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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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BRIEFING ON ANNEALING DEMONSTRATION PROJECT

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PUBLIC MEETING

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Nuclear Regulatory Commission

Room 1F-16

11555 Rockville Pike

Rockville, Maryland

Tuesday, August 27, 1996

The Commission met in open session, pursuant to notice, at 2:05 p.m., the Honorable SHIRLEY A. JACKSON, Chairman of the Commission, presiding.

COMMISSIONERS PRESENT:

SHIRLEY A. JACKSON, Chairman of the Commission

KENNETH C. ROGERS, Member of the Commission

GRETA J. DICUS, Member of the Commission

NILS J. DIAZ, Member of the Commission

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

JOHN C. HOYLE, Secretary

KAREN D. CYR, Deputy General Counsel

RAY ART, ASME

DOUGLAS CHAPIN, Principal Officer, MPR Associates

STERLING FRANKS, DOE

DENNIS HARRISON, DOE

DAVID HOWELL, Westinghouse

DEBORAH JACKSON, Materials Engineering Branch, RES

MICHAEL MAYFIELD, Chief, Materials Engineering Branch, RES

DAVID MORRISON, Director, Office of Nuclear Regulatory Research

JACK STROSNIDER, Chief, Materials and Chemical Engineering Branch, NRR

WILLIAM RUSSELL, Director, NRR

JAMES TAYLOR, EDO

P R O C E E D I N G S

[2:05 p.m.]

CHAIRMAN JACKSON: Well, good afternoon, ladies and gentlemen. The purpose of this meeting is for the NRC staff and Department of Energy representatives to brief the Commission on the Marble Hill and Midland annealing demonstration projects as well as other annealing program activities.

This cooperative effort between the NRC, the Department of Energy and the industry is being conducted to evaluate the engineering materials and regulatory issues associated with annealing in the United States. The program provides for the sharing of information gained by technical experts in the United States as well as that gain from annealing performed on Russian-designed reactors.

In July of this year, the first annealing on a United States commercial reactor pressure vessel was performed as part of the Marble Hill program. Therefore, I believe it is especially appropriate for us to be discussing the overall progress of the annealing program at this time. We look forward to your presentations.

I understand that copies of the presentation slides are available at the entrance to the meeting and I understand further that we will have a three-shift presentation; is that correct?

MR. TAYLOR: That's right.

CHAIRMAN JACKSON: Unless there are any other comments, Mr. Taylor, please begin.

MR. TAYLOR: Good afternoon.

With me at the table from the staff, Dave Morrison, Bill Russell and Mike Mayfield. To my right, Sterling Franks and Dennis Harrison from the Department of Energy.

As you noted, Chairman, this will be somewhat unusual in that we will have representatives from several organizations who will be participating. The staff will first provide some general background information on the annealing demonstration program from the NRC perspective. We will then turn the briefing over to Mr. Franks and his people to describe the Department of Energy's program.

At the conclusion of their presentation, the staff will return to the table to provide you further perspectives and the status of plants for the annealing demonstration of the Palisades vessel, ultimately, we hope. Not the demonstration, that's Midland, but the actual leading up for the annealing of the Palisades vessel.

Before starting the presentation, I would like to note that this project has been of significant personal interest to me. Since we promulgated the thermal annealing rule, I felt it was very important to demonstrate the

engineering feasibility of thermal annealing for U.S.-designed reactor vessels. I was very pleased when the Department of Energy initiated this program, worked with the staff at DOE and Terry Lash in implementing the memorandum of understanding which we signed between DOE and NRC by which we were able to participate in this annealing demonstration.

I feel this program is a very important step in the process of demonstrating thermal annealing as a viable option for assuring the integrity and safety of U.S. reactor pressure vessels. I want to congratulate and thank DOE and the industry for taking the initiative in performing this program.

Mike Mayfield from the Office of Research will continue the introductory part of the program.

MR. MAYFIELD: Good afternoon.

The NRC's regulations and regulatory guidance contain considerable information and devote considerable attention to assuring the integrity of the reactor pressure vessel. However, as you know, the pressure vessel, particularly in the belt line region, is subjected to neutron irradiation which brings about long-term embrittlement, reduction in fracture toughness and reduction in ductility of the materials.

Now the problem that brings about is it makes the

pressure vessels more vulnerable to failure under both normal operating conditions and accident conditions such as pressurized thermal shock.

The regulations impose limits on normal operating conditions, the pressure and temperature limits, as well as limits on the level of embrittlement for the reactor pressure vessel. The focus is to assure the safety of the pressure vessel. However, this can effectively limit the operating life for plants.

Thermal annealing is the only known method for mitigating the effects of neutron irradiation.

If I could have the next slide, please?

[Slide.]

MR. MAYFIELD: Thermal annealing is simply a process whereby the belt line region of the reactor pressure vessel is heated to a temperature above the normal operating temperature and held there for a period of time. Typically we talk in terms of a one-week period as the hold time. The -- by elevating the temperature, you are reducing the effects of the neutron irradiation, you restore the ductility and the fracture toughness. The major differences or the major contributors to the level of reduction of embrittlement are the difference between the annealing temperature and the normal operating temperature and the hold time, those are the key variables that we are concerned

with.

Now, as was noted, the first annealing of a commercial reactor in the United States is scheduled for 1998. We have in anticipation of that promulgated a regulation and a regulatory guide addressing thermal annealing. Both of those documents address both the material considerations and the engineering issues associated with thermal annealing.

If I could have the next slide, please?

[Slide.]

MR. MAYFIELD: While we haven't annealed reactor pressure vessels in the United States, there is considerable experience with annealing the Russian-designed VVER 440 reactors. In fact, they have now successfully performed 15 annealings on 14 different vessels. The Novovoronezh Unit 3 was annealed twice. The first time, they didn't anneal it at a sufficiently high temperature to get the recovery they wanted to sustain continued operation so they went back and did it a second time at a higher temperature.

The NRC had a team on site to witness the second annealing of the Novovoronezh Unit 3 and it was in 1991. And we had a team on site to witness the recent annealing at the Loviisa plant in Finland.

We have been actively involved with the Russians through the Working Group 3 of the JCCNRS where we have had

an opportunity to look in detail at the materials issues, the way those materials embrittled as well as the recovery and re-embrittlement estimates they have for their plants.

With all of this information and while it has been very useful, it doesn't address all of the issues, particularly the engineering issues, for U.S.-designed reactor pressure vessels.

If I could have the next slide, please?

[Slide.]

MR. MAYFIELD: As you can see on this slide, there are substantive differences in the design of the VVER 440 vessel compared to a typical U.S. design. This drawing on the left side is for the Palisades reactor vessel. You can see that the Russian vessels are longer, the wall is thinner and they are only concerned with heating one circumferential weld whereas, for many of the considerations in the U.S., we are talking about heating the full belt line region because the limiting materials typically would be an axial weld for U.S. designs.

So the Russians have a somewhat less onerous problem in terms of deformation of the vessel. We are concerned with the U.S. designs because you are heating a longer region, you are getting more deformation in the vessel in general, more bending moment in the nozzle region and potentially more distortion of the flange.

So while the Russian and East European experience has been useful, it didn't address all of the engineering issues.

If I can have the next slide, please?

[Slide.]

MR. MAYFIELD: We felt that it was important to find a way to address those engineering issues. While the vessel was of significant concern, we were also concerned about potential for heating the concrete and the biological shield wall, potential for overheating the embedments in the concrete that support the vessel.

So when DOE structured their program to evaluate annealing, we were quite pleased to see that they were addressing engineering issues, materials issues and regulatory issues. However, the staff's primary interest was in the annealing demonstration -- I'm sorry in the engineering issues associated with their demonstration program. We have had, and continue to have, an ongoing dialogue with DOE and their contractors relating to the materials issues so we felt like the big uncertainty in the scheme of things was on the engineering issues and that was on the portion of the program that we addressed in the memorandum of understanding.

CHAIRMAN JACKSON: Now what you refer to as the engineering issues, are they the ones that are in some sense

embodied in what you highlighted as the differences, in some sense, between the Palisades and the VVER, the kinds of considerations one has to have?

MR. MAYFIELD: Yes, ma'am. We are particularly interested in looking at demonstrations of how the vessel would behave, deformation, any permanent deformation in the vessel or the piping, concrete temperatures.

CHAIRMAN JACKSON: And by "materials" you mean restoration of the properties; is that correct?

MR. MAYFIELD: Yes, ma'am, restoration of the properties as well as re-embrittlement trends.

CHAIRMAN JACKSON: All right.

MR. MAYFIELD: If I could have the next slide, please?

[Slide.]

MR. MAYFIELD: As Mr. Taylor noted, the NRC is participating with the Department of Energy through a memorandum of understanding on addressing our participation in this program. Because we were sure the licensees would be referencing the reports from the DOE program, we felt like we needed to clearly define the scope and nature of the staff's interaction with the Department of Energy in this activity. We needed to make sure we retained our independence as we were looking at what was going on in the demonstration and, at the same time, we wanted to make sure

we got as much information as we possibly could, so we needed to be as close -- as closely involved in the program as was practical and at the same time maintain some independence.

So through the memorandum of understanding we are performing an independent review and evaluation of their demonstration projects looking both at the Marble Hill demonstration that you will hear more about this afternoon and the Midland demonstration that is coming up in the fall.

We are performing independent validation analyses, both thermal and stress analysis before the demonstration looking at the design of the heaters, the design of the heat-up and cool-down rates, we have installed some confirmatory instrumentation on certainly at Marble Hill and we are looking at instrumentation to put on the Midland plant.

We will look at our independent measurements and compare those with the measurements made through the Department of Energy measurement program and then we will also, as warranted, perform post-annealing validation analyses looking at both thermal and stress analyses to make sure that we understand what has gone on during the demonstration and to validate the analyses that were performed in designing the demonstrations.

So our focus, again, has been to get as much

information as we could possibly get out of these demonstrations.

If there are no other questions, I would like to turn this thing to Mr. Franks and the DOE contingent.

CHAIRMAN JACKSON: At some point, perhaps, you might, before it is all done, you mentioned that you thought the materials issues in some sense were easier to deal with.

MR. MAYFIELD: I didn't mean to imply that.

CHAIRMAN JACKSON: Okay.

MR. MAYFIELD: We have an ongoing dialogue on that issue. I didn't mean to imply they are easier to deal with.

DR. MORRISON: A different department.

CHAIRMAN JACKSON: It's not your job description, right?

MR. MAYFIELD: It unfortunately is in my job description; I just didn't mean to imply they are easier. Just we are talking about those issues.

CHAIRMAN JACKSON: Okay, thanks.

MR. MAYFIELD: Mr. Franks.

MR. FRANKS: Thank you.

Chairman Jackson and Commissioners, I am pleased to have the opportunity to come and describe our program to you today and will look forward to letting the vendors do the talking but I want to also mention the kind words that we received from the NRC flow both ways.

We have the utmost respect and regard for the way the program has been conducted to date. The relationship that was formed with this MOU clearly demonstrates that we can do companion R&D and a mutual goal without a lack of confidence or trust and still maintain the arm's length distance that we need to from a regulatory standpoint.

So, Mr. Taylor and Mr. Lash certainly challenged Dave Morrison and myself to establish the flagship program that I hope you are going to be interested in hearing about today.

With that in mind, I want to mention a couple of points about it from a DOE perspective. Clearly, the NRC has recognized as well as some of the -- as well as the Department of Energy the importance of conducting this annealing demonstration. However, not as many people within the country shared our enthusiasm about the need for the demonstration.

With the turnout I see today, if we can get that kind of information out to our stakeholders and demonstrate that we are sincere and that this is going to be a viable component to an energy strategy to maintain our existing fleet, that would be helpful.

With that aside, another key component that is embodied in this program is not only is this a U.S. program but, as mentioned, we are relying on Russian information

technologies but, as well, we are trying to make sure that the rest of the world watches our demonstration because it will be unique and different than what has been done in the past. It is significantly larger and significantly more complex. So, with that in mind, I would like to go into some of the key areas of information that we felt like we needed to demonstrate.

First slide, please?

[Slide.]

MR. FRANKS: I don't want to read these to you but I want to give you the sense of these.

In designing the program, one of the key elements of that was, with the sizes we're dealing with, will we be able to maintain and regulate a heat source that would elevate the temperatures and maintain those temperatures at an elevated condition until such time as the annealing occurred?

Also in doing an in situ test, would we be able to demonstrate that the overall integrated plant, reactor coolant system plant, would respond in a manner that would require us to -- would allow us to not have to disassemble the plant in some fashion but to allow us to go ahead and heat it up and demonstrate an integrated plant response to the annealing to assure that there was no damage.

Additionally, we wanted to make sure that our

computer codes and models adequately described the process and that they were accurate in terms of supporting our analytical techniques.

Why did we choose two technologies? When we first started down this path, we recognized several risks in trying to come up with this large-scale demonstration. One of them was the uncertainty and risk and concern with the utilities. The other was from an actual component standpoint with this large device, heating device, would we be able to do the anneal to the point we wanted to.

I didn't feel comfortable and neither did Mr. Taylor or Dr. Lash so we sold the program on a two-pronged approach, looking at two different technologies, one to allow that if one were to not accomplish the desired objectives that we would have two chances at it. Secondly, as equally important to me, was that both of them would be successful and then we would have a mechanism for competition and I think that is very important as we go forward looking at potentially 30 plus plants that might employ this technique.

Additionally, we wanted to take this time to document the lessons learned in doing the demonstration so that we could consider ALARA considerations, maintenance considerations in the lead plants and try to take into account the lessons we learned on the nonirradiated vessel

and then apply those on an irradiated vessel.

With that in mind, I would like to turn it over to Dennis Harrison to introduce our program participants.

MR. HARRISON: Good afternoon.

Before I introduce program participants, if you could get the next slide, please?

[Slide.]

MR. HARRISON: This is just some general information on the two demonstrations. Key information here is, as was mentioned earlier, the vessel types, nozzle supported, CE fabricated, B&W fabricated, NSSS designs, Westinghouse 4-loop, B&W 2-loop.

With that, I would like to introduce our first -- the Marble Hill.

MR. ART: My name is Ray Art and I am with the ASME Research Center here in Washington.

Could we have the first slide, please?

[Slide.]

MR. ART: This is an overview of our presentation. I'm going to talk about the first three or four slides and then David Howell from the Westinghouse Corporation will be discussing the details.

As you can see, the general objectives of the Marble Hill project, the Marble Hill ADP team members and the indirect gas heating system. Then I will turn it over

to David and he will take care of the rest of them.

We have a special treat for you this afternoon. We have a video tape which we will show at the end.

CHAIRMAN JACKSON: Thank you.

Could I get you to speak a little closer to the microphone? Thank you.

MR. ART: The general objectives of the Marble Hill project, the joint industry/government effort to demonstrate the engineering feasibility of a reactor vessel annealing system, and I do mean joint. We've got -- you will see the team members. We also had the Japanese and French involved in this program.

The Marble Hill project demonstrates indirect, gas-fired annealing technology, as was indicated earlier. This was the first success in-place anneal of a U.S. commercial reactor vessel in a typical U.S. nuclear power plant.

The Marble Hill ADP members are shown here and under the leadership of the Department of Energy and Sandia National Labs, the American Society of Chemical Engineers served as the primary contractor for the project with the Westinghouse Cooperheat Team doing the technical design and the operation itself.

Electric Power Institute, Research Institute, did include a number of their members as contributing funds to

the project, including the EDF or the French utilities.

The Westinghouse Owners Group was another large group that contributed. Consumers Power who, as you know, runs the Palisades plant, Duquesne Light, which runs the Beaver Valley station.

The Central Research Institute, Electric Power Industry is the Japanese component and they visited the site and participated in the steering committee meetings.

Meanwhile, we had invited and received close observation by the NRC staff throughout our presentation.

Could I have the next viewgraph, please?

I am going to turn it over to David Howell, who will give you the details now of how we did this operation.

MR. HOWELL: Good afternoon.

[Slide.]

MR. HOWELL: What we have on this slide in front of you is a schematic of the heating technology that was used as the Marble Hill demonstration. As Mr. Franks had mentioned, the demonstration had two significantly technologies that were used. I will try to go through in brief detail the differences or the uniqueness of the indirect gas approach.

If we could have the slide -- yeah, the slide that's back up on the screen.

