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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

APRIL 20, 2016

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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 8:30 a.m., Ronald G. Ballinger, Chairman, presiding.

COMMITTEE MEMBERS:

RONALD G. BALLINGER, Chairman

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

MICHAEL L. CORRADINI, Member

DANA A. POWERS, Member

HAROLD B. RAY, Member

JOY REMPE, Member

PETER RICCARDELLA, Member

GORDON R. SKILLMAN, Member

JOHN W. STETKAR, Member

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER BROWN

ALSO PRESENT:

JEFF CIOCCO, NRO

SANGYOUN JEON, KNF

WONSANG JEONG

YONGGUN KIM, KEPCO-AE

JAEYONG LEE, KHNP

MARVIN LEWIS*

JIYONG (ANDY) OH, KHNP

TAESUN RO, KHNP

ROB SISK, Westinghouse

DONNA WILLIAMS, NRO

*participating via telephone

T-A-B-L-E O-F C-O-N-T-E-N-T-S

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

8:31 a.m.

CHAIRMAN BALLINGER: The meeting will please come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on the Advanced Power Reactor APR1400 Application.

I'm Ron Ballinger, Chairman of the Subcommittee. Subcommittee members in attendance are -- everybody. Dennis Bley, Pete Riccardella, Harold Ray, Gordon Skillman, Dana Powers, Mike Corradini, John Stetkar, Charles Brown, Joy Rempe. That's it.

The purpose of this meeting is to receive a briefing and an overview on the APR1400 design.

The Subcommittee will hear presentations, the first of many, many, many in the future, by and hold discussions with representatives of the NRC staff and Korea, or KHNP, the applicant regarding these matters.

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

Christopher Brown is the Designated Federal Official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the *Federal Register* on 1 April, 2016. Portions of this meeting may be closed to protect information that is proprietary to KHNP; that will be this afternoon and tomorrow's meeting, pursuant to 5 USC 552(b)(c)(4).

A transcript of the meeting is being kept and will be made available as stated in the *Federal Register* notice.

It is requested that speakers first identify themselves -- actually first press the little green button, identify themselves and speak with sufficient clarity and volume so they can be readily heard. Also, silence please all cell phones and other things that might beep.

We have not received any requests from members of the public to make oral statements or written comments.

I will now proceed with the meeting, and I'll call on Donna Williams, Branch Chief at NRO, to begin.

MS. WILLIAMS: Good morning. I'm Donna Williams, the Acting Chief of Licensing Branch II in the Office of New Reactors. I would just like to thank KHNP for coming out today to present this to us. I know you're a lot of folks and we appreciate the effort you made and we're looking forward to hearing all the presentations that you have today. I think it will be very informative for all of us. Thank you.

CHAIRMAN BALLINGER: So who's the lead? Mr. Lee?

DR. LEE: Yes, good morning ladies and gentlemen. My name is Jaeyong Lee. I am the project manager of this APR1400 design certification project of Korea Hydro and Nuclear Power Company.

I'd like to take this opportunity to thank NRC staff and the ACRS members for the time today. It's also my honor to have the opportunity to present the overview of this APR1400 design certification to the ACRS Subcommittee members. As you may know KHNP has been eagerly pursuing to obtain the design certification from the U.S. NRC since 2009. It's not only for the design purpose, but also for enhancing the nuclear standard in

Korea. Therefore, KHNP will support fully these resources to reserve all the big issues raised by ACRS and the NRC staff as well. Once again, thank you for joining this scheduled meeting.

CHAIRMAN BALLINGER: Thank you. Next? Oh, Jeff? Okay.

MR. CIOCCO: Muscle my way in here amongst KHNP. Excuse me.

(Laughter.)

MR. CIOCCO: Looks like we're already ahead of schedule.

CHAIRMAN BALLINGER: That will change.

MEMBER STETKAR: Jeff, make sure you turn your mic on. It's behind the laptop there. I've been the -- no, it's right down toward the base. There you go. I'm the designated microphone reminder.

MEMBER CORRADINI: And he enjoys that.

MEMBER REMPE: Just because it will help later on, why don't you put it over to the side so it's very close to where you're speaking and others might be speaking --

MR. CIOCCO: All right.

MEMBER REMPE: -- so we don't have to worry about -- we can't hear you.

MR. CIOCCO: Okay. Good morning, everybody. My name is Jeff Ciocco. I'm the lead project manager for the NRC and the title of my presentation this morning is the APR1400 Standard Design Certification Review. I have copies of the handouts in the back as well.

The agenda, I'm going to talk today, I'm going to talk about the reactor review and the contents of the application. I'm not going to talk about the reactor. It's a big light water reactor, big 1400-megawatt electric PWR. KHNP is going to present that today. I'm not going to present any safety findings. We are doing our safety evaluations right now. I'm going to tell you about the review that's underway, a little bit about the review that happened as the predecessor to this. I'm going to tell you about the application that came in, the contents of it and what the staff is doing now.

So the agenda is I'll talk about the APR1400 application. This is Docket 52-046, the 46th of the Part 52s. I'm going to talk about the topical reports that we have under review; there's five of them, and I'm going to talk about the actual Design Certification Safety and

Environmental Review which is currently underway.

So before I start with the first bullet, which is the current review that's underway, if you'd just give me a minute I'm going to backtrack a little bit and just give you a little bit of the background here.

As I think most of you know, the APR1400 is based on the System 80+ design. That was an early Part 2, or an early Part 52 certification which is currently -- it's Appendix B to Part 52. It's called the design certification rule for the System 80+ design. The Final Safety Evaluation Report, the FSER, can be found in NUREG-1462, and it was published in August of 1994. It was our second docket in Part 52. It was Docket 52-002. So this design is an evolution of that System 80+.

And that's some important background because whenever staff comes back later and we present the safety evaluations, you'll see some tracing back to the Final Safety Evaluation Report of the System 80+ where we had to look at deltas where they used codes that were used back on System 80+ and how they're applied to the current APR1400. And like I said, this is not the System 80+. This

is the APR1400 Docket 52-046, its own stand-alone application. But it's an important reference point and I think KHNP is going to talk about it as well.

That System 80+ was initially submitted by Combustion Engineering, which is now ABB-CE. And under the Part 50 regulations it was later requested to be certified under Part 52, which it was years ago. And like I said, that's Appendix B to Part 52.

So now getting you up a little more current where we are with the APR1400, the first pre-application began with NRC staff in April of 2010, which led up to KHNP and KEPCO jointly submitting its first application for standard design certification on September 30th of 2013.

So staff did its acceptance review. We reviewed the application to see if it was sufficiently complete and technically adequate. Well, staff determined and we issued a letter on December 19th of 2013 notifying KHNP and KEPCO that we were not accepting the application for docketing. We issued a non-acceptance letter and in that letter; and it's publically available, we stated that the majority of the application was very good. A lot of the critical design areas were

there, but we found several holes in the application that we did not feel were sufficiently completed, technically adequate for us to do a design certification review, particularly in the 42-month time frame that NRC had set as a standard for doing this design certification.

So we issued that non-acceptance in December of 2013. So between December 2013 and December 2014, my first bullet there, we entered into a second preapplication period with KHNP. So from their letter they had from us, the areas that we felt were insufficient in the first application for them, we called them the non-acceptance issues. And for instance, the digital I&C platform wasn't satisfactory.

And there was kind of a laundry list of maybe 9 or 10 things. The PRA wasn't adequate, the environmental report, the severe accident design mitigation alternatives and a few others. Stress corrosion cracking, the reactor core supports. There were a few things that we said they were inadequate in the first application. So KHNP engaged us in a very active second preapplication period to address these non-acceptance areas.

We had several public meetings with

KHNP. They put the pen to paper, they did a lot of reanalysis, a lot of redesign. And at the end we had a public meeting where they kind of presented their stance on the non-acceptance issues, which led them to where we are now, to my first bullet here.

So this is the current application. So once again, KHNP and KEPCO jointly submitted a design certification, the Part 52 application, on December 23rd of 2014, which contains; and this is all publically available information, the design control document, the DCD. There's a Tier 1 and Tier 2. And there's a public and non-public version. I'm going to explain that in a minute.

They were required to submit an environmental report required under Part 52.47. There's also technical reports that were submitted that kind of sit behind the DCD, about 60. And you'll see they're either -- and this is where the proprietary information is contained or not contained in the application. It sits in the technical reports. And the majority of them are incorporated by reference into the design control document. And you'll see them referenced in the chapters. Some are just provided as technical

information to the staff and made publically available, but aren't necessarily referenced in the design control document.

And I know I provided Chris and everybody that, because under the requirements of -- I think it's Part 52.53 where we have to refer the application to the ACRS, so I've notified ACRS staff and provided the application, the non-public version, as well as all the underlying topical and technical reports to ACRS. So you have that right now available to you.

CHAIRMAN BALLINGER: Can I ask just one --

MR. CIOCCO: Yes.

CHAIRMAN BALLINGER: -- since you're getting into process? When were these design certification documents accepted by staff?

MR. CIOCCO: March 4th. That's my next slide. But it's going to be March 4th of 2015, just about a year ago.

CHAIRMAN BALLINGER: Okay.

MR. CIOCCO: A year and a month ago.

So we have the technical reports. And they also included the design inspection, tests, analysis, and acceptance criteria, ITAAC. That's

in Tier 1. It's in the Tier 1 document. It's also in Section 14.3, which contains the ITAAC. And we also have a public web site which contains the application and the entire review schedule.

Next slide.

MEMBER SKILLMAN: Jeff, let me ask this question, please.

MR. CIOCCO: Yes, please.

MEMBER SKILLMAN: For this construct of the technical reports being IBR'd or non-IBR'd in fact up into the DCD what controls are in place to ensure that changes to the technical reports are under some form of configuration control so that our deliberations on the design control document, particularly Tier 1, are not diluted by changes in those technical reports that may be subsequent to our activities?

MR. CIOCCO: There's a document flow whenever there's a change to -- for instance, if a request for additional information is written on any particular topic -- and in the response to the RAI we have them answer several questions. First, they answer the question if there's technical analysis, whatever, we ask them is there any change? Based on this RAI response is there any

change to the design control document? Any change to the DCD that would be Tier 1 or Tier 2? Is there any change to a technical report? Is there any change to a topical report? Is there any change to the environmental report? Is there any change to the PRA, because that has a lot of tentacles.

So we look at changes as kind of a flow up whenever there's a change to a technical report, which could be revised, could be a revision to a technical report. And then it would be reflected, if it's incorporated by reference, in an update to the DCD. We're currently in Rev 0 of the DCD. There could be a Revision 1 later this summer incorporating all of these changes.

And ultimately for you whenever you see the staff's Safety Evaluation Report, which is what you're going to review in addition to the DCD, we have to be clear in there what rev of the DCD that we are writing the safety evaluation against -- and for us that's a flow down.

We have to be clear on which revision of the technical report, which revision of the topical report and which RAIs. So I think there's pretty good document control starting at the lower

levels. The kind of information that sits behind the DCD and how it flows into the DCD.

MEMBER STETKAR: Jeff, in simple terms though if they make a change to a technical report, that requires a new revision of the DCD, doesn't it?

MR. CIOCCO: Not necessarily. It depends --

MEMBER STETKAR: Not necessarily?

MR. CIOCCO: No. No, if you look at the references; and not every reference --

MEMBER STETKAR: Wait a minute.

(Simultaneous speaking.)

MR. CIOCCO: -- a Revision 0.

MEMBER STETKAR: Aren't --

MR. CIOCCO: Because a technical report will be referenced in a chapter by its title and document number, prop and non-prop, but not necessarily Rev 0, Rev 1, Rev 2.

MEMBER STETKAR: Okay.

MR. CIOCCO: Okay?

MEMBER STETKAR: Okay.

MEMBER BLEY: The DCD and your SER isn't directly tied to a particular version of the topicals and technical reports.

MR. CIOCCO: They're tied to very specific versions.

MEMBER STETKAR: But the topical reports have separate SERs.

MR. CIOCCO: Yes, I'll get to that in a minute.

MEMBER STETKAR: Technical reports -- I've always viewed technical reports as just an adjunct to the text of the DCD.

MR. CIOCCO: Correct. They sit behind the DCD and some are -- yes. Yes, but we have to be clear whenever we come in and present this. Whenever we present the safety evaluation we'll let you know. It'll be in the text as well, but there will be a summary from us which DCD chapter we reviewed, what technical report and what versions. So you have all of that information. We don't want any doubt in your minds of which -- if a technical report was updated -- and they do get revved -- that you have the most current revision of that technical report.

MEMBER BLEY: It's been a couple years since I sat through a design cert, but a couple of them I have these awful memories of --

MR. CIOCCO: Yes.

MEMBER BLEY: -- you guys all -- both the applicant and you guys coming in and giving us all this stuff. And when we start asking questions, the response is, oh, well, that's all changed in the new version, which makes the review really difficult.

MR. CIOCCO: Well, I have a big aversion to that happening as well, and certainly don't want it to happen. And we'll take the steps. I mean, there were a lot of lessons learned I think from the prior design certification, because there are tens of thousands of pages of information that have to be reviewed on these big, big PWRs, no doubt about it. So we try to painstakingly work with your staff so you know what revision of the DCD, technical reports, topical reports, as well as the thousands of RAI questions and responses that are answered. So we'll make sure. I mean --

MEMBER BLEY: But let me follow up with one --

MR. CIOCCO: Yes.

MEMBER BLEY: -- because one thing we began to see was in between actual submitted revisions of the DCD as the RAIs went on there's -- at least in one case I remember, the seemed to be a

continuing update, not published, of the DCD. And finally we started getting to see that just before the meetings when everybody came in. Because otherwise, it's not worth our time reviewing.

MR. CIOCCO: I understand.

MEMBER REMPE: So you mentioned the connection between this plant and the System 80+, but if this -- as you said, this application will be a new application.

MR. CIOCCO: That is correct.

MEMBER REMPE: And so, if there's any history with containment atmospheric pressure, CAP --

MR. CIOCCO: Yes. Right. Right. Right.

MEMBER REMPE: -- credit, that's irrelevant. This is a new plant, right?

MR. CIOCCO: Anything is irrelevant unless it's referenced in this application --

(Laughter.)

MR. CIOCCO: -- if they reference back specifically.

MEMBER REMPE: But what the staff --

MR. CIOCCO: And I'm not going to --

MEMBER REMPE: -- did in the past is

irrelevant with respect to CAP credit, right?

MEMBER CORRADINI: I think what --

MR. CIOCCO: Oh, yes.

MEMBER CORRADINI: -- Dr. Rempe is asking if there's something that happens to be historically similar, we're not going to be referred back to the System 80+. We're going to see an analysis that's specific for this design. That's my interpretation of the question.

MEMBER REMPE: Right. And it's a new design and decisions about CAP should be new.

MEMBER CORRADINI: Well, for example.

MEMBER REMPE: For example.

MR. CIOCCO: Right. Right. Yes, true.

MEMBER REMPE: Okay.

MR. CIOCCO: And there are certainly -- we as staff review the application and we see where they reference back to a System 80+, a code, an analysis, whatever, and whether we have to go back and look at the deltas between that and this application. Correct.

MEMBER BROWN: Jeff, I have --

MEMBER SKILLMAN: Jeff, I --

MR. CIOCCO: Yes?

MEMBER SKILLMAN: Excuse me. Charlie,

go ahead.

MEMBER BROWN: In my particular area, back to the technical reports again, the first question is is the DCD as what have been presently given --

MR. CIOCCO: Yes, sir.

MEMBER BROWN: -- complete at this point?

MR. CIOCCO: Yes, sir. It's Rev 0. Yes.

MEMBER BROWN: Do the technical reports at the -- the technical reports are not works in progress? They are complete at this point?

MR. CIOCCO: They are --

MEMBER BROWN: They are something that's being revised or the design is being changed? I'm particularly interested in one of the past projects, maybe two of them, the resolutions of some of the comments or the concerns we had in my area. They were incorporated into the technical report based on the letters and reports we wrote, which really did necessitate an update to the DCD and show the explicit revision of the technical report in the DCD so that you had that resolution documented --

MR. CIOCCO: Yes.

MEMBER BROWN: -- as part of the design. So I'm sitting here munching away on, well, you may not have revisions listed in the DCD. And that's fine, but somewhere -- well, it's not fine, maybe.

(Laughter.)

MR. CIOCCO: Well, let me say that the application was docketed in March of last year, so we're 13 months into the review. Everything is fluid at this point. Staff is in -- and I'm going to get to a slide about where we are in the review. Nothing is completed yet. Our safety evaluations in Phase 2, the ones that we're taking to the ACRS, are not completed. They are in review. So everything is fluid. RAIs are being written. RAIs are being responded to. Changes are being made by change pages in the RAI responses. Some to technical reports. Some to DCD information being added. So, yes, things are fluid right now.

MEMBER BROWN: So I guess my --

MR. CIOCCO: Yes. I mean, they have to be because we are in the review.

MEMBER BROWN: I understand that point.

MR. CIOCCO: Yes.

MEMBER BROWN: Yes, I don't quibble with that. I'm just trying to get a grip on when we review certain specific areas --

MR. CIOCCO: Yes.

MEMBER BROWN: -- when we write a report and have concerns or have recommendations --

MR. CIOCCO: Right.

MEMBER BROWN: -- if they are agreed to, we may have to insist that they be incorporated in the DCD as opposed to a technical report.

MR. CIOCCO: Sure.

MEMBER BROWN: In other words, you IBR the technical report with these exceptions or these changes made and the DCD.

(Simultaneous speaking.)

MEMBER BROWN: I'm just trying to figure out how we do that when --

MR. CIOCCO: Yes.

MEMBER BROWN: -- and the letter writing.

MR. CIOCCO: If it comes out in your letter writing out of your Phase 3 completion -- and we'll look at your recommendations. You obviously look at our safety evaluation and --

MEMBER BROWN: I'm not looking for ones

you reject. I'm looking --

MR. CIOCCO: Yes.

MEMBER BROWN: -- at the ones you agree with --

MR. CIOCCO: Right.

MEMBER BROWN: -- and pass through and the licensee or the applicant agrees with also. So --

MR. CIOCCO: Yes. Yes.

MEMBER BROWN: All right. I was just trying to get a calibration.

MR. CIOCCO: Yes. Yes, we understand. We are writing the review. This review was front-end loaded. We're in the middle of a six -- it's a six-phase review, so -- and we're only 13 months into a large, large review.

MEMBER BROWN: Understood. Thank you.

MEMBER STETKAR: Jeff, something you said -- kind of a follow-up of what Dennis asked. He said, well, in the RAIs there are commitments to change pages for the DCD. That's the type of process that really frustrated us in our Phase 2 reviews, because everything was in a state of flux and it's all documented in the RAIs.

I will tell you that none of us have

the time to go read RAIs. None of us have the time to do that. So if it's not --

PARTICIPANT: Not even you?

MEMBER STETKAR: Not even me.

(Laughter.)

MEMBER STETKAR: And if it's not documented in the SER that's delivered to the Subcommittee --

MR. CIOCCO: Right. Right.

MEMBER STETKAR: -- and the Full Committee for the Phase 2 review, that's -- and that's when stuff is in --

(Simultaneous speaking.)

MR. CIOCCO: Yes, correct. I understand what you're saying, yes.

MEMBER STETKAR: That's --

MR. CIOCCO: Yes. I understand, yes.

MEMBER STETKAR: -- where it leads to frustration --

MR. CIOCCO: Right. Right.

MEMBER STETKAR: -- because we have had that experience where there's this undercurrent of stuff that's all buried in the RAIs, and we don't have the time to review that.

MR. CIOCCO: Right. Right. It's --

MEMBER STETKAR: It's bad enough that we have to read a couple thousand pages of stuff a week.

MR. CIOCCO: I understand, and I know what your requirements are in the 52.53 for the review and -- but, I mean, out of necessity when they do an RAI
-- and I'm not talking about commitments. I'm talking about actual changes --

MEMBER STETKAR: Yes.

MR. CIOCCO: -- in the RAI response. Out of necessity in responding to an RAI they may have to make a change to the DCD and to a technical report, and maybe a topical report.

MEMBER STETKAR: And that's exactly what I'm talking about.

MR. CIOCCO: And I understand what you're saying. You want to see it reflected when you review, right, so you're on the same page as we are whenever we write the Safety Evaluation Report. Yes. Yes, I understand.

MEMBER SKILLMAN: I wanted to pull on an answer that you gave to John regarding changes and whether those changes actually are a change to the design cert.

MR. CIOCCO: Yes.

MEMBER SKILLMAN: John kind of raised that question if there are changes. You said no, that's not a change in the cert. It strikes me that the way 52 is written, if there is a change to Tier 1, if the design cert had already been approved, that requires a license amendment.

MR. CIOCCO: Oh, right.

MEMBER SKILLMAN: Hold that thought.

MR. CIOCCO: Okay.

MEMBER SKILLMAN: Now we're talking about underlying information that affects Tier 1 presentation in the DCD. And I would assert if the technical reports and topical reports amend Tier 1 information, we're heading for a rev on the DCD.

MR. CIOCCO: Correct. Sure. And the same with Tier 2.

MEMBER SKILLMAN: So the answer to John would have been --

MR. CIOCCO: And the same --

MEMBER SKILLMAN: Okay.

MR. CIOCCO: -- with Tier 2. Sure. Any response from KHNP to a question that we ask, or on their own necessity, a change to Tier 1 or Tier 2 will be captured in the next revision of the

DCD. It has to be.

MEMBER SKILLMAN: I think that that's what John asked. So the answer is really yes, not no?

MEMBER BLEY: Well, there's two pieces.

MR. CIOCCO: The answer is --

MEMBER BLEY: The technical information will get rolled into the DCD, but the actual rev number of the document will not of the technical report.

MR. CIOCCO: Yes.

CHAIRMAN BALLINGER: I think what you're hearing loud and clear is that the staff should have T-shirts that say "42 months" on the front of them. And we have a lot of work to do in 42 months and we need to be sure that we don't complicate things by having confusion.

MR. CIOCCO: I understand. I understand they are --

MEMBER SKILLMAN: What I'm talking about is crisp control of configuration management on the documentation so we know what you reviewed, you know what we're looking at, and we are on the same page.

MR. CIOCCO: I Understand.

MEMBER SKILLMAN: That's the only --

MR. CIOCCO: That's our responsibility.

MEMBER SKILLMAN: That's my only point.

MR. CIOCCO: Correct. Yes. These are complex reviews.

MEMBER SKILLMAN: Thank you.

MR. CIOCCO: We understand, yes.

MEMBER SKILLMAN: Okay. Thank you, Jeff.

MR. CIOCCO: Okay. You're welcome.

Okay. All right. So the next page, the regulations require us to make certain notifications upon receipt of the application, to conduct an acceptance review and to docket the application. So what I start with -- let's see if my pointer works here -- maybe not. Is that working?

Anyway, the first bullet tells you when this application came in, December 23rd of 2014. Then we wrote the letter of receipt on February 2nd, to KHNP, to the co-applicants. We also had a -- we were required to publish in the *Federal Register* a notice of receipt of the application. So between December 23rd and March 4th of 2015 we conducted our acceptance review of the application.

This was a -- we evaluate the application for the sufficiency of completeness as well as the technical adequacy for staff to be able to conduct a technical review of the application.

So as you can see, we determined once the application was resubmitted that we did docket the application on March 4th. That was also published in the *Federal Register* notice, a docketing on March 12th. And then we issued our schedule letter a few months after which laid out our six-phase review schedule I'm going to show you in a second.

And I also included a kind of significant date here. This is kind of jumping ahead a little bit, but we issued a letter last month on March 3rd kind of updating the status of the review in this publically available schedule letter to KHNP and KEPCO. And what we said, we pretty much said three things: We said the good news is that Phase 1 of the review is complete. We've issued internally our preliminary Safety Evaluation Report and we've issued RAIs. Phase 1 is completed on schedule.

We also said Phase 2 is currently underway. Phase 2 is on schedule, however, there's

a lot of technical challenges that are being worked on and in order for us to meet our aggressive schedule here we need to resolve these technical issues.

And we also said in -- the third kind of message of this was by the summer of this year we want to meet with you and kind of do an assessment of the progress of this review and make sure that we're still on schedule to meet the 42-month schedule and our Phase 2 milestones. So that was a pretty significant letter that was issued on March 3rd.

Now I'm going to just jump ahead. Just so you can see, this is the -- here's the standard contents of the design certification application. It includes the application submittal letter. And so everything here is publically available. I know it's small print, but you've got handouts. It's got the application letter itself. It's got the environmental report, Tier 1.

And the next you'll see is the 19 chapters of the design control document. And what it doesn't show is under Chapter 19 there's -- Chapter 19.1 is the PRA; 19.2 is severe accidents. Standard Chapter 19. It also includes in Chapter

19, not shown here, is -- 19.3 is the beyond-design-basis external events, the Fukushima evaluation, 19.4 is the loss of large area fires, and 19.5 is the aircraft impact assessment. And KHNP is going to get into some of the technical details of that, but those are subsections under Chapter 19. So the importance of this page is it shows you this is all of the publically available information of the DCD, and it's on our public web site.

If you go to page 6, what's -- and this is important for your review to know is that these are the chapters which also contain non-public information. This has the security-related information. And I didn't put the accession numbers here, but as you're doing your review you're going to notice that these chapters have a public and non-public version. And you have the non-public version. So these contain security-related information. That was the only purpose of this slide was just to show you of that big subset this is a small subset of those on the first slide. So that's the application.

Next I'm going to talk just briefly about the topical reports that we have in house.

There are five topical reports that are incorporated by reference into the APR1400 DCD. You can find them referenced in Chapter 1 as well as the specific chapters. These were submitted back in 2012. These were submitted in advance of the application.

One of the topical reports is the QAPD, the Quality Assurance Program description. And staff has issued its safety evaluation on this. And I think they're on Rev 4 of the QAPD. They have to update it regularly mainly as they change organization because it contains a lot of the KHNP and KEPCO organizations charts in there. And that's really the only changes. This is the Part 50 Appendix B QAPD. It's approved. Staff has issued and published its Safety Evaluation Report.

We're currently conducting the detailed licensing reviews of the four remaining topical reports. As Mr. Stetkar said, a Safety Evaluation Report, a stand-alone Safety Evaluation Report will be prepared for each of the topical reports. The SERs will be reviewed by KHNP and then presented for approval to the ACRS. Typically we present these, as we have in the past, with its related chapter of the DCD. And I'll explain that in a

second.

Next is just a table showing you what the five topical reports are and its related DCD Tier 2 section. So the first one is the large break LOCA methodology. And that's 6.2, mostly in Section 15.60, Accident Analysis. That's under review. Next is the critical heat flux correlation. It's the DNBR evaluation. Thermal design, that's Section 44 as well as some in Chapter 15. Then we have the PLUS7 fuel design topical report. And you can see these are all in Rev -- these except for the QAPD are all in Rev 0.

The Quality Assurance Program description document, which is tied to Chapter 17, that's already been completed. And the fluidic device, which is that -- it's a flow damper which sits in the bottom of the advanced accumulator, the fluidic device design for the APR1400. And we have completed the review of the fluidic device topical report. We've just issued the safety evaluation to KHNP. They're doing a prop review as well as a factual accuracy check.

Once that's completed we get their comments, we make the revisions. We'll be sending that down to the ACRS. That will be the first

safety evaluation that you have. We've pretty much completed our review and we're going through issuing right now the critical heat flux correlation, the DNBR analysis, topical report. So we made really good progress on these topical reports and the reviews are underway.

Okay. Now where we are currently with the APR1400 DCD review. As I mentioned awhile ago, this is the 42-month schedule that the NRC has issued. And prior to the application coming in and prior to being documented, the Agency recognized the need to do things differently and try to deliver our products on a faster schedule while still meeting all of our safety review responsibilities before we came up with this 42-month schedule. So a lot of preparation was underway and the preapplication is to help us meet and produce a 42-month schedule on this project.

A couple things we knew coming into this. This is pretty much a known design.

Yes?

MEMBER STETKAR: Before you launch into this slide --

MR. CIOCCO: Okay.

MEMBER STETKAR: -- my neurons are

firing really slow this morning. They've submitted five topical reports. Is that the full set of topicals that they plan, or are there plans for topicals in other areas? Do you know?

MR. CIOCCO: I don't know of any additional interest in submitting any other topical reports.

KHNP, do you?

PARTICIPANT: No, no.

MEMBER STETKAR: Okay.

MEMBER CORRADINI: So everything else --

MEMBER STETKAR: I was just trying to get a handle on topicals because that's --

MEMBER CORRADINI: Others -- okay.

MEMBER STETKAR: Thank you.

MR. CIOCCO: Yes. So, right. So that's the scope. The DCD, the technical reports and topical reports.

So as I was saying, as far as us building just a little bit of the background and building the 42-month schedule, this is a known design. We've been through two preapplication periods with them. We have the topical reports. The applicant made good progress on many of the

complex issues prior to submitting the application like on their GSI-191, some performance design testing that they did prior to submitting the application. We did some things internally as far as prioritizing the project, made sure that we had the staffing before we built.

And this kind of gets to where I'm at now. This is our six-phase review schedule completion dates. And these are the end dates. And if you look at the first -- the 42-month schedule is encompassed from when the application was tendered in March of 2015 through the end of Phase 6 here, which is September 2018. That's the 42-month schedule. And then on top of that we have the rulemaking which goes out beyond that because we have to issue the final Safety Evaluation Report.

So Phase 1, as I said, is completed. It was completed on schedule. That went from March of 2015 through February 2016. Phase 2, writing a Safety Evaluation Report with open items, is underway. And staff has -- and if you listen carefully, you can probably hear people putting pencil to paper upstairs right now as they're writing the safety evaluation, kind of music to my

ears. But they've actually delivered to me --

MEMBER CORRADINI: People actually pencil and paper?

(Laughter.)

MR. CIOCCO: Yes, we do. Yes.

MEMBER CORRADINI: Just checking.

MR. CIOCCO: As well as computers. But we have several sections already completed in Phase 2 and there are no open items. And that's really our goal was to do a really complete Phase 1 review, review the DCD in detail, review the technical reports and topical reports, identify any holes that you find there, put the pen to paper, write the preliminary safety evaluation and then write RAIs against that document. So we're really trying to front-end load the review to have as few open items as we can in Phase 2 of the review.

And then you can see the other Phase 3 -- and these will go along in parallel. These aren't in series. So --

MEMBER CORRADINI: Since you're into process --

MR. CIOCCO: Yes.

MEMBER CORRADINI: So to -- I won't use the words "speed things up." To be more

expeditious in your -- do you meet more with the KHNP folks face-to-face to essentially clarify issues and then document the clarifications appropriately, or is it more back and forth? I'm trying to understand --

MR. CIOCCO: It's both actually. I'll get to that. But it's really both. We try to use all of the best tools we have at our disposal in addition to obviously reading the documents. We write RAIs. We have public meetings. We average three to four public meetings per week. We do a lot of audits to look at the calculations behind the DCD. We have face-to-face public meetings. We have public teleconferences with KHNP.

So we try to implement all of the tools that the agency has to conduct a good licensing review. Because everything really needs to be at our disposal for us to meet a 42-month schedule. So we're really trying to implement all of the best practices that we have over all these years of doing these big design certification reviews.

