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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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APR1400 SUBCOMMITTEE

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WEDNESDAY,

MARCH 22, 2017

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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 8:31 a.m., Matthew W. Sunseri, Chairman, presiding.

COMMITTEE MEMBERS:

MATTHEW W. SUNSERI, Chairman

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

MICHAEL L. CORRADINI, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

DANA A. POWERS, Member

JOY REMPE, Member

GORDON R. SKILLMAN, Member

JOHN W. STETKAR, Member

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER BROWN

ALSO PRESENT:

TONY AHN, KHNP

SURINDER ARORA, NRO

JOE ASHCRAFT, NRO

CLINT ASHLEY, NRO

DAN BARSS, NSIR

JOHN BUDZYNSKI, NRO

NAN CHIEN, NRO

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CRAIG HARBUCK, NRO

MICHELLE HART, NRO

ALFRED HATHAWAY, RES

JUN HEO, KHNP

SEKHWAN HUR, KEPCO E&C

SUNG JI HYUN, KHNP

INYOUNG IM, KHNP & KEPCO

DIANE JACKSON, NRO

HYEOK JEONG, KEPCO E&C

DEOGJA KANG, KEPCO E&C

REBECCA KAY, NRO

JUNGHO KIM, KHNP

TAE HAN KIM, KEPCO E&C

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CHANG JAE LEE, KEPCO

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JAIHO LEE, KHNP & KEPCO

JEONGHYEONG LEE, KEPCO E&C

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DAE HEON LIM, KEPCO E&C

SHANLAI LU, NRO

TIM LUPOLD, NRO

GREGORY MAKAR, NRO

STEVE MANNON, AECOM

MICHAEL MCCOPPIN, NRO

JILL MONAHAN, Westinghouse

KEN MOTT, NRO

SEONCHANG MUN, KEPCO E&C

DOOHWAN OH, KEPCO E&C

HUNGU OH, KEPCO E&C

JIYONG OH, KHNP

JIHWANG, PARK, KEPCO E&C

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DAN WIDREVITZ, NRO

JAIHWA YOON, KEPCO E&C

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

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

8:31 a.m.

CHAIRMAN SUNSERI: All right. We're going to call this meeting to order. It is the resumption of the review of the APR1400, Chapters 13, 16, and 6. Yesterday we completed Chapters 13 and 16, and we will pick it up today with Chapter 6.

Before you, you have a revised schedule that pulls up everything into today, and we will just work through the schedule. If we get finished today, that will be great. If not, we do have some time tomorrow that we can spill over into tomorrow.

Okay. Having said that, let's introduce the members. With us today we have Joy Rempe, Walt Kirchner, Jose March-Leuba, John Stetkar, Ron Ballinger, Matt Sunseri, Mike Corradini, Dana Powers, Gordon Skillman, and our Designed Federal Officer is Christopher Brown.

We will now start the meeting with -- I guess I should ask Jeff if he got any -- no? Okay. No? All right. So, we will just turn it over to KHNP for your presentation on Chapter 6.

MR. TAK: Good morning, ladies and gentlemen.

I am SungHyun Tak from KEPCO E&C. This presentation is for Chapter 6, Engineered Safety Features, ESF for APR1400.

Next. This slides shows the contents of Chapter 6, Overview, Section Summary, and Summary.

Next. Overview of eight sections and presenters are shown from this slide, from 6.1 to 6.8.

Next. These documents are submitted for Chapter 6.

Next slide. Now I am going to talk about Section 6.1, Engineered Safety Features Materials. Here are two Subsections, 6.1.1, Metallic Materials, and 6.1.2, Protective Coatings and Organic Materials.

Next. ESF materials are selected for compatibility with core cooling coolants and containment spray solution. ESF components are designed and manufactured in accordance with ASME for the 2007 edition and 2008 agenda. And ESF pressure retaining materials with the applicable material requirements are ASME Section III and the applicable ASME Section II material specifications.

Reactor coolant water chemistry is controlled by the chemical and volume control system. The containment spray water from the in-containment refueling water storage tank is controlled by trisodium phosphate in the holdup volume tank to maintain pH during a loss-of-coolant accident.

The material used in the chemical and structural inside the containment are selected to minimize corrosion and hydrogen generation resulting from contact with spray solutions. The use of aluminum and zinc is minimized in the containment, to minimize the hydrogen gas with a chemical reaction with the core cooling or containment spray solutions.

MEMBER POWERS: When you say "minimized," what does that mean?

MR. TAK: We have to minimize aluminum and zinc for as little as possible.

MEMBER CORRADINI: So, I guess Dana's question would be, since minimum doesn't mean zero, where does it appear? Okay?

MR. YOON: I am JaiHwa Yoon, KEPCO E&C.

The minimization of the aluminum and zinc is compound to the analysis of the hydrogen concentration analysis and/or another necessary evaluations; for example, the GSI-191 chemistry packs and the necessary system.

MEMBER POWERS: Well, it is a little bit surprising --

MR. YOON: So, there is no criteria for the amount of the aluminum and zinc. We try to minimize, just minimize the aluminum and zinc.

MEMBER POWERS: Suppose I put aluminum in a nice basic solution like pH10 --

MR. YOON: pH?

MEMBER POWERS: -- pH10 for trisodium phosphate. What happens to it?

MEMBER BALLINGER: It's a bad hair day.

(Laughter.)

MEMBER POWERS: And you get a little hydrogen coming off. And I don't quite understand what you have minimized by keeping the solution basic and, then, keeping the aluminum down. I mean, it seems to me that the aluminum is getting corroded by your trisodium phosphate solution pretty badly.

MR. IM: My name is ImYoung Im from KEPCO

E&C.

When we write component to specification, preliminarily we recommend not to use aluminum or zinc, but the vendors request us this composition is necessary. And there's no other choice then. We have to accept that, and we provide that information to the hydrogen --

MEMBER CORRADINI: So, I figured that was a practical issue.

MR. IM: Yes.

MEMBER CORRADINI: But have you done some back-calculations to kind of answer Dr. Powers' question, that how much, given a set of assumptions, how much aluminum or zinc is too much? I mean, is there some calculational estimates so that you know when to say to the vendor no? Do you know what I'm asking?

MR. IM: Yes, but I am afraid that there is an analysis that exceeding -- the hydrogen generation is exceeding the criterion.

MEMBER BALLINGER: But I am sure we are going to get to GSI-191. But, with aluminum, there is a calculation that I am sure has to be done with respect to GSI-191. So, if the amount of aluminum that's in the containment becomes minimum, you would have to define what minimum actually is, in order not to exceed the debris issue with GSI-191.

So, somewhere there has got to be a specification, I would assume. And I don't know where zinc is in here. I have never heard of it, actually.

MEMBER POWERS: You've never heard of zinc?

(Laughter.)

MEMBER BALLINGER: I've heard of zinc, but not inside containment.

MEMBER POWERS: Well, there's a lot. With respect to zinc, does this mean that you are restricting the use of zinc primers for your epoxy coatings?

MR. YOON: I don't know that, but they are -- I know that the zinc is not considered in the chemical impacts of GSI-191. But the zinc is considered to the evaluation of hydrogen analysis.

MEMBER POWERS: Yes, usually, that is looking at galvanized materials. But you have a lot of zinc -- I can't say that everybody, but a lot of people use a zinc primer for the containment shell and elsewhere where they are putting an epoxy paint on it.

And does that mean you're just restricting the use of the zinc primer, and if you don't use the zinc primer, what primer do you use?

MR. YOON: I need to check. I need to check --

MEMBER POWERS: Excellent. That's fine.

MR. YOON: -- the use of zinc with the final, yes.

CHAIRMAN SUNSERI: So, maybe another way to ask this question is, I'm looking at the DCD, page 6.1-6, and there's a statement that says, "The surface area of aluminum inside the containment that can be exposed to spray water is limited to a design of less than 281 square meters." So, what's the basis for that? I mean, there must have been some analysis to say that amount produces something when it reacts and we want to limit that, I presume.

MR. YOON: Read one more time the section number.

MEMBER CORRADINI: Section 6.1.1.2.1.

(Laughter.)

MEMBER POWERS: You're feeling your oats today. That's what you're doing.

(Laughter.)

MEMBER CORRADINI: I was told to read it; I read it.

(Laughter.)

(Pause.)

It's under, according to your document, it's under Engineered Safety Features Materials, Metallic Materials for containment spray and core pool compatibility.

But I think all we are asking -- and it doesn't have to be answered today -- but all we are asking eventually is just to get some understandable basis

MR. YOON: I know that the surface area is calculated by the APR1400 by using the --

CHAIRMAN SUNSERI: Okay. Well, we have lodged the question. So, you can note that.

MEMBER BALLINGER: But, if you look at that number, what Member Powers is saying, using zinc-based primer in the containment shell, that doesn't count. Two hundred and eighty-one square meters is very, very small compared to the containment shell.

CHAIRMAN SUNSERI: Well, this is aluminum.

MEMBER BALLINGER: Oh, aluminum? Excuse me. All right. Got it.

CHAIRMAN SUNSERI: Okay. Thanks. He got it.

MR. TAK: Okay, next slide. Protective coatings and organic materials are described in this Subsection. Regulatory Guide 1.54, and related is ASTM D5144 for protective coating, D3843 for quality assurance, D3911 for DBA tests, and others apply.

Coatings Service Levels --

MEMBER CORRADINI: I'm sorry. Maybe you're coming back to it and I am missing the direction. There was an open item about the IRWST coating for treatment of the surface. Are you going to come to that later?

MR. TAK: One more time, please.

MEMBER CORRADINI: There is an RAI, an open item RAI, in the SER entitled, "IRWST Liner - Protection Against Corrosion". And I just wanted to understand the basis of what you have to provide for the IRWST for further information. I assumed it was stainless steel lining, but maybe I am incorrect.

(Pause.)

I can give you the RAI number.

MR. YOON: I know what your question is.

MEMBER CORRADINI: Okay. If you want to

wait and come back, that's fine. I just wanted to make sure I understood where that sits. Because you have a unique IRWST with a feeding volume that I am still trying to understand. So, it kind of connects back to where it is and what the concern is about corrosion. So, you can come back to it when it is appropriate.

MR. YOON: Yes. I will give your questions to our engineers.

MEMBER CORRADINI: Yes, that's fine. Thank you.

MR. TAK: Okay, continue. Let's continue.

Coating Service Level is classified in accordance with Regulatory Guide 1.54. Service Level I and III coatings are safety-related, and Service Level II coating is non-safety-related.

Coating quality assurance and maintenance requirements meet 10 CFR 50, Appendix B, and 10 CFR 50.65.

Organic materials are used for cable jackets, cable insulators, reactor coolant pumps, lubricant, as shown on this slide.

Next.

MEMBER POWERS: In the long-term, what

kind of corrosion do you get from hydrochloric acid coming off your cable jacketing material?

MR. YOON: One more time.

MEMBER POWERS: Well, you're using chlorosulfonated polyethylene and polychloroprene cable jacket material. It is in the containment. It is subject to a certain amount of dose, a certain amount of temperatures. So, you get low-light CL coming off it. And I just wondered, in the long-term, does that cause you any localized corrosion problems?

(Pause.)

CHAIRMAN SUNSERI: While we are waiting, I just want to acknowledge for the record that Charlie Brown has joined, Member Charlie Brown has joined.

MR. D. LEE: My name is Dongsu Lee. I'm the Project Engineer from KEPCO E&C.

When we calculate the pH during a long time in that location, at the time that we are calculating how much exceeding material from the organic high-power cables, and we calculate that pH during a long time.

MEMBER POWERS: I was really wondering if you got any HCL, enough HCL coming off during normal ops to cause localized corrosion problems from the chlorosulfonated polyethylene.

MR. D. LEE: During normal --

MEMBER POWERS: During normal operations.

MR. D. LEE: Yes. But, when you calculate it, the time is that we assumed 60 years, a long time, 60 years lifetime.

MEMBER POWERS: Okay.

MR. D. LEE: We also considered LOCA condition, output and data, and radiation as a constant for that.

MEMBER POWERS: Oh, okay.

MR. D. LEE: Yes.

MEMBER POWERS: I understand. Thank you.

MR. MUN: I'm Seongchang Mun.

CHAIRMAN SUNSERI: It's okay. You can continue.

MR. MUN: My name is Seongchang Mun, KEPCO E&C. I am responsible for the containment pressure and temperature analysis for containment function and design.

CHAIRMAN SUNSERI: Could you maybe move your microphone a little closer? Yes, a little closer.

MR. MUN: Thank you.

Section 6.2, this Section covers containment functional design, containment heat removal systems, containment isolation system, combustible gas control in containment, containment leakage testing, and, lastly, fracture prevention of containment pressure vessel. I am going to talk about the Subsection 6.2.1, Containment Functional Design.

APR1400 containment functional design is based on the relevant legacy requirements, such as General Design Criteria, Regulatory Guides, Standard Review Plans, and design standards.

When we got to the regulatory basis, we have three categories: the regulatory basis for method analyses and the regulatory basis for containment and subcompartment pressure and temperature analysis, and, plus, the regulatory basis for minimum containment pressure for performance.

Mass and energy release analysis conform to the GDC 50, Appendix A, and SRP 6.2.1.3, and SRP 6.2.1.4. That is the regulatory requirements for the design of containment and subcompartments, GDC 4, 16, 38, and 50 applies. The Regulatory Guides 1.206 and SRP 6.2.1.1.A and 6.2.1.2 state how the containment and subcompartments shall be designed to meet the requirements of the GDC. ANSI/ANS 56.4 and 56.1 provide the recommendations for the pressure and temperature analysis for containment and subcompartments.

For the minimum containment pressure analysis for performance capability studies of the ECCD, 10 CFR 50, Appendix K, Regulatory Guide 1.157, SRP 6.2.1.5, and BTP 6-2 applied as the regulatory requirements.

I am going to talk about the mass and energy release analyses. Mass and energy release analyses are categorized as the following time periods: blowdown, refill, reflood, and post-reflood and decay heat. Post-reflood and decay heat is described in the next slide.

For the blowdown, the blowdown period extends from the time zero until the primary system is essentially depressurized to the containment pressure. The CEFLASH-4A computer code is used for the analysis for this blowdown phase.

Next, the first post-blowdown period is, we call it refill. However, this period is conservatively omitted from the analysis.

And the next phase is reflood. The

reflood is assumed to end when the liquid level in the core is 2 feet below the top of the active core.

MEMBER CORRADINI: I don't think this is where you are going to answer the question, but let me pose my question. So, this is assuming a large-break LOCA dominates. Where should we look -- I'm assuming Chapter 15, but I couldn't find it in 6 -- where should we look for an analysis of break spectrum to verify that the peak clad temperature you are most concerned about is large-break?

We have seen, the Committee has seen in other analyses for other applications that it may not necessarily be a large-break peak clad temperature. So, is some sort of break spectrum analysis done in Chapter 15?

MR. MUN: Yes, right.

MEMBER CORRADINI: So, we should look there when we get to that?

MR. MUN: Yes.

MEMBER CORRADINI: Okay. So, just to give us a helpful hint, maybe where to look would be appreciated.

MR. IM: This is release analysis to maximize the containment pressure.

MEMBER CORRADINI: So, this is only for M&E?

MR. MUN: M&E.

MEMBER CORRADINI: Okay. Excuse me then. Okay.

MR. IM: The maximum break.

MEMBER CORRADINI: So, this is only for equipment qualification conditions?

MR. IM: Yes, and as part of the --

MEMBER CORRADINI: All right. Then, I misunderstood.

MEMBER REMPE: So, along those lines, since we have interrupted you, the staff mentioned about the issue of thermal conductivity degradation and how the analyses in their Draft SE did not consider that in the models. Are you planning in subsequent updates to the DCD -- because this was discussed when we discussed Chapter 4, and it was an open item. And I know the staff had said they were getting close to resolution. Will you redo these analyses in an update to this section?

MR. IM: For the DCD?

MEMBER REMPE: Yes. Because it seems like there might be more energy transferred.

MR. IM: Yes, my coworker can answer for your questions.

MR. S. PARK: I am S. J. Park from KEPCO E&C.

We did mass/energy release analysis, and we presented the result to NRC. And we revised the DCD and the Technical Report. In the DCD, we are back briefly to the effect of electricity for the mass/energy analyses.

MEMBER REMPE: Okay. So, I am not quite sure understood that. So, you may have to repeat it. But is the bottom line that you will be updating these analyses --

MR. S. PARK: Yes.

MEMBER REMPE: -- or that it was not a large effect? I didn't quite hear.

MR. S. PARK: We see the effect for mass/energy analysis is -- we ponder. We increase the 400-degree Fahrenheit of the pressure and temperature, and the result is very small.

MEMBER REMPE: Okay. Thank you.

MEMBER CORRADINI: So, just to be sure, it is not that you recalculated accurately? You did a sensitivity by increasing it by 400 --

MR. MUN: Yes.

MEMBER CORRADINI: -- and then, looked at that? Okay.

MEMBER REMPE: Thank you.

MR. MUN: Yes, we use FLOOD3 computer code for the mass and energy release during the reflood phase.

Next slide. The following page is post-reflood. During this period, the dominant process is the continued cooling of the steam generators by the Safety Injection System water leaving the core. We also used FLOOD3 code for this phase.

Finally, the final post-blowdown phase is the decay heat period. During this period, all the residual energies from the primary system and the steam generator secondary system metal and coolant with the core decay energy are taken into account for steaming the coolant. The GOTHIC computer code is used for the mass and energy release calculation for this period.

MEMBER CORRADINI: So, maybe it exists in the chapter and I missed it. But, if one were to pick up and look at the partition of the energy from these various periods -- and I don't remember for equipment qualification -- is it just the short-term energy and mass release that dominates? I am most curious about the decay heat period for long-term cooling. And I assume long-term cooling means three days?

MR. MUN: I don't know.

MEMBER CORRADINI: I am trying to understand the qualification in terms of mass/energy release by period.

MR. MUN: Yes.

MEMBER CORRADINI: Is it dominated by the initial blowdown phase and reflood phase?

MR. MUN: Yes. You know, no, the peak pressure is determined prior to the end of the reflood. And after the following period, the following phase is post-reflood and the decay heat period. We call it the long-term cooling period.

And after the end of the post-reflood, all the peak condition and containment pressure, peak pressure and temperature was determined before the end of the post-reflood. So, after the end of the post-reflood, we used the decay energy -- the decay energy contributed to energy release.

MEMBER CORRADINI: But, also, you have got all the stored energy everywhere else.

MR. MUN: Yes.

MEMBER CORRADINI: That is why you use GOTHIC?

MR. MUN: Yes.

MEMBER CORRADINI: Okay. But let me restate my question. And then, again, you can -- maybe it is dependent upon the component as to whether or not you have to worry about the long-term temperature behavior. Because, normally, when you do equipment qualification, it is not just necessarily the temperature limit, but it is the time at temperature for the particular component, depending on its material.

So, is that the reason? So, this signature is done and, then, you apply it differently for different components?

MR. IM: Yes, based on the pressure/temperature analysis, we generate a plot for the time to the pressure and temperature. So, there are two kinds of codes that are generated, like for the LOCA and for the MSLB.

MEMBER CORRADINI: For the cases you show, yes.

MR. IM: Yes. And these codes are

provided to the vendor to make the clarification. So, all this bounding code applies to the safety-related qualified components.

MEMBER CORRADINI: Okay. All right. Okay. That helps me.

My second questions is, I am curious about GOTHIC. Using GOTHIC, do you have to choose appropriate parameters to give you a bounding pressure and temperature? Because, at least as my understanding of GOTHIC, it is must more best estimate. It is going to give you a more realistic pressure and temperature versus a bounding. So, how does this -- or maybe this is going to be a different part of the DCD we are going to discuss this. How are the parameters chosen to give you a bounding signature?

MR. MUN: GOTHIC, of course, I know the GOTHIC is wider used for the best estimate and calculations, analysis.

MEMBER CORRADINI: So, what do you do to it to make it bounding?

MR. MUN: Bounding? It is the bounding condition. In the analysis, we used it, we used the bounding value for the initial condition, plus temperature and relative humidity.

MEMBER CORRADINI: So, the initial peak?

MR. MUN: Yes, right.

MEMBER CORRADINI: And what was used, since I'm guessing -- I couldn't find it -- what was used to create the bounding condition? I am sure it wasn't adiabatic. So, you must have had some sort of heat transfer coefficient to the cold wall.

MR. MUN: Bounding condition just means -- let me speak in Korean to my coworker.

MEMBER CORRADINI: Sure. That's fine. That's fine.

(Pause.)

MR. MUN: Yes, usually the GOTHIC is used for best estimate analysis. We use GOTHIC with the most conservative model, especially --

MEMBER CORRADINI: So, adiabatic?

MR. MUN: I'm sorry? Adiabatic?

MEMBER CORRADINI: Insulated, yes.

MR. MUN: For instance, the GOTHIC containment models include lots of passive heat sink, heat structure, and the outside of the heat structure is treated as adiabatic.

MEMBER CORRADINI: Okay.

MR. MUN: That is one of the conductive assumptions for our model.

MEMBER CORRADINI: The outside surface?

MR. MUN: Outside is adiabatic.

MEMBER CORRADINI: Okay, but just to pick a little bit, the inside resistance is condensation, heat transferred to the cold wall. So, what is used as that --

MR. MUN: Yes, we usually -- during the high-temperature and the pressure condition in the containment environment, the surface of the heat structure is exposed. That exposure to the containment is on the wall. The condensation, radiation, and conduction occurs.

And we use a most conservative model --

MEMBER CORRADINI: Which was?

MR. MUN: -- for the wall condensation model, a model we call the Tagami-Uchida.

MEMBER CORRADINI: Okay. And that is the accepted conservative approach?

MR. MUN: Yes, right.

MEMBER CORRADINI: Okay. I thought so. I just wanted to make sure.

MR. MUN: Yes. Thank you.

MEMBER REMPE: So, while we are sidetracked, let's talk about nodalization that you used for the GOTHIC model. Was it the same nodalization that you later used? The number of control volumes that you used for GOTHIC, were they the same as what you used for your MAAP analysis? Or did you use smaller control volumes for GOTHIC?

MR. MUN: Of course, smaller volume increases your higher containment peak pressure/temperature.

MEMBER REMPE: Uh-hum.

MR. MUN: Of course. Besides more control volume, we used the smallest higher-toxic water volume. All of the conditions are biased to maximize the containment peak pressure.

MEMBER REMPE: Okay. So, you used a more refined -- because I didn't see it. Like, on Chapter 19, there's a nice little diagram that shows the number of control volumes for MAAP. I did not find that for GOTHIC. But you did use a more refined number of control volumes in your GOTHIC analysis?

He is shaking his head yes?

MR. IM: Yes, define this small --

MEMBER REMPE: Okay. Because I know the

staff had pushed you, had asked for sensitivity studies for nodalization, and I believe it was for GOTHIC. And you had said, hey, the pressure didn't change. And so, we don't need to do any more sensitivities. But you do have a more refined nodalization scheme for GOTHIC.

And so, later on, when we start talking about hydrogen and combustible gas generation, I am curious if you did any comparisons between the results obtained from MAAP with this very large dome control volume in the top of MAAP versus what you got for GOTHIC. Because that would provide me confidence if you saw any differences, if you have those kinds of results to compare.

And I'm kind of going off-topic, but I am curious about this because you have CONTEMPT and you have GOTHIC and you have MAAP analyses, and I am curious on how they compared.

MR. S. PARK: I am S. J. Park from KEPCO E&C.

When we calculate the CONTEMPT peak heat using the GOTHIC, we use the LOBSTER (phonetic) model, only one. That is more comfortable, very, very comfortable, but we only want containment volume.

MEMBER REMPE: Also, it was a very large --

MR. S. PARK: Yes.

MEMBER REMPE: Only one big --

MR. S. PARK: Yes.

MR. MUN: Just a minute. Let me speak in details.

Our containment model has totally five or six volumes. The one largest volume is the containment. It does not include the IRWST volume.

And the second largest volume is IRWST volume. It is below the containment volume. And these two elements are connected with a flow path.

MEMBER REMPE: Okay.

MR. MUN: On either side we also use the mass/energy release for the decay heat release period, long-term period.

I'm sorry. Actually, two containments -- and IRWST volume is used for containment of peak pressure and temperature, yes.

MEMBER REMPE: Okay. I guess to make it clear in my mind -- and this is just not for Chapter 6; it is for Chapter 15 and 19 -- it would really help if we could see the different nodalization schemes you used with CONTEMPT, GOTHIC, and MAAP. And actually, even there was an RAI 497825 where you actually listed the volumes, and the numbers there -- I want to have some confidence you used the same volume total for the net-free volume in these different analyses.

And again, maybe it is just I am having trouble because there were changes made in where we are at, but it would helpful me if I could see that consistent volumes were used in these analyses and what the different nodalization schemes were. And if there were any results where you could show that it was appropriate to have a very large dome volume for the hydrogen generation and the potential for combustible gas generation, I would be curious.

Because in other designs that had large containments, there was concern about stratification, and you might have -- because you had a more refined nodalization, you might have higher hydrogen concentrations.

So, again, I wanted to bring this up sometime today, and I am getting way off-topic, but this is the first time I saw a containment analysis. So, I am bringing it up now. Okay?

MEMBER CORRADINI: I'm sorry, I just want to make sure that the purpose of each of these is different. That is why, for M&E analysis, you are looking to give a bounding signature for equipment qualification, and that is what we are talking about now. Whereas, I think Dr. Rempe is thinking downstream where there are other application areas.

MEMBER REMPE: But, again, when you have downstream these very large volumes, if we could get some confidence that it is okay to use that with these other analyses with other purposes, it would be helpful. And that is why I am bringing it up.

MEMBER CORRADINI: Okay. So, let me return to this one, just so you can understand my question. So, the reason I was asking about the internal -- and this is what I thought you were going to tell me -- but it seems to me that the peak on the signature is a function of the model inside containment. But, once I hit the peak, all subsequent analysis signatures are a function of just conduction into the solids, because that dominates, essentially, the resistance.

So, what I guess I was curious about is, the reason I asked about the model is, how you determined the peak pressure that you come up to. And then, it kind of just sits there and hovers.

And then, if I remember correctly, Tagami-Uchida are essentially a volume, it is a volume model. There is no nodalization issue. It doesn't matter what the volume is. It is link-scale-independent? So, for this at least, it doesn't matter.

MR. SISK: This is Rob Sisk.

MEMBER CORRADINI: Just to be clear, it will matter for what Dr. Rempe is worried about later on.

MEMBER REMPE: Yes, I just brought it up since we disturbed the flow of conversation.

MR. MUN: The analysis is called for the model, how do we build the -- how do we configure the reactor volume. It is dependent, can be different depending on what we publish.

MEMBER REMPE: And that is what Professor Corradini was saying, and I agree. But, again, having some sort of comparison of the different volumes, and if you did assume a different value for a particular reason, but because you did not do the nodalization study, and I think that is very important later on with the combustible gas generation, if you are going to try to use a very large volume, I think it would be helpful if you did see with some of these other analyses that there was no stratification.

MR. MUN: Yes, I will go on.

Yes. LOCA or mass analyses are performed for spectrum of a break location and safe condition flow. A total of five cases of LOCA we analyzed. It includes double-ended hot leg slot break, double-ended suction leg slot break with maximum or minimum safety injection flow, and double-ended discharge leg slot break with maximum or minimum safety injection flow, and double-ended -- yes, we included five cases. For the single failure, one emergency diesel generator failure we considered.

Next. I will talk about the secondary pipe rupture. To determine the effect of a main steam line break on the continuing pressure, mass and energy analysis -- and just SGN III computer code -- are performed at five core power levels.

The break size of spectrum is performed to determine the largest breaks at which a pure steam blowdown can occur. As a single failure, a main steam isolation valve failure while a containment spray system failure is considered. A main feedwater line break is bounded by the main steam line break because main feedwater line break is in two-phase blowdown at the low energy.

Next. For APR1400 containment pressure and temperature level analyses, the computer code GOTHIC is used in the analysis. The GOTHIC containment model used conductive of break flow models, the classic drop model and heat transfer model on the wall.

All the assumptions of initial conditions in other models are set to maximize the containment pressure and temperature result. For the analysis result, as shown in the table, the maximum containment pressure is calculated as a 51.2 psig, which means the containment design has a 14.7 percent pressure margin over the calculated peak pressure. In addition, the containment pressure at 24 hours after accident initiation is maintained, far less than 50 percent of calculated peak pressure. From this result, it is demonstrated that our containment design meets the requirement regarding the design limits for maximum pressure and pressure limit at 24 hours.

Next. For the containment subcompartments, this figure, Section 6.2.1.2 provides subcompartment analysis for the steam generator rooms, pressurized room, pressurized spray valve rooms, regenerative heat exchange room, and the letdown heat exchange and valve rooms. Most conservative high-energy line breaks is postulated for each subcompartment analysis. The computer code COMPARE-MOD1A is used in the subcompartment analysis.

Based on the analysis result, the maximum pressure of each subcompartment is well maintained less the design limit with more than 40 percent over pressure margin. From the result, it is demonstrated all the containment subcompartment designs meet the requirements regarding the design limit for the maximum pressure described in this Section 6.2.1.2. We have no open item with subcompartment analysis.

Next. The minimum containment pressure analysis for the ECCS performance capability is performed. The analysis is performed using a conservative methodology for calculating the minimum containment pressure for ECCS performance which is described in the 10 CFR Part 50, Appendix K, requirements.

RELAP5/MOD3.3 and the CONTEMPT4/MOD5 computer code are used for calculating the mass and energy release and the pressure as the containment responds, respectively. The analysis results are presented in this DCD Section 6.2.1.5. We have no open item with this analysis.

Next.

MR. YOON: I am JaiHwa Yoon. I'm going to talk about the Subsection 6.2.2 and the following sections. This Subsection of the containment spray system is the containment heat removal system. The containment spray system has two functions. The first one is to reduce the containment pressure and temperature following the MS line break or also current accident. The second one is to remove heat fission products from the containment atmosphere following LOCA, which is addressed in Subsection 6.5.2.

The system has two 100-percent capacity divisions which are separated physically and mechanically. Each division has one containment spray pump, one containment spray heat exchanger, and one CS pump mini-flow heat exchanger, and the spray nozzles. In addition, the system has an emergency containment spray backup system for severe accident management.

Next. This is just a quick diagram for the containment spray system. In an APR1400 design, since the containment spray pump and the SC coolant pump in the DV zone are interchangeable to each other, so the SC coolant pump has got the containment spray pump during the accident. When the SC pump is not available and the flow path is lined up with the CS function.

The diagram on the upper right side shows the ECSBS. To the extent the ECSBS can provide the spray water from the center water source for the containment using the fire engine tool in case that all spray pump or IRWST are not available.

MEMBER POWERS: Your containment spray pump capacity is what? The capacity of the containment spray pump?

MR. YOON: Containment spray pump?

MEMBER POWERS: Yes, the capacity?

MR. YOON: The capacity?

MEMBER POWERS: Yes, the flow rate. Five thousand gallons a minute?

And the number of spray headers?

MR. YOON: Spray nozzle?

MEMBER POWERS: How many spray headers on each train?

MR. YOON: Two trains.

MEMBER POWERS: Two trains?

MR. YOON: Yes.

MEMBER POWERS: How many headers? Something like 80?

MEMBER CORRADINI: Nozzles or headers?

MEMBER POWERS: Nozzles.

MR. YOON: The spray nozzles, I don't remember the number of spray nozzles, but the spray nozzles cover almost the containment area.

MEMBER POWERS: Sure. Yes, sure. And are they all directed down or are they directed at different angles?

MR. YOON: Yes, the triangles, the spray nozzles is considered like the angles and, then, the curves, too. Yes. Yes. Anyway, the --

MEMBER POWERS: I assume you don't specify the actual nozzle? You leave that up to the COL applicant?

(Pause.)

MR. IM: The answer is that they already considered the angles of the nozzles, so it could actually spray inside the containment.

MEMBER POWERS: You're trying to get a uniform spray distribution?

MR. IM: Yes. Right.

MEMBER POWERS: And in the application itself, you say the droplet size distribution is to be determined by testing and to be suitable for fission product removal. What is that?

MR. YOON: Yes, the spray nozzle angles and the portion -- the area is tested by the vendors.

MEMBER POWERS: Yes, yes.

MEMBER CORRADINI: I think he is asking what is the specification that must be met.

MEMBER POWERS: I mean, it is suitable for proficient product removal, and I just wondered what that was.

MR. SISK: We have your question. We will have to have a discussion to -- we understand.

MEMBER POWERS: Presumably, a droplet this size will remove some fission products, and a droplet at 40 microns will remove some fission products. Which one is it?

MR. SISK: I understand your question, Dr. Powers. We will have to have a discussion.

MEMBER SKILLMAN: I would like to ask this question, please. What testing has been completed to demonstrate that the spray droplet size and the chemistry of the droplet are effective in removing the fission products to the sump?

MR. YOON: So, sector effect of the chemistry of the spray nozzles?

MEMBER SKILLMAN: Yes.

MR. SISK: This is Rob Sisk, Westinghouse, again.

This is related very much to what Dr. Powers was referring to. I think this topic, we don't have the right people here to address that question fully and accurately. We need to discuss that separately.

MEMBER SKILLMAN: Well, there is the chemistry, there is the drop size, there is the pH, and it is also the temperature because it varies.

MR. SISK: I've taken the note back of your comment.

MEMBER SKILLMAN: Thank you, Rob.

MR. SISK: Okay. Continue on.

MR. YOON: Yes.

Go to the next slide. To start, this is right. It covers the containment isolation system. The APR1400 containment isolation system is designed to meet the 10 CFR 50, Appendix A, GDC 55 to 57, to combine the release of any radioactive nuclides from the containment following postulated DBA.

These configurations are examples for containment isolation design in the APR1400. These examples show that one or alternating isolation pair inside the containment and one alternating isolation pair outside the containment are provided in the system, in accordance with GDC 55 and 56. And according to GDC 57, four alternating isolation pairs are provided outside containment.

MEMBER STETKAR: I have a question.

MR. YOON: Yes?

MEMBER STETKAR: I hate these section numbers, but I will put them on the record. DCD Section 9.4.6.2.2.2-9 -- part of what we do is we look at different parts of the DCD together -- indicates that you have a containment low-volume purge system. You have a high-volume purge that is operated during shutdown and you have a low-volume purge. That section indicates that it is operating during normal plant power operation when required. That is the way it is listed.

Do you know how often that low-volume purge is actually operating during normal power operation? And do you know the size of those low-volume purge lines? I could not fine the size of those lines. This will become relevant later; trust me.

MR. YOON: I know that, actually, the low-volume purge is just the containment penetration, and the low-volume purge system is not open in the normal operations.

MEMBER STETKAR: It is not? Well, Chapter 9 seems to tell me that it is. And I know other plants that run those systems during normal plant operation. I am talking low-volume purge, not high-volume. I know the high-volume purge is not operated during power operation. Your Chapter 9 says that it is operating during normal power operation, quote, "when required," end quote. But I don't know when it is required.

MR. IM: This is the low volume, not the big volume.

MEMBER STETKAR: Not the big volume. I know the big volume is only during shutdown. That's clear.

I am aware of many plants that have this type of purge system design and that keep what you call the low-volume purge operating some fraction of the time during normal power operation. That is based on their desires for containment, atmosphere cleanup, habitability. Operators may need to enter the containment for inspections and things like that.

But it is an operational consideration. I just don't know what you assume as far as your safety analyses. As I said, later this will become more relevant when we talk about NPSH.

MR. YOON: I will check the response of --

MEMBER STETKAR: Okay. Thank you. Thank you.

MEMBER CORRADINI: I had a feeling where you were going. So, if you demand containment isolation due to accident, does this purge line automatically, if it is not already closed, is it required to close? I assume it is.

MEMBER STETKAR: It is.

MEMBER CORRADINI: Okay.

MEMBER STETKAR: Just because it is required, it isn't guaranteed that it is always successful, though.

I wanted to bring it up at this point because it is relevant to containment isolation.

Okay? I have established that I don't know how big it is and for how long it is open.

MR. YOON: Yes, I will continue?

This slide covers the containment hydrogen concentration in the APR1400. The passive autocatalytic recombiners, PARs, and the igniters consider the hydrogen concentration in the containment and IRWST. They are present by volume during a severe accident.

These figures, the part design, and these pictures is the igniter observed in the power plant.

Yes?

MEMBER POWERS: These are natural circulation passive recombiners?

MR. YOON: The operations --

MEMBER POWERS: Yes, there is not a fan in them?

MR. YOON: The power is passively operated, so the --

MEMBER POWERS: Are they open to the containment atmosphere during normal operations? How do you prevent the accumulation of catalyst poisons and coatings on the surfaces to exclude the catalyst during normal operations?

MR. IM: They analyze the atmosphere inside the containment and they decide the future location that is most efficient to remove those --

MEMBER POWERS: And that means that during normal operation they are also most efficient at accumulating oil vapors, cleaners, paint vapors, and whatnot, on the surfaces. And that will exclude the catalyst particles. That may also poison the catalyst particles, especially if they are palladium-based and there is any sulfur at all present. And so, how do you assure that in the event of an accident those surfaces, those catalytic surfaces are available for action?

MR. YOON: We do not perform the analysis of the impact, the analysis of the impact on the pollutions or other effects, including the normal operation. But the pipes are inspected and tested periodically at the recurring operations. So, the pipe is --

MEMBER POWERS: But it is not entirely clear to me how during normal operations you test it. Do you squirt some hydrogen into it and see if it warms up?

MR. YOON: In the recurring operation,

during the recurring operation the pipe is tested. So, various tests by separating some of the catalytic into parts, so we can check the status of the part, catalytic.

MEMBER KIRCHNER: Are the cartridges in the bottom of the units, are these changed out at a regular interval?

MR. YOON: Yes.

MEMBER KIRCHNER: Which would direct Dr. Powers' question in one way.

MEMBER REMPE: So, I have a different question.

MEMBER KIRCHNER: May I continue?

MEMBER REMPE: Oh, sure.

MEMBER KIRCHNER: So, you have 30 of these in the containment. What analysis did you do to ensure that you would get the circulation, including the hydrogen, to actually go through these combiners? It sounds plausible that 30 of these devices would be sufficient, but did you do some fluid dynamic analysis to determine the locations? Or you just used engineering judgment and said, "I think it feels good to put one in each compartment" or one in each along the perimeter of the containment? Is there some basis for actually locating the PARs in the containment? Some analytical basis for distributing the units inside the containment to address Dr. Rempe's earlier concerns about stratification and other issues in terms of the containment atmosphere being well-mixed or not?

MR. J. OH: This is Andy Oh, KHNP, of the Washington office.

In case of the severe accident, the MAAP is calculated for each compartment, the concentration of the hydrogen. So, based on that reserve, we placed the PAR to prevent a detonation for the hydrogen. So, that is kind of the basis for the location of the PAR.

MEMBER KIRCHNER: Thank you.

MEMBER REMPE: So, I looked at Chapter 19 where the PARs as well as the igniters are located, and there are, if I am reading the diagram correctly, there are no igniters above the top of the steam generator compartment area. So, there is nothing in the top of the dome. There are a couple of the PARs that are before you at the top of the cylinder of the containment, not in the dome region.

So, I am curious what -- again, the same question that Walt had -- because, again, what analysis was used? Was it engineering judgment? If analysis was used, what was the refinement of the control volumes used in that analysis?

MR. J. OH: Yes. When we do some analysis for the detonations, we call it DDT analysis, over to the DDT. But the small amount of volume that is required, propagated to propagate to the detonation -- so, when you see the high volume for the upper side of containment, it is very big. So, that is the reason enough volume cannot be enabled to DDT.

And also --

MEMBER CORRADINI: Can you repeat that? Can you just repeat what you said again, please? Because it is kind of important. I think I know where you were going, but I wanted you to -- if you could just repeat it, please?

MR. J. OH: Yes. I think I have to think about that again during the severe accident analysis.

MEMBER CORRADINI: Okay. So, I guess where I thought you were going was that I have to assume a very large amount, more than all the cladding oxidation, to get to concentrations where I would get to DDT. That is what I thought you were saying, but if you want to check that out, that would be --

MR. J. OH: Yes, I need to check, think about it.

MEMBER REMPE: So, to counter what you thought they said, if that is, indeed, what you were going to say, I would counter with, yes, if you assume a big volume, you do need a large amount of hydrogen. But, if there is stratification because of higher temperatures or different compositions, hydrogen might be lighter, you might have a peak --

MEMBER CORRADINI: Hydrogen is always lighter.

(Laughter.)

MEMBER REMPE: Yes. Yes.

MEMBER CORRADINI: The second law goes against you. When mixed, it is hard to unmix, unless I have a particular physical phenomena, which would be --

MEMBER REMPE: What makes it mix, well-mixed? How do you know it is well-mixed?

MEMBER POWERS: The easiest way to get demixing is just to condense the steam out --

MEMBER CORRADINI: Right.

MEMBER REMPE: Right.

MEMBER POWERS: -- on a cold surface,

which is what she is worried about.

MEMBER CORRADINI: Right, we are arguing with each other on this, but there are -- the HVR experiments in Germany have shown that you have to get to relatively high concentrations to create an unmixed state and a stratified hydrogen layer on top. That's all I will say.

MEMBER REMPE: Okay. So, I guess that's something that I --

MEMBER CORRADINI: There were international standard problems long ago in the hydrogen program that showed you would have to get to concentrations into detonation to actually have it stratified. So, that is why I was asking about the DDT as the --

MR. J. OH: Yes, in order for considering DDT not only for the hydrogen concentration, but steam concentration and oxygen concentration, it should be considered comprehensively. So, for the severe accident, I think for our Technical Report, it is considered that all the factors together, not only for the three factors for the size for the compartment -- we have some detailed discussion we will be implementing to the severe accident chapter review for your Subcommittee.

MEMBER REMPE: So, there's a Technical Report associated with Chapter 19 that will go through the details of your evaluation --

MR. J. OH: Yes.

MEMBER REMPE: -- and citing the experiments that Professor Corradini is talking that will provide confidence?

MR. J. OH: Yes.

MEMBER REMPE: Okay. Thank you.

MEMBER KIRCHNER: So, I will go back to the very first question of this session by Dr. Powers. I would have assumed the answer on how do you define what's minimizing the amounts of aluminum and zinc in the containment vessel would be some percentage, a small percentage of what you would get from oxidizing the cladding. That is what I was thinking the answer might be. And I don't know what that would be, but let's pick something like 10 percent.

MEMBER BALLINGER: I have been searching. I read it. I think that is exactly what it says.

MEMBER KIRCHNER: I was just intuiting in that because --

MEMBER BALLINGER: Yes. No, no, I think

it says that. But I have been going through this thing trying to search on keywords --

MEMBER KIRCHNER: Okay. Thank you.

MEMBER BALLINGER: -- and not being able to find it.

MEMBER KIRCHNER: But that would be a justification to define minimizing material in --

MEMBER CORRADINI: So, just to a contrarian, since Dr. Powers nudged me on this, why do you even need a PAR at all? You have a large dry containment. Is this just extra stuff? I was looking for the right word, but --

(Laughter.)

MEMBER POWERS: You found a good one.

MEMBER CORRADINI: I'm not sure a large dry containment requires this, given its pressure requirements and expected behavior, but maybe I am wrong. Am I wrong?

MEMBER SKILLMAN: Yes, I know a large dry that had a huge hydrogen explosion, firsthand.

MEMBER MARCH-LEUBA: But these guys are not the circulation draft, which is driven by the catalytic conversion of hydrogen. So, when there is no hydrogen, there is no flow from there, right?

MEMBER POWERS: There is flow through them all the time. It is just not driven --

MEMBER MARCH-LEUBA: But it is not driven --

MEMBER POWERS: And the problem is that you go in here. Every time you open up the containment, if you go in and you do stuff, people walk around; they sweat; they give off vapors. During operations the containment gets quite warm. You get organics coming off things. They accumulate up.