What you see in the slide is a schematic showing a

heat source which is propane gas burners on the outside of containment that is heating air that is blown through a ductwork system that goes into containment and then down into a large stainless steel heat exchanger that is actually in the vessel itself. There is no interaction between the hot air in the vessel and the actual wall of the vessel itself. It is totally contained inside a five-zone heat exchanger and then recirculated and then piped back out of containment through the exhaust ductwork.

There are several unique things about that design that made us want to pursue that. One is that it is much lighter weight from the standpoint of what has to be handled in containment itself, it is very easily decontaminatable because the outside surface is basically stainless steel and it does not have any components inside the vessel that really are prone to failure. It is really an air-moving machine. And it also very definitely separated the contaminated air from any of the hot air that was going through. So that was one of the thrusts of the design.

If I could have one of the next slide? Or, actually, before we show the next slide, I would like to run the video and we will give you a little picture of what happened at Marble Hill and then we can walk through some of the details that took place at the site if we can run the video now.

What you see, of course, is the sign for the utility. This is a cancelled plant that was cancelled in the early '80s. The Marble Hill had two units. The first unit, which is what we did the demonstration in, was 65 percent complete. All of the piping was intact.

What you see right now is a picture of the vessel with all the instrumentation, internal instrumentation was welded to the vessel.

What you are looking at right there is a thermal plug that blocked the air from transitioning down the nozzles. There was instrumentation as well on those thermal plugs such that we could tell what the stresses in the piping were. You can see several runs of instrumentation that were welded to the vessel and the lines coming out. There is a detail right there of one of the instrument lines that has been attached to the inside of the vessel and the routing of that cable as it goes up and out of the vessel.

It is very important to the demonstration for that to be done in a quality manner such that it did not interfere with the installation of the heat exchanger in any way.

You can get a picture of some of the runs in the vessel and as they were installed in the beginning, they were tagged, marked, checked out thoroughly, calibrated before any of the actual heat exchanger was installed.

What you are looking at right now is the loop piping coming out of the vessel with the main isolation valve. Several instruments were installed on the vessel. When we go around the piping, we will be going through that a little bit later as to the detail.

What you have in that video right there is the heat exchanger itself with the air ducts going in and out, technicians are going ahead and installing the final instrumentation. The lift rig being lowered down onto the heat exchanger on the reactor vessel top cover. You can see insulation that is on the top cover to prevent the heat from escaping and keeping the control of the actual heating process itself.

On the outside of containment are the gas tanks and you are looking at one right now that control the flow of gas to the burners, as we will talk about later it is really fully combusted, the gas, before it enters into the heat exchanger thus no combustion actually takes place anywhere inside of the piping or the ductwork.

The hot air, the air is piped from fans into the burner receptacle. This is a burner right there that you're looking at, the silver, and this is the flame that comes out of the burner and then heats the air that is taken down into the heat exchanger itself. It is a very controlled process that is utilized.

The heat exchanger itself is now being positioned over the vessel and lowered in over a series of guide studs, guide pins very similar to what you would see for a normal internals installation. As you can see as it goes down into the vessel, guided down over those long guide studs that you see sticking up right there it looks very much like, actually, a lower internal is being installed into the vessel.

As you can see, it's passing over the guide studs as it is going down into the vessel. You have a series of guide studs both fine and gross control such that it picks up on the studs, avoiding any damage to the vessel as it is going down.

Now, one of the things we obviously had the luxury of at Marble Hill that we will not have as much of at a commercial plant is being right down on the vessel flange and much more of a hands-on approach to guiding that in. But the basic process will be very similar.

What you see right now is the actual setup with all ten lines, both five inlet and five exhaust coming out of the burners and entering into containment. The bottom set of ductwork going in is the hot inlet air and the top set of ducts coming back out are the exhaust air. Fully insulated and safe to the touch from the standpoint of any hot pieces of material.

Then going down into what we call a bedspring structure that goes down into the vessel, into the heat exchanger that is sitting in the vessel.

Instrumentation runs coming out on the top of the deck. This is just a strip chart recorder for gross temperature inside the data acquisition trailer, which is where you are looking at right now, all of the instrumentation both external and internal being monitored and being used to both control the anneal as well as monitor the movements of the vessel and the stresses and strain results.

Once the annealing was completed, the disassembly took place, basically in reverse. You can see the ductwork that was taken out. There is some discoloration but there was no deformation whatsoever in the ductwork that was detrimental.

They are now just disassembling the instrumentation runs so they can go ahead and pull the heat exchanger out, lowering the lifting rig down and taking the heat exchanger out of the vessel.

We were very fortunate at Marble Hill that many of the existing cranes and things that were intended to be installed were functional and running and it took some work to keep up with the maintenance on them but it worked out pretty well for us.

As you can see, the heat exchanger pulled out. Once again, it is a stainless steel skin and there is some discoloration due to the heat but not unexpected. On the sides of the heat exchanger, several retractable thermocouples that measure temperature as well on the vessel which would be used in a real anneal because, obviously, there is not an opportunity to jump down in the vessel and weld thermocouples on the ID of the vessel.

Good picture of one of our technicians.

[Laughter.]

MR. HOWELL: Once again, the disassembly of the vessel. We learned a lot of things which we will talk about a little later from the anneal and how to process the equipment in and out of the containment that will be very helpful for an actual anneal.

And I believe that is the end of the video.

Okay, if we move to the next slide, please.

[Slide.]

MR. HOWELL: Going through what the purpose of some of the demonstration would be, along with the actual implementation, several items had to be completed to validate a model. We had thermal and stress analyses were completed and the purpose of that is to validate the model of the vessel for future efforts as well as to make sure that the actual results we got matched the calculated

results.

It also provided a basis for instrumentation selection, the type of instruments we were to use as well as the location of those instruments based on the stress and thermal analysis. Of course, it input for these measurements we wanted to take and NDE inspections that we wanted to take for the critical portion of the vessel. They were both done in 3D, both the analytical and thermal models.

Next slide, please.

[Slide.]

MR. HOWELL: Several of these sensors, and I detailed them on this slide, there were actually 228 thermocouples and RTDs that were put, as you saw in the video, both on the reactor vessel internal and external surfaces, the RV nozzles, the flange, any of the supports. The cavity concrete, as was mentioned before, was very important to us to ascertain a temperature and, of course, the piping.

We also checked not only temperatures but displacements. We wanted to characterize the movements of the various components in the vessel. The support pads, the bottom of the vessel as well as the piping. We had 14 string gauges as well on the reactor coolant piping and the nozzle and pipe welds.

We wanted to be very clear that when we left this vessel it was in a shape that could be used again, so we did pre and post dimensional checks and we did those based on the results of the thermal stress analyses at key interface locations for both the vessel internals and the head setting operations which are the key measurements for continued operation to make sure the actual components will go back into the vessel.

We also did some noninstructive examinations including dye penetrant, visual and ultrasonics on the selected loop and piping welds that were of interest based on the critical stresses.

Next slide, please.

[Slide.]

MR. HOWELL: As we commenced the actual site effort once we had all of the results of the thermal stress analysis and we had the maps where we were to put the instruments and the procedures completed on how to do the measurements, we arrived on site on May 6 to do a cleanup of the Marble Hill site.

As you can imagine, a site that has been cancelled for about ten years was not in the best of shape and we had several days and weeks of cleanup to make it safe, which was one of our top priorities on this project.

We actually commenced the heating, the annealing,

of the vessel heatup on June 24 after about a month, a month-and-a-half of preparation. We commenced soak on June 28 at four o'clock and we completed the entire effort which includes the cooldown to less than 200 degrees on the 8th of July.

The team, basically, after the cleanup, imposed measurements, post NDE, left the site on July 24 and are now working very diligently to come up with several reports, the draft field service report which basically has all of the data that was collected on the site as well as the procedures. It is being issued today to ASME and then will be issued from ASME to the rest of the team.

The final report, the draft that Westinghouse will be putting out to ASME will be complete in November and then we expect the issuance of that report to the public in early 1997.

May I have the next slide, please?

[Slide.]

MR. HOWELL: What you have in front of you here is basically a profile of the time-temperature curve that was used. The dotted line is the average heatup rate, approximate heatup rate which was 16 degrees Fahrenheit per hour and you can see the actual very close to that. It came up to approximately 850 degrees with a minimum soak of 825 all the way across for the seven-plus days and then dropped

down at a cooldown rate of approximately 14 degrees per hour at the end.

Next slide, please.

[Slide.]

MR. HOWELL: So what were the results? We believe that very successful results in that we demonstrated that the full scale reactor vessel process at the nominal temperature of 850 degrees was doable, we did that for seven days. We did establish that the critical dimensions were maintained pre and post and within the acceptable tolerance of the manufacturing specifications. We were able to control the heatup, soak and cooldown with the indirect gas-fired process very well.

There are several advantages in that we were able to actually input heat with one zone and draw heat out with another zone at the same time to maintain those curves at the minimum possible time that was allowable within the curves.

The reactor vessel ID and OD instrumentation functioned very well. They were all verified after the demonstration that they did function, they were operational, calibrated out very well. And the ending inspection of the vessel proved that there were no indications that were present that were not present before, so that's also a very positive sign.

As I said before, one of our top priorities on this program was the safety of our people and we had absolutely no lost time accidents at the Marble Hill site.

Next slide, please.

[Slide.]

MR. HOWELL: The final assessment, once again, we believe this to be in excess of a commercial-style reactor vessel and it is indeed feasible. There were no reactor vessel deformations that were deemed significant. We were very pleased that the analytical model predicted both temperature strains and displacements very accurately. We had absolutely no damage that was noticeable to any of the plant, balance of plant, piping loops, concrete supports or anything else. And then we -- the vessel -- we believe that the vessel annealing hardware and operation costs are reasonable and we gained some insights on how to make them better.

We also believe that this particular heating system is very viable, as is electric, but both very viable way to do this project and this process, very reliable. As I said before, lighter weight and all of the components accessible during the operation if there were to be any problems. And we were very pleased, as I said before, about the ability to control the -- control the multi-zone heatup and cooldown with a forced cooldown capability.

We were able to quickly remove and install the equipment and believe that that is also a very big benefit for us in decontamination of the equipment and for ALARA reasons.

That is really the end of my prepared presentation, if you have any questions.

CHAIRMAN JACKSON: Any questions?

COMMISSIONER DICUS: Let me ask you one thing. I understand that there were no particular significant problems encountered in this process but did you have a list of potential problems and the problems you found, were they on your list or were there unexpected problems?

MR. HOWELL: Well, actually, we had a very detailed readiness review process that the Department of Energy and the team, the Westinghouse team went through and had predicted several instances that we should be ready to take on. One, for instance, was the loss of on-site power and the loss of gas during the actual annealing and soak period.

Both of those did occur and we were very well prepared for them. And, as you can see in that curve, did not even push us close to being out of the soak range, so we did go through that process and felt that we successfully handled it.

CHAIRMAN JACKSON: Okay, thank you.

DR. CHAPIN: My name is Doug Chapin and I am a principal officer of MPR Associates, which is an engineering company here in the Washington area, and I want to tell you about the other half of the project, the Midland ADP, and in the interest of time, my presentation is arranged so that there are four or five pictures in the front and then some text at the back and what I will do is get the pictures put up and then I will sort of talk from the text.

So if I could have the first picture, please, figure one.

Commissioner Rogers is probably familiar with this picture. He has been briefed on the Russian annealing a couple of times. This is a picture of the actual furnace being lowered into the vessel at Novovoronezh reactor in 1991. This was an annealing that the NRC witnessed and was very interested in and we had three people who went and participated in that process and were on site.

What you see in this picture is the furnace itself with three rows of heaters and then the layers of insulation over the top and when I get to the picture of the American furnace, you will see that one of the major differences is that our furnace needs to be much taller because we need to anneal a much taller zone on the vessel.

Could I have the second figure, please?

This shows an elevation view of a B&W two-loop

plant and it is a different configuration than the Westinghouse plant and there are a couple of features that are important as far as the annealing is concerned.

At the bottom, this vessel is supported by a skirt so that when we heat the vessel, this vessel will grow up from the support at the bottom. The large hot legs and the cold legs from the steam generators are long runs of piping and we have to account for the loads and the thermal growth that are associated with the piping in the --

CHAIRMAN JACKSON: Excuse me, could you put the picture back on, please?

DR. CHAPIN: Oh, I'm sorry, yeah.

Go back to figure two. There we go.

The support skirt is at the bottom and then the two large steam generators to the far right and left and the hot legs often called "candy canes" from the shape that you can see, they go out of the vessel and then they run up vertically and come back in.

The cold legs come from the bottom of the steam generator into the pumps and then back into the vessel. So this is a little different configuration and this is one of the things that is different and we are going to get sorted out in this annealing is the difference between the nozzle arrangements and the support configurations between the two plants.

The team that's associated with doing this Midland is MPR is the prime and there is a Russian consortium called MOHT, which is the same company that has done the annealing or group of companies that has done the annealing in Russia, and Framatome Technologies who used to be B&W Technologies, as the other major player.

The key supporters are, of course, DOE and our primary contact is with Sandia and then the various utilities who support the group are the Empire State Electric Research Company, ESERCo, the Electric Power Research Institute, Consumers Power, General Public Utilities, the Tennessee Valley Authority and then there are two international participants, CRIEP, the Central Research Institute of Electric Power in Japan, and we also have a commitment from EDF and I guess you would characterize that as the check is in the mail, but we have international participation as well.

Can I have figure three, please?

Let's leave it up and I will talk about it a little bit.

This shows the furnace in the vessel at Midland and, as you can see, the furnace here is much taller. There are probably about nine rows of electric heaters as opposed to three in the Russian furnace. And if you look at the plan view at the top that shows where the nozzles are, you

can see that the nozzles are rather asymmetric around the top of the vessel. The hot leg nozzles are larger and are centered between the two cold leg nozzles and then the injection nozzles for core flooding are between those.

One of the advantages of the electric furnace technique is that it provides a high degree of control of the heat input to the furnace and so one of the things that we will be able to check out in this particular annealing demonstration is our ability to control the temperatures not only axially but azimuthally, if you will, around the vessel and account for the various heat losses. We will measure the axial and circumferential temperatures and we will control the furnace with an automatic feedback loop using a computer control system.

We will have about 72 thermocouples which are associated with the furnace itself which are retractable and when the furnace is installed, they are tucked into the furnace and then once the furnace is installed they go out and touch the inner wall.

In addition, we will have about 140 or so additional instruments, thermocouples, strain gauges, displacement gauges which will be put around on the piping and the supports so that we can monitor the parameters.

Could I have figure four, please?

This shows a plan view of the plant and what I

want to use this for primarily is to illustrate where we put the finite element model.

As my colleagues from Westinghouse and ASME pointed out, one of the key results of this demonstration project is the ability to have a good model of what's taking place so that we can migrate this technology, this analysis capability to other situations so we have made a detailed finite element model.

If I could have figure five please?

This shows the finite element model and the colors represent temperatures. The high temperature is the red zone and that's -- these are preliminary numbers and not precise but, to give you a feel, the red is say roughly 850 degrees Fahrenheit and the blue at the coldest ends is about 100 degrees Fahrenheit and so this is the temperature distribution in the vessel and we use a code to determine what the stresses are that result.

We are using a commercially available program which is called ANSYS, which is a standard code and so this is something which will be readily usable.

Then, if I could go to the last slide in the package, number 10, please?

[Slide.]

DR. CHAPIN: This gives a sort of status and the future milestones. We started the work in May of 1995. We

have had a lot of interactions with the Russians. The next trip to Russia will probably be in about a week and a couple of our engineers will go over to go over some key test results and some fabrication results that will be available in Russia at that time.

The site work has begun and we expect to have the furnace on site in November of this year and we will do the annealing in December and we expect to have the reports all issued by September of next year.

That's all I have at the moment.

CHAIRMAN JACKSON: Commissioner Rogers?

COMMISSIONER ROGERS: No questions.

CHAIRMAN JACKSON: Thank you.

MR. FRANKS: I think that concludes our technical presentations so we will turn it back over to the staff.

CHAIRMAN JACKSON: Mr. Howell, Dr. Chapin, I hope you are going to still be here, I have a couple of questions.

DR. CHAPIN: Yes, ma'am.

MR. HOWELL: Yes, ma'am.

CHAIRMAN JACKSON: Thank you.

This is group three.

MR. MAYFIELD: As you heard from the Westinghouse folks, they completed the annealing and have gotten off site. We had a team of a number of folks that we will talk

about in just a minute that were on site. We had a number of observations that we made that we are going to ask Debbie Jackson to address. But before turning the presentation over to her, I wanted to make at least three key points with you.

