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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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692ND MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

THURSDAY

FEBRUARY 3, 2022

+ + + + +

The Advisory Committee met at the Nuclear
Regulatory Commission, Two White Flint North, Room
T2B1, 11545 Rockville Pike, at 8:30 a.m., Joy L.
Rempe, Chairman, presiding.

COMMITTEE MEMBERS:

- JOY L. REMPE, Chairman
- WALTER L. KIRCHNER, Vice Chairman
- DAVID A. PETTI, Member-at-Large
- RONALD G. BALLINGER, Member
- VICKI M. BIER, Member
- CHARLES H. BROWN, JR., Member
- VESNA B. DIMITRIJEVIC, Member*
- GREGORY H. HALNON, Member
- JOSE A. MARCH-LEUBA, Member

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MATTHEW W. SUNSERI, Chairman

ACRS CONSULTANT:

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

HOSSEIN NOURBAKHS

*Present via teleconference

P R O C E E D I N G S

(8:30 a.m.)

CHAIRMAN REMPE: Okay, this meeting will now come to order. This is the second day of the 692nd meeting of the Advisory Committee on Reactor Safeguards. I'm Joy Rempe, Chairman of the ACRS. Members in attendance are Ron Ballinger, Matt Sunseri, Dave Petti, Walt Kirchner, Vicki Bier and Jose March-Leuba. We are expecting to soon be joined by Charlie Brown, Greg (Pause.)

MR. NGUYEN: Chairman Rempe, I think we lost you after Greg. (Pause.) Can anyone externally confirm my assertion?

MR. SNODDERLY: Yes, Quynh, we can't hear. (Simultaneous speaking.) We cannot hear the ACRS members though in the room.

MR. NGUYEN: (Pause.) I texted the chairman, letting her know when we lost her.

MR. SNODDERLY: Thanks, Quynh. This is Mike. Did you want me to text Larry or Scott and let them --

MR. NGUYEN: Sure. Thanks, man.

MR. SNODDERLY: All right, I'll do that. (Pause.) There we go.

MR. NGUYEN: Thank you. (Pause.) Good

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1 morning, I've been notified that Headquarters has
2 lost internet capability, so --

3 UNKNOWN FEMALE: Who's talking?

4 UNKNOWN MALE: Quynh.

5 UNKNOWN MALE 2: That's Quynh that's
6 talking.

7 UNKNOWN FEMALE: I know, but who's got
8 their computer on?

9 UNKNOWN MALE 2: Me.

10 UNKNOWN FEMALE: Okay, tell them that
11 we're trying.

12 UNKNOWN MALE 2: All right.

13 MR. NGUYEN: Yes, we can hear you now.

14 UNKNOWN MALE 3: We got you.

15 CHAIRMAN REMPE: So we're going through
16 (Simultaneous speaking.) Matt's computer, should we
17 go ahead and finish the intro if you can hear me?

18 MR. NGUYEN: Yes, we lost you after you
19 were announcing Greg.

20 CHAIRMAN REMPE: Okay. (Simultaneous
21 speaking.) So, Matt, should I just come over there by
22 you?

23 MEMBER SUNSERI: Yes, yes, sure.

24 CHAIRMAN REMPE: This isn't good.

25 (Pause.)

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1 UNKNOWN MALE 3: Okay, so one is the boss
2 and one is the rest? Okay.

3 CHAIRMAN REMPE: Okay, so this is Joy
4 Rempe again. I apologize that we lost internet
5 connectivity. We still do not have it on the main
6 computer. We're going through an individual member's
7 computer and (Simultaneous speaking.) we'll just cope
8 with this as we can. But, I believe, Quynh, you said
9 we lost the connectivity when I was announcing that
10 Greg Halnon, Vesna Dimitrijevic, and Charles Brown
11 will be joining us later and they have been excused
12 from the initial part of the meeting. But we do have
13 a quorum.

14 Similar to yesterday, the committee is
15 primarily meeting in person with some ACRS staff, NRC
16 staff and participants attending virtually.

17 The ACRS was established by the Atomic
18 Energy Act and is governed by the Federal Advisory
19 Committee Act. The ACRS section of the US NRC public
20 website provides information about the history of the
21 committee and documents, such as our Charter, bylaws,
22 Federal Register notices for meetings, letter reports
23 and transcripts of open portions of our full and
24 subcommittee meetings, including all slides presented
25 at these meetings.

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1 The committee provides its advice on
2 safety matters to the commission through its publicly
3 available letter reports. The Federal Register notice
4 announcing this meeting was published on December 28,
5 2021. This announcement provided an agenda and
6 instructions for interested parties to provide written
7 documents or request opportunities to address the
8 committee. We have received no written comments or
9 requests to make oral statements from members of the
10 public regarding today's session.

11 A communication channel has been opened to
12 allow members of the public to listen in on the
13 committee discussion and we periodically open the
14 meeting to accept comments for participants listening
15 to our meetings. Written comments, if not previously
16 provided, may still be forwarded to Dr. Hossein
17 Nourbakhsh, the designated federal officer for today's
18 meeting.

19 During today's meeting, the committee will
20 consider the following topic: Holtec Spent Fuel Pool
21 Heat Up Calculation Methodology Topical Report. A
22 transcript of the meeting is being kept and I request
23 that speakers identify themselves and speak with
24 sufficient clarity and volume so that they can be
25 readily heard. Additionally, participants should mute

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1 themselves when not speaking.

2 At this time, I'd normally ask Hossein
3 Nourbakhsh to lead us through the discussion, but we
4 have an internet connectivity issue and so I'm going
5 to reboot the system and rejoin the meeting. We hope
6 we get internet connectivity, but we do not have it on
7 the main system at this time. So, stay tuned and
8 we're going to have a bit of a break, okay?

9 MEMBER MARCH-LEUBA: So, we are on recess?

10 CHAIRMAN REMPE: Yes (Simultaneous
11 speaking.).

12 MEMBER MARCH-LEUBA: You're talking to
13 this microphone that helps.

14 CHAIRMAN REMPE: Yes. Okay so, we will
15 officially have a recess while we try and figure out
16 what's going to happen here.

17 (Whereupon, the above-entitled matter
18 went off the record at 8:36 a.m. and resumed at 8:44
19 a.m.)

20 CHAIRMAN REMPE: Thank you all for your
21 help remotely. Let's turn the meeting over to Member
22 March-Leuba to lead us through the Holtec discussion.

23 MEMBER MARCH-LEUBA: Thank you, Chairman
24 Rempe. I was going to start the meeting by saying
25 that, of course, we are going to be talking about the

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1 Holtec Spent Fuel Pool Methodology, and I was going to
2 tell Holtec and the staff that I maliciously told them
3 to prepare for a 20-minute presentation so I can now
4 graciously give them 50 percent over time, which we
5 already have used so I'll stick to the original 20
6 minutes.

7 Without further adieu, Ekaterina from the
8 staff is going to give us some opening remarks.

9 MS. LENNING: Good morning, Full Committee
10 Chairman, Full Committee members and staff. My name
11 is Ekaterina Lenning, Division of Operating Reactor
12 License and Office of Nuclear Reactor Regulation. I
13 am project manager for the Holtec International HI
14 2200 750, revision zero, Holtec Spent Fuel Pool Heat
15 Up Calculation Methodology Topical Report review.

