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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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AP1000 REACTOR SUBCOMMITTEE

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OPEN SESSION

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WEDNESDAY

FEBRUARY 7, 2018

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:02 p.m., Harold B. Ray, Chairman, presiding.

COMMITTEE MEMBERS:

HAROLD B. RAY, Chairman

RONALD G. BALLINGER, Member

DENNIS BLEY, Member

CHARLES H. BROWN, JR., Member

MICHAEL CORRADINI, Member
VESNA B. DIMITRIJEVIC, Member
WALTER L. KIRCHNER, Member
JOSE A. MARCH-LEUBA, Member
DANA A. POWERS, Member
JOY L. REMPE, Member
PETER C. RICCARDELLA, Member
GORDON R. SKILLMAN, Member
JOHN W. STETKAR, Member
MATTHEW W. SUNSERI, Member

ACRS CONSULTANT:

UPENDRA ROHATGI

DESIGNATED FEDERAL OFFICIAL:

WEIDONG WANG

ALSO PRESENT:

CLINT ASHLEY, NRO
JAMES BRADLEY CHAMBERLAIN, Southern Nuclear*
JASON EISENHAUER, Westinghouse*
DONALD HABIB, NRO
JESSE KLINGENSMITH, Westinghouse*
YUEN-LI LI, NRO

KEVIN MCNAMEE, Westinghouse
GREG MAKAR, NRO
ANDREW PFISTER, Westinghouse
SHAYAN SINHA, Westinghouse
COREY THOMAS, Southern Nuclear
BOYCE TRAVIS, NRO
ANDREA D. VEIL, Executive Director, ACRS
KAI ZHANG, Westinghouse*

*Present via telephone

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

P R O C E E D I N G S

1:02 p.m.

MEMBER RAY: Well, now that we've got essentially everyone here, we'll please call the meeting to order.

This is a meeting of the AP1000 Reactor Subcommittee, a Standing Subcommittee of the Advisory Committee and Reactor Safeguards.

I'm Harold Ray, Chairman of the Subcommittee.

ACRS members in attendance are Ron Ballinger, Matt Sunseri, Dick Skillman, Dana Powers will join us shortly as will Mike Corradini, Dennis Bley, John Stetkar, Jose March-Leuba, Walt Kirchner, Charlie Brown, Joy Rempe and Vesna Dimitrijevic. And, thank you, Pete Riccardella.

He wasn't there when I wrote my list down and so I missed him.

Thank you.

Also, ACRS Consultant, Upendra Rohatgi is present and will assist the Subcommittee in this review.

Weidong Wang is the Designated Federal Official for the meeting.

In this meeting, the Subcommittee will

review a Westinghouse Topical Report, WCAP 17938-P Revision 2 entitled AP1000 In-Containment Cables and Non-Metallic Insulation Debris Integrated Assessment and the associated staff Safety Evaluation Report.

The WCAP proposed changes to Tier 2 provisions of the existing AP1000 DCD. These provisions are critical to ensuring that the natural circulation function of the passive design is not compromised by debris which might result from a pipe break or from chemical effects following flooding.

These are GSI 191 considerations as uniquely applied to natural circulation, differential pressures in the AP1000.

The existing DCD requires that zero debris result from a pipe break or flooding. And, this was to be achieved by use of insulation and chilling materials and by location or protection of electrical cable so that debris would not result from pipe rupture or flooding.

Further development of the design has made it necessary to use alternate materials for which suitable equivalency, those words in quotes, must be demonstrated and to establish more specific requirements for the electrical cable.

The standard of zero debris remains a requirement -- remains the requirement, therefore, our review is to establish whether the alternate materials and requirements addressed by the WCAP that we are reviewing maintain that -- comply with that requirement.

We will hear presentations from the NRC staff and the representatives from the design certification holder.

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

Part of the presentations I expect after our break will be closed in order to discuss information that is proprietary to Westinghouse and its contractors pursuant to 5 U.S. Code 552(b)(c)(4).

Attendance at these portions of the meeting that deal with such information will be limited to the NRC staff and its consultants, Westinghouse and those individuals and organizations who have entered into appropriate confidentiality agreement with them.

Consequently, we will need to confirm at that time that we have only eligible observers and participants in the room for the closed portion.

The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate, and this is important, for deliberation by the Full Committee.

The rules for participation in today's meeting have been announced and are part of the Notice of this meeting published previously in the Federal Register.

A transcript is being kept and will be made available as stated in the Federal Register Notice.

Therefore, we request that participants in this meeting use the microphones located throughout the room when addressing the Subcommittee.

The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

We'll now proceed with the meeting, but first, let me turn to Don and ask if he has any opening remarks.

MR. HABIB: Thank you very much and I appreciate this opportunity to make the presentations and we don't have any other remarks at this time.

MEMBER RAY: That's fine.

Then, I'll turn it over to which ever of the gentlemen here will take charge for Westinghouse and please you to proceed.

MR. SINHA: Good afternoon.

My name is Shayan Sinha, I will be presenting the public slide material for Westinghouse.

We also wanted to thank you for the opportunity, we are grateful to be able to discuss this topical report with the ACRS.

I'd like to begin by talking about a little bit of background of the GSI 191 related design basis, specifically, how they apply to AP1000.

So, the resolution of GSI 191 requires nuclear plants to place limits on potential sources of debris inside containment. This is to ensure that you don't have potential -- some blockage following a loss of coolant accident where there's a pipe break inside containment.

The AP1000 actually significantly reduces and eliminates many of the debris sources that are found in typical Generation II plants. And, by incorporating a lot of these lessons learned into the design prior to construction and operation.

The maximum allowable fibrous debris inside containment for AP1000 is 6.6 pounds. And, this is all attributable to latent debris. So, in other words, the expectation is that following a loss of cooling accident, there would be no debris generated as a result of that -- fibrous debris generated as a result of that LOCA.

There's metal reflective insulation used within the AP1000 extensively including only insulation for the reactor vessel itself.

The DCD provides requirements of what must be demonstrated if and AP1000 decides to use a type of insulation other than metallic reflective insulation, or MRI. And, these requirements include that we need to demonstrate that the insulation is a suitable equivalent to MRI for the purposes of GSI 191.

And, in order to qualify as a suitable equivalent, testing must be performed to show that debris is not generated or transported.

And, finally, there's a requirement in the DCD that states that the suitable equivalent testing must be approved by the NRC.

So, the purpose of this topical report, WCAP 17938, is to gain approval for three items.

The first item is to establish a zone of influence applicable to AP1000 in-containment cables that demonstrates that the cabling will not generate debris following a LOCA.

The second is to gain approval for that the non-metallic insulation used in the AP1000 reactor vessel insulation system is a suitable equivalent to MRI for the purposes of GSI 191.

And then, the third item is to gain approval for the AP1000 to utilize the approved methodology for defining debris generation break size from NEI Guidance Document 04-07.

So, this methodology is generically approved, is part of the safety evaluation for NEI 04-07 by the NRC. However, what we're trying to do in this topical report is gain approval to use this methodology for AP1000.

And, as I'll demonstrate in the -- I'll discuss in the next few slides, testing analysis has been completed that shows that the cabling and the NMI does not generate debris following a LOCA.

So, there was two factors that led to the creation of this topical report, WCAP 17938. The first factor is that the AP1000 -- there was an issue identified that the AP1000 cabling contained fibers and other materials that were not originally considered as a debris source when -- as part of the AP1000 GSI 1919 related evaluations.

