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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

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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

MATTHEW W. SUNSERI, Chairman

ACRS CONSULTANT:

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

HOSSEIN NOURBAKHSH

*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

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

UNKNOWN FEMALE: Who's talking?

UNKNOWN MALE: Quynh.

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

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

UNKNOWN MALE 2: Me.

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

UNKNOWN MALE 2: All right.

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

UNKNOWN MALE 3: We got you.

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

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

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

MEMBER SUNSERI: Yes, yes, sure.

CHAIRMAN REMPE: This isn't good. (Pause.)

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

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

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

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

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

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

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

themselves when not speaking.

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

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

CHAIRMAN REMPE: Yes (Simultaneous speaking.).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ahead. Are you going to share your slides?

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

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

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

MEMBER MARCH-LEUBA: Okay, Stefan.

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

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

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

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

DR. ANTON: Yes?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MS. STERDIS: Yes.

DR. ANTON: Yes, okay.

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

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

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

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

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

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

Any comments on here before I continue?

MEMBER MARCH-LEUBA: Nothing from me.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

DR. ANTON: That is correct.

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

DR. ANTON: Yes.

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

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

but that's probably why they didn't.

DR. ANTON: Yes.

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

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

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

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

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

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

DR. ANTON: Thank you very much.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MR. KAIZER: Yes, sure.

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

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

MEMBER MARCH-LEUBA: Okay.

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

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

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

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

MR. KAIZER: Thank you.

MEMBER MARCH-LEUBA: Keep going.

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

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

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

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

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

MR. KAIZER: Yes.

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

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

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

MR. KAIZER: Yes.

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

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

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

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

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

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

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

MEMBER BROWN: Can I ask a question?

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

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

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

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

MEMBER BROWN: Oh.

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

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

MEMBER MARCH-LEUBA: If you look at --

MEMBER BROWN: To make assumptions.

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

MEMBER BROWN: Thank you.

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

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

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

MEMBER BROWN: No, that was a good question.

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

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

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

MEMBER BROWN: That's what I figured.

MEMBER SUNSERI: Balanced by conservatisms

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

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

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

MEMBER BROWN: No, I understand that.

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

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

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

MEMBER BROWN: Yes.

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

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

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

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

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

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

MR. JONES: Okay.

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

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

MEMBER MARCH-LEUBA: Steve, please read

the ML number on the transcript.

MR. JONES: Sure.

MEMBER MARCH-LEUBA: So we can follow this.

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

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

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

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

release.

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

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

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

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

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

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

MEMBER MARCH-LEUBA: All right. Any

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

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

MS. SKOV: I'm here.

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

MEMBER MARCH-LEUBA: Yes.

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

MEMBER MARCH-LEUBA: Okay.

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

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

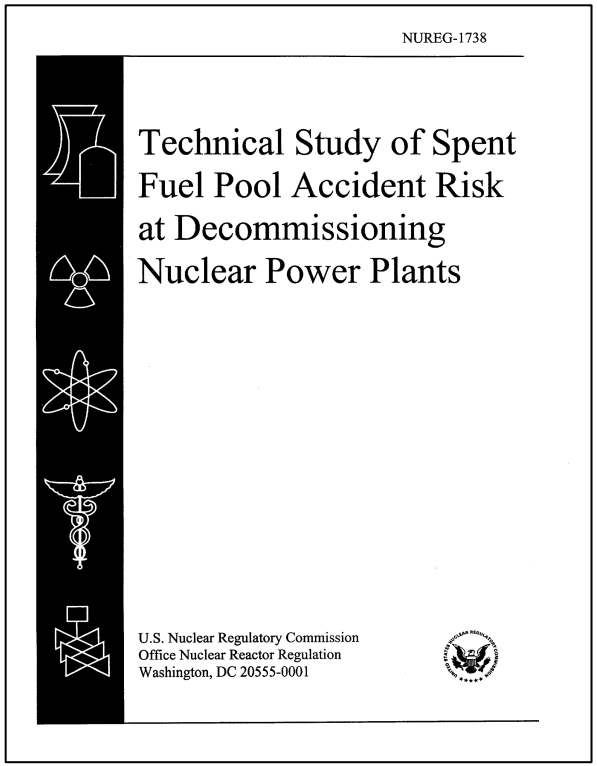
Drain Down Methodology Goal

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

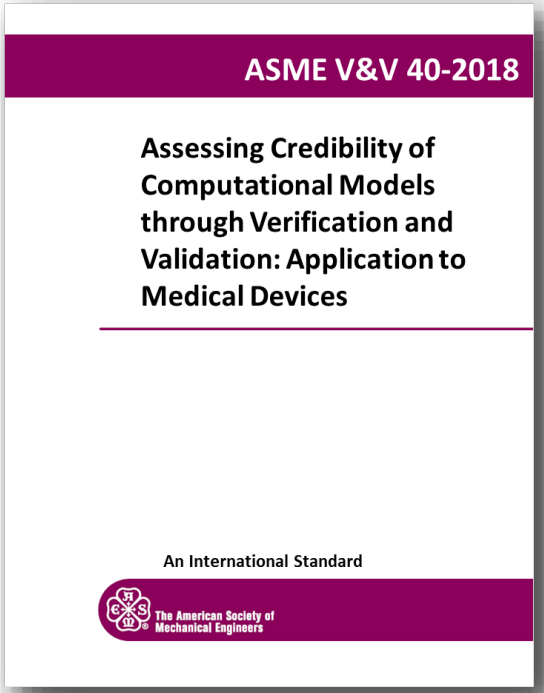
Review Goal

- 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.

