Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
590th Meeting

Docket Number: (n/a)

Location: Rockville, Maryland

Date: Friday, January 20, 2012

Work Order No.: NRC-1387 Pages 1-93

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NUCLEAR REGULATORY COMMISSION

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590TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FRIDAY

JANUARY 20, 2012

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., J. Sam Armijo, Chairman, presiding.

COMMITTEE MEMBERS:

J. SAM ARMIJO, Chairman

JOHN W. STETKAR, Vice Chairman

HAROLD B. RAY, Member-at-Large

SANJOY BANERJEE, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

COMMITTEE MEMBERS (CONT.)

JOY REMPE, Member

MICHAEL T. RYAN, Member

STEPHEN P. SCHULTZ, Member

WILLIAM J. SHACK, Member

JOHN D. SIEBER, Member

GORDON R. SKILLMAN, Member

NRC STAFF PRESENT:

DEREK WIDMAYER, Designated Federal Official

ALLEN HOWE, NRR/DORL

MEENA KHANNA, NRR/DE/EMCB

KAMAL MANOLY, NRR/DE

GERALD McCOY, R-II/DRP/RPB5

JOHN TSAO, NRR/DE/EPNB

ALSO PRESENT:

GENE GRECHECK, Dominion Energy

ERIC HENDRIXSON, Dominion Energy

DAVID SUMMERS, Dominion Energy

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P R O C E E D I N G S

8:30 a.m.

CHAIR ARMIJO: Good morning. The meeting will now come to order. This is the second day of the 590th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting, the Committee will consider the following: Augmented Inspection Team Report on North Anna and preparation of ACRS reports.

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

We have received no written comments or requests for time to make oral statements for members of the public regarding today's sessions. There will be a phone bridge line. To preclude interruption of the meeting, the phone will be placed on a listening mode during the presentations and Committee discussion.

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

Now I'd like to turn the meeting over to staff and I believe that would -- Dana is going to leave us through that, sorry.

Dana?

MEMBER POWERS: You do it so well. Thank you. This is an information briefing. I was asked to prepare any documents based on this briefing. I suppose if we want to, we can.

Most of you are aware -- what was it, August 23rd -- that there was an earthquake. Those of us who have experienced in California think that a 5.8 earthquake is not something to get too excited about, that East Coast earthquakes are a little different. It occurred near Mineral, Virginia, close to the North Anna Nuclear Power Station. The earthquake caused Units 1 and 2 to automatically shut down. There was a loss of offsite power. No damage was reported to the system. But it was the first instance of an operating reactor exceeding its design basis earthquake.

Consequently, there has to be a fairly extensive inspection prior to restart and what we're going to hear about is both what the licensee and the staff have done in connection with that inspection and restart process.

To begin our discussions, I guess Allen Howe is going to give us an opening statement and then we will move to the licensee.

MR. HOWE: Thank you, and good morning. I'm Allen Howe, Deputy Director, Division of Operating Reactor Licensing in the Office of Nuclear Reactor Regulation. We appreciate the opportunity to brief the ACRS on the actions that were taken following the earthquake that occurred near North Anna last August.

As you said, the licensee will provide an overview of their activities and then that will be followed by a staff presentation of the inspection and technical review activities that were performed following the seismic event.

Just very quickly, following the earthquake, NRC staff did complete numerous activities including an augmented inspection which evaluated the licensee's performance during the event. And we also conducted restart readiness inspections. In addition, we completed a comprehensive technical evaluation of the actions taken by the licensee to demonstrate that it was acceptable the units to restart.

Our inspection and technical evaluations covered a wide spectrum of technical disciplines and there was very close coordination among the organizations that were involved in the review.

At this time, I'd like to quickly introduce the staff leads for the inspection and the technical review activities. To my left is Gerry McCoy. He's a Branch Chief in the Division of Reactor Projects in Region II and responsible for the Dominion Units. Gerry led the inspection efforts on behalf of Region II and he'll be speaking about the inspection activities, including the AIT, the restart readiness inspection and the start-up monitoring. Meena Khanna, to the left of Gerry is a Branch Chief in the Office of Nuclear Reactor Regulation. She led the effort on technical review in the Office of NRR. She will also be providing the presentation describing the technical review efforts that took place during the activities leading up to the restart decision. We also have staff here in the audience should questions come up that can provide answers to any of the technical issues that may come up.

At this point, I'd like to turn the presentation over to Mr. Gene Grecheck from Dominion.

MEMBER POWERS: Gene, welcome.

MR. GRECHECK: Thank you. Good morning. As Allen said, I'm Gene Grecheck. I'm Vice President of Nuclear Development for Dominion. And I've met some of you in what is normally my role. I'm normally in charge of our new reactor projects, North Anna III in specific, but very soon after the August 23rd earthquake I was asked to take leadership role in the recovery and the licensing efforts to -- first to determine what the extent of damage at North Anna was and then to work with the NRC staff to obtain the necessary restart.

With me, I have Eric Hendrixson. Eric is the Director of Engineering at North Anna. And as a matter of fact, at the time of the earthquake, he was the Director of Engineering for the corporate office and was in the process of transitioning out to the North Anna site. So he was in a unique position, both from a corporate engineering standpoint and the station engineering standpoint to guide the engineering efforts.

Also with me is David Summers over in the corner. David is head of our licensing organization and was our primary point of contact with the NRC staff during your review.

So a little bit of a summary -- between August 23rd and November 11th when we received permission to restart the units, we devoted more than

100,000 hours of effort, both in on-site inspections and engineering analysis. As you can see, we spent over $21 million in this process, so this was an extraordinarily comprehensive and complete review of the North Anna Station and its seismic response. We'll talk a little bit in a few minutes about NRC-endorsed guidance, but we exceeded the requirements of the Regulatory Guide that we published some --

MEMBER POWERS: Why did you feel a need to exceed?

MR. GRECHECK: I'll get to that in a moment, Dana. I think you'll see it because there's a flow chart and I'll show you how we did --

CHAIR ARMIJO: Yes, I'd be interested to see that. Does that $21 million include the cost of repair of the damage?

MR. GRECHECK: To the extent that there was repair, yes.

CHAIR ARMIJO: Yes, I know it was minimal. I just wanted to know --

MR. GRECHECK: It does, but as we'll see, there was very little to repair. This is mostly inspection, walk downs, analysis.

CHAIR ARMIJO: So it wasn't any hardware repair, replaced --

MR. GRECHECK: No.

CHAIR ARMIJO: Thank you.

MR. GRECHECK: So the primary finding was that there was no functional damage to any safety-related systems at the station.

Part of what we're going to talk about and part of what was interesting and I think was educational for all of us in this is that we are very used to talking about the design basis and as was pointed out North Anna was the first station in the United States to exceed its design basis earthquake while in operation.

What we found is that that terminology of design basis earthquake is useful and it's useful in the purpose of design. It is a necessary underpinning of designing a plant to respond to a postulated event. But it is not very useful in terms of determining actual damage to a station after an event has occurred.

The key factors in what caused seismic damage are the acceleration which is typically what we consider about the ground motion response. It's also important to know what frequency that vibration is occurring at and it is also very important to note how long that strong motion was in place.

Now frequency and acceleration are taken into account on the typical graph and you'll see that in a moment, but duration is not. So when you have an actual event without knowing the duration and without looking at that duration it's not possible to simply say oh, I had such and such acceleration at such and such a frequency and be able to directly say what response I expected at the plant.

As I said, seismic acceleration response spectra are used to conservatively design plants, but don't take duration into account. But there is a factor which has been in the literature for some time now called cumulative absolute velocity which attempts to do both. It attempts to integrate essentially the energy that is imparted by the vibration over the period of time that that strong motion existed and then with a great deal of empirical evidence, it has been correlated, the CAV values against what has been observed over hundreds of earthquakes around the world in terms of what actually happens when you have this particular event. And we'll talk about that.

MEMBER BLEY: Are you going to talk about that in some detail?

MR. GRECHECK: Yes.

MEMBER BLEY: Okay, I'll wait until you're done then.

MR. GRECHECK: Well, some detail.

MEMBER BLEY: Let me pose my question ahead of time. Maybe you can address it as you go through it. For some seismic analyses associated with risk assessments I've seen a lot of work looking at complete time histories of the -- all these factors over time and multiple cases of those to examine the capability of the equipment. If you can explain how well this single parameter does -- play it against those kinds of detailed kind of history considerations, I'd really appreciate it.

MR. GRECHECK: I'll try to do that. So this graph here is -- first should be familiar. We've seen this a lot, graphs similar to this and it is also what caused the initial concern right after the event after this data became available. There's a number of curves on this, so let's walk through them. The bottom two, there's a red line and a purple line. Both of them look like a little trapezoid, those are the operational basis earthquake and the design basis earthquake for North Anna as described in the North Anna FSAR.

The purple one is the design basis earthquake. You can see it starts -- the axes on this thing is frequency. This is a logarithmic scale and frequency, runs from essentially zero to 100 hertz and then the acceleration is measured as a fraction of gravity on the vertical scale.

We also hear a lot about a number and everybody wants to know what was the design basis number a plant was designed to and by convention that is the number anchored at 100 hertz. So it's whatever the value happens to be at the far right-hand side of the scale. So that purple graph you can see goes up to a peak of perhaps .36 or so G and then comes down and ends at .12 and so if you look at the literature you'll see that North Anna 1 and 2 have a design basis of .12G. So that's the first thing that when you're trying to explain to the public what the design basis of a plant is, and they read that it's .12G and then they hear that well, at some frequency, for example, that the acceleration was .4, they say well, you were four times the design basis and that's not at all correct because as you can see it various by frequency.

The OBE, the operational basis earthquake, is just arbitrarily set at 50 percent of the DBE, so that's that lower curve.

The green curve up at the top represents the synthesized curve for the IPEEE effort that was done some years ago when the NRC staff asked all plants to look at what were the -- to the ability of plants to survive in events significantly larger than the design basis. For North Anna that green curve represents what the IPEEE looked at the North Anna plants for and you can see that that is quite a bit in excess of both the design basis and the blue and orange lines which represent the actual measured accelerations from this earthquake.

MEMBER CORRADINI: Gene, can you just say that again? The green is what now?

MR. GRECHECK: The green was the basis for the IPEEE review of the North Anna plants back during the 1990s.

MEMBER CORRADINI: So it was the source input to see if you'd serve the pot?

MR. GRECHECK: Right.

MEMBER BANERJEE: What was the basis on which that line was constructed?

MR. GRECHECK: Eric, do you remember?

MR. HENDRIXSON: It was guidance given by the NRC a number of years ago and I can't recall the Reg. Guides on what to apply to the power station.

MEMBER BANERJEE: So it looks like it's

about a factor of two almost.

MR. GRECHECK: A little over two.

MR. HENDRIXSON: Two and a half.

MEMBER BANERJEE: Well, whatever it is, but how did they arrive at that factor?

MR. GRECHECK: I really don't recall.

MEMBER CORRADINI: Can we ask the staff?

MEMBER BANERJEE: Yes, can we get that answer. How was that curve established, the green one?

MEMBER CORRADINI: The green one, yes. If not now, eventually.

MEMBER BANERJEE: If not now, later.

MEMBER SHACK: Well, there were lots of discussions in the '90s of what the seismic margin should be and I think EPRI proposed one and a half. The staff proposed two, maybe two and a half. And the Commission came down with 1.67 as -- so my guess is it's one of those floating numbers at the time.

MEMBER RAY: It was looking for vulnerabilities that could be addressed. That was the whole point of the exercise.

MEMBER BANERJEE: But there must be some basis.

MEMBER CORRADINI: It's essentially two

and a half. I was just curious if it was just an engineering judgment or if there was some technical basis.

MEMBER POWERS: I don't know that it's two and a half, Mike.

MEMBER CORRADINI: Based on Gene's description, the red is 50 percent lower than the purple and the green is 2.5 times bigger than the purple --

MEMBER BANERJEE: On the extreme right.

MEMBER CORRADINI: At the extreme right.

MR. HENDRIXSON: And that particular curve is a function of your particular strata and seismic activity and analysis.

MEMBER CORRADINI: So the green dependent on the region of the country and geology and all kinds of stuff.

I guess what I'm asking is the purple was the one that was developed on region. Everything else is a scale up is the way I interpreted it.

CHAIR ARMIJO: We have a staff member.

MR. HOWE: Good morning, this is Allen Howe again. And we understand the question is what was the basis for the development of the curve for the IPEEE. And we're looking for someone to respond to that question to you. So we'll take that one right now and try to get back to you before the end of the meeting today.

MR. MANOLY: This is Kamal Manoly with the Division of Engineering NRR. The RLE, the Review Level Earthquake, that's based on seismic margin assessment that was done as part of IPEEE. In the simple explanation it really reflects the capacities for the safe one shutdown path and that is based on the HCLFPF 95.5 percent and basically it tells you that that's the kind of capacity you expect in components in the one safe shutdown path. Some components did not meet that review of earthquake and they were evaluated independently as part of the restart effort.

MEMBER RAY: It was the form abilities identification that was the point of the exercise.

MEMBER POWERS: For our purposes, we can let that one float. Gene, just go ahead.

MEMBER BANERJEE: What were the other curves?

MR. GRECHECK: So the blue and the orange, the ones that are more irregular, those were the actual measured data from our seismic instrumentation in the Unit 1 containment.

MEMBER BANERJEE: So what's the orange and what's the blue?

MR. GRECHECK: Orange is the -- we measured in three directions, so east-west, north-south and vertical. So the orange is the east-west direction and the blue is the north-south direction.

MEMBER CORRADINI: And where is the vertical?

MR. GRECHECK: The vertical is not on this graph. It's a different graph because actually the design values are different, so I just chose to use those.

MEMBER BANERJEE: So the purple and the reds were for horizontal acceleration?

MR. GRECHECK: Correct. There's a similar graph for vertical. I just didn't --

MEMBER BANERJEE: Is it the same order of magnitude?

MR. GRECHECK: Yes.

MEMBER BANERJEE: It's sort of more or less isotropic at acceleration, that's the assumption?

MR. GRECHECK: Presumption.

MEMBER BANERJEE: Presumption.

MR. GRECHECK: So a couple of things jump out at you here is that certainly at some frequencies the actual measured acceleration exceeded what the design basis curve showed, but you can see that it was enveloped by the IPEEE curve so we had this data right at the beginning, so we said okay, it exceeded the design basis. It was less than IPEEE so we would have expected at a very, very first level that we should not expect to see significant damage to the plant, but this was very early.

