortunately the tests are not long term and one would have to make an assumption this rate would be linear with continuing time; but we do have supporting evidence that says that the intergranular attack is a function of caustic concentration, that the higher the concentration, the

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more likely that this occurs as opposed to stress corrosion, and that the attack rate is not inconsistent with the operations of the nondestructive tests.

DR. GREEN: Could it be aggravated by a galvanic attack with the tubesheet material, which would explain the attack right in that region? And, we go up the tube, so are there any tests run?

MR. KLEIN: We have performed a number of tests where the tubes are rolled into simulated tubesheets and that entire assembly immersed in caustic. The results generally support some protective effect of the tubesheet.

I can only report what the findings are, and those are the findings. Rather than a detrimental effect, we find some supporting evidence of some protective effect.

DR. WEGST: Isn't that what you predicted?

MR. BERRY: Generally speaking, galvanic corrosion at high temperature solutions is not very great. In the number of tests that we have conducted, you can measure a galvanic current but it's a very small amount; and then when you separate the specimens after the test and descale the individual specimens, they corrode as if they weren't coupled at all.

Now, in a very strong caustic solution, of course, these protective films aren't going to form quite as readily, so you might get some galvanic effect but, again, it could be that you could get protection from the steel or you could get activation from the steel. It depends on a number of factors.

Normally, Inconel is at the passive region in the reactivation polarization curve. If you couple it to steel, you could depress the potential where it would get into the active region. That may be part of the cracking effect that has been observed; but on the other hand, in caustic, Inconel probably assumes the potential that is not in the passive region. It may be in the no corrosion at all region, in other words, stable region, but that's further complicated by what impurities are in the system, which may raise the potention back up in the passive region.

Unless you made these measurements, it's almost impossible to say.

Generally speaking, I would expect some protection by the coupling to steel.

MR. CURTIS: I would like to add another observation, and that is, that every tube, I think almost without exception, that has an indication, positive indication of IGA at the top of the tubesheet is associated with a dented tubesheet; and the one tube that we pulled, row 17 column 52 in steam generator A that had the stress corrosion cracking down the crevice did not have a dent signal. The tube was not dented.

MR. HERBERT: How deep in the crevice was that?

MR. MALINOWSKI: About four inches, four to six inches down into the crevice. The experience of other units experiencing IGA in the tubesheet crevices is that those units do not have denting

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at the top of the tubesheet, so we have a mechanism right at the top of the tubesheet, i.e., denting process, that corrosion process which is serving as a concentrator, actually, I think taking that crevice from down in the tubesheet and moving it right to the top of the tubesheet and we have lots of evidence, I think, to support that it's true.

DR. EGAN: We don't have a stress analysis model that reflects that.

MR. MALINOWSKI: Pete DeRosa can answer that.

MR. DE ROSA: What was the question?

DR. EGAN: The mechanism depends on having the crevice in the tubesheet completely sealed so that whatever the contaminants are don't run down in there causing the IGA in the tubesheet. That means your stress analysis model before and after you put the sleeve in should be fixed at the edge inside of the tubesheet.

MR. DE ROSA: Emphasis on the analysis was transferring the loads into the sleeve. Tube model

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was fixed at the support plate. Loads would only be carried by the tube and not the sleeve. So an attempt to maximize the load that the sleeve was seeing, boundary condition was not imposed. Do you understand what I am saying?

DR. EGAN: Yes. But if you go back and look at the original system without the sleeve and you fix it at the tubesheet, you are going to have your peak stresses right there in that region.

MR. DE ROSA: On the tube?

DR. EGAN: Yes, in the tube, yes. Your stress, as I see numbers like 18 and so on, they are nowhere near the desired allowables which are to prevent bursting but they are sufficient to give you a stress corrosion crack if you have got that environment.

MR. DE ROSA: Some of the tubes that have seen the attack do not have the dent on top. 14/70, that tube we discussed earlier, had a perfectly normal tubesheet signal.

DR. EGAN: It doesn't have to have a dent.

It only has to be rigidly fixed in there.

MR. DE ROSA: It might be pertinent to the discussion of how can you plug the top of the tubesheet if you do get a dent, that does mean you have accumulated a degree of magnetite right at the top of the tubesheet, between the tube and the tubesheet.

DR. GREEN: It reacts to the magnetite. How would that affect the galvanic effect if there is magnetite present?

MR. MOODY: I believe that is one of the open items we are going to get into later on this morning. That is open item seven.

The question of Mr. Noble, some information concerning past inspections was provided, a table from an earlier submittal from the 1980 refueling outage, I would ask you, Dan, to append that to your handouts from yesterday's presentation.

MR. MALINOWSKI: I have copies of that for the Board now.

DR. GREEN: Correction, please. My question item number seven, primary side. The question I just raised was the presence of magnetite on the secondary side, that would contribute to possible galvanic action. If you have the Inconel and carbon steel plus the magnetite present, could that change possibly the galvanic action causing the localized attack in that region?

MR. BERRY: You are going to get the same answer.

MR. MOODY: Why don't we, when we get to that item, we will revise that item to address both primary and secondary side crevice.

MR. MALINOWSKI: There are other questions?

MR. MOODY: Any more comments by the Board?

MR. NOONAN: One comment I would like to make. This discussion talked about the sludge pile. We have looked at a number of generators where we see significant intergranular attack down into the tubesheet. In these particular generators we could not see that occurring. It's all occurring at the top of the tubesheet or higher.

There is another generator, another utility that is running its generators on phosphate at low control and you see just the reverse picture of what you see here. You see significant attack down in the tubesheet, some attack occurring above the tubesheet but small compared to what you see here.

DR. EGAN: Does that have the same operational time?

MR. NOONAN: Little bit shorter but not much shorter. Not much different. The bottom line is, at least to the NRC staff, we are still feeling we really don't know what the cause is other than what maybe Mr. Curtis brought up about denting occurring and the only real difference might be seen here compared to the other generators we have looked at. We are just not sure, to be very honest about it. We don't know the answer to that.

I would like you to go back to either your second to the last slide or your last slide where you had a list of items.

MR. MALINOWSKI: This?

MR. NOONAN: Go back a little more, the one where you talked about these sludge pile and leakage rate.

MR. MALINOWSKI: That o ne?

MR. NOONAN: Third item from the bottom.

MR. MALINOWSKI: In the unlikely event of the tube leakage on tubes close to the boundary, some reinforcement can be expected from the sludge limiting leakage.

MR. NOONAN: That might give you a warm feeling but as far as the staff is concerned, we are not about to be giving credit for sludge with leakage.

MR. MALINOWSKI: It doesn't. It applies only to those tubes that are closest to the boundary where there is actually sludge present; and, again, that is not an area we could interrogate through the tube hole examination to verify, for example, that those are -- that is a hard sludge pile, but there

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is no reason for us to believe that it is different from what's in the reference.

MR. NOONAN: I know what you are trying to do. I am trying to point out I don't want to get involved in the discussion as to credibility of that statement.

MR. MOODY: For the record, will you indicate whether or not there is anything in the sleeving design or process that is based on any credit for that?

MR. MALINOWSKI: No, there is nothing in the sleeving process that utilizes that at all.

MR. MOODY: So it's an observation?

MR. MALINOWSKI: We have only used it in connection with the reasons why the leakage rates were low on the -- in place (inaudible) of those five leaking tubes.

MR. NOONAN: Nothing to do with your sleeving program?

MR. MALINOWSKI: No.

MR. NOONAN: I don't like to see that

statement in there.

MR. MALINOWSKI: Is there anything else?

MR. MOODY: Are the sludge maps from the other steam generators present?

MR. MALINOWSKI: They can be provided.

MR. MOODY: Are they readily available that we can move into that now or would you need some more time to get those sludge maps?

MR. MALINOWSKI: I will need time to go get them. That's about what it takes. They are upstairs.

MR. MOODY: All right. It is now an open item, so why don't we, unless there are other comments from the staff, why don't we move on to agenda item eight and we will return to the sludge maps as an open item.

I will note on the open item list that was provided to everybody earlier, open items from yesterday's presentation, that there are two, one item, item eight, and one part of item one, specifically 1(e)

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which are intended to be addressed as part of this next presentation.

MR. RAWLINS: The presentation will be a summary of the systems chemistry operations given by Dr. Wootten, who is the manager of chemical operations in field development.

MR. NOONAN: Before we start that discussion, we can eliminate NRC questions five and six. That's been handled in discussion between Mr. Murphy and the Westinghouse people.

MR. MOODY: I would like to keep those as open items so that Pete DeRosa can come back and inform the Board, at least summarize the discussion between Mr. DeRosa and Mr. Murphy.

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Not on the record. Do we have any writing or other data to append to the transcript which will show the subject matter and results of the discussion?

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DR. WOOTTEN: Good morning.

As Mr. Rawlins said, I am John Wootten. I am manager of chemistry operations and field development.

My presentation this morning will include the following items. I would like to give a brief overview of the chemistry history in the recent years leading up to the April, 1980, outage. I will then discuss a proposed program that we have developed with the SCE personnel to remove contaminants and corrodants from the units and address the chemistry during subsequent operation.

Two open items that I was asked to address, 1(e), which is the removal of magnetite from the primary side, and also item number 8, which was the composition of the sludge simulant that was used in some of the corrosion tests. I would hope to address those during the course of the presentation. I will try and point them out at the point when I am addressing those questions.

I am going to be addressing the period

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since October, 1974, when the secondary side treatment was essentially phosphate 2.6 with phosphate concentrated in the range 5 to 10 ppm.

Review of the data, plant log data, et cetera, we can identify the ratios as low as 2.4 have been seen and in some cases, exceeding 3.0. I don't want to go into the physical chemistry of phosphate solutions at this point in time but just for the record and for the Board members who may not be sufficiently up on them, when you talk about ratios exceeding 3, you are talking about free caustic, so when you are talking about ratios 2.8 and above, you have got the possibility of free caustic occurring because of the solubility relationships in the way you get solids coming out of solutions that have different ratios in the solution itself leaving ratios higher than that in the solution.

When these deviations from 2.6 occurred during the operating life of the plant, corrective treatment by lower ratios of phosphate were added to bring the bulk ratio back up to the aimed at 2.6.

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Also during those times condenser maintenance was implemented.

The cause of fluctuations has been attributed to condenser leakage, seawater concentrations getting into the bulk stream generator solution. At times it has been identified that the pH of the steam generator bulk solution went down below 7 and in those points in time sodium hydroxide was added to it as a corrective treatment to bring the pH up to the operating pH's.

Evidence for the sea water in leakage can be gained by looking at chloride concentrations in the bulk solution chemistry of the steam generators. In 1974 and 1975 chloride concentrations between .3 and greater and .5 were present for greater than 90 percent of the operating time. The recent years, 1976, 1977 and 1978, the percentage of operating time has come down to between 78. It was levels of only 25 to 30 percent of the operating time. In 1979 through 1980, which is the last cycle of operation essentially, several occurrences of salt water in leakage at low

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leakage rates did occur and chloride levels have been spotted from the plant data ranging from .5 to 1.5 ppm.

During May and June of 1978 San Onofre was operating in a load follow operation. During that time fluctuations in the Marcy-Halstead ratio were observed. The Marcy-Halstead ratio is the phosphate ratio that is obtained by analytically measuring the phosphate concentration, measuring the pH and then looking back to a series of curves, you can pick up the sodium concentration, therefore, the sodium ratios.

There was significant time periods during that two month period when the ratio did exceed 3. It was very difficult to stabilize the water chemistry because of the load fluctuations, you were getting effects of hideout and hideout return occurring.

Hideout is the apparent loss of chemicals from the bulk solution depositing or reacting with chemicals in crevices and places of super heat causing an apparent loss of concentration in the bulk solution.

When you shut down, when you no longer have the super heat in the crevice, you tend to get

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hideout return, concentration of chemicals returning back to the bulk solution.

During the last cycle from October, 1979, through the shutdown in spring, 1980, the Marcy-Halstead ratio has slowly increased. During the first quarter of 1980 the average ratio was around 3.0 which was observed. The analytical ratio during those times is not so clear. The analytical ratio is actually the ratio of the analytical sodium values divided by the analytical phosphate values. Because of not so much data on the sodium, the analytical ratio is not quite so clear, although spikes of greater than 3 were seen.

When you get seawater leakage into a steam generator, seawater contains about 20,000 ppm chloride and about 12,000, I believe, ppm sodium, you obviously are introducing sodium into the general bulk, so an analytical ratio is not a clear indication and, therefore, the Marcy-Halstead ratio is a better one although if you take away the stoichiometric sodium associated with chloride analysis and the ratio in the Marcy-Halstead should become very close. We looked at

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the amount of chemicals that were added to the San Onofre unit 1 during 1979 to try and understand this upward trend in the Marcy-Halstead ratio. The chemical additions do not explain why that upward trend was occurring.

