# Official Transcript of Proceedings

# NUCLEAR REGULATORY COMMISSION

| | |
|---|---|
| Title: | Advisory Committee on Reactor Safeguards<br>US-APWR Subcommittee: Open Session |
| Docket Number: | (n/a) |
| Location: | Rockville, Maryland |
| Date: | Thursday, September 19, 2019 |

Work Order No.: NRC-0573 Pages 1-131

**NEAL R. GROSS AND CO., INC.**
**Court Reporters and Transcribers**
**1323 Rhode Island Avenue, N.W.**
**Washington, D.C. 20005**
**(202) 234-4433**

# DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, as reported herein, is a record of the discussions recorded at the meeting.

This transcript has not been reviewed, corrected, and edited, and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

US-APWR SUBCOMMITTEE

OPEN SESSION

+ + + + +

THURSDAY

SEPTEMBER 19, 2019

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2D10, 11545 Rockville Pike, at 8:30 a.m., Matthew W. Sunseri, Chair, presiding.

COMMITTEE MEMBERS:

MATTHEW W. SUNSERI, Chair

RONALD G. BALLINGER, Member

DENNIS BLEY, Member

CHARLES H. BROWN, JR. Member

VESNA B. DIMITRIJEVIC, Member

WALTER L. KIRCHNER, Member

HAROLD B. RAY, Member

JOY L. REMPE, Member

DESIGNATED FEDERAL OFFICIAL:

CHRIS BROWN

STAFF PRESENT:

JOHN BUDZYNSKI, NRO/DESR/SRSB

LARRY BURKHART, ACRS/TSB

DAVID DESAULNIERS, NRR/DIRS

BRIAN GREEN, NRR/DIRS/IRAB

NADIM KHAN, NRR/DE/EENB

JASON PAIGE, NRR/DLP/PLPB

SHEILA RAY, NRR/DE/EENB

FANTA SACKO, NRR/DE/EENB

ANGELO STUBBS, NRO/DESR/SPRA

GETACHEW TESFAYE, NRO/DLSE/LB1

ALSO PRESENT:

ETSUKO GOOD, MHI
ROBERT HALL, MHI
SHINJI KAWANAGO, MHI
AKIRA KIRITA, MHI
ATSUSHI KUMAKI, MHI
KENJI MASHIO, MHI
TAKAYUKI MORI, MHI
TAKAFUMI OGINO, MHI
HIDEKI TANAKA, MHI
AKIHIRO TODA, MHI

# A G E N D A

P R O C E E D I N G S

8:30 a.m.

CHAIR SUNSERI: Good morning. The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards US-APWR Subcommittee.

I am Matt Sunseri, Chairman of the US-APWR Subcommittee. Members in attendance today are Ron Ballinger, Harold Ray, Walt Kirchner, Joy Rempe, Charlie Brown, and Dennis Bley. Let's see here. Chris Brown is our Designated Federal Officer for this meeting.

The Subcommittee will review the staff's evaluation of the US-APWR topical report, the advanced accumulator, along with SERs with no open items for Chapter 8 and 18. Today, we have members of the NRC staff and MHI to brief the Subcommittee.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act. The Committee can only speak through our published letter reports. We hold meetings to gather information and perform preparatory work that will support our deliberations at full Committee meetings.

The rules for participation in the ACRS meeting were announced in the Federal Register on June

13, 2019.

The ACRS section in the USNRC public website provides our charter, bylaws, agendas, letter reports, and full transcripts of all full and subcommittee meetings, including slides presented there. The meeting notice and agenda for this meeting were posted on that website.

Portions of this meeting can be closed as needed to protect proprietary information, and we will have a closed meeting today on the advanced accumulator information.

As stated in the Federal Register Notice and in the public meeting notice on the website, members of the public who desire to provide written or oral input to the Subcommittee may do so and should contact the Designated Federal Officer five days prior to the meeting, as practical.

We have also set aside ten minutes for comments from members of the public in attendance or listening in to our meeting. As a result, though, we have not received any written comments or requests for time to make oral comments from the public regarding today's meeting.

A transcript of the meeting is being kept and will be made available on the ACRS section of the

USNRC website. We request that participants in this meeting speak, please use the microphones located throughout the room and speak clearly and identify themselves with sufficient volume so the transcriber can hear.

Now, we had a meeting yesterday on human errors, if you will, and we learned that the most error-likely situation in this room is the operation of these microphones. So, think about them kind of like a walkie-talkie, you've got to push the button to talk and then, when you're done, push the button to turn off the mic.

The way you do that is, if you take a look at these little speakers right here. So, if you can see, if the green light is on for mine. There's some words at the bottom and one of the words is push. So, if you push that button, the green light comes on, you push it again, the green light goes off. All right?

All right. A telephone bridge line has been established for the public to listen in. To minimize disturbance, the public line will be kept in a listen-only mode.

And also, we have MHI on their own line, a separate line, of which they can interact with us -- or, is that right? They can interact? So, at this time, if the MHI could at least acknowledge that you can hear us and that we can hear you, I would appreciate that. So, somebody on the MHI line, please speak.

MR. BURKHART: Chris is opening the line right now.

CHAIR SUNSERI: Oh, I thought you said it was going to be --

MR. BURKHART: He's doing it right now.

CHAIR SUNSERI: Okay. So, we'll have to -- but it will be open throughout the meeting though, right? Okay.

MR. BURKHART: Yes, is it ready? We're going to ask them to --

CHAIR SUNSERI: They should --

MR. KUMAKI: Is MHI attending on the line?

PARTICIPANT: Yes, thank you.

CHAIR SUNSERI: Okay, very good.

MR. KUMAKI: Do you need the name?

MR. BURKHART: Do you need a name?

CHAIR SUNSERI: Only when they speak, if they could state their name.

(Off-microphone comments.)

CHAIR SUNSERI: Thank you, we can hear you. To avoid disturbance, I request now that attendees put their electronic devices, like cell phones, in the off or noise-free mode. And I have just a few remarks before we get started with the agenda.

So, this is going to be a review of a pressurized water reactor. And the Committee has a lot of experience with pressurized water reactors. So, as we go through the overview, just keep in mind that we are experienced in this area and you don't have to emphasize every aspect of the PWR, but focus on the unique aspects as it relates to this design, and that will help move the meeting along.

As far as the Committee goes, and for the Applicant, we are entering something we call the Phase 4 review of this application. Phase 4 means we'll be looking at the staff's Safety Evaluation Report with no open items, all right? So, keep that in mind as we go through here, and I'll ask the Committee members to think about the process-wise.

In some of our more recent Applicants, when we enter the Phase 4, we're testing a new way of doing business, right? What we are following with this application is the old way of doing business, all right? So, we may think about making a shift, as we have done with the more recent Applicants. So, think about that and we'll take comments at the end.

Also, there's a large amount of material that's going to be presented today, and some of what we're going to hear about in Chapters 8, 18, and the accumulator, may be in the overview as well.

So, I ask members to hold your comments on any material that would be related to 8, 18, or the accumulator until we get to those specific chapters, unless it's necessary to clarify some point or something else. So, the intention is not to get into the details during the overview, but we'll get into details during the chapter review.

Something that you will see that is unique today, that I've not experienced in these meetings is, we have an interpreter back here and the interpreter is to aid the Applicant if through my Texas English, which sometimes is not completely understandable, that they have to translate for the Applicant.

(Laughter.)

MEMBER BLEY: Will she do both English and --

MEMBER REMPE: And Texas?

CHAIR SUNSERI: English and Texas, right, yes.

(Laughter.)

CHAIR SUNSERI: Right. And I've already mentioned that we have MHI on the line. So, Chris, you have something you want to add?

MR. BROWN: The MHI line, open all the time?

CHAIR SUNSERI: Yes, we want them --

MR. BROWN: Okay.

CHAIR SUNSERI: -- to be able to interact.

MR. BROWN: Okay.

MEMBER BLEY: Matt?

CHAIR SUNSERI: Yes?

MEMBER BLEY: Can I ask that the speakers really emphasize anything that's changed since the last time around?

CHAIR SUNSERI: Okay, yes. And then, the last point I was going to make, and I should have made this during the processes, we've had extensive review of this application already, and I think George is going to give an overview, but we've written eight letters already.

And we've written two letters on the topics that we're going to be talking about today. So, we've written letters on Chapter 8 and the accumulator topical report. We held a meeting on 18, but for whatever reason, we did not write a letter.

So, that's kind of the status of where we are. I have the letters here with me, if anybody wants to look at them.

But the two points of interest that we had from the last review are in the area of Chapter 8, we wanted confirmation that the published reliability estimates for gas turbine generator emergency power supplies account for all relevant ancillary and support equipment that is included in the reliability for emergency use of generators. So, that's something we can quiz how they do that would be different than last time.

And then, the accumulator --

MEMBER BROWN: Was that the only Chapter 8 issue?

CHAIR SUNSERI: That was the only Chapter 8 issue --

MEMBER BROWN: The open phase thing was a later thing that we did not review at that time, that came up later, and I see the SER and the Applicant --

CHAIR SUNSERI: Probably.

MEMBER BROWN: -- covered that --

CHAIR SUNSERI: Probably.

MEMBER BROWN: -- in the revised documents.

CHAIR SUNSERI: We did have a generic statement in all of them that we would anticipate that any open items that the staff had would be closed, and that's the case too. So --

MEMBER BROWN: I'd also like --

CHAIR SUNSERI: -- there were --

MEMBER BROWN: I'd like to --

CHAIR SUNSERI: -- a few of those.

MEMBER BROWN: -- comment. It was seven years ago when we looked at --

CHAIR SUNSERI: Yes, that was --

MEMBER BROWN: -- maybe even eight years ago.

CHAIR SUNSERI: That was 2011.

MEMBER BROWN: Yes, 2010 for some of them.

CHAIR SUNSERI: And in 2014, we looked at the accumulator and our only concern with that was that we concur with the staff's recommendation to increase uncertainties that are used in the loss of coolant analysis for high-flow and low-flow injection regimes.

And I'm just going to stop there, because for whatever reason, we chose to write a proprietary letter and this has proprietary markings all through it. So, when we get to the accumulator section, I know I've talked to the Applicant already, they've done a lot of work in this area and we'll get to hear the big difference there.

So, any other comments before we -- all right. I think that suffices for an introduction. So, at this point, I would like to turn to George Wunder for any opening remarks. George is the Project Manager for this review.

MR. WUNDER: I'll be very brief. Good morning, Mr. Chairman, Lady and Gentlemen of the Committee.

CHAIR SUNSERI: That's error one.

(Laughter.)

MR. WUNDER: Good morning, Mr. Chairman, Lady and Gentlemen of the Committee, Chris. I'm George Wunder and I'm the Project Manager for the staff review of the US-APWR design certification application. Thank you for having us here today.

It's been a while since there was a Subcommittee meeting on this design center, so I'm going to give you a very brief history of the project, so you understand where we are and where we plan to go.

The US-APWR design certification application was submitted at the end of December in

2007 and it was docketed in February of the following year.

The review progressed and SER chapter were prepared. Between the summer of 2011 and the spring of 2013, we held Phase 3 meetings on 14 of the 19 chapters.

On November 5, 2013, the Applicant informed us that because significant resources would be needed to support recovery from the events at Fukushima, they were required to reduce support for the design certification review. The Applicant made clear their commitment to the completion of the project. Since that time, the review has proceeded at a slower pace.

In early 2018, the Applicant identified some areas in which progress could be made. These were the advanced accumulator, for which they had recently revised the topical report, and several chapters with RAIs that were either already resolved or easily resolvable. And these were Chapters 5, 7, 8, 10, and 18.

The advanced accumulator safety evaluation with confirmatory items was issued in June of 2018. The final SER with no confirmatory items was issued in June of 2019. Chapters 8 and 18 were issued in July and August of 2019 and Chapters 5, 7, and 10 are under staff review and we hope to bring them to the Subcommittee in 2020.

And that's pretty much where we are. If you have any questions, it's fine, and if not, we can turn it over to someone more interesting and I will pick up my name tag and go home.

CHAIR SUNSERI: All right. Thank you, George. So, at this point, I'll turn to the Applicant and Kumaki-san, if you're ready?

MR. KUMAKI: Good morning, everyone. Can you hear me? I'd like to start my presentation of US-APWR design overview. My name is Atsushi Kumaki from MHI NS Engineering. This is a subsidiary company of Mitsubishi Heavy Industries. And so, MHI is Applicant of US-APWR design certification application.

And this is Mr. Joseph Tapia. He's a principal consulting engineer in Mitsubishi Nuclear Energy System. So, he will support my presentation, if I couldn't understand, he will support. Thank you.

So, this is the contents of the presentation today, starting from introduction over US-APWR licensing activities and also, objectives of today's presentation. Then, the overview of US-APWR design feature will be explained.

So, MHI submitted the application for US-APWR design certification in December 2007. NRC performed it's safety review from that time and several ACRS meetings have already been held. And so, now, we are still continuing the review phase on US-APWR DC.

So, today is very comfortable for us to discuss about the Chapter 18 and 8 and advanced accumulator. So, before that, I will introduce an interview of US-APWR design.

So, today's meeting objective is to provide the current ACRS with US-APWR design overview. So, several member has already changed, but I saw same people, I'm familiar with, so thank you very much for attending.

And also, this morning, I will present the design overview. And this afternoon, other experts for the Chapter 18, human factor engineering, and the Chapter 8, electrical system, and also, topical report for advanced accumulator, will be introduced this afternoon.

This is a kind of conceptual sketch of US-APWR. It looks like very similar to normal PWR, but we have, if you can see this, inside the containment, the bottom, we have refueling water storage pit, inside the containment. It's one of our features for US-APWR.

And it hidden here, we have advanced accumulator, sorry to put figure, but we have advanced accumulator inside the containment. And also, you can see the Main Control Room, which is applied for the digital I&C system. So, those are features on US-APWR.

The first part is a main feature of US-APWR. This table show the progression of Mitsubishi PWR design. So, for each number of loops, two loops, three loops, four loops, in pressurized water reactor.

So, you can see the output of power, and the inner diameter of reactor vessel, a number of fuel assemblies, some points of steam generator and reactor coolant pump. And this is the later reference plant in Japan, for those loops.

And at the bottom, we have APWR, it's a four-loop. And this is the base of our US-APWR. So, basic design concept of US-APWR is the same as our Japanese APWR.

The new technologies of APWR are fully tested and well-verified and established. So, those new technologies were incorporated in also US-APWR. Then, US-APWR generates 1700 megawatt class and it is based on the established APWR technology.

And those, we have some enhancement point, so we take the latest technology to improve plant efficiency and also, we take minor modification to meet U.S. regulatory and RTT requirement.

For example, for U.S. regulatory, we assessed aircraft impact assessment and also, security assessment. And it is very good experience for us and we know the U.S. regulation. And also, we consider about the RTT requirements -- yes?

MEMBER BROWN: When you said security, was that physical security?

MR. KUMAKI: Yes.

MEMBER BROWN: Okay. It wasn't cyber, it was physical security?

MR. KUMAKI: Not cyber, no.

MEMBER BROWN: Okay. I just wanted to make sure we understood the differentiation there. Thank you.

MR. KUMAKI: And also, as for utility requirements, we consider about the online maintenance for safety system. So, we provided for that kind of thing.

This table show the comparison of major parameters among conventional four-loop APWR and the

US-APWR. APWR generates 1538 megawatt output by large capacity core and large capacity main components, such as steam generator, reactor coolant pump, and the turbine, and so on.

Then, US-APWR generates 1700 megawatt output, with ten percent higher efficiency than APWR. And US-APWR provides the same thermal output, 4451 megawatt, but its steam generator, US-APWR steam generator has high performance and the large capacity, comparing with APWR. And its turbine also high performance, applying 74 inches across low-pressure turbine blade.

MEMBER REMPE: But just to remind me, it's been a while since we discussed this, I know when we discussed the steam generator years ago, the question was raised, is it as big as what was deployed or was attempted to be deployed at SONGS? And the answer, as I recall, was no.

The one in the US-APWR is smaller than what was used at SONGS, the replacement, and it was within your experience base, that you had used it elsewhere. Is that not a correct recollection?

MR. KUMAKI: And after that, so we examined the SONGS program and those we understand the reason why the problem was occurred. So, on that experience, we verified our US-APWR steam generator and made the design review, kind of design review.

MEMBER REMPE: Okay.

MR. KUMAKI: And so, if we manufacture next year we may consider, but --

MEMBER REMPE: Okay.

MR. KUMAKI: Okay. So, as for the size of steam generator, it's smaller than SONGS.

MEMBER REMPE: That's what I recall and that it had actually been deployed somewhere else in Japan too, already?

MR. KUMAKI: It's not in operation phase.

MEMBER REMPE: It is not in operation? Okay, I'd forgotten some details. Thank you.

MR. KUMAKI: Okay. This is a comparison of parameters for reactor core and internals. The middle of APWR has a large capacity core, the number of fuel assemblies was increased from 193 conventional plan to 257 assemblies. And the neutron reflector was installed for enhancement of reliability on reactor vessel, especially for radiation, and also fuel economy.

Then, US-APWR has a low power density core, using 14-foot fuel assemblies to enhance fuel economy for 24 months long-term operation. And applying the same core thermal output with APWR, US-APWR could use the same design of related system, such as ECCS or RHRS.

And the reactor vessel of US-APWR applies top-mounted in-core implementation system, ICIS, to enhance the reliability and the maintainability for the vessel penetration on the bottom. And also, comparing the conventional plant and the Japanese APWR, we enhanced the checkpoint on US-APWR.

CHAIR SUNSERI: Let me interrupt for just a sec. Just for the record, Vesna Dimitrijevic has joined the Committee. Thank you, or good to see you, Vesna. Please continue.

MR. KUMAKI: Okay. Next is the safety system and I&C system. Comparison with conventional four-loop plant, APWR enhanced safety by simplified and reliable safety system.

Mechanical four-train system, with direct vessel injection. And also, elimination of low head safety injection pump by utilizing advanced accumulators and elimination of recirculation switching by in-containment refueling water storage pit. So, those are the enhancement points on APWR.

And furthermore, US-APWR enhanced safety by four-train electrical system. And also, online maintenance capability, if we consider the single failure phase. So, that means we provided a 50 percent times four trains. That means one train may be failed from a single failure and one train may be on the online maintenance. So, that's why other two trains means 100 percent for safety capability of that.

So, at the first summary on this presentation. So, these are the main feature of US-APWR. Enhanced economy was achieved by large capacity and high plant performance and also, high fuel performance for 24 months operation.

Enhanced safety is achieved by improved safety response by using advanced technology, such as advanced accumulator or four trains. And enhanced reliability was achieved by well-designed and verified proven technologies.

So, from this slide, I will introduce the US-APWR design features in a little more detail, not so detail, but a little more. This is advanced technology applying in US-APWR.

So, reactor has 1700 megawatt across large capacity and also, neutron reflector. Engineered safety features has simplified configuration with four mechanical subsystems and also, four electrical subsystems.

In-containment refueling water storage pit, which eliminates switching of the long-term core cooling. And we also applied advanced accumulator. And as for steam generator, it has a high performance separator and increased capacity, with compact sizing, applying the triangular arrangement of tubes.

For I&C, we applied the full digital controls and protection systems and using compact console, such as these pictures. More big picture will be raised later.

And also, our turbine has 74-inch length blade in low pressure turbine and fully integrated turbine rotor.

MEMBER BALLINGER: When you say fully integrated, does that mean mono-block?

MR. KUMAKI: Yes, mono-block.

MEMBER BALLINGER: Mono-block, not built up?

MR. KUMAKI: Yes.

MEMBER BALLINGER: Okay.

MR. KUMAKI: So, a little detail for nuclear design features. So, as I explained, we have a large thermal output and low power density.

So, for conventional plant, 193 fuel rod assemblies and the 12-foot. So, you can see, the bottom power density varies. So, on APWR, the power density was lower than conventional, and also, US-APWR more lower than APWR to perform the long-term core cooling and flexibility of core.

So, this is neutron reflector features. So, stainless steel radial neutron reflector was designed to improve neutron neutralization, which reduce the fuel cost and significantly reduce reactor vessel irradiation compared to the conventional plant, which has baffle plate design.

So, this figure shows the critical experimental results performed in Japan. In case of conventional baffle plate, the thickness almost 20 millimeters, that measured the reactivity gain on virtual axis is quite low.

On the other hand, neutron reflector have 155 millimeter thickness, will produce high gain. So, this differential gain corresponds to the saved enrichment of 0.1 weight percent Uranium-235.

MEMBER KIRCHNER: May I ask a question?

MR. KUMAKI: Yes.

MEMBER KIRCHNER: So, when you did that, how did that change your seismic design for the reactor core and vessel? That's a substantial increase in mass inside the vessel.

MR. TAPIA: We don't have the number to characterize the differences between the conventional and the added mass, but we'd be happy to provide that in a subsequent submittal.

MEMBER BALLINGER: Was that baffle plate -- I mean, that reflector's about six inches thick, that's of the same order as the pressure vessel thickness.

MR. TAPIA: It's thick, yes.

MEMBER KIRCHNER: Maybe that's just something for --

CHAIR SUNSERI: Yes, we can --

MEMBER KIRCHNER: -- in the future.

CHAIR SUNSERI: Right, we'll --

MEMBER KIRCHNER: Not for today.

CHAIR SUNSERI: -- make a note for a future, that's probably Chapter 3 or 4 issue, 3 and 4, yes.

MEMBER KIRCHNER: Thank you.

MR. KUMAKI: We will provide the answer later. So, this slide shows the fuel design features. So, as I explained previously, US-APWR applied the low power density core, using the 14-foot fuels.

And that enables flexible core operation, using gadolinium pellet. So, gadolinium is to reduce the peak linear heat rate, so it's helpful to design the core under the constraint of enrichment and also burnup.

And fuel economy was enhanced applying 97 percent theoretical density pellet and also zircaloy-4 grid for neutron economy.

Right part of this slide shows kind of high reliability points grid fretting-resistant design was fully -- by 11 grids and grid span design. The grid span lengths is shorter than conventional 14-foot fuel plants, which is kind, South Texas is a 14-foot fuel plant.

And corrosion resistant cladding materials, ZIRLO, and also, anti-debris bottom nozzle with built-in filter were applied.

This is a comparison of main structure on reactor internals, the particular point is upper-mounted ICIS. So, for conventional, they have a bottom-mounted, and we changed to upper-mounted ICIS to enhance the reliability and the maintainability of bottom penetration of reactor vessels.

And the neutron reflector was installed for enhanced strength of reliability in the reactor internal and fuel economy. And this is kind of repeat again, but also, for neutron reflector, the bolt numbers, on conventional baffle plate, they have 2,000 bolts. But on neutron reflector, we were reduced to 50. And also, the material is stainless steel 316, so, it's very good for erosion.

This is very typical diagram on reactor coolant system. So, we have four loops, four primary coolant loops, each loop has steam generator and reactor coolant pump, but those are the large size. And as for pressurizer, we also increase the volume of pressurizer to make a good response and controllability on the transient of the plant.

This table shows a ratio of reliability on US-APWR to conventional four-loop plant. So, as for core thermal output, it's almost 25 percent larger than conventional plant. And also, steam generator heat transfer area is around two-thirds larger than conventional plant, for higher efficiency.

And reactor coolant pump flow, 20 percent larger than conventional, for larger output. And also, pressurizer volume was increased around 60 percent, for the greater margin for transients in plant.

This also kind of repeat slide, but for reactor vessel, we enhanced the reliability on reactor vessel, applying the material Alloy 690. And also, we apply the vessel head plenum temperature is colder than conventional plant, for the vessel integrity.

And reduction of weld lines, using integrated forging for the manufacturing of reactor vessel and neutron reflector, for the neutron fluence reduced to 1,000.

As for CRDM, control rod drive mechanism, housing, conventional plant have a canopy seal for this small part. This is very weak for the stainless corrosion crack and we considered the program and we improved the point to eliminate the canopy seal on this CRDM.

This is the steam generator. Steam generator has high performance moisture separation, to avoid turbine blade erosion. And also, we applied anti-vibration bar, to avoid vibration rupture of steam generator tubes.

CHAIR SUNSERI: So, just let me, Kumaki-san, just a quick question here. Back to the steam generator, is this similar in flow characteristics to the APWR? Which is -- you have some in service, right? Some of those are in service, right?

MR. KUMAKI: APWR is not in service now. Oh, for the standpoint of flow, it is the same.

CHAIR SUNSERI: Okay. Thank you.

MR. KUMAKI: Okay. For reactor coolant pump, has a large capacity and high efficiency and with improved impeller and diffusor.

And the particular point is advanced seal. This seal provides stabilization of number one seal leak-off characteristics and also, extension of seal life and countermeasure to station blackout. When station blackout occurs, the seal injection and the cooling for thermal barrier will be stopped.

Then, the hot and high pressure reactor coolant will come up, but we need to stop for the SBO phase. We made a test to endure the eight hours for the SBO phase.

For safety system, reliable and simplified design is achieved by 50 percent configuration for safety injection with direct vessel injection. And also, we applied advanced accumulator, which will be explained in the afternoon. And also, in-containment refueling water storage pit improved the reliability and safety by eliminating the circulation switching.

So, this is a comparison between conventional four-loop and the US-APWR. A four-train system for the US-APWR, but conventional has a two-train only. And the advanced accumulator, which can eliminate low head SI pump.

And the in-containment refueling water storage pit have a higher reliability for long-term core cooling. So, conventional plant need a switch for the injection phase and the long-term core cooling phase, but in this US-APWR, it will have an inside containment RWSP, we don't need to switch the suction line of injection pumps.

Comparison of number of each components. So, US-APWR has four accumulator, each advanced type, and 50 percent times four trains safety injection system. And also, containment spray pump, the bottom is a containment spray. It also has 50 percent times four trains. And this system is used for residual heat removal from the normal shutdown phase.

This also is high head injection system design features of four independent train, without interconnection between trains, because of the direct vessel injection line we have. And the sufficient capacity for safety injection pumps meets safety injection requirement in core re-flooding stage.

And this is design for the common containment spray system and the residual heat removal systems, pumps, heat exchanger.

For normal operation, containment spray

function will be standby, and for plant shutdown, RHR function will be operated by taking from hot leg line and using pump and cooled by heat exchanger and returned to cold leg.

So, accident phase, the refueling water storage pit, this water will be taken by pumps and cooled by cooler and spray from the top of containment.

This is a figure of in-containment RWSP. I think I almost explained already, so I direct to go next.

This is the containment vessel. This is very typical for conventional, we have pre-stressed concrete containment vessel. I think I don't need any explanation.

And the full layout, we applied a simplified layout, placing for each corners of reactor building, we placed safety systems for each corners. It can be reduced about 20 percent building volume, comparing with conventional plant.

This is an explanation for advanced accumulator, but the detail will be provided in afternoon, but I need to explain as necessary things. So, this is injection pattern for after LOCA, large break LOCA.

So, for current conventional plant, this red line is requirement for injection flow. And normal accumulator will work for this blue line, for conventional plant. So, injection will start, but stop soon.

After that, to cover the requirement of this red line, we have a low head injection pump right here, and high head injection pump, yellow area. Those will cover the requirement of injection.

For US-APWR, the advanced accumulator will make a two-pattern flow, this blue line. So, this phase, on core re-flooding phase, accumulator will work for small injection flow. It will cover the low head injection part, so we can eliminate this low head injection pump. And after the accumulator stopping, the safety injection pump, high head injection pump, only work for that.

This is a mechanism of advanced accumulator for switching. In the initial, the water level is higher than the top of this standpipe. So, the flow will made by main standpipe line and also, side inlet line will make a large flow and the inject to RCS.

When the water level come down below the top of this standpipe, the inlet flow will come only side and the inject as a small flow to reactor coolant system.

So, from now on, several familiar system, such as emergency feedwater system and also component cooling water system, I will explain. But the point is, all those have four trains system, 50 percent time four-train systems.

As for the emergency feedwater system, we apply the diversity consideration applying the turbine-driven pump and also, motor-driven pump to each. So, this system make high reliability with simplified system and also, it allow online maintenance, it weakens the single failure, but we have two 100 percent trains.

I think this is kind of repeat again, so diverse point of power source. And four train system and also two independent feeds. I think it's enough for us.

So, for component cooling water system and also, essential service water system, we apply the four-train system. For component cooling water, we have four sets of pump and heat exchange and also, we have two sets of surge tank. Those are available for the online maintenance. And also, essential service water system, the same independent four-train configuration.

The mechanical part is over and from now, I&C main features, I will explain. So, US-APWR instrumentation and control system is fully digital I&C system, including computerized main control board, minimum conventional switches, only for regulatory compliance, with is Reg Guide 1.26, the title is Manual Initiation of Protective Actions.

And also, we have microprocessor-based safety and non-safety systems, multiplex communications, including Class 1E signals. It's based on defense-in-depths and diversity concept, with four-train redundant safety system. And non-safety system also have a redundant configuration.

Considering the common-cause failure. Diverse backup non-safety system is provided as a maximum standard deviation.

This is a very complicated figure and very detailed. It's in the DCD, but I don't want to explain everything. But please look at this kind of thing, only.

So, as for safety I&C design features, protection and safety monitoring system is safety features, including reactor trip and the engineered safety features actuation function. And also, monitoring of the safety-critical parameters, according to Reg Guide 1.97, which is Criteria for Accident Monitoring Instrumentation.

We applied the four-train redundancy for all safety systems and the electrical, physical, functional communication and data isolation to accommodate the signal interface between safety systems, signal interface safety to non-safety system, and also, non-safety human system interface for safety functions with safety HSI.

Branch Technical Position 7-14, which is Guidance on Software Reviews for Digital Computer-Based Instrumentation and Control Systems, and 7-19, which is Guidance for Evaluation of Diversity and Defense-in-Depth in Digital Computer-Based Instrumentation and Control Systems, are taken into account for software integrity.

Our platform for main control board is a MELTAC by Mitsubishi Electric, which was qualified with extensive experience in Japanese plants.

For non-safety I&C design features, plant control and monitoring system is non-safety features, including reactor turbine generator, plans of plant control room monitoring, and redundant configuration, functional isolation of shared sensor signals.

Diverse actuation system is a countermeasure for common-cause failure in the digital safety system, according to BTP 7-19 and also, 10 CFR 50.62, for anticipated transient with scram.

Diverse automation is provided for reactor trip, turbine trip, EFWS, emergency feedwater system, based on actuation, are required within ten minutes of an event.

Diverse manual controls are provided for safety injection, containment vessel isolation, and so on, and are critical safety functions. Diverse monitoring is considered for safety critical parameters.

So, this picture shows prototype console of a main control board, with large display panel, operator console, applying visual display units. This control board is well considered for human system interface. And that human system interface item will be discussed also in the afternoon, Chapter 18 session.

So, the function of HSI system are fully computerized video-based approach, integrated display for monitoring and soft control, and dynamic alarm prioritization and computerized procedures.

The system was developed according to

NUREG-0711 program model, including task analysis and human factor design, step-by-step prototyping and verification and validation by plant operators.

The design basis of staff are operators, supervisor, and safety technical advisors.

The main features are all operations are available from non-safety VDUs. All safety operations are performed from safety VDUs. And the inventory of fixed-position HSI is minimum for convention HSI, for manual system lever action, regarding Reg Guide 1.26, which is Manual Initiation of Protective Actions, and critical functions on bypass or inoperable status regarding the Reg Guide 1.47, Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.

CHAIR SUNSERI: I know you'll probably get into this more later, but at this point, could you just remind us what the number of staffing is? How many operators, how many supervisors?

MR. KUMAKI: The actual operator is two, one. And the supervisor is one.

CHAIR SUNSERI: One operator, one supervisor?

MR. KUMAKI: Just a moment.

CHAIR SUNSERI: And one technical advisor?

MR. TAPIA: We have our expert right here.

MR. MASHIO: My name is Kenji Mashio, from MHI. I can respond your question. And so, the minimum staffing we have -- this HSI control board can operate by minimum one RO, reactor operator, and one SRO. But based on the regulation, we have two reactor operator.

CHAIR SUNSERI: Okay. All right. Thank you.

MR. KUMAKI: Okay. Let's go to the electrical system design features. It's very conventional and we have two independent offsite transmission systems. But we have a four-train onsite safety power system and four-train safety gas turbine generator for emergency and four-train safety batteries.

And as for the non-safety AC power, we provide, this one is a typo, so we have two non-safety GTG alternate AC power.

This is also a very typical one-line diagram on electrical system. We have safety electrical, four trains, and also, we have a non-safety, we need to provide one more, we will have two.

So, this is summary of this morning presentation for design overview of US-APWR. US-APWR is designed on proven and reliable technologies and it provides improved plant efficiency, incorporating improved steam generator and turbine system.

It provides reduced fuel cycle costs and improved operational flexibilities, by low power density core, applying 14-foot fuel assemblies. And also, it provides minor modification of APWR for U.S. and RTT requirements, such as online power maintenance and so on.

And also, we don't need to forget about safety point, we enhanced the safety, applying the four-train systems, and also advanced accumulator and so on.

Okay. This is end of my presentation. Thank you for your kind attention.

CHAIR SUNSERI: Thank you very much. And I think the few questions that you received is an indication of our depth of knowledge on the PWR and we appreciate you going through this in a deliberate manner. Yes, go ahead, Walt.

MEMBER KIRCHNER: Just a quick question. So, you're using gas turbine generators both for the for-safety units, as well as the non-safety. So, is the plan to have significant gas storage on-hand or use propane or?

MR. TAPIA: It's actually diesel. It's atomized diesel.

MEMBER KIRCHNER: So, you're using diesel --

MR. TAPIA: Yes.

MEMBER KIRCHNER: -- as the fuel?

MR. TAPIA: Yes.

MEMBER KIRCHNER: Okay, thank you.