A couple of other things to point out is that one of the lessons that is coming out of the work that has been done on East Coast earthquakes over the years that is part of the central and eastern United States' effort and part of the foundation for what may be Generic Letter 199 is that the frequency distribution of an earthquake on an East Coast earthquake at least is not at all what this curve predicts. You can see peaks at higher frequencies typically around 20 hertz. This is what the models are predicting.

So even with this event, we were able to see these peaks at higher frequencies that previously at least during the initial licensing of North Anna 1 and 2 were not part of the model.

Any other questions on this graph?

All right, so now let's talk a little bit about the actual event. Here again, we're looking at accelerations in the three directions, east-west, vertical, and north-south. This is an actual time history of the event as measured. The shaded area represents the design basis acceleration. And so you can see that right at the beginning of the event, at about two seconds into the event, we had a peak acceleration, but that peak acceleration was very short. The numbers on the side, you can east-west, the 3.1 seconds, 1.5, and 1.0, that is the definition of strong motion which I think represents 70 percent of all the energy was released during that period. That's a standard definition of strong motion.

You can see that that strong motion essentially was something between one and three seconds. And the actual peaks, for example, in the north-south direction you can see some very, very sharp peaks that exceed the design basis level, but there's essentially one point there. So what you had was a single event where something had a single sharp acceleration, but then for the vast majority of this event was essentially background.

This surprises many people because, for example, my office is at our Innsbruck office about 40 miles from the plant and I felt this event and it was a long time. I mean you stood there and you were very much aware of the fact that something was happening. But the thing that struck me after I saw this is that by the time you were aware that something was happening, the event was over, the event of significance. So for 20 or 30 seconds or so you felt vibration, but the strong motion was long gone by the time that you were even aware that something had really happened because it was a very, very short event in terms of strong motion.

MEMBER CORRADINI: And that's a definition that the staff uses as part of licensing or is that something more scientifically --

MR. GRECHECK: It's not part of the license. The license is based on the design spectrum which is what we were talking about before.

MEMBER CORRADINI: So this is just analyzing --

MR. GRECHECK: This is analyzing actual measures --

MEMBER CORRADINI: That's the definition. If somebody said what is strong motion -- okay.

MEMBER POWERS: So one of the problems of our design basis evaluation is just what Gene brought up is we do frequency and acceleration. We don't do duration. And that's something for us to think about.

MR. GRECHECK: Now for the purpose of design, a duration has to be assumed and depending, for example, if you're going to do a shaker table test, and you have to shake it for some period of time and typically those times are in the 30-second range or so. So what you do is you shake your test object at the maximum design acceleration for that entire time period. So there is a duration that is part of the design effort, but that duration is a very long duration and so you can't say it has nothing to do with duration. But the thing is is that in order to be able to say how does what actually happen compare to what I tested for, what I designed for, you need to look at duration and that is not -- that's not part of the quoted design basis.

MEMBER POWERS: We have very long durations in Pacific Rim earthquakes.

MR. GRECHECK: Yes.

MEMBER POWERS: Thirty seconds is not a long time for the Pacific Rim. Again, it's a function of where you are and what the geology -- do you know what geological source the earthquake was from?

MR. GRECHECK: No, not specifically. There is no identified -- as I said, two is not uncommon.

(Laughter.)

MR. GRECHECK: There's no identified seismic fault or anything that this was identified with. And again, I'm getting off into non-scientific things here, but in general, what I understand about East Coast events is that, of course, there are no tectonic, active tectonic plates on the East Coast, but there were a long time ago. And the seismic event, the action that created say the Appalachian Mountains way, way back left a lot of residual stress in the rock. And what we're seeing is just this relieving of residual stress somewhere in the rock that is there. But there's no identified feature that's associated with that.

MEMBER CORRADINI: But Dana said something I didn't hear. So Dana, your point was the 30 seconds is an assumed and that given historical things could be considered short or long.

MEMBER POWERS: Depends on where you are and what kind of earthquake you have.

MEMBER CORRADINI: But from a testing standpoint that's a pretty typical order of magnitude that people test at.

MEMBER POWERS: I'm not familiar enough

with shaker table to tell you a definitive answer.

MEMBER CORRADINI: I just didn't hear what you said.

MEMBER BLEY: I think that's correct. That's about right.

MEMBER RAY: They go as long as 45 seconds. I did a shaker table.

MR. GRECHECK: Certainly for our testing that we were able to go back and look at, but that's the time frame.

So to put this cumulative absolute velocity in some perspective, the blue bars on this graph represent the calculated CAVs for the three directions for the North Anna event. The cumulative absolute velocity, if you calculated one for the design basis, would be the yellow bars. And the green bars represent again a calculated CAV if you assumed the IPEEE event over the time period.

So --

MEMBER BANERJEE: And the yellow and the green are integrated over 30 seconds?

MR. GRECHECK: Yes.

MEMBER BANERJEE: And the other one is --

MR. GRECHECK: -- what we measured.

CHAIR ARMIJO: So it's the negative

acceleration and the positive acceleration are all --

MR. GRECHECK: It's all integrated.

MEMBER CORRADINI: So it's the absolute --

MEMBER RAY: Does the licensing basis give you the duration that you use here for the DVE, the yellow bar?

MR. GRECHECK: Yes, well, it does in the embedded Reg. Guides that are subtiered to the higher level.

MEMBER RAY: But I would suppose those post-date North Anna's design, don't they?

MR. GRECHECK: Probably not. I think probably some of this was already there.

MEMBER CORRADINI: I didn't understand your question. Are you talking about the black line or the yellow --

MEMBER RAY: The yellow line. I just wondered where they got the duration from because my experience is those durations that they would have used came after North Anna was licensed.

MR. GRECHECK: There had to be a basis for the testing that was done for the North Anna equipment which, like I said, was in that 30-second range. So I'm assuming there was some regulatory basis.

MEMBER RAY: Yes. That's fine.

MR. GRECHECK: There's a line here called the regulatory limit and that number is extracted out of the Reg. Guide that was issued and we'll talk about that Reg. Guide in a few minutes. That Reg. Guide specified a level of .16 as a cumulative absolute velocity number. And that Reg. Guide is based on EPRI document. And the EPRI document says that if you show that it was .16, then you're using this empirical evidence that I was mentioning before where they looked at all of these earthquakes, hundreds of earthquakes around the world.

It was stated that no observed structural damage had ever been seen to an engineered structure at that level. So you have a very, very high confidence that you're not going to see damage certainly to a seismically-designed structure when what they call a commercially-designed structure had never seen any damage at that level.

Now there's a number of CAV limits out there that are talked about. The .16 value was specified by the staff when they endorsed the EPRI document. EPRI had originally proposed a value of .3,looking at a longer event. The staff had some questions about that so they limited the scope of the event and said well, with a shorter time period we're going to use .16.

In our conversations with EPRI subsequent to this event, they're saying that our time history looks more like what they were thinking about in terms when they specified this .3 number. And so from their perspective, the more appropriate number --

MEMBER SHACK: I thought the .16 was also based on a filtering that you threw out accelerations that were too low.

MR. GRECHECK: That's correct, yes. Too low over a --

MEMBER SHACK: Point three --

MR. GRECHECK: Had all of that.

MEMBER SHACK: Had everything.

MR. GRECHECK: But if you looked at our entire event and you looked at all of that low --

MEMBER SHACK: I guess that was my question, was yours computed with the filtering?

MR. GRECHECK: This was. What you see here was calculated with the filtering and was compared against the .16 value.

The reason I bring that up is because it is --

MEMBER BANERJEE: The filtering is a threshold?

MR. GRECHECK: It's a threshold.

MR. HENDRIXSON: The way it works is you calculate, integrate over all the time the absolute value and you exclude the tail end if over a duration of one second all the vibrations were less than 0.025Gs. So you have to go whole second with less than 0.025Gs.

CHAIR ARMIJO: If you didn't have the filtering, how much greater would the regulatory limit be in your --

MR. HENDRIXSON: About .23 for the worst vibration which was the north-south which is the one on the furthest --

MEMBER CORRADINI: So the blue would have gone from whatever it is to about .23?

MR. GRECHECK: It would have gone from .17 to about .23.

MEMBER CORRADINI: And when you do the filtering, you do it with the yellow and the green. You did it just with the actual data?

MR. HENDRIXSON: Correct.

MR. GRECHECK: But again, that .23 would be compared against a .3. Why is that comparison important? Because the Reg. Guide basically states that if you are below that limit, then by definition you have not exceeded the OBE. Not the BBE, the OBE. By definition, you have not exceeded the OBE. So in the case that we were having here, we barely exceed the OBE value in one direction and that's what led to this entire discussion.

MEMBER BANERJEE: Now when you talk about this, maybe you perhaps clarify. You said that no seismically-designed structure had failed below this?

MR. GRECHECK: No commercially --

MEMBER BANERJEE: Or no commercially --

MR. GRECHECK: No commercially-designed structure had failed above -- below .16.

MEMBER BANERJEE: Below .16. So a building which has been designed to normal building codes would survive this?

MR. GRECHECK: Yes, without structural damage. You would have cosmetic damage, but you would not have structural damage. And it has never been observed. So it's with all of this data. The attempt was to be able to come up with an empirical, predictive value to say I can measure this very quickly. You can measure this within an hour or so after the event. You know what the CAV number was, and you can immediately predict what you expect to be able to find.

MEMBER BLEY: Gene, you just said something that I can't been aware of. I thought the focus came from Figure 4 with the spectra showing the frequencies at which you exceeded. And you just said that it was the CAV point here where you exceeded it that really set this off. So can you clarify a little bit?

MR. GRECHECK: Okay, from a legal standpoint --

MEMBER BLEY: Yes.

MR. GRECHECK: The regulations state that if you exceed the design basis, then you have to prove and I think Part 100 has some words in it that you have to prove that no functional damage occurred.

MEMBER BLEY: And those words are based on the spectra?

MR. GRECHECK: They are.

MEMBER BLEY: Okay.

MR. GRECHECK: However, the words are in the Reg. Guide that says that if you're below .16 then you have not exceeded the OBE.

MEMBER BLEY: I didn't know that was there or not.

MR. GRECHECK: It's not easy to reconcile.

MEMBER BLEY: Maybe we can ask the staff.

(Laughter.)

MR. GRECHECK: But I am pointing out that that statement is there and I think that our -- it would have been a different exercise perhaps if this value had been 10 percent lower.

MEMBER BANERJEE: Is there a scientific basis for this? Because essentially it's a velocity. It's not an energy, right? So what is the scientific basis of using that, rather than some form of an energy spectra?

MEMBER CORRADINI: It's not a velocity. It's an impulse.

MEMBER BANERJEE: It's a velocity.

MEMBER CORRADINI: If there's some fixed mass that's being whipped around like this, it's an impulse.

MEMBER BANERJEE: Well, under repeated forcing. But eventually it's the velocity, that's what it is.

MEMBER CORRADINI: Perhaps.

MEMBER SHACK: You have acceleration, you get a velocity.

MR. GRECHECK: And I think that's why the term is in there, but again, I don't -- it is a weird criterion --

MEMBER BANERJEE: I can't see any obvious scientific basis for it. There must be some.

MR. GRECHECK: If you read the EPRI document, they do say it's empirical. It is not some sort of fundamental value.

MEMBER CORRADINI: I mean, if it's an impulse, you can make it look like an energy if you put your mind to it.

MEMBER BANERJEE: No, you can't. You have to square the velocity.

MR. HENDRIXSON: I believe the basis is the amount of -- the time it takes and the amount of energy it takes to start a structure into a harmonic when you can start causing damage. So if it's a short pulse, then your entire systems and structures won't start moving in a harmonic and causing damage to those structures. So time is of interest, as well as the magnitude of the acceleration. And if you integrate that over time, that gives you a feel for how much energy the structures are beginning to display.

And the .16 or .3, depending upon how one calculates CAV is based on going out and looking at engineered, non-nuclear, non-safety related, but engineered structures and how they behaved for various earthquakes. For the most part in the Pacific Basin is where most of the data is from.

MR. GRECHECK: All right, I'm going to move ahead and there was significant design margin. We knew a lot of margin existed in the plant before we started, but this is just some of the examples of that. So the plant told the story. So here's all the analytical things. The analytics told us we should be in good shape. We don't really expect to see very much, but let's go and look.

So here's the first example. This is from the turbine building. This is on the turbine deck. The turbine building is a non-seismic structure at North Anna. This is on the top floor. As you know, as you go up in elevation, the accelerations are magnified and you get higher effects. There are these demineralizer tanks to give you a sense of the scale. You can see a man standing next to one of them, so these are pretty tall tanks, high center of gravity, high center of mass. They are supported on some relatively spindly angle iron supports that you can see there.

And on the right-hand picture is a magnified view of the bottom of one of them. This represents the most serious structural damage that was seen at North Anna.

MEMBER POWERS: This was it?

MR. GRECHECK: This is it. I had a New York Times reporter, Matt Wald, who came to the site about a week after the event, and he had a photograph with him. The photographer was looking forward to being able to take Pulitzer Prize winning pictures of the damage. And he was very disappointed when I pointed to this and said that's it.

MEMBER BANERJEE: Was he able to spin this into some horror story?

MR. GRECHECK: Actually, it was a very positive story.

MEMBER SHACK: Is this 12 inches by 12 inches, this pedestal?

MR. HENDRIXSON: I believe it's a 6 by 6 pedestal, and 3 by 3 web steel above it.

MR. GRECHECK: And so clearly, there was movement and there was some spalling of the corner of the concrete here, but this is it.

The next represents what was reported in Bloomburg this day as a crack in the North Anna containment wall. This is an interior wall. And the crack that you can see running horizontally across the top of the picture is a crack in grout across two pored concrete slabs. This was simply a grout that was placed during construction, but you could paint the wall. The grout did crack along -- a pretty long distance, probably maybe 20 feet or so, a horizontal distance. But this was not structural. It was not in the concrete. It was in the grout.

MEMBER BANERJEE: How did Bloomburg News report this?

MR. GRECHECK: It was reported as a crack discovered in North Anna containment wall.

Finally, we have dry-cask storage at North Anna and these are -- at least partially, are these vertical casks that you can see in the upper picture. A few days after the event, we did go out to the pad to look and saw evidence that the casks had actually moved. You can see there's a ring there on the concrete. That's where the cask had been originally. That's about four and a half inches or so of horizontal displacement. These casks are about 100 tons, but they're not restrained in any way. They're just sitting on the pad.