16 Presenting today for the staff will be
17 Josh Kaizer, who is the lead technical reviewer for
18 this topical report, and Adam Rau, Division of Safety
19 System NRR.

20 I would to thank you for the opportunity
21 to present this staff review and evaluation of
22 Holtec's topical report and spent fuel pool heat up
23 calculation methodology. We look forward to today's
24 meeting and thank you again for the opportunity to
25 present.

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1 MEMBER MARCH-LEUBA: Thank you. I believe
2 we also have some introductions from Holtec management
3 or the staff and then we will move straight to the
4 technical presentation. Go ahead.

5 MR. TRICE: Good morning, my name is Kelly
6 Trice. I'm the President of Holtec Decommissioning
7 International.

8 We appreciate the opportunity to address
9 the ACRS Full Committee regarding the Holtec topical
10 report on the method for determining the spent fuel
11 assembly heat up during a theoretical drain down event
12 of a spent fuel. This topical report is important to
13 Holtec and our decommissioning process as it
14 measurably enhances nuclear safety by providing an
15 innovative, yet simple to calculate, methodology for
16 arranging the spent fuel in the pool, such that the
17 risk of zirconium fire reaction is eliminated sooner
18 than the traditional methodologies currently being
19 utilized in the industry.

20 We thank you for your time this morning
21 and look forward to a constructive discussion. Ms.
22 Andrea Sterdis and Dr. Stefan Anton will be our
23 presenters for both the open and closed sessions.
24 Thank you.

25 MEMBER MARCH-LEUBA: Dr. Anton, yes, go

1 ahead. Are you going to share your slides?

2 DR. ANTON: Yes, just a second. We will
3 be sharing the slides momentarily.

4 MEMBER MARCH-LEUBA: Excellent, thank you.
5 We see them now.

6 CHAIRMAN REMPE: So actually just to
7 interrupt real quick, I just want to confirm the court
8 reporter did start recording when we came back. I
9 forgot to say that we're back on the record. Could
10 the court reporter confirm that we are. (Non-verbal
11 response.) Thank you. Sorry about that, Jose, go
12 ahead.

13 MEMBER MARCH-LEUBA: Okay, Stefan.

14 DR. ANTON: Yes, thank you very much.
15 This is Stefan Anton. I'm the Vice President of
16 Engineering at Holtec International and I'm the author
17 of the topical report, where we will present some
18 details and the background here. Second slide,
19 please.

20 Okay, on a high level what is the purpose
21 of the topical report? It is to develop and provide
22 a methodology to proactively determine the best
23 overall spent fuel pool arrangement so that the risk
24 of a zirconium fire is eliminated as soon as possible
25 after a permanent defueling of a plant. This

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1 methodology that can be then used, if it's
2 implemented, to gain a significant and real safety
3 benefit by reducing the time that such an event of a
4 zirconium fire would be feasible.

5 MEMBER MARCH-LEUBA: Doctor, just for the
6 benefit of the public --

7 DR. ANTON: Yes?

8 MEMBER MARCH-LEUBA: What you mean by as
9 soon as possible is this is a spent fuel pool and we
10 are putting spent fuel from the core into the pool.
11 You refer as the number of years that have passed
12 since the last time you loaded fuel from an active
13 core, that's correct?

14 DR. ANTON: That is correct. There is
15 basically the time in months or years after the fuel
16 has been loaded into the spent fuel from the core into
17 the spent fuel pool that has to pass before it can be
18 considered that a zirconium fire is no longer
19 feasible. That is the time that we are talking about
20 and our methodology will be allowing to minimize that
21 time compared to what is being used in the past. The
22 next slide.

23 A little bit more about what kind of
24 problem we are actually addressing here. If there is
25 a theoretical beyond design basis event of a drain

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1 down of a spent fuel pool, so the loss of water then
2 of course, the cladding of the spent fuel assemblies
3 would heat up due to the fact that we don't have any
4 water cooling in the spent fuel pool.

5 Now we are concerned there about the
6 cladding temperature, that is our main concern, not
7 the fuel itself. If the cladding temperature exceeds
8 a certain value, there is the possibility of an
9 exothermal reaction with the air that is now replacing
10 the water and that possibly can result in what is
11 commonly called a zirconium fire or zirc fire. That
12 is at the heart of it and that is what we are trying
13 to show that it's not feasible after a certain period
14 of time. Next slide, please.

15 So what are the acceptance criteria and
16 what is generally the principle approach that is used
17 to evaluate that. The acceptance criteria is a
18 combination of a temperature and a time. The criteria
19 is namely that a cladding temperature, again, we're
20 talking about the fuel cladding does not exceed 900
21 degrees Celsius within 10 hours from the start of the
22 drain down event. This is not something that we
23 developed within the topical report. This is a common
24 acceptance criteria that has previously used numerous
25 times, been accepted by the NRC and there are numerous

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1 publicly available documentations that show where this
2 comes from and what the basis for this is. But just
3 in very short, the 900 degrees Celsius is one of the
4 temperature levels where certain reactions between the
5 air and the fuel cladding can occur and the 10 hours
6 that is based on the assumption that within a certain
7 period of time, there would be some remedies available
8 to limit the temperature so it is assumed that within
9 10 hours, you can actually initiate some kind of a
10 cooling to the spent fuel pool. Again, that was not
11 developed as part of the topical report, this is
12 generally accepted acceptance criteria that you need
13 to meet.

14 MEMBER MARCH-LEUBA: May I stop you here
15 and have some discussion? We have some deliberations
16 after our Full Committee. That's why I asked the
17 question earlier to clarify in the mind of the public
18 the time you were talking two slides before was two or
19 three years after you unload the fuel from the core.
20 This time, this 10 hours that you are talking to now,
21 is time from the accident that made the pool drain.
22 So these are completely different times scale, hours
23 versus years.

24 DR. ANTON: That is correct. This is
25 different. This 10 hours would be in case you

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1 actually have a drain down event that within 10 hours
2 after that drain down initiated, that the cladding
3 does not reach 900 degree Celsius. The previous time
4 that we talked about is how long you have to wait
5 after loading spent fuel into the pool until you would
6 make sure that you don't reach 900 degrees Celsius
7 after 10 hours.

8 MEMBER MARCH-LEUBA: Yes, so I had an
9 opportunity to educate myself a lot more deeper on
10 NUREG-1738, which is where these numbers are reports
11 of the criteria. The way I read that 10 hours is the
12 time necessary for evacuation of the personnel or the
13 public around the plant. It's not clear which
14 evacuation they are talking about. Not time to
15 restore the level.

16 MS. STERDIS: So this is Andrea Sterdis.
17 You're correct, Jose. What that is, is that's the
18 time that if you read in the NUREG-1738, it's been
19 concurred that if you have 10 hours from an
20 instantaneous drain down to the time that the fuel
21 would reach 900 degrees C, there's plenty of time for
22 alternate methods to get water into the pool to
23 prevent the zirc fire and then there's also sufficient
24 time that if the state and local officials determine
25 there's a protective action they want to implement,

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1 then there's time there to do that as well, so you're
2 correct.