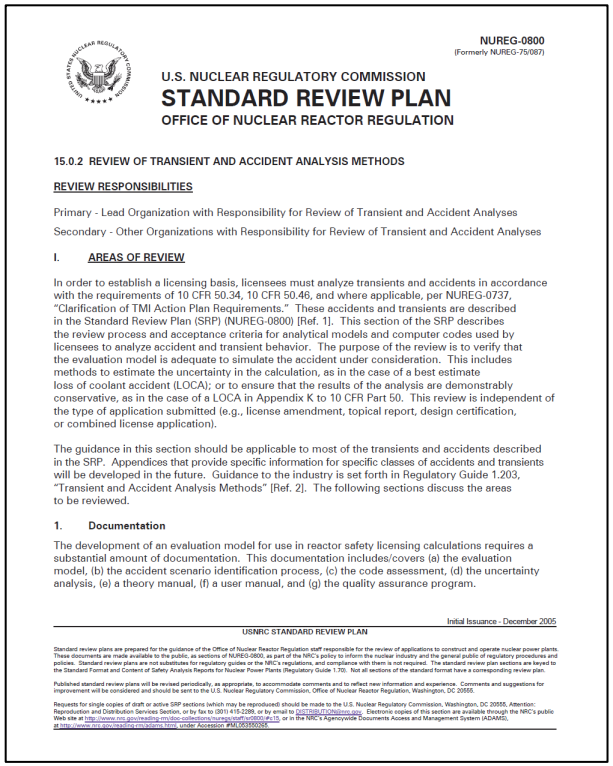
  → Demonstrably Conservative Methods



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



NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

15.0.2 REVIEW OF TRANSIENT AND ACCIDENT ANALYSIS METHODS

REVIEW RESPONSIBILITIES

Primary - Lead Organization with Responsibility for Review of Transient and Accident Analyses

Secondary - Other Organizations with Responsibility for Review of Transient and Accident Analyses

I. AREAS OF REVIEW

In order to establish a licensing basis, licensees must analyze transients and accidents in accordance with the requirements of 10 CFR 50.34, 10 CFR 50.46, and where applicable, per NUREG-0737, "Clarification of TMI Action Plan Requirements." These accidents and transients are described in the Standard Review Plan (SRP) (NUREG-0800) [Ref. 1]. This section of the SRP describes the review process and acceptance criteria for analytical models and computer codes used by licensees to analyze accident and transient behavior. The purpose of the review is to verify that the evaluation model is adequate to simulate the accident under consideration. This includes methods to estimate the uncertainty in the calculation, as in the case of a best estimate loss of coolant accident (LOCA); or to ensure that the results of the analysis are demonstrably conservative, as in the case of a LOCA in Appendix K to 10 CFR Part 50. This review is independent of the type of application submitted (e.g., license amendment, topical report, design certification, or combined license application).

The guidance in this section should be applicable to most of the transients and accidents described in the SRP. Appendices that provide specific information for specific classes of accidents and transients will be developed in the future. Guidance to the industry is set forth in Regulatory Guide 1.203, "Transient and Accident Analysis Methods" [Ref. 2]. The following sections discuss the areas to be reviewed.

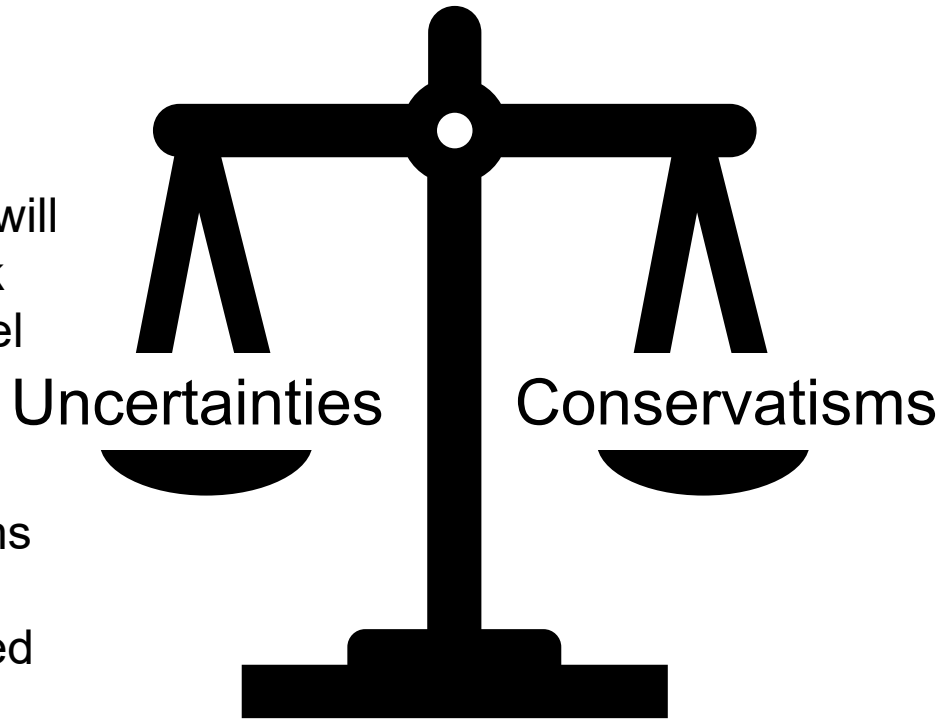
1. Documentation

The development of an evaluation model for use in reactor safety licensing calculations requires a substantial amount of documentation. This documentation includes/covers (a) the evaluation model, (b) the accident scenario identification process, (c) the code assessment, (d) the uncertainty analysis, (e) a theory manual, (f) a user manual, and (g) the quality assurance program.

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 conservativity 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.

Methodology proposed in Holtec Topical Report (TR)

- 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.