CHAIRMAN BALLINGER: So I look at this and I see ACRS in two places. And I did the math.

MR. CIOCCO: Yes.

CHAIRMAN BALLINGER: Seven months to

review the SER with open items and six months to review the FSER with no open items based on that time schedule.

MR. CIOCCO: Yes. Yes, so we've been working with your staff as far as when we can start coming down with -- since these phases run in parallel, Phase 2 is a completion date of November 16th, however, we're going to start producing chapters of the safety evaluation in advance of that date so we can start meeting with the subcommittees and the full committees prior to the completion date of the overall Phase 3 of June 20 next year.

So our goal is to present to the subcommittees and the full committees all of our 19 chapters plus the three additionals in 19.3, 4 and 5 to the ACRS subcommittees and the full committees before that June 20th date. Phases 3 and 5 aren't necessarily critical path. Finishing Phase 6 ultimately is the goal, writing the Final Safety Evaluation Report.

And I mean, you have your job to do under 52.53. We understand that. But we had to look at the -- we had to build a schedule based on 42-month, and it's a non-trivial exercise looking

at the resources of the staff, looking at prior reviews and how much time it takes to do a six-phase review, how much time to put in Phase 1, Phase 2, Phase 3, Phase 4, 5 and 6, and several iterations with our staff and management to kind of come up with what we thought was the best fit at the time to do 42 months from March of 2015 through September of 2018.

But you're right, Dr. Ballinger, there is -- we do have the time allotted for Phase 3 and Phase 5, and we want to work closely with Chris and staff to get those chapters scheduled.

MEMBER SKILLMAN: Jeff, let me ask this: What discipline is provided to make sure that when the staff is requesting additional information that that need really exists and that the staff is just not exercising KHNP?

MR. CIOCCO: Right. Well, we follow -- I mean, the office -- the Agency has guidance as far as writing RAIs. Our Office of New Reactors has guidance to the staff. I mentioned awhile ago that we took a lot of steps before the application was submitted and doing a lot of reviews with the technical staff as to how to write a safety evaluation, you know, some of the best practices.

What are the best practices for writing an RAI?

And we made the guidance available. We had training for the staff. And a good RAI contains, first off, the regulatory basis. What's the reason that you need to ask the RAI? So whenever -- and we have generally four staff, including management, two management and two staff, reviewing each RAI before it gets issued.

Number one, is there a good regulatory basis for asking the question? What is the acceptance criteria that the staff needs to make a finding on that is the basis for asking the question? And then what is the question that's being asked? So we have the guidance. We have training for the staff, we exercise due diligence and we have the checks as the approvals before it goes out to the applicant.

And, I mean, we've got a lot of positive feedback from the applicant that the value of the RAIs -- they go out draft to the applicant before they become final and the feedback is that they're very good questions. And some they can answer in 30 days that we ask and some take a little bit longer because of technical analysis. But we make sure that we have the checks and

balances in place to make sure that we're not asking trivial RAIs.

MEMBER SKILLMAN: Okay. Thank you, Jeff.

MR. CIOCCO: Yes, you're welcome.

And then, so those are six phases in the rulemaking including the environmental assessment.

So this is kind of where we're at. My next slide. I just have two more slides. One is the -- Phase 1 is completed. Phase 2 review is in its 10th month, because right out of Phase 1 we had some sections that were done within three or four months. They wrote a preliminary Safety Evaluation Report. Some had an RAI; some didn't. As soon as they were done, we jumped right in and we started a Phase 2 review right away. So that's why it's in its 10th month. These reviews are going along in parallel.

The environmental review is underway. We have to write an environmental assessment. The majority of this is the SAMDA, the Severe Accident Mitigation Design Alternatives. That's included in the NEPA documentation. RAIs are being issued, responded to, evaluated and dispositioned as we

speak. This has been going on since we started the review.

As I mentioned earlier to a question, we are utilizing public meetings, audits, inspections in the review process as a means to review as much information behind the DCD and stuff that staff needs to make its findings. All these tools are being implemented as part of our review.

And then finally just in summary, the Phase 2 safety evaluations with open items and associated topical report. Safety evaluations will be -- they're currently underway. They're being written and they will be presented to the ACRS in Phase 3 of the review process, the Subcommittee and Full Committee.

So that's the conclusion of my just kind of contents. What are we doing? This is what we're doing. Thank you very much.

CHAIRMAN BALLINGER: Questions?

(No audible response.)

CHAIRMAN BALLINGER: Thank you.

MR. CIOCCO: Thank you.

CHAIRMAN BALLINGER: We're now back on schedule.

DR. LEE: Good morning. My name is

Jaeyong Lee, the project manager. I am very pleased to share the work with you. I present a brief overview of the APR1400 design certification project. More details will be present by our experts after my presentation.

After general introduction to the status of nuclear power generation in Korea I briefly go over the history. Then I present the design features and the general arrangement of the APR1400. After that I'll talk briefly about the design review status. Finally, I conclude my presentation.

First, brief, currently there are 24 nuclear power plants operating nationwide in Korea. There are four major sites. One on the west coast and three on the east coast. On the west coast it's a Hanbit power station, which six plants are in operation. Hanul and Wolsong and Kori sites are on the east coast. There are 18 plants in operation. Typically APR1400, four units are under construction and four units are in the planning at Kori and Hanul sites.

By the way, I am from this city, Daejeon.

(Laughter.)

MEMBER CORRADINI: All are PWRs, or which are can dos?

DR. LEE: The Wolsong site we have four units of can dos.

MEMBER CORRADINI: Oh, I see. I'm sorry. I missed that. Excuse me.

MEMBER RICCARDELLA: What percentage of the generation in Korea is from these nuclear plants?

DR. LEE: There are around 40 percent of electricity came from the nuclear.

MEMBER RICCARDELLA: Thank you.

DR. LEE: This figure shows the project organization structure of our project. KEPCO. KEPCO is the mother company of all participating companies except Doosan and overseas consult companies. KEPCO and KHNP are co-applicant for this design certification, but all the work related to this practice managed by KHNP. KEPCO Nuclear Fuel is the fuel vendor and KEPCO Engineering and Construction Company, they are the design company for this NSSS design and BOP design. And Doosan Heavy Industries, they are the major equipment vendor. And many foreign engineering companies, including Westinghouse Electric Company and AECOM,

participating in this project as consultant to KHNP.

Korea --

MEMBER CORRADINI: Consultants? General consultants or for fuels?

DR. LEE: Both way, the general and the specific area. And Korea Atomic Energy Research Institute, KAERI, they perform the thermal hydraulic test for our project.

This project was initiated early in 2009 through the submission of a letter of intent to the U.S. NRC. From 2010 to 2014 KHNP performed total 18 preapplication meetings with the NRC staff to discuss details and this just -- in late December KHNP submitted design certification application to the NRC. Two months later, as Jeff said, we received a letter from the NRC notifying us of successful docketing. Since then KHNP has successfully responded to RAIs, and Phase 1 review was completed in January this year. This figure shows the docketing.

Next I share some of the design features and general arrangements of APR1400.

Originally the development of the APR1400 began in 1992. We reached licensing

agreement between KHNP and ABB-CE, which is now merged into Westinghouse. KHNP, the Korean design company, has been developing the OPR1000 based on the Palo Verde Unit 2 NSSS design and ANO 2 core design. KHNP incorporated the advanced safety features into improve the OPR1000. Finally APR1400 was born by incorporating more advanced design features and several design features and applying for the latest code and standard to meet these EPRI URD.

MEMBER REMPE: Excuse me.

DR. LEE: Yes?

MEMBER REMPE: As part of the transfer from -- through this licensing agreement with ABB-CE, could you talk a little bit about how much was transferred? For example, the severe accident management guidelines and the emergency operating procedures, was that part of the transfer?

DR. LEE: Yes, I think so. The -- most of NSSS design technology was transferred to KHNP, including the design company in Korea.

MEMBER REMPE: Okay. Thank you.

DR. LEE: The reference plant of APR1400 are Shin Kori Units 3 and 4. The Shin Kori Unit 3 is scheduled to go into commercial operation

around the middle of this year. And the same type of reactors are being built in Barakah, UAE. And as I mentioned earlier, six more plants, six more units of the APR1400 are under construction or planning in Korea.

MEMBER CORRADINI: So I have a question. What's the black symbol on top of the containment? The black thing. Looks like a bird.

(Laughter.)

CHAIRMAN BALLINGER: It's not a shadow, that's for sure.

MEMBER CORRADINI: Since I was on the site I never asked that question, so since I'm curious --

DR. LEE: I don't know.

(Laughter.)

CHAIRMAN BALLINGER: It's a really big bird casting his shadow, if it's anything else.

DR. OH: You know, for Kori site I think it's a --

CHAIRMAN BALLINGER: A sea gull.

DR. OH: The Kori site is including Doosan, so the one represented the bird that they are -- or that sea gull. So it's represented a sea gull, a big sea gull.

MEMBER CORRADINI: Curious.

MEMBER REMPE: After that important question, I have another question.

(Laughter.)

MEMBER REMPE: Some of the documents that we've reviewed or we're reviewing now for the DCD will talk about the APR1400 being essentially in the design stage, yet this view graph says it's an essentially complete design. It's under construction.

DR. LEE: Right.

MEMBER REMPE: How should we interpret those type of comments? Was it because of the -- when the documents were issued -- it's a complete design, so when I read that, I'm wondering what I'm reading.

MR. SISK: This is Rob Sisk from Westinghouse. Maybe I can help through. It really is a complete design in that they have built -- Shin Kori 3 is getting ready to --

MEMBER REMPE: Right.

MR. SISK: -- line in. But recognize that in the U.S. there are differences that have to be addressed, both in terms of the regulations and in terms of the timing. So it is -- there are

things in the APR1400 that is being addressed specifically to meet U.S. requirements, NRC requirements. So from that aspect there are design features that have to be addressed to support --

(Simultaneous speaking.)

MEMBER REMPE: So this is a certified design for the U.S. plant -- to meet U.S. requirements when we finally -- when the NRC gives it a design certification?

MR. SISK: That is correct.

MEMBER REMPE: Okay.

MR. SISK: This will be -- this is being presented as a Part 52 certification for --

MEMBER REMPE: Well, I understand that, but I just was curious because I thought --

MR. SISK: -- for application.

MEMBER REMPE: Okay.

MEMBER CORRADINI: So not that we need to care, but I'm still curious. So is Shin Kori 3 and 4 identical. Is Barakah identical to Shin Kori 3 and 4 or is Barakah closer to what's being presented here?

DR. LEE: Yes. It's almost identical, yes.

MEMBER CORRADINI: To which?

DR. LEE: Shin Kori 3 and 4 and the Barakah 1 and 2 is -- so almost I think represented as the Shin Kori 3 and --

MEMBER CORRADINI: Okay.

DR. LEE: -- 4. And basically the -- this design, the Shin Kori 3 and 4 design was finalized in the time frame of 2002.

MEMBER REMPE: Right.

DR. LEE: And now we have more than 10 years to get -- between that and now and we need to apply those new code and standard for this --

MEMBER REMPE: We see that with other plants in the U.S. and I just -- because this whole design certification process is a little difficult at times because things change.

It would be good as we go through this design certification to point out some of the differences between the Barakah and the Shin Kori 3 and 4 and then what's occurring here, if we could have that perspective.

MR. SISK: Yes, again Rob Sisk, Westinghouse, the consultant to KHNP. Dr. Lee brings a very good point. Recognizing that the design has gone on, one of the things I know the staff and the ACRS is very familiar with is things

like AIA.

MEMBER REMPE: Yes.

MR. SISK: That became very important here. At Fukushima this comes --

(Simultaneous speaking.)

MEMBER REMPE: Absolutely.

MR. SISK: Those have to be incorporated into the design. A lot of effort is going into not just being a stagnant design in Korea or in Barakah, but to incorporate the operating experience and lessons learned to the design.

I think where there are some unique differences and changes you'll hear some of that through the discussions.

MEMBER REMPE: Yes.

MR. SISK: So --

MEMBER REMPE: It's a problem with the design certification process when you -- it changes --

(Laughter.)

MEMBER REMPE: I'll leave at that.

MR. SISK: It typically is. I've been involved in the earlier ones.

MEMBER REMPE: Yes.

MR. SISK: And one of the nice things about this we hear a little bit in the --

(Simultaneous speaking.)

MEMBER CORRADINI: So I guess the only thing is to me this is a natural evolution. So you're going to have the Chevrolet appearing in various countries. You'd expect the -- sometimes it's right-hand drive; sometimes it's left-hand drive. It's interesting, but --

MR. SISK: Well, the reality is internationally; and I think we could say generally, all the regulators have unique regulatory requirements and needs. APR1400 DCA is designed to meet the U.S. requirements. But recognize we have -- I say "we" on behalf of KHNP and KEPCO -- have the benefit of a constructed plant. And that really I think is something that might be a little bit unique from what we've seen in the past --

CHAIRMAN BALLINGER: But there's really no point in getting us confused --

MEMBER STETKAR: Right. That's right.

CHAIRMAN BALLINGER: -- between the two.

MEMBER STETKAR: When we review the --

CHAIRMAN BALLINGER: Because we confuse ourselves all by ourselves enough.

MEMBER STETKAR: When we review the EPR, there are differences between what was submitted for the U.S. EPR compared to what somebody may eventually build somewhere in Europe. But those are irrelevant. And asking questions about why the differences is also irrelevant because what we're reviewing is what is presented to us, stand-alone on its own merits. So that's -- if it's insufficiently documented then we ask questions. But differences --

MEMBER BLEY: Why don't we all agree to that and move on? I want to advise you of something that will be of interest later, probably not in this week's presentations.

You started with a U.S. design and you moved it over there. You probably made changes especially with regard to the control room and procedures. Now you've brought that together for operators in Korea and now we're bringing the design back to the U.S. And I'll be real interested in things you're doing with regard to the control room and with regard to emergency procedures for operators to account for differences

in practice and even culture between the countries. Westinghouse has some experience in this area in a different design. And when we get to those areas, be real interested in hearing how that translation went from the U.S. to Korea, and especially how it's going from Korea to the U.S. and what things you have to do to adapt this to our practices in operations.

DR. LEE: Okay. Thank you.

Okay. So design life time of major equipment of the APR1400 on this 60 years. And the power is 4,000 megawatt. And electric power is 1,400 megawatt. And primary and secondary operating conditions are the same as those of System 80+, but the primary temperature of the plant is equal to 615 Fahrenheit in the steam generator tubes.

The APR1400 for DC deviates from its reference plant in several points such as the ultimate heat sink, single unit area and so on. But in the design change KHNP changed the design of the different plants to take advantage of proven operating plants and their performance.

One thing I want to highlight is the effective date of applied code and standard. The

code docketing date of APR1400 is August 2014, which is six months before the target docketing date.

One of the strongest point of the APR1400 is the coping capability of the station blackout by applying the longer battery time and FLEX implementation. Furthermore, the tolerance to external damages has been improved. It was proved that the APR1400 having improved tolerance for the AIA, loss of large area and physical security analysis.

I'm happy to tell you that the APR1400 is very sturdy for the safety issues such as GSI-191, experimental studies of LOCA generated debris accumulation and head loss with emphasis on the health effect. It has diverse reactor protection systems for common cause failures.

CHAIRMAN BALLINGER: When you say "FLEX," do you mean the on-site FLEX equipment that they have in the U.S., or do you mean the complete FLEX process where you have off-site equipment that's available for transport to on-site? So when you say "FLEX," what do you mean when you say "FLEX implementation?"

(Simultaneous speaking.)

DR. OH: In terms of FLEX implementation for -- we just develop some strategy for the beyond--the-design-basis external event. And some of -- as you know, there's on-site resources and off-site resources. Off-site resources and a DC application don't consider that extant. But the only on-site equipment --

CHAIRMAN BALLINGER: Okay.

DR. OH: -- we considered that. In order to accommodate some of on-site equipment, we have some design for connections for our design. That means in a FLEX implementation.

CHAIRMAN BALLINGER: Okay. So it's sort of --

DR. OH: The design --

(Simultaneous speaking.)

CHAIRMAN BALLINGER: -- FLEX-like?

DR. OH: Right.

MEMBER STETKAR: No, it's -- they have an 8-hour Phase 1 FLEX coping strategy and 8 to 72 hours using on-site equipment. I don't want to call them portable, but it's very similar to stuff. And after 72 hours you fly stuff in.

DR. LEE: Okay. Even though the APR1400 design is based on System 80+ design, there

are several differences. Firstly, the containment shape is different. System 80+ has a spherical steel containment, but APR1400 has a cylindrical shape, the pre-stressed concrete containment. And the summary parts are a bit different.

And regarding safety injection systems, APR1400 has three DVIs in the safety injection tank, which is one of the passive device to control the SI flow. And as I mention before, the hot leg temperature is down to 621 to 615. And RCS overpressure protection system of the APR1400 consists of four POSRV, but the System 80+ has four PSVs and two SDS. The APR1400 adapt integrated head assemblies for the reactor vessel head and this upper structure comparing to conventional head of System 80+. And to minimize the -- and mitigate the severe accidents. We adapt the in-vessel retention and the special cooling systems in the APR1400 in addition to the cavity flooding systems.

MEMBER CORRADINI: Can you repeat that again, please, for the severe accident?

DR. LEE: Yes. For the severe accident in order to mitigate those severe accident, we adapt this IVR, in-vessel retention, and install core cooling systems into this CFS and PAR.

MEMBER CORRADINI: Okay. Thank you.

MEMBER REMPE: Actually in the documentation for Section 19 it mentions that it's not taken -- this cavity flooding system is not taking credit for in the PRA, but I was curious, does that mean that you don't include that in your PRA, like inadvertent -- I mean, is the whole system missing from the PRA?

DR. OH: I think the cavity flooding system is we take into account for the PRA, but IVR/ERVC we don't give it -- give some credit for the -- in a PRA.

MEMBER REMPE: So the system is included in the plant PRA --

DR. OH: Right.

MEMBER REMPE: -- but it's just you don't take credit for the --

(Simultaneous speaking.)

DR. OH: Yes.

MEMBER REMPE: That's good. Okay. Thank you.

DR. LEE: And this picture shows the bird's eye view of APR1400. The containment building is the in front of auxiliary building and divide in four quadrants. And there is a compound

building, but it's to the other building.

And this drawing shows the main reactor cooling group. And the schematics are the same as those of System 80+ except for the -- this overpressure protection system on top of the pressurizer.

This drawing shows the quadrant array of the auxiliary buildings which house the containment building.

Now I'm going to show you the review status of the APR1400 design certification so far.

This table shows the review schedule for the APR1400 design certification. As you saw already, the Phase 1 review was complete in January this year. Now we are in Phase 2 -- which was stated -- which we hope to complete by November this year. And Phase 3, ACRS review is scheduled for June 2017. If we keep up with all the review phase well, then the final SER will be issued in September of 2018. As the PM of this project I do my best to keep this project on track.

KHNP has a lot of interactions with the NRC staff to effectively respond to RAIs. We have five biweekly conference calls. The topics are project managing, PRA, Chapter 3, Chapter 15,

recently Chapter 9. Those kind of conference calls, as foreign engineers we feel a big burden. And that verifies and confirms our extended design certification either by face-to-face or electric reading room audits. And also we have had QA inspections twice for GSI-191 issue and computer codes.

From the GSI-191 inspections in 2014 there are four findings for closing. KHNP collect and responded to the findings and all findings were closing of 2015. And just four observations were raised from the computer code inspection held in early March this year. We are correcting those observations using the correctable action plant process.

Finally, I summarize and conclude my presentation. The APR1400 adopted proven technologies from the operating experience of the OPR1000 and construction experience with the reference plants. The APR1400 used most of safety analysis code and methodologies of the certified System 80+. The APR1400 standard design approval was issued by Korean regulatory body in 2002. And my last comment is that the APR1400 is an essentially complete design.

Thank you very much for your attention. And any comment or questions would be appreciated.

CHAIRMAN BALLINGER: Okay. We're actually half an hour ahead of schedule by my thing, so we should probably just move on and --

MR. SISK: If we can just get a few minutes to change out the presentation and --

(Simultaneous speaking.)

CHAIRMAN BALLINGER: Sure.

(Pause.)

CHAIRMAN BALLINGER: Okay. We're ready to go?

MR. RO: Okay.

CHAIRMAN BALLINGER: Proceed. Thank you.

MR. RO: Okay. Good morning. My name is Taesun Ro working for KSNP. It's my great honor to present my topic on the APR1400 NSSS design.

First, I will talk about the design overview of the NSSS systems. Then I will talk about the -- briefly major NSSS systems such as reactor coolant system, safety injection system and so on. Then I will explain more detail about the unique design features adopted in the APR1400. Those safety injection tank with fluidic device and

pressurizer pilot-operated safety relief valve. I will spend some time on these design features later. And finally, I will summarize my presentation.

First, design overview. NSSS design of APR1400 is identical to that of Shin Kori Unit 3 in Korea recently under the power ascension tests. It is similar to the System 80+ certified design except for unique design features as explained by Dr. Lee. And it is consistent with the regulations of the United States of America and it adopts the industry codes and standards applicable in the United States.

Regulatory basis. APR1400 complies with the NRC regulation documents such as the Code of Federal Regulation, Regulatory Guides and so on. It complies with the rules and regulations in effect as of September 2014 of the United States.

Major NSSS systems. The RCS, the reactor coolant system is arranged as two loops with a reactor vessel, two steam generators, four reactor coolant pumps and pressurizer.

This is the RCS schematic diagram. It's already explained. The reactor is composed of the reactor vessel: reactor internals, including

the upper guide structure assembly and the core support barrel assembly; and the reactor core, including the fuel assembly and control element assembly.

Reactor coolant pump is a motor-driven, single-stage centrifugal pump. The pump takes suction from the bottom and discharge through radially. The flexible coupling is provide the connect the pump shaft with the motor. The pump flywheel is towards to increase the rotating inertia of the pump, provide sufficient coastdown flow following loss of power to the pumps. RCP shaft seal system has three-stage mechanical seals. This is cooled by seal injection water and high-pressure water cooler.

MEMBER SKILLMAN: Sir, please back up two slides.

MR. RO: Okay.

MEMBER SKILLMAN: On this slide where have these internals been used before?

MR. RO: These internals is to -- used for to guide the flow paths, or it's -- and it also used for the support the fuel assembly and so on.

MEMBER SKILLMAN: Okay. Thank you. Has this design of internals been used anywhere

else?

MR. RO: Yes, I explain we use this design for the Shin Kori Unit 3 and 4, but that's almost the same design concept is used for the OPR1000, as Dr. Lee mentioned.

MEMBER SKILLMAN: Same diameter? Same material --

(Simultaneous speaking.)

MR. RO: Oh, it's a different.

MEMBER SKILLMAN: Oh, different?

MR. RO: Yes.

MEMBER SKILLMAN: Okay. Oh, so has this exact design been used before?

MR. RO: As far as the Shin Kori Units 3 and 4 the geometry is the same, but the OPR1000 is different.

MEMBER SKILLMAN: Okay. Geometry is the same. That means the same material thicknesses, the same section thicknesses, the same lengths of ligaments, the same support system from the ledge of the reactor vessel?

MR. RO: As far as I know is all same, but I think it's better to check with my expert --

(Simultaneous speaking.)

MEMBER SKILLMAN: I think that would be

a good idea.

MR. RO: -- designs.

CHAIRMAN BALLINGER: I should remind, if you think that any question that we ask you has to do -- would result in you having to disclose proprietary information, you have to let us know --

MR. RO: Okay.

CHAIRMAN BALLINGER: -- so that we can delay that to further time.

MR. RO: Yes. But all my materials include -- does not include any non -- proprietary information.

MEMBER SKILLMAN: Yes, I would like that question to stand. The question is where have these internals been used before? The gentleman basically communicated these are identical and have been used before. And I would like to know that that is accurate. Do you understand what I'm asking?

MR. RO: Yes, sir.

CHAIRMAN BALLINGER: Thank you.

MEMBER REMPE: Well, Dick, I think he said that the geometry is different than the OPR1000, but it's identical to Shin Kori 3 and 4, which is under construction, but he wanted to

check. So I think it's a little different than what you characterized the response.

And so, the materials as well as the geometry differences would be of interest, please.

MR. RO: Okay. I will check --

MEMBER REMPE: Thank you.

MR. RO: -- if there's any difference between the Shin Kori 3 and 4 and the APR1400.

MEMBER SKILLMAN: Thank you. Oh, let's go to the reactor coolant pump.

MR. RO: Okay.

MEMBER SKILLMAN: Three-stage seal.

MR. RO: Yes.

MEMBER SKILLMAN: Is this seal in use today?

MR. RO: Yes, it's the same seals used in the single seal pump.

MEMBER SKILLMAN: So are there any changes to the materials of construction or to the seal face design?

MR. RO: So, any changes?

PARTICIPANT: No, we didn't --

(Simultaneous speaking.)

MR. RO: No, I don't think that we change any design for the seal.

MEMBER SKILLMAN: Same reactor flywheel, same pump flywheel, same design, same material?

MR. RO: Same design, yes.

MEMBER SKILLMAN: Okay. Thank you.

MR. RO: The pressurizer provides the RCS pressure and volume control. It has sufficient capacity to accommodate pressure and volume changes due to operational transients without opening the safety valves. There are four pilot-operated safety relief valves on the top of the pressurizer. The POSRV provides the overpressure protection and manual rapid depressurization of RCS to initiate feed-and-bleed operation in the total loss of feedwater event.

Steam generator is a vertical U-tube recirculation type heat exchanger.

MEMBER STETKAR: Your pressurizer does not have simple spring-loaded safety valves, right? They're all pilot-operated valves?

MR. RO: Right, all pilot-operated valves.

MEMBER BLEY: Excuse me. The gentleman running the computer over there, your papers are hitting the microphone. Thank you.

MR. RO: And tube material is alloy 690. And this material is highly resistant to the primary water stress corrosion cracking. An integral economizer is employed on the cold leg side of heat exchanger to enhance thermal effectiveness. Flow restricter is installed at the steam generator outlet nozzles to limit the steam flow in the unlikely event of a main steam line break.

MEMBER REMPE: Excuse me, Dr. Ro. On the steam generator I'd like to ask a question similar to what my colleague Mr. Skillman asked. Is the length of this steam generator -- is the size of it similar to what's being installed in Shin Kori 3 and 4? And is it larger than what was installed in the OPR1000, or is it the same?

MR. RO: It's the same. It's larger than the steam generator of the OPR1000, but --

MEMBER REMPE: Okay.

MR. RO: -- as far as the Shin Kori 3 and 4 is concerned, it's the same size.

MEMBER REMPE: And we'll be discussing later some of the testing done to support the Shin Kori 3 and 4, I hope, on the steam generator.

MEMBER CORRADINI: I think the

colleagues are asking about lessons learned, so I guess the closest thermal power plant is Palo Verde. So to me that would be my question. I guess I'd ask a link to an operating plant that's in the country, which I think is closest to Palo Verde in terms of thermal power. So that's, I guess, the logical connection.

MEMBER REMPE: Right, but it's higher in thermal power, so I assume it's bigger than what's at Palo Verde.

MEMBER CORRADINI: By only 87 megawatts.

MR. RO: It's bigger than the steam generator of the Palo Verde.

MEMBER CORRADINI: Yes, but Palo Verde is 3,913, right?

MR. RO: Thirty-nine thirteen --

(Simultaneous speaking.)

MEMBER CORRADINI: And this is 4,000.

MR. RO: This is 4,000, right.

MEMBER REMPE: But he said the steam generator is bigger than Palo Verde, though, too.

MEMBER CORRADINI: Yes, OCR is --

MEMBER REMPE: No, I believe he said -- is it bigger or the same size as Palo Verde?

MR. RO: It's bigger than the steam generator at Palo Verde.

MEMBER CORRADINI: Ah.

MR. RO: It's bigger than the -- naturally bigger than the OPR1000 steam generator.

MEMBER CORRADINI: Okay.

MR. RO: Yes.

MEMBER REMPE: Yes, thank you.

CHAIRMAN BALLINGER: But T-HOT is 615 Fahrenheit --

MR. RO: Yes.

CHAIRMAN BALLINGER: -- versus 621. Is that what -- I think that's Palo Verde is.

MR. RO: Right. Yes.

CHAIRMAN BALLINGER: And so the generator had to be a little bigger. And why did you choose 615? Is that the URD thing from --

(Simultaneous speaking.)

MR. RO: Yes, URD requires the lower temperature than 621, but we cannot meet the URD requirements, though, because the -- it cause very -- had low efficiency in the carbon relationship because the low pressure of the steam generator. So we compromise the -- regarding the temperature. And because the 690 is quite good at the stress

corrosion cracking, so we don't think we have to reduce the temperature much.

CHAIRMAN BALLINGER: Yes, URD was 605, right?

MR. RO: Yes, right.

CHAIRMAN BALLINGER: Yes.

MR. RO: URDs are usually primary stocking.

Okay. Then next is safety injection system. The main functions of the safety injection system is to provide emergency core cooling and reactivity and inventory control. SIS also supplies the safety injection flow for feed-and-bleed operation. SIS consists of four mechanically and electrically separate trains. The borate water from the in-containment refueling water storage tank is injected directly to the reactor vessel.

MEMBER CORRADINI: Since we've been -- we were discussing similar things yesterday, the SIT is a word for -- is similar to the accumulators?

MR. RO: Yes. I will explain later.

MEMBER CORRADINI: Okay. And then eventually probably in closed session I'd be curious about the actuation pressure. In closed

session.

MR. RO: Okay.

MEMBER CORRADINI: And one last question. The in-vessel refueling water storage tank is literally around the whole outside of the containment?

MR. RO: Right.

MEMBER CORRADINI: Interesting.

MR. RO: Is anyone to -- safety injection tank is inside containment.

MEMBER CORRADINI: Yes, I know that.

MR. RO: But I --

MEMBER CORRADINI: We can wait later.

MR. RO: Okay.

MEMBER CORRADINI: I just wanted to make sure that SIT is the same thing in other vernacular as an accumulator.

MR. RO: Yes.

MEMBER CORRADINI: Okay. Thank you.

MR. RO: This slide shows the SIS flow diagram. As I said, the SIS is composed of four separate trains and each train contains one safety injection tank with a fluidic device, safety injection pump, valves and connecting pipes. The pump takes suction from the IRWST and is sucked to

the reactor vessel through DVI nozzle.

Shutdown cooling system function is to remove decay heat and residual heat in the RCS. The shutdown cooling system consists of two mechanically and electrically separated trains. Shutdown cooling pump is interchangeable with containment spray pump. SCS suction line relief valves provide RCS low temperature overpressure protection.

This slide shows the SCS flow diagram. As mentioned, the SCS is composed of two separate trains identical and each train has the shutdown cooling pump, mini-flow exchanger, shutdown cooling heat exchanger, valves and pipes. Shutdown cooling flow comes from the hot leg and returns to the reactor vessel through DVI nozzle. Those valves are the SCS suction line relief valves for RCS low temperature overpressure protection.