These catalytic materials hunger for exactly the stuff that's coming off, and it excludes the surface. If there is sulfur -- and there frequently is sulfur in lubricating oils and things like that -- they will actually poison the catalyst. Otherwise, it excludes the catalyst and just blocks access to the gases.

I mean, they are very high-surface area things and they are very easy to exclude. And about the only choice you have is to be (a) a little careful on the things you allow into your containment, and particularly if you are painting in the containment, and to test them every once in a while to see if they are still functional.

Otherwise, you get into a trap of blocking flow during normal operations. And now, you have got to be sure that the blocks come off when you need them, and that is a complication you don't even want to think about there.

MR. SISK: I think we understand the issues that are raised. There were several here that are very good. There are some additional discussions in the future here, whether it is Chapter 9, Chapter 15, or Chapter 19, that we are going to be revisiting these topics.

MEMBER POWERS: On the testing you might want to look at the Canadian process. They go in and they pull -- in your case it would be a cartridge -- and they test it. And if it is bad, they replace all the cartridges. If it is good, then they don't. I mean, that is a pretty conservative testing process.

MR. SISK: We have captured the items and we will pick it from there.

MEMBER POWERS: And then, we can worry about whether they need this at all.

(Laughter.)

MR. YOON: I guess the next slide. This slide covers the containment leakage testing. The containment with the penetrations and the isolation barriers is designed to permit periodic leakage rate test, as required by GDC 52, 53, and 54.

APR1400 leakage rate testing program implements the performance-based leakage testing requirements of 10 CFR 50, Appendix J, Option B, using the specific methods and guidance provided in NEI 94-01 and ANSI/ANS 56.8, as modified and endorsed by Regulatory Guide 1.163.

For containment integrity, the leakage rate test, Type A, the measurement of the leakage rate shall be less than 0.75. For containment the local leakage rate test, Type B and C, the combined leakage rate for all types of tests shall be less than 0.6.

Next. This slide covers the fracture prevention of containment pressure vessel. The ferritic parts of the containment pressure boundary consists of the ferritic portions of the containment pressure vessel and/or penetration assemblies or analysis attached to the containment vessel.

The ferritic materials meet the fracture toughness criteria and the requirements in ASME Section III, Division 2, CC2520 or ASME Section III, Division 1, NE 2300, as appropriate for individual components.

Thank you.

CHAIRMAN SUNSERI: All right. So, before we begin Section 6.3, why don't we take a break here? It is a good stopping point for our first break of the morning. So, we will resume at five after 10:00.

(Whereupon, the foregoing matter went off the record at 9:49 a.m. and went back on the record at 10:06 a.m.)

CHAIRMAN SUNSERI: All right. We are back in session and ready to resume with the KHNP presentation, 6.3.

MR. IM: Okay. Thank you.

Good morning. My name is ImYoung Im from KEPCO E&C.

I am going to present on the safety injection system. Section 6.3 consists of the following five sections, and I will touch briefly on each subsection.

Next. The safety injection system is designed to meet all the regulatory requirements and the major requirements that are in GDC or 10 CFR 50, Appendix A, and the system criteria for the emergency core cooling system are provided in 10 CFR 50.46.

GSI-191, or NRC Reg Guide 1.82 also provide this criteria.

Next slide. The major function of the safety injection system is emergency core cooling. The safety injection pump injects borated water into the RCS through direct vessel injection nozzles to flood and cool the core following a loss-of-coolant accident. This also provides heat removal from the core for an extended period of time following a LOCA.

Next slide. By injecting borated water into the RCS reactivity and inventory are controlled during accident and safe shutdown. Borated water increases the shutdown margin following an elective or quick down of the system due to a main steam line break by aligning the flow path to inject this through the hot leg.

Next, please. The safety injection system is also used for feed-and-bleed operation. SIS provides a feed flow to remove the core decay during beyond-the-design-basis event, of feedwater to steam generators. Manually opening POSRVs is used for bleed test for this event.

MEMBER STETKAR: I'm sorry, by total loss of feedwater, you mean auxiliary feedwater and --

MR. IM: Both the auxiliary --

MEMBER STETKAR: Thank you.

MR. IM: The safety injection system consists of four independent trains, and each trains takes suction from the IWRST, and the safety injection pump provides flow through DVI nozzles. Each train is provided with a safety injection tank. Train 1 and train 3 inject to the DVI nozzle diagonal to the reactor vessel. As we discussed yesterday, even though the four trains are independent, with diagonal trains, it is required to mitigate the accident.

Minimum pump flow rate is conservatively evaluated based on pump performance requirements and flow resistance. This is used for the safety analysis.

Next slide. The system performance evaluation is by the safety analysis for the postulated accidents in DCD Chapter 15. So, I do not discuss it here.

MEMBER STETKAR: I'm sorry to make you go back.

MR. IM: Yes.

MEMBER STETKAR: Can you go back to the drawing on slide 26 that shows the -- there you go.

This drawing -- we had a discussion earlier about hydrogen control -- this drawing does not show the three-way valve to the IRWST from the POSRVs. That's a factual statement. That is not a question.

There is a three-way valve --

MR. IM: I understand. The three-way valve is used for the severe accidents.

MEMBER STETKAR: Okay.

MR. IM: So, this is just for the schematic for the --

MEMBER STETKAR: It is for feed-and-bleed.

MR. IM: Yes.

MEMBER STETKAR: But I just wanted to do -- the three-way valve, it is my understanding that under severe accident conditions, as indicated by high core exit temperature -- and I do not remember the value -- the operators are instructed to open the POSRVs and align the three-way valves to blow down into the steam generator compartment. Is that correct?

MR. IM: Yes, during the severe accidents. I remember the concern is for the hydrogen buildup in the IRWST.

MEMBER STETKAR: Right.

MR. IM: If you bleed, you have to crunch to IRWST, then the concentration in the --

MEMBER STETKAR: The gas space of the IRWST is higher.

MR. IM: Yes, hydrogen is severe. So, that should be controlled and it follows through valves to divert to the containment --

MEMBER STETKAR: And that diversion, if I remember, is into the steam generator compartment, isn't it?

MR. IM: Yes, inside --

MEMBER STETKAR: It's not to the -- just into the general containment atmosphere?

MR. IM: Yes.

MEMBER STETKAR: It is communicates to the compartments --

MR. IM: Yes, it communicates, yes.

MEMBER STETKAR: Okay. Thank you. I just wanted to make sure I had that understanding correct.

MR. IM: Yes.

MEMBER SKILLMAN: Before you change to a higher number, would you go back to slide 25, please?

Sir, in your introductory comments you

made the comment that, as part of the LOCA response, the operators realign the SI pumps into the hot legs. I'm reading a portion of the Safety Evaluation, and I am curious where that practice has been proven. What other plants actually swap the safety injection pumps from the DVI lines to the hot legs?

I will read part of this document, so that you can understand my question.

MR. IM: Yes.

MEMBER SKILLMAN: "The SIPs begin injecting borated water from the IWRST following the SI actuation signal. The operators of the plant accomplish long-term cooling following a large-break LOCA by manually realigning the SIS for simultaneous hot leg and DVI injection flow. The operators align two of the four SIPs to discharge to the RCS hot legs. The applicant intends for the hot leg realignment to provide flushing flow to preclude boron precipitation and the ultimate subcooling of the core when shutdown and cooling cannot be used."

So, I am curious, where is this practice being used?

MR. IM: Yes. There is proof. You can see the progress to the hot leg with boron. So, those are such that the vessel loader 1B is closed, and the two isolation valves are opened in the main control room. So, you don't need to switch the pumps. So, just aligning it, you can inject to the hot leg.

MEMBER BALLINGER: I think the question is, where is this done now?

MEMBER SKILLMAN: Yes, where is this presently practiced? What other plants --

MEMBER STETKAR: All Westinghouse plants in the United States do it.

MEMBER SKILLMAN: That's news to me. Okay.

MEMBER STETKAR: Okay.

MEMBER SKILLMAN: Maybe it's my background. So, I'll take that hit.

MEMBER STETKAR: I don't know about combustion plants, but I know all Westinghouse plants in the EOPs do the same thing, partial realignment to hot leg.

MR. J. OH: This is Andy Oh again.

The old OPR plants also do the hot leg escalation to combustion engineering.

MEMBER SKILLMAN: Okay. Fair enough. I come from a population that did not do that. Did not, no. Okay. Thank you.

MR. IM: The safety injection system is an engineered safety feature system, and most of the pumps and valves are safety-related active components and are subject to in-service tests. The test is to be performed according to the ASME OM. The pre-operational and performance test is to be done according to Reg Guides. Especially Reg Guide 1.79 provides this guidance for pre-operational testing of ECCS.

Next, please. The safety injection actuation signal is automatically generated by low-pressurizer pressure or high-containment pressure. System monitoring during accidents or normal operation or tests is provided in the main control room.

So, this is the presentation for the safety injection system. Thank you.

MEMBER CORRADINI: So, can I ask a background question?

MR. IM: Yes.

MEMBER CORRADINI: I know you gave us a tutorial to begin with, but I don't remember what. What is the necessity of the HVT compared to the IWRST, the logic there where you drain to the HVT and, then, you --

MR. IM: Why do we need HVTs?

MEMBER CORRADINI: Yes. Is it back to a GSI-191 issue?

MR. IM: What is the issue? Why do we need HVT?

MR. J. OH: This is Andy Oh again.

For the HVT, one of the functions is, you know, there's some screen. Before gathering into the HVT there is some screen, mechanical screens. And also --

MEMBER CORRADINI: So, debris separation? Okay.

MR. J. OH: Debris separation.

MEMBER CORRADINI: And that's the main reason?

MR. J. OH: And also, three -- what is it? -- it is for pH control. Material is also okay, given the HVT.

MEMBER STETKAR: The baskets are in the HVT, the PSBs.

MEMBER CORRADINI: Okay. Thank you.

MEMBER STETKAR: And?

MR. J. OH: And one more thing is the

mechanical screen in a spillover to the IRWST -- so, there is some flooding that the debris also can be prevented to flow over to IRWST.

MEMBER CORRADINI: Because of the loop?

MR. J. OH: Yes.

MEMBER CORRADINI: Okay. So, for the uninitiated, it is just a dirty part of the IRWST with additional inventory? Because, essentially, it is the same water inventory before it goes through screening and chemical addition. That is why I was looking at it. Is that a fair way to look at it?

MEMBER STETKAR: Normally dry.

MEMBER CORRADINI: Normally dry?

MR. J. OH: Normally dry.

MEMBER CORRADINI: Normally dry, but that is where everything is accumulated and, then, passed on to the IRWST? Okay. Thank you.

We will return to that, anyway, when we do the GSI discussion, I assume. Okay.

MR. J. PARK: Good morning, everyone. My name is Jihwang Park from KEPCO E&C.

I will present habitability systems of the APR1400.

Next slide. Design bases:

The habitability systems are designed to allow control room operators to remain in the control room envelope and take actions to operate the plant safely under normal conditions and maintain it in a safe condition under abnormal conditions.

Meet the requirements of applicable Regulatory Guides and GDC 19.

Maintain conditions that are comfortable for plant personnel and provide reasonable assurance for the MCR equipment function.

And protect the plant personnel in the CRE from the following:

Exposure to potentially airborne radioactivity in the outside atmosphere.

Exposure to potentially toxic chemicals that are postulated to be released near the plant site.

The effects of high-energy line breaks in the surrounding plant areas.

Smoke from an onsite fire.

The control room envelope, CRE, is located at elevation 156 feet and 174 feet in the auxiliary building.

The CRE volume, except the HVAC equipment rooms, is approximately 200,000 cubic feet.

The CRE includes the following areas: the main control room, technical support center, meeting room, computer room, HVAC equipment rooms, kitchen and dining room, and toilets.

The control room HVAC system starts sharing during plant normal and abnormal conditions. The control room HVAC system has three operation modes: normal, emergency, and recirculation modes.

This slide shows the control HVAC system flow diagram in emergency mode. After the initiation of designated ESF actuation signals, the control room HVAC system is automatically switched to the emergency mode. In the emergency mode, the air cooling unit starts automatically and fills out the outside makeup air and part of the turnout from the CRE. And the air handling unit throws the filtered air from the air cleaning unit and the operator air from the CRE, and provides conditioned air to the CRE.

Next is the design evaluations. First, radiological protection. An analysis for a LOCA is performed to determine the post-LOCA doses. In the analysis, the radiation sources each may reach out to exposure to the control room personnel are considered based on the Regulatory Guide 1.183.

For the MCR shielding design, the shielding design to mitigate the effects of direct exposure to the MCR personnel is provided. And the analysis results shows the exposure to the MCR personnel does not exceed the occupational dose limits of 50 millisieverts, which is discussed in GDC 19 for a postulated DBA.

Next is toxic gas protection. The control room habitability following the accidental release of toxic chemicals is evaluated in accordance with Regulatory Guide 1.78 and NUREG-0570. The toxic gas analysis results show that the release of the toxic gases do not affect MCR habitability. And adequate self-contained breathing apparatus are available inside the CRE to prepare for emergency situation due to toxic gases.

MEMBER STETKAR: That third bullet, what do you mean by "prepare for emergency situation due to toxic gases"?

MR. J. PARK: If control room operators need to leave the control room, to cooperate with the experts.

MEMBER STETKAR: Okay. If they need to go to the room or shut down the room, for example?

MR. J. PARK: Yes, that is correct.

MEMBER STETKAR: Okay. Thank you.

MR. J. PARK: And next is testing and inspection. Pre-operational test and in-service test are performed to provide the reasonable assurance that system and component capabilities are achieved and maintained. Periodic testing to confirm the CRE integrity is performed using test methods and at test frequencies, in accordance with Regulatory Guide 1.197. The air in-leakage test of the CRE boundary is performed in accordance with ASTM E741.

Next, instrumentation requirement. Two redundant radiation monitors are installed in each of two outside air intakes to annunciate high-radiation alarms and to initiate CREVAS. Instrumentation for the control room emergency makeup ACU is designed to meet the requirements of ASME AG-1 and Regulatory Guide 1.52.

And that is our presentation of the habitability system.

MEMBER STETKAR: I have some questions. I wanted to let you finish.

Have you performed room heatup

calculations for the main control room if you lose all control room ventilation cooling?

MR. J. PARK: Actually, in DBA?

MEMBER STETKAR: No. I asked a question about, if you lose all main control room cooling, have you performed room heatup analyses for the main control room? I did not mention DBA.

MR. J. PARK: Okay. Actually, we did perform the calculation for the Fukushima event, which is we lost all the control room --

MEMBER STETKAR: No, Fukushima is loss of power. I asked a question, that if I lose main control room -- I want to make this on the record -- if I lose main control room cooling, normal plant operation --

MR. J. PARK: No.

MEMBER STETKAR: -- no design-basis accident, no Fukushima, lose main control room cooling, have you performed a room heatup analysis for the main control room.

MR. J. PARK: No, we didn't.

MEMBER STETKAR: Okay. Thank you.

Then, the questions that I have are, if you do perform a room heatup analysis, what is the maximum temperature in the main control room if the operators do nothing? That is one followup question. So, that is just what the room heatup is.

What are the equipment qualification temperatures for the digital controls in the main control consoles and the displays to the operators? That is No. 2. That is equipment survivability.

And No. 3, for habitability, can the operators continue to operate in the main control room under those conditions or will they need to go to the remote shutdown area, the remote shutdown room?

MR. J. PARK: I understand.

MEMBER STETKAR: No. 4 is, if they do need to go to the remote shutdown room, and if core damage occurs, where are the functions of the technical support center performed, because the technical support center will be under the same high-temperature and bad environmental conditions?

So, those are four followup questions regarding environmental controls for the main control room. There are other followup questions for the PRA, but we will get to that in Chapter 19.

You can take those back. I mean, they are on the record.

MR. SISK: We have it.

MEMBER STETKAR: You got it? Thanks, Rob.

MR. SISK: Thank you.

MR. J. PARK: Next I will talk about the fission product removal and control systems in Section 6.5. This section covers the engineered safety feature filter systems, the containment spray systems, and the fission product control system.

The first presented system is the ESF filter system. The ESF filter systems are designed to mitigate the consequences of postulated accidents by filtering radioactive particulates and iodine from the air, and meet the requirements of Regulatory Guide and ASME clauses.

There are three subsystems in the ESF filter systems:

Control room emergency makeup air cleaning system to control the area, the emergency exhaust system, and fuel handling area emergency exhaust system.

The air cleaning unit, ACU, and the ESF filter systems filter the potential radioactive particulates and iodine from the air. The control room emergency makeup air cleaning system limits the exposure to the MCR personnel to be less than 50 millisieverts total effective dose equipment, in accordance with GDC 19.

MEMBER POWERS: What is your unfiltered in-leakage in the control room?

MR. J. PARK: Could you repeat that, please?

MEMBER POWERS: What is the volumetric flow of unfiltered in-leakage into the control room?

MR. J. PARK: Only about, it is about 200,000 cubic foot.

MR. SISK: Two hundred thousand.

MR. J. PARK: Two hundred thousand cubic foot.

MEMBER POWERS: That's, presumably, the flow through the filter system. I am worried about how much in-leakage do you get that doesn't go through the filter system.

MR. D. LEE: My name is Dongsu Lee.

When calculated, the consequence on RSCs for the LOCA -- I'm sorry -- habitability at the time, we have assumed 100 CFM.

MEMBER POWERS: One hundred CFM?

MR. D. LEE: Yes.

MEMBER POWERS: Do you know where that predominantly comes from?

MR. D. LEE: By the engineering judgment and we computed the other kinds, and we bound that number.

MR. J. PARK: Go to the next. This slide covers the containment spray system. The system's function and configurations were already presented in Subsection 6.2.2. So, I will present the design evaluation for the fission product remover and the control by using the containment spray system.

For the mixing of the containment air in post-LOCA condition, the minimum mixing rate of 2 unsprayed volumes per hour is used in the analysis to transport the post-LOCA activities in accordance with the SRP.

In the post-LOCA conditions, the pH of the IRWST water is evaluated to provide reasonable assurance that the minimum pH value can be maintained above 7 for 30 days in LOCA condition.

MEMBER POWERS: What kinds of acidification mechanisms did you consider in calculating that pH?

MR. J. PARK: Mr. --

MR. D. LEE: Yes, let me introduce the calculation of the pH. At the time that basically we considered the SP and boric acid water analysis during the LOCA, as I have mentioned previously, HCCL and also the nitrogen was considered and the HR was considered. But for that calculation, we assume that especially the radio receives the impact at the time you considered 60 time and, also, a four-hour LOCA condition, TID, Total Integrated Dose rate.

MEMBER POWERS: Say that again? For your nitrogen calculation, nitric acid calculation, what was your atmospheric dose rate?

MR. D. LEE: For the nitrogen?

MEMBER POWERS: Yes. In order to calculate the nitric acid formation, you assume some dose rate in the containment.

MR. D. LEE: In terms of the nitrogen gas, we assumed that from the water and air, and the radiolysis impacts, that nitrogen exceed can be generated, but we did not do this calculation.

MEMBER POWERS: I mean, there has to be some rate at which nitric acid gets formed by radiolysis. It is driven by the dose rate. What did you assume for the dose rate?

MR. D. LEE: The TID there.

MEMBER POWERS: You took the TID source term and calculated dose rate from that?

MR. D. LEE: Yes. When you calculate the TID, we assumed the LOCA condition, and with the batteries, the system works from the core, with the core. We assumed that.

MEMBER POWERS: Okay.

MR. D. LEE: Yes.

MEMBER POWERS: Thank you.

MR. J. PARK: I will continue? For the consequence analysis of LOCA, the elemental and particulate iodine are shown to be removed by the containment spray system, based on the model described in the SPR, and 10 percentile value of the Powers model built into RADTRAD was used as an aerosol deposition removal effect.

MEMBER POWERS: Brilliant modeling. Well worth using.

(Laughter.)

MR. J. PARK: Next. This is slide covers the fission product control system. The primary fission product control system following a DBA is the containment spray system and the containment. The fission product leakage to the environment is reduced per the listed limit by the fission product removal function of the containment spray system and the leak-tight pressure boundary of the containment. For the containment leakage, the in-service leakage testing program is detailed in Subsection 6.2.6. And the radiological consequences following the DBA is described in Chapter 15.

Next. Thank you.

MR. TAK: In Section 6.6, In-Service Inspection of Class 2 and 3 Components of the APR1400 are described. This slide shows an overview of Section 6.6.

Next. As is shown on this slide, the requirements for 6.6.1, Component Subject to Examination; 6.6.2, Accessibility; 6.6.3, Examination Techniques and Procedures; 6.6.4, Inspection Intervals, are addressed in accordance with ASME Section XI.

Next. 6.6.5, Examination Categories and Requirements; 6.6.6, Evaluation of Examination Results, and 6.6.7, System Pressure Tests are also addressed in accordance with ASME Section XI. And augmented in-service inspection for high-energy fluid system piping is addressed in Subsection 6.6.8.

MR. MUN: I will briefly explain Section 6.8, the design of the in-containment water storage system. This slides provides an overview of DCD Section 6.8.

Design Bases. The in-containment water storage system consists of in-containment refueling water storage tank, holdup volume tank, and cavity flooding system. During a normal operating conditions, the IRWST provides the borated water for the safety injection system when the safety injection system is in a standby mode. It also provides borated water for filling the refueling pool during the refueling operation. At an accident, the IRWST has a role of a water source for providing water to the RCS and containment spray through the safety injection system and the containment spray system. IRWST also provides the heat sink for cooling the steam discharged from the POSRV following RCS pressurization accident.

The holdup volume tanks provides water collection and the storage functions prior to returning to the IRWST during an accident.

Finally, the cavity flooding system floods the reactor cavity to cool and protect the reactor vessel in a severe accident.

MEMBER CORRADINI: So, I had a question that maybe I just don't understand. No, you can go to the slide, the cartoon, your next slide.

So, there is a thing noted in the SE about swing panels to protect against pressure transients. What is a swing panel and where is it? I couldn't figure that out.

MR. YOON: The swing panel is not shown in these figures. The swing panel is located in the 100 elevations in the containment. So, actually, it is --

MEMBER CORRADINI: What elevation? I'm sorry.

MR. YOON: If the swing panel is shown in the figures, at this point it would be located now. The swing panel is located and stored in this point.

MEMBER CORRADINI: Okay. So, it's above the tank in the gas volume? Above it?

MR. YOON: Yes.

MEMBER CORRADINI: Okay. And what's its purpose?

MR. YOON: The purpose, the swing panel, the purpose of the swing panel is it controls the pressure between the IRWST and, then, at the containment, too.

MEMBER CORRADINI: So, it's a damper in one direction. So, if there is an overpressure above the IRWST gas volume, the swing panel opens to --

MR. YOON: Yes.

MEMBER CORRADINI: -- let gas in?

MR. YOON: Yes.

MEMBER CORRADINI: Okay.

MR. YOON: So, there are three doors. The two doors discharge it to the IRWST, and the one door is into the IRWST.

MEMBER CORRADINI: Okay. So, let me ask my question differently. Why even have a swing panel at all? Why do you need a blockage there? What's the reason for even having a panel? Why isn't it just open communication?

(Pause.)

Does it have to do with water flow paths on there?

MR. YOON: The swing panel is not water flow path. It is only to the "L" flow path.

MEMBER CORRADINI: Okay, but I'll ask my question again. Why have a panel at all? Why isn't it just an open pathway? If you are worried about a pressure transient, why have a panel at all? That's what I don't understand.

MR. YOON: I need to check your question.

MEMBER CORRADINI: Okay. Okay. And then, another just geometrical question. So, the swing panel, if I understand it, is sitting inside above what we see here.

MR. YOON: Yes.

MEMBER CORRADINI: Okay. So, my second question is, the strainers to clean up the debris are sitting inside the IRWST. So, the HVT just collects stuff by gravitational settling and, then, that U-bend, essentially, then transports the water over before it is strained out?

MR. YOON: Yes.

MEMBER CORRADINI: Do I have that correct?

MR. YOON: Yes.

MEMBER CORRADINI: Okay. And then, the final thing is that is the feed for all your pumps, is the bottom piping?

MR. YOON: Yes, this here.

MEMBER CORRADINI: Okay.

MR. YOON: Yes.

MEMBER STETKAR: Aren't there -- on this picture they're not shown -- but aren't there also strainers in the HVT? I don't remember if they're on the inlet.

MEMBER CORRADINI: Well, I'm looking at another figure from the DCD Tier 2, page 800, and they do show something there. So, there's two sets.

MEMBER STETKAR: I know they're there because they are blocked during shutdown. So, I just want to get it on the record that they are there and where they are.

MEMBER CORRADINI: What I am trying to get is I am trying to get your cartoon matching up with some of the cartoons in the DCD, and they are not exactly the same. So, if this is just a cartoon of a cartoon, that's okay.

So, there are strainers in the HVT also, right?

MR. YOON: Yes, this is the HVT.

MEMBER CORRADINI: Okay. And there are screens or something there, too?

MR. YOON: There is no screeners in the HVT.

MEMBER CORRADINI: Okay.

MEMBER STETKAR: Wait a minute. I read that there are screens in the HVT because I know the low-power and shutdown PRA models explicitly say that those screens are covered to prevent debris from entering the HVT during shutdown work inside the containment. So, one thing is wrong, either your statement or what's assumed in the PRA. The question is, are there screens for the HVT?

MR. YOON: But the screens in this. This figure is the pressure. First, the debris is screened at this point.

MEMBER STETKAR: Okay.

MR. YOON: And then, the debris is settling, and there is some debris, right --

MEMBER STETKAR: Good.

MR. YOON: Yes.

MEMBER STETKAR: So, there are screens. They are shown -- you're calling them trash racks, but they are that right there that you are pointing to.

MEMBER CORRADINI: Oh, they are a trash rack?

MEMBER STETKAR: Yes.

MEMBER CORRADINI: Okay. And then, the final question is, not shown here, there's a piping that goes down for after flooding out of the HVT, not out of the IRWST, is that correct?

MR. YOON: Wait. I'm sorry?

MEMBER CORRADINI: There is a pipe that has to be opened by a motor-operated valve that flows water from the HVT into the reactor cavity?

MR. YOON: Yes.

MEMBER CORRADINI: Is that correct?

MR. YOON: Yes. The pipe, the problem is the piping is not shown in these figures.

MEMBER CORRADINI: But it is from the HVT?

MR. YOON: Yes, but the piping is corrected to the IRWST, to the HVT, and then, to isolation valves that are located in the HVTs. And then, the valves are connected to the reactor cavity. Yes.

MEMBER CORRADINI: Okay. All right. But they're not shown. We'll come back, then, when we do severe accident.

MEMBER STETKAR: I believe there's two sets of valves, such that you open the valves that connect the IRWST to the HVT and you open valves that connect that connected pool to the reactor cavity, such that you equalize levels in the cavity, the HVT, and the IRWST --

MEMBER CORRADINI: All in one shot?

MEMBER STETKAR: Yes, but there's two sets of valves, and I can't remember precisely how they're configured.

MEMBER CORRADINI: Okay. Thank you.

MR. SISK: This is Rob Sisk with Westinghouse.

I do want to just help a little bit. There are two areas in the DCD that I want to reference you to. The swing panels are described in Subsection 6.8.2.2.5, and you can get a discussion on it there. And as stated in the DCD, the swing panels are closed to minimize the release of IRWST water into the containment atmosphere during normal operating plant operations. So, you want to be able to have the pressure released, but you don't want the water to be disappearing from your IRWST during normal operation.

MEMBER CORRADINI: Oh, so it's for evaporation purposes?

MR. J. OH: Yes. As stated in Section 6.8.2.2.1.

MEMBER KIRCHNER: So, just a question of clarification. There is a second figure 6.8-2 that shows the IRWST and the cavity flooding system. So, the elevation of the holdup volume tank is, I suppose if it were completely full, would be somewhere at the level of the bottom of the core, the reactor vessel level.

But, in terms of flooding the cavity, it would just flood cavity below the reactor vessel? Or is there sufficient water volume to immerse the vessel?

MR. J. OH: Yes, this is Andy Oh, KHNP, Washington office.

The cavity flooding system is not sufficient to flow over the vessel. But, in order to inject the water to the cavity, we need the shutdown cooling pumps to flow over to the reactor vessel. The cavity flooding system is just for lower level for coating catching and some cooldown of coating function.

MEMBER KIRCHNER: Thank you.

MEMBER CORRADINI: Okay. So, I am back with the swing panels. I'm sorry. So, this looks like a vacuum breaker, but kind of a weak vacuum breaker. So, are you telling me that I can pressurize the IRWST to a higher pressure than the rest of containment?

MR. YOON: Yes.

MEMBER CORRADINI: How much? Since that affects the GSI-191 question that I want to ask later on.

MR. YOON: I think it's --

MR. SISK: Do you understand the question?

MR. YOON: Yes. Pardon me, please.

MEMBER CORRADINI: Okay. The swing panel, as was explained, allows for it to open into the IRWST, but it shuts, so that you don't get evaporation, water loss, into the rest of the containment. So, that means it must hold some pressure. How much pressure does it hold? Is there a spec on that?

MR. YOON: Just a moment.

MEMBER CORRADINI: That's okay.

(Pause.)

MR. YOON: The swing panel is located in the particle pipes --

MEMBER CORRADINI: Yes.

MR. YOON: So, the three-way --

MEMBER CORRADINI: So, it's a two-way?

MR. YOON: Yes, it's two ways.

MEMBER CORRADINI: Oh, okay.

MR. YOON: Say three directions, there are three directions. The two directions go out the containment. I have to speak to containment, two directions. Another door is the inner open to the containment.

MEMBER CORRADINI: Okay. But they are bidirectional? They open both directions?

MR. YOON: Only one direction. Two doors, two same kind of -- two doors is the only outer directions, and another same kind of door is the inner direction.

MEMBER CORRADINI: Okay. Then, I misunderstood.

MR. YOON: Yes.

MEMBER CORRADINI: I have got to think about it again. I'm sorry. Thank you.

MR. MUN: Instrumentation. In the containment water storage system, various water level instrumentation are installed in the IRWST, holdup volume tank and the reactor cavity. The water level instrument is used to monitor the IRWST water level and switches to the holdup volume tank and reactor cavity during normal operations. And it is also used to monitor the water level of IRWST, holdup volume tank, and reactor cavity during the accident condition.

The temperature and pressure instruments are also provided in the IRWST to monitor the pressure and temperature in the IRWST.

MEMBER REMPE: So, earlier I should have asked the question and I didn't. So, maybe I will try to do it here. But during the discussion today, you talked about you do analyses and find out the peak temperature as well as the pressure that equipment such as instrumentation would have to survive. There's a limited set of instrumentation for severe accident conditions.

In the Draft SE, the staff indicated that it appeared that in the case of the combustible gas generation that that instrumentation was only qualified with respect to temperature. Is it also, you don't consider any sort of pressurization history also? Or is it pressure and temperature for that instrumentation? Because some of the cases analyzed with the MELCOR evaluation, which they explained were similar to what was done with MAAP, did have ignition if you didn't have the three-way valve working or other components working.

Do you understand what I'm saying or is the question too long?

MR. SISK: Rob Sisk, Westinghouse, again.

Let me just see if I do understand the question. Are you discussing the need for temperature and pressure on equipment qualification or the environment? Because you are also talking about the pressure, which may be controlled by something other than the instrumentation, right?

MEMBER REMPE: Well, I am specifically looking at instrumentation because there is a certain amount of instrumentation for severe accident monitoring or post-severe accident monitoring. And in the staff Draft SE, they only talk about the temperature curves from the combustible gas generation analysis. And I was curious if pressure and temperature was considered, because there might be a hydrogen ignition in some scenarios where certain components didn't work.

MR. SISK: For the equipment qualification evaluation?

MEMBER REMPE: Yes.

MR. SISK: For the same question?

MEMBER REMPE: This is severe accident instrumentation. So, it is beyond-design-basis conditions.

MR. MUN: Just on the design-basis conditions we produce the pressure and temperature in MELCOR for the design basis.

MEMBER REMPE: Okay. So, for the severe accident instrumentation, you do not consider any sort of pressure shocks?

MR. MUN: It can be answered by our severe accident team.

MEMBER REMPE: Okay. So, that's a question for the future, then, too, please.

MR. MUN: This is the most top item, I think.

(Laughter.)

As one of the design evaluations, the NPSH available for circulation pumps and the containment spray pumps are evaluated. The NPSH available is determined from the pressure difference subtracting the friction noted at the pump suction and the steam vapor pressure from the containment pressure in the static head of the pumps.

In the evaluation of the NPSH available, our design assumes that the containment pressure is equal to the IRWST liquid vapor pressure. This is assumption is based on the CAP analysis demonstrating the containment accident pressure maintains above the IRWST liquid vapor pressure with a sufficient accident.

MEMBER STETKAR: That also assumes that the containment is fully isolated and not open to the atmosphere, is that correct? Say yes.

So, my earlier question, if I have a large opening in the containment and the containment is vented to the atmosphere, will your pumps lose net-positive suction head if the IRWST is at saturation? So, if the containment is at atmospheric pressure and the IRWST is at, if you are using Fahrenheit, 212 degrees Fahrenheit, will I still have adequate net-positive suction head for the SI pumps and the CS pumps? Do you know that?

(Pause.)

MR. J. OH: So, this is Andy Oh, KHNP, Washington office.

Your question is --

MEMBER STETKAR: Okay. Keep the containment open to the outside atmosphere, such that water boils at 212 degrees Fahrenheit. Under those conditions, will I have adequate net-positive suction head for the CS pumps and the SI pumps? The SI pumps are more limiting because they have a larger net-positive suction head requirement. So, if you want to just talk about SI pumps, we can talk about them. Got it?

If the answer is yes, that's great. If the answer is no, my questions are going to follow up on how long does it take to get to boiling for each type of accident? And that determines time windows for people to start cooling the IRWST. That's the direction I'm going.

MR. MUN: Just a moment.

We performed the CAP analysis based on the SECY-11-0014. Earlier submissions omit -- yes, so, of course, we know. And based on the analysis with those, if we trust the reserve of the CAP, I think the boiling condition has not occurred, even above 100 Celsius degrees.

MEMBER STETKAR: I know the rules that you followed. I know what you did. That's not the question that I asked.

MEMBER CORRADINI: We can ask the staff.

MEMBER STETKAR: Yes, I'll ask the staff. But the staff is only going to tell us what the staff has told us for the last seven years, that they're okay taking credit for CAP.

I'm trying to understand, in this particular design, how much margin do we have. And, indeed, there are ways of cooling the IRWST such that it may not become saturated, but that determines time window. Because operators may need to do that, it determines time windows for the operators to do those actions.

So, in the real world of risk assessment, I am trying to understand how much margins we have and how much times are available, in particular, if the containment is not isolated.

MEMBER CORRADINI: Do you understand his question? Okay. I think what he is asking you is, if H ATM is equal to 1 atmosphere --

MEMBER STETKAR: Right, right.

MEMBER CORRADINI: -- do you still get a positive number? And then, if the answer to that is no, how long do you have to rely on CAP in terms of magnitude and duration?

MEMBER STETKAR: Well, no, it isn't how

long do you have to rely on CAP. How much time is available to keep the IRWST subcooled?

MEMBER CORRADINI: Subcooled.

MEMBER SKILLMAN: Let's go to the next slide.

MEMBER KIRCHNER: Well, the next slide may answer that --

MEMBER SKILLMAN: The next slide really goes to this.

MEMBER KIRCHNER: -- because I think, John, they assumed for the IRWST -- let's assume it is sitting there percolating, so it is greater than boiling at atmospheric pressure because the containment is vented or open.

MEMBER STETKAR: No, the containment is closed in all of their analyses.

MEMBER KIRCHNER: But I'm looking at how they constructed the table on the next page. It seems to me -- and maybe they should answer this --

MEMBER STETKAR: Yes. Yes.

MEMBER KIRCHNER: -- if you have a high temperature in the IRWST, they are assuming that the H-atmosphere equals vapor. So, you take those two out.

MEMBER STETKAR: Right.

MEMBER KIRCHNER: And the question is, is the H static sufficient minus the loss to provide the net-positive suction head? It appears in the table on the next page, with some margin for uncertainty, that it is. But maybe they should answer, huh?

MR. MUN: From our analysis, the most severe, the most worst case for the LOCA, the margin we have is more than 8.5 psi difference. It means the containment pressure. During all the transient, the worst -- the smallest pressure difference between the containment pressure and the IRWST vapor pressure is at least more than 8.5 psid. We have that margin, pressure margin.

MR. J. OH: This is Andy Oh, KHNP, of the Washington office.

That case, actually, per Chapter 6, they didn't take into account for the containment is open and the containment estimates be raised for atmospheric pressure. So, I think for the PRA, one of the scenarios we just have taken into account IRWST is not cooled down. So, in this scenario we just made some calculation. But I don't remember the calculation time. But when we are going through the

Chapter 19 PRA, we can discuss this matter again.

MEMBER STETKAR: Okay. Well, it's relevant for Chapter 19 certainly, which is why I wanted to start asking the questions today. But it is also relevant for our Subcommittee's understanding of margins for net-positive suction head in a, if I can call it this, a deterministic sense, only because the ACRS has traditionally had concerns about the maintenance of adequate net-positive suction head without the need to account for containment accident pressure.

And we have kind of raised this issue as a Committee in letters in the past, in particular, for new designs where you are not necessarily constrained by having an existing plant with existing pumps and existing design-basis accident analyses. And there are ways for new plants to not necessarily have to rely on containment accident pressure.

That's why I raise it now, because that is a more deterministic licensing issue, rather than the PRA issue. It is obviously relevant to the PRA also.

And I'll stop now. I'll let the other people who can boil water speak.

MEMBER REMPE: When I looked at this

analysis, the question in my mind was, did you think about not relying on CAP? Because in the EPUs we are seeing people come in that had originally tried to rely on CAP who have finetuned their analysis and decided they don't need it anymore. Has KHNP tried to do this without relying on CAP?

MR. YOON: Yes.

MEMBER REMPE: And you need this CAP reliance?

MR. YOON: Yes.

MEMBER REMPE: Okay. Thank you.

MR. MUN: I will continue from this slide. Our design uses NPSH required, effective in accordance with SECY-11-0014. And the 21-percent margin is additionally considered for effects of the uncertainty factors. NPSH are effective of penetration reserve for the safety injection, and the containment spray pumps are listed in this table.

The NPSH are effective on 22 feet for the safety injection pumps and 17.5 feet for the containment spray pumps. The NPSH margin for the pumps are calculated with these. NPSH are effective and are providing --

MEMBER STETKAR: I found a couple of

different references in the DCD for the required NPSH. The values you have on this slide are consistent with the values in table 6.2.2-1. In table 6.3.2-1, the required NPSH for the safety injection pumps is listed as 20 feet, 6.1 meters, which is less than this. So, this would be conservative compared to that for this calculation.

In DCD table 5.4.7-1, the required NPSH for the shutdown cooling pumps, which are identical to the containment spray pumps, is listed as 5.49 meters, or 18 feet, which is more than this value. So, this would be optimistic in terms of your calculation compared to that table.

In other words, the calculation, if they are using a higher-than-actual-required net-positive suction head, the calculation is conservative the way they do it. But, if the actual net-positive suction head is higher than this value, then this calculation might be optimistic.

So, I'm not sure what the actual required net-positive suction head is for each of those pumps because I can find different values in different tables.

MR. YOON: I remember that in the -- maybe it is the SCC pump or, yes, anyway, the pumps in the DCD is revised in response to the RAI. So, maybe I know that the DCD is really -- the data in the revised DCD is consistent with this data.

MEMBER STETKAR: Ah, okay.

MR. YOON: Yes.

MEMBER STETKAR: Okay. Thank you.

MR. YOON: Yes.

MEMBER CORRADINI: Now you're happy; now I'm confused. So, which one of these is the reference NPSH? Is it what we're seeing here?

MR. YOON: Reference NPSH?

MEMBER KIRCHNER: From John's citation, then, indeed, they are calculating 20.5. It is more than the 18. But, if they are using this correction for uncertainty, it isn't, right? Or am I missing something?

MEMBER STETKAR: No, what I'm looking at is simply what they are listing in the bottom table --

MEMBER KIRCHNER: Yes, that's what I'm looking at, too.

MEMBER STETKAR: -- as NPSHr effective feet of water. That's effective required NPSH in feet of water.

In one table that I found for the SI pump it is 20, rather than 22. And I don't care about that. But, for the CS pump, it is 18, rather than 17.5. And if it actually is 18, then this is optimistic.

The SI pump is still limiting, I mean of the two pumps.

MEMBER KIRCHNER: Yes, I agree.

MEMBER STETKAR: I just want to make sure that all of the calculations are consistent.

And Rob had something he wanted to add.

MR. SISK: No, no, I am just reconfirming -- this is Rob Sisk, Westinghouse -- I just wanted to reconfirm. The data here, the 17.5 is the correction that has gone into Rev. 1.

MEMBER STETKAR: Okay.

MR. SISK: That is the correct datapoint here.

MEMBER STETKAR: Okay. So, that tells me that that table over in Chapter 5 --

MR. SISK: Has been revised.

MEMBER STETKAR: -- has been revised.

MR. SISK: Correct.

MEMBER STETKAR: Okay. Because there

wasn't a table for the containment spray pump in Chapter 6. So, I had to go to Chapter 5 to look for the equivalent pump.

MR. SISK: That's correct, yes. That's confirmed.

MEMBER STETKAR: Okay. So, these are --

MR. SISK: These are the values.

MEMBER STETKAR: Okay. Thank you.

MEMBER CORRADINI: And if I might just to clarify, so in these calculations the H vapor and H atmosphere essentially cancel out? Because I am assuming that I am what --

MEMBER MARCH-LEUBA: Not necessarily.

MEMBER CORRADINI: I want to know what their assumption was. I thought their assumption was that H vapor and H atmosphere cancelled.

MEMBER MARCH-LEUBA: Only if the temperature is higher than 212.

MEMBER CORRADINI: Correct.

MEMBER KIRCHNER: But that was the case that John was worried about.

MEMBER CORRADINI: As I understand, you're correct. But, if I understand, in all the assumptions it is assuming that it is saturated through the whole calculation. That is the other point.

MEMBER MARCH-LEUBA: Okay. That I do agree.

MEMBER CORRADINI: Okay.

MEMBER BALLINGER: So, at 1.73 feet for the SI pump, how much of that is CAP? In other words, if you were to remove CAP, what would that number do?

MR. MUN: I'm sorry, could you --

MEMBER BALLINGER: If you didn't use CAP, containment accident pressure, if you didn't use it, what would the number be changed to from 1.73 for the SI pump?

MR. MUN: I think this is not related to CAP because we assumed the vapor pressure and the -- we assumed the containment pressure is equal to the containment vapor pressure. That is an additional margin, but --

MEMBER MARCH-LEUBA: Yes, but that is CAP. That is a synonym with CAP. So, assuming that those terms are equal, it is assuming containment accident pressure.

MEMBER REMPE: I don't think we know is the answer to your question. Again, I don't think that you did analyses, but they got them presented to us that said what would happen if you didn't assume CAP. But, apparently, they decided that they need it, is I guess the answer to the question.

MEMBER BALLINGER: There is absolutely no discussion of that --

MEMBER REMPE: I know.

MEMBER BALLINGER: -- anywhere in the DCD.

MEMBER REMPE: I was curious. I mean, again, it would be interesting to know if you could explore some other assumptions and you wouldn't need to use it, but that has not been presented to us.

MEMBER BALLINGER: Not in the RAIs, either.

MEMBER REMPE: I know, because the staff has a position.

MEMBER CORRADINI: So, let me ask maybe, John, that maybe we defer this to Chapter 19.

So, in the risk assessment, you do do "what if" calculations about cooling the IRWST and recovering? In other words, if we asked these questions under the construct of the risk assessment, there are analyses that are available?

MR. J. OH: Yes, this is Andy Oh again.

