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

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FUTURE PLANT DESIGNS SUBCOMMITTEE

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THURSDAY

JUNE 25, 2015

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Michael Corradini, Subcommittee Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL CORRADINI, Subcommittee Chairman

JOHN W. STETKAR, ACRS Chairman

RONALD G. BALLINGER, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR., Member

DANA A. POWERS, Member

JOY REMPE, Member

MICHAEL T. RYAN, Member

STEPHEN P. SCHULTZ, Member

GORDON R. SKILLMAN, Member*

DESIGNATED FEDERAL OFFICIAL:

MAITRI BANERJEE

ALSO PRESENT:

DOUG BOWMAN, NuScale

GREG CRANSTON, NRO

BILL GALYEAN, NuScale

STEVE MIRSKY, NuScale

JOSE REYES, NuScale

TIM TOVAR, NuScale

KENT WELTER, NuScale

*Present via telephone

A-G-E-N-D-A

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

(8:33 a.m.)

CHAIRMAN CORRADINI: The meeting will come to order. This is a meeting of the Future Plant Designs Subcommittee of the ACRS. My name is Mike Corradini. I'm acting chairman of the Future Plant Designs Subcommittee.

ACRS members in attendance today are John Stetkar, Dana Powers, Ron Ballinger, Joy Rempe, Steve Schultz, and Mike Ryan. And we expect Dennis Bley to join us.

Ms. Maitri Banerjee is the Designated Federal Official for this meeting.

Today we have members of NuScale power team to brief the subcommittee on the technology for their integrated PWR, pressurized water reactor.

The design topics of today's agenda include an overview of the design, of the integral system test facility, refueling and module installation, PRA updates, and design basis events.

This is to be an information briefing as we are preparing to review the NuScale-specific NRC review standards, or the DSRS.

I'm expecting this briefing will inform and educate us about the eventual NuScale design that will be part of the design certification.

The rules for participation in today's meeting were announced in the Federal Register on June 10, 2015.

The meeting was announced as an open to public meeting. However, as shown in the agenda on the NRC website, we may need to close portions of the meeting at the end to the public to protect information proprietary to NuScale and its vendors.

And I will just intercede and say we will have public comment before we go into closed session.

The agenda of the meeting indicates that we will close the meeting for a couple of items.

We have two bridge lines established, one for the public to hear the deliberations, and that will be put on mute. And then an unpublished line to allow certain of the NuScale Power engineers and NRC staff to participate remotely.

The bridge number and password for the lines were published in the agenda. To minimize disturbance the line will be put in a listen-only mode.

Before we go into closed session I'll also ask the NRO staff and NuScale to confirm that only people with due clearance and need-to-know are in the room.

I'll note that Dr. Rempe has a conflict of interest in the area of NuScale severe accident considerations because of prior work she completed for NuScale in this area. And Dr. Rempe will recuse herself from discussions in this area.

I invite Greg Cranston, the NRO project manager, to introduce the presenters and start us off today. Greg?

MR. CRANSTON: Good morning, I'm Greg Cranston. I'm the senior project manager for the NuScale project. And with me is Mark Tonacci who is the branch chief for the Small Modular Reactor Licensing Branch.

I'm going to just give a brief overview as to where we are, and then I will turn over the meeting to NuScale, and then can introduce the people that are participating from their group.

We are in the process of pre-application phase for the NuScale project. One of the key items that we've been working on are preparation of the design-specific review standards.

As far as NUREG-0800, where the standard review plans are, there's about 134 of those standard review plans that are used as-is for NuScale. And we have developed an additional 116 design-specific review standards, the majority of which are relatively minor changes, but maybe 10-15 percent have significant changes based on the unique aspects of the NuScale design.

Those final drafts are going out this week for public comment for a 60-day comment period after which we will take the comments, review them, incorporate them as appropriate. And we expect to issue the final DSRS in the middle of next year.

We also have started interactions with ACRS with respect to DSRSs to determine which design-specific review standards they may want to review in more depth prior to us issuing the final package. And those interactions will be ongoing.

The other activities that are coming up in the near term is the testing has started at the integrated test facility in Corvallis, where the mockup is, at Oregon State University.

And we will have staff out there next month to start observing some of the tests as well as doing a QA inspection to see how they're implementing their testing operations.

That's all I wanted to cover as far as the NRC introduction is concerned. Unless there are any questions, at this time I'd like to turn it over to

NuScale to proceed.

CHAIRMAN CORRADINI: Is Mr. Mirsky, Steve, are you going to be the one that takes this?

MR. MIRSKY: Yes. Good morning. My name is Steven Mirsky. I am the NuScale licensing manager. I operate an office two blocks from here in Rockville, Maryland, where we maintain a library of NuScale documents and a state-of-the-art video conference facility to allow the NRC staff to engage in meetings with our staff back in the home office in Corvallis, Oregon.

NuScale appreciates the opportunity to make this presentation to the ACRS subcommittee. And I want to emphasize that we are very interested in as much interaction, questions, and discussion during the presentation as possible.

Dr. Corradini already introduced the order of presentations. The first presentation will be made by Dr. Jose Reyes who's on my right. Dr. Reyes is the chief technical officer of NuScale Power. He's the co-inventor of the NuScale power module design.

Prior to that he was the chairman of the nuclear engineering department at Oregon State University, where he has distinguished himself in, among other areas, as a world leader in nuclear power plant thermohydraulics and scaling.

He was the active leader and manager of the Westinghouse AP600 and AP1000 test facility that was constructed and operated also at Oregon State University.

Prior to that Dr. Reyes was thermohydraulic staff at the Nuclear Regulatory Commission. He holds a Ph.D. and master's degrees in nuclear engineering.

And the other thing I'd like to mention is that we request respectfully if, at the end of this meeting, that this Subcommittee provide feedback to the Commission on your review of what we presented.

And we are also very interested in feedback you can provide us in terms of topics you'd like to further discuss when you come out to visit us in Oregon on July 21 and 22.

For the purposes of introducing the other gentlemen here who will be presenting after Dr. Reyes, to Dr. Reyes's left is Doug Bowman. There was a mistake on his name tag. Doug will be presenting the slides on refueling and module installation.

And after our break and public discussion for the closed meeting Dr. Kent Welter, who is the gentleman sitting at the end of this row here, will be presenting on design-basis events.

And Bill Galyean, the gentleman next to Dr. Welter, will be presenting a PRA update.

So, if there are no other questions?

CHAIRMAN CORRADINI: Let me just clarify one thing for the NuScale team.

So, because this is a subcommittee, we're going to have, as we had said, an information briefing. It is not the practice of ACRS to issue any sort of response, or any sort of report, letter report to the Commission unless we have a full Committee meeting. So, there's no intent to communicate with anybody other than each other, and informally with the rest of the members.

Only if we have a full Committee meeting where staff is requesting a letter, or we feel the need to issue a letter to report to the Commission, would you see something from us. So, today we're listening, asking a bunch of questions, having fun, but no letter report.

MEMBER STETKAR: And anything you hear from members here are solely individual members' opinions. They are not questions from the ACRS, nor any opinions that might be authored are not ACRS opinions. They're simply individual members. We need to be very clear about that.

MR. MIRSKY: Thank you for that clarification. So, with that, Dr. Reyes.

MR. REYES: So, I'll be giving an overview of our designs.

CHAIRMAN CORRADINI: If I might, actually, you just reminded me of something.

So, we've got these great mics which beep and bop a lot. So, unless you're speaking keep the green light off. The way you get the green light on and off is at the bottom where it says essentially push. I mean, it's obvious, but we're engineers so we want to --

(Laughter.)

CHAIRMAN CORRADINI: So, empirically you can try it a few times and make a mistake. But when it's off it's better because it actually, for people on the line it makes it quiet enough they actually can hear what you're saying.

MR. REYES: So you'd like mine on?

CHAIRMAN CORRADINI: I would prefer it.

MR. REYES: Okay, it's on.

MEMBER STETKAR: It's also -- the transcript of the meeting is picked up through the microphones. So, it's important for our transcript.

MR. REYES: Okay. So we'll go to the first slide. So I'll be giving a bit of a presentation, an overview of our design. And this is the standard acknowledgment, a disclaimer, since we are receiving funds from the Department of Energy.

So, I'll give you a talk about the NuScale 12 module plant design. And then that will be followed by just a brief introduction to our overall testing programs, and then focus in on the NuScale integral system test facility.

So, it's a different concept in terms of how you would deploy a NuScale power plant. The idea is that we would manufacture in a factory both the reactor pressure vessel as well as the containment. And so that would be assembled in the factory. Now, it would be shipped in three parts -- shipped without fuel -- by truck, rail, or barge. You can see it in the central picture there.

So, it would be shipped by truck, rail, or barge depending on what part of the country you're in, in three separate pieces. The upper two-thirds of the reactor vessel and the containment vessel, the lower one-third of the containment vessel, and then the lower one-third of the reactor vessel. So, it's three pieces to create the module.

When it arrives it's assembled onsite. It's fueled onsite. That module when assembled sits underwater during normal operation.

So, it sits below-ground underwater, the containment as well as the reactor vessel.

MEMBER POWERS: When you say it's assembled, is it just mechanical joints?

MR. REYES: Yes, it's a flange system.

MEMBER POWERS: There are no welds?

MR. REYES: No welding onsite for assembly of the module. So, it's assembled onsite, and that's also how -- when we talk about the refueling you'll see also how that helps us with the refueling process.

Each module is connected then to a skid-mounted turbine generator set. That produces about 50 megawatts electric of gross power. So, very small, relatively straightforward in terms of the design of our steam turbines. I'll talk a little bit more about that later. That creates one power unit, the module and the skid-mounted turbine generator set.

The design that we are looking to -- and we've discussed in pre-application with the NRC is a 12-module plant. So, you'll see additional pictures of that. Basically, we have six modules on one side of a reactor building, six modules on the other side.

Again, all in one building underwater and below ground.

CHAIRMAN CORRADINI: So, Jose, except for what I assume are economic reasons, there's nothing that makes the twelve versus six versus one.

MR. REYES: Right. So, we've looked at different combinations or arrangements of modules.

The basis for the twelve comes from our customer advisory board. So, we've been meeting approximately every six months since 2008 with, I think now we're around 23 utilities who participate in the customer advisory board.

And so this size range, six modules, somewhere around 300 megawatts electric total was good for one size of coal-fired plant replacement, 600, you know, 570 or so would be for another size.

So, basically, it was kind of geared towards what the customers had requested at the time. But you're right, there could be other configurations. But currently for design certification we're pursuing a 12-module plant.

We'll go to the next slide. This is showing us --

MEMBER SKILLMAN: Hello? Jose, can you hear me?

MR. REYES: Yes.

MEMBER SKILLMAN: A question, please. Back on your slide 5, top center, the image of your what appears to be Schnabel car and I guess two-thirds of the finished assembly. What is the approximate weight of that assembly, please?

MR. REYES: That's -- this is an open meeting?

CHAIRMAN CORRADINI: So if you want to wait till closed session we can wait.

MR. REYES: Let's wait on that if you don't mind.

CHAIRMAN CORRADINI: We'll postpone that one, Dick, until closed.

MEMBER SKILLMAN: Okay, I'll wait until closed. I'm going to sign off here and go back on mute. Thank you.

MR. REYES: Thank you.

MEMBER REMPE: Since we've interrupted you, I was curious. In your interactions with the staff have they suggested that there be any additional emphasis on licensing requirements at the factory other than the normal QA required for components that are nuclear-grade?

MR. REYES: Right. At this point my understanding is that it's just the normal QA for assembly of components, reactor-quality components.

MR. MIRSKY: We are, under ITAAC, looking at factory ITAAC where we would close out some ITAAC that would normally be closed out at the site, at the factory.

MEMBER SKILLMAN: Let me build on Dr. Rempe's question, please. I'm presuming that the manufacturing is in accordance with the codes required by 10 CFR 50, 50(a) or 50(a)(2) or whatever it might be. This is all Section 3, Class 1, Section 3, Class 2?

MR. REYES: That's correct.

MEMBER SKILLMAN: Okay, thank you.

MR. REYES: Next slide. On slide 6 here it shows the layout of a 12-module plant. So, in the center you have the reactor building. So, it's a seismic category 1 building which houses all 12 modules. And then the wings on the side are the turbine buildings. So, you have six turbine generator sets in one building and six on the other side.

In terms of acreage, the protected area inside the fence is about 32 acres to give you a sense of size. And then the entire site in terms of what's shown there is about 70 acres. So that gives you a sense of dimensions.

So, here's -- slide 7 is a bit of a close-up which shows us a cross-section of the reactor building.

So, you can see that on the right-hand side of that picture all six modules -- there are six modules underwater that sit below these biological shields.

Those modules, that includes the containment and the reactor pressure vessels. That's important to recognize the distinction.

One of the novel features of the design is that we actually fabricate the containment offsite. So that makes it a lot easier to install, as a single unit. So, this is one cross-section.

On the opposite end of that building would be six other modules that would each have their own turbine generator sets.

You'll learn more about how we do the refueling a little bit later, but this image does show the flange tools that we would use to assemble and disassemble the modules underwater.

Just things to notice. Again, the water level is just below the top of the containment module. So, the tops -- the penetration locations are all dry and basically insulated.

Then you have a bit of level below. And then all of that sits below ground.

CHAIRMAN CORRADINI: So, just to repeat what you said to make sure I'm clear. So, all containment penetrations are sitting above the water line.

MR. REYES: Correct.

CHAIRMAN CORRADINI: And so it's just an integrated -- some particular steel alloy, which is the containment, all essentially below water.

MR. REYES: That's correct, yes. This is -- it's a stainless steel liner on both sides, basically, of the containment shield.

So, this is a borated pool. So the materials that we use are standard materials that have been used in industry for many, many years.

MEMBER REMPE: So, I believe the information we were given said that your burnup requirements is greater than 30 gigawatt days per metric ton uranium. Do you have a particular number that you believe is reasonable at this time?

CHAIRMAN CORRADINI: Let's be careful what we're talking about in open session, please.

MEMBER REMPE: Well, okay. I'm sorry, is that?

MR. REYES: Well, currently, I can give you some general things. Certainly we're working with

AREVA on our fuel. And so we'll have some better numbers on their particular fuel. So now that we're using an advanced fuel I would expect that the burns would be a little bit greater than that.

MEMBER REMPE: With that, again, I know we're in open session, but are you thinking of going to high-burnup fuel like we talk about with the regular commercial fleet?

MR. REYES: No, we're not at this point.

MEMBER REMPE: Okay, thanks.

MEMBER SCHULTZ: Jose, is the sides of the picture, the diagram here, is that ground level on the right and left side?

MR. REYES: Yes, those brown -- exactly right. That's ground level there. And that depth is not proprietary. It's about 70 feet to the bottom of the pool.

MEMBER SCHULTZ: I'm interested in above-ground level and across.

MR. REYES: From there to the top, up on top there is about 80 feet.

MEMBER SCHULTZ: Thank you.

MEMBER SKILLMAN: Jose, could you just generally explain the routing of the steam line on image 7, please?

MR. REYES: Sure. And you really can't see it from this image. But on the previous image if you want to go back there what we have then are the -- we have the six turbine generator sets aligned with steam lines coming from one side of the reactor building to that turbine building.

And then on the other side we have steam lines going to the other turbine building with the same symmetrical arrangement of turbine generator sets. Does that help without giving --

MEMBER SKILLMAN: Yes.

MR. REYES: And certainly when the staff comes to visit in closed session we can provide drawings and things like that.

MEMBER SKILLMAN: Yes, what I'm really interested in is an airplane crash and the protection of steam and feed. And the gaps between the buildings that are shown on image 6, which is why I asked the question.

MR. REYES: Sure, okay.

MEMBER SKILLMAN: Thank you, thank you.

MR. REYES: And then we'll talk just very briefly here in terms of the concept here.

The idea -- this is a novel aspect of the design so I wanted to point that out. The idea here is that we would refuel each of these modules once every two years. And it's about a 10-day refueling outage.

So, the way we would do that refueling, and you'll see this later on in the closed session, I guess, is we actually can move the modules and disassemble those. They go into this dedicated refueling area. And while we're doing that the rest of the plant continues to produce power.

So, that's a different concept than what you've seen before. But we'll talk more about that in the refueling session. The advantage to this, of course, is that if you're refueling -- and this is not proprietary, but 37 assemblies in our core. So it's a relatively simple refueling in terms of moving bundles.

What we do is we have an in-house dedicated crew that does the refueling and all of the maintenance for each module. So, what that does for us is instead of requiring a large contractor workforce to come in during a refueling outage, 800 to 1,200 contract workers, we have a permanent in-house crew that is becoming more and more proficient with each refueling.

So it's relatively a simpler approach. That was one of the considerations we had early on. So, it certainly helps us with operations and maintenance, and having a dedicated crew. Instead of having to put folks in security clearance, health physics training, assembling and disassembling refueling equipment. Okay, next slide.

This is the top view. We have that central reactor building crane which is how we move our modules. We have the refueling pool. We have this import trolley which is how we deliver the module sections.

And then we have the reactor vessel and containment vessel flange tools which allows us to assemble those.

So, you can see it's a relatively large common pool. Between the spent fuel pool and the refueling pool is a weir wall which allows us to transport fuel between those two sections. Our fuel assemblies are only two meters in length so they're reduced height fuel assemblies. Okay, next slide.

Early on, one of the things that we looked at were areas where we could simplify in the plant. So, significant design simplification.

I'll point out that there are two new systems that we did add. One is the containment evacuation system, and the other is the containment flooding and drain system. So those are two that you have not seen before.

But, we don't have containment sprays or fan coolers. We don't have auxiliary feedwater. We don't have an ECCS injection system per se in terms of a pump system.

No steam generator blowdown systems. We don't -- because our turbine generator sets are fairly small we can air-cool or water-cool our generators. So we don't have a hydrogen supply for the generators.

No reactor coolant pumps and no ECCS pumps or tanks, associated tanks, or RPV injection lines. So, we've really reduced the amount of equipment per module in order to greatly simplify the design.

CHAIRMAN CORRADINI: If I might. So, with all this good comes some other challenges. I mean, I remember some of the public papers you've presented on this. So, maybe we'll wait till closed session, but I'm curious about level of evacuation, or low-pressure containment I assume was what you mean by that, and some other details. But we should maybe wait till closed session.

MR. REYES: Yes, there's some aspects. And I can talk about some things generally.

CHAIRMAN CORRADINI: Okay, that's fine.

MR. REYES: So, now we'll look at a single module here and talk a little bit about some of the details. So, what that shows on slide number 10 is the reactor pressure vessel residing inside the containment vessel.

In terms of sizes, rough sizes, the entire module from the floor to the cap of the containment vessel, somewhere around 72 feet or so. So, that's an open number. We've published that.

And diameter-wise it's about 15 feet in diameter. So, that's the entire containment vessel.

The reactor vessel is about 9 feet in diameter and somewhere around 60 feet in terms of height. At the base of the reactor pressure vessel you have the reactor core. So those are the 2-meter fuel assemblies that we've had built now at AREVA.

Standard control rod drives. Wherever we could use existing equipment we tried to do so. So, these use magnetic jack control rod drives.

And right above the control rod assemblies we have a riser pipe. So, we heat up the water in the core. The hot water rises because of density and elevation differences. It comes out the top. We have an integrated baffle plate for the pressurizer. And then that makes the turn and flows down over two independent helical coil steam generators.

This is another difference I wanted to

point out. In this design --

CHAIRMAN CORRADINI: It's inside out.

MR. REYES: We view it otherwise.

(Laughter.)

CHAIRMAN CORRADINI: Of course you would. But from common experience.

MR. REYES: Exactly. Exactly right.

MEMBER BALLINGER: If you count the fossil industry this is the normal way.

MR. REYES: Exactly right. That's what you see in the fossil industry.

So, this helical coil steam generator, the reason I went with that was because you get a lot of surface area in a fairly compact volume.

And so what that does for us, especially for our natural circulation system then, because you have relatively low flows so your convective heat transfer coefficients on the outside of the tubes are relatively low.

So, you have Q equals hA-delta-T. We have a good delta-T, but we have a small h. So, to compensate for that you need a lot of surface area. And so that's how we get the higher efficiencies with this system, because we have --

CHAIRMAN CORRADINI: And I'm not sure when you're going to say it, but I think you can say it now. Where were these tested? I forgot.

MR. REYES: So, these have been tested in Italy, at Piacenza. And I'll talk about two test programs that have been run. And we've just completed both of those.

CHAIRMAN CORRADINI: Is that the same test facility that AP600 did some of their testing if I remember? I'm remembering where some testing was done for the AP600 certification.

MR. REYES: Right, they had what was called a SPES facility. It was used for testing AP600. It's the same organization doing that testing. I have a couple of quick pictures I can show you.

MEMBER SKILLMAN: Jose, this is Dick Skillman. Let me ask one or two questions.

MR. REYES: Sure.

MEMBER SKILLMAN: This technology is very similar to what B&W attempted back in the seventies with CNSG.

And one of the areas that became a challenge was the in-service inspection of these helical heat exchangers.

And it is the complexity of finding one's way into the tubes, or maybe more pertinent, having a weeper or a leaker, how you determine which tube needs attention.

Could you speak at least for a minute on the attention NuScale has given to that issue? And also what attention has been given to the codes that we generally use for in-service inspection.

MR. REYES: Sure. So, we've done our initial feasibility studies. So, basically we've actually built full-length coils. The largest radius and the smallest radius coils at full length.

We've demonstrated that we can get a probe in from the top and retract the probe. This is eddy current probe. So, we're using standard technology there.

The thing that we've done that's different is that this is not a tightly wound coil. And so I think what's been done in the past is something that's a lot more tightly wound.

This is actually a fairly -- if you look at each individual tube there's only about three turns over the entire length of the bundle. So, it wouldn't appear that way. So, it's a relatively gentle slope is what we've done on our tubes.

And that then allows us to get the eddy current probes down the tubes and perform inspection.

So we're doing inspections from the inside of the tubes.

But I've got a picture later that I can show you that includes that. So, those results were very good and it resulted in one patent.

There was one modification we made to the standard tube probe driver that allowed that to be a bit easier to do. So, we have done that initial feasibility study.

MEMBER SKILLMAN: Thank you.

MR. REYES: Sure. This system will produce highly super-heated steam. And that's what we've demonstrated in our testing in Italy, that we can get a high degree of super heat.

That allows us then to provide our expected steam conditions for the turbine manufacturers.

It's a natural circulation system. It's an integrated design, so you have the core, the steam generator, and the pressurizer all in that single reactor vessel.

That eliminates then the standard -- there's no large-break loss of coolant accident phenomena in this system. Everything is relatively small piping, and everything is integrated within a single package there in the reactor pressure vessel.

CHAIRMAN CORRADINI: So, again, you may

want to defer this, but are there any pipes below the top of core? And if so, what are they used for?

MR. REYES: There are none.

CHAIRMAN CORRADINI: So all instrumentation, all penetrations are above the --

MR. REYES: They come in from the top. The two penetrations -- again, these are above the top of the core -- are the CVCS lines and the recirculation valves. Those would be the two lowest. But they're well above top of core.

MEMBER SCHULTZ: Jose, is the steam generator inspection that you described part of what you anticipate for your maintenance program? Or are you thinking of that just to identify problems if they are observed?

MR. REYES: No, that would be part of our normal maintenance program.

MEMBER SCHULTZ: And part of the outage period that you described earlier?

MR. REYES: Correct.

MEMBER SCHULTZ: Thank you.

MR. REYES: Okay, we'll jump to the next slide. This shows one of our power trains. And this, as you can see on the right-hand side we've gone through a fairly simple turbine system. Again, this is a skid-mounted turbine generator set.