So, as this issue was resolved, corrective actions were taken and these corrective actions included developing a testing program to establish a zone of influence for the containment cabling.

And, the second factor is that the non-metallic insulation is required for certain subcomponents of the reactor vessel insulation system because some of these subcomponents performed functions other than insulation such as shielding or in vessel retention.

So, if you take a look at this diagram here to the right, the CA31 module shown at the top of the reactor vessel performs a shielding function. It is needed to prevent radiation streaming upward into containment.

And then, the lower neutron shield which is more on the bottom half of the reactor vessel shown here forms a shielding function that provides shielding for the lower reactor cavity.

Then, finally, the water inlet doors at the very bottom of the vessel support this in vessel retention support for certain beyond design basis events.

MEMBER REMPE: So, when I was reviewing the information for this meeting, I kept thinking to myself, jeepers, shouldn't Westinghouse have known that the cabling -- I mean, this isn't your first PWR, right, that would exist and these materials might exist and that you might need this material?

And, why, you know, right now, the way you presented it, it was like, well, okay, we figured you might have to do some qualification for NMI.

But, I just was surprised. I mean, did this all come as a surprise to you all and you didn't think about it during design certification?

MR. PFISTER: So, I'll take the question on cabling first because they're separate.

Traditionally, cabling isn't considered a source of debris for GSI 191. As we try to do, we look into what the industry has done. That's not a source that's generally being considered as a debris generation source.

Or, if it is, it's just rolled into the other margin for operating plants.

And, the insulation design within cabling is going to be vendor specific.

And so, as we went through the process of, you know, defining the specification for cabling, working with vendors and procuring cabling, you know, we became aware that there is fibrous materials as insulation within some cables, not all cables. But, that is a material that cable vendors use.

So, within the design certification, there's some generic language that says, you know, insulation or other materials won't become debris.

And, because we work through NEI guidance where we have established ZOIs, whether it was through an NEI program or a PWR OG program or something specific for AP1000, there had never been an established ZOI for cabling.

So, we identified, this is a gap and said, not necessarily that it is a debris source, but it certainly could be one. So, we had to take the necessary steps to say, where must it be located relative to high energy lines in order to preclude it from being a debris source?

So, that's where this came from.

MEMBER RAY: Where -- you said -- well, we are going to have some specific questions about the testing of cabling and so on. Is that best addressed in the proprietary portion of the discussion?

MR. PFISTER: Yes.

MEMBER RAY: Okay, go ahead, Walt.

MEMBER KIRCHNER: This might be proprietary, too, so I can hold it. I was just curious what the shielding material is that --

MR. PFISTER: So, we use two different shielding materials. So, I'll speak generically about them.

MEMBER KIRCHNER: Okay, or you can just wait until later and we can --

MR. PFISTER: Yes, and then I can answer it generically now and then --

MEMBER KIRCHNER: And, not to force you all the way back to slide two or one, how do you know you have 6.6 pounds of latent material? And, how do you measure that and what's the -- is there a tech spec that governs operation as a result of that?

MR. PFISTER: So, as to the shielding question first and --

MEMBER KIRCHNER: There's some precision there --

MR. PFISTER: -- the 6.6 --

MEMBER KIRCHNER: -- that's often hard to measure in light weight --

MR. PFISTER: Yes.

MEMBER KIRCHNER: -- material.

MR. PFISTER: So, the shielding material, so within the lower neutron shield, we use a boron silicone material. And, to note, that all the shielding is non-safety related shielding. So, this is shielding that we only credit during normal operations and shutdown, not shielding that we credit for accidents.

And, within CA31, which is shield -- essentially shield blocks that will go into more detail --

MEMBER RAY: Let interrupt you for just a second.

You were asking about the 6.6, weren't you?

(OFF MICROPHONE COMMENTS)

MR. PFISTER: He asked -- so, I was answering the question about shielding then I was going to answer --

MEMBER RAY: Okay.

MR. PFISTER: -- the 6.6.

MEMBER RAY: I missed the --

MR PFISTER: And, within the CA31 which

are 60 individual blocks inherently designed within the refueling cavity floor, we use boron carbide for shielding there.

So, relative to your second question, how do we demonstrate 6.6 pounds? And so, ultimately, that's something that must be demonstrated prior to fuel load and prior to each refueling.

It's done in almost the exact same way you would do it for an operating PWR is that, as part of your containment cleanliness program, you have to quantify and demonstrate containment cleanliness. You typically do that, they almost call it a white glove test where you go around and you test certain areas.

And then, you know, the -- I think the industry standard is, of the debris that you quantify for all of containment, the assumption is 15 percent of that debris is fibrous.

And so, when they do their containment cleanliness and they go in, you know, to their pre-fuel load inspections, you know, as part of their containment cleanliness program, that would define how you measure the total amount of debris.

And then, industry standard is 15 percent of that is assumed to be fibrous.

MEMBER KIRCHNER: What struck me was that the 6.6 is a fairly precise number.

MR. PFISTER: Yes. And so, the 6.6 was established during design certification as part of the fuel assembly and sump testing. And so, that's essentially the limit we were able to push our fuel assembly testing to.

You know, with the combination of latent debris and chemical debris to show we didn't get unacceptable DP across the fuel.

MEMBER KIRCHNER: No, I knew the basis for the amount, but I was curious about how you measure it to that precision.

MEMBER RICCARDELLA: Are your limits smaller than a conventional PWR because of the passive nature of the system?

MR. PFISTER: Essentially, the answer is yes. So, you'll see a range of limits within PWRs. You'll see what they consider high fiber plants where the limits are much, much higher.

And, you'll see low fiber plants. You know, we're probably the lowest of the low fiber plants.

But, a lot of that's driven by acceptable DP we can withstand due to the passive recirculation.

MEMBER RICCARDELLA: Okay, thank you.

MR. SINHA: Okay, so, on slide six, this just summarizes the results that came from our program to evaluate the non-metallic insulation and the in-containment cables.

So, firstly, the first bullet talks about the zone of influence of four diameters. There are four times the debris generation break size was established for in-containment cables. And, this was done through an extensive large-scale jet impingement testing program which was conducted at a facility that had been previously used by the pressurized water reactor zoners group for other operating plant evaluations related to GSI 191.

And so, this cable as the OI, was able to be incorporated into the design requirements and then the location of the cables and the cable trays, we consider them as, you know, as the locations were developed for the plant.

The WCAP also invokes the alternative evaluation methodology from NEI 04-07 for determining the limiting RCS break size, you know, in our debris generation evaluations.

And so, this was done through a structural evaluation that reviewed whether the hot leg or cold legs would fully separate following a loss of coolant accident.

And then, this is compared against the NEI 04-07 criteria and shown to be acceptable for AP1000.

And then, finally, jet impingement and submergence testing program was performed for the non-metallic insulation. And, the insights from this programs were used to strengthen the design of the elements for the reactor vessel insulation system.

So, essentially, this resulted in design changes that used a thicker and more robust encapsulation for the neutron shield blocks.

And then, the final slide is the conclusions for the public portion.

The jet impingement testing program that was conducted was used to justify a cable ZOI for L/D for the AP1000 in-containment cabling.

The cabling was found to contribute no post LOCA debris.

The application of the NEI 04-07 ultimate break methodology was acceptable for the AP1000. And then, the encapsulated non-metallic insulation was found to not produce debris when subjected to the jet impingement from the limiting RCS lines -- line breaks.