MEMBER BROWN: Matt?

CHAIR SUNSERI: Yes, Charlie?

MEMBER BROWN: I did restrain myself a little bit on the I&C. When we reviewed this back in 2009 and 2010, the Chapter 7 stuff, we made some considerable enhancements, thought processes, over the last eight years, nine years, which I will save until we do the subsequent one. Just let you know.

CHAIR SUNSERI: I was curious about that, but I thought you were --

MEMBER BROWN: Well, I --

CHAIR SUNSERI: -- paying attention to the --

MEMBER BROWN: No, I was paying --

CHAIR SUNSERI: -- other comments and not saying --

MEMBER BROWN: -- very much attention.

CHAIR SUNSERI: -- saving it to the --

MEMBER BROWN: Well, it's just not appropriate now.

CHAIR SUNSERI: Right.

MEMBER BROWN: It's not the right form to try to address those comments.

CHAIR SUNSERI: Right.

MEMBER BROWN: So, we'll wait until that. I'm just trying to give the staff a heads-up to know that we will have some additional questions, when it comes to that.

And also, MHI might just remember that Member Brown restrained himself and will have some questions, politely restrained himself, will have some questions when we get around to Chapter 7 again. Okay. Thank you very much.

CHAIR SUNSERI: Very good. All right. So, very good. You allotted the right amount of time for our questions and we didn't have very many, so that puts us ahead of schedule, so thank you for that. I think we should now go ahead and move forward with this into the next agenda item.

And that would be the Chapter 8, Electrical Power. And it looks like that we have this set up to where we're going to have the Applicant go over all of your material for both Chapter 8 and 18. And then, we'll turn it over to the staff and then, they will provide their response. So, Dennis, you got a question?

MEMBER BLEY: I was just remembering, we had some concerns about the operating data for this kind of gas turbine. We didn't think there had been a lot, so I hope you're going to address that.

CHAIR SUNSERI: Right. That was one of our follow-up items. Okay. So, let's go ahead and transition then into the next group. And thank you for that, Kumaki-san. And which are going to be the lead for this? Tanaka-san? Okay. So, you got schooled on the microphone? Okay.

So, just before we get started, I want to just say that we are ahead of schedule, but somewhere after 10:00-ish, if there's a good point in your presentation, we'll stop and we'll take a break, okay? So, if you are ready, we are ready.

MEMBER BROWN: Could you reemphasize on this chapter, I took a, I mean, I looked at the SER and part of the DCD, but could they emphasize, hopefully, if there's any changes from the design as it was presented back in 2010 and 2011? Is that going to be covered and identify differences or what's happened subsequent to nine years ago?

MR. TANAKA: In this presentation, I explain the best point, based on the NRC comments or ACRS comments.

MEMBER BROWN: So, you will cover fundamentally emphasized differences from eight or nine years ago? From the DCD to now, if there were any major changes?

MR. KAWANGO: Yes, and my name is Shinji Kawanago. And basically, we didn't change any basic design of our electrical system. Only --

MEMBER BROWN: That's what it looked like, when I looked at the basic overall diagrams, they looked the same.

MR. KAWANGO: The same. The same. The only --

MEMBER BROWN: The big picture overview diagram, not --

MR. KAWANGO: No, only the changes are minor change, because of the RAI by NRC, for example, the open phase issue and so on.

MEMBER BROWN: Thank you. That's all that?

MR. KAWANGO: Yes.

MEMBER BROWN: Okay, that's what I thought. Thank you.

MR. TANAKA: Okay?

CHAIR SUNSERI: Okay. You may go ahead.

MR. TANAKA: Can I start? Okay. Good morning. My name is Hideki Tanaka, electrical engineer of MHI. I will explain the Chapter 8 on the US-APWR. First, I'll explain the presenters, Joe Tapia and Shinji Kawanago, with MHI NS Engineering, and myself, Hideki Tanaka, of the MHI. Okay.

This page shows the contents of this presentation. Especially in this presentation, I will explain the features of the electrical system in the US-APWR and closed open items identified in SER, Phase 3 SER and RAIs issued after the Phase 3 SER. Okay.

Overview of the chapter. Chapter 8 is electric power. And in this chapter, we have the subsections 8.1 through 8.4.

The next page, this page shows related document. Opposite table shows status of the DCD. We issued DCD before and this is latest DCD. And number two is a tracking report of the DCD. So, we -- this report shows revised point from the Revision 4 DCD based on the RAI responses.

And this table shows technical report.

MEMBER BROWN: Can I make sure I understand? The tracking report would then cover the open phase circuit stuff, as opposed to the August 30, 2013 version? That's what I got from your comment there.

MR. TANAKA: This tracking report does not include the open phase.

MEMBER BROWN: It doesn't or it does?

MR. TANAKA: Does not.

CHAIR SUNSERI: They're going to do something similar to other applicants and defer the open circuit stuff to the COL applicant, I believe.

MEMBER BROWN: Well, they made some comments in the SER identified that there were some changes made, but then, there were the COL items for some points of it. Some of the stuff looked like it was okay, that they had proposed, and there seemed to be a couple of items that were deferred to the COL.

So, I was just wondering where -- when they went through the RAI response process, did anything get reflected back into the DCD or was, I guess we can ask the staff that also, or was something actually incorporated into the DCD, one of the versions of the DCD?

MR. KAWANGO: And actually, when we got

RAI and also, we had RAI response, in the RAI response, we clearly indicate how to change the DCD itself and also the ITAAC and also the --

MEMBER BROWN: Right.

(Simultaneous speaking.)

MR. KAWANGO: -- and so on.

MEMBER BROWN: I remember some of that. I also remember something being deferred, a later RAI, something moving towards the COL.

MR. KAWANGO: Yes.

MEMBER BROWN: All right. I'll just cover that later.

MR. KAWANGO: Yes. And --

MEMBER BROWN: That's fine.

MR. KAWANGO: And also, the -- and in our presentation, we will explain later, including on what is a COL item and so on.

MEMBER BROWN: Okay, thank you. You can go on.

MR. TANAKA: So, this table, number three is onsite AC power system calculation. This report shows this and other calculations and so on.

And number four and number five is relating to the gas turbine generator. Gas turbine generator is high reliability and compact and no cooling water required. So, we use gas turbine generator as emergency power source, instead of the diesel generator usually used.

MEMBER BROWN: Did you say no water is required?

MR. TANAKA: Yes.

MEMBER BROWN: That's what I -- okay.

MR. TANAKA: Yes, air cooling.

MEMBER BROWN: Another memory jogger here, okay.

MEMBER BLEY: Was that the main reason you chose the gas turbine or were there others?

MR. TANAKA: One of the reason.

MEMBER BLEY: Can you --

MR. TANAKA: One of the main reason.

MEMBER BLEY: Can you go through the other reasons?

MR. TANAKA: Yes. Gas turbine generator is compact, layout space is smaller than the diesel generator. And reliability is, we believe reliability is higher than diesel generator.

MEMBER BLEY: Okay, thank you.

MEMBER BALLINGER: Yes, Mitsubishi is one of the world's leading --

MEMBER BLEY: I know.

MEMBER BALLINGER: -- suppliers of gas turbines.

MR. TANAKA: Okay. So, gas turbine generator is a first of a kind, so we performed the qualification testing. So, number four and number five is the qualification program and the test result. Okay.

Next is a feature of the electric power system. This page shows features on the offsite power system. I would like to explain this using this single-line diagram.

We have two offsite source. One is from the RAT, this is normal preferred power source. And the other, from the main transformer and -- the transformer. This is alternate preferred source. And these are physically separated. Okay.

Next page, this page shows RAI issued from the -- Page 2, I will explain later. The next page --

CHAIR SUNSERI: If I could ask you to be careful with the microphone and done shuffle the paper over the speaker. It makes noise.

MR. TANAKA: Oh, sorry. This page shows details on the onsite power system, so you don't have to use this single-line diagram for this explanation. Okay.

In this figure, blue line shows Class 1E system and red line shows the non-Class 1E system. We have a four-train safety Class 1E system. And each train has emergency power source, gas turbine generator.

And we have a four times 50 percent capacity. So, we can assume the online maintenance and the single failure and even those considering, we still have 100 percent of capability for the safety function.

Also, we have two buses backed up by generator. We call that permanent buses, this P1 and P2. These buses can be backed up by alternative AC power source.

Usual existing plant has investment protection load, such as HVAC or pump or something like that. That connected to the Class 1E bus.

But in US-APWR, those non-safety load is connected to this permanent buses. So, in our US-APWR Class 1E system and non-Class 1E system is completely separate. And in SBO condition, the HVAC can be connected to the Class 1E buses to cope with the SBO. Okay.

From this page, gas turbine generator is explained. And this page shows the specification.

And unique point is the starting time. Diesel generator starting time is usually ten or 15 second, but the upright advanced accumulator, so the starting time, requirement for the starting time is less than 100 second, so that we can use the gas turbine generator.

MEMBER BLEY: On the previous slide, you said you have four times 50 percent capacity. Give me more details on what you mean by that. Is that on the gas turbines? What do you have four times 50 percent capacity on?

MR. KAWANGO: The meaning of the 50 percent is, as you know, on our --

MEMBER BLEY: We're talking gas turbine, right?

MR. KAWANGO: Yes.

MEMBER BLEY: Okay.

MR. KAWANGO: No.

MEMBER BLEY: No?

MR. KAWANGO: No, no.

MEMBER BLEY: What are you talking about?

MR. KAWANGO: Basically, capacity, meaning the capacity, definition of the capacity always defined by what is safety load, okay? And safety injection pump and CV spray pump and so on. Our mechanical system is a 50 percent times four. Okay? Fifty time four, our mechanical system.

MEMBER BLEY: Each train is 50 percent times four?

MEMBER BROWN: You're talking about the equipment that's powered?

MR. KAWANGO: Yes. And equipment which needs power is --

MEMBER BLEY: So, you need, you're basically saying on the safety systems, you need any two trains out of four trains for safety equipment?

MR. KAWANGO: Any two trains.

MEMBER BLEY: Any two?

MR. KAWANGO: Two, any two. And this, again --

MEMBER BLEY: So, that reflects back then to the gas turbines as well, for the emergency gas turbines, you need at least two of them working --

MR. KAWANGO: Yes, that's right.

MEMBER BLEY: -- to meet your --

MR. KAWANGO: That's right.

MEMBER BLEY: -- demands?

MR. KAWANGO: Yes.

MEMBER BLEY: Okay.

MR. KAWANGO: That's right.

MEMBER BLEY: Okay.

MR. KAWANGO: Yes.

MEMBER BLEY: Okay. That's -- it was a little too general for me, that's why I asked.

MEMBER BROWN: Can you back up to that Slide 13? You say a short-time rating of 4950 kW, two questions. I want to get them clear. How long is short-time? That's question one. Is that five minutes? Is it 30 minutes? Is it -- how long can you overload it at 4950? If you --

MR. KAWANGO: I suppose --

MEMBER BROWN: -- don't know it, that's okay.

MR. KAWANGO: I suppose your question is related to the overload and the capacity and based on IEEE requirement?

MEMBER BROWN: I -- let me back up. All you've listed here is the capability to run short-time rating at 4950 kW, as opposed to its continuance rating of 4500. And so, my question is, how long can you run it at 4950? How much time?

CHAIR SUNSERI: Charlie, aren't those numbers usually related to things like starting the single largest loads?

MEMBER BROWN: No, no, no, that's a load.

You put a -- in other words, if you have enough load that you can load it up that way before you shed, or something like that. So, it's not a startup type issue, that's a transient, you're talking seconds.

CHAIR SUNSERI: No, but what I'm saying is the thing is running at 4950 or whatever and you, or somewhere close to, yes, running at 4500 and you start some big load, right?, and then, it's --

MEMBER BROWN: No, that's a starting issue, not a continuance running issue.

CHAIR SUNSERI: But that's a short-time.

MR. KAWANGO: May I answer?

CHAIR SUNSERI: Yes.

MR. KAWANGO: Sorry.

CHAIR SUNSERI: Yes, please.

MR. KAWANGO: Yes. And simple answer to you is two hours during a 24 hours.

MEMBER BROWN: Okay, that's fine.

MR. KAWANGO: Yes. That is a requirement from the IEEE.

MEMBER BROWN: That's fine. That's fine, that answers -- that's the point, two hours is a long time.

CHAIR SUNSERI: Right.

MEMBER BROWN: When you do a transient and start a motor, you're talking seconds.

CHAIR SUNSERI: Right.

MEMBER BROWN: And it's largely not kW, many times it's reactive power. If it's a current, it's a current issue and you heat windings and that drives your starting type issues. But this is a long time type. The second question, I've now forgotten.

(Laughter.)

MEMBER BLEY: That's good, Charlie.

MEMBER BROWN: To be honest.

MEMBER BLEY: Because I have another question --

MEMBER BROWN: I'll remember it later.

MEMBER BLEY: -- then, on the four 50 percent capacity trains. If I have a safety injection pump out for maintenance in one train and I have some other big load out for maintenance in another train, it's possible -- what's not possible?

MR. TAPIA: You can't take --

MEMBER BLEY: Tech specs don't stop something from breaking.

MR. TAPIA: Oh, but you said maintenance for both of them.

MEMBER BLEY: Okay. I'm sorry.

MR. TAPIA: And that's --

MEMBER BLEY: I'm sorry. You've got two major loads out of service in two different trains.

MR. TAPIA: So, you're allowed to take one train out for maintenance. And then --

MEMBER BLEY: I understand.

MR. TAPIA: And then, the design assumption is that you lose another train due to single failure.

MEMBER BLEY: Okay.

MR. TAPIA: So, that leaves you with two 50 percent capacity --

MEMBER BLEY: Okay.

MR. TAPIA: -- trains left, which is 100 percent. That's the design basis for the four trains.

MR. KAWANGO: And Joe answered you. And basically, our definition is online maintenance, okay? And we just observed when we have the online maintenance, just we allow to have the online maintenance for only one specific train, okay?

So, that when we have the online maintenance for the safety injection pump on Train A, we cannot do the online maintenance for the B Train or C Train, okay?

MEMBER BLEY: I understand.

MR. KAWANGO: Just the one train, so that

--

MEMBER BLEY: But you could have a failure somewhere?

MR. KAWANGO: Yes, sure. Sure.

MEMBER BLEY: In fact, you could have more failures. When we get to the PRA, we'll dig into that a little bit, but I wanted to make sure I understand the definitions here.

MR. TANAKA: Okay. This page shows Class 1E gas turbine generator testing program. So, our testing performed based on the Reg Guide 1.9 and IEEE 387, ISG-21. And we issued technical report for the test program and the test result.

And this page shows contents of the initial type testing. We performed the load capability tests to demonstrate the capability to carry the load.

And we performed the start and load acceptance tests to establish the capability to start and accept load within the required time period. So, in this test, we performed 150 start tests. This will be discussed later.

And we also performed the margin tests to demonstrate the capability to carry the most severe load plus ten percent margin.

And in the Section 8.3, we had three open items and one new RAI. This will be discussed later.

The next is Section 8.4, station blackout. In the station blackout, we don't have -- I mean offsite power, all offsite power and EPS are not available, and we use alternate AC power source to cope with SBO.

Design basis, we have diverse alternate AC power source from the EPS system to minimize a potential common-cause failure. And we use gas turbine generator for the alternate AC power source. And alternate AC power source can be connect to any of the Class 1E buses. And coping duration for the SBO is eight hours, in accordance with Reg Guide 1.155.

And in Section 8.4, we have two open items and one new RAIs. So, in this section three, I will explain the closed open item and the RAIs. First item is regarding the open phase, the Section 8.2. We received three RAI and our response is described in the next page.

So, the detection and protection method. We provide OPC detection system on the high voltage side of the main transformer and reserve auxiliary transformer. So, the both preferred power source will have OPC protection device.

And second item, the single failure criteria. This figure shows logic of the automatic protection system for the open phase detection system. Left side is for the main transformer and the right side is for the reserve auxiliary transformer.

And each system has a System 1 and System 2. This means redundant system. And in the accident condition, this SI signal initiated, we only use one protection signal, we can protect. So, we consider the single failure in this protection system.

And this page shows the COL item and the ITAAC. We have two COL item. One is determined specific type of OPC detection system device. And determine the setting of the device. And the second item, COL item, is determine the -- served as the requirement of the device. Also, we -- this table shows ITAAC for the operator's protection system. Okay.

Next page --

CHAIR SUNSERI: Let me stop you there. So, Charlie, does that address your --

MEMBER BROWN: No, it covered, I read the SER response and I didn't have this detail. So, that was -- or at least I couldn't find it at home.

CHAIR SUNSERI: Yes.

MEMBER BROWN: I -- it's been accepted, at least in the SER it sounded, their explanation sounded reasonable.

CHAIR SUNSERI: Okay.

MEMBER BROWN: I didn't see this particular detail, it just said it was going to be a COL item, there it is.

CHAIR SUNSERI: Yes. Okay. All right. Thank you.

MEMBER BROWN: Excuse me, I didn't have my phone on, did you hear me okay? Okay.

CHAIR SUNSERI: All right. Continue.

MEMBER BROWN: Thanks, Matt.

MR. TANAKA: Next, this page shows open item regarding the degradation of the medium voltage cabling on the -- around the board. So, originally we didn't provide a COL item, but we revised the DCD to include the COL item, to describe the cable monitoring program. So, that this has been closed.

Next one is regarding the gas turbine generator reliability. Originally we didn't provide target of the reliability. So, in the diesel generator, IEEE 387 has a number of starting test as 100 times starting test.

And for the gas turbine generator, we set the reliability target 0.975 with 95 percent confidence. This come from the Reg Guide 1.155. And we calculated that this starting number was a starting time based on this reliability target, we decided 150 start is required. And we have performed this number of starts.

MEMBER BLEY: You're not doing the PRA today, but do you have any idea what the PRA used for the diesel generator reliability? I bet it wasn't --

MR. TANAKA: Yes.

MEMBER BLEY: -- one minus 0.975.

MR. TANAKA: Yes. Actually, in the PRA, we use reliability of the diesel generator for the conservatism. I mean, reliability of the gas turbine generator is higher, so in the PRA modeling, we used higher --

MEMBER BROWN: Lower?

MR. TANAKA: -- lower, lower --

MEMBER BROWN: Lower reliability?

MR. TANAKA: Lower reliability, yes.

MEMBER BLEY: You didn't use something lower than this? So, I think I heard what you said and you said, we know that our gas turbine generators are more reliable than the diesels, so we'll use the diesel generator failure rate, which might be at ten to the minus three. But this testing hasn't given us any confidence that these are more reliable than a failure rate of ten to the minus three.

MR. KAWANGO: We will check the number with our technical report and in our technical report, we calculated the actual reliability data for the gas turbine generator, by using the industrial actual starting and test data, and also the actual some experience.

MEMBER BLEY: This is the 07024 report? 07024-P?

MR. KAWANGO: Yes.

MEMBER BLEY: Okay. I'll study that a little bit more carefully then.

MR. KAWANGO: And, hold on, may I explain a little bit?

MEMBER BLEY: You could explain a lot.

(Laughter.)

MR. KAWANGO: And actually we calculated the reliability data by using actual data with gas turbine generator and calculation result is ten minus five, or something like that. Very, very low --

MEMBER BLEY: These are from --

MR. KAWANGO: Actual data --

MEMBER BLEY: -- that are out in the field being used?

MR. KAWANGO: Yes, that's right.

MEMBER BLEY: Okay.

MR. KAWANGO: So, we discussed --

MEMBER BLEY: I'll read that report more carefully; I haven't had a chance to study that yet.

MR. KAWANGO: Okay.

MEMBER BLEY: Thank you.

MR. KAWANGO: Sorry, ten minus four.

(Laughter.)

MEMBER DIMITRIJEVIC: Well, then, what was the reason that you decide to use the diesel generator, which are less reliable data, if you have the industry data for gas turbine?

MR. KAWANGO: Because, yes, because we discussed with NRC and, of course, maybe good way to use gas turbine generator data, but we thought, we conclude, that conservative data is better for use.

MEMBER DIMITRIJEVIC: So, did you use also diesel generator common-cause data or common-cause failure of the --

MR. KAWANGO: Yes, data factor is the same.

MEMBER DIMITRIJEVIC: So, do you have a common-cause group of six gas turbine?

MR. KAWANGO: Oh, no, no, actually is four.

MEMBER DIMITRIJEVIC: And what about your backups?

MR. KAWANGO: Backup is a completely different manufacture and design.

MEMBER DIMITRIJEVIC: So, it's separate?

MR. KAWANGO: Separate, yes, that's right.

MR. TANAKA: Okay. Next RAI is also regarding the gas turbine generator. In our qualification testing, in the starting testing, we performed the maintenance of the injectors every 50 starts.

But we did not provide such information in the technical report and the technical specifications. So, we revised the DCD to incorporate technical specification service requirement for this nozzle cleaning maintenance.

And the next one is for the battery sizing calculation. We originally used the Japanese experience for the battery load profile. And we revised those information based on the U.S. manufacturer's information in detail.

And the next one is for the SBO, RCP seal leakage rate. In the DCD, we indicate, the RCP seal leakage rate is 0.2 gpm. But in the U.S. industry standard, NUMARC 87-00 shows 25 gpm. So, we were requested to justify the difference.

And our response was that isolation barrier stops the leakage from the number one seal and only number two seal easily meets it, so this item also has been closed.

Next one is the AAC reliability. We needed to show the inspection and the testing requirement for the AAC to demonstrate the reliability. So, we revised the DCD to include service test of the AAC and during every refueling outage, we perform the loading test also.

And this page shows also the station blackout. In the station blackout, HVAC equipment is stopped, so turbine driven emergency feedwater pump room temperature will be increased. So, we needed to calculate the room temperature. And we provided conservative assumption and it uses numerically stable calculation method. So, the result, we showed temperature is below the 175 Fahrenheit during the coping period.

Okay. Summary --

MEMBER DIMITRIJEVIC: Sorry, I have a question on ventilation. Does your gas turbine need, where they're located, they do need ventilation for operation? And how about ventilation in your switch gear room?

MR. TANAKA: In the gas turbine generator room, we have ventilation.

MEMBER DIMITRIJEVIC: But is it required? I mean, your ventilation is component cooling water cooled?

MR. TANAKA: Oh, no, no.

MEMBER DIMITRIJEVIC: What is it? Is it --

MR. TANAKA: Yes, no cooling water required.

MEMBER DIMITRIJEVIC: No, no, you don't need the cooling for gas turbine, I got that, it's a huge advantage. Now, I wonder if you need ventilation, maybe on the other second, you need cooling for the room?

MEMBER BLEY: If the room heats up, air cooling may not work so well.

MEMBER DIMITRIJEVIC: Yes.

MR. KAWANGO: And our answer, regarding room of the gas turbine generator, we needed to have the fan, cooling fan, only fan. We don't need to have the actually the air conditioner and a --

MEMBER DIMITRIJEVIC: But did you do calculation to prove?

MR. KAWANGO: Sure, sure, sure, we --

MEMBER DIMITRIJEVIC: How about for your switch gear room, where your AC buses are?

MR. KAWANGO: We need --

MEMBER DIMITRIJEVIC: Or especially --

MR. KAWANGO: Yes, we need to have ventilation cooling system, which needed to rely on cooling water, yes.

MEMBER DIMITRIJEVIC: So, my question for you is in the case of the blackout, station blackout, do you need the cooling water? Can you survive -- because if you need ventilation where your buses are, then you do need cooling water and then, you need the service water.

MR. KAWANGO: I needed to answer be careful, but based on the requirement of the 10 CFR 50.63, okay, 50.63 we will start this alternate AC power source within one hour, okay? Within one hour. So, during this one hour, just from the station blackout starting and this one hour duration, okay?, we evaluate the room temperature of the, of course, the switch gear and also, the I&C control room and the turbine room, feedwater pump room.

And we calculate and evaluate that is within design temperature, we calculate. And after the one hour, of course, we can start the alternate gas turbine, alternate AC power source as alternate, to supply the essential bus, so we can use the cooling water and also, the ventilation system and so on.

MEMBER DIMITRIJEVIC: So, your backup can supply everything HVAC coolers, the- service water --

MR. KAWANGO: Yes, that's right.

MEMBER DIMITRIJEVIC: -- cooling water?

MR. KAWANGO: That's right.

MEMBER DIMITRIJEVIC: So, they're not -- they're the same size as your regular gas turbines?

MR. KAWANGO: It's bigger, a little bit bigger.

MEMBER DIMITRIJEVIC: A little bigger?

MR. KAWANGO: Yes.

MEMBER DIMITRIJEVIC: All right.

MR. TANAKA: Okay. So, summary, all open items with Phase 2 SER have been closed. And additional three types of the RAIs have been closed. That's all. Thank you for attention.

CHAIR SUNSERI: Well, I think Charlie left, I suspect he had a bio break.

(Laughter.)

CHAIR SUNSERI: He had questions about the break process. Well, let me ask the other members if you have any questions for the MHI folks? Nothing else? Dennis? Vesna? Joy? I think, I know Charlie had some questions about the I&C infrastructure. Is that in a different chapter? That's 7? Oh, okay. All right, then.

Well, I suppose we are done with this one then. Thank you. And we will, at this point, while we transition to the next group, which will be Chapter 18, we'll take a break. So, we'll come back at 10:30 and reconvene. So, we are recessed until 10:30.

(Whereupon, the above-entitled matter went off the record at 10:14 a.m. and resumed at 10:31 a.m.)

CHAIR SUNSERI: Okay. We're going to reconvene the meeting now. And this will be the start of Chapter 18 presentation by the Applicant.

MR. MASHIO: Good morning, ladies and gentlemen. I'm Kenji Mashio from MHI. I present Chapter 18, Human Factors Engineering Program. And I lead this presentation, but as a person sitting here, Bob Hall and Joe Tapia, help your question me that you may have.

I have three talking point in this

presentation. First is the structure of the submittal. Second one is basically our basis for the US-APWR HFE application. And also, I'm talking about HFE program management.

CHAIR SUNSERI: I know your speaker is on, but could you move it a little closer to you, you're kind of soft spoken.

MR. MASHIO: Okay. So, first, structure of the submittal. So, as explained in Chapter 8, we submit DCD Revision 4 and tracking, update tracking report. In addition, for the Chapter 18 mockup we submit and docket. This mockup, is purpose of this mockup to consolidate all associate mockup for the Chapter 18 and submit by the data.

And we have technical report, based on the human factor engineer program plan. And so, I have one program management plan and eight HFE program implementation plan.

And we also have our imaging -- our document, which is not docketed, but audit by NRC staff. And the topical report, this describes our US-Basic HSIS, which I explain in detail later.

The technical report, we -- the following element of HFE program is submitted for the implementation plan. And so, one program management plan and eight implementation plan.

And this PMP and IPs address specific HFE activities and provide detailed methodology for those, addressing the criteria in Chapter 18. And all our PMP and IPs have same configuration with the document from Section 1 through Section 8. So this, NRC staff is really reviewing information for each section.

And regarding the procedure development and training program development, these element are addressed by the Chapter 13 review. And we have one COL item for the human factor performance monitoring.

So, audit, NRC staff audit the following design. So, one is HSI design style guide, which applied the HSI designer developed the screen design as a HSI design based on the style guide. And the feature is comply with NUREG-0700.

And also, staff reviewed OER result and this include US-Basic HSI. So, this include not only the U.S. OE, but also the Japanese operating experience. So, I will talking later.

And a topical report, this topical report actually has been approved and the SER was issued. But in this presentation, this topical report is vital source for the US-APWR application, because this US-Basic HSIS is applied for the US-APWR HSI design.

And this summary report we resubmitted after completion with HFE activity. And OER is basic HSI portion has been completed. But the rest of the plant-specific US-APWR application will be implemented.

We have two ITAACs. First ITAAC is we conduct integrated system verification, which ensures operator performance is stable and that there are no failure criteria which touch on the human engineering discrepancy issue.

And also, we have another ITAAC. This is as-built control room design actually installed in the site, according to the design specification feature, which are being verified using the ISV.

CHAIR SUNSERI: So, I'm actually going to ask my colleague Dennis over here, is that typical for that control room design to be part of the ITAAC? It just seems like it would be a design qualification.

MEMBER BLEY: Yes, I don't remember for sure. If you go across the design certs, on a lot of them, they weren't as far along when they got here as this plant was, on having its control room design pretty well along. So, I don't think there's a standard thing, but I don't remember the ITAACs, so I'd have to go back and --

CHAIR SUNSERI: No, no, that's okay. It just kind of stood out to me, but if it doesn't to you, that's fine.

MEMBER RAY: Well, it would depend, I think, Matt, on what credit was taken for the benefits that they're describing there. And that's -- I can't imagine, but normally, I agree with you, it would be unusual to have it be an ITAAC.

MR. TAPIA: There are similar types of ITAACs with regard to the structures of the reactor buildings and such. Such as the thickness of the wall is inspected and conforms to the design. So, this is not unlike some of those ITAACs.

CHAIR SUNSERI: Yes, no, I probably understand that Joe. I guess, it just, in my mind, if I look at these two together, it seemed like Item 1 is just, there's nothing wrong with it, it's just that whoever's building it is going to assume all the risk for any problems with it, right? Thank you. You can continue.

MR. MASHIO: This picture shows basic process. So, first, our topical report describes US-Basic HSIS and feature applied to the US-APWR HSI design process.

And then, we submit our technical report, which includes a program management plan and eight implementation plans. And those document is docketed and reviewed by NRC staff.

And then, after implementation plan have been approved, then we implement it based on these implementation plan. Then, after we complete implementation, then we will submit to a docket as a summary report.

And so, I'm going to the next topic for the HFE program management plan. The US-APWR HFE program management plan is in accordance with NUREG-0711 Revision 2. And this HFE program assures HFE, human factors principles satisfy applicable regulatory requirements.

And following are HFE element covered by our US-APWR HFE program. And as notes show, procedure development and training program has been reviewed by Chapter 13. And COL applicant will address human performance monitoring program as COL items.

The next, this picture shows the overall process for the HFE. And blue portion are covered by the US-Basic HSI process, which described in our topical report. And the green portion are covered by US-APWR DCD and the technical report, as implementation plan.

So, I focus on the green portion, because this blue portion has been approved by the -- so, now, I focus on the green portion.

So, HFE will be implemented based on the US-APWR plant design and then, we build US-APWR inventory, featuring our control and monitoring and information, is actually contents of the systems and the plans.

But in other hand, we also utilize US-Basic HSI. This is generic HSI functions, such as around present or plant operator interact with systems. Such kind of basic functions is utilized and incorporated for the U.S. HSI design, here.

And this is standard portion, but we have some site-specific information, we also integrate as site-specific inventory information. And then, we conduct V&V. Then, we implement the design.

CHAIR SUNSERI: So, back on that one, is it fair to say that the blue part of this diagram is basically done now? That work is complete and --

MR. MASHIO: Yes.

CHAIR SUNSERI: Okay. So, when you were in the middle block there, U.S. operator assessment of US-Basic, there's a step leading into that, I think I'm missing it here, but the translation, U.S.

conversion --

MR. MASHIO: Here?

CHAIR SUNSERI: Yes. Was there any significant -- what was significant about that? I mean, was there any significant way? It's not just converting metrics and units, right? There's some fundamental principles, right?

MEMBER BLEY: This was a big deal, we talked about it a lot at the last meeting. In fact, Bob Hall gave us a couple of technical papers that described the process. I'll let them talk about it, but it was a whole lot more. I think they first tried that and then, that didn't work.

And then, they did some more work, and then, they found just the whole operating practice over here affected how you have to set this up. So, it was a major conversion, but you guys ought to talk about it some.

MR. MASHIO: Yes, actually, this -- I will touch on this issue in the later, because my presentation covers some US-Basic HSI design process. So, I talk later.

But in summary, we tested with U.S. licensed operator, using the dynamic simulator. And then, we have some adjustment based on the gap between the U.S. operator framework and Japanese operator framework. So, we had a gap and we resolved gap and incorporated design procedures and training.

CHAIR SUNSERI: Okay, that's good. I can --

MR. MASHIO: Okay.

CHAIR SUNSERI: -- I'll be patient.

MEMBER REMPE: I can't remember what we discussed back then, but just from my -- a question has been running through my mind since I read this chapter. Is MHI a member of the PWR Owners Group? Other design centers are.

MR. MASHIO: No, we are not member of the PWR Owners Group.

MEMBER REMPE: So, there's a lot of things, especially when you talk about accident management procedures, that I would envision that the COL applicant surely would want to be a member of it.

And that -- how does one convey, or is it appropriate to convey that as part of the design certification, that one would -- I mean, there's been a lot of things that have happened over the years, that it would seem prudent, or is that just beyond the scope of the design certification? You see what I'm saying?

CHAIR SUNSERI: It's an interesting question, yes, I see what you're saying.

MEMBER REMPE: Especially with what happened with the post-Fukushima actions.

CHAIR SUNSERI: So, that may be --

MEMBER REMPE: I don't know who answers that question, but --

CHAIR SUNSERI: Yes, I don't know who, right.

MEMBER REMPE: -- it's something that, when I was reading this, I was wondering about that. And maybe I'll ask the staff about that, unless MHI --

CHAIR SUNSERI: Yes, or maybe --

MEMBER REMPE: -- has a response.

CHAIR SUNSERI: -- direct it at Joe, maybe that would be something that might be worthy to think of going forward, when you get a U.S. customer or whatever, how are they going to stay plugged in with the PWR fleet, if you will.

MR. TAPIA: I understand the question. And typically, the PWR Owners Group is comprised of utilities, not designers. And the functions there would be incorporated, I believe, into the COL applicant's documents.

This is a good question, I'm speculating on my part here and thinking out loud about the answer to your question. But I would imagine that the COL applicant would apply all of those PWR Owners Group's inputs into their application.