We do produce the super-heated steam. So what that does for us is that there's no separators or dryers on the reactor vessel.

And on the turbine side we don't require any moisture separator reheaters for this design. So, it's a really very simple system. Highly reliable.

You find these types of 50-megawatt turbine sets in the fossil fuel industry.

CHAIRMAN CORRADINI: So, this is a standard order that's already available?

MR. REYES: In terms of the casing it's a standard size. They will optimize the blades for our application once we give them the final requirements.

MEMBER BLEY: I missed why you don't need a moisture separator.

MR. REYES: So, we've opted not to use one because the turbine that we've selected is sufficient. So, the last stage turbine bucket, the moisture content is adequate.

MEMBER BLEY: It can tolerate it.

MR. REYES: Yes.

MEMBER BLEY: Okay.

MR. REYES: Let's see. We've got two designs for this. We have a water-cooled condenser.

We also have the air-cooled condenser. You do pay a penalty for going to air cooling, but it's actually fairly tolerable.

CHAIRMAN CORRADINI: Are you allowed to say the difference in the heat rate?

MR. REYES: Yes.

CHAIRMAN CORRADINI: If not, we can wait.

MR. REYES: No, that's actually -- so, our net electrical power production from our plant is about 570 megawatts electric with the water-cooled system. I think we drop to about 540 megawatts electric with an air-cooled system.

Okay, so that's kind of a standard ranking cycle system. Okay, next slide.

So, I'll talk about the containment design. So, let me just talk a little high level, first of all, how the containment was sized.

So, the volume was important. In addition to just physically being able to transport it we looked at the volume of the containment to do two things.

One, we sized the volume such that any leaks from piping or valves on the reactor pressure vessel would never exceed the design pressure of the containment.

So we can open up our safety valves, we can open up our vent valves on top, the recirculation valves simultaneously. And we would never exceed the design pressure of that containment. So, that was really one of the design features of the containment. It's a bottle inside of a bottle.

MEMBER BLEY: On your air-cooled model, you must have big air blowers or something, something like a big radiator.

MR. REYES: I don't have those images here, but it's basically -- there's a lot of good technology available now for air --

MEMBER BLEY: Air-cooled?

MR. REYES: Typically requires a lot of surface area and the blowers to do that. So, you're paying that penalty because you're using your power to basically drive the blowers.

So, in terms of our containment, the first thing is pressure. So we won't exceed design pressure.

The second thing is volume in terms of water volume. So, when the levels equilibrate between the containment and the reactor pressure vessel it's designed so that the water level will always be well above top of the core.

So, there's enough inventory in the reactor pressure vessel to make sure that whatever you lose, when you look at the flood levels they're well above top of the core.

We do operate the containment in a vacuum. And I'll just give you a rough number. It's typical of a containment vacuum, somewhere around 1 psi or so, maybe a little bit higher. Just as a general range.

So, what that does for us is it interrupts any convective heat transfer from the air. So we don't require insulation on a reactor vessel. So, this is one of the areas that we were looking at in terms of reducing concerns about sump screen blockage and things like that. So we don't have any insulation on the reactor vessel.

CHAIRMAN CORRADINI: Eventually I want to get back to this one. So, radiative losses are not a big penalty for you, so you've taken that penalty just to eliminate all insulation on the vessel? Or also the -- well, I guess it's only the vessel.

MR. REYES: Yes, pretty much anything that's inside the containment.

Now, we say minimize because we're looking at other sources of potential -- we do our wiring and things like that which we're looking at very carefully to make sure there's no problems there. But that's exactly right. It's not a very big loss.

MEMBER SKILLMAN: Jose, what is the mechanism by which you maintain 1 psi?

MR. REYES: So, this is one of the systems I mentioned earlier that we've added which is a containment evacuation system.

So it's actually a line which goes into containment and will do a continuous draw back and forth. Because it's not a very deep vacuum it's fairly standard equipment. We're not looking at anything exotic to get the --

CHAIRMAN CORRADINI: But I assume it's a safety system.

MR. REYES: It's a vacuum pump. I don't know if we really --

CHAIRMAN CORRADINI: Hit your magical green button.

MR. WELTER: I'm sorry. This is Kent. No, it is not a safety system.

MEMBER STETKAR: And why is that?

MR. REYES: So, in the event that we lose a vacuum it's an operational problem because now you've lost your insulation, and then you have a significant heat loss. So, at that point you would just shut down.

So, it doesn't perform a safety function. It's only there as insulation.

CHAIRMAN CORRADINI: So, if I ask John's question a little bit differently, from an accident analysis standpoint you don't require the vacuum.

MR. REYES: Correct. Correct, yes.

MEMBER SKILLMAN: This is Skillman. Let me pursue that a little bit more. You've got three requirements interlocking here for your primary and secondary and now I think for this containment evacuation system there. General design criteria 55, 56, and 57.

It seems if you get a vacuum pump connected to your containment you actually have in that vacuum pump the containment boundary.

So, why isn't that a safety boundary? At least at the same level as your containment, and whatever exhaust protected.

MR. TOVAR: Jose, can I speak? My name is Tim Tovar. I'm the manager of plant operations. The containment evacuation system is not a safety system. However, it does have safety-related isolation valves in the system.

CHAIRMAN CORRADINI: I was guessing that was going to be the answer.

MR. TOVAR: And the other piece as far as the safety analysis, the vacuum will likely have a tech spec that specifies the vacuum level in containment.

So, if we do lose vacuum, if the containment evacuation system isn't able to keep up for some reason, then we would perform a unit shutdown.

MEMBER SKILLMAN: Thank you for the answer. I think we'll pursue this a little further. Plumbing connected to containment, even though it might have a few isolation valves, if it can exhaust radioisotopes becomes a challenge in itself. So, maybe we can talk about that a little later.

CHAIRMAN CORRADINI: Dick, I think to a first approximation this would almost be like some plants I know that are subpoena-atmospheric. Same sort of approach with their essentially maintaining something at 10 or 12 psi.

MEMBER STETKAR: Or large dry containments that have a normally operating containment ventilation system.

MR. REYES: Yes. That line, of course, is relatively small. Okay, well, let's go to the next slide.

So, in terms of our cooling systems we have two means of removing our decay heat. One is our decay heat removal system, and the other is our emergency core cooling system. So we'll just jump right to the next slide here.

So, I'll give you the details. This is our decay heat removal system. And the idea here is that we're going to use the steam generator to remove our decay heat. So that's basically what we're doing there.

We isolate our main steam isolation valves, our feedwater isolation valves. And now we've isolated that module basically from the rest of the plant in terms of those connections.

We then open up our decay heat removal actuation valves and that allows us to direct steam flow from the steam generators to two passive condensers.

So, we're taking the steam from the steam generator, directing it to those heat exchangers shown inside the pool. And they're physically attached to the containment so you can see the schematic on the right and the actual image on the left.

CHAIRMAN CORRADINI: They look like towel racks.

(Laughter.)

CHAIRMAN CORRADINI: Sorry, but that's what they look like. In a European hotel.

MR. REYES: They really do look like the -- we'll make sure there's no towels hanging on it.

So, we're condensing steam. The condensate then, just through gravity draining, you have basically a boiling condensing system and you're removing all the heat from that.

So either one of those trains is sufficient to remove all the decay heat. So they are each 100 percent removal systems.

If for some reason the steam generators -- and they are independent steam generators -- if they're not available to remove the decay heat we would go then to our next system which is an emergency core cooling system.

Again, we isolate our main steam and our feedwater isolation valves. And we now open up two valves. The reactor vent valves on top of the reactor vessel.

And now you're venting steam off the pressurizer head directly into the containment. So, you're pressurizing your containment.

That steam will condense on the inside surface of containment because you're rejecting the heat to the pool. And it will flood up. So these are tests that we've done in the NIST facility. But it will flood up. And once you get it somewhere above the recirculation valves it will actuate on a safety signal that then will open up the recirculation valves and the remaining ECCS valves, and allow you to get water back into the reactor pressure vessel.

MEMBER BLEY: I was just wondering what the makeup requirements on the pool are in case you have a situation there.

MR. REYES: So, let me make sure I understand the question. Are we talking about the pool inside the containment? Or you mean the large pool?

MEMBER BLEY: The large pool.

MR. REYES: Oh, the large. Since there's no physical connection -- I mean, there's no pool water actually being used inside containment, there's no connection there, that basically is being maintained on a constant level.

MEMBER BLEY: You might be boiling it off, right?

MR. REYES: Over a long, long period of time. Yes, over a long period of time.

MEMBER BLEY: That's what I don't have a feel for.

MR. REYES: Okay. So, this pool size is around 8 million gallons. Excuse me, 7 million, give or take.

MEMBER BLEY: I'm not real quick at the

calculation, so what's that turned into hours? Days?

MR. REYES: So, if you imagine -- it would take about three days before you would start to get some boiling in terms of --

MEMBER STETKAR: That's for a single unit delivering?

MR. REYES: That's all twelve.

MEMBER STETKAR: All twelve?

MR. REYES: If all twelve were in that condition it would take about three days before you really would see some bulk boiling. And that's the rough estimate.

So, for a single module you wouldn't really see much of a temperature change in the pool.

MEMBER STETKAR: Okay, thank you.

MR. REYES: Sure.

CHAIRMAN CORRADINI: So I know you're not talking about the initiator, but I think I understand how this works.

You basically connect the vessel by vent valves to the containment, and then look at the containment as your heat rejection.

MR. REYES: Correct.

CHAIRMAN CORRADINI: But that would imply some sort of loss of integrity in the vessel that leads you to do this whole process, right?

MR. REYES: Exactly.

CHAIRMAN CORRADINI: Unidentified at this point.

MR. REYES: Unidentified. And then I think when we talk about design-basis events we'll cover that.

Okay, so those are our two mechanisms. So, our emergency core cooling system essentially consists of four valves. Next slide.

Okay, now we jump into test programs since that was really kind of the topic.

We do have our NuScale reactor qualification test plan. So that outlines all of our testing programs, both for design certification and for our first of a kind engineering.

So, we have the integral effects test. We also have full-scale component testing as well as a range of separate effects tests that we're performing currently.

In this image you can see a couple of different tests we've been doing. So, to the upper right corner there we have our CHF testing, critical heat flux testing, that we complete at Stern Labs in Canada.

So, these were full-length bundles at prototypic flow rates and powers to determine what the CHF boundary looks like. So we've used that information to help develop some of our correlations.

It's a little hard to see in the picture. Right below the bundle. That was our -- that went upright, and that was part of our steam generator tube inspection test.

So, those were full-length tubes. We actually mocked up the entrance and the area that would be available for the inspection team to go in and using standard equipment, standard drivers, demonstrate that we can actually get the probes in and back out.

CHAIRMAN CORRADINI: So, Jose?

MR. REYES: Sure.

CHAIRMAN CORRADINI: Chairman Stetkar is one for details. So, the thing on the lower left, is that your spirals generator?

MR. REYES: Yes, that was -- so we had two helical coil test programs that we ran at SIET in Piacenza.

One was a three-tube system which is what you see there. And basically, what we have -- and I don't know if that's an earlier version or not.

We actually have a three-tube system which is highly instrumented and heat-traced on the outside. So, we're applying the heat flux from the outside to the inside.

And what we're citing there was the phenomena inside the tubes. So, we had radial thermocouples at numerous axial locations.

We're identifying what's going on in terms of heat transfer inside tubes. So, going from subcooled, to boiling, to super-heated steam. We've got very detailed measurements on that.

CHAIRMAN CORRADINI: So, the question that I think we're mumbling about is that's more than three turns. It looks like.

MR. REYES: Yes. Oh, that's a good point. That might be another --

MEMBER STETKAR: That's not a prototype.

MR. REYES: That may not be the prototype. We do have a prototypical one that we've used. Maybe that's not the right -- that might be an earlier picture.

CHAIRMAN CORRADINI: You have to be careful with him. He's dangerous.

MR. REYES: Yes, that's a very good point. So we'll get that picture replaced to the current configuration.

I was looking at that myself and said well, it seems like there's one tube there. But we do have three tubes. And so we have an inner tube, a central tube, and then an outer radius tube at full scale, at prototypic diameters, prototypic lengths and radii. So, that was --

MEMBER SCHULTZ: The Stern Lab CHF testing, is that -- I thought I heard you say it was complete, but I saw somewhere else that it was in progress.

MR. REYES: So, yes, Stern Lab tests are complete.

MEMBER SCHULTZ: They are complete.

MR. REYES: We are doing additional testing with AREVA. I think those will be in Erlangen.

These will be critical heat flux tests. Same flow rate conditions, but now using AREVA bundles. So it will be prototypic to the AREVA fuel bundles.

MEMBER SCHULTZ: All right. Is there a schedule for that at this point?

MR. REYES: You know, that's a good question. I'll have to look that up for you.

MEMBER SCHULTZ: Thank you.

MR. REYES: But it is starting this year.

MEMBER BALLINGER: What's the tubing

material and what's the peak temperature?

MR. REYES: So, we're using an Inconel 690 tubing. And I'm sorry, what was your second?

MEMBER BALLINGER: Maximum temperature. Not the cladding, the tubing temperature.

MR. REYES: Oh.

MEMBER BALLINGER: The super-heated steam.

MR. REYES: Oh.

MR. BOWMAN: I can answer to mine. The operating number would be about 586 degrees, I believe. And then I think the analytical limit is about 600 or so.

CHAIRMAN CORRADINI: Do you have your green light on?

MR. BOWMAN: I'm sorry. Yes, the number at normal operating conditions that we're looking at right now, so it's preliminary, it's about 586.

And then my analytical limit is 600 degrees, what we'd go to.

MR. REYES: So it means our steam pressure is lower.

MEMBER BALLINGER: I'm doing the mental conversion to Centigrade. And then the next question is where is the hottest weld on the steam generator?

And what is the temperature of the hottest weld on the steam generator?

MR. REYES: Yes, so that would be at the exit of the --

MEMBER BALLINGER: That would be at the exit, and it would be at 600 Fahrenheit. Okay, thanks.

MR. REYES: So, this also shows a picture of a full-scale.

So, the first helical coil tests that we did at SIET we call our TF1. That was the three-tube with external heat. The large-scale -- this is a full height, full-scale bundle in terms of sizes -- was performed with fluid to fluid. So, now we have hot water flowing through a central riser pipe, coming out over the top and over the tube, just like you'd see in the actual plant at full temperature conditions.

So, that was -- so, what that provides us for a given set of feedwater inlet conditions which are prototypical of the plant, we can come up with measured values for our super heat under prototypic flow and temperature conditions. Next slide.

This upper left-hand just shows them assembling our helical coil steam generator at the prototypic length and tube diameters.

The individual coils, again, it's a little deceiving in this picture, but this has 252 tubes. And so it looks like they're packed together, but they're actually a fairly simple slope.

MEMBER SKILLMAN: Jose, what is the length of the tube when you begin to bend it?

MR. REYES: We can give you that number at the closed session.

MEMBER SKILLMAN: Fair enough. Thank you.

MR. REYES: So, that gives you kind of a sense of the bundle. Down below is the casing for it. To the right, we have built -- excuse me, to the far right. What we have there is a mockup. This is the upper two-thirds of the actual containment and reactor vessel.

So, this has been assembled. And when you come to visit you'll get to see that.

What that does for us is allows us to start looking at in-service inspection and maintenance. So, it is a physical mockup of the containment with the platform and all the valves on top of it.

And then internal to that we have a reactor vessel with control rod drives, and all the associated valving and equipment there.

CHAIRMAN CORRADINI: Full-length down to

where the core would be?

MR. REYES: No, not all the way down to the core. But you can see, because this is about the upper, I want to say it's --

CHAIRMAN CORRADINI: So the internal mockup stops at what we're looking at.

MR. REYES: Right, exactly.

CHAIRMAN CORRADINI: Well, we'll see it.

MR. REYES: You'll see it there, yes.

CHAIRMAN CORRADINI: We'll get to ask all the same questions.

MR. REYES: So that gives us a good sense of accessibility to different components. And it allows us to change things if we need to in a physical model.

So, down below you can see -- for scale you see some people on the lower left-hand side. That would be the actual outside diameter of one of our NuScale containments.

So that gives you a sense of size. Physically that's what it would look like.

MR. REYES: In the center we have our fuel assembly testing. And that's mechanical testing of a fuel assembly.

So, what we have is a range of tests.

There's eight test programs that we've launched here or are being launched in this year.

So, we're doing a steam generator flow-induced vibration test, control rod assembly, and driveshaft drop alignment test, fuel, mechanical, and hydraulic testing which is what's being done in Richland, Washington, at AREVA facilities there.

The phase 2 of the critical heat flux testing for AREVA -- and I'll be specific to the AREVA fuel assembly -- will have a core inlet flow distribution test, pressurizer baffle plate CCFL testing, a control rod guide tube flow-induced vibration and flow tests, and then a steam generator orifice hydraulic test for looking at the stability of our steam generator inlets and feedwater inlets.

So, there's a lot of testing going on. And we'll cover it -- when you visit we can cover in detail each of these programs if you'd like to learn more.

Okay, now we'll jump into the NIST facility. You will be seeing the NIST facility when you come to visit.

On the left, of course, is what the module would look like. On the right then is the NIST facility, the NuScale Integral System Test facility. Not to be confused with the other NIST.

What I did was a broke up the system into three parts so that I could measure the interactions between the components.

What you would expect to see would be to walk up to a pool and see a top of a containment. In order to understand and to measure the flows between the reactor vessel and the containment we have two separate pipes up on top. The large-diameter pipes on top and large-diameter pipes on the bottom.

The top piping represents our reactor vent valves, and down below our recirculation valves.

So, on the far right we have the reactor pressure vessel which contains an electrically heated fuel bundle simulator with a riser, helical coil steam generator, and a pressurizer.

The dark blue is our high-pressure containment. And so that's connected directly to the pool. So, it's like a two-sided tank.

The high-pressure containment, what that does, it functions like the containment. It looks different in terms of the geometries because when you take a cylinder and you try to scale it down you can't preserve both the surface area and the volume.

So, what I did with that is we trace-heated the curved portions of those tanks. So, we pre-heat before we run a test. So, you don't get condensation on those curved surfaces.

There's a flat plate which is a prototypic thickness and materials in terms of the connectivity and thermal diffusivity properties which acts as our heat transfer plate.

So, I size the heat transfer plate to be the scale heat transfer area for the containment, and the volume of scale to be the properly scaled volumes.

And so what we see is a very good pressure transfer. And we can show you our pre-test calculations when you come to visit.

We get a very good pressure history in that containment which replicates the full-scale plant.

The green is the pool. And that's not pressurized, but it is filled with water up to the top, basically. The top is open to atmosphere.

We've done a couple of things. We learned a lot from a previous facility. So, something that's new to this facility is we did include thermal breaks on our heat transfer plate so that we actually have insulated that plate from the pool to reduce any heat losses from the plate to the pool, through the sides of the pool, basically. So we have a thermal break there.

We've also added these windows so that we can do laser PIV velocity measurements of the boundary layer for the fluid in direct contact with the outside of the plate.

CHAIRMAN CORRADINI: So, which side are you doing the PIV?

MR. REYES: On the low-pressure side in the pool.

CHAIRMAN CORRADINI: So the green tank.

MR. REYES: Correct, on the green tank.

CHAIRMAN CORRADINI: I'm just trying to see what's happening in terms of the --

MR. REYES: Yes, when you start doing the analysis what you find is that the condensation heat rates are relatively high no matter what you do in terms of -- when you have relatively high pressure in your containment you have a large mass fraction of steam.

So what you see is that the condensation rates are very high. And they offer fairly little resistance to your heat transfer.

So what dominates then is your conduction through the wall and the free convective heat transfer on the outside.

So, conduction measurements we can do very well. Those plates have multiple thermocouples so we can do the conduction heat transfer measurements.

And now with the lasers we can actually do very good measurements of what we think is happening on the outside surface. So we're able to quantify our heat transfer through the plate, and back out kind of what's going on in terms of the condensation.

CHAIRMAN CORRADINI: And then you can back-calculate through the plate thermocouples?

MR. REYES: Correct. So, we can do an inverse conduction calculation. Yes, exactly.

CHAIRMAN CORRADINI: The only other thing though, since -- thanks to Professor Wu, I have asked about this. You do get a thermal inertia effect if you start off heated. Then once you pulse in the steam the whole thing then heats up to a new equilibrium.

MR. REYES: Correct, yes. So that describes a little bit of the facility. If you go to the next slide I think it's just -- we'll talk about capabilities.

We really want to understand the coupling between the reactor vessel and the containment since it is tightly coupled. It's different than the phenomena that you may have seen in the past.

So, in terms of a blowdown you pressurize the containment. And it doesn't take very long to equalize the pressure between the containment and the pressure vessel. And basically your flows out of the breaks become very, very low, very small.

We also use the facility to characterize our DHRS. We have both a reduced scaled DHRS as well as a full-length DHRS. The actual DHR is not very long so we can test both in that same facility.

We're using the data to validate what we call our NRELAP5 code. So, it's a RELAP5-3D code which has been -- which we've added models to account for. The steam generator heat transfer and specific features of our design.

CHAIRMAN CORRADINI: I forgot to ask you this earlier. Is this the -- there's so many versions of RELAP. So, which version is that that you started with?

MR. REYES: So, this is the RELAP5-3D version that we got from the Idaho National Laboratory.

CHAIRMAN CORRADINI: So, this is the one that Idaho watches over that is NRC blessed?

MR. REYES: NRC blessed?

MEMBER REMPE: It's beyond the NRC version. They went to 5-3D.

CHAIRMAN CORRADINI: I'm asking this from a QA standpoint. Because a lot of the universities have these. And there are multiple versions. So, I'm just curious which one you're using relative to a topical report.

MR. WELTER: The NRC version is, I believe, RELAP3-3 currently. And that's different from the INL version which is 3D.

We performed a commercial-grade dedication of the source code from Idaho National Lab and put it in our development environment. And then it's under our NQA 1 program for verification, validation, and implementation of the new models.

CHAIRMAN CORRADINI: So, it's an extension of what some people call the NRC version of RELAP5.

MR. WELTER: DOE. Yes, there's two right now. There's the NRC version which is 3-3, and the DOE INL version which is 3D. And we took the DOE INL version and dedicated that. And that's what we're using as our platform.

CHAIRMAN CORRADINI: Okay. And then, again, this is detail but eventually we'll come back to it.

The only difference between them as I understand it is essentially how you do the heat structure coupling.

Do you use that to your advantage in your modeling? Or is it just this was the most convenient one to use?

MR. WELTER: In terms of maybe the 3D vessel components you're speaking of?

CHAIRMAN CORRADINI: Right.

MR. WELTER: No, we use primarily a 1D approximation.

CHAIRMAN CORRADINI: Okay.

MR. WELTER: And there are some other minor details between the codes.

MEMBER REMPE: Since we're on this topic, over the years there's always corrections, right?

And when I've queried the NRC about how they keep up, they have said that there's some sort of connection where they all look at the corrections and they implement it in the -- the ones that are the NRC version, the 3.3, they share lessons learned.

Are you part of that connection group where when the corrections come out you also incorporate it into your version?

MR. WELTER: Yes. We actually have both 3-3 and 3D at NuScale, and we periodically run both. We have input decks for both of the codes.

And we're part of the U.S. NRC CAMP

program. And so we get the updates from 3.3. And we're also part of the INL 3D user group. So we do go back and forth.

MEMBER REMPE: Thank you.

MR. REYES: So let's just give you a range of testing that we can perform to validate our code.

So, the loss of coolant accidents, which include a CVCS line break. We can go to long-term cooling. Actually, we can go very long-term.