In order for operator action time, we did some calculation under the consequence that the IRWST is not cooled, how long we can prevent the cold temperature to --

MEMBER CORRADINI: Okay. So, we can come back to it at that time. Okay. That's fine. We will come, then, because I figured you had done some recovery calculations.

Thank you.

CHAIRMAN SUNSERI: So, are we good to move on as a Committee? Okay, yes, let's go.

MR. MUN: In this slide I will talk about the hydrodynamic loads and pool temperature for the design. During an RCS pressurizing accident, the air would get started into the IRWST through the PSR response, may influence on the IRWST structure.

The hydrodynamic load analysis is to calculate the impacts on the air bubbles pressure on the IRWST wall. This provides the maximum pressure load for IRWST structure design.

The hydrodynamic load is calculated using the empirical model applied to the System 80+, which was previously approved by the NRC. And the pool temperature is calculated using the ANSYS-CFX computer code.

From the analysis result, it is estimated that the maximum pressure load following the air bubbles compression and expansion is 21.2 psi with a frequency of 4 hertz to 14 hertz.

For the pool temperature, it is estimated that both the average temperature and the local temperature of IRWST water are well-maintained below the temperature limit, 200-degree Fahrenheit required by the NUREG-0783. We have no open item on this analysis.

Next. In-service inspection and testing of ASME Section III, Class 2 and 3 components, are conducted in accordance with ASME Section XI and Operation and Maintenance.

Yes, next. Summary. The conclusion is as follows:

Yes, as you have seen, the APR1400 engineered safety features are designed to meet the United States regulatory requirements.

The containment integrity and the plant safety system are designed with the design margins to cover any postulated accident condition.

Thank you for your attention.

CHAIRMAN SUNSERI: Thank you.

So, any other questions KHNP from the Committee?

(No response.)

No? All right. Well, once again, we are making up good time on the schedule here. We do have some other meetings at 12:00 that some of the members have to attend to. So, I think at this point in time I would like to call for a lunch break, and we will resume the meeting at one o'clock with the staff presentations.

Will the staff be ready? All right.

So, we are recessed until one o'clock.

(Whereupon, the foregoing matter went off the record at 11:18 a.m. and went back on the record at 1:02 p.m.)

CHAIRMAN SUNSERI: All right, we're ready to recommence the meeting. So we're called to order.

The ACRS members present are the same as before in the morning session, with the exception of Member March-Leuba, who has excused himself. He's not feeling well so we'll continue without him.

At this point, we're ready to continue with the staff presentations on Chapter 6. I'll turn it over to Jessica Umana.

MS. UMANA: Good afternoon. We have another exciting presentation to keep you awake for the afternoon, Chapter 6.

I'm Jessica Umana, I am the project manager for Chapter 6, which is Engineered Safety Features. Today you'll be hearing from some of the reviewers involved with Chapter 6. You'll see here are the name of the presenters, the staff that you'll see presenting today.

And again, I always like to spare this slide a couple of seconds because, as you can see, this required a lot of coordination with a lot of reviewers to get this presentation, as well as the safety evaluation together.

I'm not going to read through this slide but these are the applicable SRP sections, where the staff conducted their reviews. And that's in the slide handouts that you have for your reference.

And now, without further ado, I'm going to turn it over to Matt Thomas and he'll be presenting on Section 6.3, which is Emergency Core Cooling System/Safety Injection System.

MR. THOMAS: Thanks, Jessica.

So yes, as Jessica mentioned, I'm Matt

Thomas. I was the technical reviewer for Section 6.3, Safety Injection System. You guys might remember me from the Safety Injection Topical Report presented a couple weeks ago.

First, I'd like to start off with telling you about the areas of review that the staff looked at for this section, the first one being the design basis review area.

The staff reviewed the APR1400 safety injection system to assure that the applicant designed it utilizing an appropriate design basis. We all know that he function of the typical large light-water reactor safety injection system is to provide emergency core cooling during accidents, which is sufficient to prevent fuel damage by removing decay heat and maintaining the core shutdown.

The staff examined the design basis accidents and the requirements for which the applicant based the safety injection system design on, as one area of review. Those accidents include loss of coolant accidents, steam generator tube ruptures, steam line break, and rod ejection.

The second area of review that staff looked at was the functionality of the safety injection system. This included review of the functional system arrangement to establish the similarities and differences of the APR1400 safety injection system with previously approved emergency core cooling systems.

The staff also reviewed the system reliability to understand the design's redundancy, independency, and single failure considerations, as well as the system's different power sources.

The staff also reviewed actuation signals and set points for their adequacy and consistency with the Chapter 15 analyses.

The staff also wanted to confirm, through this review, the system's -- safety injection system's automatic characteristics.

The staff also reviewed the safety injection system's functioning for different accidents to confirm the design basis adequacy. So, that's mentioned earlier. This included ensuring overlap with the CDCS system down to the smallest break and ensuring like different criteria, for instance, steam line break. Your criteria is reactivity control versus like a LOCA, where it's inventory control.

The staff also reviewed the safety

injection system's instrumentation and controls to confirm the system is appropriately instrumented and can be controlled as operated -- and operated as designed.

The staff also reviewed other components such as the safety injection pump, the safety injection tanks, the IRWST and the piping and valve design to ultimately confirm the adequacy of those designs and functions.

And lastly, the staff reviewed the safety injection system's capability for short and long-term core cooling, to confirm that it is appropriately designed to meet those short and long-term core cooling requirements, such as the applicant discussed earlier, mitigating boron precipitation in the long-term by hot leg injection.

Next slide. Thanks.

The next area of review was the protective features of the safety injection system. The staff, in this area of review, reviewed the system to assure adequate protection against gas accumulation. The staff also reviewed the system for protection against dead head operation and positive suction head to prevent cavitation.

As part of the net positive suction head issue, the staff audited their calculations to confirm that Reg Guide 1.82 was followed.

The staff reviewed and also collaborated with the Division of Engineering to assure adequate system seismic classification of piping and components of the safety injection system.

The staff also conducted an audit to verify safety injection tank relief capacity to ensure adequate over pressure protection.

Furthermore, the staff reviewed the safety injection system design to assure adequate harsh environment qualification considerations, as well as examining the failure modes and effects analysis to verify no single point vulnerabilities in the system.

And lastly, for this review area, the staff reviewed the safety injection system's design for appropriate placement in the plant to confirm protection against external and natural hazards.

And the last area of review for the safety injection system dealt with the testing, technical specifications, and surveillance requirements.

As part of this review, the staff looked at the ITAAC, with the goal of determining necessary -

- determining that they are necessary and sufficient.

The staff reviewed the pre-operational tests, with the goal of determining sufficiency of the tests for confirming system performance and capability prior to operation.

The staff reviewed the in-service testing considerations as well, to confirm the safety injection design provides for the capability to periodically demonstrate the capability during operation.

As I mentioned earlier, I was the reviewer of the safety injection tank fluidic device topical in that I had a cursory look at that topical report and the full-scale testing again, to make sure it is applicable to Section 6.3 as it is incorporated by reference. So like confirming the consistency of dimensions and characteristics of the tank to make sure that that's consistent.

And lastly, the staff reviewed the tech specs with the goal of determining the limiting conditions for operation, suitability, and adequacy, as well as the adequacy of the frequency and scope of the surveillance requirements.

Next slide, please. Now, I'd like to go

through the findings that were made as part of the review.

In regards to the design basis review area, the staff found that the safety injection system is appropriately designed for accident mitigation. I would also like to note that this safety injection design is extremely similar to other large light-water reactor emergency core cooling systems.

In regards to the functionality review are, the staff found that design includes all components for safety injection. Again, going back to the similarity between other operating ECCSs.

The design is reliable. The staff found that the design is reliable because it provides four redundant and independent trains of safety injection that no one single failure can inclusively inhibit. Each train is powered by its own independent, normal, and emergency power source and is adequately physically separated.

The safety injection actuation signals are adequate because they are independent and redundant and automatically initiate safety injection without operator action.

The set-points are adequate because they appropriately initiate safety injection before detrimental core conditions can occur, as shown in the safety analyses later, which you'll see. That's part of Chapter 15.

The safety injection system can function for a range of accidents because it is actuated via diverse signal, such as the low pressurizer pressure and high containment pressure signals and has employed centrifugal pumps whose discharge capacity is a function of the discharge pressure.

The safety injection tank fluidic device will also passively inject only when the reactor coolant system pressure drops below that set-point.

As I mentioned earlier, the safety injection system contains the appropriate components necessary to complete the safety injection function, which includes the water source, which is the IRWST in this case, in the safety injection tank water, the water delivery method, which are the pumps and the tanks, safety injection tanks, and the interface between the source and delivery method which, in this case, is the sump strainer.

The IRWST and the sump strainer detailed design review is done as a part of 6.2 but there is interface with 6.3.

Additionally, the safety injection system components, in particular the pumps in the safety injection tanks are adequately instrumented and controlled such that operators have a normal and backup means for controlling and monitoring the safety injection system from the main control room, as well as the remote shutdown room.

And lastly, the operational modes of the safety injection system are appropriate for short-term and long-term core cooling and reactivity control.

I will point earlier I think there is a question about what other plants use this hot leg injection for long-term core cooling. It was mentioned Westinghouse plants are -- and I am aware of at least plant in the United States, a combustion engineering plant that also has hot leg injection capability.

Slide 6, please -- or sorry. Next slide.

In regards to the protective features review area, the staff found that the safety injection system was appropriately with protection against gas accumulation via the safety injection fuel tank system and system vents.

Furthermore, the applicant has provided appropriate controls such as ITAAC and tech specs that initially and continually monitor for gas accumulation.

MEMBER SKILLMAN: Matt, would you speak more about that, please?

MR. THOMAS: Sure.

MEMBER SKILLMAN: Is the venting of hot points automatic or is that an operator-required action, please?

MR. THOMAS: That is an operator-required action.

MEMBER SKILLMAN: Okay, how do they know when to do it?

MR. THOMAS: I believe the tech spec surveillance requirement for that is once every 30 days but perhaps KHNP can shed more light on that.

MR. T. KIM: Yes, we have a surveillance requirement. This is Tae Han Kim from KEPCO. Yes, we have a surveillance requirement for every 30 days.

MEMBER SKILLMAN: Thank you. Okay, thank you.

MR. THOMAS: The staff found also that the safety injection pumps were adequately protected against dead head operation, via employment of a minimum flow line and there exists adequate net positive suction head margin under the appropriate worst-case accident conditions.

As I mentioned earlier, the staff audit confirmed that the applicant followed the appropriate methodology detailed in Reg Guide 1.82.

The safety injection system -- the staff found also that the safety injection system has been appropriately classified as seismic Category I. The staff also found that the safety injection system piping valves, the safety injection tanks area all adequately protected against over pressure via conservative pipe and valve design. So the pressure rating of piping and adequate relief valve capacity as confirmed in one of the staff audits for the safety injection tanks.

The staff also found that the design appropriately locates components to the extent practical, of course, outside of containment to protect against harsh environments. The staff further found that a single failure of any component of the safety injection system will not affect more than one train because of the degree of redundancy and independency built into this system.

And lastly, the staff found that the safety injection system was appropriately located within a seismic Category I building, which adequately protects against natural and external phenomena.

And for the last area of review, I'll go through those staff findings as well.

The staff found that the safety injection system ITAAC were appropriately developed from the Tier 2 design descriptions and figure and are necessary and sufficient to provide the reasonable assurance that the as-built system will be constructed and operated in conformity with the design certification and other applicable regulations.

And the staff, likewise, found the pre-operational test appropriately developed from the same system design description and figures and are sufficient for confirming system performance and capability prior to operation.

The staff found that the safety injection system is designed to allow in-service testing in accordance with the ASME operations and maintenance code.

And lastly, the staff found that the tech specs are technically adequate because the system's safety function, as analyzed in Chapter 15 can be readily achieved by meeting the limiting conditions for operation.

The surveillance requirements are also technically adequate because they verify operability of key components of the system whose failure could adversely affect the availability, reliability, and capability of the safety injection system.

Furthermore, the tech specs and surveillance requirements were found to have the appropriate bases, which were developed from, again, the same Tier 2 system design descriptions and safety analysis information.

There was one exception to this area of review and that was the APR1400 has a capability to recycle boron. The question was raised if you continually recycle boron and to the extreme you never batch new boric acid powder, what happens to the boron tin. Does it deplete? Does it put you outside of your safety analysis in terms of shutdown requirements? That was addressed as an open issue and is still being considered at this time by the applicant.

Next slide, please.

I would like to go over the conclusions now.

MEMBER STETKAR: Matt?

MR. THOMAS: Yes, sir.

MEMBER STETKAR: In no operating units in the United States have a boron recycle system?

MR. THOMAS: Can you repeat the question?

MEMBER STETKAR: Do any operating units in the United States have a boron recycle system?

MR. THOMAS: I do know that a lot of those systems have been in abandoned in place. I am aware another reviewer in my branch has talked about some operating experience that -- and I'm not sure if the plant still uses the recycling or if this was years ago that did indicate at least admin controls were appropriate for verifying the boron tin concentration in addition to the boron concentration. But in terms of if there are any plants at this moment that are currently still recycling boron, I'm not sure.

MEMBER STETKAR: Okay, I don't know. I mean I'm just honestly trying to --

MR. THOMAS: But yes, there has been operating experience where that boron tin does deplete

--

MEMBER STETKAR: Okay.

MR. THOMAS: -- and without any control for it and then it might put you outside of your safety net.

MEMBER STETKAR: Thank you.

MR. THOMAS: Yes.

CHAIRMAN SUNSERI: And Matt I have a question for you, too. And this is, I will have to set it up a little bit because I'm still, in my mind, trying to visualize how this containment refueling storage tank is configured and how sealed up it is or whatever.

So my mental picture of it right now is that it's a tank that is essentially enclosed, with the exception of the swing gate dampers that will allow you the pressure-relieving of vacuum breaking and that the source of supply to it is through this volume holdup tank or holdup volume tank.

So my question then becomes when you get an actuation signal and all of the safety pumps start drawing down the IWRST, do these swing -- does in particular the vacuum-relieving swing gate have to operate to allow breaking a vacuum in there so that you don't lose your net positive suction head? So, that's my question.

MR. THOMAS: Okay. Yes, I think I would have to defer that to the applicant. It's my understanding that yes, those swing gate dampers are there for that reason.

CHAIRMAN SUNSERI: So just before you pass it on then, so if that is indeed the case, then, I did not see any operability requirements for that gate to ensure that it's going to actually operate and allow that in a safety situation. So, that would be the full question.

MR. THOMAS: Yes, I'll take note of that. Thanks. I don't know if I can answer that question at this moment.

MR. LU: This is Shanlai Lu from staff. For 6.3, ECCS injection system review, this part of section review covers from the pump suction but all the way down to the downstream of the pump and isn't related to IWRST containment design. The staff is going to talk about that later.

Indeed, that was not a 6.3 part of section reviewed area where we begin starting from the suction line all the way to the pump and the discharge, and then also the safety injection tank.

And then okay, here we go. We have a staff to answer your question.

CHAIRMAN SUNSERI: Okay, thank you.

MR. TRAVIS: This is Boyce Travis. I did the review for 6.2, which also includes the IWRST. It is my understanding that those spring panels are not required to operate. The expectation is that effectively what will happen is the swing panels will operate because there will be a containment -- the pressure in containment will peak and those swing panels will operate. But I believe, and I will have to get back to you on this this afternoon but I believe that through the HVT, they can also sustain the containment because of where the spillway is located. The spillway is at containment pressure for the HVT. And so that's going to provide the containment pressure as vapor pressure for the IWRST as well.

MEMBER CORRADINI: So since you brought it up, I'm still trying to figure out why I need a swing panel. They strike me as useless because the evaporation rate -- I would do an evaporation rate calculation. I can't imagine I would lose that much that I wouldn't monitor and replenish, if necessary.

MR. TRAVIS: I think there's a couple of reasons. I can't speak to their design choice. I don't know that it's necessary, per se, but there is both an evaporation and a water purity concern in the IRWST in terms of I know the Structural Branch has asked the question about dissolved oxygen in the IRWST. And so they want to reduce the amount of oxygen in there as well but --

MEMBER CORRADINI: So it's more -- it's as much chemistry control as it is the evaporation?

MR. TRAVIS: That's my understanding of it.

MEMBER CORRADINI: Oh, okay.

MR. TRAVIS: I can't speak to the design reason for choosing to use the swing panels like that.

MEMBER CORRADINI: But during an accident, to get to Matt's question, you would be replenished -- whether it would be a little LOCA or a big LOCA, you'd still be dumping water in by another pathway, right, because the HVT is feeding the water into the --

MR. TRAVIS: That's correct, yes.

MEMBER CORRADINI: Okay. And as you said, I'm pressurizing. So those other panels would open.

MR. TRAVIS: Right. So there's both negative and positive vacuum. One of them opens, I believe, if containment goes 1.5 psi above the inside of the IRWST, the inboard swing panels open. If the IRWST is more than half a psi different than containment, the swing panel from the IRWST out into the containment opens.

MS. GRADY: This is Anne-Marie Grady in the Containment Systems Branch. I was going to say what Boyce just said.

In looking at the hydrogen combustion analysis because they do, in fact --

MEMBER CORRADINI: Yes, I think you've got to go to the microphone.

MS. GRADY: Oh. This is Anne-Marie Grady and I was looking at the swing panels in the IRWST because the POSRVs discharge to the IRWST and they do, in fact, open when Boyce said. They open inward on half a PSID and outward on 1.5 PSID. So, if there are extra noncombustible gases in there, it vents into the containment.

Wanting to know more of the physical details of the panels -- I'm sorry, the vents, these are vertical vents sitting on top of the IRWST and they have panels on the sides of them. I issued an RAI, which I can give you the ML number for, if you'd like it, and KHNP came back with a very detailed description of how they operate with physical dimensions. And of interest to me because of the combustion analysis was the fact that there are four of these vertical vents and in each of these vertical vent, there is a PAR in each one, that was my interest. That's how I got the information. But they are six feet by six feet. They are quite large, actually. So if you want the ML number, I can give it to you for the RAI. ML16189A321.

MEMBER CORRADINI: Thank you.

MEMBER STETKAR: But that doesn't answer the question of do they need to open so that the pumps do not cavitate. Under normal conditions, if I start safety injection, don't do design-basis accidents, don't do LOCAs. I start this for feed and bleed cooling. I open the valves. I start the darn pumps. I don't have any overpressure in the containment right now because the guidance doesn't tell me to wait until I get a certain overpressure in the IRWST before I start the pumps. It just says open the valves and start the pumps. The IRWST is subcooled and if it looks hermetically sealed container at that point, the pumps are not necessarily going to be all that happy.

MR. THOMAS: So yes, I think the question comes down to do the swing panels of the IRWST need to be included in tech specs for operability requirements.

MEMBER STETKAR: Right. That's right.

MR. THOMAS: Understood.

MEMBER STETKAR: The path between the HVT and the IRWST might save you. It might. It might I just I didn't think about that one either.

MEMBER CORRADINI: All right, thank you, Matt.

MR. THOMAS: Thank you.

So lastly, I'll go through the conclusions. Overall, the staff found that the safety injection system is adequately designed. The applicant has considered all necessary features of a typical large light-water emergency core cooling system and incorporated those features into the APR1400 safety injection system. The applicant's ITAAC and pre-operational tests are appropriate for confirming the initial performance of the safety injection system and the tech specs are adequate for verifying the continued reliability, availability, and capability of the safety injection system, except for the one open issue, boron-10 depletion. That is still being considered by the applicant.

And I think we will get with the Tech Specs Branch and Containment Branch to discuss the operability of the swing panels, if that needs to be incorporated.

Thank you for your time and that's the end of my presentation, pending any questions.

CHAIRMAN SUNSERI: Any other questions from the members? All right, thanks, Matt.

MR. THOMAS: Thanks.

MS. UMANA: Okay, were going to move on to Section 6.4 and 6.5 with Nan Chien and Michelle Hart.

MR. CHIEN: On result for the system review part, besides some for the radiation part.

The control room in Chapter 6.4 basically followed traditional control room design. So there was no surprises. And can we go to the -- okay. Next one.

Okay, we went through the design basis and it's fairly concentrated on TBD 19 and we found some problem with the tech spec as to testing the air conditioning unit and initially the design was tested ten hours. So now we talk about it and applicant realized that it only needs to test 15 minutes because that's an issue we resolved and we think applicant has, other than that, there is no other issues.

The system was in emergency mode and recycling mode.

MEMBER CORRADINI: Could you speak a little louder or bring it closer to you?

MR. CHIEN: Yes. It followed the typical design. You have emergency mode. You have recycling mode and in reviewing, we did not see any surprises for this design. So basically, we are satisfied.

Michelle has some radiation review.

MS. HART: I didn't have any issues in the radiation review, as written into Chapter 6.4. I mean they did evaluate the dose from the external plume and from the plume inside the control room and direct dose from the filters, which are outside the control room.

And so they did all that appropriately and according SRP 6.4 and also some guidance in Reg Guide 1.183.

However, there was a draft open item, which you haven't seen Chapter 15 yet. There is a draft open item in SER Section 15.0.3 on the modeling of the control room air intake in the DBA dose analysis. They have two diverse intakes and they periodically open both dampers after they initially close to check to see which intake has the less radioactivity and then they close the one that has more radioactivity in pull from the one that has less.

It was not clear to me that the design-basis accident dose analyses modeled that periodic reopening of both air intakes at the same time and so we had asked them a question. We found this through an ITAAC on the radiation monitors for the intakes. We did not find it in Chapter 6 or in Chapter 9.

So, we have asked them a question in Chapter 14 about this issue and we're still resolving this issue but preliminarily, it looks like the analysis does have enough margin to cover the periodic reopening. We just have to make sure that the COL applicants will understand that the analysis has certain parameters the amount of time that they can have it open.

So our findings, regardless of that, our findings are only confirmatory items. There are no open issues in Chapter 6. Contingent on these confirmatory items, and they're mostly to clarify system descriptions in tech spec bases and also in Chapter 6.4 pursuant to some RAI responses they had to change some information or clarify the system operation. Therefore, we find the system adequate and acceptable.

Do you have any questions on that particular aspect?

I will go ahead and discuss Chapter 6.5.4, which is ESF filtration systems, basically. There are three systems that have filtration systems and they were described earlier by KHNP. We evaluated them for conformance to Reg Guide 1.52. We evaluated the carbon adsorbers and the HEPA filters and we also evaluated instrumentation requirements and the release point radiation monitors and verified that they had appropriate ITAAC and technical specifications.

The only, there were no open items. It was a fairly standard review. There was one confirmatory item to clarify the carbon adsorber description in the design certification document. And contingent on that, we do find the ESF ventilation systems and related filtration capabilities acceptable.

Next slide. For Chapter 6.5.2, this is the review of the containment spray system and as a fission product removal system. This is not the review of the system itself but of its capability to remove fission products.

As described earlier by the applicant, it does -- they do take credit for particulate spray by iodine -- particulate iodine removal by the sprays, elemental iodine deposition on the wetted surfaces. This is all reliant on the IRWST pH analysis. We did audit their calculations and also did confirmatory analyses and we looked at the amount of TSP buffering and made sure that that was appropriate, especially for iodine retention in the IRWST so it doesn't get rereleased into the containment.

There was one confirmatory item and that was also to clarify the description in the DCD and some of that description was to tell us how the coolant was moving from the containment through the HVT to the IRWST. I was confused by that aspect as well.

But contingent on their clarification of that description, which they had provided a draft version of that in RAI response, we do find the description of the containment spray system and modeling of the related fission product removal acceptable.

MEMBER POWERS: Michelle, did you audit their calculations of acidification?

MS. HART: I did not. I was not the reviewer for the pH control. The reviewer was from the containment -- I mean the Materials and Chemical Branch and he has moved to NMSS. But I do have someone here who can speak to, generally, these types of analyses.

MR. MAKAR: This is Greg Makar from the staff.

In the Materials and Chemical Engineering Branch, we do -- as Michelle said, I didn't do this particular review but normally we would ask for the buffer as well as any acidification generated by hydrolysis of things like containment or cable insulation and jacketing, as well as the generation of nitric acid from radiolysis. And I have not -- I can't say whether -- I can't confirm that that was done in this case but that's normally how we do it.

MS. HART: And I know in the discussion earlier, you were asking about the source term that was used for the radiolysis and I don't have any information on that either but I do not know if it was the TID-14844 source term or if they had used the NUREG-1465 type source term because their design-basis accidents in Chapter 15 do use Reg Guide 1.3.

MEMBER POWERS: Well, there's a recommendation. There's a topical report on what to expect.

MS. HART: Right.

MEMBER POWERS: And it's dominated by the xenon and krypton. So, it's not very crucial whether you use TID or --

MS. HART: Right.

MEMBER POWERS: They both have exactly the same --

MS. HART: They are about the same, yes.

MEMBER POWERS: -- noble gases.

The really tough question is -- the harder questions are what you use for g-values on the cable insulation, the HCL release, and the g-values for nitric acid formation in a steel atmosphere. But I guess that --

MS. HART: I, unfortunately, can't answer that.

Okay and so then the final section that I will be discussing today is Section 6.5.3 and this is fission product removal structures. And the main structure that they have for fission product removal is the primary containment and they do take credit for natural deposition with the powers ten percentile natural deposition model. And that's for aerosol removal.

And they did have a discussion of the containment building ventilation system, however, they did not take credit for that for fission product removal.

The design features that control fission products during the postulated accidents were found acceptable and do meet the requirements. I did ask them about the applicability of the Powers Model for their particular design, since it was based on correlation to currently operating plants and they did provide information on that. But I didn't have any other questions on aerosol deposition.

Any questions?

MEMBER CORRADINI: I'm trying to think of a question to discredit the Powers Model but I can't think of one.

MS. HART: I know it's kind of difficult to believe we still use that, right?

MEMBER CORRADINI: That was good.

MS. HART: That is on the record. I am sorry. It's a standard question I have for all of my plants. Why does it apply to you?

MEMBER POWERS: You know you like Play Doh, it lasts beyond its years. That's P-L-A-Y-D-O.

MEMBER CORRADINI: It's D-O-H but --

MEMBER POWERS: Could you tell me where the Human Resources Office is? I think I'm in a hostile working environment here.

MS. HART: Sorry about that.

MEMBER POWERS: We had better move on.

MS. UMANA: Well that's all we have for our 6.4 and 6.5.

So, while we transition staff out, I'm just going to introduce the next section. We're going to have 6.1.2, 6.2.1.1, 6.2.1.5, and 6.2 presented by Greg Makar and Boyce Travis.

MR. MAKAR: Beginning with Section 6.1.2, this is coatings and other organic materials and this is a section where that describes the types of organic coatings, inorganic coatings, which is inorganic zinc, and other organic materials.

This is done primarily as a way to see if the coatings that are in containment or communicated with the ECCS are following the guidance in Reg Guide 1.54, that's the most common way to meet our regulations with respect to coatings. And that Reg Guide covers a variety of quality assurance aspects, as well as personnel qualification and certification and condition monitoring.

The other organic materials also contribute to acidification, as we just discussed. That's normally not reviewed here but it's incorporated and we've heard in other reviews such as how much pH buffer is required in containment.

So in this review, we have found that they do follow Reg Guide 1.54 with no exceptions. The coatings are, therefore, Service Level I. All containment coatings meet the Service Level I requirements. That means they've been qualified under DBA conditions and are considered safety-related.

There were no open items in here but we had some questions for them. We required clarification on what the coatings were but the definitions they were using to confirm if they were like conformed to the reg guide description of the different coating systems. What substrates and coating materials were used in what places and how much.

The evaluation of these coatings as a debris source is done in Section 6.8, which we'll talk about a little later. And in addition to what was clarified in the DCD, there's also a requirement for the COL applicants to manage coatings that maybe weren't -- that were applied in containment that did not meet Service Level 1 requirements, as well as describing the coating program that their plant will have and the implementation mile stones and tracking the amount of organic cable installation and jacket material.

MR. TRAVIS: All right. So moving on to Section 6.2.1.2, which is the subcompartment analyses, there are six subcompartments in containment that contain piping that is not subject to leak before break considerations, which obviously excludes thing like the reactor cavity of large piping that is subject to leak before break.

In order to perform their calculations, the applicant used COMPARE, which was previously reviewed by the NRC for this application and approved.

The staff audited the applicant's calculations. They used appropriately conservative discharge models to calculate the mass and energy release form the piping in these subcompartments.

The coefficients and heat transfer characteristics corresponded with the guidance that we provide and they further added a one percent margin, so effectively multiplied by 1.01 for the mass and energy release.

There were no open items related to this section. As part of our review we performed a confirmatory analysis of a sample subcompartment, in this case the pressurizer spray valve room. We calculated a peak differential and we used MELCOR to do this. We calculated a peak differential pressure margin of 1.43, which agrees pretty well with the applicant's calculation of -- 1 point -- they get .40. I get .41 when I run their numbers but either way, very close.

As such, we found that the applicant's calculation for subcompartment pressures was acceptable, as they met the requirements associated with GDC 4 and 50 and our confirmatory analysis agrees reasonably well with what they provided.

MEMBER CORRADINI: So I can't pull it up as quickly as I want to but it's a high energy --

MR. TRAVIS: So something like at the top of the pressurizer -- in this case, the pressurizer spray valve room, it's the line that leads to the IRWST where they -- their POSRV line. So that --

MEMBER CORRADINI: So that's a break there.

MR. TRAVIS: Yes, exactly. So we're talking about like on the order of four- to nine-inch pipe, very short sections.

MEMBER CORRADINI: I'm just trying to understand where you did the confirmatory analysis.

MR. TRAVIS: Okay, yes, in this case, it was the top of the pressurizer spray valve room, one of the POSRV lines.

MEMBER CORRADINI: Is that one of the limiting locations for in terms of equivalent qualification?

MR. TRAVIS: Well so for --

MEMBER CORRADINI: Or for mass and energy release. Excuse me.

MR. TRAVIS: Yes, this was the most

limited case. As part of the SRP guidance, we specified that they should have a 40 percent margin. In this case, they were very slightly over 40 percent. So this one of the ideal choices for doing confirmatory analysis.

There is another subcompartment where they have I think a 41 percent margin. I think that's in the steam generator subcompartment.

So yes, to answer your question.

MEMBER CORRADINI: And then, just to get the particulars now, I've got to find it. I saved it somewhere.

When you do the 1.405 or the 1.43, where are you computing that at the peak pressure or the initial bump? Because these typically have a shape or they bump up, they come down, and they come back up.

MR. TRAVIS: Actually for the subcompartment analyses, these curves are generated over the course of about three seconds. It's a very sharp peak and then it comes back down and sort of oscillates around a much lower value. So the first thing they show peak --

MEMBER CORRADINI: In this case.

MR. TRAVIS: In the case that I looked at, yes.

MEMBER CORRADINI: So it's the first peak.

MR. TRAVIS: The first initial peak is much larger than the others.

And I will point out a typo on this slide. It should be design DP over calculated DP, rather than calculated DP over design DP.

But yes, it is -- the initial peak, for the calculation I looked at, it was much larger than any subsequent peak.

MEMBER CORRADINI: Okay.

MR. TRAVIS: And before we move on to the next slide, there was a question asked earlier about -- I asked an RAI about the normalization schemes related to 6.2.1.2. I'll note that for peak containment pressure and temperature, it's conservative to assume a single node because all of the energy gets deposited in that node and there's nowhere to store energy if it's elsewhere. And so you get a higher peak containment pressure and temperature by using the single node.

In the subcompartment analyses you want to nodalize them as finely as possible so that you can make -- create the largest DP between nodes. The reason I asked the question is because our SRP specifies that they do a nodalization sensitivity scheme. They didn't. And so part of the response, we went back and looked at some other designs. In general, if you nodalize the subcompartment along anywhere where there's a flow restriction or a reduction in area, you get a reasonable response that isn't going to change much if you nodalize it any further. They did that and so we found that it was acceptable.

MEMBER REMPE: They did that? I thought from when I read this that they basically said that the delta P wasn't very much. I didn't realize they had gone and looked at other designs.

MR. TRAVIS: So, no, that was as part of our review. We looked at other -- we looked at what we've accepted in the past.

MEMBER REMPE: Okay.

MR. TRAVIS: For theirs, they just took the nodalization along anywhere there was a reduction in area, which is the generally acceptable method for doing a nodalization scheme for something like this.

MEMBER REMPE: You weren't tempted to try and -- I mean MELCOR could have more fine nodalization and even later on in some of the other calculations, they used the same nodalization or they said they used something very similar. And why not try and do something a little more fine than with your tools?

MR. TRAVIS: I know MELCOR -- like the case that I used in the pressurizer spray valve room, because of the way MELCOR is like a lumped parameter volume code, I'm not going to see a whole lot of difference if I subnodalize mine.

For the containment, we actually do have two models or we have a one node model and a multi-node model. For the purposes of peak pressure and temperature, the multi-node model produces lower pressures and temperatures and so we don't talk about those results in the safety evaluation because they're not --

MEMBER CORRADINI: Do you know why that is the case? That doesn't make sense to me.

If I have a large open volume --

MR. TRAVIS: So part of the reason -- and this is getting a little outside the scope of the review. Part of the reason is that the subcompartments if there is dead-end volumes for water to be stored in, you'll store massive energy outside of where -- outside of the greater volume. And so it won't participate in increasing the pressure in the peak node. But that's only part of it and I would have to do substantially more analysis to give you a full answer to that question.

MEMBER CORRADINI: That's fine. That makes sense.

MR. TRAVIS: So moving on to 6.2.1.5, which is Minimum Calculating Containment Pressure, this is an Appendix K requirement for the reflood phase. They want to calculate or the goal is to calculate the lowest possible containment pressure to be used as the input for your ECCS calculations.

To perform their calculation, the applicant used CONTEMPT4. That's a fairly standard code for the purposes of minimum containment pressure. It's been used multiple times in operating facilities.

As part of our review for this section, we found a number of errors in the table for massive energy release. The values that it was producing were I'll say non-physical. So we asked an RAI.

As part of resolving this question, the applicant updated their tables, their heat sink model and a number of other things and re-performed the analysis for this. The analysis that they redid actually ended up with a slightly, I'll say a slightly higher containment pressure than what they had in the DCD initially. So it showing I will say less conservative but it reflects -- it's a better reflection of the actual values, rather than the incorrect values that were in the DCD.

Because of the inconsistencies in the table, I performed a confirmatory analysis on this section. The results of that are on the next slide.

MEMBER CORRADINI: This was with the same nodalization or just a big --

MR. TRAVIS: This one is just a big volume with MELCOR. Their CONTEMPT4 is similar. It's not like WGOTHIC in this case.

The MELCOR is in the green dashed line on this slide. The updated RAI response it says P DCD. It is really what will be Rev. 1 of the DCD. What's currently there is in the blue dots.

A lower pressure is I will say the lower you get the more conservative you are. So the only -- for the purposes of this, we get very similar results to them outside of that peak where we're within a couple of percent. That has to do with just different modeling choices, a different method of modeling the containment spray system. And I will note that this MELCOR calculation is what I'll call Rev. 1 of our MELCOR calc. We've been going back and forth with the applicant to update the heat sinks because there's been some discrepancy. And you'll hear from another of our reviewers for containment pressure and temperature. And so that may account for some of the other discrepancies in this curve.

MEMBER REMPE: Maybe the other reviewer will talk about it but there was an RAI going back and forth about the volume selected. And I understand the applicant this morning, too, that people picked some things, the values to be different because of trying to be conservative.

MR. TRAVIS: Okay.

MEMBER REMPE: But has someone from the staff tracked through all these different numbers for volumes that have been cited and they are comfortable that the correct ones have been used?

MR. TRAVIS: Well for all of our Chapter 6 analyses we definitely collaborated on these. I know for a fact that the volume in 6.1.5 and the volume in

6.2.1.1A are different because one is trying to minimize containment pressure and one is trying to maximize containment pressure. So as part of their RAI responses, they provided us with what I'll call the nominal expected containment volume, the minimum containment volume, and the maximum containment volume.

And so we found that they appropriately used the minimum containment volume for peak pressure and the maximum volume for minimum pressure. And so we're comfortable with what's being done in Chapter 6. I can't speak to whether -- you talked about the MAAP. I can't speak to anything with regards to the MAAP code but we do collaborate with the PRA Branch on the MELCOR models.

MEMBER REMPE: That's good to hear. Thank you.

MR. TRAVIS: You can go to the next slide.

So moving on to 6.2, which is Containment Heat Removal Systems, this will cover spray, the IRWST and long-term cooling or GSI-191, as it is commonly referred to.

First of all to talk about the containment spray system, as mentioned by the applicant, there's two 100 percent capacity cooling trains sourced from the IRWST.

The nozzle orientation was discussed a little earlier in the presentation. They used I believe there are four headers per train, so a total of eight areas that have nozzles to spray. These nozzles are oriented in a variety of different orientations and in our review, they have to cover the entirety of the containment area above the operating deck. They conservatively assume that no spray goes below the operating deck. There is an emergency containment spray system below the operating deck where they can spray below the operating deck that they don't credit.

The efficacy of the spray system at reducing the pressure is discussed as a totality with the rest of 6.2.1.1.A. So you'll hear more about containment pressure response as part of that.

I will say that as part of this section we asked an RAI on the spray droplet size spectrum. They did provide us with what -- I don't know if it's the vendor spec or the expected specification for the droplet size but it includes the droplet size regime down from like 100 microns up to something like 590 microns. The average is expected to be a little under 400 microns, I believe. In their containment spray analysis, they assume 1,000 microns for the size of the droplet. So that's conservative to what the droplet size spectrum for reducing pressure and temperature.

As part of the section, there's a COL information item. I'll discuss it a little more in the following slides.

So also as part of this section we reviewed the IWSS, which is the in-containment water storage system. That's the combination of the IRWST, the HVT, and all the holdup volumes that participate in this analysis.

As mentioned earlier, the HVT contains a trash rack at the top or where the water comes into the HVT there's a trash rack which is like a large area screen, if you want to call it that, in vertical screens there.

MEMBER CORRADINI: How tall is it?

MR. TRAVIS: The screen, I believe -- I'd have to get back to you with exact numbers. I don't want to --

MEMBER KIRCHNER: Well this is a good

point, maybe, to ask my question.

MR. TRAVIS: Sure.

MEMBER KIRCHNER: The schematic that KHNP provided seems to indicate that the trash rack is at elevation 107 and six inches and the containment floor is at 100.

MR. TRAVIS: I was going to say six feet.

I was going to say six feet is the number that stuck in my head.

MEMBER KIRCHNER: Okay.

MR. TRAVIS: So either six or seven feet.

MEMBER KIRCHNER: Let me use this to ask my next question, then. Have you looked at the volumes of water that are in the IRWST, the HVT, and what the trash rack could, assuming it's blocked completely, how much water would they hold up? And would it hold up enough water to vapor lock the HVT spillway?

I'm always concerned about -- I'll make an observation or a comment.

MEMBER CORRADINI: You're worried about the same thing, yes.

MEMBER KIRCHNER: I don't like designs that have upside down use because they are prone to often not letting the water go where you want it to go because of vapor lock or level problems and such.

So has someone done the mass balance to look at do you have enough water to keep that HVT intake covered? It's at elevation 88. I don't know enough about the circumferential dimensions to do a back of the envelope calculation to see if it would get uncovered.

MR. TRAVIS: I will make a number of points. Hopefully, some of them will answer your question.

The IRWST is substantially larger than the HVT. The IRWST is basically, like you said, circumferentially goes around the containment. And the HVT is a very small room on the inside that passes the water out to the IRWST.

As part of this review, we did look at what I call a holdup volume analysis where we look at all the possible data and volumes and heights of water that could exist in the containment. The results of that has the minimum water level in the IRWST that then passes input for like the NPSH analyses. We did not assume that it was possible to fully block the trash rack because the trash rack openings are substantially larger than a strainer.

MEMBER CORRADINI: So are we talking about holes this big, holes this big, or holes that big?

MR. TRAVIS: Closer to your first.

MEMBER CORRADINI: So it's like a chain-link fence.

MR. TRAVIS: Yes, functionally closer to that. I could get you exact numbers on that, if I go back to the technical report.

For reference, the strainer holes are a little under a tenth of an inch and the HVT holes are on the order of inches, rather than a little under a tenth of an inch.

MEMBER CORRADINI: Okay.

MR. TRAVIS: So --

MEMBER KIRCHNER: Is there a tech spec on what the minimum level in the IRWST is?

MR. TRAVIS: Yes, there is a tech spec on that and that's what's assumed -- that's what's passed in all the analyses that we look at.

MEMBER CORRADINI: And you take that as the NPSH -- you take that elevation to compute your minimum.

MR. TRAVIS: That's correct. It's merely

an input to the minimum NPSH calculation.

MEMBER CORRADINI: And what's that variation from maximum to that allowable minimum?

MR. TRAVIS: So I want to say feet in the IRWST it is something like 15 or 18 feet of water in the tank. So on the order of --

MEMBER KIRCHNER: I can tell you. It's 86 minus 73. I'm using the center line of the suction for the -- as

MR. TRAVIS: Okay, yes, so the minimum water level in the IRWST I believe is 4.75 feet. That's the minimum of all the holdup calculated. The maximum water level -- I'd have to go get the exact numbers from --

MEMBER CORRADINI: That's fine. I was just trying to -- since we are going to ask you questions later on about what it is --

MR. TRAVIS: I understand.

MEMBER CORRADINI: I'm trying to put in that what if with this what if.

MR. TRAVIS: I have the report under my seat. I could start pulling up figures.

MR. MAKAR: The trash racks are seven feet.

MR. TRAVIS: Seven feet tall, yes.

MR. MAKAR: Seven feet tall. And the open is one and a half inches.

MR. TRAVIS: Yes, 1.5 inches.

MEMBER KIRCHNER: So is there a possibility to -- it's not a good term but I'll use it -- vapor lock that connection between the HVT and the IRWST?

Say you have a low level and the pumps start, they draw the level down very quickly and you sit there and cavitate.

MR. TRAVIS: So the minimum water level in the IRWST is below the U-bend in the HVT.

MEMBER KIRCHNER: Yes, I see that.

MR. TRAVIS: And so the HVT is not -- the IRWST is not going to be drawing directly on the HVT, if that makes sense, unless --

MEMBER KIRCHNER: I understand that.

MR. TRAVIS: Okay.

MEMBER KIRCHNER: But when it all comes back, if it comes back --

MR. TRAVIS: The expectation -- I mean based on the calculations we've done, the water -- there are no locations the water should be able to go other than into the HVT and then flow through the IRWST. We did not look at the potential to vapor lock that U-bend with debris as part of our --

MEMBER KIRCHNER: Okay, thank you.

MR. TRAVIS: Where was I on this slide?

MEMBER CORRADINI: So just so I understand your answer to Walt, so your point is that there's more than enough water, even at its minimum level, and given the fact the HVT is so small and the fence has got large enough holes that I would always be filling the HVT and feeding under all conditions you thought of. You couldn't think of way in which the HVT would be water-starved.

MR. TRAVIS: That's correct, yes.

MEMBER CORRADINI: How much -- then let me ask you a different question.

If it was totally empty of water -- it starts off empty.

MR. TRAVIS: That's correct as well.

MEMBER CORRADINI: Okay. So is there any hydraulic calculations that the applicant showed you that made sure that they -- how much water do I need to be above the U-bend to essentially fill and --

MR. TRAVIS: So the holdup calculation

assumes that the U-bend at the what I'll call the midpoint of the U-bend is where the dead volume in the HVT is.

As part of --

MEMBER CORRADINI: So it's like a spillway. It's big enough this way that this thing rises up and just kind of inches over.

MR. TRAVIS: That's exactly right. I mean it is a spillway. That's how I referred to it before.

MEMBER CORRADINI: Okay. And the benefit -- I'm sorry. I don't want to redesign it but I just want to understand it.

MR. TRAVIS: It's okay.

