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8 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
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11 The contents of this transcript of the
12 proceeding of the United States Nuclear Regulatory
13 Commission Advisory Committee on Reactor Safeguards,
14 as reported herein, is a record of the discussions
15 recorded at the meeting.
16
17 This transcript has not been reviewed,
18 corrected, and edited, and it may contain
19 inaccuracies.
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1 UNITED STATES OF AMERICA

2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

5 (ACRS)

6 + + + + +

7 APR1400 SUBCOMMITTEE

8 + + + + +

9 OPEN SESSION

10 + + + + +

11 TUESDAY

12 APRIL 17, 2018

13 + + + + +

14 ROCKVILLE, MARYLAND

15 + + + + +

16 The Subcommittee met at the Nuclear

17 Regulatory Commission, Two White Flint North, Room

18 T2B1, 11545 Rockville Pike, at 8:30 a.m., Ronald G.

19 Ballinger, Chairman, presiding.

20

21 COMMITTEE MEMBERS:

22 RONALD G. BALLINGER, Chairman

23 CHARLES H. BROWN, JR., Member

24 MICHAEL CORRADINI, Member

25 VESNA B. DIMITRIJEVIC, Member

1 JOSE A. MARCH-LEUBA, Member
2 DANA A. POWERS, Member
3 JOY L. REMPE, Member
4 PETER RICCARDELLA, Member*
5 GORDON R. SKILLMAN, Member
6 JOHN W. STETKAR, Member
7 MATTHEW W. SUNSERI, Member
8
9 ACRS CONSULTANT:
10 STEPHEN SCHULTZ
11
12 DESIGNATED FEDERAL OFFICIAL:
13 CHRISTOPHER BROWN
14
15 ALSO PRESENT:
16 JEONG HYEON BAEK, KEPCO E&C
17 LAUREL BAUER, NRO
18 JOSEPH BRAVERMAN, Brookhaven National Lab
19 QUINTANA LUISS CANDELARIO, NRO
20 MARWAN CHARROUF, MPR
21 SUNGJU CHO, KHNP
22 WOOCHONG CHON, KHNP
23 JORGE CINTRON-RIVERA, NRR
24 JAMES GILMER, NRO
25 SYED HAIDER, NRO

1 NICHOLAS HANSING, NRO
2 MICHELLE HART, NRO
3 DAVID HEESZEL, NRO*
4 RAUL HERNANDEZ, NRO
5 ATA ISTAR, NRO*
6 JUNG BUM JANG, KEPCO E&C
7 JAEHOON JEONG, KNF
8 REBECCA KARAS, NRO
9 STORM KAUFFMAN, MPR
10 MOHSEN KHATIB-RAHBAR, ERI
11 GEESEOK KIM, KEPCO E&C
12 HAKSUNG KIM, KNF
13 TAE-HAN KIM, KEPCO E&C
14 YUNHO KIM, KHNP
15 YOUNGKI KIM, KEPCO E&C
16 WILLIAM A. KRIEL, KHNP
17 SUNGUK KWON, KHNP
18 YOUNGCHUL KWON, KHNP
19 SANG GYU LEE, KEPCO E&C
20 KAEYEOL LEW, KNF
21 CHANG-YANG-LI, NRO
22 Y.C. LI, NRO
23 DAEHEON LIM, KEPCO E&C
24 MARK LINTZ, NRO
25 SHANLAI LU, NRO

1 TIM LUPOLD, NRO
2 GREGORY MAKAR, NRO
3 MICHAEL D. MCCOPPIN, NRO
4 JILL MONAHAN, Westinghouse
5 ALISSA NEUHAUSEN, NRO
6 JINSUO NIE, NRO
7 JIYONG OH, KHNP
8 JUHYUN PARK, KHNP
9 SUNWOO PARK, NRO
10 ERIC REICHELT, NRO
11 ROBERT ROCHE-RIVERA, NRO
12 RICARDO RODRIGUEZ, NMSS
13 THOMAS SCARBROUGH, NRO
14 ROB SISK, Westinghouse
15 JOE STAUDENMEIER, RES
16 JAMES STECKEL, NRO
17 EDWARD STUTZCAGE, NRO
18 WALTER TAUCHE, ERI
19 TOMEKA TERRY, NRO
20 VAUGHN THOMAS, NRO
21 CARL THURSTON, NRO
22 BOYCE TRAVIS, NRO
23 ALEXANDER TSIRIGOTIS, NRO
24 CHRIS VAN WERT, NRO
25 ANDREA D. VEIL, Executive Director, ACRS

1 MARIELIZ VERA, NRO
2 DAVE WAGNER, KHNP
3 JAY WALLACE, RES
4 WILLIAM WARD, NRO
5 YUKEN WONG, NRO
6 JUNG YONG ZAN, KEPCO E&C
7
8 *Present via telephone
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10
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T-A-B-L-E O-F C-O-N-T-E-N-T-S

KHNP Presentations

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

2 8:30 a.m.

3 CHAIRMAN BALLINGER: The meeting will now
4 come to order. This is a meeting of the APR1400
5 Subcommittee of the Advisory Committee on Reactor
6 Safeguards.
7 I'm Ron Ballinger, chairman of the APR1400
8 Subcommittee.
9 ACRS members in attendance are -- we will
10 have Vesna Dimitrijevic I think. Joy Rempe, Jose
11 March-Leuba, John Stetkar, Matt Sunseri, Dana Powers,
12 Dick Skillman and Mike Corradini. We may be joining
13 -- let's see, Charlie Brown will probably be here
14 shortly I guess.
15 Chris Brown is the designated federal
16 official for this meeting.
17 The purpose of today's meeting is for the
18 subcommittee to receive briefings from Korea Electric
19 Power Corporation and Korea Hydro and Nuclear Power
20 Company Limited regarding their design certification
21 and the NRC staff regarding their safety evaluation
22 report specific to chapter 2 section 2.5 geology,
23 seismology and geotechnical engineering, chapter 3,
24 design of structure systems, components, and
25 equipment, chapter 7, instrumentation and controls,

1 chapter 15, transient and accident analysis, and
2 topical report large break loss of coolant accident.
3 The ACRS was established by statute and is
4 governed by the Federal Advisory Committee Act, FACA.
5 That means that the committee can only speak through
6 its published letter reports.
7 We hold meetings to gather information to
8 support our deliberations. Interested parties who
9 wish to provide comments can contact our offices
10 requesting time after the meeting announcement is
11 published in the Federal Register.
12 That said, we also set aside 10 minutes
13 for comments from members of the public attending or
14 listening to our meetings. Written comments are also
15 welcome.
16 The ACRS section of the U.S. NRC public
17 website provides our charter, bylaws, letter reports
18 and full transcripts of all full and subcommittee
19 meetings including slides presented at the meetings.
20 The rules for participation in today's
21 meeting were announced in the Federal Register on
22 Friday, April 13, Friday the 13th of 2018.
23 The meeting was announced as an open,
24 closed to the public meeting. This means that the
25 chairman can close the meeting as needed to protect

1 information proprietary to KHNP and its vendors. No
2 requests for making a statement of the subcommittee
3 has been received.
4 And we will be doing -- part of the
5 meetings today will be closed so we'll be switching
6 over.
7 A transcript of the meeting is being kept
8 and will be made available as stated in the Federal
9 Register notice. Therefore I request that
10 participants in this meeting use the microphones
11 located throughout the room.
12 When addressing the subcommittee
13 participants should first identify themselves and
14 speak with sufficient clarity and volume so that they
15 can be readily heard.
16 There's a little black triangular looking
17 thing in front of you that has a little light at the
18 top. You need to make it light up green when you
19 talk.
20 We have a bridge line established for
21 interested members of the public to listen in and we
22 have a second bridge line for KHNP and other people I
23 think.
24 To minimize disturbance the public line
25 will be kept in a listen-in only mode. The public

1 will have an opportunity to make a statement to
2 provide comments at a designated time towards the end
3 of the meeting.
4 I request now that meeting attendees and
5 participants silence their cell phones and other
6 electronic devices.
7 Also if you're on one of the bridge lines
8 please mute your line unless you're making a comment
9 or talking because it limits the amount of noise we
10 have.
11 NRO staff and contractors are on a
12 separate non-public bridge line with Member
13 Riccardella. I apologize, Pete Riccardella is also
14 going to be here.
15 Except for Member Riccardella I ask staff
16 and contractors participating by phone to please keep
17 your phone muted. I already said that.
18 Pete, are you on the line?
19 MEMBER RICCARDELLA: I'm here, but I don't
20 think you can hear me.
21 CHAIRMAN BALLINGER: We can hear you now.
22 MEMBER RICCARDELLA: Okay, very good.
23 Thank you.
24 CHAIRMAN BALLINGER: And before we get
25 started Member March-Leuba needs to make a comment

1 related to conflict of interest.

2 MEMBER MARCH-LEUBA: Thank you, Mr.

3 Chairman. In a previous life I used to work for NRO

4 as a consultant on APR1400 matters especially on the

5 corporate rotation calculator and cell points.

6 And if those items come along I will not

7 participate in discussions.

8 CHAIRMAN BALLINGER: Okay. That being

9 said now I invite Bill Ward is here hiding behind --

10 make a comment and start the meeting.

11 MR. WARD: Good morning. Thank you again

12 for meeting with us. We are pleased to present

13 section 2.5 three chapters in the large break LOCA

14 topical report over the next two days.

15 I know we've been working at a very

16 aggressive schedule and it's been a little bit frantic

17 at times but we're happy to have the opportunity to

18 present these and we appreciate the subcommittee's

19 patience and willingness to work with us to get things

20 done. So thank you.

21 CHAIRMAN BALLINGER: So I think the floor

22 is yours.

23 MR. SISK: Thank you, Chairman. This is

24 Rob Sisk, Westinghouse. And again on behalf of KHNP

25 we do appreciate this opportunity to continue the

1 presentation of the APR1400 design certification
2 application to the ACRS subcommittee.
3 Without further ado I will just turn the
4 meeting over now to Mr. Kwon to get us started on the
5 chapter 3 presentations.
6 MR. KWON: Good morning, ladies and
7 gentlemen. I am Youngchul Kwon, senior structural
8 engineer working for KEPCO Engineering and
9 Construction Company. Now here we'll be presenting
10 the work results for the open attempts related to
11 APR1400 design control document tier 2 chapter 3.
12 This presentation material consists of
13 overview of chapter 3 summary of open attempts,
14 product.
15 This document tier 2 chapter 3 consists of
16 13 sections. Overview of chapter 3 is shown on this
17 slide and next slide.
18 The submitted document related to chapter
19 3 are APR1400 design control document tier 2 chapter
20 3, design control document tier 1 and various
21 technical reports shown on this slide and next slide.
22 The total 260 RAIs were captured in
23 regards to chapter 3. Total number of open attempt is
24 23. And this will be addressed in this presentation.
25 This slide shows open attempts for chapter

3 with related RN numbers, topic names and their assessed numbers.

This slide also lists open attempts for chapter 3. And same.

Now we start to present the summaries of open attempts. There's no open attempt in sections 3.1 through 3.5. Staff tracked the RAI question 3.6.2-2 as an open attempt for the topic of pipe rupture hazard analysis.

In regards to these RAs, tested assessment of the dynamic effects of jet impingement and first wave. And considerations in determining which break locations in ASME class 1 and battery systems.

Staff also requested to provide technical report for pipe rupture hazard analysis, PHRA summary incorporating jet impingement, first wave and resident effects.

KHNP provided the PHRA summary report incorporating the post- break locations and the methodology for assessment of jet impingement and place waves in October 2017.

Also KHNP provided the text description regarding non-conservatisms over ANSI/ANS 58.2 1988 version in the revised response to this RAI in October 2017.

1 The staff tracked the RAI question 3.6.2-3
2 as an open item for topic of break exclusion area.
3 On this topic staff requested to provide
4 acceptability of expanding the break exclusion area to
5 the auxiliary building anchor wall beyond the
6 isolation valve.
7 And requested to provide justification
8 with the results of pipe rupture analyses.
9 KHNP provided confirmation that calculate
10 the maximum stress results for the grade approach
11 piping in break exclusion area were low compared to
12 the SRP BTP 3-4 stress limit for postulated break
13 locations in the revised response to this RAI in
14 September 2017.
15 The staff tracked RAI question 3.6.2-6, 7
16 and 8 as an open item for the topic of blast wave and
17 potential feedback implication and (inaudible) effect.
18 On this issue staff requested to provide
19 clarification on the verification and validation, V&V,
20 of the computational fluid dynamics CFD model for
21 blast wave effects.
22 Methodology for evaluation of a blast wave
23 and justification of the criteria used for considering
24 the effect of a potential oscillatory jet loads.
25 As a resolution KHNP provided a technique

1 called report, APR1400 high energy line break with jet
2 impingement containing CFD analysis, V&V results and
3 the source of the literature resources in June 2017.
4 KHNP provided in technical report that the
5 feedback implication and the resonance effects due to
6 a high energy line breaks does not occur in APR1400
7 with thermodynamics and the lack of perpendicular flat
8 surfaces.
9 During the review the staff requested
10 additional information or clarification for evaluating
11 the dynamic jet impingement and the blast wave effects
12 to complete the staff's review.
13 KHNP provided the revised technical report
14 including the clarification such as literature summary
15 and CFD V&V in October 2017.
16 This slide shows the open item for leak
17 before break analysis related to RAI question 3.6.3-9.
18 On this topic staff noted that the pipe
19 crack evaluation program PICEP input did not agree
20 with the values stated in the APR1400 design control
21 document and requested to confirm the input values and
22 calculations in the design control document are
23 correct and to provide copies of the PICEP input
24 files.
25 As a resolution KHNP revised the fluid

1 temperature in the PICEP input and calculation and
2 provided the response with the revised input values
3 and calculations.
4 These results were incorporated into
5 associated design control document and technical
6 report, leak before break evaluation of a surge line.
7 On the open RAI question 3.7.2.-1 for the
8 topic of hard rock high frequency staff requested to
9 provide -- create a number of modes to capture
10 incoherent motion.
11 I'm sorry, missing the word incoherent
12 motion -- to capture incoherent motion in print. And
13 provide justification for ISRS reduction levels in
14 excess of those provided in SRP section 3.7.2
15 subsection 2.4.
16 Also staff requested providing the revised
17 results for ISRS comparisons and seismic loads between
18 the certified seismic design response spectra, CSDRS,
19 and the hard rock high frequency spectra and the
20 justification for the acceptability of all HRHF
21 exceedances.
22 In regards to this issue 16 modes was
23 selected to capture, convert the incoherent motion.
24 It was justified that this converged solution gave the
25 ISRS reduction levels still exceeding the reduction

level set forth in SRP 3.7.2 as described in technical report evaluation of impacts of HRHF for response spectra on structure system components appendix C.

On the open RAI question 3.8.3-5 for the topic of analysis methods and the results for reactor containment building internal structure staff requested to explain the analysis method under seismic loading for floor slabs between the secondary shield wall and the containment shell, and to explain the connections between the floor slabs and containment shell.

Regarding this issue for the seismic load of a floor slab response spectrum analyses were performed using the FRS which envelop both containment shell and secondary shield wall. A detailed procedure for design and analysis of the floor slabs were described in design control document subsection 3.8.3.4.

And the design results were provided in DCD table 3.8A-43 and 44, and figures 3.8A-61.

Also KHNP provided connection details between the floor slabs and containment shell in design control document subsection 3.8A.1.4 and figure 3.8A-60.

This would allow the movement of both

horizontal directions in tangential and radial.

On open RAI question 3.8.5-1 for the topic of analysis and design for critical sections staff requested to include the missing information of other design sections and provided the lacking design results of concrete structures with a consistent format.

To resolve this issue KHNP provided the information of selection criteria for design sections in design control document section 3.8A and added the missing design sections, dome, liner, slab, steel beam and their design results in DCD subsection 3.8A.1.4.

KHNP provided the information of design results for concrete structures where the information was lacking. Accordingly, associated DCD subsections and tables for IRWST structure and the basement structure were updated.

On the open RAI question 3.8.5-4 for topic of waterproofing membranes staff requested to provide the description whether waterproofing membrane will use the APR1400 design and also requested to provide the design effects of the waterproofing membranes on shear resistance of a nuclear island the common basemat if they were used.

As a resolution KHNP confirmed the use of

waterproofing membranes in APR1400 design and provided the information for typical installation details as shown in design control document subsection 3.8.5.1 and figure 3.8-27.

KHNP also provided the sliding resistance effect associated with the waterproofing membrane beneath concrete basemat in the RAI response and the design control document subsection 3.8.5.1.

The design parameter of coefficient of friction will be verified by COL item number 3.8(11).

On the open RAI question 3.8.5-7 for the topic of a construction sequence staff requested to describe how the construction sequence and the differential settlement of foundations were considered in the load and the load combination and requested to provide the approach for four types of settlement, maximum vertical settlement, tilt settlement, differential settlement between structures and the angular distortion based on analysis results.

As a resolution the member forces and the moments from the analyses with and without construction sequence were considered in design load case of the design load combination. And the detailed description were added in design control document subsection 3.8.5.4.

1 For four types of settlement the approach
2 for assessment and their results were provided in the
3 DCD subsection 3.8.5.4. And technical report
4 Stability Check for Nuclear Island Common Basemat
5 section 5.
6 These four types of settlement will be
7 verified based on the site-specific soil conditions by
8 the COL item number 3.8(18) and the COL item number
9 3.8(19).
10 On the open RAI question 3.8.5-8 for topic
11 of design and analysis procedures for nuclear island
12 common basemat the staff requested to justify the use
13 of equivalent static accelerations with a 100-40-40
14 combination method considering phasing motion of three
15 superstructures, and requested to explain how to
16 consider torsional load in the basemat analysis.
17 To consider phasing motion of three
18 superstructures of reactor containment building,
19 containment structures, reactor building integral
20 structure and auxiliary building the results from both
21 the linear SRSS combination on the member force level
22 and the nonlinear method using 100-40-40 combination
23 on the input level were enveloped.
24 Additional detail descriptions were added
25 in DCD subsection 3.8A.1.4 and technical report

1 Stability Check for Nuclear Island Common Basemat
2 section 3.2.5.
3 For the member forces and the moments from
4 torsional analysis of superstructures they were added
5 to the seismic load cases by absolute summation.
6 Additional detailed descriptions were added in the
7 above mentioned design control document and technical
8 report.
9 On open RAI question 3.8.5-12 for the
10 topic of applied loads for nuclear island common
11 basemat staff requested under the KHNP response to RAI
12 question 3.8.5-8 to provide the maximum bearing
13 pressure resulting from both the linear SRSS
14 combination and the nonlinear 100-40-40 combination to
15 resolve phasing of the responses from each of the
16 three superstructures when analyzing nuclear island
17 common basemat.
18 For bearing pressures for nuclear island
19 the common basemat they were recalculated from both
20 the linear SRSS combination and the nonlinear 100-40-
21 40 combination. Enveloped bearing pressures were
22 provided in design control document subsection
23 3.8A.1.4.
24 MEMBER STETKAR: Mr. Kwon?
25 MR. KWON: Yes.

1 MEMBER STETKAR: And if we delve into
2 proprietary information we can wait.
3 I'm not a structural engineer but I
4 noticed that when you did those recalculations the
5 maximum bearing pressures changed substantially.
6 For example, the static bearing pressure
7 in DCD revision 1 was about 642 kilopascals and it was
8 revised to 937 kilopascals.
9 The bearing pressure with the applied
10 earthquake loads in revision 1 was 1,416 kilopascals
11 and it was revised to 2,586.
12 To me not being a structural engineer
13 those sound like rather substantial changes. Could
14 you tell us what was changed in the analysis to result
15 in those large changes?
16 You said that you recalculated the loads.
17 MR. KWON: The division of --
18 MEMBER STETKAR: I understand. I'm asking
19 what changed in your analysis to result in those
20 rather substantial revisions.
21 As I said if there's something proprietary
22 that we need to discuss in a closed session I'm
23 willing to wait. But if it's something simple.
24 I did not read both versions of the RAIs
25 and the technical reports to try to delve into it nor

do I necessarily have all of the detailed structural engineering capabilities myself.

I found those changes to be rather substantial.

MR. SISK: This is Rob Sisk. They were just talking a little bit about what changed. We'd have to go back to the documents in detail to give you.

MEMBER STETKAR: Fine. Thanks. I'm happy with that. Thanks.

MR. KWON: I'll check the changes. On the open RAI question 3.8.5-13 for topic of loads and load combinations for nuclear island common basemat staff requested to confirm that the crane loads are considered in the design of the entire containment and other seismic category 1 structures, and confirm that the crane/trolley load is considered in different positions to maximize the loads on the structures.

The crane loads were considered in the design of the containment structure and other seismic category 1 structures.

The positions to give maximum polar crane loads in the design of containment structures were described in design control document subsection 3.8.1.3.

In case of auxiliary building the enveloped crane loads from various fuel handling area crane locations were considered and described in design control document subsection 3.8.4.3.

The parking positions of the actual polar crane and trolley will be verified by COL item number 3.8(21).

On open RAI question 3.8.5-16 for topic of subgrade modulus of soil profiles for APR1400 staff requested to update stability evaluations in all applicable parts of design control document sections 3.8.5 and 3.8A and technical report to reflect the current models, analysis approach and the results.

Also staff requested to provide the descriptions for bearing pressure evaluations in the emergency diesel generator building and the diesel fuel oil tank structures.

Regarding this item the updated basemat on the stability evaluations applying the distributed soil spring elements for static conditions and the solid soil elements for dynamic conditions were added in design control document subsection 3.8A.1.4.

And the technical report titled Stability check for Nuclear Island Common Basemat section 4.2.3 and table A-7.

1 And the description for bearing pressure
2 evaluation were added in design control document
3 subsection 3.8A.1.4 for nuclear island common basemat
4 and subsection 3.8A.3.4 for emergency diesel generator
5 building and diesel fuel oil tank basemats
6 respectively.
7 On open RAI question 3.8.5-17 for the
8 topic of a differential settlement of nuclear island
9 common basemat staff requested to explain the
10 determination method of differential settlement.
11 The differential settlements were
12 determined based on the construction phase and the
13 post-construction phase. And a detailed procedure was
14 added in the design control document subsection 3.8.5
15 and technical report Stability Check for Nuclear
16 Island Common Basemat section 5.
17 Next open item will be presented by Mr.
18 Kim.
19 MR. GEESEOK KIM: Good morning. My name
20 is Geeseok Kim. I'm working for KEPCO E&C as a
21 mechanical engineer.
22 This slide showed open item for the pump-
23 induced load on reactor vessel internal components.
24 The staff requested to provide the test on
25 application of the measured pump pressure pulsations

1 and related hydraulic model. Also to request to add
2 a description of the DPVIB computer program to DCD.
3 KHNP provided information on methodologies
4 for application of the measured data. The
5 methodologies are prequal to obtain functions for all
6 configurations from measured data.
7 Particularly KHNP submitted a PNV document
8 for DPVIB computer program.
9 This slide shows the open item for control
10 element guide tube buckling integrity and operating
11 experience.
12 The staff requested regarding the buckling
13 integrity of the control element guide tube under
14 Level D conditions and requested that operating
15 experience in Korea.
16 Theoretically if the guide tube is
17 deflected it cannot buckle. Therefore, buckling does
18 not occur in the guide tube. But the buckling
19 integrity of the CEA guide tube was evaluated and the
20 detail calculation was submitted.
21 KHNP reviewed operating history in Korea
22 domestic plants and confirmed that there are no
23 historic damage in the fuel assembly.
24 This slide shows the buckling analysis and
25 the position (inaudible) in the tube.

1 The analysis of the CEA guide tube is
2 evaluated in accordance with ASME section 3 and
3 subsection NGA 3211 and NGA 3133.
4 The evaluation is a proponent for the
5 condition. Actually the movement of tube is shown
6 back at the figure. The tubes are raised up, both
7 sides, you just put plate.
8 However, pure (inaudible) plate is not
9 fixed and the tube could be translated at the
10 direction.
11 Using the ASME 1334 critical buckling are
12 determinator. This critical load missed the limit of
13 the buckling.
14 Also we can load, the load of the tube is
15 calculated using the stress of the tube which is
16 calculated from the stress report summary.
17 Therefore, finally we check the CEA guide
18 tube. It is not susceptible to buckling.
19 We go to the guide tube tolerance. One of
20 the functions of the CEA is that mechanical clearance
21 of the CEA and the fuel internals are such that the
22 shared positioning and the reactor trips are obtained.
23 The accumulation of tolerance. These are
24 shown in DC section 4.2.1.
25 Also the second sentence show the

1 alignment check provides reasonable assurance that the
2 frictional force that could result from adverse
3 tolerance is below the force that could significantly
4 increase scram time.
5 This sentence is shown in DCD section
6 4.2.4.
7 MEMBER REMPE: I have a question. It's a
8 curiosity question. My understanding when I was
9 reviewing the material is that this RAI was motivated
10 because swelling was observed in the control tips at
11 Palo Verde.
12 And I was -- well, first of all I was
13 curious on what materials were in the control tips at
14 Palo Verde and then I was expecting -- I know that the
15 RAI response said we searched through and we've never
16 had this happen with any of our Korean plants.
17 But I was expecting to ensure that this
18 did not happen if an APR1400 was built in the U.S.
19 you'd say don't use that material.
20 And so could you give me a little
21 background so I could understand just for my own
22 curiosity on what material was used at Palo Verde that
23 did have that swelling?
24 MR. SISK: This is Rob Sisk. I don't
25 think we can comment on what was used or what's not

1 used in Palo Verde so I'm not sure we could really
2 comment on that.
3 MEMBER REMPE: Well, if there was a
4 problem in the past, the swelling of a particular
5 material, I think it would behoove us to all remember
6 what it was and it doesn't get used again.
7 And so I think it's a reasonable question.
8 Do you know, Ron, what it was just from your own
9 background?
10 CHAIRMAN BALLINGER: No.
11 MR. SISK: Again, Rob Sisk. We could
12 check into that. Our fuel people are actually here
13 and we can discuss that with them later.
14 MEMBER REMPE: Okay. Perhaps the staff
15 knows too, I don't know. But I'm curious on that just
16 for my own knowledge. Thank you.
17 CHAIRMAN BALLINGER: Sorry for the
18 interruption but we're joined by Member Dimitrijevic
19 and Member Brown.
20 MEMBER SUNSERI: Maybe just to add to
21 Joy's comment. There was an industry problem control
22 rods made with hafnium. And that material swelled and
23 it -- especially at the tip of the rods where they
24 were close to the core.
25 And the fix was to eliminate the hafnium

1 and go to silver-indium-cadmium and taper the tip a
2 little bit so it would allow for some growth. But I
3 don't know if that applies to this unit or not.
4 MR. SISK: We're aware of that as well.
5 That's fairly old OE. I don't want to say anything
6 until we really kind of check back with the right
7 people.
8 MEMBER REMPE: If you would. For my own
9 knowledge to know what it was. Thanks.
10 MR. GEESEOK KIM: The third sentence also
11 to confirm the instability of the CEA, the CEA
12 positioning test is performed in every reporting
13 period. According to the requirements and technical
14 specifications for section 3.1.4.
15 This slide shows open item for the in-core
16 instrumentation support system.
17 The staff requested to provide information
18 about static O-ring seal for the inquiry into
19 instrumentation system which inform the rate of
20 coolant for the boundary.
21 The staff commented that the summary of
22 this information including clarification and the
23 (inaudible) should be included in the DCD.
24 KHNP provided explanation for the
25 classification, design requirements and the design

conditions of the static O-ring seal in the RAI response.

Also reflected this item in revision 1 of the DCD section 3.9.5.

KHNP also provided test result information including functional and physical properties to ensure that reactor pressure boundary is maintained throughout service life.

The static O-ring seal are replaced in every reporting period.

This slide shows open of the loading condition level D service loading.

The analysis --- also, the staff requested to describe and justify why difference between DCD tier 2 and table 3.9-1 and the loads applied to the reactor pressure vessel internals for all service levels.

The major difference between DCD tier 2 and table 3.9-1 is that IRWST in containment 30, the dirty water discharge loads are described in the loads and the load combinations in the DCD.

But table 3.9-1 shows the only title of transient events.

So KHNP provided explanation for the events that resulted in IRWST injection and discharge

1 loads in DCD.

2 This slide shows open item for the bases

3 for reactor internals classification.

4 The next step also requested to provide

5 the information of the non-classified seismic category

6 1. And to complete classification list in DCD.

7 KHNP provide a response. All of the

8 reactor internals are classified as seismic category

9 1. The classification of the (inaudible) including

10 internal provided in tier 2 table 3.2.-1.

11 KHNP other response to NRC issued to RAI

12 7927 and HR20 pertain to issues with the table 3.2-1

13 and the system quality group clarification related to

14 reg guide 1.26 to not include the changes pertaining

15 to this RAI.

16 Currently the complete clarification that

17 is including internal structure is incorporated in the

18 DCD revision 2 table 3.2-1.

19 This is an open item for the pump and the

20 valve inservice testing program table.

21 The staff requested to evaluate and modify

22 all pumps and valve in table to be consistent with NRC

23 regulations in 10 CFR 50.55a.

24 KHNP added additional information of

25 inservice test requirements for pumps and valves in

1 the RAI including our reports the revision to DCD
2 table 3.9-13.
3 This slide is regarding environmental
4 qualification of the mechanical and electrical
5 equipment.
6 Staff requested to provide justification
7 why in IEEE standard 323-2003 is acceptable for
8 qualification of class 1E electrical equipment in the
9 harsh environment.
10 In this respect the staff -- actually the
11 IEEE standard 323 1974 version remain. It currently
12 stand out.
13 And it has been endorsed by reg guide 1.89
14 for environmental qualification.
15 Nevertheless KHNP is about to apply IEEE
16 standard 2003 version as the applicable standard for
17 environmental qualification.
18 KHNP provided justification for the use of
19 the IEEE standard 2003 stating that it conforms with
20 10 CFR 50.49 and there are no technical differences
21 between the 2003 and 1974 versions.
22 The IEEE standard 2003 version reflects
23 current practices for environmental qualifications.
24 KHNP provided a basic table comparing the guidance
25 contained in IEEE standard 1974 and 2003 versions.

1 This slide is regarding the environmental
2 qualification of mechanical and electrical equipment.
3 The staff requested KHNP to clarify that
4 qualification documentation will provide auditable
5 records that show the equipment can perform its safety
6 function during and following a design basis event as
7 applicable.
8 Second, the staff requested KHNP to
9 discuss the other applicable design event conditions
10 and how the design is demonstrated to conform to 10
11 CFR 50.49.
12 The staff requested KHNP to clarify the
13 discrepancy between IEEE 323-1974 and 2003 versions on
14 the synergistic effects and explain how synergistic
15 effects are considered for type test qualification in
16 IEEE 2003.
17 KHNP provide the response as follows.
18 First KHNP justified the documentation we provide
19 audit report that show the equipment can perform its
20 safety function during and after the process begins.
21 By clarifying this application based on
22 IEEE standard 2003.
23 Second KHNP responded that the other
24 accidents do not result in limiting conditions for
25 safe shutdown consideration such as loss of coolant

1 accident, main steam line break and high energy live
2 break, and the design is demonstrated to conform to 10
3 CFR 50.49.
4 Third, KHNP responded there are more
5 discrepancy for synergistic effect between the two
6 standards because the synergistic effects have already
7 been considered in IEEE 2003 version.
8 And justified how synergistic effects are
9 considered for test qualification by explaining the
10 sequence of the age conditioning specified in IEEE
11 2003 version.
12 CHAIRMAN BALLINGER: Excuse me, but
13 somebody out there does not have their phone on mute
14 and we're getting shall we say unusual noises. So
15 please put your phone on mute.
16 MR. SCHULTZ: Mr. Kim, could we go back to
17 the previous slide. Yes, you've done that. Thirty-
18 one, slide 31. No, I'm sorry. Thirty-three.
19 I don't understand the third bullet here
20 where you described the IEEE standard and you've
21 described what is expected in that standard. I'm just
22 not sure in response to the RAI how you -- what your
23 response was.
24 In other words have you then taken this
25 into account in your evaluation and therefore the

1 issue is resolved or could you elaborate on that third
2 bullet and what you've done with the information?
3 MR. GEESEOK KIM: I am not actually
4 amazing in this area.
5 MR. SCHULTZ: Perhaps we can discuss it
6 with the staff. I didn't see in the staff's
7 presentation that they were going to go into this
8 level of detail.
9 MR. SISK: This is Rob Sisk. Just for
10 clarification to make sure I understand the question
11 being asked your question is related to how age
12 conditioning was applied.
13 MR. SCHULTZ: I think so. Again I'm
14 trying to understand the sequence of information
15 that's presented on the slide.
16 In the third bullet it's just a
17 declaration that this is what the expectation is. And
18 I was looking for if you will the step that
19 demonstrates that it's been included or that it has
20 been considered and therefore the issue is addressed.
21 Or if it's just being provided for
22 information. It seems like another statement needs to
23 be provided to say and it was considered rather than
24 these are the things that need to be considered.
25 That's all I was looking for.