High condensation, we'll be doing separate effects tests there. The cooling pool convection heat transfer, and a whole range of non-LOCA type transients.

And Kent is, of course, managing all of our safety methods development.

Our simulator, I will point out the simulator that you will see in our control room in Corvallis is using the same -- the safety analysis codes are being also used in the simulator. So we try to maintain that fidelity between the two.

CHAIRMAN CORRADINI: So, the analysis tool is your simulator tool.

MR. REYES: Correct. We're using NRELAP5 as our simulator tools.

MEMBER SCHULTZ: Kent, let me ask this

question. I'm sorry.

CHAIRMAN CORRADINI: Before we do that there was a look.

MR. WELTER: I think there might be just a slight correction. We are using RELAP but it's RELAP-HD. It's a slightly different version of RELAP, but it's fundamentally --

CHAIRMAN CORRADINI: For the simulator.

MR. WELTER: For the simulator. So it runs faster in realtime and it's a different model, but it's essentially the same code.

MEMBER SCHULTZ: Kent, back to your experience or activity with the users group. I presume that you may have found some issues associated with code application that others have not because you're doing something different with it.

Are you also interacting with the users group to report issues that you have found based upon your specific application?

MR. WELTER: Yes. Yes, we have. We are exercising 3D in a slightly different way. It's still a pressurized light water reactor so fundamentally the phenomena is very similar.

But we have found some minor errors and corrections. We provided that feedback and INL may have corrected a number of those bugs if you will.

MEMBER SCHULTZ: Thank you.

MR. REYES: Okay, next slide. So, this is just the NIST facility being assembled. So you see the cooling pool and the containment vessel. Next slide.

Here on slide 22, here it's assembled. And there you have the full length DHR. It's an eight-tube version of the system so we're able to do essentially testing at full power per tube conditions. So it will give us quite a bit of good data there.

So, actually it will reside inside that large cooling pool. Next slide. This is looking at the internals. The reactor vessel didn't change very much. We added some additional volume in terms of length. But we put in a new core bundle. But the helical coil steam generator basically stayed the same. Then that shows the baffle plate and the reflector.

Next slide. This is just, again, showing a little bit more detail. From the previous version of the NIST facility to this version we've gone from about 130 instruments to 700 instruments. So it's a lot more detail. So we can characterize all the different aspects and perform our mass and energy balances. We have laser PIV and the full height DHRS.

Next slide. We do have a new data

acquisition system. And so this is our interface with 700 instruments. It also includes all of our safety logic for the facility. And we also are able to do sequence of events monitoring. So, for every action that occurs in the plant we're able to get a timestamp and the action. So we can track the evolution of a test fairly carefully.

And of course we have the big red button which is for the emergency stop. Next slide.

Okay, this is just showing you the first round of tests here. We call these critical path tests for code validation. So, this is what the code folks said they needed up front early on.

So, the order of these tests will change, most likely. So, the elevation characterization, some of that is being done right now in our cold shakedown test. We will do high-pressure condensation tests. These will be specific separate effects testing where we're controlling the steam flow rates at fixed pressure and getting that data in the new system, all the way up to the very high pressures.

Previously we could only do about just under 300 pounds per square inch. Now we can go the full 900 pounds for condensation.

We'll do the full-length DHRS

characterization, cooling pool characterization, natural circulation tests, the CVCS discharge line pipe break which would be one of our LOCA studies, pressurized spray line break, and then the ECCS reactor vent valve spurious opening.

Like I said, the order of these will change. Now, subsequent to this, we'll do quite a few more tests. So this is the first round of tests that we'll do which we're calling the critical path for what the code folks need right away.

So, when you come out, I'm not sure which of these tests you may see. Most likely it will be -- we don't usually let folks in when we're hot and pressurized. So it probably won't be hot and pressurized when you come to visit.

CHAIRMAN CORRADINI: Is this right next to the APEX facility?

MR. REYES: It is, yes.

CHAIRMAN CORRADINI: So it's in the same building set.

MR. REYES: The same complex, yes. So, we're in the building next to it.

Okay, I think that was the last slide. Yes, and then that just summarizes what I just said. How did we do, 20 minutes?

CHAIRMAN CORRADINI: Questions by the committee before they switch over to the next topic. Hearing no questions let's just switch.

MEMBER BROWN: I do have one.

CHAIRMAN CORRADINI: Go ahead.

MEMBER BROWN: Since I'm not a -- I was trying to connect -- you'll have to explain this to me. I'm not a thermal hydraulic-type guy.

So, I look at the overall design that you showed with the containment reactor inside, steam generators, pressurizer up in the dome, and all that.

Now, I go look at the -- so it's a very tightly connected system. Then I look at your test facility and I see three different pieces which doesn't appear to have the connection.

And I'm going back to my Naval experience where when we did this we made them bigger so that we could actually see the same configuration when we ran the test to ensure that our data was representative of the actual operation.

So, I'm totally disconnected. I understood what you were talking about, but I have no idea how you validate that that configuration is representative of the actual integral set.

MR. REYES: Right. So, in order to do

that I had to develop a scaling analysis report which -- and that was available at the Rockville office.

So, what that does is it goes through all the important phenomena and identifies -- and for us some of the key phenomena was the peak containment pressure, collapsed a level above the core were two -- are figures of merit.

And it demonstrates how you design your test facility to simulate the full-scale behaviors. So, the scaling also then is kind of that pivot point that says, okay, this is how you design the facility.

Now, we're running pre-test calculations for the test facility as well as pre-test calculations for the full-scale plant.

And the first stage to see how well you've done in your scaling is do they agree. Do the pressure trends, the water levels and things like that, do they match?

So, there's a solid logic to it, but the connection is the scaling analysis report, which is where the thermal hydraulic guys are with that.

MEMBER BROWN: Okay, let me -- I'm trying to integrate your information here.

MR. REYES: Sure.

MEMBER BROWN: You're modeling the

full-scale behavior with your analytical tools, whatever it is. So you make your predictions through some known conditions to see what the various parameters results are, or some transients, or whatever you're doing.

And so your validation -- this is what I heard. I'm not saying this is right -- that you then take your test results under what you think are the same physical parameters and see if those results replicate what you've got in your model, your analytical model.

MR. REYES: So, basically what we're doing, the scaling report --

MEMBER BROWN: I was wrong, in other words, right?

(Laughter.)

MR. REYES: I won't say that.

CHAIRMAN CORRADINI: Charlie? You were wrong.

(Laughter.)

MEMBER BROWN: I know how to admit it. I have a history of knowing when to say I'm wrong. It's not often. It doesn't happen often.

MR. REYES: So, basically, with the scaling analysis, there you're looking at the fundamental physics of a problem.

So, for example, I look at a break flow and I say, well, this flow will be choked. And I use choke-flow models and I say, okay, how can I size the valve at this reduced volume to give me the right pressure transient behavior, the pressure behavior and the mass flow rates out the break.

And I say I should size my valve or my flow area to a certain scaled size in order to get the prototypic mass flow rates out of there at the scale basis.

CHAIRMAN CORRADINI: Charlie, I think if Sanjoy was here he'd give you an esoteric explanation.

But I think what Jose is saying is he's basically scaling off of time scaling. He wants to make the time scaling such that he doesn't get some distortion in what's going on.

And so I think when you're close though when you're saying that you do a test. You have this scaling logic to build the test. You run the test. You have to compare. And then you extrapolate the calculation based on the scaling logic.

MR. REYES: And the scaling logic for this facility is fairly easy because I went to 1:1 time scale and full pressure.

MEMBER BROWN: My fundamental problem is

the actual physical interface interactions don't seem to be accounted for in the test, in your scale test. That's all.

MR. REYES: And so part of the scaling is to identify where there would be distortions. And so we identify things that we say, okay, this is different in our physical model, and this is the distortion. And this is the effect of that distortion, whether it's large or not.

CHAIRMAN CORRADINI: Kent, did you want to say something?

MR. WELTER: I was just going to add that we're using Reg Guide 1.203 as a guide for evaluation model development for -- this is primarily a facility scaled for loss of coolant accident analysis. And so we're using Reg Guide 1.203 which provides a framework and a structure and guidance on how to do the scaling, how to identify the figures of merit, how to identify your developmental assessment base, how to do uncertainty analysis and quantification.

So, all of that, the integral test facility is one piece of a large evaluation model for loss of coolant accident analysis.

And that's where we address things like the scaling distortion and the uncertainties associated with the full plant model versus the prototypic facilities.

MEMBER BROWN: I'll quit. This just seems to be more unique than some of the other things.

CHAIRMAN CORRADINI: I think, I mean historically if memory serves me this is kind of how they've done a lot of loss of coolant analysis historically in terms of -- I can't remember the name. CSAU. I was losing it there for a minute there. Code scaling analysis and uncertainty approach.

MEMBER BROWN: Okay, I'll quit.

MS. BANERJEE: Is the report available in the docket?

MR. REYES: It's available at the office currently.

MS. BANERJEE: If the members want I can try to get a hold.

MEMBER BROWN: I wouldn't understand it if I read it, so I will admit that.

CHAIRMAN CORRADINI: But I think what he said at the end is very important. It's that if you can get full-size 1:1 time scale and pressure it makes the scaling a whole lot simpler than if I start mucking with geometrical or time scaling. So, I think that's the key point that he ended off with.

MEMBER BROWN: I heard that. Thank you. Thank you for your patience.

MEMBER SCHULTZ: Jose, from what Kent said then you've got -- in your scaling approach you've established acceptance criteria which have been predetermined. And you've got predictions which you're trying to match up. And all of that is integrated into the overall process from the outset.

MR. REYES: Correct.

MEMBER SCHULTZ: Is that what you're working to do?

MR. REYES: Right.

MEMBER SCHULTZ: According to the tests.

MR. REYES: Right. And where we are now in terms of the scaling analysis. And Kent mentioned the MDAC process and what we're following there.

Right now that scaling is based on the facility in terms of its design basis, and then the NuScale's design.

And as time progresses there will be additional scaling work that happens which will use the as-built drawings and the best and final design for the plant. So, it's a process that emerges a bit over time.

MEMBER SCHULTZ: Thank you.

CHAIRMAN CORRADINI: Other questions by

the subcommittee?

Okay. So we have a decision point. Either we're going to take an hour in the wonderful world of modular insulation, or we're going to take a 10-minute break.

I'm looking at the subcommittee. We're a democracy. Okay, 10-minute break.

(Whereupon, the above-entitled matter went off the record at 9:46 a.m. and resumed at 9:56 a.m.)

CHAIRMAN CORRADINI: Okay. Doug, you're going to lead us through the module installation discussion and refueling?

MR. BOWMAN: Yes, that's correct.

CHAIRMAN CORRADINI: Okay. It's all yours.

MR. BOWMAN: All right. Good morning. Doug Bowman. I'm one of the operations engineers at NuScale Power.

And this is our standard acknowledgment and disclaimer for the work we're doing under the DOE award. Go ahead and hit next slide.

All right. An overview of refueling. So, currently, as Jose stated, we're working with a two-year fuel cycle. So, we will essentially as we go on be doing refueling about every two months.

So our intention is to use a dedicated refueling crew that will be entirely separate from the operations crew that's in the control room operating the remaining 11 modules.

That will include an SRO to allow for direction of activities and basically control the module and the rest of the refueling process.

And a big piece of this is once a module is disconnected, and I'll talk about the details of that a little later, the refueling crew assumes primary responsibility for that module.

It's no longer under the purview of the control room crew. We still have a shift manager onsite that has a broad overview of the whole site. But that SRO becomes responsible for that module.

MEMBER BLEY: That SRO stays with the refueling crew as they move from module to module. He's full-time.

MR. BOWMAN: That's correct. He'll be part of that integrated crew. We talked about the concepts. We're going to minimize the use of staff augmentation and contractors, have a dedicated crew that becomes very familiar with all the processes. They're doing it every two months.

So, basically our entire refueling is about 10 days, but they'll either be into preparation, cleanup activities from the previous one, or getting ready for the next one all the time.

So they should become very highly proficient at those activities and we should become very efficient at getting them accomplished.

MEMBER STETKAR: Doug, I know it's really preliminary, but he's dedicated -- he or she.

MR. BOWMAN: He or she.

MEMBER STETKAR: The person, the SRO person, is dedicated to the refueling team group. They need to keep their SRO license up to date.

MR. BOWMAN: That's correct.

MEMBER STETKAR: Are you conceiving of rotating individuals through this position?

I'm trying to think of what proficiency other than an SRO license that's signed and stamped this person might have to help out with other things.

MR. BOWMAN: I guess I have a hard time conceiving. It would be up to a customer, because I've seen both manners used. I've seen limited SRO licenses for fuel handling only.

MEMBER STETKAR: Okay, okay.

MR. BOWMAN: I was licensed at Byron and

that's the way we handled it.

On the other side of the coin I was licensed at Cook and we used people that rotated off shift, did the refueling, and came back on and maintained proficiency.

MEMBER STETKAR: Okay. Just curious, thanks.

MR. BOWMAN: Sure, no problem.

MEMBER BLEY: I'd just toss in, the one thing I like about the sound of this is I know regular plants, they get ready for refueling -- regular, yes -- they get ready for refueling, but they haven't seen the procedures in a long time. They walk through them and then all of a sudden the guy who did the prep can't show up on shift. And somebody comes in who isn't up to speed on that. So I think this is a really good idea if you can make it work right.

MR. BOWMAN: Right, it's very telling. From my experience many years, many refueling outages, the guy who did the all the development work, spent 18 months working on it and getting ready for it, and all of a sudden you bring in a whole new group of people that have been operating the plant for a time period. And it becomes tough to transition between those two roles.

MEMBER SCHULTZ: Doug, here you've got a 10-day window.

MR. BOWMAN: Correct.

MEMBER SCHULTZ: And I presume that's not an eight-hour day. You're on shift for the 10 days?

MR. BOWMAN: That's our concept right now. I would say we haven't really got a real strong detail of exactly what the shift makeup would be, how many shifts we would have, that kind of thing yet.

But we have a conceptual schedule. We've done some time estimates on it. We'll talk about that.

MEMBER SCHULTZ: And so even with a dedicated crew for this part of the operation they've got plenty of other time to be on operational shift.

MR. BOWMAN: That's correct. Right, training.

MEMBER SCHULTZ: And training. Well, refueling is one-sixth of the time, right? For a 12-unit. Or for any module.

So, there's, again, plenty of time for training, and operational work, and other work onsite. Thank you.

MEMBER BLEY: As long as all the schedules hold true.

MR. BOWMAN: All right, the next slide we have here is a mode table comparison.

On the left-hand side you'll see the NuScale draft mode table. On the right-hand side a current PWR mode table for comparison.

So, a couple of things to highlight. We have eliminated the startup mode. When we did our evaluation of this -- this mode table is preliminary so it may change. I will highlight that.

We've eliminated the startup mode. We didn't really come up with any unique items that required a separate startup mode during our evaluation.

We've combined the hot shutdown and cold shutdown into a single mode called safe shutdown. And that's in line with some of the SECY papers that have been done on passive plants.

We've created a new mode called transition. And that covers the actual moving of the module to perform the refueling -- the disassembly, and then perform the refueling. Not the refueling, but to prep for refueling.

Then beyond that it's pretty much the same as what you've seen in the past.

CHAIRMAN CORRADINI: I'm curious. You're going to get to this so perhaps I'm ahead of the game.

The reactor coolant average temperature less than 200, that's pretty much an estimate. Because I understand in past times you guys have shown us some time, some conceptual videos.

I thought core was open, or vessel was open as you were moving it. So it would be much less than 200. Or am I misremembering?

MR. BOWMAN: I have a detailed slide on what the model configuration is when we move it. I can show you that in a few minutes.

CHAIRMAN CORRADINI: Okay.

MR. BOWMAN: Any other questions? Steve, next slide, please.

All right. So, in order to help conceptualize what we're going to do in refueling I've done what a lot of the commercial plants have done. We've created 12 windows.

MEMBER SKILLMAN: Hello?

CHAIRMAN CORRADINI: Go ahead.

MEMBER SKILLMAN: Doug, this is Dick Skillman. I was trying to catch up to your request for questions.

MR. BOWMAN: Sure.

MEMBER SKILLMAN: On your slide 4 in the NuScale draft mode column you're very clear on 200 degrees Fahrenheit and 300 degrees Fahrenheit.

My question is why do you choose those numbers? And in specific is the over 300 degree Fahrenheit number at mode 2 related to retention of the 1 psi pressure in your containment?

MR. BOWMAN: No, no, no. The 300 degrees is actually related to primarily when we're allowed to flood containment which is part of the process for performing refueling.

And it's less than the safe shutdown number required by I think it's 420 degrees for the passive plants in SECY.

So, that's why we selected 300 degrees. It's really related to allowing containment to flood up from a thermal stress analysis standpoint.

MEMBER SKILLMAN: Okay. And the 200 is simply that of boiling? That's a margin?

MR. BOWMAN: Correct. Absolutely.

MEMBER SKILLMAN: Yes, sir. Thank you.

MR. BOWMAN: Okay, next slide. So again, we've broken this down into 12 windows. We will go through each one of the windows in some detail. There's a few we don't have a whole lot of information on because there's not a whole lot of work to be done to be quite honest.

But we have a shutdown and cooldown window, transition, preparation, and disconnection.

We actually move the module to the containment flange tool. We disassemble it. We perform -- at this point, once we get past disassembly there's three windows that move in parallel essentially - the upper module work window, the refueling window, and the lower containment vessel work window.

The critical path is through the upper module work window, actually, not through refueling. Refueling is relatively quick given the way we perform our refueling. And most of the work is on the upper module.

And then once we've completed those three - 5, 6, and 7 - we reassemble the module, we move it back to the operating bed, reconnect it, do a heatup, and then startup and ramp to full power.

You can see we have the same overview slide picture above that gives you a general layout.

Things to highlight on that picture, I know it's a little small, but the containment flange tool and the reactor flange tool. And then the location of refueling machine. And then up at the top you see the module import trolley. And that's also a place where we call the drydock which can be partially pumped down as part of the activities that go on. All right, Steve, go on to the next slide, please.

All right. So, here's a visual of our 10-day refueling schedule as we have conceived it at this point.

You can see there's approximately 30 hours for shutdown and cooldown, about 12 hours for transition preparation and disconnection, 2 hours to move the module to the containment flange tool. And then we have 20 total hours for disassembly.

About 8 hours into that we release the lower containment to do work. And that lower containment work window is very small.

And upon completion of disassembly release the work on the upper module work window which, again, is our critical path, and refueling. About 72 hours for the upper module work and 32 hours for refueling.

Once we've completed all three of those windows we can then reassemble the module which is about 40 hours. We transition to the operating bay which is two hours movement. Reconnect, perform module heatup, and then again, reactor startup and ramp to full power to complete out the 240-hour schedule.

One other item to highlight here. So, these times and estimates are all based on task analysis and work done by previous SROs from existing commercial plants who have been doing most of our task analysis work.

So, we have current industry OE. We are pretty knowledgeable on general processes and how they work. Obviously there's some details here that we work with the engineers to work out. But that's how we've come to our estimates at this point. Next slide, please.

MEMBER BALLINGER: I have a question. What happens if you have a bad hair day in that one of those tools becomes inoperable? What happens then?

MR. BOWMAN: We would have to work through and repair them at that point. I mean, obviously that schedule would be held up based on -- especially like a containment flange tool would stop the whole outage until you had completed that.

CHAIRMAN CORRADINI: If I might ask, how long can you go before something -- well, asking Ron's question a different way is do you have -- in terms of the work plan do you have duplicates of crucial tools so that if something goes down you've got a duplicate onsite? Or do you have to go back to some sort of manufacturing?

MEMBER BALLINGER: I see in the schematic one of this and one of this.

MR. BOWMAN: Okay.

MEMBER BALLINGER: I don't see two of this.

MR. BOWMAN: The flange tools are currently being designed. So I don't have a lot of detail on them. I've seen some conceptual drawings.

My understanding is that there will be actually an installed spare for those tensioners that we'll be using to dismantle.

For example, that's one thing. We'd have a spare down on the tool already existing. So if one of them broke we could easily drop it out.

But just talking with our engineer for that work, he expects that we will be able to do everything remotely. Even repairs work will be able to be done remotely. We don't intend on having to have a human go down and do any of that work.

Does that answer your question? I'm not sure I got to it.

MEMBER BALLINGER: I'll ask those questions when we get out there too.

MR. BOWMAN: Sure. No problem. All right.

MEMBER SCHULTZ: Doug, the 32 and a half

hours of shutdown and cooldown, is that thermohydraulic -- a thermal calculation? Temperature.

MR. BOWMAN: Yes, essentially based on cooldown rates. And what we expect -- we'll talk a little bit more about shutdown and cooldown in a minute.

But, yes. There's a portion of that that's done actively with feedwater and condensate. Another portion from passively once you flood containment.

So you really don't have a -- you're relying on those passive conditions to cool you down the rest of the way.

MEMBER BLEY: I'm a little entranced by having this worked out to the quarter hour. It's something we've never done before.

(Laughter.)

MR. BOWMAN: It's the best we can come up with at this time.

(Simultaneous speaking.)

MEMBER BLEY: I don't know where you go. A lot of this is new. But maybe you go to the chemical industry somewhere where they have closed-up systems that they work on.

Do you have any anticipation of where failures are going to show up? And where you're going to have expert repairs going on that are going to stretch this thing out?

And I don't know where you get that, like I said. But if I were you I'd be looking around chemical process industry and other places too, to get a good handle on that.

MR. REYES: As part of our first-of-a-kind engineering testing programs we include fabricating an actual module assembly stand. Those tools will be fabricated and we'll actually test them.

So, we'll have actual working versions of this thing prior to bringing the plant.

MEMBER BLEY: I didn't just mean the tools, I mean --

MR. REYES: The process.

MEMBER BLEY: I mean when something breaks inside your pot, you know. And I don't know what it's going to be, but something is going to.

CHAIRMAN CORRADINI: I guess this is out of my league, but if 240 hours turned into 480 hours does that upset that apple cart? Or is that still -- is there enough flex in the two-month schedule that you can handle that?

MR. BOWMAN: Right now there would be enough flex in the schedule to handle that. Obviously with two months to accomplish 10 days it gives us some room to maneuver.

But at some point in time you're going to be -- you would be stuck. There's only one set of tools to dismantle and perform the refueling. So you can only have one module out at a time.

MEMBER BALLINGER: And does that end up -- along Dennis's point, does that end up cascading into a really difficult situation where let's say you go two months. Now there's a refueling outage that's supposed to happen, but it can't happen. And then do things cascade?

MR. BOWMAN: I don't know that we've done enough detailed analysis there to really understand the pieces.

But yes, we have a fairly large, to me. We have 60 days to perform a 10-day window. I would expect we can accomplish it, especially given the simplicity of the module too.

There's just not as much as -- in a typical PWR where you've got so many things that can go wrong with it. A fewer number.

There's still things that can go wrong, absolutely. I mean, we try to anticipate those.

MEMBER BLEY: I just suspect it's so

simple-looking that one gets overly optimistic.

And even if you stretch this out -- and physically you could do this stuff. Pretty soon you might bump into -- if you were an owner rather than a designer, you're going to bump into, well, I've got to get my operators back to training because they can't stay in there if they're not keeping their training up and that sort of thing.

So there's a lot of details somebody is going to be worrying about.

MEMBER BALLINGER: We were at Palo Verde and they have three units. And they have refuelings going constantly. And so we were talking with them about issues related to training.

MEMBER STETKAR: They have refuel planning going constantly.

MEMBER BALLINGER: They have refuel planning going on. These guys have refueling going on all the time.

MEMBER SCHULTZ: I think it's very much similar, very much similar in terms of planning and execution. Execution is 10 days. You're done.