And then, the cabling and the NMI were evaluated for chemical debris and found that neither types of components would contribute to chemical debris.

And, this -- the conclusions related to jet impingement and chemical debris were used to make the conclusion that the non-metallic insulation in the reactor vessel insulation for AP1000 is a suitable equivalent to MRI for the purposes of GSI 191.

And then, I just wanted to highlight the overall conclusion that the WCAP justifies that there's no debris -- no new debris generated for AP1000 from the cables and the non-metallic insulation.

So, that is all we have for the public portion. We can open it up for questions.

MEMBER BROWN: Just a question on the previous slide, two previous slides, six.

What the design was changed to use thicker and more robust -- what's meant by more robust? I missed that if you --

MR. SINHA: Yes, we're going to detail it more --

MEMBER BROWN: You're going to talk about that -- okay, then, we'll wait.

MR. SINHA: So, it's the weld type that we use.

MEMBER BROWN: It's the what -- the weld --

MR. SINHA: We use a more robust weld type.

MEMBER BROWN: -- the welding --

MR. PFISTER: The welding techniques that we use.

MEMBER BROWN: Okay, all right.

MEMBER RAY: Any other questions?

MR. ROHATGI: Anyway, are you going to change the weld technique that you'll discuss later on?

MR. SINHA: Yes.

MR. ROHATGI: Because they're not going to be all the same techniques?

MR. SINHA: Correct.

MR. ROHATGI: Okay.

MR. SINHA: Yes, the different subcomponents have different weld techniques.

MEMBER RAY: Okay, we've got the scope of the discussion here clear, I think, and the purpose of it and so on.

Anything else?

(NO RESPONSE)

MEMBER RAY: If not, we will have an opportunity for public comment following the staff open discussion.

MR. SINHA: I apologize, I actually had -- there's one other comment I wanted to make was about the utility -- the licensee, Southern Nuclear wanted to make a comment about the usage of this topical report for Vogtle Units 3 and 4.

MEMBER RAY: Okay, that's fine. Please --

MR. THOMAS: Yes, this is Corey Thomas from Southern Nuclear, Vogtle 3 and 4 Licensing.

First of all, this WCAP is important to us from a construction sequence to allow us to continue with the installation of non-metallic insulation inside containment and installation of the cable inside containment.

Thank you.

MEMBER RAY: Yes, and because of that, we were all geared up to write your letter this week. But, we understand that we've got a little more time. So, we'll have the Full Committee consider whether they wish to write a letter on right now forecasted to be the April Full Committee meeting.

Okay, again, we're in public session. We will ask for any public comment, but following the staff presentation.

So, we'll trade places now and proceed with the staff and then return -- we may get to the closed session before our break if things continue to move this quickly.

And, you'll want to remove that card, that's good.

Okay, Don, could you launch the ship, please?

MR. HABIB: Thank you and good afternoon. The staff's here to make our presentation -- public presentation for the AP1000 In-Containment Cables Non-metallic Insulation Debris Integrated Assessment and the draft Safety Evaluation that it prepared.

So, these are our speakers and they'll introduce themselves.

I'm going to turn it over to Clint Ashley who's the first presenter.

MEMBER RAY: Before you do, let me say, on the agenda I was given, maybe I should direct to

Weidong, shows only Westinghouse speaking in the closed session. That implies to me that you don't have any closed material to present.

MR. HABIB: That's correct. But we do --

MEMBER RAY: But, we may have questions for you that need to be discussed in closed session. So, I just want to make that clear to everyone that staff will remain with us for purposes of questions that involve proprietary material and that could be relevant to the discussion we're about to have.

So, anyway, for all intents and purposes you'll be with us also in the closed session.

Go ahead.

MR. ASHLEY: So, good afternoon.

My name is Clint Ashley. I'm a Technical Reviewer in the Office of New Reactors.

And, we'd all like to thank you for the opportunity to present our draft Safety Evaluation on this particular topical report.

And, we do look forward to addressing any of your questions. And, as you mentioned, I think these slides are non-proprietary. But, we recognize that some of the discussions may go into proprietary information and we'll hold those over until the closed session.

So, going back one slide, we're just going to cover a few topics here initially and I'll discuss the introduction and overview and then we'll roll right into the staff's approach and our findings.

The next slide shows the presenters here, members of the technical team as well as the project manager. We also worked closely with NRR Technical Reviewer, Steve Smith, as part of this process. So, I wanted to make sure I acknowledged their involvement in this review.

So, the next several slides really just try to explain at a base level what a topical report is for those that may not be familiar with them, what guidance the staff used during the review.

And, you've already heard Shayan this morning what this topical report is all about. So, I'll probably be able to breeze through some of those background slides.

The -- a topical report is a standalone document containing technical information about a nuclear power plant safety topic and provides the technical basis for a licensing action.

And, typically, the objective is to add

value by improving the efficiency of other licensing processes. For example, the process for reviewing license amendment requests or we call them LARs.

They improve the efficiency of the licensing process by allowing the staff to review proposed methodologies, designs or other safety related subjects on a generic basis so that they may be implemented by reference by multiple licensees once approved by the NRC staff.

And, in this particular topical report, Westinghouse updates the AP1000 plant safety analysis related to generic safety issue 191 which is concerned with the assessment of debris on pressurized water reactor sump performance.

The WCAP seeks review for three items and we'll talk about these in the next few slides.

The main guidance for evaluating this topical report is the Nuclear Energy Institute, NEI document 04-07. And, that was published in 2004 time frame, if I'm not mistaken.

The NEI 04-07 submission as approved in accordance with the staff's Safety Evaluation provides an acceptable overall guidance methodology for the plant specific evaluation sump performance.

And, that staff safety evaluation was also completed in 2004 time frame.

One thing the NEI 04-07 document mentions is that it didn't really have enough information to conclude anything about chemical effects other than more study was needed.

So, the industry put together another topical report, 16530, that the staff approved. And, I believe that approval was completed in maybe the 2008 time frame.

So, as Westinghouse already communicated earlier, the AP1000 safety evaluation really is based on a zero loss of coolant accident generated fibrous debris source term.

So, no LOCA generated fibrous debris, they've gotten rid of all that fibrous insulation that a lot of operating plants are plagued with.

And, the way they achieve this is through the use of metal reflective insulation. This is on main coolant piping, steam generators, all those large main coolant system components.

The DCD also does allow or permit a suitable equivalent insulation. And, as part of this WCAP, Westinghouse recognizes that there's going to be at least three locations for suitable equivalent insulation to replace metal reflective insulation.

And, the last bullet on this slide, the DCD does specify that NRC approval is required to use a suitable equivalent insulation.

Westinghouse already communicated this information. It's about electrical cabling. And, it was -- I would view it as more of a discovery item as Andy Pfister had communicated. So, I don't think there's any need to brief anymore on this slide.

Next?

So, in light of the AP1000 design basis in which the AP1000 design does not generate fibrous debris during a LOCA, and that coupled with a detailed design reviews which took place on cabling and non-metallic insulation.

The WCAP seeks approval for the following three items.

And, the first one is zone of influence for electrical cabling.

The second is use of non-metallic insulation as a suitable equivalent to metal reflective insulation.

And, the last one is use of the NEI 04-07 alternate evaluation methodology for assessment of debris generation.

And, the next slide talks about what it means to be a suitable equivalent insulation from a debris generation perspective.

Testing must be performed that subjects the insulation to conditions that bound the AP1000 plant conditions.

