UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

April 18, 2017

MEMORANDUM TO: ACRS Members

FROM: Maitri Banerjee, Senior Staff Engineer **/RA/**
Technical Support Branch
Advisory Committee on Reactor Safeguards

SUBJECT: CERTIFICATION OF THE MINUTES OF THE ACRS FUTURE PLANT DESIGNS SUBCOMMITTEE ON FEBRUARY 22, 2017, ROCKVILLE, MARYLAND

The minutes for the subject meeting were certified on April 18, 2017. Along with the transcripts and presentation materials, this is the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc with Attachment: A. Veil
M. Banks

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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WASHINGTON, DC 20555 - 0001

MEMORANDUM TO: Maitri Banerjee, Senior Staff Engineer
Technical Support Branch
Advisory Committee on Reactor Safeguards

FROM: Dennis Bley, Chairman
Future Plant Designs Subcommittee
Advisory Committee on Reactor Safeguards

SUBJECT: CERTIFIED MINUTES OF THE ACRS FUTURE PLANT DESIGNS SUBCOMMITTEE MEETING ON FEBRUARY 22, 2017

I hereby certify, to the best of my knowledge and belief, that the minutes of the subject meeting on February 22, 2017, are an accurate record of the proceedings for that meeting.

/RA/ **April 18, 2017**

Dennis Bley, Chairman — Dated
Future Plant Designs Subcommittee

Certified on: April 18, 2017
Certified by: Dennis Bley

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
FUTURE PLANT DESIGNS SUBCOMMITTEE
ADVANCED NON-LIGHT WATER REACTOR DESIGN CRITERIA
FEBRUARY 22, 2017, ROCKVILLE, MARYLAND - OPEN

The ACRS Future Plant Designs Subcommittee held a meeting on February 22, 2017 in T2B1, 11545 Rockville Pike, Rockville, Maryland. The meeting convened at 1:00 p.m. and adjourned at 4:10 p.m. The meeting was open to the public.

Written comments and a request for time to make oral statements were received from Derick Botha, a members of the public. His written comments may be accessed in ADAMS under ML17052A815, and are attached.

ATTENDEES

ACRS Members/Staff:

Dennis Bley, Chairman
Michael Corradini, Member
Charles Brown, Member
Walter Kirchner, Member
Dana Powers, Member
Jose March-Leuba, Member
Harold Ray, Member
Joy Rempe, Member
John Stetkar, Member
Gordon Skillman, Member
Matthew Sunseri, Member
Margaret Chu, Member
Ron Ballinger, Member
Andrea Veil, ACRS Staff
M. Snodderly, ACRS Staff (Designated Federal Official)
M. Banerjee, ACRS Staff*

NRC Staff and Consultants:

Jan Mazza, NRO	Deborah Jackson, NRO
John Segala, NRO	Steve Bajorek, RES
Jeffrey Schmidt, NRO	Bob Fitzpatrick, NRR
Imtiaz Madni, NRO	Nicholas McMurray, NRO
Andrew Yeshnik, NRO	Sheila Ray, NRR
Jake Zimmerman, NRR	

Other Attendees:

David Alberstein, INL	Mark Holbrook, INL
Tanju Sofu, ANL	Michael Tschiltz, NEI
Trevor Cook, USDOE	Steven Unikewicz, NuScale
Derick Botha, Public Participant*	Edward Burns, X-Energy

*Connected via telephone

SUMMARY

The purpose of this briefing was for the ACRS members to review the Advanced Non-Light Water Reactor (Non-LWR) Design Criteria (DC) published in a draft regulatory guide, DG-1330, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors," for public comments. The Subcommittee heard presentations by and held discussions with representatives of the NRC staff. The presentation slides and handouts used during the meeting are attached as is the transcript of the meeting.

The following list describes significant issues discussed during the meeting with corresponding pages of the transcript referenced.

SIGNIFICANT ISSUES	
Issue	Reference Pages in Transcript
Chairman Bley convened the meeting introducing the ACRS members present. He noted the members of the NRC staff were to brief the Subcommittee on the development of advanced reactor design criteria (ARDC) and related initiatives. He invited Debbie Jackson, NRO, to introduce the staff presenters and start the briefing.	4-7
Ms. Jackson introduced the NRO speakers.	8
Mr. John Segala noted that issuance of the draft guide served one of the strategic goals for assuring NRC's readiness to effectively and efficiently review and regulate non-LWRs as noted in NRC's draft near-term implementation action plans (IAPs). The scope of staff's presentation included the Non-LWR design criteria that deviated the most from the General Design Criteria (GDC) codified in 10 CFR Part 50, Appendix A. He stated the staff would be appreciative of an ACRS letter if the ACRS identifies significant issues or challenges at this stage.	8-10
Chairman Bley wanted to know how a potential applicant would submit their own Principal Design Criteria, as discussed in the DG. Submittal of a topical report was mentioned.	10-11
Member Corradini wanted to know if the same process would be applied to the potential applicant of a modular LWR. The available GDC and the process for exemption requests were mentioned.	11-12
Upon Chairman Bley's question Ms. Jan Mazza discussed the need for changes to incorporated appropriate nomenclature. Chairman Bley wanted to know if most advanced reactors would be able to find the right design criteria among the three sets provided in the DG.	13-15

Discussion on incorporating the DG into the regulatory frameworks for non-LWR: Member Corradini wanted to know how a determination on design-basis accident versus a beyond-design-basis accident would be made. NGNP experience was mentioned. Mr. Segala pointed out that under NRC vision and strategy and implementation action plans Strategy 3, staff is working with the industry in developing a licensing basis event selection process, and the industry is building on the NGNP approach. Future topical reports on licensing basis event selection and PRA technical adequacy were mentioned, and an interest in ACRS briefing was noted.	15-19
Member Corradini wanted to know if any RES activity is ongoing regarding the fundamental and unusual technical issues related to a liquid fuel reactor. Staff noted and described activities in this area under Strategy 2. A discussion followed.	20-24
Member Rempe wanted to know how staff would implement the Commission expectations for enhanced margin, and increased reliance on passive features in advanced reactors.	25-26
Member Skillman noted the new criteria developed for SFR and mHTGR and asked if staff found outliers where the existing GDC just don't function properly. A discussion followed and staff went into the logic of developing ARDC 34 and 35 (residual heat removal and ECCS, respectively).	27-30
A discussion on the basis for not covering severe and beyond-design-basis accidents for non-LWRs in the design criteria development took place.	31-32
Ms. Mazza's presentation provided an overview, background, the approach taken to develop the non-LWR design criteria, the current status, and intended use. Member Corradini asked how a molten salt reactor with molten salt as a coolant and TRISO fuel in a tennis ball or in a prismatic arrangement would address DC-10, Reactor Design. A discussion followed and the staff noted that a Commission policy might be required given the case.	33-38 Slides 3-16
Upon member Rempe's question a discussion on staff's plan to address policy decisions followed.	39-40
Discussion on when the principal design criteria would become license conditions: Status of GDC applicability to non-LWRs, and need for new principal design criteria based on better understanding of the technology and phenomena involved would be required.	41-46
Ms. Mazza noted the most significant changes to be for criteria related to reactor design, containment, electric power, reactivity control, residual heat removal, emergency core cooling, and the new technology-specific design criteria. The DG has been out for public comments, with the period expiring on April 4, 2017, with a plan to issue the regulatory guide in December 2017.	46-47

Jeff Schmidt's presentation on Design Criteria No. 10, Reactor Design: Discussion on mHTGR-DC 10 in which the concept of the specific acceptable fuel design limits (SAFDL) was replaced with the specified acceptable system radionuclide design limit (SARRDL). A long discussion followed regarding TRISO fuel failures (pre-existing, catastrophic failure, and failure threshold or a cliff), fuel qualification, and the dose criteria for an AOO or a postulated accident (SAARDL to meet siting dose limits for most limiting LBE). Member Corradini asked why the same concept of release, the SARRDL concept, and its relation to containment function was kept limited to mHTGR only. The discussion ended with noting the possibility that staff may use the same concept for liquid fuels.	47-56 Slides 18-19
Discussion on the concept of SAFDL (fuel thermal design limits) vs. SARRDL and if the latter is more critical for Criterion 16 related to containment vs. Criterion 10 on reactor design: Members asked why a SAFDL with a revised definition could not be used for mHTGR DC-10. Some members were concerned that this could create more uncertainty for designers and applicants.	57-63
Further questions on SARRDL from members led David Alberstein of INL explain the safety design approach of modular HTGRs. He noted the mechanistic source term methodology is used to back-calculate the limit on circulating and plated-out activity from the maximum allowed offsite dose at the exclusionary area boundary. He also noted that for TRISO fuel the time-at-temperature phenomenon is more relevant than a temperature limit, and that SARRDL is an attempt to limit the initial conditions relative to circulating and plated-out activity for analysis of postulated accidents. He explained how a reactor designer will use SARRDL.	63-69
Member Powers noted that TRISO fuel failure should not be treated as random. Mr. Alberstein explained how the product and process specifications are used and how a bad batch of fuel could be handled. The circulating helium activity is monitored to show that SARRDL, a fuel performance limit, is not violated. Upon member Rempe's question, Mr. Schmidt pointed out how re-mobilization of plated-out activity could be handled through the mechanistic source term methodology. Members noted that staff needed to be consistent in addressing both the circulating and plated-out activity, and that a better definition of SARRDL may be needed.	69-77
Mr. Schmidt concluded his presentation by noting that mHTGR DC-10 may involve policy engagement to allow incorporation of AOO dose consequences (in SARRDL) which was not involved in SAFDL.	77-78
Mr. Imtiaz Madni presented Containment Design Criteria AR/SFR/mHTGR DC-16, and mHTGR DC-70, 71, and 72. He noted mHTGR-DC 16 will be subject to policy decision by the Commission. The rationale of changing "leak-tight" requirement in GDC-16 to "low leakage" in SFR DC-16, how a filtered vented containment would fit the new definition in SFR DC-16, how the	79-102 Slides 20-34

statement "as long as the postulated accident conditions require" would be defined, the application of defense-in-depth, containment boundary in relation to the intermediate cooling system, and the testing regimen were discussed. Members wanted to know the design basis leakage number used for the Fermi containment.	
SFR DC-16: Mr. Madni presented the basis behind requiring a high-strength pressure-retaining low leakage containment structure surrounding the reactor and its primary cooling system for SFR. He discussed NRC rationale for adaptations to GDC, and consideration of sodium spray fire. Member Powers pointed out that the design should consider failure of a previous barrier.	102-106 Slides 21-27
Member Skillman's concern on need for testing on SFR was answered by Mr. Sofu. For mHTGRs functional containment testing requirements are addressed in new criteria 70-72.	106-110
Mr. Madni stated the mHTGR DC-16 is based on the premise of a functional containment, and involves a Commission policy issue as noted in Slide 30. Mr. Alberstein noted the safety function of the reactor building to be protection of the geometry that allows for passive heat removal under accident conditions, and nor related to radionuclide release. He also discussed the functional containment design objective to be not exceeding the EPA protective action guides at the exclusionary boundary.	109-115 Slides 28-31
Mr. Madni mentioned the mHTGR policy issue related to functional containment. A discussion followed.	116-118 Slide 30
Mr. Madni presented the new design criteria 70, 71 and 72 for the mHTGR. A discussion on the term "integrity" related to pathway for passive removal of residual heat to the ultimate heat sink followed. A question of steam generator tube rupture was asked. Members noted interest in HTGR analysis of containment function under accident conditions. Availability of historic information was noted.	119-128 Slides 32-34
Mr. Schmidt presented ARDC 26 and 27 related to reactivity control, where the criteria 26 and 27 are combined into one ARDC-26. Question was asked if ARDC-26 could be applied to new LWRs. Members were concerned that unlike GDC-26, requirements for controlling the rate of reactivity change resulting from planned normal power changes are not addressed in ARDC-26.	128-153 Slides 36-37
Mr. Schmidt presented ARDC/SFRDC-34 and 35, criteria for RHR and ECCS. He explained that although most non-LWR designs use one system to satisfy ARDC/SFRDC- 34 and 35 requirements, the option to address a post-accident coolant injection system was provided in ARDC-35. ARDC-34 addresses residual heat removal under normal operations and AOOs, and ARDC-35 the postulated accident residual heat removal. He explained the testing and inspection requirements in criteria 36 and 37.	154-156 Slides 39-40

Mr. Schmidt presented mHTGR DC-34 and why a criterion 35 was not needed.	157-160 Slides 41-42
Member Bley asked if any design criteria would address the integration of security with safety. Given there is no current design criteria for security, staff is preparing a document on security design considerations following the advanced reactor policy statement. They plan to release it for public comments and present it at the April advanced reactor workshop. Member Corradini re-iterated his concern that a natural or manmade external event could upset the geometry and impact passive heat removal, and these types of events need to be considered while integrating security to safety design aspects.	160-163
Member Kirchner wanted to know if the mHTGR reactor building would be safety grade. Messrs. Holbrook and Alberstein from INL answered and a discussion took place. It was noted that for passive heat transfer, the mHTGR needed to take credit for protecting the building geometry.	164-168
Mr. Bob Fitzpatrick presented ARDC-17 on electric power and its development. He discussed the logic behind not using the term "offsite power," and the redundancy requirement. A debate broke out regarding "independent" and how defense-in-depth in existing GDC-17 will be maintained. Need for electric power for functioning of the main control room was discussed. SFR DC-17 or mHTGR DC-17 have the same electrical requirements.	168-200 Slides 44-50
Staff presentation on design criteria specific to Sodium Cooled Fast Reactors: Mr. Madni presented SFR DC-71 through 74. Member Bley asked if these criteria were considered during the licensing of the Clinch River Breeded Reactor. Discussion took place on provisions to address sodium concrete interaction, sodium water reactions, power conversion system operating fluid, and if some generalization of the criteria might be needed.	201-210 Slides 53-56
Mr. Andrew Yeshnik presented SFR DC-78 and 79, and the basis behind developing these criteria. A discussion on SFR spent fuel took place, followed by the direct auxiliary cooling system (DRACS) system in a PRISM reactor.	211-222 Slides 58-59
Mr. Nick McMurray presented SFR DC-70, 75, 76 and 77 that apply to the intermediate coolant system. These are the basic criteria for this system in the event that a SFR requires an intermediate coolant system to meet SFR DC-78. Question on developing quality group standards for advanced reactors was discussed. Experience with EBR II, Fermi 1 and FFTF were noted, and handling through code cases was mentioned. Activities under IAP Strategy 4 were noted. Discussion took place on how staff implements "highest quality standards," and application of quantitative risk assessment. Potential of the liquid metal coolant to degrade the primary coolant boundary was discussed.	222-237 Slides 61-64

Chairman Bley noted that ACRS got written comments from Derick Botha, a member of the public. Mr. Botha presented his comments related to the advance reactor design criteria 26, regarding the redundancy of the reactivity control systems.	238-247
Chairman Bley asked for public comments. Mr. Mark Holbrook from Idaho National Laboratory, noted that they plan to submit comments on DG-1330 prior to the April 4th public comment cut-off date. He also noted the Commission policy work on functional requirements.	247-249
Ms. Mazza stated the staff was looking for a letter from ACRS on DG-1330. Need for the letter was discussed among members.	250, 253-254
Chairman Bley provided his comments: 1) lack of clarity regarding SARRDL; 2) need for reliable electric power for monitoring habitability, lighting, radiation monitoring, and communications (re: ARDC 17). He asked members to address issues that the Committee should stress in case a letter is written on DG-1330.	251
Member Rempe reiterated the need to consider failure of the primary system that might subsequently lead to a failure of the containment (noted in above paragraphs on Criterion 16). She also mentioned that plated-out activity as well as circulating activity be discussed, as well as some clarification on spent fuel storage capability.	252-253
Members Brown and Kirchner provided comments. The need for controlling the rate of reactivity insertion with the harder spectrum reactors and certainly with the SFR was noted (Criterion 26). Members shared Chairman Bley's concern on electric power.	254-256
Member March-Leuba noted further clarification with words like "independent, redundant, diverse" may clarify staff's intent in the DG.	256-257
Member Stetkar noted if the Committee writes a letter it should note the need to define "vital function" in terms of staff expectations in ARDC-17.	257-258
Member Corradini noted the need for connection between ARDC 10 (Reactor Design) and 16 (Containment Design). He also stressed the need to determine licensing basis events before approaching the design criteria.	258-259
Member Powers noted the language in the DG should facilitates or at least not preclude the use of quantitative risk assessment. Member Skillman agreed with comments from the other members on Criteria 17 and 26, need for policy regarding functional containment, and extending the words in Criterion 16, Containment Design, to "as long as postulated accident conditions require."	259-262
Member Ray mused on the difficulty of demonstrating the independence of offsite sources (re: GDC 17) that ought to be addressed if identified as an option. He agreed with member Corradini that in the absence of knowing the	262-263

basis for establishing the design basis accidents it may be a little challenging to be comfortable with the design criteria.	
Member Sunseri shared with previous members' comments on Criterion 16. Member Ballinger noted criterion 61, Fuel storage and handling and radioactivity control, could have been left as is with additional emphasis on inspectability etc. given the containment design may be different for different advance reactors	264-265
Mr. Schmidt, NRO responded to member Corradini's question on Criterion 26 that any intrinsic quality of the design can be credited as a shutdown mechanism. A discussion took place.	265-267
Chairman Bley noted that if the Committee decides to write a letter during the March meeting on IAPs, he may include the design criteria comments in the same letter. Chairman Bley adjourned the meeting at 4:10 p.m.	267-268

MEMBER REQUESTS AND QUESTIONS	
Item	Reference Pages in Transcript
Item 1: Members wanted to know the design basis (leakage) used for the Fermi (containment)	99
Item 2: NRC staff was requested to provide the security design considerations document being prepared.	163

<u>Documents provided to the Subcommittee</u>

1. U.S. Nuclear Regulatory Commission, Draft Regulatory Guide DG-1330, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors," February 2017 (ML16301A307).
2. Summary of October 11, 2016 Public Meeting Regarding Non-Light-Water Reactor Design Criteria (ML16314B333)
3. INL/EXT-14-31179, Revision 1, Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors, December 2014 (ML14353A246 and ML14353A248)
4. ACRS letter "Next Generation Nuclear Plant (NGNP) Key Licensing Issues," May 15, 2013 (ML13135A290)
5. U.S. Nuclear Regulatory Commission, "Next Generation Nuclear Plant Assessment of Key Licensing Issues," July 17, 2014 (ML14174A626).
6. DOE, Tanju Sofu, Argonne National Laboratory, "Sodium-cooled Fast reactor (SFR) Technology Overview," IAEA Education and Training Seminar on Fast Reactor Science and Technology, ITESM Campus, Santa Fe, Mexico City, June 29–July 3, 2015.

7. DOE slides “Sodium-cooled Fast Reactor (SFR) Technology and Safety Overview,” February 18, 2015.

DISCLAIMER

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

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

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

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
Future Plant Designs Subcommittee

Docket Number: (n/a)

Location: Rockville, Maryland

Date: Wednesday, February 22, 2017

Work Order No.: NRC-2905 Pages 1-255

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FUTURE PLANT DESIGNS SUBCOMMITTEE

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WEDNESDAY

FEBRUARY 22, 2017

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:32 a.m., Dennis C. Bley, Chairman, presiding.

COMMITTEE MEMBERS:

DENNIS C. BLEY, Chairman

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

MARGARET CHU, Member

MICHAEL L. CORRADINI, Member

WALTER L. KIRCHNER, Member

JOSE A. MARCH-LEUBA, Member

DANA A. POWERS, Member

HAROLD B. RAY, Member

JOY REMPE, Member

GORDON R. SKILLMAN, Member

JOHN W. STETKAR, Member

MATTHEW W. SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:

MICHAEL SNODDERLY

ALSO PRESENT:

DAVID ALBERSTEIN, Idaho National Laboratory

STEVE BAJOREK, NRO

DERICK BOTHA, Public Participant

BOB FITZPATRICK, NRR

DEBBIE JACKSON, NRO

IMTIAZ MADNI, NRO

JAN MAZZA, NRO

NICHOLAS MCMURRAY, NRO

JEFFREY SCHMIDT, NRO

JOHN SEGALA, NRO

TANJU SOFU, Argonne National Laboratory

ANDREA D. VEIL, Executive Director, ACRS

ANDREW YESHNIK, NRO

*Present via telephone

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

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

8:32 a.m.

CHAIRMAN BLEY: The meeting will now come to order. This is a meeting of the Future Plant Design Subcommittee of the Advisory Committee on Reactor Safeguards.

I'm Dennis Bley, Chairman of the Subcommittee. ACRS members in attendance today are: Michael Corradini, Joy Rempe, John Stetkar, Harold Ray, Charles Brown, Dick Skillman, Ron Ballinger, Matt Sunseri, Walter Kirchner, Margaret Chu and Jose March-Leuba. And we expect -- and Dr. Dana Power. Mr. Michael Snodderly is the designated federal official for this meeting.

Today we have members of the NRC staff to brief the Subcommittee on Draft Regulatory Guide DG-1330, Guidance for Developing Principal Design Criteria for Non-Light Water Reactors. The design criteria were developed through a joint initiative of DoE and NRC. DG-1330 has been published in the Federal Register for public comments.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, 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 office requesting time after the meeting announcement is published in the Federal Register.

That said, we set aside 10 minutes for spur of the moment comments from members of the public attending or listening to our meetings. Written comments are also welcome.

The ACRS section of the U.S. NRC public web site provides our charter, bylaws, letter reports and full transcripts of all Full and Subcommittee meetings, including slides presented there.

The rules for participation in today's meeting were announced in the Federal Register on February 2nd, 2017.

The meeting was announced as an open/closed meeting. This means that we can close the meeting to discuss sensitive issues and presenters can defer questions that should not be answered in the public session.

A written statement and request to make an oral statement was received from Derick Botha speaking as a member of the public who also works for NuScale. Mr. Botha's written comments can be found at ADAMS Ascension No. ML-17052A815, and copies have been provided at the back of the room. We have provided him 10 minutes to make a presentation at the end of the scheduled other presentations.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the Subcommittee. Participants should first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We have a bridge line established for the public to listen to the meeting. The bridge number and password were published in the agenda posted on the NRC public web site. To minimize disturbance the public line will be kept in a listen-in only mode. Public will have an opportunity to make a statement or provide comments at a designated time toward the end of this meeting. Also to avoid disturbance I request that attendees put their electronic devices like cell phones in the off or noise-free mode.

It's my understanding that NRO is interested in member comments and questions on the Principal Design Criteria, but will not be seeking a Committee letter until later this year after they have prepared a final Draft Reg Guide.

At this time I am going to invite Debbie Jackson to introduce the presenters and start the briefing.

Debbie?

MS. JACKSON: Thank you, Dr. Bley, and good morning, everyone. We're really looking forward to this meeting. The staff has put an extensive amount of effort into developing these design criteria, many different offices.

So I'd like to start by introducing the staff speakers. Jan Mazza, who's a project manager in the Division of Engineering, Infrastructure and Advanced Reactors; John Segala, the branch chief for the Advanced Reactor and Policy Branch, and Jeff Smith, technical reviewer in the DSRA.

So with that, I'd like to turn it over to John who will make opening remarks. Thank you.

MR. SEGALA: Thank you, Debbie.

Good morning. We are pleased to be here to discuss the Non-Light Water Reactor Design Criteria and the associated Draft Regulatory Guide. The release of the Draft Regulatory Guide is a major milestone for NRC's preparations to review non-light water reactors. Over the past several years there's been a significant interest in industry and in the development and licensing of non-light water reactors. In December of 2016 the think tank Third Way updated its report identifying over 58 companies developing advanced reactor designs and other nuclear technologies.

In response to the growing interest in advanced reactors, the NRC issued its vision and strategy document for advanced reactors in December of 2016. This included a strategic goal of assuring NRC's readiness to effectively and efficiently review and regulate non-light water reactors.

To help achieve this goal the NRC developed a draft near-term implementation action plans, or what we call IAPs. These include six strategies. Strategy 3 involves the development of guidance for flexible regulator review processes within the bounds of the current NRC regulation.

This includes developing a conceptual design review process and a stage review process.

The Draft Regulatory Guide for Non-Light Water Reactor Design Criteria supports Strategy 3 of the implementation action plans. The staff plans to discuss the vision and strategy document and the implementation action plans with the ACRS on March 8th of 2017.

This effort to adapt the General Design Criteria in 10 CFR Part 50 to non-light water reactors is a joint -- was started in 2013 as joint initiative between the Department of Energy and the NRC and was supported by technical experts across the agency, and many of those are here today.

The Non-Light Water Reactor Design Criteria being presented today represent technical areas that the staff felt deviated the most from the General Design Criteria and warranted additional considerations.

I do -- we aren't looking for a letter at this time at this stage, however if the ACRS does identify significant issues or challenges at this stage, it may be beneficial to get a letter to help us address those comments during the public comment period on the Draft Regulatory Guide, but we can discuss that more at the end of the meeting to see what the next steps are. The NRC plans to finalize the Reg Guide by the end of this calendar year 2017. So I'll now turn it over to Jan Mazza.

CHAIRMAN BLEY: Well, before you do --

MR. SEGALA: Okay.

CHAIRMAN BLEY: -- just a couple of general questions from me, if you don't mind.

As I read through this, and it points back to the GDCs as well, but I think it says over and over again that these are guidance for people coming forward with a design to determine their own Principal Design Criteria and submit those. But the way they'll do that, is that established or is it expected to be for a topical report? That's kind of the impression I got.

MR. SEGALA: They could do it as a topical. They could submit it as part of their application. We anticipate that this would probably be done during preapplication stage. That would be our hope, to identify these early. They could select whatever Principal Design Criteria they think is appropriate for their design. And then they're going to have to justify why those are the appropriate design criteria. And then the staff would review that. And we may propose additional ones or whatnot based on specific design features that they have. But a topical report would be one way of doing that, or they could do that through some other means.

CHAIRMAN BLEY: I have a couple other general questions.

MEMBER CORRADINI: Can I follow up that one question?

CHAIRMAN BLEY: Oh, sure.

MEMBER CORRADINI: So if I am a small modular reactor, not the current one under consideration, but others that might come as light water, same process?

MR. SEGALA: Well, the design criteria are -- in 10 CFR Part 50, Appendix A are appropriate for light water reactors.

MEMBER CORRADINI: So if something is --

MR. SEGALA: So they could come in I think with Principal Design Criteria, but they would have to take an exemption from the current GDCs, is my understanding. And we would entertain that as part of a --

MEMBER CORRADINI: Okay.

MR. SEGALA: And NuScale could have taken that approach, but I think they chose to generally apply the General Design Criteria as a way to get through the review quicker rather than trying to develop a whole new set of Principal Design Criteria.

MEMBER CORRADINI: Okay. So then just to follow up, so let's say company X approaches NRC and in a preapplication stage says that this one applies; this one doesn't, etcetera, etcetera. Then there would be some sort of SER? What sort of document would finally come out of the staff that would indicate that both the applicant -- potential applicant and the staff are on the same page as to what the Principal Design Criteria?

MR. SEGALA: Well, for instance, if it was a topical report, we would -- we could write a safety evaluation on the topical report. If you go back to PRISM and some of the SAFER -- and we wrote preapplication safety evaluation reports where we evaluated Principal Design Criteria and --

MEMBER CORRADINI: Okay. Thank you.

MR. SEGALA: So there's different ways that we can do that.

CHAIRMAN BLEY: I still have a couple general questions so I don't bog you down later.

In the current Reg Guide we have the advanced reactor criteria and then we have specialized criteria for sodium fast reactors and for modular high-temperature gas-cooled reactors. A couple of things about that.

One is in a fair number or cases it appears that the only difference between the advanced reactor design criteria and the other two are places where the name of the reactor shows up. Am I misreading? Is there some other difference? I mean, I would have expected it to just say, yes, it's the same as the AC/DC, but it doesn't. It reiterates the whole thing.

MS. MAZZA: Is there some nomenclature that we wanted to make sure got put in for the sodium fast reactor design criteria and for the modular high-temperature gas reactor design criteria particularly with the reactor coolant pressure boundary? And it's different for SFRs, and it's the reactor helium pressure boundary for mHTGRs, and it's the reactor coolant boundary for SFRs because there's no pressure. And then for ARDCs I think we kept it as the same as a reactor coolant pressure boundary.

So that kind of nomenclature we were trying to make consistent --

CHAIRMAN BLEY: Make consistent?

MS. MAZZA: -- throughout.

CHAIRMAN BLEY: Okay. And the last one of these real general ones from me is it says that the ARDCs are expected to be appropriate for most other kinds of designs, except you might need some of the stuff out of either the SCFR or the modular high-temperature gas reactor. Is it your -- well, whoever it is, they have to write their own and submit them. But it's your expectation that somewhere among these three most others will be able to find criteria that are appropriate to their designs?

MS. MAZZA: Well, I would think so, but then you come up with some -- there's 58 different designs. There's a lot of --

CHAIRMAN BLEY: Right now, yes.

MS. MAZZA: -- variability out there. And like if you think about liquid fuel molten salt reactors, they'd have to have some specific --

CHAIRMAN BLEY: It just struck me that language was almost unnecessary. Whoever comes in has to propose their own?

MS. MAZZA: Right. And so this is just guidance. And it's just a way for industry to understand what staff was thinking as how the GDCs could be applied, not having a specific design in mind.

CHAIRMAN BLEY: Okay.

MS. MAZZA: Okay.

CHAIRMAN BLEY: Thanks. Go ahead.

MR. SEGALA: I think the designers are looking for more certainty. We could have just not done this whole exercise and they could have proposed their own, but this gives them a level of certainty that this is what the staff is thinking and if they go down this path, they're more likely to find an easier review than if they started from scratch on their own.

MEMBER CORRADINI: So, John, just following on. So although these are quote/unquote "guidance," is it the intent of the staff to incorporate what is in this Reg Guide into the SRP or modify 0800 appropriately for each individual reactor design, or generically, or how would you proceed? Because that's key to getting some certainty in terms of what the regulatory process, when you get into the nuts and bolts, is going to be about.

MR. SEGALA: I mean, at this point our thinking is just issue it as a Regulatory Guide, get it out there. And as part of our vision and strategy and implementation action plans we're looking at longer-term activities to look at developing new frameworks for non-light water reactors in terms of guidance and even regulations. And so we're going to be -- over the next 5 to 10 years we're going to be looking at building that framework. And if that's modifying the SRP or if that's coming up with new guidance documents -- so we would have to do that. So that's something that we're planning to do. I don't think we have all the answers right now.

MEMBER CORRADINI: So I'm not sure if you're going to address this, but -- so my logic is -- and I went through these three columns of possibles. There is always a reference to it must meet the appropriate design-basis accident and it must essentially meet the various 10 CFR 20, 10 CFR 100. Where in the design criteria is there a logical decision making process on what is a design-basis accident versus a beyond-design-basis accident? Where does one go to understand where the accident possibilities fall?

MR. SEGALA: Well, I'm not --

MR. SCHMIDT: Yes.

MR. SEGALA: Do you want --

MR. SCHMIDT: Yes. I don't think -- this is Jeff Schmidt. I don't think we've gotten to that point of classifying what each transient -- where it may be, whether it's relative to an AOO or postulated accident.

MEMBER CORRADINI: But is -- so the follow-on question is do you leave it up to the company X and company Y to throw out a possible? Because last time we were here doing this in 2011, NGNP threw out some classifications, and something was thrown back at them saying no, no, no.

MR. SEGALA: Well --

MEMBER CORRADINI: We have a deterministic worry about accident A, and in our ACRS letter we said if accident A is that important, how come it doesn't appear in any PRAs on either side? So I'm -- to me this is the crux of an uncertainty.

MR. SEGALA: Yes, so as part of the vision and strategy and implementation action plans

-- and this also falls under Strategy 3, is we're working with -- NEI and Southern are developing a licensing basis event selection process to -- basically a process for laying out what are the licensing basis events. And it will also identify what the design-basis accidents are.

And so we're going to be working with industry. We have these -- every six to eight weeks we have these external stakeholder public meetings where we've started engaging with NEI on this topic. And we're going to be moving forward. Ultimately if the staff approves this process, then a designer would apply that to their design and use that process and come up with the design-basis accidents that we would then use these design criteria against.

CHAIRMAN BLEY: Are you planning to delve into that in some detail in our March meeting on --

MR. SEGALA: We will be discussing it. I don't know how much detail, but --

CHAIRMAN BLEY: We're a little sensitive to this because back what Mike was talking about, the DoE had a proposed approach. We reviewed the staff's review of that approach and had some comments on it. And then when the final staff document came out, all of that was expunged. So we're a little lost in what's happened and what's going on.

MR. SEGALA: Well, I think what we have is we're trying to include a spot in the agenda for NEI to give a presentation. We can look into how much detail we can go into at this stage, but they are -- industry, NEI and Southern are building on the NGNP approach. They're looking at the questions that the staff raised and they're trying to incorporate that into this newer version. But we've just started interfacing with them on this.

CHAIRMAN BLEY: Okay.

MR. SEGALA: And they plan to submit a series of topical reports, one on licensing basis event selection and then PRA technical adequacy. They plan to submit some topicals. We're going to be reviewing those when they get submitted. And I assume if ACRS is interested in those, we could brief the ACRS on those.

CHAIRMAN BLEY: One, we are very much. Two, I hope you go back and look at our old letter, because those comments would certainly come back again.

Anything more on that?

MEMBER CORRADINI: I had one other.

CHAIRMAN BLEY: Okay. Go ahead. And then I --

(Simultaneous speaking.)

MEMBER CORRADINI: So I'm kind of curious about from a research standpoint, since research fundamentally is good. If I have company Y that comes in and says I have a molten salt reactor that there's liquid fuel going around and around and around, is there any activity in Research right now to understand the fundamental technical issues related to a liquid fuel reactor versus a not, or other technical issues that are kind of unusual? It seems to me Research ought to get ahead of the game and start thinking about this sort of stuff.

MR. SEGALA: So as part of our implementation action plans we have a Strategy 2 which deals with developing and assessing computer codes and analysis tools in terms of -- for each technology what would be appropriate tools. We plan to leverage existing tools rather than NRC developing its own custom capabilities.

