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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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650TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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THURSDAY

FEBRUARY 8, 2018

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Michael Corradini, Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL L. CORRADINI, Chairman

RONALD G. BALLINGER, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

MARGARET SZE-TAI Y. CHU, Member

VESNA B. DIMITRIJEVIC, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

DANA A. POWERS, Member
HAROLD B. RAY, Member
JOY L. REMPE, Member
PETER RICCARDELLA, Member
GORDON R. SKILLMAN, Member
JOHN W. STETKAR, Member
MATTHEW SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:
MICHAEL SNODDERLY

ALSO PRESENT:
DERICK BOTHA, NuScale
MARK CARUSO, NRO
DARRELL GARDNER, NuScale
REBECCA KARAS, NRO
WILLIAM RECKLEY, NRO
JEFFREY SCHMIDT, NRO

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NuScale Design Certification Application Request for Exemption from General Design Criteria 27

P R O C E E D I N G S

8:30 a.m.

CHAIR CORRADINI: Okay, the meeting will come to order.

This is the first day of the 650th meeting of the Advisory Committee on Reactor Safeguards.

During today's meeting, the Committee will consider the following, NuScale Design Certification Application Request for Exemption from General Design Criteria 27, biennial review and evaluation of the NRC Safety Research Program and preparation of ACRS reports.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, FACA. As such, this meeting is being conducted in accordance with the provisions of FACA.

That means that the Committee can only speak through its published letter reports.

We hold meetings to gather information to support our deliberations. Interested parties who wish to provide comments can contact our offices requesting time after the Federal Register Notice describing the meeting as published.

That said, we also set aside ten minutes for extemporaneous comments from members of the public

attending or listening to our meetings. Written comments are also welcome.

Mike Snodderly is the Designated Federal Official for the initial portion of the meeting.

The ACRS section of the U.S. NRC public website provides our charter, bylaws, letter reports and full transcripts of all our full and Subcommittee meetings including all slides presented at those meetings.

We received no written comments or requests to make oral statements from members of the public regarding today's session.

And, there also will be a phone bridge line. To preclude interruption of the meeting, the phone will be placed in a listen in only mode during the presentations and Committee discussions.

A transcript of the portions of the meeting is being kept and it is requested that the speakers use only one of the -- use one of the microphones, identify themselves and speak with sufficient clarity and volume so they can be readily heard.

A couple of other notes, I just want to make sure everybody silences their phones or appliances or anything so we don't have any buzzing or

ringing during the meeting.

And, also make an announcement, I very proudly would like to announce that Dr. Margaret Chu has just been elected to the National Academy of Engineering.

(APPLAUSE)

CHAIR CORRADINI: And so, we're honored to have her with us today.

Okay.

(OFF MICROPHONE COMMENTS)

CHAIR CORRADINI: That question, I'm not going to answer.

Okay, so, our first topic is the NuScale Design Certification Application Request for Exemption from GDC 27.

We had a Subcommittee meeting on, I guess, running this portion of the meeting, we had a Subcommittee meeting on --

(OFF MICROPHONE COMMENTS)

CHAIR CORRADINI: Thank you, I knew it was a Monday or a Tuesday, January 23rd, a couple weeks ago.

And, we discussed this with both the license --- the application and the staff. And so, I think we had most people there. I think three or four

weren't able to attend.

So, to most of the Committee, this will be a bit of a summary of what we heard over four or five hours.

So, to start us off, I think, Darrell, will you be the one that starts us off on this topic?

So, go ahead.

MR. GARDNER: Good morning.

Thank you, Mr. Chairman.

So, this is, as you mentioned before, a Full Committee presentation of a topic that we presented on on January 23rd.

Appreciate the opportunity to come back and speak to the Full Committee.

It will be myself and Derick Botha today. We're going to split the presentation up into pieces. So, we'll go ahead and get started.

So, just an outline of what we're going to talk about today. First of all, we wanted to get into the GDC 27 exemption. Again, the reason we're here is to support the staff's information SECY that's going up to the Commission related to our request for exemption on GDC 27.

We'll spend a little bit of time talking about the design in terms of the reactivity control

systems, again, a high level.

We'll talk about the exemption review criteria that we've looked at and some design evaluation overviews that we've done today.

And then, of course, a summary of the key points at the end.

I would like to point out, as we spoke the last time, that the Full Committee hasn't yet had the opportunity nor the Subcommittees to look at the entire design of the NuScale design. So, we're out in front of that normal review process with respect to this exemption.

So, many of the things we're going to talk about is going to necessarily be at a high level before we've had the time to get into lots of details on the design. That will be forthcoming as we get into the review of the rest of the application.

So, with that said, so, with respect to the GDC 27 exemption, as we mentioned the last time, so there is the possibility, low likelihood, of a return to power condition with very limited assumptions and conditions.

That's generally driven by the passive cooldown nature if the NuScale design to low RCS temperatures. We don't have these whole points at hot

standby, hot shutdown the plant through a transient with no power is going to cooldown.

MEMBER MARCH-LEUBA: By very limited conditions and assumptions you mean low probability or what do you mean by that?

MR. GARDNER: Yes, so it's -- so, and Derick's going to get into that in a little bit more detail, but it would be --

MEMBER MARCH-LEUBA: I'll wait.

MR. GARDNER: Okay.

MEMBER MARCH-LEUBA: Thank you.

MR. GARDNER: So, again, as I mentioned before, the focus here is really against these criteria of how you would evaluate such an exemption to the GDC.

I will say that NuScale looked at this as part of our design review when the condition was identified. And, we did not identify a need to take an exemption from the GDC. Okay?

Our understanding of the language is that the design approach would satisfy the GDC as it's currently written.

Our legal team went and did some reviews in this area and they determined that similar considerations were made back during the original

drafting of the GDCs. In fact, some of the original draft language included language related to subcritical, the industry comments questioned that and the language was changed to the language that you see today.

And, which we believe sort of suggests that the Commission considered this and intentionally made a change in the language.

Nevertheless, we believe that the design is consistent with both the literal language and intent of those GDCs as finally published.

We did submit a white paper on this subject in 2016. And, I think that you've had access to review that paper.

Key points in the paper that there are two functions that we believe are principally addressed by these GDCs. And, that's a protective function and a shutdown function with GDC 26 and 27.

And, we think those are separate issues and language, and GDC 26 brings out that specific shutdown function.

CHAIR CORRADINI: So, can we just -- so, from the standpoint of you and the staff, 26 is satisfied and the reason is? Or, not satisfied, but it does not require an exemption and the reason is,

again? Can you just repeat what you just said that I understand it properly?

MR. GARDNER: Well, I'll probably let the staff speak to that when they come up.

CHAIR CORRADINI: Okay, fine, fine.

MR. GARDNER: That has not been an issue so far, it's just been the language of 27.

CHAIR CORRADINI: All right, thank you.

MR. GARDNER: Okay, so, again, during the staff review of a document that we submitted during pre-application called the gap analysis, the staff reviewed that and took a position that an exemption from GDC 27 was necessary. And, they cited their reasons for that need.

So, again, as part of the application development, we prepared an exemption from the GDC.

I would like to point out that whether or not exemption is required, I know there was some discussion about that at the last meeting, that we believe the design solution and the safety demonstration are not changed by whether or not an exemption is necessary. It's the same outcome.

Also, there was some discussion about, you know, the need for a PDC versus a GDC. And, we simply wanted to point out that the language in 10 CFR 50

Appendix A does direct the applicants to define principle design criteria for the design and with respect to design basis.

So, I know there was some discussion about that in the past. And, hence, we have proposed a PDC that's provided here on the slide. The principle difference being one is that our system doesn't have poison edition through the ECCS system language which we removed. And, the addition of the second paragraph that's specific to how we intend to satisfy the design basis with respect to maintaining the reactor subcritical.

MEMBER KIRCHNER: Just a question, Darrell.

Are you also planning on submitting something that's different than the current GDC 34 which was ECCS system performance?

MR. GARDNER: So, what I remember is we've taken exemption from a number of GDCs. I'll have to look that up but I think 33, 34.

MEMBER KIRCHNER: Have you --

MR. GARDNER: I think it's more related to testing.

MEMBER KIRCHNER: Have you also filed for an exemption from 34 or you are proposing a PDC that's

different?

I understand your design is different, I get that.

MR. GARDNER: Could I look that up on the break and get back to you?

MEMBER KIRCHNER: Thank you.

CHAIR CORRADINI: If I may, just to reflect on what we said in the Subcommittee, so our focus today is 27, we might want to clarify other things. And, in particular, the SECY which identifies the criteria staff is going to consider in evaluating the exception request.

MR. GARDNER: That's correct.

MEMBER KIRCHNER: But, I would just observe, Mr. Chairman, that piecemeal -- the GDCs, the intent at least, is a system of principles that provide defense in depth and some assurance of protecting the safety and health of the public.

And, a number of these GDCs interrelate with each other. For example, 34 presumes that you are shutdown. You only have decay heat to remove.

So, it's a system, it's not just piecemeal legislation of things that you pick and choose as you would like.

MEMBER SKILLMAN: Darrell, the second

bullet in your PDC surgically identifies the control rods. And so, as that bullet is written, it would be difficult for anyone to argue with you in that standing. The control rods will keep the thing subcritical.

The real issue is, at least in my perspective, after an AOO, the control rods and the other system ensure that k-effective is less than one and it stays there.

In the interpretation that you're using, you've basically said, let me back up, you've communicated that shutdown on a hold down are not required. It's simply not exceeding the SAFDLs, the fuel limits.

And so, in this PDC, in your PDC 27, you've really avoided fully addressing shutdown and hold down except to the extent that your control rods will give shutdown.

And, I don't think any of us can argue with that.

But, the larger principle is absent and I think at least that's what's driving my angst here.

MR. GARDNER: Sure, I think I would say that it's a combination of how we satisfy GDC 26 and 27.

MEMBER SKILLMAN: I agree with that.

MR. GARDNER: So, Derick had some comments on that.

MR. BOTHA: Yes, and I think --

CHAIR CORRADINI: You need to go green.

MR. BOTHA: And, I think what I, too, just to add on GDC 26 and the language, we're not focusing too much on that today because the exemption is on GDC 27.

But, we did quite a bit of review of the history behind the GDCs and that's described in the white paper and the way that the draft GDCs changed to the final GDCs and how they're changed is not thoroughly documented, but you can go and look at the original language. I've done that. And, the original language used the word shutdown for all the function.

And, the comments from industry was specifically from Oak Ridge, and that's mentioned in the white paper, that when you look at the functions with regard to activity control, you need to distinguish between dynamic reactivity control, so that's to certain negative reactivity.

It does not necessarily relate to shutdown but it relates the function of predicting the fuel. You need to distinguish between that and the margin

that you need to establish for that and you need to separately look at the capability to maintain the core subcritical.

So, previously, if you look at the shutdown function under cold condition, it just had in the draft GDC's language to say, well, you just have to have some margin. They took that out and just said, well, you just have to be subcritical and there's no mention of having margin with a stuck rod and the GDC 26 language.

And, that's -- so, based on the comment and the changes, the intent there was, well, when you look at the important function which is to protect the safety of the fuel, there you have to -- and, specifically, the rapid shutdown function.

There a shutdown -- assuming a stuck rod is important because if one rod comes in slowly before it's on board, you may not get any reactivity as fast as you need to to protect your fuel.

So, that's -- that was the reason, at least the way we interpret it, to look at those distinctions.

So, we would say that that distinction is intentional and that our designs -- if you look at our designs with all rods inserted, we can maintain the

core subcritical under all conditions.

So, we would say we meet both of the exempt and the literal language of that GDC 26.

And, I don't know if that answers your question.

MEMBER SKILLMAN: Well, it certain is an explanation that I understand. But, the conclusion that you end up at is where I depart from agreement. And, I hold very tightly onto your evaluation, it's on page 14 of your white paper.

And, these are the words that caused me the greatest angst.

Regulation of low probability events with no safety consequences such as the unlikely potential for a benign return to power would be inconsistent with past resolution and issues.

And, I would say, I don't agree with that at all. I believe through our history, there has always been the idea you might have a return to power for a transient, I concur with that.

But, not for the long-term and certainly not a return to power that's neither monitored nor controlled. And, the idea of a benign return to power is kind of like, in my mind, a benign root canal.

It has substantial importance. And, when

we see the NSSS vendor say, we can have a criticality. It's really not so bad because the fuel cell heat, I must tell you, I am alarmed.

And, in this Committee, I'm speaking for myself, that, to me, provides conflicts on your second bullet because it says to me, okay, NuScale is saying we can drive with subcritical with rods, that's dandy. I would like to be assured that with the rods and whatever else you have, you not only ensure its subcritical, but it's stays there.

And, I don't see that coming out. You're claiming it's in 26, I'm saying 27 is related to it. And, when you make the case that you're protecting the fuel, I would say, you're counting on decay heat to produce voiding to ensure shutdown.

So, you're going for fuel limits, not hold down. I think 27 really intends that this machine be shutdown, not just protect the fuel.

And, I believe that that is there from the six or seven criterion from the original 1967 criterion. I believe they were carried over into the 70 general design criteria, which are the ones that we see today.

So, I'm -- I guess I'm calling out on that second bullet because, by surgically identifying rods,

I would say, yes, I'm sure, if all your rods are working, you'll go subcritical. If they're not, maybe not. And, you don't, in my view, have a back up that is proof certain driving subcritical. Okay?

MR. GARDNER: We can appreciate the comment.

I would just say, I think you're raising the matter of policy which is the basis behind why the staff is proposing the information SECY to the Commission to get that policy question addressed.

MEMBER SKILLMAN: I've stated my case.

MR. BOTHA: And, I think there may be -- when we go to the design evaluation, there may be some of the information there that can provide additional context to explain why the design as is is more than the additional certainty than you -- that you would require for that function. But, I think that's going to come later in the presentation.

MEMBER SKILLMAN: Okay. And, just looking ahead --

MR. BOTHA: But, I appreciate --

MEMBER SKILLMAN: Looking ahead, you may be right. But, I will tell you, for a core that's depending on natural circulation with a rod stuck out and potentially with uncertainty about geometry, the

flow rates that are necessary to homogenize and get the boron concentrations you need, and the numbers I'm stuck on, are about a 100 ppm of percent delta-k/k.

For a 2 or 3 percent rod, you need an increase in 200 to 300 ppm boron to achieve the shutdown.

And, I've lived that life at TMI 2, we didn't know what we had. We were depending on natural circulation. Thank heaven we had a reactor cooling pump to make sure that we had homogenized boric acid concentration.

You have no such mixing capability. So, I've thought this through pretty clearly and I think there are some weaknesses and they're certainly not identified in your current Chapter 15 analysis. Those are the only analysis that were provided to us.

MR. GARDNER: So I understand the question, I would say that -- so, some of the details that you're talking about would be things that we would get in as we get into those detail system design description and analyses that are going to come during the chapter review.