MEMBER REMPE: I would hope so, especially during operation. And it's my experience that there are other design centers who are actually leading members of the Owners Groups over the years. And it's good to have that industry interface. But anyway, that's just an observation.

CHAIR SUNSERI: Well, yes, well, we kind of evolved over the years, I mean, as there were three different distinct vendors, right? You'd just see the combustion engineering owners group, Westinghouse, and GE. But as the industry consolidated, it just turned into the PWR Owners Group and the BWR Owners Group, right?

And so, this would almost be like taking it back to the old way, where there were separate NSSS vendors with their own design. But I don't know, I'd have to think about it a little.

MR. TAPIA: We haven't had that interaction --

CHAIR SUNSERI: Yes.

MR. TAPIA: -- with the utilities, I

guess, is the answer, from our perspective, at this point.

CHAIR SUNSERI: Okay.

MEMBER REMPE: Okay. Thank you. It's just something that's been running through my mind.

MR. MASHIO: Okay. May I go to the next slide?

CHAIR SUNSERI: Yes.

MR. MASHIO: Okay. So, the scope of the HFE program management plan include following subject, based on the NUREG-0711 review criteria.

And the second bullet means this HFE activity methodology is described in the implementation plan and each element if we complete activities and we submit document and submit by staff as a summary report.

The next couple of slide include assumptions and constraint. And first, US-APWR HSI is based on the application US-Basic HSI. And so, this generic HSI technology is combined with specific HSI Inventory for the US-APWR plant design, to create US-APWR HSIS.

And the third bullet is, if we have some or any other site-specific information, we integrate the same into our site-specific HSI.

And fundamental design assumption and constraint is, again, we utilize our US-Basic HSI and so, this RO, the one RO and one SRO can operate all condition, including the postulated accident. But again, this morning, I explained based on the regulatory requirement, we accommodate two operators in the control room.

And the next is scope of the planned facility. So, this is not only the MCR, but also the other HSI which our operator staff can interact. But other facility, we utilize our graded approach. So, we take our graded approach to the implement HFE process to other facilities.

So, that all for the PMP. And then, I'm going to explain about US-Basic HSIS. And again, this US-Basic HSI feature is described in the topical report. And this contains our concept of operation and the other HSI key feature.

And in appendix, there are some history of the development of Japanese PWR control room, which is starting point to develop the US-Basic HSI, which I explain later. And we also have our V&V experience in Japan in the Appendix B and US-Basic HSI design process described in the Appendix C.

And background, so MHI used the fundament element Japanese Basic HSIS as starting point to create US-Basic HSIS. And Appendix A contains information about Japanese Basic HSIS and development history.

And the Japanese HSI is composed with Basic HSI and HSI Inventory. This HSI Inventory is developed as part of our US-APWR DCD, in accordance with US-APWR HFE program.

So, this is a general process to develop the US-Basic HSI and the site-specific HSI development. And the first Phase 1 are described in topical report. This is like translation from our Japanese Basic HSI to the US-Basic HSIS.

And the Phase 2 is, this is development of plant-specific, which is US-APWR application inventory, which combined with US-Basic HSIS. And the Phase 3 is confirm site-specific assumptions of Phase 2, or make minor changes, if needed.

And Phase 1, this is US-Basic HSIS design process. So, we separate several subsidiary process, which is Phase 1a and 1b. And the 1a is just a convert from the Japanese language or in general unique signs to the American style.

And then, we also implement, for the U.S. operating procedures. And also, we incorporate the OE result to the US-Basic HSI preliminary design specification. Then, we developed the simulator. Then, we had a test with U.S. licensed operators, using the U.S. operating procedures.

Then, there are many comments regard our human factor discrepancy. Then, we address those discrepancy and to change the design specification.

So, one of the major comment is computer-based procedure functions, because this Japanese style of the operation is different from the U.S. operating style. So, we adjust CBP functions and format. So, again --

MEMBER BLEY: Could you tell us a little the second test, that you made the changes on the simulator?

MR. MASHIO: Yes. So, we also changed the simulator, because we need to verify the operator performance using the dynamic simulator. So, we also made a change for the dynamic simulator and test again in the Phase 1b. And to confirm the design change specification is appropriate one.

So, as described here, we invited eight crews in Phase 1a, and five crews in Phase 1b, to verify HSI.

MEMBER BLEY: These were American

operators?

MR. MASHIO: That's correct. And again, this Phase 1 Alpha is, we identify the difference, then we improve the design to adjust U.S. operation scheme.

And during the review, we coordinate, organize multi-disciplinary, such as not only HFE person, also the associated member, such I&C, plant operations, system engineers. And the results of those are implemented in the various points.

And the operating experience sources include NUREG/CR-6400, each required by NUREG-0711. And we mentioned that we also reviewed our INPO database, also the Japanese OE sources.

And these HSIs are experiences, very limited for the nuclear industry, so we decide other non-nuclear industries, such as airplane or trains, both U.S. and Japan.

And all of OE information is screened by the HFE related issue, such as human error type, training type, procedure type thing. We analyze which are causes. Then, we reflect the design. So, those document is documented internally and NRC staff is audit that document.

And the next couple of slide explain the concept of operation. So, I just explain the key feature. So, the normal MCR mode, so this slide will be -- may send a different message, but I just collect by brief.

So, this control room console can conduct one operator, one RO and one SRO can operate all remote. But based on the U.S. regulation, we staff two RO and one SRO and one STA. So, that means the next is --

MEMBER BLEY: Excuse me, when you did that, did you layout a division of responsibilities? We usually see one RO focused on the primary systems and another on the balance of plant and electrical plant. Did you do that or is it up to the COL to figure out what to do with the extra operator you have?

MR. MASHIO: Yes, actually, the scenarios for the, to test it is, we utilize U.S. operating procedures, which basically is we split the role. One RO responsible for the reactor side and another RO is responsible for the turbine side. So, we, basically, we use normal U.S. configuration, I think. But in addition, that we also tested just one operator, using he responsible for both side.

MEMBER BLEY: Everything?

MR. MASHIO: Yes, yes. So, but --

MEMBER BLEY: Any difference in the tests?

MR. MASHIO: Different --

MEMBER BLEY: Results of the tests?

MR. MASHIO: Yes, different, yes. This HSI VDU is integrate. And so, this reduce operator work, physical workload. And so, basically, he can go through one-by-one, based on the SRO's direction. So, it's -- we verify they could go through it.

But challenging thing is for the dedicated HSI condition, so normal operating, non-safety VDU is not working, then they switch to the safety VDU only. This is challenging for the operators to mitigate the accident.

But they -- we have some modification, such as -- this is very detailed. But we made a change with the safety VDU HSI design, we verified they can complete accident mitigation using only safety HSIS.

MEMBER BLEY: Okay.

MR. MASHIO: So, yes.

MEMBER BLEY: Thank you.

MR. MASHIO: So, next picture, this is the console layout and so, we have a large display screen here and operator console, and two RO can sit in front of the operator console.

Then, behind that, supervisor console, SRO can sit here. And we have SRO -- STA can sit and he can advise control room staff, in case of the accident.

And we also have diverse HSI panel here. So, all these HSIs down, as a common-cause failure, then they move to here and to cope with the accident using these panels.

MEMBER BLEY: There were some interesting tests done at Halden, I wonder if you were privy to those, where they took the shift technical advisor, the STA, and had him in sort of this configuration. And then, they moved him separate from all the other people, just observing.

And they got some very interesting results on the effectiveness of the STA under those different circumstances. You might take a look at that, I think you might find it interesting. It's been about four years ago, yes. I can give you a contact over there.

MR. MASHIO: Okay. Can I go to next slide? So, this computer-based HSI provide operation display and it features fundamental interface. Basically, operator can touch on the display and all action can be conducting using VDU.

And the operator workload is reduced, providing the information at the integrated display. And they cannot movement inside the console. So, they just utilize VDUs in front of him. So, those workload, these functions can, one RO operate whole remote.

And diverse HSI also have some operating supporting function. So, these are computer checking status, plant status, then provides information to the operators. And this operating supporting function also contributes workload as well and also reach our ends.

And the large display panel provide -- I can show this picture. So, we have -- this is pictures of the control room. And this one is the large display panel. And we have three fixed display and one variable display.

So, this fixed area, all major information, such as, you can see these are primary power systems and the turbine and the generator system, all important parameters can be shown in this fixed display. And all alarms is pop-up in the fixed display. So, the operator can view this information over other information.

In addition, in the variable area, any

display feature the operator console, also the supervisor console, can display here. So, this can allow MCR staff has the same information and use them to communicate with each other.

So, I explained those. And in this control room, we also have paging feature, all facility from MCR. Also, we have intercom functions, which are communication from between MCR staff and LOCA staff.

And they are not in this picture, but we also have maintenance console, which can use during the periodic maintenance or shutdown condition. And the tagging feature also implemented in this diverse HSI.

So, I think that that's all. Yes. That's all our presentation.

CHAIR SUNSERI: That's the end? Okay. We had a lot more slides in the material that was sent to us.

MR. MASHIO: Yes, I think I --

CHAIR SUNSERI: Seventy.

(Simultaneous speaking.)

(Laughter.)

CHAIR SUNSERI: Now we can ask all kinds of questions. Okay. So, thank you. We'll ask the members if you have any additional questions?

MEMBER DIMITRIJEVIC: I'm just curious, did you have to provide the list of important human actions from your PRA Chapter 19 in Chapter 18?

MR. MASHIO: Yes. Yes, we documented and we collect all our list of significant actions from PRA --

MEMBER DIMITRIJEVIC: Right.

MR. MASHIO: -- and HRA, yes.

MEMBER DIMITRIJEVIC: So, do you remember, like ad hoc, which actions seem to be important?

MR. MASHIO: Yes. One was, this is steam generator activation of the ruptured SG, this one -- yes.

MEMBER DIMITRIJEVIC: For the steam generator tube rupture?

MR. MASHIO: Tube rupture, yes.

MEMBER DIMITRIJEVIC: How about switching? You don't have to switch to recirculation, so there is nothing in the LOCA which is important?

MR. MASHIO: Yes, LOCA is no, I think there's no action. In the large LOCA, it's automatic function, such as SI injection by automated, so they're not necessary for the operator action in the LOCA.

MEMBER DIMITRIJEVIC: And those gas turbines, can they be manually loaded?

MR. MASHIO: No, gas turbine also automatically started, initiated.

MEMBER DIMITRIJEVIC: But do you credit the manual backups of the recovering power or loading the --

MR. MASHIO: Yes, in general, yes, basically, this is safety interlock, so they are not necessary to take manual action, yes. But if -- we also consider the degraded HSI mode, which is if, you know, our system is not functioning, such as common-cause failure, then we --

MEMBER DIMITRIJEVIC: You go to recovery?

MR. MASHIO: Yes, yes.

CHAIR SUNSERI: Dennis, did you have something?

MEMBER BLEY: I didn't, just checking things.

CHAIR SUNSERI: All right. Any other comments?

MEMBER BROWN: Yes.

CHAIR SUNSERI: Charlie?

MEMBER BROWN: I've got to find it now. You had a slide we talked about how the operators --

CHAIR SUNSERI: Mic.

MEMBER BROWN: I'm sorry, mic. There was a slide where you talked about how the operators accessed the VDUs. Ah, here it is, it was Slide 36. I'm going backwards now to eight years ago, when we first looked at this, because they're the same, it's the touch screens. And have you all got any of these touch screen control panels in service anywhere in actual plants today.

MR. MASHIO: Yes, actually, Tomari Industry, this latest three-loop plant in Japan, utilize this touch screen based --

MEMBER BROWN: How long have they been in service?

MR. MASHIO: This commercial operation is 2009, December.

MEMBER BROWN: Okay, about ten years --

MR. MASHIO: Yes, yes.

MEMBER BROWN: -- ago, then?

MR. MASHIO: Yes, but after the Fukushima accident, Tomari Industry also stopped and is currently --

MEMBER BROWN: I lost track of what you just said.

MR. TAPIA: They shut down.

MR. MASHIO: Shut down, yes.

MEMBER BROWN: After what? After Fukushima?

MR. MASHIO: After Fukushima, yes.

MEMBER BROWN: Okay, so that was 2011?

MR. MASHIO: Yes.

MEMBER BROWN: Okay. My memory's locator bits are not working real well right now. The reason I ask is, I hate touch screens.

(Laughter.)

MEMBER BROWN: Personal opinion, based on experience, that every time I've touched one thing, all of a sudden, the screen disappeared and something else popped up.

How much -- did you all get any feedback in that period of time? It says you have two ways of doing it, either by touching a screen or clicking, so I presume you click on it with a mouse of some kind like this?

MR. MASHIO: Yes, actually, I had some interview with, actually the Comanche Peak person participated in the test and I remember their feedback for the touch screen is very efficient.

Because the -- all the touch screens are not have accuracy to, pointing device is not accuracy, but this touch screen feature, we made the text, this is, I think, 2008 or 2009, maybe ten years ago. Even though ten years ago, these touch screens are efficient, so, this accuracy to pointing.

MR. TAPIA: He's also asking about, do you have feedback from the Japanese operators?

MR. MASHIO: Yes. Sorry. So, in the operating plant in Japan, actually, I did not go to the interview for them, so actually I have no opportunity to get feedback from them.

MEMBER BROWN: Okay, all right. That's --

MR. MASHIO: Yes.

MEMBER BROWN: -- fair answer. I just, it's just a particular -- I've watched a few where people's laptops and they touch and all of a sudden, things move around.

And these are dedicated, they're fixed screen panels, as you all have described them, I just went back and looked at the DCD, okay. So, it's not like a smartphone, where things are sliding all over the place. So, I was just curious as to, number one, the sensitivity to the touch.

MR. HALL: Let me talk about the testing we did during --

MEMBER BROWN: Oh, that would be --

MR. HALL: -- that Phase 1a and b.

MEMBER BROWN: -- if you have some, that would be nice.

MR. HALL: And there are a number of papers out there. There was a test report written, but it was never submitted to the NRC, but there are papers out there, Dennis referred to one of them. They sent -- just staying with the touch screen. U.S. operators, all from Comanche Peak --

MEMBER BROWN: Okay.

MR. HALL: -- Phase 1 had 22 of them, because we were looking at two operators versus one operator, very little difference between the two. Phase 2, we did ten operators, we never doubled up on the -- ten people from Comanche Peak.

As far as the touch screens were concerned, the first go around, there were questions and concerns. And the questions and concerns were size of the touch --

MEMBER BROWN: Fat fingers versus small fingers.

MR. HALL: Exactly -- on the screen. And touching what you thought you were touching, but not. Sensitivity of it, how long you had to touch it, how hard you had to touch it to make it respond. Changes were made and during the Phase 1b tests, resolved. So, the outcome of all of those tests had very positive operator response to how the screens functioned.

MEMBER BROWN: Okay.

MR. HALL: But some of your questions, and what happens on my Apple Watch, those were investigated and changes made. Because I touch on the wrong things too.

MEMBER BROWN: Well, when I go to the grocery store here, I have to get a number for the deli section, and there's a little touch screen and you'll touch, nothing happens. I have to touch it eight, nine, ten times, put my whole hand on it, still doesn't go.

MEMBER BLEY: Lick your finger.

MEMBER BROWN: That doesn't work either, but that's -- I don't want to do that the third or fourth time --

MEMBER BLEY: I will tell you --

MEMBER BROWN: -- because I don't want to get other people's germs.

MEMBER BALLINGER: Have you thought about there being a no-fly list at your grocery store?

MEMBER BROWN: Ron, I'll defer you to you on that one.

MEMBER BLEY: I'm going to give you another example. Out at Palo Verde, they tried one of these glass-top simulators and put their whole control room simulator on it. And they ended up liking it so much, they bought about 20 of them, put them all around the plant, so people could run the simulator anywhere. And they've had no trouble with it.

MEMBER BROWN: That's good.

MEMBER BLEY: They've really --

MEMBER REMPE: Did it ever lock up and they had to reboot? Or did they -- was that part of your testing?

MR. HALL: It never did in reality, but we forced some things such as that. What we did is, the first time around, and please don't quote me on the exact numbers, but the first time around, I think we ran six scenarios, with secondary and tertiary failures built into them.

Second set of tests, we ran I think eight scenarios, again with anything from a screen lock-up to total loss of display systems to alarm lock-ups, et cetera. And ended up with quite good responses, if you look at the test results.

MEMBER REMPE: So, they just had to wait

and reboot? Or what did they do? Go to an alternate screen?

MR. HALL: Typically, go to an alternate, unless in fact everything locked up at once. And we looked at response times for deciding whether the screen had in fact locked up or not.

We didn't -- initially, it was, you didn't realize the screen was locked up until you touched it and nothing happened. We changed that and put an indication, where you could see a heartbeat, that it was or was not functioning, things like that.

MEMBER REMPE: Okay, thanks.

MEMBER BROWN: The other reason for my question was that I was in the Naval Nuclear Program and we had great debates, starting from 1970, there weren't touch screens in 1979, shows you how old I am, but as we transitioned up to the later classes of ships, the ones that we started developing in the late '90s, before I retired in '99, we were still having all control functions with switches, so that you could maintain a touch-feel for where they were, as opposed to selecting actual control functions.

We selected touch screens for pulling up a menu of alarm details or something like that, but not for the actual starting or stopping of a pump, whether it's a reactor coolant pump or a safeguard pump or feed pump or et cetera, et cetera, et cetera. Now, I don't know what they're doing on the new plant, I don't remember reviewing that.

But I do know there was a lot of very, for the sailors, since actions are happening very, very fast in some of the submarines, well, in all of the submarines or the carriers, that you wanted -- this way, they could have the touch, actual positional feel, and know whether they were in slow, fast, intermediate, or what have you.

So, I was just curious what you experience you had. So, that was the purpose of my question. Thank you for your elucidation.

CHAIR SUNSERI: Any other member comments?

MEMBER BROWN: And Dennis's feedback.

CHAIR SUNSERI: Any other comments? Okay. So, wrapping up the section with the Applicant. I recorded two items that I think we'll give to you as part of follow-ups for future presentations.

The first one will be, and I'm not sure where, I'm just going to throw these out and you'll decide when you hear the topic, but it's either going to be Chapter 3 and 4, and it will be the follow-up on the seismic analysis of the reactor vessel due to the increased mass of the neutron reflector.

The second item will probably be a Chapter 7 discussion, but I just want you to be aware that, since we reviewed the digital I&C system in the first go round, there's been some lessons learned in our area, and we have developed some principles of operation around digital systems.

I think there's five principles. You talked about two of them, defense-in-depth and diversity, there's others. So, I would commend you to emphasize how you're addressing these principles in your presentation when you come to Chapter 7 on digital I&C. And Charlie can give you the five principles.

MEMBER BROWN: Of course. There was a staff engineer, NRC staff, asked also what I was talking about, so I explained it to him during the break.

The point is, we've been emphasizing five fundamentals in developing the architecture. You have an architecture defined in your DCD and it's amplified by one of your topical report or technical report, I can't remember what the term is, which I just went back and looked at also.

But they were independence, redundancy,

deterministic processing, diversity, and defense-in-depth, and control of access. We didn't cover -- the control of access wasn't amplified as much back in 2010 and 2011 as they are today.

Largely, that was -- you have networks in your plant and the networks communicate exterior to the plant. And the point of that was that protection systems and safeguard systems, outputs, can go to the control room, which is internal to the plant.

But when you go to networks that have external access out to the internet world, they should be, any information passed on should be hardware-based, one-way communications, not software controlled firewalls.

And we've emphasized that pretty strongly, just from a -- it's a control -- forget cyber, that's a whole 'nother world. This is strictly access control. And so, and I explained that to him.

The other point was watchdog timers and how they communicate. You do have a whole section on, or there is a section on, I went back and checked this also, just to make sure, on watchdog timers, in your tech topical report on the MELTAC platform.

There may be some nuances, I went back and took a quick read on it, and there's a few nuances that we'll probably bring up. So, I presume you'll have people that can discuss that at that time. That's all I want to make sure we cover. Okay?

CHAIR SUNSERI: You don't have to get back to us, it'll just be part of your presentation.

MEMBER BROWN: That's right. You don't -- I'm not expecting anything, other than --

MR. TAPIA: Is that the same for the first one on the seismic --

CHAIR SUNSERI: Yes.

MR. TAPIA: Okay.

CHAIR SUNSERI: Yes.

MR. TAPIA: So, I don't owe you anything?

CHAIR SUNSERI: You don't owe us.

MEMBER BROWN: No.

CHAIR SUNSERI: I don't recall --

MR. TAPIA: Just be sure we cover that.

CHAIR SUNSERI: -- anything that you owe us as a result of Chapters 8 or 18.

MR. TAPIA: Understand, thank you.

CHAIR SUNSERI: Okay.

MEMBER BROWN: I'll amplify one other thing on the watchdogs. If you look at the last projects that we looked at, the new design certs, you have to vote on trip signals from each of the independent channels.

And there's -- you use a processor for that as well, it's not an analog voting, like the old days. So, if they lock up, the watchdog timer needs to detect that.

And all your tech report says, it says there's a failure. It doesn't say what is processed as a failure, what does that do? Does it send a trip out as one of the trips to the reactor trip breaker, the two out of four that runs for that, or not? Or is it just an alarm that goes to somebody?

For the safeguards part, you obviously don't want to start safeguard systems. But for reactor trip, you really need to initiate a reactor trip for that one channel, just to make sure -- as well as an alarm.

So, that's kind of the context. And we'll bring that up when we get to that particular chapter review.

MR. TAPIA: Understand your comment.

MEMBER BROWN: And there's no feedback you need to do anything right now, you got totally clear.

MR. TAPIA: Sure.

MEMBER BROWN: Okay?

MR. TAPIA: We're engaged with the staff

right now on this very item.

MEMBER BROWN: And I did explain that to one of the staff, who knew exactly what I was talking about.

MR. TAPIA: Thank you.

MEMBER BROWN: All right.

MR. TAPIA: We'll be prepared.

MEMBER BROWN: Thank you.

CHAIR SUNSERI: All right. So, we've completed this agenda item. Mashio-san, thank you for your presentation, very good.

And what I would like to do is, it's a little too early to break for lunch, so I'd like to have the staff come up here and present the Chapter 8 SER. It's only a few slides and I think we might be able to get through that. Then, we will break for lunch.

So, George, as you're getting together here, I would also think that, depends on how fast this goes, we might just roll into 18, and I don't know if we can complete that.

MR. WUNDER: Okay.

CHAIR SUNSERI: And then, if we could, I mean, the advantage to that is, that's a perfect breaking point for the public session and we can close the public and go into closed session after lunch for the accumulator.

MR. WUNDER: We've got the people here and we're ready to do it, if that's your desire.

CHAIR SUNSERI: Okay. We'll see how this goes, all right?, the first chapter. And whenever, you just let us know when you're ready.

MR. WUNDER: Okay. I got the button this time, I made a little note there, so that I'd remember it.

One of the challenges we face when we resume work on a safety evaluation that's been idle for some time is that the technical staff who worked on the document may have moved on to other positions. One of the things that makes us such an effective agency, though, is that not only do we have first-rate talent, but we have a very deep bench.

And in the case of both Chapters 8 and 18, the principal contributors for the Phase 2 review have moved on. So, we went to the bullpen. Sheila, Nadim, and Brian all have a wealth of experience as technical reviewers and they have a complete mastery of the subject matter. And I will leave it now in their capable hands.

CHAIR SUNSERI: Well, you have an

advantage over us, when the ACRS members leave, they just leave, right?, there is no bench for us.

(Laughter.)

CHAIR SUNSERI: So, go ahead, please.

MR. KAHN: Thank you, George. As George mentioned, my name is Nadim Khan. The US-APWR electrical power system consists of --

CHAIR SUNSERI: Is your -- yes, could you pull that a little closer, please?

MR. KAHN: Okay. The US-APWR electric power system consists of the offsite power system and the AC and DC power system.

During the staff's review, there were two open items. Both issues were closed in Phase 4 and today, I will discuss the open items and the resolution of these items. The open items are related to open phase condition and GTG reliability.

The first open item is regarding the open phase condition and the staff's position is outlined in BTP 8-9. BTP 8-9 discusses the electrical power system's design vulnerability due to an open phase condition in the offsite electrical power system.

The staff requested the Applicant explain how its electrical system design would detect, alarm, and respond to an open phase condition. The protection features for the open phase condition per BTP 8-9, the Applicant provided COL Item 8.212, in which the COL applicant is to determine the type of open phase detection and protection system and address the guidance in BTP 8-9.

The staff determined that COL Item 8.212 will ensure that the COL applicant will determine an open phase detection and protection system that meets the guidance in BTP 8-9, including detection, alarm in the main control room, and protection features, in that the Class 1E medium voltage buses will transfer to a power source without an open phase condition.

DCD Tier 2 Section 8.2 includes a general description of the criteria for addressing OPC. Since the Applicant has provided a COL item, ITAAC, and tech spec to ensure the open phase detection and protection system provides detection, alarm in the main control room, and protection features, the staff finds this issue closed.

With that, I will turn it over to Sheila.

MEMBER BROWN: Before you leave --

MR. KAHN: Yes?

MEMBER BROWN: -- oh, jeez, I lost it. Oh, here it is. In your SER, which I can't find now, oh, there it is, I'm recollecting this, my notes are crummy, you made the -- in your evaluation of the open phase, you summarize their response to you all.

And I thought, in their response, they identified that the present design would do a certain amount of things, but there were a couple of items that you all identified in a follow-up RAI that it wouldn't and that they would -- and their response was, that's what they would incorporate.

Is my -- in other words, it's not like they're totally devoid of any open circuit protection going into this. So, the current design had some features.

MR. KAHN: Yes, there is protection for the high side.

MEMBER BROWN: For the high side, that's what I thought. And then, they said that in the --

MR. KAHN: The RAT.

MEMBER BROWN: Both the RAT and the UATs?

MR. KAHN: So, the main transformer is on top of the UATs.

MEMBER BROWN: Yes.

MR. KAHN: So, there's protection on the high side of the main transformer and the RATs --

MEMBER BROWN: Okay.

MR. KAHN: -- which is a non-Class 1E.

And then, they proposed to use the undervoltage detection system on secondary side of the UATs and the RATs.

MEMBER BROWN: That's already existing?

MR. KAHN: Yes.

MEMBER BROWN: Okay. It's already there?

MR. KAHN: Yes.

MEMBER BROWN: Okay.

MR. KAHN: But when you use undervoltage detection system, there isn't a change in voltage magnitude, but there is a change in the phase.

MEMBER BROWN: That's what I remember you discussed, the phase shift that you get and --

MR. KAHN: And that's why -- and they will have a COL item that will address how to -- the protection on the secondary side --

MEMBER BROWN: All right. So, it will --

MR. KAHN: The UAT and the RAT.

MEMBER BROWN: I got it. That's -- all right. So, that's a loose end. In other words, they were kind of covered, but not totally covered?

MR. KAHN: Yes.

MEMBER BROWN: And that's fundamentally what the COL item covers?

MR. KAHN: Yes.

MEMBER BROWN: Okay, thank you.

MS. RAY: Any other questions?

MEMBER BROWN: No.

MS. RAY: All right. Thank you. My name is Sheila Ray and I will be presenting the second item on GTG reliability.

MHI proposed the use of gas turbine generators as the Class 1E emergency power source for the onsite AC power systems. GTGs have not been used in the operating fleet as Class 1E power sources. Therefore, there is no operating experience and no reliability data for the U.S.

In the absence of operating experience and reliability data, the staff requested the Applicant to perform type tests to ensure the GTGs will perform their intended function and achieve their target reliability level.

MHI discussed the qualification methodology and initial type tests for the GTGs in Technical Report MUAP-07024. Specifically, the type test includes load capability testing, start and load testing, and margin tests, per IEEE standard 387-1985, as endorsed by Regulatory Guide 1.9.

The Applicant documented the successful qualification of the Class 1E GTGs in Technical Report

MUAP-10023. MHI successfully performed 150 start and load acceptance tests of the GTGs.

The report demonstrated that the GTGs were able to start and ready to accept load well within 100 seconds, which is the GTG start time used in the accident analysis. The successful starts satisfy the reliability criterion of 0.975 with 95 percent confidence.

In conclusion, the staff finds that the Applicant's approach to demonstrating the Class 1E GTG reliability is adequate, considering compliance with GDC-17, conformance to Reg Guide 1.155, as well as successful qualification via type testing. This concludes the staff's presentation.

MEMBER BROWN: I guess one question, when you -- and this is my interpretation of what you're saying, to make sure I understand it. You said it was they did the 150 starts and ready to accept load within 100 seconds, fine. Did they actually apply the load within 100 seconds? Full load?

MS. RAY: I will have to go back and check.

MEMBER BROWN: Being ready to accept it is one thing, being able to accept it is another.

MS. RAY: Understand. I know they did

have load banks, so they may have put load on. I would request the Applicant, if they have any information.

MEMBER BROWN: The rating of these is 50 --

MS. RAY: It's 4500 kW.

MEMBER BROWN: Forty-five hundred, that's right, thank you.

MS. RAY: Right. And then, 4950 for the short-time.

MEMBER BROWN: That's overload, but, I mean, you should be able to start.

MS. RAY: Correct.

MEMBER BROWN: And I don't know what the maximum, whether they -- do they time the loads coming in? Or is it based on applying -- I'm going back to my Navy experience, because I just, if I had a 450 kW turbine generator set or a 1000, we applied the full load to it.

MS. RAY: Right. So, they also did another test, this is a test not required by IEEE 387, but recommended by the manufacturer, where they loaded the GTG from 25 percent to 100 percent and also checked the reject of that load. So, they would have done loading 75 percent all the way, and 100 percent

--

MEMBER BROWN: That's starting at 25?

MS. RAY: Right.

MEMBER BROWN: They started -- so, they already -- my point was, if you have to time your loads, if you have to have a timed load application, that's fine, I don't have a problem with that. But that ought to be explained and at least identified so a COL doesn't not understand that when they actually do their plant design.

MS. RAY: The technical report, the second one, and I believe also the first one --

MEMBER BROWN: This is the 23, right?

MS. RAY: The 23, and I believe the 07024, showed the loading sequence for all of the trains of the GTG. So, it's very clear for the COL applicant, the timing and amount of load being applied.

MEMBER BROWN: So, it doesn't have to -- these, then, would not be designed to accept a full 4500 kW load instantaneously?

MS. RAY: Instantaneously, no.

MEMBER BROWN: Okay. So, that's --

MS. RAY: It's sequenced on.

MEMBER BROWN: All right. And when -- I don't know what you all's requirements are, but I presume that means when it's loaded, the deviation from the final allowable steady-state frequency and voltage, it has to -- you can dip only a certain amount out of the band and you have to recover, I don't remember what the IEEE specs are.

MS. RAY: That is correct. There is a --

MEMBER BROWN: And then, you have to recover within a couple of seconds or something like that.

MS. RAY: That is correct. And the second report, the 10023, demonstrated that, that they were able to, I believe they were able to come back to nominal voltage and frequency within approximately four seconds.

MEMBER BROWN: Okay. All right. Okay, you answered my question.

MS. RAY: Okay.

MEMBER BROWN: Thank you.

MS. RAY: Thank you.

MEMBER DIMITRIJEVIC: But if you have the second test, where they loaded, to show the disconnect and connect and sequence of load, then they have some running data too, right? The diesel generators always have a problem with the first hour of running. So, did they have any -- this is all starting failure data, which you presented here, right? Did you have any running failure data?

MS. RAY: I do believe the -- there is an initial test program where they will run the GTGs two hours short-time, 22 hours continuous.

MEMBER DIMITRIJEVIC: Okay.

MS. RAY: So, there are tests where they will be demonstrating the GTG that is actually installed. Does that answer your question?

MEMBER DIMITRIJEVIC: Yes, that answer my question. I was just wondering, would that data be available to look in that way. Because it will be interesting, because we do have a gas turbine, not as a safety system, but we don't have good data for it.

MS. RAY: Correct.

MEMBER DIMITRIJEVIC: Yes.

MS. RAY: And I believe at the COL stage, I believe there are ITAAC for the GTG.

MEMBER BROWN: The way I -- I'm sorry, are you finished?

MEMBER DIMITRIJEVIC: Yes.

MEMBER BROWN: My interpretation of that is, they ran tests on gas turbine generators that they have. When the COL, if you actually go build one of these, that doesn't mean they're going to get the same gas turbine generator, it might not be available anymore. So, they'll develop one, but it has to meet these requirements.

MS. RAY: Correct. The --

MEMBER BROWN: Is that -- okay.

MS. RAY: The DCA will say, these are the ratings that I request. The COL applicant, if they use a different manufacturer, then they would have to show qualification testing.

MEMBER BROWN: If it's different from the one that was tested via these --

MS. RAY: Correct.

MEMBER BROWN: Okay. Thank you.

CHAIR SUNSERI: Did you have any other material?

MS. RAY: No, that was all we had. Any other questions?

CHAIR SUNSERI: Any other questions from the members? Okay. Well, then, I guess, we thank you for that presentation. And we will take Chapter 18 now.

MS. RAY: Thank you.

CHAIR SUNSERI: Thank you. No, no, no, we're going to roll into Chapter 18 and see how far we get. We may break, we'll probably go -- if we don't finish by 12:30, we'll break for lunch at 12:30. No, no, just the public part.

MR. WUNDER: Okay. I guess we're ready to move on to Chapter 18.

CHAIR SUNSERI: And we're ready for you.

MR. WUNDER: I guess we're ready to move on to Chapter 18 and the man without a name card is Dr. Brian Green.

DR. GREEN: I had written down my introductory notes here and I had good afternoon, but I've got to adapt, so good morning, everybody. I'm Brian Green, I'll be summarizing the Chapter 18 review today.