MEMBER BALLINGER: Logic would say yes.

MR. TOVAR: I'll mention something. My name is Tim Tovar, again.

I was a fleet outage manager at First Energy for -- the corporate fleet outage manager for three years there working with Davis-Besse, Perry, and Beaver Valley which is a two-unit site.

This is a baseline refueling schedule. So, this is a 10-day baseline. But we're always going to have, just like any outage, like Beaver Valley has a Westinghouse baseline schedule of 20 days. And almost never do they have a 20-day outage.

This is not assuming any major repairs like steam generator tube plugging and so forth.

If we get into extensive modifications or repairs certainly this refueling schedule will be greater than the scheduled 10 days.

And certainly we have that time built in so that we can handle that without impacting the next refueling outage.

Some of the benefits with the NuScale plant, having 12 and 6 outages every year, and the ownership of the plant itself, doing those refueling outages, we're going to get so much OE so quickly, and there's so much ownership with that that we anticipate that it will become a much more efficient process.

If you look at refueling outages some of the problems are it only happens once every 18 months, or once every two years.

And people get into this survival mode. You know, I just want to get through this outage. And they stop. You know, they go into the outage with great thoughts of improving the process.

But then you get into a survival mode where you want to get through it. And maybe you stop paying attention to, okay, what am I going to improve for the next outage.

Here we have the same people doing it over and over and over again. There's self-interest in making the outages more efficient and better.

So, we anticipate that outages will be routine, very efficient, and much smoother than current commercial nuclear power plants.

CHAIRMAN CORRADINI: I think, Dick, you had a question?

MEMBER SKILLMAN: I did, both to Tim and to Doug. I'm back on slide 5.

Just from an optics perspective here are 12 modular reactors and a single reactor building crane. All the experience I have is that crane usage becomes critical path.

I'm wondering if there has been consideration to having a second, virtually identical reactor building crane so that if you are locked onto one module and having difficulty you have a second crane for whatever might need attention.

MR. TOVAR: This is Tim. As far as the reactor building crane, we won't have a second crane.

We only do have one refueling station so we can only refuel one module at a time. It's not a consideration to be able to refuel a second module.

The module itself, the heavy pieces are the lower containment vessel, lower reactor vessel, and the upper portion. Certainly we need the refueling crane for that.

But the pieces and parts are so much smaller that we have other options. Say, for example, the remove and spool pieces are maybe, say, for example, two-inch or four-inch pipes that we'll be removing.

The weights don't require the big crane to handle a lot of the parts that are removed in the disassembly.

If you look at a commercial nuclear power plant, the big crane that they use, many times a polar crane is often critical path. And we don't anticipate that the refueling crane is going to be -- or the polar crane for us, this refueling crane will be critical path.

MR. REYES: So, just a follow-on to that. This is Jose.

I did speak to the crane vendor when we were first looking at the numbers of cranes. And one of the things they commented was the fact that we actually move the crane every two months or so was a big plus.

Because you're not having a crane, using it for a short period, then letting it sit for 18 months, and then trying to get it to operate.

So, they thought the frequency of crane movement was helpful in terms of maintenance and making sure that this would work on a regular basis. That was their input.

MR. BOWMAN: For a commercial nuclear power plant access to the polar crane is difficult. And a lot of the electronics are in an adverse condition, or an adverse environment.

For us it's accessible all the time. We can test the crane at any time and make sure that it's ready to go prior to the outage with plenty of margin.

CHAIRMAN CORRADINI: I enjoy this operating experience, but I'm just worried about the safety of it. So, if you guys back up on the economic problem then I'm not going to worry about it. Let's keep on moving.

MR. BOWMAN: Okay. Next slide, please. Keep going.

All right, so shutdown and cooldown. We will execute shutdown and cooldown. It will be pretty similar to what we see in a current PWR.

We'll ramp the unit down to approximately 20 percent and then we'll trip the unit.

We'll start primary system boration to refueling concentration. We'll perform a cooldown to 300 degrees using feedwater and turbine bypass. So, we're using our existing power conversion system to perform the cooldown.

Once we get below 300 degrees we'll depressurize the RCS to 200 psia using pressurizer spray and then flood containment in the cooldown.

So we actually take and fill the module containment outside the reactor vessel to approximately the pressurizer baffle plate with pool water to perform the remainder of the cooldown.

CHAIRMAN CORRADINI: So, the containment is flooded with pool water?

MR. BOWMAN: Correct. I'll have a picture that will show that a little better here in just a second.

MEMBER BLEY: Your spray, it's pump spray.

MR. BOWMAN: It's pumped flooding, yes.

MEMBER BLEY: A spray.

MR. BOWMAN: Oh, pressurizer spray. Yes, yes. We use our CVCS recirc pumps to provide pressurizer spray.

MEMBER BLEY: Are you going to tell us at what point in this process do you turn it over to the shutdown crew, the refueling crew?

MR. BOWMAN: We'll talk about that in just a second.

MEMBER BLEY: Okay.

MR. BOWMAN: Steam generators are placed in wet layup. We do our crud burst and cleanup is performed.

And just to highlight again, we use normal feedwater and turbine bypass to cool down the module. We don't ever use the decay heat removal system to perform that portion of it.

MEMBER STETKAR: And why don't you have steam generator blowdown normally?

MR. BOWMAN: Well, given the design of the steam generators we don't anticipate the need for it.

Being on the tube side instead of -- chemistry is on the tube side. So we're not worried about hideout and places for those things to stay and remain.

MEMBER STETKAR: Okay.

CHAIRMAN CORRADINI: And where they would stay you can inspect, if necessary?

MR. BOWMAN: Correct.

CHAIRMAN CORRADINI: Because there's -- don't go back to your picture, but there's like an annular manifold up on top and below.

MR. BOWMAN: There's actually four separate manifolds. And two of those manifolds, upper and lower, create one steam generator.

But yes, those manifolds are accessible. And we'll briefly talk about how we inspect those in just a minute. Go ahead and go to the next slide.

All right, so we've completed our crud burst so we can start into what we call transition preparation and disconnection.

We shutdown CVCS as the crud burst is cleaned up. We can fully depressurize the RCS now. And we actually open the ECCS vent and recirc valves at this point. We'll talk about the configuration.

MEMBER BLEY: What kind of crud levels are you expecting? I mean, you don't have the normal sources of -- the worst sources of crud in the existing PWR.

MR. BOWMAN: That's true, but our control rod design is similar to Westinghouse's. We will get some from that.

So, we actually have a chemistry individual who's been working on that. He expects actually, based on what he knows so far, a fairly similar level of crud.

We have lower flow rates. We don't have quite the -- our flow velocity is less, so that's one downside.

MEMBER BLEY: No Stellite anywhere, is there?

MR. BOWMAN: Right.

MEMBER BLEY: Of course, there's not in most operating plants now.

MEMBER STETKAR: If they were going to use it --

MEMBER SCHULTZ: The crud burst chemistry and process is expected to be like a PWR outage?

MR. BOWMAN: Actually, very similar, yes. Hydrogen peroxide to initiate the crud burst. You create an oxygen-reducing environment on your way down by borating. And you set it up so you can do that crud burst.

So, it was very similar. You need to clean it up. Not much difference at all.

Again, the advantage of our design, that we try to use existing technology as much as possible wherever we can.

So, we open the ECCS valves. I'll show you a picture on that in a minute.

We remove the bioshield. That was the structure over the top of the module that you saw in the other picture.

We closed all the containment isolation valves at this point. We work on electrical and I&C disconnections.

And containment is then pressurized to prevent the water from coming over the top of the head when the flange is separated.

So we actually put a slight overpressure on the containment to control water level when we separate the containment flange later. We do that at this point.

Our mechanical disconnections are completed after we pressurize containment and the crane lifting device is connected.

One thing I will highlight. Given the fact that this was a non-proprietary meeting, most of the pictures you guys are going to see in this are older concepts.

Our current designs aren't shown. So this is an older picture of a lifting device at this point. Okay, next slide.

MEMBER REMPE: Thank you. Could you elaborate on what disconnections, what I&C? Or is that in the closed session for discussion?

MR. BOWMAN: Well, I&C, we have most of your general instrumentation, i.e., temperature, pressure level. We would have controls. The control rod drive mechanisms would be part of that electrical and I&C disconnection. Pressurizer heaters.

I'm trying to think what else off the top of my head.

MEMBER REMPE: So you said --

MR. BOWMAN: Yes. And to some degree or another the NIs are disconnected at that point.

MEMBER BLEY: I'm assuming you have some clever kind of easy disconnect for all of that. Is that right? Or is it you go in and have to take them all apart?

MR. BOWMAN: The mechanical disconnections are flange tool pieces. But I realize the largest pipe we're dealing with is 6-inch.

MEMBER BLEY: No, I meant for all the

electrical connections.

MR. BOWMAN: I don't think the details of those designs are completed yet.

We intend to make it easy. It's going to be on the platform. It's going to be fairly obvious to people what they have to disconnect. We don't expect it to be -- you're worried that we're going to be doing terminations? I expect there to be a connector of some sort.

MEMBER BLEY: I'm just wondering.

MEMBER SKILLMAN: This is Dick Skillman. For the transition, after you've latched on and you're prepared to remove the module, what consideration have you given to retaining some form of reactivity monitoring?

MR. BOWMAN: At this point we're not believing we need any reactivity monitoring because we really don't have a credible problem that would cause a change in the reactivity state of the vessel once it's disconnected, or the module.

So we are going to -- we expect to do, for example, level temperature and pressure. But we don't anticipate the need for nuclear monitoring at that point.

MEMBER SKILLMAN: Okay.

MR. BOWMAN: Okay, next slide, please. Okay, so here's our simplified graphic of the model during transition.

So recognize, we've talked about this. The module is integrated, meaning that our safety systems are all included in the module.

We remove the module, all our safety systems go with the module.

And not only do they go with them, they're all in their actuated state whenever we move it. So, we have full access to DHR cooling, containment cooling through flooding, our ECCS valves are all open.

So you can see at the top the ECCS reactor vent valves are open. You can see the location of the pressurizer baffle plate, and just below that is where the water level is expected to be, both inside and outside as all the valves are open.

And then near the bottom above the core we have the location of the ECCS reactor recirculation valves.

CHAIRMAN CORRADINI: What's the black -- the thing just below the ECCS recirculation valves?

MR. BOWMAN: That's a representation of the flange, the reactor vessel flange.

CHAIRMAN CORRADINI: Okay, thank you.

And then just to repeat what you said before, you spray it down to a certain temperature and pressure, and then all valves open. And so in that state away you go.

MR. BOWMAN: Right. Yes.

CHAIRMAN CORRADINI: All right.

MR. BOWMAN: Okay. Next slide, please. So, we're going to walk through this in fair detail, actual moving the module.

We all understand this is a unique part of NuScale design so I'm going to walk through exactly how we move it.

You can see we have a module represented in bay 1 at this point and we're going to move the module via animation to the containment flange tool.

So you can see I've got a pretty detailed list. The module is raised just enough to clear the pool floor.

We really haven't detailed that out. We currently model that as about a foot off the pool floor.

And then the crane trolley is at the center line of the pool. Oh, they didn't work. Never mind. I'll just walk through it then. No problem.

The crane travels along the center line of the pool. The green lines are actually load paths. And when the crane's under load these are the only areas it's allowed to move along.

So, it moves along the center of the pool to the lift point which is just between -- just beyond bays 6 and 12.

At that point the module is lifted approximately 30 feet to clear the containment flange tool. And then it's moved over to the containment flange tool at that point. And then it's set down in the containment flange tool.

When we set it down in the containment flange tool there will be cameras monitoring it. We'll have a load cell on it to make sure it's not getting hung up or anything untowards is happening.

CHAIRMAN CORRADINI: So, when you say the flange tool, it's almost like a pedestal on which this thing sits.

MR. BOWMAN: It actually sits inside of it and basically there will be kind of a turntable to allow you to access all the flange bolts at that point.

CHAIRMAN CORRADINI: So the tool --

MR. BOWMAN: There's a number of tensioners. The concept I've seen, there's a number of different tensioners on it. And those tensioners would access and de-tension a stud, and then rotate to the next one.

But you'd be doing, for example, three or four at a time.

MEMBER STETKAR: But you rotate the whole base for a fixed stud removal?

MR. BOWMAN: We don't move the module. We move the tools, the de-tensioning.

The base doesn't move. I believe we're looking at kind of a turntable on top of the base.

CHAIRMAN CORRADINI: So, you lift it over this thing, the record player, and then once you turn on the record player it kind of goes and does its thing.

MR. BOWMAN: Yes, that's exactly the concept we're looking at.

MEMBER SKILLMAN: Would you explain your concept right now relative to seismic capability from the time you latch on to the time you replace or place the module into its receptacle?

MR. BOWMAN: Yes. So, the reactor building crane is a NOG-1 designed crane. It's fully single-failure proof and fully seismic class 1 with one connected to the module.

So, our intention is that it's qualified to move the module and qualified to all seismic events that the plant's qualified to.

MEMBER SKILLMAN: Thank you.

MR. BOWMAN: Okay, next slide, please. All right, so again, here's an older drawing, but a concept of how the disassembly would work.

Containment flange tool de-tensions the containment flange studs and provides a stand for the lower containment vessel.

The remainder of the module is picked up once you've de-tensioned all the studs and it's set into the reactor flange tool.

The reactor flange tool is very similar except for a few exceptions. It is, in fact, the place where we're going to refuel from so it's the stand for the core during refueling.

So it contains the nuclear instrumentation necessary to support that refueling. And it also de-tensions the flange and does the rest of the work for it.

CHAIRMAN CORRADINI: And that unscrews the flange that I was asking about before.

MR. BOWMAN: Yes, yes. So, the containment flange tool does the containment flange. Reactor flange tool does the reactor flange.

It should be very similar devices. From what I understand we're planning on using the same fasteners for both of them at this point.

CHAIRMAN CORRADINI: And this is in-detail design in terms of the tool?

MR. BOWMAN: Yes. They're currently on a detailed design for that.

We have an individual who formerly worked for the DOE doing a lot of the black cell work. So we're used to remote tooling. And it's working on that design.

MEMBER SKILLMAN: At this point in the conceptual design are the de-tensioners for the bolts and studs hydraulically driven, or are they mechanically driven?

MR. BOWMAN: They are hydraulic. I know they're hydraulic. Yes, we intend on them being hydraulic.

MEMBER BLEY: Are you going to get into how when you put this all back together you know you've got a good seal on all of these flanges?

Because this is all done remotely underwater with tools that ought to work just right.

MR. BOWMAN: Correct. Our seals will be testable. We will perform leak tests on them. Once we complete assembling them that leak test will be done immediately following that.

MEMBER BLEY: Have a capability for some

kind of internal hydro and all that.

MR. BOWMAN: Absolutely. So, the seal will be built. The seal will be similar to what you're used to for a head seal right now, a C-shaped O-ring.

The details of exactly how we'll get in there test them, we'll have some kind of internal seal that will allow you to pressurize both of those outer O-rings to make sure they're both leak tight.

MEMBER BLEY: Probably while it's still in place.

MR. BOWMAN: Yes. While it's in the tool. Okay, next slide, please.

All right, the upper modular work window. This is where the majority of the work for the outage goes on.

The upper module is secured in the module upender and the crane and lifting rig is removed. So we're in the drydock area of the pool now.

Once that's completed you close the door on the drydock and you pump the drydock partially down. Calling it a drydock is a bit of a misnomer. We only pump it down partially to allow for shielding while people are doing their work in there.

Steam generator eddy current, as performed -- as asked earlier we intend on performing steam generator eddy current every outage at this point.

MEMBER BLEY: One hundred percent?

MR. BOWMAN: I don't know that that's been detailed out. I would expect a sampling portion at this point, not 100 percent. Unless we refine something.

MEMBER BALLINGER: You're below the magic 604 Fahrenheit which was for 600. For 690 that's a very low temperature.

So, I'm not sure -- do you expect degradation with time?

MR. BOWMAN: No, but I would never not go below it.

MEMBER BALLINGER: Yes, but 100 percent --

(Simultaneous speaking.)

MR. BOWMAN: No, I don't believe we're going to be doing 100 percent. We'll be doing some small percentage.

MEMBER BALLINGER: Okay. So there's some regime there.

MEMBER BLEY: They've got all this automated stuff and I was just wondering.

MR. BOWMAN: We also do a majority of the instrument testing, repair and calibration at this point in the outage.

We do an upper reactor flange inspection and an upper containment flange inspection.

We intend right now to adopt the current industry practice of performing 20 percent of the ISI welds, forgings, and surfaces that are required for the 10-year ISI each outage.

We will perform any in-service testing that's required, meaning mostly the safety relief valves, reactor recirculation valves, reactor vent valves, and any check values within the upper module.

MEMBER SKILLMAN: Would you speak to us a little bit about your conceptual thoughts. If you find a problem with a valve or several valves how will you gain access to effect repair? Conceptually.

MR. BOWMAN: The upper portion of the module is intended to be accessible. And we have to access it a number of times -- the upper portion of the reactor vessel. So that would allow us access to the safety relief valves and the reactor vent valves.

I know the recirc valves are a little more difficult to get to, but they're also intended to be accessible, and inspectable, and replaceable if required.

MEMBER SKILLMAN: Thank you.

MR. BOWMAN: The vent valves are 6-inch

and the -- I'm trying to remember what size the recirc -- are an inch and a half. They're not big components at all.

MEMBER BALLINGER: What thoughts have been given maybe to these welds and things like that historically in our industry that have become the bane of our existence?

Has any thought been given to mitigating beforehand the stresses that might exist on water-facing -- high-temperature water-facing welds?

Like special welding techniques to induce compressive stresses. Those kinds of things that would make your ISI inspection results a lot more predictable.

MR. BOWMAN: That's an excellent question.

MR. REYES: We don't have the right person to address it.

MEMBER BALLINGER: I mean, dissimilar weld cracking is the number one problem that we have.

MR. BOWMAN: The only thing I can really comment on that right now is I know we intend on minimizing welds, and trying to do the best job we can to make them accessible for inspection, et cetera.

So that's a good question we could give you a response to later.

MEMBER SCHULTZ: Doug, since you've got a program planned now where you say, well, 10-year inspection, we'll inspect 20 percent every year.

That sounds really good until you find something. And then the next step is, well, don't you have to inspect everything.

And so are you thinking about how you're going to develop a program that's going to allow you to really monitor what's happening and what's going on so that you -- it seems like you want to look a little more deeply in terms of trending and inspection than you would if you were doing it every 10 years.

MR. BOWMAN: And again, I'm definitely not an ISI expert, but one of the things that Tim talked about that's going to help us a lot is the advancement of OE as we see it.

We're going to be seeing modules every two months.

MEMBER SCHULTZ: Yes, yes.

MR. BOWMAN: And we'll have a very good trend of what that looks like over time.

So, I anticipate we will be able to very quickly understand what our critical areas are for ISI inspection and probably have a fairly good idea what the scope is.

MEMBER SCHULTZ: It's not like industry and EPRI don't have a good experience base.

MR. BOWMAN: Right, exactly.

MEMBER SCHULTZ: So, you can lean on all of that too.

MR. BOWMAN: Yes.

MR. TOVAR: We'll operate similar to the commercial nuclear power plants now in that if we do an inspection, what if we find something will always be a contingency.

We'll have work packages already developed and understand the scope of work, the timing, the expertise that we need, and so forth. So, we'll be able to step into that and minimize the impact of the outage.

But certainly you don't go into inspecting something and just blindly expect it to be okay. So, just like the industry does now we'll make sure that we're ready to go for contingencies.

MR. BOWMAN: Okay, next slide. Okay, refueling. So, refueling. Actually much simpler than the current fleet of PWRs.

We pull a fuel assembly directly out of the core, the reactor vessel, and put it directly into the spent fuel pool at the same machine. No upenders, no transfer tubes, none of that to go onto.

Pick it up, put it directly into the spent fuel. So, actually much simpler than the current industry in terms of PWRs.

We only have 37 fuel assemblies. This is a fairly quick process. We've given it 32 hours to accomplish.

Each assembly can be taken directly from the core and placed in the spent fuel pool. Each one only requires a single handling event.

We would also complete any lower reactor vessel inspections could be performed in this window if necessary. And refueling can be completed either as a partial core offload or -- in fuel shelf floor or full core offload and reload depending on the work that's going on, and the customer's preference to be honest.

MEMBER SKILLMAN: Let me ask a question. I'm looking at your slide 13 and as I recall you indicated you have about 8 million gallons of water in this pool.

CHAIRMAN CORRADINI: Dick, you're going to have to speak up.

MR. BOWMAN: I can hear him.

CHAIRMAN CORRADINI: I know, but the

recorder can't.

MEMBER SKILLMAN: I'm on slide 13 and I'm looking at what is the common spent fuel pool water along with what is the shield water around the 12 modules. The pool water is the name that is described on slide 13.

My question is what consideration has been given to the event where you have fuel leakers or weepers as a consequence as you remove the fuel assembly that is the offending one, that you begin to add soluble fission products into the pool.

What consideration have you given? Because your pool is common to all 12 reactors as well as the spent fuel pool.

CHAIRMAN CORRADINI: You contaminate the pool he's worried about.

MEMBER SKILLMAN: Correct.

MR. BOWMAN: So, we have -- number one, we intend to perform en masse fuel sampling for all the -- fuel assemblies at this point. So we'll be trying to identify leakers immediately.

Of course, we'd have a program to monitor during operation to try to minimize and eliminate those leakers, of course.

But we do have a rather large cleanup

system that's also been installed to help remove those fission products once they're there.

And we would try to quickly eliminate those leakers, and reconstitute the fuel, and isolate those leakers as soon as we can, leaking fuel pens as soon as we can.

MEMBER STETKAR: This is Tim again. We will have procedures that -- basically we're ready for this.

But we anticipate during our normal RCS sampling that we would identify the fact that a module does have any fuel leakers.

And if -- we understand the fact that we are opening this up to the entire pool, so we'll likely have some kind of contingencies where we'll have, say, additional filtering, TriNucs, or something like that where we try and control the spread of contamination at the source as much as possible.

And then we do have the regular pool cleanup that minimizes -- due to the flow will minimize the spread of contamination.

It will go more directly into the filtering and cleanup system rather than drag it across the rest of the module.

MR. BOWMAN: I believe the current concept is to have the cleanup take a draw off the pool so all the water is drawn through the pool and then into the cleanup system, and then returned back out.

MEMBER STETKAR: Doug, I have no idea what names you give to these various bays so I'll just call it the place where the reactor vessel sits when you're refueling bay.

There's obviously -- if I look at the plan view of that is there any way -- there's no way of isolating that bay from the rest of the pool.

MR. BOWMAN: No, it's open to the remainder of the pool.

MEMBER STETKAR: And it's always open.

MR. BOWMAN: Yes.

MEMBER STETKAR: Okay.

MR. BOWMAN: The only place that's isolable is the actual drydock itself. And the weir between the spent fuel pool and the --

MEMBER STETKAR: So that's the only place, despite -- okay. Thanks.

MEMBER BALLINGER: I'm assuming this pool is lined.

MR. BOWMAN: Yes.

MEMBER BALLINGER: With stainless steel.

MR. BOWMAN: Next slide, please. All

right. So we've completed all three of our work windows we need to to complete refueling. And we're going to move into are-assembly at this point.

The prerequisites, of course, we need to have those three windows completed. We place the upper module on the lower reactor pressure vessel and tension the flange. So the reactor pressure vessel is currently -- it's still sitting in its location and it always was at the reactor flange tool.

We connect the control rods and perform a latch and stroke test. That's performed one control rod at a time. And we intend on having a testing setup that will only allow us to test one control rod at a time.