For example, in the first five months of that year when the ratio was reasonably close to 2.6, you can see that approximately 372 pounds of sodium were added to three steam generators at the equivalent phosphate ratio of 2.5. During the latter part of 1979 for the equivalent five-month period when the trend in the Marcy-Halstead was beginning to rise, coincidentally the same amount of sodium was added 372 here. 366 here, but a much lower sodium to phosphate ratio. This is what you would have expected, the ratios begin to rise, so the utility personnel do not have to add as much sodium to try and maintain the sodium to phosphate Marcy-Halstead ratio of 2.6 due to the phosphate.

I will try to explain why the trend is occurring. Possibilities exist that other agents such

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as calcium, potassium, lithium, were in the solution and were possibly not analyzed for or that some of the hardness elements may have gotten in; and I will be addressing that point in a couple of viewgraphs later.

I have talked a little bit about hideout and hideout return. I would like to make the point that shutdown and startup operations do release phosphate. You do get hideout return occurring.

In reviewing the data from several shutdowns and startups, you can make a statement that during shutdown you tend to get low ratio phosphates returning and during startup when you are ramming up in power, you tend to get high ratios returning. These high ratios were not controllable in some cases by blowdown alone and chemical treatment had to be incurred with monosodium phosphate to bring the bulk solution ratio back to the value of 2.6.

I think the evidence is there that this continuing hideout and hideout return certainly indicates that the steam generator crevices and the

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sludge continue to harbor some appreciable amount of phosphate chemicals.

In reviewing it, in examining a slide in the presentation, because I want to use the next slide when I address the open item number eight, which will be in a couple minutes time, in reviewing the chemistry operations, one fact came up that I'd like to address right now.

The plant startup of raw water source in San Clemente has changed in recent years. In earlier years of operation the makeup water source was seawater. Evaporated seawater was used for the makeup. A few years ago the raw water source changed from seawater to a fresh water, San Clemente city water, which comes from the Colorado and Feather Rivers. This water consists of an appreciable amount of hardness elements above that that is seen in seawater and the 1978 to 1980 analytical data on the constituents indicated an increase in the hardness of the makeup. This hardness of makeup is introduced, you could get precipitation of hardness with phosphate, which certain could lead to difficulties in control and increase in the hideout of the phosphate material.

MR. BERRY: Point of clarification. They added raw water without any evaporated water?

DR. WOOTTEN: No. The source of the makeup water was changed.

MR. BERRY: It still was evaporated?

DR. WOOTTEN: Certainly. Instead of evaporating seawater, they evaporated the fresh water.

I would like to summarize the history. I think I made most of these points, so I am not going to belabor this slide; but essentially a review of the operating plant chemistry shows evidence of free caustic exists in the bulk water. I didn't make the point during the presentation on the review but I did make the point that sodium hydroxide was added during low pH. That addition was stopped in 1979. Startup/shutdown/power operation chemistry cycled from low ratio to high ratio phosphates. I think I better change that. I said it the wrong way around. It's actually shutdown to startup cycle to high ratio

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phosphate. Phosphate inventories not removed during hideout return situations and condensor leakage, low rates, continued for a number of weeks. Make up water source changed to city water.

I would like to address open number eight now, which is the composition of the sludge simulant used in some of the corrosion tests and model boiler tests.

When the steam generators at San Onofre had sludge lanced, normal procedure is to take samples of the material that is removed and washed out during those operations. Those samples are filtered, solids are collected, portions of the solids are collected, transported back to Pittsburgh, and an analysis of the sludge carried out. In some cases the sludge and the filtrate from the sludges are kept and analyzed and I would like to report now some sludge analysis data over the periods of years 1975 through to 1980. This is not part of the handout. I can make it part of the handout if the chairman so desires.

MR. MOODY: Please.

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DR. WOOTTEN: All right. The point I am making on these slides is that if you imagine the sludge lancing operations, you are pushing water through the generators at a high rate of flow. You are dispensing solids. You are collecting solids. You will be very lucky if every solid analysis or every solid sample you collect, it was identical. You expect to get a wide variation in the particles and the particle sizes that you had for analysis.

The point I am making on these sludges is that the compositions of the sludges can be divided into several groups. You can see materials that you can identify as corrosion products from the feed train, condensor, et cetera. You can see corrosion products that are associated with parts of the steam generator. You can see materials that you can identify as being part of the water treatment, sodium phosphate, and you can also see materials that you can identify as coming from the condensor in leakage, such as seawater contaminants. You can see the copper, iron, nickel, zinc, these are all corrosion products. Zinc and copper can possibly be coming from the feed train materials. Sodium and phosphate can be associated with the water treatment. Sodium, phosphate, calcium, sulfur, possibly carbonates coming in from the seawater. So the conclusion could be made that the sludge consists of those or is made up of corrosion products, water treatment chemicals and contaminants introduced by condenser and leakage.

DR. GREEN: Basic copper or copper oxide?

DR. WOOTTEN: I believe in most of the cases that we have looked at with San Onofre sludge, the copper predominantly is copper metal.

A more recent set of analyses were performed on samples taken during the recent outage. These were actually not analyzed by Westinghouse. They were done in California by an independent laboratory and remarkably, the concentrations or the makeup of these sludges from three different steam generators are consistent for what you would expect for this type of examination.

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Again, you can see the major elements of corrosion product materials. You can see the major elements of corrosion product materials. You can see corrosion product materials coming from the feed train system. You can see the sodium to phosphate water treatment chemicals, whole host of other materials, and I think the question was made yesterday what about the mining materials included in some of these, they are relatively insignificant. I have included some of these.

So what we did, we do at Westinghouse to simulate sludge, we took the 1978 sludge data, because when these tests were started, that was the latest sludge analysis that we had on hand, and we took the 1978 sludge analysis, taking the predominant, major items, such as sodium phosphate, copper, iron oxide, magnesium oxide -- we used magnesium oxide itself -- nickel oxide and zinc oxide to give us a simulated sludge.

A corrosion test that Mr. Vaia described yesterday that was used had that type of material and

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materials were put together, ground up, mixed up very well and used as is.

In the model boiler tests we did one step further. We took that sludge, mixed it and ground it together. We put it in an autoclave and heated it up with a concentrated sodium phosphate solution to fossiltize it and then that sludge was taken out, dried, and packed into the sludge simulance that Mr. Vaia described yesterday in the model boiler tests.

Some of the tubes that were removed from San Onofre were brought back to Westinghouse and examined, metallographic examinations made on the tubes. We performed some SEM analysis on the fracture surfaces. If you remember, some of these tubes, when they were pulled out of the steam generator, they broke open and we thought here was a possibility of looking at the fracture surface to try and identify contaminants or possible corrodants existing on the fractured surface.

I would like to show two representative

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EDAX spectra looking at the fracture surface of one tube row 11 column 69.

You can see we have identified sodium and phosphate coming from water treatment chemicals. You can see we have identified sodium and phosphate

T-27 coming from water treatment chemicals. There is aluminum, silicon, titanium, chromium, nickel, nickel iron and chromium being the base metal of the Inconel 600. Aluminum and silica coming from seawater contaminants. Aluminum may have come from the holder of this specimen, which the specimen was held in.

This is the same tube, row 11, column 69 at a different angle around the fracture surface. Again, you see the Inconel 600 metal base, sodium, magnesium, silicon, sulfur, chloride, potassium, titanium, chromium, iron, nickel, elements that we have identified in the sludge as coming from the seawater contamination.

One final slide with regards to sludge, which is included in the handout, is that during the tube pulling operation, the recent tube pulling operation, we went into the tubesheet with a squeegee bottle of deionized water and tried to wash down from the hull remainings in the tubesheet and possibly some of the sludge of the tubesheet, trying to wash down some of the corrodants that may be existing, remaining in place. The droppings were collected, split into two and put into bottles and sent back and we analyzed these.

You see, that this is just addressed to the sodium to phosphate ratio initially. You see that the average sodium to phosphate ratio, you see from these six tubesheet whole deposits is 5.3. The ranging was from 2.9 to 18 in some cases, certainly indicative of caustic solution.

Identifying other elements that come from seawater, sulfate, 3.8 average ranging from less than 2.0 to approximately 12. Chloride we'd expect 14.6 average ranging from essentially 0 to 35. Potassium, magnesium, calcium and silica, less than 1.

I think the tube washings together with

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some of the EDAX analysis and the overview of some of the sludge analysis indicates that the sludge consists of corrosion products, water treatment chemicals, condensor leakage contaminants. Add that together with the review of the bulk water chemistry where we have shown that free caustic existed during some of the operation period, I think it's not inconsistent you can say the corrodant from these washings or these washings, it's not consistent to say the corrodant could be the caustic solution.

I would like to move on now and discuss the steam generator chemistry program that had been developed. The objective of this program is to reduce the concentration of the contaminants, corrodants which have led to corrosion of the steam generator tubes. We believe that these contaminants are contained within steam generated deposits in the sludge pile.

The program I am addressing today is designed to maximize the reduction in concentration of corrodant and provide buffering with 2.4 ratio sodium phosphate in localized regions of the tubesheet. This program is expected to reduce the potential for tube corrosion and the program essentially consists of three operations. These operations are cold water soaks, hot water soaks, and then a detailed chemistry as to ramping in power during the plant startup, which I will describe in detail.

Another operation which we believe may also be beneficial and which is presently under development is the depressurization technique to flush and burp things out of crevices. We have some programs going on at the present time that are addressing that program with specific reference to the San Onofre case, and this operation will be considered at a later time when we have optimum procedures for removal of contaminants.

MR. NOBLE: I am not clear on something. These procedures will be developed in time for use?

DR. WOOTTEN: At a later time. They are not proposed to be used at this point in time.

Cold water soak, we would recommend this

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take place at essentially 70 degrees. The rationale of this is that, as I mentioned earlier, a review of previous history during shutdown shows that you get a significant return of phosphates. So, this soak will be the first attempt to remove accessible soluble material. The time to soak is immediately following the completion of the sleeving operation when the steam generators are buttoned up, maybe other work is going on on the site. It's possible to fill the steam generator, soak it, fill it again. One of these soaks can be used at the same time as the secondary hydro is carried.

I believe Mr. Curtis will be addressing that in a later presentation.

The number of soaks we would do here, we state that we would do as many as we can, whatever is practicable prior to the hot soak. Essentially what we are going to do is fill the steam generator with pure water to cover the tube bundle, sample and analyze for a host of materials, for example, pH, conductivity, sodium, phosphate, chloride, silica.

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They will be analyzed on site. Samples will be kept and analyzed later for sulfate, potassium, magnesium, calcium, iron, copper, nickel, and lead.

The hot soak, it is recommended that this soak be carried out at a temperature range of 300 to 350 to 400° F. The rationale behind the hot soaks is that Westinghouse has a lot of data that was developed five or six years ago that shows that temperature range is the range for optimum solubility of sodium phosphate, the optimum temperature range for the release of phosphates from phosphate magnetite. I haven't mentioned that before but essentially magnetite will react with sodium phosphate solutions to give an iron phosphate and release of sodium hydroxide.

A large amount of laboratory testing and simulation was carried out at the same time. As I mentioned earlier where we had capsules of magnetita in autoclaves. We passed phosphate solutions through at various concentrations and various ratios. It was apparent that the molecular ratio of phosphate,

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sodium to phosphate, that reacted with the magentite, was about 2.13. So if you started with a phosphate ratio of 2.6, essentially a 2.13 ratio, it will be releasing or giving the ensuing solution going through as a higher ration than the 2.6 you started with.

If you go higher than 400 degrees, solubility drops off quite dramatically. So the higher the temperature within this range, you can expect the kinetics to be more favorable. We would expect hot soaks to have greater penetration than the first soaks. The procedure is essentially the same although in the hot soak, we would possibly fill the steam generators to a somewhat higher level than we would in the cold soaks. This, we believe, will give us a better circulation during convection, to have water going around the wrapper and pump through the bundle. We had heat 350 to 400 using pump heat and the soak would be planned to last for up to 48 hours in duration. We would follow the concentration increase. We'd analyze materials, as I described, for the cold soak. We would follow the concentration

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increase. If the concentration plateau was reached before the 48 hours, the soak would be terminated. When we got to the 48 hours, we would start to feed and bleed to a hundredth dilution to bring the sodium phosphate ratio down to low concentrations, 2 to 5 ppm, et cetera, with the sodium phosphate level less than 2.8.

When we had achieved that condition, we would proceed to plant startup. At plant startup we would heat to hot standby. It's not depicted on the viewgraph but we would anticipate that during that heatup we would be monitoring the chemistry very closely to watch for changes in concentration in the bulk solution, possible hideout return or loss of material during the heatup.