I played a small role in this review. Actually, I was on the acceptance review and then, I went to NRR for a while, and now, I'm back. So, I'll do my best to represent the material the staff did here. All right.

Staff's review of the US-APWR was somewhat unique from the design certifications of applications that preceded it. This is because MHI submitted MUAP-07007, the topical report which describes a generic human system interface platform for NRC review, in addition to the application materials that are typically submitted for design certification.

The generic platform described in the topical report was reviewed by the staff and it was concluded that it conformed to NUREG-0700, the staff guidance that the staff uses to assess the design of human system interfaces.

The submission of the topical report describing the generic platform was unique from previous design certifications. The DCD describes a human factors design program that will be used to build upon the generic HSI platform described in the topical report.

Staff reviewed MHI's human factors program and found that it conformed the NUREG-0711, the staff guidance for reviewing human factors programs.

While reviewing the transcripts of the previous ACRS meeting, I noticed there was a fair amount of confusion as to why there was a need for a human factors program, if the staff had already reviewed the human system interface platform described in the topical report.

I think Kenji did a great job of describing that this morning. I prepared a slide to discuss it and I'll dig into it, but if you feel you've heard enough of it, we can move on.

So, the initial APWR design is being

licensed and constructed in Japan. The design was created using a process that is similar to the one described in NUREG-0711. This design process helps to ensure that designers conduct appropriate human factors analyses, design activities, evaluations, and implementation activities that focus on human performance.

The adequacy of the HFE activities associated with the Japanese HSI design was not a significant consideration in the staff review. However, the staff acknowledges that these design activities provided MHI with an early opportunity to identify and resolve potential issues with the Japanese HSI design. This is shown in the first arrow on the graphic above.

Since the Japanese predecessor design was created using good human factors principles, it forms a solid baseline for the US-APWR design, with regards to the human performance.

MHI recognized that some aspects of the predecessor design did not universally apply to operators in other countries. In other words, some modifications were necessary for the US-APWR to support U.S. operators and to comply with U.S. regulations.

Some examples of these changes include converting units to U.S. standards, translating and adapting procedures to English and to the U.S. concept of operations, as well as other considerations.

Topical report refers to these activities as Phase 1a, which I think of as Americanizing the Japanese design, and Phase 1b, which is used to resolve any issues associated with these modifications. You'll find this is demonstrated in the second arrow on the slide in front of you.

What is more similar to the other design certifications that you've reviewed before is the third arrow here. And that's the third iteration, where MHI will conduct the activities described in the DCD and the implementation plans.

The outcome of this process will be the US-APWR human system interface design. The activities conducted during this iteration are in many ways similar to the activities conducted by previous design certification applicants.

These activities are the primary focus of the staff's review that we're discussing today. Activities include a variety of human factors analyses and design activities that guide the development of the US-APWR human system interface inventory.

In addition, a series of verification and validation tests will be used to provide performance based data to confirm that operators can safely operate the plant.

Moreover, MHI provides yet another iteration of design activities and evaluations during a future site-specific design phase, which will consider any unique aspects associated with a particular site. And that's illustrated in the fourth arrow.

As you can see, MHI's design of HFE processes started long before the design certification process and it continues after the design certification is over. The iteration is, in my opinion, a strength of the processes they have and it's one of the human factors principles described in 0711.

A few -- the topical report has already been approved, but I want to summarize it briefly here.

At the time that the Phase 4 SER was being written, the US-Basic Human System Interface was, I believe to be the most detailed design description that the staff had seen at this point. Many years have passed since then, so things are a little difficult to describe.

But part of that, staff had to rely primarily on reviewing implementation plans, essentially promises about how the plan will one day be designed. So, in a sense, the fact that the topical report was available to us, we actually got to see it interact with the design in way we hadn't had yet.

Staff conducted an audit of the HFE design descriptions and found that they were consistent with NUREG-0711. This provided confidence that good human factors design principles were applied to the US-Basic HSI.

Some brief comments about the design certification. Design certification review builds upon the US-Basic HSI described in the topical report by completing the work according to the implementation plans that are in the DC.

The staff reviewed the implementation plans to ensure they met the acceptance criteria in NUREG-0711 and to ensure that they were consistent with the high level descriptions in the DCD. The ITAAC described in Tier 1 helped to ensure that the activities described in the implementation plans are conducted appropriately.

This slide has a summary, I know it's a little bit of an eye chart here. These are -- this demonstrates the 12 different elements of the human factors review, as described in 0711. This basically just shows what level of interaction the staff has had with these different elements.

For instance, the HFE program management plan is a complete element, we don't expect to do any future work with that. We have several implementation plans, which is consistent with what we've seen in previous reviews.

The procedure development and training program development were reviewed under Chapter 13. There's significant overlap between these two technical areas, so that was done to reduce redundancy.

And the human performance monitoring is a COL action item.

There are no open items and there are no confirmatory items in Chapter 18.

In conclusion, the topical report describes an acceptable generic platform called the US-Basic HSI. This basic design will be iterated upon using the implementation plans incorporated by reference in the DCD, which the staff has found consistent with the applicable guidance.

The implementation plans provide the staff with confidence that future iterations on the basic HSI will be consistent with the state of the art human factors principles, as required by 10 CFR 50.34 and other U.S. regulations.

In addition, ITAAC are used to verify that the human factors practices described in the DCD and implementation plans produce adequate results that are ultimately incorporated into the final US-APWR design.

This concludes my prepared remarks. Have you got questions?

CHAIR SUNSERI: So, there was a -- thank you, Dennis. There were two ITAACs that the Applicant discussed. One dealt with essentially confirming the design aspects of the human system interaction, which is going to be done very near the operational phase, right --

DR. GREEN: That's right.

CHAIR SUNSERI: -- this ITAAC? And then, the second one, I think was confirmation that the installed equipment conformed with the design, right? So, two would, in my mind, normally be separated in time, but they've been put together --

DR. GREEN: Yes.

CHAIR SUNSERI: -- in some way. What's your thoughts on that?

DR. GREEN: Well, and I was looking at it too, as you brought up the question earlier. They can be separated in time and I think that's why there are two of them.

The first one, and I'm sorry, I don't have this on a slide, the first one that MHI had showed had a reference to the integrated system validation, which is the testing.

It's controlled by one of the implementation plans, where they would take the final design and the simulator and run it through a bunch of scenarios, to make sure that the operators can do the things that they claim that they can do.

So, the first one references the integrated system validation. So, they're looking to make sure that those results are adequate and that those tests are run appropriately.

The second one is based on design implementation, and this is focused more on the as-built design, so that, in the case that there is some distance in time between an integrated system validation is run and when the as-built is done, the design implementation implementation plan -- I apologize for the clumsy terminologies, it's really difficult to say implementation twice in a row --

CHAIR SUNSERI: That's all right.

DR. GREEN: -- but that's what it's called. It basically is a check to make sure that the assumptions that you validated in the ISV remain true at the as-built.

So, let's say the design looks one way on paper, when they put it in the simulator and then, they run the tests and everything looks good. And then, you get into the building and something needs to change.

The DIIP, or design implementation implementation plan, the second ITAAC, is a reconciliation to make sure that they go back to the ISV, make sure that those assumptions remain true, and if they don't, then maybe a design change is warranted or additional testing.

So, that's why there are two that look kind of similar, it's to address that potential impact in time.

CHAIR SUNSERI: I mean, I was just thinking a bit more simplistically, like you buy a digital system or whatever and there's usually a factory acceptance test and a site acceptance test.

And that's -- I was kind of equating those two ITAACs as a similar kind of thing, but you described it very well though, I think it's different in my mind.

DR. GREEN: Yes, they look kind of similar in the wording, the ITAAC wording is always a bit of -- it's a very specific thing. And I agree, it looked a little -- I could see why you had the question you have.

CHAIR SUNSERI: Okay.

DR. GREEN: But the intent behind them is different.

CHAIR SUNSERI: Okay, thanks. That clears it up for me.

MEMBER REMPE: So, I have a question that I raised with the Applicant that I'd like to discuss with you, too, about the fact that they have the procedures -- and maybe this comes under Chapter 13 and your statement about state of the art human factor principles, and thinking about the follow-up about what's happened with the severe accident management guidelines, as well as some of the accident management procedures.

The fact that there's not an owners group membership with MHI, and maybe this comes up solely with the applicant, but where they have developed procedures to pass off to the applicant already, that I guess you've reviewed, right?

DR. GREEN: I'm not sure specifically what the staff reviewed, I'd have to go look back into that. But there is not a requirement for them to have the procedures done at the time of the design certification.

MEMBER REMPE: And some people do pass it off to the applicant, but it almost --

DR. GREEN: Right.

MEMBER REMPE: -- sounded like, from what I read in this chapter, that they had done a lot of their procedures. They explicitly stated it in Chapter 18.

DR. GREEN: Yes, I'd have to go back and look at it. I mean, my understand was that during the Phase 1a, the Americanization, that there was some consideration of that done. I wasn't part of that team, so I'm not sure to what degree that is complete.

MEMBER REMPE: They split the load for the operators, they mentioned too.

DR. GREEN: Yes. So, part of Chapter 13, at a COL stage is where they would look at final procedures. So, we're looking at, in Chapter 18 space, it's more of a preliminary set, that may change. And then, there are validation processes for those down the line.

MEMBER REMPE: And would the staff not be a bit concerned that they don't have any membership in an owners group? And I mean, the reactor oversight process is where one would be reviewing the severe accident management guidance. Is there a way to encourage the applicant to belong to an owners group of some sort?

DR. GREEN: I don't know of one, I mean, I think there would be benefit to it, I don't know that there's a means to force them to join one. But I don't --

MEMBER REMPE: If there's no --

DR. GREEN: -- a lot about that.

MEMBER REMPE: Yes, I guess you'll get it with the ROP then, is how you would deal with it. I just was curious on the process.

DR. GREEN: I'm unsure how to -- of the full answer to that.

MEMBER REMPE: Okay, thanks.

CHAIR SUNSERI: Any other member questions? All right. So, thank you, Dr. Green, for the presentation, very helpful. And we have no other questions. So, at this point in time, I'd like to turn to the public.

So, first, we'll ask the members of the public in the room for comments and then, we'll turn to the phone line. And while we're doing this, I'll ask for the phone line to be open.

So, for members of the public in the room, if you want to make a statement, please come up to the microphone, state your name and make your statement. All right. There are none. So, now, we will turn to the public phone line.

If somebody is on the public phone line, could you just speak up, say you're here, just so we know the line is open. Once we confirm the line is open, we'll ask for comments. Anybody on the public line?

So, I will just go ahead and assume it's open and ask for comments. Any comments on the public line? Okay. We're going to close the public line. And with no other questions, we've completed the agenda now through the opportunity for public comments.

What we're going to do is take a break for lunch. We're going to resume at 1:00 and we will start with the advance accumulator. Applicant will go first and then, the staff. And those will be a closed session, due to protection of proprietary information. All right. We are recessed until 1:00.

(Whereupon, the above-entitled matter went off the record at 12:03 p.m.)

# US-APWR
# Design Overview

## September 19, 2019
## Mitsubishi Heavy Industries, Ltd.

# Presenters

**Atsushi Kumaki**

MHI NS Engineering Co, Ltd.

**Joseph Tapia**

Mitsubishi Nuclear Energy Systems, Inc.

# Contents

# Introduction

- The US-APWR Design Certification (DC) application was submitted in December 2007.
- The safety review by NRC has progressed, and several ACRS meetings have been held in the past.
- After Fukushima in 2011, MHI has concentrated the resources to support domestic plant restarts and the slowdown of US-APWR DC activities is still needed.

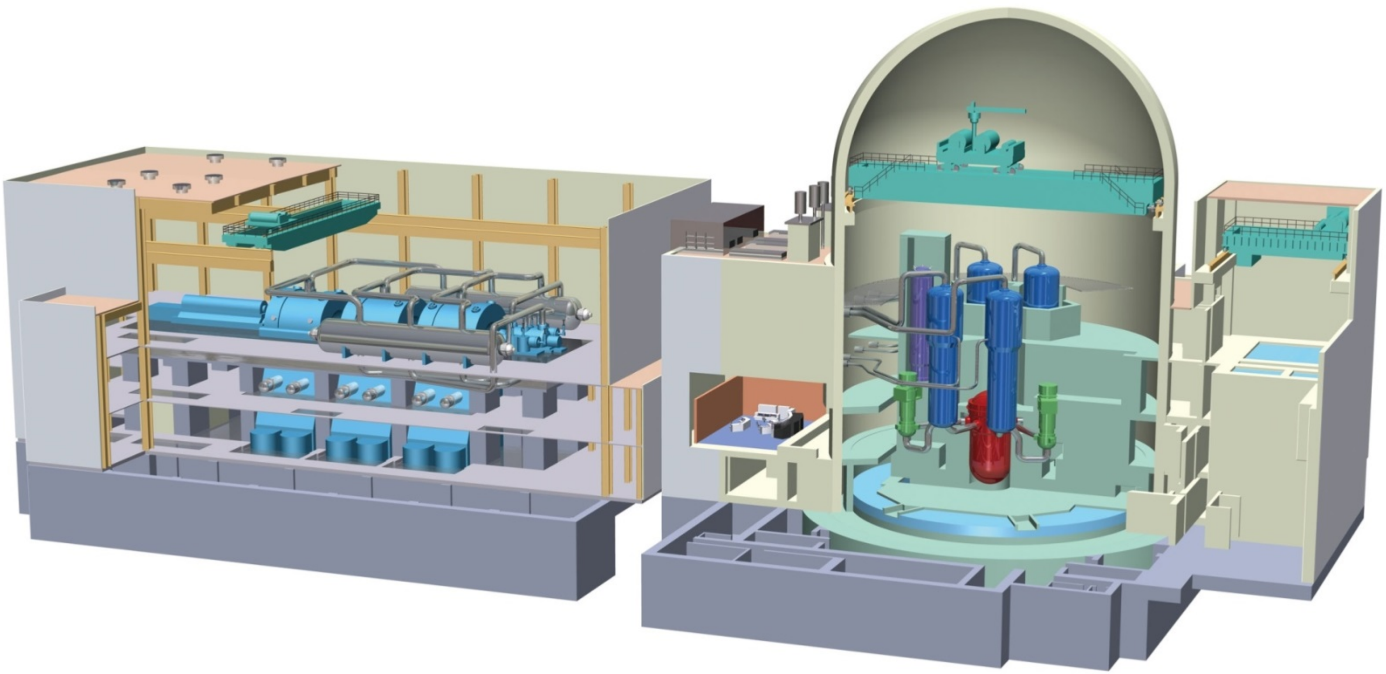
# Today's Meeting Objectives

MITSUBISHI HEAVY INDUSTRIES, LTD.

- To provide the current ACRS with US-APWR design overview
- To provide the ACRS with details on ;
  - Chapter 18 (Human Factor Engineering),
  - Chapter 8 (Electrical System) and the
  - Topical Report for the Advanced Accumulator

UAP-HF-19001-4

# US-APWR Design Overview



UAP-HF-19001-5

# Main Features of US-APWR

UAP-HF-19001-6

# Progression of Mitsubishi PWR Designs

MITSUBISHI HEAVY INDUSTRIES, LTD.

| Number of Loops | Output of Electric Power | Reactor Vessel | Number of Fuel Assembly | Steam Generator/ Reactor Coolant Pump | Reference Plant |
|---|---|---|---|---|---|
| 2 Loop | 600 MWe Class | I.D. 11.15 ft (3.4 m) | 121 Assemblies | Standard | Tomari Units 1 & 2 (Commercial Operation : 6/1989 & 4/1991) |
| 3 Loop | 900 MWe Class | I.D. 13.12 ft (4.0 m) | 157 Assemblies | Standard | Tomari Unit 3 (Commercial Operation : 12/2009) |
| 4 Loop | 1200 MWe Class | I.D. 14.44 ft (4.4 m) | 193 Assemblies | Standard | Genkai Units 3 & 4 (Commercial Operation : 3/1994& 7/1997) |
| 4 Loop (APWR) | 1500 MWe Class | I.D. 17.06 ft (5.2 m) | 257 Assemblies | Larger Capacity with the same concept | Tsuruga Units 3 & 4 (Under licensing) |

UAP-HF-19001-7

# US-APWR Design Basis

- Basic design concept of US-APWR is the same as APWR
- New technologies of APWR are fully tested, well-verified and established
- US-APWR, 1700MWe class, is based on the established APWR technology with
  - ✓ Latest technologies to improve plant efficiency
  - ✓ Minor modifications to meet U.S. Regulatory and utility requirements

# Comparison of Main Features

MITSUBISHI HEAVY INDUSTRIES, LTD.

## Plant Parameters and Major components

| | | Conventional 4 Loop | APWR | US-APWR |
|---|---|---|---|---|
| Electric Output | | 1,180 MWe | 1,538 MWe | 1,700 MWe Class |
| Core Thermal Output | | 3,411MWt | 4,451 MWt | 4,451 MWt |
| Steam Generator | Model | 54F | 70F-1 | 91TT-1 |
| | Tube size | 7/8” | 3/4” | 3/4” |
| Reactor Coolant Pump | Design Flow | 93,600gpm | 112,000gpm | 112,000gpm |
| Turbine | LP last-stage blade | 44 inch | 54 inch | 70 inch class |

- **APWR**
  - ✓ 1538MWe output is achieved by large capacity core and large capacity main components such as SG, RCP, turbine, etc.
- **US-APWR**
  - ✓ 1700MWe class output is achieved from a 10% higher efficiency than APWR.
    - Same core thermal output with APWR
    - High-performance, large capacity steam generator
    - High-performance turbine

UAP-HF-19001-9

# Comparison of Main Features

## Reactor Core and Internals

| | | Conventional 4 Loop | APWR | US-APWR |
|---|---|---|---|---|
| Core Thermal Output | | 3,411MWt | 4,451 MWt | 4,451 MWt |
| Core and Fuel | NO. of Fuel Assem. | 193 | 257 | 257 |
| | Fuel Latice | 17×17 | 17×17 | 17×17 |
| | Active Fuel Length | 12ft | 12ft | 14 ft |
| Reactor internals | | Baffle/former structure | Neutron Reflector | Neutron Reflector |
| In-core Instrumentation | | Bottom mounted | Bottom mounted | Top mounted |

- **APWR**
  - ✓ Large capacity core by increasing number of fuel assemblies
  - ✓ Installation of neutron reflector to enhance reliability and fuel economy
- **US-APWR**
  - ✓ Low power density core using 14ft. fuel assemblies to enhance fuel economy for 24 months operation
  - ✓ Enhanced reliability and maintainability of reactor vessel by top mounted ICIS

# Comparison of Main Features

MITSUBISHI HEAVY INDUSTRIES, LTD.

## Safety system and I&C

| | | | Conventional 4 Loop | APWR | US-APWR |
|---|---|---|---|---|---|
| Safety Systems | Trains | Electrical | 2 trains | 2 trains | 4 trains |
| | | Mechanical | 2 trains | 4 trains | 4 trains |
| | Systems | HHSI pump | 100% × 2 | 50% × 4(DVI) | 50% × 4(DVI) |
| | | LHSI pump | 100% × 2 | - | - |
| | | ACC | 4 | 4 (Advanced) | 4 (Advanced) |
| | RWSP | | Outside CV | Inside CV | Inside CV |
| Containment Vessel | | | PCCV | PCCV | PCCV |
| I & C | Control Room | | Conventional | Full Digital | Full Digital |
| | Safety I&C | | Conventional | | |
| | Non-Safety I&C | | Full Digital | | |

- **APWR**
  - ✓ Enhanced safety by simplified and reliable safety systems
    - Mechanical 4 train systems with direct vessel injection design
    - Elimination of LHSI pump by utilizing advanced accumulators
    - Elimination of recirculation switching by In-containment RWSP
- **US-APWR**
  - ✓ Enhanced safety by 4 train safety electrical systems
  - ✓ Enhanced on line maintenance capability

UAP-HF-19001-11

# Results of US-APWR Design Features

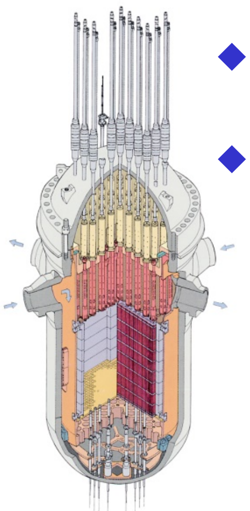
- Enhanced Economy
  - ✓ Large capacity and high plant performance
  - ✓ High fuel performance for 24 months operation
- Enhanced Safety
  - ✓ Improved safety response by using advanced technologies
- Enhanced Reliability
  - ✓ Well designed and verified proven technologies

# US-APWR Design Features

UAP-HF-19001-13

# Advanced Technologies

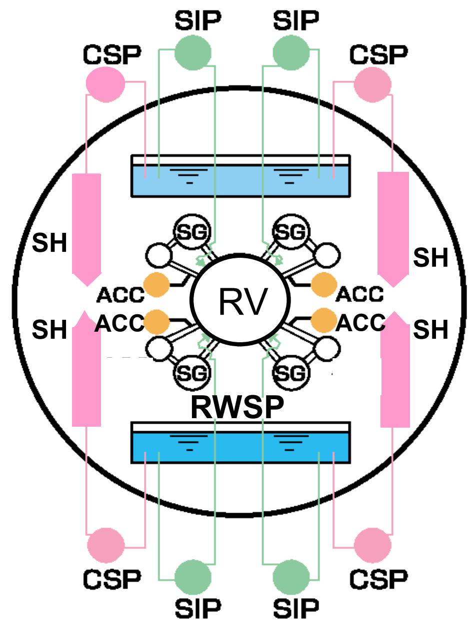
## Reactor



◆1700 MWe class large capacity

◆Neutron reflector

## Engineering Safety Features




◆Simplified configuration with 4 mechanical sub-systems

◆In-containment RWSP

◆Advanced accumulator

## Steam Generator

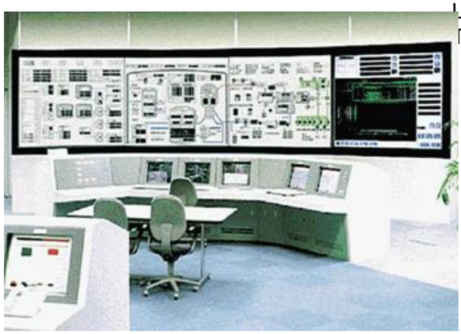
◆High performance separator

◆Increased capacity with compact sizing

## I & C

◆Digital control & protection systems

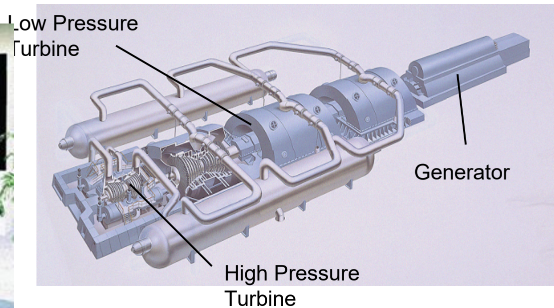
◆Compact console



## Turbine

◆74 inch-length blades in LP turbine

◆Fully integrated LP turbine rotor

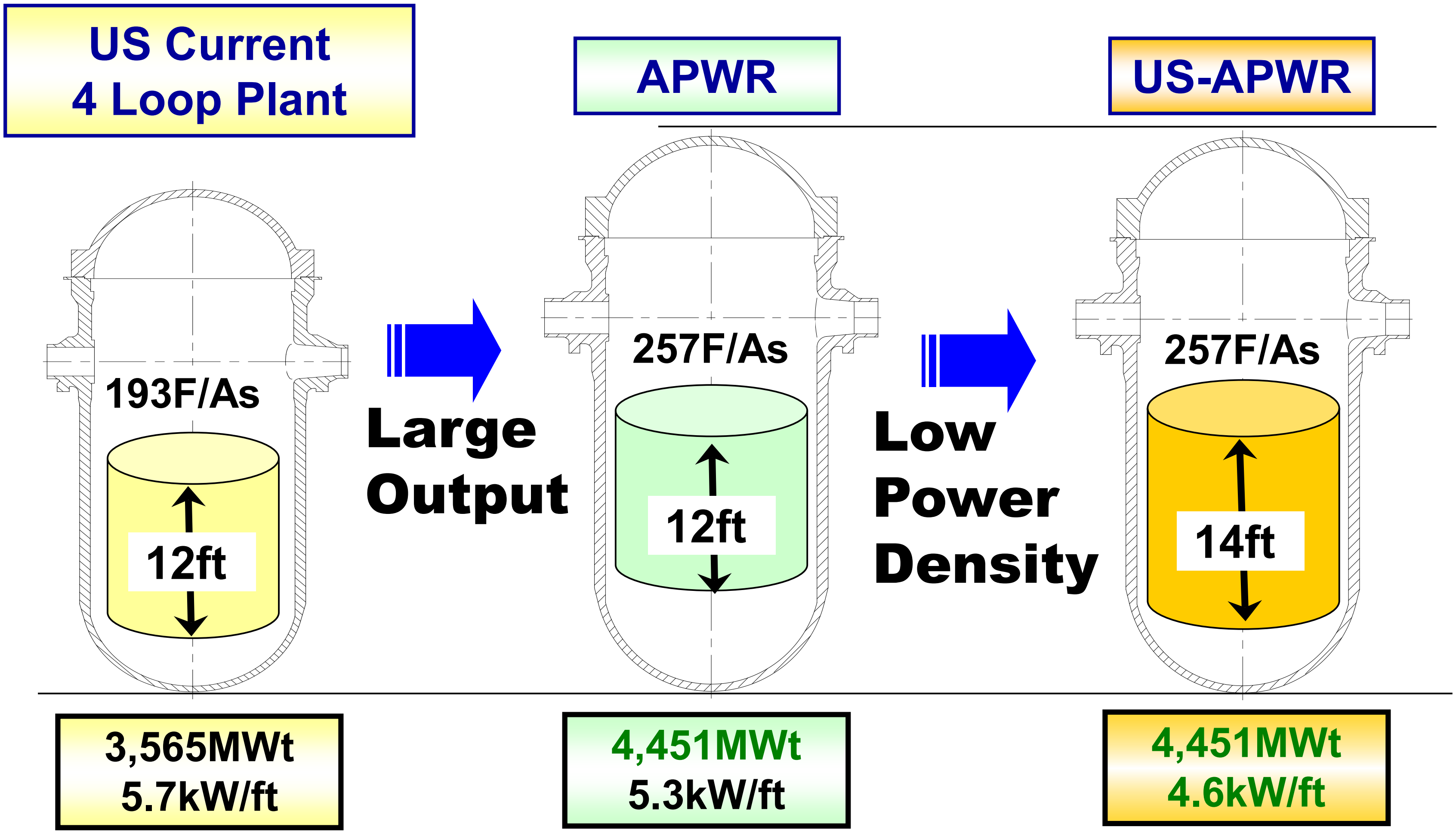



UAP-HF-19001-14

# Nuclear Design Features

MITSUBISHI HEAVY INDUSTRIES, LTD.

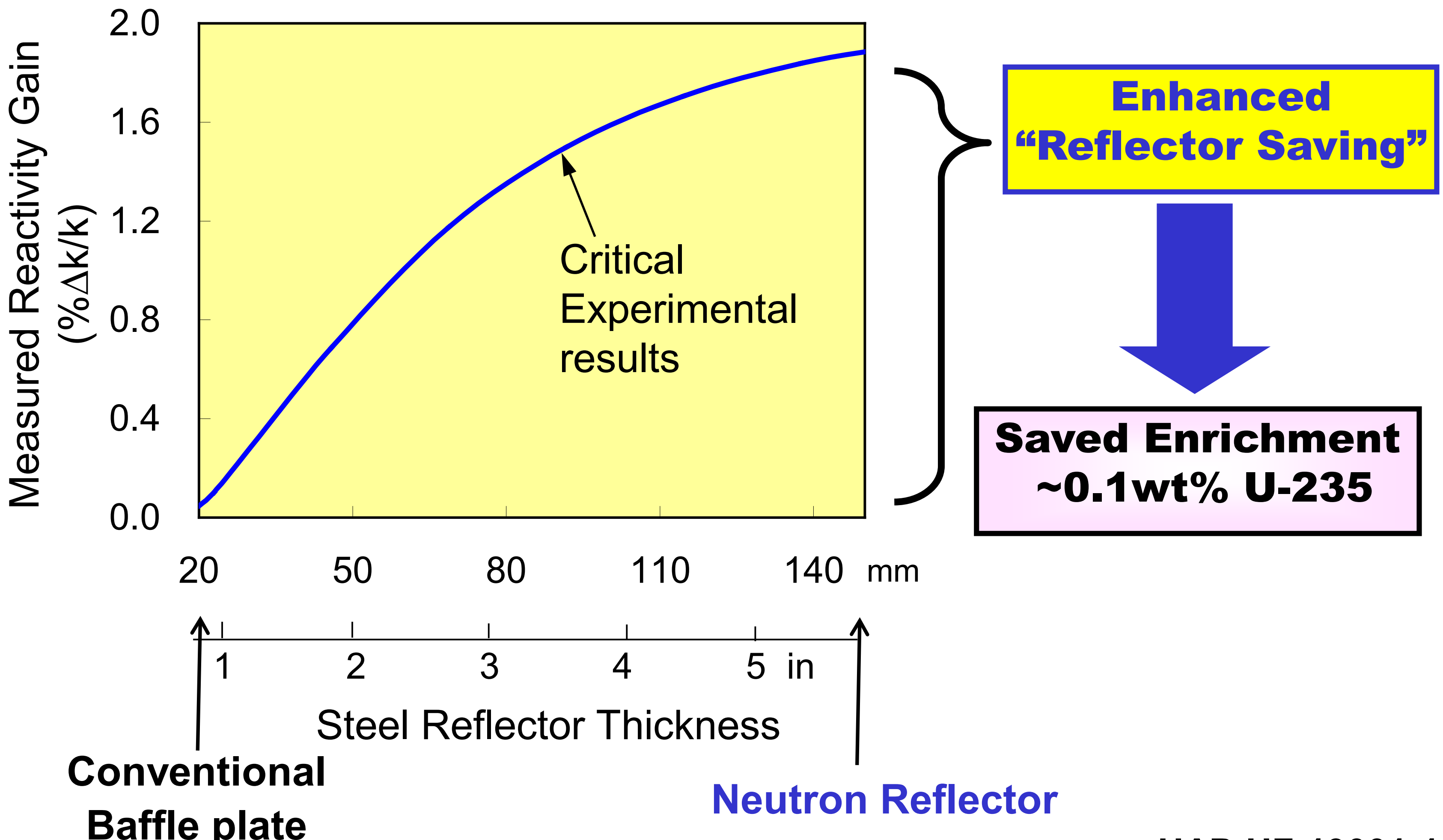
➢ Large thermal output and low power density




UAP-HF-19001-15

# Improved Core Design

## Neutron Reflector Saves Uranium




UAP-HF-19001-16

# Fuel Design Features

## Enable Flexible Core Operation

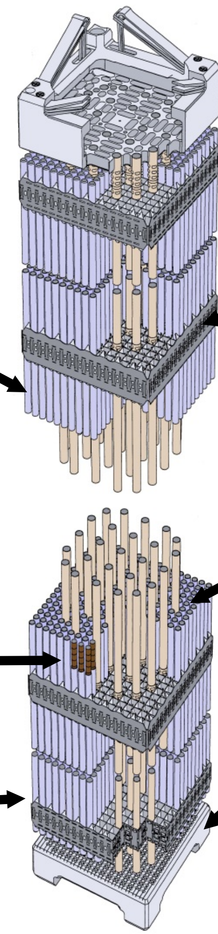
Fuel Active Length : 14ft
Fuel Rods Array : 17x17

Higher Gadolinium Content Pellet (10wt%)

## Enhance Fuel Economy

Higher Density Pellet (97%T.D.*1)

Zircaloy-4 Grid (for Neutron Economy)



## High Reliability

Grid Fretting Resistant Design (Shorter Span Length*2 with 11 grids & Grid Spring Design)

Corrosion Resistant Cladding Material (ZIRLO™)

Anti-debris bottom nozzle with built-in filter

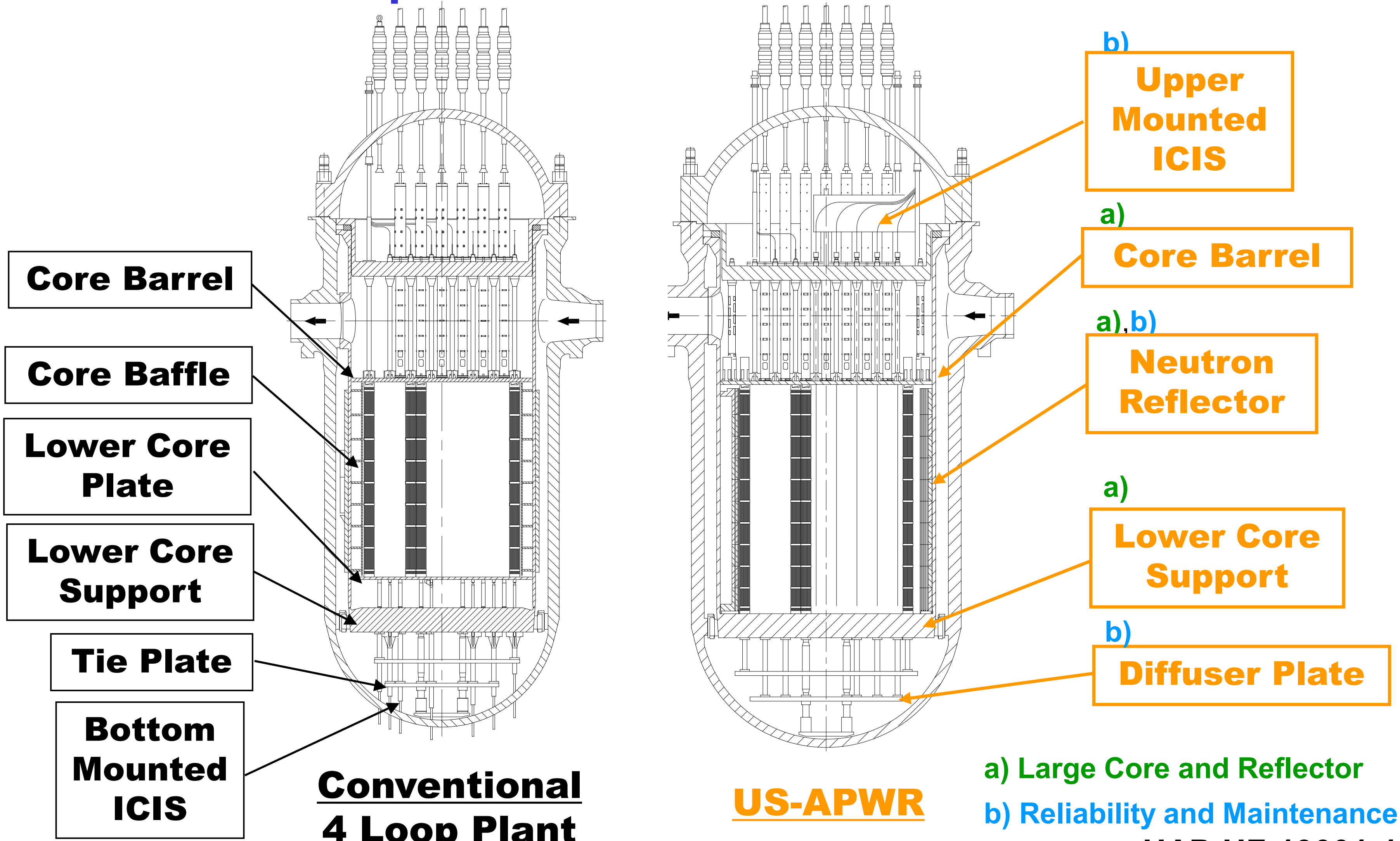
*1 T.D. :Theoretical Density
*2 compared with conventional 14ft Fuel

UAP-HF-19001-17

# Reactor Internals Design

MITSUBISHI HEAVY INDUSTRIES, LTD.