3 MEMBER MARCH-LEUBA: Okay, so the NUREG
4 also has a sentence that says, I mean this NUREG is
5 difficult to read, I mean it took me several tries to
6 go over it. It's very noncommittal. Defined
7 temperatures of 800 and 900, 1,000, 1,200 depends on
8 the atmosphere, like if you have steam the temperature
9 is much higher than when you have only oxygen. But
10 there seems to be an agreement on the 900 degrees as
11 being a good cutoff. However, the NUREG warns that
12 the criteria should be judged based on the
13 application, so we'll go through that with the members
14 in the letter the way I wrote it. My recommendation
15 is going to be that this SER from the staff is
16 approving the methodology to calculate a temperature
17 at a given time. Whenever you want to apply it for a
18 license amendment request, you will have a different
19 license amendment and we will expect the staff to
20 review the criteria for applicability to the
21 particular application.

22 CHAIRMAN REMPE: Could I ask, tell me a
23 little more about what sites were considered? Did
24 they go through some sort of bounding site parameters
25 to come up with this time for mitigating that?

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1 MEMBER MARCH-LEUBA: There is no
2 description of the 10 hours. Basically it is the
3 customary time we have been using forever.

4 MR. KAIZER: This is Josh Kaizer, NRC
5 staff. I was actually having discussions this morning
6 and I have a nice little document, but a lot of this
7 discussion started with a Maine Yankee backfit
8 contention. There was a SECY on it. The NUREG
9 followed it and there was another SECY after that.
10 So, I did want to provide that there is more detail
11 about the specific acceptance criterion and my
12 understanding is that 10 hours was kind of an estimate
13 of either getting a mitigation system into place or
14 doing evacuation and it's depending on whether you're
15 looking at like the SECY or the NUREG, depending on
16 which one they focused on.

17 MEMBER MARCH-LEUBA: Okay, so we'll ask
18 you again in about half an hour when it's your time.

19 CHAIRMAN REMPE: So while you're thinking
20 about what you're going to answer to us, you know,
21 sometimes people will use a bounding set of parameters
22 from the EPRI study of 95 percent of the plants or
23 something like that or did they just pick one plant,
24 like Maine Yankee, because that's what was under
25 discussion?

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1 MR. KAIZER: I am not sure and I can tell
2 you my answer will probably be a further explanation.
3 I'd say because of that uncertainty of where this
4 acceptance criterion came from, the staff tried to
5 make it very clear in SSE that they were focusing
6 solely on that acceptance criterion. We didn't say it
7 in the SE, we're not saying that this acceptance
8 criterion is acceptable for satisfying a particular
9 regulation or anything like that in the topical report
10 SE, we're just saying that if staff. I think this is
11 kind of what Jose was saying earlier with his LARS, if
12 an applicant comes in or licensee comes in and says,
13 hey I want to use this acceptance criterion, if the
14 staff finds this acceptance criterion acceptable, for
15 lack of a better term, for a specific licensing
16 request, then the Holtec method is an acceptable way
17 to demonstrate that the specific criterion has been
18 met.

19 CHAIRMAN REMPE: Again, I appreciate
20 whoever came up with these additional details, Member
21 March-Leuba, but, yes that's an interesting little
22 tidbit.

23 MEMBER MARCH-LEUBA: Yes and from my point
24 of view, I think the methodology and the intent from
25 Holtec is excellent. It is to be commended. What I

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1 want to get the concurrence from the members when we
2 discuss the letter is that we have a warning in the
3 body of the letter saying that the SCR only approves
4 the methodology. It does not approve the acceptance
5 criterion and it is application dependent. They will
6 have to review it. I would like to give an
7 opportunity now during the presentation for Holtec and
8 the staff to correct me if I'm wrong. My statement is
9 the SCR approves the methodology with an understanding
10 of the timing for the methodology. We are talking
11 about 10 hours for heat up because it will change the
12 methodology if it was 10 seconds, but you do have an
13 understanding of what the application is likely going
14 to be, but you don't approve a particular criterion
15 today. That will be reviewed later. If I'm mistaken
16 in my statements, please you have time now to do it.

17 DR. ANTON: This is Stefan Anton, let me
18 first apologize for not characterizing that correctly.
19 I was focusing more on the development of the
20 methodology and I'm glad that my colleague, Andrea,
21 here could clarify that. She said yes, that that's
22 also our understanding. We are just developing the
23 methodology and the acceptance criteria could
24 potentially be site specific, if I may say it that
25 way. Is that correct?

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1 MS. STERDIS: Yes.

2 DR. ANTON: Yes, okay.

3 MR. KAIZER: And I will also confirm that
4 that was the intent of the staff safety evaluation.
5 Jose said it well and I would even go so far as to say
6 I think that that is what is written clearly in the
7 staff safety evaluation.

8 MEMBER MARCH-LEUBA: Excellent, thank you.
9 We are in violent agreement. Let's continue with the
10 presentation.

11 DR. ANTON: Yes, okay, very good. I'm
12 still on the previous slide. How do I know, what is
13 the principle approach to actually show that the
14 acceptance criteria is met. Since there is a
15 temperature involved and there is a time involved,
16 this, from a technical perspective, could be a
17 transient thermal analysis that needs to be performed
18 to see how the temperature would start rising after
19 the beginning of such an event. Then out of that
20 calculation, you would see under certain conditions if
21 the 900 degrees is met or not met within the 10 hours.

22 Now the certain conditions would be the
23 heat, the decay heat of the fuel assemblies, that's
24 basically your variable that you have in there. So
25 you would determine what is the maximum decay heat of

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1 the fuel assembly that would assure that the 900
2 degrees or whatever it is, let's stay with the 900
3 degrees in 10 hours, is not reached.

4 Now the decay heat of the fuel assembly is
5 linked to the cooling time of the fuel assembly. Once
6 the fuel assembly comes out of the core and goes into
7 the spent fuel, the decay heat of the fuel assemblies
8 is very high and then it goes down over time. Once
9 you determine the decay heat limit, that you would
10 provide as a criteria, you then back calculate and
11 find out what is the minimum cooling time of the fuel
12 assembly. So the minimum time that has to pass after
13 the fuel is placed out of the core into the spent fuel
14 pool. That is the time that we talked about in the
15 previous slides where we see that this time with our
16 methodology we can show that a shorter time limit can
17 be applied there and show that even after a shorter
18 time, the zirc fire is no longer feasible.

19 Any comments on here before I continue?

20 MEMBER MARCH-LEUBA: Nothing from me.

21 DR. ANTON: Okay, thank you. Then let me
22 basically say we make an improvement compared to what
23 was done in the past and what was reviewed and
24 approved by the NRC for certain site specific
25 applications. There was a standard approach that has

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1 been used. It is using a transient thermal
2 calculation with a number of conservative assumptions.
3 I listed the five principle and relevant assumptions
4 here.

5 Number one, the transient thermal analysis
6 was only done for a single fuel assembly out of the
7 pool. You use the bounding fuel assembly, the one
8 with the highest decay heat of all assemblies that are
9 in the spent fuel pool at a certain time. That is
10 number one and two. The other three basically say you
11 look at this fuel assembly in perfect thermal
12 isolation. You do not assume that the fuel assembly
13 can transfer any of the heat to the surrounding fuel
14 assemblies. You do not consider any air flow through
15 the rack at the assembly, so it's basically completely
16 isolated and you don't consider any other heat loss of
17 this single fuel assembly with the high heat flow.
18 Basically, all the decay heat that is in the assembly
19 is used to basically increase the heat load of that
20 assembly. That's then how you come up with the
21 temperature over time to see if 900 degrees is reached
22 or not reached within 10 hours.

