Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Advisory Committee on Reactor Safeguards APR 1400 Subcommittee: Open Session
Docket Number:	(n/a)
Location:	Rockville, Maryland
Date:	Wednesday, February 21, 2018

Work Order No.: NRC-3544 Pages 1-131

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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APR1400 SUBCOMMITTEE

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OPEN SESSION

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WEDNESDAY

FEBRUARY 21, 2018

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ROCKVILLE, MARYLAND

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

COMMITTEE MEMBERS:

RONALD G. BALLINGER, Chairman

CHARLES H. BROWN, JR., Member

MICHAEL L. CORRADINI, Member

VESNA B. DIMITRIJEVIC, Member

WALTER L. KIRCHNER, Member
JOSE A. MARCH-LEUBA, Member
DANA A. POWERS, Member
JOY L. REMPE, Member
GORDON R. SKILLMAN, Member
JOHN W. STETKAR, Member
MATTHEW W. SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER BROWN

ALSO PRESENT:

TONY AHN, KHNP
CLINTON ASHLEY, NRO
ALEX BURJA, NRO*
NAN CHIEN, NRO
CHUNG RAE CHO, Doosan
GREG CRANSTON, NRO
ANTONIO DIAS, NRO
ADAKOU FOIL, NRR
CHEWUNG HA, KHNP
GARY HAYNER, Jensen Hughes
RAUL HERNANDEZ, NRO
ATA ISTAR, NRO

BHAGWAT JAIN, NRO
RANDY JAMES, KHNP
DAWNMATHEWS KALATHIVEETTIL, NRO
JOO WAN KANG, KHNP
SUNG HOON KANG, Doosan
REBECCA KARAS, NRO
JUNG-HO KIM, KHNP
YOUNG MAN KWON, KEPCO E&C
OLIVIA LAREYNIE, NRO
HIEN LE, NRO
HAKRO LEE, KHNP
MARVIN LEWIS, Public Participant*
CHANG LI, NRO
DAE HEON LIM, KEPCO E&C
MARK LINTZ, NRO
SHANLAI LU, NRO
GREG MAKAR, NRO
JIHONG MIN, KHNP
MATTHEW MITCHELL, NRO
RICHARD MORANTE, BNL*
ALISSA NEUHAUSEN, NRO
RYAN NOLAN, NRO
JIYONG OH, KHNP
NGOLA OTTO, NRO

MARIE POHIDA, NRO
SHEILA RAY, NRR
CAYETANO SANTOS, NRO
THOMAS SCARBROUGH, NRO
ROB SISK, Westinghouse
JAMES STECKEL, NRO
ANGELO STUBBS, NRO
JEONG-KWAN SUH, KHNP
MATT THOMAS, NRO
VAUGHN THOMAS, NRO
ANDREA D. VEIL, Executive Director, ACRS
ROBERT VETTORI, NRO
DAVE WAGNER, AECOM
WILLIAM WARD, NRO
GEORGE WUNDER, NRO
ANDREW YESHNIK, NRO
JINKYOO YOON, KHNP

*Present via telephone

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

P R O C E E D I N G S

8:30 a.m.

CHAIRMAN BALLINGER: The meeting will now come to order. This is a meeting of the APR1400 Subcommittee of the Advisory Committee on Reactor Safeguards. I'm Ron Ballinger, Chairman of the APR1400 Subcommittee.

ACRS members in attendance are Mike Corradini, Dick Skillman, Dana Powers, Matt Sunseri, John Stetkar, Jose March-Leuba, Walt Kirchner, Joy Rempe, and Vesna Dimitrijevic. I think I pronounced that right, a second time. Pretty good. I think Charlie Brown will arrive a little bit late.

First, today's meeting is for the Subcommittee to receive briefings from Korea Electric Power Corporation and Korea Hydro and Nuclear Power Company regarding their design certification, excuse me, application, and the NRC staff regarding their safety evaluation report with no open items specific to Chapter 9, Auxiliary Systems, 19.3, the undesigned base external vents, 19.4, loss of large area, and 19.5, aircraft impact assessment.

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 offices requesting time after the meeting announcement is published in the Federal Register.

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

The ACRS section of the USNRC public website provides our charter, bylaws, and letter reports, and full transcripts of all full and subcommittee meetings, including slides presented at the meeting. The rules for -- for precipitation -- participation in today's meeting were announced in the Federal Register on Friday, February 21st, 2018 -- not.

The meeting was announced as an open and closed to public meeting. This means that the chairman can close the meeting as needed to protect information proprietary to KHNP or its vendors.

That means this afternoon's, after the breaks meeting, according to our schedule, they're marked closed. They're closed for the purposes of the staff wanting to avoid having to open and close things if they make -- if there are discussions related to proprietary information.

No requests for making a statement to the Subcommittee has been received from the public. A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. Therefore, I 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 they can be regularly heard.

Not to presenters, there's a small black microphone in front of you. When you speak, please be sure that the green light on the top of the microphone is glowing green. To make this happen, you must press the pad at the base of the microphone.

We have a bridge line established for interested members of the public to listen in. The bridge number and password were published in the agenda posted on the NRC public website.

To minimize disturbance, the public line will be kept in the listen only mode. And I understand we have two lines open for staff members to participate.

The public will have an opportunity to make a statement or provide comments at the designated time towards the end of the meeting, actually, towards the end of the Chapter 9, or at the end of the Chapter 9 session presentations.

NRO staff and contractors are on a separate bridge line for Chapter 9. We ask that the staff place their phone on mute until you are called upon. And we'll do some signaling to make that happen.

Now Bill is here, yes. I now invite Bill Ward, NRO project manager, to introduce the presenters and start the briefing. Bill?

MR. WARD: Thank you. This meeting is third to the last of the subcommittees. We're really happy that we are making good progress on this, and we hope we can meet the dates of the other two. As they're scheduled, I don't see any problem with that. And we're glad to be here again and hope we answer all your questions. Thank you.

This is Rob Sisk, Westinghouse, consulting to KHNP. Just again, appreciate the opportunity to present the APR1400 as we continue through the review process. And without further ado, I'd like to introduce Mr. Hakro Lee to lead us through Chapter 9.

MR. H. LEE: Good morning, ladies and gentlemen. This is Hakro Lee from KHNP. This presentation is for the Chapter 9 which covers auxiliary system for APR1400 design.

The contents are provided in this slide. Main contents are overview of Chapter 9, 9.1.2, new and spent fuel storage, summary of main topic in Section 9.1.2, summary of open items, response to Phase 3 questions, current status, and attachments. Here we can see an overview of the titles and major contents each section in DCD.

The following documents have been submitted for addition to Chapter 9. There were five open items in full Committee in last July. These are three of the main topics. Description of issue and resolution for each item will be described in orderly.

These items are five open items. Description of issue and resolution for each open item will be described in orderly. From now on, 9.1.2 new and spent fuel storage will be presented by Mr. Kang.

MR. KANG: Good morning, ladies and gentlemen, my name is Joowan Kang from Tucson. I am going to start with introducing redesign pictures of fuel racks in DCD Section 9.1.2.

The new spent fuel racks are constructed of stainless steel and designed as a seismic Category 1. For NFSR, two modules are located in the New Fuel Storage Pit. The remaining pieces of NFSR are bolted to the embedment plate at the bottom of the pit to preclude tipping during seismic events.

For SFSR, 29 modules are located in the spent fuel pool which consists of over six vents in Region I and 23 vents in Region II. The main features of SFSR modules are free-standing with a pedestal. That's the base plate.

Installation of SFSR modules in the spent fuel pool, they are surmounted in borated water with the space between the racks and cell walls at all times, especially to keep the reaction of several material as called METAMIC is used.

Next. This slide shows the safety evaluation of event. As the background of this slide, the revision chair or technical report for fuel racks, mechanical analysis was issued on December 2014 at the 8:38:25, RAI 8272. The latest technical report was revised as a revision study on August 2017 to reflect resolutions.

As of the recent oral evaluation, the seismic models were proposed 36 cases dynamic simulations to determine the loads and displacement for the racks. The structural evaluation results shows that the new and spent fuel cylinders met the requirement as specified on SRP 3.8.4, Appendix D, and ASME Section III, Subsection NF, Class 3.

The postulated mechanical accident analysis are performed based on the impact image and configuration of each rack scenario as well. An evaluation result of each rack scenario, the new and spent fuel racks are just acceptable modules of safety and no effect on the computation to maintain a civil criticality over the fuel.

Next. This slide is related to the number time histories and the critical discretion of artificial time histories based on SRP 3.7.1, Option 2. It stated that for nonlineal structural analysis the number of time histories should be greater than four. Therefore, we provide that for the number of time history sets.

Five sets of artificial acceleration time histories were developed to match the safe shutdown escape instruction as far as background.

MEMBER REMPE: There was a message a few minutes ago that you needed to plug in your computer.

You're about out of power.

CHAIRMAN BALLINGER: What is it that you can't see?

MEMBER REMPE: Someone, ha, ha, ha.

CHAIRMAN BALLINGER: We're on it.

(Off the record comments)

CHAIRMAN BALLINGER: For those of you who may be listening on the phone, the presentation computer died. And we're resurrecting it. So hold on for a few minutes.

MEMBER POWERS: In his testimony before a Senate committee, former Chairman Dick Meserve, when asked what he had discovered about nuclear engineers said, "One of my findings is they cannot talk without view graphs."

(Laughter)

CHAIRMAN BALLINGER: There are exceptions.

MEMBER POWERS: They cannot talk well without view graphs.

(Laughter)

CHAIRMAN BALLINGER: There are exceptions.

MEMBER STETKAR: The appropriate characterization ends with a period after the word well.

(Laughter)

CHAIRMAN BALLINGER: Theron, how long do you think it's going to take?

(Off the record comments)

(Whereupon, the above-entitled matter went off the record at 8:43 a.m. and resumed at 8:48 a.m.)

CHAIRMAN BALLINGER: Okay, we're back in session. Thank you for being considerate, or inconsiderate.

MR. KANG: This slide is related to the number of time histories and technical justification of artificial time history sets based on SRP 3.7.1, Option 2. It states that for manual rises to the number of time histories should be greater than four. Therefore, we provided that for the number of time history sets.

Five sets of artificial acceleration time histories were developed to match the safe shutdown earthquake instruction response criteria. Also we provided technical participation for artificial time history sets to review and provided on Section 3 of technical report. The results showed that the suitability of the time histories was verified, according to SRP 3.7.1.

Next. This slide relate to the study of

a seismic analysis of racks. Due to free-standing fuel storage rack modules in the pool, the seismic response are nonlinear and involve a complex combination of emulsions, so just to provide additional information about the structure around the modeling.

First, sufficient information of the rack and fuel assembly model and it's parameters. Second, sensitivity analysis results of the impact force and rack response to variation in spring constants. Third, sensitivity analysis results of integration time step used in performing the seismic analyses for SSE.

The next slide show what be provided. Next? What we provided for information is a detailed description of the rack and fuel assembly model for seismic analysis. And model element properties are derived from the dynamic characteristics of the detailed 3-D shell model of the racks.

What we performed is sensitivity analysis for spring constants in the model, such as rack-to-rack, rack-to-floor, and fuel-to-rack. And comparison of a run at one half the fixed time step used for all other runs.

What is provided for analysis result is the effect of sensitivities was a change in the predicted loads within the variation found for different time histories and less than the variation for different function depletion, such as CHERIFON 2, CHERIFON 5, and CHERIFON 8.

Next? This slide relates to mechanical accident analysis. First, we had to consider detailed evaluation for drop accident analysis. First, consider finite element model on evaluation of a nonlinear dynamic analysis for the impact effect of drop accidents. Second, consider deep drop locations to maximize the deformation of the rack base plate. Third, consider all other fuel assemblies in place when a fuel assembly drops through an empty cell.

Next? This slide is a resolution we gave. All drop accidents analyzed by developing a finite element model of a rack, base plate, a fuel assembly, and the pedestal using ANSYS LSDYNA program to evaluate maximum plate, drops are considered at the two locations that maximize the distance of the point of support. And drop analysis model was considered fully loaded.

As a different analysis result, loss of breastplate such as a puncture has not occurred. The breastplate of the new and spent fuel storage racks are calculated per 2.99 inch and 2.72 inch respectively.

These value are less than that the minimum disturbance between the breastplate and the drying surface. Therefore, throughout the simulation, the NFSR base plate to contain the pit flow or the SFSR base plate to protect the fuel liner.

Next? From now on, we will present five open items in Phase 3 and a list of them. The staff checked RAI 8191 (Q 09.01.01-13) as an open item. The staff gets to confirm that mechanical accidents do not cause the rack deformation that would affect criticality.

The resolution related that -- and the damage of -- any damages to the rack is limited to the portion above the neutron absorber and does not affect their configuration relative to the criticality analysis. The staff's review for the technical report was completed.

Next? This slide relates to neutron absorber material. The staff has the RAI 8578 (Q 09.01.01-39) as an open item. The purification process of the standard fuel rack may expose the Metamic neutron absorber to evaluate the temperature really in close proximity.

So staff concerns regarding the adequacy of utilizing as-fabricated Metamic coupons in the neutron absorber monitoring program The resolution we did is that purification test exposure to Metamic material to 1900 giga Fahrenheit for 48 hours and demonstrates no change in the run obstruction. This item is closed.

The next presenter is Mr. Lee again.

MR. H. LEE: So from now on I'm going to present again. The staff stressed RAI 8582 (Q 09.01.03-4) is an open item. Related to this open item, the staff requested to identify the minimum safety water level and update the DCD accordingly, also requested to revise the thermal-hydraulic calculations using the minimum safety water level.