MEMBER SKILLMAN: Then --

MR. GARDNER: We're not really prepared to get into that level of detail --

MEMBER SKILLMAN: Then, are we --

MR. GARDNER: -- here.

MEMBER SKILLMAN: -- premature in trying to work our way through this?

MR. GARDNER: Well, I think the question we're looking at today is whether these are the appropriate criteria to consider. And then, how those criteria satisfy will be answered during subsequent reviews and when we bring the chapters that demonstrate how we've addressed those criteria.

MEMBER REMPE: So, I wasn't --

MEMBER SKILLMAN: Thank you.

MEMBER REMPE: -- at the Subcommittee meeting, but I did read the transcript, which doesn't make me an expert.

And, one thing that puzzled me, because really, this is something that is -- when you get into the SECY and what the Commission is going to decide on, it's not just your reactor design and all the details, it's a policy change, as you mentioned.

And, the staff has two criteria they're asking to have met is how they're going to evaluate your exemption.

And, your slides today don't discuss those criteria at all. And, I will be discussing with the

staff, too, and asking them.

But, because how the staff looks at those criteria, I'm puzzled if how much margin they're going to want. I mean, basically, they're going to rely more on your ability to assess the frequency of such events. Right?

And, how much data that they want to have certainty that you're not -- with respect to the long-term cooling being satisfied.

And, have you discussed with the staff, do you understand what you're going to have to meet if you have to go through with this exemption? And, are you comfortable with it?

I mean, have they conveyed to you how much uncertainty you're going to have to meet these criteria with? I mean, I was looking at this, I was going, oh, be careful what you ask for here because you may decide it may be difficult to meet those criteria.

And, those criteria may, you know, they're going to have to apply them if somebody else comes in with a design, Joe's reactor, and I'm just -- I was puzzled that no one discussed that during the Subcommittee meeting.

MR. GARDNER: Sure.

A couple thoughts. What is the exemption request is specific to NuScale and the PDC would be specific to NuScale. So, it's not a change to the rule for GDC 27, it's --

MEMBER REMPE: But, somebody else can follow along.

MR. GARDNER: They would have to pursue a similar process for exemption request and/or rule making so it's not --

MEMBER REMPE: And, how much uncertainty the staff allows with your concept and how much margin, how much data they require, all of those things will set precedent for future reactors.

And, I just was curious, have you discussed with them? Do you understand what you're going to have to meet if they come in there and you feel comfortable that those margins are going to be appropriate and not a burden?

MR. GARDNER: Certainly it's under review now. I don't think the staff has progressed far enough to reach a conclusion. I'll let them speak to it when they come up.

But, it is under review and we're having those kind of dialogues as we speak.

MEMBER REMPE: And, it doesn't cause you

any heartburn, huh? Not at all? Okay.

MR. GARDNER: Not today.

MEMBER REMPE: Okay.

CHAIR CORRADINI: I think Joy is asking in a polite way, I hope you understand what you're getting into.

MEMBER REMPE: Be careful what you ask for.

MR. GARDNER: I think we heard that admonishment at the Subcommittee meeting.

CHAIR CORRADINI: Okay, fine. Okay, good.

Proceed.

MR. GARDNER: Okay, that's all I had, so I'm going to turn it over to Derick to get into some -- a little bit of overview of the design.

MR. BOTHA: Yes, just, before I get into that, a little bit of my background for Full Committee.

Prior to NuScale, I worked at PBMR in South Africa. I spent about 10 years there and I've got about 7 years under my belt at NuScale. I'm the Innovation Manager at NuScale.

But, I've also got quite a bit of experience -- technical experience -- in thermal systems modeling and safety analysis as well as on

licensing. So, I helped with putting the design certification together and also worked on -- did some extensive work on this topic.

Just before I get started on this slide, how much time do we have left for this session?

CHAIR CORRADINI: We have about 30 minutes.

We will allow you another 30 minutes.

MR. BOTHA: Okay.

CHAIR CORRADINI: For the NuScale presentation.

MR. BOTHA: Thank you.

CHAIR CORRADINI: No problem.

MR. BOTHA: So, just very briefly, an overview of the reactivity control systems and also specifically with this issue.

So, we have two reactivity control systems that's most relevant to this topic. There is -- we have -- also, before I get into these two, we also have containment flood and drain system through which you can also add boron and water is also is a non-safety related system, but these are the two we use most of the time during all operations.

MEMBER STETKAR: Derick, we haven't received all of the detailed information about the

design.

You've mentioned in the paper, and you just mentioned it also, the cavity flooding and drain system.

Is that connected to what you call the CVCS in your plant? In other words, is it --

MR. BOTHA: No, no, it's a completely --

MEMBER STETKAR: It's a completely separate --

MR. BOTHA: Completely separate system.

MEMBER STETKAR: Thank you, that's all. Thanks.

CHAIR CORRADINI: It was an internal discussion point. Thank you.

MR. BOTHA: Okay.

And, there's some redundancy in the CVCS system as well.

MEMBER STETKAR: I just wanted to -- thank you.

MR. BOTHA: Okay.

So, the safety related system we have is our control rods. And, that enables us -- we certainly use it during normal operation for boron control, but that enables us to rapidly shutdown the reactor. That's our safety related system.

But, also, enables us to keep the reactor shutdown with all rods inserted under all conditions.

And then, we have our CVCS system that's on one safety related system during normal power operation that enables us to control our reactivity balance and make sure we have enough shutdown margin so you don't have your rods inserted too deeply.

And then, also, if you shutdown, it provides you the capability to provide additional shutdown margin. And, obviously, we'll get into the stuck rod discussion.

So, those are the two systems we have.

Now, if you look at the --

MEMBER KIRCHNER: Derick, may I interrupt now at this minute?

So, during our Subcommittee meeting, when you talked about your design and your approach, you inferred, I believe, and the transcript will reflect how you answered my question, that you didn't want to have extra penetrations of containment or the reactor vessel.

But, clearly, the CVCS system does penetrate both vessels. Certainly, that part of the system inside the reactor, I would assume, is safety grade, quote, unquote. But, we haven't seen the

details.

So, you are calling this a non-safety grade system, the CVCS?

MR. BOTHA: That's correct.

MEMBER KIRCHNER: And, the reason is, you do not want to have -- this is a system that needs power?

MR. BOTHA: That's correct.

MEMBER KIRCHNER: And, therefore, you would need Class 1-E power to run the system?

MR. BOTHA: That's correct.

If you wanted to rely on it from a safety perspective.

So, I -- go ahead, I think you had --

MEMBER KIRCHNER: Well, at least from my vantage point, and it shows that the GDCs are open to wide interpretation.

The idea of having two independent and diverse systems, I've always felt were presumed, perhaps, incorrectly that these, to the extent that they were relied on to achieve the objectives of the GDCs would be safety class systems.

MR. BOTHA: No, not for the existing fleet.

And, but, I think there's two questions

you had there. One was regarding the penetrations, the other one --

MEMBER KIRCHNER: Yes.

MR. BOTHA: -- was regarding the GDCs.

And, I think maybe the staff can answer your question on the GDCs with regard to other designs.

MEMBER KIRCHNER: Yes.

MR. BOTHA: But --

MEMBER KIRCHNER: Maybe put that aside, but I -- you do have a system that does -- you went through your design options and thinking, and I thought I remember you saying distinctly we decided we didn't want further penetrations of the --

But, indeed, the CVCS system has to do that to get the boron injection where you need it.

MR. BOTHA: So, I'd like to respond to that and I'll give you a short answer now and then I want to give the rest of the answer as part of the next bullet or the point here on the slide.

So, the first point, before I get to the next point that you just have to keep in mind while I provide this answer is the way our safety systems work in our ECCS worked is either when you get into a situation where you don't have power or if you respond

to IO events and it's -- if independent, what your safety system or your protection system would do is isolate containment.

MEMBER KIRCHNER: Right.

MR. BOTHA: So, those isolation valves would actuate so you don't have to rely on those external piping and, obviously, the power that powers the system.

But, I'll provide the rest of the answer in terms of that should give you some context of what we meant with additional penetrations.

So --

MEMBER KIRCHNER: So, with these -- maybe this is perhaps, I guess we have a Subcommittee meeting with NuScale to look at -- coming up.

CHAIR CORRADINI: On the 20-something.

MEMBER KIRCHNER: Yes, this might inform the discussion.

Let me hold off on that.

MR. BOTHA: Of course.

MEMBER KIRCHNER: Okay, keep going, sorry.

MR. BOTHA: So, for the -- so, if we look at our design holistically and our design approach, is we wanted to design a system that is passively safe, doesn't depend on power. So, it relies on passive

systems for critical -- to perform the safety functions. That's our overall design philosophy.

And, you've sort of seen a little bit of that when we looked at the topical report that we provided on not having any 1-E power systems for our design. So, I think that's been presented to you, to the ACRS.

So, with that in mind, if we want to maintain that design philosophy and we want to provide addition reactivity control means, the way you would do that is with a passive boron injection tank.

And, the sensible way to do that is that tank has to sit outside of containment and you'd have to have a dedicated safety related line that penetrates both of the vessels.

So, that was really to provide you context for the previous comment we made for additional penetrations.

And, the comment we made along with that is, that's additional systems. It's additional complexity to the design. And, introduces additional failure modes.

But, I think the more important point with regard to adding such a system is, you're not measuring -- you're not measurably increasing the

safety of the design. In fact, you could argue you're decreasing it because of the additional failure modes.

But, I'll get back to that under the design evaluation.

I think with regards to our reactivity control systems, so, in terms of what we rely on in terms of safety is primarily the control rods.

Now, that's different from the existing fleet in several respects, but the one is, for the existing fleet, they rely on adding additional water for a number of events, so specifically, your LOCA type events, and that's part their ECCS function.

And, as part of that injection capability, they're adding boron.

So, we don't have safety injection as one of the functions of our ECCS system. All right? So, that's not how we designed the plant. So, that's a significant difference.

I think the other difference that Darrell also alluded to is, when we use our passive heat removal systems, the system naturally cools down for a large reactor, if you look at non-LOCA type events for PWR, you can control the cooldown and stay at this hot shutdown condition.

But, I think more importantly, for them to

get to a cold subcritical condition consistent with GDC 26, you need two systems for a traditional PWR. You need your rods for your rapid shutdown function to protect your fuel.

And then, once you've got your rods inserted, you also have to add boron to get to that condition.

So, you need both systems to get there.

For the NuScale design, you can get there with either system. So, we provide redundancy over and above what the PWRs provide.

So, that's not saying that there unsafe at all, that's just saying we've added additional capability because of the way we've increased our -- the capability of our -- because of the fact that we've increased the capability of our rods.

So, that's an important distinction.

So, for us, the control rods alone can maintain shutdown for the complete RCS temperature range.

So, with regards to --

MEMBER SKILLMAN: I'd sure like to challenge that. I operated a number of fuel cycles and we started at 1800 ppm, pulled rods, went critical around 1500.

MR. BOTHA: Yes.

MEMBER SKILLMAN: And, out 695 days, we were at 10 ppm boron. We almost to zero.

MR. BOTHA: Yes.

MEMBER SKILLMAN: When we shutdown, we shutdown with control rods.

MR. BOTHA: That's correct.

MEMBER SKILLMAN: And, it stayed shutdown.

MR. BOTHA: At hot conditions?

MEMBER SKILLMAN: No, well --

MR. BOTHA: At hot conditions?

CHAIR CORRADINI: That's his point. It didn't go cold.

If you went cold, it wouldn't, that's his point.

MEMBER SKILLMAN: I got it.

MR. BOTHA: So, with --

MEMBER SKILLMAN: No, wait, with all rods in, I can be cold in subcritical.

MR. BOTHA: Not with the PWR. With a BWR, but not a PWR.

MEMBER SKILLMAN: Tell me about it, how you refuel a P? All rods in, cold.

CHAIR CORRADINI: You inject boron later. You have to re-boron.

MEMBER SKILLMAN: Okay, all right. Okay, not just --

MEMBER STETKAR: Depending on how you get it in and what you get it in with, but you put boron in.

MR. BOTHA: And, I think --

MEMBER SKILLMAN: Clear in my mind.

MR. BOTHA: And, to add to that, so --

CHAIR CORRADINI: And, there's a failure mode associated.

MR. BOTHA: -- there's a whole, I don't want to get off track here too much -- there's a whole -- there's several safety issues that were discovered with the PWRs under best heat removal.

So, with the cooling down with natural circulation, and the means they get there with subcritical is with a non-safety related CVCS.

That is the stock standard way you get to a cold shutdown condition with a PWR, is with a non-safety related CVCS.

And, that's not submitted as part of their FSAR, it's additional documentation that's on there as part of their licensing basis. So, that's not even evaluated as part of the safety evaluation for their licenses.

And, that additional documentation was because of these additional issues that was identified by the NRC.

MEMBER SKILLMAN: Okay.

MR. BOTHA: So, a little bit more just to provide context with regards to the stuck rod condition.

So, because we've got a small core and the number of control rods we have, each of those rods, so you're going to have the same number of rods as a large PWR, each one of those rods is worth a lot more.

So, if you have one of them stuck out, that's a lot of additional negative reactivity that's not there.

So, because of that, there's a limited state of condition that you could see where you could have a return to power.

And, we've analyzed that in terms of the number to understand the conditions under which this could occur, we've used our best estimate methods to determine when this could exactly occur. And, we're going to talk a little bit later in the presentation about best estimate versus conservatism as to deterministic. So, I want to defer that.

But, to characterize when this could

occur, as I mentioned before, immediately, even with a stuck rod, you will go -- you will immediately shutdown the reactor. It's only when you start cooling down.

So, we'll firstly, to sort of characterize it, stay shutdown if you have all rods inserted. If you do have a stuck rod, it only happens in the large -- latter portion of your refueling cycle.

And, the reason is, for the first 70 percent, your boron concentration is high enough that, as you cool down, you're actually concentrating boron because of the increase in your moderate gains. So, then you would stay shutdown for the first fuel cycle.

Then, if you do get into this condition but you've shutdown. You've got a stuck rod and it's late in cycle, it can only happen if you don't have your CVCS system available.

So, that means either you don't have to have power, and we mentioned flood and drain systems that you could also use, so that also doesn't have to be available.

Now, if you're in that condition, you don't have power, CVCS isn't available and it remains available for a very long time, which is very improbable, then what would happen is typically late

in cycle, you would have decay heat and that'll generate enough boiling so that you'll stay shutdown for a very long time.

So, we're talking for more than 30 days.

Now, really, what is not unique, if you look at a large break LOCA, PWRs don't create a rod insertion for a large break LOCA. They rely on boron injections as part of the ECCS.

And so, for the first portion of that transient, the means that they're allowing for shutdown is boiling. So, it's not a -- and it's physical, so it's actually it's not a -- it's a well understood condition if you produce heat and water boils.

And, that reduces the density of your moderator.

MEMBER REMPE: So, your reactor is smaller, but do you have any data needs that you have identified to support some of this high level qualitative response that you're giving us today?