As part of that effort we're going to

be looking at the phenomena that are important in the different technologies and making sure that the analysis tools have the capabilities to analyze that phenomenon and are appropriately benchmarked and all.

I don't know -- but we are -- Research -- and Steve Bajorek over there is leading that effort for NRO.

So I don't know if, Steve, you could add --

MR. BAJOREK: Yes, this is Steve Bajorek from Research. We've actually spent a fair amount of time looking at the molten salt reactors of the various types that we're looking at. Those are probably the -- they have the most differences from a technology and a policy perspective than the other types.

We've been participating in the EPRI GAIN workshops on modeling and simulation. And actually was just at a DoE workshop last week where they're going through the history of MSRs.

We started some work in code selection. The idea is we're going to look at the available codes, not only from what we have at the staff, but also what has been produced by the DoE labs for potential applications for confirmatory analysis.

MEMBER CORRADINI: So one just follow-up, Steve. So codes aside; I love codes, they're wonderful, but I'm thinking from a physics standpoint there are some kind of interesting questions that have to be answered. Has that already been started as an RES activity for NRO?

CHAIRMAN BLEY: Well, let me bend that question just a little bit, because we're setting up for the March meeting because as we read through your document Criteria 2 becomes more important. At first it looks like computer codes, but is really the place all of this -- all the physics and everything else is hidden.

And I guess extending on what Mike said, are you thinking of at least starting with something maybe like a PERT on these different things to identify where you need to do the hard work?

MR. BAJOREK: Just before I came down here at 8:15 I wrote a scope of work that is starting exactly that.

Now it is complicated at this point because a lot of the potential applicants, their designs are somewhere between a Napkin PowerPoint to something that you can actually look at. But there has been a lot of work actually done in molten salt activities at Oak Ridge and sodium fast. So our first shot is to look at those things which are more generic in nature, looking at the processes that, yes, we think most of those molten salts and sodium fast reactors would have.

Then in later years as a design comes in, we would sit down again looking at the deltas between the generic phenomena and what would be inherent to that, the specifics of that design. So we're kind of moving on that fast, but the first part is what I'm calling, for lack of a better term, a pre-PERT evaluation in order to get those phenomena out and known to people.

CHAIRMAN BLEY: Okay. I'm glad to hear that. And we're going to be real interested in that in March. I think that's key. We kind of didn't flag that one early on because we saw computer codes and weren't all that excited, but the --

MR. BAJOREK: Yes, I think --

(Simultaneous speaking.)

CHAIRMAN BLEY: -- under it is of great importance.

MR. BAJOREK: Yes, we called Strategy 2 computer codes --

CHAIRMAN BLEY: You did.

MR. BAJOREK: -- but it's really more encompassing than that. It looks at materials, it looks at PRA, it looks at all of the functional areas where we're going to need to develop capabilities.

CHAIRMAN BLEY: So expect questions there. Before we --

MEMBER REMPE: I --

CHAIRMAN BLEY: -- we're coming back to the design criteria.

I'm sorry. Yes? Who was that?

MEMBER REMPE: Me.

CHAIRMAN BLEY: Oh, I heard a voice.

(Laughter.)

MEMBER REMPE: -- to a -- the actual design criteria, I have a general question, too, if you guys are done.

CHAIRMAN BLEY: I'm not done, but go ahead.

MEMBER REMPE: Oh, okay.

CHAIRMAN BLEY: I'll do mine after yours.

MEMBER REMPE: Okay. Well, at the beginning of your document you talk about Commission expectations for enhanced margin, increased reliance on passive features. Is there going to be -- or how will that be implemented by the staff? Is there going to be a metric for it? Because I've been involved in other discussions other places where it wasn't possible really to have a metric for that.

Is that something that you guys -- basically you've got the criteria, but there's nothing really in there to give that -- the Commission confidence that that's going to occur. Is that a true statement other than you might have increased time, but frankly it's not a requirement. Do you understand what I'm asking?

MR. SEGALA: Yes, I'm not sure we have specific criteria. I mean, the advanced reactor policy statement does say that we expect for those to be -- have enhanced margins to safety, inherent safety, passive features. And then they list a whole set of criteria: less reliance on human action, addressing severe accidents, all those things. I mean, those are expectations for us of these Generation IV reactors as we review them.

There's not a requirement that says that they have to meet every single one of those considerations, but those are considerations that the Commission expects of this generation of --

(Simultaneous speaking.)

MEMBER REMPE: There's no metric for evaluation though, right?

MR. SEGALA: No.

MEMBER REMPE: Thanks.

CHAIRMAN BLEY: And I have one last question. And --

MEMBER SKILLMAN: Dennis, I have one, too, if I --

(Simultaneous speaking.)

CHAIRMAN BLEY: Let me speak this one and then --

MEMBER SKILLMAN: Yes. After you, yes.

CHAIRMAN BLEY: This may be very short. If you have slides later on talking about the key assumptions and clarifications regarding the design criteria, page 10 of your document, that's fine. We'll wait until then. Otherwise, I've got some questions about that.

MS. MAZZA: We don't have any -- I don't have a specific slide on that.

CHAIRMAN BLEY: Okay. Dick, is yours short --

MEMBER SKILLMAN: Yes.

CHAIRMAN BLEY: -- or long? Why don't you do yours and then we'll come back to this one.

MEMBER SKILLMAN: First of all, I commend the staff for using the crosswalk to get us from the GDC over to the ARDC. It's very helpful.

But here's my question: If I look at the SF design requirements, you've added 70 through 78. That's nine new requirements. And for the high-temperature gas reactor it's -- or modular high-temperature gas reactor it's 70, 1, 2 and 3. That's four more. Back in the day there were 70. They got cut back to 64. So we have a population of General Design Criteria with which we're generally comfortable for light water reactor.

Here's my question: In the toil of the staff in putting together this guide, did you find any areas where these don't fit? Are there outliers where the existing General Design Criteria just don't function properly? And if so, where is that information captured?

Here's the reason for my question: This could be a very administrative task going through the General Design Criteria as they currently are written and determining that this design doesn't fit this design. It kind of fits this design. We could make it work on this design. But were there any instances where the staff said, you know what, this doesn't fit at all?

MS. MAZZA: I don't -- I think we pretty much were able to -- for each design criteria we were able to utilize the underlying safety reason to apply to non-light water reactors. I don't think we ever -- we had an area.

Can you recall of anything, Jeff, or --

MR. SCHMIDT: No, I mean, we tried to identify if the current General Design Criteria, the basic fundamental principles would still carry over into a new -- a non-light water design, like reactivity control, decay heat removal. A lot of the GDCs are written generically enough that they still carry over, the thoughts carry over, they safety functions carry over into the ARDCs.

We tried to identify areas for the two specifics listed, for the sodium fast reactor and the high-temperature gas reactor where we thought additional might be needed. And that was pretty much informed by the previous -- like PRISM, for example, preapplication review. So we took lessons learned from that and decided if we needed specific GDCs for the different technologies. And I think fundamentally that the GDCs work pretty well for the advanced reactors, too, because they're basic safety functions.

MR. SEGALA: And, Jeff, can you talk at all about ECCS and how -- I mean, we're going to present on that, but --

MR. SCHMIDT: Yes, we'll --

MR. SEGALA: -- in some of our discussions about how that may not be applicable to -- it's in many the designs.

MR. SCHMIDT: Yes, I think that's probably a good idea.

MR. SEGALA: Yes.

MR. SCHMIDT: I mean, we can give you an example. We had a lot of discussions on GDC 34 and 35, which is basically residual heat removal and ECCS, right?

The concept that we currently work on for light water reactor is effectively -- the ECCS is a makeup system. It's an inventory-add system. Most of the advanced reactors don't need or don't anticipate having an inventory makeup system.

They're either going to preserve inventory somehow or they can lose coolant or whatever their working fluid is and still be fine from a decay heat removal standpoint.

So originally we had ARDC 34 created that rolled up both ECCS and residual heat removal. But then there was some discussion within the group saying, well, I don't think you necessarily want to preclude the injection as part of the design, right? We're living with injection today. There may be designs out there that need injection still. So we ended up breaking up 34 and 35 into separate GDCs again back to kind of the original format based on that working group discussion.

So we went through each GDC thinking where it would still apply and not apply and trying to incorporate what we thought were the different designs out there. So there was a thought process going through each one of those.

MEMBER SKILLMAN: Thank you.

Dennis, thanks.

CHAIRMAN BLEY: Okay. As I read through that list of -- I read it as key assumptions and then said, gee, some of these aren't assumptions. But you say also clarifications, which takes care of the second one for me.

The third one I'm just not -- this seems a true statement: "NRC regulations include severe and beyond-design-basis accidents. Some of these regulations may not be applicable to non-LWRs or they may not address severe and beyond-design-basis accidents for non-LWRs. The NRC may address this as non-LWR technologies and designs mature." That one doesn't seem to have any relevance to the ARDC for me. Why is it there? What are you trying to tell us?

MS. MAZZA: I think we're trying to say that the scope of this does not include beyond-design-basis events.

CHAIRMAN BLEY: Oh, but you need to do that somewhere else?

MS. MAZZA: Somewhere else it needs to be done. We acknowledge that there are -- they're out there, but it is not within the scope of --

(Simultaneous speaking.)

MEMBER CORRADINI: So just to fall back on it? So there is going to be a process? Back to my what's licensing basis events and where do they fall, that's still in a TBD stage, because that assumption kind of -- the same thing -- I had the same thought as Dennis, which is, okay, so you guys say it's not applicable to that, so what is and isn't applicable? What are the accident classes? Okay.

CHAIRMAN BLEY: And where do they go? Yes. One, two, three, four, five. Proposed GDC adaptations were minimized to those needed for improved regulatory certainty and clarity. What's that mean? What did you do? Did you actually do something or is this just a --

MS. MAZZA: It was an attempt to try to utilize the current GDC as is to the extent possible.

CHAIRMAN BLEY: Okay. The next one, "NRC intends" -- oh, this is the one that I kind of hit out earlier -- "intends ARDC to apply to the six -- all six advanced reactor design types identified in the DoE report. In some instances SFR or mHTGR may be more applicable."

But that's almost irrelevant because whatever you're doing you have to come up with your own list. And that just strikes me that would be a better thing to say.

And the next one is really just a

statement, but maybe that's a clarification. I guess that's all I wanted to do with those. They just seemed a little -- like a grouping of different kinds of things, but that's good enough.

Finally, Jan.

MS. MAZZA: Okay. So a lot of what I have to say we've already talked about, so I'm going to try to --

CHAIRMAN BLEY: Well, that's good.

MS. MAZZA: -- move quickly here.

So as you know, I'm the -- I've been the project manager on this since 2014, and recall that we came and briefed you in July, the Subcommittee, and then you asked to come back for more in-depth discussion. So that's why we're here today.

So I'm going to make my opening presentation. It's going to be followed by the technical presentations on the specific design criteria.

This is just an overview of what my presentation is going to include. We'll talk about again a brief background, current status, talk a little bit about the intended use of the Reg Guide. We've talked about that a little bit, but I'll go through that again in case there's more questions. The Draft Reg Guide highlights, and then future activities.

For background very quickly, this started in June 2013 when the NRC and DoE agreed to pursue an initiative to provide guidance to non-light water reactor designers for developing Principal Design Criteria. The idea was to establish the design criteria similar to the light water reactor-focused GDCs in 10 CFR 50, Appendix A. The regulations in 10 CFR, Appendix A state that the GDCs establish minimum requirements for the Principal Design Criteria for water-cooled nuclear power plants and they're generally applicable to non-light water reactors.

So, and then if you go onto the contents of applications and technical information sections of 10 CFR 50 and 52, it states that applications must include the Principal Design Criteria for the facility based on the General Design Criteria.

So, there was a phased approach that was taken. The first phase was completed by DoE in 2014 when they published their report titled, "Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors." Some of the members of that team are in the room today and are on the telephone.

And then NRC's been working on phase 2, which is to consider the DoE report and references and to develop regulatory guidance commensurate with our NRC staff position.

So current status. NRC staff, team of subject matter experts, we've been working. We've made significant progress. As everyone knows, we considered the DoE report and we developed our own proposed version of the ARDC, SFR-DC and mHTGR-DC. And that version went out for informal public comment in April. And by the end of the public comment period we'd gotten about 300 -- over 350 comments from over 20 different stakeholder organizations.

So we considered those comments and then we also held a public meeting in October and had discussions during that public meeting. And we used all that to develop our Draft Reg Guide, which was issued February 3rd, 2017. And comments are due April 4th, 2017.

So now I want to talk a little bit about the intended use of the Reg Guide again. As mentioned earlier, the PDC are derived from the General Design Criteria in 10 CFR 50, Appendix A, which establishes the applicability of the GDC to both light water reactors and non-light water reactors.

So call your attention to the red script on this slide. The General Design Criteria are also considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the Principal Design Criteria for other such units.

So the 10 CFR 50, Appendix A indicates that the General Design Criteria are guidance for non-light water reactors. And as such, non-light water reactor applicants would not need to request an exemption from 10 CFR 50, Appendix A General Design Criteria when they are proposing their Principal Design Criteria.

And then the Reg Guide is intended to provide guidance for reactor designers, applicants and applicants of non-light water reactor designs for developing their Principal Design Criteria.

So the applicants could use the Reg Guide to develop all or part of their Principal Design Criteria, and they can choose amongst the

ARDCs, SFR-DCs, and modular high-temperature gas reactors DCs to develop each Principal Design Criteria. For example, for fluoride high-temperature reactors certain mHTGR-DCs may be more applicable because they use TRISO fuels. And so in this case this designer could propose some ARDCs and then some mHTGR-DCs when they develop their PDCs.

And then you could imagine that molten salt reactor designers would maybe come up with completely new design criteria for their specific technology.

So the Reg Guides intended to provide insight to the staff's current views on how the GDC could be interpreted to address non-light water reactor design features and is not considered to be binding in what might eventually be required from a non-light water reactor applicant.

MEMBER REMPE: Okay.

MEMBER CORRADINI: So let me ask a --

(Laughter.)

MEMBER CORRADINI: That was amazingly good.

(Laughter.)

MEMBER CORRADINI: However, let me just

ask one question. So let me -- we're going to get to DC 10. So let's say I have a -- I deal in specifics -- I have a molten salt reactor that only uses molten salt as a coolant, but it uses TRISO fuel in a tennis ball or in a prismatic thing. Can I go to DC 10 and say it fits the HTGR one and not the advanced reactor one?

MS. MAZZA: You can propose that, yes.

MEMBER CORRADINI: Okay. Fine. Thank you.

MEMBER REMPE: So I have a question.

MR. SEGALA: But you also have to justify why it's appropriate for your design.

MS. MAZZA: And it may require a policy -- it might be a policy issue because --

MEMBER CORRADINI: Why that?

MS. MAZZA: Because I think up to now the Commission's considered the TRISO fuel for mHTGRs and not for other types of technology. So that might be an issue. I don't --

MEMBER CORRADINI: Okay.

MS. MAZZA: It's just a maybe.

MEMBER CORRADINI: Okay.

MEMBER REMPE: I have a couple questions now. First of all, are you seeing any of the 58 companies saying -- getting a lot of feedback from them saying, jeepers, we need more help for us? For example, the lead-cooled reactor that Westinghouse is proposing, or whatever. Are you getting a lot of noise from anybody?

MS. MAZZA: No.

MEMBER REMPE: The other question is is what -- there are several of the advanced criteria that have indicated this is a policy decision. At some point -- maybe this is a discussion for March, but when will the activities to try and go forward with all these policy decisions -- what's the grand scheme on that?

MS. MAZZA: The grand scheme is to try and do policy decisions that are generic first --

MEMBER REMPE: Yes.

MS. MAZZA: -- get the most general ones that benefit the whole industry first taken care of. And then as we get more preapplication with certain technologies or specific vendors that's where we would uncover policy issues for a specific -- an issue that would be --

(Simultaneous speaking.)

MEMBER REMPE: So I like the idea of when you really get a real application and before you -- because there might be a general one, but nobody ever comes forward. And so I -- but we can discuss that I guess next March.

MR. SEGALA: And that's kind of our -- in beyond the design criteria. That's our general approach right now for all of the advanced non-light water reactors is to look at technology-inclusive issues in the near term. And then as we get applications, migrate into the more design-specific issues.

MEMBER REMPE: Yes, but there might be a lot of technology-inclusive ones and nobody ever comes forward is what I'm kind of wondering about. But I guess that's something we can discuss later.

CHAIRMAN BLEY: I have two things, one quick thing for the Committee. You were just handed something that's Committee business and nobody else should see that.

In the implementation section on page 20 there's a whole rigmarole about this is not backfitting and anybody who wants to do a license amendment could use this, but we don't have any non-LWRs licensed right now as far as I know except research reactors or test reactors, right? So it's kind of superfluous information or --

MS. MAZZA: Yes, it's boilerplate.

CHAIRMAN BLEY: Okay. That's what it reads like. Okay. I thought maybe you had some real purpose to have it in there.

MS. MAZZA: I didn't even write it.

CHAIRMAN BLEY: Never mind.

MS. MAZZA: Somebody else --

(Simultaneous speaking.)

CHAIRMAN BLEY: Go ahead.

MS. MAZZA: Okay. So it's important to know that the current GDC are regulations for light water reactor and therefore use the words "shall" and "must" that are appropriate for regulatory requirements. The proposed ARDCs, SFR-DCs and mHTGR-DCs also use the words "shall" and "must" for consistency with the GDC and so that the non-light water reactor applicants can use them in the same manner as the GDC when developing their Principal Design Criteria.

However, the use of "shall" of "must" in a guidance document alone does not make them regulatory requirements. Other regulatory mechanisms or controls would need to be implemented for an employee to make them so.

So I have some --

MEMBER CORRADINI: Just for clarification, going back to my question about the SRP, if rhetorically an applicant adopts one of your three -- one of the three or a mix of them and says this is the basis for our Principal Design Criteria, then in effect when you conduct your review the "shall" and "must" is "shall" and "must," is that correct?

MS. MAZZA: Yes.

MEMBER CORRADINI: Okay.

MS. MAZZA: Once we agree that -- we review and agree that that's the Principal Design Criteria, then it's -- particularly if we have it in a topical report and we've developed an SER for it.

MR. SEGALA: I mean, I think ultimately these Principal Design Criterias would probably become -- depending on whether they came in under Part 50 or 52, if they came under Part 50, they would ultimately become license conditions on their license.

MS. MAZZA: Okay. So now I'm just going to cover some highlights of the Draft Guide. Appendices A -- it begins with the standard front matter: the introduction, discussion, staff regulatory guidance and implementation sections. And then the guidance section includes the crosswalk, which we've provided you earlier, but is also in that section, which gives the status of each non-light water reactor compared to the GDCs.

And then we have Appendices A through C, which have the actual design criteria and the staff's rationale for adaptations of the design criteria to the -- from the GDCs. And then the SFR and mHTGR design criteria have their extra sets of technology-specific.

MEMBER CORRADINI: So just a clarification. So I was following what was -- I get confused with all these various documents -- what was -- I'll find it -- which was the NRC's ML-16096A420, which was released to the public back earlier, not 1330. Are there substantial differences between the two in terms of rationale and wording? I didn't do that kind of cross-check.

MS. MAZZA: In some cases there are, yes.

MEMBER CORRADINI: Can you alert us where there are, because I just assumed they were identical. That was my mistake.

MS. MAZZA: So I think mainly you're

going to see it --

MEMBER CORRADINI: Okay.

MS. MAZZA: -- in today's discussion.

MEMBER CORRADINI: Okay.

MS. MAZZA: That's where we had the most comments and that's where we had the most --

MEMBER CORRADINI: Okay. Thank you.

MS. MAZZA: -- interactions. And so --

MEMBER CORRADINI: Thank you. The only reason -- part of the reason I ask is the way it was in the public document was easy. I could look at the peanut butter reactor compared to the gas reactor compared to the sodium reactor and say what are the differences in terms wording and logic, whereas in this case they're kind of in three different appendices.

MS. MAZZA: Right.

MEMBER CORRADINI: Okay. Fine. Thank you.

MS. MAZZA: Okay. All right. So next slide shows a table of how many General Design Criteria were modified, utilized as is, not applicable or are new technology design criteria. And as a point of reference there's currently 55 General Design Criteria in 10 CFR 50, Appendix A.

So you can see that one was deleted. That was No. 27, which subsumed into No. 26. There's 10 new SFR design criteria, three new mHTGR design criteria. And then 16 of the mHTGR design criteria were determined to be not applicable to mHTGR designs. So it sort of gives you a tally of what -- how this --

(Simultaneous speaking.)

CHAIRMAN BLEY: Just thinking ahead a little now. For the two specific reactors types we have here, DoE and others have done a lot of work, so you had a lot of background for it. But it strikes me that what we're going to hear about next month or maybe sometime later where you're digging into what other issues might be lurking in the physics of these reactors -- that could lead to something new showing up in either the general ARDC or in specific ones for specific technologies. Do you agree with that?

MS. MAZZA: I guess it's a possibility. And since we have these appendices, we can modify the Reg Guide --

(Simultaneous speaking.)

CHAIRMAN BLEY: You can do it?

MS. MAZZA: We can develop another

appendix for a whole new technology, have Appendix D.

CHAIRMAN BLEY: It just strikes me that some of that work may lead to new research that we need to better understand things, but it could also lead us to the point that we need some new additional design criteria to protect against something we learn in that research.

MR. SEGALA: And the way we laid out the Reg Guide it allows for the staff to consider new GDC or new design criteria. If it needs to be for safety, we can propose new ones.

MS. MAZZA: Okay. So the most significant changes, which are the topics of today's discussion, are shown here on this slide. Reactor design, containment, electric power, reactivity control, residual heat removal, emergency core cooling, and then the new technology-specific design criteria.

Future activities. The Draft Reg Guide is out for a 60-day comment period which ends on April 4th. Plan to hold an additional public meeting after the staff has reviewed the public comments and has started to develop the Final Reg Guide. And so at some point we need to address any

ACRS comments. So John talked about that a little bit earlier. We'll have to maybe at the end of the meeting decide what the next steps are. We also recognize that a Full Committee meeting is going to be needed before the Final Reg Guides goes out. And then we plan to issue the Reg Guide in 2017, December 2017.

So that's pretty much it for what I had. Is there any more questions of a general nature before we start getting into the technology-specific design criteria?

(No audible response.)

MS. MAZZA: Okay. So I'd like to introduce Jeff Schmidt. He's going to talk about Design Criteria No. 10, Reactor Design.

Jeff?

MR. SCHMIDT: All right. Thank you, Jan.

Yes, so we've listed here what we think are kind of the high visibility big issues associated with some of the Advanced Reactor Design Criteria. So I guess I'd like to start off with mHTGR-DC 10. And that really is kind of replacing the concept of the SAFDL, or the specific acceptable fuel design limits with the SARRDL concept, which is specified acceptable system radionuclide design limit.

The thought process here is that the TRISO fuel, which is kind of inherent in our modular high-temperature gas reactor design concept, does not fail catastrophically and that it degrades what I would call gracefully under AOOs and accident conditions and that you would move from a concept that's more performance-based. And the fact that since it doesn't fail catastrophically you don't have say specific mechanical criteria that you would say in light water fuel that would lead to kind of a rapid increase in fission product release.

The SARRDL kind of goes beyond just the fuel releases into also the -- what might be released or mobilized in the primary coolant system or the primary circuit. So it kind of includes both the fuel and what is in the primary system. SARRDL also --

MEMBER POWERS: Can I ask a question here?

MR. SCHMIDT: Sure.

MEMBER POWERS: You say the TRISO doesn't fail catastrophically. The fact is TRISO fuel could start off life failed.

MR. SCHMIDT: Yes, it can. Yes, just like normal light water fuel could be manufactured in a failed state and operated in a failed state.

MEMBER POWERS: Well, the difference of course is it's pretty easy to detect whether you've gotten normal light water fuel is failed, whereas finding a TRISO particle that's failed might be a chore.

MR. SCHMIDT: Yes, I mean, I think that --

MEMBER POWERS: Could be a real chore.

MR. SCHMIDT: Yes, the concept is that you would be monitoring circulating activity similar to the way you would be monitoring RCS activity in a light water reactor. And there's going to be a certain statistical number that have imperfect coatings, right? And that will have to be accommodated I think in some type of form, whether it be like a tech spec limit, like an RCS activity currently. That would be below the SARRDL limit that you would be monitoring the coolant activity and having a limit effectively below the SARRDL limit.

MEMBER POWERS: I guess I'm a little

confused. What is the SARRDL limit?

MR. SCHMIDT: The SARRDL limit would be similar to -- for an AOO that we have today, right, we protect the fuel from failure, right? The whole idea of a SAFDL limit today is that during an AOO you don't expect any additional fuel failures. It doesn't say that you don't have preexisting fuel failures. I think the thing you're referring to is preexisting fuel failures.

MEMBER POWERS: Yes, I mean, it's manufactured in a kinetic process that cannot be healed by simply reheating it or anything like that, so it starts off live.

MR. SCHMIDT: But I think that's a concept that we currently deal with already in the light water fleet.

MEMBER KIRCHNER: Jeff, can I jump in with Dana here and test you a little bit?

MR. SCHMIDT: Yes.

MEMBER KIRCHNER: Now what you say is generically kind of correct, but TRISO fuel does typically exhibit a cliff. Where you exceed that temperature, you get a marked release of -- or "failure," quote/unquote, of the TRISO particles. And that becomes a design-basis for -- well, designing the system to start with, and power and peaking and other control issues. So why do you -- does this fuel design limit include a thermal boundary of some level that brackets where you expect the particles to fail noticeably, if not catastrophically?

MR. SCHMIDT: Right, I would expect that the -- it doesn't have a specific number associated with it.

MEMBER KIRCHNER: No, but testing of the fuel will indicate a cliff at some point.

MR. SCHMIDT: Right, and --

MEMBER KIRCHNER: And that's true of LWR fuel.

MR. SCHMIDT: Yes, and I think our expectation is that for AOOs and postulated accidents you would stay below that cliff.

MEMBER KIRCHNER: So that becomes part of the definition of the fuel design limit?

MR. SCHMIDT: I guess if a cliff was established, yes.

MEMBER KIRCHNER: Well, you'd need to do that in qualifying the fuel.

MR. SCHMIDT: Right, that's true.

MEMBER KIRCHNER: And you will see that

cliff.

MEMBER CORRADINI: But I was going to -- I was just -- if I might just inject, I mean, there's a whole fuel testing program underway, close to being done. And so I think that cliff is known for the new TRISO. So that's what -- this one struck me interesting because it connects you to whatever the other DC is with containment because you kind of -- you read about this and it sends you down to 16. And then you read 16. It sends you back up to 10. And I'm trying to decide if it's not 17 percent peak clad oxidation and 1 percent core-wide and 2,200 F, there's got to be some sort of bad zone that above which I cannot get into.

MEMBER KIRCHNER: And that becomes the design-basis for things like the AOOs, etcetera, as to be defined I guess at this point. But it does exist.

MEMBER MARCH-LEUBA: Yes, I think the problem I'm having listening to this conversation is that the SARRDL is a very DC to satisfy during operation. You measure the activity you have in your coolant and you're okay. But it's very hard to do during the design, whereas for light water reactors I have the 17 percent, the CHF and I'm okay.

MR. SCHMIDT: Right. Right. I mean, there -- if there is a limit that you have catastrophic failure, I would assume that it would be in a postulated accident scenario. And for AOOs I think you could probably safely say that a class of AOOs, which still have to be determined what the class of AOOs are, that you wouldn't have that catastrophic failure and that the SARRDL limit would still be something you would have.

MEMBER KIRCHNER: Well, precisely, because when you get to the passive heat removal and the other criteria that you've changed, you are designing that core and hence the power of that unit based on this threshold so that you can ensure under say a depressurization event, and you lose the helium, and it's just sitting there passively, that the TRISO temperatures are not above this cliff.

MR. SCHMIDT: Right.

MEMBER KIRCHNER: So I'm a little -- is there more definition behind specified acceptable fuel design limit?

MR. SCHMIDT: I mean, it really is

working from the concept of -- kind of backwards, working from the fact that you have say dose limits. And then working inward to what you can have in your primary circuit and the transients that you can have within your primary circuit, whether it would meet the dose criteria for an AOO or a postulated accident.

MEMBER CORRADINI: So can I try this a different way, because it relates to 16, which I'm not sure -- so I'm going to ask the question now and then you can tell me to wait until 16 rolls around.

MR. SCHMIDT: Yes, I might have to.

MEMBER CORRADINI: By the very fact you define a containment function versus a containment in the historic sense, then you're looking at puff releases versus long-term releases. And you want to basically make sure that in a puff release, which is not just the fuel, but the whole shebang together, it doesn't exceed the boundary limits.

MR. SCHMIDT: Right.

MEMBER CORRADINI: That's my impression of what this all means.

MR. SCHMIDT: Right, there's a defense-in-depth philosophy that goes along with that, and fuel is obviously an important component in these.

MEMBER CORRADINI: Okay. So then; and you can store this one, you don't have to answer it, to me the way you guys approached this I thought was very inventive, but why is it only gas reactors? Why not work backwards for all reactors?

Forget about the water since that's past due. But for all types of funny looking reactors, if I start with the outside dose and I identify what the AOOs are, what the DBAs are and what the beyond-DBAs are, it seems to me working backwards in what the operational activity is so that I could have a containment function, not just allowed in a gas reactor -- but I could have a containment function allowed in a sodium reactor or in a molten salt reactor.

And that's why I asked the question about if I'm coming in with an applicant and he's got that, then he can go over and point to the containment function logic of 10 and 16.

MR. SCHMIDT: We had a fair number of public comments like that.

MEMBER CORRADINI: Okay.

MR. SCHMIDT: That the SARRDL could be

-- the SARRDL concept of working outside in could be applied in all reactor designs pretty much.

I think that the staff felt a little uncomfortable going there without knowing all of the different fuel designs. The TRISO fuel is kind of a well-known concept. I don't think the staff wanted to make that leap yet and still wanted to keep SAFDLs for fuels that maybe we didn't have as much experience base with.

But I think one of the reasons we're considering SAFDLs is because for liquid fuels there is no mechanical boundaries that I can prescribe to it. So in some sense we may be driven to more of a SARRDL concept because liquids don't -- liquid fuels don't have any cladding or mechanical limits I can prescribe to them.

So I thought -- the thought process within the group was we're pretty comfortable with TRISO fuel. We think we have to go there for liquid fuels. So I think we need to discuss this concept and get public comments on this concept.

So the SARRDL concept sets both AOO and postulated accident dose criteria. So that is a little different. GDC 10 is typically an AOO criteria. This is setting the criterias both for

AOOs and postulated accidents, so it is changing the scope of GDC 10.

So on the next slide --

MEMBER KIRCHNER: May I challenge you again?

MR. SCHMIDT: Sure.

MEMBER KIRCHNER: Criterion 10 works well as it is for -- from the LWR GDCs, for mHTGR in principal. It says that -- well, I won't read the whole thing, but appropriate margin to assure specified acceptable fuel design limits are not exceeded during any condition of normal operation including the effects of AOOs.

So what's wrong with that for mHTGR? I'm just challenging you here.

MR. SCHMIDT: I don't think there's anything wrong with it. All I'm trying to say is that the SARRDL has an AOO dose criteria you prescribe --

(Simultaneous speaking.)

MEMBER KIRCHNER: No, I understand that.

MR. SCHMIDT: -- for postulated accidents. That's all I'm saying. I guess I'm not really understanding your question.

MEMBER KIRCHNER: Well, I'm not thinking that the designers will do this, but they are clearly going to design first from the standpoint of where they know the threshold for significant release of fission products from TRISO particles is.

MR. SCHMIDT: Right.

MEMBER KIRCHNER: Give themselves some margin, do their analysis core-wide for peaking and all kinds of conditions, and then assure themselves -- because this is a reliability issue from the standpoint of the customer in terms of operations and such, that they have significant margin. And they will do that, pardon me, not on a dose basis, but they'll do it on a thermal basis.

MEMBER CORRADINI: They'll back out a dose to a thermal number.

MEMBER KIRCHNER: Well, they may do that after the fact, but the point is they're not going to go to thermal conditions that will significantly challenge the TRISO particles. And that will be the basis of the design, not this.

MEMBER MARCH-LEUBA: Yes, but reinforcing the -- it's exactly what I was saying before. If I'm an Indian -- I'm an applicant and

I'm running my calls to figure out where my design satisfies mHTGR-DC 10 or not, I don't what the SARRDL is in my code. I know the thermal properties of my fuel.

MR. SCHMIDT: Right. So you have to back it out to a thermal limit for your TRISO particle.

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: So basically for my particular fuel I would have to define SAFDLs to satisfy the SARRDL, right? So I don't see a need a changing GDC 10. I mean, maybe you need to specify how you define the SAFDLs. Like for example, BWRs we do 99.9 percent of the fuel rods are not fail. And that's your SAFDL.

MEMBER KIRCHNER: Yes, so just to agree and go back to Mike, it seems to me that this is more critical for your containment or functional containment arguments, confinement or whatever you're going to call it, rather than for the actual core design.

MEMBER CORRADINI: I agree with you guys, but if you look at what the staff is proposing as changes, they're just drawing the envelope further out. But eventually however, wherever they draw the envelope, I think I agree with you they're eventually going to have to come to -- given a fuel type, given a fuel performance set of data, it's going to come to some sort of temperature that I must not go above to satisfy the defined SARRDL or whatever --

(Simultaneous speaking.)

MEMBER KIRCHNER: This is the argument I would expect to see for the functional containment, not for the general design for the core.

MEMBER MARCH-LEUBA: Yes, my argument is that if I'm an applicant, this doesn't help me design my reactor. I need definite threshold that I can compare my calculation against to see if I'm okay on that. This is an operational limit which is very easy to satisfy operationally, but during the design process you're not helping me.

MEMBER CORRADINI: So can I ask my colleagues a question, not you?

So what you're really saying is this creates more uncertainty than certainty for the applicant?

MEMBER MARCH-LEUBA: Yes.

MEMBER CORRADINI: That's what I hear

you say.