1 If you need to get back that's fine.

2 MR. GEESEOK KIM: Yes, I will check. This

3 slide is regarding the structural integrity of the

4 piping and the pipe supports during the operation of

5 the safety injection tank and the fluidic device.

6 Staff requested three items to clarify how

7 cavitation effect and vibration originating from the

8 operation of the safety injection tank and its fluidic

9 device, how we take into account in the structural

10 design evaluation of the safety injection tank, its

11 discharge piping and pipe supports.

12 Secondly, to clarify whether the operation

13 of the safety injection tank with its fluidic device

14 can result in other phenomena such as water hammer.

15 And third, to clarify the structural

16 evaluation model of the safety injection tank is

17 coupled with the fluidic device.

18 KHNP --

19 CHAIRMAN BALLINGER: Can you go back to

20 the previous slide? Again I guess I'm now more

21 sensitized to the kinds of questions that Steve asked.

22 But the last bullet, the structural

23 evaluation model of the SIT is coupled with the FD.

24 What does that mean? Does that mean the

25 issue is taken care of because they're coupled?

1 MR. GEESEOK KIM: Yes.
2 CHAIRMAN BALLINGER: That's what you're
3 saying.
4 MR. GEESEOK KIM: Yes.
5 CHAIRMAN BALLINGER: Okay, thank you.
6 MR. GEESEOK KIM: KHNP provides the
7 following.
8 First, the cavitation noises are non-
9 periodic and their frequencies are much higher than
10 the modal frequencies of the safety injection tank and
11 the safety injection line.
12 Therefore there is no possibility of
13 resonance due to the cavitation implosions.
14 Second, the APR1400 safety injection
15 system is designed to prevent the water hammer by
16 eliminating possible void trap in the system based on
17 the NUREG/CR-6519.
18 However, based on NRC feedback, the
19 pressure and the dynamic forces on the piping system
20 due to safety injection tank blowdown effect are
21 calculated. The results show that all pipe stress
22 meet code allowable and the support can be acceptable
23 in existing support design.
24 Third, the structural evaluation model of
25 the safety injection tank for seismic analysis is

1 coupled with the fluidic device because it is
2 installed inside of the tank with the welding.
3 Currently chapter 3 is completed. KHNP
4 continues to monitor chapter 3 to assure any
5 conforming changes are addressed.
6 Twenty-three open items that were
7 identified in phase 2 and 3 have been resolved with
8 adequate and sufficient discussion with the staff.
9 The changes in chapter 3 as reviewed and
10 marked up in response to the RAIs were incorporated
11 into the revision 2 of the design control document.
12 MR. SISK: So this concludes the
13 presentation on chapter 3. We can move into 2.5 at
14 this point or if there are questions.
15 MR. SCHULTZ: I have one question. Mr.
16 Kwon, this will lead you back to the beginning of your
17 presentation but since we're going to talk about large
18 break LOCA this afternoon I wanted to get just a
19 little more information on your response to 3.6.2
20 dynamic effects in piping and 3.6.3 on leak before
21 break.
22 In the staff's evaluation of the RAI and
23 in discussions that they had with you one thing that
24 they noted that wasn't in your presentation today was
25 the benefit of the inspection program capability that

1 you have for piping and weld inspection.
2 And I wondered if you could describe a
3 little more about what your expectations are for in-
4 service inspection of piping and welds especially the
5 large piping and welds.
6 This is with respect to especially the
7 dynamic effects on piping. One of the things the
8 staff mentioned in their discussions associated with
9 the RAI and your response had to do with the
10 expectation that you have capability for 100 percent
11 inspection of piping and welds and I just wanted to
12 get confirmation of that, that you had set that as
13 expectation in the operation of the facility.
14 MR. GEESEOK KIM: You mean that the piping
15 (inaudible)?
16 MR. SCHULTZ: Yes, well the inspection
17 program can affect what one's findings would be with
18 respect to the dynamic effects of piping and leak
19 before break.
20 So I just wanted to get your confirmation
21 of what your expectations would be for an appropriate
22 inspection program of piping and welds.
23 MR. GEESEOK KIM: Inspection is performed,
24 as you know. It is a component on the average of 10
25 years. Every bit for major piping but is that

1 benefits and also to control that. Almost all classes
2 including class 1 is inspected. Through the
3 inspection, most of the --- vibration -- piping
4 system. That's the inspection.
5 MR. SCHULTZ: Those are the preoperational
6 testing. And then you have your 10-year inspection
7 requirement.
8 MR. GEESEOK KIM: Yes.
9 MR. SCHULTZ: You do have excess ability
10 for 100 percent inspection in 10-year intervals.
11 Thank you.
12 MEMBER REMPE: So is this something that's
13 passed on to the person that's building the plant and
14 so is there like an ITAC that identifies all the
15 requirements for the in-service inspection as part of
16 the design certification?
17 Where's the boundary on how you convey
18 what you want the person building the plant to do an
19 in-service inspection?
20 MR. YUNHO KIM: I'm Yunho Kim from KHNP.
21 Actually we don't have the right person to answer that
22 question.
23 MEMBER REMPE: I can't hear you even
24 though you're talking into a microphone. Say it again
25 real loud.

1 MR. SISK: It's on. Rob Sisk. We don't
2 have the right people here to discuss the details of
3 the inspection program.
4 In general I will say the inspection
5 program tends to be a utility program.
6 MEMBER REMPE: Right.
7 MR. SISK: So it's a combination of both
8 the designer and the utility.
9 CHAIRMAN BALLINGER: It's an ASME code
10 issue. So section 11 in particular defines the
11 inspection intervals for everybody.
12 MEMBER REMPE: Okay.
13 MR. SISK: Any other questions on chapter
14 3? We'll go on to 2.5.
15 This is Rob Sisk again. While they're
16 getting ready for 2.5 we did have a follow-up
17 discussion or we would like to have a little bit of a
18 follow-up on the question that came up in chapter 3 on
19 what changed in the analysis. I think that was Mr.
20 Stetkar's question. I invite Youngki Kim to provide
21 some additional details for us.
22 MR. YOUNGKI KIM: Youngki Kim from KHNP.
23 I explain about the reason why the bearing stress was
24 somewhat different compared to the report of the
25 original response. Report of the original response,

100-40-40 method, used just combination of A, incorporating NRC question for combination number was increasing to 96. So combination increases potentially. So we think that's the reason why the bearing stress was increasing so much.

MEMBER STETKAR: I didn't quite understand it. But why did you -- what caused you to change the load that much. If I understand your response.

MR. YOUNGKI KIM: You apply 100-40-40 in combination of stress and the pressure. So you combine the load. Combinations to part of the critical stress. So I was told that, before the other response, you had only eight combination cases when you apply another vessel following, the combination number is increased from 8 to 96. We think that's the reason for the increase of the bearing stress.

MEMBER STETKAR: Okay. Maybe I'll follow up with the staff. Thank you. That helps a little bit. Thank you.

MR. SISK: So we're ready then to proceed onto section 2.5.

MR. KWON: Youngchul Kwon, again. I will present results for an issue item related to APR1400 design control document tier 2 chapter 2, section 2.5.

This material consists of an overview of

1 section 2.5 summary of issue item, current status and
2 attachments.
3 Design control document tier 2 chapter 2
4 section 2.5 is described about geologic, seismologic
5 and geotechnical site parameters for APR1400 plant
6 design.
7 A list of submitted documents related to
8 section 2.5 is shown on this slide. Total of 21 RAIs
9 for chapter 2 questions and response. No open item.
10 In section 2.5 there is only one issue
11 item for topic of static stability of foundation.
12 In regards to this topic staff requested
13 to provide bearing pressures and the settlements of
14 design control document section 2.5.4 per the related
15 open RAIs question 3.8.5-7 and 16 of design control
16 document section 3.8.5 when they were resolved.
17 Based on the response of RAI for DCD
18 section 3.8.5 KHNP provided the revised static/dynamic
19 bearing pressures for nuclear island common basemat,
20 emergency diesel generator building and diesel fuel
21 oil tank in design control document section 3.8A.1.4
22 and 3.8A.3.4.
23 The bearing pressures will be verified by
24 evaluating with allowable bearing CPCS based on the
25 site-specific properties by COL item number 2.5(13).

1 Also KHNP provided the revised maximum
2 differential settlements inside buildings and between
3 buildings in the design control document table 3.8A-17
4 and 39 and design control document section 3.8A.3.4.
5 For site suitability determination the
6 predicted settlements will be verified whether they
7 exceed the maximum settlement specified in design
8 control document table 2.0-1 site parameters by COL
9 item number 2.5(14).
10 Currently DCD chapter 2 section 2.5 is
11 completed. KHNP continues monitoring section 2.5 to
12 assure any conforming changes are addressed.
13 Changes in section 2.5 as reviewed and
14 marked up in response to RAIs were incorporated into
15 revision 2 version of the design control document.
16 MR. SISK: That concludes our presentation
17 on section 2.5. Very short and sweet.
18 CHAIRMAN BALLINGER: Thank you. At the
19 risk of jinxing we're very far ahead and I think the
20 staff is ready to go. So I think we should just keep
21 going.
22 MR. ROCHE-RIVERA: So the slides just
23 presenting the technical staff involved in the review
24 of chapter 3. Specifically in this case we'll be
25 presenting the staff review for section 3.7 and 3.8.

1 So my name is Robert Roche-Rivera and I'm
2 a structural engineer in NRO. And I am the reviewer
3 for DCD section 3.7.2 which documents the applicant's
4 seismic system evaluation.
5 Specifically this section of DCD addresses
6 the seismic analysis methods and models which are used
7 to establish the seismic demands for the design of the
8 seismic category 1 structures of the APR1400 standard
9 plan.
10 In the next few slides I'll be presenting
11 the staff's evaluation of the applicant's seismic
12 system evaluation to the hard rock high frequency
13 spectra.
14 So the seismic analysis and design of the
15 APR1400 standard plan is based on the certified
16 seismic design response spectra or CSDRS.
17 Additionally the APR1400 is evaluated for
18 the effects of the hard rock high frequency, called
19 HRHF.
20 The HRHF spectra is a spectra that's
21 represented before a number of rock sites in the
22 central and eastern United States.
23 It has higher spectral amplitudes past
24 about 10 hertz that's when it's compared to the CSDRS
25 and it peaks at about 25 hertz.

In performing its evaluation the applicant took into consideration the incoherency of ground motion which reduces the in-structure responses such as in-structure response spectra in the high frequency range.

The staff review of the applicant's evaluation found that it lacked technical justification with respect to the number of spatial coherency modes used in the evaluation. The ISRS or in structure response spectra spectral amplitude reductions that were greater than the limits set forth in SRP section 3.7.2.II.4 and the adequacy of the structures for withstanding the seismic demands induced by the HRHF spectra.

To address these issues the applicant reevaluated the HRHF effects on the APR1400 standard plan with consideration of more than twice the original number of spatial coherency modes.

The applicant demonstrated the adequacy of the number of modes considered in their reevaluation based on comparisons of ISRS for alternative spatial coherency mode sets.

That is the revised set used in their reevaluation and a set with reduced number of spatial coherency modes.

1 And comparisons of ISRS showed really
2 close agreements for these alternative coherency mode
3 sets.
4 Based on such demonstration that an
5 adequate number of coherency modes have been
6 considered in the hard rock high frequency evaluation
7 the staff found the associated reductions with the re-
8 analysis to be acceptable.
9 And lastly the staff found the APR1400
10 structures to be qualified for the seismic demands
11 imbued by the hard rock high frequency spectra based
12 on higher CSDRS spectral accelerations relative to the
13 hard rock high frequency spectra throughout the
14 dominant frequency range for structure, higher
15 equivalent accelerations that are used in the
16 structural design obtained from the CSDRS which is the
17 design basis for the APR1400 standard plan, and the
18 applicant's demonstration that the reinforcement based
19 on the CSDRS, again the design basis for the standard
20 plan, it's adequate for the hard rock high frequency
21 demand.
22 That concludes my presentation and with
23 that I will turn it over to Mr. Vaughn Thomas.
24 MR. THOMAS: Thanks, Robert. Good
25 morning. My name is Vaughn Thomas and I'm the

structural in the Office of New Reactors.

For the next few minutes I'm going to present the staff's safety findings related to the analysis and design of the operating concrete floor slabs which are part of the containment structures for the APR1400 application.

The operating floor slabs are located between the secondary shield walls and the containment walls.

Those slabs are supported by steel beams and beam seats attached to both sides of the walls. The staff focused its structure review on the design approach and methodology to ensure that the applicant's design for the CIS is reasonable and acceptable in terms of the scope, the level of details and the technical accuracy of the information provided by the applicant.

The staff found the review in accordance with agency regulatory requirements and staff guidance.

In reviewing the analysis methods and results associated with the design of the concrete internal structures the staff noticed that the DCD did not describe in detail the design analysis procedures and the decoupling criteria for the operating floor

1 slabs.

2 So as a result the staff requested

3 additional information to ensure that the structural

4 integrity of the concrete floor slabs are maintained

5 in accordance with the agency's regulatory

6 requirements.

7 To resolve this issue the applicant

8 performed additional calculations and sensitivity

9 analysis of the concrete floor slabs following the

10 decoupling criteria in SRP section 3.7.2.

11 In other words applicant performed

12 separate LOCA analysis of the design of the operating

13 floor slabs.

14 And applicant's results demonstrated that

15 the gap which is needed to prevent interaction between

16 structures of 2 and 1/16 of an inch is adequate to

17 allow the relative displacement between the

18 containment internal floors and the containment wall.

19 And that 2 and 1/16 of an inch is greater

20 than the maximum displacement of 2.04 inches.

21 MR. SCHULTZ: What was the nature of the

22 sensitivity studies that they performed?

23 MR. THOMAS: The reason for that was that

24 when we review the application we noticed that between

25 the containment wall and the secondary shield wall

there were some slabs there.

We did not see any description or analysis in the documentation that says how they intend to address this particular walls or slabs.

So we ask them the question is it -- is a wall as part of the final analysis or -- and they said that well, they decided to design the walls separately. And they thought our acceptance criteria in 3.7.2 in terms of mass ratio and frequency ratio because it's relatively small.

And that's all the analysis they did to perform that.

MR. SCHULTZ: The sensitivity analyses were part of that? In order to incorporate the information on these additional slabs. Or is it all one piece?

MR. ROCHE-RIVERA: No, it is separate. Separate.

MR. SCHULTZ: Okay.

MR. ROCHE-RIVERA: And that's what I'm going to the next bullet that's about --

MR. SCHULTZ: Okay.

MR. ROCHE-RIVERA: It says the applicant re-analyzed the entire CIS including the primary shield wall, steam generator wall and the refueling

1 pool wall and the pressurizer wall using the reaction
2 forces obtained from the LOCA analysis, that's for the
3 concrete floor slabs.
4 The end result is increasing member forces
5 and rebar arrangements for all those structures that
6 are part of the containment internal structures.
7 So as a result the applicant also provided
8 additional markups, figures, tables and text that
9 describes in detail the design analysis approach of
10 the operating floor slabs with the new design results
11 of the CIS.
12 So in conclusion the staff considered the
13 information provided by the applicant, demonstrated
14 that the structural integrity of the CIS is adequately
15 maintained following the agency's regulatory
16 requirements.
17 So currently this issue is being tracked
18 as a complementary item pending the next revision of
19 the APR1400 DCD.
20 This concludes my presentation and if you
21 do not have any questions I will turn it over to Ata
22 Istar who is joining us over the phone to continue.
23 CHAIRMAN BALLINGER: I do have a question.
24 MR. THOMAS: Go ahead.
25 CHAIRMAN BALLINGER: Can we go back.

1 Whenever I read about concrete construction and I see
2 a number like 1/16 of an inch I just know that's not
3 correct.
4 So what is too small in other words? Two
5 and 1/16 inch gap, what is too small?
6 MR. THOMAS: Okay, this is how it comes
7 about. So when they did analysis of the CIS itself a
8 maximum displacement for the CIS itself was 2.04
9 inches.
10 CHAIRMAN BALLINGER: Okay, so now I'm
11 asking the question 0.04.
12 MR. THOMAS: Right. Analysis. Results.
13 Analysis, results, that's what it shows.
14 CHAIRMAN BALLINGER: This is a TI87
15 calculation. Okay. And so both of those numbers are
16 basically artificial.
17 MR. THOMAS: It's what the analysis
18 results shows in the final analysis, yes.
19 CHAIRMAN BALLINGER: Okay, I'm just
20 curious as to whether or not you actually have overlap
21 in theory. Not in theory, excuse me, in practice.
22 Whether you can have an overlap.
23 MR. THOMAS: So this is one reason we look
24 at it is again they perform that separately. And when
25 you run the analysis for the CIS overall it shows a

maximum displacement.

CHAIRMAN BALLINGER: I understand all that, what you do, but I'm just concerned about what you do with an answer. And then you ask about what's the uncertainty on that.

You've concluded that you're okay based on the calculation, but if you applied -- if you asked yourself what's the uncertainty on those two numbers do you in fact get overlap.

MR. THOMAS: Keep in mind that still following the regulatory guidance for example still within codes 349.

CHAIRMAN BALLINGER: Okay, thank you.

MR. THOMAS: Okay. Ata is on the phone so Ata, are you there?

MR. ISTAR: I'm here. Can you guys hear me?

MR. THOMAS: Yes.

MR. ISTAR: Good morning. I'm structural reviewer for section 3.8.5 which is foundations of seismic category 1 structures.

And I will go through some of the selected questions that the applicant responded and resolved and the markups provided in the DCD and the topical reports.

1 Starting with the critical section. The
2 applicant did not capture all of the critical sections
3 following their criteria.
4 The applicant added the missing critical
5 sections in the DCD including structural steel and
6 reinforced concrete sections.
7 And the staff determined that the design
8 of these sections were consistent with the SRP 3.8 and
9 the applicable codes and standards.
10 Next page please which is related to the
11 waterproofing.
12 During the review it was not clear to the
13 staff whether the waterproofing membrane was used for
14 the foundations.
15 The applicant responded that the
16 waterproofing membranes will be used for exterior
17 below grade horizontal and vertical surfaces of the
18 structures in APR1400 design with minimum coefficient
19 of friction of 0.55.
20 The applicant has also assumed a
21 coefficient of friction of 0.55 in the stability
22 evaluation which is to be verified by the COL item
23 3.8(11).
24 Going to the next page related to the
25 construction sequence and differential settlements.

1 The applicant did not provide any description for the
2 construction sequence and differential settlement of
3 nuclear island foundation.
4 And the applicant incorporated detailed
5 explanations of the construction sequence and clearly
6 determined the criteria for four settlement types
7 which are maximum vertical settlement, tilt
8 settlement, differential settlement between buildings
9 and angular distortion for the nuclear island
10 foundation.
11 CHAIRMAN BALLINGER: Excuse me, can you go
12 back one slide?
13 MR. ISTAR: Yes, sir.
14 CHAIRMAN BALLINGER: The third bullet.
15 How is the applicant going to verify that the friction
16 coefficient is 0.55?
17 MR. ISTAR: I don't know how to respond to
18 that one, but that is the value that was provided by
19 the KHNP. And we have to abide with that number.
20 And how are they going to do it, that's
21 during the construction sequence or construction of
22 the plant. I believe that somehow they have to prove
23 that the minimum value of coefficient of friction is
24 0.55.
25 MR. BRAVERMAN: Excuse me, my name is

1 Joseph Braverman from Brookhaven National Laboratory
2 and we provide technical assistance to the staff in
3 this review.
4 That would be a COL information item and
5 so the COL applicant would have to provide
6 documentation. Typically that's done by test data.
7 CHAIRMAN BALLINGER: Okay. So it's an
8 actual test. Because this is a hard number that
9 affects everything.
10 MR. ISTAR: I think I'm going to nuclear
11 island basemat analysis.
12 It was not clear to the staff how the
13 seismic and other loads are determined and applied to
14 the various structures in the APR1400 basemat design.
15 And the applicant responded for the
16 seismic loads the equivalent static analysis
17 methodology is used and the envelop of the results of
18 the linear case (SRSS combined method) and the
19 nonlinear case (100-40-40 combined method) for three
20 soil profiles, soft, medium and stiff, are used in the
21 analysis of nuclear island basemat.
22 The staff finds this response acceptable
23 because the applicant used the equivalent static
24 analysis methodology and combined methods for the
25 design of nuclear island basemat consistent with the

guidance provided in regulatory guide 1.92 and SRP 3.8.5.

Going into the last open item, maximum bearing pressure at nuclear island basemat.

The applicant was requested to determine the maximum soil bearing pressure for the nuclear island basemat for linear and nonlinear dynamic load combinations based on the updated analysis.

The applicant calculated the maximum soil bearing pressure for all load combinations (static, nonlinear, linear and SASSI analysis cases) and determined that they are lower than the allowable static and dynamic bearing pressure CPCS.

This will conclude my presentation and if you have any questions.

MEMBER STETKAR: I don't know if you were listening in when we had the presentation from the applicant, but I noted that when they re-performed the analyses the stated static maximum -- the maximum bearing pressure under static loading conditions increased apparently from about 642 kilopascals to 937 kilopascals.

And the maximum bearing pressure under seismic loads in combination with the static loads increased from about 1,416 kilopascals to about 2,586

1 kilopascals.

2 I also preface this by saying I am not a

3 structural engineer but those changes struck me as

4 being rather large.

5 Could you explain to not a practicing

6 structural engineer what changed in their analyses to

7 result in those rather large differences?

8 MR. ISTAR: I think I remember that

9 discussion earlier, but I think the reason for that is

10 the bearing area under the foundations is the most

11 critical area.

12 And there was lengthy discussions about

13 the bearing area, change in the bearing area. And if

14 you were to pick up the right bearing area you're

15 going to have a different bearing pressure.

16 MEMBER STETKAR: So they in their initial

17 analyses did not have the correct bearing area, is

18 that what I'm hearing you say?

19 MR. ISTAR: I don't want to conclude like

20 that, but it was a lengthy discussions during our

21 meetings with the staff, KHNP staff, engineering

22 staff.

23 I think it was concluded that the correct

24 bearing area had to be -- were selected for the

25 loading conditions that was applied. And appropriate

1 bearing pressure was calculated based on that.

2 MR. BRAVERMAN: Can I add something to

3 that. This is Joe Braverman again from Brookhaven

4 Lab.

5 The staff's review of the original design

6 they raised some questions which I think led to the

7 increase in results.

8 The first one is the type of seismic

9 analysis performed. This is for the basemat design.

10 And there are three superstructures that sit on top,

11 the containment, the internal structures and the

12 auxiliary building.

13 So apparently the applicant used different

14 types of analysis. For the containment and the

15 internal structures they used response spectrum type

16 analysis and for the auxiliary building they used

17 equivalent static.

18 So in the response spectrum analysis you

19 lose the sign or the phasing whereas equivalent static

20 you apply a G value one direction so you know the sign

21 of the defamation of it, et cetera.

22 The applicant used the reaction forces at

23 the bottom of these superstructures and applied these

24 forces onto the basemat. So the staff questioned

25 using different types of analysis for the

1 superstructure. You use the phasing, how can you
2 apply the forces to the basemat.
3 So after some discussions the applicant
4 revised the analysis method and for all three
5 superstructures they used only equivalent static
6 analysis method. So now you know the direction of the
7 forces.
8 Of course in an earthquake they can
9 oscillate in both directions so they have to consider
10 the various phasing permutations.
11 And also involved is the type of
12 combinations method when you combine three earthquake
13 components there's two methods.
14 One is SRSS method and the other is the
15 100-40-40. And so KHNP spoke about the increase in
16 the permutations up to 96. I don't know if you want
17 to get into why it's so large.
18 So the combination of changing the
19 analysis approach, increasing the number of
20 combinations to 96 and what was the other thing.
21 And the last thing was these combination
22 methods for directions are usually done at the member
23 force level. So when you have a finite element in the
24 basemat that's when you use a combination SRSS, 100-
25 40-40.

1 Originally they had done it at the input
2 level.
3 And the last thing is I believe they only
4 did nonlinear analysis because the structure can
5 partially uplift due to enough inertial load. But we
6 questioned what happens if you don't have that uplift
7 because they made some conservative assumptions.
8 So they did two cases with uplift and with
9 no uplift. And then they enveloped those results.
10 So the cumulative effect of all these
11 enveloping permutations you end up with a higher
12 bearing pressure.
13 However, these higher bearing pressures
14 were still shown to be less than the criteria they put
15 in as a COL an information item.
16 MEMBER STETKAR: Thanks and I know that,
17 the final conclusion. But thanks, that helps me a lot
18 to understand. Thank you.
19 MEMBER REMPE: So I have a follow-on to my
20 earlier question too about the swelling of the
21 material used in the control rods.
22 Was it happening. Is someone here from
23 the staff?
24 MR. ROCHE-RIVERA: Not in this panel.
25 MR. THOMAS: I think that was 3.6 I

1 believe.

2 MEMBER REMPE: It was RAI 928068 is all I

3 can remember. I unfortunately am not allowed to have

4 my -- I can't refer back to the actual documents.

5 MR. THOMAS: I heard a question this

6 morning and I believe it was in the mechanical group.

7 MEMBER REMPE: Okay, so you need someone

8 else here to answer that question.

9 MR. THOMAS: Yes.

10 MEMBER STETKAR: We're going to come to

11 other parts of chapter 3 tomorrow I think is what

12 they're saying. And it might be under those.

13 MR. THOMAS: Yes.

14 MEMBER REMPE: Okay. That sounds fine.

15 Please ask them to let me know tomorrow.

16 MR. THOMAS: They will be there I'm sure.

17 MEMBER REMPE: Okay.

18 MR. THOMAS: If there are no other

19 questions I guess we'll turn it over to the next

20 presenters. Thanks.

21 CHAIRMAN BALLINGER: We're at 10 minutes

22 after 10. We're again quite far ahead which is a good

23 thing.

24 So what I'd like to do is take a 15-minute

25 break and come back at 25 after 10.

(Whereupon, the above-entitled matter went off the record at 10:08 a.m. and resumed at 10:26 a.m.)

CHAIRMAN BALLINGER: We're ready to go. Bill.

MR. WARD: Good morning. My name is Bill Ward. I'm the lead project manager for the APR1400 review for NRC.

Can I check, David Heeszel, are you on the phone?

MR. HEESZEL: I'm here.

MR. WARD: Okay, thank you. So I'm going to present the APR1400 DCD chapter 2 site characteristics. This presentation will cover section 2.5. We presented the rest of these sections previously.

The review team are listed here and they are in the audience to answer questions.

In November of 2017 staff presented the advance safety evaluation report of other sections of chapter 2 except for section 2.5 which covers the geology, seismology and geotechnical engineering topics.

In the phase 3 subcommittee of September 2016 staff discussed the draft safety evaluation

report with open items for section 2.5 and we had no open items.

The section 2.5 staff coordinated with chapter 3 staff on crosscutting issues that originated from chapter 3 RAI 2558285 question 3.8.5-7. This was related to the settlement characteristics as they relate to the structural stability of the foundation.

And we stand by the previous conclusion that was presented to the subcommittee in September 2016, specifically that the applicant properly identified the appropriate geological, seismologic and geotechnical site parameters and properly identified the specific information to be provided as far as the future COL item.

About a month ago the staff completed the phase 4 advance safety evaluation report for section 2.5 and submitted it for review.

This report closed some of the confirmatory items we had previously identified and discussed with you in the prior ACRS meeting. It was based on revision 1 of the DCD.

We are now currently reviewing revision 2 of the DCD to ensure the confirmatory items identified in that report have been incorporated.

That's all I have for section 2.5.

1 MEMBER STETKAR: Bill, I had one item.
2 I'm still puzzled a bit about something that I've been
3 whining about through all of these subcommittee
4 meetings.
5 And that is the assurance that the DCD
6 contains enough information for the COL applicant to
7 provide assurance that the interfaces between in
8 particular the component cooling water piping tunnels
9 and the auxiliary building and diesel generator
10 building because they connect to those buildings can
11 be designed and are acceptable.
12 Now I understand we've had several
13 discussions about the essential service water building
14 and the component cooling water heat exchanger
15 building and those piping tunnels in the past.
16 And I know that there are now COL
17 information items that specify explicitly that the COL
18 applicant is responsible for the seismic -- the design
19 of those buildings and the tunnels.
20 The only thing that I can't find is any
21 specification in the DCD that tells the COL applicant
22 that when they design those tunnels what's the
23 allowable maximum differential settlement between
24 those tunnels and the rest of those other buildings.
25 There's specifications in table 2.0-1 for

1 differential settlement among the nuclear island, the
2 emergency diesel generator building and the diesel
3 fuel oil tank building which are the three buildings
4 in the scope of the DCD.
5 And there's a COL information item that
6 says the COL applicant is responsible for designing
7 everything else.
8 But it doesn't tell me how much
9 differential settlement is allowed between the pipe
10 tunnels and those other structures. Those all being
11 seismic category 1 structures.
12 And it can be important if you've got big
13 pipes running through there.
14 So I was curious how the staff, I
15 understand how you've kind of resolved the COL
16 responsibility for the structural design if you will
17 of the SW and CCW heat exchanger buildings and the
18 tunnels themselves. I'm worried about the interface.
19 MR. WARD: The discussion about the actual
20 details of that, I know there's the settlement
21 differences. I think that's more of a chapter 3
22 issue, but I'm going to ask --
23 MEMBER STETKAR: Well, it is, that's why.
24 But the discussion about the settlement is actually in
25 2.5 as you've mentioned.

1 So right now it's why I've got chapter 3
2 and chapter 2 of the DCD open in front of me here.
3 MR. WARD: I'm going to ask if Vaughn or
4 Ata want to start with that. Any discussion about the
5 settlement differences between the tunnels and the
6 other category 1 structures? How do we ensure that
7 the COL has that proper information and ensure they
8 don't exceed any.
9 MR. BRAVERMAN: Hello, this is Joe
10 Braverman again.
11 The DCD does provide total settlements and
12 tilt settlements I think in chapter 2 and certainly
13 chapter 3 for other components like tunnels and piping
14 which would be a COLA item.
15 In that case the COLA is going to have to
16 come up with how much settlement the tunnel or buried
17 piping may be subjected to and then assume worst case
18 scenario out of phase. The building goes one way and
19 the piping goes the other way.
20 And there are methodologies by civil
21 engineers and standards on how to calculate --
22 MEMBER STETKAR: I understand all of that.
23 It's in the DCD very clearly specifies maximum
24 allowable differential settlement between and among
25 three specific buildings.

1 It's 3.0 inches under static and a half
2 inch under static and seismic loads.
3 What it doesn't do in the DCD, I can't
4 find it. Maybe it's in there somewhere but I can't
5 find it where the tunnels connect to those in scope
6 buildings. I can't find anywhere where it says what's
7 the maximum differential settlement at that interface.
8 MR. BRAVERMAN: Right at the interface.
9 MEMBER STETKAR: Yes, like where the
10 piping would connect from the tunnel to the piping
11 inside the building, for example.
12 MR. BRAVERMAN: When tunnels or piping
13 connect to a structure they always put some kind of
14 flexible joint.
15 MEMBER STETKAR: Would you allow 12 inches
16 differential settlement?
17 MR. BRAVERMAN: No.
18 MEMBER STETKAR: Okay. Would you allow
19 0.0007 inches differential settlement? That's what
20 I'm looking for so that when I as a COL applicant
21 design my tunnels and my connections I know what
22 margin I have to play with from the designer's
23 perspective.
24 MR. BRAVERMAN: I believe the COL
25 applicant would have to come up with the deformation

of the tunnel and then design a flexible joint that can accommodate it. And if it cannot then he has to design the proper tunnel to minimize the deformation so that the flexible joint can tolerate that deformation.

The -- KHNP cannot know ahead of time what a tunnel for certain site conditions, how much that tunnel may run. I believe the COL applicant would have to come up with that calculation and show that it can satisfy the needed deformation.

Should I try that another way if it's not clear?

MEMBER STETKAR: Well what leaves me hanging a bit is that in many cases the DCD makes rather explicit statements about certain criteria that a COLA applicant must satisfy to provide assurance that indeed the scope of whether it's a structural design, or whether it's a cooling water supply, or whether it's an offsite power supply, or whatever those things that are within the COLA scope of supply they're pretty explicit so that the COLA applicant understands what's expected when they do their site-specific design work.

And in most cases as I said whether it's an electric power supply or whether it's cooling water

capabilities or whatever they do tend to be fairly specific.