We then also leak-test the reactor flange.

Once that's all completed we'll place the upper module in the lower containment vessel and tension its flange and then perform its leak test.

And then the module is then moved to the operating bay following the load path that we talked about previously.

MEMBER BALLINGER: I'm assuming that we're talking about a thermodynamic impossibility. But what happens if you drop one of these things?

MR. BOWMAN: I think that would be a good question for Bill to answer a little later.

MR. GALYEAN: We can talk about that during the closed portion, PRA portion.

MR. BOWMAN: PRA has taken a look at that.

MEMBER SKILLMAN: That's why you have a second crane.

(Laughter.)

MEMBER BALLINGER: And a prayer rug.

MR. BOWMAN: All right. So then we get into reconnection. Our prerequisites are the CVCS system is operating on recirculation, and feedwater and condensates on long cleanup.

We connect our power instrumentation and controls. We verify their operability, instrumentation control operability.

MEMBER BROWN: Can I ask a question?

MR. BOWMAN: Sure.

MEMBER BROWN: Are they underwater?

MR. BOWMAN: What's that?

MEMBER BROWN: Are the connections underwater?

MR. BOWMAN: No, the connections are on top of the module.

MEMBER REMPE: So, they're never submerged at all in this whole process. Are they exposed to high humidity conditions?

MR. BOWMAN: The connections themselves are never submerged, no. The humidity would be what it is within the pool. I expect at times that could be somewhat high, yes.

MEMBER REMPE: You'll catch on when things are degraded and you'll replace them.

MEMBER BROWN: In your other pictures you showed -- or maybe I missed it. I didn't see any neutron detectors, sensors, pressure, temperature. There was nothing showing the relative locations of those for your monitoring of the plant.

MR. BOWMAN: Neutron detectors, the ex-cores are actually on the outside of the containment vessel.

So, there are four ex-cores similar to the current PWR fleet. Those will be -- basically they'll have to be waterproof. Those are the one set of instrumentation to some degree that do get --

MEMBER BROWN: So, they're not in a tube.

MR. BOWMAN: Well, there's a tube outside of the containment vessel that we set them in and then put it in --

MEMBER BROWN: Does the tube have water in it?

MR. BOWMAN: Yes.

MEMBER BROWN: So, connectors for the detectors are underwater? For the neutron detector.

MR. BOWMAN: Yes. Right. The remainder of the instrumentation is all --

MEMBER BROWN: -- done before somewhere?

MR. BOWMAN: They're similar to what -- what it would use as a temporary detector. Similar in design to what's used as a temporary detector during refueling.

MEMBER BROWN: But these aren't temporary.

MR. BOWMAN: No, these are permanent.

MEMBER BROWN: So, are they disconnected also during the operation of refueling?

MR. BOWMAN: Yes. During the disassembly portion of the thing they would be removed.

MEMBER BROWN: What ensures that they get resealed properly when you reinstall them?

MR. BOWMAN: I don't know that I have enough detail right now to answer that question, but that would be part of our design would be to ensure that they are completely waterproof and capable of surviving for the period they need to.

MEMBER BROWN: Those are fairly

low-signal devices which don't particularly care for moisture of any kind in the electrical connection area.

MR. BOWMAN: Right.

MEMBER BROWN: Even little bitty bits --

MR. BOWMAN: We'll have to be very good at it.

MEMBER BROWN: -- of moisture. You'll have to be very, very good.

CHAIRMAN CORRADINI: He won't forget this question.

MR. BOWMAN: I understand.

CHAIRMAN CORRADINI: Although he looks -- but he won't.

MEMBER BROWN: What about your other sensors? Pressure, temperature, flow. Do you have any flow sensors at all?

MR. BOWMAN: We do have flow sensors, yes. For the RCS.

MEMBER BROWN: And where --

MR. BOWMAN: They're internal to the containment. So, none of them are ever wetted.

MEMBER BROWN: So there's instrument piping coming out to the detectors and they're above the water level boundary?

MR. BOWMAN: Yes. I see what you're after. When we're doing a refueling where we flood up to, yes, they are above.

MEMBER BROWN: When you're operating.

MR. BOWMAN: When we're operating we're at a vacuum inside containment and that's what most of them are exposed to. Or the RCS conditions.

MR. TOVAR: I think we're getting a little bit -- I'm not sure we're talking about this.

The connections for all the instrumentations are going to be at the top of containment. And we'll do those disconnects just like the piping will be in the top of containment.

I don't know if we know the --

MEMBER BROWN: -- pressure detector you'll have tubes, piping going up so that your pressure detectors will connect into the piping above the water.

MR. TOVAR: Yes.

MEMBER BROWN: Outside the containment.

MR. TOVAR: Yes.

MEMBER BROWN: -- differential pressure or whatever, represents?

CHAIRMAN CORRADINI: I guess given that we don't have detailed design in front of us they're going to go back -- I'm giving them the chance to go back and check it, rather than get on the record that they might be --

MR. TOVAR: I don't think we've gotten to the level of detail where we know if there are any connections beyond the ones that are at the top of containment that we actually disconnect for the refueling to transition.

I don't think we know the level of details going down to the actual instruments, if there's any other connections. I don't believe there will be, but we can't state that categorically. We'll have to get the I&C folks.

MEMBER BROWN: Well, you'd normally have to have temperature sensors. It has to be in the medium that you're going to --

MR. TOVAR: Sure, sure.

MEMBER BROWN: -- that you might want to measure. We haven't had any discussion -- or no comment at all about how you get those plugged into the flow mediums where your various waters, whether it's primary or secondary, and then how those connections get out.

I mean, you know it's standard PWRs. I mean, there's instrument wells and things like that that are welded in, and there's been no comments or illustrations about how that's done.

CHAIRMAN CORRADINI: I don't think we're at the point where we're --

MEMBER BROWN: Well, details do matter at some point when you have to --

CHAIRMAN CORRADINI: I don't think we're at that point yet.

MEMBER BROWN: Well, I'm sorry. I guess I would probably disagree since this whole configuration of an integral plant is tied up in how you get information out as well as how you have moving water around.

So, I'll pass. I'm just --

MR. REYES: There's additional information available. I think it's just having the right people in the room to respond.

So, we would need our mechanical person to talk about the penetration of instrumentation. We need our I&C folks to talk about specifics.

So, I think, very good questions. I'm writing them down. But I think there are some good responses.

MEMBER BROWN: Well, we can go on. I got the point.

MEMBER REMPE: Before you do though, just as an add-on. During the refueling I thought you did say you would keep some sort of instrumentation in. And could you tell us in the reactor vessel, what instrumentation would be in the reactor vessel during the refueling process?

MR. BOWMAN: We anticipate being able to monitor level temperature and pressure during the movement of the module.

And then we would have nuclear instrumentation available at the reactor flange tool during refueling operation.

MEMBER BROWN: That's your temporary you talked about?

MR. BOWMAN: No, no, no. That's an installed set of nuclear instruments at the reactor flange tool.

So, again, they would be similar in design to -- I hate to use the term, they're called dunkers that we use in the current PWR world to do refueling with. So, very commonly used.

MEMBER REMPE: Thank you.

MEMBER BROWN: Thank you.

MR. BOWMAN: Okay, reconnection. We have to insert our in-core instrumentation. It does come in from the top. It's similar to Combustion

Engineering's design in terms of how that works.

We connect containment evacuation system and begin containment and RCS de-gas. So, recall the module is currently in a configuration where the vent valves and the recirc valves are open.

So, when we start cleaning the evacuation system we'll be drawing a vacuum on the entire RCS and containment. We use that as part of our de-gas process.

We complete the remainder of the mechanical connections and then we shut the ECCS vent and recirc valves while we're under vacuum.

After that we turn around and pressurize the RCS with nitrogen. This provides a net positive suction head for the CVCS recirculation pump.

We push nitrogen into the pressurizer area to provide a pressure.

CHAIRMAN CORRADINI: So, I was going to ask. So, essentially the -- what would have been the steam space now becomes a nitrogen space.

MR. BOWMAN: That's correct, nitrogen blanket on just to provide pressure for the pumps. Next slide, please.

We establish normal CVCS recirculation, place the module heatup system in service. One of those unique things about not having reactor coolant pumps is you have to provide separate heating externally.

So, we'll be using a steam heater on the CVCS system to perform heatup.

MEMBER BROWN: Relative to Mike's question, is that nitrogen up in the pressurized -- what you call the pressurizer?

MR. BOWMAN: Yes.

MEMBER BROWN: So, where you would normally -- okay. You've answered my question.

So, you pressurize that with nitrogen once you've got everything buttoned up.

MR. BOWMAN: Right. Correct.

MEMBER BLEY: Do you have a donkey boiler for the first module?

MR. BOWMAN: We intend on having an installed ox boiler to provide steam for this system. I believe there's actually two of them, but I'd have to go back and take a look.

Okay. Module heatup system is put in service to restore feedwater and perform a steam generator flush at this point, essentially overflowing to the first steam trap, steam generators.

We verify containment is operable and

drain containment. So that's one of our systems, the new systems that Jose talked about. We have a containment flood and drain system that will drain most of the water out of the module -- out of containment.

We install -- once containment is operable and we've drained it we can then install the bioshield and perform our first dilution towards critical boron concentration.

We then begin the process of drawing a vacuum on containment now that we've drained it. We draw a steam bubble in the pressurizer and we do our final dilution to critical boron.

And we wind up with the module heatup system in service with stabilizing RCS temperature at 430 degrees and pressure at 1,850 psia. That's full pressure and that's above our minimum temperature for criticality so we can perform a startup. Next slide, please.

We do -- even coming out of refueling we will perform a control rod startup, not a dilution startup. We'll always be doing control rods.

Once we've gone critical we'll perform physics testing, withdraw rods to raise power to 15 percent and T-ave to 546. So, basically we ramp both of those at the same time, power and T-ave. Five forty-six will be our normal temperature.

We remove the CVCS heater from service, place the main turbine in service, and synchronize the generator to the grid and send to 100 percent power from there. Next slide, please.

So, to go back and cover -- that's the refueling process. I'll now go cover the few things that are different about module installation.

Most of what you've seen or I've discussed is really part of module installation as well.

But the module arrives in three parts. It has an upper module, a lower containment vessel, and a lower reactor vessel.

The module has its factory ITAAC completed when it arrives at the site. The lower containment vessel and lower reactor vessel are placed in their respective tools. So, we can't have any other operations going on at this point. And the upender is used for all three of these items.

And then we place the upper module in the import trolley or the upender. And then the following windows are completed.

We perform an initial fuel load with the reactor vessel. We then do assembly connection, module heatup, and startup.

And that is -- if I can go to the next slide.

CHAIRMAN CORRADINI: Okay, so additional questions from the members?

MEMBER BLEY: It's nothing to do with safety, but when you build the reactor building -- sorry, Mike -- do you install all the steam pipe you're going to need? Or do you just put in what they're buying the first time? Have you thought about that kind of stuff?

MR. TOVAR: Yes, we have thought about that. We've gone through with Fluor some of the initial construction concepts. And we do have to put in all the piping that's --

MEMBER BROWN: You're all piped up for 12 modules.

MR. TOVAR: Yes, yes. For a 12-pack plant if we're going to -- if that's what we're building for the customer it will be all installed.

MR. MIRSKY: I might also add that we're planning a presentation on that exact topic late summer/early fall. Just construction while there's operation and startup going on in terms of briefing.

CHAIRMAN CORRADINI: The subcommittee shouldn't feel slighted. We're going to have a lot of meetings. Charlie, lots of meetings. I just want to make you happy.

Okay, other questions from the committee.

MEMBER SCHULTZ: Yes, one quick one. It seems nice that you've provided a fuel shuffle option for refueling, but it also seems with the number of assemblies that are in core that not providing that option could provide some real benefit, especially given that, as you said, you've got a one-pass move from the core to the fuel pool.

It would seem you could manage the fuel for these 12 units within the fuel pool and get them from the core into the pool, from the pool into the core a lot quicker, and perhaps have some safety benefit in terms of misloaded fuel assemblies and so forth that would be well worthwhile exploring.

In other words, it could be advantageous from a fuel management point of view as well as a safety issue related to fuel misload.

And also be at least as quick, perhaps quicker than shuffling.

MR. BOWMAN: So, we have a variety of operational backgrounds, both BWR and PWR. Coming from a Westinghouse background we always did full-core offload. So that was common to me.

The BWRs tend to do fuel shuffles. And I know the CE designs --

MEMBER SCHULTZ: They've got a lot of assemblies.

MR. BOWMAN: Right. The CE design also -- they tend to do fuel shuffles as well. So, we provided both.

In my experience I've never seen a fuel shuffle, so I'm not sure exactly the downfalls of that. But I understand it's a little more difficult in terms of --

MEMBER SCHULTZ: But in the pool because of the number of assemblies you've got for the 12 units and the power production you've got a lot of option for fuel management within the pool itself.

MR. BOWMAN: Correct.

MEMBER SCHULTZ: I would think you'd want to utilize that and do fuel management from the pool, if you will, instead of in the core.

MR. BOWMAN: Right. Again, it makes sense to me too, so. But we provided all the options.

CHAIRMAN CORRADINI: Other questions?

MEMBER BALLINGER: With respect to the fuel I see in your diagram and ISFSI.

MR. BOWMAN: Yes.

MEMBER BALLINGER: So that's for dry

storage, I'm assuming, of spent fuel.

Now, the current dry storage systems don't match half-height fuel assemblies. Are you going to do something, or is somebody going to do something to develop a canister system that would integrate well with the current kind of dry storage technology.

MR. REYES: Right, right. So we're looking at that right now in terms of the half-life. And there's different options that are possible, but we haven't settled on which one.

CHAIRMAN CORRADINI: They need to sell one first.

MEMBER BALLINGER: True, but there's current stuff going on within the staff and everything on dry storage, and transportation, and all that kind of things that you might keep track of.

MEMBER SCHULTZ: What's your time limit associated with wet storage and the pool that you've got?

MR. BOWMAN: Ten years is our design.

MEMBER SCHULTZ: Ten years on design. Okay.

CHAIRMAN CORRADINI: Other questions? Okay. Let me turn to the audience here while Maitri goes and gets the public line turned on.

MR. TOVAR: Sir, one thing I just wanted to clarify.

One of the things that was said was that the module during refueling was never submerged.

When we do bring it over to the R-tool and the C-tool because of the lift height restrictions of the crane that portion is lower than the regular pool floor.

So, in order to lift it that 30 feet to get it into the tool, once it is in the tool it is lower than the normal height of the rest of the pool.

So, we do actually get water up to the level of the top of the containment vessel. It doesn't wet the containment isolation valves or any electrical penetrations or anything. But I just want to make that clear.

CHAIRMAN CORRADINI: We'll be back to you on that.

MR. TOVAR: Okay.

CHAIRMAN CORRADINI: So, are there members of the public here that want to make a comment?

Hearing none --

MS. THOMAS: Comments and questions from the public?

CHAIRMAN CORRADINI: Yes, ma'am. Go

ahead. Please identify yourself.

MS. THOMAS: Ruth Thomas with Environmentalists Incorporated.

And boy, there's a lot to go over. To start with I'm glad that you're going to be having visuals that show -- what's that noise? -- visuals that show the refueling.

That is something that hasn't been clear at all. I've been talking with the people in the information digest how do you refuel a regular reactor.

Now, we would like the visuals on how this is going to be done with the small module -- I don't know what that noise is, but it's --

CHAIRMAN CORRADINI: You're fine. That's just the high-quality phone line.

MS. THOMAS: Oh. And so we understand that this small module reactor is still in the early stages of development. Would you say that was correct?

CHAIRMAN CORRADINI: Yes, ma'am. And these are all public presentations so we can provide to you exactly what was provided to us. That should not be a problem.

MS. THOMAS: Well, I know sometimes I get the slides and they aren't what I call visuals. They're kind of talking points.

CHAIRMAN CORRADINI: In this case they'll be pictures. What we see, you'll see.

MS. THOMAS: What was that?

CHAIRMAN CORRADINI: I said you will get exactly what was presented to us which were visuals.

MS. THOMAS: And so who was the -- I heard Department of Energy mentioned. And an individual who apparently, I hope it's more than one individual that has a background in this.

Is that where the idea of having module reactors started? With the Department of Energy?

CHAIRMAN CORRADINI: I think -- we're not in a position to answer questions from the public, but rather we'll take your comment and note it.

Maitri Banerjee is our designated federal official which will contact you and get you the visuals.

MS. THOMAS: Okay, great. Well, I'm glad to see the public, and I hope there's more than one person from the public on the line, to be involved early in this because that's where you get people who are -- well, they don't have a conflict of interest.

In fact, their interest is in having something that's going to be safe. And by safe I don't mean the way the Nuclear Regulatory views as safe.

And now, particularly with so much

information. Let's see, I have five written pages.

Our questions are -- we can't possibly ask in the five minutes, particularly if the reception is so poor.

So who would we be sending our questions? And these would be questions that we want the answer.

CHAIRMAN CORRADINI: You can send your comments and questions to Maitri Banerjee who is the designated federal official.

MS. THOMAS: And will she be getting to the experts to get the technical and full answers? Because I don't see how one person could cover all this. It must take -- it takes some scientists.

And usually it's engineers, scientists that understand nature and that understand that these are unique materials that never have been in existence before.

I would suggest, and others have suggested that the conversation and dialogue start with talking about the materials.

What you're talking about is ways to overcome the detrimental and lethal characteristics of the materials you're working with.

And it seems like that ought to be in the beginning as to why such materials were chosen in the process for electricity. Thank you.

CHAIRMAN CORRADINI: Thank you very much. And Ms. Banerjee is the individual to send your comments to and will communicate with you with the visuals so you can get what we have. Thank you very much.

Is there another member of the public online?

(No response.)

CHAIRMAN CORRADINI: Okay. Why don't we close the line. Thank you very much.

MS. THOMAS: I have one other question.

CHAIRMAN CORRADINI: We can't answer questions. We can take your comment.

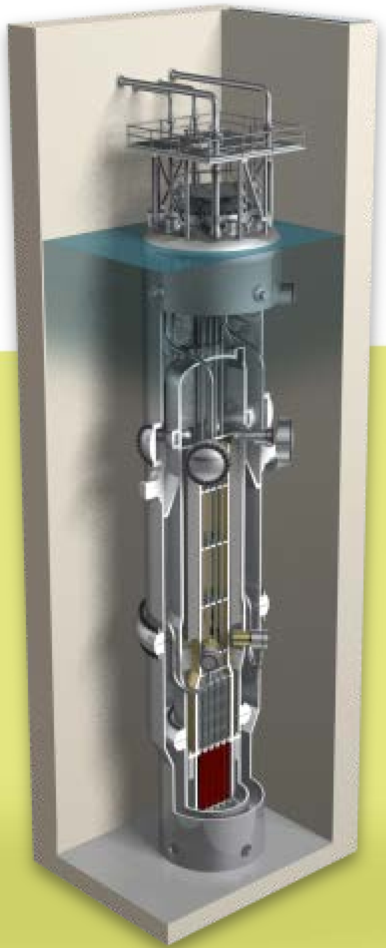
MS. THOMAS: Okay. My comment is with the importance, the critical future in mind there's only one person on the line. And that's -- and there must be something wrong with the way the NRC is communicating with the public.

I don't know the number of people in the United States, but I don't feel honored to be the only one listening in. I feel sadness.

CHAIRMAN CORRADINI: Thank you for your comment. Why don't we close the line so we can go into closed session.

Can NuScale please verify that the people in the room are who are allowed to be in the room since we're in closed session? And Maitri, can you make sure the outside line is closed?

(Whereupon, the above-entitled matter adjourned into closed session at 11:08 a.m.)



ACRS Future Plant Designs Subcommittee Information Briefing

Presentations

- Overview of Design & Integral System Test Facility
- Refueling & Module Installation
- PRA Update
- Design-Basis Events

June 25, 2015

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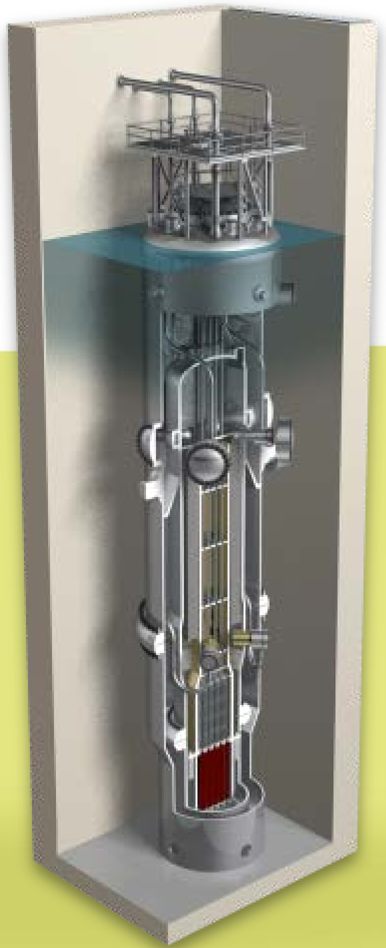

Overview of Design and NIST-1 Test Facility

Dr. José N. Reyes, Jr.