## Comparison of main structures




UAP-HF-19001-18

# Reactor Internals Design

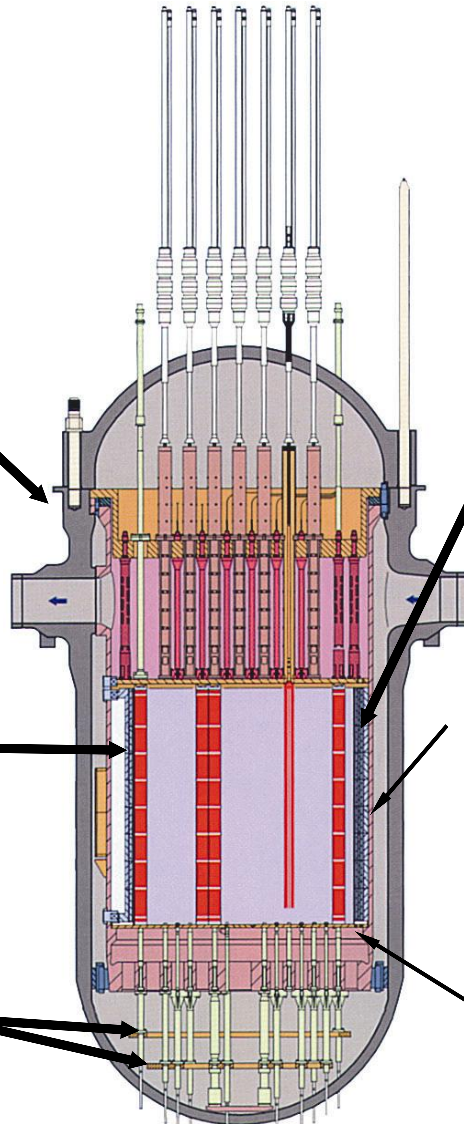
**Large volumetric core structure**

**Large reactor internals**
for large output

**Enhanced reliability**

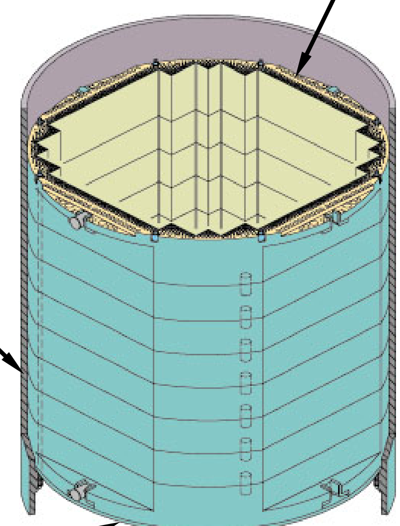
**Neutron Reflector**
for simplified structure
（Number of bolts ：
2,000 → 50)

**Improved Tie Plate**
for stabilized flow



**Enhanced performance**

**Neutron Reflector**
for fuel cost reduction

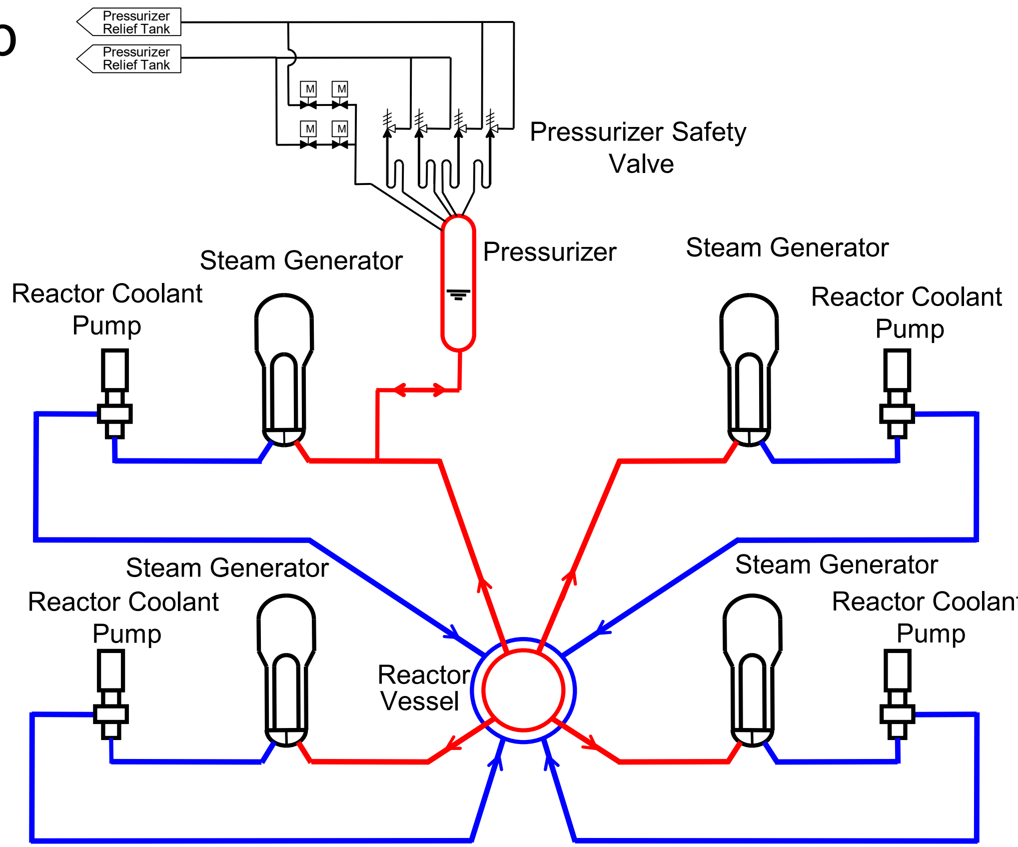



UAP-HF-19001-19

# Reactor Coolant System

## ➢ Design concept of the RCS

- ✓ Basic configuration is the same as conventional 4 loop plants
- ✓ Large main components with large thermal output and high efficiency
- ✓ Enhanced plant response and controllability with large volume Pressurizer




UAP-HF-19001-20

# Reactor Coolant System

## ➢ Larger main components

- ✓ Larger diameter and height of Reactor Vessel with enhanced reliability
- ✓ Larger heat transfer area in SG contributes high efficiency
- ✓ Larger reactor coolant flow rate of RCP with 8000 HP motor

## ➢ Enhanced plant response and control

- ✓ Larger Pressurizer volume provides greater margin for the transients

| Specifications | US-APWR | Conventional 4 Loop Plant | Ratio |
|---|---|---|---|
| Core thermal output | 4,451MWt | 3,565MWt | 1.25 |
| SG Heat transfer area | 91,500ft$^2$ | 55,000ft$^2$ | 1.66 |
| Reactor Coolant Flow | 112,000gpm | 93,600gpm | 1.20 |
| Pressurizer Volume | 2,900ft$^3$ | 1,800ft$^3$ | 1.61 |

# Reactor Vessel / CRDM

MITSUBISHI HEAVY INDUSTRIES, LTD.

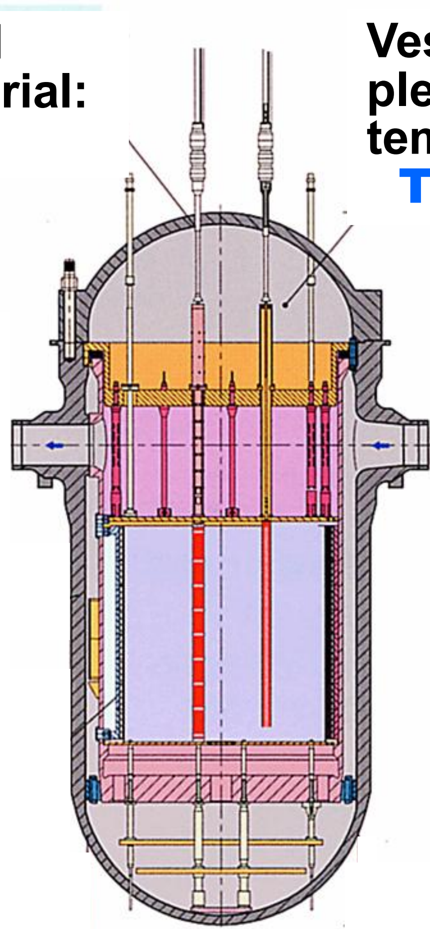
**Enhanced reliability**

## Reactor Vessel

Vessel head nozzle material:
Alloy 690

Vessel head plenum temperature:
Tcold

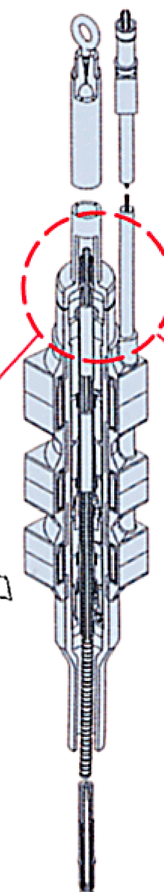
Reactor Vessel:
Reduction of weld lines using integrated forging

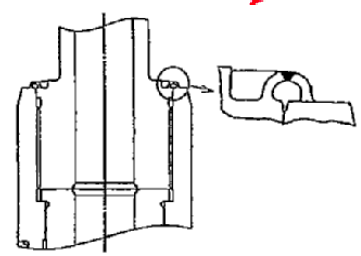


Neutron reflector:
Reduction of Vessel fluence (Reduce to 1/3)

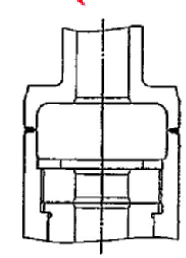
## CRDM housing

Elimination of canopy seal





Canopy seal for Latest 4 Loop plant



US-APWR

UAP-HF-19001-22

# Steam Generator

MITSUBISHI HEAVY INDUSTRIES, LTD.

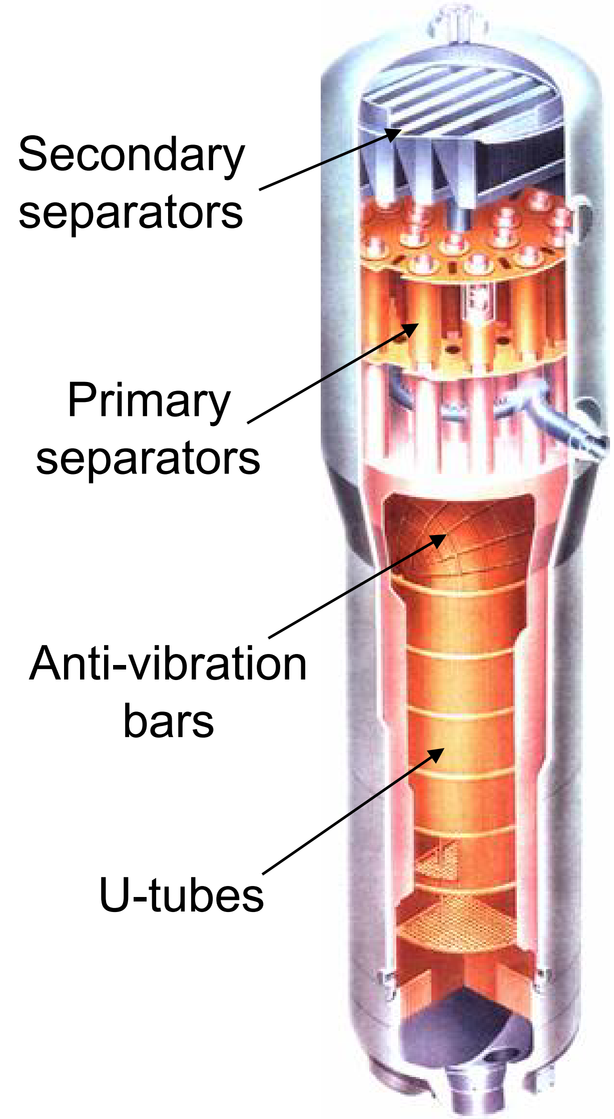
## Design Features

### ➢Primary separator

✓High performance moisture separation
Moisture carry over at SG outlet: less than 0.1%

### ➢Anti-vibration Bar

✓Sets of 5 V-shaped AVBs with 10 support points of the outer most tube




| | |
|---|---|
| Tube material | Alloy 690 |
| Tube OD | 0.75 inch |
| Tube arrangement | triangular |
| Tube pitch | 1 inch |
| Heating surface | 91,500 $ft^2$ |

UAP-HF-19001-23

# Reactor Coolant Pump

## ➢Improved hydraulic performance

✓Large capacity and high efficiency by improved impeller and diffuser

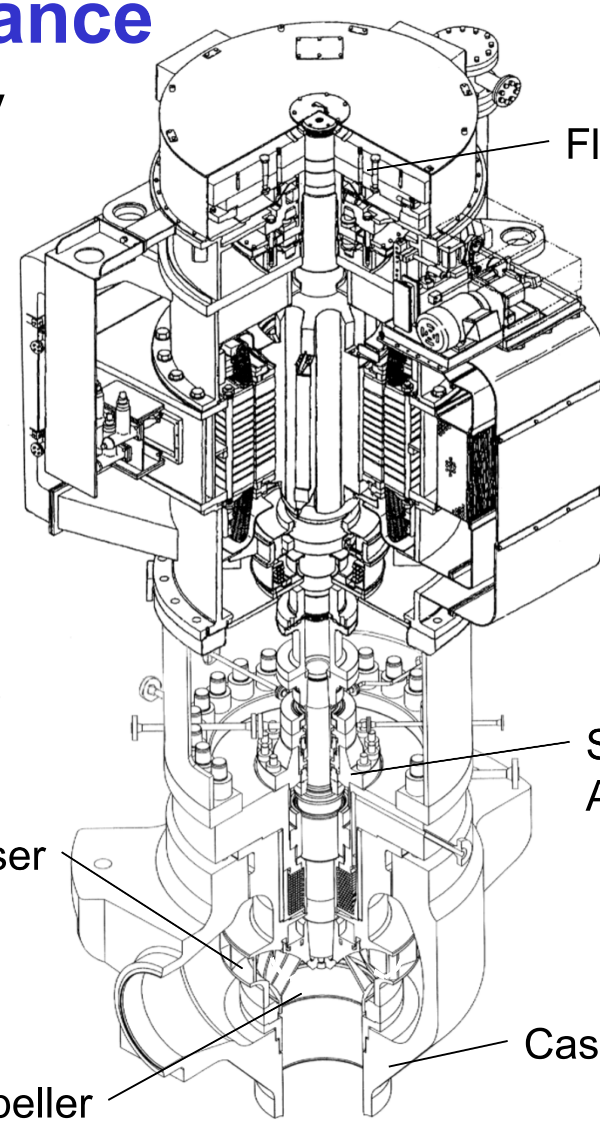
- Pump Efficiency : Over 85%
- Flow Rate : 112,000 gpm/loop
- Head : Approx. 310 ft

## ➢Advanced seal

✓Stabilization of No.1 seal leak-off characteristics

✓Extension of seal life

✓Countermeasure to station-blackout




UAP-HF-19001-24

# Safety Systems

MITSUBISHI HEAVY INDUSTRIES, LTD.

## ➢Simplified and Reliable Safety Systems

- ✓ Safety systems with enhanced redundancy and independency
- ✓ Reliable and simplified design is achievable by 50%×4 configuration for Safety Injection (HHSI*) Pumps in conjunction with adoption of Direct Vessel Injection (DVI) design

＊ : High Head Safety Injection

## ➢Utilization of Advanced Accumulators

- ✓ Accumulators with function of Low Head Injection Pumps

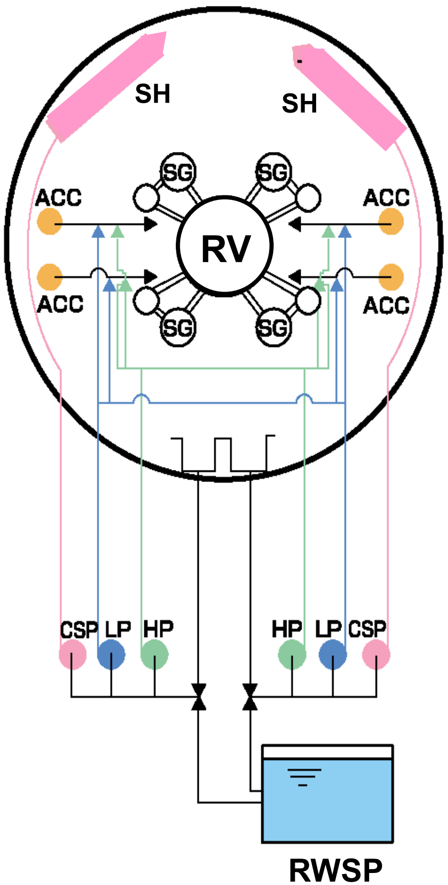
## ➢In-Containment Refueling Water Storage Pit

- ✓ Improved reliability and safety by eliminating recirculation switching

UAP-HF-19001-25

# ECCS Configuration

## Conventional 4 Loop PWR (2 train)

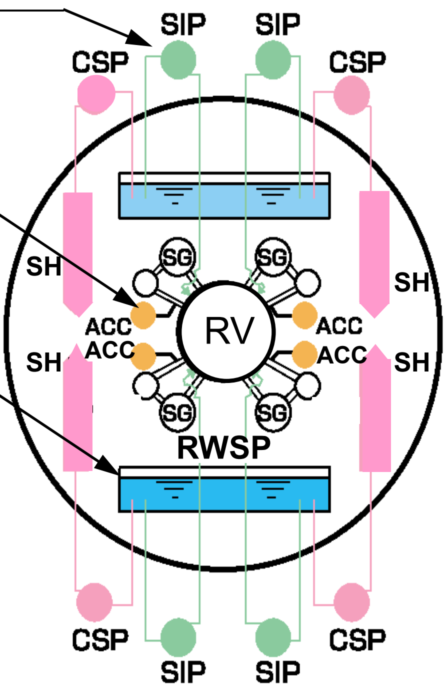



## US-APWR (4 mechanical train)

◆4 train (DVI)
→ Higher Reliability
Simplified Pipe Routing

◆Advanced Accumulator
→ Elimination of LP

◆In-containment RWSP
→ Higher Reliability




| | | |
|---|---|---|
| ACC | : | Accumulator |
| HP | : | High Head SIP |
| LP | : | Low Head SIP |
| SIP | : | Safety Injection Pump |
| CSP | : | Containment Spray Pump |
| SH | : | Spray Header |
| RV | : | Reactor Vessel |
| RWSP | : | Refueling Water Storage Pit |

UAP-HF-19001-26

# Comparison of ECCS Equipment

MITSUBISHI HEAVY INDUSTRIES, LTD.

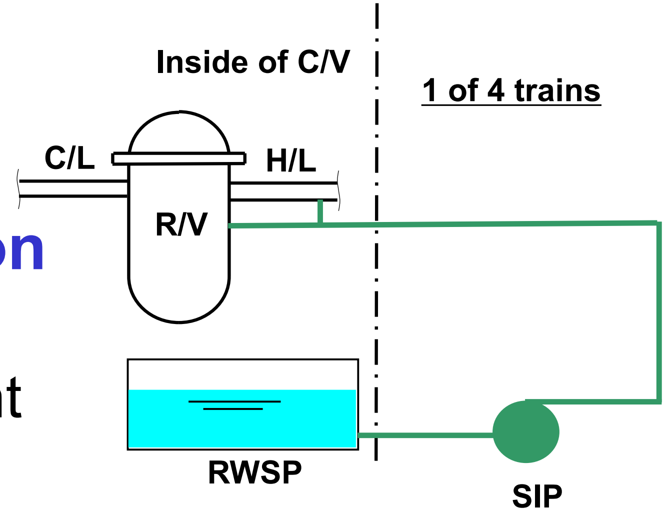
| | Conventional 4 Loop Plant | US-APWR |
|---|---|---|
| Accumulator | 4<br>(conventional type) | 4<br>(advanced type) |
| SI Pump<br>- High Head Pump<br>- Low Head Pump | <br>100%×2<br>100%×2<br>(used also as RHR) | <br>50%×4<br>— |
| CS Pump | 100%×2 | 50%×4<br>(used also as RHR) |

UAP-HF-19001-27

# Design feature of high head injection system

MITSUBISHI HEAVY INDUSTRIES, LTD.

- **4 independent trains without interconnections between trains**
- **Sufficient capacity of safety injection pumps**
  - ✓ Meets the safety injection requirement in core reflooding stage

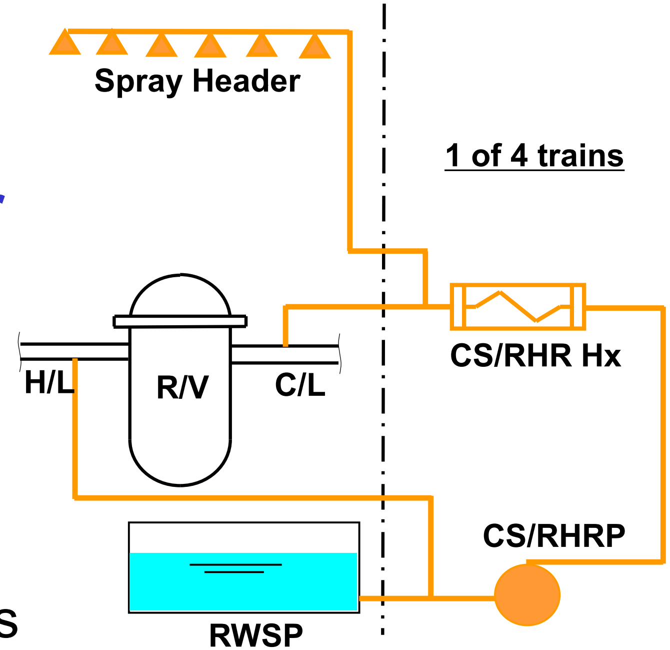



| Item | US-APWR | Conventional 4 Loop Plant | Reason and/or Advantage |
|---|---|---|---|
| Train | 4 train | 2 train | • Enhance the reliability<br>• Provide On-line Maintenance under single failure |
| High head Injection | DVI<br>4 SIP | Loop injection<br>2 SIP + 2 Charging/SIP | • No interconnection between trains |
| Refueling Water Storage Pit | Inside CV | Outside CV | • Eliminate recirculation switchover |

UAP-HF-19001-28

# Design Feature of CSS/RHRS

- Common CSS and RHRS Pumps / Heat exchangers
- CSS and RHRS are not required for operation at same time
  - ✓ Normal operation: Stand by as CSS
  - ✓ LOCA: Operated as CSS
  - ✓ Plant shut down: Operated as RHRS
  - ✓ Pump suction and discharge valves are interlocked for prevention of human errors

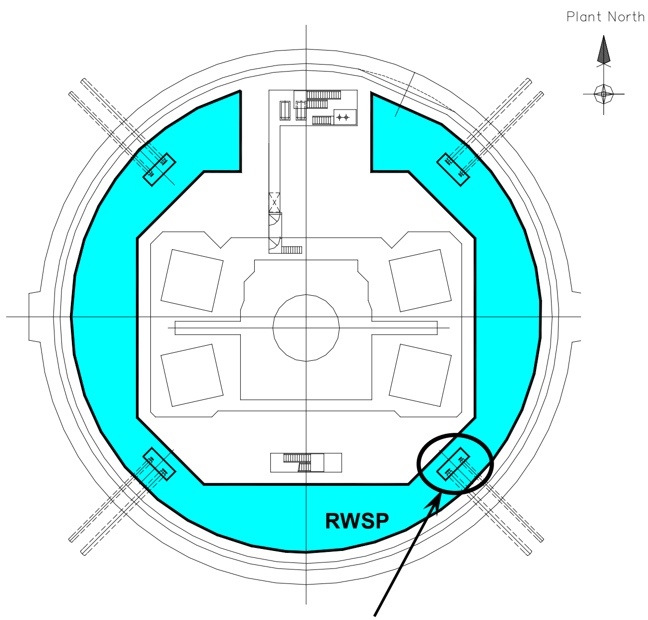


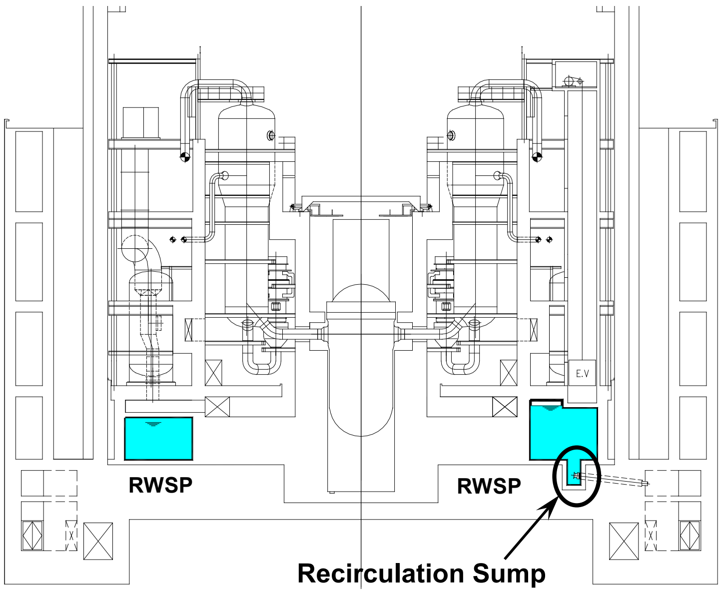

| Item | US-APWR | Conventional 4 Loop Plant | Reason and/or Advantage |
|---|---|---|---|
| Containment Spray | 4 CS/RHRP<br>4 CS/RHR Hx | 2 CSP<br>2 CS Hx | • Enhance the reliability<br>• Achieve OLM under single failure |
| Residual Heat Removal | Integrated to CSS | Integrated to LHSIS<br>2 RHRP<br>2 RHR Hx | • Simplify safety system configurations |

UAP-HF-19001-29

# In-containment Refueling Water Storage Pit

- ✓ Located at the lowest part of containment
- ✓ Provides a continuous suction source for both the safety injection and the CS/RHR pumps
( Eliminates the switchover of suction source )
- ✓ 4 recirculation sumps are installed

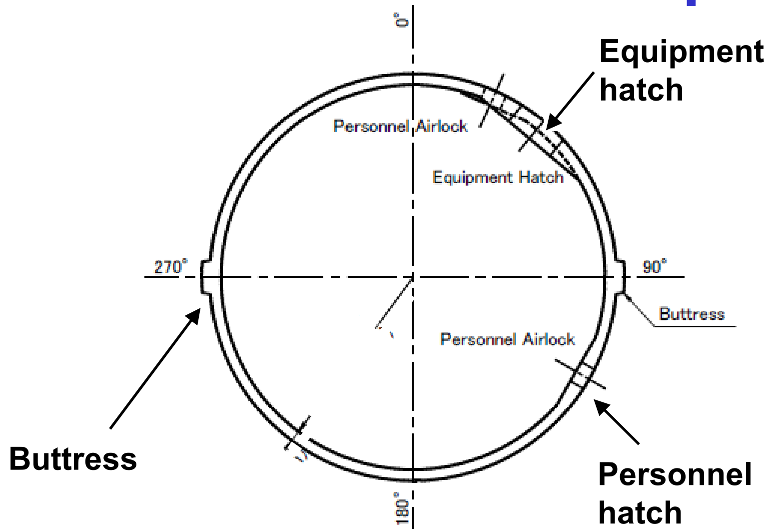


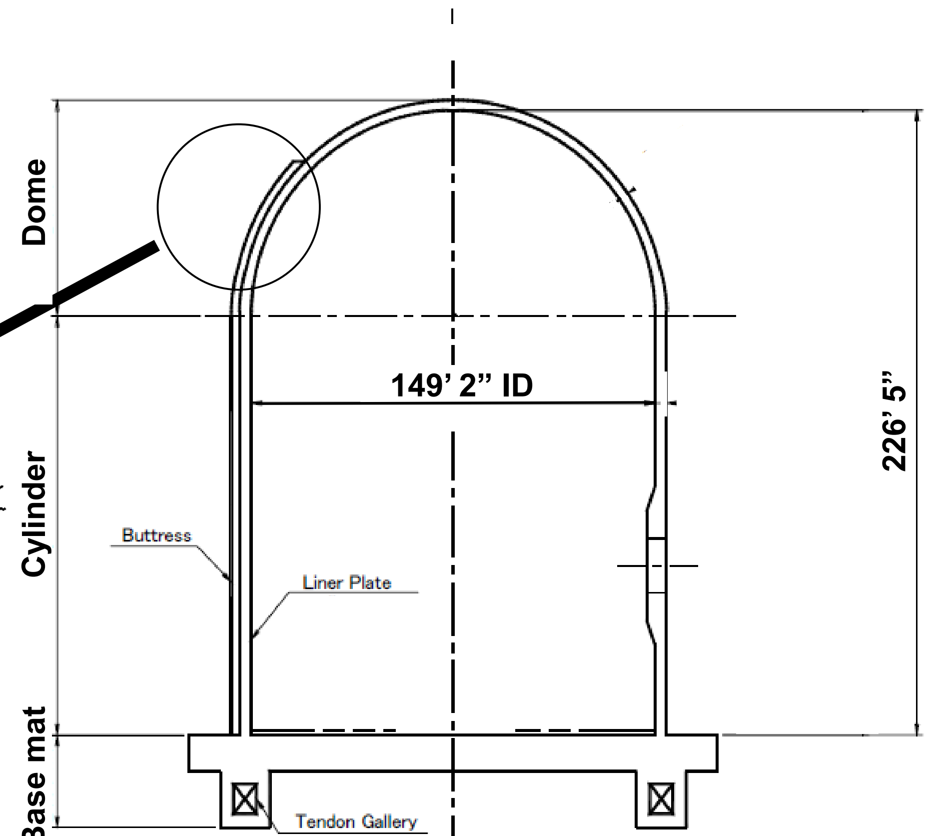

UAP-HF-19001-30

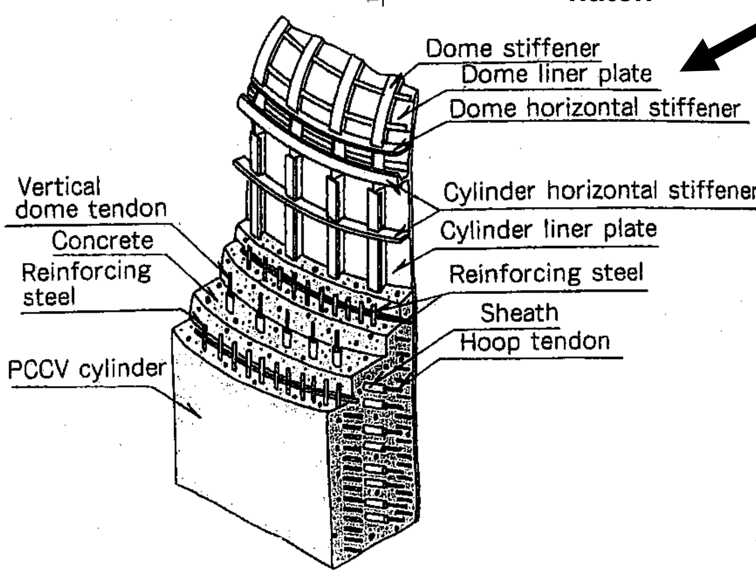
# Containment Vessel Design

## ➢Robust and reliable pressure vessel with steel liner




| Design Pressure | 68 psig |
|---|---|
| Maximum Allowable Leakage Rate | 0.1 percent / day |

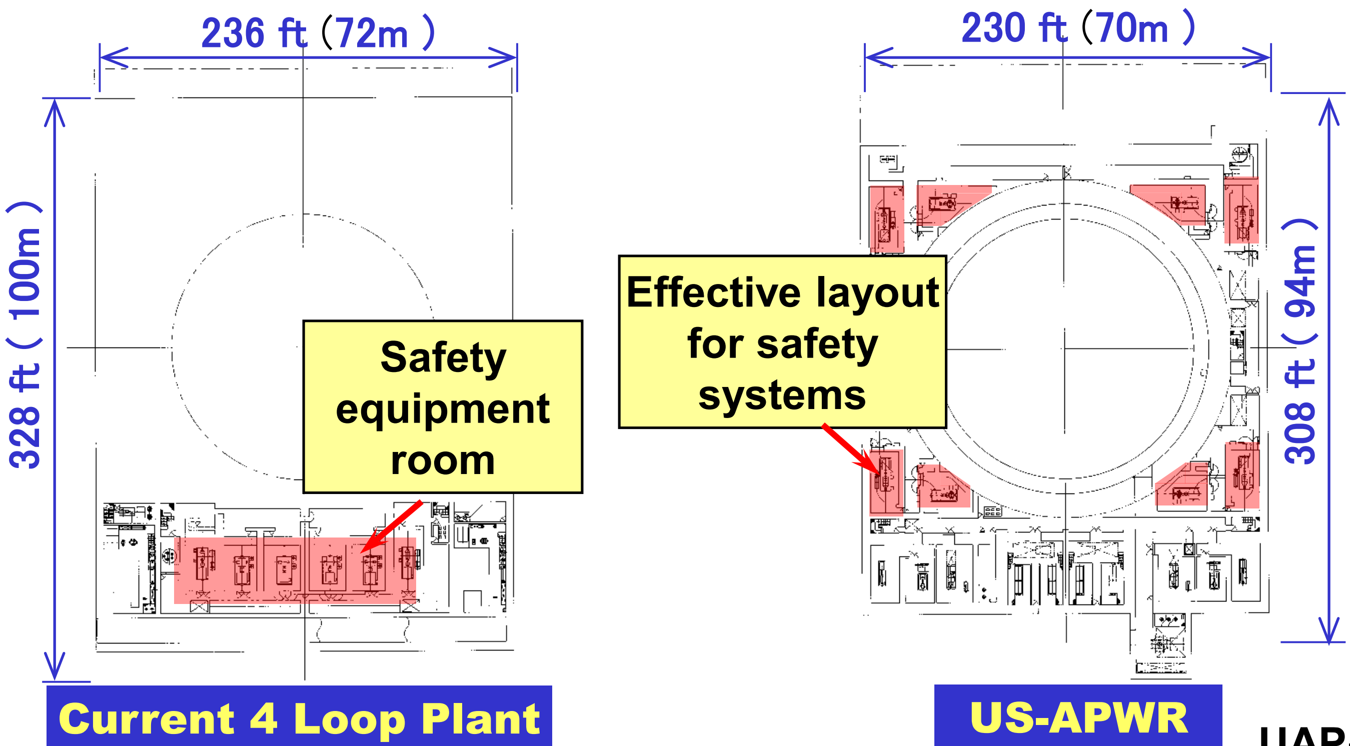


# Simplified Layout for Safety Systems

MITSUBISHI HEAVY INDUSTRIES, LTD.