The minimum safety water level was provided in the response to RAI 8582 (Q 09.01.03-4) In addition, thermal-hydraulic analysis report was also revised.

Additionally, the staff identified that the normal water level has been identified as elevation 154 feet, while in other places it shows as elevation 153 feet. These two levels represent different conditions through the response to RAI 8582 (Q 09.01.03-5).

The staff stressed RAI 8613 (Q 09.05.02-4) as an open item. Related to the requirements of 10 CFR Part 50, Appendix A, GDC 1 through GDC 4, the staff requested to justify why the communication systems are not considered as risk significant SSCs. The staff issued a follow-up RAI 548-8822, (Q 09.05.02-6) related to this open item.

KHNP responded that the communication systems of the APR1400 are designed to meet GDC 1 through GDC 4 and do not interface with any safety-related or risk-significant SSC. The four communication subsystems are designed to assure that any single event does not result in a complete loss of plant communication.

The staff stressed RAI 8613 (Q 09.05.02-5) as an open item. The staff requested to provide the detailed description of all ITAAC items along with their acceptance criteria and ITP for the communication systems in Section 14.2.

In addition, the staff requested to clarify what the applicant means by functional arrangement of communication systems. Related to this open item, the staff issued a follow-up RAI 8822, (Q 09.05.02-7).

KHNP provided the new ITP for plant communication system and the detailed description of all ITAAC items for communication system through the response to the follow-up RAI.

And KHNP revised DCD Tier 1, Subsection 2.6.9 providing the detailed description of plant communication systems instead of the term of functional arrangement.

So from now on, I will answer the question in ACRS Subcommittee on May 18th, 2017. During KHNP presentation on Section 927 Chilled Water System, ACRS asked about the basis for the non-safety-related plant chilled water system to provide cooling water for the safety-related TDAFW pump room.

I will explain the reason why the non-safety-related cubicle cooler is installed in the TDAFW pump room. It is basic principle to use the safety-related HVAC system to cool the area where a safety-related accumulation is located.

In case of TDAFW pump room, the non-safety cubicle cooler is installed, and it does not serve any cooling function at accident condition. The reason why non-safety related cubicle cooler is applied for the room is that the room is high energy line break, HELB, area which means the essential chilled water just have temp would be damaging and have accident if the cubicle cooler is safety-related.

Because of loss of cooling during accident, the TDAFW pump shall be qualified to be operable at maximum temperature for the operation period.

Now I will explain the summary for heat-up calculation of TDAFW pump room. The purpose of the room heat-up calculation is as follows. First, determine the maximum temperature in the TDAFW pump room. Second, demonstrate that the maximum temperature of the room does not exceed the maximum allowable temperature during 72 hours under loss of HVAC system.

The GOTHIC program is used to perform heat-up calculation. Maximum allowable temperature, 150 Fahrenheit degrees of the room, is decided based on the steady-state temperature of Condition 2 mentioned in NUMARC 87-00. The maximum temperature of TDAFW pump room is about 155 -- 145 Fahrenheit degrees. The TDAFA pump rooms are maintained below 150 Fahrenheit degrees during 72 hours and under loss of cooling.

MEMBER STETKAR: Does that maximum temperature occur at 72 hours? In other words, is the temperature still increasing at 72 hours?

MR. H. LEE: Sorry, would you say again?

MEMBER STETKAR: Does the maximum temperature of whatever you cited, 145 degrees, occur at 72 hours? Or, what I'm asking is, is the temperature still increasing at 72 hours?

MR. H. LEE: The equivalent temperature

condition is 145 during 72 hours.

MEMBER STETKAR: What I'm asking is, what we asked you for was to show us the temperature profile. I have not yet seen that temperature profile.

(Off the record comments)

MR. SISK: This is Rob Sisk. Just to clarify, the temperature profile, it increases up to 145. It is more asymptotic. It does not continue up at a continual rate. But it asymptotically reaches 145 and stays.

MEMBER STETKAR: Could you tell me when it reaches 120 degrees?

(Off the record comments)

CHAIRMAN BALLINGER: So to be clear, we do not have the exact profile here. But the approximate value, it hits 120 in about 16 hours.

MEMBER STETKAR: Sixteen hours, okay, that's interesting. Do the turbine-driven auxiliary feedwater pumps have electronic speed control? And is there any instrumentation located in the turbine-driven auxiliary feedwater pump room that controls either turbine operation, or auxiliary feedwater flow, or steam generator level, or information in the main control room?

MR. SISK: We do not have that information available.

MEMBER STETKAR: The reason I ask these questions ---

(Off the record comments)

MR. YOON: I am Mr. Yoon from KHNP, Administrative Office. The equipment related to turbine-driven aux feedwater pump, and something like that, that equipment is located in another room, not installed in that room, of course, to prevent damages in the event of high energy line break.

MEMBER STETKAR: To me, that doesn't make much sense. Because if the steam line breaks, I don't have the turbine-driven pump. So I don't understand why I have to install the equipment in another room. But if you say that on the record, you are now on the record that any electronic equipment for the turbine-driven pump and instrumention is not located in the turbine-driven pump room. Is that correct?

MR. YOON: Yes.

MEMBER STETKAR: Hum? You are now on the public record in a meeting saying that is part of your design? I was not aware of that. That's an important piece of information.

MR. YOON: As I'm -- to my knowledge, the pressure transmitter is located in the containment. So turbine-driven fuel pump is located in the aux building.

MEMBER STETKAR: I understand that. But I'm asking -- I didn't ask about a pressure transmitter. I asked whether there was any -- the reason I -- let me cut to the chase. The reason I'm asking this is that I have read documents that indicate that the maximum allowable temperature in several locations in the plant that contain, I'll just call it electrical and INC equipment, is 120 degrees Fahrenheit, the maximum allowable temperature. And that's a fairly typical temperature for qualification of that type of equipment.

However, you state that the maximum allowable temperature, in the turbine-driven auxiliary feedwater pump rooms in particular, is 150 degrees Fahrenheit, 30 degrees higher.

That to me says, well, you either have to have electronic equipment that is qualified to be better than all of the other electronic equipment in your plant, or you don't have any electronic equipment in that room, or it's qualified to 120 degrees. And that's why I was interested in when you had reached 120 degrees in your room heat-up calculation.

So if there's no electronic equipment in that room, which we just heard on the public record, the official record of our meeting, then I don't have a problem. But that is now our understanding of your design.

MEMBER REMPE: Further, can we ask if that's the way Shin Kori is designed and built?

MEMBER STETKAR: I'll just note they can design this one differently than Shin Kori.

MEMBER REMPE: They can, but I just am curious if they've changed it from Shin Kori.

MR. H. LEE: From my colleague, I received some kind of related information about your question. He mentioned that when we decided the maximum temperature in each room, it incorporated to our purchased specification later. So I'm not sure that electrical panel or some kind of equipment shall be located in some rooms. We're not --

MEMBER STETKAR: We have it on the record. The staff has our question.

MR. SISK: We don't have the information at this point for Shin Kori. Andy?

MR. OH: At this point in Shin Kori, this is Andy Oh, KHNP Washington Office, at this point we don't have the information for Shin Kori.

MR. H. LEE: I will continue on my presentation. Chapter 9 is complete. KHNP continues to monitor Chapter 9 to assure any confirming changes that are addressed. Five open items that were identified in Phase 2 and 3 have been resolved with adequate and sufficient discussion with the staff.

Changes in Chapter 9 as reviewed and marked up in response to the RAIs will be incorporated into the next revision of the DCD. Thank you for listening.

MR. SISK: And that concludes the Chapter 9 presentation. We want to leave time for questions if there were any.

CHAIRMAN BALLINGER: Any additional questions from the members? Thank you. And we get --- no? Ready for the staff's presentation?

MALE PARTICIPANT: Is it closed?

CHAIRMAN BALLINGER: No, Chapter 9 is not closed.

There are two staff members who are on the phone, we think. Can you identify yourselves just so that we're sure that you're there please?

MR. MORANTE: This is Rich Morante from

Brookhaven National Laboratory on the phone.

CHAIRMAN BALLINGER: Thank you.

MS. BURJA: And this is Alex Burja from the Reactor Systems Branch.

CHAIRMAN BALLINGER: Thank you. I'm not sure what the order is, who's doing what when.

(Off the record comments)

MR. WUNDER: Okay, good morning, Mr. Chairman, ladies, and gentlemen of the Committee. I'm George Wunder, and I'm the project manager for Chapter 9 of the APR 1400 design certification review.

Last month we presented Chapter 4 to you. And at that time I told you that the team had put that together, that chapter together. It was like the 1927 Yankees of review teams. Well, the team that I'm going to introduce to you today, they're more like the 1969 Mets. And I say that because --

(Laughter)

MR. WUNDER: -- I say that because --

MALE PARTICIPANT: Nobody is sure about the Mets.

MR. WUNDER: I say that because I think it's -- sometimes I think it's a miracle that we got this thing done. Thank you. As you can see at a glance, there are multiple contributors. I think there are 19 of them plus our consultant makes 20.

And when you have that many contributors, it makes for some unique problems for the project manager to coordinate and integrate it all into a unified chapter. And it would have been nigh impossible had not everyone on the technical staff done such a wonderful and professional job.

So it's a real pleasure to introduce the team. From the Plant Systems Branch, we have Raul Hernandez, Hien Le, Chang Li, Angelo Stubbs. And this is my favorite part, whereas the 1969 Mets had Nolan Ryan, we've got Ryan Nolan -- can't make this stuff up -- also Bob Vettori, Dennis Andrukat, and Thinh Dinh from the Materials and Chemical Engineering Branch.

Sir?

MEMBER KIRCHNER: Where are Sever and Darling?

MR. WUNDER: Sever's right there.

(Laughter)

MR. WUNDER: From the Material and Chemical Engineering Branch we have Andrew Yeshnik, John Honcharik, Greg Makar, from the Containment and Ventilation Branch, Danny Chien. From Structural

Engineering we have Vaughn Thomas, Pravin Patel, and B.P. Jain. We have Dawnmathews Kalathiveettil from the Instrumentation and Control Branch, Alexandra Burja who is joining us on the phone from Reactor Systems, and Adakou Foil, and Sheila Ray from way over in NRR in the Electrical Engineering Group.

We also have our outstanding consultant from Brookhaven National Lab, Rich Morante, who's also joining us on the phone. And I would be remiss if I did not mention the incredibly valuable contribution of two of our project managers, Carolyn Lauron and Brian Hughes, who stepped in when I was called out of town on an emergency. And they put in many, many very long hours to make sure that we got this thing done by our deadline. And finally, in the roll of Gil Hodges, we have our extremely able lead project manager, Bill Ward.

We have not presented Section 9.1.2 to the Subcommittee prior to this. So I thought we'd start off with that section, and then we can move on and go over the open items in the remaining sections.

So I am joined by B.P. Jain, and Rich Morante is on the phone. And I'm going to turn you over to B.P for Section 9.1.2. Thank you. B.P., take it away when you're ready.

MR. JAIN: Good morning. This is B.P. Jain. I'd like to acknowledge my team who have contributed to the review of this complex section, Vaughn Thomas, Pravin Patel, and Rich Morante at BNL.

So here I am basically going over the work this team did and reviewing the fuel racks, spent fuel pool racks. So the primary objective under this review is to view the structural design and mechanical design of the fuel storage racks to make sure that they can withstand effects of outbreaks and mechanical accident loads resulting from the fuel assembly drops.

The other complements with this fuel pool and the liner have been presented before, so I will not address those. And they were covered under Section 38346. And the same thing goes with criticality evaluation, I would not address that. It's been addressed by the staff in the SER Section, 911.

So overall, we will be addressing more -- just to give you an overview of what I'm going to be talking about and what the staff did to review this new fuel and the spent fuel pool structure --

MEMBER REMPE: B.P., just be very careful. Your papers were hitting the microphone. And that makes the poor little guy that's the reporter --

MR. JAIN: I'll be careful.

MEMBER REMPE: -- literally going deaf.

MR. JAIN: I'll be careful. So overall, the high level overview, to give you the presentation, the staff reviewed the KHNP's technical report and the mechanical analysis for new and spent fuel pool racks. It was around three in August 17. And the review basis for the staff is guidance in Appendix B of the SRP 3.8.4 with the appropriate title, Guidance in Spent Fuel Pool Racks.

The staff reviewed the seismic input analysis to the mathematical model of the racks and the non-linear analysis which the KHNP performed. The staff also reviewed the mechanical accident scenarios, especially resulting stresses and what scenarios they have considered.

Staff looked at the computer codes they used and see if they are reasonable for the kind of problem they are trying to solve.

Staff reviewed the analysis methodology including the design parameters which went into making the model, such as the hydrodynamic loads, the gap springs for rattling, and so on and so forth.

Overall, we sat back and looked at the ---

it's a very complex problem, a lot of input goes into it. It's a non-linear problem. So staff looked at the reasonableness of the results. Do the results make sense, and not really going micro, analyzing each and every parameter.

Staff also looked at the COL item that the KHNP identified. During this process, staff had 39 RAIs. And KHNP did an excellent job in responding to all of them. And there are no open RAIs remaining.

So the staff basically concludes at a high level that these racks and these complements meet the applicable ASME code allowable stresses. And the seismic displacements of these racks, because spent fuel pool rack is free-standing, are small compared to the physical dimensions of the design. And they would not invalidate the criticality analysis which has been performed under a different section, 9.11.

And the other concern with these free-standing racks is would they impact the pool wall. And the staff assured itself that they would not. Displacements are small. So that's overall the real strategy, what the staff looked at.