Chemical and volume control system. The major functions of chemical and volume control system is to provide RCS inventory control, chemistry control and reactivity control. In addition, CVCS provides auxiliary spray to the pressurizer and seal injection to the RCPs.

This slide shows the CVCS flow diagram.

The letdown flow from RCS heads through the regenerated heat exchanger and letdown heat exchanger. Then the temperature, letdown temperature drops to the operating temperature of the purification system. Then the letdown flow passes through the letdown orifices and letdown control valves. Then the pressure is also reduced to the operating pressure of the purification system. Then the letdown flow passes through the filters and ion exchanger and enters to the volume control tank.

The charging pump normally takes the suction from the volume control tank and discharge to the reactor coolant system through charging nozzle. A portion of the charging flow is diverted to the RCPs or seal injection. When all the centrifugal charging pumps are not available and not operable, then auxiliary charging pump is used for seal injection.

Unit design features. Safety injection tank with a fluidic device is an accumulation tank with a passive device that provides inherent reliability without the need for any active components. It controls the injection flow rates during refill and re-flood phases in the event of

large break LOCA, and thus it ensures effective use of SIT water during LBLOCA.

The fluidic device is installed at the bottom part of the SIT. And fluidic device has a supply port at the center and four control ports around the supply port. Supply port is connected to a stand pipe.

I brought the fluidic device scaled down model. Let's take a look at --

MEMBER REMPE: Watch it on top.

MR. RO: It's a little bit heavy.

(Laughter.)

MEMBER REMPE: Okay.

MR. RO: Typical flow pattern inside the vortex chamber is shown in these figures. The vortex chamber is lower part of the fluidic device. The SIT water enters through the supply port, flows into the vortex chamber through the supply nozzles. There are four supply nozzles in the fluidic device. The SIT water enter through the four control ports, flows into vortex chamber directly through the control nozzles. When the SIT water is only injected through the control nozzles, then the water is injected tangentially, so it establishing a strong swirling flow. That cause -- the resistance

in the vortex chamber is high.

That means we have a small flow rate during -- when the SIT water is only injected through the control nozzles. However, when the SIT water is delivered through both supply nozzles and control nozzles, then the flow from the supply nozzle and the flow from the control nozzle collide each other. That results in no minimal swirling flow. That cause reduce the resistance. That means we have -- we're going to have the large flow rate.

First full-scale test was performed by the Korea Atomic Energy Research Institute in Korea. And this figures shows the full-scale test facility located at the Korea Atomic Energy Research Institute. A series of tests were performed to evaluate and verify the performance of SIT with fluidic device. Results show that the repeatability was confirmed and pressure loss coefficient is not much affected by initial pressure and manufacturing tolerances. And the design requirements including the pressure loss coefficient are met for both large and small flow injections. The design requirements were determined based on the various large break LOCA analysis, and the results -- the details will be explained tomorrow's session

relate to the safety analysis.

Topical report for fluidic device design has been submitted on January 2013. As mentioned, advanced TR safety evaluation was issued last week.

Next is the pilot-operated safety relief valve.

MEMBER RICCARDELLA: Excuse me for a second. Did the OPR1000 have this fluidic device?

MR. RO: No.

MEMBER RICCARDELLA: It didn't? So it's brand new with the APR1400?

MR. RO: Yes, brand new for APR1400.

MEMBER RICCARDELLA: Thank you.

MEMBER CORRADINI: So this is a unique feature only to this? Only to this design? APR1400. Excuse me.

MR. RO: Yes. Yes, it's --

MEMBER CORRADINI: So Shin Kori has it also?

MR. RO: Right, Shin Kori.

MEMBER CORRADINI: So maybe just to be clear, the testing for the SIT was done in support of Shin Kori?

MR. RO: Right.

MEMBER CORRADINI: Okay.

MR. RO: Yes.

MEMBER CORRADINI: That's what I was guessing. Okay. Thank you.

MR. RO: So all the test results are included in this topical report.

MEMBER CORRADINI: Sure. Okay. Thank you.

MR. RO: The pilot-operated safety relief valve has high seat tightness, low possibility of chattering and is reliable for steam, water and two-phase discharge. However, the installation and the maintenance are a little bit complicated. The POSRV provides the overpressure protection by automatic actuation of spring-loaded pilot valves and rapid depressurization by manual actuation of motor-operated pilot valve.

This figure shows the POSRV assembly. The PSORV assembly is composed one main valve and two spring-loaded pilot valves and two motor-operated pilot valves. The spring-loaded pilot valve is actuated automatically for overpressure protection when the RCS pressure exceeds the opening set pressure. And spring-loaded pilot valve includes one motor-operated isolation valve and one manual isolation valve. Motor-operated pilot valves

are actuated manually for rapid depressurization. Two valves are installed in series. Those are normally closed and power removed.

CHAIRMAN BALLINGER: I assume that this arrangement gets rid of the set point drift problem that these valves have had in the past?

MR. RO: Yes, we have some set point drift problem for the PSV.

CHAIRMAN BALLINGER: Yes.

MR. RO: So instead of using the PSV we adopt the pilot-operated safety lift valve to -- so we think that this POSRV is better for the drifting or the tightness.

CHAIRMAN BALLINGER: Okay.

MR. RO: Okay. In summary, APR1400 NSSS design complies with -- we think complies with the U.S. NRC regulatory requirements. And the SIT with fluidic device is an innovative design which ensures effective use of SIT water. And the SIT with fluidic device was verified in full-scale test facility, as I've shown before, as well as the pre-operational test of Shin Kori Unit 3 that was done last -- or the two months -- two years ago. So we confirm that the fluidic device perform correctly. The POSRV provides dual functions of overpressure

protection and rapid depressurization.

Okay. Thank you for your attention.

CHAIRMAN BALLINGER: Thank you.

MEMBER BROWN: I have a question. Is that okay, Ron?

CHAIRMAN BALLINGER: Sure.

MEMBER BROWN: Back on the -- oh, on the POSRV's rapid depressurization, how many are required to achieve -- you've got four installed. How many are required to get the rapid depressurization required for the injection systems and all the rest of the safety systems? All four of them or just two of them, or what?

MR. RO: That depends on the scenario that we can --

MEMBER BROWN: Worst case scenario --

MR. RO: Worst case --

MEMBER BROWN: -- you need rapid, rapid depressurization. How many valves do you need to operate?

MR. RO: So -- okay.

MEMBER BROWN: Is my question clear?

MR. RO: Yes.

MEMBER BROWN: Okay.

MR. RO: Okay. I understand your

question but --

MEMBER BROWN: Okay. I just wanted to make sure.

MR. RO: I'm remember how many --

MEMBER BROWN: I'm an electrical guy, not a mechanical one.

MR. RO: -- valves are used for some specific scenario --

MEMBER BROWN: Okay.

MR. RO: -- but I think someone can help us. Dr. Oh, can you help us?

DR. OH: Yes, this is Andy Oh from KHNP Westinghouse Office. And as far as I know, the POSRV is approved, but in terms of the successful feed-and-bleed we need require the two open for the POSRV. And also in addition for the SIT pumps we have four SIT pumps, but in two SIT pumps can succeedently from the feed-and-bleed based on our -- the EOP standard analysis.

MEMBER BROWN: So that means you need two --

DR. OH: Two.

MEMBER BROWN: -- to accomplish all the functions --

DR. OH: Right.

MEMBER BROWN: -- within your injections and other operations?

DR. OH: Right, sir.

MEMBER BROWN: Okay.

MEMBER SKILLMAN: I would like to build on that question, please. My memory is that under ASME Section 3 Class 1 your reactor coolant system boundary must be protected by spring valves. In other words, a standard valve with a spring. These are actually pilot-operated springs. So I'm wondering how in the United States this valve is acceptable under ASME Section 3. Can someone answer that question, please?

MEMBER STETKAR: In particular if those little manual valves are closed, the safety valve isn't going to open.

MEMBER SKILLMAN: On all of the pressurizers in the United States there are two springs --

(Simultaneous speaking.)

MEMBER SKILLMAN: Let me finish.

MR. RO: The PSORV has two -- dual function, as I explained. It can be opened by automatically and --

MEMBER SKILLMAN: This is a code

question.

MR. RO: Yes, your question is code question. Right.

MEMBER SKILLMAN: And so my question is why are these four valves acceptable in lieu of at least two spring code safeties?

MR. RO: Yes, as far as I know, I heard from my expert the pilot-operated safety valve meet the ASME Code requirements.

MEMBER SKILLMAN: Well, I will challenge that and would like to understand.

MR. RO: Okay. I will check with my expert regarding your question. And then I will convey our response sometime later.

MEMBER SKILLMAN: Yes, sir.

MR. RO: Okay?

MEMBER SKILLMAN: Thank you.

CHAIRMAN BALLINGER: I think in BWRs they are pilot-operated relief valves, spring-loaded pilot-operated relief valves.

MEMBER SKILLMAN: Well, I have a little bit of experience with this and I'm curious what the answer will be relative to the code. This is a code question.

CHAIRMAN BALLINGER: Any more questions?

MEMBER RAY: Yes, going back to slide 9, I guess I've been deliberating on something that appears there that I wanted to ask about.

It says the shaft seal system is cooled by seal injection water and high-pressure water cooler. And I'm trying to understand how it works. Will we be looking at that in some more detail in the future to understand how these two -- seal injection water, I understand that. High-pressure water cooler, I may understand that, but I'm not sure I understand the two of them taken together.

MR. RO: Yes, the seal injection water, it comes from the CVCS, the charging pump. So it's evident, apparent. But the high-pressure water cooler is a kind of heat exchanger. Does the clean water pass the secondary side to cool the seal injected, injected seal. So it's kind of the heat exchanger cooled by the water system.

MEMBER BLEY: Doesn't it cool the reactor coolant that's passing through the seal?

MR. RO: Would you say again?

MEMBER BLEY: Well --

MEMBER STETKAR: Harold, if you replace that "and" on that slide with an "or."

MEMBER RAY: Well, okay, John. You've

looked at this maybe, and that might solve my problem, but I do understand needing to cool leak-off before it becomes -- before it flashes, if we're talking about leak-off water. But I'm not sure why it's a high-pressure water cooler. And I do understand seal injection which normally inject cold water and the leak-off is already some cooled. You don't have to have a high-pressure cooler. So I'm trying to understand how this works. And more importantly, what the failure modes are.

MR. RO: Okay.

MR. SISK: Perhaps if I can, the purpose of today -- and I really appreciate these types of questions, but I do want to recognize because I think the question came up, we do intend to come back with the chapter reviews, with the technical reviews to go into more detail of everything you're hearing today. And so this is an opportunity, if you will, to present the general issues. Certainly we want to hear the questions and concerns, but as I guess we said earlier, we will be back. We will be able to provide you with more details on these --

(Simultaneous speaking.)

MEMBER RAY: Well, that's fine, Rob. I just -- because it was there and I kept thinking

about it and thinking about it, I couldn't figure out what does it mean? But you can answer later. That's fine.

MR. SISK: Well, but I do want to encourage the question, because we certainly benefit from that. We'll be better prepared for it at follow-up meeting so that you have the information you need.

MEMBER SKILLMAN: Since you've made that introduction or that invitation, let me ask one more. Comes from many years basically running engineering at a PWR, smaller than this, but almost identical in some features.

What provision have you made in your design to be able to inspect the reactor coolant pump rose?

MR. RO: Rose?

MEMBER SKILLMAN: Rose. Not the diffuser. The rotor. Rotors so big around, seven vanes, cast material, difficult to access, but sometimes accessible through the primary piping.

So my question is, is there a way to inspect the rotor without having to remove the motor, remove the top works, remove the seal and remove the barrel? Because all of those are

separate stages to get to the rotor.

MR. RO: Okay. I understand.

MEMBER SKILLMAN: Thank you.

MR. RO: So I think next time we will explain --

MEMBER SKILLMAN: Thank you.

MR. RO: -- what's on the matter.

MEMBER SKILLMAN: Yes, sir. Thank you.

MR. RO: Okay. Thank you.

CHAIRMAN BALLINGER: Thank you. Okay. We're told that there is somebody on the outside line, so we're getting that open now.

Are there any folks in the audience who would like to make a comment?

(No audible response.)

CHAIRMAN BALLINGER: There's good news and bad news. The good news is we're way ahead of schedule. The bad news is that we're way ahead of schedule. Because the proprietary meeting is not until the afternoon and because of the docket we pretty -- because of the schedule we have to pretty much fix -- stick to that schedule, I think. Right?

(Simultaneous speaking.)

CHAIRMAN BALLINGER: We don't? Okay.

MEMBER STETKAR: We haven't finished the

public session.

CHAIRMAN BALLINGER: Oh, good. Well, we're about to finish it.

MEMBER BLEY: Ron, I want to make sure you heard what John said. This is Subcommittee --

CHAIRMAN BALLINGER: Yes.

MEMBER BLEY: -- so you can adapt the schedule.

CHAIRMAN BALLINGER: I've been suitably chastised.

MR. SISK: We still have a few more presentations yet. We're not done.

CHAIRMAN BALLINGER: Wait a minute. I'm just looking at the schedule. Okay. Thank you.

Next?

(Simultaneous speaking.)

CHAIRMAN BALLINGER: Oh, that's -- I think we really need one. Okay. So we'll take a 15-minute break.

(Whereupon, the above-entitled matter went off the record at 10:20 a.m. and resumed at 10:36 a.m.)

CHAIRMAN BALLINGER: Okay. Can we start up again? Thanks.

MR. JEON: Good morning, ladies and

gentlemen. My name is Sangyoun Jeon from KEPCO Nuclear Fuel. I will present about the fuel design for APR1400 system.

I have divided my talk into five main parts. Firstly, I will explain about some introductions including the PLUS7 fuel development and the regulatory bases. PLUS7 is the name of the fuel design for APR1400. And secondly, I will explain about the PLUS7 fuel design for design characteristics and the design verification. And then I will move onto the PLUS7 irradiation experience. After that I will explain the stages of the PLUS7 licensing. And finally, I will summarize my presentation.

Okay. Let's start with the introduction. The PLUS7 fuel design was jointly developed with Westinghouse for APR1400 in Korea from 1999 to 2002. And the PLUS7 fuel was developed to improve the fuel performance compared to Guardian fuel. Guardian is the standard fuel design for System 80+. And KEPCO and KHNP submitted PLUS7 topical report and technical report to NRC for APR1400 DC licensing. This is the document number of the topical report for PLUS7 fuel design. And this is the document number for -- of the technical

report for fuel assembly seismic and LOCA analysis.

MEMBER CORRADINI: Just so I -- I'd ask to those topical reports. So if I were to look to look at CHF casting, do I go to those topical reports, or a different --

MR. JEON: We have separate topical report for the CHF test.

MEMBER CORRADINI: Okay. But you're not going to discuss that in your presentation?

MR. JEON: I have a -- I will touch a little bit --

MEMBER CORRADINI: Okay.

MR. JEON: -- about that in -- yes.

MEMBER CORRADINI: Thank you.

MR. JEON: Yes, the PLUS7 fuel design was developed to comply with the following Code of Federal Regulations, NRC regulatory documents and the industrial code and standard.

To move on, I will explain about the PLUS7 fuel design. This figure shows overall configuration of the PLUS7 fuel design. The PLUS7 fuel consists of one top nozzle with easy removal features and one bottom nozzle with a debris filtering feature and one top inconel grid for reduced rod bow and one bottom inconel grid for high

burnup capability. And there is one protective grid for debris filtering feature. And there are nine mid grid for high-seismic capability, high thermal performance with mixing vane and fretting wear resistance with a conformal spring and the dimple. All those components are connected by four heat guiding dimples and instrumentation cue. The 236 high burnup fuel rods are included -- inserted into the each cell of the -- those space grid.

The PLUS7 fuel incorporated the proven Guardian structure and the proven Westinghouse type fuel features to improve the fuel performance. This table shows the design improvement of the PLUS7 fuel compared to the Guardian fuel. The PLUS7 use the ZIRLO cladding material for high burnup capability. We optimize the fuel rod diameter and implemented the axial blanket to enhance the neutron economy. And we developed a conformal spring and the dimples to increase the fretting wear resistance. The Guardian fuel use a cantilever spring and arched dimple.

We also developed the straight strap for highly seismic capability and we implemented the mixing vane to enhance thermal performance. And we developed assembled top nozzle for easy removable

and we developed the small hole and the slot bottom nozzle to increase the debris filtering efficiency.

From now on I will explain some detail of the each design improvement. For the high burnup capability we use the ZIRLO cladding tube and we develop the variable pitch plenum spring. And for the neutron economy we developed the optimized fuel rod and the axial blanket.

CHAIRMAN BALLINGER: So the ZIRLO -- is there any thought to using the next generation optimized ZIRLO, or whatever it's called, for the cladding?

MR. JEON: For this PLUS7 design we used the standard ZIRLO.

For the thermal margin -- for the enhanced thermal margin we developed the mixing vane, and the mixing vane is attached at the top of the inner strap of the middle grid. And for the high seismic capability we developed a straight strap grid instead of the wavy strap grid.

For the fretting wear resistance we developed the conformal spring and the dimples to increase the contact area between fuel rod and the spring and the dimples. The Guardian fuel had a cantilever spring and arched the dimple, which has

the small contact area between fuel rod and the spring and dimples.

For the debris filtering efficiency we developed the small flow hole and the slot bottom nozzle to increase the debris filtering efficiency. Guardian fuel has the large flow hole bottom nozzle.

MEMBER CORRADINI: So we will later talk about testing relative to this difference?

MR. JEON: Yes.

MEMBER CORRADINI: Okay. Thank you.

MR. JEON: Now I'd like to move onto the design verification of the PLUS7 fuel. We performed out-of-pile test and the in-reactor verification test. For the out-of-pile test we performed the fuel assembly mechanical test, fuel assembly hydraulic test and the critical heat flux test. For the in-reactor verification test we performed the pool side examination and the hot cell examination.

For the out-of-pile test we performed the mechanical and the hydraulic test using the FACTS and the VIPER test facilities located at Westinghouse Columbia Plant. And the critical heat flux test was performed using Heat Transfer Research Facility located at Columbia University. Based on the fuel assembly mechanical and hydraulic test

result the mechanical and the hydraulic performance of the PLUS7 fuel was verified. And we developed the KCE-1 CHF correlation based on the critical heat flux test result. And the correlation was applied to the PLUS7 design analysis.

MEMBER CORRADINI: So this is where I was going to ask my question. When were those tests done?

MR. JEON: Excuse me.

MEMBER CORRADINI: When were the critical heat flux tests performed? When.

MR. JEON: It was 2000.

MEMBER CORRADINI: Oh, okay. Sixteen years ago? Okay. Because the facility doesn't exist anymore.

MR. JEON: Right.

MEMBER CORRADINI: That's why I'm --

MR. JEON: Yes, this facility was, yes --

MEMBER CORRADINI: Okay.

MR. JEON: -- closed.

MEMBER CORRADINI: Thank you. So just a follow-on. So from the standpoint -- that's -- I guess it kind of goes back to -- you don't have to go back to the slides, but going back to your PLUS7

mixing vanes -- so that mixing vane design in your grid spacers are from at last 16 years ago?

MR. JEON: Yes.

MEMBER CORRADINI: Okay. Thank you.

MR. JEON: And this is the document number of the topical report for the KCE-1 correlation.

For the in-reactor verification test the four lead test assemblies were manufactured and loaded at Ulchin Unit 3 from Cycle 5 to Cycle 7. And the four commercial surveillance assemblies were selected from the commercially supplied fuels at Yonggwang Unit 5 Cycle 5. And we performed the pool side examination and the hot cell examination after the LTA and the CSA irradiation. Based on the pool side examination and the hot cell examination results it was confirmed that the measured data after the addition were within the design limit of the PLUS7 fuel design.

Now I will present about the PLUS7 irradiation experience.

MEMBER SKILLMAN: Before you do that I would like to ask this question. In the design description; and this is Section 352 of the design description, I'm going to read a sentence and try to

understand what you've presented.

"A CEA is composed of 12 fingers full strength, 4 fingers full strength and 4 fingers part strength CEAs. Neutron absorbing material is used for full strength rods or boron carbide pellet and so on."

What you've shown is four fingers. Where are the 12-finger CEAs used in this design?

MR. JEON: The 12 fingers are inserted into the four different fuel assemblies in the core. There are several fuel assemblies in the core. So 12- fingers CEA will be inserted into the 4 fuel assemblies.

MEMBER SKILLMAN: Four locations?

MR. JEON: Yes, four --

MR. JEONG: The design of fuel assemblies the exactly same. The same fuel assemblies inserted in the -- loaded in the core. The 12 fingers is -- go -- inserted into 3, or 4 CEAs for assemblies. So three assemblies are connected with the fingers.

MEMBER SKILLMAN: Could you go back to your plan view of your grid, your spacer grid?

You're showing just four locations there for your absorbing rods. So I'm trying to

understand the 4 versus 12 versus 3. So perhaps you could clarify that.

MR. SANGYOUN JEON: Yes, four CEA, the one CEA with four fingers will be inserted in just one -- into the one fuel assembly.

MEMBER SKILLMAN: Yes.

MR. JEON: And the 12-finger CEAs will be inserted into the -- there will be one fuel assembly right here and one fuel assembly here and one fuel assembly here and one fuel assembly here.

MEMBER SKILLMAN: Yes.

MR. JEON: So one, two, three, four fuel assembly has 12 type 2 assemblies. So 12- finger CEA will be inserted into those 4 fuel assembly.

MEMBER SKILLMAN: Oh, now I understand. Okay. I was trying to understand whether you had fuel assemblies that had four or fuel assemblies that had --

MR. JEON: Twelve.

MEMBER SKILLMAN: -- 12. Now I understand. Thank you. Okay. Thanks.

MR. JEON: Okay. So based on the out-of-pile test and the in-reactor verification test results more than 4,000 PLUS7 fuel assemblies were

supplied since 2006. And we supplied 4,250 fuel assemblies to 13 reactors in Korea in the 18-month cycle. And the maximum fuel road discharge burnup is 59,000 megawatt metric ton uranium. And recently we manufactured 302 fuel assemblies for UAE project and those fuel assemblies are ready to ship for Barakah Unit 1.

MEMBER SKILLMAN: One more question, please. What was the basis of the choice for an 18-month fuel cycle versus a 24-month fuel cycle?

MR. JEON: Originally the -- we designed with a 15-month cycle in Korea at the beginning of the fuel development stage. And we increased the fuel cycle from 15 months to 18 months to increase the economy. But right now we are trying to increase the fuel cycle from 18 months to 24 months, but it's not implemented yet in Korea. So currently we are supplying the fuel with an 18-month cycle.

MEMBER SKILLMAN: Thank you.

MR. JEON: Okay. Now I explain about the licensing status of the PLUS7 fuel design. KEPCO and KHNP submitted the PLUS7 topical report and the fuel assembly seismic technical report in 2014. The NRC audit was performed for fuel assembly seismic technical report in 2015, last year, and

there were some issues related to fuel assembly EOL seismic analysis. So currently the KEPCO and the KHNP is working on the fuel assembly EOL test and the seismic analysis and the issues will be resolved by end of July 2017 based on the additional test and analysis results.

So in summary, the PLUS7 fuel assembly design was joined developed with Westinghouse for APR1400 in Korea, and this PLUS7 design evaluation was performed to comply with Code of Federal Regulations and the NRC regulatory document. And the PLUS7 fuel was verified through the out-of-pile test, critical heat flux test and the in-reactor verification test. And the fuel assembly EOL seismic analysis related issues will be resolved by end of July 2017 based on the additional test and analysis result. More than 4,000 PLUS7 fuel assemblies were supplied since 2006 and excellent in-reactor performance was demonstrated up to now.

Thank you for your attention.

CHAIRMAN BALLINGER: Questions?

(No audible response.)

CHAIRMAN BALLINGER: Thank you.

MR. KIM: Hello. I will start?

CHAIRMAN BALLINGER: Yes.

MR. KIM: Good morning. My name is Yonggun Kim and in KEPCO-AE System Design Group. This is a honor for me to have an opportunity to introduce the containment system for APR1400.

This presentation is started with the introduction. And next the design features for containment system in APR1400 will be introduced. And it will be closed with a conclusion.

This presentation is to present an overview of the design features for the APR1400 standard design regarding the 3 system.

Well, APR1400 containment system design are based on relevant regulatory requirements such as the general design criteria, regulatory guides, standard review plans and general standards.

Following are the design features I will introduce in this presentation for containment system for APR1400. The containment P/T analysis, containment spray system, containment isolation system, containment hydrogen control system, and the last one is design features to address GSI-191.

First, the containment P/T analysis. For APR1400 containment P/T analysis GOTHIC containment/RCS model is used with conservative break flow models and wall heat transfer model.

Cases for the P/T analysis include 5 cases for LOCA and 10 cases for secondary system pipe breaks. Based on the P/T analysis the peak containment pressure is calculated as 51.1 psig, and the containment is designed with a pressure of 60 psig. So there is a 10 percent pressure margin in APR1400 containment design.

Also, the P/T analysis results show that containment pressure system has sufficient heat removal capacity to reduce and maintain the containment pressure below 50 percent of the peak pressure within 24 hours after the postulated accident.

And next is the containment spray system. The containment spray system for APR1400 has functions that reduce the containment pressure and temperature following a main steam line break or LOCA and removes fission products from containment atmosphere following LOCA.

MEMBER POWERS: I want to acquaint you with the kinds of questions that we'll have with respect to the second statement. It will be important for us to understand -- I don't expect an answer right now because these are fairly detailed questions. It will be important for us to

understand what the droplet size distribution is and the trajectory analysis on those droplet sizes, the droplet agglomeration coefficients that are used and that. We will also need to know of any additives in the material. It would be useful to know the spray header types, coverage, angle and that sort of thing.

MR. KIM: Well, that type of informations are described in the DCD or at the end. The spray pattern standards, spray droplet size are confirmed by the test from vendor for the nozzle.

MEMBER POWER: That will be important for us to explore --

MR. KIM: Yes.

MEMBER POWER: -- those topics and in substantial detail to understand your second bullet there.

MR. KIM: Yes. Well, if we can have a chance for those issues, then we can provide the detailed information.

MEMBER POWERS: Yes, a difficulty we run into a lot is claims are made about the droplet size distribution based on a single spray nozzle from the manufacturer.

MR. KIM: Yes.

MEMBER POWERS: And of course a single spray nozzle does not account for the fact that other spray nozzles are injecting droplets that agglomerate. And so you have bigger droplets and bigger droplets are less efficient than little droplets.

MR. KIM: Well, this system has two 100 capacity divisions, each separated physically and mechanically. And in each division there are one containment spray pump, one heat exchanger, and nozzles. In addition, APR1400 containment spray system has emergency containment spray backup system, shortly ECSBS, for severe accident management.

This is a schematic diagram for APR1400 containment spray system. In APR1400 since the containment spray pump and shutdown cooling pump in the same division are interchangeable to each other. So the shutdown cooling pump can backup the containment spray pump during the accident when the containment spray pump is not available.

And this is the -- it's just ECSBS. During a severe accident ECSBS can provide spray water from external water source to the containment

using fire engine truck when all spray pumps including the shutdown cooling pump and the IRWST are not available.

MEMBER SKILLMAN: Would you comment please on the approximate capacity of the backup spray system?

MR. KIM: So about the 750 gpm.

MEMBER SKILLMAN: And what is the full spray flow of the normal containment spray?

MR. KIM: Five thousand gpm per pump.

MEMBER SKILLMAN: So it's just a little bit over 10 percent?

MR. KIM: Right. And it's based on the analysis of the civil standards.

MEMBER SKILLMAN: Thank you.

MR. KIM: You're welcome.

And APR1400 introduced a isolation system. APR1400 containment isolation system is designed to meet the 10 CFR 50, Appendix A, GDC 55, 56 and 57 to confine the release of any radioactivity from containment following postulated DBA.

These configurations are examples for containment isolation system design. These examples show that one check valve or one -- one automatic

isolation valve inside containment and one automatic isolation valve outside containment are provided in relevant system in accordance with GDC 55 and 56. And according to the GDC 57, two automatic isolation valves are provided outside containment.

And next is containment hydrogen control system. In APR1400 the hydrogen concentration in containment is controlled by the passive autocatalytic recombiners, shortly power and igniters. And the -- it is totally in the containment in the IRWST and the hydrogen is controlled below the plant by volume during severe accident. And the figure, the upper figure is power design and the lower figure is the igniters. The igniter is -- this picture is taken from the reference plant.

MEMBER POWERS: These passive devices are open during normal operation?

MR. KIM: Excuse me? Pardon?

MEMBER POWERS: Is there air circulation through those --

MR. KIM: Circulation.

MEMBER POWERS: -- during normal operations?

MR. KIM: During normal operation air

circulation is accomplished by the ECSBS system in containment.

MEMBER CORRADINI: I think he's asking is it open? Are these passive autocatalytic recombiners open to the containment during normal operation?

MR. KIM: Right. The power you mean. Right.

MEMBER POWERS: We'll be interested in understanding the poisoning on these surfaces.

MR. KIM: Poisons?

MEMBER POWERS: Yes.

MR. KIM: Well, actually the power is tested about the poison in the -- during the accident. And so, I believe that this is qualified for that kind of issue.

MEMBER POWERS: We'll be interested in that qualification because of them that have been done that I'm aware of are pathetic representations of the environment in a real accident.

MR. KIM: Well, next is the design features to address the GSI-191.

MEMBER CORRADINI: We're all ears.

MEMBER SKILLMAN: Could we go back for a second to Dr. Powers' question? The question really

is what is in your containment atmosphere during normal operations? You're running with boric acid concentration in your reactor coolant system.

MR. KIM: The concentration of hydrogen you mean?

MEMBER SKILLMAN: No. In your reactor coolant system you're running with some boron?

MR. KIM: Right. Yes.

MEMBER SKILLMAN: A thousand ppm, twelve hundred ppm? You're critical as you go through your fuel cycle 18 months, 24 months. You're holding rods and you're dropping boron. Right?

MR. KIM: Yes.

MEMBER SKILLMAN: What happens if you get a pinhole leak, a very, very, very tiny leak, a reactor coolant pump seal is weeping just ever so little, just enough to put boric acid in your containment environment and it's being circulated by your containment cooling system, your normal containment cooling system? Where is that boron going? And what is in these autocatalytic recombiners? What is it, palladium, platinum?

MR. KIM: Yes, platinum.

MEMBER SKILLMAN: What happens when the boron gets in there? So, that's Dr. Powers'

question. What if that material is poisoned and you're depending on it for post-LOCA hydrogen control? And it's something we've all dealt with. We understand that issue.

And so, what Dr. Powers is really saying is when you show that your PARs have been tested, how do you know your platinum palladium recombiner material, which is granular, has not been poisoned by years and years of sitting in what you think is a clean environment when it reality that environment has poisoned your PARs? It happens.

MEMBER POWERS: Dr. Powers is probably equally concerned about off-gassing from all the organics in the system.

MR. KIM: Well, I think that the answer can be provided after our discussion. So I can answer the question at the next meeting.

MEMBER SKILLMAN: Thank you.

MR. KIM: Yes.

MR. JEONG: Basically for the PAR is every 18 months there's an inspection and issue related to health. So --

MEMBER STETKAR: Please talk into your microphone.