23 This methodology, these assumptions, make
24 the calculations very simple. You can almost do it
25 with a simple analytical calculation approach on a

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1 piece of paper, just a few formulas or you can use a
2 simple spreadsheet. That has always been the
3 advantage of this. This is kind of the previously
4 used approach. So let's go to the next slide.

5 The difference in our approach, let me
6 just mention that the disadvantage of this previous
7 approach is that it doesn't give you any indication of
8 what would be a good or not so good configuration of
9 fuel assemblies in your spent fuel pool to actually
10 minimize the temperature at a given time of your
11 cladding. Your spent fuel pool has a mixture of high
12 and low decay heat assemblies so using this
13 methodology it doesn't really tell you what to do
14 there. That is one of the major disadvantages.

15 What we do, the principle difference of
16 our methodology is now that we consider limited heat
17 transfer between the assemblies. A hot assembly in
18 our methodology is allowed to exchange heat with
19 surrounding assemblies and they could be of a lower
20 heat load and so they could partially absorb some of
21 the heat from the hot assembly. With this
22 methodology, we can actually develop a thermally
23 optimized loading pattern throughout the spent fuel
24 pool, so we can basically say okay if you move fuel
25 assemblies in a certain way and put them in certain

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1 locations, you can actually get in a better situation
2 with respect to the feasibility or the possibility of
3 a zirc fire.

4 At the same time, I was talking about the
5 conservative assumptions, we still keep the
6 conservative assumption that overall there is no heat
7 transfer from the assemblies to the outside. The fuel
8 assemblies, as a whole, are assumed not to exchange
9 any heat to the environment. Most importantly, we
10 keep still the assumption that there is no air flow
11 through the vents. This is quite a significant or
12 dramatic simplifying assumption because it basically
13 assumes that fuel assemblies that sit in the
14 individual rack cells and we basically assume that the
15 rack cell is basically closed both at the top and at
16 the bottom so that we have no air flow through there.
17 There could be situations where that would be the
18 case, if somebody is lying on top of the rack or if
19 there is still water at the bottom, but it is a very
20 extreme assumption in that respect. To say that
21 again, we are not changing that assumption.

22 MEMBER MARCH-LEUBA: This is Jose. I
23 agree with you that that feels like a very
24 conservative assumption. My question is different,
25 can you answer this in a non-proprietary setting; if

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1 not, just tell me no, that's proprietary. Has Holtec
2 performed a scoping analysis for a particular spent
3 fuel pool and can you tell us how much benefit you get
4 from this analysis. I mean do you gain one month of
5 decay time or do you gain 10 years of decay time? If
6 you can do it in a non-proprietary setting.

7 DR. ANTON: Yes, let me just double that
8 here with my colleagues. I'll just for a second go on
9 mute if we can discuss this here. (Pause.)

10 MEMBER MARCH-LEUBA: This is only for our
11 benefit. This information is not necessary, so if you
12 have any problems whatsoever, please don't feel
13 obliged to do it.

14 DR. ANTON: (Pause.) Yes, I can actually
15 confirm that, I discussed that here. We have
16 performed some informal calculations just to see what
17 the effect would be. They indicate to us that if
18 there would be air flow allowed through the fuel
19 assembly, even after an infinite amount of time, it
20 would not reach the 900 degrees Celsius, so this is
21 quite a dramatic assumption. If we find out the
22 criteria that meets the 900 degrees after 10 hours and
23 at the same time if you would let the air flow in
24 there, you could leave it there indefinitely and you
25 would not reach the 900 degrees Celsius.

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1 MEMBER MARCH-LEUBA: Thank you for that,
2 but just for the record, I'm suggesting you supplement
3 to this topical report, you are not getting air flow
4 allowed in your calculation. Your current topical
5 report says no air flow.

6 DR. ANTON: That is correct.

7 MEMBER MARCH-LEUBA: Yes. You may want to
8 submit a supplement, but it would a different review.
9 Thank you. Continue.

10 DR. ANTON: Yes.

11 MEMBER BALLINGER: This is Ron Ballinger.
12 The way I read it, what your analysis does is simply
13 change the slope of the heat up rate. This changes
14 the slope. It extends the time, but the relaxation of
15 the air flow thing is so dramatic, I still wonder
16 whether that makes any difference at all because
17 everybody has to assume basically no air flow, then
18 changing the slope looks good from a stylized point
19 of view, but the conservatism is so large that it's
20 just a stylized calculation.

21 MEMBER MARCH-LEUBA: The concern with
22 allowing air flow is they will have to demonstrate
23 that when you're blowing on a fire, you don't increase
24 it, that's the concern. I don't think it is a real
25 concern because you never reach the ignition point,

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1 but that's probably why they didn't.

2 DR. ANTON: Yes.

3 MEMBER MARCH-LEUBA: I cannot wait until
4 the supplement to review it. Keep going.

5 DR. ANTON: Okay, yes, good. That's why,
6 if we would try to take credit for that, and we have
7 discussed that, it would get significantly more
8 complicated. That's why we stayed with the current
9 approach that we actually would not take any credit
10 for that because we were aware of the complication
11 that this would create.

12 That gets me on my slide to the last
13 bullet there because we did not want to have a
14 complicated calculation in this. We wanted to have
15 this approach, this methodology to more or less
16 straightforward and not to be too complicated. And we
17 wanted to be still consistent in our assumption with
18 the previously approved methods. That already then
19 gets me to the summary. We submitted the topical
20 report that improves on the method to determine if a
21 zirc fire is possible or not in a spent fuel pool and
22 that allows us to come up with certain criteria. But
23 at the same time, we still focus here on the
24 significant conservatism of the air flow not being
25 there, which was done to keep it simple, but also to

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1 keep it consistent with the previous analysis and make
2 it actually easier for the implementation and also for
3 the approval.

4 That gets me to the end of our
5 presentation. Any other questions here or discussions
6 that we need?

7 MEMBER MARCH-LEUBA: Members, anybody want
8 to add something? Okay so in the interest of time, I
9 want to thank you, Stefan and Holtec, for a very
10 organized and well presented topic, which I know is of
11 value to the nuclear industry.

12 DR. ANTON: Thank you very much.

13 MEMBER MARCH-LEUBA: Thank you very much.
14 Josh, we'll give you 20 minutes now.

15 MR. KAIZER: Okay. Thank you very much.
16 My name is Joshua Kaizer. I, along with Adam Rau,
17 were the reviewers for this topical report. Next
18 slide, please, Kate.

19 So they've already talked about the drain
20 down methodology and we've already spent a while to
21 talk about the acceptance criterion. There are two
22 other points about that I wanted to bring up.

23 The first was this 900 degrees C for at
24 least 10 hours is a bit fuzzy. Jose alluded to it.
25 If you go back and you read NUREG-1738, it actually

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1 lists a number of temperatures. It can be 900 and all
2 air, it could be 1,200 in steam. The question is
3 which environment is it. It's probably going to be a
4 mixture of air and steam. How much, we don't know.
5 So most people and I think pretty much everyone says
6 the conservative thing of, okay, we'll just go with
7 the lower temperature.

8 There is, even in the acceptance criterion
9 itself, there is some built in conservatism and you're
10 saying, okay 900 not any more than that, for following
11 the spent fuel pool drain down.