MEMBER SKILLMAN: Let me ask this question, please. From your overall strategy, to what extent are the results that you are communicating dependent upon a precision of installation of the racks?

MR. JAIN: They are not related to the precision of installation of the rack, I can say after the fact. Because the displacements are, even if they were uncertain -- there are uncertainties, obviously, in any of these analyses -- the fact of safety or additional margins, what we find will, in our judgement, more than compensate for some of those things.

MEMBER SKILLMAN: Can you cite an approximate dimension that is allowable between the installed racks? Is it a centimeter, half a centimeter, half an inch, three-quarters of an inch?

MR. JAIN: The way these -- they are installed, the base plates are pretty close to each other. And I believe the, if I recall the dimensions, like, one inch between the base plate and one class of racks. Another class of racks, it's a couple of inches. And the displacement, just to give you an order of magnitude, is like quarter inch due to seismic. So even if it was, you know, you double the displacements, it still would not close the gap.

MEMBER SKILLMAN: Thank you.

MR. JAIN: So just to focus, what the focus area -- what the staff looked at, and again this was guided more by the staff guidance in SRP 3.8.4., so we looked at the physical description of the racks and the arrangements, then striations. Staff also looked at what are the applicable design codes, standards, and specifications for manufacturing these racks.

Obviously, seismic and impact loads are the big part of it, because they are free standing racks. Again, we wanted to make sure that we considered all the loads, the load combinations for various scenarios of allowable stresses.

We looked at them with analogy first, just to analyze the design, and what the acceptance criteria, when you say they have met the allowables, and things like materials, appropriate quality control programs, things of that nature, we also looked at.

The physical descriptions, and I would not go over that. I think KHNP has covered, but at a high level, there were a few figures which have been pulled out with production, where a pictorial view of the plant, how these racks are sitting in the pool.

But basically, the new fuel racks, they are sitting in a pit. And the highlight of that is it's bolted to the floor. So it's not free-standing.

So it's less critical during seismic movement. They are constructed with the same stainless steel material as the spent fuel pool racks. And they are spaced at 14 inches fuel assemblies for criticality, of sub-criticality maintainment.

Next? The spent fuel pool racks are different in the sense that they are free-standing, and there is a gap between the racks and between the racks and the pool wall. By the way, just a gap between the racks and the pool wall is about 33 inches. So it's quite substantial. It's not sitting right next to it.

Again, the pool is divided, for talking purposes, two type of racks, Region I, Region II. They have a different configuration. Pitch is different, but nothing else. And from a structural point of view, it does not make much difference whether call it Region I rack or Region II racks.

So the staff looked at their physical descriptions and the level of detail they provided in their DCD and the tech report and determined that the guidance in SRP is fully complied with. So it's consistent with the guidance, the physical description, and the staff finds it acceptable. This shows just the isometric view of the typical rack.

The staff reviewed KHNP's design core standards and specifications, what they indicated in their tech report. And for material, they used some ASME code Section 2 and ASME Section 3 for designing core section and Appendix F. And they used -- Reg Guide 1.61 they cited and Reg Guide 1.29. These are the key documents there.

There are other materials they have referenced, but that's all, again, consistent with what the SRP guidance 384 calls out for in terms of the codes, and specifications, and the reg guides. So staff finds that they are all consistent, and therefore the codes and standard they have used are acceptable to the staff.

So the seismic analysis makes a big chunk of staff's review of these racks and primarily because of the complex, free-standing structure. It's non-linear in nature. So staff had a lot of questions and understood, at the end of the day, staff ensured that they meet all the applicable requirements of the SRP guidance and analysis methodology.

Just to go in a little more detail, staff looked at the information, what they had computed. And basically, the envelope, the spectra at the base of the rack, and the pool wall. And that was their target spectra, this one spectrum of that place.

They completed synthetic time histories consistent with that spectra and followed the requirements of Reg Guide 3.71 which basically tells you what certain parameters you need to meet in order to qualify to be able to use those time histories. And it requires more than four-time history to be used. KHNP used five. So staff finds it acceptable.

And I'll pick a model, so KHNP used the 3-D model of the racks and extracted the equivalent B properties to simulate the rack structure dynamically. Same thing they did with the fuel. They had PWR fuel, P7, and based on the test results, they computed a frequency and the stiffnesses. And they simulated as a beam element out of that. So staff is pretty comfortable with the way they've approached to compute the properties of equivalent beam model.

With regard to the rattling and the impact between the fuel and the rack, or the rack to rack, or the rack to floor, the Applicant used the gap element. Basically they're active and they're under compression. And they used the appropriate properties of the springs' stiffnesses to simulate the gap.

Staff asked again where ability is there, I mean, how sure are you about those stiffness values? So staff asked them to do the uncertainty analysis to vary those stiffnesses by 20 percent, pluses and minuses, and make sure that what you are doing is bounded. So that was the regarding of the gap stiffnesses.

Hydrodynamic effects, there's a hydrodynamic mass between the fuel and the rack, then the plate and the floor, and then the pool wall and the rack. And they are pretty much, I would say, standard approaches, formulas to compute the hydrodynamic mass.

Some people do it 3-D, hydrodynamic elements and so on. But KHNP chose to use sort of hand calculations which are pretty accurate, have been tested out. So that was their approach. And staff points those tested out approaches were acceptable and then that's it.

To simulate or to check or to confirm the fuel integrity, the two components of the colliding and rate of the fuel is balanced or held together. And then the spacer grid would be in the fuel bundles.

So they, I mean KHNP, based on their test results of the buckling capacity of the spacer grid, the model that's spring in the model, to get the responses during the citation so they assure the fuel integrity will be maintained. So they have simulated the impact, fuel impact with the rack in that manner.

And staff looked at their results, the fuel test results, and they are consistent with what they have used in their bigger analysis. So the fuel is represented pretty accurately.

As I said before, they have also used the radiation in the fuel properties, the new fuel versus end of life fuel. Because your stiffnesses change, the fuel stiffnesses. So what effect that has, we wanted to study that to make sure that you do analysis only once, but there's bounding analysis in terms of the rack stresses.

Seismic analysis methodology, overall we find it's consistent with what's being done in other applications and what the reg guide requires that. So they applied the three dimensional to a three dimensional model with three dimensional time histories in two horizontal and one vertical direction. They found, in nonlinear time it's the analysis for five sacrificed time histories. So there are five analyses for one condition or one variation.

As these are free-standing racks, the focus and the selection plays an important role, so they have used the lower bound, upper bound, and the mean values, the lower bound being 0.2 coefficient reflection, upper bound is 0.8, the mean is 0.5. So for each of the time histories, they used three separate coefficient reflections to get the results of the responses during earthquake.

Their design basis analyses consists of the fully loaded racks. But the staff was not sure if that really balanced the response during seismic, because being a non-lineal response. So they also studied the various patterns of the fuel loading, like, 50 percent loaded, 25 percent loaded, or the checkered load, some empty racks, and enveloped the results of all those analyses. So that uncertainty regarding the fuel loading was very well covered.

Numerical solutions is all highly nonlinear analyses. So staff wanted to make sure that your direct integration time stamp is fine enough so that the results are converging. And they demonstrated that the time integration was small. By changing it 20 percent, they found the results are changed.

So overall, they performed 20 such analyses. Like, you have a five-time histories, and you have three different sets of coefficient reflection. So it gives you 15. That's for spent fuel. And then new fuel racks, you don't need friction or radiation, because it's bolted. So five cases there. So altogether, it's 20 cases they analyzed.

And then there are about 16 cases where they studied the barometric variation group I talked about, like varying the different masses, the stiffnesses. So that total is about 36 simulations. And the results, the stress analysis they performed there's the bounding of all of this work. So staff considered that they have covered or attempted to cover the uncertainties to the extent reasonable.

They have also, related to the computer program ANSYS where they used for this analysis, staff wanted to make sure that for this class of problem, meaning free-standing, highly nonlinear analysis, this model computed the record they're using, is converging, or is reasonable.

So they demonstrated that by, well, a combination of a few things. ANSYS has been used, its staff has used and approved ESBWR, so staff feels pretty comfortable.

But in addition to that, we asked them to sort of analyze the same problem or simplified problem, so everything remaining same. You change the codes. And the results, and again, mostly we are looking for displacement. And we found them pretty reasonable. They will not match, will not be a match. Because the approach to solve the problem is different but fully reasonable.

So based on this seismic analysis review, we find that their input, the model, and the parameters, the methodology they have used, and validated computer code they've used, they all meet the guidance in SRP 3.8.4, 3.7.1, 3.8.1, and Reg Guide 161. And therefore we find it acceptable.

The second part of the assessment is the mechanical analysis due to accident. The full scenarios are postulated in the SRP 3.8.4, Appendix D. Basically, one of them is a straight, shallow drop. The fuel assembly drops at, well, it can drop, what is it, a straight drop away from the pedestal. And one is on the pedestal.

Away from the pedestal, you're trying to maximize the deflection of the base plate where the fuel is supported to make sure that it does not -- it's not that excessive that it touches the floor below, impacts the floor below.

Then the other scenario is you drop it on the pedestal. And by that, you're trying to maximize whether it's going to penetrate the concrete and go downward. So that's purpose of doing that scenario.

Third one is you just accidentally drop, and you want to make sure that you're not hurting the rack cell to the point that you come close to the neutron absorber. Because then the sub-criticality becomes an issue. So that's, like, just a drop on the corner of the fuel bay.

And the last one is the stuck fuel assembly. You're trying to pull the assembly, it gets stuck, you know, against the wall of the shell. And again, you want to see that stresses in the racks are within the code allowables.

So all these four scenarios, KHNP analyzed it, used the detail, two dimensional, finite element model and used ANSYS LSDYNA code which is validated code. And the rack, when it drops, the fuel assembly is dropped back. It's considered fully loaded. So it's not empty, so maximize. Because the plate deflection will be more when the pool is loaded, and then you drop more. So that's one of the rationales.

So with all these analyses, what they performed, they showed two things. One, the minimum factor of safety, meaning the margin, if you want to call it, really it's not a factor of safety. That isn't the right term. It is 1.4. And that occurs for the drop. It's right on the pedestal.

So there's the concrete compressive strength, the impact load on the concrete and allowable compressive strength. That's where the margin of 1.4. The margin at other places, for other three scenarios, is much greater than 1.4. It's, like, of the other two or three. We just mention only the lowest one.

CHAIRMAN BALLINGER: Excuse me.

MR. JAIN: Yes?

CHAIRMAN BALLINGER: When you say a margin of 1.4, 1.4 against what?

MR. JAIN: Against allowables --- computed allowables.

CHAIRMAN BALLINGER: Okay. And what's the -- you're talking about destruction of the concrete, penetration of the concrete?

MR. JAIN: No. No, no. These are, like, not within code allowables. You don't go into those penetration or spalling, or any of that, no. When a load acts on the concrete, it causes compression, regular compression. And code gives you allowables to what that compression stress should be.

CHAIRMAN BALLINGER: Okay.

MR. JAIN: So it's, again, design basis, code allowables. So it's not like we covered an aircraft impact when things are penetrating and --- no. They are not there.

And, in fact, the SRP guidance does not allow that either. So we --- although it's called accident, but is it a scenario? Really, it's a mechanical accident, unplanned, unanticipated accident.

MEMBER SKILLMAN: Let me ask this question on the next to the last carrot under analysis, the slide reads as follows, "Demonstrated that the impact of the straight, deep drop of the fuel assembly on a specific location does not cause any significant deformation to the base plate."

MR. JAIN: Right.

MEMBER SKILLMAN: Does that mean that there are other locations that are not specified that can be?

MR. JAIN: Okay, let me just ---

MEMBER SKILLMAN: Areas where the base plate is deformed?

MR. JAIN: I understand your question. Let me clarify what is meant here. So they --- when the plate is fully loaded with the fuel, the base plate, you would expect, right, kinetics. The maximum deflection will be at the center, simply supported here. And if you drop the fuel assembly at the center of the plate, in the cell, you will increase that deflection.

And that's what we are watching, that the floor is still cleared when it deflects. So that is a critical location for dropping the fuel for that particular scenario.

MEMBER SKILLMAN: Well, how about the scenario, as you mentioned a few minutes ago, the edge of the rack is about 33 inches away from the wall of the pool.

MR. JAIN: Uh-huh.

MEMBER SKILLMAN: It's 780 millimeters or 800 millimeters. If a fuel assembly is dropped between the rack and the wall, does that impact load exceed what you have just described?

MR. JAIN: Well, first of all, it's not postulated, so I cannot really straight away address it to you, number one. Number two, so this is really non-required scenario, Scenario Number 5, if you will. Because all the fuel that's supposed to drop, we are testing the rack. Our focus is the rear of the racks, whether the racks meet all the stress requirements during postulated scenarios. So if the fuel drops between the pool wall and the rack, probably it will fall on the floor.

MEMBER SKILLMAN: I would expect it to.

MR. JAIN: Right. And if it falls on the floor, that should not be a problem at all, because we have covered --- that is covered under when it drops right on the pedestal.

MEMBER SKILLMAN: Except that you have an impact load that is the, if you will, the full face of the lower end fitting that could have a higher local penetration impact load than if it were spread more widely as would be the base of the fuel rack.

MR. JAIN: Yes.

MEMBER SKILLMAN: Like a bullet.

MR. JAIN: Right. I could not answer the question simply because that case would have been covered under the design of the spent fuel pool.

MEMBER SKILLMAN: So your focus today is simply only the racks.

MR. JAIN: Yes. My focus is just the racks. And the design of the spent fuel pool is covered under

384-something, which I mentioned at the beginning, 383.4.6.