Your first glance is oh, why did this move? But again, you're talking about a smooth bottom tank on a concrete -- relatively smooth concrete pad. The pad itself is seismically designed. The pad didn't see any damage. The casks are monitored for leakage across their seal. There was nothing detected there. But it did actually --

MEMBER SKILLMAN: How many of the casks moved?

MR. GRECHECK: Out of the 27 casks there, I think 24.

MR. HENDRIXSON: All but two.

MR. GRECHECK: Two or three.

MR. HENDRIXSON: Four and a half inches was the maximum, somewhere --

CHAIR ARMIJO: And they all moved semi-uniformly or did they vary?

MR. GRECHECK: It was just -- the example that a lot of people have given us, some of us will remember the old football games where you had the vibrating table. That's exactly what happened.

MEMBER SKILLMAN: I'd like to go back to your first slide, 9 here, please. Four years ago, NRC published Reg. Guides 148, 160, and 161. And that was the industry's introduction to active seismic. And as Harold said, you could shaker table at 45 seconds and people made their way to Alabama to use the shaker tables down there.

One of the tricks we all learned was we had a component with a high natural frequency and you'll find those tanks have a very high natural frequency. The way you protected them was by putting them on spindly legs. And if you could drop below three or above 30 hertz, you could actually make the large components become insulated from the ground motion and they wouldn't dance.

I would just offer what you see there on that connection which is the angle iron to the floor is how the concrete reacted to the bending that came down from a large overburden from the high mass above it. But what we did for all the NSSSs is try to go to either extremely strong structures or extremely fragile legs that would let the ground motion move under the components. And it appears as though a number of these images that you've shown identify components that have effectively been insulated from the ground motion because the legs are so spindly and those took the movement. But I believe that that's what we're seeing here.

MEMBER STETKAR: Gene, did you see any in-plant electrical effects?

MR. GRECHECK: No.

MEMBER STETKAR: Does North Anna have still pretty much old style relays or have they been replaced with solid state --

MR. GRECHECK: It's been replaced. It has the original Westinghouse solid state protection system that was --

MEMBER STETKAR: Okay, so your protection system is solid state. What about switch gear and stuff?

MR. HENDRIXSON: It's a combination of both technologies. Relays and lots of solid state devices.

MEMBER STETKAR: Are the relays that you still have pretty small light-weight relays?

MR. HENDRIXSON: A combination of both -- I call them the ice cube relays as well as the Westinghouse.

MEMBER STETKAR: Your peaks are kind of 15 and 30 hertz or so. Thanks.

MR. GRECHECK: All right, regulatory guidance. We talked about this a little bit, but we'll talk now about the process that we went through to determine what we needed to do at the plant post-event.

Again, the EPRI during the 1980s developed NP-6695 with guidelines for nuclear plant response to an earthquake. It was an excellent document, about a 100-page manual essentially. You open it at the beginning and you follow it. It was an excellent document for the case we had.

We have been working with EPRI now to provide them some OE on this and I think they're going to make some changes to it based on some of the experience because again, this was the first time we were able to place this document into actual use at an operating plant.

During the 1990s, the staff endorsed this document in two Reg. Guides, 1.166, Pre-Earthquake Planning and Immediate Actions Post-Earthquake; and then the 1.167 which was really the most useful one, Restart of the Plant Shutdown by a Seismic Event. And for the most part with some very, very minor exceptions endorse the use of the EPRI document.

All right, so if you go into the EPRI document, I'm going to show you two flow charts that basically take you through what EPRI says you should do post-event. So here's the immediate actions. We start up at the top. You feel the earthquake. Does the plant trip or not? Again, contrary to, for example, this is not -- these are not the Japanese units. There are no seismic trips in this plant. There are no seismic sensors that can cause a reactor trip. So a reactor trip will be caused by some thing that is a result of the vibratory motion.

In North Anna's case, the plant tripped on a negative rate flux, nuclear instrumentation trip and we could get into a lengthy discussion about that --

MEMBER STETKAR: You dropped rods.

MR. GRECHECK: We did not drop rods.

MEMBER STETKAR: You didn't drop rods?

MR. GRECHECK: We did not drop rods, but we had differences occurring because of the vibration of both the core internals and the water inside the core were causing differences between the NIs on the four sides. And the NIs interpreted that as a negative flux.

Interestingly enough, the two units tripped simultaneously and they both tripped on the same two NIs showing the same differential.

CHAIR ARMIJO: Very interesting.

MEMBER BLEY: You have no seismic trips?

MR. GRECHECK: We have no --

MEMBER SKILLMAN: All of your NIs were operating?

MR. GRECHECK: All of the NIs were operating and both units saw the exact same accelerations in the same direction and the same two NIs saw the same --

MEMBER SKILLMAN: That's remarkable.

CHAIR ARMIJO: Is there anyone following up on that to really nail it down on the cause and explain it?

MR. HENDRIXSON: Yes, we actually went through a detailed root cause evaluation which is docketed. It goes through the various things that can create that trip.

MEMBER STETKAR: That's the first indication is you got from those two channels.

MR. GRECHECK: That's what tripped the plant. Within a second or so of that --

MEMBER RAY: Excuse me, before you go on, have you yet had a chance to reconcile that with the impression one would have had from the CAV numbers you put up there? In other words, you'd think this had to propagate all the way down into the core internals and so on, would have perhaps required a longer duration event.

MR. GRECHECK: No, because we -- actually, we were fortunate that we have some very high resolution records on these NIs. They had a very, very short time slice. And you can see the seismic wave propagating through

the core at the time where it came

through. It's a pretty interesting graph to look --

MEMBER RAY: The thing that's interesting at this point in my mind is just that there's a lot of damping and so on that has to be overcome and I would have thought it required more duration. But that's fine.

MR. GRECHECK: It's a very short event. It comes and goes. The oscillations stop very quickly, but by that time you've already met the trip and --

MEMBER RAY: There's a huge amount of damping involved. So as soon as the excitation is removed, it will stop like that.

MEMBER SKILLMAN: What consideration did you give to relative motion inside the reactor vessel of the reactor internals against the reactor vessel bumpers or core catcher?

MR. GRECHECK: It was looked at and it was inspected.

MEMBER SKILLMAN: And evaluated?

MR. GRECHECK: And evaluated.

MEMBER SKILLMAN: Thank you.

MR. GRECHECK: Just to follow up on the question about -- what the operators were aware of as this occurred was not so much what they were aware is that about a second later we lost offsite power because our over-pressure protection relays in our transformers picked up the vibration, saw that as a sudden pressure in the transformer, and tripped the transformers offline. So about a second after the reactor trip, we lost offsite power.

MEMBER CORRADINI: So regardless of the source of all this --

MR. GRECHECK: We would have tripped anyway.

MEMBER CORRADINI: I guess I wanted to ask it differently. In terms of -- if the first event didn't cause the trip, when you do some sort of analysis, what do you think would cause the trip? The offsite would have been the one you would have judged would be the first thing that would have sensed it?

MR. GRECHECK: As a matter of fact, we believe that was -- the initial response.

MEMBER CORRADINI: Initially, that's what you thought was causing it until you investigated it further.

MR. HENDRIXSON: The turbine trip was the loss of offsite power. The reactor trip was the NIs. The reactor trip signals didn't get to the turbine trip before it tripped. The turbine trip signal didn't get to the reactor protection before the NI.

MEMBER SKILLMAN: In this case, were the sudden pressure switches your friend or your enemy?

MR. GRECHECK: Well, in this case, I think they were our enemy, but you don't want to lose sudden pressure protection either because they're there to protect the transformer.

MEMBER SKILLMAN: Some units have gotten rid of them.

MEMBER STETKAR: Did you see any damage to insulators out in the switchyard, ceramic insulators?

MR. GRECHECK: There was some.

MR. HENDRIXSON: The real damage wasn't to the insulators themselves, the ceramic. They moved, they rocked and they -- I don't want to say broke the seal, but the rubber seal, a gap was made and oil came out.

MEMBER STETKAR: On the transformers?

MR. HENDRIXSON: On the transformers themselves.

MEMBER STETKAR: Without break?

MR. HENDRIXSON: So they were still intact, but we lost some oil as a result of that and had to obviously reset the seals.

MR. GRECHECK: I think that's a very good question in terms of the switchyard itself when they did --

MEMBER STETKAR: The switchyard itself --

MR. HENDRIXSON: There was some damage. There was some damage.

MEMBER SIEBER: What's the kV of the switchyard?

MR. HENDRIXSON: It's 500, 345, and 230.

MEMBER SIEBER: So they're pretty big?

MR. HENDRIXSON: Yes.

MR. GRECHECK: All right, so following this flow chart, you take the immediate operator actions. You do operator walkdowns, and then the next gate that you have to decide is did you exceed the OBE or not? Obviously, we concluded that we did, so you move to the next chart.

Here's where the differentiation occurred. The blue on the left is where you start. And EPRI has some definitions in their document about different levels of intensity of damage. They go from zero to three. Three is essentially catastrophic, you know, massive structural damage. Zero has a number of definitions, but basically says nothing significant found.

You can do a walkdown of the plant and

make that determination very quickly. So very, very quickly, we did walk down the plant. We said we're in a zero case. And if you follow the chart for zero, you can -- you go down in that area and say do you see any damage to safety-related equipment? No. Do you see any damage to earthquake damage indicators which are the most susceptible equipment in the plant? No. And you're done. You do your surveillance tests and you start up the plant. That's pretty much the path.

MEMBER CORRADINI: The second diamond, damaged earthquake damage indicators, does that mean there's actually instrumentation on --

MR. GRECHECK: You have equipment which you have evaluated previously as being most susceptible.

MEMBER CORRADINI: So some pre-analysis says go look here, there, okay.

MR. GRECHECK: As a matter of fact, we were talking about the IPEEE before. When you did the IPEEE walkdowns, there were certain equipment that did not -- you could not demonstrate 100 percent confidence that they would survive that higher event. So you know that these are the ones that are going to be most susceptible.

MEMBER CORRADINI: And that's where you go look.

MR. GRECHECK: That's where you go look.

MEMBER CORRADINI: Visual inspection, okay.

MR. GRECHECK: So if you followed this flow chart for a damage intensity zero event, then this is essentially what you would do. This is a relatively short inspection. It doesn't take a great deal of effort. But this is what the EPRI document suggests is necessary for an intensity zero or damage intensity zero event.

However, if you evaluate it as being one, two, or three, then you go off on to the right-hand side. So what we did is we, just from the beginning, we just arbitrarily said let's assume we're in a Level 1. And that's what leads to this expanded inspection so everything else that you're going to hear about today, from us and from what the staff described is this expanded inspection effort where we just looked at everything we could think of and to verify that there was no damage.

MEMBER BLEY: Dana asked you in the beginning why you went beyond NRC requirement and you just again said you did. You haven't yet told us what led you to do that?

MR. GRECHECK: We did because we wanted -- again, this is the first time this has ever happened and we believed that for ourselves and anticipating what the staff would need, we decided that we needed more evidence than what this would suggest we would have derived.

Remember, for us, again, we were in the same mindset as everyone else. We exceeded our design basis. We didn't see anything. But we had no prior experience with this and we're saying what do we need to do to prove to ourselves, even not considering what the staff's questions were going to be, that we don't have any damage. And so we decided to do a Level 1 inspection.

So again, we went beyond this classification. We started providing the staff, I think about -- the event occurred on August 23rd. On September 7th we met with the staff, provided the plan of what we were going to do to discuss this process. Of course we, at that time, said that we had several weeks of inspections ahead of us before we were going to be done, but we presented that all to the staff and said here's what we're intending to do.

Over the next couple of months we had a great deal of interaction with the staff. As you can see, we got about 130 requests for additional information, in many cases asking us for inspections and analyses beyond even what we had originally proposed and in many cases we did those. The staff will talk to you about the inspection teams and we've already talked about the root cause evaluation. All of this was part of this overall effort to get ready to restart the plant.

I'll give you a few more pictures and then we'll be done. Part of the inspection was to go look again, as we just talked about, where -- if we were going to find damage, where would you expect to find it?

This is a picture of the Unit 2 circulating water tunnel. This is a picture that you're not going to often see because normally there's hundreds of millions of gallons a minute traveling through here. But this is basically a horizontal concrete box that is underground. Again, if there was going to be lateral motion you would see it here because you've got this rectangular box here that would be susceptible to damage. There was no damage found in this tunnel. But we did take the opportunity of the outage to be able to go in here and do a very extensive inspection of this tunnel.

MEMBER SKILLMAN: Did you have to clean this before you could make these images?

MR. GRECHECK: Actually, if you see the white spaces there, that's the cleaning that we did for detailed inspections. That's what it looks like without cleaning for the majority of the wall.

MEMBER SKILLMAN: So it was not filled with slime and mussels and mud?

MR. GRECHECK: No.

MEMBER SKILLMAN: Thank you.

MR. GRECHECK: They had both units down. Unit 2 was scheduled for refueling -- a refueling outage about three weeks after the event, so we entered into the refueling outage early, defueled the Unit 2 reactor, looked at all the fuel assemblies as they came out. Looked at fuel assemblies in the spent fuel pool. Looked at new fuel assemblies which had been delivered to the site in anticipation of the refueling. Did not see any fuel damage.

Buried piping, there was a lot of speculation again about what could be in buried piping. The picture that you see on the left here is a transition. It is very close to the safeguards building. It's a transition between several buildings and again, if you were going to have buried piping damage, you would expect it to be in these relatively short transitions between buildings. If the buildings were going to be moving, this is where you expect high stress locations to be. This is maybe what, ten feet down or so?

MR. HENDRIXSON: Yes, I'd say more like six or eight feet.

MR. GRECHECK: But anyway, we excavated all the way down there to look at these locations where we would have expected to see damage. Again, did not see any damage to any of this.

CHAIR ARMIJO: Is that buried piping inspection called for if you're under the EPRI damage 1 category or is that --

MR. GRECHECK: I don't believe so.

CHAIR ARMIJO: So you actually went beyond the EPRI 1.

MEMBER SIEBER: Do you have a way to measure differential movement between buildings?

MR. HENDRIXSON: Yes. There's a survey that we do and there's survey markers and we do that also.

MEMBER SIEBER: Did you do the surveys?

MR. HENDRIXSON: Oh, yes.

MEMBER SIEBER: You do that periodically?