So, we'd heat to hot standby applying a maximum blowdown and monitor the chemistry as described earlier. We would hold until the blowdown chemistry is stabilized for at least 24 hours with a sodium phosphate ratio less than 2.8. We would then ramp to 25 percent power and hold for the

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chemistry stability as above. At this point in time I believe it would be possible to put the feed water onto what is termed miniflow, which is cycling the feed water back to the hot well and overburden, therefore, removing a large burden of the corrosion products from the feed train that may have been building up during the number of months of inoperation of this plant, getting those out of the system so they are not transported into the steam generator.

If you do start putting large burdens of corrosion products into the steam generator as I described earlier, the reaction of that with phosphate, any phosphate remaining could start developing undesirable caustic solutions. So we would propose to monitor transport of lead from the condensate feed water system until they were down to levels and we would go to full feed flow.

Again, it's not depicted on these viewgraphs but we would expect the condenser to be in good shape during the course of this operation, not to have high leakage rates.

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Once we got to 25 percent power, if we do not see any high ratio of phosphate hideout return, then we would do, commence a phosphate inspection to reach a 50 ppm phosphate in the bulk solution and sodium to phosphate ratio of 2.3 and to hold for at least 24 hours.

What we are doing here is we are trying to get a high concentration of a correct ratio phosphate into crevices, sludge piles, to buffer any remaining contaminants or high ratio phosphate that we have not yet removed.

We would then ramp to 50 percent, 75 percent and 100 percent power with at least a 24 hour hold on each of those ramping stations to maintain chemical stability. Once we had got to 100 percent power, the recommendation is to reduce the phosphate level to 20 ppm, with a range of 15 to 30 ppm and a target ratio of 2.4, and the limits on the ratio is 2.3 to 2.6. The tightening of the limits on the ratio, that would be determined using the Marcy-Halstead ratio, but independent checks on

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that should be made with the analytical ratio and subtracting the stoichiometric amount of sodium, that being calculated from the chloride values present.

That's fine. That's a fine procedure but the question should then be asked, what if at 25 percent power you get a high ratio phosphate returning. The procedure would then be modified somewhat. For example, if a high ratio phosphate return is observed at 25 percent power, we would continue blowdown and hold for chemistry stability for at least 24 hours. We would not add phosphate.

We would ramp to 50 percent power to establish whether hideout return occurred there. If it didn't, then we would add the phosphate at 2.3 ppm concentration at that power level.

If we still got hideout return occurring at 50 percent power, we would hold for 24 hours until the chemistry stability had been achieved and ramp up to 75 percent power.

We have seen during some startup that

there has been hideout return even when we get up as high as 75 percent power, so there is a possibility that some hideout return can exist.

We expect the hot soak will remove a large proportion of this material that would possibly return from hideout, but we have to have this precaution step in case we still get some hideout return occurring.

The aim, as I said, is to remove as much as possible the high ratio of phosphates or sodium hydroxide solution in the sludge pile.

So once we are up to 100 percent power, the phosphate concentration would be reduced to 20 ppm with the named sodium Marcy-Halstead ratio 2.4 with the range being 2.3 to 2.6.

I would like to address the other open item, item 1(e), which is what procedures are we developing to remove the magnetite that was introduced in the primary side during the decontamination operation.

It's my understanding that approximately

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20 pounds of magnetite was introduced in the primary side and because of the characteristics of that magnetite in the settling time, that magnetite is now located in a horizontal pipe just in from the channel head.

MR. CURTIS: I would like to add. Up to what point?

DR. WOOTTEN: Up 20 pounds of magnetite.

MR. BERRY: Based on material balance. Going in and coming out? Is that how you established the 20 pounds?

MR. CURTIS: Right, right.

DR. WOOTTEN: The first step in the removal of magnetite that was introduced in the primary side is to get as much of that magnetite out as is possible by either electromagnetic techiniques, putting a magnet in and magnetite is magnetic, getting as much out of it as possible by a magnetic technique, or in combination with a filtration recirculation system, which essentially is a vacuum type operation that will suck out the slurry of material, translate it through a

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number of filters and pump it back into where it came from; so it's a small circulation system that will filtrate the magnetite from the area that it's located.

When that is being done, and I talked about the people yesterday from the decontamination operation, it's possible that we may be able to rig up a small television camera identifying where it is and follow the operation by small television camera seeing how well we are doing that.

Once we have as much of that magnetite as we feel is possible to get out by this technique or a combination of those two techniques, we would start up then with one mix bed, resin charged with a new HOH charge. The CVCS filtration system would be operated with the HOH bed plus a 2 micron size filter at the end of the filtering system until the Westinghouse limits on suspended solids is met, which I believe in the present operation manual you have is 1 ppm solid.

DR. GREEN: Point of information. Is

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this done with pumps, the water through the whole primary circulator? I am not clear where that's being done. What is the piping arrangement?

DR. WOOTTEN: Yes, it's wholly circulated but it's channeled off to the CVCS cleanup.

DR. GREEN: Is it going through the steam generator and pumping it --

MR. CURTIS: No.

DR. GREEN: During this operation? Are you isolating it from the steam generator? I am not clear on the piping arrangement.

MR. CURTIS: It's feed to bleed operation at this point. We are not talking about -- this operation is going to be done at less than 150 degrees; therefore, we will not be operating dual pumps and feed and bleed type operation.

MR. MOODY: Dr. Green, do you want somebody to describe the piping?

DR. GREEN: How are you going to insure it doesn't get in?

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MR. CURTIS: I can't be sure. In fact, there is magnetite in the steam generator right now, reactor kiln -- let me rephrase my response. Reactor full operating continuous, they will be pumped, therefore, magnetite will be flushed through the steam generator. In fact, there is magnetite in the tubes, suspected magnetite in the steam generator right now as a result of the U-bend, as a result of the decone operation.

MR. NOONAN: Point of clarification. I still am not understanding what you are saying. Are you telling me that you are going to pump it through the core, through the reactor coolant pumps?

MR. MOODY: Why don't we treat that as an open item for the moment and we will return to that question if there is some question about ability to answer that right now.

MR. CURTIS: There is no question about ability to answer it. I was going to address it in some greater detail, maybe with the cleanup operation, where is the magnetite, bulk magnetite in the system

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right now. It's in the loop, hot leg of the B steam generator. That magnetite will be swept out by a wet vacuum system. Whatever residual magnetite there is might be on the order of a pound or so, will be swept out and purified by the CVCS system and it will include operating reactor pumps.

MR. MOODY: Describe that piping arrangement and that operation just briefly for Dr. Green.

DR. GREEN: You are not pumping, you are just --

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DR. WOOTTEN: That's the first operation standing. Initially the system is not buttoned up. A wet vacuum or in combination with an electromagnetic technique is used to get the majority of the magnetite out.

DR. GREEN: It's an open pipe?

DR. WOOTTEN: Right. Majority of that 20 pounds or up to 20 pounds of magnetite will be removed by that technique. The system is then buttoned up. Then the pumps are pumped to get up to

150 degrees and circulation through the whole system does occur, but it's bled off to the CVCS cleanup system.

DR. GREEN: Bleed off?

DR. WOOTTEN: Yes. It's the standard way. It goes to the CVCS cleanup system where the filtration and the demineralized beds and filters will take out any residual magnetite that may be left. I think I answered your question.

DR. GREEN: Right.

DR. WOOTTEN: The point is, as Mr. Curtis said, the cleanup is going to be prior to heatup above 150° F. The control rod drive mechanisms will not be operational and the RCP inspection is going to be operating at the time of the cleanup. We are going to follow the cleanup with regards to other impurities such as aluminum, silica and sodium because at this point in time we would also be cleaning up possibly any of the flux materials that may be dissolving, so that really does answer your question, there will be some translation to the steam generator. We would

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be cleaning up the sodium on the demineralized beds, feed and bleed, then we would bring this down to the limits that we would normally be operating at.

Primary chemistry during operation is essentially the same as what it was or has been during the years of operation. I don't want to dwell on that point.

We have received from the Edison people, Westinghouse has received from the Edison people a document outlinging in quite some detail the secondary side operation.

A few of the parameters that Westinghouse is recommending at this point in time that are somewhat different from the previous operation is the phosphate is going to be at a somewhat high level than the previous operation. The previous operation, as you remember, was 5 to 10 ppm phosphate. The recommendation here is to targetthe phosphate volume at 20 ppm and a range of 15 to 30. We would target the sodium to phosphate ratios at 2.4. From that you can mathematically calculate what the sodium analytical value would be

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assuming no condenser leakage occurring. You can also calculate the curve and calculate what the pH 25 then would be for this series of water treatment chemistry.

The chloride level we would offer as a guideline, which is based essentially on looking at the previous history of San Onofre and coming up with a value that we believe is obtainable with the system as it is as to go no higher than half a ppm of chloride. Obviously we should be shooting for as low a value as possible, but half a ppm we believe is attainable and take all certainly preventive actions, condenser checking, et cetera, should be carried out. Also make the recommendation that monitoring of the makeup water evaporator should be monitored closely and that a sampling schedule of the stored condesate should be maintained to preserve the quality of the condesate makeup. Those two items, I believe, are included in the San Onofre document we are doing right now.

That completes my presentation. If there are any questions we haven't answered --

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MR. BERRY: John, you mentioned, I think, in your first slide that you really had no effective hideout on pH prior to 1978?

DR. WOOTTEN: No, I don't think I said that.

MR. BERRY: That's what I understood. I may be wrong.

DR. WOOTTEN: My first slide, this is the one you are talking about? Sodium hydroxide was added.

DR. GREEN: You are attributing all these changes to seawater?

DR. WOOTTEN: No. I am saying times when the pH of the steam generator went below 7, normally you are operating around 9.46, but extreme cases where it went down below 7, sodium hydroxide was added. Other times the ratio of the sodium to phosphate, that was added to feed, the ratio was increased to a higher sodium ratio.

DR. GREEN: You do get a pH change just because of hideout?

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DR. WOOTTEN: Yes.

DR. GREEN: That is my point.

DR. WOOTTEN: That's correct, sure. And, in fact, the May, 1978, June, 1978, load fluctuation, the point I was trying to make, that the Edison personnel were trying to load follow that point because of the fluctuations in the load ramping down and going up again, you were getting hideout, hideout return. It was impossible to operate the sodium to phosphate concentrate value.

DR. GREEN: You were shoveling it in in large quantities. This San Clemente River water, you are thinking, of course, the impurities are carried over by entrainment?

DR. WOOTTEN: Possibly entrainment.

DR. GREEN: And, therefore, you would be getting primarily calcium type?

DR. WOOTTEN: Calcium, magnesium, hardness type elements.

DR. GREEN: Is it too late to perform the soaks before sleeving? If these are present, you are going to sleeve with these contaminants next to your tubes and you are going to braze under those conditions and I presume now everything is open, and it's too late to do that?

DR. WOOTTEN: Yes. Everything has been open, channel heads are open, the lead shields are in place. You'd have to go and plug all the tubes you pulled, water driving everywhere. It would be somewhat of a mess.

MR. CURTIS: Only one thing you can conceivably do if you accept the hypothesis that the generators are damaged, would be the cold soak because we certainly don't want to pressurize the primary system to heat the unit up to compensate the hot soak. That would be the only conceivable approach. I think of all of the flushes that are involved, that one accomplishes the least anyway. I don't see any strong incentive to go that route.

DR. GREEN: Then my final question that I have is, this hot soak that you are going to conduct for only 48 hours, I suspect that you are not going to go anywhere near, come to a steady state value in 48 hours. Dan Noble may want to make some more comments.

DR. WOOTTEN: I would like to make a comment.

DR. GREEN: Maybe he can't make a comment, I don't know.

DR. WOOTTEN: Let me just answer that question; and then, if Dan Noble wants to follow up, it's fine.

We have data from the field plants that have operated on phosphate, that have done a hot soak at that temperature. That indicates you do reach an equilibrium before 48 hours.

DR. GREEN: Is that right?

DR. WOOTTEN: Yes.

DR. GREEN: Do you have your comments, Dan?

MR. NOBLE: I don't recall.

DR. GREEN: (Inaudible) recommendation was you run it at 400° F Isothermal with the pump heat.

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MR. NOBLE: It seems it was longer than that.

DR. GREEN: Of course, you have got phosphate coming out of that system, out of that system for a number of months.

FROM THE FLOOR: Another variation in our process, it was low cycling. It went from 40 percent back to 25 or from 60 back 40.

DR. WOOTTEN: Let me make another point, Warren. We are not worried about phosphates per se. It's the high ratio phosphates we are worried about. That's why those slides, you saw less than 2.8. If we see 2.3, 2.4 ratio coming out, we just blowdown to reduce the concentration and stay with that ratio because we are going to be adding that same ratio later. 2.4 is coming out and we are going to put that back in, we are not going to spend a lot time removing stuff that we are going to put back in. What we are trying to get is the high ratio out.