MEMBER SKILLMAN: Thank you.

MR. JAIN: That's in the SEO.

MR. JAIN: The next, this slide shows a couple of cartoons for various accidents we talked about.

Now we talk about the load to load combination. So we spent time and looked, talking about the seismic and the mechanical accident. Those are the two primary loads which really control the design of the racks. Nevertheless, there are other loads for completeness, that load, five loads, safe shutdown, thermal loads, mechanical accident loads.

And then there are combination of these loads can occur. And what are the corresponding service levels for those combinations. And that's all specified in our regulatory SRP. And the KHNP's design is consistent with the requirement, what's in Appendix D.

As you can see, they are all -- seismic and mechanical accident loads never get combined. So each one is treated separately. And there is no live load for these racks. It's just a dead load.

Okay, and thermal loads, I'm going to talk about. They're secondary loads, according to ASME code, so they are looked at, they're evaluated. But then they are evaluated by themselves and shown to be within the code allowables.

This is the general procedure that KHNP has followed. And this is really a no-brainer. This is what you would do to design anything, any structure. So some other design considerations would go into the analyzing and designing these various elements. There are wells between the cell to base plate, base plate to pedestal, and cell to cell.

Then obviously, these local stresses caused by the impact loads, the rattling loads, the cell wall may buckle, because of the heavy fuel load on the base plate. Secondary stresses as I said, they are also looked at.

And then the compute, you need to compute the stress in the fuel assembly to make sure the integrity of the fuel assembly is maintained. And that is done by checking the stress in the cladding which holds the fuel palate together, and the structural integrity of the fuel stressor grates.

So how you go about doing your analysis and design, you calculate the forces, what you get from knowing your seismic analysis of these racks, and mechanical accident load. Then you combine those responses of the forces and the given element, for example, well design or rack wall design, and combine them according to a load combination which was shown before. And then you calculate the maximum stress.

You compare that maximum stress with the acceptance limits that I specified in Section 3 of the ASME code, subsection NF. That provides the limits for various service levels, A, B, and D. And you compute the safety factor or margin, if you will, the ratio of the allowable to the calculated stresses. Now, in all cases, the staff finds that the ratio is always greater than one. And that's a requirement.

MEMBER STETKAR: B.P.? In your response to Dick, you mentioned some section that would analyze the load on the spent fuel pool liner, if I were to drop the fuel assembly into the spent fuel pool. I can't seem to find that in the DCD, at least the section that you mentioned.

MALE PARTICIPANT: And neither can I.

MEMBER STETKAR: Could you confirm that indeed the design certification evaluates that load and where it is?

MR. JAIN: Well, like I said, we were going to make it an action item. I'm not familiar. I did not --

MEMBER STETKAR: I'm trying to do it real time here, and I'm not coming up quickly with anything.

MR. JAIN: Well, I was thinking more like the staff's SER would address that.

MEMBER STETKAR: Okay. Well, it ---

MR. JAIN: And again ---

MEMBER STETKAR: -- should be addressed in the DCD someplace.

MR. JAIN: I can only ---

MEMBER STETKAR: Anyway, just take it away and if you can get ---

MR. JAIN: Yes, yes. Sure. I'm just going by my experience with other designs. So am not familiar with this particular design spent fuel pool. So I could not be certain.

So these are the acceptance limits, what the stresses, computer stresses are checked against, some other things we talked about already. These stresses are from subsection NF, ASME code Section 3. Material properties, we'll use that 200 degrees to maximize the thermal load and get the lower allowables.

And the -- I guess Service Level 8, they are all consistent but specify the code, NF, Section 3320. And then for service level D, that was used mostly for seismic and mechanical accident loading. They used that too in Appendix F of that section, 1334. And it's all consistent.

Since we've got free-standing racks, the sliding and overturning is a concern. And the requirement is that the fact of safety against sliding or overturning should be at least 1.5.

We find these acceptance criteria, what KHNP used, they're consistent with Appendix D in SRP Section 3.8.4 and 3.8.5. And 3.8.5 talks about the fact of safety against sliding and overturning. And therefore, we find the acceptance criteria used for the design of these racks acceptable.

Material, quality control programs, and inspections, the rack material is reviewed by staff under Section 9.1.2, so same material, SA type 240. That's been used for all racks, not only for this one but other designs. So material is consistent.

Fuel assembly data is from PWR PLUS7 assembly. Design and fabrication inspection is per NF requirements, Section 3 code. Quality control, QA program, QC program, they commit to Appendix B for quality control program. And then 10 CFR 5065 regarding monitoring to ensure that the racks are capable of fulfilling their intended functions during operation and after.

So the staff finds these codes and their commitment to the QA programs and inspections consistent with the SRP requirements. And they find it acceptable.

KHNP identified a few small items, four to be more specific. First one is periodic condition monitoring, the need to continue to remain valid. It's one of the things that you mentioned about the way they fabricate and put it in place. Is that important? Well, that's how they maintain the check, by periodic condition monitoring, that they are not drifting apart or they continue to maintain the geometry which was analyzed for it.

They need to perform the confirmatory dynamic analysis to make sure that, at a given site, their design stresses still remain valid. They also need to develop plant procedure and admin control for handling the fuel over the pool, the specific admin controls.

And for seismic, they need to do inspection to see if the racks have drifted apart. And if they have, then they need to bring them back in analyzed condition or demonstrate why they're still adequate, if they don't take any corrective action. So that's one of the core items. So staff finds those acceptable and reasonable.

For the conclusion, the staff has reached that, based on its review, that the structural design of the fuel racks meets the ASME code, Section 3, Subsection NF, design requirements. Minimum factor of safety for the fuel racks seismic event, including a mechanical accident scenario, is 1.19.

The spent fuel rack displacement to the design basis seismic events is small and do not close the large gap of 33 inches between the wall and the spent fuel pool racks. The relative displacements of the spent fuel pool racks is about quarter inch, 0.28 inches, due to design basis size. And the rack to rack separation is 1.18 inch. So that gives you a margin against impact of four.

For the other variety of racks, which is in Region I, the margin is a little greater. It's better than six, simply because they're separated to begin with, so the gap between them is larger. So it gives you a larger factor of safety.

Free standing racks, they do not overturn during seismic events. And factor of safety is much, much better than 1.5 against sliding and overturning. It's on the order of, I believe, it's 15, if I'm not mistaken. Because the displacement is so small, and the rack is very heavy, it doesn't go --- it cannot tip. It's not able to tip.

So due to small seismic movements, criticality analysis, which has been performed for normal conditions, still remains valid. And they continue to provide the function, what they're designed for. That's what the staff's conclusion is.

CHAIRMAN BALLINGER: I had a question -- I got it. I was trying to go back and look at my notes, but I couldn't find it. The SA-564, grade 630, steel for the bolts, that's a precipitation hardened stainless steel. And it's offered in multiple heat treatments to vary the strength.

Can you tell me which heat treatment is going to be used? There are at least three aging treatments. The very high strength one is the lowest temperature age, but it is susceptible to hydrogen embrittlement.

MR. JAIN: I would pass that question to KHNP. I'm not knowledgeable in that area. I could not answer the question. We can take it back to KHNP and get you a specific answer.

CHAIRMAN BALLINGER: Yes. This material is otherwise known as, I think, 17-4 PH which is a more common name for it. But the very high strength version is ---

MR. YESHNIK: I'm not exactly --

CHAIRMAN BALLINGER: -- be careful.

MR. YESHNIK: I'm not exactly sure if I have that off the top of my head. I want to say it's the 1100 degrees Fahrenheit heat treatment.

CHAIRMAN BALLINGER: Okay. The 1100 one is the better one.

MR. YESHNIK: Okay. And also this material is in compression, so hydrogen embrittlement really isn't going to affect --

CHAIRMAN BALLINGER: Well, except for during seismic loading and things like that.

MR. YESHNIK: I mean, maybe.

(Simultaneous speaking)

CHAIRMAN BALLINGER: We're all into maybe.

MR. YESHNIK: Yes.

MR. JAIN: The staff will get back to you more specifically.

CHAIRMAN BALLINGER: It's the 900 F aging treatment that's usually the most problematic. And they use this material for bolts at the bottom of the Macondo Oil Platform which failed.

MR. JAIN: Well, this concludes my presentation with the new spent fuel and spent fuel pools storage racks. They will maintain a coolable geometry preventing criticality and protect the fuel assembly from seismic and mechanical loading factors. That's what the staff's review indicates.

MEMBER KIRCHNER: B.P., just out of curiosity, when in another section, wherever it is, when you look at the actual pool design, do they use the same -- do you use a consistent set of assumptions, in terms of seismic loading, and history, and such, that's compatible with how the racks are loaded?

MR. JAIN: They need to be, yes.

MEMBER KIRCHNER: Yes, okay.

MR. JAIN: They need to be.

MEMBER KIRCHNER: Where would we find that other analysis. I'm trying to think, that's ---

MR. JAIN: Again, it should all be addressed or should be addressed in that SER for spent fuel pools and the liner.

MEMBER KIRCHNER: And they will look at things like hydrodynamic loading on these racks there.

MR. JAIN: Well, there would need to get the factor --

(Simultaneous speaking)

MR. JAIN: -- yes, the factor of the racks in the pool.

MEMBER KIRCHNER: Yes. Thank you.

CHAIRMAN BALLINGER: And I have one more. I think you may have addressed this in an earlier presentation. But you said that when you do the drop analysis, you assume that the fuel racks are fully loaded.

MR. JAIN: Correct.

CHAIRMAN BALLINGER: So have you looked at the situation where you have an open cell, and you get a drop on an adjacent fuel assembly? Does that do anything to change the configuration, crush the open cell area?

MR. JAIN: No. I don't believe that scenario has been considered, simply because we do not believe that that's -- the parameter we are trying to view, in looking at, will really affect that parameter, meaning would it increase the deflection of the base plate of the fully loaded racks. It will not.

Number two, would it increase the load on the pedestal? It's not going to do that either. So from the postulated mechanical accident, what you're viewing here and what the possible effect of the parameter we are trying to maximize, we believe that, if that were the case, that would need to be covered.

CHAIRMAN BALLINGER: Thank you.

MR. JAIN: Just to add that, there's sufficient margin on top of it. So if there were uncertainties, the minimum margin is 1.4. That's against the concrete. But if you talk about the racks and the base plate, that structure, the margin there is even much larger, like two to three. So, you know ---

CHAIRMAN BALLINGER: Is that it for your presentation?

MR. JAIN: Yes, I'm done.

CHAIRMAN BALLINGER: Okay. We're going to have a transition between the open session and the closed --

MEMBER POWERS: No, you're ---

CHAIRMAN BALLINGER: Pardon?

MEMBER POWERS: No, you're not. You're going to ask for public comment.

CHAIRMAN BALLINGER: I was about to get there. That's why I was making the comment.

MEMBER POWERS: You're slow. You're very slow.

CHAIRMAN BALLINGER: Yes, I am slow, okay. So that means we'll need public comments now for this presentation. So while we're getting the --

MR. BROWN: Professor Ballinger, they're not done their presentation.

CHAIRMAN BALLINGER: They're not?

(Off microphone comments.)

CHAIRMAN BALLINGER: That's part of my slowness. Okay. Continue.

MR. WUNDER: Andrew?

MR. YESHNIK: Okay. Well, good morning, everyone. My name is Andrew Yeshnik and I am the reviewer for the materials and chemical engineering issues with the spent and new fuel rack. My slide is going to be pretty brief because you've already seen this information today.

So, the spent and new fuel racks are designed with normal materials that we would expect to see in these applications. We have type 304Ls, authentic stainless steel, and type 630, the PH grade which we already talked about. And I did take a look at the DCD, and it is the 1100 degrees Fahrenheit heat treatment on those.

The spent fuel racks also have the metamic neutron absorber which is not credited for any structural capacity. The spent fuel liner is type 304 stainless steel. The spent fuel racks are designed, fabricated, and inspected to the requirements of Section 3NF and the liner is ASTM grade, but the quality assurance is upgraded with ASME NQA1 in Appendix B QA program.

The new fuel is stored in dry storage, so there's no expectation of any degradation mechanisms for that. The spent fuel is stored in the spent fuel pool. The water chemistry is in conformance with the EPRY primary water chemistry guidelines which is described in SR Section 9.1.3 and evaluated in Staff's SVRN Section 9.1.3.

And the coupon monitoring program for the metamic material is described in Section 9.1.1 and in Staff's SVRN, and we found that to be acceptable. So for the racks themselves, the authentic stainless steel has sensitive controls and delta ferrite content controls that are consistent with Staff guidance. And the cleanness of the new spent fuel racks are consistent with NQA1 subpart 2.1.

So in general, Staff finds that the approach that the Applicant had is consistent with the SRP, and we found it to be acceptable. I think that concludes all of my comments for this. So if there's any questions, if not we'll pass it on to Raul.

MR. HERNANDEZ: Well, good morning. My name is Raul Hernandez. I'm the reviewer for our plant systems branch. And I looked at the fuel storage as a system.

The new fuel storage feed and the spent fuel pool were looked into making sure that they maintain their safety function which is that the assemblies are maintaining a safe and sub-critical array during all credible storage conditions and to provide a safe means to load the spent fuel into shipping casks, like, making sure that as a system overall, all the different components that have been presented, that the fuel is going to remain safe.

The Staff reviewed the design of storage systems and the new fuel storage PID and the spent fuel in accordance with the guidance in SRP 912. Particular, we looked into the configuration and the design of, seismic design of the different components that are credited to maintain the pool level and the safe location, making sure that all of them be properly identified as required.