Testing demonstrates that debris would not be generated to include chemical debris.

And, this must be approved by the NRC.

That's all called out in the DCD.

And so, the three requests for NRC approval are detailed in the subsequent slides.

And, at this point, I'll turn it over to Boyce Travis who's going to talk through the items one and two.

MEMBER RAY: Boyce, before you begin, let me just say that these points that were just covered about in quite detail in the DCD were in anticipation that we would be here having this discussion at the time.

That sort of detail isn't spelled out later, but it was just in unresolved matters as to whether MRI would be totally satisfactory throughout the design. So, there was a provision made for suitable equivalent. Here we are.

Go ahead.

MR. TRAVIS: As Clint mentioned, my name's Boyce Travis. I'm a Technical Reviewer in the Containment Branch at NRO. I'll be discussing the first two requests in the WCAP.

So, item one of the WCAP requests approval for a ZOI for electrical cabling and containment. In order to determine the acceptability of this, staff's goal was to ensure that the tested cables represented a bounding set for all the AP1000 cables and to ensure the test conditions for the facility bound the target conditions expected in the AP1000 plant.

In order to make this determination, staff observed the cable jet impingement testing facility. We assessed the applicability of the test facility to produce the conditions representative of the AP1000 plant.

And, in doing so, we reviewed both the test material -- physical test materials and the prepared test reports for the facility. And, as part of our review, we issued RAIs.

And some additional detail on how we came to our finding is on the following slide.

So, as part of the review, staff looked at observations from previous NRC visits to the test facility.

In about six, seven years ago, the Office of Research visited the facility which was, at the time, being contracted by the PWR Owners' Group. At that time, the test facility was instrumented to determine whether it was capable of producing jet conditions that would be representative of the large PWR.

At the time, the group from research found that they thought it would be able to do so. And, this topical report leverages some of that instrumented testing in its evaluation of the test facility that they used for both the cabling and the NMI.

So, as part of the review and the topical report, the test conditions that were generated by the facility for this testing were compared to the facility conditions from the previous testing to verify both repeatability and the expected target conditions were at jet impingement pressures expected for a PWR, in this specific case, the AP1000.

MEMBER RAY: Yes, I think we have some

questions perhaps on this point. Our consultant will discuss them.

I don't think they will go into proprietary material. They have to do with process.

MR. TRAVIS: Okay.

MEMBER RAY: And, your oversight of how you're auditing of it.

But, if they do, then, of course, we'll stop and resume after we go into -- but we should discuss in the open session as much as we can that's not proprietary.

So, go ahead.

MR. ROHATGI: Yes, looking at this, when you did the cable testing and you're saying the conditions will bound the LOCA conditions in AP1000?

MR. TRAVIS: That's correct.

MR. ROHATGI: But, that didn't come out very clearly because, I don't want to go in detail of the size of the jet and all, but --

MEMBER RAY: Try and use the other microphone also. There's two microphones not being used there.

MR. ROHATGI: Okay, so, what I wanted to know is that how do you decide that this test facility bounds the condition expected in the containment?

MR. TRAVIS: Sure.

So, I'll try to do this at a high level and that's all I can do in the open session.

But, with respect to the pressure produced by the -- so, the previous testing performed at the facility was well instrumented. And so, for an expected conditions in the -- for expected test reservoir conditions, we have an expected pressure profile that's going to be generated by the jet.

At all conditions -- I'll say this, based on the locations that the cables were placed during testing and the distance the cables were from the jet -- from the facility exit nozzle, the instrumented conditions led staff to believe that for those -- for the -- specifically with regard to the cables, once we get into talking about the blocks, it becomes a little more nebulous.

But, specifically with regard to the cables, the pressure the cables experienced from the jet is -- would be equal to a greater than that they would see in the AP1000 based on the instrumented test facility and the reservoir conditions of the test facility as was reviewed by the staff.

MR. ROHATGI: So, the jet has a velocity, I don't know, stop me if I go in anything -- so the jet which is running impinged has a velocity profile and the center of the jet will have the largest static pressure?

MR. TRAVIS: That's correct.

MR. ROHATGI: I mean static pressure may be uniform. So, the question, so, when you impinge on this cable, have you moved around the jet to see each of the cables is subjected to largest static pressure or it was just one short?

And, because the damage was -- seems to be random from some cable on the left were damaged or sometimes on the right, but how do they connect to the center of the jet?

MR. TRAVIS: So, I think we're going to be getting in to proprietary discussion very quickly there.

MR. ROHATGI: Yes, I'll wait, I'll wait.

MR. TRAVIS: So, if we could hold that to where I can fully anser the question?

MR. ROHATGI: That's fine, thank you. Okay, thank you.

MR. TRAVIS: Okay, so, I guess I'll go back and try and continue -- pick up where we left off.

So, as I was saying, as part of the review, staff determined that the facility produced conditions that would bound the expected conditions at a distance, a scaled distance from the jet as would be experienced in the AP1000.

And so, as part of testing, the applicant performed tests at different scale, length over diameter ratios and determined a ZOI for what -- when damage would occur, when the onset of damage would occur and when no damage would occur due to cables.

And then, did repeated tests to determine -- to make sure that those conditions were represented or that those test conditions could be repeated.

And so, that was, at one point, the applicant conservatively made their request that their acceptable ZOI would be that which showed no debris generation.

The primary concern is quantifying a ZOI for the cables based on experimental observation and debris generation. And so, by choosing a ZOI that showed no damage to the cables, the staff felt that was a conservative choice in making what would be an acceptable ZOI for cable damage.

I'll note that the applicant tested both aged and unaged cables to serve as a representative bounding set. And, those cables were aged both thermally and radiation -- they were fresh and unaged cables -- fresh and unaged cables tested both from a thermal perspective and a radiation perspective.

We can move on to the next slide.

MEMBER RAY: Could you repeat that for the record just to make sure it's --

MR. TRAVIS: Sure.

MEMBER RAY: -- clear. It was a little --

MR. TRAVIS: So, the --

MEMBER RAY: -- trailing off at the end there.

MR. TRAVIS: Yes.

There were aged and unaged cables tested. Aging consisted of both of thermal and radiation aging.

MEMBER POWERS: The thermal aging and the radiation aging were done together or separate?

MR. TRAVIS: That I would to -- I believe separately, but I would have to go back and check that to be sure.

MEMBER POWERS: Well, NRC funded Roger

Cliff to look at in-containment cable degradation during service life. And, what he observed was that cable damage due to radiation and thermal conditions were synergistic. So, why would you do the aging separately if there's synergism between thermal and radiation damage?

I mean, this is research funded by the NRC, it's publically available.

MR. TRAVIS: So, I think that's a fair question. As I said, I'd have to go back and look at when the aging was performed.

I will say that, yes, because at the test facility and saw the cables. They were tested and I have verified the aging reports that do exist.

But, if we can hold my full answer to closed session, I'll go back and -- I have the topical report right there, and go back and look and make sure that I have a complete answer for you --

MEMBER POWERS: I'm very patient.

MR. TRAVIS: -- in a few minutes.

MEMBER POWERS: -- I'm not going anywhere until Saturday.

MR. TRAVIS: Understood.

And so, back to the slides.

With regards to the cabling, the staff found that the topical report provided an acceptable technical basis for determining no debris will be generated by the cables at or beyond the proposed ZOI.

The testing generated -- the testing as part of the WCAP demonstrated no debris generation would occur outside that ZOI. And, therefore, the staff determined that that ZOI was acceptable.