MR. JEONG: Their performance will be

verified the base on regular basis for that over every outages.

CHAIRMAN BALLINGER: I think you have to speak louder.

MR. JEONG: Yes, and also there some hole in RCS that will be collected to the sumps. And also the operator can notify that there's some leakage in them. There is some -- prepared on this and action will be taken. But there is not significant impact to the PARs in the case, so we expected.

MEMBER SKILLMAN: Well, we'll be interested in this topic when we have the detailed review.

MR. JEONG: Okay.

MEMBER SKILLMAN: Thank you.

MR. KIM: Next is design features to address GSI-191. Before starting into discussion of the design features for GSI-191, I would like explain the flow path to IRWST sump strainer during LOCA for APR1400.

Well, during LOCA containment spray pump and the SI pump takes suction from the IRWST. The injected water and the sprayed water are then collected in the containment flow and the water on

the floor is affording whole volume tank right here. And finally, the water returns to the IRWST through the spillway. And then the returned water is taken by the CS pumps and the SI pumps via the strainers on the sumps. This is the flow path and circulation operation of APR1400 during LOCA. And for your information there are four sumps in the IRWST.

Now I introduce the --

MEMBER CORRADINI: May I just ask?

MR. KIM: Yes.

MEMBER CORRADINI: So this is the -- no, I've got it over here. This is the outer annular IRWST ring --

MR. KIM: Right.

MEMBER CORRADINI: -- right, that we're looking at. It's a cross-section.

MR. KIM: A cross-section.

MEMBER CORRADINI: So the logic of this is you capture all the spray water that comes in up to some angle and then it essentially just flows back in?

MR. KIM: Yes.

MEMBER CORRADINI: To what you call the HVT?

MR. KIM: Yes, right.

MEMBER CORRADINI: So the thought process is it's to essentially recirculate this?

MR. KIM: Right.

MEMBER CORRADINI: Okay.

MR. KIM: Yes.

MEMBER CORRADINI: All right. I just wanted to make sure I understood the diagram. Thank you.

MEMBER SKILLMAN: I would like to ask further. I've seen in the design description the HVT. What is the relationship? Do have a plan view that shows the HVT in relation to the IRWST?

MR. KIM: Yes, we have the plan view. And you can see the more -- the figures in the technical report for GSI-191. The plan view is kind of the secure --

(Simultaneous speaking.)

MEMBER SKILLMAN: Okay.

MR. KIM: Yes, --

(Simultaneous speaking.)

MEMBER SKILLMAN: It appeared as though the IRWST was, if I can use the word, "in-board" from the skin of the containment by several meters, or a meter or two, and the HVT was between the IRWST and the containment wall.

MR. KIM: Yes.

MEMBER SKILLMAN: Is that the basic layout?

MR. KIM: Yes, right.

MEMBER BLEY: When you say it's in the -- I think you said in the technical reference --

MR. KIM: Technical report.

MEMBER BLEY: Technical report?

MR. KIM: Yes, right.

MEMBER BLEY: Okay.

MR. KIM: Yes, it's submitted already to --

(Simultaneous speaking.)

MEMBER BLEY: And it's the one on the containment, or is it a technical report? Which one is it?

MR. KIM: For GSI-191.

MEMBER BLEY: Oh, for GSI?

MR. KIM: Yes.

MEMBER BLEY: Okay.

MEMBER SKILLMAN: We can look over there. Thank you. Okay.

MEMBER CORRADINI: So somewhere later, not today, I'm sure it will be later, I'm very curious about how much of the return water goes to

dead volumes that don't go back to your HVT.

MR. KIM: Yes, the --

MEMBER CORRADINI: But not today.

MR. KIM: -- the whole volume, right?

MEMBER CORRADINI: But not today. I just -- but that's the reason I'm trying to understand your drawing.

MR. KIM: This also in the technical report.

MEMBER CORRADINI: I'm sure everything's there.

MR. KIM: So now I introduce APR1400 design features for GSI-191. Actually, according to the Regulatory Guide 1.182, Revision 4, and NEI 04-07, the following evaluations was conducted, and the result of the evaluations are described in the technical report.

Well, for debris generation; so we are following the guidance of the NEI 04-07, we selected the RCS hot leg break as the most limiting break location. Since the APR1400 design use reflective material insulation, shortly RMI, inside containment, so generated debris would be the RMI and coatings and latent debris. But the RMI is -- no question there's debris because of -- is -- it

has -- density is high and so valency to sump strainer is very low, so it will not be transported to the sump strainer.

And for chemical effect --

MEMBER STETKAR: Mr. Kim, I have a question. Your documentation says RMI is used for reactor coolant system --

MR. KIM: Inside the containment.

MEMBER STETKAR: Yes.

MR. KIM: Yes.

MEMBER STETKAR: Are your main steam and feedwater lines inside the containment also RMI?

MR. KIM: Yes.

MEMBER STETKAR: Okay. Thank you.

MEMBER POWERS: Your containment coating is epoxy?

MR. KIM: Pardon?

MEMBER POWERS: The containment coating is epoxy?

MR. KIM: Containment?

PARTICIPANT: Coating.

MR. KIM: Coating?

PARTICIPANT: The coating on containment.

MR. KIM: Yes, to cover it. And coating

-- the containment liner is coverance. And as -- I think that --

MEMBER CORRADINI: But the coating -- I assume IOZ is some sort of zinc oxide coating? That's what we're trying to understand.

MR. KIM: Coating the wall is coated with epoxy and inorganic zinc.

MEMBER POWERS: Inorganic zinc primer.

MR. KIM: Yes, primer.

MEMBER POWERS: And then that's coated with an epoxy?

MR. KIM: Yes.

MEMBER POWERS: Do you know what epoxy it is?

MR. KIM: The type of epoxy, you mean?

MEMBER CORRADINI: You can get back to us if you don't know.

MR. KIM: Yes, I think that others -- because they can answer that.

MR. SISK: We'll provide the details on that in our next get together.

MEMBER POWERS: Whatever. Just understand the direction of our questions on this. That's really what we're doing. In fact, the whole issue of qualified coatings has to -- qualified and

non-qualified coatings.

MR. KIM: We qualified all coatings in the containment coating.

MEMBER POWERS: That may be true, but there will be a certain inventory of unqualified coatings and we'll need to understand both the qualification test and the what the inventory of unqualified coatings is.

MR. KIM: Well, for chemical effect it was evaluated using the methodology in WCAP-16530-NP-A. And this WCAP report is referenced in the Regulatory Guide 1.82.

And for debris head loss evaluation APR1400 design conservatively assumes that all the generated coatings and latent debris and chemical precipitates are transported directly to a single sump. And the allowable head loss for debris head loss tests at the sump strainer is two feet-water and the debris head was -- the test results is 0.81 feet head loss at the sump strainer. Therefore, the test results satisfied the lower head loss with sufficient margin.

In the evaluation of the NPSHa for the ECCS pumps APR1400 design credits the containment accident pressure for the IRWST temperature greater

than 212 Fahrenheit degree. With the assumption of that the containment accident pressure is equal to the IRWST liquid vapor pressure.

For the ESSC pump NPSHa required APR1400 design used --

MEMBER SKILLMAN: Could we back, please? Was any consideration given to not using containment accident pressure in this design, either by elevation of the pumps or by any other reasonable engineering methodology?

MR. KIM: Well, we don't think about any consideration like that.

MEMBER CORRADINI: So I think what Member Skillman is asking is we would prefer a hardware change to using CAP credit.

MR. KIM: Yes. So we don't think about now -- current design.

MEMBER STETKAR: You should be aware that the ACRS is on record of --

MR. KIM: Yes, I understand.

MEMBER STETKAR: -- not endorsing containment accident pressure.

MR. KIM: Yes.

MEMBER STETKAR: So this will be a point of contention in your design with us. We're on

written record for many, many years.

CHAIRMAN BALLINGER: Is CAP used in Shin Kori 3 and 4?

MR. KIM: Yes.

MR. SISK: Appreciate the comment.

MEMBER STETKAR: It's a warning shot across the bow, but it's a big warning shot.

(Laughter.)

CHAIRMAN BALLINGER: Carbide-bladed buzz saw.

MEMBER RAY: Well, let me just add one thing, which is people have made changes as a result of what John Stetkar just related to you. So it has had an effect in some cases in the past, the concern that we have about relying on CAP.

MR. KIM: Well, we explain NPSHa effective. APR1400 design used NPSHa required effective in accordance with the report of SECY-11-0014. And 21 percent margin was considered for the effect of the uncertainty factor.

The table shows that NPSH effective of calculation result. The SI pump has 22 feet-water and CS pump has 17.5 feet over NPSHa effective. Using these, NPSH are effective NPSH margin for APR1400 ECCS pump calculated, and these are provided

in this table. SI pump has NPSH margin over 1.73 feet-water. And for CS pump 3 feet-water margin is exist.

Well, the --

CHAIRMAN BALLINGER: If you were to not use CAP, what would these numbers look like?

MR. KIM: It's based on the calculation methodology of the -- over 212 Fahrenheit degree. We consider that the containment pressure and the vapor pressures are equal. And that is the basis. And it is the minimum. The results is the minimum NPSH margin considered methodology.

MEMBER CORRADINI: So I think what Dr. Ballinger was asking is how much delta-P are you using for CAP credit? That's what I think you're asking.

CHAIRMAN BALLINGER: Yes.

MR. KIM: If we don't consider the CAP credit, then we need about 40 or 30 feet -- yes, about 30 feet.

MEMBER CORRADINI: Thirty feet of water?

MR. KIM: Thirty feet maximum is required.

MEMBER CORRADINI: Okay.

MR. KIM: Yes.

MEMBER SKILLMAN: Let me ask this: The flow rates that you show for safety injection and for core spray --

MR. KIM: Yes.

MEMBER SKILLMAN: -- do you require all of that flow to meet your accident containment and fuel conditions? In other words, if you were to back down the SI pump flow from 1,235 gallons a minute to say 1,000 or 950, you would significantly reduce your NPSH requirement just because of the way those pumps are designed. Would you then be able to meet your requirement, your cooling requirement without the application of CAP credit?

MR. KIM: The flow through the core, you mean, right?

MEMBER SKILLMAN: Well, I fully understand. I'm saying do you need that much?

MEMBER CORRADINI: He's asking do you need that much of a flow rate?

MEMBER SKILLMAN: Could you knock that -- could you throttle or put in passive devices so that you --

MR. SISK: If we can, I -- I understand the question --

MEMBER SKILLMAN: Answer it later?

MR. SISK: -- and I understand the process. We're going to go back and take a look at your comment relative to CAP, what the options are, what sort of --

MEMBER SKILLMAN: Thank you.

MR. SISK: -- what alternative you would consider.

MEMBER SKILLMAN: Thank you.

MR. SISK: We'll do that at a later time, if we can.

MEMBER SKILLMAN: That's fine. Thank you very much.

MR. KIM: So I will go to next page. So regarding the containment accident pressure we have a RAI for this, and we are currently working on the consultive estimation of NPSH margin certainty and the risk calculation for assessing the plant risk associated with crediting containment accident pressure in the NPSH assessment.

Well, the next is the ex-vessel downstream effect. For the ex-vessel downstream effect evaluation the sump strainer bypass test was performed and the test results show that 1.67 kilogram of the latent fiber debris is bypassed through for sump strainers. Using this bypassed

fiber debris and other debris ex-vessel downstream effect evaluation was performed on each component in the ECCS system in accordance with WCAP-16406-P-A.

SI pump and CS pump will be qualified by the pump vendor. And for heat exchangers no plugging is expected, however, the wear and the performance will be confirmed by the heat exchanger vendor. For other components such as valves, orifices, nozzles and so on no blockage and no settling is expected. And wear is expected to be negligible.

And for in-vessel downstream effect according to the WCAP report of 16793-NP KHNP performed the in-vessel downstream effect test for APR1400 to confirm the plant-specific effect on fuel assemblies during post-LOCA with the debris latent through it. The test results show that the maximum pressure drop through fuel assembly is within the allowable pressure drop with a sufficient margin.

And for LOCADM analysis the results for deposit thickness and peak cladding temperature satisfy the acceptable criteria of 50 mils for thickness and 800 Fahrenheit degree for cladding temperature.

So final is conclusion. The APR1400

containment system is designed to meet the U.S. regulatory requirements. The design features regarding GSI-191 have been evaluated in accordance with the NRC Regulatory Guide 1.82, Revision 4. So we believe that the containment integrity and the plant safety are maintained with sufficient margin during postulated accident conditions.

These are all in this presentation. Thank you for your listening.

CHAIRMAN BALLINGER: Thank you. Questions from members?

MEMBER POWERS: I noticed that in your testing for GSI-191 you were using as material calcium phosphate. Does that suggest that you will buffer your sumps with phosphoric -- with sodium phosphate?

MR. SISK: We'll discuss that further later. I think the tests were done using the standard mix that the industry has been using for --

(Simultaneous speaking.)

MEMBER POWERS: Yes, but it makes some sense to use calcium phosphate if you're not going to use phosphate as a buffer.

MR. SISK: Understood. We'll get back with the details on that.

MEMBER POWERS: And that's fine. That is perfectly okay. I just want to make sure you know what kind of questions we're going to ask.

MR. SISK: Yes. Appreciate it. Thank you very much.

CHAIRMAN BALLINGER: While we wait, other questions?

MEMBER STETKAR: Just to help you out on ACRS -- this is not a comprehensive list, but if you want a set of references to ACRS letters on CAP -- I'll give you some dates anyway. May 19th, 2010. February 17th, 2011. Those are -- you can look them up. December 24th, 2013. And April 21st, 2014. I may have missed a couple, but that will give you some general kind of contemporary things. There's an earlier history, but that's at least within the last six years. I tried to limit it to the bodies who are currently in the room.

MR. SISK: Thank you. And we will -- we'll take a look at the history and we'll be discussing it with the staff. As noted, it's an RAI. And we'll be talking more about that as the days go forward. Thank you.

MEMBER POWERS: That's great.

CHAIRMAN BALLINGER: So I think the line

is open. Is anybody out on the line? If you are, could you make yourself know?

MR. LEWIS: Marvin Lewis, member of the public.

CHAIRMAN BALLINGER: Good morning, Marvin. Care to make a statement?

MR. LEWIS: Yes, I'm glad I was able to get through to this one. Unhappily the ACRS yesterday I wasn't able -- meeting -- I wasn't able to get through to.

Yes, I'm very interested in this. It sounds like Korea has a few reactors going. And I'm just wishing them luck. Thank you. That's all.

CHAIRMAN BALLINGER: Thank you, Marvin.

Is there anybody else out there that would like to make a statement?

(No audible response.)

CHAIRMAN BALLINGER: Hearing none, can we close the line?

Are there any people in the audience that would like to make a statement?

(No audible response.)

CHAIRMAN BALLINGER: Hearing none, the closed session is this afternoon, so we can break for one hour and be back at 12:35, please. We're

recessed.

(Whereupon, the above-entitled matter went off the record at 11:35 a.m.)

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

APR1400 STANDARD DESIGN CERTIFICATION REVIEW

ACRS APR1400 Information Briefing

Jeffrey Ciocco
Lead Project Manager
Office of New Reactors

April 20, 2016

AGENDA

- The APR1400 Application
- The APR1400 Topical Reports
- The APR1400 Design Certification Review

APR1400 APPLICATION

- KHNP & KEPCO Design Certification (DC) Part 52 application submission on 12/23/14 (ML15006A098) contains:
  - Design Control Document (DCD)
    - Tier 1 & Tier 2; Public & Non-Public Versions
  - Environmental Report
  - Technical Reports (~ 60); Public and Non-Public Versions; Incorporated by Reference (IBR) & Non IBR
  - Design Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)
- The Public website http://www.nrc.gov/reactors/new-reactors/design-cert/apr1400.html contains the application and the review schedule.

APR1400 APPLICATION

SIGNIFICANT APR1400 DC APPLICATION DATES

- KHNP KEPCO Application Letter (ML15006A098): 12/23/2014
- Letter of Receipt to KHNP KEPCO (ML14357A347): 02/02/2015
- 80 Fed. Reg. 5792 Receipt of Application: 02/03/2015
- Letter of Docketing to KHNP KEPCO (ML15041A348): 03/04/2015
- 80 Fed. Reg. 13035 Notice of Docketing: 03/12/2015
- Schedule Letter to KHNP KEPCO (ML15091A241): 06/02/2015
- Schedule Letter to KHNP KEPCO (ML16067A165): 03/07/2016

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APR1400 APPLICATION

Publicly Available - Non Security Related Informatin (Non SRI)

Document Title	Accession #	Doc Date	Docket #	Availability	Sensitivity
Submittal Letter	ML15006A037	12/23/2014	52-046	Public	Non-Sensitive
Environmental Report	ML15006A038	12/23/2014	52-046	Public	Non-Sensitive
Tier1	ML15006A039	12/23/2014	52-046	Public	Non-Sensitive
Chapter 01 - Introduction and General Description of the Plant	ML15006A040	12/23/2014	52-046	Public	Non-Sensitive
Chapter 02 - Site Characteristics	ML15006A041	12/23/2014	52-046	Public	Non-Sensitive
Chapter 03 - Design of Structures, Systems, Components, and Equipment	ML15006A042	12/23/2014	52-046	Public	Non-Sensitive
Chapter 04 - Reactor	ML15006A043	12/23/2014	52-046	Public	Non-Sensitive
Chapter 05 - Reactor Coolant System and Connecting Systems	ML15006A044	12/23/2014	52-046	Public	Non-Sensitive
Chapter 06 - Engineered Safety Features	ML15006A045	12/23/2014	52-046	Public	Non-Sensitive
Chapter 07 - Instrumentation and Controls	ML15006A046	12/23/2014	52-046	Public	Non-Sensitive
Chapter 08 - Electric Power	ML15006A047	12/23/2014	52-046	Public	Non-Sensitive
Chapter 09 - Auxiliary Systems	ML15006A048	12/23/2014	52-046	Public	Non-Sensitive
Chapter 10 - Steam and Power Conversion System	ML15006A049	12/23/2014	52-046	Public	Non-Sensitive
Chapter 11 - Radioactive Waste Management	ML15006A050	12/23/2014	52-046	Public	Non-Sensitive
Chapter 12 - Radiation Protection	ML15006A051	12/23/2014	52-046	Public	Non-Sensitive
Chapter13 - Conduct of Operations	ML15006A052	12/23/2014	52-046	Public	Non-Sensitive
Chapter14 - Verification Programs	ML15006A053	12/23/2014	52-046	Public	Non-Sensitive
Chapter15 - Transient and Accident Analyses	ML15006A054	12/23/2014	52-046	Public	Non-Sensitive
Chapter16 - Technical Specifications	ML15006A055	12/23/2014	52-046	Public	Non-Sensitive
Chapter17 - Quality Assurance and Reliability Assurance	ML15006A056	12/23/2014	52-046	Public	Non-Sensitive
Chapter18 - Human Factors Engineering	ML15006A057	12/23/2014	52-046	Public	Non-Sensitive
Chapter19 - Probabilistic Risk Assessment and Severe Accident Evaluation	ML15006A058	12/23/2014	52-046	Public	Non-Sensitive

APR1400 APPLICATION

	Document Title	Accession #	Doc Date	Docket #	Availability	Sensitivity
Non-Publicly Available - Security Related Information (SRI)	Tier1	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter 01 - Introduction and General Description of the Plant	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter 03 - Design of Structures, Systems, Components, and Equipment	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter 05- Reactor Coolant System and Connecting Systems	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter 06 - Engineered Safety Features	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter 09 - Auxiliary Systems	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter 11 - Radioactive Waste Management	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter 12 - Radiation Protection	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info
	Chapter19 - Probabilistic Risk Assessment and Severe Accident Evaluation	Non-Public	12/23/2014	52-046	Non-Public	Security Related Info

APR1400 TOPICAL REPORTS

1) There are 5 Topical Reports “Incorporated by Reference” (IBR) into the APR1400 DCD (see next slide).
2) The Quality Assurance Program Description (QAPD) Topical Report Safety Evaluation is completed and publicly available.
3) Staff are conducting the detailed licensing reviews for the remaining 4 Topical Reports.
4) A Safety Evaluation Report (SER) will be prepared for each Topical Report.
5) The SERs will be reviewed by KHNP and presented for approval to the Advisory Committee on Reactor Safeguards (ACRS).

APR1400 TOPICAL REPORTS

List of Topical Reports

Report Number[1]	Title	DCD Tier 2 Section
APR1400-F-A-TR-12004-P APR1400-F-A-TR-12004-NP	Realistic Evaluation Methodology for Large-Break LOCA of the APR1400, Rev. 0	6.2.1.5.1, 15.6
APR1400-F-C-TR-12002-P APR1400-F-C-TR-12002-NP	KCE-1 Critical Heat Flux Correlation for PLUS7 Thermal Design, Rev. 0	4.4, 15.0~15.6
APR1400-F-M-TR-13001-P APR1400-F-M-TR-13001-NP	PLUS7 Fuel Design for the APR1400, Rev. 0	4.2, 4.4
APR1400-K-Q-TR-11005-NP	QAPD for the APR1400 DC, Rev. 4	17.1, 17.2, 17.3, 17.5
APR1400-Z-M-TR-12003-P APR1400-Z-M-TR-12003-NP	Fluidic Device Design for the APR1400, Rev. 0	6.3.2.1

(1) P – denotes document is proprietary.
NP – denotes document is non-proprietary.

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APR1400 DC REVIEW

The 6-Phase DC Review Schedule Completion Dates:

- Phase 1 - PSER and RAIs 02/01/2016 [completed]
- Phase 2 - SER with OIs 11/16/2016 [underway]
- Phase 3 - ACRS Review of SER with OI 06/20/2017
- Phase 4 - Advanced SER with No OI 12/15/2017
- Phase 5 - ACRS Review of Draft FSER with No OI 06/27/2018
- Phase 6 - FSER with No OI 09/12/2018
- Rulemaking 05/15/2019
- Environmental Assessment 08/31/2018

APR1400 DC REVIEW

- Phase 1 review is completed (PSERs and RAIs)
- Phase 2 review is in the 10th month
- Environmental Review is underway
- RAIs are being issued, responded, evaluated, & dispositioned
- Utilizing public meetings, audits, and inspections in the review process

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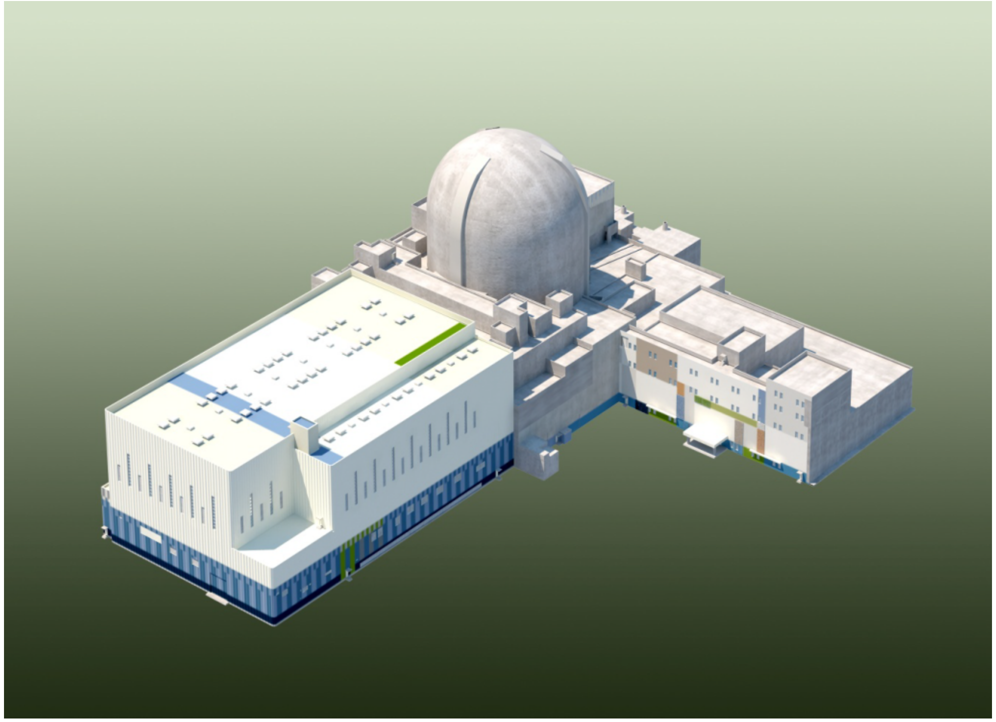
SUMMARY

- The Phase 2 Safety Evaluations with Open Items and associated Topical Report Safety Evaluations will be presented to the ACRS in Phase 3 of the review process.

NON-PROPRIETARY

Overview of the APR1400 DC Project



KEPCO/KHNP

Apr. 20~21, 2016

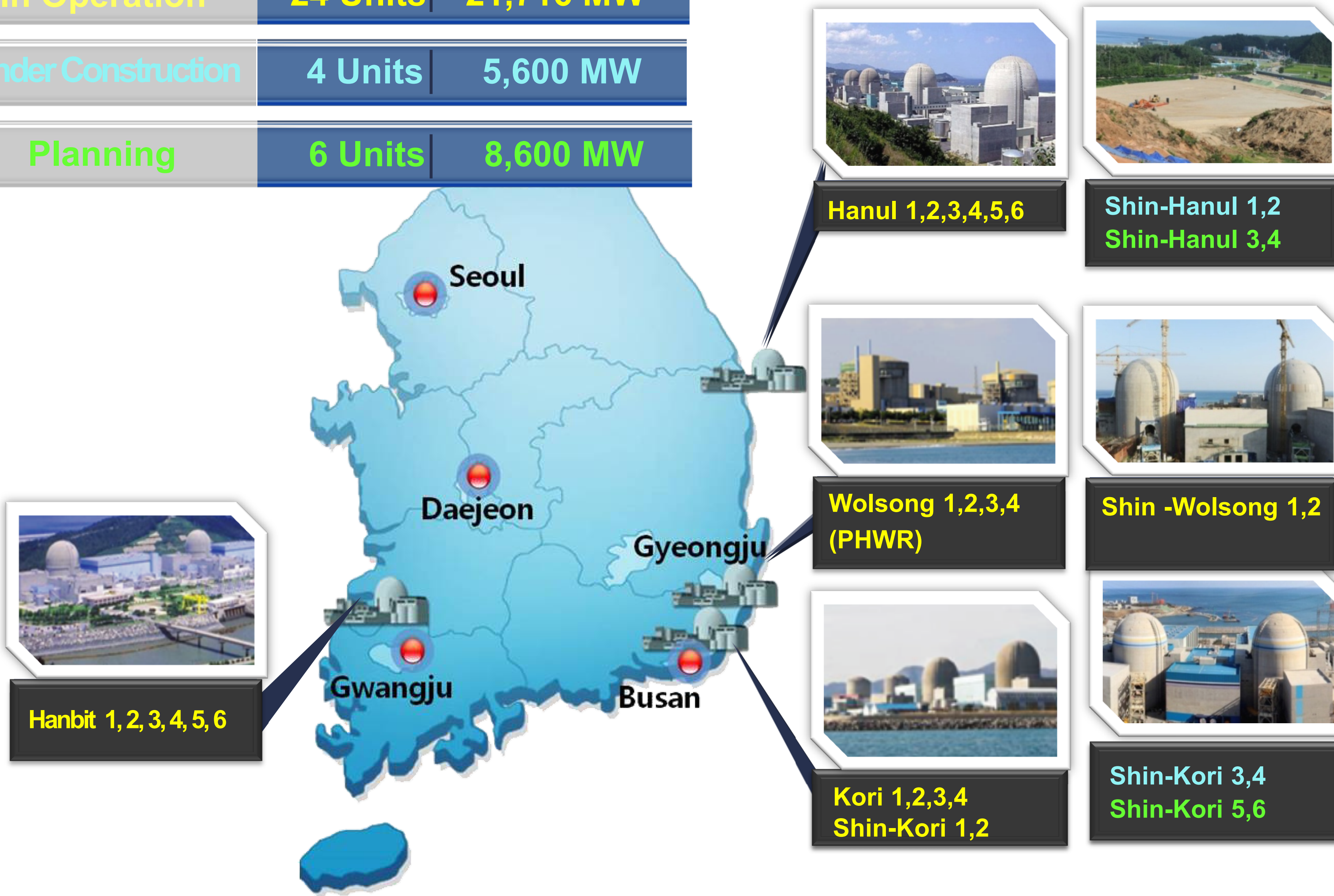
Contents

- Introduction
  - NPPs in Korea
  - Project History
- Design Features and General Arrangement
- Design Review Status
- Summaries

Contents

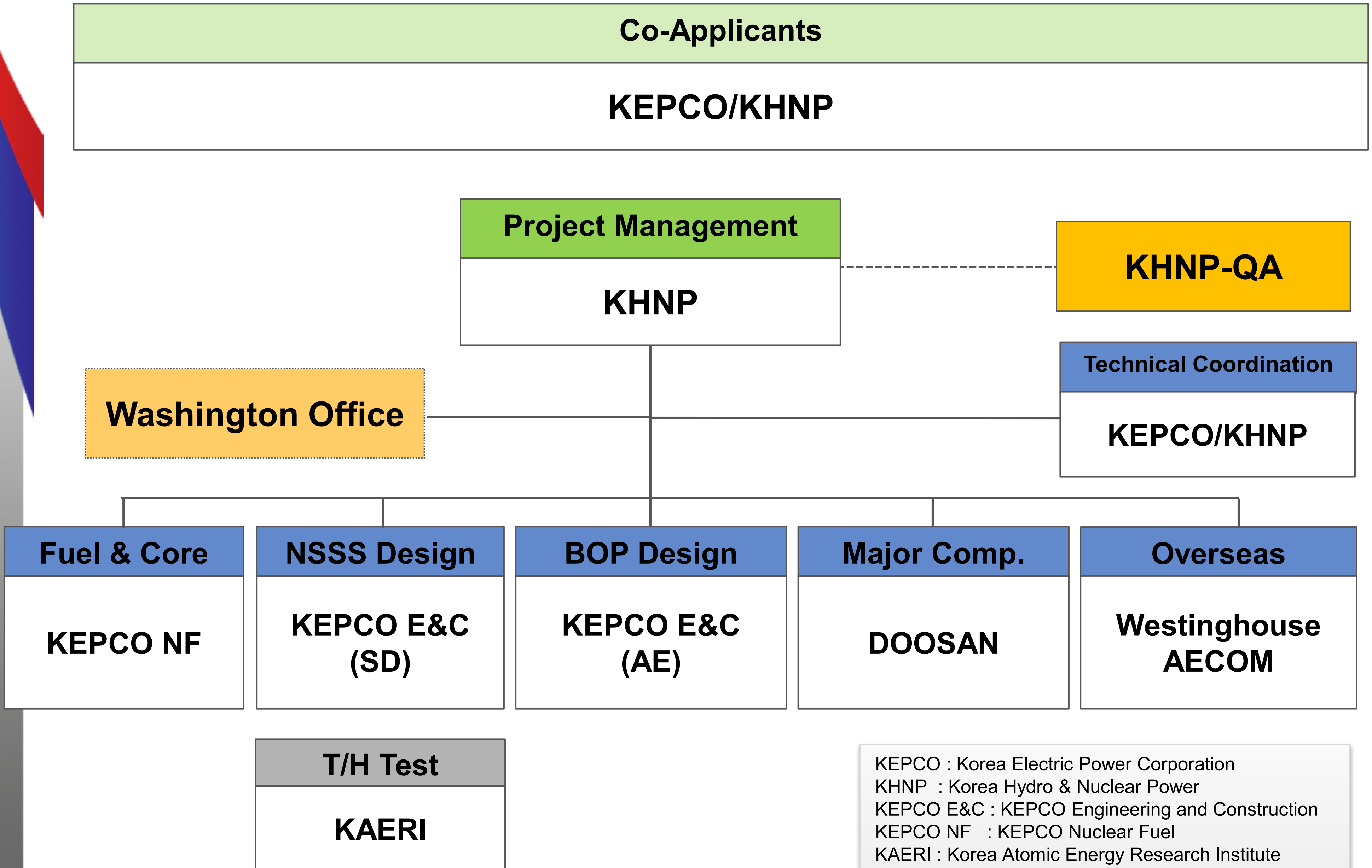
Nuclear Power Plants in Korea

In Operation	24 Units	21,716 MW
Under Construction	4 Units	5,600 MW
Planning	6 Units	8,600 MW



NON-PROPRIETARY

Project Organization



NON-PROPRIETARY

Project History and Progress

- [Mar. 2009] Submittal of the Intent of APR1400 DC Application to US NRC
- [Apr. 2010~Oct. 2014] Performed total 18 PARMs
- [Dec. 2014] Submittal of the APR1400 DC application to the US NRC
- [Mar. 2015] Receive the Docketing letter of APR1400 DC application
- [Apr. 2015] Receive the First RAIs[Ch. 2 & 3]
- [Jan. 2016] Finished Phase I Review

0-21. 2016)

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

NRC NEWS
Office of Public Affairs, Headquarters
Washington, DC. 20555-0001
www.nrc.gov ■ opa.resource@nrc.gov

No: 15-012 March 4, 2015
CONTACT: Scott Burnell, 301-415-8200

NRC To Begin Full Certification Review of APR1400 Reactor

The Nuclear Regulatory Commission has docketed for review Korea Electric Power Corp. and Korea Hydro and Nuclear Power's application to certify the APR1400 reactor design for use in the United States.