When a system is required to be seismic one, it's included in Chapter 3, and that's already been presented to the Commission here. The Staff issued several RAIs, and the Applicant has addressed all the RAIs satisfactorily. There's no open items in this section.

The Staff determined that the fuel source system is designed in accordance with the SRP guidelines and meets all the applicable regulations including GDCs 2, 4, 5, 61, 63, the ALARA concerns, and 20.1406.

This is going to be brief. There's no major issue here. Is there any question in the overall design of the pool?

(No audible response.)

MR. HERNANDEZ: That's the last of my items. Then we go to the --

MR. WUNDER: Okay, now we're -- that concludes the Staff presentation of Section 9.1.2.

So now all we have to do is go through the few open items we have. And if I could change out BP Jane for DK. Thank you.

And the first item I believe belongs to Alex Burja who is on the phone. So if we can get her unmuted.

MEMBER STETKAR: Alex, if you're out there, just say something. You should be unmuted.

MS. BURJA: Can you hear me now?

MEMBER STETKAR: Yes.

MS. BURJA: Okay. I'm not sure what happened, but I'm here now. So, is my slide up?

MR. WUNDER: It is.

MS. BURJA: Okay, great. So at the time of our last presentation, the two items that remained open associated with DCD Section 9.1.1, criticality safety of new and spent fuel storage, were mainly associated with ongoing work or resolution of disuse and other review areas that might have potential impact on Section 9.1.1.

The first issue involved the effect of thermal conductivity degradation. In particular, the Staff had asked in an RAI un Section 9.1.1 how the maximum fuel temperature assumed for the depletion calculation in the burn up credit criticality analysis accounted for GPD.

This issue was resolved because in the response to RAI 7954 which was related to the plus seven fuel design topical report, the Applicant showed that the assumed maximum fuel temperature and the criticality analysis found the accepted maximum fuel temperature for this design plus the Staff approved CPD penalty. So therefore, it is acceptable to the Staff.

The second open item which related to the mechanical analysis review. So as a Phase II and Phase III Staff's review of the storage rack mechanical analysis technical report was incomplete, and there were several technical issues that remain to be resolved.

So due to these issues, the Staff was unable to determine whether any mechanical accidents could have impact on criticality. But as you just heard, this issue was resolved because the Staff an Applicant worked to resolve the technical issues related to the storage rack mechanical analysis technical report, and the Staff has completed its review of the report.

The Staff concludes that the criticality analyses found any criticality related effects of the analyzed mechanical accident. Are there any questions?

CHAIRMAN BALLINGER: Fifteen second rule is applied. No questions.

MS. BURJA: Thank you.

MR. WUNDER: Eighty-five seventy-eight is yours, isn't it?

MR. YESHNIK: Yes.

MR. WUNDER: Okay.

MR. YESHNIK: I thought that there was another party --

MR. WUNDER: No, that's it.

MR. YESHNIK: Okay. So, my open item is Question 9.1.1-37, and it involved a question on the exposure of the metamic material to elevate temperatures during fabrication, and whether the neutron absorber coupons needed to be heat treated to reflect that condition.

And the Applicant stated that the qualification testing has already demonstrated that there is no effect on neutron absorbing properties. The Staff re-looked at the qualification testing that's at the bottom of the slide and agreed that the 900 degree tests for 48 hours demonstrating that there is no change is sufficient.

And the Staff also reviewed generic

literature and concluded that the welding temperatures are bounded by normal manufacturing temperatures so that there is no predicted issue. And that's it.

MR. HERNANDEZ: Section 9.1.3 contained, at the time of the presentation of Section 9.1.3 to the Subcommittee, Section 9.1.3 contained an open item. And this open item was related to the assumptions used on the spent fuel pool, thermal hydraulic analysis.

The Staff had identified some apparent inconsistencies between the information on the DCD and the assumptions used on the thermal analysis, the Applicant responded to the Staff's RAI by revising the thermal hydraulic calculation and making this calculation available for the Staff to audit.

They provided clarification of the assumptions used under thermal analysis and proposed DCD markups that have already been incorporated into the DCD. The Staff reviewed the information that was provided in the RAI, the DCD, and the technical report that summarized the thermal hydraulic analysis and confirmed that the revised thermal hydraulic analysis used conservative assumptions that are consistent with the SRP guidance, and therefore meets the applicable GDC in this case, GDC 61.

MEMBER STETKAR: Raul, I'm just going to bring this up when we discuss Section 19.3. But since you're here and I'm not sure that you'll be here for that section, let me just ask you about it.

If I look at the differences in those times that you mentioned, I understood I would say in my opinion a rather substantial difference that the time to heat up and boil off water for example to within ten feet of the top of the fuel assemblies went from about 25 hours down to about a little over 15 hours.

That to me, these are numbers that are in section 19.3, but they're related to heat up and boil off of spent fuel pool inventory, which is not directly related to the design of the spent fuel pool cooling system.

But I'm curious about what did they do in the revised analyses that would result in such differences in heating up and boiling water?

MR. HERNANDEZ: You are looking at two different thermal analysis.

MEMBER STETKAR: Well, I'm looking at one pool that heats up.

MR. HERNANDEZ: Yes. But the difference is this. In Section 9.1.3, we're looking at the thermal analysis of the performance of the safety related cooling system.

And the initial conditions are different. This is a design basis event. So you have less water and a different set of initial conditions. When you're looking at Chapter 19, accident scenarios, the guidance for Chapter 19 is from -- your initial set of conditions are different.

You're not on the design basis event. You're already, you start from normal conditions and then you have this beyond design event. So those two are not exactly comparable events. You have different water levels, different heat loads, different conditions.

MEMBER STETKAR: All right. I'll wait until this afternoon, then. Thank you.

MR. KALATHIVEETTIL: Good morning, everyone. My name is Don Matthews Kalathiveettil, and I will be presenting the closure of two open items with respect to Section 9.5.2, communication systems.

First open item was RAI 548 Question 9.5.2-6. The issue was that the Applicant had classified all the communication systems as non-safety related. And the DCD stated that the communication systems did not require compliance with 10 CFR Part 50 Appendix GDC's 1, 2, 3, and 4.

Since compliance with these GDCs is part of the acceptance criteria of SRP Section 952 and the availability of these communication systems is important for programs that has emergency planning, the Staff did not agree with the Applicant's stance and requested through the RAI to demonstrate how the communication systems would meet the applicable GDCs.

The Applicant's response to the RAI included a commitment that the design of the communication systems will comply with GDCs 1, 2, 3, and 4. It also included detailed markups of the DCD that explained how the communication systems would meet all the applicable GDCs.

Subsequently, the Staff reviewed the information we just provided by the Applicant and determined that the design information and commitment given by the Applicant was sufficient to meet the intent of DCDs 1, 2, 3, and 4.

The second open item was RAI 548 Question 9.5.2-7. The issue was that the DCD lacked sufficient information in APRIL 1400 FSR Tier 1 Table 2.6.9-1. This table contains the various ITAAC related to the communication systems. 10 CFR 52.47(b)(1) requires that it is answered in certification application contains the necessary and sufficient ITAAC.

Hence, the Staff requested additional information through the RAI. The Applicant's response to the RAI included detailed markups in which it was explained which procedures are needed to ensure that each communication subsystem would be able to perform its required function.

It also included the necessary and sufficient information about each subsystem in the ITAAC and acceptance criteria sections of Table 2.6.9-1. Subsequently, the Staff reviewed the information provided by the Applicant and determined that sufficient detail was now provided in Tier 1 to meet the intent of 10 CFR 52.47(b)(1).

This basically concludes my presentation for this section. Any questions?

CHAIRMAN BALLINGER: Once again, we now can -- well, we're transitioning.

MEMBER STETKAR: Will there be a closed session?

CHAIRMAN BALLINGER: There will be a closed session. So we would like public comments now for what has been presented so far. Is there anybody in the room that would like to make a comment?

MR. OH: This is Andy Oh, KHNP Washington Office. Before finishing this session, the KHNP would like to correct something regarding tub and tubing aux feedwater room heater calculations. First thing is that for members that is the temperature profile.

So our temperature profile indicated that about the 52 hours in room, the temperature is at 140 Fahrenheit and 72 hours it increased to 145.

MEMBER STETKAR: Andy, let me make sure I have that. At what time is 140?

MR. OH: Fifty-two hours, 140.

MEMBER STETKAR: Okay.

MR. OH: Seventy-two hours, 145.

MEMBER STETKAR: So, okay.

MR. OH: It is in an increasing slope. It is approximately 2.25 Fahrenheit per hour. That's the first question, your first answer from the member. Second is one of our, the technical staff had mentioned that there's no electrical the INC equipment inside the tub and tubing aux feedwater room.

But when we checked our design document, we identified the control panel is located inside tub driven aux feedwater room.

MEMBER STETKAR: All right, thank you.

MR. OH: We corrected that fact. And second thing is -- third thing is that staff member indicated there is two different criteria is used in the room heater calculation. One is 120 Fahrenheit, the other is 150 Fahrenheit.

KHMP is using the criteria from the NUMARC 87-00. That says condition one is equipment located in the condition one room are considered to be a low constant with respective elevated temperature effect, and will likely require no special action to assure operability for our station blackout.

That is category one. NUMARC 87-00 recommend to use that 120 Fahrenheit, and specifically there's some example for that is for -- example is they specified that exempt means electrical equipment instrumentation how they did category one.

And also, it indicated that there is category two room is equipment located in condition two rooms generally requires not force the cooling in order to ensure operability for a four hour station blackout. And also they make some specific example for that room is for either is RCIC and feedwater room is steam driven aux feedwater pump room.

That is our basis to using what that criteria for the room feeder calculation. In conclusion that we used the 150 Fahrenheit as a criteria, and we also notify with that that we have some control panel inside it that aux feedwater, the temperature in the aux feedwater room.

So in order to protect that equipment, the KHMP 1400 design and the equipment spec is that some that equipment have to survive over 160 Fahrenheit. That is also very consistent with the single core design.

MEMBER STETKAR: Thank you. That clarifies at least my understanding of what is in that room. And it does clarify the fact that the electrical and INC equipment inside that room must be qualified to a substantially higher temperature than other electrical and INC equipment throughout the plant. So we have that on record now. Thank you.

CHAIRMAN BALLINGER: Okay, back to the, are there any comments from the public in the room?

(No audible response.)

CHAIRMAN BALLINGER: Hearing none, are there any members of the public on the bridge line that would like to make a comment?

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

CHAIRMAN BALLINGER: Yes, Marvin?

MR. LEWIS: Wonderful, thank you. Appreciate it greatly. Look, I listened to this, and as you well know, I listen to other ACRS meetings and what have you. And one of the things that has been bothering me for a long time, but I think especially here, is when you start talking about things that are not easily traced, this often falls under category of warehouse.

In other words, suppose you need a bolt or a nut to finish a shipment, what do you do? You grab a bolt and a nut that looks like it and throw it into the bin and ship it. That's called warehouse.

And I just was wondering, it may not be here, but how do you assure that the right materials come through and are just not picked up to finish a shipment? Thank you.

CHAIRMAN BALLINGER: Thank you. Are there any other members of the public that would like to make a comment?

(No audible response.)

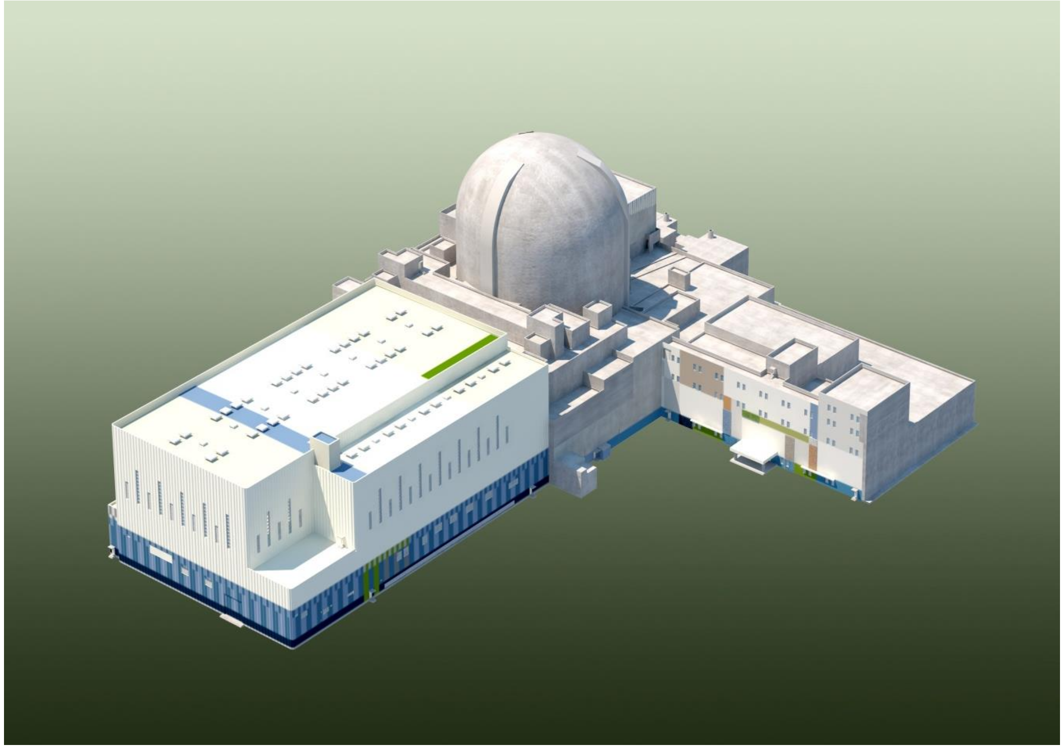
CHAIRMAN BALLINGER: Hearing none, we'll

close the bridge line. And we're now going to make a transition, so it's time to make a break. We'll break until about 20 minutes 'til. And at that time, we'll have a closed session.