As part of this finding, the staff imposed the limitation and condition as part of the WCAP stating that performance of cables within the ZOI, if any are present, is outside the scope of the WCAP and any cabling that was located within the ZOI would have to be assessed by an applicant or a licensee referencing the AP1000 and the WCAP to determine that it was acceptably protected.

MEMBER REMPE: I have a question. In the report that Westinghouse submitted, they concluded that chemical testing was not needed. Submergence testing was not needed. And, they cited several reasons.

And, in the first reason they said was because of a letter that ACRS wrote. And, you guys actually mentioned that, too. But, nobody said, in your letter, at least your draft, you didn't mention that that didn't seem like a very good reference to support that ACRS dismissed it.

And, I was a little offended that they would even try and use that. Because I read what was in that ACRS letter, it sure didn't support that you didn't need that.

And, you're shaking your head yes, that was a bad thing to do and I would have made the applicant prove that sentence.

MR. TRAVIS: For that discussion on chemical effects, you're correct.

MEMBER REMPE: Okay.

MR. MAKAR: What we did -- what we added to that was the -- or in addition to that letter, there were a phenomena identification and ranking table. And then, a subsequent analysis which wasn't mentioned in their topical report that addressed organic materials from a variety of standpoints.

And so, they -- the reason that cable materials haven't been included in our standard chemical effects evaluations is because, as aa debris material in and of themselves is they have fallen into the category of uncertainty if you apply the accepted methodology that's based on a lot of conservative assumptions.

And, there are things that we don't know about like cables and other materials whether they would form a chemical precipitant or not.

Organic materials, including cables, have been looked at in different ways. Now, from a chemical resistance standpoint, they -- some of these materials are chosen, for example, in the chemical process industry because they have such good resistance to chemicals and elevated temperatures at -- over a variety of chemical conditions.

It could change with aging some, but they're often a material choice for aggressive chemical conditions.

What they are always -- the way they're always included is from the acidification acids they can generate under a radiation field in the post LOCA environment.

And, that acid is then included in the calculations that determine how much pH buffer one needs in the containment.

From -- then there are other possible contributors from the organics like agglomeration of things that are in the water and whether that helps you or hurts you from a debris generation and transport standpoint.

And, also complexation. So, if these materials from the -- if the organic materials can bind with metallic ions or other things in the water, they can increase the solubility which could mean less precipitant.

So, we've looked at organic materials from a variety of ways and I don't think that, you know, the references we made didn't go into all that detail.

MEMBER REMPE: Yes. Well, again, I mean there were several things they cited. It was just one of them didn't seem to jive and I was surprised that that wasn't disputed in your draft SE.

MEMBER RAY: Okay, I just -- before we go off of this slide, because later on, my guess is as someone was just mentioning, we're going to get into things where we may forget the last point.

I just wanted to reiterate it, performance of cables within the zone of influence, if any, is outside the scope of the WCAP.

We're not trying to decide how much damage --

MR. TRAVIS: That's exactly right.

MEMBER RAY: -- would result to cables inside the zone of influence.

MR. TRAVIS: That's exactly right.

The staff's finding is based on at 4-D there will be no damage to the cables.

MEMBER RAY: Yes.

MR. TRAVIS: Inside that 4-D, the WCAP makes no finding.

MEMBER RAY: This is a -- the safety evaluation is very thorough, very detailed, talks about a lot of things which, based on rules like this, really aren't relevant because they're talking about things that, at the end of the day, are outside the scope of what we're doing.

MR. TRAVIS: I'll just make a note real quick that I think NEI 04-07, technically, you could define the onset of incipient damage as your acceptable ZOI. That's why I said the applicant chose to conservatively define 4-D --

MEMBER RAY: Four instead of three.

MR. TRAVIS: -- or whatever.

MEMBER RAY: Yes.

MR. TRAVIS: I won't get into the numbers in the open session.

But, yes. And so, that's why we were very prescriptive in this determination.

MEMBER RAY: Yes.

MEMBER SKILLMAN: Can I ask this, please?

The gentleman from Vogtle announced that this is an important action that we're undertaking here.

With regard to that last bullet, are we in a zone of urgency where there are cabling activities going on at Vogtle that hinge on the last bullet?

MR. TRAVIS: I definitely don't have the expertise to answer that. Don, this project --

MEMBER SKILLMAN: That might be an inappropriate question. But, what I'm wondering is if there is a practical issue that is before us that we don't fully recognize?

MEMBER RAY: Well --

MR. TRAVIS: Yes, we're going to --

MEMBER RAY: I don't --

MR. TRAVIS: We don't have anything on that.

MEMBER RAY: I don't believe there is.

MEMBER SKILLMAN: I think the answer is no, but that I've just seen some --

MEMBER RAY: Let's just assume for now the answer's no. As I said, we were expecting to need to get our part of this done this month, now is such that we don't have to do it that quickly. That doesn't answer your question, but proceed.

MR. TRAVIS: Okay.

So, on the next slide, I'll start talking about WCAP item two which requests approval for the use of the non-metallic insulation as a suitable equivalent to the metal reflective insulation.

This approval is a -- would be at limited locations and would be bounded by testing and analysis as requested in the topical report.

I'll also, at a high level, note that the approval of the blocks differs significantly from the cables in that a single set of jet impingement testing is not enough to qualify the blocks.

The blocks themselves require both testing and analysis -- different types of testing and analysis to all form of coherent justification for why they act as a suitable equivalent.

And so, as part of the staff's review for the non-metallic insulation blocks, we have served both jet impingement and submergence testing, evaluated thermal expansion testing performed by the applicant, assessed the applicability of all the test facilities at the affirmation test facilities.

Again, reviewed test materials and test reports and issued a number of RAIs related to the non-metallic insulation.

In further detail on this next slide, for the qualifying the neutron shield blocks with regards to jet impingement testing, they were tested to qualify the ability -- their ability to withstand jet forces under a variety of ZOIs and block configurations including those both that they expected to be present in the plant and perhaps were more conservative in those expected in the plant.

This testing was then supported by a discussion of confined jet behavior as based on their location of the neutron shield blocks, it was not obvious that a free jet was the appropriate model.

And so, the confined space of the reactor cavity could have presented a compounding factor for the jet pressure.

And so, to qualify that confined space, the WCAP embarked on a literature review which the staff reviewed for applicability.

And, ultimately the staff's finding for

jet impingement on the NMI was based on a combination of the presented testing and the literature review for confined space which allowed the staff to verify that the predicted NMI jet impingement pressure would be bounded by the test facility at the requested ZOI.

Ultimately, staff feels that the test demonstrated the request nature of the blocks and showed that in the actual plant, no debris would be generated due to a jet at the ZOI expected.

On the next slide, the qualifying NMI also required evaluation of chemical effects as the neutron -- some of the neutron shield blocks are below the containment flood up levels.

So, there's both a debris generation and a submergence piece to this.

Submergence testing measured releases for different levels of NMI encapsulation. Staff used the testing as a means to evaluate that design's ability to prevent chemical effects.

And, ultimately, the testing that the applicant performed demonstrated and showed that a complete encapsulation of the block was necessary to prevent the release of any elements that could generate chemical effects and that additional chemical effects resulting from materials inside the non-metallic insulation would be predicated on what the amount submerged aluminum was present in containment.

And so, that led us on the next slide -- so the staff's finding is that the topical report provides an acceptable technical basis for determining that no debris will be generated by the blocks.