I mean, have you gone through and said, oh, yes, to support some of these things, we know we'll need to get X, Y and Z data?

MR. BOTHA: So --

MEMBER REMPE: Not typical of the --

MR. BOTHA: So, you're talking about --

MEMBER REMPE: -- differences?

MR. BOTHA: So, that's really in the neutronic analysis. And, I'm not -- that's not really my area, so I can't answer that. All I can tell you is that the physics that underpins that and so the reactor physics and the codes and the methods they use is all closely related to the PWRs that's operating.

And, in the areas that where we are different, that's well quantified and that's evaluated as part of the review of the application.

But, in terms of the specifics of how they model it, especially on the neutronics side, but on the thermal hydraulic side, I mean, it's just --

MEMBER REMPE: The passive response, everything you feel like you've got data to support --

MR. BOTHA: That's right.

MEMBER REMPE: -- your validation? There's nothing unique about -- because we haven't looked at the design details themselves --

MR. BOTHA: Yes, so --

MEMBER REMPE: -- but I just was curious if you --

MR. BOTHA: So, we have --

MEMBER REMPE: -- identified a couple of

things, oh, we've got to get data to support that or something?

MR. BOTHA: Yes, and we have on this program, we have it on this facility. You'll get into all of that with --

CHAIR CORRADINI: If I might just interject.

MR. BOTHA: Yes.

CHAIR CORRADINI: So, for the Committee, we have a two-day session scheduled in the Subcommittee, a week in March, to understand the system completely.

And, on May the 15th, we have a Subcommittee meeting on codes and critical heat flux for the design.

MEMBER REMPE: I understand that and I understand that this is really the policy decision, but I'm just curious, with the policy decision, are there going to be some data needs?

And then, again, how much uncertainty do you have to have with some of the data needs and --

CHAIR CORRADINI: But those are -- that's -- I think those are the logical places to bring it up. The main one is --

MEMBER REMPE: Yes, well, with the staff

--

CHAIR CORRADINI: -- talking --

MEMBER REMPE: -- though, is where I'm curious on it.

CHAIR CORRADINI: Okay.

MEMBER KIRCHNER: Derick, may I quickly ask, what's the typical boron concentration at beginning of life and then at end of cycle? You do rely on boron, right?

MR. BOTHA: Yes.

MEMBER KIRCHNER: Throughout the whole --

MR. BOTHA: Yes, and --

MEMBER KIRCHNER: Your earlier comments might have inferred that you don't rely on boron for --

MR. BOTHA: No, no, so --

MEMBER KIRCHNER: -- for shutdown control.

MR. BOTHA: So, I can answer the second part of your questions, not the first part.

MEMBER KIRCHNER: Okay.

MR. BOTHA: So, what we mean with we don't rely on the CVCS inserting boron, if you have an event --

MEMBER KIRCHNER: During the event?

MR. BOTHA: -- you --

MEMBER KIRCHNER: Yes, I got that part.

MR. BOTHA: So, you do -- so during normal operations, certainly, you rely on boron and change the boron concentration.

MEMBER KIRCHNER: Okay, thank you.

MR. BOTHA: So, that gives you a high level overview of our reactivity control systems and this condition where we could realistically expect to see a return to power.

So, that, I think, brings us to the next part of our presentation is the criteria.

So, how do I know it's safe? So, specifically, with regards to the exemption and the review criteria that the staff's going to get more into this, but, what I have here is the GDC 27 perspective.

So, for GDC 27, that's really covers postulated accidents and the key criteria that we would look at from a GDC 27 perspective is are you able to cool the core? Right?

So, it's core cooling, that's what's required by the GDC 27.

And, the review criteria in Chapter 15 for that is whether you stay below your peak cladding temperature, okay, so that your geometry of your fuel

needs to be such that you allow for cooling or coolant to flow through the core.

You don't want to damage your fuel to the extent that it prevents core cooling. That's really the address behind core cooling with regards to GDC 27.

So, if you look at the review criteria that the staff are proposing, and they're proposing maintaining CHF limits. So, maintaining CHF limits is more limiting than peak clad temperature because you're maintaining CHF limits, the core has to remain covered.

But, not only that, the heat load needs to be low enough that you wouldn't exceed your CHF limit. So, you wouldn't even come close to challenging your core geometry in terms of core cooling.

MEMBER POWERS: Let me ask you a question.

MR. BOTHA: And this -- go ahead.

MEMBER POWERS: You're talking about a situation, something's gone wrong and you're saying, okay, this is wonderful and whatnot. You have not raised the issue of risk, the conditional risk, when I'm in this situation at all.

If something has gone wrong, it seems to me plausible that something else goes wrong.

And so, what is the conditional risk associated with this particular state?

MR. BOTHA: When you're in this condition, when you have a return to power.

I cannot give you the detailed answer, I can only give you the high level answer in terms of when we go and look at those type of conditions, we do that as part of our PRA and that certainly feeds into our safety analysis to identify what could go wrong under different conditions.

But, from a PRA perspective and looking at all the failure modes, we certainly identify all the plausible paths that leads to core damage.

And, under this condition, I think the one detailed answer I can give you, when you're down to a 100 kilowatts of heat, you don't even need ECCS flow to keep -- to provide heat removal because your heat production is so low that you can remove heat through conduction through your two vessels.

So, each --

MEMBER POWERS: That one I never believe because they never take into account the contact resistence when they do those analyses.

MR. BOTHA: For the contact resistence for --

MEMBER POWERS: When you go try to transfer heat through any boron removal, there's always contact resistence.

MR. BOTHA: On these two --

MEMBER POWERS: That somehow never gets taken into account.

MR. BOTHA: But, on these two --

MEMBER POWERS: And, it's only getting worse, by the way.

MR. BOTHA: There's the internal and the external heat transfer coefficients. And, you can certainly get into that as we get into the details of the review.

CHAIR CORRADINI: But, I think, if I just nail down, you don't have the answer to his question in terms of residual delta risk, that's what I think he's asking.

MEMBER POWERS: Yes.

MR. BOTHA: Yes, I can't give you the exact number except for the principle and the principle is if you're down to 200 kilowatts, there is not a mechanism that leads to core damage.

MEMBER POWERS: I can always find mechanisms to get to core damage for any state. It's just how likely are they?

MR. BOTHA: That's right.

So --

MEMBER POWERS: And, it seems to me, this is one of those things that just begged for a risk assessment.

And, I mean, I just can't imagine how I would make a decision on this --

MR. BOTHA: Sure.

MEMBER POWERS: -- without a fairly transparent risk assessment on this.

MR. BOTHA: Sure.

MEMBER POWERS: It's because you say, okay, something's gone wrong, as soon as something's gone wrong then I know lots of things can go wrong.

MR. BOTHA: We haven't any core damage frequency -- core damage mods from this condition, but that's certainly something you could question as you get into that part of the review.

So, I think the points on this slide is that the GDCs, so, if you look at the criteria for the exemption, they're conservative both in the terms of requiring CHF.

And, once you're looking at CHF, normally, CHF is a requirement for AROs. So, if you have an ARO, you don't need to meet CHF, so requiring that you

need to meet CHF and limit the event to be less frequent than an ARO so that there's not expected in the life of the plant, I think is a conservative requirement with respect to GDC 27.

So, that's on the criteria.

With regards to design evaluation, I think we want to try and focus on this with respect to the criteria and just look at some of the differences between our Chapter 15 evaluation and the probabilistic evaluation or the realistic evaluation, if I may, just because I think that provides some context.

But, the detail for this certainly will come out as you get into the Chapter 15 review and the SER for Chapter 15. For example, when we get to Chapter 19 review.

So, just going over these two evaluations, I think what's important on looking at the deterministic evaluation first, is just in terms of big picture -- the bigger picture.

If you look at how events are analyzed in Chapter 15 and what the criteria are for analyzing those events, being shutdown is not a specific acceptance criteria in Chapter 15.

So, what I mean by that is, you get some

of the events that, for example, for BWR, inadvertent pressure relief valve actuation where the reactor is not even tripped.

So, it is not a requirement that you have to trip the reactor for your Chapter 15 events, so for that specific event, the reactor stays at power. And, you then evaluate the CHF or the fuel for that event for a BWR.

That's just an example, but if you look at the acceptance criteria, they're really focused on providing conservative assumptions to -- and bounding analysis to demonstrate that you do not exceed CHF or exceed the pressure limits on your primary system for AROs.

And then, that you maintain your critical core geometry for accidents.

So, that's the focus of Chapter 15. And, we'll -- we're going to get into a little bit for large PWRs, why you get acceptance criteria or you have to be shutdown when you demonstrate those analysis. And, that's really looking at from a functional perspective as opposed to the requirements section perspective, which I'm sure the staff will point out from a precedent.

And, that's the whole point, from a

precedent perspective, we are unique such that, if you make these Chapter 15 assumptions, then you see this return to power.

So, what -- from the Chapter 15 perceptive, let's look at what those conservative assumptions look like.

So, the first one is the worth rod stuck out. That is not a single failure criterion, that's one of the assumptions that you have to make as part of your analysis and that's per the GDCs.

The next one is the moderator temperature coefficient. So, you usually make a bounding assumption in terms of what your moderator temperature coefficient is, that's pretty typical for Chapter 15.

Then, your cooldown rate, so you look at maximum cooldown rates. So, xenon and boron concentration, so your xenon that you assume and the boron concentrations you assume are all bounding.

And then, again, no credit for your non-safety systems.

So, if you make those assumptions, what you find is that you will have a return to power for every event. And, that's because of the assumptions you make.

Now, what's the probability that those

conditions or assumptions will actually occur? Well, that's effectively zero. You'll not see those assumptions under real-life conditions.

In terms of the event progression, so, what you then see with those conservative assumptions is you have a return to power about two-plus hours with a DHRS cooldown.

We went through the -- what the -- and the staff may do it, I'm not sure, I haven't seen their presentation, but we went through that previously -- for the previous presentation.

And then, at some point, you'll transition to your ECCS. And, that depends on whether you have power or not. So, if you lose DC power, you assume you've lost DC power, then you will transition to ECCS before 24 hours. If you have DC power, we have automatic means of transitioning to ECCS at 24 hours, and that's to preserve power on the batteries.

And then, with -- once you're on ECCS, the limiting condition with respect to internal is really being that maximum decay heat rather than -- and then you'd be subcritical.

So, being subcritical with maximum decay heat is really the limiting condition with regards to ECCS internal.

And, again, the criteria for this that the staff requires is the CHF. So, we do the safety evaluation, demonstrate that whether this is safe or not. The CHF limits might exceed it.

In terms of the probabilistic evaluation and also the more realistic evaluation, we still made -- so when went over the three contributions to the ten to the minus below -- less than ten to the minus six probability for this event in the Subcommittee meeting, we haven't gone through the assumptions and there's some conservative assumptions in terms of how we evaluated it.

The first one is pretty important, I think, in terms of some of the questions the ACRS has raised. And, that is, we assume that the failure probability for the CVCS, which I think is in the order of ten to the minus three, is really the unavailability on demand.

So, that does not take into account that when you had a demand fail, that you can bring it back online when you have time. And, that's a pretty important point.

There's a big difference between the failure on demand probability for equipment as opposed to, well, will this equipment be out of service for 30

days?

MEMBER STETKAR: Derick, please don't lecture the Committee on PRA. We would like to see your PRA.

MR. BOTHA: I understand.

MEMBER STETKAR: And review how you've evaluated the full spectrum of scenarios that could lead to the condition and the consequential reliability of all of the possible systems, including operator actions and the time available for those actions.

Everything else that you say is pure speculation at this point.

MR. BOTHA: From the Committee's perspective.

MEMBER STETKAR: From the Committee's -- from my personal perspective, the Committee -- I don't speak for the Committee.

MR. BOTHA: Yes.

MEMBER STETKAR: For example, in your assertion on this slide that CVCS failure on demand is more likely than an extended unavailability of both CVCS and CFDS.

We have documented PRA experience to show that there are more likely scenarios that take out

several systems if you do an integrated PRA.

It's why, for example, currently operating plants installed systems like AMSAC, installed alternate rods injection --

MR. BOTHA: Sure.

MEMBER STETKAR: -- for BWRs because those combinations of AOOs, like a loss of main feed water in combination with common cause failures, indeed, were more likely than the assumed single failures in your safety analysis.

So, don't lecture us on PRA. We want to see your final PRA. And, until this Committee has the opportunity to see that PRA, anything that you say about numbers is kind of a waste of our time.

That's my own personal perspective, but --

MR. BOTHA: Thanks.

MEMBER STETKAR: -- to keep us on track.

MR. BOTHA: I would like to respond to that, but I'm cautious of the time.

CHAIR CORRADINI: You should be.

MR. BOTHA: Yes, thank you.

So, I think just going through this -- I think I've gone through the conditions. I'm not going to go through the rest of the probabilistic evaluation because I've covered that on a previous slide, so I'm

going to the next slide.

MEMBER MARCH-LEUBA: Before we run out of time and they don't let me ask you a question, can you go forward to slide 12, one of the backup slides? Because I know I'm being polite, I kept quiet and then when I ask a question, he doesn't let me ask it.

(LAUGHTER)

MEMBER MARCH-LEUBA: Unequivocal.

So, the CVCS injects into the vessel, correct?

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: What's the location of injection? It's above or below the core?

MR. BOTHA: Above the core.

MEMBER MARCH-LEUBA: It's above the core?

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: That's good.

The issue that I think has been raised and I believe is under ECCS conditions when you're depressurizing, you don't have any flow, then you will inject CVCS on the boarder, we've got the lower plenum.

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: Are easier to put in the upper plenum.

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: So, it will go through the core as it goes down.

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: So, for March 22nd and the next two years, we are going to be asking about boron certification a lot. Just giving you a -- I mean, this is not what we're doing now, but there is a high -- a significant, a non-zero likelihood --

MR. BOTHA: Sure.

MEMBER MARCH-LEUBA: -- that your backup system, the CVCS does not work under ECCS conditions.

No need to answer me now, I'm just giving you a --

MR. BOTHA: We can also insert that with a spray line as well, which is also above the core.

MEMBER MARCH-LEUBA: But, make a note on our description March 22nd to cover that.

MR. BOTHA: Thank you.

So, if I can go schematically --

MEMBER MARCH-LEUBA: Another factor, can you go to the slide, the next one, I know it's about 13.

The reactor pool water, you see borated?

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: And, there are positive steps to keep it soft? I mean, is it in the tech specs that you will keep it --

MR. BOTHA: I don't know.

(SIMULTANEOUS SPEAKING)

MR. BOTHA: I mean, it's connected to the spent fuel pool.

MEMBER MARCH-LEUBA: Because, if you go to the slide 14, when those valves open, you have the possibility of injecting that water into the core, the reactor pool.

MR. BOTHA: No.

MEMBER MARCH-LEUBA: On the next slide.

MR. BOTHA: No.

MEMBER MARCH-LEUBA: The valves are now open.