MEMBER MARCH-LEUBA: Yes. I mean --

MR. SCHMIDT: That hasn't been reflected in the public comments, but I understand your concern that you -- the designer itself has to work to a temperature which would then as you propagate out the fission products lead to the --

MEMBER MARCH-LEUBA: Which is --

MR. SCHMIDT: -- dose requirement.

MEMBER MARCH-LEUBA: -- a SAFDL, which is what we already have. And now what we have to work out for your fuel is how do we define the SAFDL? And we define it based on the release.

MR. SCHMIDT: I think it gets hard to -- because there are -- in a current light water fleet, right, there are a pretty finite number of rods and conditions, right? So it's fairly easy to monitor and postulate failures on say 50,000 rods or something like that. But when you're talking maybe millions of TRISO particles, getting individual fuel temperatures associated with those million particles of fuel, it's not clear to me that that's practicable. You might be able to work it down to specific -- with whatever you want to call a fuel element --

MEMBER KIRCHNER: No, no, no. That's not how they're going to do this. They're going to do a core analysis and they'll come up with -- let me simplify this. They'll put thermal profiles over the core and they'll look at how that -- test the boundaries on the TRISO particle performance. They're not doing a million-particle temperature analysis, although you could probably imply that, but not individually. So --

MR. SCHMIDT: So I think what you're saying is what I was saying before is working to like an element, some type of --

MEMBER KIRCHNER: Yes, that's what --

MR. SCHMIDT: -- defined, whether it be a pebble or a prismatic block, right? You would be establishing limits on those.

MEMBER MARCH-LEUBA: Yes, and my -- this is different comment. It's a little higher level. My comment is that this is not really a change. It was already included the previous DC. What you -- you are specifying what the SAFDL is based on. You're going one step forward.

But the question is how are you going to define those SAFDLs? Are you going to do an element? Are you going to do a calculation? And that's what I'm going to do when I'm designing the reactor. So I mean, I keep saying the SARRDL, it's a good design criteria. That's what we're shooting for. But as a designer it doesn't help me much.

MR. SCHMIDT: Okay.

MEMBER CORRADINI: One last one. You've been ignored. But so let me take you through 16 compared to 10. Since the puff release to me is the containment function issue that changes you from a leak type to a designed leaking, then operational limits at pressure are the circulating activity. But if I have operational limits at pressure, but then I get a depressurization action, which is a DBA, then I've got stuff sitting on walls and stuff that's going to get blown out that I then have to know what it is so I'm very clear that I don't exceed my site boundary.

And I'm not sure leaving it this way makes it more certain as to what the applicant can do. It strikes me as -- it leaves me in this big gray area that either I have to do experiments or I have to have a very good computer program, which, with all due respect, I'm not sure they exist. And so I create more uncertainty. That's what I think

I'm hearing from my colleagues.

MR. SCHMIDT: Are you referring to just the primary circuit --

MEMBER CORRADINI: Yes.

MR. SCHMIDT: Well, yes, I agree. I mean, I agree it's the fuel and the primary circuit or whatever gets mobilized as a total, right? And that total will change with time, right, as you potentially deposit more into the graphite. Your limit that protects the SARRDL might be -- have to be lower as you deposit more into the graphite over time.

So, yes, I -- the SARRDL concept wasn't just supposed to be a fuel only concept, right? It's the whole primary circuit concept of what might be released depending on AOO or a postulated accident to the environment.

MEMBER CORRADINI: Okay.

MS. MAZZA: So would it be appropriate to have someone from the labs speak to this as well, because they were actually the ones that developed the SARRDL concept? We have some --

CHAIRMAN BLEY: Sure.

MS. MAZZA: -- folks in the audience.

I think, Dave Alberstein, did you --

would you want to make a comment at this point?

CHAIRMAN BLEY: Well, come to the mic, state your name and where you're from.

MR. ALBERSTEIN: My name is Dave Alberstein. I'm representing Idaho National Laboratory.

For the HTGR it's been a subject of discussion for years about how one would define a SAFDL for coated particle fuel. And coated particle fuel failure modes, they're probably -- it's either 11 or 13 of them. Some of them are mechanical, some of them are thermo-chemical. Peak temperature by itself is not a suitable criterion. It's really subject to time at temperature.

And in trying to come up with a SAFDL we finally concluded that there's no simple way to specify a few numbers that really tell the complete story about what's going on with TRISO-coated fuel.

The safety design approach of modular HTGRs is to focus on retaining the radionuclides in the fuel rather than relying on downstream barriers like a high-pressure low-leakage containment to retain the radionuclides. So we turned our attention to circulating activity and played-out activity. Circulating activity can be measured continuously. At Fort St. Vrain there were tech spec limits on that. There were also tech spec limits at Fort St. Vrain on plated-out activity, condensed radionuclides on surfaces in the primary system. Those can be measured directly using plated-out probes.

And one can back calculate from an offsite dose at the exclusionary boundary a maximum number on circulating activity and plated-out activity that one can have and still meet regulatory dose requirements at the EAB. One does this back calculation using mechanistic source term methodology, which was the subject of an NGNP white paper that was reviewed by the staff, and which we did presentations to this Committee on back in 2013.

We wanted to tie a limit directly to offsite dose. The current GDC 10 specifies basically no incremental fuel failure during AOOs. And as was mentioned, you're talking about maybe a few thousand, several thousand fuel pins in a light water reactor. In an HTGR core you're talking about billions of fuel particles. And it's statistically not possible to assure that out of those billions of particles that none of them would fail during that AOO, but the consequences of such failures are relatively low compared to LWRs because of the radionuclide inventory in each particle is very small.

One other point that Walt Kirchner made should be addressed. As I said, there are many mechanisms that affect TRISO particle performance. There is no one set temperature necessarily at which the fuel turns to Swiss cheese. Okay? It's a time at temperature phenomenon. And it's definitely true that in doing core design analyses the engineer is going to look at the peak temperatures, they're going to look at the time at temperature characteristics of the core. And from that they're going to do mechanistic analyses or radionuclide release, and those initial conditions then will serve as the initial conditions for accident analyses.

So what the SARRDL is is an attempt basically to limit the initial conditions relative to circulating and plated-out activity for analysis of postulated accidents. I think that pretty much covers it.

MEMBER MARCH-LEUBA: Okay. Can I -- going back to my recurring topic, if I'm an applicant and I just run my calculations on my code and I send the application to the staff, and now they have to decide whether I exceed or do not exceed the SARRDL during an AOO, how does the staff do it based on the calculation? Because what I keep saying is this is a really great thing to do. During operation you measured it.

MR. ALBERSTEIN: Yes.

MEMBER MARCH-LEUBA: And if you start missing too much, you stop.

MR. ALBERSTEIN: Yes.

MEMBER MARCH-LEUBA: Okay? But how do I approve that design based on your calculation?

MR. ALBERSTEIN: You're going to have information available to you from the fuel qualification program on how coated fuel particles behave during AOOs and how they would behave under more severe accident conditions. I hate to use the word "severe," but under more extreme accident conditions. And --

MEMBER MARCH-LEUBA: So you will have some objective criteria that you apply to your code that says as long as I'm below this, I'm okay?

MR. ALBERSTEIN: As long as my circulating activity is below a certain number and as long as my plated-out activity is below a certain number, I know that if I have an accident I'm still going to meet those criteria at the exclusionary boundary.

Tech specs would typically be set below the SARRDL because you don't want to blow a safety limit when you blow a tech spec. Okay? They'd probably be somewhere in the neighborhood of 75 percent of the SARF. That leaves you head room for AOOs and any incremental particle failure that might occur during AOOs --

MEMBER MARCH-LEUBA: Yes, and --

MR. ALBERSTEIN: -- or accidents.

MEMBER MARCH-LEUBA: -- that was my academic discussion, because TRISO's so good that they will operate at 10 to the minus 3 of the limit, right?

MR. ALBERSTEIN: Well, we're shooting for lower than that now.

MEMBER MARCH-LEUBA: Yes.

MEMBER POWERS: May I ask you a question about that? You portray the failure of these particles as though they were random events, but your fuel is a product of a kinetic manufacturing process and it's subject to perturbations that cannot be corrected by just reheating the fuel or re-centering or something like that. So is it not possible to have a batch of fuel that has an undetectable defect so that it's not a random failure, but rather if one goes forward everything from that batch fails?

MR. ALBERSTEIN: I'm not sure I heard all of that, but there will be manufacturing specifications for initial defective particles, for heavy metal contamination outside of particle coatings. There will be fuel failure models that have been verified and validated to predict coated particle failure rates under transient conditions.

MEMBER POWERS: Suppose --

MR. ALBERSTEIN: I don't know if that addresses everything you said, Dana, because I didn't hear it all.

MEMBER POWERS: -- that you change your supplier for silicon carbide or the silicon carbide precursors and so that during your well-established, well-characterized manufacturing process you now get a different stacking arrangement in your silicon carbide barrier. There's 728 metastable silicon carbide structures known, and some of them are good and some of them are terrible.

MR. ALBERSTEIN: Okay. I know what you're after now. In addition to product specifications, there will be key process parameters in the fuel fabrication process that will also be specified. Light water reactor guys like to stay away from process specifications as much as they can. I'm sure the particle fuel guys would like to do that, too, but it is true that particularly with silicon carbide some of the coating performance characteristics are dependent on the processes used to lay those coatings down. And there will be process specs that ensure that the coatings are laid down in such a manner that their performance is consistent with performance model expectations and safety design-basis expectations.

MEMBER CORRADINI: So you guys are -- so in my cooking world you're saying it's not just the soufflé, but it's the recipe for the soufflé that's got to be monitored?

MR. ALBERSTEIN: Some of the recipe has to be monitored, yes.

MEMBER CORRADINI: But I think Dana's point -- or part of Dana's point I thought was then you could get a bad batch. It could get through. So that's a fuel reliability problem. So you'd essentially -- by your method would then have to derate the plant because of circulating of played-out activity that you know to be there above the allowable?

MR. ALBERSTEIN: If you had a bad batch come through and didn't pick it up in the various QC steps associated with fuel fabrication, you'd probably see it pretty quickly in the circulating activity. And then you'd know that you have to take some kind of corrective action, the nature of which would depend on just how bad it was.

MEMBER CORRADINI: Okay.

MEMBER REMPE: So in listening to this discussion I'm curious why the staff doesn't have anything on a plated-out monitoring device or probe. The criteria solely looks to me focused on the circulating activity. Is that something that you need to consider?

MR. SCHMIDT: Yes, the mechanistic source term white paper dealt with plated-out re-mobilization. It's anything that can be released from the primary circuit. And that's what I was trying to get when I was saying the SARRDL is not only a fuel criteria, right? Right now we consider the SARRDL as pretty much a fuel-only criterion GDC 10. But in this case it's anything that can be liberated that would lead to a dose consequence, right?

And to answer a question is I think the staff would have to have a -- have to buy into the mechanistic source term methodology that would go from -- that would lead from an AOO or an event to a dose. So you can't -- you don't look at just the fuel performance. It's the integrated system response to whatever those are that determine the dose. So it's a bigger scope. It's not just the fuel.

CHAIRMAN BLEY: Well, it is, but if I -- when I read the Reg Guide, the SARRDL just kind of crops up and there's not much background here. When I read the DoE documents, there's a lot more of what's behind it. And it seems to dangle out here in a way that doesn't make it clear what you're going to have to do.

MEMBER REMPE: For example, you have, "The radionuclide activity circulating within the helium coolant boundary is continuously monitored such that the normal operation limits and SARRDLs are not exceeded." It seems like you should have also the plated-out activity.

MR. SCHMIDT: Yes. Yes, it is -- and that's one of the comments we got in the public comments is that -- and that's what I was trying to address in these slides. It's really the overall mechanistic source term methodology that's needed. So it's plated-out, it's absorption, it's fuel failures.

MEMBER REMPE: Are you planning to change the text in this?

MR. SCHMIDT: No, we'll probably comments --

MEMBER REMPE: Oh, okay. I didn't catch that. Okay.

MR. SCHMIDT: We'll probably get comments on that to modify the text, yes.

MEMBER REMPE: Okay.

MR. ALBERSTEIN: If I could add one more thing. When we were developing this thing, we kind of thought of it not so much as a fuel design limit, which is what the LWR has got to do, but as a fuel performance limit. That's what we were focusing our attention on, because that's directly relatable to circulating activity which can be measured, which in turn is directly relatable to dose.

MEMBER KIRCHNER: Well, I'll yield, but -- and I appreciate Dave Alberstein's comments, and I understand those, but this begs for more definition and more definition. And my own opinion would be that the existing LWR criterion would work just fine here. It's later in the containment area that this is much more important, but the existing criteria talks about the reactor core, associated coolant control, protection systems, etcetera, so that you do not exceed specified acceptable design limits.

Now keeping control of your circulating activity is an issue for an LWR just like it is for an HTGR. And so it does beg the question that was asked earlier about what the design-basis events are going to be and the AOOs and how you're going to apply that.

CHAIRMAN BLEY: I'd chime in. From what I've been hearing and from what I read quickly in some of the previous DoE documents, GDC 10 right now is focused on making sure the fuel design limits are not exceeded. The discussion in multiple ways over here said for this fuel it's the manufacturing process more than the design. So that's really saying at a minimum the old GDC ought to say fuel performance limits aren't exceeded, because it's not so much the -- the design's pretty clear, but the implementation is where the problems occur if they occur.

But I definitely agree. The current appendix for the HTGR doesn't really explain the SARRDL and how it ought to be used in enough detail. It's pretty vague without ties to all of the rest of the information.

MEMBER KIRCHNER: Dennis, I agree you could just wordsmith this to say "acceptable fuel performance and design limits are not exceeded."

CHAIRMAN BLEY: And it's very general and you specify it somewhere else, yes.

MEMBER KIRCHNER: It's very general. And I appreciate the circulating inventory issues and the played-out issues and the DOF and all the rest, but --

MR. SCHMIDT: Okay. Go to the next slide, I think. We'll see if we can get to the next one. Through the next, yes. That was by design.

(Laughter.)

CHAIRMAN BLEY: But you had an hour, so you knew which it was coming.

MR. SCHMIDT: Yes, I did. So an AOO scenario, depending on how they classify scenarios; I know we haven't gotten there yet, but may lead to a low-dose consequence and should be tied to obviously something associated with an AOO frequency. And that's 10 CFR 20.1.3.01, annualized dose limits.

Postulated accident dose criteria not violated assuming the SARRDL initial condition. Again, so we you have an AOO component and you have a postulated accident criteria, which are two different criterias. But the SARRDL is serving the same purpose, or both purposes. And as we mentioned multiple times, circulating helium activity is monitored to show the SAFDL is not violated.

The SARRDL concept is performance-based, and like we talked about before, the TRISO fuel and the possibility of that liquid fuels will need a concept similar to that because they won't have the mechanical and it's typically associated with the SAFDL.

And then the last bullet, as many of us

have discussed here, may involve policy engagement to allow AOO dose consequences. Current SAFDL limit does not allow for any increase in dose consequences. So the SAFDLs are created such that we have protection systems that don't cause any additional fuel failures on an AOO event. That might not be the case here.

So before we leave that DC 10, are there anymore questions?

CHAIRMAN BLEY: Well, just this one before we leave it. As you said earlier, or one of you said, we'll -- oh, I think it was John -- we'll come back to whether you want a letter now or not. This could be one area where at least you've heard a lot of comments from individual members; we'll talk at the end, but if it's an area where it might be important to hear officially from the Committee, we'll talk about that at the end.

MR. SCHMIDT: Okay.

MS. JACKSON: Anything else on No. 10?

CHAIRMAN BLEY: I think we're -- well, we're 15 minutes ahead, but we ought to take the break now because the next one at least has a lot more slides. I don't know if it has as much discussion.

(Laughter.)

CHAIRMAN BLEY: And then we are going to
-- we have an unusual lunch today. We have something else going on. We have to break for lunch at about 11:30 and then we'll come back at 1:00 after that. So we'll hear on 16 when we come back. We'll recess 15 minutes until 10:15.

(Whereupon, the above-entitled matter went off the record at 10:01 a.m. and resumed at 10:19 a.m.)

CHAIRMAN BLEY: We are back in session, and, Jan, back to you.

MS. MAZZA: The next presentation is going to be on containment design, and we have Imtiaz Madni here. He's going to be presenting on this topic.

CHAIRMAN BLEY: Down at the bottom. Yes. That kind of noise goes right into the head of our court reporter, so be a little careful.

MR. MADNI: Good morning. My name is Imtiaz Madni, and my presentation will cover, as Jan, mentioned, the design criteria related to containment design. General Design Criteria numbers 10 to 19 established the need for multiple barriers to the release of fission products. This is consistent with defense-in-depth concept of providing reasonable assurance of facility operation without undue risk to public health and safety.

Within that group of criteria, 10 to 19, we have GDC 16, which have listed the requirements for containment design. I will go over the NRC language for the advanced reactor criteria corresponding with GDC 16 as it appears in the draft reg guide that incorporates the most recent public comments. And for mHTGRs, I will cover the additional design criteria specifically on mHTGRs, which is 70 to 72, since these are integral to the function containment concept.

So if you look at the next slide, we start with ARDC 16. And as far as the content is concerned with all the design criterion, we decided to stick with the GDC 16. The deliberation was based on function containment, and we decided to stick with GDC 16 as the design criterion.

For non-LWR technologies, other than SFRs and mHTGRs, designers may use the current GDC 16 to develop applicable principal design criteria. Non-LWRs, of course, could share common features with SFRs and mHTGRs. In such cases, designers may propose using SFR-DC 16 or mHTGR-DC 16, as appropriate.

Note that the use of mHTGR-DC 16 will be subject to policy decision by the Commission. More details on this can be seen in a later slide for mHTGR-DC 16.

MEMBER CORRADINI: So can I make sure that I understand what's just been said. So you're saying this is a proposal still to be determined by Commission policy?

MR. MADNI: Yes.

MEMBER CORRADINI: Okay.

MR. MADNI: The next slide. This slide shows the language for SFR-DC 16. And here the first bullet are reactor containment consisting of a high-strength, low-leakage pressure-retaining structure surrounding the reactor and its primary cooling system shall be provided to control the release of radioactivity to the environment and to ensure that the reactor containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

So here I just want to mention that this language is essentially the same as what was sent out for public comment. In other words, there were no real changes made except the word primary cooling system. We had its cooling system, and we had a lot of comments trying to say that the SFR containment designs are only required to surround the primary cooling system. There's no requirement in through the intermediate loop within the containment since this system will not contain radioactive materials. So the requirement is not there. It could cover it, but the requirement is not there. And, therefore, instead of using its cooling system, just use primary cooling system.

So that was the change we made in response to public comments. Other than that, we have the same stuff that went out for public comments.

MEMBER CORRADINI: I'm not sure where you are in your slide, but can you explain why bullet two was added to the design criteria?

MR. MADNI: Okay. So this sentence in the first bullet, "to ensure that the reactor containment design conditions important to safety are not exceeded," so that's explaining what that condition is. That should not be exceeded. The containment leakage is a performance-based criterion, "The containment leakage shall be restricted to be less than that needed to meet the acceptable on-site and off-site dose consequence limits, as specified in 10 CFR 50.34."

MEMBER CORRADINI: But why add that? Isn't that an assumed behavior, expected behavior in the current GDC? Well, regardless of the GDC, it's required by regulation. So, well, I'm just trying to understand, I'm looking at what was added, and it was added there. And the rationale later on was discussed. It was -- I should go back and look at --

MR. MADNI: I can look at the GDC language and see what it is.

MEMBER CORRADINI: Well, that's okay. I understand it's regulation. I'm just, it just struck me as interesting you've added something this time, and I wanted to know if there was a reason for it, other than just to be complete.

CHAIRMAN BLEY: GDC is leak-tight, so it's inapplicable.

MR. YESHNIK: My name is Andrew Yeshnik. I'm part of this group. I believe that we had that statement where we removed the leak-tight requirement from this criteria to give an acceptance criteria for that --

MR. MADNI: I was going to discuss that in the next --

CHAIRMAN BLEY: Well, the first bullet says low leakage, so that already addresses that to some extent.

MR. YESHNIK: Kind of the low leakage. And we're saying, basically, the low leakage is tied to the off-site release.

CHAIRMAN BLEY: In 50.34.

MEMBER MARCH-LEUBA: So if I design a containment venting system through a really, really good filter to satisfy those off-site doses. Would that be acceptable under this? I mean, is the word leakage -- how do you define leakage? Venting leakage?

MR. YESHNIK: I believe, in this case, we would say that is leakage part of normal operation or part of an accident condition?

MEMBER MARCH-LEUBA: It's always there.

MR. YESHNIK: And I think that, for the context of this one, we're talking about normal operation.

MEMBER CORRADINI: But I think where Jose was going is kind of where -- I asked it earlier, but I'll ask it of this group versus the previous group. So that means I could basically say for a Sodium Fast Reactor that I choose to use the mHTGR concept of a continual containment function versus a low-leakage containment. Also, just for the sake of quibbling, all structures leak, so the original GDC had some sort of leakage limit, as this one. That's why adding the second bullet just struck me as --

MR. MADNI: The original GDC specified, the original GDC specified a leak-tight containment. On here, we got the approval from the Commission. I wanted to cover this when the right slide comes. I have that information there.

MEMBER BALLINGER: GDC 16 says essentially leak-tight, which is weasel words, just like these weasel words.

MR. MADNI: So here, instead of saying that is essentially leak-tight, we are saying it is low leakage and satisfies this criteria.

MEMBER BALLINGER: Okay, thank you.

MEMBER SKILLMAN: I'd like to ask this, please. The original requirement has that same statement that you have at the end of your first bullet. As long as the postulated accident conditions require, the original requirement has that.

MR. MADNI: Yes, that last language is the same.

MEMBER SKILLMAN: Yes. And then in the discussion here, particularly for the Sodium Fast Reactor, there is an explanation giving the NRC rationale for an adaption or adaptation to the GDC, and it explains the SECY 93-092 .

MR. MADNI: Yes.

MEMBER SKILLMAN: And that seems to draw upon what is NUREG-1368. It gives rise to this idea of 24 hours.

MR. MADNI: Yes.

MEMBER SKILLMAN: What is the definition of the time for as long as the postulated accident conditions require? Before you answer, let me give you a real example. At TMI 2, at TMI 2, the first thought about containment was what's being released from the upper parts of the containment through the penetrations, maybe leaking through at a dome. As we got deep into 1979, it became clear our real concern was whether the floor was going to leak, the floor, and whether we were going to leak that water into the Susquehanna

River. So those of us who were involved had our lenses adjusted to realize it isn't just the radionuclides that are gaseous that are of a concern, but it is what might leak out of the rest of the containment. And for us, for as long as those postulated accident conditions required meant until we pumped that sump and got rid of that gas, and that was years, not days or weeks or months.

So how is that lesson learned captured in what you are proposing here? My thesis is as long as the postulated accident conditions require doesn't mean just the duration of the thermal-hydraulic event. It is the duration for as long as the containment is needed.

MR. MADNI: Yes. I just wanted to mention one thing, and we'll note what you said and see how we can apply it and maybe discuss how we need to address this, what you said, into this design criterion that we have. But I just want to mention that the scope of our reg guide is for postulated accidents, meaning the time-based accidents. So the design basis accidents you will not expect to last for weeks. So if you're talking about things that, you know, are considered within the scope of the design.

MEMBER SKILLMAN: But let me push back. So you had an accident, it is a design basis accident. For how long do you need the containment? And I would assert that you need the containment for as long as you need to contain what came from that accident. It isn't just that short thermal-hydraulic event. It is the consequence of the event that you are containing.

MR. MADNI: So I put this down as something that we need to work on. It's a very good point.

MEMBER POWERS: I don't think we've ever viewed the containment in that fashion. I think we have viewed the containment -- I mean, prior to WASH-740, I think we did view the containment that way. But I think since WASH-740, we've recognized that containments are there as a barrier that they can fail under sufficiently severe accidents, and we look to them to provide us that interval of time to do evacuations of potentially people at risk, should there be a failure and a release of radioactivity. I don't think we've ever -- I mean, like I said, prior to 740, a lot of people felt containments could stand up to severe accidents, but I can always define a severe accident as failure of containment. It doesn't take ten minutes to do that, and it will be perfectly plausible. It will have a probability of ten to the minus 6. I mean, all I have to do is put two or three things together to get to that level.

MR. MADNI: Of course, I wanted to mention that when we are looking at the containment for an SFR, we should remember that our forcing function into the containment is not going to be large, so you don't need a high-pressure containment. You have --

MEMBER KIRCHNER: Not so fast. If you have a sodium fire, you definitely will generate pressure, and that's part of your requirements.

MR. MADNI: Yes, I'm going to come to that. When you have a sodium fire, there's some public information on that. What is the expected rise in pressure from spray fire or fuel fire, whatever it may be. I'll cover those aspects in a couple of slides.

But by and large, the load on the containment for SFRs is not expected to be large. And that's why you can get away with low pressure containment design. Low leakage, low pressure, but high strength.

MEMBER CORRADINI: But just let me take you back to Jose's question, just so we've got it clear.

MR. MADNI: I forgot what his question was.

MEMBER CORRADINI: Okay. So a number of us are still, I'm still over here on the side that the prior speaker sitting in that chair suggested the containment function. If I have a containment function with venting which needs a policy decision -- I haven't forgotten that -- could be just as applicable to an SFR as it could be to an mHTGR, so I would essentially have a continually venting containment under more of a confinement thing with filtering and it may satisfy all these things. But it's a defined leakage, I'm not sure if it's low or essentially low or whatever the words are, but a defined leakage with filtering and venting, and that could satisfy this approach.

MR. MADNI: You mean which approach?

MEMBER CORRADINI: Well, it could satisfy, it could be usable within a Sodium Fast Reactor context.

MR. MADNI: In the sodium reactor

context, we are not considering a function containment. We're considering a barrier.

MEMBER CORRADINI: I understand, I understand. I'm just simply saying what Jose was asking originally was one could map that into a sodium and ask for that as a consideration. That's what I thought you were saying.

MEMBER MARCH-LEUBA: I was asking if this would allow you to do that because I'm a big proposal of defense-in-depth.

MR. MADNI: Yes. So defense-in-depth we have covered by a barrier. In the mHTGR, you have function containment where you have multiple barriers, and the most significant barriers are within the fuel, while here that's not the case.

MEMBER MARCH-LEUBA: I think I understand how you think. The question is is the language consistent with what you're saying?

MR. MADNI: Okay. Maybe we can talk --

MEMBER MARCH-LEUBA: My concern is we've lived for 60 years with defense-in-depth, and we've been very successful with it.

MR. MADNI: Yes, to this is also part of defense-in-depth.

MEMBER MARCH-LEUBA: Okay, thank you.

MR. MADNI: You have the fuel, you have the clad, you have the circuit, cooling circuit, you have the guard vessels, and then you have the containment. So we will have defense-in-depth --

MEMBER KIRCHNER: So one minor point. May I ask why do you call out the primary cooling system? I think I know why you're calling that out and drawing the boundary on your containment.

MR. MADNI: Instead of, instead of cooling system --

MEMBER KIRCHNER: I wouldn't even specify that. But I know what you're trying to do, which is limit the extent of the containment.

MR. MADNI: Mainly to define the requirements of the acceptance, you know. So what is the containment required to do? The design of the applicant may come up with a much bigger containment. That's fine. But what is it required to do? It's not required to go anything beyond the primary system because that's where the safety systems are. That's where you have the sodium becoming radioactive. To me, a system is non-safety. You don't need to cover that. Of course, you have some other things that you have to worry about --

MEMBER KIRCHNER: But the intermediate system where it penetrates, where it interconnects with the primary system does become a safety --

MR. MADNI: Those would be under the --

MEMBER KIRCHNER: So that assumes that you'll have isolation valves or something to --

MR. MADNI: Those would be under the containment. And then the intermediate system, of course, you have to, the concern about leakage from there, what happens. So that we cover in subsequent slides, what are some of the things you have to be careful. Those are other design criteria. I think, is that --

MR. MCMURRAY: This is Nick McMurray. I'm going to discuss the intermediate coolant system this afternoon. But since we're kind of talking about it right now with relation to what a containment function, if you would isolation valves, that would be part of it. And the wording for the intermediate coolant system requirements is related to what the function would be. So would it be up to the containment valves? Clinch River did not have proposed containment valves, so their entire intermediate system had higher requirements or would have to have higher requirements for something like that.

So, again, it goes to a design specific idea. But, in general, yes, agree of how the intermediate coolant system would relate with the primary coolant system.

MEMBER KIRCHNER: Thank you.

MR. MADNI: All right. So we'll go to the next one. The next few slides, I will address the rationale for the adaptations for GDC 16 for SFR-DC 16.

This slide addresses the rationale for the use of the term low leakage as shown in the previous slide. And that comes from the NRC SECY 93-092, which was responded to with the SRM for that SECY in which the Commission basically approved the non-prescriptive method. Instead of leak-tight, you could have low leakage. So --

MEMBER KIRCHNER: So let's challenge that for a minute, not the Commission's statement but what this means when you implement it. So by striking, essentially, leak-tight, does that change the testing requirements on containment isolation and leak rates? How are you going to structure that part, in terms of your review?

MR. MADNI: The testing will do that.

The testing will do that. But it cannot be leak-tight testing. It will be testing for the function, whatever functions are there in the containment, they have to be subject to testing and --

MEMBER KIRCHNER: Well, let me try this out on you. So you have an isolation valve somewhere. Does it leak or it doesn't?

MR. MADNI: No, this is not about other things. It's just about the containment leaking.

MEMBER KIRCHNER: You're talking about part of the containment as an isolation valve, so when you test it, if it leaks, that's okay?

MR. MADNI: The isolation valve leaks, we have to check on this. I don't think it's okay.

MEMBER KIRCHNER: No, I know. I'm making a rhetorical statement. But I'm just asking you what do you think you're buying by striking, essentially, leak-tight where some leakage is allowed? Containments will leak. I'm just thinking ahead to the implementation and what it means when you actually do your review and then further down the road when you actually operate a system.

MR. MADNI: Well, then you have -- I'll

request Tanju Sofu who is one of our DOE counterparts to support me on this. I just want to mention that when you have, when you say leak-tight, then you have to do leak-tight testing, also. And we're not saying we should do leak-tight testing.

MEMBER KIRCHNER: What kind of testing will you do?

MR. MADNI: Tanju, do you want to --

MR. SOFU: So Tanju Sofu from Argonne National Laboratory. The idea is that the containment and cover gas system will have design leakage rate specified, and it will be periodically tested. I think that would be a trivial test. You pressurize the system to see if you're able to hold the pressure for a prolonged period of time.

MEMBER KIRCHNER: Okay. So you have an Argonne cover over the primary system. I think you would want that pretty leak-tight, right? You wouldn't test and want little leakage --

MR. SOFU: It wouldn't be leak-tight because that would be seals that would withstand certain pressure. Beyond that, it would actually stop leaking. So the design leakage rate would be specified.

MEMBER CORRADINI: I guess I've got to break in. It strikes me that we're kind of, we're redefining what already is being done with some sort of testing regimen, whether it be the cover gas of the Sodium Fast Reactor or the containment. You're going to have to do a leak test, and you're going to have to pump it up with some pressure. You're going to calculate what's leaking, and it either goes within the specs or outside the specs. Are we missing anything?

MR. MADNI: No, that's correct.

MR. SOFU: That makes sense, that makes sense.

MEMBER CORRADINI: Just to potentially different pressure or --

MR. MADNI: So for example, for the S PRISM design, the containment is -- and Tanju, correct me if I'm wrong -- the containment, we have the guard vessel that surrounds the reactor vessel, which is completely sealed, and there's inert gas in there. And the gap between the vessel and the guard vessel -- and this is part of the containment, the guard vessel -- is wide enough so that in case there's a leakage from the vessel, then the core will not be uncovered.

So now then on top of that, you have another portion of the containment, which has leakage. And there's a certain pressure, as Tanju mentioned, for the guard vessel part of it to have some kind of leakage from there into the upper part.

MR. SOFU: I think the whole difference is for pressurized light water reactor systems, the pressure-retaining requirements are much more restrictive than you would encounter for a non-pressurized system, which would probably be exposed to temperatures and pressure due to sodium fires. And, therefore, the containment structure, as you think, for a PWR would be, a structure for an SFR would be very different from a PWR containment structure.

MEMBER KIRCHNER: That I understand. I was just challenging you as to what you're buying by striking, essentially leak-tight and what does that mean further on down the road in implementation? Because when I charge that Argonne containing dome, I want it to be essentially leak-tight. Just a rhetorical statement.

MR. SOFU: I think the DOE team considered that. This current proposed language is less prescriptive than GDC 16. And some industry comments that DOE consulted with that included GE, TerraPower, and they were more comfortable with the current language that specifies a low-leakage containment with the second paragraph indicating what that low leakage would mean with 50.34.

MEMBER CORRADINI: But just so you understand our point, and then I'll stop. If you do it as -- I've forgotten who was sitting in that spot before. If you work it from the outside-in, from the EAB or the LPZ inward, and what's the allowable dose to meet the site, eventually I'm going to have to determine some sort of leak rate and an associated design basis accident for this design, which I'm guessing is going to be sodium fire. It's not going to be anything else since, historically, in the 50's, that was the design basis accident for containment for a sodium reactor.

MEMBER KIRCHNER: Out of curiosity, what was done for Fermi's containment and how did they meet the GDC 16?

MR. MADNI: Unfortunately, I picked some because we had a lot of things to do, we did not pick all of them. I picked some that did not include Fermi, so I'll have to go back and check what the Fermi containment design was.

MEMBER KIRCHNER: I will make an observation that we, as a proponent, and I have been one, we tend to ignore past experience. I would be very interested to see what the design basis was for the Fermi plant which did have an incident.

MEMBER REMPE: But were the GDCs enacted when Fermi was licensed? They came later.

CHAIRMAN BLEY: No, they came in the early 70's, I think.

MR. MADNI: Many of the GDCs as applied to SFRs came during the time of the CRBR construction permit and also during the PRISM pre-application stage. At that time, a lot of these design criteria came into the fold of use, and so we recognize that analogy issues.