MEMBER CORRADINI: The reason that they turn it down is, again, for debris -- minimization of any debris carryover versus just having a spillway.

MR. TRAVIS: Well I mean I can't speak to their reason for their design choice. I'll say that in their analysis they often assume a more conservative debris level. They don't take credit for any ability of that HVT or spillway to hold up debris. All of the debris gets to the IRWST with the exception of pieces larger than 1.5 inches that are blocked by the trash rack.

MEMBER CORRADINI: Thank you. Thank you.

MEMBER KIRCHNER: But not to belabor it, is it when you did that, I'll call it a dynamic mass balance to look at holdup, is it possible for the pumps to start cavitating and not recover?

MR. TRAVIS: So --

MEMBER KIRCHNER: Because just assume that the IRWST is at the minimum level. I don't know how many minutes it would take for the recirculation of everything that's been sprayed and/or injected to find its way back to the HVT, assuming minimal holdup by the trash rack. But could you just suck the IRWST level down such that you get a fairly low net positive suction head and sit there and cavitate?

MR. TRAVIS: So not but -- I'll say no but I'll answer your question with some time line related pieces.

So the holdup analysis that we did assumes all the limiting cases that exist at peak containment pressure. By the time you get to the point where you've pulled the level of the IRWST down to where you're worried about or it's at or near its minimum level, a lot of the -- like so condensation on surfaces, vapor that's in the containment atmosphere, all of that, the pressure and temperature of the containment have come down somewhat. And so the actual level in the IRWST is going to be higher than that minimum level at the time that you reach where you're going to be pulling that suction on the IRWST level.

MEMBER CORRADINI: So let me take one more swing at it just so I'm sure.

I thought you were going to -- because I -- the HVT is like this and the IRWST is like a donut.

MR. TRAVIS: Yes.

MEMBER CORRADINI: So this guy fills very quickly by any return from any sort of loss of inventory.

MR. TRAVIS: Yes, once you've started the return process, which does take a few minutes but it's not such that you're draining the entirety -- okay. Sorry.

MEMBER CORRADINI: He's looking at -- what I thought Walt's after is the delay between the time things start coming apart and they find their way to the HVT and how much the water level falls so that you don't starve the pumps in that time period.

MR. TRAVIS: Sorry I didn't get to that

immediately, then. Yes.

I guess I'll say we didn't do an explicit analysis for all these timings but the orders of magnitude for the times are such that it wasn't a big concern with regards to filling those volumes up.

MEMBER KIRCHNER: Thank you.

MEMBER SKILLMAN: Just to add to this, what I see on your design control document is that the operating water volume in the IRWST is 86 -- 87,000 cubic feet.

MR. TRAVIS: That sounds about right, yes.

MEMBER SKILLMAN: And the volume of the holdup tank is 7,500 cubic feet --

MR. TRAVIS: Right.

MEMBER SKILLMAN: -- one-tenth.

MR. TRAVIS: And so that's the total volume. I mean yes, the total volume of the hold tank.

I will say and I have to go back and get exact numbers again with regards to the dead end volume of the holdup tank is something like half of that. And so --

MEMBER SKILLMAN: My point is if you inject even a fraction of the higher WST you have to be cascading into the --

MR. TRAVIS: Well so it --

MEMBER SKILLMAN: -- to answer Dr. Kirchner's question.

MR. TRAVIS: Yes, in the LOCA case, I guess I'll say in the LOCA case you pressurize -- a lot of the water actually pressurizes containment, sits on surfaces. So maybe you drain 20 percent out of the IRWST just before you start to get that return but it's nowhere close to.

Okay so as we talked about earlier, the IRWST is sealed. It has swing panels to accommodate pressure differences both internally and externally. The strainer or the POSRVs for the pressurizer are submersed in the IRWST rather than being like a reactor coolant drain tank in some designs. So you return that water immediately.

And we have looked at the dynamic effects due to pressurization. The use a very similar method to BWR suppression pool and it's been approved by the staff.

And then, obviously, the IRWST is key in long-term cooling and we're going to talk about that more in the next few slides. So go to the next slide, please.

Okay, so with regards to GSI-191 items, the break selection for this design is fairly straightforward. Because they assume only latent fiber, the limiting break is effectively what break can generate the most coating and RMI debris resulting from a break. So where is the largest concentration of those debris sources? It turns out that's in the steam generator room, usually.

We looked at the design drawings and where their pipes could possibly rupture and found that they did their analysis in accordance with NEI 04-07.

The steam generator room near where the hot leg enters the steam generator I believe is generally the limiting case for RMI and coatings.

ZOI was performed and consistent with the NEI 04-07. They looked at material-specific ZOIs for RMI, epoxy coatings, and inorganic zinc.

We asked an RAI based on some experience with other plants about other sources of fibrous debris that could be generated as a result of a break, not latent fiber, such as cables. We found that some plants use -- have used fibrous insulation in their cables. The applicant responded that as part of their foreign materials exclusion program, no cables or other sources of fiber are allowed to be located within the containment. And so that satisfied our concern.

Debris characteristics related to GSI-191, the RMI is assumed standard 25 percent small, smaller pieces, 75 percent larger chunk pieces, consistent with the NEI 04-07.

The assume 100 square feet of strainer area is sacrificed due to various materials in containment like labeling, tags, tape, things that would get to the strainer and cover the holes. That assumption is consistent with other designs we've seen in the past. They're on the same order of other designs we've seen in the past.

MEMBER CORRADINI: That's the same as what? I'm sorry.

MR. TRAVIS: Other designs we've seen in the past, on the order of 100 feet.

MEMBER CORRADINI: But that's a judgment.

MR. TRAVIS: That's correct. It is an engineering judgment.

MEMBER CORRADINI: So they're just sticking with historic judgment.

MR. TRAVIS: So yes. The reason for that --

MEMBER CORRADINI: That's fine. I just wanted to understand the basis.

MR. TRAVIS: Yes, it's judgment. And as part of other conservatisms we'll see later on, it's assumed that all of that is located on a single strainer and the other strainer is assumed to be not pulling anything. So I mean it's substantial -- it would be substantial -- I believe it's substantially conservative, once you consider all the other assumptions that it made in terms of looking at the strainer.

MEMBER CORRADINI: But the reason I'm asking that is eventually you're going to get to a K loss or a head loss that then figures into the eventual calculation, which we have seen the result of.

MR. TRAVIS: That's correct.

MEMBER CORRADINI: And this essentially affects a large part of that head loss.

MR. TRAVIS: Yes. Yes, I mean you've cut off a sixth or something of the strainer area.

The only fiber input for the plant is

latent fiber. They use a value of 15 pounds mass and that will be controlled by a containment cleanliness program. That acceptance criteria was added as a result of an RAI.

The NEI 04-07 standard is 30 pounds mass. So, we, after some deliberation, have given the acceptance criteria in the containment cleanliness program to operate with more than 15 pounds mass and the containment would be outside the design basis. So we found that acceptable.

Move on to the next slide.

So transport for this plant, again, these are fairly straightforward assumptions that are relatively easy to confirm. All debris reaches the containment floor. None is held up.

All non-RMI debris gets to the IRWST and, therefore to the strainer.

Large RMI, larger than the inch and a half for the trash rack doesn't get to the HVT. All smaller RMI is assumed to settle out on the floor of the HVT or the IRWST.

In the context of the design, we found these acceptable. So the one assumption they are making that is not immediately obviously conservative is that they assume that the RMI settles out.

Based on the settling velocity, the design of the strainer and the likelihood that there's going to be some settling of RMI leading up to that, we found that acceptable.

MEMBER CORRADINI: So let me make sure. I had it but I know what page it's on, 800 and something. The location of the strainer looking on a top view compared to the HVT is not one-to-one. It's off by 90 degrees. Am I remembering correctly?

MR. TRAVIS: So the HVT -- so I believe the strainer, the four strainers are located --

MEMBER CORRADINI: They're like 60 degrees away from the --

MR. TRAVIS: That sounds about right, yes, I couldn't give you --

MEMBER CORRADINI: At 180 degrees, they're equidistant.

MR. TRAVIS: Yes.

MEMBER CORRADINI: The two are equidistant from either side.

MR. TRAVIS: That's correct.

MEMBER CORRADINI: So it's the longest possible distance when I would -- if I were to equally space the two strainers. So I have got to come out of the HVT, feed the IRWST and the junk has got to make its way 60 degrees around the bend.

MR. TRAVIS: That's correct.

MEMBER CORRADINI: Okay.

MR. TRAVIS: And the expectation is that I mean also the strainer -- I mean there is space between the bottom of the strainer and the floor. So, there's room for --

MEMBER CORRADINI: It's sitting up.

MR. TRAVIS: Yes, it's not like it's going to build up like a mountain on its way up to the strainer.

So upstream effects, the staff reviewed -- and this includes the holdup analyses I spoke about earlier. We reviewed and audited their holdup analyses. There were some, as was mentioned earlier, there have been some inconsistent numbers between technical reports, places in the DCD and their analyses. We asked RAIs to make sure that we understood the correct minimum value corresponding with their analyses that we audited for. And that minimum water level is 4.75 feet above the IRWST floor.

In-vessel will be discussed later on as part of Chapter 15, assuming that's okay with you guys.

So getting into strainer head loss, the head loss is based on full debris transport to the strainer. In practice, this is limited by the latent fiber. There is more than enough chemicals to form a particulate or a mess with the fiber and so the fiber is the limiting term here. Once you have accounted for the reduction area due to tags and what not.

MEMBER CORRADINI: In theory, I understand what you just said but for the newer members and maybe for the older that can't remember, can you re-educate us, please?

MR. MAKAR: Chemical effects refers to the possibility of precipitation of compounds that would have a say gelatinous or very viscous properties that would in and of themselves just move through the solution but when they reach a fibrous bed and one has a combination of fibers and particulates, especially, it's very good at filling in those gaps and only a little bit of that precipitate is required to cause high head losses.

So if you don't have fiber, if you can't form a fiber on the screen, you don't really have to worry about the chemical precipitous until they get into the fuel. But if you do have a fibrous bed, then it won't take much chemical precipitate to cause high head loss.

MEMBER CORRADINI: And that, just so we connect the dots, that is assumed and then leads to 100 square foot assumed as the blockage.

MR. TRAVIS: Right. I mean so as part of -- the basis for this was testing that they did. I witnessed some of that testing. The assumptions that lead into the analyses are that a single strainer is where all the suction -- so all the fiber has gone to a single strainer and the all the suction is going through that single strainer. So the head loss is based on the test head loss values for fiber and particulate that form on the strainer and effectively cause that interruption or not interruption but resistance to flow.

MEMBER CORRADINI: And so let me ask this. I've got four strainers. The four strainers are interconnected or am I feeding four different --

MR. TRAVIS: So --

MEMBER CORRADINI: I'm asking the question about is it worse to block one strainer at 100 square feet or four strainers at 25 square feet.

I'm trying to understand the minimum blockage, the maximum effect on head loss with the minimum amount of blockage.

MR. TRAVIS: So I guess for the purposes of --

MEMBER CORRADINI: Do you know what I'm asking?

MR. TRAVIS: Yes. Yes, I understand.

So for the purposes of what we're looking at is if -- I'm going to use some example numbers that may or may not be exactly right. I believe each strainer has 600 square feet of area to allow flow through. So they are effectively saying well, all of the debris is going to be located on 500 square feet of strainer area because only that one strainer is going to be pulling, rather than what you're saying if all of the strainers participated, you'd have debris spread around 2,300 feet of strainer area. And so less area allows for a larger fiber bed or a larger thickness of fiber and particulate, which creates a higher head loss.

MEMBER CORRADINI: Say that last part

again, please. I'm sorry.

MR. TRAVIS: So less strainer area is assumed to participate because the more strainer area you allow to participate -- so the amount of fiber builds up a larger thickness on a smaller area. It's a volume problem effectively. If there's a certain amount of volume and fiber available, you want to concentrate on as little strainer area as possible. It results in the most conservative numbers.

MEMBER CORRADINI: Okay, so can I say it back to you?

MR. TRAVIS: Sure.

MEMBER CORRADINI: So I have four. If I put all the junk on one, that's the worst case.

MR. TRAVIS: If you put all the junk on one and all the -- you're making the assumption that all of your flow is going through that strainer.

MEMBER CORRADINI: To that strainer.

MR. TRAVIS: Yes, that's correct.

MEMBER CORRADINI: But is that part of the assumption that I thought -- I thought all four participated and equally fed the SI pumps and the containment spray pumps.

MR. TRAVIS: For the purposes of the

analyses, they assume a single strainer is doing the --

MEMBER CORRADINI: Oh. So, they're assuming one train, feeding through one strainer. The other three are inoperative.

MR. TRAVIS: And so if I remember correctly, there is a single strainer for -- so a single strainer for each of two containment spray pumps and those two each also have an SI pump on that train of strainer.

And so for the purposes of spray, you have to assume that because you lost a train, your single failure was you lost the EDG. One train of spray doesn't participate. You only have one train, one strainer.

MEMBER CORRADINI: And everything accumulates on that strainer.

MR. TRAVIS: That's correct.

MEMBER CORRADINI: Okay.

MR. TRAVIS: And so getting to NPSH, the applicant followed the guidance we've provided in our -- that was discussed in SECY-11-0014. It includes adding a margin of uncertainty to the ECCS pumps.

They conservatively calculate the static and friction head losses for the strainer and those two terms are tested as part of ITAAC or will be part of an ITAAC that will be performed.

As the applicant discussed, that NPSH available includes credit for containment pressure up to the vapor pressure of the IRWST fluid.

To answer your question, Member Stetkar, from earlier, if the containment is at atmospheric pressure and the IRWST is at 212, they have the margin that they specified on this slide in the previous.

MEMBER STETKAR: Thank you.

MR. TRAVIS: And so that margin is three feet of water for the containment spray system and 1.73 feet of water for the SI system.

And so that collection of conservatisms that has gone into calculating it is the reason the staff -- all the design basis values is the reason the staff finds the number acceptable.

MEMBER CORRADINI: So let me ask you the question that maybe you don't want to answer. Say you haven't thought about it or you don't --

So I'm curious more about -- so maybe you're just going to tell me to wait for a subcommittee meeting that we're going to have in April about this, about more realistic calculations and the sort. Is staff doing what I would consider to be best estimate calculation of this where I don't plug all one strainer, I actually have a reasonable -- or not for this applicant but we will call it generically a reasonable water source and I start thinking about that I have a leaky containment such that it's not exactly the h-atmosphere minus h-vapor but there is a differential there. And what we would get by various physical effects that would create a transient analysis. Has staff given up on trying to do that?

MR. TRAVIS: That's a difficult question to answer. I'll say we've done a little of it internally. We haven't committed or fully gone to the full -- I think we haven't gone to the full extent to what you are talking about. We have looked at some of the values individually.

For the purposes of --

MEMBER CORRADINI: Well for this, I know you have taken the --

MR. TRAVIS: It's a design basis analysis that we're looking at, of course.

MEMBER CORRADINI: But I'm trying to understand. I'm not asking the applicant. I'm more asking staff, in this case. I'm trying to understand where the -- I think I know where the margin is but there's so many things layered on top of so many things I have a hard time sometimes unwrapping where the stuff is.

MR. TRAVIS: So I've prepared a backup slide to show you one element of the conservative that I can discuss a little.

There are a whole host of other conservatisms. So this is what I'll call just a generic PWR. It's not --

MEMBER CORRADINI: Nicely put.

MR. TRAVIS: It's not APR1400. I'll say that.

MEMBER CORRADINI: Good. Even better.

MR. TRAVIS: If you just add -- so in a normal NPSH analysis, you don't assume holdup in the MELCOR or your WCAP or whatever calculation you do because it's not conservative with respect to pressure.

I think it is something we all agree is a physical phenomenon that happens. Water holds up in various dead end volumes in the containment. Once you account for that, the storage of that energy reduces the NPSH by the amount shown on the slide. And so that's just one element of conservatism. There are a number of others.

MEMBER CORRADINI: So say that -- just do that one slowly for me, at least.

MR. TRAVIS: Sure. So the red graph here is a single node containment, maximum conservative mass and energy release, the red graph is the sump temperature of what exists in the -- during the accident.

MEMBER CORRADINI: So everything that gets pumped into containment and really makes its way to the --

MR. TRAVIS: Yes, effectively, immediately goes to the sump.

MEMBER CORRADINI: Okay.

MR. TRAVIS: And so the blue dashed line is 212 degrees. And so anything above that line is what you all consider CAP.

Once you put the holdup volumes in to the analyses, so all you do is you add in six, or seven, or eight -- I don't remember the exact number for this analysis, data and volume that hold water up before it can return to the sump, that's all they did. No change in energy release. No change in total containment volume. Then the sump temperature reduces to the black line because there's energy being stored that isn't in the sump that doesn't effectively fully participate. And you can see that as the transient goes on, the two curves superimposed over each other because everything started to equilibrate basically.

And so this is just an example of one conservative element that takes place. I mean once you take into account there could be multiple transient spray operating, the --

MEMBER CORRADINI: And with the other slides, you've anticipated this.

MR. TRAVIS: Yes. I didn't know exactly to what extent we were going to discuss this.

MEMBER STETKAR: How difficult is that?

MEMBER CORRADINI: The staff is good.

MR. TRAVIS: I appreciate hearing that.

MEMBER CORRADINI: Thank you. That helps.

MR. TRAVIS: And so I think there's one more.

We were advised that you guys or someone from the ACRS wanted to discuss the ability of the shutdown cooling system to meet a containment spray pump functionality. And so this is a figure from Tier 1 of the DCD. As part of tech specs, they had the ability to align a shutdown cooling pump to perform a containment spray pump, the function of a containment spray pump. The SCPs start on a containment spray actuation signal and they can take the suction path shown in red to draw in the IRWST and then inject downstream of the containment spray pumps but upstream of the headers to perform the containment spray pump.

MEMBER CORRADINI: And are they on a different train such that what we were talking about --

MR. TRAVIS: That I would have to look. I'm not sure off the top of my head what --

MEMBER STETKAR: Are you trying to address the question that I had about a suction valve for the containment spray pump?

MR. TRAVIS: Yes.

MEMBER STETKAR: Okay. Where on this line is the suction valve for the containment spray?

Let me rephrase my question from weeks ago. If remove a containment spray pump from service in a way that the pump is physically removed from the pipe, that's the easiest way to think of this, I take it away so that the pipe looks like the end of an open pipe. If I do that, how can I use the associated shutdown cooling pump for anything from the IRWST?

MR. TRAVIS: So this slide has, the shutdown cooling pump takes a suction on the IRWST unconnected to the containment spray line.

MEMBER STETKAR: I'm sorry. It's the same suction header, isn't it?

If anybody would ever put the entire drawing on a single piece of paper that shows the containment spray pump and the shutdown cooling pump suction lines, all the way from the IRWST to the pump, I could better illustrate my question. Nobody will ever show me that. I always have to go to two different drawings.

MR. TRAVIS: I'll have to get back to you then outside.

MEMBER STETKAR: Yes, because every -- just look at all of your drawings and think of removing the thing called the containment spray pump away such that the piece of piping that is connected to the suction for that pump is open to the room that the pump lives in and then tell me how you can get water to the suction of the shutdown cooling pump from the IRWST without draining the IRWST into the containment spray pump room or sucking air through the shutdown cooling pump.

MR. TRAVIS: Understood. I understand your question. I may or may not be able to answer it with the drawings I have access to.

MEMBER STETKAR: Yes, that's the whole --

MEMBER CORRADINI: But you're not looking at a non-functional pump. You're looking at almost like a loss of pump accident. It falls off the pipe.

MEMBER STETKAR: No, I'm sorry. I have seen many pumps in my life have problems where they take the pump out of service and they have to open the physical pump itself. I have seen this in my life. People occasionally have to do this. More often, they have problems with the motors, things like this but occasionally, they have problems with the pump.

When you have problems with the pump and you must open the pump to work on it, that is an open hole. You have to make sure that water is not pouring out of the hole, drowning the guys who are trying to work on the pump. So, therefore, you have to make sure you have all sources of water shut off to the pump and you have to make sure that when an automatic signal occurs, the people who are working on the pump don't get drown by the water because it opens it out.

MEMBER CORRADINI: But then to reframe your question, you want to make sure the isolation valves are such that they can branch around it without --

MEMBER STETKAR: I want -- it's why God invented manual valves on the suction lines of pumps and I can't on any drawing find a manual valve on the suction line of the spray pump. If this were a complete drawing, you would see a manual valve on the suction line of the shutdown cooling pump that can achieve the function that I was just talking about. I can't find one on the suction line of the spray pump. And believe me, I've tried to make water work. I'm not trying to make this stuff up.

There's two different ways I can get water to the suction of the shutdown cooling pump from the IRWST. The one that in the DCD they indicate as an interlock and there's a different way that you can get but, either way, if I open up those lines, I pour water into the containment spray pump room, if the pump is physically not there or open to the environment.

That's the genesis of my whole question.

MR. TRAVIS: Unfortunately, generally I have access to the same drawings you do. So I'd have to get a more detailed drawing in order to answer that question. So I'll take that and try to address that.

MEMBER STETKAR: If somebody can show me that valve --

MEMBER CORRADINI: Is that more a question for the applicant?

MEMBER STETKAR: Well, I asked the applicant and they tried to explain to me that you could get water there but I'm not, for some reason, registering with them that it's not an issue that the pump is out of service because its physical piping is intact and simply the circuit breaker is open. It's if I must do mechanical maintenance on the pump itself, the impeller. Yes, I don't know how it's put together.

MR. TRAVIS: I'll be nice. That's generally outside of the confines of what we're reviewing in terms of --

MEMBER STETKAR: Okay.

MEMBER CORRADINI: You were kind enough to show us the drawings.

MR. TRAVIS: And Greg will address the rest of GSI-191.

MEMBER POWERS: Are you concluding your presentation?

MR. TRAVIS: That's correct, yes.

MEMBER POWERS: I'd like to refer you back to 25 but you don't need to show the slide because there's nothing on it that's helpful.

In the course of your discussion of slide 25, you indicated that the applicant had provided you with a droplet size distribution and it ran from 100 microns up to 590 microns.

MR. TRAVIS: Those may or may not be the correct numbers. I can provide you with the ML number for the RAI response.

MEMBER POWERS: Well, the question is it sounds to me like a number distribution. But when you do the calculation for heat transfer you implicitly use a mass-weighted size distribution. And based on the numbers you gave me -- well, you indicated they used 1,000 microns in the calculation.

MR. TRAVIS: That's correct. That I can confirm.

MEMBER POWERS: And based on what you gave me, which I made an estimate and I came up and said no, it should be about 1200 microns.

I'm not sure there's a -- given the uncertainties and the limited information I had, there's a great deal of difference between them. My point is it is not evident to me that there's a great deal of conservatism based on their analyses.

MR. TRAVIS: So I guess I was speaking merely to the droplet size with respect to the heat removal ability of the droplets.

MEMBER STETKAR: That's right but that's still what you use, that you use in case of it because you're taking the volumetric feed in and you're turning that into droplets. And so you're implicitly using a mass-weighted or volume-weighted distribution there to do that.

MR. TRAVIS: That's correct, yes.

MEMBER POWERS: So it's not evident to me that all of that is conservative there.

MR. TRAVIS: Okay. I mean that's something that I will have to go back and take a look at myself. I know, in general we've taken the position in the past that if all of the droplets are of smaller size than whatever they chose to their analyses and that larger sized droplet can fully participate in heat transfer.

MEMBER POWERS: So that hinges on the belief that this member distribution is, in fact, finite and, I assume, log normal.

MR. TRAVIS: Right and that part I understand.

MEMBER POWERS: The trouble is on a number basis, there aren't very many big droplets but they are close to mass.

MR. TRAVIS: That part I understand, yes.

MEMBER CORRADINI: So just for clarity, on 6.2-10, a Sauter mean diameter of a 1,000 microns from the nozzle specifications is used. Reference 3.

So that's what 1,000 is, it is the appropriate Sauter mean diameter, the correct volume to surface area.

MEMBER POWERS: The question is what does the distribution really look like because --

MR. TRAVIS: As part of the RAI response, they did provide a log normal distribution and I can provide you with the ML number for that.

MEMBER POWERS: Yes, that would be most interesting because it's fairly glib to say that these are log normal distributions when they've actually been measured. I've never seen one that is. And when you do the number distributions, you get these little tiny -- but that's because they don't see the five great big ones that make up most of the mass.

MR. TRAVIS: I guess one thing I will say, I believe -- so based on the amount of time it takes for that droplet to participate in heat transfer, they still had a substantial amount of margin, even with the 1,000 micron droplet because of the height from the lowest spare ring to the top of the pressurizer.

But I will get that ML number for you.

MEMBER POWERS: I mean the other thing you have to remember is as this droplet is coming down, it's sweeping out the little ones and it's growing bigger, and bigger, and bigger, all the way down.

MR. TRAVIS: I'll say in some codes it may or may not perform --

MEMBER POWERS: -- it's not.

MR. TRAVIS: Yes, and so that I think is part of the problem.

MEMBER POWERS: My essential point is it's not evident to me --

MR. TRAVIS: Okay.

MEMBER POWERS: -- that there's an enormous amount of conservatism in this calculation. It sounds like a fairly typical and not unreasonable calculation but there's not great conservatism located there.

I mean it's not apparent there's a great deal of conservatism located there.

MR. TRAVIS: I understand and we'll follow up with you some on that. Thanks, Dr. Powers.

MEMBER POWERS: But I'd love to see the distribution anyway, just to see if it's --

MR. TRAVIS: I can provide that to you no problem.

MEMBER STETKAR: And Boyce, when you go back, the only drawings I have are what's in the DCD and my question about this valve stuff is Figure 6.3.2-1 and Figure 6.2.2-1 are the two that I'm working with.

MR. TRAVIS: Right and so there are also some figures in Tier 1. For the shutdown cooling, the Tier 1 figure is better than the one in Tier 2, if that makes sense, just for reference. It may or may not --

MEMBER STETKAR: I will look at Tier 1.

MR. TRAVIS: Okay.

MEMBER STETKAR: Thank you.

MR. MAKAR: So I apologize. I think --

MR. TRAVIS: I'm sorry. No, I'm done with mine. It's someone else's now.

So with regards to the strainer structure on integrity, the staff looked at the strainer from a stress analysis perspective, assumed a conservative maximum loading for both fiber and particulate on the strainer and the strainer met the associated -- the criteria associated with the Reg Guide, the ASME Code and the remaining code requirements on the slide. There's a single confirmatory evidence section and no open items.

And then for excess or downstream effects, the staff looked at the Reg Guide 1.82 conformance and the WCAP that's associated with GSI-191. As part of that, the staff looked at the components, both the SI and CS pumps, the valves in each train, the containment spray heat exchanger, all the piping instrument lines, the orifices which have a minimum hole size of eight-tenths of an inch and the containment spray nozzles which have a minimum hole diameter of 22 100ths of an inch.

Mission time associated with post-LOCA for the ECCS is required to operate using post-LOCA fluid is 30 days and so that is what the staff considered.

Staff used the insights associated from the WCAP-6406, which is evaluation of downstream sump debris effects in support of GSI-191. And then the staff found it acceptable in safety evaluation from 2007.

As part of this analysis, so irrespective of the NPSH, for this analysis we consider that 100 percent of latent debris bypasses the strainers and 100 percent of both the latent fiber and the latent particular and 100 percent of the coatings bypass the strainers. And so that is what was considered in the downstream analysis.

The pumps, including the mechanical seals are qualified per ASME QME-1-2007 to operate with the post-LOCA fluids for 30 days and all of the associated SSEs in the piping, such as the heat exchangers, valves, the piping, the nozzles, are designed to operate for 30 days using the post-LOCA fluid and are evaluated for wear, blockage, and fouling using the same methodologies described by the staff and accepted in the safety evaluation for that WCAP.

There is a single open item associated with this section. Latent particular debris may settle in some of the large diameter, low flow sections of the piping. The applicant is still in the process of evaluating that.

MEMBER SKILLMAN: Boyce, let me ask a question, please. I'm in your safety evaluation. It is your page 6-96. And this is the text that I'm referring to in my question.

The IRWST strainer hole size is 2.38 millimeters, 0.094 inch, therefore, on the gap of the component is 2.38 millimeters plus 0.238. It looks like ten percent or less of this value, the flow path may be blocked.

Why was the choice of ten percent provided in that statement?

MR. TRAVIS: I'm going to defer that to the reviewer who wrote that portion of the safety evaluation. He's coming up to the microphone.

MR. STRNISHA: James Strnisha, I'm the reviewer.

That is the approved methodology in the WCAP so we went along with that same criteria.

MEMBER SKILLMAN: Okay. It sounds like

someone winged it at ten percent. I'm just making the statement. That's what that appears to me.

Well, I will accept that. Thank you for the explanation.

Thank you.

MEMBER STETKAR: Can I come back to Boyce?

MR. TRAVIS: Sure.

MEMBER STETKAR: When you do that -- I hate to -- I didn't know we were going to talk about these suction valves. So go back to your drawing that you had with the red thing there in the backup drawing.

Where I started on all of this was a statement in the DCD that says open/closed position indication is provided in the main control room and the remote shutdown room for SCS-CSS pump suction cross-connect valves SI-340 and SI-342 and is provided in the MCR for SCS-CSS pump discharge cross-connect valves SI-341 and SI-343.

During the subcommittee meeting on Chapter 5 I asked KHNP how does a shutdown cooling pump know that it needs to start automatically for containment spray. In other words, how does that pump know that it's being used as a surrogate. And they told me there are interlocks on those two valve positions that I just mentioned, 342, in particular, on the suction side, such that when that valve is open the shutdown cooling pump knows that it's supposed to be a containment spray pump. Shutdown cooling pump valve 342 is not the red flow path that you've shown. It's the other one.

MR. TRAVIS: And so --

MEMBER STETKAR: I can get water through the red pump, through the red flow path to the shutdown cooling pump but if it doesn't know it's supposed to be a containment spray pump, 342 being closed, this other flow path is through a normally closed valve that, as best as I can tell, doesn't get an open signal. The shutdown cooling pump will cavitate.

MR. TRAVIS: And so the part about the valves being normally closed and opened is absolutely correct. I will say that this, as part of tech specs, there is a statement that says a shutdown cooling pump -- so they have to manually align a flow path and that flow path is proceduralized.

And so I --

MEMBER STETKAR: Can a -- well, what I

don't know -- this is -- I'm trying to understand how the system is designed to work in kind of licensing space because as I read through the DCD, I'm led to believe that I remove a containment spray pump, physically remove it let's say, that the shutdown cooling pump is then available automatically for a spray. That's what I thought we were told and what I thought -- that is what I was led to believe.

MR. TRAVIS: I would not characterize that as exactly correct. So as part of tech specs, they have to have two trains of spray available. And they can take credit for a shutdown cooling pump taking the place of a spray train if they do a manual alignment before that --

MEMBER STETKAR: Okay. But let's just go on with that. Is the manual alignment opening -- let's take the drawing here. I'm trying to understand how the darn things works. Is the manual alignment opening valve SI-342 on this drawing? That has to be a yes or no.

MR. TRAVIS: That I'd have to defer to the applicant.

MEMBER STETKAR: Okay. What I was told by them is the answer to that is yes, I open that valve

342 and when that valve is in the open position, the controls for that shutdown coolant pump will then know that that pump is supposed to be a spray pump. So, therefore, when I get a spray signal, bang, that circuit breaker closes and that pump starts as a spray pump. So yes, they may have to open that 342 valve. But if that's the valve that they have to open, then is when I get into the problem of dumping water into the spray pump line, which is the dotted line going upward on this drawing.

I can, indeed, get water through the red suction path that you've shown with 342 closed. But if 342 is closed, then my state of knowledge is that the spray pump -- I'm sorry -- the shutdown cooling pump then does not know it's supposed to start automatically.

MR. TRAVIS: And so my understanding of the system is based off of this -- or this is the Tier 1 information that said the shutdown cooling pump starts on a containment spray actuation signal and runs in mini-flow until -- that was my understanding of the system. I would have to follow-up with you for more information on that.

MEMBER STETKAR: Okay. So I just want to

be clear because if the interlocks are actually on the other valve, the valve in the flow path that you've shown as red --

MEMBER CORRADINI: 341 and 342.

MEMBER STETKAR: -- which is valve 346.

MEMBER CORRADINI: That isn't what it shows.

MR. TRAVIS: I have it as 341 and 343 but that's fine.

MEMBER STETKAR: Okay, let me go back because I want to be really clear.

In the DCD, the DCD identifies valves 340 on this drawing -- 340 and 341 as the suction and discharge valves or 342 and 343 for the other train. So just think 340 and 341. Those are the cross-connect valves.

So there is no dispute that the discharge from the shutdown cooling pump to the spray header goes through 341. It's all on the suction side that I'm talking about.

MR. TRAVIS: Right, I understand that.

MEMBER STETKAR: Okay. And the other valve to get the red, if indeed the interlock -- that other valve number is 346. You don't show it. It's below that check valve 160 on this drawing.

So if the interlock is really on that 346, I can make the whole system work but the DCD description of what the suction valves and the discharge valves and the interlocks is wrong.

MR. TRAVIS: That's -- I understand your point and I will have to, again, follow that up with someone from the applicant.

MEMBER STETKAR: I hope we're all clear because there was confusion during Chapter 5. I wasn't expecting the staff to come back on this one during this meeting. So that's why I'm kind of struggling a little bit. Have you got it?

MR. J. OH: This is Andy Oh, KHNP Washington Office.

In case containment spray is required maintenance during the model 1 and 23 and the maintenance requires kind of the stuff Member Stetkar described some breach of the pressure, in that case, at the interchange for the shutdown cooling, the replacement of shutdown cooling function with the containment spray cannot be accomplished. In that case, KHNP would have to apply tech spec.

MR. TRAVIS: Right, the LCO. Okay, yes.

MR. J. OH: The LCO.

MEMBER STETKAR: You'd be down to one containment spray.

MR. TRAVIS: They're not allowed to -- I mean they have an LCO action. They have to have two containment spray pumps operating.

MEMBER STETKAR: Okay.

MR. J. OH: However --

MEMBER STETKAR: And you did all of that to save two manual suction valves.

MR. J. OH: Yes, however, some of maintenance that not require breach of the pressure boundary of the containment spray, then shutdown cooling pumps still it can replace the function of containment spray.

MEMBER STETKAR: Right. I'm not arguing that at all.

I do notice that, like most system designers, the shutdown cooling pumps seem to have local manual suction isolation valves. So apparently to save the cost of two manual suction isolation valves, occasionally the plant will have to enter a tech spec limiting condition for operation.

MR. TRAVIS: I can't speak to design

decisions.

MEMBER STETKAR: I just want to make sure I -- I originally wanted to make sure that I understood the flow paths when the shutdown cooling pump knew that it had to operate as a containment spray pump.

MR. TRAVIS: Right.

MEMBER STETKAR: Because I looked in Chapter 7. It doesn't really give you that --

MR. TRAVIS: Right.

MEMBER STETKAR: -- that amount of detail in 7.

Okay, thank you.

MR. MAKAR: I'm going to present our review of the post-LOCA debris source, referred to as chemical effects. And there is a great deal of uncertainty about the materials released in containment so closure rates for metals, release rates recalled them for non-metals. The rates and how they are related to temperature and pH, what exactly precipitates and when does it stay a precipitate or re-dissolve, things like that.

So in order to address this uncertainty, the staff has some guidance that makes conservative assumptions. So when we look at a chemical effects in that review, we are looking to see if the applicant has followed the staff-approved guidance or has done something on their own, for example, done their own corrosion rate testing and testing of precipitates in some way. And so if they choose another methodology, then we will ask them to justify that.

Ours is based on, it's described in Reg Guide 1.82 in the latest revision, Rev. 4 and it refers to 2008 detailed guidance from the staff as well as -- and that includes an approved topical report that calculates release rates and makes assumptions about what precipitates form.

So when we look at the applicants, the application in this area, we were interested in what source term they're using, so what kind of materials, pH values, temperatures, the type and amount of chemical precipitates that result from their analysis and how they applied these chemical precipitates in strainer head-loss testing, as well as in fuel assembly testing, and whether they applied any, even if they used the staff's approved guidance, whether they use any what we call refinements, things that might reduce conservatism.

So in this case -- yes.

MEMBER POWERS: When you launch one of these analyses, does it make a difference to you whether trisodium phosphate is being used a buffer or not or is it almost indifferent to that?

MR. MAKAR: Trisodium phosphate would make a difference in two ways. One is how its effect on the -- or how it determines the pH profiles. The second way is that for materials that release calcium, so some concrete calcium silicate insulation, the staff's approved methodology assumes that if you have phosphate present that all calcium will precipitate. So if you have some release from concrete say or calcium and you are using sodium hydroxide or sodium tetraborate, you would not have calcium phosphate precipitate.

MEMBER POWERS: You don't have a calcium borate precipitating in this?

MR. MAKAR: No. No, there are the three that -- you know an applicant could propose something else. We may have had one that did but the methodology that they are using assumes that the precipitates are going to be sodium, aluminum, silicate, sodium, oxyhydroxide or calcium phosphate.

MEMBER POWERS: There, of course, are lots of other insoluble phosphates.

MR. MAKAR: The staff -- when the staff looked at the testing that we sponsored, as well as the industry testing that led to this topical report, it seemed like a -- based on what they could -- you know it is difficult to identify and even know that you have precipitates. But they judge that conservative based on the test results to always assume that you are going to get this, that all of your calcium is going to --

MEMBER POWERS: That is an assumption.

MR. MAKAR: And the calcium phosphate, if you actually use it in a test, it's pretty nasty as far as head loss goes.

MEMBER POWERS: Right.

MR. MAKAR: So we determined that what materials they had, the releases, in their case, are coming from aluminum in containment, concrete, and some silicon. Silicon comes from the insulation, the small amount of fibrous insulation, as well as from concrete. The aluminum comes mainly from the metallic aluminum, a little bit from concrete.

MEMBER POWERS: Zinc doesn't enter into

the calculation here?

MR. MAKAR: It doesn't. That doesn't mean that staff doesn't believe zinc could generate a chemical precipitate. It certainly corrodes, depending on the pH and temperature. And there have some indications in the testing that it does form a precipitate, not just a corrosion product that's observed on the surface but something that would cause head loss.

The staff approved using those other three precipitates only if you stick to this methodology. It hasn't been ruled out for cases where people want -- if an applicant wants to use a refinement where they are going to justify long-term solubility or some cases where they don't assume precipitates form, that's cause to look at other things that were not requiring them to look at now.

And so I mentioned what the three precipitates are that apply to this case. It's the calcium phosphate, aluminum oxyhydroxide and sodium aluminosilicate.

The quantity for their base case is about 240 kilograms. I think that's the number. Staff did a calculation using the same conditions and had about the same result, which we should.

We also note that they -- one of the conservatisms is the pH range that they chose, that they are assuming very early in LOCA that they would be at the high end of the pH because of the trisodium phosphate. So they're not beginning at a pH of 4 or 4.5. They are getting up in the closer to ten. And so they have a very high corrosion rate of aluminum, which is the vast majority of their source term here.

So they are generating a lot of aluminum corrosion at the beginning.

So we also ran a case with a more realistic pH profile, one that we see from -- typical pH profile that we see from applicants using trisodium phosphate and the amount of precipitate in that case that we calculated was more like 100 kilograms. So less than half.

So we think they have some conservatisms in here. Using this methodology, the form of these precipitates is more than 90 percent aluminum oxyhydroxide. That is there is a surrogate material that staff has approved that can be prepared in the laboratory for use in strainer and fuel assembly testing. It is sodium aluminum oxyhydroxide. So the same. The surrogate they are using is a representation of what they are calculating they have for the most part.

And so we also evaluate how they used this and prepared this surrogate for their testing. And in their case, they followed our guidance.

We do have some questions that are identified as open items in our SER. We since have a response on all of them.

And one was that the DCD currently allows more aluminum surface are than was evaluated for chemical effects so that a revision has been proposed to the DCD to put those together. That's a non-conservative direction.

There is also the temperature profile. It was unclear to us how to -- we didn't understand fully the temperature profile that they used after the first approximately 11 days. So that was another calculation we did to assume that the temperature did not continue to decrease after that time and saw what effect that had.

But now they have clarified what temperature profile they are using. And in addition, because of the test, the results of their testing where they saw an initial head loss upon adding chemicals, it wasn't sustained. So that's part of our guidance, too, that if you've added a significant amount of the chemical source term and you stop seeing an increase in head loss then you've done enough and you can stop at that point. And that was their case.

So adding to their chemical source term, at this point, would not change the results of their testing.

And we also had a question about how they were using water volume. They were making -- explained or stated that they were using water volume and making conservative assumptions about it but it is not clear to us how that's used in the methodology. So they've clarified that.

And the final one was the preparation of the surrogate chemical in their testing. We had needed some clarity. We didn't understand fully how they did that. That's been closed.

The others are confirmatory items for changes in their technical report or the DCD.

And that concludes the presentation on chemical effects.

CHAIRMAN SUNSERI: All right, any

additional questions from the members?

I may not be completely clear on the shutdown cooling pump, containment spray pump. Are we resolved on the issue now?

MEMBER STETKAR: My state of knowledge is that I think you beat this horse to death.

My state of knowledge is that if a containment spray pump is removed from service, let me call it, electrically, so just open up the circuit breaker, that the corresponding shutdown cooling pump can be aligned by opening -- I've forgotten the valve numbers already -- opening two valves and then that shutdown cooling pump will receive an automatic containment spray signal to start. Am I okay so far?

Let the record show that KHNP people are nodding their heads in agreement.

If, however, the containment spray pump requires disassembly for maintenance, opening for whatever, then that containment spray division is inoperable, that the shutdown cooling pump cannot be used to replace the containment spray pump and the plant would enter the technical specification 72-hour LCO for that division.

Is that correct? And again, containment -

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MR. J. OH: Yes, this is Andy Oh, KHNP Washington Office. Yes, that statement is correct.

MEMBER STETKAR: Okay, thank you.

CHAIRMAN SUNSERI: Okay, so we've put that one to bed, then.

MEMBER STETKAR: That's the way it is.

CHAIRMAN SUNSERI: Okay, great. All right. So we are at a break point here. Let's take a 15-minute break and return here at 20 after 3:00 to continue with the presentation.

Thank you.

(Whereupon, the above-entitled matter went off the record at 3:06 p.m. and resumed at 3:22 p.m.)

CHAIRMAN SUNSERI: All right, we are reconvening the session and we have Anne-Marie Grady that will be kicking us off.

MS. GRADY: Good afternoon, Chairman and members of the subcommittee. I am Anne-Marie Grady in the Containment Systems Branch Severe Accident PRA and I'm here to talk to you today about combustible gas control and containment.

The objective of the review for combustible gas control containment is essentially to make sure that the design for combustible gas control meets 10 CFR 50.44 and in this case it is (c).

To determine whether or not it met 50.44(c) we look at the five elements that are in 50.44(c) in those numbers that there are. And the criteria are for significant beyond DBA to ensure there is a mixed atmosphere in containment; that the concentration of combustible gases both locally and globally are below the level of either support combustion or detonation that could cause loss of containment integrity.

The second criteria is the concentration be limited below ten percent, both locally and globally, the ten percent being the lower cutoff point there. Detonation is not an issue in the containment. And detonation in this plant, as in many other PWRs would be what would compromise containment integrity. Combustion generally is -- a containment design generally can withstand combustion.

For criteria number three, the equipment and systems needed to maintain containment integrity shall be able to perform their functions during and after a hydrogen burn.

Okay, fine. Number 4, equipment shall be provided for continuously measuring hydrogen concentration inside the containment for a significant beyond DBA.

And number five, a structural analysis shall be completed that demonstrates containment integrity will be maintained during and after a hydrogen burn. So a structural analysis to consider a hydrogen burn as one of the design loads for containment integrity.