MR. BOTHA: No, that's the containment vessel is isolated from the pool.

MEMBER MARCH-LEUBA: Does it?

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: Okay, it might. I can see you wrestle with it.

MR. BOTHA: Okay.

MEMBER MARCH-LEUBA: But, we will want to review that during the next couple of years.

MR. BOTHA: Sure, but I understand the concept, thank you.

MEMBER MARCH-LEUBA: But, I did --

CHAIR CORRADINI: The engineers want to know more.

MR. BOTHA: Yes.

CHAIR CORRADINI: Okay, back to your --

MR. BOTHA: In terms of the design evaluation, I think this is a -- I'm going try and hit the high level --

The big picture in terms of this slide is, I previously made the point that compared to PWRs, we have redundant means for shutting down the core. So, they need both the rods and injection, we can do it with either one of the two.

An additional level of safety that we add with our design, and that's because of the low power entity in the core to some extent, is that when you have a single rod stuck out or multiple rods stuck out, so if you're going to -- so this type of scenario, the natural -- the passive means of the decay heat removal systems and the physical phenomena that drives reactivity in the core is such that you're always able to remove the heat.

So, even if you do not shutdown and you're

not relying on your reactivity control systems, there's inherent means for core protection in this design.

So, I think the one -- and then I'll --

CHAIR CORRADINI: And, can I summarize what I think you just said? You don't need operator action to deal with an that? That's what I think you just said.

MR. BOTHA: That's right.

CHAIR CORRADINI: Okay, fine.

MR. BOTHA: And, again, we would have operators and they would react, but you won't have to allow them.

CHAIR CORRADINI: Fine.

MEMBER SKILLMAN: Derick, you reference again and again you've got two shutdown systems, you've got the rods and you've got CVCS.

MR. BOTHA: That's correct.

MEMBER SKILLMAN: And, I would just observe that CVCS may be effective at one point in a cycle and not very effective later in the cycle.

The lower the boron concentration becomes, the more you are dependent upon natural circulation to provide mixing.

And, Mike Snodderly had forwarded you the

comment I made, I'll be curious for the analysis that shows your capability to use CVCS to raise boron concentration to that level that provides the hold down that compensates for the stuck rod.

My hunch is that the natural circulation rate is generally low and the mass of water into which your delta boron must be injected will be an extremely long time period because you have no forced circulation. It is all convection.

MR. BOTHA: Yes, it's --

MEMBER SKILLMAN: So, I'm looking for that analysis.

MR. BOTHA: Yes, and I think the short answer for today is, it's long, but it's small in comparison to the time you have before you get to return to power condition.

But, I'll leave you with that thought.

MEMBER SKILLMAN: Thank you, okay.

CHAIR CORRADINI: For a later analysis discussion.

MR. BOTHA: Yes.

MEMBER SKILLMAN: Yes.

MR. BOTHA: So, I think with -- yes, so let's try and finish on time.

I think -- so, let's just summarize, I'm

not sure it's -- I think the one point I'll just make on the last slide is, for the existing plants, part of the reason, if you look at their ECCS type heat removal requirements, it's very important for the PWRs, and you mentioned TMI experience in terms of the operators being very concerned about whether the plant is shutdown or not.

And, there's a different concern in those types of plants, and that is, if you're not shutdown, the heat removal systems for those plants are designed such that it can remove decay heat and no more.

And, because its active system do not shutdown then you try and cool the system, it's just going to give you more heat. So, you over-burden your heat removal systems if you're not shutdown for existing PWR, which is not the case for NuScale.

So, for those plants, it's very important that when you're on those safety systems, that you're sure you're shutdown, because, if you're not, you're going to get core damage which is different from the NuScale case because you're not concerned about core damage.

So, that is not to say that we don't have the operators, and effect that what you find is how -- there's a lot of interesting features of our design

that leads to a far more reliable active systems because you have all of this time because they are simple systems, the active systems, they are not as critical as in terms of how you have to get your ECCS sequencing right for a large break LOCA, for example.

So, you actually need more reliable, non-safety active systems in our design, even though in a non-safety related effect, if you call it non-safety it doesn't mean they're not reliable and that you can't use them and that the operator is not there.

So, just in summary, so we'll be pursuing an exemption from GDC 27 consistent with the NRC staff position. So, we've selected our reactivity control systems to be consistent with our overall design philosophy of a passive, simpler system that increases the safety of the plant and we've provided rapid shutdown with our control rods and that's sufficient to protect the fuel.

And, we have more than enough reliable capability to maintain subcritical condition -- maintain the reactor at subcritical under cold conditions and I've covered the passive heat removal that protects against control rod malfunctions and that's not only for a stuck rod, but for multiple stuck rods.

We went -- from the previous presentation, we went through the advanced reactor quality statement. And, for that specific statement to demonstrate that our design philosophy and design options we've selected is consistent with the advanced reactor policy statement of the NRC.

And, I think in summary, I'd just like to state that, so, if you look at the probability of this event, it's less probable than a core -- than a core damage frequency on an existing plant. So, it is not that, even though it's such a low probability, there's no potential for radiological consequences under those conditions.

It's cold conditions, it's very low power. It's far less taxing on the fuel than your normal operating conditions. So, if you look at our reactivity control systems, and we went some of the precedence, they're more reliable than what the existing fleet provides in terms of shutdown capability.

And, they're -- and then, even if they are not there, we've got additional safety built into the system because of the near and passive nature of our advanced systems.

MR. GARDNER: I just wanted to go back on

the question about GDC 34 that we got earlier. I do have an answer for that.

And, specifically, GDC 34 was related to decay heat removal systems. And, the -- we did take exemption from the electrical power aspects of those. I remembered there was a series of GDCs that we needed to exempt.

But, it was from the portion of the GDC that included reliance of safety related power which we don't have in this design. So, it wasn't related to the heat removal process.

MEMBER KIRCHNER: I don't mean to get into an open discussion on this, but are there any other GDCs that you're going to take an exemption to?

CHAIR CORRADINI: We should get that information to the Committee.

MEMBER KIRCHNER: We said get it as a Committee because then, you look at a more holistic approach to their PDCs than --

CHAIR CORRADINI: I'll make note --

MEMBER KIRCHNER: -- coming to us one by one.

Thank you.

MEMBER REMPE: Well, then they didn't really want to -- the exemption for this one so they

may have some that they didn't really want that they get forced into.

And, I -- so that list ought to include the whole --

MEMBER BLEY: Yes, we get a list of all the exemptions.

MEMBER REMPE: And, then if there's some questions with respect to the staff saying, no, you may need one on this, too.

MEMBER MARCH-LEUBA: Can I summarize the event we're worried about? And, correct me if I'm wrong, we need to lose offsite AC power because, if we had AC power, we would have injected boron.

You have to lose any non-safety related AC power inside the plant because, if you had it, you would have injected boron.

And then, you have to fail the most reactive rod. And, you have to be towards the end of the cycle where you're see is --

So, if all those four conditions happen --

MR. BOTHA: And, you have to be on low decay heat relating cycle, which you wouldn't have for most cycles.

MEMBER MARCH-LEUBA: But, you will get that.

MR. BOTHA: Yes.

MEMBER MARCH-LEUBA: I mean, to get here, we'll look at --

MR. BOTHA: Also, a very long time.

MEMBER MARCH-LEUBA: So, I'm wondering if we have more than one assumed failure? I mean, you're supposed to have single failure not parts.

MR. BOTHA: That's right.

MR. GARDNER: I think that was the point on this slide where we said Chapter 15 space, the probability is one because it's deterministic.

MEMBER MARCH-LEUBA: Yes, so, I wanted to make sure I didn't misunderstand it.

CHAIR CORRADINI: Okay, so, I'm going to thank you. I think we're okay with the other members. Are there other last minute questions?

Thank you very much.

Sure, go ahead.

MEMBER DIMITRIJEVIC: Can your charging system operate with loss of offsite power?

MR. BOTHA: Yes.

MEMBER DIMITRIJEVIC: If you lose that -- because you just said something about the isolation of containment which made me look and that was --

MR. BOTHA: You wouldn't isolate

containment on the loss of offsite power.

MEMBER DIMITRIJEVIC: Okay.

MR. BOTHA: In fact, our system is different in that you're not relying on offsite power --

MEMBER DIMITRIJEVIC: No, no --

MR. BOTHA: -- to power your onsite systems that are important. You can -- so, the answer is, no, you don't need --

MEMBER DIMITRIJEVIC: So, your charging is supplied from the diesel generators and things like that?

MR. BOTHA: Can be.

MEMBER DIMITRIJEVIC: Can be? All right. What is the sort of as John said, that we have to see assumptions in your --

MEMBER MARCH-LEUBA: Probabilistic.

CHAIR CORRADINI: Okay, we'll make a switch over to the staff.

(OFF MICROPHONE COMMENTS)

CHAIR CORRADINI: Green light.

MR. SCHMIDT: This is actually from -- leftover from yesterday.

(LAUGHTER)

MR. SCHMIDT: Recycling.

Yes, I'm sorry, we don't have the presentation up for the screen, so we're going to have to go by the paper copy.

CHAIR CORRADINI: So, all the Committee have the slides in front of them, he's going to go and tell us what slide to look at.

MR. SCHMIDT: Yes.

So, my name is Jeff Schmidt from the Reactor Systems Group. And, Tim Drzewiecki will be helping me with this presentation.

Basically, it's the same presentation I gave to the Subcommittee except for one slide change on slide six, and we'll talk about that because there was some confusion. I thought I would just try to address that.

So, this is, again, the staff's criteria that we're going to be using for the exemption request for GDC 27.

MEMBER RAY: Can I just underscore something?

MR. SCHMIDT: Sure.

MEMBER RAY: Criteria that you will be using?

MR. SCHMIDT: Yes.

MEMBER RAY: And, we all need to keep that

in mind.

MR. SCHMIDT: That's correct, that's what we're proposing.

MEMBER RAY: We're not talking about what the answer is in this time.

MR. SCHMIDT: No, what's proposed in the SECY paper. Thank you.

MEMBER BLEY: And, that's what you want a letter on are the criteria reasonable?

MR. SCHMIDT: That's right. That's correct.

MEMBER RAY: You don't want us to tell you what the results of apply of the criteria must be, but --

MR. SCHMIDT: I propose we not do that.

MEMBER RAY: What the criteria are?

MR. SCHMIDT: Yes, that's -- let me make that clear, it's the criteria.

MEMBER RAY: Well, we've had a little confusion about that.

MR. SCHMIDT: It's the criteria.

So, I guess I'll just go over the purpose, which is I think we just discussed, brief the ACRS on the acceptance criteria the staff plans on using to evaluate the NuScale exemption to GDC 27, to monitor

activity control system capability as described in the staff's draft Commission paper.

MEMBER STETKAR: Jeff, my hearing is getting bad, can you pull the mic closer to you or scream at it? Thanks.

CHAIR CORRADINI: Older people need that sort of assistance.

MR. SCHMIDT: I think I'm there, too.

MEMBER STETKAR: Ey, sonny?

CHAIR CORRADINI: Okay, go ahead.

(OFF MICROPHONE COMMENTS)

(LAUGHTER)

MR. SCHMIDT: So, quick technical background. I think NuScale covered a lot of this, so, I'm going to go pretty quickly through this.

Late in the pre-app the staff learned the NuScale reactor would return to and sustain fission power.

MEMBER RICCARDELLA: Your slides aren't up.

CHAIR CORRADINI: I know, he just said that we don't have them.

MEMBER RICCARDELLA: Oh.

(LAUGHTER)

CHAIR CORRADINI: Slide three, yes, in

front of us.

MR. SCHMIDT: Thank you, slide three.

Under Chapter 15, Design Basis Assumptions and it's under Chapter 15 Design Basis Assumptions is the key word there.

Assumptions include a stuck rod, which we've talked about. It's consistent with the current GDCs.

Loss of AC power, the non-safety related CVCS system and sufficiently negative MTC are the criteria that really drive this.

Using design basis assumptions, return to power will occur following most AOOs and postulated accidents in the long-term.

So, any -- most of the transients in Chapter 15 could eventually lead to this state.

CHAIR CORRADINI: With the DBA assumptions?

MR. SCHMIDT: With the DBA assumptions.

CHAIR CORRADINI: Okay.

MR. SCHMIDT: The DBA assumptions --

CHAIR CORRADINI: I just wanted to make sure we're --

MR. SCHMIDT: -- should never be forgotten.

CHAIR CORRADINI: Okay, fine.

MR. SCHMIDT: With those assumptions --

(OFF MICROPHONE COMMENTS)

MR. SCHMIDT: So, maximum -- again, with the DBA assumptions, maximum core return to power is approximately 9 percent, peak pin power and the location of the stuck rod can be up to 50 percent I'm going to kilowatts per foot basis.

The design remains subcritical if all control rods insert.

MEMBER MARCH-LEUBA: Just a minor -- NuScale is saying that MTC is sufficient peak only towards the end of the cycle was the staff does not agree with it?

MR. SCHMIDT: I'm not sure we're there yet.

MEMBER MARCH-LEUBA: Okay, so, can --

CHAIR CORRADINI: Can you repeat that, Jose, I didn't catch.

MEMBER MARCH-LEUBA: The -- Nuscale claims that the MTC is sufficient is in the -- it fails to be sufficient at the end of cycle, on the last 30 percent. This slide says it's most of the time.

MR. SCHMIDT: Right.

So, there is some discussion.

MEMBER MARCH-LEUBA: You don't have a disagreement, you just don't have a concurrence?

MR. SCHMIDT: That's correct.

MEMBER REMPE: Is there a discussion in part of this about how much data they need to provide to give folks confidence in that? Is it lack of data or is it -- why is there discussion?

MR. SCHMIDT: It's a function of what you're going to assume MTC value to be which changes on a core reload basis.

MEMBER REMPE: But, there's confidence, it's just you would end up with additional requirements on a core reload is what you're saying?

MR. SCHMIDT: That could be a path pursued.

MEMBER REMPE: Okay.

MR. SCHMIDT: That is --

(OFF MICROPHONE COMMENTS)

MEMBER REMPE: No, they could put additional requirements on the reload, not require additional data. They're not talking about a prototype demo, they're just saying we may be more limiting on what they would do during a reload is what I'm hearing from them.

MR. SCHMIDT: For the MTC, but there is a

phenomena we're looking at that NuScale may have data to support that we may be requesting. To kind of go with your testing.

MEMBER REMPE: Yes, there's maybe testing, but I'm not hearing any -- I mean, there's been other cases in history where the staff has said, I might like to see prototype demonstration, that would really set things off in a hurry. And, that's not coming up in the discussions?

MR. SCHMIDT: No.

MEMBER REMPE: Okay.

MR. SCHMIDT: No, it has not yet.

Slide four, please?

General Design Criteria 27 states reactivity control systems shall be designed to have a combined capability in conjunction with poison addition by the emergency core cooling system of reliably controlling reactivity changes to assure under postulated accident conditions and with appropriate margin for stuck rods, the capability to cool the core is maintained.