12 The other thing I wanted to kind of get up
13 and talk about, because I know Dr. Rempe kind of
14 mentioned it, was the acceptance criterion itself,
15 where it actually comes from. I'm currently viewing
16 this as kind of an acceptance criterion that the
17 applicant proposes to the NRC and then the NRC
18 accepts. We do have a number of acceptance criterion
19 that are, I'd say, enshrined in our guidance documents
20 and SRPs, but a lot of those acceptance criterion that
21 are even in SRPs were initially proposed by applicants
22 to satisfy a regulation.

23 One of my favorites because I deal with
24 CHF a lot, is this 99.9 percent of fuel rods in the
25 core will not experience a boiling transition. That

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1 number was not a number the NRC generated. That
2 number came from an old publically available GE
3 document and they said, hey NRC, we think this
4 acceptance criterion is good to satisfy this
5 regulation. So I wanted to highlight that to say that
6 when an applicant gives us something, it is not out of
7 scope for them to say we think this acceptance
8 criterion can be used to satisfy this regulation and
9 the NRC agrees to that. So I want to provide that
10 background.

11 We know the acceptance criterion and the
12 methodology goal here was Holtec's method should be
13 able to perform the analysis of the spent fuel pool
14 after drain down and demonstrate that, or predict a
15 peak clad temperature, and demonstrate that hey, for
16 at least 10 hours, that temperature doesn't go above
17 900 degrees C. Next slide, please, Kate.

18 All right, so our review goal was
19 basically determine is Holtec's method credible.
20 Credible is a new term really old concept. It's just
21 can we trust their computational model. Credibility,
22 I think, I like the word because it's nice to have a
23 specific word that means can we trust this
24 computational model for its intended purpose. I think
25 it comes from one of the first uses was like a NASA

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1 paper from 2000s. There I give a picture of a recent
2 ASME standard that started to talk about credibility.
3 While the NRC has been focused on this area, I'd say
4 even before it's inception in 1975, we call it
5 credibility now. So we're really looking at is
6 Holtec's method credible, i.e., can we trust it to
7 predict the peak clad temperature following a spent
8 fuel pool drain down, in order to demonstrate that
9 that temperature remains below the 900 degrees.

10 The review challenge in this area, there
11 was very limited validation data. Normally when we
12 look at a model's credibility for a computational
13 model, you are going to base that credibility decision
14 on verification and validation. Certainly
15 quantification activities, I think, we tend to much
16 great weight the validation, the experimental data you
17 have to prove that your model is predicting reality
18 and, in this case, there is limited data, but honestly
19 in many cases there is limited data. So when you do
20 have that limited data, you default to demonstrating
21 that the methods are conservative. There are a lot of
22 conservatisms in this method. This is not out of
23 scope. I would even argue that if you go back and you
24 read Appendix K, that's what Appendix K was doing.
25 When you don't know how physics behaves, you try to

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1 figure out okay, well I don't know the exact behavior
2 of this, but can I come up with a number that bounds
3 what we believe the uncertainties are to be. That was
4 the challenge. Next slide, please.

5 MEMBER MARCH-LEUBA: Josh, no, stay on the
6 slide three for a moment.

7 MR. KAIZER: Yes, sure.

8 MEMBER MARCH-LEUBA: First you have
9 Appendix K's similarity is a very good example. I
10 appreciate you wrote it to the record. I wanted to
11 ask you another question. You wrote a NUREG KM0013,
12 which we reviewed, but you are now referencing the
13 ASME standard, I have not been able to find the final
14 version of KM0013. Is it still in that form?

15 MR. KAIZER: It is. That is my fault. I
16 actually owe someone to review it. I have, I think,
17 two more things to finish off and not much has
18 changed. It is basically just getting that final
19 thing out, but because --

20 MEMBER MARCH-LEUBA: Okay.

21 MR. KAIZER: Of some other work, it keeps
22 getting piled up.

23 MEMBER MARCH-LEUBA: I hate to have a
24 reference in our letter to our draft report, but it's
25 basically final draft, right?

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1 MR. KAIZER: Yes, it is. I really
2 apologize and I appreciate, I won't say yelling at me,
3 but I'll call it yelling at me because this way I can
4 justify to my bosses, hey, I really need to get this
5 done. ACRS is yelling at me for it. So that is
6 helpful to me. (Laughter.)

7 MEMBER MARCH-LEUBA: You can count on our
8 yelling.

9 MR. KAIZER: Thank you.

10 MEMBER MARCH-LEUBA: Keep going.

11 MR. KAIZER: All right, next slide,
12 please. So the safety evaluation mirrors SRP 1502,
13 now SRP 1502 is the staff's guidance on how to review,
14 it's basically transient accident analysis methods.
15 I would argue it's really any computational model. If
16 you're doing modeling for aircraft seat design or
17 small medical devices, whatever, you would follow
18 pretty much the same criteria.

19 Based on, I'd say, it kind of started with
20 a CSAU, which was a document from the 1980s and then
21 developed further in through MDAP, which was from the
22 late '90s, but it is basically if you're going to
23 trust a simulation, you would need to kind of fill out
24 all these steps. The only difference between the SE
25 and what's in the SRP is we've just kind of rearranged

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1 things a little. Same criteria are all there, but we
2 just rearranged them in what we think is a more
3 logical process.

4 The other thing I wanted to stress on the
5 safety evaluation was Appendix A, which was the
6 staff's confirmatory analysis. A lot of times there's
7 confusion on what role a confirmatory analysis plays.
8 The NRC staff can't base its regulatory conclusion on
9 the confirmatory analysis because that analysis is not
10 done under Appendix B program. A lot of times it's
11 done by the staff. The staff makes their own
12 decisions, but that analysis is there to confirm the
13 staff's regulatory conclusion. I think the analysis
14 for our case was extremely helpful. It made things
15 a lot clearer and it did play a very important role,
16 but I did want to stress that we didn't base any of
17 our safety conclusions on the analysis, but we did use
18 that analysis to confirm those conclusions.

19 MEMBER MARCH-LEUBA: You know, I brought
20 this -- this is Jose again, I brought this up in
21 previous meetings that code to code benchmarks are to
22 be relied upon for confirmation, but not exclusively.
23 Here we are almost crossing the boundary, but I
24 believe your approval of this methodology is based
25 more on physical conservatisms.

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1 MR. KAIZER: Yes.

2 MEMBER MARCH-LEUBA: And not exclusively
3 on your code to code comparisons, right?

4 MR. KAIZER: I agree with that. I have
5 seen it written in papers. I feel very proud that I
6 actually have written in the paper not only why code
7 to code is not good, but give like a specific equation
8 that shows you the error of why it's not good. I do
9 agree with that. I think that it is important to note
10 that confirmatory analysis can confirm what the staff
11 is saying, but if the staff reaches a regulatory
12 conclusion, it has to be for other reasons. I mean I
13 would even argue saying that code to code comparisons
14 by the applicant, the level that you can trust those
15 comparisons is not nearly the same as if you can trust
16 validation data and also I think not nearly the same
17 as if you can trust a good conservative judgment on
18 something.

19 MEMBER MARCH-LEUBA: Thank you. As I said
20 before, I think we are in violent agreement.

21 MR. KAIZER: Yes.

22 MEMBER MARCH-LEUBA: I just want to keep
23 bringing it into the record that are many new reactors
24 with esoteric fuels that are coming into review that
25 are going to have very little data available. We need

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1 to keep the code to code comparisons in mind for other
2 applications. This one doesn't have any problem in
3 this regard. Thank you.