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

NON-PROPRIETARY

APR1400 DCA
Chapter 9: Auxiliary Systems



KEPCO/KHNP

February 21, 2018

ACRS SC Meeting (Feb.21, 2018)

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Overview of Chapter 9

❖ Section Overview

Section	Title	Major Contents
9.1	Fuel Storage and Handling	• Criticality Safety of New and Spent Fuel Storage • New and Spent Fuel Storage • Spent Fuel Pool Cooling and Cleanup System • Light Load Handling System (Related to Refueling) • Overhead Heavy Load Handling System
9.2	Water Systems	• Essential Service Water System • Component Cooling Water System • Domestic Water and Sanitary Systems • Ultimate Heat Sink • Condensate Storage Facilities • Chilled Water System • Turbine Generator Building Closed Cooling Water System • Turbine Generator Building Open Cooling Water System
9.3	Process Auxiliaries	• Compressed Air and Gas Systems • Process and Post-Accident Sampling System • Equipment and Floor Drainage Systems • Chemical and Volume Control System

Overview of Chapter 9

Section	Title	Major Contents
9.4	Fuel Storage and Handling	• Control Room HVAC System • Fuel Handling Area HVAC System • Auxiliary Building Clean Area HVAC System • Turbine Generator Building HVAC System • Engineered Safety Features Ventilation System • Reactor Containment Building HVAC System and Purge System • Compound Building HVAC System • Design Features for Minimization of Contamination
9.5	Other Auxiliary Systems	• Fire Protection Program • Communication Systems • Lighting Systems • Emergency Diesel Engine Fuel Oil System • Emergency Diesel Engine Cooling Water System • Emergency Diesel Engine Starting Air System • Emergency Diesel Engine Lubrication System • Emergency Diesel Engine Combustion Air Intake and Exhaust System • Gas Turbine Generator Facility

Overview of Chapter 9

❖ List of Submitted Documents for Chapter 9

Document No.	Title	Revision	Type	ADAMS Accession No.
APR1400-K-X-FS-14002 -P & NP	APR1400 Design Control Document Tier 2: Chapter 9 Auxiliary Systems	0	DCD	ML15006A048
		1	DCD	-
APR1400-K-X-IT-14001 -P & NP	APR1400 Design Control Document Tier 1	0	DCD	ML15006A039
		1	DCD	-
APR1400-Z-A-NR-14011	Criticality Analysis of New and Spent Fuel Storage Racks	1	TeR	ML17094A138
APR1400-H-N-NR-14012-P/NP	Mechanical Analysis for New and Spent Fuel Storage Racks	3	TeR	ML17242A310

❖ Summary of RAIs

No. of Questions	No. of Responses	No. of OI
277	277	5

Overview of Chapter 9

❖ List of Main Topic in Section 9.1.2

No.	Related RAI	Topic	ADAMS Accession #
1	287-8272 (Q 09.01.02-15)	Seismic Load	ML17243A348
2	287-8272 (Q 09.01.02-20)	Seismic Analysis of Racks	ML17244A512
3	287-8272 (Q 09.01.02-23 & 24)	Mechanical Accident Analysis	ML17244A512

Overview of Chapter 9

❖ List of Open Items

No.	Related RAI	Topic	ADAMS Accession #
1	RAI 167-8191 (Q 09.01.01-13)	Abnormal Conditions	ML15344A144
2	RAI 469-8578 (Q 09.01.01-39)	Neutron Absorber Material	ML16169A030
3	RAI 473-8582 (Q 09.01.03-4)	Minimum safety water level of SFP	ML16123A040
4	RAI 491-8613 (Q 09.05.02-4)	10 CFR Part 50, Appendix A, GDC 1, GDC 2, GDC 3, and GDC 4 in communication system	ML16222A952
5	RAI 491-8613 (Q 09.05.02-5)	1. ITAAC and ITP for communication system 2. Meaning of 'functional arrangement' in communication system	ML16211A158

9.1.2 New and Spent Fuel Storage

❖ Key Design Features

- New Fuel Storage Rack (NFSR)
  - Two modules (Total 112 cells) of NFSRs are constructed of stainless steel, and are designed as seismic Category I.
  - NFSRs are located in the NFP, and are bolted to embedment plates at the bottom of the pit to preclude tipping.
- Spent Fuel Storage Rack (SFSR)
  - SFSRs are constructed of stainless steel, and are designed as seismic Category I.
  - SFSRs are located in the SFP, and are freestanding with pedestal resting on embedment plates. SFSRs are made up of Region I (Total 352 cells) and Region II (Total 1,440 cells) and provide total 29 rack modules. (Total 1,792 cells)
  - METAMIC™ is used as a neutron absorber.

9.1.2 New and Spent Fuel Storage

❖ Safety Evaluation

- Dynamic simulations for total of 36 cases runs (including sensitivity runs) are performed to determine the loads and displacements for each rack.
- NFSRs and SFSRs under the postulated mechanical accident possess acceptable margins of safety.
- NFSRs and SFSRs are designed to meet the requirements which are specified on SRP 3.8.4, Appendix D and ASME Section III, Subsection NF, Class 3 component supports.
- In response to NRC feedback on both the TeR and RAI No. 8272 responses, APR1400-H-N-NR-14012-P was completed (as Rev. 3) on August, 2017.

Summary of Main Topic in Section 9.1.2

❖ Seismic Load

- Related RAIs : 287-8272 (Q 09.01.02-15)
- Description of issue :
  - Staff requested to clarify and confirm that it used at least the five sets (greater than required four) of time histories for the nonlinear structural analysis of the NFSR and SFSR.
  - Technical adequacy justification for artificial time history sets.
- Resolution:
  - KHNP developed five sets of artificial acceleration time histories for three orthogonal directions specific to the NFSR and SFSR.
  - The suitability of the time histories was verified in accordance with SRP 3.7.1, Option 2, criteria for multiple sets of time histories.

Summary of Main Topic in Section 9.1.2

❖ Seismic Analysis of Racks

- Related RAIs : 287-8272 (Q 09.01.02-20)
- Description of issue : Staff requested to provide the followings:
  - Sufficient information of the rack and FA model and its parameters (e.g., spring elements, hydrodynamic mass, time history integration time step) considered for the seismic evaluation of NFSR and SFSR
  - Sensitivity analysis results of the impact forces and rack responses to variation in spring constants considered in the nonlinear seismic analyses
  - Sensitivity analysis results of the integration time step used in performing the nonlinear time history analyses for SSE.

Summary of Main Topic in Section 9.1.2

- Resolution:
  - KHNP provided a detailed description of the Rack and FA model. NFSR and SFSR models are composed of 3-D elastic beam elements and lumped mass elements with properties derived from the dynamic characteristics of the detailed 3-D shell model of the racks.
  - Sensitivity analyses were performed for spring constants (i.e., stiffness) in the model; rack-to-floor, rack-to-rack and fuel-to-rack stiffness's at ±20% of the nominal value. The effect of the sensitivities was a change in predicted loads within the variation found for different time histories and less than the variation for different COFs.
  - Comparison of a run at one half the fixed time step used for all other runs showed small changes in calculated results comparable to the run to run variation with different time histories.

Summary of Main Topic in Section 9.1.2

❖ Mechanical Accident Analysis

- Related RAIs : 287-8272 (Q 09.01.02-23 & 24)
- Description of issue : Staff requested to provide the followings:
  - A nonlinear dynamic analysis for the impact effects of drop accidents, considering a finite element model
  - Location of the drop on the rack base plate that were considered to maximize the deformation of the rack base plate and whether it also considered a deep drop into a cell along the perimeter and half way between the supports
  - Consider all other fuel assemblies in place when a fuel assembly drops through an empty cell

Summary of Main Topic in Section 9.1.2

- Resolution:
  - KHNP responded that all drop accidents are analyzed by developing a finite element model of the rack, rack base plate, a fuel assembly and the pedestal support using appropriate shell, beam, and solid body elements of ANSYS LS-DYNA program.
  - Drops as far away from the support provided by a pedestal are considered at two locations (a central cell and a peripheral cell at the midpoint of a side) that maximize the distance to the points of support.
  - The effects of all of the stored fuel assemblies in the rack is considered by modifying the density of the baseplate to simulate the loading effects of the other fuel assemblies.

Summary of Open Items

❖ Open Item: Abnormal Conditions

- Related RAIs
  - RAI 167-8191 (Q 09.01.01-13)

- Description of issue
  - The staff is unable to confirm the applicant's statement that the mechanical accidents do not cause rack deformation that would affect criticality, until the seismic and structural review of the new and spent fuel storage racks (APR1400-H-N-NR-14012-P) is complete.

- Resolution:
  - KHNP provided that any damage to the racks is limited to portions above the neutron absorber and does not affect their configuration relative to the criticality analysis. The staff's review for APR1400-H-N-NR-14012-P, "Mechanical Analysis for New and Spent Fuel Storage Racks" was completed.

Summary of Open Items

❖ Open Item: Neutron Absorber Material

- Related RAIs
  - RAI 469-8578 (Q 09.01.01-39)
- Description of issue
  - The staff concerns regarding the adequacy of utilizing as-fabricated Metamic™ coupons in the neutron absorber monitoring program because the Metamic™ material will be heated during fabrication (due to welding).
- Resolution:
  - KHNP provided that welding near the neutron absorber would not have an effect on corrosion resistance or neutron absorption of the material. The Metamic™ material qualification included exposing Metamic™ to a 900°F environment for 48 hours and examining the cooled material for changes in material properties. The qualification test demonstrated that the 48 hours in a 900°F environment resulted in no change in areal density, product weight, or dimensions.

Summary of Open Items

❖ Open Item: Spent Fuel Pool Cooling and Cleanup System

- Related RAIs : 473-8582 (Q 09.01.03-4)
- Description of issue
  - Staff request to identify the minimum safety water level of SFP and update the DCD accordingly.
  - Staff request to revise the thermal-hydraulic calculations using the revised minimum safety water level and update the DCD accordingly.
  - Additionally, the staff identified that the normal water level has been identified as elevation 154’, while in other places it shows as elevation 153’.
- Resolution:
  - The minimum safety water level for SFP was provided through the response to RAI 473-8582, Q 09.01.03-4.
  - Thermal-hydraulic calculation has been revised based on minimum water level (EL. 146’).
  - KHNP proposed DCD changes in order to indicate clearly that these two levels (EL. 153’ in Technical Specifications and EL. 154’ as normal water level) represent different conditions through the response to RAI 473-8582, Q 09.01.03-5.

Summary of Open Items

❖ Open Item: Communication System

- Related RAIs : 491-8613 (Q 09.05.02-4)
- Description of issue
  - Staff requested to justify why the communication systems are not considered as risk significant SSCs, related to the requirements of 10 CFR Part 50, Appendix A, GDC 1, GDC 2, GDC 3, and GDC 4.
  - Staff issued a follow-up RAI 548-8822, Q 09.05.02-6.
- Resolution:
  - KHNP responded that the communication systems of the APR1400 are designed to meet GDC 1, GDC 2, GDC 3, and GDC 4 and do not interface with any safety-related or risk-significant SSC.
  - The four communication subsystems are designed to assure that any single event does not result in a complete loss of plant communication.

Summary of Open Items

❖ Open Item: ITAAC and ITP for communication system

- Related RAIs : 491-8613 (Q 09.05.02-5)
- Description of issue
  - Staff requested to provide the detailed description of all ITAAC items along with their acceptance criteria and ITP for the communication systems in Section 14.2.
  - Staff requested to clarify what the applicant means by functional arrangement of communication systems.
  - Staff issued a follow-up RAI 548-8822, Q 09.05.02-7.
- Resolution:
  - KHNP provided the new ITP for plant communication system and the detailed description of all ITAAC items for communication system through the response to RAI 548-8822, Q 09.05.02-7.
  - KHNP revised DCD Tier 1, Subsection 2.6.9 providing the detailed description of plant communication systems instead of the term of functional arrangement.

Response to Phase 3 Questions

❖ The Question in ACRS APR1400 Subcommittee on May 18, 2017

- 9.2.7 Chilled Water System
  - Question: The basis for the non-safety-related plant chilled water system to provide cooling for the safety related turbine driven auxiliary feedwater (TDAFW) pump room
  - Response:
    - In order to avoid damage caused by HELB accident to safety-related system (ECW), non-safety-related cubicle cooler is installed in the TDAFW pump room.
    - The heat-up calculation is performed to determine the maximum temperatures in the TDAFW pump room under the loss of cooling.
    - TDAFW pump shall be qualified to be operable at maximum temperature for the operation period.

Response to Phase 3 Questions

❖ The Question in ACRS APR1400 Subcommittee on May 18, 2017

- Summary for Heat-up calculation of turbine driven auxiliary feedwater pump room
  - Purpose:
    1) To determine the maximum temperatures in the TDAFW pump room
    2) To demonstrate that the maximum temperature of the room does not exceed the maximum allowable temperature during 72 hours under loss of HVAC system
  - Calculation Program: GOTHIC (Generation of Thermal-Hydraulic Information for Containments) program
  - Maximum Allowable Temperature: Maximum allowable temperature, 150 °F of the room is decided based on the steady-state temperature of Condition 2 mentioned in NUMARC 87-00
  - Result : The TDAFW pump rooms are maintained below 150 °F during 72 hours under loss of cooling.