So, the staff, in its review, as you heard this morning, you know, NuScale's view on it was that the plain language reading of GDC 27 would not require you to get to shutdown in the long-term.

The staff disagreed with that and focused that the reliably controlling reactivity really meant shutdown in the long-term. And, there's what's described a little bit this morning is, if you look at the whole structure of the GDCs, it kind of implies shutdown in the long-term. So, that's where the staff was focused on.

Again, in support of the staff, the SECY-94-084 policy and technical issues associated with the regulatory treatment of non-safety systems in a passive plant provided additional information to the staff.

It says that conditions other than cold shutdown may constitute safe shutdown as long as the reactor subcritical decay heat removal and radioactive materials containment are properly maintained in the long-term.

So, again, we focused on reactor subcriticality.

Then, you look at the definitions --

MEMBER BROWN: Can I --

MR. SCHMIDT: Sure.

MEMBER BROWN: I just want to clarify that for myself. If -- that goes along with the idea that shutdown means subcritical as well as coolable?

MR. SCHMIDT: That's correct.

MEMBER BROWN: Okay, just wanted to make sure.

CHAIR CORRADINI: And, in that --

MEMBER BROWN: What?

CHAIR CORRADINI: But, there's more to it. He's quoting part of the --

MEMBER BROWN: The SECY --

CHAIR CORRADINI: -- 94-084, but if you go back to 94-084, it also says that this could be accomplished. You don't necessarily need to accomplish this only with safety grade systems.

MR. SCHMIDT: Safe shutdown, you need safety related systems. Cold, you do not necessarily.

CHAIR CORRADINI: Historically?

MR. SCHMIDT: Historically, yes, that's true.

CHAIR CORRADINI: Okay.

MR. SCHMIDT: Historically.

CHAIR CORRADINI: That's right, I just wanted to make sure.

MR. SCHMIDT: I think the SECY helps clarify that.

MEMBER RAY: Clarify it in the -- is there a change in criteria to reflect that clarification or

what?

MR. SCHMIDT: I think, for me, the SECY clarifies it in the fact that safety related are necessary to get to safe shutdown. Cold shutdown can be used in non-safety systems.

MEMBER RAY: And, is that part of the criteria that we're reviewing then?

MR. SCHMIDT: No.

MEMBER STETKAR: Is that accurate? Because 94-084 addressed the notion of RTNSS. I mean, one of the RTNSS stuff addressed ATWS. And the RTNSS stuff is non-safety related as are all of the fact that AMSAC systems or, you know, whatever they call them, boilers, ARI and that kind of stuff.

So, is it accurate to say that safe shutdown must be achieved using safety related equipment consistently with the notion of that SECY paper?

MR. SCHMIDT: I think with -- you're also bringing 50 point -- 10 CFR 50.2 it says basically shutdown is safe shutdown.

MEMBER STETKAR: It says safe shutdown, but it doesn't say I have to achieve it using safety related --

MR. SCHMIDT: Well, that's in pumps and

pipes and validated equipment.

CHAIR CORRADINI: Say that again, Jeff, please?

MR. SCHMIDT: The definition of the -- so, you look under 50.2, it's the definition of safety related equipment. Right?

And, it talks about achieving safe shutdown in 50.2.

MEMBER STETKAR: Okay, I'll have to look that up.

MEMBER RAY: Yes, I think that's the nub of what has been a discussion item I had earlier is are we making a change here for the first time? And, if so, is it got the visibility it needs to have to be generic? Or, is it a one off change from the past?

So, I don't want to divert things here, but it's something I'm kind of soft about.

CHAIR CORRADINI: I think we can wait until the discussion. I don't completely appreciate what you just said. I just wanted to make sure that we're clear that you were making the difference between safe shutdown and cold shutdown.

MR. SCHMIDT: That's correct.

CHAIR CORRADINI: That's where you were going?

MR. SCHMIDT: That's correct.

CHAIR CORRADINI: Okay.

MR. SCHMIDT: As we just talked about, the definition of safety related SSE -- I'm on slide five -- the safety related SSEs in 10 CFR 50.2 state the capability to shutdown the reactor and maintain it in a safe shutdown condition. It doesn't refer to cold there.

The NRC has license designs with return to power in the short-term following postulated accidents. We heard that this morning from NuScale.

So, the NRC has not licensed a power reactor that does not achieve subcriticality in the long-term using only safety related systems.

Again, we talked about that a little bit this morning that the premise of our GDCs assumed, I think, shutdown in the long-term.

Staff's responded to NuScale that an exemption to GDC 27 would be required. And, such an exemption would warrant Commission consideration and direction prior to the staff's approval.

Slide six.

CHAIR CORRADINI: Can you make sure I think I know what that just means. That means, let me put it in a process question.

So, we're looking at I bundled those two criteria that you're going to use to evaluate the design as the analysis goes, whether it be the systems or the risk -- the reliability, that's one. And, that's an alert to the Commission, they filed the exemption.

And then, once you do the evaluation, it goes back, that's the way I read this, it goes back to the Commission for consideration or you are then free to -- do you know what I'm asking?

MR. SCHMIDT: Not exactly, because I'm not overly process familiar so I'm going to turn to --

CHAIR CORRADINI: Good, I don't like process, either. I just want to understand what those words meant.

MR. SCHMIDT: I think the word -- so, those words meant we would need Commission engagement, nothing more than that.

CHAIR CORRADINI: Engagement isn't approval.

MR. SCHMIDT: Not --

CHAIR CORRADINI: Here's a clarifier --

MR. RECKLEY: If I can? What we meant by that --

CHAIR CORRADINI: And, you are?

MR. RECKLEY: I'm sorry, Bill Reckley from the staff.

What we meant by that is, ultimately, because this will either be a licensed facility or a design certification, the Commission will get ultimate approval of this at that stage.

CHAIR CORRADINI: Oh, okay. I got it, that's true. Okay, that helps me.

I didn't -- okay, thank you very much, Bill.

MR. SCHMIDT: Now, on slide six.

And, I added this slide just because in the Subcommittee, there was some confusion, I got a lot of questions of what is the exemption, so I tried to clarify it here just for everybody's purpose.

The exemption is from the staff's position that reliably controlling reactivities in GDC 27 includes the requirement to achieve subcriticality beyond the short-term using only safety related equipment following a postulated accident with a stuck rod.

So, that's what the exemption is for.

MEMBER MARCH-LEUBA: And, for those of us who don't have a law degree, every light water reactor is required to follow GDCs, all of them, unless they

get an exception to one or more GDCs and they propose their own PDCs?

MR. SCHMIDT: Yes.

MEMBER MARCH-LEUBA: Is that correct?

MR. SCHMIDT: That's correct.

MEMBER MARCH-LEUBA: So, this will only apply to this particular reactor?

MR. SCHMIDT: That's correct.

Beyond the short-term means long-term natural equilibrium state achieved by the reactor. So, we're trying to separate out this short-term, long-term issue because PWRs can go potentially recritical in the short-term on a main steam upgrade.

MEMBER BROWN: So, I'm sorry, I was trying to make sure I understand where this -- that's your basis for saying why you need an exemption? That's -- you're stating that's what it says, the exemption -- that's your position that reliably controlling includes this part of it?

And, beyond the short-term means this and that's -- therefore, you need an exemption?

So, if you end up approving the exemption, you're fundamentally saying that doesn't apply anymore?

MR. SCHMIDT: We're saying that it's a

valid exemption to -- so, our interpretation stays the same --

MEMBER BROWN: You can be critical in the long-term --

MR. SCHMIDT: -- exemption --

MEMBER BROWN: -- and not as opposed to just the short-term?

CHAIR CORRADINI: Can I -- he's nodding. I just want to make sure your question is asked and answered.

His -- I thought what you were asking is, when this if, if.

MEMBER BROWN: If, that's correct.

CHAIR CORRADINI: And, the analysis is presented and if the staff thinks the analysis, after evaluation, is acceptable for NuScale, they would essentially propose a different way to satisfy this which are not necessarily say with a set of assumptions, I can only use safety grade equipment to achieve subcriticality.

MR. SCHMIDT: Right. And, the subcriticality part is the part that is in question. Right? That's the exemption.

MEMBER BROWN: Okay, but I still am fuzzy. If you go back to their discussion, I'm trying to

remember this, it's not just that they achieve it with non-safety related stuff, it wasn't clear, at least based on their presentation, to me, that the non-safety related stuff would then come -- would fulfill that.

In other words, the CVCS may or may not be needed. Because, it's just sitting there perking along and nobody cares.

MR. SCHMIDT: So, when they --

MEMBER BROWN: And, they're critical and generating power in whatever level that power is.

MR. SCHMIDT: Yes.

So, you've got to kinda break it into two separate thoughts. The Chapter 15 analyses only credits safety related systems to mitigate upset conditions, AOOs postulated accidents.

So, the CVCS is a non-safety system. So, from a Chapter 15 standpoint --

MEMBER BROWN: For NuScale, it's a non-safety system?

MR. SCHMIDT: Yes, yes.

It doesn't exist to me. It's not credited to mitigate a Chapter 15 event. Does it still exist? Yes. Could it be capable of injecting boron? Maybe, maybe not, whether it's isolated power, there's a lot

of assumptions there. Right?

But, in Chapter 15, it does not exist to me.

MEMBER BROWN: Yes, I got that part. So, it's only the rods and then they live with whatever criticality they get?

MR. SCHMIDT: Whatever comes out of it. That's correct.

MEMBER BROWN: That part I get. So, but, if you end up approving, you go through your analysis and you determine that, yes, their argument in the other column that they had over there on slide whatever it was, 9 or 10 or 8, what have you, that would fundamentally redefine -- allow you to not comply with this specific interpretation of GDC?

MR. SCHMIDT: It is an exemption to that GDC.

MEMBER BROWN: Or position. Yes, well, it's really a big policy issue.

MR. SCHMIDT: And, that's why the policy --

MEMBER BROWN: In my own mind, okay, whether -- that's my personal opinion. It's a big policy change.

MR. SCHMIDT: And, I --

MEMBER BROWN: That you can sit there and perk forever.

CHAIR CORRADINI: Well, I mean, just to repeat what I thought I heard in the Subcommittee is Jeff's point is, there are two reasons that they felt, one, by the -- I'll call it by the letter of the law, this was required.

But, also, to alert the Commission that this is --

MR. SCHMIDT: A policy issue.

MEMBER DIMITRIJEVIC: Well, have something also to summarize just to make sure I understand well.

There is the two requirements in GDC, I understood it --

CHAIR CORRADINI: Green light again.

(OFF RECORD COMMENTS)

MEMBER DIMITRIJEVIC: Okay, so let me -- there is still a requirement. One is to reliably control the activity and one is the capability to core cooling.

Chapter 15 specifically mentioned GDC 27 for the core cooling. So, when you analyze core cooling, you can use a Chapter 15 assumption, however, for reliably controlling reactivity, there is no anything which tell us that we should assume -- we

should only credit safety systems and then we can assume loss of offsite power, things like that.

So, I really am not sure I can remake that what you said would you put them reliably to control activity is beyond the short-term and safety related equipment only?

And also, some loss of offsite power, I don't know how that affects all the picture because I'm not sure what's happening there, which was also credited.

So, Chapter 15 assumptions are used to reliably control activity and may not be the case, we are not sure or do they apply?

MR. SCHMIDT: I think, as we kind of went through the regulatory background, that's how the staff got to what was interpreted as reliably controlling reactivity. Right?

Reliably controlling reactivity in and of itself, those words are difficult to interpret, nebulous, ambiguous.

MEMBER DIMITRIJEVIC: Right.

MR. SCHMIDT: So, what we did is we looked at past precedent, we looked at the SECY, we looked at the assumptions of the basic GDCs as was talked about this morning, we looked at the definition of safety

related equipment.

And, in our determination with working with OGC quite a bit, we took the position that reliably controlling reactivity meant shutdown in the long-term because that's kind of the fundamental bases of our regulations.

MEMBER DIMITRIJEVIC: All right. And, you also took out the only safety equipment that could be credited?

MR. SCHMIDT: We got the safety related equipment from 50.2 -- 10 CFR 50.2.

MEMBER DIMITRIJEVIC: Okay. This is -- so this is your interpretation but you have agreement within the -- that this interpretation is valid?

MR. SCHMIDT: We had -- we spent a lot of time with OGC on this. So, this, again, it's based on a universe of things, not an individual data point.

So, the staff feels comfortable in its position.

MEMBER MARCH-LEUBA: Going back to Harold's and Charlie's comments, the concern I have is we are modifying the GDC 27 specifically for this reactor, nothing -- because we suspect --

MR. SCHMIDT: We are taking an exemption to it.

MEMBER MARCH-LEUBA: Yes, we're providing an exception when we find -- and they appear you see, only for this here. Are you asking me to judge whether that's okay or not on a reactor that I don't know anything about?

MR. SCHMIDT: No, you're --

CHAIR CORRADINI: No, you are not being asked to judge the criteria you're going to use to evaluate.

MEMBER BLEY: Later, we'll have to see if they actually meet the criteria.

MEMBER MARCH-LEUBA: Well, why are we changing the criteria for one particular reactor --

CHAIR CORRADINI: Because they've asked.

MEMBER MARCH-LEUBA: -- that we don't know anything about?

MEMBER STETKAR: No, because they've asked. And they're allowed to ask.

MEMBER BLEY: I'd like to make a couple of points.

One is, we keep saying Criterion 27 has two requirements, it's not quite the way it's written. It says you must be able to reliably control the reactivity to assure that you can cool the core. That part is to assure you can cool the core.

They are saying, even if we don't -- we do that because we are reliably cooling the core, first point.

The second point, for anybody who wasn't here yesterday, the advanced reactor design criteria don't exist yet but we were looking at them and there on this issue, the staff is really making their clarification right in the criteria saying they have to reach safe shutdown.

But, that isn't in the current GDC.

CHAIR CORRADINI: Green light, green light.

MEMBER DIMITRIJEVIC: I just want to say I split in two parts, but I believe the main point is to cool the core and that they satisfy that. So then, we -- no, no, I know.

CHAIR CORRADINI: But, the other thing is just --

MEMBER DIMITRIJEVIC: None of the expression --

CHAIR CORRADINI: I'm sorry -- I didn't mean to interrupt you.

The other thing, Dennis, is I think what you said I'd agree with, just to clarify, the safe shutdown is not cold shutdown. That's Jeff's point

three slides ago. I just wanted to make sure we're on the same page, that's all.

MEMBER DIMITRIJEVIC: But we said yesterday during the discussion, we said that we do not have a firm definition of what safe shutdown and the safe shutdown doesn't necessarily mean safe shutdown safety equipment -- safety related equipment.

It just means long-term -- so I agree with him.

CHAIR CORRADINI: Is that a question for Jeff?

MEMBER DIMITRIJEVIC: No, I just wanted -- didn't we bring during yesterday's --

CHAIR CORRADINI: Well, I don't want to confuse yesterday with today, that's what I'm -- yesterday doesn't really exist, that's something that's going on in parallel.