- Lay down safety equipment at corner area of reactor building just close to RCS loops
  ⇒ Building volume / piping quantity is reduced
- Building volume (per kW) was reduced about 20% in US-APWR by total plant effective layout



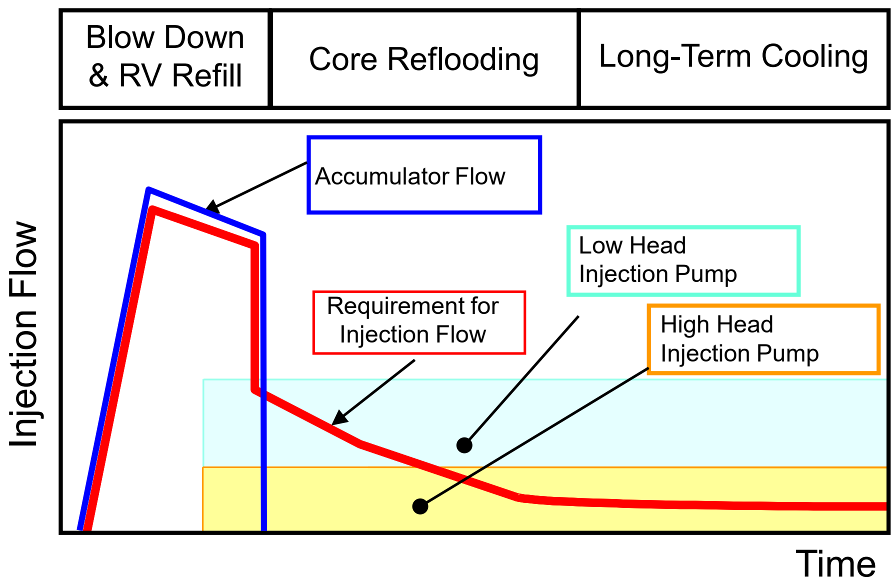

UAP-HF-19001-32

# Advanced Accumulator

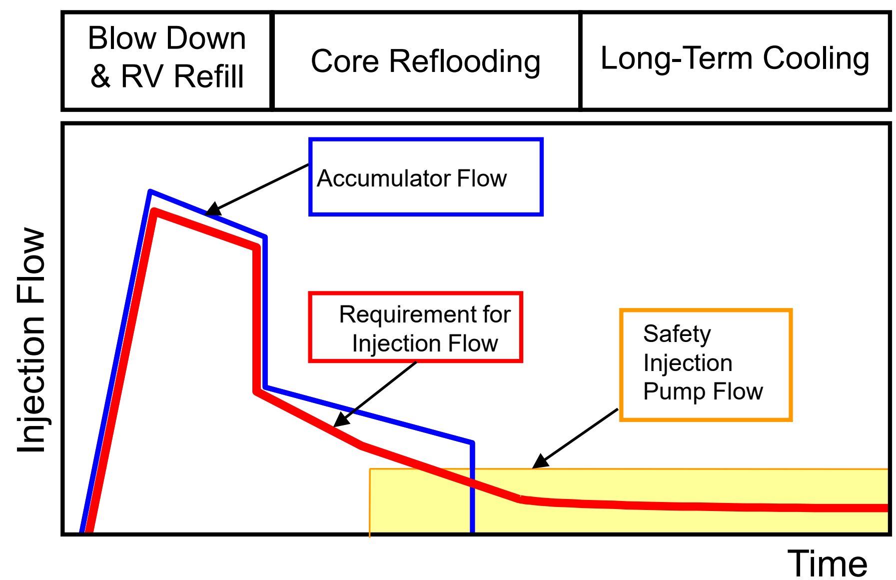
- ➢ Automatic Switching of Injection Flow Rates
- ➢ Elimination of Low Head Injection Pumps
  - ✓ Improvement of reliability
  - ✓ Reduction of total capacity of safety injection pumps
  - ✓ Substitution for RHR function by CS* Pumps/Coolers

＊: Containment Spray

## Current 4 Loop plant



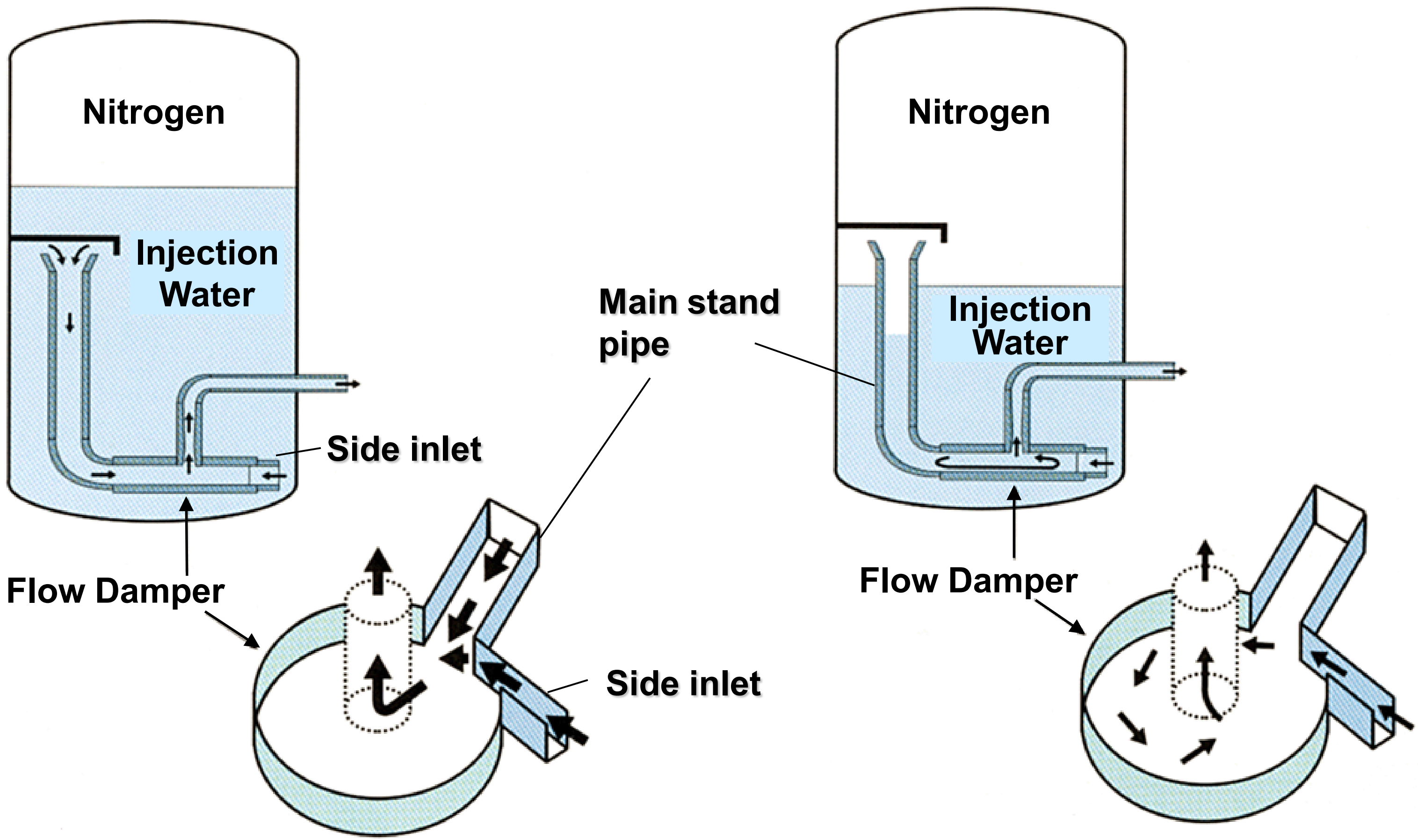

## US-APWR




UAP-HF-19001-33

# Mechanism of Advanced Accumulator

## Flow damper passively switches the flow rate.




***Large Flow Rate***

***Reduced Flow Rate***

UAP-HF-19001-34

# Emergency Feedwater System

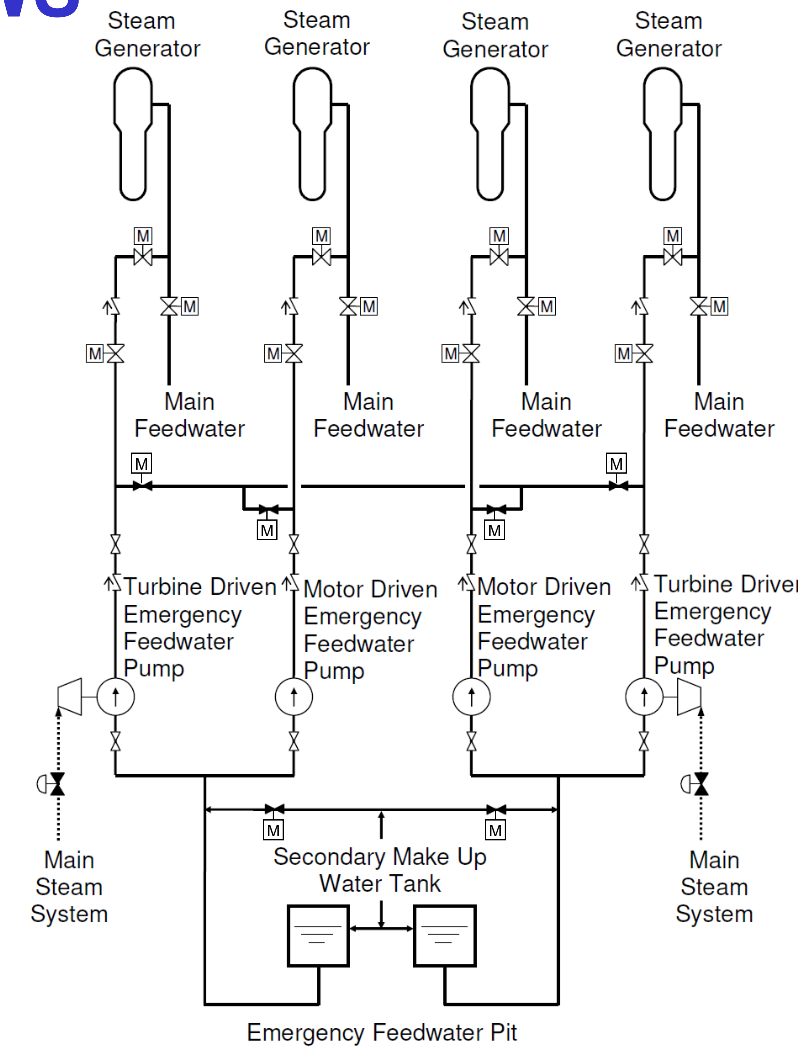
MITSUBISHI HEAVY INDUSTRIES, LTD.

## ➢Design concept of the EFWS

- ✓Achieve high reliability with simplified systems
- ✓Allow On-Line Maintenance assuming single failure

## ➢Feature of the EFWS

- ✓Independent 4 train system
- ✓2 safety grade water sources
- ✓Diverse power sources for the pumps
- ✓Cross connection inlet and outlet of the pumps (normally isolated)




UAP-HF-19001-35

# Emergency Feedwater System

MITSUBISHI HEAVY INDUSTRIES, LTD.

## ➢ 4 train configuration allows simplicity and high reliability

- ✓ 4 pumps with diverse power sources
  - 2 motor-driven pumps
  - 2 turbine-driven pumps
- ✓ Cross connection inlet of the pumps allows On-Line Maintenance (OLM)

## ➢ 2 safety grade independent feedwater sources

- ✓ Two 50% capacity emergency feedwater pits
- ✓ Cross connection inlet of the pumps backs up each feedwater source

| Item | US-APWR | Conventional 4 Loop Plant | Reason and/or Advantage |
|---|---|---|---|
| System Configuration | 4 train | 2 train | A pump is allowed OLM under the single failure |
| Emergency Feedwater Pump | M/D EFWP: 2<br>T/D EFWP: 2 | M/D EFWP: 2<br>T/D EFWP: 1 | Diverse power sources |
| Emergency Feedwater Source | 2 | 1 | 2 independent pits (backup available) |

UAP-HF-19001-36

# CCWS & ESWS

MITSUBISHI HEAVY INDUSTRIES, LTD.

## (Component Cooling Water System & Essential Service Water System)

- **Design concept**
  - ✓ CCWS and ESWS constitute a safety cooling chain
  - ✓ Achieve high independency and high reliability
  - ✓ Allows On-Line Maintenance assuming single failure

UAP-HF-19001-37

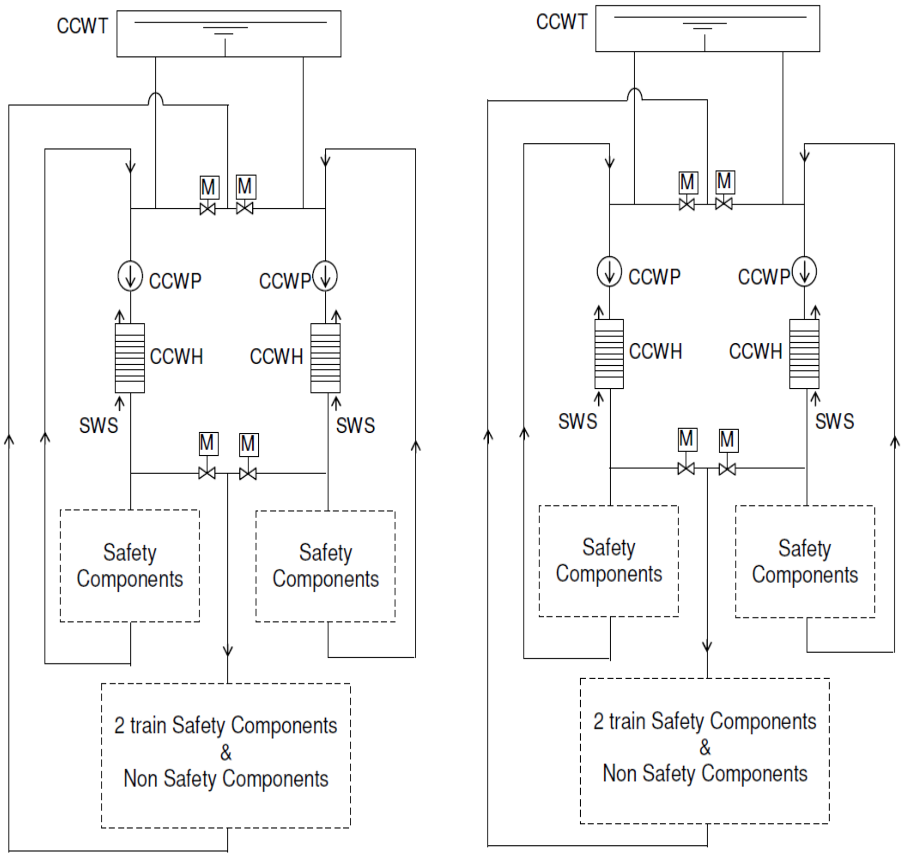
# Component Cooling Water System

## ➢Component Cooling Water System

✓ 4 safety train configuration

✓ Separated into 2 independent sections even in normal operation

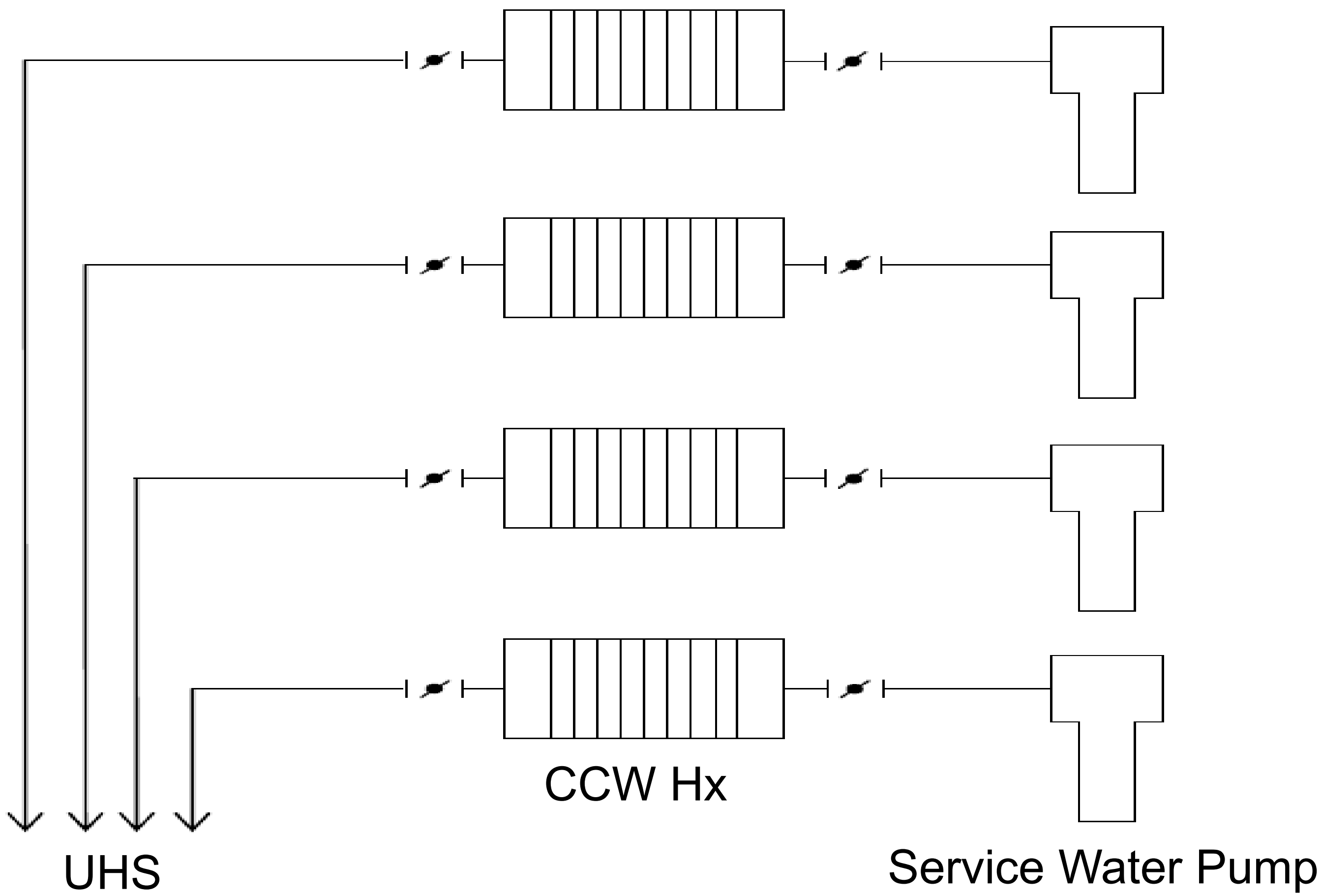
- OLM available in each train
- 2 train safety components (e.g.;SFP Hx.) are supplied with cooling water from 2 of 4 safety trains




UAP-HF-19001-38

## ➢Essential Service Water System

✓ Independent 4 train configuration




UAP-HF-19001-39

# I&C Main Features

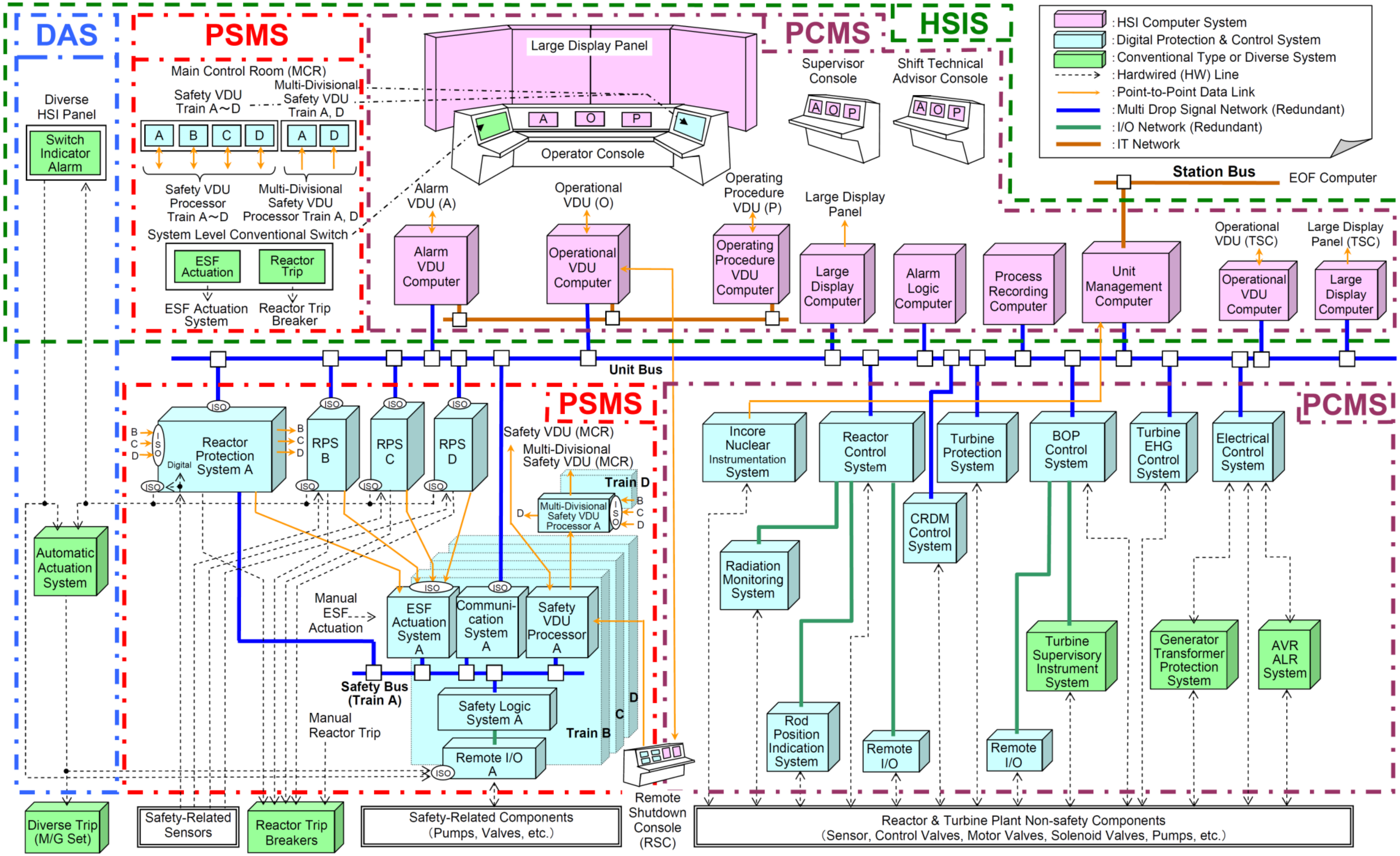
MITSUBISHI HEAVY INDUSTRIES, LTD.

- **Full Digital I&C System**
  - ✓ Computerized main control board
  - ✓ Minimal conventional switches, only for regulatory compliance
  - ✓ Micro-processor based safety and non-safety systems
  - ✓ Multiplexed communication including class 1E signals
- **Based on Defense-in-Depth & Diversity concept**
- **4 train redundant Safety System configuration**
- **Redundant configuration for Non-Safety Systems**
- **Maximum standardization with diverse back-up Non-Safety System for CCF (Common Cause Failure)**

UAP-HF-19001-40

# I&C Overall Architecture

MITSUBISHI HEAVY INDUSTRIES, LTD.




DAS : Diverse Actuation System PSMS : Protection and Safety Monitoring System HSIS : Human System Interface System PCMS : Plant Control and Monitoring System

UAP-HF-19001-41

# Safety I&C Design Features

MITSUBISHI HEAVY INDUSTRIES, LTD.

- **PSMS: Protection & Safety Monitoring System**
  - ✓ Reactor Trip and ESF Actuation Functions
  - ✓ Monitoring of the Safety Critical Parameters (RG 1.97)
  - ✓ Control of ESF, Safe Shutdown and Important Interlocks
- **4 train redundancy for all Safety Systems**
- **Electrical, physical, functional, communication and data isolation to accommodate**
  - ✓ Signal interface between safety systems
  - ✓ Signal interface safety to non-safety systems
  - ✓ Non-safety HSI for safety functions with safety HSI
- **Integrity of software per BTP 7-14 and BTP 7-19**
- **Qualified platform with extensive experience**

# Non-safety I&C Design Features

MITSUBISHI HEAVY INDUSTRIES, LTD.

## ➢ PCMS: Plant Control and Monitoring System

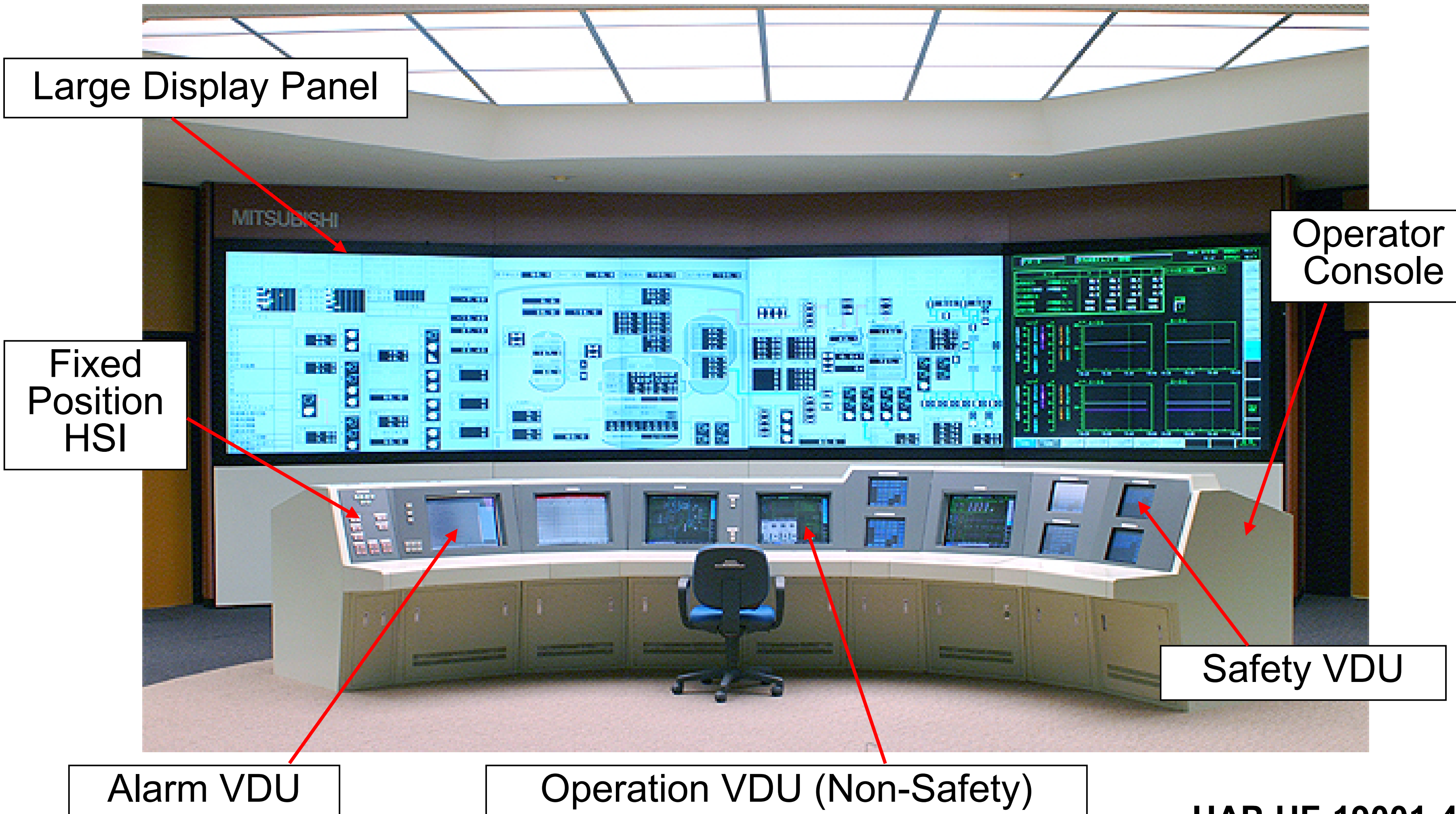
- ✓ Reactor, Turbine / Generator, BOP control & monitoring
- ✓ Redundant and fault tolerant configuration
- ✓ Functional isolation of shared sensor signals from PSMS with Automatic Signal Selector
  (for compliance with 10CFR 50 Appendix A GDC 24)

## ➢ DAS: Diverse Actuation System

- ✓ Countermeasure for CCF in the digital safety system
  (according to BTP 7-19 for Software CMF & 10CFR 50.62 for ATWS)
- ✓ Diverse automation: Reactor Trip, Turbine Trip, EFWS
  (based on actuations required within 10 minutes of event)
- ✓ Diverse manual controls: SI, CV Isolation, etc.
  (diverse component level actuation for critical safety functions)
- ✓ Diverse monitoring: Safety critical parameters
  (diverse signal processing and HSI)

# HSI System

## Computerized Main Control Room




UAP-HF-19001-44

# HSI System Design Features

MITSUBISHI HEAVY INDUSTRIES, LTD.