Chief Technology Officer

June 25, 2015

NuScale Nonproprietary

PM-0615-15103-NP

Revision: 0

Acknowledgement & Disclaimer

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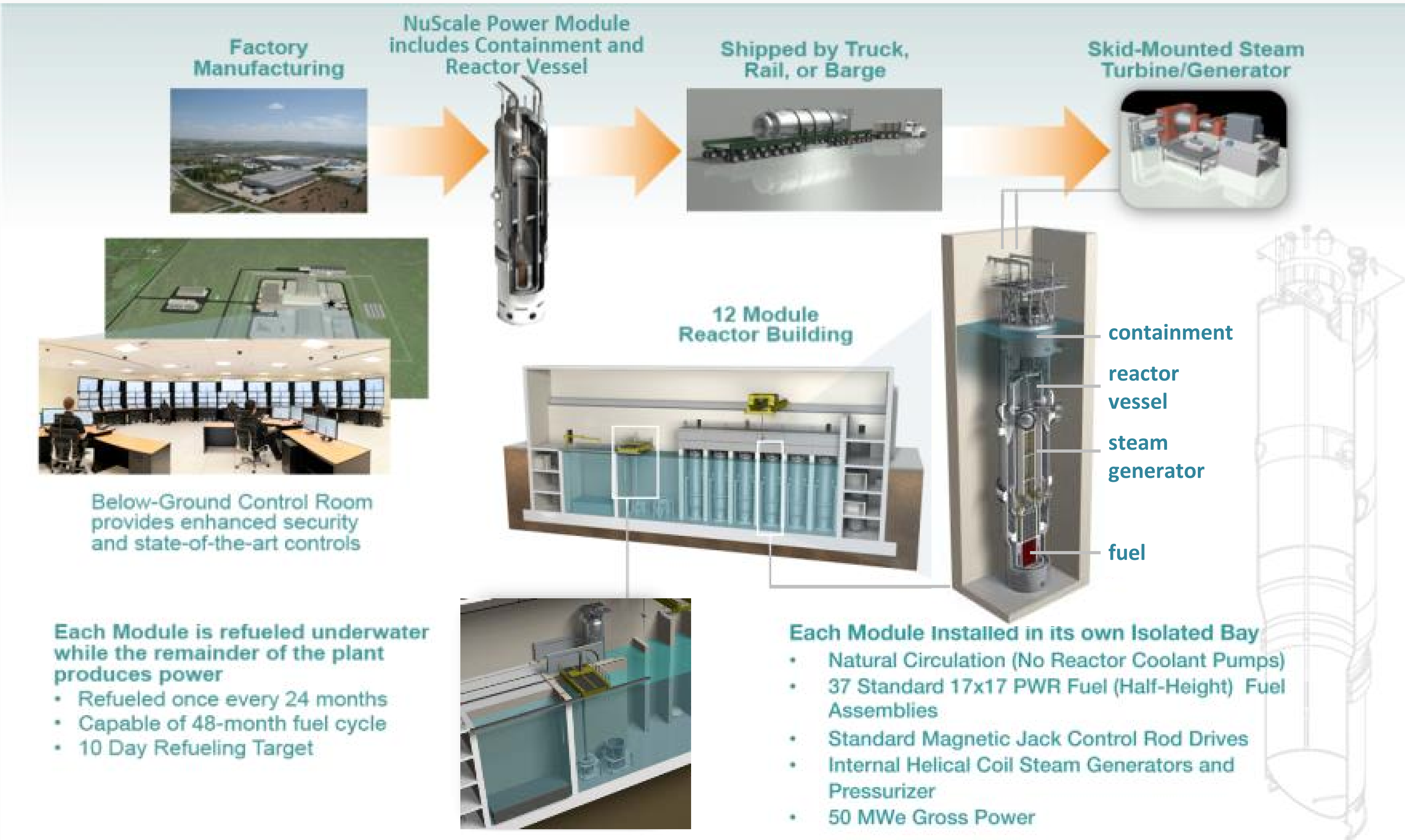
Objectives

- Provide an overview of the NuScale 12-module plant design
- Provide an introduction to the NuScale Integral System Test facility (NIST-1)

Plant Design Overview



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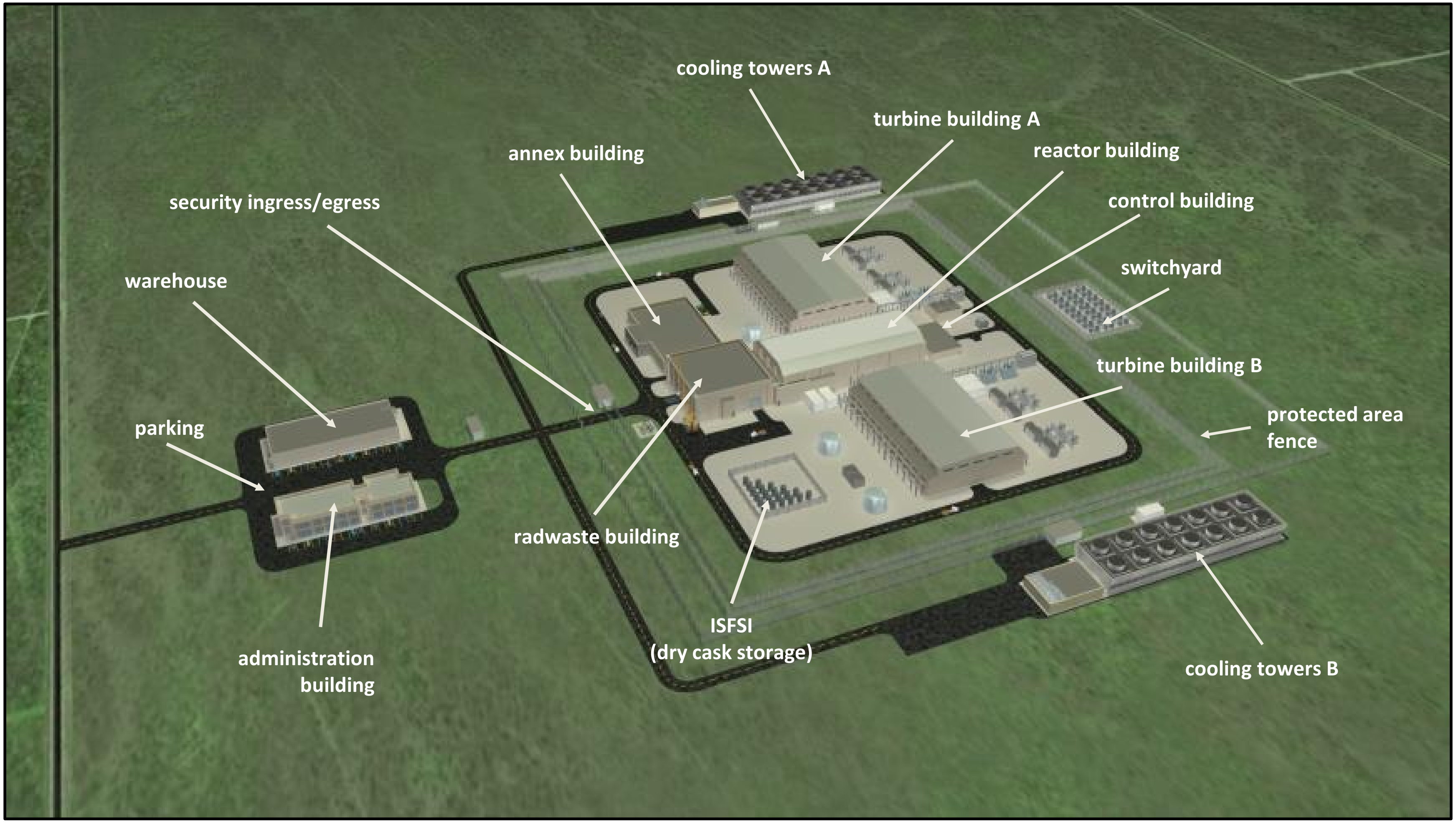
Site Aerial View



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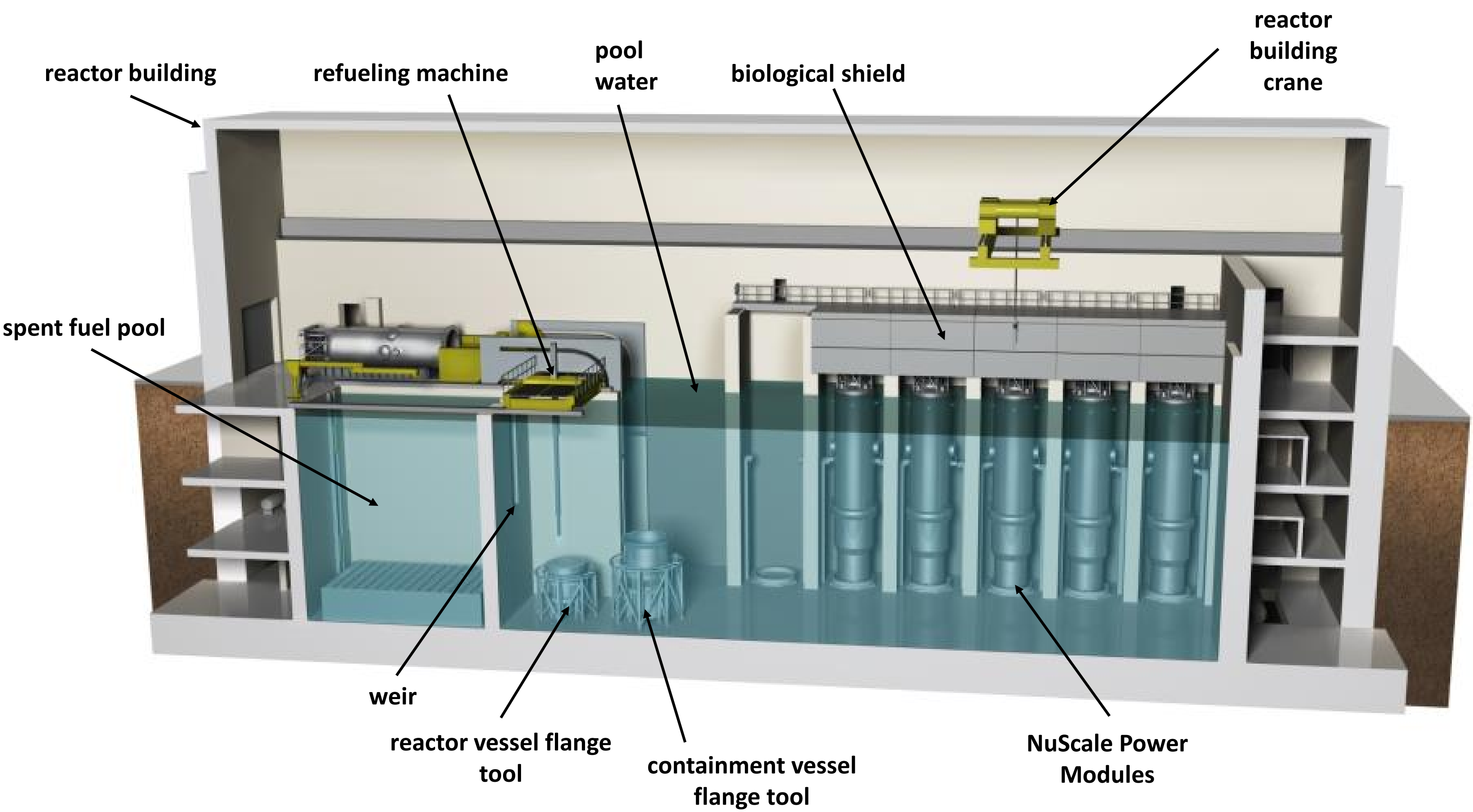
Reactor Building Cross-Section

Reactor building houses reactor modules, spent fuel pool, and reactor pool



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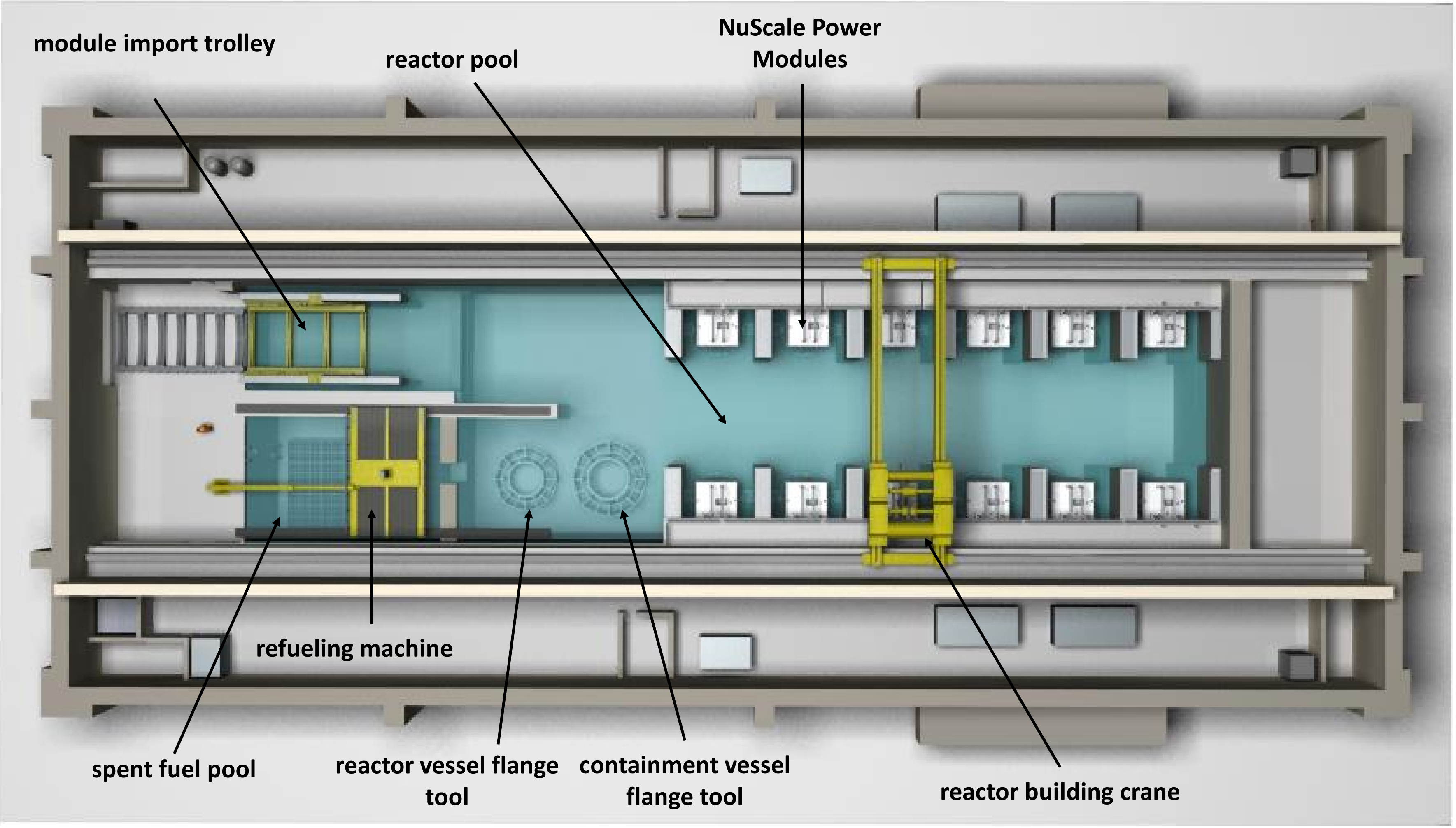
Reactor Building Overhead View



Design Simplification

- **New system**
  - containment evacuation
  - containment flooding and drain
- **Eliminated systems**
  - containment spray
  - containment fan cooler
  - auxiliary feedwater
  - ECCS injection and recirculation
  - steam generator blowdown
  - electrical generator hydrogen supply
  - safety-related electrical systems
- **Eliminated components**
  - reactor coolant pumps
  - ECCS pumps, tanks, and RPV injection lines
  - containment sumps and tanks
  - refueling water storage tank
  - reactor coolant hot leg and cold leg piping
  - pressurizer surge line and relief tank
  - reactor vessel and primary coolant system insulation
  - safety-related emergency diesel generators

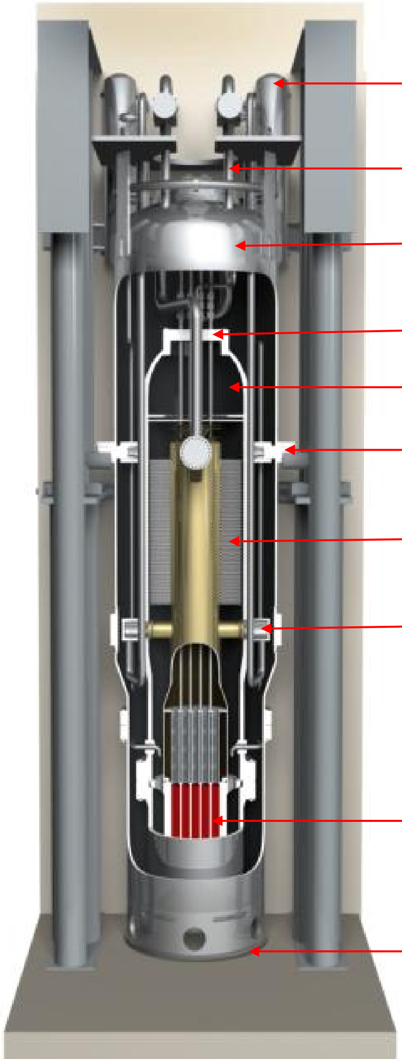
Reactor Module Overview

Natural convection for cooling

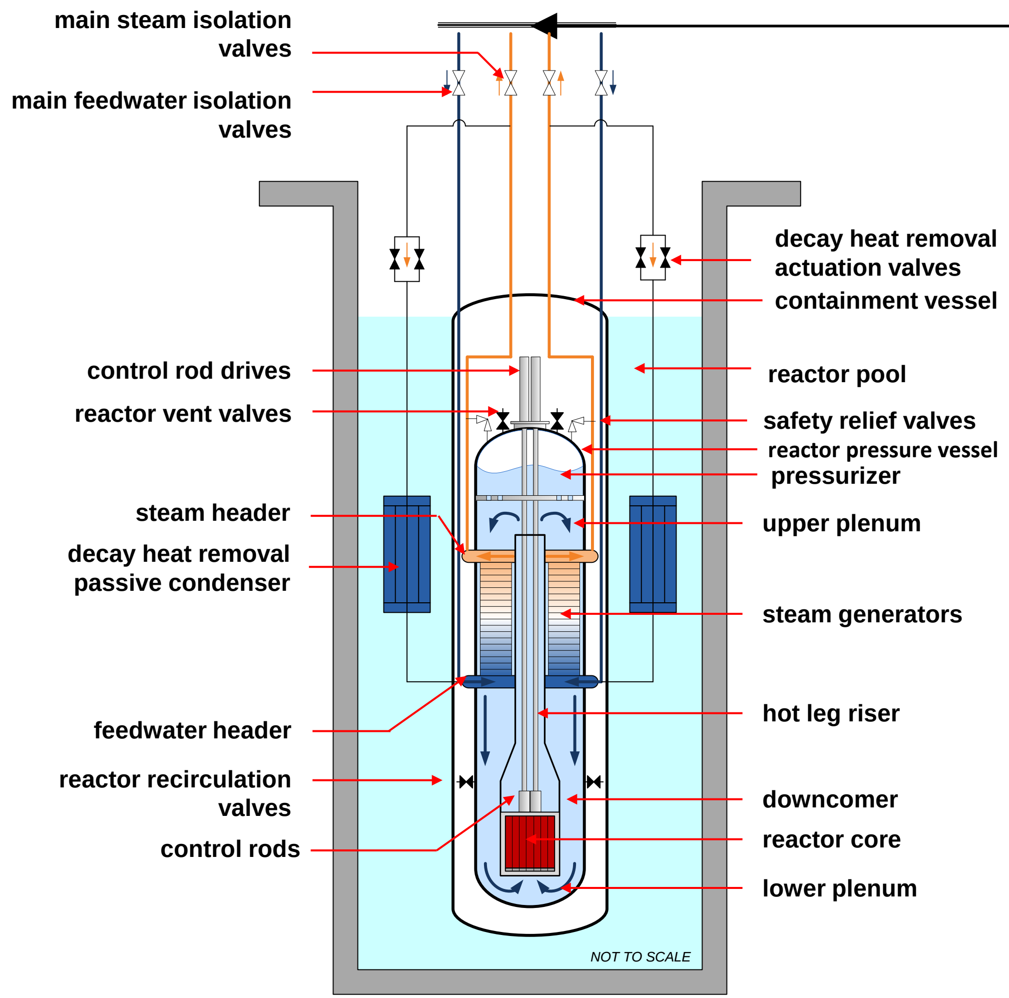
- Passively safe, driven by gravity, natural circulation of water over the fuel
- No safety-related pumps, no need for emergency generators

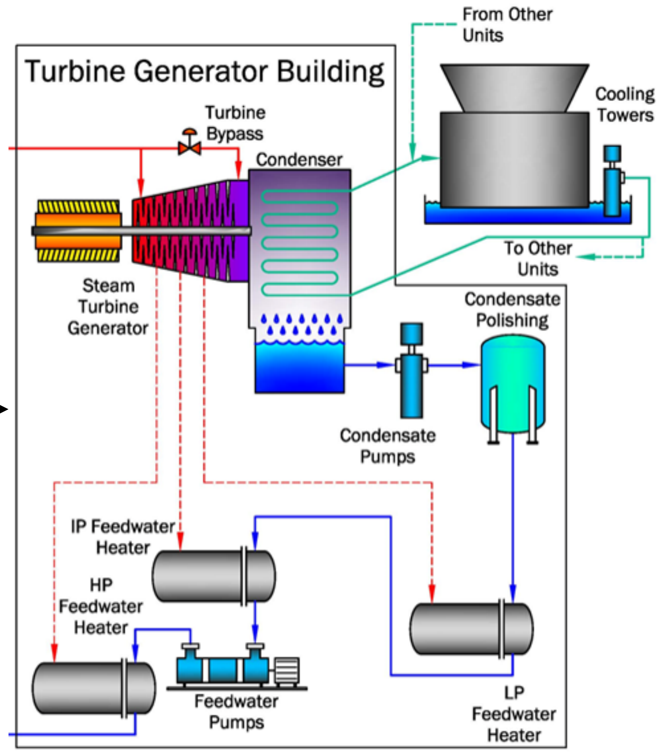
Simple and small

- Reactor is 1/20th the size of large reactors
- Integrated reactor design, no large-break loss-of-coolant accidents



NuScale Power Train (Video)





- Each reactor module has a dedicated turbine-generator (T-G) train eliminating the loss of other modules in the event of a turbine trip
- Small, simple components support short simple refueling outages
- Water-cooled or air-cooled condenser

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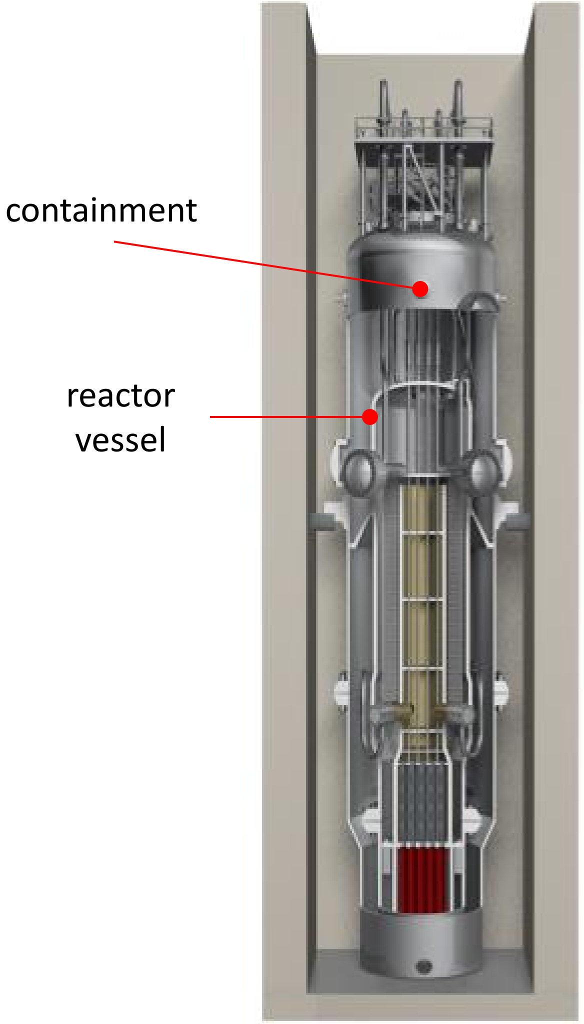
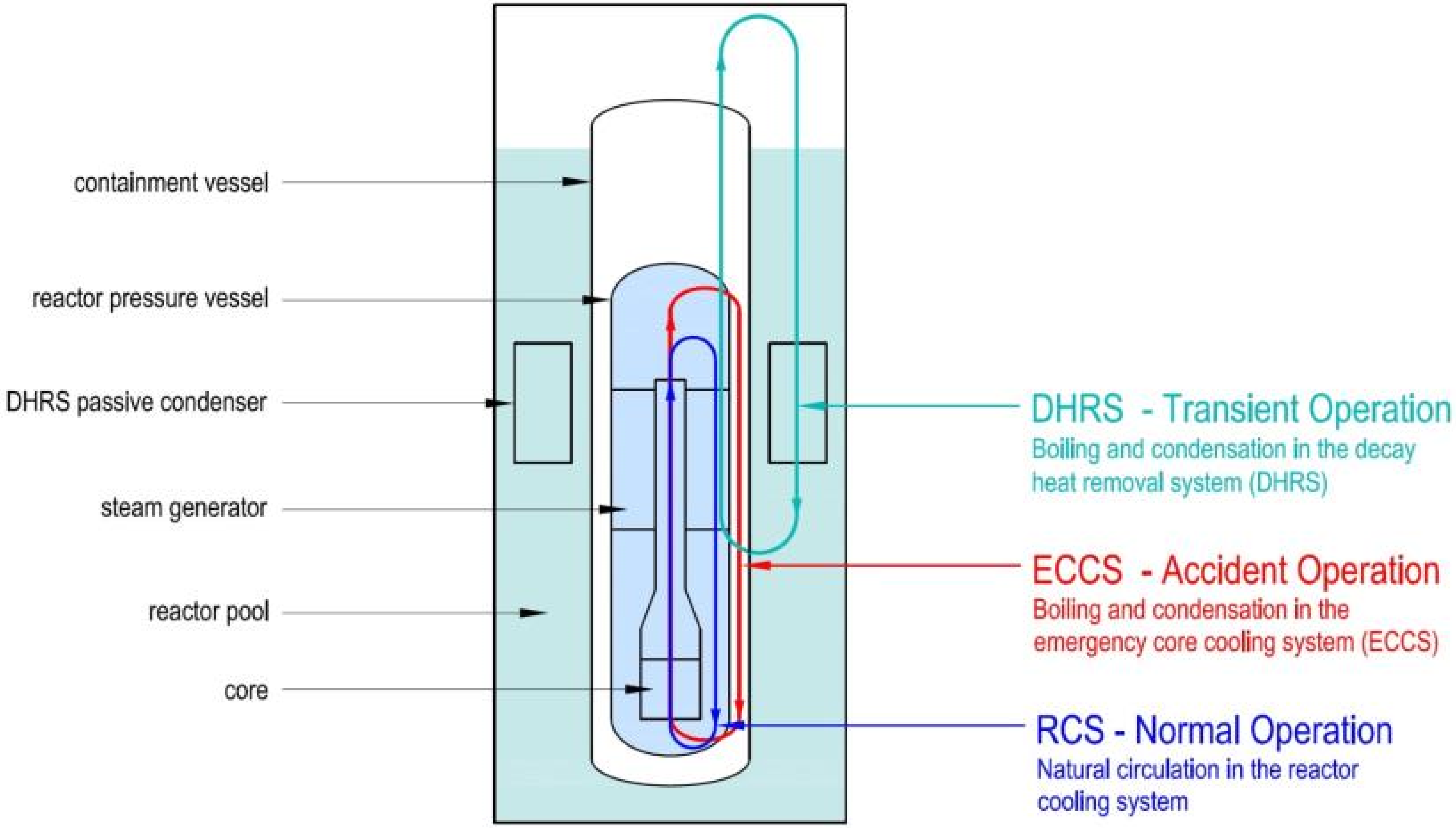
Containment Design