Current Status

- **Chapter 9 is complete**
  - KHNP continues to monitor Chapter 9 to assure any conforming changes are addressed.
  - 5 open items, that were identified in Phase 2 and 3, have been resolved with adequate and sufficient discussion with the staff.

- **Changes in Chapter 9 as reviewed and marked-up in response to the RAIs will be incorporated into the next revision (Rev.2) of the DCD**

Attachment: Acronyms

COF	Coefficient of Friction
COL	Combined License
DCD	Design Control Document
ECW	Essential Chilled Water System
FA	Fuel Assembly
GOTHIC	Generation of Thermal-Hydraulic Information for Containments
HELB	High Energy Line Break
ITAAC	Inspection, Test and Acceptance Criteria
KHNP	Korea Hydro and Nuclear Power Co.
NFP	New Fuel Storage Pit
NFSR	New Fuel Storage Rack
RAI	Request for Additional Information
SFP	Spent Fuel Pool
SFPCS	Spent Fuel Pool Cooling System
SFSR	Spent Fuel Storage Rack
SSE	Safe Shutdown Earthquake
TDAFW	Turbine Driven Auxiliary Feedwater

Attachment : List of COL Item related to OIs

COL Identifier	Description
COL 14.2(17)	The COL applicant is to prepare the site-specific preoperational and startup test specificatio n and test procedure and/or guideline for offsite communication system.

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Protecting People and the Environment

Presentation to the ACRS Subcommittee

Korea Hydro Nuclear Power Co., Ltd (KHNP) APR1400 Design Certification Application Review

Safety Evaluation with No Open Items:

Chapter 9 AUXILIARY SYSTEMS

February 21, 2018

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Introduction

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New and Spent Fuel Storage Racks

- Function
  - New and spent fuel storage racks provide safe storage for fuel assemblies and maintain a coolable geometry, preventing criticality, and protect the fuel assemblies from seismic and mechanical load effects

- Safety Review Scope in Section 9.1.2
  - Structural design of new and spent fuel storage racks to withstand effects of natural phenomena (seismic) and mechanical accident scenarios involving fuel assembly

- Spent fuel pool and pool liner design
  - Staff's safety evaluation of the spent fuel pool and the pool liner provided in SER Section 3.8.3.4.6

- Criticality Evaluation
  - Staff's safety evaluation of the racks criticality in provided in SER Section 9.1.1

New and Spent Fuel Storage

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Overview

- Review Highlights
  - Reviewed TR "Mechanical Analysis for New and Spent Fuel Storage Racks," APR1400-H-N-NR-14012-P, Rev. 3, August 2017
  - Review basis Appendix D to SRP Section 3.8.4,"Guidance on Spent Fuel Racks"
  - Seismic input and finite element models used for nonlinear seismic analysis
  - Mechanical accident scenarios involving dropped and stuck fuel assembly
  - Computer codes and validation
  - Analysis methodology including design parameters, and assumptions made in finite element analyses
  - Review results for reasonableness
  - Applicable COL information items
- Request for Additional Information (RAIs)
  - Staff issued 39 RAIs and all questions were resolved

Staff concludes that stresses induced in the racks and its components meet the applicable ASME Code allowable stresses, rack seismic displacement are small and do not impact each other or the pool wall and its sub-critical configuration is unaffected.

New and Spent Fuel Storage

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- Areas of Review
  - **Physical description**
  - **Applicable design codes, standards, and specifications**
  - **Seismic and impact loads**
  - **Loads and load combinations**
  - **Structural design and analysis**
  - **Structural acceptance criteria**
  - **Materials, quality control programs, and Inspection**

Physical Description

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New Fuel Storage Racks (NFSRs)

- Located in the new fuel storage pit in Fuel Handling Building
- Two identical racks, each with a 7 x 8 array of storage cells
- Total of 112 fuel storage locations
- NFSRs are bolted to embedment plates at the bottom of the pit and do not slide
- The NFSRs are constructed of stainless steel
- The center-to center spacing between adjacent fuel assemblies is designed to be 14 inches to maintain sub-criticality

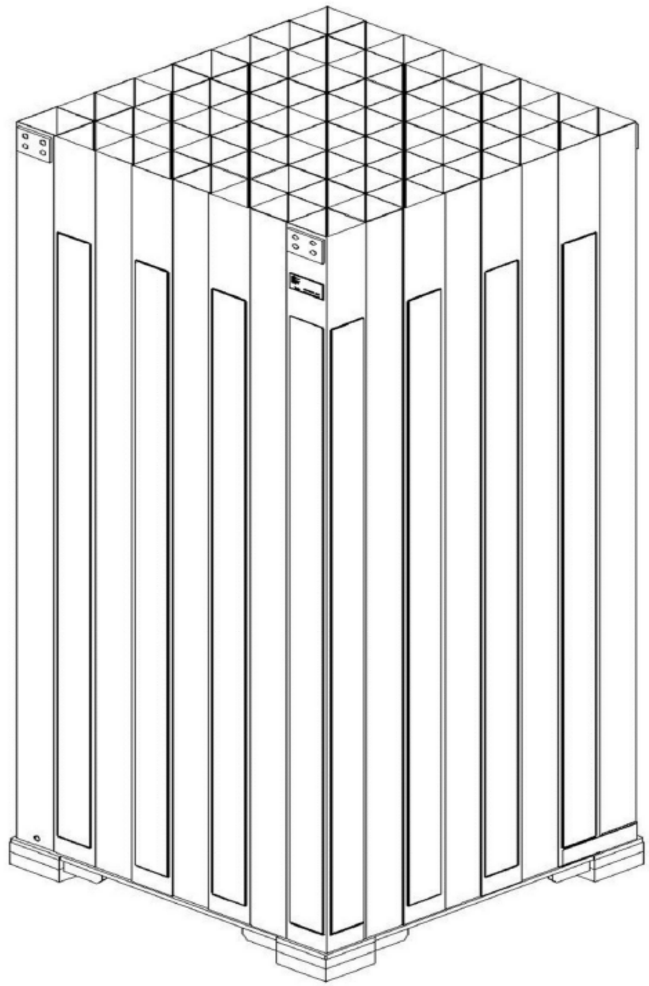
Physical Description

Spent Fuel Racks (SFRs)

- 23 SFSRs located in the Spent Fuel Pool (SFP) with gaps between the adjacent racks and the surrounding fuel pool walls
- SFSRs are freestanding, with pedestals resting on embedment plates in the reinforced concrete floor of the SFP
- The SPF is divided into two regions, region I and region II.
- Region I contains four 8 x 8 array racks and two 6 x 8 array racks; The center-to center spacing between adjacent fuel assemblies is designed to be 10.83 inches to maintain sub-criticality
- Region II contains nineteen 8 x 8 array racks and four 8 x 7 array racks; The center-to center spacing between adjacent fuel assemblies is designed to be 8.86 inches to maintain sub-criticality

Physical Description

Figure 2-8 Isometric Schematic of the SFSR
(Region II)



Design Codes, Standards, and Specification

- Applicant identified the following industry codes and regulatory guides that are applicable to the design, fabrication, construction, materials, testing, and inspections of the new and spent fuel storage racks for the APR1400 plant:

  - ASME Code, Section III, Division 1, Subsection NF and Appendix F, 2007 Edition through 2008 Addenda
  - ASME Code, Section II, “Materials,” 2007 Edition through 2008 Addenda
  - RG 1.29
  - RG 1.61

- **The staff found the use of these codes, standards, and specifications to be consistent with the guidance given in SRP Section 3.8.4, Appendix D and therefore acceptable**

Analysis for Seismic and Impact Loads

Nonlinear Seismic Analysis

Input Motion

- Target input response spectra - envelope of rack base and the SFP wall
- Input Time histories -Five time histories developed enveloping the target spectra with the guidance in SRP 3.7.1 for multiple time histories.

Analytical Model

- A 3-D coupled Rack-Fuel beam model for each rack and whole pool multi-rack model
- Hydrodynamic effects: Rack-to-rack, rack-to-pool wall, rack baseplate-to-pool floor, fuel assembly-to-cell wall
- Mass and stiffness of fuel assembly and fuel spacer grid for impact
- New and end of life (EOL) fuel properties
- Gap and contact spring and sensitivity analysis of spring parameters

Seismic analysis Methodology

- Three directional orthogonal time histories applied simultaneously
- Nonlinear seismic time history analysis performed for 5 sets of acceleration time histories

Analysis for Seismic and Impact Loads

Seismic and Impact Loads

- Nonlinear seismic analyses performed for three values of the coefficient of friction: 0.2, 0.5, and 0.8
- Considered the configurations of the SFSR at full, 25-percent full, 50-percent full, and empty mixed loadings and the NFSR fully loaded
- The numerical solution was obtained by direct integration of the nonlinear equations of motion
- Considered sensitivity analysis for Integration time step
- Considered 20 Dynamic simulation
- Considered additional 16 simulations for the sensitivities of various seismic model parameters (e.g., gap springs stiffness)
- Validated and verified (V&V) ANSYS Computer code for nonlinear fuel rack analysis

The staff found the applicant's seismic nonlinear analysis including the seismic input, seismic model parameters and the analysis methodology and validation of the computer Code ANSYS to be reasonable and consistent with the regulatory guidance in SRP Section 3.8.4, Appendix D, Section 3.7.1, Section 3.8.1, Section II.4.F (guidance for the use of validated computer programs) and Regulatory Guide 1.61, and therefore are acceptable.

Analysis for Seismic and Impact Loads

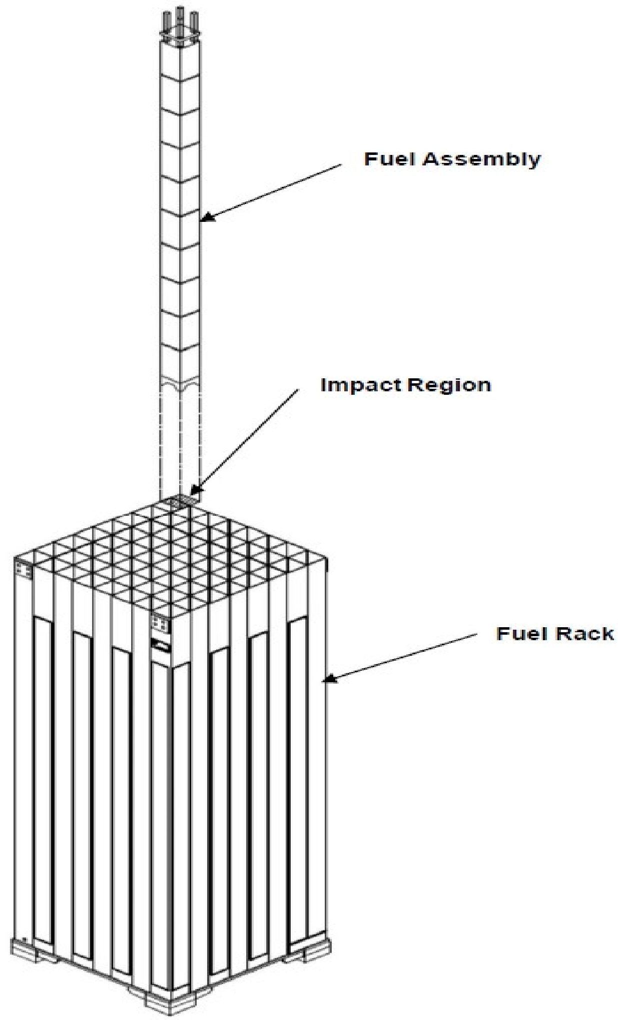
Mechanical Accidents Analysis involving Fuel Assembly

- Four mechanical accident scenarios considered
  - Straight shallow drop on SFSR (NFSR has no neutron absorber to damage)
  - Straight Deep Drop Away from NFSR and SFSR rack pedestal
  - Straight Deep Drop Over a SFSR Pedestal
  - Stuck Fuel assembly
- Analyses
  - Accident scenarios analyzed by a detailed 3-D finite element model using LS-DYNA computer code
  - Rack is considered fully loaded in the drop analysis
  - Drop locations are appropriate to evaluate maximum plate deflection
  - Demonstrated that the impact of the straight deep drop of a fuel assembly on specific locations on the baseplate does not cause any significant deformation to the baseplate
  - Minimum safety factor for all four accident scenarios is greater than 1.4

The staff found that the applicant used a detailed 3-D finite element model to analyze the mechanical accident scenario and deformation acceptance limit are consistent with the guidance in SRP 3.8.4, Appendix D and therefore acceptable.