MR. HENDRIXSON: Correct, six months or a year. I forget the frequency.

MR. GRECHECK: And there's many other inspections that we are not even describing here. I mean we put people up in man baskets and inspected the entire exterior of the containment ball, looking for anything there. I mean we did a lot of visual inspections throughout the plant looking for anything that could be interpreted as damage.

MEMBER SIEBER: Did you test or inspect penetration?

MR. HENDRIXSON: Yes.

MEMBER SIEBER: Pressure test them?

MR. HENDRIXSON: Yes, the Type C test.

MR. GRECHECK: Here's an example of one of those earthquake indicators. This tank is one of the susceptible tanks that came out of the list of the IPEEE. This has this high confidence, low probability failure HCLFPF value of only .19. So this would be anticipated to be something that would be done of the first things to show damage. And again, there was nothing see here.

This is another low HCLFPF component again. This is an as-found picture. You can see that there is not even any disruption to the insulation.

MEMBER CORRADINI: Just so I understand. So when you did the green curve and you did that analysis, did you tend to find large mass components that would be the things that worried you or were there small mass components like electrical relays or cabinets or things that aren't as heavy, but if they got wiggled at a different frequency, would really cause a problem. Do you know what I mean?

MR. GRECHECK: Yes. We did corrective actions to some of them, like for example, one of the anticipated issues was that the suspended ceiling in the control room which has one of those egg crates diffuser panels, those could fall. So we fastened all those together such that they would be less susceptible to fall during an event.

There were cabinets that by tying the cabinets together you were able to change their frequency. There was a series of things that were done in the post-IPEEE environment to try to fix those things that could be.

MEMBER REMPE: When you started the diesel generator, it had a leak and what was the cause of the leak?

MR. GRECHECK: It was improper maintenance. The flange had been improperly installed.

MEMBER REMPE: Okay.

MR. GRECHECK: And that leak occurred into its run. It was not right at start up.

MEMBER BROWN: Right.

MR. GRECHECK: All right, so summary, we looked at 134 systems. We looked at 141 structures. Forty-six of these susceptible components were specifically looked at. Surveillance testing. We did a comprehensive set of surveillance testing that include MOV stroking, motor runs, just about anything again. And again, not just looking for go, no go, but looking for trending because we could look at the data from the previous pre-earthquake test and say did we see any change in behavior from pre-earthquake and post-earthquake.

CHAIR ARMIJO: If you would go to your fuel examination, Slide 18, the picture there. Was it all visual or was there any kind of measurements, gaps between the fuel assemblies?

MR. HENDRIXSON: It was a visual and an enhanced visual and then with the close-up camera you get those dimensions.

MEMBER CORRADINI: And you were looking for some sort of bowing or --

MR. HENDRIXSON: Yes, or deformation of the ridge and things of that nature.

MEMBER BANERJEE: Did you go in with endoscopic examinations, anything like that?

MR. HENDRIXSON: Most of it was face-on.

MEMBER BANERJEE: Face-on.

MR. GRECHECK: So a few short-term actions that we completed before start up. One of the issues we discovered is that our seismic instrumentation dates essentially back to the early 1970s. It was not designed for rapid analysis and it is not a free-field instrument. It's based in buildings. The primary data that we've been presenting to you here is from a sensor that is in the basement of the Unit 1 containment right on the base map.

So some people have asked some questions about was that truly free field and can you really compare it? I think we were able to demonstrate that it was close enough. But subsequent to the event, we have installed a temporary free-field monitor on site, away from any buildings. One of the nice things about this is that you can see it's relatively small. It's digital. It provides you the capability of calculating CAV, for example, very quickly after an event. And so in the future we'll be able to do the preliminary analysis much faster. And we've revised our procedures specifically to tell the operators and engineers how to use this equipment.

MEMBER SCHULTZ: Where did you locate it?

MR. GRECHECK: It's close to our training center, so it's on the site, but it's in an open area away from any buildings that could alter its response.

MEMBER SCHULTZ: Where there any other findings related to the operational response, the response of the operators, the response of the site crew?

MR. GRECHECK: Actually, the site crew performed in exemplary fashion. It was very, very, very good response.

I think the staff will describe to you some of the actions we agreed to and so I won't go through these in detail. There's a Confirmatory Action Letter which was issued to discuss some of these long term --

MEMBER SIEBER: Before you jump to that, part of the story of the event was that you started four diesel, had to shut down one of them because of a leak. What caused the leak?

MR. GRECHECK: Joy just asked that question. The flange had been improperly installed.

There was a gasket and a flange and that -- clearly --

MEMBER SIEBER: That event did not cause the --

MR. GRECHECK: It was a prior maintenance action that had caused the --

MEMBER SIEBER: You have an extra diesel, right?

MR. GRECHECK: And we started that diesel and that diesel functioned.

MEMBER SKILLMAN: Let me go back to Steve's question The way your Operating and Maintenance teams performed, was the trigger for their actions you're having entered the unusual event and then having followed your procedures from the ground motion to giving instructions to your people? Was that the flow or did the shift supervisor say oh, my goodness, I've got a problem. I need everybody in here right now with their flashlight.

MR. GRECHECK: Well, it occurred on day shift on a Tuesday. So the shift manager, of course, everybody felt the earthquake so he -- and we had a dual-unit trip, so enter E0 appropriately. The AP for seismic event and we actually went into an alert so we -- the emergency response team then directed the damage control team to actually recover a steam-driven aux feed pump that was out of service in the middle of a surveillance test. And then the shift manager, of course, directed his crew to secure the diesel. It was a coolant leak -- and load the SBODs all on to that bus.

MEMBER SKILLMAN: I'm asking a larger question. You were in a situation where you had a UE and you were following your procedures for the UE and it turned out what triggered the UE was an earthquake.

MR. HENDRIXSON: Actually, were in alert.

MEMBER SKILLMAN: Or an alert, I'm sorry.

MR. HENDRIXSON: And the alert was actually called based on shift manager discretion because he said I felt an earthquake. I've got do a unit trip. Something serious is happening here and I need to activate the emergency response organization.

MEMBER SKILLMAN: So you called your people up.

MR. HENDRIXSON: Right. Thank you.

MEMBER SIEBER: I want to go back to the diesel one more time. When you do maintenance on the diesel when you're on the surveillance test crew, no leak at that time, right? How long was that surveillance test?

MR. HENDRIXSON: It was at least three

runs. Each is an hour long, plus --

MEMBER SIEBER: It's a start, load, and run for an hour.

MR. HENDRIXSON: Exactly.

MEMBER SIEBER: You did not do anything beyond that when you did the maintenance, right?

MR. HENDRIXSON: Those were the basic post-maintenance tests.

MEMBER SIEBER: Didn't leak then.

MR. HENDRIXSON: Correct.

MEMBER SIEBER: Only leaked when the seismic event, you concluded the seismic event didn't cause it?

MR. HENDRIXSON: It actually didn't leak for about 45 minutes. And then after that period of time it began to leak.

MEMBER SIEBER: I guess operation is a sort of a seismic event in and of itself as far as it's concerned.

(Laughter.)

MEMBER SHACK: Gene, on North Anna 3, there's a picture safe shutdown earthquake based on our best modern knowledge and all our methods. It's been reported that you even exceeded the safe shutdown spectrum there, too. Is that right?

MR. GRECHECK: At low frequencies, yes. I pointed out before that the new models tended to focus at higher frequency. The model that was in use at the time of the early site permit which is not the CEUS model that is now being released, but at the time the early site permit which is in the 2003 time frame, that model was -- did correctly predict an envelope, the high-frequency vibrations, but it appears to have under predicted the low frequency. So we are examining that now and we are going to apply the CEUS model to North Anna 3.

MEMBER BLEY: When you say "low frequencies" what --

MR. GRECHECK: Two to three hertz.

MEMBER BANERJEE: The curve in the spectrum that you've shown, you said I think that most of the systems that you examined would not have been damaged even by that green curve. What -- were there some systems that would have been and which ones would be?

MR. GRECHECK: So we get into this seismic margin confidence type thing that HCLFPF value that I was pointing out before. So analytically, we came up with a list of about 50 items that you could not say you had 100 percent confidence that they would survive that event.

MEMBER BANERJEE: Typically, what were these things, important things?

MR. GRECHECK: Yes. Many of them are tanks. You have again high center of mass tanks. You look at the way they're anchored to the ground. And you say well, some of these might fail under those kinds of accelerations. So I think it was mostly tanks and --

MR. HENDRIXSON: Invertors were in there.

MEMBER STETKAR: Did you look at end beds on your --

MR. HENDRIXSON: Yes.

MEMBER STETKAR: Are your switch gear up high in the building?

MR. HENDRIXSON: We basically hand-over-handed the entire switchyard and actually in-depth inspections of the switch gear. The energizer go in and hand-over-hand --

MEMBER STETKAR: I don't know how they're anchored.

MEMBER BANERJEE: Were these particularly vulnerable to what part of that spectrum? Because if you looked at it, the high frequency end was quite a bit higher than the lower frequency. So was this vulnerability coming from the low frequency part, the high frequency part?

MR. GRECHECK: I think it was equipment dependent. You would compare each piece of equipment against its vulnerability, whether it's high or low.

MEMBER BANERJEE: And you could identify this based on the frequency?

MR. GRECHECK: You can calculate what the natural frequency of that particular item is, so again, you would know where the harmonics would occur. So things that are very massive, may have a lower harmonic frequency than some of these smaller items.

So to wrap up again, acceleration criteria were very briefly exceeded in certain directions, but this was a very short direction earthquake. We had, based on previous evaluations, we had established the safe shutdown systems, could handle accelerations above the design basis and I think this confirmed it. No safety-related systems or structures or components required any repair due to this event that we saw and basically we did an extraordinarily comprehensive review of the station and didn't find any damage.

And so on the basis of that and like I said in a very extensive review by the staff and many, many questions answered, we ended up receiving permission to restart the units September 11th and in the week or so subsequent to that, we restored both units to 100 percent where they are today.

MEMBER SKILLMAN: I've got a question. I see in your first slide was 21 million at inspection. What was your lost generation for the time you were --

MR. GRECHECK: Actually, that's a very difficult question to answer because by pure happenstance, this was a very mild period. Late August, early September, well, most of September in Virginia was much cooler than it normally is. The loads were down, so therefore it's kind of difficult to specify what the financial, what the replacement power cost was for that time period. Obviously, it was substantial, but it was not as bad as it could have been.

July was very hot and had it happened in the months before, it would have been a much more serious economic impact.

MEMBER SKILLMAN: Thank you.

MR. GRECHECK: Thanks.

CHAIR ARMIJO: Any other questions for the speaker? In that case, we'll turn to the staff.

(Pause.)

MR. McCOY: Good morning. My name is

Gerald McCoy and I am the Branch Chief for Region 2 for the Dominion plants. And I led the inspection response to the earthquake in Mineral, Virginia.

When the earthquake occurred, the Senior Resident Inspector, Greg Kolcum, was in the control room at the North Anna Power Station and he was observing the recently completed surveillance Mr. Grecheck was talking about on the turbine-driven auxiliary feedwater pump. We also had another NRC inspector on site. His specialization was emergency planning. He was on site during the earthquake and he assisted in the response there on the site.

These inspectors observed the plant's response during the event and immediately notified Region 2. At the same time North Anna was declaring an alert, 14 other nuclear licensees were declaring NUEs due to the same earthquake. In response to these notifications, the NRC activated its Operations Center and the Regional Instant Response Centers to monitor the affected plants.

North Anna was the only site to experience reactor trip following the earthquake. The NRC subsequently learned that the ground movement during the earthquake exceeded the levels to which the plant was originally designed at certain specific frequencies.

Later, on August 23rd, Region 2 dispatched an additional inspector to the site to assist in the inspection effort. Also, a seismologist and a mechanical engineer from here at White Flint were also sent to the site within days of the event.

Because of the elevated risk from the loss of offsite power from the failed diesel generator, an evaluation was performed in accordance with Management Directive 8.3 which is entitled "NRC Incident Investigation Program." And it resulted in the formation and dispatch of an augmented inspection team to the site on August 29th. And their goal was to better understand the circumstances of the event and Dominion's response.

In addition to the augmented inspection, a restart readiness inspection, and a start-up monitoring inspection were also conducted to assess the licensee's inspection process and to determine the condition of the plant after the earthquake.

Mr. Mark Franke, DR's Branch Chief from Region 2 led a team of seven inspectors, including a seismologist, two structural engineers, two electrical engineers, and two resident inspectors. The inspection was conducted during the period of August

30th through October 3rd, 2011. The purpose of the inspection was to conduct an independent review, collect factual information and evidence of what occurred at the plant as a result of the earthquake, to assess the licensee's response and identify any generic issues.

The team's primary focus was on the plant's response to the event itself, rather than on the evaluation of the plant to support eventual restart. However, during the time period covered by this inspection, Dominion was conducting tests and inspections of plant structures and components. Members of the augmented inspection team observed some of these inspections and documented their observations as part of the restart assessment process.

The results of the augmented inspection team were provided at a public meeting held near the North Anna Power Station on October 3, 2011. The team's observations of the event included the observation of the ground motion from the earthquake exceeded the plant's license design basis at certain frequencies.

At this point, no damage had been noted to any safety-related systems of the plant. The safety system functions were maintained during the earthquake. The operators responded to the event in accordance with their established procedures and North Anna responded to the event in a manner which protected public health and safety.

MEMBER STETKAR: Gerry, your third bullet there says some equipment issues. Is that limited to the diesel or were there other items that you identified?

MR. McCOY: There were other items. It's the diesel itself. There was issues with the seismic monitors. In particular, I'm thinking about there was an issue caused by the power to the seismic monitors and the alarms. That's why they had to declare the alert on a call from the shift manager's advice from the earthquake itself because they didn't get the annunciator they were supposed to get, so we looked at that, too.

There was one Juliet diesel was exhibiting frequency oscillation, so the team noted that and we looked into that further. The alph auxiliary feedwater pump terry turbine lube oil level switch had an issue that we wanted to look at and it turned out just to be an alarm issue with an alarm that wasn't expected, so we looked into it and it made sense in the end.

MEMBER STETKAR: There were other things, but those are things that other than the power for the seismic monitor, those are other things that could occur during any what's called a plain vanilla trip.

MR. McCOY: Correct.

MEMBER STETKAR: Thanks.