First of all, from what we have seen so far, we have not seen the detailed data, but from the site observations and what information we have so far, it does appear that the first annealing demonstration was successful. They got the vessel within the anticipated temperature range, followed the anticipated temperature profile pretty well and didn't seem to distort the vessel. So that was certainly key observations for us.

There were no particular -- well, no significant problems identified from the staff's observations so, while we were on site, we were looking very carefully for what was going right, what was going wrong. You will hear a little bit about some fire protection issues that were identified. We have passed those on to the NRR staff and back to Consumers Power for their consideration as they are planning the Palisades demonstration.

So based on the information that the staff has available to it so far and our site observations, we feel like this first demonstration was successful.

If I can have the next slide, please?

[Slide.]

MR. MAYFIELD: I noted that there were a number of people on site. We had at varying times 16 people from the staff and our contractor, Oak Ridge National Laboratory, on site. This was a program that was managed by the office of research, however, we had interaction from the NRR folks, from the EDO staff and from two of the regions. This is, we believe, an example of what we can do when we work from an interdisciplinary approach as well as interoffice approaches to these things.

So we feel like the staff had an opportunity to get a good look at the demonstration and we think we had the right people on staff at the right time or on site at the right times to take a look at what was going on in the demonstration.

Now, Debbie Jackson was our task manager for the on-site activities and we have asked her to provide you a summary of the staff's observations.

MS. JACKSON: Thank you. Good afternoon.

As Mike stated, the preliminary conclusion from the staff was that the anneal was very successful and these conclusions are based on the information that we have received from the pre and post NDE inspections and the pre and post dimensional analysis.

The NRC staff was on site to observe the setup of

the heater, installation and removal of the heater, the ductwork and the instrumentation, assembly and installation of the reactor vessel top cover, pre and post NDE inspections and dimensional checks, setup of the burners and the heatup, soak and cooldown.

One point that we wanted to stress was that the Westinghouse and Sandia personnel were helpful and they were accessable to the NRC and Oak Ridge staff while we were on site. They assisted in answering questions and escorting us while we were on site and at one point the flexibility of the NRC staff was increased by allowing two NRC personnel to be trained to escort other NRC and Oak Ridge visitors on site.

All of the instruments operated as specified. The NRC staff, while on site, obeyed the rules in the Westinghouse site procedure and the site safety was greatly enhanced by a cleanup operation which was mentioned previously and the appointment of a full-time safety engineer whose planning and effective execution of safety procedures was very obvious while we were on site.

May I have slide number 11, please?

[Slide.]

MS. JACKSON: One thing I would like to emphasize, even though these findings were not a major problem at Marble Hill, they would present a problem if these were

identified at an operating plant. Some of the activities took a little longer than anticipated. The fabrication of the ductwork required on-site engineering. The fabrication of the ductwork was prolonged by some additional welding that had to be done on site.

And a dimensional problem was encountered with the installation of the thermal plug that you saw in the video. It had to be removed, machined and reinstalled while we were on site.

The issues dealing with fire protection, there was a problem with the proximity of potential ignition sources which -- specifically electrical equipment, to the propane tanks which were located on the site. And the propane tanks at an operating plant would have to have been rotated 90 degrees from the position they were at Marble Hill. If the tanks were inadvertently ignited, they would move toward safety-related structures, which would not be acceptable.

Another issue was the manual fire suppression capability was only provided by fire extinguishers and a single hose with a fire hydrant and all of these issues were discussed with Palisades personnel from our fire protection engineer.

May I have slide number 12, please?

[Slide.]

MS. JACKSON: An observation procedure was

developed for use by the NRC and Oak Ridge personnel in preparing for site visits, site observations and preparing trip reports. And the procedure was consistent with the DOE/NRC MOU and it emphasized that the NRC's role while on site was to be an observer. No inspections were to be performed while we were on site.

May I have slide number 13, please?

[Slide.]

MS. JACKSON: Both organizations involved, the NRC and the DOE team, will be obtaining reduced data which was recorded from the Westinghouse, Cooperheat and NRC instruments and these instruments included temperature detectors, strain gauges and displacement gauges.

The real data that's being reduced includes measurements that were taken at different time intervals at every one to two minutes. No conversions were required on these measurements. They were all recorded in their proper form.

We wanted to note some of the occurrences that happened during the anneal. I had previously mentioned the setup of ductwork that required additional welding while on site. The plant personnel responded by adding an additional shift of welders while we were there.

There was a minor problem with a loose connection from the diesel generator from the saddle tank on the

outside to a compartment that resulted in a leak of fuel inside the compartment.

There were problems with the polar crane at various times during the anneal. It was inoperable due to blown fuses, failed circuit cards, motor repairs and overhauling which was required but, as was previously mentioned, the anneal still went on with that.

A report documenting the staff's assessment will be provided in the near future and will be available for review.

This concludes my portion of the presentation.

CHAIRMAN JACKSON: Let me ask you a question and to some extent I am also asking it of Mr. Howell and Dr. Chapin.

Are there any other issues other than what you have outlined that remain in transferring the gas and electric technology from the demonstrations, well, you've seen the one, to irradiated vessels?

MS. JACKSON: There probably would be problems -- well, in terms of the ductwork, the ductwork, the fit-up of the ductwork, that was something that would result in increased personnel exposure because it would just take a longer time to weld the pieces of ductwork together instead of having the ductwork come on site fabricated. It arrived at Marble Hill in 10-foot sections and collars had to be

welded to connect the 10-foot sections together so if the sections could arrive on site in longer pieces, then that would require less work while on site.

That would be my only observation. If someone else has something --

CHAIRMAN JACKSON: Are there any issues with respect to ease of installation of equipment with the bioshield heating, with insulation interference, anything like that?

MS. JACKSON: I think --

CHAIRMAN JACKSON: And maybe some of the --

MS. JACKSON: I think someone from Westinghouse would be more --

CHAIRMAN JACKSON: In terms of your experience, because you have actually been involved, it is a different technology but you have actually done irradiated vessels, you've done the demonstration with the gas-fired and so I guess what would you say are any critical issues that relate to going from the actual -- apparently successful demonstration in an unirradiated environment to --

MR. HOWELL: Well, as Debbie mentioned, there are things that we will definitely do differently at Palisades on the ductwork part of the detailed design of the Palisades program, to provide quicker connection ductwork and more basically planning on the lengths of pipe and things of that

nature that would be put into place. So that is a key difference that we would have to deal with because of the dose levels.

Obviously, this particular demonstration, as I expect is the case with Midland, does not mock up the actual shielding that is required for the lower internals and upper internal structures that has to be put in in an actual annealing. That design is being completed now for the actual shielding of those components and the routing, in our case, of the ductwork around that shielding.

So those are two, you know, specific differences that we have to address and we are addressing at this time.

CHAIRMAN JACKSON: What would be the effect on the reactor vessel which was being annealed if the heat source really was lost? You mentioned you were able to maintain the soak but what would happen if you actually lost your heat source and what would be the effects on the reactor vessel?

MR. HOWELL: The heat source itself is such that we have a lot of backup so that is a very low probability but the intent really is to maintain a vessel at 850 degrees for a certain period of time. If the heat source were to be lost for some period of time, it could be regained and relit and gone back to get the appropriate time added into that. We believe that would be also successful. So as long as the

total time at annealing temperature is maintained.

CHAIRMAN JACKSON: Is that true? You're saying, if it were annealed, if it were meant to be annealed for a week and it was annealed for two days and you lost your heat source and so it totally cooled down, then you annealed it for five more days, that's the same as annealing it for seven?

MR. HOWELL: There is a timing factor that would have to be taken into consideration but basically the total time at temperature is what gives you the metallurgical recovery.

MR. STROSNIDER: Jack Strosnider with the staff.

I just mention that in the event that for some reason the time temperature envelope is not followed during the anneal, the rule that was promulgated actually addresses that situation and there are certain requirements with regard to reassessment and whether the licensee could take credit for that or not. So that's been anticipated although, as was pointed out, the intent obviously is to have enough redundancy not to have that occur.

CHAIRMAN JACKSON: I note that there is a concern with something called temper embrittlement that has to do with segregation of impurities. Can you -- can anyone here give us some background on that and its potential impact on annealing projects in the U.S.?

MR. MAYFIELD: Well, this is something that we have been looking at as part of our materials research program for some time. There are some results. Well, it is a problem with some of the Russian reactors, the phosphorus content tends to run higher. So it is a much more significant problem for them than it has been for us.

Nevertheless, even for our materials, there is some potential for temper embrittlement. It is something that we have been looking at, we have programs underway to address it. Based on the information that we have available, the research results we have available, we do not believe that it is a significant problem for the U.S. materials. We believe that, to the extent it is an issue, it has been incorporated in the recovery database so it is modeled as part of the recovery equation.

It is implicitly in there. However, that is not a very satisfactory answer. It probably doesn't suit you; it certainly didn't us. So we have asked Oak Ridge to pursue this in a more aggressive manner.

There are data available from the British that suggest that for our classes of materials this could be an issue. However, when we looked at those data, it appears that they went to some lengths to create a situation where the materials would respond to a temper embrittlement phenomenon.

Based on the information we have, again, we do not believe it to be a significant issue today, however, it is something we are continuing to pursue in the research parameter.

CHAIRMAN JACKSON: Can you tell me how well the results of the annealing can be determined by existing nondestructive measures? I mean, how do you know that, in fact, the annealing was successful and you've actually been involved with --

DR. CHAPIN: What is normally done is you actually take samples and you do an annealing recipe and you demonstrate that for the steels that are involved, that the annealing recipe has in fact restored the properties. The Russians have, in fact, taken samples from the inside of the vessels after they have been annealed using electro discharge machining techniques very like we used to cut pieces out of the inside of the TMI II vessel and have essentially established on a scientific basis, if you will, at the Karchatov Institute that for this set of materials, this irradiation history, this annealing, this reirradiation, the desired property change is obtained.

MR. STROSNIDER: I just wanted to add two comments. One with regard to the temper embrittlement issue, we have asked the licensee also to address that issue for Palisades specifically and their plan involves some

testing to look for inner granular failure and some evidence to see if that's something that might occur, in which case they might have to take some additional actions. So we have sent them in one of our requests for additional information for them to identify how they are going to address that.

I guess the other comment is with regard to the recovery of the material toughness, if you look at the rule, I think, the reg guide, there are actually three ways that this can be done. One is using surveillance specimens which can be put through the same heat treatment. Another would be to remove specimens from the vessel. Finally, there is the analytic methods that have been developed based on the database.

Those are not nondestructive testing methods, as you asked, and we recognize that, but I think when we use these alternative methods what we have done is applied appropriate margins so that we feel that we have covered the uncertainties. Now, there is probably a penalty that is paid there in applying those margins but that's the best approach we have at this time.

CHAIRMAN JACKSON: So you feel there is additional conservativism built in because of this lack of direct ability to do that?

MR. STROSNIDER: Right.

DR. CHAPIN: Madam Chairman, could I address a

couple of other practical factors, I guess, that came out of the Russian --

CHAIRMAN JACKSON: Yes, please.

DR. CHAPIN: One of the things you mentioned was radiation levels and one of the things that is striking is the radiation levels in the Russian plants are very different than those in the U.S. plants. So even though we have irradiated vessel experience in real plants in Russia, the radiation levels at an American plant will likely be higher and so we will have to deal with the shielding and with access to the vessel flanges, all of the real things that need to be done.

CHAIRMAN JACKSON: Let me just stop you there for a second. Is that the reason the expected dose rates at Palisades are a factor of 10 higher than those at the -- that were estimated for the Loviisa Unit I in Finland? I mean, what is it that gives you that difference?

MR. RUSSELL: The dose rates are almost an order of magnitude difference between what was seen in the Russian reactors and what is seen in U.S. reactors.

CHAIRMAN JACKSON: Right.

MR. RUSSELL: I am not able to address specifically the issues of the dose estimates now. That is still under review by the staff and whether it is ALARA or not and some of the steps they are going to take to reduce

the budget for dose that they are expecting for the job.

COMMISSIONER DIAZ: But if I might say, this is something that is directly related to those reactors. The power level is 440 megawatts and the construction of the vessel is different so that is a significant difference.

DR. CHAPIN: And the vessels are clad, usually, in the United States and so there is more nickel content and so typically the dose level is higher.

CHAIRMAN JACKSON: Okay.

DR. CHAPIN: Two other items.

One is water. The presence of water in the vessel or the likelihood of water being introduced into the vessel while it's hot is a bad thing and so the Russians have spent a lot of effort in their own plants making sure the vessel is carefully isolated from sources of water.

This sounds straightforward but, if you look in our plants, you have a refueling pool, you have to have a place to put the reactor internals and so there are some engineering issues associated in a real plant with how you make sure things really are dry and that water is not present.

The last one is the variability of the insulation. In a real plant, and I think this is one of the things that we learned, we will learn out of these two plants, the vessel insulation will not be perfect and so you can't do

the stress analysis on the basis of a neat boundary condition assessment of it being perfectly insulated. There may be patches, there may be pieces missing or cracks. And so those have to be accounted for in the real -- in the real world.

CHAIRMAN JACKSON: That's good. That's what I was interested in. Thank you.

MR. TAYLOR: Okay, Jack?

MR. STROSNIDER: If you could have slide 14?

[Slide.]

MR. STROSNIDER: I would like to provide a little bit more background on the regulatory framework involved with reactor pressure vessel assessments. Mike Mayfield talked briefly about it. I will talk a little bit more about that.

Then I want to talk about Palisades reactor pressure vessel and the licensee's annealing plans of that vessel and also I want to mention then some revised fluence calculations that are under review for the Palisades vessel.

There is a number of regulations that apply to reactor pressure vessels. I am hitting some of the high points here. In particular, 10 CFR 5061 normally referred to as the Pressurized Thermal Shock Rule. Vessel embrittlement is a function of fluence and chemistry, particularly copper and nickel and 5061, the ETS rule,

specifies how to evaluate embrittlement of reactor pressure vessels as a function of fluence in the chemistry.

It also establishes screening criteria to limit the amount of embrittlement to assure that there is adequate margins in the vessel for anticipated transients and pressurized thermal shock type events.

The level of embrittlement is calculated in advance such that there should be time to take appropriate actions if a reactor vessel is predicted to reach the screening criteria. Those actions can consist of either a plant-specific evaluation. The screening criteria were developed based on generic assessments. There is the option for a licensee to look at their plant-specific systems, thermal hydraulics, reactor vessel design, et cetera, to evaluate it that way. Or the other option is annealing.

With regard to annealing, as was mentioned earlier, we have promulgated 10 CFR 5066, the annealing rule, and also Regulatory Guide 1.162, which provides guidance on how to implement that rule.

Just to hit a few high points in that rule and regulatory guide, there is a requirement that a licensee which desires to anneal the reactor vessel submit a thermal annealing report three years before actually performing the annealing. This thermal annealing report has four major sections in it. One is an operating plan. The operating

plan consists basically of describing how the anneal is intended to be performed; that is, what sort of heating system, what sort of temperature time history, that sort of thing.

Also, it includes an assessment of what sort of thermal gradients, thermal stresses and strains would exist in the vessel and it addresses radiation dose ALARA considerations.

The second part of the report is the inspection and test plan and this is basically the precert by the pre-anneal and the post-anneal in-service inspection or testing that would be done to demonstrate that the vessel wasn't damaged, wasn't deformed, you know, in a damaging way.

Then there is a section with regard to fracture toughness. That is, predicting the level of recovery from the anneal and also a followup on, after the vessel is put back in service, what the re-embrittlement would be. That has to be defined how that is all going to be done. Then, finally, a section which deals with identification of changes, necessary changes in the technical specifications or unreviewed safety questions.

So that has to be submitted three years prior to performing the anneal. The NRC staff will evaluate that thermal annealing report and put their evaluation in the public document room. It is really an opportunity for us to

look at their plan and raise any red flags and, as I said, particularly with regard to the unreviewed safety questions, it's the licensee's responsibility to identify those, that we look at the plan with particular focus on that.

A couple other important things is that both before the annealing is performed and after the annealing is completed, the NRC would document their review in the public document room and there is also a public meeting that would be held before and after the annealing to basically inform the public what was done and the NRC's evaluation and inspection results.