The documents, the material that comprised the scope of the review was the APR1400 DCD Tier 1, Section 2.11.4, which is Containment Hydrogen Control System, DCD Tier 2, Section 6.2.5, Combustible Gas Control, and Section 19.2.3, Severe Accident Mitigation.

It was also based on the APR1400 Severe Accident Analysis Report, which is on the docket and in the SER there is the ML number. If you haven't already obtained it, you can go to it readily.

Supporting both the DCD and the severe accident analysis report, KHNP did many calculations. I would call it a massive hydrogen combustion calculation, at least when I was reviewing it at 1138 pages, I thought it was massive. And two other calculations, one to look at equipment survivability and one to look at potential detonation. Those calculations were available to us and still are in the electronic reading room but they are not on the docket. They are, however, referenced in the SER and they will be referenced in the severe accident analysis report. So there is traceability with them, even though they are not on the docket.

MEMBER REMPE: So we won't have access to the document they referred when we do Chapter 19? You said the 1100 page document is not going to be made available.

MS. GRADY: No, it's in KHNP electronic reading room. And for those of us who have access to the electronic reading room, it has been available and it is still available.

MEMBER STETKAR: Joy, the simple answer is no, it's not available to us.

MEMBER REMPE: Because I do have the ERI document. I thought -- I just hadn't seen this other document yet.

MS. GRADY: There are three of them but I don't know the answer to what is available to you from their electronic reading room.

MS. UMANA: So generally what KHNP has done is they put these documents up in the electronic reading room for staff to access them. And sometimes I have a staff member that doesn't have access and we request access. If you want access, I have to check with KHNP first to make sure that you can be granted the access, if you really want to see this document.

MEMBER REMPE: Okay. So if this is the document that, again, I don't remember the document number KHNP mentioned earlier today but before we do Chapter 19, I would like to request that members have access to this document.

MS. GRADY: These documents are a hierarchy. That third bullet right there are the real basis analyses.

The second bullet summarizes them in the level of detail that is quite satisfying, covers many accident scenarios, and that is on the docket and that is in ADAMS. So you can review that.

And then of course, the DCD is a higher level document. They are all arising from that level of detail.

MEMBER REMPE: Right. Again, as I go through this for Chapter 19, it would be nice if I could go ahead and request it. I can't tell until I go through the severe accident analysis report but I would like to -- I think I'm not the only member that might be interested in this. And so it would be good if they would provide that access to us.

MEMBER STETKAR: We do have the second bullet document.

MS. GRADY: Right.

MEMBER REMPE: Yes.

MEMBER STETKAR: Okay, I've seen that.

MS. GRADY: And the SER identifies the others that are in the electronic reading room.

So you have the title. You know what they are.

MEMBER REMPE: Okay. Again, I need to finish reading what's on the second bullet but it would be nice if we just go ahead and request it and then if I don't need it, I won't need it but other members may feel of a habit of interest.

MS. GRADY: Yes.

MEMBER REMPE: By the way, since I've interrupted you, in the draft SE you refer to temperatures for equipment survivability during combustion events. The range -- and you have -- it's on page 6142. Did you look at temperature and pressure or did you --

MS. GRADY: Temperature, and pressure, and radiation.

MEMBER REMPE: Okay because, again, the draft SE only mentioned the temperature envelopes. In fact, it has Table 19.2.3-5, it is a summary of temperature envelopes for equipment survivability.

MEMBER REMPE: But you did look at pressure also.

MS. GRADY: Yes.

MEMBER REMPE: Okay.

MS. GRADY: And the conclusion for equipment survivability will be provided to you when we do Chapter 19 in April.

MEMBER REMPE: And that pressure includes some sort of spike from a burn or anything like that, too.

MS. GRADY: Yes, it does.

MEMBER REMPE: Okay.

MS. GRADY: The last bullet that comprised my review was we had the contractor ERI do a confirmatory calculation for the burning of the hydrogen in the containment, the potential for detonation of the hydrogen containment that's there, a calculation number, and the ML number is as a reference in the SE. So that's available to you also. And their calculation was 411 pages.

So let me just say that there have been very many accident scenarios that have been evaluated for combustion and/or potential detonation. I know KHNP's, the calculation I looked at had 55 different variations, 55 different scenarios, sensitivity studies, and the one for our confirmatory calc had 17.

MEMBER REMPE: But in the confirmatory calc, which was based on MELCOR, and even the ERI document used the MELCOR results, everybody used the same the containment nodalization.

MS. GRADY: Exactly, 36 containment nodes. KHNP used MAAP and they used 36 containment nodes. We used MELCOR and we based our nodalization, ERI did on the nodalization as enacted.

MEMBER REMPE: Again, as I mentioned earlier today when I was discussing it with KHNP, I am puzzled why, especially with MELCOR, where you could have more finely divided up the containment, why the staff didn't try and explore that.

And I did hear esteemed Professor

Corradini today tell me well, they didn't need to because of some German tests. And that may be true because I haven't reviewed those German tests but esteemed Member Powers told me later that the German tests didn't adequately consider a lot of the features that might be important in the containment.

So I am interested in why the staff decided that it was okay to just keep using the same nodalization as what KHNP used.

MS. GRADY: I would say that we felt that it covered what was going on in the containment. The nodes are not the same size. They are, pardon my showing you --

MEMBER REMPE: I saw that drawing, yes, but there is a very big volume up high in the dome.

MS. GRADY: Yes, and you seemed in your question to be particularly concerned about the dome but the dome in here is not the largest containment node at all. The largest containment nodes in this model are the volumes above the two steam generator cubicles.

MEMBER REMPE: Okay. So, there's the containment node and then there's some volumes -- or the dome, and then there are some volumes that look kind of large also right --

MS. GRADY: The small dome portion at the very top.

MEMBER REMPE: And then there are two that are fairly large.

MS. GRADY: Then there's a big one that encompassed the polar train. Then there's two even larger ones that are above the steam generator.

MEMBER REMPE: And you feel it's just fine not to have any sort of finer nodalization in all those large volumes?

MS. GRADY: Yes.

MEMBER REMPE: And the basis for that feeling is?

MS. GRADY: We have used nodalization to this level of detail for other applications and been satisfied with the results.

MEMBER REMPE: Did anybody do any sort of sensitivity studies to make them satisfied in the history of this?

MS. GRADY: Sensitivities on the nodalization?

MEMBER REMPE: Uh-huh.

MEMBER CORRADINI: I'm not sure what you

want them to do.

MEMBER REMPE: I just would like to know why they feel comfortable with it.

MEMBER CORRADINI: The fundamental model of MELCOR and MAAP and all of these is the same, is it is essentially a tube and tank model, which means what's a loss coefficient between a volume in an open area that's here in the room and here in the room. The answer is there is no loss coefficient.

So no matter how many of these you are going to put together, you are going to get good mixing.

MEMBER REMPE: We don't think there might be any stratification?

MEMBER CORRADINI: That isn't the same thing as mixing. Stratification driven by what? Driven by density or temperature is one thing but that's not going to capture it by putting a lot more volumes in. It's going to be captured in by either by condensation in the upper region, where I make it lean enough that essentially it is almost like molecular weight is going to cause the stratifying or because I've got a very strong hydrogen plume coming out of these things that it never mixes coming out of wherever they come out of, the steam generator rooms.

I think it's more a matter of source, strengths, and condensation rates versus the nodalization. That's my guess, if I were to guess.

MEMBER REMPE: And is there no way to trick the codes into considering that if you had a CFD analysis, for example?

MEMBER CORRADINI: We go back a long time but if memory serves me, Los Alamos had a tool by some group, I think it was the famous group at Los Alamos, Jack Travis' group, and they showed well-mixed conditions under a range of conditions, as you would with a -- for a large dry. I'm talking for a large dry in the upper dome region. But that's many, many years ago that I remember these analyses.

Walt I think may remember the group because they were -- Los Alamos was doing -- T3? T3 division.

But my only memory is that for large dries, you get enough of a mixing just by the natural circulation patterns that everything is pretty well mixed, even with low rates of flow.

MEMBER REMPE: Okay, so that's your memory. Shouldn't the staff have some sort of basis that they could rely on, except tradition?

MS. GRADY: And in general we have other results KHNP has, and so do we have in our confirmatory calc the size of hydrogen concentration in each one of these modes. And almost all of them have about the same hydrogen concentration at a particular time, which shows good mixing.

MEMBER REMPE: Okay.

MEMBER CORRADINI: I think what she's asking, though, are what are the limits of that and are you near those boundaries? I think that is another way of putting what Joy is asking of the staff. Are you far away from boundaries where you get stratification due to either temperatures, or densities or flow rates, or are you close to those boundaries? I don't think those boundaries have been determined for a large dry. Every analysis I have seen for a large dry, historically, has shown very good mixing, even with low, natural convective flow rates.

MEMBER REMPE: It would be good to have some documented understanding, other than tradition. And again, you may be right that there is a long history but I just am curious on why people feel comfortable with that.

CHAIRMAN SUNSERI: All right, I think we understand the issue. I don't think we're going to resolve it here. So, let's move on.

MS. GRADY: KHNP selected five initiating events for accidents to model, whose sequences represented the spectrum of severe accidents important to hydrogen accumulation and distribution, the most probable core damage sequences from the Level 1 PRA and representative LOCA sequences. Chosen were large break LOCA, medium break LOCA, small break LOCA, total loss of feedwater, and SBO.

KHNP combustion analysis for these scenarios credited severe accident mitigating systems. The severe accident mitigating systems are aux feedwater, safety injection tanks, the PARs, hydrogen ignitors, the cavity flooding system, the containment spray system, rapid depressurization using the POSRVs and the operation of the three-way valves.

KHNP, using the MAAP code, calculated the hydrogen concentration versus time for 24 hours for the selected scenarios for all containment nodes modeled in the combustion analysis.

The combustion analysis for all of the

base cases results in hydrogen concentration in the containment, both locally and globally, is maintained below 10 percent when all of the severe accident mitigating systems are credited.

The staff --

MEMBER CORRADINI: Can I stop you there? I still want to think that at least we ought to note that Dr. Rempe's question is a fair one and probably under the most stagnant conditions versus containment spray conditions, which would cause a lot of mixing.

So you're under stagnant conditions.

MEMBER REMPE: It would be nice to have some -- sometimes we have questions and it would be nice to see something back on that. And again, I don't know if it should come from the staff or the applicant but it would be good since the staff has agreed that this nodalization is adequate.

MS. GRADY: Oh, I'm sorry. Would you repeat the last phase?

MEMBER REMPE: Since the staff has concurred that the nodalization is adequate, it would be nice to see something that is explaining why the staff feels comfortable with it.

MS. GRADY: Yes. The confirmatory

calculations on mixing the containment for the same five base cases and also crediting all of the severe accident mitigating systems came up with the same results, that is that the concentration of the hydrogen in the containment in any of the nodes was below ten percent or it was steam inerted.

MEMBER SKILLMAN: Anne-Marie, does that conclusion imply that all elements of all of the mitigating systems must be operable at all times?

MS. GRADY: Various scenarios relied on certain mitigating systems and then there have been sensitivity studies I'm going to talk about next but whichever ones would be needed for the scenario.

MEMBER SKILLMAN: So that's slightly different, at least in my judgment, than the sentence that communicates that the containment remains below ten percent hydrogen when all systems are credited. That suggests that all elements of all systems must be functional at all --

MS. GRADY: If they're needed in that scenario, that's right. For example, it credits PARs. It credits them at 75 percent efficiency. It credits all of the hydrogen ignitors. It credits aux feedwater, if that scenario requires aux feedwater, et cetera.

So yes, if it's required.

MEMBER SKILLMAN: So what is missing in that second bullet are credited for that specific scenario.

MS. GRADY: The second bullet?

MEMBER SKILLMAN: Yes, see the second bullet? The second bullet, the combustion analysis --

MS. GRADY: Yes.

MEMBER SKILLMAN: -- results in below ten when severe accident mitigating systems are credited for that particular scenario is I think what you're saying.

MS. GRADY: Right but every one of those scenarios, for examples, doesn't require rapid depressurization. If you have a LOCA, you don't need to rapidly depressurize and operate the three-way valves. Those are mitigating systems. But for the LOCA scenario, particularly the large break LOCA, you don't need them.

So whatever is appropriate, yes.

MEMBER SKILLMAN: Okay, it's a scenario-specific conclusion --

MS. GRADY: Yes, it is.

MEMBER SKILLMAN: -- is what I think you're communicating.

MS. GRADY: Yes.

MEMBER SKILLMAN: Thank you.

MS. GRADY: KHNP then performed sensitivity studies on the base case scenarios and basically looked at the base case scenarios going one by one and crediting or not crediting a particular mitigating system. They ran the same scenario, for example, but didn't credit the PARs. And then they ran the same scenario but credited the PARs and didn't credit the ignitors, and on and on and on, as you can imagine for the various mitigating systems. And they found that the hydrogen concentration doesn't exceed ten percent anywhere in the containment, except in the IRWST and in the steam generator compartment for high pressure scenarios such as SBO and total loss of feedwater, as long as the POSRV, via the three-way valve is available.

And they also found all of the LOCA sequences, the hydrogen concentration doesn't exceed ten percent anywhere in the containment, as long as the PARs and the ignitors are available and no containment sprays are actuated.

Staff's confirmatory calculation -- sorry. Staff found the potential exists to exceed ten percent hydrogen concentration in the IRWST and the area above it near the SBO or the total loss of feedwater with no operation of the three-way valve and there is potential to exceed ten percent hydrogen concentration in the reactor pressure vessel annulus for large break LOCA without PARs or without ignitors.

Large -- now we get on to the cases where we have found nodes in the containment where it does exceed ten percent. And we're now going to look at those nodes in particular and investigate the possibility of detonation.

Detonation could potentially challenge containment integrity and local detonations could affect equipment survivability.

KHNP analyzed the potential for detonations from flame acceleration during a deflagration to detonation, so-called DDT. The potential for DDT in any node in the containment where the hydrogen concentration exceeded ten percent was evaluated. So if the nodes came in under ten percent, those nodes were screened out, weren't evaluated further, because there was no potential for DDT. Now we start focusing on the nodes in containment where the concentration did exceed ten percent.

MEMBER POWERS: Is the ten percent criterion DDT --

MS. GRADY: I'm sorry?

MEMBER POWERS: Is the ten percent criterion for DDT just an empirical observation?

I don't know of a theoretical reason why you can't get DDT at lower than ten percent. I have to admit I am unaware of experiments where we got DDT less than ten percent but there is no theoretical reason why you can't.

MR. PAUL: Eric Paul, ERI. We looked into in what conditions DDT is possible and it is using the OACDs, that report, there is a correlation that we used to predict DDT conditions. It is possible for it to occur just below ten percent but only when there's essentially no steam and high temperatures.

So, for all practical purposes, ten percent is a lower bound.

MEMBER POWERS: But I mean that's just strictly an empirical correlation with data from a bunch of investigators.

MR. PAUL: Yes.

MEMBER POWERS: And in fact I can conceive of geometries may not arise in reactors that would give you a transition to DDT, anything above the flammability limit, I think.

MEMBER CORRADINI: Long and narrow.

MEMBER POWERS: Long and disrupted.

MEMBER CORRADINI: Yes, where you accelerate.

MEMBER POWERS: Yes, you have got to have a range to accelerate and you have got to have enough turbulence to cause acceleration.

Inherently, it's unstable. It wants to go out on you. So you need a wide channel to propagate it.

But empirically for -- they have done a huge number of tests up in Russia looking at geometries and that is where the correlation comes from I think.

MS. GRADY: We did use the ten percent criterion and KHNP used the ten percent criterion as well and used the cell-width methodology to evaluate potential for DDT and the methodology is found in the NEA/CSNI document that's referenced there. And basically it looks at in a node where the concentration is greater than ten percent, looks at the conditions in that node, looks at the concentration. It looks at the pressure. It looks at the temperature. In other words, it's really looking at the potential for flame acceleration to occur.

Then, considering a measure of whether or not flame acceleration could occur, then it looks at the surroundings to see if the physical space would allow enough space for the flame to accelerate to DDT. So, it's an analytical process but it's a screening process. And basically, we're hoping -- KHNP was hoping, we were hoping that by evaluating the flame acceleration and the cell-width methodology that we could, in fact, screen out nodes in the containment by this method.

So I guess I'm forecasting right here that we didn't start analyzing detonation loads in the containment. We're hoping to screen it out and we're going to find out that is what we in fact ended up doing.

Cell width is --

MEMBER POWERS: Would this methodology predict detonation in a boiling water reactor building located on the coast of Japan?

MS. GRADY: In a boiling water reactor building? Its inerted. We wouldn't even be worried about that.

MEMBER POWERS: Well, the dry well is inerted.

MS. GRADY: Pardon?

MEMBER POWERS: The dry well is inerted; the reactor building is not.

MS. GRADY: Ah! I don't know the answer to that.

MEMBER POWERS: That would seem to be a pretty good test for this methodology.

MS. GRADY: The reactor building is relatively large, though, isn't it? So the cell width --

MEMBER POWERS: Highly compartmentalized.

MS. GRADY: Pardon?

MEMBER POWERS: Highly compartmentalized below the operating deck.

MEMBER REMPE: But unfortunately, with all accidents, they are not well-instrumented and so it would be hard to apply this method with the data available from that location in Japan, right, Member Powers?

MEMBER POWERS: Well, I would remind you, Member Rempe, that there have been a huge number of calculations of that accident at the port to do it quite well. Might it not be useful to use those to see if this methodology works?

MEMBER REMPE: It would be of interest but knowing the source it might have a lot of uncertainty.

MEMBER POWERS: You have no faith in the calculation of capabilities at all?

MEMBER REMPE: I just keep thinking about TMI not being a well-instrumented experiment and I think we could say the same thing about that.

MEMBER POWERS: Actually, I will remind you that we know a great deal about the hydrogen detonation and hydrogen, including having estimates of flame speed, direction, location of the ignition point and cell width.

MEMBER REMPE: At TMI but it took a lot of years and all that but right now, it might be kind of hard. It would be nice to do, though in the long-run. It's just an observation.

MEMBER POWERS: Not much of one.

MS. GRADY: KHNP, applying the cell-width methodology, found that there was no DDT potential in the containment, as long as the POSRV discharge via the three-way valve is available.

If the POSRV discharge via the three-way valve is not available in high pressure sequences, the IRWST air space and the areas above it have the potential for DDT.

There is also DDT potential in the lower containment areas for any sequences with ignitor failure and cavity flooding failure.

So, a combination of potential for DDT with also an assumption of not having the availability of severe accident mitigating systems. And for POSRV, the three-way valve and the ignitor failure and the cavity flooding failure are the mitigating systems.

MEMBER CORRADINI: Can you remind me, since you said it early in the presentation and I didn't -- I missed it. What's the source, what's the inventory source that was used in these calculations?

MS. GRADY: Oh.

MEMBER CORRADINI: Did you say it and I missed it?

MS. GRADY: If I didn't, I meant to. It's the hydrogen generated from the oxidation of the fuel clad having 100 percent of the fuel.

MEMBER CORRADINI: Okay, I thought it was 100 percent.

MS. GRADY: Yes.

MEMBER CORRADINI: Okay, fine. Thank you.

MS. GRADY: You're welcome.

MEMBER REMPE: Remind me. Didn't they actually truncate? It was MELCOR that they truncated because sometimes they would have structures oxidizing in the vessel in these calculations and they didn't want to go above 100 percent. And so they would truncate the in-vessel source, right?

MS. GRADY: It's my understand that both MAAP and MELCOR, if you were trying to predict the clad and oxidizing, wouldn't reach 100 percent. They have the opposite effect and they have to artificially add to get up to the 100 percent that -- 10 CFR 54 would apply --

MEMBER REMPE: They did add some stuff?

MR. PAUL: Eric Paul, ERI. It depends on the scenario. For the LOCA cases, we did need to add hydrogen to get to 100 percent. For the high pressure cases, she's correct that it would have -- MELCOR would have naturally produced more than the amount of hydrogen specified by the regulation. And so we did cap the hydrogen production artificially.

MS. GRADY: Thank you.

Okay, equipment survivability.

MEMBER KIRCHNER: Can I ask a question at this point?

MS. GRADY: Yes.

MEMBER KIRCHNER: So you did agree that there's the potential for this hydrogen detonation. Did you analyze what might happen?

MS. GRADY: No, absolutely not.

MEMBER KIRCHNER: And do you think there are any vulnerabilities in places like the IRWST to such a detonation, in terms of equipment failures, or it is robust enough that at least the structural integrity would be preserved? I'm thinking about things like strainers and screens and such that might be dislocated by such a detonation in the cavity.

MS. GRADY: As long as we can credit the three-way valve, taking the discharge from the POSRVs and sending it to the steam generator compartments, we can avoid that condition in the IRWST. And the three-way valve in the POSRVs discharge is one of the severe accident mitigating systems.

MEMBER KIRCHNER: Thank you.

MS. GRADY: You're welcome.

Let me say a word about equipment survivability. Equipment survivability is generally covered in Chapter 19.2.3. It really is a program to take severe accidents, take the mitigating systems that are required to mitigate a severe accident, establish what equipment is required, establish what conditions are required, that they function under, establish how they have to function and for how long they have to function. And the overall findings for equipment survivability will be found in Chapter 19.2.3.

However, 10 CFR 50.44(c) says when you look at equipment survivability and when you look at the severe accidents that you could look at and have to evaluate for, one of the conditions you have to assume, in addition to all of the others, is that you have to assume that you have the 100 percent hydrogen from the oxidation from the cladding and have it burn in containment. So it's an additional load. It sort of piggy backs onto an existing.

And all I'm really going to be talking about here is that we have calculated the results of the conditions in the containment if the hydrogen burns as an input into the equipment survivability finding that will come in Chapter 19.

So we're looking strictly at one of the loads that that program has to withstand.

KHNP selected bounding temperature profiles from the burning of hydrogen calculated for a broad spectrum of severe accidents. So they didn't choose a bounding one. They chose several and selected from them.

Staff calculated temperature profiles for two scenarios and compared them with the temperature profiles from the burning of hydrogen in containment which are found in figures in Chapter 19.2.3 in Figures 16 through 20, representative of the environmental conditions created by the burning of hydrogen.

Staff finds the temperature profiles comparable. We didn't use exactly the same scenarios. We used similar ones and got similar results. So that is meant to be the hydrogen combustion input into the equipment survivability analysis as one of the inputs. And you'll hear more about that in April.

KHNP selected the bounding pressure from an adiabatic isochoric with complete combustion analysis to determine the peak containment pressure when combustible gases during the course of a severe accident burn.

Staff calculated the AICC pressure for all five base cases and found that their results are bounded by the applicant's AICC pressure.

So, the input, both the temperature and the pressure from burning of hydrogen, staff believes are appropriate inputs into the equipment survivability.

And this is a requirement of being able to monitor hydrogen in the containment under severe accident conditions as required by 50.44(c). KHNP has a containment hydrogen monitoring system, which monitors hydrogen inside the containment for severe accidents and provides continuous post-accident indication of the containment hydrogen concentration and provides it in the control room. It remains functional post-accident. In fact, it's part of the equipment survivability program. It has two redundant trains. It samples the containment atmosphere. It also samples the atmosphere in the air space in the IRWST. And this information is going to be used for accident mitigation -- accident management. Excuse me.

And staff finds that their combustible containment hydrogen monitoring system meets the requirements of 50.44(c)(4).

Containment evaluation of structural integrity. Structural integrity is something that is evaluated by the Structural Branch and they will be talking to you I think also in April and talking about the various loads that they look at on the containment integrity.

And here again we, for 50.44, provided one of the inputs, one of the loads that they have to consider in the containment integrity analysis. And again, the pressure load is based on the hydrogen burn from 100 percent of fuel clad-coolant interaction and the AICC pressures was selected by KHNP to be part of the input into this containment structural integrity analysis. And we have provided that to structural and they will provide you their conclusion with structural integrity, considering this is one of the loads.

That's all I have.

CHAIRMAN SUNSERI: All right. Any other questions from the committee?

So, I just want to reiterate that we want you to note that we do expect some feedback on Dr. Rempe's question regarding the basis for the way you selected the nodalization. Okay? Thank you.

MS. GRADY: Thank you.

CHAIRMAN SUNSERI: You may notice that we have juggled the schedule of presenters around. We did this in an effort to get the right people that are available here and the staff and the consultants there so that we can finish the sequence of presentations this afternoon and not have to bring back anybody tomorrow.

So, Jessica, walk us through this.

MS. UMANA: Yes, we're going to walk through -- I mean I'm sorry, we're going to cover Section 6.1.1, 6.2.7 and 6.6 next. And just to give people an idea of where we're going, after that, we're going to cover -- I think this will help a bit if we go here, so you can see it. I'm rattling off numbers and it probably means nothing.

Then we're going to go to 6.2.1.1, 6.2.13, and then 6.2.1.4 and lastly, we'll cover Sections 6.2.4 and 6.26. Hopefully, they won't take us too far over 5:00-ish.

CHAIRMAN SUNSERI: Yes, I mean we're not

going to shortchange any discussion. We want to step through these methodically.

MS. UMANA: Let me find the presentation for this next presenter. Okay, here we go.

MR. WIDREVITZ: Hello, everyone. My name is Dan Widrevitz, and I'm presenting for several reviewers today.

The first section I'll be presenting is 6.1.1, Engineered Safety Features, Metallic Materials. So this is just on metallic materials in the ESF system.

So the review itself covers the four main bullets of the review covered, the materials and fabrication aspects, specific to austenitic stainless steel, ferritic steels, and finally the composition and compatibility of the ESF fluids with those materials.

So in terms of the review, the review itself is predominately a check on using the appropriate ASME Code sections and requirements, as well as compliance with several regulatory guides concerning things like welding and sensitization of material.

As part of our review, we had two nonacceptable issues both of which now have a path forward with the safety evaluation draft that you have left that open but there is a path forward.

First, there were inconsistent approaches provided for preventing sensitization of steel. The applicant had described this in several sections of the application. We had a lot of back and forth, fine tuning the language and making sure that things lined up adequately.

In the ESF system, the path forward was to resolve the inconsistencies and supplement the DCD with the clear description of the sensitization prevention measures. And then the second, at the time unacceptable issue, was that there was an unclear quality assurance requirement for the IRWST liner and the information that has been provided, and we are looking forward to seeing revision to the DCD that will state that the IRWST liner will meet the ASME NQA-1 quality assurance requirements.

So are there any questions for 6.1.1?

Okay, if not, I'll continue to 6.2.7. I think the slide might be longer than the actual application section. Section 6.2.7 confirms that the adequate fracture toughness requirements for metallic materials have been or will be applied, essentially for the Section III, Division 2 materials, that's Article CC--2520 and for the Section III, Division 1 materials, that's Article NE-2300. That's just an impact testing.

Any questions for Section 6.2.7?

Okay, Section 6.6 is the ASME Class 2 and Class 3 inspection section. The scope of review covers the components subject to inspection; accessibility, examination techniques and procedures, inspection intervals, examination categories and requirements; evaluation of examination results; system pressure test; the augmented ISI to protect against postulated piping failure; relief requests and code cases; and the combined license information items.

Once, again, this is largely an exercise in demonstrating compliance with the ASME Code. Overall, it was found acceptable with a number of revisions for the DCD pending, including some markup clarifying the use of code compliant exemptions; inclusion of a COL item addressing accessibility similarly for Class 2 and 3 as for Class 1; and a clear enumeration of the appropriate examination methods.

In addition, the applicant agreed to remove an inappropriate COL item asking COL applicants to provide any necessary ASME Code relief requests as a COL item. Obviously, as this is a new plant, which should be built so that you shouldn't need any relief requests but we all know things can happen.

That's it for 6.6. Are there any questions for 6.6?

All right, thank you for your attention. I don't know, am I just really boring?

MS. UMANA: Up next we have Syed Haider.

MR. HAIDER: Thanks, Jessica. Good afternoon. My name is Syed Haider. I am the lead technical reviewer at NRO for the APR1400 DCD Section 6.2.1.1, 6.2.1.3, and 6.2.1.4.

The CR Section 6.2.1.1 deals with the review of the containment structure and the related analyses of peak pressure and temperature resulting from the postulated loss of cooling accident or LOCAs and the postulated secondary system pipe ruptures that are in main steam line breaks or SMLBs and main feed water line breaks inside the containment.

The SER Sections 6.2.1.3 and 6.2.1.4 deal with the related mass energy release analyses for the LOCA and secondary system pipe ruptures. KHNP had also submitted a technical report on the mass energy release methodology that is referenced in the DCD and provides additional details related to these three containment functional design sections that I will be presenting today.

Basically, I will be focusing on ten items that were open as of August 19, 2016 in the Phase II SER that the ACRS currently has. However, as a result of the subsequent interaction with KHNP through public telecons and updated RAI responses, the staff was able to close two open items, while four open items were made confirmatory as they require the applicant to revise the DCD and technical report per the submitted markups.

So six open items have been essentially resolved. And the remaining four items that are still open are mainly related to the peak pressure and temperature analysis. The staff expects to receive supplemental response from the applicant to close them.

I will present the most updated status of the ten items in these staff findings. Next slide, please.

The first open item belongs to the staff's review of the applicant's peak pressure and peak temperature calculations for the limiting LOCA and limiting secondary pipe rupture. NRC regulations mandate sufficient margin between the peak calculated containment pressure and the containment design pressure. The staff guidance stipulates the containment design pressure to provide at least a ten percent margin above the accepted peak calculated containment pressure.

KHNP performed a break spectrum analysis of five LOCA and ten MSLB cases using a GOTHIC model. Based on the GOTHIC model results, the DCD reports a greater than ten percent margin to the containment design pressure for the double-ended discharge leg slot break LOCA. That is the limiting DBA for the containment peak pressure.

The staff also performed confirmatory calculations using MELCOR computer code that led to higher peak pressure and temperature and lower peak pressure margin than the one reported in the DCD. In order to understand the difference between the licensing and confirmatory calculation, the staff issued two RAIs to inquire about the selection and conservatism of the plant-specific design parameters, initial and boundary conditions, passive heats sinks, and other input data, such as sensitivity coefficients and modeling assumptions.

The staff also obtained the applicant's GOTHIC decks and modeled the containment. As they did the decks model, the containment is two lumped-parameter volumes representing the containment atmosphere region and the IRWST.

Based on this review, the staff also asked the applicant to perform additional GOTHIC sensitivity analyses. Next slide.

MEMBER KIRCHNER: May I just ask --

MR. HAIDER: Sure.

MEMBER KIRCHNER: Syed, at this point, how -- what was the difference between the MELCOR results for your confirmatory calculations and the applicant's, just percent, so to speak, roughly, and the largest deviation?

MR. HAIDER: It was significant. The DCD report 14.5 percent margin, while we were getting two to three percent margin. That was significant.

So the staff reviewed the GOTHIC decks for the limiting LOCA and MSLB cases and concluded that the outer surfaces of the containment shell and the inner surface of the containment floor are conservatively modeled adiabatically. However, the staff found that the GOTHIC deck has more heat sinks than are documented in the DCD, which could potentially explain some of the differences between the applicant's and the staff's peak pressure and temperature calculations.

The heat sink issue will be discussed separately under open item number three.

MEMBER CORRADINI: So the difference between a few percent and 14 percent is they had more cold surfaces.

MR. HAIDER: They had more cold surfaces and we also found that to bring the calculation to nine will also require us to reintegrate the area, the areas of the heat sinks as they were tabulated in the table.

MEMBER CORRADINI: Oh, okay.

MR. HAIDER: It's not that obvious. I mean in none of the RAI responses it came across like that. The DCD doesn't report like that but this is also turning out to be the case.

I'll talk more about that in open item number three.

So while reviewing the decks, the staff identified three non-conservatisms in the GOTHIC model with respect to the containment peak pressure and temperature.

One non-conservatism is that the DCD analysis used the DLM, or diffusion layer model, for condensation heat transfer, while as said by the staff, the applicant's sensitivity analysis showed that using Tagami and Uchida correlations was more conservative.

So these three correlations have been used to model convective condensation and the effect of non-condensables. DLM is an analogy-based analytical model, while Tagami and Uchida are essentially based on experimental data.

MEMBER CORRADINI: Can we go back to that? I'll just say on the record that it's the exact opposite. The diffusion analogy model is probably physically correct. The Tagami and Uchida model is unverifiably empirical.

MR. HAIDER: That's not what I said.

MEMBER CORRADINI: Oh, I thought that's

what you said.

MR. HAIDER: What I really mean to say that the DLM is an analytically-based model --

MEMBER CORRADINI: Right.

MR. HAIDER: -- while Tagami and Uchida are based on experimental data.

MEMBER CORRADINI: Right but the data -- I've said this for a long time, the data for Tagami and Uchida is based on a scaling that makes -- that isn't understandable; whereas, the analogy model makes sense under a range of scales.

MR. HAIDER: Yes.

MEMBER CORRADINI: It is scale independence.

MR. HAIDER: But the staff experience has shown that this is less conservative and that's why NUREG-0588 suggests that normally you achieve Uchida heat transfer correlations should be used. That's an explicit guidance.

MEMBER CORRADINI: Oh, I understand it's guidance but --

MR. HAIDER: Yes, it's the guidance.

MEMBER CORRADINI: But I still think eventually staff ought to look into that because I don't think that guidance is physically correct.

MR. HAIDER: But when the applicant did the sensitivity analysis --

MEMBER CORRADINI: It doesn't matter. It's wrong. Using Tagami and Uchida has been wrong for a long time. I mean it is conservative but that doesn't mean it's right.

MR. HAIDER: Okay. When they did the sensitivity analysis they found that using Tagami and Uchida -- using Tagami --

MEMBER CORRADINI: I'm with you.

MR. HAIDER: -- was more conservative.

The second non-conservatism is due to the inertial length of one foot used in the DCD GOTHIC calculations, while it could be chosen as large as the containment height that was shown to be more conservative. The applicant is expected to update the inertial length in the GOTHIC model.

A third potential non-conservatism is due to the fact that the burnup dependent thermal conductivity degradation or TCD was not accounted for in the original M&E mass energy release used by the applicant in the containment pressure and temperature analyses.

The concern is that when TCD is accounted for the fuel thermal conductivity will decrease, which will result in a higher initial core stored energy and raw temperatures that may lead to more severe mass energy release and thus higher peak containment pressure and temperature.

Now the applicant is implementing the DCD in their ECCS evaluation model and the Reactor Systems Branch is reviewing DCD --

MEMBER BALLINGER: Can we go back a little bit? You say there's a difference between 14 percent and 2 percent, round numbers.

MR. HAIDER: Round number two or three percent.

MEMBER BALLINGER: Okay, so that's 12 percent. Of that 12 percent, have you broken it down to see which of these three items dominated or didn't or what? Because I keep coming back to what Member Corradini is saying. If 80 or 90 percent of the difference has to do with using the model, which is not reasonable, I wonder about that.

MR. HAIDER: Okay. What I can really add here is that the inertial length and the DLM versus Tagami explained about one to one and a half percent each. That's what I can recall about 0.5 psi ea. That was roughly the number.

DCD, I don't know because that is something that they had -- the whole issue doesn't include the DCD deck.

MEMBER CORRADINI: I thought in another question earlier today they said they did a sensitivity with an additional 400 degrees. Is this a different part of the DCD that maybe I missed?

MEMBER REMPE: This is the same thing.

MEMBER CORRADINI: Confusing?

MEMBER REMPE: And they did tell us they had done a sensitivity. Is that in their response and you just haven't evaluated it yet or are you happy with that?

MR. HAIDER: I think someone told me that they are going to submit about a 600-page long response or something like that.

MEMBER REMPE: So we're carrying an advance notice of what the response we will have.

MR. HAIDER: That's right. That's right. So that would include DCD.

MEMBER KIRCHNER: Wouldn't it be fair to say that the first bullet at the top of the slide, especially more heat sinks, I mean this is a service of volume problem that dominates more than the heat transfer coefficients. And so a mistake in modeling going in, total surface area available and such is probably much more important than which heat transfer coefficient you choose.

MR. HAIDER: That's true.

MEMBER KIRCHNER: So how is that going to be reconciled? It's odd to think that the applicant, who should know the design better than you, would have the -- I'm interpreting heat sinks to surface area. So would have the surface area is incorrect.

MR. HAIDER: It's not that the surface area are incorrect. It's like how the surface areas are interpreted and how the thickness is interpreted.

So in the earlier version, when we found two to three percent margin, we were interpreting the surface area to be two-sided surface area. But if we use the sink surface area as single-sided, then similarly the numbers are kind of aligning with the GOTHIC prediction.

But this is something that has to be resolved with the applicant. Is it clear?

MEMBER KIRCHNER: That may be much more

important than, assuming you're not picking a boiling heat transfer correlation or something entirely inappropriate, that may dominate the variance in pressure loadings versus the details because there is so much thermal inertia here that --

MR. HAIDER: That's true. I think this needs to be how the surface areas and the thickness that are reported in the table are interpreted. And it looks like that there is room for interpretation.

MEMBER KIRCHNER: Okay.

MR. HAIDER: So the applicant has agreed to address the three non-conservatisms in the GOTHIC model and plans to submit the revised limiting GOTHIC analysis index and update the DCD to reflect the revised licensing basis calculations. And that would account for the three non-conservatisms.

The updated results will allow the staff to make the safety findings regarding the calculated containment peak pressure, peak temperature, and available containment pressure margins during the first 24 hours after the DBA initiates.

The issue is being tracked as an open item. Next slide, please.

The second open item is also related to

the updated GOTHIC calculations. Basically GDC 38 requires that containment heat removal systems shall rapidly reduce the containment pressure following any LOCA. The staff's SRP guidance has specified that the containment pressure should be reduced to less than 50 percent of the peak calculated pressure for the design-basis LOCA within 24 hours after the postulated accident.

DCD states that the calculated containment pressure at 24 hours, which is 25.54 psig, is 42.2 percent of the peak calculated pressure of 51.09 psig for the limiting LOCA.

As a result of the RAI question, the applicant corrected the value of the containment pressure at 24 hours from 25.54 psig to 21.64 psig. The staff found the applicant's use of gauge pressure values in psig for calculating the pressure reduction margin at 24 hours after the accident to be acceptable per Reg Guide 1.206's pressure unit specification.

MEMBER CORRADINI: So maybe the two percent and the 14 percent is finally hitting me. So when you say that, you're taking how close you are to the limit so 2 percent and 14 percent could be a psi and 4 psi.

MR. HAIDER: Yes, that's right.

MEMBER CORRADINI: Okay. I misinterpreted 2 and 14 percent when you first mentioned it but now I get it. Thank you.

MR. HAIDER: So however, the staff still needs to verify the containment peak pressure and peak pressure margin at 24 hours in the approved licensing basis calculation results that would support for the three non-conservatisms as described earlier and also the area reconciliation issue.

The issue is being tracked as an open item. Next slide, please.

The third open item emerged when the staff tried to understand the differences between the result of the applicant's limiting peak containment pressure and the temperature calculations as reported in the DCD and the staff's confirmatory calculations. Two RAI questions were issued in this regard.

The staff reviewed the conservatisms built in the APR1400 containment response analysis that involved the heat sink parameters, containment volume, nodalization, and various modeling assumptions.

I think there was one question asked about the nodalization. Yes, in earlier we did do the sensitivity analysis by using nodalization of the containment. And I believe we used 30 nodes and that turned out that there was not a whole lot of difference between the 30 node results and the single node results.

MEMBER REMPE: So 30 versus 2.

MR. HAIDER: Thirty versus one.

MEMBER REMPE: Versus one. Okay, so I'm still back on this MELCOR-MAAP thing where they both stayed with the 37. And so --

MR. HAIDER: But I'm talking about the MELCOR.

MEMBER REMPE: Right, right. Well MELCOR versus MAAP and they both used the 37. So I still would like an answer on why 37 is adequate, like we talked about earlier but I appreciate that this has been done here.

MR. HAIDER: Okay. These are the RAI responses as related to the staff's review of the GOTHIC deck, the staff performed a full accounting of the input data sensitivity coefficients such as inertial length, heat transfer correlations and uncertainties. As I described earlier and I don't have to go over that again, that the main source of discrepancy was found to be the three additional heat sinks that we found and also the reinterpretation of the area and the thickness that are tabulated in the DCD table.

So these are the two issues that we have to resolve under open item number 3. Next slide, please.

The fourth open item was interpreting and ensuring collaboratism with the peak containment pressure and temperature in accordance with GDCs 16 and 50 requirement for sufficient design margin in the containment structure under the limiting design-built accident conditions.

DCD Table 6.2.1-24 lists the initial conditions for containment peak pressure analyses. An RAI was issued to ascertain whether the initial and boundary conditions were conservatively chosen to maximize the peak calculated containment atmospheric pressure and temperature.

After reviewing the RAI response, the staff further inquired about why no instrument uncertainty was applied for additional conservatism to the initial containment atmosphere temperature of 120 degrees Fahrenheit that is chosen from the temperature limiting condition of operation or LCO in the tech specs.

The applicant made two arguments in the supplemental response to justify not using any instrument uncertainty in the initial temperature condition. One was that the NRC regulation 10 CFR 50.36 defines the limiting condition of operation or LCO as the lowest functional capability or performance levels of equipment required for safe operation of the facility.

Secondly, the SECY paper 11-0014 states that LCO limits shall be used for the bounding values as the initial conditions for containment accident analysis.

So the applicant concluded that an additional conservatism due to instrument uncertainty is not warranted.

The staff fact-checked both the statements in the respective documents and found it acceptable that no instrument uncertainty is added to the temperature LCO limit for the containment initial temperature condition. Therefore, the open item is closed. Next slide.

The next open item belonged to the

containment backpressure that is assumed by the applicant to be constant 58 psia throughout the reflood phase of the design-basis LOCA mass energy release analysis, following determination of the critical flow.

An RAI was issued to understand the basis for selecting this pressure for input to the FLOOD3 code and whether an even lower value of the containment backpressure would be more conservative from the mass and energy release perspective during the reflood phase.

The staff needed to confirm that the boundary condition was chosen to yield the conservative mass and energy release and higher peak containment atmosphere pressure and temperature. Again, the objective was to ensure conservatism in the design of reactor containment structure and containment heating water systems under the limiting design basis accident conditions.

The applicant responded that 58 psia value is selected as it is lower than the calculated containment pressure between the end of blowdown or EOB and when the containment peak pressure is reached.

The applicant submitted the peak, minimum, and EOB pressure values for a big spectrum analyzed for a range of safety injection conditions using two different computer codes. However, the staff determined that the lowest containment pressure showing up in the submitted data is actually 57.157 psia, which is not that far from 58, but it is still lower than 58 psia used for the limiting DBA.

So the applicant was asked to submit a supplemental RAI response to justify not using a more conservative say 57 psia containment backpressure.

The issue is being raised as an open item.

MEMBER KIRCHNER: Could you -- this is interesting. So you have 1 psia difference and, therefore, instructions were back to the applicant to use that lower value and I understand that. But what kind of certainty do you think is on these results?

MR. HAIDER: It may not be a whole lot but for the sake of completion -- completeness.

MEMBER KIRCHNER: No, I don't argue with your logic but I would just for a perspective during the peaks, but what do you think the uncertainty is on that 58 psi or 57.157?

MR. HAIDER: See the difference between 58 and 57 would affect the mass and energy release.

MEMBER KIRCHNER: Yes.

MR. HAIDER: The mass and energy would impact the containment peak pressure. Of course, it would not be a whole lot, I mean if you asked for the engineering.

MEMBER KIRCHNER: Well, I didn't express what fundamental issue I'm asking -- 57.157, that's a degree of precision that probably would be masked by your knowledge of previous slides, the heat transfer coefficient, the surface area in play, et cetera. So I'm just struck by that precision, five significant figures.

So what kind of uncertainty do you have -- what's an unexpected uncertainty range for these numbers?

MR. HAIDER: See I might have presented that number directly copying from the RAI but I would not expect more than a couple of percent.

MEMBER KIRCHNER: Okay.

MR. HAIDER: But again, the objective was completeness.