DR. GREEN: Few questions. I am concerned with the corrosion test that you ran in the sludge you

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used. For example, you used copper. I would prefer copper oxide because that's the way the copper gets into the steam generator and is more reactive as a copper even though you found the copper, the copper oxide perhaps should have been added rather than the copper for the sludge simulant.

DR. WOOTTEN: Can I answer that question? I disagree. I agree with the statement that maybe the copper could be going in as copper oxide but we are talking about a sleeving process, we are talking about what's going to happen, the corrosion material at the place where the sleeves are being put in with what's adjacent to that tube right now. Adjacent to that tube right now is copper metal not copper oxide.

DR. GREEN: You don't think as you are proceeding when, in fact, 500 ppb of chloride coming in, there couldn't be some oxide?

DR. WOOTTEN: That's a different question. The design review --

DR. GREEN: I am saying --

DR. WOOTTEN: The corrosion we are

addressing right now is the sleeve in place with the sludge that's there right now. The sludge right now contains an element of copper. That's what is in the stimulant.

DR. GREEN: Don't you think during the course of operation the copper oxide gets into the annulus and perhaps today, right, it's copper but you are going to be running with 500 ppb of chloride, which, in that kind of feed train --

DR. WOOTTEN: Correction, maximum.

DR. GREEN: Maximum, I agree, but that level of chloride could, you know, add copper oxide to the system during the operation.

DR. WOOTTEN: Could you please amplify a little bit how does half a ppm add copper? I guess I don't understand.

DR. GREEN: There could be a corrosion in the feed train plus the oxygen could add copper oxide is coming into the steam generator. You would agree with that?

DR. WOOTTEN: Some form of copper into

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the steam generator.

DR. GREEN: In other steam generators with general entry into the steam generator but the copper that is found is generally copper oxide. That's the reason for my question.

DR. WOOTTEN: That's a statement.

DR. GREEN: I still think some tests should have been run with copper oxide.

Secondly, you found silica.

DR. WOOTTEN: I don't want to belabor this. We are trying to simulate the sludge. That was the point of the test, corrosion tests. We are trying to simulate the sludge. The sludge does not contain copper oxide. You can say maybe sodium carbonate is coming in and maybe you at one point in time found a little bit of sodium, do you put that in?

DR. GREEN: Do you find copper oxide gets to the annulus, it's exposed in the sleeve, it's going to be in the form of copper?

DR. WOOTTEN: I think predominantly the transport of copper to the area where the sleeve

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exists, it will be there as copper.

DR. GREEN: Secondly, you found silica in sulfate, I think in various forms in the sludge, in the solution. I don't recall but that was added to the material for the sludge and solution test. My recollection was it was caustic soda and chloride plus a sludge that didn't contain silica and sulfate. My concern, small quantities of those materials could be agressive and provide a more accurate evaluation of the sleeving.

DR. WOOTTEN: I hear what you say, Stanley. There is a whole host of materials that's contained in the sludge analysis. Some of them are near the chlorides and sulfates, like 200 ppm, 25 ppm, .0002. Where do you draw the line as to what you want to add?

What we took is what we felt were the major elements in the sludge that exist right now at the San Onofre unit and simulated that to the best of our ability.

DR. GREEN: In some theories silicate and sulfate could be important contributors to intergranular attack.

MR. MOODY: Dr. Green, do you believe that the levels of those elements that are identified as being present in the San Onofre sludge are in large enough quantities to be significant and should have been included in it?

DR. GREEN: I don't know. All I know, those materials, you know, have in other cases been aggressive. I'm not sure. All I am saying is you try to mockup as accurately as you can.

MR. BERRY: Two components that we would suspect, one would be lead, of course. You operate with lead all the time, so that may not give you a problem, but the fact that you heat this up to 1,950 -- when you braze, when you braze and, of course, 1,950, sulfur reacts with nickel. So, you might want to worry about that sulfur type compound, I think.

DR. WOOTTEN: I think Mr. Vaia addressed that when he looked at the burn-in of contaminants in

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45 the sludge, he didn't find any evidence.

MR. BERRY: He didn't have them. He didn't have sulfates and didn't have lead.

DR. EGAN: He didn't do any corrosion tests.

MR. BERRY: Those we suspect as being contributors to problems and I doubt if even a sulfate is stable at 1,950. It may be active enough to give you problems in reacting with the nickel alloy.

MR. KLEIN: Dr. Berry, may I interrupt. We did test tubes that were brazed in the actual San Onofre sludge. We analyzed the surface and we then probed for any diffusion of those elements into the metal. There were none.

MR. BERRY: You did have the San Onofre sludge?

MR. KLEIN: Yes.

MR. BERRY: Done in the steam generators?

MR. KLEIN: Yes.

DR. GREEN: I again am concerned about this .5 ppm max chloride you talk about for the secondary side operation. As I recall, Dan mentioned tests were run at .11 of chloride. That was an aggressive enough environment for your tests. Considering your specifications are much higher -- do you want --

DR. WOOTTEN: That's not a specification. That's a recommended maximum value. We believe that the Edison personnel will achieve values much less than that.

DR. GREEN: What's been the record of operation before shutdown? What were the averages?

DR. WOOTTEN: I showed some values up there ranging from .3 to .5 in the 1979 to 1980. I believe the maximum value seen was 1.5 ppm.

DR. GREEN: So that it's been operating at that. There is evidence that the sodium phosphate reacts with a magnetite depending on the sodium phosphate ratio. Is the 2.6 value been selected to optimize?

DR. WOOTTEN: What 2.6?

DR. GREEN: The value of the sodium to phosphate of 2.6, that ratio, you say, is you are trying to achieve that ratio?

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DR. WOOTTEN: I have to correct you. We are trying to achieve a ratio of 2.4.

DR. GREEN: Is that the ratio that was considered with your knowledge on the reaction with the magnetite?

DR. WOOTTEN: That was one of the things that was taken into consideration to recommend that ratio, yes.

MR. NOBLE: Trying to lower the sodium to phosphate ratio in the crevices, there is a potential for getting an acid phosphate condition, reactivating the thinning mechanism here. What kind of protection do we have against that happening?

DR. WOOTTEN: Could you explain that phenomena to me?

MR. NOBLE: Well, if you lower the sodium to phosphate ratio sufficiently, you will get into the thinning mechanism that we have previously described.

DR. WOOTTEN: I don't think the buffering action we are recommending ofa 2.3 ratio and 50 ppm

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phosphate will lower the ratio sufficiently low enough where thinning occurs. I think the history of thinning occurs, has been seen on plants that operated at low ratios. It was 2.18 to 2.3 when the thinning occurred previously in operating histories, so I don't believe that possibility exists.

MR. NOBLE: Well, again, the ratios in the crevices versus those in the bulk water are known not to be the same and I am just -- I think I have a concern there is a potential for overcorrecting in the crevices.

MR. MOODY: I don't want to -- we had some bad experience yesterday -- I think towards the end of the day -- about treating comments by the Board like that as in terms of concern. I think if there is a concern raised, that Westinghouse ought to address that and not necessarily agree with the concern, as I understand you don't, but provide a basis for that disagreement.

DR. WOOTTEN: Well, I think the situation exists where we believe you have a contaminant or a corrodant existing in the sludge pile that if you look at it from a sodium to phosphate point of view, it's a high ratio, it's a high ratio. What we are proposing here in this program is to go through a series of cold water soaks, a hot soak, which will then, which will address getting as much of that high ratio phosphate out as possible. When we ramp up to power, we would expect to see some hideout return possibly occurring still with flowdown until the bulk solution was within the specifications we recommend. We would then add --

DR. EGAN: Can I interrupt. Are you getting it out of the place we are interested in getting it out of, that is, the interface between the sludge pile and the tubesheet? It seems to me that's where the action is. What you are suggesting to do is not really going to get it out of there. You still have the sludge pile there.

DR. WOOTTEN: You still have the sludge pile there. We believe that there is a certain amount of communication between the sludge pile and

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the outside bulk solution. We would expect by that 48 hour soak to remove a large amount of that material.

DR. EGAN: I didn't see any flow conditions simply coming out and going back in here.

DR. WOOTTEN: There is blowdown occurring. There is a feed and bleed occurring.

DR. EGAN: You have a sludge pile sitting there.

DR. WOOTTEN: We have looked at -- digressing from the subject a little bit, we have had a contract with EPRI. Maybe Dr. Green can address this answer better than I can because he was the contract monitor on that.

T29 Looking at the confusion of material from crevices, for miscellaneous magnetite crevices and recalling the data, it appeared to me that there was a substantial amount of hideout return when you dropped from a load to a hot standby condition. That was focused primarily on cleaning crevices and dented region and support plates.

DR. WOOTTEN: That was focused on a support

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plate dented region that had a magnetite material that was possibly lower in porosity than what the sludge pile exists today; so if you can get hideout return from that type of deposit, I would expect you can get it better from a sludge pile.

DR. EGAN: I am questioning whether it comes out and goes right back out. You have no flow compared to the system where you are looking at around the support plate. You have this great 20 inch thick thing sitting over your tubesheet.

DR. WOOTTEN: No. It peaks at 20 inches. It's down to --

DR. EGAN: You have essentially no flow.

DR. WOOTTEN: I do have some flow. You have the cold water coming down the wrapper and circulating up through the bundle and it will be transversed through the sludge pile to a certain extent.

DR. EGAN: I don't believe we have any information that tells us that.

MR. CURTIS: We at Edison have viewed

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the flushing-soaking operation with some suspicion based on just that. What are we looking at? What is going on? What is it that we are going to see that's returning to solution? Is it going to be material from the crevices or is it going to be material from the sludge that does not necessarily impact the corrosion process? That applies certainly to the center region of the bundle. However, it does not necessarily apply to the peripheral tubes, and I think that the driving force for us to implement this program is to provide protection for the peripheral tubes more than anything else because there, we are certain that what we are getting out is that material right at the top of the tubesheet at least in the main.

So when we weighed it, we questioned the validity of doing that process; but, again, the peripheral tubes, I think, provide adequate incentive to do it.

DR. GREEN: Further, it has to help. You don't know how much is coming out from it right at the tubesheet or at the top but there is some diffusion. It's admittedly slow and the more you soak, the more you remove these agressive ingredients, it's going to help. You can't say exactly, is it going to come from the bottom or top; it all helps.

MR. CURTIS: In doing it and coming up with this 48 hour termination time, we considered these factors, where is it coming from. It's conceivable you can sit there ad infinitum soaking and bringing material out because of the sludge, presence of the sludge pile, and you have to consider there are limitations on makeup water availability, there are other primary plant constraints. This process is not as simple as it might sound. When you are sitting there at 250 degrees flushing and feeding and bleeding on the secondary side, you are also cooling down the primary side and it's not a continuous type process that you can readily achieve.

Do you follow what I am saying? We have weighed all of these factors and said San Onofre is unique with the sludge pile, let's give it the best shot.

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As Dr. Green indicated, it's got to provide some benefit.

DR. GREEN: Ideally you would like to do this depressurization which creates some artificial movement, but they are not ready to do that.

DR. EGAN: You have to sweep that across the tubesheet.

DR. GREEN: It's pretty clear diffusion through 18 inches of sludge is going to take a lot longer than 48 hours. It's pretty clear there could be some paths in between, between the interface, between the tubesheet and the sludge or in the annulus between the tubes; and if you get these communication paths, I think it's going to help. We don't know how much, though.

DR. WOOTTEN: I'd like to continue now addressing Mr. Noble's question. I think I was halfway through it.

I don't see how by soaking with a 2.3 ratio at 50 ppm and with phosphate, how you can achieve a ratio below that in the sludge pile. That value of

2.3, you know, we believe is sufficiently high enough that we will not be getting thinning occurring.

MR. BERRY: Dan, we are talking about soaking or talking about operation?

MR. NOBLE: I was talking about soaking potentially versus getting the higher phosphate ratio back in, you know, once they returned to normal operation, but I was more concerned about the soaking.

You have a pretty narrow window to operate in and you bias it on the high side, you get into stress corrosion; you bias it in the low, then you get on the thinning problem.

DR. WOOTTEN: That's why the final ratio, 3.2 to 3.6 ratio.

DR. GREEN: That's why I raised the question about the consideration with reaction to magnetite. There are a whole flock of potential reactions with magnetite at different temperatures, sodium to phosphate ratio right in the sludge region that alter. It's a pretty complicated area.

MR. NOBLE: It's awful difficult to tell

based on bulk chemistry what's happening in the crevices.

MR. MOODY: Are there other questions of the Board?

MR. HERBERT: I have another question but maybe it's not for this subject, although it is.