So that is sort of a summary of the regulatory framework that applies to annealing. With regard to Palisades, we completed an evaluation in April of 1995 in which we concluded that they would reach the screening criteria. At least they were okay until 1999. That evaluation was consistent with the 5061, the Pressurized Thermal Shock Rule. The current license for Palisades expires in 2007 so they would fall somewhat short of the current operating license with regard to the life of the vessel.

So, if I could have slide 15?

[Slide.]

MR. STROSNIDER: Recognizing that, Consumers Power Company, the licensee for Palisades, has developed a plan to

anneal the Palisades vessel. It would occur during the 1998 refueling outage. We are in the middle of the review of this plan.

They put together a thermal annealing report consistent with the regulatory guide and they have submitted portions of that and specifically they have submitted the operating plan which, as I mentioned, talks about heat source, how it would be done, thermal and stress analysis, those aspects of the annealing. They even submitted the inspection and test plan and also the fracture toughness evaluation that is recovery and re-embrittlement.

They have submitted those portions of the plan with the exception of some work they are going to do to use the results of the Marble Hill anneal to benchmark and to demonstrate the adequacy of their plan in some of these areas. And just to give some examples, and we just went over some of this, but I think some of the important parts of the annealing demonstrations.

First, to demonstrate that the calculational methods, that is the computer codes that are being used for the heat transfer and stress analysis, in fact, work and for Marble Hill those analyses were done ahead of time and they will be compared with the actual results from the instrumentation.

The next thing is to demonstrate what

instrumentation is actually necessary and that it works well in terms of monitoring the reactor vessel and other components, including the piping and bioshield wall and containment structures during the annealing for temperature and deformations.

This is an important area if you couple the analysis and the instrumentation aspects because installation of instrumentation is very expensive, not only in terms of money but in terms of exposure. So there is a desire in a plant-specific basis to minimize the instrumentation necessary and the idea of part of the demonstration anneals is that you can identify critical instrumentation and verify that you have an adequate amount to control the annealing. Obviously, a demonstration of the heating system and the ability to control temperatures.

One of the requests for additional information that we sent out did ask the licensee to address the differences between Marble Hill and Palisades and specifically tell us what differences would be expected and why.

So that is how some of this annealing demonstration program is being applied on a plant-specific evaluation.

If I could have slide 16?

[Slide.]

MR. STROSNIDER: The other thing that's going on with regard to the Palisades vessel is that in April of '96 the licensee submitted a revised fluence analysis for the Palisades vessel and this basically -- they proposed a change in the fluence evaluation from that that was used in our earlier evaluation.

What they have submitted indicates as much as a 25 percent reduction in fluence, as a result of revised geometry and dimensions for the vessel, reassessment of the fluence in earlier cycles, I think looking at the actual power levels and what was happening there, and changes in the computer code, the calculational methodology.

This submittal is under review. We are reviewing it in parallel with the annealing report that was sent in. We do plan to perform independent calculations to verify their calculations.

It is important, obviously, to note a 25 percent reduction in fluence could have some impact on their plans for annealing. In fact, if we found that a 25 percent reduction was, in fact, acceptable or appropriate, that would extend the life of the vessel to around 2011, which would be past the end of the current operating license. So this is an important review going on in parallel.

CHAIRMAN JACKSON: Do you anticipate completing that review in a time frame -- I note that you had indicated

that Palisades was planning to anneal their vessel during the 1998 refueling outage and so the way things are tracking --

MR. STROSNIDER: I understand, and this review is being done by Reactor Systems Branch, but I understand that that should be completed by the end of the year, assuming that we get appropriate responses to the RAIs, requests for additional information, that we sent out.

So I think, yes, it will be done well before the anneal.

Also, with regard to the annealing plan itself, those additional sections that remain to be submitted, we are anticipating receiving those by the end of the year. So, early next year, we should be getting pretty far along in these reviews.

So I guess that is basically a summary of where we are in licensing space. We've got two reviews that are going on and it will be sometime early next year or so when we can really give you the results of all of that.

MR. TAYLOR: That concludes the staff's presentation.

CHAIRMAN JACKSON: Questions? Commissioner Rogers?

COMMISSIONER ROGERS: Yes.

With respect to Palisades, my recollection seems

to be that they were trying to move on a much faster schedule than what you have just described some time ago, isn't that right? Didn't they have a plan to be much further along on this than they are right now?

MR. STROSNIDER: I think that's correct. Some of their earlier plans had a more aggressive schedule.

COMMISSIONER ROGERS: And there was a great concern about our being able to, from our end, being able to support that schedule that they were on. My recollection was that they wanted to have something done by this fall but I --

MR. RUSSELL: If we go back to the '94 time frame when we discovered the information that was reported to us about the differences in chemistry values and what that meant, there were different approaches that were taken that ultimately culminated in the staff issuing a safety evaluation report, I believe, in the spring of '95 which indicated they had until the 1999 time frame. That's when the '98 type scheduling was established.

Prior to that, where we went in and did the more sophisticated evaluation, in fact Mike Mayfield and the staff were running the computers over weekends and quite late at night to do some of the analysis, we thought it could be that they had exceeded the screening criteria either at that time or would shortly, which would mean that

the time frame for needing an anneal was sooner.

So we did an analysis using the same approach that we used in developing the rule originally and the regulatory guide, although we did do Monte Carlo analysis to more systematically address some of the uncertainty.

As you recall, it was a rather skewed distribution of chemistry values for copper and that made the analysis somewhat difficult. It was some very high values and it almost looked like it was random so there was no bell-shaped curve. So that gave us some difficulty in handling the review. We did it in a more rigorous method and we were able to determine that there was time through the year 2000 or 1999 time frame, so that relieved some of that pressure.

Questions on whether there are going to be related technical specification changes associated with this, obviously there could be some with pressure temperature curves following an anneal but the issues relating to an anneal itself are the ones that we were focusing on today and they seem to be reasonably on track.

The parallel review of the new methods that they are using to calculate fluence, whether we are able to agree with a 25 percent reduction or in some smaller number and the time frame for that, we are going to try and complete that by the end of the year.

COMMISSIONER ROGERS: One other question. Are

there any concerns about airborne contamination within containment when you are annealing one of the irradiated vessels?

MR. STROSNIDER: I think the answer is, yes, that is an issue, obviously, that has to be addressed. I think, as I understand it, one of the advantages of this gas-fired hot air method was you basically contain that, you don't stir up a lot of airborne activity. But it is a concern that should be looked at.

I should mentioned that the Palisades review by NRR staff is a multi-discipline review so it is not just materials. We have health, physics people, fire protection and other people involved so I can't personally give you a lot more specifics on it except to say, yes, it is something that needs to be considered and will be looked at.

CHAIRMAN JACKSON: Commissioner Dicus?

COMMISSIONER DICUS: No questions.

CHAIRMAN JACKSON: Commissioner Diaz?

COMMISSIONER DIAZ: Yes, just a comment.

I tried, and "tried" is the right word, to conduct a materials program with Russia for the last three years and one of the problems I was having is control. That is the problem they have with their pressure vessels is they really did not have quality control, quality assurance and so every vessel is completely different and every amount of copper

and other extraneous materials is different.

I do believe that we do have a little better handle on our vessels and therefore that would be a favorable thing to note down the fact that we can predict and we can do these things a little better.

The Russians do have a very serious problem. They really don't know most of the time what do they have in those vessels. I hope we do.

MR. RUSSELL: That was actually the subject of a generic letter and we are developing a national database and we have briefed the Commission on that in the past but we are making progress on it and no longer treating the information as proprietary so that it's available to all so that information on sister vessels can be exchanged and there is good progress being made both on the B&W fabricated vessels which we were quite a lot further along, plus also the CE fabricated vessels.

I believe the database is available electronically and the software that allows it to be manipulated is also available so that utilities can see what information has been submitted to the NRC and do their own searching. So this is an area where we have made progress in the last three years and we hopefully will not be surprised by further findings of unusual copper results that cause us to go into a faster mode of deciding what needs to be done on a

vessel.

MR. STROSNIDER: Just to expand on that a little bit, if I might, as Bill mentioned, we put out a generic letter. This was a supplement to Generic Letter 9201 and what we found from our first round of reviews when we put all these data into a database was that licensees weren't necessarily treating the data consistently and, in some cases, weren't aware of all of the data that were available.

So a supplement to the letter required the industry to go out and search out all data and, in fact, there is, as Bill indicated, a massive effort by the industry right now going back to original fabrication records and we expect that there will be a significant amount of data added.

We are going to be receiving results and getting heavily into the review of those next year and I think it is going to about in December of '94 we completed a review of all the reactor pressure vessels in the United States based on the data we had available at that time. We will, next year, have to go back and redo that based on the new data that we receive.

At that point in time, I think we will have the most comprehensive base line that we can have on reactor vessels. So we still have some more work to go there but the whole idea is to do that in a time frame to avoid any

surprises. We would like to get those data now and reassess all the plants and if there are any plants whose status is going to change from our previous evaluation we will identify that as early as possible.

MR. RUSSELL: We did, however, apply the lessons learned from Palisades in a conservative manner to make sure that there was sufficient time for other vessels and that Palisades, based upon everything we had, was the limiting vessel.

There were a few others that were close that we documented in reports and some of those have fallen off the list as a result of additional work being done by licensees or additional information becoming available So we don't believe that there are going to be any further surprises but that's a difficult issue until all of the information is in and we see how it's applied.

COMMISSIONER DIAZ: But would you both agree that we are in better shape?

MR. STROSNIDER: We are in better shape than we were in '92 and we are getting better and by the time all the answers come in in '96 and '97, we will be able to answer it much more definitively, especially for license renewal purposes. I think that is where it is really going to be significant as it relates to corrective action for vessel material properties to operate for an additional

period of up to 20 years.

CHAIRMAN JACKSON: From our observer status, at this point, it is probably premature to ask whether there are any particular lessons learned from these demonstrations that need to be passed along in any kind of generic communications or reg guides? We were talking about the generic letters in a different context, but --

MR. STROSNIDER: I am not sure about generic communications. One thing that we are looking at is some of the same people who did these observations will be participating in developing a temporary instruction for inspection when this is implemented.

As we indicated, those observations we had in some areas like fire protection have certainly been passed on to Palisades.

CHAIRMAN JACKSON: Any other questions?

[No response.]

CHAIRMAN JACKSON: Well, I would like to thank the Department of Energy representatives as well as the members of the NRC staff for briefing the Commission. It appears, at least, that the results of the project to date are encouraging and I would urge you to resolve any technical issues both expeditiously and thoroughly. Sometimes, people think that is an oxymoron but it is important so that the public as well as the users of the technology can be

confident in the overall process.

Unless there are any further comments, we're adjourned. Thank you.

[Whereupon, at 3:34 p.m., the briefing was concluded.]

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON ANNEALING DEMONSTRATION PROJECT - PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Tuesday, August 27, 1996

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken stenographically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: Christopher Catchall

Reporter: Mark Mahoney

STATUS OF REACTOR PRESSURE VESSEL THERMAL ANNEALING DEMONSTRATIONS

Michael E. Mayfield, Chief, EMMEB
Deborah A. Jackson, EMMEB
Division of Engineering Technology
Office of Nuclear Regulatory Research

Jack Strosnider, Chief, EMCB
Division of Engineering
Office of Nuclear Reactor Regulation

August 27, 1996

REACTOR VESSEL THERMAL ANNEALING

Background

- Reactor pressure vessels subject to long-term irradiation and embrittlement damage
- Embrittled vessels more vulnerable to failure due to operating and accident loads (reduction in ductility and fracture toughness)
- Thermal Annealing is only known method for mitigating effects of neutron irradiation

REACTOR VESSEL THERMAL ANNEALING

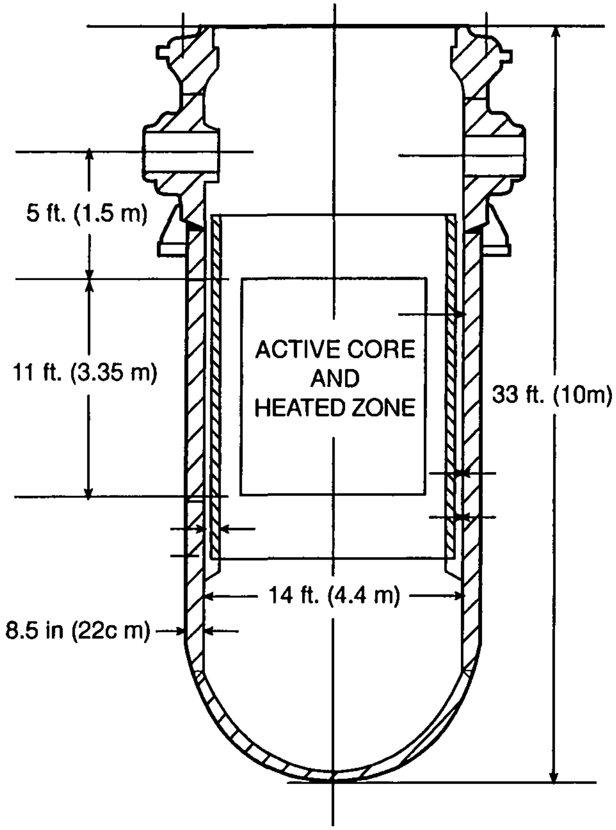
Background (cont'd)

- Thermal Annealing is a process in which the highly embrittled area of the vessel is heated above the operating temperature for one week thus relieving embrittlement and restoring the ductility to almost unirradiated level.
- First annealing of a U.S. commercial reactor scheduled for 1998
- NRC promulgated a regulation and regulatory guide addressing thermal annealing
  - Addresses material and engineering issues

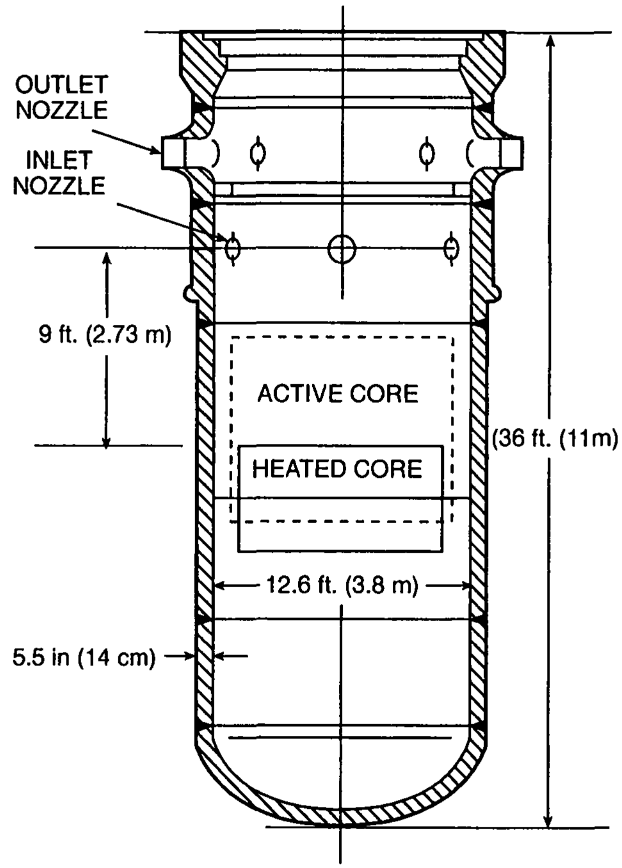
RUSSIAN AND EUROPEAN EXPERIENCE

- Russians and East Europeans have successfully annealed the VVER440 design vessel 15 times (Novovoronezh Unit 3 annealed twice)
- NRC team witnessed the annealing of Novovoronezh Unit 3 and Loviisa Unit 1
- On-going cooperative program with Russians (JCCCNRS Working Group 3)
- Material, Nozzle and weld locations in Russian designed reactor vessels are different
- Russian and East European experience is useful but does not address all questions for US designs

COMPARISON OF US AND VVER REACTOR VESSEL



PALISADES REACTOR VESSEL



VVER 440 REACTOR VESSEL

ANNEALING DEMONSTRATION

- Engineering issues need to be addressed
- DOE structured program to evaluate annealing
  - Engineering issues
  - Material issues
  - Regulatory issues
- NRC's primary interest is in the Engineering Demonstration
  - Materials issues being addressed through ongoing programs

ANNEALING DEMONSTRATION PROGRAM

- NRC participating through Memorandum of Understanding
  - Independent review and evaluation of DOE Annealing Prototype Demonstration Projects (ADPs)
  - Independent validation of ADP analyses
  - Independent evaluation of ADP measurements, and installation of confirmatory instrumentation
  - Independent validation of thermal and stress analysis models.