MEMBER DIMITRIJEVIC: Well, maybe we can again ask for definition of safe shutdown.

MR. SCHMIDT: Yes, it's subcritical with adequate heat removal with safety related equipment.

MEMBER DIMITRIJEVIC: Does it say it's safety related equipment and where does it say that?

MR. SCHMIDT: On 10 CFR 50.2.

MEMBER DIMITRIJEVIC: It says it's safety

related?

MR. SCHMIDT: It's the definition of safety related equipment, what its function is.

MEMBER RAY: That's how you define safety related.

MR. SCHMIDT: Yes, right.

MEMBER RAY: It's required for safe shutdown.

MEMBER BROWN: And, you say shutdown, it theoretically is cooling as well as subcriticality.

MR. SCHMIDT: Yes, yes.

MEMBER BROWN: Then that's specifically --

MEMBER BLEY: Not theoretically.

MEMBER BROWN: I used the wrong word, I agree with you.

MEMBER BLEY: But, it doesn't mean cold shutdown --

MEMBER BROWN: I understand that.

MEMBER BLEY: -- for AP1000.

MEMBER BROWN: Yes, I understand that point.

MEMBER RAY: It just --

MEMBER BROWN: I'm just trying to wrap my head around the fact that whatever you set your criteria and if we write a letter agreeing with your

criteria, that'll fundamentally puts us on the position that we're going to eventually agree if you come up with your analysis that it's okay to sit there and cook forever.

But, I'm using that --

MR. SCHMIDT: For a longer period of time that --

MEMBER BROWN: Very long period of time potentially.

CHAIR CORRADINI: Under DBA assumptions.

MR. SCHMIDT: Under DBA assumptions.

CHAIR CORRADINI: Which could be highly lower probability.

MEMBER BROWN: Put all that aside, okay, I understand that point. The point is, wrapping your head around the fact that you're going to let -- you're going to agree to let a reactor operate and be at power for a long period -- critical at power when you're supposed to be shutdown and you can't control it.

MEMBER BLEY: We'll let a reactor melt under some conditions because we call them beyond design basis call nine, two stuck rods maybe.

MEMBER BROWN: Yes, but this is not beyond basis, this it what we're dealing with right now.

MEMBER BLEY: One could talk about the conditions that exist there, the way we got to this point. You know, when you go back and think about how all this started when we came up with this idea of design basis accidents, and AOOs and transients that happen always.

AOOs might happen in the life of the plant, accidents -- design basis accident aren't expected to happen in the life of the plant.

But, back then, we said, but they're credible. They could happen. And, some special cases then of accidents we said, well, those aren't credible.

Well, you have to think about this one. We got ourselves into this niche of in a certain period of time under various conditions, we're closing out are we reaching a point where, in those days, we would have set aside credible and won't even looked at it.

What we have now is a risk assessment that could look at it and tell you how likely it is and what the consequences are, we haven't got to that part yet.

MEMBER RAY: I'm not disagreeing at all with what you just said, Dennis. I would just say,

when we make the change that you're suggesting, we need to be very clear about it, I think. We're moving from the past to the future and this is when we're doing it rather than just have it happen without making that explicitly clear.

CHAIR CORRADINI: Why don't we let him --

MEMBER BROWN: One other comment, if I can. When we write our letter, and if we agree with the assumptions of the criteria that they're using and if they come through with an analysis, okay, for NuScale to them, they evaluate it and they say that meets the things we agreed with in our letter, that effectively means we're agreeing with --

MEMBER BLEY: Well, we're going to --

MEMBER BROWN: -- noncritical --

MEMBER BLEY: We're going to evaluate those analyses when we get consultants to help us.

MEMBER BROWN: Yes, I understand that. I'm just saying this is a -- to me, it's a very, very steep, slippery slope that we're working with and we've got to be very careful how we do it.

It just -- I still have a hard time wrapping my head around a critical reactor for days while it's generating heat.

CHAIR CORRADINI: But, under --

MEMBER BROWN: Even if it's coolable.

CHAIR CORRADINI: I don't want to get into discussion, I want to let you keep on going.

MEMBER BROWN: Yes, we can go on.

CHAIR CORRADINI: You need to go on.

MEMBER BROWN: I'm finished.

MR. SCHMIDT: Okay, slide seven, please? Slide number seven.

Actually, I want to skip slide seven because we saw this morning -- it's the GDC, let's just move on to eight.

Slide eight, staff's review approach, staff applied the enhanced safety focused review approach at the beginning of the review.

Identified this issue as receiving more emphasis in terms of review scope and depth compared to the traditional review using our ESFRA tool.

I think we've all recognized this is new ground. So, staff is early in the review of the analysis, Phase I. Continues to apply ESFRA in its review.

Technical audits of the NuScale analysis is ongoing as well as staff confirmatory analyses.

Slide nine?

Staff's review and acceptance criteria, so

the staff is going to look at it two ways, Chapter 15 considers conservative assumption analysis for stuck rods, evaluating the SAFDLs as given by GDC 10 as the acceptance criteria to demonstrate adequate cooling by maintaining the fuel clad fission product barrier.

This is consistent with the methodology typically used to analyze PWR main steam line break, short-term return to power.

It does not consider the probability of occurrence. In other words, for Chapter 15, the occurrence is one. And then, we evaluate conservatively.

The exemption review considers all the above Chapter 15 criteria. Shutdown is maintained assuming all rods inserted and the probability of occurrence is low and not within the lifetime of the module.

MEMBER RICCARDELLA: To me, that's very vague, I'll just use the term. I mean, what does that really mean?

I mean, if I had a probability of occurrence of .049 per module year, then that translates to 100.49 in a hundred years which is less than .5. So, therefore, it's not expected to occur.

I mean, it's just not well defined, that

issue. Should we be using a number?

CHAIR CORRADINI: You're talking about which one?

MEMBER RICCARDELLA: I'm talking the probability of occurrence is low, not expected within the lifetime of a module.

CHAIR CORRADINI: I got you.

MEMBER STETKAR: Jeff, let me pursue that a bit because if I live next to one of these things and it's got 12 modules in it, and let's presume that all of these are fully independent events that there is no common cause, there's no external events that could affect multiple modules.

Wouldn't I be interested as a member of the public that it doesn't occur within the lifetime, at least of the facility, which is 1200 module years, not 100 module years, and I'd want to have pretty good assurance that this is a small contribution to my overall risk from the facility.

So, focusing on whatever the lifetime of a module and whatever the probability of occurrence is low, doesn't really tell me anything.

MR. SCHMIDT: So --

MEMBER STETKAR: And, I do not believe anything that I read in marketing until I see the risk

assessment that looks at all of those other events that could, in fact, affect a single module in ways that they haven't thought about or multiple modules in ways that it's not at all clear that they've thought about.

So, how does the staff -- I mean, in terms of general principles, I get the general principle.

MR. SCHMIDT: Yes, so, the general -- I think that's what the takeaway is, the general principle.

We've had a lot of discussion of what to put on this slide.

MEMBER STETKAR: Well, it's not only in the slide, but you're asking -- but are you sending it up to the Commission, so you want to make sure the Commission understands what you're talking about.

MR. SCHMIDT: I agree with you that it's -- my personal opinion is that it's the facility, so I multiply it times 11 because I usually have one in refueling.

So --

MEMBER STETKAR: I think of something in refueling as still having the susceptibility to damage. So, I multiply it by 12.

MR. SCHMIDT: I don't think any of these

--

MEMBER STETKAR: So, we're at 9 percent difference.

MR. SCHMIDT: Right, and I don't think we were in a position yet to put a more specific number. This can be less than the lifetime of the module and it can be significantly less time than the lifetime of the module.

And, I think that just needs to come out of the review.

MEMBER RICCARDELLA: Just saying isn't a significant contributor to overall plant risk or something of that sort.

MEMBER STETKAR: This is a bit of -- again, I personally understand the principle but in terms of the staff's expectation, NuScale's understanding the staff's expectation and the Commission's understanding of your expectation, it's a bit vague.

MR. SCHMIDT: It is.

MEMBER STETKAR: Yes, if I were NuScale, I'm not sure whether you're asking me to bring a rock or a 100,000 pebbles.

MR. SCHMIDT: This is the -- so, this is like the upper bound of it, this isn't -- we wouldn't

want to go within the lifetime of the plant. This is like the upper range, not necessarily the lower range.

CHAIR CORRADINI: But, I'm listening carefully because we're going to have a discussion eventually about this.

So, what I hear you telling me is, this is an upper -- you're using the term upper bound -- this is an upper bound which means you're going to have to evaluate, again, I'm not a PRA person, but I have enough of them in the room they'll tell me, a series of sequences, a series of conditions and then look at the estimates and look at the uncertainty on the estimates and still have a comfortable margin. That's what I -- that's tell me.

MR. SCHMIDT: That's where we're going, yes.

CHAIR CORRADINI: Okay.

MEMBER REMPE: You know, I have documented in the SECY and that's why I've been asking all these questions today. And then, it's not just the frequency of the event, it's what confidence do you have in the heat removal phenomena.

And, I mean, there's a lot of, I think, you know, you're going to have to -- I'd like to see more --

MR. SCHMIDT: Well, you know, I think we're going to try to address that more in the Chapter 15 sense. Right?

So, the uncertainties with heat removal capability, you know, we'll use conservative analyses.

MEMBER REMPE: To demonstrate adequate cooling by maintaining the fission product barrier.

MR. SCHMIDT: Right, so that's --

MEMBER REMPE: So, what's adequate? How do I demonstrate adequate cooling and with what confidence?

CHAIR CORRADINI: Well, I don't -- I mean, my quick answer is, I've got sufficient margin of CHF.

MEMBER REMPE: How much is sufficient margin and what --

CHAIR CORRADINI: That's the low likely one.

Well, I --

MEMBER REMPE: How much margin? I mean, Dana brought up about the conduction phenomena.

CHAIR CORRADINI: Currently, the current margin, the current PWR margin.

MEMBER REMPE: Okay. So, then, you need to have -- sometimes we talk about with the uncertainty that we consider in LOCA analyses, right,

are you going to go to what confident level?

CHAIR CORRADINI: Well, I think -- that's what I thought his answer was is that he would essentially use those sorts of --

MR. SCHMIDT: We will use a Chapter 15 which is recognized to have a lot of conservatism in it.

MEMBER DIMITRIJEVIC: When comes to hydraulic and success criteria. So, you want to use success criteria from Chapter 15 and from probabilistic analysis with realistic assumption.

Also, I heard probability of occurrence, what does it mean probability of occurrence? Probability of occurrence meaning what? Is this core damage -- is this frequency, first, is it core damage frequency? Is that what is probability of occurrence? What do you mean by probability of occurrence?

MR. SCHMIDT: It's the probability of occurrence of return of power. In other words, there are a series of events that have to happen for you to return to power. It's the overall probability of that happening.

MEMBER DIMITRIJEVIC: So, probability of returning of power given what?

CHAIR CORRADINI: A series of events that

he -- that they went through.

MEMBER DIMITRIJEVIC: Okay. But, that's means it doesn't take into account initiating challenge frequency, that's extremely important. We're talking about probability.

The second thing is, probability of events mean a loss of offsite power, charging, right, so they will have to credit the things which you discredit in Chapter 15. So, do the realistic probability risk assessment, right?

That's -- right, so, therefore, you would do the realistic probability assessment, but you will use the thermal hydraulic success criteria from Chapter 15. So, that would be a little mess mush for that.

(LAUGHTER)

CHAIR CORRADINI: I like that, a mess mush.

MEMBER DIMITRIJEVIC: The second thing is that, if you want to call this -- if you want probability of occurrence that mean that probability that it will get back to criticality, that will not be risk measure because risk measures in that PRA probability analysis is core damage frequency and large release frequencies.

So, you couldn't account for that risk because according to their analysis, they would never melt.

So, now, the question is, what does this -- what do you want this slide to -- I mean, this is not really well defined.

MR. SCHMIDT: So, again, the probability of occurrence for my purposes here is the probability of occurrence of return to power.

MEMBER DIMITRIJEVIC: What's frequency of occurrence because you want to consider all challenges, right? I mean, you want to consider beyond design basis event, too, right?

MR. SCHMIDT: Those will be addressed by other people, but yes.

MEMBER DIMITRIJEVIC: So, you want to consider all challenges and your end state is getting back to power within 30 days which is also beyond PRA. I mean, you know, we want to use the right features put here, the PRA proves the risk for this type of event is low or something like that.

CHAIR CORRADINI: But, I think, if I -- we seem to have another staff member that's willing to help us, but I think we're kind of coming back to Pete's point which is, what do you compare it to?

But, low compared to what?

And, they're saying their probability -- their comparison point is at least within the lifetime of the module. That's the comparison point for the frequency.

MEMBER DIMITRIJEVIC: Lifetime of module for what? Lifetime is the time, so that should be frequency. I mean, this is not well defined.

MEMBER POWERS: You keep saying that, it seems to be perfectly transparent.

MEMBER STETKAR: If you expect it to live a 100 years, it would, to me, it would mean the frequency is less than 1 in a 100 a year.

MEMBER BLEY: I'd like to get back to where Pete and John were --

CHAIR CORRADINI: Can I get the staff member who seems to want to volunteer information that will get him in trouble? Mark, please identify yourself.

MR. CARUSO: This is Mark Caruso from the PRA and Severe Accident Branch in NRO.

And, I believe what they're talking about is no more than the same thing as we've always had some, you know, belief that LOCAs and locked rotors were design basis accidents which were not expected to

occur within the life of the plant, some basis for it.

I think we're probably now, after some years, some 30 years, we probably have a better idea that they are in that category.

And, I think all they're saying is that this is a new design basis accident. To get to this condition, which would include you don't have power, you can't borate, you've got -- you've gone down so far in decay heat that you don't have the voids and you have the moderator coefficient, all those conditions exist for this event and it should have -- it should be an event whose likelihood is in the same vein with LOCAs and any others.

And, it has acceptance criteria for acceptance criteria.

Now, I will point out that one of the parameters in LOCAs you're allowed to even have some fuel damage, a few percent.

The criteria is being Part 100. Here, we're saying -- I think they're saying, well, it's our criteria is even more stringent. You don't need the SAFDLs. That's DMB and whatever.

So, that accurate, Jeff?

MR. SCHMIDT: Yes, that's exactly accurate.

I mean, I can't speak to the probabilities, but I guess my feeling is the probabilities will work out to an accident criteria just like Mark pointed out.

And, we're using SAFDLs, which is an AOO criteria which, again, is expected to happen in the lifetime of the plant.

So, from that standpoint, the criteria that the staff is proposing is conservative because, again, if the probability works out to a locked rotor or an accident like a LOCA, we allow fuel failure for those.

CHAIR CORRADINI: I guess I forgot that, that's a good reminder. Thank you.

MS. KARAS: This is Becky Karas. If I could just also clarify.