Part of the discussion was the in-place brazing tests that were run and the data collected from that to substantiate that there was no pickup of harmful materials in the Inconel. What zone in the tube bundel were these tests made? Were they in the zone where we have had the higher frequency of failures or were they in the central zone of that, where we had virtually no failures?

MR. CURTIS: They were the tests -- I don't have the row and column numbers, but they were done in steam generator C, I believe, and they were done under, right under the manways, which would place it essentially in the zone or near the zone where the leakers occurred.

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MR. MOODY: Paul, are you interested in the row and column numbers?

MR. HERBERT: I am interested in location, where these tests were made.

DR. WOOTTEN: Mr. Malinowski may be able to answer that question.

The question is when the brazing tests were carried out in the field, do you happen to know what the row and column number of those tubes were?

MR. MALINOWSKI: I identified three tubes that I thought were the ones.

MR. CURTIS: Why don't we get the correct numbers and not speculate, get the information. We have it.

MR. MALINOWSKI: If it wasn't 1043 and 1051 and 2580, then I don't know which ones they were.

MR. CURTIS: We can check with the field service people and get an answer.

MR. MOODY: Why don't we make it an

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open item until we get that.

Anything else from the Board.

One thing I want to clear up. Dr. Green pursued a line of questions in this chemistry area that principally dealt with the sludge makeup and --

DR. GREEN: And the solution.

MR. MOODY: And the solution and I guess, Dr. Green, I would like you to restate your view on the subject and I will either make it an open item or like so many other statements that we have taken in the last couple of days, Edison will take it under advisement but not create it as an open item that needs to be handled in the fashion of an open item.

Could you restate for the record in some summary fashion as Dr. Egan did earlier today what your view is relative to your line of questioning and the answers provided.

DR. GREEN: My opinion is that the testing did not adequately represent the aggressive environment that could be present during operation. In particular, some of the tests should have included

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copper oxide instead of copper. Some small amount of silica and sulfate should be included in the tests; and further, some of the tests should recognize that the chloride level in operation was higher than what was actually tested during the corrosion valuation tests.

MR. MOODY: All right. I guess I would like to make that an open item and it would be an open item for Westinghouse to express their view on the need for that and we needn't do that at this moment. If you want to note that as an open item and deliberate on it a bit and then we will return to that with the open items.

We had intended that open item 1(e) discuss magnetite cleaning of RCS, and open item 8 would be addressed by Dr. Wootten's discussion. Recognizing that I have created a new open item that relates to but is not the same as 8; Dr. Green, and, Dr. Herbert, I think you were the principal sponsor of open item 8, are you satisfied that open item 8 has been adddressed?

DR. GREEN: He addressed it and it was part of my previous comment.

MR. MOODY: That is why I say notwithstanding the fact it created a different open item.

Are any of the Board members interested in more information on what we call open item 1(e), discuss magnetite cleaning of RCS?

(No response.)

Do you have anything?

MR. HERBERT: Nothing further.

MR. NOONAN: I have a question on 1(e) but I can wait until Blaine gets up there because it will relate to that.

MR. MOODY: Why don't we take a break for about ten minutes. I guess my question relates as to whether or not you have any questions on Dr. Wootten as well and I thought the answer --

MR. NOONAN: The answer is no.

MR. MOODY: Except for 1(e)?

MR. NOONAN: 1(e) I have a question.

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(Short recess taken.)

MR. MOODY: Back on the record.

I want to make a procedural announcement and, that is, that everybody here today should sign in as they did yesterday back at the table and that can be done, I guess, on the way to lunch. We will plan on breaking for lunch hopefully after agenda item 9, initial operation, and questions thereto; but before we do that, I guess over the break it was pointed out to me the staff, in fact, does have a couple of questions on agenda item 8.

So would you like to address that, Vinc.

MR. CONRAD: You obviously have some specific recommendations on, say, the condenser, leak integrity, for example. You wouldn't want to operate at, say, five parts per million chloride indefinitely, so you probably must have some guidance on that.

DR. WOOTTEN: That is addressed in this document that Edison has transmitted to us and we are presently reviewing that. That is addressed in that document. I guess the comment I made earlier about the .5 ppm maximum, that's not a value that we are saying they should be running at .5 ppm, you understand. That's a level where they should be trying to get as low as, way below that value. That's a figure that we have identified looking at previous operation history, calculating that back to leak rates, that's a value that we think that action should be identified at that point in time.

MR. CONRAD: All right. But does it go into more specifics, how long and what levels and so on as trigger points to start doing something?

DR. WOOTTEN: I don't believe it does.

MR. CONRAD: I think that would be very desirable. In the case that the soaks don't reduce the phosphate ratio to your goal, what phosphate ratio are you willing to accept to go back into operation?

DR. WOOTTEN: I think the procedure says that it's going to achieve that goal because the procedure says to hold, to blowdown and hold for at least 24 hours until chemical stability has been achieved, which is the phosphate ratio we designed, so we will hold and blowdown until we get it.

MR. CONRAD: To get back to operation, you are probably all right while you are in operation and maintaining that low ratio but what if it becomes evident through startups and shutdowns there are fluctuations, that you are still getting a serious degree of hideout return? What triggers a renewal of the soaking procedure, for example?

DR. WOOTTEN: I'm not certain that that's a pertinent question in this discussion, but I think I should pursue it anyway because I think it becomes pertinent. I think the recommendation would be that any shutdown, you would perform a series of soaks and flushes, whether they are exactly the same or more. Depending on the experience we get from this first operation, this first procedure, we may recommend an extended, extended soak or combined with the overpressurization flush.

MR. CONRAD: Any shutdown to hot standby or cold shutdown?

DR. WOOTTEN: I think, again, that becomes a judgment call as to what happens. We can go through a whole scenario.

MR. CONRAD: That is part of the plan, to examine it as the case comes up?

DR. WOOTTEN: Yes.

MR. CONRAD: That's all.

MR. MOODY: All right. Why don't we proceed with item 9.

MR. CURTIS: My name is Blaine Curtis and I am here in the capacity as the Edison program manager for the steam generator sleeving program.

My involvement in the program goes back through and including the diagnostic phase of the steam generator inspection effort. What I want to talk about is are those conditions with the exception of the chemistry operations, that Dr. Wootten talked about, that we intend to apply during our startup operation and return to power, initial operation that bear directly

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upon the repair program effort. The areas that we want to talk about are, A, what is listed as hydrostatic testing prime in-service inspection program that we intend to propose, for continued operation, your initial operating period that we would intend to run prior to the first in-service inspection, and some information relative to revised primary to secondary side leakage limits.

As we all know from previous discussions, the peripheral tubes, although they have been subject to individual pressure tests and have been examined by rotating pancake coils as well as the bobbin coil, we have not been able to, because of the geometry of the primary side channel head, to remove any of those tubes to get any positive confirmation of what we believe to be the level of degradation in that region. So what we are proposing to do is during the process of startup, is to undergo a primary to secondary side hydrostatic pressure test, probably more accurately characterized as a leak test, and this would be done after the sleeving repair had been implemented and after an initial secondary side hydro had been accomplished to discern whether or not there are any leaking tubes, tubes that require plugging and so forth; and, of course, after the soaking operations and as a part of, in fact, the hot soaking operations that Dr. Wootten discussed and the motivation or the criteria for this test or the objective, I should say, is to provide a whole bundle integrity test.

We would be, in fact, testing not only the peripheral tubes, but we would also be testing the sleeve tubes and, in particular, we would be testing and challenging the integrity of the brazed joint and the rolled joint for those tubes which are in the leader-follower program, those that have been deliberately defective.

The process is simply to run the unit up with reactive kilohm temperature of approximately 400 degrees and then exercise the pressurizer heaters to drive the primary side pressure up to approximately operating values of about 2,100 pounds absolute. That would yield a secondary side pressure on the order of

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250 pounds and thereby achieve a primary to secondary side differential pressure of 1,900 pounds as compared to the normal operating differential of 1,300 pounds; and using this as a basis to provide, to demonstrate bundle integrity and margin to normal operating conditions and to at least get close to the differential pressures that you might expect to see in the event of a mainstream line break or a feed water line break.

As is indicated on the slide, we would then follow this primary side pressure test with an additional secondary side test and these tests are accomplished by filling the secondary side of the steam generators, pressurizing, using the auxiliary feed water system to a level of approximately 800 pounds while the primary side is depressurized and then pulling the manways open and checking for any leakage at the bottom of the tubesheet; and both of those operations would, in effect, accomplish two objections.

They would determine whether or not there were any leakers, primary to secondary leakage, secondary to primary leakage and would, in effect, provide some

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assurance under accident conditions, representative accident conditions in loss of steamline break and feed line break, there is adequate protection, integrity in the bundle. That would be performed during the startup operation.

In the next slide in your handout it simply indicates the flow diagram indicating the test logic.

As part of the overall package, if you will, to provide assurance that the sleeving repair effort does restore the units to their full integrity, provides adequate margin against all of the design bases conditions, we are including as an element of that program the in-service inspection program. This is intended to address both the sleeved and nonsleeved tubes in the generators.

The fundamental criterion is that in-service inspection utilizing eddy current techniques, that indications in excess of 50 percent on both the sleeved tubes and the nonsleeved tubes would be plugged.

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The first component of the in-service

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inspection program is the eddy current testing and, as Dr. Junker indicated yesterday, we plan to do a complete 100 percent baseline eddy current testing using the magnetically biased bobbin coil on the sleeve tubes prior to return to power.

We will take credit for the already existing eddy current data that we have on the bundle and we both in the periphery and in the other regions of the U-bends for those tubes that are sleeved.

At the first shutdown, that is to say, the first in-service inspection, we would plan to conduct an eddy current program again using the magnetically biased bobbin coil for the sleeved region and also we would use a push-pull hopefully pancake type coil for the peripheral tubes and we would inspect at a minimum three percent of the tubes in each of generators A, B, and C. The inspection criteria would conform to or be consistent with the guidelines of NRC Regulatory Guide 1.83. Dependent upon the results of those inspections, we would perform

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subsequent inspections consistent with the requirements of the Regulatory Guide 1.83 and our own technical specifications and we would expect, given successful results on this first interval, those would be conducted on normal refueling outages.

In addition to these eddy current testing, using -- and I would say these point out that these tests utilize essentially off-the-shelf technology, and keeping in mind that there is a developmental work underway at Westinghouse with respect to developing improved eddy current techniques for examination of the brazed region, in particular, and possibly ultrasonic techniques for that region, as a compensatory measure for the absence of those improved techniques, we would propose what we call a leader-follower program in which we would in each steam generator select four tubes that would be deliberately perforated at the tube sheet area to permit the ingress of aggressive contaminants. These are sleeved tubes and these would be earmarked for eventual removal in successive outages for in-service inspection.

As was previously indicated, a program would be established for metallurgical examination of tubes, eddy current testing of tubes, ultrasonic examination of tubes. The leader-follower concept would be that, as an example, on the first operating interval of these four tubes in each generator, we would select one tube from each of these four, no greater than four in each generator for initial examination at that time in simulation. We would pull those sleeves out of the generator and send them back to the Westinghouse laboratories for further nondestructive and destructive examination.

MR. NOBLE: Point of clarification here. How many of these leaders are you going to pull from the generators?

MR. CURTIS: We pull one at a time.

MR. NOBLE: Is it one per generator?

MR. CURTIS: One per generator.

MR. NOBLE: At the first outage?

MR. CURTIS: At the first.

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DR. WEGST: How many, how long? First outage you pull one, then what is your schedule for the next one?

MR. CURTIS: I would say that would be somewhat contingent upon the results of that first pull; but giving if things were going well, we would just plan to pull those successfully in each subsequent outage, one at a time.

The location, the selection of these leader tubes would be in the region most susceptible to IGA as has been identified in the diagnostic program.

In view of the sleeving program, the analytical work, the design work, test work that's been done, in view of the eddy current program, pressure testing program, tube removal efforts that led us to our conclusions relative to the condition of the peripheral tubes, we believe that there is sufficient technical basis to return the San Onofre unit 1 to full power operation at the conclusion of the sleeving program.

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We would propose that an operating period be established, an initial operation period be established of six months of effective full power operation, at the conclusion of which we would perform the in-service inspection which, I believe, has been previously described.

Some of the factors that bear on this operating interval are the corrosion rates that Mr. Malinowski has discussed; and if you applied the worst case of corrosion rate of the interior of the bundle at 15 percent per year, we can see for tubes on the periphery, assuming those are in the 40, 45 percent range, we would experience degradation which would not take them in excess of the established plugging limits within that six month operating interval. And similarly, for the sleeved tubes, if you apply the similar corrosion rate to the thermally treated Inconel sleeves, the 4 mills of penetration would correspond to roughly nine or ten percent through-wall penetration during that initial operating interval.

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So from the standpoint of tube degradation under projected worse case corrosion rates, there would be no infringement upon the plant safety margins for any of the tubes sleeved or unsleeved during that operating interval.