4 MR. KAIZER: Understood. All right, next
5 slide, please. All right, this is my last slide. The
6 staff believes that the conservatisms of the method
7 more than outweigh the uncertainties. If I've said
8 that in the, I'd say a more formal speak, the NRC
9 staff believes, this is the second bullet, the NRC
10 staff believes that there is reasonable assurance that
11 the method will conservatively or accurately predict
12 peak cladding temperature following spent fuel pool
13 drain down. I did want to provide a little bit more
14 detail about what do I mean by reasonable assurance
15 because that is something that we get the language
16 from the regulation but it is not necessarily clearly
17 and explicitly defined.

18 In this sense, when I say we have
19 reasonable assurance that this method will
20 conservatively or accurately predict the peak clad
21 temperature, what I mean is there is always a balance
22 between uncertainties in the method, things you don't
23 know, things that have a variance and the
24 conservatisms of the method and you need those
25 conservatisms to kind of outweigh those uncertainties.

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1 The balance between the two here is very similar to
2 the balance in other models and simulations, where the
3 staff has also decided yes, we can trust this
4 simulation for safety analysis purposes.

5 That is the open summary of the review.
6 Any other questions or comments?

7 MEMBER MARCH-LEUBA: Members, this is the
8 conclusion of the presentations. We will not have a
9 closed session, because we do not have time. Any
10 comments?

11 MEMBER BROWN: Can I ask a question?

12 MEMBER MARCH-LEUBA: Yes. Speak into the
13 microphone.

14 MEMBER BROWN: My command voice is not
15 enough? This is, when I looked at this, I tried to
16 get a handle on why they feel it's credible, but why
17 isn't it, is my opinion and I listened, even though I
18 missed a bit of the first part, I did go through it.
19 What's the complicating thing that's different, other
20 than the single assembly being analyzed from a physics
21 and heat transfer standpoint that makes, I guess,
22 people not saying hey, this is okay? I mean this is
23 convected heat flow, boundary conditions. You've got
24 to know what your temperature is in the spent fuel
25 pool, you know, the elements themselves, you know,

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1 what their decay level is, I guess, to find out how
2 much heat. What is the piece that makes the
3 difference from what we did before and now we have to
4 question why the model -- the new way of being able to
5 do a bunch of assemblies and arrange them as opposed
6 to basing it on one assembly? (Simultaneous
7 speaking.) I didn't get that out of the report.

8 MEMBER MARCH-LEUBA: Yes, I am afraid that
9 that might be a proprietary answer.

10 MEMBER BROWN: Oh.

11 MEMBER MARCH-LEUBA: I can fill you in off
12 the microphone if you want, but unless, Stefan, can
13 you give him a short answer in non-proprietary?

14 MEMBER BROWN: I was thinking when I look
15 at it, you've got assemblies, you've got them stacked
16 in various arrangements. You've got to do heat
17 transfer, convective heat flow with air moving up or
18 not moving up --

19 MEMBER MARCH-LEUBA: If you look at --

20 MEMBER BROWN: To make assumptions.

21 MEMBER MARCH-LEUBA: If you read the
22 transcript for the subcommittee, I personally said
23 that Holtec is not going to get the Nobel Prize for
24 this methodology. (Simultaneous speaking.)

25 MEMBER BROWN: Thank you.

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1 MEMBER MARCH-LEUBA: It's very simple and
2 adequate.

3 MEMBER BROWN: Okay, (Simultaneous
4 speaking.) that's fine then, we don't need to go.
5 (Simultaneous speaking.) I just did not see where this
6 was some great leap forward or anything like that,
7 it's basically stuff I learned in college.

8 MEMBER MARCH-LEUBA: Yes, but that's why
9 I asked earlier from Holtec how many months or years
10 they earn by using this methodology.

11 MEMBER BROWN: No, that was a good
12 question.

13 MEMBER MARCH-LEUBA: I wouldn't be
14 surprised if they earn a lot, three or four years.

15 MEMBER BROWN: Well I would think so also
16 based on the thought process. The whole approach
17 seemed to make more sense than what we did before.
18 All right, I'll stop right there. No need to mouse
19 milk this.

20 MEMBER SUNSERI: Charlie, you with
21 Joshua's picture up there, I mean the biggest
22 uncertainty is what is the heat level of the assembly?
23 (Simultaneous speaking.) And that is --

24 MEMBER BROWN: That's what I figured.

25 MEMBER SUNSERI: Balanced by conservatism

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1 in the model, but that's the biggest thing really in
2 going ahead and using this for optimizing a spent fuel
3 pool (Simultaneous speaking.)

4 MEMBER BROWN: Isn't there a way to
5 measure some temperatures to get some idea of what the
6 element --

7 MEMBER MARCH-LEUBA: Fortunately, we don't
8 drain spent fuel pools very often.

9 MEMBER BROWN: No, I understand that.

10 MEMBER MARCH-LEUBA: That's the problem
11 with why they don't have experimental data
12 (Simultaneous speaking.)

13 MEMBER BROWN: We understand the physics
14 of decay heat, I mean we've been calculating decay
15 heat for these plants for 70 years.

16 MEMBER MARCH-LEUBA: And one big advantage
17 is that we are not designing a spent fuel pool for
18 future loading. We already have all the fuel that
19 came out of the core. This is decommissioning. We
20 know what's in there.

21 MEMBER BROWN: Yes.

22 MEMBER MARCH-LEUBA: And they have been
23 doing the burn up in the core as it was burning so
24 they know the decay heat of each bundle (Simultaneous
25 speaking.) pretty accurately.

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1 MEMBER BROWN: I'm just trying to make
2 sure I didn't miss something. I was totally
3 comfortable with reading the whole thing, so it seemed
4 to make a lot of sense to me based on, and recognizing
5 I had heat transfer in college, had at NR whether I
6 liked it or not, I had to deal with it all the time,
7 so this seemed to be fairly straightforward. It's a
8 matter of what is the complicating factor. I think
9 you've answered the question for me. All right, thank
10 you.

11 MEMBER BALLINGER: This is Ron Ballinger.
12 I don't remember whether this is true or not, but does
13 the analysis, is it truly adiabatic at least the
14 conservative one or does it allow for the positive
15 feedback from the zirc water reaction?

16 MR. JONES: Yes, this is Steve Jones. I'm
17 acting chief of the containment and plant systems
18 branch. I just wanted to go back a little bit in
19 history. NUREG-1738 did look at both an air cooled
20 scenario where there's early oxidation of a fuel
21 beginning say at 565 degrees Celsius and compared that
22 with an adiabatic heat up scenario where all the heat
23 is confined to the fuel assembly itself. Then looking
24 at 900 degrees where the reaction rate, the oxidation
25 rate, greatly accelerates beyond 900 degrees in air.

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1 The staff determined that considering all the possible
2 scenarios and configurations that could occur
3 following, you know, extreme seismic events or other
4 events that would really challenge the structure of a
5 spent fuel pool, it was best to consider an adiabatic
6 scenario in terms of evaluating when it was okay to
7 reduce the scope of emergency planning responses.