MR. McCOY: The next inspection the NRC conducted was what we called the restart readiness inspection. This inspection was of Dominion's readiness to restart the North Anna units and have occurred from October 5th to November 7th, 2011. The objectives of this inspection was independent evaluate Dominion's assessment that no functional damage had occurred to safety systems which included evaluation of the licensee's walkdown, their corrective action follow up and the review of their actions to support start up.

This team was led by Mr. Andy Sabisch. Mr. Sabisch is the NRC Senior Resident Inspector at the Oconee Nuclear Power Station. He led a team of eight inspectors including participation from other NRC regional and headquarters offices with experience in structures, piping, electrical components and plant operations.

The inspection included an independent

assessment of Dominion's inspections and testing of systems and components. A risk-informed sample of the plant systems or walkdown by NRC inspectors and these observations were compared with those made by Dominion. The team reviewed the evaluation so what was found during Dominion's walkdowns to determine if the issues were properly categorized. The team also reviewed the licensee's plan for starting up the plant. The results of this inspection provided an input into the eventual NRC approval to restart the plants.

The conclusions reached by this inspection team was that the licensee's inspection process was adequate to identify any damage which had occurred to the safety significant systems in the plant. The team members performed a limited number of inspections of risk-significant systems in areas and no significant damage was identified. The team conducted spot checks to verify that the licensee properly evaluated any damage which was identified during the license's inspection. The team did not identify any damage to safety-related equipment from the seismic event. Minor issues identified by the restart readiness team such as the identification and non-earthquake related damage which had not been entered into the licensee's corrective action process and enhancements which could be made to the two hotel emergency diesel generator root cause evaluation.

MEMBER SCHULTZ: Excuse me, what are the examples you might give for the items that were not in the Corrective Action Program?

MR. McCOY: Not in the Corrective Action Program. There were cases that the inspectors, I mean, you send inspectors out in the plant and they're going to find things. That's what we encourage them to do. The things they found were like they found corkboard in odd places. They found damage to insulation. It wasn't related to the earthquake itself. It wasn't the case where two pipes were hitting, but it's just damaged stuff and they talk to the guy who is beside him and said hey, is this in the corrective action system? And they said no, and they said why not? Isn't that the process?

So it was just a case of me sending inspectors out and finding issues and making sure licensees got it on their list of things to correct. But it wasn't related to the earthquake, so we just put it in their process and carried on with our inspection.

MEMBER BROWN: Did you question why it

wasn't there? Did they answer that?

MR. McCOY: The licensee -- there was concern. There was a concern in the discussion between myself and the licensee and it was -- it's not something we usually see with Dominion, so I was kind of concerned that the fact that all of a sudden now you guys aren't putting things in your corrective action process, what's the problem? And they did stop and have a rebrief for their employees and say we are having issues. We are here specifically to look at the earthquake damage, but we still have to follow regular processes. So I think -- I attributed it to the loss of focus on their part. They were focusing on the earthquake. They didn't quite see the other things our inspectors coming in with new eyes were seeing about their plant.

Next is a start-up monitoring inspection. NRC continued the inspection process while the licensee was in the process of restarting the plant. The inspection was conducted during the start up of both Unit 1 and Unit 2 from November 11th through November 29th, 2011. The objective of this inspection was to independently evaluate Dominion's assessment that no functional damage had occurred to safety systems through the observation of control room activities, surveillance tests, and inspections of important plant systems as conditions change during start up.

This inspection was led by Mr. Rodney Clagg. Mr. Clagg is the NRC's resident inspector at North Anna Power Station. He led a team of seven resident inspectors from other nuclear power plants. This team concluded that the licensee's process ensured that the structure systems and components of the North Anna Power Station could perform their safety functions following the earthquake and would support a return to the safe power operation without undue risk of health and safety to the public.

This inspection team completed this verification through the observation of control room activities and direct inspection of start-up activities including mode changes, heat up, reactor start up, power extension for cold shutdown to rated thermal power. It also included direct inspection of surveillance testing, operability determinations, maintenance risk assessments, emergent work control, modifications, post-maintenance testing, and a review of Corrective Action Program documents, partial inspection walkdowns of selected systems, structures, and components including secondary systems and other activities as applicable. No additional earthquake-related damage was identified to the plant systems during the start-up process.

I now invite Ms. Meena Khanna, the Branch Chief for the NRC's Office of Nuclear Reactor Regulation to discuss the Agency's technical review efforts.

MS. KHANNA: Thank you, Gerry. Again, my name is Meena Khanna and I did lead the technical review efforts out of NRR.

There was a question earlier that I just wanted to touch base on. There was a question about the IPEEE curve. And we found the guidance document. It's NUREG-1407. So I just wanted to mention that to you. So hopefully that will address it. And if you need any additional information, we can ask our seismic expert, Dr. Nilesh Chokshi, to help us out with that as well. Okay?

The restart requirements. The regulatory requirements governing this event are delineated in 10 CFR Part 100 Appendix A. Basically this states that if the vibratory ground motion exceeds that of the operating basis earthquake, then the shutdown of the nuclear power plant will be required.

In addition to that prior to resuming

operations, the licensee will need to demonstrate to the Commission that no functional damage has occurred to those features necessary for the continued operation without the undue risk to the health and safety of the public.

I'd like to take a second here to also indicate that I will be interchangeably using the terminology of safe shutdown earthquake and design basis earthquake. They mean the same for North Anna. So if you near me say SSE, safe shutdown earthquake. That is the same as design basis earthquake.

As far as the technical review, the regulatory review guidance that the NRC followed was established in the mid-1990s. As you heard Mr. Grecheck address the Reg. Guide 1167 which is entitled "Restart of a Nuclear Power Plant Shut Down by a Seismic Event" which is endorsed by the EPRI NP6695 -- I'm sorry, which endorses the EPRI NP6695 guideline was also used. And that's entitled "Guidelines for Nuclear Plant Response to an Earthquake."

I'd also like to note that the EPRI guidelines does talk about guidance on what to do if the plant exceeds the OBE as well as design basis earthquake. Both short-term and long-term actions are addressed in the EPRI guidelines. In addition to the

EPRI guidelines and the Reg. Guide, we also took it one step further and used the IAEA Safety Report No. 66 which also addresses lessons learned from the International Plant which was the Kashiwazaki plant in Japan and this plant had also exceeded its design basis earthquake. So this provided valuable information to us in conducting our reviews, especially with respect to hidden defects.

MEMBER CORRADINI: So if I might just ask, so in the conversation with Gene, there was -- I don't want to call it an inconsistency, a difference between 10 CFR 100 and the Reg. Guide which points to the EPRI document in terms of -- maybe I'm misinterpreting, so I'm not sure if it's inconsistent or it's just a different term. Are you going to address that here?

MS. KHANNA: Yes, just the 10 CFR Part 100 basically just indicates that if you do exceed the OBE, then the plant will be required to be shut down and NRC approval needs to be addressed, needs to be sought from the licensee. However, the EPRI guidelines goes into what the plant needs to do to address what actions need to be taken once it's exceeded the OBE in licensing. Is that what you were getting at?

MEMBER CORRADINI: I'm probably going to

do this wrong, so let me try again. So the way you just explained it is we looked at this multi-colored set of curves and then given the fact that they exceeded what they were designed for, that puts them in a situation they have to look at things. But then they look at the Reg. Guide to decide what they have to do in terms of -- Gene had a decision matrix.

MS. KHANNA: That's right and that comes out of the EPRI guideline so the Reg. Guide endorsed the EPRI guidelines.

MEMBER CORRADINI: Let me posit one thing. So in the north-south -- I don't remember what direction it was, the blue bar was slightly above the black line. That black line comes out of the Reg. Guide. Am I correct in understanding that? And that points to the EPRI document. So you -- based on some natural event, you exceed what is their design base, but then once you go in terms of this only if that blue bar gets above the black line do -- any more than a zero corridor inspection.

Am I interpreting that correctly? I want to make sure I get this right.

MS. KHANNA: I think you've got it correct. The EPRI guidelines will indicate to you that the level, based on the amount of damage the plant sees at the site, that basically tells them what level they need to go and when we're talking about the various levels that going to be in the EPRI guidelines. Does that help? Okay.

Okay, so in addition to the IAEA safety report, obviously we have great technical expertise here, so we also utilized the technical expertise that we had and that was really helpful with the area of fuels and on the evaluation as well, which I'll get into a little bit more detail later.

Like I indicated, significant level of NRC effort was placed to independently evaluate the impact of the seismic event including structural and seismic experts throughout the Agency. We also dedicated a special restart team. We had several senior level advisors as part of this team dedicated project managers, so we took this very seriously and had a separate team that was working basically on this 24 -- I'm not going to say 24/7, but around the clock and doing what we needed to do.

The overall review and evaluation assessed the scope and the adequacy of the licensee's inspections, as Gerry had indicated, as well as the testing and the evaluations and the technical reviews were also informed by the inspections that Gerry had mentioned earlier. And again, the staff did not identify any significant safety issues stemming from the seismic event.

As Allen had indicated earlier, the NRC's inspection assessment activities did involve a wide spectrum of technical disciplines and there was definitely coordination among the reviews and the inspection activities across the offices with the Agency.

Also, as part of this, I'd like to mention that we did come up with an action plan. We developed an action plan. There were so many activities going on. As you heard, the inspection activities -- there were audits done on the fuels that I'll talk about later. We have 2.206 petitions. As you can imagine there were quite a few public meetings, Commission briefings. And also what we wanted to do was make sure that we captured the short-term actions as well as the long-term actions and Gerry had mentioned that there were -- I don't know if he had mentioned it, but there were two generic issues that were identified out of the AIT inspection report and those were both with respect to the seismic monitoring instrumentation. So what we've got in place right now is we're putting together an information notice to address those two generic issues. So again, all these items are being tracked within our action plan. We also developed a com. plan because we believe that was important.

The NRC performed a comprehensive independent technical review to ascertain whether it was acceptable for the North Anna plant to restart. This slide lists many of the technical areas that were reviewed which includes reactor vessel internals as well as mechanical structural engineering and electrical engineering. I won't go through all of this, but based on this list, you can see that almost every single technical branch in NRR was impacted and was involved in this review.

I'd like to highlight a few examples to demonstrate the independent nature of our review. To address the integrity of the fuels, we did conduct audits of the fuel and I believe Tony Mendiola, his group actually went to the site and reviewed Dominion's efforts for confirming the integrity of the fuel. In response to our review of Dominion's efforts, Dominion also performed additional calculations to demonstrate the integrity of the fuel assembly components to ensure that they were not compromised as a result of the earthquake.

With respect of our review of the piping systems, Dominion performed additional analyses as well as to provide the NRC staff confidence that the earthquake did not adversely impact the piping and to ensure that the previous analyses were not invalidated as a result of the earthquake. For example, a leak before a break, and just ensuring that any prior existing flaws were not impacted by the earthquake as well.

Also, I'd like to mention that with respect to inspections of snubbers, Dominion had committed to doing functional testing of the snubbers with respect to Unit 2 and as a result of our questioning attitude, they also completed functional testing of the snubbers for Unit 1 as well.

And then later on in the presentation I'll talk about the long-term activities, long-term items that were addressed in the CAL and that was also due to the questioning attitude of the staff license renewal, was heavily involved in that because as you know, there was a license renewal issue for this plant. So there were several activities that came out of that that will be addressed in that Confirmatory Action Letter.

NRC staff conducted a safety review in accordance with the established acceptance criteria.

This was a first of a kind review. The staff -- this was very basically new to the staff. It was a complex review, so we wanted to ensure that we had consistent technical reviews across the office. So before we started a review, we came and developed some acceptance criteria and really what helped us Inspection Manual Chapter 9900. That gave us good guidance and that's basically the operability determinations and functionality assessments for resolution of degraded or nonconforming conditions. So that was the basis of our acceptance review criteria. And that really helped out. We made sure that we had Office of General Counsel involved and made sure that in every step that we were doing that they were watching what we were doing and making sure that we weren't doing anything illegal.

The NRC ensured that Dominion demonstrated that the plant is safe to operate prior to approving restart. And as we indicated earlier, the staff did not identify anything from our inspections or the technical review to preclude plant operations as a result of the seismic event. The results that were reviewed determined that the plants may be restarted safely and the bottom line was that the NRC was not going to allow plant restart until we were confident that it would be operated safely.

And as Mr. Grecheck indicated, on November 11, 2011, after the plant was shut down for approximately 80 days, the Office Director of the Office of Nuclear Reactor Regulation issued the restart approval decision for both North Anna Units 1 and 2. The decision was based on the staff's independent assessment which concluded that Dominion had acceptably demonstrated that no functional damage occurred to those features necessary for continued operation as a result of the August 23rd earthquake, thereby ensuring that there was no undue risk to the health and safety of the public.

I'm sure you've read our safety assessment. You can find that it's extremely comprehensive. We tried to make sure that we captured everything. Again, this was a one time -- this was a first of a kind event and we wanted to make sure we captured our technical review in case we needed it for knowledge transfer later on in the future. Also, we issued a confirmatory action letter to address the licensee's commitments for long-term actions.

The next few slides, I'm not going to go through each of the ten long-term actions that were identified in the CAL. However, I do want to highlight a few items here. Dominion did commit to perform the long-term evaluations in accordance with the NRC endorsed guidance, so the EPRI guidelines do talk about long-term actions and that's what Dominion committed to. We completed our reviews regarding these evaluations and the long-term commitments are addressed in the NRC CAL which is also dated November 11, 2011.

As indicated earlier, as a result of the earthquake, the plant exceeded its design basis earthquake ground motion. To address this issue, Dominion committed to update their final safety analysis report to include this new seismic ground motion as reflected in the August 23rd earthquake which is also addressed in Item 3 of the Confirmatory Action Letter and that's identified as multiple due dates.

With regards to Item 10 --

MEMBER RAY: Could you back up? Item 2 up there isn't very far off, March 31, 2012. And is there any insight at all on the source characterization? Does the NRC have any work in progress to look at that or are you waiting for a submittal?

MS. KHANNA: Kamal?

MR. MANOLY: This is Kamal Manoly with NRC. That started to be addressed as part of the 50.54f letter that will be issued some time which essentially is an extension of GI-199.

MEMBER RAY: Okay, so basically, it's not going to be something special for this event.

MR. MANOLY: That's correct.

MEMBER RAY: Given all else that's going on in that area.

MR. MANOLY: Dominion committed that they would follow whatever action comes out of the GI-199 effort.