So the next slide, I'll just read it. Furthermore, all past, current, and planned SFR use a high-strength low-leakage pressure-retaining containment concept which aims to provide a barrier to contain the fission products and other substances and to control the release of radioactivity to the environment.

And so I just have some examples. For example, PRISM, I already talked about what kind of containment the S-PRISM design had, at least on paper. And by the way, the entire containment structure is below grade. The lower part and the upper part, all below grade.

For a SFR, a carbon steel containment structure with a diameter of 135 feet, height of 186 feet, 8 inches depth below the operating floor, and wall thickness above grade one and three-eighth inch, design pressure 10 psi gauge. Two guard tanks are under the primary tank and any use between them allow the detection of sodium leakage. The guard tank was, in turn, surrounded by concrete shielding, which acted as a final containment vessel.

CRBR design was similar. And then JSFR, the Japanese SFR, is the new design, an innovative containment vessel, namely steel plate reinforced concrete containment vessel is called the SCCV, is developed with the Japan SFR.

So these are just examples I picked from the public literature.

MEMBER POWERS: Also, I think the FFTF fits the -- and I don't know what the Russians are doing.

MEMBER BALLINGER: So those designs, in effect, define what you consider to be high strength? Because I don't know what that means.

MR. MADNI: High strength?

MEMBER BALLINGER: Yes. It says high strength, low leakage. High strength. I'm not sure what --

MR. MADNI: That was the terminology that was used by the GE-Hitachi when they presented the PSID to the NRC.

MEMBER POWERS: I think high strength is always defined relative to the load. High strength is always defined relative to the load.

MR. MADNI: The load, yes.

MEMBER POWERS: I know, Ron, and we put up with that. Blacksmiths had their place in this world.

MR. MADNI: The next slide shows more information related to the need for a high-strength pressure-retaining structure. The reaction of sodium with air or water, sodium fires, and hypothetical reactivity accidents caused by sodium voiding or boiling could release significant energy inside the reactor containment structure.

Therefore, a high-strength, low-leakage, pressure-retaining structure surrounding the reactor and its primary cooling system is required.

Note that the design can have a low design pressure for the containment. Several technical reports and presentations support the need for pressure-retaining structures surrounding SFRs.

So this is something that is just introduction to what follows. I've just given it as an example four different citations from the public literature that talk about the need for pressure-retaining containment structure. The first one is from the TAREF group. This was the NEA-sponsored TAREF group, which is the Experimental Facilities for Sodium Fast Reactor Safety Studies Task Group on Advanced Reactors. And they mentioned on pages 52 and I think, 22 and 54 they mentioned the need for a pressure-retaining containment because of sodium fires.

MEMBER POWERS: One of the features of containments that I think you need to consider in this design criterion that sometimes gets overlooked in thinking about them is that failure of previous barriers, such as the pressure system, the reactor pressure system itself, should not lead ipso facto to the failure of a containment system. That's one of the flaws in some of these designs that say, okay, I'll have my reactor vessel and then around it I'll put a shield vessel because you can have a failure of the actual pressure vessel system that leads ipso facto to the failure of that shield vessel just by --

MR. MADNI: Very, very important, yes.

MEMBER POWERS: And that's one of the reasons that when, in defining defense-in-depth, I kind of like the definition that says that we have a sequence or a series of barriers of increasing conservatism and independence. So you might want to think about in your general design criteria --

MR. MADNI: That's the language there.

MEMBER POWERS: -- to have some language that says I don't preclude failure of the containment, but I do want to try to minimize the probability that failure of a previous barrier leads inevitably to the failure of that --

MR. MADNI: For example, if you have the reactor vessel and then surrounding that is the guard vessel which assets the containment, then the guard vessel should have its foundation somewhere else. It should not share the same foundation as that. It could be also materials be different, manufacturer be different, a lot of things can probably be different so that they don't fail together.

MEMBER POWERS: Yes. You just don't want to have --

MR. MADNI: That's very important.

MEMBER POWERS: -- have an assured failure of a subsequent barrier because of failure of a previous barrier.

MR. MADNI: Yes, thank you. That's very good. I appreciate it.

The next one is the GEN IV, the report from GIF, which is the GEN IV on safety design criteria for GEN IV Sodium-Cooled Fast Reactor. It says most of the design basis for containment shall consider pressure increase and thermal loads due to sodium fire. That's another citation. These are all referenced in the reg guide, so you can look at it if you want.

And the next one is our esteemed colleague, Tanju Sofu, he presented a training course in Mexico City. This was in 2015, I believe. Or was it 2016? 2015 I think. And in which he was talking about SFR technology overview, and he did mention that a low design pressure for the containment is due to heat produced by potential sodium fire.

And the next one is a reference to an article that appeared in the Annals of Nuclear Energy. This was in 2016 I think where they did a test on a test facility with a sodium spray fire, and they found that peak pressures in containment went over 3.5 bars absolute within the first five seconds, gradually tapering downwards to less than 3.5 bars at 25 seconds. So these are some examples.

So the pressure here is a little higher than the others. But, nonetheless, we see that there's kind of low pressure increases, not too much.

MEMBER SKILLMAN: I'd like to go back to a little chat we had a few minutes ago where our colleagues kind of said we're going to test these containments and we're going to show that they are capable of doing what they're supposed to do. They'll be tested at different pressures, but they'll all be tested.

For the mHTGR containment requirement,

which is 52, capability for containment leak rate testing not applicable; 53, provision for containment testing and inspection not applicable. And so, Mike, our previous discussion where I think you were perhaps led to believe there will be testing, there is not going to be testing.

MEMBER CORRADINI: I'm waiting for the next slide to ask him this question.

MEMBER SKILLMAN: Hold on. Walt bored in on, I think, an overarching issue that perhaps our background took us to, which is the value of a very, very tight containment. That was the life we lived in our previous lives.

What we have here, particularly for the SFR and for the mHTGR, is a containment that's not so tight. And it's endorsed by the NUREG-1368 and by the SECY 93-092. It's endorsed. And so there is here basis for a containment that is not as tight, at least as our backgrounds would suggest that it should be and what operating experience has shown is extremely valuable.

So I think that is the anxiety that I detected around the table a few minutes ago, and I'd just like to be clear. These containments that are being proposed for SFR and for mHTGR are not going to be tested.

MEMBER CORRADINI: Well, I guess I don't take it exactly that way. I'm not sure if I --

MEMBER SKILLMAN: I'm just going to stick with what's in the draft guide, and those are the words in the draft guide.

MR. MADNI: I just wanted to mention for the mHTGR, we do have the fifth barrier which is the reactor building. And that's not given credit for as far as the requirement for, you know, the requirements for 10 CFR 50.34, those limits. The reactor building is not credited, given credit for. So, therefore, it's there as a bonus, but first we don't have a Commission approval on both of these things right now. So this is still a work in progress.

MEMBER POWERS: I think the challenge you're going to have is if the reactor building ipso facto does fail, your containment function fails.

MR. SOFU: So in the SFR-DC criteria 50, 51, 52 addressed those testing and inspection, in particular 52 and 53. And those are essentially the same as GDCs with minor provisions, minor changes that inserts the word structure to the containment so that it is to be distinguished from functional containment.

MR. MADNI: Yes, it's only the mHTGR that they're not, they're not applicable. For SFR, it is applicable, all the testing --

MR. SOFU: All the 50 series would address that concern.

MEMBER CORRADINI: But I think, well, I don't want to get ahead of you because you're next slide is going to be mHTGR, so maybe I'll just wait until you get there. But I think for the Sodium Fast Reactor concept, they have to have testing because they're demanding, essentially, a low-leakage system.

CHAIRMAN BLEY: And it requires it.

MR. MADNI: All right. So now we move to mHTGR-DC 16, containment design. The content of the design criteria is a reactor functional containment, consisting of multiple barriers internal and/or external to the reactor and its cooling system, shall be provided to control the release of radioactivity to the environment and to ensure that the functional containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

MEMBER CORRADINI: So if I might stop you there, now Dick's question I think is relevant, which is there's a number of confinement systems operating under DOE orders, they must do testing. They must. So the fact that you said it's not applicable somewhere else in all this stuff can't be right.

MR. MADNI: No, see, you have to then go to, you have to go to new GDCs because those GDCs are specifically for leak-tight containments.

MEMBER CORRADINI: So 70 through 73 to pick up what is --

MR. MADNI: Yes.

MEMBER CORRADINI: Okay. Excuse me. I'll go look. I apologize.

MEMBER SKILLMAN: But what you're saying is that the reactor building design is not credited that even though it's identified in the criteria.

MR. MADNI: The reactor building is a safety grade. It's a safety grade, but it's just not given credit for the functional performance of the function of containment.

MEMBER RAY: Are the tech specs, for

example, going to require openings in the reactor building that's not being credited to be maintained closed when the reactor is in operation?

MR. MADNI: The reactor building is not pressure-retaining.

MEMBER RAY: Okay. But why do we keep mentioning it as if we should take some, I don't know, emotional credit for it I guess or recognition of it --

MR. MADNI: Because let's say you have, let's say you have, let's say you have a large break in the helium circuit, which is at high pressure, and that high pressure goes into the reactor building, from the helium circuit it goes into the reactor building, and it has louvers. And whatever design that we have so far, these designs are just as examples. Some design may come with a different style of the venting system --

MEMBER RAY: Does the building have a door?

MR. MADNI: The building has doors and other things but --

MEMBER RAY: How do you keep the door open?

MR. MADNI: It has a louver.

MEMBER RAY: Okay.

MR. MADNI: And that louver, just as an example, you have a louver that opens up and lets the puff of helium come out, and then it closes again. And, thereafter, you have a lot of room for the containment to take the stuff that comes out later on because much later you have a lot of surface area in the --

MEMBER RAY: I do understand that. I'm just saying how do I ensure that I don't have doors open, for example, but I don't go and close because an event has just occurred?

MR. MADNI: Well, it's the safety grade equipment, and you have testing requirements for it.

MEMBER RAY: But you told me we're not taking credit for it. Are you saying, notwithstanding that we don't take credit for it, we're still going to have tech specs that say you can't open the door?

MR. MADNI: Oh, yes, you have for all those requirements.

MR. ALBERSTEIN: Can I comment? This is Dave Alberstein again. The safety function of the reactor building that results in it being safety related is not related to radionuclide.

MEMBER RAY: Exactly right.

MR. ALBERSTEIN: Instead, it's related to protection of the geometry that allows for passive heat removal under accident conditions, and testing to ensure that safety function is provided for in the 70 series criteria.

With regard to testing of the functional containment itself, let me back up just a little bit. There are five components to the functional containment in a modular HTGR: fuel kernels, fuel particle coatings, and the graphite material that surround all of that, okay? Assurance that those are operating properly is provided through the SARRDL and the monitoring of circulating activity.

The fourth barrier is the reactor helium pressure boundary, and I believe it's Criterion 15 that provides for testing of that, so that's covered.

With regard to the radionuclide retention function of the reactor building, it was correctly noted that one can meet regulatory requirements for off-site dose, 50.34 and 52.72 and all that, one could meet that without taking credit for radionuclide retention by the reactor building. There is, in fact, as Dana mentioned, some radionuclide retention there, but credit need not be taken for it to meet regulatory requirements.

To meet a design objective and a user requirement of not exceeding the EPA protective action guides at the exclusionary boundary, which is a pretty ambitious objective, one does need to take credit for radionuclide retention by the reactor building. But that is not part of the safety function, per se, of the reactor building.

MEMBER CORRADINI: But if we just go back to testing, I would have to look at, if I choose to do the fifth of your defined five, I would have to do testing to show that it is feasible.

MR. ALBERSTEIN: It's going to be design specific, but it's typically about a volume per day. Not much of a barrier.

MR. MADNI: About close to 100 percent per day.

MEMBER CORRADINI: So it's not a confinement system --

MR. ALBERSTEIN: In terms of what it takes credit for to meet regulatory requirements for off-site dose, it is not.

MEMBER CORRADINI: So there's not filtering of what's leaking?

MR. ALBERSTEIN: That's a design-specific issue that each designer would have to address.

MEMBER CORRADINI: Okay.

MEMBER RAY: Well, I don't know when you're going to have to test it, which was your question, but I think you also have to have requirements for maintaining its configuration.

MR. ALBERSTEIN: Yes.

MEMBER RAY: Or its integrity of whatever --

MR. ALBERSTEIN: I think Fort Saint Vrain reactor building was sort of like that. I don't remember any specific requirements about doors. There was testing to make sure that the louvers would open at a certain pressure, which was relatively low. But --

CHAIRMAN BLEY: I spent enough time at Fort Saint Vrain. We can talk about it later offline. But Design Criteria 72 does address what Harold just brought up.

MR. MADNI: All this is very

insightful, and we can gain from this definitely. So we'll move to the next slide. I think we already talked about the next slide.

Okay. The next, slide 11, the NRC staff has brought the issue of functional containment to the Commission and the Commission has found it generally acceptable, as indicated in SRM to SECY 93-092 and SECY 03-0047, which is policy issue related to non-light water reactor designs.

In the SRM to SECY 03-0047, the Commission instructed the staff to develop performance requirements and criteria working closely with industry experts, for examples designers, EPRI, etcetera, and other stakeholders regarding options in this area, taking into account such features as core, fuel, and cooling systems design and directed the staff to submit options and recommendations to Commission for a policy decision.

So that's where it stands at present, and the status is that we are still working on it. So we don't have any Commission approval as yet.

MEMBER CORRADINI: So let's just back up so I understand. So from 1993 until 2003 and now we're 15 years later, after two different SRMs that said this is a good idea, there's been no effort to think about the criteria that make it so? Is that what I'm hearing?

MR. MADNI: I see what you're saying. We are inheritors of the situation.

MEMBER CORRADINI: Okay. So no.

MR. MADNI: We have to check with those experts who are involved in this before we came to --

MEMBER CORRADINI: Because I read 93-092 since I forgot that it was out there, and it's kind of vague as to what it says. But it does endorse this concept, and I'm just surprised there's been no staff work and research to at least scope this out as to what this would be since they're all, many, not all, many DOE facilities work on a confinement system with filtering on a continual basis, so I'm sure there's some actual operating experience.

MR. MADNI: I think one of the things is the NGNP also closed, and there's not that much funding for a reactor and so forth. I know this much that right now we have inherited the situation, and we look into it and see where, what's happening and how we can make it go forward. We'll do that.

MR. SEGALA: I just want to add to that. I think if we had an application in front of us, that would be something that would have driven us in a budget process to pursue these activities. So as applications have come and gone, the work on this, you know, hasn't continued.

MEMBER REMPE: And I'd second that, and that's what I was trying to say at the beginning of this about the policy issues, that until you have a real application, even though several designers may be out there touting no containment or whatever, until they're ready to back it up with paper submittals, I'm not sure I would just do it because it applies to a lot of these proposed designs out of 58.

MR. SEGALA: And so until we get specific applications in-house, we are looking at generic technology-inclusive kinds of issues that we can tackle in the near term and --

MEMBER REMPE: Again, just because a lot of folks are in that club doesn't mean they're going to come forward, and that's my concern with the budget limitations that you're faced with.

MR. MADNI: All right. I think we'll skip this one. Okay. I just wanted to mention one thing in the next slide, and that is that GDC 38 to 43 and 50 to 57 are not applicable to the mHTGR design since they address design criteria for pressure-retaining containments in the traditional LWR sense. So requirements for the performance of mHTGR reactor building are addressed by new Design Criterion 71, which is the design basis criteria, and Criterion 72, provisions for periodic testing and inspection.

So we'll move to the next one, which is mHTGR-DC 70, reactor vessel and reactor system structural design basis. The new mHTGR design-specific GDC was added to address the roles of the reactor vessel and reactor systems in maintaining the internal geometry necessary for passive removal of residual heat and for insertion of neutron absorbers for reactor shutdown. So that's what the first bullet is.

And the second bullet is the rationale. New mHTGR design-specific GDC are necessary to ensure that the reactor vessel and reactor system, including the fuel, reflector, control rods, core barrel, and structural supports, the integrity is preserved for passive heat removal and for the insertion of neutron absorbers. That's what the new mHTGR-DC 70 addresses.

MEMBER CORRADINI: So what does integrity maintain mean during postulated accidents? If I have a loss of pressure accident in mHTGR, does that mean the integrity is maintained and I just lost the gas?

MR. MADNI: Yes, the integrity means that it should be able to have the pathway for removal of residual heat to the ultimate heat sink.

MEMBER CORRADINI: Oh, oh. Okay. But the physical integrity of the primary system could be compromised?

MR. MADNI: Well, if it's --

MEMBER CORRADINI: Because in all of the designs, whether it's pebbles or blocks or whatever, they basically have, essentially, a different mechanism of removing decay heat that has nothing to do with the integrity of the primary system. I'm just reading this. I apologize.

MR. MADNI: Well, I'll have to look into this because the neutron absorbers also have to be inserted to shut down the reactor, so there should be space for them to insert. If the geometry is disturbed and you don't have space for the rods to insert, then that will be a problem. So that's a requirement to make sure that it fulfills its function. The integrity is important for fulfilling both functions, removing residual heat and also --

MEMBER CORRADINI: So we're talking geometric integrity, not pressure integrity?

MR. MADNI: Yes, yes, that's right, that's right.

MEMBER CORRADINI: So I guess I lost that somewhere in there. So is it better to say their geometric integrity is maintained? Because that's what you're getting at.

MR. MADNI: Okay. I can, we can check that --

MEMBER CORRADINI: At least I think that's what you're getting at.

MR. MADNI: So that's a good question. Is it geometric integrity?

MEMBER CORRADINI: All the passageways are there so things can move.

MR. MADNI: Yes, that's right. That's the objective of that.

MEMBER CORRADINI: Okay, fine. Got it,

I got it.

MR. MADNI: So we could add the word geometric, I mean . . .

MEMBER RAY: I agree. I think that's essential because I read it differently.

MR. MADNI: Yes. Mike, I think it says in the third line on the first bullet geometry. So you are right, it is the geometric integrity.

Okay. So the next two slides have to do with the reactor building design basis and checking inspection of the reactor building.

So the design of the reactor building shall be such that during postulated accidents it structurally protects geometry from passive removal of residual heat from the reactor core to the ultimate heat sink, which is the atmosphere, and provides a pathway for release of reactive helium from the building in the event of depressurization accident. So this is a requirement for the reactor building.

MEMBER KIRCHNER: So what if you have a steam generator rupture? Is that part of the design basis? What if it goes into the core or it goes into the building?

MR. MADNI: We did not go into the

individual scenarios, even though that's important. That could be our further step. I mean, it's something to think about. Let me note it down.

MEMBER KIRCHNER: It is because it gets at, even though you struck Criterion 50, one of the parts of the containment design basis is energetic reactions, etcetera, chemical reaction and so on. So you do have those possibilities in an HTGR, depending if they go with the Rankine cycle or . . .

MR. MADNI: Yes, we'll make a note of it. MEMBER CORRADINI: Maybe I missed it, maybe I've lost track of it, but somewhere in earlier GDC or mHTGR-specific language, there was mention of and the need to guarantee from ingressive air or steam. Now I've lost it. Did I miss it in 14? Yes, here it is under mHTGR 14.

MR. MADNI: Fourteen? Okay.

MEMBER CORRADINI: For the very reason that Walt is asking.

MR. MADNI: Okay. It says here that the heat and pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage if rapidly propagating failure or gross rupture and of unacceptable ingress of moisture, air, secondary coolant, or the fluids.

MEMBER KIRCHNER: So what is an unacceptable ingress?

MR. MADNI: Let's see what is an -- the easiest would be to ask our expert to answer that question, what is unacceptable.

MR. ALBERSTEIN: Dave Alberstein again. It turns out what's going to be limiting in terms of ingress during normal operation is going to be accident levels that could lead to excessive oxidation of graphite components of the core. With regard to blow-down accidents, compared to the type of energy that gets dumped into the containment in a light water reactor depressurization event, the amount of energy carried by the helium is very low, and all that's needed for the reactor building to do is have that pathway for helium release, get it out of the building initially with that initial puff release, as some people call it, and then, after that, by not having high pressure retained in the building, you have less of a driving force available for radionuclides released later in the accident and the quantities of radionuclides released later in the accident are much higher than those associated with the puff release.

There have been a variety of analyses done, and I believe some were presented to this subcommittee in 2013 that show that high-pressure, low-leakage containment for HTGRs actually result in higher off-site dose than the reference designs that are used in current modular HTGR designs.

Does that cover everything that you were asking about?

MEMBER KIRCHNER: That helps. I was specifically thinking of steam generator rupture.

MR. ALBERSTEIN: Yes. Steam generator, two failures lead to water in the leakage into the helium pressure boundary, inside the helium pressure boundary. They don't create high external pressure that would impact the reactor building.

MEMBER CORRADINI: So let me ask -- so this is to the staff, not to the DOE side, so let's leave it to you guys. Is there any sort of analysis that one can go back historically, maybe for the pre-application review you did in '86 for the mHTGR at that time, that goes through a series of example calculations that talk about this? I'm looking for some sort of analysis, not detailed, I don't need a fancy computer code, but even a systems analysis of this that one can look at because I'm curious about how this would functionally behave with time.

MR. MADNI: You're talking about which slide in particular?

MEMBER CORRADINI: I'm interested in some particular, not acceptable but at least representing a set of accidents and how a containment function would work. I think members of the Committee would find this educational.

MR. MADNI: The NGNP of the mechanic system, a white paper, cover a lot of this in four different aspects. One of them was licensing basis event selection, and another one was container performance. There were five or four different activities that had been reported in that --

MEMBER REMPE: But there's also, back in the 80's, like you're talking about, the mHTGR did submit evaluations of core conduction cool-downs, and they discussed the reactor building then and they talked about its performance. So, yes, those kind of things exist.

MEMBER CORRADINI: Back in the '86 --

MEMBER REMPE: Yes, around those years, yes, late 80's. Yes, so there's a lot of those kind of documents in the past. Now, I don't know if the staff would still consider them relevant but, yes, of course.

MR. MADNI: I would have answered that question on the helium thing, but I requested the expert to talk about the water thing. The helium thing, I would have answered that.

MEMBER MARCH-LEUBA: One more question. It's a completely different topic. You're concentrating mostly on the thermal loads for containment, fire, things like this. What happens to the external loads? I'm thinking hurricane, missiles.

MR. MADNI: Are you talking about mHTGR or SFR?

MEMBER MARCH-LEUBA: All of them.

MR. MADNI: Well, if you look at, for example, the mHTGR, then the reactor building is below grade, and it's supposed to be there to provide defense against external hazards.

MEMBER MARCH-LEUBA: But is that the design criteria or is that --

MR. MADNI: Pardon?

MEMBER MARCH-LEUBA: Is that the design criteria? Where does it --

MR. SEGALA: General Design Criterion 2 is still applicable.

MEMBER MARCH-LEUBA: Okay.

CHAIRMAN BLEY: Anything more for this panel? Okay, thank you. We're going to recess now until 1:00, and we'll see everybody back here at one.

(Whereupon, the foregoing matter went off the record at 11:27 a.m.)

CHAIRMAN BLEY: We are back in session. Welcome back.

I guess we're to Jeff?

MR. SCHMIDT: Yes, you are.

CHAIRMAN BLEY: Again.

MR. SCHMIDT: Again. This is the second time, but you get a third time.

CHAIRMAN BLEY: That's wonderful. Can't wait. This is the big one. Go ahead.

(Laughter.)

MR. SCHMIDT: Okay. So with a recent applicant, we have been reviewing GDC 26 and 27, which are reactivity control. And we decided that we would try to rewrite 26 and 27 into one, ARDC 26, that would hopefully clarify for people what the staff position is on the current GDC 26 and 27.

So we've combined GDC 26 and 27 into one. 26 is basically two independent reactivity control systems; 27 is reactivity control during postulated accidents.

One of the issues that had come up was, you know, GDC 26, as it currently exists today, describes AOO mitigation and reactivity, but it also kind of discusses normal plant operations in it, and it also has tacked on to the end of it cold shutdown requirement. So it kind of encompasses multiple things which has led to confusion over time. So we're hoping with 26 rewritten, and it's ARDC 26, and what I think is, you know, fairly voluminous rationale on this one, that we are going to hopefully solve some of these issues associated with GDC 26 and 27.

So what we did is we looked back at the draft GDCs from 1965, 1967, and the NuScale gap letter that went out, and basically rewrote 26. As I mentioned, the current GDC 27 deals with postulated accidents. There was a lot of consternation about what in GDC 27 calls reliably controlling reactivity.

CHAIRMAN BLEY: You just said something that has got me curious. These are non-lightwater reactor reactors, except you threw NuScale in there.

MR. SCHMIDT: That's how this came about that we needed --

CHAIRMAN BLEY: Yes, I know.

MR. SCHMIDT: -- to make --

CHAIRMAN BLEY: Which brings up a question for me. If I am a different kind of lightwater reactor, and I look at these ARDCs and say, "This is really more appropriate for me than the existing GDC," is it reasonable for me to come in and say, "This will be my principal design criteria for my design"?

MR. SCHMIDT: We would be using the NuScale gap letter as the justification for that. Staff has taken the position that the NuScale gap letter -- that one could argue is how we are interpreting 26 and 27.

CHAIRMAN BLEY: Okay. So even though they are non-lightwater reactor, they are essentially the same here.

MR. SCHMIDT: Yes.

CHAIRMAN BLEY: Okay.

MR. SCHMIDT: I mean, this is a lesson learned from that exercise, that we wanted to try

-- we get a lot of public comments on the draft GDCs for reactivity control. A lot of people didn't know how to interpret those, so we thought since the lessons learned from the NuScale design could be applied here, we would take a stab at it and try to get additional public comments. So --

MEMBER SKILLMAN: But, Jeff, let me ask you, with the proposed wording for the ARDC, you identify 26 sub 1 and 2 as shutting down and sub 3 as holding down, but you don't mention reactivity during normal operational control.

MR. SCHMIDT: That's right.

MEMBER SKILLMAN: And it just seems like that is an item that was in the original criterion 26, at least that made sense.

MR. SCHMIDT: Yes.

MEMBER SKILLMAN: You would say, you know, yes, you've got to have a reactivity control system that ensures that the fuel stays within limits for the basic design for the plant. That's missing.

MR. SCHMIDT: Yes. Our logic in that was that the system which protects -- I'll use the word SAFDLs here because everybody is more familiar. The system that would protect SAFDLs is always there, and we're not removing that. So if you have a reactivity control system in normal operation that is not well designed or is operated incorrectly, that the safety system would detect and shut you down.

We didn't think you needed a statement on how to normally operate your reactor. You still have the protection systems in place, such that safety is met.

MEMBER SKILLMAN: I would submit that -- I can understand your words, but with what is presented here, it really isn't a reactivity control system as much as it's a shutdown control system.

MR. SCHMIDT: It is. It's geared towards -- the new ARDC 26 is geared towards two independent means to shut down. That's right. That's where we're -- that's what the intent of the rewrite was for. Yes.

MEMBER SKILLMAN: Then would you consider revising the wording for the new 26 that says "shutdown control systems," and paren "normal controls assumed"?

MR. SCHMIDT: Yes. I think I wouldn't be opposed to that, yes.

MEMBER SKILLMAN: I mean, just as a matter of reading the text and understanding what the derivation has been from the original 26. It's kind of obvious that the normal control is not there.

MR. SCHMIDT: Yes. We tried I think in the -- well, in the last paragraph of our rationale, we describe why we got rid of it. I will point out one other thing. There is another paragraph missing on cold shutdown that should be in the rationale that isn't that we have to put in. It didn't make it all the way to the -- what went out. So we're missing a paragraph on cold shutdown.

MEMBER SKILLMAN: Can you give us a hint about that one?

MR. SCHMIDT: And I'll talk about it in my -- up next. How about that?

MEMBER SKILLMAN: Okay. Fair enough. Is this the only place where a paragraph is missing? Because as I went through this, I said I would have -- on other criteria, I would have said to -- I said to myself, I wonder if something is missing from this one.

MS. MAZZA: No. This was my mistake.

MEMBER SKILLMAN: This is the only --

MS. MAZZA: I did a copy and paste it into the document, so, yes, it's the only place where there's a paragraph missing.

MEMBER SKILLMAN: There's only one working and it's right here.

MS. MAZZA: Yes. Unfortunately.

MEMBER SKILLMAN: Okay.

MS. MAZZA: And I did speak to our Reg Guide Branch today, and we're going to either issue an errata or replace this document and do an FRN for it. So we're going to correct it before the end of the public comment period, so people have a chance to look at it.

MEMBER SKILLMAN: Thank you.

CHAIRMAN BLEY: I'm just curious, Jeff, I kind of get the rationale you described for Dick, but did you get any comments about, gee, it's odd not to have the normal operations side in here?

MR. SCHMIDT: Not that I recall, no. I got more comments on --

CHAIRMAN BLEY: Okay.

MR. SCHMIDT: -- I got more comments on, why is it in here? Yes, because it's --

MEMBER CORRADINI: Really?

(Laughter.)

MR. SCHMIDT: I think it was considered, you know, a means of operating the plant that there are -- would be other protection systems that would prevent fission product barriers from being violated, and that's adequate.

MEMBER MARCH-LEUBA: Yes. But the second is academic because nobody in the same mind would design a system that doesn't have a reliable control system.

MR. SCHMIDT: Right. I don't think we disagree on that.

MEMBER MARCH-LEUBA: But good design practices from the I&C point of view, you want to minimize the challenges to protect your system. So I understand what you are saying. I have a protection system you cannot get out of here. You can do anything you want in there, and that's one school of thought. The other one is if I keep challenging my protection system, I'm reducing the safety of my reactor.

CHAIRMAN BLEY: I'll find a hole one day.

MEMBER MARCH-LEUBA: Yes. I'll eventually find the whole. So I can argue it both ways, and it's academic because nobody will --

MR. SCHMIDT: I would think people who want to operate their plant and make money would probably not be tripping out a lot.

MEMBER MARCH-LEUBA: Yes. So it is --

MR. SCHMIDT: So that wasn't the philosophy. Granted --

MEMBER MARCH-LEUBA: But it is a good design principle to not challenge your protection system.

MR. SCHMIDT: And I wouldn't argue that. I just don't know if that rises to the level of a GDC or ARDC.

MEMBER STETKAR: There is -- and I have no idea going forward in terms of reactor oversight process, we do have these things called something that I can't remember anymore. You know, number of inadvertent scrams and that sort of stuff, that sort of thing from the --

MEMBER SKILLMAN: Reactivity events.

MEMBER STETKAR: Inadvertent scrams from a regulatory oversight process that gets you in a different column. I have no idea how that's going to be implemented for the new reactors. I would assume that something like that would be carried forward, you know, so that gets you away from this notion of, yes, yes, I don't control it all that well, and I'm willing to accept 15 scrams a year.

MEMBER MARCH-LEUBA: And it is not realistic. If somebody wants to make money, we'll do that. So --

MR. SCHMIDT: And so we see that as maybe outside our regulatory framework.

MEMBER MARCH-LEUBA: Yes. Myself, I would not have taken positive steps to remove it. I cannot read both ways.

MR. SCHMIDT: I think one of the reasons why we chose to remove it, though, was if you look at 26, it's generally very confusing because, you know, the -- I think technically the second sentence is really AOO protection, fast shutdown, right? And then it morphs into kind of a planned normal operation reactivity control. And then the third -- the last sentence says "cold shutdown."

So, like I said, it's introducing like AOO mitigation, but also normal operation, and then however you want to classify cold shutdown, which we'll get to in the next slide.

So it was generally confusing to people because you're mixing like AOO mitigation and normal operation.

MEMBER MARCH-LEUBA: Okay. So you made a good argument. Simplicity overrides.

MR. SCHMIDT: I think that was our philosophy. We try -- like I said, we try to add clarity to this, and we try to maybe refocus it more back on shutdown requirements.

CHAIRMAN BLEY: I have just a quick question here. When I look at the three appendices and look at the ARDC and the mHTGR-DC and the sodium-GDC -- sodium-DC, I think -- I think, unless I'm misreading, that the design criteria words are all the same, and the only place there is different words is in the justification, the rationale. Am I correct?

Which means -- it would almost be, you know, we are going to use the ARDC one, but here is some more rationale to go with it because you -- I think you repeated them verbatim.

MR. SCHMIDT: Yes. Yes. I don't think there is any -- going from memory, I don't think there is anything fundamentally different. The main thing was to get these concepts out in the

ARDC, and that we thought they would apply to all of the reactor designs. So I don't think there is fundamentally any difference that I can recall right now for sodium or high temperature gas reactor reactivity controls.

CHAIRMAN BLEY: Okay. I think they are identical, but okay.

MR. SCHMIDT: I think they should be identical. They tended to be.

CHAIRMAN BLEY: Yes.

MR. SCHMIDT: That's what I --

CHAIRMAN BLEY: Usually if they are identical, you would say it's the same as the ARDC.

MR. SCHMIDT: Yes. Yes. I mean, the --well, it does say it, and then it repeats it.

CHAIRMAN BLEY: And then it repeats it. Yes, okay.

MR. SCHMIDT: So like what I was just saying is, you know, the new ARDC focuses on two independent means to shut down, just to your point. It was -- we are focusing on shutdown now. And the basis for that is 10 CFR 50.2, the definition of safety-related equipment says to achieve and maintain shutdown. It doesn't say protect SAFDLs, for example, as the goal of a safety-related piece of equipment. It says to achieve and maintain shutdown.

And then SECY-94-084 basically, relative to reactivity control, will say -- said subcritical. So that's kind of where we're getting our basis for our reactivity control and our emphasis on shutdown.

MEMBER KIRCHNER: So what is -- I keep testing these just to see what's lost.

MR. SCHMIDT: Okay.

MEMBER KIRCHNER: So going back to reliably controlling reactivity, there is -- in the original GDCs, or those that are in 10 CFR 50, more accurately, they are worried about rates of reactivity change, not just shutdown. And that is important, and it gets more important in some of the concepts that you are going to be looking at, particularly liquid fueled reactors. So not -- I'm looking for what functionally is lost here by deleting that.

MR. SCHMIDT: The ARDC --

MEMBER KIRCHNER: And you will have xenon and other problems in these reactors as well.