KEY POINTS OF MARBLE HILL ANNEAL

- First annealing demonstration appears to have been successful
- No significant problems identified from staff observations
- Majority of the fire protection issues identified are unique to gas fired design

NRC STAFF AND CONTRACTOR PARTICIPATION
MARBLE HILL ADP

Office	Division/Branch	Staff	Key Responsibility
RES	DET/EMMEB	ME Mayfield	Mgmt. Oversight
	DET/EMMEB	GC Millman	Task Mgmt.
	DET/EMMEB	SN Malik	PM for ORNL Support
	DET/EMMEB	DA Jackson	Site Coordinator
NRR	DE/EMCB	EM Hackett	Materials/Mechanical
	DE/EMCB	KR Wichman	Materials/Mechanical
	DE/EMCB	MA Mitchell	Mechanical
	DSSA/SPLB	EA Connell	Fire Protection
	DRPW/PDIII-1	MK Gamberoni	PM Palisades
EDO		BC McCabe	EDO Liaison
Region I	DRS	EH Gray	NDE
Region III	DRS	MS Holmberg	NDE
	DRMA	TJ Kozak	Radiation Protection
ORNL		WE Pennell	PM ORNL
		CB Oland	Instrumentation
		L Ott	T/H-Stress Analysis

STAFF OBSERVATIONS
MARBLE HILL ADP

- General
  - Anneal was performed successfully. No apparent damage to the RPV, piping or components
  - Staff observed installation and operational steps
  - Site personnel were very accessible and helpful
  - Instrumentation had been carefully installed
  - RCL penetrations sealed to prevent extraneous convection currents
- Site Safety
  - First priority of site personnel
  - Greatly enhanced by cleanup operation and appointment of a full-time safety engineer

STAFF OBSERVATIONS
MARBLE HILL ADP

- Radiation Protection
  - Practical experience to apply when reviewing ALARA estimates and radiation protection procedures for an anneal at an operating plant
  - On-site fabrication of heater/ductwork led to more than expected person-hours
- Fire Protection
  - Minor deviations from NFPA Standard No. 58 for LP-Gas storage and use
  - Orientation of LPG storage tanks relative to "safety related" structures was a concern to the staff
  - Manual fire suppression capability was minimal

Note: Fire protection items were included in Request for Additional Information for Palisades

OBSERVATION PROCEDURE DEVELOPED BY NRC

- Provides background and objective for onsite activities
- Identifies site activities/equipment to be observed and level of observation. This includes:
  - Assembly and installation of major equipment
  - Installation and testing of instrumentation internal/ external to RPV
  - Installation and testing of NRC confirmatory instrumentation
  - NDE and dimensional measurements of the RPV
  - Fire Protection
  - ALARA
  - Demonstration anneal
- Intended to provide basis for Temporary Instruction

REMAINING ACTIONS

- DOE
  - Reduce data
  - Compare measured results to predicted values
  - Resolve analytical model, as necessary
- NRC
  - Obtain reduced data for all instrumentation
  - Compare measured results to predicted values
  - Validate DOE results with results from confirmatory instrumentation
  - Resolve analytical model, as necessary
  - Determine generic nature of unanticipated occurrences
  - Prepare Temporary Instruction for use during a thermal anneal at an operating plant

PALISADES REACTOR VESSEL ANNEALING BACKGROUND

- 10 CFR 50.61 Pressurized Thermal Shock (PTS) rule

– Establishes screening criteria for PTS

– Plant specific analysis or annealing required if criteria are projected to be exceeded

- 10 CFR 50.66 and Regulatory Guide 1.162 provide guidance for RPV annealing

- Palisades satisfies screening criteria through 1999 (April 1995 safety evaluation)

STATUS OF PALISADES ANNEALING PROGRAM

- Consumers Power Company (CPCo) has developed a plan to anneal the Palisades RPV during 1998 refueling outage.
- Annealing plan consistent Regulatory guide 1.162, "Format and Content of Report for Thermal Annealing of Reactor Pressure Vessels."
- Portions of the annealing plan have been submitted to NRC and will be supplemented to reflect benchmaking results provides by the Marble Hill ADP.
- Additional information will be submitted later this year and following the annealing.

REVISED FLUENCE ANALYSIS

- CPCo submitted a revised reactor vessel fluence analysis in April 1996
- Review of revised fluence calculations is proceeding concurrent with the annealing review
- Acceptance of a lower fluence value would change the date Palisades reaches the 10 CFR 50.61 screening criteria.
- CPCo could change plans to anneal the Palisades vessel if revised fluence calculations are approved.

MARBLE HILL ANNEALING PROTOTYPE DEMONSTRATION PROJECT BRIEFING TO THE NRC COMMISSIONERS 27 AUGUST 1996

BY

RAY ART - ASME
DAVE HOWELL - WESTINGHOUSE NSD

OVERVIEW OF PRESENTATION

- o General Objectives of Marble Hill Project
- o Marble Hill ADP Team Members
- o Indirect Gas Heating System
- o Description of Thermal/Stress Analysis Model
- o Description of Monitoring Instrumentation
- o Description of Vessel Inspection
- o Key Results
- o General Conclusions on the Marble Hill ADP

- o Overview of Key Fabrication, Construction and Disassembly Effort (Back up Slide)

GENERAL OBJECTIVES OF MARBLE HILL PROJECT

- A joint industry-government effort to demonstrate the engineering feasibility of a reactor vessel annealing system

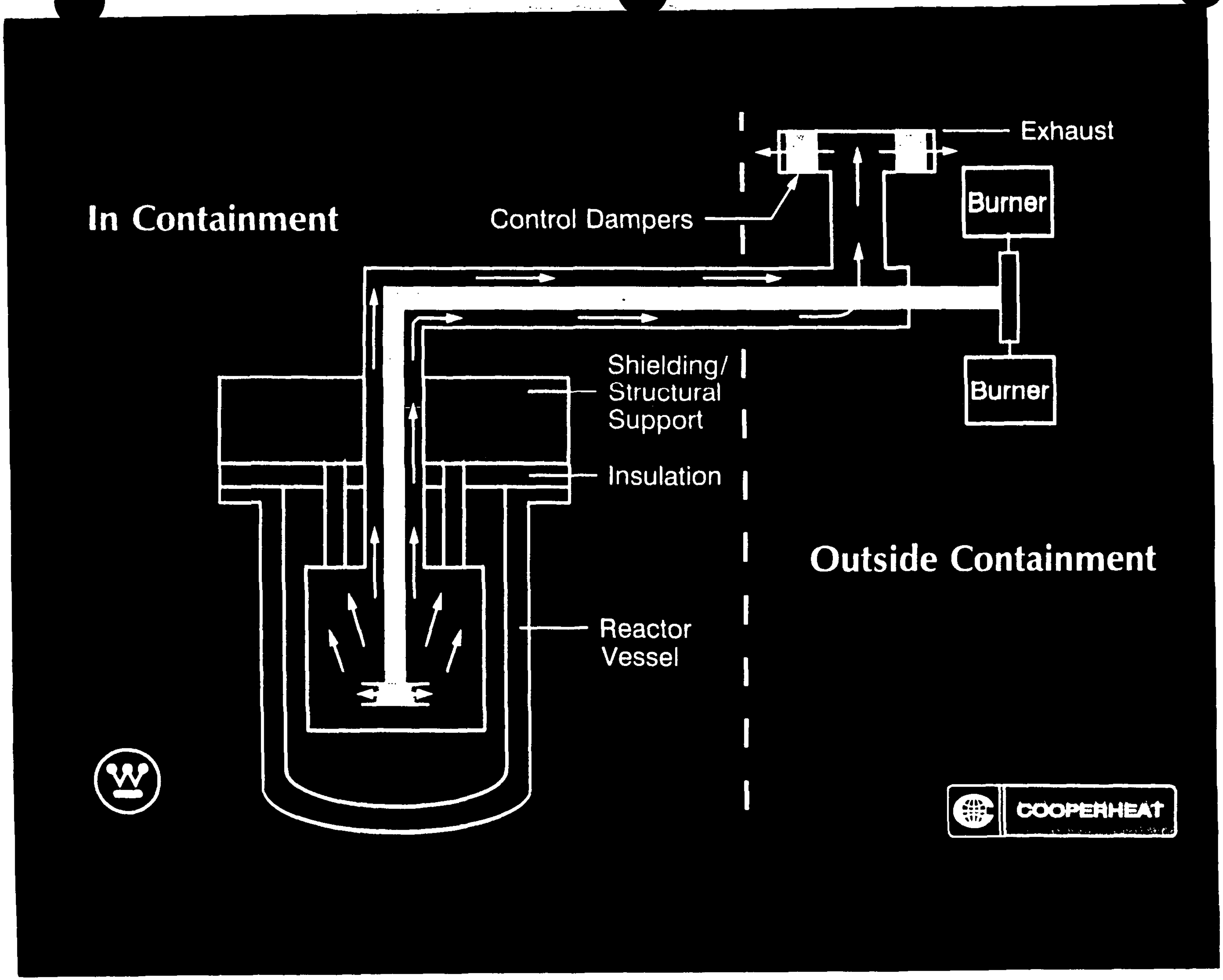
- Marble Hill Project demonstrates indirect gas fired annealing technology

- First successful in-place anneal of US commercial reactor vessel in a typical U.S. nuclear plant

MARBLE HILL ADP TEAM MEMBERS

Department of Energy
Sandia National Laboratories Industry
American Society of Mechanical Engineers
Westinghouse
Cooperheat
Electric Power Research Institute (with participating utilities)
Westinghouse Owner's Group
Consumers Power
Duquesne Light
CRIEPI

The USNRC is observing the progress of the project activities (design and site)


In Containment
Control Dampers
Exhaust
Burner
Burner
Shielding/
Structural
Support
Insulation
Reactor
Vessel
Outside Containment
COOPERHEAT

DESCRIPTION OF THERMAL/STRESS ANALYSIS MODEL

- o Purpose of thermal/stress analysis and modeling
  - Provide a validated model for future efforts
  - Provide the basis for instrumentation selection and location
  - Provide the input for reactor vessel measurements and NDE inspection locations
- o Approach
  - 3-D Thermal
  - 3-D Analytical Model

Description of Monitoring Instrumentation

- Temperature: 228 sensors (thermocouples and RTDs)

  RV external surfaces, reactor coolant piping, RV nozzles, RV flange, RV supports, cavity concrete, RV internal surfaces

- Displacement: 22 sensors

  RV external surfaces (support pads, vessel bottom), reactor coolant piping

- Strain: 14 sensors

  Reactor coolant piping, RV nozzle to pipe welds

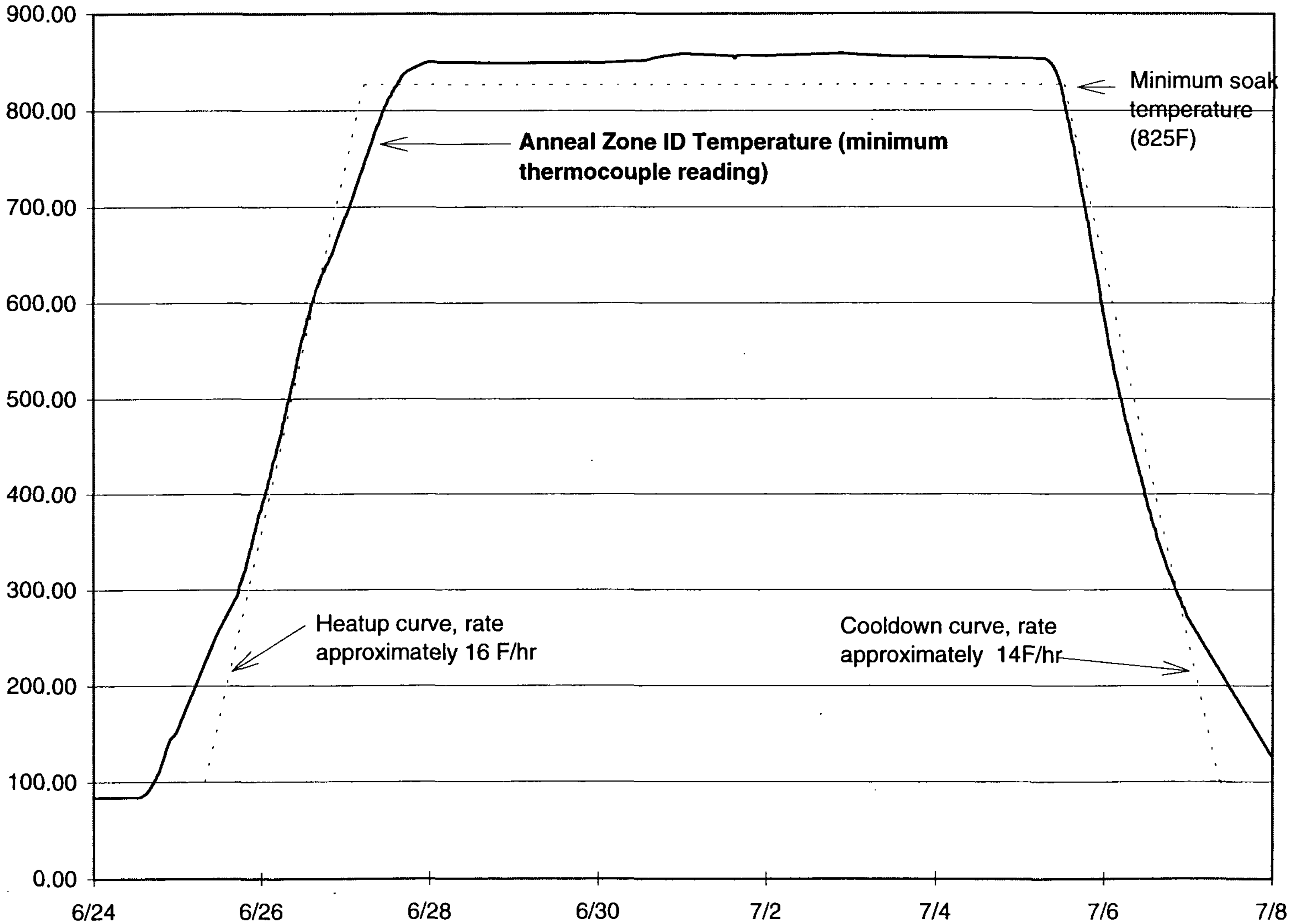
DESCRIPTION OF VESSEL INSPECTION

- o RV Dimensional Checks (Pre and Post-Anneal)
  - Key interface locations with the reactor vessel internals and vessel head seating
- o Nondestructive Examination (dye penetrant, visual inspection and ultrasonic testing)
  - Dye Penetrant, Visual Inspection and Ultrasonic Testing at selected Reactor Vessel and Loop Piping Welds

MARBLE HILL ADP MILESTONES

- Arrival on site of ASME Team (clean-up team) - 6 May 1996
- Commencement of heat up to the annealing temperature - 24 June 1996/13:43
- Commenced anneal soak - 28 June 1996/04:00
- Completed cool down to less than 200 degrees - 8 July/02:54
- Departure of ASME Team on site (demob team) - 24 July 1996
- Issuance of Field Service Report to ASME - 27 August 1996
- Issuance of Draft Final Report to ASME - November 1996
- Issuance of the Final Report to the public - Early 1997

Temperature of Reactor Vessel Anneal Zone ID



KEY RESULTS

- Demonstrated full scale Reactor Vessel Annealing Process at a nominal 850 degrees Fahrenheit in the annealing zone (I.D.) for greater than seven days

- Critical dimension measurement, pre and post anneal, have been completed and any changes were within acceptable tolerance

- Able to control heat-up, soak and cool-down with indirect gas fired heating

- Reactor vessel ID and OD instrumentation functioned as expected no failure

- NDE inspection of reactor vessel and associated loop piping has been completed and no reportable indications were present.