- **Functions of HSI System (Human System Interface System)**
  - ✓ Fully computerized video based approach
  - ✓ Integrated display for monitoring and soft control
  - ✓ Dynamic alarm prioritization & computerized procedures
- **Development Process (NUREG 0711 Program Model)**
  - ✓ Task analysis and human factor design
  - ✓ Step by step prototyping and V&V by plant operators
- **Staffing**
  - ✓ Operator, Supervisor & Safety Technical Advisor
- **Main features**
  - ✓ All operations are available from non-safety VDUs
  - ✓ All safety operations from safety VDUs
  - ✓ Minimum inventory of Fixed Position HSI
    - Conventional HSI for manual system level actuation (RG 1.62)
    - Critical Functions & Bypass or Inoperable Status (RG 1.47)

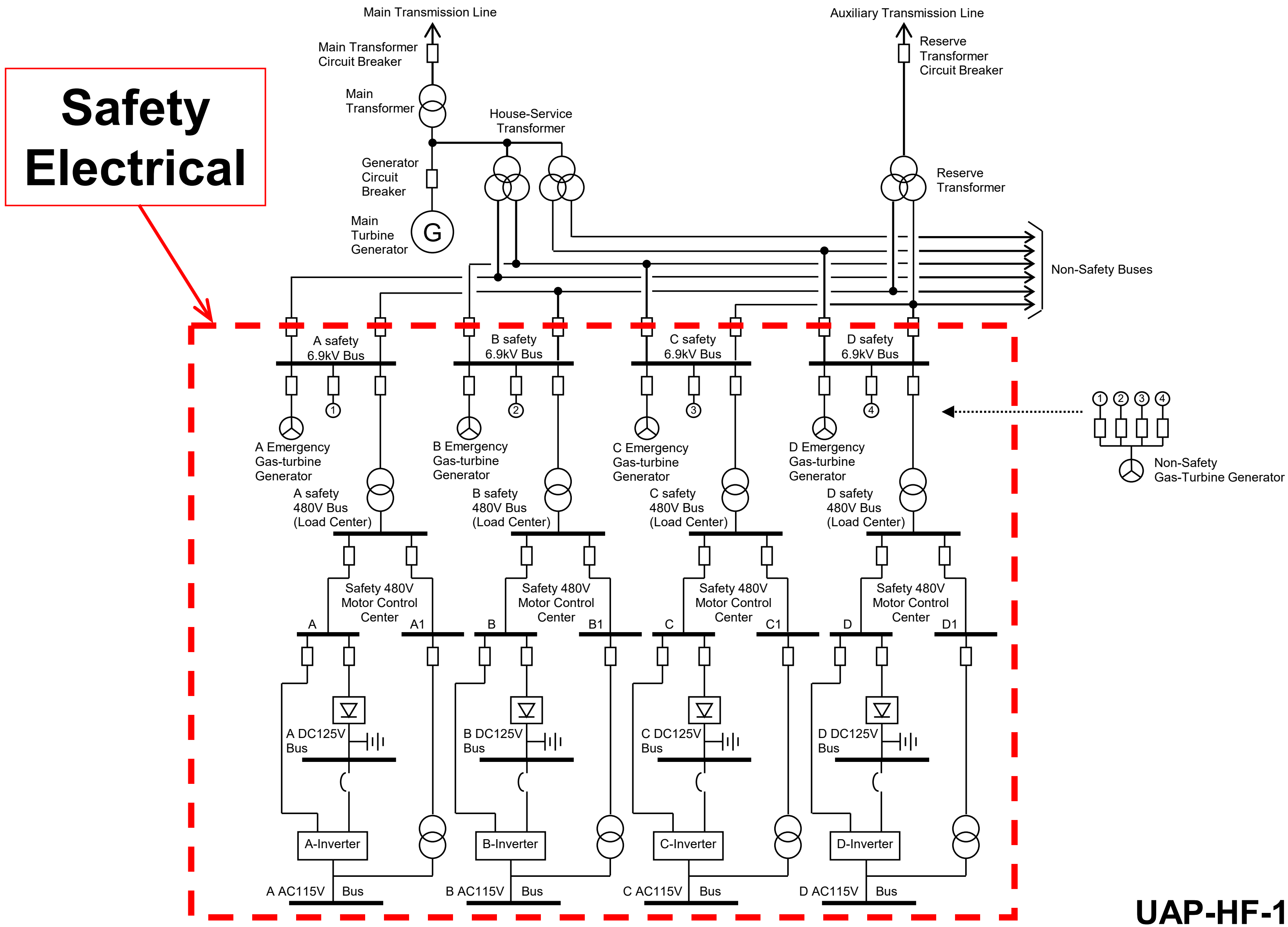
# Electrical System Design Features

- 2 independent offsite transmission systems
- 4 train onsite Safety Power Systems
- 4 train Safety Gas-Turbine Generators (GT/G)
  - ✓ Starting time requirement is extended with GT/G
  - ✓ Higher reliability and easier maintenance than DG
- 4 train Safety Batteries
  - ✓ 2 hours capability for loss of AC power
  - ✓ Supplies power to equipment that must be energized prior to starting time requirement of GT/G
- One non-safety GT/G alternate AC power
  - ✓ Supplies power to equipment required during SBO
  - ✓ Starting time requirement : 5 minutes
  - ✓ Manually connected to safety bus at SBO initiation

UAP-HF-19001-46

# Electrical System Diagram

MITSUBISHI HEAVY INDUSTRIES, LTD.




UAP-HF-19001-47

# US-APWR Overview

- US-APWR is designed on proven and reliable technologies and provides:
  - ✓ Improved plant efficiency incorporating improved steam generators and turbine system
  - ✓ Reduced fuel cycle cost and improved operational flexibilities by low power density core with 14 ft. fuel assemblies.
  - ✓ Minor modifications of APWR for U.S. utility requirements.

# MOVE THE WORLD FORWARD

MITSUBISHI
HEAVY
INDUSTRIES
GROUP

MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

# US-APWR
# Design Certification Application
# Tier 2: Chapter 8

September 19, 2019

Mitsubishi Heavy Industries, Ltd.



MITSUBISHI HEAVY INDUSTRIES

# Presenters

## Joseph Tapia

Mitsubishi Nuclear Energy Systems, Inc.

## Hideki Tanaka

Mitsubishi Heavy Industries, LTD.

## Shinji Kawanago

MHI NS engineering Co, Ltd.

# Contents

# 1. Overview of Chapter

# 1. Overview of Chapter

- **Title of Chapter**

  Chapter 8: Electric Power

- **Scope of Chapter**

  According to RG 1.206 and SRP, Chapter 8 consists of following subsections:

  8.1 Introduction
  8.2 Offsite Power System
  8.3 Onsite Power Systems
    8.3.1 AC Power Systems
    8.3.2 DC Power Systems
  8.4 Station Blackout

# 1. Overview of Chapter

## DCD

| # | No. | Rev. | Document Title | Issue Date | Submittal Date | MHI Ref. |
|---|---|---|---|---|---|---|
| 1 | - | 4 | DCD | - | Aug. 30, 2013 | UAP-HF-13212 |
| 2 | - | 0 | DCD Revision 4 Update Tracking Report | - | Mar. 14, 2014 | UAP-HF-14025 |

## Technical Reports

| # | No. | Rev. | Document Title | Issue Date | Submittal Date | MHI Ref. |
|---|---|---|---|---|---|---|
| 3 | MUAP-09023 | 1 | Onsite AC Power System Calculation | Aug. 2013 | Sep. 3, 2013 | UAP-HF-13221 |
| 4 | MUAP-07024 | 3 | Qualification and Test Plan of Class 1E Gas Turbine Generator System | Sep. 2012 | Sep. 28, 2012 | UAP-HF-12270 |
| 5 | MUAP-10023 | 7 | Initial Type Test Result of Class 1E Gas Turbine Generator System | Dec. 2013 | Dec. 18, 2013 | UAP-HF-13311 |

# 2. Features of Electrical Power System

## Offsite Power System (8.2)

➢ **Design Features**

✓ The two (2) sources of offsite power provide:

1.) Normal Preferred Power from Reserve Auxiliary Transformers (RAT)

2.) Alternate Preferred Power from Unit Auxiliary Transformers (UAT) thru Main Transformer

✓ The two (2) offsite power supply circuits are independent and physically separated.

✓ Either offsite power supply circuit has the capacity for normal operations and Design Basis Events (DBE) to comply with the applicable GDC's.

# 2. Features of Electrical Power System

MITSUBISHI HEAVY INDUSTRIES

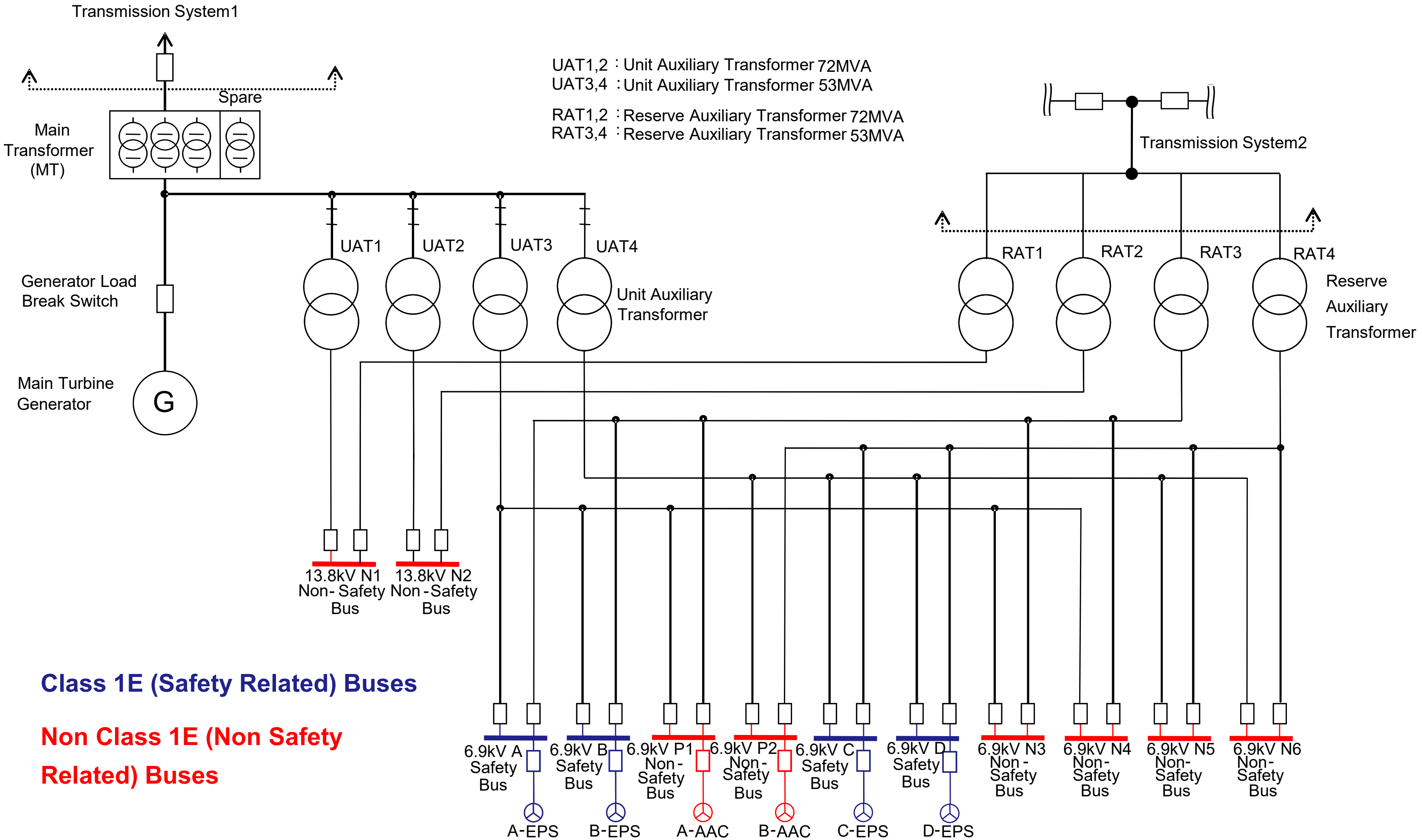



**Figure-1 Main One-Line Overview**

# 2. Features of Electrical Power System

## Offsite Power System (8.2)

- **Closed Open Items and RAIs (discussed later in detail)**
  - ✓ ***RAI on 8.2 "Bulletin 2012-01"***
    ***Protection against OPC (Open Phase Condition)***

# Onsite Power System (8.3)

- **Design Features**
  - ✓ Four train Class 1E AC electrical power systems
  - ✓ Each train includes an independent Class 1E GTG as its emergency power source
  - ✓ On-Line Maintenance with Single-Failure Criterion remains satisfied
  - ✓ "Permanent" buses supplied from Alternate AC Power Source (AAC-GTG)
  - ✓ Non-safety related loads are electrically separated from class 1E buses.
  - ✓ Required non-safety related loads are supplied from AAC during LOOP
  - ✓ AACs provide power to all SBO required loads to bring and maintain the unit in safe-shutdown.

# 2. Features of Electrical Power System

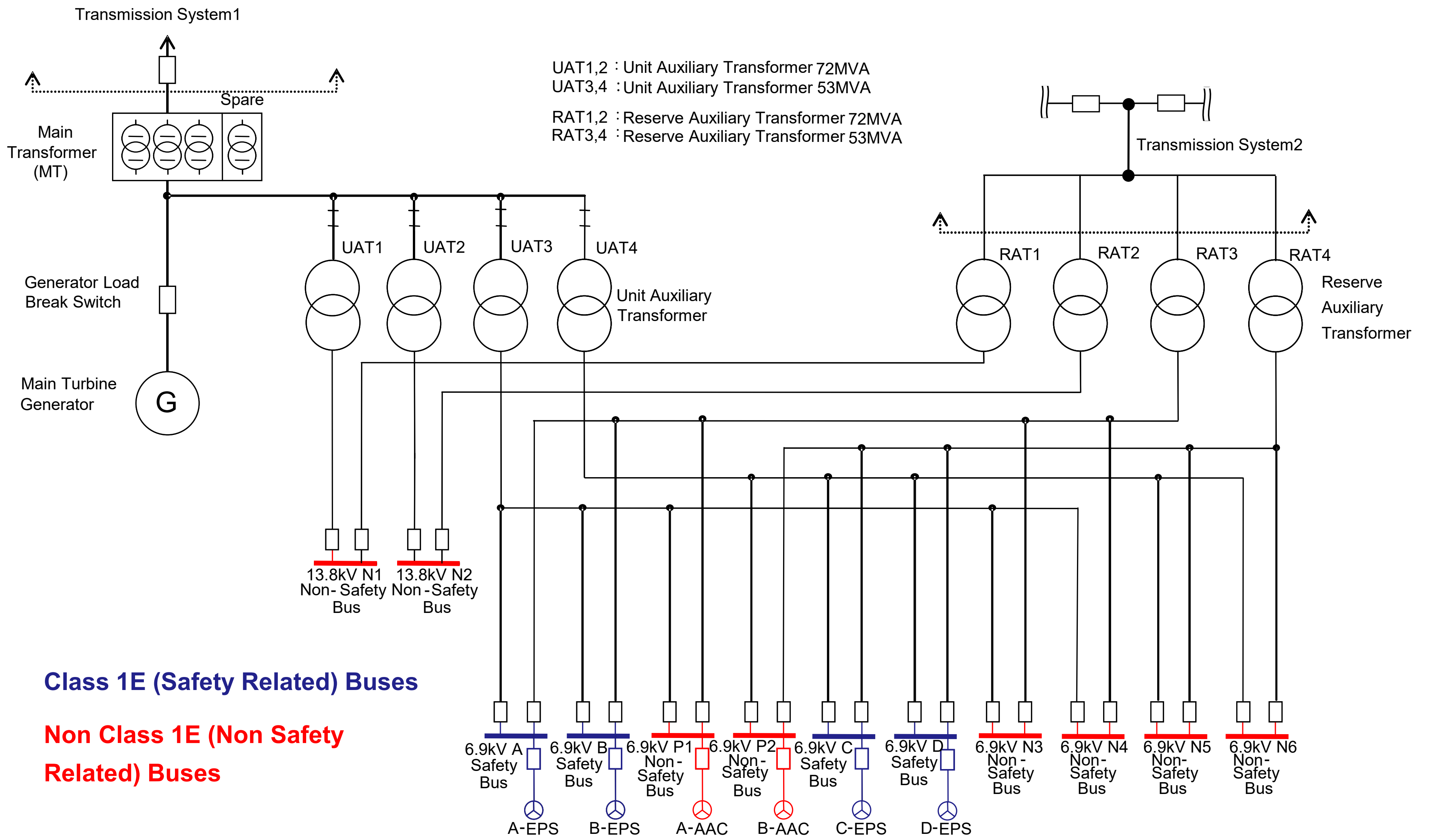



**Figure-1 Main One-Line Overview**

# Class 1E Gas Turbine Generator Specifications/Ratings

- **Gas Turbine Ratings**
  - ✓ Continuous Rating: 4500 kW
  - ✓ Short time Rating : 4950 kW
- **Generator Ratings**
  - ✓ Continuous Rating: 4500 kW / 5625 kVA
  - ✓ Power Factor of 0.8
  - ✓ 6900 Volt; 3 Phase, 60 hertz
- **Start time**
  - ✓ < 100 Seconds start time

# Class 1E GTG Testing Program

- **Regulatory guide 1.9**
  - ✓ Application and Testing of Safety-related Diesel Generators in Nuclear Power Plants
- **IEEE 387**
  - ✓ IEEE Standard Criteria for diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.
- **ISG-21 (Draft)**
  - ✓ Interim Staff Guidance On the Review of Nuclear Power Plant Designs using a Gas Turbine Driven Standby Emergency Alternating Current Power System
- **MHI Technical Report (Qualification Test Plan and Initial Type Test Result)**
  - ✓ Qualification and Test Plan for Class 1E Gas Turbine Generator System : MUAP-07024
  - ✓ Initial Type Test Result of Class 1E Gas Turbine Generator System : MUAP-10023

# Class 1E GTG Initial Type Tests

- **Load Capability Test**
  - ✓ IEEE 387 6.2.1
  - ✓ To demonstrate the capability to carry rated load
- **Start and Load Acceptance Test**
  - ✓ IEEE 387 6.2.2
  - ✓ To establish the capability to start and accept load within the required time period.
  - ✓ 150 Start Tests
- **Margin Test**
  - ✓ IEEE 387 6.2.3
  - ✓ To demonstrate the capability to carry the most severe load step + 10%

# 2. Features of Electrical Power System

MITSUBISHI HEAVY INDUSTRIES

- **Closed Open Items and RAIs (discussed later in detail)**
  - ✓ ***Open Item 08.03.01-1 :***
    ***Maintenance and Testing of Inaccessible Cables***
  - ✓ ***Open Item 08.03.01-2 :***
    ***Gas Turbine Generator Reliability (GTG)***
  - ✓ ***Open Item 08.03.02-1 :***
    ***Battery Sizing Calculations***
  - ✓ ***RAI on 8.3.1.4.4.2 "Conformance with RG 1.9"***

    ***GTG's qualification test which was stopped every 50 starts to perform maintenance***

MITSUBISHI HEAVY INDUSTRIES

# Station Blackout (8.4)

- **Basic Concept for Coping with SBO**
  - ✓ The AACs are available in the event of SBO, when all offsite power sources and EPS's are not available to bring the unit to a safe shutdown condition and maintain that status

- **Design Basis**
  - ✓ Diverse AACs to minimize the potential for common cause failures between EPS system
  - ✓ The non-class 1E AAC is a packaged gas turbine-generator connected to a 6.9kV AC "Permanent" bus
  - ✓ AAC can be aligned to any of the 4 class 1E buses in response to an SBO
  - ✓ AAC supplies safe shutdown loads during the SBO coping period (8 hours)

# 2. Features of Electrical Power System

- **Closed Open Items and RAIs for Section 8.4 (discussed later in detail)**
  - ***Open Item 08.04-1 :***
    ***RCP Seal Leakage Rate***
  - ***Open Item 08.04-2 :***
    ***AAC Power System Periodic Testing***
  - ***RAI on 8.4.4.3 “Station Blackout Coping Analysis” (Effects of Loss of Ventilation)***

    ***Justification of stable operation of the TDEFW pumps for one hour without room cooling***

# 3. Closed Open Items and RAIs

# 3. Closed Open Items and RAIs

| RAI on 8.2 “Bulletin 2012-01” | |
|---|---|
| **RAI 1017-7058, Question 08.02-17**<br>**RAI 1096-8266, Question 08.02-18**<br>**RAI 1100-9574, Question 08.02-19**<br><br>**Protection against OPC (Open Phase Condition) (Bulletin 2012-01)**<br>- Concerning Bulletin 2012-01, “Design Vulnerability in Electric Power system,” (ADAMS ML 12074A115) related to the recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station<br>(1) Detection and Protection Method<br>(2) Single Failure Criteria<br>(3) COL and ITAAC | **Response to NRC RAI**<br>US-APWR DCD Section 8.2, ITAAC and COL Item were revised.<br><br>More detail design information is as follows; |

# 3. Closed Open Items and RAIs

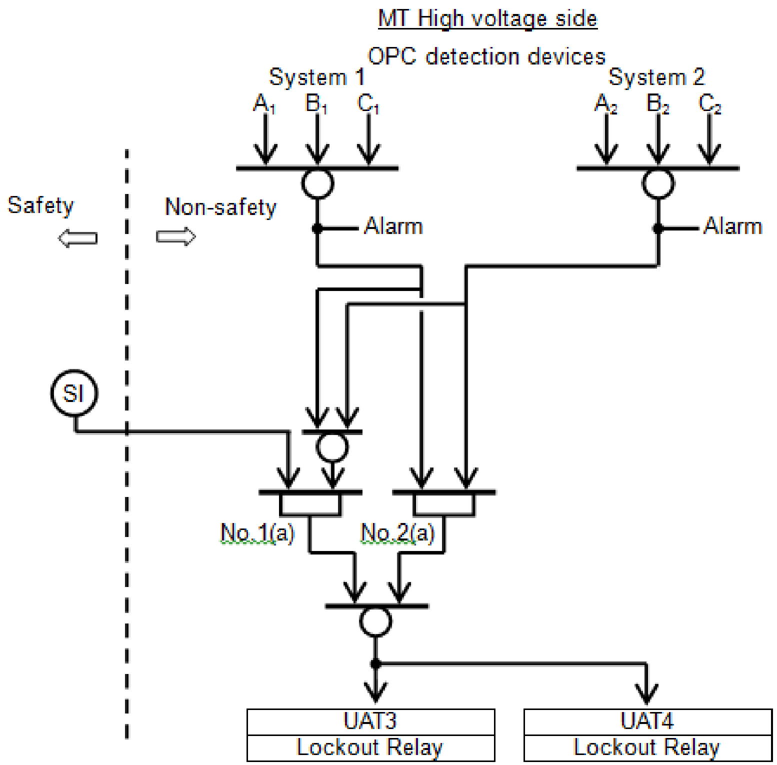
## ➢ MHI Response

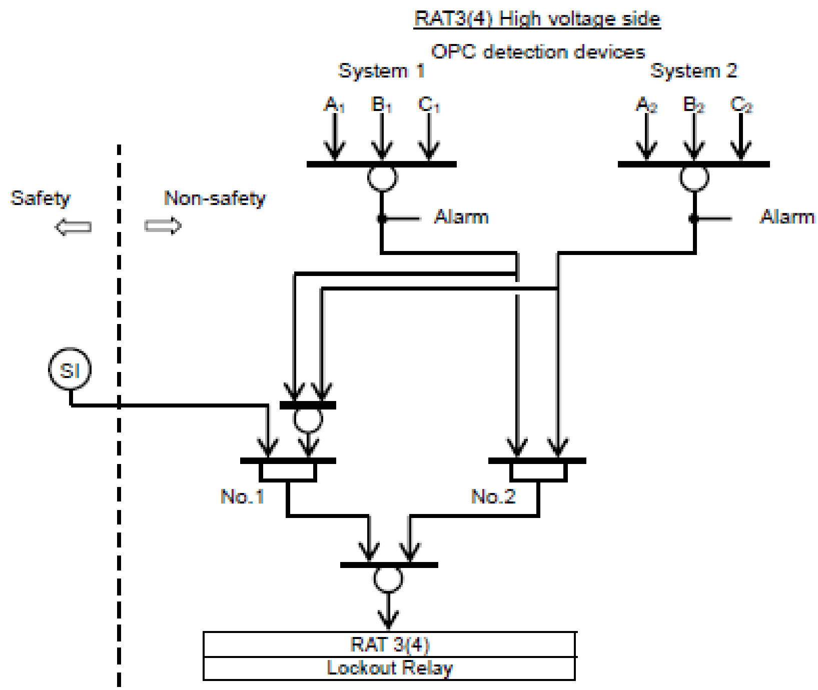
### *(1) Detection and Protection Method*

*OPC detection systems are provided on the high voltage side MT and RAT.*

### *(2) Single Failure Criteria*

*OPC detection system has redundancy.*



# 3. Closed Open Items and RAIs

MITSUBISHI HEAVY INDUSTRIES

## *(3) COL Item and ITAAC*

- ✓*COL items on detail designs and surveillance requirement were added DCD section 8.2.*

| | |
|---|---|
| COL 8.2(12) | ~~Deleted~~ The COL applicant is to determine the specific type of the OPC detection devices which properly address and meet the requirements of B.1. & B.2. of BTP 8-9, taking into account the site-specific design configuration, installation condition, (field) performance testing and qualification status, and operation experiences of the OPC Detection and Protection system. The COL applicant is also to provide the detailed design of the OPC Detection and Protection system for the COL applicant site.<br>The COL applicant is to perform a field simulation on the site-specific design of the offsite power system to ensure that the settings of the OPC Detection and Protection system are adequate and appropriate for the COL applicant site. |
| COL 8.2(13) | The COL Applicant is to provide surveillance requirements for the device(s) used to detect open phase condition on the high voltage side of the RATs and MT, with or without grounding. |

- ✓*One ITTAC was added Tier 1 of DCD.*

Table 2.6.1-3 AC Electric Power Systems Inspections, Tests, Analyses, and Acceptance Criteria (Sheet 8 of 8)

| Design Commitment | Inspection, Test, Analyses | Acceptance Criteria |
|---|---|---|
| 28 The Class 1E equipment is protected from open phase conditions with monitoring, detecting and alarming in the main control room. | 28.i Analysis will be performed verify the Class 1E equipment is protected from open phase condition. | 28.i A report exists and concludes that the Class 1 E equipment is protected from open phase condition by open phase protection system. |
| | 28.ii Inspection and test will be performed to verify the as-built protection system bounds the result of analysis for Class 1E equipment protection from open phase condition and to verify that open phase condition will be monitored, detected and alarmed in the main control room. | 28.ii The as-build protection system bounds the result of analysis for Class 1E equipment protection from open phase condition.<br>The as-built detection system design monitors, detects and alarms in the main control room. |

# 3. Closed Open Items and RAIs

| Open Item 08.03.01-1 | |
|---|---|
| **<u>Maintenance and Testing of Inaccessible Cables</u>**<br>- Generic Letter 2007-01 guidance on preventing the degradation of medium voltage cables that are installed in underground duct bank.<br>- The applicant has not provided a COL Information Item for this. | **<u>Response to NRC RAI NO.10 REVISION 4</u>**<br>US-APWR DCD Section 8.3.3 and Subsection 8.3.1.1.9 were modified to include COL Information Item;<br>"The COL Applicant is to describe the cable monitoring program for underground and inaccessible cables within the scope of the maintenance rule.“ |
| | |

# 3. Closed Open Items and RAIs

| Open Item 08.03.01-2 | |
|---|---|
| **Gas Turbine Generator Reliability (GTG)**<br>- Technical Report MUAP-07024-P, Rev. 2, provides technical information about the GTG and their qualification plan, but does not provide type test data that supports reliability target. | **Response to NRC RAI No.394-3048**<br>MHI has developed one technical report "Initial Type Test Result of Class 1E Gas Turbine Generator System" (MUAP-10023).<br><br>MHI performed 150 start and load acceptance tests of the GTGs with zero failures. These tests prove that the GTGs satisfy the reliability criterion of 0.975 with 95 percent confidence. |
| | |

# 3. Closed Open Items and RAIs

| RAI on 8.3.1.4.4.2 “Conformance with RG 1.9” | |
|---|---|
| **RAI 818-5872, Question 08.03.01-42**<br>**RAI 876-6210, Question 08.03.01-43**<br>**RAI 962-6578, Question 08.03.01-46**<br>- The qualification testing was stopped every 50 starts to perform maintenance on the injectors, but this information was not provided in the submitted technical reports (MUAP-07024-P (R2), MUAP-10023-P (R3)) and Technical Specifications.<br>- The applicant to provide information to support that the scheduled maintenance activity conducted, the fuel nozzle cleaning, was part of the test procedures. | **Response to NRC RAI**<br>US-APWR DCD Section 8.3.1.1.3.9 and Technical Specification Surveillance Requirement (SR) were revised to perform fuel nozzle cleaning as a maintenance activity. MUAP-07024-P and MUAP-10023-P were revised to include a summary of the fuel nozzle cleaning procedure and parameters monitored during the qualification testing. |
| | |

# 3. Closed Open Items and RAIs

| Open Item 08.03.02-1 | |
|---|---|
| **Battery Sizing Calculations**<br>- The applicant indicated that its assumptions for the types of loads were made based on Japanese experience and products.<br>- The applicant agreed to provide a more in-depth explanation of this issue which will be incorporated in the upcoming DCD revisions | **Response to NRC RAI No.388-2858**<br>MHI provided detailed information regarding current for loads included in the battery sizing calculations. The calculations factored US manufacturers' information and differences from the Japanese manufacturers.<br>US-APWR DCD Table 8.3.2.1 was revised. |
| | |

# 3. Closed Open Items and RAIs

| Open Item 08.04-1 | |
|---|---|
| **<u>RCP Seal Leakage Rate</u>**<br>- The applicant has stated that : The leakage of reactor coolant through the seals of each RCP is assumed to be 0.2 gpm. Therefore, the total loss of coolant inventory within 1 hour from the seals on all four RCPs is expected to be 48 gallons.<br>- The applicant needs to justify the deviation from industry standards for its RCP design by actual test results or demonstrate that the design can cope with the higher leakage rate. | **<u>Response to NRC RAI No.419-3126</u>**<br>MHI answered that the isolation valve stops the leakage in No. 1 seal and the leakage from the No. 2 seal is limited. |
| | |

# 3. Closed Open Items and RAIs

| Open Item 08.04-2 | |
|---|---|
| **<u>AAC Power System Periodic Testing</u>**<br>- The applicant's DCD states that the AAC power system will be inspected and tested periodically to demonstrate operability and reliability.<br>- The inspection and testing will be conducted by the COL applicant over the lifetime of the NPP, therefore, the DCD should include these inspection and testing requirements as a COL Information Item. | **<u>Response to NRC RAI No.683-5251</u>**<br>During the quarterly surveillance test, the AAC is started and brought to operating conditions. Additionally, during every refueling outage, the AAC generator is tested by performing a timed start and rated load capacity test. Testing and maintenance of the AAC is evaluated under the reliability assurance program and the maintenance rule program as described in the DCD. |
| | |

# 3. Closed Open Items and RAIs

| RAI on 8.4.4.3 "Station Blackout Coping Analysis" | |
|---|---|
| **RAI 938-6535, Question 08.04-16**<br>**RAI 991-7026, Question 08.04-17**<br><br>**(5) Effects of Loss of Ventilation**<br>- Justification of stable operation of the TDEFW pumps for at least one hour without active room cooling | **Response to NRC RAI**<br>The heat-up analysis is based on conservative assumptions and uses a numerically stable calculation method. The TDEFW pump room air temperature remains below the 175 $^{o}$F acceptance criterion up to 24 hours after a complete loss of cooling under SBO, which covers the coping period. |
| | |

# 4. Summary

# 4. Summary

- ✓ All open Items with Phase 2 SER have been closed.
  - ➢ Open Item 08.03.01-1
  - ➢ Open Item 08.03.01-2
  - ➢ Open Item 08.03.02-1
  - ➢ Open Item 08.04-1
  - ➢ Open Item 08.04-2

- ✓ Additional RAIs have been closed.
  - ➢ RAI on 8.2 “Bulletin 2012-01”
  - ➢ RAI on 8.3.1.4.4.2 “Conformance with RG 1.9”
  - ➢ RAI on 8.4.4.3 “Station Blackout Coping Analysis

MITSUBISHI
HEAVY INDUSTRIES

MOVE THE WORLD FORWARD

MITSUBISHI
HEAVY
INDUSTRIES
GROUP

MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

# Presentation to ACRS Subcommittee
# Chapter 18

September 19, 2019

Mitsubishi Heavy Industries, Ltd.