MR. SCHMIDT: Sure. Sure. But the idea -- we haven't changed the philosophy of fast enough reactivity control, negative reactivity control, such that the SAFDLs are not violated. That was not -- so the rate of reactivity insertion has to be sufficient such that transients are still mitigated. That has not been changed or lost.

MEMBER KIRCHNER: Where does it say --

MR. SCHMIDT: It should say in the rationale.

MEMBER KIRCHNER: No, I'm not talking about the rationale. I'm talking about the GDC. I'm referring to your GDC. I'm starting with the advanced reactor one. Means of shutting down, means of shutting down, and a system for holding it cold, shutdown -- subcritical under cold conditions. But this loss from the GDCs in Appendix A is their concerns about rapid reactivity insertions and controlling that.

CHAIRMAN BLEY: Walt, where are you reading? Maybe I'm missing something.

MEMBER KIRCHNER: Page 992 of 10 CFR 50, Appendix A, Criterion 26.

CHAIRMAN BLEY: You're reading the note.

MEMBER KIRCHNER: I'm not reading the notes. I'm reading -- I'm in the GDC.

MEMBER SKILLMAN: That's in the actual GDC. He's in the GDC.

MEMBER CORRADINI: Yes. But the GDC is -- here is the actual words of the GDC.

MEMBER SKILLMAN: What words are missing? They're the same.

MEMBER KIRCHNER: The second reactor -- well, forget whether it's the second or the first. The reactivity control system shall be capable of reliably controlling the rate of reactivity changes resulting from planned -- and I don't see that, or maybe I'm misreading --

MEMBER CORRADINI: No. That's in the ARDC also.

MEMBER KIRCHNER: Where? Where?

MEMBER CORRADINI: I'm reading the attachment that is the same.

MEMBER KIRCHNER: No, it's not. It's not in the ARDC.

MEMBER CORRADINI: No.

MEMBER KIRCHNER: It's on A7 of the new code at DG-1330.

MEMBER CORRADINI: I'm in the wrong -- I'm in the earlier version of the NRC. I apologize.

MR. SCHMIDT: Criterion 26. The control and rates of addition are not there. That's what I raised, and that's what Walt has raised.

MEMBER KIRCHNER: So I'm anticipating forward -- looking forward several of these designs, not to pick on the liquid fuel design, but certainly that would be a huge concern and a huge impact on the design -- fundamental reactor design as well as the control system for reactivity control. So do you feel something is being lost here?

MR. SCHMIDT: The intent was, if you look at Item 1 in ARDC 26, the last phrase "design limits for fission product barriers are not exceeded."

MEMBER KIRCHNER: No, I get that, but it starts off by saying "a means of shutting down."

MR. SCHMIDT: Yes. The intent was that you're inserting -- I guess it's probably clear on the rationale, but the term "design limits for fission product barriers" were to indicate that you have to have sufficient reactivity inserted such that you don't violate the SAFDL. That's what the intent of that last phrase was to mean. So we are still addressing the rate of reactivity insertion. That was our --

MEMBER KIRCHNER: I guess what I'm struggling with is the implication is that whatever happens you will just shut down the -- scram the reactor.

MR. SCHMIDT: Well, in --

MEMBER KIRCHNER: Because you're saying a means of shutdown. That's different than controlling reactivity fluctuations and oscillations.

CHAIRMAN BLEY: Well, I'm reading the same thing, but let me -- up in the beginning of the GDC, they talk about controlling reactivity changes. Down in the second-last sentence they talk about controlling the rate, resulting from planned normal power changes, and that's what they told us in the beginning is what they removed, this normal operations situation. And that's where rate shows up. It's down in the second half of the GDC.

MEMBER BROWN: Of the original GDC.

CHAIRMAN BLEY: Of the existing -- the real GDC.

MEMBER KIRCHNER: No, I know that. But I'm looking at -- maybe I'm looking at Appendix A, Number 26. I didn't see anything about rate.

CHAIRMAN BLEY: Yes. I'm sorry. In the existing GDC --

MEMBER KIRCHNER: Yes. That's my point.

CHAIRMAN BLEY: -- they have the statement about rate, but it's only applied to reactivity changes resulting from normal power changes, which is what these folks told us. They didn't include the stuff about normal operations.

MEMBER KIRCHNER: I hear that.

CHAIRMAN BLEY: And that's where rate showed up in the GDC.

MEMBER KIRCHNER: I know. But what I'm saying is, what is lost in doing this?

CHAIRMAN BLEY: Okay.

MEMBER KIRCHNER: And that -- by deleting it. Because the implication here is you go to shutdown in the new ones, because the system -- it says "a means of shutting down the reactor." And, two, it feeds off the same way. And ditto, in effect, in Number 3.

MR. SCHMIDT: It's true that we eliminated normal operation rate of reactivity insertion by design. The other --

MEMBER KIRCHNER: No, I got that.

MR. SCHMIDT: The other transients we did not mean to say that rate of reactivity insertion is not important. It is important. And we try --

CHAIRMAN BLEY: But those are calculated in the transients themselves.

MR. SCHMIDT: Right. I mean, normally, if you look at a Chapter 15 event, right, control rods protect your SAFDLs, and it's a function of the scram curve, which is a rate term. But the end result also of the scram is a shutdown condition, whether it be hot or cold.

So what we were trying to do here is the first part was really trying to talk about transient conditions and protecting the fission product barriers, which would include SAFLDs and, say, RCS in the normal lightwater world. That was the intent of it, was not to miss the rate argument.

Now, if there is a better way to do that, we're -- I'm open to suggestion. But it was not our intent to do that.

MEMBER REMPE: And you have clearly stated about the -- at the last paragraph that's on your rationale for 26, you talk about the rate, and you have said that this is an operational requirement. It's not necessary to ensure reactor safety.

MR. SCHMIDT: That's right.

MEMBER REMPE: So whether we agree with it or not, he has tried to clarify what he means.

CHAIRMAN BLEY: In the rationale.

MEMBER REMPE: In the rationale, yes.

MR. SCHMIDT: And the idea of fission limit or design limits for fission product barrier was meant to say you have to insert enough reactivity to protect your SAFDLs. Okay? I mean, we're open to wording changes. Obviously, we'd like input. So I can only say I think -- I think if you read the rationale, maybe we need to change some wording in the ARDC itself, but that was never the intent of -- to ignore rate.

MEMBER KIRCHNER: Okay. Thank you.

MR. SCHMIDT: Yes. Okay. So let's go to the next slide. Again, this --

MEMBER BROWN: Can I just ask --

MR. SCHMIDT: Sure.

MEMBER BROWN: This is an ignorant question maybe, but that's an indirect way of trying to get reactivity rates. When you say SAFDLs, I mean, what is that, specific allowable fuel design limits?

MR. SCHMIDT: Yes.

MEMBER BROWN: So I can have a transient that allows the fuel temperatures to go up, but I -- and all I have to do is have an insertion rate that is enough to keep it from going too high as opposed to just driving it negative. I mean, that just seems to be counterintuitive to if you have a transient where you want to make sure the fuel temperatures don't increase, that you do it just so I'm just kind of barely going to allow it to not exceed its design limits. That just seems kind of crazy to me, so -- but that's what you're -- I'm phrasing that --

MR. SCHMIDT: Yes. I --

MEMBER BROWN: At least I understand what you're doing.

MR. SCHMIDT: And that can increase fuel temperatures, like an overpower event. But as long as you don't violate what we consider the fuel failure criteria, and you mitigate it prior to that failure point, that's acceptable.

MEMBER CORRADINI: They've demonstrated

full scale for certain reactor types. EBR-2 is a perfect example.

MEMBER BROWN: I'm just harkening back to my experience, which is foreign to this.

CHAIRMAN BLEY: Well, you had something similar there. I'm --

MEMBER BROWN: We had a lot -- a lot, a lot, a lot of concern, you know, with reactivity addition rates and making sure we could -- we didn't challenge the temperature limits any more than we had to. So we may have overdone it because our ability to shut -- you know, shut --

CHAIRMAN BLEY: But there were, I thought -- I don't remember. A lot of their designs had overpower and overtemperature delta Ts and things, which let you go some distance in normal operating mode before you hit a criteria to trip. It's kind of similar.

MR. SCHMIDT: Yes. I mean, we don't -- we don't hold it to the normal operating conditions and below. We allow some transient to occur as long as we don't violate things. So, but, you know, it is fair to say that -- I'm sorry -- that we are somewhat refocusing this on two independent means to shut down.

We haven't eliminated the SAFDL on the reactivity requirement, but we have kind of -- we have kind of focused on, again, two independent means of shutting down the reactor. I think where that is going to be -- where we are going to see a lot of public comments on is the ability to maintain shutdown. Some of these designs, as they cool down, may go recritical again, right?

MEMBER CORRADINI: Do you mean they kind of burp?

MR. SCHMIDT: I mean that when your -- when your decay heat goes away and goes below whatever you're removing for heat, right, from your decay heat removal system, the system will naturally cool down and, depending on what means you've used for shutdown, may go recritical again.

So I think we're going to get a lot of public comments on maintain and how long do you have to maintain.

CHAIRMAN BLEY: Now, as I read -- I don't know what we call them -- Criterion 3, a system for holding the reactor subcritical under cold conditions, that doesn't say you need two systems capable of doing that.

MR. SCHMIDT: That's correct. It does

not. I think that what I'm saying here is this -- you need a safety-related system for AOO fission product barrier, which we talked about already, and you need, one, the safety-related system to get to a safe shutdown condition. However that design is specifying its safe shutdown condition, it seems like a lot of designs are going to have different definitions of safe shutdown. That has to be a safety-related system.

So SAFDL protection, fission product barrier protection, are safety-related to get to safe shutdown. To move from safe shutdown to cold shutdown is a non-safety system.

CHAIRMAN BLEY: But it could be one of the other two systems could get you there, right?

MR. SCHMIDT: Yes. If you had --

CHAIRMAN BLEY: You don't need a third system to --

MR. SCHMIDT: No. The intent is not to have a third system.

CHAIRMAN BLEY: Okay.

MR. SCHMIDT: Is that it for -- any other questions?

MEMBER SKILLMAN: Yes, let me ask this. If the time that it would take to get to cold shutdown is a complicated time, and what I mean by that is it isn't just your decay heat generation rate curve for that core, but for whatever reason getting to cold shutdown is challenging, why wouldn't the system to get to cold shutdown be a safety system? That could be your last chance to prevent from having recriticality.

MR. SCHMIDT: Right.

MEMBER SKILLMAN: In other words, you want it shut down and you want absolute certainty that it will remain shut down. You don't want it awakening itself independent from your awareness.

MR. SCHMIDT: You know, the -- basically, the thought process and the -- has been for reaching a safe shutdown condition. You can maintain that for a certain period of time and it be acceptable. It's not like we won't have the capability of reaching cold shutdown. It will be on a non-safety system, and we have some description in the rationale that there are features of this non-safety system the staff would like to see.

So I think it's not a safety-related system, but it is a system that we would be I think looking at certain requirements, say like seismic conditions, and there's other highly reliable function, that you would get the cold shutdown, that you -- you haven't lost that function. It's just not safety-related.

MEMBER STETKAR: In my opinion, it's akin to a RTNSS system for, you know, the AP1000.

MR. SCHMIDT: Yes.

MEMBER STETKAR: Its importance is determined by its relationship to overall plant safety and risk. And if it's important, then it's RTNSS; it doesn't have to be safety. And if it's not important, it's not important.

MR. SCHMIDT: That's what our philosophy was behind this.

MEMBER STETKAR: I just wanted to make sure I understood that.

MR. SCHMIDT: Yes. That's the thought process. Okay?

Am I also up next?

MEMBER CORRADINI: Your name appears on the next topic.

MR. SCHMIDT: Yes, yes. Okay. All right. Well, that one better --

(Laughter.)

MR. SCHMIDT: Okay. So we're going to

switch gears here and go to RHR and ECCS. We talked a little bit about this this morning, and there was a fair amount of dialogue within the group of how we were going to handle this. And it went back and forth quite a bit, but this is where we ended up.

So ARDC 34 deals with residual heat removal during normal operations in AOO, and ARDC 35 deals with postulated accident residual heat removal, and the basic premise was we kept it like the GDCs today. That's the basic premise.

The reason we decided to do that was, as we talked about this morning, is that there may be some advanced reactor designs that we can't think of that may have an ECCS system to deal with postulated accidents, and we were thinking that there could be still an injection system.

Now, that's not the case for most of the advanced reactor designs, but I guess we consider it still acceptable, if you wanted to go down that path. So we separated out 34 and 35.

That was really the thinking there, and that propagated also to the sodium fast reactor thought process, too. But it will be different for the modular high temperature gas reactor, and I'll get to that in a second.

So if you have one system, as most non-lightwater designs do, we wanted to make it clear that if you're basically doing normal operations, AOOs, and postulated accidents with one system, that ARDC 36 and 37 apply to that.

So we wanted to make it clear that if you've got one system, you're still associated with the testing and inspection criteria. If you have a separate ECCS system, then ARDC 36 and 37 only apply to that ECCS system, which is consistent with today's GDCs. And I think I mentioned the sodium fast reactor already, so --

MEMBER CORRADINI: So I'm rereading it just so I get it right. So you have a certain design in mind the way this is written. But my understanding is, again, maybe you're going to get to this for the mHTGR, but in some designs for the sodium systems they have a similar decay heat removal system as in the mHTGR, which is a --

MR. SCHMIDT: Passive pools.

MEMBER CORRADINI: -- I'll call it a reactor cavity. They call it RVAC, but an RCCS or an RVAC.

MR. SCHMIDT: Right.

MEMBER CORRADINI: And others they've got the -- now I can't remember -- the DRAX. So do these cover both possibilities under the SFR?

MR. SCHMIDT: Yes. In the normal -- I think the sodium fast reactor design you're referring to, it would be all under one system would do all the functions; is that correct? Is that what you're assuming here?

MEMBER CORRADINI: That's my -- yes.

MR. SCHMIDT: Yes. So, yes, then it would -- it would be one system, and the inspection and testing would apply to that system. You know, the difference between the sodium and the high temperature gas reactor is that you have to still maintain a coolant in the sodium fast reactor to get that -- to get that conduction to the passive heat transfer.

With a high temperature gas, I'm going to say on the next slide is you don't need coolant. It's designed such that the power and surface area --

MEMBER CORRADINI: That's the difference.

MR. SCHMIDT: -- that's the difference.

MEMBER CORRADINI: All right, sir.

That makes sense.

MR. SCHMIDT: Okay. So I guess let's go to the next slide, Jan.

So we kind of got into this a little bit already, but the modular high temperature design has certain assumptions that we're assuming for this design, such as power density and geometric arrangement, allows for passive cooling without a helium inventory. Right? That's the basic premise of this whole concept here.

Since no helium inventory is required, HTGR-DC 35 is not applicable, and the design basis residual heat removal is addressed only by HTGR-DC 34. So that's why we've taken a slightly different tack for the modular high temperature gas reactor in that we only expect one system to do it.

MEMBER CORRADINI: So let me ask a question that maybe isn't in a design criteria. Remember it sits somewhere else. So with these advanced systems with passive decay heat removal, whether it be in a DRAX or an RCCS, how is -- how are -- what design criteria do you point to that assures that they are protected about external threats?

MR. SCHMIDT: That would be in ARDC 2

or 4.

MEMBER CORRADINI: Okay.

MR. SCHMIDT: I mean, those ARDCs still apply. This is just focusing on, you know, the residual heat removal capability.

MEMBER CORRADINI: Yes, yes, yes. So I should go back to 2 or 4 and convince myself that the words cover -- the only thing that -- the reason I'm -- I think it's because of their passive nature and their need for small driving pressures, I don't need as -- I don't think I need as dramatic of an external event to cause an upset of the system, and then bollocks up the decay heat removal capacity, if you know where I'm going.

MR. SCHMIDT: I understand where you're going to, and you may be correct. Yes, I really don't know.

MEMBER CORRADINI: To me, it's not an internal plan issue that is the Achilles heel of some of these things. It's an external.

MR. SCHMIDT: Right.

MEMBER CORRADINI: Okay.

MR. SCHMIDT: Right. Yes.

MEMBER CORRADINI: And we're not --

MR. SCHMIDT: But it's trying to

preclude that.

MEMBER CORRADINI: No, no, that's fine.

MR. SCHMIDT: We still -- we have to evaluate that. I mean, if you flooded your decay heat removal system somehow, you are using air, then, yes.

So the only other thing that was really added for modular high temperature gas reactor DC 34 was that the concept really is that residual -- you don't need another system to transfer residual heat from the core to the ultimate heat sink. So we put that wording in, is that we don't expect to have like a component cooling water system that's necessary for the residual heat removal. It's almost a direct line to the ultimate heat sink. So it just specifies that, just describes that.

Residual heat removal is designed to ensure the SAFDLs are not violated for -- or, I'm sorry, SARRDLs. SARRDLs. I got into the old habit. So the residual heat removal on the high temperature gas reactor is -- the SARRDL is not violated during normal operations in AOO. The fuel temperatures remained below the design value, so postulated dose criteria are not violated.

So cool the core in supporting

structures, that is the one thing we kind of added here, and it may be redundant with other ARDCs a little bit, is that -- we talked about this morning is that you have to maintain a certain geometry for residual heat removal to be maintained.

So one of the additional functions in the modular high temperature gas reactor is that geometric arrangement has to be preserved. And I put it in there to reinforce that.

Okay? That's it.

CHAIRMAN BLEY: Are you done?

MR. SCHMIDT: I hope so.

CHAIRMAN BLEY: For the day?

MR. SCHMIDT: I'm done for the day.

MS. MAZZA: Any other questions on this? Our next presentation --

CHAIRMAN BLEY: Before you go ahead, we were just -- there has long been guidance to integrate safety and security issues here, and that's kind of where Mike was coming from a little. We may not have as hardened a facility as we had before, and it kind of should -- should -- and especially given, from what we hear, some people who will be or have applied, are thinking of having a heavily integrated security and safety approach.

Should there be anything in these design criteria to address that -- and, in particular, the ones you've just been looking at -- to address some other outside forces that might -- for which we might be more vulnerable in some of these designs than we are in current design?

MR. SEGALA: So originally -- this is John Segala. Originally, as part of the effort to develop the non-lightwater reactor design criteria, we also have what we call security design considerations as part of this effort. That took a little bit longer to develop, so we have since split those efforts up. So we are actually --

CHAIRMAN BLEY: It's hard to keep them integrated, isn't it, keep --

MR. SEGALA: Yes. There is no current design criteria for security, so that's why we call them security design considerations. And the advanced reactor policy statement says that you are supposed to consider security at the same time when you're developing the design because it's easier and better to deal with that at that stage rather than trying to apply it after the design has already been developed.

So, anyway, the security design

considerations is actually going through concurrence right now. We're about to issue a Federal Register Notice, we're hoping by the end of this month, maybe early next month. So you should be seeing that soon. And then that is going to go out for public comment. And if we're able to resolve those comments, you know, in a timely manner, we may fold these efforts back in together, or we may just choose to keep them separate. We haven't decided yet how to move forward with that, but that is something that we're going to be pursuing.

Also, we have -- on April 25th and 26th, we have our advanced reactor workshop. It's a joint initiative between Department of Energy and NRC. We're planning to -- one of the topics on the draft agenda right now is to talk about security during design, you know, to share that information.

So I don't know if that answers your question, but --

MEMBER CORRADINI: Well, where I was coming from is I'm back to my original question about I've got these various systems which rely on small pressure differences that will apparently, by experiment, work very well as long as the geometry is maintained. So if I upset the geometry either by natural or manmade external events, now all of a sudden my decay heat removal function goes away.

And I'm struggling to figure out, has this been considered by any of the potential applicants in private discussion, since much of this is security-related, and has staff felt good about what they've seen, or is this yet to be discussed, or is there no direction from staff? That's where I'm kind of coming from.

MR. SEGALA: I think that's one of the main reasons why we're trying to get these security design considerations out, because we want the vendors to start thinking about this now as they are in the early stage of the design development.

MEMBER CORRADINI: Okay. Thank you.

CHAIRMAN BLEY: I guess we'd -- yes, we'd like to see your draft that's going out whenever it's available.

MR. SEGALA: There is nothing scheduled right now.

CHAIRMAN BLEY: I know. But just getting it to see -- to start with. We can do the same thing as we're doing here. After we get comments and come back would be a good time.

MS. MAZZA: So the next presentation is on electric power systems. And Bob Fitzpatrick is our speaker, but he is on his way over here from Building 1, because he thought he would be going after the break. So I told him to be here at 2:30, and then I just called him on his cell phone and he's coming. So I don't know what you want to do in the meantime.

CHAIRMAN BLEY: Let's take our -- we might finish early, huh?

MEMBER KIRCHNER: Would you allow some retrogression?

CHAIRMAN BLEY: Absolutely.

MEMBER KIRCHNER: Okay. While we're on the mHTGR, I wanted to go back to the reactor building, the GDC that you crafted. And if I understood you correctly, then the expectation is that building is safety grade, because you rely on the building to maintain the geometry. Or am I jumping to conclusions?

MS. MAZZA: Yes.

MEMBER KIRCHNER: I can't find it all of a sudden.

MS. MAZZA: I see a nod over there.

MEMBER KIRCHNER: What number is that

now?

MR. HOLBROOK: This is Mark Holbrook from Idaho National Laboratory. It is safety-related for the functions that it provides, which you're referring to the structural integrity to maintain geometry. So, yes --

MEMBER KIRCHNER: Right.

MR. HOLBROOK: -- that is a safety function, so it would be -- they will certainly have safety requirements for safety-related --

MEMBER KIRCHNER: So how encompassing on the building design is that? And I'll let you know where I'm going. I was thinking back to our discussion with you about the function of the building to vent on a depressurization event, and then the louvers to close. So that, too, becomes a safety function, right?

MR. HOLBROOK: It would probably be a design-specific issue, especially depending on the question of whether it's filtered or unfiltered. So --

MEMBER KIRCHNER: So --

MR. HOLBROOK: Again, as was mentioned earlier by David Alberstein, and we don't rely on those functions for the design basis events that meet the dose criteria at the boundary limit per 10 CFR 50.34. So they may not be, you know, a safety function that needs to be verified or tested as far as the venting.

MEMBER KIRCHNER: As far as the venting.

MR. HOLBROOK: But the --

MEMBER KIRCHNER: Right.

MR. HOLBROOK: As far as the venting is concerned. But as part of the transfer of heat through the system out to the outside of the building, that is part of the requirements that you will see in the existing -- I think it's Criterion 71 or 72 having to do with testing related to the building. You know, is there specifically a mention in there of, you know, the ducting or -- I'm not using the right word, but the pathway maybe for removal of heat from around the reactor cavity vessel area out through the building. Okay?

MEMBER KIRCHNER: No. I was just struck by the statement that we're not taking credit for it, but you're going to great lengths to ensure you can take credit for the passive heat rejection and function of the building.

MR. HOLBROOK: Yes.

MEMBER KIRCHNER: Sounding more and more like a confinement to me. Just an observation.

MR. HOLBROOK: Okay.

MEMBER KIRCHNER: I just wanted to understand what functions of the building would be safety-related and what would necessarily have to go through that pedigree of testing and design, et cetera.

MR. ALBERSTEIN: We don't need to credit the building as a fission product retention device. Okay? We do need to take credit for the building for protecting the geometry, for passive heat transfer. On these RCCSs, there are various designs available, but I know that for the air-cooled RCCS variant that GA did analyses back in the '80s to see how much flow blockage that thing could take while still maintaining core temperatures within desirable limits. And it was something like 90 percent.

So you'd have to virtually cut the thing off completely in terms of destroying the geometry before that would become an issue.

MEMBER CORRADINI: But the -- since I've done some and seem some experiments at Argonne with that facility, it has a high profile.

MR. ALBERSTEIN: It does.

MEMBER CORRADINI: So one can cut it off -- one can see it to cut it off.

MR. ALBERSTEIN: One further point, they have also done analyses, which I know Joy Rempe is probably pretty familiar with, where they assume the RCCS wasn't there, and the heat was conducted/transmitted from the reactor vessel through the walls of the reactor building to the surrounding earth. And under those conditions, fuel temperatures still stay below those values that have been shown in the ATR fuel qualification program to result in substantial fission product release.

MS. MAZZA: Are we ready for electric power systems?

CHAIRMAN BLEY: We are indeed.

MS. MAZZA: Okay. We have Bob Fitzpatrick here.

CHAIRMAN BLEY: Welcome back.

MR. FITZPATRICK: I'm Bob Fitzpatrick, Electrical Branch, NRR. And I'm here today to talk about the alternate fire systems, which is ARDC 17, which is analogous to GDC 17, electrical power systems.

If I might read it, it's fairly short actually, but electrical systems -- "Electrical power systems shall be provided to permit functioning of structures, systems, and components at point of safety. The safety function for the systems" -- that's the electrical systems -- "shall be to provide sufficient capacity, capability, and reliability to assure that specified acceptable fuel design limits and design conditions of the reactor coolant boundary are not exceeded as a result of anticipated operational occurrences, and vital functions that rely on electric power are maintained in the event of postulated accidents.

"And the onsite electric power systems shall have sufficient independence, redundancy, and testability to perform their safety functions, assuming a single failure."

Can I have the next slide?

Okay. This is the version that the DOE sent us in their report of December 2014. "And after careful internal consideration of the above, the staff concludes that the DOE version of ARDC 17 is well crafted and appropriate for its intended purpose."

But this did not come easily to us. When it first came in, it took us actually four phases of review here to come to this conclusion. When it first came in, we said, no, it's just too simple. It's -- you know, it's not enough, and that was our position.

And then it came back, you know, well, we really -- these are advanced reactors, and so we need to do something that -- you know, that wouldn't make an applicant call for an exemption to a GDC, or an ARDC at this point.

So we started trying to nibble down the four paragraphs of GDC 17 to try to make it, you know, more palatable. And we sent that through the management chain and they said, "This really doesn't do it. It doesn't give them the flexibility we're looking for."

So then we said, "Okay. Well, let's look at ARDC 17 as presented, and what can we do to improve it?" And so we spent time trying to improve it. And what we thought were clarifications really turned out to be restrictions.

So we sent that through the management chain, and it came back saying, "You're still not getting it." And so finally the first part of the review team got it, said, "Okay. We understand." We looked at ARDC 17, really, with open eyes and we said, "Yes, this really does do what we want it to do."

So we were having a meeting with DOE, and said, "Okay. Well, before we go to that meeting, let's pass it through the other senior members of the branch." So we did, and wouldn't you know that they were all doing the same things of trying to make it better, you know. So it really has gone through a lot of review, and we do think it's where it should be.

Next slide, please?

Okay. The first paragraph of ARDC 17 establishes the need for multiple power sources. From the second paragraph, one is called Onsite, and at least one more system, which could be akin to current offsite power systems but affords the applicant flexibility to choose and justify what the other system should be.

That was one of the points of feedback through the system as we were going through this that -- not all of these advanced reactors -- and they are advanced reactors -- might be cited on a grid. So if we would call it offsite power, like GDC 17 does, everyone knows what that is, and it might not be what this plant might need or have.

So that's why it goes unnamed. It's another source, and it has to meet all of the performance criteria of the first paragraph. And it can be, you know, whatever the applicant wants at that point. If it's going to be a power reactor, it's going to be putting power on the grid, it's going to have a grid to count on.

And I'm sure that anyone -- any reactor that does that, any advanced reactor, will take the credit for the grid. And so, you know, it will be just like normal, what we see today.

Another point I would like to make just for the record is that, you know, as people -- you know, my colleague before me today have talked to you about systems and criteria for them, these are new systems that they haven't really seen before. You know, they will understand them when they start reviewing them, but they haven't reviewed that before.

The power system is going to be just like any other. There is no new novelty in the power system. It's going to be busses, breakers, and cables. So we know how to review that. You know, that's not anything that we have to gain experience on.

For the second paragraph of ARDC 17, it provides for an onsite power system, not unlike the ones we have today, but tailored to the needs of the reactor design with appropriate parts, meaning the single failure criteria. So that's the gist of what we have agreed with the DOE team as a good starting point for the power systems.

If I can have the next slide?

But continuing the comparison to GDC 17, the third and fourth paragraphs are no longer needed and they are missing.

The third paragraph of GDC 17 describes the redundancy in the offsite power system. Due to the lesser role of offsite power in passive designs, for example the AP1000, those redundancy requirements have been removed. The SECY papers and the standard review plan talks about passive designs, like the AP1000, and already grants that type of design an exemption to GDC 17 where it only needs one power line.

So what we are really talking about is transferring that concept to the advanced reactors, and they need a power system. And it's up to them, again, to determine what it is.

The third paragraph of 17 really -- GDC 17 really requires that -- it was really the AEC's attempt to make a non-single failure-proof system, offsite power, as single failure-proof as they could. So they call for redundancy here and there and two lines and separate towers, and all that stuff. But if you only need one, that goes away. So that is basically the entire gist of the third paragraph of GDC 17, and so that's why it was removed.

The next slide?

The fourth paragraph of GDC 17 emphasizes the need for independence between the various power sources, and the concept of independence between the systems is really embodied in the first paragraph because literally, when you call for systems, you have to have more than one because they must be independent in order to count them as multiple. So that's where we stood with finally coming to grips with ARDC 17.

If I can have the next slide?

CHAIRMAN BLEY: Well, that last one you said, the S on "systems" being the --

MR. FITZPATRICK: Right.

CHAIRMAN BLEY: -- thing that by definition they have to be independent. Is that perfectly clear to everybody, or is that kind of narrowly what you guys think about?

MR. FITZPATRICK: Well, that's certainly what is clear to me. That is one of the types of things that we try to augment in our process of getting there. Maybe we should say more here or there, but --

CHAIRMAN BLEY: I'm just a little uncomfortable that when the most experienced people have moved on maybe it won't be as clear to --

MEMBER KIRCHNER: How much does it cost you to insert the word "independence" in front of "systems"? And so "independent systems."

MEMBER MARCH-LEUBA: Let me give you an example. I have two feet, which you can argue they're independent, but they're not, right?

MEMBER POWERS: I've seen how you walk. They are.

(Laughter.)

MR. FITZPATRICK: I don't think it would cost anything to add "independent" into the --

MEMBER MARCH-LEUBA: If you mean it, put it in there.

MR. FITZPATRICK: The next slide?

MEMBER SKILLMAN: Before you move from that, I guess I can conceive of a design that would meet this requirement that is nothing but automobile batteries. Has nothing to do with what might be produced as a product, but I could meet -- I believe I could meet this requirement with a forest of batteries that are hooked up properly.

MR. FITZPATRICK: Then you can take your shot and submit it for review.

MEMBER SKILLMAN: Well, I appreciate the feedback, but I'm sure --

(Laughter.)

MEMBER SKILLMAN: No. My first reaction is, not so fast there, partner. There is something hiding in the original 17 that drove the designers to look very thoroughly at defense-in-depth. And I don't believe that that same context is in the revised 17. I can see by making the words plural one might assume that that is in there, but I'm with Dennis Bley. I don't think that that is clear.

And I'm serious about batteries. I

know that when we went -- I know batteries are used extensively, and sometimes they are commercially dedicated and you buy them at the drugstore. And they certainly don't look like nuclear grade, but they do the job very well.

It just seems that in the effort to squeeze out unneeded nouns and adjectives something very important has been lost in terms of requiring I'm going to say defense-in-depth that was at least something that I found valuable in the original Criterion 17, and it's absent.

MR. FITZPATRICK: Well, certainly, I agree with you that it was valuable in the original 17. If someone -- literally, you know, as it stands now, if they literally wanted to submit a design with all kinds of batteries, whatever, I mean, they can give it a shot and we'll look at it.

17 really focused on a quasi-single-failure offsite power system. And we're saying that, you know, that's gone by now with the passive designs and all the SECY papers and the standard review plan that say we don't need that anymore. You know, the performance of the reactor design is such that it doesn't need that because of the onsite system having capabilities to

last for at least 72 hours.

MEMBER KIRCHNER: But to elaborate, without pinning it down to offsite, onsite, and so on, what was in the original was the parenthetical phrase that the safety function for each system, assuming the other system is not functioning, shall be to provide, and there it's the same as what you've adopted here.

I don't want to belabor it, but I tend to agree with Dennis that the suggestion here, or as Dick is inferring, you get a measure of defense-in-depth by having some independent subsystems. So that if you lose one, you still have lights on in the control room, et cetera, et cetera.

MEMBER MARCH-LEUBA: The concept they're looking for is -- thinking I&C is diversity. It's -- typically we say diversity of defense-in-depth because if you alarm two independent systems which have two different power lines that come from two different places, and a single earthquake gets them both, that's probably by design.

So, I mean, diversity is something I would like to see in there, too, or at least think about it. I mean, I'm -- you don't want to have only two diesel generators and they have two independent systems, because one is located in the east and one is located in the west.

MR. HOLBROOK: This is Mark Holbrook from the Idaho National Lab. Does the second paragraph in the ARDC 17 get you where you need to go? "The onsite electric power shall have sufficient independence, redundancy, and testability to perform their safety functions, assuming single failures," does that get where you need to go? Is that what you're looking for?

MEMBER KIRCHNER: That might be it, yes, thank you.

MEMBER MARCH-LEUBA: What do you mean there were redundancies? Each of the systems must be redundant?

MR. HOLBROOK: Basically, depending on the safety functions that you're talking about that are provided by the electrical power. So, again, it's going to be design-specific.

MEMBER MARCH-LEUBA: If you work at a plant, I like them to be diverse also.

MEMBER SKILLMAN: You know, I'm going to say no. That doesn't get me to where I get to.

If you know the history of Oconee, they had KIWI, designed without diesels. No. And the whole emergency power for Oconee was KIWI, hydro.

MR. HOLBROOK: That's right, because of --

MEMBER SKILLMAN: And the NRC said, "Wait a minute. Time out. You'd better put a diesel in there." Hence, Duke went through quite an exercise to power their plan with electricity.

MR. HOLBROOK: Well, that is going to, you know, resolve itself somehow through somebody deciding what the term "sufficient independence" means.