8 MEMBER BALLINGER: Yes, that's a different
9 question.

10 MR. JONES: Okay.

11 MEMBER BALLINGER: I mean the 1738 does
12 consider the feedback from the zirc water reaction,
13 but what I'm asking is does this methodology consider
14 -- I don't think it does. I think it just --

15 MR. JONES: No (Simultaneous speaking.)
16 It's not intended (Simultaneous speaking.) to because,
17 I guess, the acceptance criteria that we've been
18 working on for the last several years is the Office of
19 Nuclear Security and Incident Response has an interim
20 staff guidance document, DPR ISG 02. I have the ML
21 number, you know, the ADAMS accession number if
22 anybody is interested, but we've been using this for
23 several decommissioning plants over the last several
24 years, since 2000 --

25 MEMBER MARCH-LEUBA: Steve, please read

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1 the ML number on the transcript.

2 MR. JONES: Sure.

3 MEMBER MARCH-LEUBA: So we can follow
4 this.

5 MR. JONES: The ADAMS accession number is
6 ML 14106 A 057.

7 MEMBER MARCH-LEUBA: Thank you. That way
8 if somebody needs to follow up, we wrote it down, too.
9 Thank you.

10 MR. JONES: Okay and that does discuss the
11 basis, how we've gone through initial proposed rule
12 making attempts in the early 2000s and just recently
13 a new rule making package was developed and presented
14 to the commission. We've maintained that 10 hours,
15 900 degrees adiabatic heat up time was an appropriate
16 criterion to use to evaluate a transition away from a
17 coordinated emergency response between the plant and
18 civil authorities outside the plant boundary to going
19 to more of a reliance on all hazards emergency plan.

20 In addition, we're also considering the
21 abilities to mitigate that have resulted from the post
22 9/11 and the Fukushima actions to provide strategies
23 to mitigate different scenarios that might occur in
24 the spent fuel pool and apply those to prevent
25 cladding damage or in the worst case, mitigate the

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1 release.

2 MEMBER MARCH-LEUBA: Steve, since you
3 brought this up, do decommissioned plants have FLEX
4 equipment? Or does it not apply to them?

5 MR. JONES: Yes. During decommissioning,
6 there's a license condition that requires them to
7 maintain some FLEX type capability with respect to the
8 spent fuel pool and (Simultaneous speaking.) we retain
9 that.

10 MEMBER MARCH-LEUBA: Thank you. That's
11 reassuring, thank you very much. (Pause.)

12 MEMBER SUNSERI: My question is not that,
13 it was more procedural. Here we say we're not going
14 to go into closed session because we don't have time.
15 I would suggest that we should check with the members
16 to see if anybody has anything. Charlie had a
17 question that was borderline already and we didn't, so
18 I would ask that question before we decide not to go
19 into closed session.

20 MEMBER MARCH-LEUBA: Anybody want to ask
21 a proprietary question? (Pause.) Thank you. So are
22 you going to ask for public comments or should I?

23 CHAIRMAN REMPE: It's up to you, but one
24 of us should.

25 MEMBER MARCH-LEUBA: All right. Any

NEAL R. GROSS

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1 members of the public that want to make a comment?
2 Remember these are comments, not questions, please do
3 so now and if you are calling us on a cell phone, use
4 star six to unmute yourself. (Pause.) That was five
5 seconds. We are done with the subcommittee meeting.
6 Ms. Chairman?

7 CHAIRMAN REMPE: Thank you. So you have
8 said you have a draft letter you're ready to read in.
9 Tammy, are you out there?

10 MS. SKOV: I'm here.

11 CHAIRMAN REMPE: Great. If you'll bring
12 it up. Why don't we take, let's see, I'm having
13 trouble seeing the very small numbers, it's 9:35,
14 right?

15 MEMBER MARCH-LEUBA: Yes.

16 CHAIRMAN REMPE: Yes, but it's not the
17 same. It says 9:37. (Laughter.) I've learned that
18 part. But anyway, let's take about a 15-minute break
19 and come back at 9:50 East Coast time folks, and we'll
20 read in the draft letter. Okay?

21 MEMBER MARCH-LEUBA: Okay.

22 (Whereupon, the above-entitled matter went
23 off the record at 9:37 a.m.)

24

25

**U. S. Nuclear Regulatory Commission Review of
Holtec International Topical Report HI-2200750,
Revision 0, “Holtec Spent Fuel Pool Heat Up
Calculation Methodology”**

**Holtec’s Method for Determining Fuel Assembly
Heat Up During a Theoretical Drain Down Event**

Joshua Kaizer, PhD

Adam Rau, PhD

Division of Safety Systems
Office of Nuclear Reactor Regulation



February 3, 2022

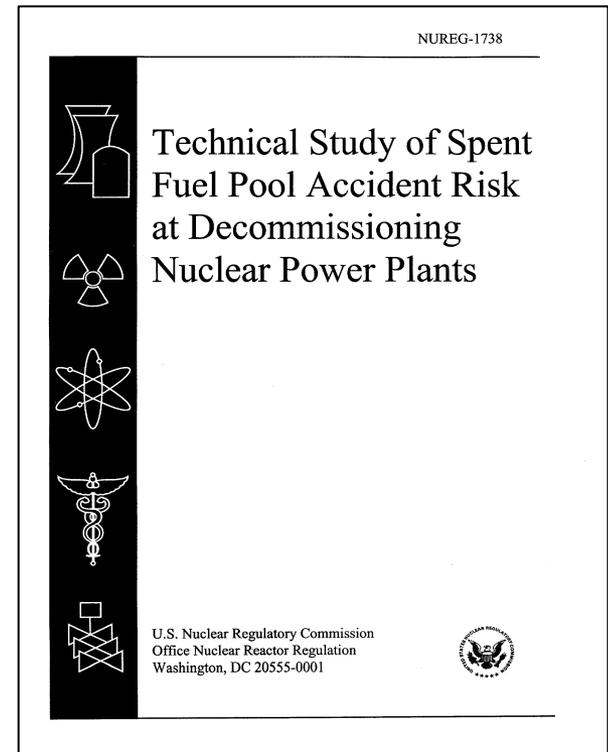
Drain Down Methodology Goal

Acceptance Criterion

- Ensuring that the spent fuel temperature remains below **900 °C** for at least **10 hours** following a complete drain down of the spent fuel pool.

Methodology Goal

- Demonstrate that the configuration of the fuel in the spent fuel pool satisfies the acceptance criterion.



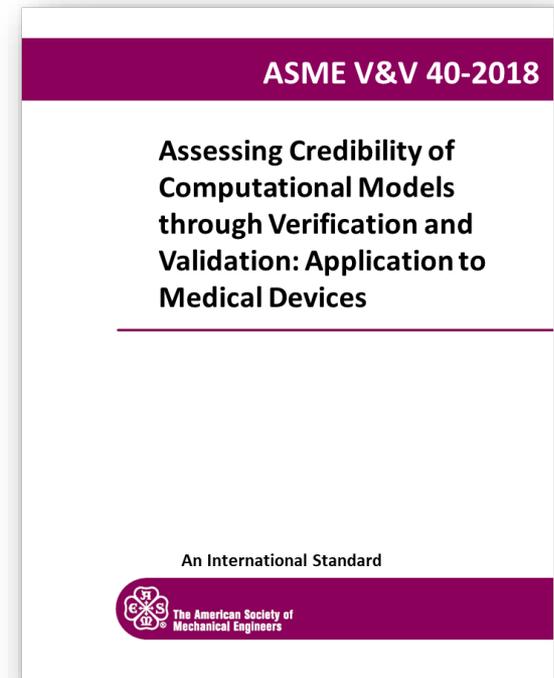
Review Goal

Review Goal

- Is Holtec's methodology credible? (i.e., is there reasonable assurance that the methodology can be used to demonstrate that the acceptance criterion has been satisfied?)