This approach is further justified, we believe, based upon the residual accident properties of the tubes as discussed earlier this morning and in yesterday's presentations. We have found in our first laboratory burst tests of tubes removed from San Onofre, that tubes which have experienced degradation at the top of the tubesheet in excess of 50 percent have, in fact, been able to withstand burst pressures on the order of, for the virgin material, 15,000 pounds, number one.

Number two, the failure mode is ductile failure as evidenced not only by the burst test, but by the specimens that were removed which were not subjected to the burst test but which were fractured on removal. I will refer you back to the slides that

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were presented yesterday for that.

Following the initial operating period of six months and the initial in-service inspection at that time, and, again, dependent upon the results of that inspection, we would propose to resume in-service inspections and operations at a normal refueling interval basis.

MR. NOBLE: What is normally the time between refuelings?

MR. CURTIS: Normally about 15 months.

For the benefit of the Board, I would like to point out that from the standpoint of the sleeving program and the steam generator problems that we are experiencing, we feel, we are confident that we can justify from the technical basis this type of an operating interval; but I would like to point out that there are external factors unrelated to the steam generator repair effort that may preclude us operating for that extent.

The obvious example would be the

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industry is faced with a requirement to implement Three Mile Island type modifications; and dependent upon the schedule for that implementation, then the requirements for a shutdown, this operating interval of six months could be something on the order of 30, 60, 90 days as opposed to the six months.

Given that that lesser operating interval occurs, I think the posture Edison would take would be to work with the staff, not only the NRC staff on the length of that interval obviously, but on the details of the inspection programs that would be conducted.

For example, it may not be based upon a 60 day operating interval prudent to remove all of the first group of leader tubes simply because they haven't been challenged in that environment for a sufficient time. So that what we are saying is that this would be reference program, the six months' operating interval.

Some leader program that's governed by

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external factors may require some modification or provocation of these principles.

As a final layer of conservatism, we propose to modify our primary to secondary leakage limits as presently established in the plant technical specifications as follows. Incidentally, those limits are right now .3 gpm in any one steam generator.

What we would do in the case of a sudden primary to secondary leak, we would apply a factor of three to those leakage rates and promptly bring the unit down for diagnosis and plug the effected tubes. Any primary to secondary leakage in excess of basically zero, if you were ramping up in our leak rate where we finally reach a 250 gallons a day threshold, we would require a shutdown. That would be a factor of two over the existing requirements of the plant technical specifications.

Finally, if we are at a level of 140 gpd and we get an excess of 15 gpd, upward trend in leak rate, we would again bring the unit down promptly for

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investigation and plug the effected tubes. Fifteen is a target value and it's basically that value we can measure with some confidence without any large statistical variation.

Second phase of the tightening up of the primary to secondary leakage limit would be that in the event that we did, of course, achieve our 430 gallons a day current expected limit, we would not only shut down for plugging, but would apply a comprehensive eddy current inspection program to the steam generators.

We feel that these operating measures provide added conservatism and provide, in addition to the other measures we are taking, would provide the necessary confidence and technical bases for being able to resume full operation at the unit for the intervals that I have stated.

MR. NOONAN: Let's have a point of clarification on that last slide. You talk about the 15 gpd per day.

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MR. CURTIS: Right.

MR. NOONAN: Can you clarify that? Is that based on one day's sample or how many days would you base that sample on in order to establish that rate?

MR. CURTIS: When we have detectable steam generator leakage, we are essentially monitoring leakage rates twice a shift is really what it boils down to. We get samples every four hours. That's a turnaround time. What that would mean on a gpd basic, there would be a sufficient data base in any given day to establish that, in fact, you had a trend in that day; but whatever the sampling period was, the data points to that, of course. If it were around .15 gpm based on the first sample, you'd want to take a second sample to confirm that; and if you did this, you'd go into this mode.

What I am trying to say is because you have already established that you have primary to secondary leakage, we are going to be on an accelerated program of sampling; and, therefore, with any one day interval, this trend would be manifested.

MR. NOONAN: It appears to be a very tight leakage rate increase and what I am wondering about, the accuracy of that rate based on a one day sample compared to two or three days' sample.

MR. CURTIS: Well, as I said, the 15 gpd is about the value that you can measure with some degree of certainty; and I think there is a matter of judgment applied to this, depending upon the data, the statistics involved, to determine what constitutes a measured increase or trend in primary to secondary leakage.

I would propose to refine the procedures for effecting that type of a criteria.

DR. EGAN: Do you have a plan for the distribution of your inspection at the first inspection period? Are you going to inspect three percent? Do you have a plan to focus in the worst region, peripheral?

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MR. CURTIS: The way I do Rule 1.83 and it, in fact, causes you to address those areas of known worse degradation and we would develop a sample which focuses on the area of greatest attack.

For example, in the periphery we would probably remove the pancake coil towards the peripheral boundary and then in the interior we would inspect the protractor region.

MR. NOBLE: Would you inspect up to the first support plate?

MR. CURTIS: Up to the first support plate.

MR. NOBLE: Point of clarification. I thought I heard you say something you are going to use the standard bobbin type coil in the areas that are sleeved but a different coil in the peripheral areas. I didn't quite catch that.

MR. CURTIS: The intent is to use in the periphery, to monitor the progression of the IGA attack for the unsl eaved tubes in the way

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we have done that through the surface.

MR. NOBLE: Rotating pancake?

MR. CURTIS: We would hope to have at that time a push-pull pancake multiple coil mounted on a single unit so you can speed up the process.

MR. NOBLE: Would your inspection plan include any sampling on the cold leg side?

MR. CURTIS: No. We did a rather extensive cold leg inspection and I didn't get a chance to look at the table but in excess of a thousand tubes, I think, on steam generator A and several hundred in B and C on the cold leg and we have found the thinning indications which were identified actually eight years or so ago have not substantially progressed.

We did a rotating pancake coil inspection of three percent of the tubes on A cold leg, I believe, this outage, and Mr. Malinowski presented those results.

We pulled one of those tubes and found no evidence whatsoever of IGA attack. We don't believe there's any basis for expending resources for a cold leg examination plus all of the evidence indicates that the phenomena is temperature sensitive and the threshold temperature is somewhat in excess of 575 degrees, so right now we don't have any reason to believe through other operating experience, our own experience in this diagnostic outage, that we have any cause for concern on the cold line.

MR. MOODY: Blaine, the table you are referring to was appended to Dan Malinowski's presentation earlier this morning.

MR. CURTIS: All right. 1,400, 366 and 279, that's quite a healthy sample on the cold leg.

MR NOBLE: With the stated knowledge regarding this corrosion, the IGA, I personally don't know enough to say that it wouldn't occur sometime in the future on the cold leg and there is, indeed, a temperature threshold effect that would indicate that it's going to be limited.

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MR. CURTIS: Well, all I can say, in twelve years of operation there is no evidence; so I wouldn't expect to have any concern in certainly this first inspection. It's not to say we wouldn't go back and check in the normal refueling, normal type refueling service inspection and test those tubes where we have known degradation, those areas where we have known degradation.

MR. NOBLE: Depending on when the first interval falls, I guess I tend to agree with you.

MR. CURTIS: What I am saying is the cold leg examinations will not be governed by the sleeving problem. They will be governed by the Reg. Guide 1.83.

MR. NOBLE: Sometime in the future do some sampling for IGA. I think it would be prudent.

MR. CURTIS: Yes, sir.

DR. GREEN: Are there any plans or any value in doing ultrasonic testing after the first

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cycle to see how the integrity of the braze is holding up?

DR. GREEN: Well, we have been discussing that. I think that the problem there is that to get a feel with the production type UT process. You have got to understand that we were back into operation now, the channel heads are now again radioactive and we are not in a position at that point in time, at least with the existing technology, to apply a UT process that could be consistent with ALARA guidelines or whatever. In other words, it became impractical at this time to address that.

As I stated earlier, they are trying to, in the process of trying to develop UT techniques that could be implemented much the same as the eddy current process is now. If that materializes, then certainly we will do that.

DR. EGAN: You will have the information for the leader tube, which is probably as good an indicator.

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MR. CURTIS: In the leader tube we would, in fact, go in and inspect with UT before we removed the tube we planned to remove. We would also eddy current test it.

DR. GREEN: A few tubes, not a large number?

MR. CURTIS: Yes.

MR. HERBERT: That's four tubes for the units, isn't it?

MR. CURTIS: Total of four over the life of the program would be three each.

DR. GREEN: Are you going to ultrasonically examine the four tubes at each shutdown?

MR. CURTIS: I guess we haven't carried our logic to that extent.

DR. GREEN: That might be useful.

MR. CURTIS: Well, we will take that under advisement.

MR. MOODY: Are there any other comments or questions by the Board?

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Mr. Noonan.

MR. NOONAN: I have got a question, Wes, but I want to hold on it until I talk to the staff members, so I don't want to ask anything right now.

MR. MOODY: All right. I guess we are a little bit ahead of schedule, whatever that schedule is. Why don't we proceed with the response to at least open item one from yesterday since Blaine is here right now. Everybody has that from what I handed out earlier this morning, I hope.

Then, 1(a) through (d), 1(e) having been answered already, Blaine.

MR. CURTIS: All right.

MR. NOONAN: Could I address one concern I had on 1(e) and that will finish it off?

MR. MOODY: Certainly.

MR. NOONAN: When you try to pull out the magnetite out of the pipe, are you going to try to measure it to see how much you pulled out, how much you actually get out of it?

MR. CURTIS: That's difficult.

MR. NOONAN: Approximately 2o pounds?

MR. CURTIS: We can do that. We hadn't planned to do that.

The way that would be done would be to do a simple weight balance on the filters being used. I think that's something we would have to investigate. That's not easily done because that magnetite is very hot and those filters are very hot and how we would do that, I'm not quite sure.

One indication of how much magnetite is in there would be simply radiation readings we do get on filter bags from the vacuuming process.

The direct answer to your question is that, no, we would not plan at present to do a balance weight determination.

MR. NOONAN: Can I ask that you consider the alternative of doing that because --

MR. CURTIS: Yes.

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MR. NOONAN: At least providing us with some type of an estimate as to how much you think you get out of it.

MR. CURTIS: Yes.

Let me, before I get into this, well, as a prelude to answering this item, try to explain to the Board what we are really dealing with here.

I wish I had a loop diagram to show you what we are talking about but, in any case, this is the hot leg and this is the cold leg. We are talking about this, in this discussion, materials that get down into the loop as a result of the many activities that are going on in the plant or having gone on in this outage.

On the hot leg side what you have got is about a four foot drop here in this elbow and then about a 16 foot run of 29 inch ID pipe from this point over to the reactor vessel nozzle. That's the outlet nozzle from the core.

Right now the plant, of course, is

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in what we call mid-loop water level and all of the loops are essentially stagnant. In the hot leg, for example, based upon personal observation, I can tell you there is about that much (indicating) stagnant water sitting in the bottom of the hot leg loop in steam generator A. Of course, that would apply to B and C.

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Over on the cold leg there is the pipe drops down and there is a loop seal and it's about a twelve foot elevation drop and this loop seal makes a turn and goes up into the suction of the reactor fuelant pump and, of course, it discharges back into the inlet of the reactor vessel.

Any material, therefore, that enters, that escapes the channel head -- let's address the hot leg -- if it's more dense than the water, it's going to end up right there; and, in fact, when we made an entry into steam generator A to look for some parts, everything that you can see was -- you could, in effect, reach right and pick it out of the loop. There

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is no mechanism for material to be migrated from this location down to the core.

That also applies to the grit. That grit will settle out in less than 40 seconds, 100 percent settlement. There is no way that grit that escapes past here can be transmitted from this point in the loop down to this, into the core.

In fact, although I am not so certain that what we saw was grit, but there was some crude deposits laying right in this area of the generator.

So what I am trying to say is that insofar as the hot leg is concerned, the materials, whether it be grit or whether it be hardware, will, in fact, be located right below the nozzle inlet.

In the cold leg the isolation from the reactor is even greater, of course, because you have the loop seal that it's going to be captured in and, of course, you have the pump and propeller itself that presents another barrier and the cold leg return loop. The conclusion is that any materials, no matter from

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what process, that have gotten into either the hot leg or the cold leg we think can be retrievable through either mechanical grapplers or through a wet vacuuming technique or through electromagnets; but in any case, we believe that essentially all materials are retrievable that get into the loops via this mechanism. I just wanted to better put that situation into perspective.

Item 1(a) says to discuss the circumstances surrounding and the significance thereof of the introduction of undesirable elements into the RCS.