- No loss time accidents occurred while the ASME team was at Marble Hill

GENERAL CONCLUSIONS ON THE MARBLE HILL ADP

- o *SUCCESS* - Annealing of an installed US commercial reactor vessel is feasible

  - No significant reactor vessel deformation
  - Analytical model accurately predicted temperatures, strain and displacements
  - No damage to the balance of plant (loops piping, concrete, supports)
  - Reactor vessel annealing hardware and operations costs are reasonable based on insights gained

- o *SUCCESS* - Indirect gas heating system:

  - Reliable equipment
  - Light weight
  - Components accessible/repairable during operation
  - Ability to control direction of heat flow
  - Forced cooldown capability

- o *SUCCESS* - No showstoppers for a commercial anneal

  - Rapid installation and removal of equipment
  - Potential for minimum contamination of equipment/ALARA insights

OVERVIEW OF KEY FABRICATION, CONSTRUCTION, AND DISASSEMBLY EFFORTS

- o Clean up and preparation of the Marble Hill Unit 1 site
- o Pre Anneal NDE and reactor vessel dimensional checks
- o Installation of instrumentation to the internal and external to the reactor vessel
- o Assembly of heat exchanger and reactor vessel top cover - HERA
- o Insertion of the HERA into the reactor vessel
- o Assembly of the ductwork and heating system
- o Heat-up to the 850 degrees fahrenheit, soak and cool down
- o Disassembly of the ductwork
- o Removal of the HERA and disassembly of the heat exchanger and reactor vessel top cover
- o Removal of instrumentation
- o Post anneal NDE and reactor vessel dimensional checks

Overview of DOE Reactor Pressure Vessel Annealing Program

Presentation to NRC Commissioners
August 27, 1996

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

Office of Nuclear Energy, Science and Technology

Key Information from Demonstrations

- Maintain vessel within acceptable annealing temperatures and times during an anneal

- Assess surrounding reactor systems to ensure no damage during and after an anneal

- Demonstrate annealing thermal/stress computer models accurately

- Evaluate the differences between
  - the two annealing heating technologies and processes
  - the two different vessels and NSSSs

- Apply lessons learned to improve
  - the regulatory process
  - future annealing procedures
  - cost analyses
  - the lead plant anneals

Annealing Demonstration Project (ADP) Facts

	Marble Hill ADP	Midland ADP
• Where:	- Southern Indiana	- Central Michigan
• When:	- June 24-July 8, 1996	- December 1996
• Technology:	- New indirect gas-fired	- Russian-designed electric
• Vessel Type:	- Nozzle supported, unirradiated, CE fabricated	- Skirt supported, unirradiated, B&W fabricated
• NSSS:	- Westinghouse, 4-loop, U-tube steam generators	- B&W, 2-loop, once-through steam generators
• Contractors:	- ASME Center for R&TD, Westinghouse, Cooperheat, Parsons	- MPR Associates, MOHT (Consortium), Framatome Technologies

Overview/Status of Midland Annealing Demonstration Project (ADP)

Presented to:

Nuclear Regulatory Commission

Commissioners Briefing

August 27, 1996, Rockville, MD

Presented by:

Doug Chapin, Principal Officer, MPR Associates

Alex Zarechnak, MPR Associates

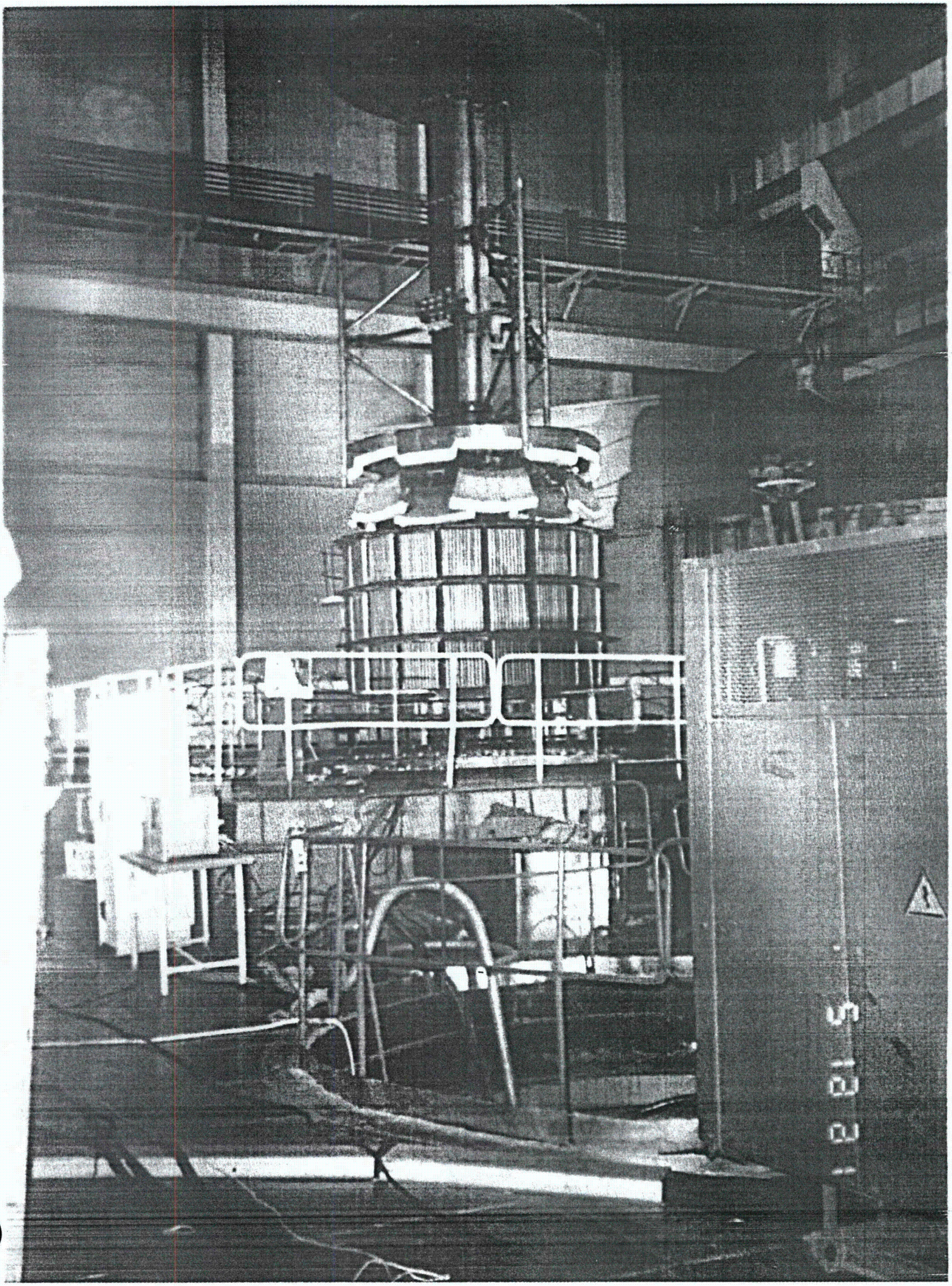


Figure 1. Annealing Furnace Being Lowered into Novovoronezh Unit 3 Reactor Vessel *(NRC sponsored visit)*

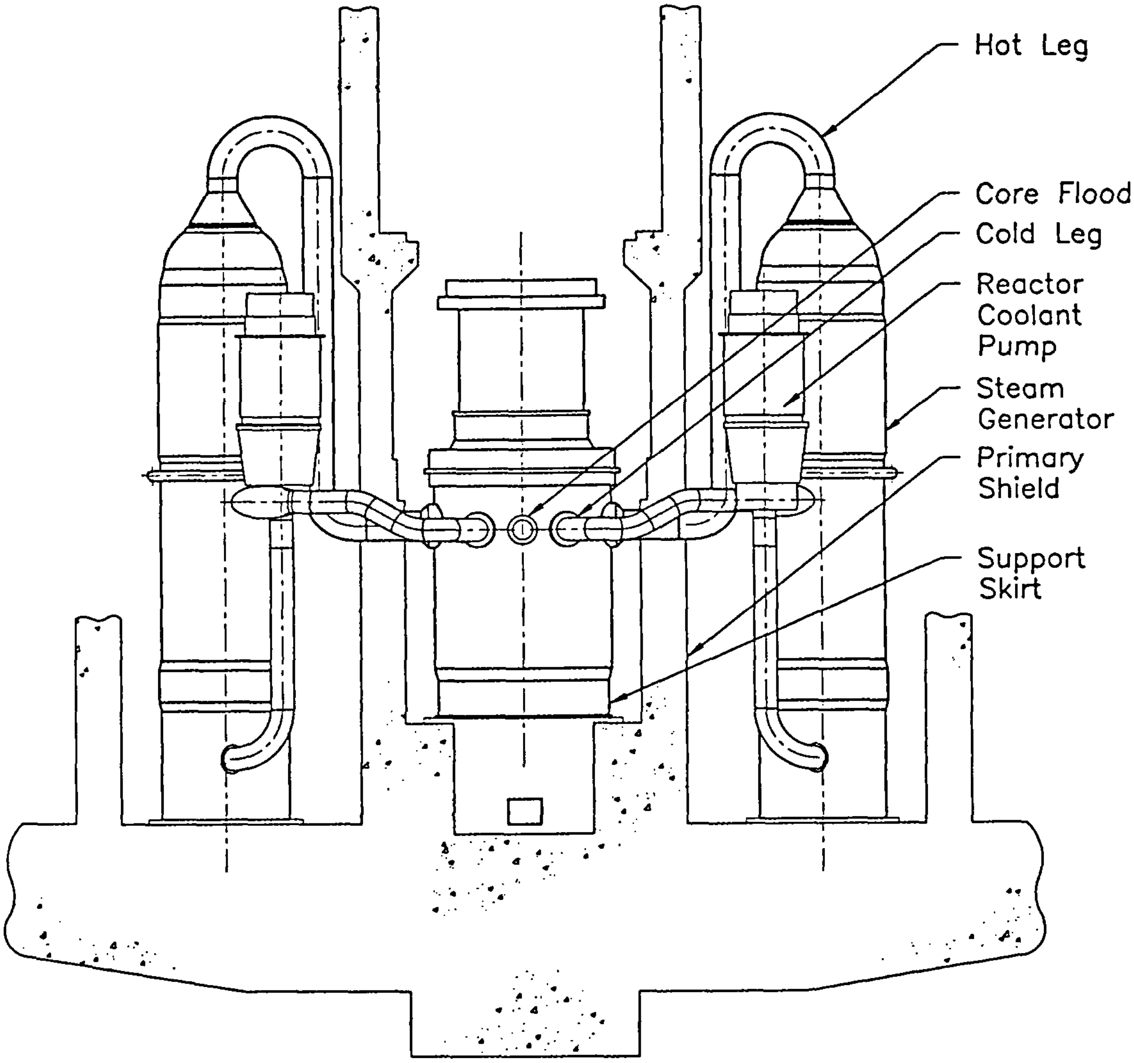


Figure 2. Midland NSSS – Elevation

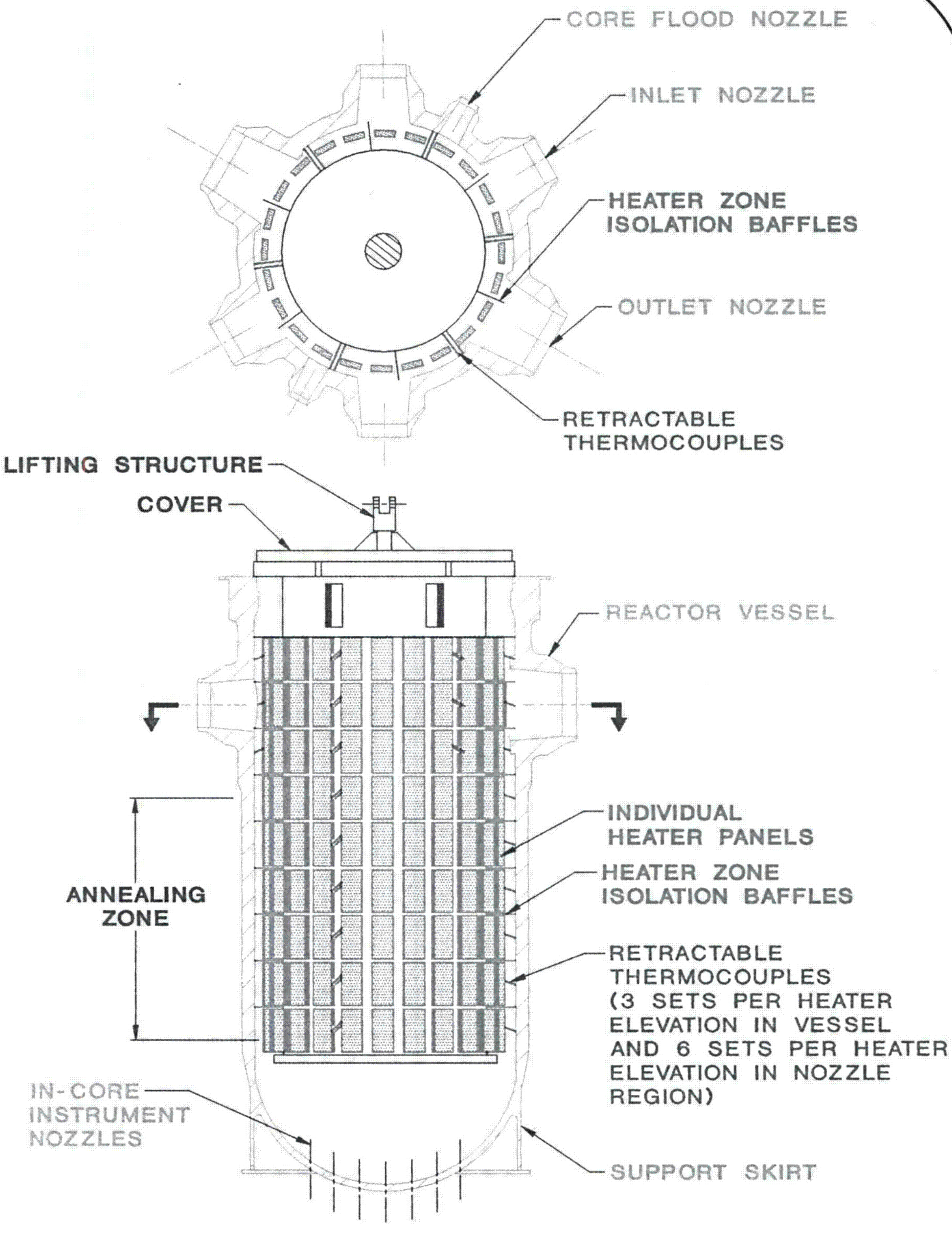


Figure 3. MPR Team Electric Annealing Furnace for Midland Reactor Vessel Demonstration