This is the only place and I've got it narrowed down because I'll give you the fact that they can build the other structures and make sure that they don't fall down as long as they connect up to the rest of the plant with reasonable assurance that the COLA applicant understands what margins they have to play with.

And I do get the notion that I can put some flexible hosing in there in principle and it'll take up the slop, but I don't think that we design seismic category 1 ultimate heat sink cooling water supplies with that amount of margin typically.

This is just sort of an aberration of the fact that they've drawn the line to separate the cooling water supplies from the rest of the stuff inside the nuclear island and the auxiliary building.

MR. WARD: I know the requirement for the applicant to provide this, I think it's item 25 the interface requirements.

And the review that's done, I don't know of a specific delta that is expected to be provided or normally provided.

MEMBER STETKAR: The only reason I bring

1 it up is I think this is the first time that we've
2 seen this type of differentiation between the cooling
3 water supply and the structural part of the cooling
4 water supply and the rest of the scope of the
5 certified design.
6 The details of the cooling water supply in
7 terms of are you going to have cooling towers, is it
8 going to be an open loop lake, that type of
9 information is always left up to the COL applicant.
10 This I believe is the first one that we've
11 seen where they've drawn the line and said everything
12 that has to do with the essential service water and in
13 particular component cooling water because that's the
14 only thing that connects into the plant at the break
15 point where those tunnels connect to the buildings
16 everything outside of that break point is the
17 responsibility of the COL applicant.
18 I think this is the first one we've seen.
19 That's why I'm kind of ranting about it as I'll
20 repeat.
21 If the staff feels, you know, obviously
22 I'm only speaking as an individual. If the rest of
23 the committee feels that there's enough collectively
24 in chapter 2 and chapter 3 of the DCD and the staff's
25 SER to provide assurance that those connections will

be designed and constructed adequately then it's fine.

MR. WARD: I think chapter 2 is primarily focused on soil characteristics and making sure that soil ranges that are defined are what will support the building that's being designed.

So I think this is all related to the interface requirements and what's in the structural.

MEMBER STETKAR: But I looked in chapter 3 and I don't find anything about the differential settlements. They're only -- at least in terms of the COL items.

MR. WARD: Okay. Well, I will take that back and we'll research it.

MEMBER STETKAR: Other than -- everything points back to that table 2.0-1.

MR. WARD: Right.

MEMBER STETKAR: But table 2.0-1 only has those three structures, the nuclear island, the auxiliary -- four structures. The auxiliary building, the emergency diesel generator building, the diesel fuel oil tank building. That's the only thing that's in that table.

MR. RODRIGUEZ: I just want to add. My name's Ricardo Rodriguez. I'm a geotechnical engineer. I worked chapter 2.5.

1 I want to reiterate what Joe Braverman
2 said. The items that you see in table 2.0-1 are
3 related to the structures that are within the scope of
4 the DCD.
5 So talk at this point of structures that
6 are meant to be built by the COL applicant I think we
7 don't have that much information at this point to
8 characterize the amount of flexibility or movement
9 allowed for those tunnels we're talking about.
10 And I want to direct you to COL
11 information item 3.7.6 which if I'm not mistaken tasks
12 the COL applicant to perform seismic analysis of
13 buried seismic cat 1, 5 and tunnels.
14 So I think at this point unless one of my
15 colleagues want to reiterate a little bit more, but I
16 think that's the position of the staff.
17 MR. WARD: What I will do is verify our
18 guidance and regulation just to make sure that we're
19 not expected to insist on any sort of particular
20 delta. I'm not aware of that at the moment.
21 MEMBER STETKAR: Okay. Thank you.
22 MR. WARD: Any other questions?
23 CHAIRMAN BALLINGER: The good news is that
24 we're way ahead. The bad news is that we're way
25 ahead. And we have to do a little bit of adjusting.

1 I'm told -- 15 minutes ago I was told that
2 the KHNP people for chapter 15 will be here in a half
3 an hour. So that means that they're likely --
4 MR. SISK: This is Rob Sisk. Our chapter
5 15 people are not here yet.
6 CHAIRMAN BALLINGER: So I'm doing the math
7 here. They should be here at about 11 o'clock. So we
8 will recess until approximately --
9 MR. SISK: We do have the comment on the
10 swelling but we're going to wait. I have the subject
11 matter expert is here. He is on his way with the
12 chapter 15. So you'll get it right from them.
13 MEMBER STETKAR: Rob, when do you expect
14 them to be here realistically?
15 MR. SISK: We're going to check now. We
16 got the same word you guys got.
17 MEMBER STETKAR: The problem is recessing
18 and coming back at a specific time only to find out
19 that they're not here is not all that efficient.
20 CHAIRMAN BALLINGER: I was going to define
21 an uncertainty.
22 MR. SISK: We're doing a real quick check
23 on the ETA now but of course with Washington traffic
24 on the Beltway you never know. They're coming from
25 Tyson's Corner.

1 CHAIRMAN BALLINGER: I think we'll recess
2 and later in the vicinity at around noon. And we'll
3 figure out where we're going then. Excuse me, 11.
4 (Whereupon, the above-entitled matter went
5 off the record at 10:44 a.m. and resumed at 11:06
6 a.m.)
7 CHAIRMAN BALLINGER: Thank you very much
8 for KHNP folks being able to accommodate us. I think
9 you look like you're out of breath actually. It's all
10 right. So, we can bring in oxygen if we need it. So,
11 we're going to be back in session. And we'll start
12 with Chapter 15. Thank you again.
13 MR. SISK: Okay. Thank you for the
14 opportunity again. And at this point I'm going to
15 turn it over to Mr. Woochong Chon to lead us through
16 the Chapter 15 discussion.
17 MR. CHON: Good morning. My name is
18 Woochong Chon. And let me think of something. There
19 was heavy rains in D.C. area the day before yesterday.
20 And I saw the news, and this one hotel was flooded.
21 And all the guests was evicted at the very, early in
22 the morning, like 2:30 a.m. 3:00 a.m.
23 And my colleagues and I were one of the
24 members of that. So, the day before yesterday we took
25 only less than two hours to sleep. And it was that

fresh experience for us. And also, it's a good time to think about safety.

If that hotel has a redundancy and independence concept, then that kind of things will not happen. But that hotel doesn't have any redundancy and independence like APR1400.

So, I'm sure that APR1400 plant has sufficient redundancy fact, and also independence. So, I'm here to present about the safety. And want to emphasize APR1400 is plenty of safety. Thank you.

Okay. Let's start of contents of this presentation. This presentation consist of three parts. First overview of Chapter 15 and summary of open items, and current status of Chapter 15.

And at the last page I describe the acronyms for your convenience. So, if you need those, some acronyms, then you can check the last page.

Okay. This slide shows overview of Chapter 15. Chapter 15 has a total of ten sections, especially 15.6.5 is LOCA analysis part. And other parts are related to transient analyst part.

This slide shows the list of submitted documents, and summary of RAIs for Chapter 15. First, in design control documents of Chapter 15, and non-LOCA, post-LOCA long term cooling, and Small Break

1 LOCA evaluation model. Those three items are
2 technical report.
3 And the last line, the realistic
4 evaluation methodology for Larger Break LOCA of
5 APR1400 is supplemented as a tactical report. This
6 tactical report is, became the base of Larger Break
7 LOCA analysis of Chapter 15.
8 So here are the open items. Tech open
9 items Phase 3 was raised. And those all open items
10 are closed in Page 4. Okay. This slide shows the
11 list of open items which are raised in Phase 3.
12 There are ten open items in Phase 3. And
13 they are listed in this table. ADAMS Accession
14 numbers are listed in the last column. And let's see
15 some more details about each ADAMS.
16 The first open item in Chapter 15 is
17 Periodic Reopening of the MCR Air Intakes, related to
18 the RAI 7973 and 8470. KHNP identified that MCR
19 ventilation system design provides for automatic
20 selection of the least contaminated outside air
21 intake.
22 And the closed MCR intake will re-open
23 automatically, so that the intake with the higher
24 radioactive can be selected again and closed. For
25 this design staff required to show that the increase

1 in dose from both air intakes being open periodically
2 can be encompassed by the current design margin, and
3 design update is the PST.
4 As a resolution KHNP provided the
5 additional information on the dose evaluation,
6 including the dose increase can be compensated from
7 the design margin of 20 percent.
8 The onsite ultimate dispersion factors of
9 the control room have intake receptors, assuring the
10 reduction factor of eight, instead of a factor of ten
11 allowed by the Reg Guide 1.194. And DCD was revised.
12 MR. SCHULTZ: I have a question on the
13 original basis of your selection of a reduction factor
14 of eight. What I recollect is that you had decided to
15 choose that reduction factor of eight before the
16 questions came up from the staff as to whether this
17 was going to be able to accommodate this issue.
18 What was the basis for choosing a
19 reduction factor of eight, versus the reduction factor
20 of ten? You could have not taken that approach. And
21 I'm just wondering whether you had, what was the
22 thinking behind using a reduction factor of eight,
23 instead of ten, in the first place?
24 MR. CHON: Okay. Actually I'm not the
25 expert for that area. So I, what I understand is just

1 give a 20 percent margin. The ten is defined in the
2 Reg Guide 1.194. So, we want to set the 20 percent
3 margin. So, conservatively we said eight instead of
4 ten. But if you need a more detailed information I
5 will ask to my experts and --
6 MR. SCHULTZ: I would like to know what
7 aspect of the control room dose evaluation led you to
8 a conclusion that you needed to have margin in this
9 particular parameter. So, if you could ask that
10 question, and provide a response on that I'd
11 appreciate it.
12 MR. CHON: Okay.
13 MR. SCHULTZ: Not today. But --
14 MR. CHON: I will check.
15 MR. SCHULTZ: -- whenever you can. Thank
16 you.
17 MR. CHON: Thank you. Okay. Next item,
18 next slide. This slide shows the summary of open item
19 related to the complete for our mixing model. In RAI
20 7917 NRC staff noted that the flow rate in Modes 4 and
21 5 when all RCPs are idle, and with one shutdown
22 cooling train in service, may not be sufficient to
23 assume complete RCS mixing.
24 Staff requested to provide the
25 justification that the complete mixing model is

1 conservative, including any potential effect of
2 incomplete lower plenum mixing. Also, they requested
3 to demonstrate that the source range detectors can
4 sense any postulated incomplete mixing.
5 As a resolution KHNP decided to add
6 additional valve in the rear to make up water line to
7 block the flow path from the unborated water source.
8 In addition, KHNP added new Tech Spec 3.1.12 and its
9 Bases to prohibit dilution operation.
10 And the quantitative analysis part for
11 these Modes in DCD 15.4.6 was eliminated. And this
12 item is also resolved.
13 MEMBER SKILLMAN: Let me ask this, please.
14 How does isolating an unborated water source address
15 the concern about mixing in the reactor vessel? Those
16 two are absolutely independent phenomena.
17 MR. CHON: Please repeat one more time,
18 please.
19 MEMBER SKILLMAN: How does isolating an
20 unborated water source address the issue of mixing in
21 the reactor vessel? I'll have to ask the staff this
22 question. Because I, it seems to me that the question
23 is really aimed at the idea of stratification, or
24 thorough mixing in the very large reaction vessel,
25 that's completely different than having a suction

1 source that's been isolated.

2 MR. SISK: Understand. I think we have a

3 response here behind you. Andy.

4 MR. OH: Yes. This is Andy Oh, KHNP

5 Washington Office. Originally this, the issue arose

6 from during the shutdown mode for Modes 4 and 5.

7 If there's some, you know, fresh water

8 came to the, came into the reactors, then it does not

9 complete the mixing, then there's a reactivity problem

10 can be happen, potentially.

11 So, in order to justify that complete

12 mixing model we have to do some of analysis for, the

13 CFP analysis, or some other thing. But it is very

14 hard.

15 So, in order to reserve that complete

16 mixing model we just installed the one valve to

17 prevent of the source of the, you know, fresh water to

18 come in, coming into the reactor.

19 So, after that is the complete mixing

20 model problem. It's not a, can be some issue,

21 potential issue. So, that's the way that KHNP

22 responded to these issues to the staff.

23 More recently there's some issue for the

24 mixing problem during raw mode. However, we just

25 reserved this issue with some of the additional

1 modification of design. So, eliminate the whole
2 source of the pressure water, potential pressure water
3 came into the reactor during our raw model situation.
4 Does that answer to your question?
5 MEMBER SKILLMAN: It answers a phenomenon
6 question about density difference, colder water versus
7 warmer water. The real driver for the reactor coolant
8 system boron concentration is decay heat. It's
9 natural circulation within the core, or within the
10 loop, depending on who much decay heat is there, and
11 what the concentrations are.
12 But it seems that the answer that's
13 provided on the slide is pointing to a water source
14 that can be colder, when in reality the question that
15 the staff asked has more to do with how one ensures
16 that the reactor coolant system is thoroughly mixed.
17 And it seems to me that those are independent issues.
18 MR. SISK: This is Rob Sisk. I think, and
19 I'll ask Andy to clarify if I got this wrong. I think
20 the question is the fact that you're introducing
21 unborated water into your thoroughly mixed borated
22 water. And rather than deal with the unborated water
23 being mixed in with the borated water, they've
24 isolated it so that the unborated water isn't mixing
25 in with the borated water.

1 MEMBER SKILLMAN: I can understand that
2 logic based on the words that are here. But I would
3 also suggest that at some point you're going to have
4 to put in, if you're going to decrease the boron
5 concentration, some over concentration water. And
6 you're still going to have some problem like this.
7 MR. SISK: I understand that point. But
8 that --
9 MEMBER STETKAR: Can I try something here.
10 I haven't been following this. And I think it would
11 be useful when the staff comes up for them to
12 elaborate on their initial concern here.
13 What I see this particular modification
14 responding to is an issue that was identified first by
15 the French, when they did shutdown risk assessment and
16 identified a condition where you could fill a loop
17 with pure water, and then start a reactor coolant and
18 inject the pure water into the core, resulting in re-
19 criticality.
20 It's not the boron mix, it's boron mixing
21 in the sense that if the pump was running you would
22 get mixing of that. It's my understanding that this
23 valve, and the corresponding tech spec protects
24 against that phenomenon.
25 Is that correct, Andy? And again, I'd

1 like to hear from the staff what their initial concern
2 was. Because we may be talking about two different --
3 MEMBER SKILLMAN: Phenomena.
4 MEMBER STETKAR: -- phenomena of two
5 different so called mixing phenomena.
6 MR. OH: Yes. And you can have two kind
7 of the mixing problem. My memory tells that, yes,
8 that's right. And a slug.
9 MEMBER STETKAR: A slug.
10 MR. OH: It's slug. And then it's when
11 RCP is re-operated, that slug is, goes into the --
12 MEMBER STETKAR: Yes.
13 MR. OH: -- documents and records. That's
14 the one, another thing is also, yes, this one for
15 pressure water source. It's just in. So, two kind of
16 things that combine together.
17 MEMBER STETKAR: This also protects you
18 against kind of a gradual boron dilution.
19 MR. OH: So originally I think for this
20 RAI deal with two kind of things. But we drove the
21 first two things in a slug, with a different way. And
22 the second thing is we also isolated the source of the
23 unborated water using a just isolation valve. But the
24 title is only for the complex completed mixing model.
25 But inside of here it deals with the two issues.

1 MR. CHON: We have another HRS meeting for
2 long term core cooling part. And the slug with
3 unborated water flow into the core. That RAI will be
4 treated in the long term core cooling HRS meeting.
5 Okay. This slide shows the summary of
6 open item related to rate of trip during boron
7 dilution at power. In RAI 8668 NRC staff noted that
8 a slow reactivity insertion transient such as boron
9 dilution at power would not be protected by the
10 variable overpower trip.
11 Staff requested to provide which reactor
12 trip would occur for boron dilution event at power.
13 As a resolution KHNP provided the clarification that
14 the core protection calculator system, DNBR trip or
15 CPCS auxiliary trip can protect the DNBR limit during
16 a slow reactivity insertion event. And this item is
17 also resolved.
18 And next open item shown in this slide is
19 Small Break LOCA Dense Break Spectrum Analysis,
20 related to RAI 8337. Staff requested to provide the
21 result of finer break spectrum for both the DVI line
22 break pumper discharge rate break.
23 KHNP performed the dense break spectrum
24 analysis for the DVI line and pump discharge rate
25 break. Break spectrum analysis number is increased

1 from 10 to 39. Here 37 is missed, typo number. So
2 that now break spectrum analysis number is 39.
3 The limiting DVI line break size is
4 changed from 0.4 feet square to 0.1364 feet square.
5 The LOCA criteria is still satisfied. And KHNP
6 revised the RAI response in technical report, and also
7 DCD Chapter 15.6.5. And this item is resolved.
8 MR. SCHULTZ: Can you provide some
9 indication, and I don't have the table in front of me,
10 but as to what margin you had before you did the new
11 break spectrum analysis? And what margin you had
12 after the fine detailed break spectrum, and changed
13 the bread size?
14 MR. CHON: You mean margin for the --
15 MR. OH: What you say --
16 MR. CHON: -- temperature?
17 MR. SCHULTZ: Yes.
18 MR. CHON: In previous version we have
19 four DVI line break and four pump discharge rate
20 break, and also one IOQSLV event. And the other one
21 is instrument tubal break. So total nine break size
22 was evaluated.
23 And new methodology we, DVI line break is
24 a total 15, and pump discharge rate break is 17. And
25 also IOQSLV event is one. And instrument tubal break

1 is one. And more smaller size break is five cases.
2 MR. SCHULTZ: No.
3 MR. CHON: The detailed PC number will be
4 answered my colleague, Mr. Lew. The PC number for
5 previous one and new calculation one.
6 MR. SCHULTZ: To a microphone, please.
7 Thank you.
8 MR. LEW: My is Kaeyeol Lew from KHNP.
9 So, previous limiting PCT is 1,166 every 39. And new
10 one for PCT is 1,684.
11 MR. SCHULTZ: So, it was a good thing to
12 do the more detailed break spectrum analysis. You did
13 get substantially different results. So, that was a
14 good thing to do.
15 Just, I wanted to get this on the record
16 that the fine detail of a break spectrum analysis can
17 be important in the analysis result that's derived.
18 Thank you.
19 MR. CHON: Okay. The next open item is
20 upper bound on the Small Break LOCA break size. This
21 open item is related to the RAI 8488. The staff
22 requested to demonstrate that the 0.5 feet square
23 break size remains the largest Small Break LOCA which
24 must be considered.
25 KHNP explained that the analysis with the

1 breaks larger than 0.5 feet square are treated by the
2 current Large Break LOCA methodology. And KHNP also
3 presented the result comparing the Larger Break LOCA
4 PCTs.
5 The PCT calculated by the Larger Break
6 LOCA was greater than the PCT obtained from the Small
7 Break LOCA methodology. It also come from that both
8 the Larger Break LOCA and Small Break LOCA PCTs are
9 much less than 2,200 Fahrenheit. Hence, this item is
10 also resolved.
11 MEMBER REMPE: So, I have a question. In,
12 it pertains to questions I'll have later on with, when
13 we talk about the Large Break LOCA methodology. But
14 your calculations were done with RELAP/MOD3.3/K,
15 right?
16 MR. CHON: Correct.
17 MEMBER REMPE: And I don't know if I asked
18 this when we discussed it previously, but this is a
19 version of RELAP that comes through ISL? Or is you
20 version that you obtained from some organization in
21 the U.S., right?
22 MR. CHON: We received the RELAP5 version
23 from the NRC.
24 MEMBER REMPE: From the NRC?
25 MR. CHON: Correct.

1 MEMBER REMPE: Okay. So, NRC relies on an
2 organization, ISL. And as with the many codes there's
3 always errors that are found in future years. So,
4 basically you are maintaining that relationship with
5 NRC and ISL to incorporate error improvements,
6 corrections periodically?
7 MR. CHON: Yes. Well, there is one
8 organization, which is KAMP.
9 MEMBER REMPE: Right.
10 MR. CHON: We also one of the member of
11 KAMP. So, we are receiving the error informations
12 periodically. But this RELAP5/3.3 applied in this
13 calculation is, error correction is not applied.
14 MEMBER REMPE: Well, probably when you
15 obtained it, it had been updated to provide those
16 error corrections. But then, in the future you'll be
17 monitoring error corrections that come, and assess
18 whether you need to do anything, is what I'm trying to
19 get to.
20 MR. CHON: Yes. We are doing assessment
21 --
22 MEMBER REMPE: Okay.
23 MR. CHON: -- every time.
24 MEMBER REMPE: Thank you.
25 MR. SCHULTZ: I have a question on this

slide. The question was to demonstrate that this break size is the largest small break which must be considered. And so, you did a comparison between the large break methodology and the small break methodology.

Why is it that you want to conclude that the large break methodology is greater than the PCT for the small break? What was it that told you that you were therefore done with the analysis to answer this question?

MR. CHON: Okay. From the smallest break size, from the 0.5 it is clear we are applying small break methodology, with C plus 4 AS code. And from the 0.5 to the 100 percent break size is, will be handled by Larger Break LOCA with RELAP5. And that's the ultimate methodology.

So, even, excuse me. The PCTs at the 0.5 feet square, the Larger Break LOCA PCTs are higher than Small Break LOCA. And these PCT will be compared with other total range of Larger Break size ranges. And we will select the highest PCT, including the 0.5 PCT.

MR. SCHULTZ: So, that's why it's good. It bounds the small break result at that location, for that break size. You wouldn't feel more comfortable

1 if they were the same PCT?

2 MR. CHON: Yes.

3 MR. SCHULTZ: But you wouldn't feel

4 comfortable, as comfortable if the large break

5 analysis methodology gave you a lower number than

6 small break. Is that, am I right with that?

7 MR. CHON: In Small Break LOCA Permanent

8 and Larger Break LOCA Permanent is a little different.

9 So, C plus 4 AS code is adopted for the Small Break

10 LOCA Permanent.

11 So, even Larger Break LOCA will apply

12 could calculate the higher PCT. But still we

13 personally delete the Small Break LOCA code. It will

14 calculate the Small Break LOCA PCTs until 0.5 feet

15 square break size.

16 MR. SCHULTZ: Okay. Thank you.

17 MR. CHON: Okay. Let's move on to the

18 next item. And this slide shows the summary of open

19 item related to the impact of thermal conductivity

20 degradation, which is TCD.

21 In RAI 7954 NRC staff noted that the

22 FATES3B code does not account for the effect of TCD,

23 and also requested a TCD impact on the fuel rod design

24 and safety analysis.

25 FATES3B code is used for the fuel rod

1 performance analysis, and generation of interface data
2 for safety analysis. To resolve this open item TCD
3 penalty was composed to mind based on analysis results
4 compared with the experimental data at various burnup.
5 KHNP performed the analyses for the design
6 evaluation for the related safety area with TCD
7 penalty. For CEA ejection, peak radial average fuel
8 enthalpy is increased less than 11 calorie per gram,
9 which is much lower than 230 calorie per gram.
10 And peak centerline temperature is
11 increased about 317 Fahrenheit at HFP case. And no
12 fuel centerline melting is occurred. For Larger Break
13 LOCA part the details of TCD effect will be discussed
14 in the Larger Break K/REM topical report section
15 later.
16 And DCD Tier 2 chapters and Larger Break
17 LOCA topical report were revised. The RAI, including
18 impact of TCD, has been resolved.
19 And this slide shows four open items,
20 which are loop seal clearing and reformation, and post
21 LOCA boron precipitation, LOCA deposition model, and
22 boron dilution. The details about these four items
23 will be treated in the long term core cooling section
24 separately.
25 Lastly, this slide summarizes the current

1 status of DCD Chapter 15. Chapter 15 is completed.
2 KHNP continue to monitor Chapter 15 to assure any
3 conforming changes are addressed.
4 Ten open items. Those were identified in
5 Phase 3, has been resolved with adequate and
6 sufficient discussion with the staff. Changes in
7 Chapter 15 as reviewed, and marked up in response to
8 the RAIs are incorporated into the Revision 2 of the
9 DCD.
10 Thank you so much for listening. And I
11 will happy to answer the question you might have.
12 CHAIRMAN BALLINGER: Questions? Thank
13 you.
14 MR. CHON: Thank you.
15 CHAIRMAN BALLINGER: Is the staff ready to
16 go?
17 (Off microphone comments)
18 MR. STECKEL: Hi, good morning. My name
19 is Jim Steckel. That's Michelle Hart on that end and
20 Shanlai Lu.
21 We'll do our staff's presentation on our
22 review of Chapter 15. And we'll go through some of
23 the items that were discussed as far as RAIs and their
24 close out.
25 We're going to start with Michelle and

we'll begin with Slide Number 2. Michelle.

MS. HART: Thank you. I'm Michelle Hart, I'm in the radiation protection and accident consequences branch and I reviewed the design basis accident dose analyses in Chapter 15.

We did have one open item in the last phase of the review for the APR1400, and it was the modeling of the control room emergency makeup air cleaning system operation and the design basis accident dose analyses, the control room compatibility analyses.

The design certification did not clearly describe the system operation where the control logic automatically re-opens the close air intake. They have two diverse air intakes at a preset interval for a short period of time to determine which air intake has the most contamination and then re-closed that contaminated air intake. So they always have the lowest contamination being taken into the control room.

The dose analyses did not make that clear that that was the operation, and neither did the discussion in Chapter 9 or Chapter 6. So we asked some questions about that.

The response, the REI responses for that

1 describe the modeling assumptions for the damper
2 operation. And that they did make revisions to the
3 design certification, Sections 9.4.1 and 15.0.3, to
4 more clearly describe the system operation and the
5 dose analyses assumptions that the interval between
6 the openings was an hour and the duration of the
7 openings was one minute in their assumption.
8 And that assumption was accommodated by
9 the 20 percent margin that they had from the X/Q
10 assumptions that they had for the intake.
11 They also revised their ITAAC to clarify
12 the damper operation, and that will be discussed in
13 Chapter 14. That's really where the question came
14 from was Chapter 14 and the ITAAC.
15 And they revised COL Item 9.4(2) and they
16 added new COL Item 15.0(2) and (3) to identify that
17 the COL applicant verified the damper re-opening
18 interval and duration are the same or are accommodated
19 by the current dose analyses. So that they're aware
20 of those.
21 The assumptions on the interval between
22 the openings and the duration of the openings. And so
23 that did resolve the issue.
24 MR. SCHULTZ: Michelle, I wanted to come
25 back to the margin that was used. And I wanted to be

1 sure that there's enough information in the final
2 document to describe to the next evaluator of dose to,
3 not double take on the margin --
4 MS. HART: Right.
5 MR. SCHULTZ: -- because it, that's really
6 one of the things I'm, or that's really the main thing
7 I'm concerned about.
8 It was roughly stated that, well, this
9 will be accommodated by the 20 percent margin but it,
10 I know it's within. You've given the parameters and
11 you wouldn't expect a very large delta associated with
12 that, but you've used up some of the margin in that 20
13 percent value, and that needs to be taken into
14 consideration when the dose analysis is done.
15 MS. HART: Sure. That was certainly one
16 of our concerns as well, that they were using up some
17 of that margin and it was not clear that the margin
18 was being used.
19 And so one of the effects of the COL items
20 that were added in Chapter 15 is to ensure that the
21 COL applicant looks at that analysis and determines if
22 they're, you know, to make them aware that that margin
23 is being used to accommodate these things.
24 MR. SCHULTZ: That's what I wanted to be
25 sure was done.

1 MS. HART: Yes.

2 MR. SCHULTZ: Because I could see that

3 being taken into account, perhaps in the uncertainty

4 of the X/Q value --

5 MS. HART: Some other --

6 MR. SCHULTZ: -- sometime in the future.

7 MS. HART: Right.

8 MR. SCHULTZ: And they only have part of

9 that left --

10 MS. HART: That is correct.

11 MR. SCHULTZ: -- based upon your

12 discussions with the applicant.

13 MS. HART: That is correct.

14 MR. SCHULTZ: Thank you.

15 MEMBER SKILLMAN: Michelle, as you

16 described, or you presented the question and how far

17 you had to go to get the answer, was there a, is there

18 a description of the quality level of the control

19 system that makes the selection for which air intake

20 is ultimately chosen?

21 Is that a nuclear safety related or is

22 that QA1, was there exploration to that level, to the

23 hardware, so that there is confidence that the

24 selected air intake is the air intake that is truly

25 desired and there is confidence that that equipment

1 will do what it's supposed to do?

2 MS. HART: We did look into that. I have

3 to admit that I don't remember what we determined.

4 I am not the reviewer for that section.

5 It would be something that was also evaluated under

6 Chapter 7, in general. But we did look into the

7 quality of the selection.

8 MEMBER SKILLMAN: Okay, thank you.

9 MS. HART: Any more questions? I will

10 turn it over to Shanlai Lu then.

11 MR. LU: Okay. All right, Shanlai Lu from

12 staff, reactor systems. So I'm going to go over the

13 remaining open items and how we closed them as part of

14 this phase of the review, okay.

15 So, I'm going to go item by item. At this

16 point, all ten open items have been closed. Some

17 include the non-term cooling aspect. I also include

18 my presentation as the high-level summary, for

19 example, boron precipitation, boron dilution in

20 theory.

21 But the details can be, if the committee

22 wants to know the more details, that will be in June's

23 presentation. But today, I already include them as

24 the high-level summary.

25 Okay, so I'm going to go through item-by-

1 item. The first item is related to fuel pellet
2 thermal conductivity degradation, the TCD issue.
3 The issue came from Chapter 40 review.
4 4.2 fuel design and then Class 7 KEPCO. And the BRD
5 presented the reasons why we had this issue, why we
6 asked for these RAIs, additional information.
7 And the reason, really the FATES3B, the
8 old, ancient code. But they have been used in that
9 design basis for this run of the, design certification
10 analysis, and in which most of the thermal
11 conductivity degradation phenomenon.
12 And with that, we performed a confirmatory
13 analysis, we found because of that it may miss the
14 centerline temperature at full power, several hundred
15 degree Fahrenheit. That's a lot.
16 So therefore, we launched an RAI. Not
17 only in Chapter 4.2 but also as the relevant Chapter
18 15 analysis, we asked for what's the impact.
19 So, as part of a few topical reports in
20 the 4.2 presentation to you guys, we already resolved
21 and presented to you, once the Staff considers the, a
22 profit conservative penalty. We add it on top of the
23 FATES3B, and analysis package can go forward.
24 And now we're going to talk about the cost
25 of the penalty. So based on the Staff's, the penalty

on the centerline temperature and on the FATES3B computer code. And they performed additional analysis anywhere impacted by the initial fuel temperature, centerline temperature calculation, for the Chapter 15 part.

So this part actually is close but I am going to go through that a little bit, okay. The CESEC code is an old code really, to calculate the ATWS code and the ATWS scenario and then the system response and the power.

And one part is the impact that could be, by the initial temperature, was the gap conductance. And they found, they already choose the code, already choose very conservative of gap conductance for that particular purposes.

And it was not intended to capture the TCD but they already got it. So, with the additional temperature increase, due to the penalty and then the impact on the gap conductance is minimal, so it's not an issue for that one.

And that there is also, we also have the, we also questioned them, what's the feedback. And then you have kinetics and then you have the operating factor, feedback coefficients might be impact because of your fuel temperature is elevated by several

1 hundred degrees. That is a hot thing, hot spot.
2 And they planned, they provided additional
3 analysis evaluation and they found the, when they
4 select the operating feedback coefficients, the upper
5 bound value and then conservative of the already
6 existing analysis, already found this temperature
7 delta.
8 So therefore -- yes, Dr. Schultz?
9 MR. SCHULTZ: So each of these were
10 separate evaluations? Bullets 1 and Bullet 2 there.
11 MR. LU: Right. And then they combine the
12 value to the CESEC code, the analysis existing, and
13 see whether from those two perspectives, are they
14 really still credible to produce conservative results.
15 And then our conclusion, based on what we provided, we
16 think there is sufficient margin error.
17 MR. SCHULTZ: You evaluated the
18 uncertainty that was --
19 MR. LU: That's right.
20 MR. SCHULTZ: -- provided as well as the
21 gap conductance values --
22 MR. LU: That's right.
23 MR. SCHULTZ: -- and determined that they
24 were appropriate?
25 MR. LU: That's right.