And, as there was no debris generated, the blocks themselves functioned as a suitable equivalent to MRI.

But, as part of this, staff imposed a pair of limitations and conditions on this subset of the WCAP.

The evaluation -- the staff's evaluation of the NMI is limited to debris generation only, not of their functions provided by the blocks such as the neutron shielding. That ability would be assessed by the supplicant on -- in the appropriate change process.

And, the staff also imposed a limit on the amount of aluminum in containment based on the blocks as the presence of additional aluminum combined with the submergence effects from the blocks.

Basically, the applicant performed their demonstration on the amount expected in the AP1000, further aluminum could influence the chemical effects generated from the submerged NMI.

And, for a discussion of the third request in the WCAP, I'm going to toss it back to Clint.

MR. ASHLEY: Next slide, please?

So, this third item, the -- and it's the final WCAP item, request approval to use the NEI 04-07 alternate evaluation methodology.

And this methodology is approved in the Safety Evaluation associated with NEI 04-07 which was done back in 2004 time frame.

But, the AP1000 plant design didn't specifically invoke this section of the NEI 04-07 document. So, they wanted to be up front in this topical report and show that they wanted to apply this particular section of the 04-07.

So, the NEI 04-07 alternate methodology in part assumes a double-ended guillotine break of the postulated pipe breaks in the reactor coolant system main coolant piping.

Unless that piping is physically limited. And, it could be limited in a number of ways, piping restraints, supports, other structural members of piping stiffness that could be demonstrated by analysis.

So, if you have this main coolant pipe that is physically limited, the advantages that you can assess a smaller break size for debris generation purposes.

Next slide?

So, as far as the staff review approach is concerned, we looked at the topical reports implementation of the approved methodology.

We did focus our review on reactor coolant system main piping breaks that are physically limited.

We audited calculations and reports used to determine that limited separation for those postulated breaks.

And, we also reviewed the WCAP's methodology for determining essentially a result in break diameter for limited separation breaks and the associated zone of influence.

Next slide?

So, our finding, the applicant's approach to determine limited separation breaks, equivalent break diameter and zone of influence was reasonable based on the information reviewed as part of the audit and the information contained in the WCAP.

The WCAP does implement the alternate evaluation methodology consistent with prior staff approval. And, based on those two items, the WCAP's use of NEI 04-07 alternate methodology was acceptable.

We did note that, because NEI 04-07 methodology, this alternate methodology, permits use of operator actions or credit for non-safety systems, that we wanted to avoid any confusion because the WCAP excludes use of operator actions or used of credit for non-safety systems as part of mitigation.

And so, we threw in this limitation and condition just to make sure that was clear.

Next slide?

So, in summary the staff reviewed the three items that were presented in the WCAP for review and approval and they are summarized on this slide.

And, the draft Safety Evaluation, the staff finds the approach described in the WCAP acceptable and the staff approves the request subject to limitations and conditions.

That concludes the staff presentation for the public portion.

MEMBER RAY: Dana, this discussion here today is only about what is the scope of the WCAP, not broader issues. But, it does conclude -- reach a conclusion about limitation on aluminum.

In the past, you suggested, I think, that zinc is an equivalent to aluminum in some cases and that it might be used in primer coating and so on.

MEMBER POWERS: It is used in the primer coating. It is the primer for the epoxy and it is the only coating on the upper part of the containment building.

They don't -- they need the conductivity through the containment shield, so they only use a primer coating above a certain level. I can never remember what that level is, but up in the higher dome that's all there is.

It is -- I would not characterize it really as equivalent to aluminum. It does form precipitates in the water. They don't tend to be nearly as flocculent and obnoxious as aluminum oxide precipitates.

But, they do and so, but are they one to one, I don't know. But, they are a consideration.

But, I believe those are taken into account in the existing limitations in the -- for the GDC 191, aren't they? I mean the --

MEMBER RAY: GSI.

MEMBER POWERS: GSI, I'm sorry.

MR. MAKAR: As a result of the methodology that AP1000 uses for chemical effects analysis, it was not required to evaluate zinc precipitants.

The staff hasn't really determined that there are zinc precipitants that occur in the post LOCA environment.

MEMBER POWERS: Well, if the staff hasn't, then they're alone in the world because everybody knows you get zinc precipitates in these things.

MR. MAKAR: Well, sorry, they were observed not as in as many tests and the conditions under which they occurred at weren't as you think.

MEMBER POWERS: Well --

MR. MAKAR: And, there were -- the quantity wasn't as much. And so --

MEMBER POWERS: My thinking is that what they really did was they took enough bromide in their test solutions to bound not only the aluminum but everything else that they can think of. Because there's a lot of stuff.

MR. MAKAR: Say that again, please?

MEMBER POWERS: They --

MR. MAKAR: Enough --

MEMBER POWERS: In the WCAP where they propose how to drove to resolve the generic safety issue, they formulate a representative solution and they put a lot of simulant materials in there.

One of the things they put in is bromide, the other one I think silicon carbide for hard particulates. But, it's not that they have any silicon carbide in the plant, but they wanted to simulate a hard particulate and fiber and a lot of things.

And, I think they took enough to simulate what they thought was the amount of zinc that they would get from, you know, blow downs and things like that.

MR. MAKAR: In some of the testing, the zinc -- the precipitate was adherent also to the zinc coupons rather than in the water.

And, that the --

MEMBER POWERS: That's the motion of time.

MR. MAKAR: And, again, the methodology is based on if you take this conservative approach with regard to aluminum and the other things that we were -- that the industry was able to identify in the water, the staff felt that that's conservative enough to account for uncertainty about some other elements where it wasn't clear what the precipitant was and what the effect was on head loss.

MEMBER POWERS: Yes, there's --

MR. MAKAR: So, I think we -- there's -- zinc is -- it would be on the table if someone used a different approach to chemical effects rather than the standard methodology is one way of saying.

MEMBER POWERS: Yes, I would -- zinc wouldn't be the first thing I would think of for chemical effects because I don't believe they use triphosphate in this system, do they?

MR. MAKAR: In this case, yes.

MEMBER POWERS: They do use it?

MR. MAKAR: Yes.

MEMBER POWERS: Oh God. That's really bad.

MEMBER RAY: Well, I raise it here only because, like I say, I don't want to increase the scope of what we're trying to address here now because it's important that we get closure on it ultimately.

But, because aluminum had been set up as a consequence of what we're doing here, I felt I needed to ask the question.

I don't think from what I've understood

of your dialogue here that we've answered the question as to whether zinc is problematic, have we?

MEMBER POWERS: I think you try to bound it with the amount of aluminum in there and it's not going to be worse than aluminum.

At least my experience with zinc precipitates is that they're pretty easy to handle. Aluminum precipitates will -- are obnoxious in the extreme.

So, if you put a lot of aluminum in, you're okay. That would be my view on the thing.

MEMBER RAY: Well, I just want to give you an opportunity to pursue it.

MEMBER POWERS: Yes, the -- but the --

MEMBER RAY: But, not --

MEMBER POWERS: -- issue of aluminum is predominant in my mind as it -- aluminum, as they pointed out, depends on how much you have submerged because the submerged aluminum will corrode and you'll get more, a lot more.

MEMBER RAY: Okay, well, I won't raise it again then if you're satisfied.

MR. MAKAR: If I can just mention that also with the AP1000, the strainer testing, and there was bare strainers so that additional chemical effects beyond what's considered in the design basis wouldn't have had an effect. And, I think some of the fuel assembly testing used higher levels that the design basis and, the evaluation on the fuel.