CHAIR CORRADINI: Sure.

MS. KARAS: I just wanted to clarify on the criterion and make sure everyone understands.

So, there are really two sets of criteria for evaluating two different aspects on this slide. Right?

So, the Chapter 15 is the design basis sort of portion of the review.

The exemption criteria down here are

really a reflection of why would we consider this, and as the SECY paper says, why would we consider this departure from past precedent?

And so, it's used for meeting, you know, the exemption criteria in the CFR that have to be demonstrated, you know, at the special circumstances and, you know, public health and safety and all of that. Right?

So, that's where, you know, the probability and the frequency of this event happening are really factored in. In other words, you know, that we would consider this specific to NuScale for their design this type of, you know, exemption, you know, provided, you know, they can show that that probability is low.

So, that's the fact that we're looking at it through that exemption request with those exemption criteria is what makes that specific to this circumstance for this reactor type.

CHAIR CORRADINI: Thank you, Becky.

MEMBER BLEY: Yes, I thought about -- I hadn't thought about it quite this way before. But, that last criteria, I'd like -- the frequency or probability of occurrence is low. That makes sense to me.

But, back to what I was talking about before, we -- this -- in the PRA we'd say we want low risk, low compared to other things.

Here, we're trying to make a hybrid of the existing semi-qualitative, semi-quantitative approach that we propose to use.

And, we had transients that happen all the time. We have AOOs, we have to address them.

And then, and they happen within the life of the life of the plant. And, typically, that's in -- they say in a 100 years.

And then, we said things that are more rare than that would be design basis events unless they're extremely rare where they'd be beyond design basis and you don't generally have to deal with them unless some special thing has come up which has happened several times.

And, that kind of makes of the order, the accidents, the design basis accidents, things that happen out of the order, 1 in a 1000 years, to 1 to 10,000 years kind of thing.

I'd be -- this says the probability of occurrence ought to be low, not within the lifetime of the module which is saying they ought to be a DBA.

And then, you'd think it ought to be

treated like the DBA which is what's been done so far.

I think it ought to be much less likely than an DBA in which case it really does fall into that beyond design basis and it fits in this framework better.

So, I -- your parenthetical bothers me and I think if it's at much less than the lifetime of the facility is where I'd go. And, that means a factor of 100 to me.

Okay, this kind of gets yourself locked around an axle in that that puts in a time frame of a DBA and why wouldn't you treat it just like any other DBA?

CHAIR CORRADINI: But, I don't -- I think we're discussing rather than asking a question. So, I want to make sure we get him to respond.

MR. SCHMIDT: Yes, so, we are treating like a DBA. It's in Chapter 15, it's a DBA. What we are -- and that's the first part of this slide was, we consider this a design basis event with a likely frequency of roughly an accident, postulated accident but we are using the success criterial of an AOO which is expected to happen in the lifetime of the plant.

And, hence, the staff is saying that since we're using a SAFDL type criteria, GDC 10, that that

is conservative and appropriate.

CHAIR CORRADINI: This truly -- I mean, my --

MEMBER BLEY: I think it would be safe in my interpretation of it, it's safe.

CHAIR CORRADINI: Any other questions? We're cutting in and I want to make sure we give ample time for public comment. Questions for Jeff?

(NO RESPONSE)

CHAIR CORRADINI: Okay. I think there's nobody in the room, so we're going to skip right to public comment on the phone line.

So, are -- is anybody on the phone line that wants to make a public -- a comment about the topic at hand?

MR. BROWN: Bridge open.

CHAIR CORRADINI: Thank you.

Anybody on the line?

(NO RESPONSE)

CHAIR CORRADINI: Hearing none, why don't we close the bridge line?

Okay, any other questions for Jeff? I think we've covered that.

Let me remind the Committee how we're going to try this relative to discussion. I've

already sent out a week ago key points that I would cover in a letter.

I got some comments back by some of the members and I modified the key points which I am going to show the key points when we start our discussion for a letter. And, I drafted a letter based on the key points.

So, we'll probably take that up after lunch.

I also, I'm being a little bit prescriptive, we can have as much discussion as you want. I've scheduled five wonderful hours this afternoon to talk over this if we want to hash it out.

Because I do know there are strong opinions across the board here and I think we've got to make sure they're appropriately discussed.

So, I'll show the key points that we had gotten about a week ago, we can discuss that. And, I have a draft letter which I wanted to pass out based on that at least to start the ball rolling.

And, I -- you also got some comments by individual members that had some pretty comprehensive comments to make, the members did.

Yes? Okay.

Thank you very much. We'll take a break.

And, we come back, I think according to schedule, we come back at 10:45 for the research review.

(Whereupon, the above-entitled matter went off the record at 10:25 p.m.)

U.S.NRC
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# NuScale Exemption Request to General Design Criterion 27

By
Jeff Schmidt – Senior Reactor Engineer, NRO/DSRA/SRSB
February 8, 2018

# Purpose

Brief the ACRS on the acceptance criteria the staff plans on using to evaluate NuScale's exemption to General Design Criterion 27, "Combined Reactivity Control System Capability," as described in the staff's draft Commission paper

# Technical Background

- Late in pre-application, the staff learned the NuScale reactor would return to and sustain fission power (become and remain recritical) under Chapter 15 design basis assumptions
- Assumptions include:
  - A stuck rod, which is consistent with current GDCs
  - Loss of AC power
  - Non-safety related Chemical and Volume Control System (CVCS) is unavailable
  - Sufficiently negative MTC (occurs during most of an operating cycle)
- Using design basis assumptions, return to power will occur following most AOOs and postulated accidents for the long term
- Maximum core return to power ~9%, peak pin power > 50%
- Design remains subcritical if all control rods insert

# Regulatory Background

- General Design Criterion 27 states,
  - The reactivity control systems shall be designed to have a combined capability, in conjunction with poison addition by the emergency core cooling system, of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained.
- Staff review focused on meaning of "reliably controlling reactivity changes"
- SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs," stated,
  - "…that conditions other than cold shutdown may constitute a safe shutdown state as long as reactor subcriticality, decay heat removal, and radioactive materials containment are properly maintained for the long term."

# Regulatory Background (cont)

- Definition of safety-related SCCs in 10 CFR 50.2 states,
  - (2) The capability to shut down the reactor and maintain it in a safe shutdown condition
- The NRC has licensed designs which return to power in the short term following some postulated accidents (e.g., PWR Main Steam Line Breaks)
- The NRC has not licensed a power reactor that does not achieve subcriticality in the long term using only safety-related systems
- Staff's responded to NuScale that an exemption to GDC 27 would be required and such an exemption would warrant Commission consideration and direction prior to the staff's approval (ML16116A083)

# What is the Exemption?

- The exemption is from the staff's position that "reliably controlling reactivity changes" in GDC 27 includes the requirement to achieve subcriticality beyond the short term using only safety related equipment following a postulated accident with a stuck rod
- "Beyond the short term" means the long term, natural equilibrium state achieved by the reactor

# NuScale's PDC 27 and Exemption Request

- PDC 27 in DCD Section 3.1.3.8 states,
  - "The reactivity control systems shall be designed to have a combined capability of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained

    Following a postulated accident, the control rods shall be capable of holding the reactor core subcritical under cold conditions, without margin for stuck rods provided the specified acceptable fuel design limits for critical heat flux would not be exceeded by the return to power"

# Staff's Review Approach

- Staff applied the Enhanced Safety Focused Review Approach (ESFRA) at the beginning of the review
  - Identified this issue would receive more emphasis in terms of review scope and depth, compared to a traditional review, using the ESFRA tool
- Staff is early in the review of the analysis (Phase 1) and continues to apply ESFRA in its review
- Technical audits of NuScale analyses is ongoing, as well as staff confirmatory analyses

# Staff's Review and Acceptance Criteria

- Chapter 15 review considers,
  - Conservative analysis assumptions, worst stuck rod and evaluating the SAFDLs (GDC 10) as the acceptance criterion to demonstrate adequate cooling by maintaining the fuel clad fission product barrier
  - This is consistent with the methodology typically used to analyze PWR main steam line break, short-term return to power
  - Does not consider the probability of occurrence (event probability is 1)
- Exemption review will consider,
  - Chapter 15 acceptance criteria are met (SAFDLs)
  - Shutdown is maintained assuming all control rods insert
  - Probability of occurrence is low (not within the lifetime of a module)
- If above are met the staff anticipates recommending granting the GDC 27 exemption and approval of a final version of PDC 27

LO-0218-58493

February 1, 2018

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

**SUBJECT:** NuScale Power, LLC Submittal of Presentation Materials Entitled “Shutdown Capability of the NuScale Power Module,” PM-0218-58480, Revision 0

**REFERENCES:** “NuScale Power, LLC Submittal of the NuScale Standard Plant Design Certification Application,” dated December 31, 2016 (ML17013A229)

NuScale Power, LLC (NuScale) will meet with the Advisory Committee on Reactor Safeguards on February 8, 2018 to discuss its exemption request from General Design Criteria (GDC) 27.

The purpose of this submittal is to provide presentation materials that NuScale intends to use at the meeting.

Enclosure 1 is the nonproprietary presentation entitled “Shutdown Capability of the NuScale Power Module,” PM-0218-58480, Revision 0.

This letter makes no regulatory commitments or revisions to any existing regulatory commitments.

Please feel free to contact Darrell Gardner at 980-349-4829 or at dgardner@nuscalepower.com if you have any questions.

Sincerely,

Zackary W. Rad
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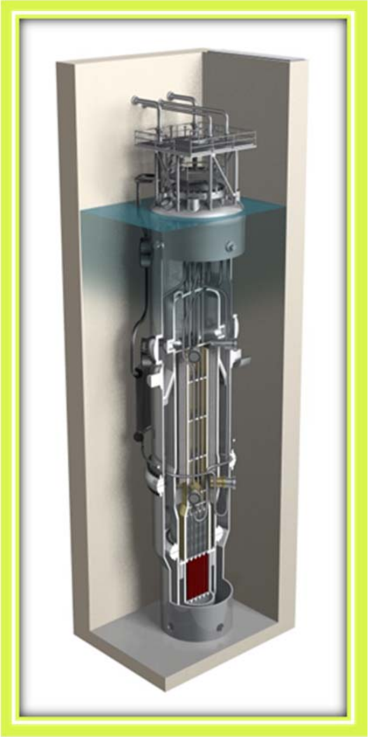
Enclosure: “Shutdown Capability of the NuScale Power Module,” PM-0218-58480, Revision 0

**Enclosure:** "Shutdown Capability of the NuScale Power Module," PM-0218-58480, Revision 0

# Shutdown Capability of the NuScale Power Module



**Derick Botha**

**Darrell Gardner**

*February 8, 2018*

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# Outline

- GDC 27 Exemption
- NuScale Reactivity Control Systems
- Exemption Review Criteria
- Design Evaluation
- Summary

# GDC 27 Exemption

- NuScale has identified the possibility of a return to power condition under very limited conditions and assumptions
  - Passive cooldown to low RCS temperatures is unique to NuScale design
- This condition was evaluated against the General Design Criterion
  - NuScale did not identify a need for an exemption and believes current design satisfies the GDC
    - Draft GDCs explicitly required systems to make core “subcritical”
    - Final GDCs revised by the Commission to address “controlling reactivity changes” to assure acceptable radiological consequences
    - NuScale design approach is consistent with literal language and intent of final GDCs
  - NuScale submitted a white paper on reactivity control (LO-1116-51829, Nov 2016) and addressed compliance with GDC 26 and 27 reactivity control functions
    - protection function: rapid power reduction to protect fuel, assuming WRSO, to protect fuel (AOOs under GDC 26) or to maintain core cooling capability to mitigate the consequences of accidents (DBAs under GDC 27)
    - shutdown function: capability to hold the core subcritical under cold conditions

# GDC 27 Exemption

- NRC staff position (ML16116A083, Sep 2016) is that an exemption from GDC 27 is required
  - design departs from precedent (i.e., long-term shutdown with WRSO)
- NuScale complied with staff position and applied for exemption to GDC 27
  - whether or not an exemption is required, NuScale believes the design solution and safety demonstration are unchanged
- Exemption and FSAR establish PDC 27
  - Regulations require NuScale to define the PDCs for the design, and relation of the design bases to the PDCs
  - PDC 27 addresses precedent by explicitly defining requirement for long-term shutdown following postulated accident: NuScale design assures long-term shutdown with all rods in, but recriticality with WRSO would not exceed CHF:
    - *The reactivity control systems shall be designed to have a combined capability of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained.*
    - *Following a postulated accident, the control rods shall be capable of holding the reactor core subcritical under cold conditions, without margin for stuck rods, provided the specified acceptable fuel design limits for critical heat flux would not be exceeded by the return to power.*

# NuScale Reactivity Control Systems

- NuScale uses two primary reactivity control systems
  - safety-related control rods and nonsafety-related chemical volume and control system (CVCS)
- The selected reactivity control systems are consistent with NuScale design objectives for passive safety and simplicity
  - design does not use ECCS makeup with boron - typically the only safety-related boron injection for PWRs
  - Following transients, RCS passively cools down to low temperatures – not just to “hot shutdown”
  - Control rods alone maintain shutdown through entire RCS temperature range
- Assuming certain low probability conditions, there is a possibility of a return to power after a trip concurrent with a control rod malfunction (stuck rod)
  - late in core life (low boron concentration) and at low decay heat (core has cooled significantly), the small core with high control rod worth could experience a return to power if the highest worth rod is stuck out and AC power is not available to operate the active CVCS system
    - in all cases, reactor immediately shuts down after a trip using only control rods, even with WRSO
  - the reactor remains shut down under cold conditions with reliance only on control rods
    - indefinitely when all control rods are inserted, **or**
    - indefinitely with WRSO during first 70 percent of equilibrium fuel cycle, **or**
    - for 30 days (typical) assuming WRSO while decay heat remains above 100 kW* (negative reactivity feedback from voiding in the core limits return to power)


PM-0218-58480
Revision: 0

Template #: 0000-21727-F01 R2

# Exemption Review Criteria

- NuScale believes maintaining core cooling is the design objective of reactivity control systems in GDC 27 (postulated accidents)
  - the “safety concern” for a return to power event is that it could challenge heat removal system capability such that the core is insufficiently cooled resulting in core damage
  - maintaining peak cladding temperature limits is considered sufficient to maintain core cooling
  - core cooling is conservatively demonstrated by maintaining CHF limits
- NRC’s proposed criteria for an exemption to GDC 27 is conservative
  - maintain AOO acceptance criteria (CHF) and restrict frequency to less than that of an AOO (not expected in the life of a module)