1 MR. SCHULTZ: They're best estimate, or
2 whatever they call their values --
3 MR. LU: No, no, I'm sorry --
4 MR. SCHULTZ: -- were appropriate?
5 MR. LU: Yes.
6 MR. SCHULTZ: The conservatism and then
7 the delta.
8 MR. LU: Yes, that's right. That's part
9 of the RAI responses they provide to us.
10 MR. SCHULTZ: Thank you.
11 MR. LU: Okay, next slide. Okay, then
12 thermal codes, other codes also impact the CETOP
13 thermal margin analysis.
14 And of course we, because of the initial
15 temperature, fuel centerline temperature could go
16 higher than what we calculated, we wanted to know
17 what's the impact on the DNBR margin during the
18 transit.
19 And then we found out, oops, and then that
20 part of the code is not sensitive, even to this issue.
21 So CETOP margin, thermal margin analysis is not an
22 issue.
23 We did see the rod ejection case and it
24 can be, you know, changed. And then because of that
25 one, so they performed additional new analysis based

on still the existing code. The code is not an impact of the, it's applicability to analyze this scenario.

But because of the pellet thermal conductivity multiplier applied in the STRIKIN-II is to be increased, to handle the penalty we added on top of FATES3B, so we re-run code. And then the good news is, there is no cure in the fuel failure centerline.

Centerline temperatures did, the prediction did go high. Higher than what previously calculated. But it's still much lower than the failure criteria there.

So therefore, the current Chapter 15 4.8 with the revised analysis, they address the Staff's concern about thermal conductivity degradation after we applied the penalty.

Okay, as the KHNP mentioned, they also updated their Large Break LOCA topical report to take into account how that methodology can take on the additional penalty. So that will be presented after lunch probably.

So with that, anything related to TCD on Chapter 15 we did provide additional analysis and RAI as part of the official RAI responses on the docket and we, Staff, reviewed, actually we performed quite a lot, confirmed to analysis based on our site, and we

1 don't see a challenge for the design. So therefore,
2 yes.
3 MR. SCHULTZ: Just a comment really.
4 MR. LU: Sure.
5 MR. SCHULTZ: Unfortunately, you've had a
6 lot of experience applying penalties associated with
7 the thermal conductivity degradation through analyses
8 --
9 MR. LU: Right.
10 MR. SCHULTZ: -- and so, using that
11 experience, have you been able to determine that the
12 application for this Applicant, had been done
13 appropriately, to demonstrate that even with
14 penalties, the analyses meet the criteria that they're
15 designed to meet.
16 At the same time, I'm sure you would have
17 preferred if the application had used methodologies
18 that incorporated the thermal conductivity
19 degradation. And I would certainly hope that in the
20 future, that those analysis methodologies are
21 developed.
22 Not only including safety analysis but
23 also physics analysis and other applications where
24 thermal conductivity is important. Thank you.
25 MR. LU: Yes, I think that's, we're on the

1 same page. And that's the reason, when we had to pre-
2 submit a QE audit, we already identified the issue.
3 But we knew that to redo that part of the
4 review and then also for them to integrate a brand new
5 code into this fabric of entire suite of codes, it's
6 almost a type audit. It may not be workable for that.
7 And by the same time, they already told
8 us, they already submitted their code. Look for code.
9 I think first is they asked for it on the field.
10 And then that part already addressed the
11 TCD issue. But they send through the review process
12 of the Korean regulator. And then that part was
13 recently approved. And it was used for Shin Kori Unit
14 3 operations, right? Yes.
15 So I think that's what we, we actually
16 interacted with teams on this particular issue to end
17 that. And that we wanted to know, do these really say
18 additional challenge after they use the code, which
19 has already addressed the TCD.
20 From the design perspective, there is no
21 challenge of the, in the original design criteria.
22 The markings are reduced but it's still past their
23 margin there.
24 MR. SCHULTZ: That's good, Shanlai, I'm
25 glad that you put that onto the record today because

1 we've talked about this in general on how you got some
2 specific advances that they have done --
3 MR. LU: Right.
4 MR. SCHULTZ: -- that I'm glad to hear
5 about. Thank you.
6 MR. LU: Yes. I think this was based on
7 your comments last year, so we went out and talked
8 through them, talked to them, and find out what, how
9 they resolved this issue.
10 And the Korean regulator came, they told
11 us how they resolved with KHMP over the Korean
12 application. I think going forward, and they come
13 back with really COL, I think that they may have
14 better methodology to go forward.
15 MR. SCHULTZ: Okay, thank you.
16 MEMBER REMPE: So, before we leave that
17 topic --
18 MR. LU: Yes.
19 MEMBER REMPE: -- and we may discuss this
20 more in the Large Break LOCA methodology, but it was
21 observed in some of the material I read, that RELAP
22 3.1 versus 3.3 uses a different thermal conductivity
23 degradation model.
24 MR. LU: Okay.
25 MEMBER REMPE: And that the 3.3 model is

less conservative. And this is an NRC code that ISL is helping you maintain and why was that done?

MR. LU: Okay. I mean, I think the best place to address that question is the presentation later, but I can add on top of it. It's irrelevant to the different RELAP versions.

The penalty we added on top of that is on the FATES3B, how you initialize it. So how do you capture the initial temperature distribution, the initial sort of, you now, as the initiate steady state condition. That's the major contributor to the initiate stored energy there.

And definitely, you are right. And then there is the RELAP 5 versions of different TCD model waiting the different version. That will be covered by today, this afternoon's presentation.

MEMBER REMPE: Okay, thank you.

MR. LU: Okay. All right, let's move forward. There is one more slide.

All right, we just talked about this. So, we did identify two open items, 15.6.5-1 and 2. And then basically capture the Large Break LOCA topical report needs to be reviewed.

And we are in the process to wrap it up, the SER. And you can hear this afternoon

presentation. We are proving that topical report.

And the analysis results for 15.6.5-1 LOCA analysis. So that part is closed right now. Both open items are closed going forward.

All right, inadvertent boron dilution during Modes 4 and 5. Okay, I think I answered Mr. Skillman's, Gordon, your question. I think that's the page.

The phenomenon, okay, you asked a question to KHNP, I think that we already addressed that one. From a Staff perspective, let me give you the, where we came from.

Okay. So during Mode 4 and 5 there is an inadvertent boron dilution due to the actuation of freshwater injection. It can happen. It can happen.

So, you know, the successful criteria or the safety concern here is, are you going to reach critical. During full Mode 4 and 5 it's not pleasant. You have the core going critical during Mode 4 and 5, that has to be stopped.

So, the question becomes, when you really have inadvertent freshwater injections through the freshwater source, as CVCS injects there and less than half critical.

So, their initial analysis assumed, when

1 there is a slug off of freshwater coming in, the
2 freshwater pump injects into the RCS system, the water
3 were immediately diluted and mixed with the entire RCS
4 coolant.
5 So previously, it's all-natural
6 circulation but it's borated water. And then you have
7 decay heat, and it depends on Mode 4 and 5, initial
8 starting point.
9 If it started from, started from zero
10 power come down, you don't have a whole lot of decay.
11 But if you have full power come down to Mode 4 and 5,
12 you still have a lot of decay heat to remove. You
13 have natural circulation going on.
14 But the situation becomes, we checked into
15 their analysis to say, they took the credit of these
16 analysis assuming complete mixing of the freshwater,
17 immediately after water is injecting into the RCS. So
18 the question, where is this, is this conserved.
19 That's the reason we asked that question.
20 So, when we asked the question then we
21 found out, and then based on the interaction with
22 them, they said it may not considered. But it's
23 really extremely hard to, within the time frame, to
24 solve this problem automatically.
25 If it's not solved automatically, then

1 we'll have to review their CFD codes of the entire RCS
2 system. Which, you don't really see many cases using
3 CFD codes for that case.
4 So therefore, then the bounding analysis
5 is performed, indicating there is a potential
6 possibility the core could reach critical.
7 Depends on how you assume that a slug of
8 water coming into the RCS might lead down into the
9 downcomer and the mix of the, because it's colder than
10 the system, it's colder water, and the freshwater
11 comes in and it may not have mixed very well, it will
12 mix, but it might not mix completely with the entire
13 RCS, to give you a number at the core inlet, what's
14 the boron concentration. So that's the reason we
15 asked the question.
16 So this also, the only caution within the
17 reactor system side, actually, it does require
18 additional significant change. Okay, that's the part.
19 And then based on, not only just because
20 of the difficulty of the analysis to performed CFD,
21 but if you perform a bounding analysis of assuming
22 non-mixing, the freshwater will reach the inlet of the
23 core, you reach critical. So therefore, the safest
24 way to do that, is not perform analysis to take the
25 credit, which may not be available during the time

frame of this particular review, but is to just secure the freshwater source.

Which is, they added a new isolation valve in the reactor, makeup a water line to block the flow paths. But following certain tech specs back.

It can, this can still add freshwater, it just use that one to control and make sure that part is isolated. And then the operator can check, during a Mode 4 and a 5, this valve is closed. That's the reason.

And then the, related to that valve, and then of course there is additional tech specs changed. And then they introduce additional tech specs change.

With that one, we do not see any potential concern, any more, about the criticality due to the freshwater.

MR. SCHULTZ: Thank you for the explanation. And I see that now in the RAI.

MR. LU: Right.

MR. SCHULTZ: As, John pointed out --

MR. LU: Yes.

MR. SCHULTZ: -- this was a concern about a slug, and it really gets down to, where are you when you start an idle pump.

MR. LU: Yes.

1 MR. SCHULTZ: Or the flip side is, when no
2 pumps are running.
3 MR. LU: That's right.
4 MEMBER STETKAR: Just for clarity, the
5 text spec requires this valve to be closed in Modes 4
6 and 5 --
7 MR. SCHULTZ: 4 and 5.
8 MEMBER STETKAR: -- when all RCPs are
9 idle. So when you have no force circulation from the
10 reactor coolant pump.
11 MR. LU: Yes.
12 MEMBER STETKAR: So, it allows you to
13 start up a reactor coolant pump so that you can
14 eventually start up the plant and start to dilute.
15 MR. LU: That's right. The slug issue by
16 itself, we are, actually, I have another point related
17 to that boron dilution item. It's within Small Break
18 LOCA, you have a loop seal, you have a slug.
19 But this particular, if you have
20 freshwater injection, it may form a slug too. But RCP
21 may not be activated to press the water through to the
22 core.
23 So therefore, the issue really, it's slow
24 mixing transient, can that be causing any Staff's
25 concern, a safety concern of potential re-criticality.

1 MR. SCHULTZ: Thank you, Shanlai, for the
2 explanation.
3 MR. LU: Okay.
4 MR. SCHULTZ: I understand.
5 MR. LU: Okay.
6 MEMBER MARCH-LEUBA: I wanted to make a
7 comment. You were kind of apologizing --
8 MR. LU: Yes.
9 MEMBER MARCH-LEUBA: -- that there was not
10 enough time to run a sophisticated analysis to
11 demonstrate that the problem even exists.
12 MR. LU: Right.
13 MEMBER MARCH-LEUBA: I think that the
14 solution that I came up with is better than the
15 analysis. Because you actually --
16 (Laughter)
17 (Off microphone comment)
18 MEMBER MARCH-LEUBA: Yes. You prevented
19 the accident and you improved the safety of the
20 reactor.
21 MR. LU: Right.
22 MEMBER MARCH-LEUBA: And I wanted to
23 congratulate you for having done that, because, all
24 the applicants would have dug their heels into the
25 sand and push backed and say, it's going to happen,

1 let me analyze it today until you agree with it. They
2 just got rid of the event and perfect, improve the
3 safety of the reactor.
4 MR. LU: Yes, I think I'm one hundred
5 percent on that on.
6 MEMBER SKILLMAN: We have operating
7 experience where loops can be stagnated and
8 independent from each other. And so the idea of a
9 freshwater slug is very real.
10 MR. LU: Right.
11 MEMBER SKILLMAN: I mean, this is not a
12 myth, this can really happen.
13 MR. LU: Yes.
14 MEMBER SKILLMAN: So, I commend you for
15 pursuing this and them for making the change. I
16 understand that it was just the way the wording was in
17 that question and response that caused me to say,
18 they're really two phenomena.
19 You do have natural circulation if you
20 have decay heat being generated. But the real issue
21 is the isolation from a loop.
22 Where you can get that isolation in cold
23 water, you can in fact have a completely barriered
24 slug that the rest of the loops, the other three
25 loops, do not know is there.

1 MR. LU: Yes, that's right.

2 MEMBER SKILLMAN: You don't find it until

3 you start that pump.

4 MR. LU: Yes.

5 MEMBER SKILLMAN: Okay.

6 MR. LU: Yes, actually the staff working

7 on this, the issue, was first right away over there.

8 And he did this job.

9 MEMBER SKILLMAN: Okay.

10 MR. LU: That was Jeff and --

11 MEMBER SKILLMAN: Yes, that's good. Thank

12 you.

13 MR. LU: So I am just presenting on his

14 behalf, but he did a good job there. And also, in the

15 KHNP, they realized the analysis, the balance between

16 the hardware change and the analysis. And I think

17 this issue was closed.

18 Okay, next one. Okay, variable overpower

19 trip during boron dilution at power. And also, its

20 potential boron dilution event but it's a standard

21 dilution event.

22 And due to the CVCS injection there, what

23 we really want to know at that time was not really a

24 safety concern, we just wanted to know, do we have a

25 variable overpower trip which will be activated or not

1 during this slow transient insertion. And, again,
2 slow reactivity insertion transient.
3 And then, they actually address this issue
4 because they pointed out that during this type of
5 event, because the core protection calculator system
6 actually intended to protect the DNBR. And then based
7 on the power level and the, would capture that.
8 So therefore, for this particular event
9 and the variable overpower trip signal, whatever,
10 actually comes in much later than the core calculator
11 power trips.
12 Therefore, and based on Staff's review on
13 Section 4.4, thermal hydraulic event in CPCS, and we
14 felt that that's already been protected, there is no
15 need to have variable overpower trip to actuate. So
16 therefore, this issue is resolved based on their
17 clarification.
18 Next slide. All right, we just talked
19 about, I think KHNP also presented this one. The
20 upper bound break size and PCT, and also, the break
21 spectrum.
22 The reason, when we started to take a look
23 at the Small Break LOCA and our reviewers, Syed
24 Haider, Syed Haider was there. And he reviewed this,
25 the Small Break LOCA, and he found that, okay, the

1 break spectrum is too course, the break size.
2 And our caution, based on our confirmatory
3 analysis, we're not so sure they're capturing the most
4 limiting break size, in the Small Break LOCA spectrum.
5 So we asked that question.
6 And that's one of the questions. Another
7 question is, between the Large Break LOCA topical
8 report analysis and the Small Break LOCA, do they
9 bound the entire spectrum, including the junction
10 point between the Small Break LOCA and the Large Break
11 LOCA?
12 And they did as part of responses, they
13 indicated, based on both Large Break LOCA and the
14 Small Break LOCA analyses, the entire spectrum,
15 starting from very tiny to all the way to double and
16 break, that's everything calculated, PCTs less than
17 2,200, we're fine.
18 And then the much denser spectrum, break
19 spectrum analysis, pointed out higher PCT. However,
20 still less than, much less than the 2,200, therefore
21 this issue is closed.
22 MEMBER MARCH-LEUBA: I've read so many
23 things that I forget. I know the staff has performed
24 confirmatory analysis for the large break.
25 MR. LU: Right.

MEMBER MARCH-LEUBA: Do you do the small break confirmatories?

MR. LU: Yes, we did. We asked them to run. We also ran our case, too. And I think one year ago -- I don't know whether you were here one year ago? Okay. Then, you maybe were not here.

I think we present both small BLOCA and large BLOCA and this afternoon the research where we are also presenting TRACE analysis in support of Large BLOCA topical reports.

MEMBER MARCH-LEUBA: And does it agree more or less on the break size? Because the break size move from -- it became smaller. It's not the trend we see with this?

MR. LU: Maybe I missed the question. I'm sorry.

MR. SCHULTZ: The break size for a small break.

MR. LU: Oh, okay.

MR. SCHULTZ: Has it changed?

MEMBER MARCH-LEUBA: It's difficult. The worst break size.

MR. LU: Oh, yes, yes, yes.

MEMBER MARCH-LEUBA: When it went through the denser.

1 MR. LU: Oh, yes. It moves. It moves
2 from the previous -- when they had a much coarser
3 break spectrum, which is about 10 cases, I remember,
4 right?
5 MEMBER MARCH-LEUBA: Yes.
6 MR. LU: Now you are running the 39 cases.
7 It's a big effort there because, you know, they have
8 to redo a lot of work. And then when they performed
9 this one, they found out after addressing all those
10 comments, issues, in particular for the break sizes
11 spectrum, after they added additional 239 cases, you
12 know, that does have a shifting peak cladding case
13 versus we applied the curve off of a cladding tempered
14 PCT break spectrum, that break spectrum changes. If
15 that's the question, you're asking, yes. That's the
16 case.
17 MR. SCHULTZ: Did the staff calculation
18 have a comparative break size to what they did for
19 small break? About the same range?
20 MR. LU: Okay. I cannot remember exactly.
21 I think we got comparable results with their RELAP5
22 calculation. But their small break load commenced
23 with our foremost limiting case. It's based on very
24 conservative Appendix K model.
25 So, therefore, I cannot say exactly

1 whether they are identical. They are not identical
2 anyhow. But which one predicts higher or lower, I
3 cannot remember now. But I can pull that out if
4 that's something of interest to you.
5 MR. SCHULTZ: But just with regard to this
6 issue --
7 MR. LU: Yes.
8 MR. SCHULTZ: You have a large break peak
9 and you have a small break peak.
10 MR. LU: Yes. That's right. That's
11 right. Actually --
12 MR. SCHULTZ: So that's why this crossover
13 is okay.
14 MR. LU: Yes. That's right. That's the
15 reason we have this case. All right.
16 MR. SCHULTZ: Are we good?
17 MR. HAIDER: Hi. This is Syed Haider. I
18 was the reviewer for the small break LOCA. I would
19 like to make one more clarification here that the peak
20 of CAREM PCT that was found by the applicant using
21 their methodology by the loop 1684 degree Fahrenheit
22 while the TRACE calculations that the staff performed
23 was for the tune of both 1200 degree Fahrenheit. I
24 don't have the exact numbers, but the applicant's PCT
25 was much larger than what the staff found.

1 MEMBER MARCH-LEUBA: And you have given
2 that to the conservative assumptions?
3 MR. HAIDER: Yes. That's precisely right.
4 The conservative assumptions in their S1M methodology.
5 MEMBER MARCH-LEUBA: In that point, do you
6 find through pricing that this low break LOCA is less
7 conservative or gives you a lower number than the
8 large break LOCA of .5 feet per square? You know,
9 what they told us is large break gives you a higher
10 PCT than these low break methodologies. And you're
11 telling me this low break is very conservative.
12 MR. HAIDER: Actually one area was about
13 doing detailed analysis on .5 in a 1 foot square, and
14 we did find that the large break at 1 foot at the
15 intersection was more conservative. That's what we
16 found.
17 MEMBER MARCH-LEUBA: Okay.
18 MR. LU: All right. So after all I think
19 it's way below 2200. There's no delineage or the
20 closest item. The next item.
21 Boron precipitation during long-term
22 cooling actuation because of staff RAIs, they re-
23 performed the analysis of boron precipitation during
24 long-term cooling.
25 So details I can present in June if you

1 guys want to hear more, but the summary is here. And
2 this did introduce addition of kelvin change, but it's
3 good news is just the EO piece.
4 So the time of switch-over from DVI line
5 to hot leg. And initially their analysis indicated
6 that they can survive for three hours with that
7 switch-over.
8 So after requesting their methodology of
9 how they really assumed the mixing in the core and
10 upper part of the plenum and then the revisor
11 analysis, they found, okay. There is a chance that we
12 have to -- they may get into the critical situation
13 during LOCA scenario during long-term.
14 Normally, we do not allow critical. And
15 then so because of that perspective, and they said,
16 all right, we are going to perform a conservative
17 analysis and then to control the switch-over time from
18 -- to reduce the switch over time from three hours to
19 two hours. And that issue was resolved.
20 MEMBER MARCH-LEUBA: And while I like this
21 type of modification to make the reactor safer, you
22 also have to evaluate it doesn't produce unintended
23 consequences.
24 MR. LU: Yes, sir.
25 MEMBER MARCH-LEUBA: Did you guys look at

1 -- I mean, does it cause any problems?

2 MR. LU: You're right. I agree with you.

3 I think that from the perspective, you know, if one

4 party push too hard and maybe another part pops out.

5 And in the situation for this particular

6 one, I think it's kind of isolated at this point what

7 we believe that it may not cause too much heartburn

8 for operator to take action earlier from three hours

9 to two hours to switch-over. And even before, you

10 know, they have to switch from three hours to half

11 hour, then we may have problem. You're right.

12 But from three hours to two hours, we

13 don't consider it's a challenge. And they should be

14 able to accommodate by their EOPs. Okay.

15 Next item. The burn dilution during long-

16 term cooling phase. And then I think KHNP indicated

17 they plan to give you a more detailed presentation in

18 June. We can talk more, too. Here's a summary.

19 And then there are two parts up on

20 dilution during long-term cooling and small break

21 LOCA, too, right? So the issue, the concern that came

22 from the staff was if you have loop seal so deep, it's

23 almost reached the mid-plane of the core at the bottom

24 of the loop, slightly above.

25 And then you have this loop seal, then you

1 have a suppression of this situation. Then what's
2 going to happen when you really discharge? That slug
3 of fresh water from the loop seal to the core, that's
4 a criticality situation.
5 I think on the address of issue, and this
6 was not analyzed specifically for APR1400. And then
7 we checked as a part of the regulatory check, because
8 that's part of TMI action for each new design has to
9 address that point, and we asked for version analysis.
10 And they performed the analysis and
11 addressed this issue. They indicated there was no
12 problem with one slug coming into the core, which
13 caused the reactor to reach critical. There is no
14 problem there. And the core will remain, you know,
15 sub-critical during the long-term cooling of the small
16 break LOCA.
17 And the basis came from the PKL standard
18 test for typical PWR scenario. It's not for APR1400,
19 but it's close enough to determining there is only
20 slug coming in. Not simultaneous four slug injection.
21 All right.
22 So that part is closed and then additional
23 analysis of responses were considered acceptable by
24 the staff.
25 MR. SCHULTZ: Shanlai, what were these

1 tests that were done?

2 MR. LU: The PKL test was done by, I think

3 it was done over Europe. And then this was

4 particularly tested just as part of support of the

5 EPR, EPR development.

6 And then by the lead developer, this is

7 not done by KHNP. But the PKL was a standard

8 benchmark tested by OECD, too. So many countries were

9 participating in the testing, both post-testing and

10 pre-testing analysis, trying to figure out whether --

11 MR. SCHULTZ: To determine the dynamics of

12 the slug release?

13 MR. LU: Exactly, exactly. Which is one

14 part of the test program -- there is only one issue of

15 that test that I was trying to address.

16 And that test did show that they have

17 never observed simultaneous discharge after you have

18 actuation of the natural separation, how come you have

19 simultaneous? It's a chaotic situation.

20 Anyway, you have slight pressure

21 difference. Now you're going to have all simultaneous

22 release of the discharge of the slugs there.

23 So that's the basis that, I think, applied

24 a reasonable, still conservative, assumption to assume

25 what amount of water will be discharged into the core

1 and what kind of mixing and whether that would cause
2 the reactor to cool. And their conclusion is no. The
3 margin is maintained. And the staff agrees with that.
4 MR. SCHULTZ: Thank you.
5 MR. LU: Okay. Next item. Okay. This is
6 part of GSI-181, and as I mentioned, that we are going
7 to talk about more details there, but I'll give you a
8 summary.
9 The LOCA deposition model, it's not an
10 issue to really have a specific concern about the LOCA
11 DM because we have a clean plant. It's important,
12 7.6 grams, something like that, per assembly fiber.
13 It's not even an issue, a concern issue for the in-
14 vessel downstream effects.
15 However, we still asked them to perform
16 the LOCA DM analysis and that to show the crud
17 formation for the given such a little amount of the
18 break transported to the core what might be the
19 problem.
20 And they provided the analysis already
21 actually at the time we gave the presentation last
22 time as a part of history. We are to finish this part
23 of the review.
24 We just did not have the chance to put
25 into the ACRS for you guys to review. So we declare

1 it still as an open item. But based on the review,
2 they followed the -- they approved Westinghouse LOCA
3 deposition model properly. And then we performed a
4 confirmatory analysis based on the spreadsheet.
5 And we have what is the PWR Owner's Group.
6 And their calculated temperature is less than 800
7 degree Fahrenheit for long-term cooling. So
8 therefore, it's not an issue.
9 And so if you want to hear more, we can
10 talk more in June if you really want to dive into more
11 details. I think that's the time. But at this point,
12 we don't see a problem there approving their RAIs's
13 responses.
14 Okay. Next item. Loop seal clearing. I
15 just mentioned about this one for the front dilution
16 perspective, but from the PCT perspective. Right at
17 the beginning of small break LOCA for only a narrow
18 spectrum of the small break.
19 This reactor may get into the suppression
20 of the two-phase water level of the core and because
21 the loop seal is ready to be discharged and is pushed
22 by the pressure in the steam generator.
23 And so there are two particular scenarios
24 here. One is that very short, right at the beginning
25 during the lowdown, right, or during the raffled or

there is another case of potentially there is a long term cooling there is a, you know, reformation of loop seal and re-discharge. So there are two points here.

So for their case, they analyze that one. That's part of the reason they are adding more spectrum. They were able to capture that narrow branch of the break size, which casts that initial loop seal clearing and then the core two-phase level suppression.

And they did the analysis. And they also analyzed, which was not done initially for the long-term cooling phase. And they performed additional small break LOCA analysis for a long time all the way to the annual established water level in a long-term cooling.

And then when the second loop seal formed and discharged, it's much, much less than 800, 600 or even 500 degree Fahrenheit. It's just a slow, very small break there.

So with that one and we also considered their RAIS responses adequate and issue a result.

Next slide. So in conclusion, here are the conclusions now. And all 10 open items were identified one year ago as part of presentation to ACRS subcommittee and were all resolved.

1 And the staff already approved and based
2 on our SCR and already approved all their RAIS
3 responses. They have done very good job to address
4 the NRC staff concerns, the RAIs and then the issued
5 have already been closed.
6 So from design perspective, Chapter 15 is
7 done. We're done. Okay.
8 CHAIRMAN BALLINGER: Thank you. So this
9 is going to be a great time for lunch. But before we
10 do that, we need to see if there are any public
11 comments.
12 So are there any members of the public in
13 the audience that would like to make a comment? And
14 I don't know if the line is open or not -- it's open?
15 So are there any members of the public on the public
16 line that would like to make a comment?
17 We always go through this exercise of
18 trying to find out if anybody is out there that is
19 actually listening. If you're out there, can you make
20 a noise that says I'm here? Okay.
21 Having heard no noise -- you had
22 something?
23 MR. SISK: This is Rob Sisk, Westinghouse.
24 Just when you get a chance, I do want to respond back
25 to the question of the swelling. I could probably do

1 it in the public session rather than the closed
2 section so we can respond to that.
3 CHAIRMAN BALLINGER: Okay. That's fine.
4 Do you want to do it now?
5 MR. SISK: Sure. We can do that. In
6 consultation with KNF and KHNP just to clear up the
7 question this morning, the question had to do with the
8 swelling of SEA.
9 That operating experience that was being
10 cited in the RAIS was Palo Verde having a swelling due
11 to the B4C and the C.F. And the result of that
12 operating experience was that they found that the
13 swelling had a propensity after 10 years.
14 So what APR1400 does is they swap out
15 their SEAS every 10 years to preclude potential. And
16 operating history so far has shown that's been totally
17 successful in resolving any concerns relative to SEA
18 swelling to B4C.
19 CHAIRMAN BALLINGER: So they have
20 experience with OPR 1000 then or some other experience
21 in Korea with plants, with swapping these out every 10
22 years?
23 MR. SISK: No, that's their process. Let
24 me put it this way. Yes, the answer to your question
25 is yes.

1 CHAIRMAN BALLINGER: Okay.
2 MEMBER REMPE: Thank you.
3 MR. SISK: Thank you.
4 CHAIRMAN BALLINGER: Okay. So we should
5 ask the members if there are questions that they have
6 before we recess for lunch.
7 MEMBER SKILLMAN: No further questions,
8 thank you.
9 CHAIRMAN BALLINGER: Anybody? Okay. We
10 will recess for lunch. Come back at 1:30. The
11 sessions we will be working on will be closed sessions
12 then. So we will recess until 1:30.
13 (Whereupon, the matter went off the record
14 at 12:29 p.m. and resumed at 3:37 p.m.)
15 CHAIRMAN BALLINGER: Okay. We're back in
16 session. We remind you that it's an open session now
17 and so we're going to try to get through the two
18 pieces of your presentation on Chapter 3. If it takes
19 beyond 5:00, we'll just stop and go on tomorrow
20 morning.
21 So proceed.
22 MS. TERRY: Good afternoon, ACRS members.
23 My name is Tomeka Terry. I am the Chapter PM for
24 APR1400 design certification application review for
25 Chapter 3, Design of Structures, Systems, Components,

1 and Equipment of the Advanced Safety Evaluation Report
2 with no open items.
3 The staff provided a list of the technical
4 staff who will present this afternoon to ACRS. In
5 Section 3.1 through Section 3.61, 3.6.5 and Section
6 3.13 there were no specific issues in these sections.
7 So, however, if ACRS members have any questions, the
8 staff will be happy to answer your questions.
9 Now I'll turn it over to Renee Li will
10 present Section 3.6.2.
11 MS. LI: Good afternoon. I'm Renee Li
12 from Mechanical Engineering Branch.
13 The topics I'm going to discuss is
14 determination of rupture locations and dynamic effects
15 associated with postulated rupture of piping. The
16 objective of the NRC staff review of this section is
17 to verify and to ensure that adequate protection have
18 been provided against the effects of the postulate
19 pipe rupture and in compliance with the GDC 4
20 requirements.
21 The NRC staff reviewed the applicant's
22 criteria used to define the pipe break/leakage crack
23 location and the configurations including the break
24 exclusion area. The staff also reviewed the
25 applicant's methodology included in a technical

1 report; I would refer as TR in my later presentation,
2 for addressing the dynamic jet impingement and blast
3 wave effects. In addition, the NRC staff reviewed the
4 pipe break hazards analysis summary report. I will
5 refer as PRHA summary report.
6 With the resolution of the open items that
7 I will discuss later the staff's overall conclusion on
8 the review of this topic are: the applicant's criteria
9 to define the pipe break/leakage crack location and
10 the configurations including the break exclusion area
11 are found acceptable.
12 Next slide. The TR methodology in
13 addressing the dynamic jet impingement and blast wave
14 effects are found acceptable. Also, the results of
15 the PRHA summary report demonstrate that the APR1400
16 design is in compliance with the GDC 4 requirements
17 and are acceptable.
18 Next I'll discuss the open item
19 resolution. The first issue related to break
20 exclusion area. the APR1400 DCD design provision for
21 break exclusion area are consistent with the staff
22 guidance. However, the break exclusion area are
23 beyond the containment penetration area. Therefore,
24 the applicant was request to justify the APR1400 DCD
25 break exclusion area as described in the DCD.

1 In resolving this issue the applicant
2 submit a RAI response. In that RAI response the
3 applicant explained how the DCD break exclusion design
4 provision were considered and applied to the results
5 of the design of piping in the break exclusion area.
6 In addition, the APR1400 design ensures sufficient
7 accessibility to perform a 100 percent volumetric
8 inservice examination of the pipe welds within the
9 break exclusion area.
10 Next slide. Moreover, the results of the
11 calculated maximum stress range were low compared to
12 the relevant BTP 3-4 stress limit for postulating
13 break locations. The RAI response also include markup
14 of Revision 1 to applicable DCD Section 3.6.2
15 subsections.
16 Based on the review of the information
17 provide by the applicant the NRC staff found that the
18 applicant has adequately demonstrate its design
19 provision and specifying a 100 percent volumetric
20 inservice examination criteria meet the applicable BTP
21 3-4 break exclusion criteria in the NRC staff
22 guideline. The applicant has appropriately justified
23 the acceptability of expanding the break exclusion
24 area beyond the containment penetration. In addition,
25 the NRC staff found the proposed DCD markup include in

1 the RAI response were acceptable. This item is being
2 tracked as a confirmatory item.
3 Next slide. The second open issue --
4 MEMBER SKILLMAN: Renee, would you back up
5 two slides, please? The conclusion that you cite at
6 the bullet at the bottom, the design ensures
7 sufficient accessibility to perform a 100 percent
8 volumetric inservice inspection of the pipe weld. At
9 this early stage, the plant not having been built,
10 without access to real isometrics, how could you make
11 that conclusion?
12 MS. LI: Okay. I think it should be the
13 design commitment in the DCD.
14 MEMBER SKILLMAN: Yes.
15 MS. LI: Right. Yes.
16 MEMBER SKILLMAN: And I think that that is
17 captured on your next slide. In the first sentence
18 you've identified the criteria for that. Thank you.
19 All right. Thank you.
20 MEMBER REMPE: I have a question on this
21 that was actually motivated by a comment from Member
22 Vesna, but isn't this more than the inspections from
23 this ASME standard, or like you were talking about
24 earlier, oh, they're just doing what the ASME
25 requires?