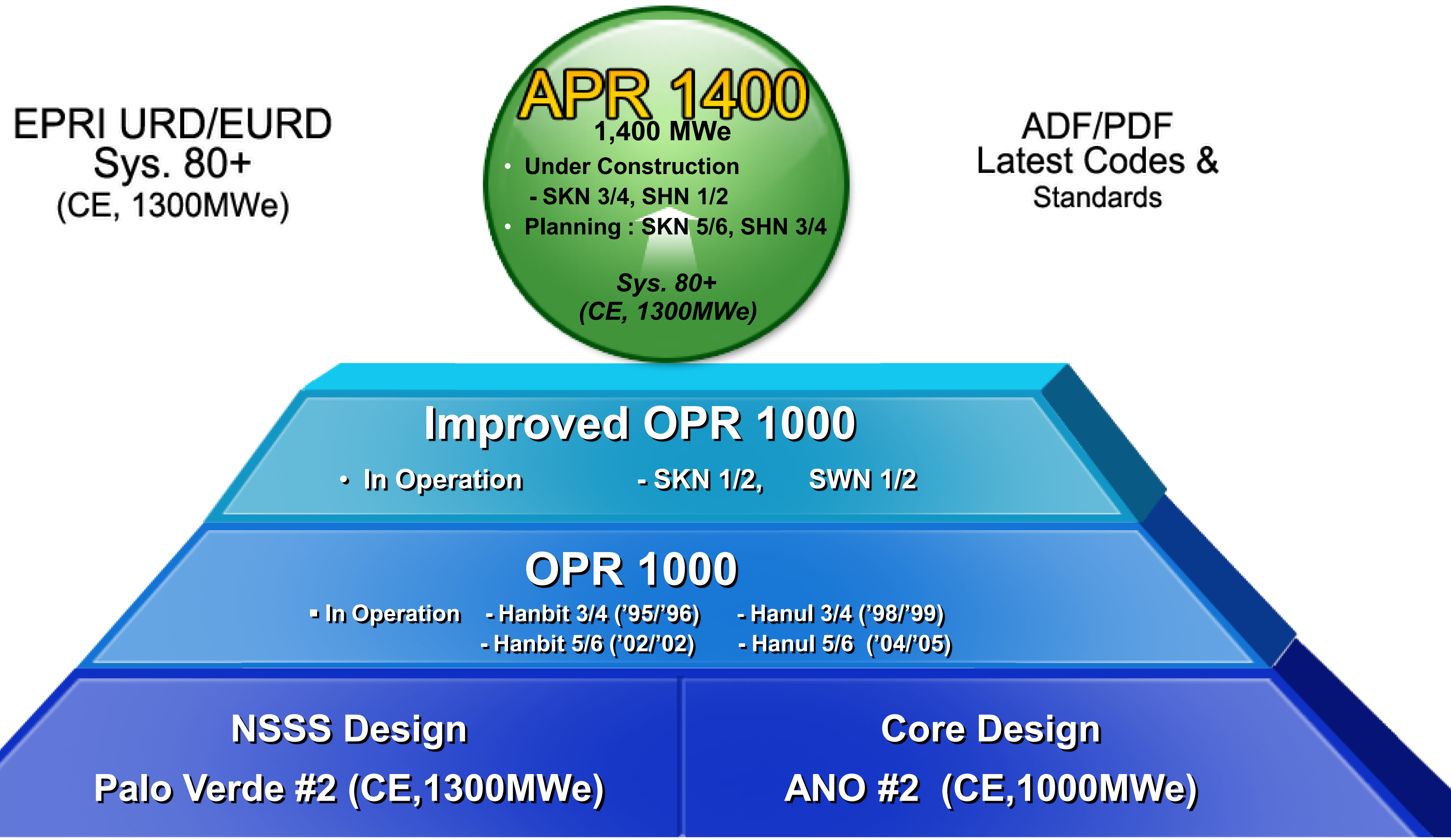
Contents

- Introduction
  - NPPs in Korea
  - Project History
- **Design Features & General Arrangement**
- Design Review Status
- Summaries

NON-PROPRIETARY

Development history of APR1400

- Development of Advanced Power Reactor 1400 (1992~2002)
- Licensing agreement with ABB-CE



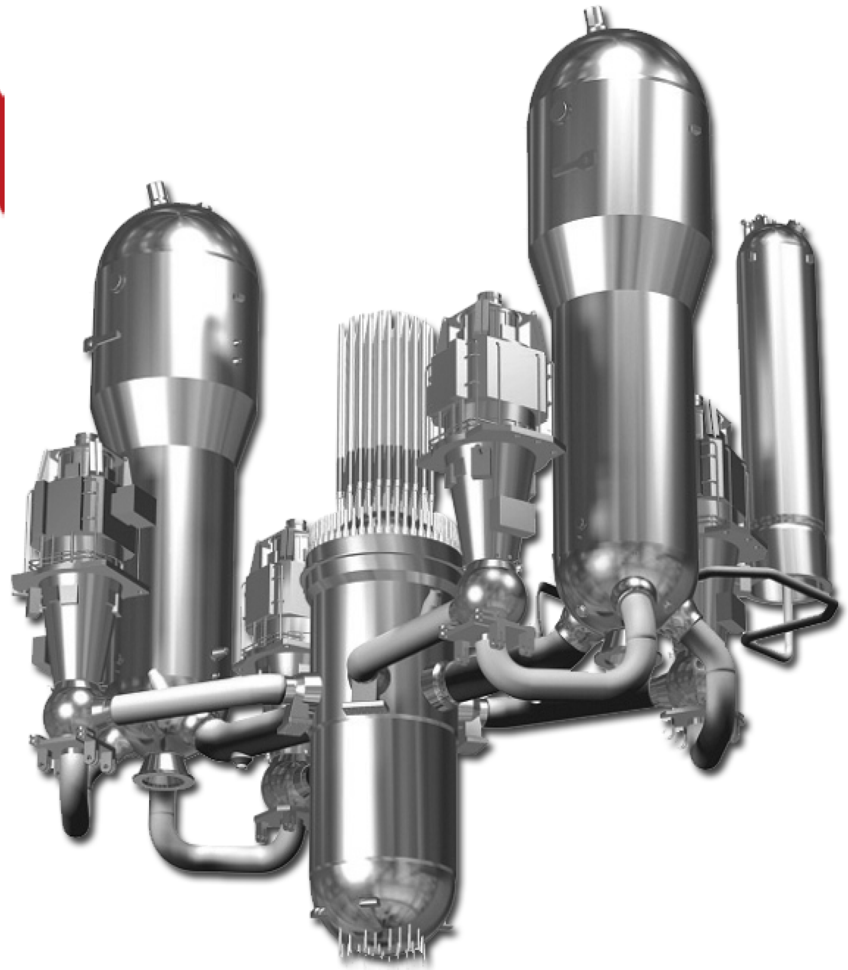
APR1400 Design Features

- **APR1400 referenced Shin Kori Units 3&4.**
- **APR1400 is an essentially complete design**
  - Construction completed in Korea (Shin Kori Units 3 & 4)
    - OL for Shin Kori Unit 3 issued on October 2015
    - Criticality reached on December 2015
  - Under-construction in UAE (Barakah Units 1 - 4)
    - OL for Barakah Unit 1 scheduled for October 2016

SKN 3&4, Korea

Barakah 1&2, UAE

Design Features of the APR1400



- Design Life Time : 60 Years for Class 1 Major Equipment
- Power : 4000MWth / 1400MWe
- Two-Loop : 2 HLs, 2 SGs, 4 RCPs, 4 CLs, 1 Pzr
- Primary Operating condition:
  - Pressure : 2250psia
  - HL/CL Temp. : 615/555 °F
- Secondary Operating condition:
  - Pressure : 1000psia
  - MF/MS Temp. : 450/545 °F
- Pzr Free volume : 2400 ft^3
- SG U-tube : 13102/SG, I690

APR1400 for NRC DC(1/2)

Basic approach of design change for NRC DC

- **Retain reference plant design (SKN 3&4)**
  - To take advantage of proven safety and performance
- **Meet US NRC Regulation Guidance effective on Aug. 2014**
  - Six month before the target docketing date

APR1400 for NRC DC(2/2)

Special Design Considerations for NRC DC

- **Enhance SBO coping capability**
  - Gas turbine generator for AAC source, 16 hr battery(Train C/D), FLEX implementation
- **Improve the tolerance to the beyond design basis**
  - Analysis of aircraft impact by 10CFR50.150
  - Application of LOLA (loss of large area) design requirement
  - Application of physical security requirement
- **Robust design for the design base accidents**
  - GSI-191 for LBLOCA
  - Diverse reactor protection systems for common cause failures
  - Application of FEM model to seismic design

NON-PROPRIETARY

Design Differences between APR1400 and System 80+

SIS: safe injection system
DVI: direct vessel injection
POSRV: pilot operated safety relief valve
IHA: integrated head assembly
CFS: core flooding system
PAR: passive autocatalytic recombiner
IVR: in-vessel retention
ERVC: external reactor vessel cooling

Containment
- System80+ : Spherical Steel
- APR1400 : Cylindrical PS Concrete

Thermal Power
- System80+ : 3,931 MWt
- APR1400 : 4,000 MWt

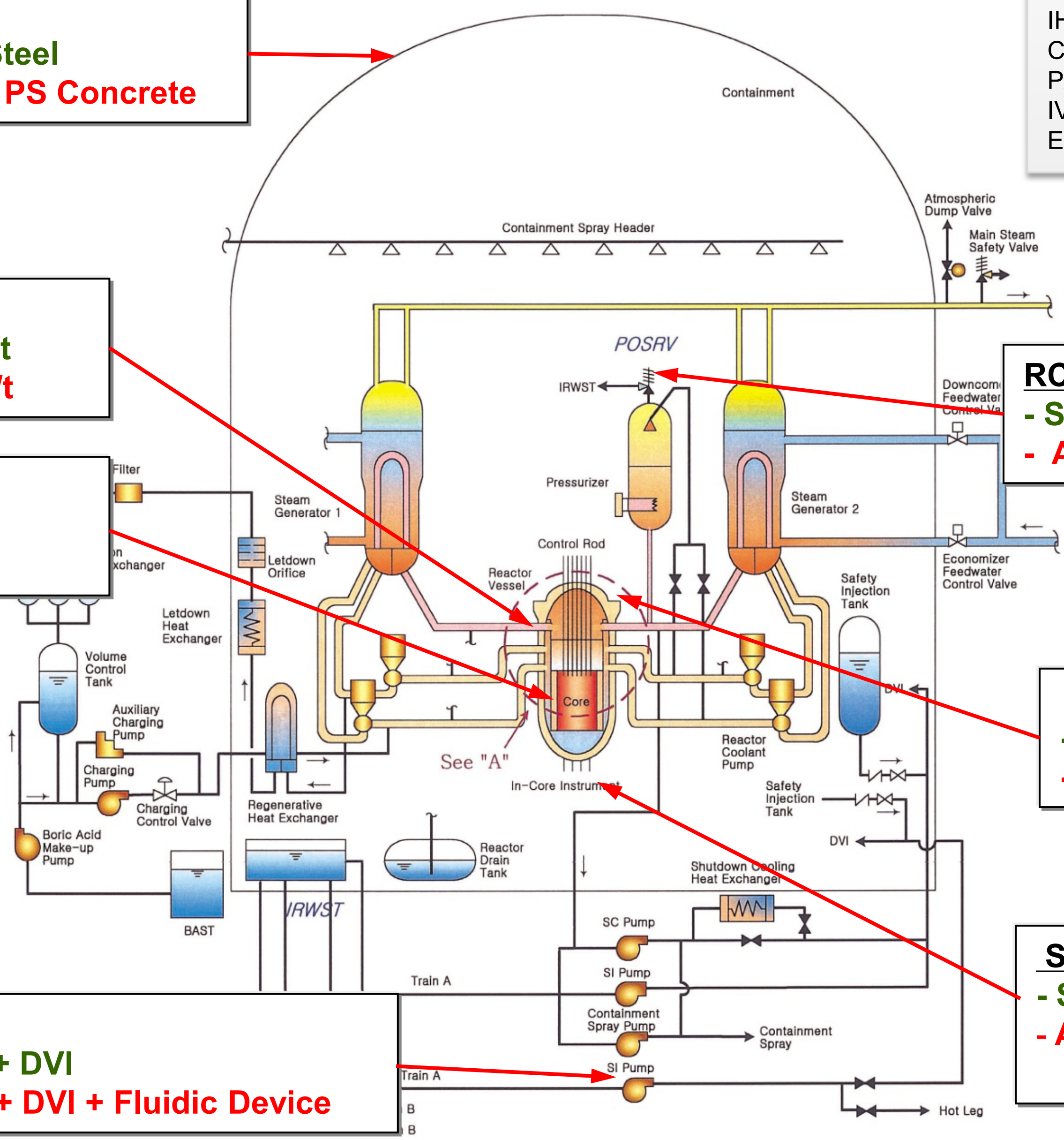
Hot-leg Temp.
- System80+ : 621F
- APR1400 : 615F

RCS OPP / RD System
- System80+ : 4 PSV + 2 SDS
- APR1400 : 4 POSRV

RV Upper Structure
- System80+ : Conventional
- APR1400 : IHA

Severe Accident
- System80+ : CFS
- APR1400 : CFS + PAR, IVR/ERVC

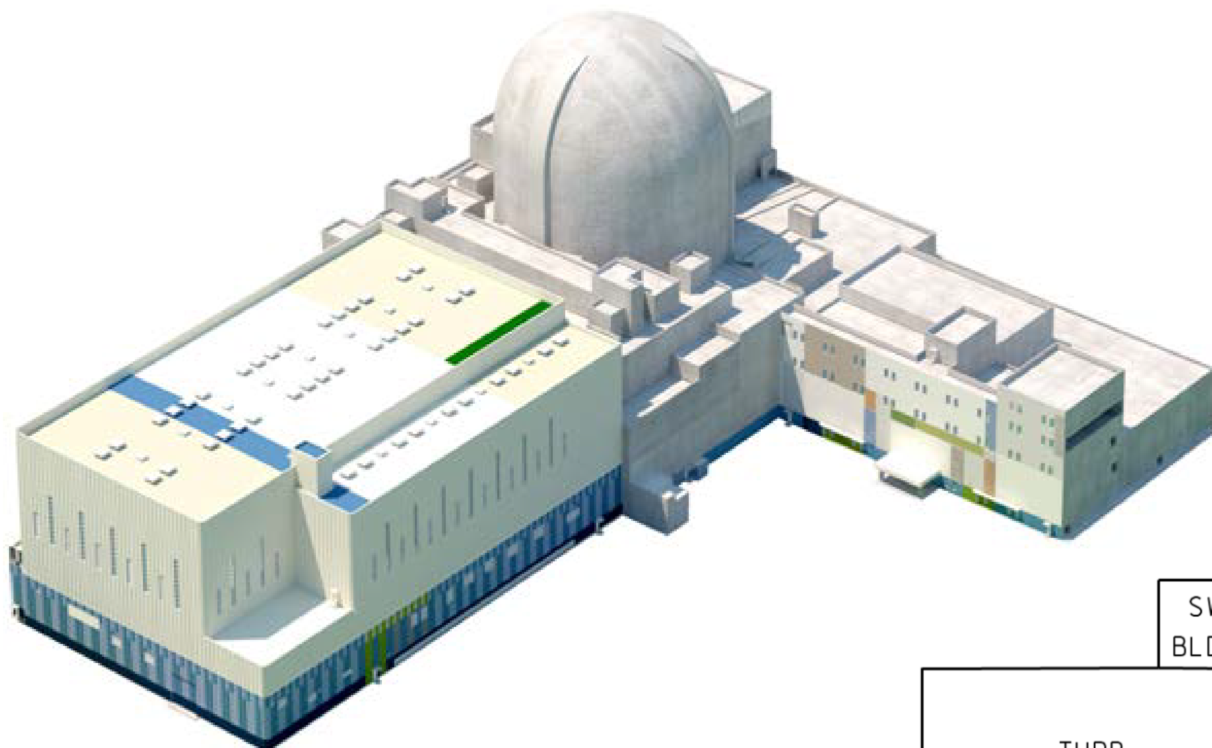
Safety Injection System
- System80+ : 4 train SIS + DVI
- APR1400 : 4 train SIS + DVI + Fluidic Device

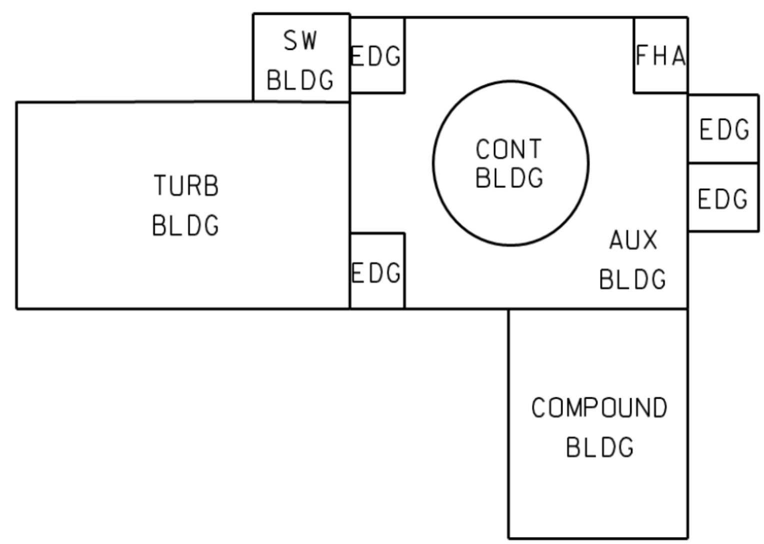


NON-PROPRIETARY

General Arrangement (1/4)

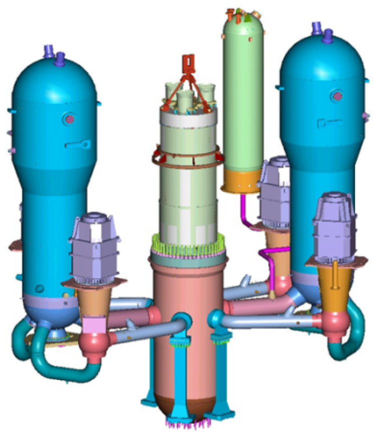
Plant General Arrangement

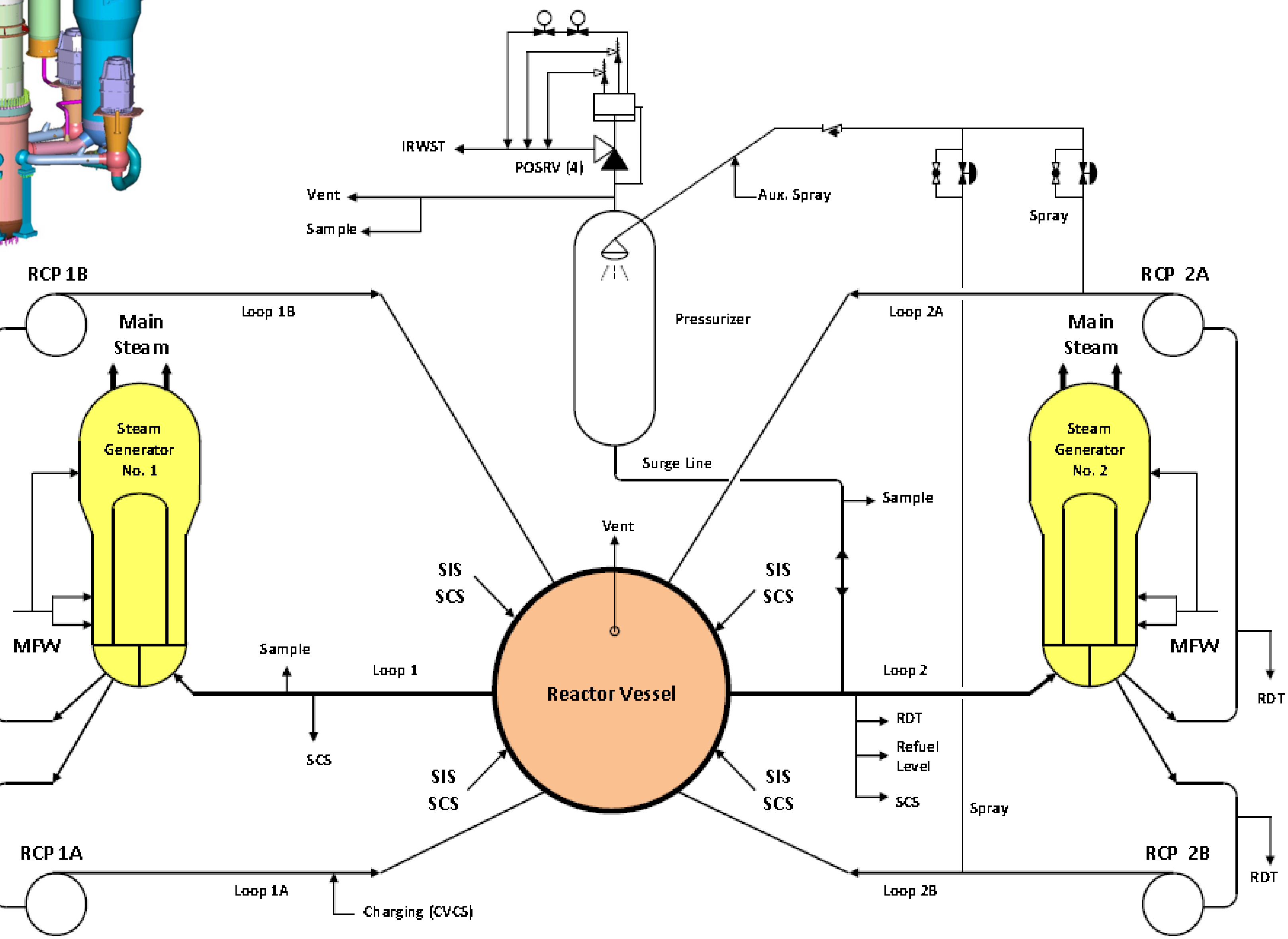




General Arrangement (3/4)

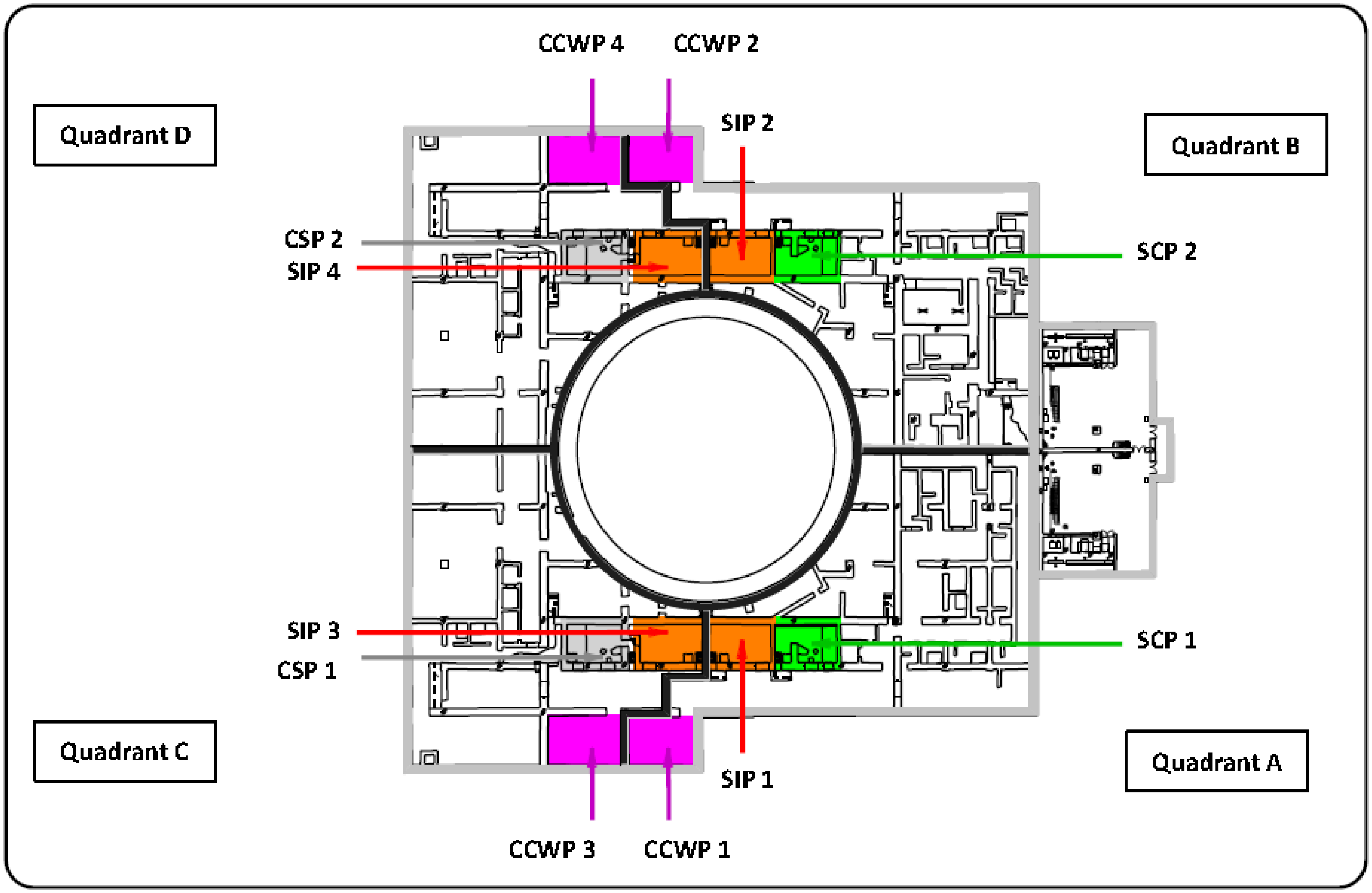
RCS Arrangement Plane





General Arrangement (4/4)

Quadrant Arrangement of Aux. Building



SIP : Safety Injection Pump
SCP : Shutdown Cooling Pump
CSP : Containment Spray Pump
CCWP : Component Cooling Water Pump

Contents

NON-PROPRIETARY

Design Review Status

Task	Description	Target Date
Phase Ⅰ	PSER and RAI Completed	Feb. 2016 Jan. 29 2016
Phase Ⅱ	SER with Open Items	Nov. 2016
Phase Ⅲ	ACRS Review of SER with Open Items	Jun. 2017
Phase Ⅳ	Advanced SER with No Open Items	Dec. 2017
Phase Ⅴ	ACRS Review of Advanced SER with No Open Items	Jun. 2018
Phase Ⅵ	Final SER with No Open Items	Sep. 2018

NON-PROPRIETARY

Interaction with NRC

- Regular meeting
  - ✓ Bi-Weekly PM Conference Call
  - ✓ Bi-Weekly Conference Call for PRA Issues
  - ✓ Bi-Weekly Conference Call for Ch.3 Issues
  - ✓ Bi-Weekly Conference Call for Ch.15
  - ✓ Bi-Weekly Conference Call for Ch.9
- Clarification meeting
  - ✓ Phone call or face-to-face meeting frequently
- Drop-in meeting
  - ✓ Staff in WDCC visits NRC to coordinate issues
- Audit
  - ✓ Design documents, Piping, Computer code V/V. etc.
- QA inspection
  - ✓ GSI-191 issue : 4 findings
  - ✓ Computer codes : 4 observations

NON-PROPRIETARY

Contents

- Introduction
  - NPPs in Korea
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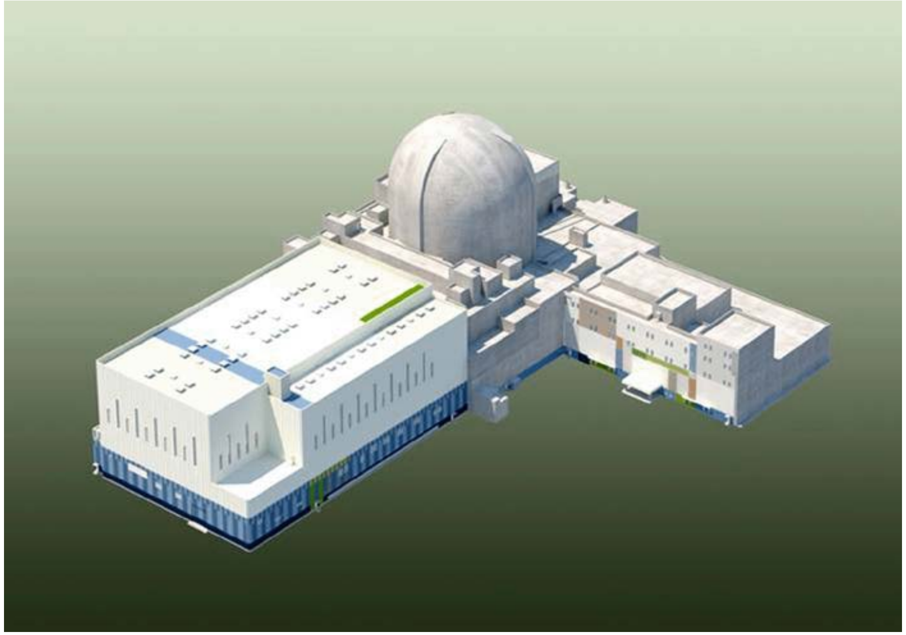
- Design Review Status
- **Summaries**

Summaries

- The APR1400 adopted proven technologies from the operation of OPR1000.
- The APR1400 used safety analysis codes and methodologies of the certified System 80+.
- The APR1400 standard design approval was issued by Korean regulatory authority in 2002.
  - The first two units of the APR1400, Shin-Kori Units 3 & 4, are being constructed and their commercial operations are under preparation.
- The APR1400 is an essentially complete design.