# Design Evaluation

| | Deterministic Evaluation (Chapter 15) | Probabilistic Evaluation |
|---|---|---|
| Purpose | Evaluate safety | Evaluate shutdown reliability |
| Conservative assumptions | 1. WRSO with limiting shutdown margin<br>2. MTC<br>3. Cooldown rate<br>4. Xenon and boron concentration<br>5. No credit for non-safety systems | 1. CVCS failure on demand vs. less likely extended unavailability of CVCS and CFDS<br>2. Occurs throughout cycle vs. latter 30% of cycle<br>3. No decay heat after restart vs. more likely decay heat levels to prevent return to power |
| Probability | =1 under Ch 15 assumptions<br>=0 that all assumptions will actually occur | <1E-6 per reactor module year |
| Event progression | 1. Return to power at 2+ hrs with DHRS cooldown<br>2. ECCS actuates resulting in subcriticality<br>- in less than 24 hours if AC and DC power is lost, or<br>- after 24 hours with DC power available<br>3. Limiting condition for ECCS heat removal and CHF is subcriticality with maximum decay heat | 1. Return to power during DHRS cooldown is prevented<br>2. Without AC power, ECCS actuates after 24 hours<br>3. Remains shut down until decay heat reduces to < 100 kW<br>4. Sufficient time to restore function to CVCS or CFDS to prevent a return to power |
| Criteria | CHF limit not exceeded | Not expected to occur during the life of a module |

# Design Evaluation

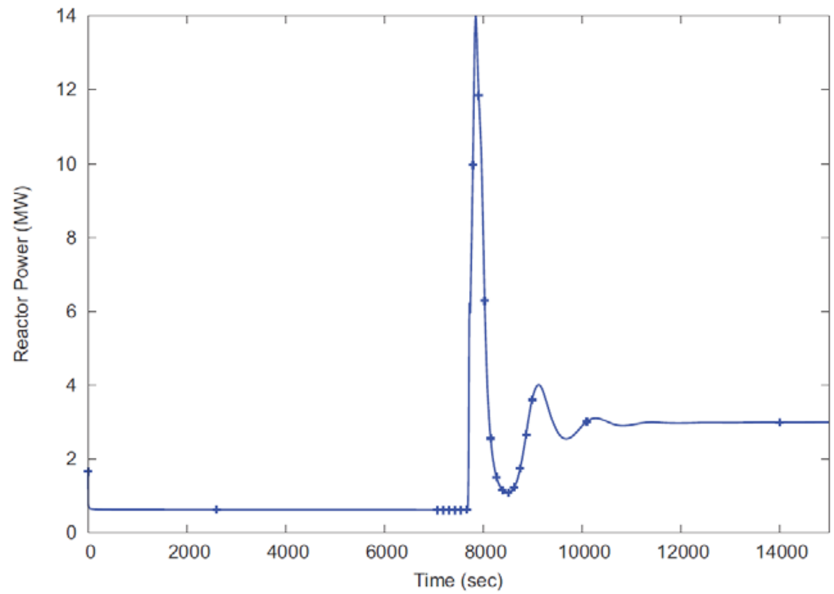
- The capacity of the NuScale passive heat removal systems (DHRS, ECCS) are sufficiently sized to ensure the core remains cooled, irrespective of control rod performance
  - core is protected after a return to power with a WRSO, or even after a failure to trip the reactor (ATWS)
- NuScale safely controls reactivity through natural, predictable, and reliable phenomena (negative void and reactivity feedback)
  - using additional systems to increase shutdown reliability will increase design complexity, reduce overall reliability and likely safety
    - licensed designs had to ensure subcriticality, using deterministic assumptions including a WRSO, to maintain core cooling (limit heat production within the capacity of decay heat removal systems).
  - DHRS heat removal characteristic in combination with negative moderator coefficient leads to self-limiting condition
    - higher power -> higher moderator temperature -> negative moderator feedback
  - ECCS heat removal characteristic in combination with moderator density decrease due to voiding leads to self-limiting condition
    - higher power -> lower moderator density due to voiding -> negative density feedback

# Summary

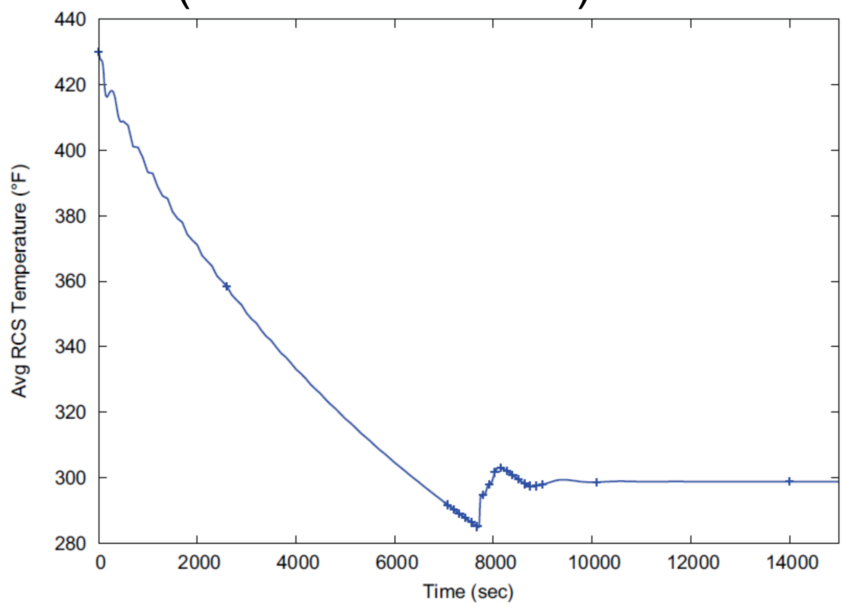
- NuScale is pursuing an exemption from GDC 27 consistent with NRC staff position
- Reactivity control systems are consistent with design objectives for simplicity and passive safety and provide
  - rapid shutdown to protect fuel
  - reliable capability to maintain subcriticality under cold conditions
  - passive heat removal that protects against control rod malfunctions
  - alignment with the NRC's advanced reactor policy statement (73 FR 26349; October 14, 2008) for an advanced reactor design
- A return to power with a WRSO is a benign low probability event with no radiological consequences

# Backup Slides

Reactor Power (Peak Power Case, EDSS Available)

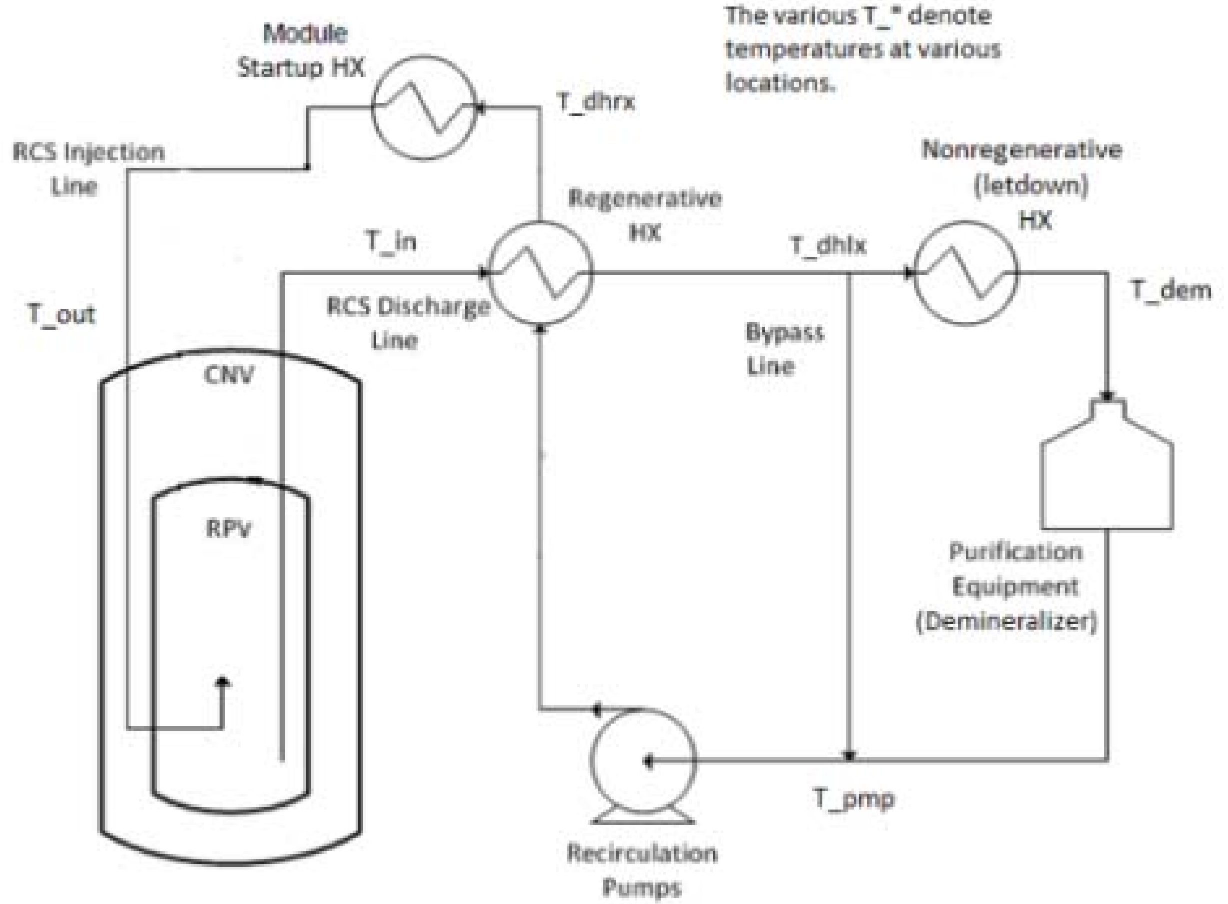



RCS Average Temperature (Peak Power Case)



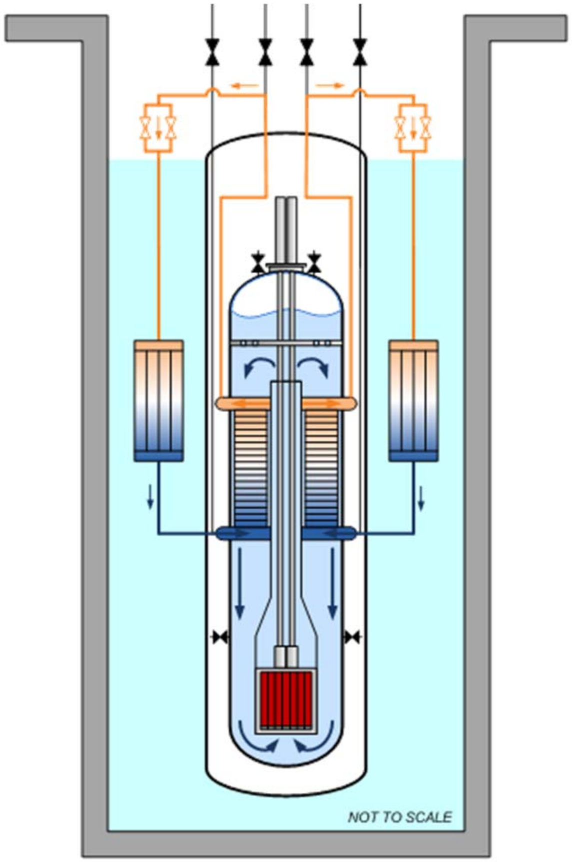
# Backup Slides

## Simplified CVCS Diagram



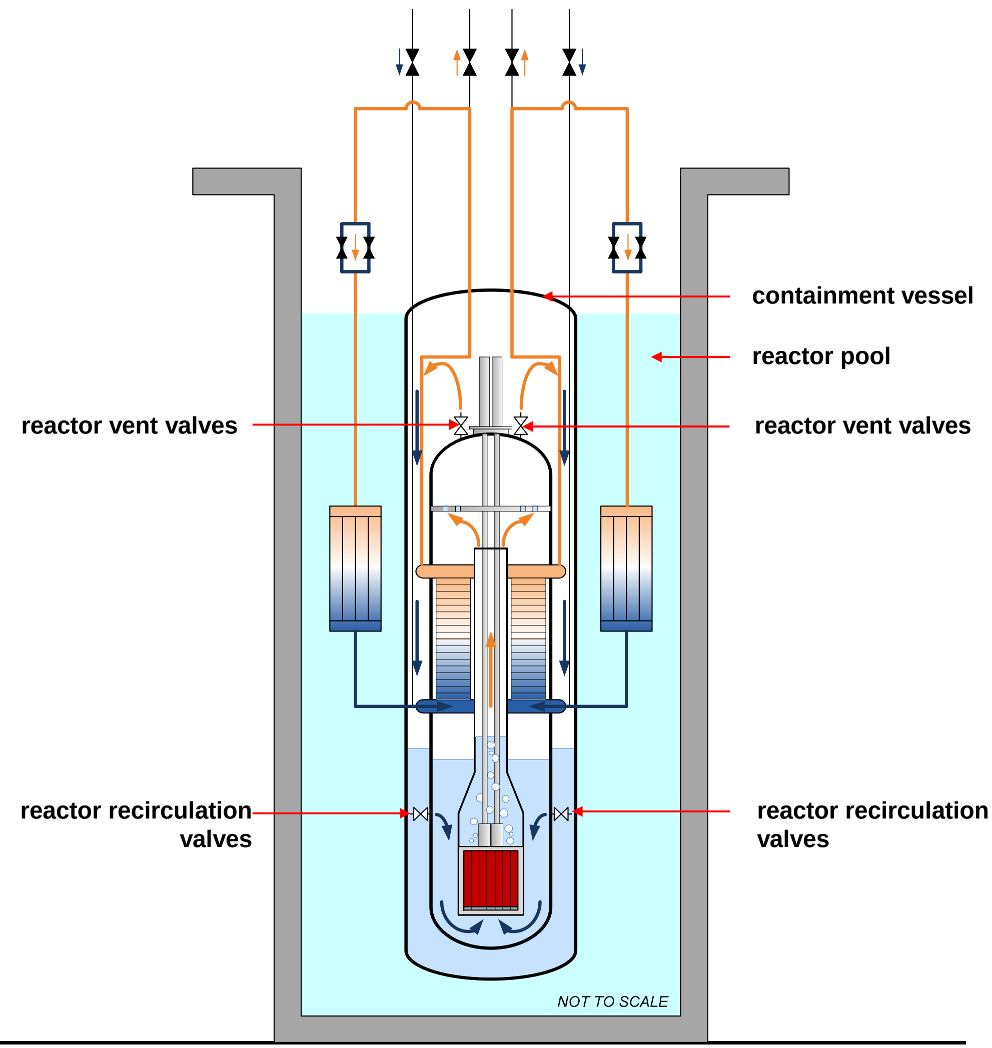
# Design Overview: Passive Decay Heat Removal System

- 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 and redundant trains (1 of 2 trains needed)



# Design Overview: ECCS and Containment Heat Removal

- Adequate core cooling is provided without the need for safety-related injection
- Reactor vent valves and reactor recirculation valves open on emergency core cooling system (ECCS) actuation signal
- Decay heat removed
  - condensing steam on inside surface of containment vessel
  - convection to the pool fluid on outside vessel wall



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