1 CHAIRMAN BALLINGER: I think Pete can
2 probably -- I hope he's on the line, can probably say
3 something, but --
4 MEMBER REMPE: Or maybe the staff knows,
5 yes. I don't know if Pete's out there, but -- go
6 ahead.
7 MR. REICHELT: Good afternoon. My name is
8 Eric Reichelt. I think I can help out. I know that
9 there was some questions earlier in the day about the
10 inspectability for these new designs. No. 1, for pre-
11 service inspection the COL is going to be inspecting
12 in accordance with the requirements and guidelines of
13 Section 3. Okay? And they've committed to performing
14 100 percent of the welds, which is a good thing both
15 for them and for us because that provides some kind of
16 a baseline further on down the line when they get into
17 ISI space.
18 No. 2, when they perform the ISIs over the
19 course of a 10-year interval when the plant is down
20 they're going to be inspecting in accordance with the
21 guidelines addressed in Section 11. Okay?
22 I think to answer your question about
23 accessibility, the staff -- I attend -- I'm one of the
24 members of the ASME Code, or one of the
25 representatives from the NRC staff that attends the NS

1 -- the ASME Code meetings on a quarterly basis. And
2 over the last 10 years we have been very vocal in our
3 meetings about having -- making sure that -- and we're
4 talking particularly with the utilities that, just
5 like what you were saying, the plants are not built
6 yet, so make sure that you have accessibility for 100
7 percent volumetric examinations. And in fact there's
8 a new ASME Code Committee that addresses
9 inspectability and accessibility. So I hope that
10 helps.
11 MEMBER SKILLMAN: Thank you.
12 MS. LI: Okay. The second issue related
13 to the PRHA summary report. To support the NRC
14 staff's safety determination on the APR1400 PRHA
15 assessment the applicant was request to submit summary
16 information on the PRHA results to demonstrate that
17 the APR1400 design meets the GDC 4 requirement.
18 In resolving this issue the applicant
19 submit a RAI response with an associate PRHA summary
20 report. In that report the applicant described the
21 criteria used in determining postulate pipe failure
22 location and the methodology for assessing the jet
23 impingement and pipe whipping effects. Associate with
24 those postulate high-energy line pipe breaks. The
25 report also summarize the postulate break locations,

1 the target impacted by the respective break, as well
2 as their associate protection method.
3 Based on the review of the information
4 provided by the applicant the NRC staff found the PRHA
5 report provides sufficient information to demonstrate
6 that the PRHA were performed in accordance with the
7 methodology and the criteria described in the APR1400
8 DCD and are in conformance with the applicable SRP for
9 which the NRC staff found acceptable.
10 The results present in the report
11 demonstrate that the APR1400 design is in compliance
12 with the GDC 4 requirement such that SCCs important to
13 safety are designed to accommodate and protect against
14 the effects of postulate pipe failure. This item is
15 closed.
16 Next slide. The third issue related to
17 blast wave and potential feedback amplification and
18 the resonance effects. The applicant was request to
19 address the blast wave and potential feedback
20 amplification and resonance effects as presented in a
21 TR initially submitted for the staff's review. The
22 applicant indicate that it would submit a TR revision
23 with alternative approach to address these two issue.
24 Subsequently, the applicant submit a
25 revised TR to address the blast wave effects. The TR

1 described that computational fluid dynamics, the CFD
2 modeling, was performed for some of the most limiting
3 steam break location. The CFD analysis approach was
4 benchmark against several experiments and analysis of
5 similar condition to verify its suitability. The
6 results of the APR1400-specific CFD analysis were used
7 to develop a methodology for assessing the blast wave
8 effects for other HELB location that have not been
9 analyze by CFD. The methodology conservatively
10 accounted for the initial energy available to form the
11 blast wave and the effects of plant geometry on the
12 blast wave loading on the impact SSCs.
13 Next slide. To address the potential
14 feedback amplification and resonance effects the
15 applicant discuss in the TR how the multiple physical
16 characteristic; for example, lack of perpendicular
17 flat surface of sufficient size to establish a
18 feedback loop, irregularity in contours of broke pipe
19 end that distort the outgoing jet, of the APR1400
20 postulated HELB would prevent occurrence of a
21 potential feedback amplification and resonance. The
22 applicant has also show how the absence of HELB
23 resonance effects was substantiate through a survey of
24 experimental results.
25 Base on the review of the information

1 provide in the TR the NRC staff found that the
2 applicant's CFC analysis perform for assessing the
3 blast wave effects for the APR1400 plant are
4 technically justified. The applicant has provided
5 sufficient information to demonstrate the validity and
6 the applicability of the test data and the methodology
7 of the referenced open literature. The applicant has
8 demonstrate that the methodology to account for
9 effects of APR1400 plant geometry on the blast wave
10 load is conservative. The applicant has adequately
11 addressed the NRC staff's concern on the blast wave
12 effects as identify in Appendix A of SRP 3.6.2. This
13 issue was therefore close.
14 Next slide. In addition, the NRC staff
15 found that the applicant has adequately discussed how
16 the multiple physical characteristic of the APR1400
17 postulated high-energy line break would prevent
18 occurrence of a potential feedback amplification and
19 resonance. The applicant has also demonstrate that
20 the absence of potential feedback amplification and
21 resonance was substantiated by a survey of
22 experimental results.
23 The NRC staff found the applicant's
24 evaluation and approach to address potential feedback
25 amplification and resonance effects as identify in

1 Appendix A of SRP 3.6.2 acceptable because the
2 applicant has adequately demonstrate reasonable
3 assurance that this phenomenon is not a concern for
4 the APR1400 plant. This issue was closed.
5 This conclude my presentation.
6 CHAIRMAN BALLINGER: Questions?
7 (No audible response.)
8 CHAIRMAN BALLINGER: Next?
9 MR. REICHELT: Good afternoon. My name is
10 Eric Reichelt. I am the reviewer for Section 3.6.3,
11 Leak Before Break for the APR1400 DCD review.
12 I would like to also introduce Jay Wallace
13 from the Office of Research who's in our -- in the
14 audience who has provided us with technical assistance
15 with the confirmatory analysis of the applicant's
16 piping evaluation designs.
17 Next slide, please. For a leak before
18 break the staff reviewed the applicable APR1400 DCD
19 sections in 3.6.3., reviewed the DCD references for
20 applicability and use. We held public meetings with
21 KHNP and KEPCO staff about technical issues and RAIs
22 leading to proposed DCD markups. The staff found
23 these DCD sections acceptable. The technical issues
24 and response to RAIs by KHNP were acceptable and were
25 therefore closed. RAI 525-8685, question 3.6.3-9 was

1 an open item since the last time we met with the ACRS.
2 That issue was the staff requested the applicant to
3 review conflicting values between PICEP input and the
4 DCD. And additionally we asked the applicant to
5 provide copies of the PICEP input files for -- in
6 order for us to complete your confirmatory analysis.
7 The applicant complied with our request.
8 The staff reviewed the revised input values and
9 calculations and received the PICEP Code from the
10 applicant. The staff performed a confirmatory
11 analysis of the applicant's piping evaluation designs
12 for the applicant different lines that are addressed
13 and that are identified in slide 13.
14 Next slide, please. Based on proprietary
15 information provided by the applicant the staff was
16 able to perform the confirmatory analysis of the leak
17 before break piping evaluation diagrams. The NRC
18 staff concludes that there is reasonable assurance the
19 applicant's LBB analysis bounds the normal operation
20 and normal operation plus safe shutdown earthquake
21 design conditions and finds the applicant's LBB
22 analysis acceptable. There are no open items for this
23 section.
24 Next slide, please.
25 MR. SCHULTZ: Eric, this was -- excuse me,

1 this was a proprietary code that was provided to you
2 by the applicant so you could do some studies?
3 MR. REICHELT: The PICEP Code is an EPRI-
4 generated code, but it was used by the --
5 CHAIRMAN BALLINGER: I think it's actually
6 written by Structural Integrity.
7 MR. SCHULTZ: That makes sense.
8 CHAIRMAN BALLINGER: Structural Integrity,
9 but it's ran on a Commodore 64.
10 MR. REICHELT: But the values that were
11 provided were provided in a proprietary table and --
12 MR. SCHULTZ: Did they provide the code
13 or --
14 MR. REICHELT: Both.
15 MR. SCHULTZ: Okay.
16 MR. REICHELT: Both.
17 MR. SCHULTZ: And then what did you do in
18 a confirmatory manner? What did you do with that
19 information?
20 MR. REICHELT: Well, I'll let --
21 MR. WALLACE: My name is Jay Wallace. I'm
22 from Office of Research. I provided the confirmatory
23 analysis of their LBB. The PICEP Code that we
24 received was the executable code, not the source code,
25 so all we could do is run it with their values to see

1 what values we got. That came on the heels of a
2 difficulty in reproducing their values. They had
3 provided plots of crack leak versus COD for their
4 desired leak rate by GPM. We couldn't reproduce those
5 and that's what led to the RAIs initially. All of the
6 rest of the values were proprietary values for the
7 coefficients and so on that we didn't input into the
8 code.
9 MR. SCHULTZ: So did you sensitivity
10 studies or just validate what they had developed?
11 MR. WALLACE: We did not do any
12 sensitivity studies. We ran the confirmatory analysis
13 with our code --
14 MR. SCHULTZ: Okay.
15 MR. WALLACE: -- that is based upon
16 ultimately XLPR Code. That's a completely different
17 set. We didn't use PICEP or -- they had also used
18 EPRI COD calculations. We have our own COD
19 calculations as well as our own Leak Rate Codes. So
20 it was absolutely independent of the work that they
21 did, only using their values.
22 MR. SCHULTZ: Thanks for the additional
23 explanation. Thank you.
24 MR. REICHELT: In conclusion the staff
25 evaluation concludes on a design-specific and piping

1 system specific basis that the acceptance criteria are
2 satisfied and therefore that dynamic effects of pipe
3 rupture may be eliminated from design consideration.
4 This concludes my presentation. I will
5 turn it over to Tom.
6 MR. SCARBROUGH: Okay. Good afternoon.
7 I'm Tom Scarbrough. I'm going to summarize several
8 sections that we reviewed in part of the DCD in
9 Chapter --
10 (Simultaneous speaking.)
11 MEMBER SKILLMAN: Tom?
12 MR. SCARBROUGH: Yes?
13 MEMBER SKILLMAN: Excuse me --
14 MR. SCARBROUGH: Sure.
15 MEMBER SKILLMAN: -- for interrupting.
16 Eric, can we go back to your conclusion,
17 please? The wording on your conclusion is so specific
18 it tells me or communicates to me that only if the
19 piping in the as-built is precisely identical to what
20 is in the DCD is your conclusion accurate. Is that
21 what you intend?
22 MR. REICHELT: In order for the COL --
23 since the -- let me see how I can phrase this for you.
24 The -- for a COL, once he comes in with an
25 application, okay, he is going to have to perform the

leak before break on his own piping layout. Obviously right now the piping layouts are not there. But the COL is going to have to perform an LBB with the applicant -- what -- in -- what the applicant did in the DCD. Okay? So the assumptions, the values, what they do need to be bounding to the applicant's DCD LBB analysis.

MEMBER SKILLMAN: Is that captured in a COL item?

MR. REICHELT: Yes, it is.

MEMBER SKILLMAN: Thank you.

Thank you. Excuse me, Tom.

MR. SCARBROUGH: So we're going to talk about several sections in 3.9. The first one is special topics.

And if you could go to the next slide, please. This covers several areas in regard to design transients. The staff found that the APR1400 transient occurrences are conservatively designed, based on the certified System 80+ transients and it was reviewed as part of that to verify that in the inservice conditions and such. There was one question about Level C, and what was determined was that was moved up basically to Level B to make it more conservative.

1 With regard to computer programs the staff
2 conducted audits of a large number of computer codes
3 and programs that were used for verification and
4 validation, V&V. Had some follow-up questions. There
5 was a follow-up item. There was one specific computer
6 program that was identified that wasn't very well
7 discussed, the DPVIB computer program, which is used
8 to calculate fluctuating pressure distribution in a
9 down-comer region. The staff went back and did a
10 separate audit of that computer program and ensured
11 that there was benchmark problems and evaluated those
12 benchmarks and prepared a follow-up audit report. So
13 with that the staff determined that the computer
14 programs were acceptable and were adequately verified
15 and validated.
16 With respect to faulted conditions, the
17 staff reviewed the DCD and determined that the faulted
18 conditions were in accordance with the Boiler and
19 Pressure Vessel Code, Section III, Appendix F, which
20 deals with service loadings for Level B service
21 limits.
22 So the next section is 3.9.3, and this
23 covers Code Class 1, 2 and 3 components, supports and
24 core support structures. The staff concluded that the
25 load combinations for ASME Code Class 1, 2 and 3

1 components and component supports conform to the ASME
2 Boiler Code, Section III.
3 With respect to dynamic system loading
4 such as pipe breaks and the POSRV actuation the staff
5 found they conform with the Boiler Code as well as the
6 dynamic fluid loadings such as valve actuation and
7 water hammer conformed with Section III.
8 With respect to component supports the
9 staff found that they will be designed in accordance
10 with the Boiler Code, Section III, Subsection NF,
11 which addresses the supports for nuclear reactors.
12 With respect to audits the staff has
13 conducted two audits on design specifications to
14 determine the design criteria, analytical methods and
15 functional capability for the ASME Code and to confirm
16 that the design information of DCD was translated into
17 the design specifications.
18 Our first audit was in the August 2015
19 time frame. We found a number of areas that needed to
20 be addressed in various components: reactor vessel
21 valves, pumps, components, supports and restraints,
22 and we provided a long list of issues that needed to
23 be addressed in those specifications and also some
24 areas actually where the DCD needed to be updated.
25 We conducted a follow-up audit and

1 prepared an audit report and found that for the most
2 part those specs had been updated, however, there were
3 some places where the specs that we were provided were
4 not the formal signed versions and there still needs
5 to be sufficient work on that.
6 So to be able to track that we issued an
7 RAI to request that KHNP notify the staff when those
8 specifications and DCD changes were available. And
9 then specified a confirmatory action item for KHNP --
10 for us to look at those specs and ensure that those
11 changes were made. So it's a confirmatory item now.
12 I believe it was an open item when we visited you
13 before, but it's a confirmatory item now, I believe we
14 verified that. Okay? So that's 3.9.3.
15 3.9.6 is the Functional Design and
16 Qualification and Inservice Testing Program. With
17 respect to this section we evaluated Section 3.9.6 to
18 make sure that using the Standard Review Plan, Section
19 3.9.6 -- we did ensure that the DCD specifies the
20 application of ASME Standard QME-1-2007, which is
21 endorsed in the NRC Reg Guide 1.100, Revision 3 for
22 the functional design and qualification.
23 When we conducted the audit of the design
24 specifications we ensured that the QME-1 standard was
25 specified in those specifications. There were a few

1 places we had to have some comments back to sort of
2 tighten up that discussion. For example, there are
3 places where it might have must mentioned difference
4 of pressure in terms of the testing for design
5 qualification, and QME-1 specifies flow as well. So
6 we wanted to make sure that it was clear that QME-1
7 would be followed. And so that was part of the audit
8 and in the follow-up audit to make sure that was
9 addressed.
10 We also noted that the IST Program has
11 specified that OM Code with additional adjustments
12 that we found from our review and had RAI responses,
13 had a number of RAIs. And we reviewed -- since we
14 talked to you last we went back and looked at DCD,
15 Revision 1 and found that those RAI responses have
16 been incorporated into DCD. And they cover things
17 like the program description, making sure it was more
18 clear, the testing of the power-operated valves, the
19 motor-operated valves. And then there were a lot of
20 changes that needed to be made in the IST table. We
21 verified that those had been made to make sure it's
22 consistent with the OM Code. So we've done that.
23 What's left regarding Section 3.9.6 is we
24 have some planned ITAAC changes to reflect the latest
25 version, and we have started going through Revision 2

of the DCD and found that, yes, that ITAAC is referencing QME-1, included the -- make sure that the proper qualification was made for those. That's an example of what we've gone back and checked on those ITAACs.

We also have -- as I mentioned, we have a confirmatory item that we're tracking for the design specification follow-up audit items and will be verifying that those changes were made and those specs were finalized when we are notified that they're available for us to review.

And then lastly we had the 3.9.6-1 question That had to do with a number of updates to the IC Program description and also the planned IST table. We verified those had been made in Revision 1 of the DCD and we were able to close that as well.

So that completes my presentation. If there are any questions -- if not, I'll pass along to Yuken Wong.

MR. WONG: My name is Yuken Wong from the Mechanical Engineering Branch. I'm the reviewer for Section 3.10, Seismic and Dynamic Qualification of Equipment. I will also present Section 3.9.2 and 3.9.5.

Section 3.9.2, Dynamic Testing and

1 Analysis of Structures, Systems and Components. The
2 staff reviewed the methodology, testing procedure,
3 inspection program, and dynamic analyses to ensure the
4 structural integrity and functionality of piping
5 systems, mechanical equipment, and their supports
6 under vibratory loading.
7 Specifically, the staff reviewed the
8 following six areas: Piping vibration, thermal
9 expansion and dynamic effects testing during initial
10 start testing for ASME Class 1, 2 and 3 piping;
11 seismic analysis and qualification of seismic Category
12 1 components; dynamic analysis of reactor internals
13 under steady-state and transient conditions; pre-
14 operational flow-induced vibration testing of reactor
15 internals; dynamic analysis of the reactor internals
16 under faulted conditions; and lastly, correlation of
17 reactor internals vibration test results analytical
18 results.
19 Next slide. The staff reviewed the
20 comprehensive vibration program, or CVAP report for
21 the APR1400 steam generator and reactor internals
22 design in comparison with the System 80 design. the
23 Palo Verde Unit 1 reactor internal design is
24 classified as the prototype and the APR1400 is the
25 non-prototype Category 1.

One open item regarding the basis for using 32 hertz instead of the zero period acceleration of 50 hertz for APR1400 to determine if the equipment is rigid or flexible for selecting the static or dynamic analysis method. The other issue of this open item is regarding whether the fluid structure interaction and sloshing effects are included in the tank analysis. The applicant revised the DCD to use 50 hertz to determine if the equipment is flexible or rigid and confirmed that hydrodynamic forces exerted by the fluid on the tank walls will be included in the analysis. The staff finds the response acceptable and the open item is closed.

The other open item is regarding the benchmarking on the DPVIB Code used for the pump position pressure analysis as discussed earlier. The staff audited the benchmarking information for the computer code as part of the Section 3.9.1 review. The applicant provided a description of the code in Revision 1 of the DCD. The staff finds the response acceptable and the open item is closed.

Section 3.9.5. Next slide, please. Reactor Pressure Vessel Internals. The staff evaluate the arrangement of the reactor internals, their functions, flow paths through the reactor vessel, and

1 the design criteria. Compare the APR1400 reactor
2 internal design and the CE System 80 reactor internal
3 design; that is the Palo Verde Units 1, 2 and 3,
4 because the reactor internals designs are similar.
5 The staff verified the core support
6 structures and internal structures are designed and
7 constructed in accordance with ASME, Section III,
8 Subsection NG.
9 Next slide, please. One open item is
10 regarding the structural integrity of control element
11 guide tubes. KHNP provided calculations to show the
12 guide tube structural integrity can be maintained
13 during a safe shutdown earthquake. The applicant also
14 reviewed the operating history of Korean plants with
15 control element assembly and guide tube designs
16 similar to the APR1400 designs and have confirmed that
17 no failure have occurred on these components that
18 would prevent control rod insertion. The staff finds
19 the response acceptable and the open item is closed.
20 The other open item is about the seismic
21 category of reactor internals. KHNP provided
22 clarification that all reactor internals including
23 internal structures are classified as Seismic Category
24 1. The staff finds the response acceptable and will
25 confirm the change in the next revision of the DCD.

1 Next slide, please. Section 3.10, Seismic
2 and Dynamic Qualification of Equipment.
3 The staff reviewed DCD Section 3.10,
4 3.7B.7.4, and technical reports related to equipment
5 qualification; verified that equipment seismic
6 qualification standards and methods are in accordance
7 with Reg Guide 1.100, IEEE 344, and ASME QME-1;
8 verified the procedures to evaluate effects of hard
9 rock high-frequency response spectras on high-
10 frequency-sensitive equipment. The staff conducted an
11 audit of procurement and design specifications to
12 verify seismic qualification methodologies are in
13 accordance with the DCD.
14 There is a confirmatory item regarding the
15 audit findings. In the follow-up audit the staff
16 verified that the applicant's resolution of the
17 staff's findings on the first audit are acceptable.
18 The staff will verify the updated procurement
19 specifications to address the staff findings.
20 This concludes my presentation.
21 MS. LI: Okay. So we have the next three
22 people to go next, and I think we probably will finish
23 before 5:00.
24 CHAIRMAN BALLINGER: Good, good.
25 MR. CINTRON-RIVERA: Good afternoon. My

1 name is Jorge Cintron. I'm an electrical engineer
2 from the Electrical Engineering Branch in NRR, and I'm
3 the lead reviewer for Section 3.11, Environmental
4 Qualifications of Electrical and Mechanical Equipment.
5 Section 3.11 provides the APR1400 approach
6 for environmental qualification of mechanical and
7 electrical equipment. The staff reviewed the
8 environmental qualification of mechanical and
9 electrical equipment to verify that the equipment is
10 capable of performing during functions under all
11 environmental conditions, anticipated operational
12 occurrences, accident and post-accident environmental
13 conditions. Some of the equipment that is required to
14 be qualify is the safety-related equipment, non-
15 safety-related equipment, supply and safety-related
16 require, and certain post-accident monitoring
17 condition.
18 For the purpose of this presentation we'll
19 be discussing an open item that we have from the
20 previous presentation.
21 The staff evaluated the applicant's
22 response to RAIs requesting justification of the use
23 of IEEE 323-2003. Regulatory Guide 1.89 provides an
24 acceptable criteria for qualifying electrical
25 equipment and endorsed the IEEE 323-1974. The APR1400

1 deviates from the Reg Guide and is proposing to use
2 the 2003 version.
3 The staff perform a comparison on both
4 standards and has requested the applicant to provide
5 a justification of why the 2003 version is acceptable
6 and how to tell the technical differences between both
7 them.
8 Next slide. The staff evaluated the
9 applicant's response and concludes that the applicant
10 has appropriately justified the technical differences
11 between the IEEE 323-2003 and IEEE 323-1974. The
12 staff has completed the applicant's -- completed the
13 evaluation, and therefore this is a confirmatory item.
14 That concludes my -- the part of my
15 presentation.
16 MR. STUTZCAGE: All right. Hi, I'm Ed
17 Stutzcage. I'm the reviewer for the radiological
18 section of Section 3.11.
19 Next slide, please. These were the open
20 items we had last time. There were several open items
21 associated with these two questions. These are the
22 issues that we discuss in our next slides.
23 Next slide, please. The first one was
24 inconsistencies with Chapter 12 information regarding
25 the neutron dose in the containment building operating

1 floor during normal operation. There was additional
2 information needed to ensure that the total integrated
3 neutron dose on the operating floor was adequate. And
4 I think we had a -- partially from an ACRS question
5 last time we asked them if they could provide some
6 operational data for the dose in the operating floor
7 area. And they did. They provided operational data
8 from the Shin Kori Unit 3 plant and it was
9 significantly lower than the dose calculated in the EQ
10 analysis. So as a result of that the staff found it
11 to be acceptable.
12 Next slide, please.
13 MR. SCHULTZ: Everything is going to be a
14 lower dose.
15 MR. STUTZCAGE: Yes, that's true. That
16 resolved that item.
17 The next one was the doses within the
18 auxiliary building during accidents did not appear to
19 adequately consider radiation streaming through the
20 containment penetrations.
21 The doses in areas with containment
22 penetrations were calculated at dose point at the
23 center of the room. So this is for rooms that had
24 containment penetrations in them. The doses were
25 calculated in the center of the room. We asked they

1 justify why that was acceptable because not all the
2 equipment is going to be in the center of the room.
3 And as a result they provided -- they revised the
4 calculations for those rooms provided the calculated
5 TIDs with the -- at a 0.30 centimeters away from the
6 penetrations. Staff found that to be acceptable and
7 that resolved this issue.
8 Next slide, please. There was a couple
9 other areas where the total integrated dose
10 calculations weren't making a lot of sense to us, so
11 we asked a few additional questions and they provided
12 some additional information. For example, rooms that
13 didn't have radiation sources within them, they had --
14 they were affected by sources in different rooms.
15 They provided some additional explanation. They
16 indicated that they updated the technical report
17 describing that the total integrated dose for areas
18 without radiation sources were calculated described --
19 calculated assuming one percent failed fuel defects
20 from adjacent sources with additional margin added for
21 conservatism. It's consistent with the guidance and
22 is acceptable.
23 The applicant also revised the
24 calculations in the transfer tube inspection area to
25 account for fuel transfer, which was -- the dose went

1 from being almost very low to extremely high
2 accounting for fuel transfer. And they also provided
3 some additional updates clarifying shielding
4 thicknesses for certain areas near and around
5 demineralizers and filter areas.
6 Next slide, please.
7 MR. SCHULTZ: If you consider all of these
8 areas that were addressed here, have they covered
9 everything that you were interested in?
10 MR. STUTZCAGE: I believe so. I believe
11 that, yes, they updated it to -- their calculations
12 are now conservative or realistic for what you'd
13 expect using the guidance.
14 MR. SCHULTZ: Good. So it wasn't clear
15 from the bullets whether they got everything that you
16 were --
17 MR. STUTZCAGE: Yes, they had addressed
18 all the areas I had concerns.
19 MR. SCHULTZ: Good. Thank you.
20 MR. STUTZCAGE: Yes. The conclusion for
21 this issue, the staff reviewed the shielding and dose
22 rate information using microshield as necessary and
23 found them to be acceptable.
24 Next slide. The last one was the
25 assumption for post-accident fluid rate outside

1 containment. The applicant did not provide enough
2 information explaining the allowed ESF leakage rate
3 assumed in the EQ analysis during and accident and why
4 the leakage was different than that used in the
5 accident analysis. There's a difference between the
6 Chapter 15 analysis and the Chapter 3 for the leak
7 rate.
8 The applicant clarified that the ESF
9 leakage rate for EQ was based on the assumed leakage
10 rate for valves and pump specified in their response.
11 The allowed leakage rate was doubled in accordance
12 with Reg Guide 1.183. The applicant also proposed to
13 update Chapter 15 and the technical report for EQ to
14 clarify that what the dose rate was the basis -- that
15 the leak rate was and the basis for it, and also what
16 the basis for the Chapter 15 analysis was.
17 Next slide, please.
18 MR. SCHULTZ: You've got the number for
19 the Chapter 15, but could you remind us of the basis
20 for what they assumed in Chapter 15?
21 MR. STUTZCAGE: I'm not the Chapter 15
22 reviewer. All that I can say is it's based on a
23 different amount of -- a more conservative leak rate
24 than is used in the Chapter 3 analysis. The Chapter
25 15 analysis uses a higher number. That's all that I

1 could say right now.

2 MR. SCHULTZ: Any clarification? You may

3 not have the right people here. I remember the

4 comparison and I just -- it's more of a curiosity

5 question. Looks like you've got the right

6 relationship between Chapter 15 and this evaluation.

7 MR. STUTZCAGE: They assume --

8 MR. SCHULTZ: Maybe that's sufficient.

9 MR. STUTZCAGE: They assume different leak

10 rates from different size valves and pumps and stuff,

11 and it just -- they used different assumptions for

12 Chapter 15 and Chapter 3, which is not typically their

13 -- they use the -- most applications use the same

14 assumptions. In KHNP's case they wanted to use

15 different assumptions. We found them both to be

16 conservative leak rates. And as I say in the next

17 slide if during actual operation the leak rates are

18 higher than what they assume here, they'd have to make

19 sure they take appropriate action and reanalyze the

20 qualification of the equipment or the -- or fix the

21 leak to make sure they don't have -- it's such a large

22 effect on the equipment.

23 MR. SCHULTZ: I think that's a good

24 answer. I appreciate it. Thank you.

25 MR. STUTZCAGE: Thanks. That concludes my

presentation.

MEMBER POWERS: I wonder if I could just a question to the last two speakers, Jorge and Edward.

Not concerning this certification at all, but just in general, are we getting information coming from the damaged plants at Fukushima that would move us to reconsider our requirements for post-accident environmental qualification of safety-related equipment?

MR. STUTZCAGE: From my perspective I don't think that we're using any of the information from Fukushima for the radiological piece. I think we're still basing it on our Reg Guide 1.183 and Reg Guide 1.89.

MEMBER POWERS: Yes.

MR. STUTZCAGE: That's -- yes, I don't -- we -- we haven't changed anything I could think of --

MEMBER POWERS: Well, it's not changed. It is are we getting information that might move us to change?

MR. STUTZCAGE: I -- yes, I don't know the answer to that.

MEMBER REMPE: I feel obligated to speak up. I think industry is exploring that and seeing if they can develop a case, from interactions I have

1 doing other activities.

2 MEMBER POWERS: One of the things that we

3 have to admit about our Environmental Qualification

4 Program is that we distinguish and separate the

5 radiological impact on the equipment and the thermal

6 humidity impact. We've always known we've done that,

7 but in our research that is the basis for our License

8 Renewal Program we find that there are synergistic

9 effects between radiation and -- so the question comes

10 up is are we adequately conservative by making this

11 distinction?

12 MR. CINTRON-RIVERA: Yes, as part of the

13 open item that we have addressing the difference

14 between both standards, that was one of the questions

15 that we asked, because as you mentioned, that is

16 required for synergistic effects, but the actual

17 testing that we perform has been more separately. So

18 we -- that was one of the questions that we asked and

19 basically what the response that we get I -- we

20 believe this provide us reasonable assurances that the

21 qualification we performed, in a way that -- the

22 sequence of the testing will be performed, that -- the

23 one that provides the most degradation. So, and that

24 was basically what industry is performing right now.

25 And as far as looking to the future, I

1 don't have much information of --

2 MEMBER POWERS: Yes.

3 MR. CINTRON-RIVERA: -- they'll now

4 performing synergistic testings or --

5 MEMBER POWERS: One of the things that has

6 arisen, and certainly following the accident at TMI,

7 but maybe it's more evident now as we continue to look

8 at Fukushima, is the potential for generating acidic

9 gases in the environment, both hydrochloric acid and

10 nitric acid. And that really is not recognized in our

11 testing program except insofar as that which is being

12 tested; for an instance, in the radiation environment,

13 can generate some acid, but it doesn't have the

14 benefit of the elevated temperatures and the humidity.

15 So it's of interest to me to know if from

16 Fukushima we derive anything that would move us to

17 change the way we look at environmental qualification.

18 It has nothing to do with this particular application,

19 but I'm just looking to the future to see if you guys

20 had any insight on this. Sounds like you've at least

21 thought about it, though.

22 Maybe I will just mention one thing our

23 testing for radiological effects or radiation effects

24 does not do is technically we test by just exposing

25 them a gamma field. We never look at the effect of,

for an instance, radioactive aerosol depositing locally on wiring and things like that. Probably not a crucial thing for light water reactors, but as we move in these more exotic reactors: gas reactors, sodium reactors and salt reactors, then the deposition in the local hot spot on equipment might be a more important thing to consider.

MR. CINTRON-RIVERA: Okay.

MR. TSIRIGOTIS: My name is Alexander Tsirigotis and I'm a mechanical engineer for the Mechanical Engineering Branch in the New Reactors, and I'm the reviewer for the APR1400 DCD Section 3.12, which is associated with the ASME Class 1, 2 and 3 piping and its associated supports.

The NRC staff reviewed the structural integrity of the APR1400 piping and pipe supports and it was confirmed that the design of the piping and pipe supports incorporates NRC guidance and is in accordance with ASME Boiler and Pressure Vessel Code, Subsections NB, NC and ND for piping and NF for pipe supports, as incorporated by reference in 10 CFR 50.55a.

The staff conducted audits of pipe stress analysis and pipe support designs to confirm consistency with the DCD and that the structural

analysis meet ASME Section 3 acceptance criteria.

During the review of DCD Section 3.12 the staff held public meetings with the applicant to discuss technical issues that came out from audits and during the resolution of RAIs and which led to proposed DCD markups, revisions to technical reports and other piping analysis. The applicant has adequately addressed all of our -- all of the NRC staff comments.