MEMBER KIRCHNER: Okay, thank you.

MEMBER CORRADINI: So let me ask Walt's question differently.

So you wanted to make darn sure it was conservative. So 57 is more conservative than 58, given where the calculation ended up. That's kind of what I heard you say.

MR. HAIDER: Yes.

MEMBER CORRADINI: Okay. But it probably is not going to make a heck of a lot of difference in the bypass flow for backpressure or whatever.

But I wanted to make sure I understood your thinking process.

MR. HAIDER: Sure. Sure, that's right.

MEMBER REMPE: Would it have been better, knowing the uncertainty to just say 57? Did you really ask them to use 57.01 -- oh, they told them to use 57. Okay.

MR. HAIDER: The sixth open item is due to the GDC 50 requirement in the SRP guidance that containment design-basis calculations should be performed for a spectrum of postulated break sizes, break locations, and single failures for determining the most severe design-basis LOCA.

The APR1400 DCD identified a double-ended discharge leg slot break with maximum safety injection flow as the limiting case of the mass and energy release that led to the most severe DBA LCOA with peak calculated containment pressure.

However, the staff noticed that all breaks analyzed for APR1400 DCD are double-ended slot-type and no double-ended limiting breaks were analyzed.

The staff also found that the double-ended hot leg slot break was just assumed to be the limiting break size for a hot leg break LOCA when no hot leg slot break spectrum analysis was performed either.

MEMBER BALLINGER: Just to make sure, this is for LOCA analysis or equipment qualification?

MR. HAIDER: This is for the LOCA analysis. The staff is trying ensure that the whole range of possible break spectrum.

MEMBER BALLINGER: Oh, I'm sorry. I wasn't sure.

MR. HAIDER: So the staff also found that the double-ended hot leg break was just assumed to be the limiting break size for a hot leg break LOCA while no hot leg slot break spectrum analysis was performed.

An RAI was issued to ask the applicant to address the gaps in the break spectrum analysis, as double-ended guillotine break and hot leg slot break spectrum were not analyzed for the mass and energy release in the subsequent containment response analyses.

In the initial response, the applicant presented analysis for two smaller break sizes that are 60 percent and 80 percent of the double-ended hot leg slot breaks. The staff emphasized that the break spectrum should include even smaller hot leg breaks to rule out any smaller break sizes as being more limiting.

CHAIRMAN SUNSERI: Just one question and this is my naiveness here. What is a slot break?

MR. HAIDER: A slot break would be if you have a pipe and the double-ended guillotine break would be thick. And now you have double-ended -- now you have area of circumference multiplied by two.

But if you impose that area as a slot, such that the liquid, the fluid can still interact, then it would be considered a slot break and it would be called -- if it's area is exactly double-ended guillotine, it will be called double-ended slot break.

CHAIRMAN SUNSERI: Okay. So I guess my old slang would have been calling that a fish mouth break or something, right?

MR. HAIDER: Yes.

CHAIRMAN SUNSERI: Okay, got it. Thanks.

MR. HAIDER: So in the supplemental RAI response, the applicant provided tables and figures of additional analyses supporting their conclusions.

The newly calculated double-ended hot leg guillotine break blowdown mass and energy release data in the exerting peak pressure were compared with those of the double-ended hot leg slot break case of APR1400 DCD.

The comparison shows that for the hot leg, even though the guillotine break turns out to be more severe than the double-ended slot break, the resulting peak pressure is still less than that of the limiting LOCA case, which is the double-ended discharge leg slot break with maximum safety injection flow documented in the DCD.

Essentially, from this analysis, they still found that the limiting break that is documented in the DCD is still the limiting break.

The RAI response also compared the newly calculated blowdown mass and energy data of the double-ended discharge leg guillotine break with the limiting double-ended discharge leg slot break case documented in the DCD, which showed that the double-ended discharge leg slot break is more severe than the double-ended discharge leg guillotine break case and it is still limiting. So the DCD is still holding.

MEMBER CORRADINI: So let me ask the question a bit different.

So you wanted it -- as I understand your description, you wanted to make sure they scanned the break area spectrum enough that they were finding the maximum in peak clad temperature.

MR. HAIDER: That's right.

MEMBER CORRADINI: Have I got this right?

MR. HAIDER: That's right.

MEMBER CORRADINI: So my first question is I guess I was expecting to hear all this discussion in Chapter 15 and not here. How did it get pulled here? Because it's being then used for mass and energy for the -- okay.

MR. HAIDER: That's right. It's the mass and energy --

MEMBER CORRADINI: So these calculations are consistently being used for the LOCA analysis, as well as for the mass and energy release analysis.

MR. HAIDER: I cannot speak for Chapter 15 but it will be in Chapter 15.

MEMBER CORRADINI: Okay. Okay but then maybe I turn to the applicant. Am I interpreting right that you are using the same consistent set of analyses between Chapter 15 and for the mass and energy? You see where I'm coming from?

MR. S. PARK: I am S.J. Park from KEPCO E&C. I think the PSTO (phonetic) analysis and the M&E analysis is not the same.

MEMBER CORRADINI: Not the same.

MR. S. PARK: Yes.

MEMBER CORRADINI: Okay. All right, so this analysis as we are looking at it here is strictly for mass and energy release, equipment qualification and we would see a different analysis in Chapter 15?

Okay. All right, sorry. I just wanted to make sure I understood if there was a connection. But thank you.

MR. HAIDER: Okay. As I said earlier, the main purpose of this RAI was to fill the gaps that the staff found in the break spectrum analysis.

MEMBER CORRADINI: Thank you.

MR. HAIDER: The applicant also submitted additional analysis of a smaller hot leg slot breaks to ensure that the mass and energy release and the peak containment pressure results for six discharge leg slot break cases from 80 percent through 5 percent of the double-ended area. So they went from 80 percent to 5 percent.

And the results show a monotonous decrease in the predicted containment peak pressure with the reduction in the break area. So the staff accepts the double-ended hot leg slot break is most conservative across the possible hot leg slot break spectrum.

Finally, the staff concludes that sufficient detail have been provided on the mass and energy release and containment peak pressure analyses and accepts that the DCD conclusion that the double-ended discharge leg slot break is the limiting LOCA case for the APR1400 design holes.

So DCD and TeR are revised and the open item has been changed to confirmatory item. Next slide.

The seventh open item pertains to the staff questions about the spillage and the applicability of the computer codes for modeling the LOCA mass and energy release.

The staff essentially asked the applicant to clarify how the spillage was modeled in the containment mass and energy release in order to align it with the values used in the licensing basis and confirmatory calculations. Transient data were provided in the DCD for many of the mass and energy release components but spillage data were listed as single integral line item.

The staff requested the transient spillage data in order to determine if there was any impact resulting from spillage or on a more discrete timescale.

When the staff was looking for sources of discrepancies between the licensing basis and confirmatory calculations, spillage was identified as an area to look into. And there was another reason for asking the question and that was for completeness of the DCD in the past several other applications have provided the spillage data in the transient form.

The staff also needed to establish whether the computer codes CEFLASH-4A and FLOOD3 used for modeling the mass and energy release during the blowdown and the reflood phases of the LOCA have been validated and approved to model DVI-type safety injection.

Next slide.

In the supplemental RAI response, the applicant provided transient mass energy release data for the spillage by integrating the transient spill data the staff confirmed that it was well within one percent of the aggregate spillage, which showed that the spillage had already been accounted for.

The staff concludes that the correct mass and energy is the input to the licensing basis and confirmatory calculations. The supplemental response also revised DCD mass and energy release tables to include the transient spillage data. Both the DCD and technical report will be revised to reflect the modified information.

The staff finds the applicant's response to be acceptable.

Now coming to the applicability of the computer codes, the applicant provided the information that LOCA blowdown transient with DVA injection is analyzed using the CEFLASH-4A code without any code model change.

Secondly, DVI injection in CEFLASH-4A is using a nodalization and flow paths similar to other regions in the vessel.

The effect of DVI-type injection during

the LOCA blowdown phase is similar to the cold leg type injection, with the exception that there is no loss of one train of safety injection for DVI type injection.

In the FLOOD3 code for the reflood phase, safety injection flow is modeled as a boundary condition for the reactor vessel annulus. This approach is similar to the one that was used in the FLOOD-MOD2 code, which is the NRC approved version.

So the staff concerns about the applicability of the computer codes have been at risk and the open item has been changed to a confirmatory item.

Next slide.

The eighth open item evolved out of a series of additional information that asked by the acceptance criteria SRP Section 6.2.1.3.

The slide outlines a summary of miscellaneous questions issued as an RAI that asked for the additional information that were not available or could not be found in the DCD or the mass and energy release technical report.

One was the description of the long-term cooling or post-reflood model that was missing. The

RAI also asked for a justification of the methods used to calculate the core inlet and exit flow rates and removal of the sensible heat from primary system metal surfaces and the steam generators.

A description of the liquid entrainment correlations was also asked for fluid leaving the core and entering the steam generators and their justification by comparison with experimental data.

The RAI also indicated that no information was found about the steam quenching by ECCS water or the applicable experimental data, or whether and how all the remaining stored energy in the primary and secondary systems would be removed during the post-reflood phase.

The RAI also asked for information to compare the results of post-reflood analytical models of any applicable experimental data.

The RAI also inquired about whether the use of the GOTHIC code for decay heat phase mass and energy release analysis can be considered appropriate for this application.

This slide captures a summary of the information provided by the applicant in the RAI response. It showed that the post-reflood transient is treated as a continuation of the reflood transient. All modeling assumptions and methods are identical, except that the carry out rate fraction for liquid entrainment calculations. It's changed from 0.8 for reflood to 1.0 for post-reflood.

The staff agrees that the CRF value of 1.0 is conservative as it would increase the system flow rate and maximize the break flow during the post-reflood period.

And the assumption of steam quenching and description of removal of remaining stored energy in the primary and secondary systems are identical to that of the reflood period.

The staff accepts that not taking credit for condensation after the turndown to low safety injection tank flow during post-reflood period was conservative.

The staff also accepted the mass release calculations for using FLOOD3 reflood/post-reflood periods are conservative as the flow resistances were minimized.

The response also provides details of the lumped-parameter GOTHIC model for the RCS used to calculate the mass and energy release through the break during the decay heat phase.

It also stated that GOTHIC used for mass and energy release calculation during the post-reflood decay heat phase was previously approved by the NRC for the Dominion Power Plant in their containment analysis methodology, which the staff found acceptable.

And the staff concludes that the applicant has provided sufficient information in the supplement revised RAI responses acceptable. The open item is closed.

The open item number 9 and then the staff issued an RAI to obtain additional information on the initial bounding condition for the main steam line break analysis. This was in accordance with the GDC 50 requirement that the reactor containment structure and the associated heat removal system shall be designed with sufficient margin to accommodate a limiting design basis accident conditions.

Essentially, the limiting single failure MSLB analysis is based on minimizing the rate of heat removal from the containment atmosphere. That required analyzing containment spray system and main steam isolation valve single failures. The second objective was the flow of saturated and superheated steam out of the break needs to be maximized, which could be based on any one of the several possible single failures, including the failure of condensate booster pump to trip or feedwater regulating valve to close.

The staff needed to determine whether the feedwater regulating valve single failure was examined by the applicant. During the time the feedwater regulating valve takes to shut the flow, a considerable amount of feedwater may enter the steam generator and gain heat from the hot parameter site. The resulting additional steam would enter the containment to further increase the containment peak pressure and especially the peak temperature.

So basically, the applicant needed to demonstrate that the current limiting MSLB analysis is bounding for all possible single failures.

The response provided a supplemental table of several other single failures of the safety and electrical system components, as well as their qualitative evaluations to show a variety of additional single failures would not affect the current bounding MSLB analysis the DMSIV as the most severe single failure.

The supplemental table fills the information gap in the DCD on other possible single failures and is added to the technical report. For example, the first line item I recall from the table is that why you did not consider these failures of main feedwater isolation valve for the qualitative evaluations said because there are two and if one fails, the other one is still available so it won't affect the single failure consequences.

DCD Tier 2, Section 6.2.1.4.4, Description of Blowdown Model and Table 6.2.1-20 are also revised for clarity regarding the initial conditions of the limiting MSLB and that the maximum feedwater enthalpy is assumed and the maximum feedwater flow is delivered to the affected steam generator in the main steam line break analysis.

MEMBER CORRADINI: Can I -- I'm trying to -- I'm kind of back one slide but you don't have go back.

MR. HAIDER: Sure.

MEMBER CORRADINI: But the intent of this is to look for the limiting break, which challenges the containment spray or challenges the performance of the containment -- that the containment spray has to be measured against.

MR. HAIDER: If the limiting single failure for the MSLB, the limiting single failure for the -- the limiting single failure for the main steam line break analysis.

MEMBER CORRADINI: Okay.

MR. HAIDER: So they have found that it is the failure of a main steam line isolation valve, which is they found to be the single failure.

MEMBER CORRADINI: Right.

MR. HAIDER: But they did not show how they concluded that the other single failures --

MEMBER CORRADINI: Okay.

MR. HAIDER: -- could not be the limiting or bounding. So they provided a supplemental table --

MEMBER CORRADINI: Okay.

MR. HAIDER: -- with additional possible single failures and their qualitative evaluation as to why they could not be the limiting single failure. An MFIV failure it turns out, it still turns out to be the limiting single failure.

So the staff found that the supplemental information is adequate and accepts that eh current limiting MSLB analysis is bounding for all possible single failures. So DCD and TeR, technical report are revised and open item is changed to confirmatory item.

And now we come to the last open item that pertains to the SGN-III computer code that is used for the APR1400 secondary system pipe break mass and energy release analysis. APR1400 DCD and mass and energy release technical report do not comment on the acceptability of the SGN-III code for the APR1400 application.

So an RAI was issued to request the documentation on whether the SGN-III computer code has been evaluated against pertinent experimental data.

The applicant's response provided information that showed that the SGN-III was validated against pertinent experimental data, as documented in System 80 Combustion Engineering Standard Safety Analysis Report Appendix 6B. It's detailed reference is included in the APR1400 DCD SER for Chapter 6.

The response also provided the validation details of the SNG-III code prediction against the test data from four different test facilities. The staff found that use of a steam separation rate multiplier of 2.5 in the methodology to be conservatively predicting the extent of the two-phase swell reaching the steam generator nozzles following the break for all four data sets. So 2.5 could explain -- could support the liquid, the two-phase swell reaching the steam generator nozzles.

The implication is that the applicant's response addresses the key issue whether or not the swell is sufficient for the two-phase level to reach and stay at the steam generator nozzles throughout the transient, due to depressurization to maximize mass and energy release during the mass and MSLB.

So the applicant also showed that SGN-II was approved by NRC for analyzing the MSLB accident for this the combustion engineering type nuclear power plants. The acceptability of the SGN-III code for this application is explained and documented in the System 80 safety analysis report.

DCD and technical reports are appropriately revised and open item has been changed to confirmatory item.

This concludes my part of the presentation. I would like to thank the committee and would like to ask if there are any other questions that the staff could address.

CHAIRMAN SUNSERI: Members? Well, thank you, Dr. Haider.

All right, one more presenter. Is that right?

MS. UMANA: Yes. We have Raj Goel, last but not least. Thank you for being patient. And he's going to be presenting on Section 6.2.4, Containment Isolation System and Section 6.2.6, Containment Leakage Testing.

MR. GOEL: Hi, my name is Raj Goel and I reviewed containment isolation system and containment leakage testing of APR. And I'm sorry I did not prepare a lot of slides but you can get this --

CHAIRMAN SUNSERI: Don't apologize.

MR. GOEL: Containment isolation system is designed to allow free flow of normal or emergency-related fluids through the containment boundary in support of reactor operations but establishes and preserves the containment boundary integrity.

The criteria for isolation requirements and associated systems are set forth in GDC 1, 2, 4, 16, 54, 55, 56, and 57 of Appendix A to 10 CFR 50 and TMI-related requirements of 10 CFR 50.34(f)(2) and station blackout requirement of 10 CFR 50.63(a)(2).

The staff used acceptance criteria described in SRP Section 6.2.4 and guidance described in Reg Guide 1.141, which endorses ANSI N271-1976, which is Containment Isolation Provisions for Fluid Systems.

The containment penetration barriers consisting of flange closure, personnel airlock and equipment hatch are under administrative control.

Review of DCD Section 6.2.4 resulted in several questions and clarifications such as why all penetrations are not included and the numbers are not included in DCD Table, justify system with single valve isolation, and some other basis. And where it fail-as-is position of CIV upon loss of power, design requirements of relief valve used as CIV, all power operated CIVs have position indication in control room, provision of vent and drain connection for leak testing of isolation valves.

And there are five open items, four of which have been reviewed since and have found acceptable.

And there is one open item remaining, which is regarding the length of pipe showing the CIV outside containment located as close to it as practical as required by GDC 55, 56, and 57.

And this requires response from the applicant and it's not yet received.

Containment leakage testing addresses the leakage rate testing program for reactor containment. It is designed to 10 CFR 50 requirements of GDC 52, 53, 54 of Appendix A that require that the reactor containment vessel and piping system and penetration the containment be designed to accommodate periodic leakage rate testing.

Appendix J specifies leakage testing requirements for the containment, its penetration, and isolation valves (Type A, B and C tests.)

A review of DECD Section 6.2.6 resulted in ten questions. The staff has evaluated the applicant's response to these questions and found it acceptable. There are no open items.

The staff concluded that Type A, B and C tests are conducted in accordance with 10 CFR 50 Appendix J, Option B, with guidance from Reg Guide 1.163.

Testing intervals and requirements are based on NEI 94-01 and NASI/ANS-56.8-1994, as modified and endorsed by Reg Guide 1.163.

Containment Leakage Rate Testing program and requirements and acceptance criteria are, as in the technical specification program.

The staff finds that the containment leakage testing meets the applicable requirements specified by 10 CFR 50, Appendix J Option B, and GDC 52, 53, and 54 of Appendix A.

MS. UMANA: That's it. 6.2.4 and 6.2.6.

CHAIRMAN SUNSERI: All right. Thank you for that concise presentation.

Any questions from the members?

MEMBER KIRCHNER: Just a quick question. So which piping systems did you find as questionable with regard to criterion 54? I think that's the right one. You want the isolation valves as close to the containment, physical containment as possible.

MR. GOEL: They have had this initially in the DCD table and when I answered that why an ITAAC is in there, then they took that distance from the table out and they say it would be it really done an analysis and we don't have the distance.

MEMBER KIRCHNER: So what are your expectations, though, for those distances? Is there a rule of thumb that you use?

MR. GOEL: They had these and we want to find maximum distance so that they had there earlier. They should provide it so that we can look at it and say they are reasonable, close to as possible.

MEMBER KIRCHNER: So your reasonable test, though, is something like length to diameter ratio being less than -- I'll make up a number -- two.

MR. GOEL: Yes.

MEMBER KIRCHNER: I just made that up. I don't know what the real -- what you used as a criterion.

MR. GOEL: The feeling is that they would have to be at least, their length -- one is distance for diameter and then they should be able to leak test both walls, so there has to be other isolation valves that leak.

MEMBER KIRCHNER: Sure, you want to be able to physically examine welds, et cetera and flanges for the valves.

MR. GOEL: Yes, sir.

MEMBER KIRCHNER: But is there some rule of thumb that you use for this appropriate distance, close as -- I hate to use this, close as reasonably achievable.

So what is your metric for this gray area, how far out you go with a piece of pipe from the containment?

MR. GOEL: They have some criteria that based why they selected and interference with others.

We have to have some distance in the table so that we can look at it and see.

MEMBER KIRCHNER: Sure, you want a visual inspection.

MR. GOEL: And they can change it later on.

MEMBER KIRCHNER: Okay, thank you. I just was curious.

CHAIRMAN SUNSERI: Yes, well I don't know of any rule of thumb of determining that. My experience from hanging around plants for 35 years is there is usually a mechanical penetration room where they lock them all in there, however big that whole room is.

MEMBER KIRCHNER: Thank you.

MR. GOEL: I agree that it may not be in ITAAC but has to be in table so that it can --

MEMBER KIRCHNER: But just I'll make something up. Say you have a two-inch Schedule 80 pipe penetration. How far will you expect the isolation valve to be from the containment, physical containment itself?

MR. GOEL: I would have to look at it that length and diameter and the other.

MEMBER KIRCHNER: Okay, thank you.

CHAIRMAN SUNSERI: Any other questions from other members?

All right, so we're at the end of the day. We've been monitoring the phone line and there have not been anybody calling in but, nonetheless, at this point, we are going to open the phone lines and ask for public comments or questions.

If there is anyone on the phone line, this is your opportunity to make a comment or provide a statement.

All right, there's no comments there. So we're going to close the phone line and we'll go to the room now.

Any members in the room who would like to make a comment or a statement? I don't see any response.

So, we'll go around the table now for final member comments. Joy?

MEMBER REMPE: Again, I appreciate the efforts and presentations by the staff, as well as KHNP.

This is, I think, Section 6 is an example of a section where it depends on some results, the open items of prior sections. And perhaps when we do Chapters 15 and 19 it will be effective -- or have some effect on what we say about this section.

And I know in some prior design certifications, that has been acknowledged in a letter. And I think this is an example of where you might want to consider it.

CHAIRMAN SUNSERI: Very good. All right, thank you.

Charlie?

MEMBER BROWN: No additional comments.

CHAIRMAN SUNSERI: Walt?

MEMBER KIRCHNER: Thank you to the presenters. No comment.

CHAIRMAN SUNSERI: John?

MEMBER STETKAR: Nothing more other than saying thank you very much. We covered an awful lot of material today.

CHAIRMAN SUNSERI: Ron?

MEMBER BALLINGER: Yes, I expect everybody running the Boston Marathon next time because this was one heck of a marathon session. We thank you very much.

CHAIRMAN SUNSERI: Mike, any comments?

MEMBER CORRADINI: No, I just wanted to thank -- I ran to thank one of the staff that ran out. I just want to thank the staff and the applicants. It was quite good. We asked a lot of questions or we had a lot of action items.

Or maybe I can use that word. We had a lot of questions that we would be looking forward to answers.

CHAIRMAN SUNSERI: All right, thank you.

Dana?

MEMBER POWERS: Thanks. I especially appreciated the justifications where the staff had done independent calculations with their own code and got things that were reasonably confirmatory and identified things as well.

I think there was a particularly powerful steps by the staff to take and I would not fault you for highlighting that more in future presentations.

CHAIRMAN SUNSERI: Thanks.

Dick?

MEMBER SKILLMAN: To the staff and to the presenters, thank you. Thank you.

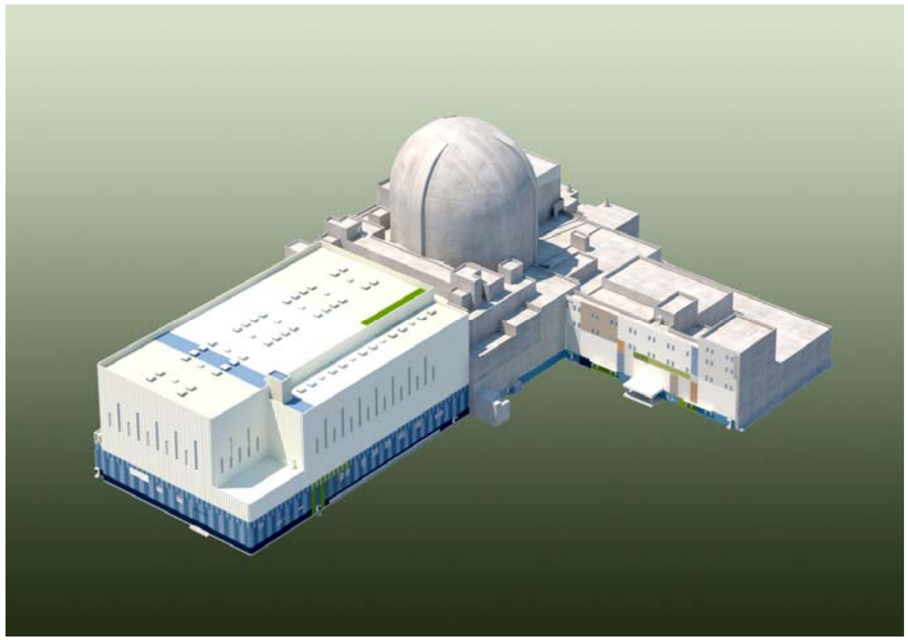
CHAIRMAN SUNSERI: So I would echo the members' sentiments on the quality of the presentations today both by the staff and the applicant. The patience that everyone showed with the schedule changes to fit everything in and also the good response, very good responsiveness to the members' questions and comments.

So thank you all. And with that, we are adjourned.

(Whereupon, the above-entitled matter went off the record at 5:08 p.m.)

NON-PROPRIETARY

APR1400 DCA
Chapter 6: Engineered Safety Features



KEPCO/KHNP
March 22, 2017

NON-PROPRIETARY

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6.8	In-Containment Water Storage System	Sunchang Moon

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Overview of Chapter 6

❑ List of Submitted Documents

Document No.	Title	Revision	Type	ADAMS Accession No.
APR1400-K-X-FS-14002-P/NP	APR1400 Design Control Document Tier 2: Chapter 6 Engineered Safety Features	0	DCD	ML15006A045
APR1400-K-X-FS-14001-P/NP	APR1400 Design Control Document Tier 1	0	DCD	ML15006A039
APR1400-Z-A-NR-14007-P & NP	LOCA Mass and Energy Release Methodology	0	Technical Report	ML15009A127
APR1400-Z-M-TR-12003-P & NP	Fluidic Device Design	0	Topical Report	ML13018A097
APR1400-E-N-NR-14001-P & NP	Design Features to Address GSI-191	0	Technical Report	ML15009A130

6.1 Engineered Safety Features Materials

6.1.1 Metallic Materials

6.1.2 Protective Coatings and Organic Materials

6.1.1 Metallic Materials

❑ Materials Selection and Fabrications

- ESF materials
  - Compatible with core cooling coolants and containment spray solution
  - ASME Section II material specifications with ASME Section III
  - Applicable Regulations: RG 1.7, 1.31, 1.36, 1.44, 1.50, 1.71

❑ Composition and Compatibility of Core Cooling Coolants and Containment Sprays

- Controlled water chemistry
  - Reactor coolant: Chemical and volume control system(CVCS)
  - Containment spray water: Tri-sodium phosphate (TSP) in holdup volume tank (HVT)
- Material used inside containment
  - Minimize corrosion and hydrogen generation resulting from contact with spray solutions (e.g Aluminum and Zinc)

NON-PROPRIETARY

6.1.2 Protective Coatings and Organic Materials

❑ Protective Coatings

- Applicable Regulation and Standards:
  - RG 1.54, ASTM D5144, D3843, D3911, and etc.
- Classification: Service Level I, II and III Coatings
- Quality Assurance and Maintenance:
  - 10 CFR 50 Appendix B, ASME NQA-1, and ASTM D3843
  - 10 CFR 50.65, NRC Maintenance Rule

❑ Organic Materials

- Cable jackets:
  - Chlorosulfonated polyethylene or polychloroprene
- Cable insulations:
  - Ethylene propylene rubber or cross-linked polyethylene
- Reactor Coolant Pumps:
  - Petroleum based oil lubricant

6.2 Containment Systems

6.2.1 Containment Functional Design

6.2.2 Containment Heat Removal Systems

6.2.3 Secondary Containment (N/A)

6.2.4 Containment Isolation System

6.2.5 Combustible Gas Control in Containment

6.2.6 Containment Leakage Testing

6.2.7 Fracture Prevention of Containment Pressure Vessel

6.2.1 Containment Functional Design

❑ Regulatory Bases

- M/E Analyses
  - 10CFR Part 50 Appendix A, GDC 50
  - NUREG-0800 (SRP 6.2.1.3, SRP 6.2.1.4)

- Containment & Subcompartments P/T Analyses
  - 10CFR Part 50 Appendix A, GDC 4, 16, 38, 50
  - RG 1.206
  - NUREG-0800 (SRP 6.2.1.1, SRP 6.2.1.1.A, SRP 6.2.1.2)
  - ANSI/ANS 56.1 (Section 4, Appendices C and D)
  - ANSI/ANS 56.4 (Section 4, Appendix A)

- Minimum Containment Pressure Analysis for Performance Capability Studies of the ECCS
  - 10CFR Part 50 Appendix K
  - RG 1.157
  - NUREG-0800 (SRP 6.2.1.5, SRP BTP 6-2)

6.2.1 Containment Functional Design

❑ M/E Release Analyses

- Loss of Coolant Accident (6.2.1.3)
  - Blowdown
    - The blowdown period extends from time zero until the primary system is essentially depressurized to the containment pressure.
    - Code: CEFLASH-4A
  - Refill
    - The SIS water refills the bottom of the reactor vessel to the bottom of the core.
    - Refill period is conservatively omitted from the analysis.
  - Reflood
    - Reflood is assumed to end when the liquid level in the core is 2 feet (0.61 meter) below the top of the active core.
    - Code: FLOOD3

NON-PROPRIETARY

6.2.1 Containment Functional Design

❑ M/E Release Analyses

- Loss of Coolant Accident
  - Post-Reflood
    - Dominant process is the continued cooling of the steam generators by the SIS water leaving the core.
    - Code: FLOOD3
  - Decay Heat Period (Long-Term Cooling)
    - Dominant mechanisms for release rates are the decay heat and the cooling of all NSSS metal and coolant.
    - Code: GOTHIC (Boil-off Model)
  - Analyses Cases
    - Double Ended Hot Leg Slot Break
    - Double Ended Suction Leg Slot Break with Max. or Min. SI flow
    - Double Ended Discharge Leg Slot Break with Max. or Min. SI flow
    - Single Failure: One Emergency Diesel Generator Failure

NON-PROPRIETARY

6.2.1 Containment Functional Design

❑ M/E Release Analyses

- Secondary Pipe Rupture
  - Main Steam Line Break (MSLB) M/E Analysis Model
    - Code: SGN III
  - Analyses Cases
    - Five Core Power Levels (102%, 75%, 50%, 20%, 0%)
    - Break Size Spectrum
    - Single Failure Sensitivity (main steam isolation valve (MSIV) vs. containment spray system)
  - Main Feedwater Line Break (MFLB) is bounded by the MSLB

6.2.1 Containment Functional Design

❑ Containment P/T Analyses

- GOTHIC Containment Model
  - Break flow models (Drop model / T-Flash)
  - Heat transfer models (Wall condensation / Natural convection)
  - Conservative assumptions (Offsite power / Single failure)
- Analysis Results
  - The containment is designed to have a minimum 10% of pressure margin.
  - Containment pressure is reduced and well maintained at less than 50% of the peak pressure within 24 hours.

Pressure	Value	Design limit	Margin
Design Pressure		60 psig	
Calculated Peak Pressure	51.2 psig	≥ 10 %	14.7 %
Pressure at 24 hours	19.0 psig (37.1%)	≤ 50 %	

6.2.1 Containment Functional Design

❑ Containment Subcompartments

- Subcompartments Analysis Model
  - Subcompartments for Steam generator, Pressurizer, Pressurizer spray valve, Regenerative heat exchanger, Letdown heat exchanger and valves
  - High energy line breaks are postulated in each subcompartment.
  - Code: COMPARE-MOD1A

- Analysis Results
  - Design pressure of each subcompartment has more than 40% of margin over the calculated peak differential pressure.

6.2.1 Containment Functional Design

❑ Minimum Containment Pressure Analysis for Performance Capability Studies of the ECCS

- Analysis Model
  - Minimum containment pressure analysis is performed by CONTEMPT4/MOD5 based on the conservative manner described in 10CFR Part 50 Appendix K requirements.
  - The Mass/Energy release data computed by RELAP5/MOD3.3/K and containment pressure calculated by CONTEMPT4/MOD5 are exchanged in every time step to evaluated the relevant ECCS performance.

- Analysis Results
  - Containment pressure and temperature responses are presented in Section 6.2.1.5.

NON-PROPRIETARY

6.2.2 Containment Heat Removal System

❑ Functions of Containment Spray System

- Containment pressure and temperature reduction following MSLB or LOCA (6.2.2)
- Fission products removal from containment atmosphere following LOCA (6.5.2)

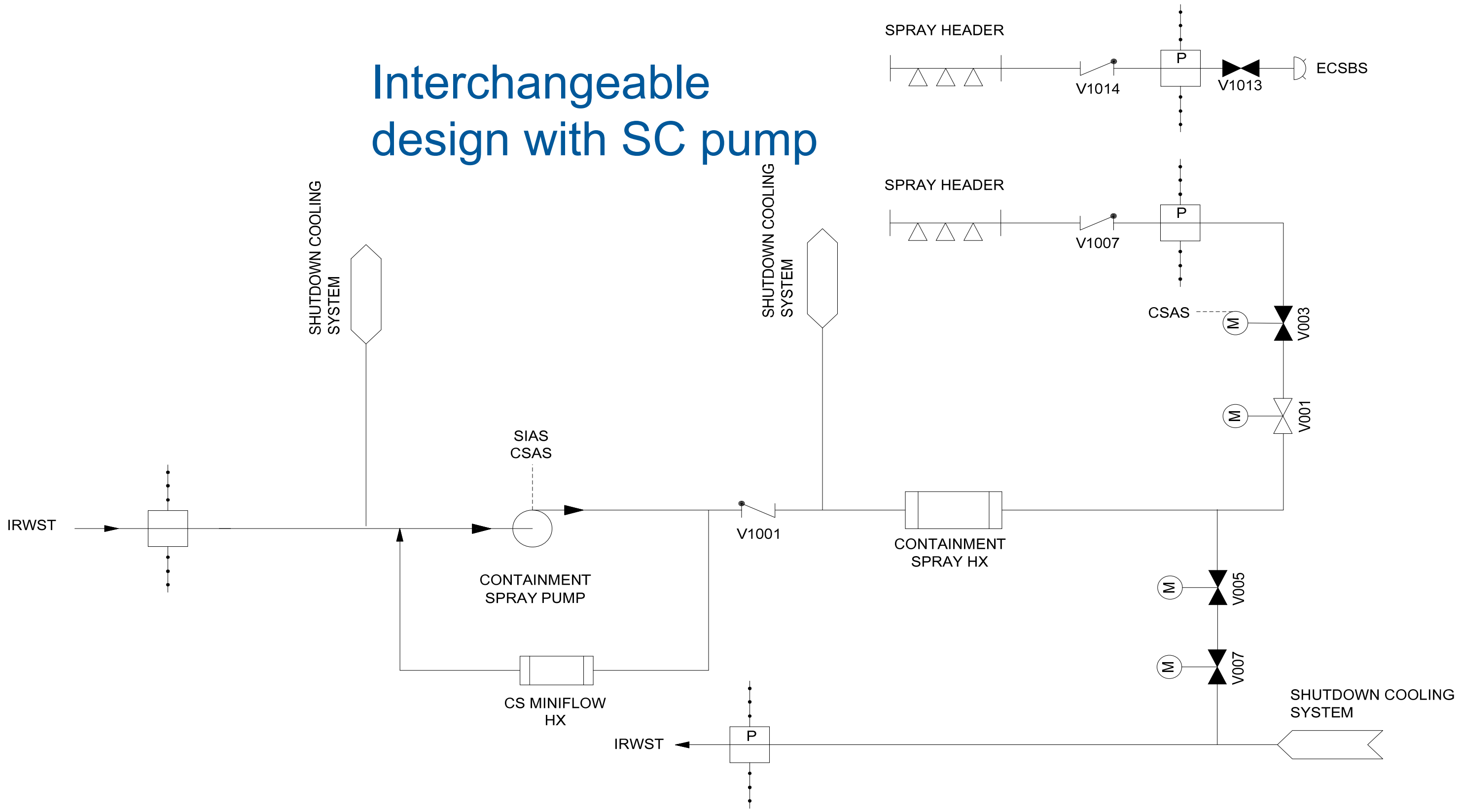
❑ Configuration of Containment Spray System

- Two 100 % capacity divisions
- In each division, a containment spray(CS) pump, a CS heat exchanger, a CS pump mini-flow heat exchanger, CS header, CS nozzles, valves and associated I&C
- An emergency containment spray backup system (ECSBS) for severe accident management

6.2.2 Containment Heat Removal System

❑ Schematic Diagram for CS System (Division I)

Interchangeable design with SC pump



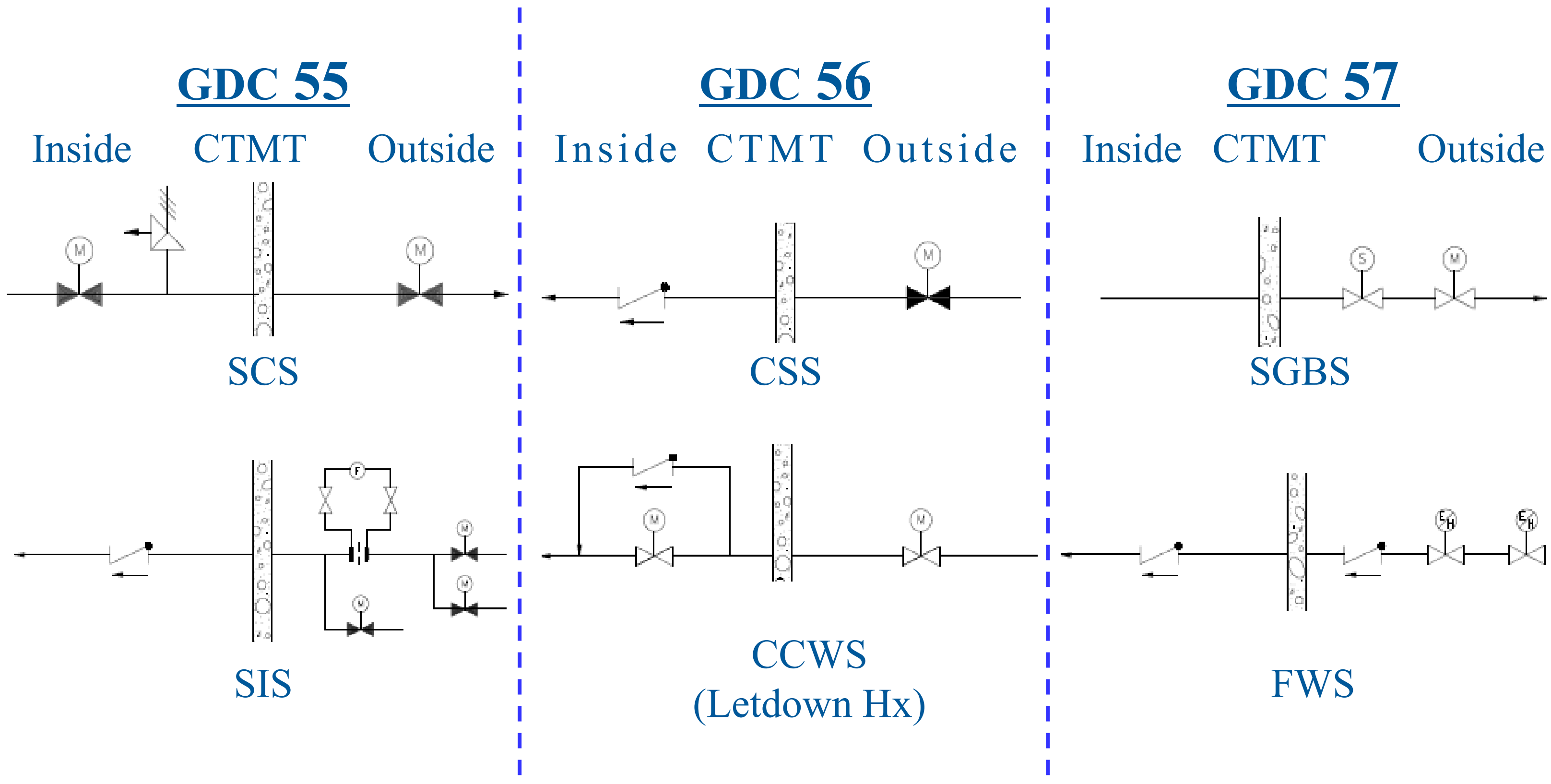
Note : Division I is shown for the representative configuration.

IRWST: In-containment Refueling Water Storage Tank

NON-PROPRIETARY

6.2.4 Containment Isolation System

- ❑ **Configuration examples according to GDC requirements**



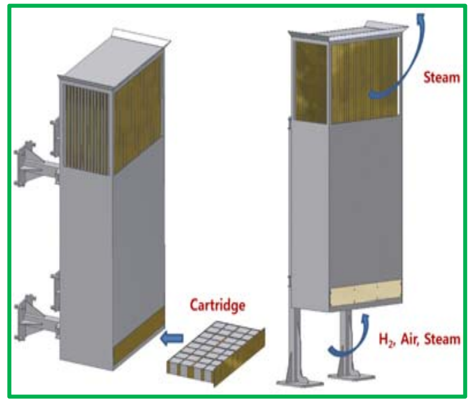
6.2.5 Combustible Gas Control in Containment

❑ Function

- Controls hydrogen concentration in containment and IRWST below 10% by volume during severe accident

❑ Configuration

- 30 Passive Autocatalytic Recombiners(PARs) in containment and inside the IRWST vent stack
  - Self-actuated, no power supply and operator action is needed.
- 8 Hydrogen Igniters (HIs)
  - AC-powered glow plug
  - Manual actuation in the MCR/RSR
  - Non-class 1E, but supplied from Class 1E bus with electrical isolation device to enhance the reliability of HIs
  - SBO: AAC generator supplies power.
  - Non-class 1E dedicated DC battery for complete loss of AC power



6.2.6 Containment Leakage Testing

Introduction

- The reactor containment with penetrations and isolation barriers is designed to permit periodic leakage rate test as required by GDC 52, 53 and 54.
- APR1400 leakage rate testing program implements the performance-based leakage testing requirements of 10CFR 50 Appendix J, Option B using the specific methods and guidance provided in NEI 94-01 and ANSI/ANS 56.8-1994, as modified and endorsed by RG 1.163.

Leakage testing requirements

- Applicable Code
  - 10CFR Part 50, Appendix J, Option B
  - RG 1.163
  - NEI 94-01
  - ANSI/ANS 56.8-1994
- Acceptance Criteria
  - Type A(Containment Integrated Leakage Rate Test): A leakage rate shall be less than 0.75 La.
  - Type B & C(Containment Local Leakage Rate Test): A leakage rate shall be less than 0.6 La.