MEMBER RAY: Okay, it's just an interesting action item to have in a Confirmatory Action Letter.

MS. KHANNA: You bring up a good point as well. There was close coordination with the Near-Term Task Force on the Fukushima and actually the seismic monitoring instrumentation, that was one issue that they were going to be addressing as part of the lessons learned, but they thought it would be more appropriate for us to address it, so that's why we're pursuing the information notice.

As Kamal indicated the GI-199 efforts, all of that we're making sure that everything is tied --

MEMBER RAY: It's just the date seems awfully close. That's why I asked.

MS. KHANNA: I just wanted to highlight, so item ten, the long-term commitment entails that Dominion will use the recent ground motion spectrum from the August 23rd earthquake in conjunction with the original design basis earthquake seismic qualification of new and replacement equipment. So this was one item that we -- the staff was requesting of the licensee and wanted to make sure that for new and replacement equipment that they were considering the response spectra from the existing design basis earthquake as well as from the as-felt earthquake that was seen from the August 23rd earthquake.

Again, the long-term commitments were consistent with those identified in the EPRI guidelines. However, you'll note that in the list there are a few that stem from the license renewal folks because there is a license renewal application that was approved. So there are a few license renewal commitments included. For example, MRP-227. And again, as I mentioned the staff did issue an action plan and that's where we're going to be tracking the closure of all these CAL action items.

That concludes our presentation. I'll now open it up for questions.

CHAIR ARMIJO: Item 7, you want them to do comparative calculated loads from the earthquake and the existing leak before break analysis. What drove that request in view of the condition of the plant?

MS. KHANNA: I'll give a high level -- I don't know if we have the appropriate person, but I believe what they want to do is any analyses that had been done for license renewal, they wanted to make sure that they were still valid. So I think they wanted to make sure that if there were any different stresses, but -- do you guys want to help me out, please?

CHAIR ARMIJO: Is anybody else -- well, I'm just wondering.

MR. TSAO: This is John Tsao from Division of Engineering. The reason we ask licensee to do recalculation of leak before break analysis is that leak before break is to satisfy GDC-4 and GDC-4 requires a Commission-approved leak before break analysis. Because of the seismic event we think that the loads, the seismic loads may increase and we are wondering whether the current leak before break analysis approved for North Anna still satisfies the staff's recommended safety margin in the Standard Review Plan 363. So this is a confirmatory analysis to make sure that leak before break application is still valid for North Anna.

CHAIR ARMIJO: Okay. It just seems like the condition of the plant and leak before break --

MEMBER SHACK: Remember, with leak before break you have to postulate a big flaw that doesn't really exist, so they're looking for that margin. So with the higher loads and the postulated big flaws, it has to demonstrate a margin. Even though it looks fine, you still need the analysis.

MEMBER RAY: Higher loads resulting from this event or --

MEMBER SHACK: Just the seismic loading now seems to be somewhat higher than originally -- the spectrum has been exceeded.

MEMBER RAY: By this event.

MEMBER SHACK: By this event.

MEMBER RAY: You're talking about this event though.

MEMBER SHACK: Right.

MEMBER RAY: Not some other change in the design basis.

MS. KHANNA: This is specific to this

event, right.

CHAIR ARMIJO: Okay, thank you.

MEMBER SHACK: That they advise, too, Harold.

MEMBER RAY: I understand. But I'm trying to keep them separate in my mind anyway.

MEMBER STETKAR: Meena, as part of the lessons learned from this, do you anticipate any revisions to Reg. Guide 166 and 167?

MS. KHANNA: That's a good question. Yes. Research, right now is going through a revision of Reg. Guide 1.667 and we're actually providing a lot of feedback to that. The Reg. Guide does need to be updated. It's been a while since it's been updated, so there are a lot of lessons learned that we gain from this review. Probably more robust than the Reg. Guide. I think you'll see a lot of the RAIs that we asked -- the staff is doing a great job.

MEMBER STETKAR: Anything on 1.166 as far as planning and operations?

MS. KHANNA: To be honest with you, I'm not aware of any. We haven't seen an update.

MEMBER STETKAR: Thank you.

MR. WIDMAYER: Meena, the Reg. Guides are -- the Reg. Guides promote the EPRI document. Is there's something going on where they're being reevaluated and updated?

MS. KHANNA: I'm not sure about that, but what we will do is when we put the Reg. Guide out, if we do any updates, obviously that would precede what's in the EPRI guidelines. So I haven't heard of any updates of the EPRI guidelines, but I would think that once we -- I don't know, David, if you would know, but --

MR. MANOLY: In the Reg. Guides that endorses the EPRI 6.695, it endorses conditions and my expectation is if EPRI does not revise the document, we will add more conditions in the Reg. Guide.

MEMBER BLEY: There was a discussion earlier when the licensee was here about the regulation requiring that you meet the design spectra or that the spectra is met and the Reg. Guide making a definition based on CAV that if you're within that value of CAV you don't exceed the OBE.

Is that an actual conflict? How is that to be resolved and is this leading to any thoughts about how the design basis will be formulated or defined in the future for new reactors?

MR. MANOLY: This is Manoly again. When you talk about design spectra, that is what's used for the design of the structures and components and the Reg. Guide talks about exceedance when you have an earthquake that's felt. So what is the design tool? I think we tried to articulate that point. The CAV is a measure to determine the threshold beyond which you should consider that you exceed the OBE.

MEMBER BLEY: So that is the basis for staff looking at an actual earthquake and deciding if you exceed the OBE.

MR. MANOLY: Yes, that's the Reg. Guide. That's in the record. But the design for the plant is the design spectra, the ASME, that's for the actual design structure and components with the margins that exist in the design process.

MEMBER BLEY: How is the requirement for how long -- if the component is tested on a shake table for the duration of the shaking arrived at and is that something that NRC approves or is that something that the licensee decides?

MR. MANOLY: Typically, the equipment are tested by -- qualified by testing, some are qualified by analysis. When you qualify equipment by testing, you do it to one SSC and five OBEs.

MEMBER BLEY: And for what duration.

MR. MANOLY: The duration is usually

around 30 seconds typically.

MEMBER BLEY: It's not a requirement?

MR. MANOLY: I believe it's in the IEEE 44, but I believe the duration is around 30 seconds.

MEMBER BLEY: It's not something you regulate other than may be referring to the IEEE?

MR. MANOLY: In Reg. Guide 100 Rev. 3, it endorses the EPRI 344 for electrical equipment and now it endorses the ASME fuel made for qualification of the technical equipment.

MEMBER BLEY: It's a little more complex than I can completely understand here on the fly.

MEMBER CORRADINI: But just to follow up Dennis' question, given the fact you're going to have lessons learned from his from how you connect the Reg. Guides to the requirements, I think at least some of us like to understand how all this is going to --

MEMBER BLEY: That's kind of where I was coming from.

MEMBER CORRADINI: Is that a fair way to putting it?

MS. KHANNA: Yes.

MEMBER POWERS: Are there any other questions?

MEMBER BLEY: Just a quick comment. Since you pointed us to a NUREG for understanding the IPEEE spectrum, actually that Reg. Guide tells how the IPEEEs were done and says you can either do a seismic PRA which would develop a site specific hazard curve, or you can do an EPRI margin study or an NRC margin study. The NRC margin study refers you to another NUREG CR that develops kind of a generic spectrum for mild or moderate rock or soil site. I suspect it's over there, but that's not on the website.

MEMBER SKILLMAN: Mr. Chairman, I would like to make a comment. I'd like to compliment the staff and the Dominion team for really taking to heart an abundance of caution when it might have been another utility that would have arm wrestled, would have said we're so close to the CAV we really don't have to do anything. Independent of how much money was spent, this exercise has shown in this particular case how robust this machine is. But it has also demonstrated a nuclear safety attitude that at least I for one am very pleased to be around. So I want to say thank you.

MEMBER SIEBER: Well, I think that compliment should extend to the licensee also.

MEMBER SKILLMAN: Oh, yes. That's what I was trying to say to the Dominion team. Thank you.

MEMBER POWERS: Sure.

CHAIR ARMIJO: All right. Thank you, Dana. Thank the staff. We're now going to take a break and we'll reconvene at 10:30.

(Whereupon, the above-entitle matter went off the record at 10:17 a.m.)

ACRS
Full
Committee
Briefing

January 20, 2012

North Anna Power Station
Earthquake Assessment

North Anna Inspection Summary

Process

- More than 100,000 hours
- $21 million in inspection, testing, & evaluation
- Exceeded NRC endorsed guidance

Findings

- No functional damage to safety systems

Forecasting Seismic Damage

Key factors

- Acceleration (vertical, north/south, east/west)
- Frequency of the vibration
- Duration of strong motion

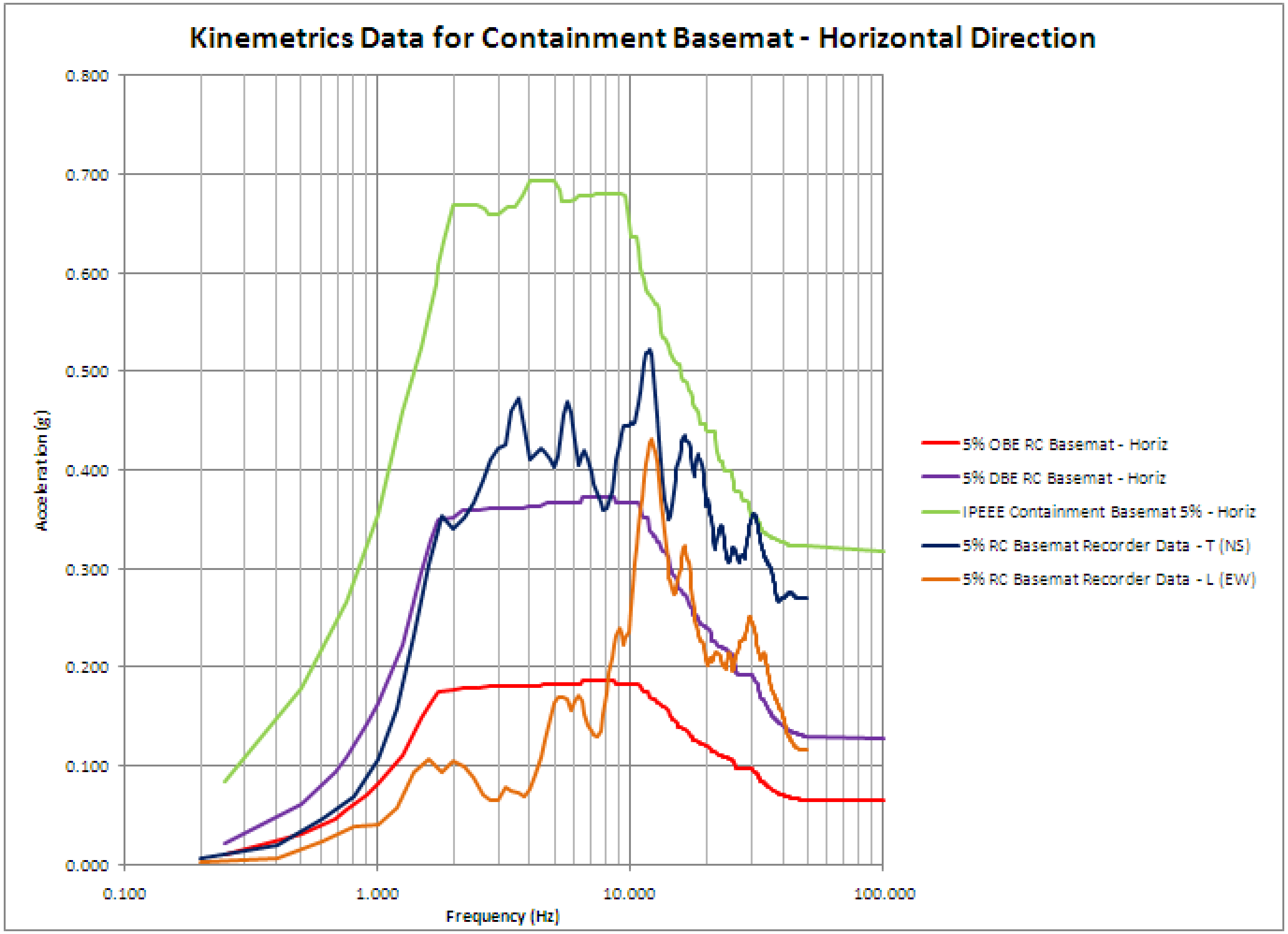
Seismic acceleration response spectra

- Used to conservatively design plants
- Does not account for duration

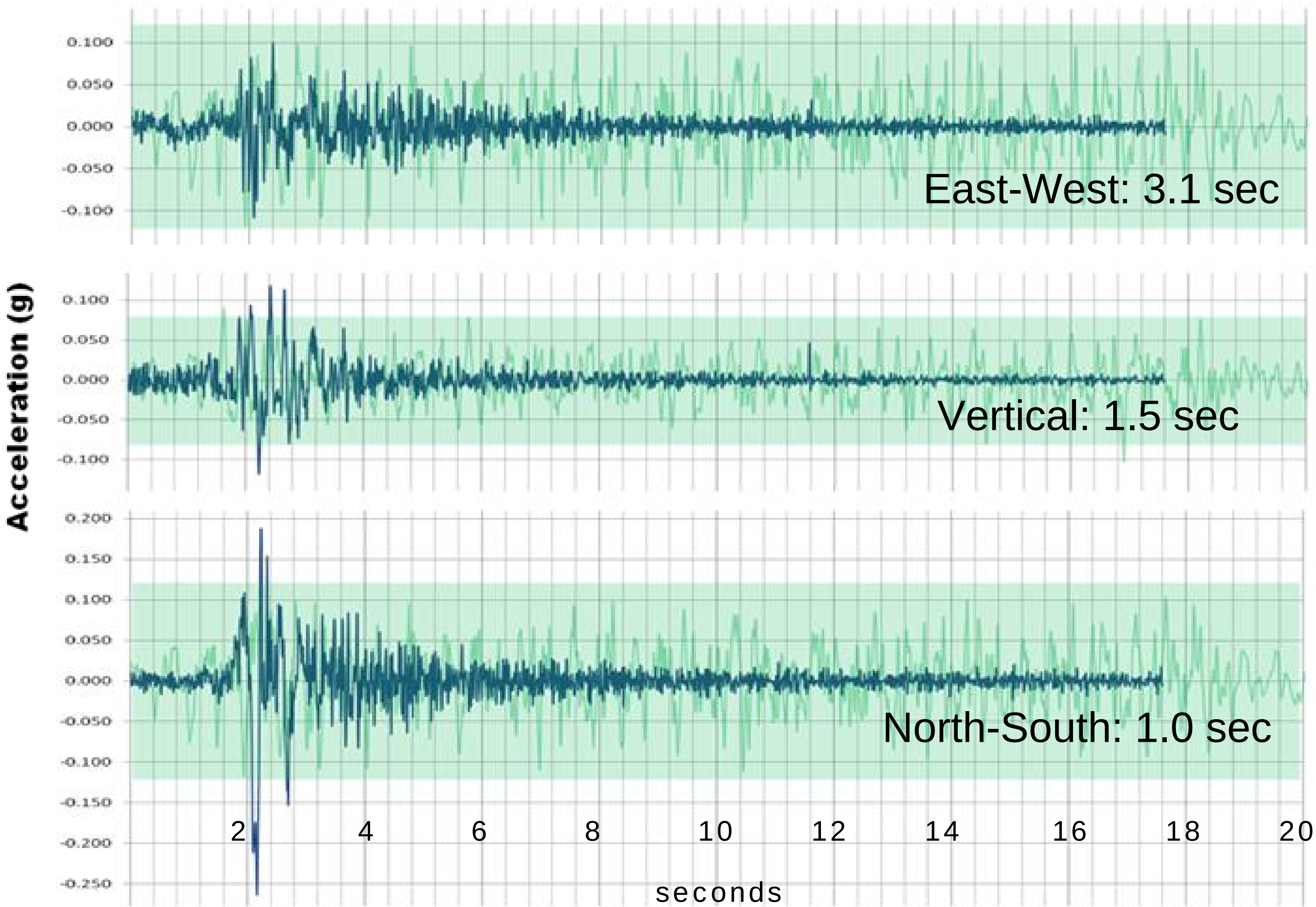
Cumulative Absolute Velocity (CAV)