During Phase 4 of the review the applicant addressed the structural effects on piping and its supports that could potentially occur from the operation of the safety injection tank and its fluidic device. The applicant derived water hammer loads which when incorporated in the load combinations for pipe stress analysis and pipe support design showed that piping and supports remained structurally adequate and met ASME Section III acceptance criteria.

To address the vibration on the safety injection line the applicant modified the safety injection tank subsystem test, DCD Tier 2 Section 14.2.12.1.22, to instrument the safety injection line to gather vibrational data and to ensure that vibration levels are within acceptable limits as found in ASME OM-SG Part 3. Part 3 of the Standards Guides

of the OM is for pre-operational and initial startup vibration testing of piping systems. And basically if the vibrational stresses are below the endurance limit of the material, they're found to be acceptable. And the applicant saw that.

Any questions?

(No audible response.)

MS. TERRY: That concludes Chapter 3's presentation for today. Any questions from the staff?

(No audible response.)

MS. TERRY: ACRS members?

(No audible response.)

CHAIRMAN BALLINGER: Thank you. I think this is a -- after we get comments from the public and go around the table this is going to be where we'll take a break until tomorrow morning.

So are there any comments from members of the public in the audience?

(No audible response.)

CHAIRMAN BALLINGER: There is no audience.

Pete?

MEMBER RICCARDELLA: Yes, I'm on.

CHAIRMAN BALLINGER: Right. Have you got any questions or comments?

MEMBER RICCARDELLA: No, no comments.

1 CHAIRMAN BALLINGER: Okay. Is there
2 anybody else, anybody out on the public line that
3 would like to make a comment?
4 (No audible response.)
5 CHAIRMAN BALLINGER: It always takes a few
6 seconds for people to un-mute.
7 (No audible response.)
8 CHAIRMAN BALLINGER: Hearing none, the
9 next thing to do is to go around the table and ask if
10 there are comments from the members. I started over
11 there earlier, so, Mike?
12 MEMBER CORRADINI: I don't have any
13 comments. I'd just thank the staff and KHNP for their
14 presentations. We through a lot of stuff today.
15 CHAIRMAN BALLINGER: Dick?
16 MEMBER SKILLMAN: I want to thank the
17 staff and the KHNP for hearing comments that we made
18 at previous meetings and weaving those comments into
19 today's presentations, specifically the one that Alex
20 just identified, the SIT vibration that I was so
21 concerned about. But there have been a number of
22 those through today's presentation that clearly
23 identify that the staff and KHNP have heard some of
24 the concerns that we've raised. So great presentation
25 and thank you.

1 CHAIRMAN BALLINGER: Dana?

2 MEMBER POWERS: Well, I'll just reiterate
3 one of the things that we need to look for as we
4 consider the certification of more exotic reactors
5 than conventional LWRs is this issue of the
6 environmental qualification of safety-related
7 equipment in the post-accident environment, because I
8 think it will be different. And there are
9 approximations, typically very conservative
10 approximations that we've made in our environmental
11 qualification requirements whose conservatism may come
12 to question as we move into these more exotic
13 reactors. I think it's an area that the ACRS may want
14 to look at as part of their general considerations for
15 the future.

16 MEMBER SUNSERI: I just extend my
17 appreciation to the staff and KHNP for their
18 presentations today. No other comments.

19 MEMBER STETKAR: Nothing more. Thank you.

20 MEMBER MARCH-LEUBA: I also don't have any
21 comments.

22 CHAIRMAN BALLINGER: Charles?

23 MEMBER BROWN: No.

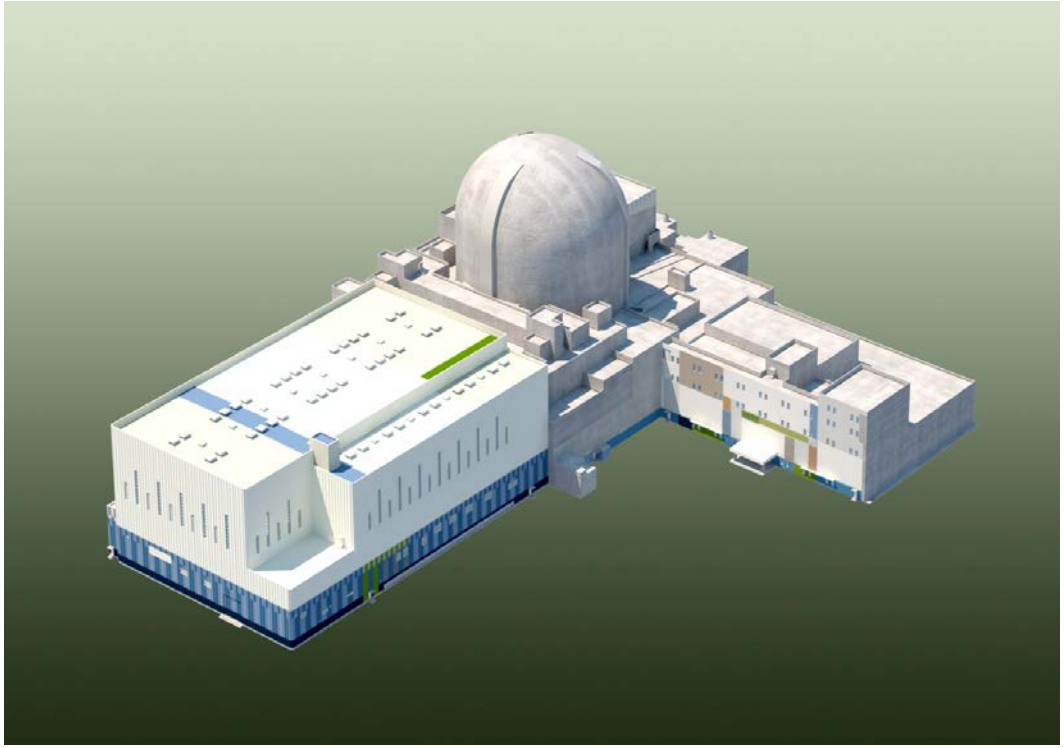
24 CHAIRMAN BALLINGER: Joy?

25 MEMBER REMPE: I just wanted to add my

1 thanks. I appreciate as always KHNP going and finding
2 an answer if they don't have it right there for us.
3 MEMBER DIMITRIJEVIC: No comments. Thank
4 you.
5 CHAIRMAN BALLINGER: Well, I'd like to --
6 well, Steve?
7 MR. SCHULTZ: I really do appreciate the
8 presentations by both KHNP and the staff. The
9 presentations really do represent substantial progress
10 in the overall review by the staff and the
11 presentations by the applicant. And I know the
12 Committee recognizes the level of effort and depth of
13 analysis that has been done to support the summary
14 presentations that we've heard today, and the
15 clarifications and answers to the questions today have
16 been very helpful. Thank you.
17 CHAIRMAN BALLINGER: And I'd like to echo
18 the comments of the other members and Steve. It was
19 a long day and a lot of -- I can see the comments that
20 were incorporated, as Dick mentioned. I counted like
21 six, and I was keeping track. So we appreciate that
22 a great deal. So that being said, we are adjourned
23 until 8:30 in the morning.
24 (Whereupon, the above-entitled matter went
25 off the record at 4:41 p.m.)

NON-PROPRIETARY

# APR1400 DCA
# Chapter 3: Design of Structures, Systems, Components, and Equipment



**KEPCO/KHNP**

**April 17, 2018**

ACRS SC Meeting (Apr. 17, 2018)

# Contents


- **Overview of Chapter 3**
  - Section Overview
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  - Acronyms
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# Overview of Chapter 3

| Section | Title | Major Contents |
|---|---|---|
| 3.1 | Conformance with Nuclear Regulatory Commission General Design Criteria | • Conformance with Nuclear Regulatory Commission General Design Criteria 1 through 64 |
| 3.2 | Classification of Structures, Systems, and Components | • Classification of Structures, Systems, and Components according to nuclear safety classification, quality groups and seismic category |
| 3.3 | Wind and Tornado Loadings | • Design features of wind and tornado/hurricane loading considered in the design of seismic Category I and II structures |
| 3.4 | Water Level (Flood) Design | • Design features of flood protection from internal and external sources considered in the design of seismic Category I and II structures |
| 3.5 | Missile Protection | • Design features of internally generated missiles<br>• Design features of external missiles considered in the design of seismic Category I and II structures |
| 3.6 | Protection against Dynamic Effects Associated with the Postulated Rupture of Piping | • Design Protection against postulated piping failures in fluid system<br>• Determination of break locations and dynamic effects associated with postulate rupture of piping<br>• Design features of pipe whip restraints<br>• Leak before-break evaluation procedure |

# Overview of Chapter 3

| Section | Title | Major Contents |
|---|---|---|
| 3.7 | Seismic Design | • Seismic input motions<br>• Seismic analysis methodology and results of seismic Category I Structures with generic soil profiles<br>• Seismic analysis methodology of seismic Category I subsystems<br>• Seismic monitoring system |
| 3.8 | Design of Category I Structures | • Design features of Category I Structures including concrete containment, internal structures of containment, other seismic Category I structures, and foundations |
| 3.9 | Mechanical Systems and Components | • Design, dynamic testing and analysis for ASME Code Section III, Division 1, Class 1, 2, and 3 components and supports including core support structures. |
| 3.10 | Seismic and Dynamic Qualification of Mechanical and Electrical Equipment | • Acceptance criteria, code and standards, procedures, and methods applied to the seismic and dynamic qualification of mechanical and electrical equipment including instrumentation |
| 3.11 | Environmental Qualification of Mechanical and Electrical Equipment | • Equipment Location and Environmental Conditions, Qualification Tests and Analysis, Environmental Qualification Method.<br>• Equipment Qualification List, Environmental Parameters Data. |
| 3.12 | Piping Design Review | • Design of the piping system and piping support including the structural integrity, as well as the functional capability.<br>• The design transients and resulting loads and load combinations with appropriate specified design and service limits. |
| 3.13 | Threaded Fasteners (ASME Section III Class 1, 2, and 3) | • Design feature of ASME Section III Class 1, 2 and 3 component fastener |

# Overview of Chapter 3

## ❖ List of Submitted Documents for Chapter 3 (1/2)

| Document No. | Title | Revision | Type |
|---|---|---|---|
| APR1400-K-X-FS-14002 -P & NP | APR1400 Design Control Document Tier 2: Chapter 3 Design of Structures, Systems, Components and Equipment | 2 | DCD |
| APR1400-K-X-IT-14001 -P & NP | APR1400 Design Control Document Tier 1 | 2 | DCD |
| APR1400-E-S-NR-14001-P & NP | Seismic Design Bases | 2 | TER |
| APR1400-E-S-NR-14002-P & NP | Finite Element Seismic Models for SSI Analyses of the NI Buildings | 2 | TER |
| APR1400-E-S-NR-14003-P & NP | SSI Analysis Methodology and Results of NI Buildings | 2 | TER |
| APR1400-E-S-NR-14004-P & NP | Evaluation of Effects of HRHF Response Spectra on SSCs | 3 | TER |
| APR1400-E-S-NR-14005-P & NP | Evaluation of Structure-Soil-Structure Interaction(SSSI) Effects | 2 | TER |
| APR1400-E-S-NR-14006-P & NP | Stability Check for NI Common Basemat | 4 | TER |

# Overview of Chapter 3

## ❖ List of Submitted Documents for Chapter 3 (2/2)

| Document No. | Title | Revision | Type |
|---|---|---|---|
| APR1400-Z-M-NR-14009-P&NP | Comprehensive Vibration Assessment Program for the Reactor Vessel Internals | 1 | TER |
| APR1400-E-X-NR-14001-P&NP | Equipment Qualification Program | 0 | TER |
| APR1400-E-N-NR-17001 -P & NP | APR1400 High Energy Line Break Jet Impingement | 1 | TER |
| APR1400-E-N-NR-14004-P&NP | Summary Report of High-Energy Piping Rupture Analysis | 2 | TER |
| APR1400-Z-M-NR-14016-P&NP | Leak-Before-Break Evaluation of the Surge Line | 2 | TER |

## ❖ Summary of RAIs

| No. of Questions | No. of Responses | No. of OI |
|---|---|---|
| 260 | 260 | 23 |

# Overview of Chapter 3

## ❖ List of Open Items (1/3)

| No. | Related RAI | Topic | ADAMS Accession # |
|---|---|---|---|
| 1 | RAI 41-7957 (Q 03.06.02-2) | Pipe rupture hazard analysis | ML17296A493 |
| 2 | RAI 166-8198 (Q 03.06.02-3) | Break exclusion area | ML17271A449 |
| 3 | RAI 359-8448 (Q 03.06.02-6,7,8) | Blast wave and potential feedback amplification and resonance effects | ML17237A145 |
| 4 | RAI 525-8685 (Q 03.06.03-9) | Leak-Before-Break Analysis | ML17333A371 |
| 5 | RAI 183-8197 (Q 03.07.02-1) | Hard Rock High Frequency(HRHF) | ML17242A320 |
| 6 | RAI 208-8245 (Q 03.08.03-5) | Analysis Methods and Results for RCB Internal Structure | ML17233A379 |
| 7 | RAI 248-8295 (Q 03.08.05-1) | Analysis and Design for Critical Sections | ML17157B583 |
| 8 | RAI 255-8285 (Q 03.08.05-4) | Waterproofing Membrane | ML17026A465 |
| 9 | RAI 255-8285 (Q 03.08.05-7) | Construction Sequence | ML17362A154 |
| 10 | RAI 255-8285 (Q 03.08.05-8) | Design and Analysis Procedures for NI Common Basemat | ML17255A944 |

# Overview of Chapter 3

## ❖ List of Open Items (2/3)

| No. | Related RAI | Topic | ADAMS Accession # |
|---|---|---|---|
| 11 | RAI 255-8285 (Q 03.08.05-12) | Applied loads of NI Common Basemat | ML17251A159 |
| 12 | RAI 255-8285 (Q 03.08.05-13) | Loads and Load Combinations for NI Common Basemat | ML17251A121 |
| 13 | RAI 255-8285 (Q 03.08.05-16) | Subgrade Modulus of Soil Profiles for APR1400 | ML17256A182 |
| 14 | RAI 255-8285 (Q 03.08.05-17) | Differential Settlement of NI Common Basemat | ML17241A144 |
| 15 | RAI 151-8078 (Q 03.09.02-9) | Pump-Induced Loads on RVI Components | ML16144A654 |
| 16 | RAI 92-8068 (Q 03.09.05-6) | Control Element Guide Tube buckling integrity and operating experience | ML17255A934 |
| 17 | RAI 92-8068 (Q 03.09.05-9) | In-Core Instrumentation Support System | ML16354A541 |
| 18 | RAI 92-8068 (Q 03.09.05-16) | Loading Condition – Level D Service Loading | ML16306A443 |

# Overview of Chapter 3

## ❖ List of Open Items (3/3)

| No. | Related RAI | Topic | ADAMS Accession # |
|---|---|---|---|
| 19 | RAI 92-8068 (Q 03.09.05-18) | Bases for Reactor Internals - Classification | ML16354A541 |
| 20 | RAI 69-7994 (Q 03.09.06-9) | Pump and Valve In-service Testing Program Table | ML16242A438 |
| 21 | RAI 27-7944 (Open Item 03.11-1) | Environmental Qualification of Mechanical and Electrical Equipment | ML15198A260 |
| 22 | RAI 527-8686 (Open Item 03.11-2) | Environmental Qualification of Mechanical and Electrical Equipment | ML17004A034 |
| 23 | RAI 549-8856 (Q 3.12-19) | Structural integrity of piping and pipe supports that could be impacted by vibration and water hammer from the operation of SIT and FD | ML17332A108 |

# Summary of Open Items

## ❖ Open Item: Pipe Rupture Hazard Analysis

- Related RAIs : 41-7957 (Q 03.06.02-2)
- Description of issue
  - Staff requested:
    - ✓ Assessment of the dynamic effects of jet impingement and blast waves and fatigue considerations in determining the postulated break locations in ASME Class 1 high energy piping systems.
    - ✓ Technical report for Pipe Rupture Hazard Analysis (PRHA) summary (APR1400-E-N-NR-14004-P&NP) incorporated jet impingement, blast wave, and resonance effects.
- Resolution:
  - ✓ KHNP provided the PRHA summary report incorporated the postulated break locations and the methodology for assessment of jet impingement and blast waves in October, 2017.
  - ✓ KHNP provided the text description regarding non-conservatisms of ANSI/ANS 58.2-1988, in revised response to RAI 41-7957 Q.03.06.02-2 in October, 2017.

# Summary of Open Items

## ❖ Open Item: Break Exclusion Area

- Related RAIs : 166-8198 (Q 03.06.02-3)
- Description of issue
  - Staff requested to provide:
    - ✓ Acceptability of expanding the break exclusion area to the auxiliary building anchor wall beyond the isolation valve and justification with the results of pipe rupture analysis.
- Resolution
  - KHNP provided confirmation that calculated maximum stress results for the graded approach piping in break exclusion area were low compared to the SRP BTP 3-4 stress limit for postulated break locations in revised response to RAI 166-8198 in September 2017.

# Summary of Open Items

## ❖ Open Item: Blast Wave and Potential Feedback Amplification and Resonance Effects

- Related RAIs : 359-8448(Q 03.06.02-6,7,8)
- Description of issue
  - Staff requested:
    - ✓ Clarification on the V&V of the CFD model for blast wave effects
    - ✓ Methodology for evaluation of blast wave
    - ✓ Justification of the criteria used for considering the effect of potential oscillatory jet loads

# Summary of Open Items

- Related RAIs : 359-8448(Q 03.06.02-6,7,8)
- Resolution:
  - KHNP provided the technical report ‘APR1400 High Energy Line Break Jet Impingement (APR1400-E-N-NR-17001-P &NP)’ containing CFD analysis, V&V results and source of the literature references in June 2017.
  - KHNP provided that the feedback amplification and resonance effects due to high energy line breaks does not occur in APR1400 with thermodynamics and lack of perpendicular flat surfaces.
  - The NRC staff requested additional information or clarification for evaluating the dynamic jet impingement and blast wave effects to complete the staff’s review.
  - KHNP provided the revised technical report included the requested clarification such as literature summary and CFD V&V in October 2017

# Summary of Open Items

## ❖ Open Item: Leak-Before-Break Analysis

- Related RAIs : 525-8685 (Q 03.06.03-9)
- Description of issue
  - The PICEP input used for calculating the leakage crack length did not agree with the values stated in the APR1400 DCD.
  - KHNP was requested to confirm the input values and calculations in the DCD are correct and provide copies of the PICEP input files.
- Resolution:
  - KHNP revised the fluid temperature in the PICEP input and calculation.
  - KHNP provided the response with revised input values and calculation, and incorporated the results into related DCD and TeR (APR1400-Z-M-NR-14016-P & NP, Leak-Before-Break Evaluation of the Surge Line).

# Summary of Open Items

## ❖ Open Item: Hard Rock High Frequency (HRHF)

- Related RAIs : 183-8197 (Q 03.07.02-1)
- Description of issue
  - Staff requested to provide an appropriate number of modes to capture and justification for ISRS reduction levels in excess of those provided in SRP Section 3.7.2 II.4.
  - Staff requested to provide revised results for ISRS comparisons and seismic loads between the CSDRS and the HRHF, and justification for the acceptability of all HRHF exceedances.
- Resolution
  - 16 modes were selected to capture converged incoherent motion. It was justified that this converged solution gave the ISRS reduction levels still exceeding the reduction limit set forth in SRP 3.7.2 II.2, as described in Technical Report (APR1400-E-S-NR-14004, Evaluation of Effects of HRHF Response Spectra on SSCs, App. C).
  - From the ISRS comparisons and re-evaluation of the seismic loads, the current designs of the RCB CS, RCB IS, and AB were found to have adequate margin, and thereby all HRHF exceedances were acceptable. The revised results were described in above Technical Report App. C.

# Summary of Open Items

## ❖ Open Item: Analysis Methods and Results for RCB Internal Structure

- Related RAIs : 208-8245 (Q 03.08.03-5)
- Description of issue

  Staff requested to explain the analysis method under seismic loadings for the floor slabs between the secondary shield wall and the containment shell, and the connections between the floor slab and containment shell.

- Resolution
  - Response spectrum analyses were performed using the FRS which envelope both containment shell and secondary shield wall for the seismic load. A detailed procedure for design and analysis of the floor slabs were described in DCD Subsection 3.8.3.4.1, and the design results were provided in DCD Table 3.8A-43, Table 3.8A-44, and Figure 3.8A-61.
  - KHNP provided the connection details between floor slabs and containment shell in DCD Tier 2, Subsection 3.8A.1.4.3.4.3 and Figure 3.8A-60, those could allow the movement of both horizontal directions (tangential and radial).

# Summary of Open Items

## ❖ Open Item: Analysis and Design for Critical Sections

- Related RAIs : 248-8295 (Q 03.08.05-1)
- Description of issue
  - Staff requested to add other design sections and to include their missing information.
  - Staff requested to provide the lacking design results of concrete structures with consistent format.
- Resolution
  - KHNP provided the information of selection criteria for design sections in DCD Tier 2, Section 3.8A. KHNP also added the missing design sections (dome, liner, slab, steel beam) and their design results in DCD Tier 2, Subsection 3.8A.1.4.
  - KHNP provided the information of design results for concrete structures where the information was lacking. Accordingly, Subsection 3.8A.1.4.3.2.3 and Table 3.8A-42 for IRWST structure, Subsection 3.8A.1.4.2.3.1 and Table 3.8A-10 for basemat structure were updated.

# Summary of Open Items

## ❖ Open Item: Waterproofing Membrane

- Related RAIs : 255-8285 (Q 03.08.05-4)
- Description of issue
  - Staff requested to provide the description whether waterproofing membranes were used in APR1400 design.
  - Staff requested to provide the design effects of the waterproofing membranes, if used, on shear resistance of NI common basemat.
- Resolution
  - KHNP confirmed the use of waterproofing membranes and provided the information of typical details for installation, as shown in DCD Tier 2, Subsection 3.8.5.1 and Figure 3.8-27.
  - KHNP provided the sliding resistance effect associated with waterproofing membranes beneath basemat in the RAI response and DCD Subsection 3.8.5.1, in which the design parameter of coefficient of friction will be verified by COL 3.8(11).

# Summary of Open Items

## ❖ Open Item: Construction Sequence

- Related RAIs : 255-8285 (Q 03.08.05-7)
- Description of issue
  - Staff requested to describe how the construction sequence and differential settlement of foundations were considered in the load and load combination.
  - Staff requested to provide the approach for four types of settlements (maximum vertical settlement, tilt settlement, differential settlement between structures, and angular distortion) based on analysis results.
- Resolution
  - The member forces and moments from the analyses with/without construction sequence were considered in dead load case of the design load combinations. The detailed descriptions were added in DCD Subsection 3.8.5.4.2.1.
  - The approach for assessment of four types of settlements and their results were provided in the DCD Subsection 3.8.5.4.2.2 and Technical Report (APR1400-E-S-NR-14006-NP, Stability Check for NI Common Basemat, Section 5). These four types of settlements will be verified based on site-specific soil conditions by COL 3.8(18) and COL 3.8(19).

# Summary of Open Items

## ❖ Open Item: Design and Analysis Procedures for NI Common Basemat

- Related RAIs : 255-8285 (Q 03.08.05-8) :
- Description of issue
  - Staff requested to justify the use of equivalent static accelerations with 100-40-40 method considering phasing motion of three superstructures.
  - Staff requested to explain how to consider torsional load in the basemat analysis.
- Resolution
  - To consider phasing motion of three superstructures (RCB CS, RCB IS, AB), the results from both the linear SRSS combination on the member force level and the nonlinear method using 100-40-40 combination on the input level were enveloped. Additional detailed descriptions were added in DCD Subsection 3.8A.1.4.2.3 and Technical Report (APR1400-E-S-NR-14006-NP, Stability Check for NI Common Basemat, Section 3.2.5.)
  - The member forces and moments from torsional analysis of superstructures were added to the seismic load cases by absolute summation. Additional detailed descriptions are added in the above mentioned DCD Subsections and Technical Report .

# Summary of Open Items

## ❖ Open Item: Applied Loads for NI Common Basemat

- Related RAIs : 255-8285 (Q 03.08.05-12)
- Description of issue
  - Under the KHNP response to RAI 255-8285 Q 03.08.05-8, Staff requested to provide the maximum bearing pressure resulting from both the linear SRSS combination and the nonlinear 100-40-40 combination to resolve phasing of the responses from each of the three superstructures when analyzing NI common basemat.
- Resolution
  - The bearing pressures for NI Common Basemat were re-calculated from both the linear SRSS combination and the nonlinear 100-40-40 combination. Enveloped bearing pressures were provided in the DCD Subsection 3.8A.1.4.2.3.5.

# Summary of Open Items

## ❖ Open Item: Loads and Load Combinations for NI Common Basemat

- Related RAIs : 255-8285 (Q 03.08.05-13)
- Description of issue
  - Staff request to confirm that the crane loads are considered in the design of the entire containment and other seismic category I structures, and that the crane/trolley load is considered in different positions to maximize the loads on the structures.
- Resolution
  - The crane loads were considered in the design of the containment structure and other seismic category I structures. The positions to give maximum polar crane loads in the design of containment structures were described in DCD Subsection 3.8.1.3.2. In case of auxiliary building, the enveloped crane loads from various FHA crane locations were considered and described in DCD Subsection 3.8.4.3.1. The parking positions of the actual polar crane and trolley will be verified by COL 3.8(21).

# Summary of Open Items

## ❖ Open Item: Subgrade Modulus of Soil Profiles for APR1400

- Related RAIs : 255-8285 (Q 03.08.05-16)
- Description of issue
  - Staff requested to update stability evaluations in all applicable parts of DCD Sections 3.8.5 and 3.8A, and technical report to reflect the current models, analysis approach, and results. Also Staff requested to provide the descriptions for bearing pressure evaluations in the EDGB and DFOT structures
- Resolution
  - The updated basemat stability evaluations with the application of the distributed soil spring elements for static conditions and the solid soil elements for dynamic conditions were added in DCD Subsection 3.8A.1.4.2.3.3 and Technical Report (APR1400-E-S-NR-14006, Stability Check for NI Common Basemat, Section 4.2.3 and Table A-7).
    The description for bearing pressure evaluation were added in DCD Subsections 3.8A.1.4.2.3.5 for NI common basemat and 3.8A.3.4.1 for EDGB and DFOT basemats, respectively.

# Summary of Open Items

## ❖ Open Item: Differential Settlement of NI Common Basemat

- Related RAIs : 255-8285 (Q 03.08.05-17)
- Description of issue
  - Staff requested to explain the determination method of differential settlement.
- Resolution
  - The differential settlements were determined based on the construction phase and the post-construction phase, and a detailed procedure was added in the DCD Subsection 3.8.5.4.2 and Technical Report (APR1400-E-S-NR-14006, Stability Check for NI Common Basemat, Section 5).

# Summary of Open Items

## ❖ Open Item: Pump-Induced Loads on RVI Components

- Related RAIs
  - RAI 151-8078 (Q 03.09.02-9)
- Description of issue
  - KHNP was requested to provide details on application of measured pump pressure pulsations and a related hydraulic model in order to calculate deterministic forcing function for loads on RVI components, and to clarify the application adequacy for design conservatism.
  - KHNP was requested to add a description of DPVIB computer program to DCD Section 3.9.1.
- Resolution:
  - KHNP provided details on application of measured pump pressure pulsations and a related hydraulic model to APR1400 design, and clarified the application adequacy.
  - KHNP submitted a description of DPVIB computer program was added to DCD Section 3.9.1.

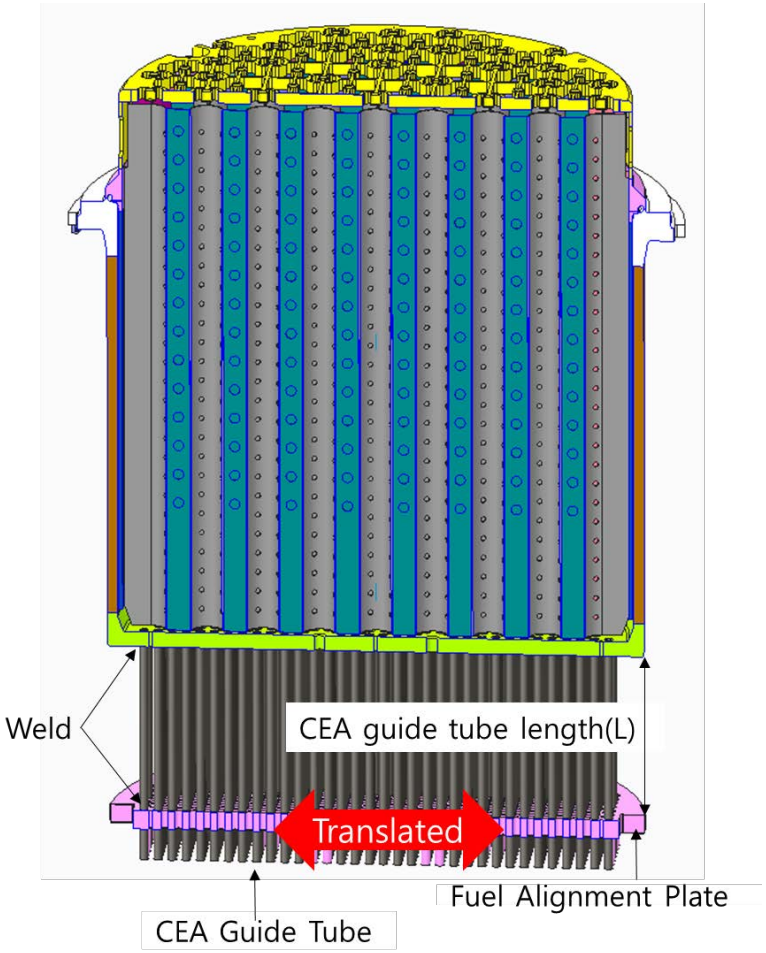
# Summary of Open Items

## ❖ Open Item: Control Element Guide Tube buckling integrity and Operating experience

- Related RAIs
  - RAI 92-8068 (Q 03.09.05-6)
- Description of issue
  - The staff concerned regarding buckling integrity of the control element guide tube under Level D condition.
  - KHNP was requested to address any other operating experiences multiple domestic plants in Korea have similar design as APR1400 design.
- Resolution:
  - Theoretically, if the guide tube is deflected, it cannot buckle. Therefore, buckling does not occurred in the guide tube. But, the buckling integrity of CEA guide tube was evaluated and the detail calculation was submitted in third supplemental response.
  - KHNP reviewed the operational history the Korean domestic plants and confirm that there have been no damage in the fuel assembly.

# Summary of Open Items

*** Buckling Analysis**




***Position requirement for CEA guide tube**

- One of functional requirements of CEA is that mechanical clearances of the CEAs within the fuel and reactor internals are such that the requirements for CEA positioning and a reactor trip are attained under the most adverse accumulation of tolerances.

- The alignment check provides reasonable assurance that the frictional force that could result from adverse tolerances is below the force that could significantly increase scram time.

- The surveillance requirement(SR 3.1.4.5) in TS, Section 3.1.4 describes "Verify each full strength CEA drop time from the fully withdrawn position to the 90% insertion position is below 4 seconds.

# Summary of Open Items

## Open Item: In-Core Instrumentation Support System

- Related RAIs
  - RAI 92-8068 (Q 03.09.05-9)
- Description of issue
  - KHNP was requested to provide information for the static O-ring seal, including its classification and design requirement. A summary of this information should be included in the DCD.
- Resolution:
  - KHNP provided explanation for the classification, design requirements, and design conditions of the static O-ring seals and the summary of these items were incorporated into the DCD Tier 2 (Rev. 1), Subsection 3.9.5.1.4.
  - KHNP provided test results of the static O-ring seal to ensure the reactor pressure boundary is maintained throughout its service life.

# Summary of Open Items

## Open Item: Loading Condition – Level D Service Loading

- Related RAIs
  - RAI 92-8068 (Q 03.09.05-16)
- Description of issue
  - KHNP is requested to describe and justify any differences between DCD Tier 2, Table 3.9-1 and the loads applied to the reactor pressure vessel internals for all service levels.
- Resolution:
  - The major difference between DCD Tier 2, Table 3.9-1 is that IRWST discharge loads are described in the loads and load combinations in the DCD, but Table 3.9-1 shows the only title of transient events.
  - KHNP provided the explanation for the events that result in an IRWST injection and discharge loads of the upset events and the faulted events listed in DCD Tier 2, Table 3.9-1.