Before July or so of this summer and between that time and the first of May, that was a period of time in which we were conducting the eddy current program and had in place the tube pulling efforts and the in-site pressure testing methods and those were in comparison to the decon, honing and sleeving methods, rather localized efforts requiring small crews and so forth; and, therefore,

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there was not a program in place at that time in terms of procedures, controlling people, materials and so forth of the magnitude and stringency we now have in place for the sleeving effort and the materials that were observed in a loop examination recently were, in all cases, materials that were associated with the tube pulling efforts and the eddy current efforts and the pressure testing efforts. In the case of the A loop, all those materials had been retrieved.

As I indicated, at the conclusion of the sleeving program we are going to go down into all of the loops, cold and hot, on all three generators with TV cameras to make a visual examination and to retrieve through either grapplers, vacuum systems or other means, any foreign debris that may be in the loops. All of the materials that are in there are, with one possible exception that I will discuss, are quiescent with respect to their impact on the reactor fuelant system.

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We have, therefore, insofar as the hardware that's in the loop, that material was introduced into the loop, as I said, at a point in time when the stringent controls that we now have in place were, in fact, not in place.

What we have done in connection with the sleeving program is instituted a process which we will abide by hereafter of material inventory control in the steam generators; and whenever anybody introduces any equipment or tooling into the steam generator channel heads, we have an inventory in and inventory out as a control over those materials.

In connection with the decon, honing and sleeving process, that way that is implemented is before the loop seals go in, the loop seals are inventoried. They are inserted. The channel head is inventoried and the loop seal is inserted and at such times as you get ready to pull the loop seal out, the channel heads are given a thorough cleanliness type inspection, the plugs are pulled and they, again,

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are inventoried; and if there is any discrepancy, actions are going to be taken.

So in terms of what we have done about it, we have put into place a material inventory control program for all material traffic going into and out of the channel head except in those cases when you have the loop installed, where, in fact, you have to have protection for any material getting into the hot and cold legs.

This is a schematic of the earlier nozzle plug that we used going into the decon operation. What it consists of is a heavy aluminum cover and attached to it is essentially an innertube type arrangement. This would be the primary seal against fluids entering the loops as a result of the decon process or the honing process. This would amount to a secondary barrier against fluids and other hardware entering the loop.

This primary or this secondary seal is a positive seal. It is passed up into the channel

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head. It opens up in this fashion and seats on the loop, so there is no way that it can fall down into the loop unless you fold it up and drop it into the loop, as we did the other day.

There have been a number of problems with this concept of having a single bladder act as the primary seal. We have had material problems with the rubber. We have corrected that by having the rubber manufacturer certify the age of the material and that it is, in fact, good material.

We have had problems with the channel head workers abrading or scratching the material as they bring the rubberized plug into the loop. We have taken steps to tighten up on those controls by having the individuals go through training in mockup.

We have had problems in the diameter of this hub plate to which the rubber is secured in that the area of greatest strain is right here, so the failures have, in fact, occurred in that location. So, we have increased the diameter of that hub in an

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effort to lower these stress levels. Notwithstanding those efforts, we continue to have problems; so we went through another design modification, which we took, in effect, retained this outer balloon and put inside of this an actual innertube and pressurized the innertube and have used that with some success; but I am hearing reports we are experiencing failures with that kind of concept, so we have in place yet another seal design, which will be, in fact, a double seal arrangement. So, we are having problems with the seals but on the decon process; but I would like to point out all of the issues that are associated with the seals, namely, the introduction of magnetite and unborated water to the system have been addressed to the staff and to, in fact, their satisfaction.

Just to dwell on that a little bit, as you know, the decontamination process is a water, grit, demineralized water, magnetite, grit slurry. That water is unborated. Should that seal fail, you get a quantity of unborated water into the loop. We have calculated that, based upon the maximum

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water inventory in the decontamination system process, which is 200 gallons, that the maximum dilution that could occur would be on the order of 50 ppm boron. We are sitting right now at about 3,600 to 3,700 ppm boron and the plant technical specifications require 2,200 ppm boron, so there are no safety issues created relative to the seal failures. Problems that are created are ones of administrative or logistical problems in trying to keep the system up.

Insofar as the magnetite is concerned, magnetite is in the system. We compute there's anywhere from 120 to 200 pounds magnetite either plated out or in suspension in the system, just based on normal operation, reactor coolant system. We feel the maximum amount of magnetite that we can get into the system through this process, through any one given failure, catastrophic failure, would be in the order of 20 pounds; and, as I indicated, the bulk of that magnetite, 95 to 100 percent of that magnetite is simply going to reside right in the leg and would be cleaned out through a wet vacuum process. I don't anticipate that there would be any sufficient significant amount of residuals, suspended magnetite, when you are bringing the plant back into operation; but as Dr. Wootten indicated, we could plan to go through a CVCS cleanup of the system prior to heating the unit up with the criterion that we bring the total suspended solids in the system down below one part per million.

The significance of the magnetite particles is on the order of 7 to 10 microns. That poses no problem for any of the plant hardware with the possible exception of the reactor coolant pump; and the reactor coolant pump seals, I should say, and those seals have 5 micron filters on them, so we don't see issues relative to magnetite getting into, whatever small miniscule amounts of magnetite that may be in the system getting into the reactor coolant pump seals. In any case, we wouldn't expect it to be any issue other than operational that would be associated with it.

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Along these lines we have taken samples of magnetite after we have sprayed through the decon process and analyzed those and find that the particle size is still on the order of the 7 to 10 micron range; so we are not concerned with submicron particles floating around in the system.

Basically all of the issues relative to magnetite and unborated water have been addressed with the staff and we are of the position that those don't pose any operational or safety concerns to the plant.

With respect to the issues of materials in the loop, I have indicated how they got there and I have indicated that we plan to retrieve those and we would propose those be retrieved with the ALARA considerations in mind; and to that end, we do not plan to go in and do the loop search and retrieval activity until after we have completed the decontamination sleeving in the generators.

That would be further warranted by the fact that there is going to be activity in the channel

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heads over the next several weeks anyway and we wouldn't want to go in until you have taken all the equipment out and make that final investigation.

There is one exception and that's the aluminum nozzle cover that was dropped into the loop; and based on an evaluation by our materials and chemistry people, we think it's prudent to retrieve that within the next few days to preclude any dissolving of aluminum into the borac acid solution, so we do plan to retrieve the aluminum nozzle cover as soon as that tooling is available, which I expect would be in the next day or so.

That, I hope, answers items 1(a), (b), and (c).

Item 1(d) was the man-rem exposure from the diagnostics effort. By that, we mean what was the man-rem accumulated prior to the sleeving program, and those figures are approximately 260 man-rem.

I believe that Mr. Emch asked also what would be involved in the retrieval effort,

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what would we estimate would be involved in the material retrieval effort yesterday and we have estimated that to be on the order of 15 to 20 man-rems.

MR. MOODY: Questions or comments by the Board?

DR. WEGST: Yes. I was waiting, I guess, until this point to bring it up. Has anybody made any estimates of what kind of man-rem exposure you are going to get from all the ultrasonic and eddy current testing that you plan to do after you get the sleeves in place?

MR. CURTIS: You mean this outage or subsequently?

DR. WEGST: This one when you put the sleeves in, you are going to ultrasonic test a lot of them, are going to do eddy current testing on all of them. What kind of man-rem exposure is that going to produce?

MR. CURTIS: We have a total estimate we did yesterday, we think was approximately 1,300.

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DR. WEGST: Is it incorporated?

MR. CURTIS: Is it what?

DR. WEGST: Is that incorporated in the sleeve installation number?

MR. CURTIS: Yes.

DR. WEGST: That includes the subsequent diagnostics after you get the sleeves in place?

MR. CURTIS: Yes.

DR. WEGST: All right.

MR. MOODY: Any other questions or comments?

MR. HERBERT: I have a question on the magnetite.

You made the statement just a moment ago about the analysis of the size of the particles and not being possible for any submicron particles in your system, do you mean you have absolutely no breakdown of these particles during that evasive action?

MR. CURTIS: That's right. They are smoothed off, the edges are rounded off but magnetite, it is very sharp and the only noticeable effect, I am told, is that they are just rounded. The particles themselves don't break.

MR. HERBERT: But it's my experience in these operations that when you round off a corner, that corner has to go somewhere. It doesn't disappear. Granted, you can still see this nice round paricle.

MR. CURTIS: Well, then, let me restate the results of the analysis.

There were no particles detected below 5 microns in the analysis.

MR. HERBERT: It may have been flushed away?

MR. CURTIS: Right.

MR. HERBERT: With the crude that you are blasting off the surface?

MR. CURTIS: But even if there are some micron particles, they wouldn't pose any issue. Number one, there wouldn't be sufficient quantity in the system; and, number two, filters are designed to remove everything greater than 5 microns; and, therefore, anything less than 5 microns ought not to pose any issue.

MR. HERBERT: The other question, how did you come up with a 20 pound upper estimate on this inventory loss?

MR. CURTIS: That's based upon the water balance that's done as part of the process. In other words, let me reflect on the system.

We made the assumption that the unit, the system -- we do a water inventory balance on the decon process. It's a recirculated system. Some of the water goes, magnetite water slurry is dumped from the system through these 16 separators and the water is made up. By simply taking these measurements we know how much water is not there and then knowing what the relative ratio of the water to the grit mix, magnetite mix is, therefore, we concluded up to 20 pounds. I believe we talked about something on the order of 180 gallons of water might have gotten

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into the system.

DR. GREEN: You mentioned you were going to remove the aluminum pretty fast because of the possible reaction to the boric acid with the aluminum. I know magnetite reacts with boric acid, the high temperature. Have they checked to make sure there is no reaction with the boric acid in these ambient temperatures?

MR. CURTIS: This system is sitting there with magnetite all over it, in the channel heads, in the tubes, plated out, and I would have to defer to Westinghouse on that question, but my feeling is that there is obviously no problem.

MR. RAWLINS: John Wootten is here.

DR. WOOTTEN: What was the question?

DR. GREEN: Any reaction between the boric acid and magnetite at room temperature. I know it reacts at high temperature but any reaction in room temperature.

~~MR. FLETCHER:~~ There is no reaction

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between magnetite and boric acid at room temperature. Magnetite certainly does behave as a very mild ion exchanger. You would get some chemical reaction on the magnetite but in terms of dissolution, no.

MR. MOODY: Other questions or comments by the Board?

Vince, do you have anything?

MR. NOONAN: I have one major concern, and prior to plant operation, we asked the question, that's of the lead shielding that you have in the steam generator, very close accounting of the inventory of that shielding to make sure what you put in there comes out prior to going to heating the plant up. Can you describe what actions are taken in that area to make sure we don't get any lead into the primary coolant.

MR. CURTIS: What Mr. Noonan is referring to is that after we complete the honing operations and get ready to go into sleeve insertion, we have talked about draping lead blankets on the cold leg side of the divider plate and we are also talking about putting lead bricks over this nozzle cover. These -- gee, I wish I knew what the name of the coating is, but, number one, the application, the pattern is engineered -- it's cut out and bricks are individually marked. The bricks are approximately 25 pound blocks, about that big (indicating), and they are covered with a plastic coating, with a spray coating and then they are covered with a plastic wrap and then a plastic cover is laid over the aluminum nozzle cover. In fact, it's in this fashion. When you lay the bricks, which are coated with plastic and wrapped in plastic onto the shield, then this cover is laid over that so there is no potential for any lead transport to the clad. Then, in the removal process at the end of the sleeving program, it would be simply a material inventory of the marked lead bricks.

MR. NOONAN: I want to make sure all the lead comes out of there.

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MR. CURTIS: It will be out.

MR. MOODY: Either comments from the Board or the staff?

Let's do one more open item before lunch and that is open item two. Pete DeRosa.

MR. DE ROSA: The question was raised yesterday about some data that suggested thinning in the tubes just below the top surface of the sludge and what is the effect of the thinning on the hydraulic expansion of the joints prior to brazing and the subsequent brazing.

We have reviewed the data and there are tubes that we will brazing and expanding in that region and our previous test data suggested that has a minimal effect on the resultant gap from hydraulic expansion, but to properly address the issue, we are initiating some testing to demonstrate the effect that might have on the brazing parameters and the braze quality.

DR. GREEN: That satisfies me.

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MR. MOODY: Thank you.

All right. Lunch, as yesterday, and we would resume promptly at two o'clock.

(At 1:00 p.m. the hearing was recessed until 2:00 p.m.)

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Steam Generator Sleeving Review Board Meeting

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Afternoon Session
2:00 P. M.

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MR. MOODY: Just for the record, let me note that the additional slides that were presented as part of agenda item eight by Dr. Wootten have been provided to the members of the Board.

The plan from here out this afternoon is as follows. We have several items from the open item list from yesterday that we will need to address and we have open items at this point in time, nine through fourteen, on a list for today which is being typed presently, and my intention is to go through those open items and then return to agenda item ten, which is summary and conclusions.