MEMBER SKILLMAN: Yes, I understand the words, and I understand your challenge, but I think it's fluff, in all candor. I think you've conceded to some words that someone else said are sufficient. When I see one of these plants, you know, one of the things that we've staked our claim on for years is they run 24/7, they run whether it's raining like crazy or snow or ice. They are dependable because they have power supplies coming from all kinds of places, and you can count on these machines.

And what I see right here is a

situation where you can have a series of batteries and a gas-powered motor and a single line coming into the plant, and one can say, "Well, it kind of meets that. It's sufficient." Now, I agree with you, bring it in and we'll see if it meets the litmus test. I'll review. But at least it just seems that the words have been -- have been so thoroughly metered that this can be made useful to the lowest common denominator.

Maybe that was the intention, but it just seems to be a major vast difference from where we have been for so many years in ensuring robust diversity and robust redundancy. And I would just suggest that those have proven over and over again to have saved the day with the fleet in the United States. Yes. That's what I'm saying.

CHAIRMAN BLEY: Go ahead, Bob.

MR. FITZPATRICK: Okay. Just one more thought that we've added to this is that for any design that may claim the need for zero electrical power to mitigate the spectrum of anticipated operational occurrences and accidents, a highly reliable power source is still needed for other functions, such as post-accident monitoring, control room habitability, emergency lighting, radiation monitoring, communications.

And I would note to the Committee that we are now reviewing the NuScale design, and we are dealing with the concept of highly reliable power source during that review. And we are scheduled to have a closed meeting with the ACRS on the 24th of March.

MEMBER CORRADINI: It's funny you brought that up. I was going to wonder if we were ever going to see the SE.

MR. FITZPATRICK: I can't speak to that, but at that point we could discuss that. Actually, we will be discussing that, rather, at that time.

MEMBER CORRADINI: Thank you.

MEMBER MARCH-LEUBA: Can we ask about that? Are we going to have that meeting? Because --

MEMBER CORRADINI: It is yet to be determined because we haven't seen the SE. We need it a month ahead of the meeting.

MEMBER MARCH-LEUBA: I know. We need to make plane reservations.

CHAIRMAN BLEY: That's our problem. That's our problem. That's not your problem.

MEMBER STETKAR: Can I ask you something on this?

MR. FITZPATRICK: Yes, sir.

MEMBER STETKAR: Where are these notions captured in total in the ARDC? Because if I read ARDC 17, I can read that a variety of different ways.

MR. FITZPATRICK: I didn't hear the end of that. I'm sorry.

MEMBER STETKAR: I can read ARDC 17 a variety of different ways, and I've seen people take words very literally. So, for example, ARDC 17 focuses on structures, systems, and components. These are not necessarily structures, systems, and components important to safety, unless, for example, I allow the fact that people in the control room ought to have information available to them.

I have seen people argue that we can go kill the operators, the plants are so safe. In fact, it would be better to kill the operators and keep them in the dark, and I design -- we have seen designs where, for example, most of the control room displays are non-safety-related and they go away.

So, therefore, you know, it's not at all clear to me in those designs how confused the operators might get. So some of this stuff about communications, control room habitability, the trite term "man-machine interface," where is that captured throughout the totality as a vital function? Because vital functions are not -- they're not defined, but they're defined in the context of structures, systems, and components, which most people relate to as pumps and pipes and valves or fans or flow pads, or that kind of stuff. Do you follow my --

MR. FITZPATRICK: I think so.

MEMBER STETKAR: You brought this up as a separate -- as a comment.

MR. FITZPATRICK: Yes.

MEMBER STETKAR: And as I read -- I can read the words in ARDC 17 that says I can completely ignore the operators in the main control room and still comply with this design criterion.

MS. MAZZA: So Number 19 still applies, control room.

MEMBER STETKAR: 19? Okay. Okay. Well, okay. I can -- 19 still complies -- applies. Radiation protection, all right, I isolate it, adequate habitability. I argue that I have a little hole in the wall with a filter on it. Still don't see anything here that says the operators are not in the dark with no information to them.

19 says it has to be habitable. Okay? But I've seen people design what they call habitable control rooms with things that look like a little check valve to allow a little bit of air exfiltration. And they argue that, well, the air will get around there somehow passively.

Control room cooling, they argue, well, I have passive heat sink, so -- and people can sweat a little bit. Radiation protection, well, that's just shielded.

This doesn't say that the operators have to know what is going on.

MS. MAZZA: The current GDC didn't say that in 19 either.

MEMBER STETKAR: Okay. Well --

MEMBER SKILLMAN: Didn't the current GDC get supplemented with NUREG-0737?

MEMBER STETKAR: I'm not sure about I&C. I have to admit, I haven't studied every nuance of these things, and sometimes --

MS. MAZZA: We have our expert in --

MEMBER STETKAR: -- neurons fire --

MR. GREEN: Hi. Brian Green, NRO, Human Factors. 50.34 would be the way we would typically do this, but Jan was correct. It's not in the current GDC that it says the operators have to -- have to be -- have the understanding. It just says that they have to be able to control the -- have a control room where they can perform the normal and abnormal operations. 50.34 is where we get into the human factors program, which says that they have to understand --

MEMBER STETKAR: It says, you know, under normal -- maintain the plant in a safe shutdown condition. So I'm -- again, I'm playing the devil's advocate. I come in and say it's better if I kill the operators because they don't have to do anything. I don't want them to meddle with this.

In current plants, the operators eventually have to do things, given enough time. So that the notion of the current general design criteria applied there because you can't absolve yourself of any operator actions forever. They do need to actually become involved, depending on the scenario.

People are now saying we don't need the operators, because the plants are so safe they will take care of themselves passively. So, therefore, why should we run the expense of providing reliable indications to the operators?

CHAIRMAN BLEY: ARDC 13 on instrumentation and control --

MEMBER STETKAR: Will get it?

CHAIRMAN BLEY: Well, to some extent.

MEMBER STETKAR: Okay. As I said, I haven't studied each other.

CHAIRMAN BLEY: But nobody here has brought that one up talking to us, which kind of implies you haven't really thought about this one. It implies you have to have those controls and instruments to be able to do this.

MEMBER STETKAR: It doesn't say they have to talk to the operators, though, because as long as they're there and they talk to the auto systems that do what the auto systems are supposed to do, that's all I need. I can interpret it this -- that way.

CHAIRMAN BLEY: That's true. You can.

MEMBER STETKAR: No, seriously. I'm playing the devil's advocate here intentionally because I have seen people who basically have the philosophy that the operators don't matter as far as safety is concerned.

CHAIRMAN BLEY: I guess kind of the bottom line on our mumbling is Bob's stuff on Slide 49 feels like it ought to --

MEMBER STETKAR: That's right.

CHAIRMAN BLEY: I agree with this.

MEMBER STETKAR: I'm not sure whether the --

CHAIRMAN BLEY: Anybody is forced to deal with it.

MEMBER STETKAR: -- the words, as written -- whether you're inviting -- unnecessary inviting this type of discussion when you finally get into the specific licensing reviews, where the staff will then say, "Well, you need some de minimis information available to the operators." We see it a lot in post-accident monitoring these days, and people argue, no, they don't need that. That's something you can do away with. It doesn't have to be safety-related. It doesn't have to be reliable.

MR. ASHCRAFT: Joe Ashcraft from NRO, I&C. I really didn't want to say anything because

I don't want Charlie to get involved with this information.

MEMBER BROWN: There you go.

(Laughter.)

MR. ASHCRAFT: So you talked about the operator -- so, and I want to talk about an application that is coming in, but it's not officially accepted yet, so I'm not going to name any names. But their pretense is no operator action for the first 72 hours, and they have no PMA variables which would require -- we'll just call it a 1E power.

Now, when you get into post-accident monitoring, the other variables, B, C, and D, if you look back to all of the old requirements -- and I think this is sort of what this GDC and this topical report that you are going to be -- see coming up is it doesn't require 1E power. It requires highly reliable.

So the whole deal with these passive reactors is, if you lose power, you're going to shut down. Now, they don't necessarily want to shut down, and that's -- you know, except when need be, and that's why they want highly reliable power.

And so then -- and this is where I'm

going to wake Charlie up, but -- so when it comes to, you know, they're saying 72 hours with no operator action; however, they may decide that they want to, you know, preempt something and get back involved with -- so that's where they're going to want the monitoring and their ability to do so.

MEMBER STETKAR: So if I can understand, what I think I'm hearing is that this, again, in terms of information to operators, if I restrict it to that concern, would also devolve into something like RTNSS that you would have to do a plant-specific evaluation to determine how much -- how important, from a safety perspective, if I use the term "risk," that information is. And if it's important enough, there will be some sort of controls over it. Not necessarily safety-related, but enhanced --

MR. ASHCRAFT: Right.

MEMBER STETKAR: -- reliability controls.

MR. ASHCRAFT: Right. So since there is no quote/unquote "operator actions" needed to -- say in the plan, etcetera, really what you're talking about is monitoring to just ensure that your passive natural recirc is working. So those are the kind of instrumentations that the operators would probably -- would want to have available. So --

MEMBER STETKAR: Okay. Thanks.

MEMBER MARCH-LEUBA: Now you've got me worried. I'm kind of hitting -- I'm sorry, I'm hitting that. Don't pay attention to this design criteria because the applicants will do it right; is that what you're saying?

MR. ASHCRAFT: Say that again.

MEMBER MARCH-LEUBA: Don't pay attention to this design criteria because the operators will do it right.

MR. ASHCRAFT: No, no, no. That's not what I'm saying. So for these passive reactors -- now we're getting back to this ARDC 17 -- is they are designed such that if you lose power, the reactor is going to go to a safe state. It's going to do everything that's needed to be done.

So even though you had reactor operators there, effectively they're not necessarily needed to shut down the plant or whatever. So, but you still need a highly reliable power, a) to make power to sell, or whatever, but also to do these other functions, including post-accident monitoring, to continue on or to recover, more or less.

So I'm not sure how they -- you asked something specific, but I'm not sure if I was --

MEMBER MARCH-LEUBA: I was just making a remark of how your comments could be interpreted.

MR. ASHCRAFT: Yes. Well, you wouldn't be the first one that doesn't like the way I make comments. I'm sorry.

MEMBER MARCH-LEUBA: Okay. All right.

CHAIRMAN BLEY: Bob?

MR. FITZPATRICK: The next slide?

This is my final slide. We talked about ARDC 17, but there is also an SFR-DC 17 and an mHTGR-DC 17. And we believe that there is no electrical need for any tailored versions of ARDC 17 for advanced reactor designs. Just as we -- when we started out the process we said that GDC 17 was design-independent and the power systems that -- you know, the ARDC 17 is the same thing as really design-independent.

The only difference you will see in SFR 17 or HTGR-DC 17 is that maybe the nomenclature for like -- things like pressure boundaries have changed, just to fit the reactor design. But there are no electrical requirements that have changed. They only remain unchanged.

MEMBER BROWN: I'm confused now after the -- the one comment. I guess when I reread this now, I'll -- I'm getting to the point where if all the power disappears, that's okay.

CHAIRMAN BLEY: No, no.

MEMBER BROWN: They're saying the ARDC is good enough for all cases. That's what you're saying. Right now, I guess I'm used to seeing in the stuff we've seen come in that you've got a couple of lines of offsite power coming in, and you've got your --

CHAIRMAN BLEY: For an active plant, yes.

MEMBER STETKAR: And in most cases, they are highly coupled and there is stylized notions of independence.

CHAIRMAN BLEY: That's true, too.

MEMBER RAY: You should never to offsite power as independent. Never, never, never.

MEMBER BROWN: I'm not trying to do that. It's just --

MEMBER RAY: I know you're not.

MEMBER BROWN: -- there are all sorts

of lines coming in, do you know down -- upstream they may have some common input. It just eliminates stuff going on around the reactor that you may -- you separate them and you at least maintain a transmission path to get whatever source in.

And we've got diesel generators onsite. I guess this implies to me now that you could have a plant that doesn't have any diesel generators onsite, and if you use -- and if you lose all the power, you just sit there and you may not -- you don't have your post-accident monitoring, you don't have your other instrumentation, you don't have anything. I don't read that here as -- I thought that's what he just said.

CHAIRMAN BLEY: No. No, no.

MEMBER BROWN: Okay. I'm sorry. Dick and I --

CHAIRMAN BLEY: There's nothing special about the sodium reactor and the gas reactor to require a different design criteria than the one for the advanced reactor that he spent five slides talking about.

MEMBER BROWN: So the need for redundancy requirements has been removed?

CHAIRMAN BLEY: What slide are you --

MEMBER BROWN: Slide 47.

MEMBER CORRADINI: You're four slides before.

MEMBER BROWN: I'm on Slide 47. Yes. After we went through, I guess I kind of missed -- based on the older stuff, I hadn't connected the dots between the third and fourth paragraphs of -- are no longer needed. They have both been removed.

CHAIRMAN BLEY: That's of GDCs. Or, no --

MEMBER BROWN: Or ARDC --

CHAIRMAN BLEY: No, no, no, no. They are saying ARDC has two paragraphs, and those two paragraphs, they've argued, are sufficient. GDC had four paragraphs, and they're saying the last two aren't necessary, and that's why they're not in the ARDC.

MEMBER BROWN: They have been removed. The redundancy requirements have been removed.

MEMBER STETKAR: The redundancy of offsite power.

MEMBER BROWN: Have been removed.

MEMBER STETKAR: Which are neither redundant nor independent in the real world.

MEMBER BROWN: John, I understand that, okay? So downstream or upstream there is a source that has power coming in via two separate lines. It's just the diesel generators aren't needed. Somehow I'm losing the bubble on the ability to have the ability to monitor the plant if power goes away, offsite power goes away.

MS. RAY: This is Sheila Ray, electrical engineer in NRR, in Electrical Engineering Branch. If I could address maybe your comment?

MEMBER BROWN: Have at it.

MS. RAY: So we looked at ARDC, and we looked at it and said, "If you need power for safety functions, are important to safety functions, then you need at least two systems." It could be two onsite systems, it could be one onsite and one offsite, it could be two offsite. So there is defense-in-depth.

MEMBER BROWN: That's not --

MEMBER MARCH-LEUBA: Yes. But if you are -- if you don't need any power to satisfy the safety requirements, what do you need to have?

MS. RAY: Then only the items -- you need highly reliable power for the five items that

Bob has mentioned, because if you don't need power for an important to safety or safety function --

MEMBER MARCH-LEUBA: Sorry. I need to look at a microphone -- let me give an example of spent fuel pool. After a severe earthquake or, let's say, a tsunami, okay, is as passive as it gets. I mean, the spent fuel pool is full of water, and if you are only going to stay there for a couple of weeks then nothing happens.

But you need to have instrumentation for the level. We find out that you need to have that instrumentation. So you could make the argument that my spent fuel pool doesn't need any power, but I certainly want your new designs to have it.

MS. RAY: I understand. So electrical is not going to say whether the function of spent fuel pool level is safety or not. We are only going to look at whether or not you need power to accomplish that function. And so far other colleagues say yes, that is a safety function, and we need power for that. Then the classification of the power system for that will have to be appropriate. If it is not a safety function or important to safety function, the power system doesn't have to have that classification.

So we allowed the flexibility in ARDC 17 for that, and we hope -- what we had tried to achieve was the independence was in -- was in the ARDC, since we're asking for at least two power systems. And how you choose to do that, that is up to the reactor designer.

MEMBER RAY: But you do explicitly acknowledge the possibility of independent offsite power systems. Is that what you said?

MS. RAY: You can have two offsite power systems.

MEMBER RAY: You can have two offsite power systems. Do you consider them independent, is what I'm asking. What are your criteria for defining "independence of offsite power systems"?

MS. RAY: I would agree with you that it's not quite fully independent, because you had two power --

MEMBER RAY: Okay. Let's just say they are not independent.

MS. RAY: Okay.

MEMBER RAY: Now, so you've got two offsite power systems, but at least I have never heard anybody define yet what an independent offsite power system would have to consist of. Why do you even identify that as a possibility?

MR. FITZPATRICK: That one is not a possibility, actually.

MEMBER RAY: Good.

MR. FITZPATRICK: Right. Because one of the test systems --

MEMBER RAY: Excellent.

MR. FITZPATRICK: -- has to be the onsite system. That's paragraph 2.

MEMBER STETKAR: Yes. You either get an offsite and an onsite or two onsite.

MEMBER RAY: That's right. That's --

MEMBER STETKAR: You can't have two offsites with no onsite.

MEMBER RAY: Anybody who wants to define two offsite systems as independent, I believe we should ask -- come here and explain to us how they would do that.

MEMBER MARCH-LEUBA: Okay. Does the language say so?

MEMBER RAY: Yes.

MEMBER MARCH-LEUBA: Okay.

CHAIRMAN BLEY: At this point, I think -- we've talked about this a lot earlier, and now again -- I'm going to call a break for 15 minutes. We'll recess until 2:45 when we will pick up the next topic.

(Whereupon, the above-entitled matter went off the record at 2:31 p.m. and resumed at 2:48 p.m.)

CHAIRMAN BLEY: The meeting will come to order, again. We're back in session and we're going on to I think the last topic from the staff.

MS. MAZZA: Okay, so, on the next set of presentations, we're going to cover the design criteria specific to Sodium Cooled Fast Reactors. And, many of them are developed initially as part of the pre-application safety evaluation report for PRISM which NUREG-1368 and for this the Clinch River Breeder Reactor, NUREG-0968.

So, NRC staff also added SFR-DC 75 through 79 to provide clarity and to address additional features that were not considered before.

So, we're going to go out of sequential order here. We're going to start with Imtiaz who's going to cover SFR-DC 71 through 74 and then Andrew is going to cover 78 and 79. And, then, Nico McMurray over there is going to cover 70, 75, and

77. So, we're not going back and forth between presenters.

So, with that, I'm going to turn it over to Imtiaz to start with 71 through 74.

CHAIRMAN BLEY: Well, I'm sorry, before we go on, we have lost our minders. And, here comes Mr. Snodderly.

MS. MAZZA: Okay.

CHAIRMAN BLEY: Go ahead.

MR. MADNI: So, I'm scheduled to cover SFR-DC 71 through 74. And, these are new design criteria specific to SFR-DC 71, Primary Coolants and Cover Gas Purity Control.

The system shall be provided as necessary to maintain the purity of primary coolant sodium and cover gas within the specified design limits.

These limits shall be based on consideration of (1) chemical attack, (2) fouling and plugging of passages, and (3) radionuclide concentrations and (4) air or moisture ingress as a result of a leak over cover gas.

Here, just a few things to note. I don't know if you have any questions on this slide.

CHAIRMAN BLEY: If you don't get any,

keep going.

MR. MADNI: Okay.

All right, so, the next is SFR-DC 72, Sodium Heating Systems.

Heating systems shall be provided for systems and components important to safety which contain or could be required to contain sodium.

These heating systems and the controls shall be appropriately designed to ensure that the temperature distribution and rate of change of temperature in systems and components containing sodium are maintained within design limits assuming a single failure.

If plugging of any cover gas line due to condensation or plate out of sodium aerosol or vapor could prevent accomplishing a safety function. The temperature control and the relevant corrective measures associated with that line shall be considered important to safety.

SFR-DC 73, Sodium Leakage Detection and Reaction Prevention and Mitigation. Means to detect sodium leakage and to limit and control the extent of sodium air and sodium concrete reactions and to mitigate the effects of fires resulting from these sodium air and sodium concrete reactions shall be provided to ensure that the safety functions of structures, systems and components important to safety are maintained.

Special features such as inerted enclosures or guard vessels shall be provided for systems containing sodium.

CHAIRMAN BLEY: So, let me just ask, we've jumped into these individually, so, back in the CRBR time, were these exempt additions to what was the GDCs that they had to deal with? Because these all seem very reasonable, so, I assume these are essentially coming from additional requirements that CRBR had to deal with?

MR. MADNI: Actually, let's see, this one, for example, here it says, NUREG-1368, so this is a need for separate criterion for protection in sodium reactions.

Also, separate criterion was included in NUREG-0968, criterion for protection against sodium and sodium potential reactions.

So, these new criterion are not new to the sense that they were considered for both CRBR and for the PRISM.

CHAIRMAN BLEY: Okay, I thought so.

MEMBER POWERS: At the time we got into

huge battles with the developers of both FFTF and CRBR over this issue of sodium concrete interactions because they claimed, well, we've lined these -- all the cavities with steel liners, so we don't have to worry about that.

And, the argument was that, you put a hot sodium down and you get steam coming off the concrete and, because the liners are pinned, you eventually rupture them and break them. And, then, you get sodium concrete interactions, probably of the worst type because it's kind of constrained and it puts huge forces on things and all kinds of bad things happen to it.

You think about trying to avoid that specific -- it was in precipitated huge experimental programs, both the NRC and by the laboratories up in at Hanford and things like that, all kinds of experiments.

And, I mean, you may have been party to some of those heated discussions, I use that --

MR. MADNI: Probably not, but I -- yes, this is a very important area, really. And, I think, in the next slide, we'll cover some of that.

When sodium spills into let's say a cell in the containment, if it is concrete, of course, it's going to react with it. If it's steel lined, then eventually it's going to react with it.

Likewise, if you inert the cell, but you don't put steel lining, then it's going to, even if it's inert, it is going to find the oxygen from the concrete. So, it's going to extract the oxygen from the concrete and still have the reaction.

So, ideally, you would have to have an inerted cell and steel lined concrete. The combination should --

MEMBER POWERS: And, you've got to vent the liner some place. And, of course, if you vent it into the containment, then it's the same as destroying your inerting and then it's kind of a design headache, you know.

It precipitate, like I said, precipitated more heat than light, I would say, in the discussions.

MR. MADNI: Okay, the last one, SFR-DC 74, Sodium Water Reaction, Prevention and Mitigation. SSCs containing sodium shall be designed and located to avoid contact between sodium and water and to limit adverse effects of chemical reactions between sodium and water on the capability of any SSC performance intended safety function. That's the first bullet.

The second bullet is, if steam/water is used for energy conversion, using the typical rank and cycle, sodium steam generator system shall be designed to detect and contain sodium water reactions and to limit the effects of the energy and reaction products released, including mitigation of the effects of any resulting fire involving sodium.

MEMBER CORRADINI: So, can I ask about this? Again, it's reasonable, but is that sitting inside the containment? I thought in the Sun design, the PRISM design, we were talking about that sitting outside the containment.

MR. MADNI: Yes. So, what happens is --

MEMBER CORRADINI: So, this is a -- I'm trying to politely -- why is this a safety issue, I'm sitting outside the containment away from the radioactive source term?

MR. MADNI: Well, let's say that you have a leakage between the water and the sodium. And, so, water enters the sodium.

MEMBER CORRADINI: Yes.

MR. MADNI: And, then there's a rapid exothermic reaction and the explosion front starts moving along the IHTS, that means Heat Transfer System, Intermediate Heat Transfer System, towards the Intermediate Heat Exchanger.

So, now --

MEMBER CORRADINI: But, I hear you, but if memory serves me, they'd run these experiments at Argonne and at Sandia and with an appropriate rupture disk, you don't get any water hammer or pressure spike propagation upstream as far as I can tell and I would -- but anyway.

But, I guess what I'm thinking of is it seems to be physically isolated from the containment. So, the connection is this pressure wave issue?

MR. MADNI: This pressure wave that can reach the IHS I-Tech and I-Tech is a safety component because it has --

MEMBER CORRADINI: That I understand.

MR. MADNI: So, if it destroys the IHS, we have some problems. So, therefore, the way to do it is to catch it when ruptured disk and take all the reaction parts away from this.

MEMBER CORRADINI: Okay, okay. Got it,

thank you.

MS. MAZZA: Any more questions on 71 through 74?

MEMBER CORRADINI: Let me ask another question. So, what if you come in with -- so there are designs out there that are not U.S. designs that have consideration of the CO2 as the operating fluid of the power conversion system and nitrogen. Is this too specific?

MR. MADNI: No, this, of course, is assuming that you have rank and cycle in the TRISO 3 system.

But, if you have a super critical carbon dioxide with the break in cycle --

MEMBER CORRADINI: Or nitrogen system?

MR. MADNI: -- or nitrogen system, then you may not have any worry about a reaction like this.

MEMBER CORRADINI: Yes, but CO2 reacts with sodium quite nicely.

MR. MADNI: Yes, but that's where the Intermediate Heat Exchanger -- Intermediate Heat Transport System comes in. Because there is a certain temperature about which the super critical carbon dioxide will react with the sodium.

MEMBER CORRADINI: I know, but, okay, I'm with you there. What I'm trying to ask in this question is, is this too specific such that there is a design criteria out there, because if my power conversion fluid is not steam, it's something else. There are still issues that have to be considered.

In other words, is this so specific that you don't -- that you might need to consider some sort of generalization of it?

MR. MADNI: It's something that we can think about seriously because it might turn out to be we may need to add one or two design criteria. Thank you very much.

MEMBER KIRCHNER: May I ask, maybe it's covered in residual heat removal for the SFR, but if I remember correctly, the acronym is DRAX?

MR. MADNI: RVAX?

MEMBER KIRCHNER: Yes. Now, there, you have sodium, potential for sodium air reaction. So, do you need to address that as a separate design criteria? Or is that covered earlier?

MR. YESHNIK: Yes, I believe that's covered in design criteria SFR-DC 78 which we'll be getting to soon.

MEMBER KIRCHNER: Okay. So, it's

coming? Thank you.

MS. MAZZA: Any more questions? Any more questions for Imtiaz? Okay.

So, now, we're going to move on to Andrew Yeshnik. He's going to talk about 78 and 79.

CHAIRMAN BLEY: Before he does, the draft I got and printed ends with 77. Have I been reading the wrong draft all along? This probably won't be the first time.

MS. MAZZA: The published version --

CHAIRMAN BLEY: It is not the first time, but I have the December 2016 version.

MS. MAZZA: So, 78 and 79 were added --

CHAIRMAN BLEY: After you --

MS. MAZZA: -- with the final draft that went out publically.

CHAIRMAN BLEY: Oh, it's in the public draft but not the one you sent to us?

MS. MAZZA: I sent you that and then I sent you the public draft.

CHAIRMAN BLEY: Later?

MS. MAZZA: Later, yes.

CHAIRMAN BLEY: You did?

MS. MAZZA: Yes.

CHAIRMAN BLEY: Nobody flagged it that it had substantially changed. Go ahead.

MS. MAZZA: I told Maitri that it changed, so --

MEMBER SKILLMAN: Let me ask a quick question, Jane, you did not intend to present 75, was that on purpose?

MS. MAZZA: It's coming. We're jumping -- we're not sequentially --

MEMBER SKILLMAN: Thank you, I'll wait, thank you. That's all right, thanks.

MR. YESHNIK: All right, so, my name is Andrew Yeshnik and I will be covering SFR-DC 78 and 79. Next?

So, SFR-DC 79 was developed to cover a gap between SFR-DC 71, which is the primary coolant to cover gas purity system and SFR-DC 33, which is the primary coolant inventory maintenance.

The wording of SFR-DC 79 is based off of GDC 33 and SFR-DC 33. But, the SFR design, the primary cooling system contains both the liquid coolant and a protective cover gas.

In some SFR designs, notably, the coil type design, a leak in the primary coolant boundary may result in only a leak of the cover gas.

The situation would not be covered by SFR-DC 33 because that criteria only requires a leak of the coolant.

The staff elected to create a new design criteria to cover the cover gas inventory rather than appending the requirement on existing design requirement.

For an SFR, the cover gas serves a support function. A loss of the cover gas does not have the same safety significance as the loss of primary coolant.

The new criteria separates the coolant and the cover gas to prevent misappropriation of safety significance. It is important to note that SFR-DC 30, 31 and 32 which contain the requirements for quality assurance leak protection, fracture prevention and inspection of the primary coolant boundary still apply to portions of the primary coolant boundary that do not contain the sodium coolant.

A small cover gas leak may be within the normal operating capacity of the purity control system. The staff created SFR-DC 79 to allow an applicant to inject cover gas to the primary coolant system in the event that the cover gas exceeds the capacity of that purity control system.

In this way, the purity control system can be appropriately sized for normal conditions and abnormal operating occurrences.

In SFR-DC 79, the phrase as necessary was added to denote that a cover gas system -- makeup system is one manner in which an applicant may limit the changes to the primary sodium coolant chemistry.

MEMBER CORRADINI: Can I ask a question here?

MR. YESHNIK: Sure.

MEMBER CORRADINI: So, I'm going to borrow from Jose's question about spent fuel. So, and I'm not familiar, so somebody can remind me, for a fast reactor, if I'm going to switch out the fuel and put it somewhere, that somewhere also has to have a cover gas inventory system, does it not?

MR. YESHNIK: I believe so.

MEMBER CORRADINI: So, this is not just the core, this is the spent fuel pool also or is that somewhere else?

MR. YESHNIK: That would not be covered in this design criteria.

MEMBER CORRADINI: So, where do I look

for it?

(OFF MICROPHONE COMMENTS)

MEMBER CORRADINI: I'm sorry, you said it real quick, I didn't catch it, I'm sorry.

MS. MAZZA: This would be in the 60 series?

MEMBER CORRADINI: 60 series?

MS. MAZZA: 60 series still apply, so --

MEMBER CORRADINI: Okay.

MS. MAZZA: -- that talks about spent fuel.

MEMBER CORRADINI: Under monitoring radioactive releases? No. Oh, monitoring fuel and waste storage? Okay, I see it, thank you.

But, the reason I'm asking the question is, is that, in a similar fashion, I technically don't remember. I assumed you'd have a sodium pool where you're doing the natural convection cooling.

MR. MADNI: Actually, you can check with Tanju, but my feeling is that --

MEMBER CORRADINI: I was waiting for him to compensate me.

MR. MADNI: When the fuel is in the spent fuel, you don't need to sodium and sodium is there to -- trying to give you the characteristics of a fast reactor. But, here, you just have it -- but I think Tanju will answer.

MR. SOFU: So, I think for most configurations, spent fuel storage is inside the primary coolant pool.

MEMBER CORRADINI: And, then, you let it cool longer enough that then when you take it out it can be essentially in a nitrogen or argon cover gas for natural convection cooling?

MR. SOFU: Yes, it could be dry storage or whatever.

MEMBER CORRADINI: Okay, all right. So, it stays within the primary pot?

MR. SOFU: Exactly, in the primary reactor vessel inside, around the reactor core.

MEMBER CORRADINI: So, it's within the blanket region?

MR. SOFU: It's outside the blanket.

MEMBER CORRADINI: Okay.

MR. SOFU: It has no connection with the reactor.

MEMBER CORRADINI: I couldn't remember. All right, thank you.

MEMBER REMPE: Would some of the --

wouldn't they need something specific for the sodium pool if they're putting it in the reactor in the pool?

MEMBER CORRADINI: It's in within the reactor vessel.

MEMBER REMPE: But, it's spent fuel within the reactor vessel and the document in front of us says just use the same as the GDCs. Are there -- there's nothing specific that would -- I mean, in a different location, it's in the reactor vessel and yet you're going to say it's the same requirements as what we have for light water reactors spent fuel pools?

And, also, I mean, what about the gas reactor? I'm a little surprised there's not something for the different reactor types design specific.

MR. YESHNIK: For that one, I would say that the choice of where to put the spent fuel is a choice of the designer and we did not go into that much of detail into these SFR designs because we have an entire family of different ones.

MEMBER REMPE: So, instead of having it saying here in your document same as GDC, maybe you should be putting something like to be determined or something like that or we've not thought about it yet?

MR. YESHNIK: For which design criteria?

MEMBER REMPE: For 63, Monitoring Fuel In Waste Storage -- I guess, yes, that's what it says here. It's on page 18 of your draft guide, at the crosswalk.

MR. YESHNIK: Yes, we can take that into consideration. I believe that we did not look at that specific aspect in detail about design choice.

MEMBER REMPE: Yes, so, maybe the words need to change a little bit that we haven't thought about it yet or something.

MR. YESHNIK: Then, we'll also have to talk to the DOE whether that is a general design choice that most vendors would make or if that's a specific one and whether that should be a general design criteria or not.

MEMBER CORRADINI: The only reason I ask it was that I couldn't remember what is the current conceptual design as to where it goes for the sodium. But, I guess it does extend to the gas and molten salt?

Because I'm not even sure for the molten salt to tolerate the plan. Thank you.

MR. YESHNIK: Jan, next?

SFR-DC 78 was developed when the staff attempted to harmonize the requirements for the residual heat removal system and the intermediate coolant system.

The requirements for the number of physical barriers and primary coolant chemistry compatibility is related to the primary sodium interactions rather than the safety significance of either the residual heat removal system or the intermediate system.

The design criteria was written to describe when an intermediate system or a double walled system is necessary.

If the interfacing system contains a coolant that is not compatible with the primary coolant, a second redundant passive barrier is required.

The second redundant barrier ensures that a leak in one barrier would not result in an unacceptable reaction with the primary sodium coolant.

This criteria applies to the residual

heat removal system and an intermediate system and potentially an emergency cooling system and would allow for double walled steam generators, intermediate cooling systems connected to steam powered conversion systems, the power conversion system utilizing gas and systems similar to the PRISM direct reactor auxiliary core system DRACS).

SFR-DC 78 would permit leakage between the primary system and other systems if the coolants are compatible. The staff envisions a tech spec limit for allowable leakage similar in the manner to that allowed in the LWR plants.

An applicant would be required to evaluate the postulated leakage which would be reviewed by the staff.

A pressure differential requirement ensures that the radioactive sodium is retained in the primary coolant system and this requirement is based off of previous SFR licensing reviews.

MEMBER KIRCHNER: So, as an example of how this would be implemented, could you go through the DRACS? What your expectation for a DRACS system would be for the PRISM reactor? Would that be double walled where it interfaces with air and single walled when it's in the pot, so to speak, immersed in the primary coolant?

MR. MCMURRAY: This is Nico McMurray.

So, the DRACS heat exchanger that sits within the big pot, the working fluid of the DRACS is compatible based on the design of the primary coolant.

MEMBER KIRCHNER: Right.

MR. MCMURRAY: So, based on that, you have the primary coolant, the DRACS working fluid and then the air in the heat exchanger. So, it would still meet that, these criteria and still be acceptable.

MEMBER KIRCHNER: So, it would be single wall inside the vessel and double wall at the heat exchanger to air?