Thank you

APR1400 NSSS Design

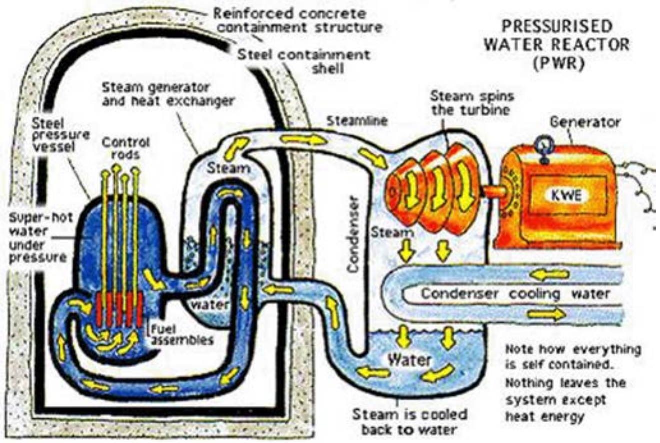


KEPCO/KHNP

April 20~21, 2016

Contents

NSSS Design Overview



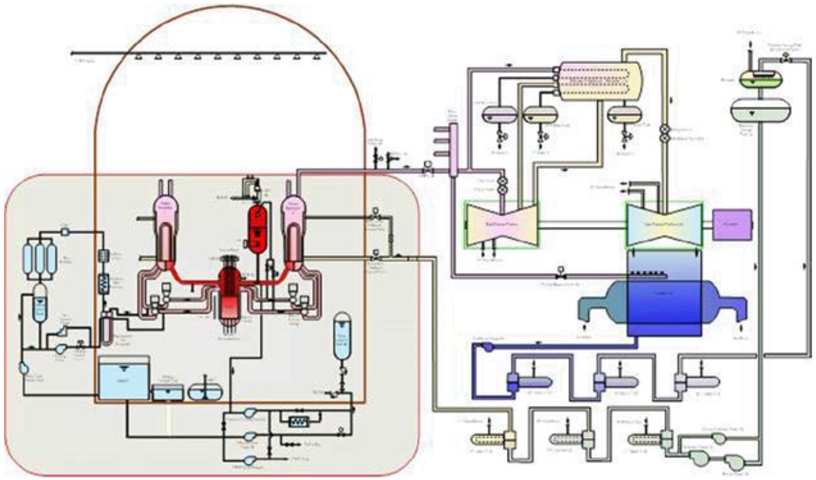
NSSS Design Overview

- **NSSS Design of APR1400**
  - is identical to that of Shin-Kori Unit 3 in the Republic of Korea, recently under the power ascension tests
  - is similar to the System 80+ Certified Design except for unique design features
  - is consistent with the regulations of the United States of America
  - adopts the industry codes and standards applicable in the United States of America

NSSS Design Overview

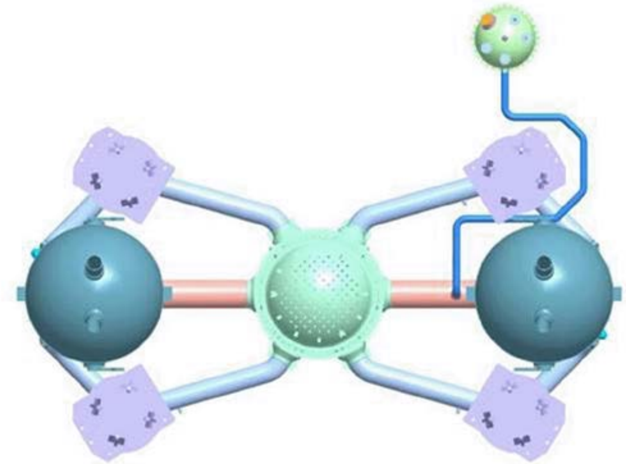
- **Regulatory Bases of APR1400**
  - Compliance with US NRC regulation documents
    - Code of Federal Regulations
    - Regulatory Guides
    - Standard Review Plan, NUREG-0800
    - Generic Letters and Bulletins
  - Compliance with the rules and regulations in effect as of September 2014 of the United States of America

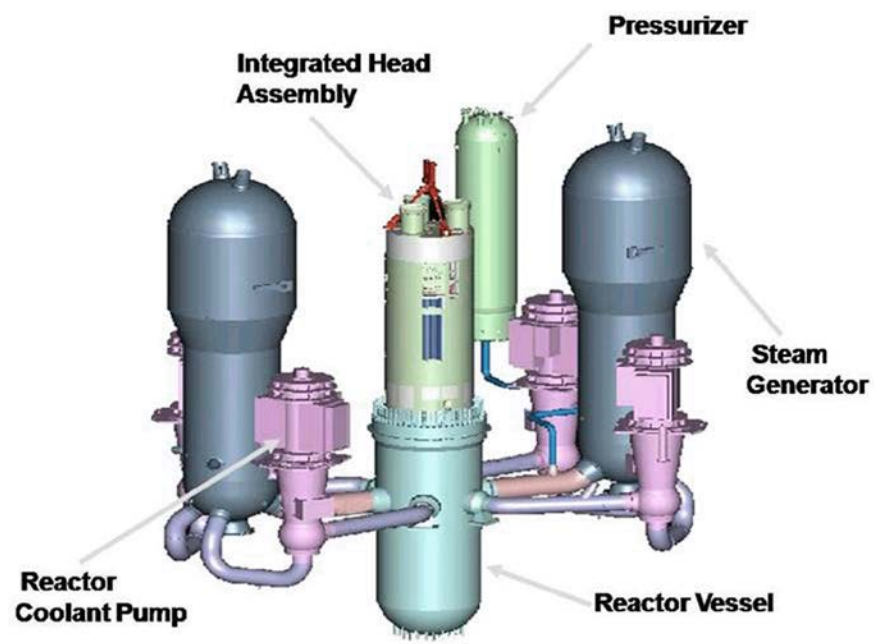
Major NSSS Systems



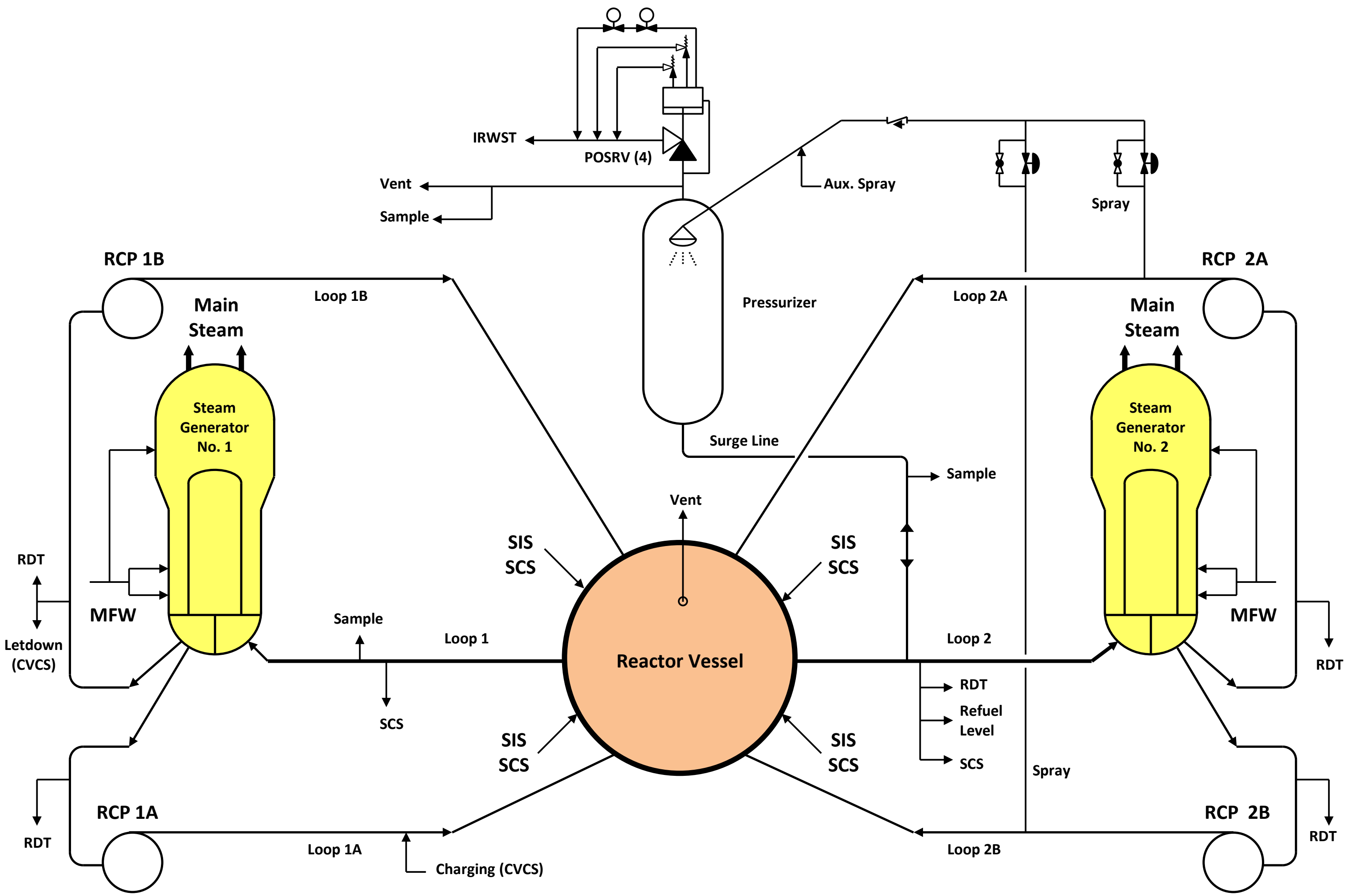
Reactor Coolant System (RCS)

- RCS Configuration
  - 2-loop
  - Reactor Vessel
    - Integrated Head Assembly
  - Steam Generators : 2
  - Reactor Coolant Pumps : 4
  - Pressurizer
    - POSRVs : 4
  - Main piping
    - Hot leg pipes : 2
    - Cold leg pipes : 4
    - Suction pipes : 4
    - Surge line : 1



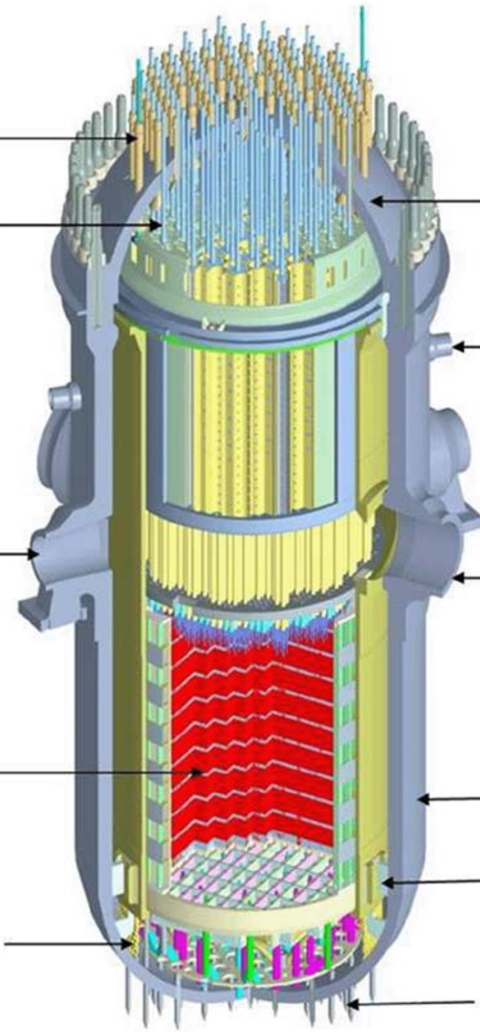


RCS Schematic Diagram



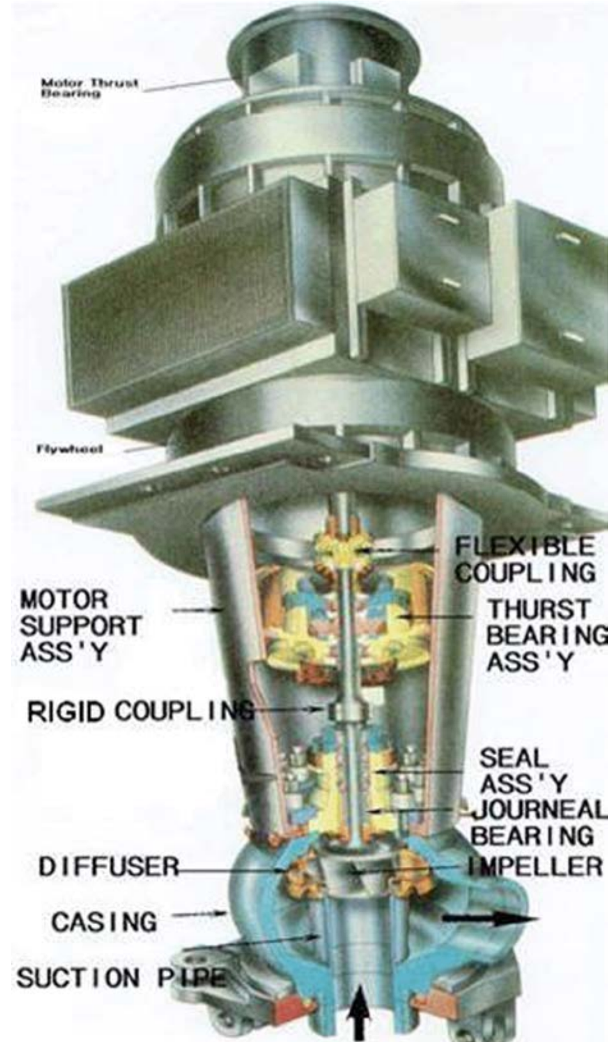
Reactor

- **Reactor Vessel**
- **Reactor Internals**
  - Upper Guide Structure Assembly
  - Core Support Barrel Assembly
- **Reactor Core**
  - Fuel Assembly
  - Control Element Assembly



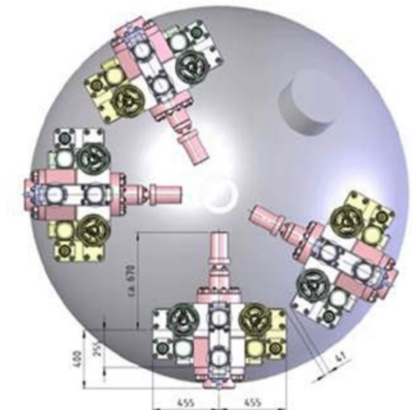
Reactor Coolant Pump

- **Motor driven, Single-stage Centrifugal Pump**
  - Bottom suction and radial discharge
- **Flexible Coupling of Shaft to the Motor**
  - Low vibration and noise
- **Pump Flywheel**
  - Sufficient coastdown flow following loss of power to the pumps
- **RCP Shaft Seal System**
  - Three stage mechanical seals
  - Cooled by seal injection water and high pressure water cooler



Pressurizer

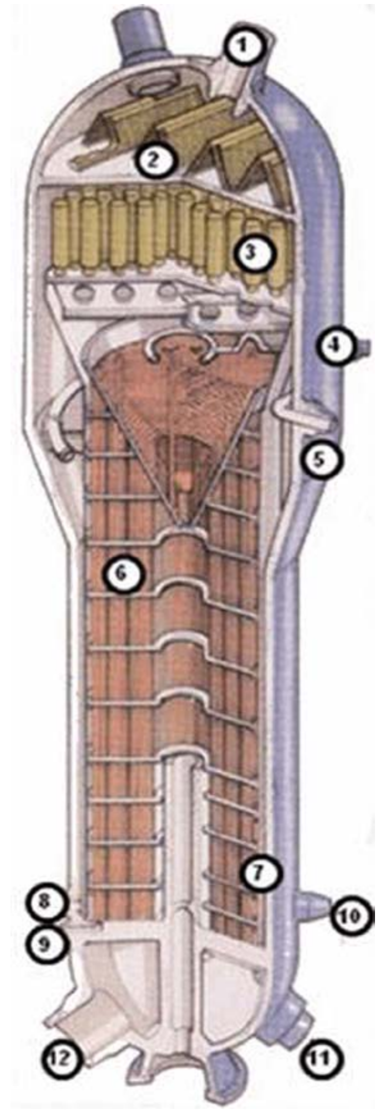
- **RCS Pressure and Volume Control**
  - Sufficient capacity to accommodate pressure and volume changes due to operational transients without opening the safety valves
- **Four Pilot Operated Safety Relief Valves (POSRVs)**
  - Overpressure protection of RCS
  - Manual rapid depressurization of RCS to initiate Feed-and-Bleed operation in a total loss of feedwater event



<Top view>

Steam Generator

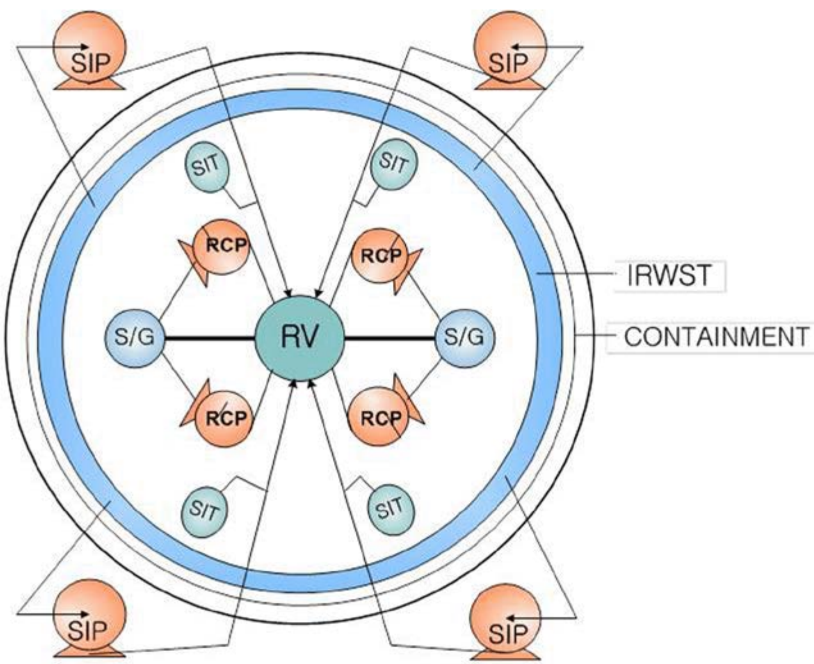
- **Vertical, U-tube, Recirculation type**
- **Alloy 690 U-tubes**
  - **Resistant to primary water stress corrosion cracking**
- **Integral Economizer**
  - **Enhance thermal effectiveness**
- **Flow Restrictor**
  - **Limit steam flow in the unlikely event of a main steam line break**



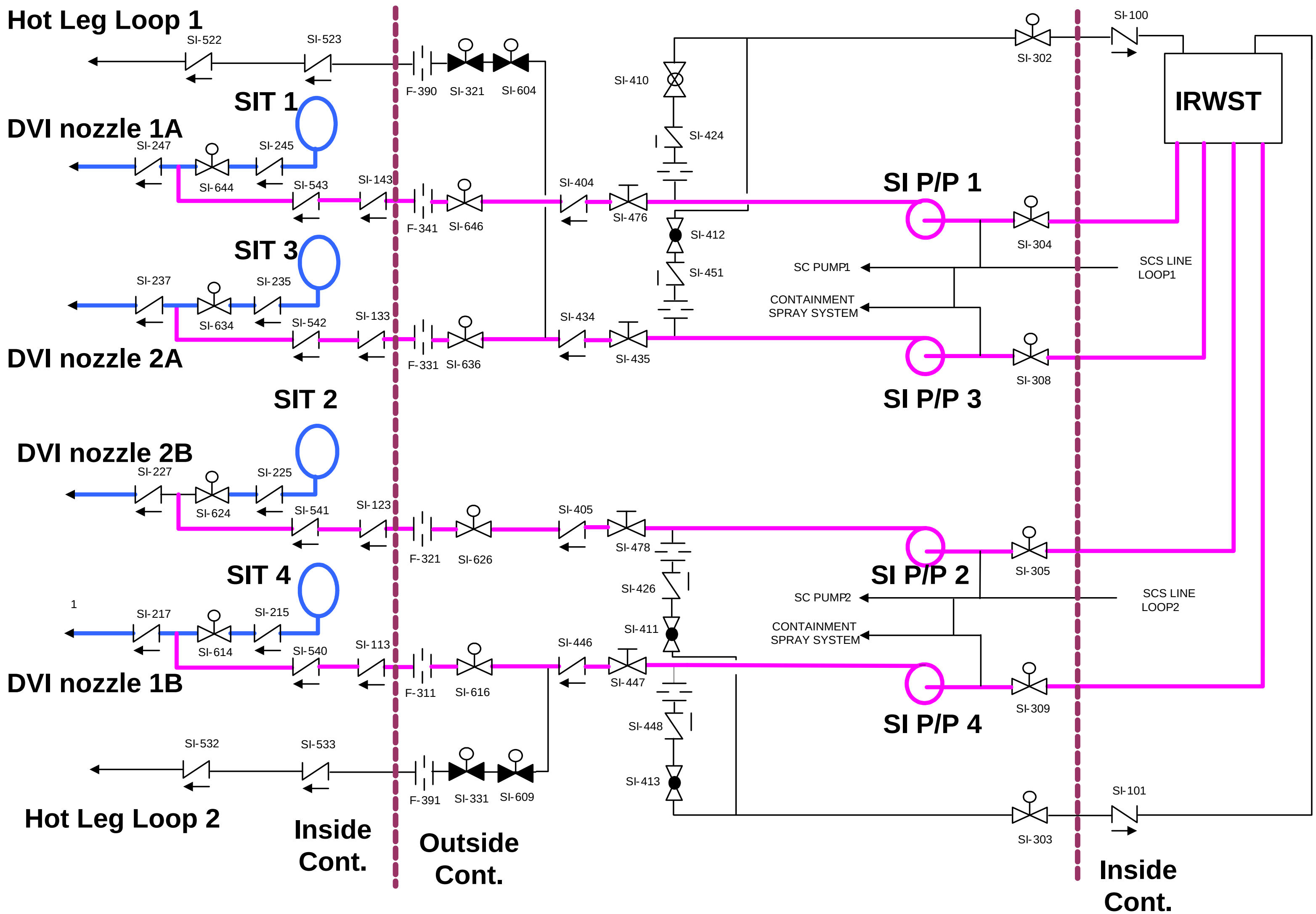
1. Steam Nozzles
2. Steam Dryers
3. Steam Separators
4. Recirculation Nozzle
5. Downcomer Feedwater Nozzle
6. Heat Transfer Tubes
7. Economizer
8. Lancing Hole
9. Blowdown Nozzles
10. Economizer Feedwater Nozzles
11. Primary Outlet Nozzles
12. Primary Inlet Nozzle

Safety Injection System

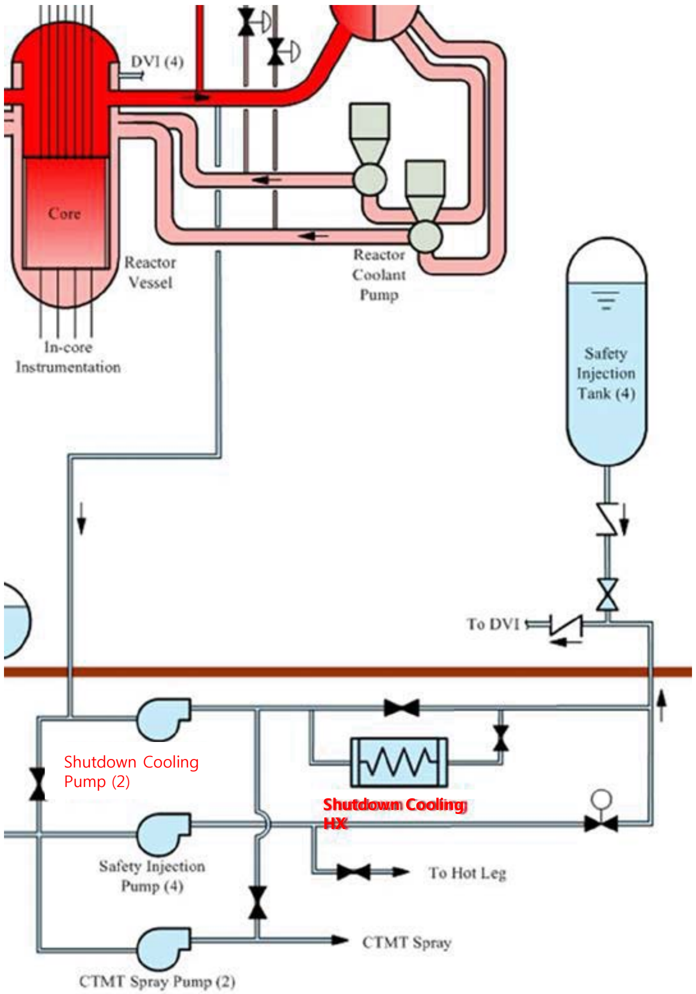
- System Function
  - Emergency Core Cooling
  - Reactivity and Inventory Control
  - Feed-and-Bleed Operation
- SIS Design
  - SIS consists of four mechanically and electrically separated trains.
  - Borated water is injected directly to the reactor vessel.
  - Borated water source is taken from In-containment Refueling Water Storage Tank (IRWST).



SIS Flow Diagram

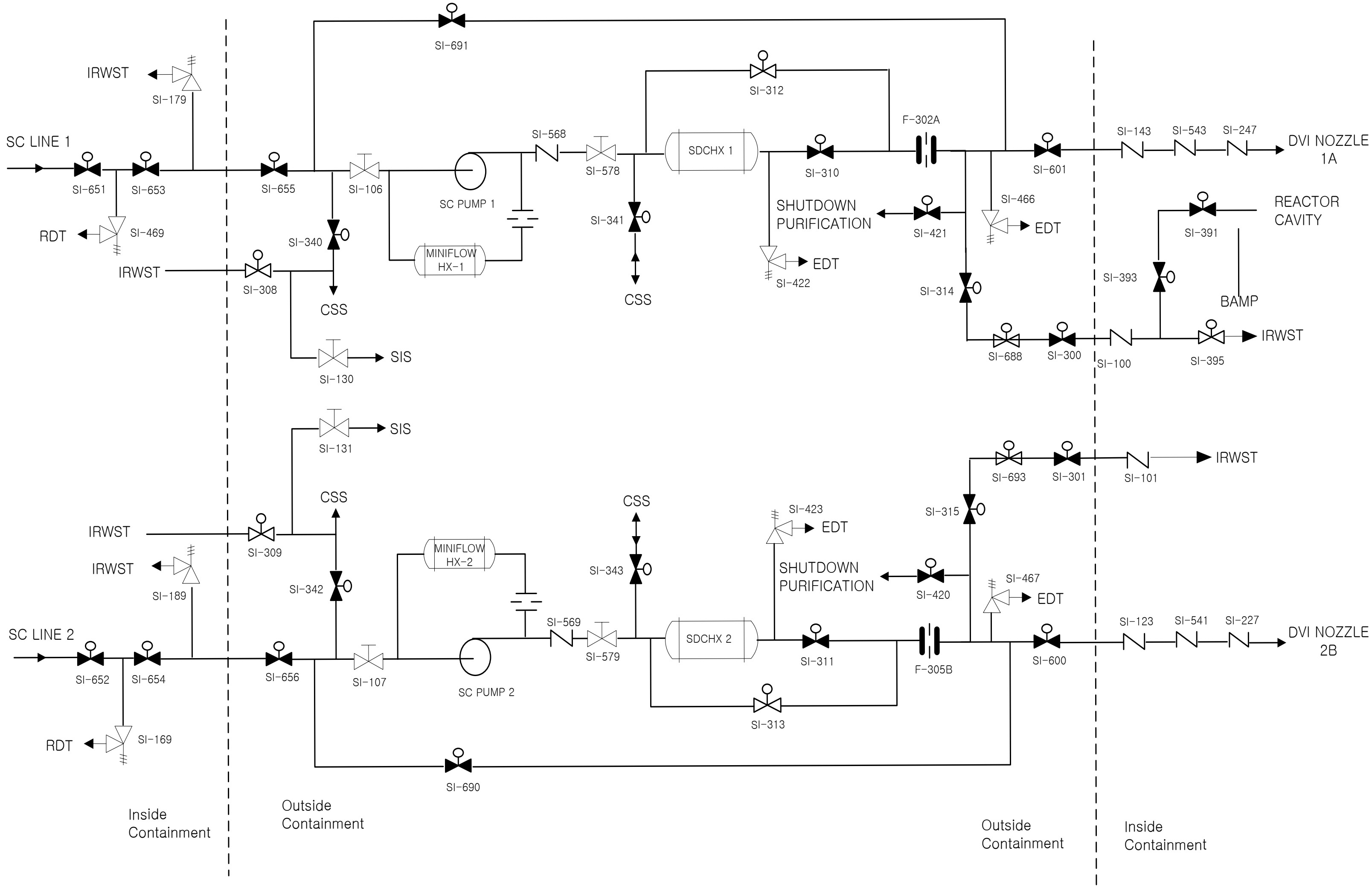


Shutdown Cooling System (SCS)

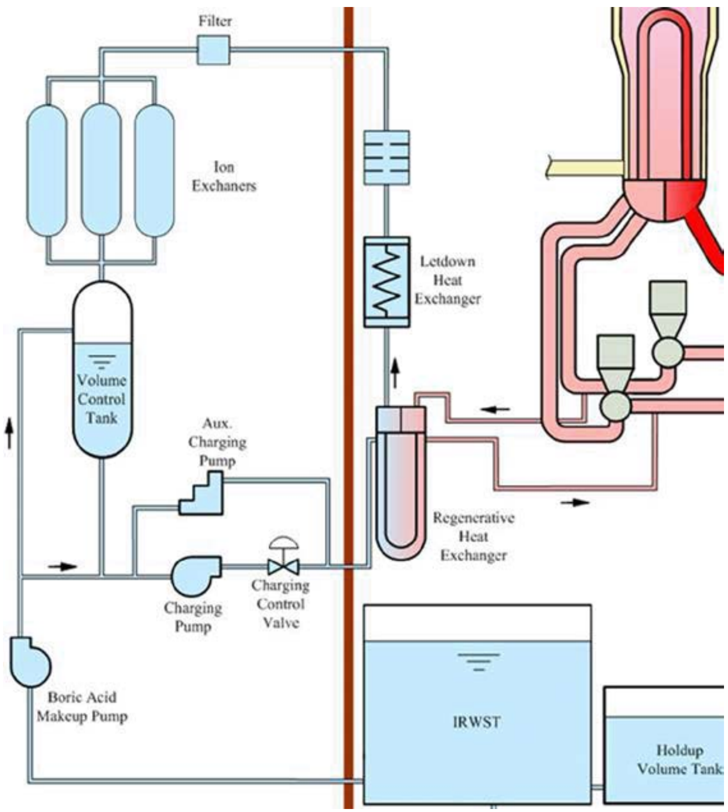


- System Function
  - Decay Heat Removal
- SCS Design
  - SCS consists of two mechanically and electrically separated trains.
  - Shutdown Cooling Pump is interchangeable with Containment Spray Pump.
  - SCS suction line relief valves provide RCS low temperature overpressure protection.