Evacuated Containment—Enhanced Safety

- Containment volume sized so that core does not uncover following a LOCA
- Large reactor pool keeps containment shell cool and promotes efficient post-LOCA steam condensation
- Insulating vacuum
  - significantly reduces conduction and convection heat transfer during normal operation
  - eliminates requirement for insulation on the reactor vessel, thereby minimizing sump screen blockage concerns (GSI-191)
  - improves LOCA steam condensation rates by eliminating air
  - prevents combustible hydrogen mixture in the unlikely event of a severe accident (i.e., little or no oxygen)
  - reduces corrosion and humidity problems inside containment

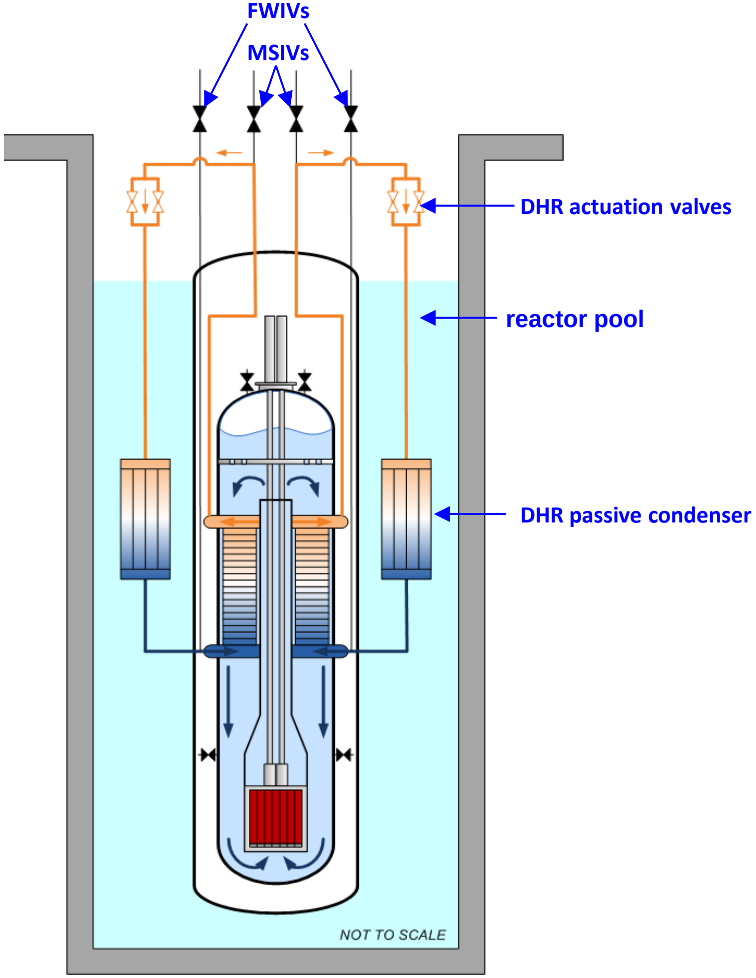


Passive Cooling Systems



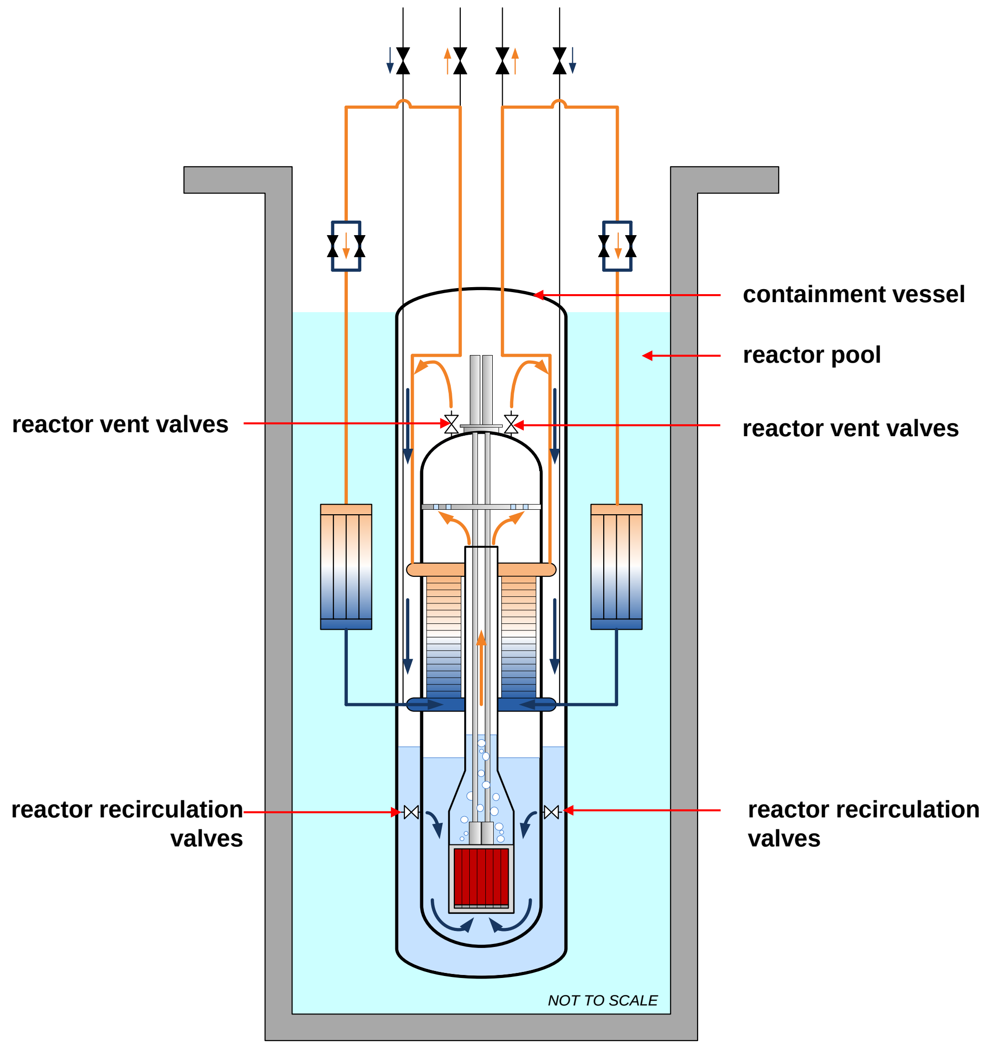
Passive Decay Heat Removal System

- Main steam and main feedwater isolated
- Decay heat removal (DHR) valves opened
- Decay heat passively removed via the steam generators and DHR heat condensers to the reactor pool
- DHR system is composed of two independent single failure proof trains (1 of 2 trains needed)



Emergency Core Cooling System and Containment Heat Removal

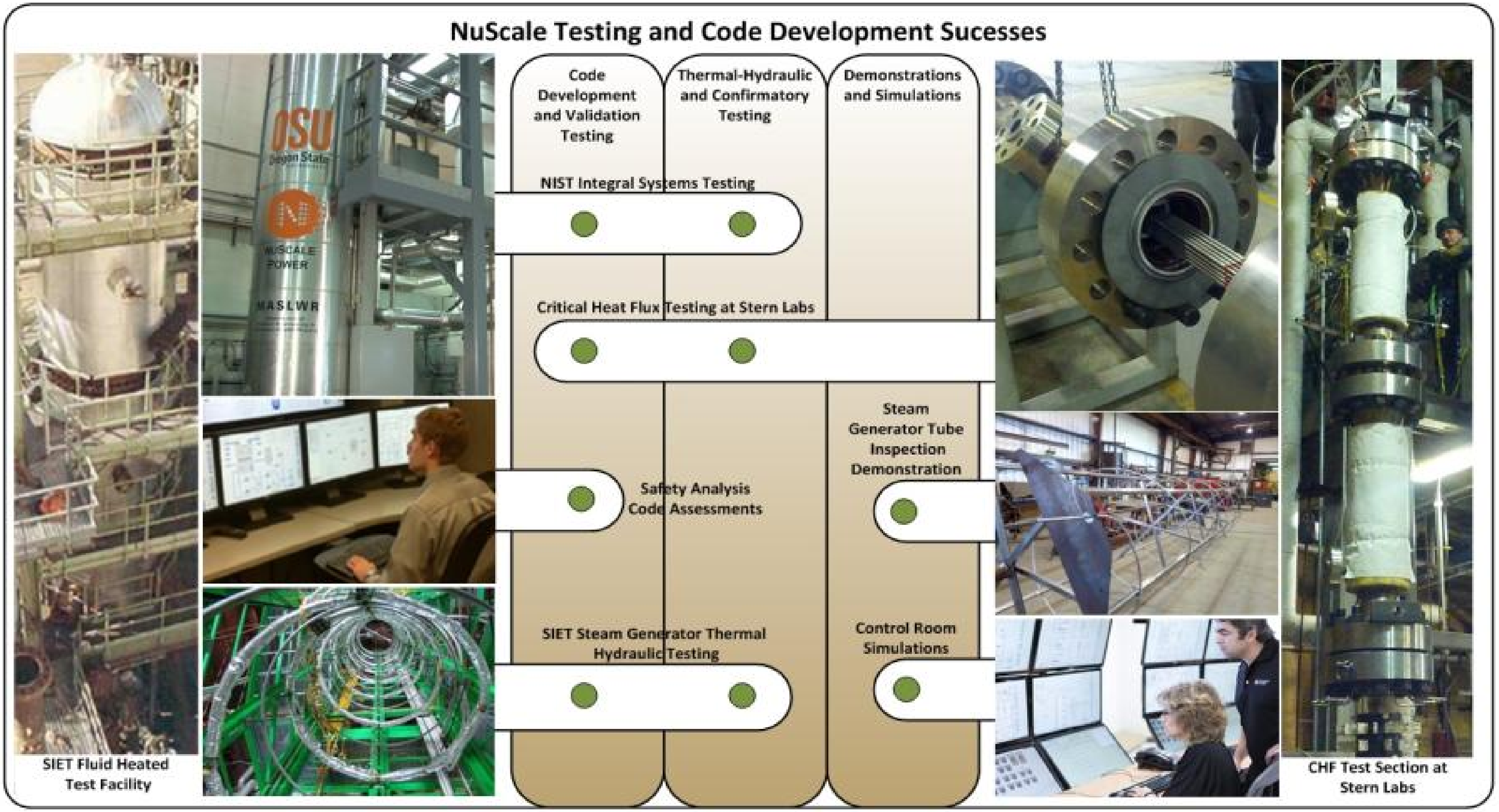
- Main steam and main feedwater isolated
- Reactor vent valves and Reactor recirculation valves open on safety signal
- Decay heat removed
  - condensing steam on inside surface of containment vessel
  - convection and conduction through liquid and both vessel walls



NuScale Test Program

NuScale Reactor Qualification Test Plan

NuScale Reactor Qualification Test Plan outlines design certification and FOAKE projects for reactor safety code development, validation, reactor design, and technology maturation to reduce first-of-a-kind (FOAK) design risk.



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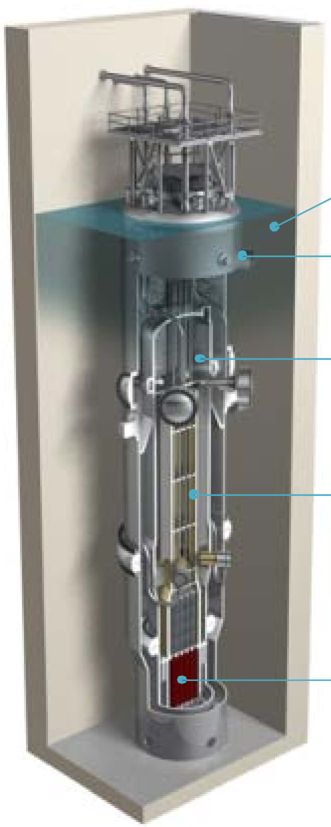
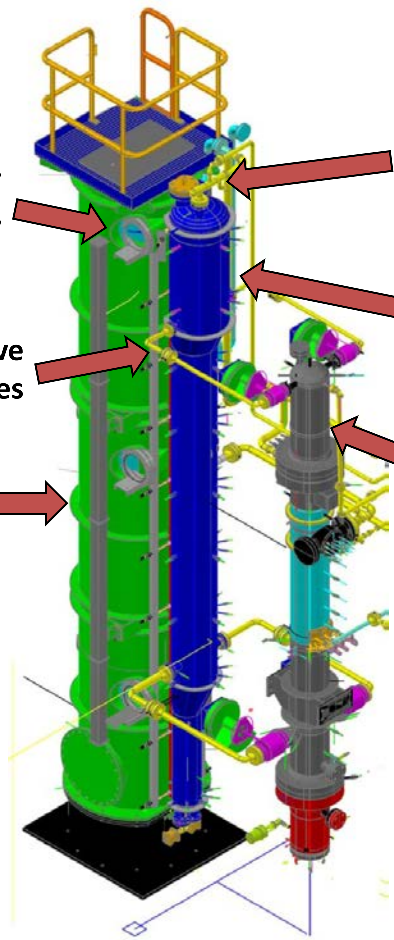
NuScale Test Programs

NuScale Integral System Test Facility (NIST-1)





Testing Capabilities/Objectives

- System interaction testing
  - reactor vessel and containment coupling (pressures and levels)
  - DHRS characterization
- NRELAP5 code validation
  - LOCAs
  - long-term cooling
  - high-pressure condensation
  - cooling pool convection
  - non-LOCA transients (scram, overheating, overcooling, NC operation)
  - CVCS line break
- Safety methods development
  - evaluation model nodalization
  - evaluation model features
  - emergency procedures
- Simulator validation

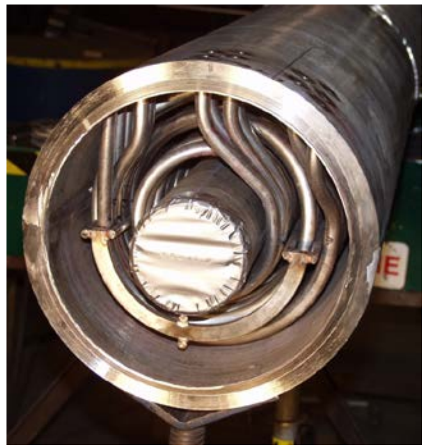
NIST-1 Test Facility

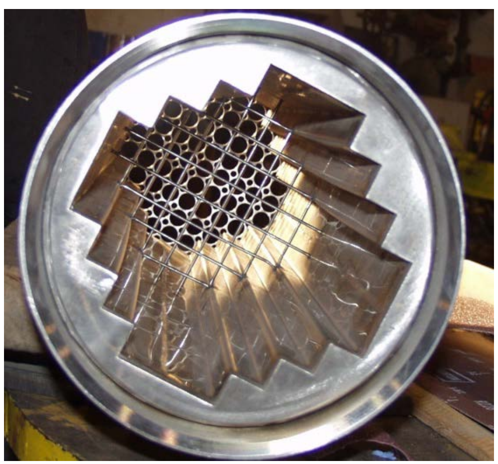
NIST-1 Test Facility

Full-length DHRS condenser test section

Reactor Pressure Vessel

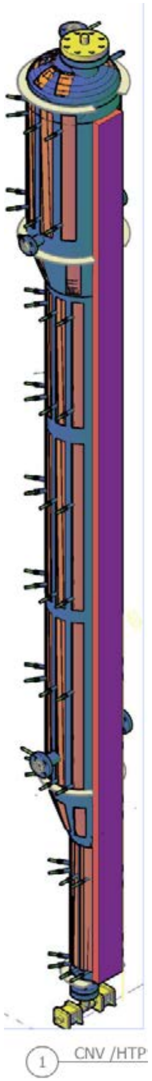
- SS304 pressure vessel built in four sections:
  - heater shell
  - lower shell
  - SG coil
  - pressurizer
- Insulated



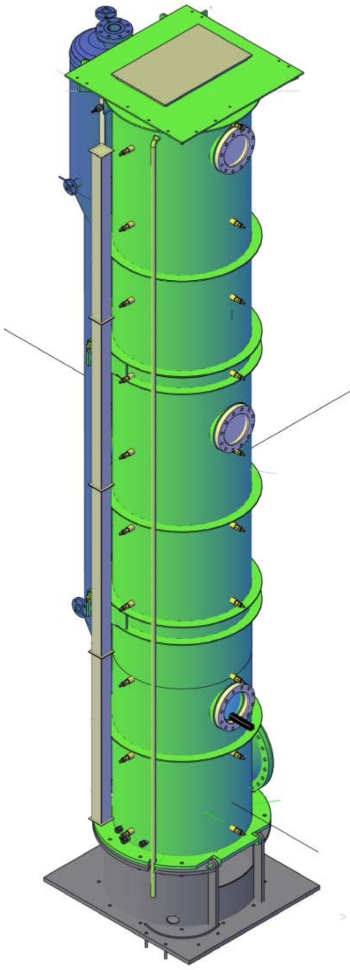


Containment and Cooling Pool

- Containment pressure rating increase
  - maximum pressure 900 psig
- Highly-instrumented heat transfer plate
  - characterize heat transfer from containment to pool



- Cooling pool view ports
  - allow particle image velocimetry (PIV) measurements to characterize local velocities near the heat transfer plate
- DHRS
  - Full-height and reduced-height DHRS to examine performance under varied DHRS and pool inventories



Data Acquisition and Control System

- State-of-the-art data acquisition and control system (DACS)
  - multi-display interface for users to monitor and control operation of the NIST-1 facility
  - interface for over 700 instruments/controls
  - visual indications of alarm conditions
  - automatically initiate control actions (trips) to prevent unsafe operations
  - log all actions and events affecting the facility
  - ability to perform precisely timed and sequenced control actions during test operations
  - prevent software shutdown if predesignated safe conditions have not been met
  - initiate facility shutdown actions if an emergency stop button is actuated

NIST-1 Tests (Critical Path for Code Validation)

Test Identifier	Test Name
NIST-HP-01	Volume and Elevation Characterization
NIST-HP-02	High Pressure Condensation (3 points)
NIST-HP-03	DHRS Full Length Characterization
NIST-HP-04	Cooling Pool Characterization
NIST-HP-05	Powered Natural Circulation Flow K Loss Test
NIST-HP-06	CVCS Discharge Pipe Break
NIST-HP-07	Pressurizer Spray Line Break
NIST-HP-09	ECCS RVV Spurious Opening

Summary

- The NuScale design
  - comprised of multiple modules housed in a common stainless steel lined below ground pool
  - each module consists of a natural circulation PWR with an integral reactor housed inside a small volume containment
  - utilizes two passive safety systems to provide stable cooling
    - DHRS
    - ECCS
- NuScale has a comprehensive test program that includes the NIST-1 test facility
  - modified to reflect design updates
  - validate NRELAP5
  - assess integral system behavior
  - testing is underway

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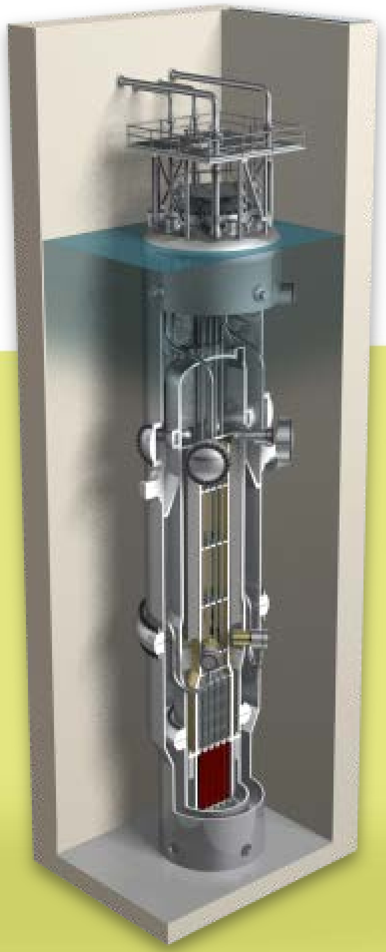
The Element of Nu



NuScale Refueling and Module Installation

Doug Bowman

Operations Engineer

June 25, 2015

NuScale Nonproprietary

Acknowledgement & Disclaimer

This material is based upon work supported by the Department of Energy under Award Number DE-NE0000633.

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Refueling Overview

- Two-year fuel cycle
- Dedicated refueling crew separate from the operations crew—including an SRO
- Once a module is disconnected, the refueling crew assumes primary responsibility

Mode Table Comparison

NuScale Draft Mode Table | Current PWR Mode Table

Mode	Title	k_{eff}	Reactor Coolant Average	Module Position	Mode	Title	k_{eff}	% Power[a]	T_{ave} (°F)
1	Operations	≥ 0.99	N/A	Operating	1	Power Operation	≥ 0.99	> 5	NA
2	Hot Shutdown	< 0.99	≥ 300 F	Operating	2	Startup	≥ 0.99	≤ 5	NA
3	Safe Shutdown	< 0.99	< 300 F	Operating	3	Hot Standby	< 0.99	NA	≥ 350
4	Transition[a]	< 0.95	< 200 F	Connected to the overhead crane	4	Hot Shutdown	< 0.99	NA	350 > Tavg > 200
5	Refueling[b]	< 0.95	< 200 F	Other	5	Cold Shutdown	< 0.99	NA	≤ 200
					6	Refueling	NA	NA	NA

(a) All CVC connections to MODULE isolated.
(b) One or more reactor vessel head closure bolts less than fully tensioned.