# Summary of Open Items

## Open Item: Bases for Reactor Internals - Classification

- Related RAIs
  - RAI 92-8068 (03.09.05-18)
- Description of issue
  - KHNP was requested to provide all of reactor internals seismic classification.
  - KHNP was requested to provide complete classification list , DCD Tier 2 Table 3.2-1.
- Resolution:
  - KHNP provide revised response including explanation of all of the reactor internals are classified as seismic Category I and proposed revision to DCD Tier 2, Table 3.2-1.
  - The complete classification list , DCD Tier 2 Table 3.2-1 is incorporated into the DCD Rev.2.

# Summary of Open Items

## Open Item: Pump and Valve Inservice Testing Program Table

- Related RAIs
  - RAI 69-7994 (Q 03.09.06-9)
- Description of issue
  - The staff requested that KHNP to evaluate and modify all pumps and valve in Table 3.9-13 to be consistent with the NRC regulations in 10 CFR 50.55a, and guidance for IST.
- Resolution:
  - KHNP added additional information of inservice test requirements for pumps and valves in the RAI 69-7994 Q 03.09.06-9 (ML16242A438) including a proposed revision to DCD Tier 2, Table 3.9-13.

# Summary of Open Items

## ❖ Open Item: Environmental Qualification Of Mechanical and Electrical Equipment

- Related RAIs : 27-7944 (Open item 03.11-1)
- Description of issue
  - KHNP was requested to provide justification why IEEE Std. 323-2003 is acceptable for qualification of Class 1E electrical equipment in the harsh environment.
- Resolution:
  - KHNP provided a justification for the use of IEEE Std. 323-2003, stating that it conforms with 10 CFR 50.49, that there are no technical differences between the 2003 and 1974 versions of the IEEE Std. 323, and that IEEE Std. 323-2003 reflects current practices for environmental qualifications. In addition, KHNP provided a basic table comparing the guidance contained in IEEE Std. 323-1974 and IEEE Std. 323-2003 by letter dated July 17. 2015(ADAMS Accession No. ML15198A260).

# Summary of Open Items

## ❖ Open Item: Environmental Qualification of Mechanical and Electrical Equipment

- Related RAIs : 527-8686 (Open item 3.11-2)
- Description of issue
  - The staff requested KHNP to clarify that the qualification documentation will provide auditable records that show the equipment can perform its safety function during and following a DBE, as applicable.
  - The staff requested KHNP to discuss the other applicable DBE conditions and how the design is demonstrated to conform to 10 CFR 50.49.
  - The staff requested KHNP to clarify the discrepancy between IEEE Std.323-1974 and IEEE Std.323-2003 on the synergistic effects and explain how synergistic effects are considered for type test qualification in IEEE Std.323-2003.

# Summary of Open Items

- Resolution:
  - KHNP provided a response that IEEE Std.323-2003 Section 4.4 states “The result of a qualification program shall be documented to demonstrate the equipment’s ability to perform its safety function(s) during its qualified life and applicable design basis events” which include the design event conditions such as high-energy line break, loss-of coolant accident, main steam line break, and/or safe shutdown seismic events, during and after which the equipment is required to perform its safety function, in Section 6.1.5.2 of IEEE Std.323-2003.
  - KHNP provided a response by justifying that the other accidents do not result in limiting conditions for safe shutdown consideration such as LOCA, MSLB and HELB; therefore, these are considered insignificant in the environmental qualification.
  - KHNP provided a response that IEEE Std.323-2003 Section 6.3.1.8.2, “Age conditioning,” refers to synergistic effects by stating “The sequence of age conditioning should consider sequential, simultaneous, and synergistic effects in order to achieve the worst state of degradation”. It is appropriate to mention in Section 6.3.1.8.2, “Age conditioning,” (a required part of type testing), because synergistic effects must be considered at the stage of age conditioning.

# Summary of Open Items

## ❖ Open Item: Structural integrity of piping and pipe supports during the operation of SIT and FD

- Related RAIs : 549-8856 (Q 3.12-19)
- Description of issue
  - Staff requested to provide the followings:
    - ✓ Cavitation effects and vibration originating from the operation of the SIT and its FD in the structural design evaluation of the SIT, its discharge piping and pipe supports.
    - ✓ The operation of the SIT with its FD can result in other phenomena, such as water hammer.
    - ✓ The structural evaluation model of the SIT is coupled with the FD

# Summary of Open Items

- Resolution:
  - KHNP provide the followings:
    - ✓ The cavitation noises are non-periodic and their frequencies are much higher than the modal frequencies of the SIT and the SI line, therefore, there exists no possibility of resonance due to the cavitation implosion.
    - ✓ Safety Injection System is designed to prevent the water hammer by eliminating possible void trap in the system based on NUREG/CR-6519. However, based on NRC feedback, the pressure and dynamic forces on the piping system due to SIT blowdown are calculated, which results that all pipe stress meet code allowable and the support can be acceptable in existing support design.
    - ✓ A structural evaluation model of the SIT for seismic analysis is coupled with the fluidic device.

# Current Status

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

- **Changes in Chapter 3 as reviewed and marked-up in response to the RAIs were incorporated into the Rev.2 of the DCD.**

# Attachment: Acronyms (1/2)

| | |
|---|---|
| **AB** | Auxiliary Building |
| **CFD** | Computational Fluid Dynamics |
| **COL** | Combined License |
| **CSDRS** | Certified Seismic Design Response Spectra |
| **DBE** | Design Basis Event |
| **DCD** | Design Control Document |
| **DFOT** | Diesel Fuel Oil Tank |
| **EDGB** | Emergency Diesel Generator Building |
| **FD** | Fluid Device |
| **HRHF** | Hard Rock High Frequency |
| **IEEE** | Institute of Electrical and Electronics Engineers |
| **IRWST** | In-containment Refueling Water Storage Tank |
| **ISRS** | In-structure Response Spectra |
| **ITAAC** | Inspection, Test and Acceptance Criteria |
| **KHNP** | Korea Hydro and Nuclear Power Co. |
| **LBB** | Leak Before Break |
| **NI** | Nuclear Island |

# Attachment: Acronyms (2/2)

| | |
|---|---|
| **PICEP** | Pipe Crack Evaluation Program |
| **PRHA** | Pipe Rupture Hazard Analysis |
| **QA** | Quality Assurance |
| **RCB** | Reactor Containment Building |
| **RAI** | Request for Additional Information |
| **RG** | Regulatory Guide |
| **RVI** | Reactor Vessel Internals |
| **SIT** | Safety Injection Tank |
| **SRP BTP** | Standard Review Plan Branch Technical Position |
| **SRSS** | Square Root of the Sum of the Squares |
| **SSCs** | Structures, Systems and Components |
| **SSE** | Safe Shutdown Earthquake |
| **SSI** | Soil-Structure Interaction |
| **SSSI** | Structure-Soil-Structure Interaction |
| **V&V** | Verification and Validation |
| | |
| | |
| | |

# Attachment : List of COL Item related to OIs (1/3)

| COL Identifier | Description |
|---|---|
| COL 3.8(11) | The COL applicant is to verify that the coefficient of friction between the lean concrete and waterproofing membrane is greater than or equal to 0.55. |
| COL 3.8(18) | A detailed construction sequence analysis to determine the resulting construction settlements, including the various standard soils profiles (S01-S04, S06-S09) and sequencing of concrete pours for the NI common basemat (RCB and Auxiliary Building), and superstructure model (Auxiliary Building, internal structures, and Shell & Dome), is presented in Section 3.8.5.4.2. A comparison of the four types of construction settlements (i.e. maximum vertical settlement, tilting settlement, maximum differential settlement between structures, and angular distortion) to the maximum criteria listed in Table 2.0-1 is summarized in Tables 3.8-12 through 3.8-14, and Section 3.8.5.4.2.2.d.<br>The COL applicant should use the construction sequence settlement analysis given in Section 3.8.5.4.2, substituting site-specific soil layer conditions, to ensure that the four types of settlement criteria described in Table 3.8-12 thru Table 3.8-14, and Section 3.8.5.4.2.2.d are satisfied. An alternative construction sequence and settlement analysis may be performed by the COL applicant in response to 1) the inability to meet the settlement criteria described in Table 3.8-12 thru Table 3.8-14, and Section 3.8.5.4.2.2.d using the DCD approach discussed in Section 3.8.5.4.2 or 2) Other site specific factors that may require a different construction plan and foundation sequence. However, in either case the COL applicant shall satisfy four types of settlement criteria described in Table 3.8-12 thru Table 3.8-14, and Section 3.8.5.4.2.2.d. |

# Attachment : List of COL Item related to OIs (2/3)

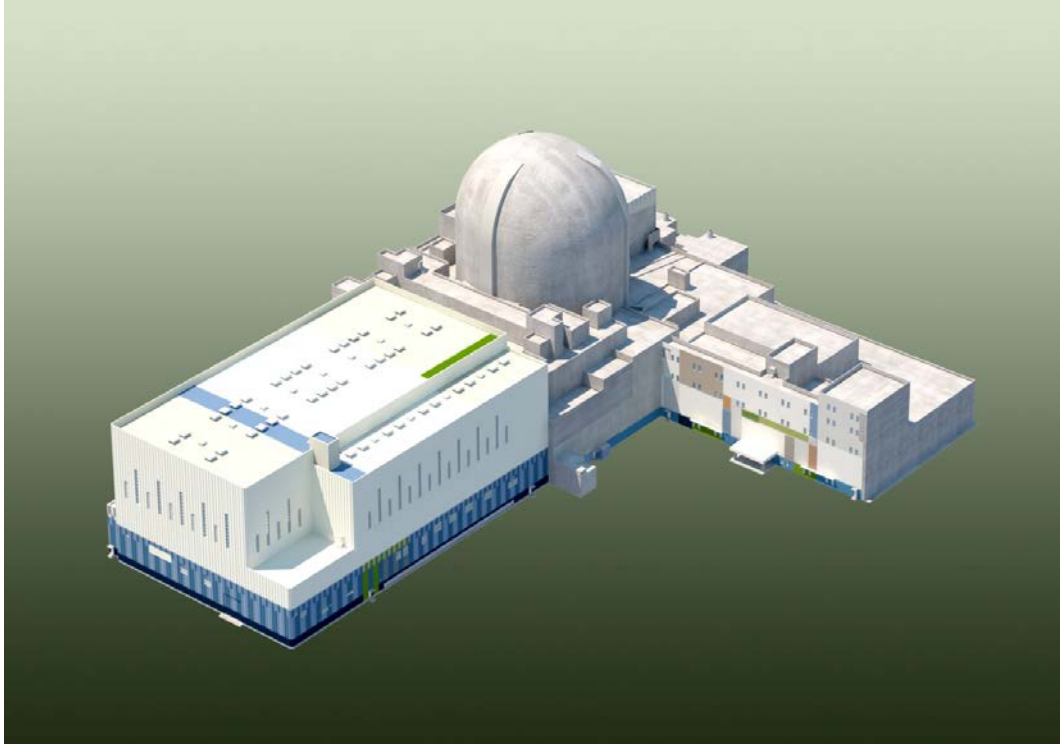
| COL Identifier | Description |
|---|---|
| COL 3.8(19) | The following items should be considered by the COL applicant:<br>1) The surveyed soil profiles will be developed.<br>2) Based on the surveyed soil characteristics, differences from the DCD soil profiles may exist. These differences may include:<br>a. Stiff or soft soil areas;<br>b. Different soil types (e.g, cohesive);<br>c. Potential for loss of cement in the mudmat;<br>d. Non-uniformity of soil layers, or<br>e. Other differences in the soil profile from the properties assumed in design certification. If any of these items and/or conditions are identified, then a site-specific evaluation[1)] shall be performed and checked for adequacy.<br>3) The time (i.e, short term and long term) instantaneous settlement and time-consolidation effects shall be evaluated in accordance with surveyed soil profiles regardless if a site-specific evaluation is needed under Item 2) above. The bearing pressure shall be checked to demonstrate acceptability with the acceptance criteria in DCD Table 2.0-1. Settlements shall be checked in Table 3.8-12 thru Table 3.8-14, and Section 3.8.5.4.2.2.d.<br>4) The COL applicant will build the seismic Category I structure according to the construction sequence used in the site-specific construction sequence analysis.<br>5) If a site-specific evaluation1) is required, the COL applicant should perform a construction sequence analysis based on the site-specific parameters. If the settlement including results of construction sequence analysis exceeds the acceptance criteria described in Table 3.8-12 through Table 3.8-14, and Section 3.8.5.4.2.2.d , the construction sequence will be modified to meet the acceptance criteria described in Table 3.8-12 through Table 3.8-14, and Section 3.8.5.4.2.2.d by COL applicant.<br>6) The effect on the design of seismic Category I structures due to construction sequence analysis shall be accounted for by the COL applicant.<br>[1)] Evaluation includes basemat and superstructure design (forces/stresses), settlement evaluations, soil bearing pressure evaluation, and stability evaluation. |

# Attachment : List of COL Item related to OIs (3/3)

| COL Identifier | Description |
|---|---|
| COL 3.8(20) | The COL applicant shall perform site-specific evaluations if the shear wave velocity is than the shear wave velocity profile used in the various basemat evaluations for design certification. The site-specific evaluations [settlement (maximum vertical displacement, tilt differential settlement between structures, angular distortion), soil bearing pressure (static and dynamic loading cases), overturning, and sliding] and 3D FEM global analysis for basemat design of seismic Category I structures shall be performed using the site-specific parameters (measured $E_{static}$, $E_{dynamic}$ consistent with soil strain assumed in SSI analysis) and the methodology described in DCD Tier 2, Subsection 3.8.5 and Technical report APR1400-E-S-NR-14006-P, Subsection 4. |
| COL 3.8(21) | The COL applicant is to confirm that the parking position of the crane and trolley when the crane is not being used is: location of polar crane: Az.280º, trolley location: 12ft 7in away from end of east part. The COL applicant is to confirm that this requirement is included in the technical specification of the COL application for the use of the polar crane. |
| COL 3.12(1) | If COL applicant finds it necessary to route ASME Class 1, 2, or 3 piping systems outside th e structure, the wind and/or tornado load must be included in the plant design basis loads c onsidering the site-specific loads. |
| COL 3.12(2) | The COL applicant will implement the monitoring program during the first preoperational tes ting and continue to monitor by using the fatigue monitoring system during the first cycle of operation to verify the design transients used in the structural design of the surge line. |

NON-PROPRIETARY

# APR1400 DCA
# Chapter 2, Section 2.5: Geology, Seismology, and Geotechnical Engineering



**KEPCO/KHNP**

**April 17, 2018**

*ACRS SC Meeting (Apr. 17, 2018)*

# Contents


- Overview of Section 2.5
  - Section Overview
  - List of Submitted Documents
  - Summary of RAIs
- Summary of Issue Items
- Current Status
- Attachments:
  - Acronyms
  - List of COL Items relating to Issue

# Overview of Section 2.5

| Section | Title | Major Contents |
|---|---|---|
| 2.5 | Geology, Seismology, and Geotechnical Engineering | • Geologic<br>• Seismologic<br>• Geotechnical site parameters used for APR 1400 structural design and analysis |

# Overview of Section 2.5

## ❖ List of Submitted Documents

| Document No. | Title | Revision | Type | ADAMS Accession No. |
|---|---|---|---|---|
| APR1400-E-S-NR-14006 -P & NP | Stability Check for NI Common Basemat | 4 | TER | - |

## ❖ Summary of RAIs for Chapter 2

| No. of Questions | No. of Responses | Not Responded | No. of OI |
|---|---|---|---|
| 21 | 21 | 0 | 0 |

# Summary of Issue Items

## ❖ Item: Static Stability of Foundation

- Description of issue

  Staff requested to provide bearing pressures and settlements of DCD Section 2.5.4 per the related open RAIs (RAI No. 255-8285, Q 03.08.05-7 and Q 03.08.05-16) of DCD Section 3.8.5 when they were resolved.

- Resolution

  - Based on the response of RAI for DCD Section 3.8.5, revised static/dynamic bearing pressures for NI Common Basemat, EDGB and DFOT were provided in the DCD Subsections 3.8A.1.4.2.3.5 and 3.8A.3.4.1. These bearing pressures will be verified by evaluating with the allowable bearing capacities based on the site-specific properties by COL 2.5(13).

  - Revised maximum differential settlements inside buildings and between buildings were provided in the DCD Table 3.8A-17, Table 3.8A-39 and DCD 3.8A.3.4.1. The predicted settlements will be verified whether they exceed the maximum settlement specified in DCD Table 2.0-1 for site suitability determination by COL 2.5(14).

# Current Status

- **Section 2.5 is completed.**
  - KHNP continues to monitor Section 2.5 to assure any conforming changes are addressed.

- **Changes in Section 2.5 as reviewed and marked-up in response to the RAIs were incorporated into the Rev.2 of the DCD.**

# Attachment: Acronyms

- COL/COLA: Combined License/Combined License Applicant
- DCD: Design Control Document
- DFOT: Diesel Fuel Oil Tank
- EDGB: Emergency Diesel Generator Building
- KEPCO: Korea Electric Power Corporation
- KHNP: Korea Hydro & Nuclear Power
- NI: Nuclear Island
- RAI: Request for Additional Information
- RCB: Reactor Containment Building
- RG: Regulatory Guide
- SSC: Structures, Systems, and Components

# Attachment : List of COL Items

| COL Identifier | Description |
|---|---|
| COL 2.5(13) | The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site-specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5. |
| COL 2.5(14) | The COL applicant will verify whether the predicted settlements within each building and between buildings exceed the maximum differential settlement specified in Table 2.0-1 for site suitability determination. If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant to demonstrate acceptability. The COL applicant will also meet settlement criteria specified in COL 3.8(18) for construction sequence and post construction settlement limits. |

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# Presentation to the ACRS Subcommittee

## Korea Electric Power Corporation
## APR1400 Design Certification Application Review

### Advanced Safety Evaluation Report

### Chapter 3: Design of Structures, Systems, Components, and Equipment

April 17, 2018

# Staff Review Team

- **Technical Staff**
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  - **Vaughn Thomas**, Structural Engineer, Structural Engineering Branch
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# Seismic System Analysis SER Section 3.7.2

**Robert Roche-Rivera**

# High Frequency Seismic Spectra – Seismic System Evaluation

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- Seismic analysis and design of the APR 1400 standard plant are based on the CSDRS
  - Additionally, the APR1400 standard plant is evaluated for the effects of the HRHF spectra
- Original HRHF evaluation lacked technical justification for:
  - Number of spatial coherency modes used in the evaluation.
    - Insufficient, based on non-negligible difference in ISRS results from original alternative spatial coherency mode sets
  - ISRS spectral amplitude reductions greater than the limits set forth in SRP 3.7.2.II.4.
  - Lacked basis to demonstrate the qualification of the APR1400 structures to HRHF demands.

# High Frequency Seismic Spectra – Seismic System Evaluation (Cont'd)

United States Nuclear Regulatory Commission
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- The applicant re-evaluated HRHF effects with consideration of more than twice the original number of spatial coherency modes.
  - Number of coherency modes shown to be adequate based on ISRS results
    - Close agreement between ISRS for alternative spatial coherency mode sets
  - Reductions to coherent ISRS found acceptable based on the applicant's consideration and demonstration of sufficient spatial modes in their HRHF evaluation.
  - APR1400 structures were demonstrated to be qualified for the HRHF spectra based:
    - Higher CSDRS spectral accelerations throughout dominant frequency range
    - Higher equivalent accelerations (used in the structural design) obtained from the CSDRS
    - Reinforcement (CSDRS demand) shown to be adequate for HRHF demand

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# Concrete and Steel Internal SER Section 3.8.3

**Vaughn Thomas**

# Design of the Operating Concrete Floor Slabs

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- Reviewed APR1400 DCD Section 3.8A.1.4.3.1.3 in accordance with SRP 3.8.3 acceptance criteria
  - Description of the design and analysis procedures not provided
  - Analysis to demonstrate that the gap between the containment and the floor slabs was not provided
- Applicant performed additional calculation and sensitivity analysis of the concrete floor slabs following the decoupling criteria in SRP 3.7.2
- The results demonstrated that a gap of 2 1/16 in. is adequate to allow the relative displacements between the containment internal floors and the containment wall
- The applicant re-analyzed the CIS using the reaction forces obtained from local analysis of the concrete floor slabs and the design results showed an increase in member forces
- Provided markup copies of the DCD which describe in detail the design connection of the concrete slab and the steel beam between the containment wall and the SSW along with the new design results of the CIS

# Foundations
# SER Section 3.8.5

Ata Istar

# Critical Sections

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- In DCD Tier 2, Sections 3.8A.1.4, 3.8A.2.4, and 3.8A.3.4 “Analysis and Design for Critical Sections,” the applicant identified the critical sections for design of the RCB.
- The applicant did not capture all the critical sections following their criteria.
- The applicant added the missing critical sections in the DCD (structural steel and reinforced concrete sections).
- The staff determined that the design of these sections were consistent with SRP 3.8 and applicable codes and standards.

# Waterproofing Membrane

- In APR1400 DCD, Section 3.8.5.1, “Description of the Foundations” no waterproofing membrane is identified for the foundation.
- The applicant responded that waterproofing membranes will be used for exterior below grade horizontal and vertical surfaces of structures in APR1400 design with a minimum coefficient of friction of 0.55.
- The applicant has assumed a coefficient of friction of 0.55 in the stability evaluation which is to be verified by COL 3.8(11).

# Construction Sequence & Differential Settlements

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- In APR1400 DCD, Section 3.8.5.1, “Description of the Foundations,” Section 3.8.5.4, “Design and Analysis Procedures,” Appendix 3.8A, “Structural Design Summary,” and TR APR1400-E-S-NR-14006, “Stability Check for NI Common Basemat,” no descriptions were provided for construction sequence and differential settlement of NI foundation.

- The applicant incorporated detailed explanations of the construction sequence, and clearly determined the criteria of four settlement types: (1) maximum vertical settlement, (2) tilt settlement, (3) differential settlement between buildings, and (4) angular distortion for the NI foundation.

# NI Basemat Analysis

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- In DCD Tier 2, Section 3.8.5.4, “Design and Analysis Procedures,” it was not clear how seismic and other loads are determined, and applied to the various structures in the APR1400 basemat design.
- The applicant responded that for seismic loads the equivalent static analysis methodology is used, and the envelop of the results of the linear case (SRSS combination method) and the nonlinear case (100-40-40 combination method) for three soil profiles (soft, medium and stiff) are used in the analysis of NI basemat.
- The staff finds the response acceptable because the applicant used the equivalent static analysis methodology and combination methods for the design of the NI basemat consistent with the guidance provided in RG 1.92 and SRP 3.8.5.

# Max. Bearing Pressure NI Basemat

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- TR APR1400-E-S-NR-14006, Section 3.2.5, “Applied Loads”
- The applicant was requested to determine the maximum soil bearing pressure for the NI basemat from linear and nonlinear dynamic load combinations based on the updated analyses.
- In its response, the applicant calculated the maximum soil bearing pressure for all load combinations (static, nonlinear, linear and SASSI analysis cases), and determined that they are lower than the allowable static and dynamic bearing pressure capacities.

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# Presentation to the ACRS Subcommittee

**Korea Hydro & Nuclear Power Co., Ltd (KHNP) and Korea Electric Power Corporation (KEPCO)**

**APR1400 Design Certification Application Review**

**Advanced Safety Evaluation Report**

**Chapter 3: Design of Structures, Systems, Components, and Equipment**

April 18, 2018

# Staff Review Team

U.S.NRC
United States Nuclear Regulatory Commission
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- **Project Managers**
  - **Bill Ward,** Lead Project Manager
  - **Tomeka Terry**, Chapter Project Manager

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# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping SER Section 3.6.2

**Renee Li**

# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

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Review Approach

- The objective of the NRC staff's review of this section is to verify and to ensure that adequate protections have been provided against the effects of the postulated pipe ruptures and are in compliance with the GDC 4 requirement.
- Reviewed the applicant's criteria used to define the pipe break/leakage crack locations and configurations including the break exclusion area.
- Reviewed the applicant's methodology for addressing the dynamic jet impingement and blast wave effects in a Technical Report (TR), APR1400-E-N-NR-17001-P Revision 1.
- Reviewed the pipe break hazards analysis (PRHA) summary report, APR1400-E-N-NR-14004-P, Revision 2.

Staff Findings

- The applicant's criteria to define the pipe break/leakage crack locations and configurations including the break exclusion area were found acceptable.

# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

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- The TR methodologies in addressing the dynamic jet impingement and blast wave effects were found acceptable.
- The results of the PRHA summary report demonstrated that the APR1400 design is in compliance with the GDC 4 requirement and are acceptable.

Open Item Resolution

- Break Exclusion Area (Open Item RAI 41-7957, Question 03.06.02-2)

  Issue: The design provisions to be employed in the break exclusion area are consistent with the staff's guidance. However, the break exclusion areas are beyond the containment penetration area. The applicant was requested to justify the APR1400 DCD break exclusion area.

  Resolution: The applicant submitted a RAI response to justify the DCD break exclusion area for the APR1400 design.

  - The applicant explained how the DCD break exclusion design provisions were considered and applied to the results of the design of piping in the break exclusion area.
  - The APR1400 design ensures sufficient accessibility to perform a 100 percent volumetric inservice examination of the pipe weld within the break exclusion area.

# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

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- The results of the calculated maximum stress ranges were low compared to the relevant BTP 3-4 stress limit for postulating break locations.
- The RAI response included markups of Revision 1 to applicable subsections in DCD Tier 2 Section 3.6.2.

Open Item Closure: The NRC staff found that the applicant has adequately demonstrated its design provision and specifying a 100 percent volumetric inservice examination criteria meet the applicable BTP 3-4 break exclusion criteria in the NRC staff's guidelines. The applicant has appropriately justified the acceptability of expanding the break exclusion area beyond the containment penetration. In addition, the NRC staff found the proposed DCD markups included in the RAI response were acceptable. This item is being tracked as a Confirmatory Item.

# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

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- PRHA Summary Report (Open Item RAI 166-8198, Question 03.06.02-3)

  Issue: To support the NRC staff's safety determination on the APR1400 PRHA assessment, the applicant was requested to submit summary information on the PRHA results to demonstrate the APR 1400 design meet the GDC 4 requirement.

  Resolution: The applicant submitted a RAI response with an associated PRHA summary report, APR1400-E-N-NR-14004-P, Revision 2.

  - Described the criteria used in determining postulated pipe failure locations, and the methodology for assessing the jet impingement and pipe whipping effects.
  - Summarized the postulated break locations, the targets impacted by the respective break as well as their associates protection methods.

  Open Item Closure: The NRC staff found the PRHA report provided sufficient information to demonstrate that the PRHA were performed in accordance with the methodology and criteria described in the APR1400 DCD and were in conformance with the applicable SRP for which the NRC staff found acceptable.

  The results presented in the report demonstrated that the APR1400 design is in compliance with the GDC 4 requirement such that SSCs important to safety are designed to accommodate and protected against the effects of postulated pipe failures. This item was closed.

# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

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- Blast Wave and Potential Feedback Amplification and Resonance Effects (RAI 359-8448, Questions 03.06.02-6, -7, and -8)

  Issues: The applicant was requested to address the blast wave and potential feedback amplification and resonance affects as presented in a TR. The applicant indicated that it would submit a TR revision with alternative approaches to address these issues.

  Resolution: The applicant submitted TR, APR1400-E-N-NR-17001-P Revision 1 with alternative approaches to address these two issues.

  A. For the Blast Wave Effects:

  - Computational Fluid Dynamics (CFD) modeling was performed for some of the most limiting steam break locations.
  - CFD analysis approach was benchmarked against several experiments and analyses of similar conditions to verify its suitability.
  - The results of the APR1400-specific CFD analysis were used to develop a methodology for assessing the blast wave effects for other HELB locations that have not been analyzed by CFD. The methodology conservatively accounted for the initial energy available to form the blast wave and the effects of plant geometry on the blast wave loading on the impacted SSCs.

# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

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B. For the Potential Feedback Amplification and Resonance Effects:

- In the TR, the applicant discussed how the multiple physical characteristics (e.g., lack of perpendicular flat surfaces of sufficient size to establish a feedback loop, irregularities in contours of the broken pipe end that distort the outgoing jet) of the APR1400 postulated HELB would prevent occurrence of a potential feedback amplification and resonance.
- The absence of HELB resonance effects was substantiated through a survey of experimental results.

<u>Open Item Closure:</u>

A. For Blast Wave Effects:

The NRC staff found that the applicant's CFD analysis performed for assessing the blast effects for the APR1400 plant were technically justified. The applicant has provided sufficient information to demonstrate the validity and applicability of the test data and methodology of the referenced open literature. The applicant has demonstrated that the methodology to account for effects of APR1400 plant geometry on the blast wave loads was conservative. The applicant has adequately addressed the NRC staff's concern on the blast wave effects as identified in Appendix A of SRP 3.6.2. This item was closed.

# Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

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Open Item Closure:

B. For the Potential Feedback Amplification and Resonance Effects:

The NRC staff found that the applicant has adequately discussed how the multiple physical characteristics of the APR1400 postulated high-energy line breaks would prevent occurrence of a potential feedback amplification and resonance. The applicant also demonstrated that the absence of potential feedback amplification and resonance was substantiated by a survey of experimental results.

The NRC staff found the applicant's evaluation and approach to address potential feedback amplification and resonance effects as identified in Appendix A of SRP 3.6.2 acceptable because the applicant has adequately demonstrated reasonable assurance that this phenomenon is not a concern for the APR1400 plant. This item was closed.

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# Leak Before Break Evaluation Procedures SER Section 3.6.3

**Eric Reichelt**

# Leak Before Break

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- Reviewed applicable APR1400 DCD sections in 3.6.3
- Reviewed DCD references for applicability and use
- Held public meetings with KHNP/KEPCO staff about technical issues and RAIs leading to proposed DCD markups
- The staff found these DCD sections acceptable
- The technical issues and response to RAIs by KHNP were acceptable and were therefore closed.
- RAI 525-8685, Question 03.06.09, was an open item discussed at previous ACRS meeting. The staff requested the applicant to review conflicting values between PICEP input and DCD, and to provide copies of the PICEP input files.

# Leak Before Break

- The staff reviewed the revised input values and calculations and received the PICEP code from the applicant.
- The staff performed a Confirmatory analysis of the applicant's Piping Evaluation Diagrams (PED) for the applicant's Surge Line, reactor coolant loop (RCL) piping (with the hot leg (HL) and cold leg (CL) evaluated separately), DVI-2 line, and shutdown cooling (SC) line (main run inside containment).

# Leak Before Break

- Based on the proprietary information provided, the staff was able to perform the confirmatory analysis of the LBB PED. The NRC staff concludes that there is reasonable assurance the applicant's LBB analysis bounds the normal operation and normal operation + safe shutdown earthquake design conditions and finds the applicant's LBB analysis acceptable.
- There are no open items for this section.

# Leak Before Break

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## Overall Conclusions on LBB

- The staff evaluation concludes on a design specific and piping system specific basis that the acceptance criteria are satisfied, and, therefore, that dynamic effects of pipe rupture may be eliminated from design consideration.

# Special Topics for Mechanical Components
# SER Section 3.9.1

## Tom Scarbrough

# Special Topics for Mechanical Components

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- Design Transients: The APR1400 transient occurrences are conservatively designed, based on the certified System 80+ design transients.
- Computer Programs Used in Analyses: The NRC staff audited verification and validation (V&V) documents of the computer programs used in analyses.

  DPVIB computer program is used to calculate fluctuating pressure distribution in the down-comer region caused by RCP pressure pulsation. The staff found the output of the DPVIB is in agreement with the test data. The description of DPVIB computer program is added into DCD Tier 2.
- Evaluated the Faulted Conditions: The evaluation of Faulted Conditions is in conformance with ASME BPV Code, Section III, Appendix F.

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# ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures SER Section 3.9.3

## Tom Scarbrough

# ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures

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- Load combinations for ASME Code Class 1, 2 and 3 components and component supports conform to ASME BPV Code, Section III.
- Dynamic system and dynamic fluid loadings, respectively DF and DFL, explicitly are defined, and they conform to ASME BPV Code, Section III.
- Component supports are designed in accordance with ASME BPV Code, Section III, Subsection NF.

# ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures

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- Audit and follow-up audit conducted of component design specifications in accordance with 10 CFR 52.47 to establish that design criteria, analytical methods, and functional capability satisfy ASME Code requirements, and to confirm that design information from DCD is properly translated into design specifications.
- As result of audit, design specifications and DCD being updated.
- RAI issued to track completion of design specification and DCD changes.
- Confirmatory item to be closed when KHNP notifies NRC that design specifications and DCD have been updated to resolve audit follow-up items with appropriate NRC review.