- Integrates all three factors
- Best indicator of energy imparted
- Best indicator of damage

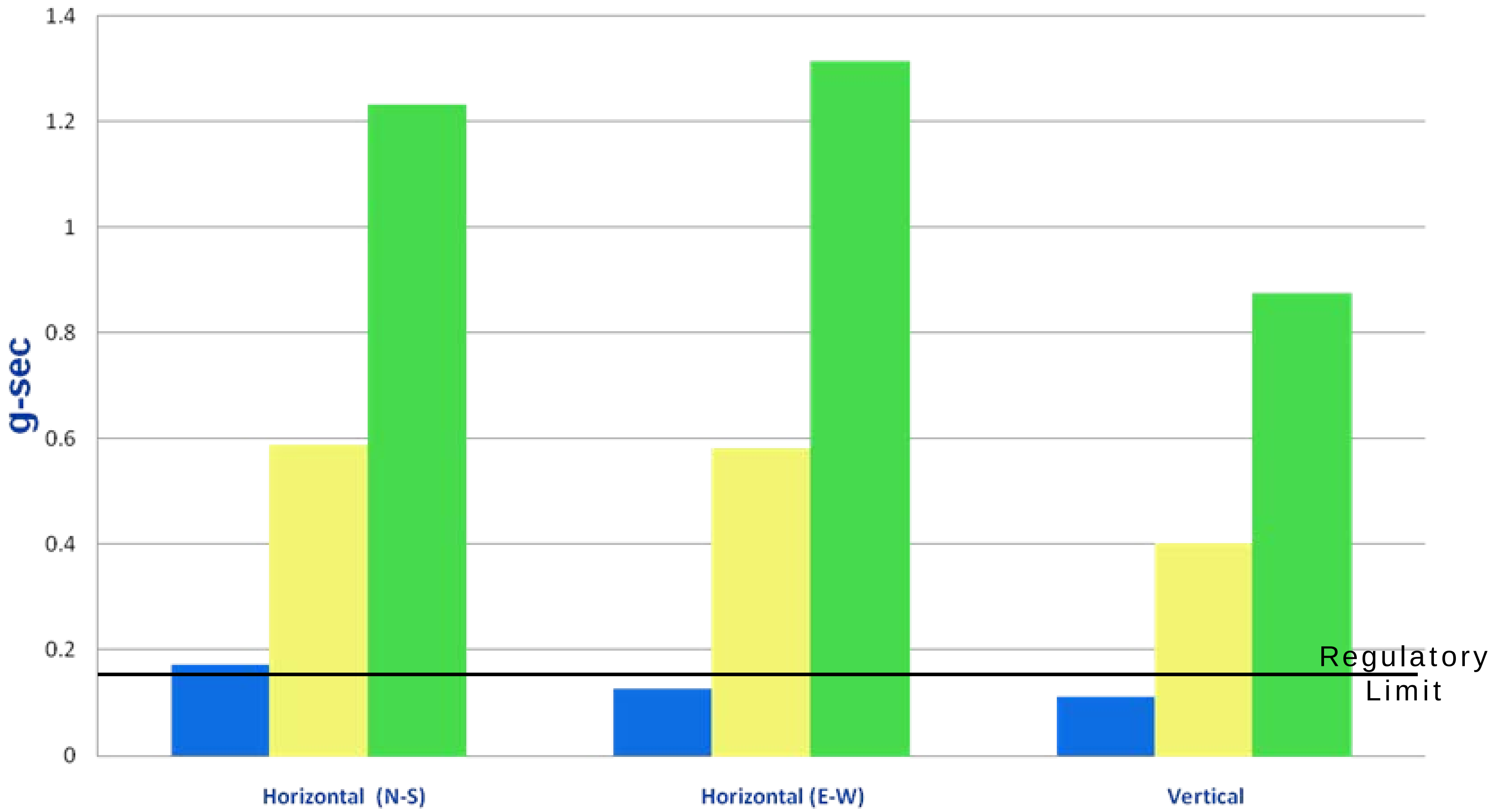
Response Spectra Comparisons



August 23rd Earthquake:
A strong, but very short event



CAV Comparisons: Regulatory Guide Slightly Exceeded in One Dimension



- August 23, 2011 Earthquake
- DBE – Design Basis Event
- IPEEE Review – 1990s updated study

North Anna Has Significant Design Margin

- Conservatism in analytical methods
- Conservatism in American Society of Mechanical Engineers Code
- Accident load design of greater capacity
- Conservatism in seismic test standards

Previous Evaluations Established Significant Margins Beyond Design Basis

The Plant Told the Story

Unit 2 Turbine Building

Non-Safety Related
Demineralizer
Tanks

Base Pedestal

Unit 1 Containment

Surface Crack In Interior Containment Wall

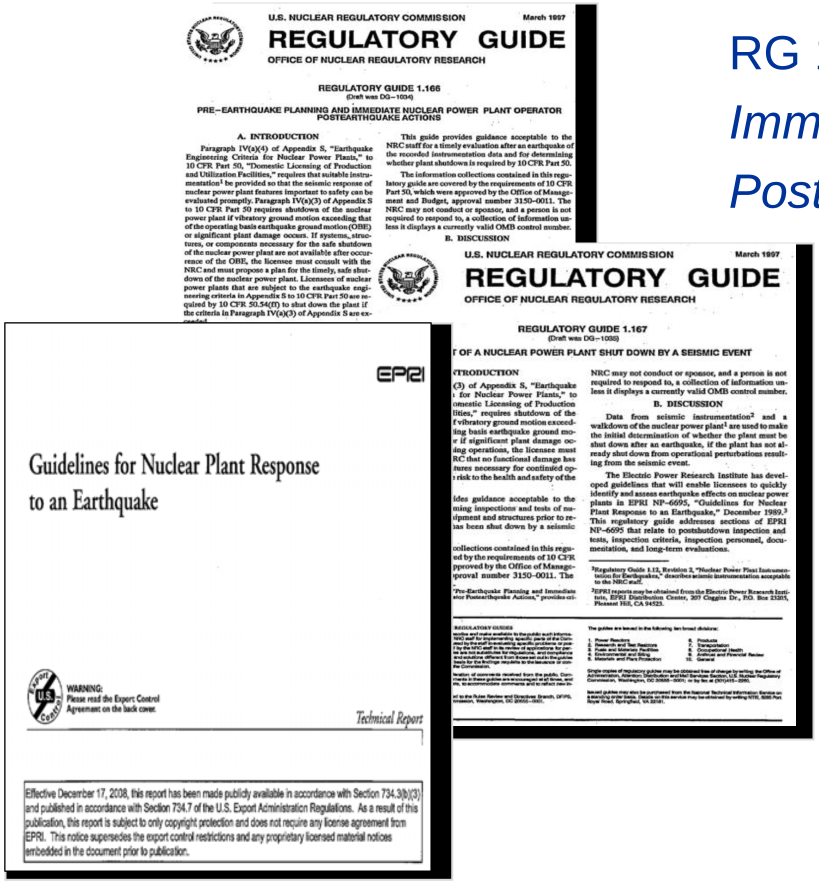
Dry Cask Storage

Casks moved between 1 and 4½ inches

Dominion Complied with and Went Beyond Regulatory Guidance

Regulatory Guidance

Station restart readiness assessment actions based on NRC-endorsed guidance



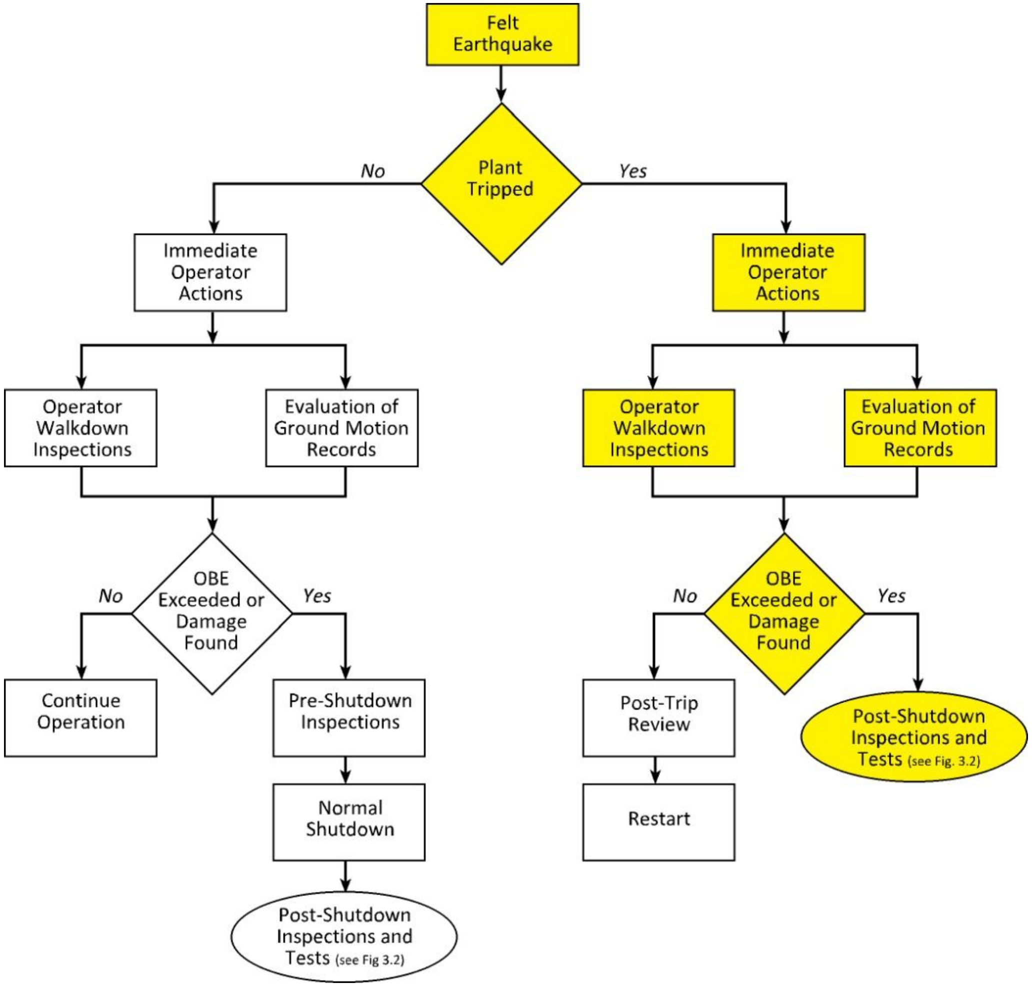
RG 1.166, *Pre-earthquake Planning and Immediate Nuclear Power Plant Operator Post-earthquake Actions,* March 1997

RG 1.167, *Restart of a Nuclear Power Plant Shut Down by a Seismic Event,* March 1997

EPRI NP-6695, *Guidelines for Nuclear Plant Response to an Earthquake,* December 1989