SCS Flow Diagram

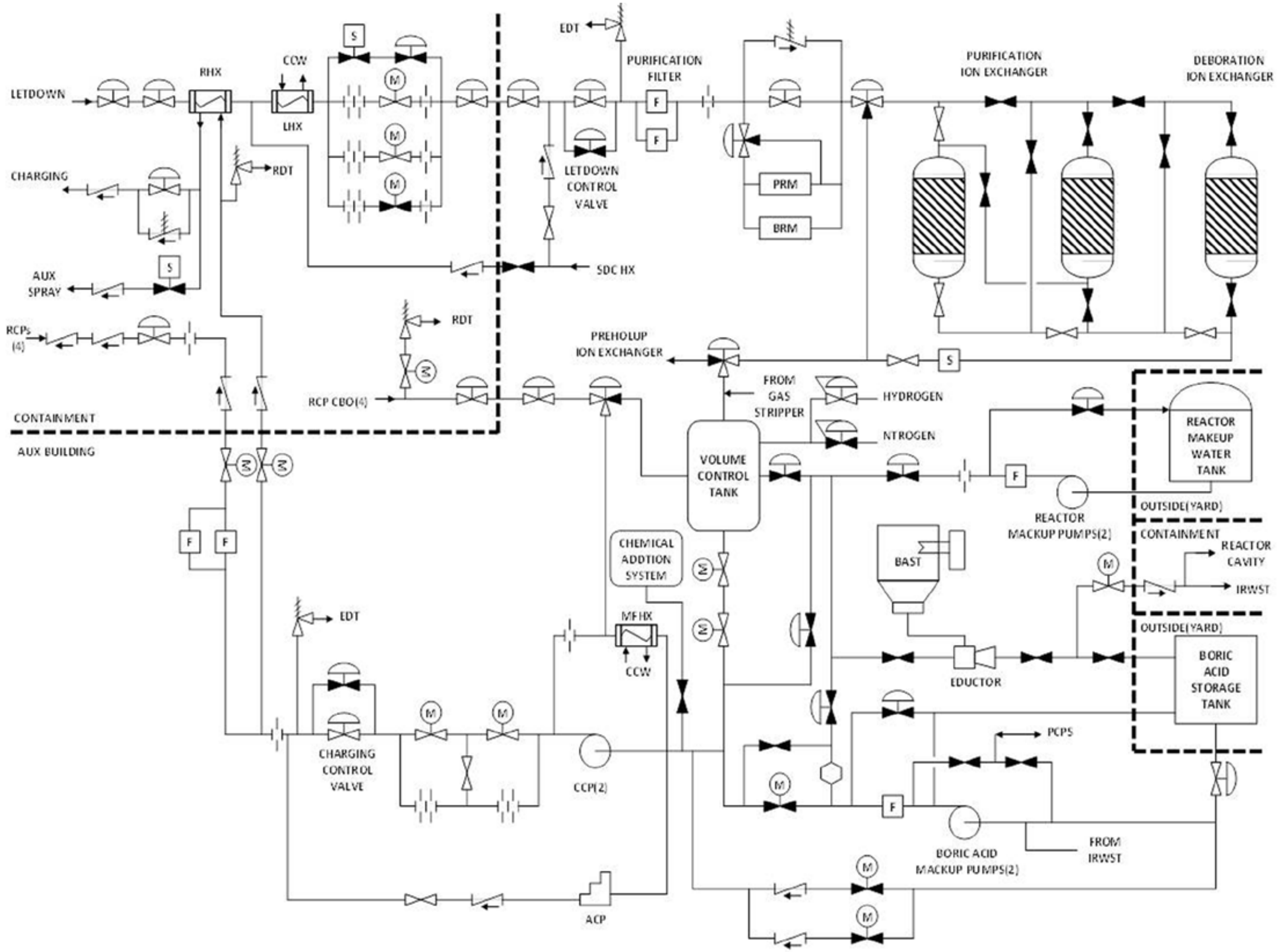


Chemical & Volume Control System (CVCS)



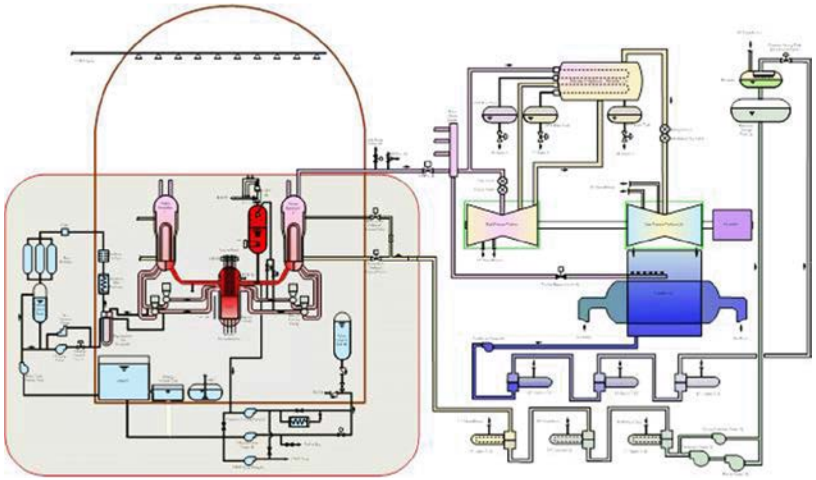
- **System Function**
  - **RCS Inventory (Volume) Control**
  - **RCS Chemistry Control**
  - **Reactivity Control**
  - **Other Functions**
    - **Auxiliary spray to the pressurizer**
    - **Seal injection to the RCPs**
- **CVCS Design**
  - **CVCS consists of charging pumps, auxiliary charging pump, regenerative heat exchanger (HX), letdown HX, filters, ion exchangers, volume control tank, valves, etc.**

CVCS Flow Diagram



Unique Design Features

- Safety Injection Tank with Fluidic Device
- Pressurizer Pilot Operated Safety Relief Valve

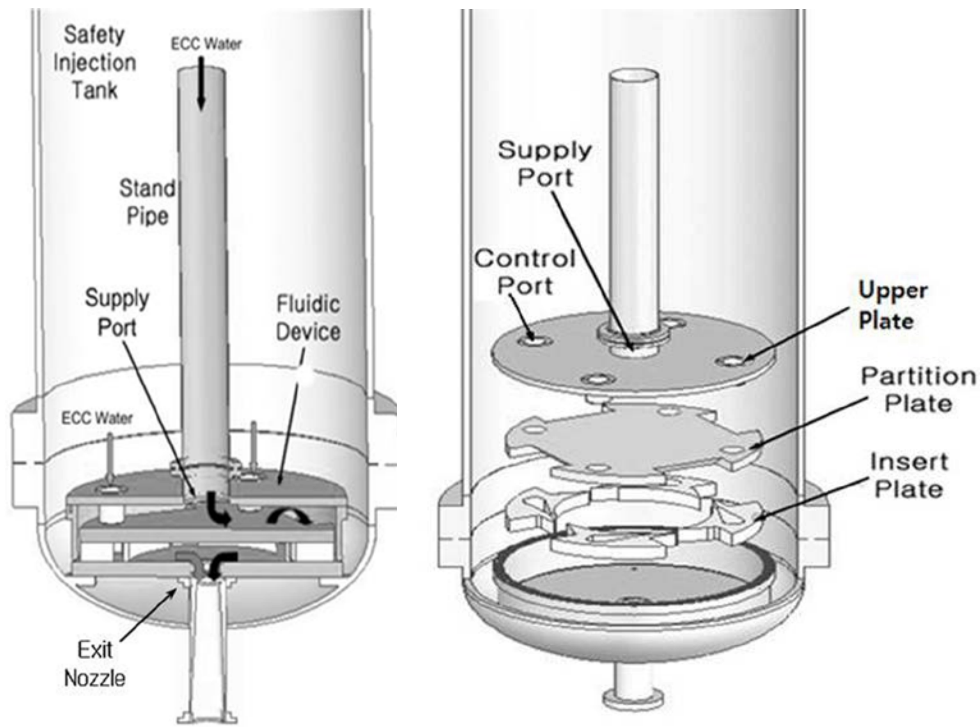


Safety Injection Tank with Fluidic Device

- **Safety Injection Tank (SIT) with Fluidic Device**
  - is an accumulation tank partially filled with borated water and pressurized with nitrogen
  - provides inherent reliability to achieve a desired injection flow scheme without the need for any active components
  - controls injection flow rates during refill and reflood phases
  - ensures effective use of SIT water

Working Principles of Fluidic Device

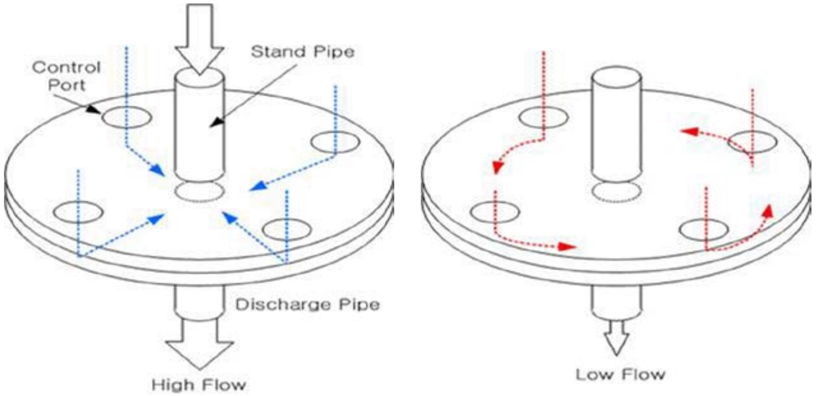
- **Structures of SIT with Fluidic Device**
  - Fluidic Device is installed at the bottom part of the SIT.
  - Fluidic Device has a supply port at the center and four control ports around the supply port.
  - Supply port is connected to a stand pipe.

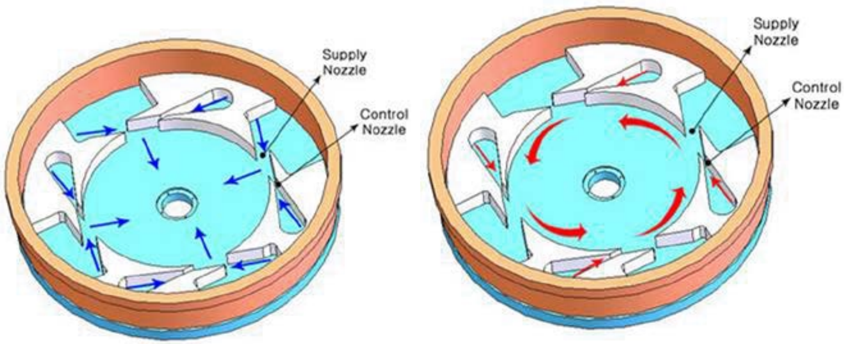


Working Principles of Fluidic Device

● Typical Flow Pattern inside the Vortex Chamber

- SIT water entered through the supply port flows into the vortex chamber through four supply nozzles.
- SIT water entered through the four control ports flows directly into the vortex chamber through four control nozzles.
- When SIT water is only injected through the control nozzles, SIT water is injected tangentially into the vortex chamber, establishing a strong swirling flow.
- When SIT water is delivered through both the supply and control nozzles, the flows through each supply nozzle and a neighboring control nozzle collide each other, resulting in no swirling flow.





Large Flow Rate　　Small Flow Rate

Performance Test of Fluidic Device

- **Full scale test by Korea Atomic Energy Research Institute in Korea**

Summary of Performance Test

- **A series of tests were performed to evaluate and verify the performance of SIT with Fluidic Device of APR1400.**
  - **Repeatability with regard to the performance was confirmed.**
  - **Pressure loss coefficient is not materially affected by initial pressure and manufacturing tolerances.**
  - **Design requirements including the pressure loss coefficient are met for both large and small flow injections.**
- **Topical Report for Fluidic Device Design for the APR1400 (APR1400-Z-M-TR-12003-NP) has been submitted on January 2013. Advanced TR Safety Evaluation is issued on April 2016.**

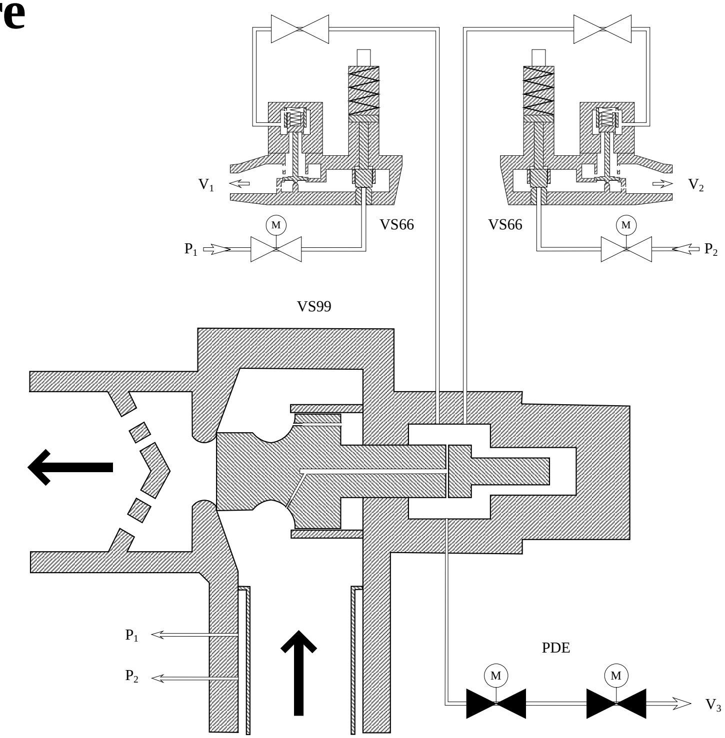
Design Features of POSRV

- **Design Characteristics of Pilot Operated Safety Relief Valve (POSRV)**
  - High seat tightness
  - Low possibility of chattering
  - Reliable for steam, water and two-phase discharge
  - Complicated installation and maintenance

- **POSRV Function**
  - Overpressure protection by automatic actuation of spring loaded pilot valves
  - Rapid depressurization by manual actuation of motor operated pilot valves

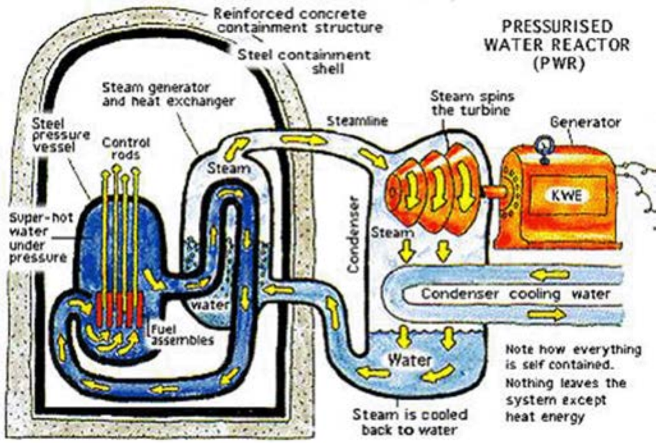
POSRV Assembly

- Main Valve (1)
- Spring Loaded Pilot Valve (SLPV) (2)
  - Automatic actuation for overpressure protection
  - Motor operated isolation valve
    - Normally open
    - Power removed
    - Closed in case of SLPV stuck open
  - Manual isolation valve
    - Isolation for SLPV test and maintenance
    - Locked open
- Motor Operated Pilot Valve (2)
  - Manual actuation for rapid depressurization
  - Two valves installed in series
    - Normally closed
    - Power removed



VS99 : Main Valve
VS66 : Spring Loaded Pilot Valve
PDE : Motor Operated Pilot Valves
M : Motor Operated Valve
V_i : Pilot Discharge
P_i : Impulse Line

Summary


Reinforced concrete containment structure
PRESSURISED WATER REACTOR (PWR)
Steel containment shell
Steam generator and heat exchanger
Steam spins the turbine
Steamline
Generator
Steel pressure vessel
Control rods
Steam
KWE
Super-hot water under pressure
Condenser
Steam
Water
Condenser cooling water
Fuel assemblies
Water
Note how everything is self contained. Nothing leaves the system except heat energy
Steam is cooled back to water

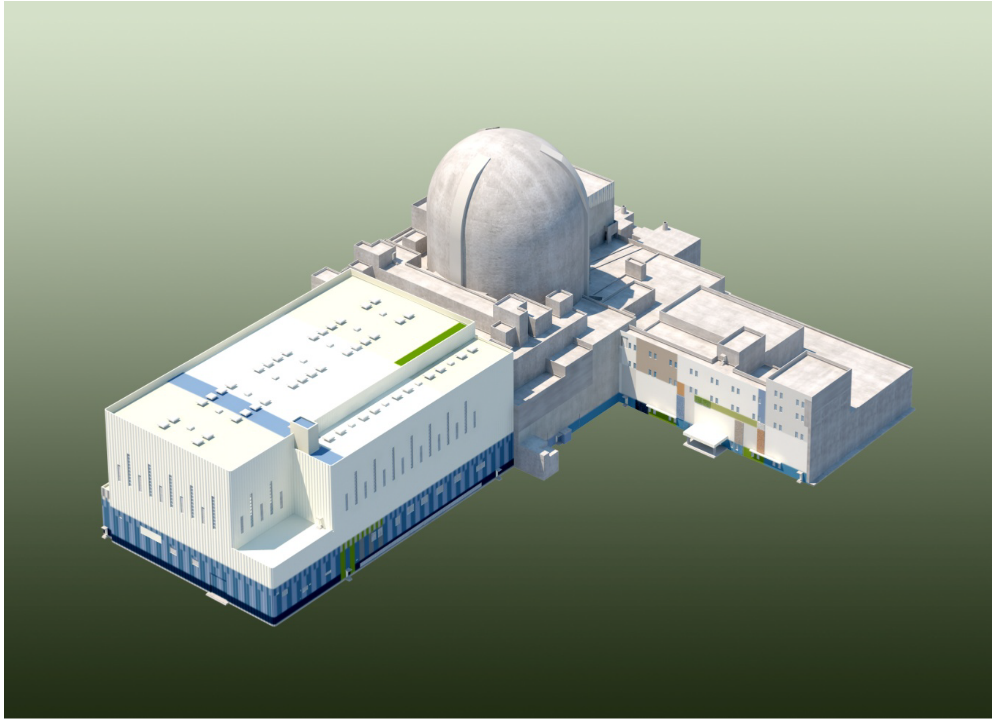
Summary

- APR1400 NSSS design complies with US NRC regulatory requirements.
- APR1400 SIT with Fluidic Device is an innovative design which ensures effective use of the SIT water. The SIT with Fluidic Device was verified in full scale test facility as well as in the pre-operational test of Shin-Kori Unit 3.
- The POSRV adopted in APR1400 provides dual functions of overpressure protection and rapid depressurization.

Thank you

NON-PROPRIETARY

APR1400 System Design (Fuel Design)



KEPCO/KHNP

Apr. 20~21. 2016

ACRS Meeting (Apr.20-21. 2016)

NON-PROPRIETARY

Contents

Introduction

(Ref. : APR1400-F-M-TR-13001-P Rev.0)

Introduction (PLUS7 Fuel Development)

- PLUS7 fuel design was jointly developed with Westinghouse for APR1400 in Korea (1999~2002).
- PLUS7 fuel was developed to improve the fuel performance compared to Guardian.

  (Guardian : Standard fuel design for System80+)
- KEPCO/KHNP submitted PLUS7 Topical Report and Technical Report to NRC for APR1400 DC licensing.
  - PLUS7 Fuel Design : APR1400-F-M-TR-13001-P Rev.0
  - Seismic/LOCA Analysis : APR1400-Z-M-NR-14010-P Rev.0

Introduction (Regulatory Bases)

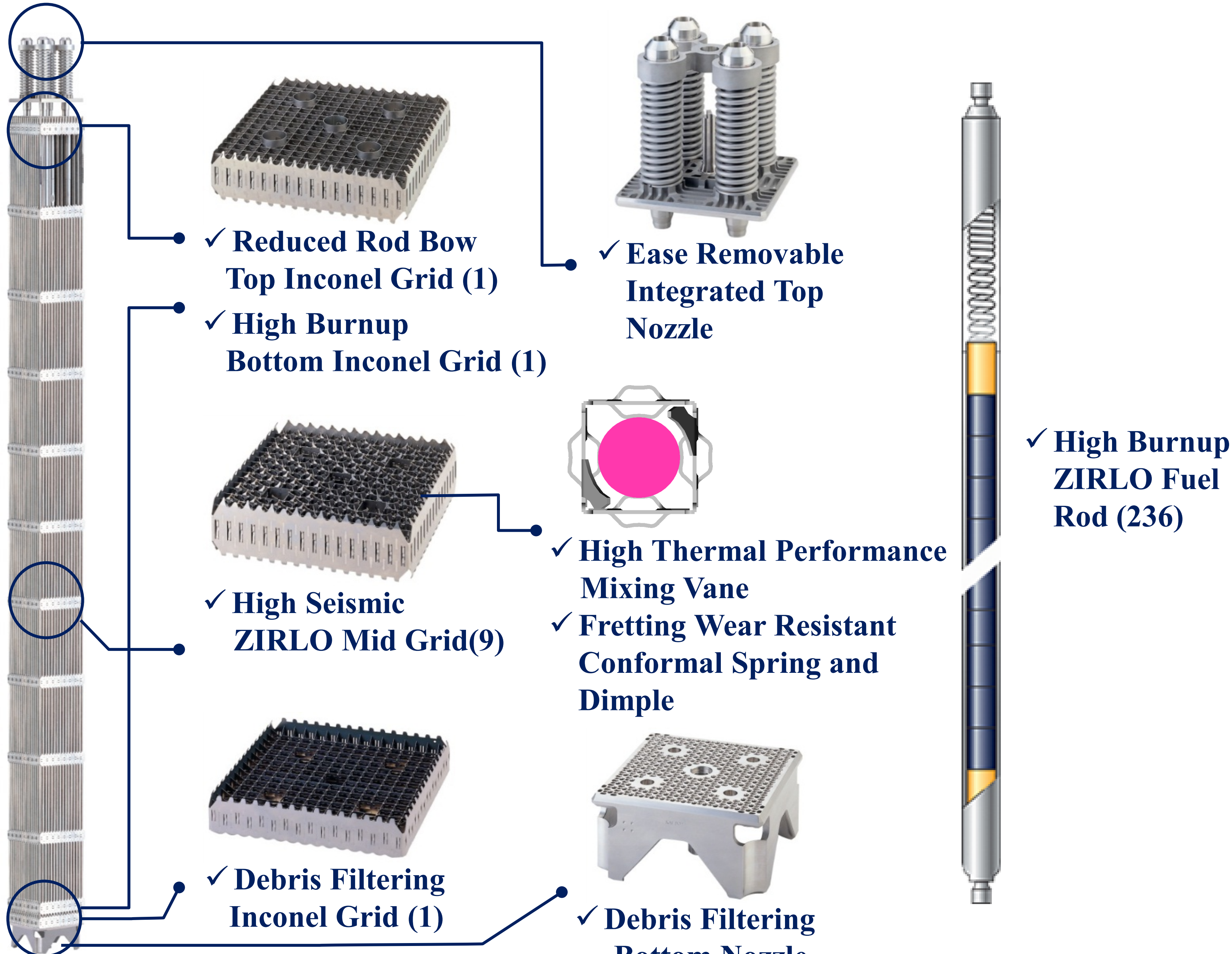
PLUS7 fuel design was developed to comply with following code of federal regulations, NRC regulatory documents, and industrial code and standards.

- **Code of Federal Regulations**
  - **10 CFR 50 Appendix A. GDC 10 Reactor Design**
- **NRC Regulatory Documents**
  - **NUREG-0800, SRP 4.2 Fuel System Design**
  - **IN 2012-09 Irradiation Effects on Fuel Assembly Spacer Grid Crush Strength, etc.**
- **Industrial Code and Standards**
  - **ASME B&PV Code Section Ⅲ**
  - **ANSI ANS 57.5 Plant Design Conditions, etc.**

PLUS7 Fuel Design

(Ref. : APR1400-F-M-TR-13001-P Rev.0)

PLUS7 Fuel Design (Characteristics)



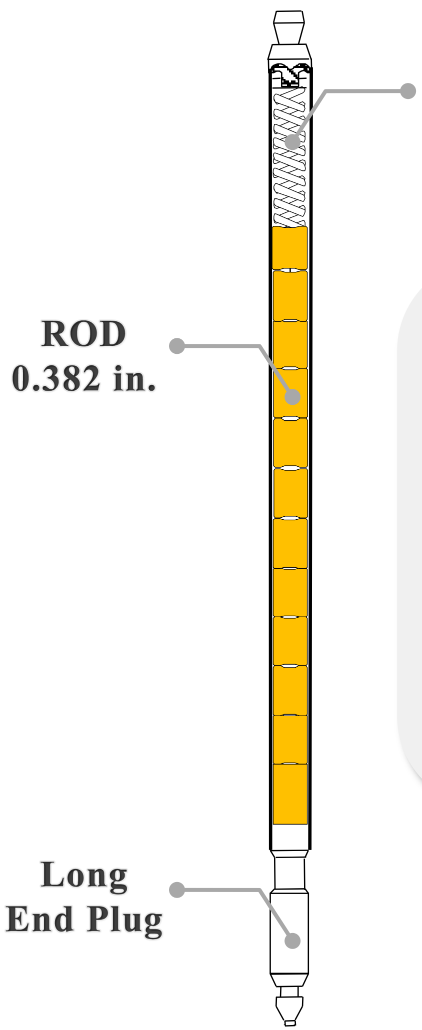
PLUS7 Fuel Design (Characteristics)

- **PLUS7 incorporated the proven Guardian structure and the proven Westinghouse type fuel features to improve fuel performance.**

Items		Guardian	PLUS7	Improvements
Cladding		Zry-4	ZIRLO	High Burnup Capability
Rod Diameter		0.382″	0.374″	Enhanced Neutron Economy
Axial Blanket		No	Yes	
Mid Grid	Spring	Cantilever	Conformal	Increased Fretting Wear Resistance
	Dimple	Arched	Conformal	
	Strap	Wavy	Straight	High Seismic Capability
	Mixing Vane	No	Yes	Enhanced Thermal Performance
Top Nozzle		Separated	Assembled	Easy Removable
Bottom nozzle		Large Hole	Small Hole & Slot	Increased Debris Filtering Efficiency

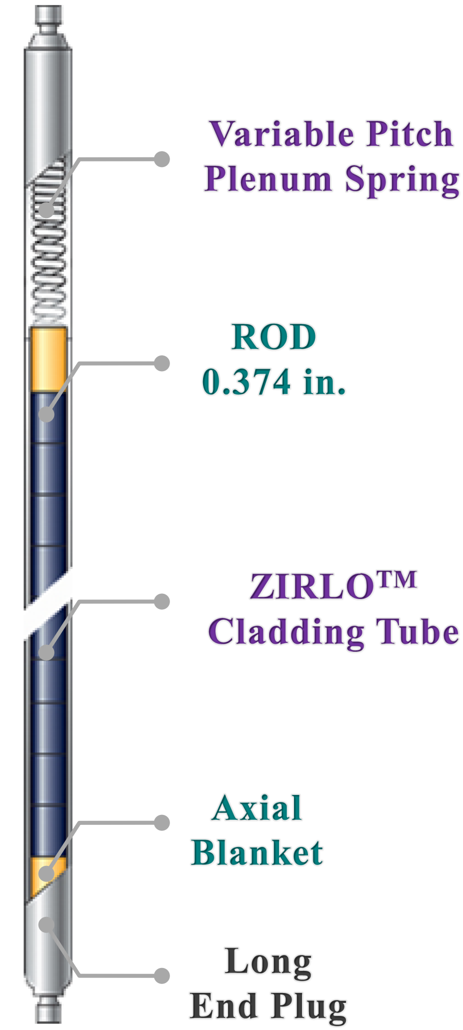
PLUS7 Fuel Design (Characteristics)

High Burnup Capability and Neutron Economy



Guardian

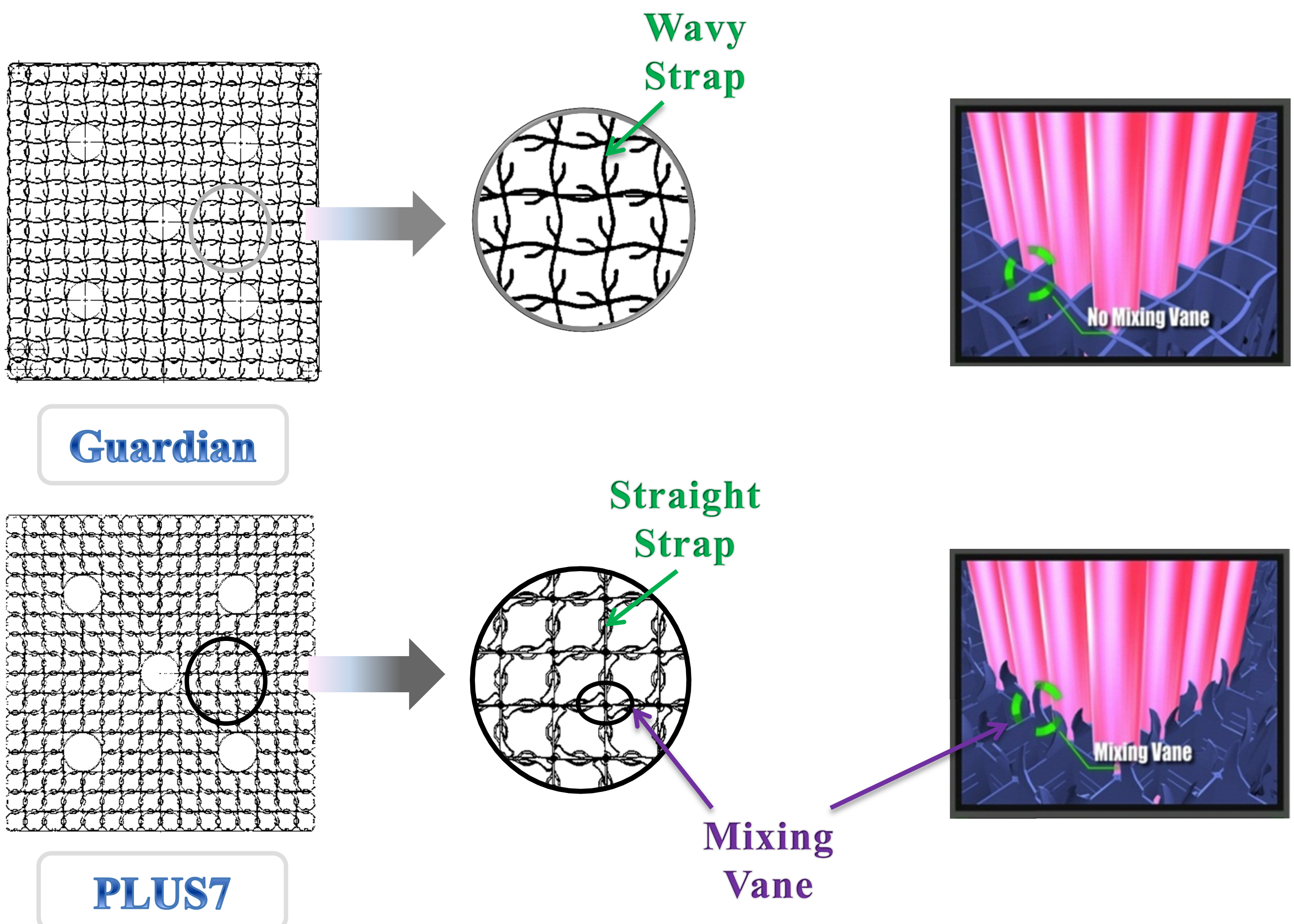
- High Burnup Capability
  - ZIRLO™ Cladding
  - Variable Pitch Plenum Spring
- Neutron Economy
  - Optimized Rod OD
  - Axial Blanket