So, it was conservative in a number of ways. So, I think additional -- focusing on this conservative methodology and staying within that design basis, staff feels adequate to still to address those -- that kind of uncertainty.

MEMBER RAY: Okay, questions?

MR. ROHATGI: Yes, just quickly, just a clarification. The NMI has no aluminum, it's all steel.

MR. MAKAR: There's no chemical effects from the metal reflective insulation.

MR. ROHATGI: So, the aluminum thing is not coming from NMI?

MR. MAKAR: That's correct.

MEMBER RAY: That's right.

MR. ROHATGI: Okay.

MEMBER RAY: Other questions?

(NO RESPONSE)

MEMBER RAY: Okay, it's five minutes after

2:00. So, we're going to make a transition here in a moment into the closed session because I think it's a little early, just an hour into this, to take a break.

And, we'll decide, depending on how the closed session goes, whether we'll then take a break during it or perhaps wrap up before need to.

So, if we can -- Westinghouse will Be the first up in the closed session.

If Westinghouse can come up and, as they're doing so, we'll invite any members here in the audience of the public who will not be remaining with us if there are any comments?

(NO RESPONSE)

MEMBER RAY: Seeing none, we will ask that the phone line be opened so that we can make a similar question to them.

Weidong, is it open and on?

MR. WANG: It is open.

MEMBER RAY: All right.

MR. WANG: All of -- yes, the line is open.

MEMBER RAY: Is there anyone on the phone line who would like to make a comment on the discussion that we've had here now?

(NO RESPONSE)

MEMBER RAY: Hearing none, we will close the phone line and ask that staff and Westinghouse ensure we have only the allowed participants.

Weidong, would you ensure the phone line is closed, please?

And, with that, we will declare that we are in closed session and ask Westinghouse to resume.

(Whereupon, the above-entitled matter went into closed session at 2:07 p.m.)

This presentation is non-proprietary

WCAP 17938 Revision 2, ACRS Subcommittee – Public Meeting

February 7, 2018

Andrew Pfister

Shayan Sinha

Background
AP1000 GSI 191 Design Bases

- **AP1000** design significantly reduces / eliminates debris sources that are typically found in Generation II plants
- Maximum allowable fibrous debris inside containment is 6.6 lbs
  - All fibrous debris is attributable to latent debris
  - There is no fibrous debris generated during a LOCA
- Metal reflective insulation (MRI) is extensively used in containment
- DCD/FSAR provides requirements that must be demonstrated if an alternative (fibrous) insulation to MRI is utilized
  - Insulation must be demonstrated to be a suitable equivalent insulation to MRI for the purposes of GSI 191
  - To qualify a suitable equivalent testing must be performed to demonstrate that debris will not be generated or transported
  - Suitable equivalent testing must be approved by the NRC

Westinghouse

Background
WCAP 17938 Purpose

Purpose of WCAP 17938 is to obtain approval of the following:

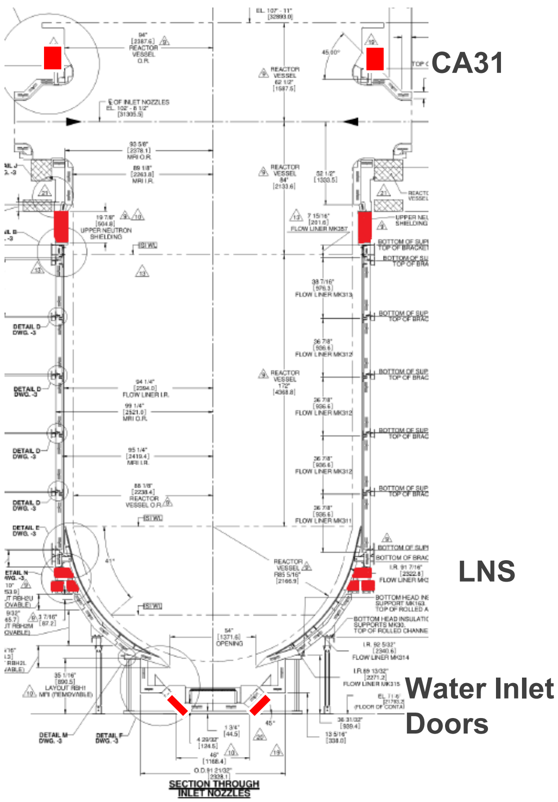
1. Establish a ZOI applicable to all **AP1000** plant in-containment cabling to demonstrate cabling will not generate LOCA debris
2. Gain approval that the non-metallic insulation (NMI) utilized in the reactor vessel insulation systems (RVIS) is a suitable equivalent to MRI for the purpose of GSI 191 as applied in **AP1000**
3. Gain approval to utilize the approved NEI 04-07 alternative methodology for defining debris generation break sizes for **AP1000**

Testing and analysis is complete to demonstrate that neither cabling nor NMI will contribute to post LOCA debris

Background
WCAP 17938

- **AP1000** cabling may contain fibrous and other materials that were not considered in initial GSI 191 debris source term evaluations
  - Corrective actions included development of a test program to establish a zone of influence (ZOI) for in-containment cabling

- NMI is required in RVIS because subcomponents of the RVIS perform functions in addition to insulation (such as shielding and in-vessel retention support)



Westinghouse

Summary of Results

- Extensive large scale jet impingement testing established a ZOI for in-containment cables of 4 L/D
  - Cabling ZOI design requirements were incorporated into the detailed design in advance of any cable or tray installation
- WCAP invokes the alternate evaluation methodology provided in NEI 04-07 to determine a limiting RCS break size in debris generation evaluation for certain **AP1000** components
- Insights from NMI jet impingement and submergence testing resulted in strengthening design for elements of the RVIS
  - Design was changed to use thicker and more robust encapsulation

WCAP justifies no new debris generation for AP1000 from cabling or NMI

Conclusions

Conclusions

- Jet impingement testing supports a Cable ZOI of 4 L/D for **AP1000** in-containment cabling
- Application of NEI 04-07 alternative break methodology is acceptable for **AP1000**
- Cabling does not contribute to **AP1000** post LOCA debris limits
- Encapsulated NMI applications utilized within the AP1000 RVIS will not produce debris when subjected to jet impingement from limiting line breaks
- Neither cabling nor NMI within the RVIS contribute to GSI 191 chemical debris limits
- NMI utilized as part of the RVIS is a suitable equivalent to MRI for the purpose of GSI 191

WCAP justifies no new debris generation for AP1000 from cabling or NMI

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation to the ACRS Subcommittee

Draft Safety Evaluation

AP1000 In-Containment Cables and Non-Metallic Insulation Debris Integrated Assessment

WCAP-17938-P, Revision 2

February 2018

Presentation Topics

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

- Introduction
- Overview
- Review Approach
- Finding
- Summary

Introduction

- NRC Technical Reviewers
  - Clint Ashley — Containment and Ventilation Branch
  - Boyce Travis — Containment and Ventilation Branch
  - Renee Li — Mechanical Engineering Branch
  - Greg Makar — Materials & Chemical Engr. Branch
  - Malcolm Patterson — PRA and Severe Accidents Branch
- NRC Project Manager
  - Don Habib — Licensing Branch 4

Introduction (cont'd)

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

- A topical report is a document that addresses a technical topic related to nuclear power plant safety.
- In topical report WCAP-17938, Westinghouse updates the AP1000 plant safety analysis related to Generic Safety Issue 191 (GSI-191).
- Westinghouse seeks review and approval of WCAP-17938 by the U.S. Nuclear Regulatory Commission (NRC) for use in the licensing process by AP1000 licensees.