Review Challenge

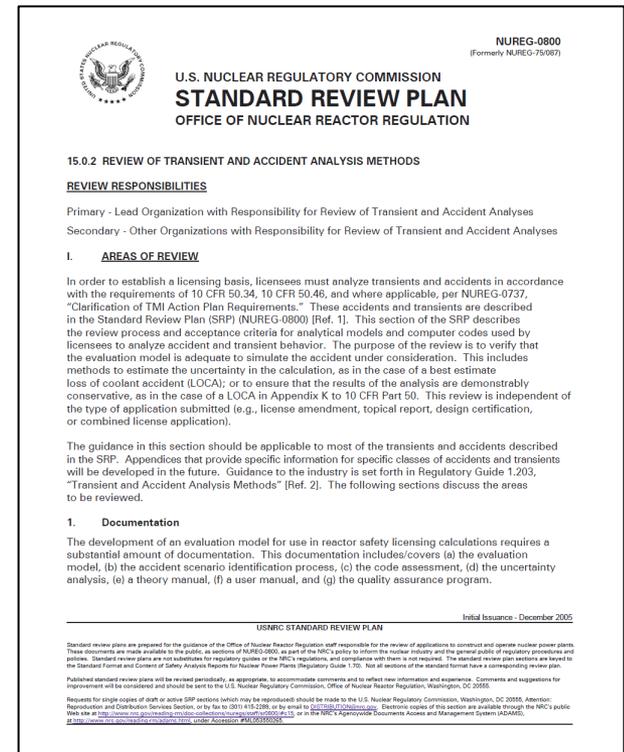
- Validation data is very limited.
 - Demonstrably Conservative Methods



Safety Evaluation Outline

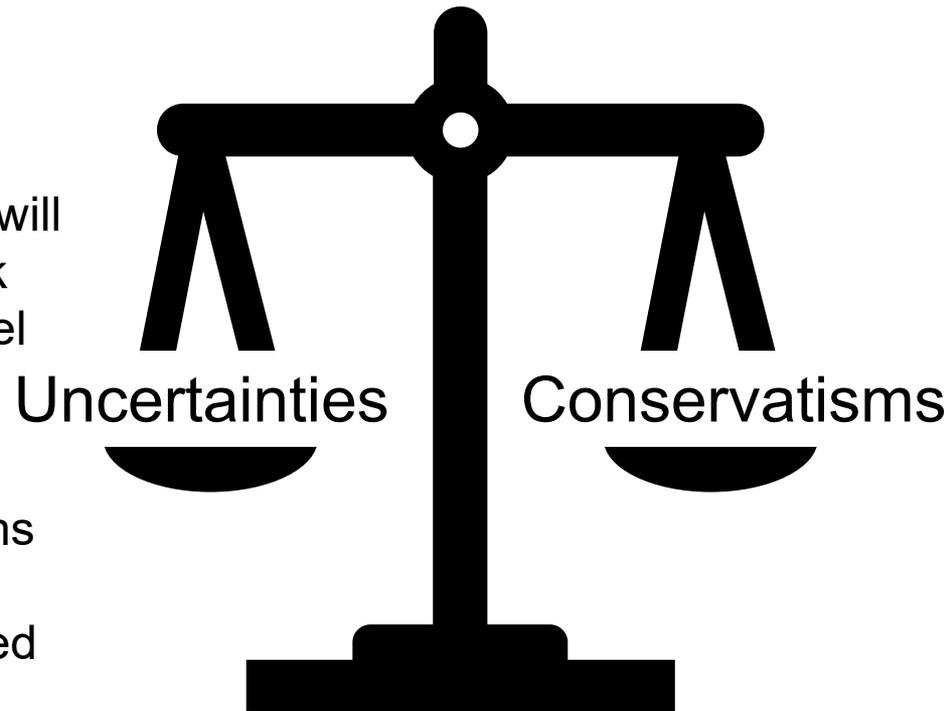
SRP 15.0.2

1. Scenario Identification Process
2. Documentation
3. Evaluation Model Assessment
 - 3.1 Model Applicability
 - 3.2 Model Verification
 - 3.3 Model Validation
 - 3.4 Data Applicability
 - 3.5 Uncertainty Quantification
 - 3.6 Quality Assurance
4. Conclusion
 - A. The NRC staff's Confirmatory Analysis



Conclusions: Conservatisms

- The NRC staff believes that the conservatisms of the method, as well as the analysis performed, more than outweigh the uncertainties.
- The NRC staff believes that there is reasonable assurance that this method will conservatively or accurately predict peak cladding temperature following spent fuel pool drain down.
- Reasonable assurance = “the balance between uncertainties and conservatisms in this instances is similar to other instances where the staff has also trusted the simulation”



Topical Report: Method for Determining Spent Fuel Assembly Heat Up During a Theoretical Drain Down Event of a Spent Fuel Pool

**Holtec Presentation to ACRS Full Committee
OPEN Session**

February 3, 2022

Purpose of the Topical Report

- Provide a methodology to proactively determine the best overall spent fuel pool arrangement to eliminate the risk of a zirc fire as soon as possible after permanent defueling.
- The methodology developed by Holtec can be used to gain a significant and real safety benefit that can be recognized.

Problem Description

- During a theoretical beyond design basis drain down event of a spent fuel pool, the cladding of the fuel assemblies would heat up due to the loss of water cooling in the pool.
- If the cladding temperature exceeds a certain value, there is the possibility of an exothermal reaction with the air, possibly resulting in what is commonly called a “zirconium fire” or “zirc fire”.

Acceptance Criteria and Principal Approach

- The criteria to evaluate if such a condition may occur, used in previous applications and reviewed and approved by NRC, is that a cladding temperature of 900 °C is not exceeded within 10 hours from the drain-down event.
- The principal approach to determine if the condition could occur or not is to perform a transient thermal analysis, and determine the parameters (e.g. cooling time of the fuel assemblies) that needs to be satisfied for the temperature to not exceed the limit within that time.

Previously used Methodology

- The methodology previously used, and reviewed and approved by NRC, is a transient thermal calculation using the following main conservative assumptions
 1. A single assembly is analyzed
 2. Highest decay heat of all assemblies in the spent fuel pool is applied to that assembly
 3. No lateral heat loss to surrounding assemblies
 4. No air flow through the rack and assembly
 5. No other axial heat loss through the top and bottom of the spent fuel rack
- Implementation is fairly simple
 - ✔ Can be done with a simple analytical calculational approach, or a simple spreadsheet.

- Principal difference between the Holtec TR and the previously approved methodology is that the Holtec TR methodology considers limited heat transfer between assemblies
 - ✓ This informs the development of thermally optimized loading patterns throughout a spent fuel pool
 - ✓ The methodology keeps the conservative assumption that there is no heat transfer from the assemblies to the outside environment
- No significant increase in the complexity of calculations

Summary

- A topical report has been submitted that improves on the method to determine if a zirc fire is possible in a spent fuel pool after the assumed drain-down of the water in the pool.
- The method still employs significant conservatisms. Specifically, it still assumes there is no air flow through the rack cell and assemblies after the drain down event.