# Functional Design, Qualification, and IST Program
# SER Section 3.9.6

## Tom Scarbrough

# Functional Design, Qualification, and IST Program

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- NRC staff evaluated APR1400 DCD Tier 2, Section 3.9.6, "Functional Design, Qualification, and Inservice Testing (IST) Programs for Pumps, Valves, and Dynamic Restraints," using SRP Section 3.9.6
- DCD provision for functional qualification of pumps, valves, and snubbers specifying ASME Standard QME-1-2007 as endorsed by Regulatory Guide 1.100 (Revision 3) is acceptable.
- NRC staff conducted audit of design specifications of APR1400 components in accordance with 10 CFR 52.47
- DCD description of IST Program based on ASME OM Code (2004 Edition through 2006 Addenda) as incorporated in 10 CFR 50.55a is acceptable for reference in COL application.
- DCD Revision 1 reviewed to verify that planned changes in RAI responses have been incorporated.

# Functional Design, Qualification, and IST Program

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- RAI 69-2994, Question 03.09.06-1 Confirmatory Item: RAI responses with planned ITAAC changes are acceptable. Awaiting next DCD revision to verify changes have been incorporated.
- RAI 550-8737, Question 03.09.03-7 Confirmatory Item: Design Specification Follow-up Audit items for functional design and qualification are acceptable. Awaiting notification by KHNP that design specifications and DCD have been updated to resolve audit items.
- RAI 69-7994, Question 03.09.06-9 Closed: NRC staff reviewed DCD Revision 1 and confirmed that planned IST table changes have been incorporated.

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# Dynamic Testing and Analysis of SSCs SER Section 3.9.2

## Yuken Wong

# Dynamic Testing and Analysis of SSCs

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- The staff reviewed the methodology, testing procedure, inspection program, and dynamic analyses conducted by KHNP to ensure the structural integrity and functionality of piping systems, mechanical equipment, and their supports under vibratory loading
- Specifically, reviewed six main areas:
  1. piping vibration, thermal expansion, and dynamic effects testing including the initial test program for ASME BPV Code, Section III, Class 1, 2 and 3 piping.
  2. seismic analysis and qualification of seismic Category I components
  3. dynamic system analysis for reactor internals under operational flow transients and steady-state conditions
  4. preoperational flow-induced vibration testing of reactor internals
  5. dynamic system analysis of the reactor internals under faulted conditions
  6. correlations of reactor internals vibration tests with the analytical results

# Dynamic Testing and Analysis of SSCs

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- Staff reviewed the comprehensive vibration assessment program (CVAP) report for APR1400 steam generator and reactor internals design in comparison with System 80 reactor design. The Palo Verde Unit I reactor is prototype and APR1400 is non-prototype Category 1.
- RAI 533-8718 Question 03-09-02-17 Closed: Applicant stated that the mechanical tanks will be designed for a ZPA of 50 Hz and the hydrodynamic forces exerted on the tank wall. A new COL item [COL 3.9(8)] was added to DCD for the COL applicant to perform the detailed analysis of mechanical tanks, including the effects of fluid sloshing.
- DPVIB computer code benchmarking: Applicant provided acceptable validation and verification information as documented in Section 3.9.1. Open item is closed.

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# Reactor Pressure Vessel Internals SER Section 3.9.5

**Yuken Wong**

# Reactor Pressure Vessel Internals

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- NRC staff evaluated the arrangement of reactor internals, their functions, flow path through the reactor vessel, and design criteria.
- Comparisons were made between the APR1400 reactor design and the CE System 80 reactor design, i.e. Palo Verde Units 1, 2 and 3, as the reactor designs are similar.
- Ensured the core support structures are constructed in accordance with ASME B&PV Code, Section III, Subsection NG. Internal structures are constructed in accordance with Subsection NG as guidelines.

# Reactor Pressure Vessel Internals

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- RAI 92-8068, Question 03.09.05-6 Closed: KHNP investigated operating history of the Korean plants with control element guide tube design similar to that of APR1400 and confirmed that no failures have occurred on these components that would prevent control rod insertion.

- RAI 92-8068, Question 03.09.05-18 Confirmatory Item: KHNP provided clarification that all reactor internals (both core support structures and internal structures) are seismic Category I. Awaiting next DCD revision to verify changes have been incorporated.

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# Seismic & Dynamic Qualification of Equipment SER Section 3.10

**Yuken Wong**

# Seismic & Dynamic Qualification of Equipment

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- Reviewed DCD Tier 2, Section 3.10, 3.7B.7.4, and associated technical reports
- Verified equipment seismic qualification standards and methods
- Verified procedures to evaluate of effects of hard rock high frequency (HRHF) response spectra
- Conducted audit of procurement (design) specifications to verify seismic qualification methodologies
- RAI 550-8737, Question 03.09.03-7 Confirmatory Item: Design Specification Follow-up Audit items for seismic qualification are acceptable. Awaiting notification by KHNP that procurement specifications have been updated to address staff audit findings

# Environmental Qualification of Mechanical and Electrical Equipment SER Section 3.11

Jorge A Cintron

# Environmental Qualification of Mechanical and Electrical Equipment

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- Section 3.11 provides the APR1400 approach for environmental qualification of mechanical and electrical equipment.
- Staff reviewed the environmental qualification of mechanical and electrical equipment to verify the equipment is capable of performing its design functions under all normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions. This equipment includes:
  - Safety-related equipment
  - Non-safety-related equipment whose failure under postulated environmental conditions could prevent satisfactory accomplishment of specified safety functions
  - Certain post-accident monitoring equipment

# Environmental Qualification of Mechanical and Electrical Equipment

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Confirmatory Item

- The staff evaluated applicant's response to RAIs requesting justification why IEEE Std. 323-2003 is acceptable for qualification of Class 1E electrical equipment in the harsh environment
- Regulatory Guide (RG) 1.89: provides an acceptable method for environmental qualification. Endorses IEEE Std. 323-1974, "IEEE Std. for Qualifying Class IE Equipment for Nuclear Power Generating Stations."
- The APR1400 deviates from RG 1.89 by using IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," for environmental qualification of mechanical and electrical equipment.

# Environmental Qualification of Mechanical and Electrical Equipment

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Confirmtory Item (Cont.)

- The staff evaluated the applicant's response to RAIs and concludes the applicant appropriately justified the technical differences between in the content of IEEE Std. 323-2003 and IEEE Std. 323-1974.
- Staff has completed evaluating the applicant revised response to the RAIs, therefore, this is a Confirmatory Item for Section 3.11

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# Radiological Equipment Qualification Review (Section 3.11)

## Ed Stutzcage

# Equipment Qualification (Radiological)

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Open Issues discussed at the previous ACRS Meeting (all associated with RAI 8089, Questions 03.11-9 and 03.11-11):

- Inconsistencies with Chapter 12 information regarding the neutron dose on the reactor Containment Building operating floor during normal operation
- Doses within the Auxiliary Building during accidents did not appear to adequately consider radiation streaming through containment penetrations.
- Additional information was needed regarding how some of the total integrated doses for areas were determined.
- Assumptions for post-accident fluid leakage rate outside of containment.

# Equipment Qualification (Radiological)

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**Inconsistencies with Chapter 12 information regarding the neutron dose on the containment building operating floor during normal operation.**

**Issue:**

- Additional information was needed to ensure that the total integrated neutron dose on the operating floor was adequate.

**Resolution:**

- Applicant updated technical report APR1400-E-X-14001-P to provide accurate operating floor dose information, based on the calculation data.
- Applicant also provided actual dose rate information on the operating floor for the operating APR1400 unit in Korea (Shin Kori Unit 3). The actual dose rate information was significantly lower than what is calculated and used in the equipment qualification (EQ) analysis for the operating area for the APR1400 DCA. Therefore, the EQ analysis is conservative.

**Conclusion:**

- As a result, the staff found the total integrated dose values for the operating floor to be acceptable.

# Equipment Qualification (Radiological)

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**Doses within the Auxiliary Building during accidents did not appear to adequately consider radiation streaming through containment penetrations.**

**Issue:**

- Doses in areas with penetrations were calculated at a dose point in the center of the room.

**Resolution:**

- Applicant re-analyzed the accident EQ total integrated doses for containment penetration areas and re-calculated the total integrated doses following an accident at a dose point 30 centimeters away from the penetrations. This provides an accurate estimate of the maximum doses that equipment within the room could be exposed to.

**Conclusion:**

- Therefore, the staff found the revised total integrated doses for penetration areas to be acceptable.

# Equipment Qualification (Radiological)

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**Additional information was needed regarding how some of the total integrated doses for areas were determined.**

**Issue:**

- Besides penetration areas (discussed on the previous slide), it was unclear how some other doses were calculated and there appeared to be potential errors with some information.

**Resolution:**

- Applicant revised the normal operation total integrated dose information for some areas:
  - Applicant provided more information in the technical report describing that the total integrated dose for areas without radiation sources were calculated assuming 1% failed fuel defects from adjacent sources, with additional margin added for conservatism. This is consistent with NRC guidance and is acceptable.
  - Applicant revised calculations for transfer tube inspection area to account for fuel transfer.
- Applicant provided additional updates clarifying the shielding thicknesses for certain areas, especially areas near and around demineralizers and filter areas.

# Equipment Qualification (Radiological)

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**Additional information was needed regarding how some of the total integrated doses for areas were determined (continued).**

**Conclusion:**

- The staff reviewed the shielding and dose rate information using MicroShield, as necessary and found them to be acceptable.

# Equipment Qualification (Radiological)

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**Assumptions for post-accident fluid leakage rate outside of containment.**

**Issue:**

- Applicant did not provide enough information explaining the allowed ESF leakage rate assumed in the EQ analysis and why the leakage was different than that used in the accident analysis.

**Resolution:**

- Applicant clarified that the allowed ESF leakage rate for EQ of 0.285 cubic feet per hour was based on the assumed leakage rates from valves and pumps specified in the response. The allowed leakage rate is doubled in accordance with RG 1.183. The applicant also proposed to update DCD Subsection 15.6.5.5.1.2 and Appendix B of APR1400-E-X-NR-14001-P to clarify that while the EQ analysis assumed 0.285 cubic feet per hour (which is doubled), the DCD Chapter 15 accident analysis used a different assumed leak rate of 18.9 L/hour (0.667 cubic feet per hour) doubled to 37.8 L/hour (1.335 cubic feet per hour).

# Equipment Qualification (Radiological)

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**Assumptions for post-accident fluid leakage rate outside of containment (continued).**

**Conclusion:**

- The staff found the ESF leakage values used in the EQ analysis to be acceptable because the 0.285 cubic feet per hour is based on conservative leakage assumptions and it is the maximum leakage allowed. If the value was to be exceeded during plant operation, the licensee would have to evaluate the impacts on the equipment and take appropriate action.

# ASME Code Class 1, 2, and 3 Piping Systems and Associated Supports Design SER Section 3.12

**Alexander Tsirigotis**

# Piping Analysis and Supports

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- Confirmed APR1400 piping and supports analysis incorporates NRC guidance and is in accordance with ASME BPV Code Subsections NB, NC, ND and NF as incorporated by reference in 10 CFR 50.55a.
- Conducted audit of piping stress analysis and support designs to confirm consistency with DCD.
- Held public meetings with the applicant to discuss technical issues during audits and RAIs leading to proposed DCD markups, revisions to technical reports and added piping analyses.
- The applicant has adequately addressed all NRC staff comments.

# Piping Analysis and Supports

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- During Phase 4 the applicant addressed structural effects on piping and its supports due to potential fluid dynamic loads occurring from the operation of the safety injection tank and its fluidic device.
- The applicant derived water hammer loads, which, when incorporated in the load combinations for pipe stress analysis and pipe support design, showed that piping and supports remained structurally adequate and met ASME Section III acceptance criteria
- The applicant modified the Safety Injection Tank Subsystem Test, DCD Tier 2 Section 14.2.12.1.22, to instrument the safety injection line to gather vibrational data and to ensure that vibration levels are within acceptable limits found in ASME OM-SG Part 3.

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# Presentation to the ACRS Subcommittee

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

**Safety Evaluation with No Open Items:**

**Chapter 2 SITE CHARACTERISTICS**

**Sections 2.5**

APRIL 17, 2018

# Staff Review Team

- **Technical Staff**
  - Luissette Candelario, David Heeszel, Ricardo Rodriguez
- **Project Managers**
  - Bill Ward – Lead Project Manager
  - Carolyn Lauron – Project Manager

# Technical Topics

## Chapter 2 – Site Characteristics

- The APR1400 design assumes a site envelope that describes the geography and demography, nearby facilities, and postulated site parameters for the design, including meteorology, hydrology, geology, seismology, and geotechnical parameters.

- In November 2017, the staff presented the site characteristics related to:
  - Geography and demography
  - Meteorology
  - Hydrology

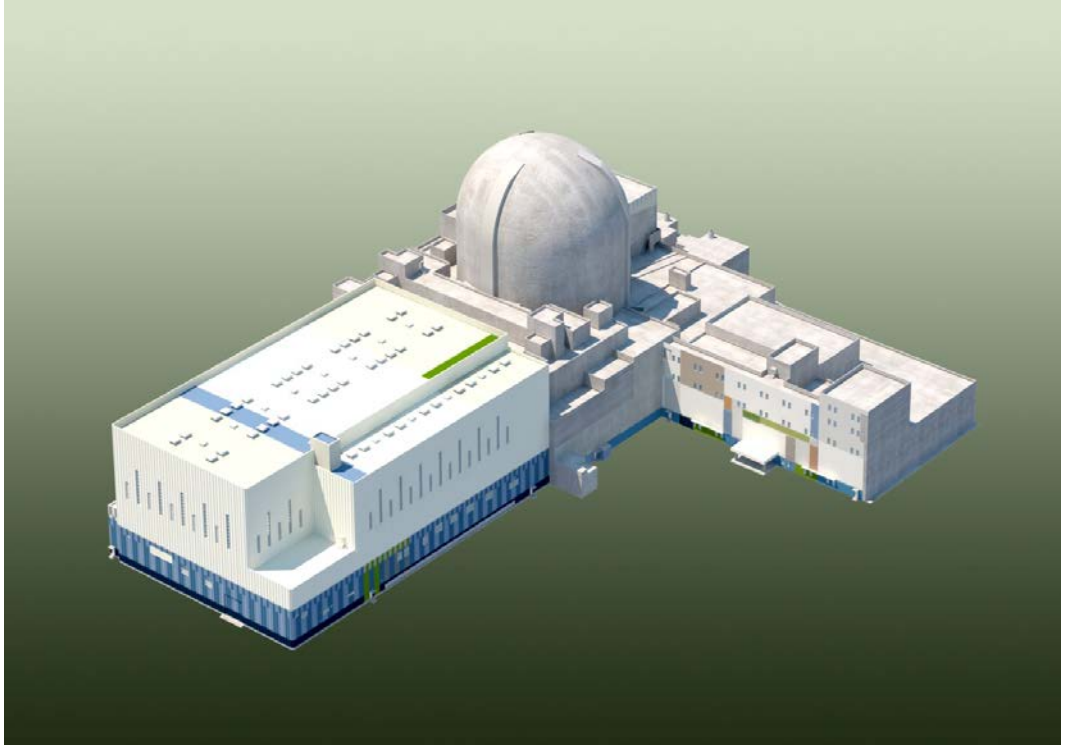
- Today's presentation covers the site characteristics related to geology, seismology and geotechnical engineering.

# Technical Topics - Overview Chapter 2, Site Characteristics Section 2.5

- There were no open items previously identified.
- The applicant properly identified appropriate geologic, seismologic and geotechnical site parameters and properly identified the site specific information to be provided as part of any future COL application.
- We are currently reviewing DCD Revision 2 to ensure all confirmatory items have been incorporated.

NON-PROPRIETARY

# APR1400 DCA
# Chapter 15:Transient and Accident Analyses



**KEPCO/KHNP**

**April 17, 2018**

ACRS SC Meeting (April.17, 2018)

# Contents

- **Overview of Chapter 15**
  - Section Overview
  - List of Submitted Documents and Summary of RAIs
  - List of Open Items
- **Summary of Open Items**
- **Current Status**

- Acronyms

# Overview of Chapter 15

| Section | Title |
|---|---|
| 15.0 | Introduction : Transient and Accident Analyses |
| 15.1 | Increase in Heat Removal by the Secondary System |
| 15.2 | Decrease in Heat Removal by the Secondary System |
| 15.3 | Decrease in Reactor Coolant System Flow Rate |
| 15.4 | Reactivity and Power Distribution Anomalies |
| 15.5 | Increase in Reactor Coolant Inventory |
| 15.6 | Decrease in Reactor Coolant Inventory |
| 15.7 | Radioactive Material Release from a Subsystem or Component |
| 15.8 | Anticipated Transient without Scram |
| 15A | Analytical Model for Determining Radiological Consequences of Accidents |

# Overview of Chapter 15

## ❖ List of Submitted Documents

| Document No. | Title | Revision | Type | ADAMS Accession No. |
|---|---|---|---|---|
| APR1400-K-X-FS-14002-P P & NP | APR1400 Design Control Document Tier 2: Chapter 15 Transient and Accident Analyses | 2 | DCD | - |
| APR1400-Z-A-NR-14006-P | Non-LOCA Safety Analysis Methodology | 1 | TeR | ML17094A190 |
| APR1400-F-A-NR-14003-P & NP | Post-LOCA Long Term Cooling Evaluation Model | 1 | TeR | ML17206A154 |
| APR1400-F-A-NR-14001-P & NP | Small Break LOCA Evaluation Model | 1 | TeR | ML17114A523 |
| APR1400-F-A-TR-12004-P & NP | Realistic Evaluation Methodology for LBLOCA of the APR1400 | 1 | ToR | ML17265A104 |

## ❖ Summary of Open Items

* 10 open items at phase 3
* 10 open items are closed in phase 4

# Overview of Chapter 15

## ❖ List of Open Items

| No. | Related RAI | Topic | ADAMS Accession # |
|---|---|---|---|
| 1 | RAI 108-7973 (Q 15.00.03-1) & RAI 368-8470 (Q 14.03.08-14) | Periodic Reopening of the MCR Air Intakes | ML15344A121<br>ML17257A542 |
| 2 | RAI 17-7917 (Q 15.04.06-1) | Complete Mixing Model | ML15146A260 |
| 3 | RAI 511-8668 (Q 15.04.06-8) | VOPT During Boron Dilution at Power | ML16232A625 |
| 4 | RAI 143-8092 (Q 15.06.05-1) | Loop Seal Clearing and Reformation | ML16363A031 |
| 5 | RAI 318-8337 (Q 15.06.05-2) | SBLOCA Dense Break Spectrum Analysis | ML16194A269 |
| 6 | RAI 398-8457 (Q 15.06.05-5) | Boron Precipitation | ML16363A415 |
| 7 | RAI 404-8488 (Q15.06.05-10) | Upper Bound of SBLOCA Break Size | ML16201A284 |
| 8 | RAI 404-8488 (Q15.06.05-11) | LOCA Deposition Model (DM) | ML16202A506 |
| 9 | RAI 430-8455 (Q 15.06.05-22) | Boron Dilution in SBLOCA | ML16363A035 |
| 10 | RAI 5-7954 (Q 11, 12, 16 & 18) & RAI 399-8510 (Q 15.06.05-7) | Impacts of Thermal Conductivity Degradation LBLOCA DCD Revision | ML17335A069<br>ML17223A687 |

# Summary of Open Items

## ❖ Open Item: Periodic Reopening of the MCR Air Intakes

- Related RAIs : 108-7973 (Q.15.00.03-1)
- Open item reference: RAI 368-8470, Q 14.03.08-14
- Description of issue
  - The MCR ventilation system design provides for automatic selection of the least contaminated outside air intake. And the closed MCR intake will re-open automatically so that the intake with the higher radioactive can be selected again and closed.
  - Staff required to show that the increase in dose from both air intakes being open periodically can be encompassed by the current design margin, and DCD update.
- Resolution
  - KHNP provided the additional information on the dose evaluation including the increase of the dose can be compensated from the design margin of 20% (KHNP used the reduction factor of 8 instead of 10 for the MCR intakes x/Qs)
  - DCD is revised.

# Summary of Open Items

## ❖ Open Item: Complete Mixing Model

- Related RAIs : 17-7917(Q 15.04.06-1)
- Description of issue
  - NRC Staff noted that the flow rate in Modes 4 and 5 when all RCPs are idle and with one shutdown cooling train in service may not be sufficient to assume complete RCS mixing.
  - Staff requested to provide the followings:
    - ✓ Justification that the complete mixing model is conservative including any potential effects of incomplete lower plenum mixing.
    - ✓ Demonstrate that the source range detectors can sense any postulated incomplete mixing.
- Resolution:
  - KHNP decided to add additional valve which is classified as Quality Group C to block the flow path from the unborated water source in Modes 4 and 5 with all RCPs idle.
  - In addition, KHNP added new TS 3.1.12 and its associated Bases to prohibit the boron dilution operation, and eliminated the quantitative analysis for these Modes in DCD 15.4.6.

# Summary of Open Items

## ❖ Open Item: VOPT During Boron Dilution at Power

- Related RAIs : 511-8668(Q 15.04.06-8)
- Description of issue
  - NRC Staff noted that a slow reactivity insertion transient such as a boron dilution at power would not be protected by the variable overpower trip.
  - Staff requested to provide the followings:
    - ✓ Which reactor trip would occur for an at power boron dilution event.
- Resolution:
  - KHNP provided the clarification that the core protection calculator system (CPCS) DNBR trip or CPCS auxiliary trips can protect the DNBR limit during a slow reactivity insertion event.

# Summary of Open Items

## ❖ Open Item: SBLOCA Dense Break Spectrum Analysis

- Related RAIs : 318-8337 (Q 15.06.05-2)
- Description of issue
  - Provide the results of a finer break spectrum for both the DVI line and PDL breaks
- Resolution:
  - KHNP performed the dense break spectrum analysis for the DVI line and PDL breaks.
  - Break spectrum analysis number is increased from 10 to 37
  - The limiting DVI line break size is changed from 0.4 $ft^2$ to 0.1364 $ft^2$
  - LOCA criteria is still satisfied. (DCD Table 15.06.05-10)
  - KHNP revised the RAI response, TeR (APR1400-F-A-NR-14001-P) and DCD chapter 15.6.5.

# Summary of Open Items

## ❖ Open Item: Upper Bound on the SBLOCA Break Size

- Related RAIs : 404-8488 (Q 15.06.05-10)
- Description of issue
  - Demonstrate that the 0.5 $ft^2$ break size remains the largest SBLOCA which must be considered.
- Resolution:
  - KHNP responded that the analysis with the breaks larger than 0.5 $ft^2$ are treated by the current LBLOCA methodology.
  - KHNP presented results comparing the LBLOCA and SBLOCA PCTs.
  - The PCT calculated by the LBLOCA methodology was greater than the PCT calculated by the SBLOCA methodology.
  - No change in DCD.

# Summary of Open Items

## ❖ Open Item: Thermal Conductivity Degradation (TCD)

- Related RAIs : 5-7954 (Q 11, PLUS7 Fuel Design for the APR1400)
- Description of issue
  - NRC Staff noted that FATES3B does not account for the effect of TCD and requested a TCD impact on fuel design and safety analyses.
- Resolution:
  - TCD penalty was determined based on the analysis of comparison to the experimental data at various burnups , and KHNP performed the analyses for the design evaluations and the related safety areas with TCD penalty.
  - For CEA ejection, peak radial average fuel enthalpy is increased less than 11 cal/g and peak centerline temperature is increased about 317 $^{o}$F at HFP case. But Peak radial average fuel enthalpy is much lower than 230 cal/g, and no fuel centerline melting occurs.
  - For LBLOCA, the details of TCD effect will be discussed in LBLOCA Topical Report section.
  - TCD-affected DCD Tier 2 chapters and LBLOCA Topical Report were revised.
  - All the RAIs including impact of TCD have been resolved.

# Summary of Open Items

## ❖ Open Item: Loop Seal Clearing and Reformation

- Related RAIs : 143-8092 (Q 15.06.05-1)
  - The details will be explained in future LTCC section.

## ❖ Open Item: Boron Precipitation

- Related RAIs : 398-8457 (Q 15.06.05-5)
  - The details will be explained in future LTCC section.

## ❖ Open Item: LOCA Deposition Model

- Related RAIs : 404-8488 (Q 15.06.05-11)
  - The details will be explained in future LTCC section.

## ❖ Open Item: Boron Dilution

- Related RAIs : 430-8455 (Q 15.06.05-22)
  - The details will be explained in future LTCC section.

# Current Status

- **Chapter 15 is completed.**
  - KHNP continues to monitor Chapter 15 to assure any conforming changes are addressed.
  - 10 open items, that were identified in Phase 3, have been resolved with adequate and sufficient discussion with the staff.

- **Changes in Chapter 15 as reviewed and marked-up in response to the RAIs is incorporated into the revision (Rev.2) of the DCD.**

# Acronyms

| | |
|---|---|
| **CEA** | Control Element Assembly |
| **CPCS** | Core Protection Calculator System |
| **DVI** | Direct Vessel Injection |
| **LOCA** | Loss of Coolant Accident |
| **LTC** | Long Term Cooling |
| **LTCC** | Long Term Core Cooling |
| **MCR** | Main Control Room |
| **PCT** | Peak Cladding Temperature |
| **PDL** | Pump Discharge Leg |
| **RCP** | Reactor Coolant Pump |
| **RCS** | Reactor Coolant System |
| **TCD** | Thermal Conductivity Degradation |
| **VOPT** | Variable Over Power Trip |

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# Presentation to the ACRS Subcommittee

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

### Safety Evaluation with No Open Items: Chapter 15
### Transient and Accident Analyses

**By**

Timothy Drzewiecki, Michelle Hart, Shanlai Lu

April 17, 2018

# Open Item 15.0.3-1

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## Modeling of Control Room Emergency Makeup Air Cleaning System Operation

**Description:** (RAI Question 14.03.08-14 sub-question 6.b)

- DCD did not clearly describe system operation where control logic automatically re-opens closed CR air intake isolation dampers at a preset interval for a short time to determine which intake has lower radioactivity concentration. The COL applicant is to choose both the interval time between damper re-openings and the length of time the intakes are both open (COL item 9.4(2))

**Closure:** (confirmed incorporated in DCD Rev. 2)

- RAI response described the modeling assumptions for damper operation and described the level of conservatism and margin in the control room dose analyses
- Revisions made to DCD Sections 9.4.1 and 15.0.3 to describe more clearly the system operation and dose analysis assumptions
- ITAAC revised to clarify damper operation
- COL item 9.4(2) revised and COL items 15.0(2) and 15.0(3) added to identify that the COL applicant verify that the damper re-opening interval and duration are accounted for in the dose analyses

# Open Item: 4.2-1 in Chapter 15

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## Fuel Pellet Thermal Conductivity Degradation

### Description

- Staff SER Section 4.2 “Fuel Design” identified this issue as an Open Item for fuel performance evaluation due to FATES3B code deficiency
- As a result, the initial steady state fuel center line temperature and the total core sensible heat/stored energy have been underestimated

### Closure

- Fuel performance CESEC-III analyses are not impacted:
  - Analyses used conservative values for gap conductance that bound any increase in fuel temperature associated with TCD
  - Large uncertainty accounted for in the fuel temperature coefficient bounds the TCD impact on the reactivity feedback during a transient.

# Open Item: 4.2-1 in Chapter 15

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## Fuel Pellet Thermal Conductivity Degradation

## Closure (Cont.)

- CETOP thermal margin analyses not impacted because these analyses use "dummy" rod (i.e., no modeling of heat transfer through the fuel pin, only deposit heat flux at fuel surface)
- DCD Section 15.4.8, CEA Ejection, fuel rod enthalpy re-evaluated (analysis still performed with STRIKIN-II):
  - Pellet thermal-conductivity multiplier applied in STRIKIN-II to increase fuel temperature to match TCD penalized FATES3B value.
  - Results still showed no fuel failures associated with high cladding temperature (at HZP) or PCMI. All fuel failures attributed to DNBR (not affected by TCD).
  - CEA ejection reanalysis results satisfied all criteria of against SRP 4.2 Appendix B and DG-1327
- DCD Section 15.6.5, LBLOCA, TCD penalty incorporated into LBLOCA methodology (APR1400-F-A-TR-12004)

Therefore, all the Chapter 15 re-analyses regarding TCD are acceptable

# RAI Questions 15.6.5-1, 2

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## Pending Large Break LOCA Topical Report Review

## Description:

RAI Questions 15.6.5-1, 2 were created to track the pending review of the LBLOCA topical report and the final LBLOCA analysis results

## Closure:

Details will be discussed during the LBLOCA topical report presentation

# Open Item 15.4.6-1

## Inadvertent Boron Dilution During Modes 4 and 5

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### Description:

RAI 7917 was issued to request justification for the use of a complete mixing model in the Boron dilution analysis for Modes 4 and 5. Staff was concerned about the possibility of reactor core returning to critical as a result of inadvertent fresh water addition

### Closure:

KHNP responded to the RAI with hardware design changes and relevant technical specification revisions

- New isolation valve (CV-186) added in the reactor makeup water line to block the flow path that could allow unborated water to reach the RCS during Modes 4 and 5
- New TS 3.1.12 added and revised TS 3.9.7 with relevant DCD changes

The design change will prevent the inadvertent fresh water injection by isolating fresh water source using the new isolation valve following the revised technical specifications. Staff considers the design changes and relevant technical specification modifications acceptable

# Open Item 15.4.6-2

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## Variable Overpower Trip During Boron Dilution at Power

**Description:**

RAI 511-8668 Question 15.4.6-8 was issued by the staff to request information about the DNBR protection provided by the variable overpower trip during a slow reactivity insertion transient, such as a boron dilution at power

**Closure:**

KHNP responded to the RAI and indicated that variable overpower trip would not be appropriate to prevent the DNB violation during such an event. The core protection calculator system (CPCS) DNBR trip or CPCS auxiliary trips are credited to protect the DNBR limit. Staff reviewed the RAI response and relevant analyses. It is concluded that DNBR limit is protected during a slow reactivity insertion event

# Open Item 15.6.5-4

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**SBLOCA Upper Bound Break Size and PCT**

**Description:**

Staff issued RAI 8488 Question 15.06.05-10 and supplemental RAI request to ensure the full coverage of the entire break spectrum by both SBLOCA and LBLOCA methodology

**Closure:**

KHNP submitted the response and relevant analyses indicating that both LBLOCA and SBLOCA methodology predicted the PCT less than 2200 ˚F for a break size of 0.5 $ft^2$. Therefore, the results are acceptable

# Open Item 15.6.5-5

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## Boron Precipitation During Long Term Cooling

**Description:**

Staff was concerned that the mixing volume assumed by KHNP for the region above the core could be non-conservative and the switch-over time during a cold leg break LOCA event could be too long

**Closure:**

KHNP re-analyzed the Boron precipitation phenomenon and submitted all the revised analysis results and relevant DCD changes. In particular, the time of switch-over from DVI line to hot leg has been reduced from three hours to two hours. The design change is considered acceptable

# Open Item 15.6.5-6

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## Boron Dilution During LOCA Long Term Cooling Phase

### Description:

- RAI 8455 Question 15.06.05-22 was issued based on Reg. Guide 1.206 regarding GSI-185 to request specific analysis for APR1400 conditions
- The phenomenon is possible due to the presence of a loop seal

### Closure:

- KHNP responded to the RAI and performed APR1400 specific analysis
- Conservative assumptions were introduced in the calculation to determine the loop seal fresh water slug discharge based on PKL tests
- The calculated Boron concentration in the core has sufficient margin to maintain sub-criticality during post LOCA long term cooling phase. Therefore, the shutdown margin is maintained

# Open Item 15.6.5-7

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## LOCA Deposition Model

**Description:**

Staff issued RAI 404-8488 Question No. 15.06.05-11 to obtain additional information about RCS coolant temperature, latent fiber weight percent and other relevant information as the input to the LOCA deposition model

**Closure:**

Based on the additional information submitted by KHNP, staff concluded that KHNP applied the approved Westinghouse LOCA deposition model properly and the calculated peak cladding temperature is less than 800 ˚F. Therefore, this open item is closed

# Open Item 15.6.5-8

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## Loop Seal Clearing During SBLOCA and Long Term Cooling

**Description:**

As the result of a loop seal, the core two-phase water level could be depressed due to the loop seal formation and clearing. Staff issued RAIs regarding the potential impact on peak cladding temperature during a SBLOCA and its long term cooling phase.

**Closure:**

KHNP reanalyzed the SBLOCA event considering the existence of the loop seal and demonstrated that although the heat-up is predicted, the impact on PCT is not significant. Staff reviewed the analysis methodology and concluded that the method is conservative. The results show that PCT is less than 2200 ˚F during the blowdown phase and less than 800 ˚F during the long term cooling phase.

# Conclusion:

NRC staff reviewed all the supplemental information provided by KHNP as the result of Phase IV review and found it to be acceptable