6.2.7 Fracture Prevention of Containment Pressure Vessel

- Ferritic materials identified in ASME Section III, Div. 2
  - Meets the fracture toughness criteria of ASME Section III, Div. 2, Article CC2520
- Ferritic materials identified in ASME Section III, Div. 1
  - Meets the fracture toughness criteria of ASME Section III, Div. 1, Article NE 2300

6.3 Safety Injection System

6.3.1 Design Bases

6.3.2 System Design

6.3.3 Performance Evaluation

6.3.4 Tests and Inspections

6.3.5 Instrumentation Requirements

NON-PROPRIETARY

6.3.1 Design Bases

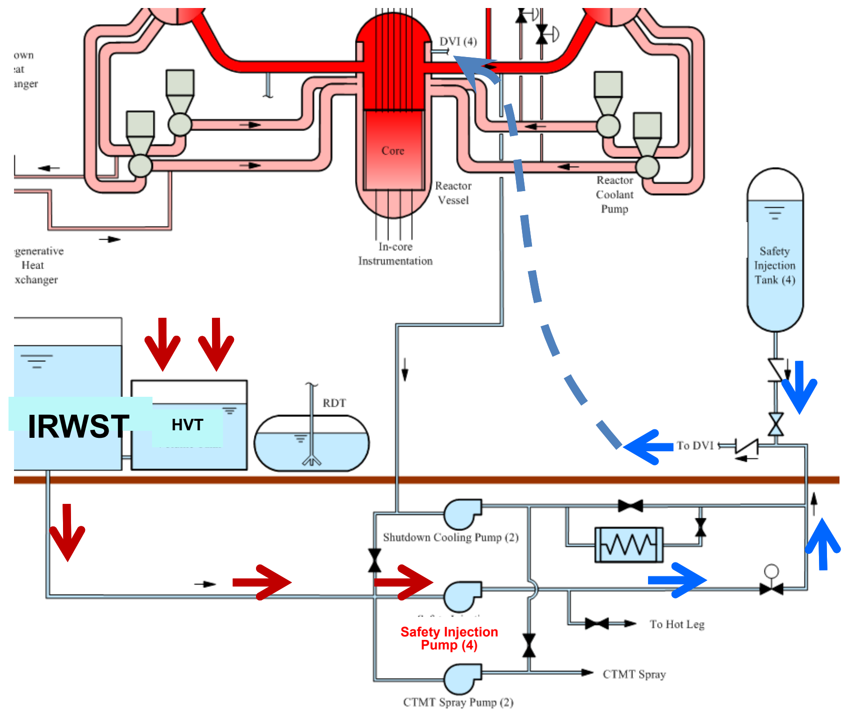
❑ Compliance with Regulatory Requirements:

- General Design Criteria 35-37 “Emergency Core Cooling”
- 10 CFR 50.46, “Acceptance criteria for ECCS for light water nuclear power reactors”
- Generic Safety Issue-191 and NRC RG 1.82

6.3.1 Design Bases

❑ Emergency Core Cooling Function

- Inject borated water into the Reactor Coolant System (RCS) through Direct Vessel Injection (DVI) nozzles to flood and cool the core following a Loss-of-Coolant Accident (LOCA)
- Provide removal of heat from the core for extended periods of time following a LOCA



6.3.1 Design Bases

❑ Reactivity and Inventory Control

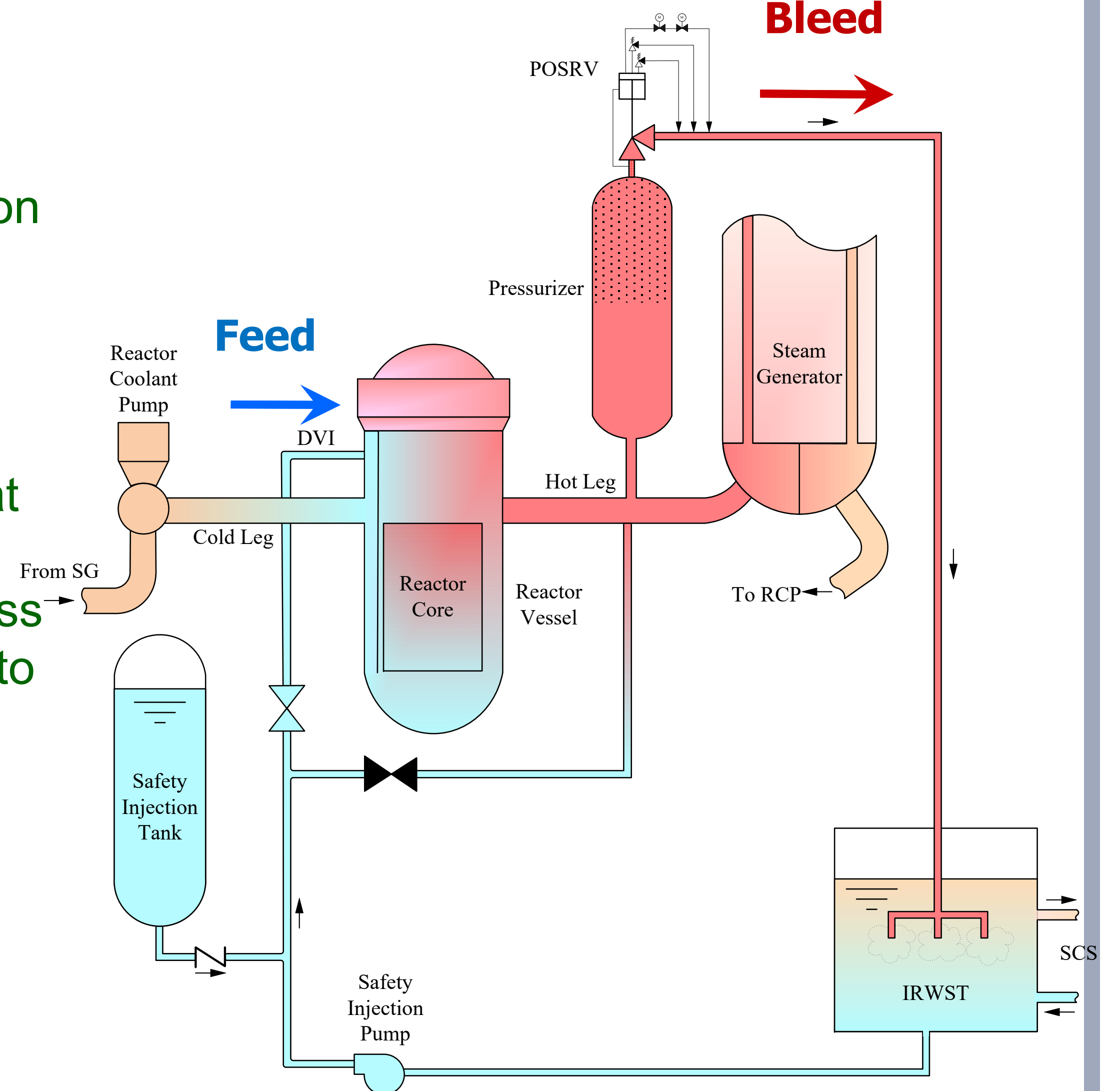
- Inject borated water into the RCS to increase shutdown margin following a rapid cooldown of the system due to a Main Steam Line Break (MSLB)
- Prevent boron precipitation in the RCS during long-term mode of operation
- Provide inventory makeup and boration for reactivity control during a safe shutdown if necessary

NON-PROPRIETARY

6.3.1 Design Bases

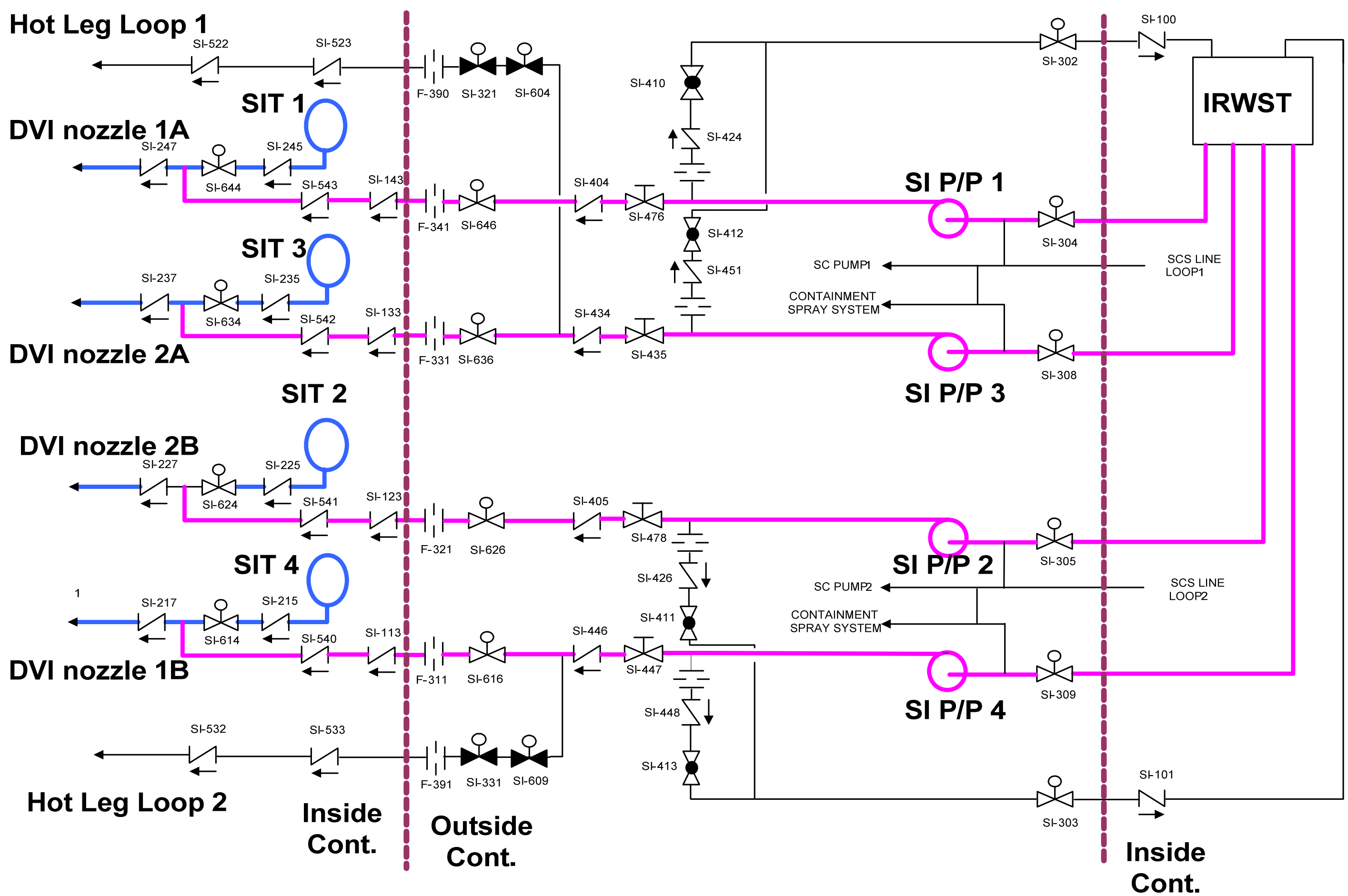
❑ Feed-and-Bleed Operation

- Provide feed flow for feed-and-bleed operation in conjunction with pressurizer Pilot Operated Safety Relief Valves (POSRVs) to remove core decay heat during beyond design basis event of a total loss of feedwater (TLOFW) to steam generators



6.3.2 System Design

- ❑ 4 independent trains

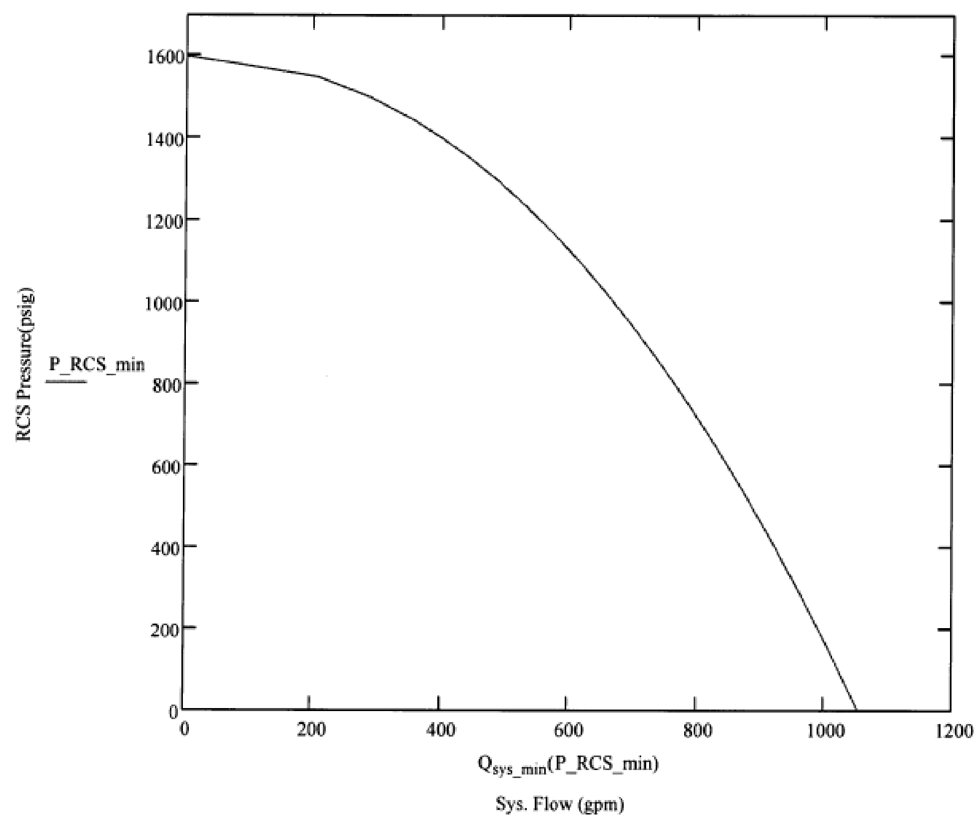


6.3.2 System Design

❑ Safety Injection Flow

- SI pumps provide reasonable assurance that the injected flow is sufficient

Safety Injection Delivery Curve (Minimum Flow)



6.3.3 Performance Evaluation

- SIS performance is evaluated by safety analysis in DCD Chapter 15.

6.3.4 Tests and Inspections

❑ In-Service Test

- ASME Section XI and OM(Operation and Maintenance)

❑ Performance Test

- NRC RG 1.79, 1.68

6.3.5 Instrumentation Requirements

❑ Automatic Safety Injection Actuation Signal is actuated by

- Low pressurizer pressure
- High containment pressure

❑ System monitoring parameters

- SIT pressures and water level
- SIP discharge pressure and flow rates
- Valve positions

6.4 Habitability Systems

6.4.1 Design Bases

6.4.2 System Design

6.4.3 System Operational Procedures

6.4.4 Design Evaluation

6.4.5 Testing and Inspection

6.4.6 Instrumentation Requirement

6.4.1 Design Bases

❑ Design Bases

- Allow control room operators to remain in the CRE and take actions to operate the plant safely under normal conditions, and maintain it in a safe condition under abnormal conditions.
- Meet requirements of RG 1.78, 1.196, 1.197, and GDC 19.
- Maintain conditions that are comfortable for plant personnel and provide reasonable assurance for the MCR equipment function
- Protect plant personnel in the CRE from followings:
  - Exposure to potentially airborne radioactivity in the outside atmosphere
  - Exposure to potentially toxic chemicals that are postulated to be released near the plant site
  - Effects of high-energy line breaks in the surrounding plant areas
  - Smoke from an onsite fire

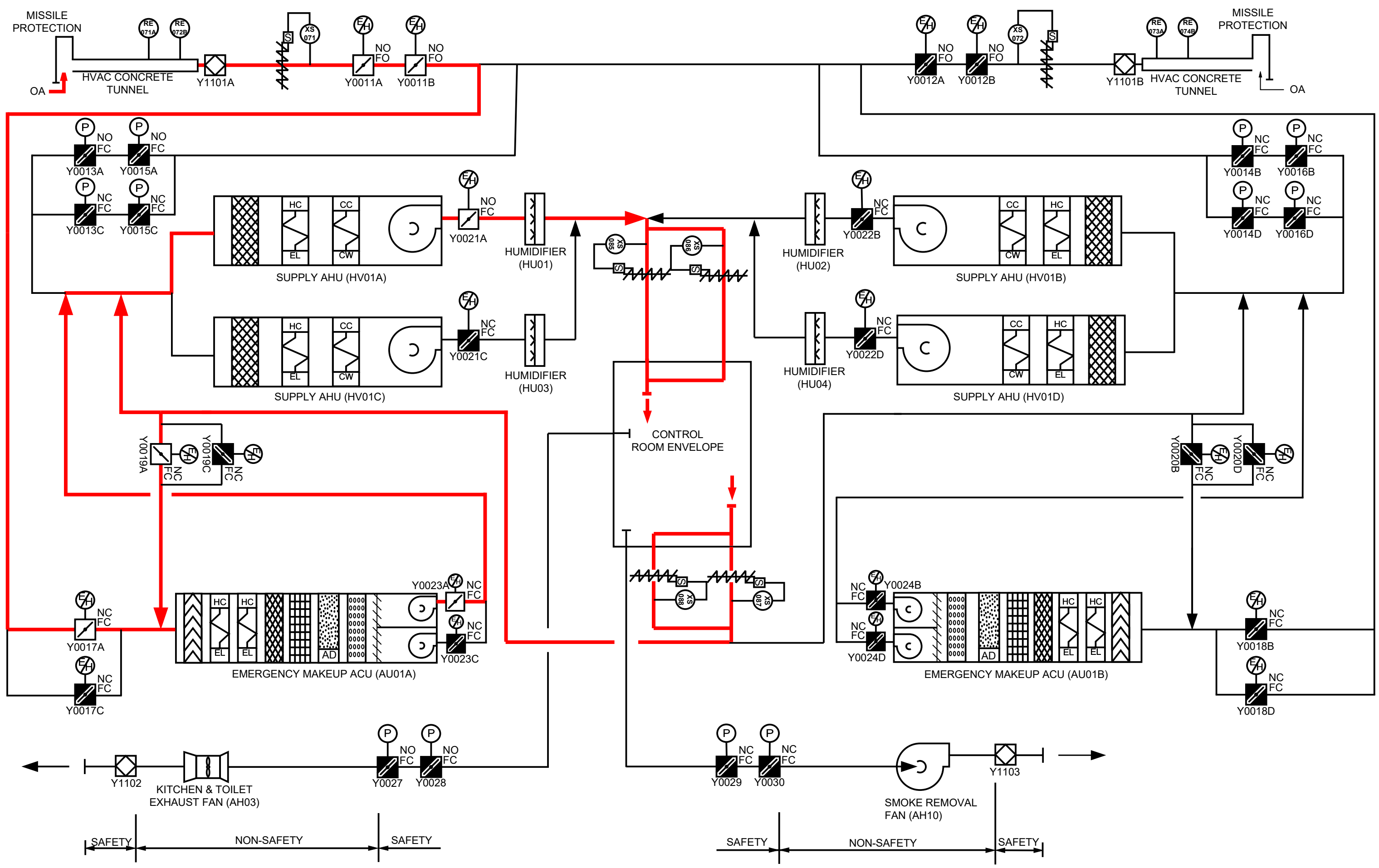
6.4.2 System Design

❑ Control Room Envelope (CRE)

- CRE is located at elevation 156 ft (47.55 m) and 174 ft (53.00 m) in the auxiliary building.
- The CRE volume except the HVAC equipment rooms is approximately 200,000 ft^3 (5,663 m^3).
- The CRE includes following areas:
  - Main control room (MCR)
  - Technical support center (TSC)
  - Meeting room
  - Computer room
  - HVAC equipment rooms
  - Kitchen and dining room
  - Toilets

6.4.3 System Operational Procedures

❑ Control room HVAC system flow diagram in emergency mode



6.4.4 Design Evaluations

❑ Radiological Protection

- Shielding design to mitigate the effects of direct exposure to MCR personnel
  - The radiation sources, which may result in exposure to control room personnel, are considered based on the RG 1.183.
- Total radiation exposures to MCR personnel
  - Design Criteria: GDC 19, RG 1.183
  - The analysis results show the exposure to the MCR personnel does not exceed the occupational dose limit of 50 mSv specified in GDC 19.

<table>
<tr><th colspan="2">Design Basis Accident</th><th>TEDE (mSv)</th><th colspan="2">Design Basis Accident</th><th>TEDE (mSv)</th></tr>
<tr><td rowspan="3">SLB</td><td>1% F.F</td><td>35.8</td><td colspan="2">LDLB</td><td>19.5</td></tr>
<tr><td>PIS</td><td>21</td><td rowspan="2">SGTR</td><td>PIS</td><td>20.2</td></tr>
<tr><td>GIS</td><td>22.2</td><td>GIS</td><td>19.6</td></tr>
<tr><td colspan="2">FWLB</td><td>19.8</td><td colspan="2">LOCA</td><td>46.9</td></tr>
<tr><td colspan="2">RCP rotor seizure</td><td>22.8</td><td colspan="2">FHA</td><td>8.55</td></tr>
<tr><td rowspan="2">CEA Ejection</td><td>CTMT leakage</td><td>35.4</td><td colspan="3" rowspan="2">Occupational Dose limit
: 50 mSv TEDE</td></tr>
<tr><td>SS release</td><td>29.1</td></tr>
</table>

NON-PROPRIETARY

6.4.4 Design Evaluations

❑ Toxic Gas Protection

- The control room habitability following the accidental release of toxic chemicals is evaluated in accordance with RG 1.78 and NUREG-0570.
- The toxic gas analysis results show that the release of toxic gases do not affect MCR habitability.
- Adequate self-contained breathing apparatus are available inside the CRE to prepare for emergency situation due to toxic gases.

6.4.5 Testing and Inspection

❑ Testing and Inspection

- Preoperational test and In-service test are performed to provide reasonable assurance that system and component capabilities are achieved and maintained.
- Periodic testing to confirm the CRE integrity is performed using test methods and at test frequencies in accordance with RG 1.197.
- The air in-leakage test of the CRE boundary is performed in accordance with ASTM E741.

6.4.6 Instrumentation Requirement

❑ Instrumentation Requirement

- Two redundant radiation monitors are installed in each of two outside air intakes to annunciate high radiation alarms and to initiate CREVAS.
- Instrumentation for the control room emergency makeup ACU is designed to meet the requirements of ASME AG-1 and RG 1.52.

6.5. Fission Product Removal and Control Systems

- 6.5.1 Engineered Safety Feature Filter Systems
- 6.5.2 Containment Spray Systems
- 6.5.3 Fission Product Control System

6.5.1 ESF Filter Systems

- **Design Bases**
  - Mitigate the consequences of postulated accidents by filtering radioactive particulates and iodine from the air.
  - Meet the requirements of RG 1.52, ASME N509, and ASME AG-1.
- **ESF filter systems**
  - Control room emergency makeup air cleaning system (CREACS)
    - Filters potential radioactive particulates and iodine from the outside makeup air and a part of the return air.
    - Limits the dose received by MCR personnel to be less than 50 mSV total effective dose equivalent (TEDE) for the duration of the accident in accordance with GDC 19.
  - Auxiliary building controlled area emergency exhaust system (ABCAEES)
    - Filters potential radioactive particulates and iodine from the exhaust air from the mechanical penetration rooms and safety-related mechanical equipment rooms.
  - Fuel handling area emergency exhaust system (FHAEES)
    - Filters potential radioactive particulates and iodine from the exhaust air from the fuel handling area.

NON-PROPRIETARY

6.5.2 Containment Spray System

❑ Design Evaluation

- Containment Mixing Rate between the Sprayed and Unsprayed Regions during post-LOCA
  - Design Guidance: SRP 6.5.2
  - Two unsprayed volumes per hour
- Containment Spray pH Control during post-LOCA
  - The minimum pH values of the IRWST water : maintained above 7 for 30 days in LOCA condition
- Airborne Fission Product Removal Coefficient
  - Elemental iodine removal by containment spray: model in SRP 6.5.2
  - Particulate iodine removal by containment spray: model in SRP 6.5.2
  - Particulate (aerosol) removal by natural deposition: 10 percentile value of the Powers model (NRC NUREG/CR-6189) built into RADTRAD 3.03

6.5.3 Fission Product Control System

❑ The fission product leakage to the environment

- Containment spray system: fission product removal function
- Containment: leaktight pressure boundary

❑ Containment leakage

- In-service leakage testing program (DCD Subsection 6.2.6)
- Radiological consequences following DBAs (DCD Chapter 15)

6.6 Inservice Inspection of Class 2 and 3 Components

6.6.1 Components Subject to Examination

6.6.2 Accessibility

6.6.3 Examination Techniques and Procedures

6.6.4 Inspection Intervals

6.6.5 Examination Categories and Requirements

6.6.6 Evaluation of Examination Results

6.6.7 System Pressure Test

6.6.8 Augmented ISI

6.6 Inservice Inspection of Class 2 and 3

❑ 6.6.1 Component Subject to Examination

- Class 2: ASME Sec. XI, IWC-2500
- Class 3: ASME Sec. XI, IWD-2500
- Exemption: ASME Sec. XI, IWC-1220 and IWD-1220

❑ 6.6.2 Accessibility

- ASME Sec. XI, IWA-1500 Provisions for accessibility
- Design and Layout

❑ 6.6.3 Examination Techniques and Procedures

- Examination techniques: Visual, Surface, and Volumetric
- Techniques and procedures: ASME Sec. XI, IWC-2000 and IWD-2000

❑ 6.6.4 Inspection Intervals

- Class 2: ASME Sec. XI, IWC-2400
- Class 3: ASME Sec. XI, IWD-2400

6.6 Inservice Inspection of Class 2 and 3

- 6.6.5 Examination Categories and Requirements
  - Class 2: ASME Sec. XI, IWC-2500
  - Class 3: ASME Sec. XI, IWD-2500
- 6.6.6 Evaluation of Examination Results
  - Class 2: ASME Sec. XI, IWC-3000
  - Class 3: ASME Sec. XI, IWD-3000
  - Examination results: ASME Sec. XI, IWA-6000
- 6.6.7 System Pressure Test
  - Class 2: ASME Sec. XI, IWC-5000
  - Class 3: ASME Sec. XI, IWD-5000
- 6.6.8 Augmented ISI Protect against Postulated Piping Failure
  - High-energy fluid system piping in containment penetration area
  - High-energy piping starting at containment penetration anchor and extending up to and including first anchor

6.8 In-containment Water Storage System

6.8.1 Design Bases

6.8.2 System Design

6.8.3 Instrumentation

6.8.4 Design Evaluation

6.8.5 Testing and Inspection

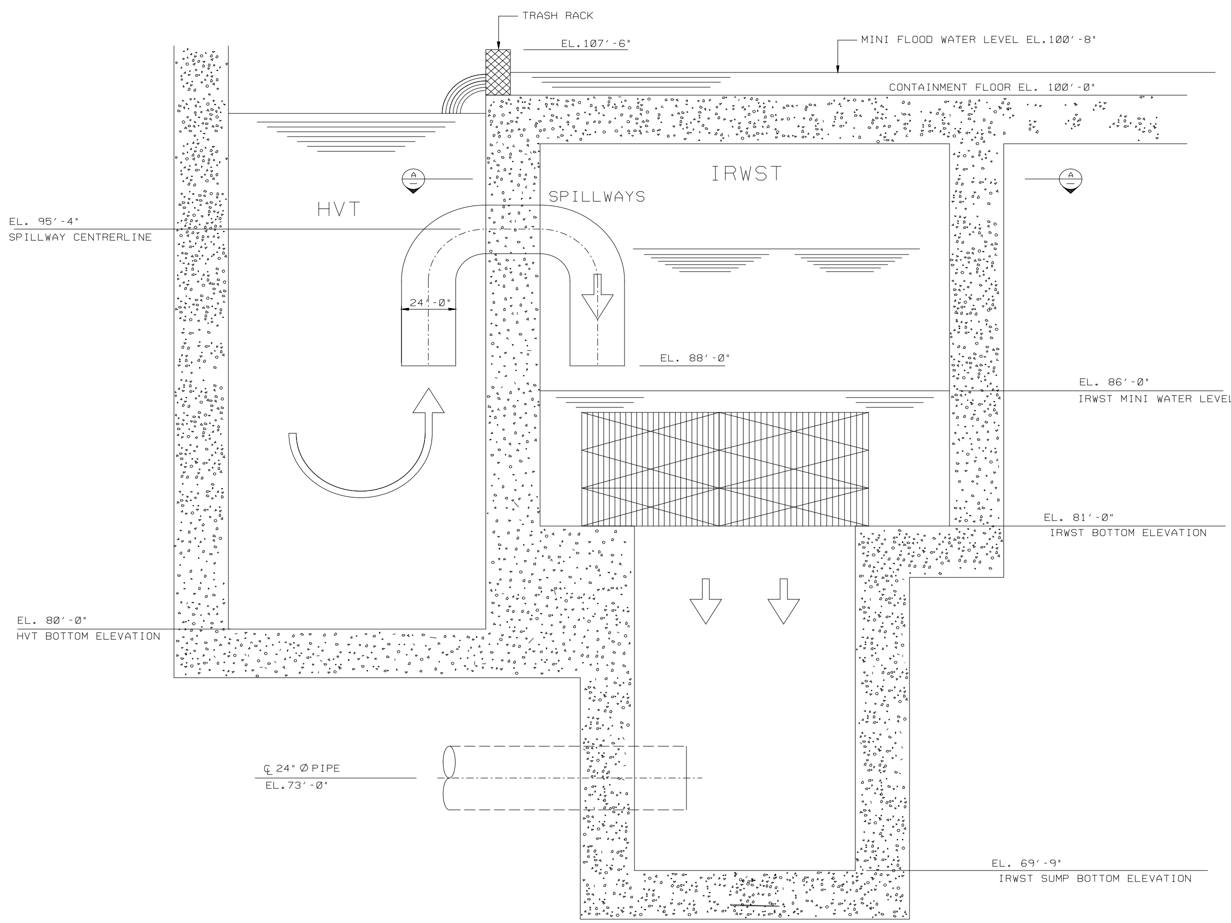
6.8.1 Design Bases

❑ System Configuration and Functions

- In-containment refueling water storage tank (IRWST)
  - Source of borated water for SI system when SI system is in a standby mode during normal operating conditions
  - Source of borated water for filling the refueling pool during refueling operations
  - Safety-grade source of borated water for CSS
  - Primary heat sink for pilot-operated safety relief valve (POSRV) discharges
  - Source of water for CFS
- Holdup volume tank (HVT)
  - Water collection and storage functions during accident conditions
- Cavity flooding system (CFS)
  - Floods the reactor cavity in the event of a severe accident

6.8.2 System Design

- Flow path to IRWST Sump Strainers during LOCA



6.8.3 Instrumentation

❑ Level

- IRWST: four wide range level indication channels
- HVT: one narrow and four wide range level indication channels
- Reactor cavity: one narrow and four wide range level indication channels

❑ Temperature

- IRWST: four fluid temperature channels

❑ Pressure

- IRWST: four wide range pressure channels

NON-PROPRIETARY

6.8.4 Design Evaluation

❑ $NPSH_a$ for SI and CS Pumps

- $NPSH_a = h_{atm} + h_{static} - h_{loss} - h_{vapor}$
- Containment Accident Pressure (CAP)
  - $T_{IRWST} \geq 212^oF$, $h_{atm} = h_{vapor}$
  - $T_{IRWST} < 212^oF$, h_{atm} = initial containment pressure before LOCA
  - In the evaluation of the $NPSH_a$ for SI and CS pumps, APR1400 design credits the CAP for the IRWST temperature greater than or equal to 212^{o}F with the assumption of that the CAP is equal to the IRWST liquid vapor pressure.

6.8.4 Design Evaluation

❑ $NPSH_a$ for SI and CS Pumps

- $NPSH_{reff}$ = (1+ uncertainty) $NPSH_{r3\%}$
  - Uncertainty factors considered based on guidance in SECY-11-0014.
  - 21% margin is applied for effects of uncertainty factors.
  - $NPSH_{reff}$ for SIP and CSP will be verified through ASME QME-1.
  - $NPSH_{reff}$ calculation results

Pump	Flowrate (gpm)	$NPSH_{r3\%}$ (ft-water)	$NPSH_{reff}$ (ft-water)
SI Pump	1,235	18.23	22
CS Pump	5,425	14.4	17.5

- NPSH evaluation results (Minimum margin at high temperature)

Pump	$NPSH_a$ (ft-water)	$NPSH_{reff}$ (ft-water)	Margin (ft-water)
SI Pump	23.73	22.0	1.73
CS Pump	20.50	17.5	3.00

6.8.4 Design Evaluation

❑ Hydrodynamic Loads and Pool Temperature

- Analysis Model
  - Hydrodynamic loads
    - Empirical model that was applied to the System 80+
  - Pool temperature
    - Average pool temperature: using the analytical calculation
    - Local pool temperature: using the ANSYS-CFX code
- Results
  - Hydrodynamic loads
    - Pressure load: 21.2 psid
    - Bubble frequency: 4 Hz ~ 14 Hz
  - Pool temperature
    - The average / local pool temperatures maintain to be less than 200 ºF (NUREG-0783)

6.8.5 Testing and Inspection

❑ ASME Section III Class 2 and 3 components

- ASME Section XI and OM(Operation and Maintenance)

NON-PROPRIETARY

Summary

- APR1400 Engineered Safety Features are designed to meet the US regulatory requirements.
- The containment integrity and the plant safety systems are designed with the design margins to cover any postulated accident condition.

Acronyms

AC	Alternating Current
AAC	Alternate Alternating Current
ABCAEES	Auxiliary Building Controlled Area Emergency Exhaust System
ACU	Air Cleaning Unit
CAP	Containment Accident Pressure
CCWS	Component cooling Water system
CEA	Control Element Assembly
CFS	Cavity Flooding System
CRE	Control Room Envelope
CREACS	Control Room Emergency Air Cleaning System
CREVAS	Control Room Emergency Ventilation Actuation System
CS	Containment Spray
CSS	Containment Spray System
CTMT	Containment Building
CVCS	Chemical and Volume Control System

DBA	Design Basis Accident
DC	Direct Current
DVI	Direct Vessel Injection
ECCS	Emergency Core Cooling System
ECSBS	Emergency Containment Spray Backup System
ESF	Engineered Safety Feature
FHA	Fuel Handling Accident
FHAEES	Fuel Handling Area Emergency Exhaust System
FWLB	Feed Water Lind Break
FWS	Feed water system
GDC	General Design Criteria
GIS	event-Generated Iodine Spike
HI	Hydrogen Ignitor
HVT	holdup volume tank
I&C	Instrumentation and Control

NON-PROPRIETARY

Acronyms

IRWST	In-containment Refueling Water Storage Tank
LDLB	Let Down Line Break
LOCA	Loss of Coolant Accident
MCR	Main Control Room
MFLB	Main Feedwater Line Break
MSIV	Main Steam Isolation Valve
MSLB	Main Steam Line Break
NPSH	Net Positive Suction Head
PAR	Passive Autocatalytic Recombiner
PIS	Pre-accident Iodine Spike
POSRV	Pilot Operated Safety Relief Valve
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RSR	Remote Shutdown Room
SBO	Station Blackout

SC	Shutdown Cooling
SCS	Shutdown Cooling System
SGBS	Steam Generator Blowdown System
SGTR	Steam Generator Tube Rupture
SIP	Safety Injection Pump
SIS	Safety Injection System
SIT	Safety Injection Tank
SS	Steam System
TEDE	Total Effective Dose Equivalent
TLOFW	Total Loss of Feedwater
TSC	Technical Support Center
TSP	Tri-Sodium Phosphate

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation to the ACRS Subcommittee

Korea Hydro Nuclear Power Co., Ltd (KHNP)

APR1400 Design Certification Application Review

Safety Evaluation with Open Items: Chapter 6

ENGINEERED SAFETY FEATURES

MARCH 22 – 23, 2017

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  - Michelle Hart and Nan Chien – DCD Sections 6.4, 6.5.1, 6.5.2, 6.5.3
  - Boyce Travis and Greg Makar – DCD Sections 6.2.1.2, 6.2.1.5, 6.1.2, 6.2.2
  - Syed Haider – Sections 6.2.1, 6.2.1.1, 6.2.1.3, 6.2.1.4
  - Dan Widrevitz – DCD Sections 6.1.1, 6.2.7, 6.6
  - Raj Goel and Anne-Marie Grady – DCD Sections 6.2.4, 6.2.5, 6.2.6

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  - Michelle Hart
- **Reactor Systems, Nuclear Performance, and Code Review Branch**
  - Matt Thomas

Overview of Design Certification Application, Chapter 6

SRP Section/Application Section	
6.1.1	Engineered Safety Features Materials
6.1.2	Protective Coating Systems (Paints) - Organic Materials
6.2.1	Containment Functional Design
6.2.1.1	Containment Structure
6.2.1.2	Subcompartment Analysis
6.2.1.3	Mass and Energy Release Analysis for Postulated Loss-of-Coolant Accidents (LOCAs)

Overview of Design Certification Application, Chapter 6

SRP Section/Application Section	
6.2.1.4	Mass and Energy Release Analysis for Postulated Secondary System Pipe Ruptures
6.2.1.5	Minimum Containment Pressure Analysis for Emergency Core Cooling System Performance Capability Studies
6.2.2	Containment Heat Removal Systems
6.2.4	Containment Isolation System
6.2.5	Combustible Gas Control in Containment
6.2.6	Containment Leakage Testing

Overview of Design Certification Application, Chapter 6

SRP Section/Application Section	
6.2.7	Fracture Prevention of Containment Pressure Boundary
6.3	Emergency Core Cooling System
6.4	Control Room Habitability System
6.5.1	ESF Atmosphere Cleanup Systems
6.5.2	Containment Spray as a Fission Product Cleanup System

Overview of Design Certification Application, Chapter 6

SRP Section/Application Section	
6.5.3	Fission Product Control Systems and Structures
6.6	Inservice Inspection and Testing of Class 2 and 3 Components

Section 6.3, Emergency Core Cooling System/Safety Injection System

Matt Thomas

Review Topics, Section 6.3

- **Design Basis**
  - Reviewed basis for which the SIS is designed
    - Core cooling to prevent fuel damage, post-accident decay heat removal, control of reactivity to maintain core sub-criticality
  - Reviewed accidents for which SIS is credited
    - LOCA, SGTR, SLB, CEAE

- **Functionality**
  - Reviewed system design
    - System descriptions, drawings, makeup of components, and arrangement
  - Reviewed for redundancy, independency, and single failure considerations
  - Reviewed for adequate power sources
  - Reviewed actuation signals and set-points
    - Automation and required actuation times/delays
  - Reviewed system functioning for different accidents
    - Required pump flow rates and functionality down to the smallest break
  - Reviewed component details and instrumentation and controls
    - Pump and SIT-FD design and operation
    - IRWST functionality and interface with SIS
    - Adequacy of instrumentation and control, RSR capability
  - Reviewed operational modes
    - Short term and long term

Review Topics, Section 6.3

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- **Protection**
  - Reviewed for gas accumulation
    - SIFT and system vents
  - Reviewed for minimum flow protection for SIPs and NPSH
  - Reviewed for seismic classification
  - Reviewed piping and valves
    - Pressure rating, relief valve capacities
  - Reviewed design for harsh environment qualification considerations
  - Reviewed failure modes and effects analysis
  - Reviewed SIS location adequacy

- **Testing, Tech Specs, and Surveillance Requirements**
  - Reviewed ITAAC
  - Reviewed pre-operational tests
  - Reviewed consideration for in-service testing
  - Reviewed SIT-FD topical report full-scale testing
  - Reviewed Tech Specs for technical adequacy

Findings

- **Design Basis**
  - Found SIS to be appropriately designed for accident mitigation
    - Designed to complete expected safety-functions of a typical LWR ECCS
- **Functionality**
  - Found system design to include all components necessary for safety injection
  - Found system to be reliably designed
    - Adequacy of redundancy, independency, and appropriate consideration of single failure
    - Adequacy of physical separation
    - Appropriately powered by onsite, offsite, and emergency sources
  - Found safety injection actuation signals and set-points adequate
    - Automatically actuated via independent signals
    - Delay times are appropriately used in the safety analysis
  - Found system function is applicable for range of accidents
    - SIPs capable of providing required flow rates down to the smallest LOCA
    - SIT-FDs will inject only when RCS pressure is below setpoint
  - Found SIS components and instrumentation and controls appropriate
    - Necessary alarms, indication, and control in MCR and RSR
    - Appropriate pump and SIT-FD design and operation
    - Adequate IRWST functionality and interface with SIS
  - Found operational modes appropriate
    - Short term and long term goals achieved for core cooling and core reactivity control

Findings

- **Protection**
  - •Found protection against gas accumulation adequate
    - Appropriateness of Tech Specs and ITAAC
  - •Found minimum flow protection for SIPs appropriate and NPSH adequate
    - NPSH calculation considers appropriate worst case conditions
  - •Found seismic classification completed for SIS and appropriate
  - •Found piping, valves, and SIT-FD appropriately protected against over-pressure
  - •Found SIS design considers harsh environment qualification
    - To extent practical, components located outside containment
  - •Found failure modes and effects analysis acceptable
    - Single failure of mechanical, electrical, or I&C component will not affect more than one train of SIS
  - •Found SIS adequately located within seismic Category I building
    - Adequate protection against natural and external phenomena

- **Testing, Tech Specs, and Surveillance Requirements**
  - •Found ITAAC to be necessary and sufficient for SIS
  - •Found pre-operational tests necessary and sufficient for SIS
  - •Found in-service testing was addressed for SIS
  - •Found Tech Specs to be technically adequate
    - Boron recycling issue is still being addressed by applicant

Conclusions

SIS is adequately designed

- Appropriate design bases
- Necessary redundancy and independency
- Appropriate consideration for gas accumulation
- Appropriate consideration for seismic classification
- Operational characteristics of SIPs and SIT-FDs adequate
- Safety analysis (Chapter 15 review) will ultimately show adequate performance

Application includes appropriate ITAAC and Technical Specifications

- Boron recycling issue still open

The SIS has been designed appropriately in the context of emergency core cooling for a typical, large, light-water reactor

Section 6.4, Control Room Habitability System

Section 6.5, Fission Product Removal and Control Systems

Nan Chien

Michelle Hart

Review Topics, Section 6.4

Scope of Review

- Control room envelope (CRE)
- Ventilation systems criteria
  - Isolation dampers
  - Single failure criterion
  - Occupancy limitations
- Pressurization systems
- Atmosphere filtration systems
- Relative location of source and control room
  - Radiation and toxic sources
- Radiation hazards
  - Radiation shielding
  - CRE unfiltered inleakage
  - Input parameters to DBA analyses
  - Radiation protection
  - Technical support center (TSC) location, size, structure and habitability
- Toxic gas hazards
- ITAAC
- TS

Review Topics, Section 6.4

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Issues

- Issue on operational testing of CREACS ACUs at least 15 minutes each month to follow RG 1.52 has been resolved
- Related draft open item in SER Section 15.0.3 on modeling of control room air intake in DBA dose analyses
  - For duration of accident, intake dampers in both trains periodically re-open for brief interval to measure radioactivity and select intake with less contaminated air

Findings

- One confirmatory item to clarify the system description in the TS bases
- Contingent on confirmatory item, control room habitability system is acceptable and meets regulatory requirements
  - Control room and TSC dose analysis review discussed in more detail in SER Section 15.0.3

Review Topics, Section 6.5.1

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Scope of Review

- Three systems
  - Control Room Emergency Makeup Air Cleaning System (CREACS)
  - Auxiliary Building Controlled Area Emergency Exhaust System
  - Fuel Handling Area Emergency Exhaust System
- Conformance to RG 1.52
- Carbon adsorbers
- High efficiency particulate air filter
- Instrumentation requirements
- Release point monitors
- ITAAC

Findings

- One confirmatory item to clarify carbon adsorber description in DCD
- Contingent on confirmatory item, ESF ventilation systems and related filtration capabilities are acceptable and meet regulatory requirements

Review Topics, Section 6.5.2

Scope of Review

- Fission product removal and transport in containment
  - Particulate iodine spray removal
  - Elemental iodine deposition on wetted surfaces
- IRWST pH analysis
  - TSP buffering
  - Iodine retention in IRWST

Findings

- One confirmatory item to clarify description in DCD
- Contingent on confirmatory item, the CSS and modeling of the related fission product removal are acceptable and meet regulatory requirements

Review Topics, Section 6.5.3

Scope of Review

- Primary containment
- Natural deposition
  - Aerosol removal by natural processes
- Containment building ventilation system

Findings

- Design features that control fission products during postulated accidents are acceptable and meet requirements

Section 6.1.2, Protective Coatings and Organic Materials

Greg Makar

Section 6.2.1.2, Subcompartment Analysis

Boyce Travis

Section 6.2.1.5, Minimum Containment Pressure for ECCS Performance

Boyce Travis

Section 6.2, Containment Heat Removal Systems

Greg Makar

Review Topics, Section 6.1.2

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Scope of Review

- Identify the organic coatings, inorganic zinc coating, other organic materials
- Evaluate the potential for coatings debris generation
- Conformance to RG 1.54, Revision 2, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants"