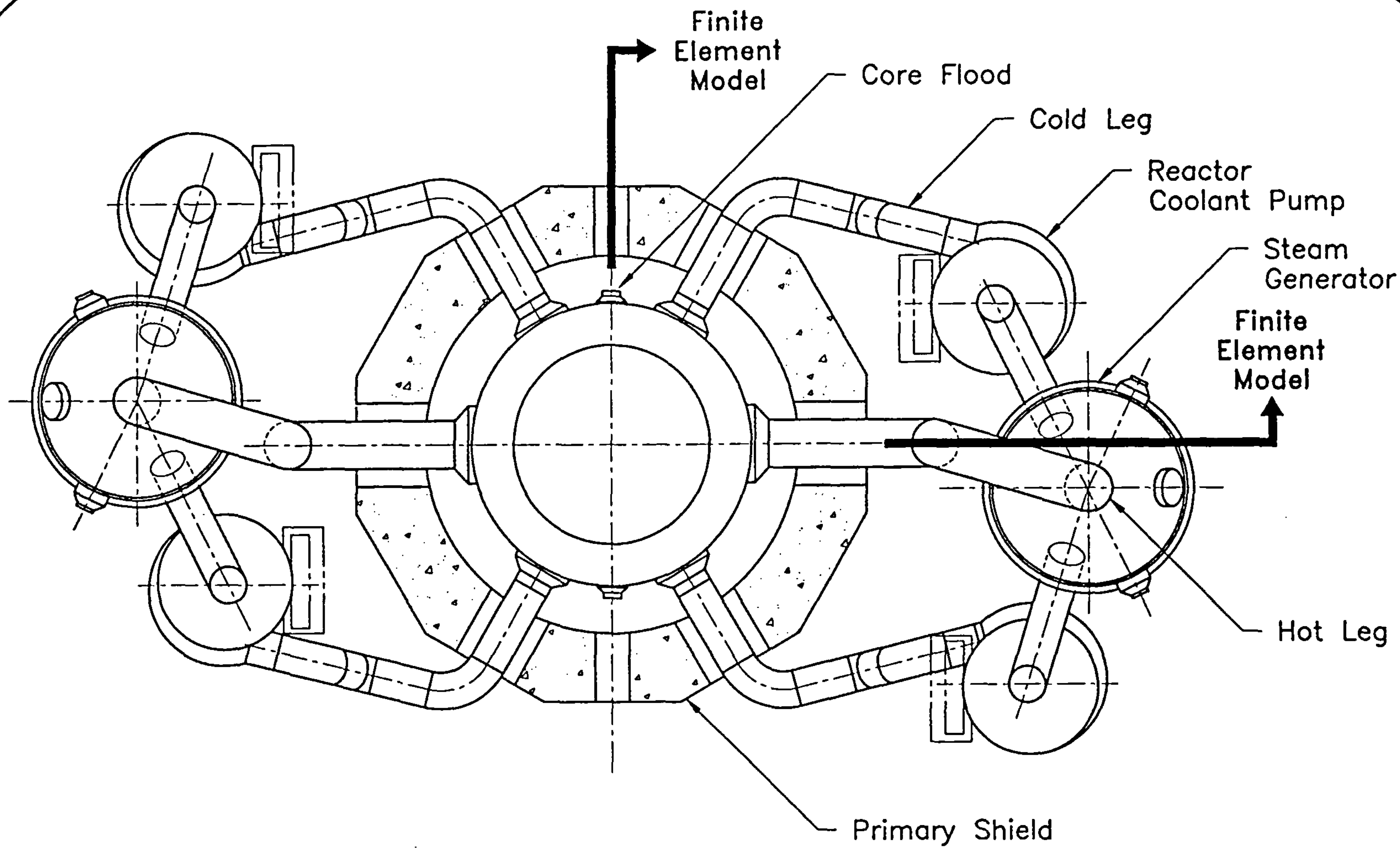


Figure 4. Midland NSSS – Plan

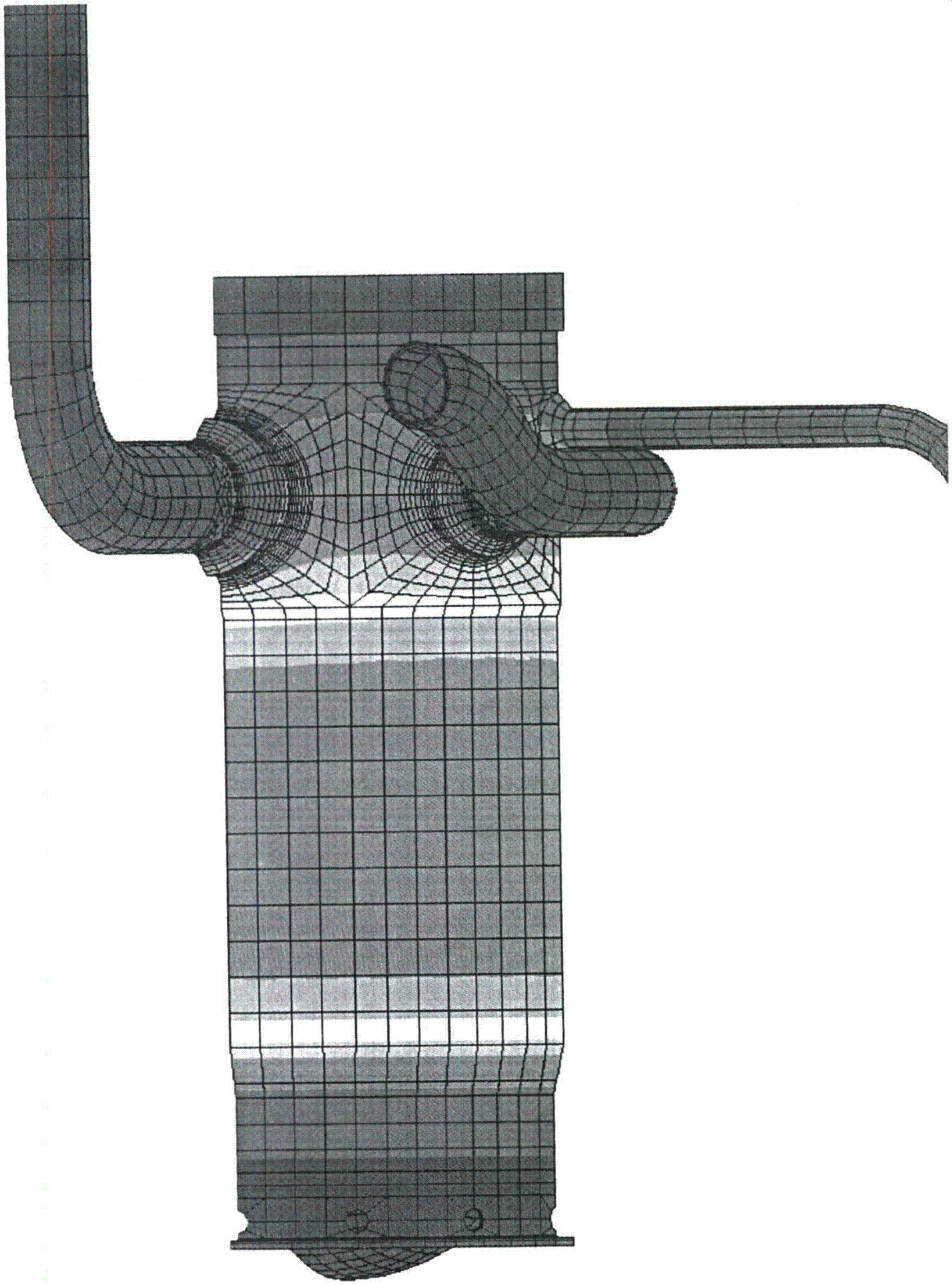


Figure 5. Finite Element Model – Calculated Annealing Temperatures

General Overview of Midland ADP

- Midland Annealing approach demonstrated on VVER-440 type vessels (Figure 1).
- Midland NSSS is B&W designed, 2-loop PWR, skirt supported RPV, 2 hot legs and 4 cold legs (Figure 2).
- Principal Midland contractor team consists of MPR Associates, Inc., MOHT (Russian Annealing Consortium), and Framatome Technologies, Inc.
- Other key Midland ADP participants include: DOE, SNL, ESEERCo, EPRI, Consumers Power Co., GPU, TVA, and CRIEPI of Japan.

General Description of the Midland ADP Technology

- Reactor pressure vessel (RPV) will be radiatively heated via electric resistance heaters (Figure 3).
- Axial and circumferential RPV temperatures will be automatically controlled using microprocessors.
- 72 retractable thermocouples mounted on the furnace to measure the inside temperature of the RPV will be used.
- The RPV, reactor system coolant piping, and bioshield will be instrumented with thermocouples (120), strain gages (14), and displacement gages (12).

General Summary of the Midland ADP Analytical Approach

- Model 1/4 of circumference of RPV (Figures 4 and 5).
- 3-dimensional transient thermal analysis predicts temperature which is used as input to predict stress using elastic model.
- All modeling performed using commercially available ANSYS code.

Midland ADP Status and Future Milestones

- May 1995 - Contract awarded to MPR Associates
- January 1996 - Preliminary furnace drawings and thermal/stress analysis completed
- August 1996 - Instrumentation set and furnace design finalized, site work began
- September 1996 - Thermal/stress analysis results and furnace fabrication and testing in Russia completed
- November 1996 - Furnace arrives on site and site work finalized
- December 1996 - Scheduled anneal start date
- September 1997 - Final report issued to public

AGENDA FOR 8/27

<u>NRC</u> (20 minutes)-[Part I]

- EDO Introduction
- Background of Rx Vessel Annealing
- RUSSIAN EXPERIENCE - Details of Experience, (# of anneals, types of
- Annealing Demonstration
- Annealing Demonstration Program
- Key points of Marble Hill Anneal

<u>DOE</u> (45 minutes) (DOE includes Westinghouse and MPR Associates) [Part II]

- Overview of DOE RPV Annealing Program
- Westinghouse - General Overview of Marble Hill ADP Team
- MPR Associates - Overview/Status of Midland ADP

<u>NRC</u> (25 minutes) [Part III]

- Staff Observations at Marble Hill
- Observation Procedure Developed by NRC
- Remaining Actions
- Palisades RPV Annealing Background
- Status of Palisades Annealing Program
- Revised Fluence Analysis

STATUS OF
REACTOR PRESSURE VESSEL
THERMAL ANNEALING DEMONSTRATIONS

Michael E. Mayfield, Chief, EMMEB
Deborah A. Jackson, EMMEB
Division of Engineering Technology
Office of Nuclear Regulatory Research

Jack Stronsider, Chief, EMCB
Division of Engineering
Office of Nuclear Reactor Regulation

August 27, 1996

PART I

Reactor Vessel Thermal Annealing

Background

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- Embrittled vessels more vulnerable to failure due to operating and accident loads (reduction in ductility and fracture toughness)

- Thermal Annealing is only known method for mitigating effects of neutron irradiation

Reactor Vessel Thermal Annealing

<u>Background (cont'd)</u>

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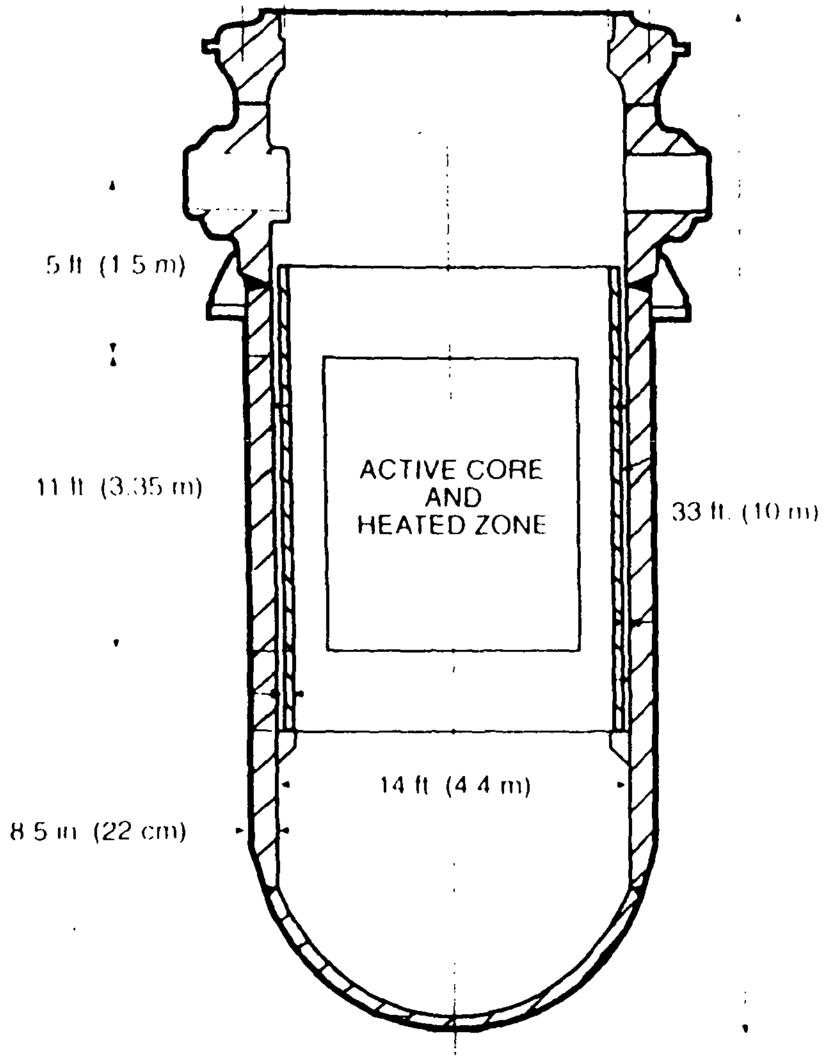
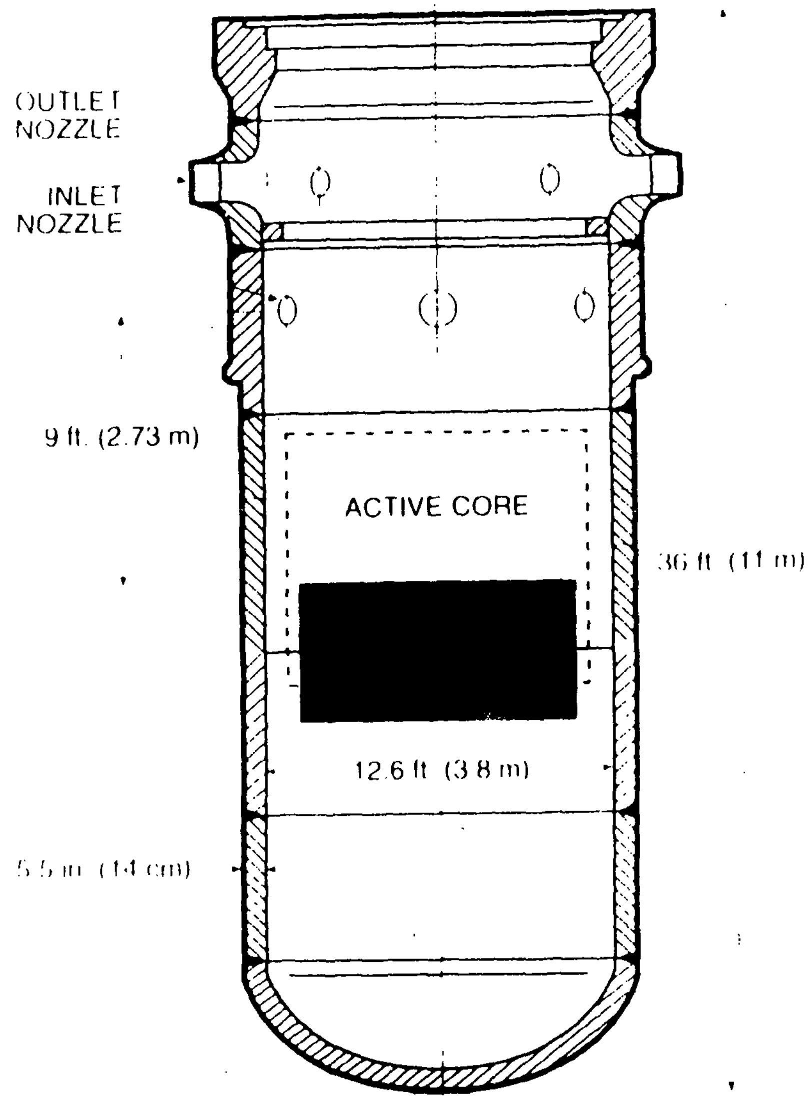
- On-going cooperative program with Russians (JCCCNRS Working Group 3)
- Material, nozzle and weld locations in Russian designed reactor vessels are different
- Russian and East European experience is useful but does not address all questions for US designs

Comparison of US and WWER Reactor Vessel



PALISADES REACTOR VESSEL



WWER 440 REACTOR VESSEL

Annealing Demonstration

- Engineering issues need to be addressed
- DOE structured program to evaluate annealing
  - Three phase program
  - Engineering issues
  - Material issues
  - Regulatory issues
- NRC's primary interest is in the Engineering Demonstration
  - Materials issues being addressed through ongoing programs

Annealing Demonstration Program

- NRC participating through Memorandum of Understanding
  - Independent review and evaluation of DOE Annealing Prototype Demonstration Projects (ADPs)
  - Independent validation of ADP analyses
  - Independent evaluation of ADP measurements, and installation of confirmatory instrumentation
  - Independent validation of thermal and stress analysis models.

PART II

Overview of
DOE
Reactor Pressure Vessel Annealing Program

Presentation to NRC Commissioners
August 27, 1996

Office of Nuclear Energy, Science and Technology

An International Cooperative Program

- Phase 1: Annealing Demonstration Projects (ADPs) [1993 - 1997]
  - Assess engineering feasibility of annealing installed RPV
  - Evaluate material property recovery and re-embrittlement rates

- Phase 2: Regulatory Process Development [1995 - 2002]
  - Support development of regulatory requirements
  - Assist with associated Codes & Standards changes

- Phase 3: Commercial Annealing Support [1996 - 2002]
  - Support first RPV anneals in U.S. licensed plants
  - Support development of post-annealing operability requirements, criteria, and inspections

Key Information Needed from Demonstrations

- Can the vessel be maintained within acceptable annealing temperatures and times during an anneal?

- Will surrounding reactor systems remain undamaged during and after an anneal?

- Are our annealing thermal/stress computer models accurate?

- What are the differences between:
  - the two annealing heating technologies and processes?
  - the two different vessels and NSSSs?