PLUS7

PLUS7 Fuel Design (Characteristics)

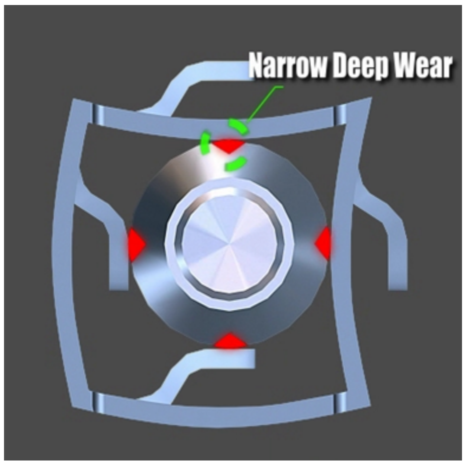
Enhanced Thermal Margin and High Seismic Capability



PLUS7 Fuel Design (Characteristics)

Enhanced Fuel Integrity - Fretting Wear Resistance

Guardian



- Cantilever Spring and Arched Dimple
  - ➢ Lower Fretting Wear Resistance

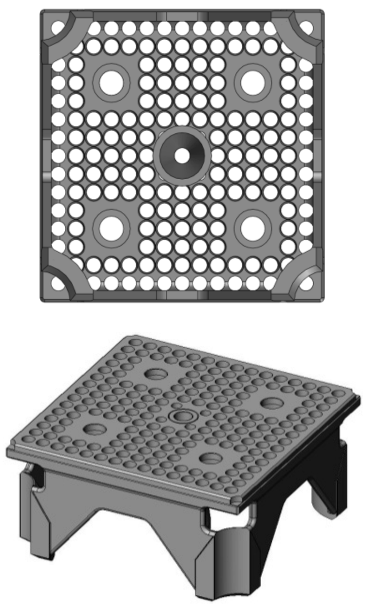
PLUS7

- Conformal Spring and Dimple
  - ➢ Improve Fretting Wear Resistance

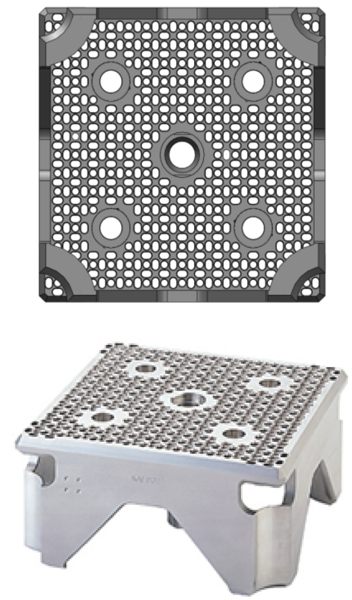
PLUS7 Fuel Design (Characteristics)

Enhanced Fuel Integrity - Debris Filtering Efficiency

Guardian



PLUS7



- Large Flow Hole Bottom Nozzle
  - ➢ Lower Debris Filtering Efficiency

- Small Flow Hole/Slot Bottom Nozzle
  - ➢ Increase Debris Filtering Efficiency

NON-PROPRIETARY

PLUS7 Fuel Design (Verification)

- **Out-of-Pile Tests**
  - **Fuel Assembly Mechanical Tests**
    - Load-Deflection, Strength, Vibration, Impact, etc.
  - **Fuel Assembly Hydraulic Tests**
    - Pressure Drop, Flow-Induced Vibration, Long-Term Wear, etc.
  - **Critical Heat Flux Test**
    - Critical Heat Flux
- **In-Reactor Verification Tests**
  - **PSE(Pool Side Examination)**
  - **Hot Cell Examination**

PLUS7 Fuel Design (Verification)

- **Out-of-Pile Tests**
  - **PLUS7 fuel assembly mechanical and hydraulic tests were performed using test facilities(FACTS, VIPER, etc.) located at Westinghouse Columbia Plant.**
  - **Critical heat flux test was performed using HTRF(Heat Transfer Research Facility) located at Columbia University.**

➢ **Based on the fuel assembly mechanical and hydraulic test results, the mechanical and hydraulic performance of PLUS7 fuel design was verified.**

➢ **KCE-1 correlation was developed based on the critical heat flux test results and the correlation was applied to PLUS7 design analysis. (KCE-1 Topical Report : APR1400-F-C-TR-12002-P Rev.0)**

PLUS7 Fuel Design (Verification)

- In-Reactor Verification Tests (LTA and CSA Program)
  - 4 LTAs(Lead Test Assemblies) were manufactured and loaded at Ulchin Unit 3 Cycle 5 ~ Cycle 7.
  - 4 CSAs(Commercial Surveillance Assemblies) were selected from commercially supplied fuels at Yonggwang Unit 5 Cycle 5.
  - PSE(Pool Side Examination) and hot cell examination has been successfully completed after the LTAs and CSAs irradiation.

➢ Based on the PSE and hot cell examination results, it was confirmed that the measured data were within the design limit of PLUS7 fuel design.

PLUS7 Irradiation Experience

(Ref. : APR1400-F-M-TR-13001-P Rev.0)

PLUS7 Irradiation Experience

- Based on the out-of-pile test and in-reactor verification test results, more than 4,000 PLUS7 fuel assemblies were supplied since 2006.
- Status of Commercial Supply for PLUS7 Fuel
  - Supplied 4,250 fuel assemblies(1,003,000 fuel rods) to 13 reactors in KOREA with 18 month cycle
  - Maximum Fuel Rod Discharge Burnup : 59,547 MWD/MTU
  - 302 fuel assemblies are ready to ship for Barakah Unit 1

PLUS7 Licensing Status

(Ref. : APR1400-Z-M-NR-14010-P Rev.0)

PLUS7 Licensing Status

- **KEPCO/KHNP submitted PLUS7 Topical Report and fuel assembly seismic Technical Report in 2014.**
- **NRC Audit was performed for fuel assembly seismic Technical Report in 2015 and there were some issues related to fuel assembly EOL seismic analysis(IN 2012-09).**
- **KEPCO/KHNP is working on the fuel assembly EOL test and seismic analysis, and the issues will be resolved by end of July 2017 based on the additional test and analysis results.**

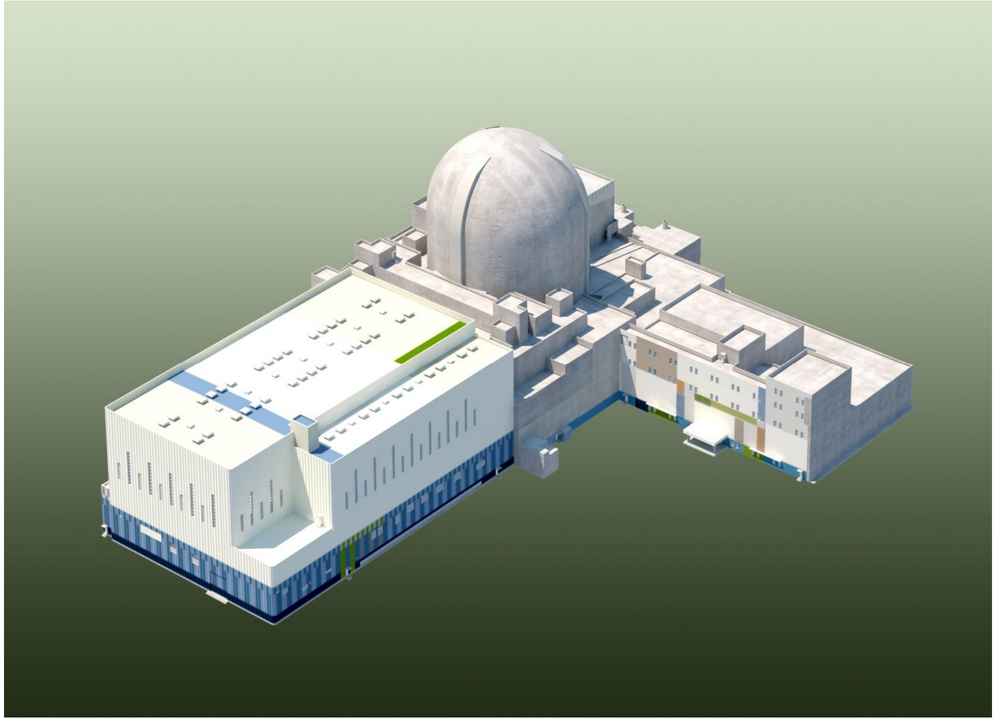
Summary

Summary

- PLUS7 fuel assembly design was jointly developed with Westinghouse for APR1400 in Korea(1999~2002).
- PLUS7 design evaluation was performed to comply with code of federal regulations and NRC regulatory documents.
- PLUS7 fuel design was verified through the out-of-pile tests, critical heat flux tests, in-reactor verification tests.
- Fuel assembly EOL seismic analysis related issues will be resolved by end of July 2017 based on the additional test and analysis results.
- More than 4,000 PLUS7 fuel assemblies were supplied since 2006 and excellent in-reactor performance was demonstrated.

THANK YOU !

APR1400 System Design (Containment System)



KEPCO/KHNP

Apr. 20~21. 2016

Contents

1. Introduction

This presentation is to present an overview of the design features for the APR1400 standard design regarding the containment systems.

1. Introduction

❑ Regulatory Bases

- Containment P/T Analyses
  - 10CFR50 Appendix A, GDC 16, 38, 50
  - NUREG-0800 (SRP 6.2.1) Containment Function Design
  - ANSI/ANS 56.4 Recommendations for P/T Analysis Methodology
- Containment Spray System
  - 10CFR50 Appendix A, GDC 2, 4, 5, 17, 38, 39, 40
- Containment Isolation System
  - 10CFR50 Appendix A, GDC 52, 54, 55, 56, 57
  - RG 1.11(Rev.1), RG 1.141(Rev.1), RG 1.155
- Containment Hydrogen Control System
  - 10CFR50 Appendix A, GDC 41, 42, 43, 10CFR50.34(f)(2)(ix), 10CFR50.44
  - RG 1.7 (Rev.3)
- Design Features to Address GSI-191
  - RG 1.82 (Rev.4), GL 2004-02, NEI 04-07, Safety Evaluation for NEI 04-07

2. APR1400 Design Features

2.1 Containment P/T Analyses

2.2 Containment Spray System

2.3 Containment Isolation System

2.4 Containment Hydrogen Control System

2.5 Design Features to Address GSI-191

2.1 Containment P/T Analyses

❑ Analysis Model

- GOTHIC Containment/RCS Model
- Conservative Break flow model & Wall Heat transfer model
- Case Analyses
  - LOCA : 5 cases (Hot leg / cold leg break, Slot break)
  - Secondary system pipe breaks : 10 cases (CSS or MSIV single failure)

❑ Analysis Results

- The containment is designed to have a minimum 10% of pressure margin.
  - Calculated peak pressure of 51.1 psig, and the containment design pressure of 60 psig
- Containment pressure is well reduced and maintained at less than 50% of the peak pressure within 24 hours after the postulated accident.
  - Containment pressure at 24 hours : 42.4% of the peak pressure
  - Containment spray system has sufficient heat removal capability to reduce the containment pressure during the accident.

2.2 Containment Spray System

❑ Function

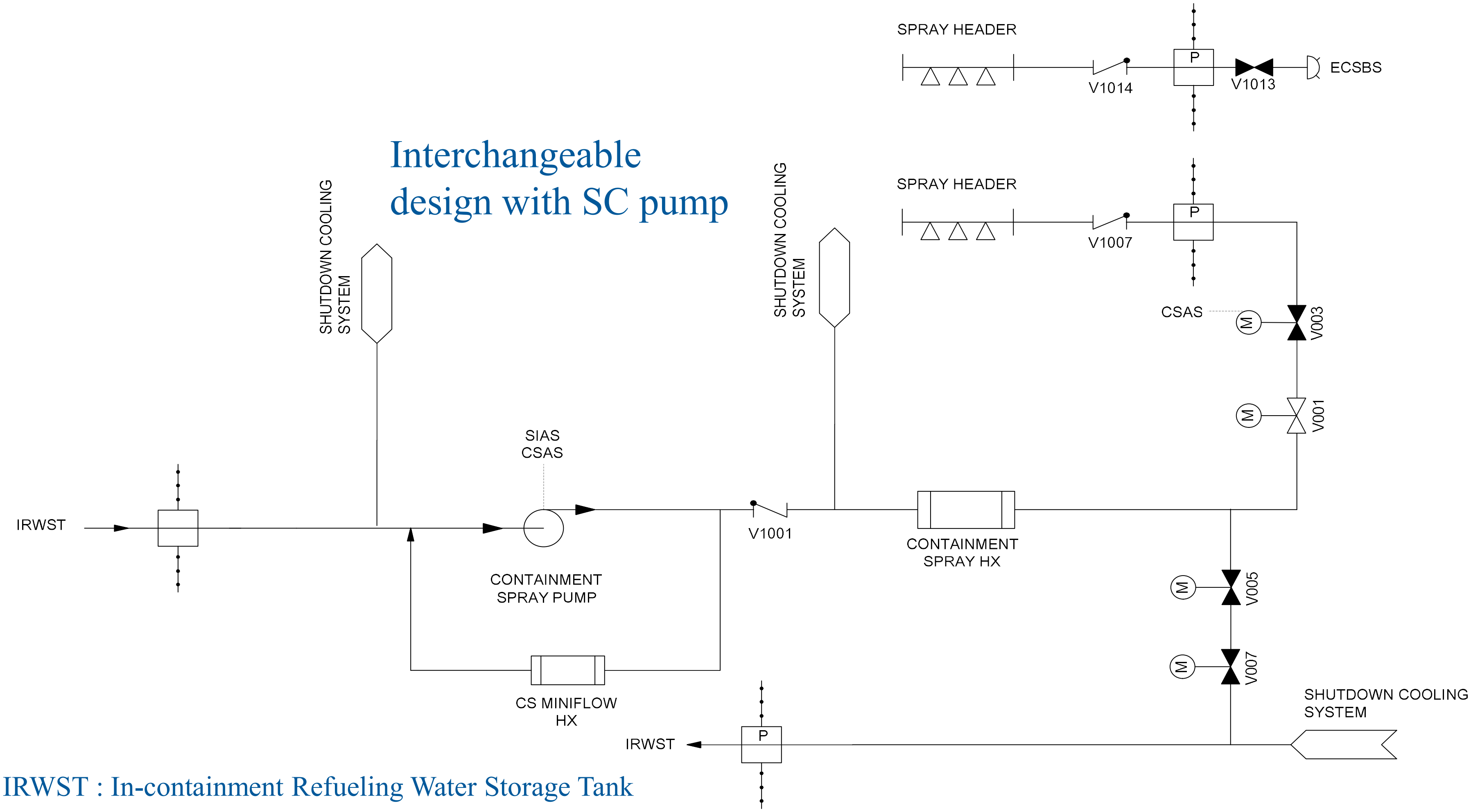
- Containment pressure and temperature reduction following MSLB or LOCA
- Fission products removal from containment atmosphere following LOCA

❑ Configuration

- 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

2.2 Containment Spray System

❑ Schematic Diagram for CS System (Division I)



IRWST : In-containment Refueling Water Storage Tank

Note : Division I is shown for the representative configuration.

2.3 Containment Isolation System

❑ Function

- Means of isolating fluid systems that pass through containment penetrations to confine release of any radioactivity from containment following postulated DBA

❑ Configuration

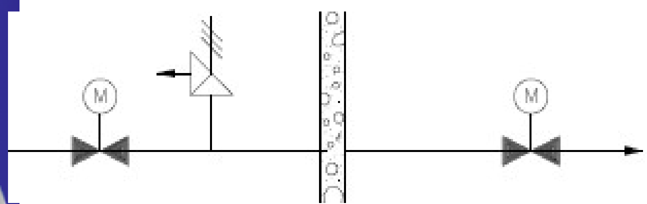
- Isolation design is achieved by applying acceptable common criteria (GDC 55, 56, 57) to penetrations in many different fluid systems and by using containment pressure to provide a CIAS.
- APR1400 DCD Tier 2 Figure 6.2.4-1

2.3 Containment Isolation System

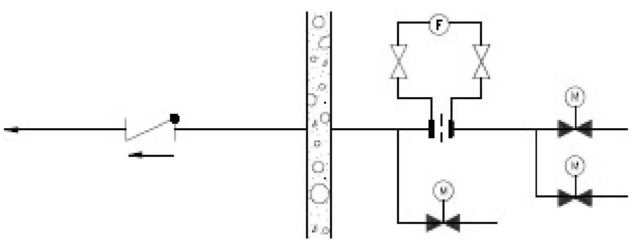
❑ Configuration examples according to GDC requirements

GDC 55

Inside CTMT — Outside CTMT



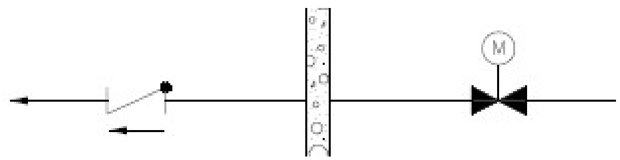
SCS



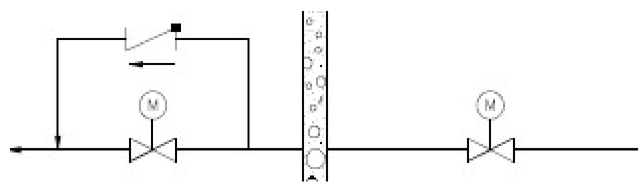
SIS

GDC 56

Inside CTMT — Outside CTMT



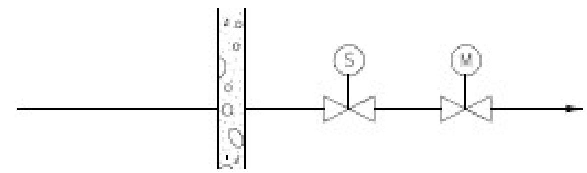
CSS



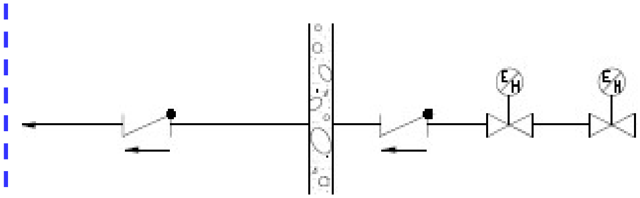
CCWS
(Letdown Hx)

GDC 57

Inside CTMT — Outside CTMT



SGBDS



FWS

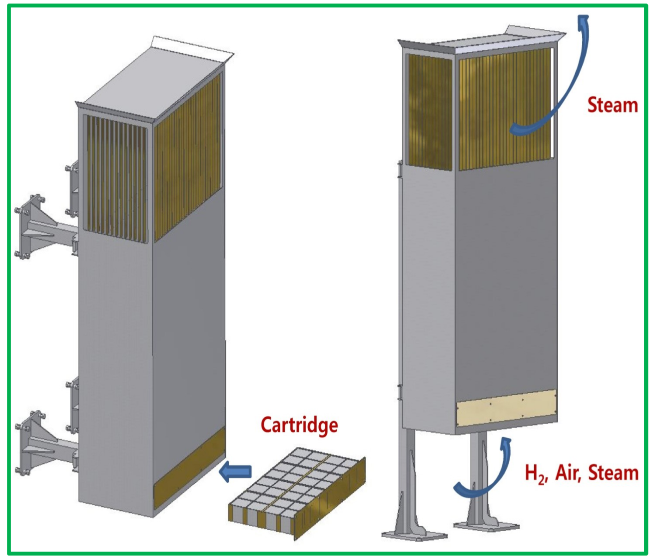
2.4 Containment Hydrogen Control System

❑ Function

- Control hydrogen concentration in containment and IRWST below 10% by volume during severe accident

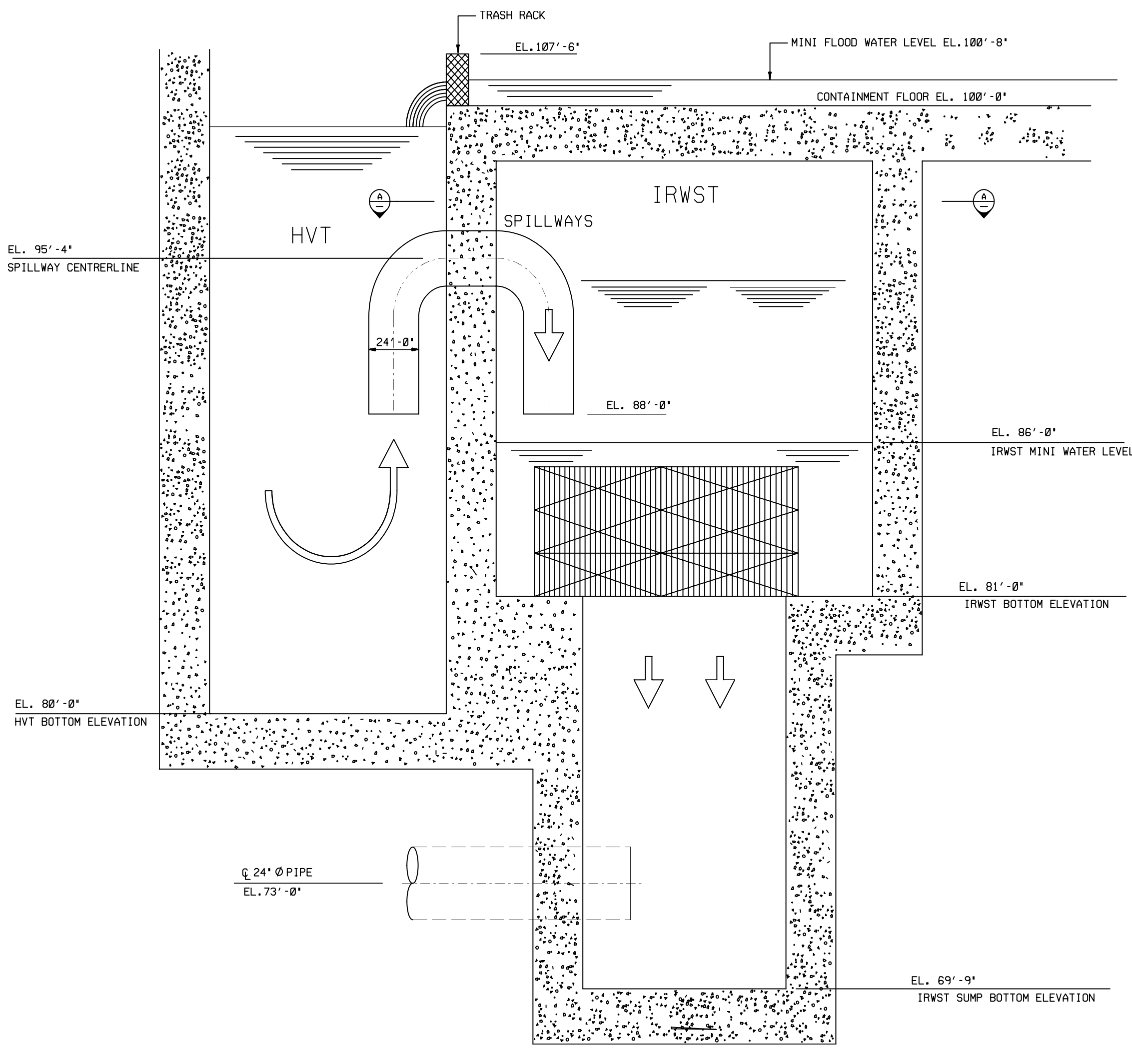
❑ Configuration

- 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



2.5 Design Features to Address GSI-191

- **Flow Path to IRWST Sump Strainer during LOCA for APR1400**



2.5 Design Features to Address GSI-191

❑ GSI-191 Evaluation

- Debris Generation
- Chemical Effect
- Debris Head Loss
- ECCS Pump NPSHa
- Ex-vessel Downstream Effect
- In-vessel Downstream Effect

❑ Evaluation Report

- APR1400-E-N-NR-14001-P/NP, “Design Features to Address GSI-191”

2.5 Design Features to Address GSI-191

- **GSI-191 Evaluation : <u>Debris Generation</u>**
  - According to the guidance of NEI 04-07, RCS hot-leg line (diameter of 42 in) break is selected, and this break location bounds variations in debris generation by size, quantity, and type of debris from other break locations.
    - Generated debris : RMI, coatings (epoxy, IOZ), latent debris (fiber, particle), concrete, aluminum
  - For conservatism, APR1400 is assuming that all generated coatings and all latent debris are transported to the sump in the IRWST.

- **GSI-191 Evaluation : <u>Chemical Effect</u>**
  - WCAP-16530-NP-A , Rev.0 methodology referenced in RG 1.82
  - APR1400 is considering plant specific LOCA conditions, and determines conservative quantities of chemical precipitates during 30 days mission time with the WCAP-16530-NP-A , Rev.0 methodology.
    - AlOOH (398.2 lbm), $NaAlSi_3O_8$ (9.5 lbm), $Ca_3(PO_4)_2$ (1.5 lbm)

2.5 Design Features to Address GSI-191

❑ GSI-191 Evaluation : Debris Head Loss

- APR1400 design conservatively assumes that all of break-generated coatings, latent debris, and chemical precipitates are transported directly to a single sump. (Flow conditions : 1 SIP + 1 CSP)
- Allowable head loss : 2 ft-water (for NPSH evaluation)
- Debris head loss test was performed with assumptions (i.e. effective strainer area, test fluid temperature), and the test result (0.81 ft-water) shows that the allowable head loss (2 ft-water) which is used for NPSH evaluation has sufficient margin.

2.5 Design Features to Address GSI-191

- **GSI-191 Evaluation : <u>ECCS Pump NPSHa</u>**

  - $NPSHa = h_{atm} + h_{static} - h_{loss} - h_{vapor}$
  - Containment Accident Pressure (CAP) in APR1400 standard design
    - $T_{IRWST} > 212^{o}F$, $h_{atm} = h_{vapor}$
    - $T_{IRWST} < 212^{o}F$, h_{atm} = initial containment pressure before LOCA
    - In the evaluation of the NPSHa for ECCS pumps, APR1400 standard design credits the CAP for the IRWST temperature greater than 212°F with the assumption of that the CAP is equal to the IRWST liquid vapor pressure.

2.5 Design Features to Address GSI-191

GSI-191 Evaluation : ECCS Pump NPSHa

- $NPSH_{reff} = (1+ \text{uncertainty})\ NPSH_{r3\%}$
  - Uncertainty factors are considered based on guidance in SECY-11-0014.
  - 21% margin is applied for effects of uncertainty factors.
  - $NPSH_{reff}$ for CSP and SIP 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

2.5 Design Features to Address GSI-191

❑ GSI-191 Evaluation : <u>ECCS Pump NPSHa</u>

- Containment Accident Pressure (RAI 25-7844 Q06.02.02-6)
  - ACRS recommends that best estimate analyses with explicit consideration of uncertainties should be performed to evaluate the available NPSH margins for the limiting LOCA event and a range of ECCS operating configurations. (Correspondences btw ACRS and NRC)
  - SECY-11-0014 (Jan. 31, 2011), "Use of containment accident pressure in analyzing emergency core cooling system and containment heat removal system pump performance in postulated accidents"
  - APR1400 is working on the conservative estimation of the NPSH margin uncertainty, and the risk calculation for assessing the plant risk associated with crediting containment accident pressure in the NPSH assessment.

2.5 Design Features to Address GSI-191

❑ GSI-191 Evaluation : Ex-vessel Downstream Effect

- Strainer Bypass Testing (Scale-down test)
  - Filter bag is used to collect bypassed fiber.
  - Bypassed fiber debris mass : 1.67 kg (through 4 sump strainers)
- Ex-vessel downstream effects assessment (WCAP-16406-P-A, Rev.1)
  - SI pump and CS pump evaluation will be qualified according to ASME QME-1-2007 endorsed by RG 1.100, Rev.3.
  - CS heat exchanger and CS mini-flow heat exchanger Evaluation

    - No plugging due to lager tube ID and enough tube velocity

    - Performance and Wear : Vendor will confirm.
  - Evaluation on valves, orifice, spray nozzles, pipes, instrument tubing, and chemical effects

    - No blockage, no debris settling, and negligible wear are expected in APR1400 standard design.

2.5 Design Features to Address GSI-191

- **GSI-191 Evaluation : In-vessel Downstream Effect**
  - WCAP-16793-NP, Rev.2
  - In-vessel downstream test
    - Hot-leg break, Cold-leg break, Cold-leg break after hot-leg switchover
    - Mock-up Fuel Assembly (FA) of PLUS7 : ½ full length
    - The amount of bypass fiber per FA : 6.93 g/FA < 15 g/FA limit
    - The test results show that the maximum pressure drop through the FA is within the allowable pressure drop with sufficient margin.
  - LOCADM analyses
    - The analyses results for deposit thickness, and peak cladding temperature satisfy the acceptance criteria (50 mils, 800°F)
  - A sufficient driving force is available to maintain an adequate flow rate, and the long-term core cooling capability is adequately maintained in the APR1400.

3. Conclusion

- The APR1400 containment system complies with US regulatory requirements.
- The design features regarding GSI-191 have been evaluated in accordance with the NRC RG 1.82, Rev.4.
- The containment integrity and the plant safety are maintained with sufficient design margins during any postulated accident conditions.