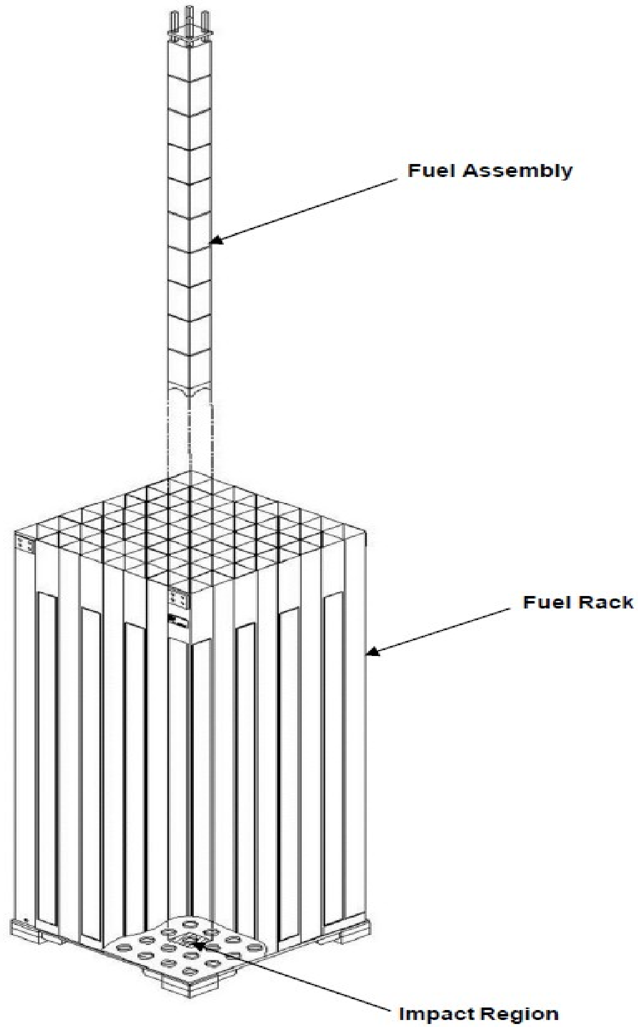
Analysis for Seismic and Impact Loads (Accident Scenario)

Figure 4-1 Straight Shallow Drop



Analysis for Seismic and Impact Loads (Accident Scenario)

Fig. 4-2 Deep Drop Away from a Pedestal



Analysis for Seismic and Impact Loads (Accident Scenario)

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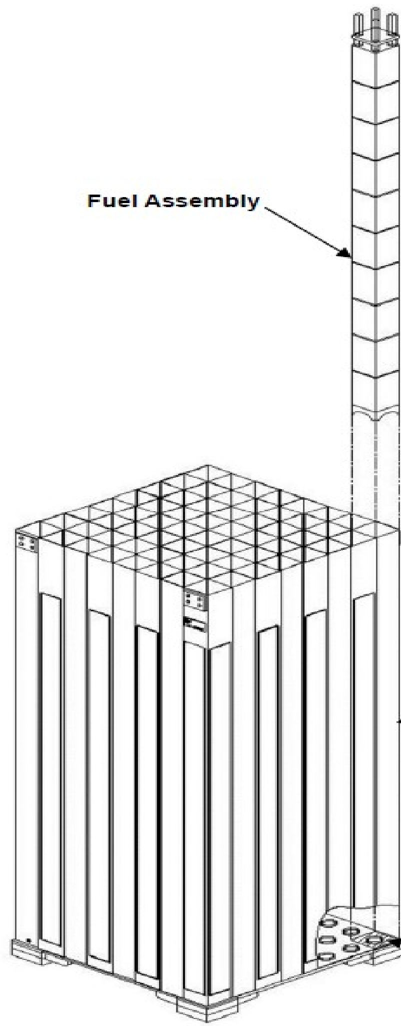
Figure 4-3 Deep Drop Over a Pedestal



Loads and Load Combinations

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- Loads
  - Dead Load including fuel assembly weight (D)
  - Live Load (L)
  - Safe Shutdown Earthquake (E')
  - Thermal loads (To, Ta)
  - Mechanical accident loads involving Fuel assembly (Fd, Pf))
- Load Combinations for ASME Code Service level limits A, B, and D

D + L	Service Level A
D + L + To	Service Level A
D + L + To + Pf (stuck fuel assembly)	Service Level B
D + L + Ta + E'	Service Level D
D + L + Fd (Fuel load drop)	Rack Functional Capability

The staff found the loads and load combinations considered for applicable ASME Code Service level limits to be consistent with the information in SRP Section 3.8.4, Appendix D and therefore acceptable.

Structural Design and Analysis Procedures

- Design Considerations
  - Applicant described the structural design of various elements of the rack structure
  - Stresses in welds between cell-to-baseplate, baseplate-to-pedestal, and cell-to-cell,
  - Local stresses caused by cell wall impact, cell wall buckling,
  - Secondary stress due to thermal effects
  - Stresses in Fuel Assembly
- Design Forces and stresses
  - Forces from the nonlinear seismic analysis or mechanical accident analysis
  - Combined with appropriate loads in the load combination
  - Calculated design stresses
- Stress Acceptance Limit
  - ASME Code Section III, Subsection NF, Level A, B, and D service limits for Class 3
- Safety Factor
  - Ratio of Allowable stress to calculated stress

Structural Acceptance Criteria (Limit)

- Acceptance limits of the rack structures are defined in ASME Code Section III, Subsection NF, as applicable for Class 3 components support.
- Material Properties" at 200 degrees Fahrenheit (F)) used to develop the stress limits for various service level conditions
- Service Level A limits consistent with ASME Code Section III, Subsection NF-3320. The applicant conservatively used service level A stress limits to evaluate service level B loading
- The Increase factor for Service level D stress limits consistent with the criteria in ASME Code Section III, Appendix F, Section F-1334
- Minimum factor of safety against overturning is required to be equal to or greater than 1.5

The staff found the structural acceptance criteria consistent with the information in SRP Section 3.8.4, Appendix D and SRP Section 3.8.5 and therefore acceptable

Material, Quality Control Programs & Inspections

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- Material
  - SA-240 type 304 L for cells and plates
  - SA-564 Grade 630 for support studs
  - Neutron absorber material (METAMIC) attached to SFSRs
  - Fuel assembly material data from PWR Plus7 fuel assembly
- Design, Fabrication, and Inspection
  - ASME Code Section III Subsection NF requirements
- Quality Control Program
  - Racks are designated seismic Category I structures and treated as safety-related components
  - Committed to 10CFR Part 50 Appendix B for Quality control program and 10CFR 50.65 for periodic monitoring

The staff found the material, design, fabrication and inspection and QA program consistent with Appendix D to SRP 3.8.4 and therefore acceptable.

COL Information Items

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Four COL Items

- Periodic condition monitoring program – confirm material and geometric assumptions remain valid during operating life of the plant
- Perform confirmatory dynamic and stress analysis considering site specific conditions
- Develop plant procedures and admin controls for fuel handling activities over the spent fuel pool
- Develop post-seismic event inspection procedure to measure gaps between fuel storage racks

The staff found COL items to be acceptable because it adequately describes actions necessary for the COL applicant.

Conclusion

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- Structural design of the fuel racks meets the ASME Code Section III Subsection NF design requirements
- Minimum safety factor for the fuel racks during seismic event and postulated mechanical accident scenarios is 1.19 (> minimum required 1.0)
- Spent fuel rack displacements due to design basis seismic event are small and do not close the large gap of 33” between the SFSRs and the SFP wall
- Spent fuel rack maximum relative displacement (0.28”, Region II racks) due to design basis seismic event is smaller than the rack-to-rack separation (1.18”, Region II racks); margin against impact is 1.18”/0.28”= 4; Larger margin for Region I racks (>6)
- Free standing spent fuel rack do not overturn due to the design basis seismic event and the safety factor against overturning is significantly greater than the required minimum safety factor of 1.5
- Due to small seismic movements, criticality analysis for the rack configuration is bounded by the SFP Criticality analysis for normal conditions included in SER subsection 9.1.1

Summary Conclusion

New and spent fuel storage racks provide safe storage for fuel assemblies and maintain a coolable geometry, preventing criticality, and protect the fuel assemblies from seismic and mechanical load effects

Materials

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- Applicant uses typical materials for fuel storage
  - New fuel racks: Type 304L and Type 630 stainless steel
  - Spent fuel racks: Type 304L and Type 630 stainless steel, Metamic neutron absorber (not credited for structural capacity)
  - Spent fuel pool liner: Type 304 stainless steel

- Fuel racks are designed, fabricated, and inspected to ASME Code Section III-NF requirements
- Spent fuel pool liner ASTM grade material with ASME NQA-1 and Appendix B Quality Assurance.
- New fuel is in dry storage – degradation will not occur.
- Spent fuel is stored in the spent fuel pool. The applicant has selected materials with good resistance to corrosion in spent fuel pool environments. The spent fuel pool water is controlled as described in FSAR Section 9.1.3 and is consistent with the EPRI Primary Water Chemistry guidelines. The neutron absorber coupon monitoring program is evaluated in SER Section 9.1.1 and was found to be acceptable.
- Sensitization controls, delta ferrite content, and cleanness controls are consistent with staff guidance (RG 1.31, RG 1.44, and NQA-1 Subpart 2.1).

The staff found the approach consistent with SRP Section 9.1.2 and acceptable.

Cooling and Cleanup System

Review Objective

New fuel storage pit (NFSP) and spent fuel pool (SFP) safety functions: maintain the fuel assemblies in a safe and subcritical array during all credible storage conditions and to provide a safe means of loading the spent fuel assemblies into shipping or storage casks.

Items of major interest

Staff reviewed NFSP and the SFP in accordance with the guidance in SRP 9.1.2
The staff evaluated system configuration and seismic design of SSCs to ensure adequate water inventory in the SFP.
All RAI responses found acceptable and proposed changes to DCD have been incorporated, there are no remaining Open Items.

Technical Topics

Section 9.1.1 – Criticality Safety of New and Spent Fuel Storage

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Open Item – Effects of Thermal Conductivity Degradation (TCD)

Issue: Staff asked in RAI 8191, Question 09.01.01-8, how the maximum fuel temperature assumed for the depletion calculation in the burnup credit criticality analysis accounted for TCD.

Resolution: In the response to RAI 7954, Question 11 (related to the PLUS7 Fuel Design Topical Report), the applicant showed that the assumed maximum fuel temperature bounds the expected maximum fuel temperature plus the staff-approved TCD penalty.

Open Item – Mechanical Analysis Review

Issue: The staff's review of APR1400-H-N-NR-14012-P, "Mechanical Analysis of New and Spent Fuel Storage Racks," was incomplete as of Phase 2, so the staff was unable to determine whether any mechanical accidents could have impacts on criticality.

Resolution: The staff completed its review of APR1400-H-N-NR-14012-P and concludes that the criticality analyses bound any criticality-related effects of the analyzed mechanical accidents.

Technical Topics

Section 9.1.1 - Criticality Safety of Fresh and Spent Fuel Storage and Handling

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Open Item - RAI 469-8578, Question 09.01.01-39

Issue: The fabrication process of the spent fuel rack may expose the Metamic neutron absorber to elevated temperatures (welding in close proximity). The staff questioned if the neutron absorber coupons needed an additional heat treatment to reflect the final condition of the Metamic neutron absorber.

Resolution: The applicant stated that the as-manufactured coupons were sufficient.

Open Item Closure: The staff re-examined the qualification testing of Metamic[1] that has been previously submitted and accepted by the NRC. One qualification test exposed Metamic material to 900 °F for 48 hours and demonstrated no change in neutron absorption. The staff also reviewed generic literature on aluminum-boron carbide neutron absorbers and concluded that temperatures above 1000 °F are expected during fabrication (solidus temperature around 1100 °F for aluminum alloys). The staff agrees that the as-fabricated neutron absorber coupons are sufficient and this item is closed.

1. "Use of Metamic in Fuel Pool Applications," HI-2022871 [ML022280353] and "Qualification of Metamic for Spent-Fuel Storage Application [EPRI Report 1003137]

Technical Topics

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Section 9.1.3 – SFP Cooling and Cleanup System

Open Item - RAI 473-8582

Issue: the staff evaluated the applicant's SFP thermal-hydraulic analysis and identified inconsistencies between the assumptions used for the analysis and the system description in the DCD.

Resolution: A response to RAI 473-8582 was provided and included:

- Revised thermal-hydraulic calculation (available via audit),
- clarification of assumptions used in revised thermal-hydraulic analysis;
- DCD markups to eliminate the inconsistency in assumptions;

Open Item Closure: The staff reviewed the information provided by the applicant in the RAI response, the DCD, and the technical report summarizing the thermal-hydraulic analysis and confirmed that the revised thermal-hydraulic analysis uses conservative assumptions that are consistent with the SRP guidance and therefore meet the requirements of GDC 61.

Technical Topics

Section 9.5.2 – Communication Systems

Open Item - RAI 548-8822, Question 09.05.02-6

Issue: Applicant had classified all communication systems as non-safety related. Hence DCD stated that the communication systems did not require compliance with 10 CFR Part 50, Appendix A, GDC 1, GDC 2, GDC 3, and GDC 4

Resolution: A response to RAI 548-8822 was provided and included:

- Commitment that the design of the communication systems will comply with 10 CFR Part 50, Appendix A, GDC 1, GDC 2, GDC 3, and GDC 4
- Detailed mark-ups of the DCD which explained how the communication systems would meet all of the applicable GDCs

Open Item Closure: The staff reviewed the information provided by the applicant and determined that the design information and commitment given by the applicant was sufficient to meet the intent of 10 CFR Part 50, Appendix A, GDC 1, GDC 2, GDC 3, and GDC 4.

Technical Topics

Section 9.5.2 – Communication Systems

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Open Item - RAI 548-8822, Question 09.05.02-7

Issue: DCD lacked sufficient information in APR1400 FSAR Tier 1, Table 2.6.9-1. Additional detail was needed to ensure that each communication subsystem is capable of performing its intended function.

Resolution: A response to RAI 548-8822 was provided and included:

- Detailed mark-ups which explained the procedures needed to ensure that each communication subsystem is capable of performing its intended function.
- Necessary and sufficient information about each communication subsystem in the ITAAC and Acceptance Criteria of Table 2.6.9-1.

Open Item Closure: 10 CFR 52.47(b)(1) requires that a design certification application contain the necessary and sufficient ITAAC. The staff reviewed the information provided by the applicant and determined that sufficient detail was provided in APR1400 FSAR Tier 1 to meet the intent of 10 CFR 52.47(b)(1).