- What can be learned to improve:
  - the regulatory process?
  - future annealing procedures?
  - cost analyses?
  - the lead plant anneals?

Annealing Demonstration Project (ADP) Facts

	Marble Hill ADP	Midland ADP
• Where:	- Southern Indiana	- Central Michigan
• When:	- June 24-July 8, 1996	- December 1996
• Technology:	- New indirect gas-fired	- Russian-designed electric
• Vessel Type:	- Nozzle supported, unirradiated, CE fabricated	- Skirt supported, unirradiated, B&W fabricated
• NSSS:	- Westinghouse, 4-loop, U-tube steam generators	- B&W, 2-loop, once-through steam generators
• Contractors:	- ASME Center for R&TD, Westinghouse, Cooperheat, Parsons	- MPR Associates, MOHT (Consortium), Framatome Technologies

SUMMARY

- RPV embrittlement is a potentially serious concern for aging pressurized water reactors.

- Annealing can be an effective RPV embrittlement management option if successfully demonstrated on a licensed U.S. nuclear plant.

- Good progress is being made on the Department's ADPs, with the annealing demonstration part of the ADPs completed at Marble Hill in July and scheduled to be completed at Midland in December, 1996.

- The Department looks forward to the first commercial anneal and providing appropriate support.

- There will be continued DOE involvement in the Regulatory process in support of the commercial annealing option.

MARBLE HILL ADP BRIEFING TO THE NRC
GENERAL OVERVIEW OF MARBLE HILL ADP TEAM

- Effort organized as a joint industry-government effort to demonstrate the feasibility of overall reactor vessel annealing system and component thermal/stress response
- Marble Hill Annealing Demonstration Project demonstrates indirect gas fired annealing technology
- First successful in-place anneal of a US commercial reactor vessel
- Industry-government team effort

Government organizations	- Department of Energy - Sandia National Laboratories
Industry	- American Society of Mechanical Engineers Westinghouse Cooperheat Electric Power Research Institute (with participating utilities) Westinghouse Owner's Group Consumers Power Duquesne Light CRIEPI

The USNRC is observing the progress of the project activities (design and site)

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MARBLE HILL ADP BRIEFING TO THE NRC

GENERAL DESCRIPTION OF MARBLE HILL ADP TECHNOLOGY

Insert Cooperheat Slide of Indirect Gas Fired Heating

Gas Fired Safety Considerations

- **Storage, handling and combustion of propane meets all applicable safety codes**
- **Combustion of propane occurs in the combustion burner. No uncombusted propane goes beyond the combustion burner**

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MARBLE HILL ADP BRIEFING TO THE NRC

GENERAL DESCRIPTION OF MARBLE HILL ADP TECHNOLOGY

THERMAL/STRESS ANALYSIS AND MODEL/INSTRUMENTATION

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- Purpose of thermal/stress analysis and modeling
  - Provide a validated model for future efforts
  - Provide the basis for instrumentation selection and location
  - Provide the input for reactor vessel measurements and NDE inspection locations

- Monitoring Instrumentation
  - Temperature: 228 sensors (thermocouples and RTDs)

    RV external surfaces, reactor coolant piping, RV nozzles, RV flange, RV supports, cavity concrete, RV internal surfaces

  - Displacement: 22 sensors

    RV external surfaces (support pads, vessel bottom), reactor coolant piping

  - Strain: 14 sensors

    Reactor coolant piping, RV nozzle to pipe welds

Results from Marble Hill ADP: All primary instrumentation operational through the entire anneal. Temperatures, displacements and strains bounded by pre-anneal analytical analysis

MARBLE HILL ADP BRIEFING TO THE NRC

GENERAL DESCRIPTION OF MARBLE HILL ADP TECHNOLOGY

THERMAL/STRESS ANALYSIS AND MODEL/INSTRUMENTATION

(cont)

- **RV Dimensional Checks (Pre and Post-Anneal)**
  - **Key interface locations with the reactor vessel internal and vessel head seating**

Results from marble Hill ADP: No significant changes between Pre and Post measurements

- **Nondestructive Examination (dye penetrant, visual inspection and ultrasonic testing)**

Results from Marble Hill ADP: No reportable indications noted

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MARBLE HILL ADP BRIEFING TO THE NRC
OVERVIEW OF KEY FABRICATION, CONSTRUCTION, AND DISASSEMBLY EFFORTS

(With selected pictures of the activities:

1) RV Measurements
2) RV Instrumentation
3) Heat Exchanger Insertion
4) Ductwork set-up
5) Burner/Blower set-up
6) Video

- Clean up and preparation of the Marble Hill Unit 1 site
- Pre Anneal NDE and reactor vessel dimensional checks
- Installation of instrumentation to the internal and external to the reactor vessel
- Assembly of heat exchanger and reactor vessel top cover - HERA
- Insertion of the HERA into the reactor vessel
- Assembly of the ductwork and heating system
- Heat-up to the 850 degrees fahrenheit, soak and cool down
- Disassembly of the ductwork
- Removal of the HERA and disassembly of the heat exchanger and reactor vessel top cover
- Removal of instrumentation
- Post anneal NDE and reactor vessel dimensional checks

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MARBLE HILL ADP BRIEFING TO THE NRC

CONSUMER POWER VIDEO

NOTE: GORALSKI HAS PROVIDED THE VIDEO

- video not available
- will use slides

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MARBLE HILL ADP BRIEFING TO THE NRC

MARBLE HILL ADP MILESTONES AND ACTIVITIES

- Arrival on site of ASME Team (clean-up team) - 6 May 1996
- Commencement of heat up to the annealing temperature - 24 June 1996/13:43
- Commenced anneal soak - 28 June 1996/04:00
- Completed cool down to less than 200 degrees - 8 July/02:54
- Departure of ASME Team on site (dmob team) - 24 July 1996
- Issuance of Field Service Report to ASME - 27 August 1996
- Issuance of Draft Final Report to ASME - 15 November 1996
- Issuance of the Final Report to the public - Early 1997

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MARBLE HILL ADP BRIEFING TO THE NRC

KEY RESULTS

- Completed full scale Reactor Vessel Annealing Demonstration at Marble Hill Unit 1 at a nominal 850 degrees Fahrenheit in the annealing zone (I.D.) and stayed within all project limits for greater than seven days

- Documented critical dimensions, pre and post anneal, to ensure acceptable tolerances and benchmark thermal stress analysis

- Heat exchanger/heating system functional as expected and met all project requirements. Able to control heat-up, soak and cool-down within prescribed limits

- Reactor vessel ID and OD instrumentation functioned as expected. The Westinghouse network equipment worked extremely well during the ADP and was key in controlling the information flow between Westinghouse, PGT and Cooperheat

- NDE inspection of reactor vessel and associated loop piping has been completed and no reportable indications were present

- Evaluation of the pre and post reactor vessel measurements data is in progress. No significant issues are anticipated

- No loss time accidents occurred while the ASME team was at Marble Hill

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MARBLE HILL ADP BRIEFING TO THE NRC

KEY RESULTS

NOTE: **Insert heat up, soak and cooldown curve associated with 3 zone heat exchanger from WOG presentation**

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MARBLE HILL ADP BRIEFING TO THE NRC

GENERAL CONCLUSIONS ON THE MARBLE HILL ADP

o *SUCCESS* - Annealing of an installed US commercial reactor vessel is feasible

- No significant reactor vessel deformation
- Analytical model developed by ASME team bounded the effort on site from temperature, stress and displacement point of view
- No damage to the Marble Hill Unit 1 facility as a result of the anneal
- Reactor vessel annealing hardware and operations costs are reasonable

o *SUCCESS* - Indirect gas heating system:

- Reliable equipment
- Light weight
- Cost efficient
- Components accessible during operation
- No electrical components that could fail in RV
- Redundance easy to supply
- Ability to put heat into one zone, while taking out heat in another zone (as found necessary during the Marble Hill ADP)
- Forced cooldown capability
- No active component in the RCA

o *SUCCESS* - No showstoppers for a commercial anneal

- Rapid installation of equipment
- Minimum contamination of equipment

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Overview/Status of Midland Annealing Demonstration Project (ADP)

Presented to:
Nuclear Regulatory Commission
Commissioners Briefing
August 27, 1996, Rockville, MD

Presented by:
Doug Chapin, President, MPR Associates
Alex Zarechnak, MPR Associates

General Overview of Midland ADP

- Midland Annealing approach demonstrated on VVER-440 type vessels.
- Midland NSSS is B&W designed, 2-loop PWR, skirt supported RPV, 2 hot legs and 4 cold legs.
- Principal Midland contractor team consists of MPR Associates, Inc., MOHT (Russian Annealing Consortium), and Framatome Technologies, Inc.
- Other key Midland ADP participants include: DOE, SNL, ESEERCo, EPRI, Consumers Power Co., GPU, TVA, and CRIEPI of Japan.

General Description of the Midland ADP Technology

- Reactor pressure vessel (RPV) will be radiatively heated via electric resistance heaters.
- Axial and circumferential RPV temperatures will be automatically controlled using microprocessors.
- 72 retractable thermocouples mounted on the furnace to measure the inside temperature of the RPV will be used.
- The RPV, reactor system coolant piping, and bioshield will be instrumented with thermocouples (120), strain gages (14), and displacement gages (12).

General Summary of the Midland ADP Analytical Approach

- Model 1/4 of circumference of RPV (see plan view)
- 3-dimensional transient thermal analysis predicts temperature which is used as input to predict stress using elastic model.
- All modeling performed using commercially available ANSYS code.

Midland ADP Status and Future Milestones

- May 1995 - Contract awarded to MPR Associates
- January 1996 - Preliminary furnace drawings and thermal/stress analysis completed
- August 1996 - Instrumentation set and furnace design finalized, site work began
- September 1996 - Thermal/stress analysis results and furnace fabrication and testing in Russia completed
- November 1996 - Furnace arrives on site and site work finalized
- December 1996 - Scheduled anneal start date
- September 1997 - Final report issued to public

PART III

Key Points of Marble Hill Anneal

- First annealing demonstration appears to have been successful
- No significant problems identified from staff observations
- Majority of the fire protection issues identified are unique to gas fired design

NRC Staff and Contractor Participation
Marble Hill ADP

Office	Division/Branch	Staff	Key Responsibility
RES	DET/EMMEB	ME Mayfield	Mgmt. Oversight
	DET/EMMEB	GC Millman	Task Mgmt.
	DET/EMMEB	SN Malik	PM for ORNL Support
	DET/EMMEB	DA Jackson	Site Coordinator
NRR	DE/EMCB	EM Hackett	Materials/Mechanical
	DE/EMCB	KR Wichman	Materials/Mechanical
	DE/EMCB	MA Mitchell	Mechanical
	DSSA/SPLB	EA Connell	Fire Protection
	DRPW/PDIII-1	MK Gamberoni	PM Palisades
EDO		BC McCabe	EDO Liaison
Region I	DRS	EH Gray	NDE
Region III	DRS	MS Holmberg	NDE
	DRMA	TJ Kozak	Radiation Protection
ORNL		WE Pennell	PM ORNL
		CB Oland	Instrumentation
		L Ott	T/H-Stress Analysis

Staff Observations
Marble Hill ADP

- General

  - Anneal was performed successfully. No apparent damage to the RPV, piping or components

  - Staff observed installation and operational steps

  - Site personnel were very accessible and helpful

  - Instrumentation had been carefully installed

  - RCL penetrations sealed to prevent extraneous convection currents

- Site Safety

  - First priority of site personnel

  - Greatly enhanced by cleanup operation and appointment of a full-time safety engineer

Staff Observations
Marble Hill ADP

- Radiation Protection

  - Practical experience to apply when reviewing ALARA estimates and radiation protection procedures for an anneal at an operating plant

  - Person-hours involved in fabrication of heater/ductwork was more than expected

- Fire Protection

  - Minor deviations from NFPA Standard No. 58 for LP-Gas storage and use

  - Orientation of LPG storage tanks relative to "safety related" structures was a concern to the staff

  - Manual fire suppression capability was minimal

Note: Fire protection items were included in Request for Additional Information for Palisades

Observation Procedure Developed by NRC

- Provides background and objective for onsite activities
- Identifies site activities/equipment to be observed and level of observation. This includes:
  - Assembly and installation of major equipment
  - Installation and testing of instrumentation internal/external to RPV
  - Installation and testing of NRC confirmatory instrumentation
  - NDE and dimensional measurements of the RPV
  - Fire Protection
  - ALARA
  - Demonstration anneal
- Intended to provide basis for Temporary Instruction

Remaining Actions

- DOE
  - Reduce data
  - Compare measured results to predicted values
  - Resolve analytical model, as necessary

- NRC
  - Obtain reduced data for all instrumentation
  - Compare measured results to predicted values
  - Validate DOE results with results from confirmatory instrumentation
  - Resolve analytical model, as necessary
  - Determine generic nature of unanticipated occurrences
  - Prepare Temporary Instruction for use during a thermal anneal at an operating plant

Palisades Reactor Vessel Annealing Background

- 10 CFR 50.61 Pressurized Thermal Shock (PTS) rule
  - Establishes screening criteria for PTS
  - Plant specific analysis or annealing required if criteria are projected to be exceeded
- 10 CFR 50.66 and Regulatory Guide 1.162 provide guidance for RPV annealing
- Palisades satisfies screening criteria through 1999 (April 1995 safety evaluation)

Status of Palisades Annealing Program

- Consumers Power Company (CPCo) has developed a plan to anneal the Palisades RPV during 1998 refueling outage.

- Annealing plan consistent Regulatory Guide 1.162, "Format and Content of Report for Thermal Annealing of Reactor Pressure Vessels."

- Portions of the annealing plan have been submitted to NRC and will be supplemented to reflect benchmarking results provided by the Marble Hill ADP.

- Additional information will be submitted later this year and following the annealing.

Revised Fluence Analysis

- CPCo submitted a revised reactor vessel fluence analysis in April 1996
- Review of revised fluence calculations is proceeding concurrent with the annealing review.
- Acceptance of a lower fluence value would change the date Palisades reaches the 10 CFR 50.61 screening criteria.
- CPCo could change plans to anneal the Palisades vessel if revised fluence calculations are approved.

BACKUP SLIDES

Thermal Annealing Rule 10 CFR 50.66

- Process oriented rule

  - licensees develop plant-specific annealing program -- submit thermal annealing report
  - must establish plant-specific annealing operation limits
  - NRC staff assesses adequacy of program

- Thermal annealing report includes

  - thermal annealing operating plan
  - requalification inspection and test program
  - fracture toughness recovery and reembrittlement trend assurance program
  - identification of Unreviewed Safety Questions (USQ) or Technical Specification changes

Thermal Annealing Rule 10 CFR 50.66 (cont'd)

- Thermal annealing operating plan must address

  - background on plant operation and surveillance program results
  - description of RPV -- dimensions and materials
  - description of equipment, components, and structures that could be affected by annealing operation
  - results of thermal and stress analyses
  - proposed specific annealing parameters -- temperatures, times, rates
  - description of methods, equipment, instrumentation, and procedures proposed for annealing operation
  - ALARA considerations
  - projected recovery and reembrittlement trends

- Requalification inspection and test program

  - describes instrumentation and measurements to be made to ensure annealing was performed within plan parameters

Thermal Annealing Rule 10 CFR 50.66 (cont'd)

- Fracture toughness recovery and reembrittlement trend assurance program
  - recovery evaluated by testing "credible" surveillance specimens, material removed from beltline or by generic computational model
  - surveillance program required to monitor reembrittlement trend

- Identification of USQs and Technical Specification changes
  - demonstrate that Commission's requirements continue to be met
  - reasonable assurance of adequate protection to public health and safety following the changes

- After annealing licensee confirms that annealing was performed in accordance with thermal annealing operating plan -- 15 days before restart
  - if cannot confirm, justification for continued operation required

Revised Fluence Analysis

- The current Palisades fluence value was calculated in 1992

- CPCo initiated an extensive fluence reevaluation on a cycle by cycle basis

- The reevaluation is under review. The proposed changes are fluence reductions as follows:

  - 13% due to physical changes; vessel IR, vessel thickness, downcomer water temperature, increased photofission and decreased neutron source for cycles 1 and 2

  - a bias of 12% reduced from in vessel and cavity dosimetry data

  - 5% bias due to the averaging process (the FERRET code)

- NRC staff is evaluating all of the proposed changes and will perform our own estimate of the fluence given the new parameters and the dosimetry data.