Overview

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

- Main guidance for evaluating WCAP-17938:
  - Nuclear Energy Institute (NEI) 04-07, "PWR Sump Performance Evaluation Methodology"
  - Safety Evaluation for NEI 04-07, "PWR Sump Performance Evaluation Methodology"
  - WCAP-16530-NP-A, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191"

Overview (cont'd)

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

- The AP1000 plant safety evaluation decision addressing GSI-191 is based on zero loss-of-coolant accident (LOCA) generated fibrous debris.
  - Achieved in part through the use of metal reflective insulation (MRI) or a suitable equivalent insulation.
  - As part of detailed design, the AP1000 plant uses a suitable equivalent insulation in three locations around the reactor vessel.
  - Use of a suitable equivalent insulation requires NRC review per the AP1000 DCD.

Overview (cont’d)

- The AP1000 plant design also includes electrical cabling that may be directly impinged upon by a loss-of-coolant accident jet.
  - AP1000 electrical cables may contain fibrous material that was not considered in the original GSI-191 debris source evaluation.
  - As a corrective action, Westinghouse conducted testing to define a zone of influence for cables.

Overview (cont'd)

United States Nuclear Regulatory Commission
Protecting People and the Environment

- The AP1000 design basis in part states that "a LOCA in the AP1000 does not generate fibrous debris due to damage to insulation or other materials included in the AP1000 design,…"
- As such, the WCAP seeks NRC approval for three items:
  1. A zone of influence (ZOI) for electrical cabling in containment.
  2. Use of non-metallic insulation (NMI) as a suitable equivalent to metal reflective insulation (MRI).*
  3. Use of NEI 04-07 alternate evaluation methodology to assess debris generation.

* Next slide

Overview (cont'd)

- To qualify as a suitable equivalent insulation, the AP1000 DCD states in part that:
  - Testing must be performed that subjects the insulation to conditions that bound the AP1000 plant conditions.
  - Testing demonstrates that debris would not be generated, to include chemical debris.
  - Testing and/or analysis must be approved by the NRC.
- The three WCAP requests for NRC approval, are detailed on the following slides.

WCAP Item 1

- Requests approval for a ZOI
  for electrical cabling in containment.
- Staff review approach
  - Observed cable jet impingement testing
  - Assessed the applicability of the test facility
  - Reviewed test materials
  - Audited test reports
  - Issued requests for additional information

WCAP Item 1

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

- Staff review approach (cont'd)
  - Staff reviewed observations from previous NRC visits to the test facility, and examined the facility conditions produced during instrumented tests
  - These conditions were compared to facility conditions for current testing to verify repeatability
  - Staff determined the facility produced conditions that would bound as-built facility conditions
  - Applicant determined a ZOI for onset of damage, then conservatively requested an acceptable ZOI tested just beyond that showing no debris generation

WCAP Item 1

- Staff Finding
  - The topical report provides an acceptable technical basis for determining that no debris will be generated by cables located at or beyond the proposed ZOI.
  - Because the WCAP demonstrated no debris generation outside the ZOI, the proposed ZOI for electrical cabling is acceptable.
- Limitations and Conditions
  - Performance of cables within the ZOI (if any) is outside the scope of the WCAP.

WCAP Item 2

- Requests approval for the use of NMI as a suitable equivalent insulation to MRI.
- Staff review approach
  - Observed jet impingement and submergence testing
  - Evaluated thermal expansion testing
  - Assessed the applicability of test facilities
  - Reviewed test materials
  - Audited test reports
  - Issued requests for additional information

WCAP Item 2

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

- Staff review approach (cont'd)
  - Neutron shield blocks tested to qualify the blocks ability to withstand jet forces under variety of ZOIs/block configurations.
  - This testing was supported by a discussion of confined jet behavior, as reactor vessel cavity could be considered a confined space.
  - WCAP used a literature review, which staff reviewed for applicability.
  - Ultimately, combination of testing and literature review allowed for verification that the predicted NMI jet impingement pressure would be bounded by the test facility jet at the requested ZOI.

WCAP Item 2

- Staff review approach (cont’d)
  - Qualifying NMI as suitable equivalent also required evaluation of chemical effects.
  - Submergence testing measured releases for different levels of NMI encapsulation.
  - Staff used the testing as a means to evaluate the design’s ability to prevent chemical effects.
  - Submergence tests showed complete encapsulation is necessary to prevent the release of elements that could generate chemical effects, and that additional chemical effects were predicated on amount of submerged aluminum.

WCAP Item 2

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- Staff Finding
  - The topical report provides an acceptable technical basis for determining that no debris will be generated by the blocks.
  - Because there is no debris generation, use of NMI as a suitable equivalent insulation to MRI is acceptable.
- Limitations and Conditions
  - Evaluation limited to debris generation
  - Limit placed on the amount of aluminum in containment

WCAP Item 3

- Requests approval to use the NEI 04-07 alternate evaluation methodology.
  - NEI 04-07 alternate evaluation methodology in part assumes a double-ended guillotine break of postulated pipe breaks in reactor coolant system (RCS) main loop piping unless physically limited by piping restraints, supports, other structural members or piping stiffness as may be demonstrated by analysis.
  - If physically limited, then a smaller pipe break size may be used to assess debris generation.

WCAP Item 3

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- Staff review approach
  - Evaluated the topical reports implementation of the approved methodology.
  - Focused review on RCS main loop piping breaks that are physically limited.
  - Audited reports used to determine the limited separation of the postulated breaks.
  - Reviewed the WCAP's methodology for determining the equivalent break diameter for limited separation breaks and the zone of influence (ZOI).

WCAP Item 3

- Staff Finding
  - The applicant approach to determine limited separation breaks, equivalent break diameter and ZOI is reasonable based on information reviewed in the audit and contained in the WCAP.
  - The WCAP implements the alternate evaluation methodology consistent with prior staff approval.
  - Based on the above, the WCAP's use of the NEI 04-07 alternate methodology is acceptable.
- Limitation and Condition
  - Excludes use of nonsafety systems and operators.

Summary

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- The WCAP requests staff review and approval for three items:
  - the application of the proposed ZOI for cables
  - the determination that NMI located in the reactor vessel cavity is a suitable equivalent insulation
  - the application of the alternate evaluation for debris assessment
- The staff finds the approach described in the WCAP acceptable and approves the requests, subject to limitations and conditions.

BACKUP SLIDES

WCAP-16530 Methodology For Chemical Effects

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- Calculates the amount of chemical precipitate calculated based on plant-specific materials and pH buffer
  - Input the material quantities (e.g., aluminum surface area, fiberglass mass)
  - Input the pH buffer chemical
  - Input realistic pH and temperature profiles
  - Conservative corrosion/release rates applied

WCAP-16530 Methodology For Chemical Effects

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- Released elements assumed to precipitate as certain chemical compounds
  - $AlOOH$, $NaAlSi_3O_8$, $Ca_3(PO_4)_2$
- All precipitates present when the LOCA occurs
- All aluminum forms a precipitate
- All calcium forms a precipitate if phosphate is present
- Surrogate chemicals used in strainer and fuel assembly testing have been shown to clog fiber beds
- Refinements to the base model must be justified