By my scorecard, on the open items from yesterdays meeting, item one has been closed, item two has been closed, item four has been closed and item eight has been closed.

It is my understanding from talking to Vince Noonan that items five and six have been discussed

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among Pete DeRosa and Emmett Murphy and the staff and have essentially been consolidated into a single question, which I am going to ask Pete DeRosa to state the question and the response as well for the record.

MR. DE ROSA: I believe the question that can clarify this, the repair report that was submitted for review stated that the seismic stresses in the tube in the region between the tubesheet and the first tube support plate are negligible, please substantiate this.

In referring to W CAP 7832 which performed the seismic plus local stress analyses on tube bundle and other components, the stresses in that region of the tube were found to be less than 1.8 psi. based on a number of that magnitude, it was decided not to incorporate seismic plus local stresses into the stresses of the 2 plus league.

MR. MOODY: Any comment on that, Vince, or, Emmett?

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Dr. Roarty

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MR. NOONAN: That closes out that.

MR. MOODY: Any comment from the Board members?

That would close what we have noted as five and six on the open items from the 10/23 meeting.

Is Westinghouse ready on open item three, which is Dr. Green's water logging question?

DR. ROARTY: Joe Roarty, Manager, Steam Generator Performance Engineering, Strategic Operations Division.

The concern of water logging has its antecedent in the reactor business wherein the fuel element, ~~route~~ routine type elements with the gap between the oxide fuel and the cladding, there is a built-in void that always comes under suspicion. What if you should have a defect in that cladding, it takes on water and then subsequently during the approach to full power you experience ~~this~~ a rapid temperature change within that cavity and the associated increase in pressure?

J. ~~H.~~ [D.] Roarty

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Typically speaking, [the] cladding is quite thin. The temperature changes in the reactor situation are 100 degrees a second or so. That type of transient is not to be ~~contrasted~~ [compared] with the water logging in a generator or where the temperature change that we described yesterday, I believe, is like 50 and 100 degrees an hour. What we have done to get a feel for how much of a ~~problem~~ [concern] this might be to the structural integrity of the sleeve or the tube is to essentially do a marching calculation of let's take a minute in time and subject an enclosed volume of water to a temperature change of 1.66 degrees, that's 100 degrees per hour.

When we do that, the first thing that happens is that the specific volume of that water is changed. It wants to occupy a bigger space. When it wants to do that, there is now a competition between the pressure increase in the cavity and the ~~combination~~ [accommodation] of a defect to relieve that pressure.

In looking at a defect with a typical

J. H. Roarty

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orifice type of resistance of 1.5, we observe that for a defect size like one-half of 1 mill, the required pressure in the cavity to relieve the amount of water, to reestablish normal pressure conditions is like 3 psi.

Now, as the defect size is reduced, for example, if one were to postulate that instead of a half of 1 mill as the orifice, the size is a tenth of 1 mill, the required pressure now to relieve that equivalent amount of mass is approaching 100 psi.

Now, as Dr. Green, in postulating the situation, the concern is what if the defect became plugged. ~~You are~~ The cavity is full of water and you now, in a sense, have a defect that is vanishingly small.

The type of arguments that we have made in the fuel business is that this system is rather dynamic. First of all, you have pressure building up. You also have thermal conditions changing here. You have flow, even call it a lubricant, and it's likely that before you would sustain much in the way of a significant pressure increase within that cavity, the argument, the credible argument goes that that defect will ventilate, in fact, the cavity.

Are there any questions?

The conclusion I draw from this type of analysis is that the expected pressure increase has quite a small effect on the structural integrity on the tube, is quite nominal. The defect aperature, although given the possibility that it could oxidize and given the possibility it may take a little pressure to, in effect, strain that oxidized close up defect, the more probably situation is that that defect will accommodate any significant pressure increase.

DR. GREEN: We talked before about an additional worse case could be even if the hole was completely blocked. That would represent about a 50 percent increase in specific volume going from room temperature up to 600° F and that would cause, then, a 50 percent increase in the volume of an annulus; so if the annulus is like 10 mills, that would represent a further increase of about 5 mills if that and it wouldn't be a disaster; it would almost be comparable to like a denting situation, so it would bulge in the tube, which I think could be withstood, so I am satisfied with the response.

DR. BERRY: Part of that would be elastic?

DR. ROARTY: Yes.

DR. GREEN: That's one he was talking about, the use of profilometers, so you could use a profilometer to monitor for that. If there was some -- an eddy current probe that could get into the space, you could use a profilometer to monitor the shape to see if that mechanism was the possible cause for that distortion. So, I am satisfied.

MR. MOODY: Any other comment from the Review Board?

Anything from the staff?

MR. NOONAN: No.

MR. MOODY: Joe, while you are up, I understand you will be answering the open item ten, which list has been passed to everybody, which shows

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Pete DeRosa

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standard, we will estimate the probability that the ultrasonic test fails to detect an unacceptable braze and in using that estimated probability, revise the theory and calculation supporting the sampling plan to obtain a revised sampling plan.

MR. MOODY: The record, I think, ought to reflect that that revised question and that response was developed in conjunction with Dr. Egan, so there is no misunderstanding.

MR. DE ROSA: The only issues that were raised this morning were addressed to that.

MR. MOODY: All right. Any other comments from the Board.

Do I interpret that to be general satisfaction by the Board with nondestructive examination as clarified by Pete?

MR. HERBERT: On my part, yes.

DR. WEGST: It's okay by me.

MR. MOODY: All right.

Dan, if you would address open items eleven,

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that the maximum stress between the tube and the support plate increased by 1.8 psi. It's 2.4 psi.

MR. MOODY: Early on in some opening procedure or remarks I mentioned that Russ Krieger of Southern California Edison and Dave Rawlins from Westinghouse would be keeping, as I am, a score of the open items and while we proceed with agenda item ten here, summary and conclusions, I would ask Mr. Krieger and Mr. Rawlins to review their notes to confirm my scorekeeping to make sure there isn't an open item.

MR. RAWLINS: We did that at the conclusion of lunch. We were in agreement.

MR. CURTIS: Let me briefly summarize what we have tried to present to you the past two days.

First of all, we presented some historical data which indicates significant caustic induced intergranular attack has occurred at the top of the tubesheet for tubes in the interior regions of steam generators A, B, and C at San Onofre Unit 1.

Blaine Curtis

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Furthermore, we have presented some information which indicates that insofar as the peripheral tubes, IGA may, in fact, be occurring, but those tubes are not significantly degraded.

We have presented some information which is based upon the review of the chemical data operating history at the plant which suggests that there is evidence of an operation in the free caustic regime in addition to other off-normal chemistry effects which would be contributing to the presence of the intergranular attack.

With this condition we have and Westinghouse have embarked upon a repair program which consists of sleeving all the tubes in the interior regions of the bundles which are affected or will be suspected of undergoing intergranular attack and in so doing, we hope to achieve a resumption of full power operation of the unit consistent with all of the plant safety requirements, design bases, margins, et cetera.

We believe that the information we have presented demonstrates that we have, in fact,

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validated the repair effort and this is demonstrated by the extensive testing results of those tests, extensive analyses that have been performed, and numerous design reviews, internal to Westinghouse, internal to Edison, jointly between Westinghouse and Edison and also with the staff.

We have also indicated that being a somewhat innovative program and a rather massive undertaking, the program will, nonetheless, be implemented with full regard for operational ALARA guidelines.

I further believe that once having sleeved the bundles, that the continuing integrity of the peripheral tubes as well as the sleeved tubes can, in part, be assured by a chemistry program for startup and operation which will reduce, though perhaps not eliminate, concentrations of aggressive contaminants and their potential for continuing the progression of intergranular attack throughout the bundle.

To provide added assurance that the repair effort will be successful in terms of maintaining our margins, safety margins, design margins during startup and operation, we intend to perform hydrostatic testing of the bundles during the startup. This will provide an overall bundle integrity test and demonstate the margin, structural integrity margin that exists in the bundle prior to operation.

Furthermore, we plan to embark upon an in-service inspection program to monitor the integrity of both the sleeved and unsleeved tubes. This program will be implemented by eddy current testing technique and the leader-follower tube removal inspection program.

In addition, I would say we are going to continue our efforts to develop open field worthy technology of the areas of ultrasonic examination as well as eddy current examination with particular attention to the brazed region of the tubes.

As a final conservatism added to the program, we plan to tighten up on the primary to secondary

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leakage limits. We feel that the primary to secondary leakage limits we have discussed are conservative and the action statements that lead to provide prompt remedial action consistent with the safe operation of the unit. The primary to secondary leakage as a basis for continued operation or shutdown to effect remedial actions is based upon a number of premises.

One, the tubes affected by IGA, that they are unsleeved, we believe we can demonstrate or have demonstrated that they, in spite of their degradation, still retain residual structural properties. We believe that the evidence is supportive of a leak before break mechanism applies to the ductile, high ductile Inconel 600 tubing and that the limits themselves are conservative with respect to the margin that is against the existing technical specifications of leaking requirements.

In conclusion, then, we believe that the comprehensive program of steam generator diagnostics, sleeving, operational monitoring and in-service

Blaine Curtis

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inspections assures that San Onofre Unit 1 can return to full power operation with adequate safety margin.

Having said that, I would like to say that insofar as the repair program, the significant items, at least that I have heard here as of the last two days, I believe will be addressed in a manner which will allow us to continue uninterrupted in the sleeving effort and we would, therefore, plan to proceed on schedule and that schedule would more than likely have us commencing with the sleeve insertion operation beginning in the unit B steam generator probably mid to late next week.

I would also like to take a few minutes to first thank Mr. Noonan of the NRC staff and the staff for their participation, thoughtful comments generated during the course of these discussions.

On behalf of the Edison corporation I would like to thank Westinghouse for their excellent preparation and presentation of information over the last two days.

Blaine Curtis

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I would like to thank Mr. Moody for his successful efforts in assembling the Review Board; and, finally, I would like to thank the Review panel themselves. I think the expertise and talents is evidenced by the inquiries, observations, recommendations they have made which are both positive and constructive and will serve us well in our ultimate objective, which is to successfully sleeve the steam generators.

Thank you.

MR. MOODY: The thanks may be premature, Blaine. (laughter.)

Are there comments or questions from the Board with respect to the concluding remarks?

Anything from the staff?

MR. NOONAN: I would like to ask one question on the schedules. You said the sleeving operation is to commence when?

MR. CURTIS: We are honing steam generator B. If we can get through that operation hopefully by Monday or Tuesday of next week, we would

Blaine Curtis

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go right into the sleeve insertion part of the job. So we would look towards starting B generator sleeving mid to late next week.

MR. NOONAN: When are projected startup of the plant?

MR. CURTIS: The schedule we are shooting for is December 24 on line.

MR. MOODY: I have a couple of procedural matters. I am going to address the question I know you were about to ask.

I guess I have three things. The first is I want to remind those present, including the Board, that the information presented in the course of these last two days and provided to the Board ahead of this meeting is proprietary and confidential in nature.

The information that Blaine just presented in the form of a two-page handout summary and conclusion is not proprietary and confidential and you can treat that in whatever manner you wish.

This, I think, bears on the question

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Vince was going to ask. In the course of this two day review meeting there have been many opinions, conclusions and recommendations expressed by the members of the Review Board and others present. These, many of these have not been carried through the course of the meeting as open items. Southern California Edison views the Board in many respects as an extension of our own technical resources available to review and evaluate the sleeving modifications proposed both by Edison and Westinghouse. Therefore, Southern California Edison intends to evaluate these opinions, conclusions and recommendations in the course of our further work; and I think it is appropriate that we do that in light of the fact that we, the Southern California Edison Company, have the ultimate responsibility for the safe and reliable operation of the units.

I, as Blaine did, would like to express my personal appreciation to the Board and to other organizations, Westinghouse and the NRC, for their participation in the meeting and would also, as Blaine

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did, like to express our appreciation on behalf of Southern California Edison as well.

Does that address your question?

MR. NOONAN: I guess I would like to make one other comment. Not to overdo this thanks, but I think the credentials of this Board are impeccable. It is a very good Board. I think the questions of the Board to the Westinghouse people were very good. I have a list of items here that we were concerned about. I think, in almost all cases, the panel asked the questions that we were concerned with and there were about six concerns that we never even thought about.

I would like to thank you and I would like to say congratulations. I think it worked very well.

MR. MOODY: Unless there is any further comment from the Board, NRC or Edison or Westinghouse, hearing none, the meeting is adjourned.

(At 2:50 p.m. the hearing was concluded.)

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C E R T I F I C A T E

I hereby certify that the proceedings and evidence are contained fully and accurately in the notes taken by me at the hearing of the within cause and that this is a true and correct transcript of the same.

Ursula H. Pappas,
Registered Professional Reporter