MITSUBISHI HEAVY INDUSTRIES

# Presenters

- **Lead Presenters**
- Joseph Tapia,
  Principle Consulting Engineer, MNES
- Kenji Mashio,
  Engineering Manager, MHI
- Robert E. Hall,
  Consultant, MHI/RTS

# Contents

1. Structure of the submittals

2. US-Basic HSI

3. US-APWR HFE Program Management Plan

# 1. Structure of the submittals

# Document Lists (1/2)

## DCD

| # | No. | Rev. | Document Title | Issue Date | Submittal Date | MHI Ref. |
|---|---|---|---|---|---|---|
| 1 | - | 4 | DCD | Aug. 2013 | Sep. 10, 2013 | UAP-HF-13212 |
| 2 | - | 0 | DCD Revision 4 Update Tracking Report | - | Mar. 14, 2014 | UAP-HF-14025 |
| 3 | - | - | DCD Markup<br>- DCD Tier 1 Section 2.9 Markup<br>- DCD Tier 2 Chapter 1 Markup<br>- DCD Tier 2 Chapter 18 Markup | - | Jun. 4, 2014 | UAP-HF-14042 |

## Technical Reports (1/2)

| # | No. | Rev. | Document Title | Issue Date | Submittal Date | MHI Ref. |
|---|---|---|---|---|---|---|
| 4 | MUAP-09019 | 5 | Human Factors Engineering Program Management Plan | Aug. 2014 | Aug. 22, 2014 | UAP-HF-14047 |
| 5 | MUAP-13005 | 1 | Operating Experience Review Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |
| 6 | MUAP-13007 | 1 | Functional Requirements Analysis and Function Allocation Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |
| 7 | MUAP-13009 | 1 | Task Analysis Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |

# Document Lists (2/2)

## Technical Reports (2/2)

| # | No. | Rev. | Document Title | Issue Date | Submittal Date | MHI Ref. |
|---|---|---|---|---|---|---|
| 8 | MUAP-10008 | 4 | Staffing and Qualifications Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |
| 9 | MUAP-13014 | 1 | Human Reliability Analysis Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |
| 10 | MUAP-10009 | 4 | Human-System Interface Design Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |
| 11 | MUAP-10012 | 4 | Human Factors Verification and Validation Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |
| 12 | MUAP-10013 | 4 | Design Implementation Implementation Plan | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |

## MHI Internal Documents

| # | No. | Rev. | Document Title | Issue Date | Submittal Date | MHI Ref. |
|---|---|---|---|---|---|---|
| 13 | JEJC-1763-1001 | 2 | HSI Design Style Guide | May 2008 | - | |
| 14 | 7DS-UAP-20140002 | 0 | Operating Experience Review Results | Aug 2014 | - | |

# Document Lists (2/2)

## Topical Report

| # | No. | Rev. | Document Title | Issue Date | Submittal Date | MHI Ref. |
|---|---|---|---|---|---|---|
| 15 | MUAP-07007 | 6 | Human-System Interface System Description | May 2014 | Jun. 4, 2014 | UAP-HF-14042 |

## Technical Reports

The US-APWR HFE submittals prior to design certification cover the HFE program management plan (PMP) and 8 HFE element IPs;

- HFE Program Management Plan
- Operating Experience Review (OER)
- Functional Requirements Analysis and Function Allocation (FRA/FA)
- Task Analysis (TA)
- Staffing and Qualifications (S&Q)
- Human Reliability Analysis (HRA)
- HSI Design (HD)
- Verification and Validation (V&V)
- Design Implementation (DI)

# 1.1 Technical Reports (2/3)

- The PMP and IPs address specific HFE activities and provide detailed methodologies for addressing review criteria
- The PMP and IPs each follow the same outline as defined below;

  Section 1: Purpose

  Section 2: Scope

  Section 3: Methodology Overview

  Section 4: Methodology

  Section 5: Implementation Team

  Section 6: Results Summary Report Content

  Section 7: NUREG-0711 Compliance Evaluation

  Section 8: References

# 1.1 Technical Reports (3/3)

MITSUBISHI HEAVY INDUSTRIES

- HFE activities related to procedure development and training program development are addressed by programs discussed in Chapter 13, Conduct of Operations

## COL Items

- COL Applicants address the HFE requirements associated with Human Performance Monitoring

# 1.2 Supporting Documents

## For audit

Following supporting documents were not docketed but audited by NRC staff;

- HSI Design Style Guide
- OER Results

# 1.2 Supporting Documents

## Topical Report

Human-System Interface System Description,
MUAP-07007, Revision 6, May 2014

## Purpose/Key issues

- Document and obtain an approval of the US-Basic Human-System Interface (HSI) System (HSIS), incorporating HEDs identified through testing performed with U.S. licensed operators
- Introduced US-Basic HSI simulator
- Formed the foundation of the HFE Implementation Plans (IPs)

# 1.3 Future Submittal & ITAAC (1/2)

Results summary reports will be submitted following the completion of each HFE activity;

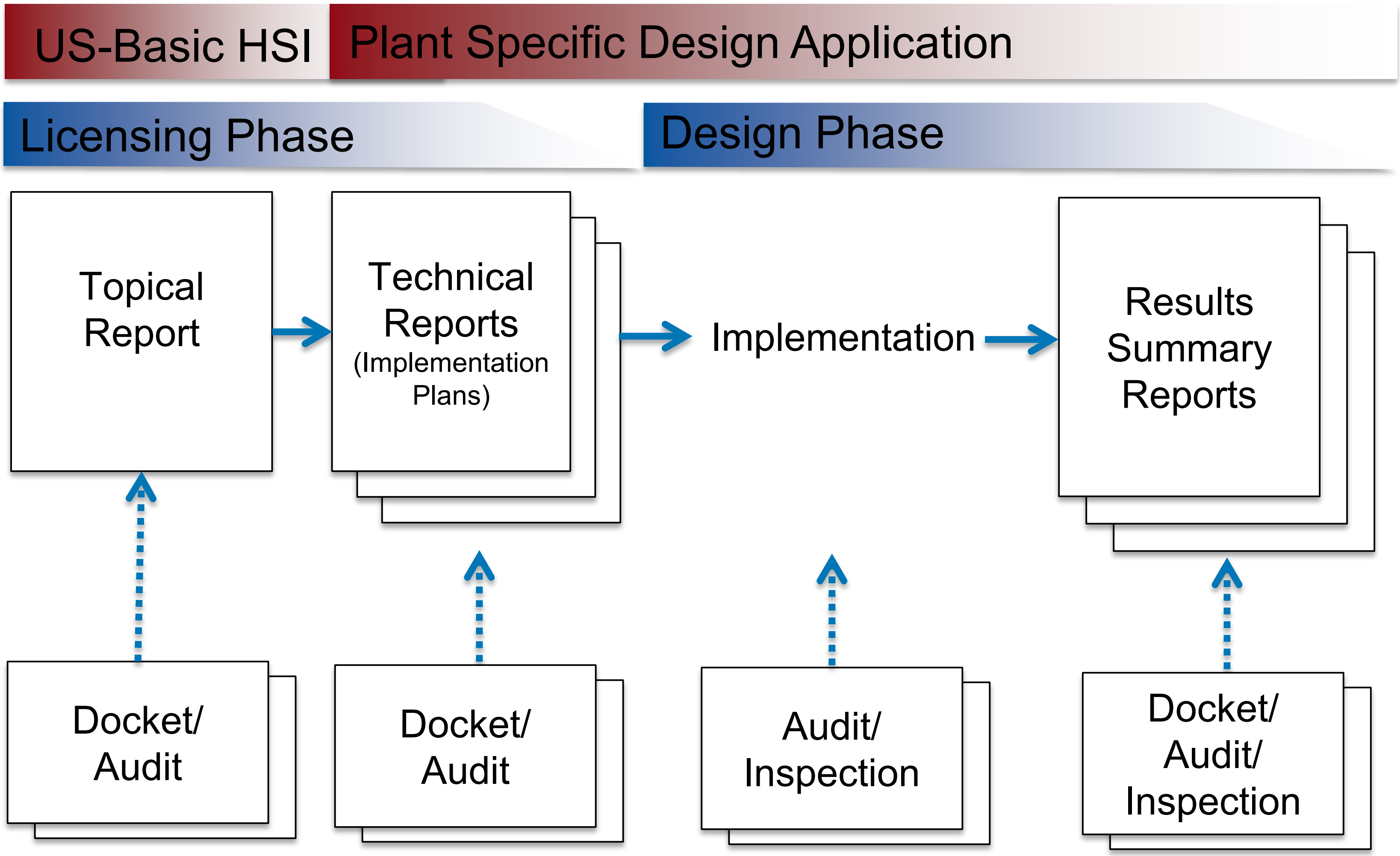
- OER (The Basic HSIS OER completed)
- FRA/FA
- TA
- S&Q
- HD
- V&V
- DI

# 1.3 Future Submittal & ITAAC (2/2)

ITAAC, DCD Tier 1 Section 2.9 Table 2.9-1 (UAP-HF-14042)

| Design Commitment | Inspections, Tests, Analyses | Acceptance Criteria |
|---|---|---|
| 1. The Control Room design incorporates human factors engineering principles that minimize the potential for operator error. | 1. An Integrated System Validation (ISV) test will be performed in accordance with the Human Factors Verification and Validation implementation Plan. | 1. All pass/fail criteria associated with each test scenario are passed either on initial performance of the scenarios or following remediation of failures. |
| 2. The as-built Control Room Human-System Interface is consistent with the final validated design specifications. | 2. An inspection of the as-built Control Room Human-System Interfaces will be performed. | 2. The as-built Control Room Human-System Interface conforms to the validated design with no configuration deviations. |

# 1.4 Summary of Document Structure



# 2. US-APWR HFE Program Management Plan

# 2. US-APWR HFE PMP (1/7)

- ✓ The US-APWR HFE program implementation is in accordance with NUREG-0711, Revision 2, “Human Factors Engineering Program Review Model,” issued February 2004.
- ✓ The HFE program assures that the HSI reflects modern human factors principles and satisfies the applicable regulatory requirements.

# 2. US-APWR HFE PMP (2/7)

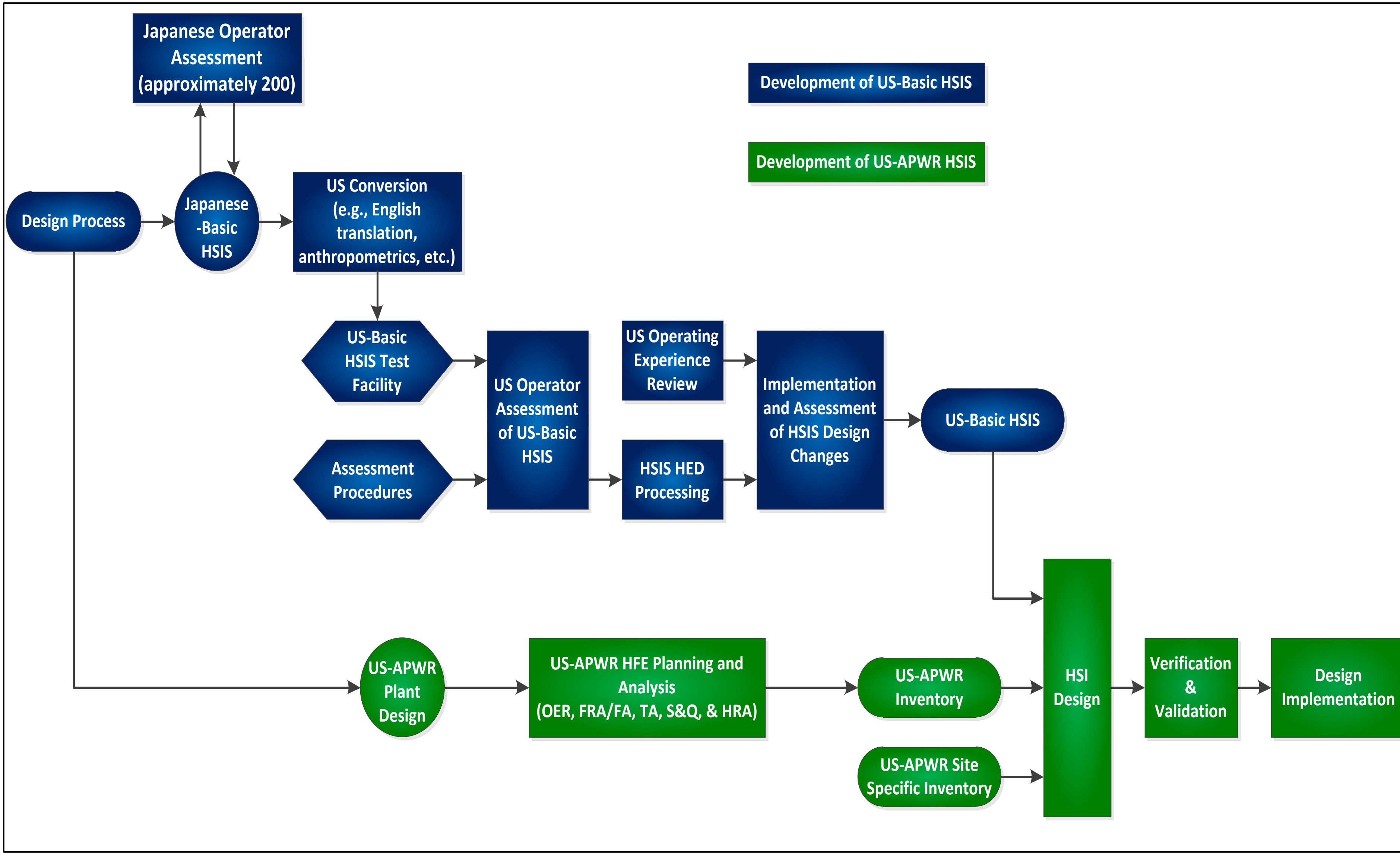
✓ The following HFE elements (as defined in NUREG-0711, Revision 2) are covered by the US-APWR HFE Program:

- HFE PMP
- OER
- FRA/FA
- TA
- S&Q
- HRA
- HD
- Operating Procedure Development*
- Training Program Development*
- V&V
- DI
- HPM**

* Procedure Development and Training program development will be reviewed in Chapter 13, Conduct of operation

** COL applicants will develop HPM program

# 2. US-APWR HFE PMP (3/7)



# 2. US-APWR HFE PMP (4/7)

- ✓ The scope of the HFE PMP includes:
  - HFE design team and organization, roles and responsibilities
  - HFE process and procedures
  - HFE issues tracking (HED process)
  - HFE technical program
  - Combined license (COL) information

- ✓ For HFE activities completed within the scope of the US-APWR design, the program element methodology is described within an implementation plan (IP) and the element is documented in a results summary report (ReSR) as per the IP.

## Assumptions and Constraints Identification

- ✓ The US-APWR HSIS is based on application of the US-Basic HSIS, which establishes the generic monitoring, alarm, control, and computerized procedure technologies to be employed in the MCR for all plant systems.
- ✓ The generic HSI technologies of the US-Basic HSIS are combined with the specific HSI inventory needed for the US-APWR plant design to create the US-APWR HSIS.
- ✓ The development process for a US-APWR site-specific HSIS confirms or changes the HSI inventory to reflect a site-specific plant.

# 2. US-APWR HFE PMP (6/7)

## ➢ Assumptions and Constraints Identification (Cont.)

- ✓ A fundamental design assumption and constraint of the US-Basic HSIS that also applies to the US-APWR HSIS is that the plant can be operated with minimum operation staff, one RO and one SRO in the MCR during postulated plant operating modes.

# 2. US-APWR HFE PMP (7/7)

## ➢ Applicable Plant Facilities

- ✓ MCR
- ✓ Remote shutdown room (RSR)
- ✓ Technical support center (TSC)
- ✓ Local control stations* (LCSs)
- ✓ Emergency operations facilities* (EOFs)

* Portion of stations or facilities

# 3. US-Basic HSI

# 3.1 Documentation (1/2)

## Documentation of US-Basic HSI features and functions

- Submitted as a topical report, MUAP-07007

## The document structure:

- Concept of Operation
- Control room layout
- Display overview and display navigation
- Operational VDU display
- Safety VDU
- Alarms

# 3.1 Documentation (2/2)

- Computer-based procedures
- Large Display Panel
- Automatic Checking of Actuations
- Diverse HSI Panel
- History of Development of Japanese PWR Main Control Room by Mitsubishi and Japanese PWR Power Utilities (Appendix A)
- HFE V&V Experience in Japan (Appendix B)
- US-Basic HSIS Evaluation Program (Appendix C)

# 3.2 Background/Development Basis

## Background

- MHI used the foundational elements of the Japanese-Basic HSIS as a starting point to create the US-Basic HSIS, applying combinations of design review, redesign, and design validation through a phased implementation
- Appendix A contains information about the Japanese-Basic HSIS & development history
  - Developed Japanese-Basic HSIS with Japanese utilities from 1987 to 2003 with guidance from NUREG-0711 and NUREG-0700
  - Japanese operators were involved in conducting V&V
  - Introduced Japanese HSIS to Japanese latest plant design and MCR modernization
  - No performance issues identified

# 3.3 Structure of the HSIS

- The Japanese HSIS, as applied in the U.S., is comprised of;
  - The Basic HSIS
  - The HSI Inventory (i.e., controls, displays, alarms) which will be developed as a part of the plant-specific analysis phase of the HFE design program

- The HSI Inventory is developed as part of the US-APWR DC in accordance with the US-APWR HFE program

## 3.4 Phased Implementation

Phase 1 (Topical Report scope)

Translated the Japanese-Basic HSIS to the US-Basic HSIS

Phase 2

Develop an application specific (e.g. US-APWR) inventory, which will be combined with the US-Basic HSIS to yield an application specific design

Phase 3

Confirm the site-specific assumptions of Phase 2 and/or make minor site specific changes to finalize the application design

## 3.5 Phase 1 the US-Basic HSIS implementation

Phase 1

Translated the Japanese-Basic HSIS to the US-Basic HSIS

Phase 1a

- Addressed language, engineering units, anthropometric changes to the consoles for American body types
- Adopted the US-style step-by-step operating procedures
- Made improvements identified from completing the OER program element from NUREG-0711 which included U.S. nuclear plants and additional, generic, digital HSI technology experience

Phase 1b

- Resolved deficiencies from Phase 1a, validated design changes, and updated Section 4 of the topical report (Revision 2) to reflect these changes

# 3.6 The US-Basic HSIS test

- In Phase 1a and 1b, the tests were implemented using the
  - US-Basic HSIS simulator
  - Static portable HSIS analysis tool
- U.S. licensed operators participated in dynamic testing: 8 crews (22 persons in total (Phase 1a)) and 5 crews (10 persons (Phase 1b))
- Went through seven scenarios that included normal and emergency events under normal as well as degraded HSI conditions
- Phase 1a results identified difference between Japan and U.S. operation style and identified design improvements documented via HEDs
- An expert panel (HFE, I&C, plant operations, US-APWR systems engineers) was organized to resolve HEDs
- Phase 1b tested design changes

## 3.7 The US-Basic HSIS OER

- OE Sources include;
  - NUREG/CR-6400, “HFE Insights For Advanced Reactors Based Upon Operating Experience,”
  - INPO database
  - Japan Nuclear Technologies Institute (JANTI) Nuclear Information Archives (NUCIA) database
  - Issues obtained from non-nuclear industries (similar HSIS technologies) in U.S. and Japan
- Findings were evaluated and included in the US-Basic HSIS

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

# Presentation to the ACRS Subcommittee

**Mitsubishi Heavy Industries, Ltd.**
**US-APWR Design Certification Application Review**

**Project History and Recent and Future Actions**

**George Wunder – Lead Project Manager**

September 19, 2019

## Project History – US-APWR Design Certification Review

- Application submitted December 31, 2007
- Application docketed February 29, 2008
- Phase 3 meetings held on between summer 2011 and spring 2013
- On November 5, 2013, applicant announced reduced support
  - Applicant made clear their commitment to completing project
  - Review has continued at reduced pace since 2013.

## Recent and Future Actions

In early 2018 applicant identified areas for progress

Applicant revised advanced accumulator (MUAP-07001) topical report

Applicant identified Chapters 5, 7, 8, 10, 18, for Phase 4 completion

Advanced accumulator SER with CIs submitted June 2018

Advanced accumulator  Cis closed June 2019

MUAP-07001, Chapters 8 and 18 submitted June-August 2019

Chapters 5, 7, and 10 under review for 2020 Subcommittee meeting

# 3.8 US-Basic HSI Design Features
## 3.8.1 Concept of Operation (1/6)

- The concept of operation is addressed in Section 4.1

- The US-Basic HSIS addresses the following subjects:
  - Crew composition
  - Roles and responsibilities
  - Personnel interaction with plant automation
  - Use of control room resources by crewmembers
  - Methods used to ensure good coordination of crewmember activities, including non-licensed operators, technicians, and maintenance personnel

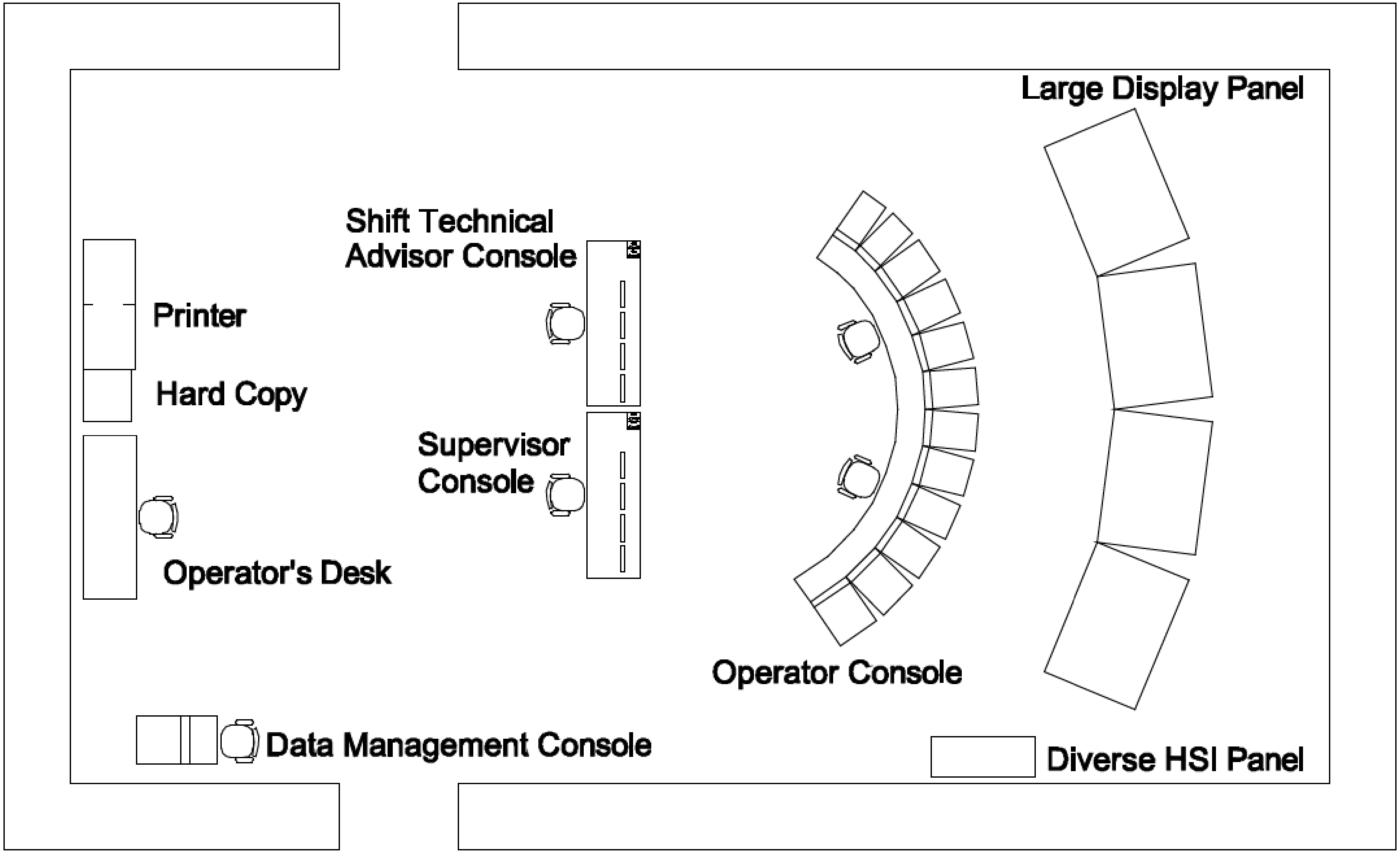
# 3.8 US-Basic HSI Design Features
## 3.8.1 Concept of Operation (2/6)

- Operating crew composition
  - The normal MCR staffing consists of one RO and one SRO
  - The normal MCR staff is supplemented by one additional SRO and one additional RO that will be at the plant to accommodate unexpected conditions
  - While the HSIS is designed to support the minimum MCR staffing described above, the space and layout of the MCR are designed to accommodate the foreseen maximum number of operating and temporary staff

The S&Q IP handles further staffing levels for the US-APWR

# 3.8.1 Concept of Operation (3/6)

## MCR personnel allocation



## 3.8 US-Basic HSI Design Features
## 3.8.1 Concept of Operation (4/6)

- The computer-based HSIS provides operational visual display units (VDUs) as the fundamental interface. The operator monitors plant status and initiates actions from a VDU by touching or clicking on the appropriate sections of the screen
- The operators workload is significantly reduced by providing relevant process control information in integrated displays on the VDUs and utilizing a compact console that minimizes required operator movement
- The HSIS also provides operational support functions that utilize the computer to consolidate large amounts of data into meaningful displays
- Section 4.1 identifies further specific interfaces and responsibilities between the crew and the HSIS

# 3.8 US-Basic HSI Design Features
## 3.8.1 Concept of Operation (5/6)

- Control Room Crew coordination with the HSIS
  - Control Room Crew coordination with the HSIS is described in each HSI design feature
  - The Large Display Panel (LDP) provides Spatially Dedicated Continuously Visible (SDCV) information to the operation personnel to enhance situation awareness
    - Helps operators maintain continuous awareness of overall plant status and critical status changes
    - The secondary purpose is to help the operations staff coordination and communication by providing a common visualization of plant information
  - The Operator Console provides all monitoring and control functions which are available in the MCR so that ROs can perform all operation tasks using the Operator Console from a seated position

## 3.8 US-Basic HSI Design Features
## 3.8.1 Concept of Operation (6/6)

- The Supervisor Console, located behind the RO, provides the same display set as those on the Operator Console, without control functions
- The STA console provides the same display set as those on the Operator Console, without control functions as well
- Each console has paging phones and internal phones to communicate with local staff
- Maintenance console, which is a temporary console (disconnected from the digital data communication bus during normal plant operation) used to support an additional operator in the MCR for tests during plant shutdown conditions and periodic inspections
- Tagging feature on the O-VDU and physical tag for local component are also addressed to support maintenance activities between MCR crew and maintenance staff

MITSUBISHI HEAVY INDUSTRIES

## US-Basic HSIS simulator

## 3.8 US-Basic HSI Design Features
## 3.8.3 Large Display Panel (1/4)

- LDP provides plant overview information and alarms to enhance MCR staff awareness of the plant status (i.e., presents spatially-dedicated continuously visible (SDCV) critical safety and power production functions with supporting component status and parameters and is the apex of entire HSI information hierarchy)

- LDP provides computer aided operator's support information;
  - i) OK monitors (computer checking relevant component status at Reactor Trip, ECCS, CV isolation, etc.,)
  - ii) Critical safety function status
  - iii) Bypass or inoperable status indication (BISI) along with safety signals (e.g., Reactor Trip, ECCS, CV isolation)

  Additional detailed information is displayed in the O-VDU screens

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

# Presentation to the ACRS Subcommittee

## Mitsubishi Heavy Industries, Ltd.
## US-APWR Design Certification Application Review

**Safety Evaluation with No Open Items: Chapter 8**

**ELECTRIC POWER**

September 19, 2019

# Technical Topics
## Section 8 – Electric Power

### Technical Topics

- US-APWR electric power system comprises of the following systems:
  - Offsite power system
  - Onsite AC power system, including 4 Class 1E trains each with a Class 1E Gas Turbine Generator (GTG), and Alternate AC source
  - Onsite DC Power System, including 4 trains of Class 1E 125Vdc

- Staff's review:
  - In the Phase 4 review the staff concluded that the DCD application, Chapter 8 met all applicable regulatory criteria.
  - In particular, the staff will discuss the closure of the following open items:
    - Open Phase Conditions (OPC)
    - GTG Reliability

# Technical Topics
## Section 8 – Electric Power

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

**Open Item #1: OPC**

- Design criteria to address OPC includes:
  - Detection
  - Alarm
  - Response to a open phase conditions

- OPC protection features per BTP 8-9
  - COL Item 8.2(12) requires the COL applicant to identify the type of open phase detection and protection (OPDP) system.

# Technical Topics
## Section 8 – Electric Power

**Resolution of Open Item #1**

- COL Item 8.2(12) will ensure that the COL applicant will determine an OPDP system that meets the guidance in BTP 8-9 including detection, alarm in the main control room (MCR), and protection features in that the Class 1E medium voltage buses will transfer to a power source without an open phase condition.

- DCD Tier 2, Section 8.2, includes a general description of the criteria for addressing OPC.

- ITAACs were added to verify that:
  - The OPDP system can detect an open phase condition.
  - The OPDP system can provide an alarm in the MCR upon detection of an OPC.
  - Class 1E medium voltage buses are automatically separated from the degraded offsite source, transferred to the alternate power source or onsite standby source.

- TS were modified to incorporate surveillance requirements for OPC protection.

# Technical Topics
## Section 8 – Electric Power

**Open Item #2: GTG Reliability**

- MHI proposed the use of GTG as the Class 1E emergency power source.

- The challenges of this proposal included:
  - First of a kind application in the nuclear fleet, therefore there was no operating experience
  - No reliability data available

- In absence of operating experience and reliability data, the staff requested the applicant to perform type tests to ensure GTGs will perform their intended function and achieve their target reliability level.

# Technical Topics

## Section 8 – Electric Power

**Resolution of Open Item #2**

- The GTGs have been qualified for Class 1E application using methodology and assumptions in Technical Reports MUAP 07024-P, “Qualification and Test Plan of Class 1E Gas Turbine Generator System.”

- The applicant documented the successful qualification of the Class 1E GTGs in Technical Reports MUAP-10023-P, “Initial Type Test Result of the Class 1E Gas Turbine Generator.”

- The result presented in Technical Report MUAP-10023-P states that to satisfy the starting reliability of 0.975 with 95 percent confidence, 150 start tests should be performed with no failures.
  - MHI performed 150 start and load acceptance tests of the GTGs.
  - The staff finds that these tests prove that the GTGs satisfy the reliability criterion of 0.975 with 95 percent confidence.

- In conclusion, the staff finds that the applicant’s approach to demonstrating Class 1E GTG reliability is adequate, considering compliance with GDC 17, conformance to RG 1.155, as well as successful qualification via type testing.

U.S.NRC

United States Nuclear Regulatory Commission

*Protecting People and the Environment*

# Mitsubishi APWR Design Certification Review

## SER Chapter 18
## Human Factors Engineering Program

Presentation to the ACRS Subcommittee September 19, 2019

# Chapter 18 Review Team

## Technical Staff

- Brian Green, Ph.D. NRR/DIRS/IRAB

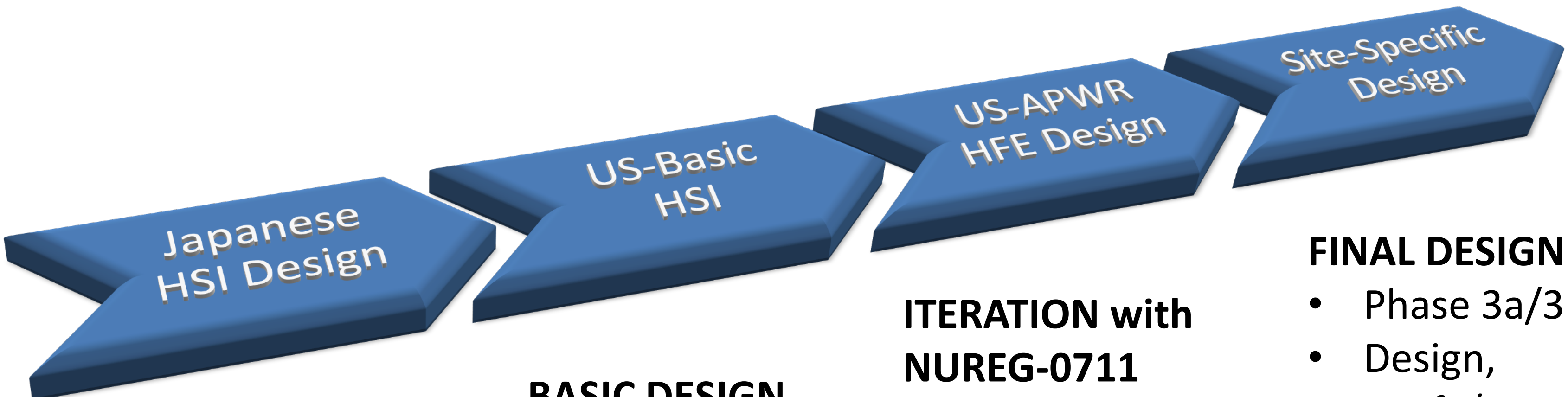
## Project Manager

- George Wunder, NRO/DLSE/LB3

# Overview

- The HFE design described in the Topical Report MUAP-07007 conforms to NUREG-0700.
- DCD Scope conforms to NUREG-0711, revision 2
  - Implementation plans are complete
    - Level of detail is sufficient to assess implementation effectiveness
    - ITAAC are used to verify acceptable results
  - Final design results are provided for the following HFE elements: HFE Program Management, Operating Experience, Human Reliability Analysis

# Overview: Iteration is Key




**PREDECESSOR DESIGN**
- Designed using process like NUREG-0711

**BASIC DESIGN PLATFORM**
- Phase 1a/1b
- Topical Report MUAP-07007
- Americanizing the predecessor design

**ITERATION with NUREG-0711**
- Phase 2a/2b
- Implementation Plans (IPs) used to analyze, design, verify/validate
- Development of HSI inventory

**FINAL DESIGN**
- Phase 3a/3b
- Design, verify/ validate, and implement site-specific aspects
- Operator training

# Topical Report Comments

- At the time the Phase 4 SER was written, the US-Basic Human-System Interface (HSI) System was the most detailed design description staff had reviewed.
- Audit and review of the HFE design descriptions verified the design conforms to NUREG-0700 (HSI design guidelines).
- Full scope simulator was used effectively in the design process.

# Design Certification Comments

- Reviewed to ensure the Implementation Plans were included by reference and there were no inconsistencies with the Implementation Plans.
- Includes ITAAC to confirm adequate completion of Implementation Plans.

# Implementation Plans

| HFE Area | Level of Review |
|---|---|
| HFE Program Management | Complete Element |
| Operating Experience Review | Implementation Plan |
| Functional Requirements Analysis and Function Allocation | Implementation Plan |
| Task Analysis | Implementation Plan |
| Staffing and Qualifications | Implementation Plan |
| Human Reliability Analysis | Complete Element |
| Human-System Interface Design | Implementation Plan |
| Procedure Development | See Chapter 13 |
| Training Program Development | See Chapter 13 |
| Human Factors Verification and Validation | Implementation Plan |
| Design Implementation | Implementation Plan |
| Human Performance Monitoring | COL action Item |

# Status of Open/Confirmatory Items

- There no Open Items.
- There are no Confirmatory Items.

# Conclusions

- The topical report describes an acceptable generic platform referred to as the US-Basic HSI.
- Implementation Plans provide confidence that iteration on the US-Basic HSI will be consistent with "state-of-the-art human factors principles" and US regulations.
- DCD Chapter 18 uses ITAAC to confirm that acceptable HFE practices are incorporated into the final US-APWR design.