EPRI NP-6695 Figure 3-1

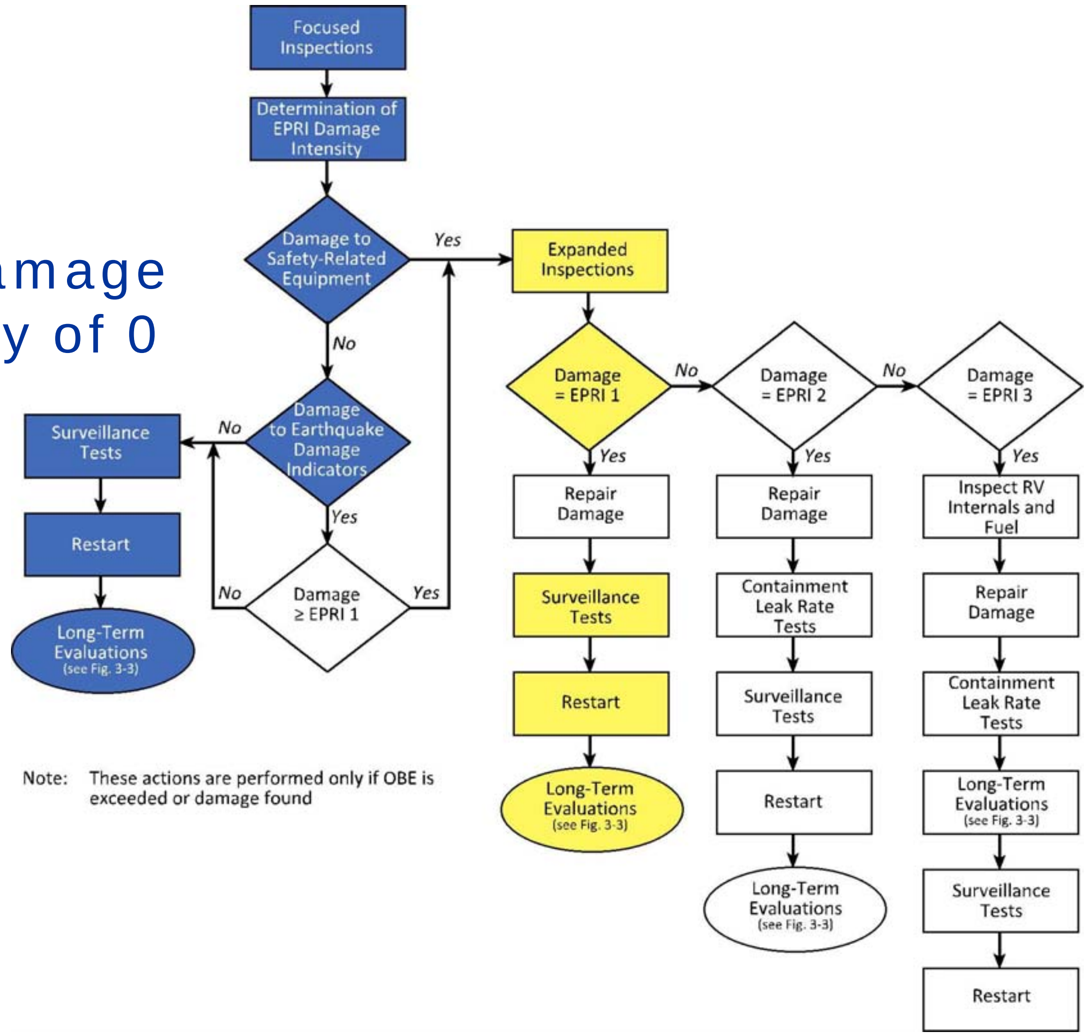
Short-Term Actions



EPRI NP-6695 Figure 3.2

Flow Diagram of Post-Shutdown Inspections and Tests

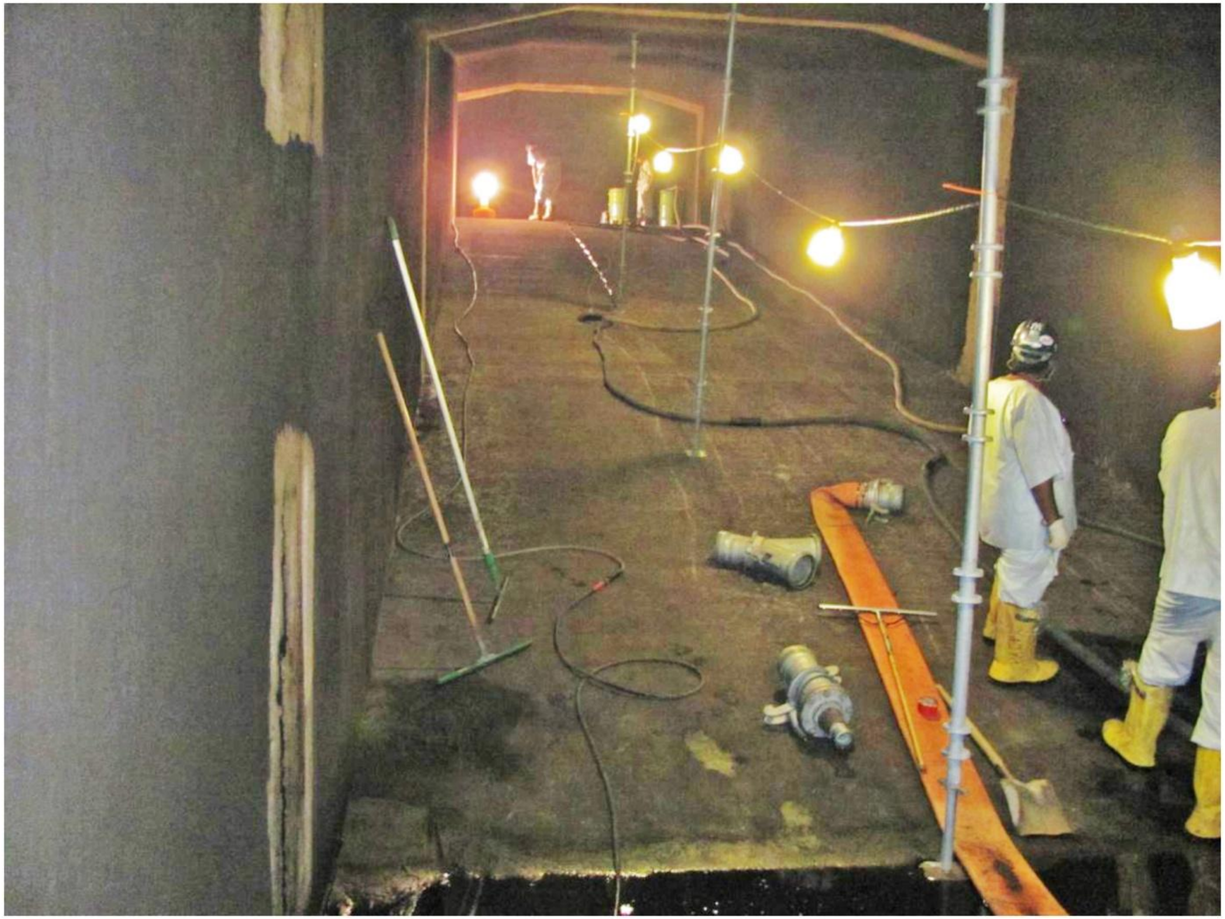
EPRI Damage Intensity of 0



Demonstration Plan

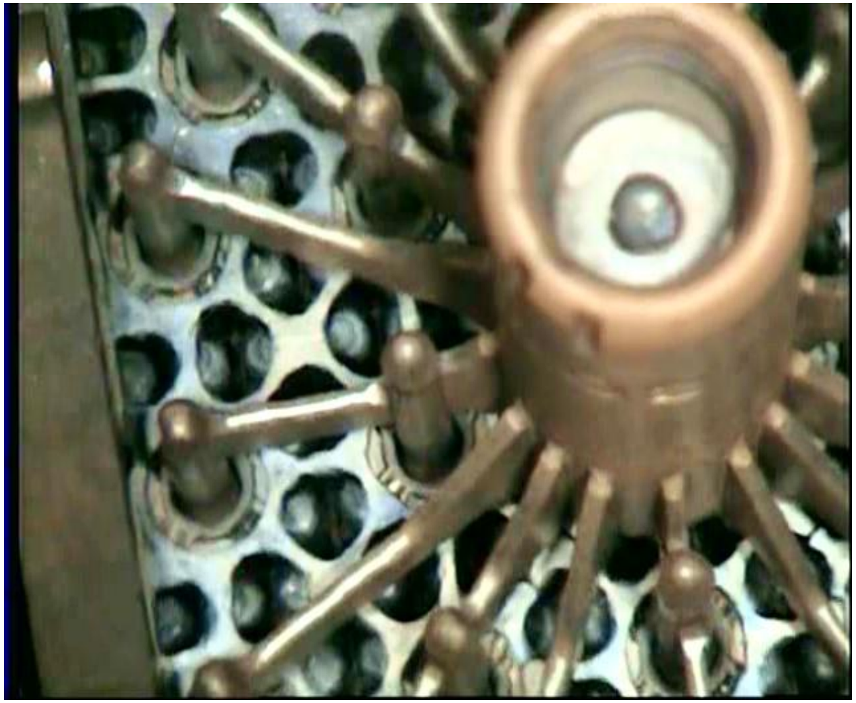
- Conservatively Inspected Beyond EPRI Damage Intensity “0” Classification
- Assessments & Evaluations for NRC
  - Requests for Additional Information (~ 130)
  - Onsite Inspections
    - Augmented Inspection Team
    - Restart Readiness Inspection Team
- Root Cause Evaluation of Reactor Trip

Investigated Components Most Likely to be Damaged



Unit 2 Tunnel Inspection

Extensive Fuel Inspections



Visual inspection of RCCA hubs

Examination of underside of a mid-span mixing grid

Buried Piping

~ 100 ft of safety-related buried pipe visually inspected with wall thickness verified by Ultrasonic Testing

Chemical Addition Tank

HCLPF value = 0.19
No seismic damage identified

Boric Acid Storage Tank

HCLPF value
= 0.21
No seismic
damage
identified

Inspection Results

- ✓ 134 System inspections completed
- ✓ 141 Structure inspections completed
- ✓ 46 Low HCLPF inspections completed
- ✓ ~ 445 Surveillance Tests/unit through Mode 5
- ✓ ~ 29 tests/unit after exceeding Mode 4

Inspections Confirmed EPRI Damage Intensity of “0”

Subsequent Actions

Short-Term Actions

- ✓ Installed Key Seismic Monitoring Equipment
- ✓ Revised Procedure to Respond to Earthquake

Long-Term Actions

- Install permanent free-field seismic monitoring instrumentation
- Re-evaluate safe shutdown equipment (components with identified lower margins)
- Perform seismic analysis of recorded event consistent with EPRI guidance
- Maintain seismic margins in future modifications
- Revise the North Anna Safety Analysis Report

Summary

- Acceleration criteria were briefly exceeded in certain directions and frequencies by a strong, but very short duration earthquake
- Previous evaluations establish safe shutdown systems, structures and components can handle peak accelerations above design basis
- No safety-related systems, structures or components required repair due to the earthquake
- No significant damage was found or should have been expected and results of expanded tests and inspections have confirmed expectations

Acronyms

CAV - Cumulative Absolute Velocity
CR – Condition Report
DBE – Design Base Earthquake
EPRI – Electric Power Research Institute
FSRC – Facility Safety Review Committee
HCLPF – High Confidence of Low Probability of Failure
IPEEE – Individual Plant Examination of External Events
MCR – Main Control Room
PT – Penetrant Test
S/G – Steam Generator
SSC – Systems, Structures and Components
RCCA – Rod Cluster Control Assembly
RG – Regulatory Guide
UPS – Uninterruptible Power Supply
UT – Ultrasonic Test
VT – Visual Test

North Anna Restart - Summary of NRC Inspection and Review Activities

Advisory Committee on Reactor Safeguards
590th Full Committee Meeting
January 20, 2012
Gerald McCoy, Region 2
Meena Khanna, NRR/DORL

NRC Inspection Effort

- Initial Response
- Augmented Inspection Team
- Restart Readiness Inspection
- Startup Monitoring Inspection

Augmented Inspection Team

Purpose

- Conduct an independent review
- Collect factual information
- Assess the licensee’s response
- Identify any generic issues

Augmented Inspection Team

Results

- No significant damage
- Safety system functions maintained
- Some equipment issues
- North Anna responded to the event in a manner which protected public health and safety

Restart Readiness Inspection

Purpose

- Evaluation of Licensee’s walkdowns
- Corrective action follow-up
- Review of actions in support of startup

Restart Readiness Inspection

Results

- The licensee adequately inspected plant SSCs to ensure that any damage would be identified
- No seismically-induced damage was identified which could affect the operability or functionality of plant SSCs
- Minor issues were identified

Startup Monitoring Inspection

- Purpose - SSCs could perform their functions through observation of control room activities, surveillances, and system walkdowns.

- Results - The licensee’s processes adequately ensured that the SSCs had not been degraded following the earthquake

Technical Review Efforts

Restart Requirements

- Appendix A to 10 CFR Part 100
  - Appendix A to Part 100—Paragraph V(a)(2) states, *"If vibratory ground motion exceeding that of the Operating Basis Earthquake occurs, shutdown of the nuclear power plant will be required.*
  - *Prior to resuming operations, the licensee will be required to demonstrate to the Commission that no functional damage occurred to those features necessary for continued operation without undue risk to the health and safety of the public."*

Technical Review

- Regulatory Guidance
  - Actions prior to restart
  - Long Term Actions

Key Technical Areas of Review

- Reactor Vessel Internals
- Reactor Systems
- Mechanical/Structural Eng.
- Instrumentation & Controls
- Electrical Engineering
- Piping

Fuels
Pumps and Valves
Balance of Plant
Containment
Steam Generators
Fire Protection

Technical Review Summary

- The NRC safety reviews were completed as part of the restart decision making process.
- The NRC ensured that Dominion demonstrated that the plant was safe to operate before approving restart.
- Inspections Completed During Restart

NRR Startup Decision

- Eric Leeds, Director of NRR
  - NAPS received restart approval on November 11, 2011 after shutdown of 80 days

NRR Confirmatory Action Letter

<u>10 Long-Term Actions</u>

1) Evaluate plant SSCs in accordance with RG1.167/EPRI NP-6695

Due April 30, 2013

2) Plan to characterize the seismic source and any special ground motion effects

Due March 31,2012

3) Revise the North Anna Updated Final Safety Analysis Report to document the event, evaluations and incorporation of RG 1.167/ EPRI NP-6695

Multiple Due Dates

4) Implement upgrades to existing seismic equipment and MCR indication and install permanent, seismically qualified backup power to a new Seismic Monitoring Panel

Due December 31, 2012

NRR Confirmatory Action Letter, Cont'd

5) Re-evaluate the plant equipment identified in the IPEEE [Individual Plant Examination of External Events] review with HCLPF [high confidence of low probability of failure] capacity <0.3g

Due March 31, 2013

6) Plan with the NSSS vendor to assure long term reliability of the reactor internals.

Due February 29, 2012

7) Compare calculated load from the earthquake and the existing LBB analysis

Due March 31, 2013

8) Perform inspections at North Anna Power Station in accordance with the latest MRP-227 revision

March 31, 2013

NRR Confirmatory Action Letter, Cont'd

9) Re-evaluate the Time-Limiting Aging Analyses that include seismic inputs to either: 1) quantitatively demonstrate that the TLAAs are still bounding, or 2) re-analyze the TLAAs, based on the August 23, 2011 earthquake.

Due March 31, 2013

10) Implement long term Seismic Margin Management Plan to address the impact of the August 23, 2011 earthquake to ensure adequate seismic margins are maintained for plant using In-Structure Response Spectra (ISRS) for buildings containing safety related SSCs

Due December 31, 2011

For Additional Information:

http://www.nrc.gov/about-nrc/emerg-preparedness/virginia-quake-info.html

Question/Answer Session