Findings

- No Open Items
- Use of coatings follows the Service Level (SL) definitions in RG 1.54, Rev. 2
- Coatings inside containment will be safety-related and DBA qualified
- Manufactured components in containment purchased with SL I coatings
- Coatings evaluated as a potential debris source in Section 6.8.
- COL applicant will …
  - Manage coatings in containment that do not conform to SL I requirements
  - Describe the coatings program and provide implementation milestones
  - Determine the amount of organic cable insulation and jacket material in containment

Review Topics, Section 6.2.1.2

Scope of Review

- Six locations in containment (excluding the reactor cavity area) with applicable high-energy piping in subcompartment rooms

- Applicant used COMPARE code (previously reviewed by the NRC) to perform the subcompartment analysis

- Staff audited applicant's calculations, which used appropriately conservative discharge models, coefficients, and heat transfer characteristics and further added a 1 percent margin to mass and energy release

Findings

- No open items
- Staff performed a confirmatory analysis of a sample subcompartment (PZR spray valve room) and calculated a peak differential pressure margin (calculated dP/design dP) of 1.43, which agrees reasonably well with the applicant's DCD value of 1.405
- Acceptable – staff finds that the applicant met the requirements associated with GDC 4 and 50 by demonstrating subcompartment pressures remain below the design pressure with greater than 40% margin

Review Topics, Section 6.2.1.5

Scope of Review

- Minimum calculated containment pressure for input to ECCS reflood conditions in Chapter 15

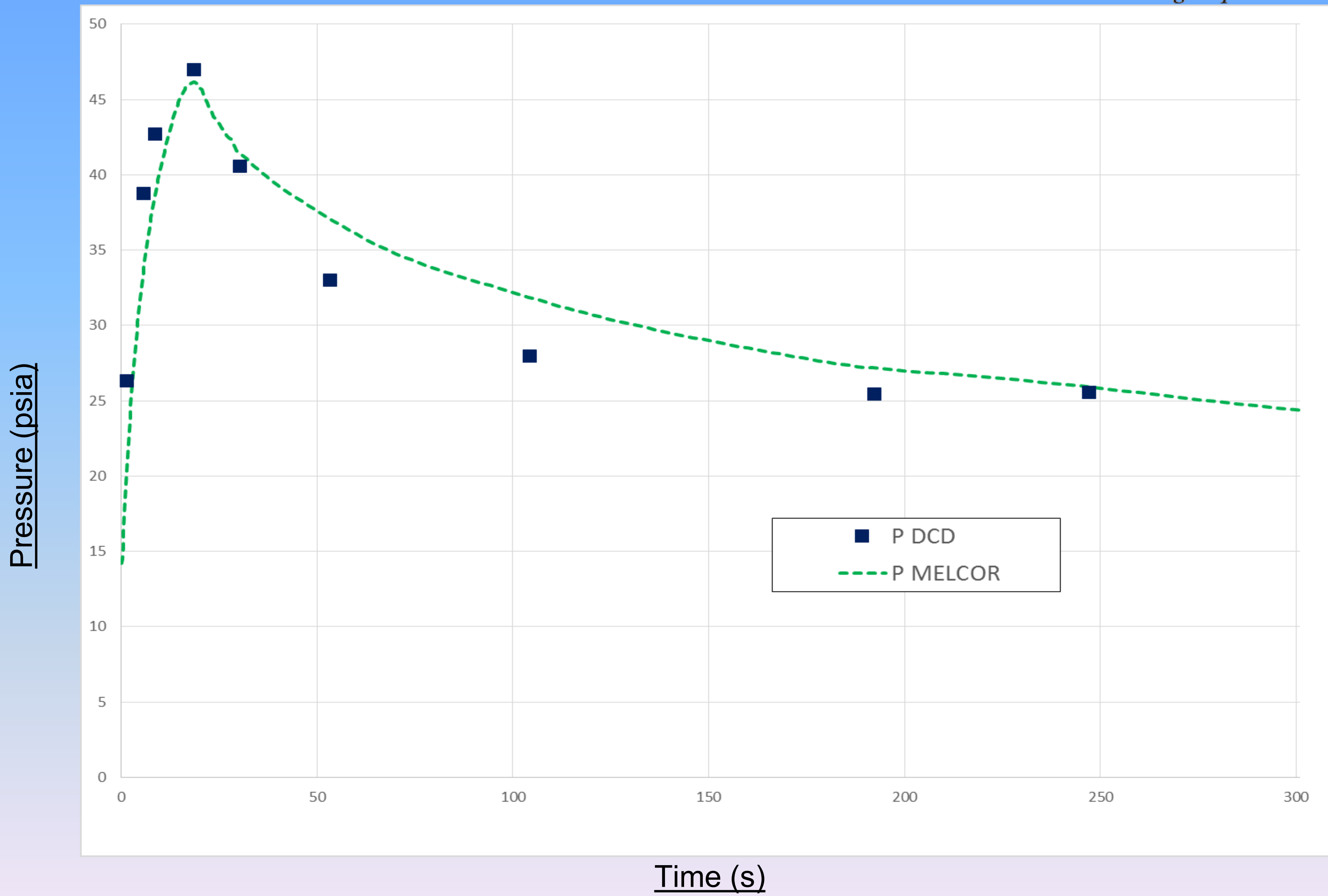
- Applicant used CONTEMPT4 code, reviewed and approved for this application in currently licensed plants

- Substantial revisions made to DCD Section 6.2.1.5 due to RAIs - Rev. 0 of the DCD contained incorrect information related to mass and energy releases for this calculation; staff issued RAI 6.02.01.05-03
  - As part of response to resolve this question and others, applicant revised mass and energy release, heat sink data, and other containment parameters
  - These revisions resulted in slightly higher containment pressure than was reflected in DCD Section 6.2.1.5, revision 0

Findings

- Staff performed a confirmatory analysis (reflected on next slide) to determine impact of analysis revisions; staff results agree well with applicant's revised calculation
- Applicant's revised calculation is acceptable

Review Topics, Section 6.2.1.5



Review Topics, Sections 6.2.2

Containment Heat Removal Systems

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Scope of Review

- 6.2.2 contains review of the containment spray system, in-containment refueling water storage system (IWSS), and long term recirculation
- Spray:
- Containment Spray System – two 100%-cooling capacity trains, sourced from IRWST
- Nozzle orientation provided in DCD; staff review indicated spray rings (using varying elevations and orientations) adequately act to spray containment cross-sectional area fully from nozzles to operating deck
  - Applicant assumed no spray below operating deck (~75% CNV volume above)
- Efficacy of spray at reducing containment pressure, in concert with rest of containment response, discussed in Section 6.2.1.1.A
- COL item requires applicant to:
  - Establish cleanliness and foreign materials exclusion (FME) program
  - Implement procedures for administrative controls on materials with the potential to impact or block the strainer
  - Evaluate impacts of maintenance and temporary changes
  - Establish a coatings monitoring program consistent with RG 1.54

Review Topics, Section 6.2.2

Containment Heat Removal Systems

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Scope of Review

- IWSS
- In-containment Water Storage System – large (627,000 gal) tank of water (IRWST) that is the source for the CS and SI systems, combined with return spillover volume (HVT) that serves as receiving tank for containment recirculation water
- HVT contains trash rack and vertical screens at entrances, and requires substantial volume fill before spillway flow to IRWST begins
- IRWST sealed, with swing panels to accommodate pressure differences and strainers over the suctions for SI and CS systems
  - Also contains submerged spargers for POSRV relief
- In-containment Water Storage System key part of long-term recirculation strategy, discussed in the following slides

Review Topics, Section 6.2.2

Containment Heat Removal Systems

<u>**Scope of Review**</u>

- <u>Long-term recirculation water source</u>
- Break Selection
  - MSLB and LOCA events analyzed
  - No fibrous insulation, so limiting break selection location (consistent with NEI 04-07) based on area with highest quantity of RMI and potential coatings area
  - Staff reviewed design drawings, confirming that RCS hot leg is largest diameter pipe and SG compartment contains highest volume of RMI and coatings

- Zone of Influence (ZOI)
  - Material specific ZOIs (RMI, epoxy, inorganic zinc), consistent with NEI 04-07
  - Staff asked an RAI requesting information on other materials that could contain consequential material, such as cables, that were not discussed
  - Applicant stated that cables do not contain fiber, and no other materials that contain fiber are located within a ZOI. The FME program (COL item) would act to restrict/control future material additions to containment

- Debris characteristics
  - RMI assumed 25% small pieces, 75% pieces, consistent with NEI 04-07
  - 100 ft^2 of sacrificial area on strainer due to misc. debris (tags, tape, etc.)
  - Only fiber input is latent fiber, assumed value of 15 lbm, to be controlled by containment cleanliness program (acceptance criteria added as result of RAI)

Review Topics, Section 6.2.2

Containment Heat Removal Systems

Scope of Review

- Long-term recirculation water source
- Debris transport
  - Applicant conservatively assumes all debris reaches the containment floor, and none is held up in inactive volumes
  - All non-RMI debris (particulate, fiber, misc.) conservatively assumed to reach the strainer
  - Large RMI does not enter HVT due to trash rack/screens; smaller RMI assumed to settle out in HVT or IRWST
  - This settling treatment was found appropriate by the staff in the context of:
    - the relatively elevated strainer,
    - the likelihood of debris settling in locations leading up to the IRWST, and
    - a conservatively calculated approach velocity (all flow through a single strainer) which remained lower than the settling velocity for fine RMI
- Upstream effects
  - Staff reviewed and audited post-accident upstream holdup analyses
  - Applicant used conservative assumptions (especially in the context of long-term recirculation) that resulted in minimum water level of 4.75 ft. above IRWST floor
- In-vessel discussed as part of LTC in Chapter 15

Review Topics, Section 6.2.2
Containment Heat Removal Systems

Scope of Review

- Long-term recirculation water source
- Strainer head loss and NPSH
  - Strainer head loss is based on all debris transport to the strainer; in practice, this is limited by the latent fiber, with area reduced to account for coverage by miscellaneous (tags, etc.) material
  - Staff witnessed first phase of testing performed by the applicant used as basis for calculating the head loss term, and the observations made by staff regarding debris preparation were accounted for during a second phase of testing

- NPSH ($h_{atm} + h_{static} - h_{loss} - h_{vp} = NPSH_a$)
  - Applicant followed guidance in SECY-11-0014 in calculating NPSH required, including uncertainty, for the ECCS pumps (17.5 ft-water for CS)
  - NPSH available includes credit for containment pressure up to the vapor pressure of the IRWST fluid (so $h_{atm} = h_{vp}$ when the IRWST T > 212 F)
  - h_{static} conservatively calculated based on minimum available water under limiting conditions (part of holdup analysis audited by the staff)
  - h_{loss} a function of system characteristics, constant
  - Both confirmed by ITAAC to ensure as-built $NPSH_a$ > analysis assumptions
  - $NPSH_a - NPSH_r$ = margin (3.0 ft-water for CS and 1.73 ft-water for SI)
  - In accordance with staff guidance, this margin is based on a collection of conservatively assessed values in the equation above (inputs use design basis limiting assumptions, not best-estimate values that would yield higher margins)

Review Topics, Section 6.2.2

Strainer Structural Integrity

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Scope of Review

- The design of AP1400 ECCS containment sump strainers
- The four independent sets of strainers are located in the IRWST
  - Topical report of IRWST Sump Strainer and Trash Rack Structural Analysis
  - Regulatory audit of the design specifications of strainers.

Findings

- No open item, 1 confirmatory item
- The design of ECCS containment sump strainers conforms
  - RG 1.82
  - AISC N690-1994 & 2004
  - ASME Code Section III allowable stress requirements
- The design of AP1400 ECCS containment sump strainers is acceptable.

RAIs

- RAI 56-7996, Question No. 06.02.02-11, status closed
- RAI 532-8689, Question No. 06.02.02-45, status closed
- RAI 519-8687, Question No. 06.02.02-1, status closed, confirmatory

Review Topics, Section 6.2.2
Ex-Vessel Downstream Effects

Scope of Review: Effect of post-LOCA debris on ECCS and CS components

- RG 1.82 Conformance and WCAP-16406
- Components in ECCS and CS
  - Pumps, valves, heat exchangers, orifices, spray nozzles, piping and instrument lines
- Mission time is 30 days
- Strainer bypass debris
  - 100% latent debris
  - 100% epoxy coatings
- Component evaluation
  - SI and CS pumps qualified by testing IAW ASME Standard QME-1-2007
  - Valves, heat exchangers, orifices, spray nozzles, piping and instrument lines evaluated for wear, blockage, fouling using insights in WCAP-16406
- ITAAC verification for SI and CS pump testing
- Open item:
  - RAI 06.02.02-22 for debris settling. Latent particulate debris (sand/grit) may settle in large diameter, low flow velocity sections of piping. The applicant is currently re-evaluating this issue.

Review Topics, Section 6.2.2

Chemical Effects

Scope of Review

- Chemical effects approach
- Source term for chemical effects
- Type and amount of chemical precipitates
- Chemical precipitates in strainer head-loss testing
- Chemical precipitates in fuel assembly head-loss testing

Findings

- Acceptable
  - Use of staff-approved methodology with conservative assumptions
  - Source term of materials and range of pH considered for chemical effects
  - Calculated chemical precipitate amount (nearly 100% aluminum oxyhydroxide)
  - Preparation and use of chemical surrogate in head-loss testing (aluminum oxyhydroxide)

Review Topics, Section 6.2.2
Chemical Effects

Findings (continued)

- Open Items at the time of Phase 2 Completion (SER with Open Items)
  - Aluminum quantity in chemical effects analysis less than amount identified in the DCD (non-conservative)
  - Temperature profile for the chemical effects calculation not fully described
  - Clarification needed on the use of water volume in chemical precipitate calculations
  - Clarification needed on preparation of chemical surrogate for strainer testing

- Resolved after Phase 2 Completion
  - Aluminum quantity – confirmatory (DCD Revision)
  - Temperature profile – confirmatory (Technical Report revision)
  - Water volume – confirmatory (Technical Report revision)
  - Surrogate preparation - closed

Section 6.2.1.1, Containment Structure

Section 6.2.1.3, Mass and Energy Release for Postulate Loss-of-Coolant Accidents (LOCAs)

Section 6.2.1.4, Mass and Energy Release Analysis for Postulated System Pipe Ruptures

Syed Haider

Review Topics, Section 6.2.1.1
Open Item No. 1 [1/2]

Summary of Review

- Scope of Review
  - GDCs 16&50: Reactor containment structure and associated heat removal system designed with sufficient margin to accommodate the calculated P&T conditions from any LOCA.
  - SRP Section 6.2.1.1A: Containment design pressure provides at least a 10% margin above the accepted peak calculated containment pressure.
- KHNP analyzed five LOCA and ten MSLB cases using a GOTHIC model.
- DCD reports a greater than 10% margin to the containment design pressure for the double-ended discharge leg slot break (DEDLSB) LOCA--the limiting DBA.
- Staff confirmatory calculations using MELCOR → Higher peak P & T than DCD
- RAI 378-8442, Question 06.02.01.01.A-9
  - Plant-specific design parameters, initial and boundary conditions, passive heat sinks
  - Input data, sensitivity coefficients, assumptions
- RAI 378-8342, Question 06.02.01.01.A-3: GOTHIC decks
  - Two lumped-parameter volumes: Containment atmosphere region and the IRWST
- Applicant performed additional GOTHIC sensitivity analyses (Revised response to RAI 296-8342, 06.02.01.01.A-3 with modified GOTHIC decks)

Review Topics, Section 6.2.1.1

Open Item No. 1 [2/2]

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Findings

- GOTHIC Models for LOCA and MSLB analyses
  - The outer surfaces of the containment shell (wall and dome) and inner surface of the containment floor are conservatively modeled adiabatically.
  - GOTHIC deck has more heat sinks than documented in the DCD.
- Three non-conservatisms identified in the APR1400 DCD GOTHIC model, with respect to the containment peak P & T
  - DCD uses the Direct-DLM HTC model as the convection-condensation combination. However, Tagami-Uchida HTC model was shown to be more conservative.
  - An inertial length of 1 ft was used in the DCD, which could be as large as the containment height of 166 ft that was shown to be more conservative.
  - Burnup dependent TCD (Thermal Conductivity Degradation) was not accounted for in the M&E release, and thus, in peak containment P & T (RAI 411-8505, Question 15.00.02-9).
- Peak containment P & T are contingent on the GOTHIC model update.
- DCD needs to be updated for the revised licensing basis calculations (graphs, tables, etc.) that account for the three non-conservatisms.
- The updated DCD results will allow the staff to make the safety findings regarding the calculated containment peak pressure, peak temperature, and minimum containment pressure margins during first 24 hours after the DBA.
- **The issue is being tracked as an Open Item.**

Review Topics, Section 6.2.1.1

Open Item No. 2

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Summary of Review

- Scope of Review (RAI 8442, Question 06.02.01.01.A-10)
  - GDC 38: CHRS shall rapidly reduce the containment pressure following any LOCA, lessening the challenge to the containment integrity. SRP Section 6.2.1.1A specifies that the containment pressure should be reduced to less than 50% of the peak calculated pressure for the DB LOCA within 24 hours after the postulated accident.
- DCD: The calculated containment P at 24 hours, 40.24 psia (25.54 psig), is 42.4% of the peak calculated P, 65.79 psia (51.09 psig), for the limiting LOCA.
- Justification requested for how the calculated containment P at 24 hours is considered reduced to less than 50% of the peak calculated P. The response corrected the value of containment P at 24 hours from 25.54 psig to 21.64 psig.

Findings

- The staff needs to verify the containment peak P and peak-P margin at 24 hours in the approved licensing basis calculations results also account for the three non-conservatism identified in the APR1400 DCD GOTHIC model.
- Associated DCD/TeR graphs and tables need to be updated.
- The applicant’s use of “gauge pressure” values in psig for calculating the pressure reduction margin at 24 hours after the accident, is acceptable per RG 1.206.
- **The issue is being tracked as an Open Item.**

Review Topics, Section 6.2.1.1

Open Item No. 3

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Summary of Review

- Scope of Review: Resolving the differences between results of the applicant's limiting peak containment P/T calculations as reported in the DCD and the staff's confirmatory calculations (RAI 378-8442, Questions 06.02.01.01.A-9 and 06.02.01.01.A-10) to gain safety insights.
- Reviewed the conservatisms built in the APR1400 containment response analysis (heat sink parameters, containment volume, nodalization, spray characteristics, and assumptions).
- A full accounting of the input data, sensitivity coefficients (inertial lengths, loss coefficients), heat transfer correlations used for containment analysis or M&E release calculations.
- DCD Table 6.2.1-23 specifies the passive heat sink data (material types, thicknesses, surface areas, boundary conditions) for a total of 16 passive heat structures.

Findings

- GOTHIC deck has three additional heat sinks.
- DCD needs to be updated accordingly (RAI 296-8342, Question 06.02.01.01.A-2).
- **The issue is being tracked as an Open Item.**

Review Topics, Section 6.2.1.1

Open Item No. 4

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Summary of Review

- Scope of Review: GDCs 16 & 50 requirements for sufficient design margin to the design P&T for the reactor containment structure and CHRS under the limiting DBA conditions. The initial conditions shall be chosen to yield a conservatively high peak containment atmosphere pressure and temperature.
- DCD Table 6.2.1-24 lists some initial conditions for containment peak P & T analyses. RAI 327-8354 issued to ascertain how the initial/boundary conditions were chosen to yield a conservatively high peak containment atmosphere P & T.

Findings

- The initial $T_{cont,atm}$ of 120 °F is chosen from the temperature LCO in the Tech Specs, and no instrument uncertainty is assumed (RAI 327-8354, Question 06.02.01.01.A-4)
- Recent supplemental response justified not using any instrument uncertainty in the initial temperature condition, for additional conservatism.
  - 10 CFR 50.36 defines the LCO as the “lowest functional capability or performance levels of equipment required for safe operation of the facility".
  - SECY-11-0014 states “LCO limits shall be used for the bounding values as the initial conditions for containment accident analysis.”
- The staff agrees that not adding the instrument uncertainty to the temperature LCO limit for the initial temperature condition will be acceptable. **Open item is closed.**

Review Topics, Section 6.2.1.1

Open Item No. 5

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Summary of Review

- Scope of Review: GDCs 16 & 50 requirements for sufficient design margin to the design P&T for the reactor containment structure and CHRS under the limiting DBA conditions. The initial conditions shall be chosen to yield a conservatively high peak containment atmosphere pressure and temperature.
- Following the termination of critical flow, the containment backpressure is assumed to be a constant 58 psia throughout the reflood phase. Staff questioned the basis for selecting this pressure for input to the FLOOD3 code, and whether an even lower value would be more conservative for the M&E release during the reflood phase of the DBLOCA. (RAI 327-8354, Question 06.02.01.01.A-6).
- Applicant responded that the 58 psia value is selected as it is lower than the calculated containment P during the EOB and when the containment peak P is reached. Two tables summarized the peak, minimum, and EOB pressures for DEDLSB and DESLSB with minimum and maximum SI, calculated for APR1400 DCD design (GOTHIC code) and Shin Kori 3&4 design (CONTEMPT-LT/028 code)

Findings

- The lowest containment pressure is 57.157 psia, which is even lower than the 58 psia used for DEDLSB with maximum SI for APR1400 DC. The applicant needs to submit a supplemental RAI response to justify not using a more conservative 57 psia value.
- **The issue is being tracked as an Open Item.**

Review Topics, Section 6.2.1.3
Open Item No. 6 [1/2]

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Summary of Review

- Scope of Review: GDC 50, Appendix K/SRP Section 6.2.1.3 stipulate that containment DB calculations should be performed for a spectrum of postulated break sizes, break locations, and SFs to determine the most severe design basis LOCA.
- All breaks analyzed in the APR1400 methodology are DE slot type, no DE guillotine breaks were analyzed. A DEDLSB, on the vessel side of a cold leg, with maximum SI flow identified as the limiting case of the M&E release that led to the most severe DBA LOCA with the peak containment pressure.
- It is not documented whether the DEHLSB was assumed to be the limiting break size for a hot leg break LOCA or it was obtained from a break spectrum analysis (small, medium, and large breaks). Applicant needed to demonstrate that the M&E release and subsequent containment thermal-hydraulic response analyses for DEHLSB are most conservative across the possible hot break spectrum including smaller slot break sizes. (RAI 290-8336, Question 06.02.01.03-1). The DE break should have been analyzed for the most limiting hot leg break through a series of trial runs to rule out smaller break sizes as being more limiting.
- The applicant analyzed only two smaller break sizes that are 60% and 80% of the DEHLSB. Small break LOCAs allow time for primary coolant to absorb energy from secondary side of the SGs as opposed to the DE breaks, which may result in rapid blow down and insufficient time period for any reverse heat transfer from the SGs.

Review Topics, Section 6.2.1.3
Open Item No. 6 [2/2]

Findings

- The applicant presented tables and figures of new analyses supporting their conclusions.
- The newly calculated DEHLGB blowdown M&E release data are compared with those of the DEHLSB case of APR1400 DCD Section 6.2.1.3, which shows DEHLGB case has slightly more severe results than the DEHLSB case. Even though the DEHLGB case is more severe than the DEHLSB case, DEHLGB peak pressure is less than that of the limiting LOCA case (i.e., DEDLSB with maximum SI flow).
- The RAI response also compares the newly calculated blowdown M&E data of the DEDLGB with the DEDLSB case of APR1400 DCD Section 6.2.1.3, which shows that that the DEDLSB case is more severe than the DEDLGB case. So, the DEDLSB case is still the limiting LOCA case.
- Applicant further analyzed smaller hot leg slot breaks below 60% of the DE area, per SRP Section 6.2.1.3, to ensure that no limiting LOCA exists for a smaller break. Recent supplemental response showed the M&E release and peak containment pressure results for six cases with 80% through 5% of the DEHLSB area. The results show a monotonous decrease in the predicted containment peak pressure with the reduction in the break area. The DEHLSB case in the APR1400 DCD is most conservative in the double-ended hot leg slot break spectrum.
- **DCD and TeR are revised. Open Item is changed to Confirmatory Item.**

Review Topics, Section 6.2.1.3
Open Item No. 7 [1/2]

Summary of Review

- Scope of Review: RAI 8393, Question 06.02.01.03-3
  - Clarify how spillage in the containment M&E release inputs was modeled in order to align it with the values used in the licensing basis and confirmatory calculations. Transient data were provided in the DCD for many of the M&E release components, but spillage data were listed as single integral line items rather than on a time dependent basis. Staff requested the transient spillage data in order to determine if there was any impact resulting from spillage on a more discreet timescale.
  - Whether the computer codes, CEFLASH-4A and FLOOD3, used for modeling the SI into the RCS by the SITs and the SIPs during the blowdown, refill, and the reflood phases of a LOCA, have been validated and approved to model DVI type injection.

Review Topics, Section 6.2.1.3
Open Item No. 7 [2/2]

Findings

- DVI and CLI blowdown transients are analyzed using the CEFLASH-4A code without any code model change. DVI injection in the LOCA blowdown modeled in CEFLASH-4A using nodalization and flow paths similar to other regions in the vessel. The effect of the DVI type injection during the LOCA blowdown phase is similar to CLI type injection with the exception that there is no loss of one train of SI for DVI type injection. In the FLOOD3 code, SI flow modeled as a BC for the reactor vessel annulus. Approach similar to that used in the FLOOD-MOD2 code, which is the NRC approved version.
- The applicant provided transient M&E release data for spillage, and confirmed that the transient M/E data do not include the “spillage” data. Based on the review of the tables, the staff concluded that correct M&E release is being input to the licensing basis analysis, and would find the applicant’s response to be acceptable.
- Revised DCD M&E release tables transient spillage data are provided.
- **Open Item is changed to Confirmatory Item.**

Review Topics, Section 6.2.1.3

Open Item No. 8 [1/2]

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Summary of Review

- Scope of Review: (RAI 394-8460, Question 06.02.01.03-10)
  - No description of the long-term cooling (or post-reflood) model available.
  - No discussion or justification of the methods used to calculate the core inlet and exit flow rates and removal of the sensible heat from primary system metal surfaces and the SGs.
  - Liquid entrainment correlations for fluid leaving the core and entering the SGs neither described nor justified by comparison with experimental data.
  - No statements are made about steam quenching by ECCS water or the applicable experimental data, or whether and how all the remaining stored energy in the primary and secondary systems would be removed during the post-reflood phase.
  - No references are made to compare the results of post-reflood analytical models with the applicable experimental data.
  - Whether the use of the GOTHIC code for the decay heat phase M&E release analysis can be considered appropriate for this application.

Review Topics, Section 6.2.1.3
Open Item No. 8 [2/2]

Findings

- The post-reflood transient is a continuation of the reflood transient, all modeling assumptions and method are identical, except that the liquid entrainment (CRF) is changed from 0.8 for reflood to 1.0 for post-reflood. The staff agrees that the CRF value of 1.0 is conservative as it would increase the system flow rate and maximize the break flow during the post-reflood period.
- The assumption of steam quenching and description of the removal of the remaining stored energy in the primary and secondary systems are identical to that of the reflood period. Not taking credit for condensation after the turndown to low SIT flow during post-reflood period was found to be conservative.
- The mass release calculation for using FLOOD3 reflood/post-reflood periods are conservative as the flow resistances were minimized in the hydraulic network.
- The response provided details of the lumped-parameter GOTHIC model for the RCS used to calculate the M&E release through the break during the decay heat phase. GOTHIC's use for the M&E release calculation during the post-reflood decay heat phase was previously approved by the NRC for the Dominion's power plant in their containment analysis methodology, for Surry. [DOM-NAF-3 NP-A, ML063190467]. The staff considers it acceptable.
- The supplemental revised RAI response is acceptable. **Open Item is closed.**

Review Topics, Section 6.2.1.4

Open Item No. 9 [1/2]

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Summary of Review

- Scope of Review (RAI 324-8362, Question 06.02.01.04-1)
  - GDC 50 requires that the reactor containment structure and associated heat removal system shall be designed with sufficient margin to accommodate the calculated pressure and temperature conditions resulting from the DBA.
  - SRP Section 6.2.1.1.A specifies that the containment design pressure should provide at least a 10% margin above the accepted peak calculated containment pressure.
  - Additional information needed on the initial and boundary conditions for the MSLB analyses.
- The limiting SF MSLB analysis is based on:
  - (1) Minimizing the rate of heat removal from the containment atmosphere: CSS and MSIV single failures were analyzed to see which one is conservative.
  - (2) Maximizing the flow of saturated and superheated steam out of the break: Could be based on any one of the several possible SFs including the failure of condensate booster pump to trip, feedwater regulating valve (FRV) to close.
- Need to determine whether the SF of the FRV was examined by applicant.
- Needed to demonstrate that the current limiting MSLB analysis is bounding for all possible SFs.

Review Topics, Section 6.2.1.4
Open Item No. 9 [2/2]

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Findings

- The response provided a supplemental table of all SFs of the safety and electrical system components applicable for the MSLB M&E release analysis as well as their qualitative evaluations to show that the current limiting MSLB analysis is bounding for all possible SFs. This fills the information gap in the DCD on the other possible SFs. The table is added in the TeR.
- DCD Tier 2, Section 6.2.1.4.4, “Description of Blowdown Model,” and Table 6.2.1-20 are revised for clarity regarding the initial conditions of the limiting MSLB and that the maximum feedwater enthalpy is assumed and the maximum feedwater flow is delivered to the affected SG in the MSLB analysis.
- There are two MFIVs in series in each main feedwater line.
- The feedwater bypass control valve is a non-safety related and normally closed valve.
- As the FBCV that is used for the SG initial filling condition by operator, it is not designed to receive any automatic actuation signal. Therefore, the staff accepts that its single failure is not considered for the MSLB analysis.
- The staff found the supplemental information adequate and accepts that the current limiting MSLB analysis is bounding for all possible single failures.
- **DCD and TeR are revised. Open Item is changed to Confirmatory Item.**

Review Topics, Section 6.2.1.4
Open Item No. 10

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Summary of Review

- Scope of Review: The SGN-III computer code is used for the APR1400 secondary system pipe break M&E release analysis. DCD and TeR do not comment on the acceptability of the SGN-III code for this application, which needs to be established.
- RAI 385-8465, Question 06.02.01.04-7, requested documentation of whether the SGN-III computer code has been validated against pertinent experimental data.

Findings

- SGN-III was validated against pertinent experimental data, as documented in SYS80-CESSAR, Appendix 6B. The response provided the comparison details of the SGN-III code results against four experiments (Kreisinger Development Laboratory (KDL) tests, Battelle tests, General Electric tests, and Vallecitos tests).
- A steam separation rate multiplier of 2.5 was found to conservatively predict the extent of the two-phase swell in the SG following the break for the all experiments. The response addresses the key issue whether or not the swell is sufficient for the two-phase level to reach and stay at the SG nozzles throughout the transient.
- SGN-III was approved by NRC for analyzing the MSLB accident for the CE-type nuclear power plants. The acceptability of the SGN-III code for this application is explained and documented in reference material “SYS80-CESSAR, Appendix 6B.”
- **DCD and TeR are revised. Open Item is changed to Confirmatory Item.**

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Section 6.1.1, Engineered Safety Features

Section 6.2.7, Fracture Prevention of Containment Pressure Boundary

Section 6.6, Inservice Inspection and Testing of Class 2 and 3 Components

Dan Widrevitz

Review Topics, Section 6.1.1

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- Not Acceptable
  - Two issues, but both have a path forward:
  - Inconsistent approaches were provided for preventing sensitization.
    - KHNP's sensitization controls described in RAI responses and discussed during public meetings are reasonable and would prevent sensitization of austenitic stainless steel.
    - Path forward: resolve inconsistencies and supplement the DCD Tier 2 FSAR with a clear description of sensitization prevention measures.
  - Unclear quality assurance requirements of the IRWST liner
    - IRWST is a ASME Section III, Class 2 structure. IRWST liner is not considered a ASME Section III, Class 2 liner because the IRWST does not perform the accident containment design function.
    - Because the IRWST liner is not an ASME Section III, Division 2 liner the staff questioned what the QA requirements for the liner was.
    - Path forward: KHNP will revised the DCD Tier 2 FSAR to state IRWST liner will meet ASME NQA-1 Quality Assurance requirements.

Review Topics, Section 6.2.7

Scope of Review

- Confirm that ferritic components of containment pressure boundary are appropriately designed with sufficient margins to assure that, under operating, maintenance, testing, and postulated accident conditions, (1) its ferritic materials behave in a non-brittle manner, and (2) the probability of a rapidly propagating fracture is minimized.

Findings

- Acceptable
  - Applicant clearly stated that materials ferritic containment materials were to be held to ASME Section III, Div. 2, Article CC-2520 and ASME Section III, Div. 1, Article NE-2300;
  - Applicant committed to applying the above.

Review Topics, Section 6.6

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Scope of Review

- Components Subject to Inspection
- Accessibility
- Examination Techniques and Procedures
- Inspection Intervals
- Examination Categories and Requirements
- Evaluation of Examination Results
- System Pressure Test
- Augmented ISI to Protect Against Postulated Piping Failure
- Relief Requests and Code Cases
- Combined License Information Items

Review Topics, Section 6.6

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Findings

- Acceptable

  Applicant adequately addressed all topics in initial submittal except as noted below:

  - Applicant provided acceptable markup clarifying several topics including use of Code compliant examination exemptions; inclusion of COL item addressing accessibility similarly for ASME Class 2 and 3 as for 1; and clear enumeration of appropriate examination methods;
  - Applicants agreed to remove inappropriate COL Item tasking COL applicants to provide any necessary ASME Code Relief Requests as a COL item.

Section 6.2.5, Combustible Gas Control in Containment

Anne-Marie Grady

Review Topics, Section 6.2.5

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Objective:

To determine whether or not the APR1400 combustible gas control in containment design meets the 10 CFR 50.44(c) requirements for water cooled reactor applicants, namely:

1) For significant beyond DBAs, ensure a mixed containment atmosphere by maintaining the concentration of combustible gases below a level that supports combustion, or detonation, that could cause loss of containment integrity.
2) The concentration of hydrogen shall be limited, both globally and locally, to less than 10 percent.
3) For significant beyond DBAs, equipment and systems needed to maintain containment integrity shall be able to perform their functions during and after a hydrogen burn; detonations of hydrogen shall also be included unless they are shown to be unlikely to occur.
4) Equipment shall be provided for continuously measuring hydrogen concentration inside containment following a significant beyond DBA.
5) A structural analysis shall be completed that demonstrates containment integrity will be maintained during and after a hydrogen burn that ignites all of the hydrogen that is released by the 100 percent fuel clad-coolant reaction.

Review Topics, Section 6.2.5

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Scope of Review:

- APR1400 DCD Tier 1, Section 2.11.4, "Containment Hydrogen Control System, DCD Tier 2, Section 6.2.5, and Section 19.2.3
- APR1400-E-P-NR-14003-P, "Severe Accident Analysis Report", Appendix A (hydrogen), Appendix E (containment performance), and Appendix F(equipment survivability)
- KHNP calculations supporting DCD and Severe Accident Analysis Report.
- Comparison of results with confirmatory calculation in contractor report ERI/NRC 16-208, Rev. 2, "Assessment of Combustible Gas Control during Severe Accidents in APR 1400"

Review Topics, Section 6.2.5

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Technical Evaluation

- KHNP selected five initiating events whose accident sequences represent the spectrum of severe accidents important to hydrogen accumulation and distribution - the most probable core damage sequences from the Level 1 PRA, and representative LOCA sequences.
- Initiating events are: LBLOCA, MBLOCA, and SBLOCA, SBO TLOFW.
- KHNP combustion analysis for these scenarios credited the severe accident mitigating systems.
- Mitigating systems include: AFW, SITs, PARs, HIs, CFS, CSS, rapid depressurization utilizing the POSRVs, and, operation of the three-way valves.

Review Topics, Section 6.2.5

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Technical Evaluation

- KHNP, using the MAAP4 code, calculated the hydrogen concentration versus time for 24 hours for the selected scenarios for all containment nodes modeled in the combustion analysis.

- The combustion analysis for all the base case scenarios results in hydrogen concentration in containment, both locally and globally, maintained below 10 percent, when all severe accident mitigating systems are credited.

- Staff contractor performed confirmatory calculations on mixing in containment for the same five base cases, using MELCOR with a containment nodalization similar to the applicant's.

Finding

- Staff confirmed that in all five base cases, and crediting all severe accident mitigating systems, the containment is well-mixed and does not support potential hydrogen detonation either by having a hydrogen concentration less than 10 percent, or a steam-inerted atmosphere.

Review Topics, Section 6.2.5

Technical Evaluation

KHNP performed sensitivity analyses on the base case scenarios, by crediting some, but not all mitigation systems, and found:

- hydrogen concentration does not exceed 10 percent anywhere in the containment except in the IRWST and in the SG compartment for high pressure sequences such as SBO and TLOFW, as long as the POSRV via the three-way valve is available, and
- hydrogen concentration for all LOCA sequences does not exceed 10 percent anywhere in the containment, as long as the PARs and HIs are available, and no containment sprays are actuated.

Finding

Staff found the potential exists to exceed 10 percent hydrogen concentration in the IRWST and the area above it for either SBO or TLOFW with no operation of the three-way valve, and there is a potential to exceed 10 percent hydrogen concentration in the reactor pressure vessel annulus for LBLOCA without PAR or HI operation.

Review Topics, Section 6.2.5

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Technical Evaluation

- Large detonations could potentially challenge containment integrity, and local detonations could affect equipment survivability.

- KHNP analyzed potential for detonations from flame acceleration during a deflagration, i.e., deflagration to detonation transitions (DDT). The potential for DDT exists for any node where the hydrogen concentration exceeds 10 percent.

- KHNP evaluated the potential for DDT, utilizing the cell width method described in document NEA/CSNI/R(2000)7, “Flame Acceleration and Deflagration-to-Detonation Transition in Nuclear Safety,” OECD/NEA.

- Cell width is a function of the atmospheric composition as well as temperature and pressure, with small cell widths corresponding to a more easily detonated mixture.

Review Topics, Section 6.2.5

Technical Evaluation

KHNP found:

- there is no DDT potential in the containment as long as the POSRV discharge via the three-way valve is available;
- if the POSRV discharge via the three-way valve is not available in high pressure sequences, the IRWST air space and the areas above it have the potential for DDT;
- there is DDT potential in the lower containment areas for any sequences with igniter failure and cavity flooding failure.

Finding

- Staff confirmatory calculations agree with KHNP's results for DDT potential in the IRWST and in the reactor cavity.
- Staff confirmed that, with all severe accident mitigation features available, there is no potential for DDT anywhere in containment.

Review Topics, Section 6.2.5

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Evaluation of equipment survivability

- 10 CFR 50.44(c)(3) requires equipment and instrumentation in containment needed to establish and maintain safe shutdown and containment structural integrity be capable of performing their functions during and after exposure to the environmental conditions created by the burning of hydrogen, from a 100 percent fuel clad-coolant reaction.
- KHNP selected the bounding temperature profiles from the burning of hydrogen calculated for a broad spectrum of severe accident sequences.
- Staff has calculated temperature profiles for two scenarios and compared them with the temperature profiles in DCD Tier 2 Figures 19.2.3-16 through 19.2.3-20, representative of the environmental conditions created by the burning of hydrogen.
- Staff finds the temperature profiles comparable.

Review Topics, Section 6.2.5

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Evaluation of equipment survivability

- KHNP selected the bounding pressure from an adiabatic isochoric with complete combustion analysis (AICC) to determine the peak containment pressure when combustible gases generated during the course of a severe accident burn.
- Staff calculated the AICC pressure for all five base cases and found that their results are bounded by the applicant's AICC pressure.
- The staff finds the equipment survivability acceptance criteria of 10 CFR 50.44(c)(3), that the containment pressure reflects the burning of combustible gases, is met.

Review Topics, Section 6.2.5

Evaluation of hydrogen monitoring

- Equipment for monitoring hydrogen in the containment shall be functional, reliable, and capable of continuously measuring the concentration of hydrogen following a significant beyond DBA for accident management.

- CHMS performs continuous hydrogen monitoring inside containment for a severe accident and provides continuous post-accident indication of containment hydrogen concentration in the control room. CHMS remains functional post accident. CHMS has two redundant trains and analyzes air samples from the containment atmosphere and the air space in the IRWST. This information is used for accident management, and to assess the efficiency of the CHCS.

- Staff finds that CHMS meets the applicable requirements of 10 CFR 50.44(c)(4).

Review Topics, Section 6.2.5

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Evaluation of containment structural integrity

- 10 CFR 50.44(c)(5) requires a structural analysis which demonstrates containment integrity will be maintained during and after a hydrogen burn that ignites all of the hydrogen that is released by the 100 percent fuel clad-coolant reaction.

- KHNP performed an adiabatic isochoric with complete combustion analysis (AICC) to determine the peak containment pressure of the burning of hydrogen.

- Staff evaluated KHNP structural analysis based on the AICC containment pressure and found KHNP's method and results acceptable. (SER section 3.8.1).

Section 6.2.4, Containment Isolation System

Section 6.2.6, Containment Leakage Testing

Raj Goel

Review Topics, Section 6.2.4

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Scope of Review – with Open Items*:*

- Containment Isolation System (CIS) is designed to allow free flow of normal or emergency-related fluids through the containment boundary in support of reactor operations, but establishes and preserves the containment boundary integrity.

- The criteria for isolation requirements and the associated system design are set forth in GDCs 1, 2, 4, 16, 54, 55, 56 and 57 of Appendix A to 10 CFR 50, and TMI-related requirements of 10 CFR 50.34(f)(2) and the SBO requirements 10 CFR 50.63 (a)(2).

- The staff used acceptance criteria described in SRP Section 6.2.4 and guidance described in RG 1.141, which endorses ANSI N271-1976," Containment Isolation Provisions for Fluid Systems".

- The containment penetration barriers consisting of flange closure, personnel airlock and equipment hatch are under administrative control.

Review Topics, Section 6.2.4

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Scope of Review – with Open Items (Continue):

- Review of DCD Section 6.2.4 resulted in several questions and clarification: such as, all penetrations number in DCD Table, systems with single valve isolation, fail-as-is position of CIV upon loss of power, design requirements of relief valve used as CIV, all power operated CIVs have position indication in control room, provision of vent and drain connections for leak testing.

- There are 5 open questions in current SE, including justification for systems with single valve isolation, design requirements for debris from interfering with valve closure, flanged closure and leak testing provisions, vent and drain connections, and ITAAC for length of pipe from containment wall to outer isolation valves. Out of these open questions, the staff has since evaluated the response to 4 questions and found the response acceptable.

- The staff is waiting for the applicant's revised response to a question regarding the length of pipe showing the CIVs outside containment located as close to it as practical, as required by GDCs 55. 56 and 57 in DCD Table. **This is being tracked as an open item.**

Review Topics, Section 6.2.6

Scope of Review – No Open Items :

- Containment Leakage Testing addresses the leakage rate testing program for the reactor containment. It is designed to 10 CFR 50 Requirements:
  - GDC 52, 53 and 54 of Appendix A require that the reactor containment vessel and piping systems that penetrate the containment be designed to accommodate periodic leakage rate testing.
  - Appendix J specifies leakage testing requirements for the containment, its penetration, and isolation valves (Type A, B and C tests).

- Review of DCD Section 6.2.6 resulted in 10 Questions. The staff has evaluated the applicant response to these questions and found it acceptable. There are no open items. The staff concluded that:
  - Type A, B and C tests are conducted in accordance with10 CFR 50, Appendix J Option B with guidance from RG 1.163.
  - Testing intervals and requirements are based on NEI 94-01 and ANSI/ANS-56.8-1994, as modified and endorsed by RG 1.163-1995.
  - Containment Leakage Rate Testing (CLRT) program requirements and acceptance criteria are as in the Technical Specifications program.
  - The staff finds that the Containment Leakage Testing meets the applicable requirements specified by 10 CFR 50, Appendix J Option B, and GDCs 52, 53 and 54 of Appendix A.