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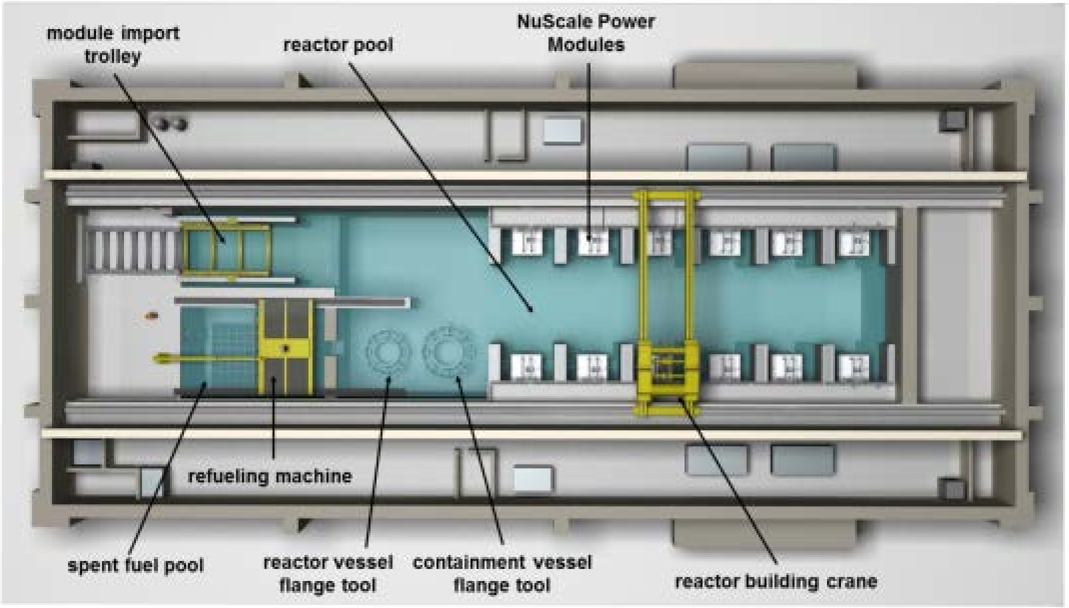
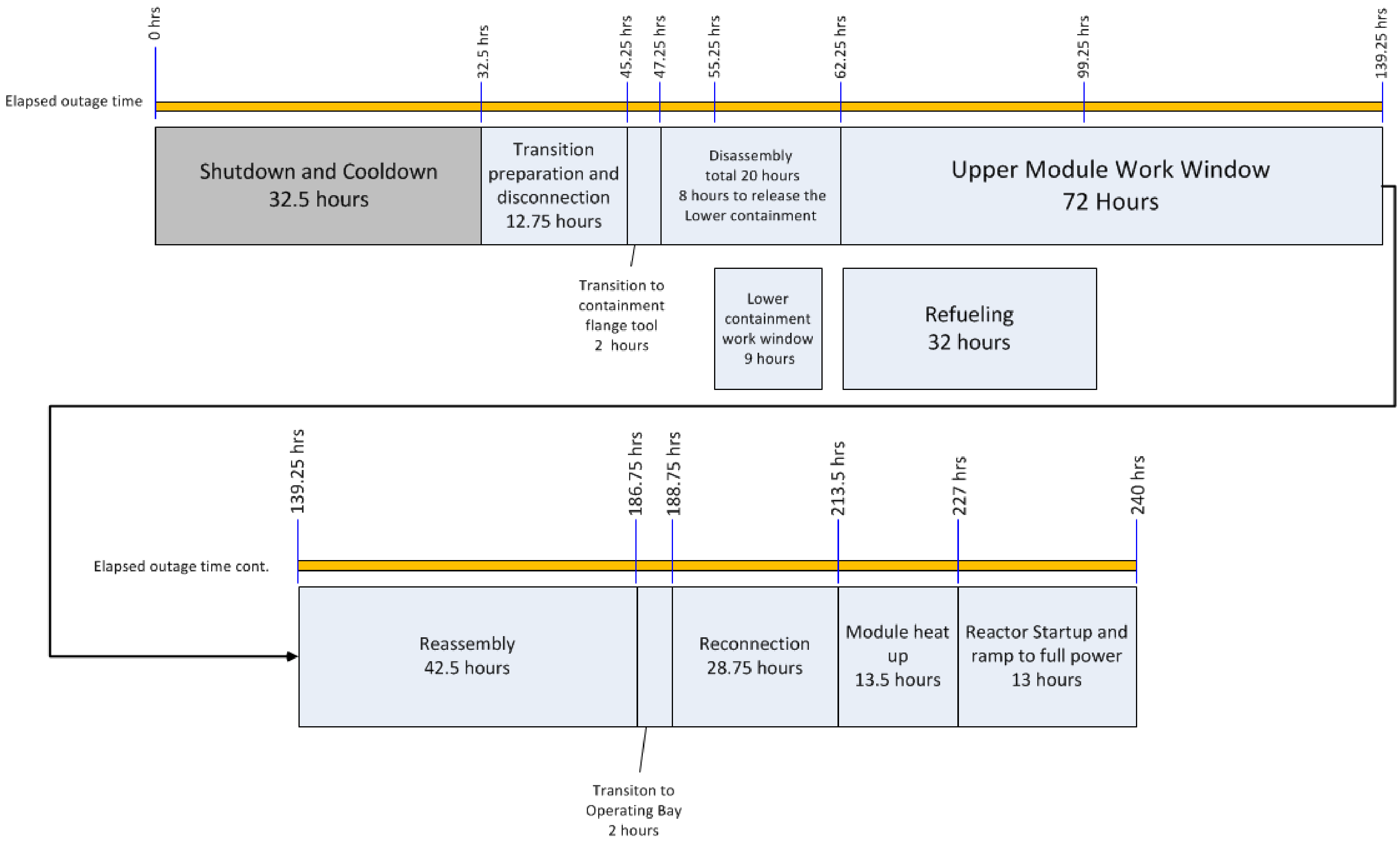
NuScale Plant Refueling



Windows

1. Shutdown/cooldown
2. Transition preparation and disconnection
3. Transition (to containment flange tool)
4. Disassembly
5. Upper module work window
6. Refueling
7. Lower containment vessel work window
8. Reassembly
9. Transition (to operating bay)
10. Reconnection
11. Module heatup
12. Reactor start-up and ramp to full power

10-Day (240 hr.) Refuel Schedule



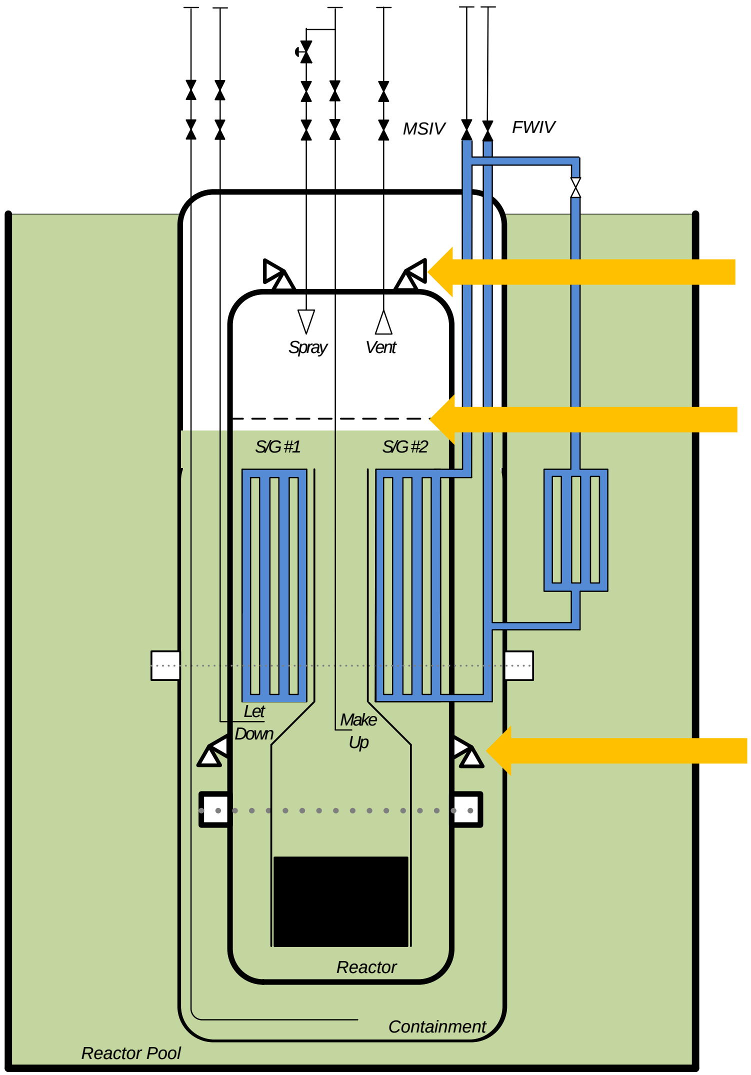
Shutdown/Cooldown

- Unit is ramped down to 20% and tripped
- Primary system is borated to refueling concentration
- Cooldown to 300 degrees F using feedwater and turbine bypass
- Depressurize the RCS to 200 psia using pressurizer spray
- Containment flooded to continue cooldown below 200 degrees F
- Steam generators placed in wet layup
- Crud burst and cleanup performed
- DHRS is not used in a normal shutdown and cooldown

Transition Preparation and Disconnection

- Shutdown CVCS
- Fully depressurize RCS
- Open ECCS valves
- Remove bioshield
- Close all containment isolation valves
- Electrical and I&C disconnections performed
- Containment is pressurized to prevent water from coming over the top of the RPV head when the CNV flange is separated
- Mechanical disconnections completed
- Crane and lifting device connected

Simplified Graphic of Module During Transition



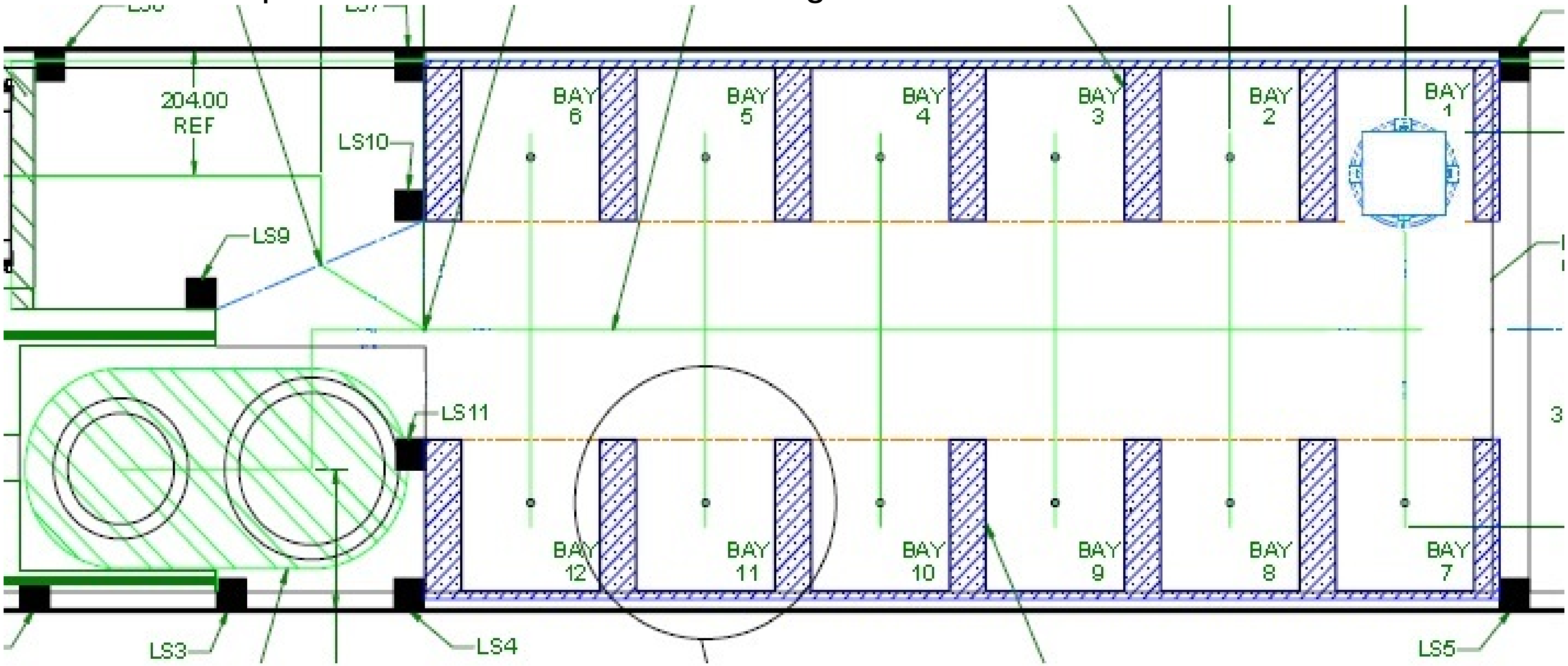
ECCS reactor vent valves

pressurizer baffle plate

ECCS reactor recirculation valves

Transition

1. Module is raised enough to clear the pool floor
2. Crane trolleys to the centerline of the pool
3. Crane travels to the lift point (just past bay 6 and 12)
4. Module is lifted 30 feet
5. Crane travels along the centerline until it is lined up with the containment flange tool
6. Crane trolleys until the module is directly over the containment flange tool
7. Module is placed into the containment flange tool



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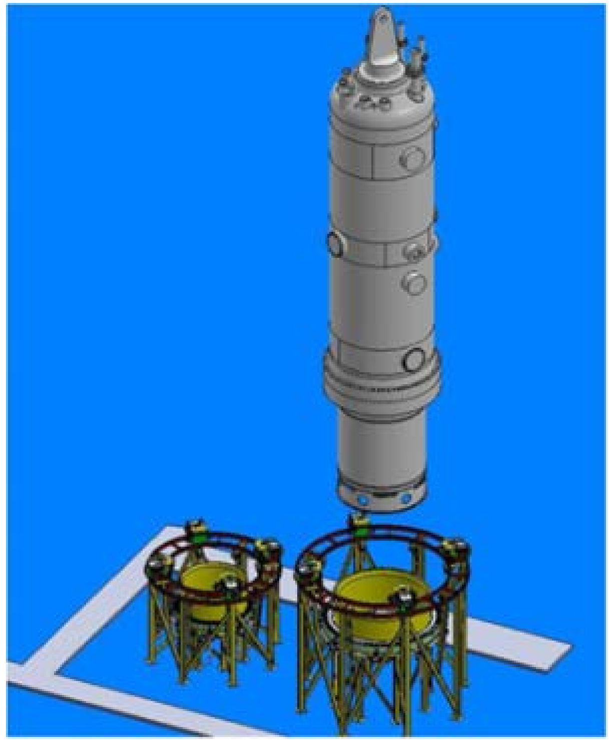
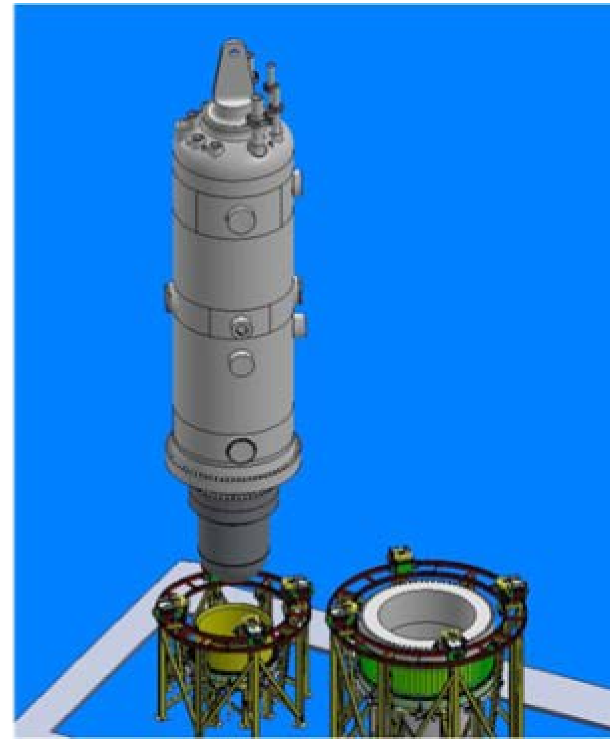
Disassembly

The containment flange tool detensions the containment flange studs and provides a stand for the containment lower vessel

The remainder of the module is picked up and moved to the reactor flange tool—where the reactor flange studs are detensioned, and then the upper module is lifted and transported to the dry dock, leaving the lower reactor vessel and the core for refueling





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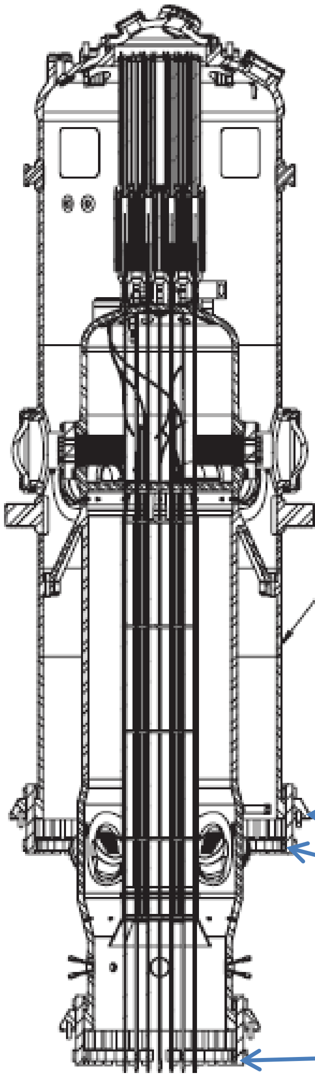
Upper Module Work Window



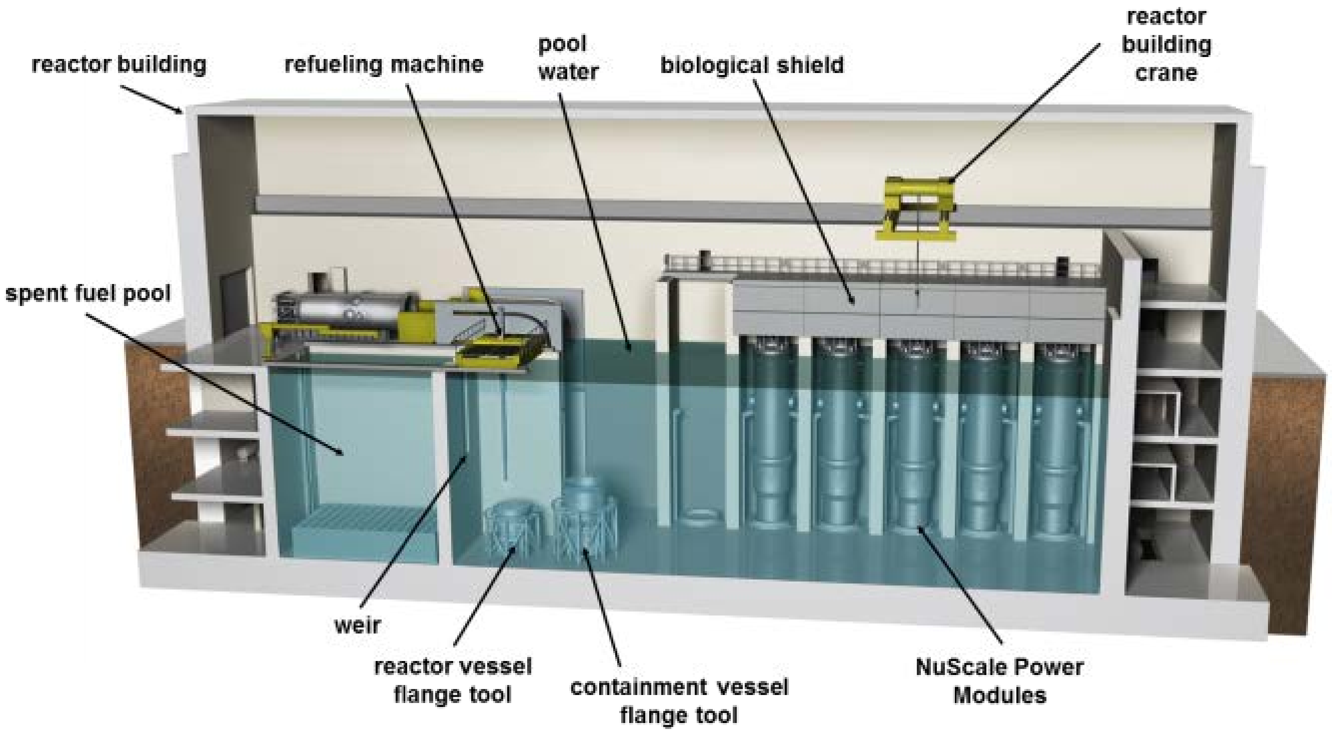
- Upper module is secured in the module upender and the crane and lifting rig is removed
- Steam generator eddy current
- Instrument testing, repair, and calibration
- Upper reactor flange inspection
- Upper containment flange inspection
- Inspect 20% of ISI welds, forgings, and surfaces
- Inservice testing (SRVs, RRVs, RVVs and check valves)
- Appendix J Type B and C testing

steam generator feedwater plenum

upper containment flange

upper reactor flange

Refueling



The 37 fuel assemblies in the lower reactor vessel can be taken directly from the core with the refueling machine and placed in the spent fuel pool.

Each assembly only requires a single handling event to take it from the core to the spent fuel storage location.

Lower reactor vessel inspections would also be performed in this window.

Refueling can be completed either as a partial core offload and fuel shuffle, or full-core offload and reload.

Reassembly

- Prerequisites
  - lower containment work window complete
  - upper module work window complete
  - refueling work window complete
- Place upper module on lower RPV and tension flange
- Connect control rods and perform latch and stroke test
- Leak test reactor flange
- Place upper module on lower CNV and tension flange
- Leak test containment flange
- The module is then moved to the operating bay following the load path

Reconnection

- Prerequisites
  - CVCS operating on recirculation
  - feedwater and condensate on long cleanup
- Connect power, instrumentation and controls
- Verify instrumentation and control operability
- Place ex-core Nuclear Instruments in their operating position
- Insert in-core instrumentation
- Connect CES and begin containment and RCS degas
- Complete the remainder of the mechanical connections
- Shut ECCS vent and recirculation valves
- Pressurize the RCS with nitrogen to provide NPSH for CVCS recirculation pumps

Module Heatup

- Establish normal CVCS recirculation
- Place module heatup system in service
- Restore feedwater and main steam and perform SG flush
- Verify containment is operable and drain containment
- Install bio shield
- Perform first dilution towards critical boron concentration
- Draw a vacuum on containment
- Draw a steam bubble in the pressurizer
- Complete dilution to critical boron concentration
- Stabilize RCS temperature at 430 degrees F
- Stabilize RCS pressure at 1850 psia

Start-Up

- Withdraw rods to criticality
- Perform physics testing
- Withdraw rods to raise power to 15% and Tave to 546 degrees F
- Remove the CVCS heater from service
- Place the main turbine in service
- Synchronize turbine generator to the grid
- Ascend to 100% power

Module Installation

- Module arrives in three parts:
  - upper module
  - lower CNV
  - lower RXV
- Module has factory ITAAC completed
- Lower CNV and lower RXV are placed in their respective tools and the upper module is placed in the import trolley, and then the following windows are completed:
  - initial fuel load
  - assembly
  - connection
  - module heatup
  - start-up

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