MR. MCMURRAY: It wouldn't, 78 doesn't require a double wall from the heat exchanger to the air because the concern is the radioactive primary coolant for where if you would have a double walled steam generator, it would be with the primary coolant. So, you would have the two barriers.

MEMBER KIRCHNER: But, what if the DRAX fails external to the vessel?

MR. MCMURRAY: The DRACS fails external

to the vessel, you'd still have the barrier between the internal of the vessel. So, you'd have --

MEMBER KIRCHNER: But, that would be single barrier.

MR. MCMURRAY: If you assume a failure, though.

MEMBER KIRCHNER: I'm just testing for consistency because you're asking for a double wall for the steam generator.

MR. MCMURRAY: The double wall for the steam generator would be if you would not have an intermediate coolant system.

MEMBER CORRADINI: A little bit louder, please?

MR. MCMURRAY: Oh, sorry.

So, the double walled steam generator would be if you would not have an intermediate coolant system.

MEMBER KIRCHNER: Okay, I missed that.

MR. MCMURRAY: Yes, so that's what the steam generator for that would be the energy conversion steam generator, not the DRACS.

MEMBER CORRADINI: Okay, but then, just to repeat, so, if I have an intermediate loop, I wouldn't have a double wall steam generator?

MR. MCMURRAY: If you wanted to have a double wall steam generator in --

MEMBER CORRADINI: I wouldn't be required to have one?

MR. MCMURRAY: Correct.

MEMBER CORRADINI: Okay, I misinterpreted that also. Okay, thank you.

MR. YESHNIK: Okay. So, in the event that a sodium fast reactor requires an intermediate coolant system to meet SFR-DC 78, SFR-DC 70, 75, 77 and 76 would provide an applicant with the basic criteria for this system.

And, my colleague, Nick McMurray will provide you more information on these.

MR. MCMURRAY: Any other questions related to 78 before I get started?

All right, yes, my name's Nico, I'm an engineer in the Office of New Reactor Materials Chemical Engineering Group.

I'll discuss 70, 75, 76 and 77 which are related for 70, the intermediate coolant system.

As Jan mentioned the background for these were all based on the two NUREGs related to the pre-SER for PRISM and the SER for the Clinch

River construction permit.

SFR-DC 70 describes the function of an intermediate coolant system and the wording is general enough to ensure that if an ICS is provided, then it will not have any impact on the primary coolant system.

As Andrew discussed, the wording on the required barriers was moved to SFR-DC 78. That wording was in previous versions of this, that's due to what Andrew discussed. That part was taken out.

The rationale of this SFR-DC links to 75, 76 and 77, which are specifically related to the intermediate coolant boundary.

If any -- and then, it's the staff's intention that if any technology or design has an intermediate coolant system, then SFR-DC 70, 75, 76 and 77 should be applied for their PDCs. I'll go into that a little bit. It'll be clear when you see 75 through 77.

Next slide?

So, in general, SFR-DC 75 through 77 are based on GDCs 30 to 32, which are the GDCs that discuss the reactor coolant pressure boundary.

So, SFR-DC 75 is based on GDC 30 and

both SFR-DC 75 and 77 are worded to give the designer flexibility based on their design.

Specifically, SFR-DC 75 contains the words commensurate with the importance of the safety functions to be performed which gives the designer flexibility for quality standards.

For example, some standards or some designs might have a system similar to PRISM and S-PRISMs auxiliary cooling system which provides an alternative method to remove heat and is connected to the intermediate coolant system.

The ACS is safety grade for S-PRISM an nonsafety grade for PRISM. This would require different quality standards for each design's ICS.

A different vendor might have a similar system to the ACS and, therefore, need to design their immediate coolant system to the appropriate quality requirements.

Additionally, and I mentioned this before, Clinch River did not have isolation valves on their intermediate coolant system. Therefore, the entire ICS had a containment function instead of only up to the isolation valves.

So, again, that would require different quality requirements for different parts of the system.

MEMBER SKILLMAN: Let me -- Nico, let me ask this. Years ago, this requirement created consternation among the designers. And, it was not until Reg Guide 1.26 was provided that there was clarity in how to interpret this.

For instance, there was kind of an understanding that the reactor coolant system pressure boundary had to be ASME-III Class 1 that tied back to 50.55a(c). We all kind of understood that. Then the question was how about ECCS? Well, it's not quite the same level as reactor coolant system pressure boundary. And, in time, 1.26 pointed us to ASME-3 Class II and 1.29 then pushed us into Seismic 1.

So, it took 1.26 and 1.29 to let there be clarity in how to interpret this.

Where is the guidance for future designers or present designers for how to apply the quality standards to the systems, the structures, the components and all of them relate to the I&C and the electrical systems in terms of those codes and standards?

MR. MCMURRAY: So, we definitely recognize that the specific guidance for what quality standards still needs to be developed considering the different systems.

Do you know specifically with ASME, they are developing Section 3, Division 5 related to high temperature materials? And, from there, they are thinking for metals, Class A, Class B, depending on safety related and important to safety or not safety related.

So, codes are developing some things. The staff also recognizes that specifically with the guidance for what's important to safety and not important to safety needs to be developed.

Something with this, definitely recognize that if there is a safety function regarding heat removal or containment function or however that's broken up in the class breaks, will require a different quality and then, as we'll get to 77, also inspection and testing requirements.

So, we recognize it needs to be done.

MEMBER CORRADINI: But, to follow Dick's question, even through EBR II is under DOE orders, they had to follow some sort of code and standard.

You've got Fermi 1 that had to follow something and then you've got FFTF, so what did they follow? They got built, they ran.

MR. MCMURRAY: Historically, they were code cases for high temperature materials.

MEMBER CORRADINI: So, they were essentially code exception cases specifically for that design?

MR. MCMURRAY: A lot of previous code cases for high temperature materials are being incorporated into a specific ASME section now. So, there is development going on with that and that will dictate the materials, the temperature ranges, eventually, the inspection and testing requirements from a code perspective and that could be used for a plant currently.

If there are no code requirements specifically. That wouldn't necessitate coming in to justify why they're using it, what's the testing, what's the inspection proposals for the staff to review.

MEMBER CORRADINI: Okay, but, this out of the realm of my understanding. But, if I have historical operating plants however long they operated, then there's got to be a historical basis where they -- okay.

And, that would be where you start?

MR. MCMURRAY: Yes.

MEMBER CORRADINI: Okay.

MR. MCMURRAY: Yes, and a lot of that previous work is being done to codify it within the ASME code, specifically for the materials which is the area I'm familiar with.

MEMBER CORRADINI: And, then, let me ask another question. So, for the three that I've mentioned, EBR 2 did produce electricity. Did they have an intermediate coolant boundary loop?

MR. MCMURRAY: No, that -- yes, I'm pretty sure they did.

MEMBER CORRADINI: Okay.

MR. MCMURRAY: Imtiaz, you know that.

MEMBER CORRADINI: As did Fermi? And, FFTF was just air heat exchangers? Thank you.

MEMBER SKILLMAN: Did either of you say the ASME is developing guidance, is the NRC developing guidance for how these should be interpreted much the same way they developed Reg Guides 1.26 and 1.29?

MR. MCMURRAY: John or Jim might be able to answer that a little better. That's something we recognize with the IAPs and the vision in strategy that were being worked on.

Additionally, specifically, with codes and standards, there's a specific IAP 4 related to the staff working with consensus standard proofs to develop that.

So, I know there's another IAP, I can't think of the number off hand for guidance development, but that's something that we recognize needs to be done.

MR. MADNI: There's a question on EBR 2, somebody had a question, I didn't catch the question. It was something --

MEMBER CORRADINI: No, it was answered. It was answered.

MEMBER KIRCHNER: So, Nick was saying about a question, so you say in your criterion that it's similar to GDC 30. But, there's a word that's been dropped out and I'll read it.

So, quality of reactor coolant pressure boundary, I'll skip through all the boilerplate, you have most of it, to the highest quality standards practical.

So, I sense that you are going to be challenged as a regulator between what's economical and what's the best available quality for these components.

MR. MCMURRAY: The staff recognizes that there are differences between the primary coolant boundary from a safety perspective as well as the intermediate coolant boundary and a safety perspective.

MEMBER KIRCHNER: Yes, I agree that there are differences.

MR. MCMURRAY: Based on the -- and that is the basis for the difference with that wording. So, it's based on the safety function specifically for 75 and then, similar to the GDC's the highest quality standards for the primary coolant boundary in the case of the safety factor.

MEMBER KIRCHNER: So, suppose this intermediate system has isolation valves, so you would go up to the isolation valves as the highest quality standards practical and then drop the quality when you got on the other side of the isolation valve?

MR. MCMURRAY: Yes, and I view it the same as how a PWR has with their main steam isolation valves for the quality requirements for the steam generator up until the second set of isolation valves. So, yes.

MEMBER KIRCHNER: Any reason for

dropping the highest quality standards practical?

MR. MCMURRAY: Focus it more on the safety -- potential safety significance --

MEMBER KIRCHNER: Okay.

MR. MCMURRAY: -- of that -- of the intermediate coolant system because again --

MEMBER KIRCHNER: Will the critics say that the Agency is deferring to economics versus safety?

MR. MCMURRAY: I think it's based on the potential safety function. And, that was -- we did hear a comment --

MEMBER KIRCHNER: Good answer.

MR. MCMURRAY: There in formal public comments saying that 75, 76 and 77 should not be there, but staff disagreed with that based on the fact that there could be safety functions for the intermediate coolant system, therefore, there should be inspection, testing, quality requirements for that system.

MEMBER POWERS: I had just a question about it says it's commensurate with the importance of the safety function. This importance to safety function, is that a not an on/off switch?

MR. MCMURRAY: That's definitely

dependent on the design. And, that's --

MEMBER POWERS: Yes, it's either an important safety or it's not important to safety. Should things be that way, especially for an intermediate coolant boundary recognizing it's the design dependence?

MR. MCMURRAY: I think we really tried to develop the wording so it would be focusing on the parts that would have that important to safety function, recognizing that there's containment valves similar to what's done in the light water reactor world or isolation valve, excuse me. You would have that class break at the valves and there would be differences between that.

MEMBER POWERS: Well, I guess what I'm wondering, is there a wording that could accommodate say quantitative risk assessment that would create a continuum so you weren't dealing with an on and off switch on these things?

MR. MCMURRAY: I think that comes down to the design specific and for the --

MEMBER POWERS: You may be correct.

MR. MCMURRAY: I think that's really what it comes down to.

MEMBER POWERS: Yes, and maybe even

with this wording it allows somebody to do that. But, you know, and maybe it appears in the guidance on these things as the appropriate place. But, it's certainly something to give some thought to.

Is, if you're going to allow people to do a graded application of things, there ought to be a mechanism -- if it's either yes or no, there's not much grading there. Some, I'll admit, but not a whole -- there's not a spectrum of grading and whatnot.

It would be -- it is something to think about, especially if the NRC is -- has not abandoned its commitment to risk informed performance based regulation. I toss it out for what it's worth.

MEMBER KIRCHNER: I note that in the side bar to number 75, you say that should be tested using quality standards and controls sufficient to ensure that failure of the intermediate system would be unlikely.

Then that begs some quantification of what unlikely is. Or, why not just make it bulletproof and do it to the ASME code Section 3 and so on and so forth.

MEMBER POWERS: Some of us can consider

the ASME code to be bulletproof. Riccardella isn't here, so I don't get beat to death.

MEMBER CORRADINI: He gets very brave in the absence of his nemesis.

MR. MCMURRAY: Any other questions, comments? All right, next slide, please?

SFR-DC 76 is based on GDC 31, the fracture prevention which, for 76 is the fracture prevention of the intermediate coolant boundary. The intermediate coolant boundary shall be designed to fail in a nonbrittle manner due to the potential impact on the primary coolant system, the energy conversion system as well as potentially any heat removal functions or containment functions.

In GDC 31, the second sentence listed design considerations. Staff removed this sentence in 76 in order to make the criteria more generic. In this manner, the design considerations may include, but are not limited to, what was removed.

So, we'll, again, ensure that the boundary will not fail in a brittle manner.

Next slide?

Last, SFR-DC 77 which is based on GDC 32, the inspection of the intermediate coolant boundary, again, also contains the words commensurate with the importance of the safety functions to be performed which gives the designers flexibility.

If the leakage of the intermediate coolant boundary constitutes a significant risk and based on the ICS heat removal and/or containment function, then there should be adequate inspection and testing requirements.

The staff left the second point in related to the surveillance program to maintain to ensure that such a program or programs are provided as needed to ensure that the integrity -- to ensure the integrity of the intermediate coolant boundary.

Currently, the staff does not expect that a projected fluence on the intermediate boundary will be at levels that would require a surveillance program that focuses on irradiation embrittlement.

However, the staff recognizes that may not be the case for every design. In addition, a material surveillance program may also be used to monitor the effects of the environmental conditions on the boundary materials.

Any question on 70, 75, 76 or 77?

MEMBER MARCH-LEUBA: Yes, when you're talking about surveillance programs, and I want to give Dennis an opening here, probably he will notice, because I don't know anything about this.

But, liquid metals are well known for dissolving pipes and we're not going to solve the designer by saying that they shall use compatible material. Because, obviously, they're going to use compatible materials.

But, do we have a design criteria that they need to surveil it just in case to ensure that the pipes are not going to be dissolved slowly by the liquid metal?

MR. MCMURRAY: Not truly a design -- a general design criteria, but surveillance programs require for the reactor coolant pressure boundary for the primary coolant boundary.

When you go into design, you will put in your allowables for corrosion and things like that as well as just the material selection itself as based on what your material or what your coolant is.

MEMBER MARCH-LEUBA: I don't know how bad sodium is, but I know a lead bismuth is notoriously famous for eating away everything.

MEMBER BALLINGER: But, if the materials in Section 2, then it's -- their temperature and operational limits and that considers corrosion in Section 2. It wouldn't be in Section 2 if it wasn't compatible, I don't think.

MEMBER MARCH-LEUBA: Okay.

MR. YESHNIK: There is AMSE is doing work on that in Division 5. Additionally, any environmental degradation during service would be covered under GDC 4. So, you could always have material surveillance program that's reinforced by GDC 4.

MR. MCMURRAY: And, the inspection and testing would -- you would monitor if there is corrosion through your inspection, your ISR program as well.

MEMBER BALLINGER: And, the ASME is also working on incorporating -- there's an ASME something which is based on API 579 and 580 which -- in which Chapter 9, I think, in that identifies how to deal with environmental effects in a very specific way.

CHAIRMAN BLEY: Okay, any more questions for this panel?

At this time, we've got a few more things to do at this time.

I'd like to thank the staff and Jan especially for organizing this and the ones you picked to present let us look at quite a few of the other design criteria as we went along.

Maitri was nice to the Committee, though, and gave us an opening here on the agenda. If any of the Members found other criteria that we haven't talked about as yet that you'd like to get on the table and discuss, this is our spot on the agenda for doing that.

If any of you -- and then, we're finished with this panel, but I think Jan will need you and John, yes, John, I knew you were here somewhere. Where'd he go?

(LAUGHTER)

CHAIRMAN BLEY: Any of the Members have anything they want to put forward?

Then, the next thing on our agenda, we received written comments that have been passed out here in the room and were sent to all the Members from Derick Botha who's calling in as a member of the public and as an employee of NuScale.

If you'd open the phone line, Mr.

Botha, are you on the line and would you like to say anything? We do have your written comments and they're on the record. They'll be included with the record and we will consider them. But, if you'd like to make a statement, this would be a good time to do it.

Derick Botha? Going, going.

MR. BOTHA: Yes, can you hear me?

CHAIRMAN BLEY: Now I can hear you, yes.

MR. BOTHA: Okay. Thank you for the opportunity and I would like to say a brief two things along the lines of the comments that I've -- the written comments that I have provided, if that's acceptable.

CHAIRMAN BLEY: You have a few minutes, go ahead.

MR. BOTHA: Thank you.

So, the way I've structured the written comments is in the form or a question and then a basis for the question as well as a comment and then a basis for the comment.

And, I think the overall theme of the written comments has to do with the redundancy of the reactivity control systems.

So, in looking at the written comments, I'm closely going to follow what was provided. So, I think the question -- and this all deals with advance reactor design criteria 26 as proposed in the February version of the draft Reg Guide.

So, the question is, in keeping with NRC's advanced reactor policy statements, how does the ARDC 26 allow for or incentivize advance reactors to use simplified inherent passive or other innovative means for reactivity control?

And, I understand that may not be a question that we can answer today, but I'd like to propose it to the panel.

And, the basis for this question is really the advanced reactor quality statement.

So, according to the Commission, in the statement, and this also in the draft Reg Guide, the Commission expects that advanced reactors will provide enhanced margins of safety and/or use simplified inherent passive or other innovative means to accomplish their safety and security functions.

So, the intent of the protection system and the reactivity control system, at least for current reactors, is to support the safety function of fission product barrier protection.

And, you can -- this is captured in the existing GDC in Section 3 of Appendix A to Part 50. Those two systems or the protection system radioactivity control systems are written for the functions that's captured in Section 2, so the protection of multiple fission product barriers.

So, if you looked at the design of current light water reactors, I think it's worthwhile noting what redundancy is required by the existing GDC and how it's implemented in the existing systems.

So, for the existing systems, if you look at the short-term response after reactive trip, the safety functions is really focused on protecting the fuel and the reactor coolant pressure down to these barriers.

And, that's accomplished by insertion of control rods. So, that's only a single system that's relied upon. There's no redundancy in that system. If you don't get -- if you don't drastically or rapidly reduce the amount of reactivity for specific events, you will incur either fuel damage or damage to your reactor coolant pressure boundary system.

So, there is not redundancy that's provided for either in the design of the systems of the GDC, so GDC 26 and 27.

And, then, in terms of the long-term response, so then it's not just the protection function but it's more focused on the reactivity control systems.

The focus is on to protect the fuel and containment barriers.

And, the primary interest there is not just reactivity control, but it's really heat removal. So, it's limiting the amount of heat being produced by keeping the reactor no critical.

And, again, there, if you look at what redundancy is required otherwise, the GDCs that would require redundancy for this function and if you look at the limitation in existing reactors, if you look at example for the loss of coolant accident, the sole system that's relied upon for reactivity controls were loss of coolant accidents is the ECCS.

And, in fact, with some loss of coolant accidents, the NRC has created this using -- relying on both the rods and the ECCS, but, for those cases, you need -- you can't preform that function with either one of the systems. You need the rods to go in and you need boron addition to --

So, there's no redundancy required or provided for in that example.

So, that's the existing reactors. So, in contrast, so for advanced reactors, you can design these systems with inherent reactivity control capability such that the heat would be removed and the fission product barriers would be protected without relying on the protection system or the reactivity control systems.

And, if you do that, that would not necessarily entail that you provide for maintaining set criticality by passive means. You know, an example in a bit on this.

So, a design with the inherent protection for fission product barriers with one reactivity control system, not requiring two as the current GDCs do to maintain the reactor set critical under cold conditions.

So, if you're relying on this one system in addition to the inherent capability that you have, what I believe would provide enhanced margins for safety and use simplified inherent passive or other innovative means, if you look at the advanced reactor policy statement to provide for your safety and security functions.

So, for such a design, you look at security and you lost your reactivity control systems, that would not entail a challenge to your fission product barriers or endangering the public.

So, such a design would not be novel. So, previous sodium cooled reactors have relied on inherent reactivity control capability for fission product barrier protection over second reactivity control systems.

And, I've got a reference there, but one example is EBR-2 which only relied on control rods as their means for reactivity control.

But, I believe that the ARDC 26 as written would actually discourage vendors from considering such a design. And, the reason -- and that leads me to the comment which is on the second page.

So, ARDC 26 prescribes that reactivity control systems for advanced reactors exceed the capability required by GDC 26 and 27 and I believe that's without due consideration for the reactivity control system capability needed to support safety functions.

So, in other words, that is required irrespective of whether those functions would be required for safety.

So, and the basis for the comments, I have written out here, I don't feel a need to repeat it at this stage, I do think it's necessary to point out that, in considering the GDC and how they were written, if you look at the draft GDC, they heavily focused on shutdown capability and requiring two independent systems for shutdown as the current ARDC 26 requires.

Those provisions requiring two independent means were removed from the draft GDCs for two reasons. The first is that the PWR designs at the time did not have that diverse capability.

And, then, the second reason is that the primary focus of the GDCs, if you look at the comments received and how it was implemented was on reactivity control for barrier protection, rod events requiring shutdown capability out right.

And, some of the comments made were that, well, if you do have conditions where you have a return to power or return to low power or heat criticality, such conditions that do not challenge your fission product barriers does not necessarily -- is not necessarily problematic and that the primary focus should be on reactivity control for fission product barrier protection.

That concludes my oral statement and if there's any questions or comments. Thank you.

CHAIRMAN BLEY: Okay, thank you very much, Mr. Botha.

Any questions from anyone? Thanks -- oh, I'm sorry, go ahead, Mike.

MEMBER CORRADINI: Just a clarification, are you speaking about a particular design or generically that this should be modified? Because your example for EBR 2 is a good example, yet, it's very specific to a specific core design with a specific fuel and coolant.

MR. BOTHA: No, I think my comment is generic and the reason for that is -- and I think there was a couple comments made along those lines during the day -- is it takes a lot of work to develop these systems and if at the outset, you're not provided the opportunity to be innovative and implement passive systems and you're sort of prevented to up front to do that, that's problematic.

It increases the barrier to do things

like that.

MEMBER CORRADINI: Okay, thank you.

CHAIRMAN BLEY: Okay, thank you very much.

At this time, I'd ask if there's anyone in the audience here in the room who would like to make a comment? If so, please step to the microphone and identify yourself and your organization.

MR. HOLBROOK: Mark Holbrook from the INR National Laboratory.

First, I'd like to congratulate the staff, thank them for their effort on behalf of our sponsors at Department of Energy and the National Laboratory team.

We worked on the front end of this and we certainly understand all the effort that went in on your part of get us to where we are today.

So, we certainly appreciate that.

And, I especially want to mention the work that you did on GDC or ARDC 26. Having worked on that myself and on the early stages, I, you know, our scope kind of limited our ability to completely rewrite the GDC like we've probably would have all liked to.

But, so, I commend you on your work to take what was originally probably the best example in the GDCs of ones that were confusing to many people and try to make it clearer and more straightforward. So, I think that's a positive thing.

We certainly also think it's very positive with the work that you've done with ARDC 17 and we certainly believe that that's a positive step forward.

Our team will have several specific comments on some of the GDCs that we discussed today. And, we will have some comments on some of the specific wording in 26, but we don't need to take time on that today.

But, we'll include all these comments in our feedback to you prior to the April 4th date. And, again, I want to thank you very much for your activity. Thank you on this.

CHAIRMAN BLEY: Thank you.

Anybody else in the room care to make a comment? Is there anyone listening on the phone line who would make a -- oh, just a moment, there's one more here.

MR. HOLBROOK: Yes, there's one point

that I was going to make. We continue to emphasize this point in different venues of we believe it's really important to have precise language when we're discussing policy issues and that would need to be taken up to the Commission.

In particular, and what we're talking about is has to do with ARDC 16 where we had slides that talked about the policy decisions that the Commission may or may not have made relative to use of the functional containment concept.

And, again, the first slide that we saw, it was a little bit confusing or maybe not clear, specifically in the rationale in GDC 6 or ARDC 16 having to do with the fact that, you know, as we mentioned in subsequent slides, it is clear that the Commission has accepted the concept of functional containment.

However, we agree, subsequently, there will have to be Commission policy work on the functional requirements that will go along with that.

So, we just want to emphasize that one point. But, other than that, I'm done. Thank you.

CHAIRMAN BLEY: Okay, at this time, is there anyone on the phone line would like to make a comment, if so, please identify yourself and provide your comment.

Going, going, gone.

Okay, before we go around the table for the Members, we could have a little discussion with you two about is there -- from what you've heard from us, and we're going to talk about this, too, do you see a need or would it help you to have a letter from us next month? We are writing a letter on the IAPs. We could add a little bit on the design criteria if there is a driving force for that.

MS. MAZZA: I think it would be helpful since we'll be getting public comments in April and then, you know, working through those and trying to get our final Reg Guide together.

So, anything that we would need to, you know, to address in order to get our final Reg Guide together would be appreciated.

CHAIRMAN BLEY: Okay. We have a very rough time in March, but I think we'll be able to do it. We had something drop off the agenda, I think, so we should be able to either add that as a separate short letter or not.

But, at this point, I'd like to go

around the room to all the Members.

I'll mention first, and I might have missed something that's important, two things jumped at me from the discussion where we seemed to coalesce on something.

One was the SARRDL, S-A-R-R-D-L, and the lack of clarity in this document about what's required and what it actually means.

And, the other one was on the electric power at slide 49 that says, even if you don't need electric power for equipment use, you still need a reliable power for monitoring habitability, lighting, rad monitoring, communications.

As we go around the room, I'm interested in a couple of things. One is, just any of your general comments, but also, should we write a letter, and if we should, what things should we stress?

And, at this point, I think I'll start with Joy and just come right around the table this way.

MEMBER REMPE: Again, I guess I'd like to express my appreciation for all the work the staff's done and their presentation today. It is -- I had my PC near the mic, but I'll put it closer. Is that better?

Anyway, I want to thank the staff for all their effort and the way they presented the material. I think it helps to hear your viewpoints on why you did certain things in this document.

And, I know that the folks from the DOE folks have also put in a lot of effort and I appreciate it.

I actually was going to suggest until the staff requested a letter, that even though we're, as Member Stetkar always like to say, however many Members babbling with our own opinion, but I thought there were a lot of good comments made by my colleagues during this meeting that you ought to consider.

In addition to the two items that you've mentioned, Dana mentioned something about the need to incorporate the thought about failures of the primary that might subsequently lead to a failure of the containment and that that was in the original GDCs and it perhaps wasn't in what was being proposed with the advanced reactors. And, I thought that was worthwhile to consider.

I know when we discussed about what needed to be monitored with the mHTGR, I think that the rationale should discuss plated out activity as well as circulating activity to be monitored.

And, then, I am a little confused a little bit about what should be done or not done with the spent fuel storage capability.

And, so, those were items I thought struck home to me about being important, but I am still a little unsure of.

But, again, I thought you could probably get that from the transcript, but if you'd like a letter, we're here to please, I guess.

So, that's all my comments. Thanks.

CHAIRMAN BLEY: It's our choice whether we write a letter or not or not.

MR. SEGALA: Yes, I think for the staff's perspective, we want to make sure that, as we address public comments that we also address any comments that the ACRS has moving forward.

And so --

MEMBER REMPE: But, I would caution you that, even though we might give you a letter, we probably -- there's a chance we might want to see the final document and write another letter and bring up something out of the blue that's come to light. And, so, that's, you know, but it doesn't hurt to have --

CHAIRMAN BLEY: That's not a maybe, we will want to see the final one and take it to a full committee.

And, again, if we can come up with a real short fuse here to do this by March because we have the one from your office that's a definite need for a letter.

But, you have heard from individuals who keep stressing that. You haven't heard from the ACRS yet.

MEMBER BROWN: Other than the electric power needs for monitoring post-whatever the passive capability is, it seems to me that there should be some emphasis on being able to know where the plant is and where other systems may be that you may need. Just having zero there just is a little bit uncomfortable.

MEMBER KIRCHNER: I wanted to thank the staff and, obviously, a lot of work has gone into getting this where it is.

I think I made, Dennis, the points I wanted to make earlier. I would still, since it's already been mentioned, this strange acronym, SARRDL, perhaps just some wordsmithing in that GDC that you're proposing on performance, design and performance limits may answer the mail there.

Still thinking about the containment changes that are proposed, particularly for the mHTGR, it seems like it's really defining a confinement system, but it's not clear.

Under the reactivity control systems, I went back and looked, you have the new 26 and then I looked at 28, which is very similar to the previous design criteria, but that one is explicitly for postulated reactivity accidents, not for normal design operation conditions.

So, I'm not so much concerned about the HTGR, but my concern about controlling the rate of reactivity insertion would go up with the harder spectrum reactors and certainly with the -- I know you're trying to be generic, any kind of liquid fuel system, in particular.

I share Charlie's concern. Post-TMI, the idea of not having an electric power system that could, even if it's not needed for what we think of as the traditional safety functions like ECCS, et cetera, having the control room in the dark, that's got to be one highly reliable system and it sounds like it's 1-4-Es, right?

Especially post-TMI, I mean, a lesson learned, we don't want the operators scavaging batteries from cars to determine where they are or what the state the plant is in.

And, I think the others, the devil will be in the details when you get an actual detailed design. So, I appreciate the staff's effort to anticipate the issues that they're going to have to resolve and then trying to address them with the additional criteria.

So, thank you.

CHAIRMAN BLEY: Thanks.

As we continue around, I ask the Members if -- of your comments, if there are some you feel rise to the level that we ought to include them in a letter, please flag that for me as we come around.

MEMBER MARCH-LEUBA: Well, I was going to say, I was going to keep it short and just emphasize that the two items I was -- I opened my mouth in the SARRDL and the electric systems.

And I do think they should raise to a letter to the level of a paragraph in a letter, no more than a paragraph.

On a general strategy or philosophy

point of view, we've seen some answers to questions that economy of words was important to the generation of the DC. And, while that is typically good for communicating language, the application of having an independent, redundant, diverse objective in front of what, if it's what mean, would really help me as a designer to do what the staff expected me to do.

So, economize words when they're need, but don't economize too much.

MEMBER STETKAR: I thought you usually say my name.

CHAIRMAN BLEY: Mr. Stetkar, could we please have your thoughts?

MEMBER STETKAR: Oh, well, thank you.

I don't have much more to add. I've been rereading this number 17. In my mind, whether we want to put something in a letter, the issue is the way it's written, I'm left confused about the connotation of the term vital functions.

If, according to the slide that we saw today, which I agree with, those vital functions include things like information to the operators, that's good. But, I can't find that anywhere else.

So, if we're going to write a letter, I

would focus on sort of it's that notion and what is the expectation of the staff in terms of maintaining what's called vital functions.

CHAIRMAN BLEY: Thank you.

Professor Corradini?

MEMBER CORRADINI: Okay, let me start off by saying, I'm not clear that we need a letter at this time given the fact that I'd expect the public is going to come at them from various directions on comments that will probably will be similar. So, that's the point one.

But, if we do write a letter, since I might be out voted, the one that I think is most interesting to me is the connection between DC or ARDC or whatever it is, 14 and 16.

In particular, I do think the DOE staff working together and developing something for the mHTGR is not necessarily mHTGR specific. It could go back other of the advance designs.

So, I'd be interested in exactly what is a containment's performance requirement for a containment function rather than a whatever we call a leak tight, kind of leak tight, low leakage containment.

I really do think that concept could be

looked at across the board.

So, it seems to me, containment performance requirement is important.

The second thing, if we're going to put something in a letter, which I don't think we need to at this point is, I'm a bit frustrated that all this has been developed without any yet discussion about how I determine licensing basis events and whether they're AOOs or DBAs or beyond DBAs.

To me, that's the big thing in the room that hasn't been discussed. We heard from the NGNP a suggestion by DOE, at the time, as the, I won't call them the applicant, but the pseudo-applicant, for the mHTGR what they might be.

And, they seemed at least the way they approached it, seemed reasonable and it actually harkened back to NUREG-1860 for technology neutral framework.

So, it seems to me that'd be a second thing eventually we want to write about.

Thank you.

CHAIRMAN BLEY: Dr. Powers?

MEMBER POWERS: Just a couple of things that Joy -- Member Rempe has already mentioned the independence of barriers and language there.

I think it would probably be useful to step back and make sure that you've used language that facilitates or at least doesn't preclude the use of quantitative risk assessment, especially in those applications where you're allowing a graded compliance with the design criteria.

I think one of the challenges we've had for some time with the general design criteria as currently written is they were written at a time when quantitative risk assessment was not a developed tool and we didn't have the PRA policy statement.

You might want to see if there's opportunity where you could facilitate use of that technology.

CHAIRMAN BLEY: Dick?

MEMBER SKILLMAN: Thank you, Dennis.

I had four items. Charlie has address in his comments the concern I had about criterion 17 and Walt reinforced it. So, that is no longer on my list. And, John also did in his comments.

The comment about the reactivity control and the reactivity rates of addition, Walt covered, that's under criterion 26.

Mike, you mentioned criterion 14 and

16, I think you meant 10 and 16.

MEMBER CORRADINI: Sorry.

MEMBER SKILLMAN: And, if that's the case, then I'm aligned with you. And, I think we have an issue of policy regarding functional containment that needs to be addressed upstairs. I think that's what you were pointing to.

And, the one that I continue to point myself is this criterion 16, containment design and the words for as long as postulated accident conditions require.

Dana pointed, hey, long time ago, that was viewed, if you will, to the fullest extent, more recently, it's more narrowly interpreted.

I would like to put on the table, that needs to be interpreted from the longest extent one can consider and here is why.

If the containment of TMI-2 had leaked, if the basement has leaked in the Susquehanna, I would assert that we would be in a different place today than we are relative to containment design. I really believe that.

And, so, I offer that how the new criterion 16 is crafted in words and interpreted might be particularly important if the mHTGR or the

SFR accident could be an accident that is a very extended one versus one that's kind of a flash in the pan, once and done, you've got a lot of water on the floor and you deal with it.

With that, thank you.

MEMBER RAY: Yes, I just want to be a little more pointed on the electrical thing. Well, I realize that independence of offsite sources may be a theoretical possibility, having operating units at the intersection of two independent utilities with their own generation, I can tell you that demonstrating that is, I don't think, feasible, particularly in the changing circumstances that grids face today.

And, therefore, if it's going to remain something that's identified as an option, I do think it ought to be addressed in some way as to what's feasible.

The first of those three plants operated initially on the theory that offsite power was from two sources that were independent and, therefore, sufficiently reliable. And, that turned out not to be the case and diesels were added later.

So, that's a more complicated thing

than I want to get into now. But, the point of it is that, offsite power, I think, should -- it's a chore to demonstrate that it's sufficiently reliable to be a single reliable source to demonstrate that two lines coming in are sufficiently independent to be two reliable sources, I just feel is not something that's practical to do.

The other thing is I want to concur with Mike's comment that, in the absence of knowing what is the basis for establishing the accidents that we're considering insofar as design basis and so on goes, it is a little challenging to be sure that we're comfortable with the design criteria.

Although, of course, we ought to be able to look at those separately. But, it would be helpful if we had a better idea as to how we arrive at the decision of what constitutes design accidents.

With that, I'm done.

CHAIRMAN BLEY: Thank you.

And, Margaret?

MEMBER CHU: I have no comments, thank you.

MEMBER SUNSERI: So, this is Matt

Sunseri.

I'd like to just appreciate my or offer my appreciation to the staff for the hard work. And, clearly, extensive effort that was put into this. So, don't let my remarks take away from what I mean there.

On the containment issue, though, I am probably, this is a personal thing, I'm stuck in my paradigm of fuel cladding, reactor coolant system, boundary containment being physical barriers to the release of the fission product.

So, the whole containment criterion 16, while I followed it, I think this is maybe just thinking about the advanced reactors in a different light maybe.

And, so, Mr. Chairman, should we decide to write a letter on this, I would suggest that we put some comments in there to perhaps help convey the robust discussion that we had in there today along making that a little clearer.

CHAIRMAN BLEY: Thank you.

MEMBER SUNSERI: But, thanks, again. That's all I have.

CHAIRMAN BLEY: Roland?

MEMBER BALLINGER: Yes, don't need to

repeat what other people have said, but with regard to the spent fuel storage, I was just -- I'm looking at criterion 61 which, near as I can tell, is absolutely identical in -- for the ARDCs.

And, given how spent fuel is stored in both sodium fast reactor designs as well as the gas cooled reactor design, maybe that's appropriate to just leave it exactly as it was before.

But, somebody might take a closer look at this because there's some criteria in there about inspectability and things like that and containment that may be different for advance reactor designs.

Thank you.

CHAIRMAN BLEY: Sir?

MEMBER CORRADINI: Can I ask -- something just popped in my head and I thought I'd -- with our gentleman who gave the public comments, so, if I came in to the staff and said, I have a second redundant shutdown system and it's because the sodium in a metal fueled reactor flowers like a petal and shuts it down automatically to acceptable limits, is that a second redundant reliable shutdown system?

EBR-2 demonstrated that whole system

and that's a second system. Is that a second redundant shutdown system?

MR. SCHMIDT: This is Jeff Schmidt from the staff.

Any intrinsic quality of the design can be credited as a shutdown mechanism.

MEMBER CORRADINI: Okay, all right. I figured that, but I wanted to make sure. Thank you.

CHAIRMAN BLEY: Okay, well, thanks.

MEMBER KIRCHNER: With the qualification, though, cold shutdown.

MEMBER CORRADINI: Well, just the fight back, AP1000 --

MEMBER KIRCHNER: It's the EBR-2 were to at hot power conditions, that was the beauty of it.

MEMBER CORRADINI: Yes, but --

MEMBER KIRCHNER: It didn't get you to a cold shutdown.

MEMBER CORRADINI: But, say safe shutdown and cold shutdown aren't the same. I remember Member Stetkar tortured the AP1000 ESBWR people at length about this and so --

MEMBER STETKAR: There is no legal

requirement anywhere --

MEMBER CORRADINI: For cold.

MEMBER STETKAR: -- to achieve cold shutdown. There is a legal requirement to remove decay heat.

MEMBER CORRADINI: But, your point is well taken. But, there is a history. We've recorded it.

MEMBER STETKAR: And, we've recorded and we have.

CHAIRMAN BLEY: Thanks to everyone. This was a very informative session. It worked out quite well.

I'm going to try to figure out if we can -- and maybe we'll do one letter on both things. I'm going to look. I wasn't expecting to do a letter, but the discussions have been robust enough, we will decide in March at our full committee meeting if we can or cannot have a separate letter or the IAPs and you'll be there to follow that.

Thanks everyone. I'm sorry?

MEMBER POWERS: I just wanted to inject my vote that we don't need a letter.

CHAIRMAN BLEY: Thank you, that's the

second vote that we don't need a letter. And, I don't really think we need a letter, but it might be helpful to the staff. So, we'll talk about it in March.

And, with that, this meeting is adjourned.

(Whereupon, the above-entitled matter went off the record at 4:10 p.m.)

Non-Light Water Reactor Design Criteria
Introduction and Briefing Objective

John Segala, Chief, Advanced Reactor and Policy Branch

February 22, 2017

Non-Light Water Reactor Design Criteria

Jan Mazza, Project Manager
Advanced Reactor and Policy Branch

February 22, 2017

Overview

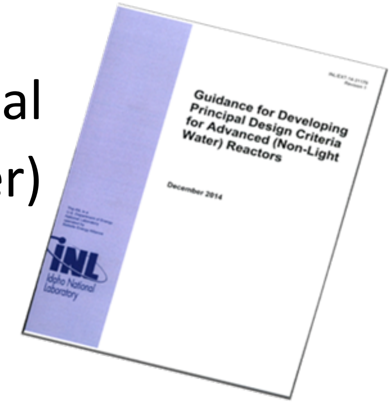
- Brief background of the initiative to develop non-Light Water Reactor (LWR) design criteria
- Current Status of the non-LWR design criteria initiative
- Intended use of the Regulatory Guide (RG)
- Draft RG Highlights
- Future Activities for non-LWR design criteria

Background

- In June 2013, DOE and NRC agreed to pursue a joint initiative to formulate guidance for developing principal design criteria (PDC) for non-light water reactor designers.
  - NRC Regulations 10 CFR Part 50 Appendix A establish General Design Criteria (GDC) specific to LWRs and "generally applicable" to non-LWRs.
  - Applicants must establish PDC based on the GDC (10 CFR Part 50.34(a)(3),10 CFR Part 52.47(a)(3), etc.).

Background cont.

- Phased Approach
  - "Phase 1" – DOE expertise is applied to research, analysis, evaluation, documentation.
    - DOE report, "Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors," completed December 2014.



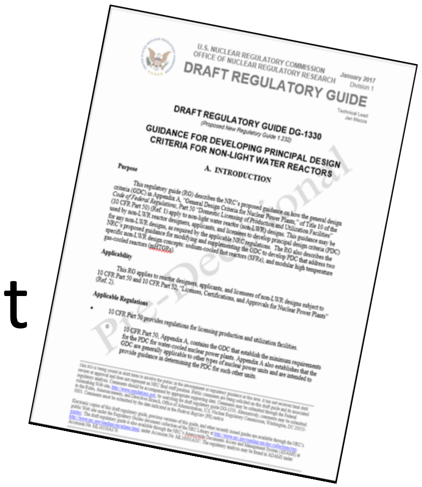
  - "Phase 2" – NRC considers the DOE report and develops regulatory guidance.
    - Issue guidance in the form of a Regulatory Guide (RG) commensurate with an official NRC staff position.

Current Status

- NRC staff reviewed and considered the DOE report in the development of the NRC version of:
  - Advanced Reactor Design Criteria (ARDC),
  - Sodium-Cooled Fast Reactor Design Criteria (SFR-DC), and
  - modular High Temperature Gas-Cooled Reactor Design Criteria (mHTGR-DC)
- The NRC version of the design criteria was sent out for 60 day informal comment on April 7, 2016.

Current Status cont.

- NRC staff finalized the draft RG using the informal public comments and discussions during a public meeting held on October 11, 2016.
- NRC staff issued the draft RG DG-1330, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors on February 3, 2017.
- Comments are due by April 4, 2017



U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH
DRAFT REGULATORY GUIDE

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Division 1

Technical Lead
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DRAFT REGULATORY GUIDE DG-1330
(Proposed New Regulatory Guide 1.232)

GUIDANCE FOR DEVELOPING PRINCIPAL DESIGN CRITERIA FOR NON-LIGHT WATER REACTORS

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes the NRC's proposed guidance on how the general design criteria (GDC) in Appendix A, "General Design Criteria for Nuclear Power Plants," of Title 10 of the *Code of Federal Regulations*, Part 50 "Domestic Licensing of Production and Utilization Facilities" (10 CFR Part 50) (Ref. 1) apply to non-light water reactor (non-LWR) designs. This guidance may be used by non-LWR reactor designers, applicants, and licensees to develop principal design criteria (PDC) for any non-LWR designs, as required by the applicable NRC regulations. The RG also describes the NRC's proposed guidance for modifying and supplementing the GDC to develop PDC that address two specific non-LWR design concepts: sodium-cooled fast reactors (SFRs), and modular high temperature gas-cooled reactors (mHTGRs).

Applicability

This RG applies to reactor designers, applicants, and licensees of non-LWR designs subject to 10 CFR Part 50 and 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 2).

Applicable Regulations

- 10 CFR Part 50 provides regulations for licensing production and utilization facilities.
  - 10 CFR Part 50, Appendix A, contains the GDC that establish the minimum requirements for the PDC for water-cooled nuclear power plants. Appendix A also establishes that the GDC are generally applicable to other types of nuclear power units and are intended to provide guidance in determining the PDC for such other units.

Intended Use of the Regulatory Guide

- The general design criteria (GDC) in 10 CFR Part 50 Appendix A, establish the applicability of the GDC to both LWR and non-LWR designs:

  These General Design Criteria establish minimum requirements for the principal design criteria for water-cooled nuclear power plants similar in design and location to plants for which construction permits have been issued by the Commission. **The General Design Criteria are also considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the principal design criteria for such other units.**

Intended Use of the Regulatory Guide cont.

- 10 CFR Part 50, Appendix A indicates that the GDC are guidance for non-LWRs. As such, non-LWR applicants **would not need to request an exemption** from the GDC when proposing principal design criteria (PDC), which are derived from the GDC.
- The RG provides additional guidance for reactor designers and applicants of non-LWR designs for developing PDC.

Intended Use of the Regulatory Guide cont.

- Applicants may use the RG to develop all or part of the PDC and can choose amongst the ARDC, SFR-DC, or mHTGR-DC to develop each PDC.
- Not considered to be final or binding regarding what may eventually be required from a non-LWR applicant.

Intended Use of the Regulatory Guide cont.

- Similar to the current GDCs applicable to LWRs, the ARDC, SFR-DC, and mHTGR-DC also utilize the words “shall” and “must” for consistency with the GDC and so that they can be used in the same manner as the GDC when developing the PDC.
- Use of “shall” or “must” is not binding; as they are contained in a guidance document.

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Draft RG Highlights

- Appendices A-C of DG-1330 contain the ARDC, SFR-DC and mHTGR-DC respectively. The NRC staff rationale for adaptations to the GDC for non-LWRs is also provided in the appendices.
- New technology specific design criteria were developed and added to the SFR and mHTGR appendices. These design criteria address design features that are not included in the current GDCs (e.g., sodium interaction with air and water, mHTGR reactor building design, etc.)

Draft RG Highlights cont.

Summary of Assessment of General Design Criteria* for Non-LWRs

Classification	ARDC	SFR-DC	mHTGR-DC
Same As GDC	15	12	12
Modified for ARDC, SFR-DC or mHTGR-DC	39	18	18
Same as ARDC	N/A	24	8
New		10	3
Not Applicable			16
Deleted	1		
Total # of DC	54	64	41

*There are 55 GDC in 10 CFR Part 50 Appendix A

Draft RG Highlights cont.

- The most significant changes as compared to the GDC are in the areas of:
  - reactor design
  - containment
  - electric power
  - reactivity control
  - residual heat removal
  - emergency core cooling
  - new technology specific (ten SFR and three mHTGR) design criteria

Future Activities

- The draft RG 60-day comment period ends April 4, 2017.
- Public meeting to discuss public comments and final RG content May/June 2017.
- ACRS comments and full committee meeting.
- Final regulatory guide issuance planned for December 2017.

Summary

- The initiative to develop a regulatory guide for non-LWR design criteria continues to progress.
- Further public and ACRS engagement is expected after the public comment period ends in April 2017.
- NRC plans to issue the final RG in December 2017.

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Reactor Design mHTGR-DC 10

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mHTGR-DC 10 – Reactor Design

- Specified acceptable fuel design limit (SAFDL) is replaced by the specified acceptable system radionuclide release design limit (SARRDL).
- TRISO fuel does not catastrophically fail but fuel coatings become somewhat less effective during AOOs and postulated accidents.
- SARRDL is not a fuel only criterion but a primary system criterion due to transient caused mobilization of plated out radionuclides.
- SARRDL sets radionuclide inventory criteria to meet both AOO and postulated accident dose criteria.

mHTGR-DC 10 cont.

- An AOO scenario may lead to a low dose consequence.
  - Should be tied to 10 CFR 20.1301 annualized dose limit at the EAB.
- Postulated accident dose criteria are not violated assuming SARRDL initial condition.
- Circulating He activity is monitored to ensure SARRDL is not violated.
- SARRDL concept is performance based and applicable to TRISO fuels and possibly liquid fuels.
- May involve policy engagement to allow AOO dose consequences.
  - Current SAFDL concept does not allow for dose consequences.

Containment Design ARDC 16, SFR-DC 16, mHTGR-DC 16, 70, 71, and 72

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ARDC 16 Containment Design

ARDC Content: Same as GDC 16

NRC Rationale for Adaptations to GDC:

- For non-LWR technologies other than SFRs and mHTGRs, designers may use current GDC to develop applicable principal design criteria.
- However, non-LWR designs could share common features with SFRs and mHTGRs. Hence designers may propose using SFR-DC 16 or mHTGR-DC 16 as appropriate.
- Use of mHTGR-DC 16 will be subject to a policy decision by the Commission.
  - See rationale for mHTGR-DC 16 for further information on the policy decision.

SFR-DC 16 Containment Design

SFR-DC Content:

- A reactor containment consisting of a high-strength, low-leakage, pressure-retaining structure surrounding the reactor and its primary cooling system shall be provided to control the release of radioactivity to the environment and to ensure that the reactor containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.
- The containment leakage shall be restricted to be less than that needed to meet the acceptable onsite and offsite dose consequence limits, as specified in 10 CFR 50.34 for postulated accidents.

SFR-DC 16 Containment Design cont.

NRC Rationale for Adaptations to GDC:

- The Commission approved the staff's recommendation to restrict the leakage of the containment to be less than that needed to meet the acceptable onsite and offsite dose consequence limits in SECY 93-092, "Issues Pertaining to the Advanced (PRISM, MHTGR, and PIUS) and CANDU Designs and their Relationship to Current Regulatory Requirements."

- Therefore, the Commission agreed that the containment leakage for advanced reactors, similar to and including PRISM, NUREG-1368, "Pre-application Safety Evaluation Report for the PRISM Liquid-Metal Reactor," should not be required to meet the "essentially leak tight" statement in GDC 16.

SFR-DC 16 Containment Design cont.

NRC Rationale for Adaptations to GDC:

- Furthermore, all past, current, and planned SFR designs use a high-strength, low-leakage, pressure-retaining containment concept, which aims to provide a barrier to contain the fission products and other substances and to control the release of radioactivity to the environment.

SFR-DC 16 Containment Design cont.

<u>NRC Rationale for Adaptations to GDC</u>:

- Reactions of sodium with air or water, sodium fires, and hypothetical reactivity accidents caused by sodium voiding or boiling could release significant energy inside the reactor containment structure. Therefore, a high-strength, low-leakage, pressure-retaining structure surrounding the reactor and its primary cooling system is required. Note that a design could have a low design pressure for the containment.

- Several technical reports and presentations support the need for a pressure-retaining structure surrounding SFRs.

SFR-DC 16 Containment Design cont.

NRC Rationale for Adaptations to GDC:

- The report, “Experimental Facilities for Sodium Fast Reactor Safety Studies, Task Group on Advanced Reactors Experimental Facilities (TAREF), indicates that it is necessary for structures to withstand the thermo-mechanical load caused by sodium fire to avoid fire propagation and dispersion of aerosols.

- The report, “Safety Design Criteria for GEN IV Sodium-Cooled Fast Reactor Systems,” notes that the design basis for containment shall consider pressure increase and thermal loads due to sodium fire.

SFR-DC 16 Containment Design cont.

NRC Rationale for Adaptations to GDC:

- During "SFR Technology Overview," IAEA Education and Training Seminar on Fast Reactor Science and Technology , the technical expert noted that a low design pressure for the containment is due to heat produced by a potential sodium fire.
- In Annals of Nuclear Energy, the article, "NAFCON SF: A sodium spray fire code for evaluating thermal consequences in SFR containment," notes that Beschreibung der Forschungsanlage zur Untersuchung nuklearer Aerosole (FAUNA) spray fire experiments show peak pressures in containment over 3.5 bars within the first 5 seconds, gradually tapering downwards to less than 3.5 bars at 25 seconds.

mHTGR-DC 16 Containment Design

mHTGR-DC Content:

- A reactor functional containment, consisting of multiple barriers internal and/or external to the reactor and its cooling system, shall be provided to control the release of radioactivity to the environment and to ensure that the functional containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

mHTGR-DC 16 Containment Design cont.

<u>NRC Rationale for Adaptations to GDC</u>:

- The term "functional containment" is applicable to non-LWRs without a pressure retaining containment structure.
- A functional containment can be defined as "a barrier, or set of barriers taken together, that effectively limit the physical transport and release of radionuclides to the environment across a full range of normal operating conditions, AOOs, and accident conditions."
- The mHTGR functional containment safety design objective is to meet 10 CFR 50.34, or 52.79 offsite dose requirements with margins.

mHTGR-DC 16 Containment Design cont.

NRC Rationale for Adaptations to GDC:

- The NRC staff has brought the issue of functional containment to the Commission, and the Commission has found it generally acceptable, as indicated in (SRM) to SECY 93-092 and SECY 03-0047, "Policy Issues Related to Non-Light Water Reactor Designs."
- In the SRM to SECY 03-0047, the Commission instructed the staff to "…develop performance requirements and criteria working closely with industry experts (e.g., designers, EPRI, etc.) and other stakeholders regarding options in this area, taking into account such features as core, fuel, and cooling systems design," and directed the staff to submit options and recommendations to the Commission for a policy decision.

mHTGR-DC 16 Containment Design cont.

<u>NRC Rationale for Adaptations to GDC</u>:

- NRC staff also provided feedback to the DOE on this issue as part of the NGNP project. In their "Summary Feedback on Four Licensing Issues-NGNP", it was noted that "…(Commission) approval of the proposed approach to functional containment for the mHTGR concept, with its emphasis on passive safety features and radionuclide retention within the fuel over a broad spectrum of off-normal conditions, would necessitate that the required fuel particle performance capabilities be demonstrated with a high degree of certainty."

- GDC 38-43, 50-57, are not applicable to the mHTGR design, since they address design criteria for pressure-retaining containments in the traditional LWR sense.

- Requirements for the performance of the mHTGR reactor building are addressed by new Criterion 71 (design basis) and Criterion 72 (provisions for periodic testing and inspection).

mHTGR-DC 70 Reactor Vessel and Reactor System Structural Design Basis

mHTGR-DC Content:

- The design of the reactor vessel and reactor system shall be such that their integrity is maintained during postulated accidents (1) to ensure the geometry for passive removal of residual heat from the reactor core to the ultimate heat sink and (2) to permit sufficient insertion of the neutron absorbers to provide for reactor shutdown.

NRC Rationale for Adaptations to GDC:

- New mHTGR design-specific GDC are necessary to ensure that the reactor vessel and reactor system (including the fuel, reflector, control rods, core barrel, and structural supports) integrity is preserved for passive heat removal and for the insertion of neutron absorbers.

mHTGR-DC 71 Reactor Building Design Basis

mHTGR-DC Content:

- The design of reactor building shall be such that, during postulated accidents, it structurally protects geometry for passive removal of residual heat from reactor core to ultimate heat sink and provides a pathway for release of reactor helium from the building in the event of depressurization accidents.

NRC Rationale for Adaptations to GDC:

- The reactor building functions are to protect and maintain passive cooling geometry and to provide a pathway for release of helium from building in case of a line break in reactor helium pressure boundary. This new criterion ensures that these safety functions are provided.
- It is noted that the reactor building is not relied upon to meet the offsite dose requirements of 10 CFR 50.34 (10 CFR 52.79).

mHTGR-DC 72 Provisions for Periodic Reactor Building Inspection

mHTGR-DC Content:

- The reactor building shall be designed to permit (1) appropriate periodic inspection of all important structural areas and the depressurization pathway, and (2) an appropriate surveillance program.

NRC Rationale for Adaptations to GDC:

- This newly established criterion on periodic inspection and surveillance provides assurance that the reactor building will perform its safety functions of protecting and maintaining the configuration needed for passive cooling and providing a discharge pathway for helium depressurization events.

Reactivity Control Systems ARDC 26 and 27

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ARDC 26 - Reactivity Control Systems

- Current GDCs 26 and 27 were combined into ARDC 26.
- Revised to add clarity for designers.
  - Current GDC 26 combines normal operation reactivity control and AOO mitigation.
- ARDC 26 focuses on two independent means to shutdown.
- Informed by draft GDCs of 1965 and 1967 and NuScale gap letters.
- Achieves and maintains shutdown for DBEs.
  - Current GDC 27 addresses only postulated accidents.
  - Unclear what "reliably controlling reactivity" means.
  - Requiring shutdown is consistent with 10 CFR 50.2, definition of safety related equipment and SECY 94-084, "Regulatory Treatment of Non-Safety Systems."

ARDC 26 cont.

- Independent means of shutdown
  - At least two systems of a different design not subject to common cause failure
  - Each capable of achieving and maintaining shutdown
    - Likely to receive comments on the “maintain” aspect
  - One system is safety-related
  - Safety-related system to preserve AOO fission product barriers, second system not required to protect fission barriers
  - Allows for means other than control rods
- Cold vs. safe shutdown SSC classification
  - Safety-related to reach safe shutdown
  - Cold shutdown reached by either a safety or non-safety system

Residual Heat Removal and Emergency Core Cooling ARDC 34, SFR-DC 34, mHTGR-DC 34, & ARDC 35

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ARDC 34 and 35 – RHR and ECCS

- ARDC 34 addresses residual heat removal under normal operations and AOOs.
- ARDC 35 addresses postulated accident residual heat removal.
- ARDC 34 and ARDC 35 are separated to allow design flexibility.
  - For example, a loss of coolant accident may be considered a DBE which might be mitigated by a coolant injection system.
- Most non-LWR designs use one system to satisfy ARDC 34 and 35 requirements.

ARDC 34 and 35 cont.

- If one system is used to satisfy ARDCs 34 and 35, ARDC 36 inspection of the ECCS system, and ARDC 37 testing of the ECCS system apply to that system.
- If a separate ECCS is used, ARDC 36 and ARDC 37 only apply to the ECCS system.
- SFR-DC 34 and 35 are the same as ARDC 34 and 35.

mHTGR- DC 34 and 35

- The mHTGR design assumes a power density and geometric arrangement that allows for passive cooling without the need for He inventory.
- Since no He inventory is required mHTGR-DC 35 is not applicable and DBE residual heat removal is addressed by mHTGR-DC 34.
- The mHTGR design assumes that residual heat is transferred directly to the ultimate heat sink and a separate system per mHTGR-DC 44, “Structural and equipment cooling”, is not necessary.

mHTGR-DC 34 and 35 cont.

- The residual heat removal system is designed to:
  - Ensure the SARRDL is not violated for normal operations and AOOs.
  - Maintain fuel temperature below the design value so postulated accident dose criteria are not violated.
  - Cool the core and supporting structures such that passive residual heat removal is maintained.

Electric Power Systems ARDC 17

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Electric Power Systems ARDC 17

Electric power systems shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for the systems shall be to provide sufficient capacity, capability, and reliability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant boundary are not exceeded as a result of anticipated operational occurrences and (2) vital functions that rely on electric power are maintained in the event of postulated accidents.

The onsite electric power systems shall have sufficient independence, redundancy, and testability to perform their safety functions, assuming a single failure.

Comments on ARDC 17

- This is the version DOE included in their guidance document (December 2014).

- After careful internal consideration of the above, NRC staff concludes that the DOE version of ARDC-17 is well crafted and appropriate for its intended purpose.

Comparison to GDC 17

- The first paragraph of ARDC 17 establishes the need for multiple power sources: one onsite and at least one more system (which could be akin to current offsite power systems) but affords the applicant flexibility to choose and justify what that other system should be.
- The second paragraph of ARDC 17 provides for an onsite power system, not unlike onsite power systems of today, but tailored to the needs of the reactor design and with appropriate parts meeting the single failure criterion.

Comparison to GDC 17 cont.

- The third and fourth paragraphs of GDC 17 are no longer needed.
- The third paragraph of GDC 17 describes the redundancy required in the offsite power system. Due to the lesser role of offsite power in passive designs (e.g. AP1000), those redundancy requirements have been removed.

Comparison to GDC 17 cont.

- The fourth paragraph of GDC 17 emphasizes the need for independence between the various power sources. The concept of independence between the systems is embodied in the first paragraph.

Further Comments on ARDC 17

- For any design that may claim the need for zero electrical power to mitigate their spectrum of AOOs and accidents, a highly reliable power source is still needed for other functions such as
  - post-accident monitoring
  - control room habitability
  - emergency lighting
  - radiation monitoring
  - communications

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SFR-DC 17 and mHTGR-DC 17

- Staff believes there is no ‘electrical’ need for any tailored versions of ARDC 17 for various advanced reactor designs.

- Design-specific nomenclature for ‘pressure boundaries’ etc. have been made where appropriate, but the electrical content should remain unchanged.

Additional Technology Specific SFR Design Criteria SFR-DC 70-79

ACRS Subcommittee Meeting

February 22, 2017

Additional Technology Specific SFR Design Criteria SFR-DC 71-74

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SFR-DC 71 Primary Coolant and Cover Gas Purity Control

Systems shall be provided as necessary to maintain the purity of primary coolant sodium and cover gas within specified design limits.

These limits shall be based on consideration of (1) chemical attack, (2) fouling and plugging of passages, and (3) radionuclide concentrations, and (4) air or moisture ingress as a result of a leak of cover gas.

SFR-DC 72 Sodium Heating Systems

Heating systems shall be provided for systems and components important to safety, which contain or could be required to contain sodium.

These heating systems and their controls shall be appropriately designed to ensure that the temperature distribution and rate of change of temperature in systems and components containing sodium are maintained within design limits assuming a single failure.

If plugging of any cover gas line due to condensation or plate out of sodium aerosol or vapor could prevent accomplishing a safety function, the temperature control and the relevant corrective measures associated with that line shall be considered important to safety.

SFR-DC 73 Sodium Leakage Detection and Reaction Prevention and Mitigation

Means to detect sodium leakage and to limit and control the extent of sodium-air and sodium concrete reactions and to mitigate the effects of fires resulting from these sodium-air and sodium concrete reactions shall be provided to ensure that the safety functions of structures, systems, and components important to safety are maintained.

Special features, such as inerted enclosures or guard vessels, shall be provided for systems containing sodium.

SFR-DC 74 Sodium/Water Reaction Prevention/Mitigation

SSCs containing sodium shall be designed and located to avoid contact between sodium and water, and to limit adverse effects of chemical reactions between sodium and water on the capability of any SSC to perform its intended safety function.

If steam/water is used for energy conversion, sodium-steam generator system shall be designed to detect and contain sodium water reactions and to limit the effects of the energy and reaction products released including mitigation of the effects of any resulting fire involving sodium.

Additional Technology Specific SFR Design Criteria SFR-DC 78 and 79

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SFR-DC 79
Cover Gas Inventory Maintenance

A system to maintain cover gas inventory shall be provided as necessary to ensure that the primary coolant sodium design limits are not exceeded as a result of cover gas loss due to leakage from the primary coolant boundary and rupture of small piping or other small components that are part of the primary coolant boundary.

SFR-DC 78
Primary Coolant System Interfaces

When the primary coolant system interfaces with a structure, system, or component containing fluid that is chemically incompatible with the primary coolant, the interface location shall be designed to ensure that the primary coolant is separated from the chemically incompatible fluid by two redundant, passive barriers. When the primary coolant system interfaces with a structure, system, or component containing fluid that is chemically compatible with the primary coolant, then the interface location may be a single passive barrier provided that the following conditions are met:

(1) postulated leakage at the interface location does not result in failure of the intended safety functions of structures, systems or components important to safety or result in exceeding the fuel design limits

(2) the fluid contained in the structure, system, or component is maintained at a higher pressure than the primary coolant during normal operation, AOOs, shutdown, and accident conditions

Additional Technology Specific SFR Design Criteria SFR-DC 70, 75-77

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Engineer
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SFR-DC 70
Intermediate Coolant System

If an intermediate coolant system is provided, then the system shall be designed to transport heat from the primary coolant system to the energy conversion system as required.

The intermediate coolant system shall be designed with sufficient margin to assure that (1) the design conditions of the intermediate coolant boundary are not exceeded during normal operations, including anticipated occupational occurrences, and (2) the integrity of the primary coolant boundary is maintained during intermediate coolant system accidents.

SFR-DC 75
Quality of the Intermediate Coolant Boundary

Components that are part of the intermediate coolant boundary shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

SFR-DC 76
Fracture Prevention of the Intermediate Coolant Boundary

The intermediate coolant boundary shall be designed with sufficient margin to ensure that, when stressed under operating, maintenance, testing, and postulated accident conditions, (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized.

SFR-DC 77
Inspection of the Intermediate Coolant Boundary

Components that are part of the intermediate coolant boundary shall be designed to permit (1) periodic inspection and functional testing of important areas and features to assess their structural and leaktight integrity commensurate with the system's importance to safety, and (2) an appropriate material surveillance program for the intermediate coolant boundary. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of coolant leakage.

Acronyms

ARDC	Advanced Reactor Design Criteria
AOO	Anticipated Operational Occurrence
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DBE	Design Basis Event
DG	Draft Guide
ECCS	Emergency Core Cooling System
EPRI	Electric Power Research Institute
FAUNA	Beschreibung der Forschungsanlage zur Untersuchung nuklearer Aerosole
GDC	General Design Criteria
He	Helium
LWR	non-Light Water Reactor
mHTGR	modular High Temperature Gas Reactor
NGNP	Next Generation Nuclear Plant
PDC	Principal Design Criteria
PRISM	Power Reactor Innovative Small Modular
RG	Regulatory Guide
RHR	Residual Heat Removal
SFR	Sodium-Cooled Fast Reactor
SAFDL	Specified Acceptable Fuel Design Limit
SARRDL	Specified Acceptable System Radionuclide Release Design Limit
SRM	Staff Requirements Memorandum
SSC	Structures, Systems, and Components
TAREF	Task Group on Advanced Reactors Experimental Facilities
TRISO	Tristructural Isotropic Fuel

Written Comments on ARDC 26 as Proposed in DG-1330

For: Consideration by the ACRS Subcommittee on Future Plant Designs scheduled to meet February 22, 2017 on advanced reactor design criteria
From: Derick Botha
Date: February 17, 2017

Question on advanced reactor design criterion (ARDC) 26 as proposed in DG-1330 (Issued February 2017)

In keeping with NRC's advanced reactor policy statement, how does ARDC 26 allow for, or incentivize advanced reactors to use simplified, inherent, passive or other innovative means for reactivity control?

Basis for question

According to the Commissions Advanced Reactor Policy Statement as addressed in DG-1330, *"the Commission expects that advanced reactors will provide enhanced margins of safety and/or use simplified, inherent, passive, or other innovative means to accomplish their safety and security functions."*

The protection system and reactivity control systems support the safety function of fission product barrier protection. This is captured in the GDC in Section III of Appendix A to Part 50, *Protection and Reactivity Control Systems,* which are written to support the design criteria in Section II, *Protection by Multiple Fission Product Barriers*.

For LWRs:

- In the short term after a reactor trip, the safety function of the protection and reactivity control systems is to protect the fuel and the RCPB barriers.
- In the long term after a reactor trip, the safety function of the reactivity control systems is to protect the fuel and containment barriers.

In contrast, advanced reactors can be designed with inherent reactivity control capability such that heat is removed and fission product barriers are protected without reliance on the protection and reactivity control systems. Inherent means for reactivity control does not need to include maintaining subcriticality, which may not be necessary for fission product barrier protection. A design with inherent protection of fission product barriers with **one** reactivity control system to maintain the reactor subcritical under cold conditions (consistent with the last sentence in GDC 26) would *"provide enhanced margins of safety"* and *"use simplified, inherent, passive, or other innovative means to accomplish"* safety and security functions. Such a design would not be novel, as previous sodium-cooled reactors have relied on inherent reactivity control capability for fission barrier protection in lieu of a second reactivity control system ("Secondary shutdown systems of Nuclear Power Plants," ORNL-NSIC-7, January 1966). ARDC 26 as written would discourage vendors from developing such a design.

Comment on ARDC 26 as proposed in DG-1330

ARDC 26 prescribes that reactivity control systems for advanced reactors exceed the capability required by GDC 26 and GDC 27, without due consideration for the reactivity control system capability needed to support safety functions.

Basis for comment

1. ARDC 26(2) requires two independent and diverse reactivity control systems that can independently achieve and maintain reactor shutdown, whereas GDC 26 only requires one system for maintaining the reactor subcritical under cold conditions. PWRs rely on two reactivity control systems, control rods and means for soluble boron addition, which in combination can achieve and maintain reactor shutdown. PWRs are not required to be able to use either one of these systems independently to achieve and maintain reactor shutdown. Prescribing that advanced designs, which may have less reliance on subcriticality to support adequate core cooling, have two independent reactivity control systems that can independently achieve and maintain reactor shutdown does not necessarily improve or reflect the safety of such designs.
2. ARDC 26(2) requires maintaining shutdown with margin for malfunctions, compared to the last sentence of GDC 26 which requires one reactivity control system that “shall be capable of holding the reactor core subcritical under cold conditions” without specifying margin for malfunctions. Based on a review of the original draft GDC published by the AEC, comments from industry and the final GDC as published, AEC intentionally did not specify that margin for malfunctions should be provided in maintaining shutdown under cold conditions. Based on comments from industry it was envisaged that malfunctions leading to a return to low power would not challenge safety functions. Prescribing that advanced designs provide shutdown capability with margin for malfunctions does not necessarily improve or reflect the safety of such designs.